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WOOL CARDING

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BY

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PREFACE

PRACTICALLY the whole of the matter in the following pages has already appeared in the form of serial articles in *The Textile Manufacturer.*

It is the hope of the author that in the present permanent form, this exhaustive work on "Wool Carding" will fill a gap in technical textile literature.

Much of any merit that the book may possess is due to Mr. A. Whitworth, Barkisland, and the author takes this opportunity of thanking him for his most valuable assistance.

Thanks are also due to all the machine makers who have so kindly supplied drawings, prints, and information.

J. B.

Halifax, 1920.

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WOOL CARDING

CHAPTER I

RAW MATERIALS USED IN THE WOOLLEN AND WORSTED TRADES

INTRODUCTION.—In order to understand fully the processes through which the various kinds of raw material used in the woollen trade pass, it is necessary that their chemical composition, physical structure, and characteristics be understood. Since wool, however, is not the only material used in the woollen trade, fibres other than wool must also be considered, particularly cotton. Therefore, though the wool fibre will be considered in detail, a brief description of cotton and silk will be given. In the production of mixed yarns and union cloths, the manufacturer must have a knowledge of all the materials which may be used, so that the characteristics of each component in the yarn and cloth may be brought out, or subdued, as required.

CLASSIFICATION OF FIBRES.—All fibres used in the production of textiles may be divided into three broad classes, according to their origin—namely, *animal*, *vegetable*, and *mineral*. The most important classes are the two former, and the latter may be dismissed at once by remarking that it includes gold, silver, asbestos, and glass-wool. Probably the most important of these is asbestos, the fibres of which reach a length of from 2 to 4 in., and are spun into yarn which is whitish-grey in appearance, and which is woven into cloth that is used principally for places and purposes where a fabric of a non-combustible nature is required, as for theatre safety-curtains, etc. Gold and silver are occasionally used in the manufacture of twist yarns for better-class tweed cloths.

ANIMAL FIBRES.—The most important fibres to a student in the woollen branch of the textile industry are those included under the heading of animal fibres. The principal member of this class is wool, which is obtained from sheep. Other notable fibres are silk, which is the product of the silk-worm; and many other wool-like hairs, the principal of which are: mohair, which is the product of the Angora goat that now inhabits Asia Minor, Cape Colony, and the United States; alpaca which is obtained from the alpaca goat, an animal found in South America; cashmere, which is the product of the Tibetan goat; vicuna, obtained from the vicuna (this animal also inhabits South America). The hair from the camel and kangaroo is also used.

Mohair more closely approaches wool in structure than the hair of any other animal; it is disposed in long silky staples and possesses a lustre comparable with that of silk. The staple averages from 6 to 8 in. in length, the fibre is fine, and has a good development of serrations. It is used for ladies' dress-goods, and the manufacture of pile fabrics, especially plushes, as the pile made from it is very durable.

Alpaca is very lustrous, the scales hard, and closely attached to the fibre, which makes it rather difficult to dye a permanent colour. Its natural colour is white, brown, or black; staple from 8 to 12 in.; and strong and silky to handle. It is used in the manufacture of linings, and all kinds of ladies' dress-goods.

VEGETABLE FIBRES.—The principal vegetable fibres used in the woollen trade are cotton, obtained from the cotton plant, and ramie, rhea, or china grass.

COMPOSITION AND STRUCTURE OF WOOL FIBRE.—The most important fibre is wool. This fibre is cylindrical in shape, and is composed of cells of various forms and sizes. The kind of cells which compose the bulk of the fibre are, roughly, spindle-shaped. The exterior cell-walls of the fibre are composed of scales, termed serratures, which are formed by cells shrinking; serratures vary considerably in size in different classes of wool. The length and diameter of the wool fibre varies greatly; its diameter may be anything from $\frac{1}{500}$ to $\frac{1}{1500}$ part of an inch, while its length may be anything from about $2\frac{1}{2}$ to 20 in. Wool is generally white, though it may be brown, fawn, black, or other colour. Some wools are very lustrous and bright, while others have practically no lustre.

A property which can be said to be peculiar to wool is its capacity to felt.

In appearance wool is curly or longitudinally wavy, and grows in the form of locks, which are termed staples, each of which is composed of a large number of individual fibres. When a wool fibre is examined under a microscope its surface appearance is seen to be similar to that illustrated in Fig. 1.

Fig. 1.

The chemical composition of wool fibre is as follows—

Constituents.	*Per cent.*
Carbon	51·05
Oxygen	21·05
Nitrogen	17·71
Hydrogen	7·58
Sulphur	2·61

The constituents of wool are not constant, and a definite chemical formula cannot be given; its composition, however, may be said to be $C_{42}H_{157}N_5SO_{15}$; it may also be classed as a proteid, known as keratin.

COMPOSITION AND STRUCTURE OF COTTON FIBRE.—The cotton fibre, when seen under a microscope resembles a twisted ribbon, and is seen to possess well-defined walls, with thickened and more or less upturned edges. These walls form a distinct cavity in the centre of the fibre, the cavity having the appearance of a flattened tube. In a good class fully ripe cotton fibre there are as many as two hundred turns or twists per inch; it must be noted, however, that these turns are not all in the same direction. The cotton fibre has generally an excellent colour, and spins remarkably well, and is the fibre which is most used for mixing with wool to help the latter to spin to a fine count, or to give strength to the yarn. The average composition of raw cotton is as follows—

Constituents.	*Per cent.*
Cellulose	91·38
Hygroscopic water	7·32
Wax and fat	0·56
Nitrogen (protoplasm)	0·63
Ash	0·11
	100·00

The chemical formula of cellulose, the principal constituent of cotton, is $C_6H_{10}O_5$, while it consists of—

Constituents.	*Per cent.*
Carbon	44·2
Hydrogen	6·3
Oxygen	49·5
	100·0

Composition and Structure of Silk Fibre.—Silk fibre, when seen under the microscope, appears to be almost transparent and like a small glass rod, and probably has fewer surface features than any fibre. The fibre is chemically a combination of two substances, which are termed respectively fibroin and sericin. Sericin, which is also termed silk glue, forms from $\frac{1}{3}$ to $\frac{1}{2}$ of the whole fibre, and is the exterior portion of the fibre; its composition is as follows—

Constituents.	*Per cent.*
Carbon	42·6
Hydrogen	5·4
Oxygen	35·5
Nitrogen	16·5
	100·0

The chemical formula is $C_{15}H_{25}N_5O_8$.

Fibroin, which forms $\frac{1}{2}$ to $\frac{2}{3}$ of the whole of the fibre, and is the interior portion, may be composed of—

Constituents.	*Per cent.*
Carbon	48·8
Hydrogen	6·2
Oxygen	25·0
Nitrogen	20·0
	100·0

Its formula is $C_{15}H_{23}N_5O_6$.

NATURE AND GROWTH OF WOOL FIBRE.—Wool is a growth on and from the skin of the sheep. The skin of a sheep consists of

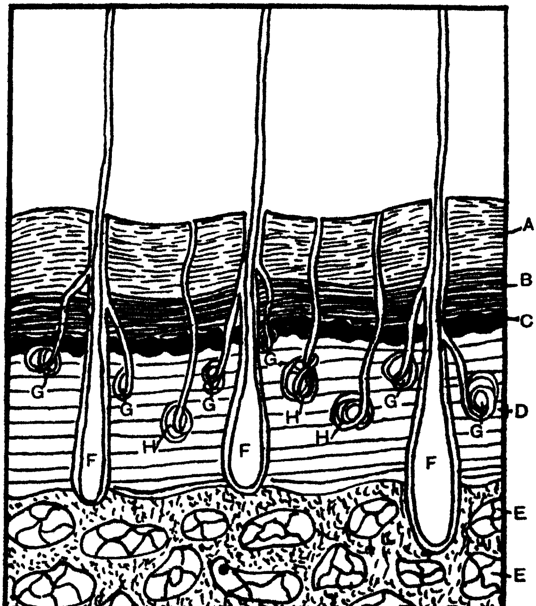


FIG. 2.

four layers, as shown in Fig. 2, which is a diagrammatic section of the skin as it appears when highly magnified. The two layers A and B are termed the scarf skin or cuticle, and the rete-mucosum respectively, and together form that part of the skin which is termed the *epidermis*. The two succeeding layers C and D, which are respectively the papillary layer and the corium, form what is termed the *dermis*.

The cuticle is the outer skin, and consists of more or less flattened horny scales; it is tough and without feeling. The rete-mucosum, which is the next layer, has a distinct cellular structure. The third layer—that is, the papillary layer—is between the rete-mucosum and the corium, and extends into both in the form of small elevations and depressions. It is very sensitive, since the nerves and blood-vessels end in this layer. The corium, which is the fourth layer, is composed of less dense connective tissue, but is closely connected with the layer above it. In the corium lie the bodies of the sweat glands, the bases of the hair follicles, larger blood-vessels, and adipose cells or lobules of fat E. The most important features of the corium are the *hair follicles* F, which are cavities in the skin, and it is in these cavities that the wool or hair fibres are formed.

Other important features are the *sebiparous, sebiferous*, or *sebaceous glands* G, one or more of which join each hair follicle. These glands secrete a kind of oil, which is excreted into the follicle and eventually to the surface of the skin. The secretion gives the hair or wool an oily softness, and keeps the skin moist and pliable. *Sweat, sudoriferous* or *sudoriparous glands* H do not join a hair follicle, but conduct the sweat which they secrete to the surface of the skin. The fibre is formed by the exudation of plastic lymph from the capillary plexus at the root of the follicle; the lymph changes until it forms cells, which become elongated and formed into the central structure of the wool or hair.

The cells which ultimately form the fibre receive their sustenance from the sebaceous glands, which, as previously stated, draw a kind of oil from the skin. This oil greases the outer cells, and prevents them from irritating the nervous lining of the follicle as they pass upwards through the skin. The fibre is actually formed by a fluid contained in the cells evaporating, as the cells force their way out of the skin. This causes the cells to collapse. The shrunken cells form the serratures or imbrications, since as the cells leave the skin they shrink, and the part shrinking first, forms a point which covers the base of the preceding one, and as the remainder shrinks in turn it forms a base over which the next cell laps in forming for itself a point; in this way a continuous fibre is formed, since the cells adhere.

The wool fibre is formed of three distinct portions, as shown in Fig. 3, which is a section of a wool fibre highly magnified. In the centre of the fibre forming the axial portion are the medullary cells A. These form what may be termed the pith of the fibre, and are only present in coarse, strong fibres. The medullary cells are surrounded by cells termed corticle cells B, which form the principal portion of the fibre. These cells are elongated, and are, generally speaking, spindle-shaped. Enclosing the whole of the corticle cells is a layer of flattened horny cells C, which form the outer covering of the fibre, and give it the appearance, when seen in plan, of a column formed of a large number of cups with serrated edges, each cup being placed in the mouth of the one beneath it, as shown in Fig. 1.

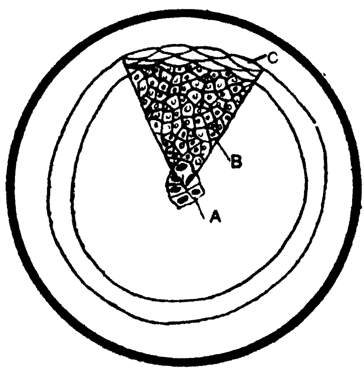


FIG. 3.

PHYSICAL PROPERTIES OF WOOL.—The most noteworthy physical properties of wool are its capacity to felt; its softness, fineness, serrations, strength, elasticity, waviness, colour, lustre, length, and hygroscopicity. The characteristic of wool which is most unique, and a property that is not possessed to any appreciable extent by any other textile fibre, is its capacity to felt.

FELTING.—Felting may be said to be the matting and interlocking of the fibres together. It is best brought about by the application of heat, moisture, and pressure. The effect of hot water to which a lubricant has been added on the dry cells composing the fibre is to cause them to become soft and swell, and by submitting the fibres to pressure while in this state the cells are compressed, and individual fibres forming the yarn and cloth are amalgamated to such an extent that the fibres and threads can only be separated from the mass with difficulty. The cells when they again become dry do not resume their former positions, but shrink into each other more and more. Felting is facilitated by the natural waviness of the fibres and by the serrations they possess; in fact, the value of any wool with regard to its felting property is dependent upon the character, number, and strength of its serrations.

An important condition affecting the capacity of any yarn to felt is the arrangement of the fibres constituting the yarn; if all the fibres were arranged parallel, with the tip of every fibre pointing in the same direction, felting could only be brought about with difficulty. It is this arrangement or disposition of the fibres, together with the natural oil or grease which fills the serrations, that prevents the wool felting on the sheep's back. In the manufacture of woollen yarns which have to be woven into cloths that have to be milled or felted the fibres are arranged in the yarn so that their tips point in all possible directions. By this arrangement the serrations of contiguous fibres fit into each other and interlock. A fabric which is thin and open in texture, when made from a good felting wool, can be felted until it becomes a dense firm cloth, and so wool is used for many purposes for which no other textile fibre is suited.

Softness and Fineness.—The softness and fineness of wool vary principally with the breed of the sheep, but they are also influenced by the rearing, whether skilled and careful, or otherwise. The quality of softness is in great demand by buyers of cloth, and in consequence it is important that the raw material should possess a soft handle. It may be said that short wools are fine and soft, while long wools are coarse, wiry, and harsh. This must not be taken as a fixed rule, since many long wools are fine and soft, and many short wools the reverse. It may be noted that to spin a fine count of yarn it is absolutely essential to use wool possessing a fine fibre. Many of the finest wools reach a diameter of $\frac{1}{2000}$ in.

Serrations.—The number of the serrations on the fibre of any wool, as previously stated, is of great importance; hence the greater the number of serrations the greater the value of the wool as a felting wool. Again, it may be said, and perhaps with greater accuracy with regard to serrations than with reference to softness and fineness, that the longer and coarser the wool the fewer are its serrations per inch. Some of the best fine wools have as many as 2800 serrations per inch.

STRENGTH AND ELASTICITY.—Strength and elasticity are properties of first importance if cloth of the highest grade must be made. Such cloth must possess strength, and a full, soft, kind, elastic, and lofty handle. The best price and sale cannot be obtained for cloth, however tasteful in design, which has a "boardy" feel and does not possess the above qualities in a large measure. The breaking weight and the elastic limit vary greatly in different samples tested; the elastic limit is usually reached upon the fibre being stretched from 0·25 to 0·6 per cent. of its length, and the maximum weight that a single wool fibre will support is about 1·2 oz. There is no doubt whatever that the strength and elasticity of wool help greatly in the manufacture of the spun yarn, and it is only necessary to compare a cloth made from pure wool, strong and elastic, with one made from, say, a blend of a cheap wool substitute and cotton, to demonstrate conclusively the importance of these two properties.

WAVINESS OR CURLINESS.—The waviness or curliness of wool is a factor which should not be underestimated, since this property affects not only the elasticity of the wool, but also its felting power. From wool, the fibres of which are naturally curly, it is possible to spin a finer yarn possessing a more compact or round thread, and one composed of fewer fibres in its cross-section. The very finest wools have as many as thirty waves per inch, while long lustrous wools have as few as one per inch. It may be assumed from this remark that the number of waves per inch is an indication of the fineness of the wool. Such an assumption, however, would not always be correct, though in the majority of cases it would serve.

COLOUR.—Wool is usually white, though quantities of brown, black, grey, and yellow wool are produced. In certain seasons, for particular purposes, one or more of the coloured wools may be in great demand, and will in consequence be valuable; but, speaking generally, the whiter the wool the greater is its value. The colour of the wool is influenced to a certain extent by the herbage on which the sheep feed; the sheep which are fed on good, rich grasslands usually produce wool possessing a good colour. It is essential that wool for making yarns which have to be used for white goods or that require to be dyed brilliant colours should possess a good natural colour, as it is impossible to get the best and purest colours from dingy yellow material.

LUSTRE.—This property is possessed by wool in a far greater degree than by cotton, but in a less degree than silk, and is directly dependent upon the size and smoothness of the horny scales that surround the fibre; thus, when the scales are large and lie flat and close to the fibre, they reflect the light, and so possess a much more lustrous appearance than when they are short and protrude from the fibre, and in consequence cut up the light. This property of lustre is important, since it gives a bright, fresh, and most desirable appearance to the wool. Wool from sick or dead sheep is not nearly so lustrous as wool from good healthy sheep.

LENGTH OF STAPLE.—Length of staple is of importance, but the value of this property varies according to the purpose for which the wool is to be used; since for the manufacture of worsted yarns it is of greater importance than for the manufacture of woollen yarns. Wools are classified as long and short stapled, as the length of staple varies greatly with the breed of the sheep, and may be anything up to 18 in.

HYGROSCOPICITY.—The hygroscopic property of wool, or its capacity to absorb and retain moisture, is a very valuable characteristic, especially for dyeing purposes. Wool will readily absorb water to as much as 40 per cent. of its weight if allowed to remain for a considerable time in a damp atmosphere. The standard regain, or that percentage of moisture added to the absolutely dry material to make the percentage of moisture acceptable to both buyer and seller, is 16 per cent. Occasionally in the mill wool becomes so dry as to contain less than half 16 per cent., in which case it is liable to become electrified, resulting in the necessity for provision being made so that carding, spinning, and weaving rooms can be artificially humidified as required.

DEFECTS IN WOOL.—A common defect in wool is the occurrence of *Kemps*, which are very bright straight hairs that appear to be diseased or dead wool fibres. They are found chiefly in fleeces obtained from neglected or indifferently bred sheep, though they also occur in the best-class fleeces. They have a glazed appearance, and are usually short, though they may be as long as 2 in., and when seen under the microscope the usual surface features of a wool fibre are not nearly so marked, and the serrations appear to have run into each other.

It must be noted that kemps, when allowed to reach the spun yarn, stand out, and do not form a part of the yarn as do the ordinary wool fibres, and are merely held in the yarn by the other fibres. Further, it is impossible to dye kemps the same shade as ordinary fibres, since they will not absorb the dyestuff nearly so readily; thus a cloth made from very kempy wool has a very speckled appearance. Cloths have been manufactured with a speckled appearance due to kemps as their principal characteristic, but usually kemps have an adverse effect on the value of the yarn and cloth. The colour of kemps is usually white, though in dark-coloured fleeces they are often black. On the sheep kemps are generally found about the neck and legs, since they occur principally where the wool merges into hair. Kempy sheep can be greatly improved by careful breeding and skilful rearing.

TENDER STAPLE.—A defect termed tender staple is often found in wool obtained from sheep that have been neglected for a certain time or which have suffered from drought. This defect manifests itself in a correspondingly thin and weak place in the wool where its growth has been influenced. The general soundness of the fibre is also deteriorated in a fairly large measure by the sheep being indifferently cared for and exposed to bad weather. Wool from old sheep appears to be as fine as that from younger sheep of a similar breed, but it is weaker and tenderer. Another defect is found in fleeces taken from sheep reared in wild and cold localities, and is known as *Cots*. These are hard or matted lumps of wool which can only be opened with extra labour and many broken fibres. Some wools are liable to be very dirty and burry. *Burrs* are rough prickly seed-carriers, which become attached to the fleece whilst the sheep is feeding. They are usually about the size of a pea or smaller, and when opened out are seen to consist of narrow strips with protruding spikes or points. The strips are usually from $\frac{3}{8}$ to $1\frac{5}{8}$ in. long. There are many types of burrs, but they are generally of the above form. In many cases they drop out during the operation of carding, unless previously removed by either chemical or mechanical means. Should they be allowed to reach the final stages of yarn manufacture the percentage of waste will be increased and a very defective yarn will result.

CAUSES OF VARIATION.—The causes of variation or difference between wools are of a four-fold nature—namely, the breed of the sheep, the climate in which they are reared, careful and skilful rearing, and food. The breed of the sheep is the most important factor, since each breed of sheep grows wool that is quite distinct in character. There are now large quantities of wool obtained from cross-bred sheep, which produce wool of a character corresponding to the amount of blood of each breed that enters into the composition of the sheep. Climate has a great influence on the character and quality of the wool, and local conditions affect, favourably or otherwise, the class of wool grown. A warm though temperate climate is distinctly favourable to the successful growth of the finest wools, while a hot and dry climate greatly assists in the production of thin, harsh, hairlike, and wiry wool.

A climate which is cold and damp favours the growth of long and lustrous wool. Careful and skilful rearing has a considerable effect on the wool grown from any breed of sheep, since by great care in breeding, and so on, the wool can be much improved. The nature of the food on which the sheep feed has an appreciable effect on the wool, as is attested by the fact that wool from sheep which graze on rich pasture land is much softer and cleaner than wool from sheep which graze on sandy soil.

CLASSIFICATION OF WOOLS.—The general practice is to divide all wools into three classes—namely, short wools, which are up to 4 in. long; medium wools, which are from 4½ to 6½ in. long; and long wools, which are about 6½ in. long and upwards. This division of wools is a practical and necessary one, as will be understood when it is stated that different machinery and different adjustments are required for each class. The wools in the latter class are practically all used in the worsted trade, but the wools belonging to the two former classes may be used in the manufacture of either woollen or worsted yarns.

BRITISH WOOLS.—A large proportion of the British wools that are used in the manufacture of woollen yarns belong to the medium class, and include the clips obtained from the South Down and the Cheviot breeds. The wool from the former is fine, close, wavy, and elastic, with a tendency to harshness, but it cannot be included amongst the best felting wools, though it is an excellent wool from which to manufacture hosiery, flannels, tennis and other cloths which do not require to be heavily felted. The wool obtained from the Cheviot breed of sheep is not so fine as South Down, but it is nevertheless a valuable wool, being soft and elastic, of good length, good colour, and sound growth.

There are large quantities of crossbred wool obtained from sheep that are a cross between the native breeds of most of the wool-growing counties in the south and middle, and some of the northern, districts of England, and pure-bred South Down or the Lincoln and Leicester breeds. The Lincoln and Leicester breeds are natives of Lincolnshire and Leicestershire, and the wool can only be grown true to type in the counties named, or in the neighbouring counties of Yorkshire and Nottinghamshire. These breeds grow very long, strong, and lustrous wool; its length often reaches as much as 20 in. As a consequence of the crossing of the native breeds with South Down, the wool is a little coarser in fibre and longer in staple than the South Down.

Considerable quantities of wool are obtained from sheep which are reared in the wild mountainous districts of the British Isles. The wool is of medium length, and contains large quantities of kemps; it is lacking in fineness and waviness, and is of a hairy character. It is principally used in the manufacture of flannels, serges, and goods of a like character.

COLONIAL WOOLS.—The most important of the Colonial or foreign wools as to both quantity and quality are those grown in the Australian Colonies. Australian wools are principally of the merino class, though large quantities of the crossbred wools are grown which are obtained from sheep that are bred from merino sheep crossed with Lincoln or Leicester rams. There are also certain quantities of long wool obtained. The principal Australian wools are Port Philip, Sydney, Queensland, West Australian, and Adelaide. Port Philip or Victorian wools are amongst the best grown, and the fleeces of short staple are highly prized by the best-class woollen spinners, since their felting properties are almost unrivalled. The wools from Sydney or New South Wales are also excellent felting wools, but are sometimes deficient in colour and strength, which is probably due to the climate being hotter and dryer than in Victoria; they are, however, soft and elastic. When the wool is deficient in colour it precludes its being dyed into light delicate colours. Queensland wools are not as good-class as either of the two former, the climate being drier and hotter, which results in the herbage not being so good; hence the wool is deficient in elasticity and strength, though it is soft in handle, and its colour, when scoured, is excellent. West Australian or Swan River wools belong to the merino class, but are inferior to the foregoing, and are of rather coarse but sound growth. They are in a general way somewhat similar to Southdown wools. Adelaide or South Australian wool belongs to the merino class, and is of average quality, being sound in growth, but dirty, with sand and excessive yolk. It is better in general character than West Australian, but inferior to Port Philip or Sydney; its length is not uniform, and its colour is not exceptionally good, though it is a moderately good felting wool.

Tasmanian and New Zealand wools are similar to the Australian wools, and are principally of a merino or crossbred class. The wool from Tasmania is excellent in quality, since the climate and pasturage are very good for the growing of wool. The wool is clean, possesses a relatively long and strong staple, will mill remarkably well, and is fine in fibre, and has a bright white appearance. It is, in short, equal to the best. The merino wool from New Zealand is much coarser in fibre than Port Philip merino, though its colour and milling property may be said to be all that can be desired.

As has previously been noted, large quantities of crossbred wool are now being exported from Australasia, and especially is this the case with regard to the wool exported from New Zealand, as about 80 per cent. is crossbred. The details of the crossbred wool vary according to the breeds which have been crossed, and possess characteristics akin to the breeds crossed. Such wool is classified into come-back or extra-fine, fine, medium, and coarse. This classification is a practical one, since the character of the wool varies according to the amount of merino blood in the crossbred sheep.

Cape wools are obtained from South Africa, and are principally of a merino class; they are fine in fibre, but there is a tendency to unsoundness, and they are deficient in strength and elasticity; their capacity to felt is somewhat limited, but they are noted for their good colour.

FOREIGN WOOLS.—The principal foreign wools that should be noted are South American, Russian, and Asiatic. South American wools, the best known of which are Buenos Ayres and Monte Video, are of a merino class, and possess a fine fibre, but are lacking in uniformity, strength, and elasticity, and in consequence of the two latter defects are deficient in milling property; they are very burry, greasy, and dirty, but when the burrs have been removed and it has been cleared of grease and dirt, they are satisfactory wools for a variety of purposes. Monte Video wool is the finest of the South American wools. Two other less known South American wools are Punta Arenas and Falkland Islands wools, both of which are coarser, more tender, and more kempy than either of the former, and the Falkland Islands wool is lower in quality than Punta Arenas. It should be noted that large quantities of crossbred wool are also exported—probably as much as 60 per cent. The best known and most important Russian wool is that known as Odessa; it possesses a strong staple of medium fineness, and has a remarkably good colour. Asiatic wools are all either coarse or medium, and are generally badly bred and very dirty. Persian wools are coarse and possess a medium to long staple, colour generally white, and are fairly sound. East Indian wools are usually coarse, short, and kempy, and are often yellow in colour.

SKIN WOOLS.—Increasingly large quantities of skin or slipe wools are being used. This wool is obtained from the skins of slaughtered sheep, which are collected, classified, and sold to firms whose business it is to remove the wool from the skin, or pelt. In British practice the most common method is thoroughly to soak the skins in water and rub the flesh side with lime and water; the skins are then placed in pairs with the flesh sides together until the roots of the fibres are destroyed, when the wool can be fliped or sliped; consequently such wools are known as "slipe" wools.

A method which finds favour in the Colonies is that in which sodium sulphide is used in place of lime-water, and as this substance has no deleterious effect on the wool, it is a much more desirable method than the British, as the lime has a bad effect on the wool, and must be removed or neutralised by some means prior to scouring, to avoid a considerable loss in soap and the production of an insoluble lime soap. The method, however, which is by far the largest used, and which gives the best results, is that known as "sweating," which is practised on a large scale at Mazamet, in

France. Skins from all over the world find their way to Mazamet. The secret of their great success in this business is said to be due to a large supply of soft water. The skins are steeped in large tanks of water and sufficiently agitated to remove a large percentage of the grease. They are next submitted to the operation of sweating, and in this the skins are hung in a room which has a temperature of about 180° F., the effect of the temperature being to open the hair follicles and thus free the wool fibres. It is of the utmost importance that the skins should not be subjected to the operation of sweating for too long or too short a time, or the wool will be damaged. The wool is dried after sweating, either in the open air or by other suitable means. A new method of removing the wool from skins is by using a platinum wire which is electrically heated; it is as yet but little used. It is obvious, however, that with reasonable care the wool will not be injured except for the burnt ends, and that the skin will be in good condition.

WASTE AND REMANUFACTURED WOOLS.—In addition to the different varieties of wool which have been previously noted, very large quantities of materials which may be termed wool substitutes are used. These consist of wool which has passed through some or all of the processes of manufacture. The different classes of wool substitutes, starting from pure wool, may be broadly classified as follows: (1) Noils; (2) waste; (3) new mungo and shoddy; (4) old mungo and shoddy.

NOILS.—These are pure wool which is short in staple and which has been combed from the material of average staple which forms the combed sliver or top. They possess characteristics exactly similar to the wool from which they have been combed, and are short and curly, but generally are a trifle finer in quality. It must be noted that in the operation of combing the noil out of the wool, all burrs, seeds, and other vegetable matter, as well as neps, are also combed out and pass out of the machine along with the noil. These impurities are removed by carbonising, and a good, clean, and pure wool material is obtained which is particularly useful in the manufacture of woollen yarns, since the shortness of the fibres may be considered as an advantage. As a matter of fact, noils differ but little from the pure wool; they are sold under a quality number—as, for instance, 44's, 50's, 56's, etc.—in exactly the same way as the top. Noils may be divided into four classes, according to the wool from which they have been obtained: (*a*) Botany noils, which are obtained from the finest wools, and which are very fine and soft, and are seldom more than $\frac{3}{4}$ in. long. (*b*) Crossbred noils, which may be had in a large number of qualities. (*c*) English or lustre noils, which are of course much coarser than the preceding. (*d*) Noils obtained from the combing of hair, as alpaca and mohair; the principal characteristics of these are their brightness and lustre. There is still another class of noil, which is always in a coloured state, since it is obtained from the combing of tops which have been previously both combed and dyed; it is always known as recombed noil. This class of noil commands a high price, as it is practically free from all vegetable matter, neps, or oil; as it has been previously combed, the fibres composing the noil have a greater average length, and are in a much more open condition. Its quality is generally Botany or fine crossbred, since recombing is only practised in the manufacture of high-class worsted yarns. The merchants, upon receiving the noils from the combers, sort them carefully and match the shades, and even make shade cards.

WASTE.—As in the case of noil, which may be said to be a by-product of the operation of wool combing, so is there a by-product of the spinning and weaving processes, which is known as waste, and which in the woollen trade is valuable. Waste that is made by the spinner is classified into two kinds—viz., hard and soft. Soft waste is made during those processes when the material is in sliver and roving form, and has therefore little twist in it. The best of this kind of waste is that known as roller laps, and is formed by ends breaking down in the drawing and lapping round the rollers until it is pulled off and pieced. This particular kind of waste is very valuable, since it is clean and well-combed material; when it happens to be coloured it is sorted, and the shades are matched, as with recombed noils. A lower quality than the above is that known as brush waste, which consists of the light fibres brushed from the machines, to which are usually added dirty roller laps. A still lower quality is the floor sweepings. Hard waste—or, as it is often termed, thread waste—is a by-product, or the waste made in the operations of twisting, winding, warping, beaming, and weaving, and the waste made in the first three operations named is clean. Individual threads must, however, be opened or reduced to a fibrous mass by a Garnett machine before it can be used as a wool substitute. There are several varieties of weaver's waste: (*a*) That which is made in the operations of beaming and dressing, and which consists principally of hard bunches of ends that must be broken up into a fibrous mass either by a rag machine or by a Garnett knot-breaker; (*b*) clean weft that has been taken out of the cloth or "pulled back" as a result of some imperfection in the cloth, or weft pulled off the bobbin ends, or spoiled bobbins; (*c*) loom sweepings or fly which is swept from under the looms, and which is dirty and consists of "fud" or refuse and thread; (*d*) small pieces of cloth, such as tabs, thrums, piece ends, etc., which may be either in the grey or have been finished, and which must be "pulled"—that is, made into a fibrous mass by the rag machine—before being used again.

Mention must be made of the spinning and weaving wastes made in the woollen mill, of which there are many kinds. That which is found under carding machines is termed "short"; after being well shaken it may be blended with other materials to form a lower quality, or, as is done by some firms, sold to shoddy or oil extractors. The fettlings from the cards form another class, when the blends being carded are good wool blends, since the fettlings from swifts are very light and can be put with the short, or through the wash-bowls. All condenser and sliver waste, which is waste made at the carding machines, is put back into the hopper of the automatic feeding machine. The waste made at the mule is of two kinds—untwisted, which is soft; and twisted, which is hard. The former may be put back into the hopper and the latter put with the hard waste. All weaver's waste in a woollen mill is, of course, hard; but since it is woollen yarn, which is softer than worsted yarn, it is easier to break up or open out into a fibrous mass than worsted, and a rag machine will in most cases open it sufficiently.

Mungo and Shoddy.—These terms are given to the fibrous material which results from disintegrating rags of all descriptions, whether they have been made from worsted, woollen, or mixed materials. The wool material which is reclaimed is used in low-woollen trade. Technically, mungo and shoddy are two distinct classes of material; the former is the result of "pulling" or grinding milled rags, while the latter is obtained from rags that have not been milled. In practice this classification cannot be said to hold good, since on the one hand all rags of a Botany quality (that is, cloths made from merino and similar wools) are used in the mungo trade; while, on the other hand, rags of a crossbred and English quality are used by shoddy manufacturers. In some districts they are both termed shoddy; in others they are termed mungo; hence local usage affects the application of the two terms.

When it is noted that the mechanical arrangement of the fibres in the yarn, augmented by the twist and the interlacing of the threads in the cloth, results in a very complicated structure, it will be seen that the operation of disintegrating, tearing, or pulling the rags into a fibrous condition must of necessity be very severe. The consequence is that the average length of the fibres constituting the cloth is greatly reduced, and the individual fibres are broken, crushed, and torn, which results in the serratures being considerably damaged. There is in addition a certain amount of damage due to the cloth having been worn. It will be readily understood that mungo and shoddy will neither felt nor spin as well as the original material. Generally speaking, however, they are similar to the original material in appearance and quality, but are softer in handle than the same quality of wool, since they are less elastic.

Mungo and shoddy have also a more dingy appearance, and can seldom be obtained in the white state, as the wool or cloth is usually dyed before being finished.

Purchasing Materials.—British wools are often bought direct from the farmer, but a practice which is gaining ground is for the farmer to send his wool to the local fair or auction. In some cases the farmer sends his wool direct to a firm which buys it regularly from year to year. In either case the terms are cash, and the buyer must provide his own sheets, and pay the cost of carriage and of packing the wool. The sheep are usually washed prior to shearing, the latter operation being carried out in May or June. On reaching the warehouse the wool is carefully classed, separate classes being made from rams' fleeces, lambs', hogs', and wethers'. These classes are further classed into selected or pick; normal or average; and cast or inferior. Separate classes are also made for coloured, kempy, cotty, and damaged fleeces.

Large quantities of Colonial wool are bought and sold by auction at the London wool sales, there being six series of sales each year, each series of sales extending over a period of about three weeks. The tendency is, however, for the buying and selling to be done at the centres of production, some of which are Adelaide, Brisbane, Melbourne, and Sydney for Australia; while for New Zealand, Wellington and Christchurch may be cited. The terms on which wool is bought at the London sales are net cash within fourteen days. A fairly large proportion of Cape wool finds its way to London, but a fair amount is sold at Port Elizabeth and other centres.

Large quantities of South American wools are sold at Buenos Ayres and Monte Video; while a smaller proportion is sold at Liverpool. The bulk of the Asiatic wools is sold at Liverpool, there being six series of sales each year.

Colonial wool is shipped in three states or conditions—viz., greasy, scoured, and fleece-washed. By far the largest proportion (probably about 70 per cent.) is shipped in a greasy condition—that is, just as it is clipped from the sheep—and no washing is done prior to shearing. The remainder is shipped in either a fleece-washed condition (that is, when it has been washed on the back of the sheep), or in a scoured condition (in which case it has passed through a complete scouring process). The advantages and disadvantages of shipping the wool in these three states are many and various. By shipping it in a greasy condition the wool is softer in handle and easier to sort; it works better in the subsequent processes, and it is possible to supervise the processes from beginning to end, which is a distinct advantage; it is also possible to reclaim valuable by-products from the operation of washing. The principal disadvantages are: Increased cost of carriage, which is considerable when it is noted that the yield of clean wool in the case of merino fleeces is only from 40 to 50 per cent., and even less; the wool is difficult to judge as to yield, and the presence of an excess of earthy impurities tends to discolour it. When the wool is imported in the fleece-washed state, a fair proportion of the impurities is removed by washing the sheep a few days before shearing, and in consequence the yield can be more easily estimated; the wool tends to keep a better colour, which results in a better colour after scouring; there is also a certain saving in carriage. There are the disadvantages, however, of the wool not being so soft in handle, and the by-products resulting from scouring are lost. Wool imported as scoured, or in the fully washed state, has the advantages of a good colour, and further shrinkage, if any, is small. The cost of carriage and subsequent scouring is reduced to the minimum. The disadvantages in this connection are, that the scouring is usually done cheaply and very indifferently, and a further operation of scouring is necessary when the wool reaches the mill; but in some cases, and for some purposes, the wool can be used without being again washed; the fleeces are broken up and rendered more difficult to sort, and the wool does not work so well, and consequently more waste is made.

Rags are generally purchased at auction rag-sales which are held weekly at Dewsbury and Batley, though in some cases they are either bought direct or through a broker. Before reaching the manufacturer the rags very often pass through the hands of the travelling rag-gatherer, the rag-dealer, and the rag-sorter, while imported rags usually pass through several hands prior to reaching the merchant, broker, or auctioneer in Batley or Dewsbury.

CHAPTER II

SORTING

SORTING WOOL.— The sorting of wool is the operation of separating the different grades or qualities on each fleece. This operation is necessary since the wool varies considerably in different parts of the same fleece. If no sorting were done, the yarns would be very irregular, and when woven, especially if the cloth had a light warp and a dark weft, the yarns would in some places appear thick and full, while in others they would appear thin almost to the point of disappearing. Further, yarns of fine count cannot be spun from material in which fine and coarse fibres are indiscriminately mixed together. Thus the different qualities found on one fleece are sorted and kept separate, and are used to make different classes of yarn. The number of sorts made depends upon the condition of the fleeces as to regularity of growth, and as to whether they have been skirted or britched. Another factor is the variety of the goods being made; as, for instance, a mill running on coarse goods would probably make only two or three sorts, while a mill making fine cloths and several other grades would probably make as many as six sorts. Where only two sorts are being made, the fleeces are simply heavily skirted—that is, the edges of the fleece are thrown out; but where three or four sorts are required, first, second, third, and fourth qualities are made, the latter quality being the britch. It must be noted that the extent of the practice of sorting is diminishing, since the operation is both expensive and slow, and the reasons already given militate against too many qualities being made. Then there is always the attendant expense of working up each sort separately, which is an item that should receive careful consideration.

OPERATION OF SORTING.—The operation of sorting is performed by a person known as a wool-sorter, and the trade can only be learnt by long experience, since the sorter can only acquire the requisite sensitiveness of touch and good judgment by long practice and familiarity with different kinds of fleeces. He judges the wool by its handle as regards its softness and fineness; though the position of the wool on the fleece, and its appearance, greatly influence his judgment. The sorter, in commencing to sort a fleece, unrolls it on a wire-covered bench; and as the fleece is often tied up with a piece of string, care must be taken to remove every portion, as no vegetable matter must be allowed to get into the wool and pass forward, since, after dyeing, the vegetable matter would show clearly, as it will not take dye in the same manner as wool. The fleece, however, is often tied up with a twisted portion of itself, which obviates any such danger. In cold weather it is often difficult to open the fleeces, due to the natural grease solidifying, and the fleece consequently becoming stiff and hard, this being assisted by the pressure exerted in packing. When this is the case it is necessary to warm the fleece in an oven and start the grease, which renders it soft and pliable. Upon unrolling the fleece the sorter shakes it vigorously to throw off all loose straw, knots, dirt, etc. It is then divided down the back along the natural division, so as to handle more easily, after which the sorter clips off all tags, tar, or paint marks. The different sorts are made according to handle; soundness of staple and elasticity; fineness of fibre; density; and uniformity of length. The finest fibre on a fleece is found on the shoulders and sides, and is separated from that found on the flanks and lower parts of the animal, which is much coarser and harsher in handle. All black and discoloured staples are separated from the white and thrown into a separate basket to be used in the manufacture of dyed yarns of a dark shade. Kempy locks are also most carefully sorted out of every grade. No definite boundary lines exist between the different qualities, as they merge into one another, and a sorter from the same pile of fleeces can make three or four qualities, or seven or eight, according to instructions. Most sorts or qualities are obtained from British fleeces.

Sorting South Down Fleecf.—The sorter, after opening, dividing, and shaking a South Down fleece, will commence to remove all tags, thorns, and other extraneous matter, and, beginning at the haunches, Fig. 4, will throw the britch A, and other strong parts that show a britchy tendency, into a separate skep. Next, all skirtings, which consist principally of the belly pieces B, are separated and thrown into another skep. The belly pieces are finer near the forelegs than the back legs. Many locks from about the breast, which are poor and tender in quality, are also put with the belly pieces. Another quality is made from the parts near the britch, which is at the rear or back of the fleece C; this quality is subdivided into white, grey, and discoloured. The remainder of the fleece, and by far the largest part, is sorted into two qualities, the best of these being obtained from and near the shoulders D; while the part of the fleece shown at C is good, but the wool does not lie so

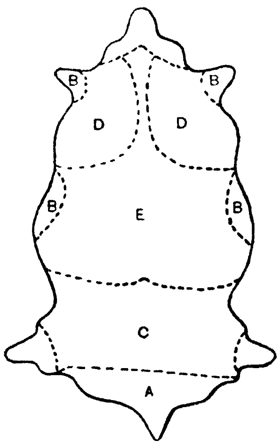


FIG 4.

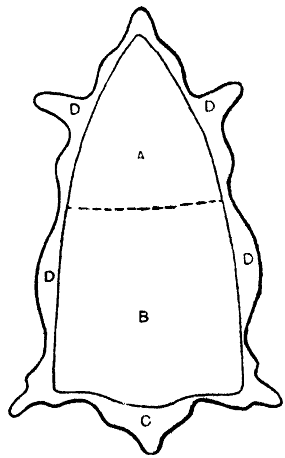


FIG. 5.

close and even. When kemps occur, which is very seldom on South Down fleeces, they are generally found in the britch and near the breast.

SORTING MERINO AND CROSSBRED FLEECES.—Merino and crossbred fleeces require very little sorting; and as they are clean, evenly grown, and well classed, the qualities are not so numerous. On a well-skirted merino fleece there is very little britch. It is not uncommon to set apart the parts at and near the shoulders, if they appear to be of a superfine quality, for some special purpose. Usually, however, only two qualities are made besides the britch, as shown in Fig. 5, where A is the first quality and B the second, while the britch is shown at C. The parts of the fleece shown at D are the skirtings. Skin wools are dealt with in a similar manner to ordinary fleeces. It is noteworthy that the wool-sorter does not name the different qualities in accordance with the name of the part of the sheep on which they are grown, nor is there throughout the trade any standard or uniformity in naming. The following are the most common terms used: Britch or breech, which is the strongest and coarsest part of the whole fleece, is from the haunches. Abb is from the hind legs, is short, and of little value. Downrights, which is fine in fibre, short, and liable to contain black and grey hair, is obtained from the neck. Seconds includes the best locks from the breast and the lower portion of the sides. Super is from the middle of the sides and shoulders. Choice and prime are clipped from the middle of the back and sides respectively. The best and choicest wool is obtained from the shoulders, and is termed picklock.

Sorting Rags.—In the first sorting the rags are divided into three sorts—viz., those which consist of all wool, those which consist of wool and cotton or some other vegetable fibre, and those which consist of vegetable fibre alone. The different sorts of mungo and shoddy that can be made are as numerous as the different varieties of cloth, which are practically endless; however, only the principal sorts will be noted. The first two sorts, which have already been noticed, are the only ones that are used in the woollen trade, and a further classification may be made in accordance with the structure of the cloth: thus, all knitted or hosiery fabrics form one sort; all woollen cloths form another; while all worsted cloths form still another sort.

Sorting Knitted Goods.—Knitted fabrics, or stockings, as they are usually termed, comprise stockings proper, jerseys, scarfs, underwear, and all descriptions of knit goods. This sort is further sorted into four distinct qualities, the term "quality" here referring to the fineness of the fibre. The finest of the four sorts is composed of the Berlins, or Botany, qualities, which are made from fine merino wools, and forms a high-class mungo. The next finest quality is made principally from stockings, and includes all between 44's and 56's quality. The Scotch or medium quality comes next, and it is in this quality that the greatest bulk of the stockings are made; while those below 24's quality are generally imported rags, and are termed Russian. This class is almost unique in that the goods of which it is composed have been worn in an undyed state, and consequently the rags are of a white or natural grey colour. The four qualities that have just been noted are further subdivided into various classes of shoddy.

The best classes of shoddy in the Scotch or medium are obtained from worsted yarns, which yield a sound, wavy, and long-fibred material. When stockings have been made from woollen yarns, the material used in their manufacture may have contained a fairly large percentage of shoddy, and consequently the shoddy obtained from such stockings will be inferior as to length, elasticity, and general appearance. Included in the Scotch quality are angola stockings, made from mixing wool and cotton in various proportions; also a class which is similar in appearance to the best Scotch quality, but which is obtained from worsted and cotton yarns. The cotton in this class precludes its use for any goods except fairly low class. If the cotton is removed by carbonising, the reclaimed wool can be again used in fairly good blends.

Sorting for colour is a very important matter in rag-sorting, and a very extensive range of shades and colours is made. All rags containing black are sorted from those containing no black, and even blacks are classified into two classes—viz., a dead black and a faded black,—the former being more valuable than the latter, since re-dyeing is not required. There are many classes made from shades of blue, such as indigo blues, best blues, etc. Separate classes are made from most light colours; the value of each such class depends very largely on the character of the shade that they can be satisfactorily dyed, as the lighter and purer the shade they will take the greater is their value. All rags that contain mixture yarns or solid colours arranged in fine narrow stripes which cannot be readily separated and classified according to colour, form a separate class, since they can only be used for purposes where a dark shade is required. Many further classifications may be made when required, for instance, the tops of stockings may be cut from the feet to form a higher class than the latter, as the former are considerably less worn.

Sorting Woollen Rags.—Rags made from woollen yarns are obtainable in great variety, and include rags from cloths as widely different in character as Cheviot and Donegal suitings on the one hand, and beavers and doeskin and other face-finished cloths on the other hand. Woollen rags often contain quantities of remanufactured material, and this itself tends to increase the number of varieties in this class. However, woollen rags may be divided into three qualities—viz., coarse, medium, and fine. The fine quality comprises all face-finished cloths, such as beavers, pilots, and meltons. This quality forms the real mungo of the trade, and is short in fibre compared with proper shoddy. It is one of the easiest to sort, and mills fairly well, being fine in fibre. The medium quality is made up mainly of medium-class tweed cloths, which are sorted into light and dark; while the coarse quality is made up principally of homespun suitings made from Donegal and other homespuns, including Harris tweeds and similar cloths. This class is always coarse and kempy in character, and in fancy colours. It is seldom, if ever, that self-coloured cloths are found. Flannels are sorted as to colour, since in this case the lighter colours can be dyed into delicate shades, and consequently command a higher price than the darker shades. The coarser bits are usually sorted from the rest, and low-class flannel forms a distinct class. All kinds of flannel, whether fine or coarse, are made into shoddy, since it is never milled to such an extent as to warrant its being classed as mungo.

Sorting Worsted Rags.—Worsted rags are sorted into three leading qualities—viz., fine, medium, and coarse. The fine quality consists principally of worsted coatings, such as those used in the manufacture of dress-suits and like purposes. The further sorting of this class is not elaborate, since all are made into one class of superior mungo, except bits that are too much off shade; and those with seams—or, in other words, those with any cotton thread in—are sorted out. The medium class is made up of dress and suiting serges, and other worsted dress goods. The worsted dress goods form a distinct class from the serges, and in this case all rags which contain cotton or silk, are separated from those containing only wool. The all-wool class is next sorted for colour, and a large number of different shades can be obtained, varying from black and various shades of blue to cream and white. The light colours command a better price than the darker shades. The serge class is a very large one, and again in this class all those which contain cotton are separated from those without. Sorting for colour is usually a simpler matter in this than in the immediately preceding case, since the larger proportion of these are black or some shade of blue. Separate lots are made of black, indigo, and navy; and all faded bits, and bits that are off shade, form still another class. A kind of serge which should be noted is that which is made from worsted warp and woollen weft; although the weft is woollen, this kind of serge is usually classed as worsted, and is sorted as such according to colour. It is cheaper than pure worsted, and is very difficult to detect in a lot of worsted shoddy.

The coarse class is made up of flag-cloths, horse-cloths, bunting, and similar cloths. A valuable shoddy is obtained from flag-cloths owing to the colours being a fast dye; but the quality of the material obtained from this class is low, though the fibre is comparatively long. A very noteworthy classification is made with regard to cloth rags of whatever class. All tailors' clippings, rags from pattern bunches, and rags which have not been made up and worn, are separated from those that have. The former class have no seams in them, and when made into shoddy or mungo they possess properties more nearly resembling the original wool than the latter class, which have had to stand the wear and tear of a made-up garment. Rags which have not been made up make new mungo and shoddy, while rags obtained from made-up and worn garments go to make old mungo and shoddy as distinct from the former. Higher prices are paid for new mungo and shoddy than for old, since in the former case the shoddy or mungo is brighter in appearance, loftier in handle, cleaner, and spins and mills better; there is also much less loss in carding and spinning new than old, the latter in many cases causing a sinkage of as much as 25 per cent.

DIFFERENT KINDS OF SHODDY AND MUNGO COMPARED.—In comparing in a general way the characteristics of stocking, woollen, and worsted shoddy and mungo, it is found that stocking shoddy is much like wool, since it has a curly appearance and a lofty handle; this helps its spinning properties. Stocking shoddy cannot, however, be said to be suitable material to use in cloths which have to be milled. The property of felting is probably impaired in a large measure by the frequent washing which it has had to undergo when being worn, and added to this is the fact that the original wool used is seldom a good felting wool. This class of shoddy is consequently generally used for mixing with wool or waste in the manufacture of cloths that are durable, smart in appearance, and cheap. Referring to the shoddy obtained from worsted rags, a noteworthy disadvantage is that the fibres are very straight; this being due to the operations of combing, drawing, and spinning through which the material has had to pass in its manufacture into worsted yarn. The result is that the spinning property of worsted shoddy is much inferior to stocking shoddy. A yarn is, however, spun from worsted shoddy which has the maximum number of fibres in the minimum cross-sectional area; consequently the yarns produced from this material are very solid and compact. The better-class sorts can be used successfully in the manufacture of cloths which have to be milled. The shoddy and mungo obtained from woollen rags more nearly resemble stocking shoddy than that obtained from worsted cloths, since the fibres are more curly and wavy; the former is, however, seen to be shorter in staple when compared with a similar quality of worsted shoddy.

CHAPTER III

WASHING

Dusting Wools.—After leaving the sorter the wool must be washed to remove all the greasy matter that has collected on the fibres during its growth. This greasy matter is comprehensively termed "yolk." All the foreign impurities, such as vegetable matter and dirt of all descriptions, must also be removed. The latter in particular should be removed in the operation of washing. Between the operations of sorting and washing it is becoming more general to introduce an operation of dusting, the object being to remove as much dirt, dust, sand, and chaff as possible prior to scouring, and a minor, but a very useful object, is to open out the matted portions of wool. The former ensures a saving in scouring liquor, while the latter renders the wool easier to wash, since it is in a more opened and lofty condition, and provides every opportunity for the scouring liquor to reach every fibre. Consequently the wool, as it leaves the washing machine, is cleaner and brighter looking than it would have been had it not been dusted.

The dusting of the wool prior to washing is not practised nearly so much as it should be. There are decided advantages to be obtained by dusting limy skin wools, since, as has been previously noted, the lime must be removed if washing is to be done both economically and satisfactorily. Further, the opening, shaking, and loosening effect of the dusting machine on the wool makes the process of distinct advantage when dealing with cotty and very matted wools, since it is better to open out the material prior to washing than leave it for the opening and carding machines to do at a later stage; and it is extremely doubtful if any larger amount of broken fibre results.

Dusting Willey.—There are many machines used for dusting and opening wools. The simplest consists essentially of a cage, which is merely a cylinder about 5 ft. long and 3 ft. 6 in. in diameter, the ends of which are solid cast-iron, and the circular covering between the ends is heavy wire netting. The shaft on which the cylinder is mounted carries cross-bars that are attached to the shaft at right angles to the axis; and the cylinder and shaft, when the machine is in action, revolve in opposite directions. Thus, when the wool is fed into the machine, and the opening through which it has been fed is fastened down and the machine started, the cross-bars beat out most of the mechanically adhering impurities through the perforations of the screen, and at the same time thoroughly shake and open out the wool. A disagreeable feature of this machine is that the impurities fill the air in the room, which the operative has to breathe, with dirt and dust. Another disadvantage which must be noted is that it is intermittent in action, which makes the process expensive where large quantities have to be dusted, since the machine must be stopped to be emptied and recharged.

AUTOMATIC SHAKE WILLEY.—Another machine which is extensively used for opening and cleaning dirty wools is the self-acting teaser or shake willey. It is also largely used for mixing purposes. A diagrammatic section of the Sykes make of shake willey is given in Fig. 6, and an elevation of the left side of the machine is shown in Fig. 7. The material to be dusted is placed on the feed lattice A, which carries it to the feed rollers B, and these feed it to the large cylinder C. The cylinder C is about 42 in. in diameter, and may be anything from 36 to 48 in. long. Wooden lags carrying teeth as shown, the latter protruding from the lags about 3 or 4 in., are fixed to spiders. The moment the material passes between the feed rollers it is dashed by the cylinder on to the grid D, over which it is drawn; consequently a large amount of the heavier impurities drop between the bars of the grid, while all light dust and other impurities are drawn away by the fan E through the grid F. The material carried by the cylinder is further opened out by the teeth of the cylinder passing between a fixed row of teeth G at the back of the machine. After passing the teeth G the material is next acted upon by three workers H, which are about 12 in. in diameter and are made to revolve slowly in the opposite direction to the cylinder. The teeth of the workers, like those at G, intermesh with those of the cylinder, and a very thorough opening is ensured. The delivery of the material from the machine is intermittent, but automatic; hence the material passes round the machine owing to the action of the cylinder until the door O is automatically swung open. When this takes place the material is ejected on to the travelling lattice J, which carries the material out of the machine and deposits it into a skep or bag or on to the floor.

DRIVING.—The principal parts of the machine are driven in the following manner: The central shaft on which is mounted the

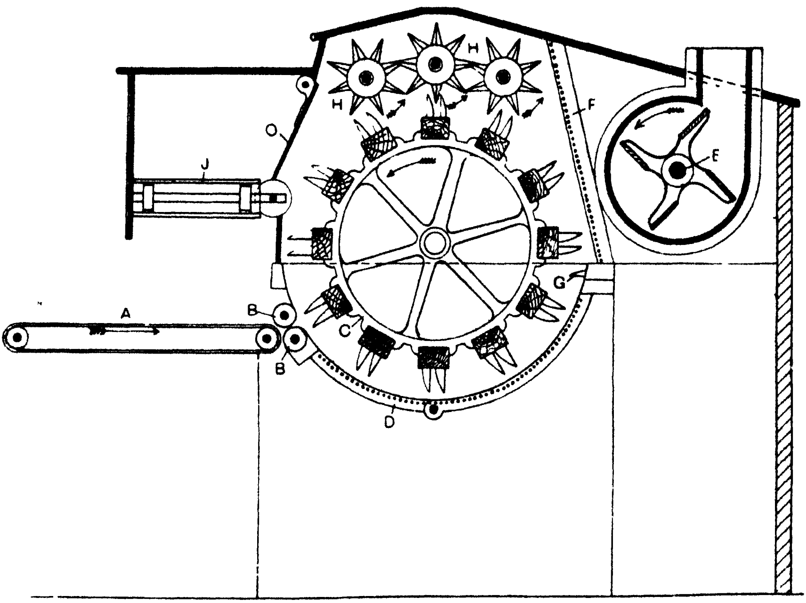


FIG. 6.

spiked cylinder is driven at a speed of about 430 revs. per min from the line shaft by belt; fast and loose pulleys are provided at K, Fig. 7. The fan is driven at a speed of from 1200 to 1500 revs. per min. by the pulley L, by means of a belt which drives the pulley M fixed on the fan shaft. A small pulley placed on the cylinder shaft behind the pulley L drives the pulley N by means of the belt P; on the same stud is a small toothed wheel Q, which gives motion to the gear-wheel R, that is fixed on the shaft of the middle worker. The other two workers are driven direct by means of gear-wheels on their respective shafts, and placed on the opposite side of the machine. The speed of the workers in revolutions per minute is only about 25; the reduction in speed is obtained by the driving pulley and gear being small, and the driven pulley and gear being large. The door O is swung open and shut by means of the cam S, which is attached to a shaft that passes through the machine, and which is driven by means of suitable gearing from the main or cylinder shaft of the machine on the other side to that shown. As the cam

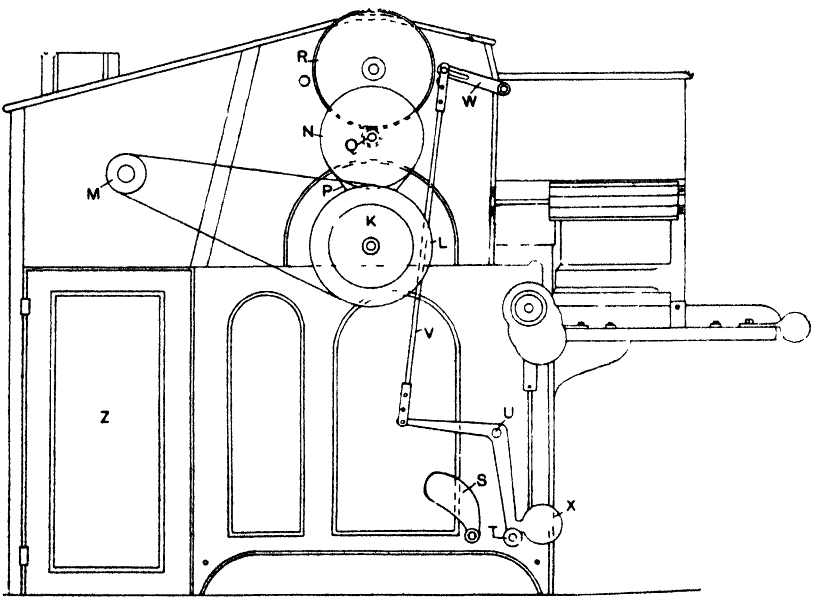


FIG. 7.

revolves, it operates on the anti-friction bowl T, thus forcing that end of the lever to which it is attached outwards; and as the lever has its fulcrum at U, the opposite end, to which is attached the connecting rod V, is lowered. The connecting rod is pivoted on a stud bolted to the connecting arm W, and the latter is in turn fixed to the shaft to which is attached the door O; consequently the door is opened when the cam operates on the bowl T. The balance weight X closes the door as the cam S moves from the toe to the heel. The time allowed for the material to remain in the machine is regulated by the speed at which the cam is made to revolve. It should be noted that the machine can be constructed so that the fan can draw air through both of the grids D and F, Fig. 6; but it is more common to draw air only through the grid F, so that there is no opposition to the heavier impurities dropping through the grid D on to the floor. Doors, one of which is shown at Z, are suitably placed so that the impurities which drop through the grid may be periodically removed. This machine is well adapted for opening, dusting, and mixing medium to short materials.

CLASSES OF IMPURITIES IN WOOL.—The object of wool washing is to remove as nearly as possible all impurities, both natural and foreign. Natural impurities consist of what is comprehensively termed "yolk," but this substance, both chemically and when considering its removal, must be divided into two parts—viz., yolk proper, and suint.

The yolk proper (or, as it may well be termed, the wool fat) is a compound which requires the use of strong scouring agents to remove it from the wool. It is composed of substances known as cholesterine and isocholesterine, in an uncombined state, and also these substances combined with fatty acids, such as stearic and palmitic. Wool fat is insoluble in water alone, but by the use of alkaline scouring agents it can be removed in the form of an emulsion. It can also be removed by solvents, such as benzine and naphtha, the latter being used in the Maertens system of solvent scouring, which is in use at Verviers, in Belgium, and at the Arlington Mills, Lawrence, Mass., U.S.A. It may be noted in passing that practically all washing in British practice is by the use of alkaline scouring agents. Suint is that part which can be removed by pure water alone, since it is soluble in water. It is the perspiration or sweat, and is made up principally of potash salts, and consequently this portion of the yolk is very valuable on account of the potash salts which it yields.

The foreign impurities consist principally of mechanically adhering matter such as dirt, dust, sand, and dung, which are practically all removed in the operation of washing, since they are held on the fibres by the yolk, and are consequently removed with the yolk; and of vegetable matter, consisting largely of burrs, twigs, seeds, dried grass, straw, and similar matter, much of which drops out in the succeeding processes. But if there is an excessive amount of burrs, etc., the wool must be submitted to a process of burring or carbonising.

AVERAGE YIELDS.—The following are average proportions of the amount of impurities, and yield of clean wool :—Long English wools will, in an unwashed state, contain about 30 per cent. of yolk and dirt, of which about 10 per cent., or rather less, will be dirt, while the remainder will be yolk; in this case the yield of clean wool will of course be about 70 per cent.; medium crossbred wools will contain about 40 per cent. yolk and dirt, of which about 10 per cent. will be dirt; merino wools will contain about 55 to 60 per cent. of yolk and dirt, of which about 15 per cent. will be dirt. English medium and low crossbred wools contain a greater amount of yolk and dirt than long English wools; while Southdown and similar wools contain a little less than medium crossbred wools. Fine crossbred wools come about midway between medium crossbred and merino wools with regard to the amount of yolk and dirt they contain.

It will thus be seen that the average amount of dirt and yolk varies considerably according to the class of wool, and as to whether it is fine or coarse. Also, if the sheep have been pastured on earthy or loamy soil the fleeces will contain a greater percentage of impurities than if pastured on peaty or mossy soil.

COST OF CLEAN WOOL.—A simple calculation is necessary in order to estimate the cost of clean wool, since the cost of the wool when washed is affected by the amount of "loss," "sinkage," or "shrinkage" which takes place. By shrinkage, loss, or sinkage is meant the decrease or loss in weight from the unwashed or greasy state to the washed or scoured state; and the weight of clean wool is termed the "yield." Supposing greasy Port Philip wool is bought at 3*s*. per pound and it loses 50 per cent. in washing, then the cost of clean wool will be 6*s*. per pound.

The following rule will in all cases give the total cost per pound when the cost of sorting and washing is to be added—

Rule.—Multiply the price per pound of the greasy wool by 100 and divide by the percentage of yield, and to this result add the cost per pound of sorting and washing. For example, if greasy Port Philip wool is bought for 3*s*. per pound and loses 60 per cent.

in washing, and sorting and washing cost *2d.* per pound, what will be the price per pound of clean wool? Price per pound will be—

$$\frac{36 \times 100}{40} = 90d.$$

Then, $$90 + 2 = 92d.$$

MATERIALS USED IN WASHING.—The materials used in washing may be conveniently divided into three groups—viz., alkalies, soap, and water. The alkalies generally used are soda ash, which is dry commercial sodium carbonate; pearl ash, which is dry potassium carbonate; and ammonia. Soda ash, or carbonate of soda, is usually purchased in a powdered form, and the best is known as 58 per cent. alkali. This is guaranteed to contain 98 per cent. of pure carbonate of soda. The 58 per cent. represents its value as compared with pure caustic soda. Soda ash should be used only when washing strong English and low-class, dirty, and limy wools; in such cases it is an advantage, as it is a cheap and powerful detergent.

Pearl ash, or carbonate of potash, in a general way is very similar to soda ash, but is considerably milder in its action on wool than the latter, and tends in a much greater degree to retain the valuable characteristics of softness of handle and lustre. It is less liable to injure the serratures and impoverish the fibres, and is consequently used in preference to soda ash in scouring the finer wools which require an alkali. The principal reason why it is not used in scouring all classes of wool is on account of its being much more expensive; its price is four to five times that of soda ash.

Caustic alkalies, whether soda or potash, should not under any circumstances be used, as their action is far too keen, and if free caustic alkali is present in the scouring liquor it will give the wool a rough and harsh feel, injure the serratures, give the wool a yellow colour, and impair its elasticity.

TESTING ALKALIES.—To test a sample of soda or pearl ash for the presence of caustic soda, take 1 grm. of the sample to be tested, and dissolve it in 100 cc. of distilled water. To this solution add an excess of barium chloride of 5 per cent. strength, and filter. Then add a small amount of phenolphthalein, and if caustic alkali is present the solution will assume a pink colour. Caustic alkali would also be present if the solution turned red litmus paper blue. The washing powers of ammonia are dependent upon the ammonium carbonate, but this alkali in such a form is not often used. The liquid which is occasionally used is roughly two-thirds water and one-third pure ammonia.

SOAPS.—Briefly, soap is a compound that is formed by boiling one of the caustic alkalies, either caustic soda or caustic potash, with one or more of the following fatty acids or oils :—Tallow, olive oil, cottonseed oil, oleic acid, palm oil, and cocoanut oil. Hard soaps are made with soda as a base, and consequently should not be used when scouring the best classes of wool, as their action is too keen. It should be noted, however, that a hard soap, which is now imported from America in large quantities for wool washing, is one that is made from cottonseed oil. Soft soaps are made with potash as a base, and if well made are much more preferable than hard soaps, as they leave the wool softer in handle, more simple, and of a better colour. It is assumed that soft soaps contain a much larger percentage of water than hard soaps; the fact, however, that one is soft and the other is hard is due to the nature of soda and potash when used as a base to form these two kinds of soap. As a matter of fact, a soda soap may contain a very large percentage of water and yet remain hard and firm.

ACTION OF SOAP.—The action of soap is not generally understood, but it appears to act in water in such a way as to emulsify greasy matters, thus enabling them to be diffused through the water, and consequently to be readily removed. Soap being a combination of alkali and fat, it is well adapted as an agent for washing wool, since it is an efficient cleanser, without being so harsh in action as to injure the fibre and remove the natural oil, as is the case when alkalies are used alone. As a general rule, however, it is not practicable to wash greasy wool with soap only; therefore, in the earlier stages of washing an alkali is added to make an effective liquor.

ADULTERATION OF SOAP.—In the manufacture of soap there are two important points to be observed—viz., that the alkali and fat should be combined in correct proportions, since alkali can take up only a certain amount of fat; and that a thorough combination of the two should be secured. If these two points are not observed there is likely to be an excessive amount of free caustic alkali present, which has a disastrous effect on wool in the presence of hot water. Soap is one of the easiest commodities to adulterate, and where large quantities are used it should be carefully tested from time to time, since it is important that any deterioration in quality should be found out as early as possible. Further, it is of much greater importance that the soap should not have an injurious effect on the wool, nor should it possess inferior washing properties. If impurities such as resin, potato-starch, china-clay, salt, fuller's earth, and French chalk, are present, there is a corresponding loss in cleansing power, in addition to the substances named increasing the amount of scum, which is of no use, and interferes with washing. Resin in particular is an objectionable impurity, as it has a tendency to give the wool a yellow, singed appearance. Soap, and especially hard soap, is liable to contain an excess of water; this kind of soap will carry as much as 40 per cent. without appearing to contain too much, consequently an excessive amount is liable to be left in, since it is cheaper than soap, and adds weight.

TESTS FOR SOAP.—If a sample of soap contains an excess of free alkali, the latter may be detected by placing on the soap a strip of red litmus paper, and if the paper turns blue it indicates that free alkali is present. Of course free alkali is present in all commercial soaps, but not more than about 2 per cent. should be present, since the soap should be as nearly neutral as possible—that is, it should have the minimum amount of free alkali. It is much better practice to use a neutral soap and add the required amount of soda ash or pearl ash as selected, than to use an alkaline soap in which the amount and kind of free alkali are unknown, and in which the alkali is in a caustic condition. There are many patent soaps and soap powders on the market, but as these are not infrequently made from odds and ends of soaps boiled up with carbonate of soda and oil, they should be used with care. In all cases such soaps are based on the ordinary washing materials, and as they are usually expensive they should as a rule be avoided.

There are many tests for finding the amount of water, free alkali, resin, salt, alum, etc., in soap; but since the successful and correct analysis of soap is a very difficult matter, it should be done by an experienced analyst if correct results are desired. A simple and an easily-conducted test to determine the amount of water present in a sample of soap, is as follows: Carefully weigh a small quantity of the soap, which has been taken from near the centre of a block, so that it has not been exposed to the air. Reduce it to fine parings and place these on a porcelain dish which has been dried and accurately weighed. Then place the dish and parings in an oven and dry at a temperature of about 225° F. for several hours. After this let it cool, and then weigh, and repeat the drying process until the weight is constant. From the original weight and the loss in weight, the percentage of water can be readily calculated.

A good general and simple test for soap is to weigh a small quantity of the sample and dissolve it in water. Then add sufficient sulphuric acid to the solution to neutralise the alkali combined with the fatty matters, and thus reduce the latter substances to their original state. Thus, by breaking up the soap, all the fatty matters and resin, if any, rise to the top, while all the earthy impurities, such as fuller's earth, etc., will gradually settle at the bottom, since they will not be dissolved.

WATER.—The importance of a plentiful supply of suitable water can scarcely be over-estimated, since the cost per pound for scouring, and the condition of the wool after scouring, are very materially affected by the kind of water used. The requirements of a good water are, that it should be clear and free from mechanically suspended impurities, and that it should not contain dissolved impurities which act injuriously on the detergents used, or combine with such detergents and form compounds which are both detrimental to the proper cleansing of the wool, and may in addition become deposited on the fibres. Distilled water would fulfil the necessary requirements perfectly, but the expense of obtaining such water precludes its use. There is no doubt that more might be done with advantage in the way of collecting, storing, and utilising the water resulting from condensed steam which has been used for heating the buildings or certain machines. Recourse, however, for the bulk of the water required must be made to the natural supplies, which may be conveniently considered as two classes—firstly, surface water, comprising that obtained from rivers and lakes, and that usually supplied by the town's service; and, secondly, that obtained from springs or wells. Most firms rely principally on water obtained from a well or wells situated within the mill property, as in most cases it is cheaper to use well water, even though some extra preliminary treatment is necessary, than to take water from the town's supply at the current rates.

IMPURITIES IN WATER.—The source of all water is, of course, rain; and rain water is pure, but its quality is changed, in some cases very considerably, by coming in contact with various gases and mineral matter. Suspended impurities are most largely found in surface water, and generally consist of sand, mud, and partially decayed vegetable matter, which are not actually dissolved in the water. They settle if the water is allowed to stand for a sufficient length of time, with the exception of fine vegetable matter, which is usually lighter—*i. e.*, has a less specific gravity,—and in some cases is almost dissolved in the water in consequence of its finely divided state.

Dissolved impurities are more commonly met with in well and spring water, where the water has been in contact with limestone, chalk, etc. The minerals named will quickly change soft rain water into what is known as hard water. Dissolved impurities which make water hard have the power of decomposing the alkaline soap, and of forming an insoluble lime or magnesian soap, since they have the power of releasing the alkali and of combining with the fats. Thus, the detergent properties of the original soap are lost, and a new compound, usually termed a lime soap, is formed, which is a sticky, pasty substance that is precipitated on the fibres, completely enveloping them, and it can only be removed by treating the material with hydrochloric acid, which acts on the material in such a way as to make it impossible to dye certain shades successfully; but, should the lime soap be present on the fibres when the material is dyed, the quality and regularity of the shade will be seriously impaired. Water of the character just described is termed "hard," whilst for purposes of comparison water containing small quantities of soap-destroying salts is termed "soft." The hardness of water is of two kinds—viz., temporary and permanent,—and the sum of the two gives the total hardness. Water that is only temporary hard contains in solution bicarbonates of lime, iron, or magnesium, and such water may be rendered soft by boiling for half an hour or over, since boiling drives off one-half of the carbonic acid, thus converting soluble bicarbonates into insoluble monocarbonates, which settle to the bottom. This method, however, is not practical, on account of the expense incurred by boiling. Water that is permanently hard contains dissolved chlorides or sulphates of lime, iron, or magnesium, and boiling only concentrates the hardness of such water.

TESTING WATER FOR HARDNESS.—Several systems of measuring the hardness of water have been devised, and though they differ in the method of calculation, they all aim at finding the quantity of standard soap solution that is required to produce a permanent lather on a definite quantity of water. When speaking of the hardness of water it is always referred to in terms of degrees of hardness, and each degree of hardness indicates that in each gallon of water there is one grain of soap-destroying salts. The work of testing water for total hardness is simple. It would be inconvenient to test a whole gallon of water, consequently only 70 cc. are tested, this quantity being termed a miniature gallon, and is taken because it contains the same number of milligrammes as a gallon contains grains; therefore when the number of milligrammes of soap-destroying salts in 70 cc. of water is found, it corresponds exactly to the number of grains of such salts in a whole gallon. When making a test, therefore, 70 cc. of the water to be tested is measured into a flask, and to this water is added small quantities of a standard soap solution. The standard soap solution may be bought ready for use from a chemical store, or it may be made by dissolving 10 grms. of pure Castile soap in 1 litre of alcohol, and since there are 1000 grms. in 1 litre, it is termed a one-per-cent. solution. When properly made 1 cc. of this solution will neutralise 1 milligramme of the soap-destroying salts in the water. Thus, by adding the soap solution gradually and shaking the flask briskly after each addition until sufficient soap solution has been added to form what is termed a permanent lather, the number of degrees of hardness is obtained. A permanent lather is understood to mean a lather that will remain on the surface of the water for not less than five minutes after the flask has been briskly shaken. If by this method it was found necessary to add 8 cc. of soap solution before a permanent lather was formed, then the water would have $8 - 1 = 7^\circ$ of hardness. The number of degrees of hardness is stated as being one less than the number of cubic centimetres of soap solution required, since it is estimated that 1 cc. would be required to form a permanent lather on distilled or perfectly soft water.

Water may be tested for the amounts of temporary and permanent hardness by first obtaining the total hardness in the manner already described. Then take as much of the sample to be tested as both the flask in which it is contained and the water itself will weigh 200 grms., after which boil for about 30 mins., or sufficiently long to remove all the temporary hardness. The flask must then be filled up with distilled water until both the flask and water again weigh 200 grms. After filtering, 70 cc. of the water may be taken, and the amount of permanent hardness obtained in the same way as the amount of total hardness was obtained. The amount of temporary hardness can of course be obtained by subtracting the amount of permanent hardness from the total hardness.

The above methods of testing do not give absolutely accurate results, but results which are sufficiently accurate for all practical purposes. Before any steps are taken with regard to softening or purifying water, it is absolutely essential that a careful and accurate analysis of the water be made by an expert chemical analyst with a view to determining both the amount and nature of the impurities present. The advisability of having such an analysis made will be understood when it is noted that if insufficient chemicals are used for softening purposes the water will not be brought to the required degree of softness; while if too large a quantity is used, the water will be again made hard.

Water Softening.—The method adopted for the softening and purifying of water depends to a large extent upon the quantity and character of the impurities present. Three methods may be and are used, either separately or in combination: (1) By allowing the impurities to settle, which is the method adopted when the impurities are mechanically suspended; (2) by filtration, which is the method adopted when the water contains quantities of grease and finely divided vegetable or other organic matter that cannot settle out, since its specific gravity is small; (3) by the use of chemicals, which is the method adopted when the impurities are dissolved in the water.

The apparatus required by the first method consists of a sufficiently large tank or tanks to meet requirements. In these tanks the suspended impurities can settle to the bottom. The apparatus required by the second method consists of a filter or filters which are composed of layers of sand, sawdust, wood wool, or layers of cloth or hay. For general filtering purposes wood wool is largely used; while for filtering water containing grease or oil, cloth and hay are very suitable. The third method is much more complicated than those previously noted, and the actual chemical process adopted depends entirely on the character of the impurities present in the water. When the dissolved impurities are carbonates of lime and magnesium, the water is treated with milk-of-lime. The latter substance is made from quicklime mixed with sufficient water to form a thin paste the requisite degree of strength. The effect of the lime is to decompose the soluble bicarbonates into insoluble carbonates which settle to the bottom as a precipitate. When the impurities are sulphates and chlorides of lime or magnesia, the water must be treated with an alkali. If calcium sulphate is present alone, then the alkali used is carbonate of soda; while if magnesium sulphate is present then caustic soda must be used. It will be seen that it is imperative that a correct analysis of the water should be made so that the exact quantities of lime or soda or both can be used.

The apparatus required to soften water by means of chemicals is usually designed with a view to facilitating the settling of the precipitate or removing it by filtration. The latter method is to be preferred, since it is continuous and enables large quantities of water to be dealt with. The Archbutt-Deeley process is typical of the method in which settling of the precipitate is facilitated, while the Lassen-Hjort apparatus is typical of the method in which it is removed from the water by filtration. In order further to emphasise the importance of using soft water it might be pointed out that each degree of hardness will destroy about 0·124 lb. of an ordinary commercial soap per 100 gals. of water. In other words, if the water used had 20° of hardness, then $20 \times 0{\cdot}124 = 2{\cdot}48$ lb. of soap which will be destroyed for each 100 gals. of water.

STEEPING OF WOOL.—The operation of steeping prior to scouring is very advantageous, especially in the case of limy skin wools, even after such wools have been efficiently dusted, since any lime that is present in the material when it is fed to the scouring machine will have the effect of decomposing soap. The lime is neutralised by the addition to the bath in which steeping is done of some kind of acid, which converts the lime into a soluble salt that passes away with the water. Sulphurous acid is generally used for this purpose. It is equally important to neutralise all traces of acid, since acid is also a potent soap destroyer. The agent used is usually carbonate of soda. The wool is then scoured in the usual way, with the exception that less scouring is necessary, owing to the wool having had a considerable amount of the impurities removed. There is no doubt that in addition to facilitating the subsequent scouring, the operation of steeping results in a very considerable saving in soap, since a large part of the soluble impurities is removed. Further, valuable potash salts can be readily reclaimed.

