COMMON COMMODITIES AND INDUSTRIES

WORSTED

J. Dumville.
S. Kershaw.

THE WORSTED
INDUSTRY

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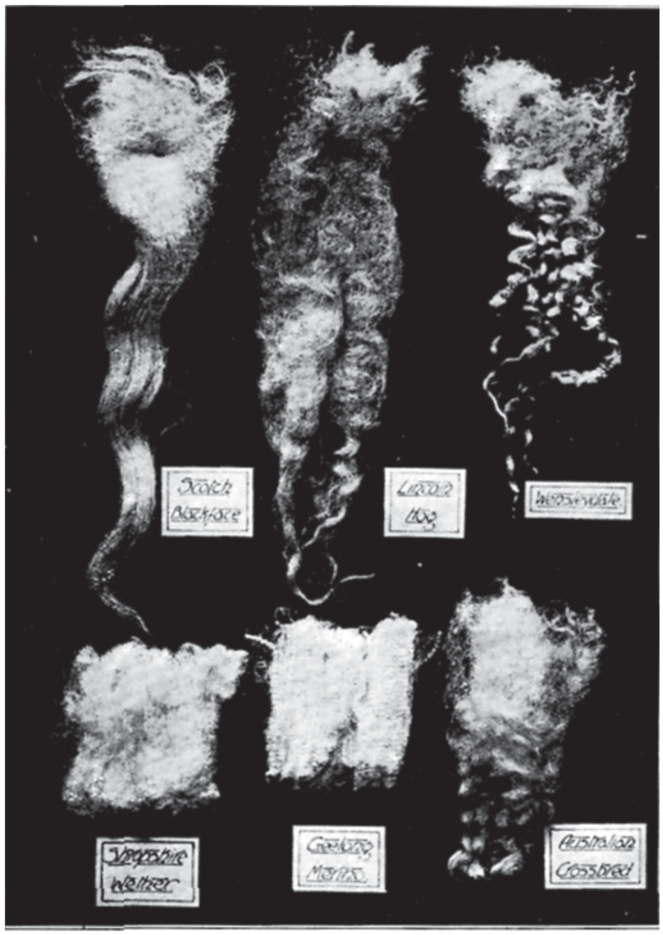

TYPICAL WORSTED WOOLS

Frontispiece

(1458M)

PITMAN'S COMMON COMMODITIES AND INDUSTRIES

THE WORSTED INDUSTRY

BY

J. DUMVILLE

AND

S. KERSHAW

TECHNICAL COLLEGE, BRADFORD

AUTHORS OF "WORSTED CONE DRAWING," "CARBONISING PROCESS," "MODERN SYSTEMS OF YARN PRODUCTION," ETC.

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PREFACE

DURING the last 30 years knowledge relating to the nature of textile fibres and their conversion into yarns and fabrics has been added to considerably, to the advantage of manufacturer, retailer, and consumer. This is particularly true with respect to the worsted industry. The books issued imparting this knowledge have been written for technical experts by authors, who have divided the subject into very definite compartments helpful to those seeking a very intimate acquaintance with some particular section of the industry. This work is designed to carry the reader through the whole range of operations involved in transforming raw wool into finished worsted yarn and cloth, to show the interdependence of one process upon another, and to indicate the contribution each process makes towards the value of the finished article.

In a work of this kind, dealing with an industry of such magnitude, only matters of first importance can be dealt with. Still it is hoped that the manner of its presentation will serve the purpose of luring those engaged in the industry, the consumer of worsted goods, and the general public to a greater interest in the production of useful commodities such as yarn and cloth.

While making its appeal to the wider public for which it is primarily intended it is hoped that the work will commend itself to masters and teachers in primary, secondary, and technical schools as a handbook of useful knowledge and particularly helpful to those students about to enter some special department of the worsted industry.

The authors acknowledge their obligations to Mr. W. H. Wyrill, formerly lecturer in weaving at the Bradford Technical College, for his assistance in writing Chapter X; to Mr. W. E. King for the careful preparation of the diagrams, and to the machine makers for the loan of blocks.

J. DUMVILLE
S. KERSHAW

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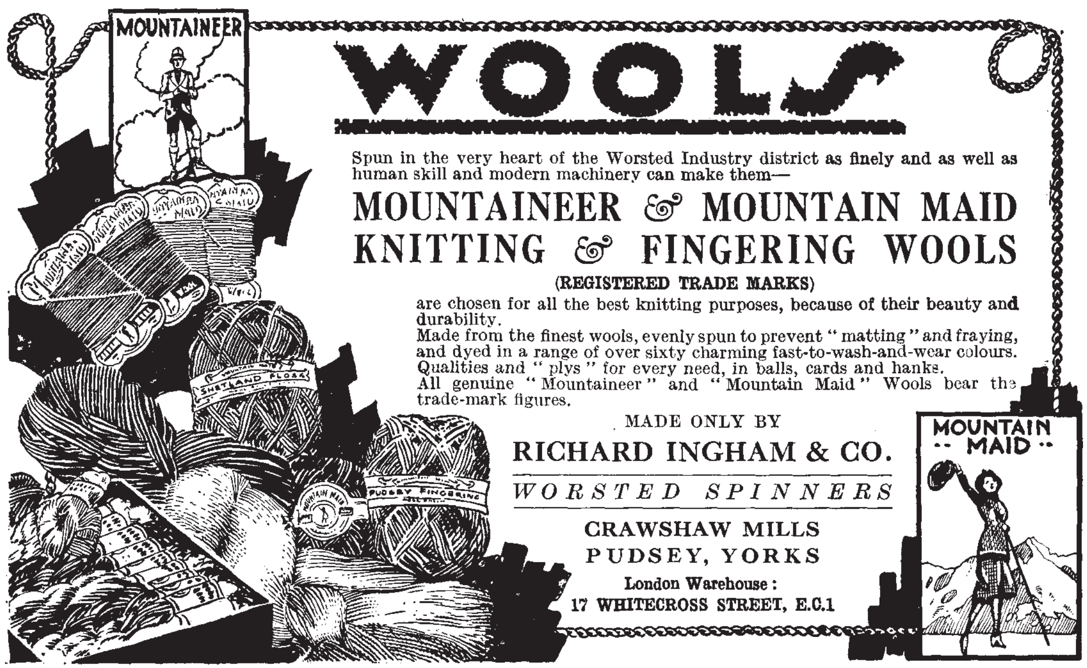

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ILLUSTRATIONS

THE WORSTED INDUSTRY

CHAPTER I

ITS GROWTH AND DEVELOPMENT

THE West Riding of Yorkshire has a world-wide reputation for the manufacture of both woollen and worsted goods. In the making of woollens it shares its success with that part of the West of England centred at Stroud and with the South of Scotland round about Hawick and Galashiels. In worsted cloth making, there are no rivalling districts in the British Isles of sufficient importance to compare with the West Riding. Other countries, such as France, United States, and Germany, have their worsted centres, and in recent years, Australia and Canada, but none of these places has assumed anything like the importance of the West Riding, or attained the reputation for excellence so generally admitted. Indeed, Bradford, the centre of the British and the West Riding worsted industry, is the recognized wool capital of the world, and is often referred to as Worstedopolis.

It is interesting to recall factors which have contributed to the establishment of the industry in the West Riding. Briefly we enumerate the following: (1) The inhabitants in this district were, before the nineteenth century, hand workers in woolcombing, spinning, and weaving, and, as only one process was made automatic and mechanical at once, in the sequence of manufacture, it was natural that the change thus wrought by inventors did not remove the industry from its location. (2) The settlement of the hand wool workers on the hills and in the vales of the West Riding was stabilized during the steam era, as the neighbourhood is rich in coal. (3) The inherent skill in handling, judging, and valuing wool was as necessary then as it is to-day. Heredity is as important an element in wool manipulation as in producing, and the descendants of the primitive wool dealers and users show the influence of their progenitors on the market and in the mill, and prove by accuracy of judgment and skill in manipulation that they have bred true. It would have been essential to move the workers along with the industry (if they can be considered as detached from each other) if removal had been found necessary at any time. (4) During the latter part of the eighteenth century, worsted machine makers became established in the West Riding, some of which are still in existence, namely, Messrs. George Hattersley & Sons, loom makers, Keighley, established 1789; Messrs. Prince Smith & Sons, combing, drawing, and spinning machine makers, Keighley, established 1795; and Messrs. Taylor, Wordsworth & Co., established 1810. These firms, and others since established, have kept abreast, sometimes ahead, of the times, and have been of immense importance to the industry. (5) No record of the relationship between the worsted industry and its locality would be complete which omitted to refer to the great impetus given to this trade in the West Riding by the local invention of machine combing. Three machines for this work were invented in this district, two by Bradford combers, and the third by Noble of Leeds, who was, however, assisted by Donisthorpe of Bradford, the latter gentleman also giving his help and advice to Lister and Holden, when they were in the experimental stage of inventing the machines which bear their names. This mechanical perfecting of wool-combing, the key process in the manufacture of worsteds, was the final achievement in the sequence of making every process automatic, and consolidated the former efforts in making spinning and weaving mechanical, and in building up the important industry for which Bradford, Huddersfield, Halifax, and the surrounding districts are justly famed. There is a division in the worsted industry, or rather two branches, usually referred to as the Bradford and Continental systems respectively. In this country the machines favoured are those designed by home inventors in the early days of worsted manufacturing, and are known all over the world as the Bradford processes. They comprise Noble combing, open and cone drawing, and throstle spinning. On these machines, the English spinner can only use good length material. On the other hand, the Continental worsted spinners use French or Heilmann combs, followed by French or porcupine drawing and mule spinning. The wools used in the Continental worsted industry are not entirely peculiar to this branch, as they comprise many of the well-known merinos and finer crossbreds The Continental users take shorter fibred classes of wool and from them produce high standard worsted dress and knit goods, proving that the raw material is not too short to make into worsted fabrics, when given the proper treatment and manipulated on right machinery.

CHAPTER II

ORGANIZATION OF THE INDUSTRY

THE worsted industry is so organized that only by concentration in one area is it successful. The large number of processes between the sheep's back and the shop window, and the piecemeal invention of machines to comb, spin, and weave wool on this principle, have been responsible for the sectionalized condition of this industry. In addition we have other sections devoted to the task of supplying and sorting the raw material, and to distributing the manufactured goods to all parts of the world. This state of affairs is not wholly confined to the worsted area in the West Riding of Yorkshire, but is a feature of other worsted centres abroad as at Roubaix, France; Leipzig, Germany; and the New England States of America.

The wool may be purchased where it is produced, that is wool buyers may visit or reside in Australia, New Zealand, S. Africa, S. America, or any other wool growing place. Only merchants in a large way of business can buy direct in this way. Buyers may deal privately with farmers, or obtain the wool by bidding at public auctions held at places such as Sydney, Brisbane, Perth and Christchurch. English wools are purchased at wool fairs, held in different parts of the country during the summer months.

The buyer then has the responsibility of shipping and transporting it to his mill or warehouse. The raw material may be sent from the country of its production to the sale rooms of London, Liverpool, Antwerp, etc., to be auctioned periodically to the assembled buyers.

The London sales are very important, being eagerly anticipated by the trade, and giving a definite tone to the market on each occasion. Firms that are not very large may send representatives to London or Liverpool, to replenish the mill supplies. A large amount of wool is bought both at home and abroad to be sold again while in its raw state. Wool merchants often buy large quantities, and for a small profit sell to others, such as top makers, spinners, and woollen manufacturers. These are established in and around Bradford, many of them also adding to their trade by buying and selling waste and noils, because it happens that all top makers are just as surely makers of noils, for which they must find sales.

Top-making firms are wool buyers and top sellers, but do not limit their operations to top making solely often selling wool in addition to tops. This must be allowed, as they may find among their wool qualities for which they have no use. It is the exception and not the rule for top makers to possess combs ; the bulk of wool combed for the worsted industry is commission combed, i.e. it is sent by top makers to woolcombers to be made into tops, the wool remaining the property of the top makers.

Top makers often employ wool sorters, who make matchings, which are then discriminately and skilfully blended to produce tops of varying quality and price. While some top makers employ wool sorters on their own premises, there are others who depend upon the woolcombers for " housing " their sorters to do this work. The largest firm of woolcombers in the world is Woolcombers, Ltd., who are centred at Bradford.

There are a few firms, trading under private names, or as combing companies, who purchase wool, comb it on their own machines, and sell tops. In busy periods they are more fortunately placed than top makers without machines, as they have not to wait for turns at the combers, as is often experienced by those without machinery.

Tops may be bought by spinners or by merchants. In this country they are mainly bought direct by spinners from top makers, but there are, in addition, what are known as top merchants. These firms buy tops to sell again. They probably meet the need of small spinners who cannot buy big lots or put down contracts with top makers. For these the top merchant contracts, buying large quantities at advantageous terms, the benefit of which is obtained by the spinners, minus a small commission charged by the merchant. Some of these have no premises beyond an office in town, all their tops being stored by the combers, to whom they pay demurrage.

Worsted spinning is a section of the trade recognized by the Bradford Chamber of Commerce as a strong and wealthy part of the industry. Worsted spinning involves the use of so much machinery, so many processes, so much wool in progress, that only those with a fairly large amount of capital can do it. Worsted spinning includes worsted drawing, or the preliminary processes, varying in number from 6 to 10 according to materials used for spinning. It also includes the subsidiary processes of twisting, winding, and warping, though the latter process is also considered a preliminary weaving operation.

In and around Huddersfield are situated worsted spinners who concentrate on the spinning of what are known as Botany and Crossbred mixture yarns. These are from wool dyed in top form. The tops are first made up in their natural colour, then dyed, and afterwards recombed, if necessary. The colours are then blended in varying proportions, and the number of shades produced is great, each firm having thousands which they can make almost at a moment's notice. Of course, greys and browns predominate, but these are often toned with one or more of the primary colours, and in addition there are yarns made from vivid hues for overchecking purposes, though in smaller quantities. Huddersfield is known for the excellent coloured yarns it produces, and many of the spinners of this district work solely in this trade.

Bradford spinners, with few exceptions, work up yarns from white wool. In addition there are large spinners of mohair and alpaca and similar fibres, making it the centre for these materials in matchings, yarns and pieces. Some of the mohair spinners make large quantities of mohair loop yarns, which are exported in enormous quantities to the Continent.

In substantiation of these paragraphs, which speak of the sectionized condition of the industry, the Bradford Chamber of Commerce has the following members (year 1922)—

Wool merchants and top makers, 195; worsted spinners, 128; and manufacturers, 279.

A visit to Bradford, or to Huddersfield, or to Halifax, would convince any one of this sectionalizm. The road traffic of tops, yarn, and pieces is evidence of it also. It is this sectionalization which accounts for the 79 yarn merchants and the 20 yarn agents being members of the Bradford Chamber of Commerce too.

There are 279 manufacturing members of the Bradford Chamber of Commerce not all of them possessing looms. The title of "manufacturer" is assumed by many who possess warps and wefts in process of weaving by a commission weaver, and by those who buy pieces in the grey and have them dyed to order, or even by those who supply dyed cloth to sell again in whole pieces. In the strictest interpretation of the term, a manufacturer should possess looms in which he weaves his own pieces, not another firm's, and sells the cloth after it has been dyed. In addition, there are 279 piece merchants, who do business in Bradford. The Bradford and Halifax trade is mainly ladies' dress goods and coatings, with linings, lustres, serges, lastings, and brilliantines also. Huddersfield cloths are both woollen and worsted, the latter consisting almost wholly of trouserings, vestings, and suitings.

The worsted industry is well served in the training of its leaders and workers in the technical colleges in the West Riding cities and towns. The department of textile industries, Bradford Technical College, situated in the heart of the worsted industry, concentrates on the technology of worsted goods, teaching the principles underlying their manufacture and examining faults with a view to their elimination. The textile section of the University, Leeds, divides its attention, and deals with the subject of woollen manufacture as well as worsted. Huddersfield, the centre of cloth-making for men's wear and for fancy designs, also has its technical college, at which the trade of the district is fully dealt with. At the Halifax Technical College full courses in the manufacture of worsteds are taken. These colleges are equipped with machinery for giving the students every opportunity of receiving practical work in all processes of manufacture. They have formerly contributed and are still largely contributing to the success of the industry in this country. The textile trade is calling for trained men with a good grounding in textile technology, who can apply their knowledge to the problems of the day, and by the application of textile chemistry, textile mechanics and engineering, obtain a maximum of efficiency, with a minimum of power. These subjects correlated to the industry are now receiving the attention they have long merited, but have been fought shy of up to a few years ago.

CHAPTER III

THE CHOICE OF MATERIALS

WORSTED manufacturers, or that proportion of them which buy wool, have to exercise care in their choice. Almost all wool of normal length, that is of twelve months' growth, can be used by them. In certain wool growing countries, however, sheep have been shorn at shorter periods than yearly, and wools of six, eight, nine, and ten months' growth are met with. These are usually too short for the Bradford trade. In the same category, so far as length is concerned, are many of the skin wools placed on the market. Sheep are slaughtered all the year round, and the length of wool upon their skins depends largely on the period of time that has elapsed from its last shearing. Even in fleeces of normal length there are portions to be rejected for the Bradford system ; for example, the fine short wool of the neck and belly, and the coarse short wool from the legs and tail. The discrimination shown in choosing wool for the worsted trade is in contradistinction to the choice of material for the woollen industry, where wools of exceeding shortness are used and often esteemed, especially when of superior fineness. The wools largely used in the English worsted industry are dealt with briefly.

British Wools. Wools grown in these islands, and over 100 million pounds are produced annually, are of great importance to the worsted industry. These wools may be roughly divided into three classes : (1) Long or lustre wools ; (2) Down or short wools ; and (3) Mountain or coarse wools. For pre-eminence in wools of the first class those grown in the British Isles are of prime importance, possessing regularity and lustre. The building up of the worsted industry in the days of hand manipulation was no doubt largely helped by the splendid wools so readily available. Typical of these wools is the Lincoln, which averages 12 ins. in length, is $\frac{1}{500}$ in. in diameter, strong in fibre and very lustrous. Its character is for length and lustre, and the Bradford system of drawing and spinning was devised to make yarns out of such wools as this. It is typically worsted in character, though not an average wool, so far as present day spinning is concerned. If we understand worsteds to be yarns in which the fibres are parallel and the surface smooth, then we come nearest to perfection in their manufacture when working up these wools. The number of fibres in a 12 lb. fleece of Lincoln wool is about 1,300,000. In preparing and combing, the elimination of short fibres is balanced by the pulling apart of others, giving the same number of fibres in a 12 lb. top.

Down wools are quite unlike lustre wools. They are much shorter, being only 7 ins. in length, as against 12 ins. These short wools are also non-lustrous, and, whereas Lincoln wools are straight and lashy, down wools are decidedly wavy or crimpy. In whatever form they are examined these two wools are very dissimilar, and make different fabrics, as one may imagine. In the days of hand spinning, down wools were the raw material for the woollen industry, but, from 1820 or thereabouts, these wools have been largely used for worsteds. They average $\frac{1}{800}$ in. in diameter, and are suitable for the manufacture of hosiery goods and dress fabrics.

Mountain wools are low in character and usually contain wool and hair mixed together. This limits their usefulness to carpet yarn making and similar yarns of a worsted character and for woollen yarns from the shorter varieties.

Australia sends to us large quantities of crossbred and botany wools suitable for worsted processes, and other wools which the woollen spinners take. The common name for the former class of wools is combing wools, and, for the latter, clothing wools. It will be shown later how some of the clothing wools can be made into worsted yarns and fabrics by modern processes. The botany or merino wools of Australia are the finest in the world, and from them are produced the most valuable of worsted goods.

New Zealand wools are almost wholly crossbred. They are splendid in character, well got up, and provide the English worsted spinners with a large and regular supply of medium and fine crossbred wool. The development of wool growing in Australia and New Zealand has been commensurate with the expansion of manufacture of worsteds in this country and others.

South Africa is coming along at a good pace as a wool growing country, and is eager to cater for the worsted trade. Formerly, the efforts made have been to please themselves rather than the trade, but recent years have witnessed a reversal of this policy, for which the Government has been largely responsible. Before this recorded improvement took place, it was customary, either from fear of the wool's shedding, or from lack of capital, for shearing to take place at the end of from six to nine months, thereby cutting out the worsted industry from using a large proportion of their wools. However, they are finding that it pays to shear annually, and only a minority of farmers shear at shorter periods.

From South America, or those parts situate within miles of the ports of Buenos Ayres, Monte Video, and

Bahia Blanca, a large amount of fine and medium crossbred wool, with a smaller amount of merino, is received in this country, but a greater quantity of these wools is received by France and Belgium. Sheep, dual purpose animals in South America, are kept primarily for mutton and secondarily for wool, this accounting for the low percentage of merino wool exported from Argentina. Much of this wool is used in the Continental worsted industry, as wools of a spongy character are preferred for this purpose.

The United States has forty-five million sheep, which are of various grades, the wools, mostly of a worsted character, being used in the home industries of that country.

Asiatic wools are usually very coarse, and vari-coloured. They find their greatest employment in the woollen industry, but some are used in the worsted centres for the manufacture of braids, beltings, and carpets.

European wools as a class are good, and suitable for making worsteds. Spain, Germany, and Austria produce merino wool ; France and the northern countries have sheep which produce wool of a crossbred character, while Russia, in normal times, pastures millions of sheep which produce wool of a bare merino quality.

CHAPTER IV

CLEANSING WOOL

All wools contain impurities which must be removed after wool sorting, before any attempt to manufacture them is made. The impurities may be classed as: (1) natural, and (2) acquired. The first class consists of wool sweat, exuded in the natural economy of the sheep from the sudoriferous glands, which terminate on the outside skin of the sheep, and is picked up from thence by the wool acting as a blotting paper and of the wool fat which flows down other glands known as the sebaceous. These latter terminate in the hair follicles, and the fat assists the wool in its journey to the outside of the skin. The two substances become thoroughly mixed on the wool fibres, and together they are spoken of as yolk. The second class of impurity on wool—the acquired—consists of dirt, sand, and earthy matters, which become attached to the wool by reason of its greasy nature and serrated surface, it being commonly found that, the greater the amount of natural impurity, the heavier will be the acquired impurity clinging to the fibres. In addition to these two classes of matter other than wool on fleeces, there is on some wools a percentage of vegetable matter, such as straw, seeds, and shivs. These are very objectionable and difficult to get rid of, the usual cleansing process being of no avail for this purpose.

The cleansing of wool is accomplished in large machines for mass production. These machines are automatic in their action, feeding, propelling, squeezing, and delivering the wool at the rate of 500 to 800 lb. an hour.

At the same time, the impurities squeezed from the wool are passed into settling tanks, placed alongside the ordinary bowls in which the wool is cleansed, or, as in the latest type of machine, they are passed out automatically into the drains or channels at intervals of time which vary according to the wools being cleansed.

The washing of wools in this country is done by the emulsion system. As has been indicated, large tank-like bowls are used, varying in capacity from 700 to 1,800 gallons, and three or four of these constitute one set. These bowls may have a depth of 1 yd., but about 15 ins. from the top a perforated brass sheet is placed, which acts as a false bottom, and prevents the wool from getting to the bottom of the bowl, and possibly out of control, at the same time allowing a big volume of water to be used, thus obviating frequent changes. Rows of inverted forks constantly move the wool forward in this upper portion of the bowl, and the movement is assisted by a slight flow of water in the same direction. Squeeze rollers take out the dirty water, and the wool is passed into the second bowl. The process is now repetitive, the wool eventually passing through the last squeeze head in a perfectly clean condition, and, in the case of merino wool, may be described as "white as wool!"

The impurities on wool behave differently when placed in water. Wool sweat is soluble, while wool fat is insoluble. The acquired impurities are also similarly varied in behaviour when steeped in water. By the emulsion system of wool cleansing, as almost universally practised, the insoluble impurities are acted upon by an alkaline solution, which, as it were, detaches the impurities, and floats them into the solution or sud. There are several agents acting together in this work, viz., water, the sole agent necessary for ridding the wool of the soluble matter, and the vehicle in which the other agents are brought in contact with the wool; soap and alkali, the particles of which break up, or insert themselves between the water particles, thus surrounding the wool fibres and adhering foreign matter, and performing their alloted function; heat, which besides giving a buoyancy and movement to all the particles in the solution, acts upon the wool fat and makes possible its easier removal; and agitation, the mechanical force of which is a cheap and effective method of shortening the time required for cleansing. All these agents are met with in domestic laundering, hard soap and dry soap representing the soap and alkali, while the "boiler" for heat, and the "rubbing board" and "peggy stick"—very violent forms of agitating mechanisms—are too well known to need anything more than casual mention.

