The structure of fabric is determined by the arrangement and method by which fibers and yarns are combined. The basic methods of fabric construction include braiding, knitting, looping, and knotting, as well as weaving. In making certain types of textiles, such as lace, a combination of these techniques may be required.

In addition to yarn and thread elements, unspun fibers are sometimes used to make cloth. When properly treated, these fibers may be compressed into a homogeneous material classified as fabric. A common example of this process is felt.

The Three Fundamental Weaves

Weaving, perhaps, offers more latitude for structural variety than any other method. The simplest form of woven structure—the plain weave—has warp and filler yarns interlaced successively; that is, each yarn passes over one and under another, alternately. With the introduction of multiple harnesses, two other fundamental structures became common, the twill (Figs. 9.1A, B, and 9.2), and the satin weaves. A twill weave is created when a weft yarn passes first under, then over a set number of warp ends and is woven to produce diagonal lines in the cloth. In the satin weave, the diagonal line is broken up and the warp and filler yarns are interlaced irregularly, producing a smooth surface. These three weaves, the plain, the twill, and the satin, are the bases for countless variations of pattern.
WEAVING VARIATIONS

Depth and dimension were given fabrics by pile weaving. Examples are seen in rugs, carpets, and velvets where yarns rise vertically from the basic structure. Pile weaving is accomplished by two methods: either by the use of extra filler yarn, employing a knotting technique, or by the use of an additional series of warp yarns with an extra warp beam.

Open mesh effects are achieved with gauze weaves. This involves a method of twisting warp yarns, in pairs, about each other and following with a weft shot. The twisting locks the filler yarn and prevents slippage, and at the same time creates the “openness” characteristic of the weave. Special devices such as beads or half heddles, called doup’s, are needed to create the twist. An example of gauze weave is shown in Figure 1.12.

WEAVING DRAFTS

The specific procedures necessary in setting up a loom to achieve the desired pattern for a fabric—the definite order of threading heddles, the tie-up, and the order in which the treadles are operated—must be recorded in order to communicate this information to others. Years ago a system was devised for diagraming these instructions, known as weaving drafts, and they are still used by weavers today. Authorities differ somewhat on the details of writing drafts, but if the underlying principles are understood, translation will not be difficult.
Figure 4.28 illustrates a fabric woven in a “plain twill” and a typical draft for this weave is shown and explained in Figure 9.3. The draft is drawn for a 4-harness, 6-treadle loom. It is not necessary to tie up all 6 treadles as shown in the draft, only those that are to be used on a project. These may be arranged in any order convenient for the weaver to use. To weave twill only, Treadles 1 to 4 would be used.

By alternately depressing Treadles 5 and 6 with this tie-up, the weaver achieves the “plain weave” or “tabby,” as it is popularly called. This weave is often used alone in making fabric, it is generally used to start and finish all woven material, and is commonly employed to tie in overshots in weaving pattern designs.

With the same threading order shown in this draft, the weaver can get a variation of pattern by merely changing the tie-up (Figs. 9.4 and 9.5). One of the variations resulting from such a change is shown in Figure 9.6. This is one of the many “broken twills” possible. Endless modifications can be developed in this manner. Figure 4.10 is an illustration of a fabric showing the variety possible with the simple twill
Fig. 9.3—Draft for twill threading and standard tie-up. The horizontal spaces numbered 1, 2, 3, and 4 represent the harnesses, numbered from front to back. The black squares indicate the position of the heddles when threaded to plain twill. Threading begins at the right; the threading draft, therefore, should be read from right to left—not left to right as in normal reading. The first warp yarn is threaded through the first heddle of Harness 4; second warp yarn through the first heddle of Harness 3; next through the first heddle of Harness 2, and so on.

The horizontal lines numbered 1, 2, 3, and 4 represent the lams, attached to Harnesses 1, 2, 3, and 4 respectively at the center points, indicated by the small circle.

