TEXTILE PROCESSING

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The textile process begins with bales of cotton and continues through various processes for the purpose of creating yarns and fabrics for many end uses.

YARN FORMATION

Yarn formation is the process of converting loose cotton fiber into a yarn structure involving a progression of distinctly different and separate processes. The primary functions of these processes are:

- Fiber opening and blending
- Fiber cleaning
- Fiber straightening and paralleling
- Formation of a continuous fiberous strand
- Twist insertion

No matter the end result desired, proper fiber selection is the foundation of any successful spinning operation.

The requirements of the end product, or of the consumer of the yarn, will be the dictating forces in determining the fiber quality and properties that are best suited for the most economic situation. Using fiber that is of *better* quality than required will prove unprofitable. Likewise, using fiber that is of *poorer* quality than required will result in losses. Therefore, correct decisions regarding the most suitable fiber properties for a given operation are paramount for maintaining profitability.

Opening

Opening breaks down compressed layers or clumps of fiber into small tufts, facilitating transport and efficient cleaning (Figure 56).

Blending

Blending brings together fiber tufts from many bales to form a consistent, homogenous mix.

Cleaning

Cleaning removes extraneous matter from desirable fiber.

Basic principles of cleaning:

- beating action
- density differences
- centrifugal and inertial forces
- air flow

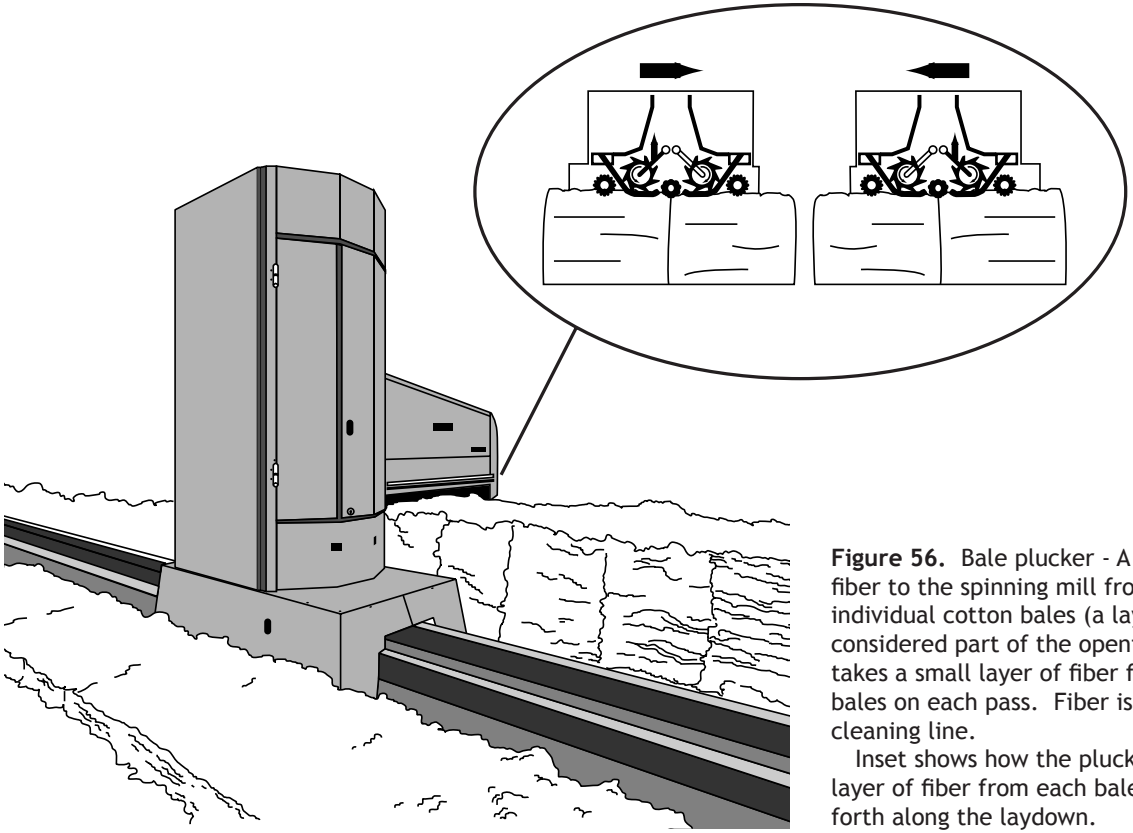


Figure 56. Bale plucker - A bale plucker feeds fiber to the spinning mill from an assemblage of individual cotton bales (a laydown). This step is considered part of the opening process. The plucker takes a small layer of fiber from the top of all the bales on each pass. Fiber is then transferred to the cleaning line.

Inset shows how the plucker head removes a small layer of fiber from each bale as it travels back and forth along the laydown.

Carding

Carding aligns, parallels, cleans, and condenses fiber into sliver (Figure 57).

Other important capabilities of carding:

- nep reduction
- short fiber reduction
- dust removal
- leveling

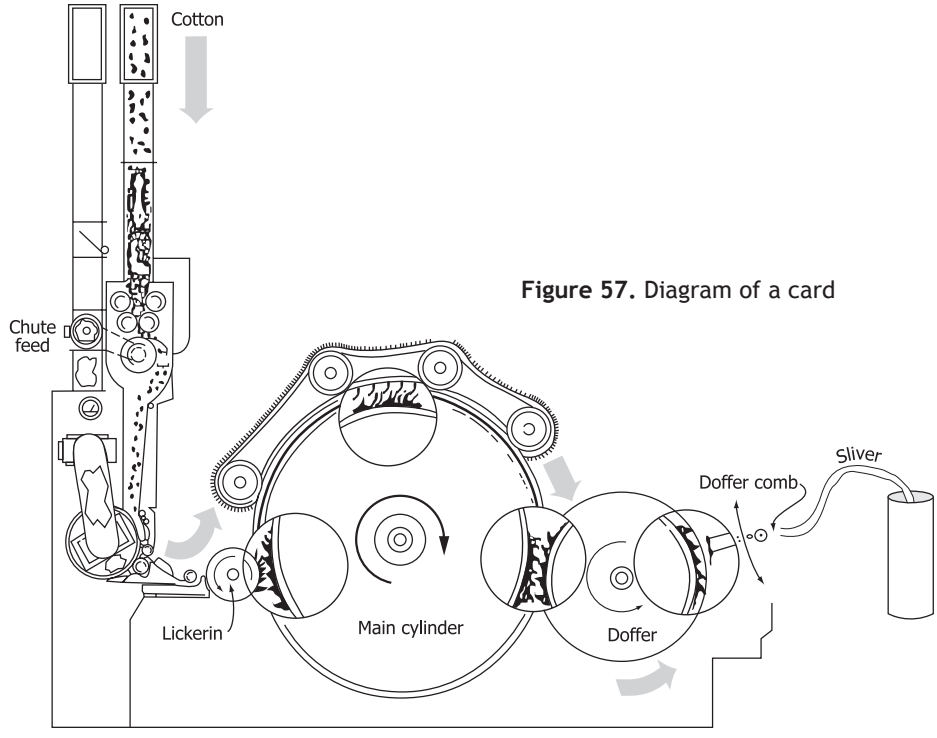


Figure 57. Diagram of a card

Drawing

Drawing blends, straightens, and levels (Figure 58).

