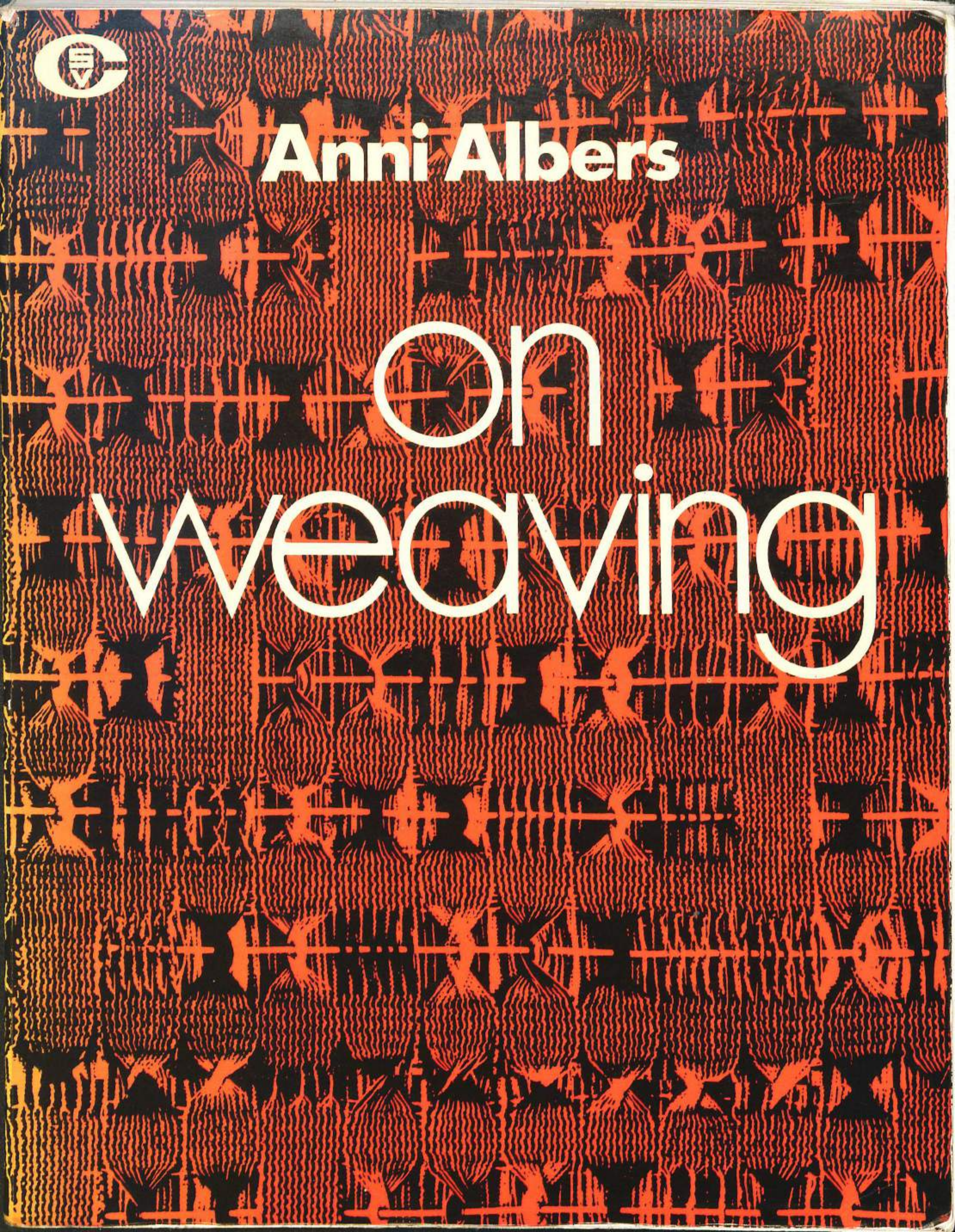
Anni Albers

on weaving



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Studio Vista London

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Introductory Note

PERHAPS I should start out by saying that this book is not a guide for weavers or would-be weavers, nor is it a summary of textile achievement, past or present. It is incomplete in that it does not take up many of the facets which together constitute the enormous field that is weaving. A vast literature has accumulated on this subject, each contribution taking up some of its many aspects. I approached the subject as one concerned with the visual, structural side of weaving rather than that dealing with the problem of warmth, for instance, or such new attributes, developed by chemistry, as being water repellent, crease-resistant, flame-retarding, etc., that are invisible.

My concern here was to comment on some textile principles underlying some evident facts. By taking up textile fundamentals and methods, I hoped to include in my audience not only weavers but also those whose work in other fields encompasses textile problems.

This book, then, is an effort in that direction.

April 1965

—A. A.

Preface

I AM in the fortunate position of being able to introduce my subject by quoting from the Encyclopaedia Britannica without being accused of plagiarism. For the article "Weaving, Hand" in it is written and signed by me. I tried to sum up there the essentials of weaving within the number of words allotted me, and thus the article is as concise as I was able to make it. To rewrite it would mean copying myself.

Though I am dealing in this book with long-established facts and processes, still, in exploring them, I feel on new ground. And just as it is possible to go from any place to any other, so also, starting from a defined and specialized field, can one arrive at a realization of ever-extending relationships.

Thus tangential subjects come into view. The thoughts, however, can, I believe, be traced back to the event of a thread.

Anni Albers: On Weaving

CHAPTER ONE

Weaving, Hand

ONE of the most ancient crafts, hand weaving is a method of forming a pliable plane of threads by interlacing them rectangularly. Invented in a preceramic age, it has remained essentially unchanged to this day. Even the final mechanization of the craft through introduction of power machinery has not changed the basic principle of weaving.

Other techniques had been devised to the same end: single element techniques — looping, netting, knitting, crocheting — and multiple element techniques — knotting, coiling, twining, braiding. In weaving, in the latter group, one system of threads, the warp, crosses another one, the weft, at right angles and the manner of intersecting forms the different weaves.

Gradually the various phases of manipulating warp and weft were mechanized until the technique of weaving surpassed all others in efficiency.

Whereas single-thread methods can be handled with few tools, weaving needs more complicated equipment since the warp has to be given tension. The device giving such tension is the loom. Weaving, then, is the process of passing the weft between taut, alternately raised warps, as in the basic plain weave, or between other combinations of selected warps, and pressing it into place.

Earliest weaving was done on the warp-weight loom, where warps were suspended from an upper bar and weighted at bottom. Weaving here progressed downward, unlike other weaving. It was used in ancient Greece and, more recently, by Indians of the North Pacific American coast. Next came the two-bar loom, with warp stretched from bar to bar, or, for extended length, wound onto the bars. Used either vertically or horizontally, the warp was held taut by a framework or stakes in the ground. Early Egyptian records show weaving on such a loom which, in vertical position, is also the tapestry loom of today.

Another loom, allowing for subtly adjustable tension, therefore finer weaving, is the back-strap loom, in which the lower bar is attached to a belt around the waist of the weaver, who, leaning forward or backward can tighten or slacken the warp. This loom made possible the extraordinary textile achievements of pre-Columbian Peru and is still found in remote regions of Asia and parts of Central and South America.

The intersecting weft, crossing between raised and lowered warps, was first inserted without tool, the extra length being wound into little bundles, as today in tapestry weaving; *i.e.*, pictorial weaving. Later the weft was wound onto sticks and released as it traversed the warp. Finally, to introduce the weft faster and in greater length, it was wound on bobbins, inserted into boatlike shuttles, and thrust across the opened warp (the shed) in hand as well as in power looms.

To beat the weft into place, a weaver's sword of wood was an early instrument. Later a comblike "reed" was introduced, combining warp spacing with pounding of the weft. Suspended from the loom framework, the reed swings against the woven fabric, pressing successive wefts against it.

A first device for speeding up the selection of warps between which the weft passes was the shed-rod, carrying raised warps. To raise the opposite warps, an ingenious device, called a heddle, was introduced. The warps running under the shed-rod were tied with string-loops to a second rod, the heddle-rod, and they now could be raised past those on the shed-rod with one upward motion. Later, series of heddle-rods, replacing the shed-rod, facilitated the production of weaves based on more complex warp operation than that demanded for the plain weave, based on the principle of opposites.

In the medieval loom, the heddle-rods, now called shafts or harnesses, were suspended from the framework, similar to the pounding device, and were attached to foot treadles, as they are on hand looms today. They are still found on power looms. Though of incalculable value in saving time, this invention limited the thus far unlimited, primitive warp selection.

To regain some of the early freedom, the highly developed draw-loom was devised. Chinese in origin, developed for elaborate pattern weaving, such as brocades and damasks, it was later adopted in Europe. It was superseded by a further mechanized warp-selection method, Jacquard weaving, still in use today, though transferred during the past century to power-driven machinery.

Among high achievements in hand weaving, Coptic as well as early Peruvian weaving must be recognized, the latter surpassing perhaps in inventiveness of weave structure, formal treatment, and use of color, other great textile periods. In fact practically all known methods of weaving had been employed in ancient Peru, and also some types now discontinued.

Today, hand weaving is practiced mainly on the medieval shaft loom with few harnesses. No longer of consequence as a manufacturing method in an industrial age, it concerns itself chiefly with fabrics for decorative use. Increasingly, though, industry is turning to hand weavers for new design ideas, worked out on hand looms, to be taken over for machine production. Hand weaving is included in the curriculum of many art schools and art departments of colleges and universities, as an art discipline able to convey understanding of the interaction between medium and process that results in form. It has survived through the ages as an art form in tapestry.

Hand weaving has also been taken up in the field of occupational therapy, having, though, as its aim there neither an educational nor an artistic end but solely that of rehabilitation.

It should be realized that the development of weaving is dependent also upon the development of textile fibers, spinning and dyeing, each a part of the interplay resulting in a fabric. Recent advances in the production of synthetic fibers and new textile finishes are having profound effect upon the weaving of cloth.

CHAPTER TWO

The Loom

ANY weaving, even the most elaborate, can be done, given time, with a minimum of equipment. The main incentive, therefore, for perfecting the weaving implements has always been that of saving time. Precision of work, it is true, is greatly aided by adequate instruments, but fabrics of great accuracy have been executed without much mechanical aid. Furthermore, the manipulating of threads does not demand much physical effort, unlike the case where a resistant material has to be forced into shape. Weaving deals with a submissive material. But since it is building a whole out of small parts — a process that is time consuming by its very nature — the invention of time-saving devices has always been a primary concern, from the earliest weaving frame to the latest power loom. In proportion to time saved, production can increase, of course, but we can suppose that the matter of production capacity was of little interest at a time when the usefulness of cloth was only gradually being established. Today, with this usefulness proved, it has grown to surpass in importance most other considerations, for better or for worse.

During the 4,500 years or, in some estimates, even 8,000 years that we believe mankind has been weaving, the process itself has been unaffected by the various devices that contributed to greater speed of execution. We still deal in weaving, as at the time of its beginning, with a rigid set of parallel threads in tension and a mobile one that transverses it at right angles. The main devices, in turn, have not become obsolete, but still form the nucleus of today's weaving instruments. If we follow the various inventions through the ages, we will not be led on historical detours, interesting per se, but will arrive at the underlying ideas in the mechanism of today's automatically functioning loom.

One of the initial problems calling for a solution in terms of equipment is that of giving tension to the first-mentioned group of threads, the warp. We will not consider, at this point, matters of operation, or preparation for it such as warping, for instance, but will concentrate on implements and their development. It is interesting to observe that the answers to some of the technical points at issue are often of startling simplicity, as are truly ingenious inventions. For instance, by attaching one end of the warp threads to a bar and weights to their other end, the desired tension is achieved in a strikingly easy manner. This, then, is the warp-weight loom, an upright loom, as is apparent from the use of weights. It is best known as the Greek loom. It was also used in England during the early Bronze Age and in the Swiss lake dwellings. It is also the loom, with a slight variation, used by the Chilkat Indians of the northwest coast of America. *Plates 1–9*

Another method of achieving tension is by stretching the warp threads between or over two bars, the prototypes of warp and cloth beams known to our day. To keep them taut, the bars are attached to a framework in either vertical or horizontal position. Both these ways have been used in various parts of the world: the upright version for tightly packed weaves such as tapestries and rugs; the horizontal one for finer and looser materials. Examples of the vertical type are found over most parts of the earth, from ancient to modern times. It was known in Egypt and Peru, in India and Asia Minor, in the European countries and Africa, for example, and it is still in use, among other places in France, for tapestry work, and in the United States by the Navajo Indians for their rug weaving. The best known early example of the primitive horizontal type is the Egyptian loom, which is set low to the ground. In the Andean highlands still fairly recently a similar type has been found.

The invention of the back-strap loom added regulative tension to the inventory of early weaving devices. One bar, carrying the spread-out, parallel warp threads, is attached to a pole or a tree; the other is fastened to the waist of the weaver, who can adjust the tension by leaning forward or backward. This makes minute regulation possible and with it a more delicate weaving operation. This back-strap loom occurs mainly in the region of the Pacific Ocean. It was, for instance, in use in Japan and the Malayan islands, and in China, Burma, and Tibet. In Peru, Guatemala, and Mexico, it can still be seen in use, and in some remote regions of Asia.

Next, we can suppose, the heddle evolved. Up to the time of its invention, the warp threads to be interlaced had to be lifted up with the fingers, so that the crossing, mobile threads, the wefts, could be inserted. After each intersection, the warps next to be interwoven had to be selected anew — shifting from odd- to even-numbered threads or vice versa — and raised as before. Only small groups of warp threads can be lifted up in this manner, just as many as a hand can easily hold. This means that, for each passage of a weft thread, as many handfuls of warps had to be picked up as the width of the cloth demanded — a tedious work. By placing a rod into permanent position under the threads to be lifted for the passing of the weft, one part of this work is greatly simplified, since the thickness of the rod causes a separation of the warps to be raised from those to remain lowered. The separation of the warps, or the opening, is called the shed; and the rod, in consequence, the shed-rod. Since the fundamental form of weaving operates on the principle of opposites, the problem of the counteropening is left to be solved. If those warps lying under the shed-rod are attached, by means of a string forming loose loops around each of them, to a second rod lying on top of the warp, the resulting device, the heddle, produces the countershed when raised. By introducing the weft alternately into the shed formed by the shed-rod and that formed by the heddle, the efficiency of the procedure — that is, weaving — is increased tremendously. For, since the shed-rod remains in position throughout the weaving of a cloth, one motion — that of lifting the heddle, not counting that of letting it go — takes care of the previously separate ones of gathering handfuls of threads over and over again. When the heddle is released, the threads raised by it settle back into their prior position, their "natural" position, under the shed-rod. "Natural shed" is an expressive term sometimes used for the first shed formation, in contrast to "artificial shed," used for the second one, which forces its threads past those maintained in their position over the shed-rod.

The type of heddle described above is the one that was destined to outlive others that evolved in the course of exploring the idea. Details such as the various ways of fastening the heddle loops to the rod, diverging with region, race, and period, may be of interest to specialists in the field; but our concern here is to trace the main line of mechanical contributions that finally were to result in today's weaving machinery. However, mention should be made of a cleverly conceived implement that, though not incorporated in the modern inventory of equipment, is interesting as another attempt at producing shed and countershed by the simplest means. This is the free rigid heddle. It is of a hard material, such as wood, bone, or even metal, and has narrow bars, each with a small hole in the middle through which a warp thread runs. Another warp thread is passed through the space between the bars. As the apparatus is raised or lowered, the latter threads slide past those threaded through the holes, thereby forming a shed, alternately above or below those threads. This invention combines the device for forming each of the two opposite sheds in one contrivance. Its disadvantage lies in the limited number of warps that can be used without calling for so large a size of heddle that it becomes unwieldy, and also in the friction that may occur when the threads slide up and down the slots. Also, it must be remembered, only the two basic sheds can be formed, thus making only a plain weave construction possible. Nevertheless, it has proved successful in the weaving of narrow fabrics and was used, for instance, in America, Germany, and Finland.

Weaving in the preheddle days could have held no greater promise as a technique of interlocking threads than did others such as twining, looping, and netting. With the simplification that the invention of the heddle brought, weaving was singled out, for millennia to come, to attain a major role in civilization.

The earliest evidence of the heddle is found in Egypt where it is estimated to have been in use before 2000 B.C. It probably was invented independently in many places and at various periods. In Peru it was known as early as several centuries B.C. For some four thousand years the idea of the heddle has remained intact, and it is easily recognized in the form of the harness in today's power loom. The shed-rod, in a sense an embryo heddle, has been given up, to be succeeded by a second, full-fledged heddle.

The next step, from heddle opposites to multiple heddles, signifies the carrying-through of the initial notion. Series of heddles, with warp threads in designated order, raised in accordance with that order, will form structural patterns. To this day, the shaft loom of our industry operates on this very principle.

The great technical advance of the heddle prepared the way that eventually was to lead to quantity production of enormous dimensions. But, as Luther Hooper wisely reminds us, in his book *Hand-Loom Weaving*, "Each step toward the mechanical perfection of the loom, in common with all machinery, in its degree, lessens the freedom of the weaver, and his control of the design in working." Thus the emergence of the heddle is also actually a limiting element, for it channels thread construction and composition of a weave into a shedding system that permits within its scheme only limited development. Centuries and even millennia had to pass before some of the lost freedom of earlier shed formations could be regained through more intricate machinery.

