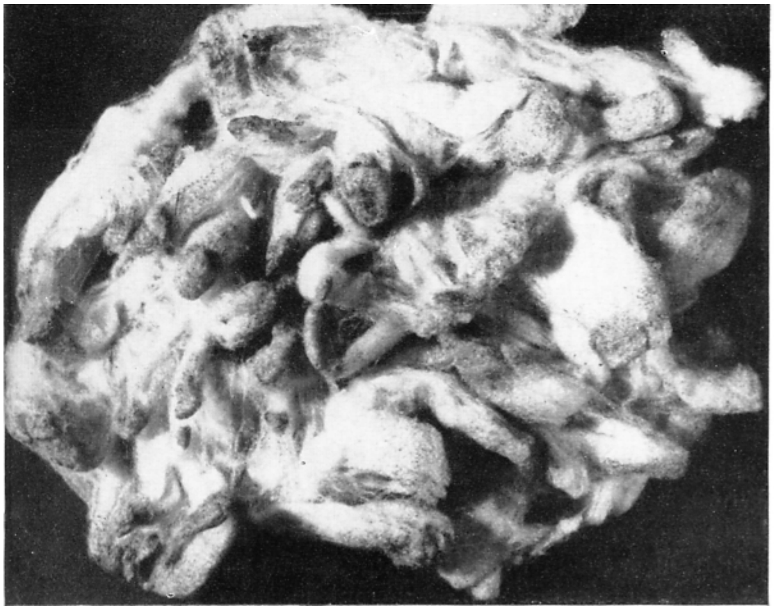
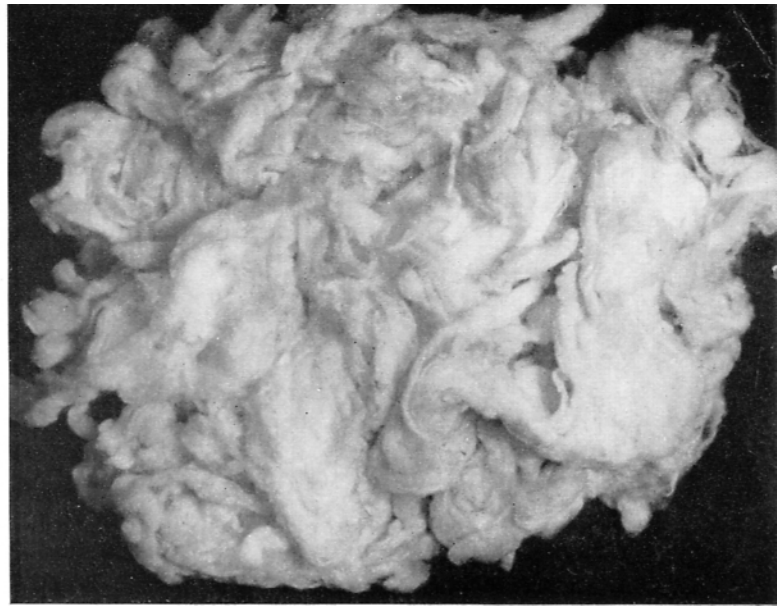


Raw wool. Note the greasy and dirty appearance.



Clean, scoured wool.

WOOL SCOURING

W. L. THOMAS,

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THE statistics for wool consumption in the United Kingdom for the past few years show the amount of raw merino and crossbred wools used for top making and woollen spinning to be well over 250,000 tons per annum, and this does not take into account various types of hair and waste materials.

The whole of this very considerable quantity of wool, whatever its ultimate form and destination, has to be cleansed in order to remove the natural grease, dirt and other impurities and leave the wool fibres in a clean, free and natural condition, ready for the subsequent processing. The percentage of these impurities varies very considerably in different classes of wool; for example, an average merino quality will contain from 45 to 55 per cent impurities, whereas a crossbred type may show 25 to 35 per cent "shrinkage", or decrease in weight after scouring. It is of vital importance that this cleansing process be carried out efficiently, and in the worsted industry, the processes of carding, combing, spinning and weaving depend on adequate initial scouring of the wool.

CLEANSING PROCESS

The cleansing of raw wool is now chiefly carried out by scouring with normal detergents in a special machine generally known as a "washing set", in some cases preceded by a water steeping process to remove, as far as possible, the heavy sand and water soluble impurities before the scouring proper.

The washing set consists of a series of tanks or "bowls", usually four in number, separated from each other by pairs of squeeze rollers. Water and steam pipes are fitted to each bowl for filling and heating, and valves for emptying the bowls rapidly when required. The bowls, when filled with water, are heated by injected steam to the required temperature, usually about 120° to 130°F. and the detergents are added to the bowls generally in liquid form of specified strength.

The wool is automatically fed into the first bowl of the series from a hopper by means of a travelling "lattice". When it falls into the scouring liquor it is gently passed along by a mechanical arrangement of moving forks assisted by possers*, to ensure quick immersion and constant circulation of the scouring liquors. When it reaches the end of the first bowl the wool is conveyed to the squeeze rollers which squeeze out the liquor and pass the partially cleansed wool to the next bowl. In some cases, a special conveyor and automatic discharge valve is fitted to the bottom of the bowl to remove the settled sand and dirt at frequent intervals. This enables the bowl to be self cleansing and thus increases the time for which it can be run between full discharges.

