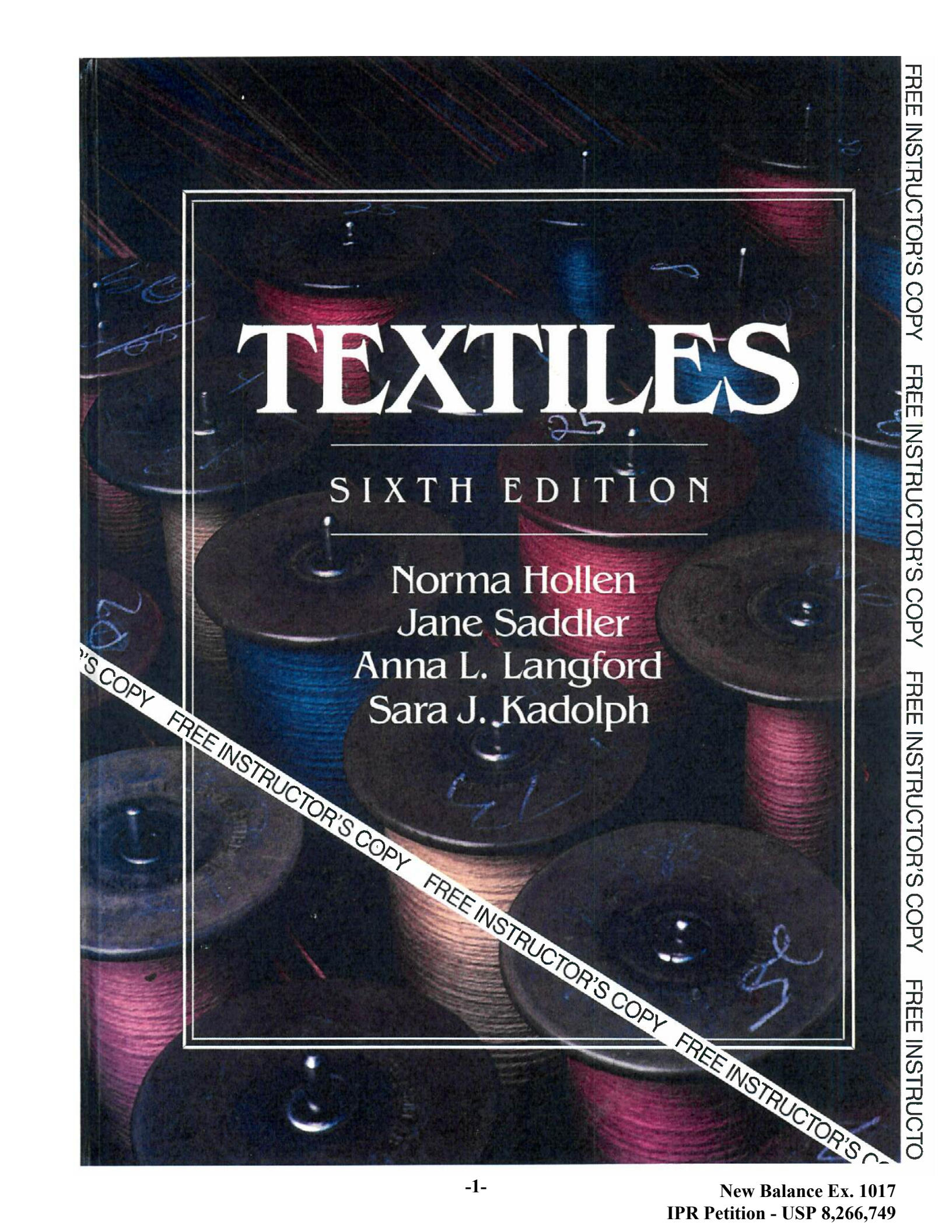




TEXTILES

SIXTH EDITION

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Warp knitting is unique in that it developed as a machine technique without ever having been a hand technique. Warp knitting started about 1775 with the invention of the *tricot machine* by Crane of England. The tricot (pronounced *tree-ko'*) machine is sometimes called a warp loom because it uses one or more sets of yarns that are wound on warp beams and mounted on the knitting machine (Figure 29-6). The first tricot machine made fabric 16 inches wide for silk-stockings cloths. In 1880, Kayser established the first warp-knitting mill in the United States.

Warp knitting provides the fastest means of making cloth from yarns. It has been said that warp knits combine the best qualities of both double knits and wovens. Warp knits can duplicate wovens in many respects while, at the same time, offering the performance and easy care of knits. Warp-knit fabrics tend to be less resilient and lighter weight than weft knits. They can have stability in both directions of the cloth or exhibit a degree of stretch, as determined by the control of the knitting stitch.

Warp knitting produces a vertical-loop construction, as shown by the line of loops in Figure 29-1. It is a machine process of making fabric in flat or sheet form using one or more *sets* of warp yarns that are fed from warp beams to a row of knitting needles extending across the width of the machine. Each set of yarns is controlled by yarn guides mounted in a guide bar that also extends across the width of the machine. Warp-knitting machines are wider than looms with a width of 170 inches. If there is one set of yarns, the machine will have one warp beam and one guide bar; if there are two sets of

yarns, there will be two warp beams and two guide bars, and so on: hence the terms *one-bar tricot* and *two-bar tricot*. All guide bars feed yarn to the same set of needles. Each yarn guide on the bar guides one yarn to the hook of one knitting needle. Chains with links of various heights control the movement of the guide bars. More guide bars give greater design flexibility. The loops of one course are all made simultaneously when the guide bar raises and moves sideways, laying the warp around the needles to form the loops, which are then pulled down through the loops of the preceding course.

