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A SURVEY OF CURRENT SHORT STAPLE SPINNING SYSTEMS [1]

by

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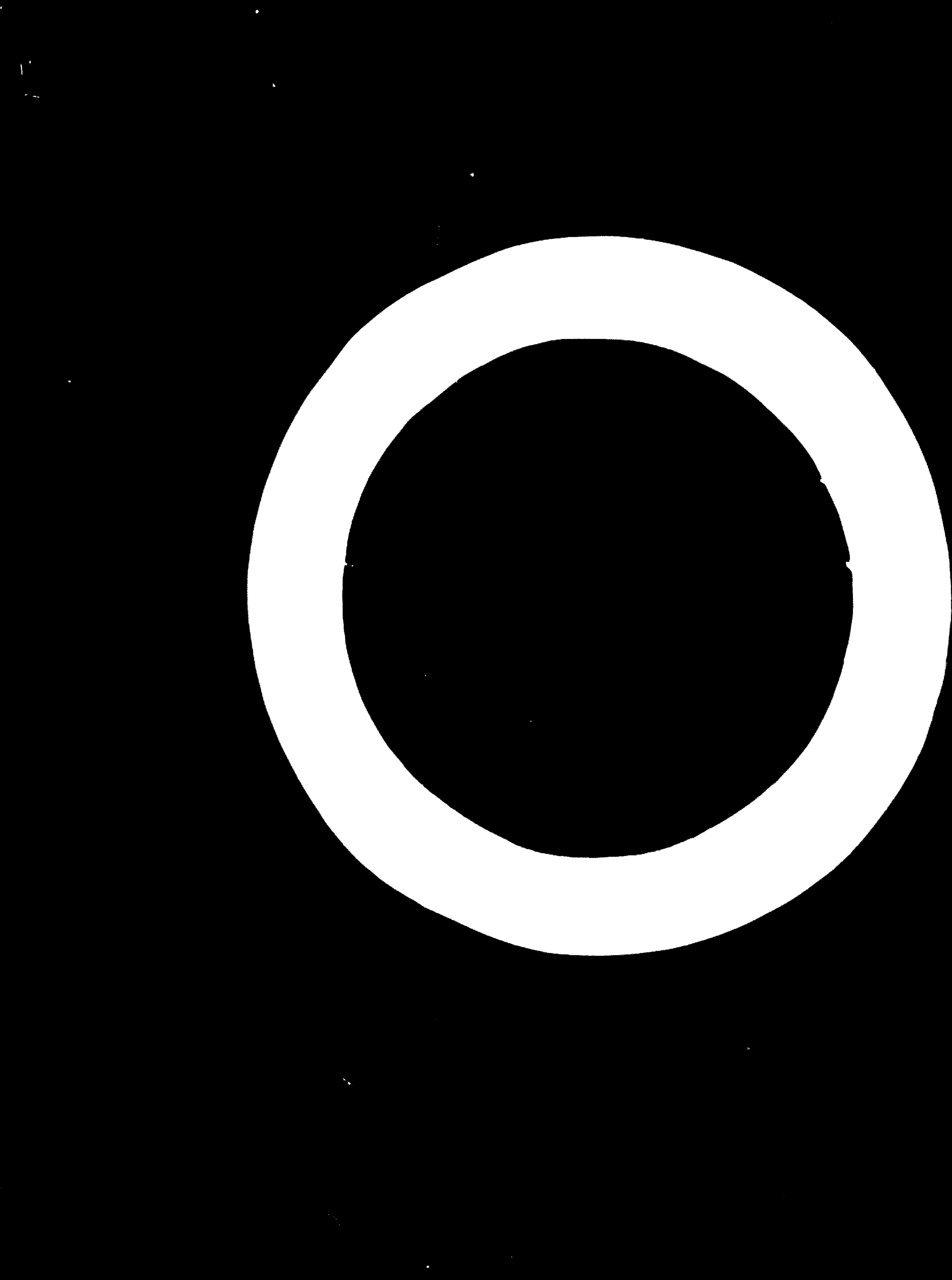


Introduction

In the past 20 years there have been very considerable developments in methods for producing and handling short staple yarns; in fact what has happened has been hailed by some as a technological revolution. The highly competitive world markets in textiles have demanded greater efficiencies and hence higher and higher productivities and improved product qualities. The most obvious and effective way of achieving higher productivity was to shorten the textile making process by reducing the number of machines in the production line, to run remaining machines faster, and to produce larger packages. The production of larger packages was necessary to reduce handling so that the effects of productivity would not be offset by increased loads on the operative.

If some drafting processes in the spinning sequence are omitted then it is necessary to use higher drafts at the remaining processes and/or doublings must be sacrificed. During carding, fibres become hooked and the direction in which the hooked fibres are presented to each process is important. Although later drafting processes tend to reduce the hooks, they are never completely eliminated; the higher the draft the greater is the need to present the fibres to the drafting system with their hooks trailing. The direction of fibres is reversed at each packaging operation and since most of the fibres leaving the card have trailing hooks, there should be an even number of packaging processes between the card and the ringframe; in other words there should be an odd number of machines or processes. When this is the case, fibres enter the drafting system of the ringframe, where the draft is normally the highest, with their hook trailing. Failure to present the fibres in the appropriate direction at the ring frame can result in a loss of strength of up to 10%. The most common line-up for carded yarns has therefore become two drawframe processes and one speedframe process between the card and ringframe.

The advent of open-end spinning offers the opportunity to further shorten the spinning sequence since the speedframe process can be omitted. It is interesting to note that, from what evidence is available, yarn quality appears to be unaffected by the direction of presentation of the fibres i.e. whether the hooks are trailing or leading, when the open-end spinning machine is equipped with a combing roller opener. In the case of open end spinning therefore, there are usually just two drawframe processes between the card and spinning machine.

Researches directed towards improved product regularity, many of which were carried out at the Shirley Institute during the late 1940's and early 1950's, indicated the necessity for better engineered machines. In meeting the demands for improved product quality, machinery makers also satisfied the requirements for increasing machine speeds. The development of the modern drawframe is a good example of this.

One of the major causes of irregular drawframe sliver was associated with torsional vibration of the rear bottom roller of the drafting system. In order to eliminate this fault the number of deliveries per drawframe was reduced from the normal six or eight, initially to four and eventually two; even a single-delivery drawframe was built. This together with an improved drafting system and better engineering has led to the modern drawframe which compared with the earlier machines is capable of producing substantially more even sliver whilst achieving a ten-fold increase in delivery speed.

Packages have become considerably larger at some processes. For example the typical card sliver can of ten to fifteen years ago was nine inches in diameter and held about 8 lb of sliver whereas today cans of 36 inches in diameter which hold up to 150 lb of sliver are common.

One packaging operation has been completely omitted in some modern spinning plants, i.e. lap formation, so that feed to the cards is completely automated. On the other hand ringframe packages have not increased in size a great deal. Large packages tend to impose a speed limit on the ring spindle; this is partly because the maximum traveller speed is reached at lower spindle speeds when larger diameter rings are used and partly because of the disproportionate increase in power needed to rotate larger packages.

<u>Opening</u>

For some time the blow room has been a largely automatic sequence and only the initial bale feeding has been done manually. Bale digesters, which were introduced during the late 1950's, can now do the initial feeding automatically and these machines are becoming a familiar feature of the modern blow room.

Most bale digesters are similar in principle and consist essentially of a means of transporting bales over a series of digesting units. The bale is normally transported by lattices which may move the bales backwards and forwards over the digesting units and which may be arranged in a straight line or in a circle. The digesting units remove tufts of fibre from the bales either by means of a beater-type opener, a spiked lattice or by finger-like projections which literally perform a plucking action.

Earlier digesters, like the current ones, were able to deliver the fibre in a very open state and were quite satisfactory for simple cotton blends. The maintenance of accurate blend proportions was a problem,however, particularly when mixings included bales of different density and size. This arose because bales of different density and size were digested at different rates, because the rate of digestion reduced as the weight of the bale reduced and because some bales became 'work-hardened' and hence relatively undigestable.

Machinery makers have been aware of these shortcomings and the latest digesters, such as those by Rieter and Hergeth are designed to overcome them. For example, the Rieter Karousel Opener, which takes six bales, has been modified so that the pressure with which the bales are pressed down onto the pluckers is automatically adjusted in order to comensate for the loss in weight of the bale as it is digested. In the Hergeth digester, the bales are placed on a lattice with a sloping cover; as the bales proceed along the lattice, they are pressed against the pluckers owing to the progressively decreasing space which is available between the lattice and cover.

A feature of the straight lattice digesters is the large number of reserve positions for bales. The Trutzschler digester for example, has reserve positions for up to 15 bales; if we assume the bales are about 400 lb, the total weight of fibre in reserve will be 6000 lb. For this reason it is common practice in some mills to have the blow room unmanned during the night shift; towards the end of the day shift, sufficient bales are placed on the digester lattices to last overnight.