SCOURING MACHINES.—In describing the operation of scouring, only one type of machine will be considered in detail, since the salient features of most other types are sufficiently similar. Many types of machines involving new features, with regard either to principle of action or to constructional details, have been introduced within recent years. The best machines agitate the wool least consistent with efficient scouring. This is an important point, since the greater the agitation of the material the more likely is it to become felted, and consequently more difficult to open in the succeeding processes. The length of a set of machines has been increased very considerably, consequently less changing of the liquor is necessary, since each bowl holds more liquor in proportion to its increased size. Other improvements have been made in the direction of increasing the number and size of the settling tanks and in increasing the weight of the squeeze rollers.

THE MCNAUGHT MACHINE.—A longitudinal section of a three-section McNaught machine is shown in Fig. 8, while a diagrammatic plan is shown in Fig. 9. In operation the wool is fed into the machine by the feed lattice A, and as it drops into the washing liquor contained in the upper bowl B, it is immersed by the immerser C. The immerser is a necessity, otherwise some of the wool would float on the surface of the liquor and pass from the machine without having been thoroughly saturated. Consequently, at the feed end of each machine an immerser, which is in the form of a brass or copper box with a perforated plate at the bottom, is fastened to the framework of the forks D, and moves with them. Since the bottom plate of the immerser is perforated, as it descends into the liquor the latter rushes into the box and thus prevents any considerable displacement, which has the effect of keeping the liquor as still as possible. When the immerser is raised, the liquor rushes out through the perforations on to the wool, and by so doing assists scouring. The wool after being immersed in the liquor is carried forward by the forks D, which are given a slow forward movement when in the liquor. The material by the action of the forks is moved slowly forward through the machine until it is moved into the nip of a pair of strong and heavy squeeze rollers E, which squeeze out a very large percentage of the liquor, after which the wool is carried by a lattice from the machine.

Bowls and Settling Tanks.— Referring to the arrangement of the bowls and settling tanks, the bowl B in which washing actually takes place is 18 to 24 in. wide and 8 to 9 in. deep, and is connected with the larger bowl F in which it is placed by perforated plates that form the bottom. The liquor in the larger bowl is comparatively still, and consequently any heavy sediment can pass through the perforations and settle to the bottom. The bottoms of both the large bowl and settling tank are made sloping so that the sediment will slide down into a channel from which it can be flushed out as desired through suitable openings. Formerly, the excess dirty liquor which was squeezed out by the squeeze rollers was allowed to run back through the material into the washing bowl, and as this is the dirtiest water, since squeezing removes large quantities of dirt, such a method was very objectionable. In this machine, as in all modern machines, the liquor from the squeeze rollers passes through the faller and side plates H, which are perforated, into a trough J. From the trough it runs into the settling tank K, in which the heavy dirt settles to the bottom and the scum rises to the top. To facilitate the settling, one or two perforated baffle plates L are placed across the tank to break up currents which form due to the flow of liquor. The liquor in the settling tank is pumped back into the washing bowl from the opposite end to that at which it enters, and is usually heated before it is sprayed on the wool which is entering the bowl. The liquor in the settling tank is cleanest at about the middle of its depth, and it is from this point that it is pumped. At least one

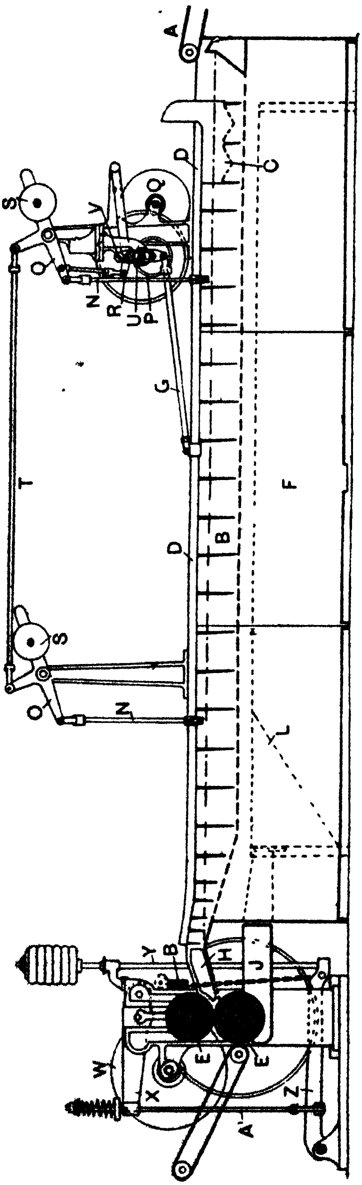


FIG. 8.

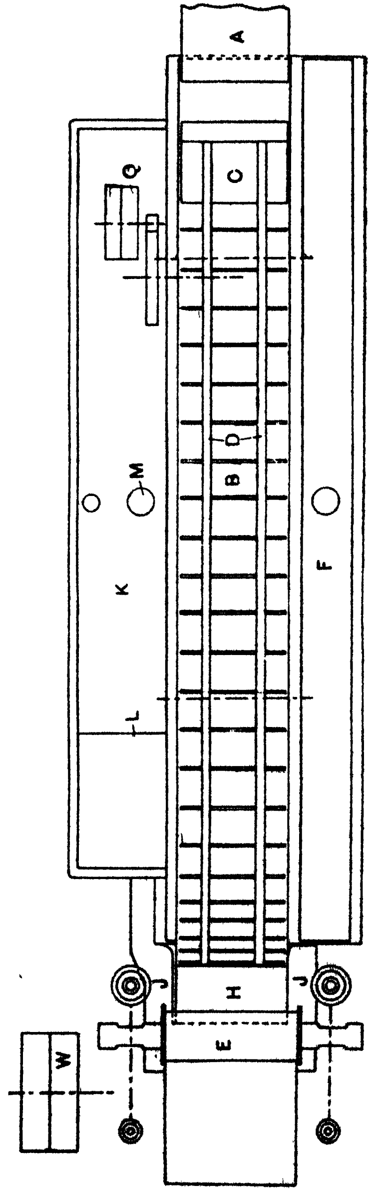


FIG. 9.

vertical waste pipe M is provided, by means of which the liquor is kept at a proper level, and by adding an excess of liquor the scum can be flushed off.

DELIVERING WOOL TO SQUEEZE ROLLERS.—In the older type of rake machines the forks brought the wool close up to the nip of the squeeze rollers; in fact, the forks may be said practically to have lifted the wool into the nip of the rollers. In the best machines, the forks in moving forward deliver the wool to the ridge formed by the bottom of the bowl at the end nearest the squeeze rollers and the perforated plates or grid which slopes down to the nip of the squeeze rollers. As there is liquor passed into the top bowl at the feed end, there is an overflow at the delivery end, as the bowls are set slightly lower at that end. This overflow, which also rids the water in the washing bowl of most of the scum, in conjunction with the movement of the forks causes the wool to be delivered to the squeeze rollers, and as the wool slides down the slope a quantity of liquor passes from it through the perforated plates or grid.

DRIVING.—The fork motion consists of a series of cross-bars which are about 10 in. apart, and which are connected by two light tubular bars that extend the length of the bowl. To the cross-bars brass prongs are fixed, and those which are required to work up the incline near the squeeze rollers are shorter than the others. The light tubular bars are attached to connecting rods N, and the opposite ends of these rods are in turn attached to levers O. A vertical up-and-down motion is given to the forks through these levers by means of a cam P, which is fixed to the cam shaft. The cam shaft receives its motion from the fast pulley Q by means of gear-wheels, which are indicated by double lines. The cam is always in contact with a friction bowl on the end of the lever R, which is pivoted to the framework of the machine at its other extremity due to the weight of the forks and framework, the weight of which is almost balanced by the balance weights S. To that end of the lever R near the friction roller, a rod is connected which is also connected to one of the levers O. Consequently, as the cam revolves an oscillating motion is given to the lever. To the top arm of this lever is attached a connecting rod T, which conveys motion to the other end of the machine so that both ends of the fork framework are moved at the same time and in an exactly similar manner. A horizontal motion is being given to the forks at the same time as the vertical motion by means of the connecting rod G, one end of which is suitably attached to the framework of the forks, while the other end is pivoted to the slotted lever U, which swings on a stud V, that is fixed to the framework. Motion is given to the lever and connecting rod by a crank fixed on the end of the cam shaft, and which carries an antifriction roller that engages with the slot in U; consequently, as the crank revolves, the friction roller causes the lever to swing backwards and forwards on its centre, and to communicate a horizontal backward-and-forward motion to the fork framework. The combined effect of the cam and crank is to lower the fork framework into the bowl and move it forward a distance of about 8 in. towards the press rollers, then raise it out of the water and move it quickly back to the starting point. Owing to the variation in the leverage of the crank when acting upon the slotted lever, the forward stroke is very slow, while the backward stroke when the forks are above the water is very quick.

Squeeze Rollers.—The bottom squeeze roller, which is usually of solid steel covered with brass, is positively driven by means of gear-wheels. A belt from the line shaft drives the pulley W, which gives motion to the gear-wheel fixed on the end of the squeeze roller. The top roller, which is covered with roller lapping to obtain a resilient surface, is, when covered, nearly the same diameter as the bottom roller. It is normally driven by frictional contact with the lower one, being pressed down and kept in contact with the bottom roller by means of weights and compound levers acting through springs, so that a very powerful but springy grip is obtained. The arrangement is as follows: The lever X, which is fulcrumed at the back, exerts pressure on one end of the top squeeze roller through the rod Y, which carries the required number of weights and exerts a downward pressure on the lever Z. The latter has connected to it near its fulcrum a connecting rod A^1, which by means of a spring at the top transmits to the top roller the total pressure exerted.

There is a tendency when a fairly large lump of wool arrives at the nip of the squeeze rollers for the top roller to be stopped, since it is normally driven by friction, and for the wool to be ground between the stationary and the revolving roller. A special motion termed a catch-box or escapement motion is introduced, by means of which the top roller is positively driven from the bottom roller, when the former ceases to revolve, by frictional contact alone. The motion consists of a clutch which is placed on the projecting shaft of the top roller, the outside half of which is loose on the shaft, and has compounded with it a gear-wheel which is driven by a gear-wheel on the shaft of the bottom roller. The number of teeth in the driven wheel being 20, and the number of teeth in the driver 18, thus the top roller when rotated from the bottom is rotated at a slower speed. Further, the bottom roller also has a slightly larger diameter than the top one; therefore the latter has a correspondingly greater speed when driven by friction. The inner half of the clutch is keyed firmly to the shaft of the roller, and the teeth of the clutch are so arranged that when the roller is working normally the fixed half of the clutch is being driven at a greater speed than the loose half, and gains tooth by tooth on the driven and loose half. As it is mounting the points of the teeth on the loose half the latter is pushed against the power of a strong spring a sufficient distance along the shaft. When a lump of wool stops the rotation of the top roller, the loose half gears with and drives the fast half, and hence drives the top roller until the lump has passed through and the roller is being again driven by friction.

An arrangement is also provided for easing the pressure on the top roller when the machine is standing. It consists of a short shaft which extends across the width of the machine and which carries a handle at one end. Two worms are cut on this shaft, which engage with two worm wheels that are suitably fixed to short shafts, one of which, for one side of the machine, is shown at B. A similar arrangement is fixed on the other side of the machine, since the weighting arrangement is duplicated for the other end of the squeeze rollers. To each of these shafts is attached a chain, one end of which is connected to the levers Z, so that by turning the handle in the proper direction the chains are wound on their respective shafts B and the pressure removed from the roller ends.

Composition of sets of Scouring Machines.—A set of scouring machines usually comprises three or four machines, the former being the number used when scouring English lustre or crossbred lustre wools; and the latter number being used when scouring merino, fine, and medium crossbred wools. Recently the tendency has been to increase the number as well as the length of the machines used for washing, the length of the bowls having been doubled during the last twenty years. By so doing, the wool is better scoured, and the increased size of the machine has permitted greater volumes of scouring liquor to be used, and the machines to work much longer before a change of liquor is necessary. A complete set of machines suitable for scouring greasy merino wools is as follows: First bowl, 32 ft. 6 in.; second bowl, 26 ft. 6 in.; third bowl, 20 ft. 6 in.; and the fourth bowl, 14 ft. 6 in.

PRIMING THE BOWLS.—Soap and alkali tanks capable of being heated by steam are usually provided, in which the soap and alkali are dissolved separately. These tanks should be fixed above the level of the bowls and connected to the latter by pipes. Economy demands that the fullest use should be made of the liquor, and after being used for a few hours in the second, third, and fourth bowls, it is very efficient; but the liquor in the first bowl is rendered dirty and its washing properties greatly diminished. It is then run off, and is replaced with the liquor from the second bowl, and strengthened with the addition of a suitable quantity of soap and alkali. The second bowl is refilled from the third, and the third bowl from the fourth, the requisite amount of soap solution being added to bring the liquor to correct scouring strength. Water must of course be added in sufficient quantity to fill up each bowl. The fourth bowl is refilled, and a good clear scouring liquor made by adding a suitable quantity of a good oily soap. Before continuing scouring after the bowls have been changed, the liquor in each bowl should be heated to the required degree, and if the wool is found to leave the last machine in a sticky condition, the liquor should be at once strengthened. The material as it leaves the last bowl should be frequently examined, so as to maintain even and thorough scouring.

TEMPERATURE AND STRENGTH OF LIQUOR.—It must be remembered that the higher the temperature of the alkaline scouring liquor, the keener will be its effect both in cleaning and in inflicting damage upon the wool. The lustre, waviness, strength, and elasticity disappear with rapidity, and even the wool itself at high temperatures; consequently the temperature should be carefully regulated in accordance with the wool to be scoured. The fineness, lustre, and strength of the fibre should always be considered when arranging the temperature. Formerly it was common for the scourer to gauge the temperature of the liquor by his hand, and this practice has not even yet been completely abandoned. It is bad, since the temperature will feel to be quite different to two different persons, and to persons in different degrees of health. The thermometer should be the only means of gauging the temperature. For the ordinary run of Colonial wools temperatures of 120° F. in the first bowl, 115° F. in the second, 105° F. in the third, and 100° F. in the fourth bowl, usually give very satisfactory results; while for very dirty, waxy wools, such as Buenos Ayres, a temperature as high as 135° F. is often required to start the grease. When washing the best English lustre wools and mohair, the temperature should be as low as possible consistent with efficient scouring; temperatures ranging from 100° to 90° F. usually give good results. In all cases it is better practice to spend more time in scouring and keep the fibre sound, than damage it by too hasty scouring and be compelled to spend more time in preparing, spinning, and felting; since, if scouring is done too quickly with too strong solutions and at too high a temperature, the serrations are damaged by being broken or "hacked," the lustre is seriously impaired, and the fibres are rendered brittle and harsh in handle. The strength of the scouring liquor is quite as important as the temperature, and should in all cases be regulated in accordance with the fineness of the wool to be scoured, rather than by its condition with regard to the amount of dirt and yolk it carries. A coarse, strong-fibred wool will stand a greater heat and stronger scouring liquor than a fine-fibred and comparatively weak wool. In the first bowl, when washing very greasy crossbred wools, it is usually necessary to use from 60 to 80 lb. of pearl ash, enough neutral potash soap being added to make the liquor feel sufficiently smooth and soft. For a fine wool rich in suint and yolk, and thus possessing a certain amount of cleansing agents, so strong a liquor is not necessary. Further, if the liquor were too strong, the handle and colour as well as the spinning and felting properties would be seriously impaired. The amounts of soap and alkali used per day of ten hours in the set of machines previously given when washing an average greasy merino are: First bowl, 110 to 130 lb. of a good potash soap and 20 to 30 lb.

of pearl ash. Second bowl, 60 to 75 lb. of potash soap and 3 to 6 lb. of pearl ash. (In some cases it should be noted that little or no alkali is used in this bowl.) Third bowl, 25 to 35 lb. of potash soap. Fourth bowl, 5 to 7·5 lb. of soap, or just sufficient to give the liquor a soft feel and neutralise and remove any traces of alkali which might still be carried by the wool from the previous bowls. For washing very greasy crossbred wools the amount of pearl ash used in the first bowl would be increased from 60 to 80 lb., while the amount of potash soap used would be reduced to from 90 to 120 lb. In the second bowl 90 to 110 lb. of potash soap and 10 to 20 lb. of pearl ash would be used. In the third bowl only 30 to 45 lb. of potash soap would be used; while in the last bowl 10 to 15 lb. of soap would be used. The above particulars are for a set of machines of the same capacity as the set referred to in connection with the particulars given for washing merino wools. It should be noted that the particulars given can only be taken as a guide indicating quantities of detergents which may be used.

DEGREASING WOOL.—Another system of removing the impurities from wool is that by which the yolk proper, or wool fat, is taken up by a volatile solvent. The suint being liberated by the dissolving of the wool fat is next removed by washing or steeping in warm water. The plant of Maerten's system of degreasing consists principally of underground reservoirs containing the naphtha; digesters, coupled together, which are also sunk into the ground, each of which is capable of holding about 3000 lb. of wool; a gas-holder containing non-inflammable gas, and a compressor capable of driving the gas through the naphtha reservoirs and digesters; oil condensers which are placed above the digesters, and through which the gas passes on its way back to the holder. These extract and collect from the gas the naphtha vapour. An air blower, heater, and humidifier are also provided, by means of which a current of warm moist air can be circulated through the digesters and forward through a condenser back to the blower. The air is circulated through the digesters to extract the solvent naphtha. The action is briefly as follows: Compressed gas is turned into one of the reservoirs containing naphtha which has been used twice before, thus flushing dirty naphtha through the first digester. The naphtha is then carried away from the digester through a pipe connection to the distillery, where the naphtha and grease extracted are separated. Gas is next turned through the second reservoir, and naphtha which has been used once before is forced through the second digester and then through the first, from which it passes to the distillery. Clean naphtha is next flushed through the first digester from a clean naphtha tank, or reclaimed naphtha is used from the distillery. After leaving this digester it is flushed through the second, from which it is passed to one of the reservoirs. The second digester is now flushed with clean naphtha, from which it is passed to the other digester. The propelling or compressed gas is allowed to go back to the gasholder over the oil condensers, which collect the naphtha vapour and send it back at intervals to the distillery, where the naphtha is reclaimed. Finally, moist warm air is circulated through the digesters to extract all the naphtha vapour, but leaves the wool in normal condition as regards the amount of moisture it contains. A condenser is placed between the blower and humidifier for the purpose of extracting and collecting the naphtha vapour. By this means all the naphtha is reclaimed, and can thus be used repeatedly with very little loss. The flushings follow each other in quick succession—almost as fast as the valves can be turned. The wool when taken out is simply rinsed, no real washing being necessary. This operation dissolves all the potash, and the wool is delivered from the operation of rinsing in an open, free, and clean condition, and retaining all its natural characteristics. The principal advantages of the system of scouring by means of volatile solvents are that it is a quick and very cheap method; a good income is derived from recovered potash and grease, the latter being purified according to requirements; the reagents are used repeatedly, and the valuable by-products are easily obtained. The agents used have no deleterious effect on the wool, and the wool is not submitted to the harmful effect of high temperatures. The principal disadvantages are: The difficulty of dealing successfully with large quantities of highly inflammable and explosive liquid; large insurance premiums must be paid; and the initial cost of the plant is considerable. There is also a certain loss of the agent used, due to frequent distillation; this, however, is a minor detail.

Treatment of Waste Scouring Liquor.—The waste liquor from washing most wools is rich in fat abstracted from the wool and soap. It is not sufficiently profitable in many cases to make it worth while treating the waste liquor; but it is forbidden by many corporations to turn untreated waste liquor into streams, rivers, or sewers. In the oldest and still the largest-used method, which is known as the Magma process, the waste liquor from the scouring machines is run into a sufficiently large tank, and sulphuric acid is added until all the alkali which is present is neutralised. The whole is then well stirred, so that all the acid is utilised, since if the acid is added and no stirring is done, it simply sinks to the bottom and very little is utilised. It is a good plan to add the acid in very small quantities at the time the liquor is being run into the tank, so that as nearly as possible all the grease will be separated, and no acid will be left in a free state. If acid is present in a free state it renders the effluent acid, and tends to carbonise the grease, in addition to its being wasted. The liquor is now left to settle, and the liberated grease rises to the top, the heavy dirt falling to the bottom, leaving the acid water in the centre. The acid water is piped out and run through a layer of lime into the sewer, while the grease is pumped out into another tank which acts as a drainer or filter, the bottom of which is laid with sawdust, ashes, or any other cheap filtering medium. The remaining water drains away and the grease solidifies, and is then cut into blocks which are wrapped in coarse packing cloth. These are then placed in layers between plates inside a steam-heated ovenpress which is worked by hydraulic power. As a result of pressing, a stream of dark-brown oil and water runs out of a pipe at the bottom of the press into a tank, where the oil and water separate themselves. The oil is pumped from this tank into a purifying tank, where the grosser impurities are taken out. The oil in its most impure form is termed black oil, and when slightly purified it is termed brown oil. Both kinds of oil are used in the shoddy and mungo trade for oiling these materials. The residue after the pressing is used largely for manure.

CHAPTER IV

DRYING

Wool Drying.—Ordinary dry air gives the best results, but it becomes so quickly saturated with moisture that it is not practicable to use it owing to the large volumes required. The common systems of drying wool have arrangements whereby currents of warm air are circulated freely in and around the wool, which is spread out in such a way as to give free access to the currents, which abstract the moisture from it. It must be noted, however, that drying with a high temperature tends to discolour the wool, injure its lustre and handle, rob the fibre of its suppleness, and impair its elasticity and strength. It is quite as important to dry the wool carefully and at a low temperature as it is to scour it with the liquor not too strong and the temperature not too high. If wool is injured by too high a temperature in either of these processes, it is much more difficult to work in the subsequent processes, and an inferior product is obtained at every stage, at a greater cost, and with increased production of waste. Wool should not be dried at a higher temperature than 160° F., and the best results are obtained by drying at temperatures ranging from 90° to 120° F. A temperature of 160° F., or even higher, will not injure the wool so long as it is giving off moisture.

Table Dryers.—A common method, and one which is very applicable and useful for drying small lots, is the table dryer. It consists of a wirework table supported on spars of wood, usually with a flat top and sloping sides, the latter being fitted with sideboards to keep the wool from slipping off. A series of steampipes placed either above or below the table supplies the necessary heat, while a fan assures adequate circulation of the heated air. The size of the table is made to suit the room in which it is to be placed, and the latter should be built to conserve the heat as much as possible. The fan, which is placed at one end or in the centre, draws the air from the outside or other rooms, and if the steampipes are underneath the table the current is forced up through the pipes by means of which it is heated, and forward through the wool on the wire table. If the pipes are above the table the inlets for the air should be distributed about the room, the air being drawn downward through the wool. There is some difficulty in properly distributing a downward current; but if it can be arranged the room is kept in better condition. If the air is drawn downwards through the wool, it is held to the table and it becomes difficult for the air to penetrate it; while on the other hand, if the hot air is forced upwards and the wool is not very evenly spread on the table, it passes through where the wool is thinnest, since it is difficult to force it through the thicker portions, consequently there is uneven drying. The thin portions are over-dried, and the thick portions are insufficiently dried. More even distribution of the air, and therefore more even drying, is obtained by forcing the air upward through the wool. The wool should be kept light on the table, and the air should not be forced at a high pressure, as it is liable to mat the material. When the wool has been on the table for a certain length of time it should be turned over; and if this is neglected, or if it is unevenly spread or left too long it will result in uneven drying, as some parts will be scorched and others left comparatively wet. The principal disadvantages of the table dryer are that a large amount of space is required in comparison with its production, the process is not continuous, and too much manual labour is necessary. It has the advantages, however, of retaining all the natural qualities of the wool, since drying can be watched and controlled at all times.

Machines for drying wool which require no manual labour have to a large extent superseded the table dryer, and machines that require manual labour to charge or empty them, or both. The ideal drying machine is one in which the initial and running costs are low, where the material is dried uniformly and delivered in an open and lofty condition, and in which ample facilities are provided for controlling the amount of heat used and the passage of the material through the machine.

The Petrie Dryer.—This type of dryer, which is made by

John Petrie, jun., of Rochdale, is the most largely used, and is a typical example of a variety known as box machines. An elevation showing part of the machine in section is given in Fig. 10. The machine consists essentially of an outer casing A, which is oblong in shape. The over-all dimensions of the machine shown, which consists of three bays, are about 27 ft. long, 8 ft. wide, and 7 ft. high. An opening is provided at each end of the machine for the purpose of feeding and delivering the wool. Below the floor level is a tubular heater B, measuring 9 ft. by 3 ft., that is made up of about 161 tubes. Connected with the heater is a 40-in. fan, which blows air through the heater and supplies the dryer with hot air. Inside the casing are three tables D, placed one above the other, which are all shorter than the framework or outer casing. They are arranged so that the space between the top and bottom tables and the outer framework is at the delivery end of the machine, while the space between the middle table and the framework is at the feed end as shown. Each table consists of two series of bars arranged alternately, one series being fixed and the other movable. The movable bars are about $\frac{1}{8}$ in. thick, and are all linked together and operated by a crank and cam arrangement, by means of which they are given both a horizontal and vertical reciprocating motion. The machine is usually coupled up to the last scouring machine of the set, so that the wool is automatically fed on to the feed lattice E, which carries it to the rollers F, which feed it to the machine. The moment the wool is free of the nip of the feed rollers it is blown by a strong current of hot air from the heater through the air duct on to the top table D, as shown by the arrows. It is carried along this table by the combined action of the movable bars and the current of air. When the material reaches the end of the top table it drops on to the one below, which is the middle one, and in so doing is turned over and carried along in the opposite direction. The wool is again turned over on dropping on to the bottom table, and when it reaches the end of this table it drops on to the delivery lattice G, which carries it out of the machine.

DRIVING.—The fan is driven direct from the line shaft by a belt H at a speed of about 1000 revs. per min. Another belt I gives motion to pulley J fixed on a shaft which passes across the

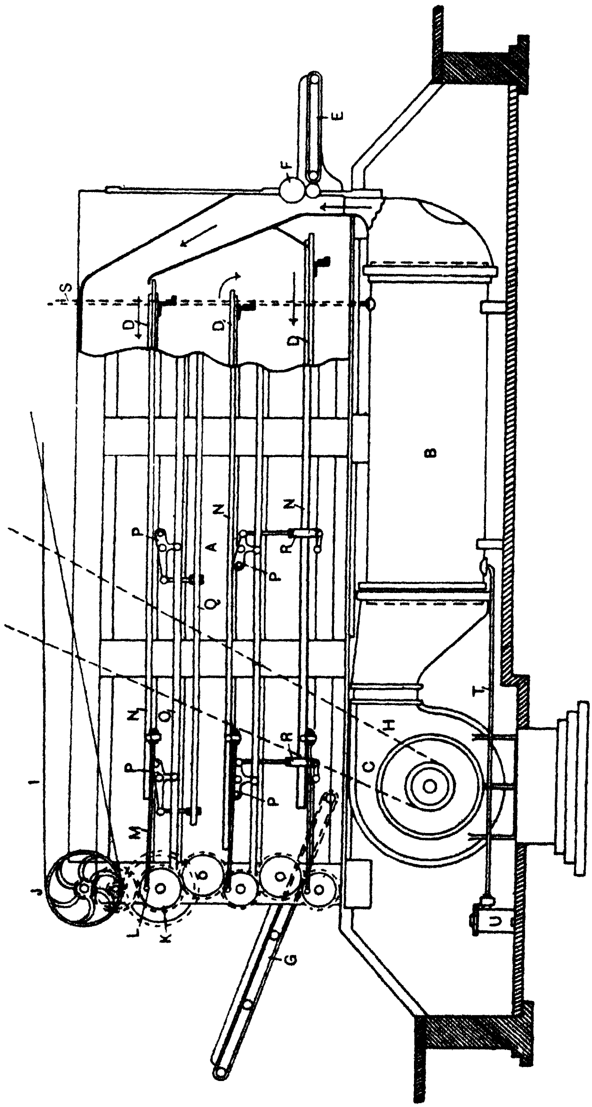


Fig. 10.

machine, and at the other end is fixed a gear-wheel, which through a short train of gearing gives motion to the wheel K on the end of a shaft that extends across the machine. The wheel K drives the gear-wheels, which are all on the same side of the machine as pulley J, and which give motion to the parts that operate the movable bars of each table. All these bars receive motion in exactly the same manner, therefore only the top table will be described. A horizontal and vertical reciprocating motion is obtained by means of a stud L fixed to the wheel K. Attached to the stud is an adjustable connecting rod M, which at its other end is connected to the bar N, that works on the outside of the end framing, but which is connected to the movable bars of the top table, and hence as wheel K revolves the bars are given a horizontal movement of about 7 in. The vertical reciprocating movement is given to the bars by means of a cam compounded with wheel K, but on the side of the wheel nearest the framing of the machine, and this cam operates the bar O. To this bar is connected a series of levers P—three usually being sufficient—and at the end of each lever in contact with the bar N, is an antifriction roller. As the bar O is given a backward and forward motion by the cam, the bars N are alternately raised and lowered. The effect of these two motions on the movable bars is to raise them about an inch above the fixed bars and move them forward about 7 in., and then lower them slightly below the surface of the fixed bars, and move them backwards the same distance prior to raising them again. The fixed bars are about 1 in. wide at the top and are set $\frac{1}{4}$ in. apart, and serve to support the wool when the movable bars are below their surface; but when the movable bars are raised they carry the material with them, and consequently the wool is carried forward a distance of 7 in. and dropped on to the fixed bars again. In this way the material is propelled through the machine. The top table is counterbalanced by the heavy bar Q, which is hung from the opposite end of levers P to that which supports the movable bars of the top table. Only the top table requires a counterbalance bar, since the movable bars of the middle and bottom tables are arranged to balance each other as shown. As the bar N of the bottom table is carried by brackets R, which are provided with antifriction rollers, and the brackets are carried by connecting rods attached to the end of levers P which operate the middle table, the bottom table is raised as the middle table is lowered, and *vice versa*. The pipe S is for supplying steam to the heater, and T shows the steam exhaust pipe leading to the steam trap U. It will be noticed that the air current travels in the same direction as the material, and that the hottest and driest air makes contact with the wool in its wettest state, and passes out of the machine with the wool. Consequently the air as it leaves the machine is a little moist, and has lost most of its heat. This is an advantage, inasmuch as the material is less likely to be injured by over-drying. At the points where the bars N are connected to the movable bars forming a part of the table, slides are provided to cover the necessary openings in the casing, and so prevent loss of hot air. The production of the machine just described is, under average conditions, about 500 lb. per hour. It might be noted that the production is influenced to a large extent by the condition of the wool to be dried with regard to its being open and the amount of moisture it contains upon leaving the last washing machine, since matted wool is much more difficult to dry than material in an open condition. The degree of dryness required is also a factor, and one which varies with almost every manufacturer; but for most ordinary purposes drying to within 4 or 5 per cent. above standard regain is good. The principal advantages of the Petrie dryer are: That the cost of drying is low; that a small amount of heat is necessary; that the drying is even and thorough; and the material is delivered in an open condition.

THE FIELDEN DRYER.—This machine is made by Messrs. Fielden & Co., of Rochdale, and in outward appearance is similar to the Petrie, being of the box type. The principal difference is in the manner in which the wool is propelled through the machine. It is conveyed on perforated plates, each of which is operated by a movable bar that is forced against a buffer or strong spring by a cam, and when the cam releases the bar it is jerked back, consequently the wool is thrown forward and given a good shaking, which is efficacious in removing dirt as well as keeping the wool in an open condition.

THE WHITELEY DRYER.—The Whiteley dryer, as made by

Messrs. Whiteley, of Huddersfield, is also similar to the foregoing as regards exterior and general principle. The principal differences are that the wool is carried to the top lattice or conveyer by means of an inclined lattice, and that the conveyers are constructed of perforated steel bars or laths which are linked together and form an endless chain which is passed round square shafts at each end. Alternate lattices travel in opposite directions. The air is also arranged to be blown upwards through the lattices and material in addition to being blown in the same direction as that in which the material is travelling.

THE WHITE DRYER.—The White dryer, as made by the Patent Conveyer Company, of Huddersfield, is also similar in general form. It is, however, notably different as regards the method of distributing the air and conveying the wool through the machine. The tables consist of two sets of movable bars, each of which is about 1½ in. wide and perforated. They are given a vertical and horizontal reciprocating motion, but in exactly opposite directions. The principle of their action is exactly the same as in the case of the Petrie dryer. The hot air enters a duct at the end of the dryer, occupying a similar position to the one shown in Fig. 10; from this duct three horizontal air ducts branch off and extend down each side of the machine. These conduct air into vertical ducts arranged at intervals down the side of the machine, which, in turn, conduct air underneath each table. In this way the air current is controlled so that air containing moisture is constantly passing over the wool, and is also being constantly reinforced with hot dry air, which is forced up through each conveyer separately, and at as many separate points as there are vertical ducts down each side of the machine. As the air is forced in the opposite direction to that in which the material is being propelled, and is also at the same time being forced upwards through the conveyers, the wool is very efficiently dried and kept in an open condition.

THE MCNAUGHT DRYER.—A dryer constructed on an entirely new principle, made by Messrs. McNaught, of Rochdale, is shown in Figs. 11 and 12. Fig. 11 is a diagrammatic section showing how the air current acts on the wool, and how the wool is transferred from one section or unit to the next; while Fig. 12 is a side elevation showing the principal parts. The same parts in each figure are given the same reference letters. The wool is placed on the feed lattice A, which carries it to the feed rollers B, B, the lower one of which is usually grooved, which makes it possible to get a good grip on the material. As the wool appears through the nip it is subjected to the action of a powerful hot-air current C, which gains considerable velocity by being forced through the com-

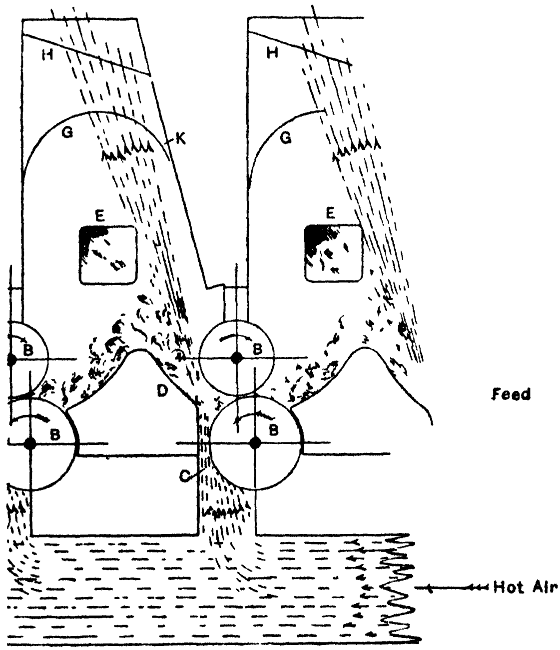


FIG. 11.

paratively small space between the bottom feed roller and the plate or bridge D. This hot air both opens and dries the wool, and as the latter leaves the nip of the rollers it is blown up into the chamber E of the unit. The current of air passes through the space between the plate D and the top delivery roller at a great velocity, but when it reaches the chamber E it expands, and its velocity in consequence decreases to such an extent that it fails to carry the material, and the latter by gravity drops on the other side of the plate, since the direction and velocity of the current are such as to carry the wool to the correct height in each chamber,

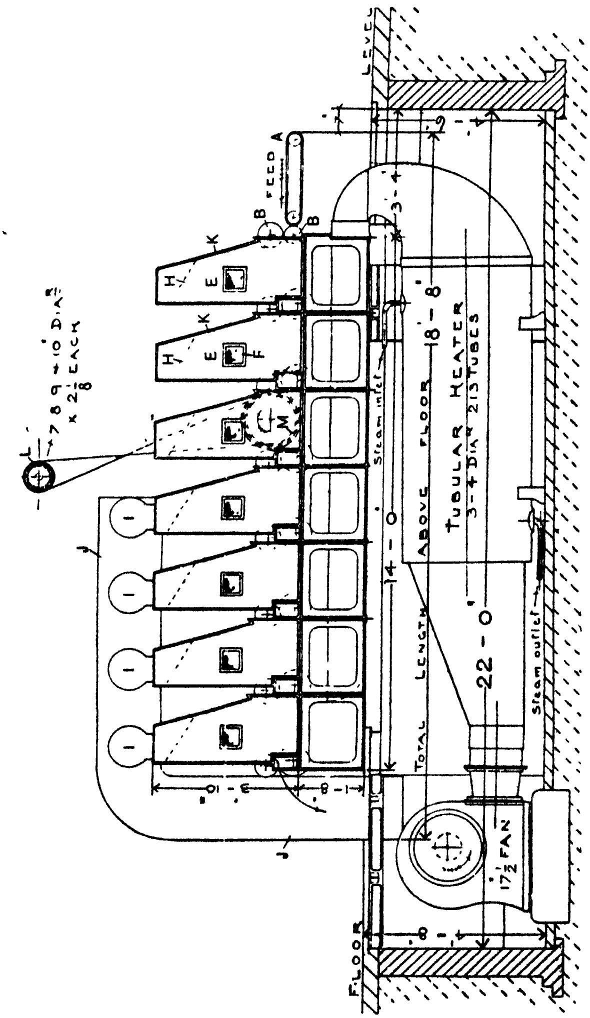


Fig. 12.

so that it drops on the slope of the plate and rolls toward the feed rollers of the next section. The sections are practically exact duplications of each other, but distinct and independent, and although for most purposes seven sections are used, as shown in Fig. 12, sections may be added or taken away as desired.

Windows F are provided so that the progress of the material through the machine can be watched. Plates G and H are perforated, and are for the purpose of catching fine impurities. Referring to Fig. 12 it will be seen that the tops of the last four sections are connected by pipes I to a return tube J, which returns the heated air from these chambers to the fan, which ensures it being reused. The air from the first three sections is very wet with the moisture taken up in drying the wettest wool, and consequently is discharged into the atmosphere. Access may be had to each section for the purpose of cleaning the accumulations on the plates G and H, or other parts by the sides, K being hinged at the bottom so that they can be swung back. The only parts of the machine requiring motion are the feed rollers and feed lattice, and these are driven from the cone drum L, which makes 96 revs. per min., and by means of a 2-in. belt transmits power to the cone pulley M, the sizes of which increase by 1 in. rises from 16 to 19 in. Thus by changing the belt, different speeds varying from 35 to 60 revs. per min. can be given to pulley M. Motion is transmitted to the different pairs of feed rollers and to the feed lattice by means of chain and sprocket gearing, which is suitably arranged down each side of the machine. Noteworthy features of this machine are that each section is supplied with perfectly fresh hot dry air, consequently the maximum drying efficiency is obtained; the wool is kept in a perfectly free and open condition, and any tendency to matting is practically eliminated; the machine is compact and extremely simple in construction; and the time required to pass the wool through the machine to dry it satisfactorily seldom exceeds 3½ mins.; therefore a very high production is obtained.

CHAPTER V

BURRING

BURRING.—Certain wools, notably Buenos Ayres, River Plate, and most Australian and Cape wools, have considerable quantities of burrs, shives, straws, twigs, motes, seeds, and so on attached to them. Up to a certain point these may be picked out in the sorting, but when they occur in large quantities this is obviously out of the question. Burrs, which are present in by far the largest quantities, and are the most troublesome, are the prickly seed vessels of a plant the roots of which extend deeply into the ground. They are consequently unaffected by the scorching sun, and when most other food is killed by drought these plants supply the principal food for the sheep. The burrs, while the sheep are feeding, catch on the wool, and become embedded in the fleece. It is important that all vegetable matter be removed from the wool as soon as possible, and when burrs are present in such quantities as to make it necessary to submit it to a special process, the wool should prior to this process be efficiently scoured and thoroughly dried. Burrs are most difficult to remove, and will pass through all the previous processes to the finished cloth, thus causing defective cloth. In passing the wool through the processes of opening, mixing, and carding, the burrs are broken up, and to a certain extent drop out of the machines as the material is opened, or are retained by the teeth of the carding machines, and removed with the fettlings. In any case, they have a bad effect on the wire of the carding machines, and when they pass through to the roving make it twitty and uneven, and cause bad spinning. If they reach the cloth they form lumps, and if the yarn or cloth is dyed they come up a different shade to the wool, since they are vegetable matter. Further, the cloth before finishing must be submitted to the preparatory processes of burling and mending; and the more imperfections as regards burrs, and so on, there are, the greater must be the time required to complete these processes, and the more imperfect will be the cloth, as in many instances removing the burrs makes a hole in the cloth. The presence of burrs and similar vegetable matter in the wool seriously increases the cost of production, and militates against obtaining good results.

There are two well-known but entirely different methods of removing burr matter from wool—namely, the chemical process, which is termed carbonising, and which is adopted when the impurities are small and numerous; and the mechanical process, which is adopted when the burrs are large and comparatively few. The relative merits of the two methods or systems form the subject of much discussion, and there is some diversity of opinion with regard to each method. The salient features of each method are briefly as follows: The chemical process preserves the length of the fibres and keeps the material intact, but has a tendency to make it tender and discolour it by turning it yellow. It is also stated, however, that when solutions of proper strength are used the effect on the wool is good and not bad, and there is no doubt that acid seems to open out the scales of the wool and so increase its felting power. The mechanical method preserves the natural colour, handle, and strength of the wool, and retains all its spinning and felting properties. It has, however, a decided tendency to break the fibres in opening out the wool and in removing the burrs, and a certain percentage of good wool is removed with the burrs and is wasted unless so much is removed as to make it worth while subsequently carbonising the burrs. The fact that the wool is opened out is in itself an advantage, since it requires less opening in the processes which follow.

There is no doubt that the whole question of dealing with burry wools is deserving of greater attention by British spinners and manufacturers, as Continental manufacturers are certainly much ahead of both American and British firms in dealing with burry wools. Most of the burry wools find their way to the Continent owing to British firms being indifferent and preferring not to trouble themselves with the question of the removal of the burrs. The Continental firms have applied themselves to this question with a considerable measure of success, with the result that a very large trade has developed in yarns and cloth manufactured from cheap burry wools, which might have been in British hands.

It is good practice during sorting to throw to one side those parts of the fleeces in which are present large quantities of small burrs, straws, and so on, so that they may be carbonised; while another pile may be made of those parts in which they are fewer and larger, so that they may be treated mechanically.

THE MECHANICAL PROCESS.—The burrs are removed in this process by a burring machine, of which there are several types. One of the most effective machines for short fine wools and burry

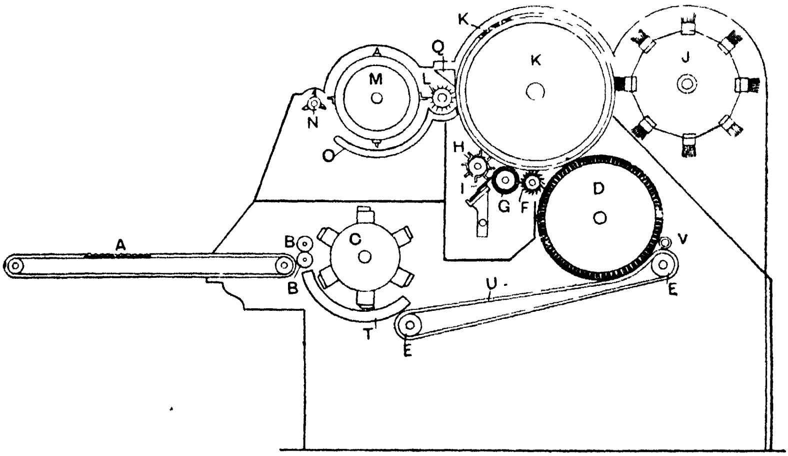


FIG. 13.

wastes is that known as the double-action burring machine, as made by Messrs. John Sykes, Limited, of Huddersfield. A diagrammatic section of this machine is shown in Fig. 13. In Fig. 14 is shown a right-hand elevation with the covers, pedestals, and fixings removed to show the working parts as well as the driving; while in Fig. 15 are shown some of the corresponding parts as in Fig. 14, along with the driving on the left-hand side of the machine. The same reference letters in each figure refer to the same parts. The essential parts of this machine consist of a comb cylinder, burr beater, feeding brush, and stripping or doffing brush fan. The action and operation of the machine are as follows: The wool to be burred is placed on the feed lattice A, and the most up-to-date firms employ a hopper or automatic feed for this purpose, though hand-feeding is as yet more general. The lattice carries the wool to the feed rollers B, which are usually ordinary fluted rollers of small diameter. As the material is leaving the nip of these rollers it comes under the action of a rapidly revolving six-bladed beater C, which gives the wool a preliminary opening and shaking; and this, in addition to it being dashed and scraped over the grid T, results in the removal of many burrs, which drop into a suitable receptacle underneath. The beater passes the opened material to the lattice U, which passes round rollers E, from which it is taken by the brush D, which is about 18 in. in diameter. The small roller V prevents any material passing round on to the underside of the feed lattice. As the brush rotates and presents the material to the comb cylinder K, it is removed from the former in a thin layer, since it has a much greater surface speed. The comb cylinder, which is 22⅜ in. in diameter, consists essentially of a number of bars as shown in the detailed part K^1 in Fig. 13. These bars are firmly fixed to spiders, which are in turn keyed to the central shaft. Fixed to the bars are needle-pointed teeth, which do not project above the outside surface of the cylinder, or at most only very slightly, and they are set so fine that the burrs cannot get behind them. Any wool remaining on the brush D is stripped from it by the roller F, which is covered with card clothing, and revolves at a greater surface speed. This roller delivers the wool to the brush G, which, revolving at a greater surface speed, and in the direction of the backs of the teeth of roller F, strips the material from it and delivers it to the comb cylinder. This brush also assists in laying the material satisfactorily on the comb cylinder. Should any wool remain on the brush G, it will probably be very burry, and could not be laid readily on the comb cylinder; it is therefore knocked off by the beater H into the box beneath, from which the waste is removed as is found necessary, and either run through the machine again or carbonised. The blade I is set clear from beater H, but just so that the brush G will scrape it, and serves to keep the brush clean. The wool is laid on the comb cylinder so that only the burrs project beyond its surface, and as it revolves, the burr roller or beater L revolving at a great speed knocks off the burrs as they are brought round by the comb cylinder, and any that are left projecting on the surface are removed by the arrester block and blade Q, which are fixed just above the beater. The burred wool is removed from the comb cylinder by the octagon-shaped doffing brush fan J, and ejected from the machine on to the floor or into a suitable receptacle placed to receive it. All the burrs removed by the burr roller and blade are thrown on to the curved grate O, through which they are beaten by the wood roller M into a box placed to receive them. Any burry matter which

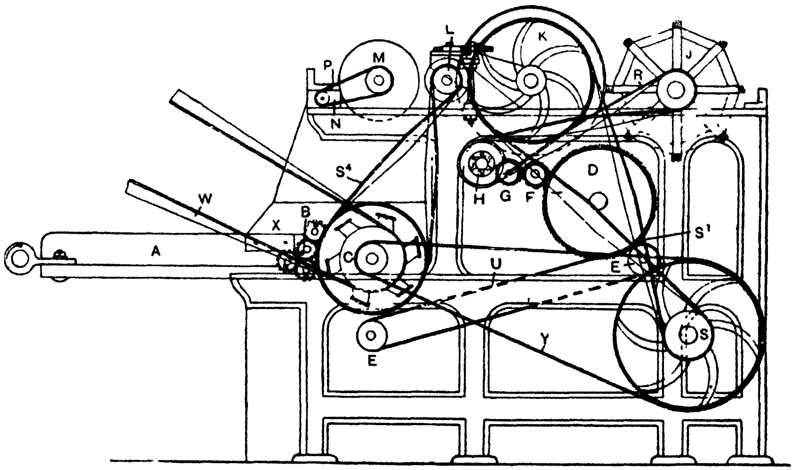


FIG. 14.

may become attached to the roller M is beaten off by the small roller N.

SETTING.—On the proper setting of the various parts of this machine depends the success of its action. The brush D must be set to touch the lattice E and the comb cylinder K, and the roller F must be set ¼ in. from the comb cylinder, but to touch the brushes D and G. The brush G should just touch the comb cylinder K so as to satisfactorily deliver the material stripped from the roller F, and the small beater H must be ¼ in. from the comb cylinder and at the same time just spring the bristles of brush G. It is of the utmost importance that the burr roller L and the block Q be properly adjusted in relation to the comb cylinder, since these are the vital parts of the machine. In proceeding to set these parts, the block Q should first be raised clear of the burr roller L, which must then be adjusted to the comb cylinder K by a gauge which is sent with the machine, after which the block is lowered until both the blade and block are perfectly parallel to the burr roller L, which it should almost touch. It should, however, be practically the same distance from the comb cylinder as the beater. All the parts can be accurately adjusted by means of pedestals suitably mounted.

DRIVING.—The beater C, Fig. 14, is driven from the drum on the line or countershaft at a speed of about 650 revs. per min. by means of a belt W, which drives to the fast and loose pulleys on the beater shaft. A belt Y drives to a loose pulley compounded with which is pulley S, and both these pulleys run loose on a stud fixed to the framework of the machine. Pulley S, by means of a belt S^1, drives the comb cylinder at a speed of about 75 revs. per min. The roller M is driven by means of a crossed belt S^2 from a pulley on the beater shaft C at a speed of about 360 revs. per min. On the same side of the machine is a pulley on the shaft of roller M, which by means of a crossed belt S^3 drives the doffing brush fan at a speed of about 600 revs. per min. On the opposite end of the shaft of roller M is a pulley which, by means of a short belt P, drives roller N, and on the same side of the machine a pulley on the doffing brush fan shaft gives motion by a crossed belt R to a pulley on the shaft of beater H. The burr roller L is driven by a crossed belt S^4 from a pulley on the end of the shaft of beater C, as shown in Fig. 14, at a speed of about 2000 revs. per min. On the side of the machine shown in Fig. 15 is fixed on the comb cylinder shaft a gear-wheel, which, through two carriers, each of which has sixty teeth, transmits motion to wheel F^1 on the brush shaft driving it, at a speed of about 15 revs. per min. The rollers F and G are driven by means of two carriers from the gear on the comb cylinder shaft at a speed of about 106 and 86 revs. per min. respectively. It must be noted that in the case of roller F, Fig. 13, this would be driven in the opposite direction, and consequently the gearing would require to be a little different from that just described. Roller V is usually driven by a short train of gear-wheels from gear-wheel E. The first wheel of this train which is driven from E is placed on the end of one of the rollers, round which lattice U passes, and thus gives motion to it. A chain Z driven by a sprocket wheel on the brush shaft gives motion to the feed rollers and feed lattice by means of suitable gearing. The production of this machine for a working day of 10 hrs. is from 700 to 800 lb. The width is 48 in., and the power required to drive it is 3 to 4 h.p.

Coarse Wool Burring Machine.—A very good machine as made by Messrs. P. and C. Garnett Limited, of Cleckheaton, for burring coarse wools such as East Indian and similar wools, which are used in the felt trade, and for manufacturing carpet yarns, is

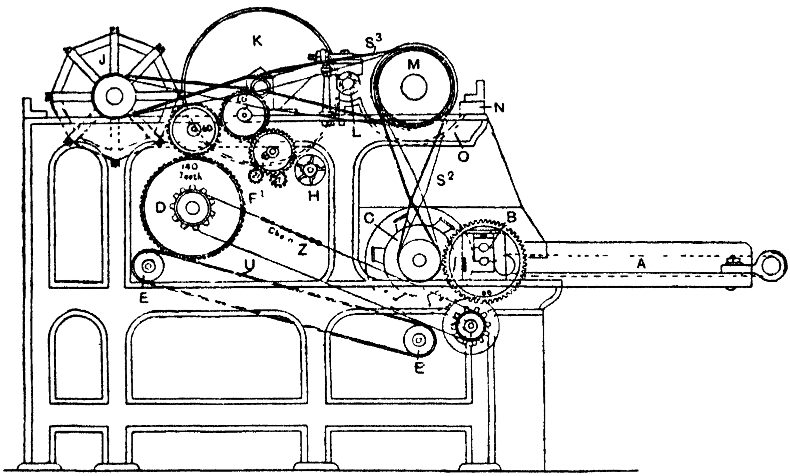


Fig. 15.

shown in Fig. 16. The figure shows the machine diagrammatically partly in section and partly in elevation. The essential parts of this machine are the picking cylinder, comb cylinder, Garnett roller or burr guard, burr beater, and doffing brush fan. The action and operation of the machine is as follows: The wool to be burred is placed on the feed lattice A, which carries it to the feed rollers B, that are usually covered with coarse Garnett wire, and as the wool is leaving the nip of the feed rollers it comes under the action of the picking cylinder C, which is revolving in the direction shown by the arrow. The strong teeth, which are set in lags fixed to spiders, catch and comb the wool, and open it out while it is still being held by the feed rollers. The teeth of the cylinder carry the wool forward as it leaves the feed rollers. Roller B^1 is a clearer for removing any material retained by the top feed roller B, and passing it to the picking cylinder. Further opening of the wool is obtained by the pins of the picking cylinder intermeshing with a row of stationary pins D, which are suitably fixed to a plate that extends the full width of the machine. The material is next presented to the teeth of the comb cylinder E, which is essentially the same as that used in the fine wool burring machine, which has been previously described. The teeth of this cylinder catch the wool and remove it from the picking cylinder. Wool that is not sufficiently opened to be properly caught by the comb cylinder is taken forward and practically scraped over the grid F, which is adjustable. Consequently the material is opened, and much burr matter is removed in this way before the wool is again presented to the comb cylinder. The comb cylinder revolving in the direction of the arrow, with the wool mainly behind and held by the teeth so that only the burrs are projecting beyond its surface, carries the burrs and wool forwards until they come under the action of the burr guard G, which is covered with Garnett wire. This roller catches any projecting burrs and carries them round. The burr beater H, which is two-bladed, knocks off the burrs and throws them into a tray, suitably placed, from which they may be automatically removed by scrapers attached to an endless belt. The scrapers move the burrs to the end of the tray, from which they are removed and conducted away by means of a shoot. The burred wool is removed from the comb cylinder in the usual manner by means of an octagon-shaped doffing brush fan I, and ejected from the machine. In some machines a burr roller is placed over the comb cylinder in such a position as to be stripped by the doffing brush fan. The object of this burr roller, which is covered with flat-topped Garnett wire, is to remove any burrs which are not removed by the burr guard. Its action is such that it catches the wool, and the burrs, being unable to get below the surface, are carried upward, and removed by a burr beater placed over the burr roller, which knocks the burrs into a tray, from which they are removed by scrapers.

Setting.—The points to be noted with regard to setting the various parts of this machine are to set the picking cylinder sufficiently close to the feed rollers to get adequate opening of the material with the minimum breakage of fibre. The burr guard must be carefully set to the comb cylinder so as to obtain proper removal of the burrs, and the burr beater must be set to the burr guard sufficiently closely to beat off the burrs. When the brushes on the doffing brush fan wear down, the fan may be set nearer to the comb cylinder so as to doff the wool efficiently. The brushes should be set slightly into the comb cylinder. Ample facilities for making all necessary adjustments are provided, and setting gauges are also supplied so that accurate setting the full width of the

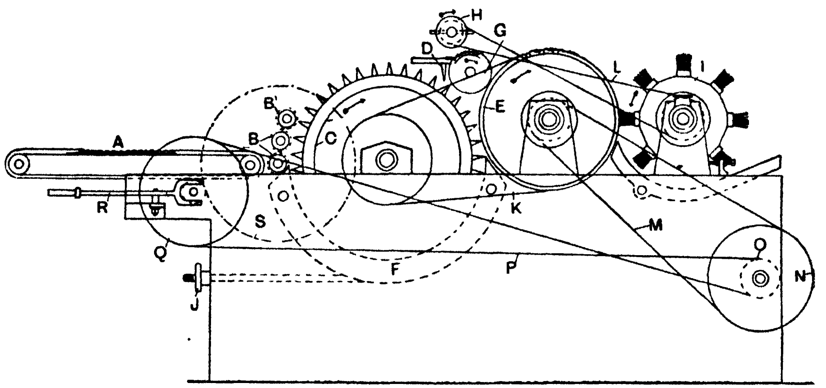


FIG. 16.

machine can be obtained. The grid F is adjustable, so that it may be set nearer to, or farther from, the picking cylinder as required, the adjustment being made by means of the hand-wheel J situated at the front of the machine.

DRIVING.—The picking cylinder receives motion from the drum on the line or countershaft by means of a belt, which is not shown. An open belt K receiving motion from a pulley on the picking cylinder shaft drives the comb cylinder at a reduced speed in proportion to the difference in the size of the pulleys. The doffing brush fan is driven from the opposite side of the machine to that shown by means of a large pulley on the picking cylinder shaft, giving motion by means of a crossed belt to a small pulley on the doffing brush fan shaft. The driving for the burr guard is also on this side of the machine, the roller being driven by means of an open belt from a pulley on the comb cylinder shaft. A pulley on the doffing brush fan shaft gives motion by means of a crossed belt L to a pulley on the burr beater shaft, and since the doffing brush fan runs at a great speed, and the pulley on the burr beater shaft is much smaller than that on the doffing brush fan shaft, it will be seen that the beater revolves at a great speed. Motion is given to the feed rollers and feed lattice from a pulley on the comb cylinder shaft by means of an open belt M, which gives motion to a pulley N that runs on a stud suitably fixed at the rear of the machine. Compounded with pulley N is a pulley O, which by means of a crossed belt P gives motion to a pulley Q fixed on a shaft. On the same shaft is a pinion which may be moved sideways by means of a forked hand lever R, and by this means can be engaged with, or disengaged from, the gear-wheel S on the shaft of the bottom feed roller. The object of this arrangement is to stop the supply of wool at any moment should it be necessary for any reason, such as a disarrangement of the parts. The top feed roller, clearer, and feed lattice are driven by gear-wheels from the bottom feed roller. All the gearing is on the opposite side of the machine to that shown in Fig. 16. There are two gear-wheels on the bottom feed roller shaft, one of which drives the clearer direct, while the other drives the top feed roller direct. An intermediate or carrier wheel conveys motion from the bottom feed roller to a gear-wheel on the front shaft of the feed lattice. With regard to burring, it must be noted that when burring coarse wools a burr guard or roller with coarse wire and longer tops should be used than when fine wools are being burred, since, if a roller with fine wire and short tops is used on coarse work, the wool as well as the burrs is liable to ride on the surface of the teeth; while, on the other hand, if a roller covered with coarse wire is used on fine work, the material is only held loosely. In both cases much good wool will be removed with the burrs, which should be retained, and too much waste will be made. To obtain the best results, burring machines should be kept scrupulously clean, so that dirt and burr matter can drop freely through the various grids. Also all receptacles for burr matter should be cleaned out at frequent intervals.

CHAPTER VI

CARBONISING

INTRODUCTION.—Carbonising, which is the term given to the chemical process adopted for removing burrs, as has already been noted, is also used for extracting wool from rags composed of cotton and wool, or wool and some other vegetable fibre—as, for instance, in the case of stuff goods which are woven with cotton warp and mohair or lustre worsted weft, and union fabrics which are made with cotton warp and woollen weft. The vegetable thread and fibre are destroyed by carbonising, and the reclaimed wool is used again. Carbonising with regard to removing burrs will be dealt with first. This process is more largely used and is more effective than the burring machine, since it without fail removes all traces of vegetable matter, whether it be in the form of burrs, seeds, shives, dried grass, twigs, or bits of jute, hemp, or other vegetable fibre which may become attached to and mixed with the wool in its transit to the mill. The impurity in the form of the fibre present is generally due to the fleeces being tied up with string, which may not be all removed; or to fibres from the bale covering becoming intermingled with the wool.

PRINCIPLE OF CARBONISING.—The success of carbonising depends upon the action of certain acids and heat. The principle of its action is based on the fact that vegetable matter consists mainly of cellulose, which substance is composed of carbon, hydrogen, and oxygen, its chemical formula being $C_6H_{10}O_5$. The two latter, it will be observed, are in the same proportion as in water. Consequently, as acid or acid vapour has a great affinity for water, the water is removed from the cellulose, which is converted into hydrocellulose, or a carbon compound that can be easily removed, as will be subsequently described. There are two methods or processes in use—namely, the wet and the dry process. The agents used in the wet process are sulphuric acid, commonly known as oil of vitriol, the chemical formula of which is H_2SO_4; aluminium chloride, Al_2Cl_6; sodium hydrogen sulphate or bisulphate of soda, $NaHSO_4$; and magnesium chloride, $MgCl_2$. In the dry process the agent used is hydrochloric acid or muriatic acid, HCl. The dry process is now almost exclusively used in removing vegetable matter from rags, since it gives new wool a yellow cast.

STEEPING.—In the best managed and equipped plants there are seven operations. The first is that of steeping the material in the agent used in the case where it is used in a liquid state, or in the case of the dry process submitting it to the action of the hydrochloric acid vapour. When sulphuric acid, or, as it is usually termed, oil of vitriol, is used, steeping is done in a wooden tank, since the acid attacks and destroys ordinary iron tanks. The quality of sulphuric acid most suitable for the purpose is known as double rectified, which registers 170° Tw. at 60° F., and the strength of the bath or solution when carbonising wool or noils containing fine shives, seeds, small burrs, and so on, should be from 4° to 6° Tw.; but for very burry wools and wools containing large and solid burrs, a bath registering 7° to 10° Tw. is usually necessary. In preparing the acid solution it is advisable to prepare it overnight, since a rise in temperature always takes place when the acid is added, and a vapour is given off which will probably injure the colour of the wool. On no account should water be added in bulk to strong acid, as the effect of the two substances uniting is to produce great heat, and very serious explosions are liable to occur. The acid should be added in a thin stream, and before the material is submitted to the bath the solution should be thoroughly stirred, as the acid being of greater specific gravity sinks to the bottom. Consequently, to get the solution of even strength and to obtain the best results, every precaution must be taken to obtain a thorough mixture of the acid and water, and also to obviate the solution registering weaker than is actually the case.

The time that the material is immersed in the acid solution depends largely upon the size and solidity of the burrs. For wools or noils containing fine shives and small burrs 15 to 20 mins. is an average time, while for wools containing large and solid burrs

40 to 60 mins. is usually sufficient. If the wool is allowed to remain in the acid solution a few minutes longer than is absolutely necessary, no serious harm is done so long as the material is kept submerged, since the solution is very dilute. It is, however, a good point in carbonising to use the weakest solution possible and steep for the shortest time consistent with good commercial results. These points are important for reasons of economy, in addition to taking every precaution against the material being damaged.

DRYING.—Removing the superfluous solution from the saturated material may be termed a separate operation, as it is usually done by whizzing it in a hydro-extractor, the solution removed being drained back to the steeping tank. Stoving or drying is the next operation, and it is during this process that carbonising proper takes place, since the burrs are converted into carbon compounds. The operation may be done in three ways. First, by means of one drying machine; second, by means of two machines, the first having a temperature of about 160° F., and the other a temperature of from 180° F. to 212° F.; and the third method is by means of an enclosed room, or by an oven or ovens. This latter method is being superseded by the two former, though it is still used to a certain extent. The material, when dried by the third method, is placed in thick layers on racks in the oven or room, which is heated in any suitable manner by either furnaces or steam to the required temperature. The wool is allowed to remain in the oven or enclosed room for a period of about 45 to 60 mins. In oven drying there is difficulty with the moisture which is evaporated from the material and the acid fumes not being able to get away, and these have a damaging effect on both the material being carbonised and the materials used in the construction of the oven. The method is also more laborious, requiring more attention and manual labour.

It is considered better practice to use two small dryers rather than one large one, since it is desirable that the material should be first dried at a temperature of about 160° F., so as to drive off the uncombined moisture before passing it through the second dryer, in which the temperature is kept at from 180° F. to 212° F., and in which the moisture in chemical combination is evaporated and carbonising completed. By adopting this method the trouble of the presence of evaporated moisture and acid fumes is practically eliminated, since the moisture is removed at two operations and adequate ventilation can be more readily provided. It is acknowledged to be the best practice to use the lowest temperature that is commercially possible, but the temperature used is seldom if ever lower than from 175° F. to 180° F., as lower temperatures than these render it necessary to prolong unduly the operation of drying. In the case of wool dried by using two machines, the first having a temperature of 165° F. and the second a temperature of 210° F., the whole operation of drying would require about forty minutes, about twenty minutes for each operation being necessary. The temperatures just given are good average temperatures. The moisture is absorbed very rapidly, and when the material reaches the second machine the sulphuric acid is in a highly concentrated state on both the wool and the vegetable matter, but it quickly attacks the latter matter and changes its chemical structure, rendering it very brittle and friable.

Crushing and Shaking.—The operations which follow drying are crushing and shaking or willeying. These may be said to be two distinct operations, as in the former the material is drawn or drafted out into a thin and comparatively uniform sliver by being passed between three or four pairs of weighted rollers, each pair of which farther from the feed lattice is running at a greater surface speed than the preceding pair. Consequently the burrs which are still hard, but which have been changed into carbon compounds, are readily crushed without injuring the material, as each pair of rollers are set slightly apart to allow the free passage of the material. The crushing arrangement is usually set in front of the shake-willey, the object of which is to shake or beat out the already powdered vegetable matter from the material. The next process is that of neutralising all the remaining traces of the acid on the material, which is done by passing the material through an alkaline bath. Soda ash is the agent commonly used, as it is much cheaper than pearl ash. The strength of the bath should not be more than from 4° to 5° Tw., and may be as low as 2°.

In neutralising each other the acid and alkali combine and form a neutral salt. The best method of neutralising is to pass the material through three scouring machines, the first being a rinsing machine, through which is running warm water; while the second is the one which contains the soda solution, and in which neutralising proper is done; and the third is a rinsing machine, which contains a clean, soapy scouring liquor. From the last rinsing machine the material is passed to the last operation, which is that of drying. A machine of ordinary construction is used, which delivers the material in a nice, soft, and lofty condition.

THE JOLY PROCESS.—In this process, which has been patented by a Frenchman named Joly, aluminium chloride is used. The wool is steeped in a solution of the chloride of a strength of from 9° to 10° Tw. for upwards of an hour, after which it is taken to a hydro-extractor for the removal of the superfluous liquid, which is drained back and used over again. The material is then dried at an ordinary temperature before being passed through a carbonising chamber or ordinary dryer, in which the temperature is as high as from 240° F. to 250° F. It will be noted that a higher temperature is used for carbonising by this method than is used in the sulphuric-acid process. This is necessary in order to liberate the hydrochloric-acid vapour which is the real carbonising agent. When carbonising proper or drying has been completed, the carbonised burrs are crushed, and the vegetable matter is shaken from the wool.

This process of carbonising is more applicable to cloth or piece-goods than to raw material, or material which has not been carded. When piece-goods are to be carbonised, the cloth is thoroughly steeped in a solution of aluminium chloride registering from 8° to 10° Tw. The cloth is then taken to the hydro-extractor, which removes superfluous solution, after which it is dried at an ordinary temperature, and then passed through a carbonising chamber or tentering machine; the temperature in either of the two latter cases being as high as 250° F. After drying for upwards of 45 mins. the cloth is taken to a milling machine, which, since the cloth is run through the machine in a dry state—that is, without any soap solution being added—crushes the burrs and carbonised matter. Both the cloth and the wool—the former after crushing, and the latter after shaking—are washed either in clear water, or preferably in water to which has been added a little fuller's earth.

There are many advantages and several disadvantages of this method of carbonising, some of which are as follows: If wool or cloth has been previously dyed, the colours are in most cases unaffected by the process; there are no noxious vapours or fumes produced, that have a corrosive effect on the buildings and apparatus used, and which add to the difficulties of the work by poisoning the atmosphere; the natural characteristics of the wool are not so liable to be damaged should the material be subjected to too great a heat; and since the aluminium chloride does not corrode the metalwork of the machines used in the operation, no rust stains are found on the material. This process has, however, the disadvantages of increasing the work of cleaning, as a sticky compound is deposited, due to the decomposition of the acid as the material passes through the machines; and when using aluminium chloride it is important that all traces of the agent be removed before soap or oil is applied to the material, and the wool when submitted to the bath should be free from oil, since if the above precautions are not taken an insoluble compound is formed which seriously affects subsequent drying. It should be noted that the aluminium chloride used for carbonising should be pure, and free from any traces of iron, as this substance has the effect of "saddening" the colours.

In place of aluminium chloride as the agent, magnesium chloride is sometimes used, the process with regard to strength of solution, time of steeping, and all other respects, being similar to that detailed with regard to aluminium chloride. The most notable advantage resulting from the use of magnesium chloride is the cheapness of the agent; while the most notable disadvantage is that it requires a temperature of about 10° F. more than is necessary in the case of aluminium chloride to set free the hydrochloric acid. The Spennarth process, in which bisulphate of soda is used, is one which is coming to the front, and it certainly has much to recommend it, as the agent is much cheaper. Moreover, it has no tendency whatever to impair the valuable natural qualities of the wool, and since the carbonised vegetable matter is rendered white, the natural colour of the wool is fully retained. Other substances which have been experimented with are calcium chloride and chloride of zinc; but the method which is by far the largest used is that in which the agent is sulphuric acid.

CARBONISING PLANTS.—A well equipped and arranged carbonis-

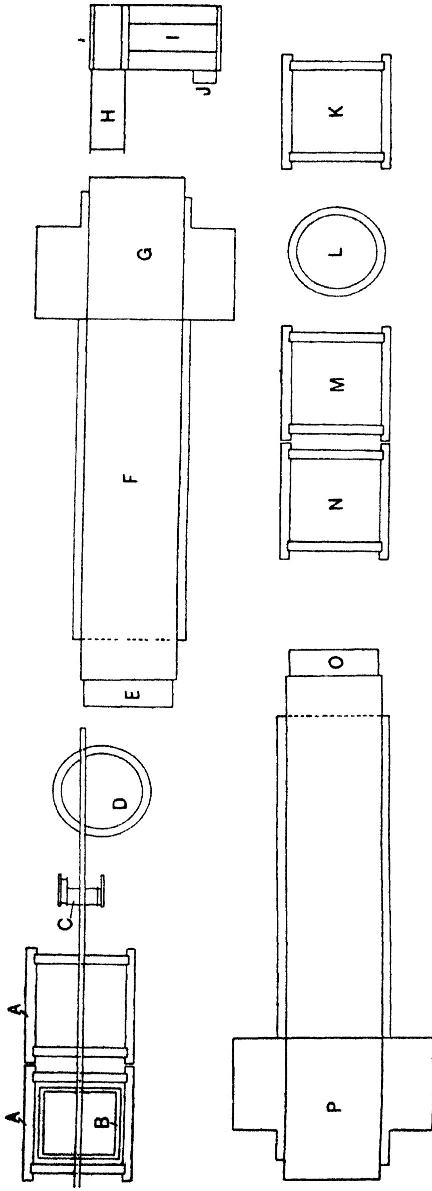


FIG. 17.

ing plant should be such as to obviate the necessity for having to carry the material over the same ground twice—that is, the material should pass from one machine to another without being carried backwards. A plan of an arrangement is shown in Fig. 17, which consists of three or four wooden tanks A, only two of which are shown. The number of tanks used varies according to requirements. In the first of these is shown a wooden crate B, filled with the wool to be carbonised. The steeping tanks are let completely into the floor. After the wool has been submerged, by means of the crate, in the acid solution for a sufficient length of time, it is lifted out by means of the small crane C and suspended over the tank so as to allow as much as possible of the superfluous acid to drain back into the tank. The crate is next taken along the runway to the hydro-extractor D, which removes a very large percentage of the remaining acid solution from the material; this solution is drained back to the steeping tank by suitable pipe connections.

From the hydro-extractor the wool is fed to the hopper E of the dryer. All the metal parts of this machine with which the wool comes in contact must be covered with lead or rendered acid-proof. When the carbonised material is delivered from the dryer at G, it is placed on the feed lattice H of the crushing and shaking machine I. This machine frees the material from all vegetable matter and delivers it at J. The remaining traces of acid are now neutralised by the wool being rinsed in the rinsing tank K, then whizzed in the hydro-extractor L, and again rinsed in tank M, which contains the soda solution. After the actual neutralising has been done, the wool is rinsed in tank N, containing a soapy liquor, and is then whizzed in the hydro-extractor L. From this latter machine it is fed to the hopper O of the dryer, which delivers the material at P in a nice clean condition, free from all vegetable impurities.

The plant just briefly explained is very efficient and complete, as will be realised when it is noted that carbonising is done by means of an ordinary lead-lined cistern with racks fixed above on which to place the material to allow the superfluous acid solution to drain back into the tank. From the racks the material is taken to a hydro-extractor, and thence to the perforated floor of a room over a boiler. This is a crude method, and there is scarcely any doubt that it would be much better to send the material out to a firm which makes a speciality of such work. Instead of tanks, scouring machines are now being used of the harrow-rake type, and these are provided with rollers that squeeze the excess solution from the material as they pass it to the delivery lattice, which feeds the wool to the next machine. The solution squeezed out is returned to the tank of the machine. By adopting machines instead of tanks for steeping and rinsing, and employing squeeze rollers, hydro-extractors can be dispensed with. In addition there is no occasion to handle the wool from the time it is placed in the hopper which feeds the steeping tank until it is delivered from the last drying machine, as the delivery lattices of the scouring machines used for steeping, rinsing, and neutralising deliver to the feed lattices of the dryers.

An improved carbonising plant made by Messrs. John and William McNaught, of Rochdale, and one in which the handling of the material is reduced to a minimum, is arranged on the plan outlined above.

In Figs. 18 and 19 are shown longitudinal and cross-sections respectively of the acid machine. In operation the wool is placed on the feed lattice A either by hand or from a hopper, and as it drops into the bowl B it is submerged in the acid by the immerser C, and then carried forward by the forks D, which are given a slow forward movement when in the solution. The material when it reaches the end of the bowl is moved into the nip of a pair of strong and heavy squeeze rollers E, which squeeze out of the wool a very large percentage of the acid solution, after which the wool is carried by a lattice from the machine. Additional immersers F are placed at intervals so as to ensure that the material will be kept completely immersed during the whole of the time that it is passing through the machine. The arrangement of bowls is shown in the cross-section, Fig. 19, and the dimensions of the bowl B in which steeping is done are given, as is also the depth of the acid solution in the bowl. The liquor from the squeeze rollers passes into the trough G, and from the trough it runs into the side tank H, from which it is pumped back into the steeping bowl. The fork motion and squeeze rollers are constructed and operated in a manner similar

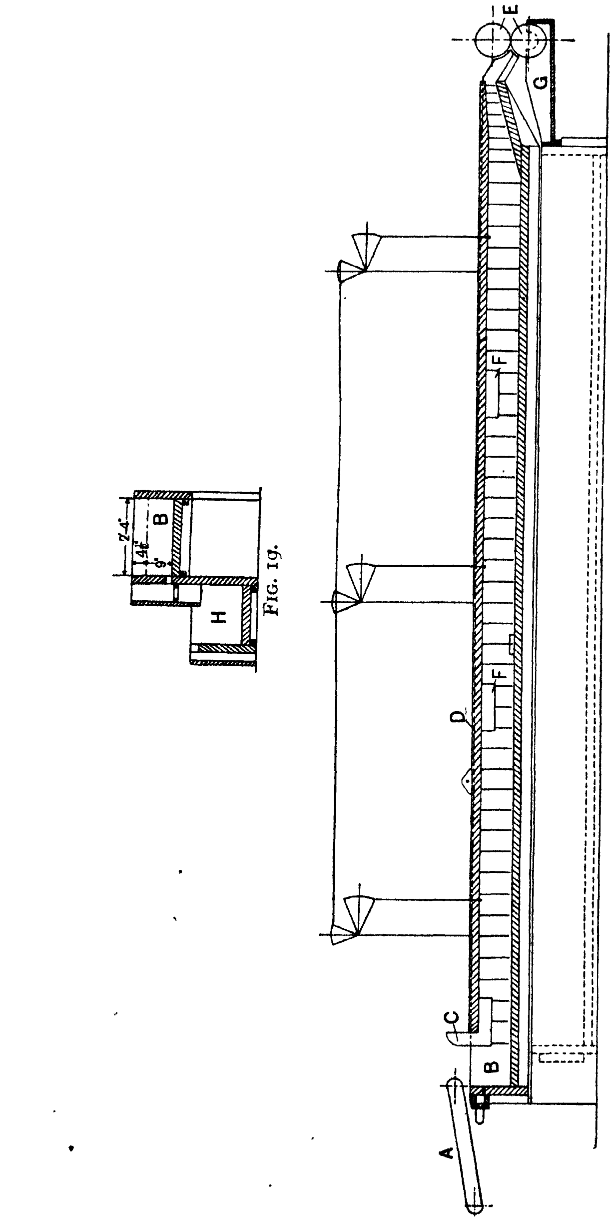


FIG. 19.

FIG. 18.

to that described in connection with the same make of washing machine.

The squeezed wool is delivered from the acid machine by a lattice to a McNaught sectional dryer, which is similar in all respects to that explained when ordinary wool drying was dealt with, the temperature being kept at about 160° F. From this machine the material is passed through a second dryer of the same type, in which the temperature is kept at 200° to 210° F., and it is in this machine that carbonising proper is done. The wool delivered from the latter dryer is by means of a lattice fed to a crushing and shaking machine.

