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WOOL
WOOL WASHING
WOOL DRYING
BARRING AND CARBONIZING
OPENING AND MIXING
WOOL OILS AND OILING
WOOLLEN CARDING
WOOLLEN SPINNING

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WOOL

FIBRES USED IN WOOLLEN AND WORSTED TRADES

CLASSIFICATION OF FIBRES

ANIMAL AND OTHER FIBRES

1. Wool Used in Combination With Other Fibres.—In order to obtain a thorough and comprehensive knowledge of the methods and processes employed in converting any textile fibre into yarn, it is first necessary to have a good understanding of the structure of the fibre and its characteristics. Especially is this true in regard to wool, which possesses certain peculiarities not shared by any other textile fibre. It is not sufficient for one engaged in woollen manufacture to understand the wool fibre alone, since cotton, silk, and other textiles are often used in woollen mills in association with the fibre obtained from the fleece of the sheep.

The necessity for a detailed consideration of the structure and characteristics of the wool fibre, and for a brief description of other fibres, particularly cotton and silk, is obvious in view of the fact that an enormous trade is done in materials which are bought as woollen or worsted cloths but which contain varying percentages of cotton. To produce mixed yarns and cloth to the best advantage the manufacturer must, of course, be able to choose raw materials which in proper combination

will, when woven and finished, constitute a cloth that brings out or subdues the characteristics of each.

2. Animal and Vegetable Fibres.—The various fibres used in textile manufacturing are, on account of their origin and the marked difference in their physical and chemical properties, divided into two great classes, namely, **animal** and **vegetable fibres**. To the animal class belong the wool of the sheep and the wool-like hair of certain species of goats and animals with similar characteristics, as well as the furs of certain other animals which are used for manufacturing purposes. Another notable type of the animal class of fibres, and one that is second only to wool in importance, is the silk fibre. The most important member of the vegetable class of textile fibres is the cotton fibre, and then follow, in about the order given, linen, hemp, jute, and china-grass, or ramie, fibre, as well as many others of minor importance.

3. Mineral Fibres.—A third class of textile fibres is sometimes formed under the head of **mineral fibres**. This includes such fibres as asbestos, glass wool, gold, and silver. Of these, probably the largest used is asbestos, which is a mineral found chiefly in Canada, the United States, and Italy. Asbestos fibres are as long as 2 inches and are spun into yarn of a whitish-grey appearance; the cloths are used for theatre curtains and other purposes where a non-combustible fabric is desired.

4. Difference Between Animal and Vegetable Fibres.—As previously stated, the difference between animal and vegetable fibres is marked. Generally speaking, the latter are smoother and more pliable than the former, wool in particular having a comparatively rough curly nature and a certain elasticity not possessed by any vegetable fibre.

The difference between the two great classes of fibres is even more marked chemically than physically. Vegetable fibres are composed largely of cellulose, and when burnt are readily consumed, leaving a very small percentage of white ash and emitting practically no odour during combustion. Animal fibres may be said to have a nitrogenous chemical structure and are burnt

with some difficulty, emitting during combustion a pungent odour characteristic of burnt horn or feathers, and leaving a charred globular residue. Vegetable fibres resist the action of alkalis, but are readily destroyed by acids, while animal fibres suffer little or no deterioration from being submitted to the action of dilute solutions of hydrochloric or sulphuric acid, though if these were used in too strong solutions the fibre would be quickly disintegrated. Animal fibres are very sensible to the action of alkalis, the effect of alkaline solutions varying considerably according to their strength and temperature and to the duration of immersion; wool, for instance, when boiled in a 6 per cent. solution, is entirely dissolved in a very short time.

5. Appearance of Wool.—The principal animal fibre, wool, has a rough serrated surface, is curly, or longitudinally wavy, and is disposed on the fleece in locks, technically *staples*, which are composed of a large number of individual fibres. When placed under a microscope and magnified to several hundred diameters, the appearance of various fibres is seen to vary in a marked degree. In Fig. 1 a view is shown of a wool fibre *a*, a cotton fibre *b*, and a silk fibre *c*, as they appear when greatly magnified.

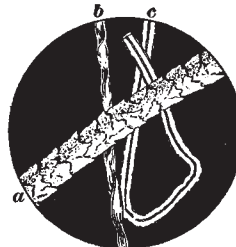


FIG. 1

6. Hair.—Not only do animal and vegetable fibres differ in physical and chemical structures, but there is also a marked difference in physical structure between certain of the animal fibres.

Hair has a smoother surface than wool, is straighter, and is not combined in staples, as each fibre grows individually. Between hair and wool, however, there are many gradations, and certain long hair-like fibres, which are disposed in staples, are commercially classed under the head of wools when, strictly speaking, they should be included among the hair products.

It is supposed that originally, when wild, all animals were either hairy or covered with fur, which is in reality fine thick hair. True wool, as typically illustrated by the fleece of the sheep, is the product of breeding and cultivation, the hairy

covering of the wild animal gradually becoming more like wool in direct proportion to the care bestowed on it and the degree to which it is domesticated. Sheep, if neglected and exposed to inclement weather, show a tendency to revert to their former hairy covering, and the fibre becomes shorter, straighter, and coarser, until sometimes, in high latitudes, it very closely resembles hair. A microscopical view of hair fibre is shown in Fig. 2, from which it will be seen that the hair fibre is somewhat different in structure from the wool fibre illustrated in Fig. 1.

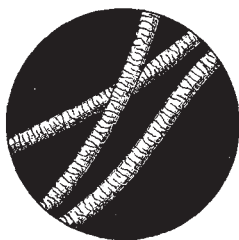


FIG. 2

STRUCTURE AND PROPERTIES OF PRINCIPAL FIBRES

7. Wool Fibre.—Wool fibre is cylindrical in shape and is composed of cells of various forms and sizes. These cells are surrounded by scales of a horny substance which vary in size and nature according to the class of wool. The diameter of the fibre varies greatly, ranging from $\frac{1}{500}$ to $\frac{1}{1500}$ inch. Some wools are very bright and lustrous, while others are dull, having no lustre whatever. The colour of the best wools is a milky white; other wools are black, brown, fawn, etc. Wool is the best felting fibre.

The composition of wool fibre may be taken as follows:

CONSTITUENTS	PER CENT.
Carbon	50·65
Oxygen	22·00
Nitrogen	17·71
Hydrogen	7·03
Sulphur	2·61
Total	<u>100·00</u>

In its chemical nature wool appears to be a proteid known as **keratin**. Its constituents are not constant, and therefore a definite chemical formula cannot be given, but the following may be accepted as the average composition: $C_{42}H_{157}N_5SO_{15}$

8. Cotton Fibre.—A fully matured, or ripe, cotton fibre resembles a twisted ribbon and has well-defined walls of a starchy

substance, these walls forming a distinct cavity in the centre of the fibre. There are as many as 200 turns per inch in a fully ripe cotton fibre. The fibre is usually of good colour and spins well to a great length, for which reason it is largely used for mixing with low qualities of wool in order to spin to high counts and to give strength.

On a careful analysis raw cotton is found to consist of the following :

CONSTITUENTS	PER CENT.
Cellulose	91·15
Hygroscopic water	7·56
Wax and fat	·51
Nitrogen (protoplasm)	·67
Ash	·11
Total	100·00

The empirical composition of cellulose, which is by far the largest constituent of raw cotton, is : carbon, 44·2 per cent. ; hydrogen, 6·3 per cent. ; oxygen, 49·5 per cent. Its chemical formula is $C_6H_{10}O_5$.

9. Silk Fibre.—Silk fibre is the fibre with the fewest surface features ; it is very fine and almost transparent, and therefore very lustrous. Silk will take dye-ware very readily, though with some dyes it is difficult to obtain a permanent colour. It is twisted with woollen and worsted yarns for the manufacture of fancy twists, and is used as a self yarn in the manufacture of fancy vestings and other special cloths.

Chemically, silk is a combination of two substances, namely, *fibroin*, which constitutes from one-half to two-thirds of the whole fibre, forming the interior portion, and *sericin*, also termed *silk glue*, which forms the outer coating. Fibroin is a proteid and its composition may be given as : carbon, 48·8 per cent. ; hydrogen, 6·2 per cent. ; oxygen, 25 per cent. ; nitrogen, 20 per cent. Its formula is $C_{15}H_{23}N_5O_8$. The composition of sericin is : carbon, 42·6 per cent. ; hydrogen, 5·9 per cent. ; oxygen, 35 per cent. ; nitrogen, 16·5 per cent. The formula of sericin may be taken as $C_{15}H_{25}N_5O_8$.

10. Flax Fibre.—When seen under the microscope flax fibre resembles a bamboo cane or a hollow tube notched at intervals. It has remarkable spinning qualities in the finer counts and when bleached is purely white. Its chemical composition is similar to that of cotton.

NATURE OF WOOL FIBRE

MODE OF GROWTH

11. Skin of Sheep.—Wool may be said to be a term which, in its strictest sense, applies only to the fleece or covering of the sheep, but which is often extended, for purely commercial

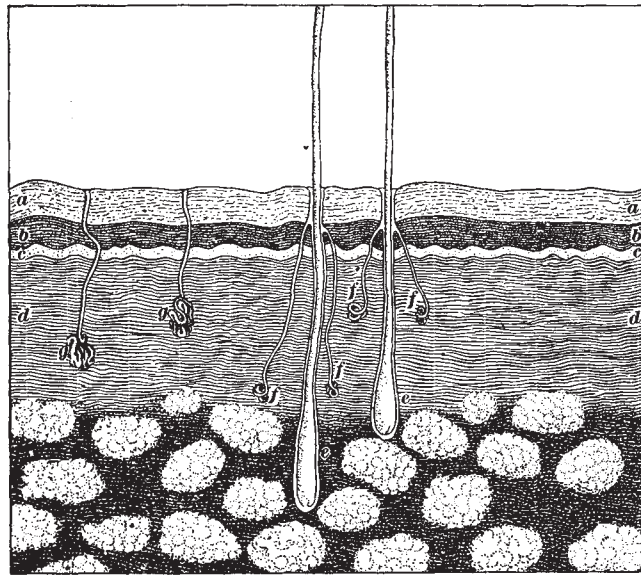


FIG. 3

reasons, to include certain other animal fibres that are more properly included under the term hair. Wool is an epidermal growth of the sheep, and its character depends on the breed of the animal, the pureness of the breeding, and the locality in which the wool is grown.

The mode of growth of a wool fibre may be seen by referring to Fig. 3, which is a section of the skin of a sheep highly magnified to show its construction clearly. The skin consists of four textures: the *cuticle*, or *scarf skin*, *a*; the *rete-mucosum* *b*; the *papillary layer* *c*; and the lowest strata, or *corium*, *d*. The cuticle, which is the outermost skin, is tough and devoid of feeling. The rete-mucosum has a fairly distinct cellular structure, but has no more consistency than mucilage. The papillary layer, which extends into the rete-mucosum above it and the corium below it, is in the form of minute elevations and depressions, and as it is in this layer that the nerves terminate, it is very sensitive. The corium, closely connected with the more compact layer above it, is a vascular structure with areolar openings. Other important features are the *hair follicles* *e*, which are cavities in the skin, their bases being at various depths. The hair or wool fibres are formed in these cavities. There are also the *sebiferous glands* *f*, which join the follicle by means of a short tube and secrete a kind of oil, and the *sweat*, or *sudoriparous glands* *g*, which do not join a hair follicle, but reach the outer surface of the skin.

12. Formation of Wool Fibre.—The wool fibre itself is formed of three distinct portions. In the centre is a medullary canal like a pith, shown at *a*, Fig. 4. This is formed of soft globular cells, and it is surrounded by a layer of elongated and somewhat spindle-shaped cells *b*, which form the bulk of the fibre. Surrounding the whole is a layer of flattened horny scales or cells *c*, which in a healthy sheep have a high lustre. These outer scales form a complete covering for the fibre, the top of each scale, or portion near the tip, being free and projecting somewhat from the body of the fibre. The scales form what are known as the **serrations**, or **imbrications**, of the wool fibre, and are one of the prime causes

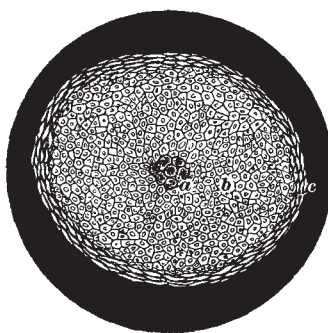


FIG. 4

of the unequalled felting, or milling, power possessed by wool. It is this felting power that enables a cloth composed of suitable wool to be so amalgamated that one fibre joins another, producing a firm thick fabric, the distinct individuality of the component threads of the fabric being lost. A person with a very sensitive touch can feel the scales by drawing the fibre through the fingers from point to root. If the fibre is drawn in the opposite direction, that is, from root to point, it will feel perfectly smooth, since, as previously stated, the scales project from the fibre in the direction of the point. An idea of the appearance of the scales may be obtained by referring to Fig. 1, in which a typical wool fibre is illustrated on a large scale.

13. Structure of Wool and Hair Fibres.—Wool and hair fibres are living shoots from the skin and are fed constantly from the roots. They are sustained by the sebiferous glands, which draw a natural oil from the skin, thus greasing the scales on the surface and preventing them from irritating the nervous lining of the follicle in their passage upwards through the skin. The fibre itself is formed by the exudation of plastic lymph from the capillary plexus at the root of the follicle, the lymph changing into granules and subsequently into cells, which cells are elongated and formed into the central structure of the hair or wool. The principal difference between hair and wool is in the outer covering of the fibre. The serrations or scaly parts of the wool fibre are formed by the cells shrinking as they emerge from the skin, the front part of the serration shrinking to a point and the remainder of the serration, which shrinks in its turn, being flattened down. The next cell in being pushed forwards overlaps its predecessor.

PROPERTIES OF WOOL

14. Felting.—The value of any wool as a felting wool depends largely on the number of serrations, together with the natural curly, or wavy, nature of the fibre. **Felting**, which is a quality possessed in a marked degree by wool only, may be said to be the amalgamation or matting of the fibres. The small teeth-like projections of one fibre catch into those of its neighbour

and become locked together, this being helped by the curly nature of the fibre inclining it to twist round anything that is near. Under pressure and in the presence of some lubricant, such as soap and warm water, the fibres of wool become matted together and identified with one another. This is exactly what happens when a woollen cloth is milled. The cloth is under pressure and in the presence of warm water and soap. With these conditions, the dried-up cells that form the scales on the surface of the fibre become softened, the serrations of one fibre become interlocked with those of the next, and the threads of the fabric become amalgamated to such an extent that they can only with difficulty be separated.

15. Shrinkage in Felting.—The process of felting woollen cloth just described is accompanied by a shrinkage which is apparently due to the fibre being composed of innumerable dried-up cells. When these cells are placed in hot water they expand slightly and become soft, an action which is facilitated by a little acid being added to the water, while a small fraction of the fibre may be entirely dissolved. The cells, after being softened, do not return to their former positions when dry again, but shrink into one another more than before; consequently, the fibres and cloth decrease in length and become bulkier and shorter.

16. Conditions in Felting.—In order that felting may take place, it is essential that some of the fibres lie in one direction while others point in the opposite direction. This object is always accomplished during the manufacture of the yarn by the repeated mixing and blending to which the fibres are subjected. In Fig. 5 a longitudinal section of two wool fibres is shown, illustrating the method by which the serrations of one fibre become interlocked with those of another. The illustration is, of course, out of proportion, but it will be readily noticed that the fibres must be inclined in opposite directions in order to felt. If they were both arranged side by side with



FIG. 5

roots and tips together, the serrations of one would readily slide over those of the other, no matter in what direction the fibre was moved.

Although the serrations of the wool fibre are a prime cause of its felting power, it must be remembered that its curliness and elasticity also influence the felting of the wool. Neither the curliness nor the elasticity, however, is the sole cause of felting, as some fibres, mohair, for instance, have a beautiful crimp, or curl, but, owing to the lack of sufficient serrations on the fibre, are extremely difficult to felt.

17. Wool Felting on Sheep.—Wool rarely felts on the sheep, owing to the fact that the serrations are filled with a natural grease, known as **yolk**, and also because, when on the sheep, the scales all point in one direction, that is, from the root toward the point of the fibre, the root being fast in the skin of the sheep. Occasionally, however, in the case of a sick sheep, the wool will felt on the sheep's back in patches, which are called **cots**. These are especially apt to occur on old sheep, particularly ewes 6 or 7 years old, and are due to a scanty supply of the animal grease, or yolk, at the places where the cots occur.

18. Liability of Wool to Felting.—Except for the manufacture of hats and felts, wool is usually felted or milled after it is spun and woven into cloth, but may sometimes become felted accidentally unless great care is taken at other stages of its manufacture, particularly in the scouring process. The felting or fulling properties of some wools are so remarkable that it is only necessary to beat the wool in order to form a felted fabric. As a rule, short wools are better felting wools than those of longer staple, since they are usually richer in serrations and finer in fibre.

19. Number of Serrations.—The more numerous the serrations on the wool, the more valuable is the wool for fulling or felting purposes. The number of serrations per inch of various wools varies from a few hundreds to several thousands; in a general way it may be said that the longer and coarser the wool, the fewer are the serrations. The Saxony Electoral wool, which has

superb fulling qualities, contains as many as 2,800 serrations per inch, while Australian merino, which also possesses excellent felting properties, has 2,400 serrations per inch.

20. Softness and Fineness of Wool.—The softness and fineness of wool, two very important properties, vary according to the breed of the sheep and the state of cultivation to which it has been brought. As a rule, short wools are finer and softer than long wools, but this does not hold true in all cases, for some long wools are very fine and soft, while some short wools are harsh, coarse, and wiry. This, however, is not generally the case. The finer the wool fibre is in diameter, the softer is its feeling. No wool can be soft unless it has a plentiful supply of the natural animal grease, or yolk, without which it has a harsh, brashy feeling. There is considerable difficulty in making accurate measurements of the actual diameter of the fibre, on account of its extreme fineness, and also because of the irregular shape of the section, the fibres being round in some instances and elliptical in others. Saxony Electoral wool, one of the finest and best-grown wools in the world, has been found to be about $\frac{1}{2000}$ inch in diameter, varying from this to $\frac{1}{1600}$ inch.

21. Strength and Elasticity of Wool.—In order to produce cloth of the highest grade, wool must possess strength and elasticity. It is one of the most elastic fibres known to the textile industry, and for this reason is unrivalled in the production of cloth with a *lofty feel*, that is, cloth having the full, soft, elastic *handle* so much desired by the commission house and buyer. The elasticity of wool is no doubt due in some degree to the curly, wavy nature of the fibre, as well as to its natural structure.

To illustrate the elasticity of wool, as compared with other fibres, take a handful of clean, dry, Australian merino, or other high-grade wool, in one hand and compress it into as small a space as possible; then release the pressure, and the wool will resume its original shape. If the same experiment is tried with a handful of cotton, the material will remain in a more or less inert lump, and will not spring back like the wool.

22. Limits and Values of Strength and Elasticity.—When a wool fibre is subjected to tension instead of compression, it is

found that the elastic limit, after which it will not return to its original length, is reached when the fibre has been stretched from $\cdot 3$ to $\cdot 5$ per cent. of its length. A single wool fibre will support from $\cdot 5$ to 1.25 ounces, depending, of course, on the fineness of the fibre. Both the breaking weight and the elastic limit, however, will be found to vary greatly with different samples of wool. The strength and elasticity greatly aid in the manufacture of woollen goods, especially in the spinning of yarn; and that they play an important part in the quality of a fabric is shown by the superior strength and handle of a piece of pure woollen cloth as compared with a fabric manufactured from, or adulterated with, either cotton or cheap wool substitutes.

23. Curliness or Waviness of Wool.—The waviness or curliness of the wool is another important factor in its value, since this quality of the fibre aids not only its elasticity, but to a certain degree its felting power. A curly fibre is very advantageous in spinning, for it can be drawn finer and a more compact and rounded thread formed. Such a fibre is also advantageous in felting. It is possible, by reason of the curly nature of wool, to spin a thread containing a very few fibres in its cross-section. Generally speaking, it may be said that the more waves per inch there are in the fibre, the finer is the wool, that is, the diameter of the fibre. This is not a universal rule, though it is often supposed to be, but it serves in the majority of cases as an indication of the diameter of the fibre.

The number of waves per inch in the wool fibre vary from 28 or 30 in fine wool, as, for instance, Saxony and merino, to only 1 or 2 in lustre and coarse carpet wools. While the waviness of the wool fibre is permanent, it is altered somewhat by the amount of moisture in the fibre, and may be taken entirely out by stretching the fibre in hot water. After drying, however, the curl usually returns, and the fibre assumes its former shape.

24. Soundness of Fibre.—One of the qualities of a wool most desirable to the manufacturer is **soundness** of the fibre. If the sheep have been ill-kept, neglected, exposed to inclement weather, or pastured on ranges where the feed is insufficient, the growth

of the wool is stunted and its quality indifferent. Such a flock will often produce what the buyer terms **tender staple**, that is, the fibres are weakened and are not so strong as the average wool. If a sheep is neglected and starved, even for a few days, there will be a correspondingly thin, weak place in the wool, where its growth was stunted during the period of neglect. This weak place will remain in the fibre even after the wool has continued to grow. It is said that the most expert buyers can, if there is a weak place in the staple of a lot of wool, tell the month in which the drought that caused it occurred.

It is a well-known fact that alkalies are detrimental to wool, and when a flock of sheep habitually range on an alkaline soil the fibre will be somewhat weaker than the average. The wool fibre should taper slightly from the root to the tip; but sometimes, where sheep are exposed to rough weather, the fibre will thicken up at the tip where it is exposed and still remain fine near the root, where it is protected from the weather.

25. Imperfections in Wool.—Wool being somewhat fibrous and porous, the fibre is easily split; indeed, when the sheep is sick, the fibres often split from the tip toward the root. If the wool is very dull in appearance it is apt to be tender. Sound wool is bright, lustrous, and moderately greasy, or yolked. After a sheep has passed a certain age, 6 or 7 years for instance, the wool produced is apt to be tender, as well as somewhat deficient as regards yolk. In testing wool for tenderness, a small lock or staple is taken and its strength tried. It can easily be seen if the wool is weak to any great extent, as it will always break at about the same place.

26. Kemps.—In fleeces from neglected or poorly bred sheep there occur certain bright, shining, straight hairs called **kemps**. These hairs are wool fibres that appear to be diseased or dead. They are straighter than the ordinary healthy fibre, and when viewed under the microscope do not show the characteristic scales or serrations of the wool fibre to such a marked extent. Kemps are more or less opaque, while the ordinary wool fibre is somewhat translucent. They occur even in best-class wool, such as Saxony and merino, but are much more frequently met

with among the lower-grade and cross-bred wools. They generally occur about the neck and legs, where the wool gradually merges into hair.

Kemps vary in length, being in some sheep 2 inches long, or even more. In brown or dark-coloured sheep the kemps are black, but in most cases they are white. They never unite with the other wool in forming a thread, but are simply held in place by the other fibres, and on the surface of the cloth will be seen as straight shining hairs pinioned down by these fibres. In the dye bath, kemps will not dye the same shade as the other fibres, owing to the fact that they do not absorb the dyestuff as readily. This causes them to show up prominently in the finished goods, thus greatly deteriorating the fabric. By careful breeding and care in housing the sheep in cold and stormy weather, the condition of kempy sheep may be greatly improved.

27. Colour of Wool.—In regard to colour it may be said that, generally speaking, the whiter the wool, the more highly it is prized, although there are certain shades of natural browns and black wools that are in frequent demand. The colour is not of so much importance as other qualities, unless white or delicately coloured goods are to be produced. The majority of wools are white, but brown, black, red, grey, and yellow are produced in small quantities, notably certain qualities of Persian and East Indian wools. The colour of the wool is largely influenced by the character of the soil on which the sheep ranges. Sheep fed on good rich grass lands generally produce wool of good colour, while those fed on sandy and red-tinged soil produce wools of a colour varying from light yellow to brown.

28. Lustre of Wool.—Lustre may be defined as the bright, or shining, quality possessed by wool in a marked degree. While wool is not as lustrous as silk, it is far more so than cotton. The lustre of the wool fibre appears to be due to the reflection of light from the horny scales that surround the fibre. As a rule, long and coarse wools are more lustrous than the finer and shorter wools. This is due to the fact that the scales of the fibre are larger and flatter, and thus form a larger reflecting

surface for the light. It may be said that the lustre is directly dependent on the size, flatness, and polished condition of the scales, and that any cause that tends to injure the scales will injure the lustre. The lustre is often injured during scouring and drying by the use of too strong or unsuitable detergents and the application of too much heat. The wool of a healthy sheep is lustrous, while that of a sick sheep appears dull and dead. A lustrous wool adds a certain brightness and fresh appearance to the fabric that is manufactured from it.

29. Staple.—The term *staple*, or *length of staple*, means the length of the fibre. Wools are classified as long- and short-stapled. *Long-stapled wools* are known as **combing wools**, and are combed for coarse worsted yarns; *short-stapled wools* are known as **clothing wools**, and are carded for the production of woollen yarns and fabrics. There is a class of wools between the long- and short-stapled wools which have a medium length of staple and are known as **fine combing wools**. They are first carded and then combed for the production of fine worsted yarns for ladies' dress-goods, worsted suitings, etc.

The length of staple varies greatly with the breed of sheep, and it may also be said that, generally, the longer the staple, the coarser and more lustrous is the fibre. The staple length varies from what is scarcely definable to 15 and even 20 inches. It is erroneous to suppose that all long-stapled wools are made into worsted and all short-stapled wools into woollen yarns. Quite short-stapled wool is now made into the fine grades of worsted yarn.

30. Hygroscopicity.—The hygroscopic property of wool, or its avidity for moisture, is one of its most marked physical characteristics and is valuable for dyeing purposes. Under normal atmospheric conditions, it will be found that 16 per cent. of the weight of wool is moisture, this being the trade standard of regain; but if the atmosphere in which the wool is stored is very damp, it may be found to contain as much as from 30 to 50 per cent. of water. Wool brought from a damp storehouse, therefore, into a warm dry mill will lose in weight. Sometimes the wool in the mill will become so dry as to contain

not more than 6 or 8 per cent. of moisture. In this condition it becomes hard to work and is easily electrified, which leads to the necessity of providing some method of artificially regulating the humidity of woollen carding, spinning, and weaving rooms. The moisture seems to be contained in the wool fibre in two conditions: (*a*) in a purely mechanical state, as a sponge would absorb water, and (*b*) in a somewhat chemical state, as water of combination.

31. Conditioning Wool.—In Great Britain and on the Continent so-called conditioning houses are established, where the buyer can determine the amount of moisture in given samples of wool. This is a very great convenience, and puts the buying and selling of tops, noils, and yarns on a sound basis.

The method of determining the amount of moisture in a sample of wool is first to weigh it carefully, and then to place it in an oven until the moisture is driven off and the sample ceases to become lighter. The amount of loss in weight and the percentage of moisture that the sample contained are then readily determined.

32. Comparison of Wools and Hairs.—Comparative details of a number of well-known types of wool and hair are given in Table I.

TABLE I
DIMENSIONS AND HANDLE OF TYPES OF WOOL AND HAIR

Type	Average Length of Staple Inches	Average Diameter of Fibre Inch	Handle	Serrations Per Inch
Merino	$2\frac{1}{2}$	$\frac{1}{1300}$	Very soft	2,400
Southdown . . .	$3\frac{1}{2}$	$\frac{1}{1100}$	Soft	2,000
Cheviot	$4\frac{1}{2}$	$\frac{1}{1000}$	Fairly soft	2,000
Fine cross-bred .	4	$\frac{1}{1000}$	Fairly soft	2,000
Coarse cross-bred	9	$\frac{1}{800}$	Rather hard	1,800
Leicester	12	$\frac{1}{700}$	Rather hard	1,800
Mohair	8	$\frac{1}{900}$	Soft and silky	1,200
Alpaca	10	$\frac{1}{1200}$	Very soft and silky	Scarcely visible

WASTE WOOLS

33. Noils.—Immense quantities of woollen yarns are spun from material that has passed partly or wholly through the processes of manufacture and may have been in fabrics that had been converted into articles of clothing. It is convenient to divide this material into two classes: (a) the by-products of manufacturing, such as **noils** and spinning and weaving wastes, and (b) wools recovered from cloths. In the first class the material is practically new, having been only partly manufactured. The most valuable of these **waste wools** are the noils, which may be classified as (a) *botany noils*, (b) *cross-bred noils*, (c) *English noils*, (d) *alpaca noils*, and (e) *mohair noils*, all of them being obtained by combing the different materials from which they take their names.

34. Botany Noils.—The **botany noils** are the combings from Australian and other fine wools, and are the most valuable. They are used for blending with wool for the purpose of making very full yarns, suitable for the manufacture of shawls, and also for mixing with cotton in the making of fine twist yarns, etc. They can be spun up to 40's and even as high as 60's. The finer of the cross-bred noils are similar to the botany noils and are utilized in the same branches of manufacturing.

35. English Noils.—The **English noils** are much coarser than the botany noils, and are largely employed for mixing with Cheviot wools in the manufacture of medium and inferior-class tweed cloths. The whole of the lower qualities of these noils is used in the blanket trade. English noils are also employed for mixing with shoddy or shoddy and cotton, being added to give fullness, while the cotton facilitates spinning. Another use to which English noils are put is to form weft yarns in serges. Cross-bred noils of coarse grade are much the same as English noils.

36. Alpaca and Mohair Noils.—Alpaca noils are very soft and lustrous, and the better qualities are used for blending with wool in the production of good-class worsted coatings and suitings. Mohair noils are lustrous, but not so soft in handle as

alpaca, though they are employed for similar purposes. The lower qualities, however, are absorbed in the making of lustre rugs, the yarns being spun to about 6's skein.

RECOVERED WOOLS

37. Shoddy.—The best of the **recovered wools** is known by the name of **shoddy**, and consists of the wool fibre recovered from soft woollen rags that have not been milled or felted, such as flannels, stockings, and knit goods. Shoddy is also made from the hard waste of woollen mills, although this is often used by the mills in connection with their soft waste and new wool. While shoddy is really pure wool, the fibre loses much of its characteristic woolly nature in the manufacturing and pulling apart again to regain the fibre.

When viewed under the microscope, the shoddy fibre is seen to differ greatly from the original wool fibre. The distinctive scales or serrations have been more or less injured, and may be entirely wanting in places, while the fibre as a whole appears to have been stretched.

38. Deterioration in Making Shoddy.—In the process of obtaining shoddy the woollen rags are torn into a fibrous mass, the length of the fibres being from $\frac{1}{2}$ inch upwards. Although the rags are first oiled and the rag picker is so designed as to perform this office with the least possible injury to the fibre itself, still the process of reducing the rags to a fibrous condition necessarily injures the fibre and breaks it until it may be but a fraction of its original length. The loss in the length and the destruction of the regular structure of the fibre make shoddy only fit for mixing with new wool for the production of poor-class

goods. White shoddy is very rare, for the material from which shoddy is made has usually been dyed.



FIG. 6

The appearance of a fibre of shoddy greatly magnified is shown in Fig. 6. It will be noticed that the characteristic structure of the wool fibre is almost entirely destroyed.

39. Mungo.—Mungo is a wool substitute that is even poorer in fibre structure than shoddy. It is the fibre recovered from hard-spun and milled, or felted, woollen and worsted goods, and varies in length from $\frac{1}{2}$ inch downwards. Owing to the hard milling and felting that the fibres have previously undergone, when recovered they are almost destitute of the serrated, or imbricated, structure of a pure wool fibre. There are two varieties of mungo. The better quality is obtained from new rags that accumulate as clippings in tailors' shops, and the inferior quality from worn and cast-off broadcloths, suitings, etc. Mungo is used for low-quality woollen goods in combination with a small proportion of new wool to give strength to the yarn.

The cheapness of shoddy and mungo, together with the wide range of colours obtainable, enable manufacturers to produce very low-priced yet attractive cloths, and consequently these substitutes are used in almost all kinds of woollen goods.

40. Collection of Rags.—The rags used in the shoddy and mungo trades usually pass through the hands of the travelling rag gatherer, the rag dealer, and the rag sorter before reaching the manufacturer. The trade in this material fluctuates greatly, especially in its international character, for while in one year Germany may export large quantities to the heavy-woollen district of Yorkshire, and France very little, the contrary may be the case in the following year. Though pullers and even manufacturers sometimes buy direct from Continental dealers, their purchases are usually made at the auction rag sales held weekly at Batley and Dewsbury, the lots there disposed of having been sent from the Continent to local brokers.

41. Sorting Rags.—When the rags are purchased by the shoddy dealer or the manufacturer, or whoever it is that is to do the final sorting and pulling, they are only very roughly classified and require to be sorted much more carefully before they can be used. Rags of vegetable fibre are separated from the rest and sold to the paper trade. Those containing both animal and vegetable fibres have to go through the process of extraction to remove the vegetable element. All vegetable threads of any kind must be picked from the rags, and all rags containing silk

are to form a separate class. The wool class is then subdivided into milled and unmilled fabrics, and there is often another subdivision into clean and dirty sorts. Milled rags are also classified into fine, medium, and coarse, while the unmilled are sorted in accordance with the colour, quality, and character of the cloth from which they have been obtained.

42. Extract.—What is known as **extract** is the wool fibre recovered from *union goods*, that is, cloths that contain wool and some percentage of vegetable fibre, usually either cotton or linen. In order to recover the wool alone, and not to have the recovered animal fibre mixed with vegetable fibres, it is necessary to resort to a chemical process. This process for the extraction of the vegetable from the animal fibres is generally known as **extraction**, but sometimes is spoken of as **carbonization**. Among the different kinds of cloth which are so treated are cotton warp and mohair- or lustre-weft cloths, inferior union cloths with a cotton warp, and thick woollen weft.

43. Process of Extraction.—The process of extraction is as follows: The rags are first carefully dusted and cleaned, and then are immersed in a solution of sulphuric acid of from 4° to 6° Beaumé strength. The acid solution is usually contained in wooden tanks, and the rags are frequently stirred and moved about so as to ensure the thorough mixing of the acid and water. When the rags have become thoroughly saturated with the acid, they are removed and the excess of the solution drained off, after which they are dried at a high temperature, varying from 100° to 110° C. This process reduces the vegetable matter to a charred or disintegrated form, while the acid has small effect on the wool. The rags are then crushed and dusted in a carbonizing duster or similar machine, and the vegetable matter removed as dust. The recovered wool fibre may now be treated with a dilute soda bath to neutralize the effects of any traces of acid that may remain in the fibre. After washing, or neutralizing, the material is run through a very coarse open carder, in order to give it the required woolly appearance.

44. Flocks.—Flocks, which are little better than dust, are waste from the finishing machines in cloth mills. They are of

three kinds. **Milling flocks** are a by-product of the process of milling or felting and always command a fair price. They are used for blending with other materials for fabrics of a tweed class. **Cutting flocks** are the refuse fibre resulting from the operation of cutting the surface fibre from the cloth. These are not often used by woollen manufacturers, except for very low-class goods. **Raising flocks** are obtained from the teazles of the raising gig, which teazles, in raising the fibre on the surface of the cloth, retain a certain amount of fibre. When taken from the teazles, the fibre is termed raising flocks, which are similar to milling flocks and are employed for similar purposes.

SUPPLY OF WOOL AND HAIR

SHEEP

45. General Classification of Sheep.—Having dealt somewhat exhaustively with the structure of the wool fibre, it will perhaps be of advantage to consider the different varieties of sheep from which wool for textile purposes is obtained. Some naturalists recognize only three varieties of sheep; namely, the *Ovis ammon*, or wild sheep, of Asia and America; the *Ovis musimon*, inhabiting the southern parts of Europe and northern portions of Africa; and the *Ovis aries*, or domestic sheep. It is claimed that all other sheep are but varieties of the above, being obtained by crossing and breeding.

46. Archer's Classification.—The best classification of the sheep of the world is that made by Prof. Archer in co-operation with representative manufacturers and naturalists. He divides the sheep that are useful to man into thirty-two distinct varieties, and groups them geographically as follows:

EUROPE	ASIA
<ol style="list-style-type: none"> 1. Spanish, or merino, sheep 2. Common sheep 3. Wallachian sheep 4. Crimean sheep 	<ol style="list-style-type: none"> 1. Hooniah, or black - faced Tibet sheep 2. Cago 3. Nepal sheep

ASIA—(Continued)		AFRICA	
4. Curumbar, or Mysore, sheep		1. Smooth-haired sheep	
5. Gārār, or Indian, sheep		2. African sheep	
6. Dukhun, or Deccan, sheep		3. Guinea sheep	
7. Morvant de la Chine, or Chinese sheep		4. Zeylan sheep	
8. Shaymbliar sheep		5. Fezzan sheep	
9. Broad-tailed sheep		6. Congo sheep	
10. Many-horned sheep		7. Angola sheep	
11. Pucha, or Hindustan, sheep		8. Yenu, or goitred, sheep	
12. Tartary sheep		9. Madagascar sheep	
13. Javanese sheep		10. Bearded sheep of West Africa	
14. Barwell sheep		11. Morocco sheep	
		AMERICA	
15. Short-tailed sheep of North- ern Russia		1. West Indian sheep, as found in Jamaica	
		2. Brazilian sheep	

This classification includes all the known varieties of domesticated sheep, the fleeces of many of which are, however, never used in Great Britain.

47. Typical Breeds of Sheep.—Most of the breeds of sheep given in Archer's classification produce wool of distinctive character, while the wool grown on the very large number of cross-bred sheep combines to a greater or less extent the qualities of the pure breeds concerned. The *merino* is the most famous of all sheep. All the best wools, those which are softest and finest, are the products of sheep that are at least partly of this breed. Spanish merinos were introduced into Australia and South Africa, where they flourish greatly, into Great Britain and America, where they have been crossed with English breeds, and into Germany, where they have been improved. Of British breeds, the *Southdown sheep*, named after their original home, the Sussex Downs, are the best. Other distinct British breeds are the *Lincoln*, the *Leicester*, the *Cheviot*, and the *black-faced*, all of which, like the Southdown, have been introduced into the United States, Australia, and other countries.

48. Causes of Difference Between Wools.—While the breed of the sheep is the principal factor in determining the character of the wool, other important causes of the difference between wools are *climate*, *food*, and *care in rearing*. Climate has a great

effect on the quality of the wool grown, a warm though temperate climate being the best. A hot and dry climate tends to the production of a thin, harsh, and wiry wool, but a cold and damp climate is favourable for growing long and lustrous wools. Drought and excessive rainfall naturally have a deleterious effect. Local conditions have also their influence, the character of the soil, for example, largely affecting the quality of the food. The same breed of sheep when fed on different herbage produce wool quite different in handle and appearance. The effect of care in rearing is exemplified by the excellent wool obtained from merino sheep in Germany and the deterioration of the product of the same breed of sheep in Spain.

CLASSIFICATION OF WOOLS

49. It is a common practice in the wool trade to divide all wools into three classes; namely, (a) *long wools*, (b) *medium wools*, and (c) *short wools*. This is a thoroughly practical classification, for different machinery or modifications of the same machinery are required for working each class. The **long wools** are those of 6 or 7 inches staple and upwards. They are, in general, non-felting and are spun into worsted yarns, the counts seldom being higher than 44's. The **medium wools** include all those from about $4\frac{1}{2}$ to $6\frac{1}{2}$ inches staple. Large quantities of these are grown, for they are equally suitable for both woollen and worsted yarns of medium quality. The highest spinning number of the best grades is rarely more than 56's top. All wools of shorter staple than $4\frac{1}{2}$ inches are termed **short wools**. They include the softest and finest wools grown and are used for both woollen and worsted yarns. The best kinds will spin easily up to 100's for single-worsted weft yarns.

BRITISH WOOLS

50. **Pure-Lustre Wools.**—The best classification of British, or *Home*, wools, all of which, when fully grown, are long or medium, is as follows: (a) *Pure-lustre wools*, (b) *first demi-lustre*

wools, (c) second demi-lustre wools, and (d) British medium wools. The pure-lustre wools are grown on the Lincoln and Leicester breeds of sheep, and can be obtained true to type only in their native counties and in Yorkshire and Nottinghamshire. The wool of the Lincoln sheep is very lustrous, has a good colour, and reaches to 20 inches in length; but it is open and wiry. Leicester wool is a little shorter and somewhat finer in quality, but is similar to Lincoln in its general characteristics.

51. First Demi-Lustre Wools.—The first demi-lustre wools are obtained largely from the North of England and the Lowlands of Scotland, though considerable quantities are grown in Kent. The Kentish wool is known as **Romney Marsh wool** and is long and bright and possesses good spinning properties, the fibre having a considerable degree of fineness. The best breeds in the North of England and Scotland are the black-faced and the *Herdwick sheep*, which produce a wool of good length, elastic fibre, and bright colour. This wool can be spun to higher counts than its general appearance would suggest, and is used principally to mix with other wools for the purpose of producing a finer yarn and improving the spinning power.

52. Second Demi-Lustre Wools.—The second demi-lustre wools are obtained for the most part from sheep that are crosses between the somewhat coarse native breed and the Leicester breed. The best known of these sheep are the *Devon*, the *Cotswold*, the *Northampton*, and the *Cornwall* breeds, all of which produce a wool that is rather coarse and lacking in elasticity, but of good length.

53. British Medium Wools.—The most valuable of all British wools are those of the medium type, of which the thickly grown, fine, soft, wavy, and elastic wool of the Southdown sheep is the best example. The largest flocks of Southdowns are in Sussex, Wiltshire, Hampshire, Shropshire, and Dorsetshire, and their wool is an ideal material for the manufacture of hosiery, flannels, serges, and the like. The full-bred Southdowns have been, and are being, used to cross with the native breeds of the Midlands and the South of England, and, though to a lesser extent, of the

North of England also. Consequently, increasing quantities of medium wools, a little longer and coarser than that of the full-bred Southdown, are being sent to the markets. A breed quite distinct from the Southdown is the Cheviot, which produces a very valuable wool, soft, elastic, and sound in staple, though not as fine as Southdown. Many inferior wools of medium quality are obtained from the hilly and exposed parts of the British Isles, particularly Wales and the North of Scotland.

COLONIAL WOOLS

54. Australian Wools.—The wool grown in the Australian colonies is perhaps the most valuable yield in the world, being immense in quantity and high in quality. The merino breed is the basis of Australian sheep rearing, having been crossed with various other breeds that are suited to certain regions. In most cases, however, the breeding is between merino sheep and either Lincoln or Leicester rams. The combined influences of climate, soil, and selection in breeding have tended to bring about a general improvement on the sheep imported.

Long, short, and medium wools are grown, though the characteristics of the country tend in favour of short rather than long wools, and very large quantities of merino wool are exported to Great Britain, the European Continent, and the United States. When seasons of drought occur the effect on the wool is disastrous, both quality and quantity being greatly reduced.

55. Port Philip and Sydney Wools.—The Port Philip, or Victorian, wools, known in the trade as P.P. wools, include some of the best wools grown, both as to length and fineness, the merino fleeces being highly valued by woollen spinners on account of their excellent felting qualities. The Victorian cross-breeds produce a wool of bright appearance and good spinning properties. The Sydney, or New South Wales, wools are a little shorter and finer than the P.P. wools, this probably being due to the fact that New South Wales is warmer and drier than Victoria. Sydney wools can easily be felted, but they are occasionally wanting in colour and strength.

56. Queensland, Adelaide, and West Australian Wools.—The wool grown in Queensland is not so strong or elastic as that produced farther south, this being due to the drier climate, which affects the herbage injuriously. **Queensland wool** is best suited for medium woollen yarns, as it is rather short and soft in handle. The **Adelaide, or South Australian, wool** is a good, sound, average quality of merino with a somewhat sandy and heavily yolked staple. The longer varieties make a good 60's to 70's top for twofold worsted yarns, while the shorter varieties, which mill fairly well, are absorbed in the medium-class woollen trade. **West Australian, or Swan River, wools** are inferior to any other Australian wools. They are coarse merinos, and are dry in handle, though sound in staple.

57. New Zealand and Tasmanian Wools.—The climate of New Zealand is cooler and moister than that of Australia, but is very favourable for sheep rearing. **New Zealand wool** is of cross-bred type, and its colour and milling and general characteristics are all that could be desired. It is highly prized for mixing with mungo, as it gives to the yarn and cloth a full, lofty, and substantial handle. **Tasmanian wools** are mostly merinos of good quality, the climate and pasturing of that country being excellent. The wool is fine, strong, and of comparatively good length, and when scoured has a snow-white appearance.

58. Cape Wools.—All the **Cape wools** belong to the merino class; they are short in staple and possess good felting qualities, but have a tendency to unsoundness. They are used in the hosiery trade and for blending with the better quality of merinos in order to cheapen the yarn and cloth. Manufacturers of medium-quality coatings and similar materials also make considerable use of Cape wools. The most notable feature of these wools is their remarkable whiteness when scoured.