The vertical lines indicate the Treadles 1, 2, 3, 4, 5, and 6. The “X” indicates where a lam is tied to a treadle. It can be seen that Treadle 1 is tied to Lams 1 and 2; Treadle 2 to Lams 2 and 3; Treadle 3 to Lams 3 and 4, and so on. This lam-treadle tie-up is known as the standard tie-up. While the pairs of harnesses used together remain the same, their order of tying to the treadles can be changed. For example, some weavers like to use the two center treadles for tabby, the 2-and-4, and the 1-and-3 combination. The first four treadles, which give a simple twill when depressed in order, can be rearranged to better accommodate a weaver who likes to alternate the left and right foot. Treadle 2 would then be moved to the position of Treadle 4, Treadle 3 to second from left, and Treadle 4 to third from left. Illustrations of the lam-treadle tie-ups are shown in Figures 6.10, 6.11, and 6.12.

Treadles 5 and 6 are used for the plain or tabby weave.
Fig. 9.4—This diagram combines directions for the threading, tie-up, and treadling. Threading and tie-up are the same as that in Figure 9.3. The numbers 1 to 6 placed horizontally indicate the treadles with the standard tie-up. Figures arranged diagonally in the vertical spaces show sequence for depressing the treadles in weaving a plain twill.

Fig. 9.5—Simple twill with a 2-and-2 sequence. The dark blocks represent the filler passing over two and under two warp yarns in regular sequence. Each successive shot of filler advances one warp yarn, thus producing the clearly defined diagonal. Treadles used would be 1, 2, 3, and 4 as shown in Figure 9.3.

Fig. 9.6—Broken twill using two twill harness combinations with the tabby tie-ups. These are 1 and 3, 1 and 2, 2 and 4, and 3 and 4. Treadles used are 6, 1, 5, and 3. Or, treadles can be arranged to suit the convenience of the weaver, which is especially important when a large amount of yardage is to be woven.
threading, stripes of twill alternating with plain, or tabby, and broken twill. This fabric also illustrates how variation in the width of stripes can add interest to a pattern.

While most weavers confine themselves to the simple structures, emphasizing textural and color values, experienced weavers do not overlook the possibilities of pattern in combination with this approach. Many interesting fabrics may result from this treatment.

**THREADING FOR PATTERN**

The method of preparing the warp, winding it onto the warp beam, and threading it through the heddles is essentially the same whether the fabric is to be plain or patterned. The difference is chiefly in the order in which the heddles are threaded. As pointed out earlier, the usual

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Fig. 9.7—Early American hand-woven coverlet, “Single Snowball” with “Pine Tree” border. (From the Smithsonian Institution. Courtesy “Craft Horizons.”) Here two 38-inch widths have been sewn together. Woven in a reversed twill weave, warp is of unbleached cotton, filler of indigo-dyed wool, three sides fringed by the extension of both warp and filler.
threading for a 4-harness loom is a simple twill, that is, a sequence of 1, 2, 3, 4; or 4, 3, 2, 1.

For pattern weaving, the threading varies with the particular pattern being used. Figures 9.7 and 9.8 show two of the many variations possible. The motif may be a series of 8 ends for a very small figure, as in the popular "rose path," or as many as a hundred or more ends, as is found in old counterpanes and complex damask patterns.

**USE OF SHUTTLES**

Pattern weaving may call for one or more shuttles. If more than one is used it will be shown on the draft, or the term "use tabby" will be stated. One shuttle will carry the background or tabby yarn and is usually woven on the 1 and 3, 2 and 4 harness combinations. This tabby yarn may be the same as the warp yarn, or a similar one. Together with the warp it forms the background structure of the cloth and at the same time binds down the pattern yarn, or floats.

The pattern yarn that is carried by Shuttle 2 is usually a yarn contrasting to the tabby; the difference may be one of size, of color, or of texture. Pattern is developed by passing the shuttle over two or more warp yarns, causing the yarn to "float" over the warp. This type of weaving in some instances is called overshot because these yarns float over, or are shot over a background of plain or tabby weaving. This can be seen clearly in Figure 9.8. Overshot weaving has many decorative possi-
ibilities, but it has its functional limitations also. Where the pattern yarn floats over three or more warp ends, this exposed length can easily be caught and pulled or abraded. Care should be exercised in the choice of yarns and patterns to make sure they are compatible with the use of the product being woven.