In one type of this machine, as made by Messrs. John and William McNaught, of Rochdale, the wool passes from the feed lattice through several pairs of heavy fluted crushing rollers, each pair of which farther from the feed lattice is driven at an increased speed. The effect of each pair of rollers rotating at a greater speed is to draw the fibres away from the material, which is in effect held by the rollers that are rotating at a slower speed, and this results in the weight per yard of the layer of material fed being decreased correspondingly. It also improves the arrangement of the fibres by placing them more nearly parallel. Consequently, as the material is passing through the last pair of rollers before reaching the cylinder, it is in the form of a thin and fairly even film or ribbon, and thus the small burrs are crushed without injuring the material, since the burrs are thicker than the material. The crushing rollers are weighted by means of springs to obtain the requisite pressure. As the material issues from the last pair of crushing rollers it comes under the action of a beater or cylinder provided with strong teeth, which revolves at a great speed. In suitable positions are fixed rails provided with similar teeth, and as the material is carried round by the cylinder, opening takes place between the teeth of the cylinder and those on the fixed bars. The heavy particles of loosened dust and dirt drop through a grid suitably placed, while the lighter dust is drawn through a grid by means of a fan or fans placed on the top of the machine. The current of air generated by the fans draws away the impurities in the top half of the machine, but the grid retains all the wool fibres. After being thoroughly opened, shaken, and cleansed, the material is delivered from the machine by means of a lattice.

An improved kind of crushing and shaking machine is shown in Fig. 20, which is a photograph of the machine taken from the front. On the left is shown the feed lattice along with some of the driving mechanism. The fluted rollers and springs for weighting same are also shown. Part of the cylinder is exposed to view by a section of the cover being removed. At the extreme right of the machine is shown the delivery lattice, and on the top will be observed the fan covers, while at the left-hand side near the top the driving

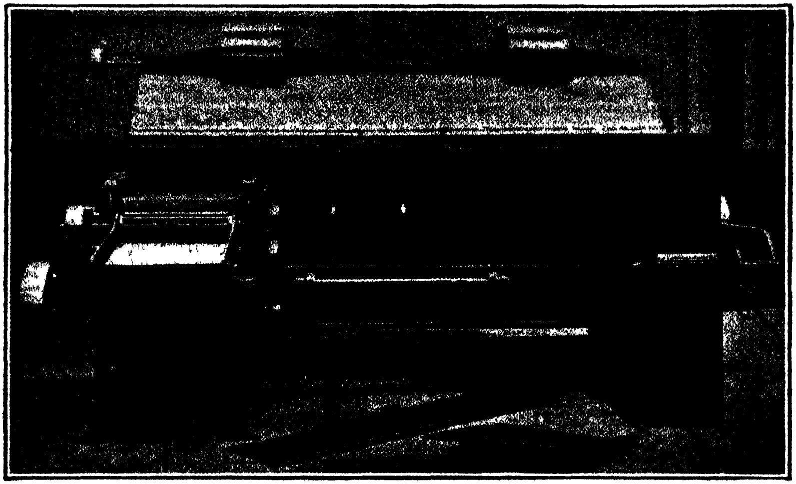


FIG. 20.

shaft and pulley for the fans will be noticed. This machine is provided with two fans.

The machines already referred to may be conveniently placed down one side of the room, and the wool from the delivery lattice of the duster is carried by a conveyer consisting of a fan and the necessary piping to the next line of machines, which are arranged down the other side of the room. The first machine of the second line is a rinsing machine, which is similar in every respect to the ordinary harrow-rake type of scouring machine. Clean warm water is continually running through this machine, and the material is delivered from it to a neutralising machine. A longitudinal diagrammatic section of the latter machine is shown in Fig. 21, while a cross-

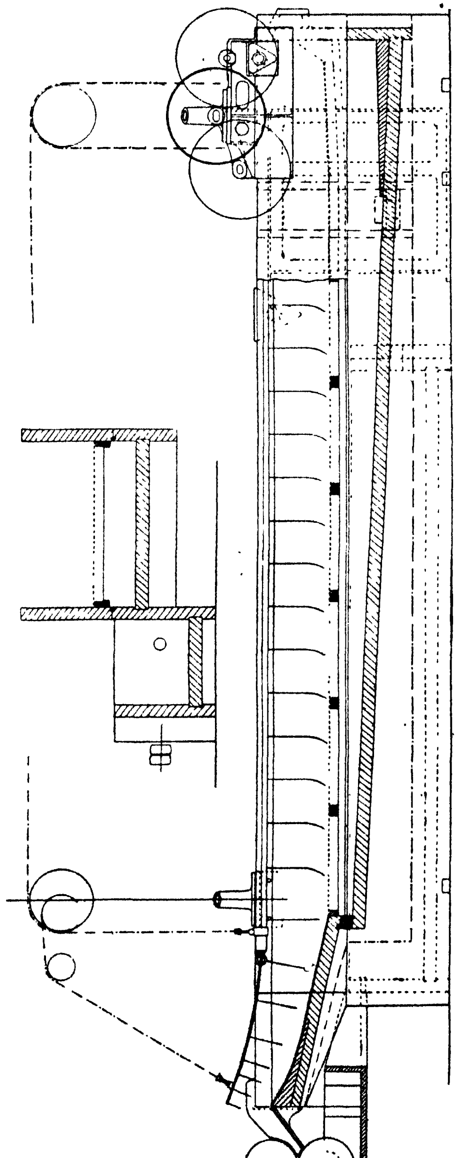


Fig. 22.

Fig. 21.

section is shown in Fig. 22. The general principle of this machine is the same as that of an ordinary harrow-rake scouring machine, and a detailed description of it is not necessary. The wool as it is delivered from the neutralising machine is fed to another rinsing machine in which is a nice clean liquor, and on leaving the latter machine, it is delivered to an ordinary sectional dryer, which is the last machine of the series, and from which the wool emerges in a dry and clean state.

CARBONISING RAGS.—What is known as the dry process is the most largely used for removing vegetable matter in the form of yarn and fibre from rags; but the sulphuric-acid process is also used. When the latter process is adopted it is practised in identically the same manner as has already been described with regard to removing burrs. The dry process appears to be most largely used, probably because the material is passed through fewer machines, and there is not the trouble and expense of neutralising as in the case of the wet process. In the dry process the rags to be carbonised are first dried and heated in a special brick chamber of suitable size to heat the rags in sufficient quantity. A hot air current is forced up and through the rags that are placed on a large perforated tray in the usual manner, as explained with regard to wool drying. After the rags have been subjected to the hot air at a temperature of upwards of 180° F. for about two hours, they are removed and fed to the carbonising box in which carbonising proper is done. This box is usually a rectangular iron box, and may be about 12 ft. long by 6 to 8 ft. square. It is suitably driven so as to revolve very slowly after it has been charged with a supply of rags, since it is important that the rags should be frequently turned over and prevented from remaining in one position, so that the acid vapour will act equally on all parts of the rags. The acid vapour is generated by the hydrochloric acid being arranged to drop into a vapour trap, and from thence on to a hot plate or brick in a retort of suitable size, which is kept heated by a special furnace, and the vapour is led into the carbonising box through one of its journals, which is hollow. The box is enclosed in brickwork, and is kept heated by means of two furnaces, one of which also heats the retort. The hot gases are led into the carbonising chamber through flues suitably arranged. Proper carbonising temperature is about 180° F., and the time the material must remain in the carbonising box varies according to the material being carbonised, but on an average about three hours is usually sufficient.

After carbonising, the rags are taken to a rag-shaker, which shakes and beats out the carbonised vegetable matter. A diagrammatic section of this machine is shown in Fig. 23, and the essential parts are the main cylinder, fan, and a grid, part of which is hinged. The construction and operation of the machine are as follows: A supply of rags is placed on a grid A, which is lowered for this purpose from the position shown into a position below the horizontal. This

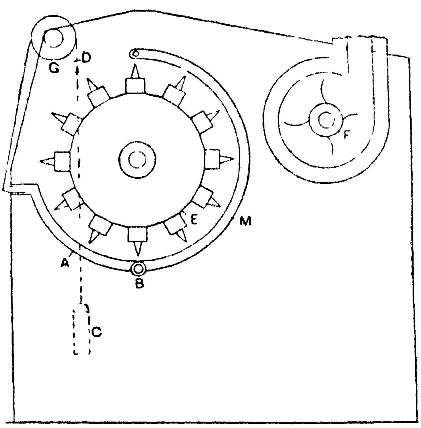


FIG. 23.

part of the grid is hinged at B to the main part M, which is permanently fixed. After charging the machine with a supply of rags, the hinged part of the grid is allowed to rise, and is kept in the position shown by means of balance weights C and the cords D, which pass round guide pulleys G and to the grid. By the raising of the grid the rags are thrown against the cylinder E, which, when the machine is started, revolves at a great speed in a downward direction, and dashes the rags against the grid and scrapes them over it, since the cylinder is provided with long, strong teeth set in plates screwed to lags, which are in turn fixed to the cylinder. As the rags are carried round by the cylinder they leave the grid at the top side, and are dashed against the casing, but fall back again, to be carried round by the cylinder. In this way the carbonised rags are given a thorough beating and shaking. The heavier impurities drop through the grid into the bottom of the machine, while the lighter impurities are drawn away by the current of air created by the fan F. To empty the machine when the rags have been freed of all vegetable matter, the grid is lowered, thus allowing the cylinder to discharge the rags, which are now ready to be made into shoddy or mungo.

It should be noted that after the material has been carbonised, and before shaking in the machine just described, it is considered good practice to submit the hot rags to a light preliminary operation of shaking, which at the same time allows the rags to cool. Especially is this the case with rags containing a large percentage of cotton, since, if these are taken direct to the rag-shaker, there is danger of fire.

CHAPTER VII

WASTE OPENING

INTRODUCTION.—Wool substitutes of all kinds must be reduced to a fibrous condition before they are incorporated in the mixing of woollen blends, and the different classes require different treatment. Ordinary hard waste and very soft rags may be reduced to a fibrous condition by being passed through a Garnett machine; but, generally, shoddy comprising all kinds of knitted fabrics such as stockings, jerseys, etc.; soft flannels; and mungo comprising all kinds of felted cloths such as beavers, pilots, meltons, worsted coatings, etc., must be reduced to a fibrous condition in a rag machine or rag-grinder, as it is often termed. It is not advisable to pass rags containing hard-twisted yarns, or waste containing hard knots and which is much entangled, through the Garnett machine.

WASTE OPENING MACHINE.—Great progress has been made with regard to improving and rendering more efficient machines for opening all classes of waste, and in the most modern machines the finest and hardest thread wastes can be opened and reduced to a fibrous condition. In Figs. 24 and 25 are shown diagrammatically the right-hand and left-hand sides respectively of a two-swift Garnett machine as made by Messrs. P. and C. Garnett, Limited, of Cleckheaton. In Fig. 24 the direction of revolution of the principal rollers is shown, as is also the direction in which the teeth point. The driving on this side of the machine is also shown. In Fig. 25 only the driving on the left-hand side of the machine is shown. It will be noticed that the main driving pulleys in the plan are placed on the shaft of the first cylinder; but this is an alternative arrangement. This machine is very largely used, and does good work. The essential parts are the feed rollers, lickers-in, and doffing comb.

OPERATION.—The material is spread on the feed lattice A either by hand or by an automatic hopper feed. The latter is the better method, especially where large quantities of material which is sufficiently open, and in particular that which has been previously passed through a knot-breaker, are used. It is more economical,

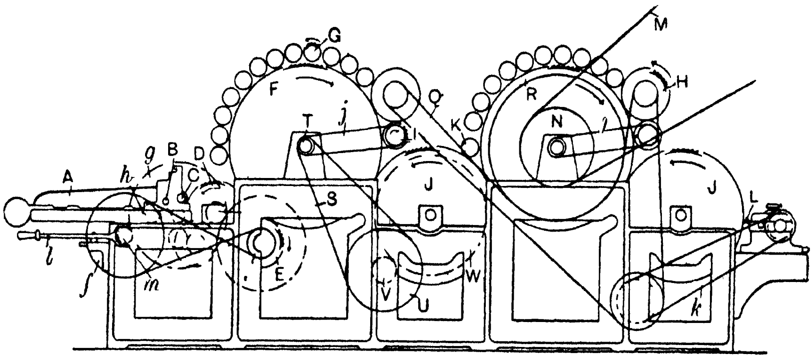


FIG. 24.

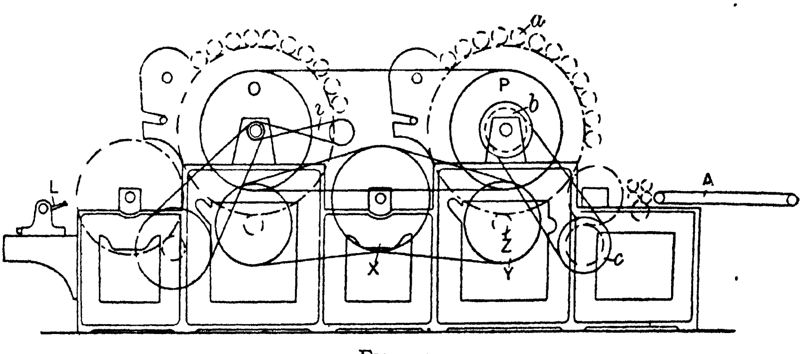


FIG. 25.

and the feed is more constant, regular, and even. Consequently better results are obtained as regards both the production and the quality of the opened material, and fewer threads which have not been acted upon are found in the material that leaves the last doffer. It is very important that no hard threads should reach the carding machinery, since they may pass through to the spinning.

Hand-feeding is very liable to be irregular, even with experienced operatives.

The material is carried by the feed lattice to a pair of fluted feed rollers B, which feed the material to another pair of feed rollers C that are covered with coarse, strong Garnett wire. The teeth revolve back, or smooth side first, so that they will retain a hold on the material as long as possible while it is being acted upon by the licker-in D, which revolves at a considerable speed in the direction of the arrow, with the teeth pointing in the direction of its rotation. As a result the material is loosened and carried away,

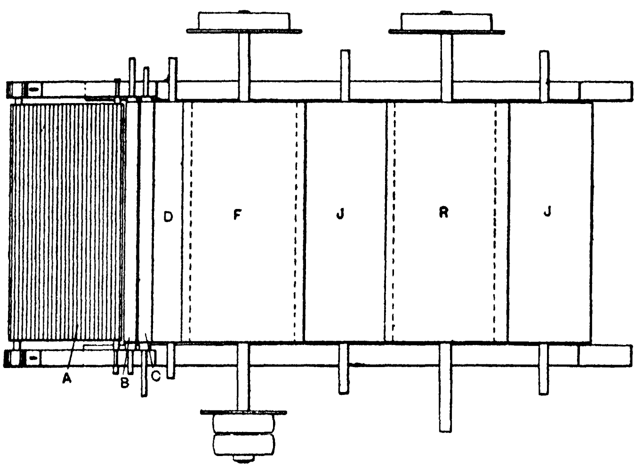


FIG. 26.

and a thorough opening takes place at this point. Another roller E, termed an under licker-in, which is revolving at a slower surface speed than the licker-in D, serves to level and open the material on the latter, and thus present it evenly to the cylinder F, the material being delivered to the finer teeth of the cylinder in such a state as to render it unlikely that it will damage their keen point. The cylinder revolves in the direction of the arrow point first, strips both the lickers-in, and presents the partially opened material to the first of a series of twelve workers G. The point on the wire of these workers works point against point with that of the cylinder, and consequently the principal work of opening takes place between the workers and the cylinder. The workers revolve very slowly in the direction of the arrow and the backs of the teeth first, and each one nearer the doffer is arranged to strip the previous one. As the workers are set progressively so as to obtain the maximum opening action, being closest nearer the doffer, the material as it is opened gets embedded in the swift, and before it reaches the doffer it must be raised to the surface of the teeth, so that the doffer will take the material and keep the swift as clean as possible. The fancy H accomplishes this, since its teeth point in the direction shown, and it revolves at a greater surface speed than the cylinder in the direction of the arrow. The surface speed of the fancy in proportion to the surface speed of the cylinder is about 3 to 2, and as it revolves point first, it removes some of the material and carries it on its surface. In order to keep the fancy clean and in good working order, and also transfer any material back to the swift, a roller I, termed a fancy stripper, is used. The fancy stripper I acts as a worker in relation to the fancy H, and having a much less surface speed than the fancy, any material which the latter carries on its surface is deposited upon the teeth of the fancy stripper I, which carries the material round and is in turn stripped by the swift. The direction in which the teeth point, and its direction of revolution, are clearly indicated. It might be noted that the fancy stripper is sometimes run in the opposite direction to that shown; but, when so run, the material is more likely to be carried round on the surfaces of both the fancy and fancy stripper, and an uneven web produced. The material on the swift is deposited on the teeth of the slowly rotating doffer J at the point where they come closest together. Doffing is assisted by the high surface speed of the cylinder compared with that of the doffer, and also the teeth are pointing upwards at the point where doffing takes place. The doffer carries the material round on its surface until it reaches the angle stripper K, which, having a greater surface speed than the doffer, and with its teeth pointing in the direction of rotation, strips it, and carries the material round to the second cylinder. This cylinder in turn strips the angle stripper and carries the material to be operated upon by the workers over the second cylinder. The second cylinder deposits the material on the second doffer, from which it is stripped by a doffing comb L. The latter has a rapid reciprocating movement in a vertical plane, and strips the material from the doffer on the downward movement and in the same direction as that in which the teeth point, the setting being very close to the points of the doffer wires.

A grate is placed under each cylinder, and is set close to it. Also between each cylinder and doffer it is usual to run a smooth roller, which is driven through a chain and sprocket wheels by the fancy stripper; this roller is placed on the underside, and is for the purpose of reducing droppings to a minimum. It will be noted that there are twelve workers over the first swift, while there are only ten over the second swift. The extra space required by the doffer and angle stripper precludes running more than ten workers over the second swift. It is, of course, possible to run more workers by raising the swifts, and running the doffers in a lower position, in which case the amount of working surface, and consequently the production, is increased.

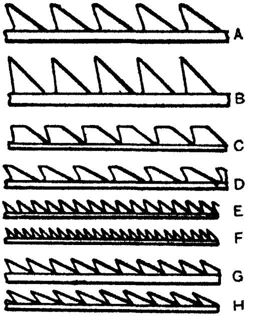


FIG. 27.

There are very many different kinds of Garnett wire used for covering the different rollers in waste opening machinery, and a few of these are shown in Fig. 27. Those shown at A and B are suitable for the feed rollers, while those shown at C and D are for the lickers-in. Any of those shown at E, F, G, and H may be used for the swifts, workers, and so on. The wire is in the form of a long strip of steel with a thickened edge at the bottom, and is wound in spiral grooves in the surface of the roller. These grooves also allow short lengths of damaged wire to be replaced with new wire without stripping the whole roller.

DRIVING.—Motion is given to the machine from the line shaft by a 5-in. belt M, that gives motion to pulleys N, which are 15 in. in diameter, and are fixed on the shaft of the second cylinder, driving it at a speed of 300 revs. per min. On the left-hand side of the machine is a body pulley O, 23 in. in diameter, driving by a 4-in. belt a pulley P of the same size on the first cylinder shaft. The swifts are 30 in. in diameter. Both the fancies, which are 9 in.

in diameter, are driven by means of a 4-in. belt Q from a 29½-in. body pulley R, that is placed on the shaft of the second cylinder between the pulleys N and the side framing. On the fancy shafts are 5-in. pulleys, which revolve at a great speed, making as many as 1770 revs. per min. The first doffer is driven, as shown in Fig. 24, by a 2¼-in. belt S, from a pulley T, 3½-in. diameter, fixed on the cylinder shaft. The belt S drives a 16-in. pulley U on the same stud as the change-wheel V, which in turn gears with and drives the doffer wheel W of 180 teeth, which is fixed on the shaft of the first doffer. The second doffer is driven in an exactly similar manner, but the driving is on the left-hand side of the machine, and is shown in Fig. 25. Each doffer is 24 in. in diameter, and is driven about 12 revs. per min., the speed being varied to suit the different classes of work. The workers over both cylinders are driven from the first doffer, the driving being on the left-hand side of the machine. A 20½-in. pulley X, which is also a change-pulley, drives by a 2¼-in. belt a 16-in. pulley Y, which runs on a stud; and on the same stud is a change-wheel Z, which drives a large gear-wheel with 195 teeth, that revolves on the cylinder shaft and drives the workers, which are 3½ in. in diameter, at a speed of from 24 to 30 revs. per min. A gear-wheel *a* is provided on each worker shaft for this purpose. The licker-in D, which is 12 in. in diameter, is driven by a 9-in. pulley *b*, fastened on the shaft of the first cylinder; this, by a 3-in. belt, drives the pulley *c*, which is 11 in. in diameter, and on the same stud is a gear-wheel with 48 teeth, that drives a wheel with 72 teeth fixed on the shaft of the licker-in.

This driving is shown in Fig. 25. The under licker-in E, which is 9 in. in diameter, is driven from a gear-wheel (Fig. 24); this drives a wheel with 112 teeth fixed on the shaft of the under licker-in. It will be clear from the sizes of the wheels that the under licker-in is driven at a much slower speed than the ordinary licker-in. The feeding mechanism is driven from a 6-in. pulley fixed on the shaft of the under licker-in, this by means of a 2¼-in. crossed belt driving a 16-in. pulley *f* running on a stud, and compounded with this is a gear-wheel *m* which gives motion to a gear-wheel *g* fixed on the shaft of the bottom feed roller C. Compounded with the latter wheel is a smaller toothed wheel, which through a carrier revolving loosely on the shaft of the bottom feed roller B gives motion to wheel *h* fixed on the end of the front roller of the feed lattice, thus giving it the desired motion. On the other side of the machine suitable gearing, which is shown, gives motion to the feed rollers B, as well as the top roller C. The driving for the angle stripper, which is 3½ in. in diameter, is shown in Fig. 25. A 2¼-in. crossed belt *i* transmits motion from a 4-in. pulley on the second swift shaft to a 5-in. pulley fixed on the angle stripper shaft. Each fancy stripper is 6 in. in diameter, and is driven, as shown in Fig. 24, by a 2¼-in. open belt *j* from a 4-in. pulley on the cylinder shaft, the belt driving a 5½-in. pulley fixed on the shaft of the fancy stripper.

The driving of the doffing comb is shown in Fig. 24; an open belt *k* being employed. A handle by which a lever may be operated is shown at *l*, Fig. 24. The object of the lever is to disconnect and stop the feeding should any part break or the feeding be such as to choke some part of the machine. The feeding only is stopped; the remainder of the machine continues to run.

CALCULATIONS.—In running Garnett machines a few simple calculations are necessary; for instance, the speed of the doffer is obtained as follows: Taking the particulars of the drive from Fig. 24, where A = revs. per min. of cylinder, 300; B = diameter of pulley fixed on cylinder shaft, 3½ in.; C = diameter of driven pulley, 16 in.; D = change-wheel, 30 teeth; E = doffer wheel 180 teeth—

$$X = \frac{A \times B \times D}{C \times E} =$$

$$X = \frac{300 \times 3{\cdot}5 \times 30}{16 \times 180} = 11 \text{ revs. per min. nearly.}$$

It will be noticed that the change-wheel is a driver, consequently the larger the wheel used, the greater the speed of the doffer. The same remark applies with regard to the change-wheel for changing the speed of the workers. From the above calculation it will be an easy matter to work out the surface speed of the doffer in feet per minute. Taking the particulars again from Figs. 24 and 25, where A = revs. per min. of doffer, 11; B = diameter of doffer, 24 in.—

$$X = \frac{11 \times 24 \times 3{\cdot}1416}{12} = 79{\cdot}12 \text{ ft. per min.}$$

In changing the speeds, or in finding the speeds of any of the rollers, the above examples and formulæ will be useful, and may be applied as found necessary.

PRODUCTION.—The space required for the two-swift machine shown in Figs. 24 and 25 is about 9 ft. 6 in. by 13 ft. 6 in., and the approximate production per day of 10 hrs. when the swifts are running at a speed of 285 revs. per min. is 350 lb. The machines are made in widths of 36 in., 48 in., and 60 in., the figures referring to the actual width of the rollers. The production in the case of two-swift machines 36 in. and 48 in. wide is 200 lb. and 280 lb. respectively per day of 10 hrs.; but this, of course, varies according to the class of material being worked, and is least when running fine and comparatively hard-twisted wastes. It will, however, be considerably greater than the approximate production stated above when working open and slack-twisted wastes. This class of machine is made with one, two, three, or four swifts as required, the number of swifts being governed by the amount of opening which the material to be run requires.

THE KNOT-BREAKER.—When weavers' "thrums" and hard bunches of threads made during warp preparation in such operations as beaming, dressing, and so on, have to be broken up, it is advisable to use a machine termed a knot-breaker, which is specially designed for dealing with hard and knotted lumps of waste. The teeth of the Garnett machine are too fine to deal with such material, and if such waste were passed straight through an ordinary Garnett machine the knots and much-tangled material would have a bad effect on the teeth, and would most likely quickly destroy their efficiency, and it is practically certain that the teeth would not last half as long as they should. However, by passing the material through a knot-breaker it is freed from all extraneous substances such as bits of leather, metal, and so on, which are liable to damage the teeth. Another noteworthy advantage is that the waste is delivered from the knot-breaker in a soft, open condition, and consequently can be successfully fed to the Garnett machine by an automatic feed. An automatic feed cannot be used successfully unless the waste has been previously prepared so as to remove all tangles and long lengths of thread.

In Figs. 28 and 29 are shown diagrammatically the left-hand

and right-hand sides respectively of a knot-breaker as made by Messrs. Garnett Limited, of Cleckheaton. In Fig. 28 the direction of revolution of the principal rollers is shown by the arrows, the direction in which the teeth point being also indicated. The driving on this side of the machine is also shown. In Fig. 29 only the

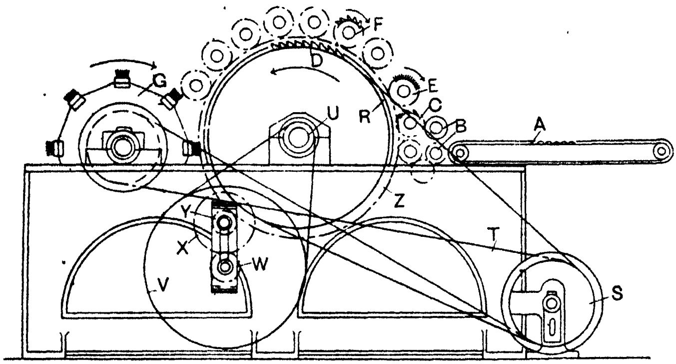


FIG. 28.

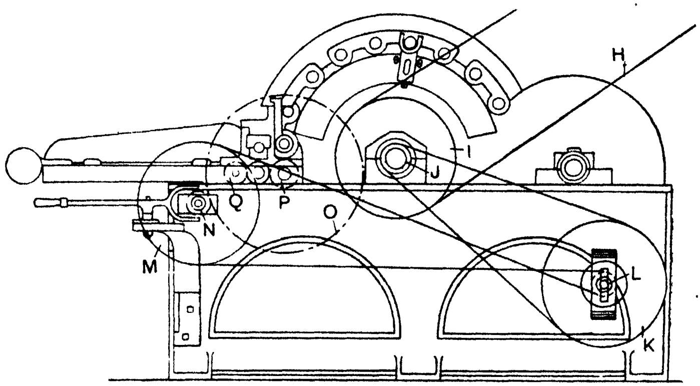


FIG. 29.

driving on the right-hand side is shown. It will be observed that the right and left sides of the machine are determined by facing the machine as the operative faces it when he is feeding the material by placing it on the feed lattice by hand. A detailed plan of the machine is shown in Fig. 30. The essential parts are the feed rollers, cylinder, workers, and doffing brush-fan.

Operation.—In operation the material is carried by the feed lattice A to a pair of fluted press rollers B, which feed the material to another pair of feed rollers C, that are covered with very coarse Garnett wire. The teeth revolve back or smooth side first, so that they will retain a hold on the material as long as possible while it is being acted upon by the cylinder D, which revolves at a high speed in the direction of the arrow, with the teeth pointing in the direction of its rotation. As a result the material is loosened and carried away, and a very efficient opening takes place at this point. Any material that remains on the top feed roller is stripped from it by the brush E. The cylinder revolving point first strips the brush and presents the material to the first of a series of seven workers F. The point on the wire of these workers works point against point with that of the cylinder, and consequently the principal work of opening takes place between the workers and the cylinder. The workers revolve very slowly, with the backs of the teeth first, and each one nearer the doffing brush-fan G is arranged to strip the previous one. Both the cylinder and the last worker are stripped by the doffing brush-fan, which, being driven at a great speed, ejects the material from the machine in a loose, open, and comparatively clean condition. It will be noted that there is the usual arrangement for stopping the feed lattice and feed rollers should any part of the machine become choked or a breakage occur, or if for any reason it is necessary to stop the feeding part without stopping the rest of the machine.

Driving.—The machine is driven from the line shaft by a 5-in. belt H that gives motion to the pulleys I, which are 15 in. in diameter and are fixed on the cylinder shaft, driving the cylinder, which is 24 in. in diameter, at a speed of about 400 revs. per min. Between the pulleys I and the framing is fixed a $3\frac{1}{2}$-in. pulley J, which by means of a $2\frac{1}{4}$-in. belt gives motion to a 16-in. pulley K running on a stud fixed near the back of the machine. Compounded with the pulley K is a $3\frac{1}{2}$-in. pulley L, which by means of a $2\frac{1}{4}$-in. crossed belt gives motion to a 16-in. pulley M. On the same stud is a gear-wheel N, which gives motion to a gear-wheel O with 112 teeth that is fixed on the shaft of the bottom feed roller C. Compounded with the latter wheel is a small toothed wheel P, which through a carrier revolving loosely on the shaft of the bottom feed roller B gives motion to wheel Q fixed on the end of the front roller of the feed lattice, thus giving it the desired motion. All the above driving is on the right-hand side of the machine, and is clearly shown in Figs. 29 and 30. A simple arrangement of gear-wheels on the other side of the machine gives motion to the feed rollers B and the top feed roller C. Fixed on the cylinder shaft is a 23-in. pulley R, Figs. 28 and 30, which by a 3½-in. belt drives an 11-in. flanged

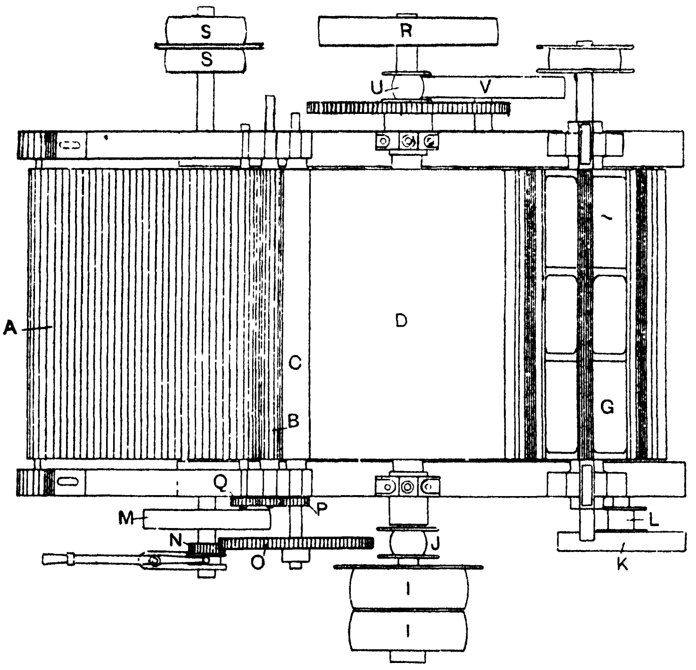


FIG. 30.

pulley S. A 2½-in. crossed belt T, driven by pulley S gives motion to a 9-in. pulley fixed on the doffing brush-fan shaft. The doffing brush-fan is 20 in. in diameter, and is driven in the manner described at a speed of about 1000 revs. per min. Immediately behind the pulley R is a 3½-in. pulley U, which by means of a 2¼-in. belt drives a 20½-in. pulley V. This revolves on a stud, and has compounded with it a pinion W with 15 teeth, which gives motion to a gear-wheel X with 30 teeth, compounded with which is a gear-wheel Y with 10 teeth, that gives motion to a larger gear-wheel Z having 108 teeth, which revolves loosely on the cylinder shaft. The latter wheel drives the workers, which are 4 in. in diameter, at a suitable speed. A gear-wheel is provided on each worker shaft for this purpose. The brush E is also driven from the same wheel. In some cases the wheel W is arranged to drive the large gear-wheel Z direct, the compound wheel X and Y being omitted. The widths of the swift, doffer, and feed or creeper lattice of the machine described are 36 in., and the over-all dimensions are about 7 ft. by 7 ft.; machines are also commonly made 24 in. or 48 in. wide to meet requirements. The calculations with regard to speeds and so on are similar to those described with regard to the Garnett machine.

CHAPTER VIII

RAG-SHAKING AND GRINDING

INTRODUCTION.—The first operation to which rags are submitted as they are received in bales is that of shaking or dusting, the object of which is to remove the dust and dirt, and all extraneous matter which often forms a large percentage of the weight of each bale. In fact, in many instances as much as 20 per cent. of the weight is dirt and dust. The removal of the dirt and dust is beneficial to the health of the operatives, and subsequent sorting is rendered much easier and more pleasant; also, the greater the amount of dirt removed from the material, the longer will the carding machines run before fettling is necessary. New mungo or shoddy is of course very clean, since it is obtained from tailors and costume and dressmakers, and is in the form of clippings. A considerable quantity is also obtained from pattern bunches, and such material not having been worn, is very clean. It will thus be seen that the amount of dusting required will vary considerably according to the condition of the rags.

RAG-SHAKERS.—There are many kinds of machines in use for removing the dirt and dust, but the principle of their action is the same, and the variations are usually only as regards details. They consist principally of a revolving cylinder or swift which revolves inside a grid, and a fan suitably placed to draw away the light dust. In Fig. 31 is shown a diagrammatic section of an intermittently acting rag-shaker. Each fresh charge of rags is fed at A through the door B, after which the door is closed to prevent the rags being thrown out by the rapid rotation of the swift. The rags come in contact with the swift C, which is stoutly built and provided with eight rows of teeth, and runs at a speed of about 600 revs. per min., while the fan D, which is started at the same time as the swift, has a speed of upwards of 1200 revs. per min. As the cylinder revolves, it beats the rags against the grid E, scraping them over it, and effectually loosening the dirt and dust and other extraneous matter, the heavier of which drops to the bottom of the machine, while the lighter dust, and so on, is drawn away by the fan through the upper part of the machine, and forced out through the tubing F. As the rags are whirled round they leave contact with the cylinder and grid, and the centrifugal force of the cylinder forces them against the door B; but as they cannot

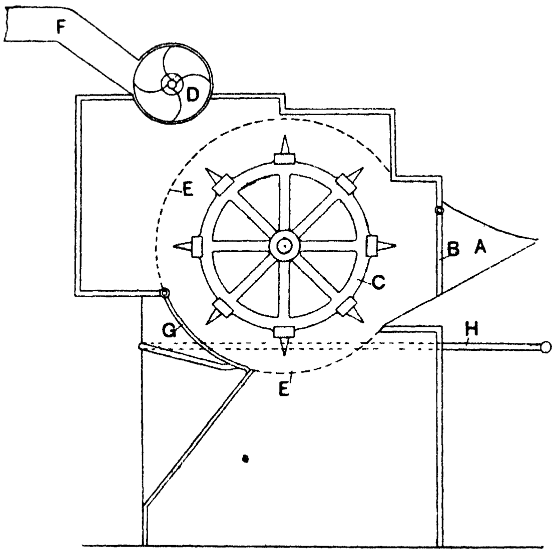


FIG. 31.

leave the machine they drop back again, to be again whirled round. When the charge of rags has remained in the machine for a sufficient length of time, the door G is opened by operating the lever H, which allows the cylinder to throw the rags on to the floor. The time the rags are allowed to remain in the machine varies, for reasons already stated, and may be anything from a few minutes to upwards of twenty-five minutes. The driving of this machine is very simple, the cylinder being driven direct from the line shaft by a belt, and the fan from the cylinder shaft by means of an open belt.

A diagrammatic section of a patent cleaning machine as made by Messrs. P. and C. Garnett Limited, of Cleckheaton, is shown in Fig. 32. This machine is automatic in action, and is in consequence easy to operate. The rags are placed on the feed lattice A, which feeds them at required intervals, its motion being governed automatically. As the lattice revolves it carries the rags up to the fluted feed rollers B, the top one of which is weighted, as shown, by springs, so as to obtain suitable pressure. The rags as they emerge from the nip of the feed rollers are beaten downwards by

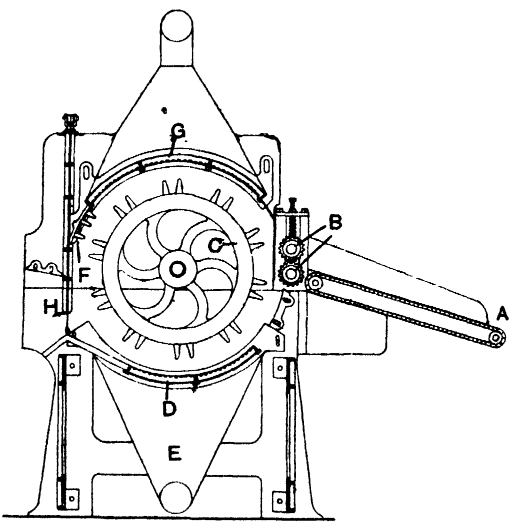


FIG. 32.

the cylinder or swift C, which is about 30 in. in diameter. When they are free of the feed rollers the cylinder in revolving at a high rate of speed takes round with it the rags, beating and scraping them over the grid D at the bottom, and thus liberating dust and dirt, which are immediately drawn away by a fan through the hood E and suitable piping. After leaving the bottom grid the rags are severely shaken between the pegs on the cylinder and the fixed pegs at F. Upon leaving this point they are beaten against the top grid G, the liberated dust and dirt being drawn away through a duct at the top and suitable piping. When the rags have been operated upon a predetermined length of time, the door H is automatically opened and the rags are ejected from the machine into a bag or basket suitably placed, or on to the floor. Change-wheels are provided so that the automatic lifting and dropping of the door can be regulated as required, as well as the movement of the feed lattice. If a very dirty batch of rags is being shaken and cleaned, the door is allowed to remain shut for a longer interval than when a comparatively clean batch is being run. The feeding is also varied accordingly. The grids are also removable for cleaning purposes, and may be changed to more open or finer grids as required. This machine is much superior to the one shown in Fig. 31 as regards keeping the atmosphere clean and pure, and consequently the conditions for the workpeople are much improved. Moreover, the dirt being carried away by the fan from both the top and the bottom of the machine, it ensures that there will be no accumulation of dirt in any part of the machine, and there will thus be a saving in work and the time of the operative as compared with the time taken in the ordinary rag-shaker, the bottom of which the workman has to clean out periodically, and the machine generally requires more cleaning. It might also be noted that as the machine is automatic in all respects, there is less likelihood of nasty accidents occurring due to the operative having to work near the cylinder. Some machines have no grid at the top, and consequently all the dirt and dust are drawn away at the bottom. Others have no fan; while others are fed continuously and have no door at the delivery. A similar machine is also built with two cylinders, with a sliding door separating them, and when the rags have been beaten by the first cylinder a predetermined length of time, the sliding door is automatically raised, and the material ejected into the chamber in which the second cylinder rotates, after which the door closes. When the rags have been beaten in the second chamber for the required length of time, the delivery door opens and the rags are thrown from the machine. Rags which are to be carbonised are not shaken in the ordinary way or before carbonising, since ample shaking is done when removing the carbonised vegetable matter from the wool material.

Necessity for Rag-Sorting.—The next operation is that of sorting the rags into different qualities and shades. Sorting has already been referred to in some detail, but it might be further noted at this point that before the rags are passed on to the operation of grinding or pulling, they must be carefully trimmed. On no account should very hard substances like buttons, hooks, eyes, or other similar objects, which have been used for trimming garments, be fed to the rag-grinder, since they are liable to cause damage to the teeth. Also in some cases they cause fire, due to the strong teeth on the swiftly revolving cylinder coming in contact with hard substances. Large pieces of rag should not be fed to the rag-grinder, and it is advisable to cut up pieces of considerable size.

RAG-BLENDING.—The process which follows sorting is that of blending, and the object of this process is to obtain a regular quality at a certain price, as well as a regular shade of pulled material. Great care should be exercised, especially when blending, to produce a certain shade. Blending is also necessary in the case of rags of the same shade but where the shade is not even, since, if blending were not done, the pulled material would not be even running as regards shade. It might be noted that in the mungo and shoddy trade the rags do not usually require re-dyeing, since every endeavour is made by properly sorting and blending to ensure that their original colour will serve; in this way the cost of dyeing is saved. When different qualities of rags are to form one batch they must be carefully selected with a view to obtaining pulled material of good and even quality; this will be clear when it is noted that some classes of milled rags when pulled yield a material with a better milling fibre than some classes of unmilled rags. Also different settings and speeds are required for different classes of rags if the best results are to be obtained.

When blending is being done the rags must be oiled if much preventable damage to the fibre is to be obviated, since considerable heat is generated and much friction occurs in the process of pulling or tearing apart the threads in the woven fabrics, and obtaining pulled material in a fibrous state. The best pulled material is that which has been made into a fibrous state with least damage to the fibres and the milling properties of the material. Much damage must necessarily be done to the fibres due to the severity of the operation which separates fibre from fibre in the case of fabrics woven from, in many instances, fairly hard twisted yarns; while in other cases the woven cloths have been heavily milled. Oiling, however, reduces the breakage of fibre to a minimum, and does all that is possible to preserve the characteristic surface features of the fibre, since it fills up the serratures and allows the fibres to slide over each other and be separated as easily as possible. Whether blending different qualities of rags or different colours to produce a certain shade, the operation is the same. If 50 per cent. of the blend is to be one quality and 50 per cent. another quality, then the layers will have to be equal—that is, composed or made up of the same weight of rags of each quality. Take another case: A blend is to be made up of 50 per cent. of rags of A quality, 25 per cent. of B quality, the remaining 25 per cent. of C quality. In this case it would be best to build the pile as follows: First spread out a given quantity of rags of A quality over as large an area of floor space as possible, taking into account, of course, the total quantity of rags which are to form the whole blend; then spread an equal quantity of B quality on the top. The next layer must be formed of rags of A quality, and then on the top must be evenly spread a layer of rags of C quality. By continuing the building of the pile in the above manner alternate layers will be of A quality, and all the rags will be used up. It is a good plan within reason to make each layer as thin as possible so as to get the most thorough mixing. As each layer of the blend is made, it is sprinkled with the required quantity of oil, or emulsion consisting of oil and water. If oil alone is used, about 10 to 15 lb. of oil will probably be sufficient for every 100 lb. of rags; but if an emulsion is used, 12 to 18 lb. will probably be required. Oil of good quality should be used in order to obtain the best results. On the lower-class blends of shoddy and mungo, however, one of the recovered oils, black or brown, is generally used; while on the better-class blends a better class of oil is used, such as oleine, or an oleine emulsion. Such an emulsion may consist of equal quantities of oil and water. In all cases when taking material from a blend it should be taken from the side—that is, worked from top to bottom and never along the top, since it is imperative that the material be so taken as to feed as much as possible from different layers and so obtain the maximum benefit of laying the material out in layers.

The Rag Machine.—After the blend has been made, the rags are fed to the rag machine, or, as it is often termed, the " devil," a diagrammatic section of which is shown in Fig. 33, and an outside elevation of the right-hand side in Fig. 34. The machine consists essentially of feed lattice, feed rollers, swift or cylinder, and fan, and the rags when placed on the feed lattice A are carried by the

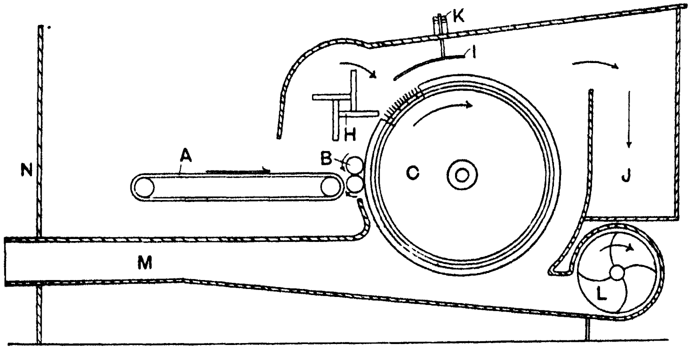


FIG. 33.

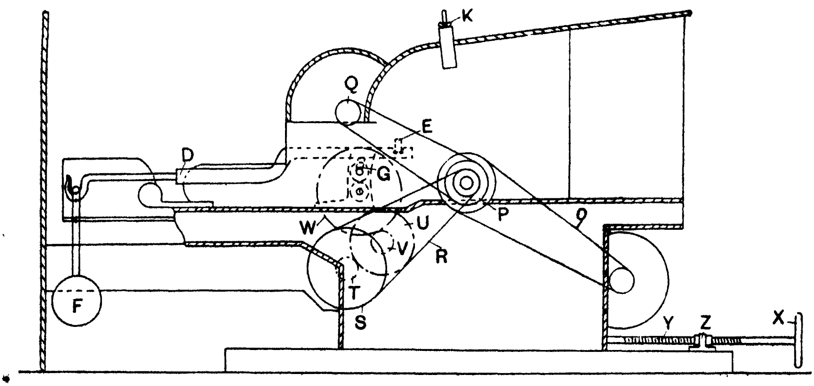


FIG. 34.

latter to the fluted feed rollers B, which, revolving at a comparatively slow speed, feed the rags to a large swift C. The direction of rotation of the lattice, feed rollers, and swift, is indicated by arrows. The top feed roller is driven by friction from the bottom one, which is positively driven by suitable gearing from the main shaft of the cylinder, the required pressure being given to the top roller by means of levers on which weights are hung. One of these levers is shown at D in Fig. 34, the fulcrum being at E and the weight at F, while the pressure is exerted on the roller at G. The lever and parts are duplicated on the other side of the machine, and the total effect of this weighting is to exert a pressure of 550 to 650 lb., which causes the flutes practically to engage, while at the same time the top roller can rise and fall according to the thickness of the feed. It is, of course, an easy matter to calculate the exact pressure on each end of the feed roller by measuring the lengths of the weight arm and force arm, when the weights of the lever and weight hanging from the lever are known.

The feed rollers are set from ½ to 1 in. from the swift, and so are enabled to retain a firm hold of the rags, so that as the latter are slowly delivered to the swift, the teeth pull or tear the rags into a fibrous condition. The cylinder is equipped with strong hardened steel teeth which are firmly fixed in stout wood lags, that are in turn fixed to spiders carried by the cylinder or swift shaft, and is 18 in. long and 36 in. diameter. It must be explained that the action of the cylinder, though usually referred to as a pulling or grinding action, is quite as much a disintegrating action due to beating. This will be understood and its desirability appreciated when it is noted that the pins of a new swift are not pointed as when they have been working for some time, but are square-cornered and comparatively rough; hence they tend to cut the rags and break the material, which results in a pulled material with a much shorter staple and damaged fibre, and hence of inferior quality, than when pulled with a swift the teeth of which are in the best working condition.

The fan or bit roller H revolves at a rapid rate for the purpose of knocking back on to the feed lattice pieces of unopened rag, or rags which are only partially opened that are detached from the feed rollers. As will be observed from Fig. 33, the fan is set close to the cylinder, and at the nearest point of contact is travelling in the opposite direction to the cylinder; consequently pieces of rag too heavy to be carried round on the surface of the cylinder, or too heavy to follow close to its surface, fly off at a tangent due to centrifugal force and air currents generated by its rapid rotation, and strike one of the wings of the fan or bit roller, which knocks them back on to the feed lattice to be again fed.

There are smaller pieces of rag and partially opened rag which pass along attached to or are close to the surface of the cylinder, and miss the fan F, but which fly off the cylinder at a later point, and hitting the adjustable bridge plate I are deflected so that they fly into the bit box J. The thumbscrew K provides a means of raising or lowering the bridge plate, there being a thumbscrew near each side of the machine. As work proceeds, the bits of rag accumulate in the bit box, and must be removed periodically and again placed on the feed lattice.

The properly opened material is carried along on the surface of the swift until it reaches the bottom side, when an air current generated by the fan L, assisted by the centrifugal force and air currents generated by its rapid rotation, forces or blows the material from the swift through the conduit M into the bin N.

DRIVING.—The driving of the machine is simple, and is shown in Fig. 34. Motion is given to the swift from the line shaft by belt to fast and loose pulleys, which are about 9 in. wide and are placed on the opposite side of the machine to that shown. On the swift shaft on the right side of the machine are fixed three pulleys. The largest drives the fan L at a speed of about 1500 revs. per min. by means of the belt O. Pulley P drives the bit roller H at a speed of from 1000 to 1200 revs. per min. by means of a belt driving pulley Q on the bit roller shaft. The smallest of the three pulleys drives by a belt R the pulley S, and compounded with the latter pulley is a toothed wheel T, which drives the gear-wheel U, and on the same stud as wheel U is the change-wheel V. The change-wheel drives gear-wheel W fixed on the end of the bottom feed roller shaft. A small gear-wheel on the end of the bottom feed roller shaft on the other side of the machine gives motion to the front roller of the feed lattice, by means of a small intermediate wheel. The speed of feed rollers and feed lattice may be regulated as desired by means of the change-wheel V. If widely differing varieties of mungo and shoddy have to be pulled, it is necessary to change the speed of the swift; and to prevent having repeatedly to rejoin the ends of the belt, and either take a little out of the belt or add a little to it, the machine is generally mounted on a bed on which it may be slid as desired by turning the hand-wheel X which operates the screw shaft Y. The screw turns in the fixed threaded bracket Z.

POWER REQUIRED.—The amount of power required to drive the machine varies as much as from 7 to 20 h.p., the affecting factors being the width and diameter of the swift, the speed at which the swift is run, and the class of material being pulled, whether hard or soft, or mungo or shoddy. The usual size of cylinder is 36 in. in diameter and 18 in. long on the teeth; it is, however, about 20 in. in length over all. Machines are made with swifts 14 in. wide on the teeth and 28 or 39 in. in diameter. The swift is the most important part of the machine, and its speed should be correctly regulated if the best results are to be obtained. Usually the speed does not get below 350 nor above 750 revs. per min. The lowest speed is run when pulling soft shoddy materials, and the highest when pulling hard felted strong mungo rags.

SETTINGS.— Unless a fairly big change is made as regards the materials being pulled, the speed of the cylinder is not changed—as, for instance, when running on shoddies a speed of 450 revs. per min. would be good, and no change would be made when changing from, say, serges to stockings. It is also necessary to consider the condition of the teeth in relation to the rags which are to be pulled, since a swift with new teeth will have a much more drastic effect on the material than one with teeth worn to a working point. Thus it will be obvious that better results would be obtained as regards both quality and production if materials difficult to pull were fed to a new swift until a working point is obtained, when materials less difficult to pull may be fed without any undue cutting or breaking of fibre.

When changing from pulling shoddy to mungo, the swift must be changed for one with more teeth per lag. In the case of coarsely pulled shoddy, a cylinder with about 24 teeth per lag would probably be used, while in the case of finely pulled mungo the swift would have about 50 or more teeth per lag. The speed of the feed lattice and feed rollers, and the setting of the feed rollers to the swift, must be varied and arranged to suit the class of material being pulled and the character of the pulled material required. On ordinary shoddy stuff pulled fairly coarse the speed of the feed lattice would probably be at the rate of about 50 in. per min., and the setting of the feed rollers to the swift about $\frac{3}{4}$ in. If a change were made to mungo pulled fine, the speed of the feed lattice would be reduced to about 20 in. per min.

The fact that the teeth of the swift wear down very quickly renders it necessary to set the feed rollers nearer the swift to keep the setting sufficiently accurate. Moreover, those parts of the teeth which make contact with the material first and practically do the work wear down flat very quickly, and make it necessary to change the swift round so that the opposite sides of the teeth will be brought into action. The time which elapses before the change is necessary, of course, varies with the work in hand, and on soft shoddy stuff it will run considerably longer than when on heavily milled mungo rags. The production of a rag machine depends entirely on the kind of material being pulled, and is about 120 lb. per hour on hard-milled mungo stuff, while on shoddy materials it may be anything from 140 to 180 lb. per hour, or even more. Production is also affected by the required condition of the pulled material, since if it is desired more or less thready so as to make its quality evident, the production will be greater than if it is required to be pulled to quite a fibrous state. For the successful working of rag machines, and to obtain the maximum production with a consistently high quality of pulled material, it is necessary to have correct speed of swift, feed lattice, and feed rollers, and correct setting of the feed rollers to the swift. The rags must be fed on the feed lattice neither too thinly nor too thickly, but it is better to err on the side of feeding too thinly rather than on the side of feeding too thickly, since there is less material returned to the feed lattice and thrown in the bit box, and less straining of the parts and a better product with thin feeding.

CHAPTER IX

BLENDING

OBJECT OF BLENDING.—The object of blending is to make a certain quantity of material of a certain quality, or to produce a certain shade or colour. Taking both these distinct objects together, since they are often combined in making one particular blend, it will be evident that innumerable blends must be made, ranging from high-class blends in which only pure wool of good class is used, down to blends which contain only low-class materials such as shoddy and mungo. Subsidiary but none the less noteworthy objects are the production of an even roving and yarn, and the neutralising as much as possible of any defects directly traceable to the operation of scouring, or other preliminary operations. The work of blending is an art which should be carefully and exhaustively studied, and the results yielded by blends carefully compared. The force of this will be amply demonstrated when it is explained that the blending of the cheapest materials does not always result in the cheapest yarns. It is not unusual for a yarn to be produced *1d.* or *2d.* a pound cheaper from a blend costing *2d.* or *3d.* per pound more; this besides producing a better and evener yarn and correspondingly better cloth.

The increased cost of cheaper blends is principally due to the waste made and the decrease in production. The principal points to be borne in mind with regard to mixing different materials are their relative fineness, strength, elasticity, and the length of staple; and the nearer the materials to be blended are alike in the above respects, the better will be the resulting yarn. If a blend is well thought out, if the materials are eminently suitable for amalgamating, and the actual mixing is thoroughly well done, there will be no doubt as regards the result.

REQUIREMENTS OF BLENDER.—The person responsible for the blending should have a thorough knowledge of the carding, spinning, weaving, and finishing capabilities of different materials, so that as nearly as possible he can make the blend of sufficient weight to yield the required weight of yarn and finished cloth. This point will be better understood when it is stated that high-class all-wool blends made from clean scoured wools such as Port Philip, Saxony, Sydney, and Cape, will yield a greater weight of yarn than the actual blended weight, since there is the minimum loss of material due to flyings, droppings, and fettlings, and most of the oil is retained by the material, which accounts for the increase in weight. The gain on the blended weight is a variable factor, and may be anything up to about $7\frac{1}{2}$ per cent. On low blends made from shoddy, pulled waste, and so on, the loss from blended weight to spun yarn is often considerable, and may be as much as 15 per cent. of the blended weight. This is due to low materials containing much refuse matter and dirt, and consequently the amount of fettlings is increased. As a matter of fact, when running on good, clean, well-washed wool blends, the machines will run as long as eight or nine days without requiring fettling; but when on blends of low, dirty stuff, the machines may require fettling every eight hours.

Factors Affecting Blend.—It must be pointed out that much depends on the carding overlooker and spinner as to the actual results obtained from any particular blend, since it has been observed that a variation of as much as 20 per cent. has occurred in the yield of yarn from a given weight of the same blend supplied to different carding overlookers and spinners. When experience has shown that a certain blend will produce the desired result in the finished cloth as regards appearance, finish, strength, weight, and handle, it by no means follows that another blend made up of similar materials as regards price and name will yield similar results.

It is often found, especially if one or more of the component parts of the blend have been purchased from another merchant, that though bought as similar material to that used in the original blend, the results obtained are much inferior, resulting in the cloth feeling comparatively "boardy," and presenting a poor, thin appearance. It requires much experience and a thorough knowledge of the capabilities of different materials to purchase and blend them to the best advantage, since the initial cost of the materials used in each blend should be as low as possible, taking into consideration their carding and spinning capabilities, and the character of the finished cloth required. The latter must be specially noted and considered when yarn is to be used in the mill and not sold, as a blend may card and spin to advantage, but the yarn may be wasteful in weaving, and produce inferior cloth that requires more care and time in finishing and handling after it leaves the loom.

TYPICAL BLENDS.—The following blends, which are fairly typical, will give some idea of the extent to which blending is done for quality alone: Blends for fine all-wool fabrics may contain corresponding qualities of Saxony, Port Philip, Tasmanian, Sydney, and Cape wools. Port Philip and Sydney wools are well suited for blending in the production of fine cloths, while Port Philip and suitable qualities of Cape wools will produce a rather cheaper but still high-class blend, since Cape wool, being fine, blends well with Port Philip; but the latter is of an altogether better quality. Medium qualities of short Colonial wools may be blended with Botany noils in various proportions, the noils being used to give fulness in handle to the resultant yarn. Cotton may be used in place of the noils in the above blend to the extent of 20 per cent. of the blend; it may also be used in addition to the noils. Medium to low qualities of Colonial wools may be advantageously mixed with suitable qualities of extract, or carbonised wool, mungo, and shoddy. New Zealand crossbreds, or other Colonial crossbreds, may be mixed with Cheviot wool.

Noils of coarse quality may be blended with various kinds of shoddy, such as pulled stockings, old serge, best flannels, certain kinds of waste, and so on. Cotton may be used in place of the noils, or added to the whole. In many blends cotton forms a large percentage, and its purpose is to help the spinning, make a dense, solid, relatively fine and strong thread, and cheapen the blend and resultant yarn. Moreover, since cotton has not the capacity to shrink that wool has, cloth that is made from yarn containing a large percentage of cotton will not shrink so readily, and the limits of shrinking are not so great or wide, and can be more readily fixed. The addition of cotton also restricts the felting power of the yarn and cloth. A typical yarn in which cotton fibres are blended with wool fibres to the extent of 20 per cent. of the total blend is Angola yarn. Pure wool is not generally used for this purpose, shoddy or some waste material of fairly low quality being most common. Comparatively large quantities of yarns termed "union yarns" are made from a mixture of cotton and wool fibres. Another distinct type of yarn made by blending cotton and wool is termed "Vigogne"; this is made from a blend containing from about 3 to 10 per cent. of cotton, the remainder being wool. In almost every case cotton is added to the blend to help the spinning and enable a much higher count to be spun than would otherwise be possible. Peruvian cotton is largely used for mixing with wool, since it has a harsh, wiry handle, and is more nearly like wool than any other cotton of consequence. Other classes of cotton are used, principally American and Sea Island; but the use of the latter is confined to mixing with fine wools for better-class yarns, while the former is by far the largest used, and gives excellent results.

The large variety of cloths, such as tweeds, flannels, various kinds of dress goods, and so on, now made in which cotton forms a part, and the widely varying qualities of same, make it necessary to pay particular attention to the quality of cotton used. The class and grade of cotton used are governed by the quality or class of the blend; as, for instance, in the case of a good blend consisting principally of a fairly good class of wool material a corresponding class of cotton would be used; but in lower-class blends, and where as much as 75 per cent. of the blend is cotton, cotton card strips would probably be used. In the blending of different classes of materials such as cotton and wool, the principal point is to select the cotton to be blended so that it will be as nearly like the wool as possible as regards length and general characteristics, and in all cases corresponding qualities of cotton should be used. The length of the fibre of the cotton used, and especially if Peruvian or Sea Island cotton is used, is often greater than that of the wool fibres. Consequently, it will be readily seen that the cotton, being also fine and strong, will add materially to the spinning qualities of the blend, and give strength to the resultant yarn. Further, in cases where the staple of the cotton is longer than that of the wool, the cotton will form the core of the thread, and be covered with the shorter wool fibres, since in the spinning of woollen yarns the long fibres tend to form the centre of the yarn, and the shorter fibres the surface.

As has already been indicated, various kinds of waste and remanufactured materials are used in the manufacture of woollen yarns, either alone or by being blended with pure wool, or some vegetable fibre—usually cotton. Large numbers of blends contain only shoddy or waste, and cotton, while others have varying percentages of pure wool. The addition to a blend of shoddy, mungo, waste, or cotton cheapens the blend and resultant yarn and cloth considerably. This fact is made use of in order to produce cheaper cloths than a competitor, and also to gain trade that would otherwise be lost owing to the cost of better qualities of cloth being too great for large numbers of people. The use of comparatively cheap waste and recovered wools in blends has enabled large volumes of trade to be done which otherwise would not have been economically possible. There have been many objections made to the use of recovered or remanufactured wools in the past, and much prejudice still exists and is exercised against the use of these materials; but as a matter of fact many of the objectors are wearing and using cloths made from blends containing some kind of shoddy, mungo, or waste, since it is practically impossible, when only small quantities of remanufactured materials are added to a blend, to say definitely, when the resultant cloth has been finished, whether any have been used or not, and in what proportion. When remanufactured materials are blended with wool, every endeavour is made to have the fibres as nearly alike as regards length and general characteristics as possible. Especially is this the case with the better-class blends. The greater the difference in the above respects, the more difficult it is to get a good mix, and the resultant yarn is inferior. It will be obvious that the nearer alike the different constituents are, the more difficult it will be to detect the presence of remanufactured wools.

Much has also been written from the hygienic point of view against the use of the materials in question, statements being made that infectious diseases were transmitted in this manner; but the fact that extremely few, if any, outbreaks of infectious diseases in the centres of the industry are directly traceable to this cause, disposes of all such statements. Moreover, as the population is increasing at a greater rate than the production of raw wool, and as the cost of wool is comparatively great, the use of remanufactured wool goes some way toward preventing an actual shortage of raw material, and is used in the manufacture of woollens of many kinds. The extent to which these substitutes for pure wool are used will be appreciated when it is stated that it is almost equal to the amount of pure wool.

METHODS OF BLENDING.—In mixing remanufactured materials with wool, it is the best policy to pass them separately, but in an oiled state, through the teaser or fearnought, before making the pile, so as to open them out and get a better distribution of the oil. When cotton is to be added to a pile it is usually passed through a fearnought or carding machine, the latter being preferable, as it renders the material more open and fluffy, and individual fibres of cotton will mix more thoroughly and intimately with the individual fibres of wool. In ordinary cases it is important that little or no oil shall reach the cotton, consequently the wool is oiled and teased prior to the pile being made in which the cotton is added. The two objects accomplished are, that by teasing the wool the subsequent blend is improved and the oil is more thoroughly distributed. It is a good plan to allow the oiled and teased wool to stand for a day or two before making the pile in which the cotton is added; this allows the oil to be thoroughly absorbed by the wool, and when the blend is made the cotton will absorb all the oil or moisture from the wool that it requires.

The following is a brief description of another method of amalgamating and intimately mixing cotton with wool, which is occasionally practised, and has notable points in its favour: The various qualities and kinds of wool fibre are oiled and teased, or put through the fearnought separately, if mungo, or shoddy, or pure wool, is to be blended; then the pile is made. The wool from the pile is placed in the hopper of the scribbler or first of a set of three machines, and as it is stripped from the doffer the cotton is introduced by passing it in sliver form along with the wool in its passage to the balling head. The two slivers passing through the revolving tube on the scribbler, which gives a little twist, before they pass to the balling head causes the cotton and wool slivers to twist round each other. The balls are then fed by means of a creel or bank to the intermediate or second scribbler, the cotton and wool being evenly distributed across the width of the card. The mixed material taken from this machine is fed by a Scotch feed to the carder. It will be seen that by mixing the cotton and wool at the last doffer of the scribbler, at the feed of the intermediate, and at the feed of the carder, it is practically impossible to obtain an imperfect mix.

When the above method is adopted, the cotton must be carded previously on a cotton card, and the sliver coiled in a can as in ordinary cotton carding. The sliver of cotton to be run along with the wool is passed from the can along the front of the doffer to be made into balls. By this method of mixing, the oiled wool and cotton are not mixed or in contact for a sufficient length of time to allow the cotton to absorb too much oil, consequently the roving will spin better, and a more even thread is the result. This is an important point, since, if the cotton becomes oily, it also becomes stringy and lifeless. Moreover, if a cotton and wool mix is run through the teaser and fearnought, and is to be followed by an all-wool blend, then these machines will require to be thoroughly cleaned, since if every particle of cotton is not removed, fibres of cotton will be found in the wool after it has passed through these machines. When silk is mixed with wool it is usually in the form of waste, and since its characteristics in a general way are more like those of cotton than wool, it is treated in an almost similar manner when blended, with regard to the exclusion of oil and the previous opening out of the material. With silk, especially when used in large percentages, there is liable to be trouble caused through excessive flyings and the electrifying of the silk. In such cases the silk must be dampened but not by water in sprays or in bulk, as this would cause the silk to mat. The best method is to lay damp cloths over thin layers of the silk and allow the whole to stand a sufficient length of time; usually standing over-night is ample. Also the wool must be perfectly clean, and the silk waste entirely free from gum.

Blending for Colour.—In addition to the innumerable blends which are now made for the purpose of producing a cloth to come in at a certain price, and possessing the characteristics of a given sample of cloth, and in which materials ranging from cotton to pure wool of a high class are used, large numbers of blends are made, primarily with the intention of producing a mixture yarn as regards colour—such, for instance, as heather mixtures, steel-greys, blue-greys, and so on. A range of steel-grey mixtures may be made by blending different proportions of black and white. Heather mixtures in very large variety are produced by mixing certain colours in suitable proportions. One kind of heather mixture is composed of black, scarlet, and green, the colours being blended in various proportions according to the shade of mixture required. Another kind is composed of black, scarlet, green, and old gold; while yet another class is composed of black, scarlet, and yellow. With few exceptions black is the preponderating colour in this class of mixture, and it mixes well with all colours, especially contrasting colours. If, however, it is mixed with analogous colours that are too dark in shade, and too sombre, the resultant effect is liable to be too dingy. Black, blue, green, scarlet, yellow, lavender, and red form very good combinations. Brown combines well with green, since these are to a large extent complementary colours.

It must be observed that by blending together materials of different colours in the fibrous state a distinct solid colour is produced, but one in which there are distinct traces of the original colours; this being quite clear if the blend or resultant yarn is examined. In blending for colour, pure wool materials which are fairly lustrous produce the best results, while remanufactured materials such as shoddy and mungo produce somewhat dingy effects, since the fibres are not so strong and lustrous, and are lacking in the valuable characteristics which pure wool possesses.

Blue-greys are produced by blending together white and blue in proportions varying according to the shade required. The following is a scheme of mixing for producing a range of six shades of blue-greys—

—	No. 1 Blend.	No. 2 Blend.	No. 3 Blend.	No. 4 Blend.	No. 5 Blend.	No. 6 Blend.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Dark blue	1	3	5	7½	10	12
Light blue	¼	¼	¼	¼	¼	¼
White	10	8	6	4½	3	1

It will be seen that No. 1 blend is the lightest and that No. 6 is the darkest in shade. The light blue is added in the proportion indicated as a toning colour to give character to each blend.

A good scheme of mixing for the production of a series of five heather shades is as follows—

—	No. 1 Blend.	No. 2 Blend.	No. 3 Blend.	No. 4 Blend.	No. 5 Blend.
	Lb.	Lb.	Lb.	Lb.	Lb.
Black . . .	2·5	3·25	4	5	6
Brown . . .	2·5	3·25	4	5	6
Blue-green . .	8·5	7	5·5	4	2
Yellow . . .	1	1	1	1	1

It is almost unnecessary to note that blend No. 1 is the lightest, and that blend No. 5 is the darkest. The yellow, which is added in the same quantity to each blend, is the toning colour to give character to the blend. At this point it might be stated that in preparing a series or range of blends grading, say, from light to dark, a suitable and practical number is five.

Another scheme of mixing which will give a series of five heather shades is as follows—

—	No 1 Blend.	No. 2 Blend.	No. 3 Blend.	No. 4 Blend.	No. 5 Blend.
	Lb.	Lb.	Lb.	Lb.	Lb.
Black . . .	4	5·5	7	8·5	10
Blue . . .	0·5	1	1·5	2	2·5
White . . .	8	6·5	5	3·5	2
Green . . .	1	1	1	1	1
Gold . . .	1	1	1	1	1
Scarlet . . .	1	1	1	1	1

It will be seen from an examination of the blends that three toning colours have been used—viz., green, gold, and scarlet. By increasing the number of toning colours a richer blend is produced, providing that they are well chosen, and one which results in yarn and cloth having a superior appearance.

Another type of blend which deserves notice is that in which a little colour is added to a practically solid shade. When the blend is well made the solid shade is just tinted, shaded, or specked with colour. In this way a speckled effect is obtained in the yarn and cloth that cannot be obtained otherwise. The following blends are examples of this type—

No. 1 Blend.	No. 2 Blend.	No. 3 Blend.	No. 4 Blend.	No. 5 Blend.
Black . 12 lb. Scarlet. 1 ,,	Dark blue . 12 lb. Yellow . 1 ,,	Dark lavender . 1 lb. Light ,, . 5 ,, White ,, . 5 ,,	White . 12 lb. Purple 1 ,,	White . 10 lb. Lavender . 1 ,, Brown . 1 ,,

In blends Nos. 1 and 2 dark shades are tinted with scarlet and yellow respectively; while in blend No. 3 the dark lavender is giving a speckled appearance to a medium shade. In blends Nos. 4 and 5 purple and brown are the specking colours on light ground shades. A useful series of blends producing five shades of coloured grey with light olive as toning colour, is as follows—

—	No. 1 Blend.	No. 2 Blend.	No 3 Blend.	No. 4 Blend.	No. 5 Blend.
	Lb.	Lb.	Lb.	Lb.	Lb.
White . . .	9	7·5	6	4·5	3
Black . . .	3	4·5	6	7·5	9
Light olive . .	1	1	1	1	1

In blending different colours the strength or weight and tone of the colours should be considered with a view to obtaining well-balanced mixtures, since if care is not taken a very crude mixture is likely to result. The primary colours are of course the most intense, and must be used comparatively sparingly. Red and yellow in particular are very effective, the former being very brilliant and showy, while the latter is very light, luminous and bright. On the other hand, blue is more retiring, though possessing lustre and bloom. The characteristics of the secondary colours—orange, green, and purple—are affected by the primaries from which they are made. Thus, orange, which is produced by blending red and yellow, is less intense than red, and not so bright or luminous as yellow; while green, which is produced from yellow and blue, has the characteristics of both the primaries, but in a less degree, as the yellow gives cheerfulness and has a mellowing effect, while the blue makes it rather hard, cold, and retiring. The tertiary colours, which are less effective than either the primaries or secondaries, are produced by mixing together two of the secondaries, and since they are not so intense and potent they may be used in greater quantities. All colours of whatever shade may be further modified by the addition of another colour, or black or white; thus a little yellow added to red will produce scarlet, while the addition of white or a light colour will produce various tints, such as pink, and so on, and the addition of black or a dark colour will produce various shades of red of a russet character.

COLOUR MATCHING.—A reference to the matching of colours will not be out of place, since it is often necessary to compare a small trial blend with a sample blend. In all cases, what is termed the overhand method is best, and is especially preferable when matching is being done by artificial light, such as incandescent or electric light. It consists in placing the samples to be matched practically on a level with the eye, and between the eye and the light. In this way the light is transmitted direct to the eye through or from the fibres, and is least affected by other objects, or immediate surroundings; while in the underhand method the light is transmitted at an angle to the eye from the samples being compared, and matching is rendered much more difficult since the immediate surroundings affect the light transmitted to a greater extent, and consequently the colours. When matching-off by daylight, which is, of course, by far the most preferable and satisfactory, it should be done as far away as possible from the direct rays of the sun so as to obtain the steadiest light, and one with the least excess of yellow light. For this reason, when matching colours before noon a north to north-west light should be taken, while if matching is done in the afternoon a north to north-east light should be taken.

CALCULATIONS.—In the production of blends it is necessary to obtain the average cost per pound of the blend both before oiling and after, when different qualities or kinds of materials are used which vary in price; also what quantities of different qualities or kinds of materials, which vary in price, must be mixed to produce a yarn at a given cost.

One example of the first kind will be sufficient to make it quite clear how such calculations are made, and no difficulty should be experienced in making any calculation of a similar kind, even though in practice more elaborate calculations are met with.

Example: Suppose a blend is to be made consisting of 150 lb. of Port Philip scoured at 2*s*. 6*d*. per pound, 190 lb. of Sydney scoured at 2*s*. per pound, 80 lb. of Berlin or fine worsted at 10*d*. per pound, and 80 lb. of worsted waste at 6*d*. per pound. What will be the price per pound of the blend? First find the cost of each material in the blend, and add the results obtained together so as to obtain the total cost, in the following manner—

			s.	*d.*		Pence.
150 lb.	of Port Philip scoured	. at	2	6	per pound	= 4,500
190	,, Sydney ,,	. at	2	0	,,	= 4,560
80	,, Berlin or fine worsted	. at	0	10	,,	= 800
80	,, worsted waste .	. at	0	6	,,	= 480
500 lb. : Total weight.		Total Cost (Pence)				10,340

Then divide the total cost of blend by the total weight of blend, and the result will be the price per pound. Thus—

$$\frac{10,340}{500} = 20\cdot68 \text{ pence per pound.}$$

It will be seen from the above example that it is merely a question of finding the average price.

When finding the cost of oiled blends the procedure is precisely the same as that already explained, with the exception that the cost of the oil is added to the total cost of the materials forming the blend; thus, the cost per pound of the blend is always increased according to the amount of oil used and price per gallon, since the weight of the oil is not added to the total weight of blend.

To find what quantities of different qualities or kinds of materials, which vary in price, must be mixed to produce a yarn at a given cost, when all the prices of the different materials are known, and also the required price per pound of the blend: The simplest form of this kind of calculation is where only two materials which are different in price must be mixed, and the correct proportions of each are required, so that the blend will come in at a certain, usually predetermined, price.

Example I.: What quantities of wool at 1*s.* per pound, and cotton at $6\frac{1}{2}d.$ per pound, will be required to make a blend of 500 lb., costing $8\frac{1}{2}d.$ per pound?

$$8\tfrac{1}{2}\begin{cases}12 & \rceil 2\\ 6{\cdot}5 & \rfloor 3{\cdot}5\end{cases}$$
$$\overline{5{\cdot}5}$$

For every 5·5 lb. of the blend, 2 lb. must be wool at 1*s.* per pound, and 3·5 lb. must be cotton at $6\frac{1}{2}d.$ per pound.

To find the weight of the wool and cotton that must be used to make a blend of 500 lb. is simply a matter of proportion, thus—

$$5{\cdot}5 : 2 :: 500 : x = \frac{500 \times 2}{5{\cdot}5} = 181{\cdot}18 \text{ lb. of wool at 1}s. \text{ per pound.}$$

$$5{\cdot}5 : 3{\cdot}5 :: 500 : x = \frac{500 \times 3{\cdot}5}{5{\cdot}5} = 318{\cdot}18 \text{ lb. of cotton at } 6\tfrac{1}{2}d. \text{ per pound.}$$

With regard to the above calculation, the following remarks may be made. Seeing that the blend is to cost $8\frac{1}{2}d.$ per pound, and 2 lb. of wool at 1*s.* per pound is used, there is, in effect, a loss of 7*d.*; but this is off-set or balanced by the fact that 3·5 lb. of cotton is used at 6·5*d.* per pound, which is in effect a gain of $3{\cdot}5 \times 2 = 7d.$

Example II.: What relative weights of each of the following materials: cotton at 8*d.* per pound, wool at 10*d.* per pound, and shoddy at $4\frac{1}{2}d.$ per pound, are required to produce a blend at 7*d.* per pound? Also, what weight of each will be required to produce 100 lb. of the blend?

From Example I. it will be seen that the prices of the different materials in question are placed under one another in column form, and to the left of the bracket enclosing them is placed the average price of the blend. Then higher values than the average price are connected or linked by brackets with values less than the average price; after which, the difference between the average price and the higher value is placed opposite the lower value to which it is connected or linked; and the difference between the average price and the lower value is placed opposite the larger value to which it is connected or linked. These numbers represent the relative weight of each sort, which has the same relation to

BLEND NO. 1.

Calculation.	Relative Weight.	Actual Weight in Blend of 100 lb.	Kind of Material.
		Lb.	
7 { 8]] 2·5 + 2·5	5	40	Cotton.
7 { 10]] 2·5	2·5	20	Wool.
7 { 4·5]] 1 + 1 + 3	5	40	Shoddy.

BLEND NO. 2.

Calculation.	Relative Weight.	Actual Weight in Blend of 100 lb.	Kind of Material.
		Lb.	
7 { 8]]] 2·5 + 2·5 + 2·5	7·5	$46\frac{7}{8}$	Cotton.
7 { 10]]] 2·5	2·5	$15\frac{5}{8}$	Wool.
7 { 4·5]]] 1 + 1 + 1 + 3	6	$37\frac{1}{2}$	Shoddy.

BLEND NO. 3.

Calculation.	Relative Weight.	Actual Weight in Blend of 100 lb.	Kind of Material.
		Lb.	
7 { 8]] 2·5	2·5	$17\frac{7}{29}$	Cotton.
7 { 10]] 2·5 + 2·5	5	$34\frac{14}{29}$	Wool.
7 { 4·5]] 1 + 3 + 3	7	$48\frac{8}{29}$	Shoddy.

BLEND NO. 4.

Calculation.	Relative Weight.	Actual Weight in Blend of 100 lb.	Kind of Material.
		Lb.	
7 { 8]]]] 2·5	2·5	$12\frac{1}{2}$	Cotton.
7 { 10]]]] 2·5 + 2·5 + 2·5	7·5	$37\frac{1}{2}$	Wool.
7 { 4·5]]]] 3 + 3 + 3 + 1	10	50	Shoddy.

their sum, or total relative weight, that the weight of each component of the blend has to the total weight of the blend.

$$7\left\{\begin{array}{l} 8 \\ 10 \\ 4\cdot5 \end{array}\right. \quad \begin{array}{l} 2\cdot5 \quad = 2\cdot5 \\ 2\cdot5 \quad = 2\cdot5 \\ 1 + 3 = 4 \end{array}$$

To find the weight of each ingredient that must be used to make a blend of 100 lb., it is merely a question of simple proportion as in the case of Example I., or working as follows—

The total relative weight $= 2\cdot5 + 2\cdot5 + 4 = 9$.