Modern washbowls are built for cleaning 800 to 1,200 lb. an hour. This is accomplished with very little trouble, and with rare stoppages for repairs. A photograph of a modern machine of this type is shown in Fig. 1. On the Continent it is common to steep the wool before cleansing it. There are two advantages gained by this method: (1) Less soap is required when actual cleansing is subsequently done; and (2) the waste water can be dealt with more satisfactorily, from the point of view of recovering some of the valuable potash salts removed from the wool. Steeping was first carried out in tanks filled with wool and tepid water and left for a period of time. It is now an automatic and continuous process, with the title of "dessuinter." The wool travels slowly on a lattice, over which are a series of water sprays, whilst beneath are a number of tanks with clearly defined gathering areas. Briefly, the last spray consists of clean water, which passes through the

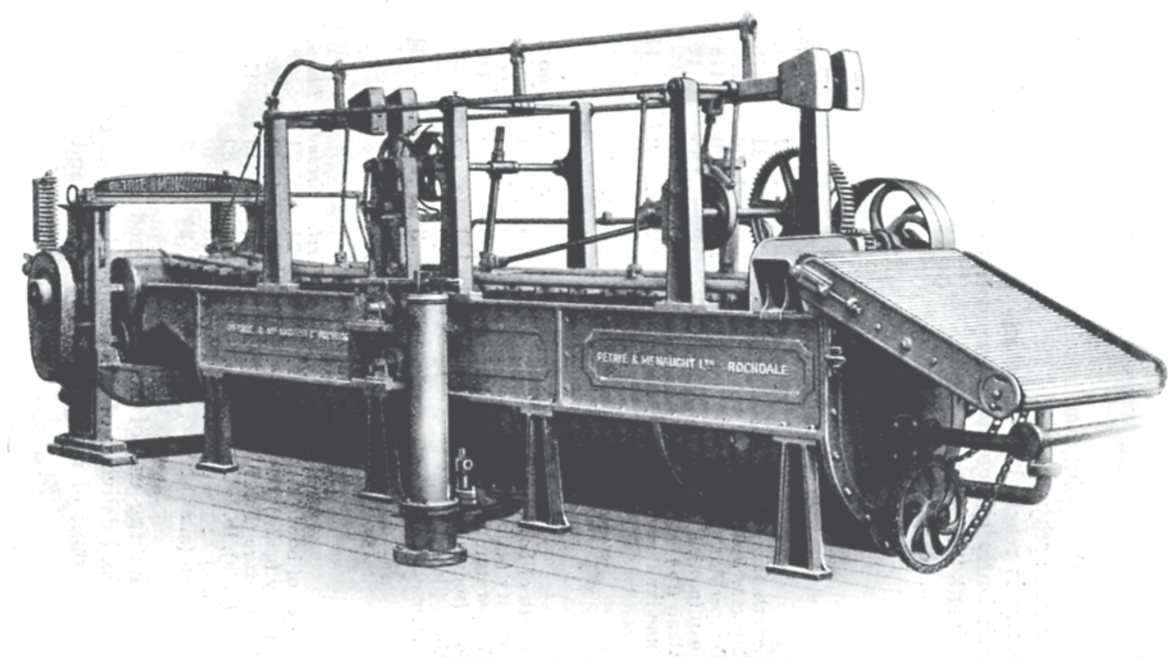

FIG. 1

SELF-CLEANSING WASH-BOWL

wool at that point, and is collected and pumped up into the last spray but one. This is repeated until the first spray is reached, from which the water is considered sufficiently charged with impurities to be run into the effluent " recovery " plant.

TABLE I

For Cleansing 4,500 *lb. Greasy Merino*
Average Yield, 50%
Time required : One day, 8¾ hours

	First Bowl.	*Second. Bowl.*	*Third Bowl*	*Fourth Bowl.*
Length of bowl (ft.) . .	30	24	21	18
Capacity (galls.) . .	1,800	1,500	1,250	1,000
Temperature (Fah.) . .	130	125	120	115
Soap (pot.), lb. . .	120	60	45	12
Alkali (lb.) . . .	35	10	—	—
Time immersed (mins.) .	3	2½	2	1½

For 5,400 *lb. of Greasy Crossbred Wool*
Yield, 65%

	First.	*Second.*	*Third.*
Length of bowl (ft.)	30	24	18
Capacity (galls.)	1,800	1,500	1,000
Temperature (Fah.)	125	120	115
Soap (soda), lb.	140	75	20
Alkali (lb.)	40	10	—
Immersion (mins.)	3	2½	1½

For 6,000 *lb. English or Low Crossbred Wool*
Yield, 75 *to* 80%

	First.	*Second.*	*Third.*
Length of bowl (ft.)	24	21	18
Capacity (galls.)	1,500	1,250	1,000
Temperature (Fah.)	120	115	110
Soap (soda), lb.	150	80	20
Alkali (lb.)	40	10	—
Immersion (mins.)	2½	2	1½

Despite the use of heavily weighed squeeze rollers at the final delivery of the washbowls, wools contain a large amount of moisture at that point, and drying is a necessary operation. In the more primitive days of worsted manufacture, this would be done by the action of the wind and sun in the open air. The big weights now cleansed hourly make this method too slow and too costly even in districts where field space is available and the atmosphere clean. It is customary in these days to attach to each wool washing set a drying machine large enough to deal with the output of cleansed wool from

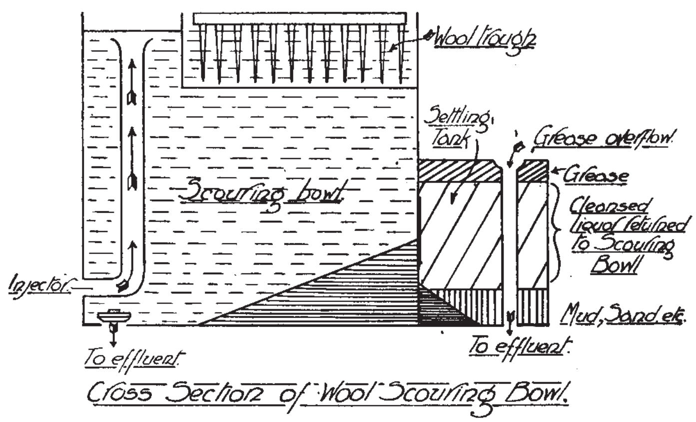

FIG. 2

the bowls. The drying machines are known as hot-air dryers, being based on the principle that the capacity of air to hold moisture is increased by a rise in temperature, and that wool or any other article will give up its water contents in the presence of hot air. For any given temperature there is a maximum amount of water vapour, which any given volume of air may take up. One cubic foot of air at 50° F. will hold 4 grains of water; at 100° F. 21 grains; at 150° F. 82 grains; and at 200° F. 260 grains. Under these conditions the air is said to be saturated with water vapour at the given temperature.

The penetrative action of air pressure is also effective in quick drying. The household linen hung in the open air dries quickly when the wind is strong. In wool drying a wind or air current is developed by a fan, and the heated air is given an additional drying power. Adequate pressure is necessary to force the air to do something more than simply to impinge on the surface of the staples of wool under treatment ; it must be sufficient to ensure that the interior of the staples are dried as well. The volume of air used must be just sufficient to allow for its moisture-absorbing capacity to be utilized to the utmost.

In a modern drying machine the wool is delivered from the last squeeze head on to the feed apron of the dryer, and requires no handling at this point. Entering the machine, which usually consists of 5 or 7 shelves or tiers, the wool is carried to the top shelf by a blast of hot air blown from a tubular heater, situated in a well under the machine and usually below the floor level. The temperature of the hot air is generally from 140° F. to 160° F. The shelves are made to move the wool forward, assisted by the hot air which may be travelling in the same direction, although in some machines the air travels counter current to the wool. There are many types of drying machines, and even with these, the immense variety of wools to be treated tax to the fullest the resources of practical men. Fine short wools, which felt very readily, have to be accommodated in drying machines where wool movement is limited, as wool felts when in a wet condition. Drying machine shelves are of several types : (1) Endless aprons made of strong felt or woven wire. (2) Shelves constructed of wood, covered with smooth sheet metal, each shelf having a slow upward and forward movement followed by a sudden downward and backward swing, giving the wool a " chuck " or " throw " and, by repeated actions, getting the wool through the machine. (3) Shelves made of laths pointing in the same direction as the wool travels. Alternate laths work in unison while the others are stationary. The moving laths lift up the wool and carry it forward a few inches, then descend below the level of the stationary laths and returning to their original position, leave the wool on the stationary laths. Successive movements of this kind convey the wool from end to end of the shelves.

While the horizontal movement of wool is accomplished by different methods, the vertical or downward movement is similar in all machines, one end of each shelf except the last being shortened, thus allowing the wool to gravitate to the shelf beneath. These dryers are usually spoken of as " tier " or " oven " dryers.

There are other types differing widely from these, though performing the same task. Stone's dryer is horizontally circular, the wool having a slow roundabout ride in a heated chamber, one circumlocution being sufficient to dry the wool. The Jumbo dryer, of which there are still many working for long wool, is shaped like a great boiler, but constructed of wire instead of boiler plates. This is made to revolve slowly with the wool inside, and a slight inclination of the frame towards the delivery end causes the wool to fall in that direction and automatically to leave the machine. The whole is enclosed as a heated chamber.

Table dryers are also used. As their name implies, these are flat-topped tables, with wire-meshed sloping sides, upon which the wool to be dried is laid by hand. Steam pipes over or under the machines, with fans to move the air in the necessary direction, are the drying agents. Turning the wool over and removing it are also performed by hand, which makes the process costly in wages, and unpopular on that account.

All wools are not given the same treatment in this process. Wool which is to be carded is treated very lightly. In fact, some firms dispense altogether with this operation, whilst others take out from 5 to 15 per cent of moisture, if the wool is to be carded. For the operation of preparing by gilling, usually accorded to long wools, more thorough drying is done. In drying wools for carding, one drying machine will probably be sufficient to serve two sets of wool washing machinery, but in the case of prepared wools, one dryer will serve only one set of wool washing machines.

Wools at this stage must be clean, both inside and outside of staples, as far as possible, but must remain in the same form, free and unfelted, as on the sheep's back. Ropiness at this stage is especially condemned, and makes the further working of the wool difficult, both mechanically and materially. The nearer the wool approximates to true whiteness, the more valuable on that account will it be, though in obtaining a good colour the soft handle of the wool must not be diminished. Over-drying can damage both the colour and handle of the wool. In attempting larger production excessive heat may be applied ; it is a dangerous policy.

Before the war the cost of cleansing and drying wool was ½d. per lb., and is now 1d. per lb., both figures based on the weight of raw or greasy wool sent to be treated. A table of particulars referring to the quantities, heat, time, etc., in wool cleansing, is given in Table I. It is computed that the annual weight of wool cleansed in the United Kingdom is 1,100,000,000 lb. Taking as an average that the wool contains 30 per cent of impurities of various kinds, a total of 330,000,000 lb. is removed in cleansing by the emulsion system of scouring. It will be realized from these figures what a task confronts the industry in keeping these impurities out of the rivers and streams. Since, however, a proper system of separating the impurities from the wash waters results in the recovery of valuable products, instead of being a costly and unprofitable process, it follows that it is worth while to purify the spent scouring liquor.

The treatment of this liquor is primarily to avoid the pollution of streams, and at the same time to provide another branch of the business where income exceeds expenditure.

The recovery of the valuable constituents of wool scouring effluent is not most effectively carried out in England. On the Continent they begin right by steeping the wool, and, with the use of modern dessuinters, obtain a regular supply of standard or average liquor, free from soap and alkali contaminations, and for the treatment of which scientific, yet simple, methods have been devised.

The English method of dealing with these liquors is by the use of sulphuric acid. The acid combines with the alkaline constituents of the liquor and the wool grease is liberated and either rises to the top of the sud, or is sunk to the bottom by heavier impurities. The acid water is run off for further purification and the grease is either collected on filters and placed in canvas wrappings or pumped direct to steam-heated filter presses. From both these the grease flows away and after some little further purification, it is ready for the market or other uses.

Up-to-date firms obtain five products from their wool scouring effluents. These are fibre, water, oil and grease, soap and alkali, and manure. A process recently evolved removes the wool grease without affecting the soap and alkali. With this system the grease is first removed and then the liquor can be used again for wool cleansing, without adding any more soap and alkali. This water can be used three times before passing it to the acid-treatment plant.

This grease removing is carried out in a horizontal churn or an hydro-extractor, with non-perforated sides. This rapidly revolving centrifugal machine separates the scouring liquor into three distinct layers on the sides of the cage.

These are—

1. An outer layer of sand and dirt ;
2. An intermediate layer of soap solution ;
3. An inner layer of clear wool grease.

The soap solution is passed continuously from the machine. The grease is removed by a special skimming device, so that only the sand and dirt have to be removed whilst the machine is standing. The grease removed by this process is more valuable than acid-removed grease. By this method of working it is possible to recover at a moderate cost the potash originally contained in it.

CHAPTER V

PRELIMINARY STRAIGHTENING

At this point the paths upon which long and short wools travel diverge, to come together again at the back-washer or the comb. Long wool (in this instance referring to wools 8 ins. long or over) are prepared for the comb by a series of operations known as gilling; while short wools are carded before combing. The rule is not a hard and fast one, and is often determined by other and more local circumstances. Thus, a 9 or 10 inch wool, from which it is intended to make hosiery yarns, may be carded and not gilled, while on the other hand, 7 inch mohair or lustre wool required for lustres or linings would in all probability be gilled. Thus the ultimate fabric requirement may determine the treatment accorded at this junction, though the rule stated is usually followed for average lots. Firms who have both carding and gilling often use them for their own convenience, rather than adhere to rules which would be irksome.

Preparing. The gill box is a typical worsted process and in various forms is used before and after combing, and also in drying. It owes its conception to Lewis Paul, who, in 1738, conceived the idea known as roller drafting, and to Fairburn, of Leeds, who invented the screws mounted between the rollers, which actuate the fallers or pinned steel bars. The most important parts of a gill box are the back rollers, the front rollers, two pairs of screws, and one set of fallers. The function of the back rollers of the first sheeter box is to receive the material from the " maker-up " and convey it forward towards the fallers, at the same time exerting such a hold on the fibres that the fallers' pins, when rising from the lower saddles, penetrate the staples, and by reason of their quicker forward movement gradually draw away and comb through the fibres. When the fibres are released from the back rollers they are carried forward in the pins until their tips reach the quickly revolving front rollers, by which they are caught and pulled through the pins. This process of drafting and combing proceeds in each subsequent machine until, when the last box of the set is reached, all except the very shortest fibres have been straightened out.

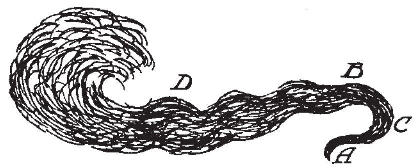

Fig. 3

LONG WOOL STAPLE

The whole of these processes may be summarized as—

(*a*) Combing of fibres by means of back draft, in which the rollers hold and the pins comb.

(*b*) Stroking of fibres by means of front draft, in which pins control and rollers draft.

(*c*) The straightening, opening and elongation of the wool by means of rollers holding or drafting the fibres.

The condition of the wool as it is received by the first box may be assumed to be as shown at Fig. 3. It is stapled, and looks very unpromising when its ultimate use is borne in mind. The root end of the staple is thick, curly, and bushy, and contains most of the short fibres while the tip end is usually curled as at *A*. To accomplish the straightening out of these staples, the mechanical arrangement is by the insertion of the faller pins amongst the fibres, or in the centre of the loop between the curl (*A* and *B*), which travels at a quicker rate than the fibres, and so straightens out the curl, effecting to some extent—according to the number of pins employed—the opening out of the wool.

The advantage of this method of attempting straightening of fibres by means of back draft will be understood if it is assumed that the curl of the staple at (*C*), Fig. 3, is projected first through the back rollers. A rising faller will touch this curl and draw away. The next faller rising will pierce the staple immediately behind the previous faller, and stroke through a longer length of staple, this increased length being equal to the pitch of the faller screw. Every subsequent faller will subject the staple to a similar treatment until it is released by the back rollers. In this way we have the natural and ideal system of combing exemplified, as it corresponds to the manner in which a lady would comb her tresses, by inserting the comb first at the tips and each succeeding insertion of the comb getting closer and closer to the roots. This progressive treatment is very effectual in reducing the breaking of fibres to the lowest possible minimum.

At the front rollers a further opening of the wool takes place. The wool is pulled through the faller pins by the quicker revolving front rollers and this action is very effective in opening up the rear end of the staples. The front rollers run about six times faster than the fallers, and this ratio is spoken of as front draft. However, in all gilling it is found that the advance part of staples receives the severest treatment; probably this explains to some extent the difficulty in successfully gilling short wools.

The arranging of the drafts, the setting of the back and front rollers their proper distance apart according to the material under treatment, and the speeding of the machines, constitute the most important points in preparing. Each machine in the series, and there are usually six, should perform an equal amount of work. By gentle yet thorough treatment at each process, the wool may be opened without excessive breakage of fibres. Wrong setting and drafting will damage the fibres, so that the combing result, or the proportion of top to noil, will be very low. A table showing the average treatment of wools in preparing is given below.

TABLE II

PARTICULARS OF PREPARERS

For Long Wools (40's Quality)

Machine.	Drafts.			Fallers.			
	Back.	Front.	Total.	Pitch of Screw.	Speed.	Pins per Inch.	B.W.G
1st sheeter box .	7	6	42	$1\frac{3}{8}$	110	$2\frac{1}{2}$	7
2nd ,, ,, .	6	6	36	$1\frac{1}{4}$	120	$3\frac{1}{2}$	8
1st can box . .	4	6	24	$1\frac{1}{8}$	130	5	9
2nd ,, ,, . .	3	6	18	1	140	6	10
3rd ,, ,, . .	2	6	12	$\frac{7}{8}$	150	7	11
4th ,, ,, . .	$1\frac{1}{2}$	5	$7\frac{1}{2}$	$\frac{3}{4}$	150	8	13

Carding. Worsted carding, so called to distinguish it from woollen, cotton, or silk carding, is the preliminary process of opening up, separating, parallelizing, and forming a sliver of unlimited length from wool fibres of limited length. Only once through the machine is necessary for this purpose, but the carding engine is large and complex in its build. It consists of a number of cylinders and rollers of equal length and varying diameter, revolving in contrary directions, some fast, some slow, and covered with card clothing differing in density of wiring, and pointing in opposite directions. However, the theory underlying carding is not difficult to understand. Card wires are usually bent at the middle < ; giving, as seen in this example, point at the right and back at the left-hand side. In the machine, where rollers are working point to point, working or opening is done. There are about twelve places on the card where this action occurs, each being progressive in nature, successive places either having denser pinning or quicker speeds or both, and the rollers are set nearer to each other. At each of these working points, an equal amount of opening is done, which ensures gentle yet thorough treatment of wool, and longer life to the card clothing.

The modern card is now fed automatically by what is known as the hopper feed. This hopper or receptacle is filled with clean wool, which is gradually withdrawn by a spiked lattice moving in contact with the wool. The wool taken from the hopper falls into a pan placed over the feed sheet of the carder. The automatic feed must place a given weight of wool on to this feed sheet at fixed periods of time. The wool is weighed in the pan, which, having received the allotted portion, stops further delivery until the time elapses, when the pan empties itself on the feed sheet, and this round of movements begins again. These auto-feeds are adjustable for different types of wool, and can be easily changed for weight and time according to feed.

The worsted card is illustrated in Fig. 4. Following a series of 3 feed rollers, there are a number of rollers termed lickers-in and dividers. The lickers-in are in one plane, and are connected with each other to pass the wool through the machine to the swifts.

The dividers are situated between each pair, some over the lickers-in and the others beneath them, the idea being to open up the wool and keep it moving in one direction, that is, towards the delivery end.

There are many matters regarding these rollers with which the practical man is thoroughly conversant. Each licker-in has a surface speed about double the preceding one, is covered with clothing of slightly finer pinning, and has a less clearance with the divider. The whole of the carding could be done with further lickers-in and dividers, but for saving floor space and for the purpose of making the card check its own work or degree of opening, a swift or large cylinder, surrounded on its upper periphery with smaller rollers, workers and strippers, has been universally adopted. The swift takes the material from the last of the opening rollers, and, revolving upwards, carries it to the first worker, where the wool fibres are further separated. The worker takes part of the material on its surface, which is returned by a stripper acting between the worker and swift. This is repeated with other workers and strippers, each pair contributing to the aim of teasing apart every individual fibre.

How these various actions of opening and stripping are performed is simple to explain. Let us recall the fact that each card wire has a point and also a back. If two rollers in contact with each other revolve in opposite directions circumferentially and with their points first, there is a contest between them for possession of the wool in which any material held momentarily by either is combed through by the wire points of the other roller. This action results in clusters of fibres being broken up, pulled out, or straightened, and its repetition effects thorough opening.

These are termed working actions and each successive working point is more severe in function than the previous one, the rollers either being set slightly closer to each other, or having denser pinning or wiring, or both. But wool put into a card on to a card-cylinder must also be got off again. Where necessary, rollers acting as strippers or clearers are placed. Each roller is cleared by a more quickly running roller revolving points first, these working against the backs of the rollers to be cleared. There are two places on the card

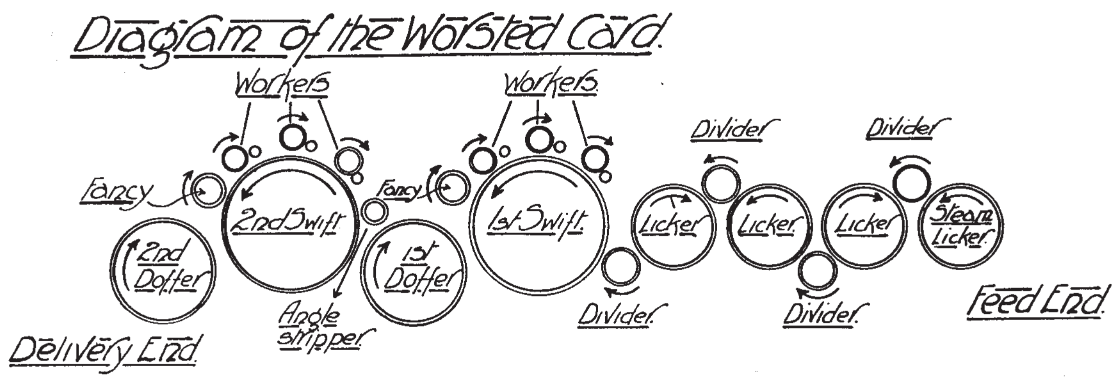

Diagram of the Worsted Card.
Workers
Workers.
Fancy
Fancy
2nd Swift
1st Swift
2nd Doffer
1st Doffer
Angle stripper
Licker
Licker
Licker
Steam Licker
Divider
Divider
Divider.
Divider.
Delivery End.
Feed End.

FIG. 4

exceptional to this last method of stripping ; these are where the first and second doffers clear the first and second swifts respectively. These latter rollers are cleared by a double action. First the fancy, revolving with its backs first, meets and overtakes the backs of the swift, lifting out the material in the swift wires on to the surface. With the wool in this position the swift meets the doffer, the points of which travel slowly in the same direction as the swift, await the swift wires, and give a point to point action. Stripping is done by reason of the wool lying on the surface of the roller. There are thus three actions in carding: (1) working, (2) stripping, and (3) brushing. Brushing, followed immediately by working, gives a stripping effect.

First, the machine must be suitable for the type of wool to be carded. Considerable skill is demanded in carding. The man responsible for setting and speeding the machine must be experienced and able to adjust the machine for every change of wool or condition. A list of speeds and other particulars is given in Table III, but these are suitable only for wool about 60/64 quality. The practical carder binds himself to no set of rules or figures, but makes changes when and where his experience deems necessary. Probably his greatest skill is seen when setting the rollers at their correct distance from each other. He first examines the wool to be carded for length, character, fineness, waviness, and condition. He makes any required alteration to speed and setting. He determines the capacity of the machine for that particular type of wool, and then begins to card. A few minutes later, as the wool leaves the other end of the machine, he sees the result of his skill in setting and speeding, in the degree of openness of the wool. In all probability one or more alterations will be necessary, but it needs the practised eye of the carder to discover the defective place in the card, or the point where the work of opening is not severe enough.