Ingolstadt have recently introduced a completely new type of opening and blending system based on what they call a blending grab. This consists essentially of a grab arm which is mounted on a carriage with a weigh pan; the carriage runs along a track of any given length alongside which are arranged the bales which form the mixing. At predetermined intervals, the carriage stops, the grab arm is lowered onto the bales, tufts of fibre are taken by the grabs and then deposited into the weigh pan. When the weigh pan contains the pre-set weight of fibre, the carriage moves to the first hopper in the opening line and the contents of the weigh pan ar discharged into it. The carriage then returns to the point along the line of bales where it had previously stopped working and resume its operation. More than one mixing can be set up along the line and partly worked-off bales of one mixing need not be removed before a second mixing is worked.

In adopting bale digesters the opportunity of using very large mixings can be lost. There are several ways of minimising these short comings however; one is by use of simple mixings of one type of bale, another is by pre-blending and another is by employing the modern equivalent of stack mixings.

The techniques of pre-blending has been used in the U.S.A. and by this means it has been claimed that bale digesters have provided the theoretical equivalent of 1,000 bale mixings.

Use of large mixings in which various components are thoroughly and intimately mixed leads to fewer processing problems and yarns which are more regular in all respects. This has been appreciated for many years and in the past this has been achieved by stack mixings, sometimes comprising several thousand pounds of cotton. The feeding of fibre into the stack and in particular the removal of fibre from it, require a great deal of labour; labour has become more and more expensive so that alternative, more mechanised, methods of achieving the same object have been sought. The modern solution is the multi-mixer; this type of machine is based on the well proven principles of the stack mixing and consists of vertical accumulator trunks, perhaps up to twelve in number, which are topped-up in sequence and from which fibre is removed by a horizontal lattice.

Fibre may be carried to the cards from the blowing room either as laps or in loose form. Laps made on modern scutchers are generally doffed and weighed and the weight recorded completely automatically;

consistent lap weight is an excellent start to good count control. Laps of acceptable weight can be transported manually or automatically. Loose fibre may be carried pnuematically to chutes or hoppers behind a series of perhaps 4 to 8 cards. Various methods are used to try to ensure that the fibre packing density in the chute is consistent from chute to chute and from time to time. Some manufacturers re-cycle the fibre around the system of chutes whilst others avoid re-cycling because they believe it can have adverse effects on quality.

Carding

Although many manufacturers offer new high production cards, these in general differ little from the cards built 20 years ago. They are certainly more robust and are certainly made to much higher standards of engineering but nevertheless look much the same and employ exactly the same principles of carding. For this reason many spinners have preferred to convert their old cards for high production rather than buy new ones; the cost of converting a card is usually somewhat less than half the cost of a new one.

The conversion consists of running the various card parts faster; the cylinder, which is often re-fitted with a steel shaft and may be dynamically balanced, is commonly run at 300 to 320 rev/min, the taker-in speed is perhaps 700 rev/min or higher and the flats speed may be increased to 6 or even 9 inches/min. Cylinders and doffers are clothed with rigid, sometimes called metallic, wire which eliminates the need for frequent stripping and reduces the card waste losses.

Flats wire is commonly of the rigid 'vee-top' type or of the semi-rigid type. The 'vee-top' is a cold drawn wire with no knee and with a diamond-shaped point (Fig.1); this type of flats wire cannot be ground so that re-clothing is necessary when such wires become worn or damaged. Semi-rigid flats wire (Fig.2) is circular or oval in cross-section and is extra hardened and extra side-ground (Traditionally flexible flats wire is also hardened and side-grounds, but semi-rigid wire is given a special treatment which results in the wire being harder than ordinary flexible wire; it is also side-ground to a greater extent. Hence the terms 'extra-hardened' and extra-side-ground'). There is a knee in this wire and the wire itself is usually set in a special deep, flexible foundation that nearly reaches to the knee of the wire. The top of the wire is rectangular or chisel shaped; unlike the 'vee-top', this wire can be ground and this almost certainly accounts for the increasing adoption of flats clothed with semi-rigid wire.

Very recently stationary carding plates have re-appeared. These are similar in concept to the granular flats of the late 1950's; instead of grit, however, the surface of the segments or plates is clothed with semi-rigid or rigid wire. Use of these plates leads to the elimination of flat strip and surprisingly, it is claimed that comparable and even improved carding can be achieved with cotton as well as man-made fibres. Since there are no moving parts power costs are reduced and little or no maintenance or adjustment is required. The plates effectively seal and hence eliminate liberation of dust from the upper region of the cylinder.

Manufacturers recommended that the plates, which are interchangeable, should be replaced with new ones when they fail to give the required carding performance; they are essentially disposable and cannot be ground.

The increase in rates of production at the card inevitably led to higher doffer speeds and initially to problems associated with stripping the web from the doffer. The first new high production card which was manufactured by S.A.C.M. incorporated a perforated doffer from which the web was stripped pneumatically. New light weight balanced flycombs were also designed and operated at frequencies of 50 cycles per second. The most common solution however has been to employ a roller take-off mechanism; such devices are able to strip the doffer at the highest current processing rates.

Often incorporated in the doffer stripping unit is a pair of crushing rollers which break-up the particles of seed coat and nep which may be present in the web when cotton is being processed. These rollers are extremely effective and the crushed trash subsequently falls from the cotton at the drawframe, speedframe and ringframe processes; improved cleanliness in the final yarn arising from use of crushing rollers at the card is comparable to that achieved with three extra beaters in the opening line.

Higher sliver delivery speeds at the card have necessitated development of improved coilers which deposit the sliver into very large cans. The most modern coilers are of the so called planetary type which are able to coil the sliver at high speed into cans of up to 36 in. in diameter without the need to rotate the can. The cans, which can hold as much as 150 lb of material, are generally fitted with castors so that they can be rolled easily into the coiling position where they are retained by means of a strap.

The linking of two cards in tandem has been successfully engineered by Carding Specialists; the sliver from this tandem set is much cleaner than that produced by single carding and the resulting yarn has the appearance of a semi-combed quality. Tandem carded material is also particularly good for open-end spinning owing to its extremely low trash content.

Platt International have achieved improved cleaning at the single card by a modification to the Platt Type 600 card in which an extra taker-in is incorporated. The material produced by this card is also claimed to very suitale for open-end spinning.

Even with low production cards it is necessary to remove the dust that is liberated if the health of the card room operatives is not to be seriously impaired. High production carding liberates considerably more dust than low production carding and dust removal systems such as the Shirley Pressure Point System have become an essential and often integral part of the high production card.

The cardroom has consequently become a room with a relatively clean atmosphere. There is, however, more dust than there used to be liberated at subsequent stages in the processing sequence. This arises as a result of higher speeds, larger packages and the use of crushing rollers at the card. Urgent attention must be given to this problem of dust liberation at later processes if another generation by byssinotics is to be avoided.

It is now common practice in high production carding to incorporate automatic waste removal. Removal of card wastes and dust is normally partially combined in that the same trunking is used to convey taker-in droppings, flat strips and under-card fly, along with dust-laden air, to a settling chamber. This means inevitably that the card wastes become mixed; the savings in labour costs arising out of automatic removal of card westes are therefore off-set to a small extent by the reduced value of mixed card wastes compared with unmixed card wastes.

Dust and waste removal systems require large volumes of air, perhaps 1000 c.f.m. per card. In order to conserve such large quantities of conditioned air the card exhausts are sometimes recirculated after suitable filtration of the air; the latter is usually achieved by rotary cage filters possibly followed by electrostatic dust precipitators.

Autolevelling

It was stated earlier that maintenance of constant lap weight provides an excellent opportunity to achieve good control in the spinning mill. This opportunity can be lost if chute feeding is adopted; also the modern, shorter process with its inevitable fewer doublings does not help the situation. In consequence it is usually considered desirable if not essential to employ some form of autolevelling in order to reduce or minimise the effects of long-term variations in feed to the card.

In order to autolevel it is first necessary to measure the thickness of the sliver or perhaps the weight of a full can of sliver; at least one manufacturer offers a drawframe which does both. Mechanical, capacitance, pneumatic, hydraulic or photoelectric devices are used for measuring the linear densities of slivers entering the drafting system.

Autolevelling may be accomplished by means of a so-called 'open' or 'closed' loop. To qualify these terms let us consider an autolevelling device associated with a drafting system at the drawframe. In open loop autolevelling, the linear densities of the slivers are measured and corrections are made at a later stage in the process, the result of the correction not being measured. In a closed loop system, detection of the error in linear density is made after the drafting has occurred, and the correction is made before the slivers enter the drafting system. As the correction is made, the detector decides whether this correction is sufficient, or whether an over-correction has been made; this information is fed back to the control device. Mixed systems are not uncommon, i.e. systems which employ both open and closed loop autoleveller.

Even when autolevellers are working perfectly, they reduce irregularity in certain wavebands only at the expense of increasing it in others. This is an important consideration which must be taken into account when deciding where an autoleveller is to be placed in the processing sequence.

This point can be illustrated by the results of an investigation made by the Shirley Institute into the performance of a card autoleveller. The spectograms for autolevelled and non-autolevelled sliver card slivers are shown in Fig.3. This shows that the autoleveller has reduced irregularity at wavelength greater than 100 yd but has increased the irregularity at wavelengths less than 100 yd. The increase in short-term irregularity is counteracted however by doublings at the drawframe with the result that its contributi n to the irregularity of finisher sliver is negligible compared with the elimination of longer-term irregularity. This can be seen in Fig.4.

