The Rieter Manual of Spinning
Volume 3


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Volume 3 – Spinning Preparation

Werner Klein

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THE RIETER MANUAL OF SPINNING

Volume 1 – Technology of Short-staple Spinning

This deals with basic, generally valid, technological relationships in short-staple spinning. Subsequent volumes are organised according to machines or machine groups. This separates generally valid basic principles from ongoing developments in machine design and construction.

Volume 2 – Blowroom & Carding

In-depth information is provided on opening, cleaning, blending and carding and additional aspects are covered such as acclimatisation of raw materials, anticipated waste from various grades of fibre, selection and setting of cleaning and blending machinery, waste recycling, transport and the functions of the various card components as well as selection and maintenance of card clothing and autolevelling systems.

Volume 3 – Spinning Preparation

Here the technical and technological aspects of the yarn production process between carding and ring spinning are covered, that means draw frame, combing section (including combing preparation) and roving frame. This is an important process stage, because the yarn quality largely depends on the quality of the intermediate products from which it is made.

Volume 4 – Ring Spinning

Technical and technological aspects of ring spinning are covered. This is the final process in yarn production. The ring spinning machine greatly influences the yarn and its quality. Ring-spun yarns still represent the standard for comparison when evaluating yarns produced by other spinning processes.

Volume 5 – Rotor Spinning

This process resulted from research into alternative spinning systems. This volume contains in-depth information on the rotor spinning process and its properties. Continual improvements in spinning elements and conditions make it now possible to spin a rotor yarn optically similar to a ring-spun yarn.

Volume 6 – Alternative Spinning Systems

To take full advantage of alternative spinning systems, a thorough understanding of them is therefore essential. This volume contributes towards reaching this goal by describing the most important alternative spinning systems in detail. One of them is the well known air-jet spinning technology.

Volume 7 – Processing of Man-Made Fibres

Ever since the introduction of man-made fibres on a commercial scale, the market share of synthetic fibres has shown an impressive growth rate. In this important field, the variety of man-made fibres with different properties is continuously increasing. For numerous applications today, fibres that are practically “tailor-made” are available. Spinners must therefore have detailed understanding of the fibre properties and the specific characteristics that affect their processing.

EDITORIAL

This third volume in the series of The Rieter Manual of Spinning, which updates the essential principles in modern short-staple spinning deals with both the technical and the technological aspects of that part of the yarn production process between carding and ring spinning.

This is of course a most important part of the process, because the quality of the final yarn depends to a large extent on the quality of the intermediate products from which it is made.

This volume comes in three parts, dealing with the combing section (including preparation for combing), the draw frame, and the roving frame. In each case, the principles of the underlying technology are discussed and there is a description of the machinery used.

It is essential for every yarn specialist to have a thorough understanding of the detailed operations involved in these processes, to know the relationships involved in the interplay of the various functions, to recognize the possible and to exploit the possibilities to their limits. This is the only way to ensure survival in the current competitive struggle.

The main author of these books, Werner Klein, is a former senior lecturer of the Swiss Textile College and author of the original edition of the „Manual of Textile Technology" published by The Textile Institute Manchester. All further authors are textile industry experts, who among others in various positions within the Rieter Company, have many years of experience to their credit. The Manual also addresses aspects that extend beyond Rieter's current product range, taking processes and solutions developed by other manufacturers into account.

The structure of this manual and the organization of its subject matter were taken over from the original Technology of Short-staple Spinning published by the Textile Institute, Manchester, whom we thank for their kind permission to continue this standard work.

It should also be mentioned that some important basic technology has been dealt with in The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning in particular the drafting action.

We wish all users of this compendium pleasant reading.

Rieter Machine Works Ltd.

CONTENTS

1. THE COMBING SECTION

1.1. Introduction

1.1.1. The comber's task

The comber is used in the production of medium, medium-fine and fine yarns, and enables a positive influence to be exerted primarily on the yarn characteristics of:

- evenness;
- strength;
- cleanliness;

and on the fabric characteristics of:

- smoothness;
- visual appearance; and
- handle.

It is also employed to improve working behavior in downstream processing, most noticeably in knitting. In addition, yarn made from combed cotton needs less twist than a carded yarn. However, as we have already mentioned, these quality improvements are obtained at the cost of additional expenditure on machines, floor space and personnel, together with a loss of raw material. Yarn production costs are increased by something less than USD 0.3 per kilogram of yarn (depending upon the intensity of combing).
To achieve an improvement in quality, the comber must perform the following operations:

- elimination of a precisely pre-determined quantity of short fibers;
- elimination of the remaining impurities;
- elimination of a large proportion (not all can be removed) of the neps in the fiber material;
- formation of a sliver having the optimal possible quality parameters.

Elimination of short fibers produces an improvement mainly in staple length, but it also affects the fineness of the raw material. Since noil is on average finer than the original raw material, the Micronaire value of combed sliver is slightly higher than that of the feedstock. It should also be noted that combing increases the parallelization of the fibers, but this is a side-effect which is not always an advantage. The high degree of parallelization might reduce inter-fiber adhesion in the sliver to such an extent that the fibers slide apart, e.g. while being pulled out of the can – i.e., sliver breaks or false drafts might be caused.

1.1.2. Types of application

The amount of material combed out varies within the range between 8 % and 25 % of the infeed stock. It follows that, as far as the raw material is concerned, quality improvements can exhibit wide variations. Correspondingly, basic distinctions are drawn between three major groups of spinning mills using combing:

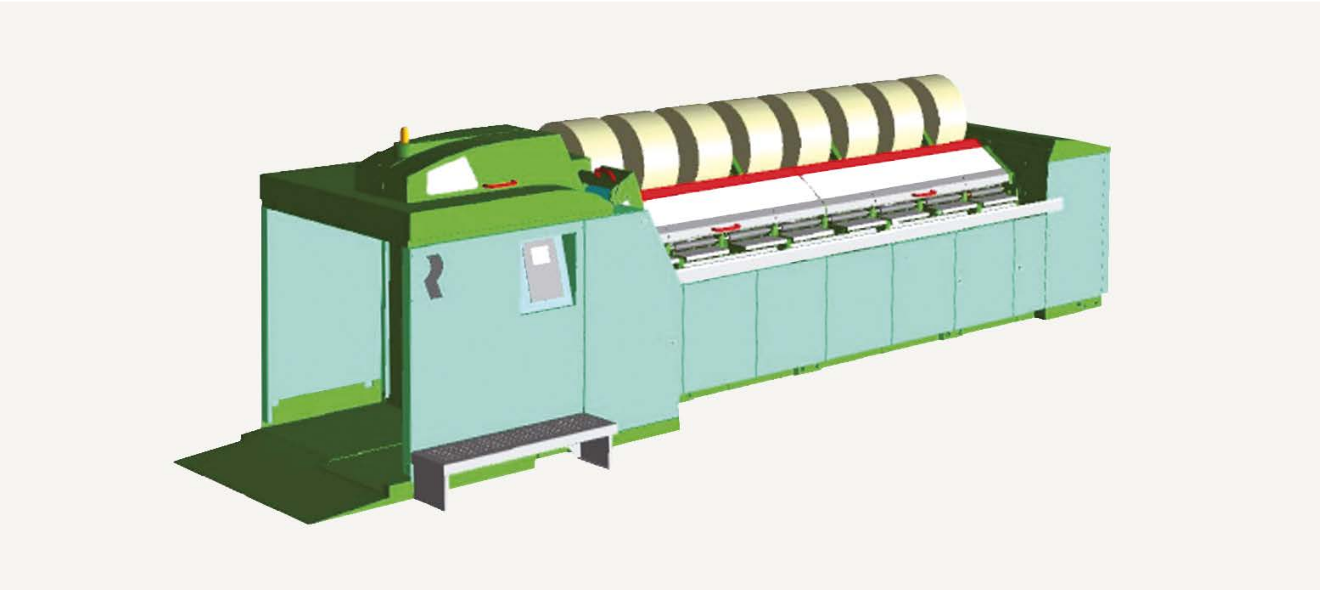


Fig. 1 – View of a rectilinear comber

1.1.2.1. Long-staple combing mills

These organizations spin first-class, expensive cotton of high strength, containing a low proportion of short fibers and little dirt. The product is a fine to very fine yarn of top quality. The demands placed on the know-how and skill of operating personnel are correspondingly high, as they are on the design and maintenance of the machines. Yarn production is low, while generation of noil is high.

1.1.2.2. Medium-staple combing mills

Here medium cotton qualities with a wide spread of quality parameters are spun into medium (to fine) yarns of good quality at economic production costs. Nowadays this is the most widely used process in practice. The proportion of noil lies in the region of the average and production is usually high. The process is problematic in that it has to maintain a high standard of quality and at the same time achieve high production at low cost: requirements that are difficult to reconcile. The maximum demands placed on medium-staple combing can only be fulfilled by optimally trained personnel.

1.1.2.3. Short to medium-staple combing mills

The raw material used here is the same as that for producing carded yarns. Often the same cotton blend is spun to both carded and combed yarn, sometimes even of the same fineness (in the coarser to medium-fine range). In comparison with a carded yarn, the combed yarn should chiefly exhibit better cleanliness, smoothness and strength. In this type of process, high production is usually sought in combination with noil levels from 8 to 18 (22)%.
Whereas in medium to coarse count mills combing is a matter of choice, for fine to very fine counts it is a must, as the number of fibers in the cross section of the yarn becomes very small, and in that case short fibers result in a lot of faults.

1.1.3. Types of comber

Quite a number of different types of comber are available, including:
- rectilinear combers (with stationary or oscillating nippers, for cotton);
- circular combers (English worsted process);
- rotary combers (production of Schappe-spun yarns);

and
- hackling machines (bast fibers).

Short-staple spinning mills use only the rectilinear comber with swinging nippers and stationary detaching rollers, as originally conceived in 1845 by J. Heilmann in Alsace and further developed in 1902 by the Englishman Nasmith and in 1948 by the Whitin company. Machine layouts used in practice are single-sided machines with eight heads. The double-sided machines of the former Platt Saco Lowell company with six-plus-six heads are no longer manufactured. Improvements in machine design since 1948 have enabled a five-fold increase in production.

1.1.4. Sequence of operations in a rectilinear comber

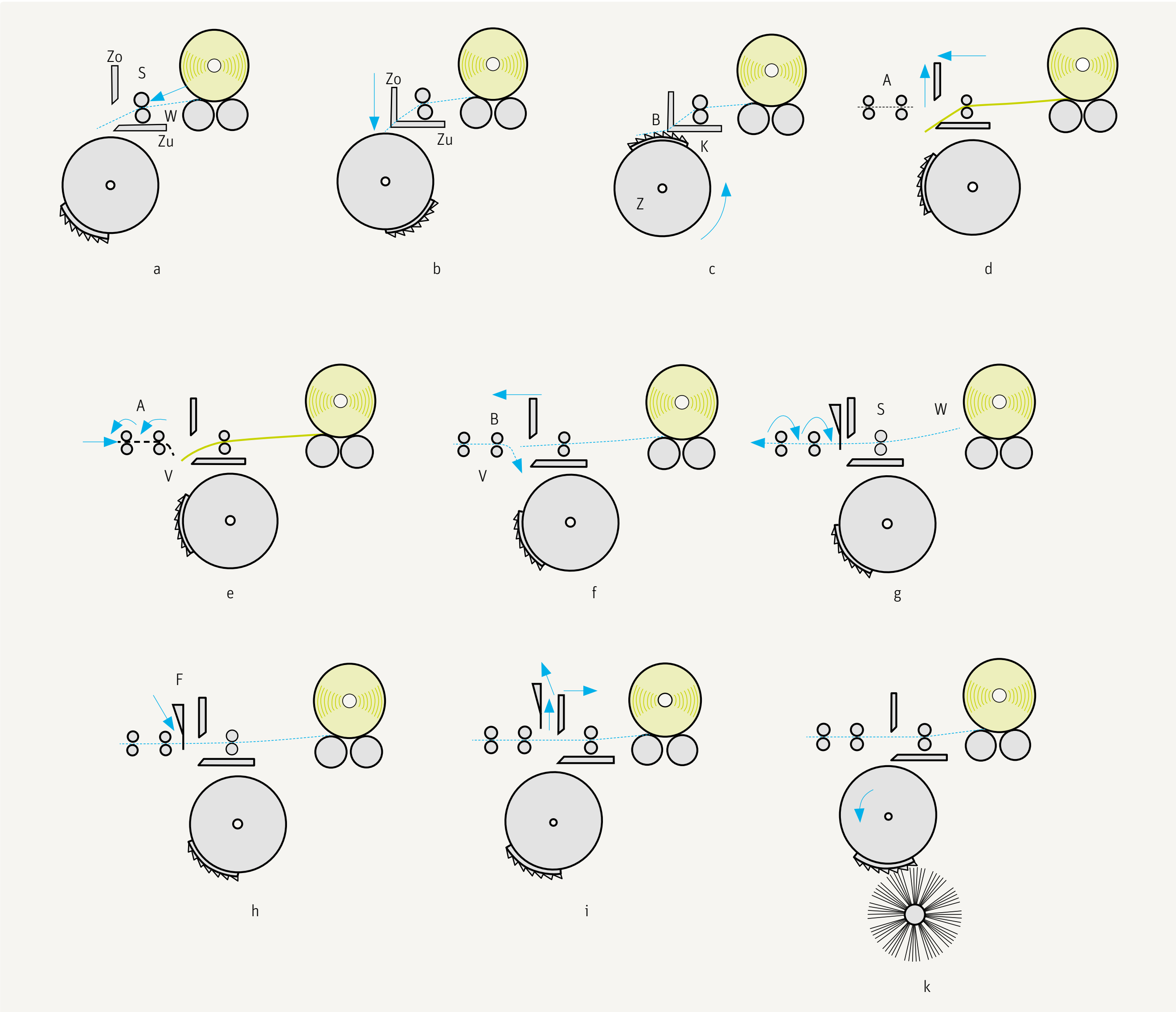


Fig. 2 – Sequence of operations

(a) Feed rollers (S) move lap sheet (W) forward by a small amount (4.3 - 6.7 mm), while nippers (Zo/Zu) are held open (feed).

(b) Upper nipper plate Zo is lowered onto cushion plate (Zu) so that the fibers are clamped between them (nipping).

(c) Combing segment (K), mounted on rotating cylinder (Z), sweeps saw-teeth through fiber fringe (B) and carries away anything not held by the nippers (rotary combing).

(d) The nippers open again and move toward detaching rollers (A) (nippers forward).

(e) Meanwhile detaching rollers (A) have returned part of the previously drawn-off stock (web V) by means of a (partial) reverse rotation, so that the web protrudes from the back of the detaching device (web return).

(f) In the course of the forward movement of the nippers the projecting fiber fringe (B) is placed on the returned web (V) (piecing).

(g) The detaching rollers begin to rotate in the forward direction again and draw the clamped fibers out of web (W) held fast by feed rollers (S) (inside the nippers) (detaching).

(h) Before the start of the detaching operation, top comb (F) has thrust its single row of teeth into the fiber fringe. As the fibers are pulled through the teeth of the top comb during detaching, the trailing part of the fringe is combed, thus making up for the inability of the circular combs to reach this part of the fringe (passive combing by the top comb).

(i) As the nipper assembly is retracted, the nippers open for the next feeding step. The top comb is withdrawn. A new combing cycle begins.

(k) Contrary to the movements of the other parts, the combing cylinder rotates continuously. During this rotation and at a certain instant the combing segment is brought into the vicinity of a rapidly revolving brush mounted below the combing cylinder. This brush removes the imperfections, etc., from the combing segment, and ejects them into an extractor that carries the noil away to a collecting filter system.

All these mechanically very demanding processing steps are carried out on 8 combing heads simultaneously at speeds of up to 500 times per minute (in Rieter's current E 66 comber generation).

1.1.5. Preparation of stock for combing

The combing operation itself (feeding, nipping, combing, detaching) is a very sophisticated process which requires:
- the best equipment;
- optimal, stable settings;
- excellent maintenance;
- careful handling.

An extremely important factor besides these, however, is the preparation of the material before combing, as the raw material delivered by the card is unsuitable for combing as regards both form and fiber arrangement. If card slivers were fed to the comber, true nipping by the nipper plates (Fig. 3) would occur only on the high points, with the risk that the nippers could not retain the less firmly compressed edge zones of the slivers. These could then be pulled out as clumps by the circular combs. A sheet with the greatest possible degree of evenness in cross section is therefore required as infeed to the comber.

Good parallel disposition of the fibers within the sheet is a further prerequisite. If the fibers lie across the strand (Fig. 4), even long fibers (a) are presented to the circular combs as if they were short fibers (as shown at b) and they are eliminated as such. This represents unnecessary loss of good fibers.

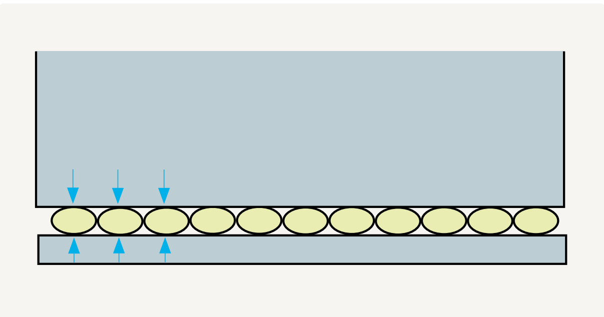


Fig. 3 – Clamped slivers between the nipper plates

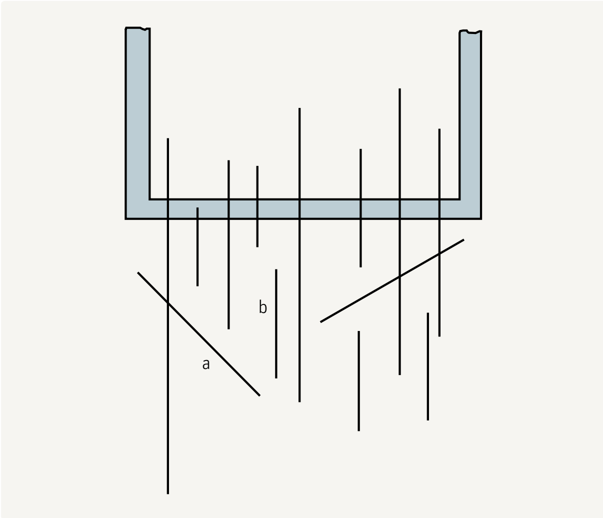


Fig. 4 – Fibers projecting from the nippers

Appropriate preparatory machines are needed to prepare the material so that it meets requirements. The fiber arrangement must also be taken into account, i.e. in this case the disposition of the hooks. As explained in „The Rieter Manual of Spinning – Volume 1", over 50 % of fibers in the card sliver have trailing hooks. If the comber is to straighten hooks, as it is intended to, then the fibers must be presented to it with leading hooks.

Because of the repeated reversal of the hook disposition during coiling and subsequent removal from cans at the machines, an even number of machine passages must be provided between the card and the comber. In earlier days sliver lap and ribbon lap machines were used. During the nineteen-nineties the sliver lap machine / ribbon lap machine process was replaced by the drawframe / sliver doubling machine process over all staple ranges.

As shown in Fig. 5, this consist mainly of:
- the batt doubling process (classical method, outdated); and principally
- the sliver doubling process, e.g. the Rieter UNIlap and the Marzoli Superlap SR 34.

1.2. Technology of combing
1.2.1. Parameters influencing the combing operation

The main parameters influencing combing are:
Raw material:
- fiber type;
- fiber fineness (Micronaire);
- fiber length;
- uniformity of fiber length (CV);

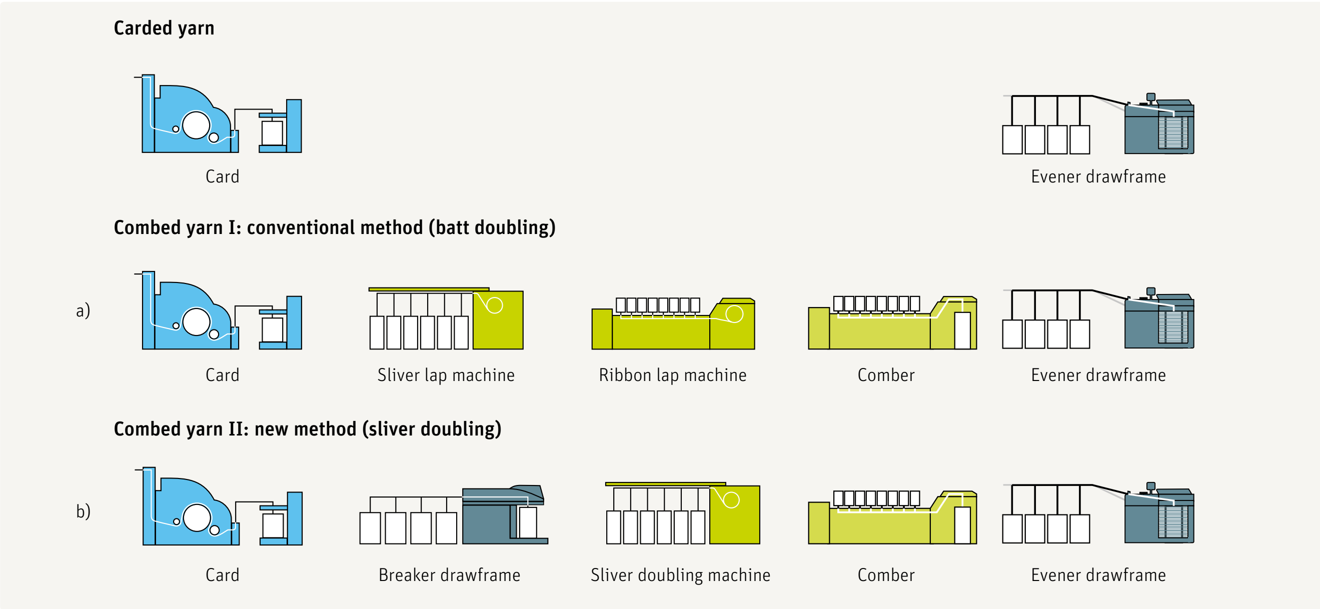


Fig. 5 – The two preparation methods: conventional method (a, batt doubling) and new method (b, sliver doubling)

- fiber stiffness;
- moisture content;
- foreign material associated with the fibers.

Material preparation:
- parallelization of the fibers in the sheet (batt);
- batt thickness;
- batt evenness;
- orientation of the hooks.

Factors associated with the machine:
- condition of the machine;
- condition of the combs;
- speeds;
- operational performance of the combs;
- type of sliver forming element (diagonal shift of the piecings);
- accuracy of the settings;
- drafting arrangement;
- movement of the elements;
- weight of the elements;
- type of withdrawal of the combed web (either straight forward or oblique).

Machine settings:
- feed distance;
- type of feed;
- detachment setting;
- point density of the combs;
- circular comb clothing (angles of teeth, density of teeth, etc);
- depth of penetration of the top comb;
- piecing;
- draft;
- drafting arrangement settings.

Ambient conditions:
- room temperature;
- relative humidity in the room.

In the following sections, the most important parameters exerting an influence on the process will be dealt with in greater detail.

1.2.2. Influence of the feed stock on combing
1.2.2.1. Parallelization of the fibers in the batt

From the viewpoint of both economics and quality, the degree of parallelization has a very great influence on the result of the combing operation. It is necessary to seek an optimum level, since a maximum is just as unfavorable as a minimum. Lack of longitudinal orientation, i.e. noticeable fiber disorder, leads, as already explained, to elimination of longer fibers together with the noil. Loss of good fibers owing to fiber disorder is reinforced to the extent that the circular combs are overloaded during passage through a disordered batt, so that they pluck and tear at the stock, thereby carrying away bunches of fibers. The same happens with an excessively thick batt. With constant machine set-

tings, the quantity of noil decreases linearly with increased parallelization of the fibers (Fig. 6) and with a decrease in batt thickness (below the optimum, of course). It therefore does not always follow that more noil is automatically associated with better yarn quality. The correct goal is always a predetermined waste elimination level.
On the other hand, an understanding of the disadvantages of excessive longitudinal fiber orientation requires a clear picture of the combing process and in particular the detaching stage. During this stage, impurities, neps and so on are held back in the sheet because of the retaining power of the thick layer. This retaining power, and hence the so-called self-cleaning effect of the batt, will be all the greater the higher the disorder of the fibers within the sheet. If the fibers have an excessively high degree of parallelization, the retaining power of the batt can be so severely reduced that it is no longer able to hold back the neps as it usually does. Some of these neps also pass through the top comb. Neppiness of the product is increased.

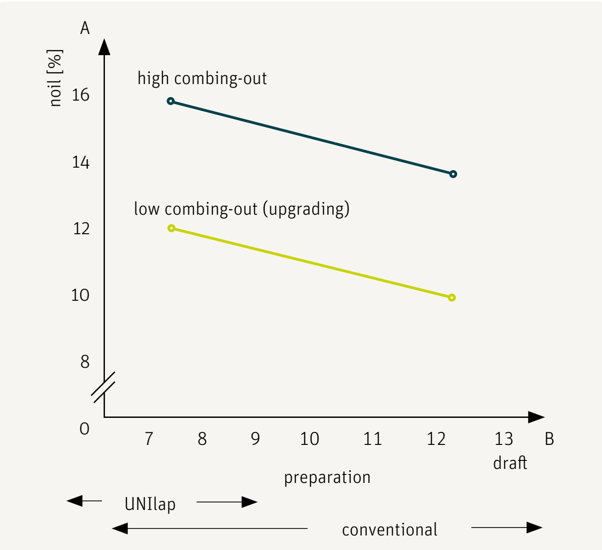


Fig. 6 – Dependence of noil elimination on the degree of parallelization of the fibers in the feedstock. (Degree of parallelization corresponding to the draft). A: noil percentage. B: draft between the card and the comber. (M. Frey, Rieter Machine Works Ltd., presented at a Colloquium in Reutlingen; Germany.)

In this operation, between 1/5 and 1/6 of the fibers presented to the detaching rollers are drawn out of the batt, i.e. only few fibers are drawn out of a thick layer of feedstock. Dur-

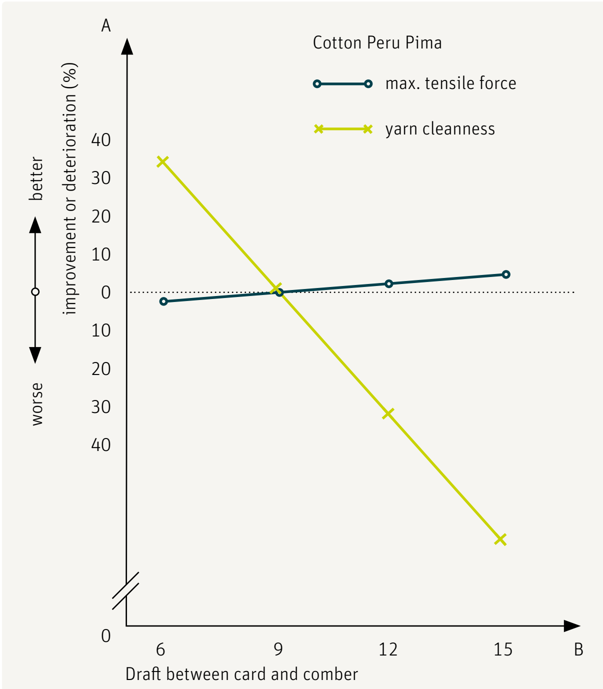


Fig. 7 – Dependence of yarn strength and cleanliness on the degree of parallelization of the fibers in the feed lap. (Degree of parallelization corresponding to the draft). A, improvement or deterioration in %; B, draft between the card and the comber based on classical system. (M. Frey, Rieter Machine Works Ltd., presented at a Colloquium in Reutlingen, Germany.)

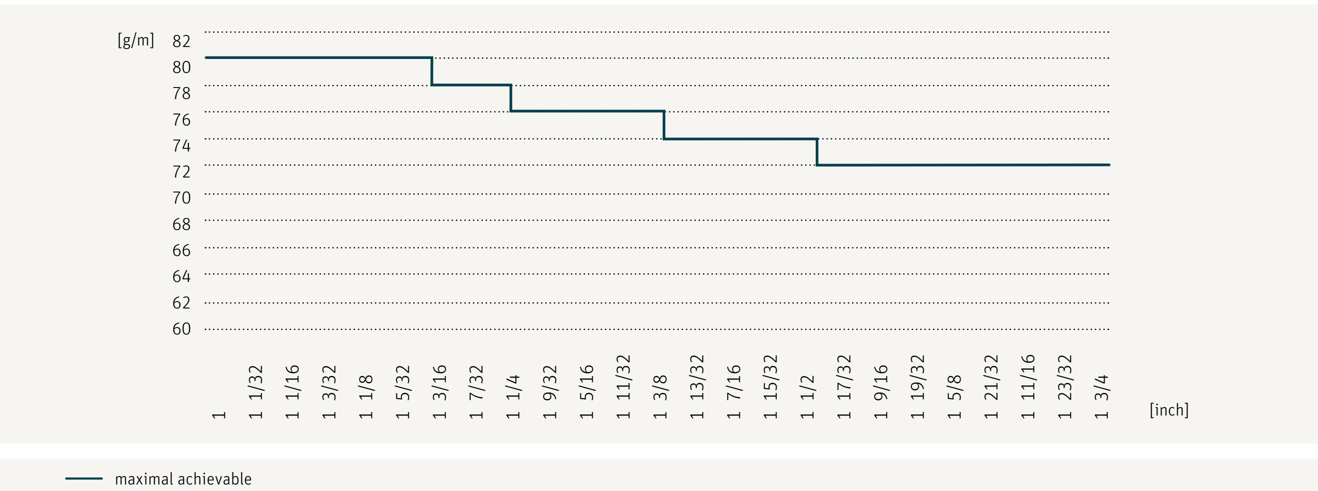


Fig. 8 – Batt weight in relation to staple length

A second disadvantage is that if the fibers are too highly ordered, the single layers of the lap do not hold together well (it lacks cohesive strength of the layers compared with that of the fiber-to-fiber adhesion at the surface of the lap layers) and mutual separation layer from layer is disturbed. A high degree of parallelization always leads to considerable hairiness of the lap. Furthermore, the lap weight must be kept low.
The degree of parallelization depends on the total draft between the card and the comber. Fig. 7 shows the relationship between fiber parallelism (draft) and yarn strength/yarn cleanliness.

1.2.2.2. Batt thickness (weight)

The self-cleaning effect of the batt exerts a considerable influence on the combing operation. This effect arises from the retaining power of the fibers relative to impurities, which depends not only on the disorder of the fibers but also on their quantity. A thick batt always exerts greater retaining power than a thin one. At least up to a certain level, the clamping effect of the nippers is also better with a higher batt volume. Adversely, a thick batt always exerts a heavy load on the comb and this can lead to uncontrolled combing. In this case, the fiber farthest from the circular combs (upper side of the nipped web) may escape the combing operation, since the combs are no longer able to pass through the whole of the layer.

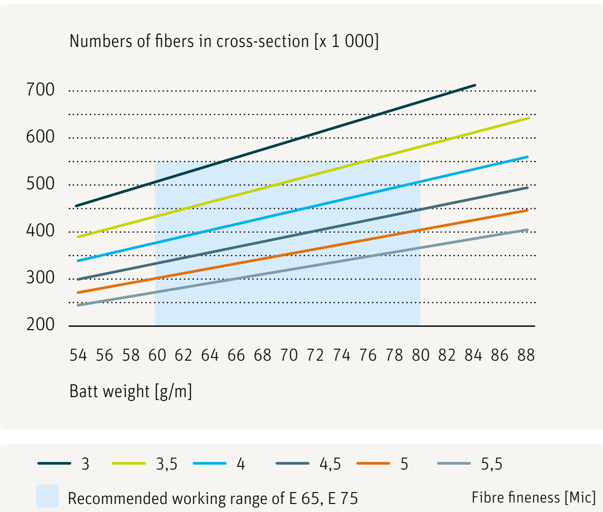


Fig. 9 – Batt weight in relation to fiber mass
(Micronaire value and number of fibers in the cross section are decisive)

The unfavorable effect of overloading the comb is greater than the favorable effect of the retaining power of the sheet. A compromise must therefore be struck between quality and productivity. Depending on staple length (and Micronaire value), the ideal batt weight lies between 72 and 80 ktex for short and medium staple cotton, and between 64 and 74 ktex for long staple cotton > 1¼″ (Fig. 9).

1.2.2.3. Evenness of the batt sheet

The more even the batt sheet (web) is across its width, the better the clamping effect at the nipper clamping line. Evening-out of the web is therefore of considerable significance. It is very important that the slivers are arranged neatly relative to one another and evenly over the entire working width at the lap machine.
The most effective method of obtaining a high degree of evenness of the sheet is high doubling in sheet form, as in the classical system, a combination of sliver lap machine and ribbon lap machine. In this respect, the operation of the ribbon lap machine was always ideal in the past. Nowadays, however, the disadvantages far exceed the advantages, e.g. the very high fiber parallelization caused by the high drafts in two stages, resulting in insufficient cohesion of the sheet. It does not permit high speeds and therefore high productivity compared with the sliver lap system. The self-cleaning effect also suffers from this high degree of parallelization.

1.2.2.4. The disposition of the hooks

As previously mentioned, fibers must be presented to the comber so that leading hooks predominate in the feedstock. This influences not only the opening out of the hooks themselves, but also the cleanliness of the web. If the batt is fed in the wrong direction, the number of neps rises markedly. It also increases the soiling and loading of top combs and circular combs, and finally the neppiness.
Both quantity and form of fiber hooks depend mainly upon the stiffness of the fibers; the latter rises to the second or third power with increasing coarseness of the fibers (Micronaire value). The hooks also display different forms; fine, long fibers will always exhibit more and longer hooks (horseshoe shape) than short, coarse fibers (hockey-stick shape). The role of fiber hooks in the spinning process therefore becomes more significant as fibers become finer. When short fibers are being spun, fiber hooks are of secondary importance.

1.2.3. Influence of combing operation on quality

Combing can be applied to a wide range of spinning processes and the range of improvement in quality is correspondingly wide. Accordingly, quality classes must be differentiated in combed yarns:

- semi-combed (upgrading) with a noil percentage below 12 %;
- normally combed, with a noil percentage between 12 and 18 %;
- highly combed, 18 - 22 %;
- super combed, with noil percentages above 22 %.

Combing with a noil percentage below 12 % is also referred to as upgrading, since this type of combing enables cotton stock to be moved up one or two classes, with the additional advantage of elimination of short fibers. Combing with a noil percentage above 22 % is rare and is generally used only where superfine yarns are to be spun.

Besides the removal of impurities, combing serves mainly to eliminate short fibers The effect is shown in a simple example in Fig. 10: a is the original staple, b the staple diagram after combing and c the diagram of the noil.
Fig. 11 shows the effect of combing at different noil percentages for a certain type of cotton. What can be generally noticed is that with increasing noil percentages the important quality parameters of strength and evenness improve, but not as much as may be expected. A far bigger improvement can be achieved in imperfections, and the big leap up to 10 % of noil is remarkable here. This is exactly the range of upgrading. A further improvement is noticeable with regard to the ends-down rate in downstream processing. Compared with carded material, the ends-down rate in spinning combed cotton is generally lower, but the improvement does not continue with the increase in noil percentage; on the contrary, the ends-down rate can start to increase again as the noil percentage rises above 20 %.

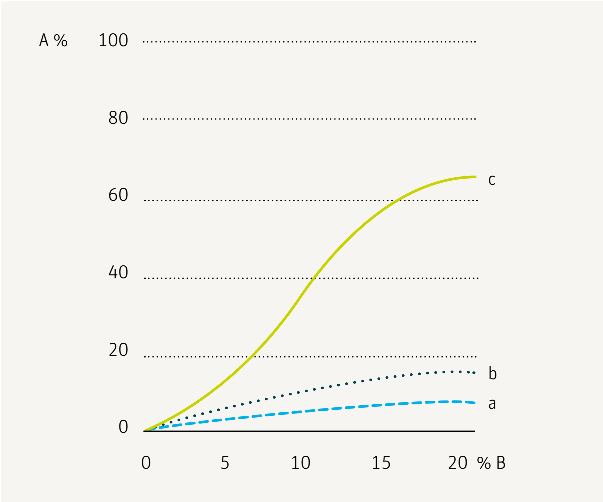


Fig. 11 – Dependence of various quality parameters on noil elimination A, improvement of yarn quality in %; B, noil elimination in %; a, yarn strength; b, yarn evenness; c, yarn imperfections; (M. Frey, Rieter Machine Works, presented at a Colloquium in Reutlingen, Germany)

1.3. The noil extraction theory
1.3.1. Derivation according to Gégauff
1.3.1.1. Definitions

The noil theory developed by Charles Gégauff and described below provides a picture of the effects of detachment setting and feed distance moved per cycle on the elimination of noil. The word „picture" is used quite deliberately in this connection, since the theory does not allow anything more exact. However, it does show the correlation between feed amount and noil percentage with either forward or backward feeding, i.e. why it differs.
However, calculations made on the basis of the theory are often intractable and should therefore not be attempted. Symbols used in these explanations* have the following meanings: (Z to E belonging to Fig. 12, s to p belonging to Fig. 13-16)

Z nippers;
A detaching rollers;

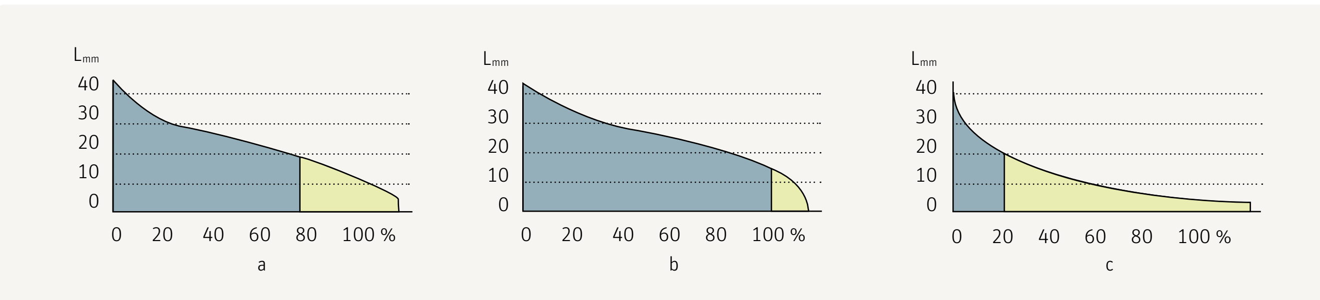


Fig. 10 – Staple diagram: a, cotton before combing; b, cotton after combing; c, noil

B fiber fringe protruding from the nippers;
K combing segment;
E detachment setting, i.e. distance between the clamping line of the nippers and the nip line of the detaching rollers;
S feed amount (mm) moved per combing cycle;
M longest fiber in the staple (mm);
a fiber $\geq$ E;
b fiber = E - S;
c fiber < E - S;
p noil percentage.