Passing through the other three bowls, in a similar manner, the wool is finally discharged from the fourth bowl in clean condition, and conveyed by means of a travelling apron to a drier, then by truck or blown by a fan to the next process – that of carding.

SUPPLIES OF SOFT WATER

One of the first essentials for the efficient scouring of wool is a plentiful supply of soft water, a condition

*Special pushers.

which is generally met, in the West Riding of Yorkshire, by supplies from the various Corporations or from private boreholes. Where hard waters are encountered the usual Base-Exchange or Lime and Soda softening plants are employed.

It cannot be stressed too often that 1,000 gallons of water of 1° hardness will destroy approximately 1 lb. of soap, and the equivalent amount of sticky lime soap so formed is liable to re-deposit on the fibre and cause trouble in the after processing.

SCOURING AGENTS

The cheapest and most effective agent for wool scouring is sodium carbonate or soda-ash, which has no deleterious effect on the fibre if properly applied.

Stronger alkalis such as caustic soda are avoided as they cause the fibres to become harsh, discoloured and even tendered or damaged, particularly at high temperatures. Milder alkalis, such as ammonia, borax and potassium carbonate or bicarbonate, are occasionally used, but they are considerably more expensive, and practical trials show no advantage over soda-ash.

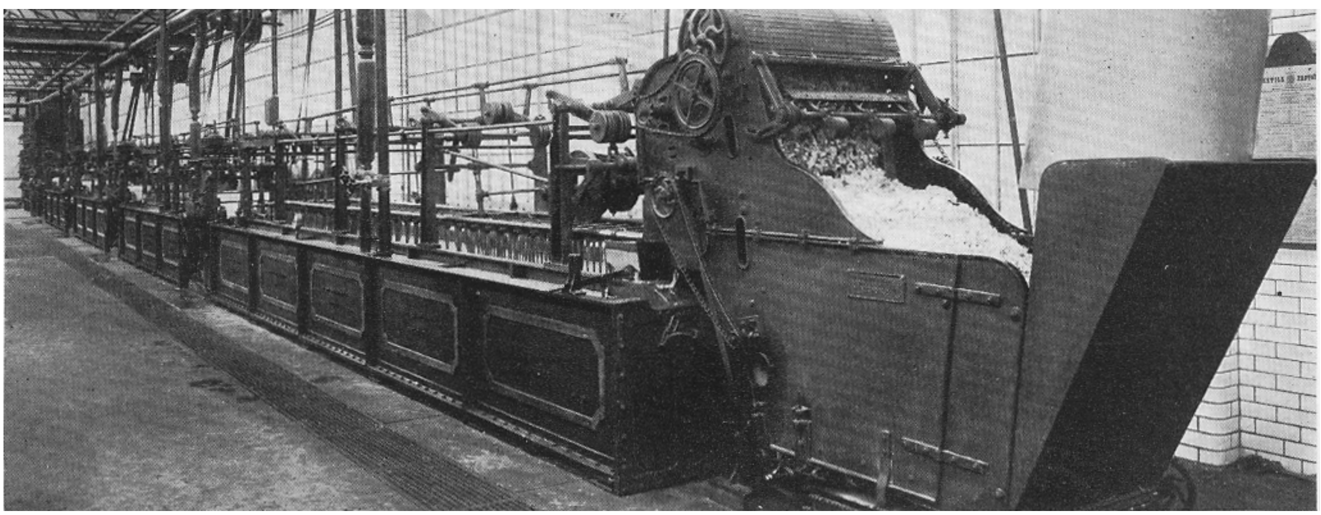
Alkali can be used to a considerable extent in the first (and in some cases the second) bowl, as up to this stage of the processing the actual fibre still has a protective coating of natural wool fat, in addition to which certain salts in the fleece have a limited neutralising action on the alkali. If alkali alone were used, however, the resultant wool would be in a harsh, unsatisfactory condition, and a considerable amount of soap is therefore required to form more stable emulsions and give the wool a lofty and lustrous appearance and handle.

The soaps used must be well made, of a specified strength in fatty acids, or real soap made from fats of good quality, free from rosin, drying oils, fish oils, or low quality bone fat and of low melting point to give greater solubility and ease of removal.

The detergent solutions are generally made up to the requisite strengths in a separate room and piped to the various washbowls, the required volumes being checked by meter or other measuring devices.

Soap and soda ash for raw wool scouring have been the most efficient detergents over the years during which sulphated fatty alcohols and numerous synthetic detergents of various chemical types have been marketed for scouring purposes. Recently, synthetic detergents of the nonionic type based on ethylene oxide have become more attractive than formerly for raw wool scouring in place of soap.

