CHAPTER 3

FABRIC MATERIALS

THE TANGIBLE ELEMENT IN TEXTILES IS YARN.* Yarn is made from fibers, slender thread-like filaments that are derived from leaves and stems of plants, from animals, minerals, and chemicals. These materials have diversified properties and characteristics: they may differ not only in appearance but also in such properties as strength, durability, and elasticity; in response to heat and moisture; and in lightness, warmth, and coolness. These factors are important to the hand weaver since they have a bearing on the use of a yarn and its suitability for certain fabrics, and may often dictate its use as a warp or a weft element.

The weaver is often confronted with a situation where he has to compromise between a yarn that is aesthetically agreeable but, because of the nature of the fiber and the yarn construction, it may be less suited to the structural needs of a fabric than a less promising yarn. Any evaluation in such cases must be based on knowledge of the fibers and, particularly, from an examination of their behavior in the weaver's preliminary design samples.

► SOURCES OF FIBERS

A list of the more commonly used textile fibers includes:

1. Natural fibers
   a. Vegetable origin
      (1) Cotton – a seed-hair fiber almost 100 per cent cellulose
      (2) Linen, hemp, jute, and ramie – bast fibers, from the stems of plants

* Thread, which is designed and made solely for sewing purposes, is rarely used for weaving; the hard cable construction is unsuitable for most textiles.

(3) Sisal and silk grass – from the leaves of plants
(4) Coir – from the outer shell of the coconut

b. Animal origin – wool, silk, and the hair fibers
c. Mineral origin – Fiberglas, metals, and asbestos

2. Man-made fibers
a. Vegetable origin
(1) Viscose rayon and cuprammonium (Bemberg) – derived from regenerated cellulose
(2) Acetate – from unregenerated cellulose
(3) Vicara – from the protein of corn

b. Mineral origin

Acrilan, dacron, dynel, nylon, orlon, and saran – with others whose uses are not so well defined. This group of fibers, including acetate, is referred to as thermoplastics because of their sensitivity to heat. Static electricity is another property common to this group of fibers.

► NATURAL FIBERS

Until the twentieth century, cloth was woven predominantly from four fibers: cotton, linen, wool, and silk. Today, the first three in this group are probably used more often by the hand weaver than all other fibers combined.

Of the vegetable fibers, *cotton* is still the most important economically. At the present time it exceeds all fibers in the total quantities produced. While the United States is the largest producer, the plant has a wide distribution and is cultivated in many parts of the world. Egypt, India, Turkey, Brazil, Russia, Peru, and China—all produce a sizable volume.

The cotton fiber is obtained from seed pods, or the bolls, of the plant. It is an exceptionally fine filament and possesses a slight natural twist—a feature that is most conducive to spinning. There are four or five species of the cotton plant and many varieties. In this country the most important is *American Upland*. This is grown throughout the Cotton Belt, from the Carolinas to Texas, and comprises the major portion of our production, supplying us with our commodity fabrics. For quality cloth and fine materials, *Sea Island* and *Pima* are often used.

Pima is a soft, silky fiber that was developed from the Egyptian species transplanted to this country more than 100 years ago. (The name Pima is taken from the county, Pima, in Arizona, where the plant was first grown.) For strength and firmness Pima is rivaled only by Sea Is-

land, a variety grown in Georgia, the islands off the coast of South Carolina, and in sections of Florida.

The nature of cotton—its general stability under conditions of heat, tension, and rough handling—makes it a valuable yarn for the hand weaver. Since cotton yarns can be spun with a variety of textures—soft or hard, dull or shiny, and in intermediate degrees—their usefulness extends over a wide range of textiles.

By means of mercerization, cotton yarns can be given extra-smooth surface qualities and rich luster. In this process the yarn is immersed in a caustic soda solution and held under tension; the fiber swells, the natural twist of the fiber is reduced, and a bright, smooth yarn is produced. Long-fiber cotton is usually used for mercerizing; after being combed and spun into yarn, the projecting ends of the fibers are usually singed by passing through a gas flame. Yarns so processed are termed "gassed."

In altering its structure, mercerizing increases the strength of the yarn. It also gives it a greater affinity for dye, and clear bright colors are attainable by vat dyeing. Mercerized cotton yarns that conform to fixed standards of quality are often sold under proprietary names, such as "Durene." The names "Pearl" or "Perle" carry similar connotation, but refer more specifically to a soft twist type of mercerized cotton.