Forward feed implies that feeding of the sheet into the nippers occurs while the nippers are moved toward the detaching rollers.

Backward feed implies that feeding of the sheet occurs during return of the nippers. The triangular areas represent stylized staple diagrams.

*The subsequent presentation of the theory is based upon information supplied by the Rieter Company and on H. B. Wolf in "Baumwollspinnerei".

1.3.1.2. Noil elimination with backward feed

During the detaching stage the nippers are located at their closest spacing relative to the detaching rollers (Fig. 12), which draw off all fibers extending to the nip line, i.e. all fibers longer than E. This length E can be entered in the staple diagram (Fig. 13) as a line m-n. All fibers to the left of the line m-n pass into the combed sliver (hatched area AmnC).

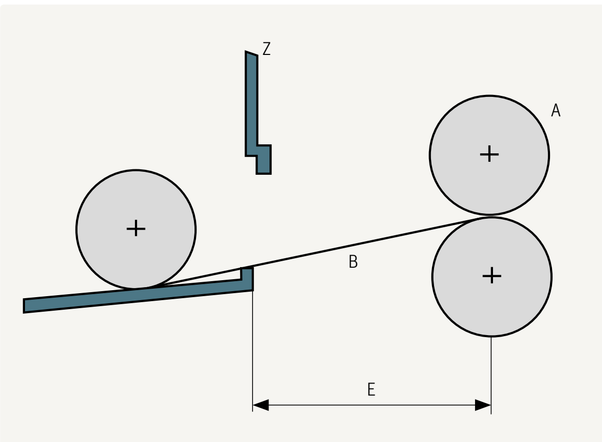


Fig. 12 – Position of the nippers relative to the detaching rollers at the closest approach (detachment setting E) during backward feed

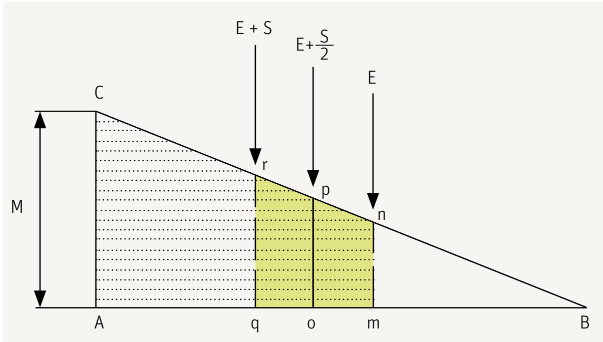


Fig. 13 – Combing out with backward feed (the staple diagram is shown)

As the nippers retract towards the combs, the feed roller shifts the fiber fringe (initially with length E) forward through feed amount S. The fringe projecting from the nippers is now presented to the circular combs with length E + S (Fig. 14). All fibers shorter than E + S are carried away by the circular combs because they are not clamped.

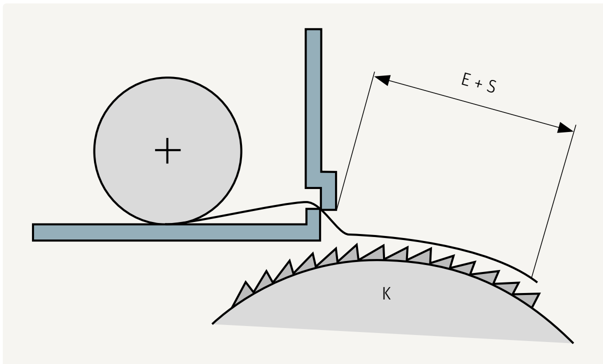


Fig. 14 – Combing out the fiber fringe

They pass into the noil. In the staple diagram (Fig. 13), this length can be entered as line q-r. In this stage all fibers to the right of the line q-r are combed out into the noil (area qBr). In the region qmnr it is therefore a matter of chance whether the fibers remain in the fringe or pass into the noil. Accordingly, a division can be made based on the mean fiber length represented within this area, and it can be assumed that the trapezium AopC represents fibers transferred to the combed sliver and the triangle oBp represents those passing into the noil. The dividing line between these areas has length E + S/2. Since in similar triangles the areas are in the same ratio as the squares of the sides, and since the noil percentage is based on the ratio of weight of waste to weight of feedstock, the following relationship can be assumed:

$$p\ \% = \frac{oBp}{ABC} \times 100 = \frac{(op)^2}{(AC)^2} \times 100 = \frac{(E + \frac{S}{2})^2}{M^2} \times 100$$

1.3.1.3. Noil extraction with forward feed

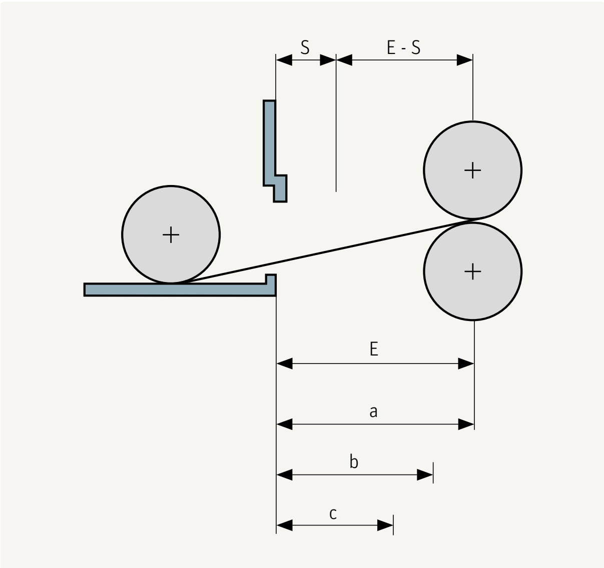


Fig. 15 – Position of the nippers relative to the detaching rollers at the closest approach during forward feed

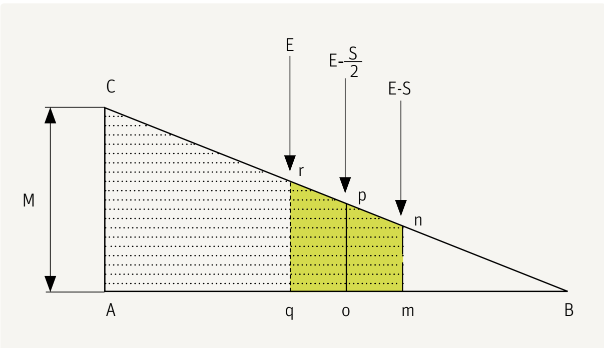


Fig. 16 – Combing out with forward feed (staple diagram).

After the detaching stage has been completed, all fibers longer than E have been carried away with the web. Since there is no feed step during the return stroke of the nippers, the fringe is presented to the circular combs with length E. During the following combing cycle all fibers shorter than E pass into the noil; this is represented in the staple diagram (Fig. 16) by the area qBr. Feed occurs during the subsequent forward stroke of the nippers, during which the fringe is increased in length by the distance S. At the next stage, that of detaching, the detaching rollers take at least all fibers longer than E (Fig. 15, fibers a) into the combed web. However, as feeding occurs at this stage, fibers b of the original length (E - S), i.e. shorter than E by the feed amount, are now moved forward to the nip line by feed through distance S. That is why fibers longer than (E - S) are now carried away into the combed web, and trapezium AmnC represents these fibers.

In this case also, the figure qmnr can be divided according to the mean fiber length by the line op (E - S/2), and thus the following relationship can be derived as before:

$$p\ \% = \frac{oBp}{ABC} \times 100 = \frac{(op)^2}{(AC)^2} \times 100 = \frac{(E - \frac{S}{2})^2}{M^2} \times 100$$

From the two derived relationships it follows that where backward feed is used, noil is increased as the feed distance is increased, whereas in forward feed noil is reduced as the feed distance is increased.

1.3.2. The quality of the combing operation in forward and backward feeding

From the preceding section it will be seen that with forward feed not only will shorter fibers be passed into the combed sliver (E - S instead of E), but also the quality of the combing operation itself must be different. Consider a fiber having a trailing end laying just in the bite of the nippers: During the forward movement of the nippers, with forward feed, this fiber passes into the combed web without any change, because the feed roller pushes it out of the nippers. In backward feed combing, this fiber will stay in the feedstock, because no feeding occurs during forward movement of the combs; the fiber is then nipped while projecting with the hook inside the nippers and combed once again. Therefore, if backward feed is used, the circular combs rake through the fibers more often, so the quality of the combing operation is increased. This shows up in the elimination of impurities and neps. However, the difference is hardly detectable in modern high-performance machines of the latest generation.

1.3.3. The influence of machine components and settings on combing

1.3.3.1. The feed amount moved per cycle

This has a noticeable influence on
- noil percentage,
- the quality of the combing operation, and
- the production rate.

A high feed amount increases the production rate but causes deterioration in quality, especially in the cleanliness of the web. Hence, the feed amount per cycle must be set lower, the higher the quality requirements, and this correlates – not exactly but approximately – with the fiber length. Fig. 17 serves as an indication in selecting the feed amount.

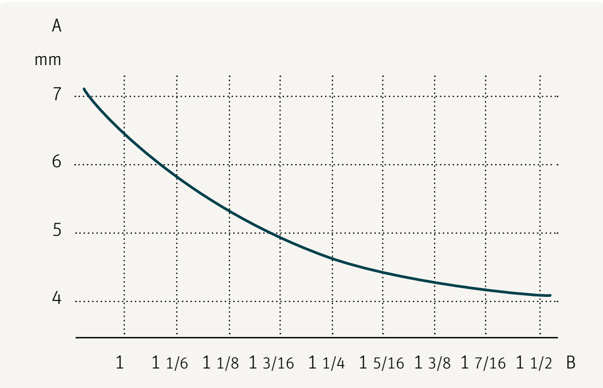


Fig. 17 – Typical values for the feed amount per cycle. A, feed amount per cycle in mm; B, corresponding staple length of cotton

1.3.3.2. Type of feed

Forward feed used to be chosen for higher production rates when quality requirements were not too rigorous, mainly for „upgrading" with noil percentages of up to 12 % (max. 14 %). When higher demands were made on quality, backward feed had to be used with noil percentages in the range of 12 - 25 %. With modern high-performance machines (combing preparation and combers) the situation has changed. Forward feed is mostly used over all staple ranges for achieving noil levels from 8 to 18 %. One main reason is the better "self cleaning effect" (see 1.5.4.3. The operation of the combs) during detaching and top combing action by generating higher retaining forces. Fiber rear ends and the hooks are more extended. Disturbing impurities (husk particles, dust and trash, leaf and husk remnants, fiber neps and seed coat fragments) and short (floating) fibers are hold back by the top comb during detaching and are combed out by the next circular combing cycle.

1.3.3.3. The detachment setting

This refers to the distance between the clamping line of the nippers and the nip line of the detaching rollers when these parts are at their closest spacing. The detachment setting provides the chief means for influencing the level of noil elimination. A wide detachment setting results in a high level of noil elimination; a closer setting is associated with a lower noil level.
Spinning mills must find the optimal setting for their own conditions. If the detachment setting is increased, starting from a certain optimum, there will be hardly any improvement in quality except in relation to imperfections (Fig. 11). The detachment setting normally lies in the range of 15 - 25 mm. If the noil percentage varies for no reason while the machine settings (including the detachment setting) are kept constant, the cause lies not in the machine but in the raw material (variability of the raw material characteristics, e.g. short fiber content).

1.3.3.4. The number of points on the combs

Comb segments on older machines had a clothing of needles. Both the point density and the fineness of the needles were adapted to the raw material. Top combs are still clothed in this way or are equipped with teeth. Clothing of circular combs has changed in recent decades: a saw-tooth clothing is used today. In comparison with needles, the new type of clothing is more robust, needs less maintenance and is more universally applicable. Since the combs are called upon to perform the main work of the machine, their influence on quality is considerable.
Needles on the top comb have a flattened cross-section and are formed with a bend. Usually they are used with a point density in the range of 23 - 32 needles per centimeter. Fewer needles are used when higher production is needed together with lower waste elimination. More needles produce more noil.

1.3.3.5. The depth of penetration of the top comb

Noil extraction can also be influenced by the depth of penetration of the top comb. Lowering of the top comb by about 0.5 mm is followed by an increase in noil of about 2 %. The main improvement due to this procedure has to be seen in the elimination of neps. As always, the optimum setting must be established, since excessively deep penetration of the top comb disturbs fiber movement during piecing. The result is deterioration in quality.

1.3.3.6. Piecing

After combing of the fringe protruding from the nippers, the detaching rollers draw some of the combed feedstock out of the sheet. This produces a tuft with a length dependent upon the staple length, but lacking all internal coherence. By means of the piecing operation, the rollers have to lay these newly formed strips of web on top of each other so that first a coherent web and finally an endless sliver is obtained. For this purpose, the single fiber tufts are laid on top of each other in the same way as roofing tiles (Fig. 18).

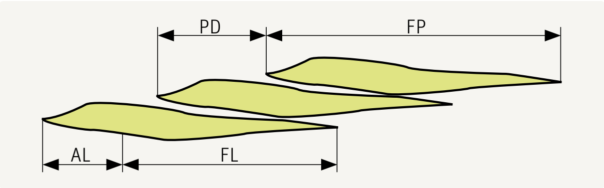


Fig. 18 – Combed web structure (section view)
PD – Piecing distance or piecing period, FL – Fiber length, AL – Detaching length, FP – Fiber package length> AL + FL

Consequently, piecing is a distinct source of faults in the operation of the rectilinear comber, but is system-related due to the discontinuous process. The sliver produced in this way has a wave-like structure, i.e. it exhibits periodic thin and thick variations.

Wave Length L = piecing distance x total draft
(source: Uster Tester 5 handbook)

These variations are visible in the mass spectrogram (Fig. 19) as combing cycles in the form of so-called piecing peaks (at about L 30 - 75 cm, due to draft height in the drafting unit). This long-wave, sinusoidal piecing fault is reliably leveled out in the subsequent autoleveler drawframe.

Example: Piecing period is shown at a wave length of 60 cm. With 6-fold doubling and drafting on the RSB drawframe, the periodic fault should be visible at 3.6 meters in the RSB spectrogram – but this is not the case. It has been leveled out. Another thing is the correct table draft (tension between delivery roller after eccentric withdrawal and infeed roller of drafting unit).

1.4. Preparation of the stock for combing

1.4.1. Outline

In general, two systems are still in use (Fig. 20):

- the earlier web doubling process (conventional method) employing a sliver lap machine followed by a ribbon lap machine; and today mostly
- the sliver doubling process, in which a normal drawframe (without leveling) provides the first passage and a sliver doubling machine follows as the second passage

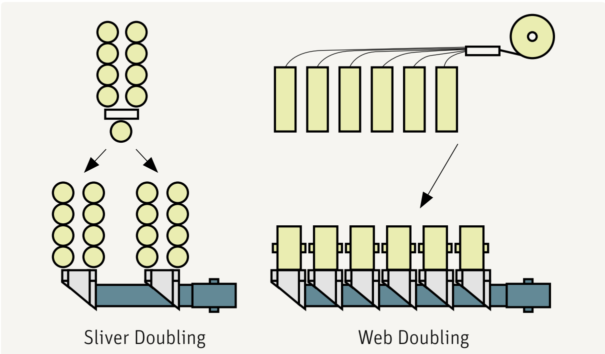


Fig. 20 – Overview of the two lap forming processes in use

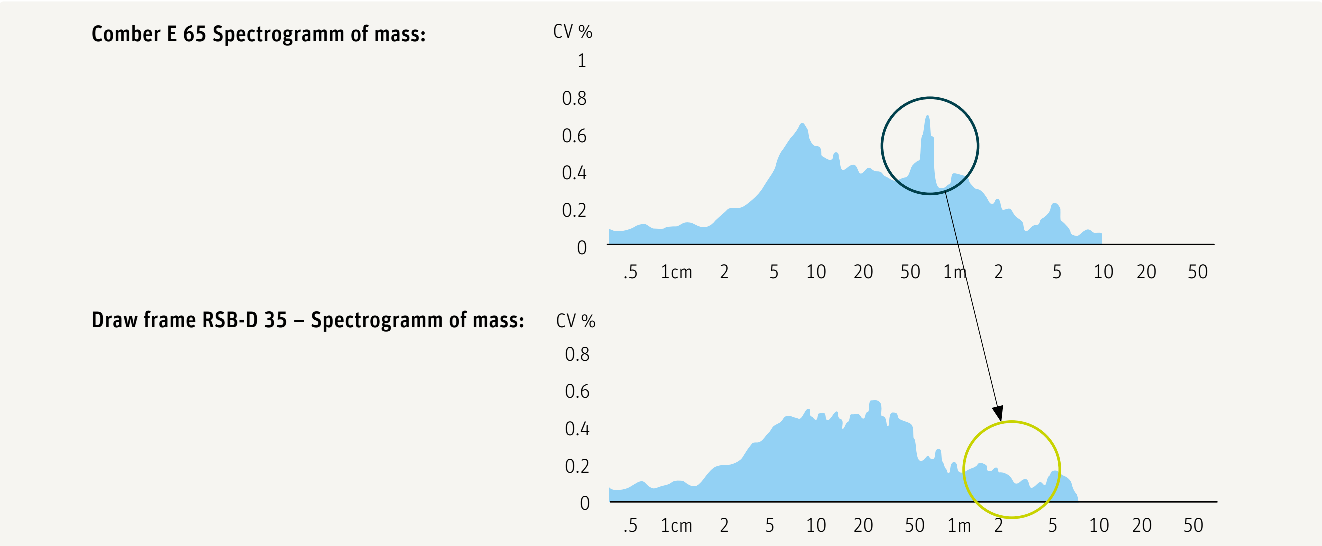


Fig. 19 – Examples: Mass spectrograms after combing and in downstream processes

1.4.2. Conventional system

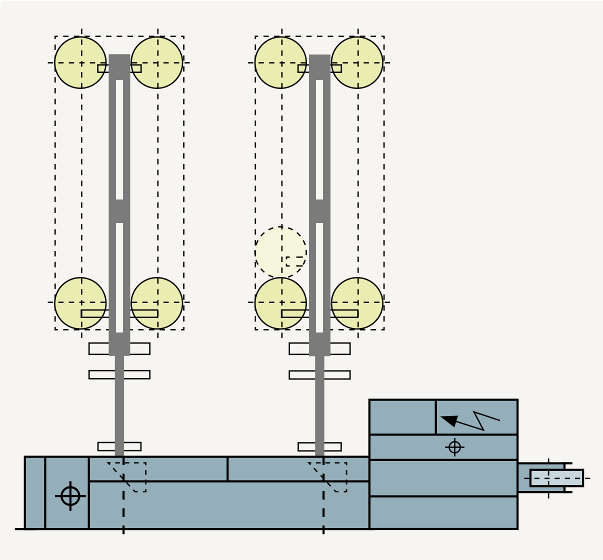


Fig. 21 – Top view of a sliver lap machine

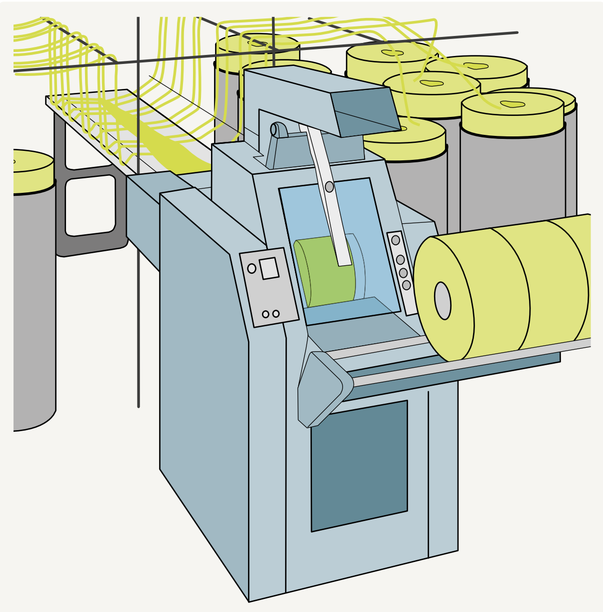


Fig. 22 – Rieter E 2/4A sliver lap machine

In this process the sliver lap machine is the first step. 24 slivers from the card are usually fed together and side by side over a table into a drafting arrangement. A loose form of web is created with a small draft of around 1.5. After pressing and smoothing, this web is rolled up to a lap by calender rollers.

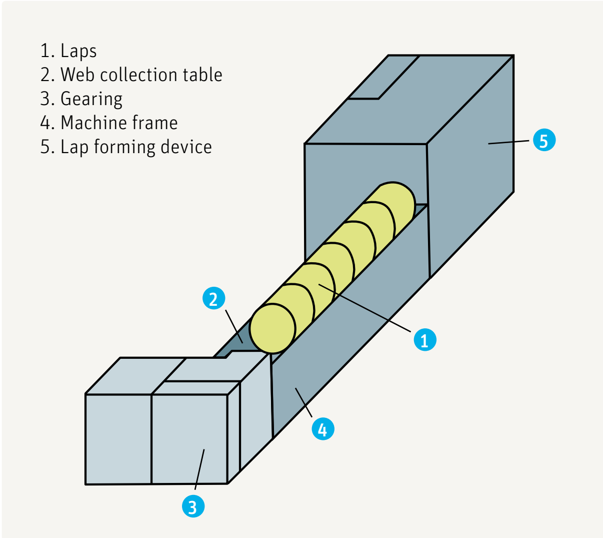


Fig. 23– Elements of a ribbon lap machine

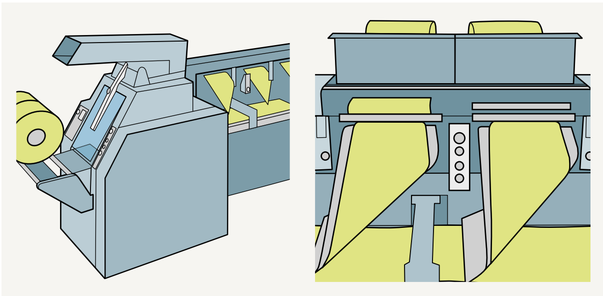


Fig. 24 – Rieter E 4/1 ribbon lap machine

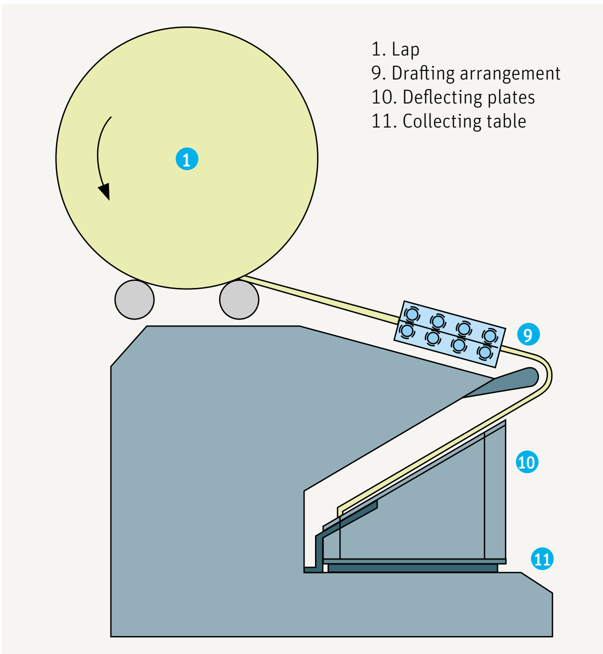


Fig. 25 – The ribbon lap machine – cross-section

Six such laps are simultaneously forwarded to the ribbon lap machine (Fig. 23). These webs pass individually through separate drafting systems arranged side by side. The 6 webs thus formed run over 6 deflecting plates (Fig. 24) and then over a collecting table into a pair of calender rollers. The 6 webs, now overlapping, are pressed together to form a compact web and rolled up to a lap on the subsequent lap rollers. An inherent feature of this classical system is very low productivity, i.e. it is therefore unsuitable for modern combing preparation.

1.4.3. Modern preparation system (sliver doubling system)

1.4.3.1. The first machines using this system

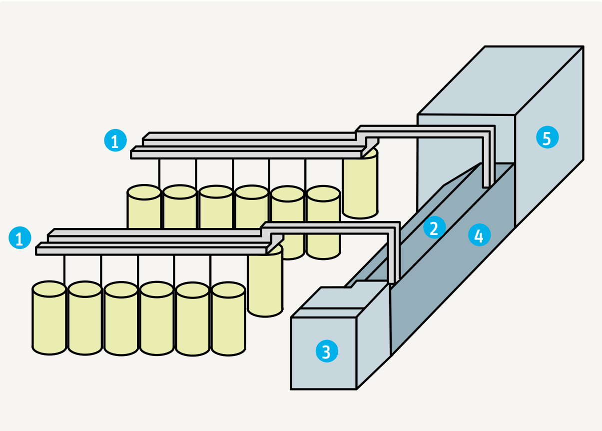


Fig. 26 – Basic design of the former Rieter UNIlap E 5/3 (lap forming machine)

The idea of creating a comber feeding lap by a single web forming process directly in front of the comber – with a drawframe passage in front of this web former, of course – can be traced back to a development in 1948 by the former Whitin Company, called the super lap machine. Although all later machines are of different designs they all are based on this idea. That is why modern high-performance preparation systems will now be explained on the basis of the Rieter machines, starting with the first designs. As already mentioned, the web former (e.g. UNIlap) always follows a normal drawframe. On the UNIlap machine the material flow starts with the creel (1, Fig. 26), consisting of two feed rails. In normal operation 12 cans are laid out under each roller-assisted feed table. Altogether, this gives a total of 24 doublings. The pre-drawframe slivers run over a guide bridge above the service alley and also over several guide rollers to the drafting system at 2 (Fig. 29). The web created by the draft of 1.3 to 2.5 passes over two deflecting plates (Fig. 27) onto the web table on which the webs are superimposed. Calender rollers draw these superimposed webs from the table to the lap winding assembly.

The strong compression created between the calender rollers forms a new web, which is rolled into a lap in the lap forming assembly. Empty tubes are automatically exchanged for full laps. Transport of the laps to the combing machine is semi-automatic or fully automatic.The following detailed description refers to the latest generation of lap formers using the sliver doubling system:

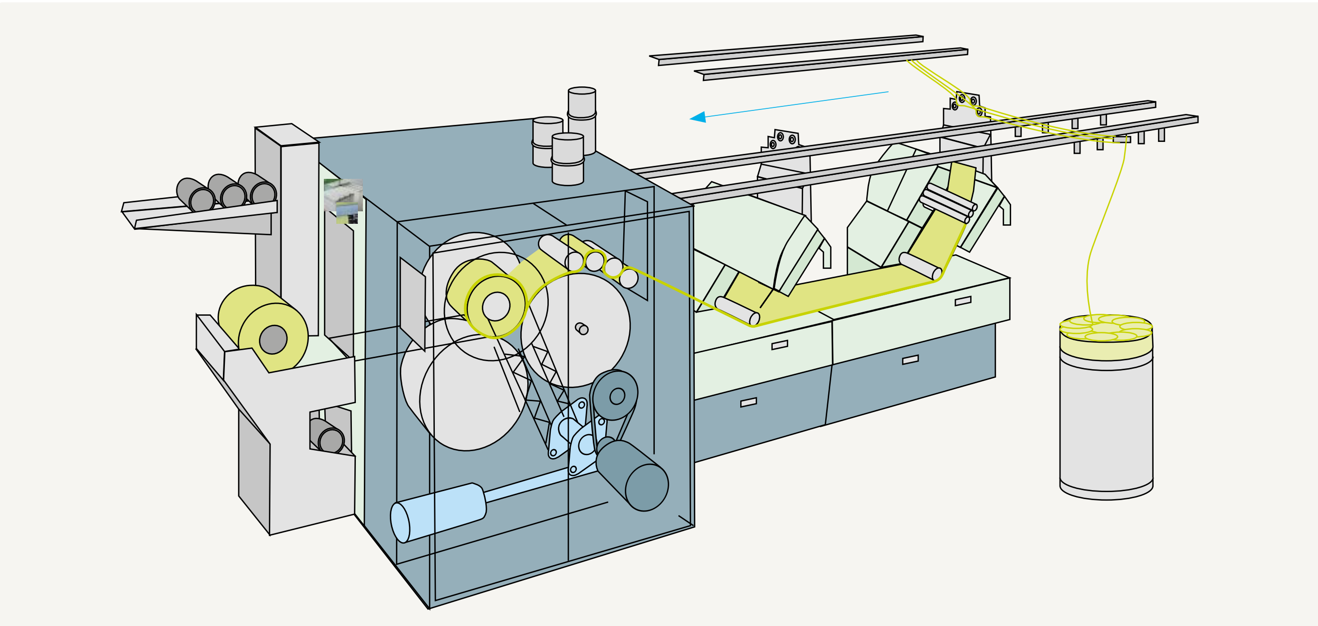


Fig. 27 – UNIlap E 32

1.4.3.2. Infeed

The first part of the machine is a creel on each side feeding two drafting arrangements from max. 28 cans from the draw-frame. Here also the slivers are guided over a service alley (one on each side) to the drafting arrangement (Fig. 25).

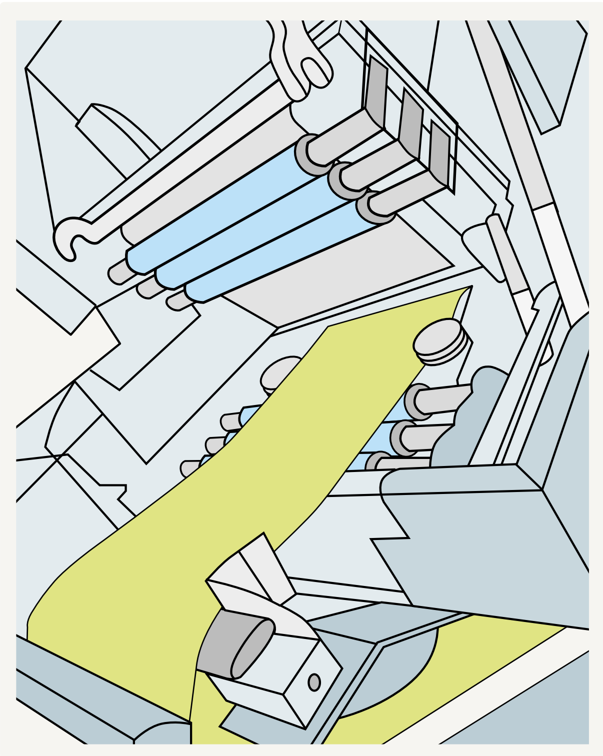


Fig. 28 – The drafting arrangement of the UNIlap system

The UNIlap machine features a 3-over-3 roller, two-zone drafting arrangement. The pneumatically weighted top rollers can be continuously adjusted from minimum to maximum per top roller. Draft distances are individually variable, as are the draft levels in each of the break and main draft zones. Upper and lower clearer aprons in combination with a suction system keep the rollers clean. The easily accessible drive for the drafting arrangement is in an enclosed housing and is fitted with appropriate change gears and oil spray lubrication.

1.4.3.3. The lap winding assembly – conventional system

After passing the web table, the web runs through four calender rollers (Fig. 29, 1). The pressure generated by two membrane cylinders can be adjusted up to 16 000 N. The calender rollers are followed by two winding rolls (2) and a lap tube holding device (3) with a lap weighting device; these have to cooperate to form the lap.

The required weighting pressure (up to 10 000 N), derived from a piston, is transferred via a pivoting lever to the weighting frame and thus to the lap tube. The UNIlap has an automatic lap pressure control which adapts the pressure according to the lap diameter. An increase in diameter of the lap raises the weighting frame, in the course of which the pressure increases. The size of the increase can be set by adjustment using setting screws. The machine stops when a preset lap length is reached, whereupon an automatic device replaces the full lap by an empty tube.

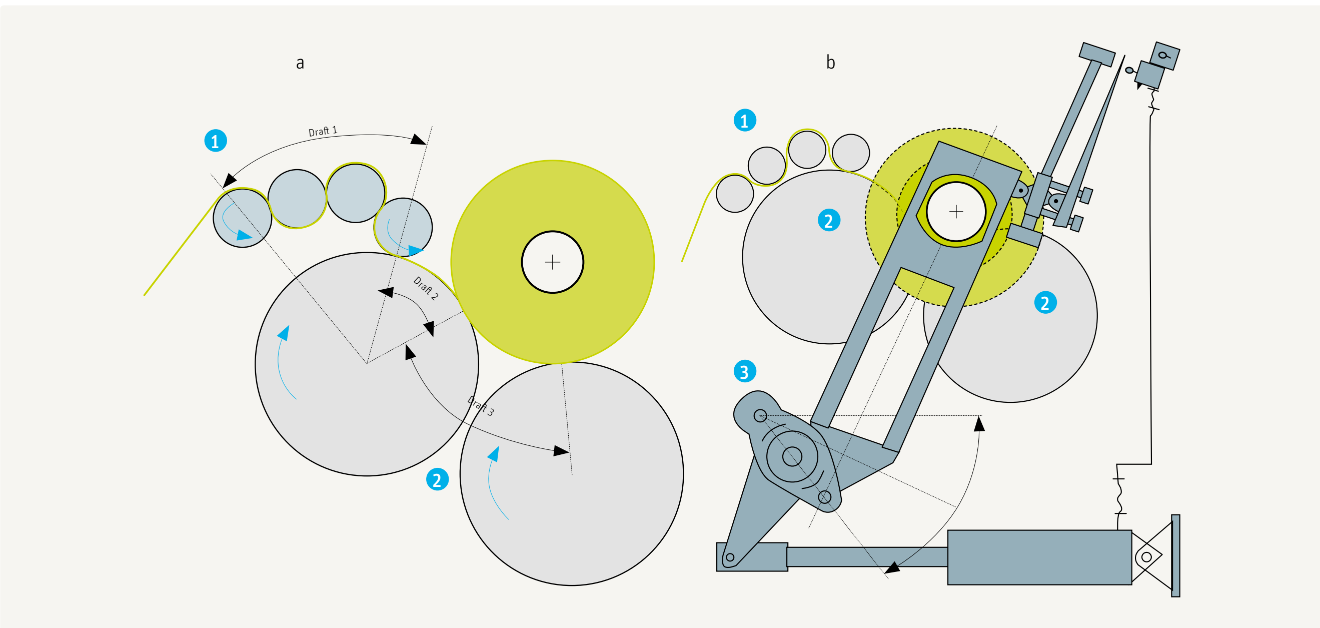


Fig. 29 – The lap winding device of the UNIlap machine

1.4.3.4. Former VARIOspeed arrangement on the UNIlap

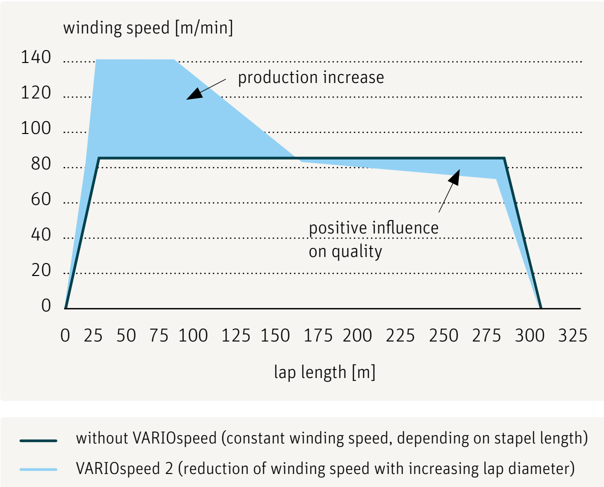


Fig. 30 – Speed diagram of the UNIlap, production gain by VARIOspeed

On this former system the UNIlap machine did not run at constant speed, since this would mean choosing the speed according to the most critical phase of lap winding, i.e. when lap winding was close to completion. However, this meant losing productivity. That is why Rieter adapted the speed of the machine to the buildup of the lap by means of the VARIOspeed set. So, for example, if a final speed of about 70 m/min was required, the machine started with a speed of 140 m/min.