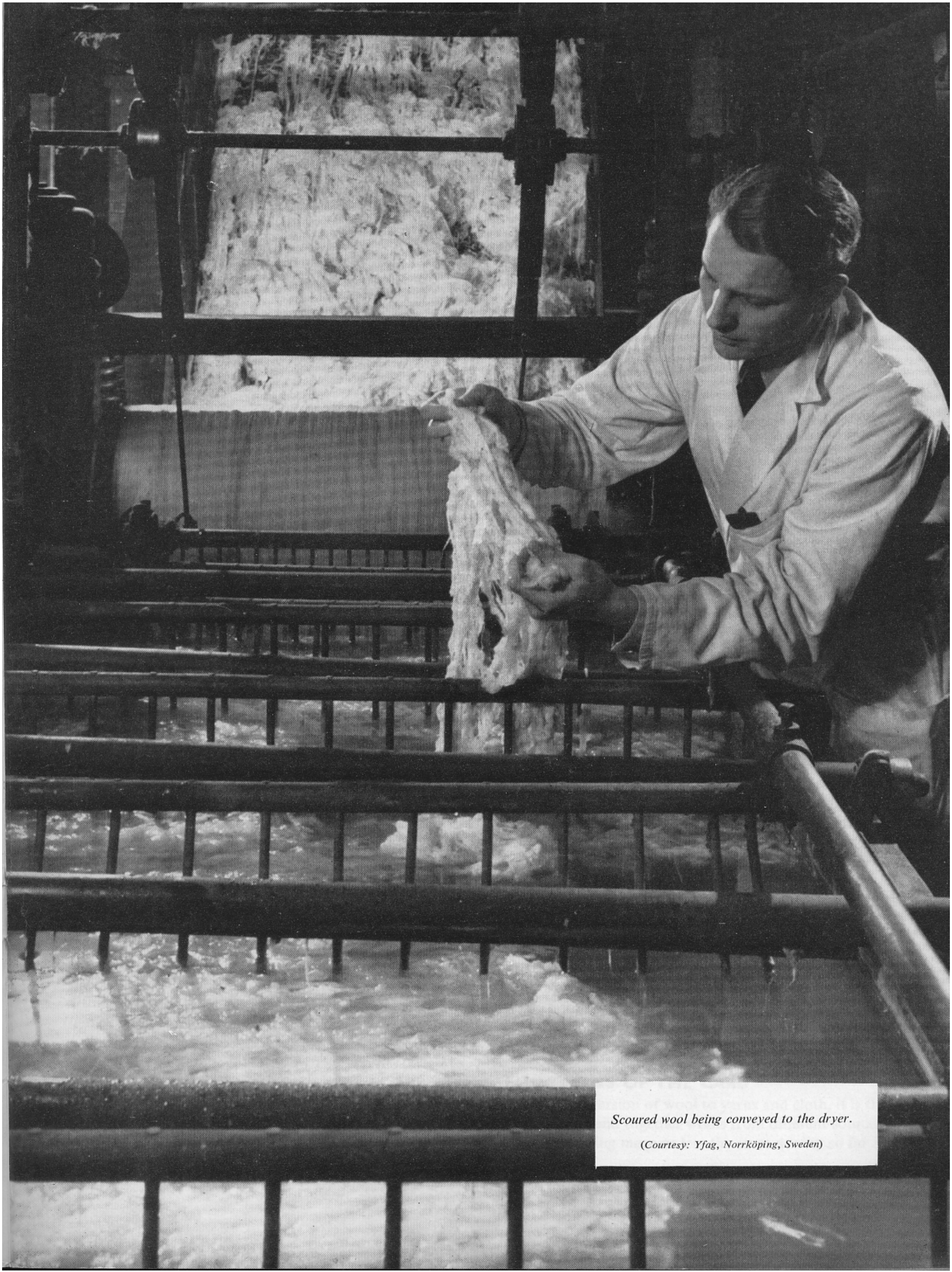
The emulsions formed by the use of these synthetic products are stable in acid solutions and this characteristic makes the resultant effluents more difficult to treat by the normal "acid cracking" treatment as carried out at various works, so much so that many sewage works authorities are objecting to effluents containing synthetic detergents being discharged into the sewers. It would be a most unsatisfactory position if the development of a scientific discovery of such importance should be held up by a sewage treatment problem, and it is to be hoped that a satisfactory method of overcoming the difficulty will eventually be worked out by collaboration between the manufacturers, the users and the sewage works managements.



Four-bowl scouring machine with automatic feed. *(Courtesy: Petrie-McNaught)*

SCOURING PROCESSES

The actual scouring process is a matter of emulsion technique, and whilst very many theories have been put forward it is certain that in the particular problem of raw wool scouring there is no generally accepted solution to be found in text books, technical articles or similar sources. The formation of an emulsion may be better appreciated by considering the effect of placing



Scoured wool being conveyed to the dryer.

(*Courtesy: Yfag, Norrköping, Sweden*)

small droplets of oil on the surface of water. These droplets tend to coalesce, forming larger drops and ultimately a pool due to surface tension. This contracts the surfaces of the oil into as small an area as possible. It follows that the most efficient agent is one that lowers the surface tension, thereby producing more stable and finer emulsions, which can readily be run off from the wool fibres.