In planning projects that are not the result of the "thrown" shuttle, the approach differs. This group includes many rug, tapestry, inlay, and other techniques that embody figurative or abstract designs in the fabric and must be either tied on or laid in by hand.

In these projects, a rough sketch is made of the design on drawing or water-color paper using soft drawing pencils, charcoal, or other mediums. This sketch may later be refined to arrive at more satisfying relationships of area and color. It is then transferred to graph paper, or any paper that the weaver may mark off in accurate squares. In using, for example, the knot technique in rug weaving, each square will represent two warp ends or one knot. While it is possible to work from a graph in reduced scale, the usual practice is to make one that is full sized.

**TECHNIQUE FOR PILE RUG**

If a pile rug is planned the pile is usually formed by the use of one of the rug knots. The pile may be made by either of two methods. In one, the yarn is cut into lengths according to the depth of the pile desired. These are then tied individually to the warp yarns. In the other method, the yarn is used in a continuous length to tie a series of knots. The yarn is first knotted around two warp ends, then passed around a stick or rod before the next knot is formed. The height of the stick or rod determines the depth of the pile. After a tabby shot, this stick can be removed, leaving an uncut pile. For a cut pile, a sharp knife or a razor blade is run down the center of the top edge of the stick. The stick is generally grooved to form a guide line for the cutting, insuring an even height of pile. Each row of knots is followed by two or more filler shots, to fill in the back of the rug and to give a firm background. Figure 9.9 shows the detail of the cut and uncut flossa.

If the flossa technique is followed, three filler yarns usually follow each row of knots; the pile in this way will stand at right angles to the warp. In the rya technique, where the pile lies flat, many rows of filler may be used. The number of filler yarns depends on the length of the
pile since the pile, when lying flat, should cover the background yarns.

The most common knot used in the flossa or rya techniques is the Turkish, or Ghiordes, knot illustrated in Figure 9.10.

If the weaver is using yarn to make a continuous series of knots, a length of yarn is first formed into a bow arrangement called a butterfly. The butterfly is made by winding the yarn around the thumb and little finger in the form of a figure eight, leaving the starting end lying in the palm of the hand. When the winding is completed, the remaining end is wound and tied about the center of the bow. Yarn can then be withdrawn from the inside of the bow by pulling the starting end. The butterfly in this way acts as a bobbin.

Important points to consider in making a rug in the knot technique are as follows:

Use a Number six- or eight-dent reed, six usually preferred.
The warp, made of heavy ply yarn, must contain an even number of ends.
Two warp ends are threaded in each of the outside dents.
Knots are made over pairs of warp ends, in a closed shed.
No knot is made on the two outside warp ends.

To make the knot, start at the left side omitting the two selvage yarns. The knot will be made over the first pair of warp yarns next to the selvage yarns as follows: put the butterfly under the left warp from right to left, slide down close to the stick; then throw to the right over
the pair of warps and slip the butterfly under the right warp from right to left; complete the knot by slipping the butterfly under the stick, toward the weaver, and pull up tight. Continue across the warp. Figures 9.11, 9.12, 9.13, and 9.14 show other variations of the flossa and Ghiordes knot techniques.

► MAKING THE SELVAGE

To make the selvage use the background yarn or filler, wrapping this yarn tightly, 3 times around the 2 outside warp yarns. Using the same yarn, cross to the other side with a tabby shot and wrap these 2 outside warps. Put it in 2 more filler shots. This will give 1 row of knots and 3 rows of filler. Filler yarn may be bubbled to cover the warp.

Cut the pile after the first filler yarn is woven in. For uncut flossa remove the flossa stick after the first row of filler.

The warp tension must be kept very tight, and the filler yarns beaten in firmly. The filler yarn should be heavy and strong. Some weavers use narrow strips of rags, cotton preferred, for filler yarn.

► INLAY TECHNIQUE

An isolated motif is sometimes desired in small textiles. This is generally woven by the inlay technique. In this method a secondary filler yarn, generally heavier and of a different color than the background, is used to develop the design. Inlay yarns are wound on small bobbins, one for each color. The filler is "laid in" to the width of the motif; then followed by one or two tabby shots across the width of the warp before the next inlay yarn is inserted.