1.4.3.5. System incorporating the latest technology

Since production speeds using the winding system based on calender rollers have reached their limit due to the system itself, Rieter developed a new lap winding system. The new lap winding system makes use of a unique belt tension and pressure arrangement. The winding belt (Fig. 31, 1), with a width similar to that of the laps, surrounds the lap to form a circumferential pressure area (omega-shaped) ranging from 180° to 270° from start to full lap. Fiber guidance and pressure distribution applied by the OMEGA principle allow constant production (i.e. constant speed during winding of the lap) at speeds of up to 180 m/min over the entire lap buildup.

1.4.3.6. Main data

Raw material	cotton up to 1 5/8″ staple
Batt weight	up to 80 ktex
Feedstock	up to 70 ktex per drafting arrangement
Doublings	up to 28
Draft of the drafting arrangement	1.36 - 2.2
Lap width	300 mm
Lap weight, net	up to 25 kg
Delivery speed varies between	70 and 140 m/min
– with OMEGA system	(at constant speeds) up to 180 m/min
Theoretical production (per machine)	up to 350 kg/h
– with OMEGA system	up to 520 kg/h

1.5. The comber
1.5.1. Outline
1.5.1.1. Classification

Two different types of rectilinear combers were formerly in use in short-staple spinning mills:
- single-sided machines with 8 combing heads (Fig. 33);
- double-sided machines with 12 combing heads.

The latter type was built only by the former Saco Lowell company (Fig. 34).

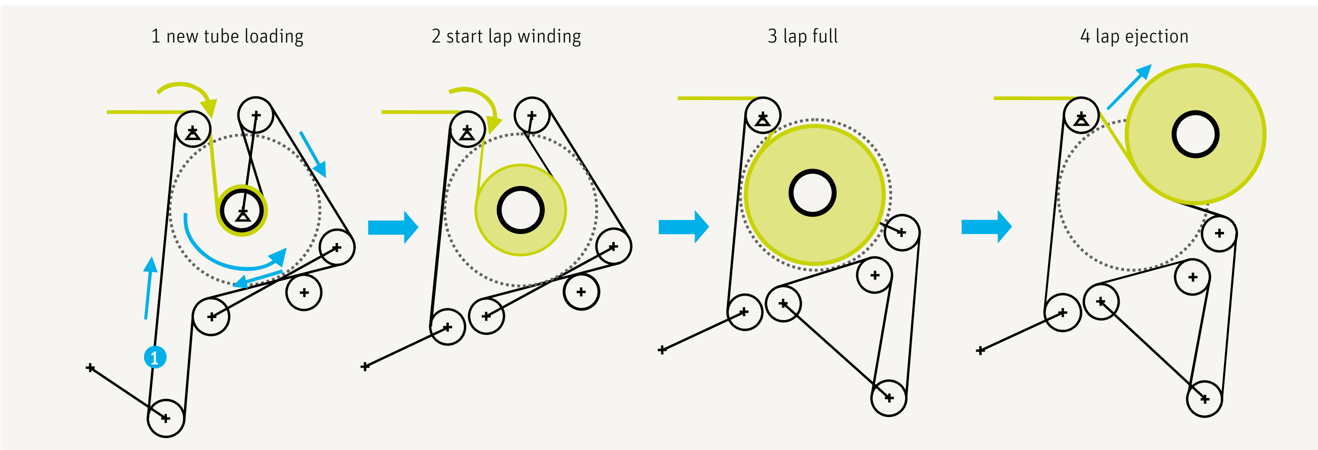


Fig. 31 – OMEGAlap winding process

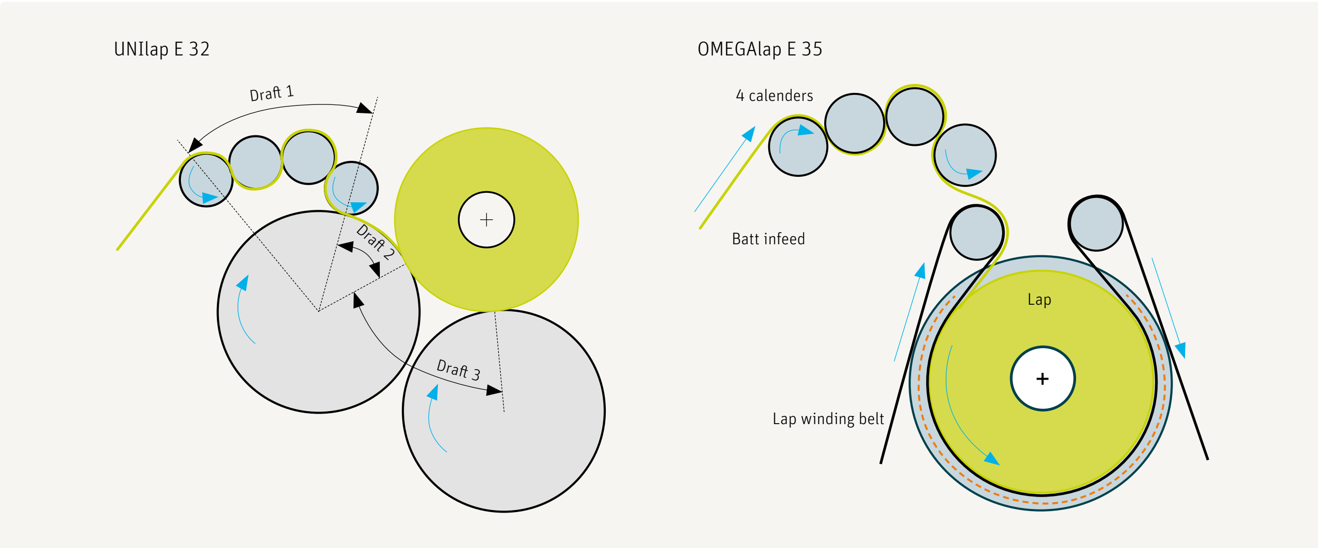


Fig. 32 – Comparison between two different winding systems of Rieter's combing preparation machines

To achieve the equivalent production rate, the single-sided machine is forced to operate at higher nip rates. On the other hand, the single-sided machine has the advantage of permitting 8 doublings (instead of only 6), of being rather less complicated and easier to automate. A single-sided machine will be described by reference to the Rieter E model.

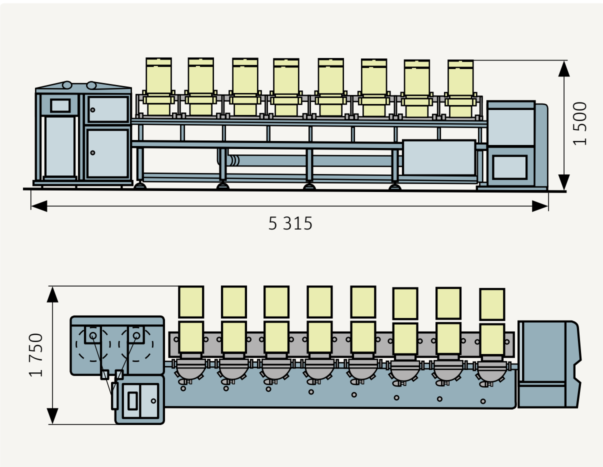


Fig. 33 – Marzoli comber

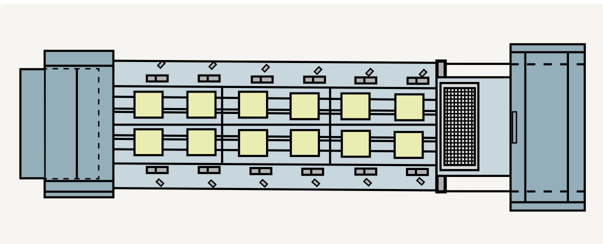


Fig. 34 – Saco Lowell comber

1.5.1.2. Description of functions of the Rieter E 66 comber

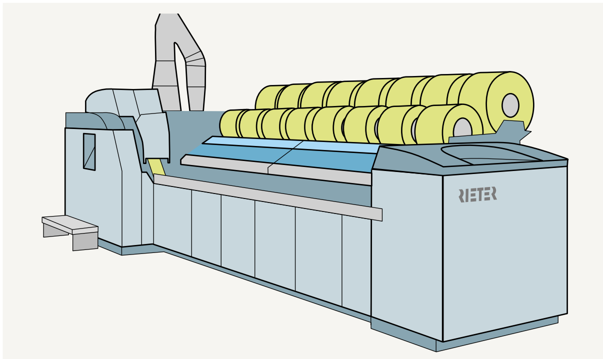


Fig. 35 – Rieter comber

The lap (Fig. 36, 2) rests on two support rolls (3), on which it unrolls slowly. Lap (1) is a reserve lap. On its way into the nippers the web passes over an eccentric shaft (4) acting as a diverter. This serves to keep web tension constant during the forward and return movements of the nippers. Forward movement of the web into the nippers is performed by feed roller (5) and is carried out in very small steps (around 5 mm). When feed has been completed, the nippers are closed by allowing spring (8) to press nipper plate (7) against the cushion plate. During the return swing of the nippers, caused by the oscillation of nipper shaft (13), the nipped web is presented to combing segment (10) mounted on rotating cylinder (11) and is combed out. The nippers swing forward again to enable the tuft to be detached from the fiber fringe by rotating detaching rollers (14), which are

mounted as a stationary unit. Since the trailing part of the fiber fringe is clamped inside the nippers, so that no combing can be carried out in this zone, the rear end of the fiber fringe has to be combed through
by another device, the needles or teeth of top comb (9), in order to complete the combing operation.

The web created by piecing at detaching rollers (14) now passes to a web plate (15) and then via lead-off rollers (16) to a trumpet (17), forming a sliver. Thereafter, table rollers (18) guide the sliver formed in this way to the transverse table, on which all eight slivers are combined and delivered together into a drafting arrangement. After the material has been drawn out in this device to a single sliver, it is coiled in a can. A brush (19) keeps the circular comb clean. The following sections provide details of various operations.

1.5.2. The feed
1.5.2.1. Feed of the lap sheet

Two fluted rollers (Fig. 36, 3), driven at constant speed, unroll the web from lap (2). An eccentric shaft (4) is fitted between the rollers and feed cylinder (5). The web is fed over this shaft, which is rotated intermittently in time with the nipper cycle. Each shaft rotation represents less than a full revolution, first in a forward direction and then in backward feed. This back-and-forth rotation ensures even tension in the web and hence prevents false drafts, which could otherwise arise as a result of fluttering of the web as the distance between the stationary rollers and the feed rollers increases and decreases with the backward and forward movement of the nippers. The eccentricity of the shaft compensates for these changes in distance.

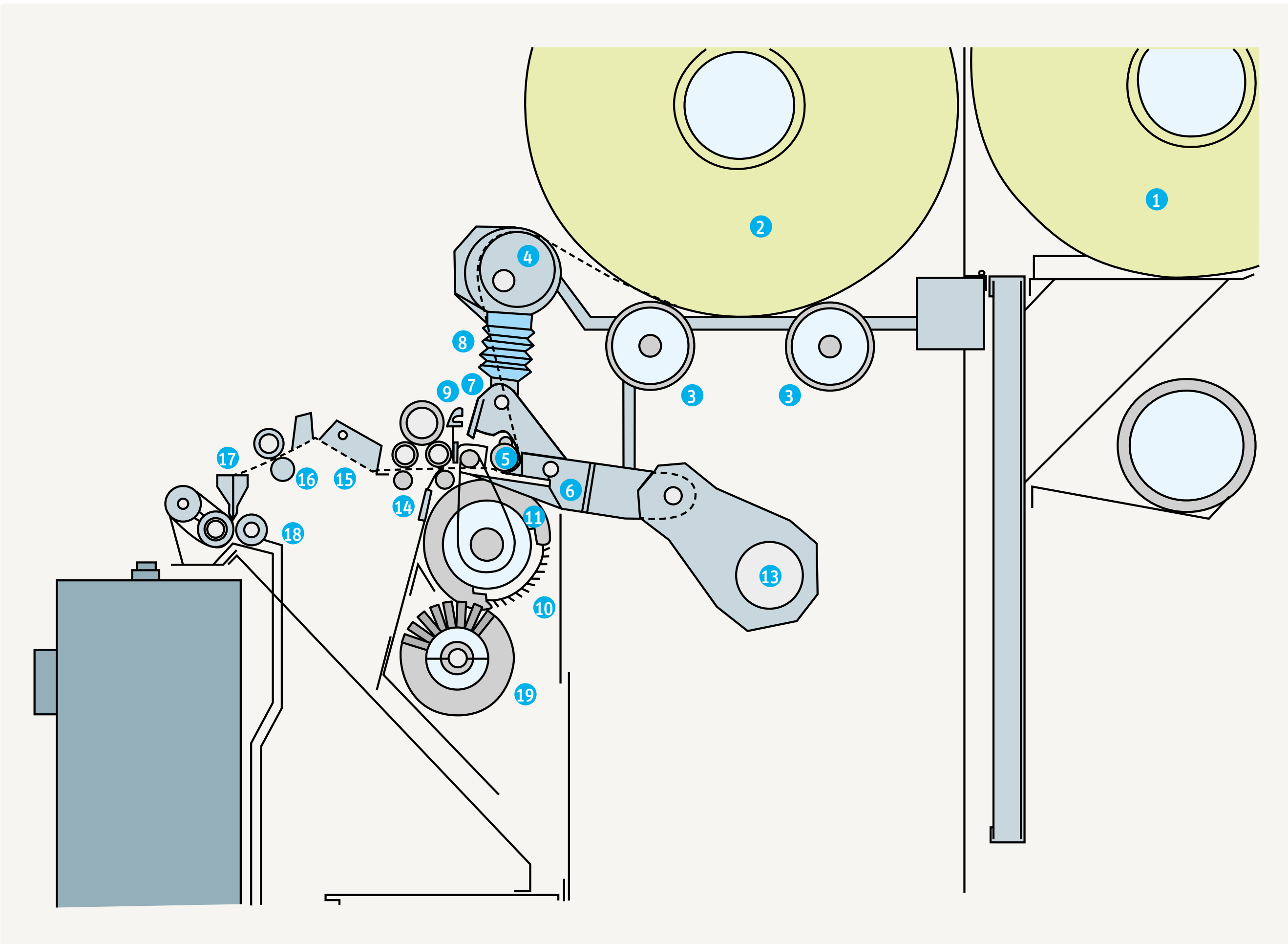


Fig. 36 – Cross-section through the Rieter E 65 comber

1.5.2.2. The feed device

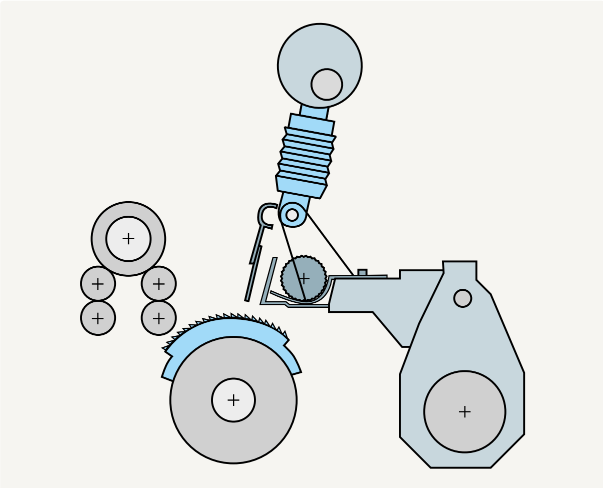


Fig. 37 – Arrangement of the nipper, the feeding and the detaching device

There is no machine drive of the feed rollers as such; they are driven indirectly by the opening and closing of the nipper plates. Forward shift of the web by the feed roller into the opened nippers can be performed:

- while the nippers move forward (described above as forward feed); or
- when the nippers swing back (described as backward feed).

Some types of comber can be operated in only one feed mode (forward feed), others can be operated selectively in either mode. Selection of the required mode then involves an adjustment. On the Rieter comber this can be carried out quickly and easily by replacement of the two drive change gears on opposite sides of the feed roller (Fig. 38). Rotation of the feed rollers to feed the lap sheet forward by 4.3 to 6.7 mm is derived from the relative movements of the upper and lower nippers. For example, in the case of forward feed, when the upper nipper plate is opened it rotates the roller via the ratchet (by one ratchet tooth) by withdrawing the pawl secured to the upper nipper plate. In the case of backward feed, i.e. rotation of the cylinder as the nippers close, a pair of gear wheels and an internally toothed ratchet are needed. The change wheels can be replaced to adjust the type of feed and the feed amount per cycle.

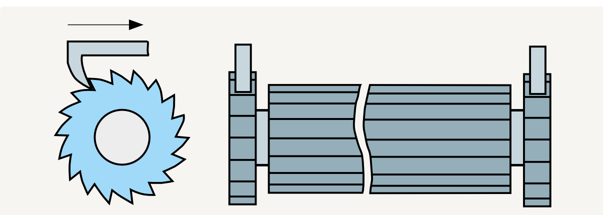


Fig. 38 – Feed roller drive

The following feed distances per cycle are used in the Rieter comber:

Type of feed	Number of teeth on the ratchet	Feed distance per cycle (mm)
Forward feed and backward feed	16	5.9
	18	5.2
	20	4.7
	22	4.3

1.5.3. The nipper assembly
1.5.3.1. The construction of the nipper assembly

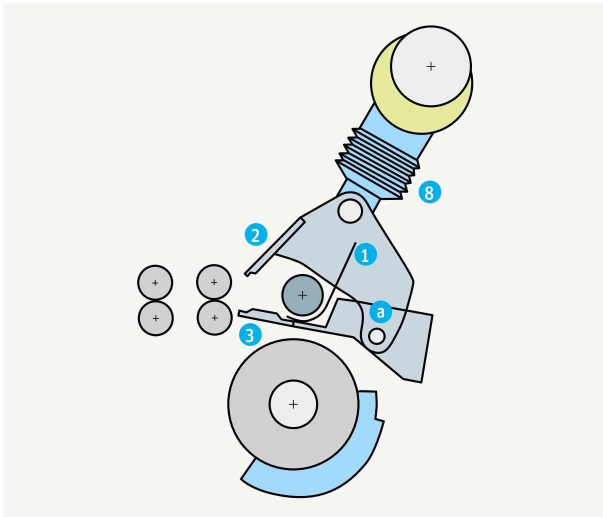


Fig. 39 – The nipper suspension

The nipper assembly (Fig. 39) is of enormous importance to the design of a comber. The mass of the nippers must be accelerated and decelerated back to rest twice per nipper cycle (up to 7 times per second in modern machines). A low-mass nipper assembly – for example, made of aluminum alloy – is therefore advantageous. Also, the nipper assembly has to clamp a relatively thick lap batt (up to 80 ktex) firmly and evenly. The nipper plates themselves must therefore be made of steel (at least the clamping region), and the upper plate must be stiff while the lower plate is slightly springy. The upper nipper is mounted so that it can pivot on the lower nipper on pivot axis (a), and can therefore be raised and lowered. Two springs (8), one each to right and left of the nipper assembly, generate the required contact pressure for the nipper closing. The so-called bite must have a special form, as illustrated in Fig. 40. The nose (n) is designed to press the fiber fringe downward during clamping, so that the fringe cannot escape the action of the circular combs.

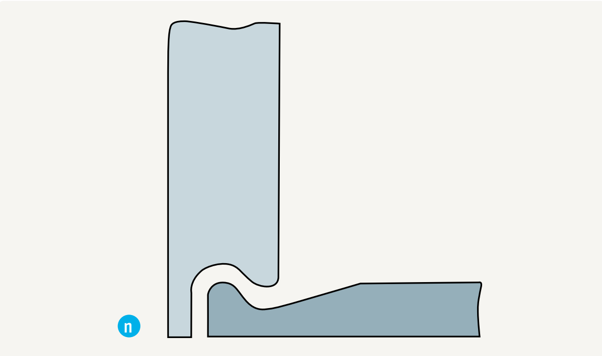


Fig. 40 – The form of the nipper bite

Detaching distance is also very important. On old combers the distance between the feed rollers within the nipper plates and the detaching rollers (in their nearest position) was too wide, strictly speaking the distance between the feed roller and the nipper mouth. This always resulted in slightly uncontrolled fiber extraction during the combing and detaching operation. Rieter solved this problem in a simple way by shifting the feed roller closer to the nipper mouth, and improving web guidance within the nipper installation by means of a special guide plate at the feed roller (Fig. 39, 1). This arrangement saves quite a considerable amount of good fibers.

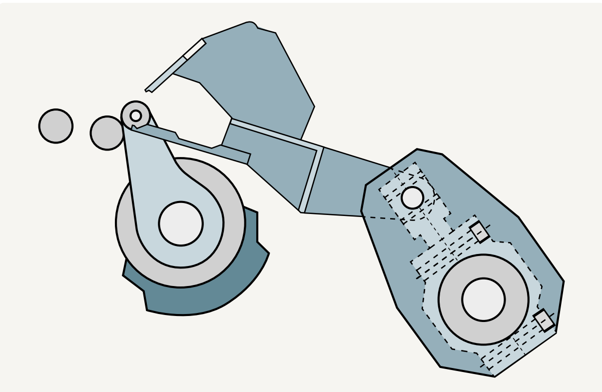


Fig. 41 – The nipper support

1.5.3.2. The nipper movements

The lower nipper plate (Fig. 42, 5) is supported at the front by two pivot levers (6), on the left and right respectively, pivoted on comb axis (7) of the circular combs, and also by two swing arms (2) screwed onto nipper shaft (1) and rotatable at point 8. During rotation of the nipper shaft – through less than a full revolution – in the course of each combing cycle, the whole nipper assembly is moved back and forth about point (8) by swing arm (2).
‚Forth' means the nippers are moved closer to the detaching rollers as far as the position of closest approach (the detachment setting), and are then withdrawn again. The upper nipper is movably supported on the lower nipper at point 10, and is also suspended from shaft (12) by means of spring (11). Therefore, as the nipper assembly is moved forward, the upper nipper is raised relative to the lower nipper owing to the different lengths (different leverage) of the lever mechanism, and the nippers are opened. As the nippers are withdrawn, spring (11) presses the upper nipper back against the lower nipper (due to the different length of the levers). It is important that the nippers are not closed suddenly and sharply, but gently pressed together with gradually increasing pressure. This gentle closure of the nippers is effected by an eccentric (12). During continuous rotation of the eccentric, the spring is periodically compressed and then released.

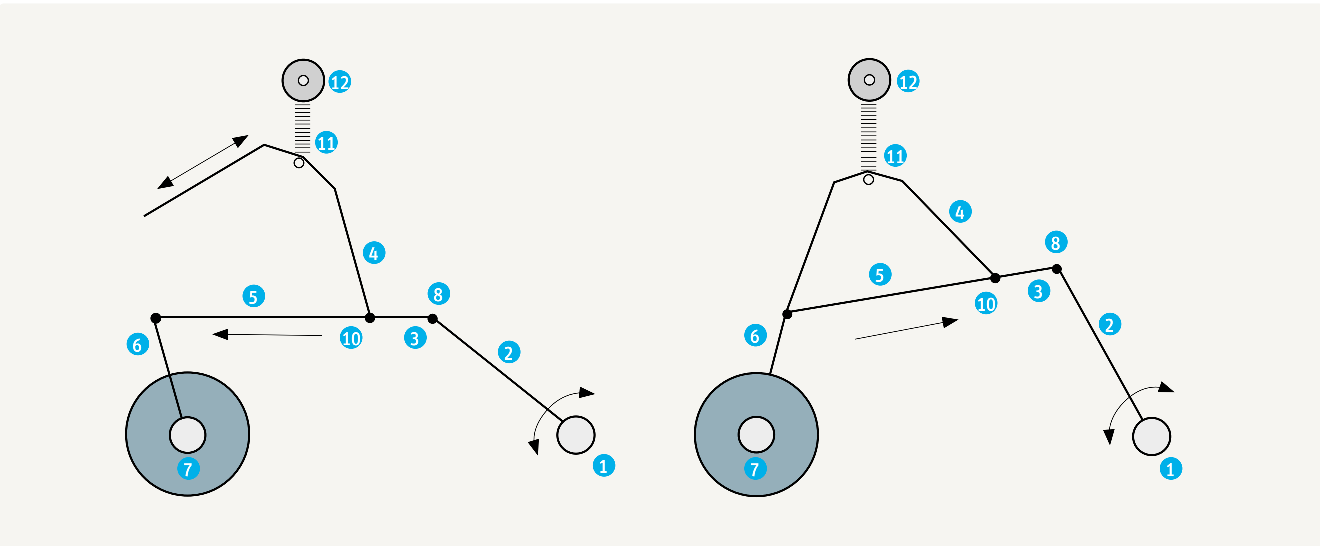


Fig. 42 – Diagram of nipper movements

1.5.3.3. Hanging and standing pendulum

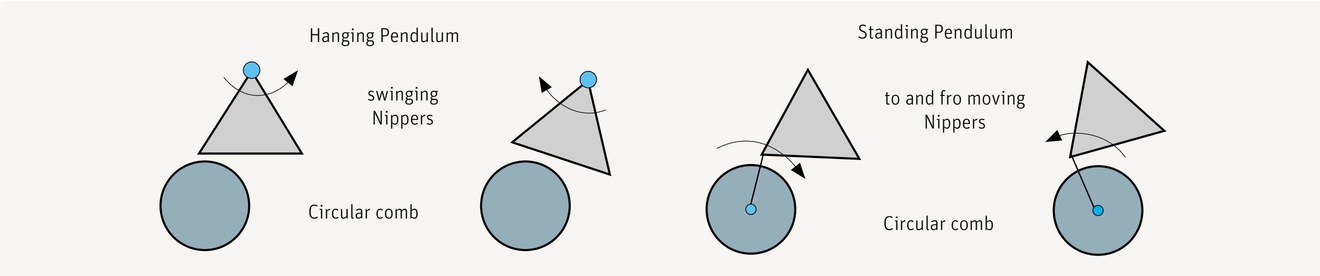


Fig. 43 – Two different suspensions of the nipper assembly

For the suspension of the nipper arrangement we distinguish between a hanging and a standing pendulum (Fig. 43), i.e. the nippers are arranged either on a crank beneath the bottom nipper plate (standing pendulum) moving forward and backward, or they are hanging on a pivot above the top nipper plate for the forward and backward movement. The arrangement one way or the other has a major influence on combing performance:

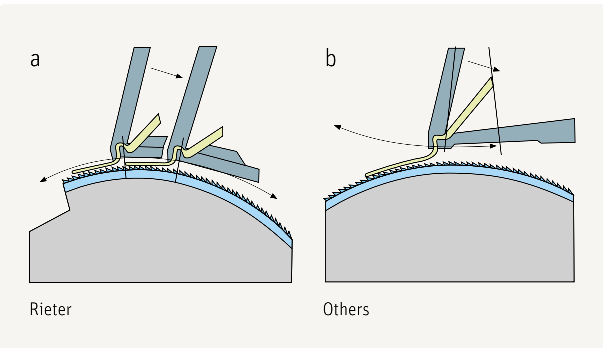


Fig. 44 – Combing performance with standing and hanging pendulum

With a standing pendulum (Fig. 45, a) the nippers, together with the batt to be combed, move concentrically with the circular comb. The distances to the clothing of the circular comb show little difference (almost constant treatment of the fringe). With a hanging pendulum (b) the variation of distances is larger, and the lowest and highest points of contact also vary, depending on settings. This results in an unfavorable combing operation.

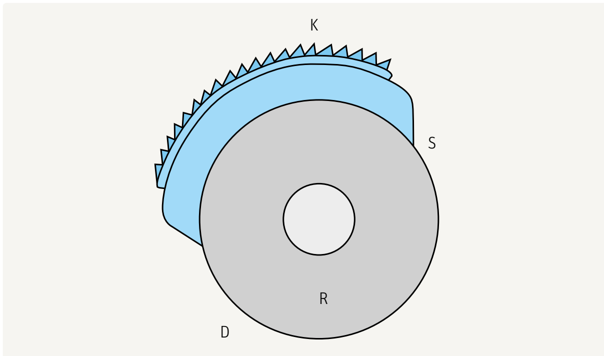


Fig. 45 – Circular comb with metallic clothing (teeth)

1.5.4. The comb
1.5.4.1. The circular comb

A cylinder drive shaft (Fig. 45, R) extends through the whole machine, and carries one combing cylinder (D) per combing head. The combing cylinder in turn supports a combing segment (half-lap) (S), which is bolted to the cylinder and is fitted with metallic clothing (K).
Only metallic clothing is now used on high-performance combers, since this clothing is more robust than the needles that were used formerly, needs no maintenance, is not liable to damage in use, and permits operation with a thick batt sheet. Today metallic clothing is available with as many as three to five zones of point density, i.e. with fewer teeth at the start, a somewhat higher density in the central zone and a still higher density in the trailing zone.

1.5.4.2. The top comb

The replaceable top comb (Fig. 46, F and Fig. 47) is arranged between nippers (Z) and detaching rollers (A) so that the fiber fringe can be drawn through the needles of the top comb during detaching. The top comb usually comprises a holder (Fig. 48, H) to which needle bar (B) is secured by screws. The needles are soldered to the bar.

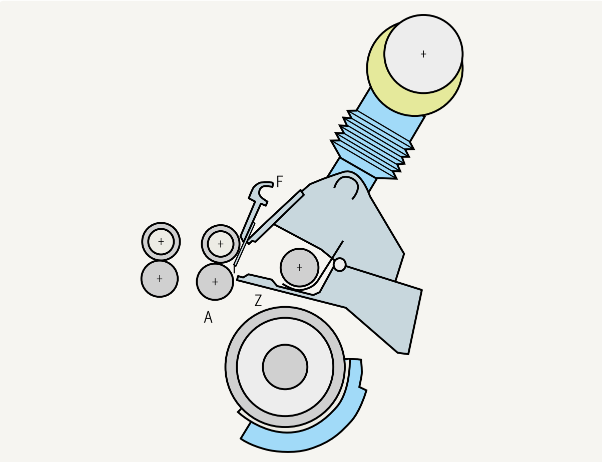


Fig. 46 – The top comb assembly

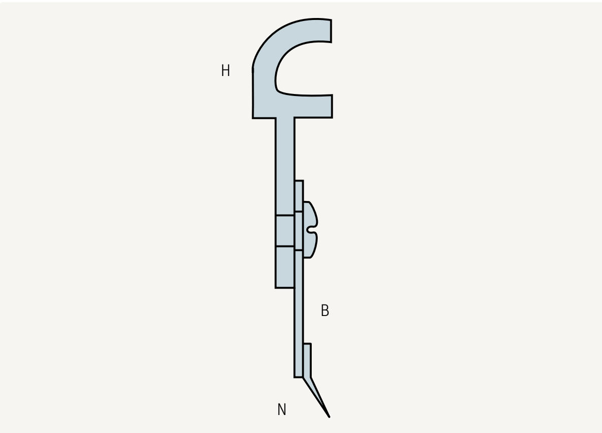


Fig. 47 – The top comb (with needles)

The holder mounts the top comb on the lower nipper plate so that the top comb swings with that plate. The needles have a flattened cross-section and a bend. Apart from its participation in the swinging movements of the nippers, the top comb is fixed, i.e. it is not subject to any additional and complicated up-and-down movements. During detaching the fiber fringe is pressed into the needles of the comb automatically. The depth of penetration is very important and is therefore designed to be adjustable. The spacing from the detaching rollers is also adjustable.

1.5.4.3. The operation of the combs

The circular combs can treat only the forward portion of the fiber fringe to be processed, since the comb clothings do not penetrate exactly to the bite of the nippers and also because the rear ends of the fibers are located within the nippers. The fairly long, trailing portion has therefore to be combed out by another device – the top comb – while being drawn through it (a passive process).

This could lead to the false impression that the trailing portion of the fringe is not processed as effectively as the front portion, because it is not passed through a complete combing zone (circular combs), but only through a single row of needles. In fact, the quality of processing of both portions is the same. This statement requires some explanation. Cleaning and elimination of short fibers is, of course, performed by the top comb, but also at the same time by the retaining effect (self-cleaning effect) of the batt in the nippers. During detaching less than 20 % of the fibers in the nippers are pulled out of the batt (Fig. 48). This low percentage of fibers is unable to take the impurities within the batt with it, because the retaining force of the more than 80 % of fibers of the thick batt that remain is too strong. Impurities, neps, and short fibers therefore remain in the sheet as the other fibers are detached. It goes without saying that this retained material also has to be eliminated somehow, somewhere. It occurs when the fringe is treated by the circular comb during the next combing cycle, or the following one. Elimination is always performed by the circular comb.
The self-cleaning effect can be influenced by several factors, including the batt weight and the degree of parallelization of the fibers. Of course, the self-cleaning effect is better, the lower the parallelization of the fibers and the more voluminous the batt. Unfortunately, however, the latter entails overloading of the combs and very poor combing performance. As usual in spinning, the golden mean has to be found.

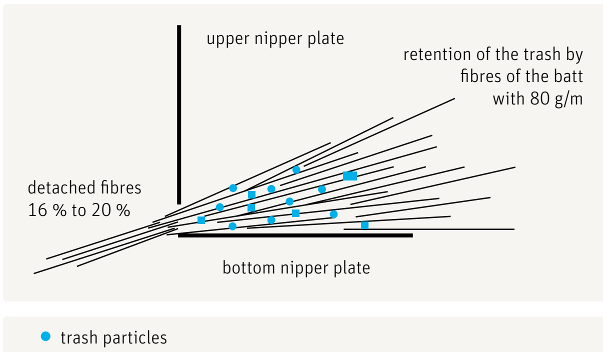


Fig. 48 – Self-cleaning effect of the batt

1.5.5. Take-off of material
1.5.5.1. Piecing

After the operation of the circular combs has been completed, the detaching rollers feed back part of the previously formed web. The nippers (Fig. 2) swing forward and lay the fiber tuft that has just been combed onto the portion of the web projecting from the detaching rollers. When the detaching rollers now rotate again in the web take-off direction, they draw the fiber tuft that is immediately combed through the top comb and out of the fringe. The coherent web at the detaching rollers is thus lengthened by a new web strip. As a result of this operation the newly formed coherent web consists of small fiber tufts laid on top of each other in the same way as roofing tiles. The subsequently formed sliver still contains these periodic irregularities, a distinct source of faults in the operation of rectilinear combers.

The sliver produced in this way has a wave-like structure (Fig. 19) with periodic variations. These variations are visible in the spectrogram as combing cycles in the form of peaks (at about 30 - 75 cm) (Fig. 20). Both the spinning mill and the machine designer must strive to keep this irregularity as low as possible. The designer therefore employs eccentric withdrawal of the web from the web plate (Fig. 52/Fig. 53). The spinning mill can influence this via the machine settings. The fiber tufts drawn off by the detaching rollers can be compared with very flat parallelograms, although normally the leading edge is blunter than the trailing edge. By using correct machine settings it is possible to lay these parallelograms on each other in such a way that any unevenness is partly canceled out. On the other hand, incorrect setting will cause an increase in unevenness. In order to carry out the piecing operation, the detaching rollers must perform a back-and-forth movement (Fig. 49) in which the forward component (V) is larger than the backward component (R), so that effective take-off (T) is achieved. In modern combers backward movement amounts to about 60 % of the forward movement:

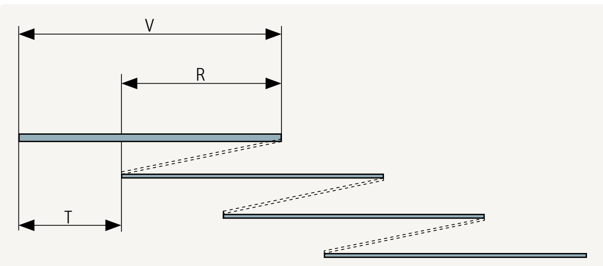


Fig. 49 – The back-and-forth movement of the detaching rollers

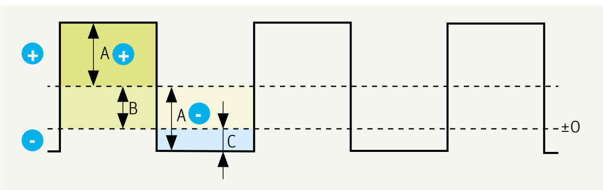


Fig. 50 – The mode of operation of the differential gear of the detaching rollers

The back-and-forth movement of the detaching rollers derives from a differential gear. An intermittent rotation (Fig. 50, A) is superimposed upon a constant basic rotation (B) generated by the comb shaft. The intermittent rotation is somewhat faster than the basic rotation. If these rotations are acting in the same direction (A + B), the result is a rapid acceleration of the detaching rollers in the forward direction (detaching operation) (Fig. 50, left). If the superimposed rotations are acting in opposite directions, not only does the intermittent rotation (A) cancel out the whole effect of the basic rotation, but it also causes a reversal of the detaching rollers (C), since the speed of the intermittent rotation is higher than that of the basic rotation.

