it is not possible by this means to free it from superfluous moisture. To increase the efficiency of the nip, rollers of decreased diameter have been tried; but owing to the difficulty of conducting the wool up to them, and also to the fact that small rollers imply severer treatment, this method of wool drying has not been found satisfactory. The moisture present on delivery from the scouring bowl varies from about 50 per cent. in the case of Merino to about 40 per cent. in the case of Cross-bred and Lustre wools. In Merino wools it is found that the moisture helps to control the fibre in the subsequent processes, overcoming electrification and to some extent the natural curliness present. Consequently it is not customary to carry these wools through a special drying operation, but to effect the drying necessary in transferring the wool from the wash-bowl to the card, which is usually accomplished by automatic conveyers. With the longer qualities of wool, however, and also with hair, careful drying to a point within, say, 16 per cent. of moisture is desirable, for if the wool be too damp the fibres "sulk" or lie lifelessly in the machines and thereby cause considerable trouble. The method generally employed for drying is that in which a large volume of heated air is brought into contact with the wool. An alternative system to this is available in which centrifugal force is employed. In this case the wool is placed in the hydro-extractor (Fig. 68), or "whuzzer." This is really a revolving cage (running at, say, 1,100 revolutions a minute), and the wool placed in it parts with its moisture much the same as would wet rags whirled round and round on the end of a piece of string. Though good in principle, this method is inconvenient when dealing with large quantities of wool, for the machine employed is intermittent in action, and, further, is not capable of extracting more than, say, 70 per cent. of the moisture present. For small lots, for yarns, and also in connection with carbonising, this, however, is a serviceable method. The machine itself is very simple, consisting of a wirework cage mounted in such a way that it can be revolved at a speed of from one to two thousand revolutions per minute. Suitable pipes and an outer covering are arranged so that the liquors thrown off are collected and drained away. The cage itself is arranged on a self-balancing principle, and may be revolved by a pulley and belt from the mill shafting, or driven independently by steam or electricity. On the material being placed inside the cage and the machine set in action, the material, by centrifugal force, is driven to the sides of the cage and there held while the free water is thrown off and collected as already described. This machine, however, must only be considered as a first or preliminary dryer.

In hot-air drying two methods are in general use: the first, "hand," or rather "table," drying, and the second "machine" drying. The former, although relatively unsatisfactory as regards quantity of wool treated for the space occupied, and also from the point of view of labour required and the turn-off, is the better arrangement from the standpoint of the condition of the material after treatment. The reason for this is that heat is applied in a less concentrated form, and so is not liable to cause discoloration or undue fibre shrinkage, while there is the additional advantage that the wool is, practically speaking, stationary, and thus there is no opportunity for the staples to become matted. In the mechanical system the wool is more automatically dealt with, and greater quantities may be more readily turned off. As a rule, the condition will be satisfactory; but there can be no doubt that it is quite easy to discolour wool by heat, and that this is done more

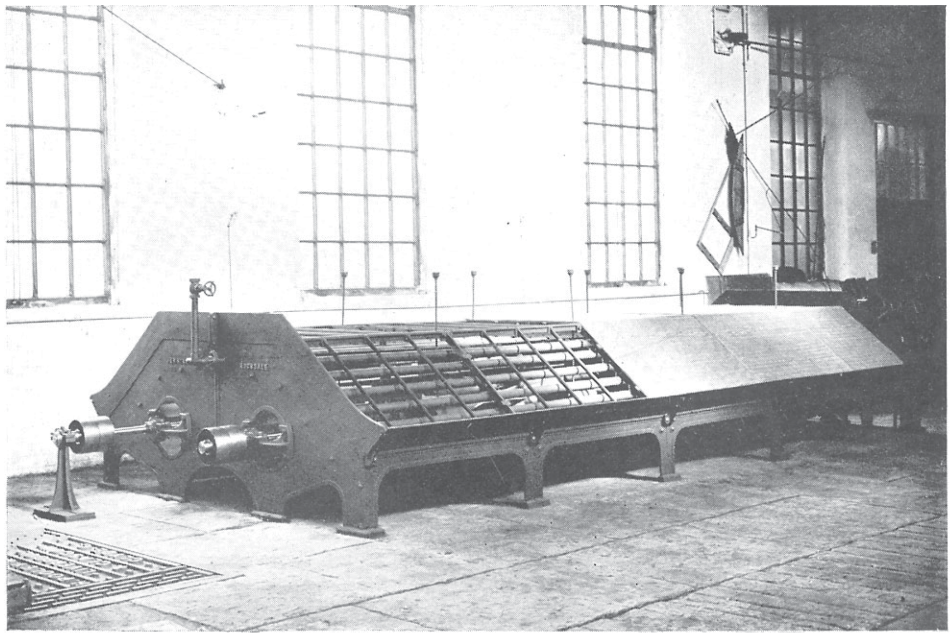


Fig. 69.—Table Dryer
(The left-hand portion shows wirework removed)

frequently than is ordinarily supposed. Thus the system to employ will depend upon particular circumstances. Often with certain classes of wool the deterioration by machine treatment is so slight as to be more than justified by the saving effected in time.

The Table Dryer.—In arrangement the table dryer is very simple, consisting of a wood or iron case with wirework as the top portion, which is shaped with flat top and sloping sides, or semicircular in form, as shown in Fig. 69. The wool is placed on the wire mesh, and to ensure uniform drying it must be uniformly spread. The hot air may be passed through the wool from the under side upwards, or may be passed from over the wool downwards, a fan either blowing the air through the wool or sucking it down through the wool. As a matter of fact, the best results are obtained by means of steam-heated pipes both over and under the wool, the air blast in this case usually being drawn down through the wool, while the under pipes by radiation maintain such a heat that the air is in the best condition for extracting the moisture from the material. Undue movement of the wool, which might result in felting, is by this means obviated. This type of machine is best placed in a chamber by itself. If the table is arranged with pipes below the wool only, the air must be forced upwards through the wool. This is liable to cause the wool to heave and to result in a certain amount of felting. In either case, but more particularly in the former, the turning over of the wool by hand is necessary to ensure complete drying.

Great care is necessary in arranging the air blasts, as it is by no means infrequent to find that the main blast gives rise to a vacuum, and that air is circulating through the wool in an inverse direction to that desired.

Mechanical Dryers.—The principle of the mechanical dryer is precisely the same as that of the hand dryer, save that arrangements must be made for passing the material to be dried continuously through the machine under conditions which will ensure the thorough penetration of the mass by hot, dry air, with the least possible agitation, and consequent felting, of the material. A matter of primary importance, however, which is too frequently overlooked, is the getting away of the moisture-charged air and supplying its place with dry, moisture-abstracting air. In fact, it must be clearly understood that the whole principle of wool drying is dependent upon, firstly, raising the moisture-absorbing properties of air by raising its temperature; secondly, bringing this dry air suitably into contact with the wet wool fibre; and, thirdly, in carrying away this air immediately it becomes saturated with moisture, and consequently inefficient as a moisture abstractor. It must be clearly understood that, irrespective of this action, heat has practically nothing to do with the drying of wool.

There are many makes of drying machines, but most consist mainly of an oven into which the hot air can be suitably introduced and expelled; the steam-pipes, fan, etc., which control the hot air; and the traversing or carrying arrangements for the wool. As the wool in these machines is so fully subjected to the action of the air, it is of the utmost importance that the air temperature should be kept within reasonable limits, not exceeding, say, 110° F. In the case of steam heating, the temperature of the oven may be taken from the steam pressure; as a rule, however, for satisfactory results the pressure should not exceed 50 lb. per square inch. The fact must not be lost sight of, that heat may considerably modify even the chemical constitution of the wool fibre, and consequently its character and appear-

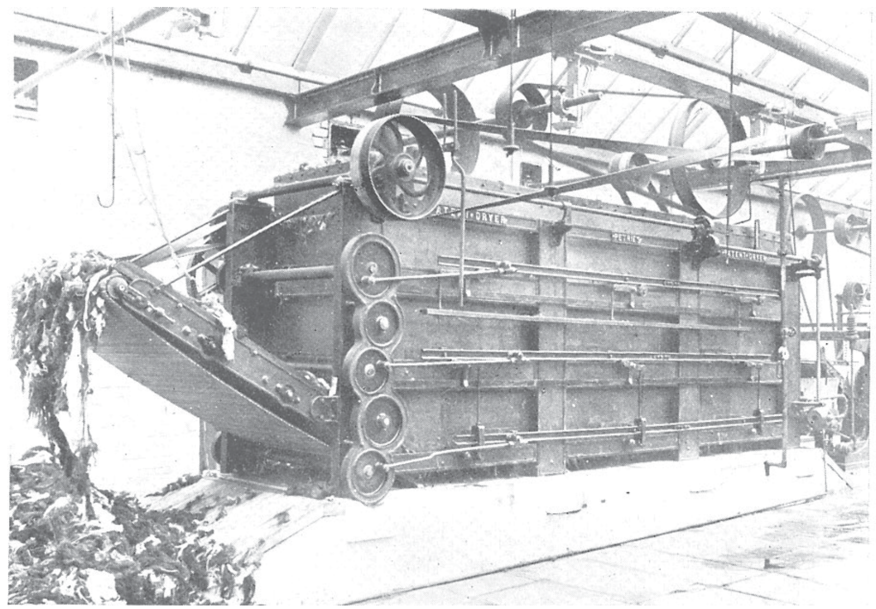


Fig. 70.—Petrie's Drying Machine

ance. Over-drying is a frequent cause of weakness in wool, as it removes the moisture essential to the constitution of the wool fibre, and further concentrates any alkali or other agent which may have been used during washing, and which may not have been removed, from the fibre. In addition, it has, no doubt, a certain action upon the natural fats, thus resulting in discoloration and further rendering the fibre liable to disintegration.

The type of drying machine made by Messrs. John Petrie, Junr., Limited, Messrs. Fielden and Sons, Messrs. Wm. Whiteley and Sons (of Huddersfield), Messrs. Summerscales (of Keighley), and others, is illustrated in Fig. 70, which in this case is made by Messrs. Petrie. Drying is accomplished in a rectangular oven, usually 21 feet long by 11 feet high. The hot air from a tubular heater (steam coil), generated by a strong fan, is passed through this oven, either along with the wool or in the reverse direction to the wool. As a rule, the fan and heater are placed underneath the oven, but if more convenient can be placed at the side. The wool is run from the feed sheet of the last scouring bowl into the hot air blast, which carries it up and deposits it on the uppermost of a series of three or five grid shelves, which by a peculiar action pass it through the machine. These shelves are arranged in tiers in the machine and are composed of bars or laths of which alternate ones are stationary, while the remainder may be actuated both laterally and vertically, their action being controlled by rods and fans conveniently placed outside the chamber. Thus the wool as deposited by the air blast on the fixed bars is raised by the movable bars, carried forward a few inches, and then as the movable bars fall below the fixed bars is retained by these fixed bars until the movable ones, having returned to their original position again, rise through the fixed bars moving the wool still farther forward. By this means the end of the first shelf is reached, and as this shelf is shorter at its delivery end than the one beneath, the wool is dropped on to the shelf below, which works the wool in the reverse direction, eventually dropping it on to a third and lower shelf as just described. The same thing occurs with the fourth and fifth shelves, the last shelf delivering the wool on to a lattice, which conducts it out of the machine. The action of these shelves will be understood from Fig. 71.

The turn-off of this machine is very satisfactory, its capacity, when of the dimensions mentioned above, being 500 lb. per hour of material delivered in standard condition, namely, 16 per cent. of moisture.

All the firms mentioned build their machines on the above-mentioned general lines. There are certain differences, however, which are worthy of note. Messrs. Fielden employ perforated plates or trays as carriers for the wool, to which a sudden movement is given this throwing the wool forward. Messrs. Whiteley use hinged lattices of woven wire or planished steel for the same purpose, while Messrs. Summerscales form their lattices of laths and fixed chains, upon which coarse canvas netting is stretched. In this latter case the dryer is heated by steam pipes set at the top of the oven, air being drawn through the roof openings specially arranged for this purpose, by two powerful fans. In this way the air pressure controls the wool staples while on the lattices and prevents too much agitation.

A dryer built on a somewhat different principle is made by Taylor Wordsworth's Successors, and is finding extensive employment in drying the longest wools and hairs. It is known as Stone's Dryer (Fig. 72), and takes the form of a large round chamber which is subdivided

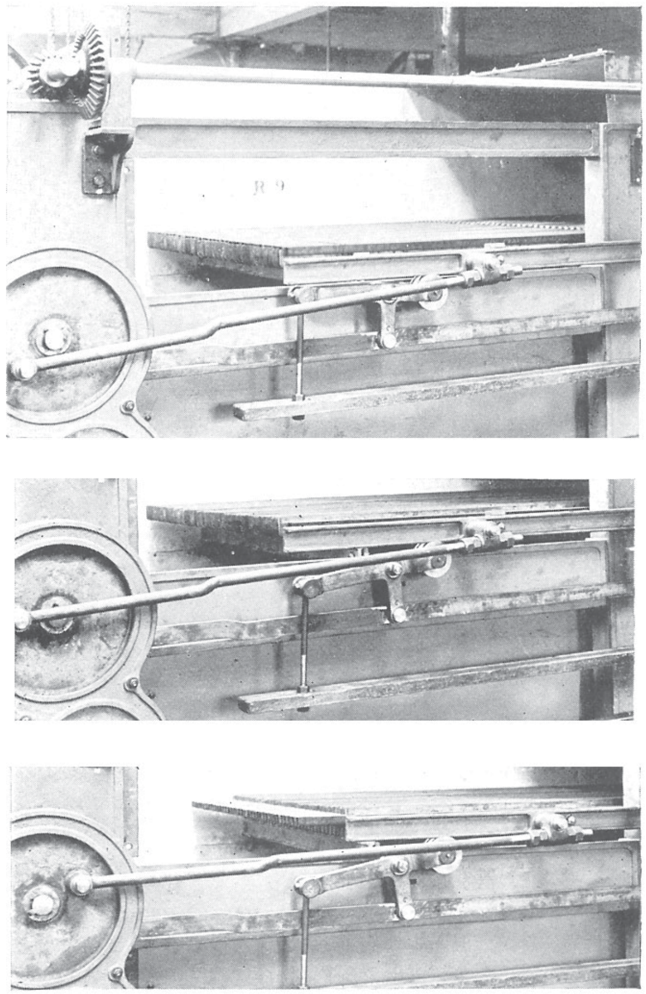


Fig. 71—Showing Action of Drying Machine Shelves

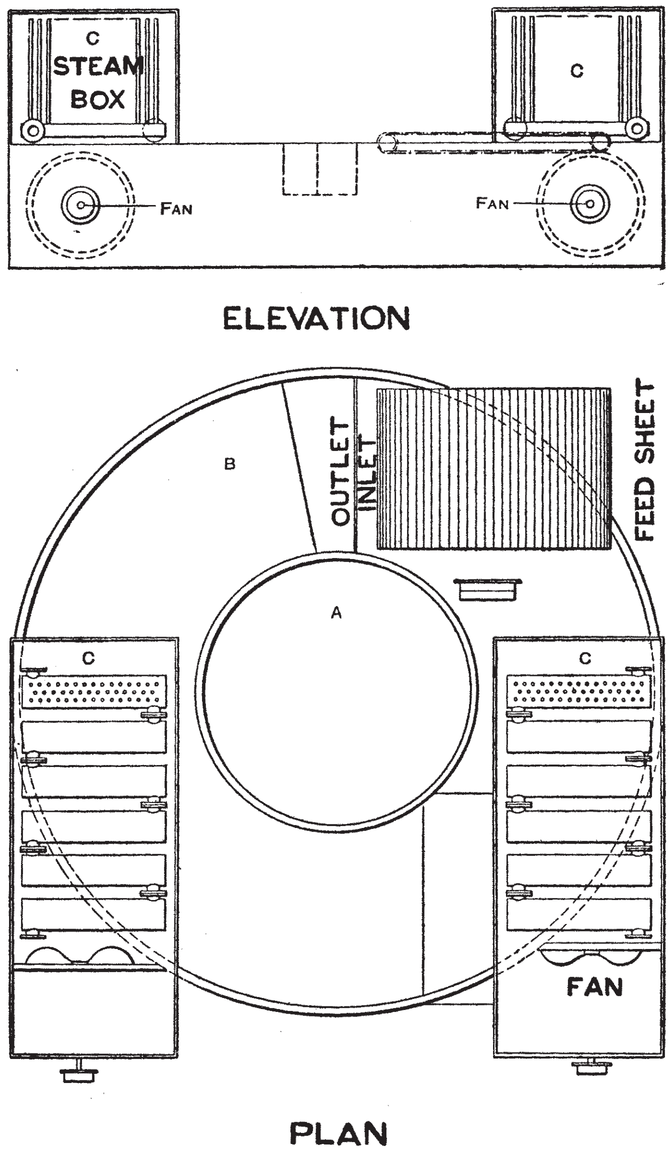


Fig. 72.—Stone's Wool Drying Machine

by perforated metal into three compartments, the inner one A containing two fans and the remaining two B a perforated revolving table, by which the wool is carried through the machine. Air generated by the fans is drawn through steam coils C; in turn it is directed under the perforated table and driven through the wool, and finally out of the machine. In this machine there is practically no agitation of the wool, yet the drying is thorough and fairly quick. If there is an objection to this machine, it is in its shape, this, in its relation to other machines, causing wastage of floor space.

The latest wool dryer placed on the market is that of Messrs. J. and W. McNaught and Co., of Rochdale. In this case the wool is, as it were, dried and carried forward by the hot air in conjunction with a series of revolving drums. The machine is divided into several compartments—five, seven, or nine—so that a low or high temperature may be employed as desired. Each compartment is, in a sense, independent of the other. Thus the wool is lifted by the hot air on to the roller of the first compartment; this hot air, now heavily laden with moisture, is passed directly out of the machine, fresh dry hot air taking its place. The roller in the first compartment now carries the wool forward to the next air blast, which blows the wool into the second compartment, arranged on similar lines to the first, and so on. It is usual to allow the air from the first two or three compartments to pass out of the machine, as it is heavily laden with moisture, while the air from the remaining compartments may successfully be used over and over again. There does not appear to be undue agitation of the wool staples, but so efficient is the drying that wool of certain classes may be passed through this machine in three minutes; thus

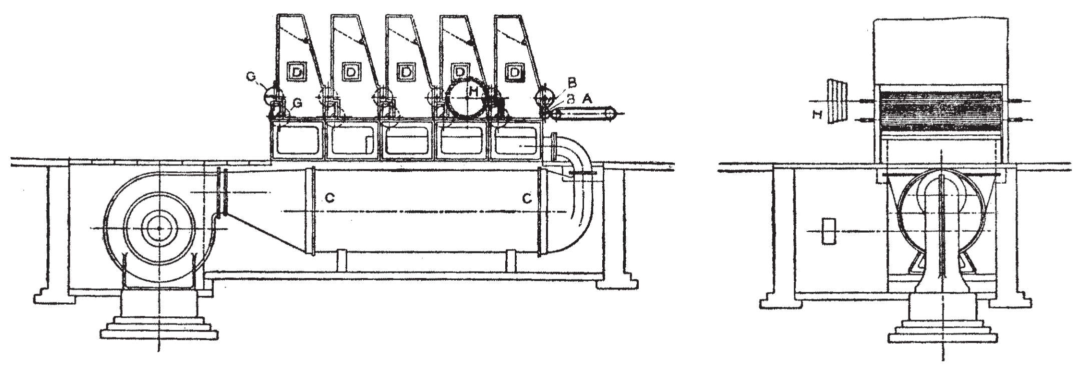


Fig. 73.—McNaught's Drying Machine

a machine 4 feet broad is said to be able to deliver 1,000 lb. of wool per day of ten hours.

In Fig. 73, A indicates the feed sheet which carries the wool to the feed rollers B. As it emerges from these rollers it receives a blast of hot air from the tubular heater C. This carries the wool upward about as high as the windows D, when it is allowed to fall

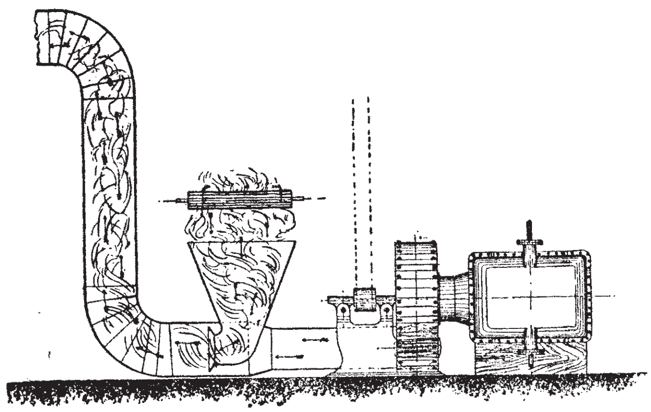


Fig. 74.—Conveyer Tube

on to an incline sloping down into the second pair of rollers, which pass the wool into the second chamber. The blast of air blowing through the wool takes with it through the perforated plate any short fibres and kemps that may be in the wool. This operation is repeated in the remaining chambers so that the wool is kept free and open until it is delivered by the last pair of rollers G. The windows D are constructed as doors so that at any time the operative can withdraw a handful of wool and examine it as to whether it has been sufficiently dried or not. The cone H is for varying the speed of the machine to suit the various classes of material to be dried.