So far we have taken up matters concerning the warp; we now come to the weft. The first, most elementary, way to introduce the weft thread or threads between the warps was, and still is today in tapestry weaving, by no other means than the fingers. A length of thread is laced over and under the stretched warp threads or inserted into the open shed. With longer wefts, wider weavings, and a speeding-up process came the idea of winding the weft yarn onto a stick that could carry it faster through the shed from side to side of the weaving. Hand in hand with the development of the loom went the development of weft carriers – shuttles. But at the point that we have now reached, a stick, sometimes delicately finished and ornamented, was all that had evolved.

More intricate than the matter of inserting the weft was that of pressing it into place, firmly and evenly, all across the width of the fabric. With the changing of the shed, the warps hold the weft when they close over it. Fingers soon will have proved inadequate instruments for this phase of work. Thus a tool had to be fashioned – flat enough to be entered into an opened shed, smooth enough to glide easily along the warp threads, firm enough not to bend under pressure, long enough to reach all across the warp and slightly beyond to permit it to be easily held. Finally, it had to have a bladelike, though blunt, edge along one side of its length for reaching deeply into the angle of the opened shed. Such specified qualities, when taking shape clearly and simply, not only result in a serviceable object, but also convey in its form thoughtfulness and purity – that is, beauty. This beater-in or batten is truly beautiful, even when not considered for its virtues as an artifact. For its swordlike appearance, it is rightly named the weaver's sword.

Once the batten had been developed in answer to a specific need, it was put to a further service which made use of its general, if not its particular characteristics – for any flat, long, smooth piece of wood might have done equally well. This secondary use was that of keeping open or even enlarging the shed once it was raised, by setting the batten in it on edge.

Though the weaving equipment worked out thus far is found in essence still in use today as an intrinsic part of our weaving machinery, the batten had to undergo further development and even merge its function with another one before finding a place there. Of the two basic components of its present form we have found one to be a tool for beating the wefts into place. To isolate the other, we have to retrace again early stages of development.

We find that the spacing of the warp created a special problem. On short warps it was solved by lacing heading cords along the ends of the warp, generally using heavier thread for this than for the rest of the fabric. Either they were interwoven, and their greater bulk held the warp threads in place; or, in an earlier phase of development, they were twined; that is, two ends of a doubled cord were twisted in such manner across the width of warp that each single warp thread was caught between the twists — an expedient way of distributing them evenly. These heading cords, in addition to their main function of spacing, also gave a sturdy ending to early fabrics woven on warps that were continuous and not, as in our manner of working, cut. For longer warps, this method of spacing proved insufficient, and lease-rods (or laze-rods or cross sticks) were introduced. These are two rods, tied together at the ends, placed near the warp beam and behind heddle and shed-rod, each carrying the warp threads of one of the two basic sheds in the given order: one all the even-numbered threads, the other all the odd-numbered ones. The friction caused by the rods keeps the threads from crossing and helps hold them in position. It also makes it easy to find the allocated place for a broken thread. For this latter function, a lease cord instead of the lease-rods was used on short warps.

An actual warp-spacer is known to have existed in Egypt, for instance, and in Borneo, but it seems not to have been widely used. It is an instrument of wood, as long as the warp is wide, with dents of wood or reed fastened to it through which the warp threads are drawn, thus spacing them as desired. Since a warp-spacer as separate instrument does not belong to the general line of development, it is mentioned here only because of the importance it gained when it made its appearance in combination with the batten.

To summarize: the present-day batten encompasses two functions, that of pressing the weft into place and that of spacing the warp. It is an apparatus that arrived on the scene when mechanization of the loom had advanced well beyond the early stages discussed before. In order to be mañageable, it needed a loom with a framework from which it could be suspended or secured in such manner as to swing freely.

Its shape is predominantly that of a warp-spacer. The dents through which the warps pass are of reed or, today, of wire. They are fastened to a light frame, thus forming what is still called the reed. This reed, in turn, is inserted into another frame which has been given extra weight and sturdiness, so that it holds the reed firmly and can pound the weft effectively into place when swung against it.

Combining spacing of the warp and beating of the weft in one motion marked a decided advance in cloth making. No longer was it necessary to insert the batten into the opened shed after every new weft thread that had been entered; for now it was always in place and had only to be pulled lightly to fall by its own weight against the weft, pounding it uniformly across the whole width of the fabric and simultaneously keeping the warp evenly spaced. Greater evenness of the cloth resulted, and wider weavings could be attempted without added effort. And, again, time was saved.

Since we have already become aware that a loss of range seems to accompany mechanical progress in weaving, let us consider the reverse side of this advance. The heddle rod, as we have seen, restricted the weaver in his handling of the warp. The reed, as part of the batten, added to this its own, though minor, limitations. Working without a reed, the weaver was free to manipulate the warp within the scope set by the shedding arrangement he was using. This meant that he could cross warp threads, for instance, and thereby produce a gauze weave, that is, lace effects. With a reed, however, only those warp threads can be crossed that are entered into the same space between dents. Only neighboring threads, usually not more than two, can be used in this manner. Commonly, in weaving, only one warp thread is drawn in between dents, thus eliminating entirely the use of deflected warp threads. The imaginative gauze weaves of early Peru are the product of "heddle-less" and "reed-less" looms!

Plates 25, 40, 44, 46, 47, 48, 58, 90, 99

Another consequence of the use of a reed — which cannot be listed on the positive side though it is not an impediment — is the mechanical nature of the spacing of the warp threads. Before the use of the reed, warp and weft adjusted themselves to each other naturally; they slipped together according to their size, their resilience, and their twist. With the warp held apart artificially, a knowledge of such relationships and also advance planning are necessary to arrive at a balanced interconnection. Where this is lacking in a fabric, threads will easily draw apart or pile up, spoiling appearance as much as usefulness. In an economy-minded age, the possibility of an off-balance thread-relationship has been exploited barbarously. By setting the warp threads wider apart than the corresponding weft threads require for a sound construction and by spacing the weft equally sparingly, yarn can be saved and cost thereby reduced. To give the material a semblance of firmness, it is finished with a size — that is, a coating of paste that holds the too-loose threads in place, at least until their first contact with water. This makeshift practice has led, however, to the recent development of new finishes which, far from being unsound, are adding valid new textile properties to the fabric to which they are applied.

Much earlier, another fusion of a batten and a warp-spacer existed. It is still in use today in the form of an implement for tapestry and pile rug weaving; that is, for work done on upright looms where only short sections of the filling have to be compactly beaten into place while at the same time the position of the warp threads is adjusted. This is a comblike instrument with a handle — a beater-in. It is found in many places, among them India, Persia, Africa, Asia Minor, Egypt in Roman times, and America before the Conquest. It is also found today among the Indians of the Southwest. Surely, it was also used in Europe in the weaving of the great medieval tapestries. It is of wood or metal or a combination of both. The dents are pushed between the warp threads and pressed or beaten onto the wefts or the knots of a rug. A batten inserted between the warps would undo the knots. In ancient America, it was a much-needed instrument, in addition to the swordlike batten, for work done on back-strap looms. For, customarily, the weaving was started from both ends and worked toward a meeting point. When this point was approached, the batten had to be discarded, for the warp no longer permitted the entry even of narrow battens. Here the beater-in took over, sometimes in the form of just a comb. With its teeth reaching between the warp threads, however short their exposed section may have become, it could push the wefts into place, even when they had almost closed the gap in the weaving.

Here we have arrived at a point where we should take stock of what had been achieved thus far. At this stage, the loom was equipped with warp beam, cloth beam, heddle-rods, shed stick, lease or cross rods, batten or beater-in, and (in the Pacific region) a back strap. Looking back today, we are aware, in awe, that it contained all the essentials of the loom as we know it in our own time. It was the loom of ancient Peru, for instance, on which the great masterworks of the textile art were woven. In Peru it did not have any further development, except for minor variations. But the fabrics made on this loom stand as a testimonial to heights of inventiveness in weaving never reached again anywhere at any time.

This loom is the loom, mainly, of cotton weaving. It is believed that another phase in the mechanization of the loom was initiated with the use of a new fiber, silk, which the Chinese were experimenting with at a time when other parts of the world were in the early stages of working with cotton and flax. The fineness of the threads made special adaptations of the weaving appliances necessary, and thus it is considered likely that we owe to the Far East the improvements that added so importantly to swift and controlled performance in weaving.

One of the first of these improvements concerned the shedding mechanism, which had to be made to function smoothly enough not to damage the fragile threads. The shed-rod was discarded and replaced by a second heddle. The heddle itself was changed in some respects. Whereas it previously had been drawn by hand in an upward direction only and therefore had consisted of only one light rod to which the upper end of the string loops, carrying one warp thread each, were attached, it now was equipped with a second rod or lath to which the lower end of the loops were secured, thus making a downward movement possible.

With the lower, second lath, the heddle took on a new name, leaving its former one to the loops only, through which the warp threads pass. It now was called a pair of shafts or, if upper and lower laths were connected at their ends by uprights, a frame. In industry it is called a harness.

A revolutionary change came with the transfer from hand to foot operation of the frames, together with their now two-directional motion. Since, in Asia, much more use is made of the feet in working than in Europe, for instance, this shift itself has been interpreted as another indication of the part the East played in subsequent developments. What was done was to suspend and also couple the shafts or frames, by means of cords running over a roller which was placed above the loom proper. Each lower lath was tied to a treadle below the loom. When a treadle was stepped on, one frame was drawn downward, while the other one linked to it automatically rose. Since the frames carried the heddles through which the warp threads were drawn, the countermovement parted them and thereby opened the shed. The hand no longer was needed in this performance and therefore was free swiftly to pass the weft and beat it into place.

A primitive loom, used in India among other places, gives us insight into early ways of suspending the roller. The loom was placed under a tree and an overhanging branch was used to hold it. To make the weaver independent, no doubt, of such specific locality and the exposure to weather, a framework with upright posts was developed to act as support for the roller-shaft contrivance. Once the idea of suspension had taken hold, it was extended to include also the batten, which had gone through its own phases of transformation, as discussed before. Here, then, was the fully developed shaft loom with free-swinging batten. It was the loom that was to take care of the textile needs of many peoples for centuries to come.

The introduction of the treadles and the pendent batten, like the earlier invention of the heddle, caused a rise in cloth production that must greatly have broadened the inceptive idea of the usefulness of textiles. For, as need presses toward fulfillment, so does obtainable fulfillment excite need — a generative cycle, spiralling to dimensions of both need and productivity that must seem excessive to any generation earlier than the one participating in it.

Though it is believed to have been devised by the Chinese specifically for the weaving of silk, the shaft or treadle loom later came universally into all-round use. It is likely that until the third century A.D. its use, together with the art of silk weaving, remained confined to China. Gradually, however, it was taken over by other parts of the East and finally reached the West: first Spain and Italy; later France, Germany, and England.

This loom became the loom of medieval Europe. In all essentials, it is also the loom of our time, though it took further centuries to transform it into the miraculous instrument of precision and speed that it is today. There was, however, no successive development. For hundreds of years it remained in the stage it had reached. Though variations were invented, they all operated within the confines of the fundamental principles on which it was built.

We have, in following the development of weaving equipment, taken the viewpoint that saving time was a leading concern. For hundreds of years, however, no inventions were added that markedly increased the speed of weaving. The inventions were, however, significant in another respect: in reconquering some of the lost range that went with the mechanization of operations.

Mention should first be made of a shedding device, introduced by the Chinese so it seems, that modified the original countermovement of pairs of shafts by making possible the raising of single shafts. The number of weave constructions that now could be woven was greatly increased, since not only even- but also odd-numbered structural patterns could be undertaken.

By interposing levers between treadles and shafts, the direct action upon the shafts was changed into an indirect one. Two different shedding methods were developed. One made it possible to raise a single shaft or any given combination by pressing on the treadle. The other operated in such a way as to make a single shaft or any combination of shafts form a shed, with the difference that here the selected shafts were raised while simultaneously all others were lowered. The effort of lifting the weight of the shafts was reduced considerably, since the lowering of the others made it unnecessary to lift them as high as would have been required if the regular warp plane had had to be maintained.

Another elaboration of the shedding mechanism, apparently also of Chinese origin, was the compound harness, which made it possible to weave small pattern effects into a different background. A second set of shafts was placed behind the regular set in front of the weaver. The regular shafts were now equipped with heddles that had, instead of small eyes, elongated ones. Those selected warp threads that were to be used in forming the pattern were passed through the small eyes of the heddles of the added pattern shafts, as well as through the elongated ones of the regular shafts in front of the weaver. This arrangement permitted the opening of a shed by the commonly used shafts independently of the pattern shafts. The latter ones could be raised when needed, and the warp threads passing through them could affect the shed by reason of the long heddle eyes of the front shafts through which they passed, no matter whether they were raised or not. The limitation of the compound-harness loom lay in the comparatively small number of pattern shafts and corresponding treadles that could be conveniently managed in addition to the regular shafts.

The various efforts to recapture a freedom that had been lost with the introduction of mechanical shedding devices led to the invention of the draw-loom, which allowed the weaving of figured designs by mechanical means. This invention, thought to be of Persian origin, was, like the one discussed before, a modification of the shedding appliances. It was of far greater consequence, however, for it inaugurated a new era of figure weaving. Instead of shafts performing the shedding motion, there was a return to single warp thread operation, though now, after many centuries, by mechanical means. The place of the shafts in the loom was now occupied by a comber board pierced with holes through which leashes were hung, each with an eye through which a warp thread was drawn and with an elongated weight at its end. These leashes were attached in groups to cords in such manner that those with warp threads which had the same position within a repeat of a design were combined. Thus, if a cord was raised, it would raise with it, for instance, all first threads within a repeat of a design. The person in charge of raising the required cords for each shed in the varying combinations of the design was the "drawboy," who was perched on top of the framework of the loom or, in later models, could select the cords at the side of the loom. The various types of draw-looms are called, according to their specific devices for raising groups of single threads, "button looms" or "simple looms."

The draw-loom operates single warp threads mechanically, and in this respect it has reached the end of possible development. However, it operates single warp threads within a limited range and therefore resorts to repeats across the width of the fabric. This, in combination with the great fineness of threads and the great number that now were manageable, led to the art of elaborate pattern weaving in compound constructions.

This loom must have been in use in Persia as early as 520 A.D., a date known because of the tribute then paid to the Emperor Wu. During the sixth and seventh centuries, Alexandria was an important center for elaborate fabrics, and later Constantinople took over this art, passing it on to Sicily in the twelfth century. From the thirteenth to the eighteenth century Europe produced on this loom the rich fabrics that are the highpoints of her contribution to the art of weaving.

The unique improvements, however, that Europe made in the developmeant of weaving lie in another area. It was the mechanization of the loom beyond the point to which it had ingeniously been brought by the Orient. The first practicable technical weaving invention made in Europe was the fly shuttle, devised in 1733 by John Kay, a reed-maker from England. It would be wrong, though, to assume that mechanical improvements of the loom had not until then occupied the inventive minds of Europe, among them Leonardo da Vinci. His plans, however, were never put into practice. In 1586, Anton Möller of Danzig is said to have invented a mechanical ribbon loom, though it supposedly was suppressed and the inventor drowned by weavers who feared competition.

Other names connected with the problem of mechanizing the loom were De Gennes, who in 1678 came forward with an invention which, however, was of no practical use, and Josef Mason, who in 1687 patented an idea concerning draw-loom mechanization.

The invention of the fly shuttle was of far-reaching significance because it achieved the mechanization of one phase of weaving – the insertion of the weft. Every step toward this mechanization – from the interweaving of loose threads by hand, to the passing of a stick carrying the weft from side to side of the weaving, to the hand shuttle with a bobbin of thread in it thrown by hand from selvage to selvage, and finally to the fly shuttle – represents a time-saving device. With this last contrivance, the shuttle is propelled through the opened shed by pulling the cord of a driving device and abruptly arresting the motion. When the shuttle reaches the opposite side, it is caught by a similar driver that returns it in the same manner. The shuttle runs along a projecting ridge of the lower part of the batten, differing here from the hand-thrown shuttle, which lightly passes over the lower warp threads of the opened shed. Kay's invention increased the speed of weaving three or four times and thereby not only affected the quantity of production but, in consequence, also reduced the price of the fabric. Important, too, was the fact that now it was possible for one weaver to do work that previously needed two, in the weaving of fabrics wider than one person could reach. His invention, like that of Möller, aroused the fear and anger of the weavers, and he only barely escaped their fury. His son, Robert Kay, elaborated on the invention and developed the multiple shuttle box for an exchange of shuttles in varying colors or other distinctions of yarns. Significant as was the part the fly shuttle played in hand weaving, it was of still greater consequence later on as part of the operation of automatic looms.

A decisive point in the mechanization of the loom was reached when Cartwright, who patented a power-driven loom in 1783 and an improved model in 1786, set up nineteen such looms. Power was first supplied by an ox harnessed to a capstan and later by steam. Though his life was not threatened, he shared the misfortune of the earlier inventors, for he saw this first weaving mill destroyed by fire.

Many contributions from many sides were necessary before the loom was ready to take a vital part in the industrial development that made England for a time the greatest producer of textiles. Only with the beginning of the nineteenth century were power looms introduced in any quantity. The first one to be set up in the United States was in 1813. The effect of the mechanized loom on time saved and thereby on increased productivity is beyond computation.