Warp knits are usually diagrammed using a *point-paper notation*. In this notation, each point in a horizontal row represents a needle. In warp knitting, all the needles knit at one time. Thus each row of points represents the needles used to produce one course. In the point-paper notation, the movement of a guide bar is diagrammed for each course. Because the guide bar controls the movement of the yarn, the guide-bar diagram shows yarn movement. Thus the diagram for each row of points represents the movement of the guide bar to create the yarn loops for that course. The next row of points would represent the next course, and so on until one complete repeat has been represented. The diagram starts at the bottom row of points and moves up the paper from course to course as time progresses. Figure 29-1 is a diagram for a warp knit. In Figure 29-2, steps (a) through (g) show the movement of the guide bar as it directs the yarn's movement to create that warp-knit stitch. In (a) of Figure 29-3, the seven steps are combined in one diagram; in (b), the resulting yarn loop is shown; in (c), the two repeats of the pattern are shown. In Figure 29-4, the knitting action of a tricot machine is diagrammed.

Yarn from the front bar usually predominates on the surface, whereas yarn from the back bars provides run resistance, elasticity, and weight.

The warp-knitting industry is expanding into nonapparel uses. It is also focusing on short runs rather than on volume production and lead times of weeks rather than months. Apparel end uses for warp knits include lingerie, underwear, sportswear, and outerwear. Industrial end uses are the most rapidly expanding area and include fabrics for sun and light protection, for controlling rock falls, for grass collection, for snow barriers, and for dam reinforcement. Warp-knit fabrics are also used as medical implants such as

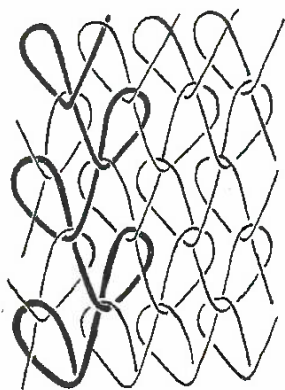


Fig. 29-1 Warp-knitting stitch.

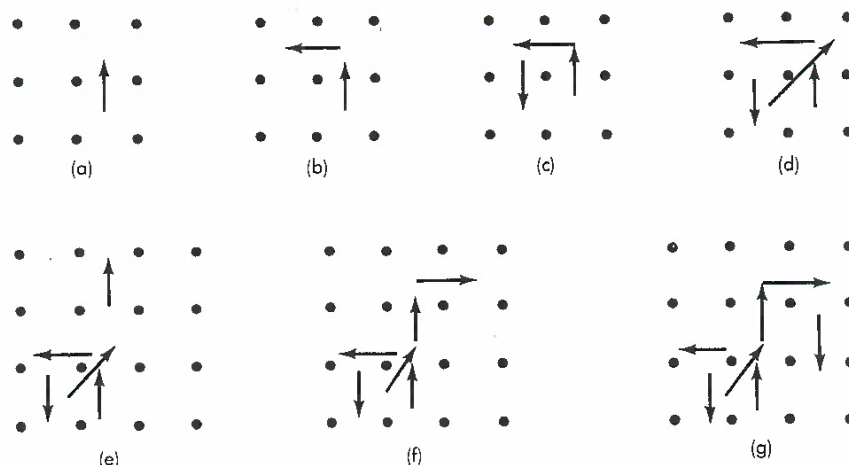


Fig. 29-2 Guide-bar movements, step by step, for warp-knit stitch.

artificial veins and tissue-support fabrics.

Even though warp knitting is fast, warp knits are not inexpensive because the process requires very regular yarns. Thus the cost of the yarns offsets the fast speed of the process.

MACHINES USED IN WARP KNITTING

Warp knits are classified by the equipment type used to produce the fabric and the characteristics of the resulting fabric. Tricot machines use a single set of spring-beard or compound needles. Tricot-knitting machines with computer-controlled guide bars, electronic beam control, and computerized take-up are able to knit 2,000 courses per minute. Raschel machines use one or two sets of vertically mounted

latch needles. Jacquard Raschel knitting machines with as many as 78 computer-controlled guide bars are available. The differences between the fabrics produced by these machines have become less distinct in the past several years. Several types of warp knitting machine are listed in the chart on page 272. Tricot and Raschel machines, however, account for the manufacture of about 95 percent of all warp-knit goods.

WARP KNITS VERSUS FILLING KNITS

The two kinds of knits differ because of the different knitting techniques and the machines used in their manufacture. The major differences are summarized in the following chart (on page 272).

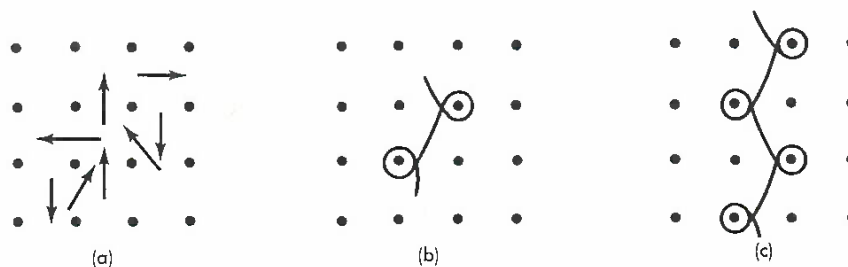


Fig. 29-3 Guide-bar movements: (a) all steps of the guide-bar movement; (b) yarn movement following the guide-bar movement; (c) series of yarn loops creating warp-knit fabric.