Transference Arrangements of Wool. — It is usually necessary to transfer wool from the dryer to the succeeding machine as directly and expeditiously as possible. For this purpose two forms of mechanical conveyers may be employed, namely, the revolving lattice and the conveyer tube. With either of these a certain amount of drying may be reckoned upon, as in the first case steam-pipes are placed under the lattice, while in the second a strong air blast, which may be hot, is employed. An example of the latter type is given in Fig. 74. It consists of a tube 10 to 14 inches in diameter, having at one end a hopper, into which the wool is deposited from the scouring or drying machine. The air generated by the fan (heated, if necessary) carries the wool forward, the delivery being arranged by means of a swivel tube into the hopper feed of one or more carders. If desirable, the wool may be delivered to the top of a large wire cage set over the carder feed, the idea being to open the staples by driving the wool up and allowing it to fall down in a flaky condition. Sometimes it is desirable simply to arrange the feed to deliver to a convenient position of the card-room, from whence it may be conveyed by hand to the card feeds.

Either the lattice or tube systems may be employed on the short wools, which do not require drying, but which should be conducted directly from the scouring bowl to the card. The tube system, however, appears to be the favourite, as it saves much labour. In the case of the longer wools an air-blast conveyer does not seem to be entirely satisfactory, as the whirling of the staples tends towards stringiness. As a rule, however, the saving effected by the conveyer justifies its use.

CHAPTER VIII

TYPES OF YARNS GENERALLY CONSIDERED

EACH process, from the scouring of the wool to the finishing of the fabric, has some influence on the resultant piece; consequently each process will require careful adjustment, and possibly modification, for each style of wool, top or yarns under treatment. Nevertheless, certain broad principles may be laid down which, while not of the nature of "the law of the Medes and Persians, which altereth not," will serve a useful purpose in outlining the modifications possible and at the same time leave the manager free to adopt any variation he deems likely to produce the most satisfactory results.

The Difference between Long Fibre Spinning and Short Fibre Spinning.—Just as weaving or, more correctly, interlacing preceded spinning, so is it probable that long fibre spinning preceded short fibre spinning. Long fibres, such as flax and long wool, can readily be made by hand into thin slivers or rovings, as they would now be termed. Twisting converts these rovings into threads, fibre binding fibre, and the necessary strength is thus obtained. Very different from this is short fibre spinning (woollen spinning). The spin here is absolutely dependent upon twisting taking place at the same time that the elongation of a comparatively thick sliver into a sufficiently thin sliver

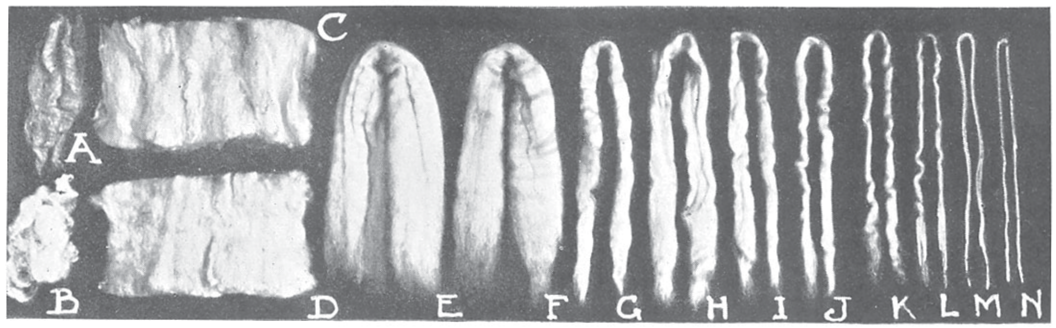


Fig. 75.—Worsted Lustre Long Wool Yarn Production; Range of Processes

A, Greasy Lustre Wool B, Scoured Wool C, First Preparer Sheets D, Second Preparer Sheets E, Third Preparer Sliver F, Last Preparer Sliver G, Combed Top H, Finished Top I, Slubbing from Two-Spindle Gill Box J, Slubbing from Four-Spindle Drawing Box K, Slubbing from Six-Spindle Weigh Box L, Reduced Slubbing in Six-Spindle Finisher M, Reduced Slubbing in Thirty-Spindle Rover N, Spun Yarn from Flyer Frame for the thread required is effected, after which the necessary additional binding twist is inserted. This operation of drawing out or "spindle-drafting," as it is termed, which at the same time prevents the sliver from rupturing by inserting a drafting twist, is one that should actually be carried out by the would-be spinner by means of the finger and thumb, or, better still, upon the ordinary hand spinning wheel; what happens will then be thoroughly realised. Once thoroughly understood, the difference between these two methods and all the apparently complicated machinery of the modern mill falls into an ordinary easily-to-be-comprehended sequence working up to a well-conceived end.

The complete sequence of all wool spinning processes may be conveniently studied under three heads:

1. Bringing the material into a workable condition.
2. Preparing the material for the true spinning operation.
3. The true spinning operation.

As will already have been realised, the bringing of the material into a workable condition is effected on similar lines, whatever the wool may be, and whatever its ultimate destination. It must be thoroughly cleansed, dried, and freed from burrs and other vegetable impurities before it can satisfactorily be prepared.

It is in the preparing of the material that the first real differentiation takes place. To take typical examples. If the fibre is long—suitable for the typical Bradford worsted yarn—its length is made the basis of the treatment; thus every operation, while straightening out the more or less entangled mass of fibres, tends to lay the fibres parallel in the sliver; to a large extent, therefore, length of fibre and twist are made to assist in the reduction of the comparatively thick slivers that come from the early preparing boxes to the thin roving which is placed upon the spinning frame, to be further elongated, and the necessary twist added to convert it into yarn. The operations usually employed are:

1. Preparing by means of a set of gill boxes.*
2. Combing and finishing.
3. Drawing.
4. Spinning.

As each of these operations is fully described in the section devoted to it, it is not advisable further to describe them here. From Fig. 75 the order of these processes can be well grasped, and a useful broad idea gained previous to studying the more or less bewildering processes and sub-processes involved in sets of combing and drawing machinery.

If the fibre is short—suitable for the typical woollen yarn—no attempt is made to obtain parallelism of fibre; in fact, the very opposite is aimed at. The fibres are jumbled together in any and every direction, forming a regularly mixed mass, from which a sliver is first formed by dividing up the broad film issuing from the carder into a number of smaller films, which may only be reduced finer and spun into yarn by means of spindle-draft. Thus the operations usually employed are:

1. Thorough mixing or blending by means of willow and fearnought.
2. Carding.
3. Condensing.
4. Roving or spinning on the mule.

* As preparatory processes for short or medium length wools, the worsted carding engine is substituted for gill boxes, as these latter cannot deal satisfactorily with fibre under, say, 7 inches.

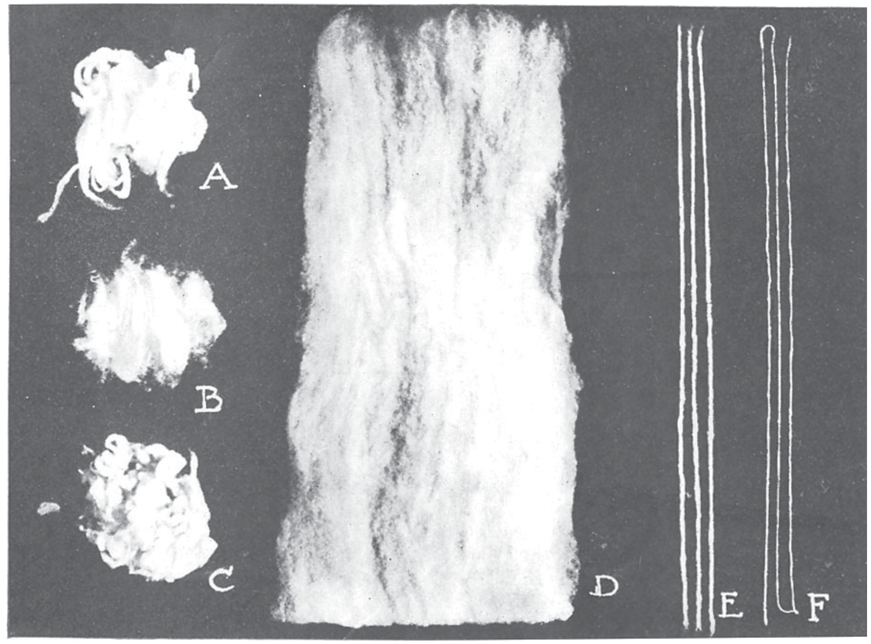


Fig. 76.—Woollen Yarn Productions: Range of Processes

A, Scoured Wool for Blending B, Willowed Waste for Blending C, Woollen Blend (oiled and willowed)
D, Scribbled Blend E, Condensed Sliver for Carder F, Mule Spun Yarn

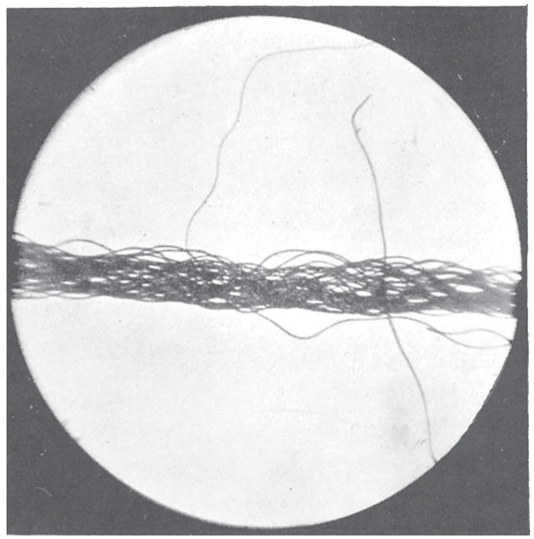


Fig. 77.—1/60's. Botany

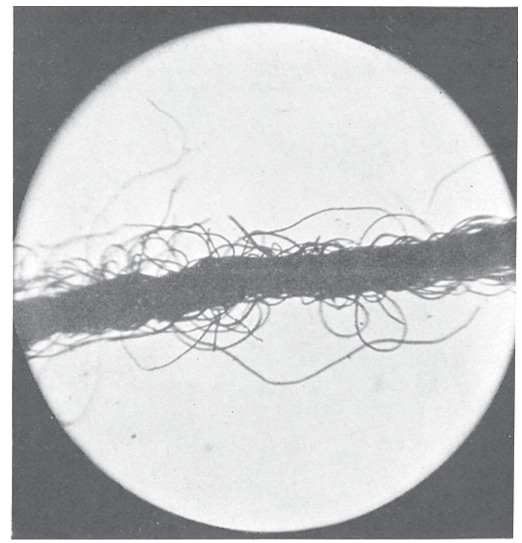


Fig. 78.—30's. Skeins Woollen

The count or thickness to which the carded sliver is condensed—affecting the extent to which it is drafted in the subsequent roving and spinning—will have a marked influence on the resultant yarn. From Fig. 76 the idea of the processes will be gained, and by comparison with Fig. 75 the very marked fundamental difference realised. Again, a reference to the photomicrographs shown in Figs. 77 and 78 will clearly show the difference between the worsted and woollen yarns. There are subtle arrangements of the fibres in the woollen thread introduced by the method of condensing, roving, and spinning which the woollen spinner will do well to realise and act upon.

Somewhat allied to both the foregoing methods is what is known as the French system of worsted spinning. In this case the preparation up to combing is somewhat similar to that obtaining in the worsted system. The drawing and spinning, however, are absolutely different, being simply based upon an open treatment of the fibre rather than upon the twist control so usefully employed in English drawing and spinning. Omitting twist necessitates support to the yarn in its passage through the various drawing boxes. This support is supplied by the porcupine coming between the front and back-drafting rollers, and, further, by the pith-like sliver being more or less consolidated by rubbing leathers coming between the front rollers and balling-head. As the French-produced sliver has neither marked parallelism of the fibres nor twist, it cannot be spun on any type of throstle frame, but must be spun on the mule. In Fig. 79 the action of processes employed in this system is clearly indicated. For short material the treatment here represented is doubtless the best yet available. The action of the fibre is of the easiest; consequently there is that preservation of its length so essential to the spinning of a strong yarn in fine counts. Moreover, the characteristics of the raw material—softness, fulness, etc.—may be pronouncedly in evidence in the finished cloth. A near approach to this type of result is obtained on the Cone Drawing system (Fig. 80), the slivers being worked with less twist, and consequently much more openly, than upon the ordinary drawing system. Much hosiery and soft dress fabric yarn is produced upon both these systems.

It will be evident that between the extremes here described will come many means. Thus mohair, being taken as the typical English spun yarn (Fig. 81), and woollen as the typical mule spun yarn (Fig. 78), it will be evident that such examples as Cross-bred (Figs. 83 and 84), Botany (Figs. 85 and 86), and Hosiery yarn come in between these extremes. In fact, as remarked at the commencement of the chapter, the manager must use his judgment as to the extent to which he applies any of the principles here dealt with.

On pp. 193-5 will be found a fairly complete list of the various typical yarns of commerce and their uses, with the material employed in their production, the principle upon which they are spun, the range of counts, and the usual turns per inch.

Twist in Yarns.—If the method of preparation and spinning has a marked influence on the resultant yarn, it will be evident that the amount and direction of the final twist inserted will be equally potent. Twist has been said to be the spinner's enemy, yet at the same time his best friend; and certainly it may be of the utmost value to him in working materials; but, on

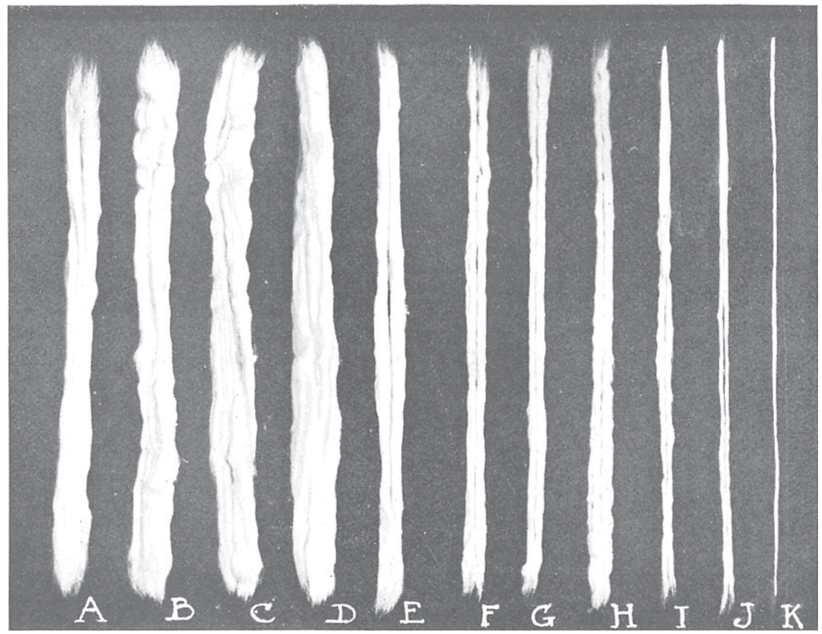


Fig. 79.—French (Dry-spun) Worsted Yarn Production: Range of Processes

A, Top from Eight-Bobbin Gill Box B, Slubbing from Eight-Bobbin Drawing Box C, Slubbing from Eight-Bobbin Drawing Box D, Slubbing from Twelve-Bobbin Drawing Box E, Slubbing from Twenty-four-Bobbin Reducer Box F, Slubbing from Twenty-four-Bobbin Slubbing Box G, Slubbing from Twenty-four-Bobbin Intermediate Box H, Slubbing from Twenty-four-Bobbin Intermediate Box I, Slubbing from Twenty-four-Bobbin Rover J, Roving from Forty-eight-Bobbin Rover K, Spun Yarn from Mule Frame

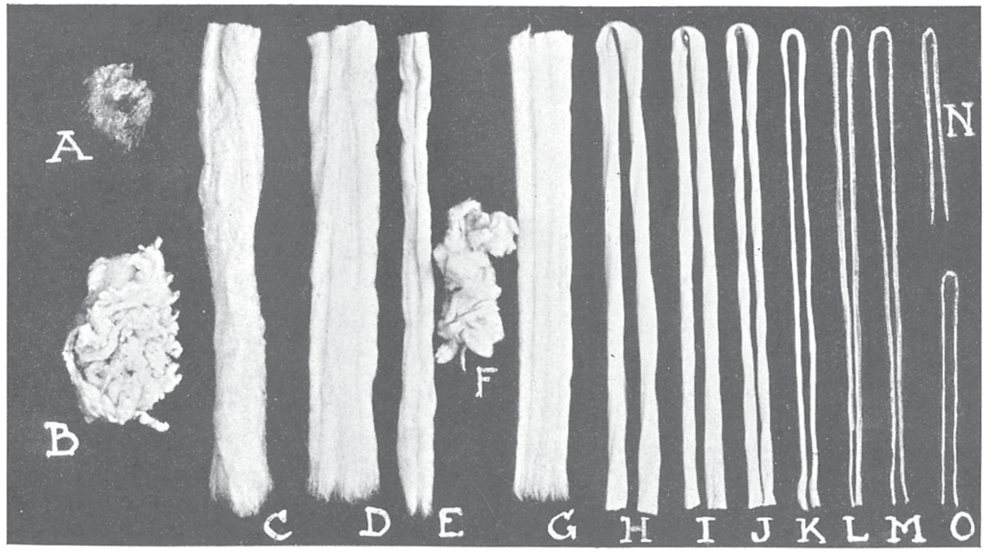


Fig. 80.—Worsted Botany Short Wool Yarn Production: Range of Processes

A, Greasy Australian Wool B, Scoured Wool C, Carded Sliver D, Back Washed Sliver E, Combed Top F, Noil G, Finished Botany Top (as placed on market) H, Slubbing from Cone Gill Box—Four-Spindle I, Slubbing from Cone Drawing Box—Six-Spindle J, Slubbing from Cone Drawing Box—Ten-Spindle K, Slubbing from Cone Finisher Box—Forty-Spindle L, Slubbing from Cone Reducer Boxes—Sixty-Spindle M, Roving from Cone Rovers—Eighty-Spindle N, Spun Yarn—Single 60's. O, Spun Yarn—Twofold 60's.