While England concerned itself with the general problem of mechanizing weaving, France took up the particular one of substituting a mechanism for the drawboy in the operation of the complicated shedding system of the pattern loom. Various efforts were made by Bouchon, Falcon, and Vaucasson, all during the middle of the eighteenth century, but none of the results was practicable. In 1805, however, Jacquard brought out a machine, an improvement on Vaucasson's, that proved successful. It rendered the draw-loom's shedding apparatus automatic by retaining the weighted leashes through which the separate warp threads ran and by fastening them to wire hooks that were raised by wire blades or deflected into a position that prevented them from being raised — a selection controlled by a chain of cards perforated in accordance with the pattern. This chain rotated around a cylinder which itself was given quarter turns by a treadle. Besides the enormous simplification that this mechanical invention meant for figure weaving, it had the advantage that designs no longer had to be tied up cord by cord. By an easy exchange of the perforated cards, any design could be woven that was calculated for the number of warps within the particular repeats for which the loom was equipped by its leash and cord set-up. Whereas previously, a loom was rigged up cumbersomely for one pattern and was repeatedly used for just the one, a shift from one to another was so easy now that the market became flooded with designs of all kinds. In the struggle for the attention of the buying public, the manufacturers outdid each other with constant changes of design — a situation we are still witnessing today.

The modern age of power weaving began in earnest when the Jacquard shedding mechanism was attached to the mechanized loom. In the second half of the nineteenth century, the technical genius of the Western world perfected the loom to the point it now has reached. It operates with the speed and precision that we expect and enjoy in the instruments that serve us. Among the various problems that had to be solved was a self-acting motion to stop the loom should a weft thread break or a new bobbin have to replace one that was used up. Furthermore, ways had to be found to unwind the warp and wind up the woven cloth automatically. An invention was also necessary to provide an instrument that would stretch the warp threads into the exact width — that is, a templet, which would not need adjusting every few *Plate 95* inches as is the case in hand weaving. Though it did not take centuries to solve these problems, more than fifty years were needed to develop the necessary contrivances.

Further developments concerned themselves with the matter of conserving power in the process of passing the weft from side to side. In the standard loom in use today, it is estimated that at least one-half of the power needed to drive the loom goes into propelling a heavy shuttle, carrying yards and yards of weft, back and forth with the required speed. In 1844, a John Smith patented a loom that drew the weft thread with needles through the shed. In 1949, a machine was built in the United States based on the same underlying principle of using lightweight weft carriers instead of shuttles. The weft here is not continuous but is just long enough to reach across the fabric and to be turned in at the selvages. The power saved makes it possible to operate this loom two or three times faster than today's standard looms. This loom has the added advantage of enlarging greatly the range of weft selection beyond the four to six choices ordinarily possible. So far this loom is not in general use, probably due in large part to its high price; and only a few models can be seen at institutes for textile research.

Another invention was a loom that operates a selecting system electromagnetically. First experiments with electromagnetic current as a selecting device were made by Eugene Vincenti who, in 1856, patented a Jacquard selective shedding system governed electromagnetically. Another loom, available today in a narrow width for sample weaving, applies the same principle to a shaft loom; that is, it operates the shaft selection electromagnetically. This loom, too, is at present not in general use, due to its high price, despite its great advantage in regard to the easy change it permits from one weave formation to another.

Our machinery has become intricate, our manner of working fast. Yet every age must have felt that way about its achievements, and only looking back does everything that went before seem slow. How slow will we appear some day?

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CHAPTER THREE

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 which 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 which, 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 the warp up 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.

Plates 11, 13, 14

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.

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; for 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°; 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,

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

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

$$\frac{2 \qquad 3 \qquad}{\qquad 2 \qquad 3}\ \text{, etc.}$$

Twill weaves, as a result of longer floating threads, are softer and can be woven more closely than plain weaves. They also are 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 which date back to the Peruvian Mochica period.

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 only produce a fabric that is the same in front and back — the satin weave can only be unbalanced, can only produce a fabric different on either side, can show only either warp or filling. In contrast also the plain weave, where the closest intersection of

Plates 12, 15

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 5-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 which, 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.

CHAPTER FOUR

Draft Notation

IF the construction of a weave consisted of nothing more than the basic weaves, it would be a simple matter to draw the directions for the intersecting of warp and filling in a representational manner, showing the actual interlacing of the threads. It would be possible, also, to indicate by numbers the warp threads alternately raised or lowered, as is frequently done in the case of simple twills. But with the modification and elaboration of weaves, matters get complicated, and a simplified manner of notation is needed.

Plates 10, 11, 12

A standard system for drafting weaves has, with slight variations, been generally accepted by industry – in power loom as well as in foot-power loom production. This shorthand of draft notation uses graph paper as a framework. The space between its evenly spaced verticals is understood to indicate the warp threads; that between the horizontals, spaced similarly and intersecting at right angles, the filling threads. The little squares thus formed denote the intersection of warp and weft. A raised warp thread is marked by filling out a square. Thus an empty square means that here the filling is showing. This is all that is needed to give an accurate account of the construction of a weave, although, of course, it does not give a naturalistic representation of it.

When the order of the interlacing threads in a weave is made out and recorded, it will be evident of what elements a weave is composed and how many warp and filling threads go into the basic unit of construction. This unit contains all the structural components and is all that is actually required as information about a weave. However, a number of repeats of this unit are usually needed to recognize the scheme of a design. In order to separate the first unit clearly from the repeats, it has to be marked as such. Ordinarily this unit is placed in the lower left-hand corner of the draft and is distinguished either by a different color – red for the unit, blue for the repeat – or, in a black and white representation, by a different graphic means. Sometimes the limits of the unit are just marked at the lower left-hand corner on the outside of the draft. The unit should thus be recognizable at first glance and convey immediately the number of warp and filling threads needed for the construction of the weave.

With few exceptions, gauze or leno weaves, for example, any weave can be drafted in this manner. Lengthy descriptions of the execution of a weave, giving the threading, the tie-up of the loom, and finally the sequence of weaving operations, can be easily reduced to this simple notation, which gives all the necessary information. The construction of a weave can be understood by reading the draft, instead of having to go through the lengthy process of actual execution. Compared to a laborious realistic portraiture of a weave, showing mainly its appearance, this notation, besides being easier and faster to perform, has the additional advantage of showing clearly those structural elements that do not appear on the surface and can thus be shown naturalistically only by distortion. In historical research work, also, the general adoption of this system of notation, so common in commercial textile work, would mean in many cases a great simplification of recording. It is amazing to see what complicated reporting is often resorted to, instead of transcribing the thread construction into the code of draft writing.

If the shorthand of draft notation as discussed above proves to be a useful tool in the construction of weaves, it is equally helpful in the analysis of weaves – that is, in the tracing of a construction already executed. In analyzing a given piece of material, every filling thread or every warp thread is followed through its course of rectangular intersections with the opposite thread system; and every raised warp thread that crosses over a filling thread is marked according to the system of notation.

Wherever the piece of cloth that is the subject of analysis can be cut, this process of tracing the course of each thread – usually with the help of a long needle – is greatly simplified. For, by cutting along a filling thread, for instance, the path of the thread can be seen in cross section when looked at from above, and the following filling threads can be lifted out one by one, giving a chance for easier observation of the thread's intersections than when seen on the face of the fabric only. The same holds true when warp threads are traced instead of filling threads. An additional aid in the process of dissecting a cloth is a magnifying glass.

Of course, more than the thread construction has to be identified in the analysis of a cloth: the color of each warp and each filling thread has to be marked at the edge of the draft; the twist of the yarn and its color, as well as the material it is made of, have to be indicated; so do the number of warp and filling threads per inch, centimeter, or any given space. When these facts have been established, all the information required for the reproduction of a cloth has been ascertained, for the procedure of weaving is merely a matter of inference.

CHAPTER FIVE

Modified and Composite Weaves

THOUGH elaborations are usually thought to be an advanced stage of work, they are often easy expansions from basic concepts. Intricacy and complexity are not, to my mind, high developments. Simplicity, rather, which is condensation, is the aim and the goal for which we should be heading. Simplicity is not simpleness but clarified vision — the reverse of the popular estimate. If you try to speak or write clearly, you are thought to lack profundity; while the impenetrable verbiage of today's writing on art, for instance, is respected for the very reason, I suspect, that it is beyond understanding and therefore is believed to be too highly advanced for the unassuming reader's grasp. All this is to say that what was said about the basic weaves holds in general for the derivatives and the compound weaves, except that the original characteristics may be diluted by some additional ones that might counteract them.

Of course, there are also gains somewhat outside of the scope of the basic, original weave, for instance, in double weaves based on either the plain weave, the twill, or the satin. Here we have, instead for instance of one plain weave, two, the layers lying one on top of the other. The same holds for twill or satin double weaves, of course. The added feature here, besides doubled strength and warmth, is that a doubled use of color is possible, an interchange from layer to layer, an interpenetration of color areas, which will be discussed later in more detail.

It is interesting to note that where the functional aspect of the basic structure is moderated, aesthetic qualities frequently move to the foreground: in fact, they often are the very reason for the structural change.

Most of the modified and composite weaves are developments from the

Plates 16, 17 three basic weaves. A rib weave is a derivative of the plain weave and is based on the same principle of opposites: the threads that were on top in one shed are down in the next — the essential feature of the plain weave. The rib weave is developed by a shift away from the plain weave's balanced proportion of warp and weft. By spacing the warp closely and using, for instance, a heavy weft thread, horizontal ribs will be formed, the warp covering the weft. Or the weft may be made to dominate the surface, as in tapestry weaving, but here by having it float successively over several warp threads in regular intervals, thus building up a vertical rib effect. The warp rib or cross rib has ribs in the direction of the weft; the weft rib or long rib has ribs in the warp direction. Numerous elaborations of rib weaves are possible, as are also combinations of warp and weft ribs.

Plate 17 Another derivative of the plain weave is the basket weave. It, too, works of course on the principle of opposites. Its characteristic is the use of floating warp and weft threads to form block patterns which, however, lack the firmness of the plain weave. By various combinations of these block patterns, arrangements can be achieved that can even give the optical illusion of space. To give greater firmness to the basket-weave plain weave, thin weft threads can be introduced that will be covered by the heavier pattern wefts of the basket weave. The Colonial American weaves with their innumerable, rich variations, as well as many Swedish and Finnish weaves, are developments of the basket-weave principle.

Plates 18, 19, 52 There are a great many elaborations of the twill weave, with a variety of different names, all sharing the original twill formation of neighboring warp threads tying with successive wefts to the right or left. There are Interlocking Twills, Steep Twills, Reversed Twills, Offset Twills, Herringbone Twills, Undulating Twills, Pointed Twills, Shadow Twills, and a long list of others. The diagonal twill lines are still evident, as is the pliability that is greater here than in plain weave or plain-weave derivations. Also, twills yield to diagonal stretching and therefore are well suited to Occidental ways of tailoring. Notice also that tweeds are twills. Twills can be easily developed once the basic principle is understood, and various methods for such developments have been devised. Though books with hundreds of recipes for them have been published, a twill suited to a specific occasion can be constructed just by the use of some sense.

Satin weaves too, of course, have their modifications and elaborations as well as combinations. Again, the original character of the satin construction is preserved. Damasks are perhaps the most successful development of the satin weave, though there are also twill damasks. Here, a warp satin is combined with a weft satin or, less strikingly, a warp twill with a weft twill, one forming the ground, the other forming patterns, often of floral design – a favorite for centuries. Since, in satins, the floating warp or weft threads cover either warp or weft more completely than in twill combinations, the pattern appears clearly; and as silk or a fine linen is usually used, a luxurious fabric results. Since, too, larger pattern areas are desirable here than are feasible with the 4-, 8-, 16-, or even 24-harness looms, the Jacquard loom is preferred for damask weaving. *Plate 20*

Corded weaves belong to another group that is clearly derived from basic constructions, for the raised-rib appearance is the result of a surface weave of plain weave, twill, or satin. In order to produce the corrugated effect, which may be in either warp or weft, threads are left floating at certain intervals and then incorporated again into the weave, allowing an extended surface weave to be pushed tightly to the unwoven section of the resting threads. It is advisable to use two warp beams for these differently engaged threads, which otherwise will easily produce divergent tension. *Plates 20, 21, 53*

To further increase the three-dimensional effect of the cords, stuffing threads that lie between surface and floats can be added without difficulty. An extension of this type of weave construction is the "Plissé" weave, where a fold in the fabric is achieved by first weaving a section of the chosen weave, then continuing with a section in which part of the warp is floating in back, and then rejoining the first part by pushing the latter section against the already completed part, thus making it hang over instead of merely forming a raised cord in the manner discussed earlier. *Plate 21*

A group of weaves slightly outside of the general line of construction is that of the mock leno weaves. Here the threads of warp as well as weft are grouped in such a manner as to fall together in little bundles, where they act together in one group and are held apart from another group which acts oppositely. Thus a lacy, open effect results, which may be emphasized by threading the warps in the reed, grouped together in accordance with the draft where they fall together, and with open spaces left in the reed where they separate due to the construction. *Plate 21*

Crepe weaves, too, are developed from the basic weaves, but they differ from the previously discussed constructions by aiming at an appearance that avoids directional patterns or a smooth surface, but rather at one that gives a mottled surface effect. By adding tying points, or stitchers, to an original basic design, a satin or perhaps a twill, or by omitting some stitchers, innumerable crepe weaves can be developed. In fact, it is easy to construct hundreds of them. It is a useful weave suited mainly for clothing.

There are innumerable other weave constructions, developed not merely as elaborations of the basic weaves and preserving their original functions, *Plate 22* but for further specific functional purposes. There are the back-filling weaves which have as their main intent a heavier, thicker fabric than could be achieved otherwise. As a by-product, such a fabric could have also different weave structures in front and back, as well as, of course, different colors. A back-filling fabric could have a plain-weave face and a twill backing or many other combinations, as long as a balance between the front and back weave is preserved; that is, as long as no problem of different tension between them occurs. One other, less admirable, purpose of the construction is to produce a fabric at less cost by using cheaper yarns in the less-visible back.

Another method of producing a heavier fabric than is possible in a single-layered construction is the back-warp weave, which adds warp threads to the back to be interwoven. However, it is a less useful construction than the back-filling one, since the warp threads have to be set very closely and a heavyweight warp thread might cause difficulties in the opening of the shed. Therefore, this weave is usually reserved for medium-weight fabrics. Again, different weaves can be used in front and back, as well as different colors.

Plates 22, 23 Double weaves have a special nimbus about them for reasons not clear to me. They are thought to be intricate, hard to grasp, open only to advanced students. To my mind they are simple to understand and can be handled by anyone with just common sense — which, I admit, sometimes seems rare.

Plates 87, 94 Double weaves are fabrics that have two separate layers which can be locked at both sides, at one side, or, within the fabric, at any number of places where the design asks for an exchange of top and bottom layers, usu- *Plates 88, 96* ally of different colors. There are also triple weaves and quadruple weaves, and multiple-layered fabrics can be constructed, though they are rarely found. In ancient Peru, double weaves in complicated designs were made, and triple weaves have been found, as well as a small quadruple piece. If a highly intelligent people with no written language, no graph paper, and no pencils could manage such inventions, we should be able — easily I hope — to repeat at least these structures.

Double weaves can be woven with as few as four harnesses when both layers are plain weaves; two are designated to operate the warp threads of the upper layer, two those of the lower one. Usually the first and third threads belong to the upper set, the second and fourth to the lower set. The first weft will cross with the first thread of the upper warp, return as second weft, and cross with the second warp thread, that is, with the first of the lower layer. To do this, warps 1 and 3 of the upper layer have to be lifted out of the way together with number 4, not active now. The third weft now returns to the upper layer and intersects with warp thread 3, thus completing the plain-weave unit of the top layer. By returning as weft 4, it crosses under warps 1 and 3 of the upper layer and warp 2 of the lower one and engages now warp 4, thus completing the plain-weave unit of the lower set. This is the complete cycle, forming a double-layered fabric of plain weave closed at both selvages. A three-layered plain-weave material demands six harnesses, a quadruple one eight, two for each layer, while a double weave in a 2/1 twill will need six harnesses, three for each layer. It is easy to devise further possibilities, all of which follow the same reasoning.

By changing the sequence of weft operation, a fabric can be made to open at the sides, thus making it possible to weave a fabric that unfolds to twice the width of the warp on the loom, three times the width, or even wider. The procedure here, if it is a plain-weave double weave, is to have the first weft weave the first plain-weave part of the top layer; next, the first part of the lower layer; then complete that layer by weaving the second plain-weave part; and then return to the top layer, completing there the plain-weave unit.

Aside from the purpose of producing by this method wide fabrics on narrow looms, weavings of three or more plies are designed in order to enlarge the color exchange of solid color areas in a fabric — a red crossing with a red warp thread, a blue with a blue — instead of having mixed areas where, for instance in plain weave, red crosses blue.

One type of weaving not yet discussed is brocade. Brocade weaves are not derived from any basic construction but have surface threads added to a basic weave to enrich the appearance of the fabric. There are warp brocades and weft brocades, both having in common design effects due to floating, additional threads. A similar effect can be produced by embroidery, where threads are also added to a foundation weave. In a brocaded fabric, however, these added threads do not cross from area to area but run strictly parallel to the weft in weft brocade or, in warp brocade, to the warp.

