# Anni Albers
# *On Weaving*

NEW EXPANDED EDITION

With an afterword by Nicholas Fox Weber
and contributions by Manuel Cirauqui and T'ai Smith

Princeton University Press
Princeton and Oxford
in association with The Josef and Anni Albers Foundation

CHAPTER FOUR

# The Fundamental Constructions

The structure of a fabric or its weave—that is, the fastening of its elements of threads to each other—is as much a determining factor in its function as is the choice of the raw material. In fact, the interrelation of the two, the subtle play between them in supporting, impeding, or modifying each other's characteristics, is the essence of weaving.

The fundamental constructions, in common with all fundamental processes, have a universal character and are used today, as they were in our early history, here and everywhere. They show the principle of textile construction clearly. With only a few exceptions, all other constructions are elaborations or combinations of the basic three: the plain weave, the twill, and the satin weave. Of these three, it is the plain weave that embodies the sum total of weaving and therewith reaches back the furthest.

All weaving is the interlacing of two distinct groups of threads at right angles. Wherever a fabric is formed in a different manner, we are not dealing with a weaving. Where, for instance, the threads intersect diagonally in relation to the edge of the fabric, or radially from a center, we have a braided material; where only one thread is used to build up the material, we have a knitted or crocheted one; where threads intertwine or loop around each other, we have a lace or a net fabric. The horizontal-vertical intersecting of the two separate systems of thread is of great consequence for the formative side of weaving. The more clearly this original formation is preserved or stressed in the design, the stronger the weaving will be in those characteristics

that set it apart from other techniques. Just as a sculpture of stone that contents itself to live within the limits of its stone nature is superior in formal quality to one that transgresses these limits, so also a weaving that exhibits the origin of its rectangular thread-interlacing will be better than one that conceals its structure and tries, for instance, to resemble a painting. Acceptance of limitations, as a framework rather than as a hindrance, is always proof of a productive mind.

The threads grouped vertically or lengthwise in the fabric are the warp threads; those running horizontally or crosswise are the filling threads. By collective names they are the warp and the weft, or filling, or woof, or pick. The warp threads are stationary in the process of weaving, while the filling threads are in motion, which indicates that the weaver for the most part deals with the filling threads and which may explain the greater number of terms for them.

*Plates 10, 13*

In the plain weave, this intersecting of warp and weft takes place in the simplest possible manner. A weft thread moves alternately over and under each warp thread it meets on its horizontal course from one side of the warp to the other; returning, it reverses the order and crosses over those threads under which it moved before and under those over which it crossed. This is the quintessence of weaving. The result is a very firm structure that, since it is comparatively unelastic, is strong under tension and also easily preserves its rectangular shape. It has an even, uniform surface, with warp and weft appearing in equal measure and producing the same effect on the front and the back of the fabric. It has a tendency to be stiff and, since the threads here cannot be pushed together very closely, it appears perforated when held against the light. Not more than two warp and two weft threads are necessary for its basic construction, and therefore only the simplest type of equipment is required. It is also a weave that demands less material for its construction and can be produced faster than any other. The usefulness of these characteristics is evident. There is probably no weave produced in more millions of yards the world over, now as in former times, than this plain weave. We recognize it in Egyptian mummy cloth and in our sheets, in unbleached muslin, potato sacks, and sail cloth—in short, wherever strength and a solid surface that does not permit threads to be caught accidentally are required.

It is interesting to note that this most practical of all thread constructions is at the same time also the one most conducive to aesthetic elaborations. The fact that warp and weft appear on the surface in equal amounts and

intersect visibly leads to the use of contrasting materials and colors for them, thereby underlining the original structure of the weave. Emphasizing this structure still further are stripes in either warp or filling and, one step further, checked effects, another of the most typical designs of weaving in a plain weave. But beyond these elemental formative additions, the condensed quality of this weave, its use of only essential components, predisposes it also to be the construction used in work of a pictorial character—that is, in tapestries. Its shortcoming for such a purpose—the necessity of having to deal with a mixture of warp and weft—is overcome by deviating from the balanced proportion of warp and filling and using disproportionately more filling. By spacing the warp so widely that the weft can be beaten together closely, it is possible to cover up the warp entirely; the filling thereby becomes the sole agent of the surface. Gothic tapestries, those of the Renaissance, Aubusson tapestries—all are executed in this simplest of constructions. The old truth applies here again—a process reduced to just the essential allows for the broadest application.