RANGES OF YARNS

Type of Yarn	*Materials Employed*	*Nature and Effect of Preparation and Spinning Processes*	*Limit of Counts*	*Turns per Inch*	*Uses*
SUPER BOTANY—white, single twist	Best Australian and Tasmanian greasy fleece wool, 64's to 90's qualities	Such as to produce smooth-faced and even yarn, with fibres of uniform length and arranged as parallel as possible. Chiefly "cone" drawn and "cap" or "ring" spun	60's-130's	60's = 12 130's = 20	As weft, occasionally as warp for Itaians, and various "all-wool" and cotton and silk warp cashmeres
FRENCH SINGLE—mule spun, white	Short "B.A." and "M.V." wools; also Australian blended to limited extent—58's to 64's qualities	Made from "dry-combed" tops, "French" drawn and mule spun, to give smooth but soft and full handling yarn.	56's	50's = 15	Soft handling dress fabrics
BOTANY COATING—white, solid shades and mixtures and marls, single and twofold	Australian fleece wool of good length and soundness and milling capacity—60's to 70's qualities. Short Australian, "B.A.," Cape wools and "skin" used for thicker counts. Discoloured wools used for dyeing into darker shades	Finest counts produced on "cone" drawing and "ring" or "cap" spun; thick counts "open" drawn and "cap" spun. Handle, soft and full—not very smooth. Mixtures obtained by gilling and drawing various coloured tops together. Marls produced by running together differently coloured rovings to give twist of pronounced colouring. Twists (coloured) formed from two colours of yarns	64's	1-40's = 9 2-40's = 10½	As warp and weft in worsted coatings, trouserings and suitings—slubbing dyed and piece dyed
FINE CROSS-BRED—white and coloured, single and twofold	Australian and New Zealand cross-bred (Down merino type) of nice length, softness, soundness, and uniformity—46's, 50's, and 56's quality. "Skin" and "Slipe" sparingly used	Fibres not straightened too much—yarn required soft and full handling. Spun on "cap" frames. Not very smooth in appearance	48's	1-38's = 15	As warp and weft in medium quality coatings and dress cloths — yarn and piece dyed
SERGE—white and coloured, single and twofold	Australian, New Zealand, and "B.A." medium cross-bred, of sharp and crisp handle and longish fibre; also certain home-grown wools of Down type. Qualities up to 50's	Made as full handling as possible. "Cap" spun. Not smooth in appearance, but bright	46's	1-20's = 7½	As above

RANGES OF YARNS—(*continued*)

Type of Yarn	*Materials Employed*	*Nature and Effect of Preparation and Spinning Processes*	*Limit of Counts*	*Turns per inch*	*Uses*
LowCross-bred,—white and coloured, twofold	Australian, New Zealand, and part "B.A." Lincoln-merino cross-bred, 32's to 40's qualities, of fair length and lustre	If lustre is important "flyer" spinning is employed: if price, "cap" spinning. "Ring" spinning occasionally used for good average yarn. Yarns are not smooth or soft, nor very even	36's	1-20's = 7½	As above, but in cheap goods
Single Lustre—super or ordinary, white	English long lustre wools and Colonial lustre and lustre merino crossbreds, 36's to 44's qualities	Chief aim to develop lustre smoothness and evenness. Best types "Nip" combed. "Flyer" spinning solely employed	40's	1-30's = 6	Lustre dress goods and linings—weft
Single Demi-Lustre—super and ordinary, white	Long-stapled wool, English or crossbred or both, not necessarily very lustrous. Qualities 32's to 40's. In low qualities (kemps present).	Yarn only fairly smooth and lustrous. Production at definite price is prime object. "Flyer" spun.	36's	1-36's = 5	As above
Mohair — super, medium and low, single and twofold	Turkey and Cape (American used for Home manufactures)	Aim is to arrange fibres as straightly and as parallel as possible to favour lustre and smoothness. Double and treble combing obtains on "Nip" and "Noble" combs, the latter for the lower qualities. "Flyer" spinning	48's	1-32's = 8 1-40's = 9½ 2-32's = 8½	Lustre dress fabrics—warp and weft
Alpaca—self-coloured and dyed, single	Peruvian (Arequipa) alpaca fleece	As mohair	40's	1-30's = 8 1-40's = 11	As above—used as weft
Camel's-hair—self-coloured	China, Egyptian, and Persian camel's-hair	Softness is the valuable characteristic. Thus yarn is soft-spun. Much is done to preserve smoothness in better qualities, which are "flyer" spun	40's		Dress fabrics and skirtings—weft
Cashmere—white, grey, and brown	Tibetan cashmere	Treatment in linen as finest botany wool yarns to produce maximum softness	60's		Dress fabrics—weft
Carpet Yarns—white and coloured. Two or more fold	Low Scotch, English, Colonial, and foreign wools, along with mohair and lustre wool noils. Vegetable fibres sometimes blended. Bright and strong qualities	Fullness very desirable. Yarns spun on worsted principle, but frequently not combed. "Flyer" spun, thick counts	24's		Weft in carpets

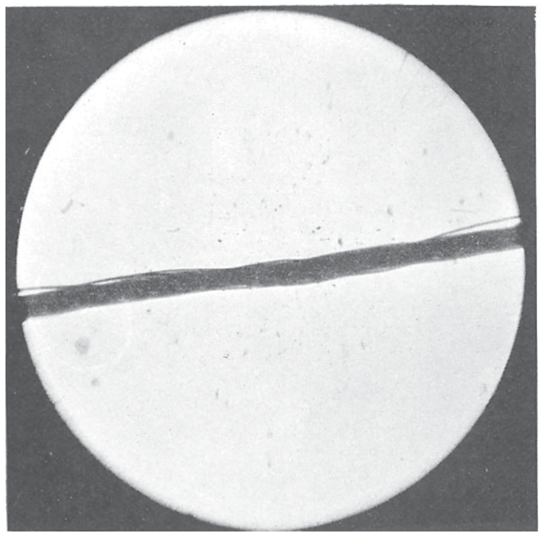


Fig. 81.—1/40's. Mohair

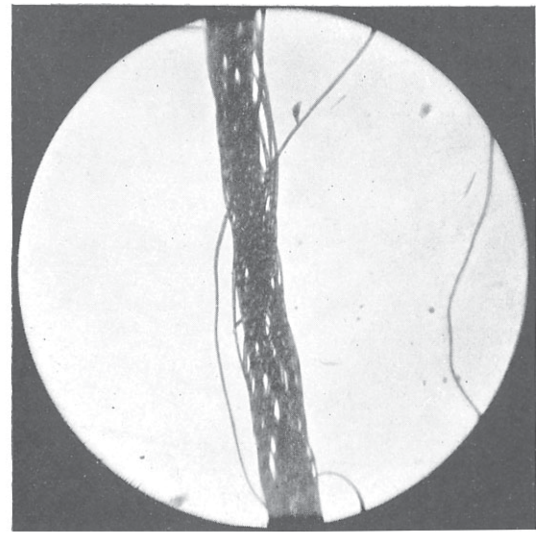


Fig. 82.—1/20's. English Lustre

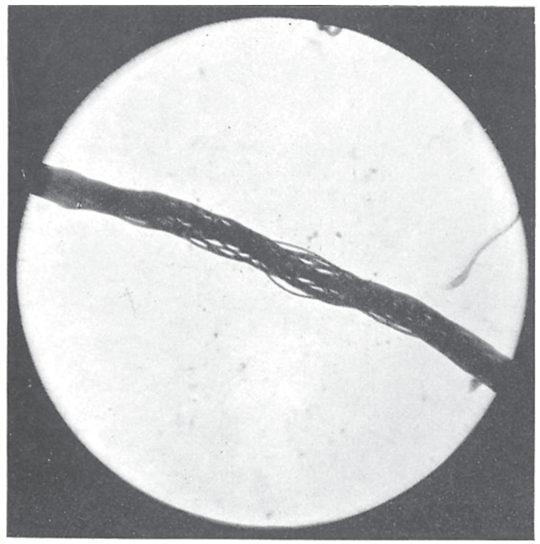


Fig. 83.—1/40's. Cross-Bred

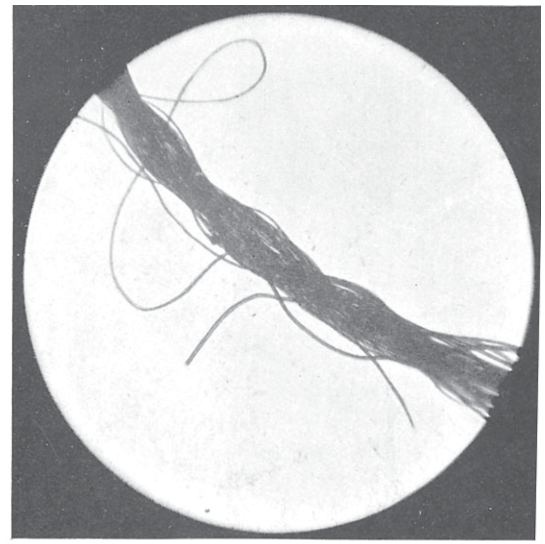


Fig. 84.—2/40's. Cross-Bred

Type of Yarn	*Materials Employed*	*Nature and Effect of Preparation and Spinning Processes*	*Limit of Counts*	*Turns per Inch*	*Uses*
HOSIERY—low, medium and fine, two or more fold; white, coloured, and coloured twists.	Low yarns: Colonial and "B.A." cross-bred; also low English fleece and "Slipe" wools—32's to 40's qualities Medium yarns: Colonial and "B.A." cross-bred fleece and "skin" wools; also medium English qualities Fine yarns: "B.A.," Australian, and Cape fleece and "skin" wools, as blended in qualities 50's to 58's	For low counts "open" drawing and "flyer" spinning; for medium counts "cone" and "flyer" spinning; for fine counts special "hosiery cone" and "flyer" spinning. Continental hosiery yarns, "French" drawn and "mule" spun. Twisting and folding on "cap" and "ring." Soft spun	32's	4-10's = $1\frac{3}{4}$ 4-16's = $3\frac{1}{4}$	Hosieries
MELANGE—single lustre	Lustre and cross-bred wool and mohair	Obtained from printed top by treatment as accorded wool and hair	40's		
GENAPPE—soft or hard twist—two or more fold	Medium and fine wool and mohair	Fibres arranged as straightly and solidly as possible in drawing and spinning. "Flyer" spun. "Gassed" to produce smoothness	40's		Fancy coatings, braids, healds, and cords
FANCY YARNS: Loop, Knop, Slub, Spiral Flake, and Spot	Various—wool, mohair and cotton	Twisting and folding together of yarns varying in material, count, and twist under conditions in which each yarn can be regularly or irregularly delivered			Fancy dress fabrics
WOOLLEN—Saxony in white, solid shades and mixtures, single. Two-fold for hosieries	Clothing wool (best classes)	Treatment the opposite of worsted. Fibres arranged transversely in yarn as well as laterally to give marked roughness and capacity for felting. Carding, condensing, and "mule" spinning employed	60 skeins (Yorkshire)	40sk = 17	Coatings and dress fabrics as warp and weft
WOOLLEN — medium and low	Wool and wool substitute (mungo, shoddy extract, and noil)	As above		8sk = 8	As weft in worsteds
WOOLLEN — Angola	Wool substitute and cotton	As above			Blankets, flannels and rugs

the other hand, it may totally spoil the finished product. The influence of twist is to solidify and harden yarn; it also renders it more durable. On the shade or colour it has a marked effect; for increased twist prevents penetration of the dye and results in a lighter shade. So much is this the case that in coloured cloths, in substituting single yarns for twofold, slightly darker colours need to be employed. If single yarns are being spun, the two factors are amount and direction of twist. The amount of twist inserted seems, on first consideration, a very simple thing, but brief consideration will show that it is not so. Twist may be stated as so many turns per inch, or as of a definite angle. Thus a yarn might be said to have 16 turns per inch, or its angle might be stated as running, say, at 30° with its length. The former is obviously the more practical, and certainly the more useful to the spinner, the production of whose frames largely depends upon the twist inserted; for spindle speed being fixed, and the twist varying roughly inversely to the thickness of the yarn spun, working backwards, fewer turns will mean thicker counts and consequently more weight through the machines; or working forwards thicker count means fewer turns, therefore a quicker delivery to the spindle by the roller, and consequently more weight turned off. From the designer's or cloth constructor's point of view twist might possibly be better stated as of a definite angle; for in the woven fabric weft has to cross warp, and the angles of twists in the two yarns may obviously affect the resultant texture. This aspect of the question, however, is still in its infancy.

Under the heading, "Amount of Twist," arises a very important matter, viz. that of relative twist. If, for example, a 1-25's Botany yarn yields a satisfactory result with sixteen turns per inch, what number of

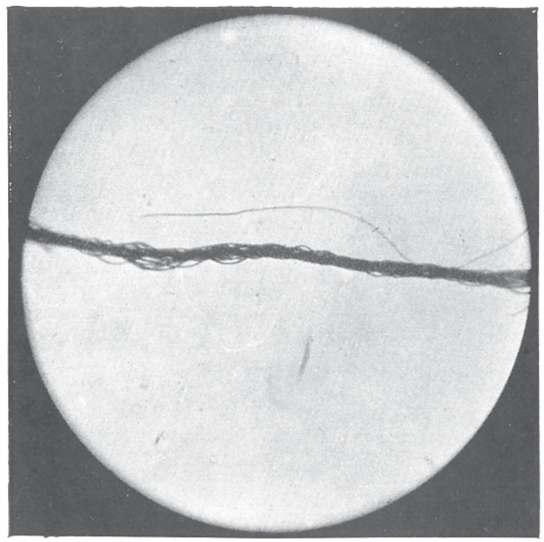


Fig. 85.—1/130's Botany

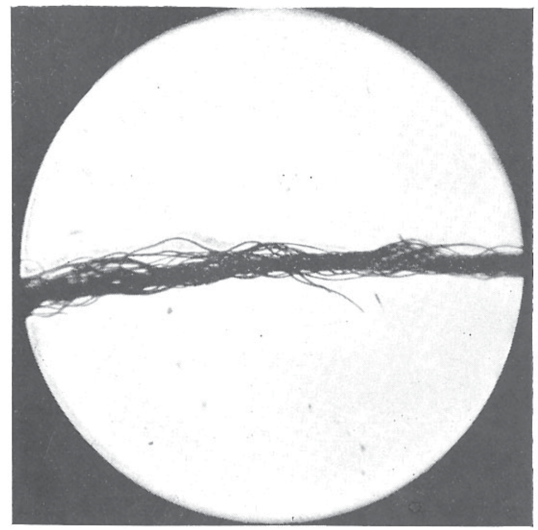


Fig. 86.—1/72's Botany

turns should a 1-36's have? On first thought, this might be taken as a simple proportion sum, thus:

As 25 : 36 : : 16 : x = 23 turns per inch for 1-36's.

Further consideration and a few rough pencil sketches will suggest, however, that twist should vary as the diameter of yarns. Thus as the square root of the yards per pound represents the diameter in the fraction of an inch:

$$\text{As } \sqrt{25 \times 560} : \sqrt{36 \times 560} :: 16 : x, \text{ or}$$
$$\text{As } \sqrt{25} : \sqrt{36} :: 16 : x, \text{ or}$$
$$\text{As } \sqrt{5} : \sqrt{6} :: 16 : x =$$
19 turns per inch for 1-36's Botany

As shown in Fig. 86A, however, this only means that nineteen turns per inch will maintain the same angle of twist *on the surface of the* 1-36's *as on the surface of the* 1-25's, the truth being that the interior relationships of fibre to fibre are actually better maintained by the direct proportion method given than by this latter method. In actual practice the spinner and designer should fully realise what this means, and add their practical experience and insight to these theoretical considerations in finally deciding the twist to adopt.

The influence of the amount of twist on the contraction of the yarn in subsequent operations is also worthy of special consideration. Some exceedingly fine examples of crepon cloth are produced by contrasting in the fabric soft and hard twisted yarns; in one case a small fibre shrinkage only results, while in the other a fibre and a structural shrinkage results, producing the marked crimping of the non-shrinking material noted in these goods.

Again, it is probable that each type of yarn is strongest and most useful with a certain definite twist in proportion to the count. This definite twist should be ascertained by careful experiment.

The effect of direction of twist in yarns woven alongside one another in the same fabric is remarkable. On the same material, spun in the same way, woven in the same way, dyed and finished in the same way, the result is so different that it is made the basis of whole ranges of "shadow" patterns.

If, then, the amount and direction of twist be taken together, and especially if applied to coloured yarns, the possible variety of effect is remarkable. This will be further realised by reference to Fig. 86B, in which the possibilities of varying the twisting of a twofold yarn are graphically illustrated.

It is thus very evident that in this and in many other cases the spinner and designer should work together if the best results are to be obtained.

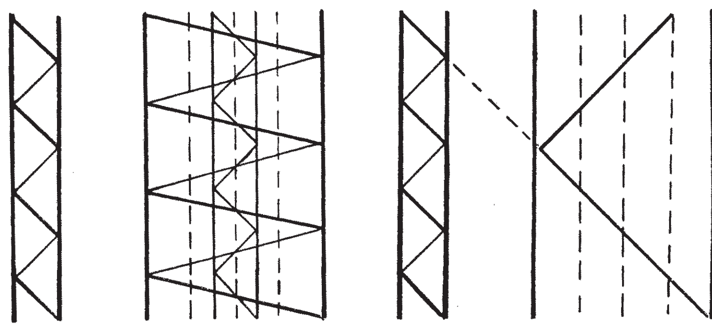


Fig. 86A

Maintaining the same number of turns per inch

Maintaining the same angle of twist

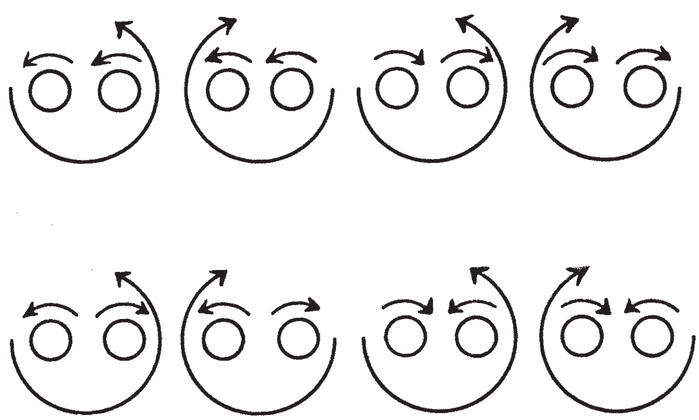


Fig. 86B

Illustrating the various conditions of twisting a simple two-fold yarn

CHAPTER IX

THE PREPARATION OF LONG WOOLS (ENGLISH), CROSS-BRED WOOLS, AND MERINO WOOL FOR COMBING

THE preparation of the various wools for any of the several systems of worsted spinning will often be a compromise; for, on the one hand, the nature of the raw material may necessitate certain treatment, and on the other hand, it is quite possible that the ultimate combing or spinning processes may equally necessitate some other treatment. It is rarely that the two requisites are identical; but, even when they are not so, sound judgment may effect a compromise that at least fairly well fulfils both requirements and yields the desired result. It is thus evident that the comber must bear in mind the nature of the raw materials dealt with, and further the ultimate requirements from the top he produces. Again, it must not be forgotten that hard leather and rigid iron are not comparable to the deft fingers and actions of the spinner; there may be limitations in the preparing, combing, and spinning machinery itself. It is possible, however, that the latter difficulty is more than counterbalanced by the regularity of movement and control exercised by steam or electrically driven machinery, for it is well to remember that the great cotton industry of this country is actually a machine created industry.

There are two characteristic methods of preparing wool for the operation of combing, these being based on the extremes of long and short wools. These two extreme methods are modified for wools of an intermediate length as experience suggests. The basis of the preparation of long wools is a straightening out process, effected by means of five or six gill boxes, usually termed "preparing boxes" to differentiate them from the gill boxes employed in the processes of "Finishing" and Worsted Drawing subsequent to combing. The basis of the preparation of short wools is a mixing up and thorough reversing of roots and tips of the wool staples, effected by means of the worsted carder—a machine designed on similar lines to the woollen carder, but so employed that if parallelism of the fibres is not actually the result of the carding, at least the wool is left in such a state that this parallelism may readily be developed in the processes immediately following. As a dividing line for these "long" and "short" wools 7 to 8 inches may be given. With these lots, which may be either prepared or carded, the ultimate purpose to be fulfilled by the material, or its cost, usually decides the process used. Thus a lustre top can be best made from "prepared" wool, and a full and soft-handling top from the "carded." The carder, however, gives a more thorough treatment of the fibres, and consequently a better "tear" (proportion of top) than the preparer, but such treatment costs more, owing to the relatively small output and high cost of the machinery required.

The Preparing Gill Box.—The preparing gill box simply consists of a suitable feeding apparatus—usually a feed sheet, back rollers, fallers or gills, front rollers, and a delivery apparatus; in the first boxes of a set,

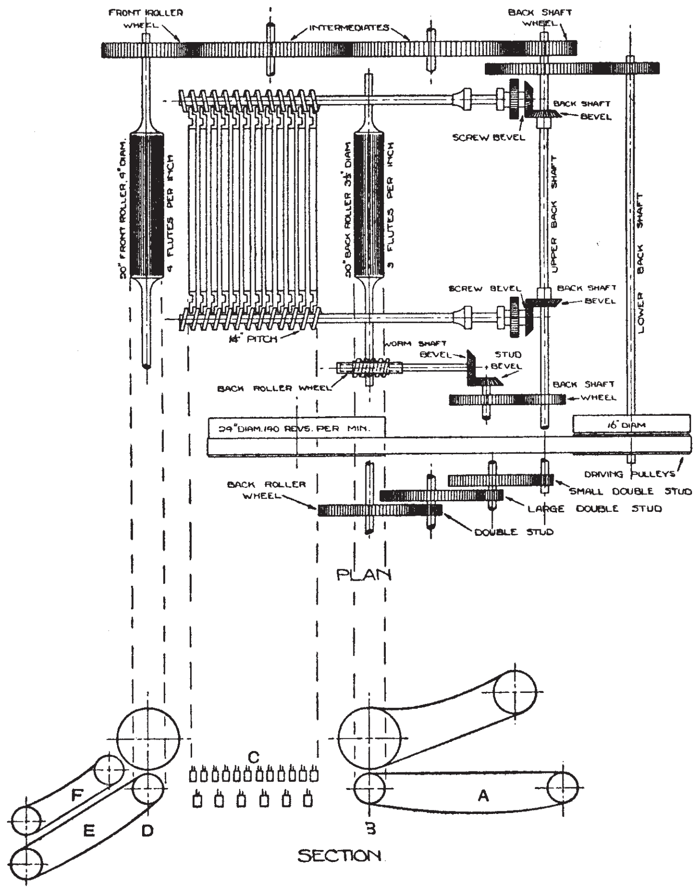


Fig. 87.—Plan and Section of "Sheeter" Preparing Box

usually a "sheeting" apparatus, and in the subsequent boxes a "can" delivery apparatus. The construction of such a box will readily be understood from Fig. 87. Its action is very simple. The wool, "made-up," is fed on to the feed sheet A in a longitudinal manner, and passes between the slowly-revolving back-rollers B. On emergence from these the gills C—worked in two pairs of screws and lifted and depressed by cams or tappets formed on these screws—rise up and pierce it, and, moving forward quicker than the rollers deliver the wool, draft it out and straighten it. The gills in turn deliver the wool to the front rollers D, which again, drawing the wool more quickly than the gills deliver it, further elongate and straighten the fibres. From the front rollers of the first two boxes of a set of say six the wool falls on to an endless leather sheet E, which in turn delivers it to a continuous leather apron F, which wraps the wool film by film upon itself until a "sheet" of wool of sufficient thickness is produced, when the attendant breaks it across and feeds it into the subsequent box. If the box is a "can" box the sliver passes through a funnel and press rollers into a cylindrical can, from which the sliver may be redrawn in a straight, unentangled condition.