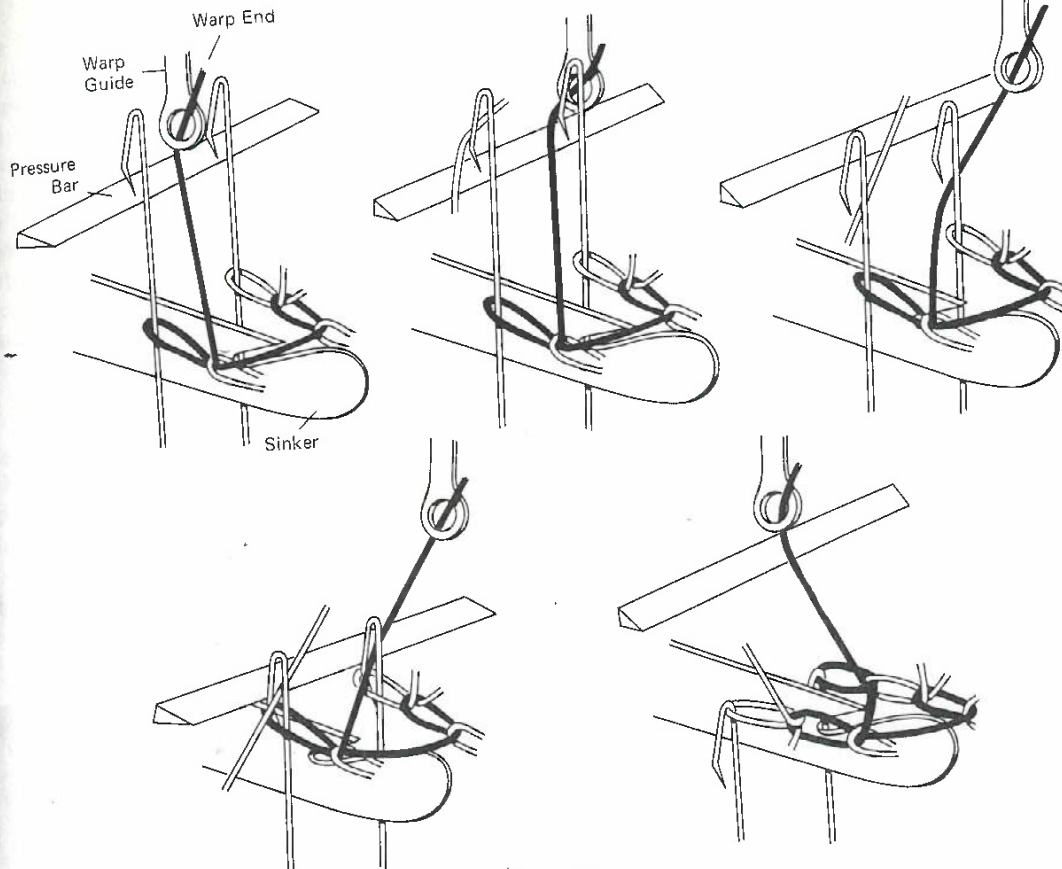


Fig. 29-4 Knitting action of tricot machine. (Courtesy of Knitting Times, the official publication of National Knitwear and Sportswear Association.)

Tricot-Warp Knits

The name *tricot* has been used as a generic name for all warp-knit fabric; specifically, it is the fabric produced on the tricot machine using the *plain stitch*. This fabric is called tricot. Tricot comes from the French word *tricoter*, meaning *to knit*.

The plain stitch is shown in Figure 29-5. The face of the fabric (top photo) is formed of vertical portion of loops and the back (lower photo) has horizontal portion of loops. The face has a much finer appearance than the back. Tricot is run-proof and nonraveling. The fabric will curl just as weft-knit jersey does. Tricot fabric has high tear strength, high resiliency, and elasticity, which is greater in the crosswise direction. Some

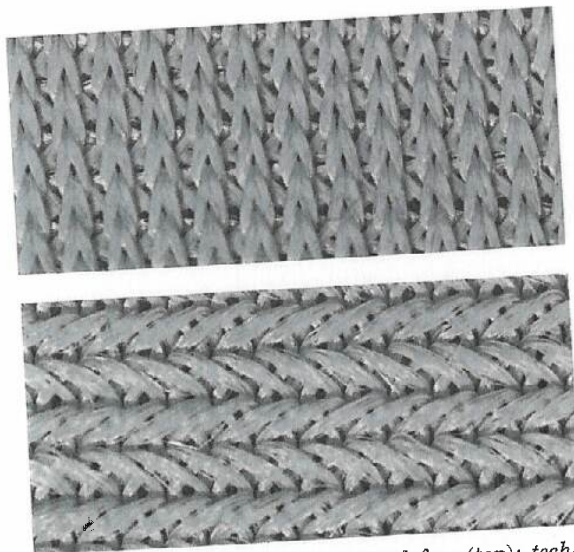


Fig. 29-5 Two-bar tricot: technical face (top); technical back (bottom).