Another construction, also fundamental in its simplicity though already one step nearer complexity, is the twill weave. Whereas the plain weave is essentially a balanced weave—that is, warp and weft take an equal part in it and consequently produce the same appearance on the face of the fabric as on the back—the twill can be either a balanced or an unbalanced weave. It is unbalanced when either warp or filling is predominant, and in that case the face and back of the cloth are the reverse of each other. For where the filling covers most of the surface, the back naturally shows for the most part warp, and vice versa. A twill in which the warp prevails on the surface is called accordingly a warp twill, and the one that shows on the face more filling than warp, a filling twill.

*Plates 11, 13, 14*

The principle of construction in a twill is that the successive filling threads move over one warp thread or over a group of warp threads, progressively placing this thread or group of threads one warp thread to the right or left of the preceding one. Thus, in the smallest filling twill, which covers three warp and three filling threads, the first warp thread is raised over the first filling thread, which floats over the second and third warp threads; the second warp thread is raised over the second filling thread, which covers the first and third warp threads; the third warp thread runs over the third filling thread, which now floats over the first and second warp threads. This manner of intersecting warp and weft produces distinct diagonal lines, the characteristic twill

lines. In a warp twill of the same size, the proportion of warp and filling on the face of the fabric will be reversed. The first and second warp threads will be raised over the first filling thread, the second and third warp threads over the second filling thread; and finally the first and third warp threads over the third one.

The diagonal twill line can, of course, run to either the right or the left. This is of consequence only in regard to the direction of the twist in the yarn used—a slant to the right, for instance, will increase the relief effect of the ridge formed by a left twist warp, while a left slant would decrease it. The angle of the slant varies with the relationship of warp to weft in regard to the size of the threads and the closeness of the setting. If these are equal, the slant will be at an angle of 45 degrees; if the warp is thicker or more closely set than the filling, the incline will be steeper; if it is thinner or more loosely set than the filling, it will be more gradual.

Innumerable twills can be designed: either balanced or uneven; either simple, with just one twill line, or compound, with a number of lines. Twills are often written in the form of numbers indicating the warp threads raised or lowered. For instance,

$$\frac{1 \quad 3}{2 \quad 1}$$

would specify an uneven 7-leaf warp twill, in which one warp thread is raised, two are lowered, three are raised, and one is lowered. A balanced twill would read

$$\frac{2 \quad 3}{2 \quad 3}$$ , etc.

Twill weaves, as a result of longer floating threads, are softer and can be woven more closely than plain weaves. They are also more pliable and inclined to give way more easily to diagonal pull, which makes them eminently suited for tailoring and thus for clothing purposes. We know them in the form of denims and other cotton materials for our work clothes and in countless wool tweeds. They were also known in ancient times, and in this hemisphere twills have been unearthed that date back to the Peruvian Mochica period.

*Plates 12, 15*

The satin weave, the third of the fundamental constructions, is believed to have been invented by the Chinese. (Luther Hooper, *Hand-Loom Weaving* [New York and London, Pitman Publishing Corp., 1920], p. 168.) In some ways it is the opposite of the plain weave. For, if the plain weave is essentially a construction that can only be balanced—that is, can produce only a fabric that is the

same in front and back—the satin weave can only be unbalanced, can produce only a fabric different on either side, can show only either warp or filling. In contrast also to the plain weave, where the closest intersection of warp and weft is sought, the farthest intersection within a given unit is chosen for a satin weave. The long, floating threads cover the points of intersection of warp and weft and permit the threads to be beaten together closely, so that a uniform, smooth surface is achieved, lacking any obviously visible structural effects.