Certain details of the preparing box require more than passing comment, and of these the faller action claims first notice. The fallers rest on bars or "saddles," as they are termed, set on each side of the machine, and they are traversed by screws or threaded shafts, two of which—an upper and a lower—are provided, again on each side of the box. To keep the fallers upright in position, the end of each is twisted to an extent which allows for the incline of the screw in which it fits. The drive is from the upper back shaft, through bevel wheels to the lower screws, and from these to the upper pair, though in this case revolution is in the reverse direction. Thus in the top screws the faller movement is outward, for drafting purposes, but in the bottom set a return action is given. Only half the number of fallers need be worked in the bottom screws, as the pitch of the latter is as coarse again as that of the upper set, giving as a consequence a faller movement twice as fast. The lifting of the fallers at one end of the traverse and the depressing of these at the other end are effected by cams set at the end of the screws; upright conductor bars and the saddle ends also serve to control the fallers and keep them in an upright position so as to ensure engagement in the thread of the screw into which they are being driven. Perfect timing is, of course, essential to avoid locking; and as similar trouble may result from excessive vibration the speed at which the fallers are dropped must be kept within reasonable limits.

Fallers.—An idea of the form of the faller will be gathered from the plan, as in Fig. 88. Full details of the types necessary for the various boxes will be supplied hereafter. Generally the pins are driven quite through the bar, and in all save the first box, where a single row is occasionally employed, the pins are arranged in double rows with pins in one row opposite the spaces in another to ensure more thorough combing. The piercing of the layer of wool when the faller is lifted is rendered more gradual through the back row of pins being $\frac{1}{8}$ in. longer than the front; but in the case of the first box, where the wool is ofttimes matted, a dabbing brush to press the fibre down is necessary also. As so much depends on the action of the pins, every care should be taken to keep them clean and in good repair. Few things have greater wearing influence than wool. In a surprisingly short time, with certain classes of fibre the ends of the pins may be bent or they may become slit, causing lumps and slubs wherever they are in contact with the wool. The pins frequently break, and if not replaced the wool goes forward to the comb with certain unopened fibres, and as a consequence produces an abnormal amount of noil.

Rollers.—In long wool in particular the nature of the fibre is such that it is easily ground into pieces if strained under the heavily weighted and coarsely fluted metal rollers which are necessary to obviate slipping of the material during the drafting process. To minimise this difficulty it is usual to run endless leathers round the rollers, in the first and second machines the top back rollers taking the leather, and in the can boxes, where shorter drafts are given, the bottom front roller only. In the two sheeter boxes the leathers serve a double purpose: in addition to providing a bed for the fibre in the roller nip, the back roller leather helps to converge the staples coming to the rollers from the ordinary feed sheet, while the front leather serves as support for the lap formed on the sheet above it. It need hardly be stated that a condition vital to good work is that the leathers be in good repair. Should they be "holed" or badly sewn, or should they sag when running, an uneven and wasty lap or sliver is unavoidable.

Weighting of Rollers.—The degree and uniformity of pressure applied to gill-box rollers is a matter of no small moment. In the older forms of machine weight is added at each side of the box by an independent wheel; this lowers a bush, which in turn compresses

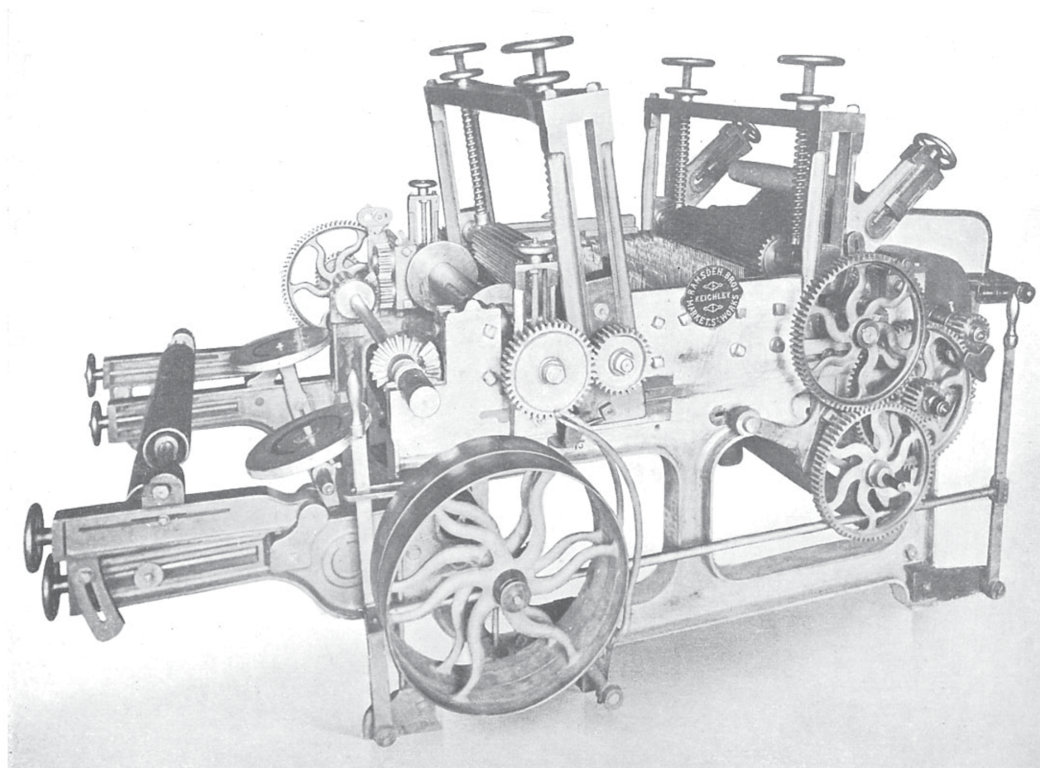


Fig. 88.—Preparer with Double Screws

a spring resting upon the top roller bearing. Seldom is the weight applied with absolute uniformity; there is too much weight at one side or too little, with either breakage of fibres or more or less slippage. The defect has been remedied, however, in recent machines. Whitehead and Layland's patent provides for an arm horizontally hinged in the centre of the framework with its ends of the hand wheels, which work as before described. In this case the bushes are free to move vertically, so that even though weight be added at one side only through the agency of the centred arm, it is adjusted to both ends of the rollers.

Making up or Feeding.—The action of a preparing box does not need much study to show that if the length of the fibre is to be preserved the material should be presented to the rollers, and by these to the fallers, in as straight a condition as possible. Too frequently feeding is neglected, especially at the first box, when the material is more or less detached, with the result that the fibres enter the nip in a crosswise direction and, both ends being held at the same time, they are broken rather than drafted by the action of the fallers. The exercise of care here will be amply justified in the superior top ultimately produced, and in the quantity of this as available from a given quantity of wool. In the second and third boxes lap feeding is employed, while slivers are formed for the later machines, and to avoid draft being applied twice in the same direction —a procedure which spoils the uniformity of the end —the end of the lap or sheet opposite to that delivered by the preceding box should be run first into the machine to be fed.

Weighing and Equalising of Slivers.—To favour regularity of end, both as regards its weight and thickness, it is necessary in preparing to employ knock-off motions from the third box onwards, which stop the machine on a determined length being delivered, and thus provide opportunity for the slivers to be weighed and their condition, whether heavy or light, to be judged. As a description of the motions employed is more conveniently given in connection with the processes of spinning, readers are referred to the volume dealing with this subject. On the weights being found, cans containing light slivers and heavy ones are put together behind succeeding boxes and the ends are then "doubled" to equalise each other. Much variation obtains as to the number of ends to combine, but for long lustre wools and hairs 12 to 14 doublings at the fourth, 12 at the fifth, and 14 at the last are considered suitable.

Addition of Oil in Preparing.—When treating certain lots, the addition of oil becomes necessary during the preparing process. This is especially the case if the operation of back-washing is to be omitted, as no further opportunity is given whereby the fibres may be oiled for the combing and spinning processes in which their control becomes a necessity. Generally about three per cent. is added, usually at the fourth box, so that in succeeding machines a perfect distribution may be effected. Special motions are employed for these purposes; these will be described in the section dealing with Back-washing.

Particulars of a typical set of preparing boxes capable of turning off about 1,250 lb. of wool per day of ten hours will be found tabulated on p. 207.

For this set—which is full-size—six boxes are taken, but very often five are used, the sixth being

DETAILS OF PREPARING SET (ORDINARY BOXES)

Suitable for Longest Lustre Wools and Hairs

		Sheeter Boxes		Can Boxes			
		1st	2nd	3rd	4th	5th	6th
Rollers	Diam. of Top Back Roller (inches)	6	6	6	5	4½	4½
	Diam. of Bottom Back Roller (inches)	3½	3½	3½	3	3	3
	Diam. of Top Front Roller (inches)	6	6	6	5	5	5
	Diam. of Bottom Front Roller (inches)	4	4	4	3½	3	3
	Flutes—Back Rollers (per inch of diam.)	4	4	4	5	5	5
	Flutes—Front Rollers (per inch of diam.)	3	3	4	4	5	5
Fallers	Pitch of Screw* (inches)	1¼	1⅛	1	⅞	⅞	¾
	Fallers in Top Screws	12	12	14	14	16	16
	Fallers in Bottom Screws	6	6	7	7	8	8
	Fallers rising per minute	120	130	140	150	160	180
	Thickness of Pins (wire gauge)	7's	8's	9's	11's	12's	13's
	Length of Pins† (inches)	3	3	2⅞	2¾	2⅝	2½
	Pins per inch	2½	3½	4½	5½	6½	7
	Set-over‡ (in inches)	22	22	20	18	16	16
Drafts and Ratches	Back Draft§	7½	5	4	3	2	1½
	Front Draft‖	6	6½	6½	7	7	7
	Total Draft**	45	32½	26	21	14	10
	Back Ratch†† (in inches)	3	3½	4	4½	5	5½
	Front Ratch‡‡ (in inches)	2½	3	3½	4	4½	5
	Total Ratch§§ (in inches)						

* Pitch of screw gives distance traversed by fallers for one revolution of screw.
† Particulars of length given are for longest rows of pins. Shorter rows vary ⅛ to ¼ inch.
‡ Set-over gives distance over which faller is pinned.
§ Back draft : Draft between back rollers and fallers.
‖ Front draft : Draft between fallers and front rollers.
** Total draft : Draft between back and front rollers.
†† Back ratch : Distance between nip of back rollers and fallers.
‡‡ Front ratch : Distance between fallers and nip of front rollers.
§§ Total ratch : Distance between nip of back rollers and nip of front rollers.

reckoned as that at the back-wash gilling process. In other cases so few as four machines are employed, but the treatment given to the wool by each machine in such a small set is such as to considerably injure it for combing purposes and for spinning, and consequently cannot be truly considered economical.

The foregoing list requires certain explanations. In the first place, a word regarding the use of the particulars it contains is necessary. Though every endeavour has been made to render such data as reliable as possible, the supplying of this may become a positive danger if a wrong idea be held regarding its utility. It should not be forgotten that different lots of wool, even when they are of the same class, often vary very widely, and that therefore no information more than that generally applicable can be given. Particulars of this character may, however, prove very serviceable in practice if the principles on which they are based be understood, if they are used as guidance, and modified for the various wools, according as reason and commonsense suggest.

It will be observed that the particulars and treatment here indicated are for the longest preparing wools and hairs. For the shorter classes of these materials more control of the fibre is necessary, and therefore the rollers of the various machines would be smaller, the fallers would be more numerous and closely arranged, and the pins would be shorter. The drafts and ratches would also need to be lessened.

Much variation of opinion obtains among practical men as to how these last-mentioned features should vary. It does seem desirable to give, first, a thorough opening of the staples through the agency of long total drafts in the first boxes, and afterwards attend to straightening by employing lesser drafts. Good straightening may be considerably favoured by a judicious arrangement of the individual drafts. At the beginning the back draft is necessarily high for opening purposes, but later this should be markedly decreased at each box, as this treatment is somewhat violent. On the other hand, the front draft should be gradually increased from the first box onwards, for the drawing of the wool through the fallers by the front rollers (front draft) is done more easily and better than by forcing the fallers through the wool as held by the back rollers (back draft).

Much depends upon the ratches of a box for successful treatment of the fibre. They must not be too long, or the fibres will "ride" the fallers; neither must they be too short, or the fibres will be broken. It is here that a careful study of the condition of the material proves useful. Should the lot be loose in staple and shortish, lesser ratches are necessary than if the fibre is good in cohering capacity through being in condition, of uniform length, and of well defined staple. Generally speaking, at the first box in the set the back and front ratches should be short; after this, when certain opening has been done and the fibres have frictional contact on each other, gradual lengthening of both ratches may be done without fear of injury.

Draft Calculations.—From the foregoing description it will be gathered that "draft" in preparing gill boxes depends on the difference in drafting capacity of (1) the fallers in relation to the back rollers, (2) the front rollers in relation to the fallers, and (3) the front rollers in relation to the back rollers. The first variation is the "back draft," the second the "front draft," and the third the "total draft," this latter being a multiple of the remaining two. For calculating purposes it is necessary to consider all the factors which influence the front and back rollers and fallers—wheels, rollers and screws—from the standpoint of whether, when dealt with in the same way, they increase or decrease their drafting capacity. If, then, all "increases" be multiplied together, and divided by the multiple of all "decreasers," the answer will be a draft sufficiently near the actual draft obtaining, for all practical purposes. Instead of the terms "increasers" and "decreasers," a division into "drivers" and "drivens" is frequently made in practice, the following rule being applied :—

Drivers : Those wheels, rollers, etc., which, when *increased* in size or speed, give *more* draft.

Drivens : Those wheels, rollers, etc., which, when increased in size or speed, give less draft.*

The larger result divided by the smaller gives the draft required.

Reason for this may readily be seen on reference to the plan of the box, as in Fig. 87. It will be observed that the back rollers, front rollers, and fallers (the drafting parts) are all driven from one point—the "upper back shaft" as it is termed. Suppose, now, the "draft wheel" (33) be increased. It would drive the front roller quicker, and the effect of this would be to increase the drafting capacity. It would therefore be a "driver." On the other hand, the "front roller wheel" (50), when increased, would reduce the drafting capacity, as it would cause the front roller to revolve more slowly. This would be a "driven." All parts should be studied in this way, but it should be specially noticed that it is draft only which decides the classification ; it is not speed ; for in the case of the back roller, *more* speed gives *less* draft, as the following illus-

* The fact that a wheel as when geared into another may be said to be *driven* by it or to be *driving*, has no bearing whatever upon this calculation. It is a matter of effect of size or speed of wheels upon draft.

tration shows, and therefore all increasers or drivers for draft are decreasers or drivens in a speed calculation. Intermediate wheels also—single stud wheels, not mounted on shafts or rollers—are not taken account of in these calculations, as these just transmit the power supplied to them without influencing the draft in any way.

	Back Roller		*Front Roller*		*Total Draft*
	(*Equal diameters*)				
(1)	10 revs.	..	70 revs.	equals	7
(2)	20 ,,	..	70 ,,	,,	$3\frac{1}{2}$
(3)	10 ,,	..	90 ,,	,,	9

Therefore to increase the front roller speed gives more draft, and to increase the back roller speed less draft. In the case of the fallers, to increase their speed gives more draft in a " back draft " calculation and less draft in a " front draft " calculation.

Below is given a complete classification of the parts in a box geared as shown in Fig. 87 on p. 201 :—

(*a*) Front Draft (front rollers on fallers) :

Draft wheel (33)	as increased	gives	more draft ;	therefore		Driver
Front roller wheel (50)	,,	,,	less	,,	,,	Driven
Front roller (4″ diam.)	,,	,,	more	,,	,,	*Driver
Back shaft bevel (20)	,,	,,	less	,,	,,	Driven
Screw Bevel (18)	,,	,,	more	,,	,,	Driver
Pitch of Screw ($1\frac{1}{4}$″)	,,	,,	less	,,	,,	Driven

Calculation stands :

$$\frac{\text{Drivers}}{\text{Drivens}} \quad \frac{33 \times 4'' \times 3.14^{*} \times 18}{50 \times 20 \times 1\frac{1}{4}''} = 5.94$$

* Seeing that it is capacity which governs draft, the circumference and not the diameter of rollers must be taken in calculations to find the front and back drafts. In the total draft calculation conversion from diameters is not necessary, as both rollers are included in the calculation, and if changed they would still retain the same relationship to each other.

(*b*) BACK DRAFT (fallers on front rollers):

Shaft bevel (20)	as increased	gives	more draft;	therefore		Driver
Screw bevel (18)	,,	,,	less	,,	,,	Driven
Pitch of Screw ($1\frac{1}{4}''$)	,,	,,	more	,,	,,	Driver
Back shaft wheel (22)	,,	,,	less	,,	,,	Driven
Large double stud (40)	,,	,,	more	,,	,,	Driver
Small stud bevel (18)	,,	,,	less	,,	,,	Driven
Worm shaft bevel (20)	,,	,,	more	,,	,,	Driver
Worm (1)	,,	,,	† less	,,	,,	Driven
Back roller wheel (30)	,,	,,	more	,,	,,	Driver
Back roller ($3\frac{1}{2}''$ diam.)	,,	,,	less	,,	,,	*Driven

† Say to double worm.

Calculation stands:

$$\frac{\text{Drivers}}{\text{Drivens}} \quad \frac{20 \times 1\frac{1}{4}'' \times 40 \times 20 \times 30}{18 \times 22 \times 18 \times 1 \times 3\frac{1}{2} \times 3.14} = 7.65$$

(*c*) TOTAL DRAFT (front rollers on back rollers):

Draft wheel (33)	as increased	gives	more draft;	therefore		Driver
Front roller wheel (50)	,,	,,	less	,,	,,	Driven
Front roller (4″ diam.)	,,	,,	more	,,	,,	Driver
Back shaft wheel (22)	,,	,,	less	,,	,,	Driven
Large double stud (40)	,,	,,	more	,,	,,	Driver
Small stud bevel (18)	,,	,,	less	,,	,,	Driven
Worm shaft bevel (20)	,,	,,	more	,,	,,	Driver
Worm (1)	,,	,,	less	,,	,,	Driven
Back roller wheel (30)	,,	,,	more	,,	,,	Driver
Back roller ($3\frac{1}{2}''$ diam.)	,,	,,	less	,,	,,	Driven

Calculation stands:

$$\frac{\text{Drivers}}{\text{Drivens}} \quad \frac{33 \times 4'' \times 40 \times 20 \times 30}{50 \times 22 \times 18 \times 1 \times 3\frac{1}{2}''} = 45.7$$

The "total draft" is of course made up of back and "front drafts." Multiplication of these drafts, and not addition, is, however, essential for correct results, for it must be remembered that one yard drafted, say, into seven at the back of the box, is re-drafted, each yard seven times more, at the front of the box. Then—

"Back draft" × "Front draft" = "Total draft,"

or

$$7.65 \times 5.94 = 45.4$$

The discrepancy 0.2 is brought about by the ignoring of small fractions. Such a result is sufficiently near for practical purposes.

In the latter boxes of the set the worm and pinion gearing to the back roller is discarded, and the ordinary double-stud drive is used instead. This is because big drafts, necessitating the very slow movement of the back roller, are no longer required. The substituted gearing is illustrated in Fig. 87, between the section and plan. For calculation purposes, it is dealt with according to rule previously given. Thus—

$$\frac{\text{Drivers* } 33 \times 78 \times 78 \times 78 \times 4}{\text{Drivens } 50 \times 24 \times 19 \times 20 \times 3\frac{1}{2}} = 39.24 \text{ ``Total draft.''}$$

When making draft changes, it is customary in the trade to use "gauge points," which are useful in lessening the time taken in working out calculations and in favouring accuracy. As in the gill box, there is only one point at which changing is done—the "draft wheel"—the remaining unchanging factors may be reduced once and for all to their lowest point and the result obtained—the standard gauge point made use of in connection with the changing factor. Thus, in the preceding example:

$$\frac{\text{Drivers } \textcircled{33} \times 4'' \times 40 \times 20 \times 30}{\text{Drivens } 50 \times 22 \times 18 \times 1 \times 3\frac{1}{2}''} = 1.385 \text{ St. G. P.}$$

Then G.P. × change wheel in use will give resulting draft,

or,

Draft required ÷ G.P. equals necessary change wheel.