The customary procedure in inlay weaving is first to make a sketch of the design or motif. This sketch is then transferred to graph paper, each square representing a definite number of warp ends. If, for ex-

Fig. 9.10 (opposite page)—Ghiordes knot used in making a flossa rug is illustrated by Joan Patterson. (Courtesy "Handweaver and Craftsman.") Yarn coming from over top of flossa rod has been passed under left warp of the pair being used to make the knot. Passed over and above the two warps, it will be passed under right warp being lifted with the finger of left hand, then under metal rod and pulled tight before going over rod for next knot. Knots are made with warp flat, no shed. Using tabby sheds, shots of weft will be passed through before next row of knots is made. This is an all-linen rug; warp is 6/3 gray tow, weft is 1½ lea rug yarn. Type of flossa bar or rod used here consists of two metal rods welded together at the ends, double rods making knot-cutting easier.
Fig. 9.11—Sample rug showing variations of the flossa techniques using cut and uncut flossa knots and a combination of flossa and flat weaves. Warp is a 16-ply cotton, 8 ends per inch; filler between rows of knots and between samples is "bubbled," thus covering the warp and making the background stiff and firm.

Fig. 9.12—Created and designed by Leo Mahsoud, tufted rug is of cotton and hemp, based on the Ghiordian knot principle.

Fig. 9.13—"Bombay," a jute-striped rug by Joseph Blumfield. Warp is brown cotton set 6 ends per inch; filler is 3 strands of roving cotton yarn mixed with metallic; raised portion is a chenille of jute yarns, looped and partially cut and uncut. Colors are soft gray-greens to tan or straw. Rugs may be woven from 4 to 15 feet wide.
ample, the inlay yarn passes over 3 warp ends and under 1, each square will represent 4 ends. Such an overshot (3 over and 1 under) gives definition and prominence to the design since the majority of the warp yarns are covered, exposing only the inlay. If the motif is to appear subdued, the inlay is simply placed in the tabby shed rather than used as an overshot and is known as laid-in design.

**TAPESTRY TECHNIQUE**

In tapestry weaving the filler yarns are inserted by hand with the aid of small bobbins, one for each color area. No tabby shuttle is used in true tapestry weaving; the filler yarn does not carry across the width of the warp, only back and forth for each color area. The need for separate
Fig. 9.15—Modern tapestry, by Saul Borisov. (Courtesy "Craft Horizons.") A painter, weaving in Mexico, creates a tapestry for contemporary interiors.

Fig. 9.16—Tapestry cushion from Skane, Sweden, in yellow, blue, black, and red wool. (From the Florence Dibel Bartlett Collection. Courtesy of the Art Institute of Chicago.)
color bobbins is apparent in tapestries such as the ones shown in Figures 9.15 and 9.16.

The warp yarns in tapestry weaving are usually set 10 to 20 ends per inch, often closer to 10 if it is the desire of the weaver to cover the warp yarns completely. The filler is beaten down in each area as it is woven, with a small comblike hand tool, generally made of wood.

The tapestry weaver works from a sketch in color, known as a *cartoon*, that is attached directly under, or behind, the warp. Modern weavers sometimes work with the cartoon at their side, or it may be attached to the framework of the loom. The cartoon is usually made to approximate the size of the finished tapestry, though it may be scaled down as shown in Figure 9.17.
While this is the method for weaving true tapestries, weavers often
devise their own methods, such as running a very small tabby yarn be­
tween rows of pattern to bind the pattern units together. Others use a
laid-in technique to develop the design, sometimes on a plain back­
ground, sometimes on a textured background.

The old, true tapestries were woven on vertical looms, but the hori­
zontal loom is used by most hand weavers at the present time. Such
techniques as tapestry, inlay, the flossa knot, and many others are woven
with the twill threading and plain or tabby weave tie-up for treadling.

The techniques discussed in this chapter are those most commonly
used in weaving materials for wearing apparel, upholstery, and drapery
fabrics. Numerous variations can be developed that will use the many
possibilities for tie-ups and the wealth of yarns now available.