Many fibers of commercial value are obtained from the leaves and stems of plants. Stem fibers are usually finer in size and more pliable than leaf fibers, and certain yarns from stem fibers, such as linen and ramie, are of particular interest to hand weavers.

Linen is made from fibers found in the stem of the flax plant. Flax, which has been cultivated for centuries, is grown for two purposes: for fiber production and for seed, from which we get linseed oil. Plants grown for fibers may yield strands as long as 30 inches. While small in diameter, they possess marked strength and, when spun into yarn, give a smooth finish and sheen that is quite beautiful in its natural state.

The fiber is not an easy one to dye, but because of demand by hand weavers, yarn manufacturers now offer an extensive range of color in linen. The cool, smooth, lintless properties of linen are found in no other fiber. These qualities added to its exceptional durability recommend the use of linen in many types of fabric, and we find it a favorite with hand weavers today as it was, indeed, two thousand years ago.

In processing flax, the long fibers are made into a strong, smooth, lus-

trous yarn called "line" linen. However, a percentage of the fibers will be reduced to short, broken lengths. These are spun into a type of linen that is known as *tow*. Cheaper grades of fiber are spun into a yarn that has a relatively coarse, uneven surface, with no appreciable luster. From the hand weaver's point of view, however, they are very usable, for they have a peculiar homespun quality that combines well with other yarns. Weavers sometimes dye the natural-colored tow themselves to get soft, muted tones that will complement another filler yarn.

A yarn less frequently used by hand weavers, but of considerable interest, is made from *ramie,* a plant native to the Orient. The plant, sometimes known as "China grass," produces a fiber with exceptional properties. It is thin, light in weight, and has a tensile strength that exceeds any known natural fiber. Varied atmospheric conditions do not affect the fiber; while it will absorb moisture, it dries quickly. Lack of elasticity, however, causes it to wrinkle easily. Ramie has pronounced luster and is believed to have been used at one time in some parts of China as a substitute for silk.

Ramie is difficult to process. The fibers in the stem of the plant are bound together by an adhesive gum and, in separating them, many are broken into various lengths. It is necessary either to sort these lengths or to cut them into a uniform size in order to spin a good grade of yarn. Special equipment is needed for spinning. Ramie is now cultivated in Florida, the Philippines, and, to a limited extent, in Mexico, the West Indies, and southern Europe.

Many kinds of leaf and stem fibers are utilized by the cordage industry for rope and twine. A few applicable to handweaving are mentioned here. Some, like jute, are spun into yarn, either using the jute fiber alone, or combining it with others within a given yarn.

To most of us, *jute* is associated with burlap, a fabric usually made from that fiber. There are many grades of jute, however; the color range may run from a tawny brown through many intermediate shades to a clear ecru tone. This is found in the finest grade, which is soft and smooth, and possesses considerable luster. Weavers, as a rule, prefer to use jute in natural tones; the fiber doesn't bleach easily, and most colors tend to impair rather than enhance the beauty of the fiber. Like tow linen, however, the natural jute might be dyed by the hand weaver in subdued shades and used as an alternate filler to good effect.

Jute has its limitations as textile material; the fiber lacks strength and, with age, loses much of its luster. It is sensitive to atmospheric conditions—more than any other natural fiber. Its major uses are for commercial products like bagging, sacks, and twine. Jute production ranks next to cotton among the natural vegetable fibers; almost all jute is produced in the province of Bengal, in Pakistan.

Hemp has a coarse fiber; it compares favorably with linen for strength and pliability. The plant is cultivated in many parts of the world, but the more competitive fibers have displaced it for many uses. Hemp, as a name, has come to be used generically in trade. It includes many leaf fibers that, while similar in appearance, are different in many respects from the true fiber.

Sisal, or henequen, often called "sisal hemp," is from the leaves of a tropical plant grown extensively in the West Indies. The fibers are often 5 feet in length and, like many of the leaf fibers, are heavy bodied, stiff, and shiny. Sisal and hemp are mainly rope fibers but the hand weaver may find them useful in floor coverings or other heavy materials.

Silk grass pertains to fibers that come from various species of the pineapple family. The name is descriptive of the natural fiber which is often used unspun. Delicate, crisp fabrics are made from it and they have surprising strength and considerable beauty. The plants are cultivated extensively in the tropics.