Then $\frac{100 \times 2\cdot5}{9} = 27\frac{7}{9}$ lb. each of cotton and wool.

$\frac{100 \times 4}{9} = 44\frac{4}{9}$ lb. of shoddy.

By an extension of the above principle or method of working, a comparatively large number of blends may be made by mixing the same materials in different proportions, and still retain the same average price. This method is extremely useful, since a blend can be made to come in at a stated price, while the amount of each ingredient or component can be varied to meet the exigencies of a tariff, or to obtain just the desired result in the yarn as regards strength, handle, and appearance. For instance, referring to Example II., the amount of cotton may be increased to help the spinning and give strength and solidity to the yarn, or the amount of wool and shoddy may be increased and the cotton decreased to give a full and woolly handle to the yarn. Also an influencing factor is that more material of one kind than another may be on hand; for instance, if ample wool and shoddy is on hand, and the stock of cotton is low, and all other factors are practically negligible, then a blend employing least cotton will be used. The above are a series of four additional blends, which will illustrate how it is possible to vary the amounts of each material forming a blend of 100 lb., and still retain the price per pound.

In the case of more elaborate blends—that is, blends composed of more different kinds of materials which vary in price—the series of blends may be increased, and the calculations will be a little more complicated, but the principle remains the same. With the increase in the number of possible blends, using the same materials and each blend being the same in price, the difficulty of deciding which blend will most nearly meet the requirements is also increased. This emphasises the importance of the fact that the person responsible for blending should have a thorough knowledge of the carding, spinning, weaving, and finishing capabilities of different materials.

LAYING OUT BLEND.—When the proper quantities of each colour and kind of material have been obtained, the next operation is that of making the pile or the laying out of the blend. This work is comparatively simple, since it is merely a question of spreading out the materials in layers one above the other. The principal points to observe are that the layers are even in thickness; that each layer is made up of the correct material; and that each of the materials is properly distributed in the pile—for instance, if only a small amount of material of one kind or colour is to be used, the layer of that material will be correspondingly thinner. It is of paramount importance that no component of the blend shall occur in patches; and with a view to preventing this it is advisable to make the layers as thin as is conveniently possible. The simplest of all piles to make is that where equal quantities of only two materials are used. For example, suppose that a wool and cotton blend is to be made from 1500 lb. of wool and 1500 lb. of cotton. Before proceeding to make the pile the mixing-room floor is swept clean; then equal quantities—of, say, 250 lb. each—are weighed, and spread over a floor space of from 4 to 6 yds. square in alternate layers.

The layers of each material are usually made from 5 to 8 in. deep; but it is better to err on the side of having the layers too thin than too thick, since the thinner the layers the more thorough is the mixing. A good average thickness is about 6 in. In making a blend of wool and cotton similar to the example just given, the wool should be oiled first and then run through a teaser or willow, with a view to obtaining a thorough distribution of the oil. In addition, it is advisable to allow the oiled wool to stand over-night, or longer if it is possible, so that the wool will be in a mellow condition. After this the pile is made as explained above. Then as soon as possible it is broken down, by being taken from top to bottom, so as to feed as nearly as possible equal quantities of the components of the blend to the teaser at the same time. It will be obvious that if the material were taken from along the top the effect and advantage which should accrue from making the pile would be practically neutralised.

In making the pile for more elaborate blends it is often necessary to adopt a modification of the above method. One fairly common instance is where a comparatively large quantity of one material is to be mixed with a small quantity, or perhaps several small quantities. In such a case it is best to make a preliminary pile and blend with the smaller quantities, and perhaps a third of the larger quantity; then, after the material has been run through the teaser,

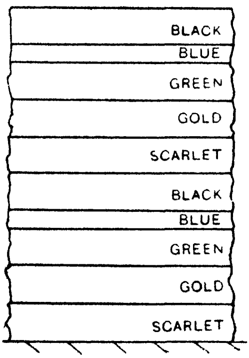


FIG. 35.

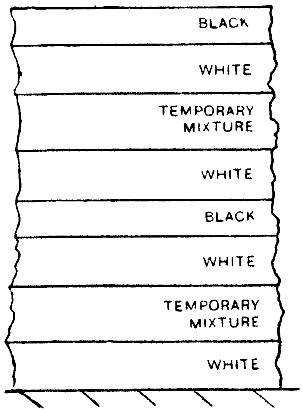


FIG. 36.

another pile is made, taking the temporary mix as one colour or quantity, and the remainder of the larger quantity as the other.

An example of such an instance is as follows: Suppose a blend is to be made from 400 lb. of black, 50 lb. of blue, 800 lb. of white, 100 lb. of green, 100 lb. of gold, and 100 lb. of scarlet. The best method would be first to make a pile of the black, blue, green, gold, and scarlet, as shown in Fig. 35. It will be seen that the temporary mixture consists of 50 lb. of black, green, gold, and scarlet, and 25 lb. of blue, arranged in consecutive layers, which, when repeated, form a pile of 450 lb. This pile is broken down, generally, with forks, from top to bottom, and passed through the teaser or fearnought. The final pile, consisting of 300 lb. of black, 800 lb. of white, and 450 lb. of temporary mixture, is then made as shown in Fig. 36. This pile, as will be seen, is made up of alternate layers of $133\frac{1}{3}$ lb. of white; while the intervening layers consist of 100 lb. of black and 150 lb. of temporary mixture alternately. It is preferable to make alternate layers of white of $133\frac{1}{3}$ lb. each, rather than make one layer of $266\frac{2}{3}$ lb., and then follow on with consecutive layers of black and temporary mixture, since with advantage a much better distribution of the materials is obtained. The layers may be made half the size. This will, of course, add to the work of making the pile, but will result in a better blend.

In the case of blends consisting of different materials the procedure is much the same. When mixing wool, shoddy, mungo, extract, or flocks, it is, however, best to run the materials through the teaser or fearnought separately, each material having been previously oiled. One notable advantage of this procedure is that each component of the blend can be oiled separately with the requisite amount of oil; and as each material usually requires a different amount, this can be efficiently distributed. The materials are also well opened, which renders blending more thorough. After each material has been oiled and teased, the pile is made in exactly a similar manner to that described; the thickness and number of layers depending upon the percentage of the material in the blend. In the case of blends in which only two or three colours or different materials are used, and one of the colours or materials is present in the quantity of only about 5 to 10 per cent., it is a good plan to card this small proportion so that it can be mixed more thoroughly. A temporary mix is first made with a suitable quantity of the larger percentage, which is run through the teaser or fearnought. Then the final pile is made with the temporarily mixed materials and the remainder of the larger percentage, the thickness of each layer and the number of layers depending on the quantities of each.

When a blend is to be made from ordinary pure wool and noils it is not necessary to run the materials separately through the teaser or fearnought, since the noils are pure wool materials, and will not require a widely varying percentage of oil from that required by the wool, nor will they require any preliminary opening. It is usually advisable to carbonise the noils prior to blending, since they contain practically all the vegetable matter combed from the wool in the form of burrs, shives, etc.

In cotton and wool blends, where the yarn and cloth have to be sold in the undyed or natural state, and where fairly large quantities of cotton are to be blended, it is not advisable to use the cotton in the natural state, owing to the difference in shade between the two. To overcome this difference a bluish stain is put on the cotton. Further, if the cotton is dyed before weaving, it is important that it should be a fast colour, since, if it is not, in the subsequent scouring of the yarn or cloth it is very liable to bleed or run.

Operation of Blending.—The mechanical operation of blending serves the twofold purpose of blending the different components of the pile intimately together, and of opening and cleaning the material. Machines used for blending are of two kinds—viz., the willow, teaser, or willey; and the fearnought, the blend being first run through the willey and afterwards through the fearnought, in places where both are installed; but it is common to run the material two or three times through the willow, as required, and dispense with the fearnought.

When dealing with the dusting of wools prior to scouring, the Sykes willow was fully explained, and this machine is quite applicable to the work of blending. Another very good type of wool willow is made by Messrs. Platt Brothers, of Oldham. This machine consists essentially of a central or main cylinder fitted with rows of teeth; a pair of workers, a cage, a fan, and feeding and delivery arrangements. Figs. 37 and 38 are diagrammatic sections, left and right hand views respectively. In operation the material is placed on the feed lattice A, which carries it to the fluted feed rollers B. The feed lattice is driven intermittently, and is fitted with an arrangement for varying the number of feeds or intermittent motions per minute, by means of cone pulleys and straps inside the regulator box C. After leaving the feed rollers B, which feed the material slowly to the cylinder, it is willowed by the cylinder working in conjunction with the workers E over the cylinder and the fixed teeth carried by bar F, which is placed just in front of the workers. The teeth of the cylinder, workers, and those in the fixed rail F, intersect as shown; also the teeth on the cylinder come midway between those on the workers and fixed bars. It will be realised after a moment's consideration that it is important, if the best results are to be obtained, to have the workers correctly

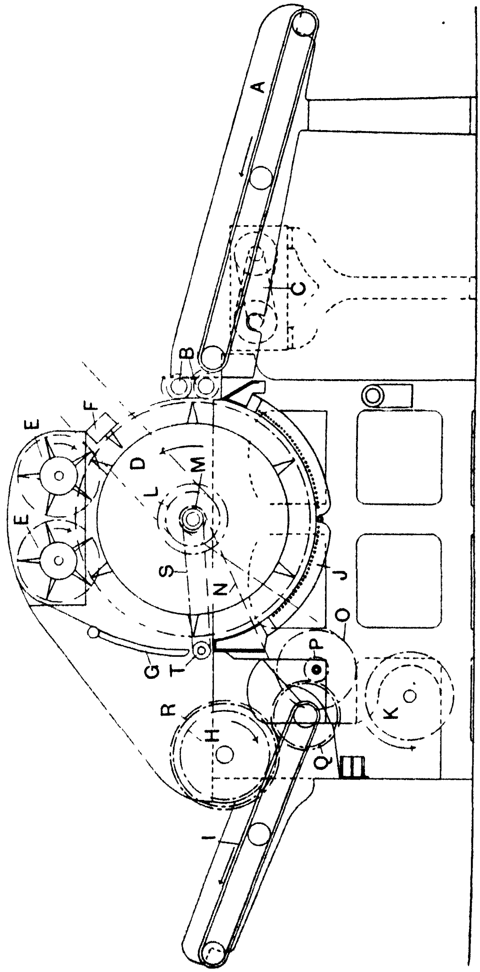


Fig. 37.

adjusted and any side-to-side movement practically eliminated, so that the teeth on the cylinder will always be midway between those of the workers. If the rollers are not correctly adjusted, inferior work results owing to excessive breakage of fibre, and the work is not nearly so satisfactory generally. After a short willowing the door G is automatically opened, and the material is thrown on

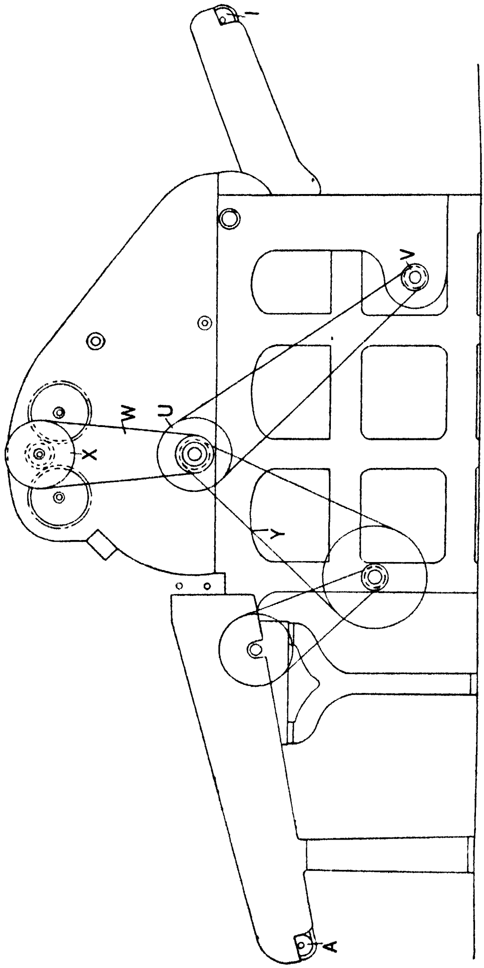


FIG. 38.

to the revolving cage H, to be carried away by the delivery lattice I. The cage ensures an even delivery of the material, as when the material is discharged or thrown directly from the machine without any running-off apparatus the heavier component parts are separated from the lighter, which to a large extent neutralises the effect of the blending.

All dust and other impurities that are beaten or willowed out by the action of the cylinder in conjunction with the feed rollers, workers, fixed bar, and grid J, are removed by the current of air created by the fan K.

DRIVING.—A belt from the line shaft gives motion to the fast and loose pulleys L, that are 12 in. in diameter, giving a cylinder speed of 350 revs. per min. The cage H and the lattice I are driven from the pulley M fixed on the cylinder shaft, by means of the crossed belt N, which drives pulley O, compounded with which is a toothed wheel P that drives the delivery lattice by gearing with wheel Q fixed on the lattice shaft. Wheel Q gears with wheel R fixed on the cage shaft. Belt S driven by a small pulley on the cylinder shaft drives a small pulley T on a roller shaft which assists in the delivery of the material to the cage, and is situated immediately beneath the bottom of the door G when it is closed. The driving for the workers, fan, and feed part of the machine is on the right-hand side, and is shown in Fig. 38. Pulley U on the cylinder shaft drives by an open belt the flanged pulley V fixed to the fan shaft. The open belt W gives motion to pulley X, compounded with which is a gear-wheel that gives motion to gear-wheels fixed on the end of the worker shafts. Belt Y, also driven from a pulley on the cylinder shaft, gives motion to the feed part of the machine as shown. The machine is automatic, and the production can be regulated according to the condition of the material being blended. All the parts are enclosed, and the fan removes dust and other impurities.

FEARNOUGHT.—The fearnought (or, as it is often termed, the cockspur or tenter-hook teaser or willey) is the machine through which the blend is passed after having been through the willow. This machine is very drastic in its action, and is no doubt responsible for much breakage of fibre; but it is very efficient as a mixing machine, and can be depended upon to deliver material forming a blend in a satisfactory condition for carding, even when widely different materials are components of the blend.

A very good fearnought, as made by Messrs. Platt Brothers, of

Oldham, is shown in Figs. 39, 40, and 41. A section is given in Fig. 39 showing the arrangement of the rollers, and the direction in which the teeth point; the direction of rotation is also indicated. In Fig. 40 is shown the driving on the right-hand side, while in Fig. 41 is shown the driving on the left-hand side.

The machine consists essentially of a central cylinder or swift covered with strong cockspur steel teeth; a series of workers fitted with similar teeth; a series of strippers and a fan doffer fitted with teeth and leather blades; and a suitable feeding arrangement. It might be noted that this machine is similar to an ordinary one-swifted carding machine, being provided with workers and strippers; but the strippers are placed on the other side of the workers—that is, contrary to their position on the ordinary carding machine. The fearnought commences the opening of the locks and staples fibre from fibre, and the cleaning of the material, which is continued by the carding machines.

OPERATION.—The material from the willow is placed thinly and evenly on the feed lattice A, which carries it to the feed rollers B fitted with cockspur teeth pointing in the direction shown, the rollers revolving in the direction of the arrows with the backs of their teeth first. As the material is fed by the slowly revolving feed rollers it is acted upon by the teeth on the swift C. A large number of the teeth on the swift pass through each piece of material before it is released by the feed rollers; consequently much opening of matted portions is done at this point. As a matter of fact, the material is practically torn or pulled from the feed rollers, which retain a hold upon it as long as possible.

The swift in moving upwards tends to comb the material over the top feed roller; hence this roller would, if no other provision was made, carry much of the material round with it. A stripper D working point against the smooth side or the back of the teeth on the top feed roller effectively removes any material going round on the surface of the latter, and the former is in turn stripped by the swift, the teeth of which work point against the smooth side of the stripper. Moreover, the swift having a much greater surface speed than the stripper, whips the material from it.

The material as it is carried forward by the swift is next brought into working contact with the slowly retiring teeth of the first

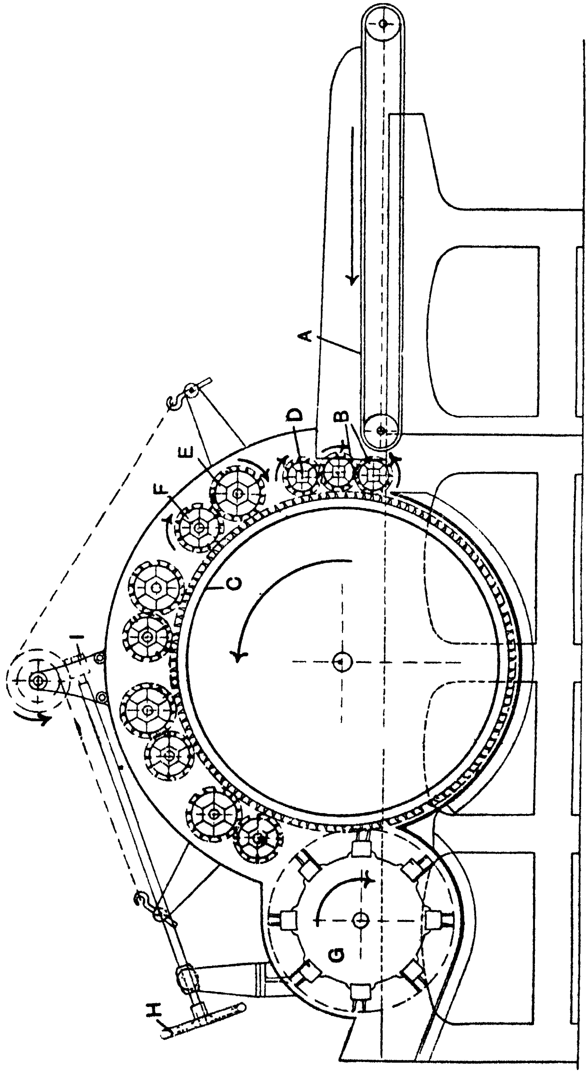


FIG. 39.

worker E. It will be noticed that the teeth of the swift and the worker operate point against point, and consequently the greatest opening takes place between these rollers. Any matted locks or staples brought into contact with the teeth of the worker must be opened, since the quickly moving teeth of the cylinder will retain a hold on a portion, while the teeth of the worker on which the material has been impaled will carry round a portion; and as the worker is slowly revolving in the direction indicated, very many teeth of the cylinder must act on it, by passing through it, before the material passes out of working contact.

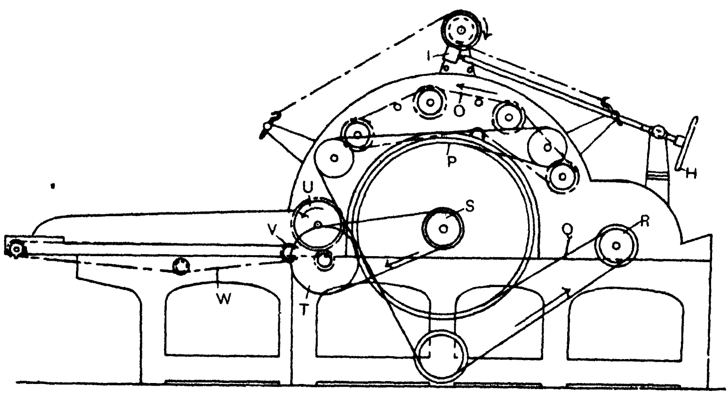


FIG. 40.

The worker is stripped by the stripper F, which, revolving in the direction indicated by the arrow and at a greater surface speed, carries the material back to the swift, and is in turn stripped by it. From Fig. 39 it will be seen that the teeth of the strippers F are set into or project below the surface of the teeth of the swift and the workers; this is to ensure good stripping. The material on the swift is submitted to the action of three more pairs of workers and strippers, and it is finally stripped from the swift and ejected from the machine by the fan doffer G. The fan doffer consists of a central shaft to which spiders are fixed, and to these spiders are fixed eight lags, each alternate one of which carries two rows of teeth, while the remainder carry only one row of teeth, and a piece of leather the edge of which is serrated or cut out so as to stroke the teeth of the swift, and ensure the removal of the material: this is the purpose of the leather on the strippers.

It must be noted that the teeth on the various rollers are set in rows round the roller, the teeth in contiguous rows being set to form a diamond, so that there is no danger of the teeth of the various rollers striking one another so long as the rollers are correctly adjusted. The grids under the swift and fan doffer are to allow any extraneous matter which is freed as the material is opened to drop through into the bottom of the machine, where it accumulates, and is periodically removed as required. Access beneath the

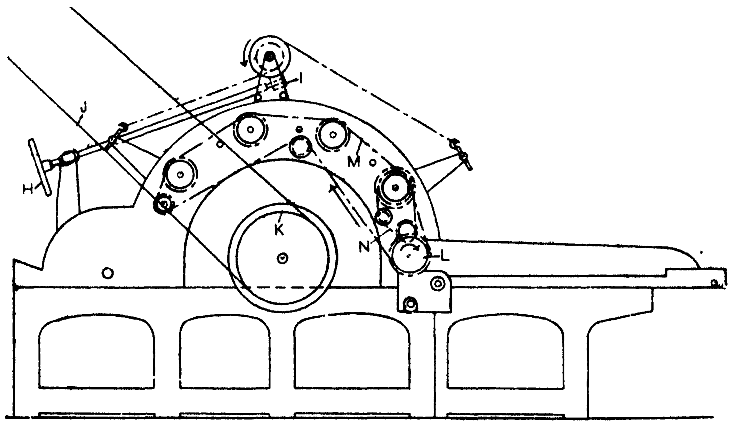


FIG. 41.

grids is obtained by removing the plates fitted in the heavy framework.

On this machine there is an arrangement for mechanically raising the covers for cleaning, repairing, or other purposes. When it is desired to raise the covers, the hand-wheel H is turned in such a direction as to cause the worm I on the other end of the shaft to turn the worm-wheel in the direction of the arrow, and wind up the chains attached to the covers and chain pulleys as shown. This method is an improvement on the old one of raising them by hand, since if, for some reason, it is required to raise them only slightly, it is necessary only to turn the hand-wheel correspondingly, when they are held up mechanically; while in the old method the attendant must raise each part of the cover until pegs catch on hooks suitably provided before he can leave it. The covers are also heavy, and not easy to lift.

Driving.—The driving on the left-hand side is shown in Fig. 41. A belt J transmits motion from the line shaft to fast and loose pulleys at K, and when the belt is on the fast pulley the cylinder is driven at a speed of about 160 revs. per min. It may, however, if required, be driven at a much greater speed. The top feed roller B is given motion from the other side of the machine, and on its shaft is a sprocket wheel L, Fig. 41, which gives motion to the chain M, that transmits motion to the workers through a sprocket wheel fixed on each worker shaft. The bottom feed roller is driven by gear-wheels of equal size from the top feed roller, while the feed lattice is driven by an intermediate from the gear-wheel on the bottom feed roller. This gearing is not shown, as it is partly enclosed, but a part of the intermediate will be observed. A chain N, which is driven by a sprocket-wheel on the first worker shaft, gives motion to the stripper D. The chain M, after leaving the last worker, passes round a sprocket-wheel on the last stripper shaft, thus giving motion to it. It is from this source that the strippers receive their motion. On the other side of the machine, as shown in Fig. 40, a larger sprocket-wheel is fixed on the last stripper shaft, and this by means of chain O gives motion to the other strippers through a sprocket-wheel fixed on each of their shafts.

The fan doffer is driven from a large pulley P fixed on the swift shaft by means of belt Q, which passes round three guide pulleys before reaching pulley R on the fan shaft. A pulley S on the swift shaft by means of an open belt gives motion to pulley T, compounded with which is a wheel that drives the gear-wheel U fixed on the top feed roller shaft. A sprocket wheel V on the feed lattice shaft gives motion to the chain W, which drives a sprocket-wheel fixed on the shaft of the other roller of the feed lattice. This arrangement helps materially in driving the feed lattice.

This machine may also be fitted with a cage and delivery lattice (or, as it is often termed, running-off apparatus) similar to that described with regard to the willow as made by Messrs. Platt Brothers. It is advisable to have a running-off apparatus fitted when blends made up of diverse materials are to be frequently run, for reasons which were explained with reference to willeying. If, however, it is desired not to go to the expense of having a running-off apparatus, as in the case of a machine already installed, the delivery of the machine should be arranged so that there will be only a small space for the material to accumulate in as it is discharged from the machine, as this prevents in a large measure the separating of the heavier components of the blend from the lighter, and the consequent neutralising of one of the principal objects of blending.

Another, but older, type of fearnought consists of a swift about 48 in. in diameter and about 48 in. wide, which is run at from 150 to 220 revs. per min. It is covered with steel teeth that stand out from the surface of the cylinder about one inch, and the teeth may be set in leather, or in the wood surface of the swift. The workers and strippers are arranged as in the Platt machine—that is, in pairs, each worker being about 8½ in. in diameter over-all, while the steel teeth stand out from the surface of the roller about one inch; they are also set 1¼ in. apart. In this machine the strippers are about 8 in. in diameter over-all, and are fitted with brushes only, that are 1¼ in. long. The workers are driven at a speed of about 40 revs. per min. by means of a chain, while the strippers make about 80 revs. per min., and are driven by means of a belt. The fan doffer may be similar to that of the Platt machine, or fitted solely with brushes in a similar manner to the strippers, and it is driven by a belt at a speed of about 800 revs. per min.

In another make of machine the chain drive has been discarded, and driving by means of a large toothed-wheel has been substituted; both workers and strippers being driven by one large wheel fixed to the swift shaft. It is important to note that in running willows and fearnoughts, besides the ordinary duties of cleaning and oiling, and so on, when a blend of wool and cotton has been passed through the machines and is to be followed by an all-wool blend, the machines must first be thoroughly cleaned inside and out. It is also a good plan, if convenient, to run a quantity of old wool waste through them prior to putting the blend through. Moreover, the teasing-room should also be thoroughly cleaned so as to preclude any possibility of cotton fibres getting into the wool blend.

CHAPTER X

OILING

OBJECT OF OILING.—Oiling may be, and usually is, done by hand during the making of the pile when blending; but in cases where the material forming the blend is all of one quality and kind, or where each kind or quality is such that the oil can be applied indiscriminately to the materials, it may be done mechanically. In the latter case the oil is applied to the material as it passes on the feed lattice to the feed rollers of the teaser or fear-nought.

Oil is applied to lubricate the fibres and make them pliable. The oil also has the effect of preserving the serratures, since it, to a certain extent, coats the fibre; and as the material is being opened and the fibres disentangled, they are less likely to suffer damage. Moreover, in the case of pure wools where washing and drying have been thoroughly done, the fibre has had practically all the natural oil or greasy matter removed, and consequently oil must be added to reduce to a minimum the fly and droppings in carding. Further, if the scouring liquor has been too strong or hot during washing, or if the temperature has been too high during drying, or there has been a lack of circulation of the hot air, the wool will have been rendered harsh and brittle, and oil is necessary to counteract this as much as possible. If greater care were taken in these processes there is no doubt that less oiling would be necessary.

Since each fibre has been scoured and cleansed of the natural preservative, it follows that the ideal method of oiling would be to lubricate each fibre equally and sufficiently. This is impossible, but various methods are adopted to get as even a distribution of the oil as possible. There are two main considerations with regard to the oiling of materials used in the manufacture of woollen yarns, and these are the oil, emulsion, or compound to be used, and the method or means adopted for applying same. The class and quality of oil, emulsion, or compound to be used depend very largely on the class of material or materials forming the blend. A black oil, if of good average quality, would be quite suitable for oiling a blend of pulled felts and carpet yarns, while for a high-class all-wool blend an olive-oil or oleine emulsion would probably be used. The tendency is, however, to use a lower class oil than the material to be oiled warrants, and especially is this the case where yarns are made for sale and they are scoured before being sold. It does not appear to be fully appreciated that there are several disadvantages in using too cheap an oil, and the first cost of the oil, while being an important matter, should not by any means be the only matter considered. It is also advisable frequently to examine and test the oil received, as in many instances a poorer quality of the same kind is sent. The processes through which the material must subsequently pass should also be considered, and it is certainly more economical in the long run to err on the side of using a superior class of oil than an inferior one. A cheap oil adversely affects the production as regards both quality and quantity in many ways, since, if too much acid is present (as is often the case with black recovered oil and oleine, due in the former case to too much sulphuric acid being used when "cracking" the waste scouring liquor, and in the latter case to the acid being left in), the life of the card clothing is shortened, and it has a deleterious effect on the material.

If the yarn is to be scoured immediately after spinning, and then dyed or sold, a lower class of oil can be used—especially if it is to be sold and not dyed—than if the material has to be stored for some time, or even if it has to pass straight to the weaving. The reason for this is that an inferior oil oxidises much more rapidly, and a sticky, resinous deposit is formed on the fibres, which is very difficult to remove or scour from the material, and the longer the material is kept in the greasy state in the form of either yarn or cloth, the greater is the degree to which oxidation takes place.

Properties of a Good Oil.—In a general way the properties of a good wool oil should include fluidity, to enable the oil to be spread in such a way as to obtain as thorough and even a lubrication of the wool materials as possible; it should be stable in composition—that is, not readily affected by the atmosphere; it should be saponifiable, in order to be readily removed when the yarn or cloth is scoured; and it should have enough body to accomplish the desired result of coating the fibres, so that opening may be done without injuring the serrations and causing excessive waste in the form of flyings and droppings. The oils in most common use are vegetable oils, since they contain least insoluble or unsaponifiable matter; and the oils that actually are in use are olive oil, lard oil, oleine or elaine or oleic acid, cotton-seed oil, black oil, and brown oil. There is also a large number of patent compositions, emulsions, and so on, on the market. Many of the former contain mineral oils, while the emulsions consist of an oil and a soap solution. Before any patent composition is bought in any appreciable quantity, it should be thoroughly analysed, since even though its initial cost may be low, it may be relatively very expensive owing to the poor results obtained by its use, either because of its containing actually injurious substances or very cheap and useless adulterants.

Making an Emulsion.—Oil is generally applied in the form of an emulsion, as this renders it more fluid and enables it to be diffused more thoroughly over the material. There are several methods of making an emulsion, but whichever method is adopted the object is to obtain an intimate mixture of the oil and water. To cause the oil and water to unite satisfactorily, generally either soda ash or ammonia is used—the former being most frequently used with low-class emulsions, and the latter with better-class. The water which is used should be soft and free from earthy or suspended impurities, and from this it will be obvious that condensed steam will best meet the requirements. When making the emulsion the water is heated, and the uniting agent or the oil added. If the ammonia or soda ash is added before the oil, the mixture should be stirred during the time that the oil is being slowly added; while if the oil is added first, the uniting agent should be added slowly, during which time the solution is being stirred. It is important that neither too little nor too much ammonia be used, since, if too little is added, the mixing of the oil with the water will not be sufficiently thorough; while if too much is used, the emulsion is too thick. With regard to the quantities of each of the ingredients in the emulsion, it is advisable to make a series of experiments with small, carefully measured quantities, with a view to ascertaining what quantities can be used in bulk to form the most suitable emulsion for the work in hand. It is of paramount importance that the emulsion shall have ample body and not be too thin. For general guidance it might be noted that the lower the quality of the oil, the larger is the amount of water and uniting agent that is necessary to obtain corresponding results.

Sources of Oils.—Oils and fats are obtained in large variety from the animal and vegetable kingdoms; but no definite and precise classification is possible; consequently it is perhaps the best to classify them according to the properties they possess in relation to the use to which they are to be put. Wool oils should be non-drying and saponifiable, since drying oils such as linseed, when exposed to the air, combine with the oxygen and become hard and sticky very quickly, and coat the fibres. Of the semi-drying oils, cotton-seed oil is the most notable in connection with the oiling of wool, since it is largely used for adulterating olive oil, and is to a certain extent used for oiling materials that have to be scoured at once and made ready for use in the form of either yarn or cloth. The chief drawback to its use is, however, the fact that it is a semi-drying oil, and oxidises fairly rapidly.

Non-drying oils, of which there are many, are the most suitable for oiling wool, since they do not dry and become sticky on the wool. The most notable one in this class is olive oil, rightly regarded as the best wool oil on the market at the present time; but its price prevents its being used except for high-class all-wool blends. The olive tree is cultivated very largely in the countries bordering on the Mediterranean, and the fruit of the tree is of considerable commercial importance both as an eatable when pickled in an unripe state, and for the oil which is obtained from it.

The best olive oil is obtained from ripe fruit which is picked during the last two or three months of the year, and the fruit is first crushed into a pulp and then taken to a press, which presses out the oil, that runs into a receptacle containing water. The oil remains on the top of the water, as its specific gravity is less; but any impurities settle to the bottom, leaving the oil in a purer state. There are many grades of olive oil, which are obtained by repeated crushings and pressings of the fruit; but other factors affect the quality of oil produced, such as the variety of tree which has grown the olives, and the ripeness of the fruit. The best-known olive oil used for oiling wool is Gallipoli, but Malaga and Seville are also well known. It might be noted that the names given to them are those of the district from which they are exported. Olive oil is frequently adulterated with other vegetable oils, and less frequently with animal oils. The vegetable adulterant generally used is cotton-seed oil, while rape-seed or colza oil is occasionally used. Colza oil is a semi-drying oil, and is less of a drying oil than cotton-seed oil. The specific gravity of olive oil is given variously as 0·916–0·919.

Lard oil is an animal oil similar in appearance to olive oil, and is obtained by pressing lard. It is more largely used in America than in England for oiling wool, but it can be recommended for medium-class work.

Oleine is much more largely used than lard oil for lubricating wool, but it is liable to contain excessive quantities of sulphuric acid, which is used in the process of obtaining the oleine from the mixture of stearine and oleic acid that is produced in the manufacture of stearine candles. Its high saponification value greatly facilitates the scouring of the resultant yarn or cloth, making the operation both easier and cheaper, since fewer scouring detergents are necessary, and in addition the material takes dye better, as scouring is thorough and even.

Large quantities of various kinds of recovered oils, and blends of oils consisting of recovered oil or oils and other classes of oil, usually vegetable, are used in the medium and low-class woollen trade. The recovered oils are obtained by reclaiming the fat or grease from the waste liquor resulting from scouring raw wool, and the grease resulting from scouring the yarn and the cloth. In the first case the grease is a combination of the grease washed from the wool and the grease from the soap used in scouring, while the latter is a combination of the grease from the soap and the grease from the oil used in oiling wool. The oil in its most impure form is termed black oil, and when slightly purified, it is known as brown oil, while by further purifying, oleine oils are produced.

Amount of Oil Used.—The amount of oil or emulsion that is used for oiling a blend depends very largely on the kind and condition of the materials composing the blend. In the case of a shoddy and mungo blend the materials will have been pulled in oil, and from three to four gallons of black oil per pack (240 lb.) will have been applied prior to pulling; hence in the actual blending only about one gallon of black or brown oil per pack will be found necessary; while in the case of a high-class all-wool blend two or three gallons of olive oil emulsion will be used.

Emulsions of various kinds are favoured in the woollen trade, and while recognising that in the case of various kinds of oleine oil and low-class oils, such as recovered oils, the soda ash used as the emulsifier will to a certain extent neutralise the acid which is always present in such oils, it should be noted that the water dries out and leaves the material in a "sad" condition, and also tends to rust the cards. The proportion of oil to water that is used varies considerably, but the condition of the material is a determining factor, and if it is harsh and brittle or limy, a greater proportion of oil is required in the emulsion than when the material is soft and moist. Similarly, when oil alone is used, the quantity depends on the class and quality, and the condition of the material. It may, however, be stated for general guidance that the amount of oil to use per pack is two and a half gallons.

Analysis of Oils.—The analysis of oils requires great care and manipulative skill, and results can be determined with sufficient accuracy only by persons who have been specially trained in this class of work. The fact that many kinds of oils are very similar as chemical compounds, but very different as regards commercial value, renders analysis very difficult. In addition, many samples of the same oil are found to vary. As oils vary greatly in commercial value, adulteration is carried to considerable lengths; for example, olive oil is very frequently adulterated with the cheaper cotton-seed oil. Oils of the same kind vary according to where produced, process of manufacture and purification, and so on; and it is advisable to stock samples of oil that are known to be good and which have proved eminently satisfactory for purposes of comparison. The following are a few good simple tests that will be of use to the practical man, and which do not need great skill to carry out. By their use a good opinion can be formed of the lubricating qualities of any oil.

It is important that wool oils shall contain the minimum of free mineral acid, since if they contain a large amount of sulphuric acid, as is often the case with recovered oils, the oil will have a bad effect on the material, and will pit the wire of the card clothing, and eventually make it quite unfit for use. In this connection it will not be out of place to note that animal oils when first prepared, and the highest grade vegetable oils, contain very little free fatty acid; but on being kept and exposed to the air the amount of free fatty acid rapidly increases, the result being that the oil becomes rancid. As a general rule low-grade vegetable oils contain a large quantity of free fatty acid, in some cases containing as much as 40 per cent.

One method of detecting the presence of acid is by the hydrometer, since the oil becomes heavier as the amount of acid it contains increases; consequently some idea of the amount of acid the oil contains, if any, can be gained from the amount of variation from what may be termed the standard or constant specific gravity. The specific gravity of olive oil is 0·916–0·919, and that of oleine is about 0·91. Another test for the presence of acid is the litmus paper test, in which blue litmus paper is turned red if the oil contains acid.

If it is required to estimate the amount of acid present, a more elaborate test is necessary. The principle of the test is as follows: Phenolphthalein, which is a very sensitive indicator, is used, and so long as the solution of oil is acid it remains colourless so far as the indicator is concerned; but when there is the slightest excess of alkali present, the solution becomes pink or reddish in colour. To obtain the quantity of acid present, a weighed quantity of oil must be taken, and the acid neutralised by the addition of a standard alkaline solution, and the amount of the alkaline solution in cubic centimetres required to neutralise the acid is multiplied by the weight of the acid that one cubic centimetre of the alkaline solution will neutralise.

If an oil is found to contain an appreciable quantity of free acid, it is important to be able to determine whether it is mineral or free fatty acid. This may be done by adding to a small sample of the oil a few drops of methyl-orange solution, which is an indicator, and then agitating by stirring or shaking. If mineral acid is present, the indicator will turn pink; but if the acid is a fatty acid, the indicator will not be affected.

The general method of testing for oxidation is to pour a little of the oil on to a watch-glass and expose it to the air in such a way as to protect it from dirt and dust. By comparing it with an oil of known quality its suitability in this respect can be readily gauged.

A test by which the general lubricating qualities of an oil can be determined is to mix about equal parts of a solution of soda-ash registering between 4° and 5° Tw., and the oil. Then shake or stir vigorously, when a milky solution is formed, and if oily drops or globules do not appear on the surface, it is an indication that the oil is suitable, since it has good saponifying qualities.

It is often desired to find the quantity of oil that has been applied to wool or yarn. This may be done by taking a carefully weighed sample and drying it in a conditioning oven until it ceases to lose weight. The loss in weight must be carefully noted. It is then washed thoroughly in soft soapy water, and dried again until it ceases to lose weight. The sample is now weighed, and the weight of oil that has been applied is the difference between last dry weight and the weight after the moisture was driven off.

The test which is necessary to reclaim the oil from an oiled sample so as to test subsequently for quality of oil in addition to obtaining quantity, is too elaborate for general use. But the principle of the test is to saturate a sample of the material with pure ether a sufficient number of times to dissolve all the fatty, oily, or greasy matters which are deposited in a flask. The ether in this flask is then vaporised, leaving the fat or oil intact in the flask. The flask having been weighed when clean and dry prior to being used, is again weighed, and the difference between the two weights represents the weight of the oily matters.

The difficulties of testing oils have already been referred to; but it must be further emphasised that an accurate and reliable analysis can only be made by one who is an expert in this class of work. However, the above tests will be useful, and will enable the practical man to gain an approximate idea regarding the quality of oil he is using.

Application of Oil.—The most largely used method of applying the oil to the material is where each layer is sprinkled with the proper proportion of oil during blending, and each layer is beaten with a pole so as to get the oil well and evenly worked into the wool. The sprinkling is done with an ordinary garden watering-can of suitable size, which has a T-shaped end to the spout, in which are several rows of holes. In some mills it is done with an ordinary can, which in some parts is called a " piggin " ; but this method is not nearly so efficient as the watering-can, since it is very important that the oil should be distributed as evenly as possible, and with the former method over-oiling of some parts and under-oiling of other parts of the blend are much more likely to occur. After each of the layers has been oiled and the pile completed, the material is run through the willey a sufficient number of times, or the willey and fearnought, as explained with regard to blending. It is a good plan to let the material stand over-night before being carded, so as to allow the blend to mellow. In wool and cotton, and wool and silk, blends, the wool must be oiled separately and passed through the willey so as to get the oil well incorporated before the pile is made in which layers of cotton or silk occur, since no oil must be applied to these materials. Moreover, it is advisable to card such blends as soon as possible after passing through the mixing machines.

Mechanical Oiling.—Mechanical oiling is gradually becoming more general in cases where the materials forming the blend may be oiled indiscriminately. The appliance is generally attached so as to oil the materials as they pass on the feed lattice of the fearnought. Oiling at the scribbler has been tried, but the oil is not incorporated in the material so thoroughly as when it is applied as the pile is being made; consequently it will be clear that it is not advisable to oil the material as it is being fed to the scribbler. Mechanical oiling is preferable to hand oiling, as the oil is distributed better. By the latter method the oil is sprinkled only on the top of each layer, which may be as much as 8 to 10 in. thick, and hence the bottoms of the layers receive no oil except from the top. But in mechanical oiling, as the material is fed very thinly on the feed lattice of the fearnought, each fibre is more nearly sprayed with its share of oil.

Mechanical oilers are made in many forms, but may be divided into two general classes—viz., brush and scraper oilers. The former have the disadvantages that they are expensive as regards brushes, which wear out fairly quickly, and require frequent re-setting to get even oiling as the bristles wear down; also the area over which the oil is sprayed is not easily controlled. But they have the advantage that the oil is much more finely distributed than in the case of the scraper type. Whether the scraper or brush type is used, the supply of oil or emulsion is carried by a tank, usually supported above the machine. In some cases two tanks are provided, one containing the oil and the other the water and emulsifier, and a pipe from each of these conducts the contents to a tank which extends the full width of the machine. This latter tank supports the bearings for the brush, when a brush is used, the surface of which is set to touch the oil or a roller that serves to bring up a thin film of oil. In either case the brush collects the oil on the tips of the bristles and carries it forward until the bristles make contact with a thin steel plate or blade which deflects them, and on leaving contact with the blade they cause the oil to be sprayed on the wool as it is passed underneath.

It is important that the oil or emulsion should be kept at one constant level in the tank carrying the brush, so that the roller or brush will take up a constant supply of oil at all times. To accomplish this object an ordinary float mechanism is provided to regulate the supply from the main supply or tanks. There are several kinds of scraper oiling mechanisms, but the principle is the same in all cases. One common form is where the tank from which the oil is taken is arranged to support a smooth roller that is as long as the width of the feed lattice, and set to project the desired distance into the oil. Hence, as it revolves it carries up a layer of oil or emulsion which is pressed into a thin film by a roller of similar dimensions resting on it. After the oil leaves the nip of the rollers it is removed by means of a scraper, which rests against the front of the bottom roller, and drips from the scraper on to the material.

A disadvantage of all mechanical oilers is that the amount of oil taken up by the brush or roller is affected by variations in temperature, since when the temperature is high the oil is thinner than when the temperature is low, and the thicker the oil the greater is the amount that is taken up and distributed on the material. It is consequently important that there should be as little variation as regards temperature as possible. To minimise the effect of variation in temperature in the case of scraper oilers, instead of having the scraper all in one piece it is arranged to consist of several smaller ones, each of which can be turned away from the roller as desired, according to the amount of oil it is required to supply to the material. Several firms of machinists make a special kind of mechanism for oiling, but they are in the main only a more elaborate form or development of those already briefly described.

CHAPTER XI

PRINCIPLES OF WOOLLEN CARDING, CARD CLOTHING, NAILING, GRINDING

INTRODUCTION.—All carding, whether worsted, cotton, or woollen, has for its object the opening, combing, and cleaning of the material, which is done by submitting it to the action of a very large number of wire teeth. In all systems of carding the principal opening is effected by two series of teeth which are set very close together and are almost always moving in the same direction when opening is being done, but at different speeds. Also at all points where opening takes place the points of one set of teeth are working against the points of the other set, though they do not actually make contact. The objects of all systems of carding are to disentangle the clusters of fibres and yet preserve the length of staple as much as possible; to remove as completely as possible all extraneous impurities such as seeds and similar vegetable matter in various forms; to effect a perfect mixing of the materials irrespective of their character; and to rearrange the fibres in a web of uniform density. The difference between woollen, worsted, and cotton carding is that in the two latter the object is to dispose the fibres so that subsequent parallelisation is rendered easy, while in woollen carding the object is to blend the fibres so that they will point in all directions, and everything possible is done to accomplish this object. Instead of drawing the sliver from the scribbler and intermediate straight through a trumpet as in worsted and cotton carding, which tends to dispose the fibres parallel, it is drawn from the side so as further to blend the fibres and neutralise as much as possible any parallelising which may have been done by the card.

Attached to the delivery end of the carder in woollen carding is the condenser, the purpose of which is to form the web of material from the last doffer into ribbons and then rub them into rovings, a process which refers to tape condensers. When ring condensers are used, the doffer or doffers which are covered with rings of card clothing take the material from the last swift of the carder, and each ring produces one ribbon; these are stripped and passed into the condenser to be rubbed into rovings. It will thus be seen that though, strictly speaking, carding ends before the roving is made, the formation of the roving may be said to be included in the operation of carding. Consequently, a distinct object of woollen carding is the formation of condensed threads or rovings of equal weight yard for yard, and even in diameter throughout their length.

PRINCIPLE OF CARDING.—Actual carding is a constant repetition of working and stripping. Working takes place where the teeth work point against point, which is when the teeth of the swift travelling at a great speed bring the material into contact with the teeth of the slowly retiring workers and doffers. Where the teeth work point against smooth side, or the back of the teeth on other parts, stripping takes place; this occurs in the case of strippers and workers, the former clearing the latter; also in the case of the swift and strippers, where the former clears the latter. There is another notable action which takes place, where the teeth work back or smooth side against back or smooth side, as in the case of the fancy and swift. The object of this action is not to remove the material and transfer it to any other roller, but to raise it to the tips of the teeth of the swift so as to facilitate the depositing of it on the doffer.

Working and stripping have been referred to previously in connection with a description of the action of the fearnought; but in the fearnought the stripper is placed on the opposite side of the worker. The above principles will be made clearer by an explanation of the passage of the material through one part. A complete set of carding machines is composed of a number of parts which are exactly similar in principle; but the number varies according to the work for which the set of machines is intended. Each part consists of a swift or large cylinder with from three to five sets of workers and strippers, together with the fancy and doffer.

PASSAGE OF MATERIAL THROUGH MACHINES.—A diagrammatic section, drawn to the scale of one inch to two feet, of the first and second parts and their complement of rollers, is shown in Fig. 42.

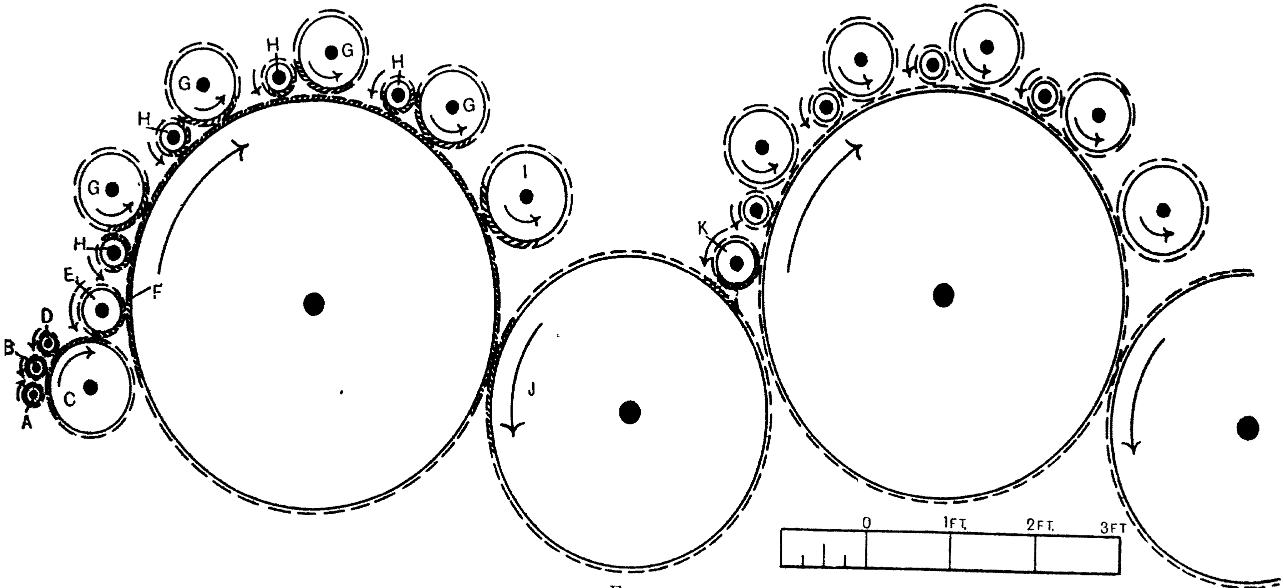


FIG. 42.

It will be noticed that the first or breast swift is set lower than the second or first ordinary swift; this is possible, as the licker-in does not stand as high as the doffers. Also there are four pairs or sets of workers and strippers over it. The wool is carried through the machine and acted upon by the various rollers in the following manner: After being fed on to the feed lattice by automatic hopper feed, it is carried to the feed rollers A and B, which are covered with leather fillet clothing about $\frac{3}{4}$ in. wide, or Garnett wire, the teeth of which point in the direction indicated. In Fig. 42 the actual shape of the teeth is not shown, as it is intended at this juncture only to show the direction in which the teeth point, direction of rotation, and relative sizes and positions of the different rollers.

The feed rollers are 2 to 3 in. in diameter, and are made from iron. As the material emerges, it is acted upon by the teeth of the licker-in C; this roller has a much greater surface speed, and consequently an important combing and opening takes place. The licker-in is made of iron, and is covered with fillet or Garnett wire. A large number of the licker-in teeth pass through the fringe of material before it is released by the feed rollers; hence much opening of the matted portions is done at this point, since the teeth of the licker-in are constantly pulling at the fibres and drawing them out. Also, as the teeth of the feed rollers are revolving back first, the free end of the material is combed by the licker-in; and when the latter roller takes the fibres, the opposite ends are drawn, to a certain extent, through the teeth of the feed rollers.

The licker-in, in moving upwards, tends to comb the material over the top feed roller; consequently this roller would, if no other provision were made, carry much of the material round with it. A stripper D, often termed the top feed roller, working point against backs of the teeth on the top feed roller B, effectively removes any material going round on the surface of the latter, and the former is in turn stripped by the licker-in, the teeth of which work point against smooth side of the stripper. Moreover, the licker-in having a much greater surface speed, whips the material from it. The size of the feed rollers and licker-in should be carefully considered and regulated in accordance with the length of staple of the material to be carded, so as to obtain a regular detachment of material from the feed rollers. If the sizes are not suitable, detaching is irregular, and the material is plucked in large tufts instead of being taken evenly and continuously by the licker-in, which results in an excessive amount of droppings at this point, and uneven roving. It also causes swift and workers to have to do opening that should have been done by the licker-in and feed rollers, which is very detrimental to the wires of the first-mentioned parts.

The licker-in conveys the material forward to the angle stripper E, which has a greater surface speed than the licker-in, and strips the latter and transfers the material to the swift. The angle stripper is made of iron, and its diameter is usually from 5 to 7 in. Its surface is covered with clothing set with ordinary card wire. Almost immediately after the angle stripper has stripped the licker-in, it is itself stripped by the swift or cylinder F, the surface speed of which is three to four times that of the angle stripper, and its teeth work point against smooth side of the stripper. Each swift is 50 or 52 in. in diameter, except the breast swift, which may be anything from 30 to 50 in.; they are made in three ways—viz., from wood lags, from wood blocks or segments, or wholly of iron. The function of the swift is twofold. It acts both as a conveying roller and as a working roller. The swift carries the partially opened material on its surface into working contact with the slowly receding teeth of the first worker G. It will be noticed that the teeth of the swift and the worker operate point against point; and as the material projecting from, but held by, the teeth of the swift is brought into contact with the teeth of the worker, it must be opened, since the quickly moving teeth of the swift will retain a hold on a portion of the material, while the teeth of the worker on which the material has been impaled will carry round a portion. The material on the surface of the worker is carried round by it until it reaches the stripper H, which, revolving in the direction indicated, and at a much greater surface speed, carries the material back to the swift, and is in turn stripped by it.

As the stripper is on the side of the worker nearest the feed end of the machine, the material taken from the worker is again conveyed by the swift to the same worker, to be again acted upon until the material is sufficiently opened. Since the workers retain some of the material brought to them by the swift, it is impossible for the material retained to reach the position in the blend that it had when fed to the licker-in; hence they are in addition an effective means of mixing the material. The strippers are generally from 4 to 5 in. in diameter, and are constructed of both wood and iron; though the latter are most common. The same system of working and stripping as just explained obtains until all the workers and strippers are passed.

By the time the material reaches the last pair of workers and strippers on each part, it has become so far embedded in the teeth of the swift, due to its having been well opened, as to make it necessary for some means to be adopted to raise it to the tips of the teeth in order that the swift may be cleared. The means adopted is the fancy I, which is generally a wood roller about 12 to 14 in. in diameter, and clothed with special clothing, the teeth of which are long and brush-like. To be effective, the teeth of the fancy must be set from $\frac{1}{16}$ to $\frac{1}{8}$ in. into those of the swift, and it must revolve at a slightly greater speed in the direction indicated by the arrow, with the backs of the teeth of the fancy working against the backs of the swift teeth.

The swift with the material on the tips of its teeth and projecting therefrom deposits it on the doffer J in a condensed condition, since the material on about 20 sq. in. of the swift is deposited on about 1 sq. in. of the doffer. Obviously, the amount of condensation which takes place is governed by the relative surface speeds of doffer and swift. Transference of the material is facilitated by the swift and doffer being set closer to each other than any other two rollers. The teeth are as fine as, or finer than, those of any other roller on each part, and they are also kept very sharp, as it is of the greatest importance that the swift should be thoroughly cleared before it passes round to repeat the operation. The doffer is generally about 40 in. in diameter, and may be built from either wood or iron. As the doffer revolves, it brings the material round to the second angle stripper K, which acts in relation to the doffer J in precisely the same way that the first angle stripper E acts in relation to the licker-in.

The second part acts on the material in precisely the same way as the first part, and when the material reaches the last doffer on the scribbler and intermediate, it is stripped or doffed by a doffing comb; while the last doffer or doffers of the carder are generally stripped by a condenser stripper. The only difference between successive parts is in the fineness or gauge of the wire; the counts and crown or setting of the wire; setting of rollers one to another; and speeds. As the material progresses towards the condenser at the end of the carder, the clothing on the rollers is in all respects finer, and the settings closer. The object is, of course, to open the material gradually and more thoroughly, until by the time it reaches the last doffer or doffers of the carder it is thoroughly opened and cleaned, and ready for making into roving.

CONSTRUCTION.—Carding machinery should be constructed in the best possible manner, absolutely true, and all adjustable parts capable of very accurate adjustment. The importance of this will be clear when it is remembered that the parts must be set to within $\frac{1}{150}$th part of an inch from one another. Formerly all the rollers were made from wood in the form of lags placed transversely, and built up round a central shaft. The lags are $2\frac{1}{2}$ in. deep or thick, $4\frac{1}{2}$ in. wide, and as long as the roller; they are bolted to the rim of five eight-armed spiders which are evenly distributed on, and securely fixed to, the central shaft by keys, four keys being used for each spider. The heads of the bolts are sunk well below the surface of the lags, and plugs fitted over the bolt heads. To afford ample facilities for bolting the lags, notches about 2 in. pitch are provided all round the rim of each spider. Small strippers are solid, and are built from lags fixed to a square central shaft. It was found, however, that wood when used in the above manner would not retain its truthfulness, the changes in temperature and humidity causing it to warp and bend, and this prevented accurate setting.

Rollers made from lags are, however, very common, but have not been made to any appreciable extent for many years. They do sufficiently good work when made from well-seasoned wood and when not subjected to great changes as regards temperature. It might be noted that red cedar is the best wood to use, especially so since the tacks hold best in this kind of wood. Rollers made from blocks or segments of wood have been introduced in order to overcome the disadvantages of rollers made from lags. It is quite probable that out of every ten new machines now being made, nine are built from wood blocks. A roller made from blocks is, if anything, lighter than one made from lags, and there is not anything approaching the same tendency to warp and bend out of shape. Segment swifts and rollers are similar in appearance to an ordinary brick wall, the blocks being about 5 in. long, 2 in. wide, and 3 in. thick, and in the best makes they are bolted to the rims or hoops of the spiders at all possible points, while in other cases stays are let in. The blocks are nailed and glued together.

Cast-iron cylinders and doffers are now fairly extensively used, especially for work which is free from hard lumps that are liable to break or tear the card clothing, and the best form is where the shell is made in one piece. The whole is bolted to spiders which are in turn suitably fixed to the central shaft. Since in the case of cylinders the roller is intended to rotate at a high speed, it is accurately balanced so as to obtain steady running, and as nearly as possible eliminate vibration. The surfaces on which the card clothing has to be nailed are carefully trued up, so that in the initial grinding of the clothing some parts will not require to be ground much more than others, and so cause the height from knee to point of tooth to vary in different parts, which is bad. Iron swifts being heavier than those made from wood, are more difficult to start, though the actual power required to run an iron swift is probably not much more than is required to run a wooden one.

Card Clothing.—Card clothing consists of wire teeth automatically inserted in a suitable foundation composed of leather, or of several layers of cloth, most of which are made wholly from cotton. The teeth are made from a reel of wire, and for each tooth the wire is first bent into the form of a staple, which is U-shaped. When the tooth has been formed it is pushed through the holes in the foundation, these holes having been made previously by means of a pricker. While the holes are being made, the fillet is held at the correct angle in relation to the pricker, so that when the tooth is forced home it will leave the foundation at a certain predetermined angle. As soon as the tooth is fixed in position the points are gripped, drawn forward the required distance, and bent over a sufficiently sharp surface, which is so placed that the knee or bend will be formed at the correct point.

The requisite qualities of a good foundation are that it should be sufficiently strong to enable it to be securely fixed to the rollers, so that there will be no danger of its rising in places during actual working; it should hold the teeth in their proper working position; and it should be sufficiently elastic to assist the teeth to regain their normal position after the strain of opening the material, so that the whole of the strain of the carding is not borne by the wire, since the effect of this latter would be to cause the wire to become loose in the foundation, or break out when abnormal strain occurred during carding. If clothing rises in places during carding, which fault is most likely to occur in the case of a swift carding too coarse work, it results in the teeth not being held up to their work properly, and, instead of carding, the teeth have more of a brush-like action. Moreover, the teeth are liable to come in contact with other parts of the card which they should not touch, and hence wear off the point of swift and workers, or the teeth may be turned back. In any case, the result will be inferior carding action.

For the covering of feed-rollers and lickers-in, Garnett wire is sometimes used, but generally clothing with a leather foundation is used for this purpose. The leather used is generally from $\frac{1}{8}$ to $\frac{3}{16}$ in. thick; while for the finest work it is made from best calf, and is only about $\frac{1}{16}$ in. thick. When compared with fillet clothing, a leather foundation is more expensive, but on the whole is more durable, though it is not so even as regards firmness, elasticity, or thickness; also, the wire, due to the strain involved in carding, wears holes in the foundation, and becomes loose much sooner than in the case of fillet, which militates against good carding. The principal reasons for the continued use of leather are its firmness, durability, and strength; but even these advantages have the corresponding disadvantage that the work of carding is thrown on to the wire instead of much of the strain being borne by the foundation. Also, leather resists the action of the oil or emulsion which has been used in oiling the blend, much more successfully than a foundation made from cloth. Leather foundation is used in the form of sheets which are from $4\frac{1}{2}$ to $5\frac{1}{2}$ in. in width, and extending the length of the roller to be covered. The standard width of the sheets may be taken to be about 5 in.

The foundation of fillet clothing consists of several layers of cloth, that are generally cemented, but which may be stitched together. The cloths are commonly made from cotton alone, although very frequently one of the layers of cloth is made from linen or from a linen warp and cotton weft, the object of the linen being to give strength and firmness. In other cases one of the layers may be a woollen cloth, or cloth made from cotton warp and woollen weft. The object of the woollen is to give strength and firmness, and at the same time the required amount of elasticity. Fillet clothing is made in very long lengths, and the standard width is 1 in. for swifts and 2 in. for doffers, though it is made in widths varying from about 1 to 2½ in. The layers are generally bound together by means of a solution of rubber or glue, the latter being the cheaper.

The work of binding the layers together should be done so efficiently as to preclude all danger of the layers parting from each other, and the elasticity of the foundation should be retained until the clothing is worn out. The top layer—that is, the layer nearest the points of the wire—should consist of vulcanised rubber so as to protect the cloth as much as possible from the effects of dampness and oil, and prevent the rusting of the wire which is in and on the back of the foundation. By having the top layer of rubber, several advantages accrue, the chief of which is that it increases the elasticity or freedom of the tooth, since it increases the yielding powers of the clothing. This tends to prevent the wire bending at the point where it leaves the foundation or at the knee, and becoming what is colloquially termed " back-broken." It also reduces the amount of breakage of the wire, which is liable to occur when excessive strain is on it during carding; also there is less likelihood of large holes being worn in the foundation. The vulcanised rubber is crude rubber treated with sulphur at a high temperature, and it is important that the minimum of free sulphur should be allowed to be present, since it has a deteriorating effect on both the rubber itself and the wire.

If the cloths are stitched together they are not so liable to separate and cause the wire to be less effective. Stitching, however, is not often done. The cheaper kinds of fillet are not provided with a rubber face, as it adds very materially to the cost. Card clothing used on machines made on the Continental pattern has generally a thicker foundation than that which is commonly applied to machines of British pattern. Moreover, on the top layer is a kind of woollen felt which extends almost to the bend of the wire, and except on the best kinds there is no layer of rubber between the felt and the top layer of the cloth. A fairly typical fillet foundation for general purposes, commencing with the bottom layer, consists of four or five layers of cotton cloth, and finally a layer of rubber. There may be as many as seven layers of cloth, which is generally 2-and-2 twill, though 2-and-1 twill and plain cloth are used, or there may be as few as three layers.

WIRE.—The material used for the teeth varies from mild steel to specially hardened and tempered steel wire; the latter is much favoured, especially for fine work. In some instances it is also tinned to render it less liable to rust or pit, due to the presence of acid and water in the oil, or emulsion, used for oiling blends. It is, however, much more common for tinning to be done in the case of card clothing for worsted cards, especially at the feed end of the card. The requirements of wire for carding are that, after suitable preparation, it should retain its working condition as long as possible. It should not be so brittle as readily to break out when carding is being done, and it should not be so soft as to be turned back. The hardened and tempered steel wire has the advantage that it is less liable to be damaged in the grinding. It also makes a springy, elastic tooth, and a finer and more efficient carding point can be produced than in the case of mild-steel wire; and since the teeth retain a good carding point the maximum length of time, it is clear that this kind of wire most nearly fulfils the requirements. With a view to obtaining high production combined with quality of product, it is certainly advisable to use hardened and tempered steel wire.

The shape of the wire is an important matter, and for all the rollers except the opening rollers—that is, the feed rollers and licker-in—round wire is generally used. For the opening rollers, except where Garnett wire is used, wire which is practically oval in section cut to a diamond point and sharpened is largely used owing to its strength. Round wire has the important advantage that it is less liable than any other shape to enlarge the holes in the foundation during carding, which defect necessarily militates against good work being done, since the teeth will not be held up to their work.

ANGLE OF SETTING.—The angle of setting—that is, the angle at which it leaves the foundation—is very important, since in conjunction with the angle formed at the bend or knee it governs the carding action of the tooth. The angle of setting varies from about 62° to 70°, and is less for coarse counts than for fine.

With regard to the angle made at the bend, this should be such that when the teeth have been ground and got into working condition, the points ought not to be more than 5° beyond a vertical line drawn from the point where the tooth emerges from the foundation. There are two reasons why the above setting should obtain. The most important of these is that, when the strain of carding is on, the foundation holding the teeth firmly, but being sufficiently elastic, allows the points of the teeth to be forced back, and in moving back, the points move in the arc of a circle; consequently, if they are set too far forward they rise to a slightly higher position and make the setting appreciably closer. If the teeth are correct, the tendency is for the setting to become opener instead of closer; and if the points project only about 5° beyond the vertical line, any movement will be very nearly in the same plane, and will not interfere appreciably with the accuracy of the setting. A minor reason is that when the inclination of the tooth is too far forward, the surface grinding tends to cause the teeth to have a too drastic action during carding. If the point comes much too far forward when it rises as it is being moved back during carding, the working condition will be completely spoilt owing to making contact with other parts, and in addition it will have a similar effect on parts with which it works point against point.

The teeth in the case of card clothing applied to machines of Continental pattern are not commonly made as above, since the points project much beyond a vertical line extending from the surface of the top layer of foundation; and as a matter of fact they extend much beyond a vertical line extending from the front of the crown of tooth. The angle of setting is also much nearer at right angles to the foundation. Also, the length of the tooth from point to bend in relation to the length from bend to crown is from 3 of the former to 4 of the latter, to 1 of the former to 2 of the latter; while in the case of machines of British pattern the lengths of wire above and below the knee are about the same.

The reason why it is possible to have the teeth made and set on machines of Continental pattern as described, and at the same time maintain accurate setting and obtain very good results, is no doubt due to the fact that the teeth are less pliable and springy, and will retain the position in which they are set when the clothing is manufactured, under carding conditions. As the whole surface of the wire is firmer, closer settings can be practised with safety and great accuracy, and as the teeth have also great retaining or hooking power owing to the setting and shape, the production of the cards is great, and the product well carded. A set of machines is composed of fewer swifts than is the case with a corresponding set of British pattern. The keenness of the tooth—that is, its retaining power—is influenced considerably by the angle of setting. The less the angle between the tooth and foundation, and assuming the angle of bend is such as to bring the point just beyond a vertical line extending from the point to where the tooth enters the foundation, the keener the tooth. It might also be noted that the lower the bend, the less the carding efficiency and more brush-like is the action of the teeth; and the higher the bend, the greater is the retentive power and carding efficiency, but the shorter the life of the clothing.

FANCY CLOTHING.—As the function of the fancy is solely to prepare the material for the doffer, and it is not required to do any working or stripping, it is provided with special clothing quite different in character from that found on any other roller of the carding machine. The foundation of the clothing is generally leather in the form of sheets. Fillet is used occasionally, but for most classes of work it is not nearly so satisfactory, owing to the amount of fly caused. As the teeth of the fancy must have a brushing action, they are made much longer than those on the swift. The length of the tooth from the crown to the point in the former case is from $\frac{3}{4}$ to 1 in., while in the latter case it is about $\frac{1}{2}$ in. Fancies provided with clothing having the longer teeth are employed on the scribbler, while fancies with the shorter teeth are used on the carder. The reason for this arrangement is that a fancy with long springy teeth has a greater tendency to cause the material to fly, and the flyings always settle toward the centre of the machine. In the case of the scribbler this produces no notable defect, since the material is levelled at the intermediate feed; but in the case of the carder it has the effect of causing the rovings or threads produced at the centre of the condenser to be heavier and of a coarser count than those from the sides.

The clothing of all the rollers of the card for certain classes of work is almost standardised as regards diameter of wire, points per square foot of clothing, etc., with the exception of the fancy. The teeth in fancy clothing are generally set in either twill or plain order. There is, however, one great objection to setting the teeth in the plain order for the fancy, which is that the teeth are apt to wear in ridges or rows by the points coming together in pairs. When this defect occurs, the appearance of the teeth is as shown in Fig. 43, instead of occupying their correct position as shown in Fig. 44. Since the teeth in the case of a fancy provided with twill set clothing retain their correct position, this kind of clothing is preferred.

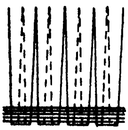


FIG. 43.

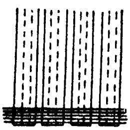


FIG. 44.

FANCY WIRE.—The teeth of the fancy are not set as close together as those on the swift, as they are set to project below the surface of the teeth of the swift as much as $\frac{1}{8}$ in. The number of points per square inch on the fancy is always less than half the number of points per square inch on the swift. A fancy which is too full of wire is of little use, since, instead of the teeth of the fancy entering those of the swift and lifting the material to their tips, they have a tendency to roll on the teeth of the swift and press the material farther in. When the teeth of the fancy are working correctly they help to keep the wires on the swift in a forward position with a keen working angle, and thus neutralise the tendency of the material as it passes through the card to pull the teeth back as it is carded between the swift, each of the workers, and the doffer. Another important matter in connection with the wire of the fancy is that it should be approximately the same thickness as the wire of the swift. For instance, a swift having clothing 100's count 10 crown, which would give 400 points per sq. in., would be made with wire of about 28's or 29's gauge, and running in conjunction with it would be a fancy clothed with 60's count 6 crown clothing, which would give 144 points per sq. in., and the wire should also be 28's or 29's gauge, and not 24's, which is the usual gauge of wire for 60's count 6 crown swift clothing.

Much experimenting has been done with fancies—certainly more than has been done with any other roller—and many forms of wire have been tried. Generally, however, the bend is at the same height above the foundation as in the case of clothing on other rollers, and the extra length of the tooth is all above the knee, as shown in Fig. 45. Clothing provided with this kind of wire is firm but elastic, and the foundation takes up part of the work. Straight-wired clothing has been tried on the fancy—that is, wire without a bend or knee, as shown in Fig. 46; but they are quite unsuitable for carding dirty or low blends, or where the production is high. There is a distinct tendency for the teeth to flatten down in working, since they have no support when acting against the teeth of the swift.

Another kind of tooth which may be used is that which is made with two bends. In this case the point is in the same direction as

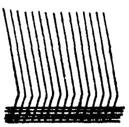


FIG. 45.

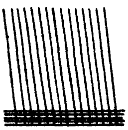


FIG. 46.

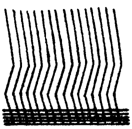


FIG. 47.

that in which the wire leaves the foundation, as shown in Fig. 47. Clothing of this kind is very efficient; but as the wire cannot be worn quite to the bend, it follows that the life of the clothing is much shorter than the ordinary kind shown in Fig. 45. It must be noted that the fancy should not be run after the teeth have worn down until the distance from the bend to the point is the same as or less than that of the wire on other rollers of the card. If the teeth become worn down too short their action is very inefficient, and their effect on the cylinder clothing is bad. Moreover, partially worn clothing can be removed and nailed on one of the angle strippers until it wears so low as to be quite unfit for use. When running on dirty blends the wires of the fancy tend to become coated with grease, but the fancy then is not as efficient as one less greasy, and the practice of running it in a greasy condition cannot usually be recommended, although in some special cases where flyings are very detrimental, the fancy is deliberately run slower to permit coating of the wires with grease with a view to reducing flyings.

INSERTION OF CARD TEETH.—The order in which the teeth are inserted in the foundation is not the same for all kinds of card clothing. In the case of leather sheets the teeth are set either in plain or twill order. The plain order of setting, as the name denotes, is that in which the teeth are set alternately as shown in Fig. 48, which shows the crown of the wires behind the foundation. At

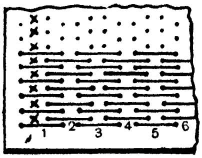


FIG. 48.

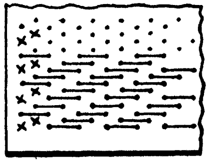


FIG. 49.

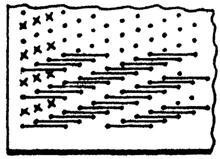


FIG. 50.

the ends of each crown is a dot representing the point which is approximately vertically over it. Fig. 49 shows the double-twill, while Fig. 50 shows the treble-twill, order of setting. By far the most generally used is the plain order. Twill-set sheet clothing is used for fancies, and also for the finer counts of card clothing, say 120's counts and upwards. The treble-twill set clothing is used for finer counts than the double-twill set. It might be noted that modified and reversed twill settings have been tried for fancies, one form being where the twill is arranged in the form of a herring-bone pattern.

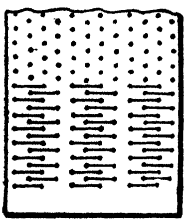


FIG. 51.

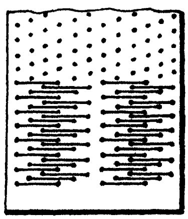


FIG. 52.

None of the patterns or orders of setting already explained can be used for fillet, as it will be noticed that along the width of the sheet at the edge there are several points missing, which are indicated by a ×. In the case of sheets the missing points are of little importance, but with fillet it is absolutely necessary to have the wire as close at the edges where they join as in the body of the fillet in order to cover the roller completely. The setting used for fillet is invariably the ribbed order as shown in Figs. 51 and 52. For coarse clothing the double-ribbed order of setting is general;

while for finer counts the treble-ribbed order is usual. The row of points near the edges are half the distance from the edge of the fillet that is between each rib, so that when the turns of fillet come together the points are evenly distributed and continuous over the whole surface.

COUNTING CARD CLOTHING.—There are three specifications which deal with the insertion of teeth in the manufacture of card clothing. These refer to the number of points horizontally and vertically per unit length, and the thickness of the wire. With the exception of the fancy, this latter detail is approximately standardised, as all card-clothing manufacturers supply cards with a definite thickness of wire within one or two gauge numbers for regular counts of clothing. The method of counting the card clothing vertically is based on the number of points in one row across the width of a 5 in. sheet, which is the standard width. When the clothing is ordered, the roller to be clothed is measured, and the number of sheets ordered is that complete number which will give a width of sheet nearest to 5 in. in width and completely cover the roller. Fillet is counted the same as sheets—that is, the number of points lengthwise of the fillet in 5 in. is taken as the base, and this is known as the count, the count being referred to as 50's count, 80's count, etc., which means 50, 80, and so on points in 5 in. in each case. The number of points per inch is easily found by dividing the number in 5 in. by 5; hence, in 50's counts there are 10 points per inch. It might be noted that the count is generally made to advance in fives, or one tooth per 1 in., as 70's, 75's, 80's, and so on, and card clothing of such counts as 72's and 88's is not made, so that the number of points per inch is always a whole number.

The counting in the opposite or horizontal direction is not based directly on the number of points in a row, but on the number of crowns. To get the dimension of clothing termed crown it is necessary to count all the crowns that come between any two consecutive points that are counted when obtaining the counts. Calculating the crown of plain set clothing will be clear from Fig. 48. Assuming that there are 3 crowns per inch in the first horizontal row, numbered 1, 3, and 5, there will also be 3 crowns per inch in the second horizontal row, these being numbered 2, 4, and 6. In obtaining the crown both the first and second rows must be included, since they come between two consecutive points which are reckoned when calculating the count. Consequently, in this example the crown is 6.

When calculating the crown the number of rows in a repeat of the pattern in the case of plain and double-rib set clothing is two, as is shown in Figs. 48 and 51, but in the case of treble-rib there are three rows to a pattern. From the above it will be clear that the crown in the examples of fillet given in Figs. 51 and 52, assuming that the fillet is one inch wide, will be six in each case, since there are three ribs to the inch in the double-rib, and two ribs to the inch of the treble-rib. It is often advisable for purposes of comparison to find the number of points per square inch. To obtain this dimension it is necessary to multiply the crown by two, as there are two points to each crown. Thus a 10-crown card has $10 \times 2 = 20$ points per inch horizontally, and if the count is 100's there are $\frac{100}{5} = 20$ points per inch vertically; hence the points per square inch are $20 \times 20 = 400$.

Card clothing of the coarser counts is generally made *square*—that is, with about the same number of points each way; but as they get finer the wires horizontally are reduced slightly. Thus a range of cards might be 60 count 6 crown, 80–8, 100–9, 120–10, and 130–10. The reason is that the wire of the fancy in working has a freer and easier entrance into the teeth of the swift, since it makes only horizontal contact along or with the swift. Fillet is limited in the crown that it can be made in for a certain width. For instance, there is no 5-crown fillet, as the crown of fillet must always be in multiples of 2 or 3 for any given width, so as to make complete ribs. Thus, 4, 6, 8, or 10 crown could each be made on the double-rib principle; while 6 and 9 crown would, for fillet one inch wide, be made with a treble-rib setting. It might be noted that if $1\frac{1}{2}$-in. fillet has 12 crowns in one repeat of its width, it is evidently 8-crown fillet; but in some cases it is more difficult to calculate exactly the crown of a sample of fillet. For instance, fine $\frac{3}{4}$-in. fillet for the condenser is often made with 8 crowns across its width, which is equal to $10\frac{2}{3}$-crown fillet. The thickness of the wire is made less as the count and crown increase. In the following table are given average dimensions of card clothing as commonly supplied by makers—

Count.	Crown.	Diameter of Wire (Standard Wire Gauge).
60	6	23 or 24
80	8	26
100	9	28
120	10	30
130	11	31
140	12	32
150	12·5	33

Variations from the average dimensions given in the table, however, often occur. General considerations with regard to the gauge and kind of wire it is advisable to use are that, if the wire is too fine, the card clothing is very inefficient; if the wire cannot keep its working angle—that is, the angle of inclination—it soon loses its carding power; and if the tooth is bent back during working it is said to be back-broken, and clothing with this defect is extremely wasteful. Other defects also occur if the wire is not suitable for the work it has to perform, and it is most essential that the wire should not be too weak. This is perhaps of greatest importance in the case of the swift, and particularly the breast swift, where most of the opening has to be done, and where in the case of low-class blends, hard lumps, such as bits of skin or rags, are encountered.