The carder is responsible also for ridding as far as possible the wool of its vegetable impurity. All modern worsted cards are fitted up with a number of "burr rollers." These are small bladed rollers for

TABLE III
WORSTED CARDING ENGINE DETAILS FOR FINE WOOLS

Name of Rollers.	No. of Rollers.	Diam. of Rollers (bare).	Speed of Rollers, r.p.m.	Surface Speed, ft. p.m.	Card Clothing.	
					Counts and Crowns.	Wire, B.W.G.
Feed rollers	2	3	0·25	0·195	Needle	point
,, clearer	1	2½	0·60	0·43	,,	,,
First licker-in	1	30	6·25	49·5	Garnett	
Second licker-in	1	24	25	163	70–7	27
Third licker-in	1	24	50	327	80–8	28
Fourth licker-in	1	24	100	654	90–9	30
First divider	1	20	2·1	11·5	65–7	24
Second divider	1	16	2·7	11·7	75–7	26
Third divider	1	16	2·8	11·9	85–8	30
Fourth divider	1	16	2·9	12·2	100–80	32
Burr rollers	5–7	4½	600	666	—	—
First swift	1	50	100	1,335	140–12	34
,, workers	3	12	3·3	11	130–10	35
,, strippers	3	4½	195	281	110–10	31
,, fancy	1	16	376	1,771	80–8	33
,, doffer	1	40½	5	54	140–12	34
Angle stripper	1	4½	195	281	110–10	31
Second swift	1	50	115	1,550	150–13	36
,, workers	3	12	3·3	11	155–14	36
,, strippers	3	4½	224	322	120–11	33
,, fancy	1	16	432	2,037	90–9	34
,, doffer	1	40½	5	54	150–13	36

detaching any vegetable matter from the wool. Thick straws, seeds, and twigs, cannot penetrate the closest card wires, but remain outside ; from this position they are dislodged by the swiftly revolving burr rollers.

This attempt is often supplemented by a special burring mechanism attached to the card. One form crushes the seeds and straws between heavy weighted rollers, one of which is smooth faced and the other fluted. A French patent, consisting of a very fine "garnetted" roller with a beater blade, is fitted to hundreds of worsted cards in this country. The close setting of the garnett roller prevents even the smallest shivs from penetrating them; a beater blade then flicks them from the surface of this roller into trays provided for their reception.

Constant running of the cards soon blunts the wire points, and in this condition they are ineffective in teasing the fibres apart without breaking them. It is necessary to sharpen the wire points at frequent intervals. This is done with emery rollers, which are arranged to work lightly against the backs of the wires; hence this process is known as card grinding. The smaller rollers of the card, such as the workers and strippers, are lifted out of the machine and placed in what is known as a grinding frame. This consists of an emery roller mounted between two brackets, in which can be placed rollers to be ground. The larger rollers, such as the lickers-in, swifts, and doffers, are ground in their normal positions in the card. It is also necessary at frequent intervals to clean out from the card wires the accumulation of fibres; small hand cards are used for this purpose, and the work is referred to as "fettling."

Backwashing. Although wool is thoroughly cleansed in the scouring process, it is possible that on the same day it may be subjected to another cleansing process. This may be interpreted by those outside the industry as being a very strange practice, especially when it is remembered that between these two cleansing operations there are only two processes, and following it there are some ten to fifteen processes before the yarn is made, and between which no further cleansing is done. But in well established industries like that of worsted manufacture it may be taken for granted that the end justifies the means. We will attempt to explain the reason for its place and position in the sequence of processes. Between the two operations of cleansing are drying and preparing by gilling or carding. Some writers have stated that the wool is sullied by reason of the dust generated from the many wire points in carding. Except at two places these card wires do not come in contact; and again, judging by the time that card clothing lasts, the wear taking place in the machine itself is infinitesimal. It is granted that, following grinding, the wool put through will be soiled, but half an hour later the effects of grinding have passed. Both preparing and carding are instrumental in opening up the wool staples, and dust and dirt which have been hidden away in the centre of staples or locks are revealed and scattered, giving to the carded or gilled wool the dingy appearance usually present at this point. So in England it is usual to recleanse the wool at this stage, while, in Continental mills, the operation follows immediately on combing. The best stage to backwash depends largely upon the subsequent use of the wool. In this country, with its overwhelming percentage of English or Bradford drawing and spinning systems as against French drawing and mule spinning, there is a great demand for tops combed in oil. Opposite conditions prevail on the Continent, and dry combed tops are demanded there. Now, wool backwashed before combing becomes, generally, oil combed tops, and wool backwashed after combing is for dry combed tops. Strictly speaking, all wool is combed in oil, but by reason of back-washing following combing, Continental top makers get dry-combed tops as their product. There are several advantages and disadvantages resulting from each method, but these are not enough to outweigh the main consideration when determining treatment, viz., its ultimate requirement as oil or dry-combed tops.

The backwashing machine is very dissimilar in construction to the scouring bowls previously described. The wool for this process is in sliver form, as against loose wool in the former process, and this necessitates different treatment, as the slivers must be kept intact. All backwashers consist of three parts (*see* Fig. 5): (1) Two or three tanks containing soapy water, through which the wool passes, each fitted with guide and submerged rollers, squeeze head, pipes, and valves for water and steam; (2) drying cylinders, and chamber in which the wool is restored to normal dryness; and (3) a gill box, also a restoring process, but more particularly for the recovery of openness and freedom from clinging. The first part of backwashers need little comment, except that no obstacle should prevent the free passage of a large number of slivers through the machine at one time. The remarks made regarding heat and strength of liquor in wool cleansing are also applicable in this process. The first tank usually contains hot soapy liquor. The second tank may be made the occasion for attempting a temporary improvement in the colour of the wool by artificial means. This refers to what is known as blueing, and is on the same principle as blueing in laundry work. Merino wool is fairly white, but coming down from the finest wools to the crossbreds and the English wools, each succeeding quality is perceptibly creamier or yellower. There is a gradual change, and fairly definitely, there is a relationship between the quality or the fineness of wool and its colour or shade. To overcome to some extent the inherent colour of wool and give to it an apparent whiteness, the complementary colours to yellow, which are blue or violet, are used. The blue is put into solution and a special apparatus is mounted over the second tank or bowl, from which the solution is transferred

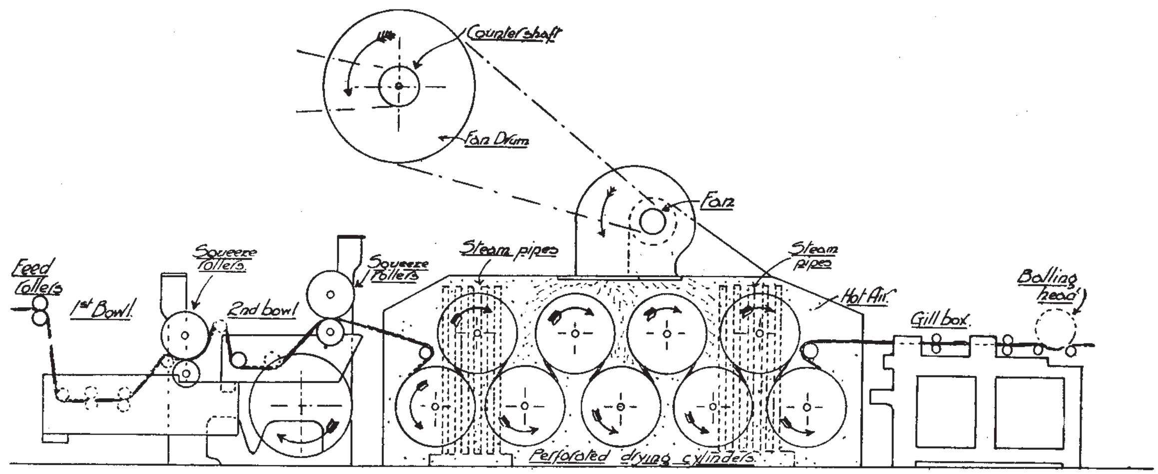

FIG. 5

HOT-AIR BACKWASHER

drop by drop, or in regular amounts throughout the day. Blueing must be done carefully, or it may give itself away in the top, by not being fugitive enough. The morality of blueing is not challenged, but its effect upon the spinning property of wool often is, and some of the comber-spinners do not blue their wool. However, just so long as worsted spinners give preference to white tops, so long will top makers cater for them by artificially improving the colour of the wool. Botany wool, which is very near white in colour, needs only a very mild or dilute blue to effect a complete improvement, but crossbred wool, from 40's to 50's in quality, requires a stronger agent to work an improvement on it. It is possible to bleach wool, not in a backwashing machine, but bleaching is usually too expensive at this stage. When wool is bleached it is done after warping and only on occasions when bleached white goods are ordered. Compared with bleaching, the permanent colour improver, blueing, is inexpensive, practically adding no cost to the operation of wool combing.

Backwashing is found to be of considerable benefit to the wool-comber as a fibre stretcher, especially with regard to the shorter and finer qualities of wool, or those wools of a wavy character. The drying of the slivers under tension gives an increased length to the fibres and a temporary set. This temporary set occurs at a most convenient juncture in the sequence of top-making, so that, in the combing process immediately following, a better "tear" is obtained, many fibres that otherwise would have been rejected as noil being of sufficient length to become top. With this advantage, in addition to the increased colour value the wool has after this process, backwashing is assured of a place in the worsted industry for many years.

CHAPTER VI

PARALLELIZATION

THE combing process is almost indispensable in the making of worsted yarns. To give a short answer to the question : " What is the difference between woollen and worsted ? " would be to reply, " Worsted is combed wool and woollen is not." This answer is true concerning more than 95 per cent of worsted yarns. The remaining percentage is a small amount of wool worked up into carpet yarns, by carding, drawing, and spinning. The drawing process in this case gives the yarn its worsted character.

The machine wool comb is a wonderful fibre sorter. The material entering the comb varies in length of individual fibres, and these are so well mixed that it appears an impossible task to separate them in respect to this feature. Yet the comb very definitely takes the wool and directs the longer fibres in one channel, and the shorter fibres are disposed of along another route. The machine accomplishes a task which is well nigh impossible by hand. The long fibres leave the comb together in sliver form, while the short fibres are tumbled over the inside of the small circles into cans placed for their reception. This work of fibre sorting, coupled with the equally wonderful way in which the fibres are combed, makes the task of spinning fine worsted yarns an accomplishment.

Woolcombing is a comprehensive term when used in its widest sense, and includes all the operations carried out in a woolcombing works. Beginning with wool cleansing, it admits carding, preparing, and backwashing,

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and concludes, appropriately, with top finishing. Combing charges include for cleansing, preparing, and combing. But woolcombing specifically is a single process, occasionally repeated, and deals only with the actual work of the machine comb. The description of this process is the aim of this chapter. Combing was the last process to defy the efforts of the inventors. For centuries woolcombing had been carried on with hand-combs in the homes of the people. That this process was not confined to one country is evidenced by the fact that the father of Columbus was a woolcomber of Genoa. From 1840 to 1860 great progress was made in making this process automatic, and the machines invented in that period were so good in principle that they still exist, with but minor improvements made meanwhile.

In the West Riding there are 3,000 wool combs. If each comb averages 330 lb. a day on 300 working days in a year, the output of combed top in this district is 300,000,000 lb. a year. This stated in suits or costumes, at 4 lb. of wool each, gives 75,000,000 for the year, a creditable performance for the worsted industry for any country.

Noble Combing. The Noble comb was invented in the year 1853, after 48 years of patient and commendable effort on the part of its inventor, James Noble, who took out his first combing patent in 1805. This is the most popular comb in use, and a woolcomber by profession or trade is usually understood to be a person skilful in minding this type of comb.

A Noble comb consists essentially of three comb circles, one large, say 43 in. diameter, and two smaller circles, inside the large one, of about 16 in. diameter. These all revolve in a clockwise direction, when looking down on them, at a surface speed of about 550 in. a minute. Each circle consists of a ring or circle of brass, in which are bored circular rows of small holes, corresponding in size to the pins which are then inserted into them, to run with the pointed ends upwards. In the large circle there may be from 8 to 11 rows of pins, and, in the small circle, from 5 to 8 rows. All large circles are set alike in respect to the fact that the inner row of pins is the densest and the outer row the most open, with intermediate rows changing from dense to open in regular order. In contrast to this arrangement, the small circles have the densest setting on the outer row, and the most open on the inner row, with the intermediate rows graduating in order. The reason for this setting will be explained later. It is sufficient to say at present that the wool fibres are withdrawn from the large circle pins from the inside of the comb, while drawing off from the small circles is made from the outside.

The machine under review is unique among textile processes in the method of feeding adopted. With most machines in work, it is at least possible for the casual visitor to distinguish the feed end from the delivery end. Not so with the Noble comb. Its feeding appears to be done all round, though there are really two places, one at each side where this is actually taking place. This requires a set of 18 balls, each with four slivers unwinding, and these are prepared by a special machine known as the "punch." In this simple machine, hardly deserving the name of process, four cans or balls of carded or prepared slivers are arranged behind it, and these are run round a spindle in parallel order, compactly and firmly.

The "punch" is now more elaborately made than formerly, in order to obtain balls of greater size, and to stop the machine when the length had been paid out. The chief parts of this simple machine are a pair of discs set about 10 in. apart, and revolving on a spindle, around which the four slivers are wrapped and upon which they are built. This spindle can be withdrawn when the ball is made, and in modern machines the spindle is withdrawn automatically as the machine stops. The simplicity of this arrangement allows a good speed to be developed, so that the production of one machine is sufficient to keep six combs in full supply of balls. A brake is always acting on the ball in process, making them very hard and compact, and giving greater weight of wool at each feed.

The Noble comb is built round the circles (Fig. 6) ; the comb really is the circles, plus means of getting the wool in and through the pins of them. Feeding is done from the outside of the large circle, and in splendid symmetry the 18 balls of uncombed wool are mounted. They completely surround the large comb circle, and each ball rests on a pair of wood rollers. The 72 ends of these balls are directed through 72 feed boxes on the same plane as the circles, and form a complete circular fringe, with an abundant supply of wool to keep it replenished. This fringe is thrown over the pins of the large circle, and in a peculiar manner is fed on to both circles at two places. It must be understood that the comb circles, the balls in their rack and the feed boxes revolve together, all, with the exception of the small circles, being firmly attached to each other.

The supply of more wool to the circles is difficult to explain, but careful reading may help to convince the uninitiated how it is done. First, the feed boxes, one on each side of the comb, mount an incline at two places, making their journey with a switchback motion. At the bottom of each incline, and continuing until the top is reached is what is known as a press knife, which holds the wool fringe firmly so that the extra length

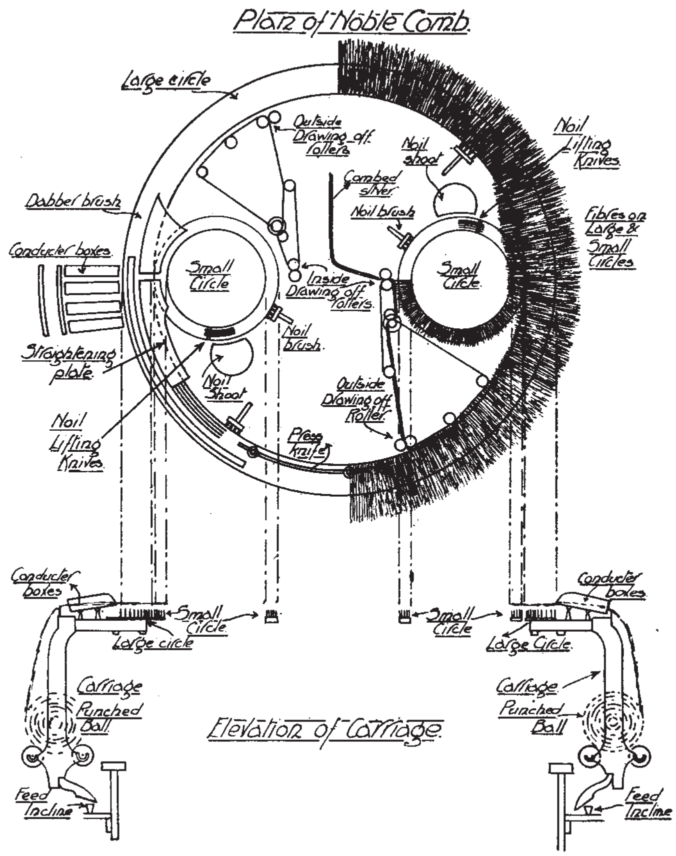

Plan of Noble Comb.
Large circle
Outside Drawing off rollers
Noil shoot
Noil Lifting Knives
Combed sliver
Noil brush
Fibres on Large & Small Circles
Dabber brush
Conducter boxes
Small Circle
Small Circle
Inside Drawing off rollers
Noil brush.
Straightening plate
Noil Shoot
Outside Drawing off Roller
Noil Lifting Knives
Press knife
Conducter boxes
Small Circle
Large circle
Small Circle
Conducter boxes
Large Circle
Carriage
Punched Ball
Elevation of Carriage.
Carriage
Punched Ball
Feed Incline
Feed Incline

FIG. 6

required in the increasing distance between comb plane and feed box plane or top of incline, must come through the feed box and from each ball in turn as they reach these points.

The press knives regulate the feed, and their position is adjustable. The lower they are set the greater is the length pulled from the ball, and vice versa. To get this extra length of wool across both circles where they meet is the next task. It must be understood that the small circle is cleared of wool fibres, and that the large circle at this point has had the long, outstanding fibres or inside fringe drawn off. The circular fringe of fibres round the comb terminates in this circle, and before further feeding can take place these fibres must be lifted out of the pins. This takes place where the incline ends, and is performed by lifting knives, one being placed between each row of pins. These knives have a slanting surface, up which the wool ascends until out of the pins, where a smooth plate covers the circle pins and supports the wool. This plate coincides with the decline or return of the feed boxes, giving the new length of fringe necessary to replenish the circles. In a very natural manner this spreads over the cover plate before reaching the place of convergence of the two circles. The cover plate is discontinued here, and just beyond it the dabbing brush descends and presses the wool into the pins of both circles. All these movements are carried on while the circles, feed boxes, and racks move continuously at their uniform speed of 550 in. a minute. Dabbing is considered inefficient if the circle is allowed to travel 1 in. between the dabs, so that a brush speed of 700 to 1,000 a minute is necessary. Dabbing by brushes is very important and costly. Other methods have been tried for this work, including air blasts, evolving discs, rotary brushes, and dabbing blades,

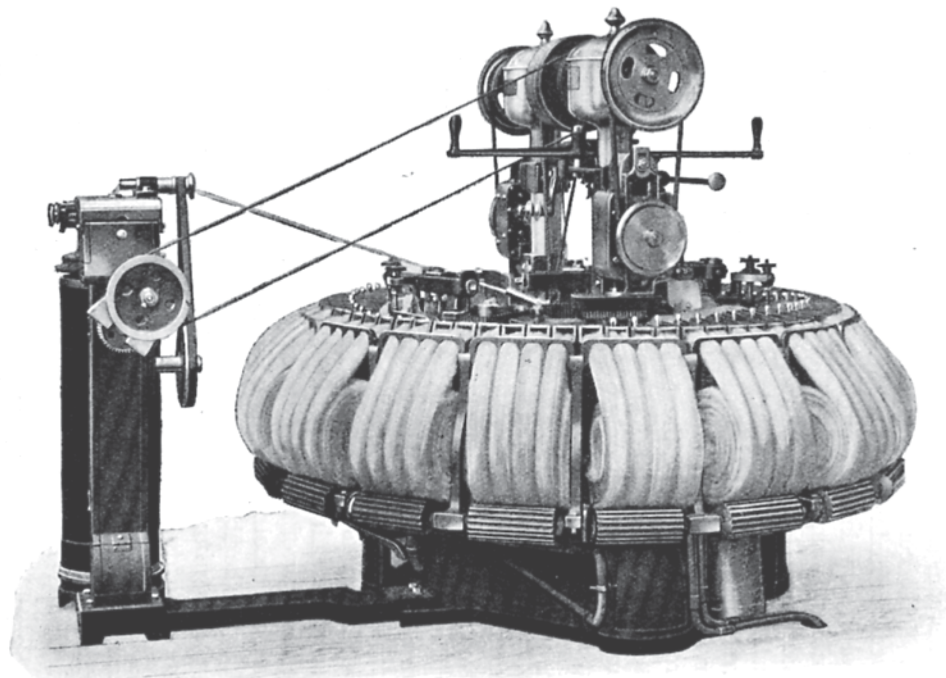


FIG. 7

NOBLE COMB

but none is so effective or as satisfactory as the brush.

This somewhat lengthy description of the feeding of the Noble comb is compensated by the fact that it covers the main part of the work on this machine. The wool is now in both circles. As these circles diverge combing begins. Two fringes are seen, one on the inside of the large circle and one on the outside of the small circle. A moment's consideration recalls their former position when under the dabbing brush, and between these two points each fringe has been combed through the pins of the other circle. The wool still inside the circle pins has not been combed. At this stage the process has only been half done. This obtains but for a few seconds. There are small upright drawing off rollers from 1 in. to 2 in. diameter, arranged in pairs, on the inside of the large circle and on the outside of the small circles. These are set near to the circle, and, by constantly revolving in this position, grip the fibres of these endless fringes as they reach them, making four continuous slivers in each machine. These are then combined to form a rope-like thread, in which form it is delivered to a can coiler placed outside the comb proper. The drawing off rollers are the means by which the combing of the wool is completed. The uncombed portion of wool in the comb pins, or that part of it consisting of the fibres extending into the fringe, is combed in the drawing off process. Fibres remaining in the large circle after drawing off are lifted out by the lifting knives in the other half of the machine, and supply the small circle there. Short fibres remaining in the small circles, after drawing off, are lifted out by the noil knives and brushes without being combed, and are directed into the noil cans. The machine is a compact one, with many settings and movements necessary to secure the round of operations, each of which must be precisely performed.

It is of paramount importance that every part of the machine must be perfectly set and in good condition. There is only one attempt at combing. Defects arising from this machine are serious, in that there is no subsequent operation which checks the work of the comb. While this particular machine, the Noble comb, can be used for all wools except the extreme long and extreme short, there are many alterations to be made when changing the quality of the wool to be combed. There are at least four different sets of comb circles, viz., for long wools, medium crossbreds, fine crossbreds, and short wools. Each set is a composite one, with lifting knives, noil knives, and drawing off rollers to suit. These are interchangeable as sets, making this comb the most adaptable of all the types. It also owes its success to its productivity. Its chief drawback is in cost in renewals, dabbing brushes and comb leathers being expensive, as well as circle re-pinning, which must be carried out at intervals. Particulars relative to the comb circles are given in Table IV on page 48.

The Lister Comb. The comb takes the name of its inventor, the late Lord Masham, who at the time of its invention in 1849 was known as Mr. S. C. Lister. It is used in the West Riding of Yorkshire for long English wools, mohairs, and alpacas, being particularly well suited to these classes of materials. There are about 150 machines of this type in work in the district named.