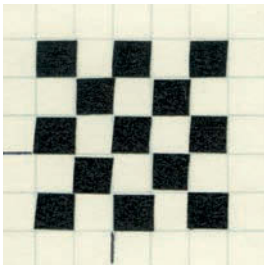
We have found that the plain weave requires two warp and two filling threads for its construction, and the twill weave at least three. The satin weave calls for a minimum of five warp and weft threads.

To discover the best position for the points of intersection of warp and filling, technically termed "stitchers," the unit of threads that is to form the satin is divided into two groups of different size that are larger than one thread, that are not divisible one into the other, and that are not divisible by a common third. A unit of five threads, for example, is divided into one group of two and one of three. After interlacing the first warp thread with the first filling thread, the places for further intersection will be, for every following weft thread, either always two or always three warp threads removed from the preceding intersection. Thus the stitchers for a five-leaf satin will be in the order 1, 3, 5, 2, 4—that is, the first warp thread intersects with the first weft thread, the third warp thread with the second, and so on. Progressing in the other possible order, the stitchers will be placed in the following arrangement: 1, 4, 2, 5, 3. Every warp thread has to be attached once within the unit to every weft thread, in a position that allows for the widest possible separation of the stitchers. Many satins can be formed by this method. The unit of six threads forms an exception, since it cannot be divided into any groups that comply with the requirements. Advancing in the order 1, 3, 5, 2, 4, 6 seems possible at first glance, when only the first unit is considered. But the repeat will reveal the defect that the first and the sixth stitchers come to be side by side. By exchanging the last two stitchers, a workable order can be given. Thus, instead of 1, 3, 5, 2, 4, 6, the progression will now read 1, 3, 5, 2, 6, 4. In larger units, more than two numbers of progression can be found. For instance, the unit of sixteen threads can be divided into groups of three and thirteen, five and eleven, seven and nine, all equally suited to our purpose here.

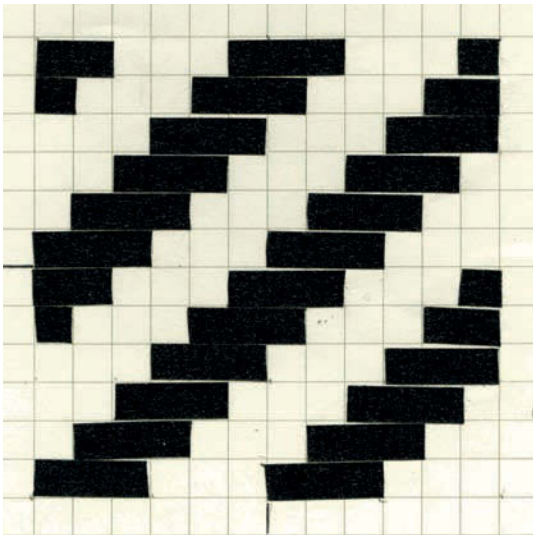
This wide separation between the points of interlacing in the satin weave makes for a very pliable, soft fabric that, in addition, can be highly glossy

when executed in a lustrous material because of the homogeneous surface of either warp or weft. The contrast to the plain weave becomes apparent again when we compare the possible functions of the two; for, whereas we considered the plain weave to be the most serviceable construction, the satin weave is a luxurious one. The soft drape, the gloss that usually goes with the weave, and on the negative side, the long floating threads that preclude hard wear predispose it for an extravagant existence. It is a weave made for splendor. We know it in the form of silk satin, used in decorous draperies or, equally decorously, in our clothes of leisure.

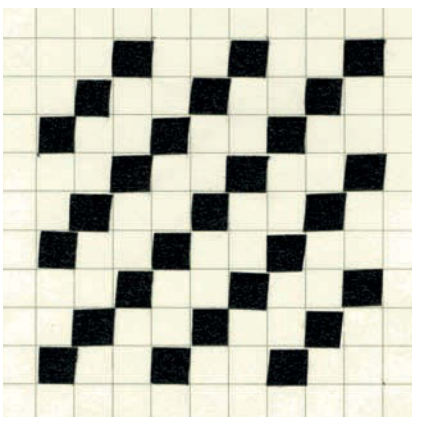
The innumerable deviations from these three basic weaves show in varying degrees the main characteristics of their lineage, depending on how close or how distant their relationship is.