Measuring for Card Clothing.—Before the card clothing can be put on the rollers—and, in fact, very often before it can be made—the diameter of the rollers must be measured, and the size and number of sheets, or the length of the fillet, have to be calculated. Small rollers covered with fillet, such as strippers, are not measured, since fillet of various counts one inch in width is made in long lengths of from 600 ft. to 1000 ft., and supplied on large condenser bobbins or in boxes. The strippers are covered, or "lapped" from the bulk, and then it is cut off at the end when the operation is finished. Filleting for special rollers, or the larger ones, is made to order. The widths in general use are ½ in. for rollers up to 2½ in. diameter, such as the feed rollers; ¾ in. for condenser strippers, which are from 2½ to 4½ in. in diameter; 1 in. for ordinary strippers and angle strippers, that are from 4½ to 8 in. in diameter; 1½ in. for workers and lickers-in, which are from about 8 to 16 in. in diameter. Very often doffers up to 32 in. will have fillet 1½ in. wide, but fillet 2 in. wide is more general for doffers and swifts that are from 32 to 54 in. in diameter.

The length of fillet required is easily calculated from the length and diameter of the roller. When "lapped" by hand the length calculated from particulars just mentioned is sufficient, as the fillet cannot be made to be exactly in its own width; but where a machine is employed for covering the rollers, the fillet is mechanically forced into position, and an extra allowance must be made for the tapered ends that are necessary at the beginning and end of a roller. The simplest and best way is to base the calculation on the length of the roller plus the width of the fillet, which is equivalent to an extra round. *Example:* What length of fillet would be required to cover the back doffer of a 72 in. scribbler 40 in. in diameter, with fillet 2 in. wide? With the following formula, which can be used to find the length of fillet for any roller—viz.,

$$\frac{\text{Diameter of roller} \times 22}{7} \times \frac{\text{length of roller} + \text{width of fillet}}{12 \times \text{width of fillet}} = \text{length required in feet}$$

—the answer would be—

$$\frac{40 \times 22}{7} \times \frac{72 + 2}{12 \times 2} = 387\tfrac{13}{21} \text{ ft.}$$

In finding the number of sheets required by calculation, the space where the tacks are inserted for holding the sheets must be allowed for. This space is generally ½ in. wide, so that by assuming each sheet or row to be 5½ in. wide, full allowance is made for nailing. The circumference of the roller divided by 5½ to the nearest whole number will give the amount of rows.

The width and number of cards for iron rollers are determined by the rows of wooden pegs or plugs into which the tacks are driven that fix the cards to the roller. The cards are invariably narrower on iron rollers than wooden ones, the average width being 4½ to 4¾ in. on the wire. Thus, there are generally 31 rows on a swift 50 in. in diameter, and 21 rows on a doffer 36 in. in diameter. The actual circumference covered is found by subtracting the nailing spaces from the total circumference thus: $157 - 31 \times \frac{1}{2} = 141\frac{1}{2}$ in. to be covered. Consequently the width of each card on the wire is $\frac{141\frac{1}{2}}{31} = 4{\cdot}56$ in., practically $4\frac{5}{8}$ in.

Fixing Cards.—Fixing the cards is the process of nailing or tacking them to the rollers. Sometimes the manufacturer of the card clothing will arrange to have the cards delivered and nailed, but it is more general for the owner of the machines to do the work of nailing. The process of nailing in the case of new machines is slightly different from that in the case of old machines. Since card nailing is a distinct trade, and is invariably done by a journeyman nailer, only a brief description of the process will be given. By far the greater proportion of the carding machines employed in the woollen trade have the rollers made from wood; as a matter of fact, all-iron machines are very seldom made. The average carding overlooker has a decided preference for wooden rollers, as there is little possibility of the wire rusting out, the clothing beds better, and when the cards are torn, which occasionally happens, they can be firmly nailed down. One great drawback of wood rollers is that they do not retain their original circular shape quite as well as iron rollers; but in the case of a well-made swift (say, 50 in. in diameter) any change which is likely to take place is very slight. There is, however, always the danger that the wood may not have had sufficient seasoning, or that a bolt may work loose. In any case, it is always advisable to turn off a thin shaving before nailing the new cards on. It is a good plan to run new machines two or even three weeks before the final turning or truing is done, and during this period the ends of the cylinders are taken off to allow as free a circulation of air as possible in order that every opportunity will be given the wood to dry under working conditions. It is then ready for a final turning-up before nailing. Before putting on the ends, all the nuts which are in the inside are tested so that slack ones can be tightened.

When renailing machines a different course is adopted. The small rollers, such as workers, strippers, and fancies, are taken to what are termed the nailing-posts; but the doffers and swifts are too large, and it is often a difficult matter to provide working room for the nailer. The small top rollers are piled up out of the way, and very often the bends have to be removed; also, when the doffers are not too heavy, one of them can be lifted out to allow the nailer room to work at the swift. To nail a doffer on the scribbler it is a good plan to place it in the supports of the last doffer, and take away the doffing comb and side drawing to give sufficient working space. An alternative method is to slide the various rollers along the frame until sufficient room is obtained at the required position. This method is, however, only practicable where the frames are straight. It might be noted that as a general rule 2 ft. 6 in. to 3 ft. is necessary for comfortable working, although it is often difficult to obtain more than 2 ft. In the actual process of renailing, the first thing to be done is to knock off the old cards; and as these have a marketable value, they should not be torn more than is absolutely necessary. A wide chisel forced behind the leather will often drive the old tacks out and liberate the card, or a long screwdriver forced underneath the card will remove the tacks from the wood.

The nailing posts where the small rollers are treated consist simply of two parallel and almost vertical posts, each having a bracket to support the shafts of the rollers. The distance between the posts can be regulated so as to take various widths of rollers. To hold the rollers firm, a handle is employed which can be fastened to any thickness of shaft by means of four set-screws, and a ratchet-and-pawl arrangement allows the roller to have movement in one direction only. Filleting only requires the tacks at the end knocking out, after which it can be easily pulled off, as the tacks placed across the roller for security are often forced out as the fillet is being pulled off in the ordinary way. After the clothing has been removed, the roller should be examined for tacks that have pulled through the foundation of the clothing, and these should be knocked out in such a way as to do the minimum damage to the wood. If any of the tacks are left in they spoil the edge of the turning tool. For turning-up, an absolutely rigid bed or rest is required, which should be perfectly straight and smooth. With the grinding frame a bed is generally supplied which is about 7 ft. 6 in. long; this will accommodate a machine with rollers about 6 ft. long.

When turning up a swift or doffer, the rest is laid on the frame of the carding machine near the face of the roller to be turned, and set exactly parallel to it. The bed is about 2½ in. deep and 6 or 8 in. wide, and as the turning tool requires to be level or horizontal with the shaft of the roller being turned, it is often necessary to pack the bed up when turning a swift, since swifts are often placed on pedestals 10 or 12 in. high. During turning the swift is revolved at an average speed of from 1000 to 1200 ft. per min. The turning tool is then carefully and slowly passed along the face of the roller, and if the swift is out of truth it is soon evident by the higher part only of the roller being touched by the tool. It is important that this process should not be forced, as nothing is to be gained, and three, or even four, thin shavings should be removed rather than one thick one. Generally, however, the turning-up process in the case of the rollers of a well-made machine is more a matter of making a clean surface for the new cards, rather than one of truing.

The small rollers are turned up in the grinding frame, and during the process are made to revolve at from 200 to 400 revs. per min. In the case of the smaller rollers the speed is highest, and this is obtained by putting on smaller driven pulleys, the object being to keep the surface speed of the rollers during turning fairly high. After truing, the surface of the roller is made very smooth by holding sandpaper against its surface. Then all the small holes and torn places, if any, in the wood should be filled with putty, so that the card teeth cannot drop out, and so that they will be supported in working position. Also, when sheets are to be nailed, a horizontal line is made along the roller, the bed being used as a ruler. Iron rollers require less preparation than wood. After knocking-off the old clothing, the dirt and grease are cleaned off with an old card, tacks are knocked out, and any unsound wood plugs must be replaced.

Nailing.—The work of nailing on the card clothing, whether in the form of sheets or fillet, cannot be too carefully done, as the life and efficiency of the clothing can be considerably reduced by improper nailing. The nailing-on of sheets, which is almost peculiar to the woollen trade, and the wrapping or "lapping" of fillet, may be said to be two branches of the same work.

Formerly the swifts, doffers, workers, and fancies were invariably clothed with sheets, but recently fillet has become much more popular, especially for the finer counts of card clothing such as are found on the carder, and the last doffer of the scribbler is often clothed with fillet. Ordinary strippers and angle strippers are always covered with fillet as well as the feed rollers and lickers-in. It might also be noted that on the Continent sheets are practically unknown. All clothing requires to be put on the rollers under tension, and if the tension is not sufficient the oil and wear of working cause it to stretch larger than the surface it is nailed to. In consequence of this slackness the teeth become loose in the foundation, and a still worse defect occurs, due to the cards becoming " blobby " or lifting from the surface of the roller, since this causes the teeth on adjacent rollers to touch, and not stand well up to their work.

Sheets require stretching in one direction only, as any attempt to stretch them in the direction of the width of the roller has a tendency to open the holes in the foundation and allow the wires to become loose. Sheets are made with a margin of ½ in. at the top and each side, and 1 in. at the bottom. Some, however, prefer to have the sheets for iron swifts and doffers nailed backwards way, as by so doing the wide margin is at the top instead of the bottom, and this precludes any possibility of a sheet being torn up during dressing or fettling.

Beginning with the straight line made by using the bed that carries the turning tool, or on one of the rows of pegs in the case of an iron roller, the sheet is secured in place by a tack at each upper corner. Then about six more are inserted at equal distances across, and the leather is pricked every ½ in. or so all along the top, and tacks inserted and driven home.

To stretch the sheet and obtain the requisite tension the nailer uses a clamp about 4 in. wide, and attached at one end to a stout strap, the other end of which is attached to a pedal or treadle. Thus the nailer can stretch the sheet as required with his feet, and his hands are left free to insert the tacks. First one end and then the other end of the sheet is gripped by the clamp, and about half a dozen tacks put in, after which the sheet is stretched 4 in. at a time and nailed down. The extra ½ in. of leather margin which has been held by the clamp is then cut off. The next sheet is laid with its upper margin over the lower margin of the previous one.

The wrapping of rollers with fillet is quite a different process from that of clothing a roller with sheets, but it might be pointed out that it is not done with the same degree of accuracy in the woollen trade as in the cotton trade. One-inch fillet is generally delivered in rolls, or in boxes, in lengths of from 800 to 1000 ft.; this system is possible since there is not the same range of counts used in clothing for strippers as there is in the case of clothing for swifts and so on. After knocking off the old fillet, turning up the roller, and so on, the end of the fillet is picked and cut to a tapered point which covers the stripper as far as possible, and consequently the fillet is wound on spirally; this incidentally renders it easier to get the edges of fillet nearer together on the roller. Accurate tensioning and winding-on machines may be, and are, employed; but as a rule handier ways are adopted by the card nailer in the woollen trade. When clothing strippers, the roller is put in the nailing posts, and when in position is at a height of about 4 ft. 6 in., and placed about 2 ft. below is a stout, smooth, iron bar. The nailer passes the end of the fillet under the bar before cutting and picking the end preparatory to nailing. Two tacks are put in at the beginning end of the fillet to fix it in a position at the left-hand side of the roller, and an assistant turns the stripper by means of a handle.

The fillet is given a half-turn between the roller and the bar, since the back of the fillet is in contact with the bar as it is being wound on, and the same side must be in contact with the stripper. During winding-on, tension is put on the fillet by the nailer passing it round his body and allowing it to run through his left hand and under the bar to the roller, at the same time knocking the laps into close contact with a hammer. The nailer generally has a leather sheet round his body and a small leather sheet in each hand for protection. After the fillet has been wrapped on the roller, a tack is put in, the end is picked, cut to a tapered point, and securely tacked. To obviate any chance of the fillet running slack, every other lap is secured with a tack. The system just described is crude, but it works well in practice, since a stripper can be covered in as short a time as is required to prepare a machine to do the work. Moreover, the carding overlooker will very often "lap" his own strippers as they wear down without waiting for the nailer. When covering doffers and swifts it cannot be too strongly urged that proper means should be adopted in the way of accurate winding machines, which register the actual tension on the clothing during winding, and also place it with mechanical accuracy.

GRINDING.—The card wire as left by the card-making machine is cut at right angles to the direction of the wire, and hence for carding purposes has no point on it. Before the wire is of any use for carding it must have a smooth point, or feel smooth when the hand is passed over it in the direction of the inclination of the wire; but when an attempt is made to pass the hand in the opposite direction the points must offer the maximum resistance. This is necessary in order that the wool may be held during opening or carding, and easily released during stripping. Moreover, the length of the wire as cut by the machine, whilst approximately accurate, is not sufficiently so for the delicate work of carding. To accomplish the objects of getting a good point, and ensuring that all the teeth are the same length, the operation of grinding is resorted to.

The larger rollers, such as swifts and doffers, are ground in their own bearings, so that when grinding is completed the periphery of the roller is perfectly circular. In the woollen trade grinding is done much differently than in the worsted and cotton trades. In the two latter trades the teeth have not only to be sharpened and smoothed when new by means of grinding, but they have also to be kept in efficient carding condition by the same means. The work of carding blunts the point, and as there is, speaking generally, no means of keeping the point by the action of the machine itself, the grinding or the emery roller is the only means of obtaining a good point. In woollen carding, however, the only occasion that grinding with the emery roller is necessary is in the case of new clothing, as after the initial grinding the various rollers are so set with regard to one another that the teeth should improve in sharpness and smoothness, and get into what is termed "condition," this state being much superior to that in which it is left by the emery roller. Care must be taken in the running of woollen carding machines to ensure that none of the rollers are too far gone as regards bluntness before being noticed.

The grinding medium in almost universal use is emery. Various other substances have, however, been tried, but they have been found to be inferior to emery, and are seldom heard of in the textile trades; they may grind quicker, but the point is much rougher.

The value of emery as a grinding agent is due to its hardness, irregular granular structure, and to each grain having fine points that are largely if not wholly responsible for its grinding powers. The emery is fixed either by being glued direct on to the grinding roller after the latter has been trued up perfectly circular, or it may be on long strips of cotton cloth 1 or 1½ in. wide, and wound spirally on to the roller like fillet clothing. In the former case the roller has to be returned to the works of the maker to be re-covered, while in the latter case fresh emery fillet can be put on at the mill very quickly when it has been rendered useless by wear.

GRINDING ROLLERS.—Emery or grinding rollers are of two kinds. There is the traverse grinder in which an emery-covered disc about 4½ in. wide and up to 13 in. in diameter is made to traverse the width of the roller being ground, whilst at the same time revolving at a speed of about 400 revs. per min. A traverse grinder gives the most accurate and desirable results; but in the case of woollen carding machines, which vary in width from 60 to 72 in., the time required to do the grinding properly is very great.

One kind of traverse grinder consists of a tubular shell on which is mounted the grinding disc or wheel. The shell is made to rotate by means of a belt or band pulley, and through a pin that is carried by the wheel projecting through a slot which extends almost the full length of the shell; when the shell rotates, the emery wheel must also rotate at the same speed. Inside, and supported by the shell, is a stout screw in which is cut a right and left hand thread, the two threads being connected at each end. As the screw is rotated by means of a fast pulley fixed at the opposite end to fast pulley driving the shell, a curved block which fits in the threads is made to pass from one side of the roller to the other and back again, and consequently the emery wheel is given a similar traverse owing to a pin projecting from the block fitting into the pin that is fixed to the inside of the emery wheel, and projects through the slot of the shell. The number of traverses of the emery wheel is generally from 8 to 15 per minute. To vary the speed of the traverse, a change must be made in the relative speeds of the screw and shell. A more recent method of driving the screw is by means of a differential motion, which is attached at the opposite end of the roller to that at which the pulley driving the shell is fixed. The shell transmits a slower motion to the screw than its own, by means of the differential motion.

The grinding roller most largely used in the woollen carding industry is a plain long roller, generally from 6 to 9 in. in diameter, and 2 or 3 in. longer than the full length of the rollers to be ground. The results obtained by this kind of roller are sufficiently satisfactory for all practical purposes, and grinding can be done in less than half the time that is required by a traverse grinder. In the latter case only about 4½ in. of wire can be ground at one time, but with the roller grinder the grinding is more liable to be done in stripes and unevenly when the emery has been worn unevenly. To prevent this fault as much as possible, the grinding roller is given a traverse of about 2 in. Other disadvantages of the grinding roller are that since the whole width of the roller being ground is in con-

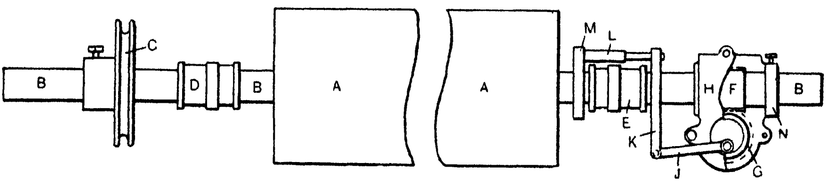


FIG. 53.

tact with the emery-covered surface at one time there is less side grinding; the teeth do not spring back into normal position so freely; more hooked points are likely to be produced, and the wire adversely affected, owing to its not being allowed as much time to cool down; and if the emery is not kept in good condition the grinding is not as even, and the parallelism of the surfaces is impaired. If in some parts the wire is higher than in others, then the emery is worn down unduly in grinding such parts; hence when the grinding roller is placed on some other part of the card it will grind unevenly. In spite of the above disadvantages, the grinding roller is almost always used except for, say, the last swift of carder and the ring doffers, some carding engineers considering it worth while to expend greater care and time in getting these into working condition.

In Fig. 53 is shown a front elevation of the kind of grinding roller commonly used. It consists of a hollow shell A, which is firmly fixed to the central shaft B, and near one end of this shaft is set-screwed the driving pulley C, while the other end of the shaft carries the mechanism by which the traverse is obtained. When in working position in the bearings the brass bushes D and E are held in one fixed position, but they allow the roller to rotate freely and also to make a short traverse. The traverse mechanism consists of the worm F, which is keyed to the shaft B, and this gives motion to the worm-wheel G, which is supported by suitable bearings, carried by a casing H, held in position on the shaft B by means of collars N. Attached to the worm-wheel G by means of a stud placed some distance from its centre is a short rod J, the other end being connected to a bracelet K, which is loose on the shaft B. By means of a connection L the bracket K is connected to a similar bracket M, that is also loose on the shaft B. These two brackets allow the grinding roller to move laterally, but they themselves are prevented from moving by being one on either side of the bush E. Thus, when the grinding roller is rotated, the worm F rotates the worm-wheel G, which in turn gives a reciprocating movement to rod J, and as brackets K and L cannot move laterally, the casing H, worm-wheel G, worm F, and grinding roller must be given a lateral motion, since these parts are securely fixed to shaft B. When emery in the form of fillet is employed it should be kept in a warm, dry room, though just before being wound on the roller it may be found advisable to put it in a damp place so as to make it sufficiently pliable. It is wound on the roller in a similar manner to ordinary fillet—that is, it is wound on spirally and the ends are tapered. Each tapered end is passed through a slot in the shell, and is firmly fixed by a steel clip that is screwed to the inside of the shell.

Operation of Grinding.—When small rollers, such as workers, strippers, and fancies, are to be ground, they are placed in a special grinding frame as illustrated in Fig. 54, which shows an end view of a common type of machine. It consists essentially of suitable framing, adjustable brackets for supporting the rollers, and pulleys for driving same. The two frame ends A are about 78 in. apart, and are connected together by stout stays. A belt drives from the line shaft to the fast and loose pulleys at B, on the low shaft C. Also on this shaft pulleys of several sizes are placed for convenience as regards driving.

The emery roller D is driven by a belt E from the pulley F on the low shaft, and it is also generally fixed on the outside of the end framing. At G is shown the roller to be ground. Its shaft is carried in bearings in adjustable brackets, one of which is shown at H. Two rollers can be ground at once, if necessary, by using the other side, which is an exact duplicate as regards parts for supporting the roller. The rollers to be ground are driven by an open

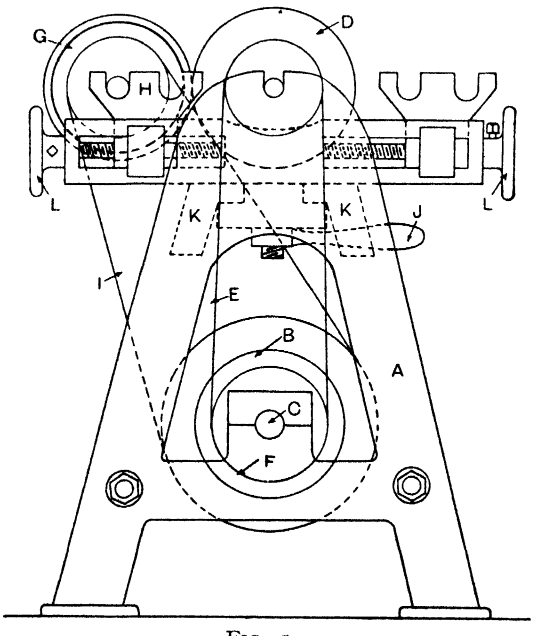


FIG. 54.

belt I as shown. When two rollers are being ground at once, they may be driven by separate belts, or by one belt of sufficient length that passes over both pulleys on the roller shafts.

A number of pulleys are required for the rollers, as small rollers must be made to revolve faster in order to revolve at the same surface speed as the larger rollers. Moreover, where a number of different makes of carding machines are installed, the shafts of the rollers that are to be ground are not all the same thickness, and consequently slightly different lengths of belts are required.

To overcome the difficulty of frequent lengthening and shortening of the belt, a buckle of suitable size is provided, and a few holes are made in the strap in suitable positions.

Carders are generally narrower than scribblers, and provision must be made so that rollers of different lengths will revolve properly in their bearings. When the parts are set in the required position to suit the length of the roller, the whole of the parts supporting the rollers to be ground are clamped to the stay K by aid of the handle J. A very accurate means of adjustment is necessary to place the rollers in grinding position, and to do this the hand-wheels L and screws M are provided. In order to facilitate the setting of the rollers to be ground, each of the brackets H is provided with two bearings as shown. This arrangement saves a considerable amount of screwing, especially so as the pitch of the thread is fairly fine.

The grinding frame just described can be used only for small rollers, say 16 in. diameter or less. Swifts and doffers are best ground in their working position in the machine. To grind the former, the emery roller is placed over the swift in one of the stripper or worker brackets, according to which is nearer the diameter of the emery roller. During grinding, the direction of the rotation of the swift requires changing; hence, when an open belt is ordinarily used for driving, it is changed to a crossed belt, or *vice versa*.

It is seldom necessary to alter the speed of the swift by changing the pulley, since the average surface speed of about 1000 ft. per min. is quite ample. The emery roller is driven by an open belt from the swift, and as a fairly high speed is advisable, the body pulley on the swift shaft is very suitable. Another advantage of using the body pulley is that the belt pulley on the grinding roller shaft comes between the bracket supporting the roller and the roller itself; hence, the belt pulling the roller downwards prevents the roller "bouncing," a trouble which is sometimes experienced when grinding coarse swifts.

Doffers can be ground by placing the emery roller in the angle stripper brackets, but as this is to one side rather than directly over the roller, it is not so suitable as special brackets or "dicky irons," which are fastened to the end of the bends. The surface speed of the doffer can be increased to approximately that of the swift by driving the doffer from the swift by means of body pulleys. If special pulleys are put on to drive the doffer, it leaves the doffer body pulley free to turn the emery roller. When the body pulley, however, is used to turn the doffer, the emery roller can be conveniently driven by a small open belt from a pulley on the end of the fancy shaft, which is quite near.

Points to Note in Grinding.—In grinding, the teeth are invariably made to revolve heel first, and the emery roller revolves in the same direction as the roller being ground, which causes it to revolve in the opposite direction where the rollers make contact. With old and uneven clothing, and in special cases where the point has become too sharp and thin, the roller being ground may be run point first in order to prevent hooked points. Also when the points have become hooked through over-grinding, much may be done to remedy the defect by running the roller point first. This method of grinding requires careful watching, and the grinding roller should be set so as only just to touch the teeth, otherwise damaged clothing is almost sure to result. Grinding should never be forced by the grinding roller being made to press too heavily on the wire, and if the work must be hurried, it is better to increase the speed of the grinding roller. In short, what is termed light and fast grinding is preferable to heavy and slow grinding.

When commencing grinding, the emery should only touch the longest wires, and with sheets this will be found to be at the top of the card, where it has been nailed over the preceding card. As this gets worn down, the emery may be brought nearer by about a quarter of a turn of the adjusting screws. Under-grinding in woollen carding is infinitely superior to over-grinding, since when left on the underside the point can be developed by the proper setting of the rollers; but the grinding, when continued too long, causes a kind of lip or hook to be formed on the underside of the tooth by the point being turned over, which makes a blunt point on the tooth, and thus prevents proper working of the material. The lip also sticks to the material, and prevents it being stripped, which leaves a considerable amount of good fibre to be removed in the fettling or dressing.

Some carders grind until the whole surface has a uniform blue, steely appearance; and if grinding is stopped immediately this appearance is obtained, the roller will be found to be in the best condition it is possible to obtain by grinding. Other serious defects, besides the one already noted of a "hooky" point, are caused by laying the emery too heavily on the wire in order to force the grinding. When grinding heavily, and especially in the case of coarse cards, a plentiful number of sparks are produced, which shows that a high temperature is produced, if only temporarily. This undoubtedly draws or spoils the temper of the wire, making it much softer, and hence causing it to wear quickly and lose point. Further, the pressure laid on the wire causes it to be bent backward each time it passes under the roller, and this opens the hole in the foundation of the card. Though this may be said to be not very serious in the case of a worker, it is positively destructive in the case of a swift, as it is never capable of doing the full quantity of carding that it should do, and when the machine is forced to a high production it results in a neppy web and roving, and in excessive waste both underneath and in good material that is left in to be removed in the fettling process. At its best a good ground point is somewhat rough, and it requires some weeks of running in order to produce the smooth, sharp point required for efficient carding. The ground point is practically flat or chisel-shaped, and the teeth of the rollers require to be run in contact with each other before the sides are worn, or smoothed down, sufficient to allow the teeth both to take up and be cleared of the material in a satisfactory manner.

The kind of point that is required by the different rollers is not the same. The teeth of the swift require to be smooth rather than extremely sharp, since if the teeth are too sharp they tend to hold the material instead of transferring it to the doffer. Workers require to have sharper teeth than the swift in order to card and open the wool; while the strippers should have a smooth rather than a sharp point, as they are merely carriers or clearers. The doffer requires to have a very sharp point in order to clear the swift as thoroughly as possible; while the teeth of the fancy should be smooth, since if they are rough they increase the amount of waste in the form of flyings. In grinding the fancy considerable care should be exercised, and the grinding roller should be set so as only just to touch the teeth lightly. Moreover, it is not necessary to grind it to the same extent as the other rollers, as smoothness is preferable to sharpness.

Lickers-in are better with smooth rather than sharp teeth, and it is only occasionally that lickers-in and feed rollers require grinding. Feed roller fillet cannot be sharpened, but when made from tempered steel wire it retains a good working point as long as the teeth remain firm in the foundation. In the case of lickers-in and feed rollers that are covered with Garnett wire, grinding should never be done until the teeth are very considerably worn, and at best the operation is difficult, and the results obtained by it are not to be compared with those obtained by new clothing. They can, however, be improved by grinding with a solid emery roller; the grinding being against the points of the teeth. It will be noticed that this is the opposite to that which obtains in the case of rollers clothed with ordinary card clothing, but it is necessary to prevent the teeth from becoming hooked. Feed rollers covered with Garnett wire are exceptionally difficult to grind, and the most satisfactory results are obtained by filing them by hand.

After grinding, the points should be made smooth by holding a soft pine board against the teeth, while the roller is made to rotate with the backs of the teeth first. This operation is continued until the teeth form notches in the board. The smoothing is facilitated by sprinkling powdered emery on the board and moistening it with oil.

CHAPTER XII

CONSTRUCTION OF CARDING MACHINES, DRIVING, SETTING, SPEEDS

CARD FRAMES.—As a detailed description of the preparation of the rollers for carding, and also their construction, has been given, the means of supporting them in the machine will now be considered. The swifts are the only rollers in the machine that are fixtures; they are supported in immovable pedestals. All the other rollers require some simple means of adjustment. Many of them are only adjustable in one direction, while the remainder must be adjustable in two directions. The side frames are generally cast in two pieces for each side if the machine is a scribbler with 3 or 4 swifts, each having the usual complement of rollers. In the case of the carder, each side frame will be in one piece, as they are comparatively short. The side frames are connected by stout cross-rails, known as mid-feathers, there being one of these at each end of the machine, and one between each of the swifts. The mid-feathers should be quite clear of the swifts and doffers, and so arranged that they come between a doffer and the *next* swift, not between a swift that is being cleared and the doffer which is clearing it. In good wool blends the latter practice may not be found objectionable, but where low-class blends are worked there is a large accumulation of dirt and card waste at this point, which in some cases should be removed daily. This is very inconvenient when the mid-feather is placed at this point, as it interferes with the work of the operative. Moreover, the waste falls on the rail, which makes it necessary to remove the waste at shorter intervals than would otherwise be necessary. To facilitate the removal of the waste from under the machine, the frames should be made and left open at the sides, and not enclosed as is sometimes the case with a view to preventing draughts under the machine, as the effect of the latter when present is negligible. The making of such openings also reduces the weight of the framing appreciably.

The frames should be made so that they clear the floor by as much as 3 or 4 in. between the feet. It is often necessary to pack up the feet, but it is not desirable, as carding machines are quite high enough for the convenience of the minders when set as low as possible. When the frames have been fitted at the machine shops, the joinings of the various parts are often drilled and a peg or spindle put in, so that in the case of any future re-erections the absolutely correct position is obtained, when the pegs can be inserted in their proper holes. The practice of pegging should also be adopted with regard to the pedestal for the swift and the feet of the bends.

To minimise irregularities of the floor, packings of various thicknesses are placed under the feet of the frames until the whole is perfectly level and the weight equally distributed. Formerly, frames were made with the flange or flat part on which the bends rested on the *inside*--that is, between the side frame and the rollers; but now the flange is always on the outside, and consequently the nuts holding the bend and pedestals are much more accessible.

One style, and that which is by far the commonest, is where the top of the framing is perfectly straight and level; but another style is where that part which supports the doffer is lowered or recessed so that the doffer bearings are fixed in a lower position than the swift bearings, and the doffer is consequently in a lower position in relation to the swift than in the first style of bend.

MERITS OF DESIGN.—Opinions differ as to the respective merits of these two designs or styles of frames. By placing the swift in a high pedestal (say 12 or 15 in. from the framing), and having the doffer shaft in bearings that are low down in the recessed parts of the framing, more surface of the swift is available for carding between the angle stripper and the point where the material is transferred to the doffer. This is one of the means adopted on Continental sets of carding machines to obtain 5 or even 6 pairs of workers and strippers over each swift. The angle stripper is quite below the centre of the swift, and the fancy very little higher; while with the ordinary plain frame and swift pedestal the shaft of the doffer is only a few inches lower, which leaves less swift available for carding, hence the maximum number of pairs of workers and strippers it is possible to use is four, and occasionally only three pairs are used. There is another important consideration besides the actual carding power with regard to this matter, which must be taken into account. This is, that the work of the doffer being one of cleaning as well as carding and carrying, when it is set only a little way below the swift there is greater opportunity afforded for the impurities such as broken burrs, seeds, and so on, in the case of wool and noils, and small bits of rag, greasy dirt, and even cotton threads, when dealing with shoddy and mungo, to drop out on to the floor. If the swift is placed too high above the doffer, these impurities are driven into or on to the doffer.

Position of Doffer.—The practice of setting the doffer low as explained may result in increased production, but the product is always decidedly inferior on the general class of stuff used in this country. On the Continent the success of the system is very largely due to the careful preparation of the blend. Noils and most of the wools are carbonised before carding, and the fine rags so largely used are often washed, and if trouble is caused with hard cotton they are carbonised as well. Their success in the production of very fine woollen yarns is undoubtedly due to the great pains taken in the preparation of the material to be carded. By having the material thoroughly cleaned before submitting it to the carding machines, the latter run much longer without requiring fettling, and hence without the defects that become apparent when this operation becomes necessary; also a high production is possible because the blend is soft and well opened.

The pedestal for the swift requires no special notice, except that it should be provided with a roomy cap that will take a quantity of grease, which gives much more satisfactory results than thin oil.

The doffer requires only a sliding movement along the frame to and from the swift. To obtain this a fitting is provided at each end similar to that shown in Fig. 55. The fancy is supported by similar bearings; they are, however, not so stout nor so wide, since the fancy is a lighter roller than the doffer. Moreover, the cap of the fancy bearing is hinged to enable the roller to be readily taken out, while the cap of the doffer is bolted down. In all cases, however, the general construction of both the fancy and the doffer supports is the same. The support A is often lined with brass, on which the shaft of the doffer rotates. At B there is a slot which limits the movement of A, and through this slot is passed a bolt C by means of which the support can be securely bolted to the frame D. To the frame is also bolted the small piece E, and through an eye in it is passed the eye bolt F, which is also securely fastened into A. On each side of E are a nut and washer as shown, by means of which the required adjustment is obtained. After an adjustment has been made, the bolt C should always be tightened up securely.

KINDS OF BENDS.—The fancy, workers, strippers, and angle strippers are not supported directly by the frame, but by what are known as the bends. These are semi-circular castings, which follow approximately the contour of the swift, and are bolted to the framing at each side of the machine; also each bend has a projecting arm for the purpose of supporting the fancy. There

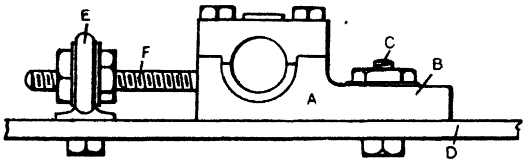


FIG. 55.

are two styles of bends—the inside bend, in which all the adjusting parts and pillars are on the inside, while the exterior is quite plain with the exception of a few projecting nuts. This is also called the box or Yorkshire bend, the latter name doubtless being given to it because machine-makers in that county prefer it. The other kind of bend is termed the Lancashire or outside bend, and all the parts for supporting the rollers and adjusting parts are on the outside of the bend. Before the respective merits of each type can be discussed, the constructional differences between the two must be explained.

BOX BEND.—The box bend is so called because the visible part consists of the plain face A, Fig. 56, which is about 7 in. deep, and has a plain top about 4 in. wide, this giving it a box-like appearance, a section of which is shaped thus : ˥. Each worker must be adjustable in relation to both the swift and the stripper in conjunction with which it works—that is, in two directions; while the stripper can be moved in one direction only, which is to and from the swift. The angle strippers are supported so that they can be adjusted in two directions, which are in relation to both swift and doffer. On the brass part B, which is $2\frac{1}{4}$ or 3 in. wide, rests the shaft of the stripper C. The bearing fits closely on the rounded end of the pillar D, in which is a small groove that is fitted with a small set-screw E. The object of this arrangement is that the pillar D may be made to revolve independently of the brass bearing B, but the bearing cannot come off the pillar. At the lower end at F the pillar is smaller in diameter, and has a thread cut on it, which screws into the tapped hole of the bolt G, fastened securely inside the bend by the nut as shown. So as to make it quite rigid, the pillar passes through a plain eyebolt H and a hole in the top of the bend. On the pillar at I is a squared part to which a spanner can be applied, and by turning the pillar at this point it is moved bodily upwards or downwards, bringing the stripper nearer to or carrying it farther from the swift. The brackets for the workers and angle strippers are similar in construction, but longer to accommodate a larger roller, and a slot is cut in the top of the bend as shown at J, Fig. 56, instead of a hole for the pillar to pass through. Also in place of the second eyebolt H of the stripper, the worker is provided with an adjusting arrangement consisting of the piece L, which is bolted to the bend, and the threaded bolt M, to the end of which is fixed the ring N that holds the pillar firmly, but in such a way as to allow it to be raised or lowered as desired. On each side of the piece L is an adjusting nut, by means of which the required adjustments are obtained.

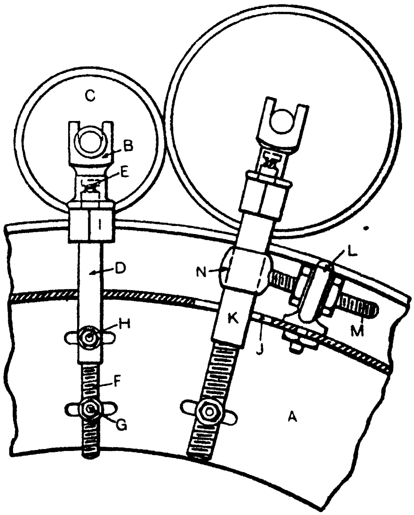


FIG. 56.

OUTSIDE BEND.—The adjustments on the outside bends are on a smaller scale, and, speaking generally, more delicate. On the bend at the proper positions are a number of raised projections A, Fig. 57, and apart from these the bend is quite plain. The pillar B has a plain face, and also a brass liner C which directly supports the roller. To get the required sidewise movement the set-screws D and E are provided, which pass through the side of the pillar and come against the projection A, so that when tightened up no side movement of the pillar is possible. By unscrewing one of the screws and screwing up the other, the requisite setting is obtained. The pillar is held to the bend by the bolt and nut F. Through the square block G inside the pillar passes the pin-screw H, which has on it two shoulders J and K, which keep the pin-screw in position, so that when it is turned the pillar is moved up or down, in accordance with the direction in which the screw is turned, through its action on the block.

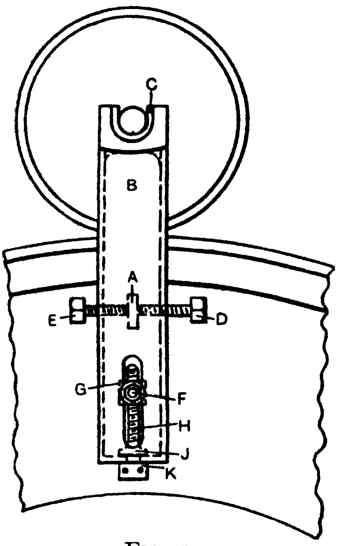


FIG. 57.

With the outside bend more accurate adjustment is undoubtedly possible, and there is no tendency, as in the case of box bends, for the pillar to turn, and so lift the roller slightly out of the bottom of its support when setting, which causes it to drop slightly nearer to the swift during working than was intended by the setting. On the other hand, there is a decided danger with the outside bends when a roller is accidentally thrown out, as they are cast-iron, and almost invariably break unless the roller happens to be thrown quite clear. Many methods are adopted for supporting and setting the feed rollers. Several have screw adjustments for each direction, but since both middle and top rollers have to move in two directions, it is necessarily complicated, and especially so as the space available is very small.

FEED ROLLERS.—The method shown in Fig. 58 is simple, and in practice fulfils the requirements very satisfactorily. At this point it should be noted that the clothing of the feed rollers is very hard and firm, and hence does not give way for a long time; and as the feed rollers work just clear of each other, so long as the wire remains firm it does not wear. It is necessary to move the bottom roller A to and from the licker-in B, and being supported in the long block C, along with the front roller D of the feed sheet, it is adjusted by means of the pin-screw E, which lies in a slot in the top of the block C, and just fits so that each end of the screw bears against the end of the slot. The screw E passes through a square piece F inside C, the piece F being securely fastened by the nut G to the frame H of the machine. Consequently, as F is a fixture when screw

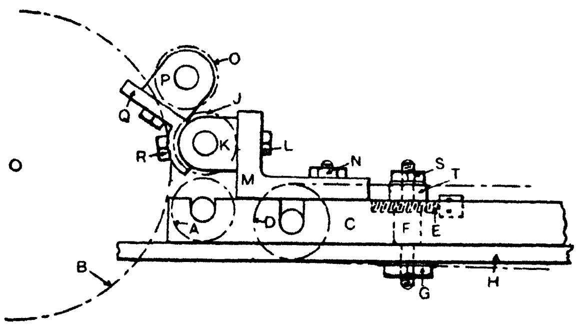


FIG. 58.

E is turned, the block C must be moved either backwards or forwards.

When the bottom roller is set to the licker-in, it is secured in position by the nut S, which clamps the bridge part T on to the block C. The middle feed roller J is adjustable towards the licker-in and the bottom feed roller, and each movement is independent, so that when properly set in one direction the process of setting it in the other does not upset the previous setting. The roller is supported by the bracket K, which is fastened by the set-screw L, that passes through a vertical slot in the bracket M, so that the roller J can be moved in a vertical direction within the limits of the slot, and set as required. The horizontal movement is obtained by the bracket M having a slot so that it can be slid on C, and when in the correct position it is secured by nut N.

The top roller O is also adjustable in two directions, as it is supported by the bracket P, which is secured to the slotted bracket Q, and allows the top roller to be moved to and from the middle roller. The set-screw R allows the bracket Q, and hence the roller, to be moved nearer to or farther from the licker-in as desired, and as the bracket moves in an arc with the shaft of the middle feed roller J as centre, the previous setting remains unchanged. As a rule the feed rollers are about $\frac{1}{16}$ in. apart, and to set them a strip of metal about that thickness, which may be termed a gauge, is useful. After placing it between any two of the rollers to be set, the roller to be moved is forced up against the gauge until the latter is loosely held, when the roller is secured in position. For instance, in setting the middle feed roller J to the bottom roller A, the gauge is put between the two rollers, and the middle roller is allowed to rest on it, when it is tightened up. The setting between the roller J and the licker-in is performed in a similar manner, the nut N being loosened and the bracket M "tapped" until the gauge is just held between the two rollers. Setting must, of course, be done separately at each side, and if the rollers are straight and true, as they ought to be, the setting in the middle will be correct.

Driving.—In considering the driving of the various rollers, the direction of rotation is almost wholly predetermined, and to within certain limits the speed as well. There are exceptions, however, and carding overlookers often modify the system adopted by the machine-maker, according to personal ideas, experience, or to overcome some defect, or to get better results in running a certain class of material. For example, it often happens that an angle stripper which has worn rather low in the wire will roll quite a considerable proportion of the material out at each side. As the roller cannot hold much dirt, owing to the depth of the tooth being small, due to wear, it becomes glazed over within a few hours after being fettled, with the result that its stripping power is lost, and the material is rolled between the doffer it is taken from and the swift it is being transferred to and the angle stripper. The general remedy for this complaint, although sometimes tin shields are fitted over the end of the triangle where the material escapes, is to run the angle stripper slower than the doffer and in the reverse direction, so that instead of being stripped from the doffer and carried underneath the angle stripper, the material may be described as being scraped off the doffer and carried over the top to the swift. This practice is employed only on the scribbler, as it does not straighten the fibres, which is most necessary on the carder, but passes the material forward in a more uneven and lumpy form. It is, however, possible to set the angle much deeper into the doffer, and so keep the points of the latter continually clean; and hence this procedure is very advantageous when running on low and dirty work, but it is unsuitable for long wools and blends of a good quality, as there is a decided tendency to break the staple.

MAIN DRIVING.—The transmitting of power from the line shaft to the scribbler or carder is almost invariably done by a stout belt. It might be noted that chain driving has recently been adopted with some success, but it is in the experimental stage, and consequently it is not advisable to make any further reference to it. On one of the swifts of the scribbler, intermediate (if intermediate forms one of the set of machines), and carder, the central shaft is made sufficiently long on one side to take two 6-in. driving pulleys. A 6-in. belt is advisable for a scribbler composed of three parts—*i. e.*, a swift and the usual complement of rollers; while a 5-in. belt is sufficient for a carder with two parts. The driving pulleys should be from 24 to 30 in. in diameter to obtain a proper grip, since slipping causes considerable trouble where there is a continuous feed from the scribbler to the carder or intermediate. The character of the drive depends on the arrangement of the scribblers and carders. Where a large number of sets are together, the carder is generally set to follow the scribbler in the same line—that is, with the hopper feed at one end and the condenser at the other. A driving belt extending along the side of the machine should be avoided, as it is a source of danger to the fettlers; consequently the line shaft should be as nearly directly over the fast and loose pulleys as is convenient and consistent with good driving. If the line shaft runs in the same direction as the swifts must run, then the belts will be open. Also, if the line shaft is very much over the carder, then the drive to the scribbler is not at all a good one, since the belt driving the scribbler has to drive from this point and the slack is underneath instead of on the top, resulting in the arc of contact being considerably decreased.

It is advisable to have belts crossed if at all possible, since when run in this manner the belts keep themselves clean and in good condition. Adhesive belt dressings can also be used to greater advantage on crossed than on open belts. Sometimes two parallel line shafts are used, so that the belt driving from line shaft to both scribbler and carder has the slack side above the pulley, thus increasing the arc of contact with the pulley. As a matter of fact, where a long lattice feed is employed between the scribbler and the carder, or where an intermediate card is used, the above arrangement is practically essential. An alternative arrangement is to have the scribbler and carder of each set of machines side by side—that is, with the hopper feeds and condensers together at the front, and the intermediate feeds extending all along the back. The line shaft runs over the machines, and the scribbler is driven from the line shaft by means of a crossed belt, since it is heavier to drive; while the carder is driven by means of an open belt.

On the opposite side of the shaft to the driving pulleys on the scribbler is a pulley from 30 to 36 in. in diameter, termed a side pulley, which drives by a 5-in. belt a similar pulley on the second or middle swift, driving it at the same speed, which for general purposes is from 70 to 100 revs. per min. On the other side of the middle swift is a smaller pulley with a diameter of from 20 to 24 in., which drives a larger pulley, generally 30 to 36 in. in diameter, on the first swift or breast. Two 5-in. belts are used for transmitting the power from one end of the machine to the other, which as a rule are quite satisfactory if kept clean—that is, free from a coating of fibres, and sufficiently tight.

If the belts are allowed to become slack, and the machines are not sufficiently oiled, it is quite possible that some slippage may take place, and produce cardings or rovings that are lighter in weight than they should be. For this reason some prefer to dispense with the advantages of a slow-running breast, and drive the middle swift from the line shaft instead of the last swift, in which case there are three side pulleys on the opposite side of the machine to the fast and loose pulleys—one on each swift of equal size. The first belt or side strap passes round the pulleys on the middle and back swifts, and a much longer belt runs over this belt and round the pulley on the breast swift. It is essential that the shorter belt should go to the last and not to the first swift, so that if either belt breaks, the feeding of the material is immediately stopped, and no harm done.

Driving Doffer.—In Figs. 59 and 60 are shown opposite sides of the breast cylinder. The side strap A, Fig. 59, drives the side pulley B on the swift shaft from a similar but smaller pulley on the second swift. Between the pulley B and the framing, and fixed on the swift shaft, is pulley C, which is 10 in. in diameter. This drives by means of a 3-in. belt the 18-in. pulley D, and running in conjunction with this pulley is the change-wheel E, which drives the doffer-wheel F, the latter wheel having about 240 teeth. A range of pinions of from about 24 to 48 teeth is provided, by means of which the speed of the doffer may be varied as required. The stud on which the change-wheel revolves is fixed in a bracket with a vertical slot, which allows of the position of the stud being varied so as to accommodate wheels of various sizes. A general rule with regard to doffer change-wheels is that the larger change-wheels are used on the thicker or low counts, where the production is high, or when running long-stapled material.

An alternative method of driving the doffer is by means of wheel-gearing alone, hence the doffer is driven positively; this method is particularly suitable for driving the first doffer, as this doffer drives the feed rollers. Driving by means of toothed wheels is also a necessity in the case of the ring doffers, because of the condenser. The belt drive, however, is simpler, and is preferable where much changing is done. In this method a spur-wheel with 60 teeth is used in place of pulley C, Fig. 59, and a large intermediate is substituted for the belt, whilst in place of pulley D a spur-wheel is used. Also, so that as small an intermediate as possible may be used, the change-wheel is arranged to gear with the doffer wheel F at a point nearer the front of the wheel—that is, at a point nearer the breast swift, instead of at or near the bottom of the wheel as shown in Fig. 59.

Driving Licker-in.—Behind the pulley C is pulley G, which drives by means of an open belt the pulley H fixed on the licker-in shaft. The pulley H is generally 1 or 2 in. smaller in diameter than the licker-in, and with a 6-in. driving pulley a suitable speed is obtained—that is, a speed which is sufficiently slow for it to be cleared by the angle stripper, and at the same time the speed of the angle stripper is sufficiently slow for it to be cleared by the breast. In some cases where very long material is being worked for thick counts, the licker-in has a tendency to become choked and stop. To obviate this, an indirect drive is adopted, which gives the belt a greater purchase. The angle stripper also clears it better, because of its slower speed. In the indirect drive the pulley H is replaced with a spur-wheel, which is driven by a small spur-wheel compounded with a pulley that is driven by means of a crossed belt from pulley G.

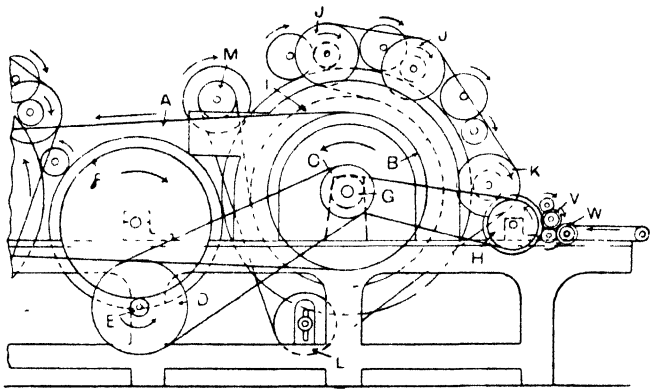


FIG. 59.

DRIVING STRIPPERS AND FANCY.—The strippers and fancy are driven from the large body pulley I, Fig. 59, which is 36 in. in diameter, and is fixed to the swift shaft inside the framing by means of a belt. The belt goes over each of the stripper pulleys J and partly round the angle stripper pulley K; thence under the carrier L: this pulley may be arranged to run free on a stud as shown, in which case the slackness of the belt due to stretching can be taken up by lowering the stud in the slot of the bracket shown. Sometimes the pulley and stud are fastened together, and the stud runs in a bearing in the bracket; this arrangement facilitates proper lubrication. From the carrier pulley L the belt passes over the fancy pulley M, which is 7 in. in diameter, and thence back to the body pulley. The first stripper and the angle stripper are too near together to allow of two 12-in. pulleys being used together. Consequently, the first stripper is driven from the other side as shown in Fig. 60, where a small pulley N fixed on the shaft of the last stripper drives a similar pulley on the shaft of the first stripper by means of an open belt.

Driving Workers and Feed Rollers.—The driving of the workers and feed rollers is shown in Fig. 60. The workers are driven by means of chain O, that receives its motion from the sprocket wheel P (with 12 teeth), which is fixed on the doffer shaft inside the framing. On each of the worker shafts is fixed a sprocket wheel Q with 8 teeth. A flanged carrier wheel R prevents the chain

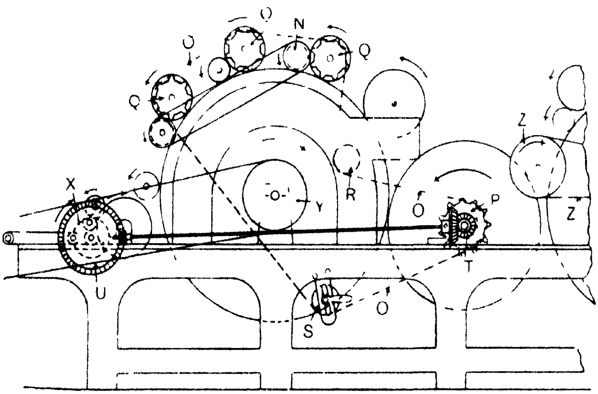
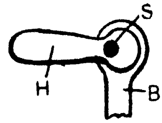


Fig. 60.

Fig. 61.



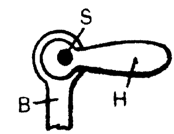


Fig. 62.

coming off the sprocket wheels Q on the workers; while the flanged pulley S, being set in a slotted bracket, takes up the slack, and is fixed in position by the handle shown.

The feed rollers are driven by bevel gearing and a side shaft, which are placed outside the framing. A bevel-wheel T, which has 35 teeth, drives the bevel with 45 teeth, which is on the side shaft. At the other end of the side shaft is a bevel-wheel which is also a change-wheel, the teeth of which range from 12 to 24, and this wheel drives the large plate-wheel U on the bottom feed roller shaft. The change-wheel is for the purpose of regulating the amount of material fed in, and by means of the change-wheel this can be increased or decreased as desired. As the feed rollers are driven from the doffer, any change in the wheel E, Fig. 59, to drive the doffer faster or slower, causes a corresponding change at the feed.

As it is necessary to run the machine empty at times, as in the case of fettling, a simple mechanism is fitted for taking the doffer wheel T, Fig. 60, and the wheel which it drives, out of gear. One of the simplest and most convenient is shown in Figs. 61 and 62, and consists of a handle H which acts as an eccentric, that fits in a supporting bracket B; the round end of this handle carries the side shaft S. The shaft, however, is not in a central position. Consequently, when the handle is pointing towards the machine as shown in Fig. 61, the wheels are in gear; and when in the position shown in Fig. 62, the wheels are out of gear, since the half-revolution of the handle causes it to act as an eccentric in relation to the side shaft, and move the shaft away from the framing.

The middle feed roller is driven from the bottom feed roller by gear-wheels of equal size, which are placed on the side of the machine shown in Fig. 59. The feed lattice is sometimes driven from the bottom feed roller by means of a carrier; but in Fig. 59 an alternative method is shown in which wheels of equal size are used, one being fixed on the middle feed roller shaft so as to drive the feed lattice in the proper direction, while the other is fixed on the front roller of the feed lattice; they are shown at V and W respectively. Since the top feed roller is really a stripping roller, it requires to be run at a greater speed than the other two feed rollers. Consequently, it is driven by the wheel X, Fig. 60, which drives a wheel half the size that is fixed on the top feed roller shaft.

The pulley Y, Fig. 60, which is fixed to the swift shaft, drives the automatic hopper feed by means of the belt shown. Also in this figure is shown one method by which the angle stripper is run in the opposite direction to that in which it usually runs. The pulley Z on the angle stripper shaft is a 12 or 14 in. pulley, and is driven by the belt Z^1, which passes tightly round the bare shaft of the second swift; in this way the angle stripper is driven at a sufficiently slow speed. In some cases it is driven from the doffer in conjunction with which it works, by means of a crossed belt; this results in a more positive and satisfactory drive.

SETTING.—Setting, which is the adjustment of one roller to another so that each will have the proper action on the material, is the most important duty of the carding engineer or overlooker. Too great care cannot be exercised in doing this work, as it has so great an influence on the productive efficiency of the machine. Good setting will give a production averaging at least double and in many cases three or four times more than when the settings are bad. Before commencing the operation of setting it must be seen that the rollers are true, and that the clothing is in good condition. This does not necessarily mean that it must be new, but that the point must have been kept in good condition; the wire must not have been allowed to get loose in the foundation, or bent backward by making contact with adjacent rollers which it ought not to touch.

The purpose of setting is twofold: (1) To ensure that the machines will thoroughly open the material, even to the point of actually separating individual fibres, and free it from extraneous matter; (2) to cause the cards to develop and retain as long as possible their maximum efficiency. It is also essential that the opening of the material should be accomplished without breaking the fibre, and thus reducing the average length of the staple. The opening, therefore, must be as gradual as possible, and must not be forced; hence the carding at the scribbler must be gentler than at the carder, since at best the material fed to the scribbler is in a somewhat matted condition, and if a matted lock of wool is forced asunder there is necessarily a breakage of fibre. The workers on the breast swift must be set farther from the swift than those on succeeding swifts, so that each of the workers will hold the material while the swift pulls, opens, or takes from the felted locks until the locks are very much reduced in bulk, and the material is passed to the doffer in a much opener and cleaner condition. Also, so that the opening will be as gentle as possible, the breast swift is run slower than the succeeding swifts. The construction of the machines with regard to the means provided for securing proper adjustment of the rollers has been previously described, consequently only the obtaining of the correct relative positions to secure the best results will be referred to.

It may be said that on the setting of the *working* rollers depend the quality and quantity of the material carded; and on the setting of the stripping or clearing rollers and the fancy depends the condition in which the teeth of the cards are maintained. On this latter point two entirely opposite opinions are held as regards the method of procedure, but it is mainly as regards different classes or branches of the textile trade; though in the Continental woollen trade, speaking generally, the opposite view is held to that which obtains in the same trade in British practice. In worsted and cotton carding the requisite point is obtained, and renewed when worn dull, by grinding with an emery roller; but almost invariably in British practice in the woollen trade the first grinding with the emery roller is the only one which the cards receive. The necessary point being obtained and improved by the setting of the rollers into each other, the improvement is in the direction of increasing smoothness and sharpness of the point. The rough flat point left by the emery roller is made into a beautiful smooth needle point after a few months' working. If evidence were required of the improvement in the point, it would be supplied by the fact that there is a decreased quantity of fibre left in the wire, and hence there is less fibre in the fettlings.

The rollers that should receive most consideration when setting are the workers and doffers as regards their position relative to the swift, and although the principle must always remain the same, the actual setting is affected by the nature of the material to be treated as regards length of staple, fineness of fibre, and counts to be spun. The setting of the feed rollers and licker-in is not affected very considerably by slight differences as regards different blends, but the greatest care is necessary when deciding on and carrying out the setting of the other rollers of the machine.

GAUGES.—As there is always a space between the working rollers, the use of gauges for accurately determining such space or distance is not only advisable, but essential. The old system of guessing by appearances from the ends of the rollers is not sufficiently accurate. It is, as a matter of fact, often misleading, since the stripper is often a fraction wider on the wire than the worker; hence at each end of the stripper there is a small circular piece of wire which has not been worn, while the remainder which has been doing the work will be shorter according to the work which it has done. Consequently, if the setting is done by the unworn end of the stripper, the working part of the stripper may be as much as one-eighth of an inch from the swift and worker. Also, owing to the light striking the card clothing at various angles and varying in intensity, the settings were seldom, if ever, accurate. Satisfactory results were, of course, obtained, but it was only very few engineers who became really proficient, and hence good results were the exception, and not the rule. Those who did become proficient, however, enjoyed a reputation; but now, with the use of gauges, it is possible to instruct any intelligent fettler, who is familiar with the machines, so that he will be able to do the work satisfactorily.

The special setting gauges that are now used for determining the distance between the rollers are supplied by the machine makers. They are thin strips of steel about 2 in. wide and 12 in. long, which are carefully ground to a thickness equivalent to the spaces in a wire gauge, and numbered accordingly. The numbers range from 16's to 36's, and they are most convenient when riveted at one end in the form of sets composed of three or four different numbers, as in this form they help to keep each other perfectly flat, and at the same time each can be used separately. The range most useful for fine work is probably from Nos. 24 to 36; whilst for coarse work a good set is from Nos. 20 to 28. No. 36 is very thin, but it is very useful for the setting of special parts, though it is too thin for the general setting of working rollers to the swift.

With regard to gauges, it is worth noting that when the numbers of a set move in fours, which is quite fine enough for practical purposes, any one number is approximately equal to the next two finer ones together. For instance, Nos. 32 and 36 are equal to No. 28, and Nos. 24 and 28 together are equal to a No. 20. Consequently, if a set or bunch is made up of Nos. 20, 28, and 32, it is equal to a range of Nos. 16 to 32—that is, all three are approximately equal to a No. 16; and Nos. 28 and 32 together are approximately equal to No. 24; and No. 20 with No. 28 or No. 32 is equal to No. 17 or 18 gauge.

OPERATION OF SETTING.—The actual setting requires to be done with the machine run off or empty, but with the belts and chains in position, because if the operation is done with the belts and chains off, the settings are apt to be disturbed when the belts and chains are replaced. Care should also be taken to remove all fly or waste from the worker or other roller shaft bearings before the setting is made. If a long English or crossbred wool was to be carded, the workers would be set so that a No. 16 gauge passes between them and the breast swift; and when adjusting the worker according to the gauge, the breast and worker should be turned until the middle of the sheet on each are opposite each other, so that the centre of the wire surface on each will be gauged, as it is generally the case that the centre of each sheet is slightly higher than either edge, and if the setting points are the edges of the sheet, then the centres will be considerably closer, and may make contact with each other. A No. 16 gives a very open setting, about $\frac{1}{16}$ in., but on a long class of wool there is less danger of nepping it by too open setting than there is of breaking it by setting too close.

SETTING WORKERS.—When setting the workers the gauge has to be passed in behind, as the stripper is in front. First one side and then the other of the machine is set, though the side which is set first must be gone over again, as the setting of the opposite side always affects the original setting to some extent. Further, it is not sufficient just to put the gauge in at the end, but it must also be tried some distance along the roller, and when the setting is correct it is just free to pass between the rollers without force, the gauge neither binding nor being too loose. When going in, the gauge will lift against the points of the wire of the swift, and in coming out against the points of the worker. It should be free both ways, since if the cards on either of the rollers are down, or have been flattened by the material during working, the setting will be appreciably closer when the material is passing through; this is detected by passing the gauge both ways. The adverse effect on the wire of too close setting is also considerable; for instance, the worker may have been set too keen in relation to the stripper, and if this has been allowed to continue for some time, the teeth of the worker will be found to be loose in the foundation, and considerably forward. When the machine is fitted with inside or box bends, the brass or bearing at the top of the pillar should be observed, as it should be perfectly square with the roller shaft. The brasses are sometimes stiff on the pillars, and when the latter are turned in the work of adjusting the brass may turn slightly with them, and so throw the shaft slightly out of the very bottom of the brass. This is why setting is always done with a heavy spanner, and the shaft always tapped down after each adjustment. It is often the case with both inside and outside bends that the mechanism which is adjusted does not respond fully to slight alterations, and for this reason also it is advisable to tap the shaft ends to make sure that there is no possibility of the parts subsequently working closer together.

PROGRESSIVE SETTING.—As has already been stated, if a long English or crossbred wool were to be carded, the breast workers would be set with a No. 16 gauge, and if the principle of gradual setting is fully carried out, the first worker will be set a loose fit for the No. 16 gauge, the second an ordinary fit, and the third a tight fit. The material is better opened after it passes the first worker than before reaching it, and locks that are too large to pass the first worker are seized, or at any rate in part, and replaced by the stripper in front of the same worker, and sufficiently reduced before being allowed to pass forward on the swift to the second worker. The second swift might also be set progressively with a No. 20 gauge—that is, the first worker set a loose fit, the second a medium, and so on. It may be pointed out, however, that so near are the gauges in thickness that in actual practice a tight fit with a No. 16 is actually as small or less than a loose fit with a No. 20.

There is much to be said for the progressive system of setting, as it gives much better results in practice than is generally supposed, the damage to the staple being decreased considerably. It is also found in actual practice that a larger amount of material can be satisfactorily carded. To generally accepted ideas it appears bad practice to set the last worker on the breast as close or even closer than the first worker on the next swift; but there are two important reasons why this is done. These are, that the carding is being done on the breast by at least half the number of teeth on the breast as there are on the next swift. For example, the card clothing on the breast swift, in the case of a set of machines for carding the material in question, would probably be 50/5, or at most 60/6; the former would have 100 and the latter 144 teeth per square inch. Also, with the slower speed of the breast the number of teeth that pass the worker in a given time is further reduced. Moreover, although the workers and doffers are always spoken of as the carding agents or rollers, it is the swift that actually operates on the wool.

The former are practically passive agents simply catching and holding the material whilst the swift cards it out. This can be verified by watching the machine at work, particularly at the breast before the staple and lock formation of the wool is entirely destroyed. If a large lock, for observation, is dropped on the licker-in, it is carried and transferred by the angle stripper. At the first worker it is held, but in the brief instant that it is held in proximity to the breast, the ends *not held* by the worker can be seen being carded and combed by the rapidly moving teeth of the breast. As the partially reduced locks are carried over the worker they are all arranged at a tangent when they have strength enough to retain their formation; this is clearly perceptible when the fibres are sufficiently long.

The second of the reasons referred to above is, when the actual carding is being done under the worker, there is a decided pull exerted by the wool on the teeth of the swift, and as the teeth are pointing in the direction of rotation there is a tendency for the material to be drawn down the slope of the wire into the teeth of the swift. Consequently, the second worker has not the same opportunity to catch and operate on the material as the first, nor the third as the second. From this it will be seen that the number of workers does not increase the carding power of the swift in direct proportion. The power of each worker decreases as the doffer is reached—that is, as it is placed later on the swift—and to compensate for the material being lower in the swift, the workers need to be set progressively.

With regard to the second reason stated above, it might be remarked that it is because of this tendency to sink into the swift that the fancy is necessary. In cases where the fancy has accidentally worked out, or has been taken out of actual contact with the swift, it is found that the doffer, even with its much greater diameter and closer setting to the swift than the workers, altogether fails to keep the swift clear. It very soon fills up with the shorter material, and the condition of the machine and the production show that there is something seriously wrong. When the material reaches the second swift, in being taken from the angle stripper, it is well on the surface again, and so the first worker can do more carding when actually set farther off than the last worker on the previous swift. It should, however, be set closer than the first worker on the previous swift, as the material is in a more open state, the matted pieces having been broken up, and bits of skin, rag, etc., removed.

A No. 24 gauge is used for setting on the last swift of the scribbler, and a No. 28 on the two swifts of the carder. Progressive setting is advisable on each swift of the carder as well as scribbler, although it is not so important as at the breast, since the hard pull due to the opening of the staples is not present to drag the wool as deep into the wires, and when the blend is composed of much matted material it is of increased importance that the first workers of the breast swift be set openly so as to prevent bending of the wire and excessive breakage of fibre.

Setting Doffers.—The setting of the doffers is similar to the setting of the workers, and in fact the doffer may be considered as a large worker. The doffer does not take all the material from the swift, as can be proved if a large piece of coloured material is passed through, say, in a mixture blend, since it can be noticed on the first worker every inch or so as it is brought into working contact with it at each revolution of the breast swift. The object of the doffer, however, is to take away the maximum amount of material, since that material which has actually passed the workers is generally sufficiently finely divided to be passed to the next swift. For the above reason the doffer is set closer than the workers. The first doffer may be set with a No. 20 gauge, the second with a No. 24, and the third with a No. 28, while a No. 30 or 32 would be used for setting the doffers on the carder. Close setting is also necessary to prevent an excess of material being dropped on the floor. It is under the doffer that the bulk of the loss takes place, particularly in the lower grades made from remanufactured materials. Hard bits of rag and dirt in the lower blends, and burrs and shives in wools, should leave the material; but if the doffer is not kept close up, a considerable amount of good fibre is dropped also, which is a direct loss. Of course, if the doffer point is dull it will cause excessive droppings.

Setting Fancy.—Indirectly the setting of the fancy, and angle and worker strippers, has a great effect on the efficiency of the card. The fancy keeps the surface of the swift clean, and makes the points sharp in front and smooth behind; this being a considerable improvement on the ground point. It also keeps the wire on the swift well forward, which enables the swift to seize and hold the material properly instead of causing it to roll and nep. To do its work properly, the teeth of the fancy must slightly enter those of the swift, and its surface speed must be greater than that of the swift. The depth that the fancy is set into the swift is governed by the material. Moreover, a setting that is suitable for one blend may be quite unsuitable for the next blend. It is often necessary to readjust the fancy when two similar blends are run through in succession; for instance, if the fancy is working satisfactorily when a blend is being run through that has been lying in the sheets for a few weeks, it will probably throw up the material in the form of fly in the case of a newly teased blend. The fly is particularly objectionable if it occurs at the carder. The effect is the same when a change is made from a heavy to a light quality of material, since it is generally the case that the heavier and shorter the material, the deeper must the fancy be set into the swift.

The fancy is usually set by ear—that is, by listening to the volume of sound produced by the contact of the two series of wires; this requires to be much greater on the scribbler than on the carder. It is most important, however, that the setting should be equal on both sides, and to ensure accuracy in this respect the fancy is sometimes set to the swift with the aid of a fine gauge, and then set into the swift by giving a certain number of turns or part turns to the hexagonal-shaped nuts by which the blocks are regulated in which the fancy shaft rests. For instance, the breast fancy might be set in by giving the nuts one complete turn, while on the carder half a turn would probably be ample; this setting would be suitable for materials, which are medium to coarse in counts and quality. If with the above setting the fancy lifts the material out of the swift, it can be regulated by decreasing its speed by putting laps of leather on the fancy pulley. The setting of the fancy into the swift should be less deep in the case of fine, lofty, and long materials; but in all cases it must touch, since if it ceases to touch, it ceases to enable the swift to be cleared. A new fancy always throws for a few weeks until the points of the wire have become perfectly smooth. Another help that comes with running is the covering of the points, to the depth the wires enter the swift, with a coating of grease; this has a most deadening effect on the fly, and is very useful on the carder. A fancy ceases to be useful when the wires are reduced to the length of an ordinary card, and when this point is reached the roller should be reclothed.

There are two theories of setting this, the most troublesome as well as the most important roller of the carding machine; though the main object is to set it as deep into the swift and run it as fast as the blend will allow. The first theory is to set in accordance with the main object just named; while the second is to set the fancy a depth judged by experience to be sufficient for the material in hand, and limit the fly by reducing the speed. In practice a compromise is necessary, and the following approximate settings that are practised on blends of medium materials will serve as a guide. Set the breast fancy into swift $\frac{1}{20}$ in., and gradually set in a less distance until the carder is reached, where the setting may be about $\frac{1}{50}$ in.; the best speed is where the relative speeds of fancy and swift are as 6 is to 5 respectively. Some engineers set the fancy the reverse of deep, and after each fettling set it deeper until the fettlings are heavy or solid rather than light.

Defects of Improper Setting.—When not thoroughly understood, or when neglected, the fancy is the cause of a number of serious defects. If it has worn down the swift, or if it is not set sufficiently deep, then it ceases to prepare the swift for doffing, with the result that the latter becomes full of material up to the points, the workers appear to be very densely covered, and the material is nepped, since it is not being doffed, and passes round and round on the swift. A similar defect is noticeable when the speed of the fancy is too low, as the material is rolled on and pressed into the swift instead of going forward. A high fancy speed, which produces a little fly, is not objectionable on the scribbler, but on the carder it would tend to form uneven roving; this tendency is due to the flyings settling towards the middle of the machine, and consequently causing the threads at the side to be considerably weaker. After the initial setting has been done it is often found necessary, when the machines are running, to alter the setting or the speed due to the fancy throwing out the material or lapping. A fancy may be throwing the material because it is set too deep or speeded too fast, or through the teeth being too straight and stiff. Also if either swift or fancy requires fettling, excessive flyings may be caused. When the fancy laps it is generally due to the clothing being rough, or the speed too slow.

SETTING OF STRIPPERS.—The setting of the strippers in relation to the swift is generally like that of the workers with which they work, and it can be done at the same time with the same gauge. It is, however, not unusual to set the strippers with a gauge a few numbers coarser. In cases where the material is troublesome and liable to fly, it is a decided advantage to set the strippers closer to the swift than the workers, as they hold the material nearer to the swift and prevent fly being made by the fancy. A more important setting is that of setting the worker to the stripper. In connection with this setting it is a curious fact that, though it is the worker which is set to or from the stripper, the stripper is almost invariably referred to as being " set to the worker." Strippers and workers are set to touch equally along their entire length; but the less they are set into each other the better. It is as a matter of fact only necessary for strippers to keep the point on the workers and keep them clean. When the setting is too deep the stripper develops a decided point *behind*, it coats rapidly with long fibre, and the wires of the worker in connection with which it works are loosened. If the setting is not sufficiently close, the worker becomes coated, because the points are not kept clean and sharp, and hence their carding efficiency is lost. Workers and strippers should be frequently examined so as to ensure that correct setting will be maintained. The setting of the workers to the strippers can be best gauged by listening while they are running, and if a faint swishing sound is heard the setting is correct. Another method is to set the workers to the strippers until the small beam or crack of light seen between them from below just disappears.

Bad work is often made by the last stripper on the carder—that is, the one over the condenser—unless it receives special attention. In running, the worker develops a fine point, but the stripper is made blunt, and may become sharp behind, which makes it necessary for the stripper to be ground. Some swifts are supported in a very high position in the machine to make room for more workers, and the fancy and doffer are placed low to allow the last worker to be also placed low. When a worker is placed low at the *back*, the work of stripping is made much more difficult, as the stripper is compelled practically to dig up the material from the worker and carry it over and round to the swift. Consequently, if the last stripper is not kept sharp and in good condition, it will not be able to take the material without rolling it and replacing it on the swift in lumps.

The remarks with regard to ordinary strippers are applicable in the main to angle strippers, except that when the angle stripper is running reversed on the scribbler it can be set fully $\frac{1}{16}$ in. into the doffer, and so keep the points of the doffer more thoroughly clean. It should be remarked with regard to the licker-in angle stripper of the scribbler, that it is set just to touch the licker-in with a view of preventing the dropping of material.

Setting and Speeding of Feed Rollers and Licker-in.—While the setting and speed of the feed rollers and licker-in are of relatively minor importance, it is decidedly detrimental if the setting and speed of these are not good. Feed rollers or nippers covered with needle-pointed clothing should be set as close as possible without touching, so as to grip the material. The points to guard against when setting the nippers, are too close setting, which tends to cause the top nipper to force the material into the licker-in; though with nippers set close and running at a slow speed the maximum opening and mixing is done. If the nippers are set too far away the opening is inferior and the feeding is not so regular and even. They are generally set by passing two or three gauges round each nipper. Nippers covered with Garnett wire are often used on long and strong materials, in which case they should be set into each other, the teeth of one running in the spaces between the teeth of the other.

The surface speed of the nippers should be as slow as possible, especially on medium and long materials, consistent with the thickness of the feed desired; this ensures the maximum opening of the material at this point, and preserves the card clothing of the breast. With regard to the licker-in, the main point is its surface speed, and while this in relation to the nippers may be varied considerably without any detrimental results, it should not be greater than about half that of the angle stripper.

Close and Open Setting.—To determine whether the setting of carding machines is too close or too open the following hints will be helpful. If the setting is too open on the scribbler, the sliver or web, when held up to the light, will be seen to be neppy and specky, and have a raw, unfinished appearance. It is of first importance to set the workers so that they will have a decided action on the material, since, if they only just catch it, they tend to roll it, especially if their points are on the dull side, and it is much better to err on the side of excessive opening. If the rollers lap, a likely cause is too open setting; this, however, does not apply to the fancy. Should one roller not clear another, if that is its function, the cause may be due to too open setting, and the material will roll towards the sides of the machine. If the setting is too close there will be excessive breakage of fibre; hence the greater the average length of the fibres forming the blend, the more open should be the setting, especially on the scribbler. There will be a large quantity of fly, and the strippers will be harder to turn or drive if they are set too far into the workers. Should the blend, however, be composed of a large proportion of mungo, the workers will need to be set keener to the swift than otherwise, owing to mungo requiring more carding.

Another indication of too close setting is the repeated breaking of slivers and roving owing to the large percentage of cut and broken fibres. Also as a result of too close setting the swift and doffer become filled with short fibre, and a hard or undue rubbing sound is heard between those rollers which are set into one another.

With regard to doffers, it is the best plan to set them close, and alter the speed to suit different kinds of material. In the case of blends composed of long materials a greater speed is necessary, and the same remark applies in the case of high productions.

Doffing Comb and Stripper.—There are two methods of clearing the material from the last doffer of the scribbler—one is by using a doffing comb, and the other is by using a doffing stripper. Two varieties of doffing combs are in use, the oldest being what is known as the crank comb, which was very suitable for the low productions at one time obtained, as the doffer could be run more slowly without having too thick and unwieldy a sliver. At present the fly comb is universal where intermediate feeds are used, such as the Scotch feed, with a side drawing. One of the simplest forms of the fly comb is shown in Fig. 63. The plate A, which has a serrated lower edge, extends the width of the doffer B, and is supported at intervals of about 8 in. by rods C, which are attached to the stout bar D.

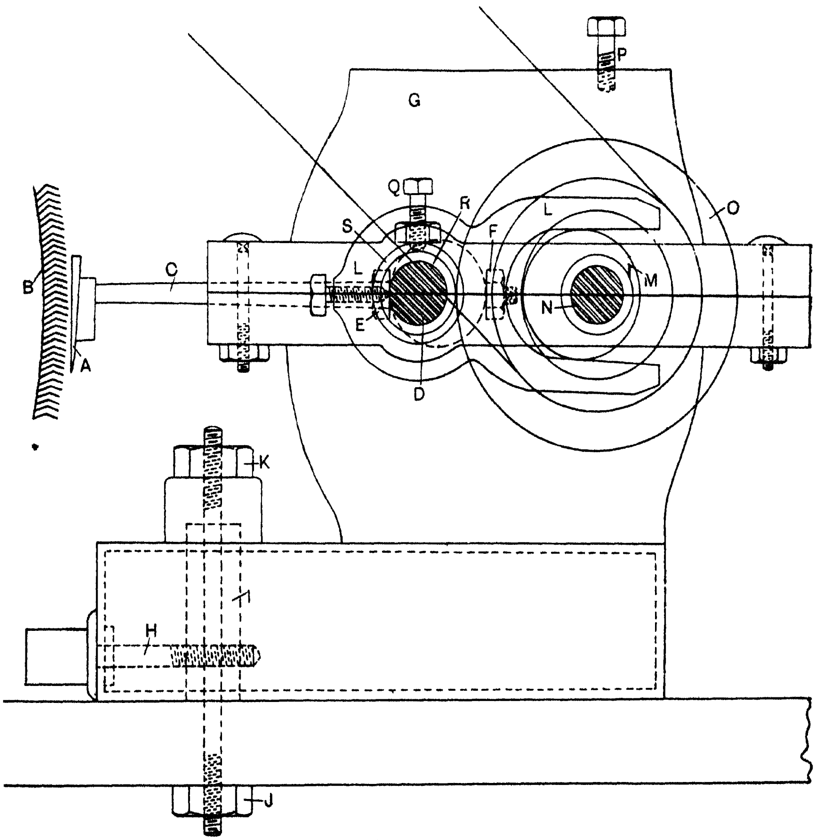


FIG. 63.