The first part of the machine is a gill box, differing from the ordinary gill box by having curved fallers, and no front rollers. The place of the latter is taken by the nip frame, this consisting of two curved nip jaws, upper and lower, which close upon each tuft

TABLE IV

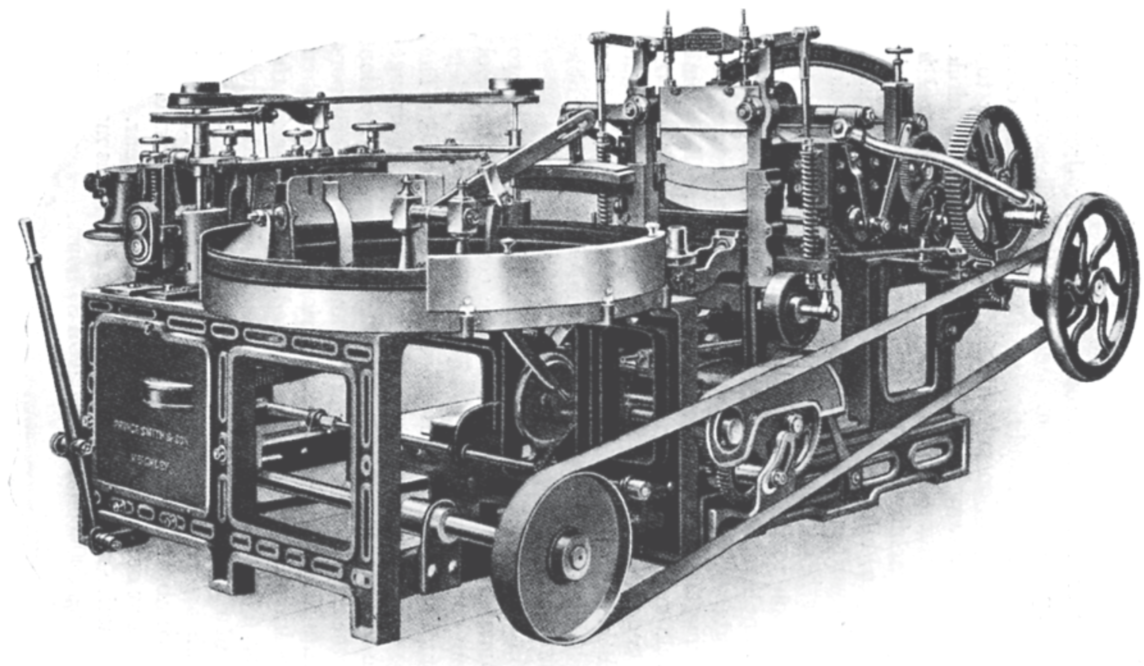
Noble Comb Details for Different Qualities

Long Wool

Large Circles.				Small Circles.			
No. of Row.	Pins per Inch.	Shape.	B.W.G.	No. of Row.	Pins per Inch.	Shape.	B.W.G.
1	23	Flat	13 × 22	1	25	Flat	13 × 22
2	20	,,	14 × 21	2	22	,,	15 × 22
3	18	,,	15 × 20	3	18	,,	16 × 20
4	13	Round	17	4	11	Round	17
5	12	,,	17	5	9	,,	16
6	10	,,	15				
7	8	,,	14				
8	7	,,	13				
Setover 4 in.				Setover $\frac{3}{4}$ in.			

Merino Wool

Large Circles.				Small Circles.			
No. of Row.	Pins per Inch.	Shape.	B.W.G.	No. of Row.	Pins per Inch.	Shape.	B.W.G.
1	42	Flat	17 × 27	1	46	Flat	18 × 28
2	40	,,	19 × 27	2	44	,,	19 × 28
3	38	,,	19 × 27	3	41	,,	20 × 27
4	36	,,	20 × 26	4	36	,,	20 × 26
5	30	Round	23	5	28	Round	23
6	28	,,	23	6	25	,,	22
7	24	,,	22	7	22	,,	21
8	22	,,	21	8	20	,,	20
9	20	,,	20				
10	17	,,	19				
11	14	,,	18				
Setover $1\frac{7}{8}$ in.				Setover $\frac{5}{8}$ in.			



By the courtesy of *Messrs. P. Smith & Son*

Fig. 8

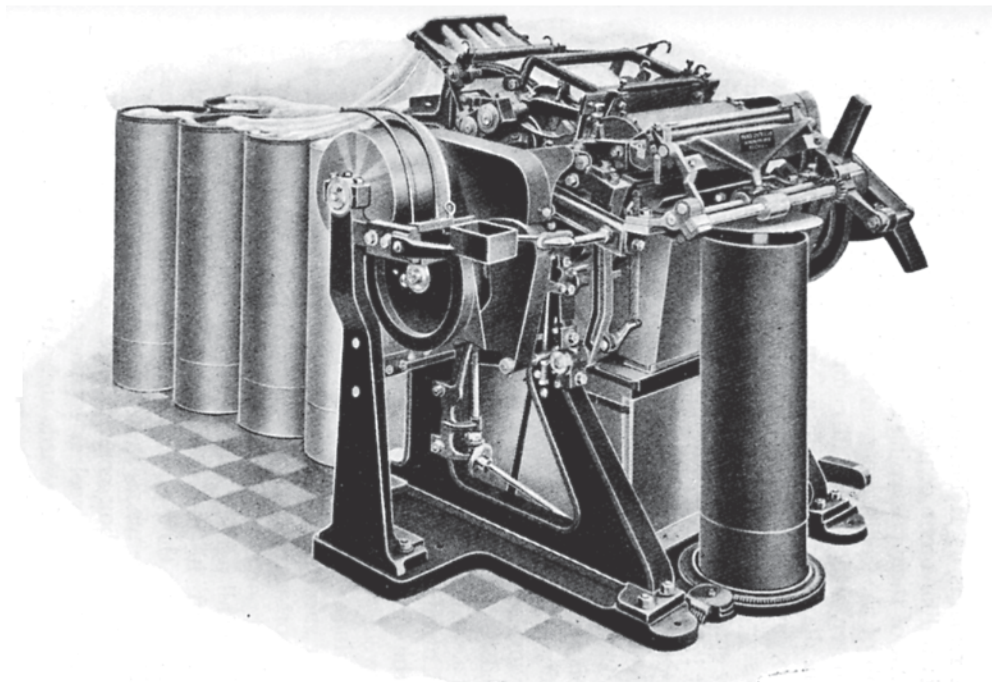
LISTER COMB

of material left projecting when a faller drops from the top to the bottom saddle of the gill box. The nip frame has, in addition to jaws that open and close, a swinging motion or oscillation from the gill box to a position midway from that point to the comb circle. To this latter position it carries each tuft of wool in turn. Reaching the extremity of this swing the nip jaws open, allowing a curved carrying comb to pierce the forward end of fringe or tuft, and in an ingenious manner it carries it to the comb circle, throwing the fibres on to its pins, and withdrawing itself to return for another supply. This is done at 40 swings to the minute. We need hardly say that precision and accurate setting are essential for successful work. The comb circle revolves with the wool fibres hanging on the outside. Horizontal drawing-off rollers, placed tangentially to the circle, removes the long fibres, leaving the short fibres or noil to be removed as in the Noble comb by noil knives and brushes.

Combing is accomplished on the Lister comb at two points, first where the nip frame combs out the wool from the fallers, and second, by the drawing off rollers combing out the fibres from the circular comb. The nip frame and carrying comb are necessary to arrange the wool on the comb circle, with the combed portion of the fringe outside the pins, and the uncombed portion inside the pins, and in position to be combed when the drawing off rollers are reached. The reason for the curved fallers is seen when each tuft is placed on the circular comb. If the fallers, nip jaws, and carrying comb are curved in agreement with the curvature of the comb circle, then the " throw " on to the circle is in a neat order and in agreement with its contour. This in practice means more top and less noil. This machine produces 500-600 lb. in a day of $8\frac{3}{4}$ hours.

The Holden Comb. The Holden comb receives its name from the late Sir Isaac Holden, who was in partnership with Mr. S. C. Lister at the time of its invention, in 1847. It consists of feed rollers, feed combs, large circle, square motion fallers, segments, and drawing-off rollers. It does its best work on wool qualities from 56's to 64's. The feed rollers revolve slowly, paying out wool in sliver form to two filling heads which, working alternately, detach tufts of uncombed wool from the feed rollers and in swinging fashion make an orbit, descending near the slowly revolving comb circle, and leaving the wool on their vertical pins to return for a further supply. The circle travels to the square motion. This consists of fallers of special shape, which rise and pierce the tufts of wool overhanging the pins of the large circle. By drawing away from the comb circle, they comb the tufts of wool. The shape of the faller in its relation to the comb circle and the pinning of the fallers make this system of combing the most perfect. The end of the faller first in contact with the fringe is farthest away from the circle, and has the most open set in pinning. This combination results in the wool's being pierced first on the extremity of the fringe with pins 11 to the inch. Gradually nearing the circle and thus combing a longer length of fringe, the pins in work are increased to 15, then 21, 23, and finally 28. One is reminded when studying this machine of the story of Heilmann's inspiration, and the principle followed in the square motion is more in accordance with the story than even that followed in the Heilmann comb. The inventor is said to have been seated in his home, while one of his daughters combed her hair. His attention was drawn to the manner in which his daughter first with the coarse end of the comb, started at the tip of her tresses, and gradually worked down with increasing length of stroke until she reached the root end of her hair. She then repeated the whole process with the fine end of the comb. To the inventor these were the very movements desired for machine combing, so that fibres could be straightened without breaking them. In the Holden comb we see this principle followed at the square motion, and this repeated action of combing through the fringe of wool overhanging the large circle is the secret of successful combing on this machine. The fallers do not comb all the fringe. They approach to within a few millimetres of the main comb, but this length of fringe, small as it is, may harbour neps or noil knots. To comb this very small length of fringe beyond the reach of the fallers a very complex mechanism, known as the segments, is required. This is another comb circle, with inverted pins, of slightly bigger diameter than the other circle, in order to embrace it, but made up of sections or segments, which only descend to the combing level, at the drawing off rollers position. Segment by segment they descend, and, moving at the same rate as the lower circle, they take up a position which ensures that the work of combing is thoroughly done, and every portion of the wool combed. Noil is removed at three places on this comb ; first by the fallers (robbings); second, by a small inverted circle beyond the drawing off rollers (backings) ; and finally by noil knives in the circle (noil). The complexity of this machine has been against its general adoption, and, while it is recognized as a very efficient comber, only two firms in this country use it.

The French Comb. The French comb is also known as the Heilmann or the Continental comb in this country. There are several types of this comb, known as the Schlūmberger, the Sociéte Alsacienne, and the Grün. These vary only in detail, for the principle is the same



By the courtesy of *Messrs. [illegible]. Smith & Son*

FIG. 9

FRENCH COMB

and remains as Heilmann himself arranged it in 1846. It is unlike other combs, which have a similarity by reason of their possessing large horizontal circles. The comb of the Heilmann machine is 16 in. long and 6 in. diameter, which is small compared with the 43 in. to 50 in. diameter of the other comb circles. Around this comb, and in close proximity are arranged all the necessary parts, and, indicative of its small size, the floor space required is merely 3 ft. by 4 ft.

It is invaluable for combing short wools, and even the longer noils, rejected by the other combs. The small setover, 15 in., makes it necessary for the comb to run quickly to obtain anything like a reasonable turn off. Even when it is running at the normal speed of 100 revs. a minute, the output is only from 120 to 150 lb. a day, varying according to the wool in work. The above speed is quick running when it is remembered that in $\frac{3}{5}$ of a second the wool must be successively fed forward, held by nip jaws, combed through by 18 rows of pins on the circle, seized by drawing-off rollers, which pull the wool through the intersecting comb, and effect a piecening with the previously combed tuft on the leather sheet in front of the box. All these movements in so short a time, with parts moving toward each other to within one mm., demand careful setting and accurate timing of all parts. This is simplified by there being one main shaft in the machine, from which almost all parts receive their motion. The machine made by the Société Alsacienne is shown in elevation in Fig. 10.

The feeding box consists of a lower grooved plate upon which the wool is supported, slotted plates for helping the wool forward, and a brass plate pinned on its under side with eight rows of pins, these rows coinciding with the slots in the middle plate, through which they alternately pierce and withdraw, just as the wool is either combed or fed forward respectively. The nip jaws are lightly constructed, but are strong enough to hold the wool while the circular comb pins pass through the fringe. When the last row of pins has

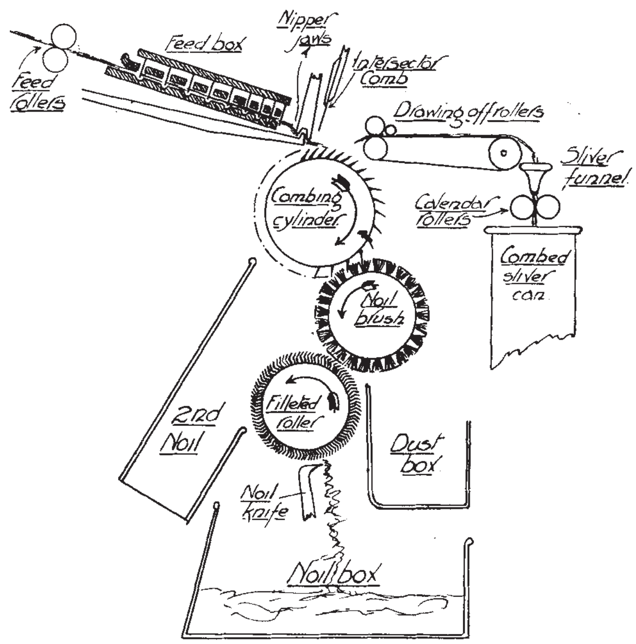


Fig. 10

ELEVATION OF FRENCH COMB

passed clear, the nip jaws release their hold, and the fringe is taken by the drawing off rollers, which move in towards the fringe for this purpose. At the same time the pins of the intersecting comb pierce that part of the fringe already combed, and with the sliver supports in position, ensuring that all fibres pass through the pins of the intersecting comb during drawing off, the combing is completed. The wool is drawn off in tufts, only the fibres actually gripped by the rollers being passed forward to the delivery apron. By a well timed reciprocating motion, capable of adjustment,

TABLE V

DETAILS OF PINNING OF COMBING CYLINDER

Separating Segments : for all Wools

Row.	Pins per Inch.	B.W.G.	Row.	Pins per Inch.	B.W.G.
1	10	20	6	30	24
2	12	20	7	30	24
3	15	20	8	35	24
4	20	21	9	35	24
5	25	22			

Finishing Segments

For Fine Wool.			For Medium Wool.			For Long and Coarse Wool.		
Row.	Pins per Inch.	B.W.G.	Row.	Pins per Inch.	B.W.G.	Row.	Pins per Inch.	B.W.G.
10	40	26	10	40	26	10	40	26
11	48	27	11	40	26	11	40	26
12	56	27	12	48	27	12	40	26
13	66	28	13	48	27	13	48	27
14	71	29	14	56	27	14	48	27
15	71	29	15	66	28	15	48	27
16	71	29	16	66	28	16	56	27
17	76	29	17	66	28	17	56	27
18	76	30	18	66	28	18	56	27

these tufts are pieced together and form a continuous sliver.

Tearage. This term refers to the removal of short fibres in the wool combing process. It is an important subject both from the standpoint of costing and from its effect upon the spinning property of the wool. The wool buyer in the worsted industry must always bear in mind that short fibres are rejected in the combing process, and are then worth less than half the value of the long fibres. In estimating the value of any lot of wool, it is necessary for him to examine it for this feature in addition to those previously mentioned. Wools vary considerably in this respect. Long wools of normal character may lose 1 in 10 in " tear " or even less in the case of good wool. Shorter wools often " tear " more freely, and cases have been known where top and noil were about equal, or 1 in 2. These proportions of top and noil from any lot of wool are always spoken of in the trade as a ratio, and not as a percentage. Thus the long wool referred to above would be stated to " tear " 9 to 1, and the short wool 1 to 1. A good shafty merino wool should " tear " at least 5 to 1.

It is possible for the comber to vary the " tearage " to some extent by resetting certain parts of the machine. If for the purpose of increasing the value of the top he is asked to make more noil, he resets the comb and, by turning fibres of a slightly longer length into the noil, he satisfies his customer's requirements. The noil percentage can be increased by careless work in cleansing and carding, but this results in tops of less value being made, although the noil ratio has increased.

Combing charges are based on " tearage," as the following figures show. For combing merino wools tearing 5 to 1 and over, $5\frac{3}{4}$d. is charged, but for merino wool tearing under 2 to 1, $8\frac{1}{4}$d. is the price per lb.

Top Finishing. None of the combs deliver slivers in anything like order suitable for placing on the market. From the Noble comb a rope-like sliver is delivered made up of four small slivers, two having in them the long fibres, and the other two consisting of the shorter fibres. The Lister and Holden combs deliver hen-wing slivers, that is, slivers having an unequal distribution of fibres, the long fibres being on one side of the sliver, and the short ones on the other. The French comb makes a very unsatisfactory sliver, this being tufted until regilling is done. To arrange these fibres in good order, two or three operations of gilling are arranged, in which the fibres are redistributed, a definite and uniform weight or thickness of sliver determined, and the wool brought up to correct standard by the addition of moisture.

The blending of the fibres is accomplished by means of drafting and doubling. A large number of ends are put up at the first finisher box to regularize the thickness of the sliver delivered in front of the box. A small draft is used, and thus a thick sliver is presented to the second finisher, where only two or three ends are fed up. The draft and doublings of the last box are made to give a predetermined weight of sliver per 10 yds. in the finished top.

Slivers direct from the combs are very dry, and therefore the application of water is an advantage. Wool under normal conditions attracts a certain percentage of moisture, therefore the artificial application simply hastens the process. It is an advantage to allow tops to rest for a period after combing before commencing to put them through the drawing process. This allows the fibres to regain their normal condition regarding length, waviness, etc., and improves their subsequent working considerably.

Recombing. When coloured worsted yarns are required, it is the trade practice to dye the wool in top form, either in balls or wound into hanks. This necessitates recombing the wool. In recombing, the hanks are first unstrung, then unwound from " tin hats," upon which they are placed for convenient working. Two or three gilling processes follow, after which the slivers are combed again. This is absolutely necessary to remove all neps from it. Either the French or the Noble comb is used for this purpose. The first named is considered very suitable, as it is possible to obtain a very small noil percentage by its use. The wool is then finished in the usual way by two gilling operations.

CHAPTER VII

WHERE ATTENUATION BEGINS

Drawing Processes. The processes already described have been concerned in cleansing the raw material from its natural and acquired impurities, arranging the fibres in parallel form, and the production of a " top " sliver consisting of fibres standardized in length by combing out those short " noil " fibres, which, if allowed to remain, would render it difficult to produce a level worsted yarn.

Drawing is the term used in the worsted industry to denote the several progressive operations concerned in reducing the top sliver to a thin roving thread suitable for being spun into yarn on the spinning frame.

The number of operations and machines for each operation in a set of drawing depends on the quality under treatment, the thickness of the roving thread required, and considerations relating to output. Generally the number of distinct operations will be for long wool, 6 or 7, for medium wool, 7 or 8, and for fine, short wool, 9 to 10.

The thickness of the sliver is reduced at each operation by means of draft, which effects a redisposition of the fibres into thinner arrangement by means of two pairs of rollers running at different surface speeds. The difference between the speed of the intake or feed roller and the delivery or the drafting roller equals the amount of draft or reduction applied to the material, Fig. 11. Two or more slivers or slubbings are put up at the back of each machine. This is termed " doubling." Drafting must be accompanied by doubling to permit repeated drafting to be performed, the doublings at the same time improving the levelness of the thread. The draft imposed exceeds the doublings, and thus the sliver delivered by each operation is finer than any one of

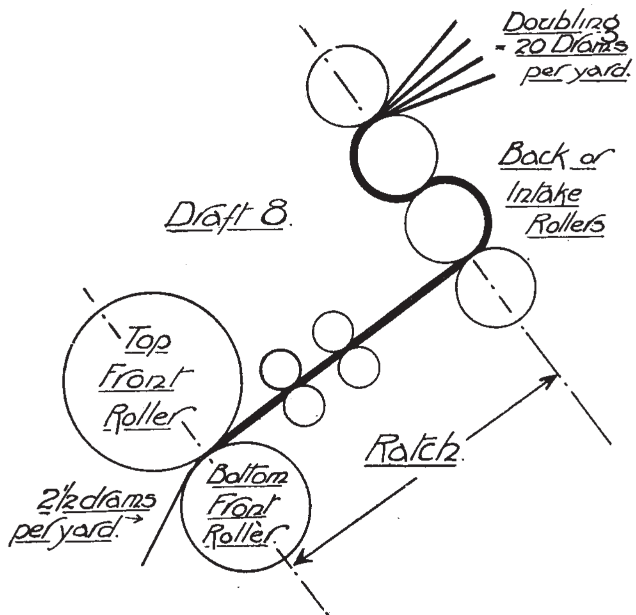


FIG. 11

ELEVATION OF DRAWING BOX ROLLERS

the slubbings composing the doublings fed into the machine.

The right determination of the drafts, doublings, and number of operations required in a set of drawing for any particular lot of material constitutes the overlooker's and manager's most important work.

A matter of importance in manipulating wool is that it should not be drafted twice in the same direction consecutively. However well the wool has been combed, the sliver will be still composed of long and short fibres. The long fibres will tend to draw the short fibres unduly forward. Defects arising from this variation in fibre length are considerably minimized by drafting the fibres alternately, first in one direction and then in the other.

The wide range of "top" qualities available, each differing in fineness, length of fibres and other features, has brought into existence three distinct types of drawing; (*a*) The English or open system of drawing; (*b*) the Cone system of drawing; (*c*) the French or Continental system of drawing.

By means of these three systems every type of worsted or "combing" wool and some of the longer so-called "clothing wools" may be satisfactorily converted into roving for conversion into worsted weaving or hosiery yarns.

Each system is suited for the production of a distinct type of roving. Whether a roving or yarn is smooth, lustrous, or soft and full-handling depends to some extent on the type of drawing used in its production. In each system the worsted yarn characteristic—parallelization of fibres—is aimed at. The several drawings are alike, in that in a series of operations the sliver is reduced in thickness by draft, and regularized in thickness by doublings.

Description of Typical Drawing Machinery

Open and Cone Systems. Gilling. The two or three gill boxes which precede the machines properly called drawing boxes serve several purposes, the most important being to open out the top slivers, to operate on the fibres as far as practicable individually, to complete

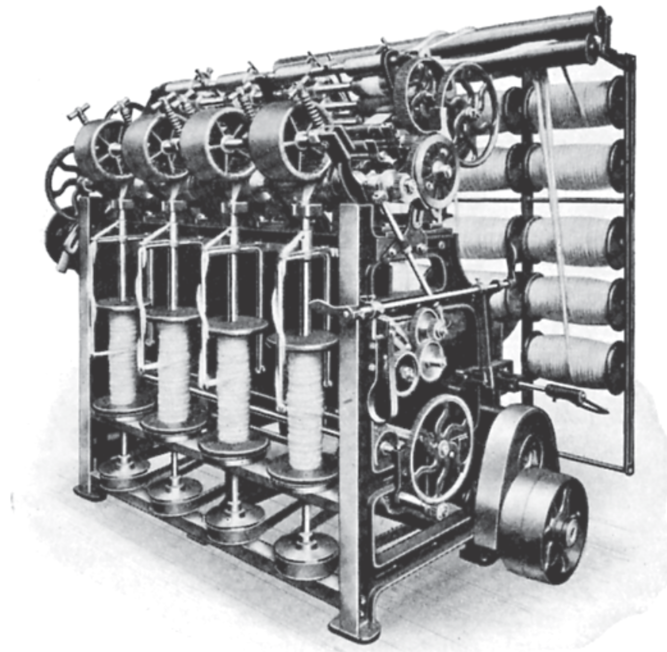


FIG. 12

4-SPINDLE DRAWING BOX

the mixing of qualities and colours being put together, and to improve the levelness of the slivers so as to render easier the work of the succeeding machines.

The parts concerned in drafting and gilling are illustrated in Fig. 13. It will be seen that the gill box

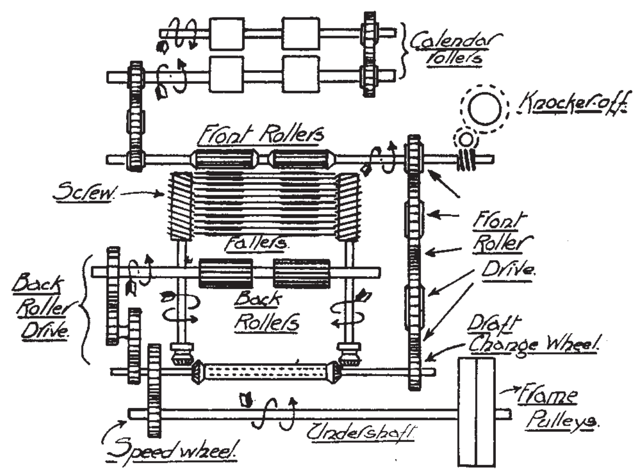


Fig. 13

PLAN OF GILL BOX

embodies back rollers and front rollers. By means of the connecting gearing shown, the relative surface speeds of these may be varied so as to draft the material to a predetermined thickness. The fallers consist of steel bars studded with steel pins, which run between the front and back rollers and control and straighten the fibres as they are drawn forward by the drafting rollers. The two pairs of single or double threaded screws from which the fallers receive their motion are also indicated on the figure.

The fallers travel on two sets of saddles, top and bottom. The top saddles are so placed as to put the centre of the faller pins in a line with the nip of the front rollers. The fallers rotate on the saddles. Cams on the bottom screws serve to lift up the fallers on to the top saddle, and cams on the top screws serve to ensure that the fallers shall drop on to the bottom saddle on attaining their closest point to the roller nip.