Some form or autolevelling can be carried out at any stage of the spinning sequence. However, for the technical reasons discussed above it is desirable to autolevel at one of the earlier processes. For reasons of economy it is also attractive to autolevel at one of the earlier processes; here fewer machines are involved and hence fewer autolevelling devices are required. In practice therefore autolevellers are most usually found at the card or drawframe and occasionally at the comber.

<u>Drawframes</u>

The spinner is able to choose a machine which exactly suits his needs from the wide variety of drawframes which are now available. The drawframe may be a single-delivery or a two-delivery machine and in either case the sliver delivery speed will be in the range 800 ft/min to about 1600 ft/min. Can changing can be manual or automatic. Can sizes may vary from 40 in. in diameter and 45 in. in height down to 12 in. in diameter and 30 in. in height. Drawframes producing the very small cans such as those offered by Platt International and by Toyoda have been developed primarily to process sliver intended for open-end spinning, in particular open-end spinning on double-sided machines; the manufacturers of at least one drawframe have employed a hydraulic ram to pack up to 15 lb of sliver into these small cans.

Modern drawframe drafting systems are designed to accommodate a wide range of fibre lengths. Bottom drafting rollers often have fixed settings and only relatively simple adjustments to the settings of the top rollers are required when fibres of a different staple length are to be processed. Rollers may be weighted by hydraulic or pneumatic means. Sliver regularity is excellent.

As discussed earlier, drawframes may be equipped with autolevelling devices. Some drawframes can be fitted with trash crushing rollers although it is more usual to fit these at the card.

Except when combing or blending (both are discussed later) two passages of drawing, 6 ends creeled at each passage, is normal practice.

Combing

Improved engineering has, over the last decade, led to appreciable increases in comber production rates. The latest machines, equipped with cam-controlled epicyclic gear drive to the detaching rollers, are capable of operating at speeds well in excess of 200 nips/min and of production rates approaching 100 lb/hr.

Although combing has been of declining importance for the production of fine cotton yarns there has been considerable activity in recent years in the use of combed cotton slivers for blending with man-made fibres.

Normally for a combed quality, card sliver is given one passage of drawing followed by a lap forming process and combing; finally, the sliver is given two post-comber passages of drawing.

Like cards and drawframes, the comber may incorporate an autolevelling device; one comber in fact has an autoleveller which employs the basic principles of both open and closed loop.

Blending

The blending of various types of cottons in a mix has been dealt with earlier in the paper. It is proposed here to discuss the techniques and machines employed in the blending of cottons with man-made fibres and man-made fibres with man-made fibres.

Blending can be done before carding, at the card or after carding.

The blending of fibres before carding i.e. in the blowroom, as might be expected gives the most intimate mixing of the fibre components; this is because the maximum number of processes follow the blending operation. There are other advantages but some disadvantages in pre-card blending. For example, some fibres are difficult to card on their own but can be 'helped through' the carding process by some other fibre; it is well known that a blend of cotton and nylon can be carded more easily than 100% nylon. On the other hand blending of cotton and man-made fibres during opening has the disadvantage that the cotton requires cleaning whereas the man-made fibre does not; this means that pre-cleaning of the cotton fibre is necessary. It is likely too that a compromise has to be made in choosing the carding conditions i.e. maximum carding rates may be different for the two or more components as may such things as the most suitable type of wire on the taker-in and the setting of the flats to the cylinder.

It is common practice to use combed cotton for the better qualities of cotton/man-made fibre blends. If this were done in association with pre-card blending then it would be necessary to either feed the combed sliver back to the blowroom or alternatively to comb the blend. In the first case there would be a serious risk of over-processing the cotton and in the second case there would be an unnecessary loss of man-made fibre and a probable deviation from the nominal proportions.

Most of these advantages and disadvantages associated with pre-card blending apply equally well to blending at the card.

Blending after carding is normally carried out at the drawframe. If the blend is of cotton and man-made fibre then the cotton will most probably have been combed and will be available for blending as a reasonably uniform sliver of known linear density. The man-made fibre, after carding, is usually pre-drawn before blending to ensure reasonable uniformity and to arrive at the desired linear density. The cotton and man-made slivers re then arranged in the required proportions in the creel of the drawframe. At least two, and often three passages of drawing are used to achieve a satisfactory blend of the fibre components.

Two machinery makers, Heberlein-Hispano and Som, have recently introduced drawframes which are specifically designed for blending. Both these machines go far to make blending at the drawframe capable of giving an intimate blend with higher uniformity of composition than blowroom blending. The two machines employ the same basic principles and so only one, the Hispablender by Heberlein-Hispano will be described.

In the case of this machine 24 cans are creeled as four blocks of six cans each which feed into four vertically disposed 3-over-4 drafting systems. The webs delivered by these systems are superimposed on to a conveyor belt which transports them into a final drafting zone which is a standard Hispadrafter drawframe. The sandwich blending and subsequent drafting and condensing into a normal sliver is claimed to be superior to three passages of normal drawframe blending and almost equal to four.

Speedframes

Despite the increased draft at the ringframe which have made it possible to spin direct sliver, the speedframe is still an essential feature of the vast majority of spinning plants. Increasing use of open-end spinning machines however will gradually but inevtiably reduce the importance of the speedframe whose future will be closely linked with that of the ringframe.

Speedframe package sizes have been stable for the past few years at about 14 in. x 7 in. for coarse rovings and 12 in. x 6 in. for fine rovings. In general flyer speeds are about 1200 to 1400 rev/min although one particular speedframe, the Rovematic by Saco-Lowell, has been used commercially for some years at operating speeds of up to 1800 rev/min.

Some machine makers incorporate a positive bobbin drive in place of the more traditional cone drum drive and offer pneumatically weighted drafting systems. On some machines the flyers are closed at both ends and some are designed in such a way that they can be doffed without removing the flyers.

As speedframe speeds and package sizes have increased, it has become necessary to increase the twist inserted into the rovings. This has impose a greater demand on he drafting syst m at the ringframe with the result that roller weightings have had to be increased appreciably.

Ringframes

There have been no outstanding developments in ringframes in recent years although ringframes certainly continue to be better engineered. Drafting systems have, of necessity, been designed to be more heavily weighted and some manufacturers have chosen to do this by pneumatic means. Improvements in the drafting systems have also made them more flexible and able to process a wider range of fibre lengths without the need to make any major adjustments. The short-term regularity of yarns has never been better. From time to time, new types of ring and new ring finishes have been introduced so that running-in procedures for new rings have been appreciably simplified and shortened and spinning speeds have gradually increased. Ringframes are currently available, in fact, which are technically capable of operating with spindle speeds of 18,000 rev/min although in general it is doubtful if, even with the smallest packages, it would be economical to do so; the power required to rotate a spindle and yarn balloon increases quite disproportionately with increased spindle speed whereas the production of the ring spindle increases only proportionately.

Use of tangential belt drives for ring spindles has been increasingly adopted by ringframe manufacturers in recent years and virtually any make of ringframe can be bought with this type of spindle drive. It is claimed that this system leads to a significant reduction in speed variation between ring spindles (less than 2% over a full frame) and to reduce, by as much as 10%, the power required to drive the spindles. Because the drive can be totally enclosed, the noise level in the vicinity of a ringframe with a tangential belt drive is noticeably lower than that in the vicinity of a ringframe equipped with a conventional spindle drive.

Over the years attempts have been made to reduce the labour requirements in ring spinning by making the spinners duties fewer and less tiring, for example, battery operated trucks have been designed so that the spinner does not need to patrol on foot.

In the past few years no fewer than 15 companies have developed ringframe autodoffers. These are either of the full frame type or the patrolling carriage type.

The full frame autodoffers are an integral part of the ringframe; in general they transfer full bobbins from the spindles to a set of pegs mounted on a belt conveyor at the side of the machine and transfer empty tubes from the conveyor to the spindles. Emptying the conveyor and furnishing it with fresh tubes is carried out by a fixed unit at the end of the frame.

The patrolling carriage autodoffers operate on the two principles. In one case the machines doff full and done empty tubes in a smooth cycle as they traverse the length of the ringframe; in the other case the autodoffer proceeds along the machine to a succession of stations at each of which it doffs and dones a group of spindles. The latter cycle of operation is reminiscent of the Shirley Autodoffer which was developed during the late 1940's.

Fixed, full frame autodoffers are applicable to frames with a short spinning cycle i.e. the coarser counts, where the higher capital cost can be justified. For the finer counts or for flexible spinning plants, the lower cost and mobility of the carriage doffer are advantageous. An equal cost point will occur dependent upon, for example, details of ringframe production, staffing, cost of installation and maintenance. One manufacturer believes that the equal cost point between whole frame and carriage doffers will occur in the region 50 tex (12's cc).

The problem of ends down at the ringframe has been tackled in two ways by the development of automatic end-piecers and by the use of devices which detect and indicate ends down. In either case analysis of end-breakage rates can be made to give management current information on spinning efficiency.