Nuts E and F enable the plate A to be adjusted so as to be the same distance from the doffer at all points. One end of the shaft D passes through the oil-tight comb box G, which is adjustable towards the doffer by means of the set-screw H. This set-screw passes through a slot in the base of the box, and has a shoulder on each side; these come against the box-plate. The screw H also screws into the block I, which is securely fixed to the framing by the nut and bolt J. The nut K is a lock-nut for fastening the block after setting has been done. Inside the box G is the fork L, which is slightly tapered inside so as to enable the play caused by wear of eccentric M, that rotates between the tines of the fork, to be readily taken up. Parts L and M are shown in full for clearness. The position of the fork in relation to the comb-shaft may be changed so as to get a higher or a lower stroke as desired. The eccentric is fixed to a short shaft N, which projects through the box, and a stepped grooved pulley O attached to the shaft on the outside of the box gives motion to the eccentric, since it is driven by a small band from a larger grooved pulley on the fancy shaft. The comb-box is in two halves, which are bolted together, and oil is admitted by removing the set-screw P. A set-screw Q is provided with a lock-nut for fixing the threaded sleeve R, which is inside the conical bearings, in position after an adjustment has been made to take up wear. There are various modifications of the fly comb just described; but they all work on the same principle.

With reference to the setting of the doffing comb, the correct position for average work is when in the centre of its stroke the centre line passing through centre of doffer should pass through centre of comb. In the case of short materials the stroke may with advantage be a little higher than when running on long materials. The speed or strokes per minute should also be varied to suit different materials with a view to obtaining the best results. A variation in speed of from 1200 to 1800 strokes per minute is usually obtainable, and in the case of long and coarse materials the former speed is approached, while when short materials are being run the latter speed is approached. Another affecting factor is the speed of the doffer.

The doffing stripper has decided advantages when used on a fillet doffer. It consists of a stripper $3\frac{1}{2}$ in. in diameter, which is covered with fairly fine fillet. It is set $\frac{1}{16}$ in. into the teeth of the doffer, and is run at the same surface speed. Near to it, and set by a fine gauge, is a plain taking-off roller, which knocks the web from the stripper in a complete sheet as regards the width of the doffer. It also keeps the point of the doffer always clean, and in the best possible condition. Other advantages of the doffing stripper are that the web from the doffer is of more uniform thickness, since the comb tends to catch and drag the fibres; a comb when very dirty is liable to cause the web to break, which is not the case with the stripper, and a stripper keeps the doffer sharp and clean.

AVERAGE SETTINGS.—Average settings for a long English or crossbred wool have already been given. When blends composed of finer and shorter classes of wools are being run, closer setting must be practised to obtain satisfactory results. In the medium-class trade the workers on the breast might be set with a No. 20 gauge, and the workers on succeeding swifts with finer gauges, the No. 32 being used at the carder; whilst for blends composed of fine, short materials, a No. 24 may be used at the breast, and in cases where the material is free from hard matter a No. 28 may be used. The settings might increase in fineness until at the carder a No. 36 is used; this gauge, however, is too fine unless the parts are particularly true and the cards absolutely tight. But, naturally, for such fine work only the best machines can be employed with satisfaction.

SPEED OF SWIFTS.—Closely allied with the subject of setting is that of the speed at which the parts run, since even if the cards are in good condition and the setting carefully done, the maximum production can only be obtained when the parts are run at the correct speed. On the speed of the swift depends the speed of all the rollers in conjunction with which it works. Swifts are often run faster than is really necessary, and in many instances the excess speed results in direct loss in the quality of production. Also on some blends flyings would be excessive if fly strippers were not used in conjunction with the fancy. The fly stripper is a small roller which is placed under the fancy, and replaces all the fibre that would otherwise be thrown back on the swift. Moreover, on the lower qualities a higher speed causes an increased proportion of material to be dropped under the machines.

It will be helpful to examine how the defects caused by high speeds are overcome by Continental makers. The swifts in British sets seldom run at more than 110 revs. per min.; while the swifts in corresponding Continental sets run at as high as 150 revs. per min. The latter type of machine is specially designed for running at high speeds, and the blends that are best adapted for such machines are composed of fine materials that lie close to the wire. Everything is done to prevent draughts, and to keep the material on the machine. The sides, bends, and brackets fit close up to the bodies of the rollers, and all the driving is on the outside; also screens are placed under the swifts, and fly strippers are placed both behind and in front of the fancy. The great speed at which the Continental sets composed of three machines, each having only one swift, are run, makes it possible to do as much carding as is done on the standard British set composed of five swifts.

When running on blends composed of materials of a close-lying nature, such as those used in the fine flannel trade, and which do not fly so much as stronger wools, the swifts may be run at from 100 to 110 revs. per min. and give satisfaction. For the general trade, where a variety of qualities is run on the same machines, 80 to 90 revs. per min. is a convenient speed, providing the qualities are not too low. Mungo and shoddy materials do best on machines with swifts running at from 70 to 80 revs. per min.; while coarse wools and hairs yield best results as regards both waste and good work when run on machines with swifts rotating at from 60 to 70 revs. per min.

SPEED OF DOFFERS AND WORKERS.—The speed of the doffers and the workers is of minor importance compared with the speed of the swifts; but to obtain the best results they must be speeded correctly. Speaking generally, on coarse counts where the production is high, and also when the blend is composed of materials of long staple, the doffers are run faster than when the production is low and short materials are being carded. In the case of coarse counts and high productions it is necessary to run the first and last doffers of the scribbler at a high speed. If the first doffer is running slowly the feed rollers must also run comparatively slowly, which causes the pan at the hopper feed to be too full, and the weighs too heavy; this causes the feed sheet to be covered too thickly, which prevents the material being opened properly by the feed rollers and licker-in. Should the last doffer be run too slowly on thick counts, the sliver at the side drawing will be too broad for the box, and hence it will rise up to the fly comb and be caught, which results in lumpy and uneven places being formed, as well as in the breakage of the sliver. A medium speed is advisable where much changing is done or a variety of counts carded.

The middle doffer or doffers of the scribbler are not of much importance. The above remark also applies to the doffer of the carder. If the speed of this doffer is too slow, the overlap of the sliver is too much, the material is too thick on the feed sheet, and if it is of a lofty character the material is likely to be caught in by the top feed roller. Except on long and strong materials the doffer should be set close to the swift and run at a good speed with a view to clearing the swift thoroughly. The reason for speeding up on long materials is to keep it in contact with the swift as little as possible, and as less carding is generally required the staple has less chance of being broken. It might appear that on short, hard materials that require much carding a decreased speed of the doffer would give more carding; but where the material is passing through in quantity it lies too thick on the workers and doffer, and the card wire can only hold a certain quantity of material, and at the same time do the amount of carding that is necessary properly to open the material and prevent nepping. Should the doffer and workers run so slowly that more than the maximum quantity of material they can deal with is forced through, the natural result is that the surplus goes past without touching the worker. The maximum carding, therefore, is obtained by placing a greater amount of bare wire in proximity to the swift, and this can only be done by increasing the surface speed. Less opening or carding can be done when spinning thick counts, since a good spin can be obtained which would be impossible with the same degree of carding were a much finer count to be spun. On fine counts it is possible to slow down the doffers and workers to give the maximum amount of carding without overloading them; but on coarse counts it is necessary to get the material through the machine to prevent overloading. Fine counts are invariably spun from fine, short materials, hence there is little liability of excessive breakage of fibre due to the extra carding involved.

Speed of Strippers.—As a rule the speed of the strippers is determined by the machinist. It might be remarked that there has recently been more attention given to this detail. The leading point is that the surface speed of the strippers must be less than that of the swift and greater than that of the workers, so that it can strip the latter, and itself be cleared by the former. The surface speed at which they are run, about 250 ft. per min., is unnecessarily high, and if the action of the strippers is watched it will be seen that on any but long-stapled stuff the material is often thrown over the stripper in an irregular manner instead of straightened as it should be. Many of the newer machines are fitted with an independent drive to the strippers by means of grooved pulleys and a rope situated outside the frame. The driving and driven pulleys are about 10 in. in diameter, so that the strippers revolve at the same revolutions per minute as the swift, but the surface speed is about one-third of the normal. The material with this drive is straightened out more effectually, and there is none thrown from the sides to make the machine untidy, as in the case of the belt drive.

CHAPTER XIII

HOPPER FEEDS, CALCULATIONS

INTRODUCTION.—Of little less importance than the actual carding is the feeding of the material into the machines. In the making of a woollen yarn there are none of the numerous drafting and doubling operations which are so vital to the successful production of worsted and cotton yarns, and which play so prominent a part in their manufacture. From the cards in the case of woollen yarns the soft rovings are taken direct to the spinning mules, and irregularities in thickness are found in the spun thread. Further, both the production and the quality of the product are lowered considerably by the unevenness, as the spinner must arrange the drawing on the mules to suit the average; hence the thinner rovings break, due to insufficient twist, and the thicker ones are twisted down, owing to the twist being excessive. It will thus be clear that great accuracy is required in feeding the material into the carding machines. The feeding is now done automatically by what are termed "automatic hopper feeds"; these are much to-day as they were when introduced from America, though improvements and modifications as regards details have been made from time to time which have rendered them remarkably efficient as compared with the earlier machines.

HAND FEEDING.—A reference to the now obsolete system of hand feeding will be both interesting and helpful. The feed or server sheet was made longer and run slower than it is with an automatic feed, and the weight passing through the machines was much less, so that the operatives were allowed 3 or 4 mins. in which to attend to other duties before it required filling again. At intervals of about 1 ft. a lath of the sheet was painted; for instance, if the sheet had 30-in. centres it would be about 68 in. long, and hence five or six laths would be painted, making five or six equal spaces.

By the side of the machine stood a special weighing apparatus, and the minder or feeder placed the material on to the scoop of the scale until it began to fall, and then spread it as evenly as possible over the area of the feed sheet bounded by the painted laths. With this method of feeding elaborate lap or balling arrangements had to be used to minimise irregularities which were unavoidable. One considerable advantage, however, was that the minder could remove hard bits such as skin, rags, and so on, and thus prevent them from passing forward and damaging the card clothing. With the automatic feed one minder can attend to two or three sets of machines where formerly he could attend to only one, the work is more even, the feed has an opening action on the material, and it assists in freeing it from impurities when there is a grid in the bottom of the hopper. Due to the even feeding, a Scotch intermediate feed can be used instead of an elaborate feed that will give a large number of doublings, the latter type of intermediate feed being necessary only when running the finest and most particular work.

Automatic Feeding.—Unlike carding machines, the manufacture of automatic feeds is specialised, and few firms make both carding machines and hopper feeds. There are three main types of feeds, but the difference between each type refers to the weighing mechanism only; hence it may be said that the main principles are the same in all types. Moreover, as each type will do the work quite satisfactorily, any superiority or preference is largely a matter of personal opinion. Each consists essentially of a hopper or box in which the material is placed from the blending sheets, and a delicate weighing apparatus which delivers a certain predetermined weight of material on to the feed lattice at perfectly regular intervals, which are such that the weighs of material merge into one uniform layer. Successive weighs also cover the same area of the feed sheet; consequently the supply of material to the cards is regular and continuous. There are several minor attachments the purpose of which is to ensure uniform weighs and that each weigh delivered on the feed sheet will be evenly distributed.

Operation of Cliffe Feed.—An end elevation of each side of a Cliffe automatic hopper feed is shown in Figs. 64 and 65. In operation the V-shaped compartment formed by the endless spiked lattice A, Figs. 64 and 65, and the front of the hopper, is filled with the blend of wool or other materials by the minder, who can then leave the machine for a period of from a quarter to half an hour, and attend to other duties. The sliding extension B allows the hopper to hold more material than would otherwise be possible, but at the same time it can be closed when very short blends are being run which do not readily stick to the spikes, and hence roll or "turn" excessively, or when a blend is finishing, since, when the extension is closed, the machine will weigh properly until the hopper is almost empty, without requiring attention. The bottom of the hopper is perforated, or in the form of a grid or cage, so that extraneous matter, such as dirt, shives, hard bits, and so on, may drop through.

The spiked lattice A, which carries the material out of the V-shaped compartment, is composed of laths which are fitted with needle-pointed pins, which project obliquely upwards from the laths as the lattice is moving upwards, and downwards when the material is being removed from the lattice and deposited in the scale pan. Metal lattices or sheets are becoming more common; these are linked up to form a chain, and their movement is positive. Motion is given to the lattice A by the 5-in. top drum or roller 6, which is mounted in slotted brackets, and is thereby adjustable with a view to keeping the lattice the requisite tightness. Near the bottom of the hopper the lattice passes round another drum. Formerly, the spiked lattice was placed vertically, but this was much less satisfactory, especially when running blends composed of materials of widely different lengths, as the long materials were taken first. Consequently, when the hopper is newly filled the best quality or qualities are delivered first, and the quality gradually deteriorates until the hopper is again refilled. With the lattice inclined as shown in Figs. 64 and 65 there is a more even delivery of the material to the scale pan as regards quality, and as the material is pressed by its own weight as much against the spiked lattice as the front of the hopper, there is less rolling, and when the hopper is getting empty, light weighs are less likely to occur. Very large hoppers with an endless rotating lattice arranged horizontally in the bottom to bring the material to the spiked lattice have also been tried, but have been discarded for the same reasons that have led to the adoption of the sloping spiked lattice.

As the spiked lattice moves upwards, the material is also carried upwards by the teeth. To ensure that only an even level mass of well-opened material is carried forward, a beater or stroker, the shaft of which is shown at C, Fig. 64, is provided. It is usually

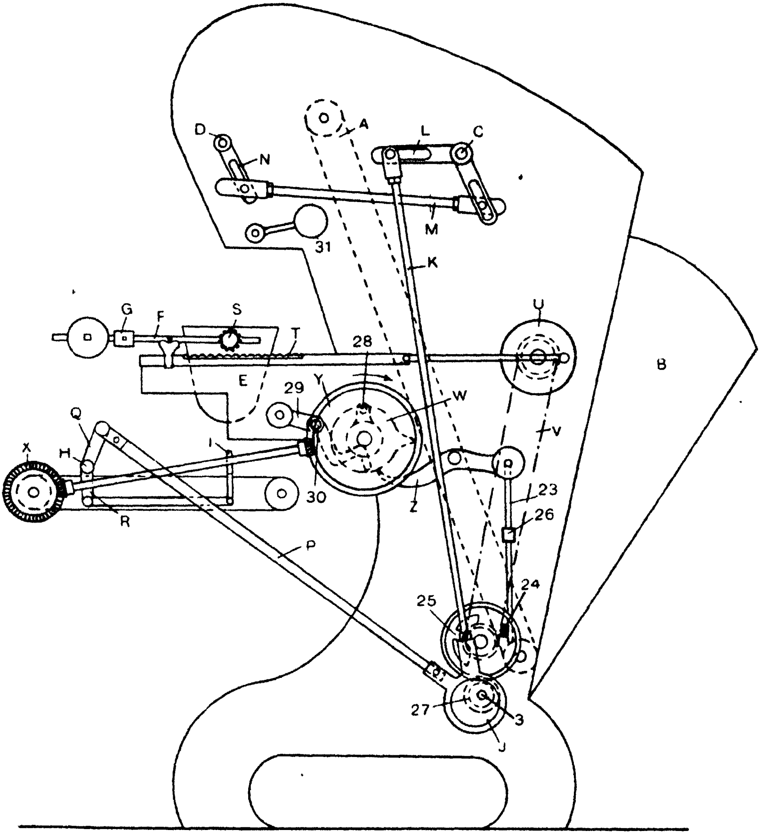


FIG. 64.

set about ½ in. from the spiked lattice. The material that is retained by the spiked lattice passes over the top, and is stripped from the lattice by a stripping comb, or brush and comb combined, the shaft of which is shown at D, Fig. 64. The comb acts on the back or smooth side of the spikes of the inclined lattice, and sweeps the material into the scale pan E, Figs. 64 and 65.

The pan is supported by the arms of levers F, Figs. 64 and 65, that are fulcrumed on knife-edges as shown, and the arms on the opposite side of the fulcrum to the scale pan are provided with balance weights. When sufficient material has been deposited

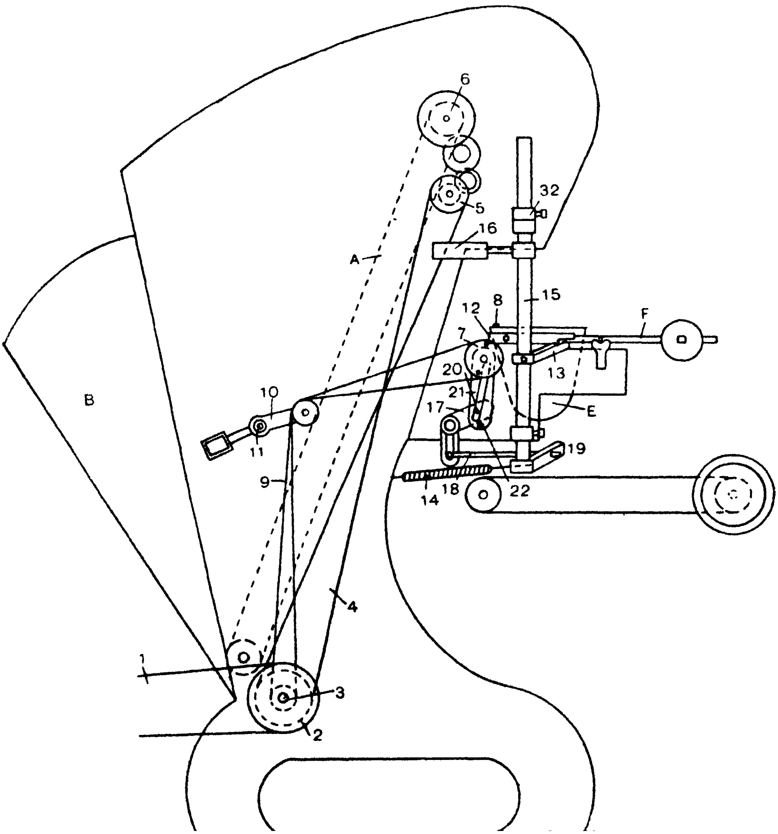


Fig. 65.

in the scale pan to counterbalance the balance weights, the spiked lattice will be stopped; but the stroker and stripping brush will continue to run. The pan will also be given half a revolution, and hence the weight of material will be emptied on to the feed sheet. Only the weight G, Fig. 64, is adjustable for the purpose of controlling the amount of material that is required in the scale pan. If this weight is moved nearer the fulcrum, less material will be required in the scale pan before the latter descends, and *vice versa.* In some makes of hopper feed the scale pan levers extend along the sides of the hopper, and consequently they are less likely to be disturbed or damaged.

The stripping comb, before steps were taken to overcome the disadvantage, was the source of uneven feeding, since, when the hopper is full, more material is pressed on the spikes, and more actually passes the stroker in a given time. Consequently, when the lattice stops and the stripping comb continues working it is found that a small proportion of material is stripped or wiped from the spiked lattice, and also some adhering to the comb might drop into the scale pan if provision were not made to prevent it. In this machine a trap door made from thin sheet metal is provided, which closes immediately the spiked lattice is stopped, and thus keeps back any surplus material that would otherwise reach the scale pan. When the spiked lattice again commences to rotate after the scale pan has been emptied, the trap door is opened, and the surplus material held back by the trap door drops into the scale pan and forms the beginning of a new weigh or panful, instead of dropping into the previous panful and causing an excess of material to be delivered on to the feed lattice for that particular weigh. An alternative method is to stop the stripping comb; but the trap door arrangement is preferable, especially on long materials, as the spiked lattice is cleared thoroughly during the time it is stopped, which is not always the case when the stripping comb is stopped.

To make the surface of the material even, and assist in making the layer of material of such thickness on the feed sheet that the feed rollers can readily take it, an oscillating patting board mounted on the shaft H, Fig. 64, descends and pushes down the material lightly. The material is pushed into a more compact condition by a push-board I, which moves backward and forward the requisite distance, and clearly defines the area of the feed sheet which each weigh is allowed to occupy.

DRIVING THE PRINCIPAL PARTS.—The spiked lattice A is driven by means of a belt 1, Fig. 65, which receives its motion from the breast swift of the scribbler; this belt drives the pulley 2 on the main shaft 3 of the hopper, which extends through to the other side of the hopper. On this shaft is fixed the pulley which drives the crossed belt 4, that gives motion to the fast and loose pulleys at 5. The fast pulley through the train of gearing shown drives the top roller 6 of the spiked lattice, and consequently the lattice.

The stroker, stripping brush, patting and push boards, are driven by means of an eccentric J, Fig. 64, which is fixed to the opposite end of shaft 3, Fig. 65. The eccentric gives motion to the connecting-rod K, which is connected to the arm L of the lever which is set-screwed to the stroker shaft C. It should be remarked that on long materials a longer stroke is necessary than when running on blends composed of short stuff; a longer stroke is obtained by moving the stud connecting the rod K to the arm L nearer to the shaft C. To the other arm of the lever is connected the connecting-rod M, which at its other end is connected to lever N, that is set-screwed to the stripping brush shaft D. The patting board is also driven from the eccentric J, through the connecting-rod P, which is connected to the lever Q, that is set-screwed to the shaft H, which extends across the machine, and has connected to it by means of levers the patting board. On the shaft H is set-screwed the lever R, which by means of the connecting-rod shown gives motion to the push board I.

Emptying Scale Pan.—When the scale pan has received sufficient material, it drops, and is banged down and held, until the pan is emptied, by one of two pins or pegs set diametrically opposite each other on pulley 7, Fig. 65, catching the plate 8, which is fixed to and projects from the scale pan. The pulley 7 is driven by the band 9 as shown. As the pulley is moved bodily a short distance in practically a horizontal direction, as will be explained later, it is necessary to provide some means of keeping the band 9 tight at all times. The means adopted is a weighted lever 10, which is fulcrumed at 11, and carries two pulleys over which the band passes. The plate 8 when it is forced down strikes the top of the catch-bar or lever 12, which is fulcrumed as shown, and lifts up the opposite end, raising the cut-out portion of 12 above the finger 13, and thus allows the spring 14, which is set-screwed to shaft 15, to give the shaft 15 a part of a revolution, and cause the belt fork 16 to move the belt 4 from the fast to the loose pulley, and stop the spiked lattice.

When the scale pan is banged down and held as described, the small spur-wheel S, Fig. 64, is brought into working contact with the rack T, which is connected to the wheel U by a connecting-rod as shown; this wheel is given an intermittent motion by means of a chain V, which drives the chain or sprocket-wheel behind U. The intermittent motion of the wheel U is controlled by the cam W that is fixed to a sleeve, carried by a stud that is bolted to the framing. This sleeve is given a continuous motion from the front shaft of the feed sheet, to which is fixed the bevel-wheel X, by means of other bevel-wheels and connecting-shaft as shown, the last bevel-wheel Y of the drive being fixed to the sleeve. As the sleeve rotates, the point of the cam W makes contact with and depresses the lever Z, thus raising the other end, which is weighted, and that has connected to it the rod 23. The rod 23 is in this way raised sufficiently to cause it to clear the projection 24 on the space-wheel 25. It should be remarked that the rod 23 is prevented from moving laterally or sideways by the bracket 26.

The space-wheel 25, which is 9 in. in diameter, is weighted at that side of its centre to which the projection 24 is fixed, by the opposite side having two pieces of metal removed as shown; apart from these, the wheel is an ordinary toothed plate-wheel. When the wheel 25 is in the position shown, the part that is at the bottom centre or nearest contact with the driving spur-wheel 27, which is fixed to shaft 3, Fig. 65, and hence is constantly revolving when the machine is in motion, has a space equal to three teeth; apart from this, it has teeth all round its periphery. Consequently, when the rod 23, Fig. 64, is in contact with the projection 24, the wheel 27 can give no motion to the space-wheel; but as soon as the rod 23 is raised, the heavy side of 25 causes it to move round, and thus its teeth are caused to mesh with the spur-wheel 27, which turns the wheel 25 until the projection again makes contact with the rod 23. The turning of wheel 25 drives the chain V, and hence wheel U, which moves the rack T horizontally, first in one and then in the other direction, and turns the scale pan half-way round and back again, thus emptying the material on to the feed lattice.

RESTARTING SPIKED LATTICE.—On the same sleeve as cam W, Fig. 64, is the stud 28, which, as the sleeve revolves, comes in contact with the lever 29, the opposite end of which is weighted so as to bring it back automatically to its normal position after the stud has ceased to act upon it. This lever is fixed to the shaft 30, which extends through the machine to the opposite side. Consequently, the stud 28 causes the shaft to make a partial revolution according to its range of action. The partial revolution of the shaft 30, Fig. 64, causes the bell-crank lever 17, Fig. 65, which is fixed to the shaft at the opposite side of the machine, to be given a corresponding part of a revolution, and the bottom arm of this lever is moved to the right. To the bottom arm of the lever is fixed the rod 18, the other end of which passes freely through a hole in the bracket 19, that is fixed near the bottom of the upright shaft 15. The end of rod 18 is threaded, and behind the bracket 19 two lock-nuts are fixed on it, so that the rod only acts on the bracket when it is moved to the right as explained. Thus, after the scale pan has been emptied the lever 17 is operated, and the rod 18 turns the bracket 19, and hence gives the upright shaft 15 a part of a revolution sufficient to cause the belt fork 16 to move the belt 4 on to the fast pulley and restart the spiked lattice.

As the movement of the lower arm of the bell-crank lever 17 and the rod 18 in the direction just described is taking place, the upper arm of the lever 17, to which is fixed the stud 20, is being moved upwards, and since the stud works in the slot of lever 21 fulcrumed at 22, it moves the pulley 7, carrying the pins that serve to bang down the scale pan when the weigh is completed, to the left, and thus takes the pins from contact with the plate 8, which then rises, due to the counterbalance weights. When the weighted end of lever 29, Fig. 64, turns shaft 30 back to its normal position, it causes the upper arm of lever 17, Fig. 65, to move downwards, and move the lever 21 and pulley 7 forward, so that when the scale pan again descends, the pins in the pulley will be in such a position that they can act on the plate 8 and bang down the scale pan. The rod 18 will also be moved to the left so as to allow the bracket 19 to move a sufficient distance round to allow the belt 4 to be moved to the loose pulley before the bracket makes contact with the lock-nuts on 18. A light flat steel spring which is not shown, but one end of which is in contact with the stud of the spur-wheel S, Fig. 64, and the other with the lever 29, assures that the scale pan is lifted when the wheel 7, Fig. 65, is forced to the left, and the pins are moved from contact with plate 8.

When the spiked lattice has been started as described, the shaft 15 carrying the belt fork 16 is locked in position until the weigh is completed and the scale pan is banged down, by the catch bar 12, the cut-out portion of which drops on to the finger 13, when the shaft 15 has been moved so far round as to cause the belt fork 16 to move the belt 4 on to the fast pulley.

The trap door which prevents any material dropping from the spiked lattice or stripping comb when the weigh has been completed is smartly closed by the weight 31, Fig. 64, being allowed to drop, through the arm 32, Fig. 65, which is set-screwed to the upright shaft 15, being moved round to the left and away from a lever that is fixed to the trap-door shaft, when the belt 4 that gives motion to the spiked lattice is moved from the tight to the loose pulley. As the belt is moved to the fast pulley after the scale pan is emptied, the arm 32 is moved round to the right, and the trap door is opened, due to the arm acting on the lever referred to, the movement of the arm 32 in this direction, of course, raises the weight 31, Fig. 64, which is connected to the trap-door shaft.

Defects and Remedies.—Defects that occur in automatic hopper feeds may be due to incorrect timing or setting of the parts; to parts in a bad state of repair, or parts requiring renewal; and to some inherent defect in the principle of construction. The timing and setting of the parts should receive careful consideration—since, for example, if the tippling motion should be so timed in relation to the other parts as to operate before the pan has received its usual weight of material, a weigh will be missed, and as the pan will not have deposited any material on the feed sheet, there will be an empty space, which must be filled by hand.

When starting a fresh blend all the parts must be timed and set with a view to obtaining regular and even feeding of the material. The beater should be set to the spiked lattice so as to do the required opening, and the speed of the lattice should be such that the scale pan will contain the required weight of material, and will consequently have dropped when the tippler motion commences to operate. To allow for blends varying as regards density or loftiness, and hence as regards the ease with which the material is taken by the spiked lattice, the speed of the latter is altered by changing the wheel which drives the spur-wheel fixed to the spiked lattice shaft. The change-wheel is altered only when a considerable change as regards the blends run is made. It can, however, be altered to give an increase in speed of as much as 25 per cent. of its lowest normal speed. Both the wheels referred to are shown in Fig. 65.

When carding low counts, or the machines are speeded up to get a high production, a larger change-wheel is necessary to speed up the spiked lattice, so as to fill the scale pan and cause it to drop before the tippler motion commences to operate. But when carding long-stapled, tethery material, a smaller change-wheel will be necessary, since the speed of the spiked lattice must be decreased to give the beater time to properly open the material. There is, of course, little likelihood with such material of the scale pan not getting a full weigh, even when the hopper is nearly empty, owing to the readiness with which it sticks to the spikes. To increase the opening action of the beater both its speed and length of stroke may be increased. The same effect is also produced by setting it closer to the spiked lattice. It should always be observed that the beater is set and operated in such a way as to cause the scale pan to be equally filled, and not contain more material in one part than another. The pan when filled drops into position to be emptied, and simply remains stationary until the tippling mechanism commences to operate. In this connection it will be useful to remark that low, dense, short-stapled material is more difficult to feed into the scale pan than long-stapled and lofty stuff, and the nearer vertical the spiked lattice is set, and the fewer the pins or spikes per lath, the more difficult does it become for the spiked lattice to take the material from the hopper.

A point to aim at when setting and timing the parts is that of providing the maximum time between the filling of the pan with the required material, and the operation of the tippling motion. If it is found that the licker-in is taking the material from the feed rollers in an insufficiently divided state, and the parts named are in good condition and properly set and speeded, the defect is probably due to the beater, which removes the excess material from the spiked lattice, being set too far from the latter.

Generally, the greater proportion of pure wool—that is, wool as distinct from remanufactured fibres such as shoddy, mungo, and extract—a blend contains, the greater is the area of the feed sheet that a given weight will cover. Consequently the scale pan must be timed to deposit its weigh at less frequent intervals, to allow time for the previous weigh to be carried out of the way. The tippling mechanism is caused to operate at the proper time by placing a change-wheel of the correct size in the train of gearing which gives motion to the mechanism in question.

Incidentally it might be helpful to note that hopper feeds which are quite satisfactory for low classes of materials of a heavy nature have been found to be too small for blends that are intended to be spun into yarns for khaki and blue-grey cloths. These blends being lofty and bulky, require much larger scale pans; and the whole hopper requires building higher, so as to provide sufficient room for the material deposited on the feed lattice to be quite clear of the scale pan.

There is usually very little difficulty as regards depositing the material into the scale pan from the spiked lattice, though in the case of very short materials, owing to their tendency to lie in small lumps below the surface of the spikes, it is not easy for the stripping brush effectually to remove all the material, and especially is this the case when the spiked lattice is moving at a good speed. If a fair percentage of the material is not swept off by the stripping brush, it may cause the scale pan to fail to drop, and in the case of the Cliffe feed a weigh will be missed; while in those machines where the scale pan is arranged to deposit the material it contains at fixed intervals, there will be a light weigh, which will result in uneven rovings. To prevent the material that the stripping brush fails to remove from leaving the machine, a board is set about one inch from the spiked lattice, which extends almost from the top of the lattice to the curved grating at the bottom.

With regard to defects caused by certain parts being in a bad state of repair, or parts requiring renewal, these are generally fairly obvious, as also are the necessary remedies. For example, if the belt which drives the spiked lattice is slipping, and thus prevents the scale pan from receiving the required weight in time, it should be made as clean and pliable as possible, or, if worn out, renewed. If the gearing, or any part, becomes defective through wear, the necessary steps should at once be taken to repair or renew such parts.

Those defects which may be classed as due to the principle of construction comprise both lack of sensitiveness and unreliability of the weighing mechanism, and the amount of skill that is required to set the machine. In the case of those machines in which the stripping brush stops, and those provided with a trap door, there is no material swept into the scale pan after the pan has got its weigh. Both of these arrangements prevent any addition to the normal weight of the material in the scale pan, and thus even weighs are obtained at all times. A little consideration will show that the defect resulting from not making provision against preventing the addition of material after the scale pan has received the normal weight, is cumulative, since the extra weight added would gradually decrease as the hopper became empty, and consequently the rovings would gradually decrease in weight until the hopper was refilled.

METHODS OF OPERATING SCALE PAN.—The question of operating the scale pan so as to deposit the material on the feed lattice has received much consideration, and of the three methods in use the best appears to be that in which the pan turns completely round. If it only turns half-way round and back again, as in the case of the Cliffe feed, there is a greater possibility, when running on blends composed of long and lofty materials, and where large weighings are necessary, of some material failing to be deposited than with pans which turn completely round. This defect, when it occurs, can be minimised by increasing the size of the whole hopper, and especially the size of the scale pan. The third of the three methods referred to is where the sides of the scale pan are hinged as shown in Fig. 66. In this case the scale pan A is in the form of two wings B and C, each of which is fixed at D and E to levers F and G respectively. A pin H which is fixed to lever F works in a slot in lever G. The wheel J receives motion by bevel gearing and a connecting-shaft from the front roller of the feed lattice, and drives the wheel I, which carries a pin K. When this pin comes in contact with the projection on the lower arm of lever L, the upper end presses down the pin H and opens the wings, with the result that the material is deposited on the feed lattice. The weight M is for the purpose of closing the wings as the pin K moves from contact with the projection; while the weight N is for the purpose of keeping the projection on the lower arm of lever L in contact with pin K, and ensuring that it will return to its normal position after a weigh has been deposited on the feed lattice. Though with this method sufficiently satisfactory results are usually obtained, it has the defect in practice that every time the pin K comes round, whatever material is in the pan is deposited on the feed lattice. Consequently, if through the hopper having been neglected it has run low, the full weigh will probably not have been made before the emptying mechanism commences to operate, which will result in light weighs. Also, as the hopper empties gradually, the first light weigh is only a trifle too light; but the second will be still lighter, and several light weighs may elapse before it is sufficiently serious to be noticed. The light

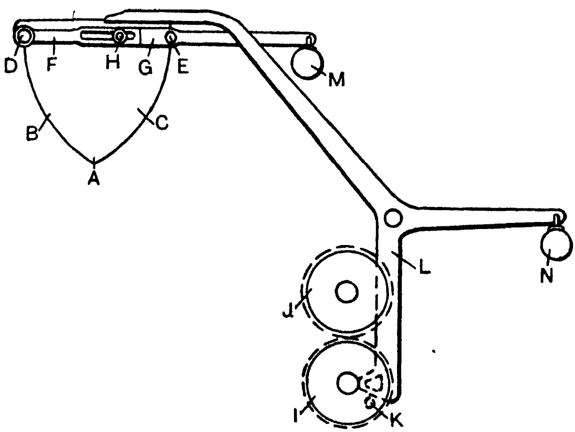


FIG. 66.

weighs will, however, have passed into the machine, and some bobbins will contain rovings smaller than they should be. In those cases where, if the scale pan contains less than the normal weight, a weigh is missed, there is an empty space on the feed lattice, and if this is unnoticed, the sliver as it leaves the scribbler will probably break.

CHANGING WEIGHT OF MATERIAL FED TO SCRIBBLER.—The weight of the material fed to the scribbler may be changed by means of change-wheels at the feed lattice and doffer, as well as by means of the adjustable weight on the scale-pan levers. This weight is generally termed the jockey weight. It is good practice to make the necessary change by means of one or both change-wheels, and use the jockey weight for making any adjustment that may be required due to the difference as regards the loss in weight during the passage through the machines between the two blends. For making small changes it will be necessary to alter one only of the change-wheels. The prevalent practice, however, with carding engineers is to make the requisite change by means of the jockey weight alone, since it is handy and it saves the trouble of making the necessary but simple calculations.

The following rule may be applied to find the correct change-wheel, whether the feed lattice change-wheel or the doffer change-wheel is used.

Rule: Multiply the number of yards per ounce, or the counts, being carded, by the number of teeth in the feed lattice change-wheel, and divide this number by the yards per ounce or the counts it is desired to card.

Example: Assuming that 8 skeins roving is being produced with a feed lattice change-wheel containing 16 teeth, what size of change-wheel will be required to change if it is desired to $6\frac{1}{2}$ skeins?

Solution: By applying the rule the number of the teeth will be—

$$\frac{8 \times 16}{6{\cdot}5} = 19{\cdot}7, \text{ practically. (Ans.)}$$

A 20-tooth wheel would be used, and any difference due to the slight discrepancy between the calculated wheel and the actual wheel used will be neutralised by suitably adjusting the jockey weight.

If the change is made by altering the jockey weight, the distance which it is necessary to move it may be calculated by a modification of the same rule, which is as follows—

Rule: Multiply the number of yards per ounce, or the counts being carded, by the distance from the knife-edge or centre of the fulcrum of the scale pan to the centre of the jockey weight, and divide by the yards per ounce or the counts required.

Example: Suppose that 8 skeins roving is being carded, and the distance between the centre of the fulcrum and the centre of the jockey weight is 8 in., what must be the distance if it is desired to change to $6\frac{1}{2}$ skeins?

Solution: Applying the rule, the distance will be—

$$\frac{8 \times 8}{6{\cdot}5} = 9{\cdot}84 \text{ in.} \quad \text{(Ans.)}$$

It should be remarked that the scale-pan lever carrying the jockey weight is marked in inches and parts of an inch, thus making it possible to make accurate adjustments.

When great changes have to be made—as, for instance, from 6 to 16 skeins—it may be necessary to alter at all three places. An example will make it clear how the changes are calculated.

Suppose that it is required to change from 6 to 16 skeins, and the feed lattice change-wheel has 16 teeth, the doffer change-wheel 48, while the centre of the jockey weight on the scale-pan arm is 10 in. from the fulcrum. How will the changes be calculated?

Solution: The first change may be made at the feed lattice. If the 16 wheel is changed for one having 12 teeth, the counts will be—

$$\frac{16 \times 6}{12} = 8 \text{ skeins.}$$

If the doffer-wheel is changed from a 48 to a 32, then the counts will be—

$$\frac{48 \times 8}{32} = 12 \text{ skeins.}$$

It now remains to make the last change to produce the 16 skeins—

$$\frac{12 \times 10}{16} = 7\tfrac{1}{2} \text{ in.}$$

CHAPTER XIV

INTERMEDIATE FEEDS

INTRODUCTION.—It has been explained that a set of machines consists of a scribbler and carder, or scribbler, intermediate, and carder. As these machines are quite separate, it is necessary to employ what is termed an intermediate feed to transfer or convey the material from one to the other. An intermediate feed is also essential in order to provide a means of levelling the material or minimising inequalities as regards the thickness of the sliver. No matter how accurately the hopper feed is set and timed, it can never make the delivery level and even across the whole of its width. All the weighs that are deposited on the feed lattice may be exactly alike as regards weight, but one side may be heavier or have more material than the other, and consequently one side of the machine will be fed thicker than the other. This is accentuated if a few teeth or pins are broken from the spiked lattice; if the stroker or levelling comb is set nearer to the spiked lattice at one side than the other; or if the material is thrown into the hopper towards one side. The intermediate feed also provides an opportunity for rendering the mixing or blending more uniform by means of doubling.

TYPES OF INTERMEDIATE FEEDS.—In practice there are three types each with distinct advantages. One notable point with regard to each of them is that the material is presented to the feed rollers, and hence to the licker-in of the carder, with the fibres sideways or parallel to the working face of the card, which is the opposite direction from that in which they are drawn from the doffer of the scribbler. In Continental practice elaborate arrangements have been devised to cause the fibres to be fed into the carder with their ends first or as they leave the doffer. This gives the yarn a smooth appearance, somewhat resembling a worsted thread, and in some cases the appearance is quite distinct from the decided woolly appearance which is typical of the British system of woollen spinning. One result of feeding the fibres sideways is that it is always advisable to have a carder with two swifts in order that the material may be approximately straightened, whereas the carder in typical Continental sets never has more than one swift, and in most cases quite satisfactory results are obtained.

The three types of feeds referred to are known as the Scotch, the Blamire, and the ball-and-bank feed. With the Scotch feed the material stripped from the last doffer is drawn to one side in the form of a sliver, and by an overhead lattice is conveyed to a point about in the middle, but over the feed lattice of the carder. A traversing carriage lays the sliver across the full width of the feed lattice of the carder, which, as it moves slowly forward, causes the sliver to assume a close zigzag form.

It will not be out of place to refer to a modification of the Scotch feed termed the Apperley or harp feed, in which the sliver is rolled into a soft rope and laid diagonally across the carder.

In the Blamire feed, which is also known as the blanket-and-batt feed, the web from the doffer falls on to a lattice that is moving at the same surface speed as the doffer, and when the web reaches the end of the lattice it is passed between tin rollers. These deposit it on to another lattice underneath, which is moved bodily on rails to and from the doffer a distance equal to the width of the carder, and in this way the web is doubled over itself some 50 or 60 times, thus producing a thick lap. This lap is wound on to a lapstick at the end of the lattice by the latter being given a slow motion in addition to that given bodily. Two of these lapsticks are laid on the feed sheet of the carder to be fed simultaneously, and in this way the doublings are still further increased.

In the ball-and-bank feed the material is drawn from the side of the last doffer of the scribbler, and is wound on to a small wooden bobbin in the form of a ball or narrow cheese. About 80 of these cheeses are arranged in a creel, and by means of a guide are fed on to the feed lattice of the intermediate so as to occupy the full width.

Details of Scotch Feed.—Beneath the doffing comb is an endless lattice A, Fig. 67, which is 7 in. wide, and on to this lattice the material drops from the comb. As the upper part of the lattice is constantly moving to one side, the sliver is delivered at one side of the machine. When the web leaves the doffer it is practically the same width as the length of the doffer; but as it falls on to the lattice it is pulled sideways, and thus condensed to a width slightly less than that of the lattice, and is thus made thick and strong to enable it to withstand the tension incidental to its transference from one machine to the other. A great improvement in the newer types of machines is the adoption of a metal lattice which is positively driven by a roller with six wings, each wing in turn fitting suitably inside the proper parts of the lattice. This kind of lattice will run for years if kept quite square and made to run true on the rollers. It can also be run slack if necessary. The height of the lattice can be regulated as desired by simply raising or lowering the bearings carrying the rollers round which the lattice passes. If the lattice is too low, the material is not carried away in the proper manner as it is doffed, but makes a small roll under the comb until it drops by its own weight, after which it begins to form another roll, and so on. The result is the production of a sliver full of lumps and thin places, in consequence of which it often breaks. Provision is also made for adjusting the lattice as regards slackness, by fixing one of the brackets carrying the guide rollers so that it can be adjusted horizontally as desired.

To make a rounder, straighter, and more solid sliver, and reduce the tendency of the edges to catch and cause the sliver to break, a batting engine or sliver motion is generally used. Many forms are made, but the object of each is to pat the sides of the sliver with two smooth plates, just as it enters the squeeze rollers. The plates are given the required motion by means of two eccentrics that are fixed to a short shaft, which is driven at a speed of 120 revs. per min. by a band and pulley from the fancy; the band and pulley are shown at B in Fig. 67. It should be noted that when the smooth plates become coated with grease they tend to make the edges raggy.; but this tendency is very much greater when fixed guide-plates become greasy. As the sliver reaches one side of the doffer, it is passed between two or three heavy iron rollers, which press and solidify it sufficiently to give it strength to pass to the overhead lattice without breaking.

The lattice A, Fig. 67, and the heavy iron rollers, are driven as shown by means of a large spur-wheel on the doffer shaft, which gears with a smaller spur-wheel, that is also a change-wheel, and with which is compounded a bevel-wheel that drives a similar bevel, which is fixed to the shaft carrying the front roller or drum around which the lattice passes.

On the front roller shaft, and on the same side of the roller as the bevel-wheel, is a spur-wheel which gives motion to the iron rollers as shown. The shafts of the three iron rollers fit loosely in slotted brackets; but, though the rollers are of equal size, the spur-wheels by which they are driven are each one tooth smaller towards the top, and consequently the sliver is tightened and slightly drawn

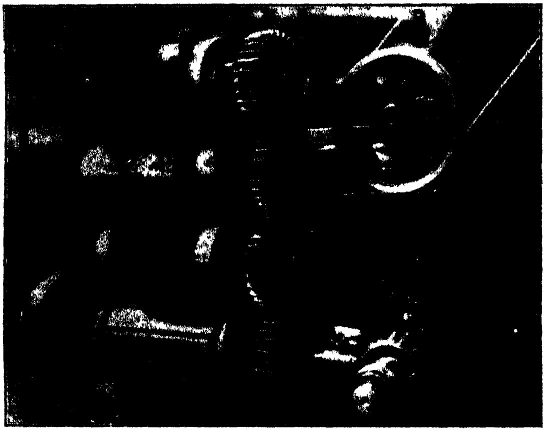


FIG. 67.

between the rollers. On the extreme outside end of the front-roller shaft is a grooved pulley in which runs a band that drives the overhead lattice. Grooves of different sizes are employed, so that the sliver can be kept at the correct tension.

An alternative method of driving the lattice and iron rollers is where the front shaft is sufficiently long to enable the driving to be done from the other side of the doffer wheel from that shown in Fig. 67, otherwise the method is the same. This arrangement is, however, generally considered to be more stable.

The small peg between the change-wheel and the bevel-wheel on the same shaft is for the purpose of stopping the motion of the lattice and heavy iron rollers when required—as, for instance, during fettling. The peg passes through the sleeve which carries the bevel-wheel, into one of two holes in the short shaft to which the change-wheel is fixed, and when the peg is in the hole nearest the change-wheel the lattice and iron rollers are given motion; but when the peg is withdrawn and the sleeve is moved away from the change-wheel until the peg drops into the other hole, the lattice and rollers stop.

After the sliver leaves the iron press rollers it passes to the overhead lattice shown in Fig. 68, which is suspended from the ceiling or roof by a shaft C. To this shaft is fixed a crossbar D, that carries two tin drums E and F, and on the same shaft as the drum E is a grooved pulley that is driven by the band, which receives motion from the grooved pulley on the shaft of the front roller of the lattice referred to in connection with Fig. 67. A lattice passes round the two tin drums, which carries the sliver. On the same centre as F is pivoted a long lever G, which carries a drum H at one end, and a balance weight near the other end. Sometimes a lattice passes round the drum H as well as round drums E and F, but this is not always the case, as the sliver will usually carry quite well from F to H. The reason for supporting the drum H in the manner stated is to provide a means for keeping the sliver as it passes to the carder at the same tension at all times. As the drum H is approximately over the centre of the carder feed lattice, it will be clear that when the carriage, which lays the sliver on the feed lattice, is at the extremities of its motion, the distance between the carriage and the drum H will be greatest. For keeping the distance practically the same, one end of the band I is fixed to the stud on which H rotates, while the other end is fixed to the carriage. Consequently, as the carriage approaches the ends of its traverse it draws down the lever G, raising the weighted end, and thus prevents the sliver from being subjected to a too great tension; while as the carriage reaches the centre of its traverse the cord is released and the weighted end of lever G drops and raises the drum H, thus preventing the sliver becoming unduly slack. To ensure the correct action of the cord two studs are suitably fixed to the frame that supports the carriage.

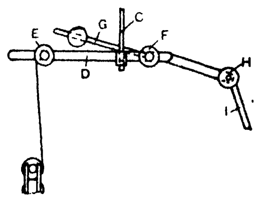


FIG. 68.

A neater method of balancing the lever G is by substituting a spring for the weight.

The principal part of a Scotch feed is that which is attached to the feed end of the carder, the work of which is to lay the sliver properly on the feed lattice of this machine. A front-elevation, plan, and side elevation of one of the newer types, as regards the part in question, are shown in Figs. 69, 70, and 71 respectively. Each part that appears in more than one view is given the same reference letter. It might be remarked that recent improvements with regard to Scotch feeds have been in the direction of making the driving of all the parts more positive.

Driving.—Motion is transmitted by belt from the first swift of the carder to the pulley J, Figs. 69 and 70, and compounded with it is the change-wheel K, which gives motion to the spur-wheel L, and hence to the main shaft of the mechanism M. The carriage receives motion from the shaft M through the spur-wheel N, which by means of an intermediate drives the pinion O. This pinion is fixed to a sleeve which at its other end carries the bevel gear P that gears with another bevel Q, with which is compounded a sprocket gear R that gives motion to the chain S. At the opposite end the chain passes round a driven sprocket-wheel, which is an idler and serves to limit the motion of the chain. A link of the chain carries the screw T, which is connected to the disc U, which in turn is fixed to the disc V, that carries a stud W, which works in the slot of the carriage X, and as the chain revolves it moves the carriage along with it from side to side. Should the traverse of the carriage require to be made longer or shorter, it is not necessary with the disc arrangement to let the chain slack or tighten it, or take out or put in links. As shown in Fig 71, the stud W will give the maximum traverse to the carriage, but if disc V is turned half a revolution with respect to the disc U, then the stud will always be on the inside of the chain, as shown in Fig. 69, and consequently the traverse of the carriage will be reduced to the minimum obtainable by the arrangement, which is, if the distance is 1 in. between the top and the bottom centres occupied by the stud W, 1 in. at each end, or a total of 2 in. on the whole traverse. The stud W, by turning the disc V with respect to U, the position of which is fixed, can be set to occupy any position between the top and the bottom centres, and hence any

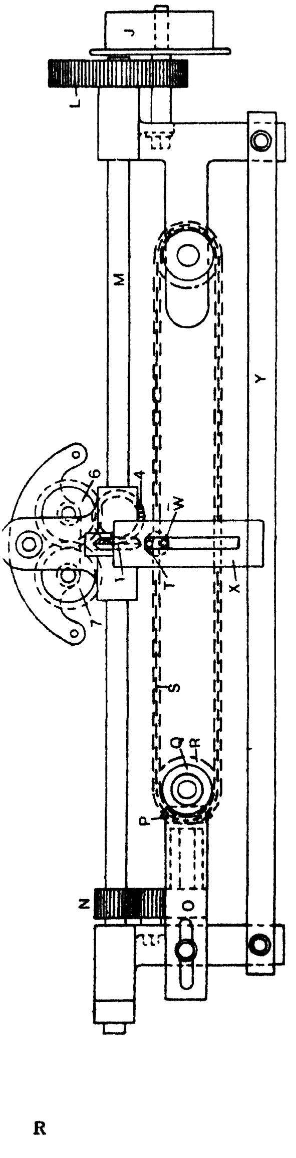


Fig. 69.

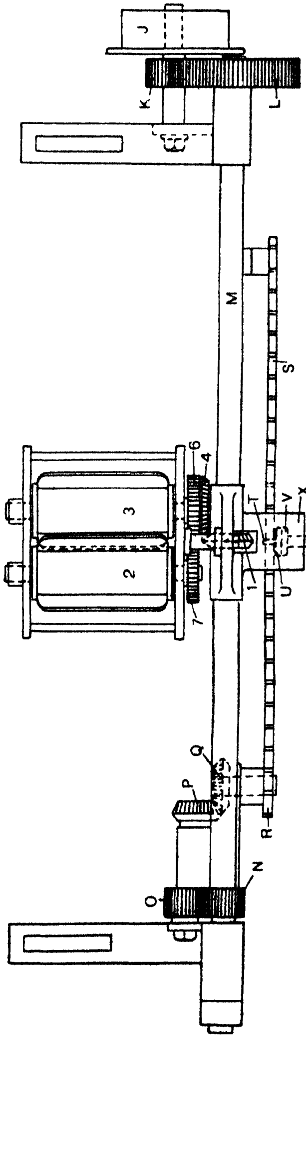


Fig. 70.

reasonable variation of the traverse can be obtained. The carriage is supported by, and slides along, both the main driving shaft M and the bar Y.

The carriage rollers are driven positively from the shaft M, Figs. 69, 70, and 71, which has a keyway cut in it practically the whole of its length, and in the carriage is a bevel-wheel 1. This wheel is free to slide along the shaft M; but as a projection or key fixed to the wheel fits in the keyway, the wheel rotates with the shaft. The continuous rotary motion thus obtained is transferred to the fluted carriage rollers 2 and 3 by means of the compound bevel and spur-wheels 4 and 5, the spur-wheel 5 giving motion to wheel 6, which is fixed to the end of the carriage roller 3, and wheel 6 drives a similar wheel 7 that is fixed to the shaft of roller 2.

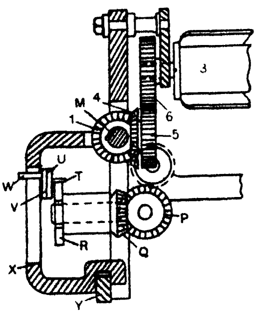


FIG. 71.

When the mechanism shown in Figs. 69, 70, and 71 is in action, there is a large sheet-iron shield or guard over the back of the feed, which covers all the chain part, and a bonnet is put over the carriage, that covers the wheels satisfactorily. Should, however, anything large enough to choke the rollers 2 and 3 get in—as, for instance, an operative's fingers,—roller 3 will rise and cease to act.

MANAGEMENT OF SCOTCH FEED.—The Scotch feed is popular, since it is simple and easy to manage, and when it has been correctly set for the work in hand it requires very little attention. The speed of the carriage is the most important point to watch when setting this feed, and it should be such that the sliver delivered from the overhead lattice will neither be dragged, which is liable to cause frequent breakage, nor allowed to become too slack, as a too slack sliver is liable to loop under the carriage and break.

The speed of the carriage depends on the quantity and the class of the material passing through. But it must be noted that the sliver has to be kept within reasonable dimensions, so as not to roll or choke in the side-drawing of the scribbler, and also so that it will enter the rollers of the carriage properly. If the back doffer is run as fast as the doffing comb can clear it, and it is required to thin the sliver down, a driven change-wheel at the side drawing can be altered, a smaller wheel being necessary to speed up the lattice of the side-drawing. The trouble that is caused by the sliver breaking frequently is often due to the fact that there is no drawing action on the sliver; this is remedied by speeding-up the lattice of the side-drawing relative to the doffer in the manner just described, which results in a much straighter sliver being produced. The carriage which lays the sliver on the feed lattice of the carder will also require speeding-up correspondingly. The speed of the overhead lattice, however, must at all times be such as to carry the sliver from the scribbler at exactly the same speed as it is delivered, without drag and without running slack.

When running on lofty stuff a greater traverse of the carriage is necessary in order to lay the sliver sufficiently near the edges of the feed lattice of the carder, because it does not lie as flat as the sliver produced from blends composed of materials of a low or close-lying nature, the edges of the sliver where it folds forming a greater curve in the former than in the latter case. Consequently, if a change were made from low to lofty materials without increasing the length of the traverse, it is quite likely that the waste ends would be absent at the condenser, due to the sliver not being laid sufficiently near the edges of the feed lattice. If the reverse occurred—that is, a change from lofty to sad materials without changing the traverse—the result would be that upwards of an inch of sliver at each side of the feed lattice would be chopped off and thrown on to the floor.

CHANGE-WHEELS.—By changing the carriage change-wheel K, Fig. 70, the speed of the whole mechanism is altered. This wheel must be altered when the speed of the last doffer of the scribbler is changed, in order to cause the carriage to take up the sliver correctly.

To find the number of teeth in the carriage change-wheel when the doffer-wheel is changed, the following rule may be employed—

Rule: Multiply together the number of teeth in the new change-wheel and the old carriage change-wheel and divide by the number of the teeth in the old doffer change-wheel.

Example: When the doffer-wheel is changed from a 42 to a

36, and the old carriage change-wheel has 30 teeth, the number of teeth in the new carriage change-wheel will be—

$$\frac{36 \times 30}{42} = 25 \cdot 7, \text{ or } 26 \text{ teeth.}$$

It has already been remarked that low and sad stock lies flatter, and so spreads at the sides, while the reverse is the case with lofty stock. Consequently, when a change as regards loftiness is made in the blend, either the traverse of the carriage or the speed at which the carriage rollers rotate must be altered, so as to ensure that the material will be laid correctly on the feed lattice of the carder. The change-wheel for altering the speed of the carriage rollers, and thus the rate at which the rollers deliver the sliver with respect to the speed of the traverse of the carriage, is that shown at 5, Fig. 71. If a change from a lofty to a sad blend is made, the change-wheel will require changing to one with one or two teeth less, so as to prevent the material from being fed beyond the width of the carder feed lattice, and *vice versa*. It must be remarked that a change of more than two or three teeth is never made as regards this wheel.

The requisite change in the traverse of the carriage can be made by means of the disc arrangement as explained when describing the mechanism of this feed. In some makes the chain is let slack by moving both the sprocket-wheels inwards, when only a slight shortening of the traverse is necessary; but when a considerable change is necessary, one or two links are taken out of the chain, as the case may be, after which the sprocket-wheels are adjusted accordingly. Whenever a change becomes necessary because of a change in the blend being run, it is best to alter the change-wheel, as when the chain has been once set it seldom requires any attention.

Should the material be laid too thickly on the feed lattice of the carder, the lattice should be run a little quicker, and if the feeding is too thin the speed of the lattice must be reduced. Any alteration in this respect does not affect the counts of the roving, as the carriage delivers the same amount of material in a given time whether the feed lattice is run quickly or slowly, the effect being to make the feeding of the carder lighter and more rapid, or slower and heavier, as the case may be.

MINOR POINTS.—It will be observed that with this feed the sliver must be able to support itself as it passes to and from the overhead lattice, and hence it is not suitable for the lowest-class blends; but there is not likely to be any trouble with blends that contain a little pure wool or much shoddy. A notable defect of the Scotch feed is that when the end of a lap leaves the feed rollers, it all goes up together in the form of a flake, which is anything from 12 in. to 1 yd. in length, due to the lap or layer of sliver being almost parallel with the axis of the rollers. This defect is of less importance in the case of a carder composed of two swifts than with a carder composed of only one swift. In the latter case the introduction of a tumbler between the licker-in and the swift is a great advantage, as it carries much of the material to the swift twice, since it clears the first worker.

APPERLEY FEED.—The Apperley feed, which was formerly used much more than it is to-day, has been superseded by the Scotch and Blamire feeds. As, however, it is still used on old sets of machines and is thought well of in the West of England, a brief description of it will not be out of place.

The web of material as it is taken from the doffer by the doffing comb is carried by the lattice of the side-drawing to one side of the doffer, and passed through a rotating funnel, which, besides forming it into a soft rope, gives it a certain amount of twist that strengthens it. This soft rope is carried by an overhead lattice to the carder, and a carrier similar to that on the Scotch feed lays the sliver diagonally on the feed lattice of the carder. To keep the loops of sliver formed by the carrier passing to and fro across the feed lattice in position, each time the carrier reaches the extremity of its motion in one direction it raises a latch, which falls back on to the loop as the carriage starts on the return journey, and thus prevents it from being drawn back. The edges of the feed lattice are also studded with short wires with a view to keeping the loops in position.

The most important point to observe with regard to the operation of the Apperley feed is to regulate the speed of the feed lattice of the carder so that sliver will be laid evenly and uniformly, since if the lattice travels too slowly the doublings will be crowded, while if it travels too fast the doublings will not be so close as to form one solid mat of material. The defect caused by each length of sliver being fed to the feed rollers of the carder almost parallel with the axis of the rollers is overcome in the Apperley feed by the sliver being laid diagonally on the feed lattice.

Blamire Feed.—Although the Scotch feed is being increasingly used, due primarily to the more efficient hopper feeds now made, it has by no means a monopoly. There are certain classes of the lower qualities of materials, such as the shorter-stapled mungoes, that are without the necessary length of staple and adhesive power to make a sliver sufficiently strong to support its own weight to and from the overhead lattice of the Scotch feed. These blends can, however, be done by lowering the lattice at the scribbler end and the roller over the carder, but a very low lattice is somewhat of an obstruction to the operatives. Moreover, whilst the sliver may run satisfactorily when the scribbler is clean, it runs much less satisfactorily after the machine has run a few hours and begins to be more or less filled up with dirt, because the carding action of the scribbler deteriorates, and the fibres being less straightened, the sliver is correspondingly weakened. Further, the accumulation of dirt on the comb or on the plates of the sliver motion causes small rolls on the edges of the sliver that catch on some part, or form a weak place that renders the sliver unable to bear its own weight, and in either case it breaks. To overcome these difficulties and obtain other decided advantages, such as increased doubling power and the advantage of the material not being unsupported for more than one or two inches at any point, the Blamire feed is still used.

The Blamire feed consists of a stripping motion, which removes the fibres from the last doffer of the scribbler and deposits them on a lattice that extends the full width of the doffer, and which carries the web of fibres straight ahead to a point a little farther from the doffer than the width of the carder. The lattice delivers the web to another lattice that is placed underneath and at right angles to the first, and the width of which is equal to the width of the carder. The second lattice is the one on which the material is formed into a thick lap, and it is supported in a suitable frame, the whole being given a reciprocating motion to and from the scribbler doffer, the extent of which is equal to the width of the carder, while the speed is the same as that of the upper lattice and the scribbler doffer. As a result of the motion just described, the web is folded layer upon layer, a layer being formed at each side traverse of the carriage to and from the doffer. In addition to the reciprocating movement, the lattice is turned slowly forward at each traverse, and hence each layer is deposited at a point slightly farther back on the lattice than the previous one. Consequently, a continuous lap is formed that varies in thickness, other things being equal, in accordance with the speed at which the lattice is turned.

The laps are fed to the carder, the feed lattice of which is made much longer than is necessary for a Scotch feed, as two of the laps,

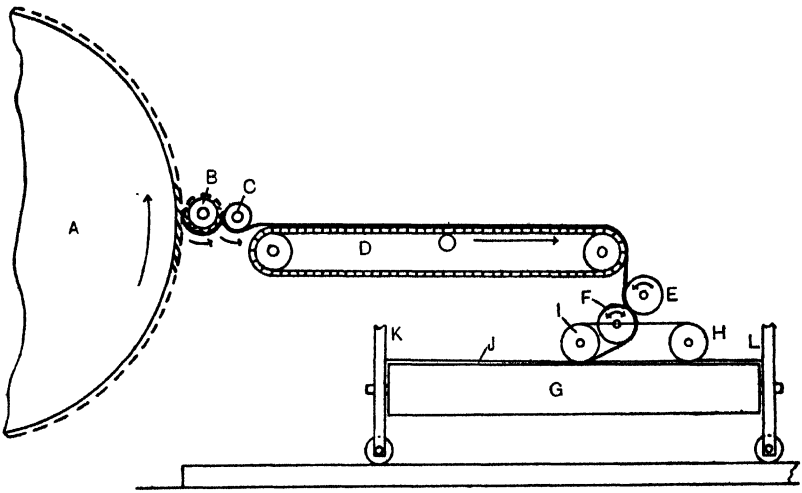


FIG. 72.

and sometimes three, are placed on it. The lattice supports the laps, and, as it rotates, the material is fed to the feed rollers with the laps superimposed, the material from the lap nearest the carder feed rollers being uppermost.

DETAILS OF BLAMIRE FEED.—A side elevation of the mechanism which works in connection with the scribbler is shown diagrammatically in Fig. 72. The stripping of the last doffer A of the scribbler may be done by means of either a doffing comb or a stripping roller. A stripping roller is preferable as it keeps the doffer sharp and clean, and gives the teeth that sharp, smooth finish which is typical of teeth in the best condition; it strips the material from the doffer in a more uniform thickness than the doffing comb, and requires much less cleaning; also with a stripping roller the danger of the web being broken is reduced to a minimum.

The stripper B, which is $3\frac{1}{2}$ in. in diameter and set about $\frac{1}{16}$ in. into the doffer, takes the material from it at the same speed as it is rotating, and is in turn cleared by the plain metal roller C, which is 2 in. in diameter and almost touches the stripper. In working, the stripper coats with grease, which effectually prevents the material remaining on the stripper and passing up behind the metal roller. The web of fibres from the metal roller is received by the long lattice D, that carries it to the two rocking tin rollers E and F, between which it passes. Motion is given to the lattice at the end farthest from the doffer, and the end nearest to the doffer is supported in U-shaped bearings, so that it can be easily lifted out and raised to allow the operative to stand inside when fettling. The frame supporting this lattice is carried at one end by the scribbler frame, while the other end is supported by two rods that are fixed to the roof. Two additional tin rollers H and I press on the lap as it is formed, so as to solidify it, and as they occupy a fixed position, their direction of rotation is reversed with the changing of the traverse of the carriage. They are generally rotated by a tight string J, which is fast to each side of the carriage at K and L; the string passes from K partly round H and I, and from I to L. The carriage which supports the lattice G is provided with wheels that run on rails as shown, and when the lap has to be fed to a 60-in. carder the carriage runs first to the right for 60 in., and then to the left for a similar distance. This motion is given to the carriage in some cases by a rack, which is operated from the doffer by means of a rack-wheel. This rack is a long bar that extends horizontally along the side of the scribbler, which is provided with pegs that are set about 1 in. apart, and gearing with these pegs is a small rack-wheel. As the rack-wheel revolves it forces the rack along, and the latter being connected to the carriage, it gives it a corresponding motion. The rack-wheel is fixed to the end of a long shaft that passes under the scribbler, and at the driving end rests in a bearing which allows a slight movement. At each end of the rack is a fork-shaped casting, which causes the pinion to keep in gear with the last peg of the rack and turn round it. Consequently, if, as the carriage is traversing in one direction, the pinion is above the rack and it is turned under it, the rack is moved in the opposite direction, and the motion of the carriage is reversed. At the other end of the rack the pinion is turned by the other fork from beneath the rack to the top, so as to drive the rack and the carriage in the original direction. This motion is very effective, but it is rather difficult to alter the length of the traverse, as pegs have to be inserted or withdrawn, as the case may be. The more modern drive is by means of a chain which travels over two sprockets, set the required distance apart. A rod is fastened to one of the links, and the carriage is moved in and out in a similar manner to the carriage on the Scotch feed.

In Fig. 73 is shown diagrammatically the details of the carriage as seen from the doffer end of the scribbler. The parts that are shown in

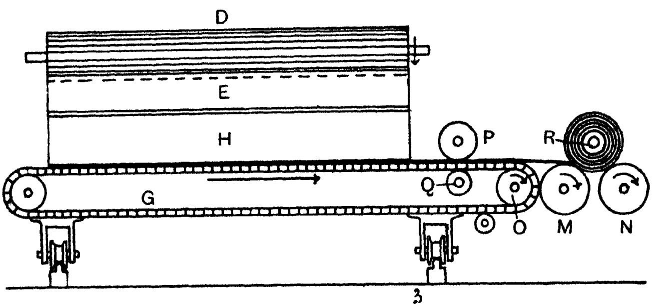


FIG. 73.

both Figs. 72 and 73 are given the same reference letters. The lattice G and the large wood rollers M and N are driven in the direction indicated by the arrows, by a sideshaft carrying bevel-wheels fixed on the shafts of the lattice roller O, and rollers M and N. As these wheels are turned only one or two teeth at each traverse, or alternate traverse, of the carriage, by means of a ratchet-and-pawl arrangement worked by the movement of the carriage from the floor, the motion of the rollers is very slow. From what has already been said it will be clear that, as the lattice moves forward, the web or lap gradually increases in thickness until almost the end of the lattice is reached, at which point it is consolidated by a heavy metal roller P that rests on the lap, but is kept from moving laterally by the shaft ends resting in slots. A supporting roller Q is placed underneath to prevent the lattice from having to support the whole weight of the roller. After passing between the rollers P and Q the lap goes to the large winding rollers M and N, between which is a lap-stick R that rests in slots in the frame, and hence can only move vertically. At the commencement the end of the lap is put round the stick, after which it is automatically wound by frictional contact with the winding rollers, and when it reaches a diameter of about 24 in. the lap is broken off and replaced by an empty stick.

In Fig. 74 the laps are shown being run in at the carder. It is important that they should not require renewing at the same time, as it is obviously much more difficult to get a level joint when two new laps have to be joined at one point than when only one has to be joined. As a rule, when one is empty the other should be half-

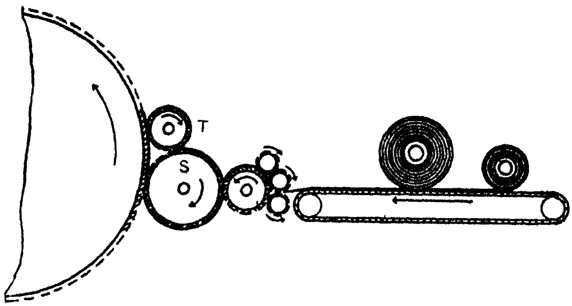


FIG 74.

full; and for the same reason the laps are run as full as possible so as to secure the minimum number of joinings. Fig. 74 also shows the introduction of the tumbler S in the feeding of the carder, which is a very decided improvement, as any flakes that pass the feed rollers are caught by the worker T, and returned to the tumbler. The tumbler is a greater advantage in the case of the Scotch than in the Blamire feed, as a flaky delivery is more in evidence in the former than in the latter.

MANAGEMENT OF BLAMIRE FEED.—If a change is made from a low blend to one composed of lofty materials, the web on the top lattice is liable to crimp due to running somewhat slack, which also renders it more liable to lap round the rollers through which it passes to the bottom lattice. In addition, soft laps are produced if the web is laid on the bottom lattice in a crimpy condition, as a crimpy lap when wound on the lapstick is not as readily compressed and as firm as a lap in which the web has been laid quite straight. A soft lap, especially when large in diameter, is not revolved as evenly by the feed lattice of the carder as a firmer lap, and the more its shape differs from the circular, the more likely are stretched laps and thick feeding to occur. To remedy this defect the driven wheel on the end of the rack pinion shaft, which is driven from the doffer-wheel through an intermediate, is changed for one with, say, one tooth less. This results in the stepped rope pulley, which is fixed on the rack pinion shaft close to the change-wheel referred to, being driven at a greater speed, and hence the rope drives the front roller of the top lattice at a greater speed, and consequently the web is kept tighter, and also, if anything, a little thinner. This change also increases the speed of the bottom lattice.

If a change is made from a low to a lofty blend, and the web crimps on the top lattice, its speed may be increased by placing the driving rope on a larger step of the rope pulley without affecting the speed of the bottom lattice. The effect of this change is to cause a greater length of web to be delivered by the top lattice for each traverse of the bottom lattice, and consequently a wider lap is formed on the bottom lattice if the length of the traverse is not correspondingly reduced.

If trouble is caused by the web breaking frequently, and lapping round the rollers, it is usually due to the speed of the whole feed being too great, and to remedy this the change-wheel should be altered for one, say, a tooth larger. It is important that the laps should be the correct width, since if they are too wide the edges are compressed by the guide plates which regulate the width of the lap that is fed to the carder. Consequently not only are the waste ends unduly thick, but the adjoining ends are also liable to be thicker than the remainder, which results in uneven roving. It might also be remarked that to obtain ends at the edges of suitable thickness it is also necessary to make laps with straight edges.

It is good practice to put up the laps made prior to fettling the scribbler at the carder immediately after the latter has been fettled, because the laps made by the scribbler just before fettling are composed of material that has not been well opened and cleaned. Consequently, by feeding these to a clean carder they are treated to the best advantage, and the carder is filled with material without deteriorating the rovings that are produced from these laps.

OTHER TYPES OF LAP FEEDS.—Besides the Blamire there are several other types of lap feeds, but they are almost unknown in this country. In one type, which is perhaps the oldest of any form of intermediate feed, the web from the scribbler doffer is wound on to a hollow drum that is about 5 ft. in diameter. After the drum has made a certain number of revolutions, it automatically opens parallel to its axis along a certain point of its circumference, and thus breaks the lap, which drops on to the floor. The lap is, of course, composed of a number of superimposed sheets of the web as it leaves the doffer, and as each lap is made it is fed to the carder.

Another form of this type of feed is that in which to form a longer lap, the web is wound round a very long lattice as many times as is necessary to form a lap of the required thickness, when the lap is broken, and wound off on to a stick to put in round form.

BALL-AND-CREEL FEED.—The ball-and-creel feed, or, as it is sometimes called, the ball-and-bank feed, is seldom used, except in the very highest-class trade, where quality is the only consideration and very fine counts are spun; as, for instance, in the fine flannel and the high-class cheviot mixture trades, since in these trades perfect evenness as regards thickness, colour, and quality is necessary. When this feed is employed the set of machines is always composed of three—a scribbler, an intermediate or clearer, and a carder, with the ball-and-creel feed between the scribbler and the intermediate.

The ball-and-creel feed cannot be used, except in very special cases, to feed the carder, because the slivers from the balls in the creel are passed straight to the feed rollers of the machine to be fed. Consequently, if the carder was fed in this manner, and there were 72 balls in the creel and 72 rings on the ring doffer of the condenser, if one ball gave out and was not immediately noticed, and replaced with a new one, it is quite likely that one ring of the ring doffer, or tape in the case of a tape condenser, would be without, or almost without, material where such a place occurred, which would mean a broken or very unsatisfactory roving at that point. Also, if one ball practically supplies one tape or ring, and it cannot supply more than two, all the inequalities of the sliver forming that particular ball would occur in the roving. In addition, as one ball gives out and is replaced, the piecings have a bad effect on the roving produced at the condenser. A notable advantage of the ball-and-creel feed is the ease with which balls of material of different shades may be introduced into the creel, thus making it possible to, in a measure, correct an unsatisfactory shade, and for this reason spinners of high-class mixture yarns, especially in Scotland, favour its use.

The balling head or machine is placed at one side of the scribbler, and the web from the doffer is made into a loose rope form by being drawn to the same side, and passed through a revolving funnel, that gives the sliver a certain amount of twist which enables it to reach the balling head successfully.

The rope of sliver is guided to the bobbin on which it is wound by means of rollers and a spout. To wind the sliver on the bobbin properly, the spout and rollers are given a traversing motion of about 3½ to 4 in. by being carried by an arm, to the underside of which is fixed a peg that projects into a groove in the surface of a rotating cam. The bobbin is revolved by frictional contact with a drum, and when it has reached a certain size, that is controlled through suitable mechanism by means of a change-wheel, it is automatically replaced by an empty one.

When from 60 to 120 balls have been prepared as described, they are set on edge in the creel, which is fixed behind the intermediate or clearer carding machine. There are usually four or five rows of balls in a full creel, and the sliver from each ball is passed between guide wires that keep them close together and ensure that a thick web of material will be fed as evenly as possible. The creel consists of two vertical stands which carry the bearings that support the rotating rollers on which the balls are set. These rollers are driven by bevel and spur gearing from a shaft that extends vertically from the top of the creel to the bottom at one side; this shaft is driven from the feed rollers by means of a connecting-rod and bevel-wheels. To keep the balls separate during unwinding, rods are fixed vertically in the creel. It might be mentioned that as the balls are frictionally driven the sliver is fed to the intermediate from each ball at the same speed, whatever the size of the ball may be.

Summary of Requirements of Intermediate Feeds.—The ideal feed should occupy a small amount of floor space, as space is usually valuable. It should be continuous—that is, the sliver should be automatically carried direct from one machine to the other, and its action should, as far as possible, be positive, so that the minimum amount of attention will be required in its operation. It should also allow, if possible, of one machine being run while another part is stopped for purposes of cleaning; as, for instance, with a set of two machines, when the carder is being fettled, and is thus stopped, the scribbler should be running, and *vice versa*. It should be simple in construction, so as not to be easily put out of order. It is also important that such a feed should have a high capacity for doubling, levelling, and mixing. It should also make as little waste as possible during and in the completing of the carding of any particular blend.

All the desirable features referred to cannot be obtained in one feed; therefore in practice it is necessary to compromise, as each kind of feed has some of the advantages mentioned, whilst lacking others. For instance, it is an advantage for the carder to be working when the scribbler is stopped, but the principle of the construction of the continuous type of feed precludes its adoption should this advantage be necessary. Again, as previously mentioned, it is desirable that as little waste as possible should be made when finishing carding any particular lot, which means that the scribbler must be able to run almost as late as the carder, so that the waste can be put back into the hopper of the automatic feeding and weighing machine. Consequently, a continuous feed must be adopted where it is found necessary as nearly as possible to use up all waste. The doubling power of the various kinds of intermediate feeds is also an important factor in determining which kind to adopt.

SPACE OCCUPIED.—The amount of space occupied by the various kinds of intermediate feeds is, as previously noted, an important matter, its importance varying with the locality in which the mill is situated, the size of the building, and the room or rooms in which the carding machinery is to be placed, along with other factors, such as the class of material to be carded, and so on. The Scotch and Apperley feeds occupy by far the least amount of space, only about 1 ft. being required between the scribbler and the carder, and on this account alone the Scotch feed is in very many cases adopted. The large amount of space that must be allowed for a Blamire feed is perhaps the greatest drawback to its more general use. Generally the carder is arranged to follow the scribbler in direct line down the length of the carding room when a Blamire feed is to be used, so that the lower lattice and carriage can run underneath the feed lattice of the carder and thus economise in space; but even when arranged in this manner a distance of about 15 ft. is required between the doffer of the scribbler and the feed rollers of the carder in the case of a 5 ft. 6 in. scribbler and a 5 ft. carder. The ball-and-bank feed requires more floor space than the Scotch feed.