The last of the series of gill boxes in a drawing set is termed a spindle gill box, because, while the drafting and doubling is performed as in the preceding can gill box or boxes, the resultant slubbing is wound on bobbins and a slight twist imposed by spindles which combine the functions of winding on and twisting. By means of the twist, the slubbing is given the strength necessary to allow it to be pulled off the bobbins into the feed rollers of the drawing box.

The pins to the inch in the fallers are determined by the fineness and length of the fibres under treatment. Fine fibres require more control in drafting and therefore a denser setting of pins than for long coarse fibres. Usually the pins to the inch for Botany are 16 to 18, crossbred 13 to 16, and long wools 10 to 14.

Drawing, Weigh, Finisher, and Reducer Boxes. An inspection of the drawing sets details given on page 69 will show that this group of machines constitutes the operations following gilling.

These machines in open drawing are built on one plan, but are reduced in strength and dimensional details as the work proceeds and the slubbing becomes finer. Each machine performs the four functions of a drawing box, i.e. drafting, doubling, twisting, and winding-on.

A side elevation view of a drawing box is shown in Fig. 15 indicating back rollers front rollers, carriers or controllers, spindles, bobbins, washers, and wheels connecting back and front rollers, also parts concerned with driving the spindles. The draft change wheel is named and by alteration of its teeth contents the draft can be varied. The twist change wheel is also shown, an alteration of which causes the surface speed of the front rollers to be changed. The spindles have a constant speed and any alteration in the rate of delivery of the front rollers varies the amount of twist imposed on the slubbing or roving.

Roving Boxes. Roving is the last operation in a drawing set and the fine thread produced must be level, free from slubs, knots and grease marks, and of a weight for 40 yards as will permit it to be spun to the required counts without excessive or deficient draft. The turns to the inch imposed on the roving require careful regulation. It must be an amount which will permit free fibre movement during the drafting operation in the spinning.

If the rovings are to be well cellared, that is, given a period of rest before being passed to the spinner, the twist must be on the soft side ; if they are to be spun new, it should be on the hard side.

Intermediate Control in Drafting. It has been pointed out that the pins of the fallers control the fibres during drafting treatment in the gill boxes. As no pins are used in open and cone drawing boxes other means of control must be adopted.

The control of the longer fibres is obtained by means of the twist imposed on the slubbing and by setting the nips of the back and front rollers a distance apart equal to the length of these fibres.

This distance is termed the ratch (Fig. 11). The intermediate and short fibres are controlled by means of the carriers and tumblers indicated. Roving levelness largely depends on the correct setting of these. The slubbings in their journey from back to front rollers

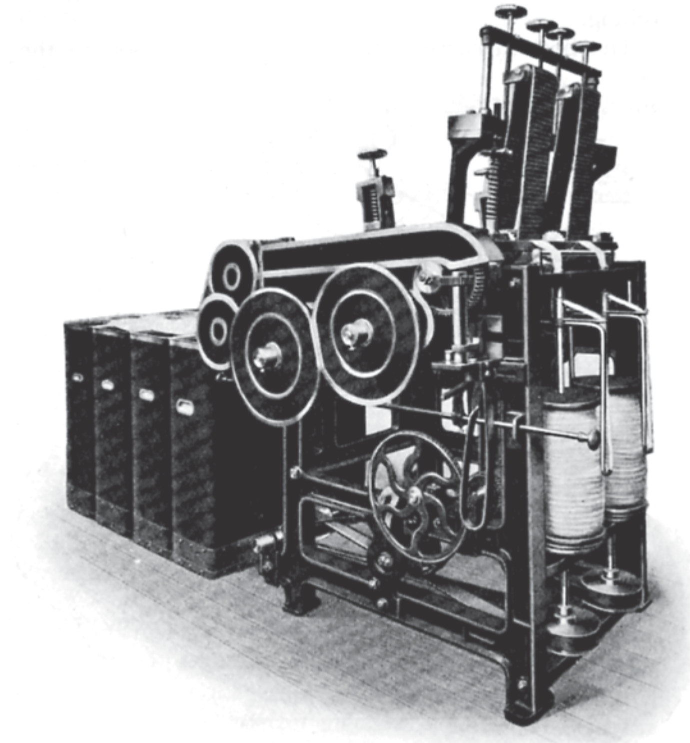


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FIG. 14

SPINDLE GILL BOX

rest on the bottom carriers. The top carriers, termed tumblers, rest on the slubbing and prevent it from rolling.

The bottom carriers are adjusted in relation to the

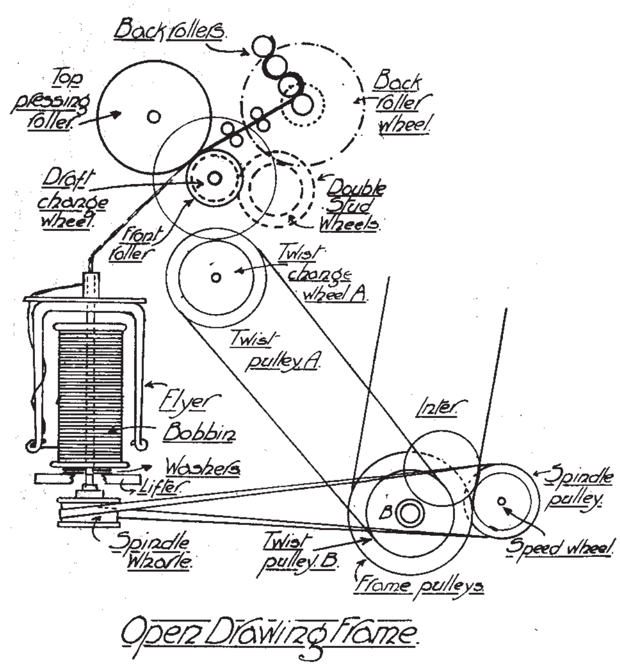


Fig. 15

nip of the front rollers so as to control the shortest fibres ; the top carriers are set so as to effect control in an intermediate position, this being determined by the average length of the fibres composing the slubbing.

English or "Open" System of Drawing. The machines in this system are simple in construction, and adaptable for the treatment of long-fibred wools, cross-bred wools, shafty merinos, mohair, and alpaca. It produces rovings suitable for making typical worsted yarns, which give smartness and definition of design to fabrics in which they are used. It is also the best system of drawing for preparing rovings for yarns intended for lustres, linings, low and medium serges, and coatings.

An inspection of the list of machines constituting a set of open drawing, (Table VI) will show that the

TABLE VI

ENGLISH OR OPEN SYSTEM OF DRAWING

For Long Wool. Capacity about 2,200 lb. of roving a week for 1/30's

No. of Operation.	Name of Machine.	Machines per Operation.	Total No. of Spindles.	Draft.	Doublings.	Drams per 40 yds.	Size of Bobbins
1	Double head can gill	1	—	7	5	255	—
2	2 spin. gill .	1	2	7	5	182	14 × 9
3	4 sp. drawing .	1	4	7	4	102	14 × 9
4	6 sp. drawing .	1	6	8	4	51	12 × 8
5	6 sp. finisher .	2	12	8	4	25·5	11 × 6
6	24 sp. rover .	3	72	8·5	2	6	6 × 3½
7	160 sp. spinning (flyer) . .	17	2,720	10	1	1/30's	—

initial operations are in the form of gill boxes. These are designed to open and level the sliver before it passes to the drawing machines proper. To the uninitiated a gill box is a wonderful machine. Those used in the drawing processes are the same in principle as those for preparing, and described in Chapter V. These are much finer in build, and have many more pins in the fallers. To watch steel bars studded with pins travel from the back rollers to the front rollers, then drop out of sight to reappear again at the back, fascinates the onlooker. Observing further that the fibres rest in the pins for a time and are then drawn forward into the nip of the front rollers, demonstrates the straightening effect of the combined action of the front rollers and fallers. In the first gill box the drafted sliver is run into cans in a twistless condition. The second box gills the material, but imposes twist on the material and winds it on to bobbins in rope-like form, the difference between the product of the can gill and the spindle gill box being simply a matter of twist. Twist plays an important part in securing efficient results in the open system. Without it the material could not be wound on to the bobbins, which the slubbing must pull round to effect winding on. In addition to its winding on function, twist assists in controlling the fibres while they are under draft in succeeding operations and is largely responsible for the roundness, smoothness, and strength of the resultant roving and yarn. Twist is imposed on the material at every operation following the can gill boxes. In each machine, draft neutralizes the twist imposed at a proceeding one, but re-imposes further twist for winding-on purposes. One further effect of the repeated adding and withdrawing of twist at each operation, and always in one direction—clockwise direction of spindle rotation—is to give the fibres a spiral formation in the slubbing, a condition valuable in the spinning operation.

The number of turns to a foot of slubbing to impose at the respective operations is not a matter of calculation but is determined by handle. In starting a new lot in a machine, a few yards of slubbing are first run through. A slight pull by the overlooker on a length about 4 in. longer than the length of the longest fibres in the material will indicate whether the slubbing is too hard for drafting purpose or too soft for winding on. If correct, the fibres will move over one another when the pull is applied. Excessive twist will be indicated by the extra effort required to cause the fibres to move on each other. If too soft, the slubbing will pull apart easily. Too much twist will increase drafting difficulties, entail unnecessary wear and tear on rollers, and reduce output ; while too little twist will cause the slubbing to stretch irregularly or break during winding on.

It is interesting to notice how the slubbing is wound on to the bobbin. An elevation of a drawing frame is given to demonstrate this in Fig. 16. The end coming from the front rollers is passed through a hole in the centre of the spindle, wrapped round one of the flyer legs, and passed through the twizzle to the bobbin.

In starting a fresh bobbin the end of the slubbing is wound round the bobbin a few times to form a connection between the flyer and the bobbin. The bobbin fits loosely on the spindle—without any positive drive—and is free to move up and down the spindle. The bobbin rests on the lifter plate, and as this is made to oscillate slowly, the position of the bobbin in relation to the twizzle of the flyer, winding on can occur over the full length of the bobbin. As the spindle revolves for the purpose of inserting twist on the slubbing, the bobbin will be pulled round. It will, however, by reason of its own weight, and the frictional resistance developed by contact with the washers resting on the lifter plate, hold back as much as possible. The retardation will be governed by the rate of delivery of the slubbing by the front rollers, which will be just sufficient to take up and wind on the length of slubbing delivered. The speed of the bobbin will be the speed of the spindles, *minus* the number of rings of slubbing put on to the bobbin in any unit of time. It will thus be seen that when the bobbin is of small diameter it will be pulled round to a lesser extent than when it is of larger diameter, In the latter condition its revolution will more nearly approximate to the speed of the spindle than in the former. This is one of the disadvantages of the " spindle lead " system, as the bobbin revolves at its fastest speed when full and weighing its heaviest.

This system is usually designated the " open " system. How the term " open " came to be used is unknown. It may be due to the simplicity of its construction or its frontal appearance. It might be more correct to term the French or twistless system of drawing " open," because of the openness of the fibre arrangement in sliver and roving, in contradistinction to the closed or twisted arrangement of fibres in the English system.

Cone System of Drawing. This is English in origin and is the system of drawing used in the cotton trade. Primarily modelled for treating the short cotton fibres, it has been adapted for worsted purposes. As the bobbins are positively driven, and can be regulated to take up the slubbing with a minimum of tension and twist, the system comes in very useful for producing roving softer and fuller in handle than can be produced on the English or " open " system.

As already stated, the mechanical features differentiating " cone " from " open " drawing, are in connection with the winding of the slubbing on to the bobbins, and the regulation of the tension applied in the process. In the latter system the bobbins are without mechanical control. In the former, the bobbins are positively controlled and driven by means of gearing, so that their uptake of material at any point of filling is kept exactly in agreement with the delivery of slubbing from the front rollers. The advantages from the material point of view arising from this mechanical regulation of bobbin speed will be obvious. Less strain will be put upon the fibres than is imposed in the " open " system, with a considerable gain in roving softness and fullness. In addition, a minimum amount of twist can be applied to suit the requirements of the material. This facilitates the movement of the fibres when under draft and preserves intact their strength and elasticity. Comparing identical materials worked on the " cone " and " open " systems, those worked on the former will have a better spinning property because of the differences mentioned. For high class coating and hosiery yarns from botany and crossbred wools, cone drawing gives very satisfactory results. The machinery, however, is more complicated and expensive, and requires highly skilled attendants. It is very unwieldy for small lots, but, for continuous working in large lots, it possesses advantages over any other system of drawing.

Whereas in open drawing the bobbin runs slower than the spindle, giving " spindle lead," in worsted cone drawing the bobbin runs faster than the spindle ; this is termed " bobbin lead." With bobbin lead the speed of the bobbin at any point of filling will be as follows—

$$\text{Spindle Speed} + \frac{\text{Surface Speed of Front Roller}}{\text{Circumference of Bobbin}} = \text{Speed of Bobbin.}$$

indicating that the speed of the bobbin decreases as it increases in diameter and weight.

The French or Continental System of Drawing. This is the twistless method of preparing rovings, and the whole of the processes are designed to promote softness and fullness, rather than the clear definition of yarn outline by the use of open drawing. The distinguishing feature of this type of drawing is that no twist is imposed on the material, with the result that the fibres are free in arrangement, soft to handle, and lofty in appearance. A prime factor in maintaining fibre separateness is that the material is drafted through porcupine pins functioning close to the nip of the drafting rollers, as seen in Fig. 16. This pin treatment at each operation serves to control the whole of the fibres—long and short—during the drafting process, and acts in this respect more satisfactorily than the tumblers, carriers, twist, and ratch, which are the controlling factors in the open and cone systems of drawing. As a substitute for twist, the slivers, after

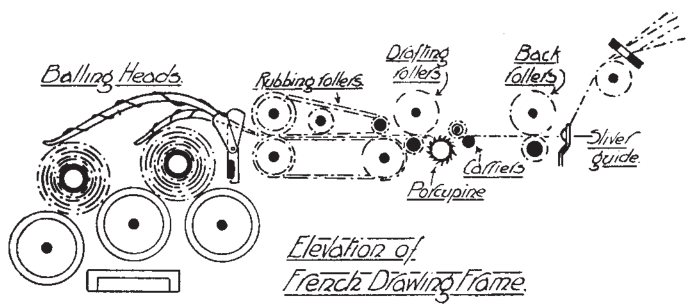
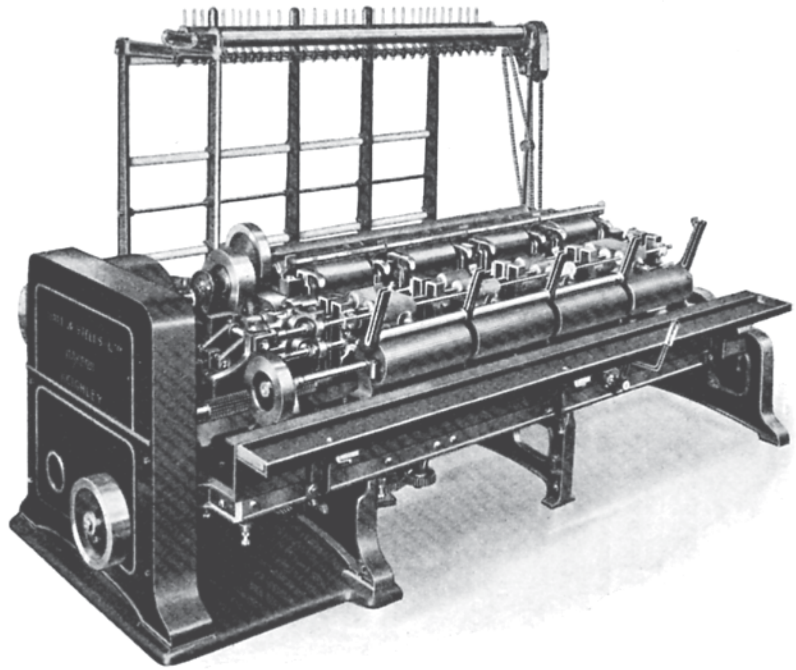


Fig. 16

leaving the drafting rollers, pass between oscillating rubbing leathers. These rub the slivers into a round pith-like form, and give a firmness and strength which enables them to be placed on bobbins and be drawn off into the next machine. Operating without twist makes a difference in the lie of the fibres in the roving and yarn. In the open and cone systems twist tends to place the fibres in spiral formation in the strand. In the French system the waviness and crosswise arrangement of fibres are secured.

Very small diameter drafting rollers are used, which enable shorter-fibred material to be satisfactorily converted into roving.

Fig. 17 is a perspective view, and Fig. 16 shows an



By the courtesy of Messrs. Hall & Stells

FIG. 17

FRENCH DRAWING FRAME

elevation of a French drawing machine, in which the creel, top and bottom back rollers, top and bottom carriers, porcupine, top and bottom front or drafting rollers, rubbing leathers, and balling head are indicated.

TABLE VII

DETAILS OF FRENCH DRAWING SET

No. of Operation.	Name of Machine.	Doublings.	Draft.	Weight for 40 yds.
1	1st can gill, O.P.S. .	6	6	256 drms.
2	2nd can gill, O.P.S. .	4	5	205 ,,
3	4 head 1st draw box	4	4	205 ,,
4	4 ,, 2nd ,, ,,	2	4	103 ,, double meche.
5	8 ,, 3rd ,, ,,	2	4	52 ,, ,, ,,
6	16 ,, reducer box	2	4	26 ,, ,, ,,
7	16 ,, slubber box	4	$4\frac{1}{8}$	25 ,, ,, ,,
8	20 ,, 1st intermed.	4	$4\frac{1}{8}$	24 ,, ,, ,,
9	20 ,, 2nd ,,	4	4	24 ,, ,, ,,
10	40 ,, rover . .	2	4	12 ,, ,, ,,
11	Two 40 head finishers	2	4	6 ,, ,, ,,

Production : 3,000 lb. a week of 48 hours.

Top Testing. Before describing the various types of machines used in the several systems of worsted drawing it will be useful to consider the method employed in analysing top slivers to determine the treatment necessary to obtain the best results.

Fig. 18 will convey an idea of the wide range of wool qualities used for making worsted yarns. These are shown in the form of top staples. It will be seen that they differ considerably in length of fibre, average length of fibres associated, fineness and waviness. They range from long, coarse 28's Scotch wool to the fine botany, 80's quality. Incidentally, the range demonstrates the need for the three systems of drawing employed, as no one type of drawing, however constructed, could suitably treat long, medium, and short fibres. With the three types of drawing, the whole range

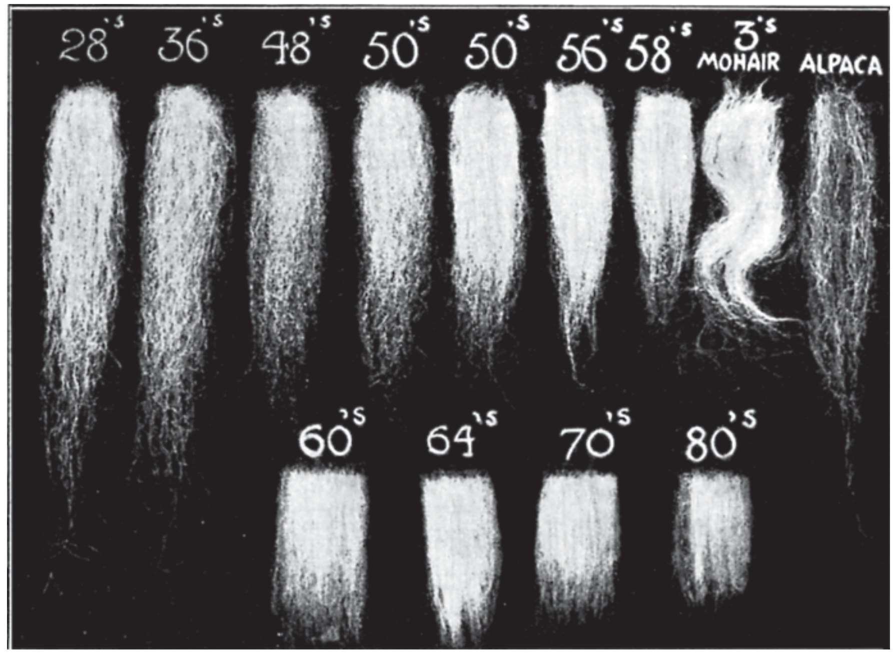


Fig. 18

TOP STAPLES

of qualities can be properly manipulated, and softness or clearer definition of yarn outline obtained.

It is the duty of the overlooker before starting to process a bulk lot of tops to examine these carefully for features of length, uniformity of length, fineness, and (so far as he is able) the capacity to spin to the yarn counts desired. From a correct determination of these he will be able to arrange the drafts, doublings, and number of operations necessary to give the best roving, and subsequently the soundest yarn. Other features being equal, the tops possessing the finest fibres are the most valuable and will spin to the finest counts. Being relatively finer they will carry a greater number of fibres in the cross-section of a given yarn than will those fibres which are thick and coarse.

Uniformity of length is an important factor in assisting in the production of a level yarn. If the fibres are uniform in this respect, they must be thoroughly mixed in the gill boxes and treated in the drawing so that the various lengths of fibres associated are uniformly distributed over the whole length of the roving. Unless this is attained, irregularity in yarn results and bad spinning ensues. When a large percentage of abnormally short fibres is present, the difficulties of making a round level yarn are increased.

Top Staples. Overlookers and managers should be proficient in making top staples and figures. Top staples are shown in Fig. 18 and are made by taking a length of the top under analysis and, after pulling away the loose fibres from the end of the top, place the ends of the farthest projecting fibres on the edge of a velvet board under the thumb of the left hand. Drawing away the length of top will leave on the board a tuft of fibres. Repeated drawings in this way, always drawing the farthest projecting fibres, will build up a

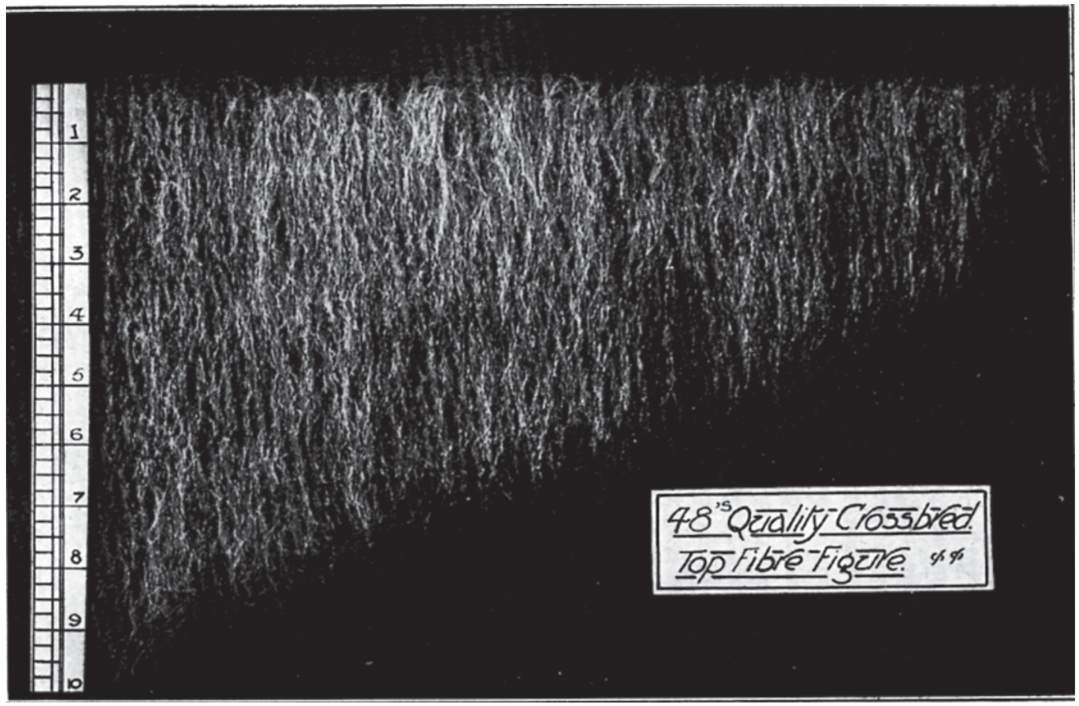


FIG. 19

top staple containing all the various length of fibres comprising the top, and as one end of every fibre in the staple is in line with the edge of the velvet board, the proportion of long, medium, and short fibres will be discernible and factors relating to value, processing and spinning property deduced by inspection.