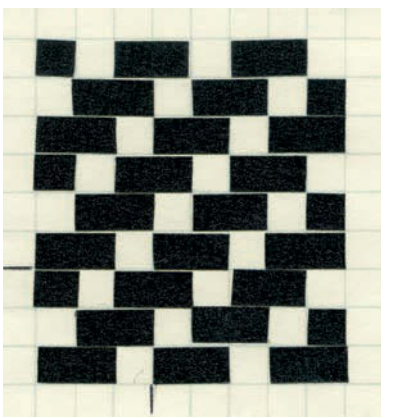
Plain weave.



Balanced twill $\frac{3}{3}$/

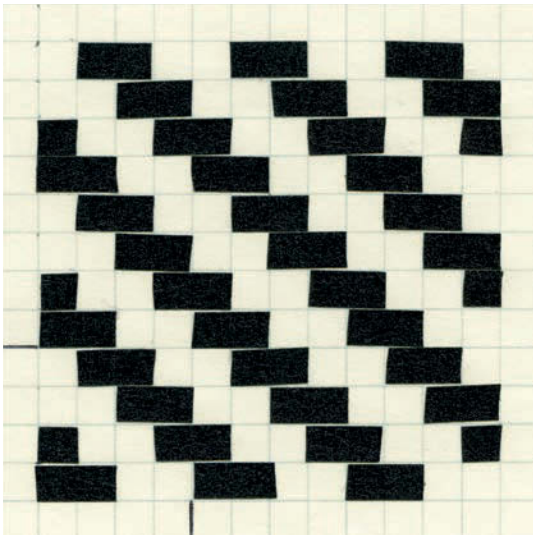


Weft twill $\frac{1}{2}$/

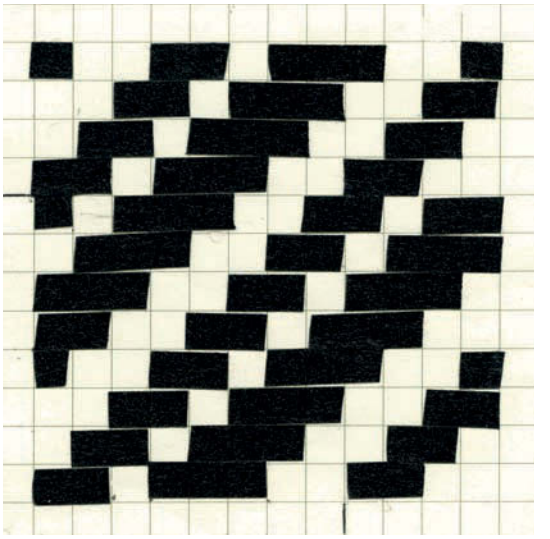


Warp twill $\frac{2}{1}$/

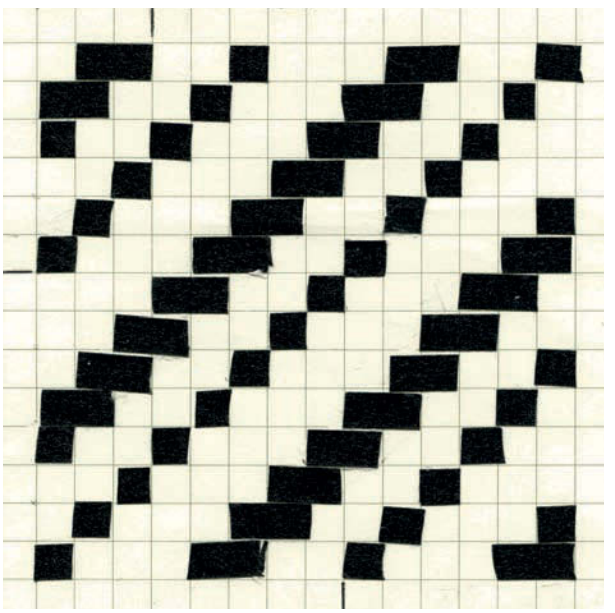
*Plate 13.* The fundamental constructions.