Coir is a coarse, brown fiber taken from the outer covering of the

Fig. 3.1—Rug of maguey fiber, palm leaf, and cocoanut cord, by Geraldine Funk.

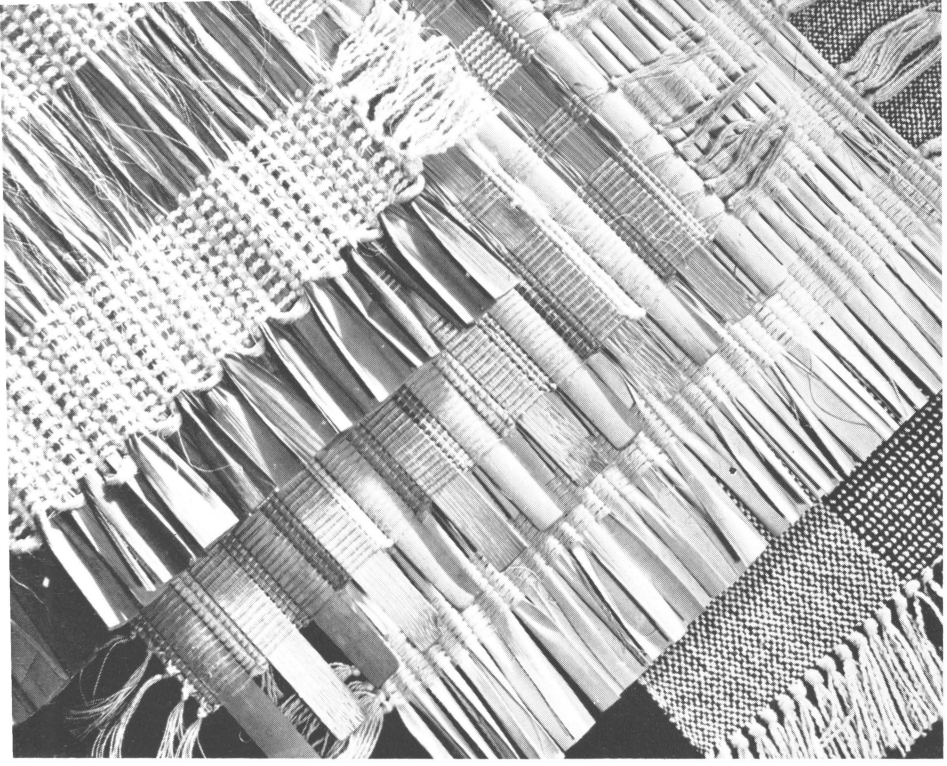

Fig. 3.2—Bamboo, royal palm, enea, maguey, junco, and cogollo were used in these mats woven in Puerto Rico, by Geraldine Funk. (Courtesy "Craft Horizons.") Many materials from faraway places are finding their way to our markets.

cocoanut. It is exceedingly strong and is used for weaving mats as well as for making brushes, rope, and other commercial products.

Raffia is known to most weavers. The material consists of strips of leaves taken from a species of palm found in Madagascar. It is pliable, sturdy, and takes a dye much the same as jute. Weavers frequently use raffia for mats and bags and, since it does not disintegrate easily, sometimes employ it in upholstery and drapery material.

Bamboo, reeds, wood slats, and other organic materials can be utilized for weaving screens, shades, and decorative panels. The possibilities of native material should not be overlooked by the hand weaver. An example of such possibilities is shown in Figures 3.1 and 3.2, a project in handweaving supervised by Geraldine Funk in Puerto Rico.

Yarns made from animal fibers fall into three main groups:

WOOL, the fleece from sheep

HAIR, from the goat, alpaca, and other animals

SILK FILAMENT, produced by the silkworm

Wool attracts many weavers. It requires different handling than other fibers but once a weaver works with it and finds he is successful, he often prefers it to any other fiber, including, incidentally, hair fibers.

The characteristic elasticity of wool—the qualities of springiness and

softness—comes from the structure of the fiber, which differs from that of hair. A wool fiber is curly and is covered with a series of scales or serrations that resemble sections of a pine cone. These two factors—curliness and the serrations—make it easy for the fibers to cling and interlock; relatively sheer fabrics may be woven from wool without danger of slippage that would normally occur with other fibers. The finer the fiber, the closer are the serrations.