* It is worth the trouble for the student to accustom himself to the names of the various wheels in the machine and the positions they occupy, so that he may calculate from data once obtained without further examination of the parts. Much saving of time may be effected by this means.

The reason for multiplying in one case and dividing in the other is worth noticing:

Multiplying by change wheel in the first case simply amounts to placing the absent factor (a "driver" and a multiplier) into its position occupied in the original calculation.

In the second example the G.P. is used to represent a draft wheel with one tooth giving a draft of one. Reasonably then for wheel required the G.P. should be divided into draft desired.

Modifications of the Preparer Gill Box.—Several attempts have been made to improve upon or supersede the ordinary gill box. In one case a graduated screw acting over a longer distance than in

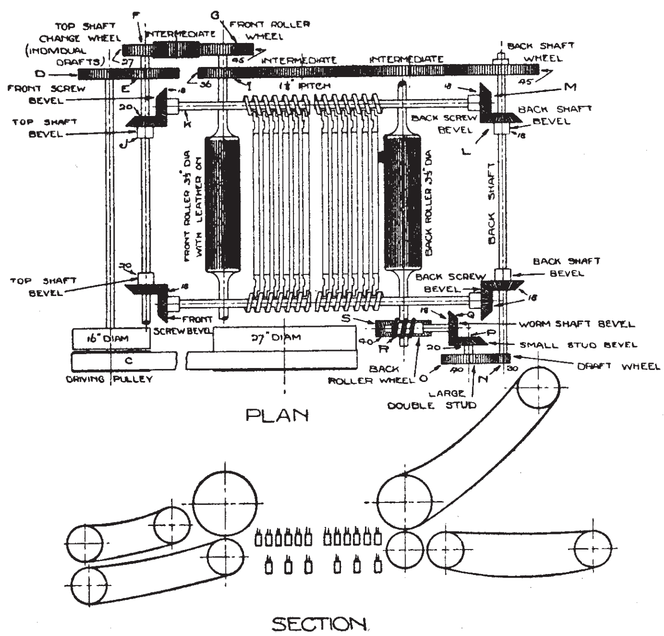


Fig. 89.—Plan and Section of the "Clough" Preparer-Box

the ordinary box was employed for driving the fallers, but as the fallers so propelled on falling from the slivers left bars of short fibres which they had collected, this arrangement never attained to any measure of success. More fortunate has been the idea of introducing two sets of screws and fallers (Fig. 89), so that there are three distinct drafts in the box—between back rollers and faller, fallers and fallers, and fallers and front rollers. Boxes of this construction may well form the first two of a set of, say, six preparers. The following are the drafting calculations for such a box :—

TOTAL DRAFT :

$$\frac{\text{Drivers}\quad \overset{\text{I}}{45} \times \overset{\text{O}}{40} \times \overset{\text{Q}}{18} \times \overset{\text{S}}{40} \times \overset{\text{F.R.}}{11}}{\text{Drivens}\quad \underset{\text{H}}{36} \times \underset{\text{N}}{30} \times \underset{\text{P}}{20} \times \underset{\text{R}}{2} \times \underset{\text{B.R.}}{11}} = 30$$

BACK DRAFT :

$$\frac{\text{Drivers}\quad \overset{\text{L}}{18} \times \overset{\text{Pitch}}{1\tfrac{1}{8}} \times \overset{\text{O}}{40} \times \overset{\text{Q}}{18} \times \overset{\text{S}}{40}}{\text{Drivens}\quad \underset{\text{M}}{18} \times \underset{\text{N}}{30} \times \underset{\text{P}}{20} \times \underset{\text{R}}{2} \times \underset{\text{F.R.}}{11}} = 2.45$$

MIDDLE DRAFT :

$$\frac{\text{Drivers}\quad \overset{\text{G}}{45} \times \overset{\text{I}}{45} \times \overset{\text{M}}{18} \times \overset{\text{J}}{20} \times \overset{\text{Pitch}}{1\tfrac{1}{8}}}{\text{Drivens}\quad \underset{\text{F}}{27} \times \underset{\text{H}}{36} \times \underset{\text{L}}{18} \times \underset{\text{Pitch}}{1\tfrac{1}{8}} \times \underset{\text{K}}{18}} = 2.31$$

FRONT DRAFT :

$$\frac{\text{Drivers}\quad \overset{\text{F}}{27} \times \overset{\text{F.R.}}{11} \times \overset{\text{K}}{18}}{\text{Drivens}\quad \underset{\text{G}}{45} \times \underset{\text{J}}{20} \times \underset{\text{Pitch}}{1\tfrac{1}{8}}} = 5.28$$

Then 2.45 (back draft) × 2.31 (middle draft) × 5.28 (front draft) = 29.8 (30 nearly) total draft.

For gauge point leave out draft change wheel (N) and proceed as before shown.

These boxes are not now used to a great extent, their place having been taken by what may be described as "cott boxes" for opening specially "cotty" wool. One reason for this is that the initial cost is great, and changes are very difficult to make. For mohair, however, these boxes seem specially appropriate.

The Carder.—The carder, as adapted to the preparation of the medium and short combing wools, usually consists of opening rollers or of a breast, serving partially to open the wool prior to the more severe carding effected by the swift proper, and two swifts each with three workers and strippers, a fancy, a doffer, and certain accessory rollers, such as the "dickey" for cleaning and clearing cylinders, the burring rollers for removing

DETAILS OF WORSTED CARDERS

(*a*) FINE QUALITIES—MERINO WOOL

Cylinders	*Number*	*Diameters* (inches)*	*Revolutions*	*Surface Speed per minute*	*Clothing, Counts and Crown*	*Pins per sq. inch*	*Size of Pins*
Feed Rollers	2	3	·25	0·195	Needle	point	steel
Clearer Roller. . . .	1	2½	·66	0·43	wire, s	trong	fillet
1st Licker-in	1	30	6·25	49·49			D.P†
2nd "	1	24	25	163	90/9	324	28
3rd "	1	24	50	327	100/10	400	30
4th "	1	24	100	654	115/10	460	32
1st Divider	1	20	2·1	11·52	70/6	168	25
2nd "	1	12	3·6	12·17	90/9	324	28
3rd "	1	12	3·9	13·27	110/10	440	30
4th "	1	12	4	13·6	120/10	480	32
Burring Rollers . . .	6	4¼	600	666			
1st Swift	1	50	100	1335	130/12	624	33
1st Workers	1	12	3·3	11·23	135/12	648	34
2nd and 3rd Workers .	2	12	—	—	140/12	672	35
1st Strippers . . .	3	7	195	280	110/10	440	31
1st Fancy	1	12	376	1171·58	80/8	256	31
1st Doffer	1	40	5	54	140/12	672	35
Angle Stripper . . .	1	7	195	280	120/10	480	31
2nd Swift	1	50	115	1535·45	150/13½	810	35
4th Worker	1	12	3·3	11.23	150/13½	810	35
5th and 6th Worker .	2	12	—	—	155/14	868	36
2nd Strippers . . .	3	7	222·25	322	115/10	460	32
2nd Fancy	1	12	432·4	2037	90/8	288	33
2nd Doffer	1	40	5	54	155/14	868	36

* Diameter of cylinder unclothed.
† Birmingham wire gauge

burrs, etc. On p. 216 and below are the cylinder dimensions, speeds and clothing of a standard worsted carder for (*a*) Fine Botany wools, (*b*) Medium Cross-bred wools, and (*c*) Lustre wool and hair, the contrasting of these three supplying the data for carding the intermediate qualities of wools.

DETAILS OF WORSTED CARDERS

(*b*) MEDIUM QUALITIES—CROSS-BRED WOOL

Cylinders	*Clothing*	*Pins per sq. inch.*
Feed Rollers (2) / Clearer Roller (1)	Needle point steel wire.	
1st Licker-in	Garnetted.	
2nd ,,	60/6	144
3rd ,,	80/8	256
4th ,,	100/10	400
1st Divider	60/6	144
2nd ,,	80/8	256
3rd ,,	90/9	324
4th ,,	110/10	440
1st Swift	110/10	440
1st Workers (3)	115/10	460
1st Strippers (3)	80/8	256
1st Fancy	70/6	168
1st Doffer	115/10	460
Angle Stripper	100/10	400
2nd Swift	125/12	600
2nd Workers (3)	130/12	624
2nd Strippers (3)	90/9	324
2nd Fancy	70/7	196
2nd Doffer	130/12	624

(*c*) LONG LUSTRE AND MOHAIR QUALITIES

Cylinders	*Clothing*	*Pins per sq. inch.*
Feed Rollers (2) / Clearer Roller	Needle point steel wire.	
1st Licker-in	Garnetted.	
2nd ,,	30/6	72
1st Divider	30/6	72
Breast	40/6	96
Breast Workers(2)	45/6	108
Breast Strpprs.(2)	30/6	72
Angle Stripper	60/6	144
1st Swift	70/7½	210
1st Swift Workers (3)	80/8	256
1st Swift Strippers (3)	70/6	168
1st Fancy	60/5	120
1st Doffer	90/9	324
2nd Angle Stripper	80/8	256
2nd Swift	115/10	460
2nd Swift Workers (3)	120/10	480
2nd Swift Strippers (3)	80/8	256
2nd Fancy	70/6	168
2nd Doffer	120/10	480

Seeing that the maintenance of length is such an important matter in worsted spinning, the gradual speeding up of the rollers from the first opener to the last doffer is worthy of more than passing comment.

Perhaps the carding overlooker is still too conservative in setting his machines, and if so it is probable that cylinder speeds is one of the matters calling for careful consideration. At least, he should not be too much under the influence of the machine maker—he should know "why."

In Fig. 90 the relative actions of the various cylinders are indicated.

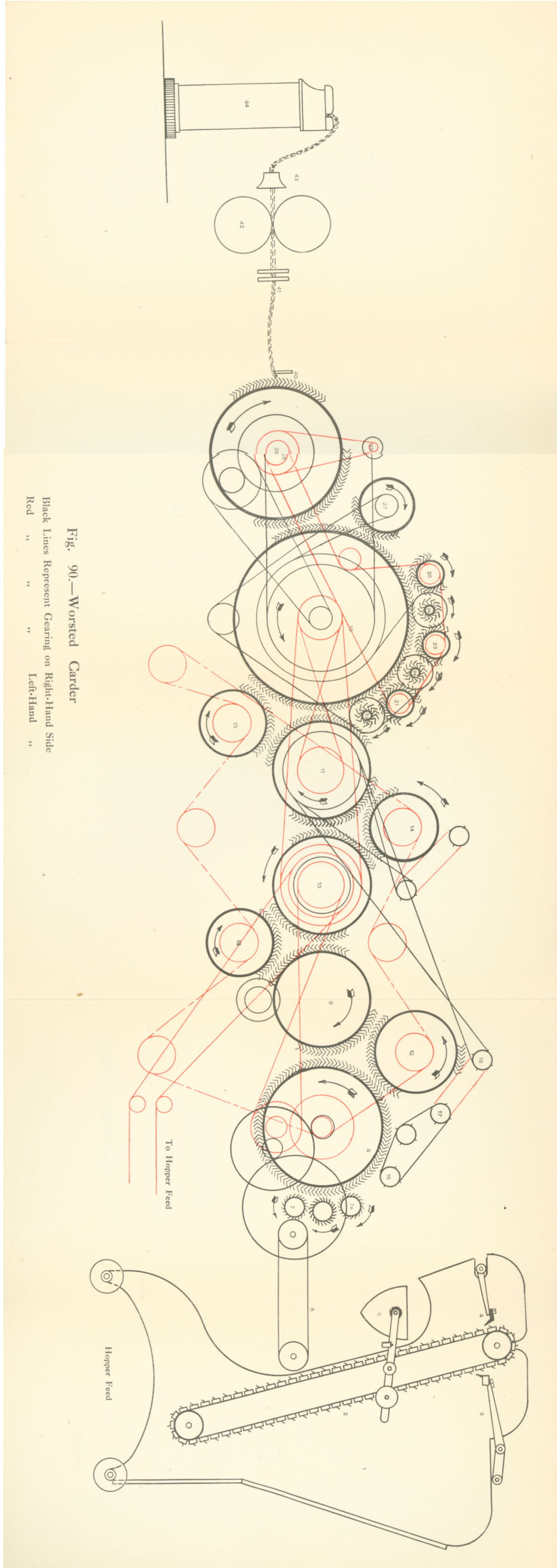
1. Fed on to the sheet by hand (6)—or, as is more general, by an automatic feed (1)—the wool is carried by this into the feed-rollers (7). The teeth of these are set in the direction opposite to that in which the rollers move, so as to effect some opening of the staples when these are seized by the upward pointing and upward moving pins of the first licker-in (8) on to which they are run. To ensure the complete transference of all material, a third feed-roller *7a* is employed which strips the top feeder, and, owing to the upward setting of the feed-roller teeth, no staples will be carried round the bottom feed-roller. The third feed-roller is in turn stripped by the licker-in by a point to smooth-side movement. Then come the following movements:—

2. Opening by point-to-point action of 1st divider (12) on 1st licker-in—material left on 1st divider.*

3. Stripping by point to smooth-side action of 2nd licker-in (9) on 1st divider and 1st licker-in—material left on 2nd licker-in.

4. Opening by point-to-point action of 2nd divider 13 on 2nd licker-in—material left on 2nd divider.

*It should be noted that the clothed cylinders intercept and open only such material as is not sufficiently disentangled to pass through them. This accounts for the stripping, which takes place between the 2nd and 1st licker-in as well as between the 2nd licker-in and 1st divider: material opened has been left on the 1st divider; material not opened at this stage has been carried round by the 1st licker-in for removal by the 2nd licker-in.



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5. Stripping by point to smooth-side action of 3rd licker-in (10) on 2nd divider and 2nd licker-in—material left on 3rd licker-in.

6. Opening by point-to-point action of 3rd divider (14) on 3rd licker-in—material left on 3rd divider.

7. Stripping by point to smooth-side action of 4th licker-in (11) on 3rd divider and 3rd licker-in—material left on 4th licker-in.

8. Opening by point-to-point action of 4th divider (15) on 4th licker-in—material left on 4th divider.

9. Stripping by point to smooth-side action of swift (19) on 4th divider and 4th licker-in—material left on swift.*

10. Working by point-to-point action of worker (21) on swift—material left on worker.

11. Stripping by point to smooth-side action of stripper (22) on worker—material left on stripper.

12. Stripping by point to smooth-side action of swift on stripper—material left on swift.

3 times

19. Raising by smooth-side to smooth-side action of fancy (27) on swift—material left on swift.

20. Opening and clearing by point-to-point action of doffer (28) on swift—material left on doffer.

21. Stripping by point to smooth-side action of angle stripper (30) on doffer—material left on angle stripper.

22. Stripping by point to smooth-side action of 2nd swift (29) on angle stripper (30)—material left on swift.

* Something similar happens with the material on the swift. The 1st. worker opens that which is unable to pass it (the remainder going on to succeeding workers). It is removed by the stripper, and afterwards taken up by the swift (already partially charged with material from the feed-rollers, but still capable of effectively stripping) and carried this time past the worker. It is, of course, separated at this point from that which is matted—the last taken up from the feed-rollers.

23. Working by point-to-point action of (31) worker on 2nd swift—material left on worker.

24. Stripping by point to smooth-side action of stripper (32) on worker—material left on stripper.

25. Stripping by point to smooth-side action of swift on stripper—material left on swift.

} 3 times

32. Raising by smooth-side to smooth-side action of fancy (37) on 2nd swift—material left on swift.

33. Opening and clearing by point to smooth-side action of doffer (38) on 2nd swift—material left on doffer.

34*. Stripping of material in film form from doffer by doffing comb (40), this being later conducted through calendar rollers (42) into funnel (43), by which it is condensed into sliver form and taken in coiler cans (44).

It was about the middle of the last century that the first attempts were made to prepare wool for combing by carding it. A cursory survey of carding would lead one to the conclusion that no worse method of preparation for combing could be devised. A more careful consideration of carding, however, would lead one to the opposite conclusion, and to-day it is quite customary to prepare wool 8 to 10 inches long for combing by this means.

There are several details respecting the worsted carder which require careful attention. In the first place, automatic feeds should claim consideration. In these days of scarcity of labour and high wages every machine is rendered as automatic as possible, and the carder is no exception to the rule. The automatic feeder, however, is not a process for the long wools, as length seems to interfere with its regular action. On short wools also the hopper should be kept filled or staples will "string."

* *See* "Wool Year Book." Marsden & Co.

Many wools come up from the washing charged with burrs, and some wools required "clear" are "kempy." The first difficulty is got over by fixing burring rollers or beaters to work in connection with the opening rollers, as shown in Fig. 90. Usually six are employed, these being set in twos over the first licker-in and the two top dividers. They are steel-bladed rollers, revolving at from 600 to 800 revolutions per minute, and their action depends on the inability of the curled-up burrs to penetrate, as is possible in the case of the wool, below the surface of the cylinder's card clothing. The wool is firmly held, but the burrs, along with a small portion of the fibre to which they cling, are broken away by the burr beaters and deposited in trays to be collected at intervals. This method, however, cannot be employed on wools which are heavy in burr; it is not sufficiently effective.

In other cases the grinding of the vegetable matter into small pieces is attempted, with the idea that in subsequent processes continued movement of the fibre will complete the removal of the impurity. A well-known and largely used type is the Harmel burr-crushing apparatus, which is set midway in the carder, at a point where the fibre leaves the first doffer. By this means both wool and burrs are opened somewhat when presented to the burr appliance, and this condition admits of the thicker and more brittle burr being crushed while the fibre is expected to escape this action. Stripping for this treatment is effected on the doffer by a doffing comb; the material, in film form, then passes over a supporting plate and over a plain steel roller, on which two sharply fluted rollers of varying pitch are pressing, for the purpose of crushing; from this it is taken by way of angle roller to the second swift. Continued crushing chokes the fluted rollers with impurity;

to remove this, fluted clearer rollers, set above but in actual gear with the crushers, are traversed continually so as to scoop out the foreign matter, later depositing it into cans.

In many machines a fluted roller is part of the calendar head by which the sliver is conveyed to the coiler can. The object of this is to give a second crushing to any burr that may be found in the now fully opened fibre. Such action, however, is somewhat severe on the wool fibre, especially if the fibre is hard and inelastic; consequently its use is not to be commended.

The final separation of the finely divided burr takes place in the comb, when its removal is effected along with the noil. Noils produced are consequently less attractive, being "burry," than is the case when the ordinary burr roller is employed. Still, the saving effected through preserving all the wool fibre for either top or noil amply compensates for any deterioration of noil caused.

"Morel" Burring.—A motion which is extremely effective in producing a "clear" top is known as the "Morel" burring mechanism, an arrangement for which Wool-Combers' Limited hold the sole rights in this country. The chief feature is the "Morel" roller, which is densely clothed with specially made "Garnett" wire, its character being such that wool placed upon it may be held completely and tenaciously in the teeth, while the burrs—too thick to penetrate the pins—stand on the surface. A steel-bladed and quickly revolving burr beater then breaks the burrs away, driving them into a tray from which they are removed by scrapers. The wool comes to the "Morel" roller from the first licker-in, on which it has been effectively opened by the "Garnett" teeth of the roller working against the teeth of two smaller " workers " similarly clothed. A quickly revolving brush does the necessary stripping from the licker-in ; it also fixes the wool into the teeth of the burring roller. After treatment, stripping of the " Morel " is accomplished by the second licker-in ; the wool is then taken to the second divider, and then direct to the first swift. The third and fourth lickers-in and dividers may be dispensed with when this motion is used, owing to the thorough opening of the fibres given prior to and during the process of burring.

The kemps referred to are usually thrown out during carding, and arrangements should be made under the card to ensure that, once thrown off, they never have the chance to get into the wool again. Thus the control of air blasts on the carder is by no means unimportant.

The grinding of the clothing on a carder must be very carefully undertaken if the card is to work to the greatest advantage.

Processes following Carding.—It will readily be understood that the sliver coming from the carder consists of a jumbled-up mass of fibre in comparison with the straight-fibred sliver issuing from the last preparing box. It will, perhaps, also be realised that not only will the mass of material be somewhat sullied from passing through the carder, but, further, that as fibre will have been most thoroughly separated from fibre, dirt, which the first scour could not get at in the washing-bowls, will now be in evidence.

It thus comes about that carding is usually followed by—

(*a*) Backwashing ; (*b*) Gilling.

It will further be evident that if a thorough cleansing of this sliver is attempted, whiteness will be expected. As this is not always in evidence to the extent desired, " blueing " is resorted to, powder blue or blueing agent being added to the rinsing or some other bath of the backwasher to impart to the " top " an artificial whiteness. It is probable that the top is not damaged, but it is certainly not really improved by this, so that, upon the whole, blueing must be regarded as an unnecessary practice. And here the English comber is inconsistent, for having got his tops clean, he at once proceeds to add up to 3 per cent. of oil to facilitate combing. Oiling is usually effected on the gill box following the backwasher, so that during the following two or three processes the oil may be thoroughly distributed throughout the sliver. Thus the English comber " combs in oil." The French comber, on the other hand, largely because he uses the French or Heilmann comb, usually " dry combs," and very often places backwashing after combing, so that he produces a " dry " top suitable for " dry spinning." With his sequence of machines, however, he can comb dry, or comb with a small proportion of oil, and still deliver a " dry top " by backwashing after combing.