1.5.5.2. Withdrawal of the web and formation of a sliver

The resulting web must be collected into a sliver by the trumpet (Fig. 51, T) and deposited on the sliver table (B) by the calender rollers (K). This is carried out continuously. However, since detaching rollers (R) are required to perform a back-and-forth movement, during which the web must be maintained intact, a reserve of material must be formed periodically between detaching rollers (R) and withdrawing rollers (Z). Accordingly, a web plate (V) is provided in this zone. During the forward movement of the detaching rollers, the excess web forms a corrugated sheet on the web plate. During the backward movement the corrugations are straightened out again. The web plate therefore functions as a web reserve zone. Collection of the web is performed at the web plate or in the zone immediately following it. The web can be collected toward the center line (Fig. 52, a), as in older web pans, or to one side (b) as on the web plate in modern combers. With a central collecting action, the slightly thicker piecing lines are formed into curves, which distinctly emphasizes the combing cycles (piecing waves). If the web is collected to one side (Fig. 52, b), the piecing lines form diagonals, resulting in partial compensation of the piecing waves. Collection of the web is performed by the sliver trumpet (Fig. 53, T). The mouthpiece of this trumpet must always be adapted to the sliver count (volume). Calender rollers (K) serve to condense the sliver.

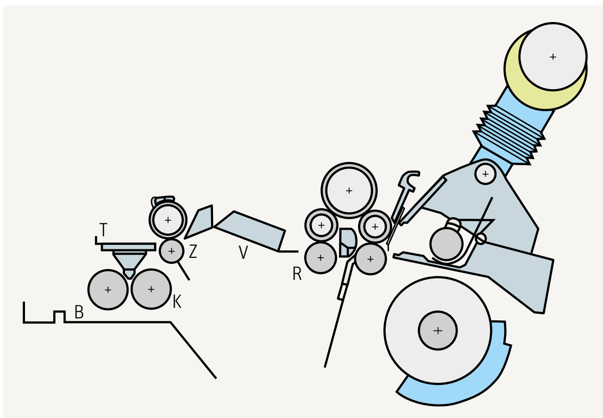


Fig. 51 – Web take-up assembly

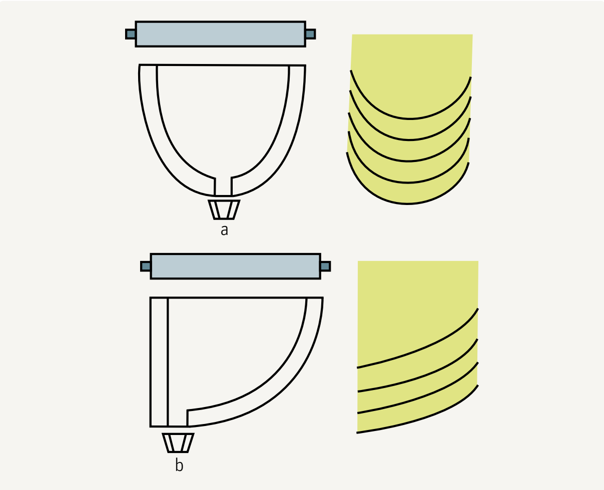


Fig. 52 – Removal of the web

1.5.5.3. Sliver take-off

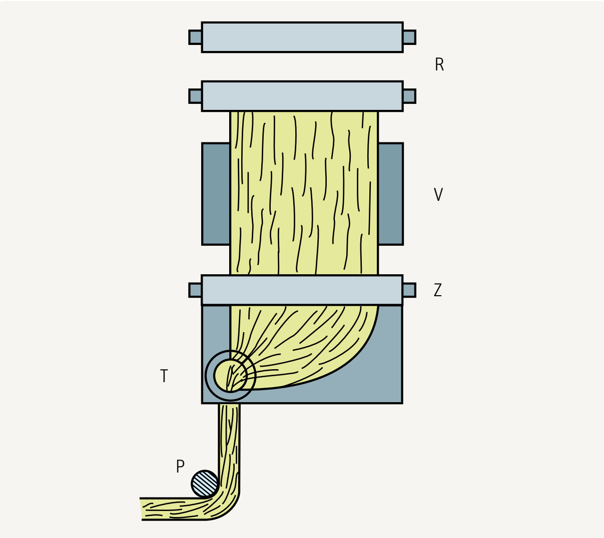


Fig. 53 – Sliver formation

The slivers run individually toward the sliver table. They are then deflected through 90° by the deflecting pin (Fig. 53, P) and are fed together over table (Fig. 54, B) to the drafting arrangement (S). Many manufacturers provide deflector pins that are adjustable or can be rotated eccentrically by minimal amounts. The distance between the sliver trumpet and the drafting arrangement can then be adjusted by these very small amounts and thus (depending on the given adjustment instructions) the piecings of the individual slivers can be shifted relative to each other. This mutual shifting results in partial compensation (suppression) of the combing piecings. Where the comber has only one delivery (modern machines), all eight slivers are drawn into a common drafting arrangement and formed into a single sliver, which is then coiled in a can (i.e. eight-fold doubling).

1.5.6. The drafting arrangement

In the Rieter comber, the sliver table leads to a vertically inclined 3-over-3 drafting arrangement (Fig. 55), sometimes with an additional pressure bar in the main draft zone. The rollers form two drafting zones. Break draft as well as main draft distances and the amounts of draft are variable. The overall draft lies between 9 and 16. At the delivery end of the drafting arrangement a trumpet collects the discharged web and guides it, with additional compacting, to the delivery rollers .

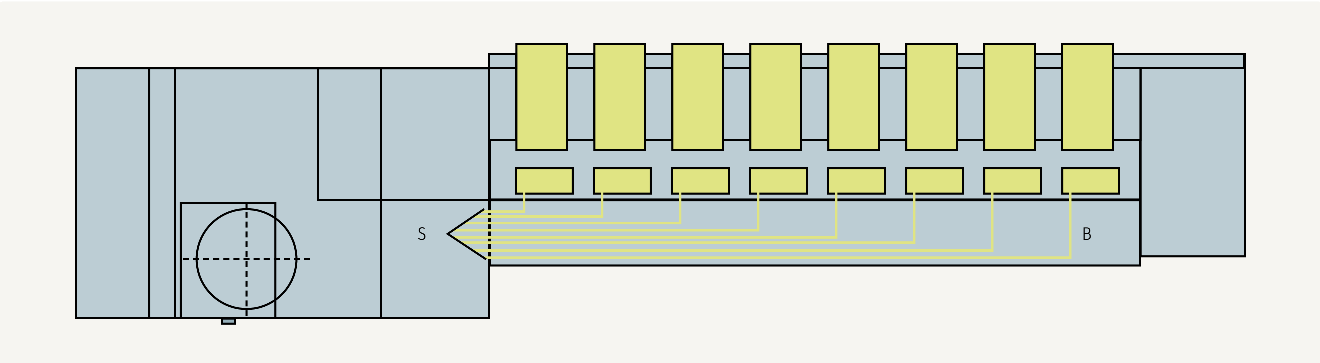
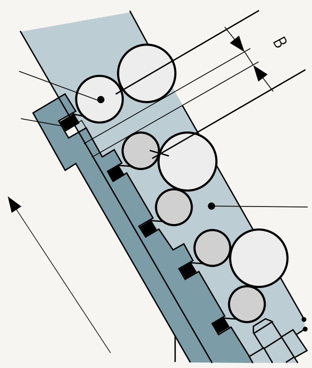
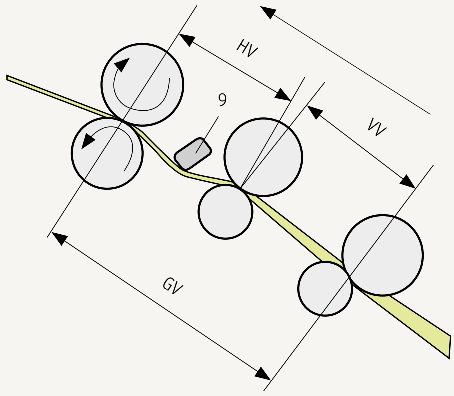


Fig. 54 – Guiding the sliver from the web table to the drafting arrangement



- tooth belt driven
- only main draft adjustable

Fig. 55 – The drafting arrangement of the Rieter combers



- tooth belt driven
- pressure bar (9) guides the fibers in the main draft zone
- break draft distance (VV) and main draft distance (HV) are adjustable
- break draft (VV) and total draft (GV) are adjustable

Fig. 56 – Sketch of the drafting arrangement of the Rieter E 65/75 combers

1.5.7. Coiling the sliver

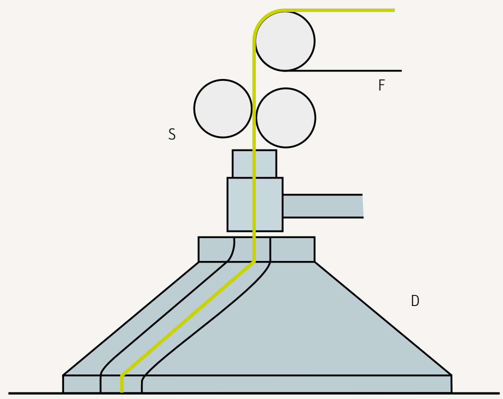


Fig. 57 – Coiling the sliver

The high delivery speeds of modern combers make it impossible to guide combed slivers from the drafting arrangement to the can without any form of transport assistance. In the Rieter machine a narrow conveyor belt (F) has been provided for this purpose. Two stepped discs (S) are located above the rotary table (D) to compact the sliver, thereby increasing the packing density of sliver in the full can. The compacting step also increases the inherent coherence of the sliver. The stepped discs serve a second purpose, as a measuring device. They form part of a hank monitor responding to the sliver density. The sliver formed in this way is coiled cycloidally, as already described for the card. The coiler comprises a rapidly rotating table (D) and a slowly rotating can turntable below. A geared movement is superimposed on the basic movements in order to increase the quantity of material loaded into the can. Can change is carried out automatically while delivery is stopped.

1.5.8. Waste removal

The eliminated material (short fibers, foreign matter, neps, etc.) remains trapped in the circular combs. Removal is performed by a rapidly rotating brush mounted below the comb-carrying cylinder (Fig. 58). This removal occurs when the half-lap comb engages with the brush, which then ejects the noil into a duct forming part of a suction system. This leads to a filter drum behind the machine (older system), to a fiber separator (Fig. 59) within the machine, or to a central waste removal system (Fig. 60).

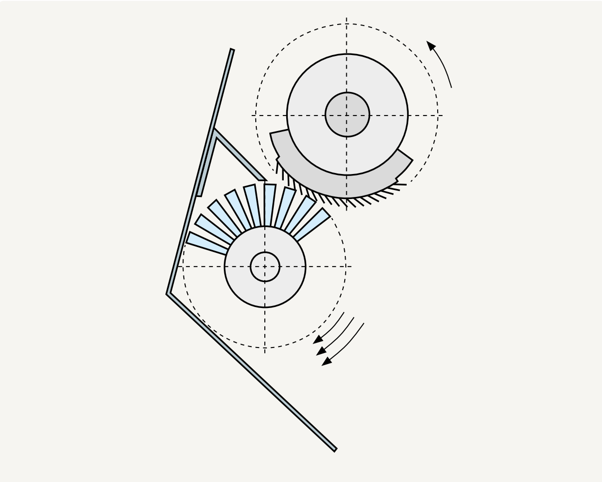


Fig. 58 – Stripping the circular combs

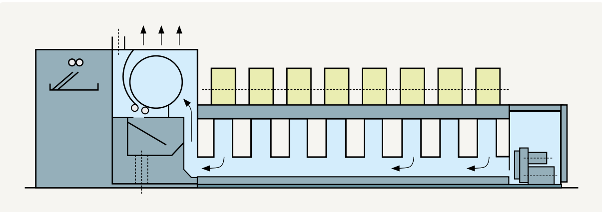


Fig. 59 – Removal of waste using a fiber separator

Although this normal brushing-out is a very efficient way of cleaning the circular combs, some material can still remain caught in them, disturbing the combing operation and causing deterioration in quality. To deal with this problem, modern combers feature a so-called slow cycle. At precisely adjustable, pre-set intervals, the movements of the machine parts are slowed down to 1/5 of normal speed. Only the brushes continue to rotate at full speed, thus subjecting the circular combs to intensive treatment to produce a thorough cleaning effect. Fig. 61 shows the increase in the level of noil with uninterrupted full-speed running time. Fig. 62 demonstrates the stability of the noil level when a periodic cleaning cycle is inserted into the operating sequence. The top comb is self-cleaning owing to the action of the thick sheet passing through its teeth when pulling the top comb out of the sheet.

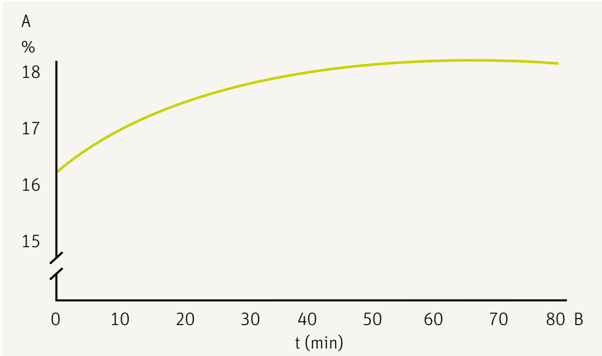


Fig. 61 – Change in combing-out as the circular combs fill up. A, noil percentage; B, running time of the machine (t(min))

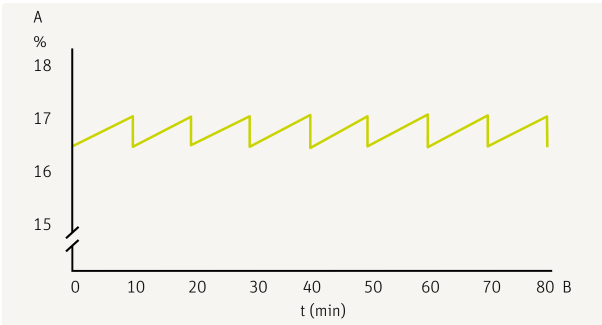


Fig. 62 – Keeping combing-out constant by periodic intensive cleaning of the circular combs

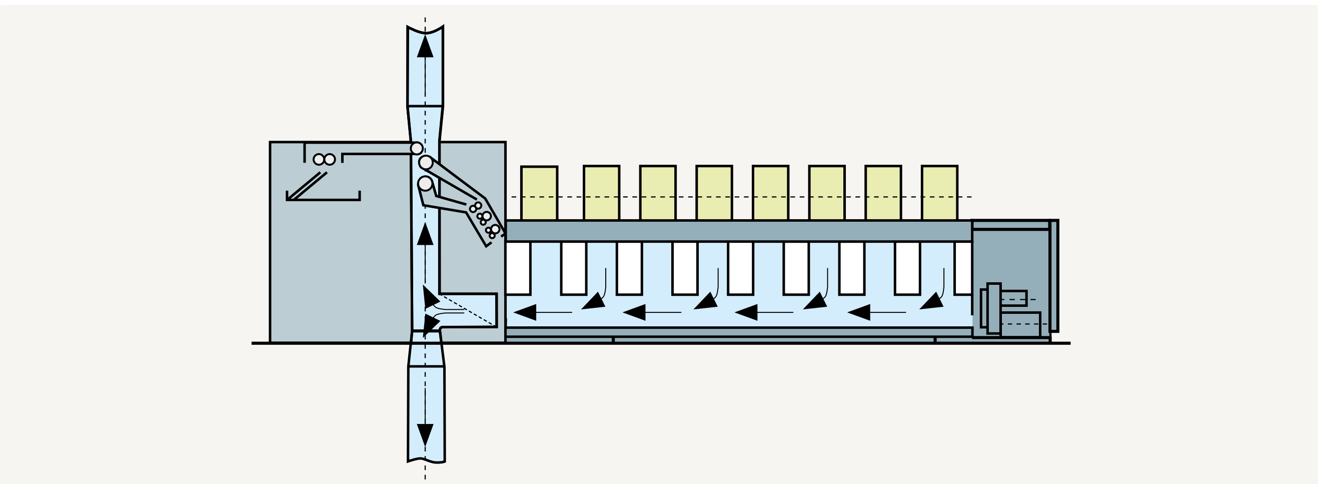


Fig. 60 – Central waste removal

1.5.9. Machine data

1.5.9.1. The sequence of movements in the machine

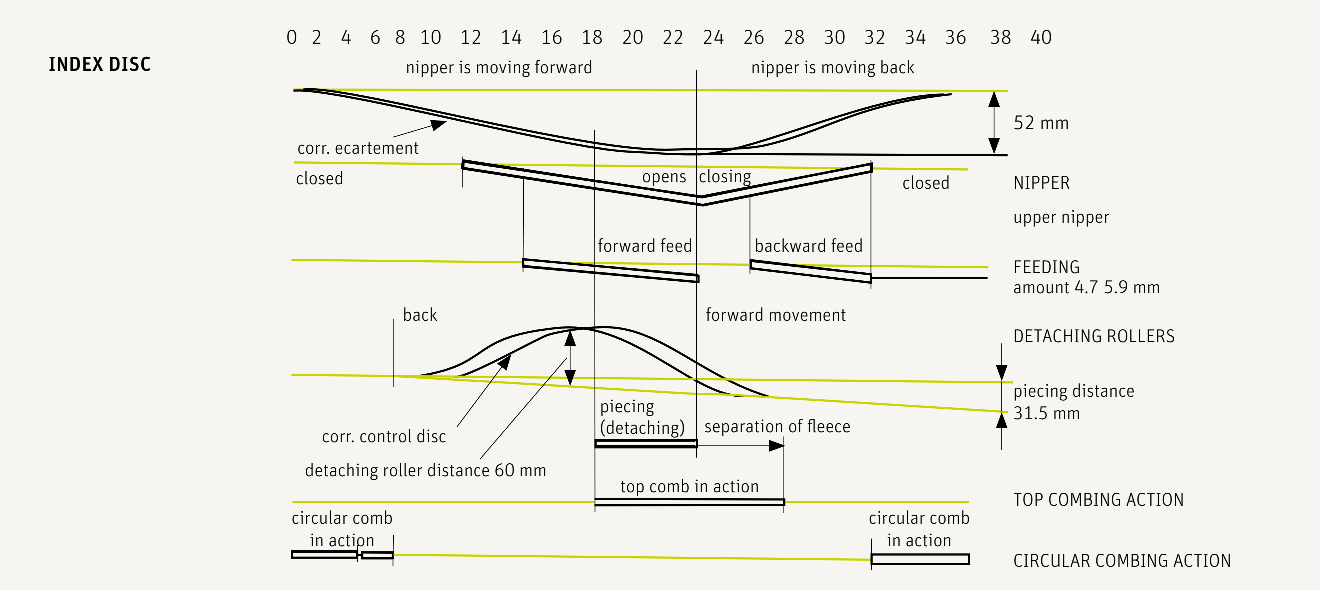


Fig. 63 – The sequence of movements in the machine; Example Rieter E 7/5

1.5.9.2. Technical data of the Rieter E 75

Number of combing heads	8
Number of deliveries	1
Doublings	8
Nips per minute	up to 500
Noil (%)	8 - 25
Efficiency (%)	up to 96
Production (kg/h)	up to 68

Can form:

diameter (mm)	600 (24 in.)
height (mm)	1 200 (48 in.)

Weights

Batt weight (ktex)	64 - 80
Delivery hank (sliver weight) (ktex)	3 - 6
Forward / backward feed	adjustable

1.6. The Saco Lowell double-sided comber

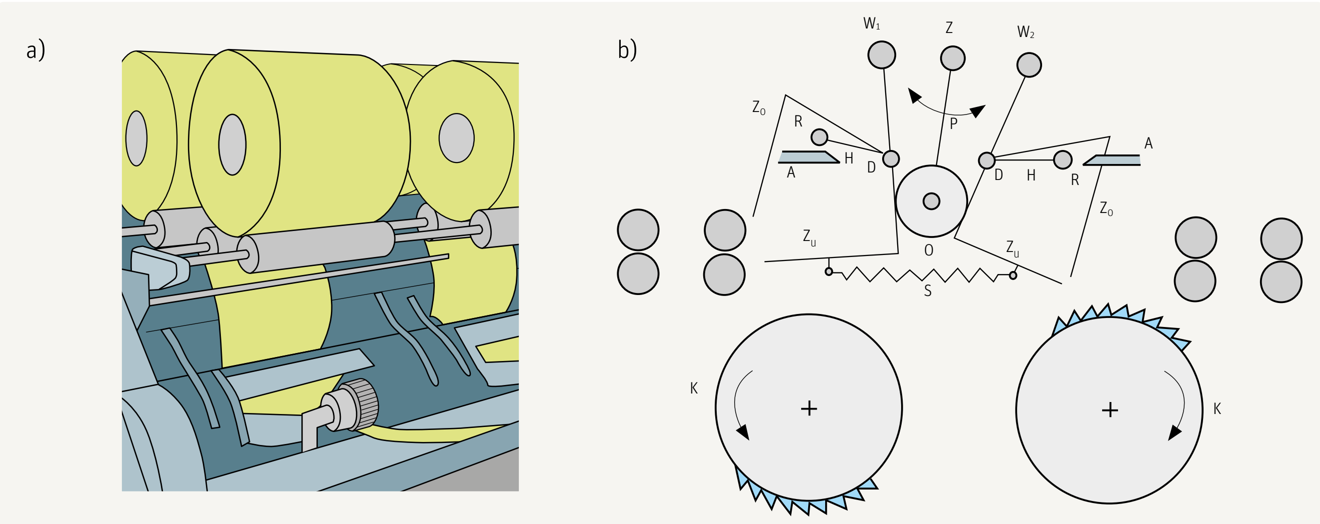


Fig. 64 – The double-sided Saco Lowell comber (a) detail of the individual head, b) movements

For several decades Saco Lowell built a very interesting machine, which differs markedly from others available on the market. It is a double-sided design, with six combing heads on each side and a corresponding mirror-image arrangement of the main operating elements on the two sides, including the two deliveries. However, the drive is centrally arranged for the two sides in common.
The swinging movements of the nippers (Fig. 64, Z_U/Z_O) are derived from the nipper shaft (Z), which rotates backward and forward through small angles. This shaft movement is transmitted via lever (P) and roller (O) to the nippers; during rotation to the right, the right-hand nipper is also swung to the right. Rotation to the left causes the left-hand nipper to swing to the left. The nippers are thus pushed forward by the swinging roller (O), always to one side only. The nippers on the other side are forced to make the same movement, as both nippers (left and right) are connected by a spring (S).
Opening and closing of the nippers is derived automatically from the swinging movement. When the whole mechanism moves to the left, as shown in Fig. 64, a small roller (R) engages at a set time with a fixed rail (A). As it runs up the rail it lifts the upper nipper plate (Z_O), with which it is combined into a rigid unit via the short lever (H). The latter is rotatably mounted at D. The nippers are thus opened and the fiber fringe is ready for detaching. As the nippers run back (and with them roller R along fixed rail (A)), as shown in the right-hand part of the illustration, the roller runs off the rail at a set instant, and a spring (not shown) presses the upper nipper (Z_O) against the lower nipper (Z_U). The fiber fringe is compressed and ready for combing. Accordingly, while detaching is proceeding on one side (the left) of this machine, combing is being carried out simultaneously on the other side, all movements being generated in a central motion. Of course, a top comb also comes into play during the combing sequence. Each head on the left-hand side produces a sliver by piecing and collecting the tufts at its delivery. The sliver of the six heads are passed together through a common drafting arrangement to produce a single sliver which is coiled in a can. Similarly, the six slivers delivered by the heads on the right-hand side are combined into another sliver for coiling in a second can. The comber has two deliveries.

1.7. Automation in the combing section
1.7.1. Outline

Automatic lap transport is a problem that has been awaiting a solution for several years. Material has to be transported in large quantities in an unwieldy form and with high lot weights, both within the combing preparation stage and then between the preparatory machines and the combers. Although automation in combing is not a very simple matter it is already available to different degrees. These differences allow mills to choose the degree of automation according to their requirements, since – as already stated in „The Rieter Manual of Spinning – Volume 1“ – automation is not a plaything nor is it obtainable free of charge.

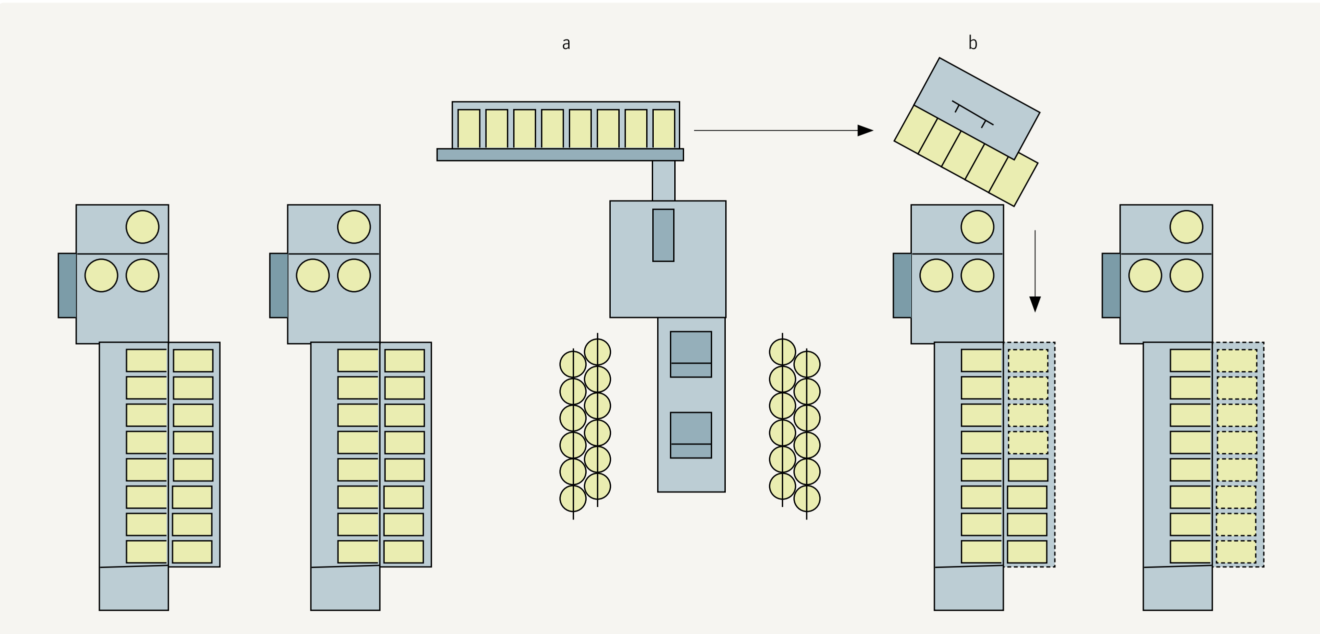


Fig. 65 – Transport scheme with semi-automated lap trolleys (4 combers are shown (2 left and two right) with the lap former in-between)

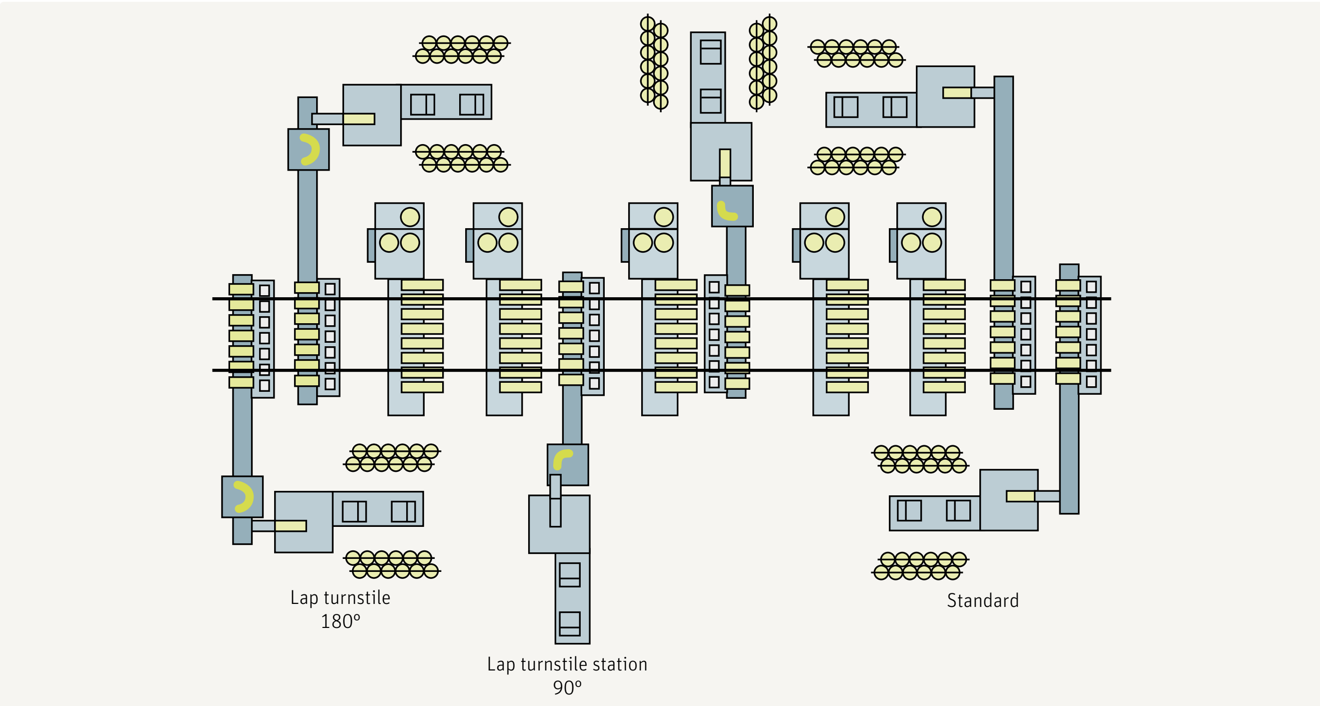


Fig. 66 – Fully automatic lap transport system, showing the lap turnstile required to present the lap end in the correct position for the combers

Investment in automation has to pay for itself. Since these installations will become increasingly important in years to come, a short description of them will be given.

In general, automation in combing can be subdivided into:
- transport automation and
- machine automation.

1.7.2. Transport automation

Transport in combing means mainly the shifting of laps from the lap former to the comber. Two automation systems are available in this case:
- semi-automatic transport and
- fully automatic transport.

The semi-automatic solution operates with lap trolleys as shown in Fig. 65. With this system trolleys are automatically loaded with laps at a filling station (a) in front of the lap former. The operator than takes the trolley (b) to the combers, where unloading is performed semi-automatically.The fully automatic system operates with an overhead transport device (Fig. 67) to carry the laps in groups of 8 at a time to the combers. An additional installation is required between lap former and combers – the lap turnstile as shown in Fig. 66 – to load the laps into the overhead carriers in the right direction (i.e. prepared for automatic piecing on the comber). The whole loading, unloading and transportation operation is performed without intervention by an operator.

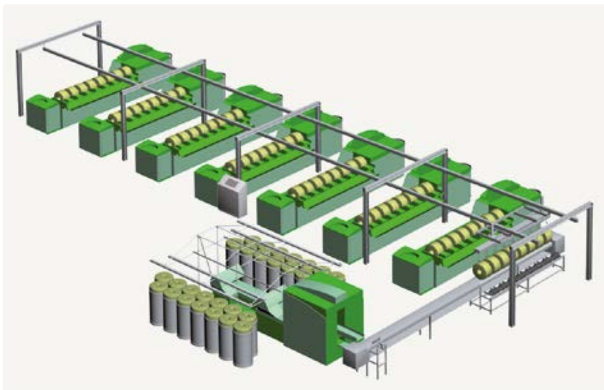


Fig. 67 – The overhead transport system

1.7.3. Machine automation (comber)

Automation of lap changing and batt piecing was an engineering challenge some 15 years ago. Rieter succeeded in solving this problem with its ROBOlap automatic lap changing and piecing device. It is illustrated below in Fig. 69, in the form of small drawings of the six operational steps.

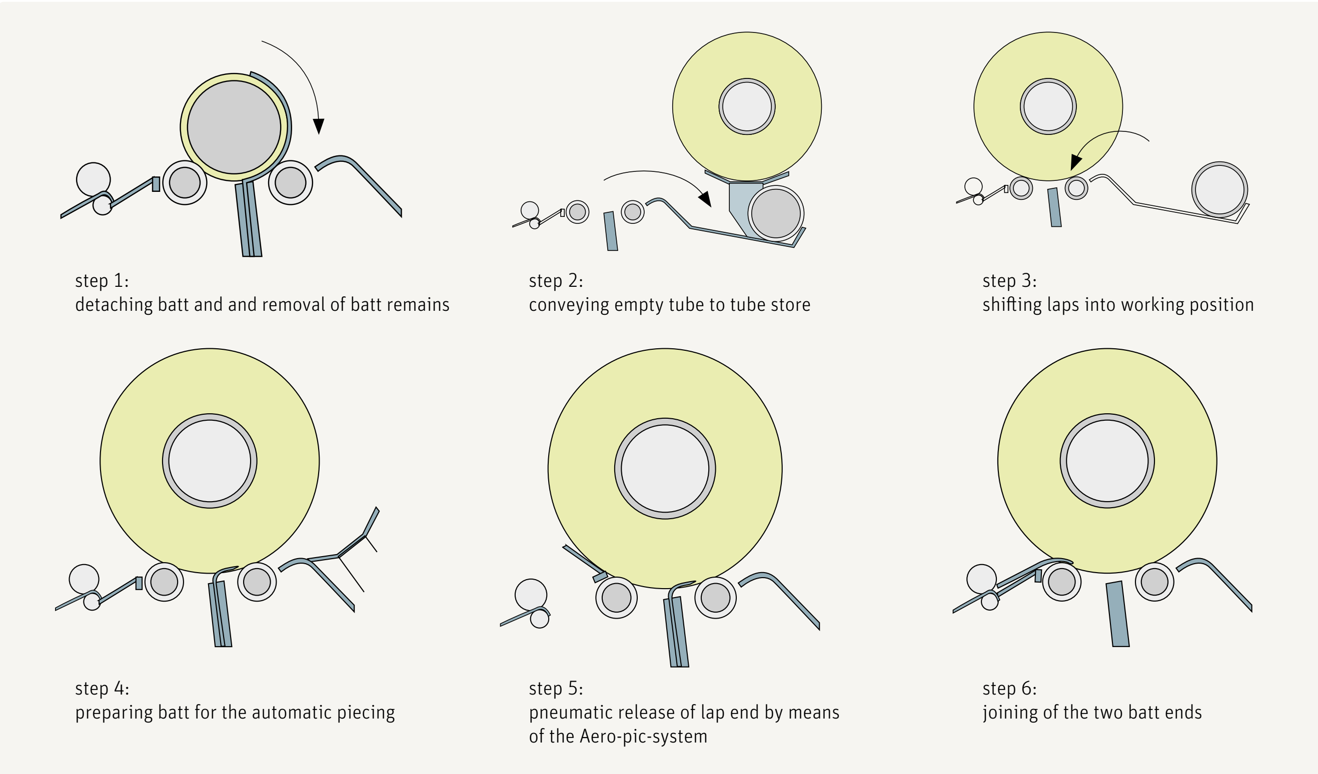


Fig. 68 – Automatic lap changing and batt piecing by the Rieter ROBOlap

1.8. Number of drawframe passages

Only one drawframe passage should be employed after combing. Two passages not only increase the cost, they also cause a deterioration in quality. Owing to the high degree of parallelization, the adherence of the fibers in the sliver is so low that false drafts can be induced, for example when the sliver is pulled out of the can behind the roving frame. However, the drawframe that performs the one remaining drafting operation should then be fitted with a short-term autoleveler.

Combers with four-fold doubling (8 combing heads, 2 delivery heads) usually require two drawframe passages after combing. This is unfavorable, not only due to the higher costs associated with it, but also because of the deterioration in quality that can result.

With the new generation of combers, i.e. eight-fold doubling (8 combing heads, 1 delivery), one drawframe passage can usually be eliminated because of the good suppression of the piecings.

1.9. Upgrading of raw material

1.9.1. New market segments due to upgrading of cotton

1.9.1.1. Definition

As we mentioned at the beginning of this volume, upgrading (semi-combing) means combing the cotton with a noil percentage of only 6 - 10 (12), i.e. below the normal combing range of 10 - 20.