Owing to the varying qualities of wool processed, the differences in size and types of washing sets used, detergents employed, "through-put" and general working, it is impossible to lay down any fixed amount of soap and alkali which must be used generally, or to compare consumptions at different works.

At the same time, it is possible by careful trials at individual works to ascertain the most efficient and economical working conditions with regard to the quantity of detergents used (say in lb. per 100 lb. raw wool scoured), the method of additions, temperature, squeeze roller pressures, and so on. Once these standard or optimum conditions have been established, simple regular records ensure that the standard is being maintained, and, what is of equal importance, any falling off in efficiency is noted and the cause ascertained.

Measurements of the effective alkalinity (or pH) of the scouring liquors at various stages of the run, together with occasional chemical analyses of the scoured wool for cleanliness, fatty matters, soap residues, alkalinity are also of assistance in controlling the additions of soap and alkali and ensuring clean scoured wool throughout the run. In many instances simple analyses of the effluents discharged from the bowls for total solids, grease, soap and alkali contents will indicate if the suds are exhausted and whether a full change, a partial change or no change of the scouring liquors is desirable at any particular time. This may, incidentally, effect economies in water, steam, materials and labour, as well as producing the minimum volume of effluent for treatment in the effluent purification works.

There are two other methods which must be mentioned in any survey of wool scouring, namely Suint Washing and Solvent Cleansing.

Suint washing makes use of the well-known detergent properties of the natural organic potash salts (known as suint) which are present in raw wool. A continuous purification process is incorporated to remove sand, dust and wool fat, and this, with a partial discharge to the sewers, enables a concentrated suint solution to be maintained and re-used. It is claimed that by this method a very considerable economy in soap and alkali is effected.

Many attempts have been made to cleanse wool by by the use of organic solvents such as benzene, white spirit, trichlorethylene and so on, but solvent scouring has had limited commercial application. Drawbacks to this system are that the solvents used are either inflammable or toxic, possibly both, and labour difficulties might arise on this account.

Both these methods have been tried out on an extensive scale in this country, but have not met with favour on account of the inferior appearance and colour of the resultant wool, and because the increased cost and complicated nature of the plant might make the cost of processing prohibitive.

BACKWASHING

After the carding process the wool, in sliver form, is given an additional scour termed "backwashing", to remove surface dirt picked up during the mechanical operation of carding and finally to cleanse the fibres. This process is carried out in a two-bowl scouring machine, specially designed for the continuous treatment of slivers. A solution of soap is generally employed as the detergent in the first bowl, and the second bowl contains water only for the final rinsing. As in the original scouring, a drier is incorporated on the back-washing machine to discharge the wool in a suitable condition for the following processes of preparing and combing.

STANDARD OF CLEANLINESS

The standard of cleanliness required is generally recognisable in the trade and incorrectly scoured wool is readily detected, both by its appearance and by the manner in which it goes through the various mechanical processes. Any failure to reach the necessary standard would soon be noticed and corrected by the operatives and management concerned.

CARDING WOOL FOR WOOLLEN YARNS

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Ph.D., F.T.I., Senior Lecturer in Yarn Manufacture, University of Leeds

If one takes a handful of greasy wool fibres and washes them in warm soapy water, then at least two things happen: first, the fibres lose their dingy appearance and become white; and second, what was previously a series of locks of fibres, each lock consisting of a series of parallel fibres, now takes on the form of a jumbled mass, the fibres being wound round each other. The tightness of the fibres depends on the degree of friction used in washing. This second point is extremely important because it is very difficult to spin fibres into yarns when they are entangled with each other. But the washing process is necessary to cleanse greasy fibres, and so the carding process, which disentangles these fibres and arranges them in a much more orderly fashion, is just as necessary.

FUNCTIONS OF THE CARD

In the conversion of wool to yarns and cloth, it is the practice to blend together wools from different sources, each wool being more or less the same quality so far as fibre diameter and length are concerned. This is done in order to maintain more easily a standard quality of yarn, for if wool from a certain source should not be procurable in any one year, then it is easier to substitute a part rather than the whole and yet maintain the same quality of cloth. Therefore, another function of the carding machine is to help mix fibres from the various constituents of the blend, so that they are uniformly distributed in the subsequent yarns. Before carding, the different wools are mixed in a teasing machine, but this operation only mixes locks of different wools, and one relies on the card to achieve the actual mixing of the fibres. This uniformity of fibre mixing in the yarn is important because it governs such properties as yarn diameter, strength, extensibility and shrinkage, for it will be realised that unless the yarn is uniform, one cannot expect it to possess uniform properties.

It is not only white wools that are blended together. Many cloths are produced by mixing together coloured fibres, a simple example being a grey woollen flannel consisting of black and white fibres. The carding machine is here again responsible for the intimate fibre-fibre mixture which is essential if the garment is to possess a uniform appearance.