FOREIGN WOOLS

59. Saxony and Silesian Wools.—Two of the most notable of foreign wools are the **Saxony** and **Silesian wools**, grown in the German provinces from which they take their name. Saxony

wool is often termed **Saxony Electoral wool** for the reason that it was an Elector of Saxony who introduced the Spanish merino into his country and greatly improved the breed. The wools of Saxony and Silesia are probably the best merinos in the world in respect of fineness, softness, and felting power. The colour also is good, and the staple is short.

60. Russian Wools.—The best of the Russian wools is **Odessa wool**, which belongs to the medium class and is characterized by a strong staple and a very good colour. It is chiefly used for blending with high-class merinos and in the manufacture of goods which are to be dyed to light and fancy shades, most of these being fancy woollen fabrics.

61. American Wools.—America seems to be well adapted for wool growing, and many fine flocks of sheep are raised in the United States. None of these are native to that country, but numerous importations of sheep were made from time to time, including such breeds as the Spanish merino, the Saxony and Silesian merinos, and the best English breeds. The merino has been crossed with the common sheep, and in many States, notably Ohio, very desirable cross-bred wools are grown. The full-blooded **American merino** produces a fleece of very high quality, particularly as regards fineness of fibre. Practically all the wool grown in the United States is consumed in American mills.

62. South American Wools.—Excepting Australia, South America is the greatest of wool-growing areas. The **South American wools** are very burry and heavy with grease, and are wanting in strength and elasticity of staple. They are also singularly deficient in milling property. The French merino breed is the basis of South American sheep rearing, and crossing has been carried to such an extent that a large percentage of the wool grown is cross-bred, the remainder being merino. The wool is freed of burrs by chemical or mechanical means, and it is then employed for the most part by Continental spinners for making into woollen yarns. That which is used in British mills is converted into dress-goods, shawls, and similar materials, for

which little felting is desired. **Monte Video wool** is the finest of South American wools, **Buenos Ayres wool** being slightly lower in quality. Of still lower quality are the **Punta Arenas** and **Falkland Islands wools**, which are liable to kemps and are rather tender and loose in growth, but are of good colour and soft in handle. The spinners of hosiery yarns favour these wools.

63. Asiatic Wools.—East Indian wools, of which a considerable quantity are shipped to Liverpool, are medium to coarse in quality and usually short and kempy. The sheep are shorn twice a year, in April and October, the October clip often being yellow in colour in consequence of the excessive rain.

TABLE II
PRINCIPAL VARIETIES OF WOOL USED BY BRITISH
MANUFACTURERS

Origin	Breed	Quality	Staple	Goods Manufactured Into	
British . . .	Lincoln	} Good, strong, and very lustrous	Long	} Worsteds cloths, linings, ladies' dress-goods, etc.	
	Leicester				
	Romney Marsh				
	Devon	} Medium	Long		
	Cotswold				
	Southdown	} Very fine			
	Sussex Down				
	Wiltshire	} Fine	Short		} Costume and tennis- outfit cloths, hosiery yarns, etc.
	Hampshire				
	Shropshire				
Dorsetshire					
Colonial . . .	Cheviot	} Medium	Medium	} Tweeds and woollens	
	Merino				
	Cross-breeds	} Very fine			
	Port Philip				
	Sydney	} Good colour	} Short	} Best woollen and worsted cloths, suit- ings, coatings, etc.	
	South Australian				
	West Australian				
	Tasmanian				
	New Zealand cross-breeds	} Fine, lustrous, and good colour	Medium	} Serges, worsteds, and cheaper blended goods	
	Cape Merino				
South American	Buenos Ayres	} Very fine, but burry and dirty	} Short	} Medium worsteds, dress- goods, costumes, and cheaper blended goods	
	Monte Video				
Russian . . .	Odessa	} Fine ; good colour	} Short	} Fancy woollens	
East Indian . .					} Variable ; generally coarse

Persian wools are for the most part coarse and of medium to long staple. They are, however, sound and of good colour.

Of the many home-grown, colonial, and foreign wools used in British mills, the more important are detailed in Table II.

SKIN WOOLS

64. Removing Wool from Skins of Slaughtered Sheep.—Wool that has been obtained from the skins of slaughtered sheep is used in large quantities. It is somewhat dead and harsh in handle as compared with fleece wools, and is more difficult to spin, mill, and dye. The method of removing the wool generally practised in Great Britain is to rub the skin with lime and water. This is not a very good practice, however, for the lime renders the wool harsh in handle and also injures the colour. If the wool comes off in a fleece, as it sometimes does in the case of lambs and one-year-old sheep, it is termed **fliped wool**, and if it comes off in locks and pieces the name given to it is **slipe**, or **skin, wool**. A better method is that employed in the Colonies, where a chemical agent, usually sodium sulphide, is used instead of lime and water. This does not affect the fibre. The French method, that of **sweating**, practised at Mazamet, gives excellent results. In this the skins are first soaked in large tanks of water until they are soft and pliable, and are then hung in the sweating chamber and allowed to remain there until the wool can be easily removed. The sweating must not be continued too long or the wool will be damaged.

65. Qualities and Uses of Skin Wools.—The best skin wools are those of Mazamet, which is the centre of the skin-wool industry, the merchants of that town collecting skins from all the principal wool-growing countries. Mazamet wools are more carefully removed from the skins, sorted, and classified than those obtained in England and the Colonies. Skin wools of all qualities are largely employed in blending with fleece wools for making yarns of practically every kind, the better qualities being used for the higher-class goods, while the inferior qualities are absorbed in the low-woollen suiting, blanket, and flannel trades.

HAIR USED FOR TEXTILE PURPOSES

66. Mohair.—Although, strictly speaking, mohair is not wool, it is an important textile fabric. It is the fleece of the Angora goat, which animal is indigenous to the mountainous districts of Asia Minor. The hair of this goat more closely approaches sheep's wool in structure than that of any other animal; it is disposed in long silky staples and possesses a lustre that almost rivals that of silk. The staple averages from 6 to 8 inches in length, and the fibre is fine and has a very good development of serrations. The Angora goat has been successfully introduced into Cape Colony, and large quantities of mohair, some of which is of better quality than that from Asia Minor, are now shipped to Great Britain. Mohair is also being increasingly grown in the United States. The alien goat has been largely crossed with the native African goat. Mohair is used for ladies' dress-goods, and is largely employed in the manufacture of pile fabrics, especially plushes, as the pile obtained is of great durability. Fig. 7 is an illustration of the mohair fibre greatly magnified.

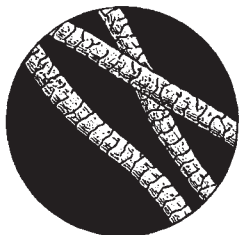


FIG. 7

67. Alpaca and Other Fleeces.—Among other animals, the hair or fleeces of which are used for textile purposes, may be mentioned the *Cashmere*, or *Tibet*, goat, which furnishes the material for the famous cashmere shawls, the *camel*, the *kangaroo*, the *ibex*, the *llama*, the *vicuña*, from which the vicuña wool is obtained, and the *alpaca*. The three last-mentioned animals are all varieties of the same species. The goat from which alpaca hair is obtained lives in the mountainous regions of South America. The hair, or wool, as it may be called, is very lustrous, the scales being hard and securely attached to the fibre, which makes it rather difficult to dye a permanent colour. The natural colour is white, brown, or black, and the staple is long, from 8 to 12 inches, strong, and silky to the handle. Alpaca is used chiefly in the manufacture of linings and all kinds of ladies' dress-goods.

TRADE PRACTICES AND TERMS

TRADE CLASSIFICATIONS

68. British, or Home, Trade Classification.—It is British practice before shearing, which is done in May or early in June, to wash the sheep. When shorn, the fleeces are rolled up into a ball and tied either with string or projecting ends of the fleece, after which they are usually sent to local wool sales or fairs. If there is no place of disposal in the neighbourhood, farmers send their wool direct to the warehouses of the buyers. The wool thus sold is generally classified as (*a*) **lamb's wool**, (*b*) **hog's wool**, (*c*) **teg wool**, and (*d*) **wether wool**. Lamb's wool is the first shearing and is clipped when the animal is about 6 months old. It is fine and soft. The most valuable wool in respect of fineness of fibre combined with length is hog's wool, which is the first clip obtained from a sheep that was not clipped as a lamb, the wool having been allowed to grow till the animal was about 14 months old. The staples are tapering, not blunt, as is the case where there has been a previous clip. Teg wool is obtained from yearling sheep which were clipped as lambs, and wether wool comprises all clips subsequent to hog or teg clips.

69. Colonial Trade Classification.—Among the terms used in trading in Australian wools are **washed fleece**, **greasy fleece**, and **scoured fleece**. By washed fleece is meant wool which was washed on the sheep's back prior to shearing, while greasy fleece is that which has all the yoke, sand, dirt, etc., adhering to it. Sixty per cent. of the wool sold in Australia is greasy. Scoured fleece is fleece wool that was scoured before packing to economize in cost of carriage, though it is contended that scouring also tends to the retaining of a good colour. Wool of this class is, however, not considered to be as soft and supple as wool shipped in the grease, and, moreover, it requires washing again before it can be used.

The fleeces are heavily skirted and passed to a trained classer. All that are of sound staple, good length, and even growth are

classed as combing wools ; those that are of shorter or uneven staple, together with tender long wools, are grouped as clothing wools. These two classes are subdivided, and the skirtings also are graded into qualities. Merinos, fine cross-breds, and coarse cross-breds form separate classes.

The Cape wools are not carefully classified, but a fairly large proportion of them are scoured in great washeries at Port Elizabeth and King William's Town and dried in the open air, the African sun giving the wool a brilliant whiteness.

WOOL SALES

70. British, or Home, Markets.—The London Colonial Wool Sales are among the most important in the world. There are ordinarily six sales a year, each continuing for about three weeks. The wool is stored in warehouses near the docks, and the lots to be sold each day are previously catalogued, arranged in order, and exposed to view in a top story with a good light. Buyers spend the forenoon in examining and valuing lots and noting the prices they are prepared to pay ; at 4 p.m. the sale commences. As many as 13,000 bales are sometimes disposed of by the auctioneer in a single day. The bulk of East Indian, Cashmere, North African, and Turkish wools are sold at Liverpool, in which port there also are sales of South American wools.

71. Colonial and Foreign Markets.—Wool sales are held every three or four months at Melbourne, Sydney, Brisbane, and Adelaide, buyers attending from all parts of the world. There is an increasing tendency to buy and ship direct instead of purchasing through the London Colonial Wool Sales. South American wools are sold at Buenos Ayres and to a smaller extent at Monte Video. These wools are forwarded by the farmers in an unclassed and unskirted state, being merely tied in sheets. They are sold by auction, and the buyers skirt, classify, and bale them. Skirting is never performed so heavily in South America as in the Colonies. By far the largest quantities of South American wools are exported to France, Belgium, and Germany.

WOOL SORTING

72. Necessity of Sorting.—Not only does the wool vary in regard to quality, staple, fineness, etc., in different breeds of sheep, but it also differs widely in these respects when taken from different parts of a single fleece. Thus arises the necessity of separating the various qualities of wool found on the fleece, in order that they may be used for different grades of cloth. The operation of grading the wool found on the fleece into the different qualities and lengths of staple is called **wool sorting**, while the person who performs the operation is known as a **wool sorter**. Sorting is performed according to (*a*) handle, particularly as regards softness, (*b*) elasticity and soundness of staple, (*c*) fineness of fibre, (*d*) density, and (*e*) uniformity of length.

Wool sorting constitutes practically the first operation in the manufacture of a piece of woollen or worsted cloth. It may be said that the wool is sorted into as many different qualities as the mill may require. As many as fourteen distinct qualities of wool can be found on a single fleece by an expert sorter.

73. Number of Sorts Required.—Ordinarily there is no necessity for making a large number of sorts, and in some mills running on low-grade goods perhaps only two sorts may be made, the edges of the fleeces only being thrown out; while another mill may sort its fleeces into three or four grades, a first, second, and third quality, with perhaps a little of the coarse breech in a fourth quality. On the other hand, a mill that is running on fine goods and making several grades of cloth may make as many as six or eight sorts from each fleece. It is seldom that more than eight sorts are made, and the general tendency is to do less and less sorting, since the operation is slow and expensive. However, the coarse, rough breech, or britch, and the skirtings, or edges, of the fleece should always be thrown out, since the yarn spun will be rough and uneven if a mixture of coarse and rough and fine and soft fibres is used.

The chief points governing sorting may be summarized as follows: The finer counts of yarn cannot be spun from wool

that is very uneven in quality ; to spin fine yarns from raw material of that character is wasteful and the yarns are very uneven. Even the best class of wool had better be sorted, for there are, of course, degrees of fineness, and the finer the wool, the higher the quality of the yarn.

74. Skill and Requirements of Wool Sorter.—Wool sorting is a trade learnt only by long experience. After working at it year after year, the wool sorter acquires a sensitiveness of touch and a judgment of the grade of a handful of wool that seem to be instinctive. An experienced wool sorter is able to sort a fleece, with which he is familiar, in the dark, telling the different qualities of wool. He learns to judge wool by its feel, or handle, and by this means alone can tell the degree of softness, fineness, and loftiness of a sample, although he is also guided by the appearance of the staple. In separating the different qualities of wool in a fleece, the sorter is guided by this sense of feeling together with a knowledge of the positions of the different qualities on the fleece.

The tools required by a wool sorter are few, and consist first of all of a wire-covered bench on which he may spread out the fleece and through which loose particles of dirt and any other foreign matter, such as straws, sticks, dust, etc., may fall. He also requires a pair of shears to clip off paint and tar with which the fleece is often marked, and as many baskets or boxes as there are sorts to be made.

75. Preliminaries to Sorting.—The fleece as it comes to the sorter is rolled into a tight bundle and tied up with either a twisted portion of itself, usually from the shoulder, or a string or small rope. In the latter case, great care must be taken to remove every portion of the rope, as any particle of vegetable matter in the wool will show a different colour when the cloth is dyed. In the winter, when the weather is cold, the fleece may have to be warmed before it can be opened, for the cold weather solidifies the natural grease, or yolk, in the fleece and renders it stiff and hard. As soon as the fleece is warmed, the yolk is started and the fleece becomes soft and pliable. After the fleece is opened, the sorter throws it on the wire bench and

proceeds to shake and pick out the vegetable matter, such as burrs, straws, sticks, etc. The back of the sheep forms an indefinite boundary that divides the fleece into two parts. The sorter first separates the fleece along this line into two sections. The next operation is to clip off all paint and tarry marks. In countries where the flocks of sheep run more or less together, it is the custom of some herders to mark their sheep with paint or tar, to distinguish them from sheep of other flocks. This fact accounts for the great number of paint and tarry marks found on fleeces.

76. Process of Sorting.—In sorting the fleece the sorter is guided by his sense of touch and by the appearance and position of the wool. All coarse harsh-feeling wool is separated from the fine, soft, and elastic portions and cast into separate baskets. The finest fibre is that grown on the shoulders and sides, while that of the flanks and lower portions of the animal is of coarse quality. As a rule, all black or dark-coloured locks of wool are separated from the white and placed in one lot, which is usually dyed black. If mixed with the white, the dark-coloured wool will, even if in very small quantities, make a *bloom* on white yarns, that is, the yarn will have a tinge of colour.

It must be understood that there are no definite boundary lines between the different qualities of fibre, but that one quality merges into another, and a sorter may make three or four, or seven or eight, sorts from the same pile of fleeces, according to the needs of the fabrics that are to be made. The poor qualities, which must be separated from the good, include all coarse and harsh-feeling wool, those portions of the fleece that are inclined to be very kempy, tender and ill-grown staples, and also all cotted, or felted, portions, as well as the hard lumps of dirty wool, and the paint and tar marks.

QUALITIES OF WOOL SORTED

77. Qualities According to Number.—As previously stated, there are fourteen distinct qualities of wool that may be obtained from a single fleece, if carefully sorted. The parts of the animal

from which these are clipped are shown in Fig. 8. The qualities, according to one authority, are as follows: No. 1 is the shoulder, where the wool is long and fine and grows in close even staples. No. 2 is equally good, but, if anything, is inclined to be slightly stronger and the fibre a trifle coarser. The best wool of the fleece is found on these two parts. No. 3 is the wool that grows on the neck of the sheep, and, while the fibre is fine, it is short and liable to contain black or grey hair if the sheep is disposed to their production. Nos. 4 and 5 produce wool that is somewhat faulty, and the length of the staple is also found to be short. No. 6, which covers the loin and back, is

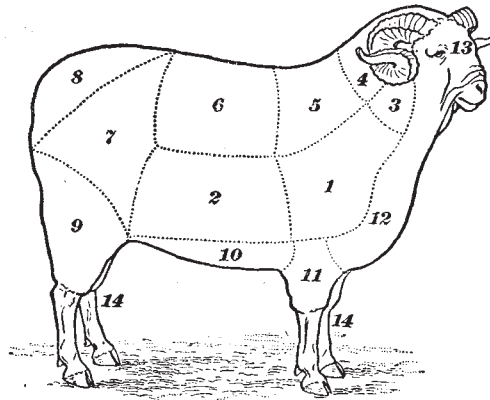


FIG. 8

still coarser and shorter. No. 7 produces a wool that is long and strong and hangs in long locks, or staples. It is apt to be very coarse on cross-bred sheep and much resembles the britch. No. 8 is the britch, or breech, which is the coarsest part of the fleece, and is often called **cow-tail** from its resemblance to the coarse tuft of hair on the end of a cow's tail. No. 9 produces a strong coarse wool. No. 10 grows a wool that is short and often dirty from the dirt accumulated when the sheep lies down. It is apt to be finer near the front legs and is commonly known as **brokes**. No. 11 produces a short and fine wool. No. 12 grows short and fine wool, which is somewhat damaged by rubbing. No. 13 is the forehead, where the wool is short and coarse and

of very little value. No. 14 is the legs, where the wool is even worse and has no practical value. When kemps occur in fleeces, they are most liable to be found in Nos. 8 and 12, although those found on the britch are much longer and stronger.

78. Names of Qualities in Woollen Trade.—Wool sorters do not name their qualities in accordance with the name of the part of the sheep on which it is grown, nor is there uniformity in naming, different terms being used in different localities. In the woollen trade the following are common: **Picklock**, meaning the choicest of all the wool, which is obtained from the shoulders. **Prime** is very little inferior in quality and is clipped from the sides. **Choice** is somewhat stronger than either of the foregoing and is the growth of the middle of the back. **Super** is cut from the middle of the sides and shoulders, while **seconds** are from the lower portions of the sides and also include the best locks from the breast. **Downrights** are from the neck, **abb** is from the hind legs, and **britch**, or **breech**, the coarsest of the whole fleece, is from the haunches.

79. Names of Qualities in Worsted Trade.—In the worsted trade **blue** is the name given to the wool from the neck, **fine** is the growth of the shoulders, **neat** is the clipping from the middle of the sides and the back, and **brown** is from the haunches. **Britch**, which in the woollen trade is from the haunches, is obtained from the tail and hind legs, while coarse britch and clippings from the lower parts of the hind legs are called **cow-tail**. **Abb** is from the haunches and **legs**, **downrights** are from the neck, **seconds** from the belly, and **brokes** from the belly and lower part of the front legs.

Merino wools have no special names given to them, botany and similar fleeces being sorted according to their respective numbers or the counts they will spin to, such as 50's, 60's, 70's, and so on.

WOOL-SORTER'S DISEASE

80. Nature and Origin of Disease.—A disease which frequently attacks wool sorters engaged in sorting dusty wool, especially the Eastern or Asiatic wools, first appears as an ordinary cold

accompanied with oppression of the chest, severe headache, and profuse perspiration. The temperature of the patient rises and a cough appears. The respiration becomes harder and the pulse weaker and weaker, until in 3 or 4 days the man dies. **Wool-sorter's disease** seems to originate in the dust of certain infected wools, which are usually from sheep that have died of anthrax. This dust, when drawn into the lungs of a person, produces a disease that is evidently due to the presence of bacilli.

The worst wool for producing wool-sorter's disease has been found to be what is known as Van mohair. Other wools that are liable to be infected are Turkey mohair, Persian wool, alpaca, camel's hair, and the wool of the Cashmere, or Tibet, goat.

81. Precautions Against Disease.—In sorting wools and hairs that are liable to be infected with the spores of anthrax, which may be inhaled into the sorter's lungs or find lodgment on any wound or cut, thereby causing wool-sorter's disease, special precautions, which are enforced by law, have to be taken. These comprise the provision of a bale-opening room with a grate in the floor through which a fan draws a current of air strong enough to keep down the dust. As an alternative to this, the bales are to be steeped in water before being opened. Each sorting table is to be connected by an exhaust pipe with a wide mouthpiece to a trunk pipe or shaft running the length of the room and at the end of which is a powerful fan or fans. Any bales found to contain *fallen fleeces*, that is, fleeces shorn from sheep that have died, are to be set apart, and the whole bale is to be washed before it is sorted. Further, there must be strict cleanliness and a liberal use of disinfectants, refuse must be collected and burnt twice a week, and no employee with an open wound is to be allowed to work. It is also required by law that no bales shall be stored in a sorting room, except in a space properly screened off, and that the dust carried away by the exhaust pipe shall be discharged into proper receptacles and not into the open air. At the close of each working day the floor of every room in which opening and sorting are being done must be sprinkled with some kind of disinfecting solution and immediately swept.

APPENDIX

CHEMICAL TERMS AND FORMULÆ

ELEMENTARY DEFINITIONS

82. Introduction.—As some of the Papers in this Course contain a few chemical terms and formulæ, it is advisable to give a brief explanation of them, but no attempt will be made to go into the theory of chemical combinations.

83. Elements.—Most substances may be decomposed, or divided, into separate substances known as **elements**. For example, if an electric current is passed through water, the water slowly disappears and two gases are formed in its place. These gases are not only unlike each other, but are also unlike the water from which they were produced. As another example may be mentioned lime, which may be separated into the elements calcium and oxygen. Some substances, such as iron, gold, sulphur, and arsenic have never been decomposed and are therefore supposed to be elements.

84. Compounds and Mixtures.—When two or more elements are combined to form a new substance, such substance is known as a **compound**. Lime and water are therefore compounds. Two or more elements may be mixed together and yet not chemically combine to form a new substance; they are then said to form a **mechanical mixture**. The mixture has the properties of the elements composing it. The most familiar example of a mechanical mixture is ordinary air, which is composed of the two elements, oxygen and nitrogen. The two gases do not combine to form a new substance; they are simply mixed.

85. Molecules and Atoms.—All substances are supposed to consist of exceedingly small, indivisible particles called **atoms**.

The atoms rarely exist singly, but form groups called **molecules**. A molecule may consist of atoms of one element or of atoms belonging to different elements. A molecule is the smallest part of a substance that may still retain the properties of that substance.

EXAMPLES OF COMPOUNDS

86. Symbols and Formulæ.—In referring to an element, it is customary simply to use a **symbol**, which is usually the first letter of the name; thus, *H* stands for hydrogen, *C* for carbon, etc. In cases where elements have the same initial letter, another distinctive letter is added; for instance, *Cl* and *Mg* stand for chlorine and magnesium, respectively. As all compounds are combinations of elements, they may conveniently be expressed, symbolically, by placing side by side the symbols of the constituent elements. The symbol of a compound is termed a **formula**. Thus, common salt consists of sodium, whose symbol is *Na*, and chlorine, whose symbol is *Cl*; accordingly, its formula is written *NaCl*.

87. The number of atoms of the same kind in a molecule is represented by placing an Arabic numeral to the right of and below the symbol; thus, H_2 means a molecule of hydrogen consisting of 2 atoms. If a compound consists of several molecules of one substance combined with one or more molecules of another substance, then the number of molecules is indicated by placing an Arabic numeral in front of the formula, but sometimes by enclosing the formula in parentheses and placing the numeral to the right of and below it. Thus, the formula for water is H_2O ; that is, 1 molecule of water is composed of 2 atoms of hydrogen and 1 atom of oxygen, while either $2 H_2O$ or $(H_2O)_2$ means 2 molecules of water, but the former expression is nearly always used.

The names and symbols of some of the elements used in chemical processes connected with textile manufacture are given in Table III.

88. Oxides and Chlorides.—A compound consisting of two elements, one of which is oxygen, is termed an **oxide**. If there

is a variation in the number of oxygen atoms that combine with an element, then the termination *ic* is given to the higher number and *ous* to the lower one ; as, for example, sulphurous oxide, SO_2 , and sulphuric oxide, SO_3 . If, in place of oxygen, chlorine or sulphur is combined with an element, then the combination is a **chloride** and a **sulphide**, respectively. Thus, calcium combined with chloride gives calcium chloride, $CaCl_2$.

89. Hydrates.—There are a number of substances which, after being dissolved in water, will, when the latter is evaporated, reappear as compounds with water ; such compounds are termed

TABLE III
NAMES AND SYMBOLS OF SOME IMPORTANT CHEMICAL ELEMENTS

Elements	Symbols	Elements	Symbols
Aluminium	<i>Al</i>	Lead	<i>Pb</i>
Bromine	<i>Br</i>	Magnesium	<i>Mg</i>
Calcium	<i>Ca</i>	Nitrogen	<i>N</i>
Carbon	<i>C</i>	Oxygen	<i>O</i>
Chlorine	<i>Cl</i>	Potassium	<i>K</i>
Copper	<i>Cu</i>	Sodium	<i>Na</i>
Hydrogen	<i>H</i>	Sulphur	<i>S</i>
Iron	<i>Fe</i>	Zinc	<i>Zn</i>

hydrates. One of the most common hydrates is ordinary washing soda, $Na_2CO_3, 10 H_2O$, which is a combination of 1 molecule of carbonate of soda, Na_2CO_3 , with 10 molecules of water.

90. Acids, Bases, and Alkalies.—An acid may be defined as a substance containing hydrogen, which hydrogen may be replaced by a metal to form a salt. Most acids are sour and are characterized by their property of changing the colour of a solution of litmus (a blue dye) to red. A base is an oxide or hydrate of a metal (or an element equivalent to a metal), which metal is capable of replacing the hydrogen of an acid, forming a salt, water being formed at the same time. An **alkali** is a base

of especially active character, soluble in water, and easily recognized by the soapy taste and feel it imparts to water, and also by its ability to restore the blue colour to a solution of litmus that has been reddened by an acid.

91. Salts.—If an acid is allowed to act on a base, water is produced first, and subsequently a neutral substance termed a salt. By *neutral* is meant that it does not affect the colour of litmus paper. In the salt the hydrogen in the acid is replaced by a metallic element. For instance, sulphuric acid, H_2SO_4 , when added to potassium hydrate, KOH , known as *caustic potash*, becomes potassium sulphate, K_2SO_4 , and water. In this case H_2 , the 2 atoms of hydrogen, are replaced by K_2 , 2 atoms of potassium.

92. Proteids.—The composition and properties of proteids are generally represented by those of the coagulated matter, called *albumen*, that exists in the white of an egg and in the serum of the blood. They resemble one another closely in composition, containing carbon, oxygen, nitrogen, hydrogen, and sulphur, and are nitrogenous products of animal and vegetable life.

WOOL WASHING

PREPARATION OF WOOL FOR WASHING

DUSTING

INTRODUCTION

1. **Objects of Dusting.**—The wool as it comes from the sorter is sometimes passed through a machine known as a **duster**, or **dusting willey**, before it is sent to the washing machine. The object of dusting wools is, as far as possible, to remove such foreign impurities as lumps of dirt, dust, shives, etc. The reason for this is that, as all such impurities are detrimental, not only to the finished goods, but to the facility with which the processes of manufacture are accomplished, it is advantageous to commence to remove them at as early a period as possible. The wool sorter is supposed to remove large particles of dirt from the wool during the process of separating the fleece into different qualities, but it is impossible for all impurities to be removed at any one time; and, in fact, they are not all removed until the wool is practically ready for spinning. It is of particular importance to have the wool as free from foreign matter as possible before it is scoured, or washed, as the saving in soap and scouring liquor when the wool is dusted and freed from sand, chaff, etc., is very apparent.

2. Another object in dusting, although a subsidiary one, is to deliver the wool to the scouring machine in a more open and lofty condition, as it is found that scoured wool which has previously been passed through a duster leaves the washing machine more

thoroughly and evenly scoured and brighter looking. The reason for this is that the wool is not only partly cleaned by the dusting, but is also opened up so that the scouring liquor will penetrate every portion of it and thus render the scouring more even and more thorough. Very long wools are, however, more liable to suffer by breakage than short wools, and because of this they are not so suitable for undergoing the process of dusting.

3. Wools That Require Dusting.—Different classes of wools are treated, in respect to dusting and opening prior to washing, according to their condition. The best greasy and washed fleece wool is, in general, not dusted, as such wools are not badly matted. Wools that are sandy and greasy may have so much sand removed and may be made so much lighter that subsequent washing is greatly facilitated; by careful treatment such wools should not suffer greatly by being subjected to an operation of dusting and opening. It is not good practice to submit wools imported in the scoured state to a preliminary operation of opening, since they are often in such a matted and felted condition that the dusting process would result in a fairly heavy breakage of fibre. Wools that have been removed from skins by means of lime and water should always be submitted to an operation of dusting prior to washing, since the presence of lime in wool that is being washed is very objectionable for reasons that will be explained farther on.

Dusting wool previous to washing, which in many cases may be advantageous, is not practised in Great Britain as much as in some other countries. Generally, it is in dealing with skin or slipe wools, and with very dusty wools and hairs, and especially those in the sorting of which the law requires special precautions, that dusting is of the greatest advantage if properly carried out, and for limy skin wools it is a necessity, if the washing is to be done economically. Further, owing to the opening or loosening effect of the dusting mechanism on the wool, the process is particularly advantageous for matted wools, and it is better to open out the lumps of wool before washing rather than leave it for the later operations of opening and carding, provided it can be done without much breakage of fibre.

TYPES OF DUSTERS

OPEN, OR CAGE, DUSTER

4. **Operation.**—A duster occasionally used in small mills is shown in Fig. 1, and is generally known as an **open, or cage, duster**. The machine consists of a large, rotating, horizontal cylinder *a* having cast-iron ends and a cylindrical covering consisting of heavy wire screening. On the shaft *b* there are arranged, in the manner shown, eight iron cross-bars *c*, each of which is

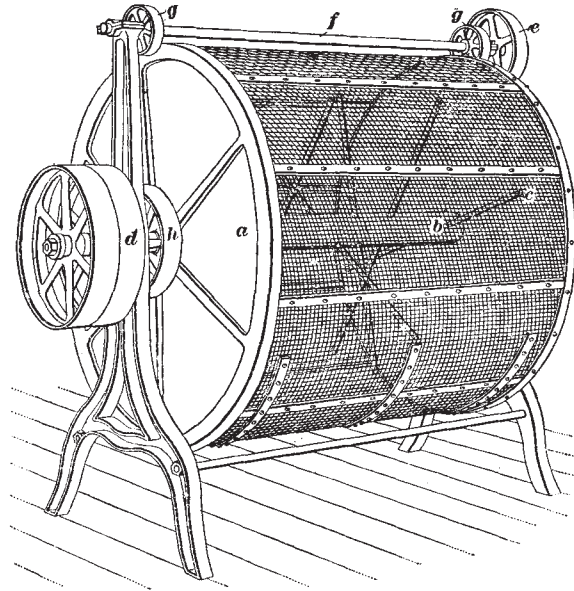


FIG. 1

about 5 feet long. The shaft, which revolves loosely in the cylinder, receives its motion by means of a fast pulley *d* from the line shaft. On the other end of the shaft there is also a fast pulley which, by means of an open belt, drives the pulley *e* of the shaft *f* supported by the upper ends of the frame. To the end plates of the cylinder there are fastened pulleys *h* which are driven from

pulleys *g*, placed at each end of the shaft *f*, by means of crossed belts, consequently the cylinder *a* will revolve in a direction opposite to that of the shaft *b*.

5. In operation, the wool is placed in the duster and the iron cross-bars beat out all the dust and dirt from the wool and force it through the screen-covered cylinder. The great objection to this machine is that all the dust and dirt is discharged into the room, where the workmen must breathe the air. Another fault is that the operation is not continuous, the wool being placed in the machine in small lots, dusted, and removed, when another lot is introduced. The open duster does good work as far as the material is concerned, but the slowness and expense of the operation, together with the unhealthy conditions caused by the dust, are serious faults. In an improved form the cylinder is running in a closed box from which the dust-laden air is removed by means of a fan.

CONE DUSTER

6. **Principle of Construction.**—The principle on which the cone duster operates is simply that of beating the wool by means of a rotating cylinder below which is suspended a screen, or grid, that allows the dust and other foreign matter to fall through, but retains the wool. The principal features of the cone duster are shown in Fig. 2, while Fig. 3 is a view of the main cylinder of the machine, which cannot be seen in Fig. 2. This cylinder is cone-shaped, the larger end being 4 feet and the smaller end about 26 inches in diameter, while the total length is usually about 7 feet. The cylinder is built up on a central shaft with arms, or spiders, to which are attached four wooden lags. Each lag carries iron teeth that project generally about 3 inches from the lag. Sometimes similar teeth are placed on the frame of the machine, so that the teeth on the lags of the main cylinder will mesh with them. Below the main cylinder is a grid made in two parts, one of which may be removed from the front of the machine and the other from the rear. The dirt that is beaten out by the cylinder falls through the grid into a chamber below, from which it can easily be removed.

7. In order that the light foreign matter and dust may be carried away from the wool, a fan *b* is often used in connection with the duster, which in this case is shown above the machine in Fig. 2. This is a 24-inch fan, so connected to the inside of the

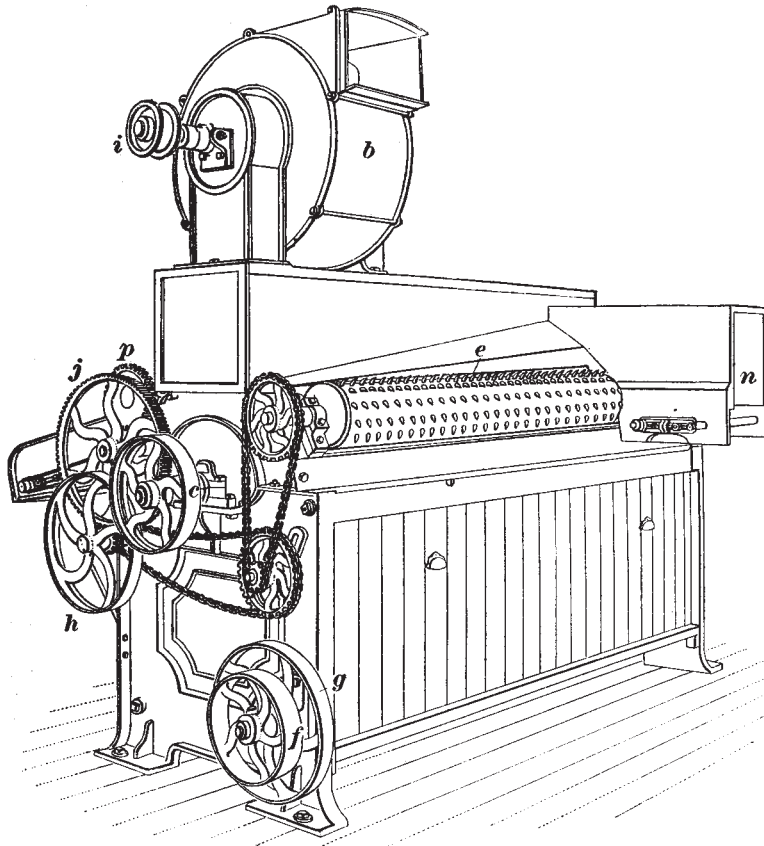


FIG. 2

cover of the cylinder that a current of air carrying away the lighter impurities is constantly passing through the duster and being delivered to a dust collector by means of suitable pipes. Beneath the fan is a screen that retains the wool, but allows the dust to be removed. The lower part of the machine is made

air-tight, so that the air in the space below the screen will be comparatively still ; by this means the current generated by the fan will not hinder the fall of the heavy particles of dirt as they are beaten from the wool and drop through the screen.

8. Operation.—The mechanism for feeding consists of a travelling feed-apron, or lattice, on which the wool is fed either

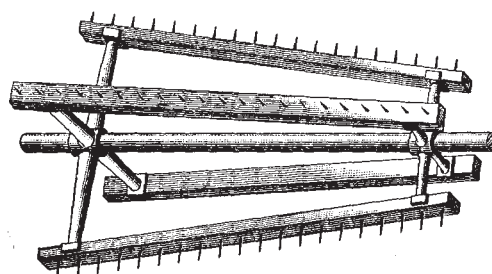


FIG. 3

by hand or by an automatic feeding mechanism. The delivery end of the feed-lattice passes the wool to a feed-roller that is covered with curved teeth, set openly ; sometimes two feed-

rollers are used. This roller feeds the wool to the cylinder, and in conjunction with the cylinder the effect of the feed-roller is to open out the material, since the cylinder operates on the material before it actually leaves the feed-roller. The wool is then beaten by the teeth on the lags of the cylinder and all heavy dirt drops by gravity through the screen under the cylinder, while the lighter dust, shives, etc., are drawn off by the fan. The material travels from the small end of the cone-shaped cylinder toward the large end in consequence of the centrifugal action of the revolving cylinder and the conical case in which the cylinder revolves, the material readily travelling toward the large end. It is finally thrown through an opening *n* at the rear of the machine ready for washing. The wool is now open and lofty and the scouring liquor can penetrate it quite easily ; thus, more even and more thorough work is assured and there is less need of agitation in the washing machine.

9. Driving.—The method of imparting motion to the various parts of the cone duster is as follows, the references being to Fig. 2. The pulley *i* on the fan shaft is driven from the pulley *c* on the main shaft of the machine. A small pulley fastened on the main shaft behind the pulley *c* drives a loose pulley *g* on a

stud ; fast to this pulley is a pulley *f*, which drives a pulley *h* with a cross-belt. Compounded with the pulley *h* is a small pinion that drives a large wheel *j* on the feed-lattice shaft. The single feed-roller is driven by a gear-wheel compounded with the gear-wheel *j*, which drives the gear-wheel *p* fastened to the shaft of the feed-roller. The main cylinder shaft carries a fast pulley on the opposite end of the machine and is driven from the line shaft. The main cylinder should have a speed of about 400 revolutions per minute, while the fan should make about 1,000 revolutions per minute.

A worker *e* is shown in Fig. 2, which is more particularly used in case of dusting card waste, noils, and similar materials. A duster used for greasy wools may be built with or without this roller, which is driven from a sprocket wheel compounded with the pulley *h*. This sprocket wheel drives a compound sprocket wheel on a stud that drives a sprocket wheel on the shaft of the worker. The power required to drive a cone duster may be estimated as $3\frac{1}{2}$ horsepower. It is not necessary to give any speed calculations in regard to a duster, as it is a very simple machine and it is seldom that changes are made ; if a change is made, it is usually in the speed of the whole machine, which necessitates changing only the main driving pulley.

DUSTING WILLEY

10. Construction.—The type of dusting machine represented diagrammatically in Fig. 4 is known as a **dusting willow, willey, or teaser**. The dusting willey here shown is simple in construction and very effective for opening out and dusting very dusty or limy wools ; it contains one cylinder and one beater. The wool is placed on the feed-lattice *a*, which carries the material to a pair of fluted feed-rollers *b*, about 4 inches in diameter. The bottom roller revolves in fixed bearings, while the top one is pressed down on the lower one by means of a lever *c* which swings on a stud attached to the frame. The lever presses down on the saddle *d* resting on the journal of the roller. The required pressure is obtained by means of the weight *e* supported by the

end of the lever. The lever and weight arrangement is duplicated on the other side of the machine.

11. Operation.—As the wool passes between the feed-rollers, which are revolving slowly, the fibres are caught and carried downwards by the curved teeth on the swiftly revolving cylinder *f*, which is about 30 inches in diameter. As the teeth carry the wool downwards, the centrifugal force, acting on it by reason of the rapid revolution of the cylinder, tends to throw the wool against the curved grid *g*. Some of the loose dirt and dust is thrown through the grid into the space beneath, being

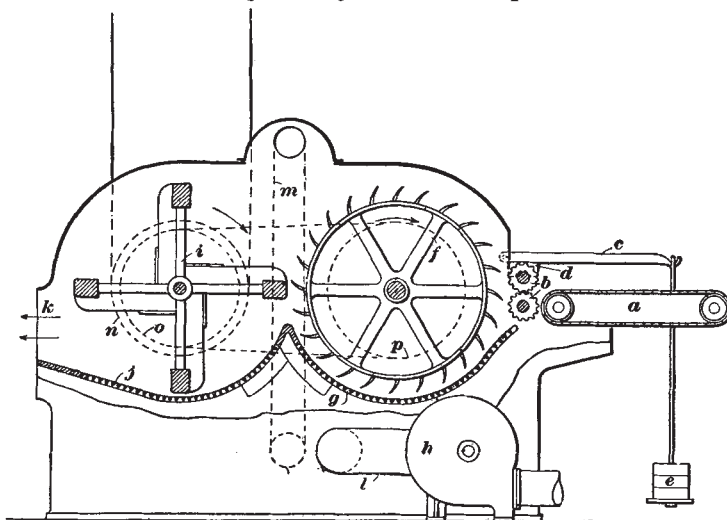


FIG. 4

drawn partly through by reason of the suction of the fan *h*, placed at the side of the machine, and constantly drawing the lighter impurities from this space through a pipe *l* and depositing them in a dust collector. The heavier impurities drop down to the floor and are removed periodically. As the wool is carried rapidly past the grid *g* it is met by the arms of a beater *i* of 30 inches diameter. The beating received by the wool at this point opens it out, at the same time loosening the dirt and dust. The beater carries the wool downwards and over a second grid *j*, where an additional amount of dirt and dust is

removed and allowed to drop through the grid, its removal being assisted by the air-current generated by the fan. As soon as the wool passes beyond the grid *j*, it is thrown from the machine by the beater through the open throat *k*, in the direction indicated by the arrows.

12. In some machines of the type shown in Fig. 4, the fan is omitted, as it is found that when short-fibred material is being dusted, a considerable amount of fibre is drawn through the grids along with the dirt. On the other hand, in some machines a supplementary suction pipe *m* is carried to the top of the casing so as to connect with the chamber above the grids; this arrangement assists in the removal of the dust set free at this point by the beating action. It is sometimes found that one beater is not sufficient, and machines are built with 2, 3, or even 4 beaters similar to *i*, each working over a grid. By adopting a machine with more beaters additional opening and dusting is obtained, since at that point where the material leaves one beater and passes under the action of the next one a certain amount of opening and dusting takes place. It is necessary in these machines that each succeeding beater shall travel at a greater surface speed than the preceding one, in order that the material shall not accumulate and possibly choke the machine.

13. Driving.—The beater *i*, Fig. 4, is driven direct from the line shaft by means of the pulley *n* at a speed of about 400 revolutions per minute. Another pulley *o* on the same shaft and of 20 inches diameter gives motion to a 24-inch pulley *p* at the end of the spiked cylinder shaft, thus driving the latter at a speed of about 330 revolutions per minute. On the opposite end of the beater shaft is an 18-inch pulley which by a belt gives motion to a 6-inch pulley on the fan shaft; thus, the latter is driven at a speed of about 1,200 revolutions per minute. On the end of the spiked cylinder shaft a small 6-inch pulley drives a 20-inch pulley that revolves on a stud fixed to the framework of the machine just under the feed-rollers; compounded with this pulley is a pinion of 20 teeth which drives a wheel with 116 teeth that is fixed on the end of the bottom feed-roller shaft. By reason of the relative sizes of wheels and pulley, it follows

that the feed-roller will run at a speed of about 17 revolutions per minute. The top feed-roller is driven from the bottom one by equal-sized gear-wheels which are made with extra deep teeth to allow for the rise and fall of the top roller, according to the thickness of the wool passing through.

SYKES SELF-ACTING TEASER

14. **Construction.**—The self-acting teaser, or willey, is utilized as an opening or mixing machine in the woollen trade ; but it is also extensively used for dusting and opening dirty wools. An exterior view of a Sykes teaser is given in Fig. 5, and a diagrammatic section in Fig. 6. The principal part of this machine is a large revolving cylinder *a*, which is about 42 inches in diameter,

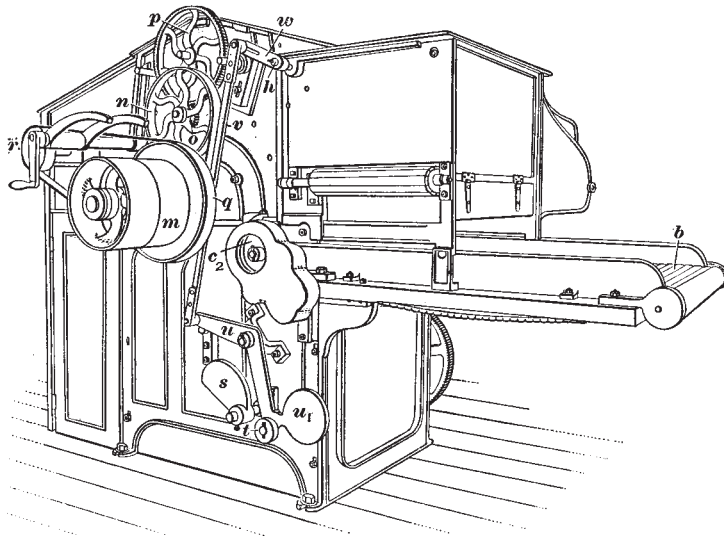


FIG. 5

measured at the tips of the teeth. The cylinder consists of wooden lags a_1 corresponding in length to the width of the machine, which may be 36, 42, or 48 inches. The lags are suitably fixed to spiders a_2 and are provided with two rows of strong curved teeth a_3 , which project from 3 to 4 inches beyond the surface of the lags.