Fibre Figures. For more detailed and complete analysis of a top a fibre figure such as that shown in Fig. 19 is useful. Skill in making these accurately is a valuable possession. It will be seen that the fibres are laid in single formation across the velvet board, one end of each fibre at the edge of the board. In this form the longest fibres come at the one side of the board, the shortest at the other end, with the intermediate lengths suitably graded between. An inspection of such a fibre figure gives opportunity to measure the maximum and minimum and mean length of fibres in the blend, and affords data as to the diameter and waviness of the fibres due to their showing up distinctly against the black velvet or serge cloth on which they rest.

The process of making a fibre figure consists in taking a top staple, holding the thickest end between the finger and thumb of the right hand, then placing the ends of the longest fibres on the edge of the velvet board and, under the thumb of the left hand, drawing the top staple gently away, taking care to permit the withdrawal of only the fibres held by the left thumb on the board. This operation is repeated, always drawing away the longest fibres remaining on the board. The work requires to be carefully done. The points to observe are : (1) Draw away only a few fibres at a time ; (2) place the same number of fibres in every inch across the board ; and (3) have just enough fibres in your staple so as to finish it at the end of the board.

CHAPTER VIII

WHERE ATTENUATION FINISHES

SPINNING is a single operation and is designed to convert the roving produced in the drawing into yarn form. The fineness or diameter of a worsted count is indicated by its count number, these numbers being based on the number of hanks of 560 yards, which equal 1 lb. avoirdupois.

Thus 1 hank	=	560 yds. in length weighing	1 lb.	is termed	1's	count.
,, 1 ,,	=	560 yds. ,, ,,	$\frac{1}{2}$ lb.	,,	2's	,,
,, 1 ,,	=	560 yds. ,, ,,	$\frac{1}{8}$ lb.	,,	8's	,,

$$\therefore \frac{\text{1 lb. avoir.}}{\text{Weight of 560 yds.}} = \text{counts ; as } \frac{\text{256 drams}}{\text{8 drams}} \text{ would equal 32's counts.}$$

It follows therefore that—

64's counts	= 64	hanks per lb.	and will contain	560 × 64 yds.	=	35,840	yds. per lb
32's ,,	= 32	,,	,, ,,	560 × 32 yds.	=	17,920	,, ,,
16's ,,	= 16	,,	,, ,,	560 × 16 yds.	=	8,960	,, ,,
1's ,,	= 1	,,	,, ,,	560 × 1 yds.	=	560	,, ,,
·5's ,,	= ·5	,,	,, ,,	560 × ·5 yds.	=	280	,, ,,

The typical worsted yarn consists of fibres arranged in as parallel order as possible, and overlapped to the extent required by the counts of the yarn. Brightness of appearance and cylindricity are also important characteristics. The tendency to felt in the resultant fabric is not an essential requirement for most purposes. Uniformity of diameter and strength is important. The excellence obtained in these two respects depends largely on correct processing in drawing, ensuring an equal distribution of long and short fibres composing the blend. Given a good roving, and providing the material is not spun over its counts limit, the spinner should easily produce a level yarn. Yarn which varies in diameter is termed " twitty."

Twist plays an important part in spinning. The twist imposed is usually stated in turns per inch. Thus a yarn given as 60's, and 19 turns, indicates that the yarn is 60's count, and has 19 turns of twist to the inch. The turns imposed will be generally more for fine yarns than for coarse. Twist affects the levelness of the yarn in consequence of its tendency to settle on the thinner places in greater proportion than on the thicker places of an uneven yarn. It thus aggravates yarn unevenness. A softer twisted yarn will look better than one hard twisted. The purpose for which the yarn is intended determines the number of turns per inch to be applied. Yarns for the knitting industry will be soft twisted. Those for weft will be bound together with medium twist ; and those for warp purposes will be, relatively, hard twisted. Twist for warps and weft is not a matter of calculation, but depends on (1) the spinner's requirement to enable him to spin the yarn, and (2) the manufacturer's requirements in cloth building.

There are four types of spinning frames used for the production of worsted yarns.

Throstle frames	(1) The flyer spinning frame (2) ,, cap ,, ,, (3) ,, ring ,, ,,	These embody the principle of continuous and concurrent drafting, twisting and winding-on.
	(4) The worsted spinning mule	This is distinct from the throstle types in that the 3 functions of spinning, drafting and twisting and winding are intermittent.

The enormous variety of worsted yarns produced, differing in counts, appearance, softness, twist, lie of fibres, and in the peculiar features required for the weaving, knitting and fancy yarn trades, prevents any one system of spinning meeting the whole of the requirements. All the four types are in use at the present time and there is no sign that any one can be dispensed with.

Construction of Spinning Frames. The continuous spinning systems—flyer, cap, ring—are alike in respect of drafting the roving into yarn form, but differ in method of inserting the twist on the yarn and in winding-on.

Fig. 20 illustrates the three types and shows the variation in build of the machines below the nip of the front rollers.

Flyer Frame. This is the oldest type of worsted spinning frame and has for its progenitor Arkwright's "water frame." The yarn after leaving the front roller passes through a hole in the centre of the flyer or spindle, is then wound round one of the legs of the flyer, and passes on to the bobbin. The bobbin is loose on the spindle and therefore free to revolve by the pull of the yarn. Its own weight, and the friction developed by its contact with the tensioning washers resting on the lifter place, compel it to retard behind the revolutions of the flyer, enough to wind round itself the yarn coming from the front rollers. The number of turns to an inch imposed on the yarn is determined by the delivery of the front rollers in relation to the speed of the spindles, i.e.

$$\frac{\text{Revolutions of spindles a minute}}{\text{Delivery of Front Rollers a minute (in inches)}} = \text{Turns by the inch.}$$

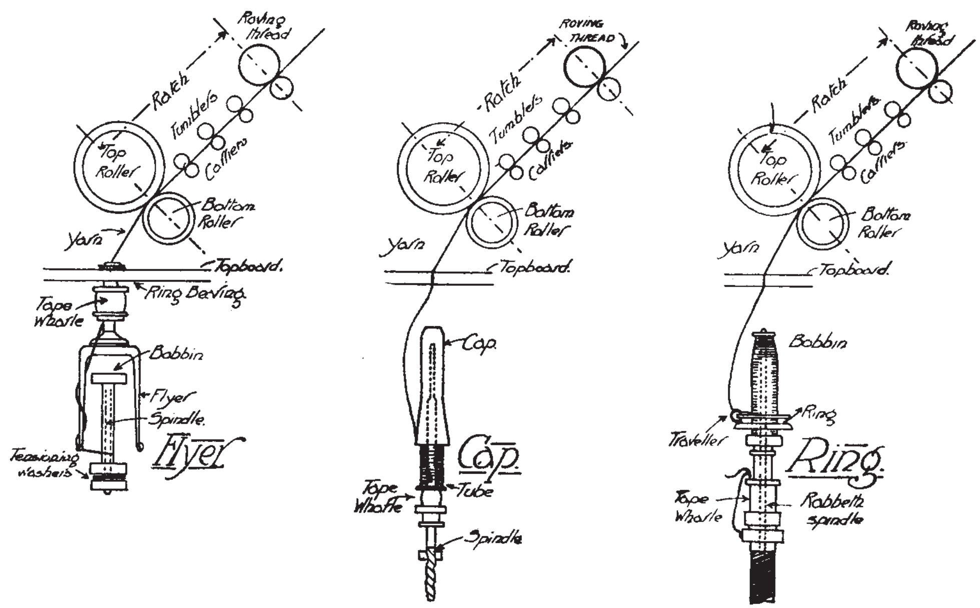
One turn of twist is imposed on the yarn at each revolution of the flyer. In this respect it is superior to the cap and ring spinning systems, these being slightly defective and variable as regards twist insertion, on account of their systems of winding-on.

The flyer system is without a rival for producing smooth yarns from long English wool, mohair, alpaca, and clear surfaced yarns of finer materials. This is due to the relatively slow flyer speed which on the mechanical doffer type of machine ranges from 2,800 to 3,200 revolutions a minute, according to the material under treatment. What is lost in quantity of output is recovered in quality of work produced.

Cap Spinning Frame. The cap frame, shown in Fig. 21 is the most productive worsted spinning frame and the type in most general use. It is simple in construction, easy to manipulate and doff, and easiest for piecing up of broken ends. Except for short wools, in the spinning of which the mule machine is superior, it is the best frame for spinning fine wools and fine crossbreds for warps and weft.

Neither the spindles nor the caps revolve. Running easily on each spindle is a brass tube shown in Fig 20 with a whorle at its base, round which passes the tape communicating speed from the cylinder. The bobbins are placed on the tubes and are made in doffing to catch on nugs fixed on the tubes, to ensure that bobbin and tube revolve at the same speed.

The method by which the yarn is wound on to the bobbin on a cap frame is somewhat of a problem except to the careful observer. In the flyer frame the yarn is wrapped round the bobbin by the flyer twizzle. The cap serves no such purpose. The edge simply guides the thread to its proper position on the bobbin, and has no other function in winding on than this. Winding on is effected by centrifugal force developed by the high speed at which the yarn revolves round the cap in the process of winding on. The average speed at which cap frames (bobbins and tubes) are run is about 7,000 revolutions a minute. When a cap frame is started and the end fastened properly to the bobbin, the high speed of the tubes causes the yarn to balloon round the cap as indicated in Fig. 20. The resistance of



Roving thread
Ratch
Tumblers
Calliers
Top Roller
Bottom Roller
Yarn
Topboard.
Ring Bearing
Tape Wharle
Bobbin
Flyer
Spindle.
Tensioning washers
Flyer
ROVING THREAD
Ratch
Tumblers
Calliers
Top Roller
Bottom Roller
Yarn
Topboard.
Cop.
Cop.
Tape Wharle
Tube
Spindle
Roving thread
Ratch
Tumblers
Calliers
Top Roller
Bottom Roller
Yarn
Topboard.
Bobbin
Ring
Traveller
Ring.
Tape Wharle
Rabbeth spindle

FIG. 20

the air retards the yarn's balloon behind the revolutions of the tube, thus causing the yarn to be wound on to the bobbin in the opposite direction to the direction of revolution of the tube. It will thus be seen that the number of turns put into the yarn equals the revolution made by the yarn as it balloons round the cap, which is not the same as the number of revolutions made by the tube. Thus the twist inserted on cap yarn is slightly variable and depends on the diameter of the bobbin at the point of winding on.

In this, as in all other spinning frames, the left or right angle of yarn twist may be obtained by running the tape or band on to the spindle from the cylinder so as to give the direction required.

Alternative methods of increasing or decreasing tension or drag on the yarn in cap spinning to suit different classes of materials and yarns—

1. Increase or decrease speed of tubes;
2. Raising or lowering of spindle rail;
3. Increasing or decreasing diameter of cap;
4. Increasing or decreasing diameter of bobbins.

Ring Spinning System. The ring frame is chiefly employed to secure a smoother yarn than can be obtained on a cap frame, though it cannot equal the flyer frame in this respect. Its advantage over the flyer frame is in the greater output possible, though the high speed of the cap frame cannot be equalled. Generally it may be considered to hold an intermediate position so far as spinning worsted yarns are considered. The ring frame is favoured by those who wish to produce low crossbreds and English yarns quicker and cheaper than is possible on the flyer frame, or finer crossbred yarns smoother on the surface than cap spun.

This type of frame differs considerably in its method

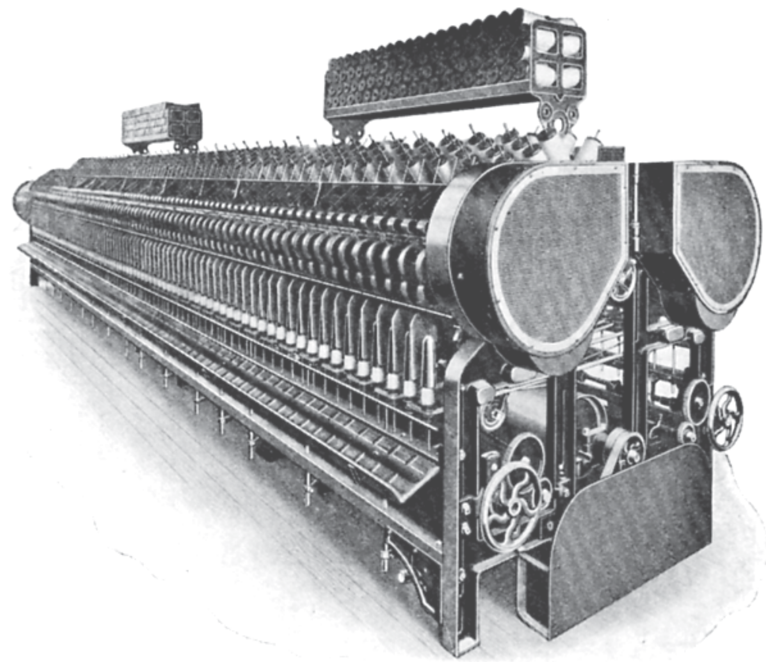
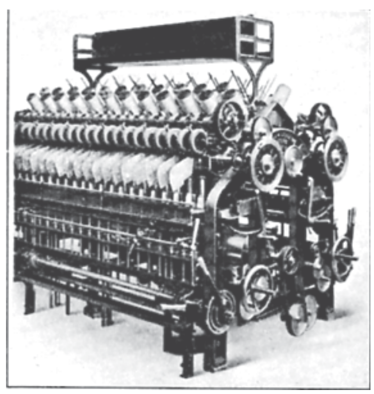


FIG. 21

CAP SPINNING FRAME

of winding on from both flyer and cap frames, *see* Fig. 20, where is an elevation of ring spinning frame. A perspective view of a ring frame is shown in Fig. 22. The spindles are of the Rabbeth type. Each spindle is a steel tube supported by and rotating in a bolster cup in two parts, charged with oil which freely lubricates the



By the courtesy of *Messrs. Hall & Stell*

FIG. 22

RING SPINNING FRAME

spindle. The whole is compounded with the spindle on which the bobbin is placed, bobbin and spindle revolving at the same speed. Each spindle occupies a position in the centre of a ring fastened to a traversing lifter plate, on the flange of which is placed a small steel traveller free to rotate on the ring. The yarn coming from the front rollers is threaded through the traveller on the ring flange and then fastened to the bobbin. Winding-on of the yarn is effected by the traveller lagging behind the revolution of the spindle, the yarn thus being drawn on to the bobbin in the opposite direction as the rotation of the spindle. If the travellers revolved at the same speed there would be no winding on. Thus the same slight variation in twist insertion occurs on the ring frame as on the cap frame. In this system the part guiding the end on to the bobbin traverses, and the distance between the nip of the front roller and the ring plate will be constantly varying, being shorter when the plate is at the top of its traverse and longer when it is at the bottom. Thus a second cause of twist variation is noticed, and, as more rings of yarn are put on the bobbin on the up traverse, a little less twist will be put on the yarn than on the down traverse, where fewer rings of yarn are added to the bobbin.

Whilst these twist irregularities are only slight, they may be important in special cases. The travellers are the usual changeable factor for varying the tension on the yarn. The heavier the traveller the bigger the tension put on the yarn during winding. A lighter traveller will cause more ballooning of the yarn around the spindle and bobbin, and apply less tension. Again the distance between the traveller and the surface of the bobbin will affect the tension on the yarn, and such tension will be proportionate to the angle formed by the yarn where it passes through the traveller. Such angle is acute when the bobbin is of small diameter and becomes obtuse as the bobbin fills. The nearer the traveller is to the surface of the bobbin, the less will be the tension and the better the spin. It should be noted that two forces act upon the traveller at the same time which compel it to move in a circle, centrifugal, tending to throw it away from the centre, and centripetal, which exerts a counterbalancing pull towards the bobbin.

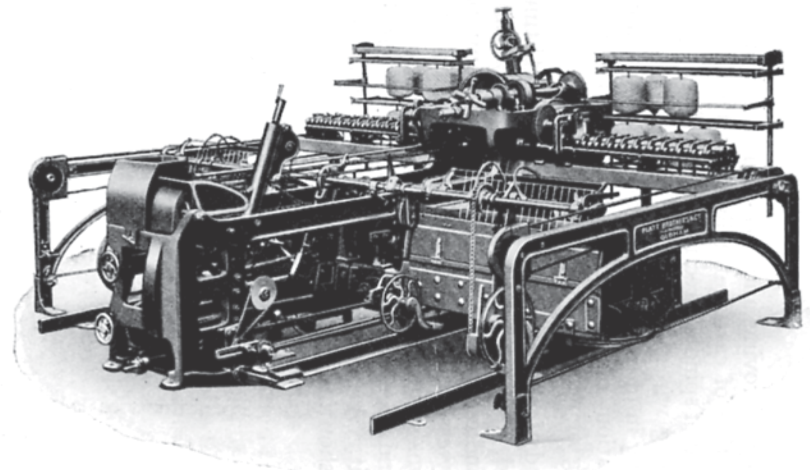
Ballooning is influenced by—

(*a*) Counts of yarn ;
(*b*) Pull of the traveller ;
(*c*) Pull of the yarn ;
(*d*) Atmospheric resistance.

Mule Spinning. The mule spinning frame is one of the most complicated machines in use. Only to a very limited extent has it come into use in the worsted industry, but it is the type of spinning frame most extensively used in the woollen and cotton industries.

It is a combination of the principles embodied in Hargreaves' spinning jenny—the progenitor of the woollen mule—and Arkwright's water frame—the progenitor of the flyer, cap, and ring frames. Because of its hybrid origin it was given the name of " mule." Many reasons may be advanced for its meagre adoption in the worsted industry. Amongst these the superiority of the throstle spinning frames for working long and medium wools is the most important. Its lower output, complexity, and cost by the spindle, have also been deterrents. Its use, however, is on the increase, as the worsted industry utilizes more short-fibred material than formerly, for the spinning of which the mule is unrivalled. In addition, Bradford, the centre of the worsted industry, is catering to an increasing extent for the knitting trade requirements. For these yarns, softness, elasticity, and fullness, are essential requirements.

The throstle spinning system, where the three operations involved in spinning—drafting, twisting, and winding-on—are performed continuously, enables a comparatively simple machine to be employed. In mule spinning the separation of the winding-on operation from that of spinning and twisting—these alternating in action—constitutes its greatest weakness as



By the courtesy of *Messrs. Platt Bros.*

FIG. 23

WORSTED MULE

a spinning device, and is also responsible for the structural complexities.

The cycle of movements made by the mule in performing the three functions of spinning may be summarized thus—

1. Drafting of roving and recession of carriage.
2. Arrestation of carriage at limit of stretch.
3. Reversal of spindle direction and placing of winding and tensioning wires in position.
4. Drawing in of carriage and winding yarns on cops.
5. Arrestation of carriage near front rollers and withdrawing of winding and tensioning wires.

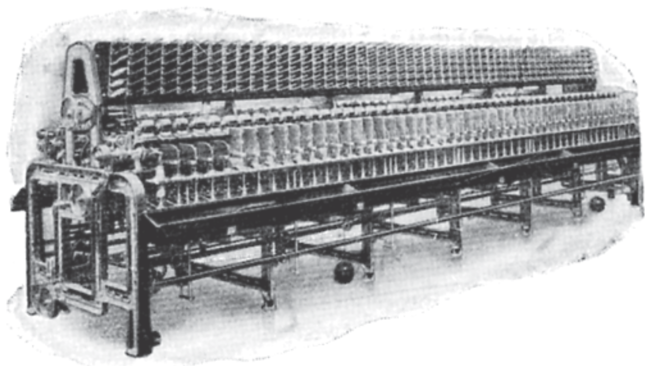
This round of movement is performed about $4\frac{1}{2}$ times a minute, and, as each mule frame will carry from 600 to 800 spindles, perfect timing of the many parts is absolutely essential. It is only because of the superiority of yarns spun on the system that such marvellous patience and perseverance have been exercised in perfecting it. A photograph of a model mule of 100 spindles is shown in Fig. 23.

CHAPTER IX

BETWEEN SPINNING AND WEAVING

Twist in Yarns. When it was first discovered that fibres could be overlapped and put into a fine thin arrangement, and that although varying in length they could be disposed so as to form a narrow ribbon of fibres, it would not be long before the discovery was made that, by twisting these fibres round themselves, long lengths of strong yarn could be made, useful for looping or for interlacing at right angles, to construct fabrics for clothing and decorative purposes. The discovery of the possibilities of overlapping and twisting fibres represents the most important event in textile manufacture, as they form the basis of spinning procedure and the essentials in cloth construction. Without twist fibres have very little cohering property. With it the strength, appearance, durability, and utility of the fibres are developed. Twist draws the fibres closer together, and utilizes the strength of the individual fibres in making a thread strong and elastic in proportion to the number of fibres in the cross-section, their surface structure and diameter. Twist may be imposed in small degree, leaving the thread soft, full, and open, or applied to an extent to convert the thread into a hard, brittle and very compact form. The fibre angle made in the yarn by the imposition of twist is valuable to cloth manufacturers, who use it not only for effecting design and peculiar appearance, but to secure an angle of reflection likely to enhance the selling value of the cloth. Thus the natural lustre of the material may be improved or diminished by the way the twist angle reflects the light to the eye. In fancy yarns such as loops, cloud, marls, crêpe, twist contributes the most important part of their value, next to that of the raw material used in their composition.

To impose twist involves the delivery of fibres from rollers suitably positioned and the revolution of a spindle, the gyration of the latter rolling the fibres



By the courtesy of *Messrs. Hall & Stell*

FIG. 24

TWISTING FRAME

round each other as they exude in ribbon form from the front rollers.

Thus the degree of twist put into yarn depends on the rate of delivery from the rollers, and the revolutions of the spindle in a given unit of time. The twist imposed is usually stated in turns to the inch, i.e. if the spindle revolves ten times while the front rollers deliver one inch of yarn, this yarn would be stated ten turns, or ten turns to the inch. The direction of the spindle will determine which way the fibres incline in the thread. If the spindles revolve clockwise, the angle will be from left to right ; ·if in an anti-clockwise direction, from right to left.

In spinning, the right twist, or clockwise direction, of spindle is usual, the anti-clockwise being used for special effects and fancy yarns requirements. In view of what has been stated relative to the strengthening influence of twist it will be understood that its effect in this respect will depend on several factors—counts, quality, and length of fibres associated. Counts can be fixed to meet requirements ; twist is not so easily determined ; the length, quality, diameter, and elasticity of fibres are not constant. Unlike a nugget of gold, which is always alike in specific gravity and character, wool is a variable commodity. It differs according to the locality in which it is produced, type of sheep, and is modified by changes in climate, weather, rainfall, and herbage, during its growth. In addition, the methods adopted for converting it from greasy wool to yarn form may modify or increase the effects of twist imposition. The amount of twist to give a yarn cannot be expressed in mathematic formulae, but must be determined by the amount required to give the fibres the required spinning property, plus an amount—if necessary—required to make it suitable for the purpose for which it is intended. The requirements for warp yarns will differ from those for weft ; those for knitted garments from those for weaving ; and those for fancy yarns demand an amount essential to the peculiar effect desired.

An interesting point in respect to twist is that in yarns which are irregular—twitty—i.e. not perfectly cylindrical, the twist, with mathematical exactitude, settles first on the thinnest part of the yarn, and is then distributed on the other parts of the yarn according to the relative diameter. Twist thus aggravates yarn irregularities, compressing the thinnest parts unduly, leaving the thicker parts proportionately softer and fuller. It follows therefore that two contending interests exercise the spinner's determination of twist, one prompting him to use twist to get good spinning and twisting conditions and reduce waste to the minimum, and the other impelling him to use a minimum of twist, because this gives him greater output and more attractive yarns.

Single Yarns. Single yarns, i.e. those direct from the spinning frame, are used considerably for weft purposes and to a lesser extent for warp purposes. For the latter kind of yarn, the turns to the inch are increased to give the necessary strength and smoothness to withstand the somewhat severe treatment to which warp threads are subjected in the loom. Single yarns are also used in large quantities for hosiery purposes. Where warp yarn is required to be soft twisted to suit fabric requirements, the necessary weaving strength is obtained by sizing. This involves running the warp through a solution of cereal paste, which hardens on the material, and increases the coherence of the fibres. As sizing is only a temporary process—to strengthen the yarn for weaving purposes—it is made of materials incapable of injuring the wool, and easily removable by gentle scouring.

Folded Yarns. In order to obtain a greater measure of strength than can be reached in single yarns, these are folded or twisted together. Smoother and softer effects are the result Also a folded yarn is much easier to manipulate than a single yarn of similar count or thickness.