Several automatic end piecers are known to be at an advanced stage of development. One particular piecer patrols about four ringframes and detects the absence of an end between the delivery rollers and lappet of the ringframe with an optical probe. The piecer stops at the end concerned first, arrests the spindle and then rotates it backwards until the end on the tube is found. The end is held mechanically and threaded through the lappet; finally the traveller is blown onto the yarn, the spindle allowed to rotate and the end advanced to the roller nip in order to make a piecing. The piecing so produced is about an inch in length. The machine can be programmed to repeat its piecing cycle any required number of times if it does not succeed the first time.

Equipping of each spindle with an inexpensive, robust end-down detector is one way of monitoring end-breaks and collecting data automatically. One manufacturer supplies such detectors which can be linked to a mini-computer which performs any required analysis and presents the results in a type-written form. At least two manufactuers offer detectors which can be fitted to their travelling cleaners, thereby avoiding individual connections to each spindle position. The fact that one or more ends are down on a particular side or section of a frame can be indicated by a light on the frame itself and/or on display boards; alternatively the information, after analysis, can be in the form of a computer print-out.

Despite all these developments, it is difficult to escape the conclusion that the ringframe has reached the limit of its development.

It produces yarn which is good enough for virtually any end use, but the need to strike the optimum balance between the three major cost components in spinning i.e. capital, labour and power, limits the speed of spinning that can profitably be used.

The ringframe process is the most costly of any in yarn production. Indeed it costs more than all the other processes put together and accounts for about 60% of the total cost of staple yarn production. Since there has been no likelihood of any significant reduction in ringframe spinning costs, the time has been ripe for a successor.

Open-end spinning

Since there are to be four papers on open-end spinning presented at this meeting I will deal briefly with this subject and then only in general terms in order to compare it with ring spinning.

Open-end spinning is sometimes referred to as break spinning and I believe that this is a more accurate description of the process. The term break spinning has been used because in fact a break is engineered either continuously or at frequent intervals, in the flow of material through the spinning machine. A fundamental difference between open-end spinning and ring spinning is that in open-end spinning the collecting package does not need to be rotated in order to insert twist into the yarn. This means that there is an opportunity to choose a method of twist insertion which requires less power than is required by the conventional ring spindle; in consequence it is economical in general to use much higher rates of twist insertion. It is also possible, in principle at least, to form any size (or type) of package, so that long lengths of knot-free yarn can be produced.

There are four basic systems into which open-end spinning devices can be grouped. These systems differ principally in the manner in which the break in the stream fibres passing through the spinning machine is repaired and hence the yarn formed. In one group the fibres are assembled into a yarn in a fluid vortex. In another group, fibres are assembled in a discontinuous fashion, initially fibres are drafted in discreet tufts which are superimposed but slightly overlapped to form a continuous strand on the surface of the rotating drafting roller; twist is inserted into the strand as it is withdrawn through a hole in the surface, of, and along the hollow axis of, this same roller. In the two other groups fibres are re-assembled on the axis or on the circumference of a rotating element respectively. It is into the latter category i.e. circumferential fibre assembly, that the present commercial open-end spinning machines can be placed.

Fig. 5 shows the essential features of this type of spinning machine. In such a unit the fibres, probably in sliver form, are fed to an opening device, which may be a succession of drafting rollers but more usually is a single spiked roller, which opens up the sliver so completely that the fibres can be fed forward individually; this is where the break occurs in the spinning system. The break is repaired as the fibres, transported from the opening unit by an air stream, collect on the inner surface of the cup-shaped rotor, which is driven at high speed for each revolution of the rotor therefore a thin layer of fibres is deposited onto its circumference in the 'collecting groove' and is held there by centrifugal force so that a multi-layer strand of fibres is built-up. This strand of fibres is peeled from the collecting groove and twist is simultaneously inserted into it because of the rotation of the rotor; thus the yarn is formed. The yarn is continuously withdrawn from the rotor and the number of fibres in the strand at the point of yarn formation is maintained constant by the continuous deposition of fibres onto the collecting groove.

Open-end spinning machines are currently available which are capable of operating speeds of 45,000 rev/min. Even taking into account the higher twist factors required in open-end spinning, this represents a four-fold increase in productivity per unit compared with ring spinning.

It is only five years since the first open-end spinning machine made its appearance and already there have been striking developments. Rotor speed have increased appreciably and will clearly continue to do so; cleaning devices for cotton fibres have been incorporated into the opening units; package sizes have increased several fold and can be transported from the spinning units by mechanical means. Some machines are even equipped with individual auto-piecing devices for each spinning end.

Open-end spinning has provided a technological break-through which is already beginning to have a tremendous impact on the textile industry.

Yarn Preparation

The preparation of spun yarns encompasses the fields of: clearing of yarn faults and fault analysis; winding of yarn on to cheeses or cones assembling of yarn packages on to creels; beaming of yarns and pirn winding.

Developments in clearing, fault analysis, automatic winding and creels, have been quite spectacular and a large part of the remainder of this paper will be devoted to discussing these topics and their application in developing countries.

Clearing of Faults

(i) Mechanical Clearers (Slubcatchers)

Mechanical clearers consist essentially of two blades separated by a gap; the gap is set according to the degree of clearing required, usually within the range $1\frac{1}{2}D$ to $3D$ where D is the calculated yarn diameter of the yarn which for cotton is given by

$$D \text{ (in 1/1000")} = 1.47 \sqrt{\text{Tex}} = \frac{35.7}{\sqrt{\text{cotton count}}}$$

thick places corresponding to slubs and piecings become jammed between the blades and cause the yarn to break. Variants of this type of clearer are the pivotted blade type and the comb clearer.

Mechanical clearers are cheap, robust, easily set and maintained, but they have three disadvantages:

(a) elliptical slubs can pass through the gap;

(b) they do not take into account the length of the fault and unnecessary stops may be made for knots, seed, fly etc. which may be quite acceptable in weaving;

(c) the yarn is roughened in its passage through the clearer and dust and fly are liberated.

The performance of a considerable number of mechanical clearers has been assessed by the Shirley Institute and in general it is found that the efficiency in detecting slubs and piecings rarely exceeds 40% (at a setting of 2D) and it can be as low as 5%. High efficiency figures are always associated with a considerable number of stops for leaf, seed, fly etc.

Amongst the best of the mechanical clearers are the Hayshaw, the Manchester Book clearer and the Barber Colman with the Crandall Blade. Other researchers, in particular Campens have confirmed these figures and shown that the ratio of spurious stops to necessary stops can be as high as 10:1; this obviously has a very great influence on productivity in winding. Nevertheless for a large number of spun yarns, nothing more elaborate than a simple mechanical clearer is required.

With high quality goods, e.g. shirtings, it is necessary to remove faults that may spoil the appearance of the garment and an electronic clearer becomes essential because it overcomes the disadvantages of the mechanical clearers and at the same time gives an efficiency that can be as high as 90% with only a very small number of spurious stops.

(ii) Electronic clearers

Electronic clearers are made by a number of different firms but the most popular ones in use are by Uster Automat (Zellweger), the Peyerfill, Loepfe and Yarnspec (Leesona). It is estimated that over 300,000 clearers are in world-wide use and at a cost of between £25 and £40 per spindle this represents about £10,000,000 of investment.

The principle on which electronic clearers depend is the continuous measurement of the size of the running yarn by a 'gauging head'; if a thick place passes through the gauging head it produces a signal which is amplified and in turn may cause the yarn to be cut. Two principal methods of gauging are used, namely photo-electric and capacitive, and in each case no direct contact is made between the yarn and the gauging parts of the clearer.

Most electronic clearers are of the photoelectric type and this system consists essentially of casting a shadow of the yarn on to a photo-electric surface; a change in yarn diameter, corresponding to a slub, causes a change in current through the photo-electric device which in turn actuates a knife to sever the yarn.

The sensitivity is usually set by a knob that controls a reference voltage, and the knife operates only if the signal voltage, proportional to the thickness of slub) is sufficient to overcome this reference voltage.

The most suitable reference voltage is set by trial and error (or by reference to fault analysis equipment such as the Yarnalyser) in preliminary trials and up to 120 clearers can usually be set to the same or several different sensitivities with one knob. These clearers are termed rate of change clearers because they depend upon the rate at which the diameter changes which of course is related to yarn speed; thus a long term gradual thickening in diameter may escape detection. Modern clearers have circuits that detect the thickening with reference to length by a special 'length of slub' control.

Thickenings due to spinners doubles caused by two rovings coalescing to form a yarn of say 12s instead of 24s are especially difficult to detect because they correspond to only 1.4 times the yarn diameter.

Modern clearers detect such faults by special electronic circuitry and since the fault may prevail over many yards arrangements are made in order that the doubled yarn is cut immediately it is detected by the clearer. In the case of photoelectric clearers the diameter of the 'normal' yarn is assessed and the signal from the spinner's double is compared with this signal to detect the presence of a double.

Electronic clearers are becoming even more sophisticated and the latest models have adaptors for detecting thin places as well as thick places and special scissors and anvils for dealing with coarse counts. In addition clearers are now available to detect a missing singles yarn in a three fold or four fold thread.