Lap preparation

Lap preparation combines a number of slivers into a wound, flat ribbon, (lap) necessary for combing.

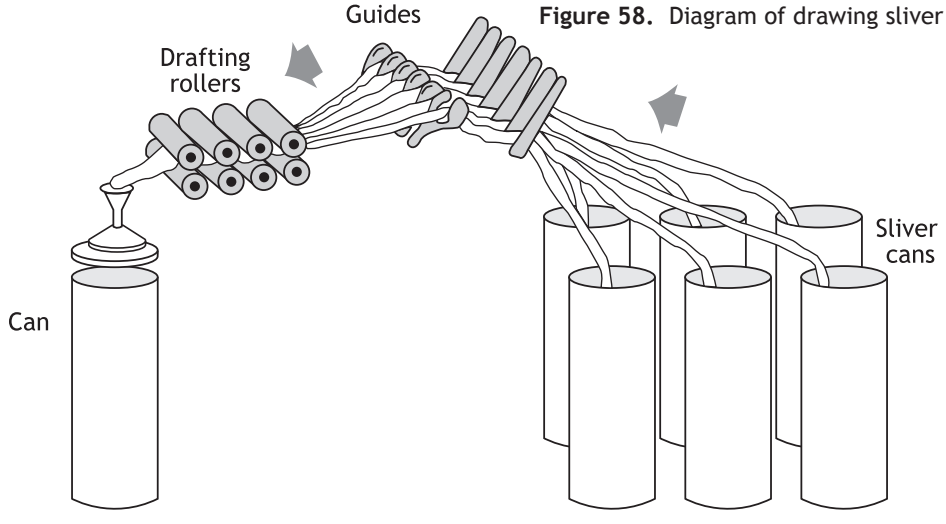


Figure 58. Diagram of drawing sliver

Combing

Combing removes short fibers, straightens, and blends.

Roving

Roving is an intermediate drafting process required for ring spinning that also places sliver onto a bobbin (Figure 59).

Spinning

The insertion of twist into the fiber strand is necessary in order to give integrity and strength to the fiber bundle. The methods employed for inserting this twisting action are distinctly different depending on the spinning technology used. Because the methods for inserting twist are different, the resulting yarn structures also display their own unique forms.

There are three main technologies available for inserting this twist for the purpose of creating a yarn structure. These are ring spinning, open end (or rotor) spinning, and air jet (vortex) spinning.

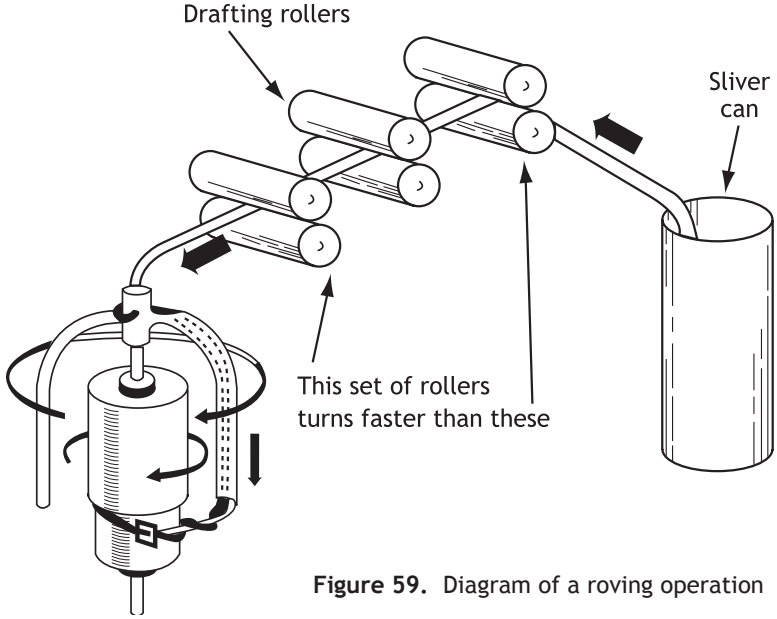


Figure 59. Diagram of a roving operation

RING SPINNING

Ring spinning inserts twist by means of a rotating spindle (Figure 60). Ring spinning is both the slowest spinning method and the most expensive spinning method due to the additional processes required (roving and winding).

Ring spinning produces the strongest, finest, and softest yarn (Figure 61). It is also the most mature spinning technology.