CHAPTER SIX

Early Techniques of Thread Interlacing

BEGINNINGS are usually more interesting than elaborations and endings. Beginning means exploration, selection, development, a potent vitality not yet limited, not circumscribed by the tried and traditional. For those of us concerned in our work with the adventure of search, going back to beginnings is seeing ourselves mirrored in others' work, not in the result but in the process.

Therefore, I find it intriguing to look at early attempts in history, not for the sake of historical interest, that is, of looking back, but for the sake of looking forward from a point way back in time in order to experience vicariously the exhilaration of accomplishment reached step by step.

This is learning. And I try to take my students also on this journey back into early time, to the beginnings of textiles. How did it all begin? There is more than one theory; and, since we do not really know, we may as well speculate. Hides of animals are probably the closest prototype to fabrics. They are flat and pliable and therefore useful in quite specific ways. We can cover ourselves with them, and this second layer of skin gives us protection from cold, sun, and wind. They can shelter us as roofs and walls. They are useful implements for carrying things. When not in use they can be folded, that is, reduced in size, and are miraculous in that respect when contrasted with stone or wood.

Perhaps the idea of fabricating a stuff of such extraordinary nature started the work in that direction; perhaps, on the other hand, it all began not imitatively but by someone adding one bit of a soft strip of bark, sinew, vine, or whatever, to another, fastening them together in various ways, experimentally, not aiming for any immediate application. The manner of such fastening leads, of course, to very different results. Here we are right in the midst of techniques, and it may be worth while taking them up one by one.

Some of the earliest mummy wrappings, reported to be five thousand years old, were excavated recently by Frédéric Engel in Paracas, Peru. (See *Journal de la Societé des Américainistes,* Vol. 49, 1960, pp. 7–36.) They are of rushes tied together in the manner of twining — that is, stiff materials were connected by means of a softer one to form a mat pliable in one direction, stiff in another. They are closer perhaps to basketry than to fabrics as we usually understand them. In fact, baskets made in a similar method were found in the same burial. Twining we will encounter again as a technique evolving into weaving, so it appears. Here, then, we have one of the origins of textile techniques, though we are not yet dealing with fabrics per se.

Basketry is thought by some to be a direct ancestor of weaving. Our conjectures can lead us, however, in another direction also, perhaps closer to the main line of textile development.

We may assume that only short ends of soft, pliable longitudinal materials were available, and that thus a process which attached short bits of it to each other to form a flat expanse surely must have come early in the history of fabric construction. The result will of necessity be an open, netlike fabric with characteristics far removed from those of hides, for instance, which are in contrast compact, solid, heavy, and opaque. With the usefulness of such a lightweight and pliable fabric established for fishing, carrying, and covering the hair (early examples of hairnets have been found in Peru), a desire for lengthening the elements of construction must have arisen, which eventually led to the spinning of fibers. With long, flexible ends to work with, further methods of construction evolved. There was looping in its various forms, netting, twining, all accomplishing, with variations, the same end: a flat, quasi-two-dimensional, pliable expanse of material. So basic was this newly fabricated structure that "material" still today is the name for it, as is "fabric." Already early in our history it added to nature's objects something we may think of as a new species in the realm of things.

Knotting, netting, and looping, all interrelated techniques, require hardly any tools except, perhaps, a stick as a bobbin to carry the now practically endless spun element of construction, the yarn, and perhaps another stick as a gauge to assure uniformity in working. Each of these techniques produces open fabrics. (For more details see Raoul d'Harcourt, *Textiles of*

Plates 24, 30, 41, 43

Ancient Peru and Their Techniques. Seattle, University of Washington Press, 1962.) Looping and also, later, crocheting and knitting add elasticity to a fabric and are single-element techniques using only the one continuous length of yarn for construction. Crocheting and knitting are believed to have been invented by the Arabs. The oldest specimens were found in Egyptian graves of the Arab period and are not earlier than the seventh or eighth century A.D. (See Kristin Bühler: "Classification of Basic Techniques." *Ciba Review,* No. 63, 1948.)

These fabrics are highly pliable and light in weight because comparatively little material goes into their making. They can be given any shape, and their size is not held to any limits except those of reasonable usefulness. When experimenting with such basic methods of construction today, we come to realize the essential qualities of textiles and begin to see present-day procedures, with their emphasis on time-saving devices, in one long perspective. Also, we may find ourselves examining loose ends of developments and occasionally adjusting them to today's purposes, sometimes by nothing more than a change of proportions, using perhaps cord instead of thread.

Plate 43

Compared to hides — always limited in size and always of unpractical shape — these textile inventions opened vast new horizons. They now made possible long lengths of regularly shaped material. Density of construction must soon have arisen as a new aim, combining the newly won traits with the desirable ones given by nature.

A drastic departure from single-element techniques came with the introduction of two separate thread systems, one stationary, the other mobile. An early form of working with these was twining. The vertical threads were brought into tension — actually, this is the main function of any loom — by suspending them from an upper bar and attaching weights to them at the bottom, or by stretching them over a second, lower bar. A doubled weft thread then crossed at right angles these threads — we now can call them warps — from side to side, locking between twists of its two strands one or more warp threads. Fabrics of this kind, excavated by Junius Bird on the northern coast of Peru and dating back as far as 2500 B.C., show knots at the selvages after each crossing due, I believe, to the still short length of yarn then available. These knots occur also in pieces from the same site that are already actually woven. (See Junius Bird and Joy Mahler: "America's Oldest Fabrics," *American Fabrics,* No. 20, Winter 1951–1952; see also Junius Bird: *Andean Culture History,* New York, American Museum of Natural

Plates 24, 28, 42

History Handbook Series No. 15, 1960.) At even such an early stage, actually a preceramic age, intricate twined structures were developed by transposition of selected warps, thereby attaining subtle, spatial effects. These fabrics are warp faced, the twined wefts widely spaced, holding the closely set warp firmly in place. It is an efficient technique, though it was eventually overtaken by that of weaving, which, as later became evident, proved to be still more effectual, more open to the time-saving devices that were eventually to lead to its mechanization. Still earlier than these ancient American fabrics, in fact the earliest fabrics found to date, are those excavated as recently as 1961 by Hans Helback at Catal Huyuk in ancient Anatolia. According to the C–14 dating method, they date back as far as 6500 B.C. (See *Archaeology*, Vol. 16, No. 1, Spring 1963, pp. 39–45.) The photographs show knotting and also, according to the author, twining, though this is barely discernible. These fabrics are far less developed than those discussed above.

Twining, working as we have seen with a double weft thread, produces a fabric somewhat stiff and heavy. It has, however, an additional feature, that of spacing the warp evenly between the weft twists. By using heavier or finer yarn this spacing can be adjusted, due to the resultant bulkier or smaller twists separating the warp threads. In fact it is a technique at home on all continents, according to Dr. Bühler-Oppenheim. (See *Ciba Review*, October 1947.) Twining is also the technique used in the Chilkat ceremonial blankets of the northern Pacific coast of the North American continent. But here the weft covers the warp completely and carries all the design elements. *Plate 66*

Once work had begun on a vertical thread system intersected rectangularly by another one, the simplified interlacing of a single weft that picks up alternate warp threads and reverses the selection with every further crossing was, it seems, a natural next step. It was an important next step, for this, now, is weaving. The advantage over twining is obvious: only half the amount of yarn is needed for each passage from side to side, and the result is a lighter fabric. Also, the process is far quicker. Saving time and labor, then as surely as now, is a proof of intelligence and a crucial factor in productivity. (There are those who believe that so-called primitive societies had no sense of the pressure of time as we experience it today. However, I have only to look into my icebox to realize what a present of time it makes me continuously by keeping me from struggling for food every day for endless days.)

At first the interlacing, now established as weaving, seems to have been timid, used only after a row or more of twining or between rows of twining.

At its beginning, a work had thus been given an even spacing, and this was re-established as the work progressed. This twined beginning is found in many of even the elaborately woven pieces of later periods. It is a technique used today mainly with stiff fibers, for window-shades, mats, etc.; that is, it is no longer in the main stream of textile development. In fact, it ceased to be in it a very long time ago. Nevertheless, it is, I believe, worthwhile to experiment with it for specified uses that may come up, or just for the sake of strengthening an understanding of structural textile processes.

The advantage of weaving becomes clear now. The weft, here a single thread, can be packed closely, resulting in a comparatively tight yet light fabric. On the other hand, it confines the resultant material to rectangularity; the width limited by the reach of the weaver's hands in inserting the weft, the length limited only by the amount of warp material that can be carried on the warp beam and of cloth that can be held by the cloth beam. This type of interlacing proved suited to devices such as the heddle, later the treadle, which gradually made possible ever-increasing speed and with it an unimagined abundance of fabrics, both in regard to sheer quantity and also in regard to variety. Weaving outstripped all other textile techniques for thousands of years, but today we may begin to wonder whether it in turn may not be overtaken by other methods moving to the foreground, such as knitting, perhaps, or a process of pouring resembling paper-making.

Plates 25, 31 Plaiting, or braiding, is another early technique, the term "braiding" referring usually to narrow bands of fabric. It is still with us today, used in the fabrication of floor-mats for instance, or braids of course. It is a multiple-element technique, though not of the warp-weft system kind, for here warp turns into weft and becomes warp again in a continuous exchange as the threads interlace themselves. In Peru, braids of amazingly intricate planning and great beauty have been excavated, which testify to the specific textile involvement of that culture. (For a detailed analysis of braiding technique see Raoul d'Harcourt, *Ciba Review*, Vol. 12, No. 136, February 1960; and, by the same author, *Textiles of Ancient Peru and their Techniques*.)

Pile fabrics also had an early beginning. They reached a high point with the weaving of rugs — that is, of heavyweight materials — in the East, mainly of course in Persia. The simplicity of the technique allows for greatest freedom of design, a freedom far beyond that of other weaving techniques. The Persian and Turkish knots of which the rugs are made are short ends of wool looped around two adjacent warp threads and pulled between them to the

Plates 26, 93

front. After a row of knots has been inserted across the whole width, one or two wefts in plain weave are introduced. The knots and also the wefts are beaten sectionally into place with a heavy, forklike tool. After several rows have been completed, the surface is sheared.

Since each single knot can be of a different color, the design possibilities of pile fabrics are practically unlimited. A pointillist design would perhaps come closest to the technical potential, though it would of course be very time-consuming. Largely as a result of this consideration, today's hand-knotted rugs are based on designs that include large flat areas and thus make only a limited use of this ingeniously simple invention.

Velvets, of course, are also pile fabrics, though here the warp forms the pile. They are a late, highly sophisticated development, and they can be made only on specially equipped looms.

Since steps toward mechanization often seem to bring limitations as well as advantages, we should look back at the regularly shaped fabric brought about by weaving to see if anything has been lost on the way. Early practices, as well as practices still in use in the hand-weaving areas of regions not yet affected by Western industrialization or Western concepts, include the shaping of weavings. There are ancient pre-Columbian shirts that are, by adding or dropping warp threads, woven wider at the shoulders than at the waist (the pre-Conquest version of our padded-shoulder look). There are shirts from present-day Guatemala that are woven with wider-spaced wefts at the waist, to make them fold more easily under a belt. And there are the shaped shoulder-scarfs called *quechquemitl*, a pre-Conquest type of garment, from the states of Puebla and Hidalgo, Mexico. In the process of construction, these are given a three-dimensional form by an intricate manner of weaving around a corner. (See Bodil Christensen: "Otomi Looms and Quechquemitls from San Pablito, State of Puebla, and from Santa Ana Hueytlalpan, State of Hidalgo, Mexico," *Notes on Middle American Archaeology and Ethnology*. Carnegie Institution of Washington, Division of Historical Research, No. 78, January 20, 1947.)

Plate 29

Plate 27

Today this problem of shaping, usually linked to clothing, is effectively solved by the process of knitting, which is moving more and more to the foreground. Our nylons, our underwear, even furlike fabrics are now produced by that process. Besides the advantage of shaping, the time-consuming warp preparation of weaving is here eliminated, and the elasticity of the product suits our present-day needs better in many cases than the stable fabrics resulting from the horizontal-vertical construction of woven materials. These usually demand laborious tailoring or complicated draping to give them shape. Furthermore, our new synthetic materials can now be molded in some cases and are moving us further toward fabrics shaped in the process of production rather than afterwards.

Thus, with a long glance backward we can discern the rise of the technique of weaving, and with a long glance forward we may see it perhaps dimming in its dominance.

CHAPTER SEVEN

Interrelation of Fiber and Construction

EVERY fabric is mainly the result of two elements: the character of the fibers used in the thread construction, that is, the building material, and the construction, or weave, itself. The intermediate step of spinning the fibers into thread also plays a part in determining the product, as does the "finishing" of the fabric, which is gaining increasing importance today. But the dominant conditioning factors are, perhaps not for so very much longer, the character of the raw material and that of the weave.

The fibers, which are the raw material, may be soft and spun into a soft thread and still may be turned into a stiff material as a result of the weave. Or the weave may make for pliability despite a non-pliant fiber or a hard-spun thread, to give some examples of counteraction. The important fact implied is the influence of one upon the other, the modulation each undergoes through the agency of the other, the tuning up or down of some inherent qualities, or their alteration. For instance, the traits of linen, a somewhat hard and very sturdy fiber, will be underlined in a plain weave, which tends to produce a somewhat stiff and very firm fabric. In fact, the two correspond so well that the plain weave is also called the linen weave. Cotton, more common than linen and used in manifold ways, becomes in a plain weave one of the most useful and versatile materials we have. Less outspoken in character than linen, softer, fuzzier, less moisture-absorbent, more dust-catching – to name a few of its qualities – cotton is, like any less clear-cut character, all the more adaptable. Wool in a plain weave loses some of its distinction. The main advantages of wool, its virtues as a good insulator and thus sought for warmth, are not supported in a construction that does not allow for a sufficient number of threads in a given space to form a thick material. In the plain weave, wool also becomes harder than it is by nature. On the other hand, it will wear well in this somewhat open weave, since all threads are closely tied in and are prevented from being caught accidentally. Out of the interaction between silk, the softest of fibers, and a plain weave, the stiffest of the basic constructions, comes taffeta – a silk become stiff. In the combination of linen and the plain weave, we had the mutual supporting of common traits; in the combination of silk and the plain weave, we have a clash of traits producing a material with new and distinctive characteristics. So striking is this new combination that the plain weave acquires still another name when used with silk: the taffeta weave.

Every weave has, of course, a material that seems best suited to its special features; or, the other way around, every fiber has a weave in which its specialty seems to be exhibited most advantageously. Wool, for instance, which suffers to some degree when used in a plain weave, profits from a twill weave. The twill strikes us as most suitable for clothing purposes, and so does wool. A twill forms a much more pliable material than does the plain weave, and thus the softness of the wool will be accentuated. Also, the more widely spaced intersections of warp and weft allow the threads to be set more closely, as we noted before, and thus makes for a heavier material, increasing the wool's capacity to preserve warmth. One reason for not using a satin weave with wool – a combination which would also make for a soft, pliable, and closely packed material – is that here the threads float over too many threads of either warp or weft to sustain hard wear; they may easily be snagged and form ungainly loops on the surface. The twill weave strikes just the right balance of pliability and practicality for wear. Wool in a twill weave is the classical combination we know as tweeds. Twills in cotton form the washable materials of our work clothes – of our overalls for instance – the firmly packed fabrics embodying the typical characteristics of both the cotton and the twill. It is no striking combination, but it is suitable enough for many purposes. Twill woven in silk is another case of hybrid traits. It results in a material that takes advantage neither of the special quality of silk nor of that of the twill weave. The outcome, however, is a most useful fabric, though one we do not boast about: silk linings for coats, suits, etc. It is softer than taffeta, not as impractical as satin, and smoother than a twill woven in any other material. Again we see the twill appearing in our clothing material.

Other fibers, other constructions, and their various combinations enlarge the series of these examples to the seemingly endless range of our fabrics. With the development of modern chemistry, a group of completely new fibers has been added to the few that have been in use for hundreds and even thousands of years. These new synthetic fibers introduce new combinations of properties and thus are drastically changing our materials as we have known them. One important aspect of this new development is that, since the preliminary stage of producing a raw material having the desired qualities of the final product already partially specifies the fabric, the manner of weaving this raw material is growing less important.

Chemistry is affecting our materials in still another important way. While the creation of new fibers determines a fabric in large part before it is ever woven, the creation of new finishes influences our fabrics equally after they are woven. These after-treatments and coatings bring about changes as radical as those brought about by the new fibers, and they, too, reduce the weight of the influence of the thread construction. Up to now, the unique characteristics of a fabric have been determined by the interaction of fiber and weave, each of more or less equal importance; but today we see an increasing shift toward having the ultimate characteristics determined by the nature of the fibers themselves or by modifications brought about through the finishing process, either before or after the fabric is woven.

The tendency to pay less and less attention to thread constructions did not set in, however, with the influence of chemistry on the development of textiles. With the coming of mass production, which is synonymous with quick production, simple constructions naturally took over the field; since they are best suited to a manufacture that aims mainly at quantity, speed, and reduction of cost. The reason that surface effects in textiles today are produced so preponderantly by the effect of the yarns themselves rather than by structural means, in machine-woven as well as in hand-woven textiles, most likely has a source in this development.