The Backwasher—This machine primarily consists of a two-tank scouring device, a drying apparatus, an oiling apparatus (if required), and a balling gill box. The general disposition will be understood from Fig. 91, in which both plan and elevation are given. The first tank contains a light scouring liquor, in which the slivers are suitably immersed. The liquor is usually made in the proportion of 2 gallons of soap liquid to 50 gallons of water. The soap liquid is made of 1 lb. of soap (hard or soft) dissolved in 1 gallon of boiling water.

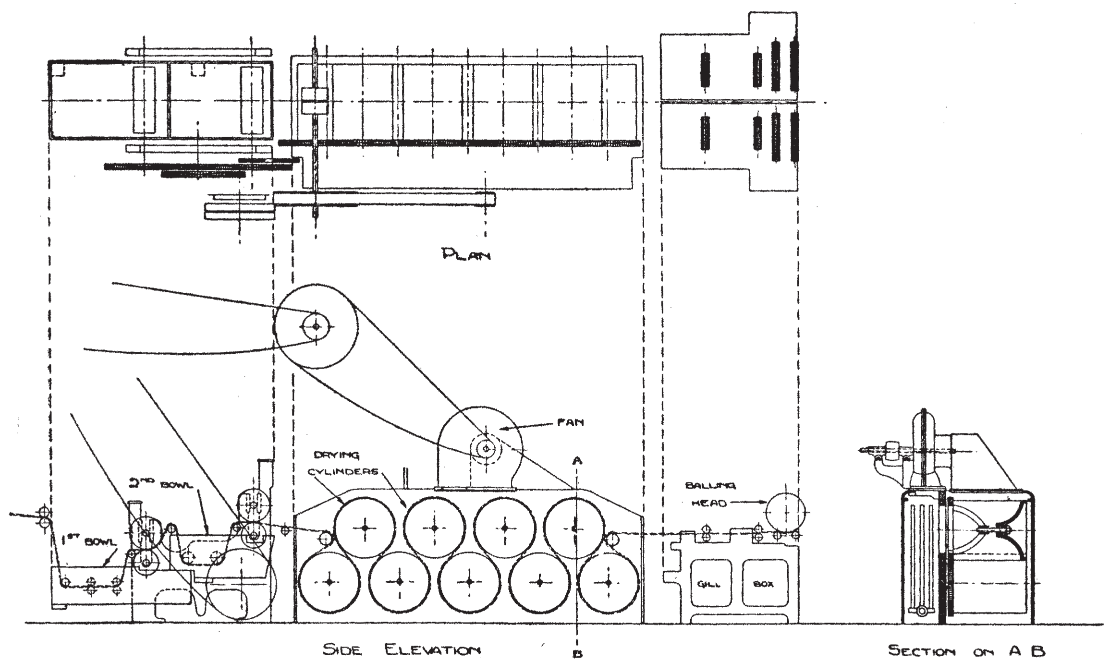

Fig. 91.—Backwashing Machine

The second tank contains the rinsing liquor, charged with the blueing agent. After passing through the squeezing rollers, the slivers pass through the drying apparatus. Until within the last eighteen months this usually consisted of a few large or a number of small steam-heated cylinders. Now, however, this method of drying has been dispensed with; perforated cylinders are employed which allow dry air to be blown through the slivers, so that air-drying may now be taken as the universal practice. This change may seem a detail, but it is one which every comber of note is having to adopt, simply owing to the better yield of top and the quality difference it results in.

The gill box which follows the drying cylinders is of the usual type, save that it may be necessary to have it designed with two heads to take the large number of slivers passing through the machine. An oiling motion of a simple type allows oil to drop on to the slivers during the passage between back and front rollers. The following are the usual percentages for the different qualities of wool:—

Down Wools	$2\frac{3}{4}$ per cent.
Merino Wools	3 per cent.
Long Wools	3–$3\frac{1}{2}$ per cent.

Following the backwasher come one or two gill boxes—"strong boxes," as they are termed—their function being further to straighten out the fibres and open neps, so that prior to combing all the fibres in the sliver are fairly parallel, this ensuring efficient combing with the least possible breakage of fibre and the greatest possible yield of "top" (Figs. 92, 93 and 94).

It should here be noted that the sliver coming from a carder possesses a definite and interesting arrangement of fibres. If broken straight from the carder

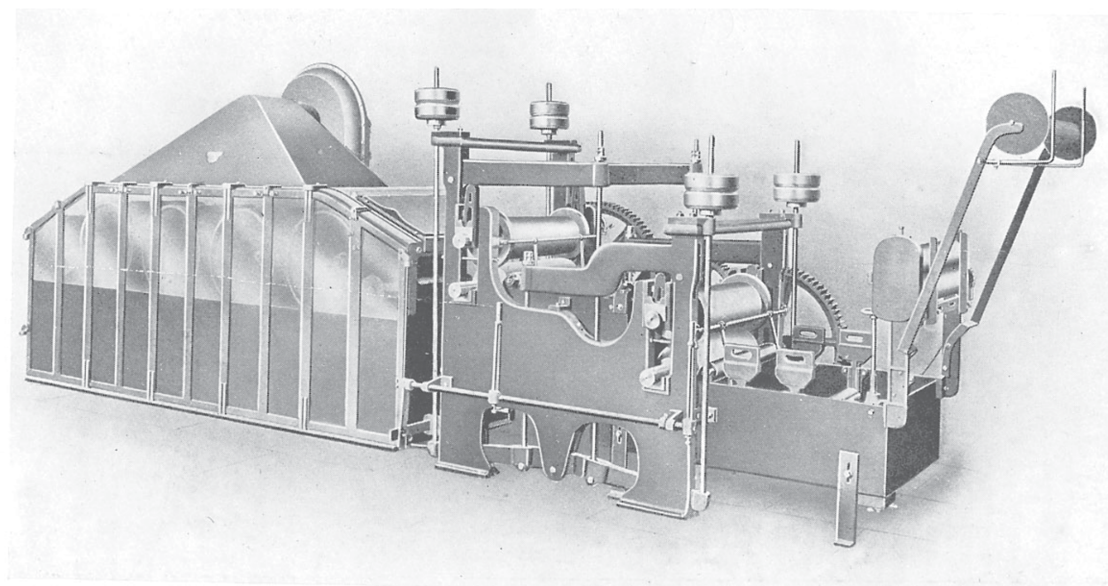

Fig. 92.—Backwasher

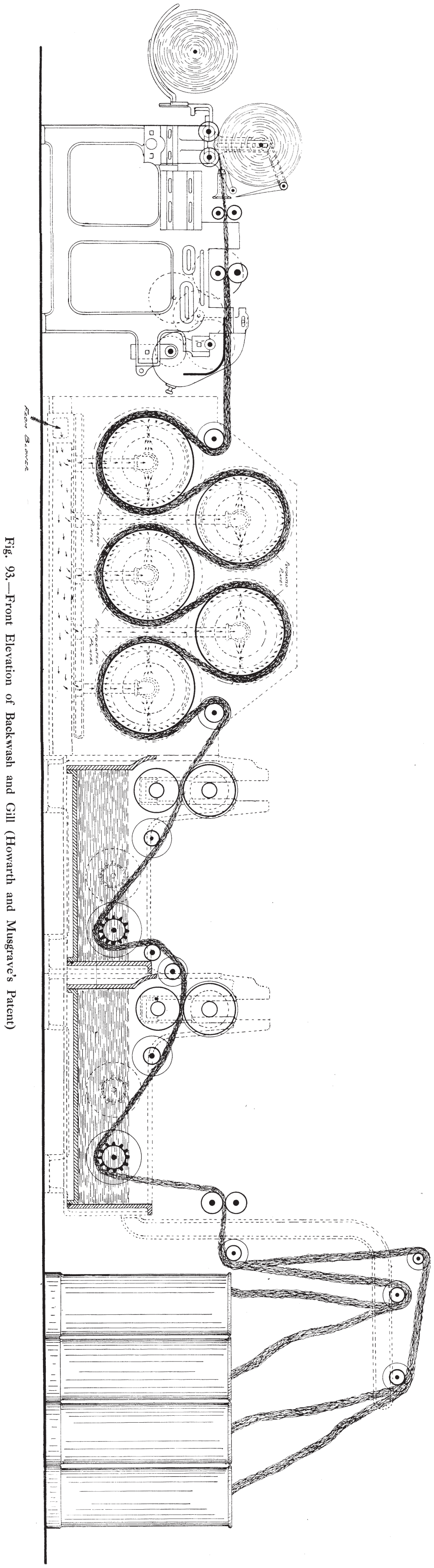

Fig. 93.—Front Elevation of Backwash and Gill (Howarth and Musgrave's Patent)

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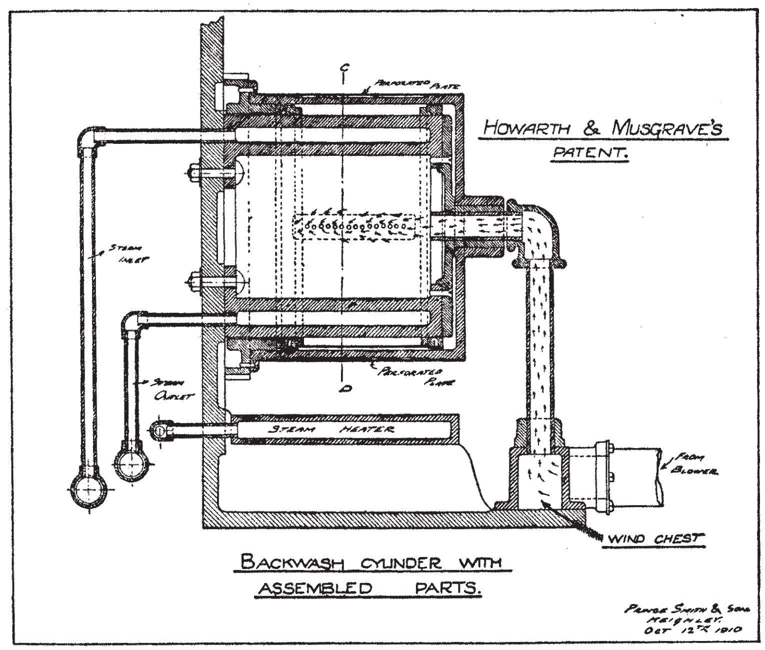
HOWARTH & MUSGRAVE'S
PATENT.
PERFORATED PLATE
PERFORATED PLATE
C
D
STEAM INLET
STEAM OUTLET
STEAM HEATER
FROM BLOWER
WIND CHEST
BACKWASH CYLINDER WITH
ASSEMBLED PARTS.

Fig. 94

it will be noticed that one hand retains the neps and short fibres while the other is quite free. This peculiar arrangement once present is never entirely eliminated; to comb to the greatest advantage, therefore, there should be two reversings only, so that the slivers are fed into the comb just as if they were fed out of the can-coiler from the carder. This is another example of the necessity for a close study of the many problems involved in the textile industry, the satisfactory solution of which must be effected if lasting success is to be achieved.

CHAPTER X

COMBING, RECOMBING, AND FINISHING

In Chapter VIII the various types of worsted and woollen yarns were fully considered. The object of thus studying the result, prior to studying the means of obtaining the result, will now be apparent. For the comber who simply combs without due consideration of the type of result required for the yarn into which his tops eventually have to be converted, will certainly secure only a partial success. Realising the difference between one extreme—the mixed, cloudy, woollen yarn—and the other extreme—the straight, clear worsted yarn—the truly practical comber can produce the top required for the desired yarn, and thus indirectly aid both spinner and cloth constructor in attaining the final desired result. A simple example will render this clear. In two respects the French upright vertical comb may be said to be an improvement on the Noble comb: first, it will leave shorter fibres in the "top," thus giving a greater yield of "top," and secondly, other things equal, it will yield a clearer "top," free from neps and other blemishes. In the spinning of fine black and white twist yarns blemishes in the white are so magnified that the least defect is an eyesore. Top for this yarn is combed on the French comb. But the possibility of leaving more "short" in the "top" for these yarns is not taken advantage of; in fact, it would be a positive disadvantage. The superior clearing quality of this comb, however, is taken advantage of, with most happy results. Points such as this should claim the thoughtful consideration of every comber.

General Principles of Combing.—There are three main factors involved in combing: first, the straightening of the fibres treated; second, the equalising of the fibre length; and third, the removal of all neps and blemishes of whatever nature they may be. In the hand-combing of English wools the straightening process was dominant. Thus the first time combing was spoken of as "jigging" and the second time combing was termed "straightening." No doubt, in the days of hand-combing wools of more regular fibre length were dealt with than is the case to-day, the straightening of the fibres being the *raison d'être* of the process. But even then fibres were broken and twisted round the comb-teeth, thus necessitating the removal from the front, back and points of the pins of "milkings," "backings," and "noil." To-day "straightening" must be regarded as the necessary condition involved in every combing process; thus, first-combed tops, being more or less disturbed by "slubbing-dyeing," must be straightened by a second filling and combing operation. The equalising of the fibre length is now more than ever necessary in view of the blending of wools which obtains in the worsted industry. Of course, blending is most readily effected in the gill-boxes forming the first part of a set of drawing machinery; but blending in the wool state and on the combs is not unknown, hence the necessity for some sort of equalisation if a good spin is to result. But again it is evident that the comber must use his judgment as to what he takes out as noil. In some cases straightening only may be required, with as much short fibre as possible left in; in other cases the really long fibres only may be required in top, as much noil as possible being taken out. As a rule, of course, the comber is judged by the percentage of top he can produce from a given blend of wool; but there is reason to believe that something more will be expected of the comber in the near future. The removal of "neps" and other blemishes should be a main point in every combing operation; in fact, so necessary is this in dealing with certain burry wools that it is customary to take a fixed length of top and count the blemishes, and then by comparison judge of the efficiency of the combing.

One or two other points respecting the principle of combing should here be noted. In the case of mohair combing for dolls' hair, combing follows combing several times, as an equalising of the fibre length is the whole *raison d'être* of the process. In combing Iceland wool, camel-hair, etc., the operation is undertaken with the idea of separating the shorter and more valuable fibre from the longer and stronger hair. In the case of combing silk and China-grass on the Noble comb, the chief difficulty is created by the slipperiness of the fibres; thus in this and most types of combing the surface friction between fibre and comb-pins is a factor to be taken into account.

Yields in Combing.—It will be obvious that different wools and blends will yield different proportion of "top" and "noil." This yield is spoken of as the "tear." The following list gives an idea of what may be expected from the Noble comb. As already indicated, the French comb may be set to give more or less noil as desired, hence these approximations are not wide enough for this more recently introduced comb :—

APPROXIMATE PROPORTIONS OF TOP AND NOIL FOR NOBLE-COMBED WOOLS

Type	*Quality*	*Proportion of Top and Noil in Scoured Wool*	*Percentage of Noil from Greasy Wool*
ENGLISH WOOLS :			
1. Long Lustre . . .	28's–44's	10 to 1–16 to 1*	7–4½
2. Medium Lustre .	46's–50's	11 to 1– 8 to 1	6–8
3. Short Down . .	50's–56's	10 to 1– 7 to 1	7–10
CROSS-BRED WOOLS :			
Australian and New Zealand :			
4. Low	32's–44's	14 to 1–10 to 1	5–6½
5. Medium	46's–50's	11 to 1– 9 to 1	6–7
6. Fine	50's–58's	10 to 1– 7 to 1	5½–7½
7. South American — ("Buenos Ayres," etc.)†	Qualities similar, but amount of noil from 1 to 3 per cent. more		
MERINO WOOLS :			
8. Australian—average	58's–64's	9 to 1–5 to 1	4½–8
9. „ —super .	70's–90's	7 to 1–8½ to 1	6½–5
10. Cape	64's–70's	4 to 1–7½ to 1	7–4
11. South American — (Monte Video) . .	60's–64's	4 to 1–7 to 1	10–6

* In English wools the bigger "tear" (*e.g.*, 16 to 1) refers to the better qualities. With qualities higher than these the amount of top decreases as quality increases up to, say, 64's. Beyond this the wools are so uniform that although the maximum noil has to be removed in order to spin the fine counts of yarn, the proportion of noil does not increase.

† These wools are often combed, especially for the hosiery yarn trade. In such cases markedly soft and full yarns are required from these rather than smooth yarns of fine counts, and consequently much short otherwise removed as noil is left in the top.

Top Costing.—As the only operations to follow combing are two finisher-box straightenings, top costing may here conveniently be dealt with.

The following example will serve to show the factors which influence price. Suppose 70 packs (240 lb. =

1 pack) of Merino wool are combed, the "result" may be—

	Lb.		Per cent.
Top . .	7,603	or	44.82
Noil . .	920	,,	5.42
Shoddy . .	72	,,	·43
Burrs . .	60	,,	·35
Sinkage . .	8,310	,,	48.98
	16,965		100.00

giving a proportion of top to noil of 8.2 to 1.

The sinkage, which comprises grease, dirt and fibre which cannot be collected, is, of course, absolute loss. The burrs (extracted during carding) and the shoddy (waste produced during carding) are worth little, say 1d. and 2d. per pound respectively; when sold they have, therefore, only a slight cheapening influence on the top, which, in estimations at least, it will be well to ignore. Noil, however, may be sold and the income utilised in meeting the combing charges, which are invariably based on the weight of top returned to the owner. Thus there would be 16,965 lb. greasy wool at, say, 13d. per lb., costing £918 18s. 9d., to which must be added the difference between 920 lb. of noil worth, say, 16d. per lb., and the combing cost of 7,603 lb. of top at 2¼d. per lb., the answer to this being £928 17s. 5d., the actual cost of 7,603 lb. of top, or 29⅓d. per lb.

When buying wool for combing purposes it is usual to make estimates of the yield of scoured wool in a given lot and the proportion of top and noil likely to result. These, along with the estimated noil value and the combing charge (obtainable from any woolcomber's list) enable, on the one hand, the approximate stand-in cost of the top to be obtained or, on the other, the value of the wool for a given price of top to be arrived at by simple calculation.

For Example.—Wool worth 13d. per lb., yield (top and noil) 51 per cent., "tear" (top and noil) 8 to 1, noil value 16d. per lb., combing charge $2\frac{1}{4}$d. Find cost of top.

100 lb. greasy wool at 13d. per lb. = 1,300d.
Yield 51 per cent., tear 8 to 1:
Therefore $\frac{8}{9} \times 51 = 45\frac{1}{3}$ lb. top at $2\frac{1}{4}$d. per lb. for combing, or . . . . . 102d.
And $\frac{1}{9} \times 51 = 5\frac{2}{3}$ lb. noil at 16d. per lb., or $90\frac{2}{3}$d.

Noil underpays * $11\frac{1}{3}$d.

Thus 1,300d + $1\frac{1}{3}$d. = $1{,}301\frac{1}{3}$d. for $45\frac{1}{3}$ lb. of top, or 28.7d. per lb.

Or to find the value of the wool:

Value of top	$28\frac{3}{4}$d.
Combing Charge	$2\frac{1}{4}$d.
Cost of scd. wool—varying top and noil	$26\frac{1}{2}$d.

Tear 8 to 1; then $\frac{8}{9}$ (top) $\times$ $26\frac{1}{2}$d. = $23\frac{5}{9}$d.
Add $\frac{1}{9}$ (noil) $\times$ 16d. = $1\frac{7}{9}$d.

Actual scoured wool value . . $25\frac{1}{3}$d.

The yield is 51 per cent.

$$\text{Then } \frac{25\frac{1}{3} \times 51}{100} = 13\text{d. (nearly †).}$$

* If noil overpays combing, the difference must be subtracted from the cost of 100 lb. of greasy wool.

† The slight discrepancy in the results of the two examples is due to the neglect of fractions in the case of the first.

Types of Mechanical Combs.—There are two types of mechanical comb, dating from the days of Dr. Cartwright—the Vertical Circular and the Horizontal Circular. Curious to relate, the French specialised on the Vertical Circular, possibly owing to its suppression in England by the late Lord Masham, while the English specialised on the Horizontal Circular. To-day the

French frequently use the English type when it better serves the purpose in view, and the English use the French type in like manner.

The Vertical Circular Comb.—This is generally spoken of in the trade as the Heilmann's. There are several types made by three or four Continental makers, and by at least one English maker under licence from the Continental firm. This type of comb has always dominated the cotton trade, so that in its other form most of the Lancashire spinners are familiar with it.