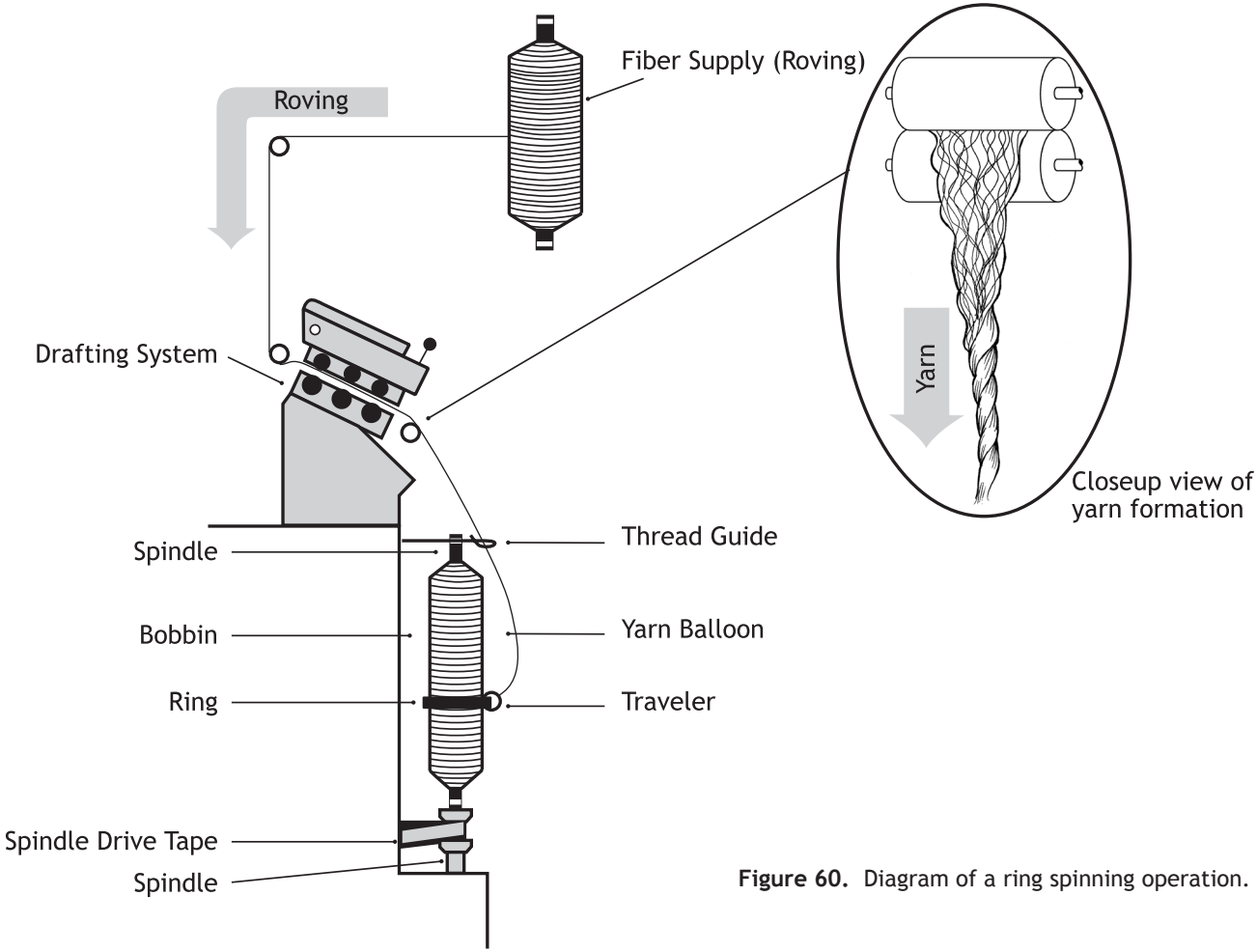


Figure 60. Diagram of a ring spinning operation.

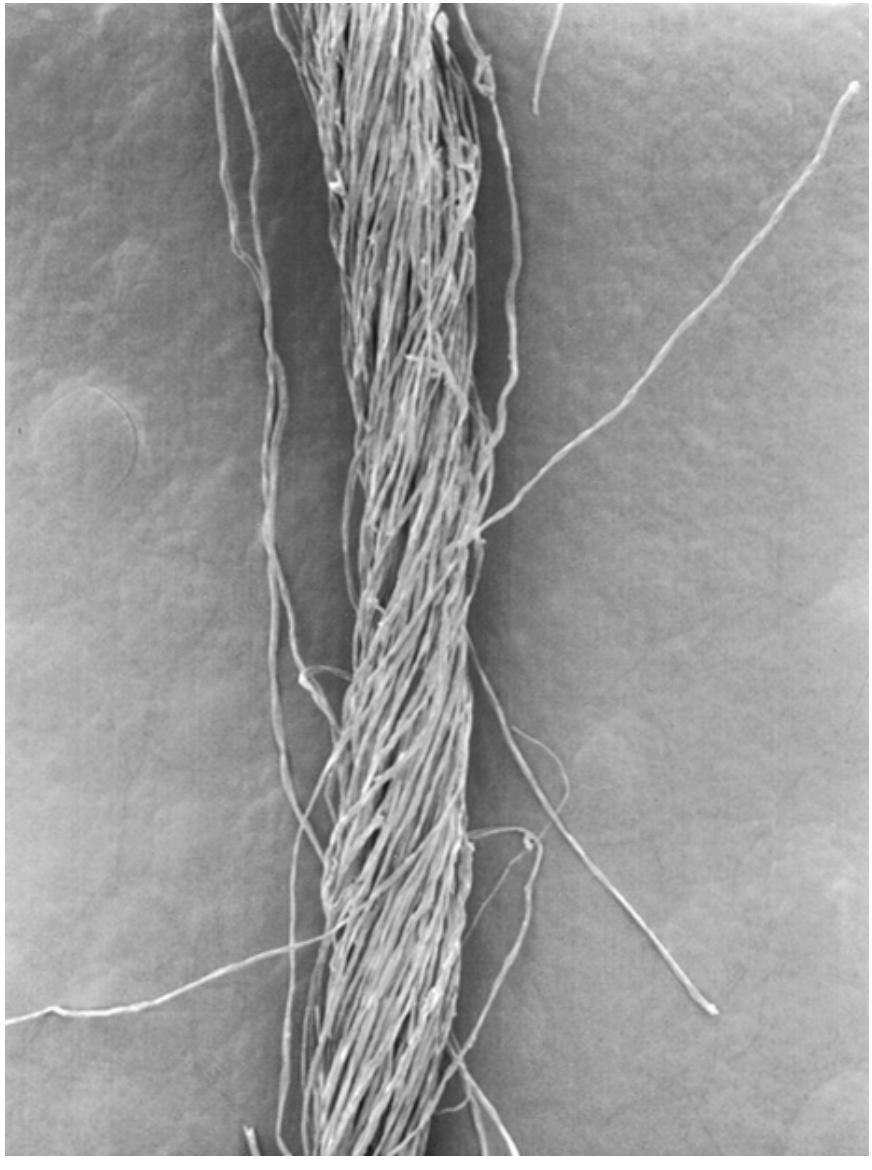


Figure 61. Ring spun yarn -This SEM image clearly shows the helix angle of twist which is responsible for holding the individual cotton fibers together. (M.J. Grimson)

OPEN END (ROTOR) SPINNING

Open end or rotor spinning inserts twist by means of a rotating rotor (Figure 62).