The general decline in the inventive use of elements of construction so commonly found today as compared to other periods is thus explained easily enough. There is no reason, however, why new contributions to textile development should not come from this side too. Developments seem to come about inharmoniously; we grow a bit here, and then a bit there — so why be impatient?

CHAPTER EIGHT

Tactile Sensibility

All progress, so it seems, is coupled to regression elsewhere. We have advanced in general, for instance, in regard to verbal articulation — the reading and writing public of today is enormous. But we certainly have grown increasingly insensitive in our perception by touch, the tactile sense.

No wonder a faculty that is so largely unemployed in our daily plodding and bustling is degenerating. Our materials come to us already ground and chipped and crushed and powdered and mixed and sliced, so that only the finale in the long sequence of operations from matter to product is left to us: we merely toast the bread. No need to get our hands into the dough. No need — alas, also little chance — to handle materials, to test their consistency, their density, their lightness, their smoothness. No need for us, either, to make our implements, to shape our pots or fashion our knives. Unless we are specialized producers, our contact with materials is rarely more than a contact with the finished product. We remove a cellophane wrapping and there it is — the bacon, or the razor blade, or the pair of nylons. Modern industry saves us endless labor and drudgery; but, Janus-faced, it also bars us from taking part in the forming of material and leaves idle our sense of touch and with it those formative faculties that are stimulated by it.

We touch things to assure ourselves of reality. We touch the objects of our love. We touch the things we form. Our tactile experiences are elemental. If we reduce their range, as we do when we reduce the necessity to form things ourselves, we grow lopsided. We are apt today to overcharge our gray matter with words and pictures, that is, with material already transposed into a certain key, preformulated material, and to fall short in providing for a stimulus that may touch off our creative impulse, such as unformed material, material "in the rough."

Concrete substances and also colors per se, words, tones, volume, space, motion — these constitute raw material; and here we still have to add that to which our sense of touch responds — the surface quality of matter and its consistency and structure. The very fact that terms for these tactile experiences are missing is significant. For too long we have made too little use of the medium of tactility. *Matière* is the word now usually understood to mean the surface appearance of material, such as grain, roughness or smoothness, dullness or gloss, etc., qualities of appearance that can be observed by touch and are consequently not concerned with lightness or darkness. There seems to be no common word for the tactile perception of such properties of material, related to inner structure, as pliability, sponginess, brittleness, porousness, etc.

Surface quality of material, that is, *matière,* being mainly a quality of appearance, is an aesthetic quality and therefore a medium of the artist; while quality of inner structure is, above all, a matter of function and therefore the concern of the scientist and the engineer. Sometimes material surface together with material structure are the main components of a work; in textile works, for instance, specifically in weavings or, on another scale, in works of architecture. Parallel to this overlapping of outer and inner characteristics in a work is the overlapping of artistic, scientific, and technological interests on the part of the weaver or the architect. The pendulum of their work swings from art to industrial science.

Structure, as related to function, needs our intellect to construct it or, analytically, to decipher it. *Matière,* on the other hand, is mainly non-functional, non-utilitarian, and in that respect, like color, it cannot be experienced intellectually. It has to be approached, just like color, non-analytically, receptively. It asks to be enjoyed and valued for no other reason than its intriguing performance of a play of surfaces. But it takes sensibility to respond to *matière*, as it does to respond to color. Just as only a trained eye and a receptive mind are able to discover meaning in the language of colors, so it takes these and in addition an acute sensitivity to tactile articulation to discover meaning in that of *matière*. Thus the task today is to train this sensitivity in order to regain a faculty that once was so naturally ours.

If we want to concentrate, then, on this segment of our work, that is, tactility, it is better to put on blinders and exclude what might distract us:

considerations of color and inner structure. We will try to approach material with just this in mind: to discover its inherent surface quality or the one which we might be able to give to it directly by working it or indirectly by influencing it, for instance, through contrast with neighboring materials.

Plates 32–35

We will look around us and pick up this bit of moss, this piece of bark or paper, these stems of flowers, or these shavings of wood or metal. We will group them, cut them, curl them, mix them, finally perhaps paste them, to fix a certain order. We will make a smooth piece of paper appear fibrous by scratching its surface, perforating it, tearing it, twisting it; or we will try to achieve the appearance of fluffy wool by using feathery seeds. What we are doing can be as absorbing as painting, for instance, and the result can be, like a painting, an active play of areas of different complexion. We are here rivitalizing our tactile sense and are not dealing with real weaving.

Now, since our interest is textile form and not the freer form of the painter, we will have to be aware of those conditions that will make of our surfaces textile surfaces. If we try to have a rhythm in them of horizontals, of verticals, of horizontals and verticals, or of staggered diagonals, we will arrive at results that resemble actual textiles, for the dominant textile elements are present: the straight lines of the directions and the surface activity. Color enters in at this point only as a by-product — since of course nothing is colorless — not as a focal point. Any color effect is, for the moment, incidental, not intentional.

We will learn to use grain and gloss, smoothness, roughness, the relief-quality of combined heavy and fine material — those elements of form that belong to the aesthetic side of tactile experience — and will find them equally as important as areal divisions and color.

Our concentration in this direction will serve two purposes: first, the important activating of our latent perceptivity of *matière;* second, the gaining of a medium suited to demonstrate, in advance of any actual execution, how a proposed design will look in its tactile properties, which are difficult to show by drawing or painting: a tactile blueprint. We will have learned to think of surface characteristics as means fully as expressive as line and color. We will also have become conscious of this medium as a distinctive textile trait. If a sculptor deals mainly with volume, an architect with space, a painter with color, then a weaver deals primarily with tactile effects. But, as was said above, qualities of the inner structure are as much part of a textile as are effects of outer tactile surface. The structure of a weaving, as well as the fibers chosen for the work, can bring about an interesting surface. There is an intricate interplay between the two. A knowledge of textile construction is thus essential for *matière* effects, as it is for the organization of a weaving as a whole. Our experiments in surface effects are therefore to be understood only as exercises to increase our awareness of surface activities, since the actual work of weaving is only in part concerned with the epidermis of the cloth. The inner structure together with its effects on the outside are the main considerations. Embroidery, on the other hand, is a working of just the surface, since it does not demand that we give thought to the engineering task of building up a fabric. For this very reason, however, it is in danger of losing itself in decorativeness; for the discipline of constructing is a helpful corrective for the temptation to mere decoration.

Our experience of gaining a representational means through the use of different surface qualities leads us to the use of illusions of such qualities graphically produced, though not by the means of representational graphic — that is, the modulated line. Drawing or print that shows hatching or stippling, rippled or curled lines, etc., and thus has a structural appearance, can be used to produce, if not actual tactile surfaces, the illusion of them. The tactile-textile illusions produced on the typewriter may illustrate this point. *Plates 36, 37*
These varied experiments in articulation are to be understood not as an end in themselves but merely as a help to us in gaining new terms in the vocabulary of tactile language. *Plate 38*

CHAPTER NINE

Tapestry

Tapestry weaving is a form of weaving that reaches back to the earliest beginnings of thread interlacing, is still with us today, and may have a future noteworthy in its promise. Taken in its widest meaning, the term encompasses the various techniques that can be used to mark off different areas of color and surface-treatment from each other in the woven plane. In a narrower sense the term refers to a technique of weaving, or variation of it, where a weft thread, covering the warp completely, passes only over the surface of those sections of the weaving that are to be built of it. The thread then interlocks at the borderlines, either with neighboring weft threads that meet it or with a warp thread, before turning back, after a change of shed, into its own field.

It is a form of weaving that is pictorial in character, in contrast to pattern weaving, which deals with repeats of contrasting areas. It works with forms meaningful both in themselves and through their relatedness within the pictorial organization. The variform elements and their free placement within the limits of a given design demand the greatest possible freedom of the structural scheme; in fact, they demand such independence from mechanization of the weaving process that hardly any of the time-saving inventions of the past hundreds or thousands of years of textile history can be utilized in this work. It is art work; and, as in other plastic arts, it demands the most direct — that is, the least impeded — response of material and technique to the hand of the maker, the one who here transforms matter into meaning.

If we think of a tapestry as an articulation in terms of forms made of threads, examples of such work go back to the earliest experiments in cloth construction. In fact, it seems as if the emerging awareness of a fabric's usefulness, when linked with the increased ease of its fabrication, tended to dilute its magic potentiality as an art medium. Throughout the centuries, the use of threads in the language of form has given way more and more to their use in service of the practical. The utilitarian side of a fabric's character so powerfully dominates our estimate of it today that we easily appraise even a tapestry, that is, a woven picture, in terms of its possible practical advantages before recognizing its merit as a formulation in pictorial terms, that is, as a work dealing with form per se.

Since we know already that only the most versatile principle of fabric construction can be used to build varied forms in varied placements in varied colors and surface treatments, we must look for the most basic technique. For, with every time-saving device that helped toward faster, and therefore increased, production, the necessary mechanization of a specific operation limited the range of the process in general. The most fundamental thread construction, of course, is the plain weave: the alternate interlacing of warp and weft threads. But whereas this construction is based on a balanced distribution of warp and weft and serves today to produce our basic utilitarian fabric, namely our millions of yards of muslin, tapestry weaving is based on an off-balance distribution, that is, a widely spaced warp covered by the weft. As noted before, it has the added distinction that the weft does not travel from selvage to selvage but moves only within the specific areas of color or surface-treatment to which it belongs. It is the manner of the interlocking of the wefts at the turning points or at their turn around a warp thread that differentiates the various tapestry techniques from each other and thereby affects the formal structure of the design. *Plates 59–63*

One of the earliest pictorial works made of threads is a weaving in which floating warp threads set in a plain-weave field form the design. It was excavated in 1946 by Junius Bird, Curator of Archaeology of the American Museum of Natural History, New York, at a site in northern Peru where he found textiles dating back to 2500 B.C. It shows a bird which is thought out in regard to form and structure with superior intelligence. We easily forget the amazing discipline of thinking that man had already achieved four thousand years ago. Wherever meaning has to be conveyed by means of form alone, where, for instance, no written language exists to impart descriptively such meaning, we find a vigor in this direct, formative communication often surpassing that of cultures that have other, additional methods of transmitting *Plate 64* information. Today, words generally carry by far the greatest load of our expressive manifestations.

Along with cave paintings, threads were among the earliest transmitters of meaning. In Peru, where no written language in the generally understood sense had developed even by the time of the Conquest in the sixteenth century, we find — to my mind not in spite of this but because of it — one of the highest textile cultures we have come to know. Other periods in other parts of the world have achieved highly developed textiles, perhaps even technically more intricate ones, but none has preserved the expressive directness throughout its own history by this specific means. In this light we may revaluate what we have been made to think of as the high points of the art of weaving: the famous great tapestries of the Gothic, the Renaissance, the Baroque; the precious brocades and damasks from the Far East; the Renaissance fabrics. Tremendous achievements in textile art that they are, they play first of all the role of monumental illustrations or have decorative supporting parts to play. They are responsible, I think, for textiles being relegated to the place of a minor art. But regardless of scale, small fragment or wall-size piece, a fabric can be great art if it retains directness of communication in its specific medium.

This directness of communication presupposes the closest interaction *Plate 65* of medium and design. A painted face obeys other laws of formation than a *Plates 73, 74, 75* woven face, and the more clearly the process relates to the form, the stronger the resultant impact will be. Much of the potency of textile art has been lost during centuries of efforts to produce woven versions of paintings, often based on cartoons of the great painters of the past — on Raphael's, for instance. But trespassing into another art form, however great that form may be, does not necessarily bring forth great art works. On the contrary, the original concept as well as the transposition suffers by the very fact of indirectness. This does not mean that no great tapestries have been created in the *Plate 92* Gothic or later periods. The Unicorn Tapestries surely are great works of art, and they are truly weaverly in their components. But many of the large wall-size hangings in our museums are not as great as their size or their placement may encourage us to believe. And a number of present-day efforts on the part of those trying to revive a declining tradition are misdirected because, again, they turn to those outside the field to excite new vitality where work has grown dull. Examples are the work of the famous French tapestry workshops which today are producing technically expert pieces that are often, however, of mainly decorative value. Only in exceptional cases, for instance, in the examples illustrated here, where artists worked mainly with flat areas, are they works of art. *Plates 110, 111, 112*

Works of art, to my mind, are the ancient Peruvian pieces, preserved by an arid climate and excavated after hundreds and even thousands of years. There are those, large or small, of the Tiahuanaco period, for instance — tapestries in the pictorial as well as the technical sense — showing the deities of their Pantheon; or works from other periods, full of the life of their world. There are also the highly intelligent and often intricate inventions of lines or interlocking forms. Their personages, animals, plants, stepforms, zigzags, whatever it is they show, are all conceived within the weaver's idiom. Where clear outlines are wanted, the threads are maneuvered into position to do this, sometimes in surprising and ingenious ways varying in inventiveness from piece to piece. A unique method, for instance, is that of interlocking not only the weft but the warp itself. Where relief effects are believed to strengthen the presentation, they are added and worked out imaginatively and skillfully, as are other desirable supports. Of infinite phantasy within the world of threads, conveying strength or playfulness, mystery or the reality of their surroundings, endlessly varied in presentation and construction, even though bound to a code of basic concepts, these textiles set a standard of achievement that is unsurpassed. *Plates 79–90* *Plate 63*

Coptic weavings, of course, also belong among inspired works in textiles, and by some they are considered to head the list. They are developed from the basic weaving structures, and thus the figures preserve the essential weaving formation. There is often in them a truly textile juxtaposition of flat and fuzzy areas. However highly developed they are, though, their more limited scope becomes apparent when they are compared with the more adventurous use of threads in the ancient American pieces. *Plates 70–77*

A technique that has been used in the Near East and Far East is Soumak. By wrapping a weft thread around one or two warp threads, possibly changing colors as it crosses from selvage to selvage and reversing the direction of wrapping on the return trip, a flat, ribbed, close, heavy fabric can be produced, suited for pictorial textiles. *Plates 26, 67*

There are, of course, many high points in the art of weaving, in many periods and many places, that could be cited as examples of the successful interaction of medium and form. I will be accused of crass one-sidedness in my feeling of awe for the textile products of Peru, which I advance as the most outstanding examples of textile art. But it is here, I believe, that we can learn most. It is here we can learn that playful invention can be coupled with the inherent discipline of a craft. Our playfulness today often loses its sense of direction and becomes no more than a bid for attention, rather than a convincing innovation. Limitlessness leads to nothing but formlessness, a melting into nowhere. But it is form – whatever form it may be – that is, I feel, our salvation.

At present we are still groping. The efforts of weavers in the direction of pictorial work have only in isolated instances reached the point necessary to hold our interest in the persuasive manner of art. Experimental – that is, searching for new ways of conveying meaning – these attempts to conquer new territory even trespass at times into that of sculpture.

Plate 107

In our time, though, and for some time to come, threads can, I believe, serve as an expressive medium. And the practical aspect of the nomadic character of things made of threads supports that belief. We move more often and always faster from place to place, and we will turn to those things that will least hinder us in moving. Just as our clothes are getting lighter and are increasingly geared to movement, so also will it be with other things that are to accompany us. And if these include a work of art that is to sustain our spirits, it may be that we will take along a woven picture as a portable mural, something that can be rolled up for transport. The Far East, of course, had this idea already long ago in the form of scrolls. Perhaps we can find for it our own form.

CHAPTER TEN

Designing as Visual Organization

IT is safe, I suppose, to assume that today most if not all of us have had the experience of looking down from an airplane onto this earth. What we see is a free flow of forms intersected here and there by straight lines, rectangles, circles, and evenly drawn curves; that is, by shapes of great regularity. Here we have, then, natural and man-made forms in contradistinction. And here before us we can recognize the essence of designing, a visually comprehensible, simplified organization of forms that is distinct from nature's secretive and complex working. *Plate 39*

Or on a beach, we may find a button, a bottle, a plank of wood, immediately recognizable as "our" doing, belonging to our world of forms and not to that which made the shells, the seaweed, and the undulated tracings of waves on sand. Also we can observe the counterplay of the forming forces: the sea slowly grinding an evenly walled piece of glass, foreign to it in shape and substance, into a multiform body suitable for adoption into its own orbit of figuration. On the other hand, we see the waves controlled, where dams and dikes draw a rigid line between land and water.

To turn from "looking at" to action: we grow cabbages in straight rows and are not tempted by nature's fanciful way of planting to scatter them freely about. We may argue that sometimes we follow her method and plant a bush here and another there, but even then we "clear" the ground. Always, though sometimes in a way that is roundabout and apparent only as an underlying scheme of composition, it is clarity that we seek. But when the matter of usefulness is involved, we plainly and without qualification use our characteristics: forms that, however far they may deviate in their final development, are intrinsically geometric.

If, then, it appears that our stamp is or should be an immediate or implicit lucidity, a considered position, a reduction to the comprehensible by reason or intuition in whatever we touch (confusion always gets a negative rating), we have established a basis for designing – designing in any field. From city-planning to the planning of a house or a road, from the composing of music to the formulation of a law, the weaving of a fabric, or the painting of a picture – behind the endless list of things shaped is a work of clarification, of controlled formulation.