15. Operation.—The material is fed on the feed-lattice *b*, Fig. 6, and as it passes between the feed-rollers *c* and *c*₁ it comes under the action of the cylinder teeth *a*₃, which open out the wool and draw it into the machine; while passing over the surface of the grid *d*, much of the dirt drops through the bars of the grid into the space below. At the end of the grid is a row of teeth *e*, which are fixed to the framework so as to intermesh with the teeth *a*₃, their combined action still further opening out the wool. The latter is then carried round until it comes under the action of three small spiked workers *f*, each of which is 12 inches in diameter. They are placed over the main cylinder

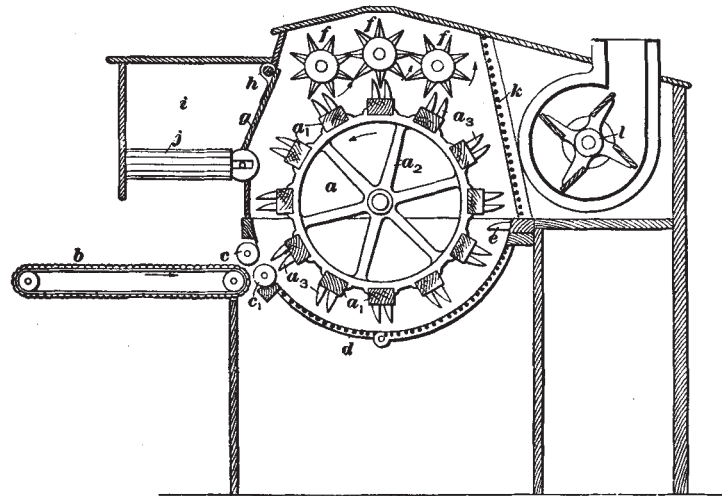


FIG. 6

and revolve very slowly in the direction indicated, and as the teeth of the workers *f* intermesh with the teeth *a*₃ to a distance of half their depth and are revolving in the opposite direction, the wool is opened still more. The wool continues in its circular path inside the machine for some time until it is thoroughly opened and dusted, when an intermittent motion causes the door *g* fastened on the shaft *h* to open outwards, and the wool is thrown into the box chamber *i* on the lattice *j* by the centrifugal force generated by the rapid revolution of the main cylinder. The lattice *j* moves in a direction at right angles to the feed-lattice,

and carries the wool out of the machine into bags, or on to the floor, as required. After being opened for a short time, the door *g* is closed for another round of operations. The dust and shive that does not get through the grid *d* is carried up to the top of the machine and, if heavy, continues to pass round until it is gradually broken up, and eventually drops through the grid. The lighter dust which is released by the action of the opening rollers at the top of the machine is drawn through an inclined grid *k* by the fan *l*.

16. Driving.—The cylinder *a* is driven from the line shaft by the belt on the fast pulley *m*, Fig. 5, at a speed of about 400 revolutions per minute. The workers *f* are driven from a small pulley behind the pulley *m*, a short belt conveying motion to a pulley *n* with which is compounded a pinion *o* that drives a gear-wheel *p* fixed on the end of the shaft of the central worker *f*. By gearing down in this manner, the speed of the worker *f* is only about 20 to 30 revolutions per minute. The ends of the shafts of the other workers can be seen in Fig. 5, motion being communicated to them from the other side of the machine from the central worker, by suitable means. The fan is driven at a high speed, usually about 1,200 to 1,500 revolutions per minute, by a belt running from the pulley *q* to a pulley *r* fixed on the end of the fan shaft.

17. The intermittent opening of the flap door *g* is accomplished by means of the cam *s*, which is fixed on a shaft that passes through and receives motion from the other side of the machine, and is driven by a train of gear-wheels from the main cylinder on the other side of the machine. As the cam *s* revolves it comes into contact with the friction roller *t* on the balanced lever *u*, and by forcing it to the right it causes the connecting-rod *v* to draw down the lever *w* attached to the shaft *h*, and so raises the door *g*, Fig. 6. The latter begins to close again as soon as the cam leaves the roller, the weight *u*₁ on the lower end of the lever *u* bringing the lever back to its original position. The length of time that the material remains in the machine is regulated by changing the speed at which the cam *s* revolves by means of a suitable change wheel on the other side of the machine.

The feed-roller c_1 is driven by a train of gear-wheels from the main cylinder shaft on the other side of the machine ; the feed-roller c receives its motion by means of equal-sized gear-wheels, the one on the roller c being seen through the casing at c_2 , Fig. 5.

The machine is usually constructed so that the fan l only draws air through the grid k , no air-current passing through the enclosed chamber under the grid ; this allows the heavier impurities to drop through into this chamber, while the major portion of the lighter dust is carried off by the fan ; doors are suitably arranged for cleaning out the chamber under the cylinder, as required. If so required, the machine can be built to have an air-current through both grids. This machine is best suited for dealing with short materials, as it is liable to break long fibres.

GARNETT DUSTING MACHINE

18. **Principal Features.**—The Garnett dusting machine may be used with required modifications for dusting wool, waste, rags,

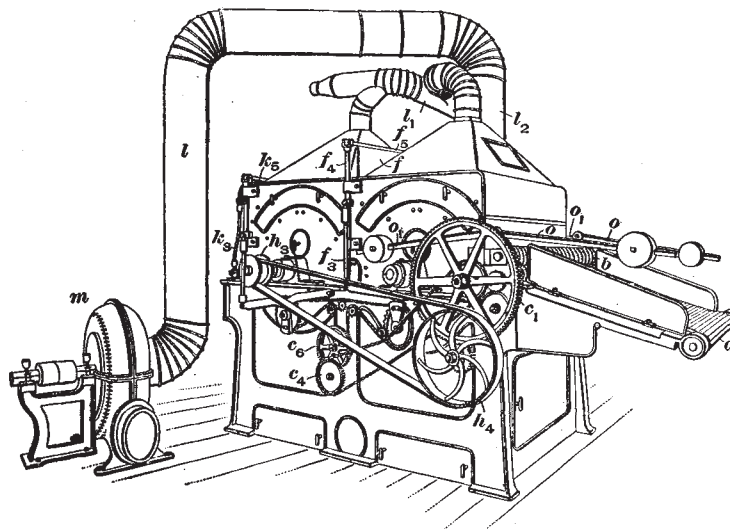


FIG. 7

etc. It is shown in perspective in Fig. 7, and in a longitudinal section in Fig. 8 ; Figs. 9 (a) and 10 (a) are elevations with partial

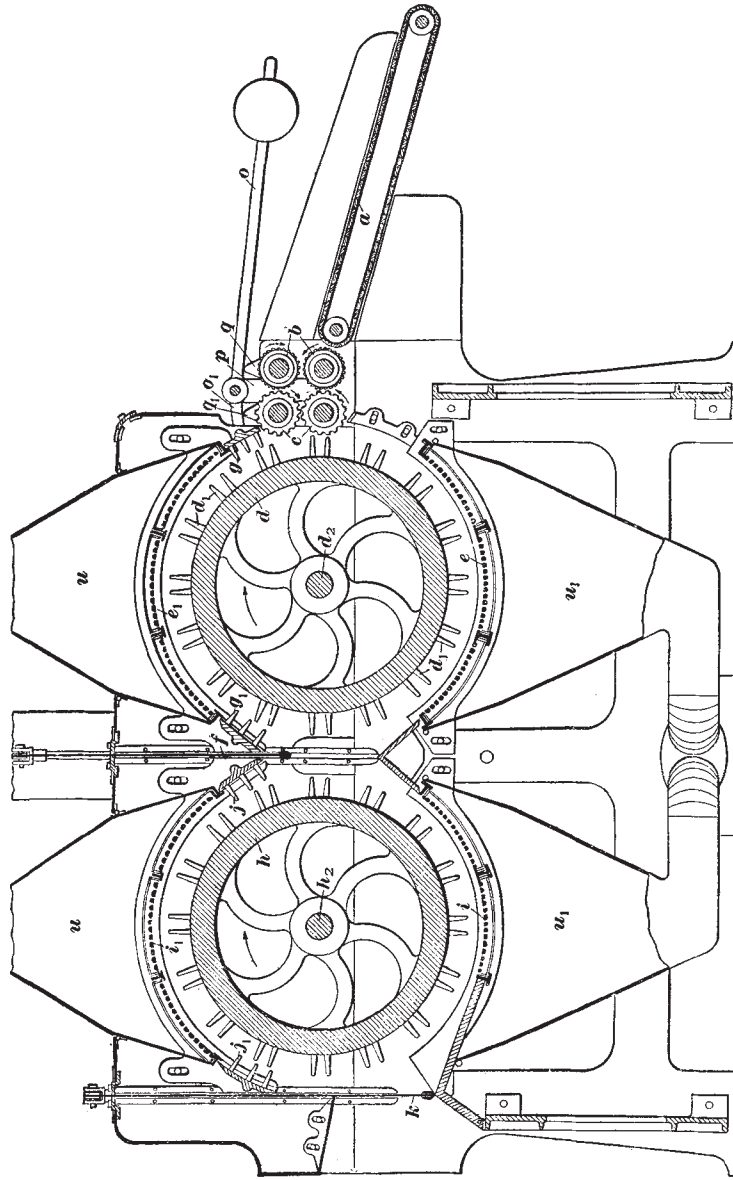
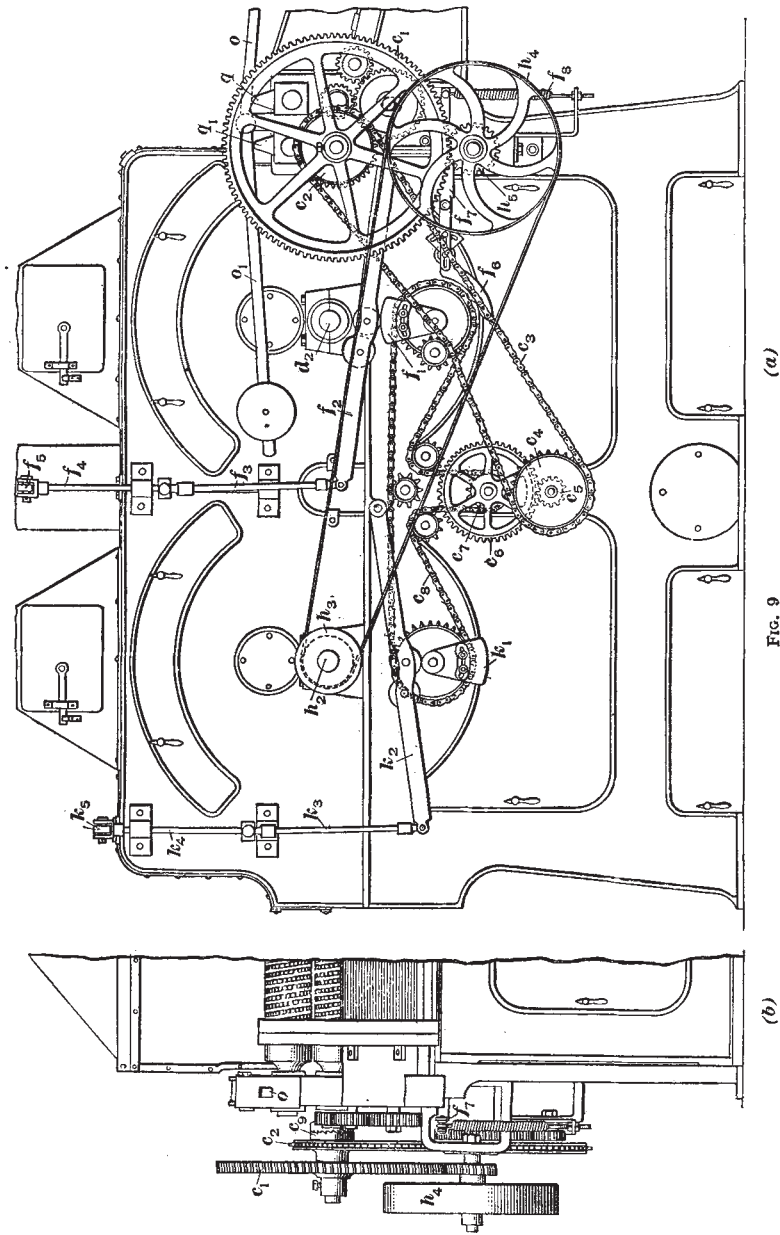


FIG. 8

end views, Figs. 9 (*b*) and 10 (*b*), of the left-hand and right-hand sides, respectively. The principal feature of the machine are the two large cylinders *d* and *h*, Fig. 8, each about 30 inches in diameter, and provided with several rows of round teeth d_1 that project a distance of $2\frac{1}{2}$ inches. Operating in conjunction with the cylinders is a series of grids *e*, e_1 , *i*, i_1 placed above and below them. The grids consist of bars of **D** section arranged with the flat side toward the cylinder, thus forming openings that increase in width in a direction away from the cylinder; the openings will therefore not readily be choked up with dirt and may easily be kept clean. The grids are interchangeable and two or three different sets may be used for different materials.

19. Operation.—The wool is fed into the machine by a feed-lattice *a*, Fig. 8, through either one or two pairs of feed-rollers *b* and *c* which are about 5 inches in diameter. The former pair are covered with Garnett wire and are used only when a better grip on long material is required while it is being submitted to the action of the cylinder *d*; the pair indicated at *c* are fluted. As the material is delivered by the rollers *c* it is beaten downwards and opened out by the pegs d_1 on the cylinder *d*, and on being released by the feed-rollers it is carried down and beaten against the grids *e* and is then carried upwards to the grids e_1 where more dirt and dust are beaten out. At either end of the grids e_1 are fixed rows of adjustable spikes *g*, g_1 arranged to intermesh more or less deeply with the pegs d_1 , the setting being varied in accordance with the material to be dusted.

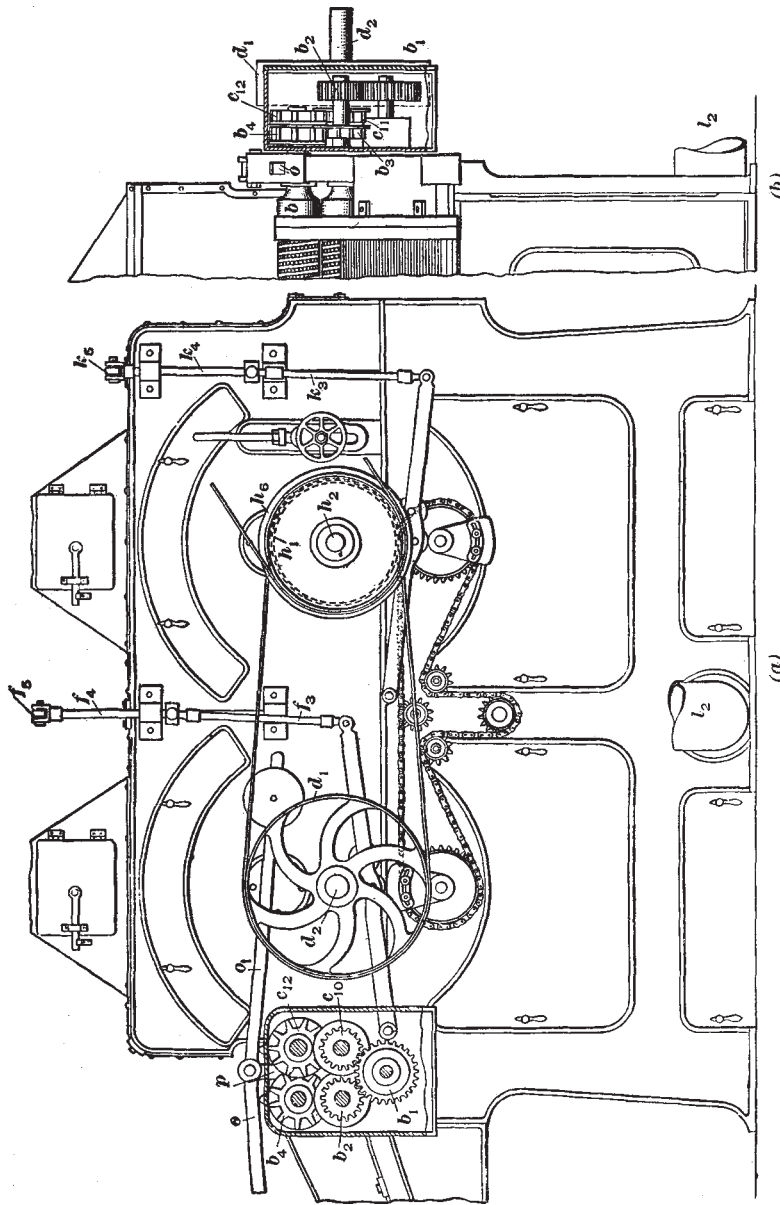
20. After the material has been allowed for some time to revolve and be beaten in the first chamber, Fig. 8, a sliding door *f* is automatically raised, and the material is thrown by the first cylinder into the second chamber, after which the door is automatically closed. The second cylinder *h* revolves at a higher speed than the first, and subjects the material to an additional dusting process by the cylinder *h*, in conjunction with the grids *i*, i_1 and the pegs at *j*, j_1 . Another door *k* at the end of the machine is then automatically opened, and the material is thrown out of this chamber into some suitable receptacle, or on to a lattice that conveys it to other parts of the mill. During



(a)

FIG. 9

(b)



(a) FIG. 10

(b)

the operation of dusting, air is being drawn out of the chambers u and u_1 through ducts l_1 , Fig. 7, and duct l_2 , Fig. 10, these ducts uniting in a larger duct l that connects with the fan m , Fig. 7, which draws the dust out of the machine and forces it into a dust collector, whence it is removed in bags.

21. Order of Operations.—The parts shown in Fig. 8 are all controlled automatically, and can be adjusted to operate at various times, as required. The round of operations takes place as follows: The feed-rollers deliver a certain quantity of material and are then stopped; the material delivered is then dusted by the cylinder d for a certain length of time, when the door f is opened and the material is thrown into the second chamber. After the door f has been shut, the feed-rollers are automatically started again to deliver a fresh supply to the cylinder d , so that the cylinders operate simultaneously. While the feed-rollers deliver material to the first chamber, the door k is opened so that the material in the second chamber may be ejected.

22. Driving.—The shaft h_2 , Fig. 10, of the cylinder h carries the main driving pulley h_6 which is driven from the line shaft. On the same shaft, but placed just inside the pulley h_6 , is a 14-inch pulley h_1 , driving a 21-inch pulley d_1 fixed to the shaft d_2 of the cylinder d ; thus the cylinder h , which has a speed of about 500 revolutions per minute, drives the cylinder d at a speed of about 330 revolutions per minute. A pulley h_3 on the shaft h_2 , Fig. 9, drives the pulley h_4 revolving on a stud fixed to the framework. On the same stud is a pinion h_5 which drives a wheel c_1 , carried on a sleeve of the bottom feed-roller shaft c , Fig. 8. The wheel c_1 carries a sprocket wheel c_2 , which by means of the chain c_3 gives motion to a sprocket wheel c_4 revolving on a stud fixed to the framing and carrying a pinion c_5 which drives a wheel c_6 . The latter gives motion to a small sprocket wheel c_7 that, by means of a chain c_8 , drives two sprocket wheels attached to the cams f_1 and k_1 .

23. The cams f_1 , k_1 , Fig. 9, operate the sliding doors f and k by a mechanism that is in duplicate on both sides of the machine in the following manner: Attached to the ends of the levers f_2

and k_2 , acted on by the cams, are connecting-rods f_3, k_3 ; the latter operate the sliding rods f_4, k_4 which support the cross-rods f_5, k_5 from which the doors f and k are suspended. The speed at which the cams f_1, k_1 revolve can be changed by substituting a larger or a smaller wheel in place of c_5 or c_6 , respectively. By this means the time allowed for dusting each lot of material in the chambers may be varied. It is noted that the relative positions of the cams are such that when the door f is open the door k is shut. The time at which material is delivered by the feed-rollers is also controlled by the cam f_1 . When this cam makes contact with a roller on the lever arm f_6 , the latter will descend and raise the other arm f_7 held down by the spring f_8 . The lever f_7 connects by suitable means with a clutch c_9 , Fig. 9 (*b*), attached to the sprocket wheel c_2 , and throws the latter into gear with the shaft of the lower feed-roller c . The feed-rollers b and c being connected by gear-wheels begin, therefore, to deliver new material to the cylinder d and will continue to do so until the cam f_1 is out of contact with the arm f_6 , when the spring f_8 will pull down the lever f_7 and disconnect the clutch c_9 .

24. The wheel c_{10} , Fig. 10 (*a*), on the shaft of the bottom feed-roller c drives by means of the carrier b_1 the wheel b_2 on the shaft of the lower feed-roller b . The lower rollers drive the upper feed-roller of each set by means of gear-wheels cut with long teeth, so that when thick portions of material pass between the rollers the upper ones will not be lifted out of gear. As seen from Fig. 10 (*b*) the rollers b are connected by wheels b_3, b_4 and the rollers c by wheels c_{11}, c_{12} . The upper feed-rollers are forced against the lower ones by means of weighted levers o, o_1 . Thus, in Fig. 8, the lever o is supported at one end by the bracket p and rests on the block q that forms part of the upper bearing of the top feed-roller b . A separate arm o_1 , also supported by p , rests on the block q_1 of the feed-roller c .

25. Care of Dusters in General.—Dusting machines, if not properly cared for, soon choke up and in this condition are useless, so far as dusting the wool is concerned. The dust boxes under the screens or grids should be frequently cleaned out, and care should be taken to clean the grids at the same time, because

if the grids are choked up the dirt cannot fall through into the dust box, even if the latter is empty. In putting up the dust pipes for the fan, care should be taken to have as few angles or bends as possible, so as to obtain a good current of air and also to avoid sharp curves or bends. Round elbows with a full sweep and round piping should be used for conveying dust or material from a duster, or in fact any machine requiring to be thus connected. Sharp angles in dust pipes destroy the force of the air-current and are liable to become choked with refuse. The dust pipes should be as large as the opening of the fan casing and preferably of galvanized iron.

WASHING PROCESS

IMPURITIES IN WOOL

YOLK, SUINT, EARTHY AND VEGETABLE MATTER

26. Object of Washing.—The operation that follows the sorting of the wool is known as **wool scouring**, or **washing**; but where wool is dusted, then this operation intervenes between the sorting and the washing. **Wool washing** has for its object the cleansing of the wool from the natural and foreign impurities that, if not removed, would effectually prevent the wool from being worked in the after processes of manufacture. In the dyeing, particularly, great trouble is caused by imperfectly washed wool, and it has been found impossible to fasten the colours evenly on such wool. The primary objects of wool washing, therefore, are to cleanse the wool of the yolk, or natural preservative, a greasy matter that covers the outside of the fibre, and at the same time to remove such mechanically adhering impurities as dirt, pieces of manure, etc., that have not been loosened in dusting.

27. Yolk.—In describing the structure of the wool fibre, reference has been made to the greasy matter with which the wool of sheep is impregnated. This substance is termed **yolk**

and consists of a mixture of the fatty or oily matter exuded from the hair follicles of the skin with the alkaline salts which form a constituent part of the perspiration of the sheep, and which are exuded from the sweat glands of the skin. The yolk is of great service during the growth of the wool fibre in protecting its physical structure from injury. While it is true that the wool grease is commonly termed yolk, it really consists of two different parts: the *yolk proper*, or fatty matter, which consists of substances that require the use of soaps or solvents for their removal, and the *suint*, or portion that may be readily removed by the application of water only, and which consists principally of potash compounds.

28. The *yolk proper*, or *wool fat*, as it is sometimes called, has a composite structure, and is composed of substances known as cholesterine and ischolesterine, both in an uncombined state and as salts of oleic and other fatty acids, the latter mainly stearic and palmitic. Wool fat is insoluble in water, but may be dissolved by such solvents as carbon bisulphide, benzine, naphtha, etc. ; or it may be removed as an emulsion by the use of alkaline detergents. The removal of the wool fat necessitates the use of strong washing agents, and were it not for this substance, the wool could easily be washed in pure water. In washing raw wool, therefore, if it contains an excess of this fatty matter it will be more difficult to wash thoroughly, and will require the use of more soap or alkali.

29. *Suint*.—This is the portion of the wool grease that is soluble in water and is usually included under the general term of *yolk*, which is the common word for wool grease when considered as a whole. *Suint* is really the collected perspiration of the sheep, commonly called wool perspiration, and consists chiefly of potash salts, principally potassium oleate, palmitate, acetate, and other salts of organic acids. The carbonates, chlorides, sulphates, and phosphates of potassium are also present in small quantities as well as a small amount of ammonia ; these form the inorganic constituents of wool perspiration. From this it will be seen that the *suint*, or portion of the yolk soluble in water, is a valuable source of potash salts.

30. Proportions of Constituents of Unwashed Wool.—The proportions of the different constituents of unwashed, or greasy, wool vary greatly, but are usually included within the limits

TABLE I
IMPURITIES IN UNWASHED WOOL

Constituents	Average for Short Greasy Wools Per Cent.	Average for Medium Cross-Bred Wools Per Cent.	Average for Long English Wools Per Cent.
Yolk	40	35	20
Dirt	15	10	10
Wool fibre, in normal condition of moisture . . .	45	55	70

given in Table I. From Table I it will be seen that wool, as it is clipped from the back of the sheep, is a very impure article and contains from 30 to 55 per cent. of impurities, the general average being in the vicinity of 45 to 50 per cent.

31. Yolk Ash.—In France and Belgium, and to a limited extent in Great Britain, it is customary to steep wool in tanks before washing or to pass it through special desuinting machinery, that is, machinery which has for its object the dissolving of the suint. The dirty brownish water thus obtained is then evaporated in specially constructed furnaces, and a product procured, known as **yolk ash**, from which the potash salts can be recovered. It is said that certain heavily yolked wools will yield, when steeped in warm water, from 70 to 90 pounds of carbonate of potash and from 5 to 6 pounds of potassium chloride and sulphate per 1,000 pounds of wool. The value of the potash salts obtained in this manner in France alone exceeds £100,000 per annum. In Great Britain and America it is not customary to make any distinction between the wool fat, or true yolk, and the wool perspiration, or suint, the whole being removed in the one

operation of washing, and the waste water allowed to run away in the drains and rivers.

32. Analysis of Yolk Ash.—The yolk ash obtained from the water in which the wool is steeped consists of about 60 per cent. of organic matter and 40 per cent. of mineral, or inorganic, substances, these latter consisting largely of potassium carbonate. An analysis of the inorganic matter contained in the yolk ash gave the results stated in Table II.

The proportions of the different constituents of yolk ash will vary according to the environment in which the sheep has been reared, and also to some extent according to the nature of the herbage on which the sheep has been fed; but the values given in Table II represent a fair average.

TABLE II
INORGANIC INGREDIENTS OF
YOLK ASH

Ingredients	Per Cent.
Carbonate of potash . .	86.78
Sulphate of potash . .	6.18
Chloride of potash . .	2.83
Other metallic elements, as lime, iron, phosphorus, alumina, etc. .	4.21

Whether wool is steeped for obtaining the potash salts or not, it is always necessary to wash it, since the steeping only dissolves the suint, or wool perspiration, and does not remove the wool fat, or true yolk. The preliminary steeping of the wool, however, is an aid in turning out the wool bright and lofty.

33. Earthy and Vegetable Matter.—The mechanically adhering impurities of wool consist of **earthy material**, such as sand, dung, and dirt, which are held on the fibre by means of the yolk and suint, and of **vegetable material** that consists of burrs, shives, seeds, twigs, dried grass, straw, etc. The mechanical impurities are all foreign, and vary greatly with the character of the soil on which the sheep range, in some fleeces being sandy and gritty, and in others consisting of a loamy dirt. The percentage of these foreign substances varies greatly, being sometimes as low as 3 or 4 per cent., and in other cases as high as 20 or 25 per cent., of the total weight of the fleece.

34. Shrinkage and Yield of Clean Wool.—The loss in weight resulting from the removal of the yolk, suint, and dirt is called the *shrinkage*, and the weight of clean wool remaining is termed the *yield*. The yield varies greatly, depending on the quality of the wool ; thus, long lustre wools do not contain as much yolk as those of shorter staple, and consequently give a greater yield. Merino fleeces yield only from 40 to 50 per cent. clean fibre ; fine cross-breds from 50 to 60 per cent. ; coarse cross-breds 60 to 70 per cent. ; and English wools 70 to 80 per cent. The average yield of clean wool varies slightly according to the season. When wool is sold in Great Britain, at the Wool Exchange, the bales of the different lots are open for inspection, and the buyer may either make an estimate, based on experience, as to the probable shrinkage in washing, or submit small samples to the mill, or to a conditioning house for the purpose of having them more accurately tested.

35. Calculations Relating to Yield.—The cost of the clean wool is affected by the percentage of yield, that is, the percentage of clean wool. If, for instance, a quantity of unwashed wool is purchased at 6d. per pound and it loses one-half its weight in washing, the cost of the clean wool per pound will be $2 \times 6 = 1s.$, not considering the cost of washing. The following rule may be used for finding the cost of clean wool, if the price per pound of the greasy wool is known and also the percentage of yield or shrinkage. If the percentage of shrinkage is given, the percentage of yield is found by subtracting the former percentage from 100.

Rule.—*To find the cost per pound of washed wool, multiply the price per pound of the greasy wool by 100 and divide by the percentage of yield.*

EXAMPLE.—What is the cost per pound of clean wool that in its greasy state was bought for $6\frac{1}{2}d.$ per pound, if the shrinkage was 40 per cent. ?

SOLUTION.—If the shrinkage is 40 per cent., the yield is $100 - 40 = 60$ per cent. Applying the preceding rule, the cost per pound of the clean wool is

$$\frac{6.5 \times 100}{60} = 10.8d., \text{ nearly. Ans.}$$

36. If the cost of sorting and washing is to be added to the price per pound of the cleaned wool the total cost may be found by the following rule :

Rule.—*To find the cost per pound of washed wool, inclusive of the cost of sorting and washing, multiply the price per pound of the greasy wool by 100 and divide by the percentage of yield ; to the result add the cost per pound of sorting and washing.*

EXAMPLE.—If greasy wool costing $9\frac{1}{2}$ d. per pound has 42 per cent. of yield and costs 1d. per pound to sort and wash, what will be the price per pound of the cleaned wool ?

SOLUTION.—Applying the rule just given,

$$\frac{9.5 \times 100}{42} = 22.6 + 1 = 23.6\text{d. per lb. Ans.}$$

37. **Condition of Imported Wool.**—Wool may be imported into Great Britain in one of the following three conditions : As *greasy wool*, as *fleece-washed*, and as *fully washed*. When imported in the *greasy* state it is in the condition in which it grows on the sheep. While in this form it retains a softer handle and generally works better in the processes that follow washing, in which the various valuable by-products may be recovered. The spinner has also the treatment of the wool under his control from its raw to its finished state. The disadvantages connected with the import of wool in the *greasy* state are the extra cost in carriage and the difficulty in judging the yield of clean wools.

38. In wool imported in the *fleece-washed* state a portion of the grease and dirt is removed by the process of sheep washing performed a few days before the wool is clipped. This results in a wool of better colour and less weight and facilitates the estimate of yield. It has the disadvantage of making the handle of the wool slightly harsher and that the by-products of washing are lost. Wool imported in the *fully washed* state has passed through a complete scouring process and is sufficiently clean to be used for some classes of goods without further washing. Such wool has a good colour and may be without further shrinkage, if it is rewashed. The disadvantages connected with a *fully washed* wool are that the fleeces are broken up to a great extent and therefore more difficult to sort, that

it is more liable to be affected by moths, and that the scouring process has been performed in a manner that will involve a minimum of expense and loss of weight.

WASHING MATERIALS

ALKALIES

39. Soda Ash.—The washing agents generally used for cleaning wool are: *Soda ash*, which is dry commercial sodium carbonate; *pearl ash*, which is dry potassium carbonate; *soda*, or *hard, soaps*; *potash*, or *soft, soaps*; *ammonia*; and various compounds of these substances with others such as silicate of soda, etc. The best soda ash, which is generally purchased in powdered form, is that known as *58 per cent. alkali*, containing 98 per cent. of carbonate of soda. The presence of caustic soda is dangerous, since in hot water it will entirely dissolve the fibre.

40. Pearl Ash.—*Pearl ash* is similar to soda ash, but its action on wool is milder, since it is less liable to attack the serratures of the fibre and remove the natural oil required to maintain its characteristics; hence, it should always be employed for washing fine wools that require an alkali. Soda ash, on account of its cheapness, is employed for washing coarse, dirty grades of wool.

41. Testing for Caustic Alkali.—To test soda ash or pearl ash for the presence of caustic alkali, first dissolve 1 gramme of the sample in 100 cubic centimetres of distilled water, then add an excess of barium chloride of 5 per cent. strength and filter the solution. The filtered solution may now be tried with a piece of litmus paper, the presence of caustic alkali being indicated by red litmus paper turning blue; a more delicate test is obtained by the addition of a small amount of phenol-phthalein, the slightest amount of caustic alkali immediately turning the solution pink, while its absence will be indicated by the solution remaining colourless.

42. Ammonia.—Ammonia is frequently added to carbonate and soap washing liquors and aids in the removal of the yolk. Carbonate of ammonia, which may be obtained in commercial form, is rarely used. The liquid ammonia of commerce, which is added to the washing liquor in small quantities, contains only about one-third pure ammonia, the other two-thirds being water. Formerly it was the custom to wash wool with stale urine, or lant. This substance owes its detergent properties to the presence of ammonium carbonate. The wool was placed in tanks containing equal proportions of lant and water and poled round until the yolk and dirt were removed, when it was taken out and carefully drained and rinsed. This process gave results in many ways superior to the present methods. The action of the lant was mild and, when dry, the wool had the desired soft and *kind* feeling.

SOAPS

43. Hard, or Soda, Soaps.—Soap is understood to be a compound of an alkali with certain fats, fatty acids, or oils. It is usually formed by boiling either caustic soda or caustic potash with one or more of the following fats or oils: tallow, olive oil, oleic acid, cotton-seed oil, palm oil, or coco-nut oil. Soaps may be divided into two classes, namely, *hard soaps* and *soft soaps*. **Hard soaps** have soda as a base and are quite frequently used for washing wool. Soda in any form, however, is not to be recommended for the very finest grades of wool. A hard soap now in common use for washing wool in Great Britain is an American soap made from cotton-seed oil.

44. Soft, or Potash, Soaps.—These soaps are made with potash as a base and are commonly called *soft soaps*. **Potash soaps** are made in the same manner as soda soaps, that is, by combining caustic potash with some fatty acid, in which case a soluble soap is obtained. It is commonly supposed that soft soap contains more water than hard soap, but such is not always the case. Soda soaps are hard and potash soaps soft, because it is the nature of these two substances, when used as the base of a soap, to form hard and soft soaps, respectively. A soda soap

may contain a much larger percentage of water than a potash soap and yet remain hard and firm. When proper precautions are not taken in manufacturing, any soap may be found to contain caustic alkali in a free, or uncombined, state ; and potash soaps, contrary to the general opinion, may very frequently contain caustic potash. When this is the case, the soap may have a severe action on the wool fibre. Soft soaps, if properly made, are the best, as they leave the wool softer in handle and of a better colour than hard soaps, but they are more expensive than hard soaps.

45. Function of Soap.—The function of the soap is to emulsify the greasy matter adhering to the wool fibres. As a rule, it is not practicable to wash greasy wool with a neutral soap, that is, a soap which contains no free or uncombined alkali. The majority of wools contain such a large quantity of grease that alkali is necessary to effect complete saponification. It is, however, very desirable that a neutral soap should be used, so that known quantities of the selected alkali may be added, rather than use an alkaline soap in which the amount of free alkali is unknown, and which usually contains the alkali in a caustic condition.

46. Impurities in Soap.—Great care should be taken in purchasing the materials used in washing wool, not only because of the necessity of obtaining an agent that will not injure the wool, but also because of the danger of obtaining an article of inferior washing properties. There are many so-called patent soaps and washing materials on the market, but they should, as a rule, be avoided, since they are usually expensive and are all based on the ordinary washing agents with which every washer is familiar. Soap is one of the easiest articles to adulterate and also one that is rarely tested unless poor results are traced directly to it.

Soda soaps may contain a large percentage of water, even as much as 40 per cent., without any noticeable effect on the soap. For this reason the manufacturer of the soap is liable to allow a large amount of water to be retained for the purpose of adding weight. There is a great loss of washing power besides inferior

work done if a soap contains resin, potato starch, salt, clay, fuller's earth, chalk, or other impurities, as they are not only useless, but wasteful, and also assist materially in forming scum, which interferes with the operation of washing.

47. Testing Soap for Presence of Water.—The analysis of soap is a very difficult matter and can be accurately performed only by experienced analysts. The following tests, however, will be useful and are not difficult to make. To determine the amount of water present in a sample of soap: Carefully weigh a small quantity of the soap, which has not been exposed to the air, reduce it to fine parings and place these in a porcelain dish which has previously been dried and weighed. Dry the weighed sample in an oven at a temperature of from 220° to 230° F. for about 3½ hours, then let cool and weigh, and repeat process until the weight is constant. From the loss in weight, the percentage of water can be calculated.

48. Testing Soap for Free Alkali.—To ascertain if a sample of soap has free alkali present: Place a strip of moistened red litmus paper on it; if the litmus paper turns blue it indicates that free alkali is present. The percentage of the free alkali present may be determined as follows: Dissolve in 150 cubic centimetres of distilled water 10 grammes of the soap, by boiling. Then add 2 drops of phenol-phthalein, which in the presence of free alkali will give the solution a reddish colour. Into this solution drop normal sulphuric acid until the colour disappears. The amount of sulphuric acid added, in cubic centimetres, should be multiplied by .4 to obtain the percentage of free caustic soda, and by .56 to obtain the percentage of free caustic potash. Should the free alkali be carbonate of soda or potash, the test should be conducted as before, but with 200 cubic centimetres of neutral alcohol in which 10 grammes of the soap is dissolved.

49. General Test for Soap.—A simple method for testing soap for impurities is to dissolve a small weighed quantity in water and then add a little sulphuric acid to the solution. The acid breaks up the structure of the soap, reducing the combined or

saponified fat to its original state, and neutralizing the alkali ; all earthy and heavy adulterations fall to the bottom of the solution, while the fatty matters and resin, if the latter substance has been used as an adulterant, float on the surface and can be taken off in the form of a cake and dried in filter paper, and tested separately, as desired. If the soap does not readily separate into its various groups of constituents, the introduction of a known quantity of paraffin wax or stearine will prove effective. It is necessary to note the amount of stearine or paraffin wax introduced, so that such weight may be deducted from the weight of the fatty matters with which they would collect. If any animal matter such as bits of skin and so on is present, it can easily be detected on melting the fatty matter.

50. Testing Soap for Resin.—To ascertain if resin is present, 1 gramme of the fatty matter, that has been freed from the soap, as explained in Art. 49, is boiled with acetic anhydride ; when the mixture is cool, 2 drops of sulphuric acid is added ; if the mixture turns a reddish-violet colour it indicates the presence of resin. The resin has a tendency to give the wool a yellow, singed appearance.

51. Testing Soap for Salt and Alum.—To ascertain if soap has been adulterated with salt a small quantity of a silver-nitrate solution is added to the soap solution ; if salt is present, a white precipitate will be formed. The presence of alum may be ascertained by adding a little ammonia to the soap solution ; if a white gelatinous precipitate is formed, it is an indication that alum is present.

WATER

52. Requirements of Good Water.—A plentiful supply of suitable water will reduce the cost per pound for washing and also greatly improve the condition of the wool that has to pass through the dyeing process or other processes preliminary to spinning. Distilled water would fulfil the requirements but for its expense. In some mills the water resulting from condensed steam that has been used for heating the buildings, or for other purposes, is carefully collected and stored. Rain-water is always

soft and is an excellent water for wool washing. Some mills arrange a system of pipes and tanks to catch the rain-water that falls on the roof. This method is not reliable, however, as during the dry season the mill is apt to suffer from a lack of water of this kind and other means must be used.

53. Sources of Supply.—The bulk of the water required for the washing machines must be taken from natural supplies, such as lakes, rivers, springs, and wells. The origin of these sources of supply is the rain-water, but while this originally is very pure, its qualities are changed by contact with gases and mineral matter. When the rain-water reaches the earth, some of it will pass through the soil and flow along various kinds of rocks containing soluble matters, such as limestone, chalk, etc. ; the latter minerals will change the soft rain-water into what is termed *hard* water.

54. Hard Water.—When water contains more than 8 to 10 grains per gallon of mineral salts in solution, usually a lime compound, it is termed *hard water*. The substances mostly found in hard water are the various lime compounds ; others are compounds of iron and magnesium. If such water is used for washing liquor, the soap will decompose, since the lime compounds release the alkali and combine with the fatty matters, producing what is known as *lime soap*. Ordinary soap is soluble and forms an emulsion with the fatty matter in the wool, but the lime soap is insoluble and forms a deposit on the wool fibres. This deposit is a sticky, pasty substance that completely envelops the fibre, from which it is difficult to remove. The only means by which it can be removed is by treating the material with hydrochloric acid, but this substance has a most deleterious effect on the material with regard to its dyeing properties. Should the lime soap be present on the fibres when dyeing takes place, the uniformity and nature of the shade will be affected. The hardness of water may be *temporary* or *permanent*.

55. Temporary and Permanent Hardness.—Water that contains in solution bicarbonates of lime, iron, or magnesium is said to possess *temporary hardness*, since the water may be softened

by boiling. The effect of the boiling is to drive off one-half of the carbonic acid, thus changing the soluble bicarbonates to insoluble monocarbonates, which are precipitated, allowing the softened water to be drawn off. This method of softening water, however, is too expensive for commercial purposes, since it is necessary to boil the water for at least $\frac{1}{2}$ hour.

Water that contains in solution chlorides or sulphates of lime, iron, or magnesium is said to be **permanently hard**. Boiling simply concentrates the hardness of permanently hard water.

56. Testing Water for Total Hardness.—The hardness of water is always spoken of in terms of *degrees of hardness*, each degree of hardness indicating that there is 1 grain of soap-destroying salts in 1 gallon of water. Instead of testing a whole gallon of water, it is customary to take a smaller quantity, usually 70 cubic centimetres, which is termed a *miniature gallon*. The quantity of 70 cubic centimetres is chosen because it contains the same number of milligrams as a gallon contains grains; therefore, when a test is made as to the number of milligrams of soap-destroying salts in this miniature gallon, the result obtained corresponds exactly to the result obtained if the number of grains of soap-destroying salts were obtained in a full gallon.

57. To make the test, a *standard* soap solution is required, which may be obtained from a chemical store; it is made up by dissolving 10 grammes of pure Castile soap in 1 litre of alcohol, the whole forming what is termed a 1 per cent. solution, since 1 litre contains 1,000 grammes. This standard soap solution is of such a strength that 1 cubic centimetre of the solution will neutralize 1 milligram of soap-destroying salts in the water, and therefore the number of cubic centimetres, minus 1, of standard soap solution required to produce a *permanent lather* on the water indicates the degrees of hardness of the water. It is necessary to subtract 1 cubic centimetre, because even in distilled water, which is absolutely soft, it is still necessary to add 1 cubic centimetre of soap solution before a *permanent lather* is produced. Hence, in case a sample of water has 3 degrees of hardness, a quantity of $3 + 1 = 4$ cubic centimetres of soap solution must be added. A **permanent lather** is understood to

be one that will remain on the surface for not less than 5 minutes after the water has been briskly shaken for a few moments.

58. When testing very hard water, a more accurate result may be obtained by diluting samples of water that are known to possess more than 10 degrees of hardness, by adding a measured quantity of distilled water. The dilution, of course, must be taken into account in determining the degree of hardness. For example, suppose that a sample of $70 \div 2 = 35$ cubic centimetres of very hard water is diluted with an equal quantity of distilled water, and that a lather is produced when 10 cubic centimetres of soap solution has been added. If no dilution had been performed, the water would be said to have $10 - 1 = 9$ degrees of hardness. However, half the sample was distilled water, so that the result must be doubled, before making allowance for the formation of lather in the distilled water. Hence, for the case just mentioned, the sample possesses $(2 \times 10) - 1 = 19$ degrees of hardness.