In general most clearers will deal with yarns in the range (100 tex-10 tex) i.e. 6s - 60s cotton counts, but the latest clearers will clear yarns as coarse as 1800 tex (0.3s cc).

Capacitance clearers are made by Zellweger Limited, Uster, Switzerland and gauge the mass of the yarn by means of condenser system and oscillator.

Since capacitance clearers depend on the dielectric constant of the textile fibres the sensitivity control has to be set differently for yarns spun from different fibres, e.g. cotton compared with Terylene. The clearer therefore incorporates a control which is set with reference to the dielectric constant of the fibres.

The dielectric constant of most textile fibres is in the range $1\frac{1}{2}$ to 8, but water has a dielectric constant of 81 and hence capacitance clearers are sensitive to the moisture content of the yarn. This effect is pronounced if the moisture content changes rapidly along the yarn, in which event spurious stops will occur, but if the moisture content changes slowly, and by a small amount, this type of clearer works quite satisfactorily.

Quality yarns demand the clearing of all large slubs and piecings and in some circumstances this can impose an excessive load on the operative. Because of this electronic clearers are a very useful addition to automatic winders since the knotters of these machines are fully able to cope with the increased number of knots that have to be tied without appreciable loss in production.

No difficulties are envisaged in the use of these clearers in developing countries but the setting and periodic checking of the clearers are details that require a competent winding mechanic or foreman.

It has been claimed that the production of break-spun yarns could well eliminate the need for winding and clearing since the package could be used as spun. At the recent Paris machinery exhibition however three large machine manufacturers were exhibiting automatic winders for rewinding and electronically clearing break spun yarns. Murata state that the fault rate in break spun yarns is about 2 per pound an d Schlafhorst put it at 4 per pound. It is known however that some spinning pots producing above average numbers of faults.

The economics of electronic clearing with ordinary manual winding of ring tubes is of interest and importance. If we make reasonable assumptions for the number of faults per pound of ring spun yarn and assume for example that the removal of a fault by a mechanical clearer is accompanied by two spurious or unnecessary stops then the operative is only gainfully employed for about $\frac{1}{2}$ of all the knots tied (since there is one knot for tying in the ring tube). The time wasted tying unnecessary knots can thus be calculated for a full year and then converted to a cash value according to the operative's rate of pay. If such a claculation is made it can be shown that the expensive electronic clearers (which are not accompanied by many spurious stops) will often pay for themselves in 2 or 3 years. In addition it has been shown that a slub in warp or weft can cause the woven cloth to be rejected and sold as seconds and each slub can cost between £1 and £4 per 1000 yard if not cleared in winding. The latest developments of established clearers are:

(a) A special Loepfe FR302 clearer for coarse yarns i.e. 2000 tex (0.3 cc) to 170 tex (3.5 cc);

(b) An adaptor DPA for Uster Automat clearers for the detection of thin places in yarns; these clearers with adaptors are capable of detecting bare places in core yarns;

(c) A new Uster clearer (UAM/X1) for coarse yarns i.e. 1000 tex (0.6 cotton counts) to 40 tex (15 cc).

(d) A new Peyer PI.12 clearer with rotating anvil for the cutter blade. A special version of this for coarse counts will deal with yarns of (1000 tex (0.6 cc) to 100 tex (6 cc) and this clearer can be fitted with a thin place detector; with this detector the clearer can be set to detect a missing component in a 3 or 4 fold yarn.

Fault Classification

Closely allied to the subject of electronic clearing is the study and classification of faults in spun yarn since the two available instruments, Uster Classimat and Crabtree Yarnanlyser can be used in conjunction with electronic clearers to decide upon the optimum settings of the latter; alternatively they can be used in their own right to categorise the faults in spun yarns taken from the production line. These fault classification instruments consist essentially of an electronic clearer with the output pulses from the clearer fed to a digital display system where the faults at different levels (length and mass/diameter) are displayed.

The Uster Classimat the equipment consists essentially of six heads for measuring the faults and an analysing instrument. The heads are mounted on a winding frame and the signals from the measuring head are displayed on 16 different counters labelled 'length' 0, 1, 4 and 8 cm and cross sectional size 100%, 150%, 250% and 400%. Faults of the same cla s at all six measurin positions are s mmated by the same counters; provision is made for a cutter to cut out these faults in certain classifications if necessary. The instrument can be used:

(a) for quality control by comparing the results with values known to be satisfactory from experience;

(b) to enable Uster clearing installation to be set at the most suitable level for the yarn being processed.

On the Crabtree Yarnalyser, a Peyerfil Optical Yarn Clearer, detects the yarn faults and feeds signals giving information on size and length to the Yarnalyser. The display on the Yarnalyser is on 14 different counters - 7 counters are concerned with yarn diameter and each of these is in two length grades, long and short. Again as for the Uster equipment the Crabtree Yarnalyser can be used for quality control or for setting Peyerfil clearers.

Manual Cone Winding

Conventional Winding Machines

In general where labour is cheap and spinning quality high manual winders are an economic proposition for medium and fine counts and a comprehensive range of machines is available from all over the world.

A rotary traverse yarn guiding system giving speeds of up to 1200 yd/min at least is used on most modern machines. Recent developments in the manual winding field are increased traverse (up to 8") larger package diameter, dust removal, increased speed, control of package density, etc.

Manual winding machines for spun yarns are made by Schlafhorst, Leesona, Gilbos, Savio and Schweiter, to mention but a few and the choice of machine is best made by the processor according to the yarn to be wound and the type of package required.

Hank winding machines are still used to some extent and modern machines have elaborate disentanglement devices to slow or sometimes stop the winding if an entanglement develops during the unrolling of the hank.

A novel approach to the problem of unwinding hanks is by the alternative method of unwinding over end. This is the Jumbo system pioneered by Gilbos and consists essentially of a hank expander to hold the hank, a large diameter chromium ring in front of the hank to aid the over-end unwinding and an 8" traverse Gilbos winder with delivery rollers to make the final cone.

The system is principally used for coarse carpet yarns but it is also finding applications with sewing threads. Speeds can be up to 940 yd/min producing cones up to 14" diameter.

Assembly winders are a special type of manual winder and the emphasis here is on developments to brake the package and the driving drum when an end breaks so that the single end is not buried in the cone.. Gilbos on their Rapidoubler claim speeds of up to 800 yds/min with a stop motion that acts in 0.07 seconds.

Rocket winders (for making long packages up to 36" long and 4" or 6" diameter) are made by De la Rue and Hacoba but their principal use is to produce dye packages giving very uniform dyeing.

Automatic Cone Winding

It is in the field of automatic cone winding that the greatest strides in yarn preparation have been made over the last decade.

The Barber Colman Spooler is well known in this field for large production units and is the best known of the large group winders where one knotter serves a large group of winding heads.

For these 'large group' machines, the knotter cannot find the end of the yarn on the tube after a break and the tube is rejected and a fresh tube tied in.

These winders are so well known that no further details of their construction are required, but two important limitations must be mentioned:-

(i) One knotter services a considerable number of winding heads, and the unwinding time of the ring tube must be matched to the interval between visits of the knotter to ensure that each ring tube is exhausted before a new one is tied in by the knotter. It is obvious that severe clearing with its resultant increase in breakage rate will reduce considerably the winding production of these machines.

(ii) It is not economical to wind a wide range of different counts on one machine, since the cycle time of the knotter must be matched to the ring tubes having the longest length of yarn; the machines are best suited for long runs on a narrow range of counts.

Latest developments in the Barber Colman Spooler include a re-tie device on the travelling knotter so that yarns that have broken at the snick plate are retied to the end on the cheese instead of the ring tube being rejected. In addition the knotter can by-pass a spindle that is winding. Both these modifications (applicable to C and CC spoolers) give much increased winding efficiency; in addition severe electronic clearing becomes feasible.

The latest development in these machines is the Orbital Feed system for ring tubes. One development of this system takes unoriented but parallel tubes from a conveyor, removes the backwind, places the end of the yarn in the nose of the tube and finally stacks the bobbins in specially designed trays for convenient distribution to the spooler.

This system can be used for any existing Barber Colman spooler.

A second development is available for 2 or 1 count B.C. Spoolers and takes the ring tubes from the loading system described above and puts them into a distributor which deposits them into their respective winding station.

<u>Small Group Automatic Winders</u>

The production of the Barber Colman Spooler is large by any standard and there is a need for automatic winding machines in the intermediate range of say 10 to 50 spindles per machine.

Machines of this type termed small group automatic winders are the 'in-line machines' such as the Leesona Uniconer, Savio automatic and the Schlafhorst Autoconer; the first two machines have one knotter and this services 10 spindles. If the fault rate is high two knotters back to back can be used for the 10 spindles. Another group of this type is that which includes the Gilbos Conematic and the Schweiter automatic where the heads not only wind, but also circulate past an automatic knotter station where a break is repaired or a fresh ring tube is tied in when necessary. The number of winding heads on frames of this type ranges from 10 to 24.

Over 300,000 automatic winding spindles are now in operation and at say £400 per spindle this represents an investment of say £200,000,000.