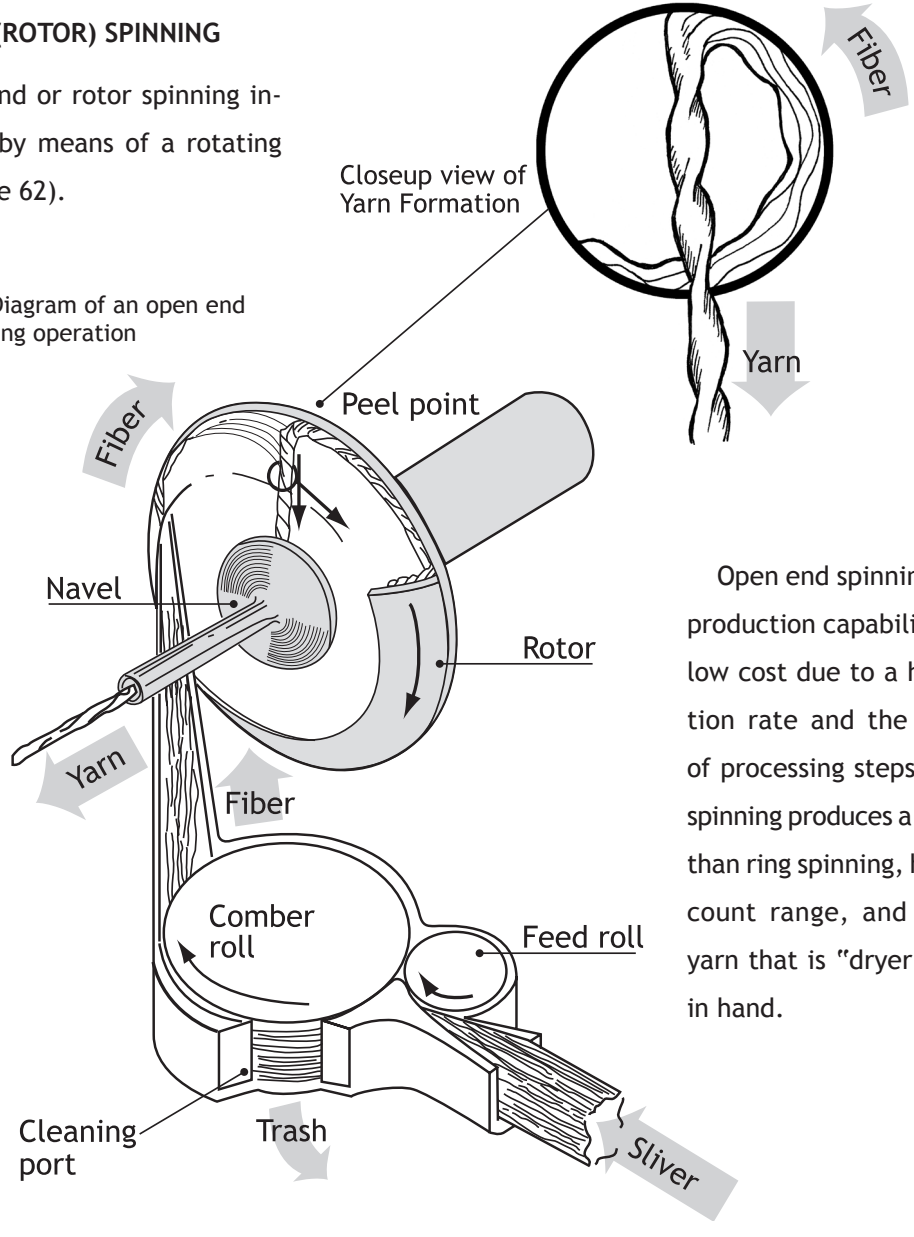


Figure 62. Diagram of an open end (rotor) spinning operation (K. Charlton)

Open end spinning has a high production capability and has a low cost due to a high production rate and the elimination of processing steps. Open end spinning produces a weaker yarn than ring spinning, has a limited count range, and produces a yarn that is "dryer" or harsher in hand.

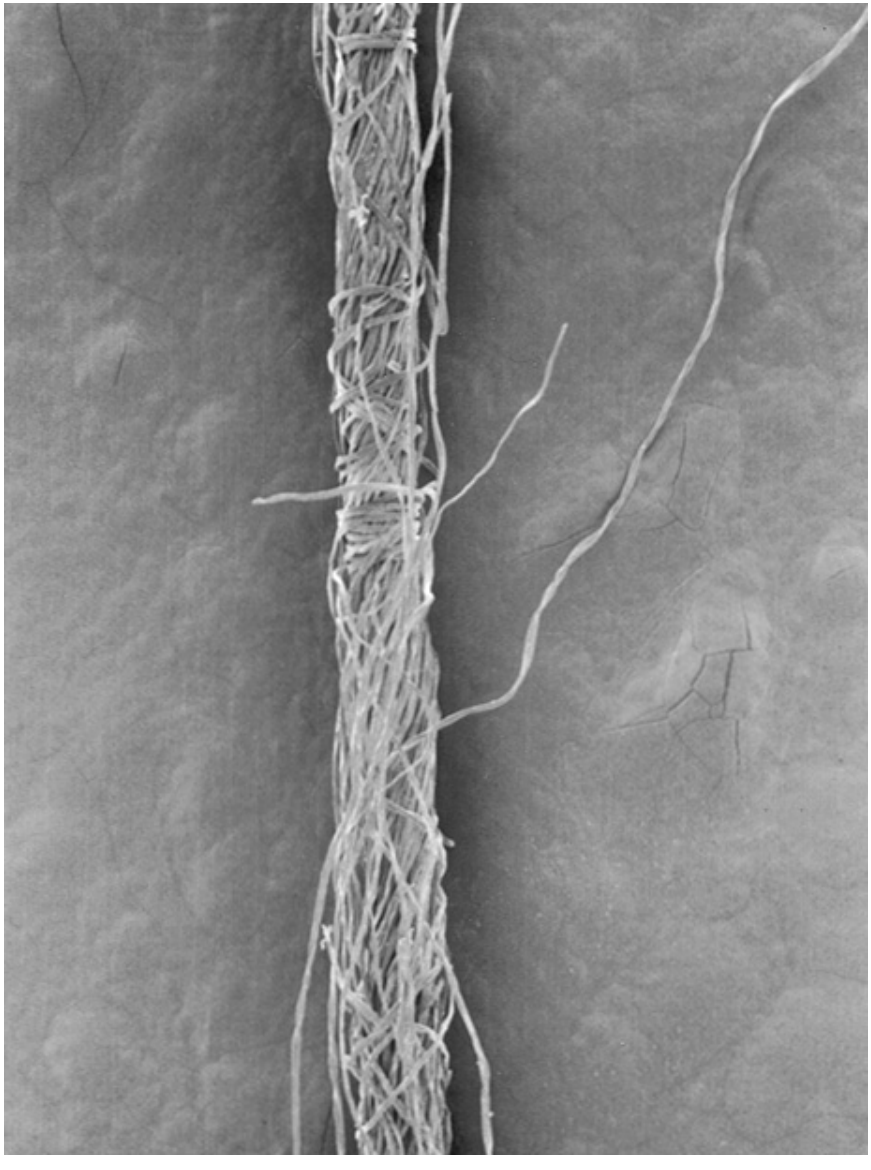


Figure 63. Open end (rotor) yarn - In comparison with the ring spun yarn (Figure 61), the difference in yarn structure is very evident in this SEM image of an open end yarn. Note particularly the wrapper fibers which are perpendicular to the yarn form. (M.J. Grimson)

AIR JET (VORTEX) SPINNING

Air jet (vortex) spinning (Figure 64) inserts twist (Figure 65) by means of a rotating vortex of compressed air. Air jet spinning has a high production capability and a low cost due to a high production rate and the elimination of processing steps.

Air jet spinning produces a weaker yarn than ring or rotor spinning (for 100% cotton) and has a limited range of yarn sizes (counts).

As the yarn count gets finer, the yarn strength improves over open end spun yarns of the same count. Vortex yarn is appropriate for medium to fine yarn counts. The softness of fabrics made from vortex spun yarns usually falls between similar open end and ring fabrics.