59. **Testing Water for Temporary and Permanent Hardness.** To ascertain the amounts of temporary and permanent hardness: Pour into a flask capable of holding 250 cubic centimetres as much of the water to be tested that its weight added to that of the flask will be 200 grammes. Then boil for about 30 minutes to remove temporary hardness, after which add distilled water until the flask and water together weigh 200 grammes; then filter the water, and after the water has cooled take from it 70 cubic centimetres and test by means of the standard soap solution. The result of the test will be the degrees of permanent hardness; this result, deducted from the total hardness, will be the temporary hardness.

PURIFICATION OF WATER

METHODS OF PURIFYING WATER

60. **Classification of Methods.**—The purification of water may be accomplished (*a*) by settlement, (*b*) by filtration, or (*c*) by chemical means. If the impurities contained in the

water are mechanically suspended, the water may be purified by settlement ; if grease is present also, filtration should be employed ; and if the impurities are dissolved in the water, resort must be had to the addition of chemicals.

PURIFICATION BY SETTLEMENT

61. Treatment of Mechanically Suspended Matter.—For water containing much matter in mechanical suspension, one of the simplest methods of purifying it is to provide a relatively large reservoir, or a large tank, in which the impurities can settle to the bottom. By mechanically suspended matter is meant impurities such as mud and sand, which are not actually dissolved in the water, but which are carried along by the current. When the water is allowed to stand quietly for a time, these impurities fall to the bottom by reason of their greater specific gravity. While this method is fairly satisfactory, as far as earthy matter is concerned, it will not clear the water of finely divided organic matter, which is usually lighter than the water and often so finely divided as to be almost dissolved in it.

PURIFICATION BY FILTRATION

62. Filtering Materials.—Organic and earthy matter in mechanical suspension is most satisfactorily removed by passing the water through a filter consisting of layers of sand, gravel, hay, wood wool, layers of cloth, or equivalent substances. Hay and cloth are of service, especially where the water contains oil or grease.

PURIFICATION BY CHEMICALS

63. Use of Quicklime and Caustic Soda.—The chemical process to be adopted depends on the substances present in the water. When the water contains only carbonates of lime and magnesium it may be treated with quicklime, using 28 grains of lime for every 50 grains of carbonates present in the water, the quicklime precipitating the carbonate of lime and being

transformed into carbonate of lime itself during the process. The quicklime cannot be added in the dry form, therefore it is usually slaked, and mixed with sufficient water to make a very thin paste, in which form it is known as milk of lime. Water containing carbonate of lime may also be treated with caustic soda, which precipitates the carbonate of lime and leaves carbonate of soda, which is harmless. For every 100 grains of carbonate of lime, 80 grains of caustic soda should be added.

64. Use of Carbonate of Soda and Caustic Soda.—While slaked lime will precipitate carbonate of lime, it will have no effect on sulphates and chlorides of lime and magnesia, and water containing these substances, either alone or in conjunction with carbonate of lime, must be treated with an alkali. The alkalies mostly used for water containing the above impurities are either carbonate of soda or caustic soda. The former is generally used where only calcium sulphate is present; but if magnesium sulphate forms a constituent of the water, then it is necessary to use caustic soda. The action of caustic soda on carbonate of lime and sulphate of lime in water containing both is as follows: The soda precipitates the carbonate of lime, and in so doing it forms sulphate of soda, which is very soluble and harmless.

65. Necessity for Chemical Analysis.—The analysis of water for the determination of the character and quantities of its chemical constituents is the work of expert chemists. It is important that such quantities should be determined as accurately as possible, since if too small an amount of chemicals is used the water is not brought to the required degree of softness; while if too large a quantity is used it is rendered hard again by the presence of the excess of lime, so that it will be seen that any process of water softening requires very accurate weighing out of the chemicals in accordance with the quantity of water to be treated.

When the purity of any water is in question, several samples taken at different times should be sent to a qualified chemical expert for analysis and advice as to the best substance to precipitate the matter in solution or to neutralize acid action. Samples of water for analysis should be sent in glass bottles, each

containing not less than 1 quart, and should be well rinsed with a quantity of the same water before filling.

66. Determining Quantity of Chemical to be Used.—When treating water containing carbonate of lime and sulphate of lime, caustic soda may be used either by itself or in combination with carbonate of soda, and the quantities needed depend on the relative amounts of carbonate of lime and sulphate of lime present in the water. The amount of caustic soda or carbonate of soda to be used per gallon of water can be found as follows :

Rule I.—*Multiply the number of grains of carbonate of lime per gallon by 1.36. If this product is greater than the number of grains of sulphate of lime per gallon, only caustic soda is to be used. To find the quantity of caustic soda required per gallon, multiply the number of grains of carbonate of lime in a gallon by .8.*

Rule II.—*Multiply the number of grains of carbonate of lime per gallon by 1.36. If this product is less than the number of grains of sulphate of lime per gallon, take the difference and multiply it by .78 to obtain the number of grains of carbonate of soda required per gallon. To find the amount of caustic soda required per gallon, multiply the number of grains of carbonate of lime in a gallon by .8.*

EXAMPLE.—A quantitative analysis of a certain water shows that it contains 23 grains of sulphate of lime and 14 grains of carbonate of lime per gallon. How much caustic soda and carbonate of soda should be used per gallon to precipitate the substances ?

SOLUTION.—By rule I, $14 \times 1.36 = 19$ grains. Since this product is less than the number of grains of sulphate of lime per gallon, rule II must be used. The difference is $23 - 19 = 4$ grains. Hence, by rule II, the number of grains of carbonate of soda required is $4 \times .78 = 3.12$ grains, and of caustic soda is $14 \times .8 = 11.2$ grains. Ans.

67. Use of Carbonate of Soda.—Water containing sulphate of lime, but no carbonate of lime, may be treated with carbonate of soda. The amount of the latter that is required per gallon to precipitate the sulphate of lime is found by multiplying the number of grains per gallon by .78.

68. Neutralization of Acids.—Acid water can be neutralized by means of an alkali, soda probably being the best one. The amount of soda to be used can best be found by trial, adding soda until the water will turn red litmus paper blue.

WATER SOFTENERS AND PURIFIERS

69. **Economy of Water Softening.**—By means of water-softening and purifying apparatus the hardness of water may be very greatly reduced. Considering the composition of commercial soaps in general and that 1 grain of carbonate of lime will combine with 13·1 grains of fatty acids in soap, it is found that for each degree of hardness in water 1·24 pounds of soap is destroyed for every 1,000 gallons of water. Thus, if water is used that has 22 degrees of hardness, then $22 \times 1\cdot24 = 27\cdot28$ pounds of soap will be destroyed for every 1,000 gallons of water used before any soap becomes available for washing. There will also be a quantity of lime soap floating about on the top of water which attaches itself to the fibres.

From results of tests before and after treatment, the hardness of water has been reduced from 52 degrees to $2\frac{1}{2}$ degrees, at a cost of about $2\frac{1}{2}$ d. per 1,000 gallons. The average hardness of treated water is, however, seldom lower than 4 to 5 degrees by any process of softening; but this is sufficiently low for all commercial purposes. Water of more than 5 degrees of hardness is unsuitable for wool washing, while as the hardness approaches 2 degrees the more suitable it will be for this work. The hardness of town water in the British Isles varies from 1·3 degrees to 30 degrees, the average being probably about 15 or 20 degrees. The water obtained from rivers, canals, or deep wells is usually very hard, the hardness ranging up to 80 degrees, while there are usually a number of organic impurities present. The mechanical operations involved in the softening of hard water include the preparation of the chemical reagents and their mixture with the water, the separation of the precipitates formed, and, in some plants, the filtration of the water after softening.

70. In some types of water softeners the chemicals are mixed in separate mixers, and then passed to the chemical tanks from which they are measured out as required. It is usually necessary to have some means for stirring the liquid in the tanks to ensure that a standard solution is obtained in each case. This

is especially necessary where milk of lime is used, as the lime settles rapidly, if not constantly stirred. With some water the nature of the precipitate causes the settling of the insoluble substances to be very slow ; when this is the case a substance known as aluminoferric is added to the water or to the chemicals. In water this substance forms a heavy gelatinous precipitate, which, while settling through the water, carries with it the small flakes of the precipitate separated from the softened water, so that the water is cleared of the precipitate much more rapidly.

WATER-SOFTENING PLANTS

71. Softening Hard Water.—There are several methods of softening hard water and there is apparatus specially designed for this purpose ; but the cheapest method is to precipitate the lime or other compounds with caustic soda. From 3 to 5 pounds of powdered caustic soda should be added to each 1,000 gallons of hard water, the amount added depending, of course, on the degree of hardness of the water. This will remove both temporary and permanent hardness and works as well with cold as with warm water. The caustic soda precipitates all the lime, magnesium, and iron salts as insoluble compounds, leaving the water soft and ready for use in washing wool. This method of softening, however, requires large storage tanks for its operation. The method is somewhat slow, and for this reason mechanical means are used to aid the settling or separation of the sediment, which is formed in the water in consequence of the action of the soda. These mechanical means may have the purpose of facilitating the precipitation of the sediment, or may remove it by filtration, this latter method being the more rapid, enabling larger volumes of water to be dealt with in a much smaller space, the operation also being continuous.

72. Archbutt-Deeley Process.—The apparatus for softening water by the **Archbutt-Deeley process**, as made by Mather and Platt, is shown in Figs. 11 and 12. The chemicals used in this case are quicklime and carbonate of soda, but, in addition, the water is carbonated, or treated with carbonic-acid gas, for the

purpose of preventing the formation of a slimy sediment. The plant illustrated is capable of dealing with from 600 to 10,000 gallons of water per hour. It includes two cast-iron tanks

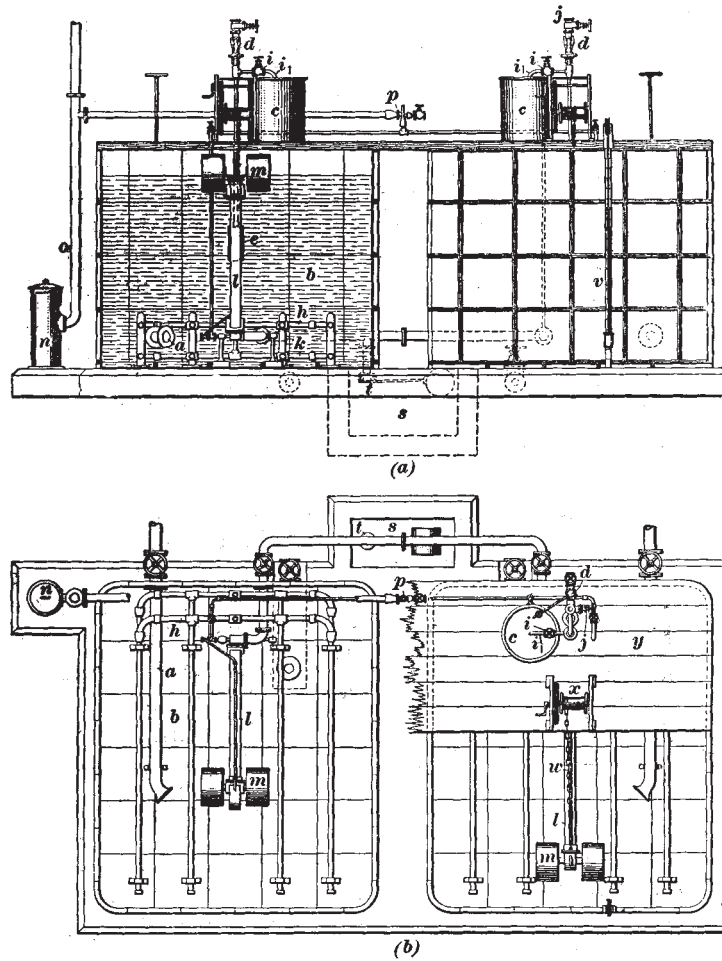


FIG. 11

fitted in exactly the same manner, the processes of filling, softening, and purifying being carried out in one tank while the other is being emptied of its purified water, suitable storage tanks

being provided for it. This arrangement is usual for treating large quantities of water, but where only small quantities are required, a single tank for softening and a storage tank are sufficient for the purpose. Fig. 11 (*a*) shows one of the tanks in elevation and the other in section, while Fig. 11 (*b*) is a plan showing the left tank with the working platform removed. Fig. 12 is a cross-section through one tank.

73. The method of operating the plant is as follows: Hard water is admitted by a pipe *a*, Fig. 12, to the tank *b*, which serves not only as a treating tank, but also as a storage receptacle. The tank is filled to a gauge mark fixed according to the quantity required to be treated. While the tank is being filled, a known weight of quicklime and carbonate of soda in the tank *c* is heated in a small quantity of water by means of a jet of live steam.

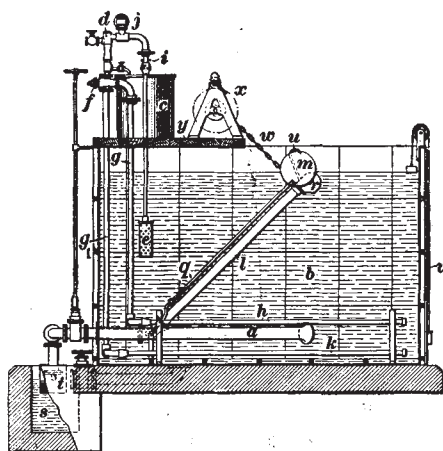


FIG. 12

When sufficient water is in the tank *b*, steam is admitted to an injector *d*, causing a current of water to pass up through the strainer *e*, through the injector, the three-way cock *f*, and the vertical pipe *g*, and back into the tank through holes in the upper row *h* of horizontal pipes. The valve or tap *i* of the pipe *i*, Fig. 11, is then opened, and the prepared chemical solution is

slowly drawn from the tank *c* into the circulating stream of water passing down pipe *g*, being thereby very efficiently mixed with the whole of the water in the tank. After the tank *c* has been emptied, the valve *i* is closed and air is admitted through the cock *j* and blown by means of the injector through the holes in the upper row *h* of the pipes; then, by means of the three-way cock *f*, the course of the air is changed, so that it will pass down

the pipe g_1 and through the perforations in the lower row k of perforated pipes in which the perforations are on the under side of the pipes.

74. The air bubbles formed by the air being blown through the perforations agitate and thoroughly stir up the mixture of water and chemicals in the tank b , Fig. 11; this operation is continued for about 10 minutes, the time varying in accordance with the water being treated. During the time that this operation is in progress, the accumulated deposits from previous operations of softening are also stirred up, and as these deposits set in fairly large flakes they materially assist the settling of the new precipitates by carrying them along on their way down. After the air-blowing is stopped the water is kept quite still, and the precipitates allowed to settle. The settling usually occupies from 50 to 90 minutes, according to the condition of the water; at the end of this period the water will be practically clear to a depth of 6 feet from the surface and may not contain more than 1 grain of suspended matter per gallon

75. The operations of carbonating the water and drawing it off are effected at the same time and automatically by means of the pipe l , Figs. 11 and 12. This pipe is hinged and is provided with floats m , which are so arranged that the mouth of the pipe remains just below the surface of the water. From the coke stove n , Fig. 11, a supply of fuel gas is drawn through the pipe o by a small steam injector p , whence it branches off to both tanks and passes down to the lower end of the pipe q , Fig. 12, which it ascends, escaping through the discharge mouth r . Here it is caught by the descending current of water and is carried down the pipe l to the small supply tank s , into which the softened and carbonated water falls, and from which the supply for immediate use is taken. The supply is controlled by the ball valve t fitted to the end of the pipe line l . At this stage the nitrogen in the fuel gas escapes into the air. If the tank s fills up and closes the valve t , the fuel gas passes out through the vent pipe u , above the top of the pipe l .

On the side of the treating tank is affixed a gauge v , a mark on which denotes the point below which water should not be drawn

off, to avoid carrying over the sludge and sediment to the supply tank. That this may be automatically avoided, a stop is provided to arrest the descent of the pipe *l* before its mouth *r* reaches this level. To facilitate the examination of the hinged pipe *l*, and, if necessary, to keep it in a fixed position, one end of a chain *w* is attached to the end of the pipe, the other end being wound round the drum of a winch *x* placed on the platform *y* over the tank.

76. The water after leaving the softening plant may be tested by adding a few drops of a solution of nitrate of silver to a sample of the water in a small white basin. If too little lime has been used the water will turn milky white; on the other hand, if too much has been used, the water will turn a dark-brown colour. When correctly treated, the water will show a faint straw colour and the best results are obtained when this colour is maintained. The precipitate is removed from the tank at frequent intervals, and in large plants doors are provided through which the mud is flushed out, sufficient being left each time to facilitate settling at the next operation.

The complete cycle of operations is intended to occupy rather less than 2 hours; and where two tanks are employed alternately, a quantity of softened water equal to the capacity of one of the tanks is produced each hour.

77. **Lassen-Hjort Water Softener.**—The construction of the rectangular type of **Lassen-Hjort apparatus** for water softening is shown in Figs. 13 and 14. A longitudinal section through the whole of the apparatus is shown in Fig. 13 (*a*), and a cross-section in Fig. 13 (*b*), while Fig. 14 is a perspective view of that portion of the apparatus that is used in measuring the amounts of water and chemicals to be mixed. The chemicals generally used in this apparatus are lime and soda ash, although caustic soda may be used instead of soda ash. The hard water to be treated is conveyed through a pipe *a*, Fig. 13, into a measuring trough, or tipper, made up of two compartments *b* and *c*. This trough is free to tilt from side to side in the tank *d*, being supported by two trunnions *e* and *f* which are carried by bearings fixed to the sides of the tank *d*. These trunnions are fixed at

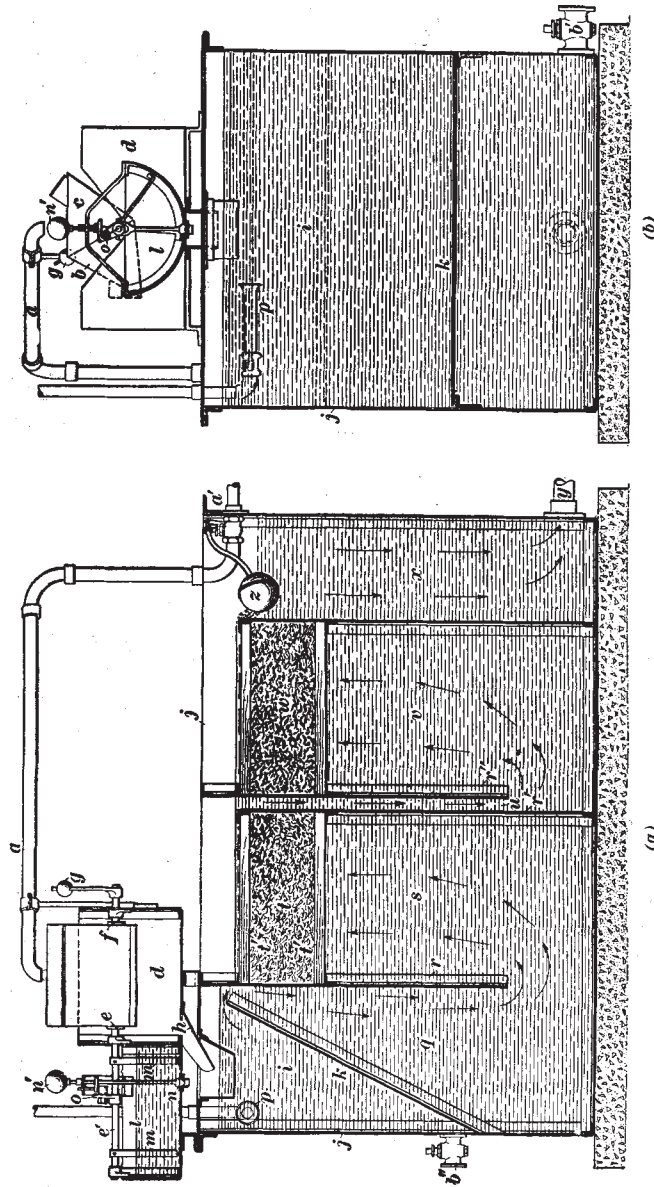


FIG. 13

such points that, as soon as the water fills the compartment which is uppermost, the trough tilts over and brings the other compartment beneath the end of the pipe *a*. The trunnion *f* is extended beyond its bearing and carries an arm to which is attached a counterweight *g*. In tilting, the weight of water in

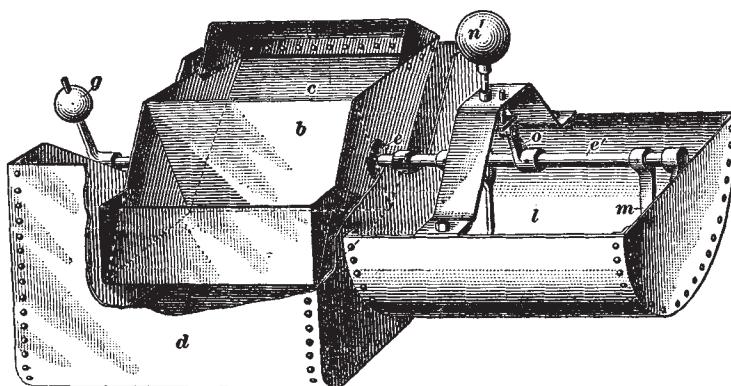


FIG. 14

the full compartment overcomes the effect of this counterweight. As the water flows continuously from the pipe *a*, the tilting trough regularly discharges known quantities of water into the tank *d*, from which the water flows down the chute *h* into a chamber *i* formed between the end of the main tank *j* and a division plate *k*.

78. The other trunnion *e* of the trough is also extended, as shown more fully in Fig. 14, forming a shaft *e'* which is carried across the semicircular chemical tank *l* and supported at its outer end by a bearing. The chemicals used in the softening process are mixed with water to form a solution, this mixing being done in an adjacent tank which is placed on the ground beside the apparatus, but not shown in the illustration. This solution is pumped into the tank *l* by a small hand pump or other means, the settling of the chemicals being prevented by the stirring action of the arms *m*, fixed to the shaft *e'*. As the trough tilts, these arms swing to and fro in the chemical tank. In the bottom of this tank is an opening that is closed by a valve *n*,

on the spindle of which is a dead weight n' , Fig. 13 (*a*). An arm or crank o is keyed to the shaft e' in such a position that at each tilt of the trough the crank lifts the valve n from its seat for a brief period, thus allowing a definite quantity of the chemical solution to pass into the chamber i . The valve n is adjustable, so that any required amount of chemical solution can be passed through at each release, the amount representing the exact quantity required for treating and softening the amount of water contained in the trough. As this occurs simultaneously with the discharge of the water through the chute h , the chemicals and the water are very thoroughly mixed. The valve n is closed by the action of the weight n' . These details are shown very clearly in Fig. 14.

79. The water and the chemicals having been thoroughly mixed by the time they enter the chamber i , Fig. 13, the solution is heated to a temperature of about 150° F. by a steam injector p . The heat thus added aids greatly in causing the impurities to be precipitated, which slide down the inclined plate k and accumulate at the narrow end of the chamber i . From the heating chamber the mixture passes over the inclined plate k into the chamber q , in which the greater part of the precipitation occurs. It then passes under the baffle plate r into the chamber s , and then upwards through a filter t made of wood wool held between rows of wooden bars t' . The filtered water then descends through the passage u between the dividing partitions r' and r'' into the chamber v , where a further precipitation may take place. The water then passes through another filter w , similar to the first, and is collected in the storage chamber x , from which it is drawn through the outlet y , as required, or into larger storage tanks.

A float z in the chamber x controls a valve a' on the supply pipe a . If the pump connected with the outlet y runs slowly and the level in x rises, the valve a' is closed partly, and the supply of water to the softener is thus adjusted to meet the demand. The precipitated matter deposited at the bottom of the heating chamber and main tank may be removed through the cocks b' and b'' . A third drain cock similar to b_1 is

provided in chamber *v*. The filtering material should be renewed frequently, to ensure continuously satisfactory operation. While the heater *p* hastens the precipitation, the process may be carried on with cold water. Where floor space is limited, softeners of cylindrical or other form may be used.

WOOL-WASHING MACHINERY

WASHING LIQUOR

COMPOSITION AND TEMPERATURE

80. **Selection of Soap.**—It may be said that for the finest grades of wool a fine quality of soap should be used, a well-made potash soap absolutely free from caustic alkali being preferred. The use of soda as an agent for washing wools that are to be stored for some time before using, invariably results in the yellowing of the fibre and gives the wool a harsh feel. Especially is this true in regard to Australian and other fine wools. For medium and coarse grades of wool, where the strength of the fibre is such that it will resist the action of a stronger washing agent, soda soap or carbonate of soda may be used; but in all cases the washing agent should be free from caustic alkali.

81. **Quantity of Soap Required.**—The amount of soap or other washing agent used should be so regulated that no more than is actually necessary to remove the yolk and dirt is used, and the temperature of the liquor should also be as low as is consistent with the results desired. A potash soap for washing very fine wools should be neutral, and from 3 to 5 pounds should be used to each 100 gallons of water. Ammonia may be added to the liquor in small quantities, or part of the soap may be substituted with ammonia. The water used for the washing should of course be as soft as possible. There is a great diversity of opinion as to the composition of washing liquors. It should be noted, however, that the principal governing factors

are the condition and quality of the wool and the purpose for which it is intended. For coarse wool the washing bath should be made up with from 15 to 20 pounds of carbonate of soda to 100 gallons of water ; and for medium grades, soap and carbonate of soda in combination may be used to advantage. Some washers test the washing liquor for strength by means of the *hydrometer*, using a carbonate-of-soda liquor of from 1° to 2° Twaddell, depending on the class of the wool to be treated. The hydrometer is described farther on.

82. Preparation of Washing Liquor.—The washing liquor should be prepared by first dissolving the detergents, that is, the soap and alkali, if alkali is to be used, in special boiling tanks which are generally heated by steam, and very often by blowing live steam into the liquor while the liquid is constantly stirred. This makes a stock solution which is added at regular and frequent intervals to the water in the washing machine, which water is heated to from 100° to 135° F. The stock solution is conducted to the washing machine through several pipes, so that the required quantities may be supplied at different points. Where detergent solution must be supplied by hand, it should be done at frequent intervals, so as not to allow the washing detergents in the liquor to become too exhausted before any more solution is added. Samples of wool should be taken periodically from each bowl and carefully compared, to see that each bowl is doing its share of work in cleansing the wool.

83. Economical Use of Washing Liquid.—When the liquid passes through a set of washing machines, which may consist of 3 to 4 machines, each having a tank, called a *bowl*, the cleaning properties of the liquid in the first bowl will after some hours' work become more and more exhausted and charged with impurities. In order that full use be made of the chemicals dissolved in the liquid, the following routine is observed in a set consisting of three machines: The dirty liquor is run off from the bowl of the first machine, this bowl being then charged with the liquor from the bowl of the second machine and strengthened by the addition of detergent solution or in some cases preferably with alkali alone ; the bowl of the second

machine is charged with the liquor from the bowl of the third machine, the required amount of soap solution being added to make the liquor the required strength. The bowl of the third machine is charged with clean liquor, which is made up of water and an oily soap, so that the wool may be delivered fully cleaned. The temperature of the liquor is then raised in each machine to the required degree and is so maintained until the next change of liquor takes place, a close observation being kept on the condition of the wool as it leaves the last machine; if it is at all sticky the liquor is suitably strengthened. The liquor is changed from one bowl to another as often as required, which is on some classes of wools twice a day.

84. Strength of Liquor.—In washing wool, the fineness and strength of the fibre should always govern the strength of the liquor used, not the amount of dirt and yolk in the wool, since the finer wools are often the heavier yolked and the fibre would be injured by a strong washing agent.

In British and American practice it is not customary to remove the suint from the wool by steeping before washing, as in continental Europe; thus, the carbonate of potash that it contains will aid in the washing of the wool and a smaller amount of detergents will be necessary. As a general guide in preparing the washing solutions, the composition of a few liquors that are in use for washing various types of wool are given. A suitable liquor for washing fine merino or botany wools might be made up as follows: To every 100 gallons of water use 5 pounds of a potash soap made from oleic acid or oleine and caustic potash, and 1 pound of pearl ash. For washing very greasy, fine, cross-bred wools, a satisfactory liquor may be made from 3 pounds of a potash soap and $8\frac{1}{2}$ pounds of pearl ash to every 100 gallons of water. For cleansing strong English wools the liquor may be made from 3 pounds of a cottonseed oil soap and $4\frac{1}{2}$ pounds of soda ash to every 100 gallons of water. The above compositions are in each case for the first machine in a set. A suitable liquor for the second machine, when washing fine merino wools, would be made up of $2\frac{1}{2}$ to $3\frac{1}{2}$ pounds of soap to each 100 gallons of water, while for the third machine,

$1\frac{1}{2}$ to $2\frac{1}{2}$ pounds of soap to each 100 gallons of water would probably be sufficient, no alkali being used in the second and third machine.

85. Temperature of Liquor.—In regard to the proper temperature of the washing liquor, it may be said that a temperature that the hand can just comfortably bear is sufficient, from 100° to 120° F. being the heat generally allowed. The temperature should never, except for special reasons, be more than 135° F., since the higher the temperature of the alkaline washing liquor the more active is it both in cleansing the wool and in inflicting damage on it. Every machine should be fitted with a reliable thermometer. In general, the highest temperature will be required for the removal of the grease while the wool is in the first machine of a set; wool imported in the scoured, or washed, state does not require so high a temperature as very greasy wools. For the general run of wools a temperature of 120° F. in the first machine to 100° F. in the last machine is good practice; but for very dirty wools, such as Buenos Ayres, a temperature of 130° to 135° F. is necessary to remove the grease, while for washing alpaca, mohair, and lustre wools the temperature should be considerably less, a temperature of 100° F. being considered sufficient for the first machine, while in the last machine it should never be more than 90° F. It is better to have a lower temperature and allow more time for washing, if the best results are to be obtained. Live steam should not be allowed to pass directly into the liquor.

86. Effect of Improper Washing.—Wool properly washed should be open and lofty and of a clear colour; the lustre of the fibre should not be impaired. Wool improperly washed, with too high temperature, too strong liquor, or a liquor in which free caustic alkali is present, has a *harsh*, rough feeling. The fibre is also rendered stiff and brittle, is apt to be yellow in colour, and much of the natural elasticity of the wool is injured. The serrations on the surface of the fibre are also injured by

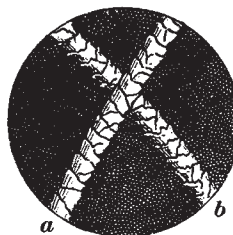


FIG. 15

losing their sharp edges, consequently the spinning and felting properties of the wool are impaired.

Fig. 15 shows the appearance of two fibres of wool under the microscope ; *a* is a fibre carefully washed at a mild temperature and with a suitable detergent, while *b* is a fibre that has been injured by excessive heat or alkali, the ragged edges of the serrations indicating that they have been eaten into by the alkali.

87. Rules for Washing.—The following rules for wool washing are a summary of what has been previously stated and should be followed in all cases where the quality of the work is an object :

1. A fundamental rule is to use as weak a washing liquor at as low a temperature as is possible to thoroughly remove the yolk, at the same time allowing ample time for the operation.

2. Nothing but perfectly neutral soaps should be used for the best results, at any rate when the yolk is easily started from the fibre. A potash soap, free from caustic alkali, is to be preferred. When the wool is very dirty and the grease stiff and hard, a slightly alkaline liquor will loosen the grease from the fibre more quickly ; but the greatest care should be taken to prevent injury to the surface structure of the fibre, especially when dealing with fine wools intended to be manufactured into yarn that has to be subsequently felted or milled.

3. The less the wool is agitated, the better will be the results, provided that the dirt is thoroughly removed. When the cellular structure of the fibres is swollen by the action of the warm washing liquor, the wool is more liable to become felted than when in a dry state and, especially when wool is being washed that has to be manufactured into worsted yarn, the greatest care should be taken to avoid felting and matting.

4. As the higher-lustred fibres, such as mohair and alpaca, are even more sensitive to heat and free alkali than wool, the greatest care should be taken in washing all fibres of this description where lustre is important, both the temperature and strength of the washing liquor being reduced with advantageous results.

5. The water for the washing liquor should be soft and should not contain either organic or inorganic impurities, although the former do not occasion as much trouble as the latter.

CONSTRUCTION AND OPERATION OF WASHING MACHINES

FUNDAMENTAL PRINCIPLES

88. Old Method of Washing.—The old method of washing wool, which was accomplished by means of tanks in which the wool was worked in the washing liquor and rinse boxes, has given way to washing by means of scouring, or washing machines. The method of immersing the wool in solutions of lant, while it gave excellent results owing to the mild action of the lant, was apt to roll and mat the material by the excessive poling to which it was subjected during the process.

The old process of wool washing is used to-day in some small mills, with the exception that potash and soda soaps or carbonate of soda have entirely replaced lant as scouring agents. The wool to be washed is thrown into tanks that contain the washing liquor, and is worked with poles for 15 or 20 minutes in order to remove thoroughly the yolk and dirt from the wool, which is then forked out and allowed to drain on wooden racks and is afterwards rinsed with pure water in another tank. The great disadvantage of this method is that, in the poling and forking, the material becomes more or less rolled and felted, causing the fibres to be broken when the wool is carded, thus reducing its value proportionately.

89. The Modern Washing Machine.—The essential parts of the modern washing machine are a long bowl, or tank, which contains the liquor, or suds; a mechanism for propelling the wool through the bowl; at one end a feed-lattice to deliver the wool into the bowl and at the other a pair of heavy squeeze rollers equipped with weights for the purpose of squeezing the liquor from the wool and passing it forwards to the next bowl or to the subsequent operation, the liquor being returned to the bowl from the squeeze rollers. The machines should be so constructed that two or more may be coupled together, making a combination of two, three, or four bowls, as desired.

90. Improvements in the methods of washing wool have been aimed for along the following lines: (a) A minimum of agitation of the wool consistent with proper washing. Formerly, it was thought that to cleanse wool successfully there ought to be much agitation of the material while it was passing through the machine. (b) An increase in the length of the machines, and increased capacity for holding washing liquor, resulting in less frequent changes of the liquor. (c) Working with the washing liquor at lower temperatures. (d) Increased provision in the way of settling tanks. (e) Improved feeding arrangements. (f) Heavier squeeze rollers.

91. The bowls in modern washing machines are of large capacity, so that large quantities of liquor can be used, thereby obviating frequent changes of same. At the same time, only a comparatively small portion of the liquor is actually taking part in the operation of washing at any one time, the remainder being contained in settling tanks, so that any sediment contained in it will have an opportunity to settle down without being constantly stirred up and agitated. This arrangement enables the liquor to be used for a longer period of time before requiring replacement. The arrangement of the bowls or tanks in washing machines, at present, is such that the actual washing is done in a comparatively small bowl, which forms part of a larger bowl, the bottom of the smaller bowl consisting of perforated plates which allow an interchange of liquor.

92. **Preliminary Steeping of Wool.**—Very dirty or sandy wool is sometimes subjected to a steeping, instead of a dusting, process, the object being to rid the wool of the large quantity of soap-destroying matter and to enable the washing liquor to be used for a longer period without changing. For limy skin wools it is essential that an operation of steeping should precede the operation of washing proper, even after a good dusting operation; it is also very desirable that the lime should be neutralized by some means. This can easily be done by the addition of some acid, as most acids will decompose lime. Sulphurous acid is mostly used, a quantity being added to the steeping water sufficient to convert the lime into a soluble salt, which passes

away with the steeping liquor, when the wool is squeezed. Wool that contains no soap, as in this case, must only be comparatively lightly squeezed if the cutting of the material is to be avoided. The remaining small quantity of acid must be neutralized before any soap is applied, since acid also destroys soap, separating it into its original constituents. The neutralizing is done by passing the wool through a carbonate of soda bath, after which the wool can be washed in the ordinary manner; but as the wool is fairly clean when it leaves the neutralizing bath, the ordinary process of washing is greatly facilitated, and does not require nearly so much soap. This process of neutralizing the lime will repay its cost on account of the great saving in soap, as compared with that required when the wool is washed before the lime is entirely removed.

McNAUGHT HARROW-FORK MACHINE

93. Principal Features.—A perspective view of the McNaught harrow-fork machine is given in Fig. 16; a cross-section and a longitudinal section of the feed end of the machine are shown in Figs. 17 (*a*) and (*b*), respectively. The mechanism by which the harrow receives its motion is shown in an enlarged view in Fig. 17 (*c*). A longitudinal section of the delivery end of the machine is shown in Fig. 18, and a detail view of the squeeze rollers with the connecting gear-wheels is given in Fig. 20. The material is fed into the machine by the feed-lattice *a*, Fig. 16, and drops into the water contained in the upper bowl *b*, Fig. 17 (*b*), where it is immersed in the washing liquor by the immerser *c*. In the absence of the latter the wool would tend to float on the surface of the water and could not then be acted on by the washing liquor. The immerser is a brass or copper box *c* fastened to the framework *d*₂ of the forks *d*; the bottom *c*₁ is perforated so that the water may pass freely in and out as the box descends and ascends, respectively. Without these perforations the box would create a considerable disturbance in the water when moving into and out of same. After its immersion the wool is carried forwards by the forks *d*, which have a slow forward movement while in the liquor. On reaching the end of the forward movement they are raised out of the liquor and drawn quickly backwards,

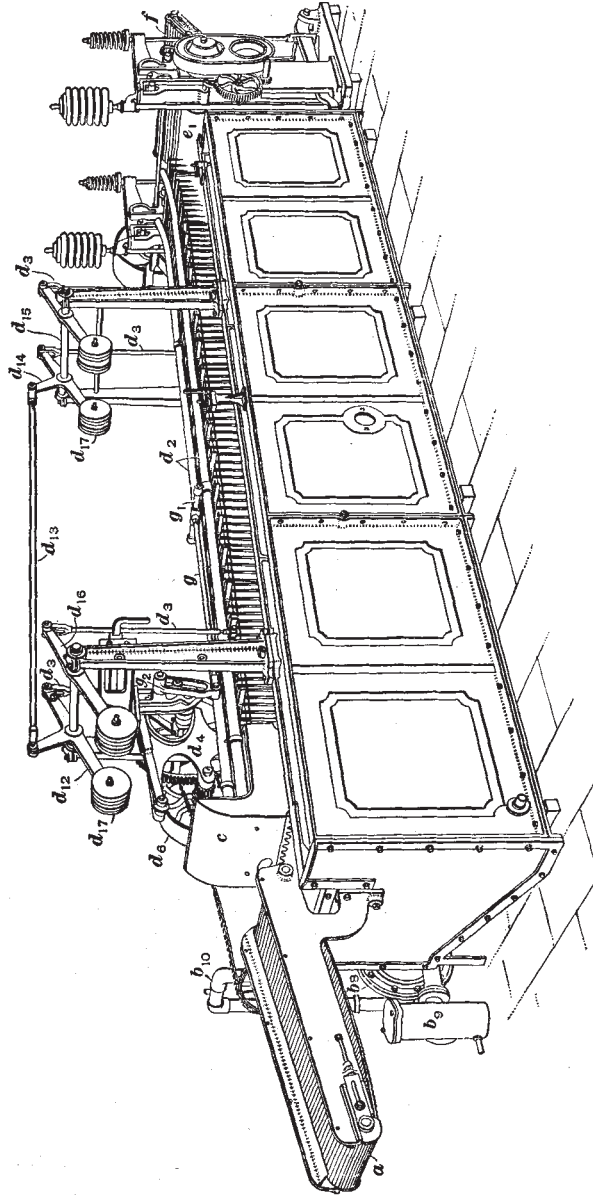


FIG. 16

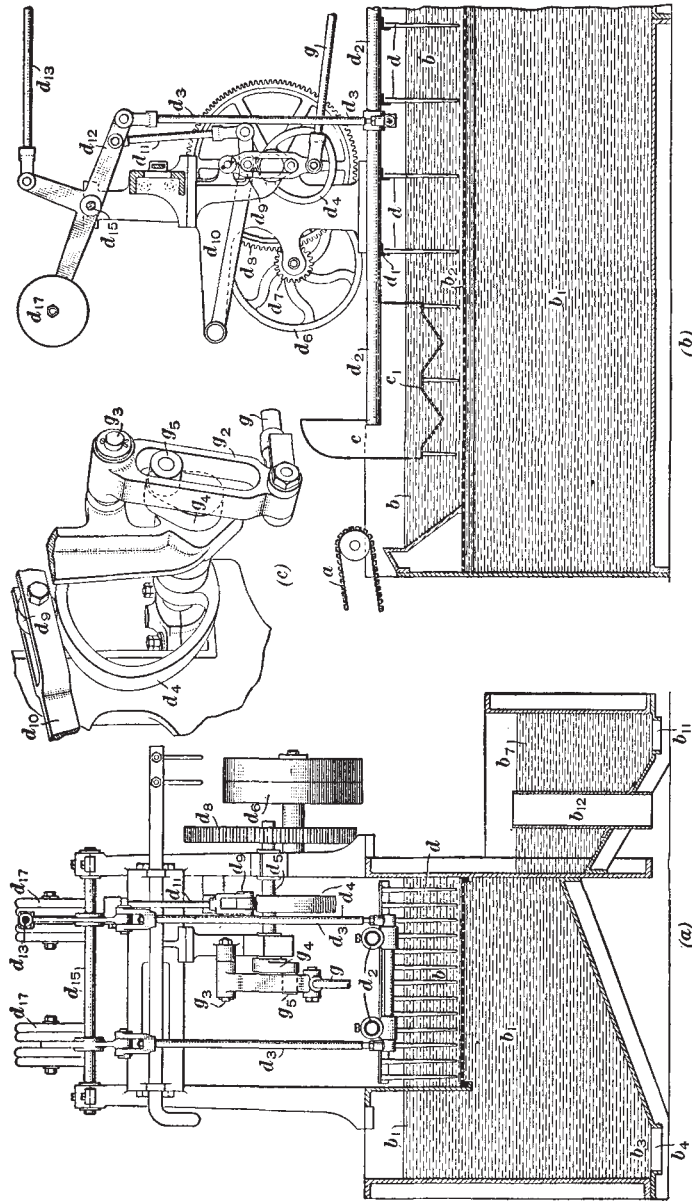


FIG. 17

and again lowered into the water, after which their motion is repeated. By reason of this motion the material is gradually moved through the machine until it finally reaches a pair of heavy squeeze rollers e, e_1 , Fig. 18, that remove the excess of liquor contained in the material and then deliver it to the lattice f ,

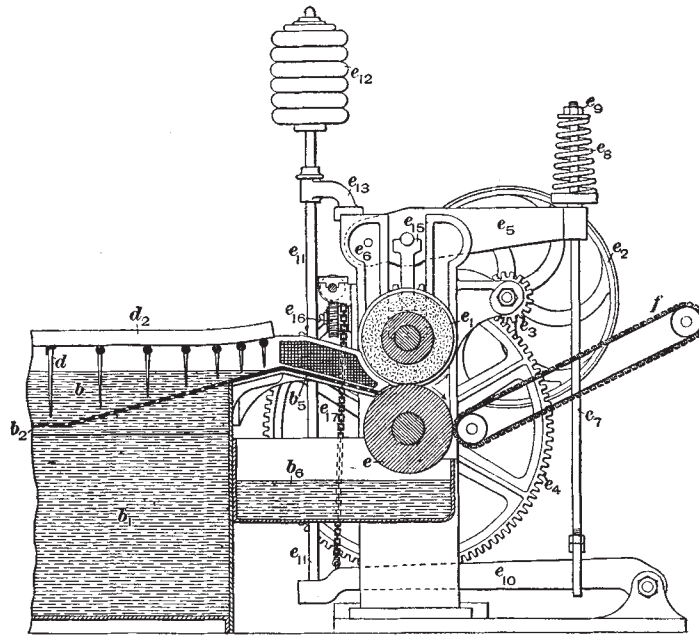


FIG. 18

which carries it forwards to the next washing machine, or, if it is the last of a set, may carry the material to the drying machine.

94. Construction of Bowls.—The construction of the bowls is shown in Fig. 17. The smaller bowl b , in which the washing takes place, is near the top of the main bowl b_1 extending along one side the whole length of the machine. The liquor in the smaller bowl communicates with that in the larger one through the perforated bottom b_2 . Owing to the motion of the forks, there is a certain interchange of liquid between the two bowls, and yet the liquor in the bowl b_1 is fairly still, thus allowing any sediment that may pass through b_2 to descend on to and along

the sloping bottom into the channel b_3 ; from here the sediment may be flushed out through a valve at b_4 , Fig. 17 (a).

95. Settling Tank.—The dirty liquor, which is squeezed out of the wool by the rollers e, e_1 , Fig. 18, was formerly allowed to run back into the washing bowl. This method was objectionable, as each lot of wool carried to these rollers had to pass through this liquor before passing out of the machine. In all modern machines the liquor that is removed from the material passes downwards through a perforated plate, as at b_5 , Fig. 18. The liquor collects in a trough b_6 , whence it runs through a pipe into a tank b_7 , Fig. 17 (a), that extends nearly the whole length of the machine, and is termed the *settling tank*. Its object is to allow as much as possible of the heavy dirt to separate from the liquor and settle down, and allow the scum to rise to the top. To obtain these results the liquor in the settling tank must be kept quiet, and it is therefore provided with two transverse perforated plates, termed *baffle plates*, which effectually stop any currents that may tend to flow along the tank.