There are two types of wool yarns resulting from different spinning methods: *worsted* and *woolen*. They can usually be distinguished from each other upon examination of the yarn: worsted yarns are relatively smooth; woolen present a fuzzy texture. In making worsted yarns the fibers are combed so they lie parallel prior to spinning. No attempt is made to straighten the fibers of woolen yarns, aside from carding. Worsted yarns, which are used for weaving smooth fabrics, generally require long fibers. The method of spinning woolen yarns permits the use of short lengths.

Most commonly used of the hair fibers is *mohair,* which is produced from Angora goat hair. It is a soft, lustrous fiber, sometimes as much as 12 inches in length. It has a smooth, slippery quality and is more elastic than wool. Yarn from mohair is easily dyed and is capable of producing many rich colors. It is often used by hand weavers in upholstery, pile fabrics, drapery, and apparel materials. The Angora goat is raised extensively in Texas and throughout the Southwest.

Alpaca fiber is similar to mohair in many respects. The fiber approximates the size and length of mohair but is considerably stronger. The color range of the natural fiber extends from light gray through the beiges to a nut brown. The alpaca is a member of the llama family and native to South America.

There are other animals that yield fibers in limited quantity—fibers that are desirable to the hand weaver but, because of the limited supply, are quite expensive. Among these is the Cashmere goat, an inhabitant of the high Himalayan Mountains. Fine, down-like underhair is plucked from the goats in the spring of the year when the animals molt. This is called *cashmere,* a fiber that is as lustrous and elastic as mohair, and finer than the finest wool. It is seldom used alone but combined with other fibers such as wool. The colors of the natural fiber run through white, gray, and brown, to black.

In an effort to achieve weaving yarns with a soft "hand," or texture, hair from the Angora rabbit is sometimes combined with wool or other fibers. These fibers are long enough for spinning, and absorb dye readily. *Angora* is spun alone as a knitting item and enjoys much popularity because of its soft texture.

Silk is an animal fiber produced by the silkworm. In the process of changing from a worm, or caterpillar, to the chrysalis stage, the silkworm wraps himself in a cocoon formed of filaments extruded from a tiny aperture on either side of the head. The two filaments are joined by a gum, and may be twelve hundred yards in length. Attendants take the filaments from several cocoons, usually 4 to 6, and join them; these are reeled into skeins. Silk in this form is known as *raw silk.* A large amount of silk fiber is in short lengths, due to damaged cocoons or irregular sized filaments. This is spun into yarn and known as *spun silk.* In making spun silk the shortest fibers are combed out and these are processed into *silk noil.* Spun silk has less luster than *thrown* or *reeled silk.* Filaments from cocoons that develop under natural conditions are coarser and less regular in size than those from "cultivated" cocoons, where the growth and feeding of the worms and the care and processing of the cocoons are under carefully controlled conditions. The greatest amount of silk fiber comes from cultivated silk, though a small amount of wild silk, called *tussah,* is also produced by worms feeding on oak or other leaves. In harvesting, these cocoons are usually damaged, resulting in short or broken filaments.

Silk is expensive because of its limited quantity and the hand labor necessary in producing and processing it. However, it is popular because of its desirable qualities: a high luster, great strength, elasticity, a light hand, and its great affinity for dye.

Of the natural mineral fibers, *Fiberglas* and *asbestos* are important commercially because of their fire-resistant qualities. While Fiberglas has been used to a limited extent by hand weavers, both it and asbestos are primarily important in products outside the scope of handweaving.

Yarns from metals have been used by weavers for centuries. Records dating as early as the third century B.C. indicate that strands of beaten gold were at that time interwoven in priestly vestments, probably by embroidering. Today the metallic yarns offered the hand weaver are nontarnishable. These are made from bonded aluminum foil and coated

with a clear or colored plastic. The yarn may have one or two filaments, such as rayon or silk, twisted about it to give added strength. This yarn, called *supported* yarn, can be used in warp.

Yarns can be made from any one of these fibers alone or from a combination of these materials. As many as four different fibers might be used within a single yarn, making a blend that would incorporate their collective advantages and minimize their individual disadvantages for a specific purpose. Since 1950 textile engineers have developed many yarns by blending; these have not only raised the quality of fabric but have decreased its cost appreciably.