Warp-Knitting Machines

<i>Tricot</i>	<i>Raschel</i>	<i>Simplex</i>	<i>Milanese</i>
Single bed	One or two needle beds	2 sets of needles	Flat—spring-beard needles
Spring-beard needles or compound needles	Latch needles Coarse gauge	Spring-beard needles	Circular—latch needles
2–3–4 bars indicate number of sets of warp yarns	May have as many as 65 guide bars		Yarn travels diagonally from one side of material to the other
Simple fabric High-speed, high-volume Usually filament yarns	Complex fabric Great design possibilities Usually spun or spun and filament	Rare	Rare
Wide fabric 170 inches	Narrow fabric (100 inches)		
<i>End Uses</i>			
Plain, patterned, striped, brushed fabric Underwear Outerwear	Sheer laces and nets Draperies Power net Thermal cloth Outerwear	Warp double-knits Gloves	Underwear Outerwear

important end uses of tricot fabrics include the following:

- Lingerie
- Sleepwear
- Loungewear
- Men's shirts
- Uniforms for nurses, waitresses and the like
- Jersey dresses and blouses
- Other outerwear
- Automotive fabrics (upholstery)

Comparison of Filling and Warp Knits

<i>Filling Knits</i>	<i>Warp Knits</i>
 Yarns run horizontally Loops joined one to another in the same course	 Yarns run vertically Loops joined one to another in adjoining course
Connections are horizontal More design possibilities More compact fabric Two-way stretch	Connections are diagonal Higher productivity More compact fabric Crosswise stretch, little lengthwise stretch
Run, most ravel Hand or machine process Flat or circular Can have finished edges Can knit shaped garments, garment pieces, or yardage	Do not run or ravel Machine process Flat Produced as yardage

The Tricot Machine. The first tricot machines which used spring-beard needles, were designed to use the finer yarns for blouses, underwear, and loungewear. Spun yarns were not knit on these machines, because the increased friction from the fuzzy ends and the irregularities that are typical of spun yarns caused excessive yarn breakage. Until the early 1970s, only 2 percent of the warp knits were made of spun yarns. Then tricot machines, such as the Reading Spunwarp machine that used a latch needle, were developed for knitting spun yarns and novelty yarns as well as textured yarns.

The modern tricot machine is the mainstay of the warp-knitting industry (Figure 29-6). It is a high-speed machine that can knit flat fabric up to 170 inches wide. The machine makes a plain-jersey stitch or can be modified to make tuck stitch, clipped dot, jacquard, and other designs. Another modification is the attachment for laying in yarn in a tricot structure.

Tricot Fabrics. Plain tricot is made on a machine employing one set of needles and two guide bars. Filament yarns are used in either smooth or textured form. Acetate is an inexpensive yarn that is used for tricot backing of bonded fabrics.

Few, if any, methods of cloth manufacture can produce anything comparable to nylon tricot in the standard ranges of 15-40 denier. Nylon tricot is light weight (17.5-6.5 yards/pound), has exceptional strength and durability, and can be heat set so that it is dimensionally stable. One of the unique features of nylon tricot is that the same piece of gray goods can be finished under different tensions to different widths that have different appearances; for example, 168-inch gray goods can be finished at 98, 108, 120, 180, or 200 inches wide.

Brushed tricots are a common application of warp-knit fabrics. The velvet-like surface consists of loops raised from the surface. Heat-set