By using the term "designing" for all these varied ways of pre-establishing form, we are, of course, doing some violence to the word. "Designing" usually means "giving shape to a useful object." We do not speak of designing a picture or a concerto, but of designing a house, a city, a bowl, a fabric. But surely these can all be, like a painting or music, works of art. Usefulness does not prevent a thing, anything, from being art. We must conclude, then, that it is the thoughtfulness and care and sensitivity in regard to form that makes a house turn into art, and that it is this degree of thoughtfulness, care, and sensitivity that we should try to attain. Culture, surely, is measured by art, which sets the standard of quality toward which broad production slowly moves or should move. For we certainly realize that there are no exclusive materials reserved for art, though we are often told otherwise. Neither preciousness nor durability of material are prerequisites. A work of art, we know, can be made of sand or sound, of feathers or flowers, as much as of marble or gold. Any material, any working procedure, and any method of production, manual or industrial, can serve an end that may be art. It is interesting to see how today's artists, for example our sculptors, are exploring new media and are thereby fundamentally changing the sculptural process from the traditional method of cutting away to one of joining. They are giving us, instead of massive contour, exposed structure; instead of opaqueness, transmission of light. Obviously, then, regardless of the material and the method of working it, designing is or should be methodical planning, whether of simple or intricately organized forms; and if done imaginatively and sensitively, designing can become art.

Let us pursue this matter of designing a little further, now that we have established in our mind where its beginning lies and where its ultimate goal.

Since our concern here is to explore the process of designing and not to analyze the design done, we should try to put ourselves in the position of the "doer," the one who is making a thing new in form. It may appear as though I am addressing myself now only to professionals. But though I know that designing takes practical knowledge of the work involved, still I am much aware that the dividing line between the trained and the untrained becomes blurred when both are facing the new. For anyone who is making something that previously did not exist in this form is, at that point, of necessity an amateur. How can he know how this thing is done that never has been done before? Every designer, every artist, every inventor or discoverer of something new is in that sense an amateur. And to explore the untried, he must be an adventurer. For he finds himself alone on new ground. He is left to his own devices and must have imagination and daring. All decisions here are his own, and only he is responsible. But though it is he who is in charge, he feels himself to be only an intermediary who is trying to help the not-yet-existent turn into reality. Standing between the actual and that which may be, the conscientious designer, as I see it, seeks to forego his own identity in order to be able more impartially to interpret the potential. For the less he himself, his subjectivity, stands in the way of the object that is to take form, the more it will have "objective" qualities and thereby will also take on a more lasting character than it otherwise could. And just as concern with material and method of treatment engages his conscious mind and frees the formative energies that we recognize when crystallized as ideas, so also, and to the same end, does the tête-à-tête with the still-amorphous absorb his self-awareness.

Let me illustrate my point with a specific design project, a textile problem in our case. To be more easily understood, it will be one of modest scope. Nevertheless, I hope it will be possible to trace the various steps involved in its realization and thereby to have a look at some of the facets of this phenomenon that is designing.

Let us assume that the task is to design a wall-covering material, quite specifically one suited for museum walls; that is, a material for a specific practical use. As conscientious designers in our passive role, we will let the fabric-to-be specify its own future characteristics, such as perhaps being dust-repellent, non-fading, woven sufficiently closely to cover up any irregularities of the wall, and, for the same purpose, having a certain amount of bulk. Furthermore, it should neither stretch nor sag, and it should be possible to clean it by brushing or wiping. Also, any small nail holes driven into it should close easily after removal of the nail. It should, in all probability, be light in color, perhaps even light-reflecting, possibly flame-retarding, and certainly mothproof if not mildewproof. In regard to general complexion: it should be quiet enough so as not to compete with any art work put on it or placed before it; that is, it should be subservient, not dominating.

Taking these suggestions, we will be led to a definite choice of raw material, of weave construction, and of color, all interactive, as will be apparent. Also, these suggestions will be decisive in the question of formal treatment — whether to choose checks or stripes, elaborate patterns or a uniform surface. An extension into the field of pictorial invention is ruled out here because of the supporting and not independent character the fabric is to have.

To go into further detail: what in particular are the proposals that have come to us from the object-to-be since its inception? It has circumscribed the range of the raw material that might be suitable. Wool, for instance, will have to be excluded as neither dust-repellent nor mothproof without special chemical treatment, while any fiber with a somewhat coated surface, such as linen or raffia or a strawlike synthetic fiber, might fit the requirements. Such a raw material also would have a certain stiffness and bulk that would prevent sagging and would help the fabric keep its shape. However, without additional processing it would not be flame-retarding, should that be required, as it sometimes is in public buildings. As to weave construction: all specifications point to a plain weave, the simplest construction existent, which makes a somewhat stiff material, in contrast to a satin or a twill weave, which would result in a more pliable fabric not desired here. The plain weave also produces, in a balanced relationship of warp and weft, a more or less porous material specifically suited to take care of the nail-hole problem. In addition, its use is a safeguard against the fabric's sagging or stretching out of shape, aided in this by the suggested raw materials, which also are inelastic in character. It also is an economical weave using less yarn than most others, a consideration that is often vital.

Continuing in our attitude of attentive passiveness, we will also be guided in our choice of color, though here only in part. For our response to color is spontaneous, passionate, and personal, and only in some respects subject to reasoning. We may choose a color hue — that is, its character as red or blue, for instance — quite autocratically. However, in regard to color value — that is, its degree of lightness or darkness — and also in regard to color intensity — that is, its vividness — we can be led by considerations other than exclusively by our feeling. As an example: our museum walls will demand light and have a color attitude that is non-aggressive, no matter what the color hue and whether there is an over-all color or a play of colors.

However, one factor may influence even our impulsive choice of color, and that is the practical question of color-fastness to light and, where this is necessary, to washing. Different colors vary of course in this respect. The coloring matter in textiles is a dye that penetrates the fibers of the material, unlike color pigment or paint, which is applied to the surface only. The action, therefore, of the dye on different fibers has to be taken into account and will affect, in turn, the choice of the raw material. Also, the dye process itself has to be considered. In piece dyeing, for instance, the whole finished fabric is immersed in the dye bath to give it a uniform color, while in yarn dyeing, as the name suggests, the yarn is dyed before it is woven, thereby allowing a fabric to be built of different color units. Only the latter, as we should be aware, allows for the full realization of the means within the weaver's sphere.

We have again reached a point where we can think in general terms, for the issue of the specific formal domain within which a craft operates has wide implications. Architecture, for instance, is concerned with space: with enclosing space, with extending into space, and with gravity and tension. Though sculptural elements (arrangement of masses), painterly elements (light, shadow, color), and textural elements (inherent structure of material and marks of working it) are also present, these should speak only quietly, not dominantly. Similarly, we can delineate the weaver's province. The meaning of the word "textural" covers that quality which is the essence of weaving. It is the result, apparent on the surface, of the manner in which interdependent thread units are connected to form a cohesive and flexible whole. This surface play, of structural origin, can be accentuated or subdued through the choice of yarn and its characteristics — glossiness, dullness, knobbiness, etc. — and of color. It becomes obvious now, I believe, why the abovementioned piece-dyeing process diminishes rather than enhances the quintessence of weaving, for it bridges over and thereby obscures with one color the separate functions of the structural elements.

If, in regard to visual articulation, texture, produced through the interlocking of threads, is the focal point in weaving, those peripheral components that can variegate it come only second in the order of importance. Properties such as warmth — of paramount importance in textiles used for clothing — do not belong to the vocabulary of form. There, then, is the quality of the yarn that is to make the fabric, whether it is rough or smooth, lustrous, shaggy, downy, uneven, etc. — qualities that are able to underline the structural appearance of the fabric or to restrain it. Today, with the rediscovery of textural interest, this secondary element of composition, yarn character, is often used as a substitute for the primary one, which is structural in nature. As a result, we find an exaggerated emphasis on fancy yarns to make up for a thread construction that is dull. In fact, this shift from structural effects to predominantly yarn effects today holds back a textile development that should center on construction as the original focal point.

Color comes only third in importance among the elements of composition within the weaver's dimensions. By giving different colors to the differently functioning threads, the structural character of the weaving will be intensified. In addition, color, more acutely than texture, conveys emotional values; but, if it is introduced as too-independent an agent, it may carry the weaving outside of its own territory into the painterly province. When color in weaving moves into a first place, suppressing the main textile ingredients, we find a regression of the art of weaving. Examples, historical and contemporary, may be found in some of the pictorial tapestries woven from painters' designs — Raphael's, Picasso's, Rouault's, etc. Many of these works, lacking in textural and structural interest, have moved to the very edge of the weaver's realm; and, though perhaps impressive as pictorial compositions, they are often of little consequence as pictures or as weavings.

We are ready, I believe, to resume work on our particular task. We have found ourselves limited to a definite range of raw material and of color and have been led to a suitable thread construction, the plain weave. Now that we have become aware of the interplay of fiber, color, and weave, let us see where another step in the act of condensation will take us.

In regard to fiber, we found linen, raffia, and a strawlike synthetic fiber acceptable. Of these, linen is best suited as warp material here. It recommends itself for the purpose at hand by its relatively inelastic character, which lessens the chance that the fabric may stretch out of shape or sag. In addition, linen has a natural color that is a grayish tan. It has this to say for itself: it will not fade even when exposed to light for a long period; it has an easy color-relationship to any woodwork — floors, for instance — and its color will show dust less readily than most; it is mothproof though not mildewproof. The slight stiffness of the linen fiber will increase that of the plain weave construction and also will add to the porousness that has been found desirable. When intersected by a weft of strawlike synthetic yarn, white and glossy in its original state, the dull natural linen will take on life by contrast, and a subtle play in natural-to-white tones could be developed, as well as a play on the scale from dull to sparkling, even light-reflecting. Again, this original white will stay white under exposure to light, and the hard surface of the fiber will retain only a small amount of dust. Since, where large areas are involved, the problem of fading is unavoidable, a solution that circumvents dyeing altogether can only be welcomed. The synthetic fiber is mothproof and mildewproof and, intersecting the linen, it will reduce by the percentage of its use the mildew problem, unsolved in the case of linen. Here, now, we have a fabric that largely answers the outlined requirements. It formed itself, actually, and what remains to be determined is mainly the formal organization of the elements.

We now have arrived at that stage of designing which demands our finest "ear," for we must try to discern the formal currents of our period in history that are on the verge of crystallizing and that may become part of our language of form, or may again become part of it. Texture — the word I tried to use only in its exact meaning and avoided in its fashionable, loose sense — is, for instance, one of the formal elements that has been of little or no interest for a long time but has again become one of today's stylistic components. We must learn to sense those elements of form that respond to our formal needs. We like things today that are light — light as the opposite of heavy and light as the opposite of dark. We must learn to detect, in particular occasions, manifestations of general developments; that is, we must learn to foresee. And to foresee we need a contemplative state of mind.

To return to our wall-covering project: with the matter of formal composition, the general air that the fabric is to have becomes the center of our concern. We have in our hands powerful means of articulation — directional elements such as verticals, horizontals, diagonals, squares, as basic examples, or, in the weaver's terms, warp or weft stripes, twills, checks, etc. We are able to convey impressions of height, of width, of boldness, of reticence, of gaiety or somberness, of monumentality or caprice, all within, though modified by, the thus-far established framework. For the subservient character we have sought for the fabric from the start directs our decisions and precludes loud instrumentation.

Again, we are here led away from pronounced lineation and contours toward a surface active only through the slight optical vibration of intersecting raised and lowered threads — shiny and dull, lighter and darker, tan and white. This material will be quiet yet alive, responsive to lighting, compliant in its relationship to objects more demonstrative than itself in color and shape; a background for a flower, a face, a painting, a sculpture.

From here we can move on to a wider point of view. We may contend that the world around us puts us under great strain and that we need calm and quietness wherever we can get them. Today, we should try to counteract habits that only rarely leave us time to collect ourselves. Every hour on the hour we seem to need the latest and, as it turns out, usually the most unsettling and gloomy report, often, when seen in retrospect, of non-essentials. Yesterday's paper is waste paper. Wisdom and insight hardly make headlines. Nevertheless, we are seldom found — on train or plane, on bus or boat, or in any given moment of imposed restraint of action — without a bundle of distractions in our hand in the form of papers or magazines.

And though it may appear that we are straying from our line of thought, it is on the contrary here on the ground of philosophy and morals that attitudes and convictions, the starting points of our actions, are formed. Two matters may here be of special concern to the conscientious designer and may make him stop and think or, perhaps, think and stop. The first is that with his help another object will be added to the many that are already taking our attention and our care, another object to distract us. (Our households contain hundreds of objects.) The second is that by trying to give this object its best possible shape, by trying to make it as timeless as possible — that is, not dictated by short-lived fashion — and by finding for it a form as anonymous as possible — that is, a form unburdened by dominantly individual traits of the planner — the designer finds himself in direct conflict with the economic pattern of our time. For the economy of today is built largely upon change, and the "successful" designer, a term I have not used before, will have to consider the matter of "calculated obsolescence." We are urged today to want more and more things, and we are subjected to a vigorous campaigning for always newer things, things that are not necessarily newer in performance. We are asked to shift from red to blue or from this bit of trimming to that for the questionable reason or unreason of fashion. It is evident, I think, that the designer who takes the longer view is by no means identical with the "successful" designer.

We have watched the coming into being of our object and have seen how medium and method of work present *themselves* to us and thereby limit our range of choice. Among other components to be considered, contributing to such limitation, is that of price. This, above others, is often felt as a restriction on the freedom of the designer. I have shown, I think, that I do not believe in the sovereignty of the designer, and I cannot concur with the view that such a limitation must mean frustration. Rather, to my mind, limitation may act as directives and may be as suggestive as were both the material itself and anticipated performance. Great freedom can be a hindrance because of the bewildering choices it leaves to us, while limitations, when approached open-mindedly, can spur the imagination to make the best use of them and possibly even to overcome them.

As much a limiting factor as price, for instance, is the matter of production. Whether production is by craft or by industrial method, this many-sided problem can be as stimulating as the others discussed earlier. Any one of them can serve as starting point in the process of crystallization that we have followed. It is interesting to note here that mechanized production, however advanced, always means a reduction in the range of possibilities, though usually it also means an increase in exactitude, speed, and quantity of output, when compared to anything done with the ancient instrument that is our hand. As to our immediate concern, the material for the wall: it constitutes no problem for machine or hand. The construction is of the simplest kind, demanding nothing but the simplest type of loom, and the choice between industrial or manual production is dependent solely on the quantity of material involved.

Today such matters as, for instance, that the finished object be photogenic can influence designing. In a time that depends greatly for success upon photographic reproduction, a consideration of this sort — in itself surely beside the point — can become a factor that may have to be taken into account. So, too, may the powerful figure of the client and, in textiles, the buyer, who often bring to the project preconceived viewpoints that may be right but, alas, can be wrong.

As you will have noticed, I have made no distinction between the craftsman designer, the industrial designer, and the artist — because the fundamental, if not the specific, considerations are the same, I believe, for those who work with the conscience and apperception of the artist. With surprise and reassurance I recently came across a statement by the painter Lionel Feininger, who speaks of one of his pictures as having "painted itself."

At the beginning we spoke here of the comprehensible orderliness which underlies all our doing and whose ultimate form is also that of art. Material form becomes meaningful form through design, that is, through considered relationships. And this meaningful form can become the carrier of a meaning that takes us beyond what we think of as immediate reality. But an orderliness that is too obvious cannot become meaningful in this superior sense that is art. The organization of forms, their relatedness, their proportions, must have that quality of mystery that we know in nature. Nature, however, shows herself to us only in part. The whole of nature, though we always seek it, remains hidden from us. To reassure us, art tries, I believe, to show us a wholeness that we can comprehend.

The Loom

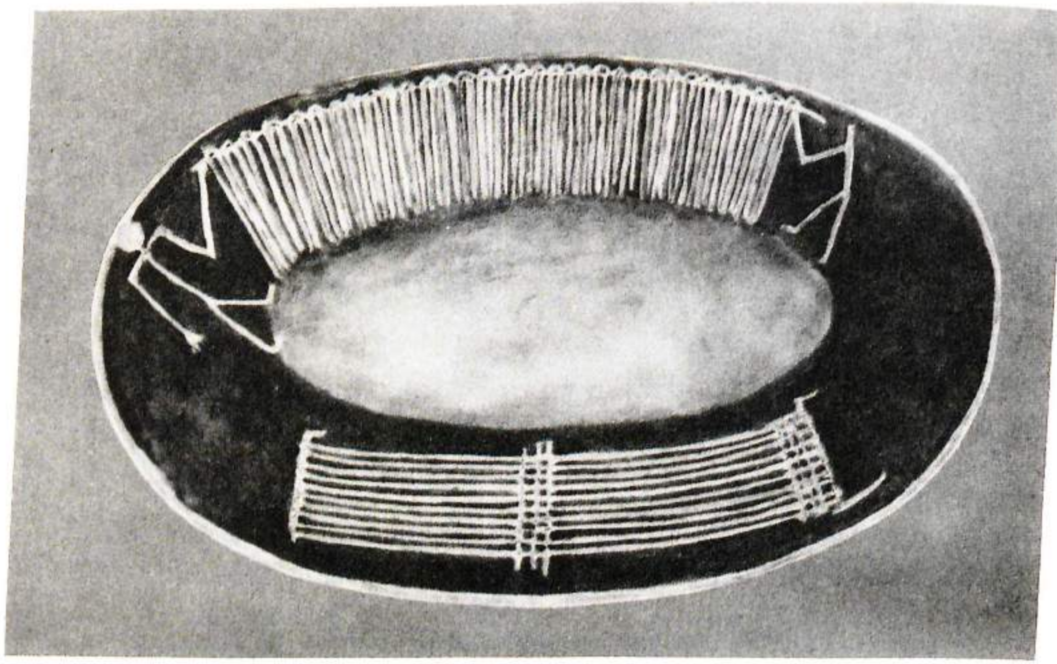


Plate 1. Earliest known representation of a loom. Predynastic Egyptian pottery, ca. 3400 B.C.