1.9.1.2. Changes in demand and in the processing possibilities

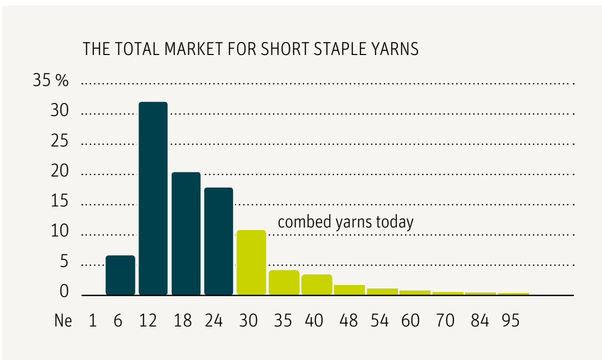


Fig. 69 – The total market for short staple yarns today

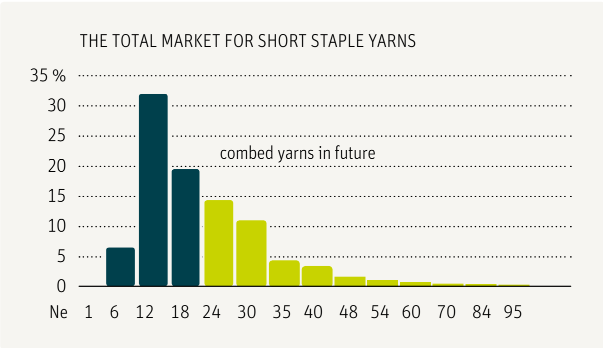


Fig. 70 – The total market for short staple yarns in future

Up to now combing has been employed for (Fig. 70):
- medium counts to improve running behavior in downstream processing and yarn quality;
- really fine counts, as the number of fibers in the cross section of these yarns is very small, and each short fiber is an interference factor here.

Combing somewhat coarser counts has not been very popular to date. It was too expensive. In the near future, however, spinning mills will be forced to give more attention to this type of combing. This is due to changes in customer markets, in the cotton market, and the availability of improved processing facilities. The latter will allow combing to penetrate into areas where the material has only been carded to date (Fig. 70).
In this respect we need to bear in mind an aspect that has already been mentioned, namely the need for more intensive utilization of our material:
- by optimized raw material employment;
- by better treatment of it on all machines;
- by reduction of waste and
- by upgrading (very important).

The main arguments in favor of upgrading are:
- increasing demands on the end product;
- increasing demands on the yarns in further processing, e.g. when working with carded yarns in knitting mills about 70 % of the processing problems can be traced back to the yarn;
- compensating for expensive raw material by improving a cheaper cotton through semi-combing.

Upgrading is all the more interesting, as the biggest improvements in quality arise when combing in the range of 8 to 10 % noil, as shown in Fig. 11.

A very interesting field of application can be rotor spinning. Compared with ring-spun yarns, rotor-spun yarns have some disadvantages in quality. Some improvements can be achieved by upgrading the raw material. For example:
- reduction of impurities in the yarn;
- better parallelization of the fibers in the yarn; and thus
- higher strength;
- smoother feel of yarn and end product.

Besides these quality parameters, operating behavior on the rotor machine also improves due to the additional extraction of trash at the comber.

1.9.2. Some preconditions

However, upgrading on a larger scale is not possible with conventional combers, as it becomes too expensive. It requires a high-performance combing section:
- productive combing preparation;
- combers with high speeds, i.e. up to 500 nips/min;
- optimal control of the combing operation itself to reduce good fiber loss (a very important factor);
- working with high feed weight (increasing productivity);
- high degree of automation.

1.9.3. Shortcomings of the combing machine

As described in the whole chapter the combing section is an insertion of mostly three machines into the normal spinning process between card and autoleveler drawframe (Fig. 71). It serves as an installation to improve yarn quality if the carded yarn does not meet requirements. Nevertheless the combing section has some negative side effects. There is no doubt that this process with three additional machines increases the cost of the yarn. A further increase in cost results from the design of the comber itself. The entire mass of the nipper arrangement has to be accelerated to maximum speed and slowed down to zero about 7.5 times a second, a process for which admirable design solutions have been found today – and which deserve considerable respect!

A continuous processing system would be a good alternative to the intermittent processing. With regard to spinning in general this is not a new method. It has been used for about two centuries in the form of circular combers, drum combers and hackle combers. Unfortunately, these systems can be used only for long fibers (such as wool and hemp), but are unsuitable for short fibers.

A system between these two is the former Saco Lowell comber dealt with in chapter 1.6: The Saco Lowell double-sided comber.

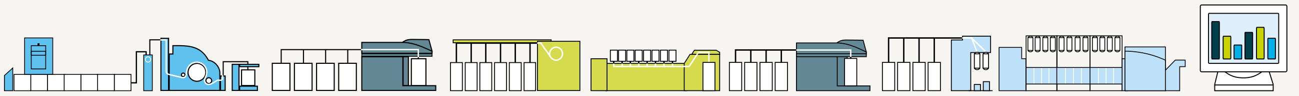


Fig. 71 – The short-staple spinning process for combed yarns

2. THE DRAWFRAME

2.1. Introduction

From a purely commercial viewpoint the drawframe is of little significance – it usually contributes less than 3 % to the production costs of the yarn. However, its influence on quality, especially yarn evenness, is all the greater for this. Furthermore, if the drawframe is not properly adjusted, yarn strength and elongation will also be affected.
There are two main reasons for the considerable influence of the drawframe on evenness. Firstly, within the sequence of machines in the short staple spinning mill, the drawframe is the definitive compensation point for eliminating errors. Inadequacies in the product leaving the drawframe not only pass into the yarn, they are actually reinforced by drafting effects following the drawframe. The yarn is never better than the drawframe sliver. Secondly, a defect arising at the drawframe itself can exert an effect of significant proportions on the overall process. High-performance drawframes currently produce over 400 kg of sliver per hour at each delivery. Very large quantities of faulty sliver will be produced in the time that elapses before discovery of the defect. It is therefore understandable that leveling drawframes are a must for every modern short staple spinning mill. It is equally clear that, of all departments in the spinning mill, the drawing section is the least suitable place for making rigorous economies. It is quite the wrong place to try to save money.

At the drawing stage for carded yarns the material rarely passes just one machine but usually two, arranged one after the other and combined to form a group. An exception is the rotor spinning mill, where often only one passage is used or even none, i.e. the sliver is fed directly from a high-performance card, but equipped with an integrated leveling device. Normally, processing in two passages is necessary to fulfill requirements. However, a second passage after the comber is superfluous, since this does not produce any improvement in quality. On the contrary, it usually adversely affects quality due to excessive parallelization of the fibers. The drawframe used in this case, however, has then to be a leveling drawframe.

2.2. The task of the drawframe

2.2.1. Equalizing

One of the main tasks of the drawframe is improving evenness over the short, medium and – especially – long term. Card slivers fed to the drawframe have a degree of unevenness that cannot be tolerated in practice, and slivers from the comber contain the „infamous" piecings; these must be obscured. It should be noted, however, that short-wave sliver evenness is not – as sometimes assumed – the sole criterion for evaluating the performance of the drawframe. It is true, for example, that unevenness over short lengths can be noticeably reduced, e.g. by very narrow setting of the rollers of the drafting arrangement, but this is often associated with deterioration in other quality parameters of the yarn, particularly strength.

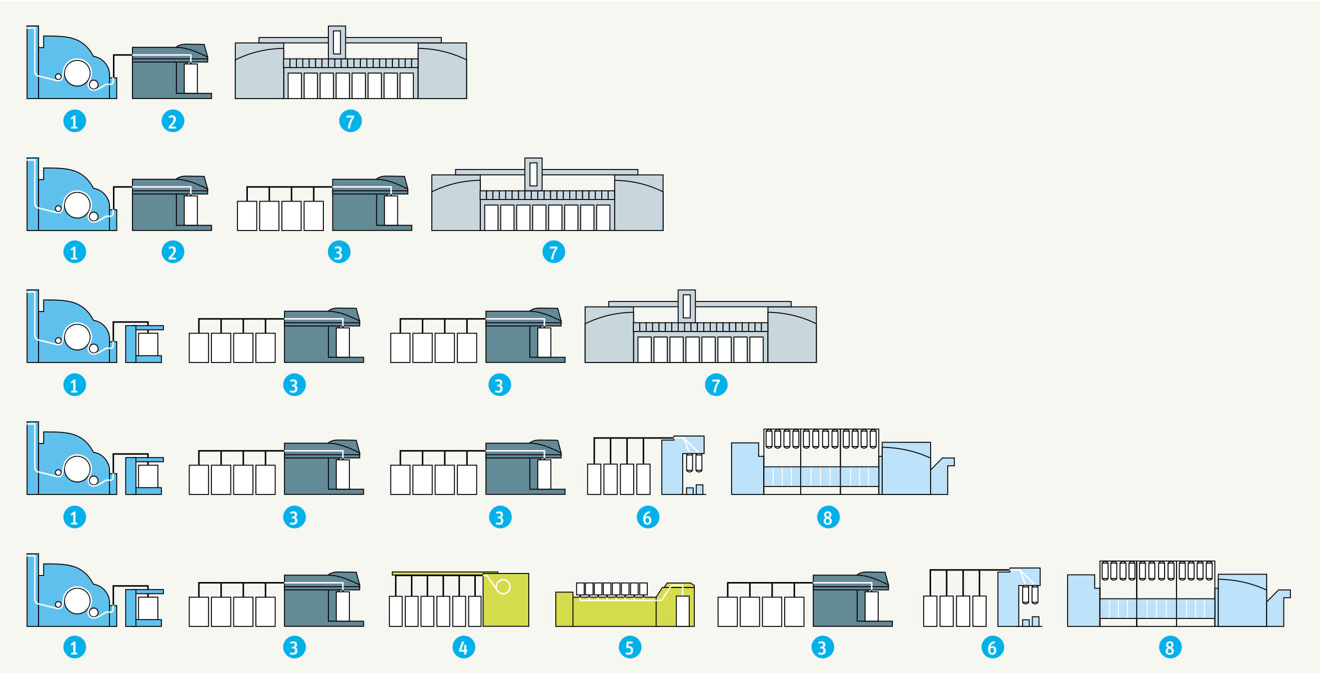


Fig. 1 – Normal processing lines
1. card; 2. drafting module for card; 3. drawframe; 4. combing preparation, 5. combing machine; 6. roving frame; 7. rotor spinning machine, 8. ring spinning machine

It is also a mistake to assume that sliver evenness – especially over short lengths – can be significantly improved by using several passages. A second passage brings hardly any improvement and a third can actually lead to deterioration. In relation to settings and number of passages, therefore, it is important to find the optimum rather than seek the maximum. Equalizing is always and in any case performed by doubling, and can optionally also be performed by additional autoleveling. The draft and the doublings often have the same value and are in the range of 6 (short fibers) to 8 (medium and long fibers). When processing pure comber noil in the rotor spinning mill, however, it is usually necessary to settle for a value of 4 or to use high-performance cards with integrated leveling devices instead of drawframes.

2.2.2. Parallelizing

To obtain an optimal value for strength in the yarn characteristics, the fibers must be arranged parallel in the fiber strand. It is mainly the drawframe's task to create this parallel arrangement. It fulfills this task by means of the draft, since every drafting step leads to straightening of the fibers. The value of the draft must be adapted to the material, i.e. to several fiber parameters, mainly:

- the staple length;
- the mass of the fibers;
- the volume of the strand;
- the degree of order (parallel disposition).

It will be clear that the draft cannot be high on a machine directly following the card (if possible, not above 8), but thereafter can increase from machine to machine.

2.2.3. Blending

In addition to the equalizing effect, doubling also provides a degree of compensation of raw material variations by blending, which occurs simultaneously. This result is exploited in particular in the production of blended yarns comprising cotton/synthetic or synthetic/synthetic blends. At the drawframe, metering of the individual components can be carried out very simply by selection of the number of slivers entering the machine. For example, to obtain a 67:33 blend, four slivers of one component and two of the other are fed to the drawframe. Of course, these slivers must have the same hank.

2.2.4. Dust removal

Dust is steadily becoming a greater problem both in processing and for the personnel involved. It is therefore important to remove dust to the greatest practical extent at every possible point within the overall process. Unfortunately, dust removal can only be carried out to a significant degree when there are high levels of fiber/fiber or fiber/metal friction, since a large proportion of these very small particles (dust) adhere relatively strongly to the fibers. Such friction arises especially on the card and the drawframe; in the latter case, mainly owing to the drafting operation. The drawframe is therefore a good dust-removing machine. On high-performance drawframes equipped with appropriate suction systems, more than 80 % of the incoming dust is extracted.

2.3. Operating principle

Four to eight card or drawframe slivers (see Fig. 2) are fed to the drafting arrangement (3). A feed roller pair (2) is located above each can (1) to enable the feeding step to

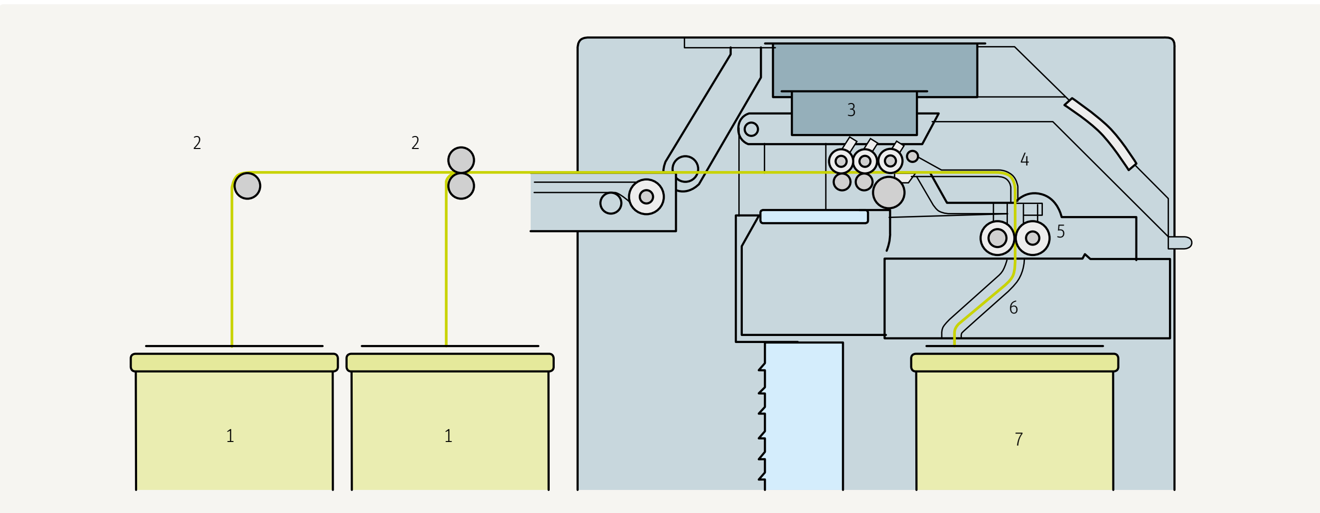


Fig. 2 – Sectional view of a drawframe

be performed in a controlled manner without false drafts. In some cases (seldom) a simple deflection bar is sufficient. The feed roller pairs are mounted in a creel frame or table and each is positively driven. The slivers running into the drafting arrangement leave it, after a draft of 4 to 8, as a web lacking significant cohesion. In order to avoid disintegration of the web, which would otherwise be unavoidable at the high operating speeds currently in use, it is condensed into a sliver immediately after the drafting arrangement. This sliver is then (for example in some makes) guided through a tube (4) via a passage (6) of the tube gear into a can (7), in which it must be laid in clean coils with optimal utilization of the space in the can. To enable the can to take up as much material as possible, the sliver is compressed by passing it through calendering rollers (or discs) or grooved discs (5).

2.4. Operating devices

2.4.1. Creel (sliver feed)

In particular, the creel must be designed so that:
- false drafts are avoided;
- the machine stops immediately when a sliver break occurs;
- sliver breaks can be dealt with easily, comfortably and safely.

For this purpose, it is necessary to provide a positively driven roller or roller pair (Fig. 2, 2) above each can, one for each sliver. Driven rollers are essential in the case of insufficient fiber adherence, e.g. combed sliver. A guiding device for feeding the slivers into the drafting arrangement is also required. A table with rollers, or simply a line of rollers, can provide the required guidance. Rollers alone are preferred in rapidly operating high-draft drawframes, since friction is lower when transport is effected by means of rolling than when it relies upon sliding. The infeed roller pairs (2) also serve as electrical contact rollers, and for monitoring the sliver. If a sliver breaks, the metal rollers come into contact when the insulating sliver is no longer present between them, and the machine is stopped. Today all drawframes have in-line sliver feed (see Fig. 3), i.e. the feed cans are arranged in one or (mostly) two rows in the direction of movement into the machine. Rieter offers a two-row arrangement in "T" form, reducing space requirements in machine length.Normally, slivers may be fed in from up to eight cans per drawing head, and the cans may have diameters up to 1 000 mm (40 inches). It is important that the slivers lie closely adjacent, but not on top of one another, as they run into the drafting arrangement.

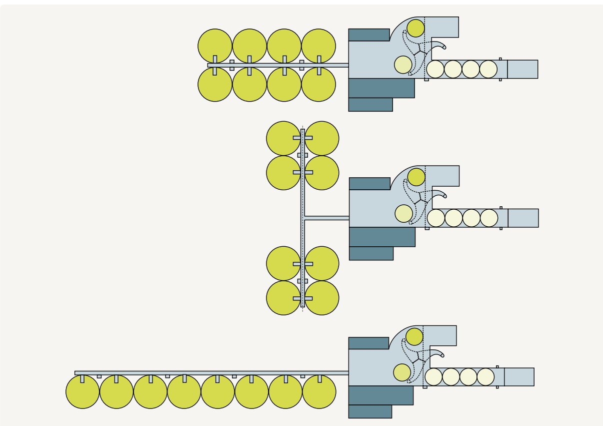


Fig. 3 – Different systems of sliver creels

2.4.2. The drafting arrangement (general considerations)

2.4.2.1. Requirements

The drafting arrangement is the heart of the drawframe and thus the part which exerts the most decisive influence on quality. The requirements placed on the drafting arrangement in general are correspondingly high:
- simple, uncomplicated construction;
- stable design with smooth running of the rollers (centricity);
- a mode of operation producing a high-quality product even at high running speeds;
- high degree of flexibility, i.e. suitability for all raw materials, fiber lengths, sliver hanks, etc., that might be processed in the short staple spinning mill;
- optimal control over the movement of the fibers during the drafting operation;
- high precision of both operation and adjustment;
- rapid and simple adjustability of roller spacings and draft levels;
- ease of maintenance and cleaning;
- optimal ergonomic design.

2.4.2.2. Influences on the draft

In all types of drafting arrangement, the factors that affect the draft are:
Factors dependent upon the fiber material:
- mass of fiber in the strand cross section;
- degree of order of the fibers (parallel disposition);
- shape of the cross section of the fiber strand;
- compactness of the fiber strand;
- adhesion between the fibers dependent upon
  - surface structure,
  - crimp,
  - spin finish,
  - compression of the strand;
- fiber length;

- evenness of distribution of fiber lengths (staple form);
- existing twist in the fiber strand.

Factors dependent upon the drafting arrangement:
- diameter of the rollers;
- hardness of the top rollers;
- pressure exerted by the top rollers;
- surface characteristics of the top rollers;
- fluting of the bottom rollers;
- type and form of fiber guiding devices, such as pressure rods, pin bars, aprons, condenser etc.;
- clamping distances (roller settings);
- level of draft;
- distribution of draft between the various drafting zones.

2.4.2.3. Elements of drafting arrangements in short staple spinning generally

(applying to all short staple spinning machines where drafting systems are used)

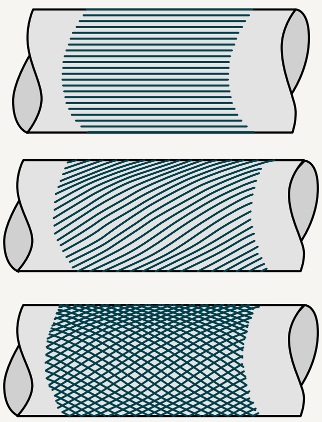


Fig. 4 – Fluting of the bottom rollers
a) axial flutes, b) inclined flutes (spiral flutes), c) knurled fluting

Bottom rollers are made of steel and are mounted in roller stands or in the frame by means of needle, roller or ball bearings. They are positively driven from the main gear transmission or by a separate drive. In order to improve their ability to carry the fibers along, they are formed with flutes of one of the following types (see Fig. 4):
- axial flutes (a),
- inclined flutes (spiral flutes) (b),
- knurled fluting (c).

Knurled fluting is used on rollers receiving aprons, to improve transfer of drive to the aprons. Other rollers have axial or, increasingly, spiral fluting. The latter gives quieter running and more even clamping of the fibers compared with axial fluting. Rolling of the top rollers on spiral flutes takes place in a more even manner and with less jerking. The diameter of the bottom rollers can lie in the range of 20 - 90 mm, but normally diameters between 25 and 50 mm are used.
A drafting arrangement includes three to six such rollers. In long machines (e.g. ring spinning machines) the bottom rollers are made up by screwing together short lengths. Distances between the rollers of the drafting arrangement are usually adjustable and can then be adapted to the fiber lengths.

Top rollers

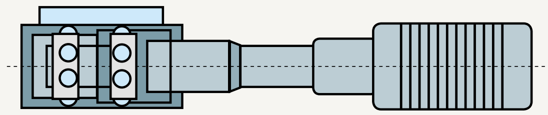


Fig. 5 – Top roller

The top rollers are not positively driven. They can be either one-piece rollers (spinning preparation machines) or twin rollers (roving frames, ring spinning machines) (see Fig. 5). Ball bearings are used almost exclusively in the roller mountings. The thick coating forming the roller surface is made of synthetic rubber. An important characteristic of this coating is its hardness. Soft coats surround the fiber strand to a greater extent than harder ones and thus guide the fibers better. On the other hand, they wear out more quickly. A soft coating is therefore used where good guidance is necessary, i.e. where few fibers have to be moved with high draft levels (e.g. at the front rollers of the ring spinning machine). Where this is not required, harder coatings are mostly used. Hardness is specified in terms of degrees Shore. The following ranges are defined:
- soft: 65° - 75° Shore
- medium: 75° - 80° Shore
- hard: above 80° Shore

Normally the diameters of top rollers are between 25 and 40 mm.

Maintenance of the top rollers
Since the coatings wear out during spinning, they must be reground from time to time. This is done periodically in accordance with a predetermined schedule, using grinding discs or rollers that remove material from the coating in very, very small layers.
If the thickness of the coating has been reduced to a defined minimum, i.e. if it has become too thin to provide adequate elasticity under pressure, then the old coat must be removed and a replacement must be glued onto the core.

Top roller pressure
To clamp the fibers, the top rollers must be forced at high pressure toward the bottom rollers. This pressure (loading) can be generated by means of:
- spring weighting (the most usual form);
- pneumatic weighting (Rieter);
- hydraulic systems (hardly used);
- magnetic weighting (was used by the former Saco Lowell company).

Nowadays only spring weighting and pneumatic weighting are used. The first is very uncomplicated, robust and easy to handle when dealing with machine faults; the second is in some cases more regular, and allows easy and quick changes of roller weighting exactly according to requirements as well as partial unloading during longer machine stoppages. It also avoids the need to adjust the weighting to a new roller diameter after roller grinding, which is sometimes necessary for spring weighted systems.

2.4.2.4. Types of drafting arrangement used on drawframes

Basic principles
Early drawframes had almost exclusively 4-over-4 roller drafting systems. The 3-over-4 roller system was developed from this earlier version, and thereafter a multitude of new forms emerged. No other machine in the spinning mill exhibits the same variety of drafting arrangements as the drawframe. Processing is carried out almost always in two drafting zones, seldom in three. In extreme cases the break drafts are between 1.05 and 2.5, but usually they are between 1.15 and 1.70. Extreme total drafts are between 3.5 and 12, but the normal total draft is between 4 and 8.
In many modern drawframes the draft is no longer adjusted by exchanging gear wheels but by simple setting of variable-speed or stepping drives or by individual motor drives. The adjustment may be continuous or in discrete steps.

Modern drawframes are more flexible in terms of the raw material they can process, and setting operations have been simplified. For example, both Rieter and Trützschler offer central roller setting systems, thus making the demanding process of setting by means of special gauges superfluous.

3-over-4 roller drafting arrangements
The characteristic feature of this arrangement is engagement of the middle pressure roller with two bottom rollers (Fig.6, B). The two bottom rollers are mounted in a common cradle and are not adjustable relative to each other. The basic concept can be improved by the inclusion of a pressure bar in the main drafting zone. This type of arrangement used to be found mainly in the combing room, but also still to a small extent on drawframes, for example in the Marzoli machines.

3-over-3 roller drafting arrangements with pressure bars
This is probably the most widely used form of drafting arrangement for drawframes. The starting point in the development of this design is the realization that the drafting arrangement runs more smoothly, the larger its rollers. This applies especially to the front rollers. The effect is due not simply to stability; for a given circumferential speed, larger rollers can be operated at lower revolutions. However, enlarging the rollers simultaneously increases the nip spacings. Accordingly, in the main drafting zone, a special guide system is needed, at least for short fibers; this is the guide rail or pressure bar (Fig. 7, P).
It can operate from below or from above.

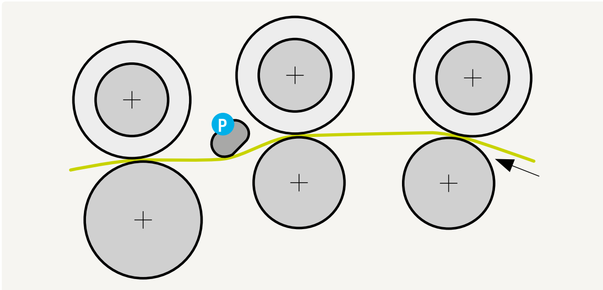


Fig. 7 – 3-over-3 roller drafting arrangement (mainly used)

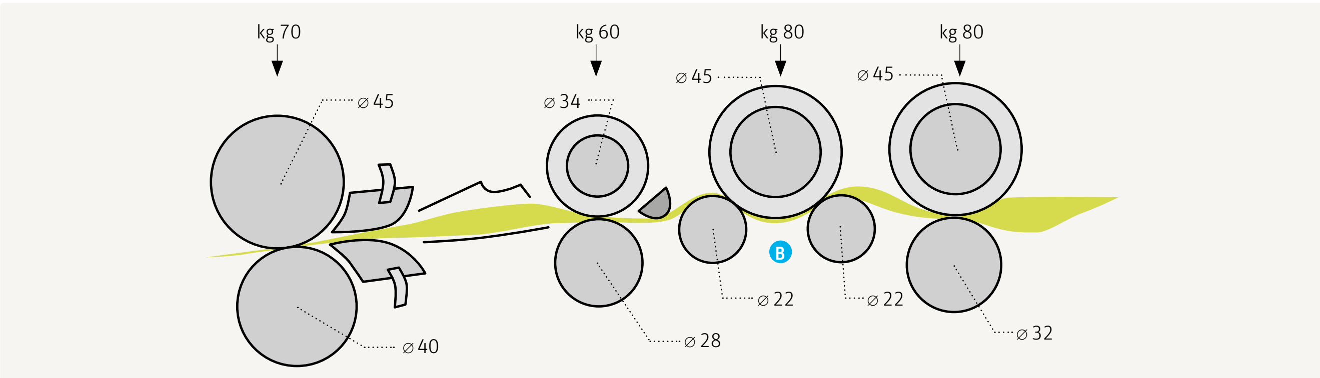


Fig. 6 – 3-over-4 roller drafting arrangement (Marzoli)

4-over-3 roller drafting arrangements with pressure bars
Strictly speaking, this is also a 3-roller pressure bar drafting arrangement, but a fourth roller with somewhat lower loading is added to the delivery roller to act as a guide (Fig. 8, G). This leads the web in a curve around the grooved roller directly into the delivery trumpet, thereby facilitating the formation of the sliver. The top rollers are uniform in diameter and are large in order to keep the strain imposed on them low.

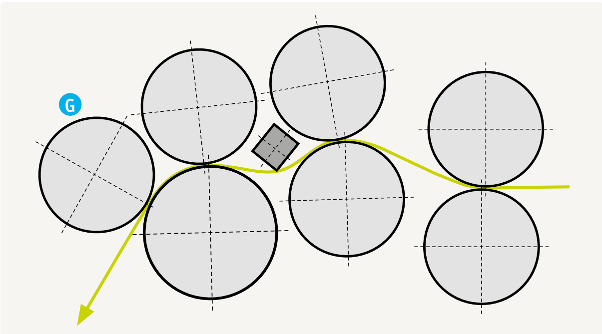


Fig. 8 – 4-over-3 cylinder drafting arrangement (formerly Zinser)

5-over-4 roller drafting arrangements
In this arrangement five (Fig. 9) pneumatically loaded pressure rollers rest on two large (90 mm) and two small (28 mm), non-adjustable bottom rollers. The pressure rollers are suspended from two yokes. They have diameters of 39 mm. Drafting is carried out in zone B (break draft) and zone A (main draft). The nip spacings can be read off the scale and can be adjusted to suit the fiber length by simple radial shifting of rollers 2 and 4. In the main drafting zone, a pressure bar ensures firm guidance, especially for short fibers. The drafting arrangement is aligned on a curve; This permitted for the first time proper guidance of web material flow from the vertical into the horizontal plane. The curved layout made the system easy to service.

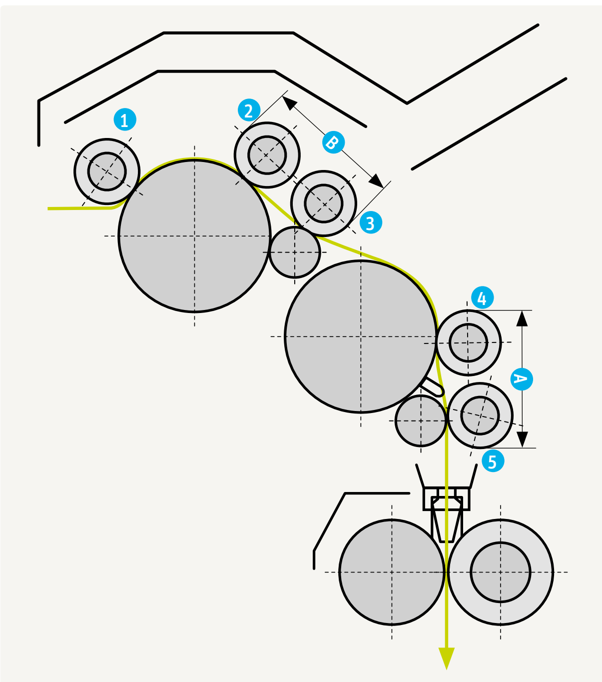


Fig. 9 – 5-over-4 roller drafting arrangement (formerly Rieter)

2.4.3. Suction systems for the drafting arrangement

One of the tasks of the drawframe is dust removal. Release of dust occurs almost exclusively in the drafting arrangement and this should be totally enclosed so that dust does not pass into the surrounding atmosphere. The dust-laden air must be extracted by suction (as shown in Fig. 10 for the Rieter machine). Each roller of the arrangement has an associated cleaning device (scraping bar and suction tube) so that fly and fibers tending to adhere to the rollers can also be carried away. In addition, on the Rieter drawframe the scraping bars are lifted from the top rollers intermittently. Trash collections therefore pass into the dust removal system. The air extracted is passed via tubes directly to filters within the machine and then into the exhaust ducts of the air-conditioning system or directly into those ducts. Filters within the machine are cleaned manually or by a wiper. This latter arrangement has the advantage not only of easier handling but also of constant suction pressure, resulting in constant cleaning efficiency.

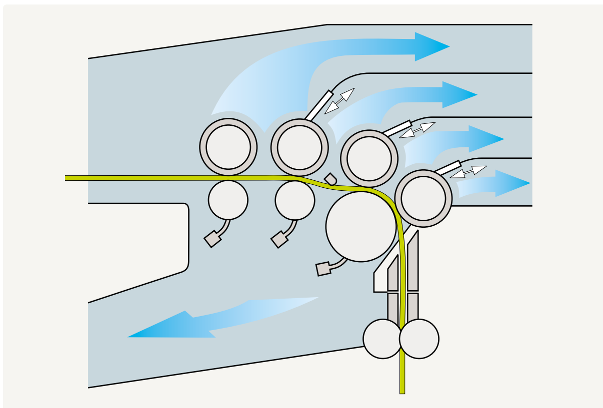


Fig. 10 – 4-over-3 drafting arrangement with suction system

2.4.4. Coiling
2.4.4.1. The delivery arrangement

To avoid disintegration of the web, it must be collected together in a converging tube immediately after the delivery roller and guided to the sliver trumpet. The design of the trumpet is very important, as it is responsible for the proper integration of the edge fibers of the fiber strand. The bore of this sliver trumpet must be adapted precisely to the sliver volume (sliver hank). These technological parts are therefore interchangeable.

2.4.4.2. Condensing

Downstream from the trumpet, the sliver runs between two calender rollers which are pressed towards each other (Fig. 9, 6). This condensing of the sliver enables more material to be fitted into the cans. Several manufacturers replace the fluted or smooth cylindrical calender rollers with grooved or stepped rollers. Since these latter rollers do not permit the fibers to escape laterally, an even better condensing effect is achieved. In this way, the total filled weight of the can may be increased by up to 20 %. Grooved or stepped rollers can be used simultaneously as measuring devices for autoleveling systems. However, this condensing action, with the greater fiber adhesion that results, must be taken into account in further processing. For example, break draft conditions are changed at the roving frame. The break draft distance might have to be increased.

2.4.4.3. Sliver coiling

As already described for the card, two rotary movements are required for cycloidal coiling of the sliver. On the one hand, the rotatable plate must be rotated above the can, while the can itself must rotate, at a considerably slower rate, below the plate. A sliver tube is provided on the plate as a fixed part to guide the sliver from the calender rollers into the can (Fig. 11). This tube extends from the center of the plate to its periphery. It is important for the coils that the circumferential velocity at the deposition point (sliver exit point) is somewhat higher than the delivery speed, so that blockages of the sliver in the tube are avoided.

However, the difference should not be too large, otherwise noticeable false drafts arise in the sliver. Due to the very high delivery speeds of modern drawframes, coiling is becoming increasingly critical. That is why the shape of the sliver tube is no longer straight, but is now curved exactly to correspond to the movement of the coiling sliver. On the Rieter drawframe a honeycomb-structured, high-grade steel sheet is also provided on the underside of the rotating plate to prevent depositions of spin finish when processing synthetic fibers.

Fig. 11 – Rieter Coiler (CLEANcoil)

Change gears are provided to permit adjustment to requirements. The plate is usually driven by toothed belts and the can turntable by gear wheels or an individual drive. The sliver may be laid in the cans in small coils (under-center coiling) or in large coils (over-center coiling) depending on the size of the cans (see The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning).
The direction of rotation may also be changed and change gears are also provided for this purpose. The plate and the can turntable were formerly made to rotate in the same direction or in opposite directions. The direction of rotation exerts an influence on the quality of the coiling operation.

The standard can format in short staple spinning was always cylindrical (Fig. 12). Some years ago Rieter introduced a new format: the rectangular CUBIcan can (see Fig. 13). Compared with the cylindrical can it has three major advantages:

- capacity is increased by about 75 %, due not only to the geometry of the can but also to the elimination of the can spring;
- it permits optimal utilization of the space available in down-stream processing (especially in rotor spinning);
- it is suitable for automation.

These advantages make the rectangular can very interesting. Drawframes for filling slivers into rectangular cans are offered by Rieter and Trützschler.

2.4.4.4. Can changers

Modern high-performance drawframes are fitted with automatic can changers. These reduce the burden on personnel, enable more machines to be allocated to one person, reduce the necessity for the operative‘s attendance at the machine, and (the chief effect) also increase efficiency. They can be classified into:

- single-step changers (flying change);
- multiple-step changers (interrupted change).

Single-step changers result in higher machine efficiency since full cans are replaced by empty ones at full speed, i.e. without stopping the machine. Multiple-step changers result in lower machine efficiency since the machine must be brought to a stop during the change. To permit long periods of operation without personnel intervention, modern drawframes are equipped with magazines for up to 8 empty cans. The full cans are ejected onto the floor or onto a can trolley.

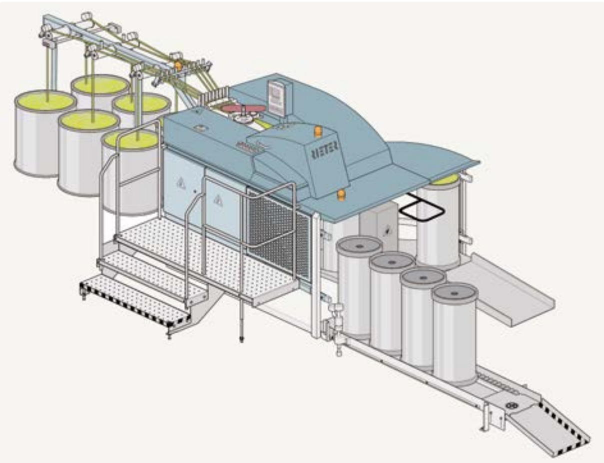


Fig. 12 – The Rieter RSB-D 40 drawframe

If feeding is performed with circular cans (the normal procedure) at the subsequent processing stages quite a lot of empty space remains between the cans. Especially on rotor spinning machines this necessitates using small diameter cans with correspondingly low feeding capacity. It is far better to use rectangular cans, which can be placed side by side in front of the machine without wasting space. That is why Rieter introduced this new type of cans as an option.