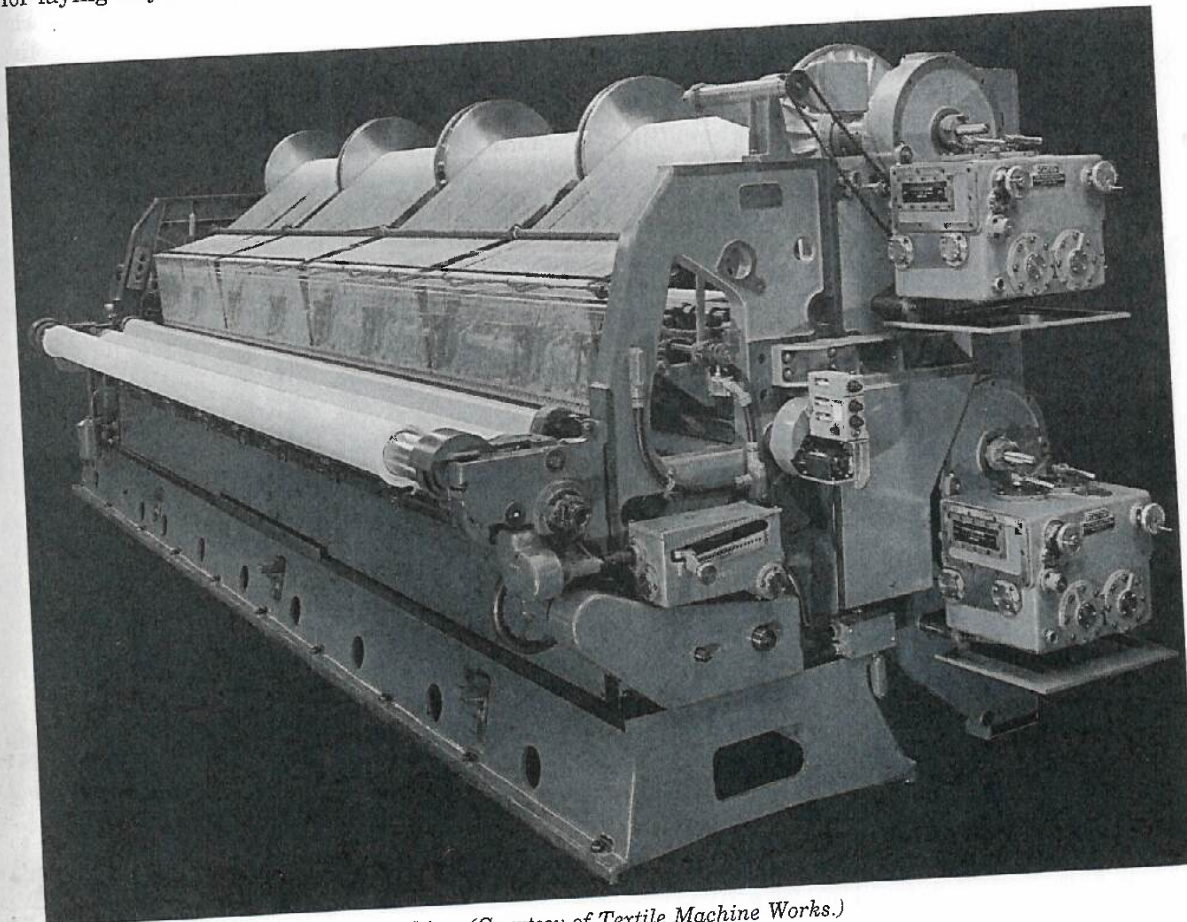


Fig. 29-6 Warp-knitting tricot machine. (Courtesy of Textile Machine Works.)

nylon must be used, so it is possible to raise the loops without breaking them. The fabric is versatile and has several end uses such as sleepwear, evening gowns, shoes, slacks, upholstery, and draperies. Velcro closures with loops acting as catches for hooks are another end use.

Napped velours can be dyed, dried, heat set, and then napped on a double-action napper, heat set again to proper width, and then sheared.

The knit stitches have long underlaps. One set of yarns is carried over 3–5 yarns to form floats; the second set of yarns interloops with adjacent yarns. Nylon is used for the adjacent looping to provide strength and durability. The floats are broken when the fabric is run through the napper. The napped side is used as the right side of the fabric even though it is the technical back (Figure 29–7).

Satin-like tricots are made in the same way as napped tricots except that the fabric is Schreinered (see Chapter 33) instead of napped. These fabrics are usually 100 percent nylon or polyester and the floats are longer.

Tricot-net fabric can be made by skipping every other needle so only half as much yarn is used and open spaces are created in the fabric.

Tricot strips for trim can be made by cutting on a slitter or by knitting in a yarn that is later dissolved.

Striped tricot is made by using acetate yarn on the second and/or third bars and pulling the heavier yarn to the face in alternating horizontal rows. Cross dyeing gives the difference in color.

Tuck effects use the same yarns as in the striped fabrics, but a change in the yarn ar-

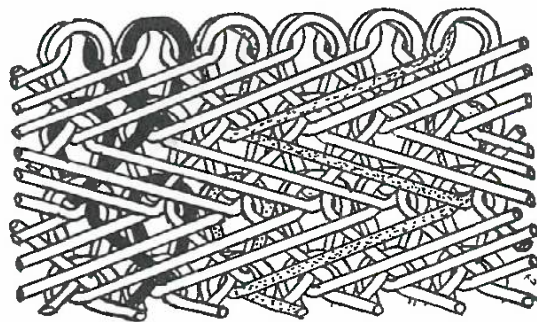


Fig. 29–7 Warp knit velour before napping. Black yarn is nylon; white and gray yarns will be broken during napping. (Courtesy of Knitting Times, the official publication of National Knitwear and Sportswear Association.)

rangement forms a “lip,” or tuck. The tucks may be straight, wavy, irregular, intermittent, wide, or narrow.

Automotive tricot upholstery—a double-knit velvet—has been introduced (see Figure 29–8).

Tricot Finishing. Nylon and polyester require heat setting to stabilize the fabric against shrinkage, to improve the hand, and to give good stitch definition and desirable cutting properties. Most heat setting is done on the pin-tenter frame. Either radiant heat or superheated steam is used. Shrinkage can be controlled to within 1 percent. If the tricot is dry heat set on the tenter frame with 15 percent extension in width, improved crease resistance during wear is achieved.

The Schreiner finish (see Chapter 33) was first used on tricot in 1957. Called Satinette, the finish causes a permanent flattening of the yarns, thus filling in the open spaces of the knit structure to give more cover and make the fabric more opaque. The fabric has a satiny smoothness.

Pleating is a natural for nylon tricot and is done with a pleating machine, which folds the fabric with pleating paper in the form desired. The fabric is steamed and the paper is removed. (A pleated effect can be achieved during the knitting process by leaving out yarns in alternate areas.)

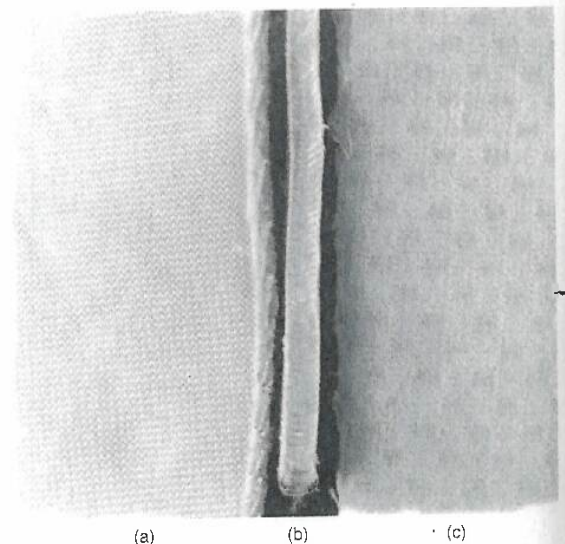


Fig. 29–8 Knit-velvet car upholstery: (a) as knit; (b) cross-sectional view; (c) after separation.