The adoption of this machine in this country so far is greatest in connection with fine wools; the comb, however, may be applied on the longer qualities, and most likely will be as the demand increases for soft-handling yarns. Although in matters of production the comb is distinctly below other types competing with it, it yields important advantages. In addition to those already mentioned, the comb is the best at present available for "dry-combing"—i.e. combing without oil on the wool—for owing to the greater control of the fibres which is possible in this machine, heat (necessary in other combs but which makes oil-less fibres far too active) may be dispensed with. Then for "burry" wools this comb is particularly serviceable. By a special knife working on the circle the burrs are thoroughly separated from either top or noil fibres and deposited in a chamber made specially for the purpose. The noil is also kept free from dust and from the very short "shoddy" fibres, and is thereby made much more attractive and valuable.

The following description of the Vertical Circular, or Rectilinear Comb, as it is termed, applies more particularly to the machine made on the Continent by the Société Alsacienne of Mulhousen and in this country by

Messrs. Prince, Smith and Son, of Keighley. Other types are the Schlumberger, of the Schlumberger Co., Gebweiler, Alsace, and the Dilette or Offermann-Grun, made by A. Grun of Lure ; but in all cases the principle is the same, constructional details forming the modifica-

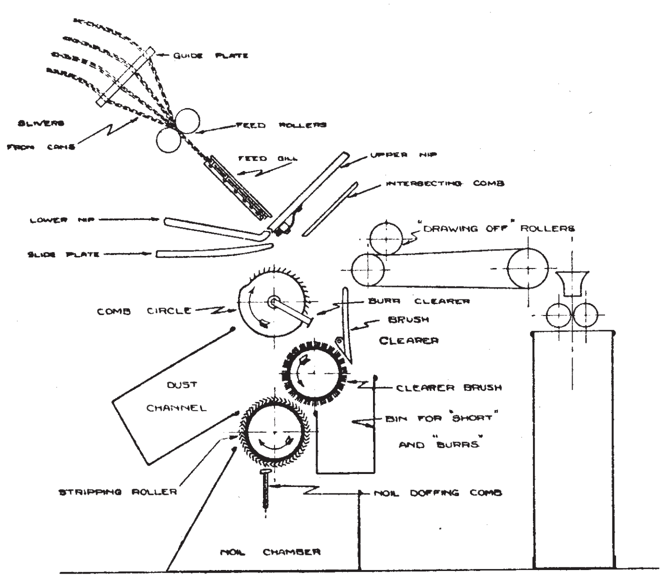

Fig. 95.—Vertical Circular Comb

tions to be noted. Generally twenty-four slivers are employed of about 1¼ oz. per 5 yards, and the feeding is done from cans. On the Continent lap feeding (which requires special preparation) is common with the shorter wools, as it is considered that better control of the fibre is possible with this arrangement. In either case the slivers go through feed rollers, a feeding gill, and a nipper to the comb circle, as is shown in Fig. 95. The feeding gill, as will be noted from the diagram, consists of three plates: a lower, which is grooved; one in the middle, which is slotted; and the top one, fitted with rows of pins to engage the spaces underneath and to hold fairly tightly any wool fed between the latter. This plate does not prevent, however, any long fibres being drawn through the feed plates; indeed, part of its function is to act as clearer. The nipper is a pair of jaws, and in front of the top one is a brush arranged so as to press down the wool, which may be held firmly by it on to the comb cylinder which is working below. To the feed gill and feed rollers a traversing movement is given; and thus while the wool is held in the nipper these may be moved back along the sliver, and in this way prepare a fresh supply of wool to be brought forward by the return traverse as the nip opens. Such movement, though apparently complex, may be effected both conveniently and accurately by an arrangement of cams and springs which, however, there is not space here to describe. The comb circle is fitted, over one half of its circumference, with about eighteen rows of pins tangentially set and perfectly graded in size and density, and thus on revolving it combs easily but completely the tuft of wool projecting from the nip. The remaining part of the cylinder is leather-covered and serves to effect the drawing away of the fibres along with a slide bar and a pair of rollers, the latter being mounted with a delivery-sheet and supporting rollers on movable arms. By the oscillation of these parts hereby possible the tufts drawn out are carried towards the can containing the combed top, in order to make way for repeated combing action. Still, continuity is established between the various tufts for the reason that the rollers have not delivered one tuft before their traverse is completed and they are back again at the nip to take up and link up the material there available which is just combed. To obtain perfect clearance when drawing off takes place an intersecting comb is necessary for that part of the tuft held in the cup. This fits above the nip, but during drawing off it is made to penetrate the web of fibres and hold back any "short" while the long fibres are carried forward.

Under the comb cylinder is a brush which, on revolving, removes the short fibre left in the comb pins. A rising and falling motion is given to this, so that an action on the leather-covered part of the cylinder will be avoided. Working on the brush is a roller fitted with card-clothing or filleting; this strips from the brush the noil fibre, which is in turn cleared by a doffing comb, to be later deposited in the noil chamber. On the brush continuing its revolution, the shorter and dusty fibre is also separated and placed in a special box in front of the comb.

DETAILS OF RECTILINEAR COMB

Comb Circle	*Feeding Gill*	*Intersecting Comb*
Diameter of circle, $6\frac{1}{2}$ in. Set-over, $7\frac{1}{4}$ in. Rows of pins, 18 Length of pins, $\frac{9}{16}$, $\frac{1}{2}$, $\frac{7}{16}$ in. Pins per inch—first row, 11 Pins per inch—last row, 64	Set-over, $3\frac{1}{4}$ in. No. of rows of pins, 8 Pins per inch per row, first row, 20 flat, second to seventh rows inclusive, 18; eighth row, 16 Length of pins, $\frac{7}{8}$ in.	Set-over, $15\frac{1}{4}$ in. Pins per inch, 68 flat Length of pins, $\frac{3}{4}$ in.

This comb is specially adapted to the combing of the finest and shortest wools, yielding a top second to none for clearness and openness.

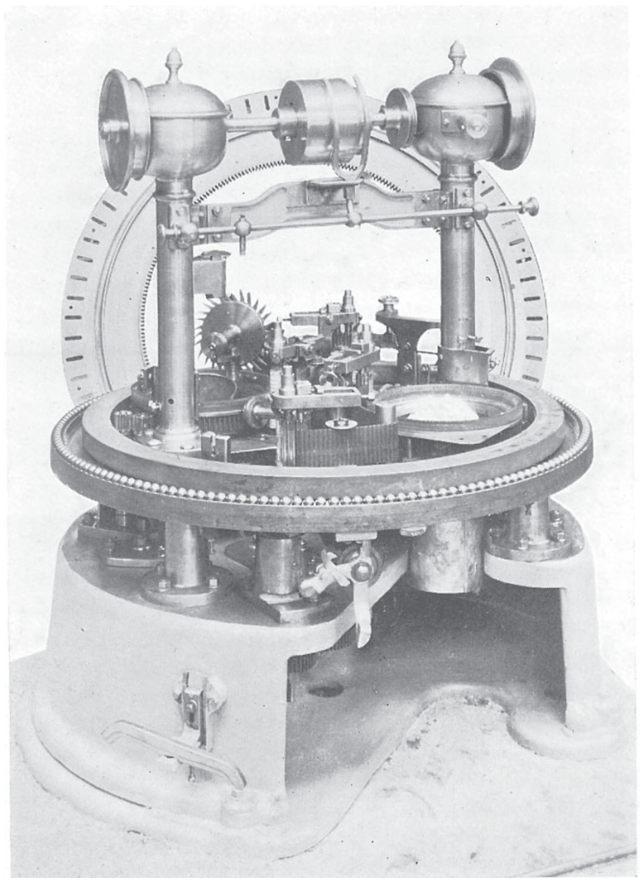

Fig. 96.—The Noble Horizontal Circular Comb

The Horizontal Circular Comb.—There have many types of this comb, of which three at present dominate the English combing industry, viz. the Noble, the Nip, and the Square Motion. As the Noble is the most universal and useful comb of the three, it must here be considered most fully and the others described by contrast with it (Fig. 96).

Briefly stated, combing is effected in the Noble comb by the circles vertically pinned, which work in conjunction with each other, and also by means of drawing-off rollers. As the particulars given hereafter show, these circles vary in pin arrangements both as regards number of rows, size and density, according to the class of wool for which the comb is fitted. One of these circles is large, being $42\frac{7}{8}$ inches diameter inside measurement; the two smaller circles, which are 16 inches measured over all, are placed inside the larger one, one at each side, and all three are positively driven. Wool in sliver form is placed over the circles at the point where the large one is in contact with the two smaller, and pressed into the pins by a dabbing-brush. As shown in Fig. 97, in which the right-hand side of the plan and elevation represents the comb charged with wool, and the left-hand side the working parts, continued revolution of the circles immediately separates the parts in contact; each comb then holds the parts of the fibres it is capable of retaining, and draws the remaining portion of the longer ones through the pins of the comb working with it, and in this way effects a clearance of these at one end. Combed fringes are in this way formed—an outside one on the smaller circles and an inside one on each side of the large circle, and these, on being drawn off by rollers, are further cleared at their opposite ends. Four ends of top are thus produced; these are conducted into a funnel at the centre of the comb, and from this run into a coiler-can, false twist being employed to impart the necessary strength. The short fibre (noil) left in the circles is cleared from the *smaller circles only* by triangular-shaped noil-knives fixed between the rows of pins; these, as the circles revolve, lift the noil clear, and, due to the knives being graded in size, they tilt it over the side of the circle into a can or shoot. In the large circle the short fibre is blended with the long, and therefore the lifting of the sliver farther over the circle, so that the end can overlap the small circle working on the opposite side of the comb, is necessary before clearance can be effected.

The slivers for this machine are arranged in balls of fours on a special " punch " box or winder. When at work the balls are placed in racks and rest upon positively driven rollers, all of which revolve with the comb circle. Eighteen of these racks form the set, and as the ball each contains consists of four ends there are thus seventy-two slivers being treated. Each sliver is taken through an endless feed-box or conductor (see sectional drawing, Fig. 97), and this is constructed with its lid hinged at the back so as to prevent backward slippage of the sliver. The box is also mounted. so that when the comb is revolving its nose is free to move up and down on an inclined plane over which it runs. Immediately drawing off from the large circle has been accomplished the sliver ends are run under a press-knife (see diagram, Fig. 97), and at the same time the feed-boxes are lifted—a movement which causes the end to slide forward. The press-knife referred to may be raised or lowered in the pins, so as to vary the length of sliver drawn and control directly the amount of noil made. Once the additional length of sliver required is obtained, the end is lifted clear of the pins by fixed knives; later it is carried, by the revolution

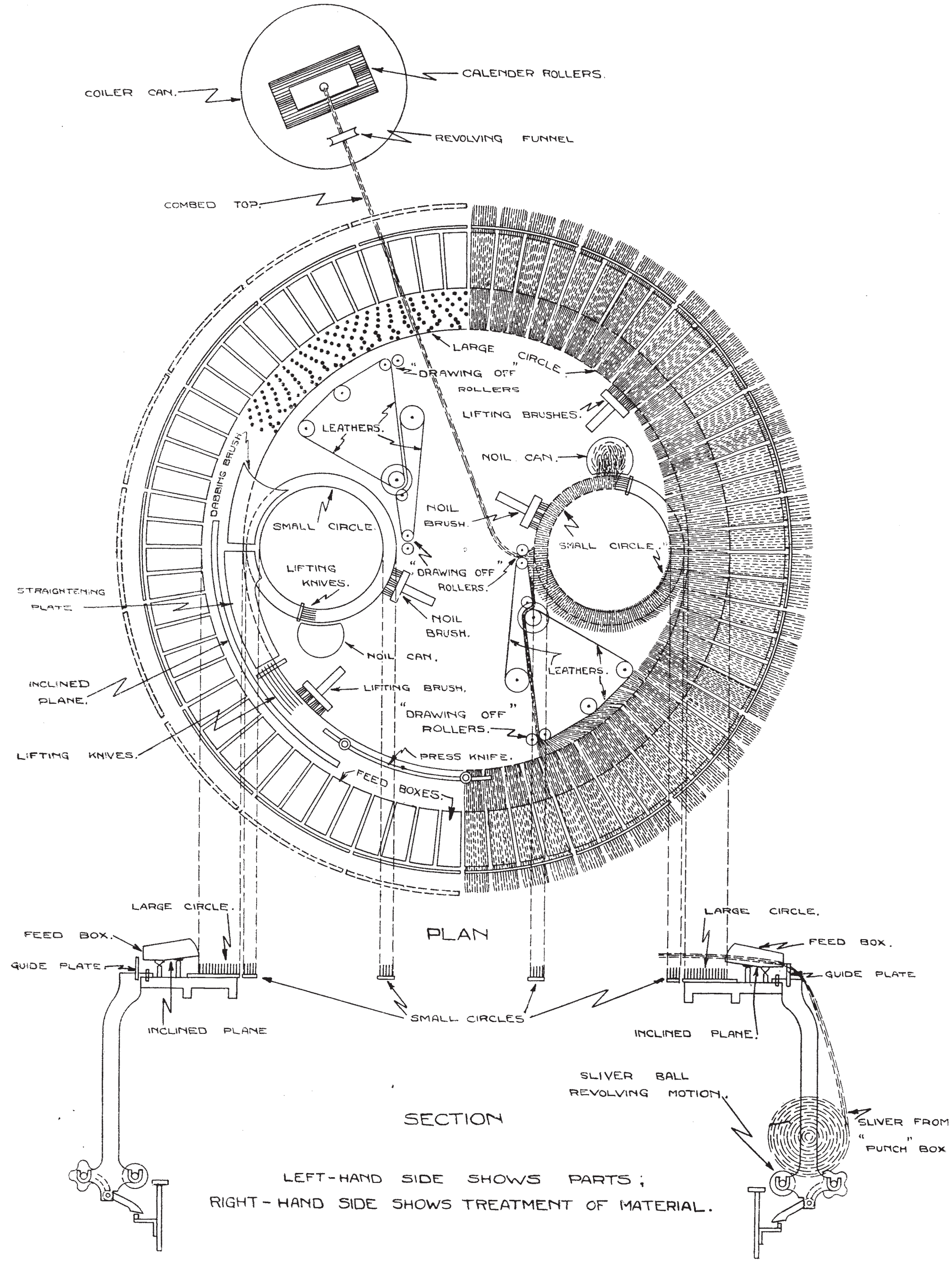

Fig. 97.—The Noble Comb

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of the circle, over a plate, on which it is straightened and then laid over the large and small circles, into which it is pressed by the dabbing-brush.

The foregoing outline indicates the principle underlying the action of the Noble comb. A few matters regarding the arrangement of the machine as constructed by various makers, and as suited to the many classes of work on which it is used, must now be considered.

In the following list details are given of the comb circles, from which will be gathered, first, the system

PARTICULARS OF NOBLE COMB CIRCLES

LONG LUSTRE WOOL (40's), MEDIUM WOOL (50's), AND MERINO (64's)

LARGE CIRCLE: $42\frac{7}{8}$ in. diam.

No. of Rows			*Pins per In.*			*Sizes of Pins (Wire Gauge)*			*Shape of Pins (round or flat)*
40's	50's	64's	40's	50's	64's	40's	50's	64's	40's, 50's, & 64's
1	1	1	23	33	42	13 × 22	16 × 25	17 × 27	First three rows flat remainder round.
2	2	2	20	32	40	14 × 21	17 × 25	19 × 27	
3	3	3	16	28	36	16 × 20	18 × 24	20 × 26	
4	4	4	11	24	32	17	22	21 × 25	
5	5	5	9	21	30	16	21	23	
6	6	6	7	18	28	14	20	23	
7	7	7	6	17	24	13	19	22	
8	8	8	5	14	23	13	18	22	
	9	9		12	20		17	20	
	10	10		10	18		16	19	
		11			16			18	

	40's	50's	64's
Length of pins . . .	2 in. or $2\frac{1}{8}$ in.	$1\frac{5}{8}$ in.	$1\frac{1}{2}$ in. or $1\frac{5}{8}$ in.
Set-over	4 in.	$2\frac{1}{2}$ in.	$1\frac{7}{8}$ in. or 2 in.
Width of rim	$4\frac{1}{8}$ in.	$3\frac{1}{2}$ in.	$2\frac{3}{4}$ in.
Thickness of rim . . .	9-16 in.	$\frac{1}{2}$ in.	$\frac{3}{8}$ in.

PARTICULARS OF NOBLE COMB CIRCLES

SMALL CIRCLE : 16 in. diam.

No. of Rows			*Pins per In.*			*Sizes of Pins (Wire Gauge)*			*Shape of Pins (round or flat)*
40's	50's	64's	40's	50's	64's	40's	50's	64's	40's, 50's, & 64's
1	1	1	25	37	46	13 × 23	17 × 26	18 × 28	First three rows flat, remainder round.
2	2	2	22	36	44	15 × 22	19 × 26	19 × 28	
3	3	3	18	32	41	16 × 20	17 × 25	20 × 27	
4	4	4	11	24	35	17	22	21 × 26	
5	5	5	9	17	30	16	19	23	
	6	6		13	25		17	22	
		7			22			21	
		8			20			20	

	40's	50's	64's
Length of Pins . . .	$1\frac{7}{8}$ in. or 2 in.	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in. or $1\frac{3}{16}$ in.
Set-over	$\frac{3}{4}$ in.	$\frac{5}{8}$ in.	$\frac{5}{8}$ in.
Width of Rim	2 in.	$1\frac{3}{4}$ in.	$1\frac{3}{4}$ in.
Thickness of Rim . . .	$\frac{1}{2}$ in.	7-16 in.	$\frac{3}{8}$ in.

In numbering the rows of pins, commencement is always made at the point of contact of the circles ; thus in the above list the first row for the large circle is the inner row and that for the smaller circles the outer one. Much the same occurs in measuring the diameters of the circles. Regarding the type of pin, the flat or oval shape is necessary to get greater density of pins and to preserve strength of foundation. Set-over refers to the distance over which the comb is pinned. Width of rim and thickness give the size of the brass circles in which the pins are fixed.

of pinning employed, and, secondly, the modifications that obtain for standard lustre, cross-bred, and merino qualities. Additional variations necessary for intermediate qualities will readily be noted on consideration of these. It is in regard to the circles that the reason for the wide adoption of this machine by the trade is very largely to be found, for by the changing of these any class of fibre may be dealt with—a fact of considerable importance, especially to commission combers in these days of small lots. At the same time, it is well to point out that the comb lends itself to certain qualities more satisfactorily than others, these being notably those of medium length, say 46's to 58's; for with the longest there is too severe an action for the preserving of the maximum length of the fibre and the highest degree of lustre in the ultimate yarn, and with the shorter types the clearance is in some cases not sufficiently thorough, while in others (short "B.A." types, for instance) the minimum quantity of noil which is extracted is more than that required. Still, as a general purpose comb when turn-off is the prime consideration, it has not an equal.

Of great importance as regards the successful running of this comb is the way in which the comb circles are mounted. When charged with wool the weight to drive is considerable, and unless they run lightly and smoothly in their bearings, driving power altogether out of proportion to the parts worked is absorbed. Much difficulty occurs here, due to the heating of the comb pins, which is necessary in order to make the fibres readily separate. Steam chests, set beneath the circles so as to almost touch, are employed for this purpose, but these have the effect of causing the circles to expand and exert undue pressure on the bearings if special attention is not paid to the form of the latter. Moreover, when this occurs fine and accurate adjustment of the circles in regard to each other and to the rollers is not possible. Formerly the circles rested on runners or discs, with additional discs horizontally set to keep them in position; these, however, did not give sufficient control. More recently ball bearings have been widely adopted with marked success. For these a semicircular groove is cut in the comb bed, and this has also its counterpart in the comb circle. Balls of $1\frac{7}{8}$ inches diameter engage the grooves for the complete circumference, and being free to revolve, the comb is rolled over them with little expenditure of power, and at the same time the expansion of the circle is efficiently counteracted.

The actual driving of the comb is effected as shown in Fig. 98, through racks cut on the comb circles and wheel and shaft gearing. Usually 264 teeth are cut in the rim of the large circle and ninety-four in the two smaller. The main shaft runs at about 520 revolutions per minute, giving a large circle speed of 3½ to 4 revolutions and a speed of the small circle just a shade in advance of this when judged by its traverse.

In this machine, as at present constructed, useful provision is made to preserve that balance in running which is essential to good work, but which may be easily lost if the floor on which the comb runs is not very good, or if the speed employed be high. Formerly four feet were the only supports of the bed-plate, and any one of these could in course of time become depressed so as to throw the part in contact out of truth with the remaining portions, in this way adversely influencing the work being done. Messrs. Prince, Smith and Son now place their comb upon a foundation-plate to which it is securely fastened; while Messrs. Taylor, Wordsworth and Co. employ a shell for the same purpose. With either of these any depression occurring at one point of the foundation affects the whole comb, and not one particular part. Perhaps the form as adopted by the last-named firm is most rigid; at the same time the under parts of the comb are not accessible as in that made by Messrs. Smith.