An interesting fact in connection with the practice of folding and making compound yarns from singles, is that, in the process of uniting the yarns, the twist in each of the respective singles can be either augmented or diminished by imposing the compound twist in the opposite direction to the spinning twist. Thus, if ten turns to the inch have been imposed on two single yarns folded together with eight turns in the opposite direction the twist of the single in the compound thread will be in each yarn two turns. If ten turns to the inch have been imposed on two single yarns folded together with ten turns in the opposite direction, the twist in the single yarns in the compound thread will be nil. If ten turns to the inch have been imposed on two single yarns folded together with twelve turns to the inch in the opposite direction, the whole of the spinning twist will have been removed, and two turns added in the opposite direction to each yarn. Thus, in the last instance, the twist in the single and in the compound thread will be in the same direction.

If ten turns to the inch have been imposed on two single yarns folded together with ten turns to the inch in the same twist direction, the twist of the single will be supplemented by the whole of the folded twist. Thus, after folding, each single yarn will have 20 turns, and ten turns folded in addition. It will be seen that by the simple operation of folding or twisting yarns together, the single twist can be reduced to zero, or developed in either direction. Great use is made of this fact in securing a wide range of yarns to accommodate the requirements of worsted cloth makers.

Counting of Folded Yarns. When worsted yarns are twisted together, the counts of the single yarns are stated, along with an initial figure indicating the number of single yarns put together: thus, two single 30's yarn twisted together would be stated 2/30's. Two single 60's yarn put together would be stated 2/60's, etc. It follows, therefore, that the resultant counts of a twofold thread are half the single counts stated.

A threefold thread is one-third the single counts stated, and a fourfold yarn one-quarter the single counts.

Then 2/30's yarn would in its resultant counts = 15's
= (560 × 15) = 8,400 yds. per lb.
Then 3/30 s yarn would in its resultant counts = 10's
= (560 × 10) = 5,600 yds. per lb.
Then 4/30's yarn would in its resultant counts = $7\frac{1}{2}$'s
= (560 × $7\frac{1}{2}$) = 4,200 yds. per lb.

Yarn Finishing Processes

There are six ways in which the manufacturer may receive his yarn, viz., on spools, bobbins, tubes, pirns, cheeses, or in hanks. Single yarn for weft purposes can usually be spun on spools of a size suitable for the shuttle in which they are to be used. Twofold yarns also may be twisted on to spools to be used in the same way. In these cases the yarn passes direct from the spinning and twisting frames to the manufacturer. Plying of yarn previous to twisting is practised by some firms. This process consists of running two or more single yarns together without twist, and afterwards the necessary twist is inserted as a separate process. It is considered that by putting the single yarns into parallel arrangement (plying), afterwards combining them by twist, gives a more satisfactory yarn than when the doubling and twisting are performed concurrently. A further recommendation of the practice of plying before twisting is that long lengths of yarn are obtained containing only single knots. Knots are very objectionable in yarn, but as they are to some extent unavoidable, it is advisable to keep them to the smallest size possible and minimum number.

Where the single yarn is for export it is placed on light paper tubes or cops. This effects economy in carriage and obviates return of tare. The tubes or cops form only a small percentage of the total weight and are so cheap that they add practically nothing to the price of the yarn a pound, or the cost of carriage. For warp purposes, yarns are transferred on special winding machines to parallel wood or paper tubes, which when carrying their complement of yarn are termed cheeses. The tubes form the core of the cheeses. Very long lengths of yarn are obtained on cheeses; this being a considerable advantage when making warps. Each cheese will carry from one to two pounds of yarn, and a length from 5,000 to 20,000 yards according to counts. Pirns are used for weft purposes and are employed largely in re-winding yarn from hanks or bobbins unsuitable for use in the looms to be employed.

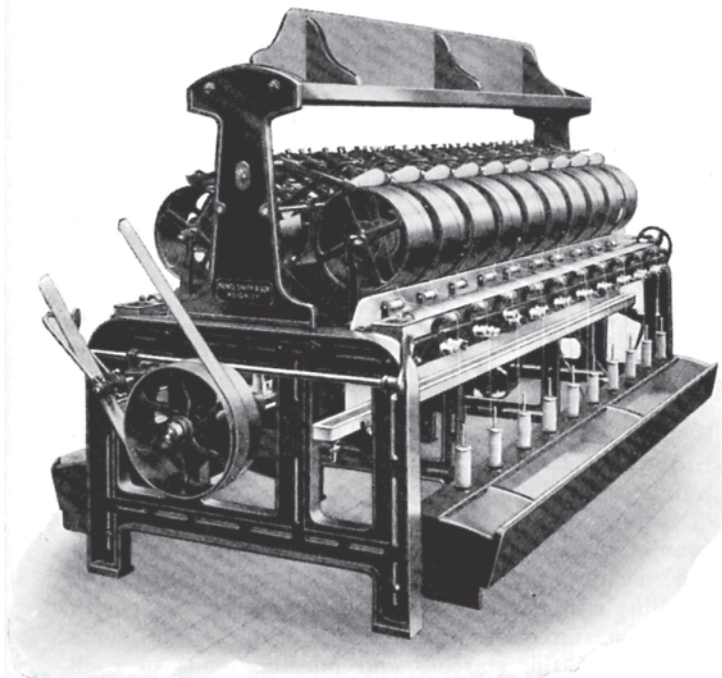
Cops are conical paper tubes used in mule spinning. The lengths of the cops and the pitch of the machine permit a long length of yarn to be wound on each cop, 2 ozs. the cop being an average weight. For single twist warps the yarn is transferred from the cop to cheeses suitable for the creel of the warping machine, the yarn being drawn from the end of the cop. Pin cops are also used in mule spinning. These are about an inch long, similar in size to the bottom portion of an ordinary cop. When these are used, five-sixths of the yarn constituting a so-called full cop is spun on to the bare spindle of the mule, and as this is very thin there is a minimum of tare.

The term " hank " has two meanings. In the worsted industry it is the term used to denote the counts standard of length, which is 560 yards, and the number of hanks equalling one pound avoirdupois indicates the counts of the yarn. Again, the term hank is applied to a length of yarn which has been carefully wound into ring form on a cylindrical reel. When the ends have been tied together and removed from the reel it is termed a hank. In this latter connection a hank may consist of any length of yarn, as it is the form in which it is built up which gives it its name.

Hanks are made up to a predetermined length or weight. They may be 560 yards in length, or multiples or sub-multiples of this number. In this instance, the correct counts of yarn may be easily ascertained by counting the number of hanks necessary to weigh one pound. Or, the hank may be made to a certain weight, say one or two ounces, as required. When made up on the weight basis, they are particularly useful for the retail hosiery trade.

Winding. The process of winding makes no change in the character of the yarn, as the operation simply involves the transference of the yarn from one kind of bobbin to another of a more suitable type, and capable of holding a longer length of yarn than the original. Yarns intended for weaving and knitting purposes, which have been put into hank form for scouring or dyeing purposes, must also be transferred by winding to cheeses or pirns to make them suitable for warp or weft or the knitting machine. By winding it is often possible to place more than double the length of yarn into the shuttle than would be possible if the spinning or twisting bobbins were used.

Many types of winding machines are employed, each type having advantages for dealing with particular classes and counts of yarn. Many are adaptable for satisfactorily winding coarse or fine counts from hanks, or spinning or twisting bobbins, or cops. The essential features of a winding machine are an oscillating guide to place the yarn on the cheese or pirn in diagonal form, so as to build up the yarn on the cheese so firmly



By the courtesy of *Messrs. P. Smith & Son*

Fig. 25

QUICK TRAVERSE DRUM WINDER

and tight that it will not fall to pieces in handling. Suitable tensioning devices regulate the firmness of the cheese and knocking-off arrangements for each thread detach the cheese from the revolving winding drum as soon as an end breaks, thus avoiding undue rubbing of the yarn on the surface of the cheese.

Reeling. Both single and folded yarns are delivered in hank form to customers, who frequently scour or dye them before putting them into use. When a spinner accepts an order for yarn to be supplied in hank form, he is responsible for delivering not only full weight but also full length. In every pound of 60's there must be 60×560 yards. If the yarn is too heavy, say 59's $= 59 \times 560$ yards per pound, the manufacturer will have less length of cloth from his yarn than he is entitled to. If, on the other hand, the yarn is light, say 61's, he will receive 61×560 yards to the pound, and as a result his cloth will be thinner and leaner than he desires, although he will get a longer length of it.

A reeling machine will consist of a 20 to 50 bobbin rail, a collapsible cylinder, the circumference consisting of bars of wood fixed horizontally by means of spokes connected to a strong shaft running the full length of the machine, and a knocking-off device to stop the machine automatically when the predetermined length has been run on to the cylinder or reel. The tying together of the starting and finishing ends of each hand is a preliminary to doffing the hanks from the cylinder.

Leasing consists of interlacing distinctive threads at one or more parts of the hank to avoid entanglement of the yarn in subsequent processes of scouring, dyeing, or re-winding.

Leasing is an important part of reeling, for, as the hanks will have to be rewound after being subjected to the disturbing influence of scouring and dyeing liquors, it should be done carefully and in a way to ensure that the yarn will re-wind with ease and without waste.

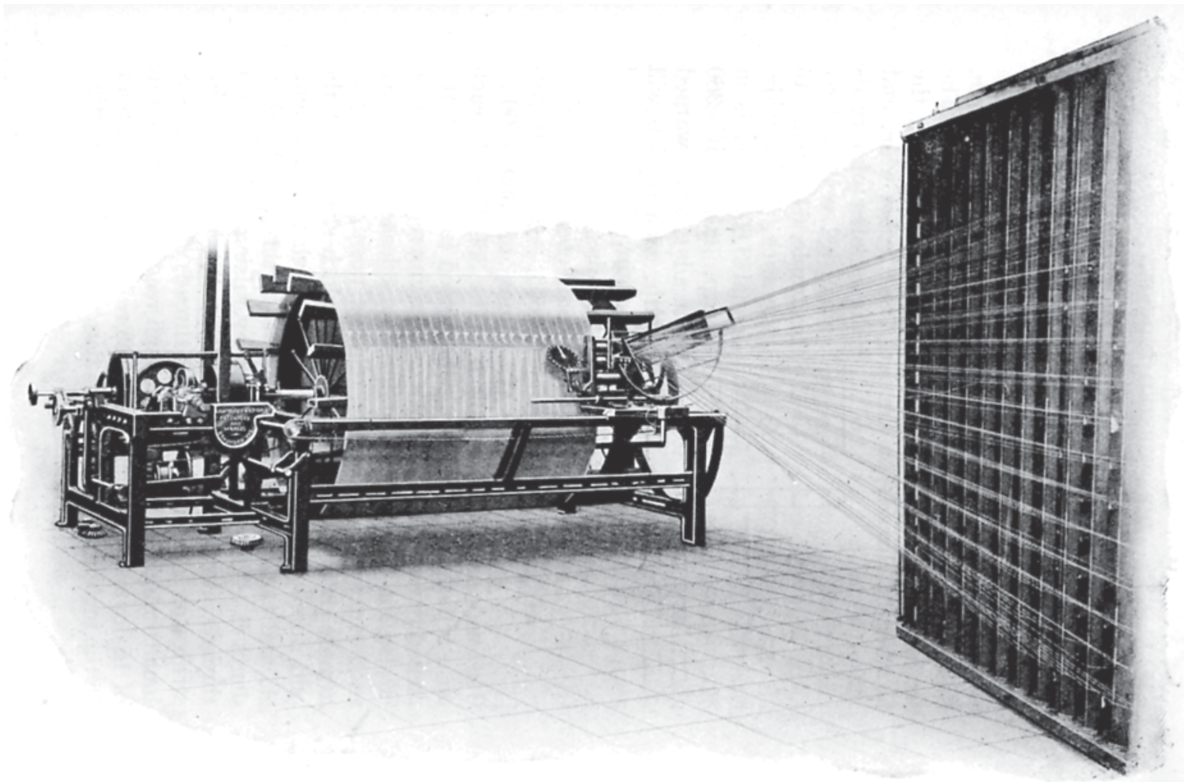
A traversing guide distributes the yarn of each hank over a space of $2\frac{1}{2}$ to 3 in. If the hank is cross-reeled, the guide is made to traverse quickly to and fro about one traverse to three-quarter revolution of reel, so that each successive layer of yarn crosses the one previously laid on. This ensures that no two adjacent threads lie parallel to each other. Lea reeling involves the movement of the guide from left to right only once during the building of a hank. As a " lea " equals one-seventh of a hank, equal in worsted to 80 yds., the guide is controlled so as to move one-seventh of the traverse when each 80 yds. have been added to the hank.

Bundling. Hanks on removal from the reel are made up in bunches, each bunch consisting of several hanks. The bunches are then made up into 5 lb. or 10 lb. bundles. This is systematically done. Thus, if 2/60's yarn is reeled in hanks of 560 yards, ten of these will be bunched together and 30 of the bunches will then be required to make up a 10 lb. bundle. The machine used for bundling is small and compact, and consists of a number of broad steel plates forming a box with the plates divided to permit bands to be placed round the bundle while it is in the box. The covering plates are hinged to be raised when the bunches are placed in the box and fastened down when the required number has been added. A sliding bottom worked by hand or power is used to compress the bunches to the required density, and when this is attained the bands are tied round the yarn, the bottom of the box is lowered, and the bundle in compact rectangular form is removed. It is then papered and is ready for delivery to customer or to be placed in stock.

CHAPTER X

FROM LENGTH TO AREA

Warping. This is the term applied to the collection and arrangement of a number of threads of a predetermined length, number and width, with the object of forming a warp. Worsted warps are usually supplied by the spinner of the yarn to the manufacturer, on weaving beams. The yarn, as it leaves the spinning frame, is not of sufficient length for warping purposes, and consequently it has to be wound on to deep-flanged bobbins or into what is termed cheese form. By this means several thousand yards may be compactly placed on each bobbin or cheese, and thus frequent stoppages are avoided when warping. Warps are made in lengths (cuts) of approximately 70 yards, and it is customary for the manufacturer to supply the spinner with the necessary particulars as to the number of cuts, threads, etc. For example, required, 100 cuts 70 yards long, 60 threads to the inch and 60 inches wide. These to be placed 10 cuts on each of 10 weaving beams with deep flanges set 60½ inches apart. There are several methods and machines employed in making worsted warps; the one largely used is what is termed the horizontal warping mill, a view of which is given in Fig. 26. In this method a creel, capable of holding 400-500 bobbins or cheeses, is placed in front of a machine constructed with wood bars radiating from a central horizontal shaft. The bars have inclined planes at the beginning end, for the purpose of building the warp upon. The warp is built up in sections, and therefore the machine is supplied with a section guide and gauge,



By the courtesy of Messrs. Lightowler & Keighley

Fig. 26—WARPING MACHINE

building mechanism, a measuring device, and a bell to give warning just before a section is completed. Machines vary in size from 10 to 30 ft. in circumference and from 4 to 8 ft. wide.

In order to produce a warp for the foregoing example, the practice is to proceed somewhat as follows: The sections are built of a width in accordance with the number of threads to the inch and inches wide, and the number of threads warped with. For example, 60 threads to the inch, 60 in. wide, equal 3,600 threads in warp, and, if 360 threads are warped with, each section will contain this number of threads; therefore to complete the warp $3{,}600 \div 360 = 10$ sections of $360 \div 60 = 6$ in. wide would be required. The 360 threads each on a separate bobbin would be placed in the creel and passed through the dents of a condensing reed. This reed is also for the purpose of forming a lease, i.e. placing each thread in a definite relative position. We give a more detailed view at Fig. 27, which shows that the odd numbered threads (1) pass through the long dents *A*, and the even numbered ones (2) through the short dents *B*. The lease is formed by raising odd and even threads alternately and securing them by inserting strings as shown at *C*. The threads are next passed four through each dent of a small reed, built at the rate of 15 dents to the inch and therefore $15 \times 4 = 60$ threads to the inch, and $360 \div 60 = 6$ in. width of each section.

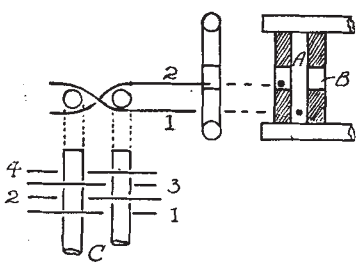


FIG. 27
LEASING REED

They are then passed under and over the measuring rollers between the section gauge, which has been previously set 6 in. wide, and finally fastened to a peg on the underside of one of the bars at the bottom of the inclined plane.

When a mill 10 yds. in circumference is employed to make a section of 700 yds. it is caused to revolve 70 times. For 10 sections this is repeated that number of times, and thus a warp of $6 \times 10 = 60$ in. wide and $360 \times 10 = 3{,}600$ threads is obtained. The building of a section is accomplished by a worm and wheel mechanism, which gradually moves the threads up the inclined plane, at the same time that the mill revolves, until the required length has been obtained. The remaining sections are arranged for by moving the section guide 6 in. to the left of the previous one, and the operation is repeated the necessary number of times. Thus one section overlaps another. The result is a compact warp ready for the weaving beam.

Beaming-off. In order to transfer the warp from the mill to the weaving beam, the latter, with deep flanges set $60\frac{1}{2}$ in. wide, is placed on suitable stands at the back of the machine, and each section tied to a rod fixed in a groove of the beam, which is then caused to revolve slowly, thus winding the warp from the mill on to the weaving beam. Meanwhile the warper is on the look-out for any imperfections, such as wrong threads, slack or tight threads, thick or thin threads, etc.

Sizing and Drying. This, when necessary, follows. It is for the purpose of laying all stray fibres in coarse crossbred, and for strengthening single twist yarns and rendering them more suitable for weaving. The warp is passed, full width, through the size bath and drying chamber in one operation. This puts a coat of size on each thread, which serves the above mentioned purpose.

For good quality, such as twofold botany yarns, this operation is unnecessary.

Drawing-in. This is the next process and has for its object the separating and drawing of the threads, in a certain order, through a set of healds, such order being called the draft. Fig. 28 is a plan view of a draft suitable for a twilled fabric requiring four healds. The double horizontal lines represent the healds, the single vertical ones the threads, and the crosses the order in which the

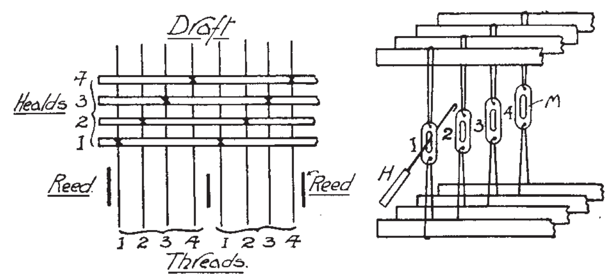
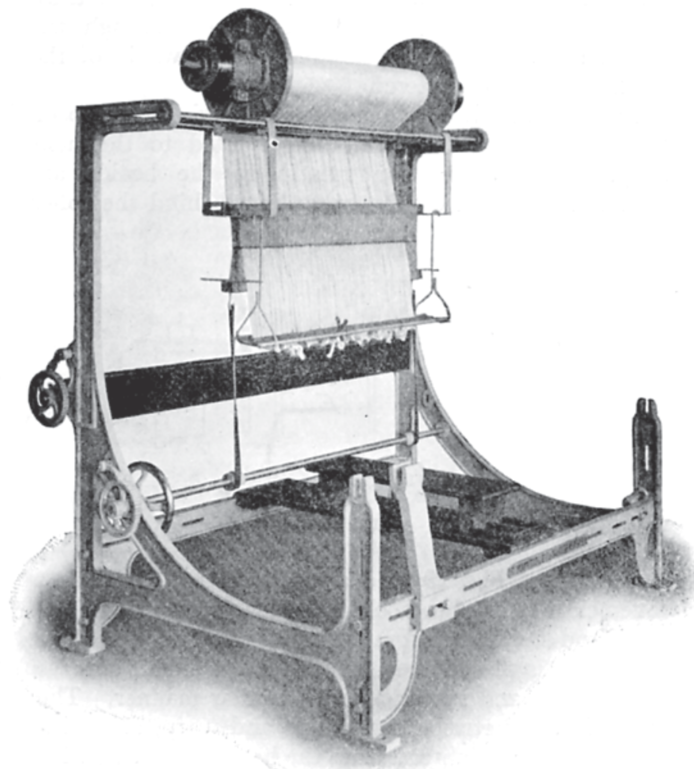


FIG. 28

DRAWING-IN

threads are to be drawn through the mails (M) of the healds. The thick short lines indicate that, after drawing-in, the threads must be placed four through each dent of a reed.

Certain types of worsted serges are woven with four healds, which previous to drawing in are mounted on a frame underneath the warp (*see* Fig. 29) in a convenient position for the operatives, one of whom—the drawer-in—sits in front, while the reacher-in sits behind the healds. Beginning on the left, the drawer-in passes a hook H, Fig. 28, through the first mail (M) on the first heald, the reacher-in takes the first thread from the lease and places it on the hook, and the drawer-in then



By the courtesy of *Messrs. G. Hattersley & Son*

FIG. 29

DRAWING-IN FRAME

pulls it through the mail. The next thread is drawn through the first mail on the second heald, the third thread the third mail, and the fourth through the fourth mail. This is repeated until the whole of the threads have been entered.

Twisting-in. When once the threads have been drawn-in they are retained and twisted to the next warp. In preparing for twisting-in the healds are placed lower down on the frame just behind the roller

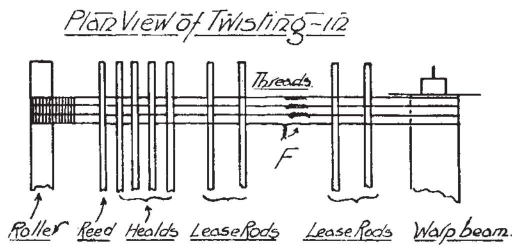


FIG. 30

on the left of Fig. 29, and a small portion of the last woven cloth is fixed to hooks on roller and the lease rods put in and suspended from the top of the framing. The warp beam is placed in stands and another pair of lease rods inserted and suspended in a similar manner. The twister-in sits between the healds and warp, and with one hand selects a thread from the heald lease, and with the other a thread from the warp lease, twists the two together with his finger and thumb and then twists them on to the warp thread of the pair. *See* plan view, Fig. 30. With reference to these processes it may be observed that they are of a somewhat tedious nature, and take up a considerable amount of time. For example, threads may be drawn in at the rate of from

1,000 to 1,500 an hour, or twisted in at the rate of 1,500 to 2,000 an hour.

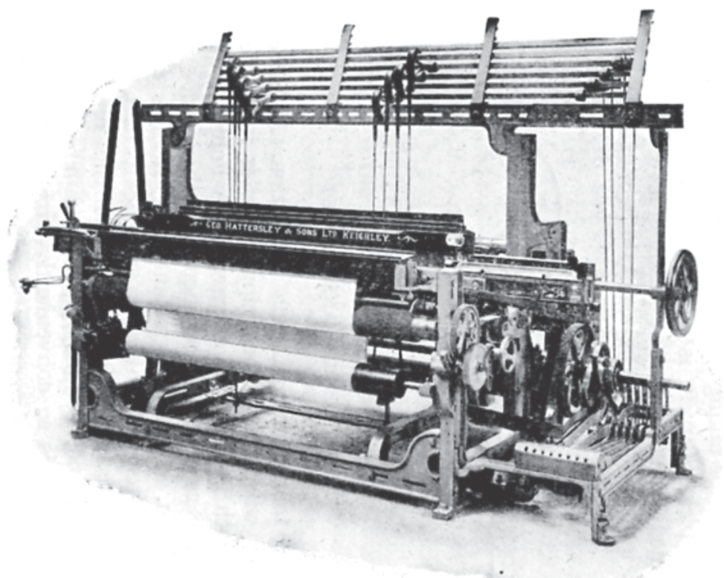
Machines are being employed for these purposes, but not universally, largely on account of the cost. The machine for tying knots instead of twisting the threads is capable of tying from 6,000 to 10,000 an hour.

Warp Mounting. When the preceding processes have been completed, the warp is ready for mounting in the loom. There are several sorts of looms employed in the worsted industry, the simplest of which is the Tappet loom. An example of this is shown at Fig. 31. It derives its name from the tappets seen on the right. It is capable of weaving worsted lustres, voiles, serges, gabardines, whipcords, etc., which do not require more than eight or nine healds in their production.