So far, then, it has been shown that the card disentangles the fibres from the different locks of wool, and, at the same time, blends these disentangled fibres to produce a uniform mixture. This may apply to different types of fibre each of the same quality and also to different coloured fibres.

The third function of the card is to produce a uniform web of fibres and then to divide this thin web, which extends across the full width of the card, say sixty inches, into a number of narrow webs about half an inch wide. Each narrow web is then rolled into a circular sliver, known technically as a condensed sliver. Since the web is endless for as long as the card functions, it will be seen that a number of endless condensed slivers is produced. These are wound on to wooden barrels, and removed from the card at intervals to go forward to the mule or ring frame, which converts the condensed slivers into yarns.

HAND CARDS

Before 1748, carding was effected by the use of hand cards (Fig. 1). These consisted of two boards on which strips of leather were fastened, and in which wire teeth were inserted. The wire teeth were inclined, in order to bring about the carding action. Tufts of wool to be carded were laid on the one board and the one was pulled across the other in such a manner that the points of the two sets of teeth opposed one another (i). This "point to point" action was repeated several times until the wool locks were sufficiently disentangled, after which the top card was turned through 180°, so that the points of the latter now stroked the backs of the bottom teeth and therefore effected a stripping action (ii). When the two cards were rubbed together in this fashion the carded wool eventually dropped out in the form of a roll which could then be drawn and spun. In early times this was achieved by the drop spindle and later by the spinning wheel.

CARDING MACHINES

In 1738 Paul, a London shroud maker, dissatisfied with the quality of hand-spun yarns, invented a spinning machine which he claimed would "spin yarns

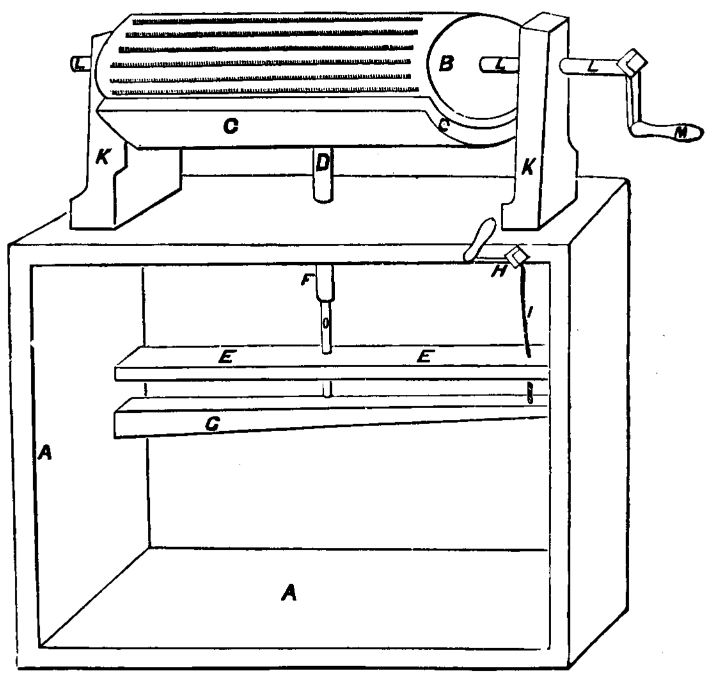
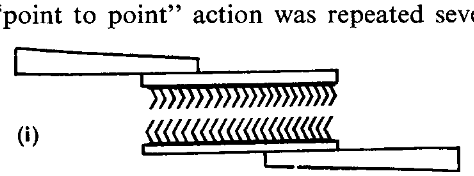
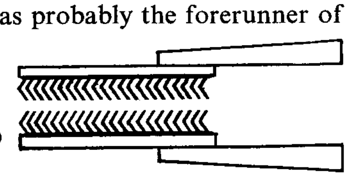


FIG. 2 *Paul's Carding Engine.*
(*Courtesy: The Textile Institute*)

of more uniform count and twist". This invention is important, because the increased production of the spinning machine emphasised the need for something better than the leisurely methods of hand carding. Thus the invention of the spinning machine led to the original patents for carding machines. In 1748 a certain Daniel Bourn, who had a cotton mill at Leominster, in Herefordshire, patented the first carding machine. The specification reads: "The properties by which this machine of carding differs from any other method hitherto invented are principally these; that the cards are put upon cylinders and that these act against each other by a circular motion and that they may be moved either by hand or by water-wheel." In the same year Paul invented two cards, one of which was probably the forerunner of the cotton card.

FIG. 1 (i)  (ii) 

The other was based on roller carding, and, like Bourn's, required far less manual labour than did the hand cards. In this machine (Fig. 2) the material had to be placed in the machine, carded and then taken off the machine; in other words the process was discontinuous. It is thought that Arkwright was responsible for converting the process to a continuous one, firstly, by the invention of a pair of fluted feed rollers which passed the material into the machine; secondly, by the introduction of a doffer to take the material from the carding cylinder; and finally, by an oscillating comb which removed the fibres from the teeth of the doffer in a continuous web-like form. Arkwright's first card is shown in Fig. 3, and a later model in Fig. 4. The latter was used at the end of the eighteenth century for carding cotton, but the similarity between this machine and the one used for carding wool in the Stroud district of Gloucestershire about 1815 indicates that the main principles of machine carding had by then been established.