96. The pump b_8 , Fig. 16, transfers the liquor from the settling tank through the pipe b_{10} into the bowl b ; during this passage it is usually heated to the required temperature by flowing through a heater b_9 . The bottom of the settling tank b_7 , Fig. 17 (a), is made sloping, so as to facilitate the collection of the sediment and its subsequent removal through the opening b_{11} . A vertical waste pipe b_{12} projects into the tank b_7 to the normal level of the liquor, so that the dirty scum floating on the surface will run down the pipe when the liquor rises above the normal level.

97. Parallel Fork Motion.—The forks, Fig. 17 (b), that propel the wool through the machine consist of prongs d fastened to angle bars d_1 . The forks, together with the mechanism that operates them, are known as the *parallel fork motion*, sometimes called the *parallel rake motion*. The forks are fixed to two tubular bars d_2 , suspended from the rods d_3 , which are raised and lowered by the action of a cam d_4 fixed to the cam-shaft d_5 , Fig. 17 (a). This shaft is driven from the line shaft by means

of the fast pulley d_6 and wheels d_7, d_8 . The cam makes contact with the friction roller d_9 of the lever d_{10} , which is pivoted at its other end to the machine frame, and gives by means of the connecting-rod d_{11} an oscillating motion to the **T** lever d_{12} . To the upper arm of the latter is coupled a connecting-rod d_{13} , which conveys the motion of the lever d_{12} to a similar lever d_{14} at the other end of the machine. Each of these levers is fastened to shafts d_{15} extending across the machine and carrying at their other ends levers d_{16} . From one end of the levers d_{12}, d_{14} , and levers d_{16} are suspended rods d_3 which support the tubular framework of the harrow; the weight of the latter is nearly balanced by the weight d_{17} .

98. In addition to their vertical motion the forks d , Fig. 17, receive also a horizontal motion by means of the crank g_4 fastened to one end of the shaft d_5 . A friction roller g_5 at the end of the crank engages a slot in the lever g_2 suspended from the stud g_3 . As the crank revolves, the lever will oscillate and by means of the connecting-rods g give a reciprocating motion to the frame d_2 . The detail view, Fig. 17 (c), shows the crank in its upper position and only a portion of the lever d_{10} . The combined vertical and horizontal motion causes the forks to descend almost vertically and then to move forward in the liquid for a distance of about 8 inches; they are then raised up and moved rapidly backwards over the surface of the liquid and then allowed to drop again. The forks will make about 10 to 12 strokes per minute.

99. Delivery of Wool to Squeeze Rollers.—At the delivery end of the machine, Figs. 16 and 18, the prongs d are made shorter by reason of the upward slope of the bowl bottom and the plate b_5 . The forward movement of the forks creates a slight wave of liquor; this causes an overflow at the delivery end of the bowl, and the wool, which has been carried to this point by the forks, is washed over and slides down to the squeeze rollers, losing on the way a considerable quantity of the washing liquor. This method obviates stringing, which is common when the wool is lifted by the forks to the rollers. Fig. 19 (a) indicates a staple of wool that has been lifted from the liquor; owing to much of the water having drained from it, the fibres

have closed up and are thus likely to retain dirt when the wool is squeezed. The open appearance of the staple, shown at (b), due to suspending the wool in liquor, indicates how easily the liquor and dirt may be squeezed out of material in this form. Floating the wool to the rollers is the best method, except that of squeezing it under water, to do which no successful process has yet been devised.

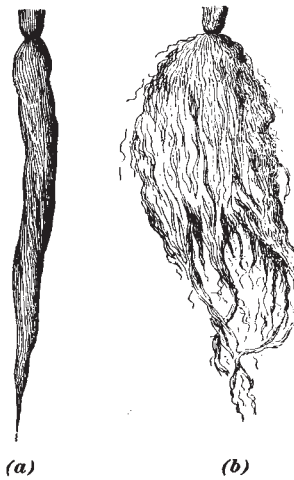


FIG. 19

100. Construction and Driving of Squeeze Rollers.—In modern washing machines the squeeze rollers are made exceptionally strong, so as to be capable of exerting a pressure great enough to remove a very large proportion of the moisture. The rollers are mounted in a heavy framework, and the bottom roller *e*, Fig. 18, is usually solid, constructed either of steel alone or of steel faced with brass. The

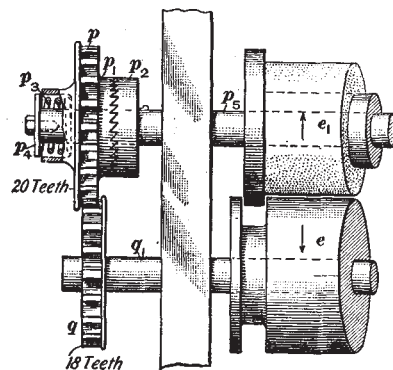


FIG. 20

metal portion of the top roller *e*₁ is always much smaller in diameter and has a flange at each end equal in diameter to the bottom roller; these flanges engage grooves in the latter, as seen in Fig. 20. The space between the flanges of the upper roller is filled up with some elastic substance, termed *roller lapping*, which consists of a thick twisted sliver of wool

usually made from long English or cross-bred wool. This sliver is wrapped tightly and evenly round the roller until its diameter is nearly equal to that of the bottom roller. This material, being elastic, will not injure the wool while it is being squeezed.

101. As the roller lapping, on the roller e_1 , Fig. 20, must be kept in good condition, the upper layers must periodically be replaced as they become worn. This is quite important when fine wools pass through the machine, since if pieces of the lapping should come off the roller and go through with the material, such pieces would appear as bright fibres after the material was manufactured into yarn or cloth and dyed. The top squeeze roller is sometimes built up of discs of cloth placed edgewise on the roller and clamped together under great pressure by means of end discs, resulting in a solid mass that may be turned down in a lathe to the required diameter. The squeeze roller e , Figs. 18 and 20, is given a slow rotary motion by belt from the line shaft through the fast pulley e_2 , and wheels e_3 and e_4 , the latter wheel being keyed to the shaft of the roller e , which drives the roller e_1 principally by frictional contact.

102. Applying Pressure to Squeeze Rollers.— Pressure is applied to the shaft of the upper roller by a lever e_5 , Fig. 18, which is pivoted at e_6 , and carries a connecting-rod e_7 at the other end. On the upper end of this connecting-rod is placed a spiral spring e_8 , which transmits to the lever any pressure exerted by the rod e_7 . The lower end of the connecting-rod e_7 supports a lever e_{10} near its pivoted end; its opposite end supports a rod e_{11} , which carries on its upper end a number of discs e_{12} . The rod e_{11} is supported in its upright position by a bracket e_{13} . The flexibility of the spring e_8 may be adjusted by means of the nut e_9 .

103. The weights e_{12} , Fig. 18, are entirely supported by the roller e_1 through the levers e_5 and e_{10} , the total pressure being exerted on the journal of e_1 by means of a saddle under the short post e_{15} . As the leverage of each of the levers e_5 and e_{10} is about 5 to 1, the total weight on the rod e_{11} , multiplied by $5 \times 5 = 25$, will give the approximate total pressure exerted on the top squeeze roller. Thus, if the total weight of the discs e_2 is 195 pounds, then the pressure on one end of the roller e_1 is $195 \times 25 = 4,875$ pounds. The arrangement for exerting pressure on the top squeeze roller is duplicated at the other end of the roller, so that the total pressure at the middle of the roller

is $2 \times 4,875 = 9,750$ pounds. The function of the spring e_8 is to allow the roller e_1 to rise quickly, when thick lumps of material pass between the rollers, in which case the spring will take up most of the motion before the weights e_{12} are affected, thus preventing the shocks to the machinery that would result from quick motions of these weights. When the machine is not in operation, it is desirable to remove the pressure from the roller e_1 so as to prevent the formation of flat places on the rollers. For this purpose the levers e_{10} are connected by chains e_{17} to a windlass e_{16} , which is operated by means of a worm and worm-wheel. By raising the ends of the levers e_{10} the levers e_5 will be relieved of the downward pull through the rods e_7 .

104. Clutch Drive of Upper Squeeze Roller.—The top roller is to a great extent driven solely by frictional contact with the bottom roller; their surface speeds are therefore the same, but when a large lump of wool is flushed into the nip of the rollers the top roller may refuse to rise and mount the obstacle. If driven simply by frictional contact it would remain stationary while the roller e continued its revolutions. If this should continue for some time, the wool would be badly torn between the rollers. To prevent this, it is necessary that at times the roller e_1 shall be positively driven by the roller e ; but as the top roller varies in diameter according to the state of repair of the roller lapping, it follows that the driving mechanism must be of a peculiar construction. One method by which the required results may be obtained is shown in Fig. 20.

The roller e_1 is connected to the wheel p through the medium of a clutch composed of the two parts p_1, p_2 . The part p_2 is keyed to the shaft p_5 , while the part p_1 with the wheel p is run loose. The outer face of the wheel p consists of a large boss, which is recessed and contains a spiral spring p_3 held in position by the plate p_4 . The spring tends to push the wheel p with the clutch part p_1 into gear with the part p_2 . The wheel q with 18 teeth drives the wheel p that contains 20 teeth; the latter will therefore make fewer revolutions per minute. As the diameter of the roller e_1 , in general, is smaller than that of e , it follows that e_1 will revolve faster when driven by frictional contact, and

that therefore also the clutch part p_2 will revolve faster than p_1 . By reason of the form given the clutch teeth, the part p_1 will gradually be pushed to the left while the gain of 1 tooth is being made, after which it will move to the right again into the position shown in Fig. 20. When the roller e_1 slips and remains stationary, the wheel p at once comes into action and begins to drive the roller e_1 in the direction of the arrow until the obstruction is surmounted, when the roller e_1 again is driven only by frictional contact with the roller e .

105. Scope and Size of Machine.—This machine is suitable for washing very fine wools, as the propelling of the wool through the machine is quite gentle, there being little agitation of the washing liquor and thus little tendency of the material to mat or felt, the latter being a natural characteristic of such materials. Washing machines are generally built in sections 6 feet long. A washing machine consisting of 5 sections, and designated as a machine 30 feet long, would actually occupy a space about $35\frac{1}{2}$ feet long, since each bowl carries a feed-lattice and squeezing apparatus. The machine given in Fig. 16 is a short one, consisting of 3 sections.

PETRIE RAKE MACHINE

106. Construction and Action of Rakes.—A perspective view of the Petrie rake wool-washing machine is shown in Fig. 21, while a longitudinal section of one end of the machine is given in Fig. 22. The squeeze rollers and the arrangement for obtaining the requisite pressure is shown in Fig. 23. This type of washing machine is generally used for long, strong wools which require a more severe treatment than fine wools.

The principal differences between this machine and the McNaught harrow type are in the method of propelling the wool through the machine and in the construction of the squeezing apparatus. In this machine each fork is operated independently. The prongs a are mounted on a bar a_1 which is bolted to a stem a_2 , pivoted at its upper end to a rod a_3 , the other end of which is connected to a fixed bracket a_4 . At a point near its centre each stem a_2 is clamped by a setscrew to a loose collar, attached to a

crank a_5 ; as the latter revolves it compels the fork to follow an

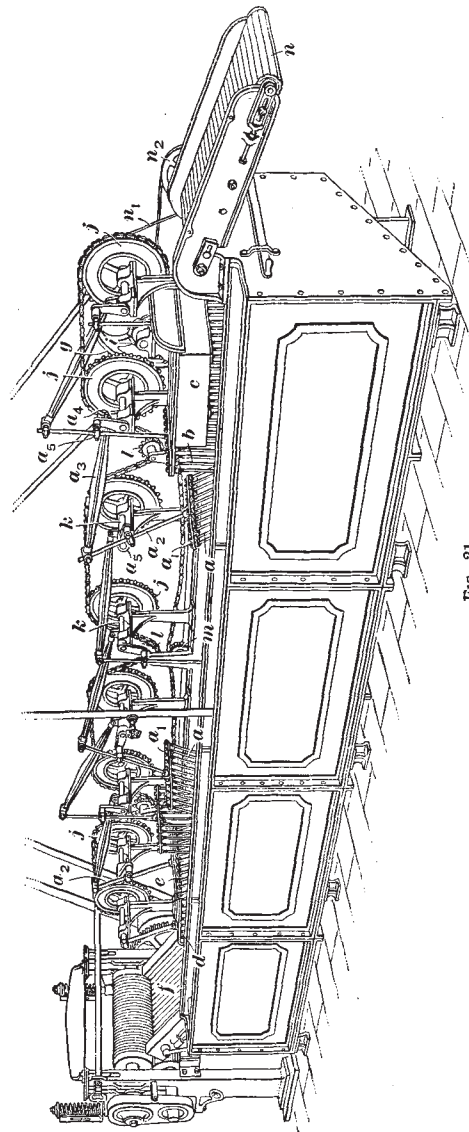


FIG. 21

elliptical path so that it will descend into the washing liquor when it is nearest the feed-lattice; the fork is then moved slowly along through the liquor, carrying with it any wool with which it comes in contact. On reaching the limit of its forward movement the fork is raised out of the liquor and passed quickly above it, to be again moved downwards and forwards.

107. Setting Forks.

The forks can be set so as to work in unison, or each fork may be met by the succeeding one, or so that one fork will follow the other after a brief interval. The usual method is to set the forks so that each successive one is a quarter of a revolution behind the previous one, with the result that as each fork brings forwards

the material and releases it by rising out of the liquor, the

material remains momentarily free before being gripped by the

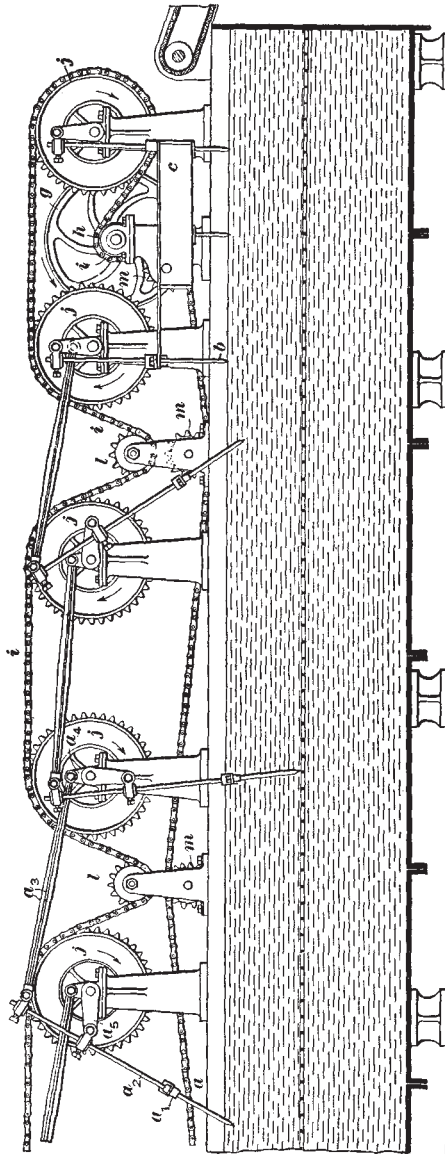


FIG. 22

next fork. This action is less likely to mat the wool, and also allows the wool to remain longer in the washing liquor. If, however, the forks are set to follow one another, the action of continually pulling the wool through the liquor results in a more severe treatment of the wool and a greater tendency to mat the material.

108. Arrangement of Forks.—The first fork *b*, Figs. 21 and 22, is connected to the immerser *c*, which is a box with a perforated brass bottom carrying two additional forks. The delivery forks *d*, Fig. 21, usually consist of three forks combined together, each with shorter prongs than the preceding one; the delivery forks are combined with the last of the ordinary forks. Each of the forks *d* is made shorter, so as to float the

material satisfactorily to what is termed the *carrier* or *slide lifter f*, which works on the upward incline at the end of the bowl, and is operated by a mechanism not shown.

109. Construction and Operation of Carrier.—The carrier or lifter *f*, Fig. 21, consists of narrow laths set side by side parallel with the longitudinal sides of the bowl; in each lath is one longitudinal row of pins set so that they incline toward the squeeze rollers. The laths are attached alternately to two reciprocating frames, so that each lath can be made to move a short distance in an opposite direction to those on each side. The lower ends of the laths extend well below the level of the liquor, so that as the wool is floated forwards by the action of the forks, it will be deposited on the spiked bars of the carrier. The reciprocating frames carrying the spiked bars move in opposite directions, so that when one is moving forwards it will carry the wool

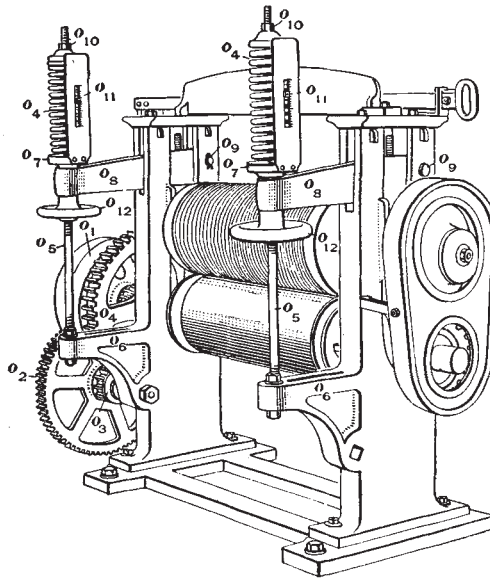


FIG. 23

to the extent of its motion, which is a few inches, but as soon as it stops in its forward traverse and begins to move backwards, the other set of bars begin to move forwards and catch the wool on their teeth, while the set of bars moving backwards simply slide under the wool without resistance; by means of this alternate movement the wool is gradually raised to the nip of the squeeze rollers. In a later design of this machine the wool is floated to the squeeze rollers in the same manner as in the McNaught machine.

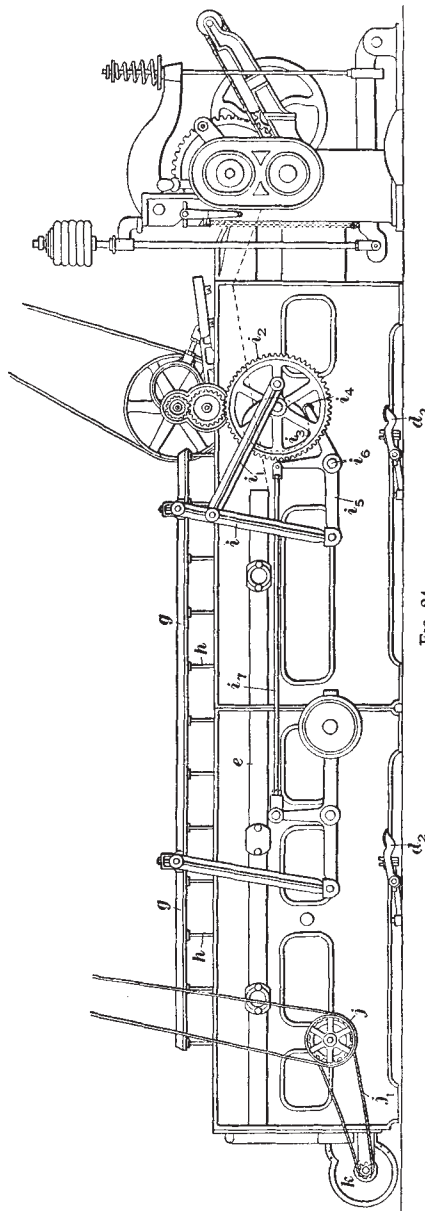


FIG. 24

110. Driving Forks.

The forks are driven by belt from the line shaft through the fast pulley *g*, Figs. 21 and 22; on this pulley shaft is fixed a small sprocket wheel *h*, which, by means of an endless chain *i*, drives the large sprocket wheels *j*. These wheels are attached to short shafts *k*, to which the cranks *a*₆ are fixed; sprocket guide wheels *l* are placed between each pair of sprocket wheels *j*, so as to ensure a sufficient contact with the chain. After passing over the last wheel *j* the chain returns to the chain wheel *h*, being guided by the wheels *m*. The feed-lattice *n*, Fig. 21, is driven by a pulley *n*₂ connected by a rope to a pulley on the shaft of the first sprocket wheel *j*.

111. Construction of Squeezing Apparatus.

The squeeze rollers and the mechanism for giving the required pressure are shown in Fig. 21 and separately on a larger scale in Fig. 23. The construction of the

squeeze rollers in this machine is similar to that in the McNaught machine. The bottom roller in Fig. 23 is driven by a belt from the line shaft, through the fast pulley o_1 , which, by means of a pinion, drives the wheel o_2 . Compounded with this wheel is a pinion o_3 which drives a wheel o_4 , keyed to the shaft of the bottom roller. The top roller is mainly driven by frictional contact with the bottom roller, but when at times a positive drive is required for the top roller, similar means are used to those shown in Fig. 20. The requisite pressure is given to the top roller by means of spiral springs o_4 , which are placed on vertical rods o_5 , that are bolted to the brackets o_6 . The spiral springs act on the loose collars o_7 , resting on the ends of levers o_8 , which are pivoted at o_9 , and act with a leverage of 6 to 1 on the bearings of the top roller. Additional pressure may be given by screwing down the nuts o_{10} , a pointer indicating on the scales o_{11} the amount of the pressure, in tons. The pressure on each bearing is usually about 5 tons, varying according to requirements and the width of the rollers; equal pressure can be put on each side of the squeeze rollers by comparing the scales. By means of the hand wheels o_{12} , it is possible to decrease or wholly remove the spring pressure from the squeeze rollers.

TAYLOR-WORDSWORTH HARROW-FORK MACHINE

112. Arrangement of Bowls.—The Taylor-Wordsworth harrow-fork machine is shown in front elevation in Fig. 24, and in cross-section in Fig. 25. In this machine the washing bowl a occupies the whole width of the machine, thus increasing its washing capacity. Access may be had to the larger bowl b for cleaning purposes by raising the perforated sections a_1 , a_2 , Fig. 25.

113. Settling Tank.—The settling tank c , Fig. 25, which is placed under the inclined bottom of the bowl b , extends the full length of the machine, and is divided into three sections. The waste liquor that runs through the perforated plate over which the wool is flushed to the squeeze rollers, and the liquor squeezed from the material by the squeeze rollers, flows by

gravity into the first section of the settling tank, where most of the sediment settles. The liquor in the first section flows over a partition into the second section, leaving the heavier sediment, but carrying with it the scum that floats on top of the liquor; this scum passes down an overflow pipe c_1 . The communication between the second and third sections is at the bottom of the partition, so that the scum cannot pass; the liquor in the third section is, therefore, comparatively clear, and is pumped into the feeding end of the bowl a , thus providing a constant supply of comparatively clean liquor.

114. The bottom of each section of the settling tank and also the bottom of bowl b is provided with flushing valves d , Fig. 25; these valves are operated by foot levers d_2 , Fig. 24, omitted in

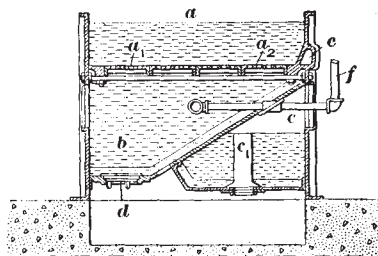


FIG. 25

Fig. 25. The duct e , Figs. 24 and 25, which runs along the side of the bowl a and communicates with it through a number of perforations, provides a means by which fresh water may be supplied to the first tank from the main supply, side connections being provided for this purpose.

Liquor may be transferred from one bowl to an adjoining one by means of straight pipes connecting openings near the bottoms of the tanks, a steam injector inserted in the pipe forcing the water through it. The liquor may be heated by means of the steam pipe f that projects into the bowl b .

115. **Driving Forks.**—The framework g , Fig. 24, to which the forks h are attached is given a reciprocating motion in a horizontal direction by means of the lever i , the connecting arm i_1 , and the gear-wheel i_2 . The forks are moved vertically by a cam i_3 that is bolted to i_2 and acts on a friction bowl i_4 , attached to one arm of a lever i_5 , which is pivoted at i_6 . The motion is conveyed through a connecting-rod i_7 to the next set of levers. The gear-wheel i_2 receives motion by belt from the line shaft through a fast pulley on the other side of the machine, a

cross-shaft, and gear-wheels. A belt from the line shaft also drives a fast pulley j and a sprocket wheel compounded with it, which by means of a chain j_1 drives a pump k that supplies the top bowl with liquor from the settling tank.

POSSER WASHING MACHINE

116. Arrangement of Bowls.—The Eastwood and Ambler washing machine, which is of the *posser* type, is shown in perspective in Fig. 26, views (*a*) and (*b*) representing the delivery and the feed ends, respectively. A diagrammatic, longitudinal section of the delivery end is given in Fig. 27. In this machine the wool is conveyed from end to end by means of a current of washing liquor. There are two bowls placed one above the other, the upper one a being the wash bowl proper, while the lower one b is the settling tank and receptacle for the bulk of the washing liquor. A pump c takes the liquor from the feed end of the bowl b and sends it through the pipe c_1 , from which it flows partly into the box d and partly through a smaller horizontal pipe that extends along the bowl. From the box d the liquor streams through its perforated bottom down on to the wool as it drops into the bowl from the feed-lattice e . The remainder of the liquor passes from the horizontal pipe through branches f into the boxes g , known as *posser*s or *presser*s, to which the supply is regulated by valves h .

117. Construction and Operation of Possers.—The liquid entering the bowl a from the box d and *posser*s g , Fig. 26, will flow toward the delivery end, as the bowl inclines in that direction. The wool, which floats along with the liquid, is acted on successively by the various *posser*s, of which in this case there are six. Each *posser* consists of a rectangular box with a perforated bottom and is suspended from the centre of a short crank-shaft i extending across the machine and supported by brackets that are fixed to the sides of the bowl a . Motion is given to these shafts by a series of gear-wheels j , of which each alternate one is fixed to one of the crank-shafts i ; as the shafts revolve, the cranks raise and lower the *posser*s. The *posser*s at

their lowest position are sufficiently close to the bottom of the bowl to squeeze any wool lying below them, and in doing this the liquor will rush up through their bottoms into the possers. When the possers are raised, the liquor pours down on to the wool, thus setting up cross-currents which more effectively remove the dirt. The depth to which the possers *g* will descend may be adjusted by turning the threaded rods *g*₁ by means of the levers *g*₂.

118. Passage of Liquor From Top to Bottom Bowls.—As each posser receives a continuous supply of liquor from the settling tank, Fig. 27, there is a considerable accumulation toward the lower end of the bowl *a*. This surplus is allowed to flow away

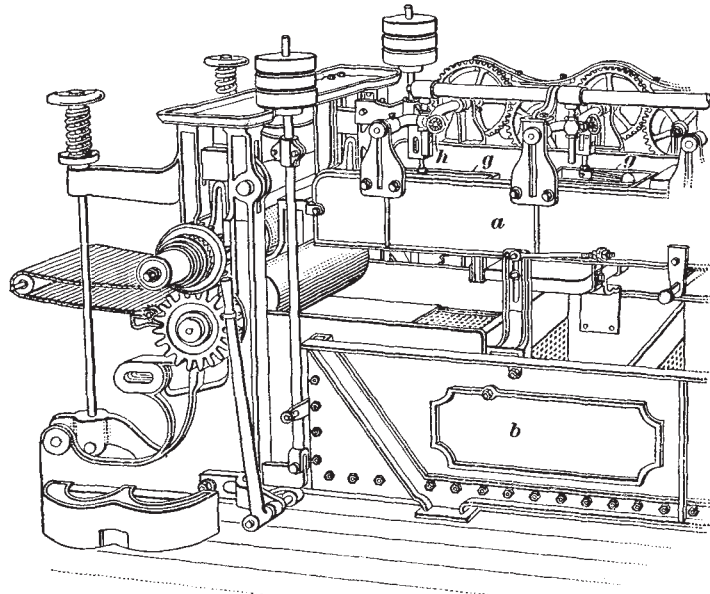


FIG. 26 (a)

through a perforated outlet *k* over the shoot *l*, through the perforated box *m* into the settling tank *n*. The remainder of the liquor in the bowl *a* flows on with the wool to a perforated plate *o*, termed a *shute*, which conveys the wool to the squeeze

rollers p and allows the liquor to drain through into the box m . From the squeeze rollers, which are of ordinary construction, the wool is carried from the machine by a delivery lattice. One method of constructing the settling tank is shown in Fig. 27, which shows the tank divided by perforated plates q and r into three parts. The part n collects the liquor from the top bowl, and as here most of the heavy impurities are precipitated, a

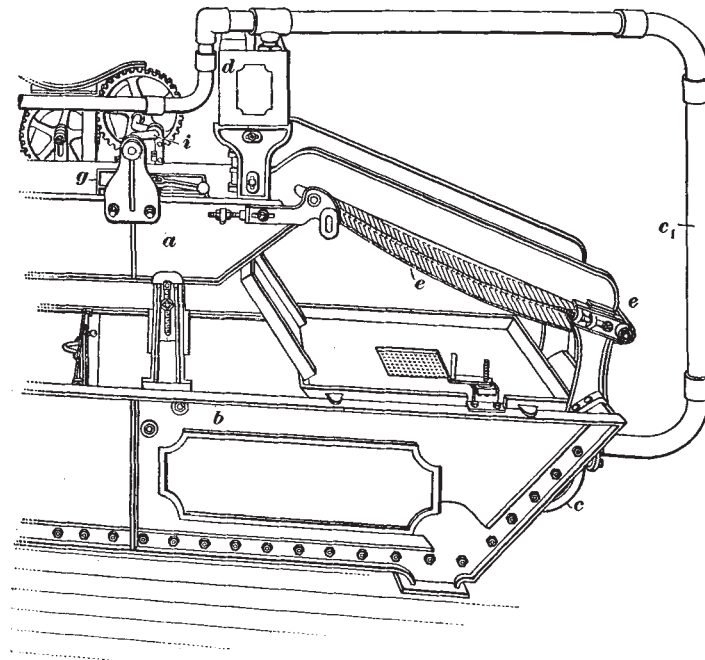


FIG. 26 (b)

comparatively clear liquor passes through the perforations in the plate q into the middle compartment s , where a further settling takes place. From here the liquor filters through the perforations in plate r into the third compartment t , whence the liquor is pumped into the top bowl. In many machines the plate q is omitted, in which case the plate r acts as a baffle plate to prevent any currents in the liquid.

SETS OF MACHINES

119. Combinations of Washing Machines.—The description so far given has dealt with a single machine, but it should be remembered that these machines are built so that they may be arranged in combinations of two or more bowls. In the case of the three-bowl combination, the first bowl contains the washing liquor, the second bowl a weaker washing liquor, and the third bowl a very weak liquor or pure water.

Washing machines are coupled together in this manner in combinations up to four for special work, such as fine, greasy wools. The combination of three machines is used in many mills for fine wools, especially for combing wools. The first

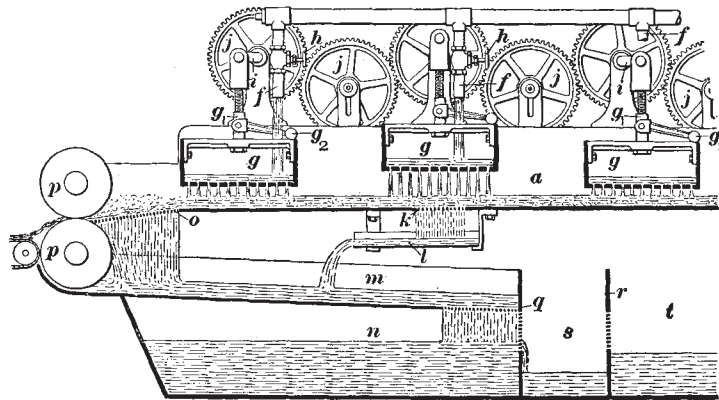


FIG. 27

machine is usually the longest, each succeeding machine being shorter by about 6 feet. It may be said that the best results are obtained by the use of four machines in the case of dirty clothing wools, the first three containing washing materials and the fourth tepid water only. This combination will give better results than the three-bowl combination so often used. When the liquor in the first bowl becomes too dirty to use, it is flushed out and the liquor in the second bowl is then run into the first and raised to the required strength, while that in the third machine is run into the second, and the third is then filled up with fresh liquor or water, as the case requires. The usual

method of transferring the water or liquor from one bowl to another is by means of a steam injector, with which all the machines are fitted with the exception of the first. The production of such a combination is from 600 to 800 pounds per hour, according to the condition of the material.

120. In combinations like those described, an extra function is performed by the squeeze rollers. The wool very often contains hard lumps of manure, dirt, and solidified grease, which cling to the fibres with more or less tenacity, but as they pass through the squeeze rollers from one bowl to the next they are broken up and easily removed by the second immersion. The squeeze rollers between the bowls also prevent the dirty liquor of the first bowl from passing into the liquor in the second bowl, etc., which would render it dirty more quickly than would otherwise be the case. A single machine requires about 3 horsepower for driving purposes.

RECOVERY OF BY-PRODUCTS

DESUINTING MACHINERY

INTRODUCTION

121. **Composition of Waste Liquor.**—The waste liquor from the wool-washing machine contains the soaps and alkalies that have been used for washing, the wool yolk, and dirt removed from the wool. The materials of marketable value that may be recovered from the liquor consist of the fatty matter in the soap used, and of the wool yolk, the potash salts from the suint, and the alkali in the soap and that which has been added to the liquor. When the alkali is in the form of soda it will not pay for extracting, but if potash it may be of value.

In many cases it is doubtful whether the by-products are worth recovering, and except for the compulsion put upon owners and occupiers of mills by the county councils the by-products from waste washing liquor would not be recovered to any large

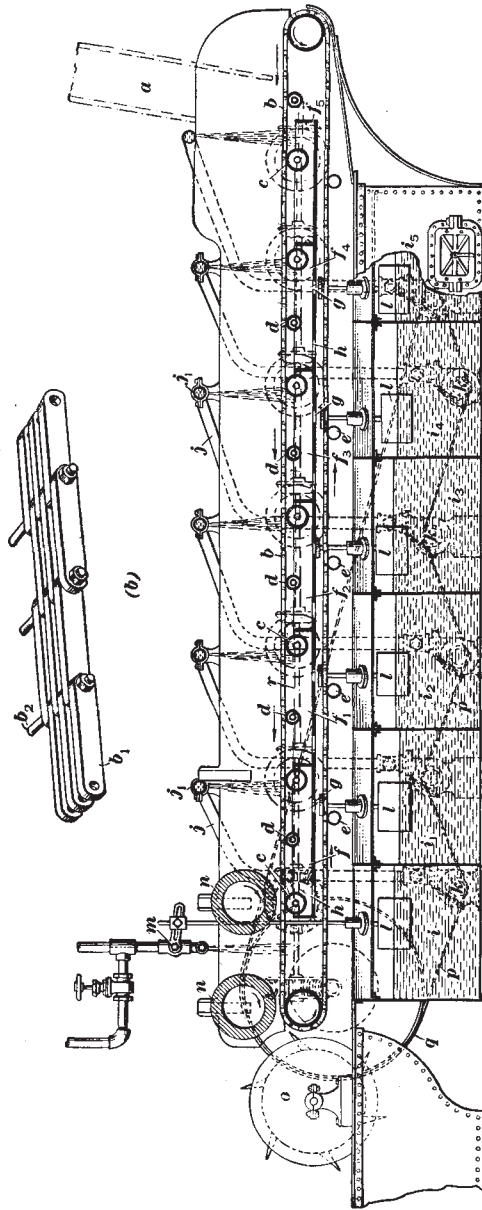
extent in British practice. The three principal methods by which the by-products may be recovered are as follows :

1. The *magma*, or *seak*, process for the recovery of the fats only.
2. *Desuinting* the wool for the extraction of potash salts only.
3. Processes for the separation and extraction of both fat and potash compounds.

MAGMA PROCESS

122. Operation.—The *magma*, or *seak*, process derives its names from those of the fatty matters extracted. In this process the fatty matters in the washing liquor are released by the addition of sulphuric acid in sufficient quantity to neutralize all the alkali present. The liberated grease rises to the top in the form of a scum or layer. The operation is usually carried out in large tanks from which the water can be drained. The remaining portion of the mixed fatty matter and water is then run over a filtering medium such as sawdust or ashes, through which the water gradually filters, leaving the nearly solid, greasy *magma*, or *seak*, behind ; this is then placed in strong bags which, when full, are termed *puddings*. The puddings are placed in hot presses which remove and collect the oil and grease. The crude product derived from this process is generally termed *black oil*, which, when slightly refined, becomes *brown oil* ; this is largely used in the shoddy and mungo trade for oiling these materials. The black oil is used for oiling rags in a process known as *rag grinding*, which has for its object the grinding of rags into a fibrous mass. The black oil, when highly refined, becomes *lanoline*, which is a substance largely used for medical and domestic purposes.

123. Skaife Grease Separator.—An appliance operating on the *magma* principle is the **Skaife grease separator**. It is continuous in its action and occupies only a small space. In the usual *magma* process, in which large tanks are used, the liquor has to stand from 1 to 2 days after adding the acid to allow the grease to rise ; but in the Skaife separator, the waste liquor is run into a small tank and sufficient acid added, then the



(a)
FIG. 28

whole solution is kept in constant agitation by blowing air in at the bottom of the tank. This agitation causes rapid separation of the grease, which rises to the top, whence it is removed by a series of paddles fixed on an endless chain, and poured into a separate tank. The remaining liquid is then run to waste.

MALARD DESUINTING MACHINE

124. **Construction and Operation.**—The process of desuinting consists in soaking the wool in water before washing, so as to dissolve the soluble potash salts, after which they are extracted from the water by a process of evaporation and crystallization. When this process is carried out without special appliances, it is difficult to obtain the potash lye in a form sufficiently concentrated to make the process economical; special machinery has therefore been devised for this purpose, of which one type is known as the **Malard desuinting machine**. A longitudinal section of this machine is given in Fig. 28, and a transverse section in Fig. 29.

125. The wool is fed to the machine either by hand or from a shoot *a*, Fig. 28 (*a*), leading from the room above, and is carried in the form of a thick pad on a perforated lattice *b*, which is constructed from short metal bars *b*₁, as shown in the detail view, Fig. 28 (*b*). These bars are connected by rods *b*₂, the whole

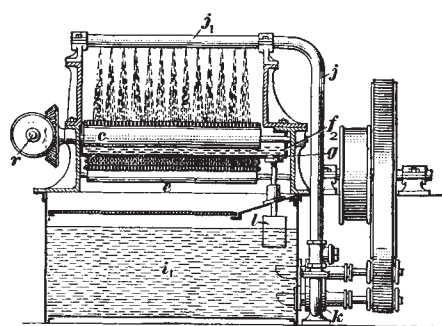


FIG. 29

forming a lattice that extends the full width of the machine. The upper half of the lattice is supported at intervals by the driving rollers *c* and carrier rollers *d*, the former being driven by bevel wheels from a long shaft *r*, which extends the whole length of the machine; this driving mechanism is shown in dot-and-dash lines. The lower part of the lattice is supported at intervals by the carrier rollers *e*.

Between the upper and lower parts of the lattice there is a series of shallow troughs f, f_1 , etc., which are provided with openings g and h .

126. Under the lattice b , Fig. 28, are a series of six tanks i, i_1, i_2, i_3, i_4 , and i_5 , each having a pump k which forces the liquid up through a pipe j leading to the top of the machine. The horizontal portions j_1 of the pipes which extend across the machine are perforated, in order that the liquid may fall as a spray on to the wool on the travelling lattice. Each pipe j is bent toward the feed end of the machine, so that it sprays the liquor directly over the tank in advance of that from which it is pumped. The liquor, on percolating through the pad of wool, drops into the compartments f, f_1 , etc., and passes out through one of the two openings g or h . Each opening g , Figs. 28 (*a*) and 29, is controlled by a float valve l , so that when one of the tanks i, i_1 , etc., is full, the valve closes the opening g ; the liquor must then flow back into the tank from which it has been pumped.

127. When the machine is started, the tanks, i, i_1 , etc., Fig. 28 (*a*), are filled with clean water, which is pumped from the tanks and sprayed over the wool, the water gradually dissolving the suint. The water that is pumped up from the tank i passes through the wool into the trough f , whence it runs through the holes g, h into the tanks i_1 and i , respectively. The wool at this point, having passed under six sprays, contains but little suint, but it is evident that in the tank i_5 the solution of suint must be the strongest, as the contents of the other tanks is gradually being transferred to this tank while repeatedly being passed through the wool.

128. The trough f_5 does not discharge its liquor back into the tank i_5 , but passes it off sidewise into an outside receptacle that connects with the tank i_5 through a pipe near the bottom. In this receptacle there is a hydrometer that controls an outlet valve, the hydrometer being so adjusted that when the liquor reaches a certain density it opens the outlet valve and allows the liquor to pass out of the receptacle to a storage tank, whence it is removed for the recovery of the potash salts. If, however, the liquid in the receptacle does not reach the standard strength,

then it is allowed to return to the tank i_5 to be again pumped up on to the wool, so as to take up more potash, until it reaches the required strength. When the wool reaches the delivery end of the machine it is passed under two large rollers n, n that squeeze out the bulk of the liquor contained in it. The wool, on emerging from the machine, is opened out by a revolving spiked roller o and passed straight into the ordinary washing machine. The pumps k are driven by means of a belt p , which passes round a pulley q fixed to the shaft of the main driving pulleys.

WHITE DESUINTING MACHINE

129. Construction and Operation.—In the White desuinting machine the wool is subjected to the action of a series of sprays, as in the Malard machine, but the construction and operation of the machine are entirely different. Fig. 30 (*a*) is a front elevation and Fig. 30 (*b*) a transverse section taken along the lines *A-B*, *C-D*; a diagrammatic, longitudinal section is given in Fig. 31.

130. The wool is fed to the machine by a travelling lattice *a*, Fig. 31, from which it drops into a shallow tank *b*. Here it is saturated with a spray of liquor sent by the pump *e* from the tank *d* through a pipe *c*. Pumps *e*, e_1 , e_2 , and e_3 are provided for pumping the liquor to the required points from the tanks *d*, d_1 , d_2 , and d_3 . The top tank *b* is a very shallow one and is set sloping to the right, so that the liquor carrying the wool with it flows in the direction of the arrow. The wool and liquor flow over the end and, guided by the baffle plate *g*, drop on a conveyer, consisting of a series of bars *f*, f_1 , which carries the wool toward the left.

131. The conveyers consist of a series of perforated metal bars, which are alternately mounted on two movable frames f_2 , f_3 , as shown in Fig. 30 (*b*). These frames are given a reciprocating motion, one moving in a direction opposite to that of the other, so that alternate bars are raised about 1 to $1\frac{1}{2}$ inches above the others and are then moved forwards toward the feed end of the machine, carrying the wool which rests upon them for a distance

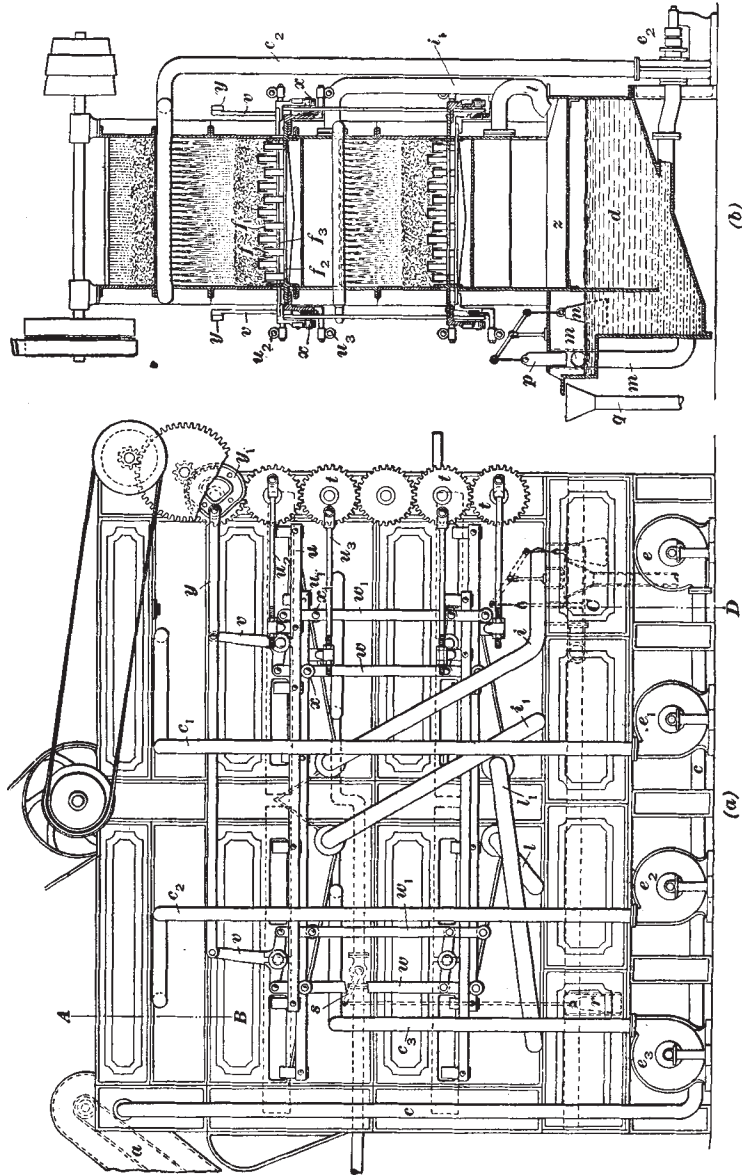


FIG. 30

of 8 or 9 inches ; the frame then drops down, is moved backwards the same distance, and is again raised. While one frame is moving backwards the other is in a raised position and moving forwards, carrying with it the material that was previously resting on the frame which is now lowered and moving backwards.