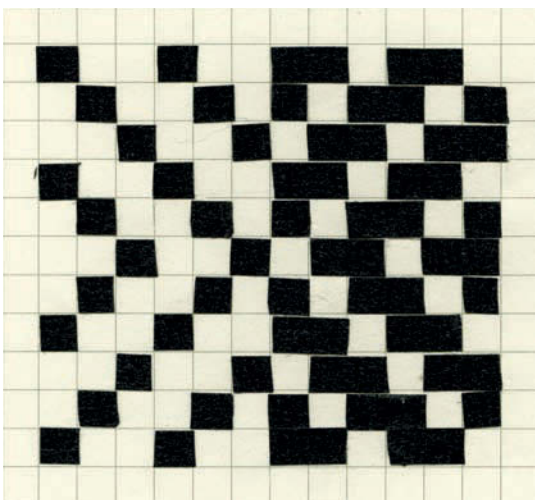
Balanced twill $\frac{2}{2}$ /



Warp twill $\frac{2\ 3}{1\ 2}$ /

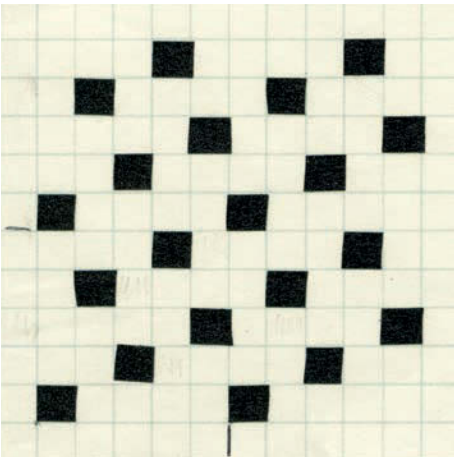


Weft twill $\frac{1\ 3}{3\ 2}$ /

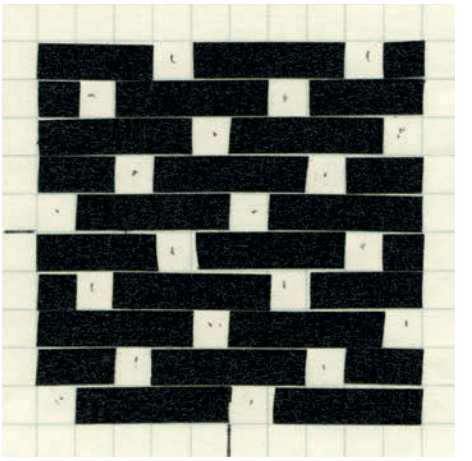


Warp and weft twill combination.

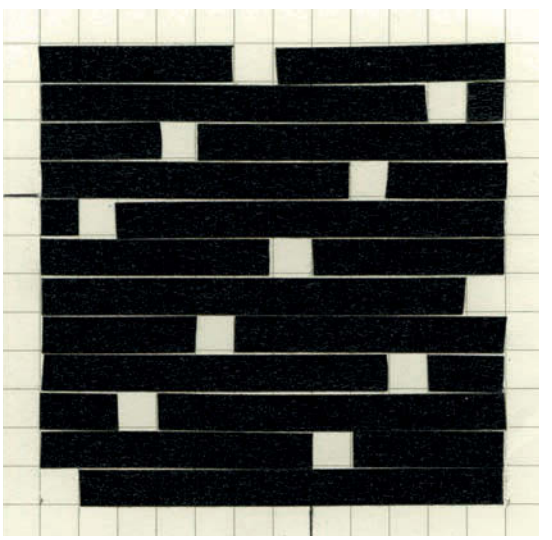
*Plate 14.* The fundamental constructions.



Weft satin 5-leaf.



Warp satin 5-leaf.



Warp satin 12-leaf.

*Plate 15.* The fundamental constructions.