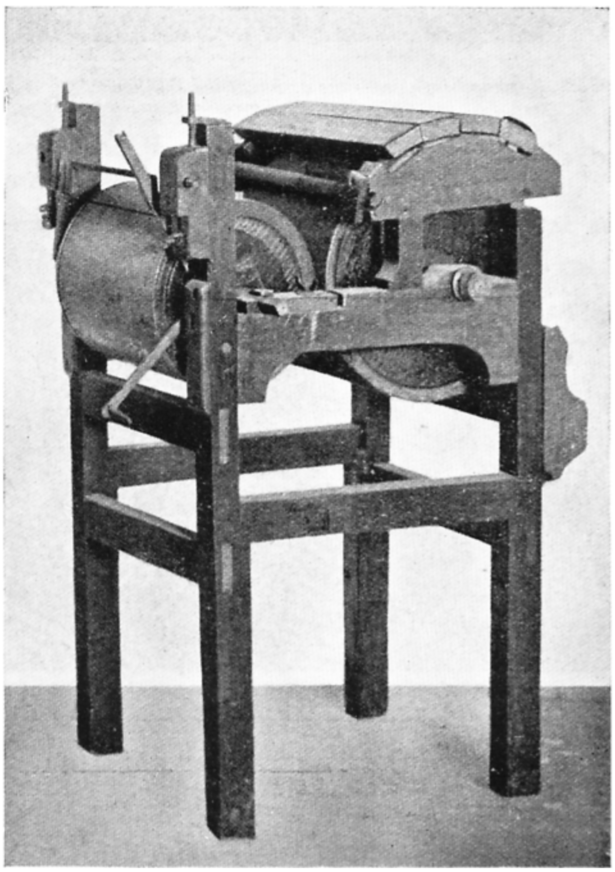


FIG. 3 *Arkwright's first carding machine.*
(Courtesy: The Textile Institute)

METHODS OF CONDENSING

In those days, the web of fibres removed from the doffer of the machine consisted of strips some five inches wide and the length of the machine. These slivers were joined together end to end by hand and reduced in diameter by the slubbing-billy, after which the rovings were spun to yarns by the mule, which in those days would be Hargreaves's Spinning Jenny. By 1821, however, this method of condensing was replaced by the invention of the single ring doffer. In this case the rings of card clothing, instead of extending across the roller, were wound round it. The rings were about an inch wide and separated from each other by a ring of plain leather, and as the doffer rotated it took from the swift a series of endless slivers, each being, of course, one inch wide. These were stripped from the doffer by a comb, and then made to pass between a pair of endless leather bands, which rubbed them into circular slivers preparatory to spinning. It will, of course, be realised that this doffing device only removed that material from the swift which happened to be opposite to the strips of card clothing; the remainder opposite the leather strips was not removed. This unproductive method was overcome by the introduction, in 1825, of the double doffer condenser, where the whole mass of fibres on the swift was removed by placing one doffer over the top of the other. Each doffer was clothed across by successive rings of card clothing and leather, but the strip of clothing on the top doffer was arranged to be immediately over the bottom doffer's strip of leather. Both these methods of condensing are still used, along with a third method, that of tape condensing, which was introduced about 1861. In this

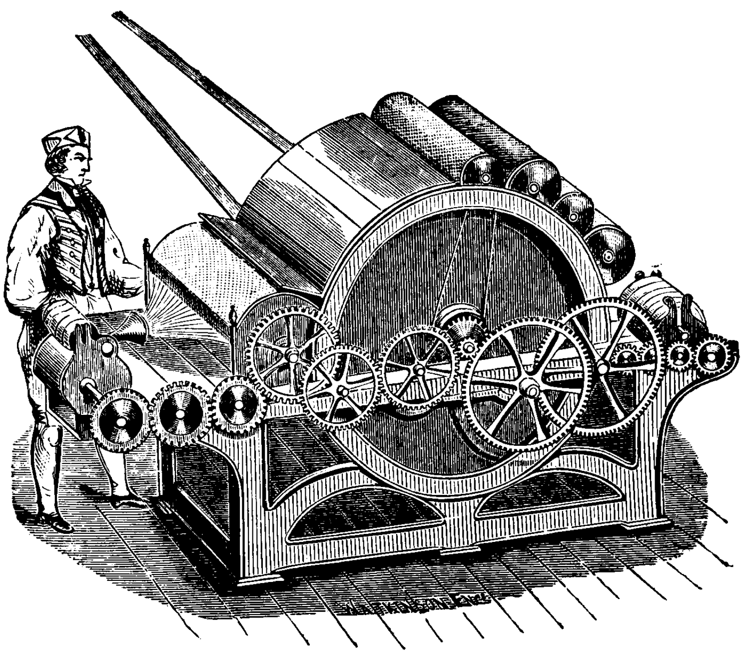


FIG. 4 *Arkwright's later carding machine.*
(Courtesy: The Textile Institute)