► MAN-MADE FIBERS

The man-made (synthetic) fibers can be put into two classes: those that are made from the vegetable-matter cellulose—the rayons and acetate; and those that are derivatives of mineral elements as, to name a popular one, nylon.

Synthetic fibers were known as early as 1880. Their development on a commercial basis, however, has occurred since 1900, and particularly since 1940. The synthetics have properties and characteristics that tend to supplement the natural fibers rather than displace them. Synthetic fibers of contrasting texture may be woven together to make interesting designs, as in Figures 3.3 and 3.4.

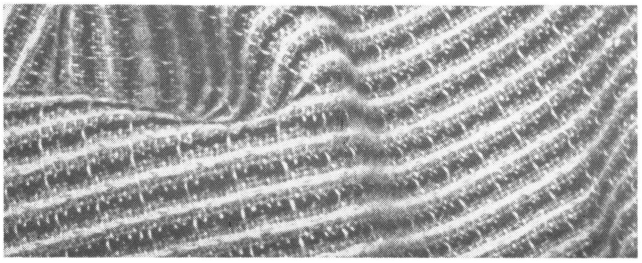

Fig. 3.3—"Web-Rib," a fabric of dynel and spun saran, designed by Marli Ehrman for the Edwin Raphael Company. (Courtesy "Arts and Architecture.")

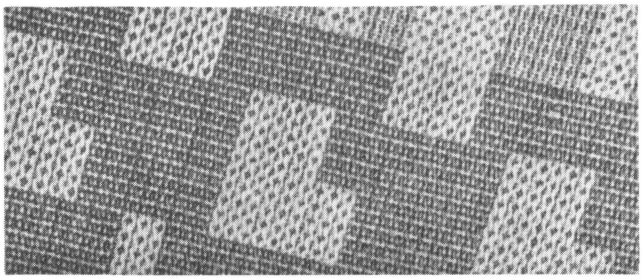

Fig. 3.4—"Form Play," of dynel and spun saran, in a heavy construction, reversible and fireproof, designed by Marli Ehrman for the Edwin Raphael Company. (Courtesy "Arts and Architecture.") These are exact copies of hand-woven designs, mass-produced by the Lumite Division of Chicopee Mills.

Aside from the fact that they can be made to resemble such fibers as linen, wool, and silk, synthetics embrace such qualities as being wrinkle proof and resistant to moths and mildew; they are washable, dry quickly, do not stain easily, and can be made into fabrics having various degrees of warmth and coolness. These qualities are often capitalized by combining synthetic fibers with natural fibers in a yarn—a practice known as *blending*—where the limitations of these fibers are minimized while their advantages are exploited. Wool, for instance, is commonly blended with various synthetics to make it crease resistant, light weight, and durable. Similar examples might be given with other fibers.

The basic steps in the production of the synthetics is first to reduce raw material into a solid, then change the solid into a liquid, and finally transform the liquid back into a solid by extruding it through a spinneret, thus forming a filament, as shown in Figure 3.5. The diameter of