There are some general features that are common to the majority of automatic winders and these have been listed as follows:-

(a) All will wind cotton yarns and practically all will deal satisfactorily with most other spun yarns;

(b) Yarns of 100 tex (6s cc) to 10 tex (60s cc) can be wound satisfactorily but some manufacturers particularly Gilbos state that is possible to wind yarns as coarse as 300 tex (2s);

(c) These machines will usually only wind from ring tubes, and only from tubes that will fit into the magazine creel; a manual winder is still generally required for rewinding from cone, hank etc., but there are indications that this position is changing with the introduction of break spun yarn on spools. Some automatic machines will deal with ring tubes up to 1¾" long.

(d) Parts of the machines such as waxers, tensioners, clearers, stop motions, etc., differ from one machine to another, and any intending purchaser must consider these items in detail before purchase having regard to the types of yarn to be wound;

(e) All 'in-line' machines have one knotter per winding head with the exception of the Autoconer, which has one knotter for 10 heads (or optionally 2 knotters per 10 heads). The chief advantages of a knotter for each head are increased production, since the head does not have to wait its turn for the knotter; there is also the ease of replacement of the knotter without having to stop all the winding heads whilst the replacement is made; on the other hand with a fixed knotter station (or a travelling knotter) cost is less important and it is possible to incorporate more refinements into the mechanism; most knotters tie a fisherman's knot, since it is normally claimed, and our results at the Institute confirm it, that a fisherman's knot fails by slippage in subsequent processes far less than a weaver's knot;

(f) All the machines have a drum drive and all except the Leesona Uniconer have the drum and cone in contact throughout winding; some manufacturers employ a slow start (after a knot has been tied) to prevent possible damage to the yarn layers on the surface of the cone.

(g) All machines incorporate blowing and suction nozzles to keep important parts of the assembly free from dust, seed, fly, etc.

Automatic feed of ring tubes to the small group automatic winders is now well established.

Schlafhorst have two main lines of development, namely the BV feed system or the Type C feeder. On the BV system there is a readying and packing station capable of feeding 32 to 40 ring tubes per minute. In the packing station the tubes are deposited completely randomly from the spinning department into a large hopper; they are then made parallel and oriented to face the same direction. Finally the backwind and underwind are removed, the yarn end is positioned in the nose of the tube and a predetermined number of readied tubes is stacked into suitable boxes which fit into the supply containers at the front of the Autoconer. The operative can drop simultaneously several of the prepared ring tubes into the magazine of the Autoconer. This BV feed system can feed any existing Autoconer installation and only minor modifications are required to the Autoconer winding heads.

For larger mills Schlafhorst have produced the Type C feeder for new installations. In this system the readied ring tubes are fed into a conveyor that travels in front of the Autoconer and puts a ring tube into the reserve position of the magazine as soon as the previous ring tube drops into the unwinding position on the Autoconer. Schlafhorst also have an automatic cone changing device to replace the full cone by an empty one.

The Leesona automatic bobbin handling system for the Leesona Uniconer is still in the development and pre-production stage but it envisages full automation with conveying buckets to and from the spinning room.

The Savio bobbin handling system consists of feeding the bobbins randomly, parallelising, sensing the tube diameter, orienting the tubes by a turntable and finally finding the yarn end by a three stage end-finding unit. The readied ring tubes are then fed to the machine magazines by a conveyor belt.

For many organisations in developing countries the Gilbos Conematic No.11 is eminently suitable since it is a very simple and straightforward machine and is easily maintained without the need for a specially trained mechanic. This is made with 12, 16, 20 or 24 spindles per knotter and it has an individual motor and belt drive to each spindle. It is made with special knotters capable of dealing with coarse counts (down to 300 tex or 2 cc), can be supplied with an 8" traverse, and can deal with ring tubes up to 17¾" long; automatic feed to this machine is from Murata (Gilbos licencees in Far East). Murata's system is from oriented parallel ring tubes supplied from auto doffers at the ring frame; the ring tubes are then fed forward on to a vertical lattice where the cop is readied and then fed to the circular magazine of the Gilbos automatic winder.

<u>Automatic open-end spun spool winding</u>

One surprising feature of the recent Paris Exhibition of machinery was the fact that Schlafhorst, Murata and Savio had obviously gone to considerable expense to design mechanisms to feed their machines with open-end spun packages. It has been claimed that the production of break-spun package could well eliminate the need for winding and clearing since the package could be used as spun. Clearly the winding machine designers do not share this view, and mechanisms fed from the open-end spun spools and to electronically clear the yarns were in evidence.

On the Schlafhorst machine, the base of an Autoconer (fitted of course with electronic clearers) has been modified to take 3 open-end spun spools. As soon as the package is empty, the full package is rotated into the winding position and a knot tied; winding is then recommenced. On the Savio machine also with electronic clearers, two packages were available, and when one becomes empty the reserve package come into operation.

On the Murata machine the re-winding of open-end spun packages is completely automatic. On their 11A Spoolmatic (which is based on the Gilbos Conematic) a group of four pegs, each holding 10 inch diameter open-end spun spools, is positioned behind the machine and a second group of four pegs with packages is situated immediately behind them. When the winding machine calls for another spool, the front set of packages is lifted bodily and the uppermost spool is deposited on a horizontal conveyor belt - if a vacant space is available for it. This conveyor then proceeds to the winding heads that are operating at 1,200 yd/min and packages are automatically fed as required. As soon as the front set of packages is used, the pegs automatically change places and the empty pegs are supplied with further packages by the operator.

Murata point out that the fault rate in break spun yarns is about 2 per lb. and electronic clearing of these is necessary; Schlafhorst put the fault rate even higher at about 4 per lb. and state that in addition there is considerable variability between spindles and sometimes the fault rate can be several times greater than this figure. In addition it is to be noted that the break spun package is not acceptable for some purpose, for example where a 9^{0} 15 cone is required for knitting or when a soft package for dyeing is required. At least one machine maker however expects to be able to supply open-end machines which can wax the yarn and wind onto a cone.

Electronic data processing and monitoring

An important feature of any automatic winding installation is the effective utilisation of these expensive machines and a number of different machine manufacturers make equipment for monitoring production.

In most cases their monitoring systems apply to winding installations but can usually be applied equally well to looms or other production machines.

Schlafhorst have an electronic information system termed The Indicator which collects and stores a wide range of data from various control systems on their Autoconer. The data can be printed out at any time and compared with target figures; the computor calculates the results and prints out data, e.g. winding efficiency, production, break rate, percentage re-ties, clearer cuts etc., when they are required by the management. The information is obtained from various electrical switches built into the Autoconer and up to 500 spindles are scanned once every second. Obviously an installation of this sort is invaluable in showing immediately any faults in the yarn and any mechanical or operative failings.

The Zellweger Uster computer system is termed the Uster Monitex H.320. In its applications to automatic winding the machines are equipped with censors that convert the operating conditions into electrical signals and the computer gives readings of the overall and individual spindle machine efficiency (visual display) slub detection, machine production, cop changes, break rate, knotter operations etc. An extension of this principle of data collection and processing is the Uster system S.1201 which can be applied to any production process e.g. warping, weaving.

Yet another production-monitoring equipment is the Peyer instrument termed Peyer Effector, which can monitor 5 groups of 8-24 spindles. Data are presented every hour of productive winding time to indicate rates of production, knots made, clearer operations etc.

Warping and Beaming

Developments in these fields seem pedestrian compared with clearing and winding developments.

Creels

For high productivity either magazine creels or two fixed creels with a travelling headstock are usual but space requirements of these are a disadvantage. For creeling the mechanisms available include swivelling arms, retractable cone holders, removable holders etc. A well made positively located swivelling arm however seems to be the most popular cone holder.

Creels are made by a number of different manufacturers but in general there is little about them that can be regarded as superior to competitive British creels such as those made by WMK Products Ltd for example. In general additive disc tensioning instead of multiplicative peg tensioning is preferred and a double pair of discs is preferred to a single pair. Some tension assemblies have a built in stop switch to indicate a yarn break for each package. A creel tension development by Benninger deserves special mention. On this equipment a flat plate tensioner unit is used which incorporates a special cutter; if the yarn tension becomes too high the yarn is immediately cut very close to the tensioner and this effectively prevents an end from being buried in the beam. Some modern creels have the tension discs loaded by a spring and can be set from a master control.

Undoubtedly the most advanced creel development of the last decade is the Schlafhorst Z25 automatic creel where an automatic knotting carriage does the tying from a fresh truck creel moved by a motor driven chain. Unfortunately this creel development is not yet marketed.

<u>Warping machines used for producing back beams for sizing and weaving</u>

British machine manufacturers include Crowther Ltd, Leesona Ltd and WMK Products Ltd; Continental manufactuers include Benninger (Swiss), Hacoba and Schlafhorst (German) and Reggianni (Italy). The Leesona and WMK machines are drum driven (indirect drive) whereas the others are spindle driven and can therefore also be used for filament warping. Spindle driven machines are of course much more expensive than drum driven machines and generally require more maintenance.

Machine developments in this field include better speed control, slow speed start and provision for making beams up to 40 in. in diameter. Most modern machines will make hard or soft beams by changing the force or pressure applied to the press (consolidating roller). Hydraulic pressure is normally used and special precautions are taken to ensure that the pressure is uniform over the full width to remove the possibility of tapered beams.