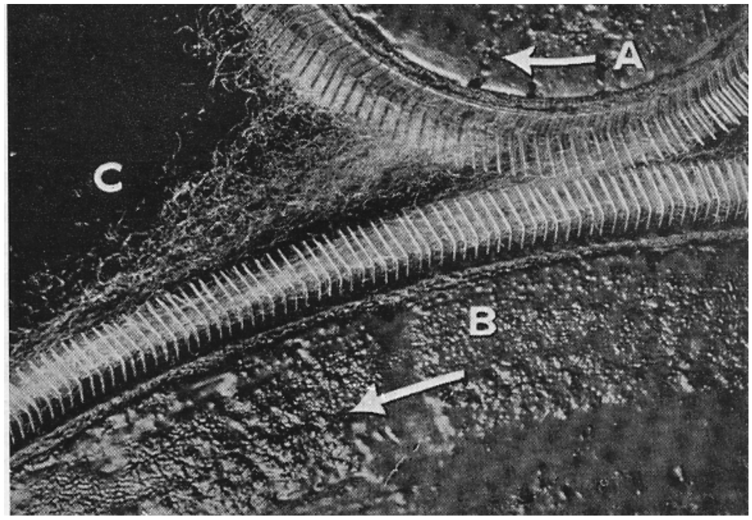
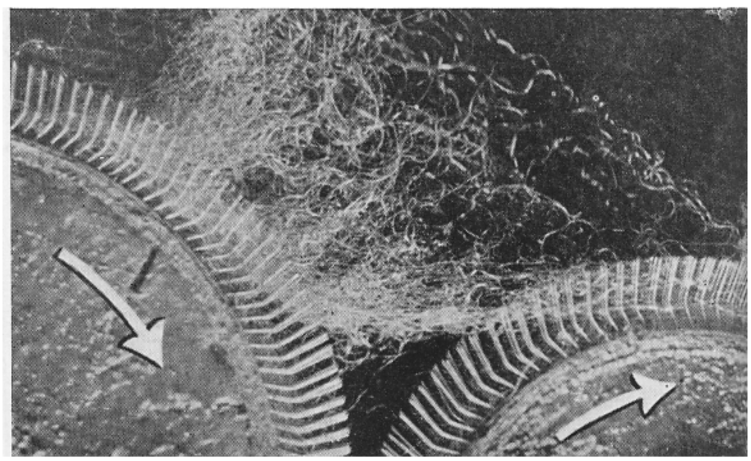


FIG. 5 *Carding Machine — the action of the Worker.*
(Courtesy: Wool Industries Research Association)

FIG. 6 *Stripping the Worker.*
(Courtesy: Wool Industries Research Association)



system, the web of fibres is removed from the last swift in the card by a doffer covered entirely with card clothing, and this web, the full width of the card, is then passed forward between a series of narrow endless strips of leather, called tapes. These tapes split the web from the card into slivers the width of the tape, say half an inch, and these pass forward to the rubbing mechanism, where they are transformed into the circular sliver suitable for spinning.

AUTOMATIC FEEDS

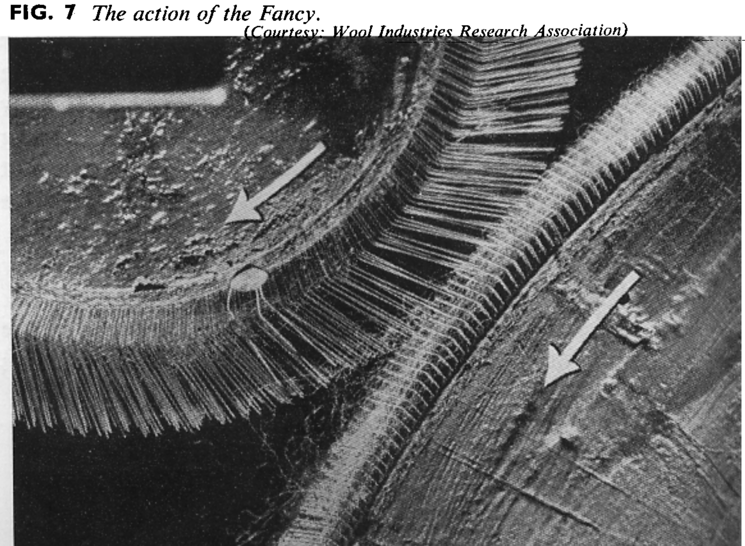
Up to this time the wool had been fed to the card by hand, weighed amounts being spread evenly on the feed sheet of the machine between marked lathes equally spaced apart. But the introduction of the condenser systems, especially the tape condenser which produced much finer slivers, emphasised the need for some automatic feed. This device, patented in 1860, simply consisted of a hopper capable of holding a large quantity of wool, which was carried forward by a spiked lattice to a scale-pan from which weighed amounts were dropped at fixed intervals of time on to the feed sheet.