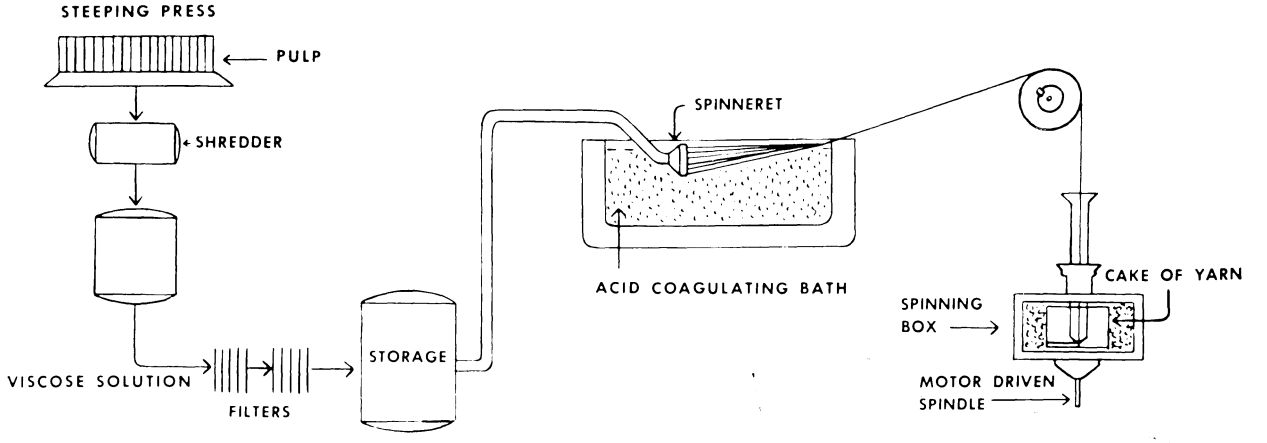

Fig. 3.5—Steps in the production of viscose rayon yarn. (Courtesy American Viscose Corporation.) A solid, either wood pulp or cotton linters, is reduced to a liquid solution which, in turn, is changed to a solid in the form of filaments, or yarn.

the individual filament can be controlled by the manufacturing processes; it can be minute, in which case many filaments might be twisted together by throwing; or the diameter of the individual strand can be increased, making a *monofilament* yarn. *Multifilament* yarns would result from twisting these last elements together. In nylon, monofilament yarn is used for making very sheer hosiery, since it is both smooth and strong. Filament yarns are used mainly where a luxurious, silky finish is

desired. A soft or dull finish is generally attained by spinning filaments which have been cut into short lengths.

An important group of fibers has been developed by scientists from cellulose. These fibers are made from wood pulp and cotton linters and have generally been known as *rayon.* There are two distinct types, however, that differ not only in their physical properties but in the method of manufacture. In September, 1951, the Federal Trade Commission established names that would differentiate these fibers. Those that were developed from regenerated cellulose (viscose and cuprammonium) would be designated as *rayon,* while the product from unregenerated cellulose would be termed *acetate.*

The classification is important to hand weavers as well as industry. Viscose rayon has greater strength than acetate, but less elasticity. If stretched to a certain point, rayon does not spring back when tension is removed. This factor should be remembered in selecting warp yarns; and if rayon is used, it may be necessary to introduce a stabilizing fiber along with it depending, of course, upon the fabric. Rayon absorbs moisture more readily than acetate, but is less sensitive to heat, so rayon will take a warmer iron than acetate. Both fibers have their place in textiles, and rayon and acetate today comprise more than 90 per cent of the man-made fibers used.

Vicara is a synthetic made from corn protein and is not affected by mildew or moths. It resembles wool and is used generally as a blend. Its shrink-resistant characteristic helps fabrics hold their shape, and it has an additional quality of having a very soft cashmere-like texture.

Nylon, which was first introduced in the late 1930's, has been widely used for many purposes, from sheer dress goods to fish lines. It is notable for its strength, being stronger than any of the natural fibers. It also resists abrasion to a marked degree, and is being used in commercial products subjected to this type of wear. The fiber shows considerable elasticity, and the percentage of recovery from tension is large. Like many synthetics, it does not take dye as readily as do many of the natural fibers. Prolonged exposure to sunlight weakens the fiber.

Orlon, a fiber that appeared in 1948, is a synthetic that is not seriously affected by prolonged exposure to sun and weather. Orlon is light in weight, strong, and washes and dries easily. Spun orlon makes a soft, fluffy yarn which is used extensively in fabrics for outer wear.

Dacron, another synthetic fiber, has been in demand for yarns used in clothing fabrics. It is washable, quick drying, and wrinkle resistant. Dacron is a warm fiber that holds its shape when woven into fabric and is resistant to both mildew and moths.

Dynel was introduced in 1950. This fiber, too, is washable, and can be spun into soft, fluffy yarn which is resistant to weathering, moths, and mildew. The fiber is creamy white in its natural state but can be bleached and, when dyed, is fast to sunlight. It has been used in blankets because of its warmth. Often blended with wool and other fibers, dynel has been used in apparel and household textiles, and in pile fabrics. While extremely sensitive to heat, it will not support combustion. It is highly resistant to chemicals.

Acrilan is a warm, soft fiber that has qualities of weather resistance. It is light weight, can be dyed with wool dyes, and is frequently blended with that fiber. While washable and quick drying, it shrinks in hot water. This fiber is especially suitable for brushed and napped fabrics.