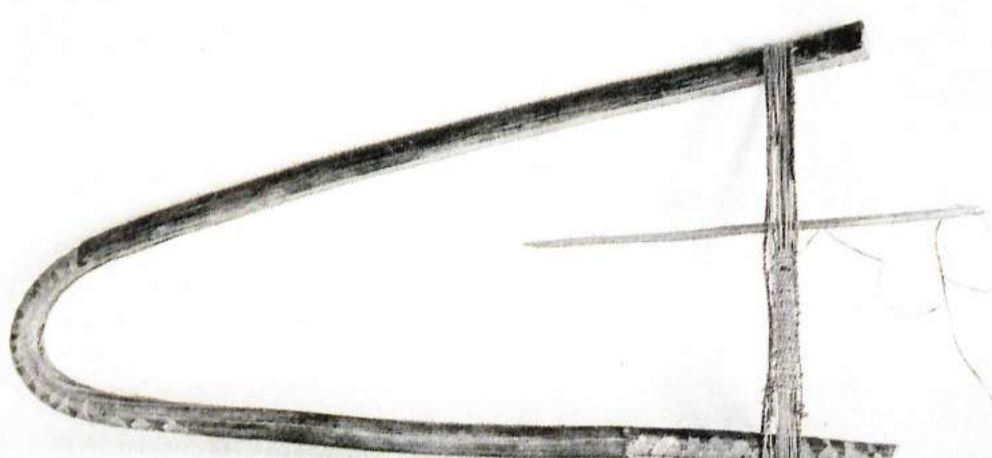
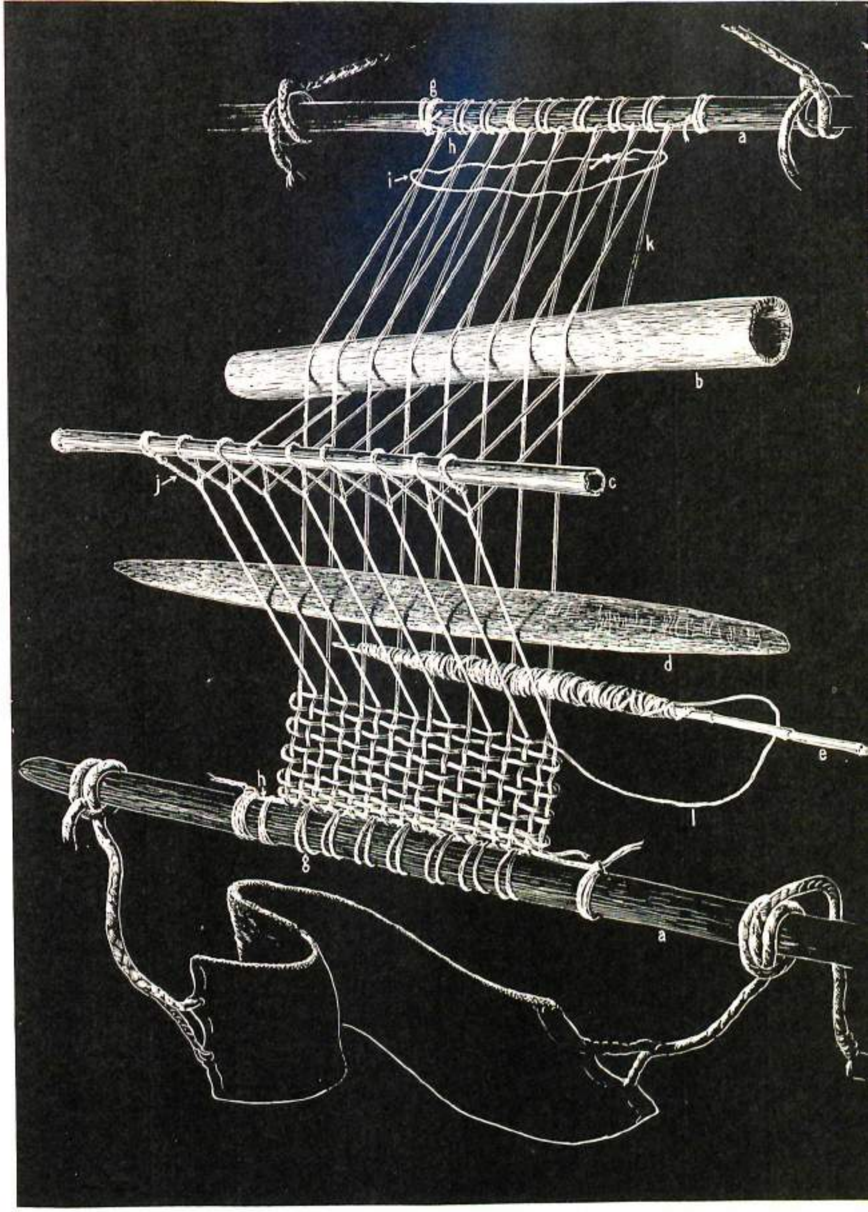


Plate 2. Loom from Bougainville Island.

Plate 3. Greek warp-weight loom. From an Athenian lekythos, ca. 560 B.C.

Plate 5. Back-strap loom (diagram) of the type used in Peru.

a. Loom bars.
b. Shed-rod.
c. Heddle-rod.
d. Batten or sword.
e. Bobbin.
f. Back strap.
g. Warp lashing.
h. Heading string.
i. Lease cord.
j. Leach cord.
k. Warp.
l. Weft.



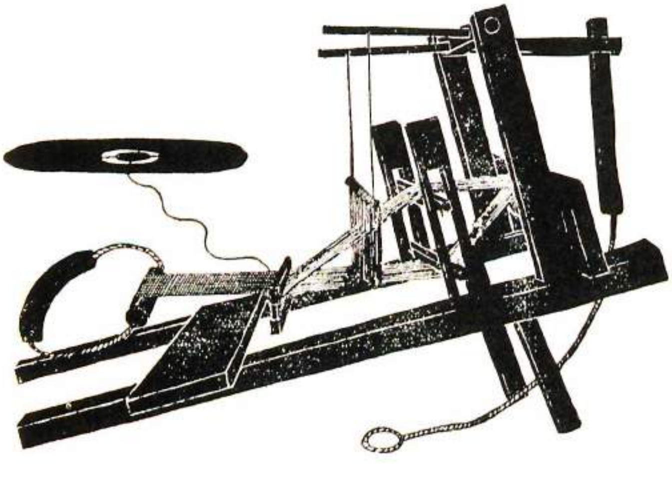


Plate 6. Okinawa loom, Japan.

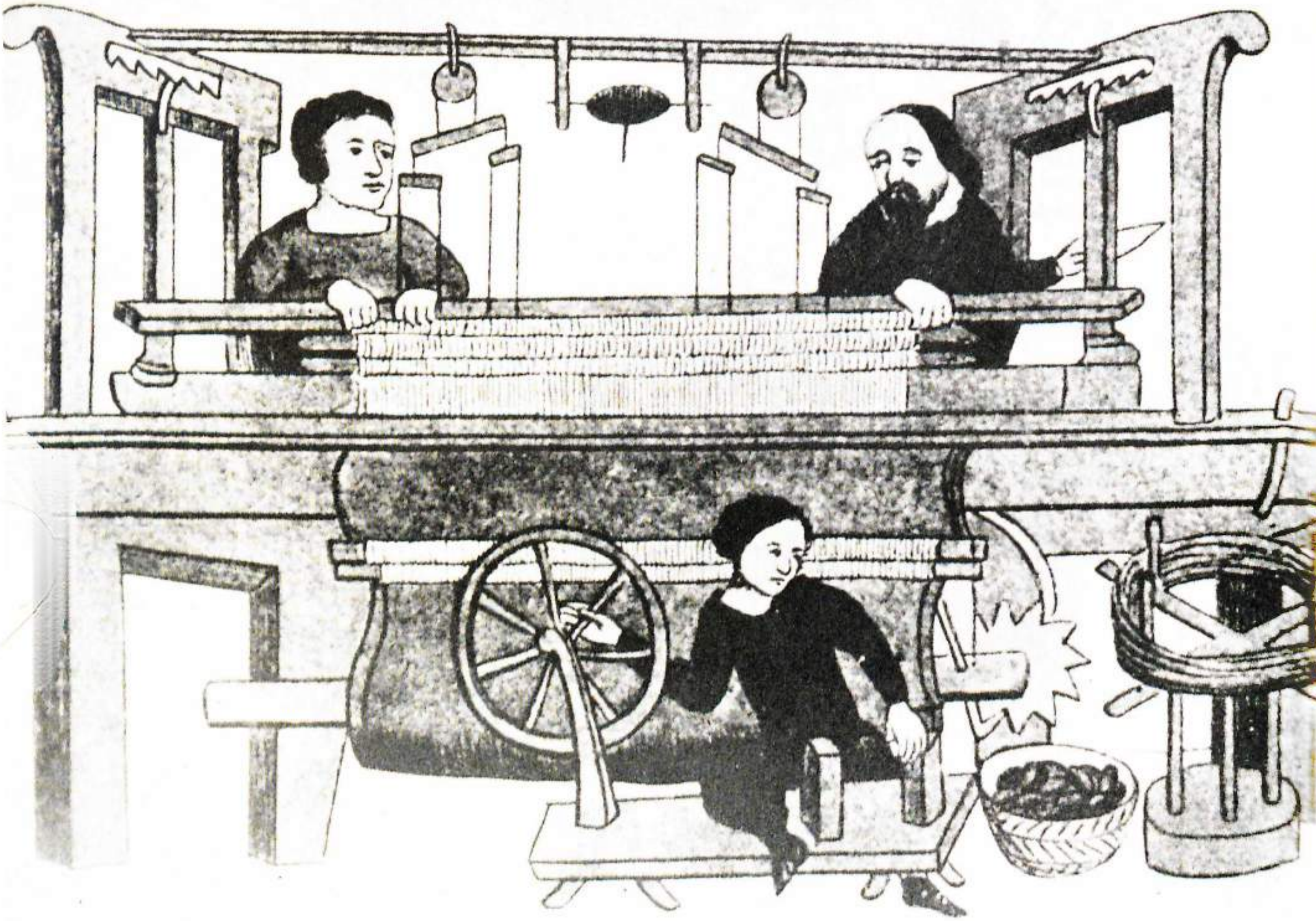


Plate 7. A medieval loom. From the Ypres Book of Trades, ca. 1310.

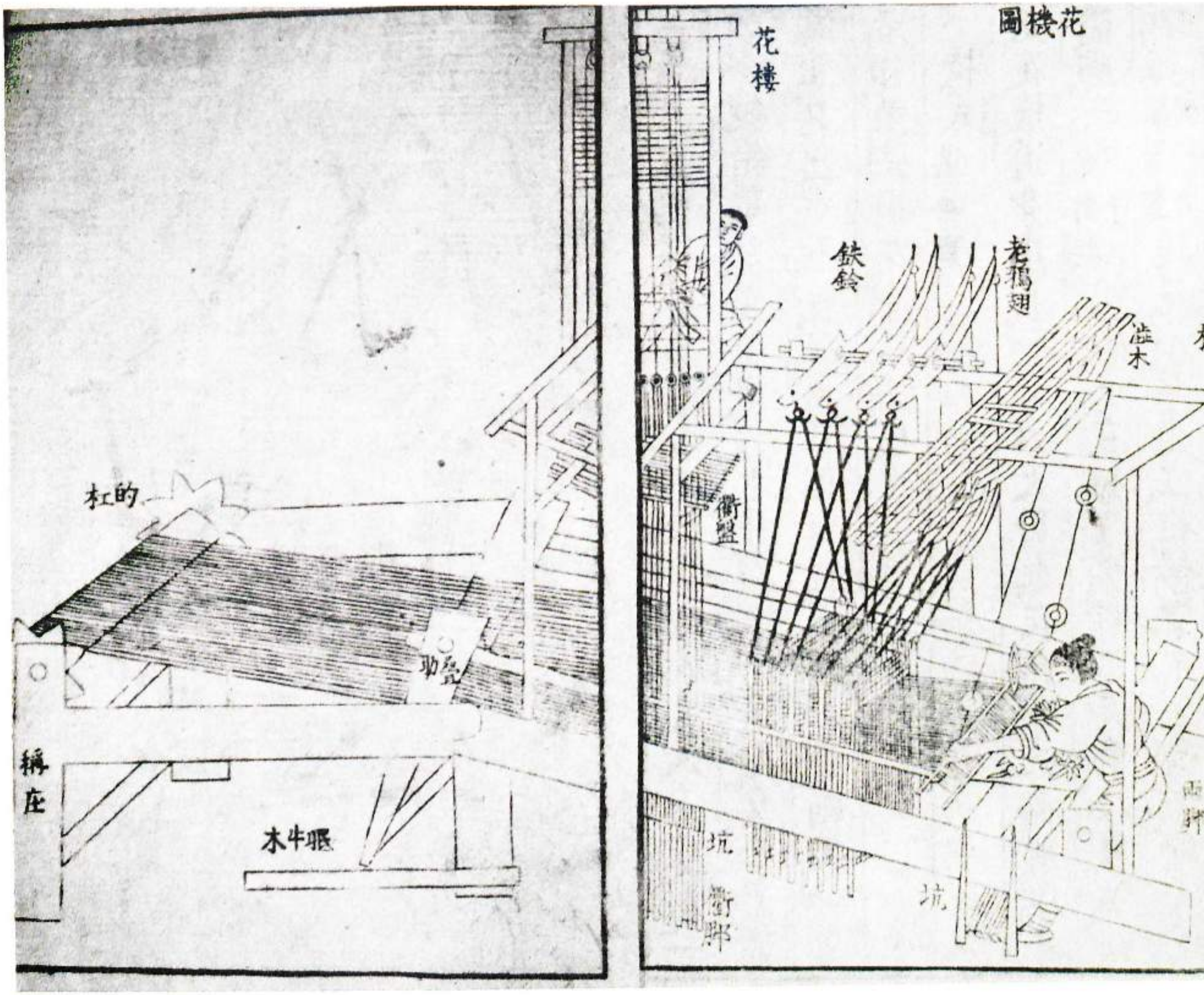


Plate 8. A Chinese draw-loom.

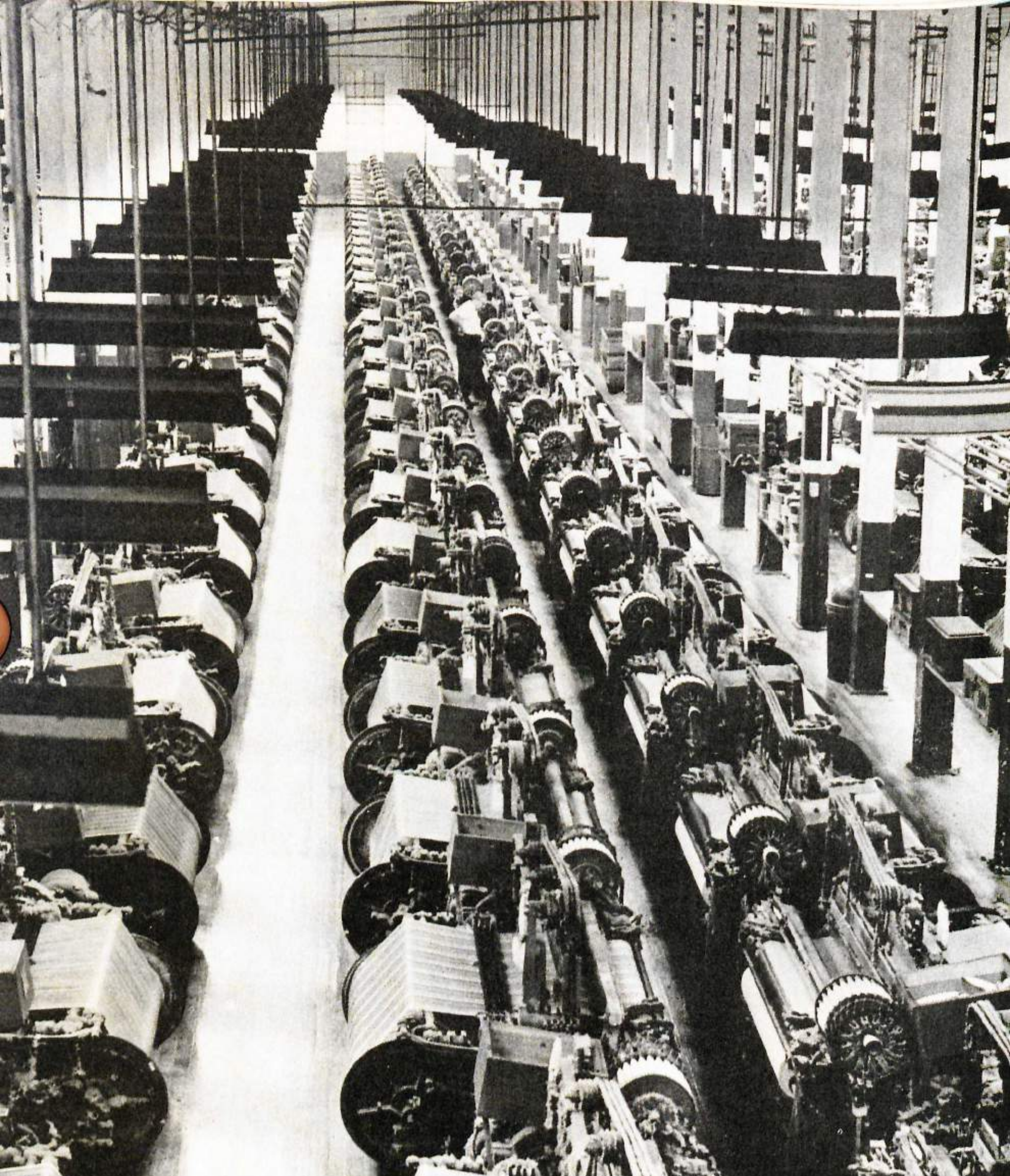


Plate 9. A modern weaving room. One man (in center of photograph) is supervising the weaving of the looms shown here—in some cases as many as one hundred looms.