132. While the wool is travelling on the conveyer it is again saturated by a spray of liquor from the pipe c_1 , the liquor being pumped from the second tank d_1 by the pump e_1 ; this liquor,

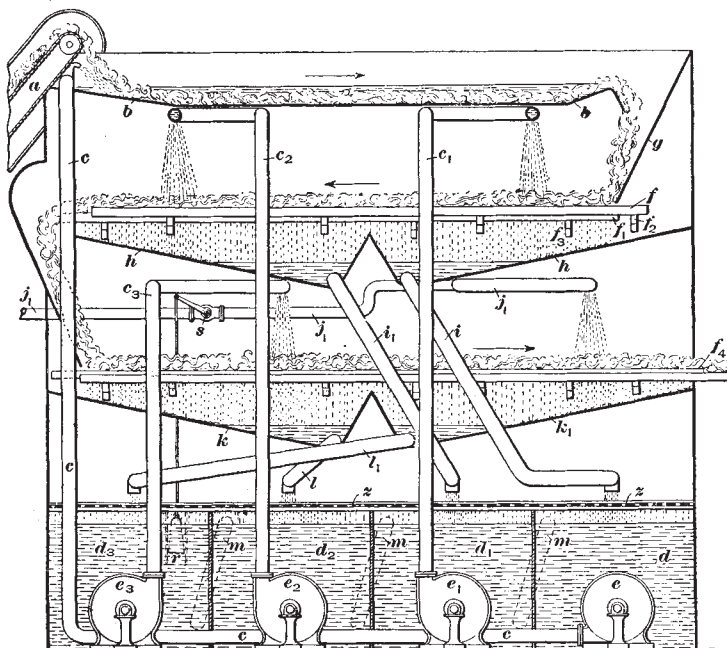


FIG. 31

together with that overflowing from tank b , passes through the wool, dissolving an additional amount of potash salts. On leaving the wool and conveyer, the liquor is collected by a tray h and returned through the pipe i to the tank d after passing through the strainer z . As the wool advances it passes under the spray from the pipe c_2 , which is supplied with liquor from the tank d_2 by means of the pump e_2 . Another tray h collects this liquor and delivers it through the pipe i_1 to the tank d_1 .

When the wool reaches the end of this conveyer it falls over on a similar conveyer f_4 , which is operated so as to convey the wool in the opposite direction through the machine. As the wool descends from the upper conveyer it is turned over, so that as it is travelling along the lower conveyer, those layers of wool are being sprayed that previously were underneath.

133. While the wool passes over the first half of the conveyer f_4 , Fig. 31, it is sprayed with liquor supplied through the pipe c_3 from the tank d_3 by the pump e_3 . This liquor is collected in the tray k and returned through the pipe l to the tank d_2 . Before the wool leaves this conveyer it is subjected to a spray of pure water from the pipe j_1 ; this water collects in the tray k_1 and returns through the pipe l_1 to the tank d_3 . The reciprocating motion of the conveyers greatly assists the percolation of the liquor through the material. When the wool leaves the machine it may pass directly into the washing machine, or, if this is not desirable, a set of squeeze rollers can be fitted to squeeze the wool, so as to free it from an excess of water. The latter method has the advantage of delivering the material with a minimum of cold water to the first washing machine, in which the temperature otherwise might be lowered by reason of the addition of too much cold water.

134. When the machine is in action the liquor in the tanks d , d_1 , d_2 , and d_3 , Fig. 31, is constantly becoming richer in potash salts. The weakest liquor, which is almost pure water, is contained in the tank d_3 , while the liquor in tank d is the strongest. The liquor collected by one tray is in every case delivered to a tank that will supply a spray that may be collected by a preceding tray, thus: from k_1 to d_3 , k to d_2 , etc. Overflow pipes m are arranged with their top openings near the top of one tank and their bottom openings near the bottom of the succeeding tank, that is, the overflow pipe from tank d_2 opens into the bottom of tank d_3 . The overflow from tank d is arranged so that when the liquor reaches a certain density, a hydrometer n , Fig. 30 (b), is raised which by suitable means lowers the gate p and closes the mouth of the overflow pipe m ; the overflow from this tank will then pass through the pipe q to a suitable receptacle,

where the potash salts may be recovered. The level of the liquor in tank d_3 is governed by the float r which controls the supply of fresh water from the main j_1 by means of valve s . The bottom of each tank is made sloping, as shown in Fig. 30 (*b*), so as to facilitate the settling of any sediment, and the pumps draw the liquor from a point in the middle of the slope, so as to obtain the strongest liquor which gravitates toward the bottom, as it is desirable to supply the densest part of the liquor to the preceding tank. For the same reason it is necessary that the overflow pipes from one tank to the other should convey the weakest liquor to the succeeding tank.

135. The conveyers receive their horizontal reciprocating motion through a train of gear-wheels t , Fig. 30, which is arranged at both sides of the machine and is driven from the line shaft. Two of the gear-wheels t on each side belong to one set of conveyers, that is, one wheel to each of the bars u and u_1 ; thus, as the wheels revolve, they give the desired motion through connecting bars u_2 and u_3 . The vertical reciprocating motion is obtained through T-shaped levers v , which carry the rods w , w_1 , provided with friction rollers x , x_1 , that support the bars u , u_1 . As the upper arms of the levers v are attached to a cam-rod y , which is operated by a grooved cam y_1 , the rods w , w_1 will reciprocate vertically and give the bars u , u_1 also a vertical motion.

As the frames f_2 , f_3 , Fig. 30 (*b*), are connected to the bars u , u_1 , they will perform the reciprocating motion required for conveying the material through the machine.

LAVAL PROCESS

136. Principal Features.—The Laval process for the separation and extraction of both fat and potash compounds consists in evaporating the waste washing liquors down to a comparatively concentrated solution and then passing this solution through a Laval centrifugal separator, which separates the fatty matters from the liquor, allowing the former to pass out of the machine in a concentrated form. The remaining liquor can then be treated by evaporation for the extraction of the potash salts.

SELF-FEED ATTACHMENTS TO WASHING MACHINES

137. Objects of Self-Feed.—There are three methods in use for feeding the wool to wool-washing machines: (*a*) Allowing the dusting willy to discharge directly into the bowl of the

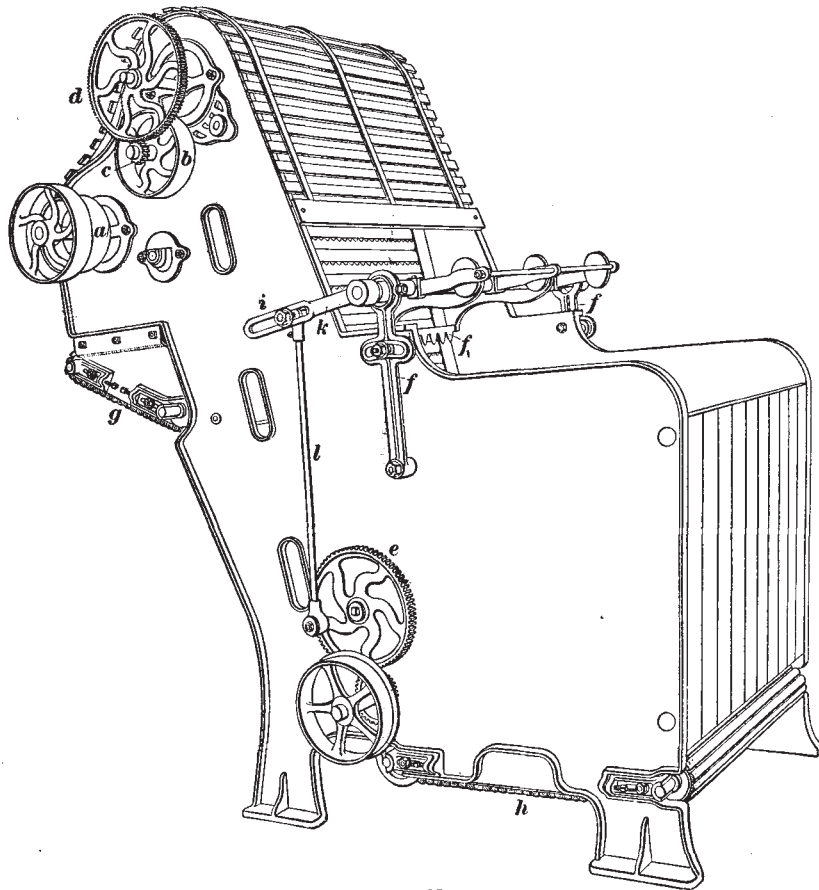


FIG. 32

machine; (*b*) spreading the wool by hand on a feed-lattice, which conveys it to the bowl of the washer and drops it into the washing liquor; (*c*) by means of a self-feed acting on the principle of an ordinary automatic hopper feed, of which there

are several suitable forms. The advantages of a self-feed are apparent, one of the greatest being that the machine fed by this means does not require the constant attention of a workman, as all self-feeds are provided with a hopper large enough to hold wool for 15 to 30 minutes' feeding. In Fig. 32 is shown a hopper feed that is built with special reference to feeding wool to washing machines. The main object of this machine is to feed the wool continuously and uniformly; another object, although a subsidiary one, is that of opening out the wool, rendering it easier for the washing liquor to penetrate.

138. Construction and Driving.—The principal part of the feed is a spiked lifting or elevating lattice, which extracts an amount of wool from the mass in the hopper, in excess of what is needed, the excess being removed by means of an oscillating comb. A stripping, or doffing, beater is so arranged in connection with this lattice that the wool which it conveys may be removed from the lattice and passed to the machine to be fed. The framework of the machine is of iron, with the exception of the rear of the hopper, which is enclosed with boards. The top of the machine is enclosed with a flexible covering composed of wooden strips, or slats. The spiked lattice is made of half-round slats, generally maple, securely riveted to four belts, and is provided with sharp spikes about $1\frac{1}{4}$ inches apart and pointing in the direction in which they travel. The spiked lattice is driven by means of a pulley *a* on the beater shaft, which drives a pulley *b* on a stud. Attached to this pulley is a wheel *c* that drives a wheel *d* on the shaft of the top roller of the lifting apron. The wheel *c* is the change wheel for altering the speed of the spiked lattice; an increase in its size drives the spiked lattice faster and gives a heavier feed to the washing machine. In the bottom of the hopper is a travelling lattice *h* for the purpose of keeping the wool constantly pressed against the spiked lattice, thus ensuring a constant supply of wool as long as there is any left in the hopper. In some feeds the same result is obtained by making the hopper **V**-shaped, so that the wool always falls down on to the spiked lattice, even when there is only a very small quantity present in the hopper.

139. The oscillating comb f_1 , Fig. 32, is driven by a crank from a wheel e on the side of the machine. There is a slot i in the lever k attached to the comb shaft, which allows a change in the position of the connecting-rod l , thus increasing or decreasing the throw of the comb. Provision is also made for moving the comb closer to, or farther from, the lifting apron by means of slots in the stands f that carry the comb. This allows an alteration in the feed of the machine at this point, as the nearer the comb is placed to the spiked lattice, the more material will be knocked back into the hopper and the lighter will be the feed.

The doffer beater that strips the wool from the spiked lattice consists of an oscillating comb which catches the wool on its downward stroke and combs it from the teeth of the lattice, which at this point are projecting downwards and therefore offer no resistance to the removal of the wool. It should make about 120 to 150 strokes per minute.

Beneath the doffer beater is a doffer lattice g on which the wool drops and is carried to its edge, from which it drops into the washing liquor. This lattice is not absolutely necessary, as the beater will allow the wool to drop in practically the same manner; the machine is therefore built either with or without the lattice, as desired.

140. Operation.—In operation, the material, which has been dusted to remove as much of the loose dirt as possible, is placed in the hopper of the feed, the travelling lattice h , Fig. 32, keeping it pressed against the spiked lattice, the spikes of which are inclined upwards to catch the fibres and locks of wool. The wool is thus lifted to the oscillating comb, which is balanced so as to run smoothly and which knocks off large bunches of wool clinging to the apron. This process makes the feed more uniform and the spiked lattice is more evenly loaded. After passing the comb, the wool is carried over the top of the spiked lattice to the beater, which removes it from the spiked lattice and either throws it directly into the washing liquor or on to the travelling apron, which drops it into the washing machine. When connected to a washing machine, this feed occupies a space 6 feet 8 inches in length and is adapted to all kinds of wools.

MEASUREMENT OF TEMPERATURE AND DENSITY

THERMOMETERS AND HYDROMETERS

THERMOMETERS

141. Construction. — A thermometer is an instrument for measuring, in degrees, the temperature, that is, the amount of heat present either in the air or in any other body. The most common form consists of a glass tube sealed air-tight and containing a small amount of mercury, or, as it is commonly known, *quicksilver*. For its effectiveness the instrument is dependent on the expansion and contraction of mercury under different conditions of heat and cold, thus causing the column of mercury to rise or fall in the glass tube, as the case may be, the reading being obtained by means of a graduated scale that registers the height of the mercury column, in degrees. The thermometers used in washing machines are generally encased in a metal casing in order to protect the glass.

142. Different Types. — There are three standard thermometers in use; namely, the *Fahrenheit*, *centigrade*, and *Réaumur*. The *Fahrenheit* thermometer is the one used for ordinary purposes. The *centigrade* thermometer, sometimes known as the *metric thermometer*, is generally used for scientific and experimental work. This thermometer is the simplest, and will no doubt, in time, come into general use. The *Réaumur* thermometer is very little used.

143. Standard Temperatures. — There are two constant, or standard, temperatures on a thermometer, the freezing and boiling points of water, and the different thermometers vary only in the methods of graduating the degrees of heat or cold. The

boiling point of water is indicated on the Fahrenheit thermometer by 212° , on the centigrade by 100° , and on the Réaumur by 80° . The freezing point of water is indicated on the Fahrenheit system by 32° , and on the others by zero. In other words, zero Fahrenheit indicates a lower temperature than zero centigrade, while 100° centigrade indicates a higher temperature than 100° Fahrenheit, etc. Fahrenheit readings are indicated by the abbreviation F. following the indicated number of degrees, centigrade by C., and Réaumur by R.

144. Interchanging Thermometer Readings.—The following rules will make it possible to transpose Fahrenheit and centigrade readings from one system to the other :

Rule I.—*To change Fahrenheit readings to centigrade, subtract 32° from the Fahrenheit reading and multiply the remainder by $\frac{5}{9}$.*

EXAMPLE 1.—Change 140° F. to centigrade.

SOLUTION.— $C. = \frac{5}{9}(140^{\circ} - 32^{\circ}) = \frac{5}{9} \times 108^{\circ} = 60^{\circ}$. Ans.

Rule II.—*To change centigrade readings to Fahrenheit, multiply the number of centigrade degrees by $\frac{9}{5}$ and add 32° .*

EXAMPLE 2.—Change 40° C. to Fahrenheit.

SOLUTION.— $F. = (\frac{9}{5} \times 40^{\circ}) + 32^{\circ} = 104^{\circ}$. Ans.

HYDROMETERS

145. Specific Gravity.—The specific gravity of a body is the ratio between its weight and the weight of a like volume of some other substance taken as a standard, which must be invariable. For solids and liquids the standard adopted is pure, or distilled, water at a temperature of 4° C., or 39.2° F. The *density* of a body is proportional to its specific gravity.

Rule.—*The specific gravity of a solid or liquid is equal to its weight divided by the weight of an equal volume of pure water at 4° C.*

EXAMPLE.—If a given volume of olive oil weighs 115 grains and a like volume of water at 4° C. weighs 125 grains, what is the specific gravity of the oil ?

SOLUTION.— $115 \div 125 = .92$. Ans.

It will be noticed that in this case the specific gravity of the oil is a fraction ; this indicates that the oil is lighter than water for equal volumes.

146. Construction of Hydrometers.—For the more convenient determination of the density of liquids, instruments called **hydrometers** are used. The form of hydrometer generally used

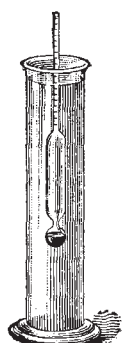


FIG. 33

in mill work is the constant-weight hydrometer, shown in Fig. 33, which consists of a glass tube near the bottom of which are two bulbs. The lower, or bottom, bulb is loaded with shot or mercury in order to make the instrument float upright, while the upper bulb contains enclosed air, which makes it lighter than water. The point to which the hydrometer sinks when placed in pure water at a temperature of 4° C. or 39.2° F. is marked zero and the tube is graduated above and below zero, the graduation being sometimes on a piece of paper placed within the tube. As a long tube would be inconvenient, it is customary to have two instruments, one having the zero near the top for liquids heavier than water (the hydrometer rising according

TABLE III

COMPARISON OF BEAUMÉ AND TWADDELL HYDROMETERS

Beaumé Degrees	Twaddell Degrees	Beaumé Degrees	Twaddell Degrees	Beaumé Degrees	Twaddell Degrees	Beaumé Degrees	Twaddell Degrees
1	1.4	10	15.0	19	30.4	27	46.2
2	2.8	11	16.6	20	32.4	28	48.2
3	4.4	12	18.2	21	34.2	29	50.4
4	5.8	13	20.0	22	36.0	30	52.6
5	7.4	14	21.6	23	38.0	31	54.8
6	9.0	15	23.2	24	40.0	32	57.0
7	10.2	16	25.0	25	42.0	33	59.4
8	12.0	17	26.8	26	44.0	34	61.6
9	13.4	18	28.4				

NOTE.—From an examination of Table III it will be seen that 1° Beaumé is equivalent to 1.4° Twaddell and that 10° Beaumé is equivalent to 16° Twaddell, and not 14° as would be the case were they both graduated on similar principles.

to the density of the liquid) and another having zero near the bottom for liquids lighter than water.

147. Method of Graduation.—If any substance is dissolved in water, the liquid becomes heavier and more dense. This density is registered in degrees on the hydrometer. For liquids lighter than water the specific-gravity value is commonly used. Two hydrometers are commonly used as standards, namely, *Beaumé's* and *Twaddell's*. Twaddell's hydrometer bears a direct relation to the specific gravity of a body, while the position of the *Beaumé* hydrometer in pure water determines its zero mark. The position occupied by it in a 15 per cent. solution of salt determines its 15° mark; the other marks are placed accordingly.

Table III gives a comparison of *Beaumé* and *Twaddell* hydrometer degrees.

WOOL DRYING

DRYING MACHINERY

DRYING MACHINES WITH INTERMITTENT ACTION

INTRODUCTION

1. Importance of Drying Process.—After wool has been scoured, or washed, it is usually necessary to dry it before passing it on to the next process of manufacture, except when the wool is to be dyed in the raw state. When this is the case, the wool is taken to the dye house direct from the squeeze rollers of the washing machine, although a slight extraction of the water may be made in some instances by means of the hydro-extractor, a machine that will be described later.

Formerly, wool was dried by spreading it in the open air and allowing the sun and wind to dry it naturally. This method, although slow and laborious, had many advantages over modern methods, and the wool when thoroughly dried was soft and kind to the touch, none of its natural qualities being injured. The modern process of drying wool with artificial heat, while accomplished with the greater speed necessary to meet modern requirements, must be carefully carried out, if injury to the wool is to be avoided. The drying of the wool is an important process, as it affects the character of the wool and may make it unsuited for the kind of yarn or cloth for which it was intended and for which, if properly treated, it might have been used.

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2. Effects of Improper Drying.—Wool that is dried quickly with a high temperature generally has a harsh, unkind feeling, and the fibre loses its suppleness, becoming stiff and brittle; the elasticity and strength of the fibre are also materially reduced. It is impossible to spin harsh, brittle wool into fine yarn, so that the value of the material is deteriorated, as the finer the yarn a wool may be spun into, the greater is its value. If material capable of spinning to a fine number or count is rendered fit only for a lower number of yarn, because of an improper method of drying, there is always a consequent loss to the mill. Cloth made from wool thus injured will not have the desired soft, velvety feeling, but will be harsh and rough. Wool that is overheated and baked will also change and assume a dirty yellow shade. The percentage of waste in carding, spinning, and weaving will be increased if the wool is rendered harsh and brittle in the drying, and consequently the cost of the finished product, although it is of inferior quality, will be increased.

3. Suitable Temperature for Drying.—The chief point to be observed when drying wool is to avoid a high temperature; but as it takes longer to dry wool at a low temperature, there is a tendency in some mills to increase the temperature in order to reduce the time of drying the wool, the fact being ignored that by so doing the saving in time is taken out of the value of the wool, and that the cost of carding, spinning, weaving, and finishing is increased relatively more than the cost of the drying is reduced. The best results are, as a rule, obtained with air at temperatures ranging from 80° to 160° F., it being advisable to use the lower temperature when drying alpaca, mohair, and lustrous wools, since care must be taken to retain unimpaired their characteristic lustre, colour, and handle. It is to be noted that as the temperature of the dry air used in drying is increased, so is its property of absorbing and retaining moisture increased. A high temperature may not injure the wool as long as the latter is giving off moisture; but if the drying machine breaks down from some cause, and there are not ample facilities for quickly emptying the machine, the material will be in danger of being baked, with the consequence that the colour, lustre, and handle

of the wool will be injured, since overdrying tends to change both the mechanical and chemical composition of the fibre.

4. Efficient Wool Drying.—The most important requirements of a good wool dryer are: Even drying; sufficient circulation of the heated air; means of regulating the amount of moisture in the wool; prevention of rolling or matting of the material; a large production; economy in generating and maintaining the required heat; moderate requirement as to space occupied by the machine; low initial cost of the machine, and low cost of operation.

5. Classification of Drying Machines.—Drying machines may be divided into two classes according to whether their action is *intermittent* or *continuous*. A dryer with *intermittent* action is a machine into which a quantity of wool is fed, on which the machine is allowed to operate for a period of time before a fresh quantity is fed to the machine, or before the quantity operated on is removed from the machine. A dryer with *continuous* action is a machine into which wool is being constantly fed, and from which wool is being continuously delivered while the machine is in action.

HYDRO-EXTRACTORS

6. Use of Extractors.—The general method of drying wet wool from the washing machine is with some form of continuously acting hot-air dryer, of which there are several of standard manufacture on the market. The drying machines in some mills are fed directly from the washers, while in others the wool is first placed in a *hydro-extractor*. A *hydro-extractor* is a rapidly revolving cylindrical vessel in which the wet material is deposited, the moisture being partially removed from the latter by the centrifugal force to which it is subjected. After the excess of moisture is removed, the material is fed to the dryer either by a self-feed or otherwise. Hydro-extractors are now very little used for this purpose, as, owing to the great improvements in the squeeze rollers of modern washing machines, the wool is delivered from them so free from moisture that a hydro-extractor would not remove any appreciable quantity of moisture.

7. Hydro-extractors are not designed to dry the material, but are largely used for removing the bulk of the water from the wet wool, yarn, cloth, etc., and are indispensable to a dye house, as from 70 to 80 per cent. of the water can be at once removed. The final drying can therefore be more quickly and cheaply performed, since as high a temperature is not required and the material is left in a more open and lofty condition. Hydro-extractors are also used for extracting the acid solution used in carbonizing, before subjecting to heat; in fact, any place where it is desirable to remove rapidly a large percentage of moisture in saturated raw material, yarn, or cloth, the hydro-extractor is an economical machine. When used for acid work, the basket of an extractor should be lead-lined so that the acid will not attack and destroy it.

8. **Self-Balancing Extractor.**—This type of hydro-extractor, shown in Fig. 1, consists of a wrought-iron casing *a* supported by standards *b*. These standards are cupped out to receive the ball-shaped heads of the supporting rods, which lead down to the lower flange of the casing and are there attached by similar ball-and-socket joints. The necessary adjustments for levelling the outer casing and parts carried by it are secured by means of a double nut *c*, termed a *turnbuckle*, one of which forms a part of each one of the supporting rods. These turnbuckles may be securely fastened by means of locknuts.

The basket *d* of the extractor is made of perforated metal and is fastened to a central shaft *e* supported at the top by a bracket *f* that rises from one side of the outer casing and extends to the centre of the machine. The basket is driven by a small steam engine *g* carried on the bracket; the machine therefore requires no belting or shafting of any kind. The engine is attached directly to the shaft of the basket, and the loaded basket serves as a flywheel when the extractor is in operation; this allows the basket to be started very quickly, as no time is lost by belt slipping, etc.

9. In operation, material saturated with water or other liquid is placed in the perforated basket and steam is admitted to the engine. In a few seconds the basket is revolving at a high

rate of speed and the water is being driven through the perforated sides of the basket by the centrifugal force generated by the rapid rotation. The water removed from the basket is retained by the outer casing, from which it passes off as waste water through a suitable outlet in the casing. In a few moments the bulk of the

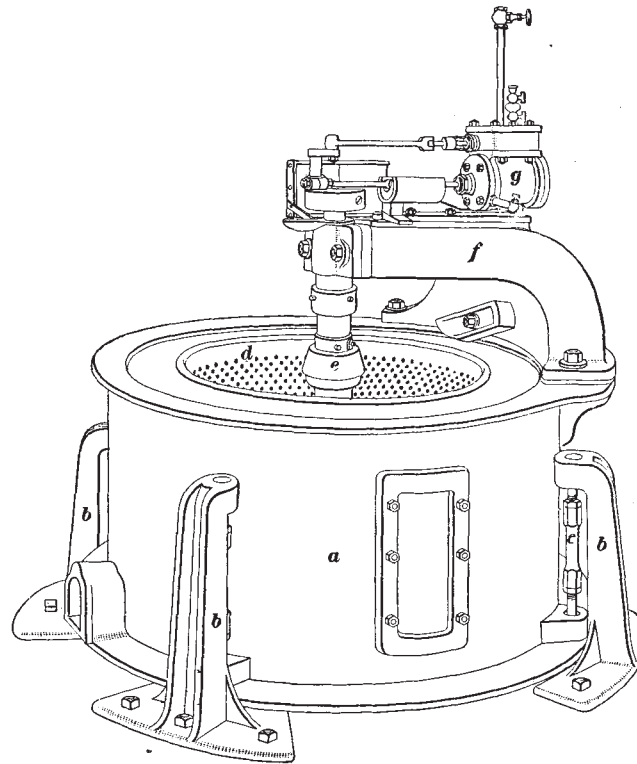


FIG. 1

water contained in the material is removed and the machine may then be stopped, emptied, and another lot placed in the basket. The extractor should not be allowed to run too long, however, in an attempt to remove too much moisture, or the material will be rolled and matted.

10. The vibration of the basket is a feature of all hydro-extractors that is impossible to remedy and is due to the unequal

loading of the heavy, wet material. In this extractor, however, the difficulties that would ordinarily arise because of this unavoidable vibration are overcome by carrying the entire machine on movable supports. The machine is thus entirely suspended and is free to vibrate in any direction, if unevenly loaded, thus preserving the parts in their original relation to one another without imparting any of the shaking to the floor or the building in which it is located. This manner of balancing an extractor is far superior to the old way of allowing the basket to wobble, or gyrate, inside the outer casing, which remained stationary, thus requiring a greater space between the basket and casing and necessitating a larger machine for the same capacity. The self-balancing hydro-extractor is made in various sizes, with baskets from 30 to 60 inches in diameter. The speeds at which they run vary from 1,000 revolutions per minute for a 30-inch, to 850 or 900 revolutions per minute for a 60-inch, basket.

11. Under-Driven Extractor.—The driving mechanism of this type of extractor is below the basket instead of above it, as in the preceding example, Fig. 1, and is therefore called an **under-driven extractor**. While this machine is not of the self-balancing type, a large number of them are in use and give ample satisfaction. One advantage of this type is that it is very easy to load and unload, as there is neither bracket nor shaft in the way, the entire top of the machine being open and clear. This fact renders the capacity of the machine larger than that of a self-balancing extractor.

The machine shown in section in Fig. 2 consists of an outer casing *a* enclosing a perforated basket *b*, which is fastened to a spindle *c* that rotates on the pivot *d*. A pulley *e* is attached to the lower end of the spindle, motion being imparted to the basket by means of a belt passing round this pulley, to which it is guided from a driving shaft by means of two guide pulleys, the one shown being marked *f*. In order to reduce the vibration and at the same time furnish a certain freedom of motion, the pivot box is supported by rubber cushions *g* carried in a gland *h*. In order that the machine may be stopped quickly, a brake shoe *j* is arranged to be pressed against the pulley *e* by means of a brake

lever *k*. The working parts of the machine are all enclosed in a water-tight, cast-iron trough, or casing, which is bolted to the floor under the extractor; but where this machine is to be erected in basements they are carried in a bedplate set on masonry.

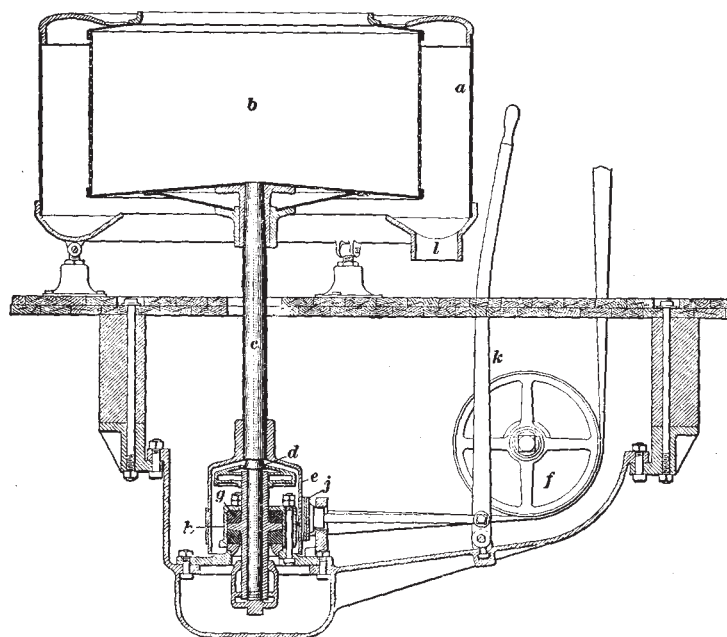


FIG. 2

In operation, the material to be extracted is placed in the basket *b*, which, if unevenly loaded, gyrates within the casing *a* until a speed is attained that makes it assume an upright position. The water thrown from the material is retained by the casing and finds an exit through the outlet at *l*.

TABLE DRYERS

12. Principle of Operation.—Table drying, which was one of the first methods used, involves the use of a **table**, or **platform**. The principle of the action of a table dryer is that of either drawing or forcing warm air through wet wool, which is spread in a layer to a depth of from 4 to 6 inches on galvanized-wire screens.

These screens are so arranged that there is an enclosed space underneath them from which the air may be exhausted by means of one or more fans, thus drawing a current of cold air through the wool; or the air may be forced by a fan into the enclosed place under the screen and be thus blown through the material spread on the screen. This latter method is to be preferred, since

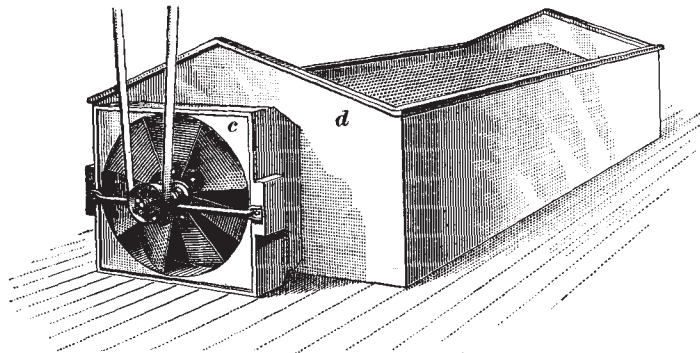


FIG. 3

any process of forcing the air up through the wool gives better results than by drawing it downwards, because the wool is rendered more lofty and open when it is lifted by the air-current than when pressed against the screen, in which case it tends to dry in matted bunches. An ordinary arrangement of a table dryer is shown in Fig. 3.

13. Construction.—A table dryer consists of a wooden, box-like framework *d*, as in Fig. 3, made air-tight except the top, which is covered with wire screens. At one end a fan *c* is attached, which is supported by an iron frame having a circular opening in which the bearing of the rotating portion is enclosed. Where it is intended to blow the warm air up through the wool, a series of steam pipes are placed under the wire screens, so that, as the air is blown into this space, it is warmed and so made suitable for drying wool. Care should be taken that the air is not forced into the dryer at too high a pressure, as this is liable to mat the material. In table drying where suction is used, that is, where the air is drawn down through the wool, the steam pipes are arranged high enough above the wire screens as to allow easy

access to the latter in order to distribute the wet wool on the screens or remove it when dry. The table may be of the shape shown in Fig. 3 or made with a flat top and sloping sides, though in many new forms of table dryers the tables are made in the shape of an arc with a view to obtaining a greater area of drying surface. Table dryers are usually made in sizes varying from 18 to 30 feet in length and from 9 to 10 feet in width. The production of a table dryer 18 feet by 9 feet would be about 1,500 pounds per day. Occasionally a whole room is used for drying, the floor of such a room being constructed of perforated iron plates, through which warm air is blown.

14. Operation.—When in a dryer of the type shown in Fig. 3 the air is drawn by the fan from outside the building or from the adjoining rooms and forced up through the table and the wool, it naturally takes the course of least resistance; hence, more air goes through where the layer of wool is lightest and thinnest, and very little through the thickest and wettest portions where it is most required. The result is that the thin portions get over-dried, and the thick portions retain too much moisture, and, unless great attention is given to the work, large holes will be blown in the layer of wool, which will allow air to escape without doing any drying. On the other hand, if air is drawn down through the wool, the material is forced down on the screens and the air cannot penetrate it readily. There is also greater difficulty in properly distributing an air-current that is forced through the wool by atmospheric pressure alone; but as the air-current passes from the machine through a pipe and out of the room, the atmosphere of the room is in a better condition. The wool should not be laid on the table in too thick a layer, otherwise the uppermost portions of the wool with which the air-current first comes into contact are over-dried, while the underlying portions are under-dried.

15. Standard Condition and Standard Regain.—The amount of moisture that the material should contain when leaving the drying machine is not generally agreed upon, but if wool is dried to a state in which it is 2 to 3 per cent. above the *standard condition*, it will work satisfactorily in the subsequent processes,

since the wool requires a certain reserve of moisture so as to meet the loss that is constantly taking place. **Standard condition** is that condition of the material in which it contains a certain percentage of moisture called *regain*. The **standard regain** is a certain quantity of moisture added to the absolutely dry material in order that its percentage of moisture may be such as to make it acceptable to both buyer and seller. The standard regain for wool is 16 per cent. Care must be taken not to extract too much moisture from the wool, as material that has been so treated must have moisture in some form added to it, and such moisture cannot be so well applied after drying.

16. Disadvantages of Table Dryers.—Table dryers are at present not used so extensively owing to several disadvantages connected with this type. The principal disadvantages are that the drying process is not continuous ; that it requires too much space in proportion to the amount of wool dried ; that it requires a great deal of manual labour in placing the wet wool on the table and in turning the material over while on the table, so as to ensure even drying, and in removing it from the table when dry ; that unless the attendants are careful to lay the wool evenly on the table and turn it over at frequent intervals, the wool will be dried unevenly, some portions of it becoming overheated while others remain comparatively wet. It is slow in operation, and, in case of dryers in which the air passes through the table from below, the whole of the heated vapours pass into the room in which drying is being done.

MOORE DRYER

17. Construction and Operation.—In the **Moore dryer**, of which Fig. 4 is a diagrammatic section, the wool is fed into the machine through the door *a*, in quantities of about 120 pounds at suitable intervals, which usually vary from 15 to 30 minutes according to the class of material. The wool is thrown on to the lower series of small perforated rollers *b*, which are about $3\frac{1}{2}$ inches in diameter and placed close enough together to prevent any of the material from dropping between them, but not so close as to prevent the air from passing through the material.

Each roller is rotated by worm and wheel gearing, which is placed outside the framework of the machine; the gearing is so arranged that the upper surface of each roller in the bottom series travels away from the opening *a*, thus causing the wool to move along

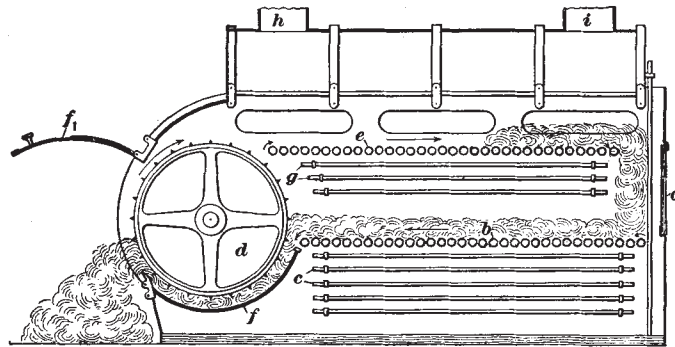


FIG. 4

in the direction of the arrow. Simultaneously, hot air is passing up through the material, the air and the rollers being heated by a series of steam pipes *c* placed under the rollers.

18. When the wool reaches the end of the series of rollers *b*, Fig. 4, it comes under the action of the spiked drum *d*, which revolves at a speed of about 110 revolutions per minute and carries the material round in the small space between the drum and the curved plates *f*, *f*₁, on to the upper series of small perforated rollers *e*, which are made to revolve in the opposite direction to those in the lower series, and which therefore carry the wool back toward the feed end of the machine. In Fig. 4 the plate *f*₁, which also serves as a door, is shown in a horizontal position, but must be supposed to stand vertical so as to form a continuation of the plate *f*. As the upper series of rollers is shorter than the lower one, the wool falls over the end of the series *e* on to the lower series and so continues its circuit. This circulation of the wool is continued until the material is in the required state of dryness, then the door *f*₁ is opened, as shown in Fig. 4, and the centrifugal force generated in the wool by the rapidly revolving spiked drum will cause the wool to be thrown out on to the floor or into some

suitable receptacle. The upper set of perforated rollers and the surrounding air are heated by the steam pipes *g*. The hot, moist air passes out at the top of the machine through the two chimneys *h* and *i*.

DRYING MACHINES WITH CONTINUOUS ACTION

MOORE AND WHITELEY DRYER

19. Construction and Operation.—When dryers with continuous action are adopted, the material from the washing machine is usually fed directly to the drying machine by means of an endless apron or lattice. This is a very economical way of manipulating the material, as there is no handling from the time the greasy wool is placed in the washing machine until it is deposited, all washed and in a dry and lofty condition, by the delivery lattice of the drying machine.

20. A Moore and Whiteley dryer is shown in perspective in Fig. 5 and in section in Fig. 6; this machine is a further development of the machine shown in Fig. 4, the new features introduced being the tubular heater and fan and an additional series of small rollers. The material is fed into the machine by the lattice *a*, from which it drops on to the upper series of rollers *b*, Fig. 6; at this point the material meets a current of hot air from the tubular heater *c*. This consists of an outer shell and ends of steel in which are set rows of steel tubes that are surrounded by steam, the air in passing through these tubes being heated to the required temperature. The usual sizes of heaters are from 9 to 15 feet long and from 2 to 4 feet in diameter; the smaller sizes are constructed with about 200 tubes $1\frac{1}{4}$ inches in diameter, while the larger sizes are made with about 280 tubes $1\frac{1}{2}$ inches in diameter.

21. The air is driven by the fan *e* through the tubular heater and the duct *d*, and passes through the machine in the same direction as the material, as indicated by the arrows. When the material reaches the end of the top series of rollers it drops on to the middle series *f*, by which it is carried along while exposed to the current of air until it reaches the end, and then the wool

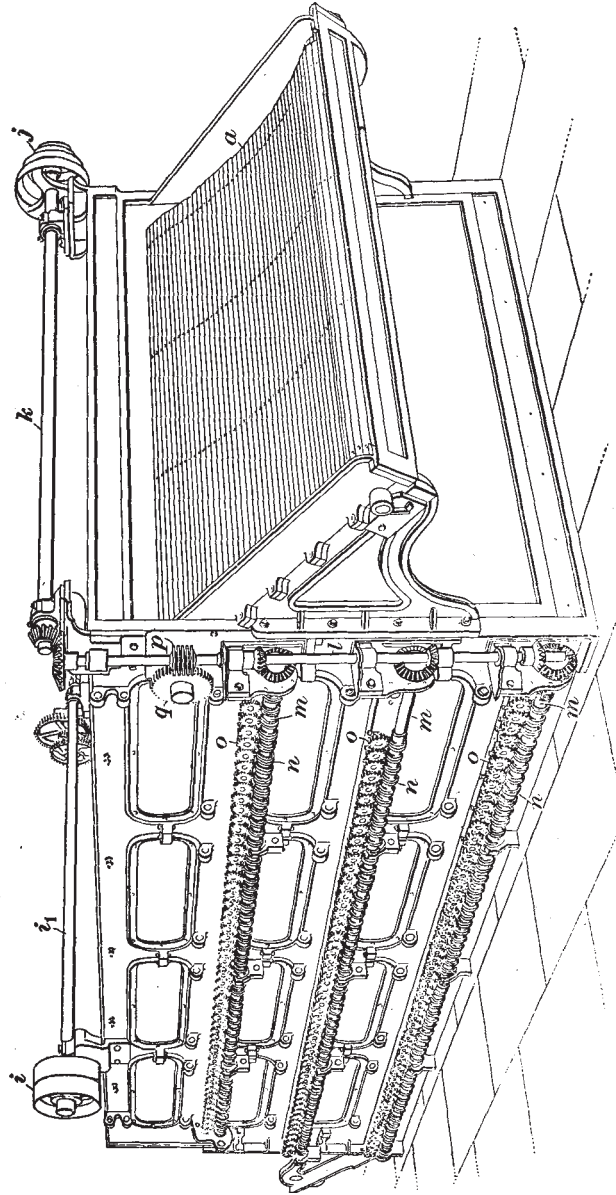


FIG. 5

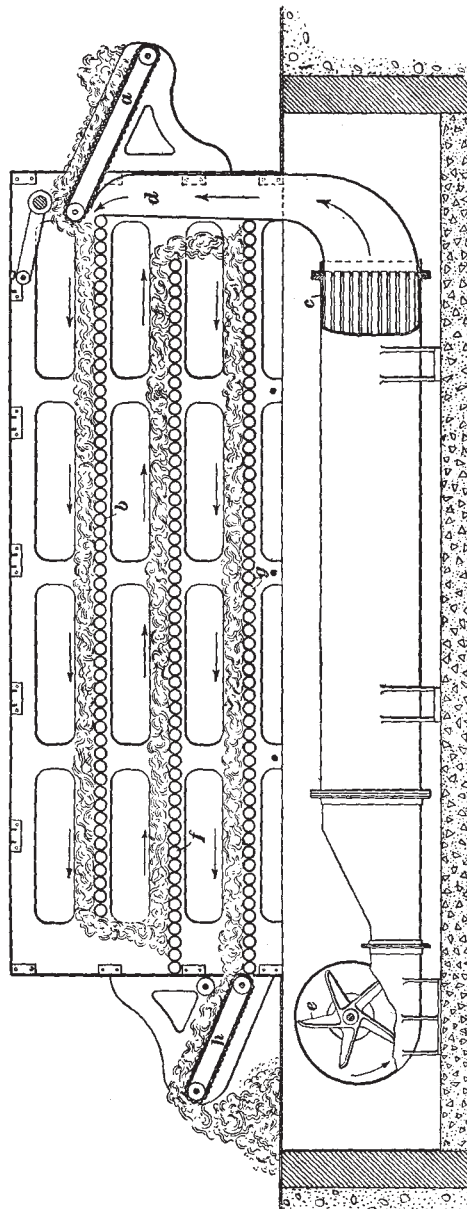


FIG. 6

drops on to the bottom series of rollers *g*, from which the material is carried out of the machine by the lattice *h*.