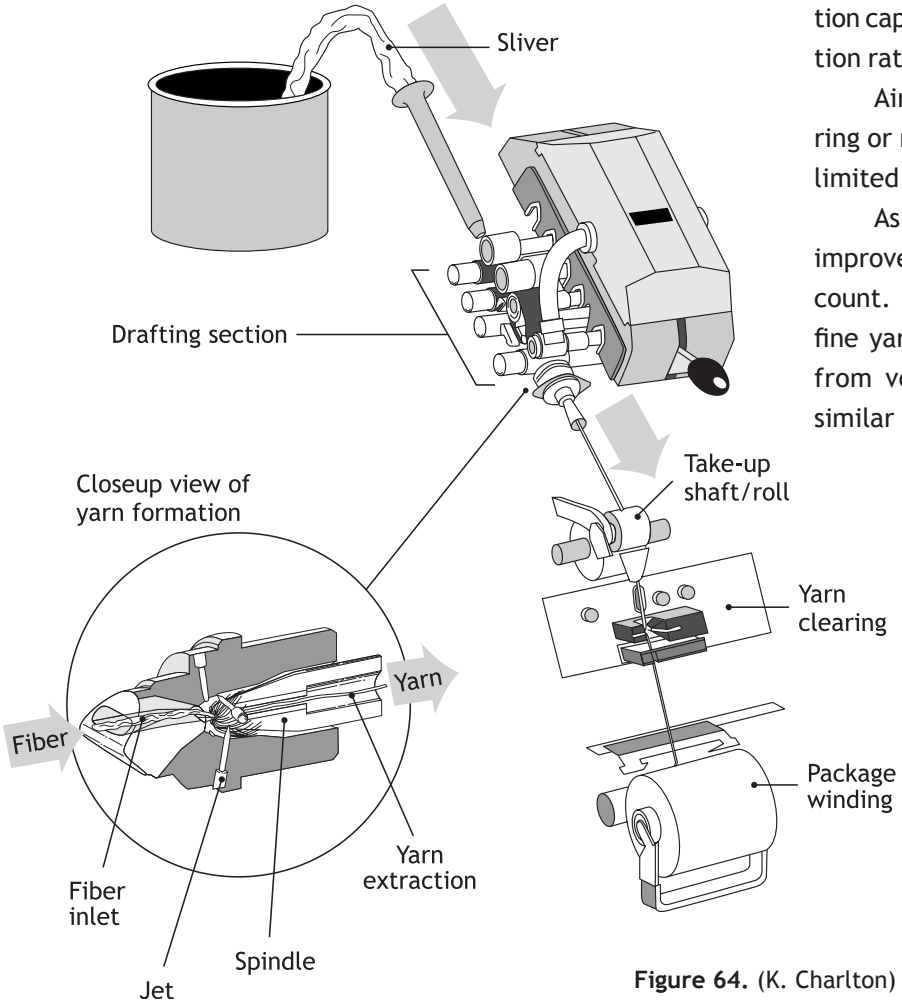


Figure 64. (K. Charlton)

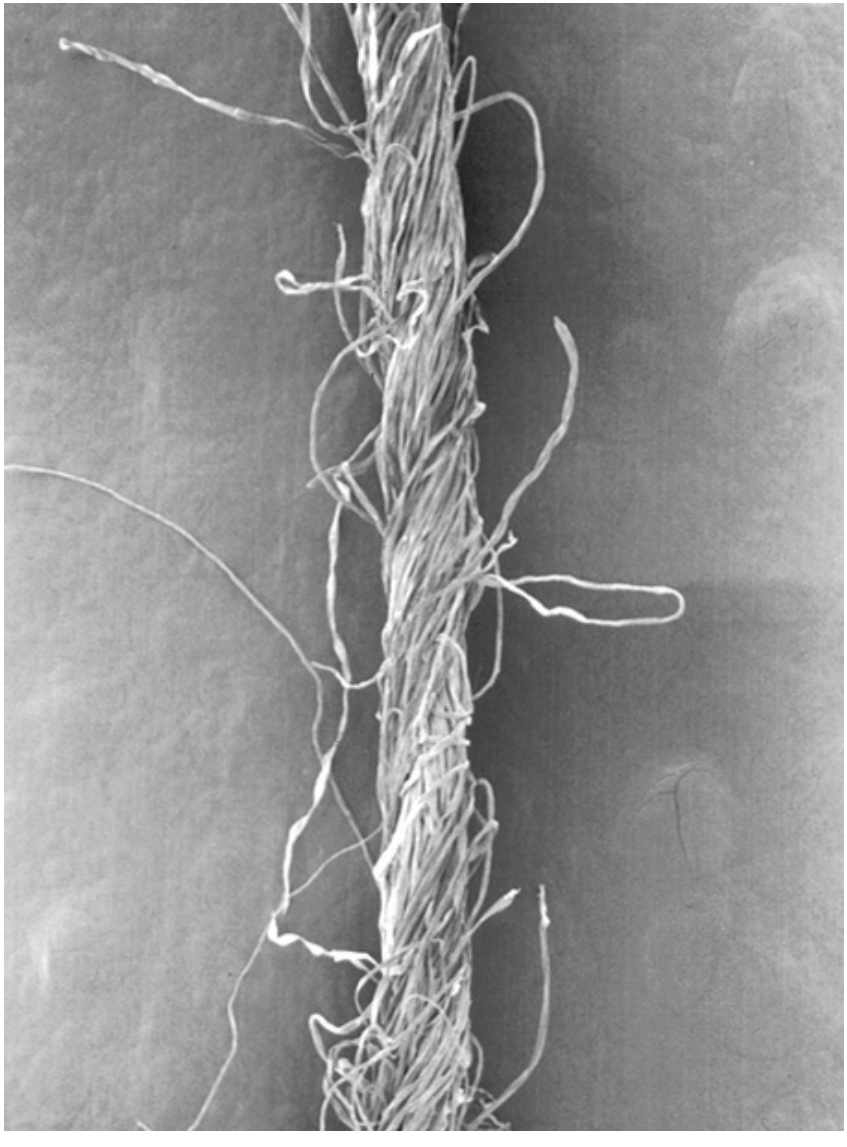


Figure 65. Air jet (vortex) spun yarn - This SEM image of a vortex yarn shows a high degree of similarity to the ring yarn structure.
(M.J. Grimson)

FABRIC FORMATION

Spun yarns can then be used in the formation and production of fabric. There are two main methods for creating fabric structures from yarn - weaving and knitting. Each structure has its own unique characteristics and end uses. For instance, denim is a woven fabric and T-shirts are usually knit fabrics.

WOVEN FABRIC

Weaving involves the interlacing of yarns at right angles, much like making a basket. Depending on the setup of the loom, many weave patterns and fabric constructions can be produced.