On mounting the warp, the beam is placed in sockets at the back of the loom and the tensioning ropes coiled two or three times round each end. The healds are temporarily suspended from the half-moon levers, and the reed placed in its position under the handrail. The warp is then tied to a short piece of cloth which has previously been passed round the gripping and cloth rollers respectively. Each heald is next suspended from a half-moon lever. The treading rods (vertical lines on the right) are hooked on to the treadles, and adjusted on the jack-levers. The springs under the healds draw them down and consequently the treadle pulleys are always kept in contact with the tappets.

Supposing the design was for a 2 and 2 twill it would be as shown in Fig. 32, in which the vertical columns of squares represent threads of warp and healds, the horizontal squares the threads of weft or picks. Marks indicate when the healds should be up, the blanks show when they should be down. The relative position of the marks shows the order in which the healds should be operated. Therefore, to produce such a twill, the tappets must coincide with the design, both in construction and setting. In other words, they should cause each heald to remain up until two picks of weft have passed under, and down until two picks have passed over the threads. They should be placed in such a relative position as to cause each to act one pick later than the preceding one, as shown on Fig. 31. This is accomplished by fixing them in that manner on a sleeve projecting from a wheel containing 120 teeth, which is slided on to the lower shaft of the loom and is secured from lateral movement by a metal collar and set screw. The tappets are driven from the crank shaft by a wheel of 30 teeth which, with the assistance of an intermediate wheel, causes the tappets to make one revolution every four picks, or every repeat of the design. The coincidence between the design and tappets will be better understood by a reference to Fig. 32, in which a diagram of a tappet is shown. The letters *a*, *b*, *c*, *d* coincide with blanks and marks on thread number one in design. The numbers 1, 2, 3, 4, correspond with those on design and indicate the setting.

When those parts have been thus arranged, and the loom started by the transference of the belt from the loose to the fast pulley, sheds or openings in the warp are formed. This enables the shuttle and weft to be propelled through these sheds from side to side of the loom and is termed picking. It is performed by tappets with rather hooked noses being set diametrically opposite near each end of the lower shaft of the loom, and consequently acting alternately on the cones, straps, pickers and shuttle. Immediately a pick of weft has been passed through a shed, the reed is pushed forward by the crankshaft to which it is connected, and thus such



By the courtesy of *Messrs. G. Hattersley & Sons*

FIG. 31

TAPPET LOOM

pick is pressed against the preceding one. A continual repetition of this forms the cloth.

Simultaneously with the come-and-go action of the crank and reed, and working in connection therewith, a mechanism for taking up the cloth at the proper rate as each pick of weft is inserted is supplied. The arrangement is such that a pushing lever and pawl, worked indirectly from the crankshaft, move a ratchet

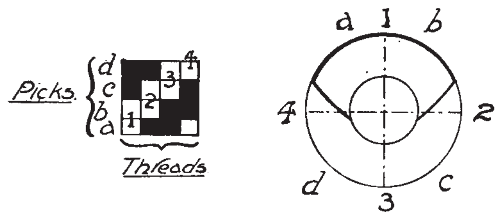


FIG. 32

TWILL DESIGN AND TAPPET

wheel one tooth forward each revolution. This sets a train of wheels and the gripping roller in motion, and the cloth is taken up as woven. A holding catch prevents the ratchet and consequently the cloth from slipping back. Obviously, when thick weft is used, the cloth will require moving more quickly than when thin weft is used. This necessitates the provision, in the train, of a position for wheels of a different number of teeth, and it is so conveniently arranged that, by placing this wheel correctly, the cloth will be taken up at the right rate, thus 60 picks to the inch, 60 teeth in change wheel; 90 picks, 90 wheels, and so on.

The cloth is rolled up as it is woven by the end's being fastened to a wood roller, which is pressed by weights against the gripping roller. In this way 70 or 80 yards may be compactly and smoothly held.

Tensioning the warp is a very important factor in the production of a marketable fabric. The amount is largely determined by the strength of the yarn, and should be well within the breaking point. If the warp is too slack the threads will not be separated clearly in shedding, with the result that they will be broken, or passed over instead of under, the outcome of which is an imperfect cloth. Slackness also produces reed marks in plain cloth and raggedness in twills and the like.

Letting off or pacing the warp is also of much importance. If it is not performed uniformly with the taking up of the cloth unevenness is the result. The many methods of doing this are too many to mention, but it suffices to say that in the majority of cases they are arranged to grip the warp beam in such a manner as to hold the warp tight during shedding, but let it off in response to the rate at which the cloth is taken up.

Dobbies. In regard to cloths which require more healds than can conveniently be woven by means of tappets, such, for example, as 12, 16, 24, or 48 healds, an entirely different method of shedding is necessary. The mechanism for this purpose is termed a dobby. The loom is similar in other respects to the tappet loom. A dobby is usually fixed to some top railing at the opposite end of the loom to the drive. It consists of levers from which the healds are suspended. Balk levers are linked up to these, to each of which a pair of catches are loosely attached. A further set of levers are placed immediately underneath these, and in turn are acted upon by pegs placed in wood lags when a heald has to be raised. The lifting knives are worked by a three-armed lever, a connecting rod, and a lever fixed to the low shaft of the loom. The knives work horizontally in slots, immediately below the catches, and thus take those dropped on to them through the action of the pegs. In this way some of the healds are raised. Therefore it follows that if no pegs appear other healds are left down and a shed is formed.

Figs. 33 and 33A are line diagrams given to illustrate further this method of shedding. Fig. 33 shows that a peg in lag *F* will cause catch *C* to be caught by knife *G* and the heald *K* will be raised. Fig. 33A shows that if no peg comes under *E′*, catch *D* will be missed by knife *H* and the heald *K* will be left down. An under-motion for drawing down the heald is shown at *U*, Fig. 33. It consists of a spring connected to two levers which are attached to the bottom heald shaft by means of cords

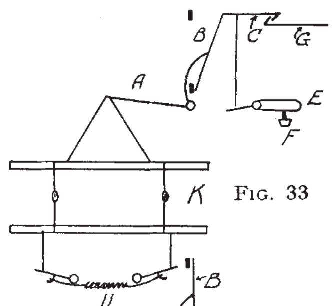


FIG. 33

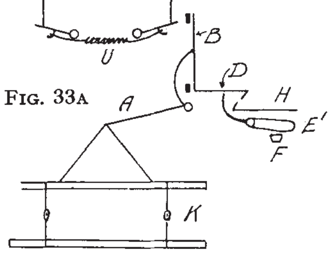


FIG. 33A

DOBBY WITH HEALDS LIFTED AND DOBBY WITH HEALDS LEFT DOWN

Jacquards and Harness. Worsted yarns are frequently manufactured into figured dress goods. When such is the case, jacquards and harness are required, because of the large number of threads of warp and weft respectively, which as a rule figured or floral designs necessitate. Full designs are usually made to coincide with the number of hooks in the machine. The harness cords are arranged so many to a hook and thus repetition is effected. Regarding the weft way of a design repetition is almost unlimited. A 304 hook

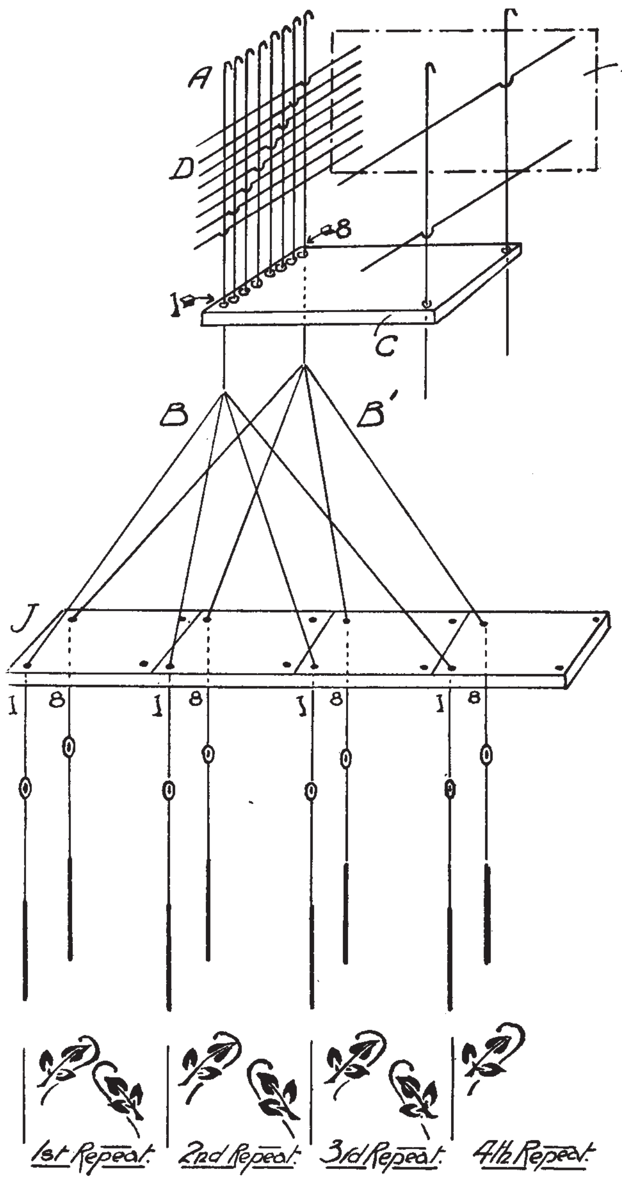


Fig. 34

SECTION OF JACQUARD

machine is largely used in the worsted industry. The jacquard is connected to the loom by a lever fixed on the crank shaft, a rod, a two-armed lever fulcrumed over the machine, and a short link. The details are shown at Fig. 34, in which *A* equals the hooks, *B* the cords, *C* the grating and *D* the needles. The needles at one end protrude about $\frac{3}{8}$ of an inch through a perforated board *E*, Fig. 34A, the holes in which

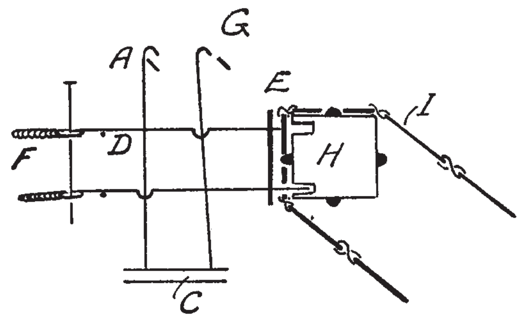


FIG. 34A
DIAGRAM OF CARDS

allow of lateral movement to the needles. Springs *F* at the opposite end keep these and the hooks normally in a definite forward position over the lifting knives *G*. A hole in a card *I* leaves a hook over the knife and certain threads are lifted, a blank on *I* presses a hook away from the knife and the cords and threads connected are left down. The harness cords *B*, Fig. 34, are attached to the bottom of the hooks by neck cords, to which they are tied. The number of cords to a neck is determined by the number of times the design requires repeating in accordance with the width of the cloth. For example, cords *B*, *B′* are passed through the holes in a comber board J in the order briefly shown by the numbers 1 to 8, that is, through the number one hole in each repeat and the cords B' through the eight hole in each repeat. Of course, it must be understood that in a full mounting the intervening spaces, as regards hooks, needles and cords, will be filled in with these. The simple sketches at the bottom of Fig. 34, emphasize the point regarding repetition.

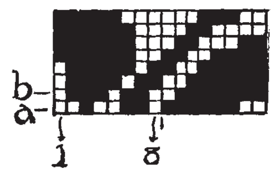


Fig. 34B

SECTION OF DESIGN

The design is produced by first making a sketch the actual size it will be in the cloth. It is next enlarged on paper with small squares on. Marks on this usually represent weft passing over warp. Blank squares indicate warp passing over weft. A section of a design at Fig. 34B, illustrates this. The design is erected on the reading stand of a card cutting machine, a straight edge on which assists the card cutter to keep on the horizontal rows of squares (representing picks or cards). A card is placed in the machine, and by pressing in certain keys with the fingers a row from 1 to 8 may be cut at a time. The letters a, b on section of design denote picks one and two. Parts of two cards corresponding with these are shown at a, b in Fig. 34C, dots representing holes in card and white squares on design.

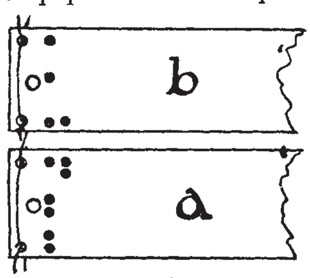


Fig. 34C

TWO CARDS : LACING AND CUTTING

The cards are laced together by strings and are then ready for the loom. They are placed on a four sided block of wood (*H*, Fig. 34A) containing a corresponding number of holes to the needles. This block is caused to press a card against the needles, blanks pressing them in, force the hooks connected to move clear of the lifting knives *G*. Holes in a card do not disturb the needles and consequently the hooks are lifted and a shed is formed. The card block is given a quarter turn after each pick of weft and thus sheds are formed in accordance with the design.

Cloth Inspection. When cloths leave the loom they are in a more or less imperfect condition due to various causes, such for instance as breakages of warp and weft during weaving. They are inspected by the "taker in," who is a specialist in detecting faults. The custom is to mark these with chalk and pass them on to the next process.

Burling and Mending. The burler takes out any lumps and curls found in the cloth and draws all knots to the back. The mender sews in all threads of both warps and weft left out in weaving.

Dyeing and Finishing. The object in finishing a grey worsted fabric is to retain the characteristics of the yarn and pattern, and therefore what is termed a clear finish is given. This briefly consists of blowing steam through them to set the threads, scouring them with soap to take out all grease marks or any other impurities, shearing off all stray fibres from the face of the cloth; they are then dyed to particulars, tentered to the required width, and afterwards pressed. After this they are wrapped up (cuttled) and usually sent direct to the merchant, who in turn sells them to the retail houses.

GLOSSARY

Alpaca. The soft, vari-coloured covering of the Alpaca or Llama goat.

Backings. Noil on Holden's comb circle after drawing-off.

Belting Yarns. Thick, hard twisted yarns made from coarse goat and camel's hair.

Bleaching. An oxidizing process in which the wool fibres are changed from their natural cream colour to white.

Blending. The association of different classes or qualities of wool, reasonably identical in features, and suited for some special purpose.

Blueing. The use of fugitive colouring matter, such as methyl blue, etc., to temporarily improve the colour of the wool.

Botany. Originally referred to wool sent from Botany Bay, Australia ; now refers to all wool of 60's quality and upwards.

Burler. A person who dresses cloth prior to finishing.

Burrs. Seeds of plants adhering to raw wools.

Carding. The operation in which clean, short wools are converted from staple to sliver form, and in which all fibres are separated from each other.

Carpet Yarns. Usually refers to soft spun worsted yarns made from uncombed wool.

Cashmere. Wool and hair from the Cashmere goat.

Classing. The separation of fleeces on the wool growing stations, according to length, fineness, and general character of the wool.

Clothing Wools. These lack length sufficient for combing, and are used in the woollen industry.

Combing Wools. Wools classed as being suitable as regards length for combing and used in the worsted industry.

Comb. A machine arranged with numerous and closely set pins for the thorough parallelization of long fibres and the removal of the short.

Comeback. Wool between Botany and fine crossbred, obtained by crossing merino sheep with fine crossbred sheep.

Condition. The hygroscopic character of wool. Its moisture holding capacity.

Conditioning. The application of moisture to wool, by natural or artificial means, up to the recognized standard.

Contracts. Purchases and sales of wools, tops, yarns, etc., at a given agreed price to be delivered within a given time.

Correct Invoice Weight. Weight of material in correct condition according to the recognized standard.

Counts. The number given to a yarn of any material, usually indicating the number of hanks per pound of the yarn.

Crimpiness. The curls or crimps of the wool fibre.

Crossbred. Generally denotes wool from foreign and colonial countries of 56's quality and below.

Cut. A standard length of warp.

Demi-lustre. Not pure lustre.

Dessuinter. French name for the steeping process.

Direct Loss. The loss in weight due to drying.

Doubling (in combing and drawing). Running several slivers or slubbings together to secure more uniformity in thickness.

Doubling (in twisting). Combining two or more yarns together with or without twist.

Down Wool. Wool from sheep native of the Southdowns of England. The " down " character refers to the bulky or spongy handle of wool.

Draft (mechanical). Speed ratio between the back or feeding rollers and the front or delivery rollers.

Draft (material). The relation of the length delivered by the machine to the length " fed in."

Drawing. A number of processes including gilling, drawing, reducing and roving, by which top slivers are converted into roving form.

Dry Combed Top. Top sliver combed without application of oil, or tops combed "in oil" and backwashed after combing.

East Indian Wool. Wool of a coarse and heavy nature coming from India and other Asiatic countries.

Effluent. The saturated dirty water from wool cleansing.

Emulsion. Refers to system of wool cleansing in an emulsion made by adding soap and alkali to water.

Fibre. A single hair, cylindrical in shape.

Finishing (combing). The two or three gilling processes following combing.

Finishing (cloth). Processes through which cloth passes after weaving to improve appearance, and give required characteristics.

Folded Yarn. Yarns composed of two or more single threads.

Grey Fibres. Fibres other than the usual wool colour, white to cream.

Grey Pieces. Cloth direct from the loom.

Half-bred. Refers to large numbers of sheep in this country between lustre, demi-lustre, and down.

Hank. The standard length adopted in yarn counting ; e.g. worsted hank, 560 yds.

Hosiery.

Lashy. Wool that is long in staple and free from curl.

Lastings. A strong durable fabric made from strong wools.
Lease. The divisions of the threads in a warp, either 1 and 1, 2 and 2, 8 and 8, etc.
Linings. Cloth usually consisting of cotton warp and lustre weft, used for lining suits and costumes.
List. The edge or selvedge of a piece.
Looming. The act of drawing the warp into gears which will place the threads in the loom in the desired order.
Lustre. The shiny appearance which some fibres possess.
Lustre Wool. Long wool from the Lincoln, Leicester, Notts, Devon, Cotswold, and Wensleydale sheep.
Marl. Usually refers to threefold twists. More correctly refers to yarns spun from two-coloured or mottled rovings.
Matchings. A pile or bale of sorted wool of the same quality.
Melange. Printed tops. Fibres with more than one colour.
Mending. Repairing of a fabric, such as stitching in threads and picks run down in weaving.
Merino. Wool from merino sheep which are very fine woolled. These sheep were formerly kept in Spain.
Mohair. The long lustrous hair of the Angora goat.
Noil. Short fibres extracted in combing.
Plying. Running two or more threads together without twist.
Quality. The extent to which material in its various forms, wool, top, yarns, etc., possess the features or characteristics necessary for its successful use. Also refers to fineness of fibre, i.e. fibre diameter.
Ratch. Distance between nip of back and front rollers.
Recombing. Combing top slivers after dyeing.
Root. End of fibre nearest body of sheep.
Roving. A strand of wool of the desired thickness for converting into yarn in one operation—spinning.
Saponification. The combining of fats and alkali to make a soap.
Serge. A term applied to fabrics of a twill character and of a rough make. Usually 2/2 twill.
Set. Implying the number of threads of which a cloth is composed within a given width.
Shivs. Small pieces of vegetable matter in raw wool.
Single Twist Yarn which has only one twist—which has not been doubled or folded.
Sinkage. The amount of impurity in wool expressed as a percentage.
Slubbing. A thick rope of twisted fibres.
Skirtings. Short staples from belly part, and from legs, neck, etc., removed from fleeces prior to classing.
Snarl. A kink or curl produced by twist receding upon itself.
Solvent. Refers to system of wool cleansing in a fat solvent such as benzine.

Spinning. The final operation of attenuating the combed sliver into yarn form.

Standard Regain. The allowance of moisture in wool, tops, yarns, etc., over the dry weight.

Staple. A lock of hair or wool.

Steeping. Preliminary treatment of raw wool with water only to remove soluble matter.

Suint. Wool sweat, soluble in water.

Tear. Ratio of top to noil in combing.

Tender. Weak wool, yarn, or cloth.

Top. A long length of combed twistless sliver in ball form. The comber's finished product.

Top in Oil. Top sliver to which the standard amount of oil has been added after backwashing to assist manipulation.

Twist. Turns imposed on a yarn to combine the fibres together and thereby add strength.

Twitty. Irregular slubbings or yarn.

Warp. A series of threads placed longitudinal in a loom and extending over the full width.

Warp Wool. Wool of a sound type, full, bold, compact, and free in its growth ; suitable for warp yarns.

Wastes. The waste made in the manufacture of yarns and cloth.

Weave. The interlacing of warp and weft with one another to form a suitable cloth.

Weft. Yarn interlaced at right angles to the warp threads in building a cloth.

Wool Fat. Greasy substance on wool fibres which flows down the sebacious glands of the skin of the sheep. Insoluble in water.

Woollen Yarn. A thread in which the fibres cross each other in every direction, presenting a rough surface.

Wool Sorters. Men engaged for dividing wool fleeces and pieces into piles or lots containing one quality only.

Wool Yolk. Combination of wool fat and wool sweat on raw wool.

Worsted Yarn. A thread in which the fibres are parallel to each other, making a compact and smooth surface yarn.

Yarn. A filament of twisted fibres or any thread structure which has been spun.

Yield. Amount of clean wool after scouring or combing. Stated in percentage terms.

Yorkshire Grease. Thick oil recovered from wool cleansing effluent.

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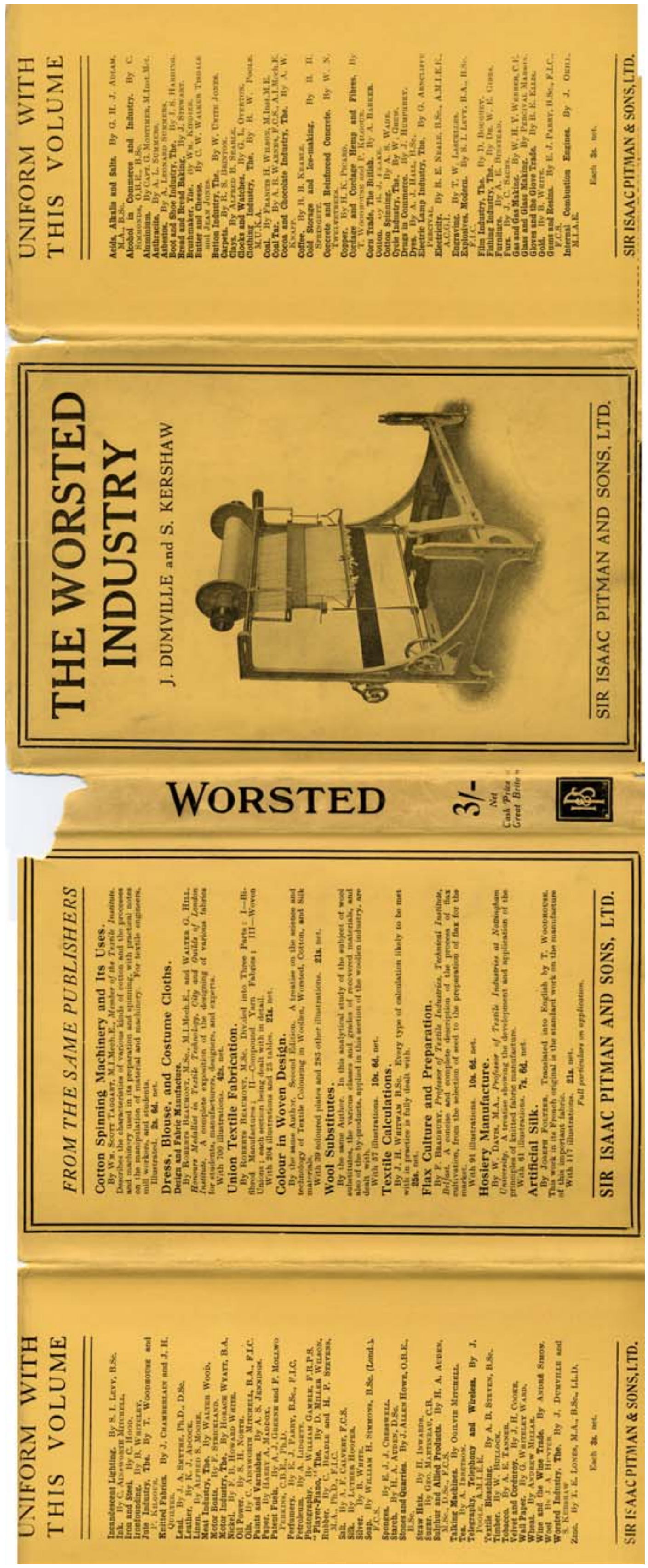

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