22. The driving of the small rollers and the feed-lattice is clearly shown in Fig. 5. A belt from the line shaft gives motion to the fast and loose pulleys at *i*, the fast pulley giving motion to the shaft *i*₁ which, through suitable means, not shown, drives the cone pulley *j*. The latter, in driving the shaft *k*, which extends the full width of the machine, gives motion by means of bevel gear-wheels to the vertical shaft *l*, on which are fixed bevel gear-wheels that, by means of other bevel wheels, drive the horizontal shafts *m*. On each of these shafts there is cut a series of

worms n , which gear into worm-wheels o , there being one worm and worm-wheel for the driving of each roller. By reason of the relative positions of the bevel gear-wheels on the vertical shaft l , it follows that the top and bottom sets of rollers will revolve in the same direction while the middle set will revolve in the opposite direction. The feed-lattice receives its motion by means of the worm p fixed to the vertical shaft l , driving the worm-wheel q on the end of the feed-lattice shaft. The fan is usually driven by belt from the line shaft.

WHITELEY DRYER

23. Principle of Action of Whiteley Dryer.—Travelling lattice or apron dryers are used to a considerable extent, but are now being displaced by other types; good results, however, may be obtained if proper precautions are taken with regard to the temperature and the time the material is allowed to remain in the machine. This type of dryer is generally made with 3 or 5 conveying aprons, or lattices, and the term **multiple-apron dryer** is often used in designating a machine of this class.

A diagrammatic section of the Whiteley 5-apron dryer is shown in Fig. 7. It will be seen that the principle of this machine is simply that of carrying the wool through a heated chamber by means of travelling aprons. This dryer is generally constructed with a metal framework which is encased on the outside with some kind of compound that will retain the heat. The air is usually heated by steam pipes or a tubular heater placed under the machine, though in some few cases the heating arrangement is placed in a separate chamber running alongside the machine. The carrying aprons are sometimes made of wooden slats specially prepared to withstand the heat, but they are preferably made of woven wire or perforated metal laths, since the heated air has a better chance to circulate through the wool, as it may also reach it from the under side.

24. Construction and Operation.—The material from the washing machine is fed on to the feed-lattice a , Fig. 7, either directly or by means of a hopper feed. The feed-lattice, which is driven by the roller a_1 , carries the wool under the feed-roller b

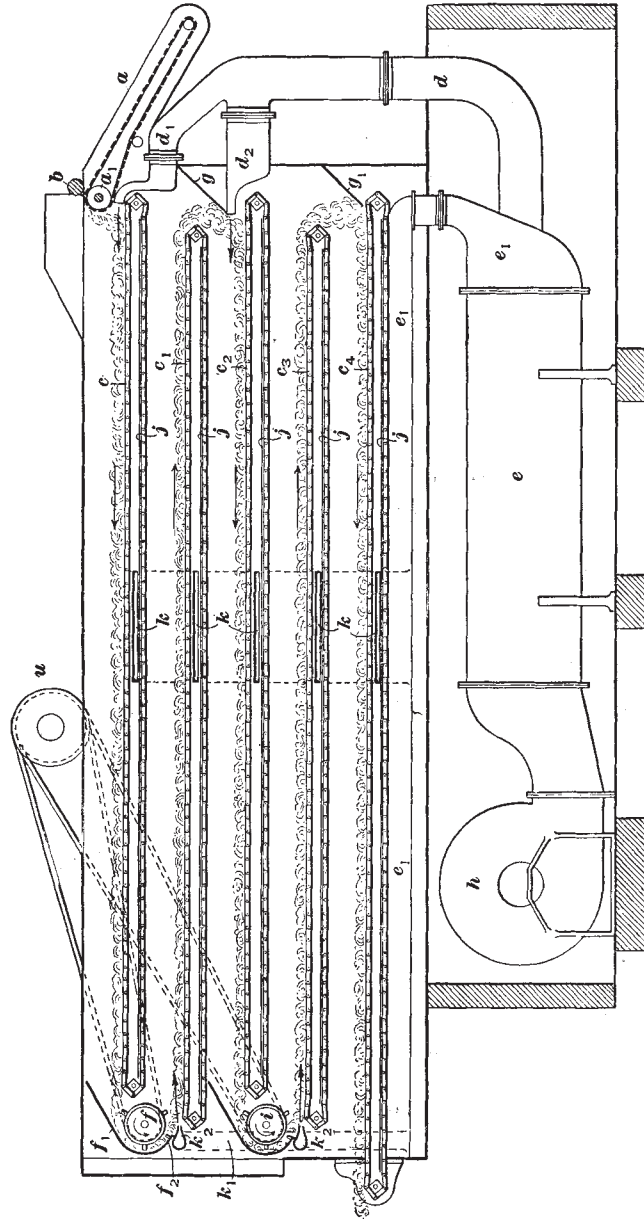


FIG. 7

to the conveying lattice c ; a revolving beater is sometimes placed at b to ensure that all the material leaves the feed-lattice. In the section shown in Fig. 7 a pipe d , having branches d_1, d_2 , connects with the tubular heater e ; the mouth of each of these branches is gradually widening to the full width of the machine, but the vertical height of each mouth is correspondingly reduced in order that its sectional area may correspond to that of the pipe. These mouths open into the drying chamber, the upper one d_1 being between the feed-lattice a and the top travelling lattice c , while the second one d_2 is between the lattices c_1, c_2 . There is another pipe e_1 that passes from the heater e under the lower lattice c_4 where it connects with two other ducts, one of which is shown at k_1 . This has two horizontal branches k_2 that extend the whole width of the machine and on the inner sides have narrow openings through which the hot air passes into the dryer. Hot air is also forced by the fan through another duct with openings k arranged between the two surfaces of each lattice. In order that the air shall pass up through the lattices and the material, horizontal division plates j are placed in the interior of each lattice, as shown. The effect of forcing air through the horizontal apertures at the ends of the machine is to materially assist the drying process, as the wool, while dropping from one lattice to the other, is in an open condition and readily penetrated by the heated air.

25. The wool deposited on the lattice c , Fig. 7, is carried to the delivery end of the machine, where it is caught by the cylindrical beater f which carries the wool round in the space between the beater and the guide plate f_1 . Toward the lower extremity of the guide plate is fixed a row of pins f_2 which, in connection with the pins on the beater, serve to open out the larger lumps of wool, thus assisting in making the drying process more uniform. While the material is passing from the beater to the second travelling lattice c_1 , it is subjected to the drying action of a current of hot air from the pipe k_2 . After the lattice has carried the material to the opposite end of the machine, it drops over the end of the lattice on to the third lattice c_2 , a guide plate g guiding the material in such a manner that it is subjected to a current of

hot air from the pipe d_2 . The wool continues its course on the lattice c_2 toward a circular beater i , where it is acted upon in a manner similar to that at f . From the lattice c_3 the material drops over the guide plate g_1 to the lattice c_4 which carries the material from the machine in a dry and lofty condition.

26. The travelling lattices, which form an important part of this machine, usually consist of horizontal perforated steel laths l ,

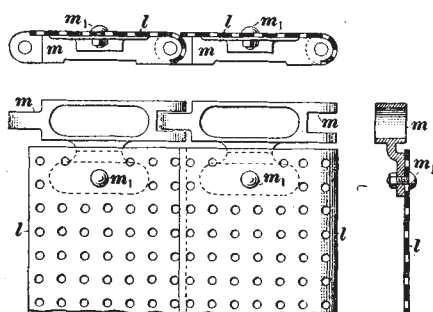


FIG. 8

shown in plan and sections in Fig. 8; these laths are bolted to endless chains m by bolts m_1 . In some machines of this make the lattices are constructed of solid steel laths attached in a similar manner to endless chains, but arranged to overlap each other so as to leave a space between each lath

which permits hot air to pass through the material. This machine is also adapted to the process of *carbonizing*, a process in which vegetable matter is destroyed by means of chemical action so that it may subsequently be easily shaken or dusted from the wool.

27. The driving of the lattices is shown in Fig. 9, which is a perspective view of a Whiteley dryer, slightly modified from that shown in Fig. 7, the hot air entering the machine from below. The fast-and-loose pulleys which receive their motion by belt from the line shaft are shown at n . The fast pulley through bevel gearing gives motion to the top shaft o , which through other bevel gearing drives two vertical shafts p and q on which are placed worms that gear with worm-wheels fixed to the lattice shafts. Alternate lattices are driven by each vertical shaft; thus, the top, middle, and bottom lattices are driven from the vertical shaft q , while the other two lattices are driven from the vertical shaft p . On the shaft of the roller of the feed-lattice a there is a worm-wheel t driven by the worm s on the

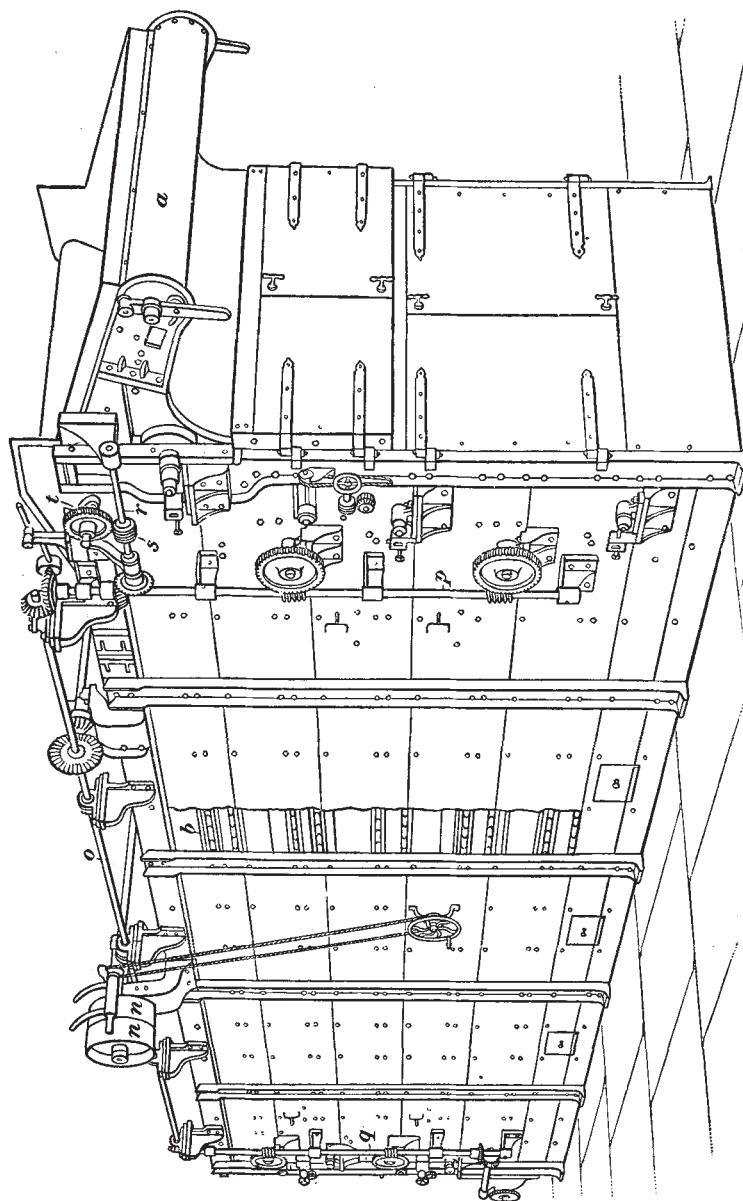


FIG. 9

shaft *r* which is driven by a pair of bevel wheels from the shaft *p*. The beaters *f* and *i* are driven from a pulley *u* by means of belts, as shown in Fig. 7.

28. Regulation of Temperature.—The steam pipes in a dryer of the type shown in Fig. 7 are sometimes placed in tiers between the lattices, the fan being omitted; this, however, is not a satisfactory arrangement, as the wool is apt to bake, owing to a lack of circulation of the heated air in the chamber. High temperatures when using a dryer of this type should be avoided, and it is better for the wool to have the lattices run somewhat slowly and have a lower temperature than to have a high temperature and drive the lattices faster. The temperature in this type of dryer should not be allowed to be higher than 160° F. if the best results are desired. All drying machines should be equipped with one or more thermometers, so that the temperature can be noted; it is also a good plan to check the accuracy of the thermometers from time to time.

The speed of the drying lattices should be so arranged that with the proper temperature the material will remain in the machine just long enough to become dry, and no more. It is better to have the wool delivered slightly moist rather than too dry and with a harsh feeling.

29. Production.—A drying machine of the type shown in Fig. 7 is suitable for a large range of materials, but it should be noted that all multiple-apron dryers are better adapted for drying or working long wools than for very short wools. The average production of the Whiteley dryer is from 3,000 to 5,000 pounds per day, but it is liable to vary, depending on the quality and condition of the wool. Some wools are much more difficult to dry than others, and the condition of the wool with regard to openness will also influence the speed of drying, since the hot air cannot reach the wet fibres forming the centre lumps. The amount of water in the wool as it leaves the washing machine has an appreciable effect on the production of a drying machine, and such water should never be more than 35 to 40 per cent. The degree of dryness required also varies with different wools, and different manufacturers using the same class of wools would

require different degrees of dryness, some preferring to submit the wool to the next operation in a fairly damp condition, while others prefer it much dryer. If the wool has to be packed either for storage purposes or for transport directly after washing and drying, then it must be much dryer than if it is to be used at once, and in some export work it must be dried to within 4 or 5 per cent. of absolute dryness.

PETRIE AND FIELDEN DRYERS

30. Principle of Petrie and Fielden Dryers.—The Petrie and the Fielden drying machines are similar in principle to the Whiteley machine, in that the wool travels through the machine upon several conveyers, dropping from each conveyer to the next in succession after traversing the length of the machine. The means of conveying the wool in the Petrie and the Fielden machines is, however, entirely different from the ordinary lattice

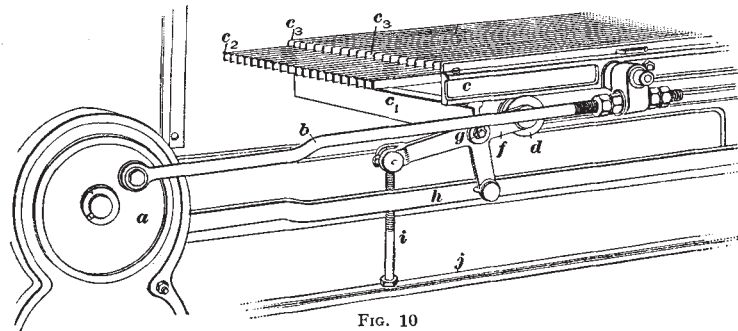


FIG. 10

arrangement, the motion being an intermittent one instead of continually revolving lattices. The Fielden dryer is similar in appearance and arrangement to the Petrie dryer excepting the conveyers, which in the former consist of perforated plates carried by cross-bars extending the full width of the machine. An intermittent irregular motion is given to the conveyers by means of cams in a manner somewhat similar to that given to the conveyers in the Petrie machine.

31. Operation of Petrie Conveyers.—An internal view of a part of the Petrie dryer is given in perspective in Fig. 10, while a

diagrammatic elevation is given in Fig. 11. As each conveyer is operated in a similar manner, their action will be clearly understood from the portion of the dryer shown in Fig. 10. Fixed across the machine at suitable intervals are bars c_1 , which carry a series of fixed iron **T** bars c_2 placed side by side across the width of the machine. These bars are about 1 inch wide at top and they extend almost the whole length of the machine; between adjoining bars there are $\frac{1}{4}$ -inch spaces containing bars c_3 , $\frac{1}{8}$ inch thick. The bars c_3 are fastened to a series of movable cross-pieces connected to longitudinal bars c , k , l , m , and n situated outside the side walls of the machine, as seen in Fig. 11. These bars rest on rollers d that form part of the levers f and f_1 . Motion is imparted to the bars c , k , etc., in two directions. A connecting-rod b attached to the bar c and to a crankpin on the gear-wheel a gives the bar c , with its series of bars c_3 , a reciprocating motion in a horizontal direction. A rod h connected to the levers f is given a reciprocating motion by a cam on the rear side of the wheel a ; the rollers d with the bars c will therefore also receive a reciprocating motion in a vertical direction. These two motions are so timed that the tops of the bars c_3 will first rise for a distance of 1 inch above the bars c_2 , then move forwards in a horizontal direction for a distance of 8 inches, again descend below the surfaces of the bars c_2 , and return to their initial positions in a horizontal direction.

32. The effect of this motion of the bars c_3 , Fig. 10, on the wool is, that as it lies on the fixed bars c_2 it will be lifted up by the moving bars c_3 , rising quite clear of the fixed bars, and carried forwards by the former; the moving bars on descending at the termination of their horizontal movement deposit the wool on the fixed bars at a point considerably in advance of the point at which it was lifted from the bars c_2 at the commencement of the motion. As a result of these intermittent motions the wool will gradually advance along the bars c_2 , constituting the fixed part of the conveyer, until, when reaching the end of each set of conveyers, it tumbles over the end on to the next set below, when motion takes place in an opposite direction. The wool thus moves backwards and forwards through the machine until it reaches the bottom conveyer, from which it is passed out of the machine.

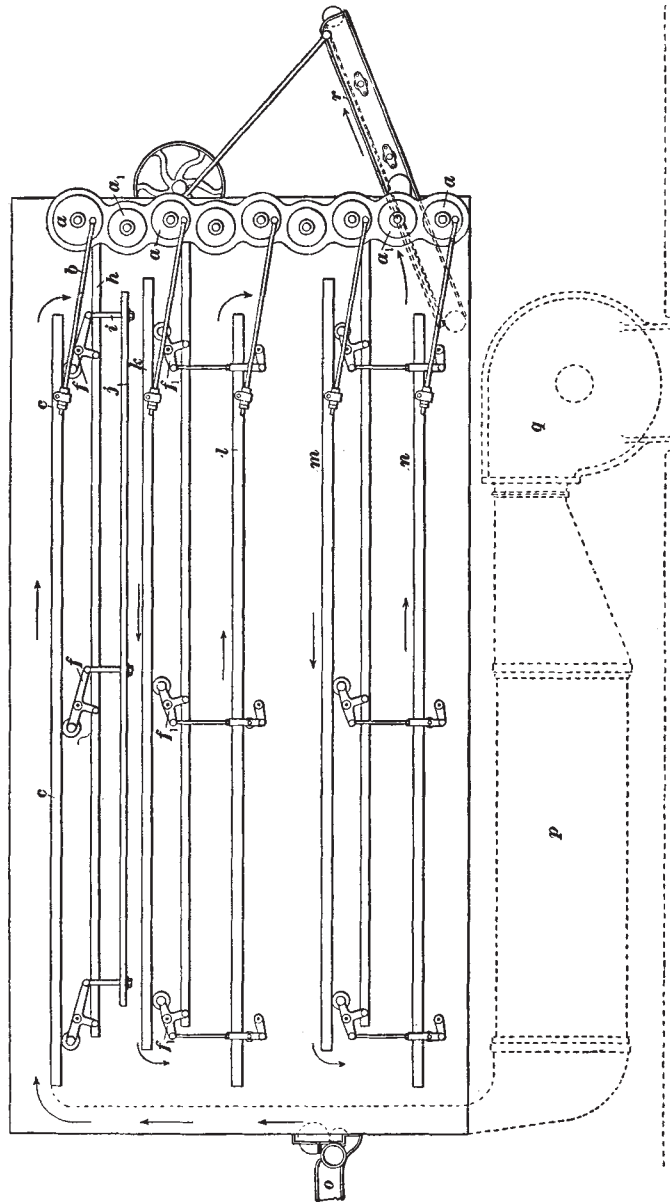
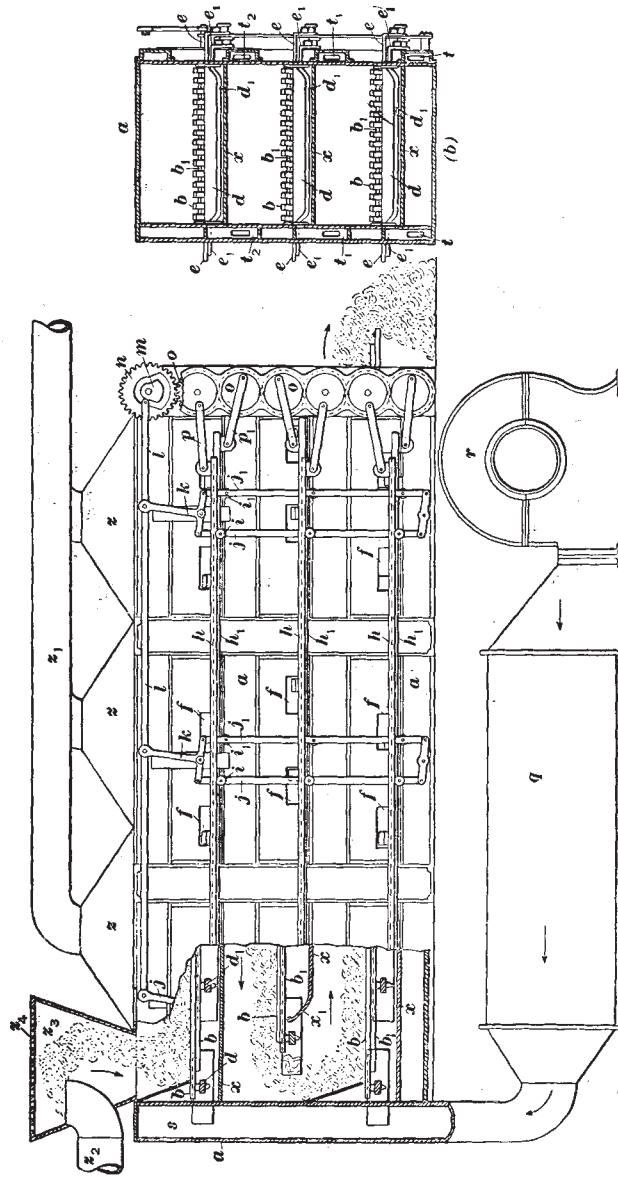


FIG. 11

33. The parts *a*, *b*, and *c* are duplicated on both sides of the machine for each conveyer. To the horizontal arms of the levers *f* are attached rods *i* supporting a heavy iron bar *j*, which serves the purpose of balancing the weight supported by the pulleys *d*. As seen from Fig. 11, this counterbalance is required only for the top conveyer, as the movable bars *l* of the third conveyer are hung from the ends of the levers *f*₁ which at their other ends support the movable bars *k* of the second conveyer; they will therefore balance each other. The same arrangement is made with the bars *m* and *n* of the fourth and fifth conveyer. Motion is transmitted to all the wheels *a* by carriers *a*₁, the entire train of gear-wheels being enclosed in a casing, as shown. It is evident, from Fig. 10, that the cross-bars that fasten the bars *c*₃ to the outside bars *c* must pass through openings in the walls of the machine. To prevent the hot air from escaping through these openings, the cross-bars carry slides that cover the openings and also fit against the side walls, so that whatever position the cross-bars may occupy, these openings are always closed.

34. The wool is fed to the dryer by a feed-lattice *o*, Fig. 11, whence it passes into a narrow, vertical chamber through which a strong current of heated air is forced from the heater *p* by means of a fan *q*. The air-current carries the wool up the vertical chamber, as indicated by the arrows, and deposits it on the top conveyer, where it is carried forwards in the direction of the arrows by the means already described. As the outside bars *c*, *k*, etc., coincide in position with the conveyers, they are used for indicating the passage of the material through the machine by means of the arrows, as shown. The direction of the air-current coincides with that in which the material moves; the latter is therefore constantly subjected to its drying influence until the material is finally carried out of the machine by the lattice *r*. The time occupied by the material in passing through the machine is usually about 30 minutes, and the production is approximately 600 pounds per hour. As the drying effect of the air is greater when it is forced up through the material instead of over it, this principle is utilized in the more recent forms of the Petrie drying machine.



(a) FIG. 12

WHITE DRYER

35. Construction and Operation.—In the White dryer the air is forced through the wool instead of passing along its surface. The machine is illustrated in Figs. 12, 13, 14, and 15, of which Fig. 12 (*a*) is a front elevation, partly in section, to show the interior, and Fig. 12 (*b*) a cross-section. Fig. 13 is a perspective

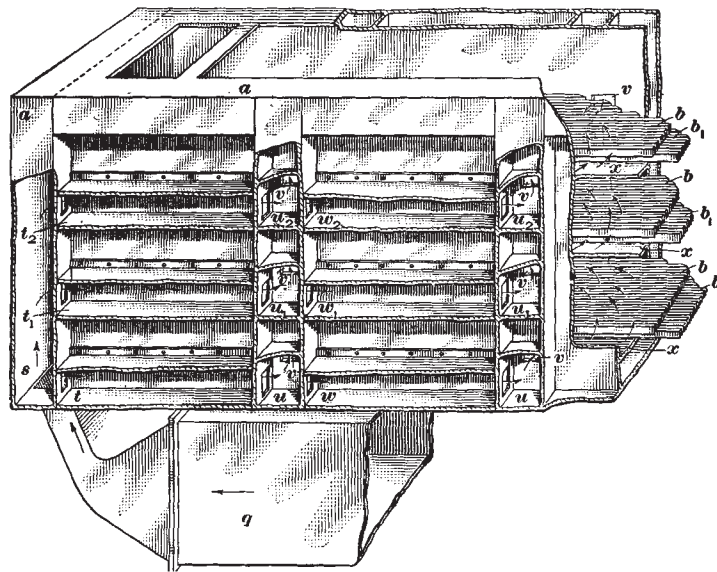


FIG. 13

view of the front end of the dryer, partly broken away to show the passage of the air through the various ducts. Figs. 14 and 15 show the construction and method of driving the conveyers. As seen from Fig. 14, in which view (*a*) is a side elevation of a portion of a conveyer and (*b*) a cross-section, the conveyers consist of two sets of movable bars *b*, *b*₁, each about 1½ inches wide. Each set of bars is supported on separate cross-bars *d*, *d*₁ by means of lugs *c*, *c*₁. As seen from Fig. 13, the bars *b*, *b*₁ extend lengthwise of the machine. The ends of the bars *d*, *d*₁ extend through rectangular openings *f* in the sides of the dryer, for which purpose they are given the flat form shown at *e*, *e*₁, Figs. 12 (*b*) and 15; slides *f*₁ attached to *e* cover the openings *f*, to prevent escape of

air. To the ends e, e_1 are bolted elbow pieces g, g_1 , which are bolted to the rails h, h_1 that extend nearly along the whole length of the machine. These rails are supported by rollers i, i_1 attached to the lifting rods j and j_1 , which are supported by the T-shaped

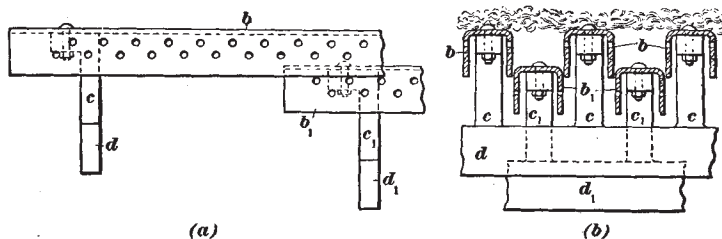


FIG. 14

levers k ; the latter are pivoted on studs k_1 that project from the framework of the machine. The upper arms of the levers k are attached to a cam-rod l , which is operated by a grooved cam m on the gear-wheel n ; this cam gives the rod l and likewise rods j, j_1 a reciprocating motion.

36. At both sides of the machine there is a train of gear-wheels o , Fig. 12, two of which, on each side, belong to one set

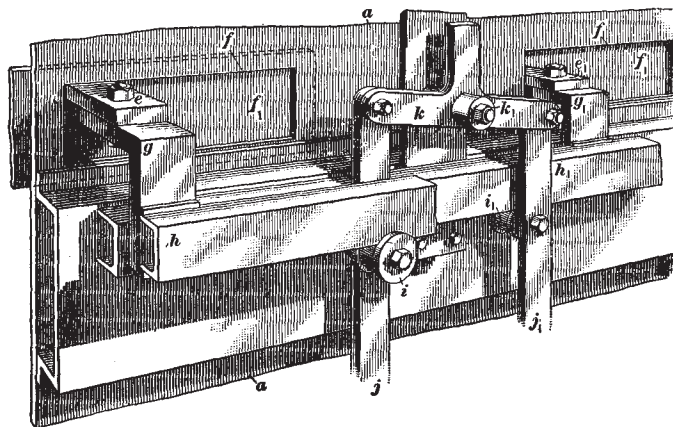


FIG. 15

of conveyers, that is, one wheel to each of the bars h and h_1 . The wheels are provided with crankpins, which by means of

connecting-rods p, p_1 give a reciprocating motion to the bars h, h_1 ; but the crankpins are so arranged that h and h_1 will reciprocate in opposite directions. The motion of the levers k is such as to lift and lower the bars h, h_1 alternately; this results in a motion of the bars with their conveyers similar to that of the bars c_3 , Fig. 10, with this exception, that while in the latter case the set of bars c_2 is stationary, in Fig. 14 both sets of bars perform a similar motion, but in opposite directions. When the bars are in their uppermost positions, they move in the same direction and alternately carry the wool forwards. The material will drop from one conveyer to another, as indicated by the arrows in Fig. 12, until it finally leaves the machine.

37. The hot air from the heater q , Fig. 12, is forced by the fan r into the vertical air chamber s , which does not communicate with the interior of the drying machine. From the chamber s branch off three horizontal air ducts t, t_1, t_2 , Fig. 13, which are arranged along each side of the machine, these ducts in turn communicating with the air chambers u, u_1, u_2 provided with orifices v . The latter open into air chambers formed under each set of conveyers by means of metal sheets x , which are fixed to the framework of the machine at each side, as shown in Fig. 12 (*b*). The chambers u, u_1, u_2 communicate with other ducts w, w_1, w_2 , which open out into another series of chambers u . It follows from the arrangement of the orifices v , in connection with the chambers formed under the conveyers, that the air will pass up through the material resting on the bars b, b_1 and then over the conveyers in a direction opposite to that in which the material is advancing, eventually passing up into the domes z and exhaust pipe z_1 . An advantage claimed for this machine is that the air is passing through the machine in a direction opposite to that in which the material is traversing it. The moisture-laden air will therefore leave the machine at the point where the wet material enters, and the latter leaves the machine at the point where the air is dry and at its maximum temperature. As the discharged air still retains some useful heat, it is utilized for the purpose of blowing the wet material from the washing machine through the pipe z_2 into the hopper z_3 . This is covered with a perforated

sheet z_4 which allows the air to escape. It is seen from Fig. 14 (*b*) that, by reason of the relative positions of the bars b , b_1 , ducts are alternately formed between them which allow currents of air to pass under the layer of material resting on the uppermost bars, as b .

McNAUGHT BOILER DRYER

38. **Construction and Operation.**—The McNaught jumbo, or boiler dryer, consists of a large cylindrical screen a , Fig. 16, constructed of wire netting, suitably attached to T-shaped iron rings b . These are connected together by longitudinal bars c , the whole forming a cylindrical screen which allows air, dust, or

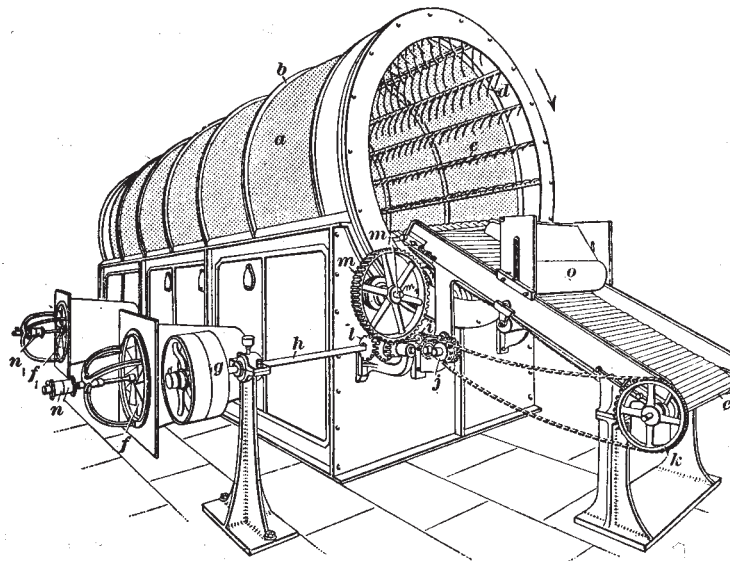


FIG. 16

dirt to pass away, but which retains the wool. The cage is mounted in an inclined position, so that the feed end is higher than the delivery end, the angle of inclination being about 10° to the horizontal. The rings b rest on grooved rollers which are fastened to inclined shafts extending the whole length of the machine and parallel to the axis of the cage.

39. Inside the cylinder and fastened to the bars c is a series of prongs d . As the cage slowly revolves in the direction indicated by the arrow, the hooks carry up the wool which is fed into the machine by the travelling lattice e ; when the hooks have reached their highest positions, the wool drops to the lower side of the cage. Owing to the inclination of the cylinder, the hooks at their top positions are slightly nearer the rear end of the cylinder; therefore, as the wool drops down vertically from the top, it will fall at a point slightly in advance of that occupied by it when it was raised from the bottom of the cage. This operation being repeated continuously, the material gradually works its way along the whole length of the cylinder until it finally drops from the top position at the rear end on to a cone drum which conducts the material to a travelling delivery lattice that conveys it out of the machine.

40. During the operation of drying, two fans f and f_1 force air into the enclosed framework under the cage and through the cage itself and the wool resting on the lower side. By reason of the continual dropping of the wool from the top of the cage through the hot air the wool is thoroughly dried, and is delivered in an open condition. The steam pipes for heating the air are usually arranged in the form of coils of pipes on which the air impinges as it passes from the fans into the enclosed framework and out through the cylindrical screen.

41. The feed-lattice e is driven from the fast-and-loose pulleys at g which receive their motion by a belt from the line shaft. The shaft h , to which the fast pulley is attached, carries a gear-wheel i , which through carrier and stud wheels gives motion to a sprocket wheel j , a chain conveying motion to the sprocket wheel k fixed to the end of the feed-lattice roller. The cage is driven from a bevel wheel l on the shaft h , which through bevel and spur-wheel gearing gives motion to the large gear-wheel m fixed to the inclined shaft m_1 on which the grooved rollers are fixed. The inclined shaft at the other side of the machine is driven by a cross-shaft and bevel-wheel gearing from the rear end of the inclined shaft m_1 . The fans f and f_1 are driven by belts from the fast-and-loose pulleys n and n_1 , respectively. The roller o ,

which prevents the wool from rolling back on the feed-lattice, revolves by frictional contact with the material and the lattice.

42. The machine is usually enclosed in a corrugated-iron casing ; in some cases, however, the machine is placed in a room of suitable size, a space of about 2 feet being left at each side and about 1 foot above the cage. The temperature in machines of this type can be easily regulated, since the machines are placed in separate chambers. The average length of the cylinder is about 20 feet with a diameter of 8 feet. The production of the machine is about 4,000 pounds per day, and it dries very satisfactorily at low temperatures.

McNAUGHT SECTIONAL DRYER

43. **Feeding Material.**—The McNaught sectional dryer is shown in perspective in Fig. 17, and a diagrammatic section of one of the units, or sections, of which the machine consists is shown in Fig. 18. The material is fed to the machine by an ordinary feed-lattice *a*, Fig. 17, and feed-rollers *b, b₁*, of which the lower one is usually grooved so as to enable the feed-rollers to hold the material as long as possible. The feed-roller *b₁* is mounted in bearings which are free to slide in a vertical direction within guides, forming part of the end framing, so that the roller will yield should any large lumps of material pass between the rollers. Above the roller *b₁* is a *packing bar c*, which is free to move vertically with the top feed-roller and is usually bolted to the same bearings. The purpose of this bar is to make an air-tight joint between the feed-roller *b₁* and the framework of the machine, and so prevent air and material from escaping over the feed-rollers.

44. **Passage of Material.**—As the material begins to leave the feed-rollers it comes in contact with a strong current of hot air from a nozzle similar to those shown at *d*, Fig. 18, each nozzle being supplied from the main duct *e*. The current is supplied by a fan and heated by steam pipes situated in the lower part of the machine. The hot air blows through the fibres of the wool, partly opening and drying it, until it is released by the feed-rollers,

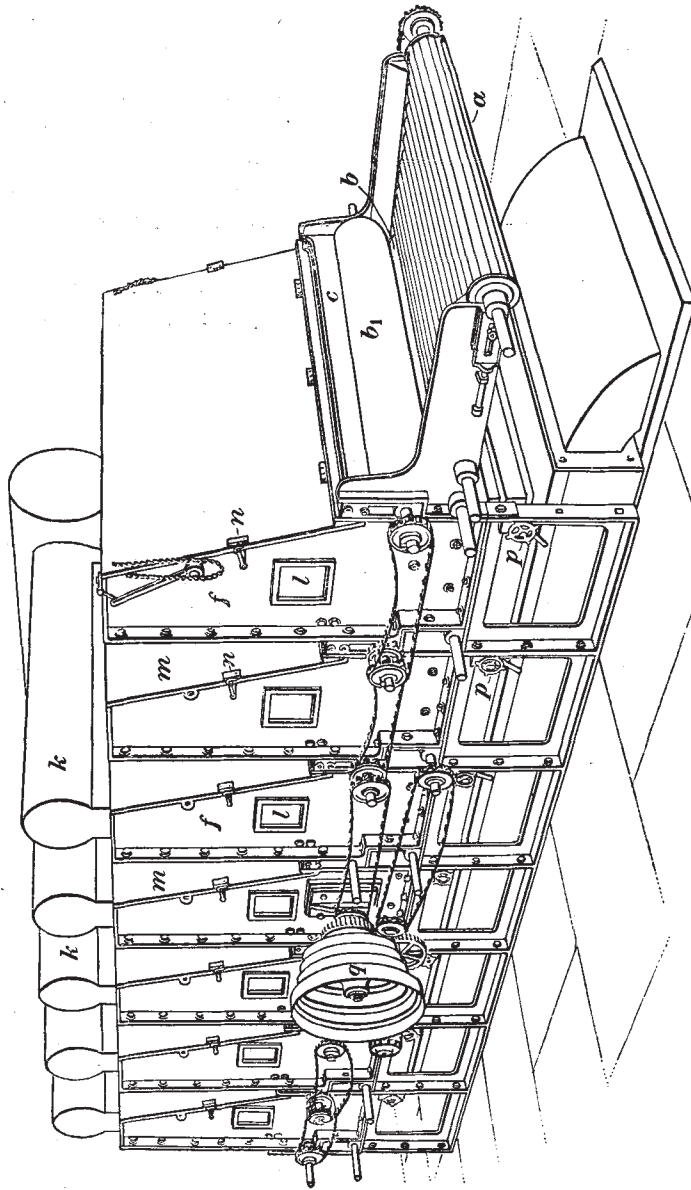


FIG. 17

when the current carries the material up into the chamber *f* in the direction of the arrows, resulting in a further opening and drying. As the air enters the chamber *f* it expands in volume, which results in a decrease of velocity. The material, held suspended by the air, will therefore come down on the left side of the bridge *h* and

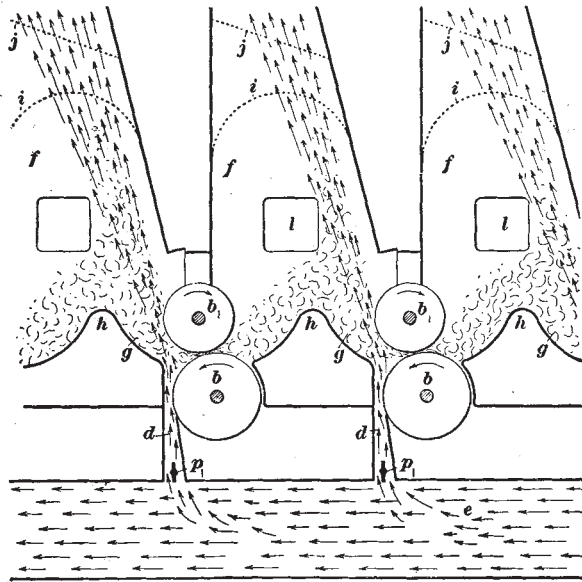


FIG. 18

be transferred by the feed-rollers *b*, *b*₁ to the adjoining section of the dryer. In this manner the material progresses through each succeeding unit until it finally passes out of the machine and is dropped on to the floor or a feed-lattice.

45. Path of Air-Current.—The moisture-laden air passes out at the top of each chamber, which is either open to the atmosphere or to a flue; the air is thus allowed to escape into the atmosphere, or is dried and used again. The plates *i* are perforated and are intended to allow any small particles of dirt or burr matter to pass through. Above the plate *i* is another inclined plate *j* which serves the purpose of stopping any small bits of vegetable matter, etc., that may have passed through the

plate *i*. Extraneous matter which accumulates on these plates is removed at intervals.

The air that is blown through the first two units comes in contact with the wettest wool and takes up the most moisture ; this air, therefore, is allowed to pass entirely out of the machine and into the atmosphere. As the air in the third and subsequent units, or chambers, takes up only a comparatively small amount of moisture, it is conducted back to the fan and heater through the pipes *k*, and is forced through the machine again, supplemented with fresh air, thus saving part of the heat given to it. At each side of the drying chambers is a glass panel *l* through which the interior of the machine can be seen at work. The inclined side *m* of each chamber is hinged at the bottom and can be readily swung back across the **V**-shaped opening between each chamber, so as to give ready access to each chamber for cleaning purposes. It is necessary to vary the force of the air-current to suit various classes of work ; this is done by hand wheels *p* which control valves *p*₁ placed in the nozzles *d*. Any number of sections or drying chambers may be joined together as described, the number required depending on the nature and condition of the material to be dried or the condition in which it is required for the next process.

46. Operation and Production.—The series of feed-rollers *b*, *b*₁, Fig. 17, and the feed-lattice receive their motion from the stepped pulley *q*, the latter being driven by belt from the line shaft ; the speed of the cone pulley shaft can thus be changed from about 35 to 60 revolutions per minute. Sprocket-wheel and chain gearing, which is conveniently arranged on either side of the machine, gives the desired motion to the feed-rollers. The gearing for driving the top feed-rollers is shown in Fig. 17 ; but most of the gearing for driving the bottom feed-rollers and feed-lattice is on the other side of the machine. The time occupied by the passage of the wool through the machine may be regulated by means of the stepped pulley *q* ; the drying action being rather rapid, any portion of the wool is not in the machine for more than 2 to 4 minutes, with the result that as much as from 700 to 1,000 pounds of wool per hour will pass through the machine.

TOMLINSON-HAAS DRYER

47. Construction.— In the Tomlinson-Haas drying machine there is a number of separate units or sections, coupled together, as shown in Fig. 19, which is a front elevation of a machine con-

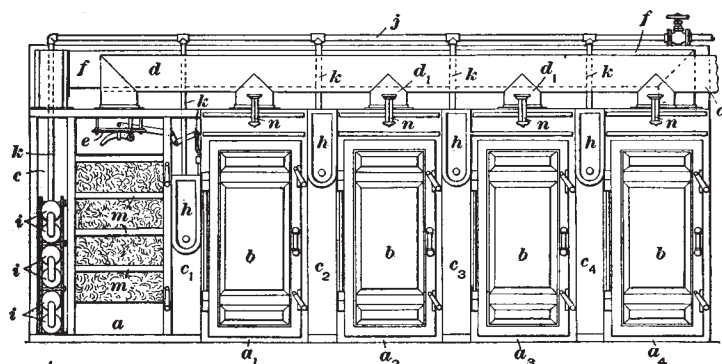


FIG. 19

sisting of five units ; the casing of the first unit is removed for the purpose of showing its interior. A diagrammatic section of the machine is shown in Fig. 20. Each unit consists of an oven *a*

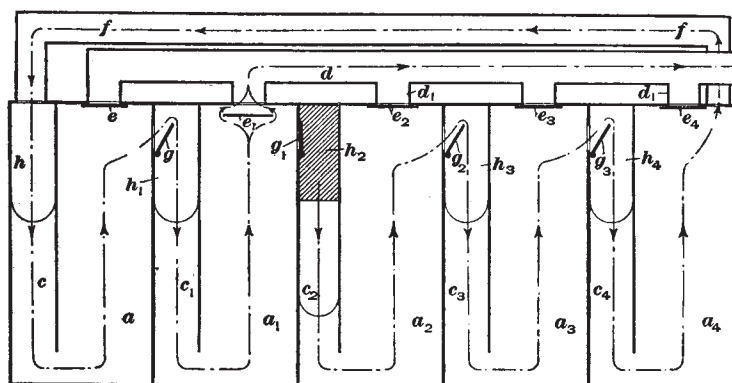


FIG. 20

with a door *b*, the ovens being heated by compartments *c* fitted with steam pipes *i*, Fig. 19. The whole is constructed of sheet

iron or steel covered with some non-conducting material, so as to minimize the loss of heat by radiation. The ovens are provided with four perforated trays m , on which the wet material is placed. Along the top of the machine is a large exhaust pipe d connected to the ovens by branch pipes d_1 ; ordinarily, these branches, excepting one, are closed by means of valves e . Another pipe f connects the top of the unit a with a_4 .