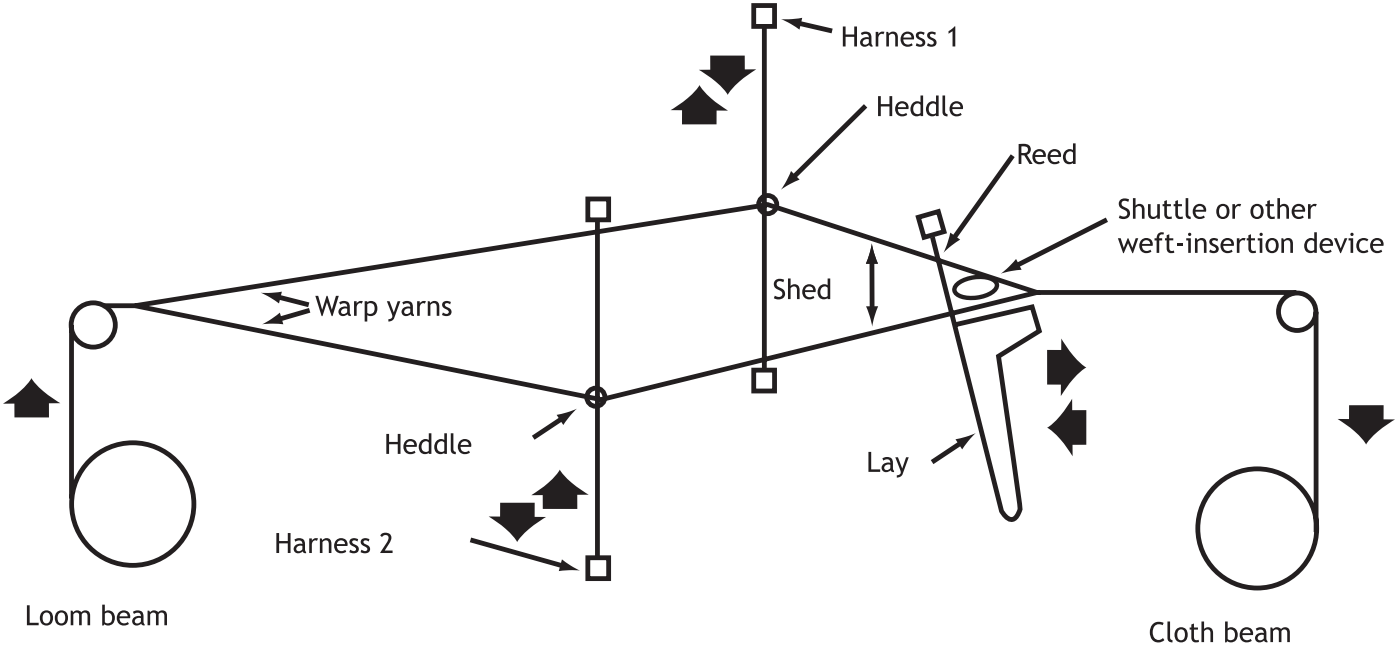


Figure 66. Diagram of a weaving loom - These elements of a loom show how a "sheet" of warp yarns on the loom beam are fed into the harness heddles where they are alternately separated by an up and down motion in order to feed the weft, or filling, yarns perpendicular to the warp yarns. This continuous cyclical action creates the woven fabric structure.

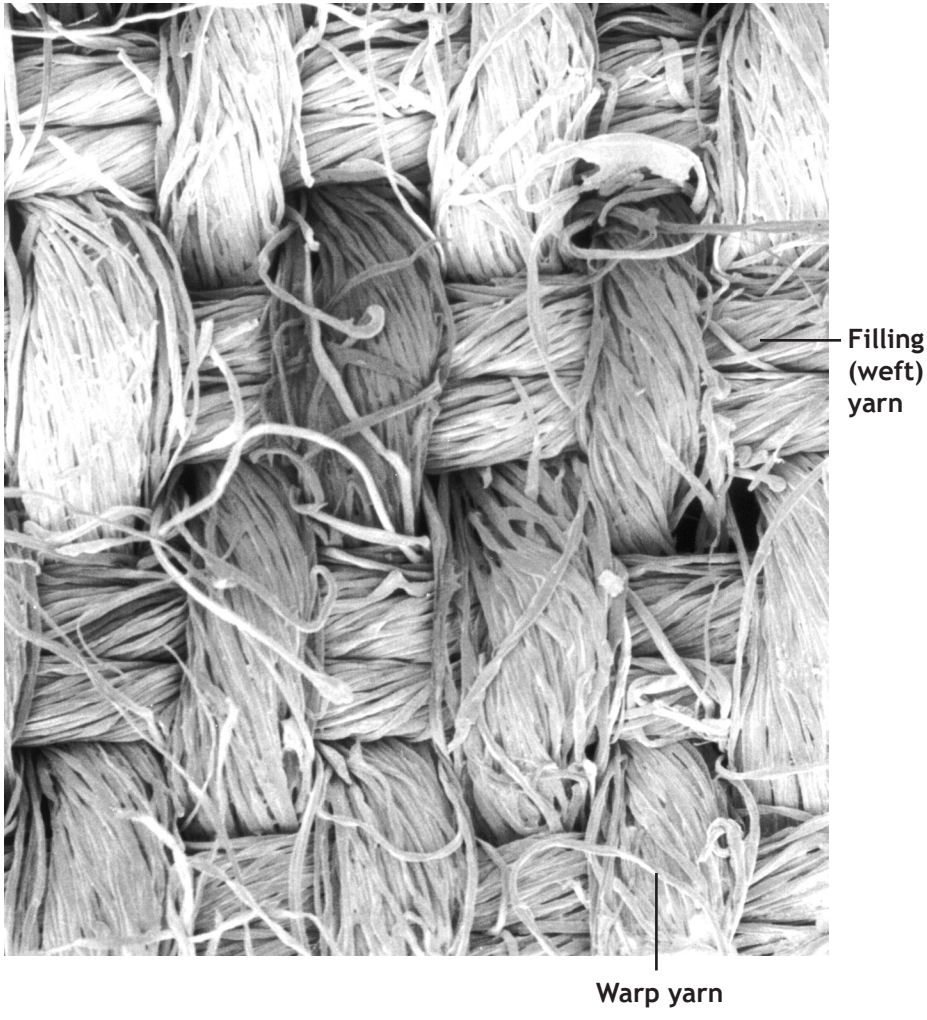


Figure 67. Woven fabric (plain weave pattern) - This SEM shows the interlacing/basket-type configuration of the yarns in a woven fabric. (M.J. Grimson)

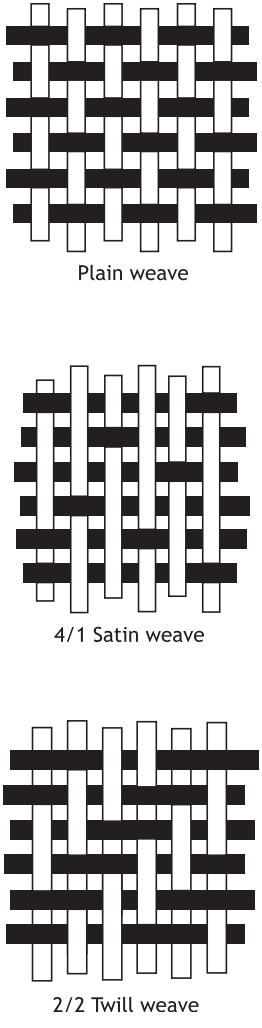


Figure 68. Basic weave patterns. These illustrations are examples of some basic fabric constructions.

KNITTED FABRIC

Knitting involves looping the yarn or yarns around and through one another, much like hand knitting or crocheting (Figures 69 and 70).