Bonding is usually done with single-tricot jerseys. Acetate or nylon tricot is commonly used for the backing of bonded woven goods. Bonding provides greater stability and gives body to the fabric.

Antistatic, antislip, and flame-retardant finishes are also used for tricot fabrics.

Raschel-Warp Knits

The Raschel-warp-knitting machine has one or two needle beds with latch needles set in a vertical position and as many as 78 guide bars. The fabric comes from the knitting frame almost vertically instead of horizontally as in the tricot machine. The various Raschel machines knit a wide variety of fabrics from gossamer-sheer nets and veilings to very heavy carpets.

Raschel knits are used industrially for laundry bags, fish nets, dye nets, safety nets, and covers for swimming pools.

Raschel Fabrics. Crochet-type fabrics have rows of chain-like loops, called *pillars*, with laid-in yarns in various lapping configurations (Figures 29-9 and 29-10). These fabrics can be identified by raveling the laid-in yarn and noticing that the fabric splits or comes apart lengthwise.

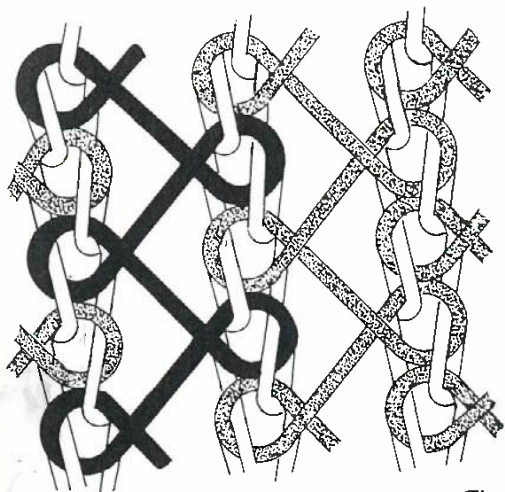


Fig. 29-9 Raschel knit. (Courtesy of Knitting Times, the official publication of National Knitwear and Sportswear Association.)

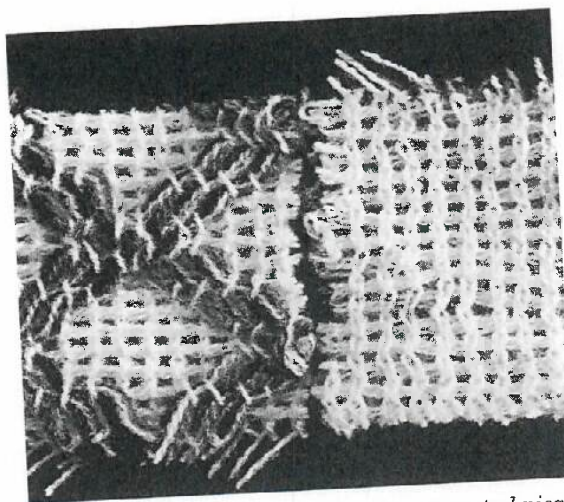


Fig. 29-10 Raschel knit with extra yarn: technical face of fabric (left); technical back of fabric (right).

Window-treatment fabrics and outerwear fabrics are knitted on this standard-type machine.

Carpets have been knitted since the early 1950s. Since their production is faster, knitted carpets are cheaper to make than woven carpets. Tufted carpets, being still much cheaper to produce, have captured most of the carpet market. Knitted carpets have two- or three-ply warps for lengthwise stability; laid-in crosswise yarns for body and crosswise stability; and pile yarns of nylon, wool, or acrylic. Knitted carpets can be identified by looking for chains of stitches on the underside. They seldom have a secondary backing. These carpets are usually commercial carpets.

Lace and curtain nets of the kind made on Leavers lace machines (see page 241) can be made at much higher speeds on a Raschel machine. The Raschel machine has a single needle bed and up to 78 guide bars. Window-treatment nets, which can have square, diamond, or hexagonal meshes, are made on tricot machines. Laces are usually made of nylon or polyester (Figure 29-11).

Thermal cloth has pockets to trap heat from the body knitted in; it looks like woven waffle cloth and is used mainly for winter underwear. Brynje is the name given to this fabric, which is much like the Norwegian fisherman's vest. This knit is also used for some thermal blankets.

Power net is an elasticized fabric used for foundation garments and bathing suits. Nylon is used for the two-bar ground construction and

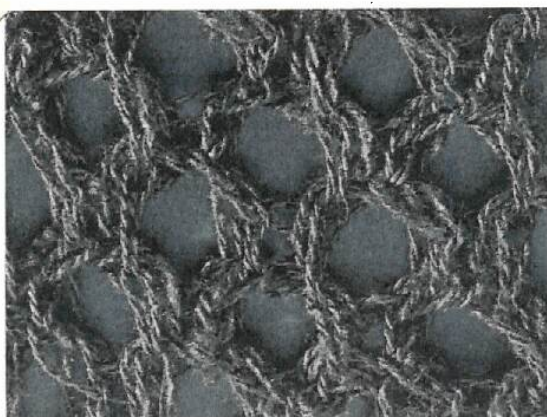


Fig. 29-11 Raschel fabric.

spandex is laid in by two other guide bars (Figure 29-12).