CARDING PROCESSES

In a modern carding machine the automatic feed passes a more or less uniform stream of wool forward to the feed rollers of the machine. From there it is carried forward by the main cylinder (Fig. 5, B) to undergo the disentangling action between this cylinder and the first worker (A). Some of the material goes forward, whilst the rest, caught by the worker, passes round the latter's circumference, from where it is removed by the stripper and again placed on to the main cylinder to go forward again (Fig. 6). It will be seen that the disentangling action also brings about a mixing of the various qualities or colours in the blend, for the wool, placed back on to the cylinder by the stripper, obviously joins up with other fibres which come on at a later stage. Each cylinder has some four to eight pairs of workers and strippers placed over it, so quite a lot of disentangling and mixing takes place over the one cylinder. But obviously there is a limit to the amount of carding which can be achieved by the one swift, for at each worker-cylinder action some of the fibres are pushed between the teeth of the swift and then are unable to take part in the subsequent carding actions. Consequently the material, after its passage past the four to eight workers, is raised by another roller called a fancy (Fig. 7). The teeth of this roller act like a brush and raise the fibres to the surface of the swift's teeth, from where they are removed by the doffer. This roller passes the fibres forward to a second swift, where further disentangling and mixing is accomplished by another set of workers and strippers. A modern carding machine consists of some three to six swifts, each with its attendant workers, strippers, fancy and doffer (Fig.8).

In order to achieve a gradual disentanglement of the fibres throughout the machine with a minimum amount of breakage, the density of pinning on the

FIG. 7 *The action of the Fancy.*
(Courtesy: Wool Industries Research Association)



various rollers is graduated throughout the machine. It is coarse at the commencement and fine at the end of the machine, and the spacing between the rollers is also graduated; for example, the distance between the wires of the swift and workers might be about 1/50 inch in the case of the first swift, and 1/100 inch in the case of the last swift.

After the fibres have passed through the first two or three swifts of the card, the web is stripped from the last doffer, and conveyed in a sliver form to another feed sheet, on to which it is laid at right angles to its forward motion into the second half of the carding machine. This break in the continuity of the card is known as the intermediate feed, and is designed to reduce any variations in uniformity of feed to the card. One cannot be sure that every weighing of material is exactly alike, and so this break in the machine with its consequent rearrangement and doubling of the slivers does compensate for this deficiency. At the same time the intermediate feed helps to mix the fibres.

PRODUCTION OF SLIVERS

The fibres then pass through the second half of the machine, which again consists of swifts with their attendant workers, strippers, fancy and doffer, until they reach the last doffer of the machine. From here the web of fibres is removed by a doffing-comb, or stripper, in a thin web extending the full width of the machine, say sixty inches, and passed to the condenser, whose function is to split up this web into a series of narrow webs, say half an inch wide. Each web is then converted into a circular sliver and wound on to a wooden bobbin ready for spinning (Fig. 9). The tape condenser, which is probably the most common type, consists of two series of endless leather bands arranged side by side. The top series of bands pass to the bottom of the machine whilst the bottom series pass to the top of the machine and at the same time the web of fibres from the back doffer is fed to the point of intersection of the tapes. Thus the web is divided up into a number of narrower webs, the width depending on the width of the tape and the number of ends corresponding with the number of tapes. In a modern machine a sixty-inch web can be split up into 240 ends, each being, of course, a quarter-inch wide. The web of fibres which lies on each tape is then removed from the tape and passes between a pair of oscillating leather aprons. These aprons have two motions; in the first place they pass the web forward, but at the same time they have a lateral movement which rubs the web into a circulaı sliver, and the web enters the rubbing aprons in a rectangular form and leaves them in the form of a circular sliver. There is no twist in the slivers. They hold together because of the fibrous nature of the material. Finally, the condensed slivers are wound on

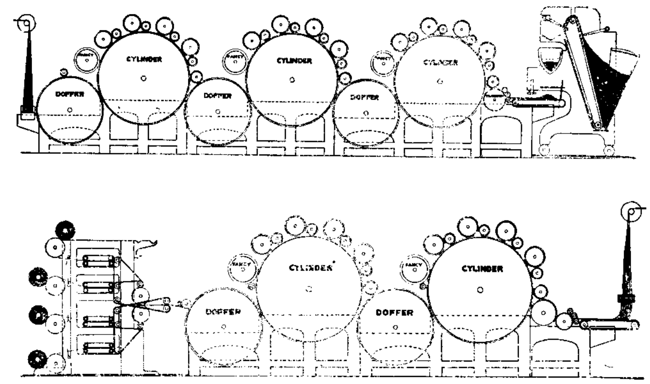


FIG. 8 *Modern Carding Machine.*
(*Courtesy: Messrs. Platt Bros. (Sales) Ltd.*)

to bobbins, side by side, perhaps twenty to thirty on a bobbin, and taken to the spinning machine for conversion to a yarn. In this process the condensed sliver is reduced in cross-sectional area, and at the same time is twisted to impart to the yarn sufficient strength for the subsequent operations of winding or warping and weaving.

FIG. 9 *Circular slivers wound on to bobbins.*
(*Courtesy: Messrs. Platt Bros. (Sales) Ltd.*