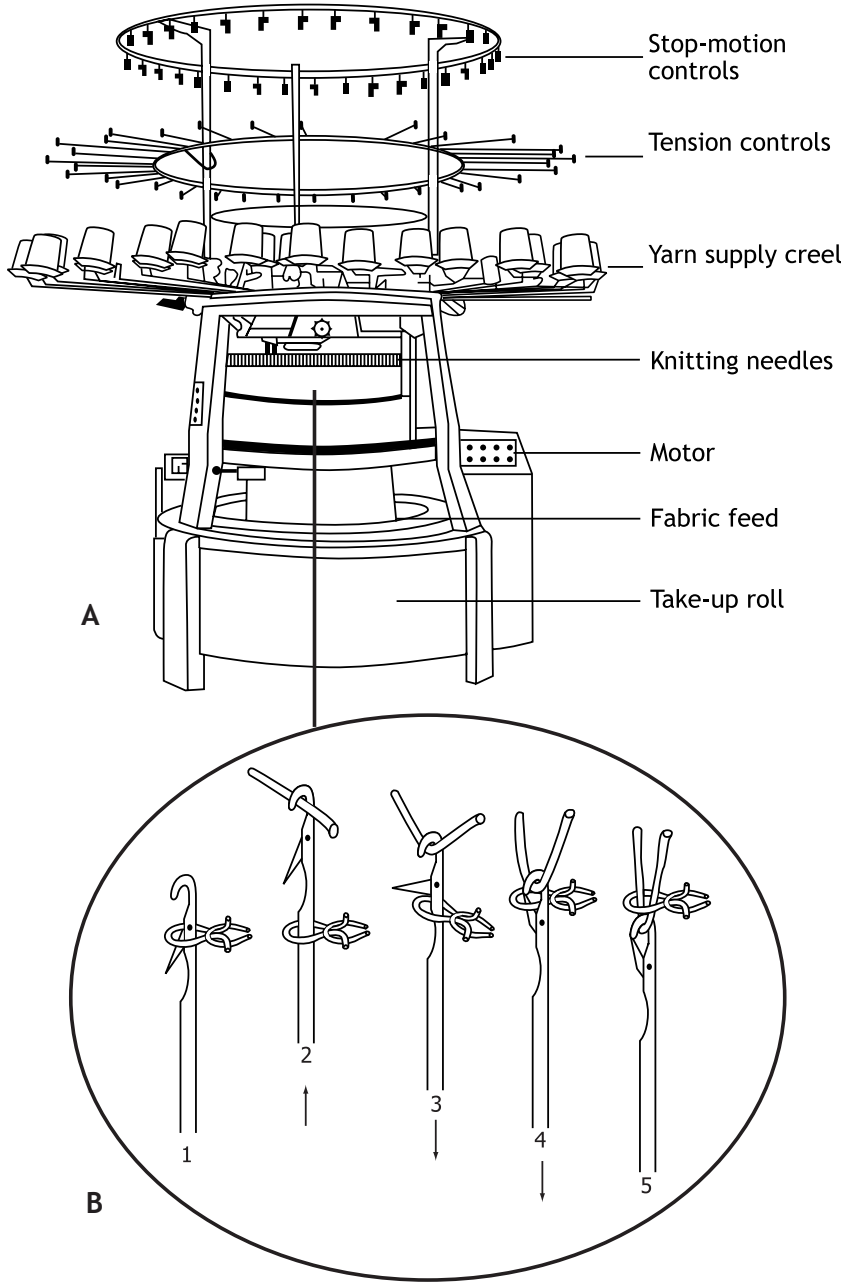
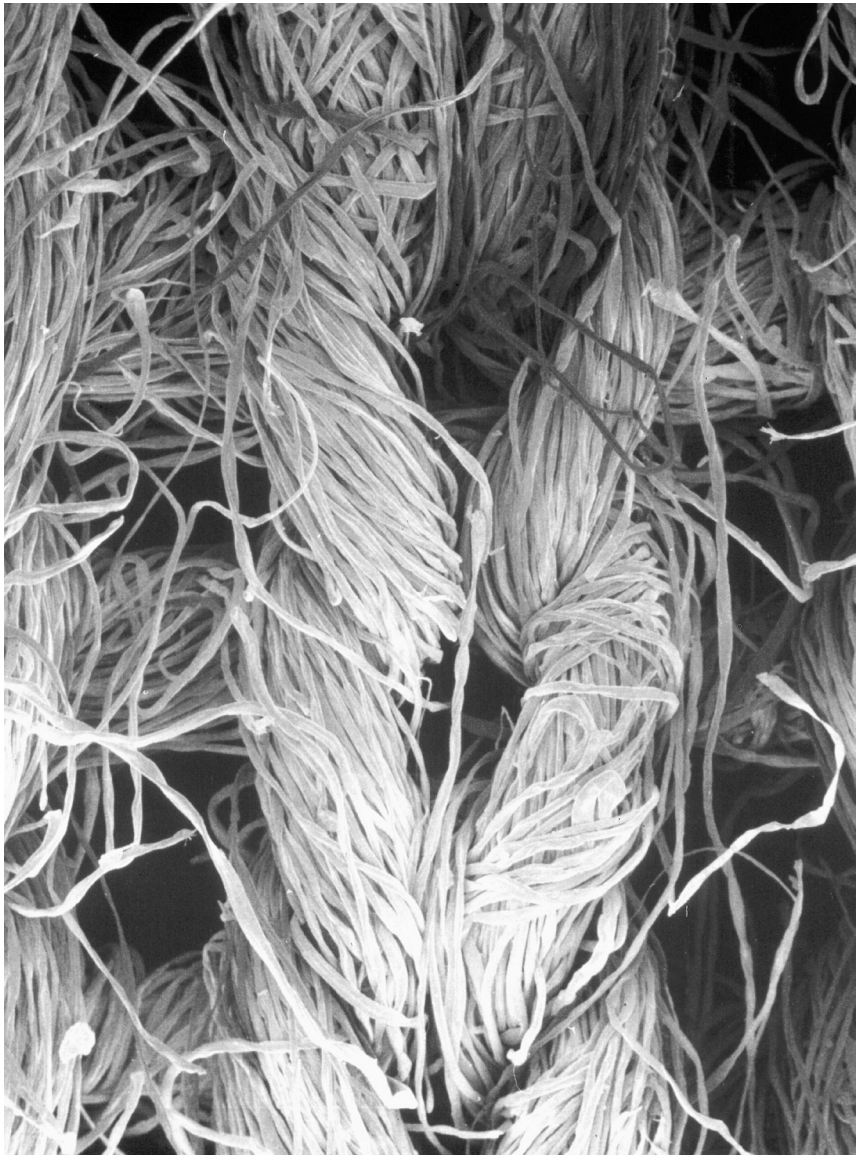


Figure 69. Circular weft knitting -
(A) Circular (weft) knitting produces fabric in a continuous spiral form from numerous yarn supply packages.
(B) Latch needle function and loop formation of knitting.



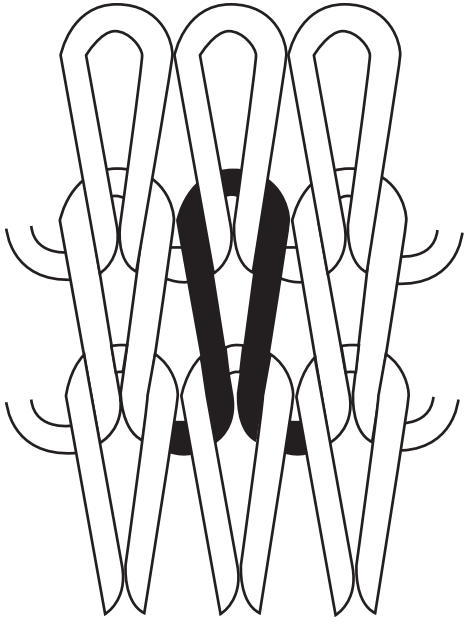


Figure 70. Diagram of knitted fabric

Figure 71. SEM of knitted fabric - This SEM of knitted fabric shows clearly the looping configuration of the yarns which is the basis of most knit structures.
(M.J. Grimson)

NONWOVENS

Nonwovens are fabric structures that are created directly from fiber, bypassing the necessity for yarn formation. These fabric structures depend on thermal bonding, chemical bonding, and /or mechanical entanglement for their integrity. Varied processes, chemistry, and machines are required, depending on the specific end product desired and the technology employed. Common uses of nonwoven fabrics include many products like diapers, disposable wipes, and feminine hygiene products. U.S. paper currency is a nonwoven product using some cotton fiber (Figures 72 - 74).