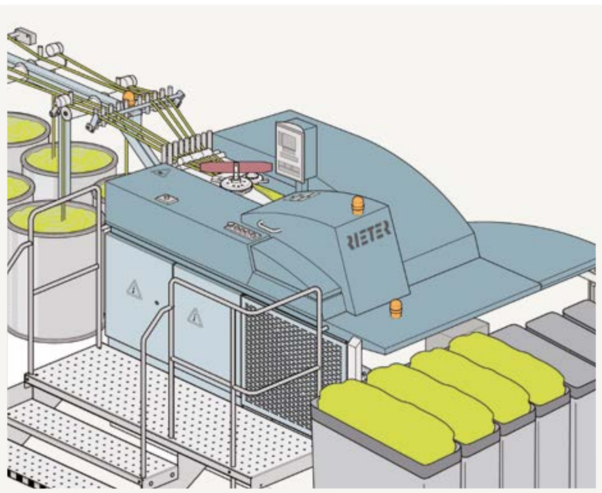


Fig. 13 – Drawframe with rectangular cans

2.4.4.5. One or two deliveries per machine

There is a worldwide trend from two deliveries to one delivery per drawframe. The single delivery has clear advantages over the double delivery drawframe:
- 10 % to 20 % higher efficiency;
- higher flexibility when integrated into spinning lines;
- well suited to automatic transport systems;
- better accessibility for operation and maintenance;
- better leveling quality;
- larger can diameters are possible (up to 1 000 mm for drawframes without autoleveling).

2.5. Monitoring and autoleveling

(For basics see The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning)

2.5.1. Aim of autoleveling

The main task of autoleveling is to eliminate deviations in mass. The efficiency of an autoleveling device used to be defined as follows: “Those machines qualify on which the reaction time is shorter than the length of the deviation to be eliminated”. This applied to the elimination of long-term deviations. In the meantime the range of application has also shifted toward short-term regulation, due to the development of servo drives operating faster and the availability of more efficient electronics. For modern autoleveling drawframes the above mentioned definition must be changed to: “Those machines qualify which allow corrections to be made as quickly as deviations appear in the incoming sliver”.

2.5.2. Classification

Monitoring systems can be distinguished according to whether they monitor
- the machine,
- the production, or
- the quality.

With machine monitoring systems, sensors are provided at all essential points to ensure that the machines are stopped immediately if a sliver breaks or runs out, if a lap forms, and so on. This is most important, since considerable damage can otherwise be caused to the machine. Production monitors respond primarily to interruptions in operation of the machine; they calculate the efficiency of the machine and the quantity produced in total and per machine. For monitors of quality, three types were formerly in use, namely those with:
- displays;
- self-compensation; and
- autoleveling.

The devices of the first group cannot replace an autoleveler, but they were valuable and very important aids to monitoring operation. Where these systems were used, the slivers delivered were continuously checked for hank consistency (and in some cases also for evenness over short lengths). If an unacceptable deviation from the set value arose, this was indicated and the machine usually stopped.

2.5.3. Monitoring devices with self-compensation
(Outdated but interesting)

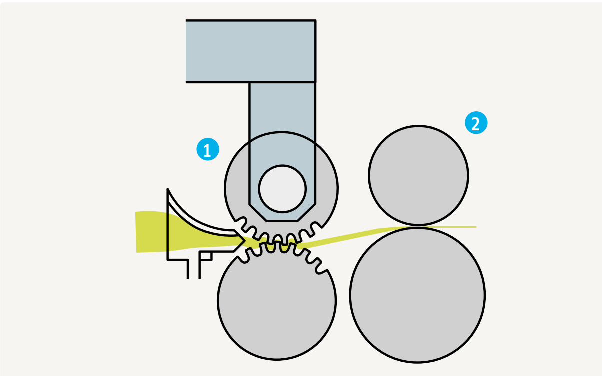


Fig. 14 – Former MECATROL by Zinser

This is a simple but interesting compensation technique. It was offered only by the Zinser company as MECATROL (Fig. 14). The so-called „toothed roller leveler" consists of a toothed roller pair (1) and a fluted/pressure roller pair (2) forming a small drafting device in front of the actual drafting arrangement. As the individual slivers pass through the assembly they press the two toothed rollers (1) apart by an amount corresponding to the sliver volume. A thin sliver permits the upper roller to penetrate more deeply into the inter-tooth spaces of the lower roller. This gives greater diversion of the fiber strand at the point where it passes through, which is equivalent to an increase in the circumference of the roller. If the rate of rotation is held constant, the result is a higher peripheral speed. Since the peripheral speed of the roller pair (2) remains constant, and while the draft is given by $V = v2/v1$, the draft is reduced between the roller pairs. A thin place is thus drawn to a lesser degree than a normal piece of sliver.

If a thick place passes through, the upper toothed roller is lifted. The sliver diversion between the teeth becomes smaller, as do the circumference and the peripheral velocity. The draft is thus increased, which produces at least a partial compensation of the thick place. The measuring and adjusting points are identical and the reaction is thus very fast. A fault in an individual sliver can be reduced to about 40-50 %. However, it is not possible to set a desired value.

2.5.4. Monitoring devices with autoleveling systems
2.5.4.1. Classification

These operate in accordance with either the open-loop or the closed-loop principle. In addition to the advantages and disadvantages of these systems listed in The Rieter Manual of Spinning – Volume 1., the following should be mentioned here:

- open-loop control can also compensate variations of short (to medium) wavelength, but
- closed-loop control can compensate only medium and long-term variations.

This implies that piecings arising from the combing operation can be partly eliminated with the aid of the open-loop system but not with the closed-loop device. That is why the closed-loop control system is unsuitable for application in short staple spinning. With closed-loop control the autoleveler drawframe can be used, if at all, only as the first drawframe passage, because a doubling operation is always needed after this process stage on a succeeding drawframe. However, the faults or the quality deterioration are not leveled out in this second drawframe passage either; they pass into the yarn. The autoleveler drawframe can only be installed as the last passage in the line with an open-loop control device. A further major influencing factor is the leveling speed. Leveling has to be performed so fast that any change in sliver weight will be corrected while still maintaining a safety reserve. This means that the correction speed of the system has to be far faster than the fastest possible change in the sliver cross section.

On the other hand, long-term stability can be improved with closed-loop systems. For this reason, and also because of the lack of self-monitoring in open-loop control, drawframes that operate with this principle can usefully be fitted with a monitoring device having a display. Leveling drawframes of this kind (open-loop control) are mostly used for the second passage, because the piecings have then already been drawn farther apart and faults arising from the first passage can also be compensated. Leveling drawframes with closed-loop control can therefore be used only in the first passage. Since both open-loop and closed-loop systems exhibit noticeable advantages and disadvantages, some time ago several manufacturers equipped their leveling drawframes with both systems in combination. Compensation is usually effected in a range of ±25 %.

2.5.5. Leveling drawframes with open-loop control

The total volume of all slivers is measured at the infeed (Fig. 15) and adjustment is effected with the appropriate time delay in the main drafting zone, i.e. the extent of the

change is retained in a storage device until the measured deviation arrives at the drafting point. Detection is usually carried out mechanically (rollers with grooves, bores or steps) or by capacitive sensors.
This system permits very precise leveling of very short lengths. A second advantage is the ability to measure far greater sliver masses due to the lower infeed speed (corresponding to the amount of draft). Recording becomes more precise. In practice, drawframe leveling using open-loop control is now predominant.

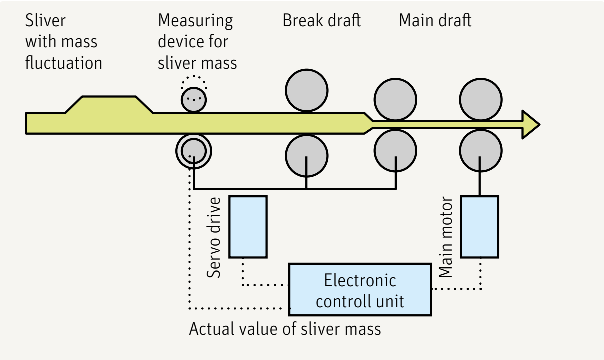


Fig. 15 – Leveling drawframe with open-loop control

2.5.6. Leveling drawframes with closed-loop control

In this system, the evenness of the sliver delivered is measured rather than the infeed sliver, as is the case with open-loop control. In contrast to the open-loop control system, where the adjusting point is located after the measuring point, the adjusting point in the closed-loop control system is located in front of the measuring point (Fig. 16). In this case measuring has to be performed at very high speeds and with relatively small fiber masses, making high demands on the sensing device and signal processing. Nevertheless, the adjustment is still made in the main drafting zone. Mechanical or pneumatic sensing devices are generally used.

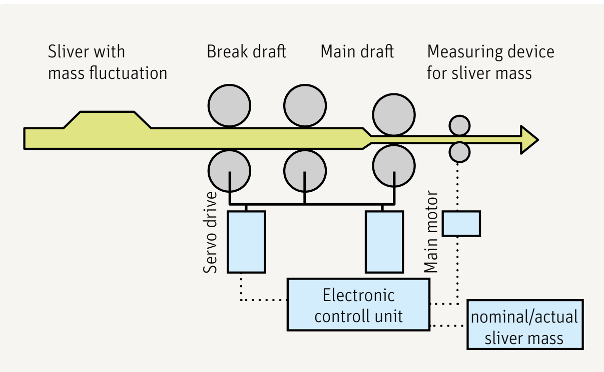


Fig. 16 – Leveling drawframe with closed-loop control

2.5.7. Correction length

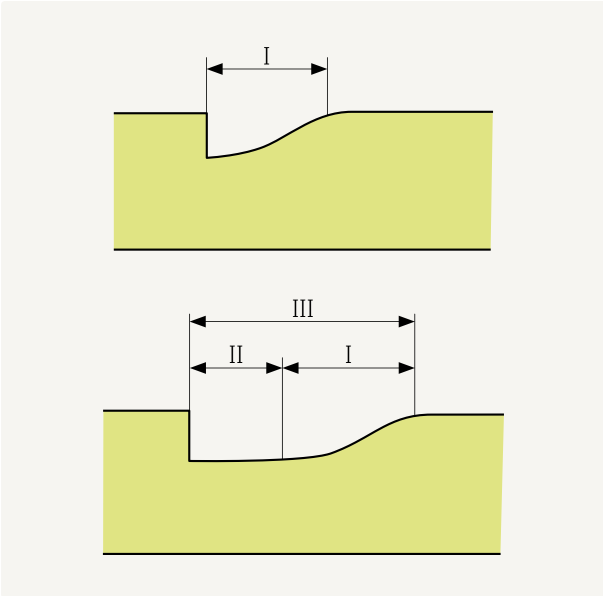


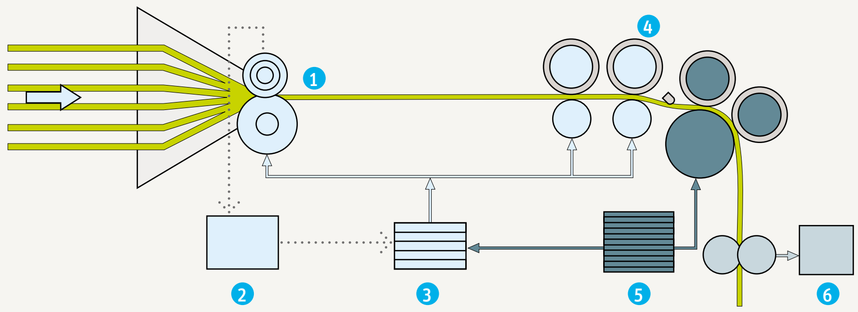
Fig. 17 – The correction length

If there is a sudden deviation from the set volume as the material passes through, a corresponding signal is sent to a regulating device to correct the fault. Owing to the mass inertia of the system, compensation cannot be effected suddenly, but must be carried out by gradual adjustment. A certain time (the correction time: in Fig. 17, I) elapses before the sliver delivered has returned to the set volume. During this time, faulty sliver is still being produced, although the deviation is being steadily reduced. The total length that departs from the set value is referred to as the correction length (I). In closed-loop systems, the correction length is further increased by the dead time. In this case it depends upon the dead time (II) and the correction time (III). The correction length depends upon the system and the speed of operation, and therefore varies considerably.

The term “correction length” is used to describe the efficiency of a leveling device. However, this term is used in different ways and sometimes also incorrectly. The current interpretation is: “The correction length is the length of the product which would be produced when leveling a rectangular deviation of the product.“ The length therefore refers to an amplitude of the fault of 1 %. The term “correction length” is therefore a theoretical value, since in practice rectangular faults do not occur. As they cannot be checked in the spinning mill, the quality of the delivered sliver is usually taken as the standard of comparison, and sliver evenness can be determined by any evenness tester.

2.5.8. The Rieter RSB leveling system

2.5.8.1. The principle



Autoleveling principle of the RSB-D 40
1. Scanning discs
2. Digital signal processor
3. AC servo drive
4. Drafting system
5. Main motor
6. Rieter Quality Monitor (RQM)

Fig. 18 – RSB leveling principle

2.5.8.2. Scanning the mass of infeed slivers

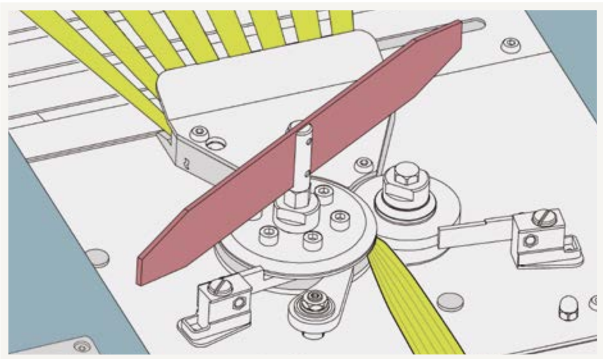


Fig. 19 – The scanning system

Scanning of mass deviation is performed by the grooved scanning disc and the associated pressure disc (Fig. 18, 1; Fig. 19). The signals are scanned at short, constant intervals, giving very exact values of the mass deviations of the infeed slivers. Determination of mass deviation by the pair of rotating scanning discs of the Rieter RSB scanning system is almost frictionless, thereby enabling the sensor device to employ high working forces, and thus to scan slivers with different bulk very accurately. This is especially advantageous if the individual cans (6 to 8) of infeed sliver are stored for different lengths of time before use. In this case the volume ratio of slivers often differs quite characteristically from can to can.

2.5.8.3. The leveling process

Using the metered signals, the leveling processor calculates a value of rotation – on the basis of a special logarithm – for the servo drive. This value is forwarded to the drafting system drive exactly when the scanned sliver piece arrives at the drafting point in the main draft zone. The synchronization of the mechanical parts, the drive, the electronics and the software is therefore very decisive. High-performance drawframes with the appropriate devices and corresponding synchronization deliver a sliver with outstanding short-term, medium-term and long-term evenness.

2.5.8.4. The leveling operation itself

Leveling is performed exclusively by adjustment of the draft. Theoretically, there are two possibilities for such adjustment, namely via the break draft and the main draft, respectively. However, the main draft is always used because it is larger, and therefore finer adjustments are possible. Furthermore, use of the break draft would run the risk of entering the stick/slip zone.
Draft variation can also be carried out by adjusting either the infeed or the delivery speed. Adjustment of the infeed speed is generally used, since lower masses then have to be accelerated and decelerated at lower speeds. Furthermore, the delivery speed, and hence the production rate, remains constant.

2.5.8.5. The advantages of high-performance leveling drawframes

In the spinning mill:
- reducing count variations;
- fewer short-term mass variations in the yarn (CV %);
- improving the coefficient of variation of yarn strength (CV % cN/tex);
- fewer yarn imperfections (IPI and Classimat);
- improving the efficiency of roving frame and spinning machine by reducing the ends down rates;
- fewer cuts on the winding machine.

In the subsequent process stages:
- reduction of ends down rates in weaving preparation and weaving;
- even appearance of the finished cloth;
- reducing the cost for claims by eliminating a remarkable number of faults.

2.5.9. The integrated monitoring system (process control techniques)

(See also The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning)

2.5.9.1. "Integrated monitoring" – essential in spinning

If the goal is efficient operation over time, it is necessary to include monitoring equipment in the overall analysis in addition to automating the activities of attendants and transport personnel. Until a few years ago, such considerations were limited to small-scale, detailed solutions on individual machines. Now, however, integrated systems covering the complete process are almost essential for spinning mills in order to utilize the above-mentioned advantages.

2.5.9.2. The method of operation

The integrated monitoring device operates completely independently of the leveling system. The position of the sensor is between the drafting arrangement and the upper can plate. It is therefore clear that faults still emerging at this can plate and thereafter are not detected. In sensor technology a distinction has to be made between systems at the delivery roller (Rieter) and at the sliver trumpet (Trützschler, Zellweger). When preset limits are exceeded the machine stops.

2.5.9.3. A quality monitoring system

(Described by means of the Rieter Quality Monitoring system (RQM))

This continuously controls the sliver mass by means of movable delivery rollers. A precision sensor unit delivers values of the highest accuracy and therefore reliability, thus preventing the production of faulty slivers. The important quality parameters are shown on a monitor, which is part of the system. These are:
- sliver count;
- sliver evenness CV %;
- length variations for 5 cm,10 cm, 25 cm, 50 cm, 1 m, 3 m, 5 m;
- detection of thick places ≥ 2cm;
- current spectrogram;
- advanced diagram displays, e.g. up to a timeframe of more than 10 days.

For example, if the spectrogram shows an error at a certain length, possible reasons for this error in the gearing diagram can be shown on the display.
The RQM can be connected to all Rieter machines and to the SPIDERweb overall monitoring system for further analysis.

2.6. Blending drawframes

In the spinning process every doubling produces simultaneous blending – especially the 6-8 doublings on the drawframe. This blending intensity is adequate for processing cotton. However, if cotton and synthetics are to be processed together, operation of the normal drawframe will no longer

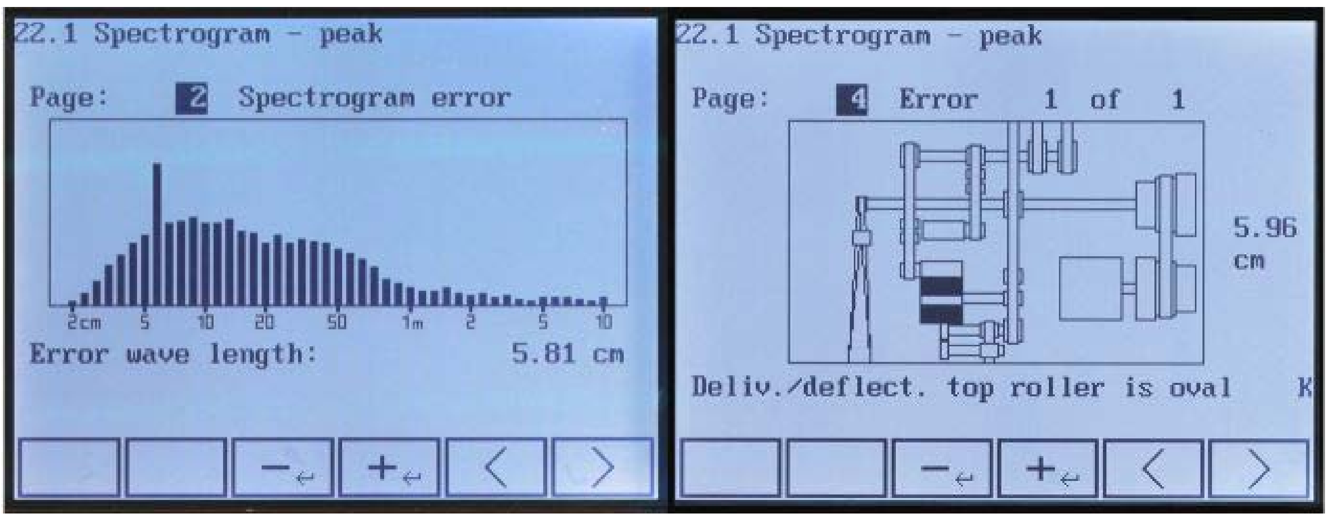


Fig. 20 – The Rieter Quality Monitor (RQM) with indication panel

be optimal, although blending is generally carried out in this way in Europe. Blending is good in the longitudinal direction, but is inadequate in the cross-section (see The Rieter Manual of Spinning, Volume 1 – Technology of Short-staple Spinning). Special blending drawframes have been available for a long time in worsted spinning and it is therefore not surprising that attempts were made to introduce them into short-staple spinning mills.

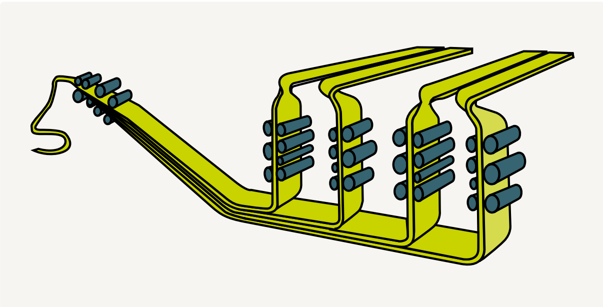


Fig. 21 – Principle of the blending drawframe

This machine (no longer offered for cotton) (see Fig. 21) had four preliminary drafting arrangements and one downstream drafting arrangement.
Each preliminary drafting arrangement processed a separate set of six slivers. The webs produced in this way were brought together on a table and fed to the downstream drafting arrangement. The sliver emerging from this point was coiled in cans.

Whereas three passages are almost always needed with normal drawframes (blending drawframe and two subsequent drawframes), two passages suffice when a blending drawframe is used (one normal drawframe followed by one blending drawframe). In addition to this advantage, and improved intermixing, a further favorable aspect should be mentioned, namely that each raw material component can be processed in a drafting arrangement of its own. However, the disadvantages are serious:

- five drafting arrangements combined in one machine (setting, maintenance, etc);
- complexity;
- cost when 100 % cotton is to be processed (when blended yarns are not required).

2.7. Logistics

If arranged for individual cans, an automatic can changer and a trolley loading station are provided. However, the first passage can also be equipped with an interlinking system between the first and second drawframe passage, i.e. not only can changing but also placing the full cans of this passage alongside the feed table of the second passage and replacing empty cans by full ones there is performed automatically. With this device (CANlink, Fig. 22) the cans are filled and pushed alongside the feed table of the second passage one by one, forming a spare row. After the feed cans of the second passage run empty, the full spare cans are pushed into the feed

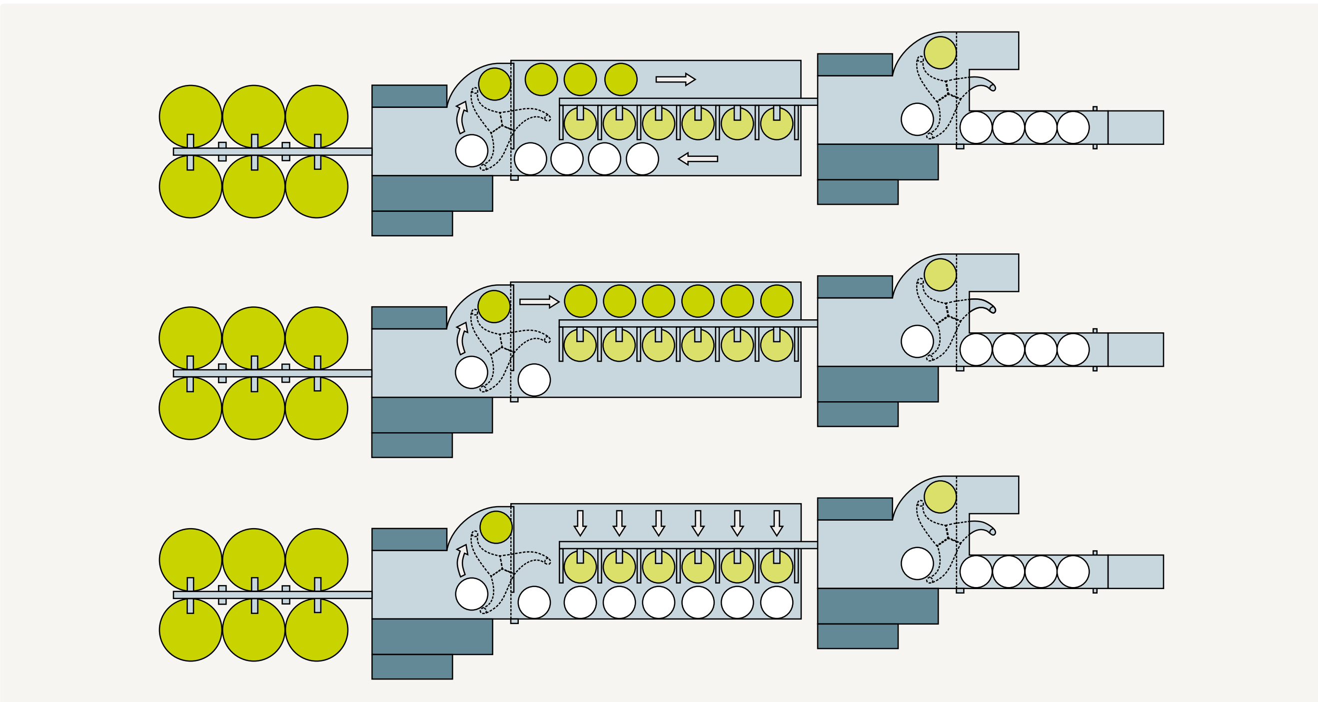


Fig. 22 – Rieter CANlink

position (in place of the empty ones) while the empty cans are simultaneous pushed out of the feed position into an empty feed row. From here the cans return to the can changer of the first passage. Operatives' work is reduced to a minimum.

At the final passage the cans from the can changer are automatically placed on trolleys to be forwarded to the next machine.

2.8. Technical data of a high-performance drawframe

Delivery speed [m/min]	up to 1 100
Production per delivery [kg/h]	up to 400
Deliveries per machine	1 or 2
Doublings	4 to 8
Draft	up to 12
Delivery hank [ktex]	1.25 to 7
Waste [%]	0.1 to 1

3. THE ROVING FRAME

3.1. Introduction

3.1.1. The roving frame as a necessary evil

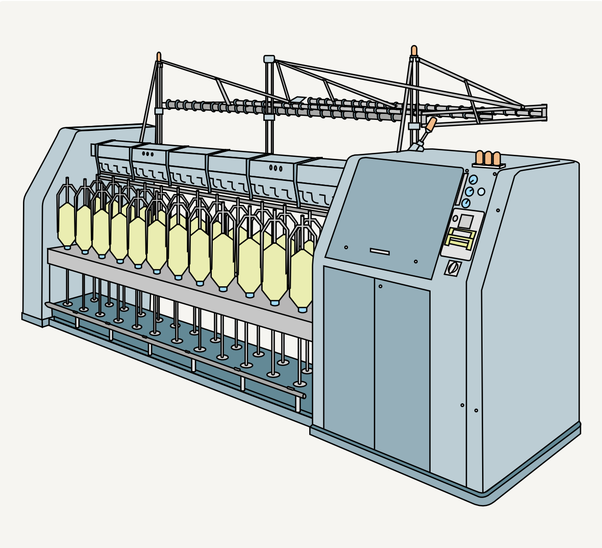


Fig. 1 – View of a roving frame

The drawframe produces a sliver that already exhibits all the characteristics required for the creation of a yarn, namely an ordered, clean strand of fibers laying parallel to one another. It is a fair question to ask why this sliver is not used as infeed material for the ring spinning machine, instead of being processed in an expensive manner to create a roving as feed material for spinning. The roving machine itself is complicated, liable to faults, causes defects, adds to production costs and delivers a product that is sensitive in both winding and unwinding. Use of the machine is forced upon the spinner as a necessary evil for two principal reasons.

The first reason is related to the required draft. Sliver is a thick, untwisted strand that tends to be hairy and to create fly. The draft needed to convert this to a yarn is in the region of 300 - 500. The drafting arrangements of ring spinning machines, in their current forms, are not capable of processing this strand in a single drafting operation to create a yarn of short-staple fibers that meets all the normal demands on such yarns. The fine, twisted roving is significantly better suited to this purpose.

The second reason is that drawframe cans represent the worst conceivable mode of transport and presentation of feed material to the ring spinning frame. In spite of this, considerable effort has been expended over decades to eliminate the roving frame. The effort is justified, but unfortunately in relation to ring spinning it remains without success. On the other hand, in all new spinning processes in the short staple spinning mill, the roving frame has been made superfluous.

3.1.2. Demands placed upon the modern roving frame

If the spinner is forced to use such an inadequate machine, which is in principle superfluous, then it should at least provide the optimum in operating capacity. Even in this respect, however, the roving frame still leaves room for improvement. The efforts of machine manufacturers should be directed toward the following aspects:

- design of simpler machines, less liable to faults;
- increase in spindle rotation speeds;
- larger packages;
- automation of the machine and of package transport.

These improvements must be achieved without any increase in production costs for the spinner.

3.1.3. Tasks of the roving frame

The chief task of the roving frame is the attenuation of the sliver. Since the resulting fine strand has scarcely any coherence, protective twist must be inserted in order to hold it together. The third task cannot be directly attributed to spinning: it lies in winding the roving into a package that can be transported, stored and donned on the ring spinning machine. It is the winding operation above all that makes the roving frame a relatively complex and problem-plagued machine. This winding operation requires, in addition to spindle and flyer, a cone drive (or variable transmission), a differential gear and a package build motion.

3.2. Description of functions

3.2.1. Operating sequence

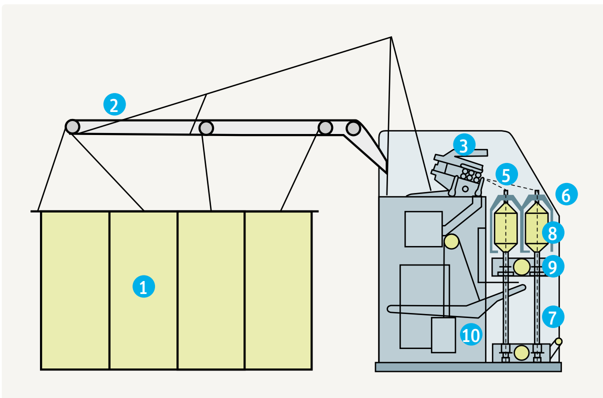


Fig. 2 – Cross-section through a roving frame

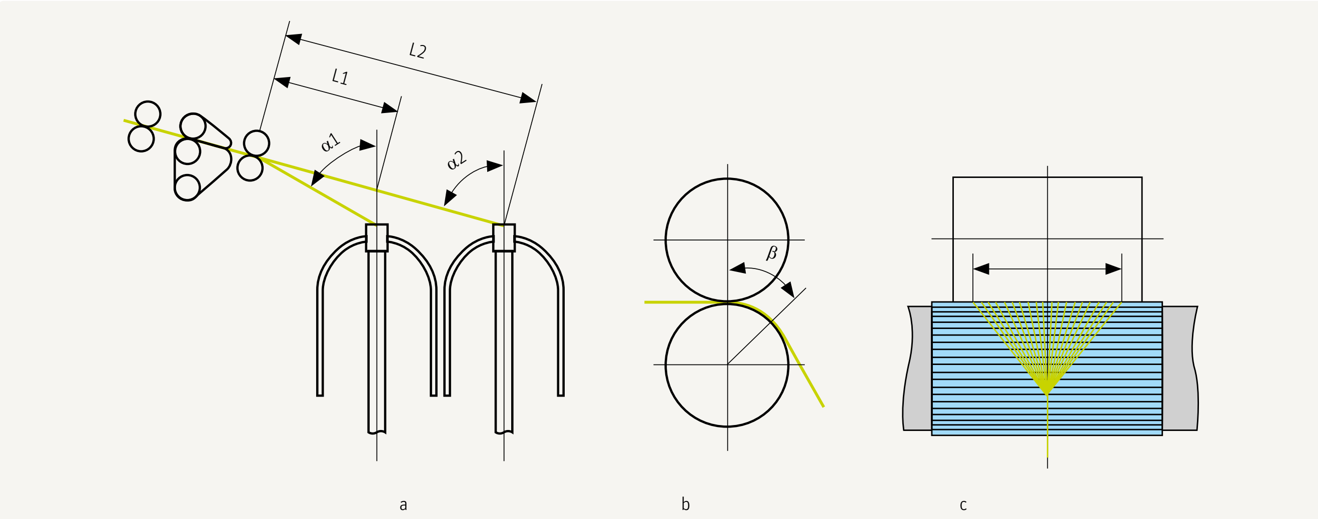


Fig. 3 – Thread path geometry at the delivery and flyer top

Drawframe sliver is presented to the roving frame in large cans (Fig. 2, 1). The can diameter does not correspond to the spindle gauge, so the cans are not arranged in one row but in several, which have to be set out behind the machine. Driven transport rollers (2) are provided above the cans. These draw the slivers from the cans and forward them to drafting arrangement (3). The drafting arrangement attenuates the slivers with a draft of between 5 and 20. The strand delivered is too thin to hold itself together and a strength-imparting step is necessary immediately at the exit of the drafting arrangement. This is performed by inserting protective twist, usually in the range of 25 - 70 turns per meter. The turns are created by rotating flyer (6) and are transmitted into the unsupported length of roving (5) between the flyer and the delivery from the drafting arrangement. The flyer itself forms part of driven spindle (7) and is rotated with the spindle.
To ensure that the roving is passed safely and without damage to the wind-up point, it runs through the flyer top and the hollow flyer leg, and is wound 2 - 3 times around the presser arm before reaching bobbin (8). To enable winding to be performed, the bobbin is driven at a higher peripheral speed than the flyer so that the roving is drawn off the flyer leg. The coils must be arranged very closely and parallel to one another so that as much material as possible is taken up in the package. For this purpose, bobbin rail (9) with the packages on it must move up and down continuously. This can be effected, for example, by continual raising and lowering of lever (10), on which the bobbin rail is mounted.

Since the diameter of the packages increases with each layer wound, with a corresponding increase in the length of roving wound per coil, the speed of movement of the bobbin rail must be reduced by a small amount after each completed layer. Similarly, owing to the increase in package diameter, the bobbin‘s rotation speed must be reduced after each layer, because delivery is constant and hence the difference between the peripheral speeds of the package and the flyer must also be kept constant throughout the winding operation. Only in this way can a controlled winding operation be achieved.

3.2.2. Effects of the arrangement of the bobbins in two rows

The arrangement of the take-up packages is rather unusual for a spinning machine. The bobbins are not arranged individually or in a single row. Instead, they are arranged in the delivery section in two rows one behind the other, with the bobbins of one row offset relative to those of the other. This arrangement is extremely economical in terms of space, but has several disadvantages: the design is made more complicated; operation of the machine is made less convenient; and automation is hindered. The technological disadvantages are still more significant.

The angle of approach of the roving to the flyer top is different for the two rows (Fig. 3, α). This results in different rolling conditions at the entry point of the roving to the flyer top. There is also a difference in the angles of withdrawal (β) of the two rovings at the front cylinder and thus in the lengths of the spinning triangles. Another effect is produced by the difference in the unsupported lengths (L), i.e. the lengths between the drafting arrangement and the flyer top (L1 + L2).
Together, these differences result in uneven take-up of twist, different degrees of integration of the fibers and finally to variations in roving fineness between the front and rear rows. Modern roving frames no longer suffer this technological disadvantage. In fact, the flyers in the rear row are equipped with an extension, which eliminates the above-mentioned differences in angles (Fig. 4).

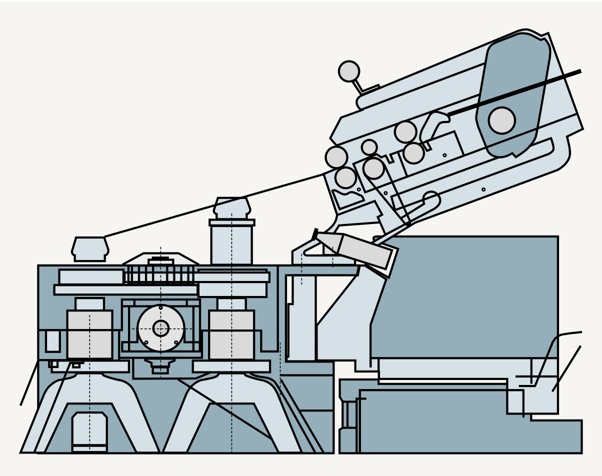


Fig. 4 – Thread path in modern roving frames

3.3. The operating zones of the roving frame
3.3.1. The creel

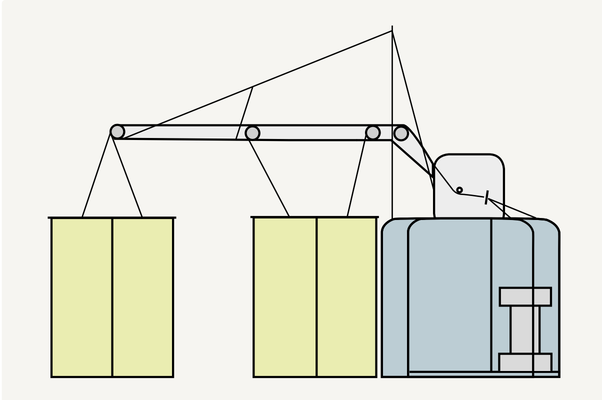


Fig. 5 – Creel framework

Above the cans there are several rows of driven rollers to help the slivers on their way to the drafting arrangement, which is often a considerable distance from the cans. On account of the high degree of parallelization of the fibers in the slivers (especially in the case of combed sliver), strand coherence is often not very great. Accordingly, transport at this place can easily create false drafts. Mills should take account of this source of possible faults. Care must be taken to ensure that the slivers are passed to the drafting arrangement without disturbance; that they are drawn, for example, more or less vertically out of the cans; and that the guide rollers run smoothly. Perfect drive to the rollers is correspondingly important. It is usually effected by chains, gear transmissions or cardan shafts.