WEFT INSERTION

Weft insertion is done by a warp knitting machine with a weft-laying attachment. Several models have been developed. The simplest attachment carries a single filling yarn to and fro across the warp knitter, and this yarn is then fed steadily into the needle zone of the machine. A firm selvage is formed on each side.

More-complex attachments supply a sheet of filling yarns to a conveyor that travels to and

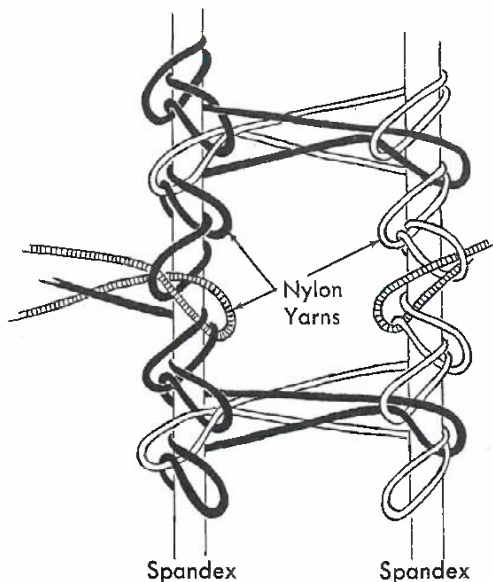


Fig. 29-12 Raschel power-net stitch.

fro across the machine. Figure 29-13 shows the Weft-Loc machine, which carries as many as 12 filling yarns in 6-inch bands. The yarns are then fed into the stitching area of the machine. A cutting device trims filling yarn "tails" from the selvages and a vacuum removes the tailings.

Weft-insertion fabrics offer the best properties of both woven and knitted cloth: namely strength, comfort, cover without bulk, and weight. They are lighter weight than double knits but have more covering power. They have increased crosswise stability of weaves but retain the comfort of knits. The fabric in Figure 29-14, which was made on a Weftamatic modified tricot machine, resembles a tricot jersey. It has a 20-denier-nylon knitting yarn and a 15 denier-polyester insertion yarn. The polyester of several colors, making a horizontal strip. Warp knits usually have vertical stripes unless printed because by nature the fabric contains only vertical yarns.

In weft-insertion warp knits, the insertion yarn is caught in a vertical chain of stitching. These fabrics are used for hospital curtains and table linens, as well as for other home-furnishings and industrial uses.

WARP INSERTION

The insertion of warp yarn into a knit structure gives the fabric the vertical stability of woven cloth while retaining the horizontal stretch of knit fabric (Figure 29-15). The cloth is basically a single tricot.

WARP AND WEFT INSERTION

Warp and weft insertion fabrics have characteristics very similar to woven fabrics. These fabrics can be much less expensive than woven fabrics and are available in wide width. They are frequently used as window treatment fabrics (see Figure 29-16).

Minor Warp Knits

SIMPLEX

The *simplex machine*, which is similar to a tricot machine, uses spring-beard needles, to