No part is of greater importance in the Noble machine than the dabbing motion, for it affects directly both the work going through the comb and the smoothness of movement of the machine itself. The difficulties

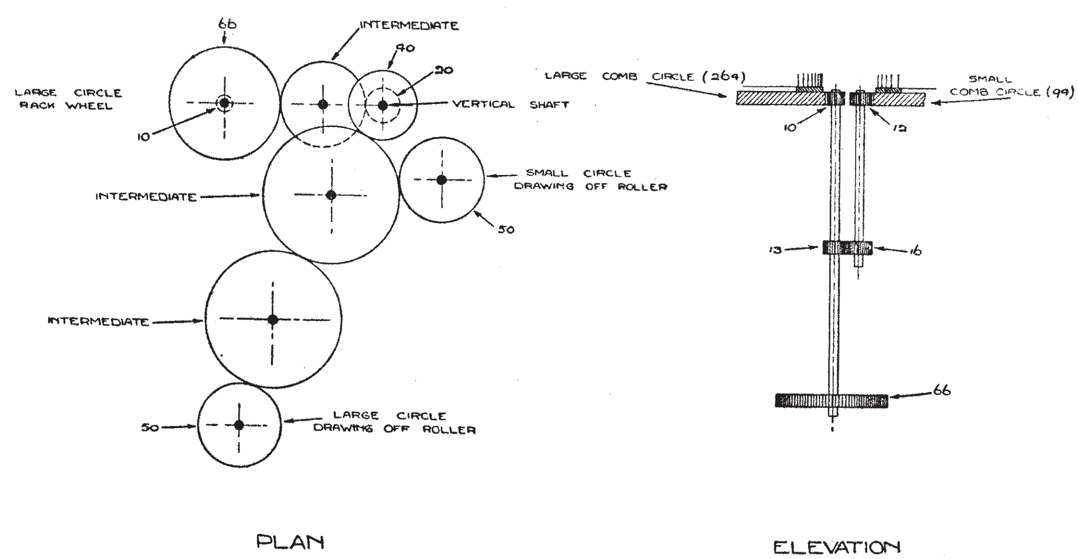

Fig. 98.—Diagram to show the Driving of the Noble Comb

attendant on its use arise through the conversion of circular motion into reciprocating, and the use of this at from 700 to 800 strokes a minute in the comb circle which is making lateral movement. Clearly the brush must be in and out of the circle instantaneously, but such movement cannot be obtained without jerkiness, which increases as the speed is accelerated, and which must set up vibration throughout the whole machine, particularly when the motion is attached to vertical pillars which are supported at one end only. Originally the motion consisted of crank-arm and pin. After this a cam working in a slide to which the brush was fastened was adopted, which marked a distinct advance; then more recently a second cam, working a dummy slide on the opposite stroke, has been included with yet more success. In the two last-named types the cam shaft is conical to ensure rigidity and easy running, and the working parts are enclosed in an oil chamber to enable the lubricant to be constantly applied.

The solution of the vibration difficulty has been most nearly achieved by Messrs. Taylor, Wordsworth and Co., who have taken the small circles away from the vertical pillars. In this case the dabber is mounted on a special support and may be driven from the main shaft as hitherto, but the drive is at an angle of, say, 45 degrees instead of vertical, and in a different direction on each side of the comb. By this means the strain is distributed in a way which distinctly favours steady running.

The change here noted has also brought another important advantage, which is obtained when the changing of the circles is undertaken. For this operation the cross shaft had formerly to be removed before the small circles could be lifted from their position round the vertical shafts, and this occupied, say, two to three hours. With the new arrangement the cross shaft is by no means in the way when changing; all that is necessary is the removing of small parts—noil and press knives, etc.—and the circles may be then lifted away. Changing under these conditions may be effected with half the labour in ten minutes; it seldom requires more than half an hour.

To the same end Messrs. Prince, Smith and Messrs. Hoyle and Preston make the vertical shaft in two parts, but connect these up for working purposes. In the first case annular gearing is employed; in the latter stud and socket. In both these cases pulley blocks are necessary when changing to remove the upper part of the comb, but through there being only one piece to handle the time taken for the process is very short.

The drawing-off arrangements require a word of explanation, for it is on their accurate setting and regular working that much regarding the appearance and character of the combed top depends. They are, of course, of small size, and fluted; a leather is run round one of the pair—the press roller, which is slightly the larger—to prevent the grinding of the fibres. To preserve the life of the somewhat costly leather a traversing motion becomes necessary, and this is obtained through cams, which receive motion from the rack.

The weighting of these is vital to good work and to the condition of the leather, and needs to be uniformly applied on both bearings. For this purpose it is now customary to use worm and pinion gearing or horizontal levers, both of which are instrumental in compressing the springs to the same degree By change of circles, as indicated, the Noble comb may be adapted to any and every class of fibre; it is largely this flexibility which has resulted in its pre-eminence in the combing trade.

"Tuft Comb."—The Lister or "Nip" comb is best described as a "tuft comb," in which one end of the tuft of fibres is combed, then the uncombed end is thrown over a revolving horizontal comb circle with the combed fibre on the outside, and finally the long fibres are separated from the short by drawing off the long fibres from the outside of the combed circle, the short fibres being left as noils in the pins, and subsequently removed by a special mechanism. It is interesting here to note that the continuous action of a revolving comb circle could only be attained by the introduction of a very ingenious mechanism causing the carrier comb to adapt itself to the curve of this circle. Thus Lord Masham had to decide either upon continuity of action obtained at the expense of ingenuity and certain complexities, or upon an intermittent action in which a straight comb feeding into a straight comb eliminated this complexity. The French comb, looked at as a "tuft" comb, should here be studied with this fact in mind.

In the Nip comb there are five main parts: a gill box without front rollers, a nip capable of being traversed, a carrying comb also made to traverse, a comb circle heated by steam chest, and drawing-off rollers. These are illustrated in Figs. 99 and 100. The slivers are fed into the gill box from cans, through rollers which pass them forward to fallers. These are densely pinned to effectively clear the fibre (*see* details, p. 250) and are of convex shape; they are also heated by a coil of gas jets to facilitate the separating of the fibre. In place of the front rollers the nip is working, and as the front faller drops to the bottom screw the nip moves up and closes over the tuft, later drawing it forward and clear-

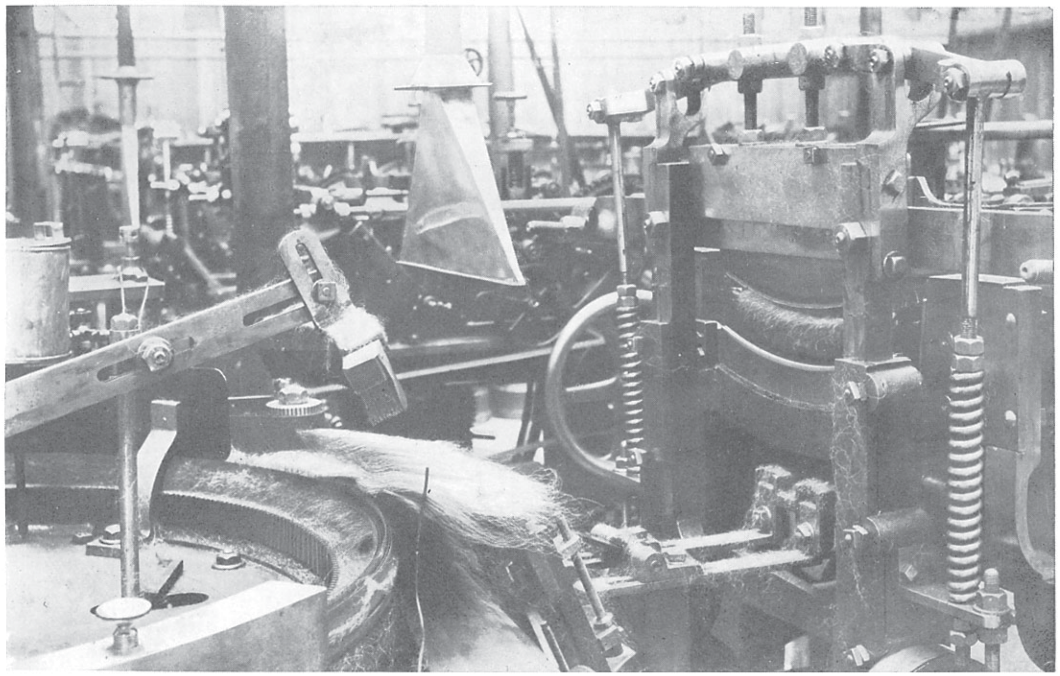

Fig. 99.—Nip Comb

(From a photograph by W. B. Fry, Esq., Saltaire)

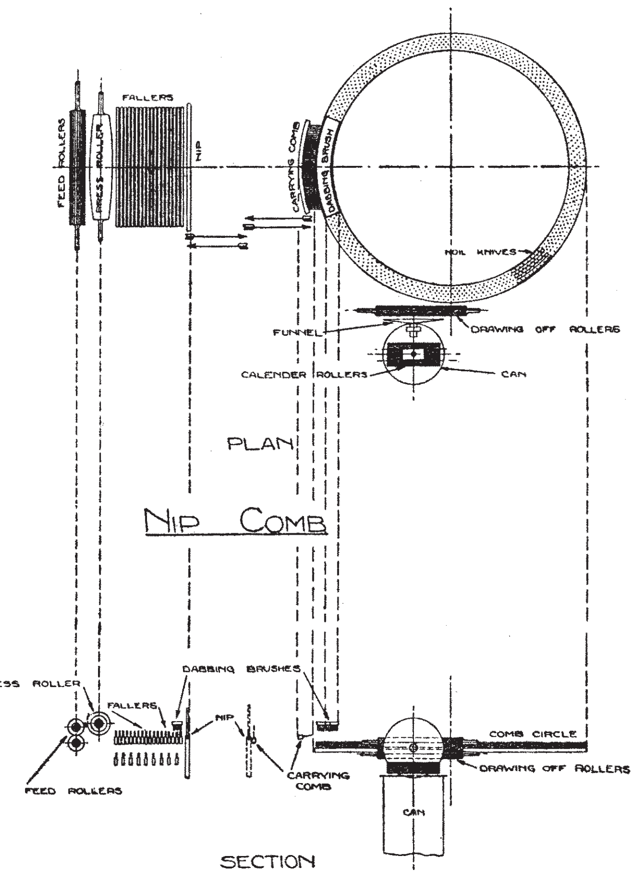

Fig. 100.—Plan and Section of Nip Comb

ing the fibres at one end in the faller pins. The nip corresponds in shape to fallers, the curve becoming necessary to prepare for a uniform overlap of the web of wool on to the comb circle. On reaching the end of its traverse the carrying comb moves up to the nip, and with its long pins takes the tuft just at this time relieved, and, moving forward, places the uncombed end on the pins of the comb circle into which it is pressed by the dabbing brush. Continued revolution of the comb circle brings the cleared end of the tuft to horizontal drawing-off rollers tangentially set where it is removed, the longer fibres first and then the shorter, the noil being left behind in the circle pins. From the drawing-off rollers the top fibres are conducted by way of a leather to revolving funnel, and thence to coiler can, false twist being employed to strengthen the end. The noil is removed by stationary knives at a further point in the circles' traverse. At various points air blasts and endless leathers assist in directing the course of the fibres.

Details of the Nip Comb.

(*a*) Long Wool.

Comb Circle :

Diameter, 48 inches ; width of rim, 3 inches ; thickness, ½ inch ; set-over, ¾ inch.

Rows of pins, 5 (2 flat and 3 round) ; length, 2 inches, but alternately 2 inches and 2½ inches in the middle row to assist in taking wool from carrying comb.

Pins per inch, 20, 18, 16, 14 and 12 respectively.

Fallers :

Length, 20 inches ; thickness, ½ inch ; set-over, 16 inches.

Rows of pins, 3 ; length of pins, 1⅝ inches ; middle row flat, remainder round.

Pins, per inch, 18, 15 and 16 respectively.

(*b*) MOHAIR.

Comb Circle :

Diameter and rim as in (*a*); set-over, $\frac{5}{8}$ inch.
Rows of pins, length and shape as in (*a*), but third, fourth, and fifth alternately 2 inches and $2\frac{5}{8}$ inches.
Pins, per inch, 20, 19, 18, 14 and 14 respectively.

Fallers :

Length, thickness, and set-over as in (*a*).
Rows of pins, length, and shape as in (*a*), but with 22, 18, and 20 pins per inch respectively.

The Lister comb is specially suited for combing long wools and hairs. It is more "humane" in its treatment of the fibre, and gives as a consequence more lustre and smoothness. Through the drawing-off by horizontally-set rollers a better arrangement of the fibres for spinning results is possible than in the Noble machine. It is the comb *par excellence* for mohair, although the Noble comb is gradually restricting its sphere of influence in this country as a first comber, when convenience or turn-off is the chief consideration.

The Holden, or square-motion, comb is another "tuft comb," in which a fringe of uncombed tufts is fed on to a revolving circle; a combing head combs this exterior fringe; the combed fibres are then drawn off as "top," and the noil is subsequently removed from the pins by a special mechanism. Why this comb is specially adapted to short wools and is unsatisfactory for long wools, why the drawing-off rollers are here placed horizontally and not vertically as in the Noble comb, thereby producing a "hen-wing sliver"—these are points which should claim the most careful consideration of the would-be comber.

The Holden comb is specially suited for combing the finest Botany wools. It yields a "top," "robbings" and "noil," of which the former is said to spin a few counts better than a Noble combed top:

Re-combing and Double Combing.— All things considered, the most economical method of introducing colour into yarns and fabrics is by "slubbing-dyeing," in other words, "top-dyeing." Thus the tops, after combing, are taken and dyed, either in hank or in extended form. This operation—or rather operations,—as there will be at least two—not only results in more broken fibre, but also in a general disturbance of the fibre arrangement, necessitating re-combing. This second combing, now often effected on the French comb, results in a beautifully clear "top," which the colour blender can work with, for the production of mixture and toned yarns, to very great advantage. Not more than 5 per cent. noil should result from this operation, and this loss should be more or less counteracted by the increase in weight given to the material through the addition of dye.

The utility of double combing for mohairs, etc., has already been referred to. It is thus evident that the comber who would be successful to-day must be prepared to consider the possibilities of the materials he handles and the capabilities of the various combs and combing operations, if he is to make the most of his opportunities.

The Finishing Processes.—When the top leaves the comb it is still in the form of a more or less irregular sliver, although the fibres may have been well averaged up and straightened. Thoroughly to level and straighten, and also to obtain the weight of sliver desired, tops —Botany or English—are usually passed through two finishing boxes of the gill-box type, consisting of back rollers, fallers or gills, and front rollers, the first one usually delivering into a can and the last being fitted with a balling head to deliver the tops in the ball form which is invariably required by the trade, and also a knock-off motion to ensure definite lengths of slivers being balled. Of course, differences in the pinning of the fallers, drafts, etc., may be introduced as experience suggests for the particular classes of work dealt with.

The following are the approximate weights fed on to the several machines, or the doublings employed on the gill boxes, etc. :—

DRAFTS, DOUBLINGS AND WEIGHTS OF LONG WOOL AND MERINO MATERIALS

	Long Wool			Botany		
	Drafts	*Doublings*	*Weights*	*Drafts*	*Doublings*	*Weights*
Washing . .						
Drying . .						
Preparing .		10 (last box)	3oz. per 5 yds.			
Carding . .						
Backwashing	8	10			16	
Straightening	7-8	9 & 9			4 & 4	
Combing . .	—	72			72	
Finishing . .	6	20 & 4	6oz. per 5 yds.		16 & 2	3 to 3½ oz. per 5 yds.

Sets of Combing Machinery.—As the processes from the raw wool up to the combed top are definitely organised as one trade, spoken of as the combing industry, it will here be desirable to study sets of machinery designed to comb long, medium, and short wools to the greatest advantage.

RANGE OF BRADFORD TOPS:

No.	*Quality No.*	*Length (in inches)* *Extremes* *Long*	*Short*	*Mean*	*Lustre or Colour*	*Handle*	*Soundness*	*Fineness (Average)*
1	28's	15	5	10	Greyish non-lustrous	Harsh	Weak and brittle (Kempy)	1-200 in. to 1-400 in.
2	32's	13½	6	9	Fairly lustrous	Fairly harsh	Weak	1-400 in.
3	36's	12½	8½	10	Fairly lustrous	Fairly soft	Fairly sound	1-500 in.
4	40's (Preparer)	12	8½	10	Very lustrous	Soft	Sound	1-600 in.
4a	40's (Carder)	9½	5	7½	Lustrous	Soft	Sound	1-600 in.
5	44's (Preparer)	11	8½	10½	Very lustrous	Soft	Very sound	1-650 in.
6	46's	9	4½	7½	Fairly lustrous	Harsh	Sound	1-700 in.
7	50's	7½	3¼	6	Lustrous	Fairly harsh	Sound	1-750 in.
8	56's	6½	2½	5½	Yellowish in colour	Fairly soft	Sound	1-900 in.
9	58's	6	3	5	Fairly white in colour	Fairly soft	Sound	1-950 in.
10	60's (Warp Qual.)	5¼	2¼	3½	Fairly white in colour	Soft	Sound	1-1000 in.
11	64's	5	2¼	3½	White in colour	Soft	Sound	1-1200 in.
12	70's	4¾	2½	3½	White in colour	Very soft	Sound	1-1200 in. to 1-1400 in.
13	80's	4½	3	3½	Very white	Very, very soft	Very sound	1-1400in. to 1-1700 in.
14	90's	4½	3	4	Very white	Very, very soft	Very sound	1-1700in. to 1-2200 in.

DETAILS OF QUALITIES

Waviness	*Uniformity*	*Probable Breed or Breeds*	*Count of Yarn Limit*	*Uses*	*Market Value Apr., 1909 (Pence)*	
Straight	Irregular	Low Scotch and Low English	16's	Carpets, low hosieries, etc.	9	Standard for Comparison — 40's
Straight	Irregular	Fine Scotch Medium English Low Crossbred	24's	Low lustres and serges	10½	
Straight	Fairly uniform	Fine Scotch Fine English Medium Crossbred	28's	As No. 2	11½	
No waviness clearly defined	Uniform	Best Scotch Medium Crossbred Fine English	36's	Best lustres, dress serges, and medium suitings	12½	
Slightly wavy	Uniform	As No. 4, but slightly shorter types	32's	Lustres, dress serges, medium suitings	11½	
No clear waviness	Very uniform	Best English Lustre and Colonial Crossbred Wool	40's	Best lustres—dresses and linings	13½	
4 waves per inch	Uniform	Shorter British Wools and Medium Crossbreds	40's	Fine serges, hosieries, and Medium crossbreds	15½	Standard for Comparison — 60's
10 waves per inch	Fairly uniform	Down Wools Fine Crossbreds Low Botanies	44's/46's	Fine serges, medium coatings, and hosieries	17	
14 waves per inch	Fairly uniform	Finest Down Wools Crossbreds and Low Merinoes	48's	Medium coatings and dress goods	22	
20 waves per inch	Fairly uniform	Fine Crossbreds and StrongMerinoes	50's	Cheap fine worsted coatings and dress goods	23½	
24 waves per inch	Fairly uniform	Finest Crossbreds Merino Skin & Fleece wools	48's/5's	Fine coatings, dress goods, hosieries, etc.	25	
28 waves per inch	Uniform	StrongMerinoes Fleece, and Skin Wools	56's	Fine coatings, dress goods, hosieries, etc.	26	
32 waves per inch	Uniform	Fine Merino (classed fleece)	80's	Very fine coattings and dress goods	28½	
36 waves per inch	Very uniform	Fine Merino (sorted fleece)	100's	As No. 12	30	
36 waves per inch	Very, very uniform	Fine Merino (sorted fleece)	150's	As No. 12	34	

Long wool set for English or Cross-bred, 32's to 44's quality :

Washing.—Three swing-rake bowls.
Drying.—One mechanical dryer or three hand machines.
Preparing.—Four sets of first and second sheeter and third and fourth can boxes.
Backwashing.—Three eight-cylinder machines, each with gill box in position of fifth preparer.
Opening and Straightening.—Three pairs of can and baller levelling boxes.
Combing.—Eight Noble combs, also punch box.
Finishing.—Five pairs of can and baller finishing boxes.

Such a set as the foregoing would turn off 4,800 lb. of tops per day of ten hours.

Merino wool set, 60's average qualities :

Washing.—Two sets of four bowls, swing harrow type.
Carding.—Twenty-four carders.
Backwashing.—Four nine-cylinder backwashers, each with gill box.
Opening and Straightening.—Ten pairs can and baller levelling boxes.
Combing.—Twenty Noble combs, with three punch boxes.*
Finishing.—Fifteen pairs can and baller finishing boxes.

This set would probably produce 4,500 lb. of tops per day of ten hours.

A most careful study of the possibilities of each machine, of the various relationships obtaining, and of the *balance* of complete sets of machinery, should here be made.

Range of Bradford Tops.—In the list on pp. 254 and 255 an attempt is made to standardise tops. In conjunction with the frontispiece it at least gives a good idea of what is possible in this direction.

* Should square motion combs be used instead of the Noble machine, two or three fewer might suffice. In such an event the opening and straightening operation might probably be omitted. Were the French comb substituted about thirty machines would be necessary.

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