3.3.2. The drafting arrangement
3.3.2.1. Description

Of the various high-draft systems that have been proposed, some of which were only in use for a short period, only the 3-over-4 cylinder system and the double-apron arrangement are still to be found in modern machines offered by manufacturers. The 3-over-4 arrangement is found relatively rarely, while the double-apron system is standard. Only the double-apron arrangement permits drafts of 20 while holding the fibers more or less under control during their movements. In general, three-cylinder arrangements are used, but four cylinders may be needed for high drafts. They usually comprise fluted lower rollers and rubber-coated pressure rollers. The hardness of the upper rollers

is between 80° and 85° Shore, but the rollers over which the apron runs often have a hardness only slightly above 60° Shore. This permits better enclosure and guidance of the fiber strand during drafting. The draft often has limits not only at the upper end (20 - 22) but also at the lower end, namely to about 5 for cotton and 6 for synthetic fibers. If drafts below these lower limits are attempted, the fiber masses to be moved are too large, drafting resistance becomes too high and the drafting operation is difficult to control.
Break drafts are usually selected around 1.1 (1.05 to 1.15) for cotton, and slightly higher for synthetics and strongly compressed cotton sliver delivered from high-performance drawframes. Values of 1.3 and slightly higher can be achieved. The main effect of the break draft is seen in roving evenness.

Modern double-apron systems exist in 3- or 4-cylinder versions. The 4-cylinder version is usually operated with a low draft in the final drafting zone. This may slightly reduce roving hairiness.

3.3.2.2. The aprons

The upper aprons (Fig. 7, 2) are short and made either of leather or, more commonly, of synthetic rubber. They are about 1 mm thick and are held taut by tensioning devices (4). In contrast, the lower aprons (1) are longer and usually made of leather, although synthetic rubber is also used. They run over guide bars (nose bars) (3) to positions close to the nip line of the delivery rollers. Leather aprons are usually about 1 mm thick. The aprons cooperate with each other to guide and transport the fibers during drafting and they exert a very significant influence on the drafting operation. It is important that the aprons should extend as closely as possible to the nip line of the front rollers. The guiding length, referred to as the cradle length (a), must be adapted approximately to the staple length. In accordance with data provided by Rieter, the following cradle lengths should be used:

Cradle length (mm)	Material
short	Cotton up to 1 1/8″; 40 mm synthetic fibers
medium	Cotton above 1 1/8″; 50 mm synthetic fibers
long	Synthetic fibers, 60 mm

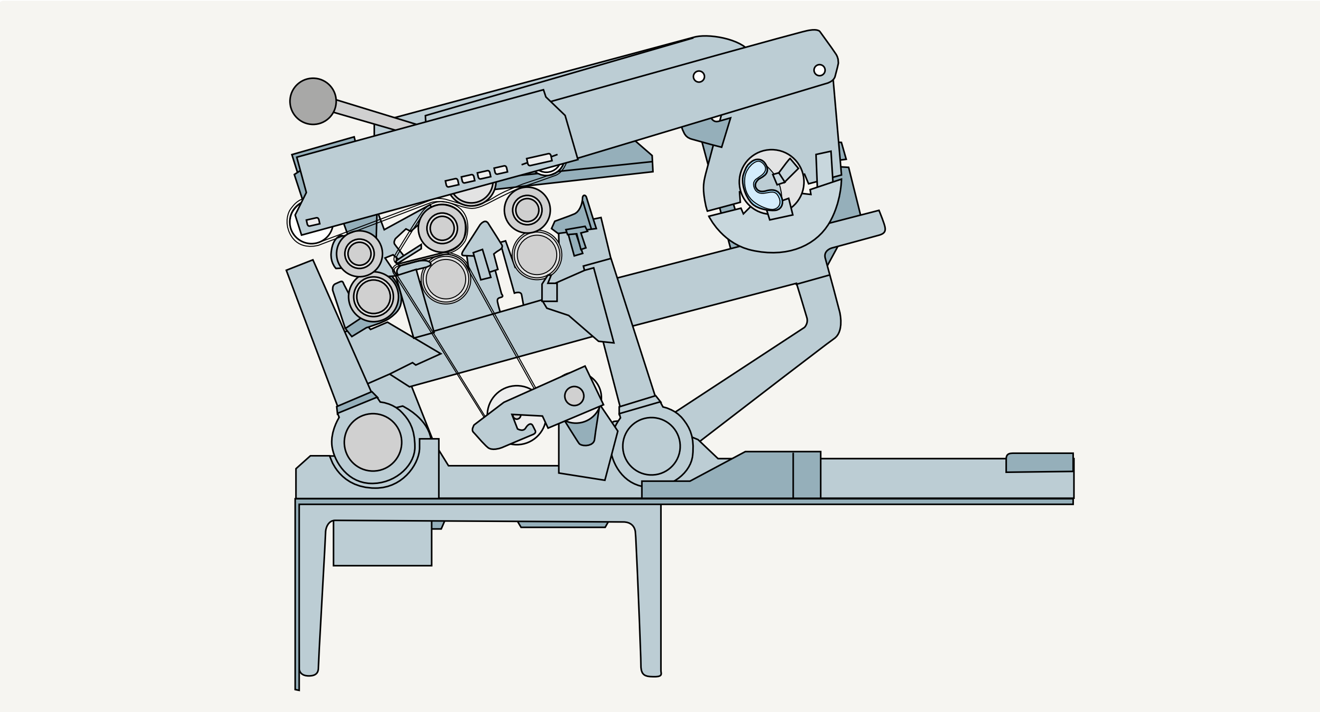


Fig. 6 – Three-cylinder, double-apron drafting arrangement

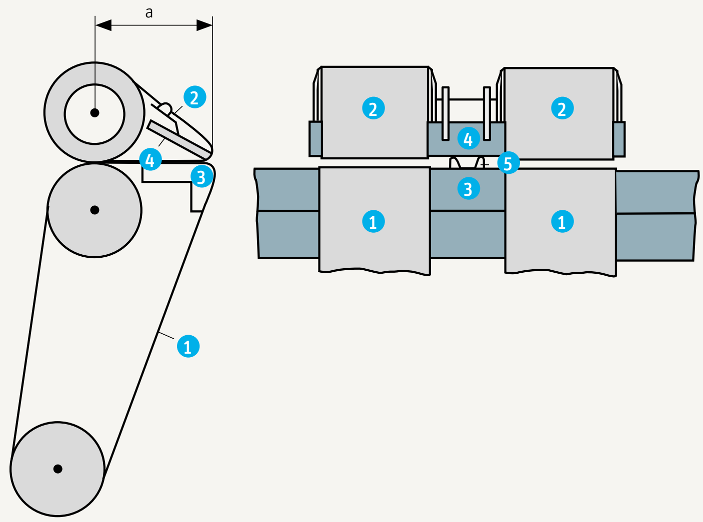


Fig. 7 – Apron guidance in the drafting arrangement

3.3.2.3. Applying pressure to the top rollers

The top rollers must be pressed with relatively high force against the lower rollers to ensure guidance of the fibers. Pressures are in the range of 100 to 250 N (300 N) per roller (shaft) and they depend upon raw material and volume. Adjustment may be continuous or in several steps. Today, the required pressure is achieved by springs or by pneumatic means (i.e. Texparts PK 5000). In the past, Platt Saco Lowell also offered a magnetic weighting system.

3.3.2.4. The condenser

Sliver trumpets (infeed condensers) are mounted on a reciprocating bar (sliver traverse mechanism) behind the rear cylinder of the drafting arrangement. They are designed to guide the sliver into the drafting arrangement. The traverse motion spreads wear evenly over the whole width of the roller coatings.
A second sliver condenser is provided in the break draft zone, also on a reciprocating bar, and a third is located in the main drafting zone. However, the latter rests on the moving fiber strand, without being fixed. The purpose of these condensers is to control the width of the fiber strand, since during drafting it continually tends to spread out. Spreading fiber masses are more difficult to maintain under control in drafting, and they cause unevenness. In addition, a widely spreading strand leaving the drafting arrangement results in high fly levels and hairiness in the roving, since the fibers either are not integrated (and are lost), or are held only at one end so that the second end projects as a so-called „hair“. The condensers should be adapted precisely to the volume of the fiber sliver. The appropriate dimensions can be found in tables.

3.3.2.5. Spacing the top and bottom aprons

The top aprons are forced by spring pressure against the lower aprons. The intensity of fiber clamping, and thus fiber guidance, depends upon this pressure and also upon the distance between the two aprons. The pressing effect should be considerable, but not too high, otherwise it is impossible to achieve controlled drawing of fibers out of the clamped strand. The arrangement must also permit precise adaptation of the minimum distance to the fiber volume. In order to be able to maintain this closely defined minimum distance between the aprons, „distance pieces“ (Fig. 8, a) of variable height are interchangeably inserted between the nose bar of the lower apron and the cradle edge of the top apron, i.e. at exit opening M.

These distance pieces are given various names, such as spacers (Rieter), distance clips (Texparts), cradle spacers (Suessen). The correct distance piece to use can be determined within a broad range from tables provided by the manufacturers, but fine settings have to be established by experiment.

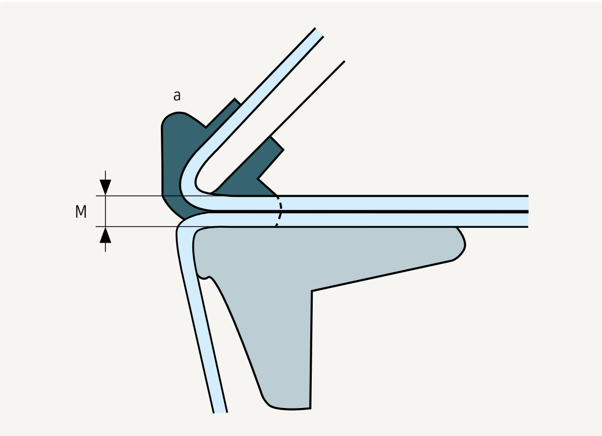


Fig. 8 – Exit opening M.

3.3.3. Spindle and flyer

3.3.3.1. Imparting twist

The flyer inserts twist. Each flyer rotation creates one turn in the roving. In the final analysis therefore, since the flyer rotation speed is kept constant, twist per unit length of roving depends upon the delivery speed, and can be influenced accordingly. High levels of roving twist represent production losses and might lead to draft problems in the ring spinning machine. On the other hand, low twist levels can cause false drafts or even roving breaks during bobbin winding. Normal twist levels are shown in the following diagram (as provided by Rieter).

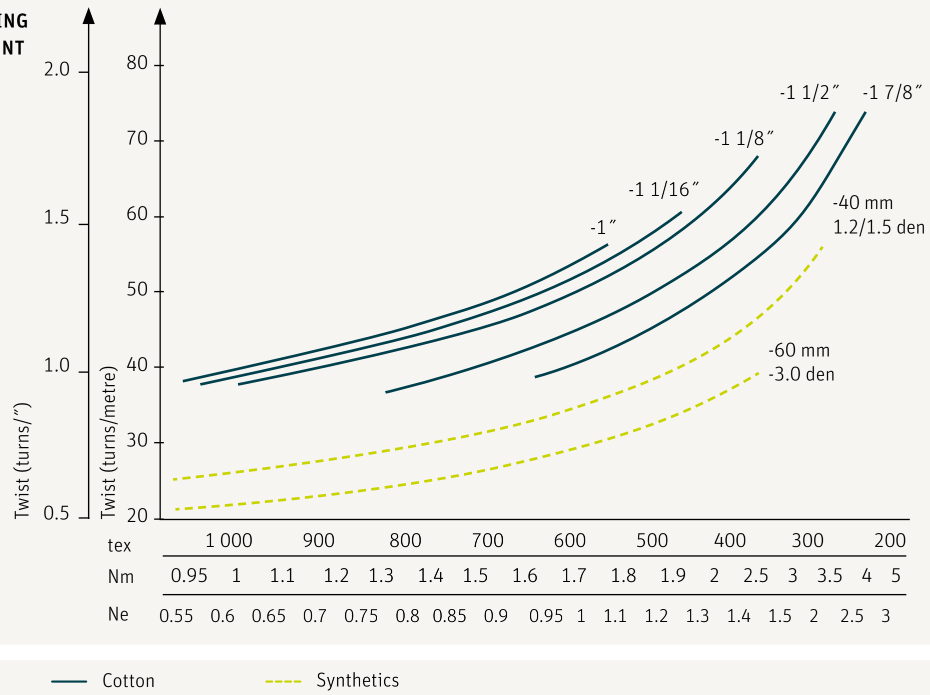
$$\textit{Turns per meter} = \frac{\textit{flyer rotation speed (rpm)}}{\textit{delivery speed (m/min)}}$$

3.3.3.2. Various designs of flyers

Limits on the performance of the roving frame are determined by both the delivery speed and the rotation speed of the flyer. The influence of the flyer depends upon its form and drive. Using these criteria as a basis, the following distinctions can be drawn between three flyer types:

- spindle-mounted flyers (Fig. 9, a);
- closed flyers (Fig. 9, b);
- top-mounted flyers (Fig. 9, c).

TWIST CHART: TWIST LEVEL ACCORDING TO STAPLE LENGTH AND ROVING COUNT



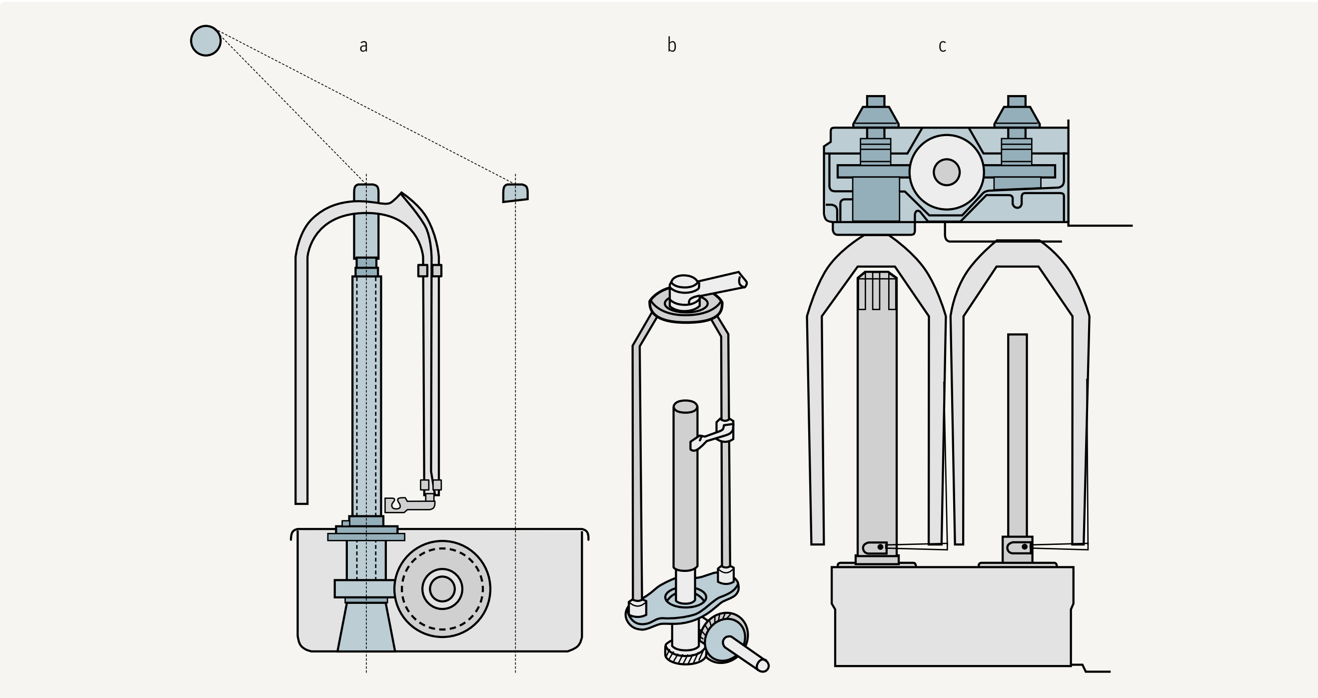


Fig. 9 – Various flyer designs

The standard form has in the past been the spindle-mounted flyer (Fig. 9, a). This is simple as far as design and drive are concerned, but not from the service point of view or for automation purposes.

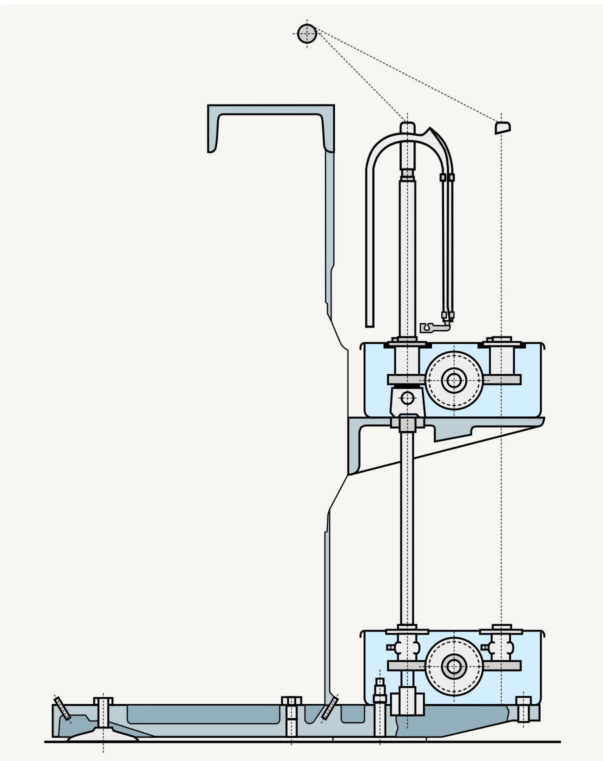


Fig. 10 – Spindle, flyer and spindle drive

In this design, the spindle is simply a support and drive element for the flyer, without any ancillary function. It is a long steel shaft, mounted at its lower end in a bearing and supported in the middle by the vertically reciprocating shaft of the package tube acting as a neck bearing. Rotation is caused very directly and over a short transmission distance from the main shaft by way of a gear train and a longitudinal shaft that extends past all spindles and is fitted with bevel gears driving bevels on the spindles themselves. The spindle tip is conical and provided with a slot. When the flyer is set on the spindle cone, a pin on the flyer projects into the slot so that the flyer and spindle are converted into a unit for drive purposes (Fig. 11). The closed flyer (Fig. 9, b), supported both above and below, has been used only by Platt Saco Lowell in the „Rovematic“ machine. It has the advantage of reduced spreading of the legs at high operating speeds. Today, the standard design is the top-mounted flyer (Fig. 9, c). Among other things, this form facilitates automation of the doffing operation. The flyer is supported by ball bearings at the neck and is driven by gear wheels or toothed belts from above.

3.3.3.3. The flyer

Earlier flyers were invariably made of steel, but they are now mostly made of light alloy (Fig. 11). At the high speeds currently considered normal steel flyers would spread at the legs considerably; this is detrimental to the operation

of the machine, and even more so to the winding operation. The amount of spreading depends upon the rotation speed. When this varies, e.g. during starting and stopping, the presser arm (5) adopts a continually varying inclination, which causes continual shifting of the winding point of the bobbin. It becomes impossible to ensure a controlled build over the complete package. In addition, light alloy flyers have lower weight. Flyers can have varying sizes, which are specified in inches. The stated sizes are actually winding dimensions, i.e. the maximum height (first number) and the maximum diameter (second number) of a wound package of material. Roving frames are supplied in the following sizes:
12″ x 5 1/2″ ; 12″ x 6″ ; 14″ x 6″
14″ x 6 1/2″ ; 16″ x 6″, 16″ x 7″

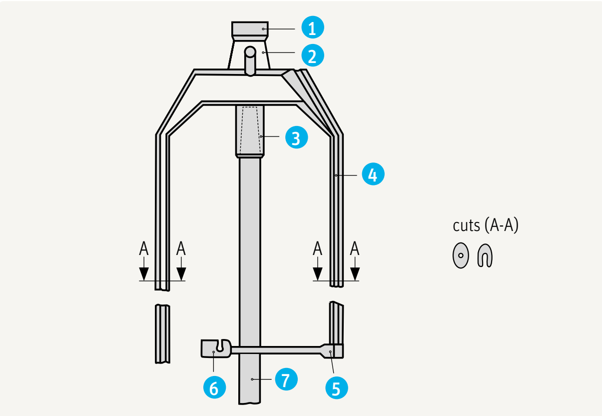


Fig. 11 – Component parts and structure of the flyer

As well as imparting the roving twist, the flyer has to guide the very sensitive strand from the flyer top to the package without introducing false drafts – not exactly an easy task. For one thing, the strand has only protective twist and is very liable to break. For another, the flyer is rotating, along with the roving, at a speed of up to 1 500 rpm. The fiber strand must therefore be protected against strong air currents. For this purpose, in most roving frames to date, one of the two flyer legs (4) has usually been „hollow", i.e. with a deep guide groove that is open in a direction opposite to the direction of rotation. The strand is drawn through this groove. The second, solid flyer leg serves to balance the grooved leg.
Newer designs no longer feature this easily accessible, „service-friendly" groove. Instead, they have a very smooth guide tube set into one flyer leg. In this case, the strand is completely protected against air flows and the roving is no longer pressed with considerable force against the metal of the leg, as it is in the previous designs. Frictional resistance is significantly reduced, so that the strand can be pulled through with much less force. This reduces false drafts and strand breaks while allowing high production speeds. However, piecing of strand breaks is somewhat more difficult.

3.3.3.4. The flyer top

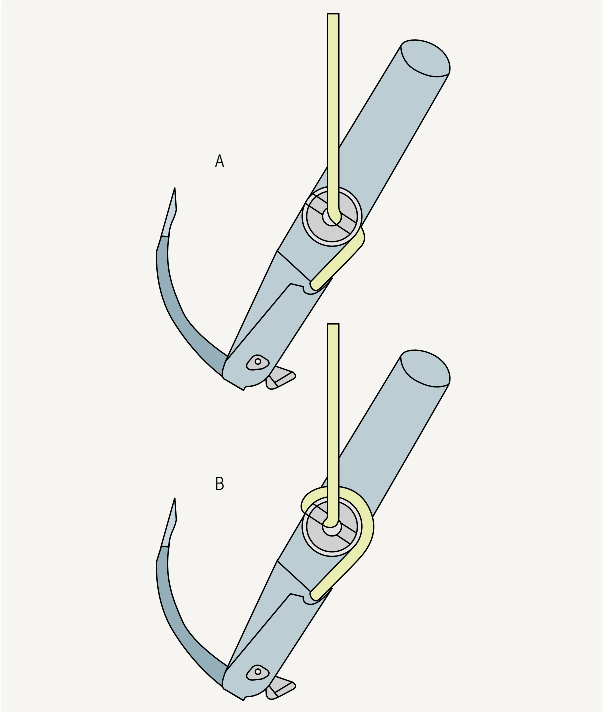


Fig. 12 – Entry of the strands into the flyer top

The manner in which the roving is carried along and guided at the entrance to the flyer determines the degree of twist and the winding tension. Where the roving has only low twist or is coarse, so that there is a risk of false drafts, the strand passes through the flyer top to the guide groove with half a wrapping (Fig. 14, A). A one-turn of wrap, as shown in (B), is selected for high-speed frames winding large packages with high twist levels. The wrap permits better control of roving tension and the package build becomes more even owing to the harder coils. Older flyers have flyer tops of smooth metal. However, most modern flyers have an insert of rubber formed with grooves, notches or indentations (Fig. 13). These flyer inserts exert a strong influence on the level of twist in the roving between the drafting arrangement and the flyer, and also on winding conditions at the bobbin. Their formation enables them to carry the roving along substantially better while imparting twist, and they additionally insert the very favorable false twist. One result of this false twist is that the roving is already strongly twisted in the unsupported length leading to the flyer. Roving breakage rates in the spinning triangle are thus reduced, and fly and lap formation are decreased. A second result of the false twist is a more compact roving, which increases the capacity of the bobbin and permits higher flyer speeds. The capacity of the bobbin is still further increased because the compactness of the roving permits winding with higher tension.

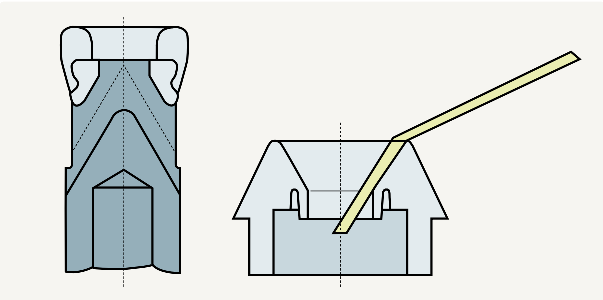


Fig. 13 – The flyer top

3.3.3.5. The presser arm

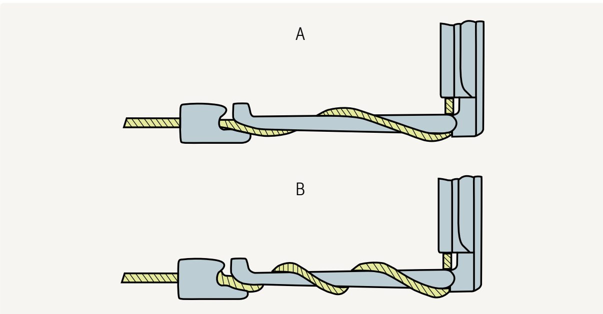


Fig. 14 – Guidance of the roving by the presser arm

A steel yoke, the so-called presser arm, is attached to the lower end of the hollow flyer leg. The arm has to guide the roving from the exit of the flyer leg to the package. The roving is wrapped two (A) or three (B) times around the yoke. The number of turns determines the roving tension. If this is high, then a hard, compact package is obtained. If it is too high, false drafts or roving breaks can be caused. The number of wraps depends upon the material and twist level.

3.3.4. Winding of the bobbin

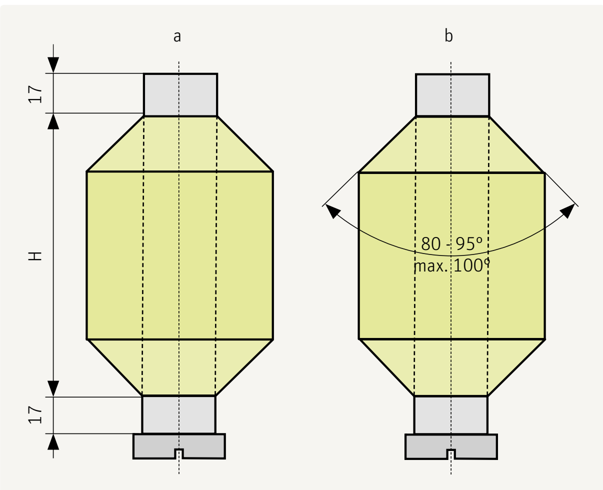


Fig. 15 – The bobbin form

A roving bobbin is a cylindrical body with tapered ends (Fig. 15). It is created by building layer upon layer of parallel coils of roving on wooden or plastic bobbin tubes acting as package cores. To form the tapered ends, the height of the lift must be reduced after each layer has been completed. The roving bobbin is the ideal package form for supplying material to the ring spinning frame; when full, the bobbin carries a relatively large quantity of material, owing to its compactness; when empty, it occupies a relatively small volume, convenient for transport and storage.
The angle of taper of the ends is normally between 80° and 95°, and depends upon the adherence of the material. The angle is made as large as possible, so that as much roving as possible is wound onto the package. However, the angle must be small enough to ensure that the layers do not slide apart.

3.4. Machine drive system

Mainly in order to achieve the desired bobbin form, a very sophisticated drive system is necessary. Until very recently, this problem had to be solved purely by mechanical means, resulting in a really complex drive mechanism.
It has only recently been possible to simplify the drive system of the roving frame considerably by the use of modern electronic drive technology.
The two drive systems are explained below.

3.4.1. Mechanical drive systems

The mechanical solutions to the very demanding drive problems in the roving frame are described and explained step by step.

3.4.1.1. Bobbin drive

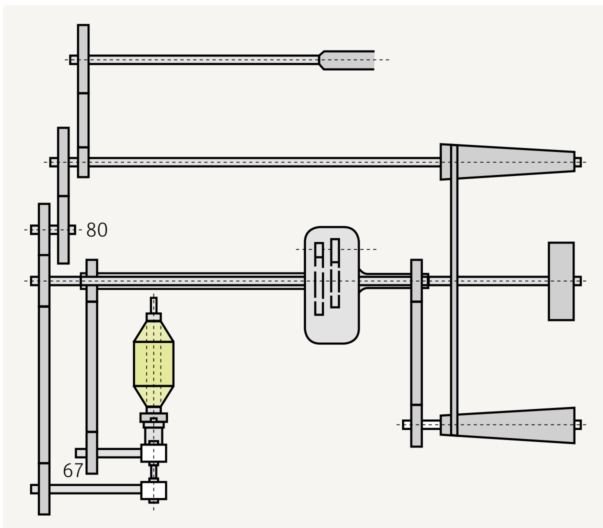


Fig. 16 – Bobbin drive (gearing plan)

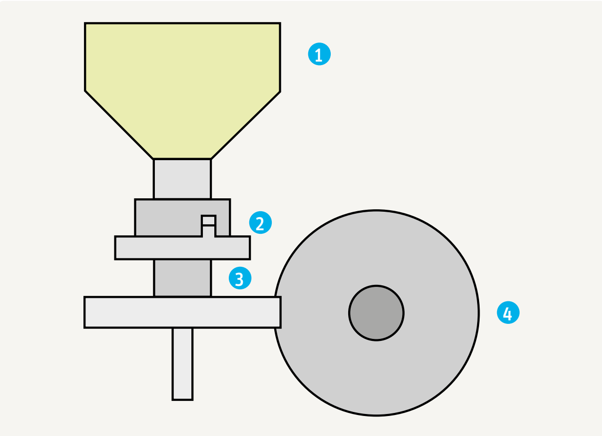


Fig. 17 – Bobbin drive (side view); drive transmission to the bobbin

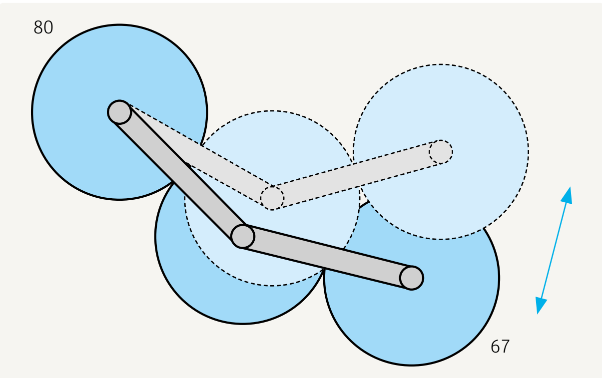


Fig. 18 – Swinging joint at the bobbin drive shaft

During winding of a roving bobbin, the flyer rotation speed is usually kept constant. The difference between the peripheral speeds of the flyer and the bobbin must also be kept constant. However, the bobbin diameter increases stepwise, after each layer of roving. The bobbin rotation speed must be reduced accordingly to maintain the required difference between the peripheral speeds. This necessitates a relatively complicated drive for the bobbin.
Variation in bobbin speed originates from the cone drums. When the builder motion shifts the cone belt, the rotation speed of the lower cone is changed. This declining rotation speed is transmitted via gearing (Fig. 16, 80/67) to the differential and is there superimposed on the constant speed of the main shaft. Further gearing then transmits the resulting rotation speed to the bobbin drive (Fig. 17, 4/3). On the bobbin rail, bevel gears (4) fixed to the longitudinal shaft drive the bevel gears (3) of the bobbin supports. But a variable drive, e.g. a PIV unit, can be used instead of the cone drums. A further difficulty in relation to the bobbin drive is the fact that the bobbins are carried on a rail that is continually moving up and down. A flexible (relatively movable) connection is needed between the main drive shaft in the gear box and the longitudinal bobbin shaft. Previously, a knee-joint (swinging joint) was used for this purpose (between wheels 80 and 67 in Fig. 16, and see Fig. 18).
However, gear wheels arranged in a knee-joint have the disadvantage that they roll on each other during the up-and-down movements. This causes additional revolutions that are either added to or subtracted from the basic package rotation, depending upon the direction of the lift stroke. Tension variation then arises. Today, transmission of rotation is mostly effected by means of cardan shafts, telescopic shafts or chain drives.

3.4.1.2. Cone drive transmission

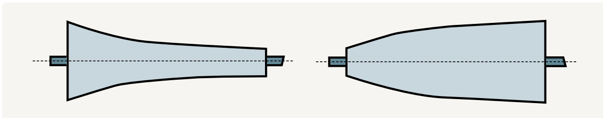


Fig. 19 – Convex and concave cones

Variation of the bobbin rotation speed originates in the cone transmission and occurs in small steps through shifting of the cone belt after each lift stroke. Bobbin rotation must be changed in accordance with a linear function. Unfortunately, shifting the belt by constant amounts on straight-sided cones does not vary the transmission ratio in a linear manner and thus does not produce the required linear variation in bobbin rotation speed. To obtain the desired linear variation function, the cone faces have been made hyperbolic (see Fig. 19), namely convex on the upper driving cone and concave on the lower driven cone. Hyperbolic cones are difficult to design. Additionally, during the winding operation, the belt is then always moved on surfaces of varying inclination. As a result cones are now mostly made straight-sided. However, in transmissions of this kind the belt must be shifted through steps of varying magnitude, the initial steps being relatively large (Fig. 20, W1) and the later ones smaller (W4). Instead of a hyperbolic profile on the cones (left), an eccentric is used in the belt-shifting mechanism (right).

3.4.1.3. Shifting the belt

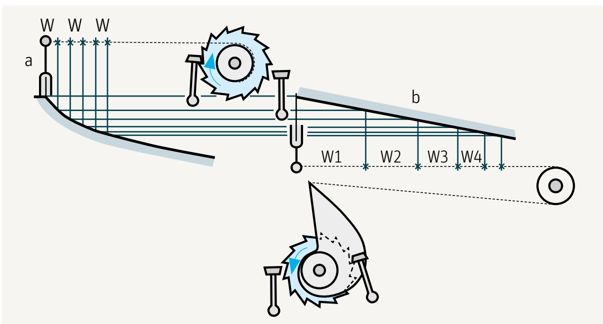


Fig. 20 – Shifting the belt with hyperbolic (a) and straight-sided cones (b)

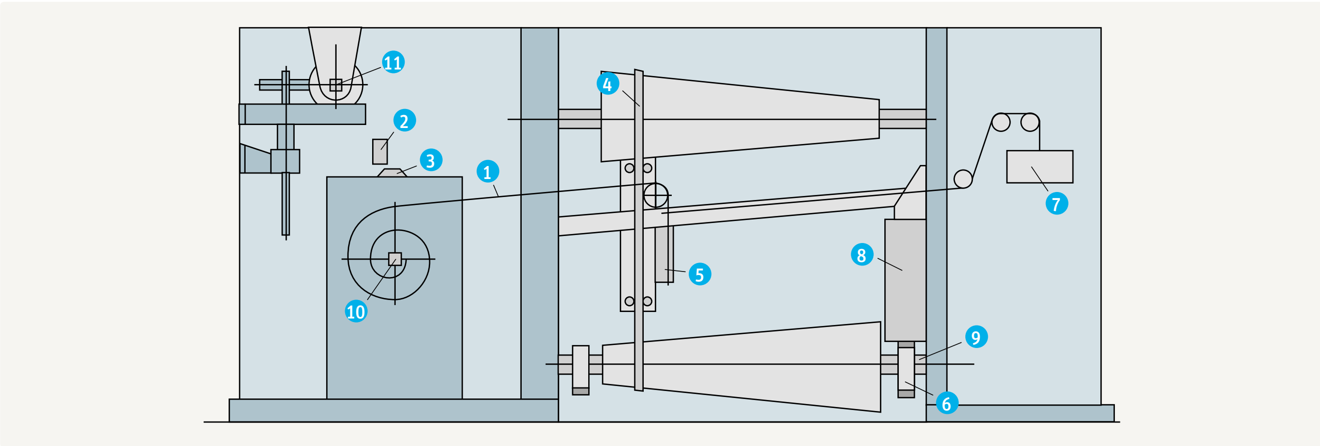


Fig. 21 – Belt-shifting device

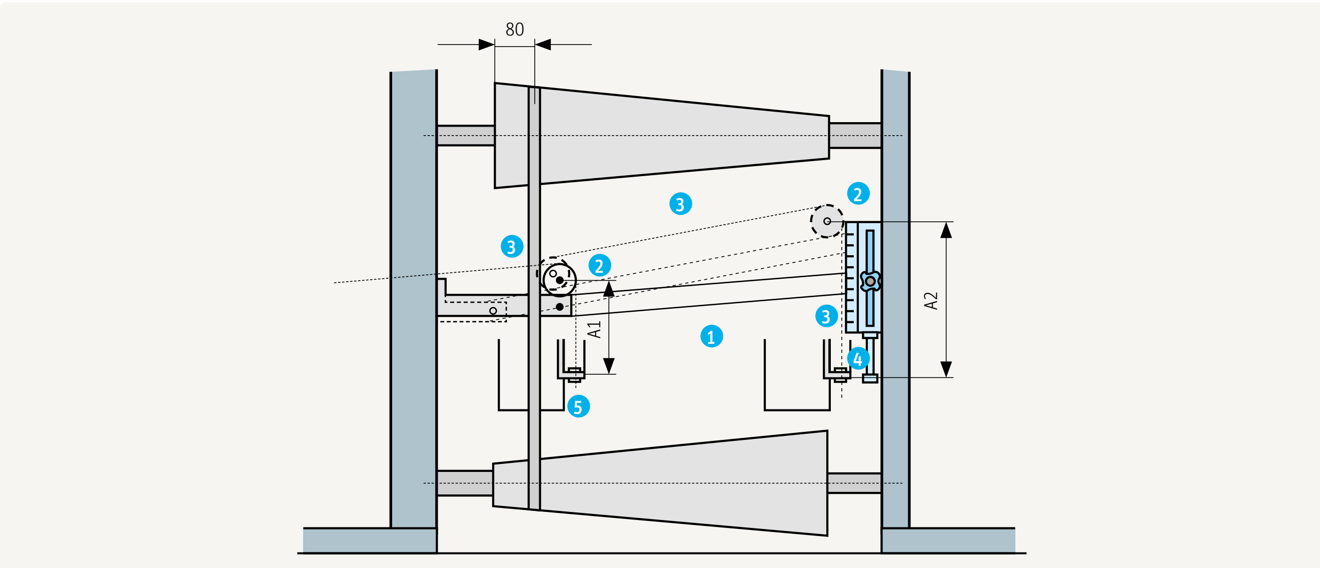


Fig. 22 – Functional diagram of the correction rail

Shifting of the belt is controlled by the ratchet wheel (on axle Fig. 21, 10). In the course of each change-over operation (after each stroke), the ratchet wheel is permitted to rotate by a half tooth. By way of a gear train including change wheels and an eccentric, this ratchet steps out the wire rope (1) and hence permits movement of the belt guide (5) to the right. The tensile force required to induce movement of the belt is exerted by a weight (7). Bobbin diameter increases more or less rapidly depending upon roving hank. The belt must be shifted through corresponding steps. The degree of shift, which depends upon the thickness of the roving, is modified by replacing the ratchet wheel or (generally nowadays) by substituting change wheels. If a ratchet wheel with fewer teeth is inserted, then the belt is shifted through larger steps, i.e. it progresses more rapidly, and vice versa. When the bobbin is fully wound, the belt must be moved back to its starting point. Today, this is usually done automatically by an auxiliary motor.