48. At the right-hand side of each oven is a flap valve g , Fig. 20, that opens into the heating chamber c of the adjoining unit, capable of being closed or opened, as required. Near the top of each heating chamber c is a slide h , which, when lowered, as shown in chamber c_1 , Fig. 19, and c_2 , Fig. 20, provides an opening through which fresh air may enter. Each slide h is connected by means of levers with a flap valve g ; thus, when the slide h_2 , Fig. 20, is open, the valve g_1 is closed. The valves g are also connected with the exhaust valves e , so that, for instance, when the valve g_1 is closed the valve e_1 is open. The steam pipes in the chambers c are supplied with steam from the main pipe j through branch pipes k . The ovens a are filled successively, and when the wool is sufficiently dry in the first oven a the trays are removed and replaced by others containing wet wool, and so on throughout the series.

49. **Operation.**—For the purpose of explaining the operation of the machine, let it be supposed that the material in the oven a_2 , Fig. 20, is dry and that it therefore is to be removed and replaced by wet material. The slide h_2 is first opened, as indicated by the shaded surface; its opening results in the closing of the valve g_1 and opening of the valve e_1 . Fresh air will now enter through the opening h_2 and pass through the chamber c_2 into the oven a_2 , through $g_2, c_3, a_3, g_3, c_4, a_4, f, c, a, g, c_1, a_1, e_1$, into the pipe d to the exhaust fan. Fresh air will also enter through the door of a_2 , when it is opened for the purpose of removing the dry material and inserting a wet one in its place. The wet material, which has previously been inserted in the oven a_1 , receives now the combined heat produced by all the heating chambers c_2, c_3, c_4, c , and c_1 . It is seen that the wet material in a_2 , at present, receives the heat only from one heating chamber c_2 . When fresh material

is inserted in the oven a_3 the slide h_3 is opened; then the conditions existing in oven a_1 will be transferred to a_2 and it will receive the maximum heat of the machine, and so on throughout the series. The temperature of the ovens is ascertained by means of the thermometers n .

PNEUMATIC CONVEYERS

50. Purpose of Conveyers.—In the manufacture of worsted yarns, when dealing with fine, short wools, it is the usual practice to dispense with the operation of drying and to card the wool in practically the same condition of moisture as that in which it emerges from the squeeze rollers of the last washing machine, the rollers of which are made specially heavy to give a very dry squeeze. Many mills are now arranging their last washing machine to deliver into the hopper of a pneumatic conveyer, or conveyer, as such a machine is usually termed.

51. Construction and Operation.—A common type of pneumatic conveyer is shown in Fig. 21, in which the material from the delivery lattice a of the last scouring or washing machine drops

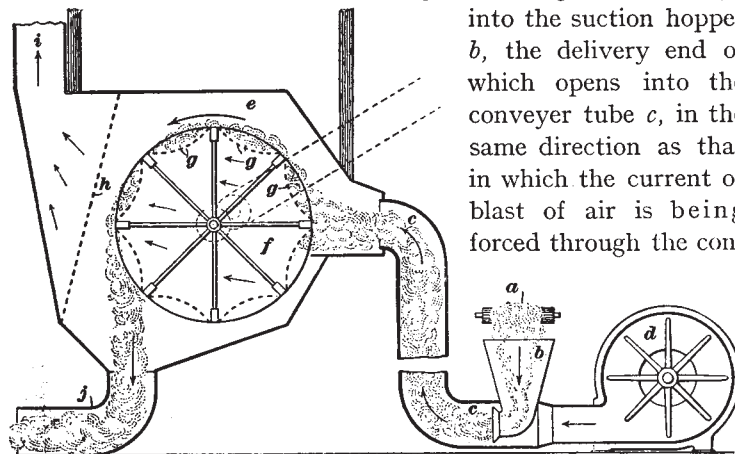


FIG. 21

into the suction hopper b , the delivery end of which opens into the conveyer tube c , in the same direction as that in which the current or blast of air is being forced through the conveyer tube by the fan d . The material is thus drawn into the conveyer tube and is carried along, in the direction indicated by the arrows, by the air-current. The conveyer tube can be

arranged to carry the wool in any direction and to any room in the mill, the wool being dried as it travels through the tube, its dryness increasing in proportion to the distance travelled.

52. The conveyer tube is arranged to deliver into a wooden box *e*, which contains a slowly revolving cylinder *f*; on the circumference of this cylinder are arranged a number of pockets *g*, which are formed of wire netting into the shape shown in Fig. 21. The current of air forces the material into the pockets as the cylinder revolves and subjects it to the drying influence of the warm air. The wool eventually drops from the pockets, the current of air in penetrating the pockets from the inner side of the cylinder assisting in the removal of the material. The air finally passes out into the duct *i* through the grating *h*, which prevents any wool fibre from passing away with the air. A portion of the air passes with the wool through the delivery pipe *j*. The air may be heated by letting it pass through an enclosed heater before it enters the fan.

BURRING AND CARBONIZING

BURRING

BURRS

NATURE AND OCCURRENCE

1. **Formation of Burrs.**—Burrs are the rough, prickly seed-vessels of various kinds of plants, and burr-bearing plants are found in nearly all wool-growing countries. The seed-vessels are covered with either straight or hooked spines, or spikes, that project outwards in all directions, and the sheep, in grazing on and among the plants, comes in contact with the burrs, the spines of which thus become entangled with the fleece. Burrs vary considerably in size and form, but they usually consist of strips or bands covered with spikes. These strips, in the natural state of the burrs, are rolled into spirals, forming flattened, prickly balls, as shown at *a*, Fig. 1, that are of the size of a pea, or smaller. When the burrs are opened out, as at *b*, the strips of spikes are from $\frac{1}{2}$ to $1\frac{1}{2}$ inches long, and they look very much like centipedes. If they occur in this form in the later and final stages of yarn manufacture, they cause serious difficulties. The seeds from an opened burr are shown at *c*.

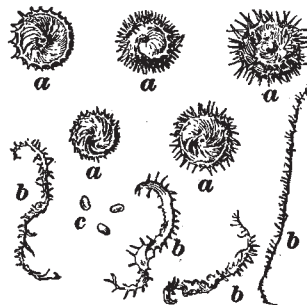


FIG. 1

2. **Burrs in Wool.**—In connection with the manufacture of wool, the term *burrs* includes not only the spiny seed-vessels already described, but also grass seeds, shives, bits of dried grass, and peculiarly twisted spikes from some species of sedge. All these are fairly common, and when wetted in the washing process they open out quite straight. They may thus lie sufficiently parallel to the wool fibres to pass a long way through the processes of manufacture, and even into the yarn or fabric. The quantity of burrs in wool varies considerably, according to the country and district in which the wool is grown, and it also varies considerably in different years, according to the nature of the season. The South American wools contain more burrs than any other, Buenos Ayres merinos being particularly burry. Many Australian wools are of a rather burry character, but not nearly so bad as the Buenos Ayres; in fact, some Australian wools are practically free from burrs, as also are many Cape, New Zealand, British, and most Continental wools. Wools that are very burry are not commonly used in British mills, since British spinners do not trouble to treat such wools. The result is that these wools go to the Continent, where they are dealt with very successfully.

3. **Value of Burr Plant.**—In order to get rid of the difficulties due to burrs, some of the British spinners and manufacturers wished to destroy the burr plant in wool-growing districts by systematic efforts. They quite overlooked the fact that this would react on them in another way. The burr plant, possessing very long roots, penetrates deeply into the ground and is able to obtain moisture in very dry seasons, when almost every other type of herbage is wholly dried up. At such times, therefore, the burr plant forms the principal food of the sheep. After catching on the wool and being torn from the plant, the burrs are gradually worked farther and farther into the wool fibres and thus become extremely difficult to remove.

REMOVAL OF BURRS

4. **Necessity for Removing Burrs.**—If the burrs are not removed from the wool they are broken into innumerable small particles during the operation of carding; these, remaining in

the roving, may make hard bunches, causing the yarn to spin unevenly and to have an irregular, rough appearance, which is characterized as *twitty*. Small particles of vegetable matter thus passing through all of the manufacturing processes and occurring in the cloth are known under various terms as **specks, motes, burls**, etc. These must be picked out by hand ; and in some cases this causes bad holes to be made in the cloth, which must be mended, the mending process being termed *burling*. Vegetable matter will not absorb dye stuffs in the same proportion as wool fibres ; consequently, it is seen on the surface of piece-dyed cloths as specks of a lighter colour. Burrs in the wool are also a great detriment to the carding machinery, as they tend to dull, bend, and otherwise injure the card clothing and also choke up the machine, so that fettling, or cleaning, is necessitated much oftener than would otherwise be required.

5. Difficulty in Removing Burrs.—From what has been said, it will be seen that burrs are matted or mixed up with the fibres and must be torn from them with considerable force, thus necessitating the employment of a burring machine ; in fact, they cling so tenaciously that the burring machine removes a certain amount of wool fibres with the burrs. Another object of the burring machine, although of a secondary nature, is to open the wool and leave it in a more lofty condition for the carding machines. This saves a great deal of unnecessary wear and tear on the card clothing, which would otherwise be strained in opening out bunches of wool that were matted.

6. Methods of Removing Burrs.—There are two distinct methods in general use for removing the burrs, namely, the *mechanical* and the *chemical*. The **mechanical method** consists in the removal of the burrs by means of some form of machine known as a burring machine, the process being termed **burring**. The **chemical method** consists in removing the burrs by means of chemical action, whereby the structure of the vegetable matter is destroyed so that it may easily be shaken or dusted from the wool ; this process is termed **carbonizing**.

7. Choice of Method.—The choice between the chemical method and the mechanical method is often one of individual

fancy, but it also depends largely on the quantity, size, and nature of the burrs present in the wool. If only a comparatively small quantity is present, and the burrs are large, then the best and most economical method would be the mechanical ; whereas, if a very large quantity is present, particularly if the burrs are small and of such a type as to entail considerable wastage of fibre by being passed through a burring machine, then the best method to adopt would be the chemical.

8. Comparison of Methods of Removing Burrs.—Each process of removing burrs has its advantages, and these may be the deciding factors as to the method to be adopted. Burring machines invariably cause a certain amount of breakage of fibre, the amount of breakage made depending largely on the nature of the burrs, and to a less degree on the care taken in setting the burring machine. Also, a certain amount of fibre always clings to the burrs and goes with them as waste ; but if this amount is large, then the burrs may subsequently be carbonized so as to recover the wool. On the other hand, carbonizing, unless very carefully performed, tends to make the wool feel harsh and also to diminish its spinning and felting properties ; but it has the advantage that it does not affect the length of the fibre, and there is practically no breakage or waste of fibre caused in the process.

TYPES OF BURRING MACHINES

SYKES BURRING MACHINE

9. Action of Beater.—The operation of burring usually follows the washing and drying of the wool, as it is impossible to burr greasy wools without loading up the teeth of the rollers and rendering them inefficient. The standard machine in the British woollen trade for dealing with fine and medium wools is typified by the **Sykes burring machine**, sectional views of which are shown in Figs. 2 and 3. The wool is placed on an ordinary feed-lattice *a*, Fig. 2, either by hand or by a hopper feed, and is carried into the

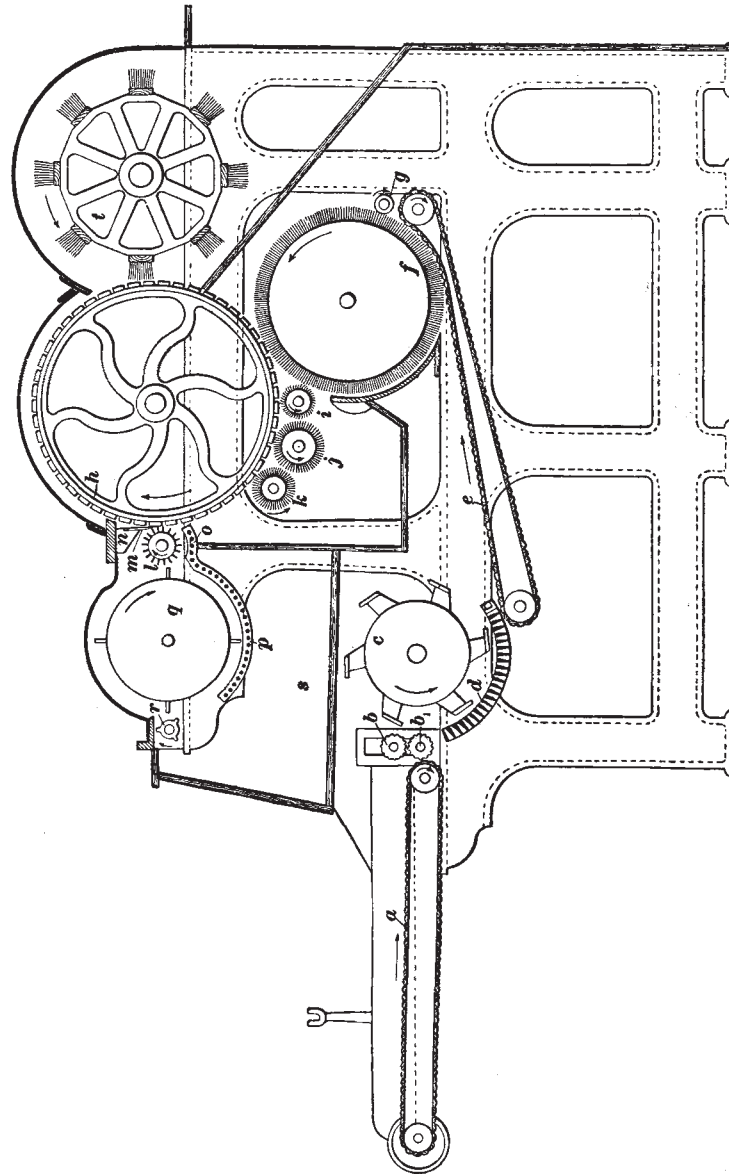


FIG. 2

nip of a pair of feed-rollers b, b_1 that are usually 2 inches in diameter and that revolve at a speed of about 6 revolutions per minute. On emerging from the feed-rollers the wool is struck by the beater c , which is 14 inches in diameter and makes 650 revolutions per minute in the direction indicated by the arrow, and is thus opened out considerably. It is then carried downwards over the grid d , through which a large quantity of the-loosened burrs fall into the box beneath, and is thrown on the lattice e in small tufts.

10. Conveying Wool to Comb Cylinder.—The wool is carried by the lattice e , Fig. 2, to the brush f , which is 18 inches in diameter and revolves at about 15 revolutions per minute. It is covered with long bristles that pick up the wool from the lattice, after which the roller g presses the wool into the brush. As the brush turns, the wool is carried round and upwards and is brought under the action of the comb cylinder h , which is $22\frac{1}{2}$ inches in diameter and rotates at a speed of about 75 revolutions per minute.

11. Construction of Comb Cylinder.—The construction of the comb cylinder is shown in Fig. 3, which is a partial cross-section. There are several wheels, or spiders, h keyed to the cylinder shaft and each has a flange h_1 at its outer circumference. A number of bars h_2 are secured to these flanges by countersunk setscrews h_3 , the bars extending entirely across the face of the cylinder, parallel to its axis. Each bar h_2 carries a brass comb plate h_4 that is secured by countersunk setscrews h_5 and clamping plates, or nuts, h_6 . The brass comb plates also extend over the full width of the cylinder and each has a row of fine needle-pointed pins h_7 , arranged to point in the direction of rotation of the cylinder. These pins are set so that they project very slightly beyond the face of the cylinder and come close to the back of the next bar h_2 . As the comb cylinder rotates, these pins catch the wool fibres and carry them along, and, as the burrs cannot get behind the pins, they are held well above the surface of the cylinder.

12. Clearing of Brush.—The comb cylinder has a greater surface speed than the brush f , Fig. 2, and so takes the wool from

the brush. Any wool or burrs remaining on the brush roller is stripped by the card roller *i*, which is covered with card clothing, is about $3\frac{1}{2}$ inches in diameter, and makes about 107 revolutions per minute, in the direction indicated, having a greater surface speed than the brush *f*. The card roller is set $\frac{1}{8}$ inch from the brush roller and $\frac{1}{4}$ inch from the comb cylinder. The roller *i* in turn is stripped by the brush *j*, which is 5 inches in diameter and makes about 86 revolutions per minute. It is set about $\frac{1}{8}$ inch from the card roller and has a greater surface speed

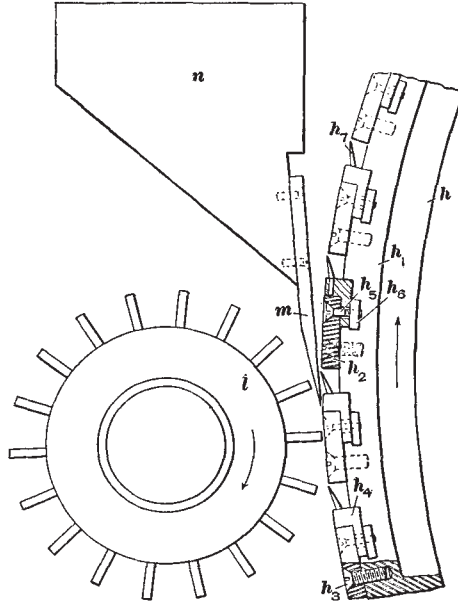


FIG. 3

than the latter; consequently, it removes the wool and the large burrs and knocks them into a box formed in the framework just below. From this box the waste is periodically removed and either put through the machine again or carbonized to recover the wool. The brush roller *k*, which is 4 inches in diameter and makes 15 revolutions per minute, clears the brush *j* of any adhering wool or burrs. Sometimes a beater is used at this point instead of a clearing brush.

13. Action of Comb Cylinder.—The brush *j*, Fig. 2, has a slight action in straightening out the wool on the comb cylinder, being set $\frac{1}{8}$ inch from the latter. After passing the brush *k*, the wool is well laid into the combs of the comb cylinder, the burrs lying on the outside and well down over the bars supporting the combs. In this condition they are brought under the action

of the burr beater *l*, Fig. 3, the beater being 4 inches in diameter and making 1,950 revolutions per minute. It is set very close to the comb cylinder, and so knocks off the larger burrs. Just above the point where the beater is closest to the cylinder is fixed the steel ledger blade *m*, which is supported by the block *n* and extends along the full width of the cylinder. It is set very close to the cylinder, so that, if any burrs get past the beater *l*, they will be swept off by the edge of the ledger blade. Only the smaller burrs reach the ledger blade, as the larger ones are knocked off by the beater *l*.

14. Laying Wool on Comb Cylinder.—The successful action of the burring machine depends largely on the evenness with which the wool is laid on the comb cylinder. If it is unevenly laid, it will be caught by the ledger blade and the fibres will be broken. If the wool is so burry that it cannot be laid well on the comb cylinder, the best plan is to pass it through the machine twice. During the first treatment the burr beater and ledger blade are set well away from the comb cylinder, so that only the larger burrs are removed. During the second treatment the burr beater and ledger blade are set well up to the cylinder, as the material is opened out by going through once, and therefore is easily laid on the comb cylinder. This double burring is seldom necessary, however. The setting of the burr beater and ledger blade in relation to the comb cylinder is done to gauges supplied with the machine, the thickness of the gauges varying according to the class and nature of the wool being burred.

15. Removing Burrs and Wool From Machine.—The burrs detached by the beater *l*, Fig. 2, and the blade *m* are thrown down on to a curved grid *o*, through which many fall. The remainder are knocked back upon the grid *p*, and are acted on by the beater *q*, which is $13\frac{1}{2}$ inches in diameter and makes 360 revolutions per minute. This beating breaks up the burrs and drives them through the grid *p* to a collecting box *s* beneath. A small beater *r* serves to knock off any burrs carried round by the blades of the beater *q*. After passing the ledger blade the wool on the comb cylinder should be clean and free from burrs. It is then carried round until it comes under the action of the brush fan *t*,

which is $20\frac{1}{2}$ inches in diameter and rotates at about 550 revolutions per minute. This brush sweeps the wool from the comb teeth, as its surface speed is much greater than that of the comb cylinder. The rapid motion of the brush and its fan action throw the wool out of the machine into a box at the back.

16. Driving of Beaters and Comb Cylinder.—The driving arrangements of the Sykes burring machine are illustrated in Figs. 4 and 5, which show the right-hand and left-hand sides, respectively. Corresponding parts in both illustrations are given the same reference letters. The main driving pulley c_1 , Fig. 4, is on the beater shaft, and beside it is a loose pulley c_2 to which the belt may be moved to stop the machine, by the use of the lever c_3 operating the guide c_4 . A larger pulley l_1 cast with the pulley c_1

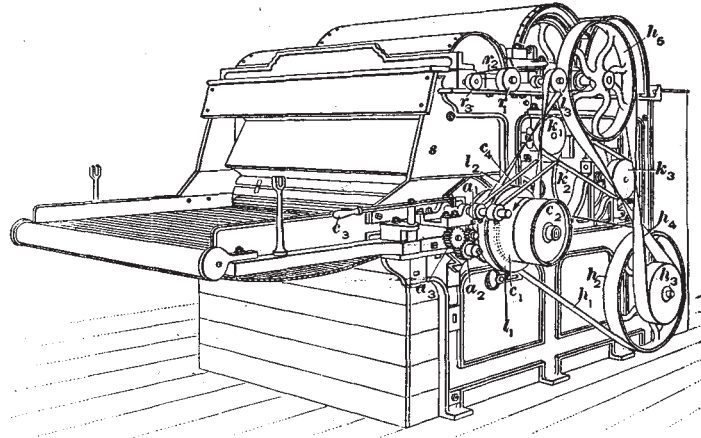


FIG. 4

drives, by means of a crossed belt l_2 , a small pulley l_3 on the shaft of the beater l , Fig. 2. Another pulley behind the pulley l_1 , Fig. 4, drives, by an open belt h_1 , the large pulley h_2 , which is compounded with the pulley h_3 , both rotating on a stud. A crossed belt h_4 transmits motion from the pulley h_3 to that at h_5 , which is on the shaft of the comb cylinder. A pulley q_1 , Fig. 5, on the shaft of the brush fan, gives motion to the burr beater q , Fig. 2, by the crossed belt q_2 and the pulley q_3 on the shaft of the burr beater. On the opposite end of this shaft is a pulley r_1 , Fig. 4,

that, by means of an open belt r_2 , drives the pulley r_2 , which is fastened to the shaft of the beater r , Fig. 2.

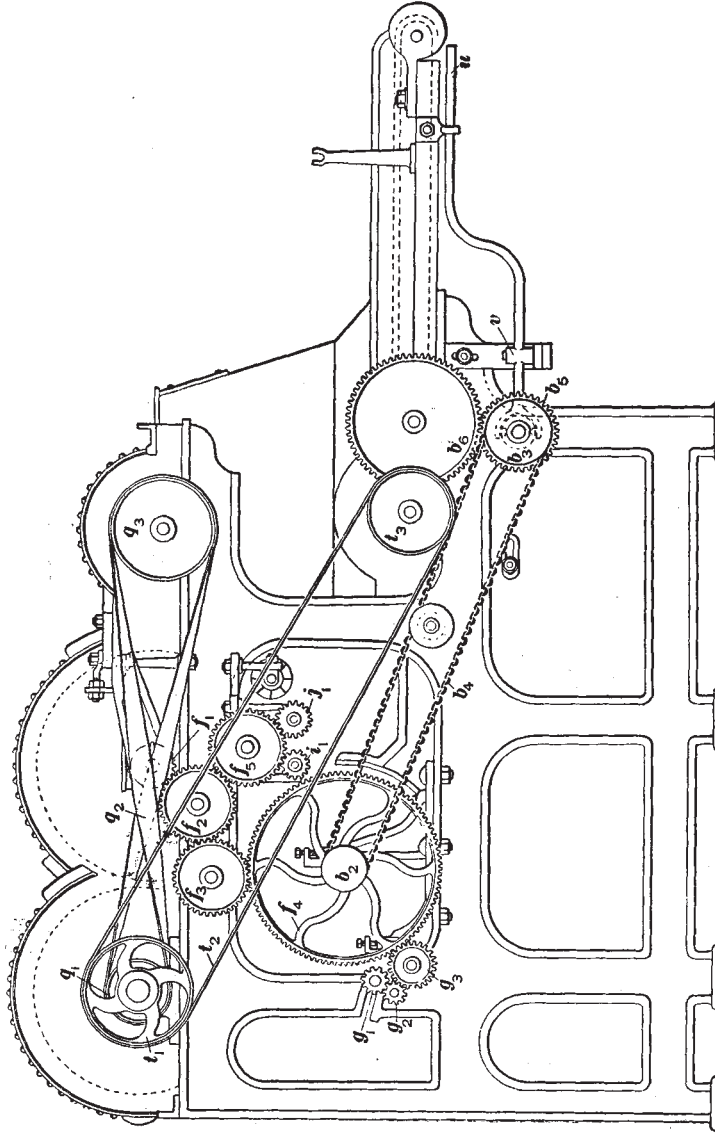


FIG. 5

17. Driving of Brushes and Lattice.—On the shaft of the comb cylinder, at the left-hand side of the machine, Fig. 5, is a gear-wheel f_1 that, through the idlers f_2, f_3 , gives motion to the wheel f_4 on the shaft of the brush f , Fig. 2. The card roller i and the brush j are driven by the wheels i_1 and j_1 , Fig. 5, which in turn receive motion from the wheel f_1 through the idlers f_2, f_5 . The shaft of the clearer k , Fig. 2, carries a pulley k_1 , Fig. 4, that is driven by an open belt k_2 from the pulley k_3 on the shaft of the brush f , Fig. 2. The brush fan t is driven by the pulley t_1 , Fig. 5, the latter being driven by the open belt t_2 from the pulley t_3 on the beater shaft.

18. Driving of Feed-Mechanism.—On the same shaft as the brush wheel f_4 , Fig. 5, is a sprocket wheel b_2 that drives a similar wheel b_3 by a chain b_4 . On the same shaft with the sprocket wheel b_3 , and just behind the latter, is a gear-wheel b_5 that is keyed to the shaft with a feather key. The wheel b_5 drives the wheel b_6 , which is on the shaft of the bottom feed-roller b_1 , Fig. 2. The top feed-roller b is usually driven by frictional contact from the lower, although, if desired, they may be connected by plain gear-wheels, so as to obviate any tendency to slip. The feed-lattice a is driven from a wheel a_1 , Fig. 4, on the bottom feed-roller, through the idler a_2 and the wheel a_3 on the lattice shaft. The shaft of the roller g , Fig. 2, carries a wheel g_1 , Fig. 5, that is driven through the idler g_2 by a pinion g_3 meshing with the gear-wheel f_4 .

19. Stopping Feed to Machine.—Since the wheel b_5 , Fig. 5, is fastened to its shaft by a feather key, it must rotate when the shaft rotates, but by means of the forked lever u , pivoted at v , it may be moved axially along the shaft so as to engage with the wheel b_6 or disengage from it. While in mesh with the wheel b_6 the feed-lattice is kept in motion, but if any of the rollers should become choked, or a part should break, the wheel b_5 could quickly be thrown out of mesh with b_6 , thus stopping the feed-lattice and the supply of material to the machine. The production of a machine of this type, having a comb cylinder 50 inches wide, is from 700 to 1,500 pounds per day of 10 hours, and about $1\frac{1}{2}$ horse-power is required to drive it.

GARNETT BARRING MACHINE

20. Feeding Wool to Machine.—The Garnett barring machine, which is specially adapted for cleaning and barring long, coarse wools, is shown in longitudinal section in Fig. 6. The wool is fed into the hopper *a*, where it falls on the lattice *b* and is carried down to the toothed roller *c*. This roller picks it up and carries it round past the stripping comb *d*, and it is then stripped from the roller by the swinging doffing comb *e* and thrown down on the feed-lattice *f*. The feed-lattice carries it up and delivers it to the feed-rollers *g*, *g*₁, the roller *g*₂ acting merely as a clearer for the roller *g*₁.

21. Action of Toothed Beater.—On emerging from the feed-rollers the wool is struck and caught by the steel teeth on the beater *h*, Fig. 6. These teeth are very strong and are set in wooden battens secured to spiders on the shaft *h*₁. The beater revolves in the direction indicated by the arrow and serves to open out the wool by lashing and combing it while it is still held by the feed-rollers. On being released from the feed-rollers the wool is carried upwards and round past a row of teeth *i* fixed to a plate *i*₁, and extending across the full width of the machine. The teeth *i* mesh with those on the beater, and by the action of the moving and stationary teeth the material is further opened.

22. Picking Cylinder.—Having passed the row of stationary pins *i*, Fig. 6, the wool is next brought in contact with the picking cylinder *j*, which has a number of rows of short, strong teeth that point in the direction of rotation of the cylinder. These teeth catch the wool and draw it away from the beater. Any lumps of wool not caught by the picking cylinder are carried round by the beater and drawn across the grid *k*, this action serving to knock out burrs and further open the wool. The burrs drop through the grid and collect in a chamber beneath, from which they are removed periodically.

23. Garnett Roller.—As the picking cylinder rotates, it brings the wool under the action of the Garnett roller *l*, which is covered with *Garnett wire* and rotates in the direction indicated by the

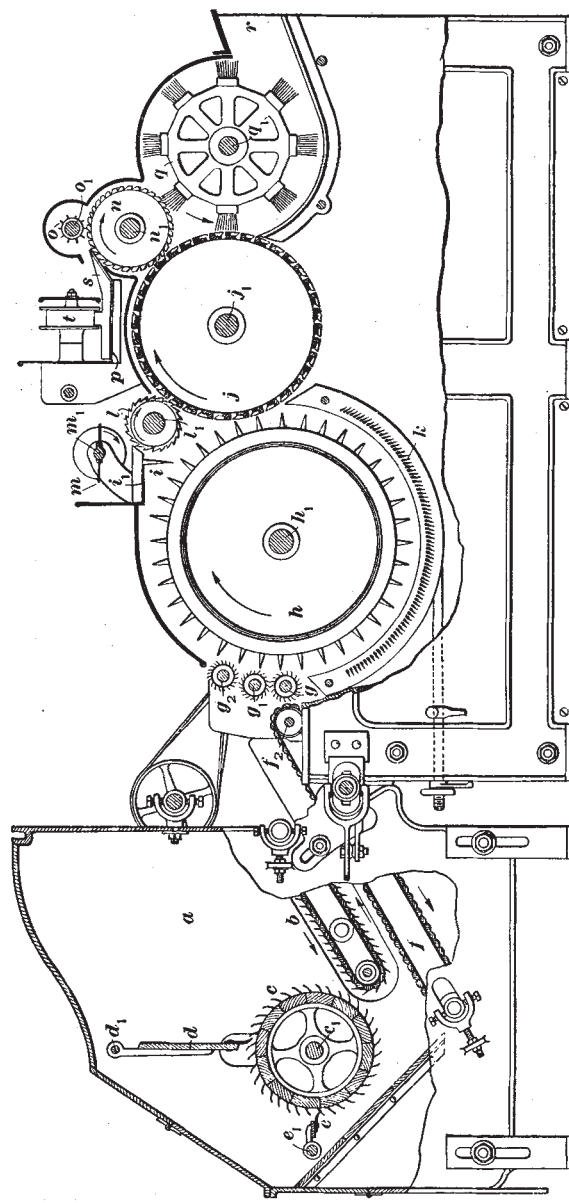


FIG. 6

arrow. The Garnett roller combs the wool on the picking cylinder and knocks off any lumps, throwing them down on the beater, by which they are carried round until sufficiently opened. Any burrs caught by the Garnett roller are carried upwards and are knocked off by the rapidly rotating two-bladed beater *m*. The burrs are thrown into the tray formed in the top of the plate *i*₁ and are removed therefrom at intervals.

24. Burr Roller.—The wool carried past the Garnett roller by the picking cylinder is next subjected to the action of the burr roller *n*, Fig. 6. This roller is covered with flat-topped Garnett wire and revolves in the direction indicated, catching the wool and carrying it round. The wire on the roller is of such form that it holds the wool, but does not allow the burrs to get down below the surface, between the teeth. In this condition the material is brought under the beater *o*, which knocks off the projecting burrs into a tray *p*, while the roller carries the cleaned wool round to the brush fan *q*. The brush fan has a much greater surface speed than either the burr roller or the picking cylinder, and so it strips the wool from both, ejecting it from the machine at *r*. The wool that is stripped from the picking cylinder by the brush fan is clean and free from burrs, as burrs cannot get past the burr roller.

25. Burr Conveyer.—The burrs knocked into the tray *p*, Fig. 6, cannot get back into the machine, owing to the inclination of the edge of the tray. They are removed from the tray by scrapers, one of which is shown at *s*, that are shaped to conform to the bottom of the tray and are attached to a belt. The belt extends across the top of the machine, being carried by two pulleys, one of which is shown at *t*. The scrapers move along the tray, sweeping the burrs toward one end, where a shoot is arranged to carry them off. The scrapers return, upside down, over the tops of the pulleys. The burrs are thus removed continuously while the machine is running.

26. Driving of Toothed Beater and Picking Cylinder.—An elevation of the right-hand side of the Garnett burring machine is given in Fig. 7, a plan in Fig. 8, with part of the cover removed,

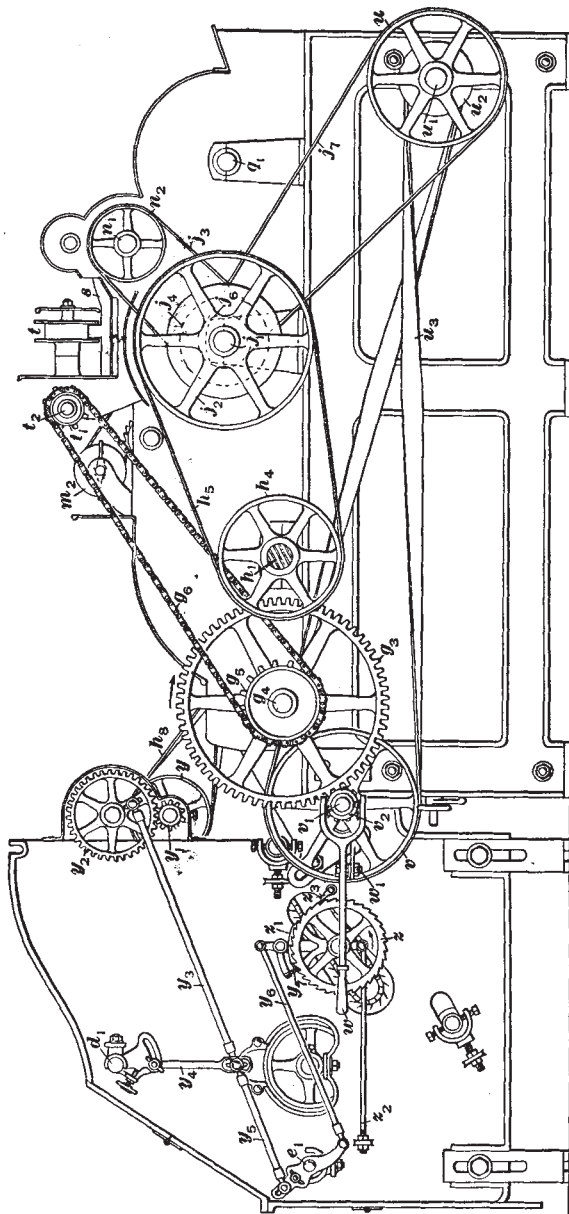


FIG. 7

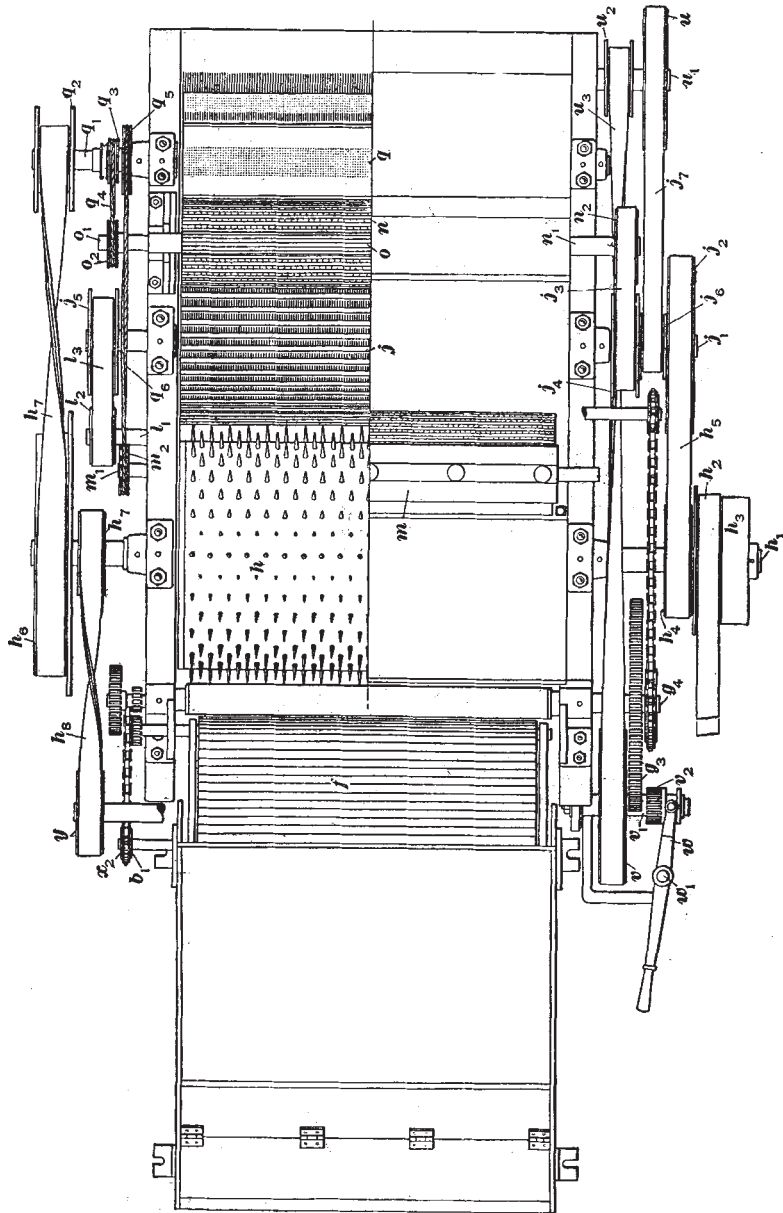
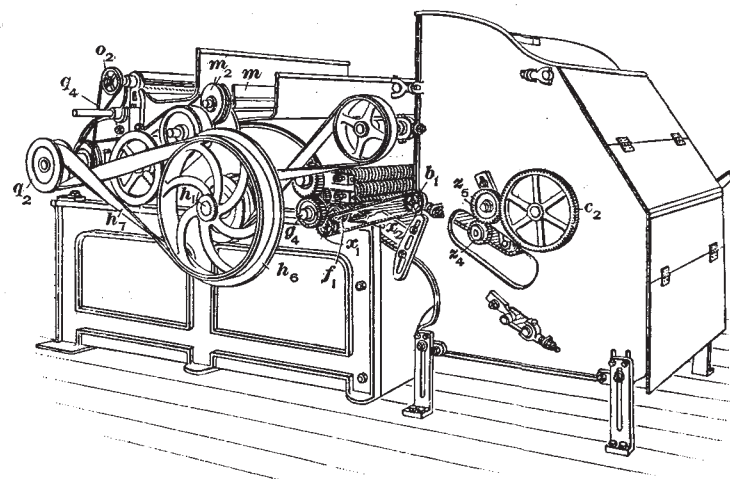
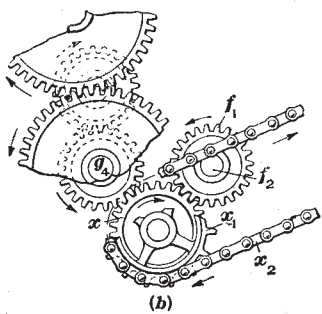


FIG. 8

and a perspective view from the left-hand side in Fig. 9 (a), corresponding parts in these views and in Fig. 5 being given the same reference letters. The driving arrangements of the various parts are clearly shown in Figs. 7 to 9. The shaft h_1 of the toothed beater carries the main driving pulley h_2 , which is fast to it, and



(a)



(b)

FIG. 9

the loose pulley h_3 , to which the belt may be moved to stop the machine. A third pulley h_4 , keyed to the shaft h_1 , drives, by means of the open belt h_5 , a pulley j_2 keyed to the shaft j_1 of the picking cylinder. The sizes of the pulleys are such that the surface speed of the picking cylinder is about half that of the toothed beater.

27. Driving of Burr Roller and Beaters.—The shaft n_1 , Figs. 6 to 9, of the burr roller carries a pulley n_2 driven by an open belt j_3 from a pulley j_4 on the shaft j_1 of the picking cylinder. As the driving and driven pulleys are of nearly equal diameters, the surface speed of the burr roller is about 80 feet per minute, which is about half that of the picking cylinder. The brush fan q has

a shaft q_1 carrying a pulley q_2 that is driven by a crossed belt h_7 from a pulley h_6 on the beater shaft h_1 . On the shaft q_1 is a rope pulley q_3 that, by means of a crossed rope q_4 , drives the pulley o_2 on the shaft o_1 of the burr beater o . Another rope pulley q_5 on the shaft q_1 carries a crossed rope q_6 that gives motion to the pulley m_2 on the shaft m_1 of the beater m . The shaft l_1 of the Garnett roller l carries a pulley l_2 that is driven by an open belt l_3 from a pulley j_5 on the shaft j_1 .

28. Driving of Feed-Mechanism.—The feed-mechanism of the Garnett machine shown in Figs. 6 to 9 is driven from the shaft j_1 of the picking cylinder. A pulley j_6 on this shaft gives motion to an open belt j_7 that drives the pulley u on the stud u_1 . Compounded with the pulley u is a pulley u_2 that, by means of the crossed belt u_3 , drives the pulley v on the short shaft v_1 . A pinion v_2 is so arranged on this shaft that it may be moved sidewise, but must always rotate with the pulley v , the sidewise motion being given by the forked lever w , fulcrumed at w_1 . When the pinion v_2 is out of gear with the wheel g_3 , as in Fig. 8, the supply of wool to the machine is stopped, since the wheel g_3 on the driving shaft g_4 of the bottom feed-roller g also drives the remainder of the feed-mechanism. The feed-rollers g_1 , g_2 are driven from the bottom feed-roller g through the several gear-wheels shown behind and above the end of the shaft g_4 , Fig. 9.

29. At the left-hand end of the shaft g_4 , Fig. 9 (*a*) and (*b*), are two pinions, the smaller of which, at its under side, meshes with a small idle wheel x that is compounded with a sprocket wheel x_1 . The pinion f_1 on the upper shaft f_2 of the feed-lattice f meshes with the wheel x and is thus driven from the bottom feed-roller. A chain x_2 that runs on the sprocket wheel x_1 transmits motion to a sprocket b_1 on the upper shaft of the lattice b , thus driving this lattice. A pulley h_7 on the shaft h_1 drives a crossed belt h_8 that runs on the pulley y , to the same shaft with which, but at the opposite side of the machine, is keyed a pinion y_1 driving the gear-wheel y_2 . The wheel y_2 in rotating gives a reciprocating motion to the rod y_3 , and this motion is transmitted by the rods y_4 and y_5 to the shafts d_1 and e_1 , thus giving an oscillatory motion to the stripping comb d and the doffing comb e .

30. The reciprocating motion of the rod y_3 , Fig. 7, is communicated to the rod y_6 , thus rocking the arm carrying the ratchet y_7 and giving intermittent rotation to the ratchet wheel z in the direction indicated by the arrow. A sheath z_1 , covering a part of the circumference of the ratchet wheel and adjustable by the nuts at the end of the rod z_2 , determines the number of teeth to be moved at each stroke, while a pawl z_3 prevents the wheel from rotating in the wrong direction. The shaft carrying the wheel z passes through to the opposite side of the machine and at the opposite end is fixed a pinion z_4 that, through the idler z_5 , drives the wheel c_2 on the shaft c_1 of the toothed roller c . In this way the roller c is given a slow rotary motion.

31. Driving of Burr Conveyer.—On the end of the shaft g_4 , Fig. 7, is keyed a sprocket wheel g_5 that drives the chain g_6 . This chain in turn drives the sprocket wheel t_1 attached to a short shaft t_2 that at its other end carries a small bevel gear-wheel. The bevel wheel on the shaft t_2 meshes with another bevel wheel on the shaft carrying the pulley t , and in this manner the pulley t is caused to rotate, thus driving the belt carrying the scrapers s by which the burrs are removed.

32. Settings of Garnett Burring Machine.—The principal adjustments for adapting the Garnett burring machine to different classes of work are as follows: The toothed beater h , Fig. 6, is fixed, but the feed-rollers may be adjusted so as to vary the lashing and opening of the wool due to the action of the beater. The picking cylinder j seldom requires any adjustment in relation to the beater, but the Garnett roller l must be carefully set to the cylinder. This is done by having adjustable bearings on the roller shaft, the positions of which may be altered. The bearings are held in position by bolts that pass through fixed lugs on the frame of the machine. Gauges are used to obtain perfectly even settings across the full width of the machine. The burr roller n and the beater o are supported by bearings that may be adjusted in relation to the picking cylinder and the brush fan. The brush fan is carried in adjustable bearings and may be moved slightly toward the cylinder and burr roller as the brushes wear down.