CONTINUITY OF ACTION.—With regard to their continuity of action, the various intermediate feeds have advantages which may be grouped as follows: (*a*) For material which is fairly long in staple and of a good quality the continuous feeds, such as the Scotch and Apperley, are considered to be the best, although the amount of mixing is not quite sufficient for the best-class trade. But for material which contains a fairly large amount of short and low stuff, the lap feeds, particularly the Blamire, are favoured, as with this type of feed the material is at no place unsupported for more than 1 or 2 in., which is a great advantage when carding very low materials. With the Scotch and Apperley feeds the sliver is entirely unsupported for a distance, and with very short, low stuff it may be too weak to carry over the overhead lattice without continually breaking. (*b*) When carding big lots or mixes of materials the non-continuous lap-and-ball feeds have the advantage that one machine of a set may be stopped for purposes of fettling while the other machine or machines may be kept running; but with continuous feeds all the machines are standing at once. Mention must, however, be made with regard to lap-and-ball feeds of the fact that when commencing a lot, the scribbler will have to run from two to three hours before a sufficient number of laps have been made, so that the carder may be started. The ball-and-creel feed is a good instance of this kind of feed, as it takes the scribbler upwards of a day to make a full set of balls that are required to fill the creel when running on the fine work for which it is generally employed. It will thus be seen that when the Blamire and the ball-and-creel feeds are used, from a half to a full day may be lost, since the carder may be so much behind the scribbler, but afterwards the machines are better employed. When carding small lots the continuous feeds have a decided advantage, as all the machines start or finish within a few minutes of each other.

As regards simplicity of construction, the Scotch feed is the best, apart from the old style of lap feed; but for purposes of comparison this latter type may be ignored. The Blamire feed is somewhat elaborate and complicated, and has a large amount of lattice area that requires to be periodically cleaned; further, when a full lap has been made two persons are required to lift it out and place it on the feed lattice of the carder without damage. The ball-and-creel feed is an even more elaborate and complicated feed, especially the balling head part, while the Apperley feed is not so handy as the Scotch feed, since it is not so simple.

Points where Doubling is Obtained.—The Scotch feed has the least capacity for doubling, levelling, and mixing. Mixing and doubling are, however, obtained at the following points: (*a*) By the side-drawing, as the fibres that are taken from the doffer nearest to the drawing-off and press rollers will enter the sliver much in advance of those fibres that are taken from the opposite side of the doffer. (*b*) By the slivers being made to overlap each other about half their width when they are laid on the feed lattice of the next machine; thus portions of at least two slivers are being fed into the feed rollers at any given moment. (*c*) By the feed lattice having a constant forward motion during the time that the sliver is being laid a slightly diagonal arrangement of the slivers on the feed lattice is obtained; consequently portions farther from each other of contiguous slivers will be fed to the feed rollers at any given moment than if the slivers were laid perfectly straight. But the fact remains that when a Scotch feed is used, if the scribbler were to produce a web of lighter weight for two or three minutes the condenser would produce rovings of lighter weight, though this is not likely to occur, seeing that automatic feeding and weighing machines have reached such a high state of perfection.

The Apperley feed has the advantage over the Scotch feed as regards mixing, in that portions of from thirty to sixty different slivers are fed into the feed rollers, the number varying according to the width of the machine to be fed and the size of the sliver. This is due to the sliver from the scribbler being laid diagonally on the feed lattice of the next machine. Should the Scotch feed be arranged to place the sliver in a diagonal form on the feed lattice of the carder, a similar amount of mixing would, of course, take place.

The number of doublings and the large capacity for mixing and levelling obtainable by the Blamire feed is perhaps unequalled when it is well managed. Each lap may consist of from 30 to 60 layers, and as 2 of these laps are laid on the feed lattice of the next machine, it will be seen that there are from 60 to 120 doublings; though this doubling power may be neutralised to a certain extent by careless piecing when a new lap is put to the carder. It might be remarked in passing that it is probably easiest with this feed to ascertain the condition of the material as it leaves the scribbler, since every facility is provided for examining the web as it is carried on the top to the bottom lattice. But with a little experience it is not difficult to tell whether the sliver has been well or badly carded in the case of the Scotch feed by merely handling the sliver. The Blamire feed is, however, losing favour, as the automatic feeding and weighing machine can be depended upon to give a uniform feed to the scribbler and thus produce as even and as good results with a Scotch feed as were formerly only producible with the aid of a Blamire feed. The mixing capacity of a ball-and-creel feed is very great, as considerable mixing takes place due to the web being drawn from the side, while still further mixing is done by feeding from 60 to 120 different slivers to the feed lattice of the intermediate. The number of slivers fed varies with the size of the creel, the size of the balls, and the width of the machine to be fed. Finally, there is the amount of mixing which is obtainable with a Scotch feed, as a feed of this type is used to convey the material to the carder from the intermediate.

Amount of Waste Made.—The amount of waste made by the different kinds of intermediate feeds is an important point. The waste which cannot be used up in the lot which is being carded is a great disadvantage of all non-continuous feeds, such as the Blamire and ball-and-creel feeds, as the waste made during the time that any particular lot is being finished cannot be put back into the automatic feeding and weighing machine, as the carder or intermediate must always be from half a day to a day behind the scribbler. With all continuous feeds, such as the Scotch and the Apperley, all the machines of a set must stop together, so that little actual waste is made. Another advantage of the continuous feed is that the result of a blend can be judged and corrected, if necessary, in a few minutes.

CHAPTER XV

CONDENSING

Object of Condensing.—Condensing is the last of the processes in connection with carding, and as the product is taken direct to the spinning mule from the carding, it is of the greatest importance that the work at this point should be as near perfect as possible. Moreover, any irregularities in the condensed roving are present in the yarn, and they also reduce the production at the mule. The web of fibres on the last swift has first to be divided into the requisite number of strips or ribbons of fibrous material, that have then to be made round and sufficiently adhesive to withstand handling and any subsequent tension to which they are submitted, and finally wound on to a long double-headed bobbin ready for spinning either on the ordinary mule or the ring frame. Consequently, the condenser may be said to consist of three parts that vary considerably as regards details, and even in principle, according to the type of machine and the work it has to perform.

Types of Condensers.—Condensers may be divided into two quite distinct types, that work on entirely different principles, and there are a number of modifications of each of these types the object of which is to render them as suitable as possible for different classes of material. The type that may be termed the English type is the ring doffer condenser in its various forms; while the other, which may be termed the Continental type, since it has been largely developed on the Continent, though it is now being extensively adopted in this country, is the tape or strap condenser. Until ten years ago it can be safely said that fully 90 per cent. of the condensers in use in Great Britain were of the ring dividing type, and that on the Continent 90 per cent. were of the tape dividing type. The rubbing and winding in each type are similar, the difference between the two being in the method of dividing the web of fibres from the last swift.

In the case of the ring-doffer condenser the film of the fibres on the last swift is divided by means of circular rings of card clothing or endless fillet, between which are spaces that vary in width according to whether one or two doffers are used. On the tape machine the doffer is completely covered with fillet, and an unbroken web the full width of the carder is taken off by a doffing comb or stripper. The web passes between two grooved dividing rollers carrying endless tapes, which divide the web into strips that are all equal in width. The ribbons of material are then rubbed into roving and wound on to the condenser bobbins in the usual way. Each of the two types of condensers has advantages for certain classes of work, and it may be said that the chief advantage of the tape machine is in the increased number of threads that can be produced when precisely the same material is being treated in each case, and it is this increased production that has led to the wider adoption in recent years of the tape machine in this country.

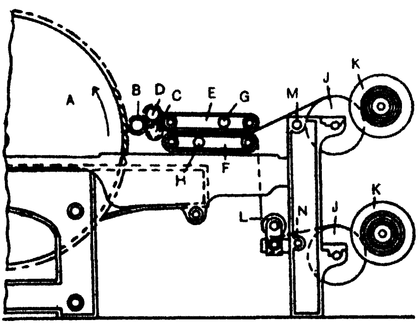


FIG. 75.

RING CONDENSERS.—There are three classes of ring condensers, each of which is suitable for certain classes of material. Fig. 75 is a diagrammatic sketch of the single-doffer, single-stripper, single-rubber machine, which is the simplest and earliest type. It consists of a doffer A that is 30 to 40 in. in diameter, and clothed with rings of fillet, carefully measured and cemented so as to be a tight fit. The wire is inserted quite over the joint, as a defective joint is not permissible, since it would cause a weak place in the roving if such an imperfection occurred, and for the same reason tacks cannot be used; consequently the rings must be made tight enough to remain in position, due to the friction caused by the tension. Between each ring is an endless leather tape cut to the width that will keep the rings in position.

The rings vary in number from about 40 or 48 to 75 for a 60-in.

carder. The latter number is about as high as can be satisfactorily employed, and to get the best results with so high a number the material must be very fine and short. When made for 48 threads the rings will be 1 in. wide and the leathers $\frac{1}{4}$ in.; for 60 threads $\frac{13}{16}$ and $\frac{3}{16}$ in. respectively; while for 80 threads the rings and leathers will be $\frac{5}{8}$ and $\frac{1}{8}$ in. respectively.

It is necessary to remove the material left on the swift due to the space between the rings, consequently the last worker on the swift is given a slow side traverse to distribute the material over the swift, though in some cases the doffer is given a slow side traverse of about 1 in. The web passes under the doffer because the doffer rotates in the direction indicated by the arrow, and is taken off by the small stripper B, $2\frac{1}{2}$-in. diameter, which revolves at the same surface speed with its smooth side running slightly into the smooth side of the doffer. The ribbons drop into the grooves of the dividing roller C, and they are prevented from going round the stripper by the top stripper or clearer D. The main purpose of the dividing roller C is more effectually to separate adjacent fibres, and give the ribbons a more rope-like appearance before they enter the rubbers, and as the ribbons are close together in this type of machine their use is essential. The shape of the dividing roller is not of first importance so long as every facility is offered for the ribbons to drop well into the bottom of the grooves, and they are separated as widely as possible.

The dividers support the ribbons and deliver them into the nip of the rubbing leathers E and F, which rub them into round, firm rovings. The rubbers are made from two pieces of leather which are tapered at the joint and cemented to make them endless; they run on rollers as shown, and to keep them in position leather buttons are riveted one inch from each end, the pitch or distance from one button to the next in the same row being about 2 in. Each row of buttons is just outside the shoulder of the rollers, and as both rollers and rows of buttons are set straight, the rubbers cannot work out of position. The rubbers are generally made 5 or 6 in. wider than the carder, and the buttons are 1 in. from the end of the rollers. The width of the rubbers, which is determined by the distance between the centres of the front and back shafts, varies from about 8 to 14 in., and rubbers 8 to 10 in. wide are termed short rubbers, while those 11 to 14 in. are termed broad. Broad rubbers are better than narrow, as the cardings are under the action of the rubbers for a longer time, and hence produce a more solid roving; also, the production is greater. Against this, however, must be set the fact that a wide rubber cannot be made as level and as perfect as a narrow one, since the size of a hide is limited, and it varies in thickness considerably between the shoulder and the tail, and the back and the belly.

Determining the size of the rubbers is often a difficult matter with the average overlooker, but in reality it is quite simple. The rollers are generally 2½-in. diameter, and approximately 8 in. in circumference; and as the circumference of the rubbers is twice the distance between the centres of the rollers plus the circumference of one of the rollers, since each rubber passes half-way round two rollers, the size or circumference of the rubbers in the case of a condenser with 9-in. centres would be $9 \times 2 + 8 = 26$ in.

To carry the material forward through the condenser the rubbers have a forward rotary movement, the speed of which is approximately the same as that of the doffer and the stripper. The rubbers also have a quick sidewise movement, as many as from 200 to 400 strokes per minute being made, the object of this motion being to roll the material into a round dense roving as it passes through. To assist further in solidifying the roving, one, sometimes two, hollow press rollers G and H are employed, which can be set nearer to or farther from each other so as to give more or less rubbing as desired. When two press rollers are used they are not placed directly over each other, but the lower one is placed nearer the back, while the upper one is placed nearer the front of the rubbers as shown, so that the pressure on the material as it passes between the rubbers will be even. Press rollers are almost always used except in the case of very narrow rubbers; an upper press roller only may be used in the case of 9-in. rubbers; while in the case of 11-in. rubbers and upwards two rollers may with advantage be used.

It might be mentioned that 6-in. rubbers, which would be used without press rollers, are only employed as the first pair in the case of what are termed tandem rubbers, which of late years have been increasingly adopted, and consist of the short pair referred to placed directly in front of the ordinary pair as shown in Fig. 76. The advantages accruing from their use are equally great on all types of machines, and include greater production, as they allow the cardings to be delivered quicker because of the increased rubbing power, and consequently it is possible to run the bobbin drums quicker and obtain roving equal to that obtained by condensers run at a slower speed and fitted with single instead of tandem rubbers. In this matter modern condensers are superior to the older types. In addition, there is the advantage, in the newer types, of a quicker rubbing stroke, obtainable by the lighter running eccentric motion as compared with the old-fashioned crank or "swiller" motion. Again, a condenser fitted with tandem rubbers is capable of condensing a greater variety of materials. This will be clear when it is

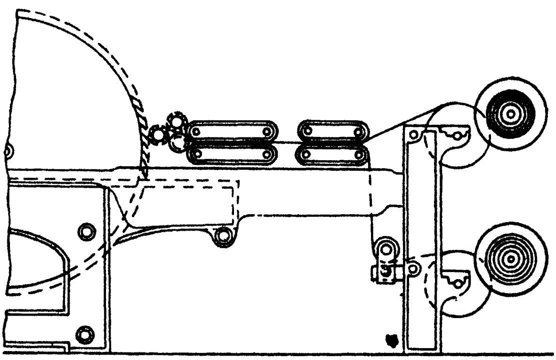


FIG. 76.

noted that the rubbing power can be increased only by increasing the speed of the sidewise traverse of the rubbers, that is, increasing the number of strokes per minute, by increasing the pressure, and by lengthening the stroke. The speed is limited by the design of the motion, and cannot be increased beyond a certain point without causing excessive vibration and wear; the pressure can be increased up to a certain point only, because after this point has been reached the cardings do not roll over, due to the action of the rubbers, but slip, and this produces the defect that it is intended to remedy; and the stroke is also limited, since, if it is increased beyond a certain limit, the threads tend to roll into each other through some slight inequality of the rubbers, or through the presence of long fibres. Moreover, long fibred wools are lofty and springy, and require more rubbing to make a solid roving, and yet the stroke must be as short as possible to prevent double ends.

With tandem rubbers the stroke of the first pair can be made so short as to prevent the cardings fouling or the production of double ends, but still cause them to be rolled up into the form of rovings; while the stroke of the second pair can be made much longer so as to cause them to solidify the threads. Another advantage of tandem rubbers is that, as the rubbers are narrower than single rubbers, they are not so likely to stretch unevenly, and consequently are less likely to produce uneven threads.

From the rubbers the rovings pass on to the condenser bobbins K, which rest by their own weight on the surface drums J. The bobbins consist of a wooden barrel 2 in. in diameter, and at each end is fixed a sheet-iron disc that is about 9 in. in diameter. Also, at each end of the barrel is a peg that projects from the barrel about 1 in. These pegs rest against stands secured to the machine framing, so that as the bobbin fills it may rise up. When the material is nicely over the top of the discs the bobbin is doffed—that is, the full bobbin is removed and replaced with an empty one.

There are various arrangements of condenser bobbins, and these may be divided into two types—long and short. Long bobbins take all the threads in one section across the width of the machine, as shown in Fig. 77. In this machine alternate threads go to the top bobbin, while the remainder go to the bottom bobbin. The length of the bobbin is determined by the gauge of the spindles of the mule, and the number of slivers. It must be within a few inches of the width of the carder, since, if the width of the carder and the length of the bobbin are not approximately the same, the side threads are subjected to considerable tension owing to the angle they make as they pass from the rubbers to the bobbin. When short bobbins are used they are approximately half the length of the long ones, and run in pairs side by side. Besides the good ends there is always a waste end at each side, which runs on to a small bobbin, and at intervals the material is pulled off and thrown back into the hopper.

From the rubbers the threads are taken alternately to the top and bottom bobbin drums, as shown in Fig. 75. But in order to take the bottom series at the proper angle, they are made to pass round a tin roller L, and then on to the bobbin. The threads are guided to the bobbins by means of the raddles M and N, that consist of a stout rod into which are fitted wire loops, between which the ends pass. In Fig. 77 the raddles can be seen just behind the bobbin drums. The raddles are given a traverse of ½ in. to 1 in. less than the gauge of the threads, and a traverse in each direction is given for one revolution of the drum. It is necessary for the traverse to be less than the gauge of the threads, since the threads tend to spread; and to ensure that each thread will run off to the best advantage at the mule they must be compact and quite distinct. Also, when the traverse is too great and the threads run into each

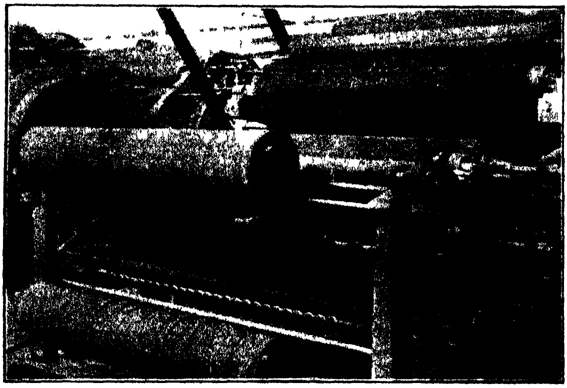


FIG. 77.

other, it is more difficult to discover a lost or broken thread. In some cases the bobbin drums and raddles are placed in an independent frame that is carried by four small wheels that rest on rails, and it can consequently be run away without much trouble; this addition, however, is more generally found on the bigger types of condensers.

The type of condenser shown in Figs. 75 and 76 undoubtedly gives the most accurate results when running on the material for which it is suitable. Each thread is subject to the same conditions, being taken from the swift at the same place by a ring of the same width, and rubbed into roving by the same rubbers. It is particularly suitable for fine counts, and was for a long time the standard machine in the Huddersfield and Rochdale trade, and will give the most perfect results on such materials as fine Botany wools, noils, and angolas; but its lack of adaptability and comparatively low production has caused it to be used much less than formerly.

DOUBLE-STRIPPER, DOUBLE-RUBBER CONDENSER.—To obtain the advantage of the production of even roving that accrues from the use of a single-doffer condenser, and also condense long materials successfully, the double-stripper, double-rubber condenser was introduced. A perspective view of this machine is shown in Fig. 77, and a diagrammatic section in Fig. 78. In this type of machine the doffer is stripped at two points, and two separate pairs of rubbers are used, consequently there is more than twice the space between adjacent threads than there is in the single-stripper type, and because

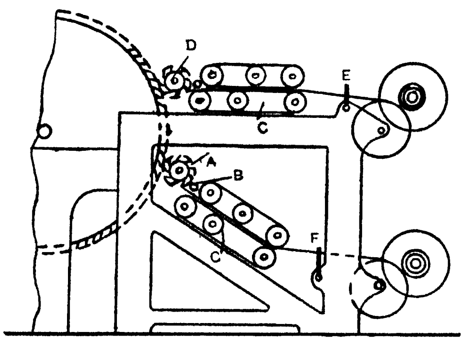


FIG. 78.

of this the rubbers may be given a comparatively long stroke, with the result that much more solid rovings are produced, and the machine can be run at a considerably greater speed.

The ring doffer is precisely the same as that used on the single-stripper machine, and as the material is carried round it is first stripped by the rings of card clothing on the first stripper A, Fig. 78, which are arranged to take the material from alternate rings on the doffer. The bare rings are 3½ in. in diameter, and the fillet is made to fit the rings quite tightly, and is sewn at the joint. Each of these bare rings is made in two parts, and one half or part has a sleeve or collar through which a set-screw passes, and when the screw is turned in it fixes it in position as it enters a hollow groove that extends the full length of the stout shaft on which the rings are mounted. The groove is provided so that when the final adjustment is made the ring can be slid on the shaft so that the fillet on the ring can be placed exactly opposite the ring of fillet on the doffer, which it has to clear. The extremity of the sleeve is threaded, and the other half of the ring is made to screw on to it. A hole is provided in the latter half into which fits the peg of a special form of spanner that is used for screwing it up, and thus completing the ring. The fillet is, of course, put on before the screwing-up is done.

There is no dividing roller in this machine, and the stripper is doffed by a plain metal roller B, Fig. 78, that is set very close, but not so close as to cause it to touch the points, and the web of fibres is deposited on the extended lower rubber C. This rubber is two or three inches wider than the top, which makes it impossible for the material to drop out of the machine. The ribbons of material are then rubbed into roving and passed to the bobbin as explained in conjunction with the single-stripper machine.

The material left on those alternate rings of the doffer that have not been stripped by the stripper A, Fig. 78, passes forward on the doffer until it reaches the stripper D, which is when bare $3\frac{1}{2}$ in. in diameter, but is either entirely covered with fillet, or with rings the correct distance apart. The latter method is advisable if the best results are to be obtained, for in the former case the stripper is working into *all* the doffer rings, and the bottom stripper A also runs into half of them, and those doffer rings that are acted upon by both strippers become lower at the point through the greater amount of wear, and produce slightly lighter ribbons of material.

Although the double-stripper machine gives the necessary space between the ends, while passing between the rubbers, to allow of long materials being run successfully, it is not a satisfactory machine in practice when running very long materials, as after running for some time the large parts of the shaft of the lower stripper between the rings collect a certain amount of fibre, which, if not removed in time, gets so large as to catch the material going forward to the top stripper and rubbers. Also, the rings of fillet of the bottom stripper rob the doffer rings carrying the material to be stripped by the stripper D of a small amount of fibre, consequently it is not unusual for the roving from the lower bobbins to be slightly heavier than the rovings from the upper bobbins. To minimise this, smooth wooden rollers about 2½ in. in diameter, and slightly narrower than the space between the stripper rings, though broader than the doffer rings, are placed on the shaft between the fillet-covered rings, and, revolving loosely on the shaft, they help to keep the material on those doffer rings that are to be stripped by the top stripper.

The double-stripper machine is a very useful type, but is often replaced by the double-doffer machine, which certainly more than compensates for any loss as regards quality that is likely to take place by the increase in production, and it can be made to give sufficiently good results for the general trade.

DOUBLE-DOFFER CONDENSER.—Decidedly the most efficient and adaptable of the different types of ring condensers is the double-doffer type. The production of a tape condenser when running on suitable material may be greater, and the single-doffer, single-stripper machine may produce a roving that is better in quality; but for obtaining good results on a wide range of qualities the double-doffer condenser compares very favourably with any other type. It can be adapted to do any of the thicker or coarser qualities if the rings are wide enough, and if the rings are sufficiently narrow it will condense the finer qualities equally satisfactorily. With rings of medium width, say ⅞ or 1 in. wide, it will do satisfactorily almost any class of material put on it, whether it is clean or dirty, fine or coarse, or long or short. In most cases, if production were the only factor, the double-doffer condenser would have been superseded by the tape machine, but both spinners and manufacturers realise that an amount of adaptability is necessary, and it is in this respect that the tape machine is lacking.

On the double-doffer condenser, as the name implies, there are two doffers, each of which is 20 or 24 in. in diameter. The rings on each of these doffers are not quite equal in width, those on the top doffer being slightly narrower than those on the bottom, with a view to counteracting the effect caused by the top doffer receiving the material from the swift first, and consequently taking a little more material from the swift than is represented by the width of the rings. Between the rings are leather bands to keep them in position, and the bands on the top doffer are vertically over the rings on the bottom doffer. It will thus be clear that the bottom doffer takes the material from that part of the swift that is not cleared by the top doffer.

If a 60-in. carder is to produce 64 threads, there will be 32 rings and 32 bands on each doffer, the rings on the top doffer would be approximately $\frac{7}{8}$ in. wide and the bands 1 in., while the rings on the bottom doffer would be about 1 in. wide and the bands $\frac{7}{8}$ in. By arranging the widths of the rings on the two doffers as explained, the ribbons from each doffer are approximately the same weight.

The strippers, which strip the doffers, may be of the ordinary plain type, and the rollers plain metal rollers; or, in the case of very narrow rings, grooved dividing rollers may be used so as to procure a better division and separation of the rovings. As a matter of fact, double-doffer condensers are generally supplied with plain metal rollers when constructed to condense up to about 72 threads; but when they are required to condense above that number, dividing rollers are used. The rubbing and winding is precisely similar to that explained in connection with the single-doffer machine.

The relative weights of the ribbons and rovings obtained from the top and bottom doffers are not constant, the affecting factors being the thickness of the material and its length, particularly the latter. When long material is being carded the top doffer naturally takes more of the material contiguous to the rings than when short-fibred blends are being run, and to counteract this it is usual to increase the speed of the top doffer by changing one of the driving wheels for one with 1, 2, or 3 teeth more, as required. Another notable point is that the quality of the rovings from the top and bottom doffers is not quite the same, the rovings from the top doffer containing a greater proportion of long fibres, and because of this, when running on particular work, the bobbins containing the rovings from the top doffer are kept separate from those containing rovings from the bottom doffer, and are spun separately at the mule. It is important to note in this connection that the difference between the rovings from the top and bottom doffers should never be neutralised by setting the top doffer away from the swift.

Double-doffer condensers fitted with tandem rubbers can be run at a comparatively high speed, although it should be noted that this depends somewhat on the quality of the material. The following table gives practical speeds that will serve as a guide—

PRACTICAL SPEEDS FOR CONDENSERS.

No. of Ends Condensed by Condenser.	Class of Yarn.	Counts or Skeins of Spun Yarn.	Revs. per Min. of Bobbin Drums 9 in. Diameter.
40	Rug and carpet.	4 to 7	32 to 40
48	Rug and similar yarns made from long wools.	8 ,, 10	28 ,, 32
64	Wool blanket and serge.	9 ,, 14	24 ,, 28
72	Finer wool cheviots.	12 ,, 20	18 ,, 24
96	Short but fine-fibred suiting.	16 ,, 30	12 ,, 18

The speeds given in the table are for condensers fitted with tandem rubbers, having about 9-in. centres. It might be remarked that the older style, fitted with broad rubbers with 12 to 16-in. centres, have neither the efficiency nor the power to divide the threads.

CONSTRUCTION OF DOUBLE-DOFFER CONDENSERS.—With regard to the details of construction and design, and also the practical details of operation, it is only necessary to refer fully to the double-doffer condenser, since this machine has largely displaced the single-doffer types, and if the double-doffer machine is thoroughly understood it will not be difficult to understand the single-doffer. In the study of the construction and design of a condenser the parts which demand attention are the driving, the arrangements for setting, and the rubbing motion, and as these have been almost standardised it will only be necessary to refer to one make of machine.

The driving of a single-rubber double-doffer condenser is clearly shown in Fig. 79. On the shaft of the last swift is a pinion gearing with the large carrier-wheel A. The latter is on a long stud so that it can be slid out of gear when necessary—as, for example, when fettling,—so as to allow the swift to be turned round without giving motion to the condenser. This wheel also drives both the top and bottom doffer-wheels through double spur-wheels. Only the gearing for the top doffer is shown. Wheel A is shown driving the doffer-wheel B through the compound carrier C, D. The bottom doffer is driven in exactly a similar manner, the bottom doffer wheel being shown at E. To change the speed of the top doffer the carrier-wheel D is changed; its size varying on some makes from 20 to 36 teeth, while on others it varies from 24 to 44 teeth. The speed of the bottom doffer is changed by altering the corresponding gear in the train by which it is driven; thus the speed of all the top and bottom parts of the condenser can be changed independently.

Behind the gear F and coupled to it is another change-wheel G, which is driven by the doffer-wheel B, but this wheel is not often altered when once the right one has been fitted. This change-wheel alters the speed of the rubbers and the dividing rollers in relation to that of the doffer, since the gear F drives the rubber wheels J and H through the intermediate K. Speaking generally, the rubbers are run faster when long materials are being carded than when short materials are being run, because the greater the speed, within reasonable limits, the more the fibres are straightened, which reduces

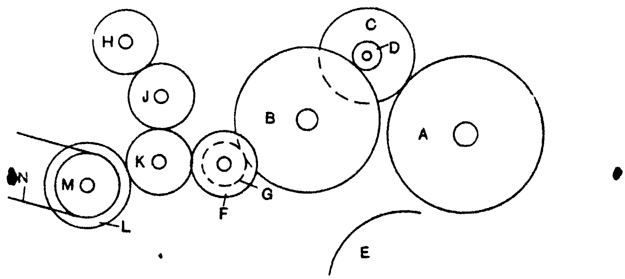


FIG. 79.

the likelihood of the ends tying. To cause the rubbers to run at a greater speed a smaller change-wheel is necessary; but on short materials which allow of no drag, a larger wheel must be used, since, if drag is allowed, uneven and broken threads are produced. The bobbins drum are driven by the belt N, which receives motion from the pulley M which is driven by the intermediate K. The gear L is a change-wheel for the purpose of regulating the tension of the threads between the rubbers and the bobbins.

The condenser stripper in Fig. 79 is driven by an intermediate from the back rubber shaft as shown. It is, however, more general to drive the rubbers as shown in Fig. 80, in which the stripper is driven by the doffer-wheel through a carrier. Although more gearing is necessary to drive the front shafts of the rubbers, it is a much more satisfactory method. In this case the doffer-wheel A drives a long train of gearing, as shown, which connects it to the front rubber shafts. The wheels B and C, D and E, and F and G, are double stud-wheels, while wheel H is simply a carrier. The wheel G drives the gear on the bottom rubber shaft, and the gear on the bottom rubber shaft drives that on the top rubber shaft. Wheel B is a change-wheel, and in order to reduce the speed of both sets of rubbers relative to that of the stripper it will be necessary to change B for a larger wheel, or, alternatively, a larger wheel may be substituted for D.

The front shafts of the first pair of rubbers are driven by gear G driving the carrier I, which in turn drives the double stud gear J and K, and K gives motion to the gear on the front shaft of the bottom rubber. A belt L, driven by pulley M, drives the top bobbin drum by giving motion to the pulley N on the bobbin drum shaft.

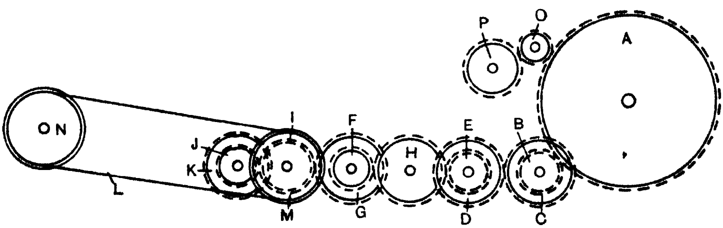


FIG. 80.

To reduce or increase the speed of the front set of rubbers relative to the back, the wheel K is changed. If a larger wheel is put on, the speed of the front set will be increased, while the speed of the back will remain the same. The gear J is changed if it is desired to change the speed of the bobbin drum independently of the front set of rubbers, and a smaller gear at J would speed up the rubbers, while the speed of the bobbin drum would remain the same. The doffer-wheel drives the condenser stripper through the carrier O, which transfers the motion to the gear P fixed to the stripper shaft. If it is required to change the speed of the stripper relative to the doffer, the wheel P is changed; and should its size be decreased the speed of the stripper will be increased, and *vice versa*.

The taking-off or dividing roller E, Fig. 81, which is a diagrammatic section of a double-doffer condenser, is usually driven by means of a gear-wheel on the end of the bottom rubber shaft at the side opposite to that shown in Fig. 80. To the frame side is fixed a grid, and to this grid the brackets are bolted that carry the studs on which the gears revolve. The grid provides every facility for adjusting the gearing as may be required.

It is simpler to drive the back shafts of the rubbers than the front, but it has been discarded for a reason which is partly theoretical though of some practical importance. A consideration of Figs. 82 and 83, in which the rubbers are shown in section, will make the point clear. In Fig. 82, in which the rubbers are driven from the back, it will be seen that the parts which come in contact with the ends are being *pushed*, and hence the tight side of the rubbers is

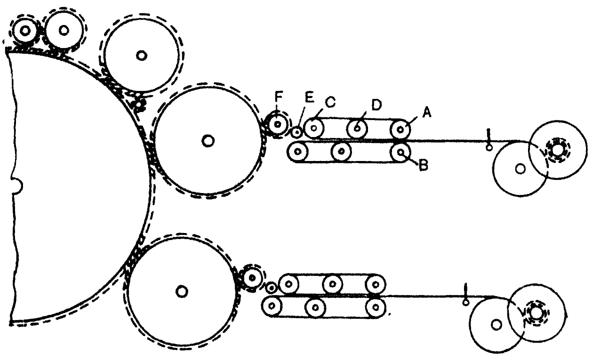
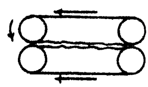


FIG. 81.

FIG. 82.



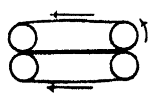


FIG. 83.

the outside, which has a tendency to accentuate any unevenness of the rubbers and thus increase the consequent adverse effect of uneven rubbers on the roving. The rubbers are driven from the front in Fig. 83, which causes the tight side to be the inside, and hence the effect of the unevenness of the rubbers is minimised, with the result that the cardings are more even, due to the better rub which is obtained.

SETTING.—In a condenser, setting is as important a factor as the relative speeds, if good level work is to be produced. When setting a condenser the ring doffers are first set to the swift, provision being made for a horizontal movement only. The doffers should be set as close as possible to the swift in order to ensure the production of a level roving, and if they are set by a fine gauge each of the four setting points will be alike, but it is necessary to check this by weighing the delivery, taking six or eight threads from each side of the top and bottom bobbins. If the weights are equal, the setting of the doffers may be assumed to be correct, but should there be any difference between the top and bottom as a whole, the requisite change is made by means of the change-wheels. Sometimes, however, the ends from the top and bottom bobbins at one side may reel equal, but vary somewhat at the other side of the machine, which is due to the unequal setting between the two. The settings should be carefully checked, and the side producing the lightest cardings will require the doffer setting a little closer. Some carding overlookers make a point of having the ring doffers so close that they are "proud"—that is, they touch the swift, but only sufficient to prevent the rings from having too much of a needle point. A ring doffer set in this manner has a peculiarly bright appearance, and the teeth do not feel smooth when the hand is passed over the back of the points. On cards doing low-class work this practice is generally adopted, as it results in a more solid roving being produced, the rings wear evener, and each one is always equally close to the swift.

All the other parts—the rubbers, strippers, and taking-off rollers—are in blocks which can be moved as a whole to or from the doffer, although each of them, except the back shaft of the lower rubber, can be moved or adjusted independently. In the case of the lower rubber the front shaft must be adjustable in a horizontal direction so as to tighten or slacken the rubber as may be necessary, while the top or upper rubber requires both a horizontal and a vertical adjustment, the latter to enable it to be set to and from the bottom rubber so as to increase or decrease the space between the rubbers as desired.

The stripper must also be adjustable in both a vertical and horizontal direction to make the space for the metal taking-off roller of suitable dimensions. Great care is necessary in fixing the different parts, and although slight deviations may be necessary when running on fine work as compared with coarse, the general principles are the same. The tension of the rubbers should be the same at each side, and it is advisable to check this both by feeling and also by measuring the distance between the shafts at each side. If there is much difference the wider end will deliver a longer length of roving, since the rubber assumes a slightly conical shape, the wider end being the base of the cone. It is not advisable to have the rubbers too tight, as it not only strains the joints but accentuates any weak places. They should be sufficiently slack to yield to the pressure of the fingers, though when too slack they have a tendency to slip. There should be the space of a thick gauge between the two rubber shafts where the rollers are together as at A and B, Fig. 81, and the space between the roller C and the lower rubber at the point where the ribbons enter should be sufficient to allow the bunch of gauges free access. Any pressure that may be required is obtained by the roller D pressing on the lower rubber, and the pressure must be carefully regulated, since if it is too great the rovings will slide between the rubbers and be delivered more or less twitty. The rubbing power of leather varies considerably. Some rubbers take on a matt, absorbent surface that grips the fibres and produces a solid roving, while others take on a shiny surface which causes the rovings to slip and come out uneven. The latter kind often need scratching with a sharp card to make them grip the fibres, but a practice that is being increasingly adopted and that is giving entire satisfaction is to run the leather flesh side on the outside, which wears with a soft, matt face all the time, and hence needs little attention.

The small dividing roller E is placed about $\frac{1}{8}$ in. above the bottom rubber and $\frac{1}{8}$ in. from the top rubber: while it should be set so close to the stripper F that it is only possible to get a fairly fine gauge between the two. It is a fact, though it may appear strange, that the fibres will stick to the stripper if the dividing roller is set too close: but if it is set so that it just clears, the dividing roller will take up sufficient grease from the material to coat its surface and quite fill up the space between the wires and the roller. When this condition obtains there is seldom trouble with the delivery of the threads, as the rubber gets them as they are taken from the stripper by the metal roller. After the dividing roller has once been properly adjusted, the only remaining point is setting the stripper to the doffer, and this is done by moving the whole of the blocks that carry the rubbers as well as the dividing roller. The stripper runs slightly into the doffer, and the distance it is set in varies from about $\frac{1}{16}$ to $\frac{1}{8}$ in. Some engineers set this roller by hearing, but this is very deceptive, as the rubbing motion side of the condenser is much noisier than the other. Others will adjust by sight and notice the depth or the length of the tooth that is kept clear and bright during working. One of the simplest and most satisfactory ways, however, is to take the stripper well out, and then close it up until a fine gauge indicates that both sides are an equal distance from the doffer. Then give the same number of turns to the setting-screw on each side. For example, on good material three quarter-turns of the screw are generally sufficient; on medium-class work, four quarter-turns; and on heavy stuff, perhaps five quarter-turns may be necessary. It is not possible to lay down definite rules with reference to setting; hence, the information given in the last sentence is only intended to serve as a guide, the actual setting adopted being affected by the condition of the doffer, the back swift, and the fancy. After a few months' working with a new stripper the point becomes very sharp and needle-like, or what is known as "keen"—that is, it becomes slender and "hooky"; so that whilst it will take the material from the doffer quite satisfactorily, it does not deliver up to the metal roller, but sticks to some of the fibres, so that carding becomes uneven and twitty. It is then necessary to "do it up" by grinding away the point. But as plain or ordinary grinding on such fine wire would produce a more pronounced hook, it is better to face it carefully, which is done by running it point first against the emery. The stripper must be set so as only just to make contact with the emery, and continue grinding until the point on the stripper is slightly hooked in the opposite direction to that in which the wires are inclined. It is then necessary to true the stripper in the frame, and run it in the right direction until it is smooth. A sharp point is not necessary on a condenser stripper, as the fibres lie on the surface of the doffer, and, moreover, the stripper has to deliver the fibres to a perfectly plain roller.

Rubbing Motion.—For many years the only system of giving the reciprocating rubbing motion to the rubbers was by means of a crank, but as the speeds attainable by this motion are comparatively low it has been largely superseded on all machines, except those of the single-stripper type, by the modern eccentric motion. The chief merits of the modern eccentric motion are the high speeds at which it may be run, its freedom from excessive vibration, comparative silent running when properly made and adjusted, and its immunity from breakdown. There are several modifications as regards detail of this motion, but all consist of a fixed eccentric working inside an enclosed frame that is connected to the connecting-bar or crosshead of the rubber shafts.

Fig. 84 is a photograph of the rubbing-motion side of a double-doffer, single-rubber condenser, which shows the general arrangement of the parts, while Figs. 85 and 86 are elevation and plan respectively, of the mechanism of the rubbing motion. The

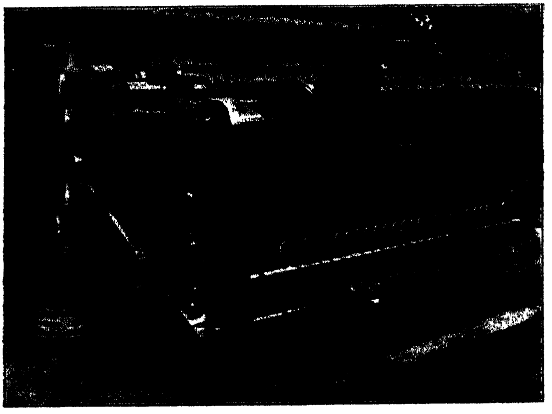


FIG. 84.

eccentric shaft A, Figs. 85 and 86, is driven by means of a rope that receives motion from a 30-in. rim on the swift shaft, that drives the rope pulley fixed to the bottom of the eccentric shaft as shown in Fig. 84. To give motion to each pair of rubbers two eccentrics B and C are necessary, the eccentric B driving the top rubber, while the eccentric C operates the bottom rubber. Each eccentric shaft is supported by brackets as shown in Fig. 84, one of which is shown at D, Fig. 85. So that the eccentrics will revolve with shaft A they are firmly clamped between the discs E and F, which are keyed to the eccentric shaft, and the discs are provided with slots in which a pin on each eccentric fits.

As will be seen from Figs. 85 and 86, the eccentrics are placed diametrically opposite each other—that is, the points of greatest eccentricity are opposite. The eccentrics work inside "boxes" or frames G and H that are technically termed "yokes." Consequently, when the eccentric shaft rotates, the yokes are given a right-to-left reciprocating motion, which, through the yokes being securely bolted to the crossheads I and J and the shafts of the rubbers being bolted to the crossheads, is transferred to the rubbers. It should be said that the rollers are bolted to the crossheads so that they are free to revolve by means of bushes.

To take up any wear that occurs, a hard steel wedge K is fitted, which can be adjusted longitudinally and fixed in position by means of small set-screws. As will be seen, the actual bearing surface is

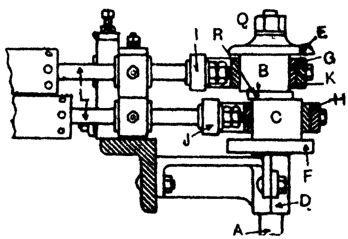


FIG. 85.

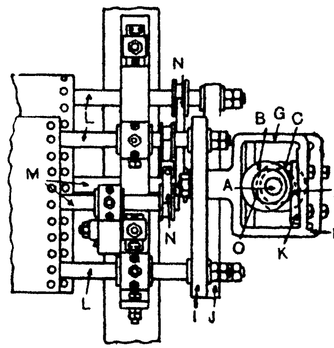


FIG. 86.

only part of the face of the yokes, and to overcome the disadvantage of unequal distribution of bearing surface an improved type has been introduced, which is provided with concave sliding pieces that fit on each side of the eccentric. On some makes of machines greasers are fitted so as to oil the eccentrics more or less automatically.

In the plan view, Fig. 86, is shown the blocks in which the rubber shafts L revolve, and the means whereby the shafts may be adjusted to tighten and slacken the rubbers as desired. To ensure that the press rollers M will reciprocate simultaneously with rollers L, links N are provided, the ends of which fit in grooved bowls. Inside eccentrics B and C are fitted small eccentrics O and P, Fig. 86, and when both the eccentrics B and O and C and P are turned with their greatest eccentricity or full faces in the same direction, as shown, the maximum throw or stroke of the rubbers is obtained. When, however, the eccentricity of the smaller eccentric is opposite that of the larger, then the stroke that is given to the rubbers is as short as it can possibly be, since the stroke of one is practically balanced by the stroke of the other. Any length of stroke between the maximum and the minimum can be obtained by changing the position of the smaller eccentric with respect to the larger as required.

The arrangement of the parts to render adjustment as simple as possible is as follows: Fixed to the shaft A, Fig. 85, by means of a key, for the reception of which a keybed is provided, is the disc F. Above this disc are the small and large eccentrics, and both the small eccentrics are cast in one piece, with their points of greatest eccentricity diametrically opposite each other. Above the eccentrics a short keyway is cut in the shaft A to receive a key, which fits into a corresponding keyway in the disc or cap E. A pin is cast on each of the larger eccentrics, which fits in a slot that extends diametrically across the discs, the slot being on the top side of the bottom disc and on the under side of the top disc. Consequently, when the nut Q is screwed down all the parts rotate with the shaft A.

Between the two inner eccentrics, and in a sense connecting them, is the disc R, in which is a hole that is shown by a black dot, and it is by this hole that the position of the inner eccentrics is altered with respect to the outer. The usual speed of the shaft A is between 200 and 300 revs. per min. In the case of single-doffer machines shaft A is vertical, but in the case of double-doffer condensers the shafts are set at an angle, which is often very considerable; but at whatever angle the shaft is set, the driving rope is made to run to the pulley at the bottom in a direction at right angles to shaft by means of suitable guide pulleys.

TAPE CONDENSERS.—When a double-doffer condenser is fitted with the eccentric motion just described and tandem rubbers, a machine is obtained which is undoubtedly as satisfactory as any for all-round work. It is possible to do either fine or coarse, clean or dirty, and with a consistent all-round satisfactory production. For certain classes of material such a type of machine may be beaten with regard both to quality and to quantity produced for that particular job by the tape condenser, but where much changing is done it cannot be beaten by any other machine. The production of a tape condenser is larger, given suitable material, chiefly on account of the increased number of threads, but it is not so adaptable.

The principle of the tape condenser is entirely different from that of the ring doffer, since, instead of rings for dividing the web into ribbons, endless leather tapes are used. In Fig. 87 is shown a diagrammatic section of one of the simpler and earlier types that will serve to make the principle clear, but which must not be taken as representative of the modern type of tape condenser. It should be remarked that certain defects of design in the earlier types that

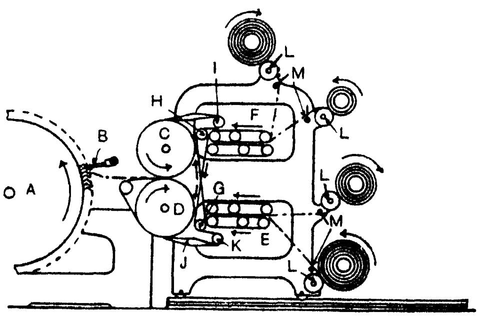


FIG. 87.

caused practical difficulties earned for the tape condenser a reputation much worse than it deserved, and even to-day a prejudice against the machine exists which can safely be said to be either due to lack of experience of a modern type or else the machine has been tried on unsuitable materials.

The doffer A, Fig. 87, is generally 40 in. in diameter, and is covered with plain clothing—that is, it is fully clothed, and not with rings, with clothing of fine counts, which is $1\frac{1}{2}$ to 2 in. wide. The clothing is wrapped on the roller in the usual manner, and as it is impossible to tack it down, it must be put on under great tension, or in working it has a tendency to slip or run to one end. To prevent this the doffer is sometimes first wrapped with plain fillet cloth in the opposite direction, or, alternatively, and which is simpler, the surface of the doffer may be painted and the clothing put on before the paint is quite dry. The above steps are taken only in the case of iron doffers. It is, however, not often that wooden doffers are used, but when they are used, the danger of the clothing slipping or the breaking of the wire through rusting at the back is eliminated.

Against the system of clothing the doffer as explained is the fact that when a fault appears on the surface, or the card is damaged by any means, the whole doffer becomes useless, because the threads produced out of the material from the damaged place will be more or less defective. Consequently, the clothing is sometimes put on the doffer in the form of endless rings, as in the case of the ring doffer. The rings are filled with teeth close to the edge, as in the case of ordinary fillet, and the rings are put on from one end of the doffer and set close together so as to form a fully covered surface. Thus, should one or two rings be damaged they can be removed and replaced without having to go to the expense of reclothing the whole of the doffer.

A doffing comb B is shown taking the web from the doffer, and from the comb the web of fibres, which should be quite level from side to side, passes to the dividing rollers C and D, which are about 8 in. in diameter, and have shallow grooves in their surface, each of which corresponds to a tape, and hence a thread. On a 60 in. machine there will be from 80 to 120 grooves and tapes, and, of course, with 120 tapes each groove will be $\frac{1}{2}$ in. wide if the waste threads are neglected. The first tape and all the odd-numbered ones will make all the threads for the bottom rubbers E, whilst the second tape and all the even-numbered ones will make the threads for the rubbers F. The first tape in passing through the machine comes down in a groove behind the top dividing roller C, passes between them on to the front of the dividing roller D—that is, the side nearest the bobbin frame and all the web opposite to it is between the tape and the roller D. It (the tape with the material underneath) passes downwards on the face of the bottom dividing roller and on one of the ridges. After leaving D the tape passes under the roller G, over H, partly round the tension roller I, and back to the dividing roller C. Between the tension roller I and the dividing roller C, the tape is given a half-turn as shown, so that each side of the tape will be in operation and carry the web alternately. Moreover, if this were not done, then one side would become thickly coated with fibre and grease. The ribbons are taken off the tapes by the lower rubbers E, the bottom one of which ordinarily removes the ribbons from the tapes; but the upper one is made to rub slightly against the tapes, and consequently the ribbons cannot get past the rubbers.

The second tape J and all the even-numbered ones pass upwards from behind D, between C and D, upwards in front of C, over H, down and under G, partly round K, and back to D. The tapes in this series are given a half-turn between K and D, and are ordinarily stripped by the top rubber of the top pair F, the bottom rubber of this pair being set to rub slightly against the tapes so as to prevent the ribbons from passing forward with the tapes. The rovings that are produced as explained are guided to the bobbin drums L by means of the raddles M, and alternate threads from each pair of rubbers are taken to each of the bobbin drums as shown. With this machine, to produce, say, 100 threads from a 60-in. carder, each pair of rubbers must deal with 50 threads, and consequently the threads are too close to produce satisfactory results on any but short-stapled material, which is largely the reason why it has been replaced by those types of machines that have four to six heights or pairs of rubbers. If a machine with four pairs of rubbers is used there will be only 25 ends to each pair of rubbers, and hence the longest materials can be condensed without any danger of the ends tying.

Tape Condensers.—There are three types of the common four-rubber, four-decker, or four-height tape condenser—namely, that in which each tape produces one thread; that in which each tape produces two threads; and that in which only one tape is used for all the threads. The first type is by far the most generally employed in British practice, and will consequently be dealt with first. A diagrammatic section of a good make of this machine is shown in Fig. 88. The doffer A strips the swift in the usual manner, and is in turn stripped by the stripper B, which is $3\frac{1}{2}$ in. in diameter, and is covered with ordinary but fine card clothing. It is preferable to strip the doffer with a roller instead of a comb, because the former does not pluck or drag the web to anything like the same extent as the latter when it is dirty; hence the web of fibres is more even, which results in evener rovings. A stripper also prevents the material from dropping on the floor, whereas when a comb gets dirty it is likely to cause the web to break; and a stripper requires less cleaning than a comb. A stripper being set to run slightly into the teeth of the doffer keeps the latter in ideal condition, while when a comb is used it is necessary to run a dicky stripper to keep the doffer in condition.

To take the web from the stripper a small plain metal roller C is used, that is set close to but not touching the stripper. In the

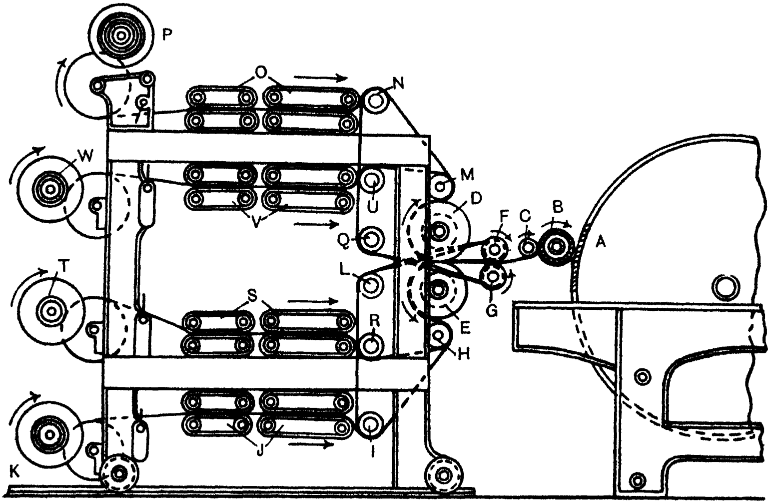


FIG. 88.

course of working this roller becomes slightly coated with grease, which helps it greatly to perform its work properly. As a matter of fact, when the roller C is perfectly clean there is often difficulty in preventing the material from clinging to the stripper. In such a case it is necessary to grease the roller with stiff grease that is similar to tallow. With this stripping motion the web is supported nearer to the dividing rollers of the condenser than is the case with the comb stripping motion.

In this machine the dividers D and E have grooves that are about 2 in. deep, through which the tapes return, the latter being kept in position and guided properly by means of the carrier rollers

F and G. After the web of fibres leaves the roller C it passes between the grooved rollers F and G, and thence to the dividing rollers D and E, which, as already indicated, consist of a series of pulleys or discs that are the width of the tape, the width of which is controlled by the width of the machine and the number of ends it is required to produce. For example, if 120 rovings are to be delivered from a 60-in. carder, there will be 60 discs on each roller, the discs on one roller coming opposite the spaces in the other, there being, of course, a space between each pair of discs equal in width to that of the discs.

As there are four heights of rubbers there are four series of tapes, and each series follows a different path. The first series, after leaving the roller F, pass between the dividing rollers D and E, partly round E on the top of the pulleys, with one quarter of the web in the form of ribbons between them and the pulleys E. The tapes then pass partly round the carrier rollers H and I, with the ribbons on the outer or under side of the tapes. On leaving the roller I the tapes pass upward, and the ribbons, being on the side of the tapes nearest to the rubbers J, are stripped by these, and formed into rovings, which are delivered to and wound on the lower bobbin K in the usual manner. The tapes then pass upward and over the roller L, which is slightly grooved to keep the tapes in position. After leaving L they are given a half-turn as shown, and passed between a pair of pulleys on the top dividing roller D back to the roller F. The half-turn, besides ensuring that the tapes will be kept clean, allows them to pass between the pulleys without rubbing against the sides.

The second series, after leaving roller G, pass between the dividing rollers D and E, upward and partly round D, then partly round rollers M and N, and the ribbons, being on the outside of the tapes, are stripped by the top set of rubbers O, which make them into rovings that are wound on the top bobbin P. The tapes then pass forward to the slightly grooved roller Q, and from thence between a pair of pulleys on the lower dividing roller back to the roller G; the tapes are given a half-turn between Q and G.

The path of the third series of tapes is the same as that of the first, with the exception that instead of passing down and around the roller I, they pass from H to R; and as the tapes leave R, the ribbons formed from the web opposite the tapes being on the outside of the latter, are stripped by the rubbers S, and the rovings from these rubbers are wound on the bobbin T. The tapes pass upwards to L, and from this roller to the roller F; they are given a half-turn between the rollers L and F.

The path of the fourth series of tapes is the same as that of the second, except that, instead of passing up and round N, they pass from M to U, and as the tapes leave U the ribbons are stripped by the rubbers V, the resulting rovings being wound on bobbin W. From U the tapes pass downwards, partly round Q, between two pulleys on E to G, the tapes being given a half-turn between Q and G.

Because of the fact that in a four-rubber, or four-height, machine there are 30 tapes in each series, instead of 60 as in the case of a double-rubber machine producing the same number of threads, and consequently twice the distance between the ends passing between each pair of rubbers, the former has a two-fold advantage over the latter, since it may be run at almost double the speed, and there is little or no danger of the ends running "double" or rubbing together even on the longest material.

Details of Tape Condenser.— The mechanical details of a tape condenser are different from those of the ring doffer type, or, perhaps, it would be more correct to say that they are a development to suit other conditions. In the first place, the blocks for the bottom and third pairs of rubbers are suspended from the frame; consequently, all the parts must be fixed in position securely. Further, the setting blocks at one side are somewhat hidden by the driving-wheels, while at the other side the rubbing motion renders the adjustment of the blocks rather difficult; consequently, all the blocks are designed to be adjusted by means of a short spindle instead of an ordinary spanner.

In Figs. 89, 90, and 91 are shown a front and a side elevation and plan, respectively, of a common arrangement for 12-in. rubbers. The arrangement occupies the position shown in the diagrams in the case of the top and second sets of rubbers, but in the case of the bottom and third sets it is inverted, as will be seen from Fig. 88. The carrier roller A for the upper series of tapes is supported by the bracket B, which can be raised or lowered by the bolt C to regulate the tension of the tapes. To lock the bracket in position a lock-nut D is provided, while the whole is secured firmly to the frame by the bolt E. The setting blocks for the rubbers consist of three parts. There is the base part that carries the shafts of the lower rubber rollers F and G, and which is securely fixed to the frame by set-screws. The shafts rotate in blocks or necks that may be moved horizontally between the projecting tongues in the base-plate. As the pull of the rubbers tends to bring the rollers inwards,

FIG. 90. FIG. 89.

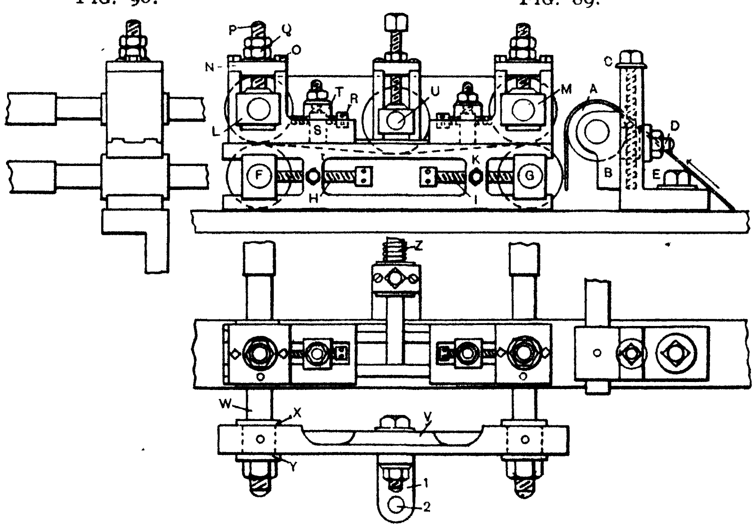


FIG. 91.

the screws H and I are provided for moving them outwards, which is the only adjustment necessary. The screws pass through a web in the frame, and are prevented from unscrewing, due to vibration, by the set-screws J and K, which bear lightly on the adjusting screws H and I. Small holes in the heads of the screws H and I are provided for the reception of a spindle, by means of which the screws can be given a quarter-turn at a time.

The upper rubber shafts are fitted in two independent and adjustable blocks L and M, which may be moved in a vertical direction, while the whole bracket supporting each roller may be moved horizontally. It is only necessary to describe the adjustment of the block L, since the adjusting of block M is done in a precisely similar manner. The two projections of the bracket have a cap N, that is held in position by means of set-screws O. These caps are not essential when the rubbers are in the position shown, but when the arrangement is inverted, as in the lowest set, they are absolutely necessary to prevent the rubbers dropping out. A bolt P that is fixed to the block L passes through a hole in the cap, and the lock-nuts Q secure the block in the desired position. The horizontal movement is obtained by means of the pin-screw R fitted in a slot in the bracket. Over the fixed part or square S in which the screw works is a bridge T. In whichever direction the screw R is turned, the bracket is bound to move accordingly, because the screw is the same length as the slot in the bracket, and the square S is a fixture.

The press roller shaft U is held in a lighter block of similar design; hence, the construction and method of adjustment need not be described. Sometimes a press roller, supported and adjusted in the same way, is placed inside the lower rubber, and is often a decided advantage as regards obtaining increased rubbing power. In fact, it is always used on the single-rubber, ring doffer condenser, and would be an improvement on tape condensers. Due to its omission on tape machines, it is necessary to lower the press roller sufficient to press the rubbers out of the horizontal as shown, which is somewhat exaggerated, or alternatively fit the machines with tandem rubbers. The latter procedure is expensive as regards first cost, and the addition of an extra pair of rubbers to each set or height makes the machine both more complicated and heavier to drive, and consequently they should not be used if their use can be avoided. Single rubbers have generally 12-in. centres, while the back in the case of tandem rubbers have generally 9-in. and the front 6-in. centres, though occasionally both have 9-in. centres.

The rubber shafts are sufficiently long to pass from the rubbers and blocks to the connector or crosshead V, Fig. 91, the latter being given a horizontal reciprocating motion by means of connections that form part of the rubbing motion. The shafts must be connected to the crosshead so that they will be free to rotate, but without play, at the same time as they are reciprocating. The shafts are narrower from W to the end, and this portion is threaded as shown. Against the shoulder formed by the shaft being narrowed down is fitted a flanged sleeve X, which is clearance distance longer than the crosshead is wide. The washer Y is held in place by a nut as shown. The shafts do not run in holes in the crosshead, but in slots that are about 2 in. long, so as to allow suitable adjustments to be made with regard to getting the rubbers the proper tightness. A light spring Z serves to keep the press roller in position. To the crosshead is bolted the bracket I, which carries the stud 2.

The rubbing motion is on the eccentric principle, and is one of the most efficient on the market. The eccentric A, Figs. 92 and 93, which are elevation and plan respectively, runs within the shell B, while the end of the arm of B fits over a stud 2 carried by the bracket 1, Figs. 91, 92, 93, and hence the required reciprocating motion is obtained. The only matter to which it is necessary to refer in detail is the means by which the length of the traverse or stroke of the rubbers is modified. There is an inner eccentric C, which is set-screwed to the shaft D, and to this eccentric is attached a plate E, which has a circular slot F extending nearly halfway round, that is concentric with the inner eccentric and not to the circumference of the plate. A set-screw G passes loosely through this slot and into the eccentric A at its widest part; consequently, by tightening up the set-screw G, the eccentrics A and C, shaft D, and plate E are made to revolve as one piece. The degree of eccentricity depends on the position of the set-screw G in the slot. As shown it is nearly at the maximum, as the eccentric parts are approximately in the same direction. The lower rubber of the pair is operated by a precisely similar eccentric and shell, which is arranged the other way up—that is, the plate E is lowest and the set-screw G is pointing upwards. The arrangement just

FIG. 92.

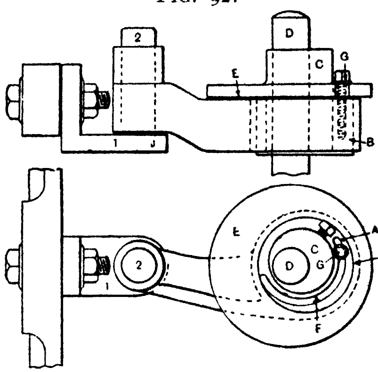


FIG. 93.

described can be put anywhere on the shaft, and in some cases six pairs of rubbers are employed in six heights.

SIX-RUBBER TAPE CONDENSER.—A six-rubber, six-decker, or six-height machine is only used for particularly fine work, where from 150 to 240 threads are produced. It is similar to the four-rubber machine as regards design, with the exception that every third thread goes alternately to an additional pair of rubbers placed above the highest in a four-rubber machine, while the other extra threads go to a pair of rubbers placed below the bottom set in the case of a four-rubber machine. In this way the maximum number of threads is obtained without sacrificing rubbing power. A disadvantage of this machine is that owing to the large number of threads there is danger of crowding on the rollers.

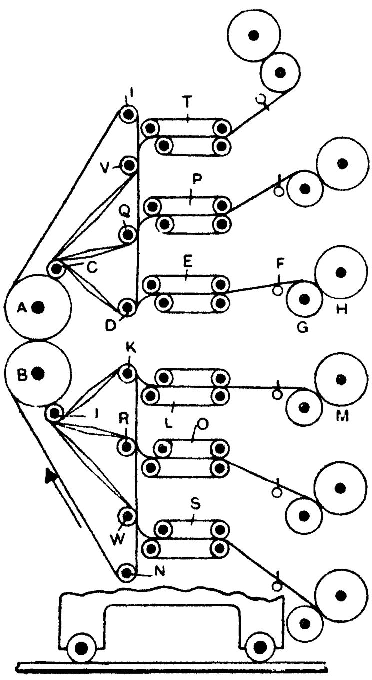


FIG. 94.

Fig. 94 is a diagrammatic section of a six-rubber tape machine, and shows a popular type of condenser in which one tape takes off two threads. The grooves in the dividing rollers are only shallow, and consequently the tapes cannot return between the grooves as in the case of the four-rubber machine previously described. This type—that is, the one in which each tape takes off two ends—can also be made to deliver to two, four, or six heights or sets of rubbers, according to the class of work for which they are required. The dividing rollers A and B are grooved to keep the tapes in position. It should be noted in connection with the six-rubber machine that the rollers A and B are placed much higher than is the case with the four-rubber machine, as they must be set approximately midway between the third and fourth pairs of rubbers in order to ensure that the distances between the dividing rollers and the top and bottom sets of rubbers will be equal. To accomplish this the doffer and stripping motion are sometimes raised higher than normal, while in other cases a sloping carrier lattice is employed to take the web from the comb or stripper to the dividing rollers.

The path or travel of the first series of tapes and their action on the material are as follows: As the web passes between the rollers A and B it is divided in the usual manner, and the tapes pass from A partly round roller C with the ribbons of material on their face. From C they pass to D, and between these two rollers they are given a half-turn to bring the material to the outside of the tapes, so that the ribbons of material can be stripped by the rubbers from the tapes. The top rubber E of the fourth pair strips the ribbons from the tapes as the latter leave the roller D, and after being formed into rovings by the rubbers, the rovings are guided by the traversing raddle F to the bobbin drum G, by which they are wound on the bobbin H. The empty tapes pass upwards to the carrier roller I and down to the dividing roller A, but they enter the *second* groove so as to form the second thread. From between the dividing rollers the tapes pass downward and partly round J, then to K, and between J and K they are given a half-turn, the ribbons being stripped by the bottom rubber of the third pair L. After the ribbons have been made into rovings by the rubbers, the rovings pass in the usual manner to the bobbin M. From the roller K the empty tapes pass partly round the carrier roller N and return to the first groove in the dividing roller B.

The second series of tapes deliver to the second and fifth pairs of rubbers O and P respectively, and the path of this series is as follows: The tapes pass from A to C, Q, I, A, B, J, R, N, and B in the order named.

The third series of tapes deliver to the bottom and top pairs of rubbers S and T, and the path of this series is as follows: The tapes pass from A to C, V, I, A, B, J, W, N, and B in the order named.

Driving of Tape Condensers.—The driving of a four-rubber tape condenser is shown diagrammatically in Fig. 95. Motion is given to the short countershaft A on one side of the machine by the sprocket-wheel B on the shaft of the last swift, which by means of a chain with detachable links drives the sprocket C that is fixed to A. On the shaft A is fixed a large pulley D, 24-in. diameter,

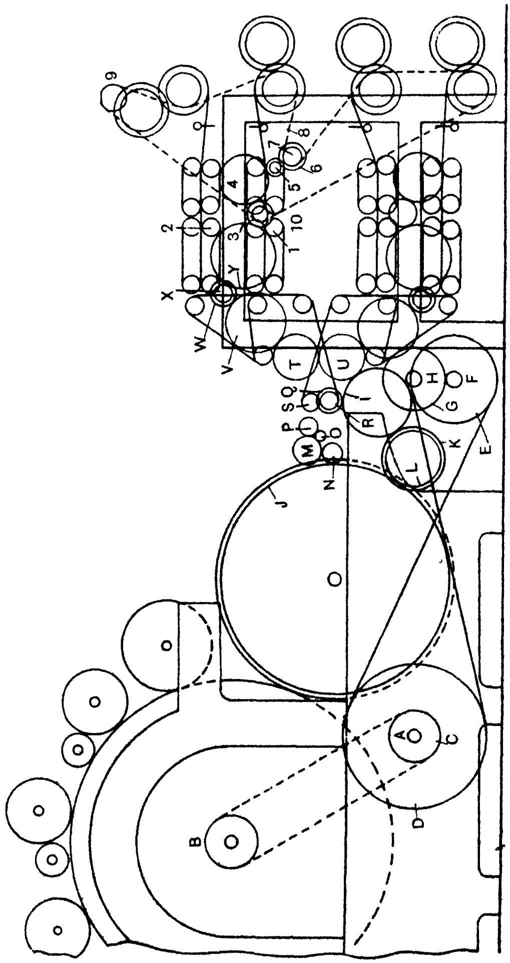


Fig. 95.

which, by means of a crossed belt, drives a pulley E, 14-in. diameter, on the condenser. Compounded with the pulley E is the change-wheel F, by means of which the speed of the whole condenser is changed; the number of teeth in this wheel varies from about 14 to 20 or 24 teeth. The wheels at this point are coarse-pitched, about ½-in. pitch, as they have a considerable weight to turn. The change-wheel is provided with two projections that fit in recesses provided in the boss of the pulley. The compound reducing pinions G and H are driven by the change-wheel, and the pinion H drives the carrier-wheel I, which may be considered to be the centre of distribution of motion, as it gears at four places.

This design of drive is that adopted for the tandem-rubber condenser, in order that there may be speed enough at the belt drive to prevent variation due to slipping, because the speed must be high owing to the amount of power that has to be transmitted. On the single-rubber condenser, however, the belt pulley and the gear-wheel H are on the same stud, the wheel H in this case being the change-wheel. Also to make the speed of the condenser approximate to practical limits, a 12-in. pulley is placed at D, which drives a 24-in. pulley at E by means of an open belt, instead of a 24-in. pulley driving a 14-in. pulley as in Fig. 95. Assuming F to have 14 teeth and G 48 teeth, it can be calculated how the speeds compare. For example, if the countershaft A runs at a speed of 80 revs. per min., then the wheel H will make, in the case of the gearing shown in Fig. 95—

$$\frac{80 \times 24 \times 14}{14 \times 48} = 40 \text{ revs. per min.};$$

while in the case of the gearing for a single-rubber condenser the gear H will make the same number of revolutions as is shown by the following calculation—

$$\frac{80 \times 12}{24} = 40 \text{ revs. per min.}$$

The doffer-wheel J, and hence the doffer, is driven by means of the double stud-wheel K L, the latter being the change-wheel. To obtain fine variations of speed the change-wheel is large in diameter, containing 74 to 78 teeth. It is by this wheel that the speed of delivery of the web is regulated. A larger wheel drives the doffer faster, and so makes the web slacker on to the dividers.

The stripper-wheel M is driven by a wide carrier-wheel N from the doffer-wheel J. The speed of the stripper can be changed relative to the doffer by changing the wheel M, but as it is a driven wheel a smaller change-wheel makes the stripper go faster. The taking-off roller is driven in a similar way from the other end of the stripper by a carrier O, which drives the wheel P fixed on the end of the taking-off roller shaft. A range of about two or three teeth only is required in the case of the change-wheel for the taking-off roller, the wheel P being the change-wheel.

The back carrier rollers which take the web are positively driven from the gear I, as a wheel Q on the lower carrier roller gears with it. The upper carrier roller is driven from the bottom one by gears of equal size R and S. To drive the dividing rollers gears T and U are fixed on the shafts of the top and bottom rollers respectively, the gear U being driven by the gear I and transmitting motion to T. All the upper pairs—the third and fourth pairs of rubbers—are driven from the gear T, and all the lower ones from the bottom dividing roller gear U. As the driving is the same in each case, it is necessary to explain the driving of the upper pairs of rubbers only. An intermediate gear V conveys the motion to the gear W, and on the same stud as W is a finer pitched change-wheel X. This change-wheel is for the purpose of regulating the speed of the rubbers relative to the tapes, so that when the ribbons of material are not stripped fast enough from the tapes a larger change-wheel is necessary. A large intermediate wheel Y carries motion from X to the front shafts 1 and 2 of each of the bottom rubbers of the two sets of back rubbers, which is the most advantageous method of driving the rubbers. The top rubber of each pair is driven by gear-wheels of equal size fixed inside the framing. The front pairs of rubbers are driven in a similar manner by means of two intermediates 3 and 4 from gear Y.

The bobbin drums are driven by a chain as follows: A fine-toothed wheel 5 is fixed on the front shaft of the front bottom rubber of the third set, and gears with a change-wheel 6, which carries the sprocket-wheel 7 that drives the chain 8. The chain turns the three lower drums in one direction, but the back of the chain is made to bear against the sprocket-wheel on the top drum shaft and cause it to run in the reverse direction. This is brought about by the carrier 9, which is adjustable to regulate the tension on the chain, and a loose sprocket 10 that rotates freely on the same stud as wheel 3 for convenience.

The type of machine the driving of which has just been explained is a most useful one, as it can not only produce a large quantity of roving in a sound condition, but the loftiest wools can be rubbed sufficiently to form a solid roving. Generally speaking, tandem rubbers are necessary only for crossbred and similar lofty wools, and where a fairly high condenser speed is desired. For mungoes and fine wools the single 12-in. rubbers are generally sufficient, and as the driving is less complicated and lighter they are to be preferred.

As regards the setting and adjustment of this type of machine there is little to be said if the material is well carded. The doffer should be set as close as possible, so that it will take the material straight from the swift. The stripper is set so that the teeth run into those of the doffer about $\frac{1}{16}$ in., which keeps the wire of the latter both sharp and clean. After running for some time the stripper becomes very needle-pointed and then hooky, when it becomes necessary to smooth it into suitable condition. It is carefully "faced" or run point first against the emery until the hookiness is taken off, and then smoothed by running it for a short time in the right direction. As this process can scarcely be done too slowly, it is advisable to have a spare stripper in good condition ready to put in position. The metal taking-off roller is set with a fine gauge to the stripper, and then after running a little while it coats with grease, which should be left on, as it is more effective than the bare roller for clearing the web from the stripper.

The condenser should be run away periodically, and all the grease that accumulates near the tapes wiped away. Sometimes a long belt is kept specially to take the place of that connecting pulleys D and E, Fig. 95, so that the condenser can be run for cleaning purposes when about a yard away from the carder. The tension of the web can be observed between the stripper and the dividing rollers, the tension of the ribbons between the tapes and the rubbers, and the tension of the rovings between the rubbers and the bobbins. and changed as desired by means of the change-wheels referred to in the description of the driving.

Single-tape Condenser.—After running for a time some of the tapes may stretch more than others, due to the inequality of the leather, though with ordinary working with well-made tapes this is not very apparent; but often an unnoticed accumulation of waste in the dividing rollers may stretch some of the tapes, and thus cause them to be slacker than the remainder. This will cause a weaker thread, since the adjacent tight tapes will rob material from the slack ones at the point where the web is divided. To overcome this the single-tape condenser, with one endless tape threaded from one end to the other, has been designed. These machines assure an equal tension throughout and at all times, and the only drawback is that when it does break it is much more trouble to re-thread it, as it is necessary to pass it a great number of times over and under the various dividing and guide rollers.

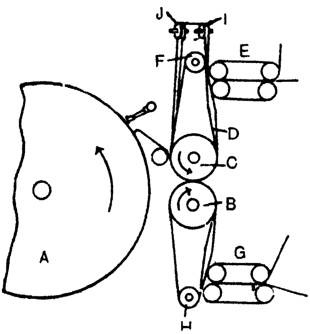


FIG. 96.

One of the earlier types is shown diagrammatically in Fig. 96, which is exceedingly simple, but it suffered from the disadvantage that the threads were crowded in the rubbers. In this machine a comb strips the doffer A, and the web passes from the comb to the dividing rollers B and C. The tape D takes the ribbon upwards on its face, and after the ribbon has been stripped by the rubbers E, which is rendered possible by the tape being given a half-turn, the tape passes over the carrier roller F, and back to the second groove of C. The tape then passes down the front of the dividing roller B, and takes from the web of material a ribbon equal to its width, which, due to the tape being given a half-turn as shown, is taken by the rubbers G. After being cleared the tape passes partly round the carrier roller H, and upwards to the third groove of the dividing roller B. The path just described is repeated across the whole width of the machine, the tape finally passing upward at the end and over the guide-and-tension pulley I and across the machine to a similar pulley J, and then commences at the beginning of the condenser again. The web is divided into ribbons, the ribbons rubbed into rovings, and the latter wound on to bobbins in the usual manner.

CHAPTER XVI

MODIFICATIONS OF CARDING MACHINES, CONTINENTAL AND AMERICAN SYSTEMS OF CARDING, FETTLING

MODIFICATIONS OF CARDING MACHINES.—Having explained the principle and construction of a typical set of carding machines of the English type, some of the more notable modifications will now be briefly described. The modifications in carding machines that have been made from time to time involve no change in principle, and their only object is to increase production or improve the quality of the yarn, or both.

One modification, and perhaps the smallest, is that in which the speed of the breast swift is decreased below the normal with a view to preserving the length of staple of the material. Another modification that is found advantageous when carding some classes of short-stapled mungo blends, since it reduces the quantity of waste dropped at the breast, is to run the breast doffer in the opposite direction from that in which it usually runs. By reversing the direction the material is carried *over* the doffer to the angle stripper, instead of underneath.

The workers may be made to rotate in the opposite direction to that in which they generally run, though this is not good practice. Also the strippers may be placed on the opposite side of each worker from the usual one, the effect of which is to keep the material close to the surface of the swift, and consequently the facilities for mixing are reduced considerably, as the material does not pass over the workers.

The direction of rotation of the angle strippers on the scribbler is frequently reversed, and in addition their surface speed is reduced until it is lower than that of the doffer, with the result that instead of taking the material underneath to the next swift, it is left by the doffer on the teeth of the angle stripper, which scrapes it off.

By running the stripper in the reverse direction it can be set closer to the doffer, which setting ensures that the points of the wire will be kept cleaner, and the angle of the teeth is also helped, which causes them to retain their keenness, and this reduces the waste due to droppings. The driving in the case of this modification is either by a crossed belt from the doffer shaft or a small open belt driven by a pulley on the swift shaft. In many new sets the belt described as the stripper strap is only used to drive the fancy, and a rope that runs outside the framing is used for driving the stripper, that is driven by a grooved pulley about the same size as the stripper pulleys, instead of a 36-in. body pulley. The strippers then run at under 100 revs. per min. instead of over 200, and as a consequence there is less wear of card clothing, and the workers are stripped quite as well.