3.4.1.4. Correction rail (compensation rail, correction rod)

If the movement of the belt does not correspond to the increase in bobbin diameter, the change wheel or ratchet must be adjusted accordingly. Sometimes, however, the adjustment resulting from changing by one tooth would have an over-large effect; a change by only half a tooth might in fact be suitable. In order to deal with such borderline cases, i.e. to provide a degree of fine setting, several roving frames are now fitted with a correction rail (Fig. 22). This is a rail (1) which is mounted in the region of the belt guide (not shown) and in its normal position is parallel to that guide. At position 4, however, the rail can be shifted to bring it into another position relative to the belt guide. A roller runs on the correction rail. The belt shifting rope is guided around this roller and is secured to the belt guide at 5.

If the rail and belt guide are not parallel, i.e. if the correcting rail has a greater inclination than the belt guide as shown in the illustration (2), the roller (dotted lines) moves further upward (3), away from belt guide (5). The distance between roller (2) and the anchoring point of the rope increases from A1 to A2. This means that the extension of the rope as determined by the builder motion is not transferred completely to the belt guide; instead, part of that extension is taken up in increasing distance A from A1 to A2. Shifting of the belt takes place through smaller steps than those corresponding directly to the paying out of the rope in the builder motion. The reverse effect is obtained if the correction rail is offset in the other direction relative to the belt guide. The increase in diameter of the bobbin is in principle a linear function of the number of layers. This relationship may not hold true in practice, because the winding conditions do not remain absolutely constant. At the start of a winding operation, roving is wound onto a hard core (bobbin tube); toward the end of the winding operation the receiving body may be softer – depending on the compactness of the roving – since the material itself now provides that body. This change, and also other changes in associated conditions, can give rise to tension variations during winding. In order to be able to adapt to these, the correction rail is often made in several parts, which are adjustable relative to each other. In this way, any desired tension level can be set from beginning to end of the winding operation by relative raising or lowering of the individual rail sections.

3.4.1.5. Lifter motion

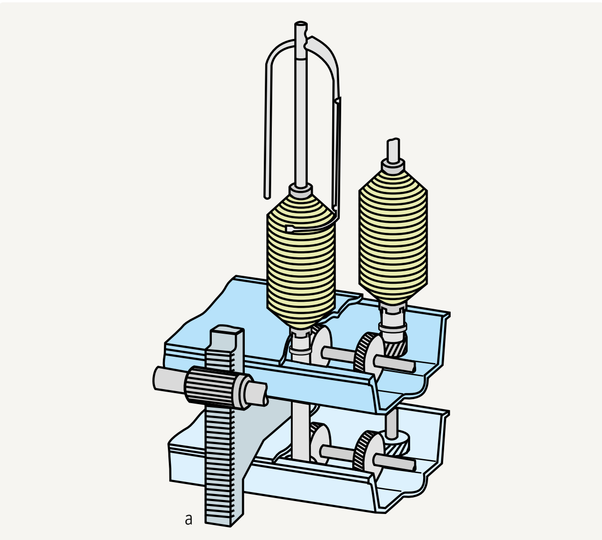


Fig. 23 – Lifter motion with racks (a)

In the package, each turn must be laid next to its neighbors. For this purpose, the lay-on point must continually be moved. This can be brought about only by raising and lowering the bobbins. This requirement cannot be met by raising and lowering the flyers, because then the unsupported roving length (from drafting arrangement to flyer top, see Fig. 3) would vary correspondingly and the angle of departure from the drafting arrangement and of approach to the flyer top would change continuously. The winding point must be shifted by moving the bobbins, which are supported on a movable rail for this purpose. The necessary raising and lowering can be carried out by means of several racks attached to the rail (Fig. 23). Some manufacturers have mounted the bobbin rail on a lever and move the rail by moving that lever up and down (Fig. 24).

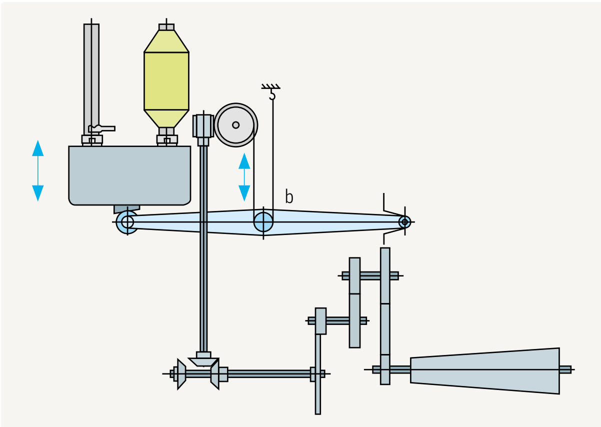


Fig. 24 – Lifter motion with levers (b)

The individual coils of the bobbin must be laid closely adjacent to each other, not only in the first layer but also in all subsequent layers. However, since the package diameter is steadily increasing, the lift speed must be reduced by a small amount after each completed layer. As can be seen from Fig. 24, the lift drive is also transmitted via the cone transmission (as for the bobbin drive), but not via the differential.

In addition, a reversing drive must be provided so that the bobbin rail is alternately raised and lowered.

3.4.1.6. Builder motion

This device has to perform three important tasks during a winding operation:

- shift the cone belt corresponding to the increase in bobbin diameter;
- reverse the direction of movement of the bobbin rail at the upper and lower ends of the lift stroke;
- shorten the lift after each layer to form tapered ends on the bobbins.

The required moment for each change-over and the magnitude of the adjustment both depend upon the roving hank and the material, and must therefore be adapted to the prevailing conditions by means of change gear positions. In the following sections, a short description of a builder motion for a roving frame will be given. In this arrangement, most of the movement changes are effected electro-pneumatically.

3.4.1.7. Shifting the cone belt

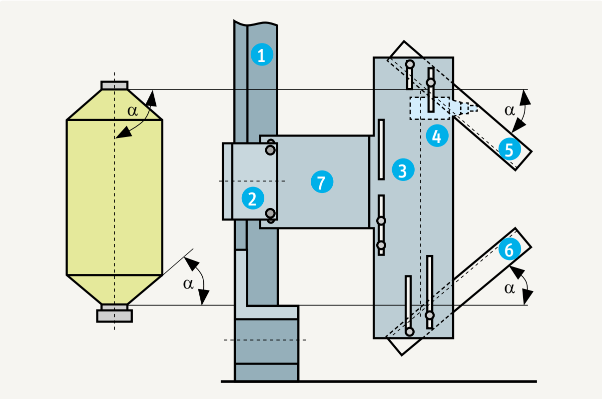


Fig. 25 – The reversing assembly of the lifter motion

The machine unit that induces all changes is the changeover mechanism, which comprises metal brackets (3/7) and rods (5/6). This mechanism is attached to the bobbin rail (at 2) and is raised and lowered as a unit with the rail. A stationary pin is struck by one of the rods (5/6) on the upward stroke and by the other on the downward stroke, and each time a microswitch (4) emits a pulse. Each pulse from microswitch (4) actuates a release mechanism to permit rotation of the ratchet wheel through one half-tooth.

3.4.1.8. Reversal of the bobbin rail movement

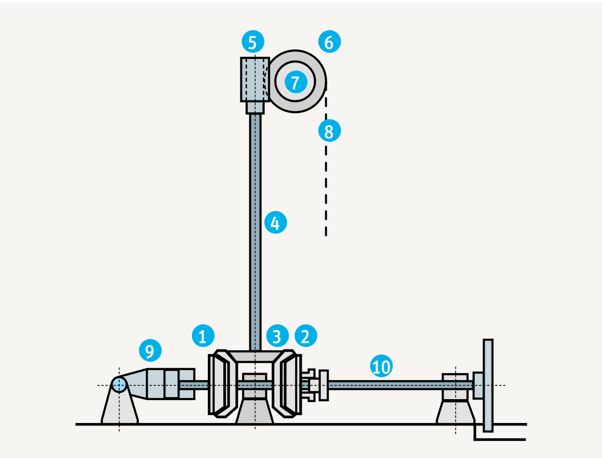


Fig. 26 – Mechanism for reversing the bobbin rail movement

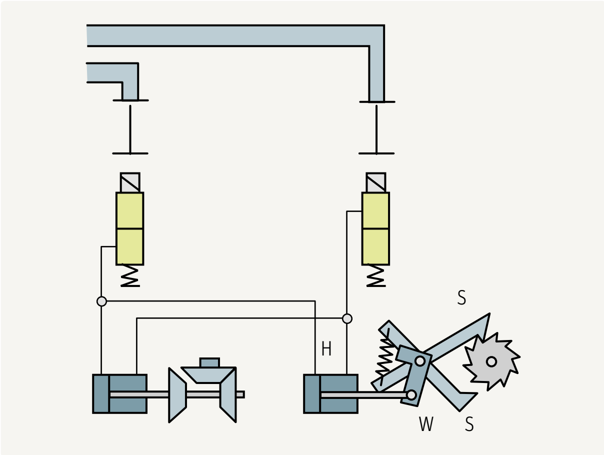


Fig. 27 – The assembly for building conical ends on the bobbins

Reversal of the rail movement originates from the reversing gear (Fig. 26, 1/2/3). An electrically operated valve pressurizes the left- and right-hand chambers of double-acting cylinder (9) alternately. Thus left-hand clutch (1) and right-hand clutch (2) are operated successively so that pinion (3) engages with either gear wheel 1 or gear wheel 2. The rotation itself comes from the shaft 10, on which gear wheels 1 and 2 are mounted, always rotating in the same direction. Operation of clutch (1) or (2) causes left- or right-hand rotation of pinion 3 and shaft 4, accordingly. The bobbin rail is correspondingly raised or lowered via bevel gear 5, pinion 6, sprocket 7 and lifting chain 8.

3.4.1.9. Shortening the lift

Rods 5 and 6 (Fig. 25) are inclined. The inclination is adjustable and corresponds exactly to the taper of the bobbin ends (angle alpha). During winding of a package, the ratchet is rotated at every change-over, and the microswitch (Fig. 27) is also gradually shifted further to the right on a slide.

Therefore, the rods engage the microswitch steadily earlier in the lift stroke, and reversal occurs correspondingly earlier. This results in a continuous reduction in the lift of the rail. The bobbins are thus built with a taper.

3.4.2. Gear change positions of the roving frame (on old roving frames)

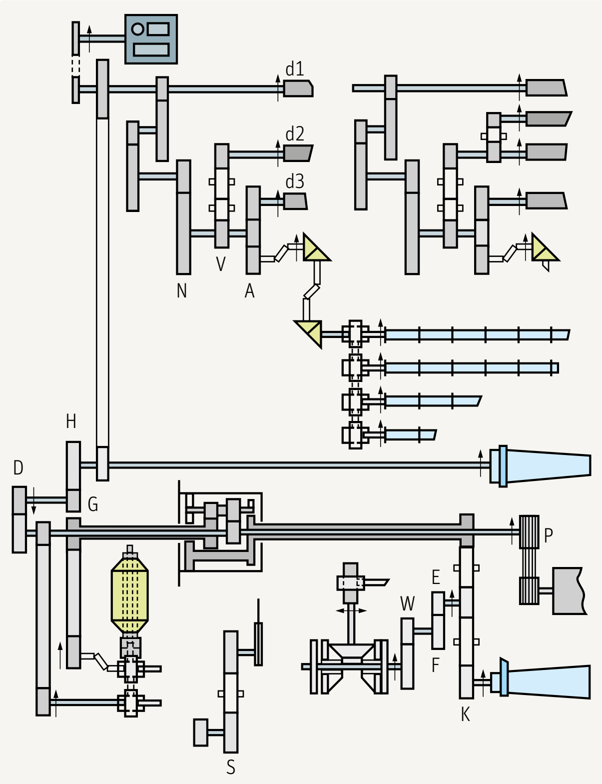


Fig. 28 – Gearing diagram of roving frame (Rieter)

- **Main shaft drive discs *(P)***
  These drive discs provide the only opportunity to adjust spindle rotation speed.
- **Infeed change wheel *(A)***
  This influences the tension in the slivers between the creel and the infeed to the drafting arrangement.
- **Break draft wheel *(V)***
  This enables the rotation speed of the middle cylinder (d2) to be changed, thereby changing the break draft with simultaneous alteration of the main draft. The break draft must be adapted to the material.
- **Main draft wheel *(N)***
  A change here results in simultaneous variation of the rotation speeds of the middle (d2) and infeed (d3) cylinders. Since the rotation of delivery cylinder (d1) remains unchanged, the main draft is altered, as is the total draft.
- **Twist wheel *(D)***
  Replacement of this wheel results in a variation of all speeds, except that of the flyers. Since the roving twist arises from the relationship between flyer rotation and delivery speed, a change in twist level arises from adjustment here.
- **Auxiliary change wheels *(H,G)***
  This is an auxiliary twist change in order to adjust the twist level within broad ranges.
- **Lift change wheel *(W)***
  The lift speed of the bobbin rail is influenced by this element, and hence the laying density of roving coils on the bobbin. A wheel should be chosen such that the coils of the first layer lie close to each other and practically hide the tube. The coils should also be arranged closely adjacent, but not on top of each other. In this way, the bobbin is made to take up a lot of material.
- **Auxiliary change wheels *(F,E)***
  These are ancillary to the lift change wheel and again enable adjustments over broad ranges.
- **Cone drum change wheel *(K)***
  If the diameter of the tube is altered, the starting speed of the bobbin must be adjusted accordingly. Since the ratchet wheel has not been operated at this stage, the adjustment cannot be made by means of the builder motion. The starting position of the cone belt can be changed or, when this is no longer possible, another cone change wheel can be substituted.
- **Ratchet change wheel *(S)***
  This determines the amount by which the belt is shifted at each operation of the ratchet and therefore must be adjusted precisely to the increase in bobbin diameter.

3.4.3. Electronic drive system

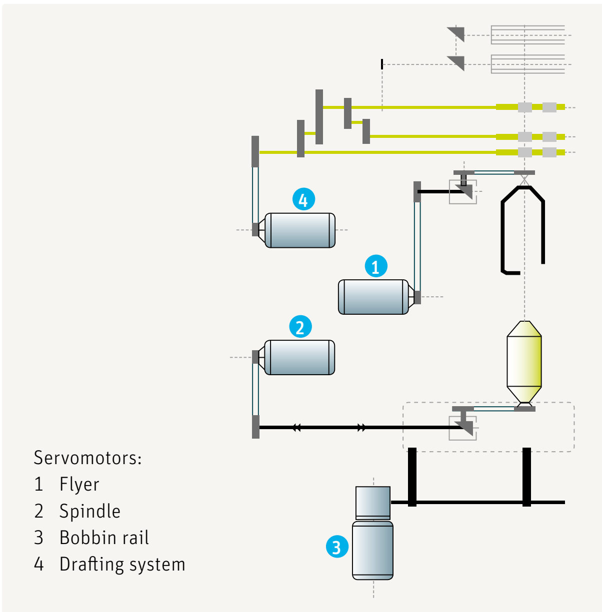


Fig. 29 – Electronic drive system

Electronic devices such as frequency converters and individual servomotors have enabled the drive system of the roving frame to be considerably simplified. Fig. 29 clearly illustrates this fact using the modern Rieter F 35 roving frame as an example.
Spindles and flyers are driven directly by individual servomotors. The control system ensures synchronized running throughout package buildup. The drives are controlled by frequency converters and are thus especially gentle in their treatment of the material. Controlled machine stop is assured in the event of power failure.
Such drive systems are not only much simpler than mechanical drive versions, but also have additional advantages such as lower energy consumption and reduced maintenance.

3.5. Special design (Saco Lowell „Rovematic" frame)

While almost all manufacturers of roving frames were building their machines on the same basic principle, Saco Lowell went down a new path several decades ago. One new feature was the closed flyer (Fig. 9, b), supported above and below and driven at the top. Still more noteworthy is the elimination of the bobbin rail. The bobbins are raised and lowered by a system of nuts and screw-threaded elements in a manner depending only upon the relative speeds of these two parts. However, this machine has not been available for some time now.

3.6. Accessories
3.6.1. Monitoring devices
3.6.1.1. The need for such devices

Roving bobbins are built up from a core outwards, i.e. the diameter increases steadily. For each bobbin dimension there is an associated defined bobbin speed and lift speed. If one roving breaks, while the frame continues production, the diameter of that one bobbin stays constant while the others continue to increase. If an attempt is made to piece the broken roving end after a certain time, this end will always break again because the peripheral speed of the smaller bobbin is no longer appropriate in the new winding conditions. In order to enable winding to continue on all bobbins after a break, it is necessary to stop the machine immediately after the break occurs: automatically operating stop motions are required.

3.6.1.2. Sliver stop motions

Monitoring at the infeed is usually carried out by light barriers, with a light emitter at one side of the frame and a light receiver (photocell) at the other. The device is located between the last transport roller of the creel and the drafting arrangement. If a sliver breaks or runs out, the end falls from the transport roller, passes through the light barrier and stops the machine.

3.6.1.3. Roving stop motion

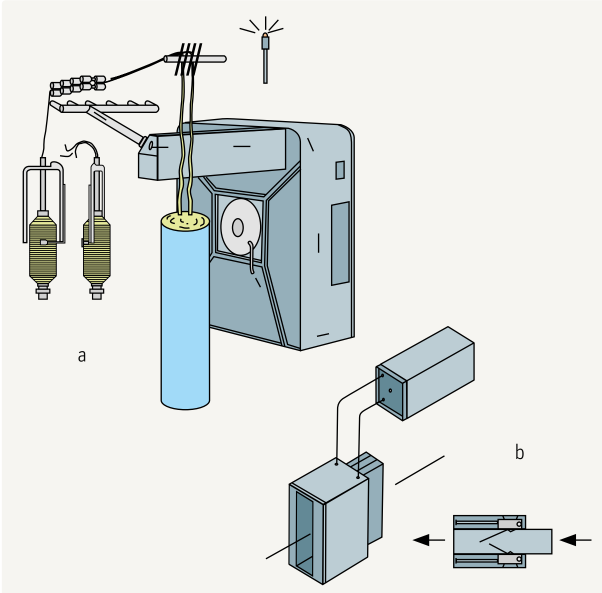


Fig. 30 – Roving stop motion by Luwa

Monitoring at the delivery of the drafting arrangement can also be performed by light barriers. In this case, the light beam is usually directed straight past the flyer tops. In the event of a roving break, the broken roving end whirls around the flyer top or so-called „hoods" form at the flyer top. This interrupts the light beam and causes the machine to be stopped.
An alternative is the use of the capacitive detection principle in a monitoring unit. The Luwa company offers such a device under the designation „Pneumastop". The device is associated with the pneumatic suction system in the delivery of the drafting arrangement. This suction system (Fig. 30, a) is an absolute necessity in order to avoid a series of roving breaks along a bobbin row following the first break in the row. If one end breaks, the suction system draws the sliver into a large collector duct extending over the full length of the machine. Fibers entering this duct pass through it into a filter chamber at the end of the machine after passing the capacitive detector (Fig. 30, b). In the detector there is an electric field between two comb electrodes. If fiber material passes through this field, the change in capacitance generates a signal to stop the machine. Modern machines are mostly equipped with individual electronic roving detectors placed at the outlet of the drafting unit. These electro-optical detectors ensure that in the case of a roving break the machine is stopped immediately.

3.6.1.4. Roving tension monitoring

The level of roving tension is an important factor with regard to the performance of the machine. With a modern drive system as described in chapter 3.4.3.‚Electronic drive system', it is possible to install a roving tension control system on the machine. For this purpose a control unit consisting of sensor and microprocessor checks roving tension between drafting unit and flyer top on two positions per machine and adjusts the tension accordingly. This ensures high roving uniformity and prevents false drafting.
Such a tension monitoring device is produced, for instance, by the ROJ company.

3.6.2. Blower apparatus

Roving frames not only produce a significant quantity of fly – they also continually stir it up. This necessitates a corresponding effort to keep the installation clean. To relieve attendants at least partly of this burden, traveling blowers are now increasingly being used. These consist essentially of a powerful fan that moves back and forth on rails above the machines. Tubes hang down from the fan, some as far as the ground, and have air exit jets at the appropriate heights. The airflow created by the fan is directed by the jets onto exposed parts of the machine. Fly is blown off onto the floor and can be sucked away by a second hose system, or can be brushed up periodically by hand (see The Rieter Manual of Spinning, Volume 4 – Ring Spinning).

3.7. Automation
3.7.1. Potential for automation

Much of the work required on the roving frame is costly, time-consuming, physically demanding and ergonomically unfavorable. Automation is therefore most desirable in order to improve working conditions, to reduce errors, to prevent damage to the roving packages and to increase productivity.
The layout of a roving frame (with its double row of bobbins arranged one behind the other, flyers directly in the forefront, and the expansive creel), is far from ideal for automation. Nevertheless, considerable advances have recently been made. The following picture emerges.

- **Can changing.** Full automation would be too complex and would bring only minor benefits because the change occurs too infrequently. However, can transport might be at least partly automated.
- **Piecing sliver breaks.** This occurs even less frequently and is therefore hardly worth consideration.
- **Piecing roving breaks.** This also occurs infrequently and could only be automated with considerable effort that would make it highly uneconomic.
- **Bobbin doffing.** This is the most useful opportunity for automation and is long overdue since the doff is a costly, frequent and ergonomically unsatisfactory operation that has a significant influence on efficiency. Fortunately, bobbin doffing is state-of-the-art nowadays.
- **Bobbin transport.** This is also an obvious candidate for automation, since about 60 % of wage costs in a spinning mill using ring spinning machines can be attributed to the cost of transport. Such systems are now available with varying degrees of automation.
- **Cleaning.** Cleaning has already been automated to a great extent by means of cleaning aprons, clearer rollers and suction systems at the drafting arrangement, and also by the traveling blowers that keep the machine clean.
- **Machine monitoring.** Stop devices are now standard equipment on roving frames. In this area, automation has already been satisfactorily achieved and the burden on personnel has effectively been removed.
- **Production monitoring.** Short-staple spinning mills operate with small profit margins that are generated at a number of individual positions. Many parameters exert an influence. Raw material is the main one, but utilization of personnel and of the installation are also important. An optimum is attained if the machines produce day and night with a minimum of interruptions. One possibility for optimizing efficiency and keeping it under control is a production monitoring system, such as the Zellweger Uster MILLDATA-SLIVERDATA system, in which interruptions in operation of all machines in the preparatory installation are recorded, evaluated and stored. Other companies offer similar systems (for instance, SPIDERweb by Rieter).
- **Quality monitoring.** In contradistinction to the drawframe, where an almost complete quality check can be carried out on the machine itself, total quality control on the roving frame would be too expensive, since too many production positions would have to be checked. Checking roving quality remains the province of the laboratory.
- **Maintenance and servicing.** Much, but not all, has already been achieved in this area by way of central lubrication, low-maintenance design and so on.

Several of the points listed have already been dealt with elsewhere in the text, so that here only package doffing and transport will be briefly discussed in more detail.

3.7.2. Doffing

The doffing process is illustrated using the Rieter F 15 and F 35 roving frames as examples.

3.7.2.1. Preparation for doffing

For successful doffing, the roving end must be placed in a specific position on the roving package. Three positions are possible (Fig. 31):

- Roving end as top bunch
  Top bunch is ideal for automated roving frames with automatic roving bobbin transport systems.
- Roving end in the middle of the roving bobbin
  This position is mainly used for machines with manual doffing.
- Roving end as bottom bunch

Bottom bunch is also used for automated roving frames with an automatic transport system, but in addition it simplifies the piecing procedure of the roving in the ring spinning machine.

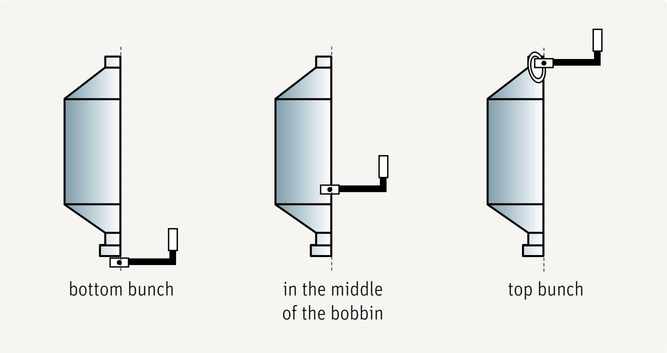


Fig. 31 – Positions of the roving end

3.7.2.2. Manual doffing

The F 15 roving frame is equipped with a doffing aid for manual doffing. In order to facilitate the doffing procedure, the bobbin rail with the full bobbins is lowered and tilted. This enables the bobbins be removed easily (Fig. 32).

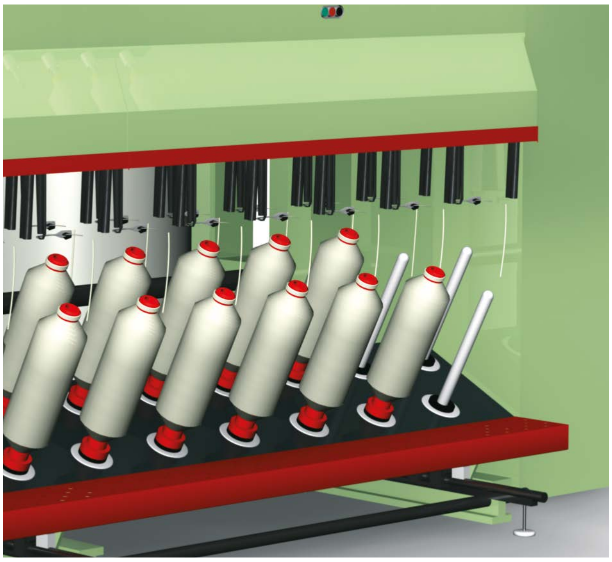


Fig. 32 – Manual doffing with tilted bobbin rail

3.7.2.3. Automatic doffing

Automatic doffing enables labor requirements and doffing times to be drastically reduced. The fully automated Rieter F 35 roving frame performs doffing in less than 2 minutes. This has been made possible by separate actuation of bobbin rail and doffer rail by two independent frequency converters.

The doffing sequence of the F 35 roving frame is illustrated in Fig. 33.

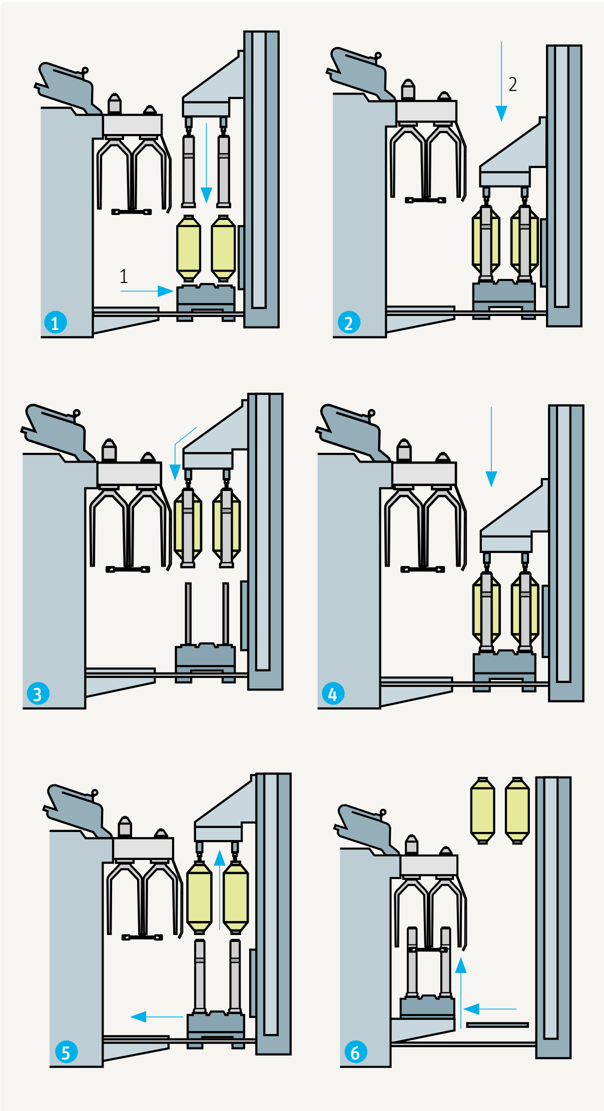


Fig. 33 – Doffing sequence

1. – The bobbin rail (1) moves out and at the same time the footboard is set up.
– The doffer beam with the empty tubes is lowered between the full bobbins (2).

2. – The empty bobbin pegs of the doffer beam grasp the full bobbins. (All the bobbin pegs are now occupied).
– The doffer beam moves up to reversing position.

3. – The conveyor belt in the doffer beam moves into intermediate position.

4. – The doffer beam puts the empty tubes onto the spindles.

5. – The doffer beam moves into top position with the full bobbins.
– The slide moves in and the footboard is lowered at the same time.
– The safety zone is free again.

6. – The bobbin rail (1) is raised to spinning start-up position.
– The full bobbins (2) are transported to the transfer station.
– The roving frame starts up automatically.

3.7.3. Transport of bobbins to the ring spinning machine

Transporting individual roving bobbins manually from the roving frame to the ring spinning machine is labor-intensive and often results in damage to the roving. The answer to this problem is a roving bobbin transport system. Today, therefore, various solutions are available for bobbin transport from roving frame to ring spinning machine with different degrees of automation to suit customer needs, for example from Rieter, Schönenberger, Electro-Jet and other companies.
Such transport systems have a number of advantages with regard to quality and costs:

Quality
- elimination of manual bobbin handling
- elimination of intermediate storage, which can result in damage, soiling and aging of the roving
- elimination of the likelihood of confusion between different roving bobbins
- ensuring the application of the “first-in, first-out” principle

Costs
- space saving
- quality assurance and enhancement
- labor savings of up to 25 % compared to manual bobbin transport by reducing physical effort, reducing the distance covered by operating personnel, improved access to the machines and improved ergonomics

Fig. 34 shows an example of automatic bobbin transport between roving frame and ring spinning machines. Two separate circuits in the area of roving frame and ring spinning machines guarantee a continuous supply of roving bobbins to the ring spinning machines.

3.8. Technical data (normal values)

Spindles per machine	48 - 160
Flyer rotation speed, rpm	up to 1 500
Production rate, g/sp.h	250 - 2 000
Sliver hank, ktex	3.8 - 5.5
Roving hank, tex	170 - 1 500
Draft	5 - 22
Bobbin weight, kg	up to 3

3.9. Appendix

Evenness of the roving over short lengths is demonstrated in the comparative figures in Table 1, from Zellweger Uster.

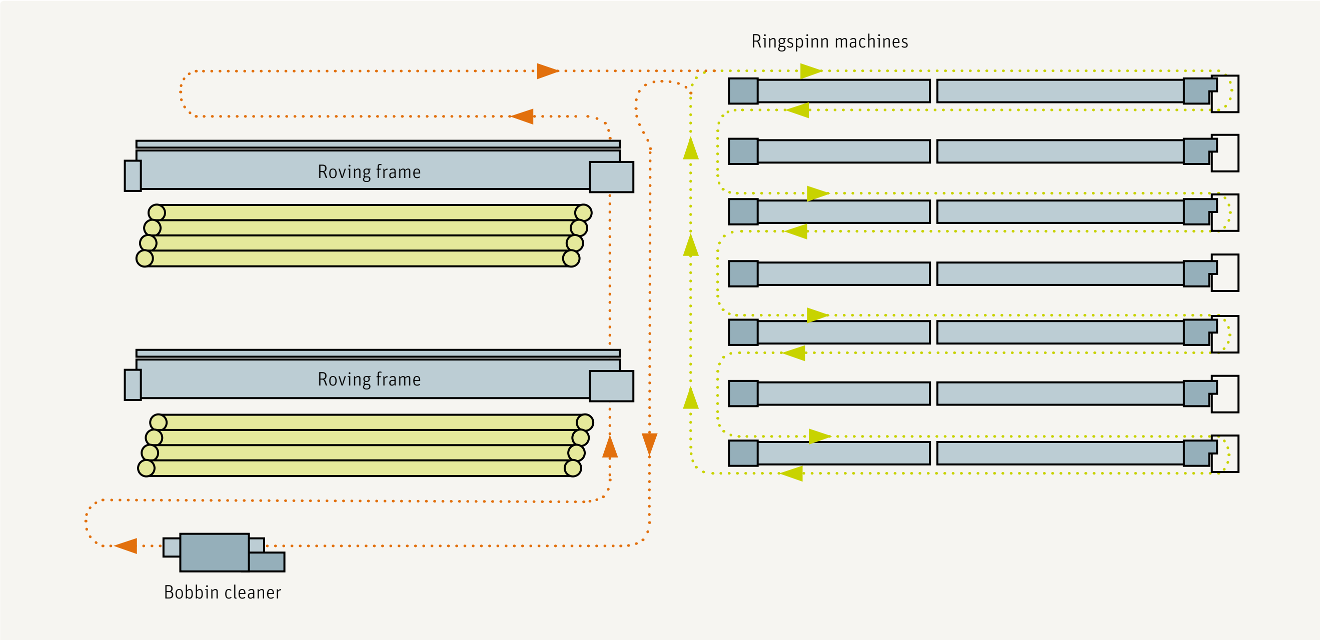


Fig. 34 – Automatic bobbin transport system (Rieter SERVOtrail system)

	Roving 100 % Cotton		
	„Ne 1 590 tex“		**„Ne 2 295 tex“**
	carded	**combed**	**combed**
Quality Level	**CVm**	**CVm**	**CVm**
5 %	4.9	3.2	3.3
25 %	5.5	3.6	3.7
50 %	6.3	4.0	4.2
75 %	7.1	4.6	4.7
95 %	8.0	5.4	5.4

Table 1 – Comparison of mills‘ evenness performance compared (data from www.uster.com, 2008)

ILLUSTRATIONS

The Combing Section

The Drawframe

The Roving Frame

The Rieter Manual of Spinning

Volume 3 – Spinning Preparation

This volume of The Rieter Manual of Spinning covers the technical and technological aspects of the yarn production process between carding and ring spinning. This is the most important part of the process, because the quality of the yarn depends to a large extent on the quality of the intermediate products from which it is made. This volume is in three parts, dealing in turn with the combing section (including preparation for combing), the drawframe and the roving frame.

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