Saran is familiar to us as the material commonly used in covering porch furniture and automobile seats, and for screening. It does not absorb moisture, is strong, and resists abrasion. It is rapidly becoming an important yarn in carpeting.

In making a selection of these fibers the hand weaver must consider their limitations and possibilities on the hand loom and in fabric. Much of this information will come from practical experience.

► KINDS OF YARNS

Fibers vary in length; the only ones that are continuous strands are those made by Man or the silkworm, and these are termed *filaments.* A group of filaments may be twisted together loosely by a *throwing* method and made into yarn; often, however, in the case of synthetics, they are cut into short lengths, called *staple.* They are then twisted and drawn into a strand by the process of spinning.

Staple is a trade reference that applies to the relative length and fineness of any given fiber; a cotton, for example, may be graded as *long staple* or *short staple;* with the man-made fibers, while the dimensions may vary, this factor is controlled entirely by manufacturing processes.

The simple yarn that results from spinning is known as a *single-ply yarn* or a *singles.* When two singles are twisted together they make a 2-

ply yarn; and three would make a 3-ply. The hand weaver, by untwisting the end of a ply yarn, can separate and identify the number of singles that have gone into its construction.

To the weaver, a single-ply yarn is generally considered as a filler yarn —not strong enough for warp. Certain woolen yarns, however, and linen singles that are wet spun, present no great difficulty to the experienced weaver. It is characteristic of most singles to have little twist. Such yarns produce a soft effect in woven material and have better filling qualities than hard-twisted yarns.

When several ply yarns are twisted together we have a *cable,* or *cord yarn.* This gives an unusually strong construction and is used chiefly for rope and twine where strength is important. Household sewing thread, however, is a cable, usually of 6-cord construction.

There is another class of yarns known as *novelties.* These are made from one or more singles or ply elements and are manipulated through twisting to form a yarn with uneven, irregular surface characteristics. When woven in fabric they contribute textural interest. The various types are identified by such names as *bouclé, ratiné, flake, chenille, slub, loop, nub, corkscrew,* and *frill.* The names given these types have a general rather than a specific application and some constructions may, on occasion, closely resemble each other. Brief descriptions of these yarns are given in the glossary.

► SIZES OF YARNS

Since novelty yarns, in construction, are extremely varied in their fiber combinations, standardization of sizes is difficult. Manufacturers, in offering such yarn, always state the yardage there is in one pound of yarn. With other types of yarn this is indicated by a size number. The size of most spun yarns (which are those used by the weaver in the majority of cases) is based on yards per pound. With filaments this number is based on the *denier size*—a unit of weight that indicates the fineness of the filament.

In dealing with filaments, the larger the number, the *heavier* the yarn. A 30-denier nylon monofilament, used in making service-weight hose, is 3 times larger than a 10-denier one that is used for sheer hosiery.

With spun yarns, the larger the number, the *finer* the yarn. A Size 20 singles cotton, for instance, is twice as small as a Size 10.

The basis for computing spun yarns differs, depending on the fiber and the spinning method used. Different fibers often can be spun on the same system. Silk, as an example, can be spun with the same equipment used for cotton. Some man-made fibers can be spun on all systems. Rayon owes much of its commercial popularity to the fact it can be spun with equal success on cotton, flax, worsted, and woolen equipment.

The cotton count starts with a Size 1 singles, which has 840 yards of yarn to the pound. A Size 5 singles would yield 5 times that amount: 4,200 yards per pound; or a Size 20 singles: 16,800. These sizes would appear as 1/1, 5/1, or 20/1; or they may appear as 1's, 5's, or 20's.

If two strands of the same size singles were twisted together, we would have 2-ply yarns that, in the above instances, would appear on the yarn package as 1/2, 5/2, or 20/2. The yardage would now be reduced one half; that is, to 420, 2,100, and 8,400 yards per pound, respectively. Similarly with 3-ply cotton yarns, divide the basic quantities by 3: they appear as 1/3, 5/3, or 20/3, and have 840 ÷ 3, or 280 yards; 4,200 ÷ 3, or 1,200 yards; and 16,800 ÷ 3, or 5,600 yards per pound.

This same procedure applies to other spun fibers but the basic unit differs: for linen, the unit is the *lea* and is 300 yards per pound; with worsted yarn, 560 yards per pound; woolen yarn, indicated in *runs*, would be 1,600 yards per pound or, if indicated in *cuts*, 300 yards per pound.