There is a continuing tendency towards greater width of beams and some machines will produce beams up to 108 in. in width. Most machines nowadays have built in hydraulic lifting gear for lifting and lowering the beams.

One very important feature of modern beamers is the provision of powerful brakes; nowadays these are generally hydraulic and adjustable. Usually the beam, press roller and measuring roller are braked synchronously in order to prevent helical crimps which can be caused by skidding of the press roller on the beam surface. Photoelectric guards to protect the operative are regarded as essential and an oscillating reed is usually necessary with beams having few threads per inch.

Pirn Winding

In the field of pirn winding there have been little changes in machinery apart from minor improvements to existing machines such as dust removal and automatic pirn replenishment on the well known Schweiter pirn winder. Developments have centred chiefly on the application of the Leesona loom winder (Unifil); higher speeds and 4-colour Unifil are now well established in this field.

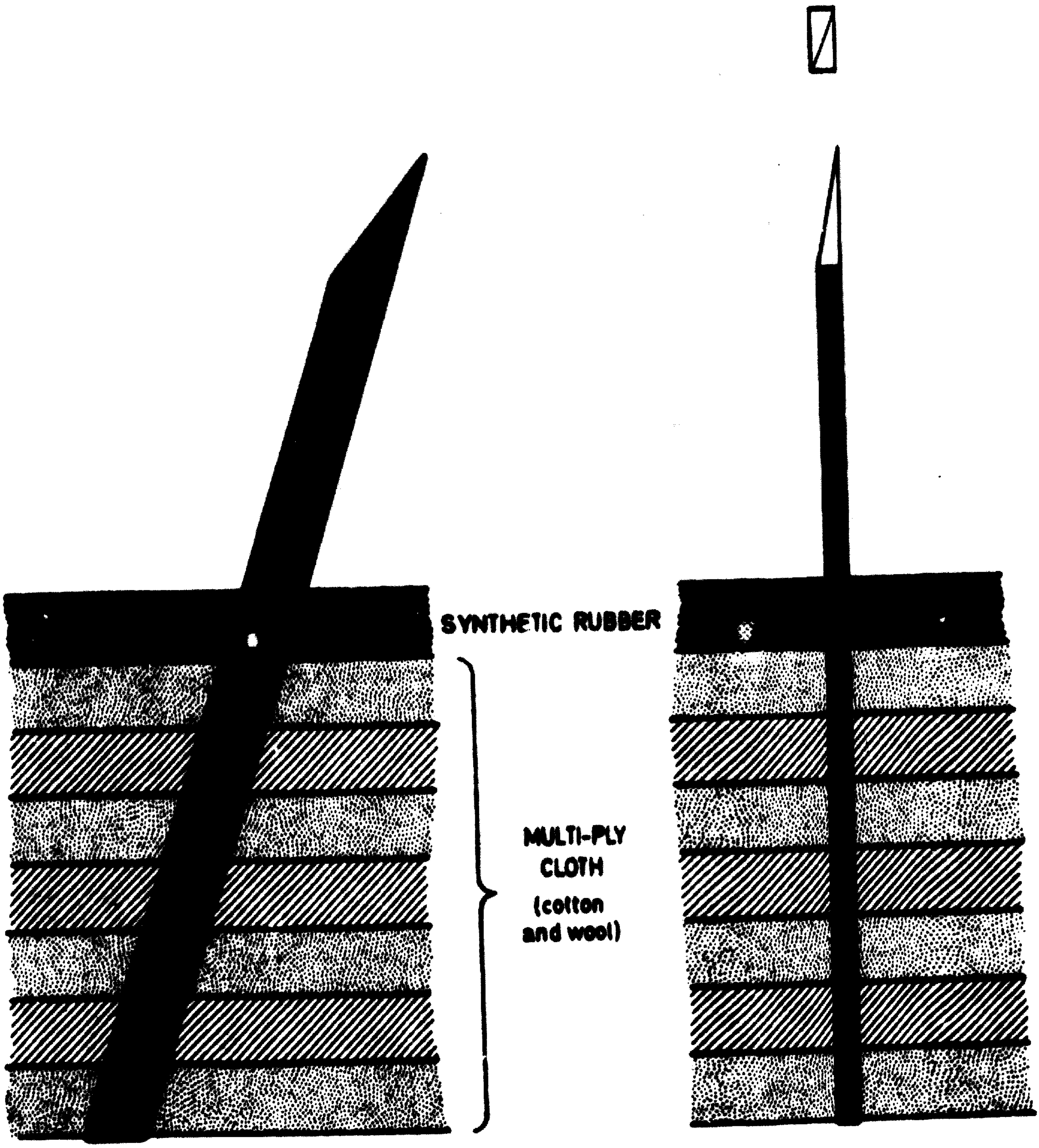
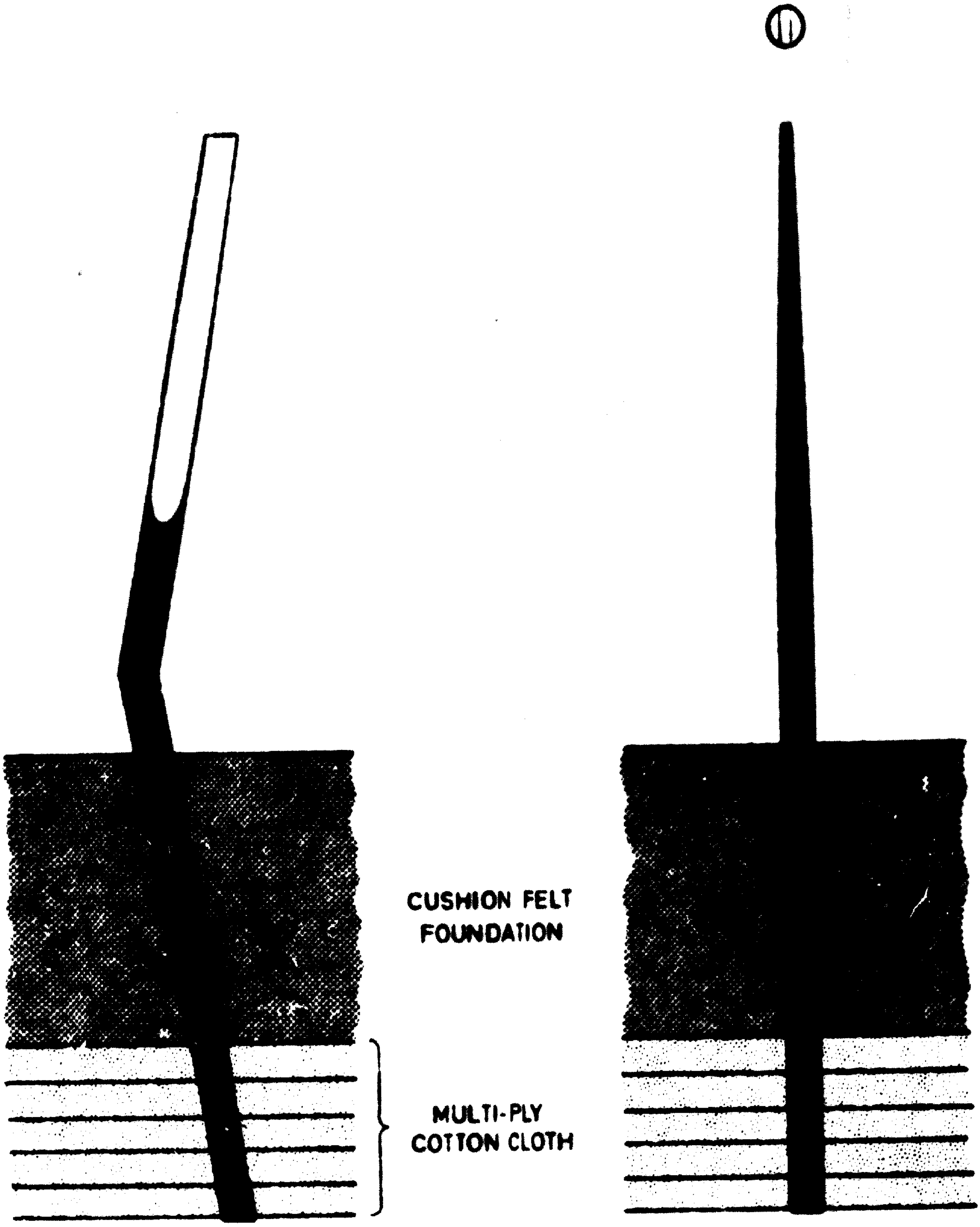


Figure 1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FOUNDATION
MULTI-PLY
COTTON CLOTH