Numerous experiments have been made for the purpose of determining the most efficient size of working rollers to use, and the results of these experiments go to show that all working rollers should be as large as conditions will allow, so as to obtain the greatest possible working contact. For example, if the workers of a card were 6 in. in diameter, and 9 in. workers were substituted, the curvature of the latter being considerably greater than the former, owing to the greater circumference, the working contact would be greater. Consequently, the time during which the material is acted upon by two working rollers of large diameter is greater than in the case of two rollers of small diameter, and the same is true as regards the distance through which the material passes while being acted upon by any two working rollers.

Many experiments have been tried on the carder, and a few useful modifications have been adopted. Some years ago a carder, known as the Brown carding machine, that had no strippers, was much in vogue. It produces a straight-fibred "worstedy" thread, that possesses qualities which give the cloth woven from it a distinctive soft appearance and great durability. The workers touch each other, and hence each succeeding worker strips the one preceding it, as the relation of one to the other is similar to that of a condenser stripper and a ring doffer. In the triangle formed between each pair of workers and the swift, a plain metal roller is fitted to prevent the material from rolling and being distributed unevenly on the swift. The material goes straight through the machine and not round the workers, which results in less mixing than the ordinary type of machine.

THE BROWN CARDING MACHINE.—Fig. 97 is a diagrammatic sketch of the Brown machine. The material is fed to the swift A in the usual manner—that is, by means of feed rollers and licker-in —or by means of feed rollers that feed the material to a licker-in, which is 4 in. in diameter, that in turn transfers it to a tumbler B, which is 10 in. in diameter, and revolves in the direction indicated by the arrow. Grid bars are set under the tumbler, between which much of the foreign matter in the material passes. The action on the material due to passing over the bars is such as to assist

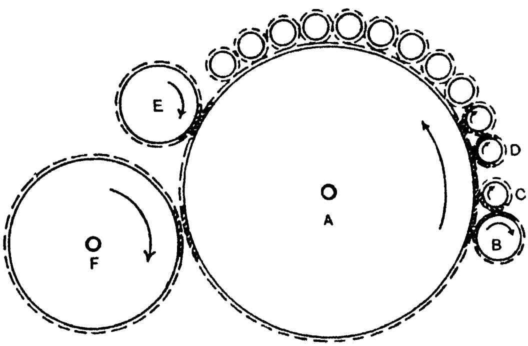


FIG. 97.

in the removal of impurities. This arrangement is so efficacious that it is frequently adopted on ordinary machines in the case of dirty blends and those that contain much material that is difficult to open.

The tumbler is stripped by the swift A, and the material is carried by the latter to the first worker C that works in conjunction with both the swift and the tumbler, the material taken by the worker being transferred again to the swift by the tumbler, which strips the worker and is in turn stripped by the swift. All the material that is not taken by the worker C is carried forward by the swift, and is submitted to the action of eleven workers D that are similar to C and are 5 in. in diameter. These workers all revolve in the same direction and strip one another, because the teeth work smooth side against smooth side or back to back, and the speed of each succeeding worker is greater than that of the one which precedes it. A chain driven by a sprocket-wheel on the doffer shaft gives motion to the workers, and the number of teeth on the sprocket-wheels on the worker shafts is one less from the tumbler to the doffer shaft, so as to get the desired increase in speed, the smallest wheel being fixed on the worker shaft nearest the doffer.

The smooth rollers that are placed in the triangle formed between each worker and the swift are about 1¼ in. in diameter, and are driven by small gear-wheels, the size of which is such as to cause an increase in speed corresponding to that of the workers. The rollers keep the material in one even sheet, and thus prevent its rolling. After leaving the last worker the material is acted upon by the fancy E, doffed in the usual manner by the doffer F, and delivered to the condenser.

Fly strippers are another feature about which opinion varies very considerably, some engineers having a good opinion regarding their use, while others hold exact the reverse opinion. A fly stripper is a small stripper which is fitted just beneath the fancy on the carder, and its object is to replace the fibres that are raised by the fancy, and which in the ordinary way would be thrown on the doffer or over the machine on to the swift, so that by preventing this they reduce unevenness of roving from side to side. They are undoubtedly a most useful addition when running on materials that are likely to be lively, such as carbonised or loose fibred materials, or where the speed of the swift is too high. They are invariably fitted on Continental sets, and often a fly stripper is fitted in front or above as well as under the fancy, but it is not usual to fit them to English sets of machines.

LICKER-IN AND TUMBLER FEEDS.—Many experiments have been made with the feed end of the carder, but to-day either a plain licker-in or a tumbler and licker-in are used. The licker-in is the older style, and many attempts have been made to improve its usefulness as a mixing and opening agent. Ordinarily the licker-in is 10 or 12 in. in diameter, but it has been tried enlarged to 20 or 24 in. with a worker and stripper fitted over it. A further development was to increase it to 30 or 36 in., with two workers and strippers; and a still further development was to increase its diameter to 36 or 40 in., and fit three pairs of workers and strippers over it. Machines that are not very old are in use to-day with enlarged lickers-in, but they are not very satisfactory, because an angle stripper cannot keep the points of the teeth clean, and lickers-in are difficult to keep clean.

What is known as the tumbler feed is extremely efficient, as it mixes the material well, frees it of a large proportion of shives and dirt, and occupies very little space. The licker-in is from 4 to 6 in. in diameter, and the tumbler from 10 to 12 in. With this feed the feed rollers pass the material to the licker-in that is revolving in the usual direction, and which transfers it to the tumbler that is revolving in the opposite direction to the licker-in, and beneath the tumbler is a grid that allows foreign matter to drop through, whilst permitting the material to go forward to the swift. Immediately over the tumbler is a small worker that prevents the material passing forward too thickly, and returns to the tumbler any material that it retains.

Methods of Doffing.—It might be remarked that on Continental carders the angle stripper is dispensed with, and the licker-in is clothed and run in the opposite direction, exactly like the licker-in on a cotton card. A notable and successful addition to machines running on thick and medium counts, and that have a large production, is one that is designed to ease the work of the last fancy on the carder by taking a proportion of the material over it. Some of the material being taken over the fancy, renders it less liable to fly. In this arrangement the last worker—that is, the one immediately over the fancy—is made larger, and may be as much as 14 in. in diameter, the increase in size rendering it possible for it to act as a small doffer. Two rollers carry the material taken by the large worker to an 18-in. roller, revolving fairly quickly, that deposits it on the tape doffer, and the doffer carries it back so that the material can be united to that left on the swift, and the whole, as one web, passed to the condenser. This arrangement is neither so successful nor necessary on fine counts as on low and medium, but it is a decided advantage on the two latter.

The underlying idea of the modification just referred to is further developed in the case of Continental and similar machines. In the Josephy and Gessner machines two fancies and two doffers are employed. In one case there is a doffing comb for each doffer, and two endless lattices carry the web from each doffer towards the dividing rollers of the condenser, while in the other supplementary rollers are utilised to bring the web on to the lower doffer.

Fig. 98 is a diagrammatic section of the type in which lattices are employed. There are five pairs of workers and strippers, but only the last pair are shown. After the material has passed the last pair of workers and strippers, it is acted upon by the first fancy A, that raises the lighter material to the tips of the teeth of the swift B, which enables the first and smallest doffer C to remove a portion. The material remaining on the swift is next acted upon by the second fancy D, that is set a little deeper into the swift than the first, and raises the material so that the swift can be completely cleared by the second doffer E. The web from each doffer is united into one in the following manner: The material is stripped from the first doffer C by the doffing comb F, and is thus transferred to the lattice G, that in turn delivers it to the lattice H, which carries the web from the doffer E, and the combined webs are carried away by the lattice J. The two doffers and fancies ensure that the swift is thoroughly cleared of material after it leaves the last doffer, and consequently it can receive and deal efficiently with a much greater quantity of material than a machine that is fitted with only one fancy and doffer. As a matter of fact, one doffer cannot clear the swift thoroughly; hence, when the latter arrives at the feed rollers it contains an appreciable quantity of material that has been through the machine, instead of being quite clean. The swift of a machine fitted with two doffers and fancies may be run at a speed of 150 revs. per min., and if a clean and soft blend is run, that is uniform in quality

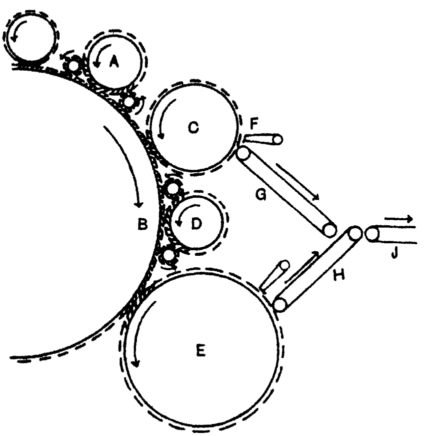


FIG. 98.

and composed of short fibres, a surprisingly high efficiency is obtained.

A development of the Josephy and Gessner types is the Hetherington Duplex Carder, in which the web from each doffer is passed by separate angle strippers to two small swifts that are placed one above the other, the upper one of which is provided with two pairs of workers and strippers and a fancy, while the lower one has only one pair of workers and fancy over it, and one large doffer receives the web from each small or auxiliary swift, and delivers it to the condenser. A diagrammatic section of this machine is shown in Fig. 99. The swift A is of the usual construction, and has the usual

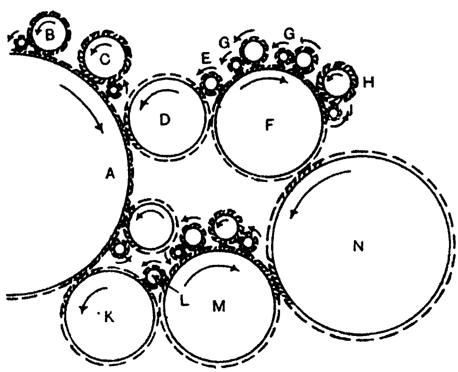


FIG. 99.

number of workers and strippers placed over it. When the material leaves the last worker B it is acted upon by the first fancy C, that raises the lighter material so that it can be cleared by the doffer D. The material taken by this doffer is stripped by the angle stripper E, which transfers it to the small swift F, over which is placed two pairs of workers and strippers G and a fancy and fly stripper H and J, that act on the material in the usual manner. That material which remains on the swift after passing doffer D is raised to the tips of the teeth of the swift by the second fancy, which is set deeper than the first, and is cleared by the doffer K. The doffer K is in turn cleared by the angle stripper L, that transfers the material to the swift M, over which is placed one pair of workers and strippers and a fancy. Both swifts F and M are cleared by the doffer N, from which the material passes to the condenser. The objects attained by the introduction of the small swifts and complements of workers and strippers are the more thorough mixing of the material, and its complete removal from the swift, which results in a considerable increase in the efficiency of the machine, since very little material is left in the wire, and hence when the swift comes round to the feed side its capacity is not reduced, due to material remaining in the wire of the swift.

CONTINENTAL SYSTEM OF CARDING.—A discussion of the different modifications of carding machines would not be complete without an explanation of the general features of the Continental type of card. This type of card resembles a cotton card more than the ordinary English type of carding machine, with the exception that it is fitted with a fancy with which a cotton card is not provided. A set of Continental machines consists of three, each one of which is usually made up of one swift, over which are five or six pairs of workers and strippers, and two fancies and doffers, although in some cases the scribbler may have a small breast, usually about 36 in. in diameter, over which are fitted two pairs of workers and strippers. The breast and its workers and strippers may be clothed with ordinary fillet clothing or Garnett wire, and a doffer and angle stripper are employed to convey the material to the swift, which is usually 50 in. in diameter.

The workers on the Continental type of machine are larger and the strippers smaller in diameter than those on the English type, the workers being about 10 in. and the strippers about 2½ in. in diameter. In this way the maximum carding surface is obtained, and it is possible to place an extra pair of workers and strippers over the swift. It is only possible to use such small strippers successfully when running on clean blends, as they are apt to get greasy when dirty and greasy work is being carded.

The machines are made wholly of iron, and on the whole are narrower than those of the English type, and the bends and frames fit close to the roller ends, so that the stripper belts and worker chains are outside, which is perhaps the most noticeable difference at first sight. The object of setting bends close to the swifts and of covering in the fancies is to reduce the draught caused by the revolution of the rollers to a minimum, and hence the amount of fly. Underscreens are fitted to prevent waste dropping, and although the whole machine may not be covered over, as previously noted, the fancies invariably are. A little consideration will render it clear that everything is done in the case of Continental machines to increase the speed of the rollers, and consequently the output, and at the same time produce a satisfactory roving. The speed at which the swifts are run is nearly double that at which they are run in the English type of machine, as many as 140 or 150 revs. per min. being common, and the makers of these machines guarantee a production that would be considered impossible in the case of English sets.

At the end of the first machine or scribbler in the Continental set is a lap feed; at the end of the second or intermediate machine an elaborate feed on the Scotch principle is fitted, with the important difference that in the case of the ordinary Scotch feed the sliver is drawn from the side, the fibres being lengthwise in the sliver, which is laid on the feed lattice of the carder so that the fibres go into the feed rollers sideways, while the fibres pass into the carder lengthwise, or ends of fibres first, in the case of the feed on the Continental type of machine. This undoubtedly tends to produce a roving that has the fibres more completely straightened, and the carder is largely relieved of the work of straightening the fibres, and hence, other things being equal, a better spin and a stronger yarn result.

Tape condensers are invariably used, and more threads are produced on each machine than is the case with the English type, as on the latter the average number of ends produced is 100, and only occasionally as many as 150, while on the former as many as 240 threads may be produced. One reason for the production of a greater number of ends is doubtless the fact that finer counts are more general. The greater production of the Continental type of machine cannot, however, be attributed entirely to the design of the machine, which aims at running the largest possible number of workers of the maximum diameter and the swift at the highest possible speed. The greater speed of the swift is rendered possible by the use of covers and fly strippers. The factor which, along with those already named, makes the high production possible is the superior manner in which the material is prepared for the cards.

In British practice the cards, besides having to card the material, have also to a large extent to *clean* it. When wool and noils are being spun, unless for union goods, the shives and burrs are to a large extent removed by the cards, and the woven piece carbonised to remove the remainder. An exception is union blanket and flannel yarns, in which the material must be carbonised first if at all burry. The amount of dirt removed from shoddy and mungo blends in passing through the cards, either in the form of droppings or fettlings, will often amount to 25 per cent. of the original weight. In British practice all the cleaning prior to carding that the rags receive is that of shaking, but in the Continental system the rags are washed and carbonised, hence there is practically no dirt to clog up the machines and cause them to be stopped at close intervals for fettling, or alternately produce indifferent work. Further, anything thready is carded or Garnetted before being put on the machines, consequently the cards have only to perform the work of opening neps, straightening, and levelling the fibres ready for the condenser. Undoubtedly the production on the English type of machine could be largely increased if the question of cleanliness were given closer attention. For instance, the black oil so largely used in the West Riding contains a considerable proportion of dirt, and the use of a clean emulsion would reduce the proportion of dirt in the cards to a considerable extent.

It might be noted that the open design of the English type precludes the possibility of an increase in speed, but it must be also noted that on most classes of work an appreciable increase in speed is not possible, and in consequence of this the number of parts of an English set has been increased until to-day a standard set will consist of a scribbler with a breast 50 in. in diameter and three swifts 54 in. in diameter, and a carder composed of two swifts each 54 in. in diameter.

The amount of room occupied by the typical English set just referred to, and the power consumed, are considerable, and it would appear to be within the region of possibility to thoughtful men to develop or invent a woollen carding machine on the lines of a revolving flat cotton card, which occupies a comparatively small amount of floor space and has enormous carding power.

AMERICAN SYSTEM OF CARDING.—The American system of carding resembles the Continental more than the English, with the exception that a tape condenser is seldom if ever used. The scribbler in the American system, which is termed the first breaker, consists of only one swift, and is fed by a hopper-feed of the usual type. As the material leaves the first breaker it is made into balls that are placed in a creel which supports them while the material is passing into the intermediate, known as the second breaker. This machine consists of only one swift, and the material is delivered to an Apperley feed that feeds it to the carder composed of only one shift, which is generally known as the finisher card. All three machines are similar in appearance, and to give an idea of the sizes of the different parts, the following dimensions may be given: Feed rollers and feed roller stripper, $1\frac{3}{4}$ in. in diameter; licker-in, $5\frac{1}{2}$ in.; licker-in fancy, 3 in.; tumbler, 9 in.; workers, 7 in.; strippers, 3 in.; and doffers, 30 in. From the particulars just given it will be seen that most of the rollers are smaller in diameter than those on the English type of the machine, and consequently there is considerably less working or carding surface in the case of the American machine. The latter type of machine is also built narrower, the width usually being 48 in., and 60 in. the exception, while the English type is generally 72 in. wide. Each machine has six pairs of workers and strippers over it, with the exception of the carder, which has only five, since room must be found for two doffers. The American set of machines is very suitable for carding material that is medium to fine in quality, fairly clean, and in good open condition—that is, requires relatively little carding.

As has been indicated, the condensing is on the double-doffer principle, a distinctive feature of the condensing being the employment of rollers covered with leather, or a combination of such rollers and rubbing leathers. In both cases the material is removed from the swift by doffers that are in turn cleared by condenser strippers, or wipe rollers as they are termed in American practice. After leaving the wipe rollers the ribbons of material pass to their respective sets of rubbing rollers, and as the ribbons pass over the bottom rollers and under the top they are rubbed into rovings, due to the fact that the rollers have both a rotary and a traversing motion, and hence act in precisely the same manner as the rubbers in the English type of condenser. The top rollers, of which there are usually five, are not set vertically over the bottom set, but in effect the first roller in the top set rests between the first and second in the bottom set, and so on, the object being to get the greatest rubbing surface. There are usually six rollers in the bottom set, and each roller in both sets is given a traversing motion by means of an eccentric, as in the case of ordinary rubbing leathers. To give a slight draft to the threads each roller is run a tooth faster than the preceding one.

The combination of rollers and rubbing leathers just referred to is sometimes used, the ribbons after leaving the wipe roller passing first between a series of rubbing rollers, usually two in the top set and three in the bottom, and then between a pair of rubbers, the bottom one of which is usually provided with a press roller for keeping it in contact with the top one. The advantage claimed for the combination of rollers and rubbing leathers is that the superior drafting action of the rollers, which has a levelling effect on the threads, is combined with the better rubbing effect of the rubbing leathers.

FETTLING OR DRESSING.—However clean the material may be that is being carded there is always a certain proportion which does not go through to the condenser bobbin. In washed wools a small percentage drops out of the machine, usually beneath the swift and doffer, and this must be removed before it accumulates to such an extent as to touch either of these rollers. In addition to the waste just referred to there is a proportion of the material and impurities left in the spaces between the teeth on the different rollers, and during the process of working these gradually get thicker or accumulate until eventually the machine has to be stopped and the accumulations removed. These impurities vary in composition, and hence in saleable value as by-products.

In the cleaner kinds of washed wools the matter removed, which is termed fettlings, is largely short fibre, with which is mixed a small proportion of shives or burr matter if the material has not been carbonised. Should the blend being carded consist largely of noils the proportion of shives is much greater. In the case of many slipe wools, and particularly those with even a trace of lime left in them, there is a very objectionable residue of a sticky nature that is formed by the lime combining with the oil, and this renders fettling very difficult, though perhaps not so difficult as when unwashed wool is carded. With lower qualities such as those containing shoddy and mungo, the amount of actual grease and dirt present in the fettlings is much greater. Blends composed largely or wholly of new shoddy are comparatively clean, there being no shive or burr matter and very little dirt.

The amount of actual dirt in the case of some classes of old mungo or carbonised rags that have not been washed may reach up to 25 per cent. of the weight of the blend in some cases.

The length of time that a machine may be run before it is fettled varies considerably. For example, in the dirtiest of low goods fettling may be necessary every eight hours, especially if the material is being spun to thick counts, which is often the case, while when carding the cleaner and better class blends it may be necessary to fettle only every two or three days, or in some cases once in seven to ten days may be sufficient. When carding the better class materials it should be borne in mind that fettling must be done long before defects develop that may be passable in the lower qualities.

When a machine is getting dirty the carding is naturally inferior in quality, and as a result the rovings or cardings become neppy and uneven, and the number that break is largely increased. As the swift fills up, the fancy will be found to throw out more fly than when conditions are normal, and on the carder the side threads will tend to become smaller than those in the middle. The workers cease to hold the material as they should, and in some cases, if the stripper is not touching, they may become completely covered with grease. The strippers throw the material over instead of straightening it out, whilst the angle strippers will roll it out at the sides or drop it on to the floor. When the doffer gets very dirty a larger proportion of good fibre is dropped, because it has not the holding power to carry the material forward. All these symptoms are seldom present together unless fettling is postponed very much beyond the usual time.

In practice all the rollers of a machine are not fettled at the same time. As a rule the swifts will be fettled every time that fettling is done, but the workers and strippers are generally fettled at alternate times—that is, first the swifts and workers are fettled, and when the swifts are next fettled the strippers and not the workers will be dressed. The fancy is not touched in the ordinary way, as a slight coating of grease on the wire helps to reduce the amount of fibre thrown out when the machine is running. It might be expected that the scribbler will require fettling oftener than the carder, but in practice this is not done, because the carder will not do its work sufficiently well if it is as dirty as the scribbler, on account of the finer work that it has to do. In some mills the scribbler and the carder are fettled together, but this is not so satisfactory as fettling them at different times, because if the former practice is followed the carder has to run for a considerable time before the rovings become of proper thickness, and when all the machines are running dirty at the same time the carding is decidedly worse than if the latter practice is followed. It is customary in some mills to fettle machines at fixed times whether they need it or not, and, consequently, either unnecessary waste is made or the machines are allowed to run longer than they should without fettling. The best plan is to look over the machines twice a day and fettle those machines or parts that require it, and thus allow for different kinds of materials.

Fettling is done by means of toothed plates termed fettler plates or combs, and those in most general use have 14, 16, or 18 teeth per inch. The plates are made from steel, and are about 6 in. long and $1\frac{1}{4}$ in. broad. In the lower edge, which is bevelled, teeth are cut that are about $\frac{1}{4}$ in. long in the case of coarse combs, and $\frac{3}{16}$ in. on the finer ones. Two holes are punched in the plate, and through these the two ends of a fork with a handle are riveted. The angle at which this plate is fixed in relation to the handle has a great influence on the ease and efficiency with which a machine can be fettled. If the plate is too nearly at right angles with the fork, the teeth of the plate penetrate too deep into those of the card; but if the angle is greater than a right angle—that is, if the plate is too flat—the teeth do not get deep enough. No definite angle can be given, as the most suitable angle varies with individual fettlers and the way the fettler uses the plate. An old plate that has been taken care of and which has no teeth bent is better than a new one, as the wear due to use makes the teeth smoother, rounder, and at the same time sharper. A comb with 14 teeth per inch is used for coarse card clothing, such as that on the breast swift of a coarse set of machines; a comb of 16 teeth is used for medium clothing, and scribblers and strippers are usually fettled with this comb; while one with 18 teeth is used for fine cards, the carder usually being fettled with this size of comb. For fettling ring doffers a fettling board is often used that consists of a flat board, 6 in. by 4 in., to which is attached a handle, and one side of this board is covered with a piece of coarse card clothing. With the board both safer and better results are obtained, as the wires of the board get between those of the rings on the doffer easier and are not so liable to damage them, because they offer less resistance than the teeth of the ordinary fettling comb. In the mungo trade it has been found advisable to use fettling boards, as the dirt removed is so heavy and deficient in fibre that it is impossible for it to hold together.

Operation of Fettling.—The method of procedure in fettling is usually as follows: The feed rollers are disconnected by the side shaft of the scribbler or carder being taken out of gear, and the machine is allowed to run itself empty. The running empty of the machine provides an excellent opportunity for cleaning the belts, which is done by means of a piece of old card that is pressed against them, and should any of the fibre and dirt that is scraped off get into the machine it cannot spoil the carded material. When the machine has run empty, which generally takes about two minutes, the belts and chains that drive the strippers, workers, and doffers are taken off, so that each roller may be moved about as desired. When lifting rollers or removing them from the machine, great care must be taken not to damage the clothing. Two pieces of piping termed lifting piping are used when it is necessary to lift any roller from the machine, and are practically indispensable if the roller is a heavy one. These pieces of piping, when a roller is to be moved, are slipped over the ends of the shaft, and it is comparatively easy for two men to lift the roller without any danger of dropping it, as is otherwise likely owing to grease on the shaft. In the older system of fettling, the workers and strippers were lifted out of the machine and placed in special stands in order to fettle them; but modern machines are so much larger, and hence heavier, that it is now no longer practicable to remove them from the machine, consequently all rollers are fettled in or over the machine. The swifts, doffers, and angle strippers are generally fettled on each occasion that fettling is done, whilst the workers and strippers over one or two of the swifts will be omitted and fettled on the next occasion.

The fettlers work in pairs, one man working on one side of the machine and the other man on the other side, the one working on the left side being termed the left-hand fettler and the other the right-hand; and four or six men will make a team. The fettlers take different swifts, and the work is arranged in approximately equal amounts, so that the different pairs of fettlers will all finish at the same time, or as nearly so as possible. When fettling the workers the men begin with the last worker, which is fettled with the men standing on the frame of the machine near the fancy. They then get up and stand by the fancy to fettle the third worker. After the third worker has been fettled, the second and first are done in the order named. The two men now turn round and fettle the strippers, beginning with the angle stripper, and then they continue with the first, second, third, and fourth strippers. Workers and strippers have to be fettled in opposite directions on account of the angle of the wire, because fettling must never be done against the point of the tooth, but always from the knee towards the point — that is, along the backs of the teeth. It will thus be clear that in the ordinary course the men, after fettling the workers, would have to turn round on the machines before commencing on the strippers; but to obviate this, another pair of men may take the strippers. To clean the swift, the last stripper and the last, or two last, workers, may be conveniently rolled back and piled up on the others, so as to make an opening, and thus render it possible to clean the swift. In order to get at the doffer it is often necessary to lift the fancy out and put it on the top of the workers and strippers over the swift, but on many machines it is sufficiently high to enable a fettler to work beneath it. The fancy is usually touched only by the carding engineer, as it is considered that it does better work when sufficiently dirty and greasy. The licker-in and the feed rollers will in many cases run for several weeks without cleaning, though the doffing comb should always be kept scrupulously clean. The ring doffers on the last cylinder of the carder will run for months without requiring to be fettled, as the condenser strippers, being set to run about $\frac{1}{16}$ to $\frac{3}{32}$ in. into the doffers, keep the latter sharp and clean.

Four men will keep from 8 to 12 sets of carding machines clean, varying, of course, according to the material and to its previous preparation. As the work of fettling is laborious, it is necessary to employ strong men, and fairly tall men have an advantage over short men. When a roller has been lifted out, the neck and bearing should be wiped free from dirt before it is replaced, otherwise the setting as done by the overlooker is altered seriously. When all the rollers have been fettled the belts and chains are put back, and the comb at the scribbler and the tape rollers at the carder are cleaned before the material is allowed to run through. For some time after fettling a certain amount of loose dirt works out and into the material; hence it is advisable to allow it to run to waste for a few minutes. A proportion of fibre also finds its way into the now empty spaces between the teeth, and the machine does not deliver full weight for some minutes; consequently on no account should the sliver or threads be put up at once, and especially is this the case if work of good quality is required. The roving is apt to be a little light for an hour or so after fettling; this, of course, is not returned to the hopper feed, but is spun, although perhaps the draft in the subsequent spinning of the roving into yarn may have to be changed slightly to make the required counts of yarn. Fettling should never be postponed beyond the time when it is clear that it is necessary if a good level yarn is required, as most serious defects begin to develop as a result. It should also be well and carefully done, and the fettlers should not allow their feet to come in contact with the card clothing on any of the rollers with such force as to injure the clothing.

CHAPTER XVII

CARE AND MANAGEMENT OF MACHINES, PRODUCTION, PARTICULARS OF CARDING MACHINES

CARE AND MANAGEMENT OF MACHINES.—Under this heading may be considered all the various factors that contribute towards the obtaining of a maximum production of satisfactory roving. It might be said that this much-to-be-desired result is not obtainable by hard manual labour, as in many occupations, but is purely a question of skill, experience, and foresight. An influencing factor with regard to this matter is that the maximum production of one machine varies considerably from that of another, and in practice, where a number of exactly similar machines are running in the same room, it is often found that one of them will be more adaptable and do better work than some of the others. Further, a blend of a certain quality and kind may be run to much better advantage on one machine than another. Consequently, one of the first essentials is to acquire a thorough knowledge of the character and peculiarities of the various machines, and as far as possible put the different kinds of blends and qualities on those machines that have been found most suitable. It is difficult, if not impossible, to explain why carding machines should exhibit the peculiarities referred to, but it is a well-known phenomenon. Such details as the smoothness, sharpness, or stiffness of the wire, or some other almost imperceptible difference in the condition of the card clothing, may be suggested as causes, but when it is realised that there is an almost unlimited range of qualities in the woollen trade, it is not surprising that some are carded better by certain machines than others. Where machines are of different types, the choice of the most suitable for a certain quality of work is less difficult to make, as, for instance, the choice between tape and ring condensers is not a difficult one to make, because the thicker and dirtier blends should be run on ring condensers, and the finer and cleaner blends on tape condensers.

Carding machines should be run continuously, since any lost time caused, say, by a breakage cannot be made up, and hence it is of first importance to keep all parts in good condition. On a set of carding machines there is about 400 ft. of belting, and all the joints on this should be kept in good order. In the case of stripper straps that have to bend both ways, ordinary tacked lap joints soon spring, and because of this a laced butt joint is frequently used. It is not advisable to run stripper straps that have more than two or three joints; such straps can be used for shorter doffer straps. Most belting makers will make stripper straps endless to measure, and where the bottom carrier pulley is in a slot, it is an improvement on the ordinary jointed belting, and especially so if a good type of stretchless belting is used. The same remarks are true in the case of chains, since as soon as they are worn and have broken a few times it is advisable to replace them by new ones. These points with reference to the running of straps and chains are more important than is often realised, because the loss of running time when a belt or chain breaks is considerable, and it cannot be made up. At many mills the carding machines are run during meal-times in order to increase the running time. Perhaps one of the main reasons why they are so run is that very little labour is required to keep them running.

MINDER'S DUTIES.—Regarding the duties of minders, and the efficient carrying out of those duties, the primary object is to obtain a good bobbin, and if the carding overlooker has done his work right, there should not be many broken threads at the condenser. One of the principal contributing factors with regard to the production of even threads is the efficient lubrication of the parts. The machines should be oiled throughout every morning—that is, all the rollers, the condenser, the intermediate feed, and the hopper feed. The strippers, fancies, and eccentric motion should be oiled again at noon, whilst the doffer and swift pedestals should be packed with tallow or similar stiff grease, that will provide a reserve of lubrication, and which will melt in the case of a hot bearing. If tallow cannot be obtained, small pieces of waste soaked with heavy oil may be placed in the oil cups. The doffer comb driving mechanism is run in oil, and it should be examined every fortnight or so to see whether there is sufficient oil in the reservoir or casing. Lack of oil will often cause the sliver at the Scotch feed to break, or it may cause the threads to run smaller than they should, due to the slipping of the belts caused by the different rollers being more difficult to turn.

FACTORS AFFECTING PRODUCTION.—A woollen carding manager should aim at the production of good work; as large a production as possible consistent with the quality of work being done; avoid the making of unnecessary waste; keep down expenses, such as those of wages, supplies, power, and so on; and see that the machinery is kept in good running order.

An important factor affecting production is the time occupied in fettling the machines. This varies with the number of fettlers working on the machines, the size of the machines, and the class of work being carded. Four ought to be the minimum number of fettlers employed, and six are preferable. With regard to the second point, modern machines are much larger than older types, and hence the area of card clothing is greater, which makes cleaning a longer process. Respecting the third point, which refers to the class of material, this affects the amount of time lost due to fettling very considerably, since if the material being carded is clean, fettling is necessary only at wide intervals; while in the case of dirty blends fettling must be done much more frequently. It may be taken as an axiom that it does not pay to blend and card dirt, and consequently every precaution should be taken to have the material as clean as possible. That this is not done is clear from the fact that many shoddy, mungo, and waste blends will lose 25 per cent. in passing through the machines in dirt and droppings. When a machine requires fettling every day, approximately 10 per cent. of the running time is lost, which means a serious loss in production.

Other factors that affect production are as follows: (*a*) the thickness of the roving; (*b*) the number of threads at the condenser; (*c*) the surface speed of the bobbin drums.

CALCULATIONS ON PRODUCTION.—It is advisable to find the theoretical production of a set of carding machines so as to be able to find out the loss of running time daily or weekly. To find the surface speed of the bobbin drums or rate of delivery of the threads, multiply the diameter of the bobbin drums by 3·1416, and multiply the result by the revolutions per minute made by the bobbin drums, and divide the total by the number of inches per yard; the result will be the surface speed of the bobbin drums. Suppose a 96-thread tape machine is running on a serge yarn that is being condensed to 8 skeins for spinning to 12 skeins, and the bobbin drums, 8 in. in diameter, are running at a speed of 21 revs. per min. The surface speed of the bobbin drums or the rate of delivery of the threads is—

$$\frac{8 \times 21 \times 3{\cdot}1416}{36} = 14\tfrac{2}{3} \text{ yds. per min.}$$

(*Note.*—On tape condensers with four heights of bobbins the drums are generally 8 in. in diameter, whilst on ring condensers the drums are generally 9 in., consequently a speed of 21 revs. per min. does not mean the same rate of delivery in each case.)

To find the yards delivered by the machine referred to in the above example it is only necessary to multiply the rate of delivery by the minutes per hour and the number of threads delivered by the condenser. Thus, the number of yards delivered per hour will be as follows—

$$\frac{44 \times 60 \times 96}{3} = 84{,}480 \text{ yds.}$$

To find the number of pounds weight produced per day of 10 hours multiply the yards delivered per hour by the hours worked per day, and divide by the counts of the yarn multiplied by the standard length of hank. Suppose the yards of roving delivered by a condenser are 84,480 per hour, the weight of yarn, 8's counts, produced per day of 10 hours is—

$$\frac{84{,}480 \times 10}{8 \times 256} = 412\tfrac{1}{2} \text{ lb. per day.}$$

A rule for obtaining the production per day of 10 hours, and which embodies all the foregoing, is as follows—

Rule: Multiply together the diameter of the bobbin drums, revolutions per minute made by drums, 3·1416, 60 mins. per hour, ends produced by condenser and 10 (hours per day), and divide the result by 36 (inches per yard), counts, and standard length of hank multiplied together. The result will be the production in pounds.

Example: Suppose a 96-thread tape machine is running on a serge yarn that is being condensed to 8 skeins for spinning to 12 skeins, and the bobbin drums, which are 8 in. in diameter, are running at a speed of 21 revs. per min. The production per day of 10 hours will be—

$$\frac{8 \times 3{\cdot}1416 \times 21 \times 60 \times 96 \times 10}{36 \times 8 \times 256} = 412{\cdot}33 \text{ lb. (Ans.).}$$

The productions obtained in the above calculations could not be expected in practice, but on clean work, where the machines are fettled every two or three days, the actual production should be within 5 to 10 per cent., and on dirtier and lower materials, where fettling is necessary each day and there is a larger proportion of waste, it may be as much as 10 to 20 per cent. below the theoretical production. Large productions can be obtained by limiting as much as possible the time allowed for fettling, grinding, and setting the machines, and also by not allowing the rest of the set to be stopped any longer than is necessary while fettling or grinding any one machine of the set. The production may be increased in two ways: By speeding up the whole machine, and by increasing the speed of the doffer and the feed rollers by changing the small gear-wheel that drives the large gear fixed on the doffer shaft. Carding machines should not be run too fast, because the percentage of flyings will be unduly increased, which not only increases the amount of waste, but the flyings settle on the machine and render cleaning more difficult, and they have a tendency to work into the bearings and round the shaft. The flyings also tend to collect in lumps that are often caught and carried into the machine, and thus render the roving uneven. It is unwise to force too much material through the machines by speeding up the doffer, nor should the sliver be made too heavy. In woollen carding the quality of the work should rarely be sacrificed for production. It might be said with a large amount of truth that the production of a set of carding machines depends quite as much on the carding overlooker as upon the machines themselves.

It is useful for purposes of reference to know how to find the percentage of efficiency of a set of machines when both the theoretical and actual productions are known. To find this, the following rule may be employed.

Rule: Multiply the actual production by 100, and divide by the theoretical production; the result will be the percentage of efficiency.

Example: Suppose the actual production of a set of machines running on a serge yarn is 370 lb., and the theoretical production is 412½ lb., what is the percentage of efficiency?

Solution: Applying the rule, the production is—

$$\frac{370 \times 100}{412\frac{1}{2}} = 89{\cdot}7 \text{ per cent. (Ans.)}.$$

A production of 89·7 per cent. would be considered satisfactory in this case.

POINTS IN WORKING CARDING MACHINES.—Economy in working carding machines depends largely on the cost of labour and the percentage of waste made. Under ordinary circumstances one girl will attend to two sets; four fettlers will follow from 8 to 12 sets of machines; and one carding engineer with an assistant will have charge of the same number of sets. The cost of labour depends on the standard rate of wages obtaining in the locality, the class of work being done, and any other conditions peculiar to the mill. The amount of waste produced should be as small as possible, and taken care of. For example, all soft and clean waste should not be mixed with the dirty, as the former can be run through the machines again without being submitted to any other process, while dirty waste collected from under and round the machines has to be dusted and willeyed before it can be carded again. Greasy waste should never be put into bins or collected and accumulated in piles, and under no circumstances should water be thrown on any such piles, because under these conditions there is great danger of spontaneous combustion, and hence of serious fires occurring.

Carding machinery requires to be cleaned at frequent and regular intervals, and machines that are not in use should be run occasionally or the wire will suffer from corrosion, this being more likely to occur in the winter than the summer months. Should the wire become rusty the efficiency of the machine will be correspondingly reduced. At noon and night each day the machines should be wiped down with a piece of waste, and at least once each week sweeping should be done underneath the machines, and the whole of the carding room thoroughly swept up. After each fettling the machines should be carefully cleaned, and all dirt and waste removed from the bearings. Also after grinding, the machines should be cleaned and the wire brushed out with a strong bristle brush.

All the belts on carding machines should be examined once a week, and especially the stripper belt. Broken or worn laces should be replaced and weak places made good, so that no time may be lost in repairing during working time. Joints should be spliced and sewn or laced, so that a solid leather surface will always be in contact with the pulley. When belts become dry they should be oiled with castor oil. Also each time fettling is done the belts should be cleaned, the best time for cleaning being when the machine is being emptied prior to cleaning. If, for some reason or other, any of the parts are disturbed, they should be carefully gone over with a view to correcting any settings that are not good. The driving of all the parts must be uniform if the best results are to be obtained. All moving parts and belts that are outside the framing should be adequately fenced, so as to prevent workmen being seriously injured, because an employer has to compensate his workmen for injuries, and a machine might as a result of such an accident be so badly damaged as to require extensive and expensive repairs, and cause loss of valuable time.

Causes and Prevention of Twits.—A twit may be defined as a thin place that causes the roving to be uneven instead of full, round, and even throughout its length. Roving characterised as twitty usually has thick and bunched places, as well as thin and what appear to be partly broken ones. From roving that is free from twits even yarn can be produced, and it is by the presence or absence of this defect that roving is said to be good or bad. Twitty roving is the cause of much trouble in carding rooms, consequently a reference to the causes that produce such roving will be helpful. If the cause is not fairly obvious, it may be due to the material not being in proper condition for carding. It may have been scoured with too strong or too hot a scouring liquor, and rendered harsh, brittle, lifeless, and wiry. If the material is dried too quickly at too high a temperature, the same condition as with faulty washing may be produced. Much may be done to remedy these defects by careful oiling and carding of the material. It is also necessary thoroughly to blend and open the material prior to carding in order that the roving will be even.

The defects in the case of the carding machines themselves that result in uneven roving being produced are almost too numerous to mention, because twits occur when any part of the set is not doing its work properly. When the clothing begins to blister through slackness, it is necessary to recover the faulty rollers and get a true surface by proper grinding. A badly set or much-worn licker-in on either the scribbler or the carder, and especially on the latter, will allow the material to pass forward in more or less unopened lumps, and thus cause twits; the remedy is obvious. When counts of roving too fine for the material being carded are being condensed, it is very difficult, if not impossible, to get perfectly even roving. Improper setting, speeding, or unsuitable clothing on the fancy are very common causes of twits, and to remedy, a thorough examination of the part in question must be made. An incorrectly set or speeded doffer is not an uncommon cause. A defective ring or rings in the case of ring doffers will cause twitty roving, and if they are in a very dirty condition or their teeth are not sharper than those of the cylinder they are stripping, twits will be caused.

A defective condenser, whether ring or tape, is a prolific source of twitty roving. The condenser stripper or strippers should be set and speeded properly. The draft given to the roving as it passes through the condenser should be neither too great nor too small. Dirty, badly worn, and badly set rubbers are a cause of twitty roving; they should also be speeded, as well as set, so as to produce even and solid rovings. The nature of the remedy will be fairly obvious from the cause, but it might be mentioned in a general way that it is a good plan to keep a close watch on the web as it leaves the scribbler, because the condition of the web at this point is an indication as to the cause of the trouble. If it is neppy and contains a large amount of vegetable matter, the roving will most likely be neppy. All points should be closely watched that have any effect on the quality of the work produced. For instance, fettling should be done as soon as it becomes necessary, and not postponed, and both the machines and the carding room should be kept as clean as possible.

Particulars of Carding Machines.—The parts of the English type of carding machine that perform the actual operation of carding are becoming more and more standardised. The sett that consists of a scribbler and carder is generally adopted, and, when covered with suitable clothing as regards fineness and so on, such a sett will yield eminently satisfactory results on all but the very best qualities of material, and those that must be very even both as regards the mixing and the thickness of the yarn.

Attention has been drawn to the fact that the tendency is towards larger machines, and not only is the width of the machines now being made greater, but the diameter of the rollers is also greater, the principal object being to obtain a higher production without employing extra labour, which has been rendered necessary by the adoption of more efficient types of condensers. When the double-doffer tandem condenser was introduced, it was soon discovered that a small carding machine was at, or nearly at, the limit of its carding power. The fitting of a new condenser, which is fairly general in the woollen trade in cases where the bodies and the necks of the rollers are good, that could be made to run at a surface speed 50 per cent. greater than the old one, soon showed that a larger type of carding machine was necessary if anything of a neppy or thready nature were to be carded satisfactorily. With the advent of tape condensers that have a condensing capacity at least double that of the ordinary type, the defects were still more in evidence. Consequently it is realised to-day that a balance of power between carding and condensing must be maintained if the best and most efficient results are to be obtained.

An average sett of modern cards consists of four parts to the scribbler, each part consisting of a swift and full complement of rollers, most of which are rollers and strippers, and two parts to the carder. The swifts are made 50–54 in. in diameter; the doffers, 40–50 in.; and the workers, 10, 11, or 12 in. in diameter. With these large working rollers there is at each point where the operation of carding takes place a comparatively large arc of working contact, or area over which the carding action of the swift is spread. This makes it possible to put a larger weight of material through the machine without overcrowding it on the workers and doffers, and at the same time prevents the objectionable rolling or nepping which shows so badly in the sliver. When properly carded and straightened on a scribbler that is large enough for the quantity and quality of the material in work, it is possible to carry all but the shortest and lowest of materials over a Scotch feed.

All material should be well carded at the end of the scribbler, and the work of opening not left to the carder. The purpose of the carder is to mix, level up, and straighten, rather than open, and for that reason only well-opened and well-cleaned material should be fed to it. The work of cleaning by the scribbler is often underestimated. It is very essential for good spinning that all, or as much as possible, of extraneous matter should be removed. For this reason, in the lower grades of short material, and where mungoes and mungo and cotton blends are specialised in, the scribbler may be composed of four swifts and a breast or five swifts, and in some cases five swifts and a breast. The breasts may be only 44 in. in diameter, with two large workers over each, and the doffers 36 or 40 in. They can be run slowly, which keeps the material in the cards, and by using four or five doffers a very great proportion of the more solid grease or dirt is dropped, as it is between the swift and the doffer that most of the waste is dropped on the floor. The advantage of slow running, and hence better opening of the material, can also be obtained when large machines are employed.

Up to a certain point an increase of carding power is obtained by speeding up the swifts, but on most classes of material the amount of gain is doubtful. In the first place the increased surface speed of the swift causes a greater proportion of material to be dropped on to the floor as waste; and, secondly, the fancies, which must run at a higher surface speed than the swift, cause excessive fly on the carder, and uneven rovings are inevitably produced. The point to be aimed at is to have the machines running at a reasonable speed, but with sufficient carding surface to open that quantity of material the condenser can deal with adequately.

The stripping rollers are of less importance than the working rollers, so far as direct results are concerned. The angle strippers are made 6 in., and sometimes 7 in., in diameter, and the strippers 4½ or 5 in., to correspond with or match the workers, whilst the fancy is usually about 14 in. in diameter. The machines are generally 72 in. wide, though the carder is sometimes made 66 in. when run in conjunction with a 72-in. scribbler. If the machine is to be used for fine counts where the finest setting is practised, then the utmost truth and rigidity of the parts is essential. An automatic hopper feed is, of course, fitted to the scribbler, and the intermediate feed is almost invariably the Scotch feed, although for certain of the shortest classes of material that will not carry over a Scotch feed the Blamire lap feed is used. Mention should be made of the balling head and creel intermediate feed that was formerly, and is yet to a certain extent, used in the fine flannel and high-class Cheviot trade. In this trade the scribbler will have two parts with a breast and a breast doffer, there being a side-drawing to a balling machine. The balls are run from a creel to a second machine in the set known as an intermediate, which may have one or two parts, whilst a Scotch feed conveys the material to a carder of one or two parts with condenser attached. A set of three machines has the advantage of ensuring a more thorough mixing of the fibres, and also affords the opportunity of introducing small quantities of bright colours.

Sets of Carding Machines.—It will be useful with respect to the clothing of the cards to give full details of typical sets of machines for the main classes of material, in spite of the fact that for the same material a difference of opinion exists as to the most suitable cards for the work. There is not the same certainty of a certain effect being produced by card clothing of given dimensions that exists in the cotton trade, and hence there is considerable latitude in woollen carding, but the results produced would in a general way be approximately the same.

The cards at the breast are the coarsest, being strong enough to withstand the work of opening matted locks or of dealing with thread or small rags. The cards increase in fineness towards the carder and as the work of opening proceeds, but there is no definite understanding in the trade, as so much depends on the individual woollen carder's ideas and experience. Some will have cards graduated 10 or even 20 counts to each swift, whilst others will have the two carder swifts and the last scribbler swift equally fine, making the difference in the clothing on the breast and first and second swifts of the scribbler. The doffer is sometimes made 10 counts finer than the swift, and the workers 5 counts finer, although they are often the same counts, and seldom coarser. Some prefer cards close in the counts and open in the crown, and others the reverse. This being the case, it is evident that only approximate particulars can be given. Feed roller covering is of two kinds, and it is purely a matter of taste which is used. There is the saw tooth or Garnett wire, which is the more desirable, and the ½-in. needle-point fillet set in leather or cloth. Double leather may be used at the scribbler with about 14's wire, and single at the carder with 16's wire. The middle feed roller is of most importance, and should always have the points clean. The licker-in may also be provided with saw teeth, though this is only to be recommended on clean wool material. On lower classes of material the spaces soon fill up, and consequently a stout, short, needle-pointed fillet is used, or what is known as diamond point. On the carder a much finer grade can be employed than on the scribbler.

Vulcanised cloth fillet that is one inch wide is usually employed for the angle and worker strippers. Stripper filleting is generally bought in long rolls or boxes that contain 800 or 1000 ft. or so, and the rollers wrapped as required. There is no necessity for the slight variation that is made in the case of the working or carding rollers, and hence as a rule not more than three counts are stocked in practice, excluding the condenser or taking-off strippers. Where coarse to medium work is done, the counts stocked may be 50/4's, 60/6's, and 70/6's, the 50/4's being used for the breast and first and second angle strippers of the scribbler, the 60/6's being used for the remaining strippers of the scribbler, and the 70/6's for the carder. For medium to fine work the 50/4's would be omitted and 60/6's substituted, the 70/6's in place of the 60/6's, and 80/8's for the carder. Stripper filleting seldom goes finer than that except for very fine work, when 90/8's or 9's may be used. In some cases fillet with a very open count is preferred, such as 40/6's or 50/9's.

The fillet for condenser strippers is generally made ¾ in. wide, so that the teeth are nearer at right angles to the axis of the stripper than would be the case with 1-in. filleting; or, in other words, it is straighter to its work. A rather thinner and more flexible foundation is used, but it must be firm, as it is set to run into the doffer. The counts vary from 90's to 120's, but the crown must be either 8's or 9's to the three-quarter inch width, giving 10⅔ and 12 crowns to the inch respectively. The former is by far the more usual.

The counts of the card on the swift determine very largely the counts of the clothing on its complementary rollers. As previously mentioned, the workers and doffers are the same fineness, or the latter are a little finer. For very coarse work the breast may be 50/5's, or, if the material is very long as well as coarse, 40/4's. On medium average work 60/6's is used, and if on the fine or short side, free from long thread, such as pulled stockings, 70/7's; whilst 80/8's is suitable for the breast in the case of the finest work. Any hard lumps of either skin or rag will be dropped at the breast, so that the second swift may be made considerably finer without fear of any damage being done. The matted pieces have been pulled up, or should be if the setting is right, and so in a coarse set the two first swifts may be made 70/7's or 80/8's. If the breast is only small and not able to do very much opening the 70/7's would be preferable. The second swift would be about 100/9's, and the back swift of the scribbler 110/10's, which should yield a well-opened sliver; but if there are only three parts to the scribbler, the step from one part to the next would require to be greater. The carder should be clothed with 120/11's, although this count is suitable only, as stated, for coarse work. In a medium set beginning 60/6's or 70/7's the swifts should be increased in fineness in a corresponding degree to about 130/11's. A fine set would range up to 140/11's or 12's crowns, but as a rule cards finer than this are not employed. They have too much wire in them, and the short material is apt to fill them up too soon.

The clothing of the fancy is always open in comparison with the swift with which it works, and it is only on the coarser cards that it even approximates as regards the number of teeth per square inch to the swift. Seldom does it exceed 90/9's counts, even on the finest cards.

The work of the fancy is to lift the material to the tips of the wire in the swift, by the teeth being set to run slightly into those of the swift, and hence if it is too full of wire it defeats its own object and presses the material in. The breast fancy on a coarse set would be suitably clothed with 40/4's, with 50/4's on the first swift, 55/5's on the second, and 60/5's or 6's on the back swift of the scribbler. For the carder 65's or 70/6's is quite fine enough. The fancies in a medium set range from 45/4's to about 80/7's or 8's, whilst the fine set would need 50/4's or 5's on the breast to 80/7's or 90/8's on the carder. One point of note respecting the fancy is that it does not follow the ordinary rule of making card clothing. The thickness of the wire is within one or two counts the same for all

TABLE I.—DETAILS OF SCRIBBLER.

Name of Roller.	Number of Rollers.	Diameter of Rollers.	Particulars of Card Clothing.		
			Count.	Crown.	Gauge No. of Wire.
		In.			
Feed roller	3	2½	—	--	14
Licker-in	1	9	-	--	14
First angle stripper	1	6	50	4	22
Breast swift	1	40½	70	7	26
Worker	3	9	75	7	26
Stripper	3	4	50	4	22
Fancy	1	12	50	5	23
Doffer	1	30	75	7	26
Second angle stripper	1	6	50	4	22
First swift	1	50	90	9	29
Worker	4	9	95	9	29
Stripper	4	4	60	6	26
Fancy	1	12	55	6	27
Doffer	1	36	100	9	30
Third angle stripper	1	6	60	6	26
Second swift	1	50	120	10	33
Worker	4	9	125	10	33
Stripper	4	4	70	6	28
Fancy	1	12	60	6	29
Doffer	1	36	125	10	34

DETAILS OF CARDER.

		In.			
Feed roller	3	2½	—	—	16
Licker-in	1	9	—	—	16
First angle stripper	1	6	60	6	24
First swift	1	50	125	11	34
Worker	4	9	130	11	34
Stripper	4	4	80	8	28
Fancy	1	12	70	7	31
Doffer	1	36	130	11	34
Second angle stripper	1	6	80	8	28
Second swift	1	6	130	11	34
Worker	4	9	130	11	34
Stripper	4	5	80	8	2
Fancy	1	12	75	7	33
Doffer	1	36	130	12	34

TABLE II.—DETAILS OF SCRIBBLER.

Name of Roller.	Number of Rollers.	Diameter of Rollers.	Particulars of Card Clothing.		
			Count.	Crown.	Gauge No. of Wire.
		In.			
Feed roller	2	2	—	—	12
Top-clearer	1	4	—	—	14
Licker-in	1	12	—	—	12
First angle stripper .	1	4	40	4	20
Breast swift . . .	1	48½	40	4	20
Worker	3	9	40	4	20
Stripper	3	5	40	4	20
Fancy	1	12	40	4	19
Doffer	1	30	40	4	20
Second angle stripper .	1	5	40	4	20
First swift . . .	1	50	70	7	25
Worker	3	9	75	7	25
Fancy	1	13	50	5	23
Doffer	1	36	75	7	26
Third angle stripper .	1	5	50	4	22
Second swift . . .	1	50	100	9	30
Worker	3	9	105	9	30
Stripper	3	5	60	6	25
Fancy	1	13	60	6	28
Doffer	1	36	105	9	31

DETAILS OF CARDER.

		In.			
Feed roller	2	2	—	—	14
Top-clearer	1	4	—	—	15
Breast swift . . .	1	30	80	8	27
Worker	2	9	85	8	27
Stripper	2	5	60	6	25
First angle stripper .	1	5	60	6	25
First swift . . .	1	50	110	10	32
Worker	3	9	115	10	32
Stripper	3	5	80	8	28
Fancy	1	13	60	6	29
Doffer	1	36	115	10	32
Second angle stripper .	1	5	80	8	28
Second swift . . .	1	50	120	11	33
Worker	3	9	125	11	33
Stripper	3	5	80	8	29
Fancy	1	13	70	7	30
Ring doffer . . .	2	20	115	10	31

TABLE III.—DETAILS OF SCRIBBLER.

Name of Roller.	Number of Rollers.	Diameter of Rollers.	Particulars of Card Clothing.		
			Count.	Crown.	Gauge No. of Wire.
		In.			
Feed roller	3	2	—	—	14
Licker-in	1	12	—	—	14
First angle stripper	1	4½	50	4	22
Breast swift	1	36	70	7	26
Worker	2	9	70	7	26
Stripper	2	4	50	4	22
Fancy	1	10	50	5	23
Doffer	1	24	75	7	26
Second angle stripper	1	7	50	4	22
First swift	1	50	100	9	31
Worker	4	8	105	9	31
Stripper	4	4	70	6	26
Fancy	1	12	65	6	30
Doffer	1	36	110	10	32
Third angle stripper	1	7	70	6	26
Second swift	1	50	120	11	33
Worker	4	8	125	11	33
Stripper	4	4	80	8	29
Fancy	1	12	70	7	32
Doffer	1	36	130	11	34

DETAILS OF INTERMEDIATE.

		In.			
Feed roller	3	2	—	—	16
Licker-in	1	12	—	—	16
Angle stripper	1	7	70	6	24
Swift	1	50	125	11	34
Worker	4	8	130	11	34
Stripper	4	4	80	8	30
Fancy	1	12	70	7	32
Doffer	1	36	130	11	34

DETAILS OF CARDER.

		In.			
Feed roller	3	2	—	—	16
Licker-in	1	6	—	—	16
First angle stripper	1	5	60	6	25
Breast swift	1	30	110	10	32
Worker	2	8	110	10	32
Stripper	2	4	70	8	29
Second angle stripper	1	5	70	6	29
Swift	1	50	135	11	35
Worker	4	8	135	11	35
Stripper	4	4	80	9	31
Fancy	1	12	75	7	33
Doffer	1	36	130	12	35

counts and crown of clothing. The fancy, however, has wire which is just a little stronger than the swift in which it is to work. In the above case a 70/7's swift would be made with, say, a 25's wire; but a 70/7's fancy, being designed for a 120's or 130's swift with a 32 or 33 wire, would only be clothed with a card having wire of about 29's or 30's.

The number and respective diameters of the rollers, also particulars of the card clothing, for a set of machines suitable for medium materials, are given in Table I.

In Table II. are given the particulars of a set suitable for coarse materials, such as those used for blankets and rug-yarns.

In Table III. are given particulars of a set suitable for fine woollen and fancy mixture yarns.

CHAPTER XVIII

SYSTEMS OF COUNTING ROVING AND YARN, ELECTRICITY IN CARDING ROOMS

SYSTEMS OF COUNTING ROVING AND YARN.—Spinners, manufacturers, and others making and dealing with roving and yarn have found it absolutely necessary to adopt systems by which the relation that exists between the length and the weight, or, in other words, the fineness, of the roving or yarn can be expressed or designated. The following, which refers particularly to woollen roving and yarn, will illustrate the necessity referred to. In order that a woollen yarn may have a definite weight or count—that is, a certain number of yards per pound—it is necessary that the roving or carding from the condenser shall be a certain weight per yard, each yard being as nearly as possible the same weight. It is therefore one of the duties of the carding engineer to make the rovings of such weight that they may be spun into the required count of yarn with a reasonable draft in the spinning. The draft that can be given on the mule depends on the quality of the material used and the count of the yarn being spun. If the material is of good quality and is not spun too fine, what is termed a half draft in the mule is reasonable—that is, if the carriage, which is the part of the mule that supports the spindles on which the yarn is wound, has a draw of 72 in., then 36 in. of roving will be let out before the delivery rollers of the mule stop. If a low grade of material is being spun, it may be necessary to let out 40 to 48 in., or even more, of roving before stopping the delivery rollers. If the mules are running on half draft—that is, letting out 36 in. of roving and drafting it into 72 in. of yarn—the roving from the condenser must be twice the weight of the required yarn. If the draft is 24 in., and the length of the draw is 72 in., then the count of the roving will be 8 skeins if the yarn must be 12 skeins, and so on.

BASIS OF COUNTING ROVING AND YARN.—It is unfortunate that no universal system of counting roving and yarn has yet been adopted, but it is hoped that in the near future some standard method of numbering or counting will be decided upon. When such a system is adopted it will undoubtedly obviate such trouble and misunderstanding that are at present experienced when yarns numbered according to different systems are being dealt with. In most systems of counting yarns a weight standard is adopted, in which the weight is a fixture, and the length of yarn required to balance the weight decides the number or counts of that particular yarn. It will thus be readily seen that if the yarn is thick a less number of yards will be contained in a given weight, and thus the number or counts of the yarn will be less than would be the case were the yarns being dealt with finer than the above. Therefore, when the yarns are numbered by the fixed-weight system, the thicker yarns will have lower numbers and the finer yarns higher numbers.

The second and less usual method of counting yarns is diametrically opposite to the above. In this case the length is fixed or standard, and the weight is the variable factor. Consequently, the weight of a fixed length of yarn determines the counts. Therefore, the thicker the yarn the higher will be the number indicating the counts, since the weight of a certain length will be in direct proportion to its thickness. The finest yarns in this method have the lowest numbers, whilst the coarser yarns have the highest numbers.

Woollen Yarns.—No definite system of counting woollen yarns has as yet been adopted, and each locality appears to have developed one of its own. The following are the most important—

Yorkshire Skein.—The number of skeins or hanks, each 256 yds. in length, that weigh 1 lb. represent the counts or skeins, as they are generally called when counting by the above system. Originally, the standard weight was 6 lb., or one wartern, and the length of a skein 1536 yds. If there were 1536 yds. of yarn in 6 lb., it would be known as 1's skein. For testing purposes a still finer division is made. Both the length and the weight are divided by 256; 1 lb. divided by 256 = 1 dram; 1 skein divided by 256 = 1 yd. Hence the method of counting is reduced to the number of yards weighing 1 dram ($\frac{1}{16}$ oz.) represents the counts. If 8 yds. are found to weigh

1 dram, the yarn is 8's skeins or counts. "Skeins" is generally written "sk." or "sks."

A hank is a continuous strand of yarn that has been wound round a revolving framework, and when removed it is a continuous coil of yarn. In some localities the term "cut" or "skein" is used instead of hank. The terms hank, cut, or skein, in themselves, must be looked upon merely as terms used to facilitate the counting of yarns, as the yarn referred to in any particular calculation may be either in hank form or in the form of a warp, or even woven into cloth. The standard length of 256 yds. is merely the length adopted in those districts where the Yorkshire skein system is used, and whatever form the yarn is in, the counts are gauged by the number of lengths each 256 yds. that would be required to balance or weigh 1 lb., and the yarn only need be brought to the standard length by calculation, and not actually converted or reeled into hank form.

Ounce System.—In the Heavy Woollen Districts of Batley and Dewsbury, where very thick yarns are spun, the ordinary skein system of counting is not sufficiently fine, as yarns are frequently spun as low as 1's and 2's skeins. Consequently the ounce (oz.) system is in general use in these localities. With this system 2's skeins, 2 yds. of which will weigh 1 dram, will, employing the ounce system, become 32's counts, as 32 yds. of yarn will be necessary to balance the 1 oz. weight. From the above it will be clear that the method of counting is according to the following rule—

Rule: The number of yards weighing 1 oz. is the counts. By using the ounce system counts between 1's and 2's skeins can be denoted by 15 whole numbers, since between 1's and 2's skeins, which by the ounce system are 16 yds. and 32 yds. respectively, there are 15 whole numbers—namely, 17, 18, and so on up to 31. Thus with the ounce system it is possible to number or designate any thick counts without the use of objectionable fractions.

In the Rochdale district many mills employ the ½ oz. instead of the ounce weight, and the yards of yarn that weigh ½ oz. is the counts. Otherwise the system is the same as the ounce system.

West of England System.—In the West of England system the number of hanks each 320 yds. long that weigh 1 lb. is the counts. For testing purposes the number of 20-yd. lengths that weigh 1 oz. represent the counts.

GALASHIELS SYSTEM.—In the Galashiels system the standard of weight is 24 oz., and the length of a hank, or cut, as it is termed, is 300 yds. The counts are determined by the number of cuts that weigh 24 oz. In actual practice it is usual to find the number of cuts each 200 yds. long that weigh 1 lb. It will be readily seen that 200 yds. per 16 oz. is exactly in the same proportion as 300 yds. per 24 oz. The 200 yds. per cut method is preferable when changing from one system of counting to another, as 16 oz. is a more suitable weight standard. The abbreviation "Gala." is used in place of Galashiels.

HAWICK SYSTEM.—The Hawick system is based upon the number of lengths or cuts 300 yds. long that are required to weigh 26 oz. Thus, if 12 cuts, or 3600 yds., weigh 26 oz., the yarn will be 12's. The weight standard is best reduced to 1 lb., and the length of the hank must then be reduced in like proportion, which brings it to $184\frac{8}{13}$ yds. The number of hanks $184\frac{8}{13}$ yds. long that weigh 1 lb. is the counts.

AMERICAN RUN SYSTEM.—In the American Run system the number of hanks 1600 yds. long that weigh 1 lb. is the counts.

AMERICAN CUT SYSTEM.—In the American Cut system the length of a cut is 300 yds. The counts are represented by the number of cuts that are required to weigh 1 lb. Worsted, cotton, and silk yarns are counted in America by the same systems as those in vogue in Great Britain.

HALIFAX RURAL DISTRICT SYSTEM.—In the Halifax system the length is the standard or fixture, and the weight is the variable factor. It should be noted that this system is exactly opposite in principle to all the foregoing systems. Here the weight in drams of 80 yds. of yarn equals the counts. If 80 yds. of yarn weigh 10 drams, the yarn is 10's counts, and is spoken of as 10-dram yarn. This is now only used locally, and is being gradually replaced by the Yorkshire skein system, which is typical of Leeds and Huddersfield.

WORSTED SYSTEM.—In the system of counting worsted yarns the standard of weight is 1 lb., and the number of hanks of yarn each 560 yds. long that are required to weigh 1 lb. is the counts. If 560 yds. or 1 hank of yarn weighs 1 lb., it is designated 1's. Were 10 hanks of yarn required to weigh 1 lb., the yarn would then be 10's. The counts of alpaca, mohair, and cashmere yarns are calculated on the worsted base—that is, as if they were worsted yarns.

When testing worsted yarn for counts a wrap reel is used, the circumference of which is generally 1 yd., and the number of lengths each 80 yds. long that weigh 1000 grains, which is $\frac{1}{7}$ lb., equals the counts.

COTTON YARNS.—The system of counting cotton yarns is one that is universally adopted. A hank of cotton yarn is 840 yds. long, and the number of hanks contained in 1 lb. of the yarn represents the counts.

LINEN YARNS.—Linen yarns are counted by the number of cuts or leas each 300 yds. long contained in 1 lb.

SILK YARNS.—Spun silk yarns, which are also known as manufactured silk yarns, are counted on the same basis as ordinary cotton yarns—namely, 840 yds. per hank, and the hanks per pound equal the counts.

The dram system of counting silk yarns is one in which the number of drams that a hank of 1000 yds. weighs equals the counts. If 1000 yds. weighs 3 drams, it is 3-dram yarn, or 3's counts.

Another method of counting silk yarns is the yards per-ounce system. This is self-explanatory : the number of yards contained in 1 oz. represents the counts.

METRIC SYSTEM.—The metric system of counting woollen and worsted yarns, which is the system mostly used on the Continent, is based on the number of hanks or lengths of 1000 metres that are contained in 1 kilogramme. In 1 kilogramme of 10's yarn there would be 10,000 metres of yarn. In practice it is not always convenient to obtain 1 kilogramme of yarn for testing purposes, therefore 1 gramme is used as the standard of weight, and the number of metres of yarn weighing 1 gramme is the counts of the yarn.

The metric system of counting cotton yarn is based on the number of hanks 1000 metres long that are contained in a half-kilogramme or 500 grammes.

It is somewhat inconvenient to convert woollen or worsted counts from the British to the metric system, or to change from the metric to the British, as it is necessary to compare yards with metres and pounds with kilogrammes. In the metric system a kilogramme of 1's yarn is 1 kilometre long, and it is only necessary to know the

British equivalents for these in order to be able to convert from one system to the other: 1 kilometre = 1094 yds.; 1 kilogramme = 2·205 lb. Therefore, in 1's metric counts 1000 metres, or 1094 yds., weighs 1 kilogramme, or 2·205 lb. Consequently—

$$\frac{1094 \text{ yds.}}{2{\cdot}205 \text{ lb.}} = 496 \text{ yds. of 1's count metric yarn is contained in 1 lb.}$$

CONVERTING FROM METRIC TO BRITISH SYSTEM.—To ascertain the counts in any British system that correspond to any given counts in the metric system:

Rule: Multiply the metric counts of yarn by 496, and divide the result by the standard number of yards contained in one hank, according to the system of counting.

Example: If a woollen yarn is 8's counts in the metric system, the counts of the same yarn in the Yorkshire skein system would be—

$$\frac{8 \times 496}{256} = 15{\cdot}5\text{'s skeins Yorks.}$$

CONVERTING FROM BRITISH TO METRIC SYSTEM.—To ascertain the counts in the metric system that correspond to the given counts of woollen or worsted yarn in any British system:

Rule: Multiply the counts by the yards per hank, and divide by 496.

Example: An 18's Yorks. skein yarn in the metric system would be equivalent to—

$$\frac{18 \times 256}{496} = 9{\cdot}25 \text{ metric counts.}$$

The standard or gauge point and the rules given above are applicable to all systems of counting woollen, worsted, or linen yarns in which the standard of weight is 1 lb., and the method of counting is where the hanks per pound equals the counts. In the case of cotton yarns where the weight standard in the metric system is ½ kilogramme, the metric counts must be multiplied by 2. It must be noted, however, that on the Continent the English system of counting cotton yarns is very largely used.

CONVERTING FROM ONE BRITISH SYSTEM TO ANOTHER.—Yarns are often sent from one mill or one district to another where a different system of counting the yarn is in vogue, and yarns made from different materials and numbered according to different systems are sometimes twisted together, either to produce a certain effect or to give strength to the resulting yarn. It is thus necessary to change the counts from one system to another, the equivalent counts in the required system being obtained. The rule for doing this is as follows—

Rule: Multiply the counts by the standard length of one hank, and divide by the standard length of the hank in the system to which the counts are being converted.

Example: What are the equivalent counts in the Yorkshire skein system of an 8's cotton yarn? Applying the rule—

$$\frac{8 \times 840}{256} = 26{\cdot}25\text{'s skeins.}$$

No matter in what system the counts are designated, there are always the same number of yards per pound of any given yarn. For example, there are 840 yds. in a hank of cotton yarn; 8 hanks make a total of 6720 yds., and if the yarn is 8's counts, 6720 yds. of the yarn will always weigh 1 lb. in whatever system the counts are expressed. A hank in the Yorkshire skein system is 256 yds. long, and $6720 \div 256 = 26{\cdot}25$ hanks of yarn made from 1 lb. of the cotton yarn when it is counted according to the Yorkshire skein system.

CONVERTING TO OR FROM THE HALIFAX SYSTEM.—In the Halifax system, if 80 yds. of yarn weigh 1 dram the yarn is 1's counts. In the Yorkshire skein system the number of yards per dram is the counts; hence the above yarn would be 80's in the Yorkshire skein system. If 80 yds. weighed 10 drams, it would be 10's yarn in the Halifax system, and in 1 dram of this yarn there would be $80 \div 10 =$ 8 yds., which indicates that the same yarn would be 8's counts in the Yorkshire skein system.

To convert from the Halifax to the Yorkshire skein system: Divide the Halifax counts into 80.

Example: What are the Yorkshire skein counts of an 8's dram Halifax yarn? Applying the rule—

$$\frac{80}{8} = 10\text{'s Yorkshire skein.}$$

To obtain the Halifax counts when the Yorkshire skein counts are given, divide the Yorkshire skein counts into 80. The equivalent counts of a 16's Yorkshire skein yarn in the Halifax system would be—

$$\frac{80}{16} = 5\text{'s dram.}$$

Almost invariably when converting the counts of yarn numbered in the Halifax system they have to be converted to Yorkshire skein, so that the rule would be more complicated than useful if it involved other systems of counting. Should, however, such a question arise, first convert to skeins, and then from skeins to the required system, using the rule given above.

CALCULATIONS RELATING TO ROVING.—It is not usual to calculate the weight of the roving from the amount of material fed to the scribbler by the automatic hopper feed, because, although the automatic hopper feed supplies the material to the scribbler uniformly by weight, this weight is not usually known or taken into account. Moreover, if an attempt were made to calculate the weight of the roving from the weight of the material fed, a percentage would have to be allowed for loss due to flyings and so on, as the material passes through the machine. The point is to bring from the scribbler a sliver that will allow for loss due to flyings and so on as the required weight of roving.

FACTORS AFFECTING COUNT OF ROVING.—The count or weight of the roving, as has been previously explained, depends on the count of the yarn to be spun and the draft of the roving in the spinning. The latter depends on the character of the material, and also on how near to the limit of its capabilities it is being spun. For example, low stuff will stand less draft than sound wool with good spinning properties. The counts of the roving as it leaves the condenser and the amount of draft that is given to it in the spinning process are considerably influenced by the type of condenser used. A tape condenser will bring off a finer roving than it is possible for a ring doffer to produce, and therefore such a roving will require a proportionately less draft to enable it to spin to the required counts.

FINDING COUNTS OR WEIGHT OF ROVING.—The weight of the roving necessary to spin a given yarn is to the amount of roving let out by the delivery rollers of the mule as the count of the yarn spun is to the draw of the carriage; therefore the following rule is necessary to find the count of roving that should be made on the condenser for a given count of yarn, the draft in the mule in spinning being known.

Rule: To find the weight or size of roving, multiply the length of the roving in inches delivered by the rollers on the mule by the count of the yarn to be spun, and divide the product by the length of the draw of the carriage in inches.

Example: Find the weight or count to which the roving must be condensed in order to give an 18's Yorks, sk. yarn when the carriage has a draw of 72 in. and the delivery rollers deliver 40 in. Applying the rule, the counts of the roving will be—

$$\frac{40 \times 18}{72} = 10\text{'s skeins Yorks. (Ans.).}$$

(*Note.*—In the operation of twisting in the spinning a certain amount of take-up takes place, consequently the roving may be made ½ a count or so finer than the calculated count.)

CHANGING WEIGHT OF ROVING.—The carding engineer, after having calculated the required weight of the roving, must take steps not only to produce the right weight, but to have all the rovings uniform. From previous reference to this matter it will be remembered that changing the change-wheel on the sideshaft of the carder does not change the weight of the roving when the carder is fed continuously from the scribbler. This gear-wheel only changes the character of the feeding of the Scotch feed. If the slivers are crowded on the feed sheet and do not lie smoothly, a larger gear-wheel on the sideshaft of the carder will drive the feed lattice faster, and consequently spread out the slivers on the apron, rendering them less closely packed. The weight of the roving is generally changed by means of the change-wheel on the sideshaft of the scribbler. A larger wheel produces a heavier sliver, as it speeds up the feed-rollers of the scribbler and also increases the speed of the feed lattice, which extends from the hopper feed to the scribbler and is driven from the feed-rollers.

REELING AND TESTING ROVING.—To find the weight or count of the roving that is being condensed it is necessary to measure or reel a certain length and find the weight, or from a certain weight to find the length. A common method is to measure a certain length by means of a stick which is either 1 or ½ yd. in length and 3 or 4 in. wide, and round which a number of rovings are carefully wound until the length desired is obtained. Alternatively, the required number of rovings are taken and laid on the yard-stick and broken off. Thus, if 20 yds. of roving were desired, by taking 20 rovings and laying them on the yard-stick and measuring them exactly, a more accurate length is obtained than by winding or reeling a smaller number round the yard-stick.

Sometimes, instead of using a stick for measuring, marks exactly 1 or ½ yd. apart are made on a post or on the wall. The required number of rovings is placed even with the top mark and allowed to hang loosely; they are then broken off squarely at the bottom mark. This ensures the weighing of an even and uniform length each time, as the tension is always the same. The first method is the most unsatisfactory, as it is somewhat difficult in winding the rovings round a stick always to keep the same tension, and if this is not done a considerable error may be brought into the calculation, since the length weighed may vary in different cases.

The usual method of testing the count of the roving is as follows: Suppose that 20's Yorks. skein is to be spun; then, according to the material being carded and the draft in the spinning, the rovings would be made between 11's and 15's or thereabouts. In finding the weight, and hence the counts, 1 yd. or 2 yds. must be run from the full width of a condenser bobbin, laid over the yard-stick, carefully measured, and the number of rovings counted so as to obtain a correct and known length. These are placed on one side of a small pair of scales, and a dram weight placed on the other side, and it will then be seen whether the roving is too heavy or too light—that is, too low or too high as regards counts—when any alteration that may be necessary can be made.

UNEVEN PRODUCTION.—The condenser bobbins, on which are wound the rovings that come from the top and bottom doffers of a double doffer condenser respectively, are for very particular work spun separately, either on different mules or on separate sides of the same mule. It is sometimes possible to have different drafts on different sides of a woollen mule, thus allowing the same size of yarn to be spun even if there is some variation in the thickness of the roving. The necessity for keeping the top and bottom condenser bobbins separate arises from the fact that it is almost impossible to set the doffers to the main cylinder so that rovings of the same weight can be obtained. Then, again, the top ring doffer makes the first stripping from the main cylinder of the carder, and takes a slightly longer quality, while the bottom doffer takes what is left on the swift.

To overcome the difficulty of uneven production, one method is to make all the rings on the top doffer $\frac{1}{8}$ or $\frac{3}{16}$ in. narrower than the rings on the bottom doffer, so as to neutralise the fact that the rings on the top doffer receive the material from a full swift, and this immediately after the fancy has raised it to the tips of the teeth of the swift. In many cases one worker over the last swift is given a traversing motion, so as to distribute the material and prevent any accumulation on the swift. But even when this precaution is taken and the speed of the top doffer is changed, there is a tendency for the rovings from the top doffer to be both heavier and of a better quality than those from the bottom doffer.

Separate weighings must be made at intervals from the condenser bobbins on which are wound the rovings from the top and bottom doffers respectively, and if there is a great difference in the weight the speed of the top doffer may be changed slightly; increasing its speed makes the rovings lighter, and decreasing it makes them heavier. With single ring doffers or doffers from a tape condenser, there is not this difficulty of uneven weights of rovings, since all the material is taken off the swift at the same time, and is condensed into rovings under exactly the same conditions and at the same time.

Electricity in Carding Rooms.—Any animal fibre, especially wool and silk, is liable to become charged with electricity arising from friction combined with a dry state of the atmosphere and fibre. Should the material become too dry, this trouble might develop, and the place where it would be most apparent in woollen carding would be at the condenser, where the action of the rubbers tends to charge the rovings with static or frictional electricity. This might cause the rovings to cling to the rubbers and to the iron parts of the carding machine and bobbin frame, thus becoming broken and winding round the rubbers. When a roving breaks and is not immediately replaced, a blank space is left on the spool, making it imperfect.

A remedy that may be used with good results should trouble with frictional electricity occur, is soap, which when added to the emulsion when the wool is being oiled seems to render the wool soft and less liable to become electrified. About 2 lb. of soap to 100 lb. of wool is generally sufficient to prevent electrification, and also to render the material moist and silky to the touch, enabling the yarn to be spun into a round and lofty thread. Alum has been found to reduce the liability to electrical effects, and is usually dissolved in the water used for the emulsion for oiling in about the proportion of ½ lb. of alum to 100 lb. of material.

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