The denier is based on the number of grams which 9,000 meters of yarn will weigh. This unit of measurement is used for reeled silk and man-made filaments, but the hand weaver in buying yarn will rarely have occasion to refer to deniers since the manufacturer generally transposes this factor into yards per pound. A thrown filament yarn—one that consists of a number of filaments twisted loosely together—might be indicated as 120/30, meaning: this yarn is composed of 30 filaments and the size of each filament is 120 deniers.

► DYEING PROCESSES

Color can be produced in yarns by several methods. Aside from *piece dyeing*, which involves dipping material already woven, yarns are dyed in three ways. In one, the fibers are dyed preliminary to spinning, which is known as *stock dyeing*. Wool yarn so dyed gave rise to the expression "dyed in the wool." While this is the most expensive way to dye yarn, it

enables the spinner to create unusual effects by mixing different hues of fiber. Many oxford grays and the variegated hues, such as heathers, are made in this manner. The popular "fleck" wools, which have spots of bright color interspersed, are effected by introducing small amounts of dyed fibers in the late stages of spinning.

Finished yarns may be dyed either in skein put-up, or when on perforated tubes—a method called *package dyeing*.

With some of the man-made fibers a new method has appeared. Instead of employing the principle of absorption in dyeing, the pigment is mixed in the raw material while in the liquid state; this solution is then extruded in the usual manner into filament, the color becoming an integral part of the fiber. The method is termed *dope dyeing* and it provides a yarn whose color is virtually permanent; color intensity can be maintained, and the hue is not affected by any of the usual cleaning processes.

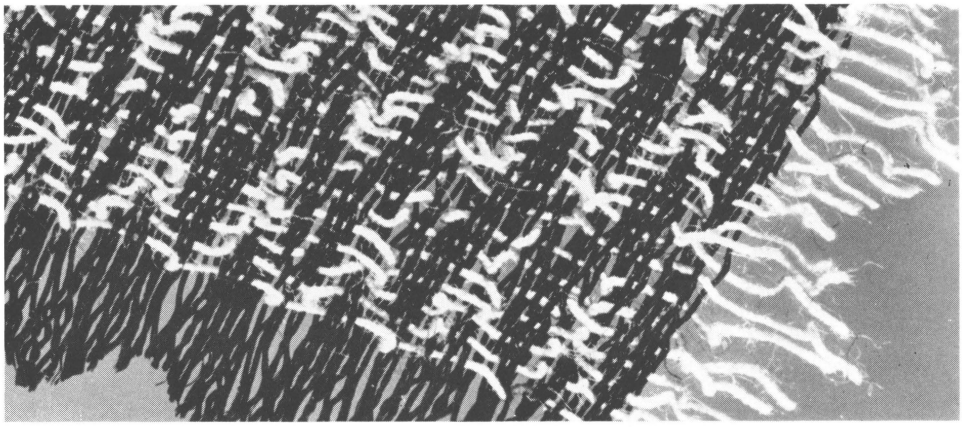

Fig. 3.6—Fabrics of Estron (acetate) plus other materials such as silk, wool, or cotton can be dyed in two-tone effects by the process "cross dyeing." (Courtesy Tennessee Eastman Company.) Acetate resists the dyes that color the other fibers and they, in turn, resist the acetate dyes.

All of our dyestuffs today are the result of chemical research in this field: some have been developed for color range, some for fastness to certain conditions of fabric use and care, and others for their affinity for certain fibers. The degree of permanency is always relative, since no pigment remains unchanged from exposure to air and light. Dye specifications on many of the yarns the weaver buys are unavailable. Under these

circumstances he must conduct his own tests to see if the yarn meets his requirements. This can often be done from the samples submitted by the dealer. When a combination of yarns is to be woven together into fabric and this material is to be piece dyed, the weaver should consult his local dyer and be advised on the practicability of using certain fibers.

In *cross dyeing*, the weaver should first become informed as to the fibers that could be used in this type of dyeing, for cross dyeing is based on the fact that one of the fibers in the piece will accept the color while the others will reject it. This is illustrated in Figure 3.6.

The hand weaver can supplement his information concerning materials from many sources: historic materials are displayed in museums and galleries; products from our modern mills are readily available; and newspapers and the popular magazines frequently carry articles that are both interesting and informative.