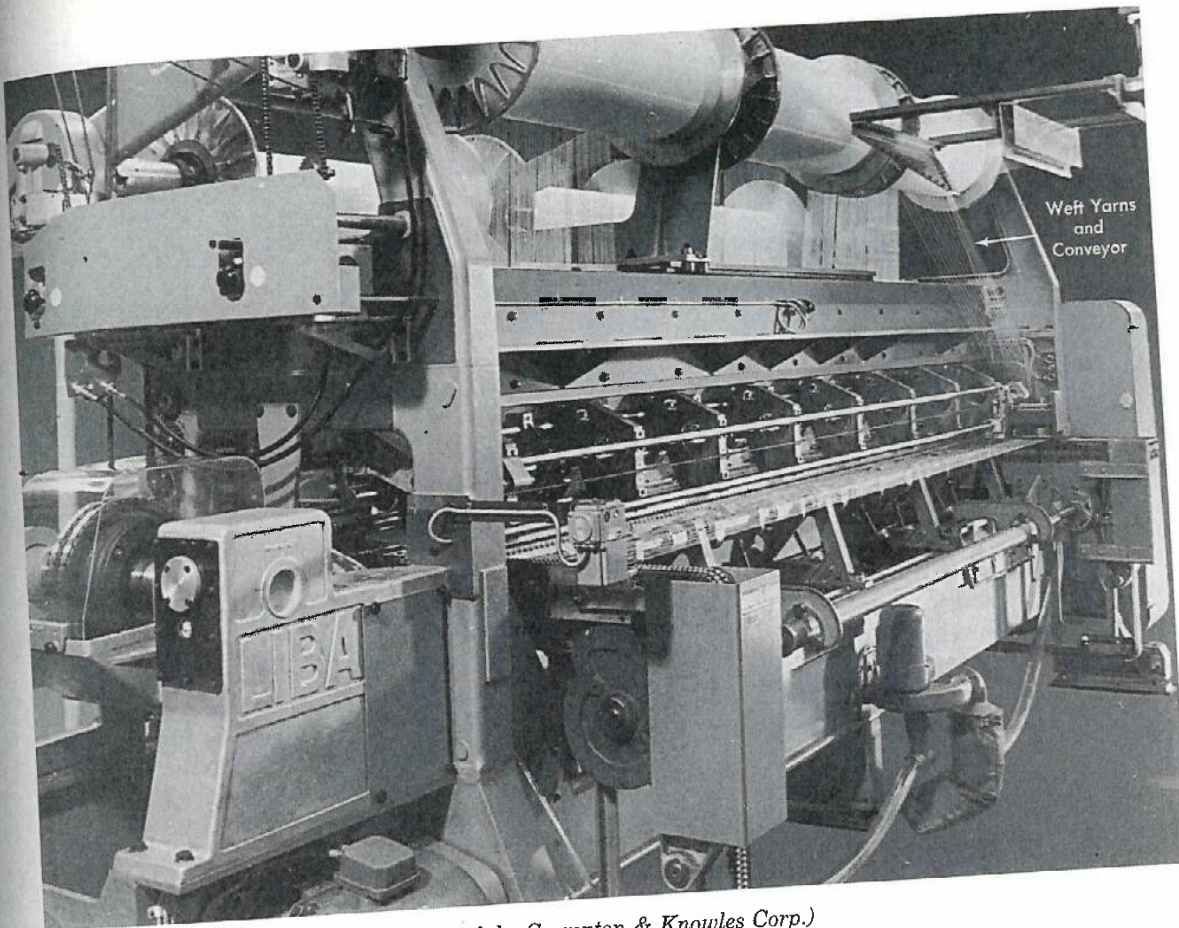


Fig. 29-13 Weft-Loc machine. (Courtesy of the Crompton & Knowles Corp.)

needle bars, and two guide bars. It produces a two-faced fabric somewhat like circular double knits. End uses are gloves (traditional), swimwear, and dresses.

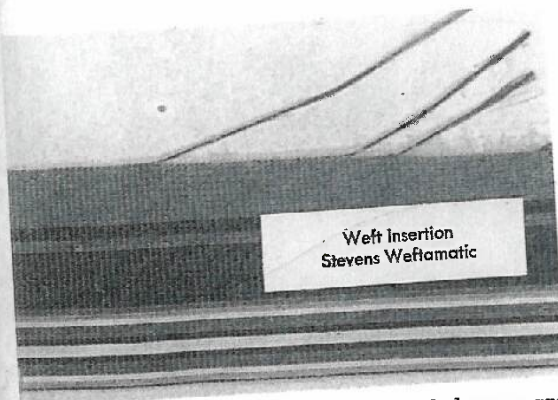


Fig. 29-14 Weftomatic fabric. The raveled yarns are the polyester filling that are inserted in the warp-knit stitches.

One company, Blue Ridge Winkler Textiles of Bangor, Pennsylvania, produces most of the simplex knits. Glove fabrics are given a suede finish by passing them two or three times over

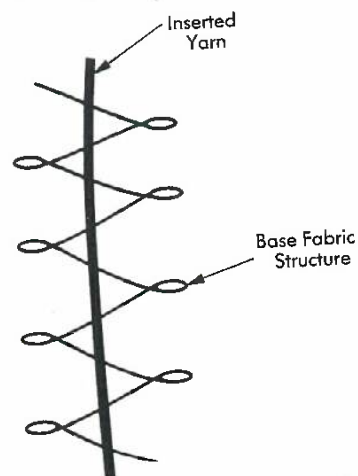


Fig. 29-15 Diagram of warp-knit warp insertion.

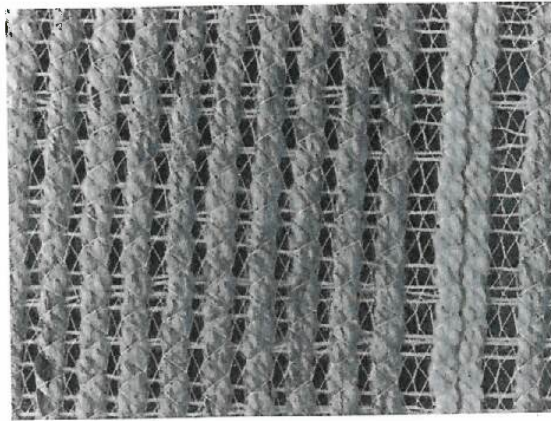


Fig. 29-16 Warp and weft insertion. Warp knit case-ment fabric for windows.

revolving sandpaper-covered rollers. The number of times the fabric is passed through the machine is determined by the degree of sueding desired. Dyeing follows.

MILANESE

The *Milanese machine* is especially constructed to produce superior warp-knit fabrics. The machine can use both kinds of needles. It is equiv-

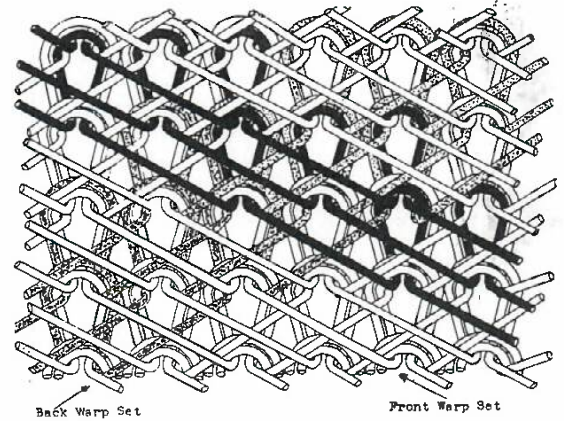


Fig. 29-17 Milanese. (Courtesy of Knitting Times, the official publication of National Knitwear and Sportswear Association.)

alent to a two-bar tricot fabric and made from two sets of warp yarns with one needle bar and one guide bar. But the lapping movements are arranged so each warp thread moves across the full width of the fabric, one set knitting from right to left and the other from left to right. This results in a diagonal formation (Figure 29-17), which shows up on the back of the cloth. The face has a very-fine rib. The fabric is runproof and is used for gloves and lingerie.