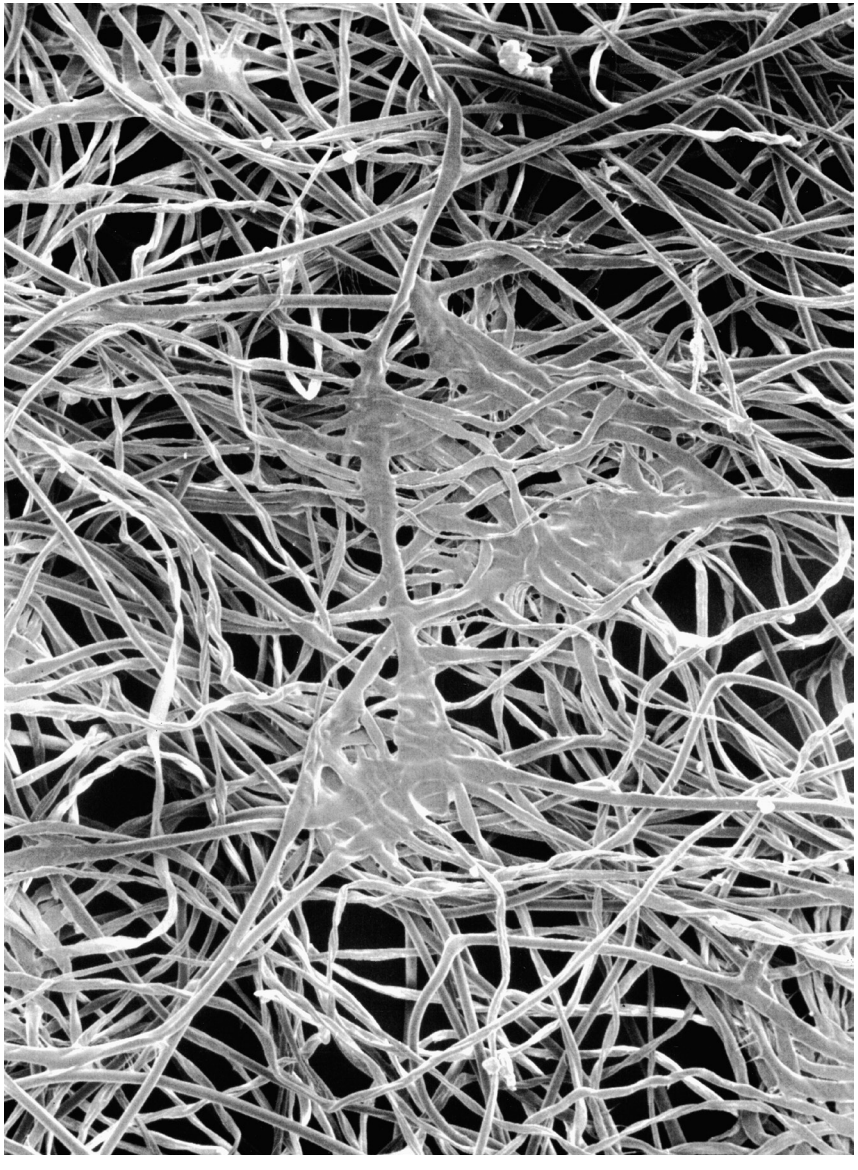


Figure 72. SEM of a thermal bonded nonwoven fabric (M.J. Grimson)

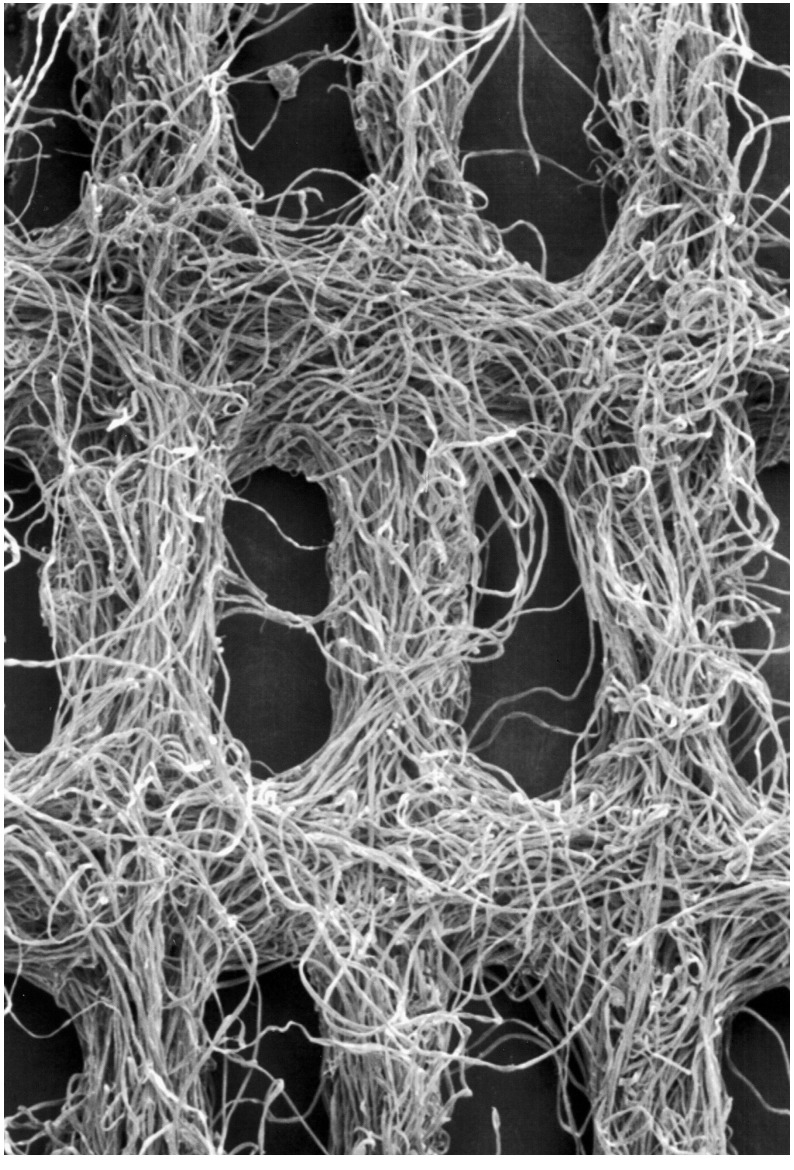


Figure 73. SEM of a hydroentangled nonwoven fabric (M.J. Grimson)

RESOURCES ON COTTON AND PROCESSING

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