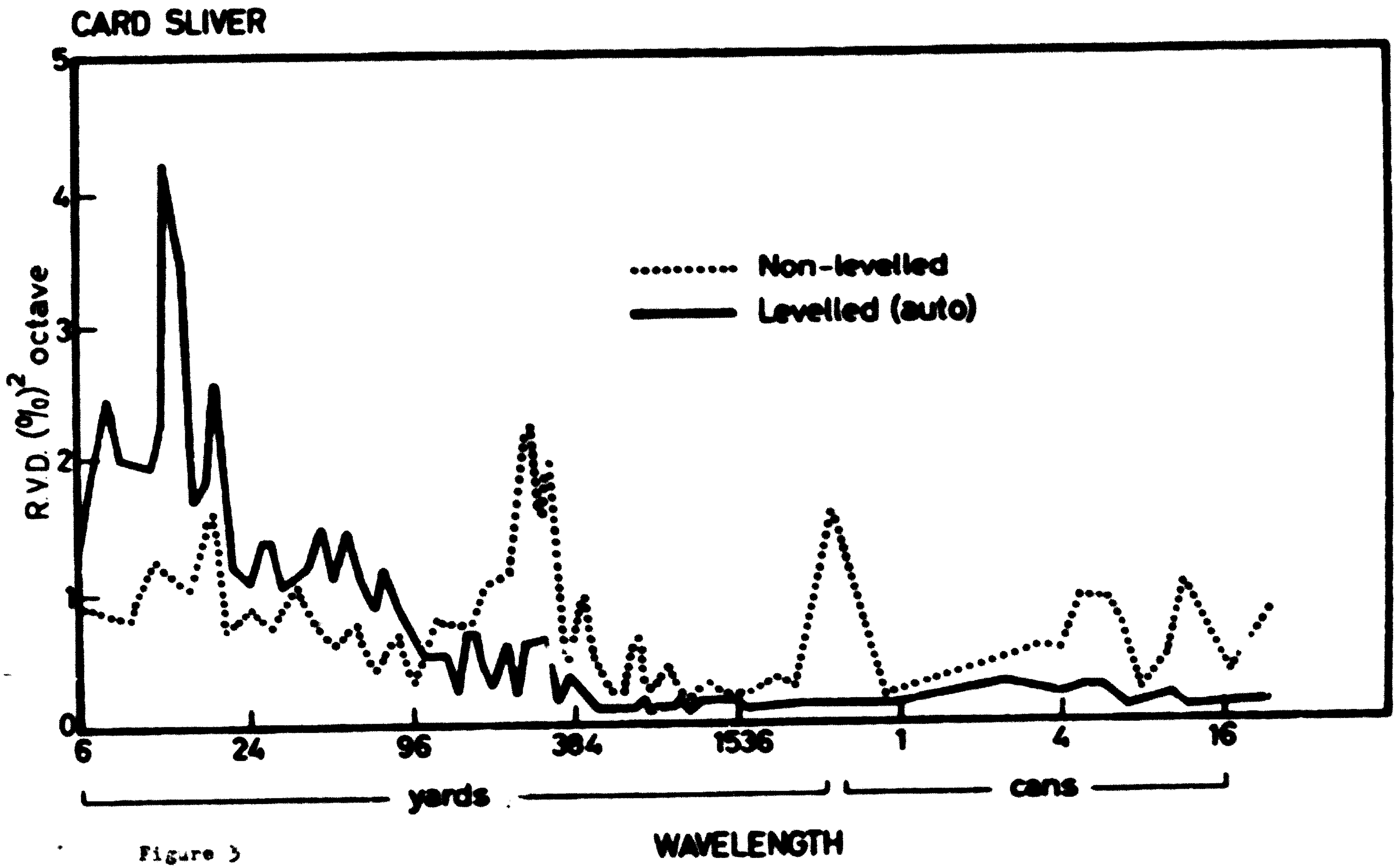
CARD SLIVER
R.V.D. (%)² octave
0
1
2
3
4
5
Non-levelled
Levelled (auto)
6
24
96
384
1536
1
4
16
yards
cans
WAVELENGTH

Figure 3

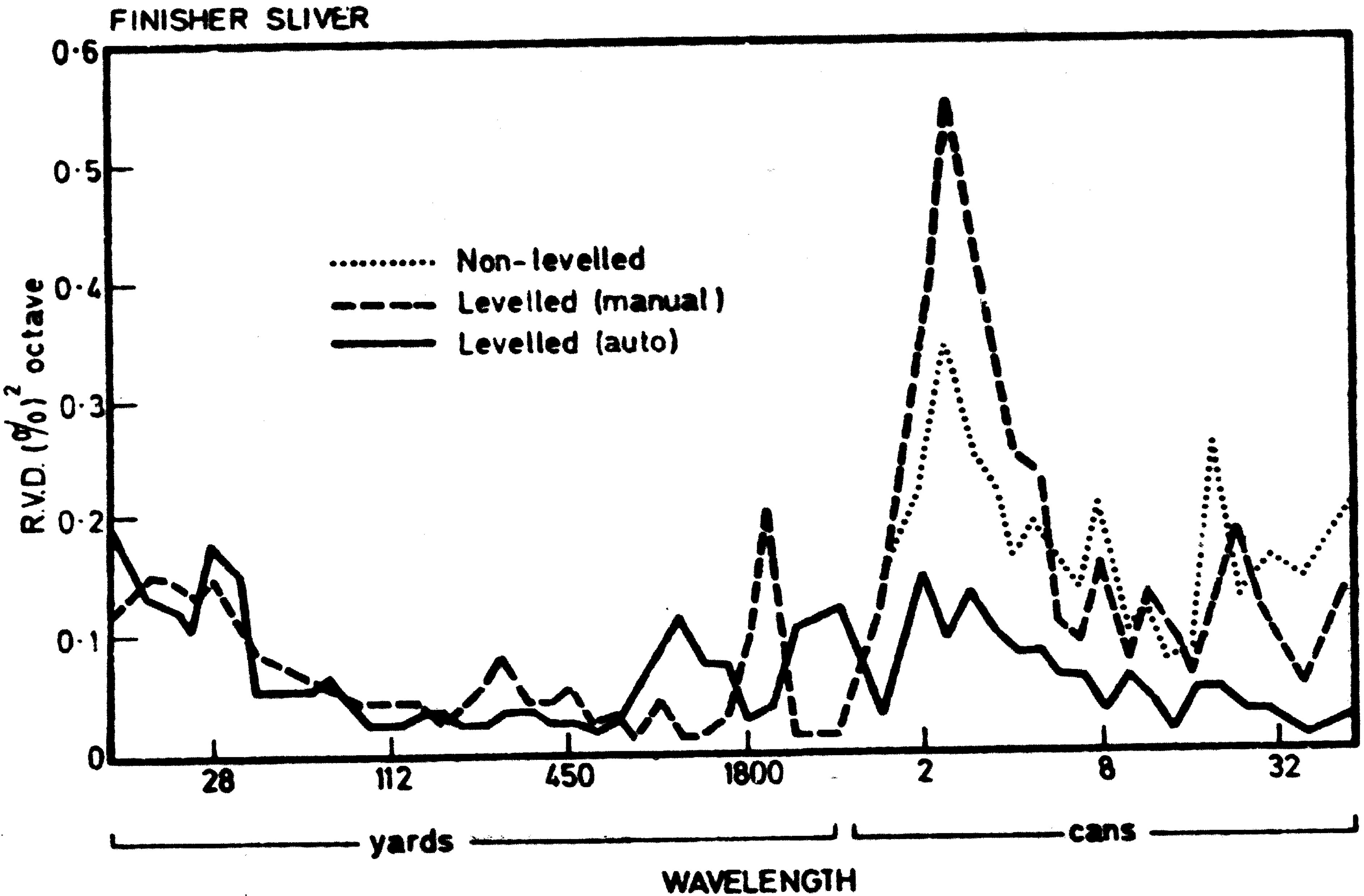
FINISHER SLIVER
0·6
0·5
0·4
0·3
0·2
0·1
0
R.V.D. (%)² octave
Non-levelled
Levelled (manual)
Levelled (auto)
28
112
450
1800
2
8
32
yards
cans
WAVELENGTH

Figure 4

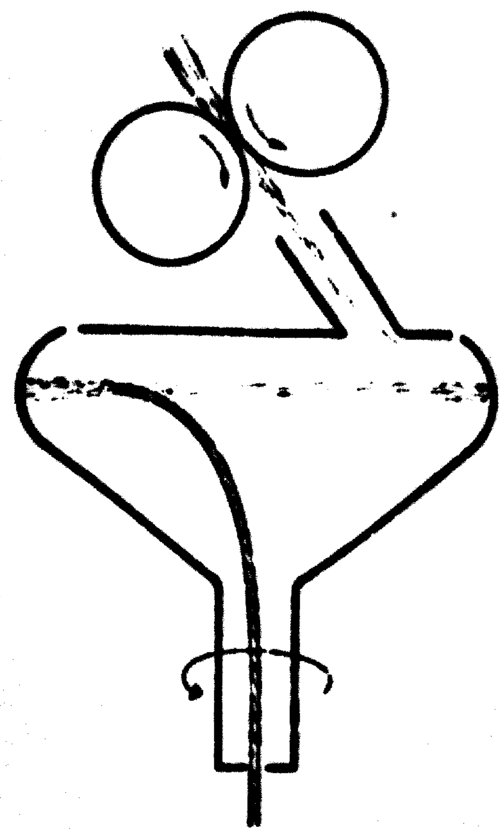

Figure 5

17. 6. 74