Draft Notation

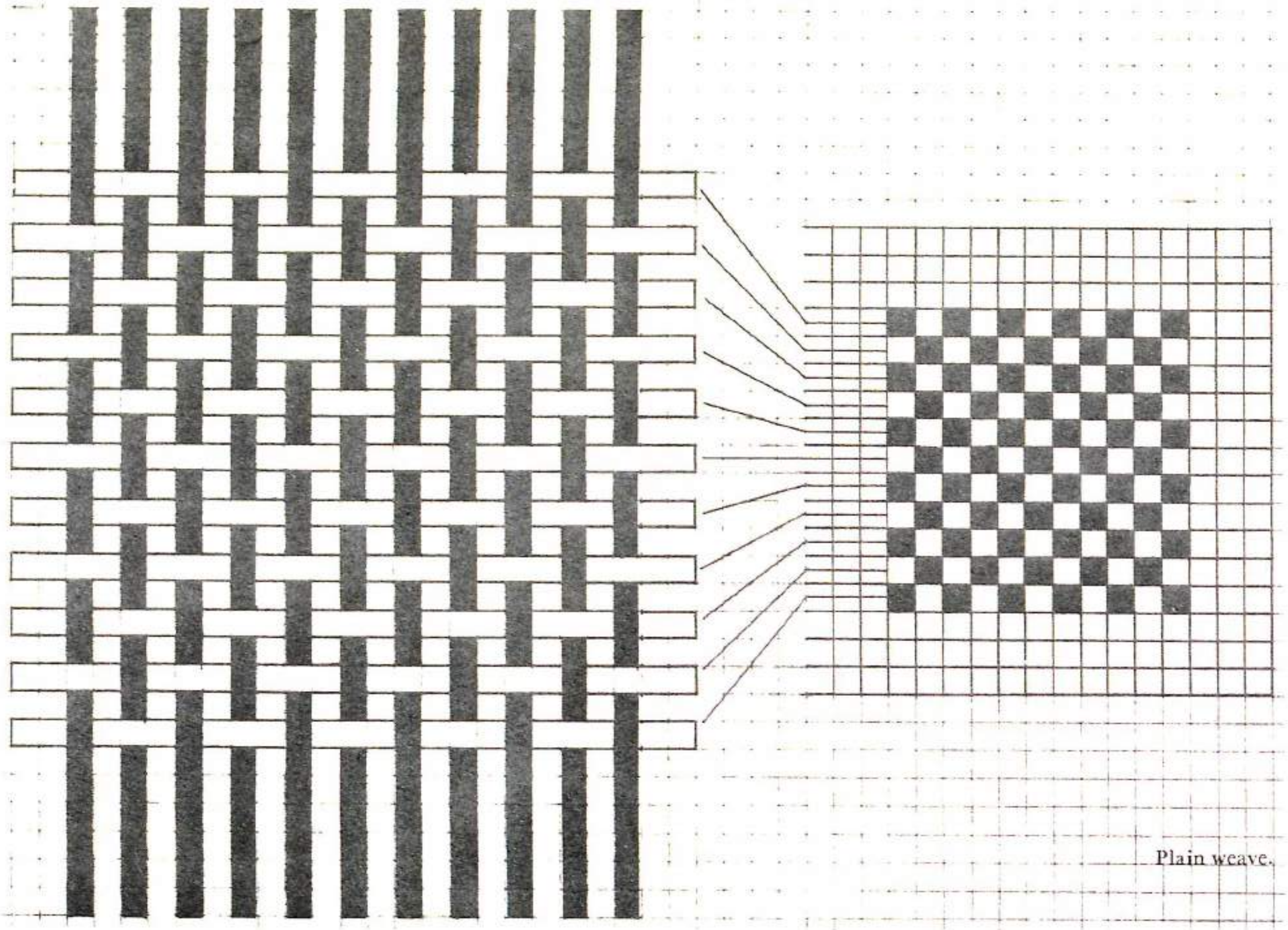


Plate 10. Diagram showing method of draft notation.

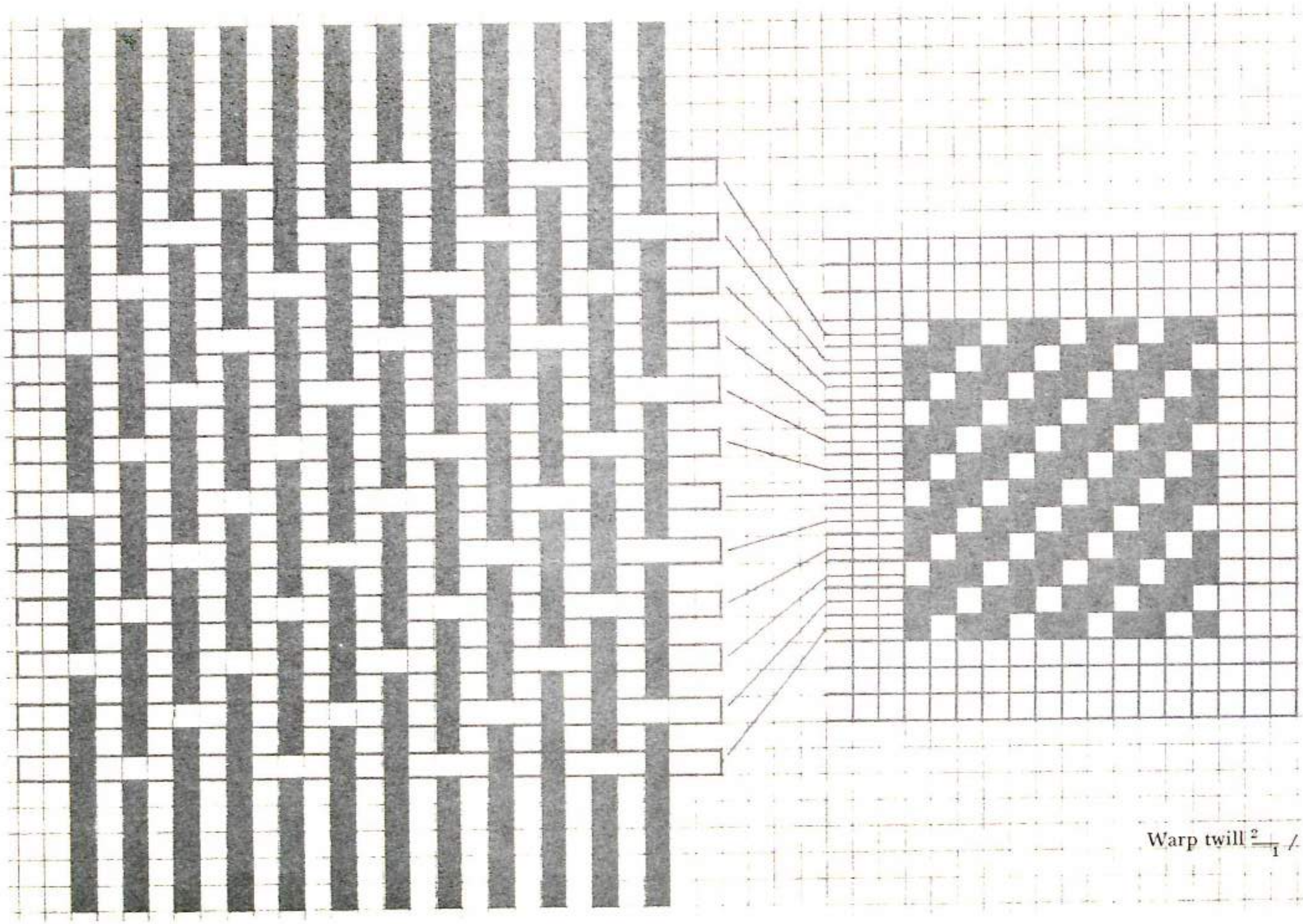


Plate 11. Diagram showing method of draft notation.

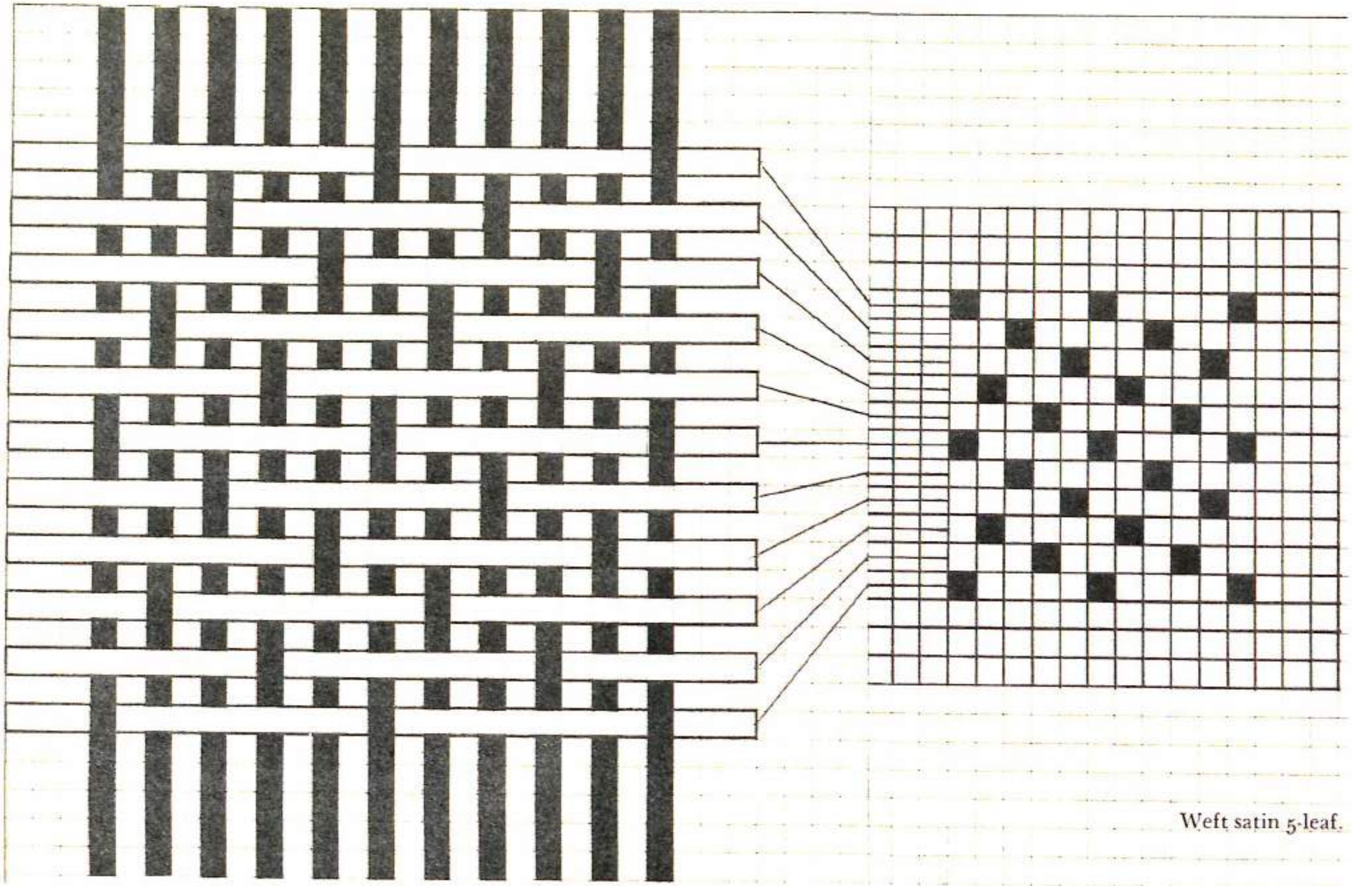
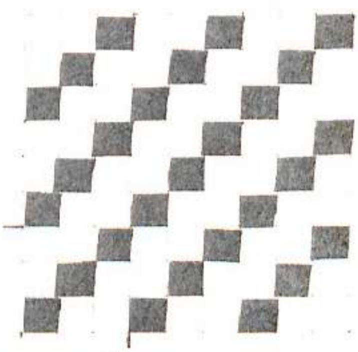


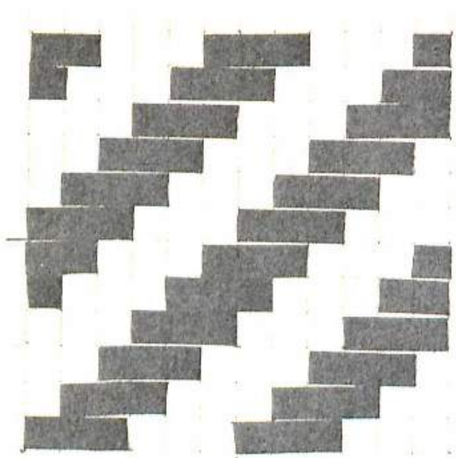
Plate 12. Diagram showing method of draft notation.

The Fundamental Constructions

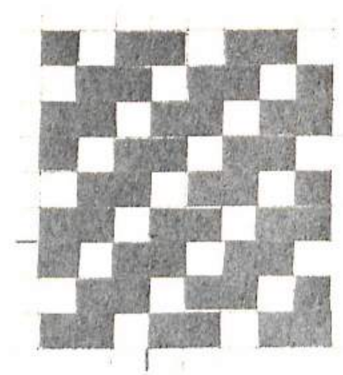
Plain weave.



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

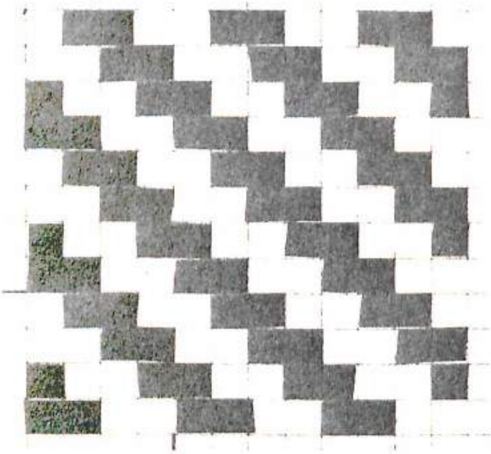


Balanced twill $\frac{3}{3}$/

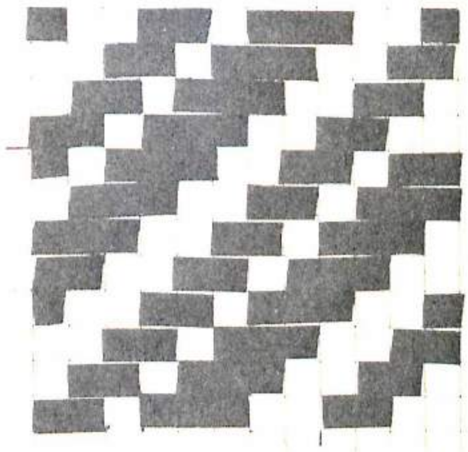


Warp twill $\frac{2}{1}$/

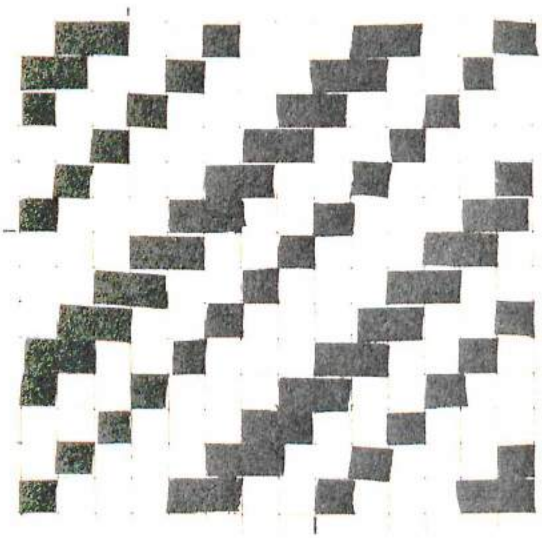
Plate 13. The fundamental constructions.



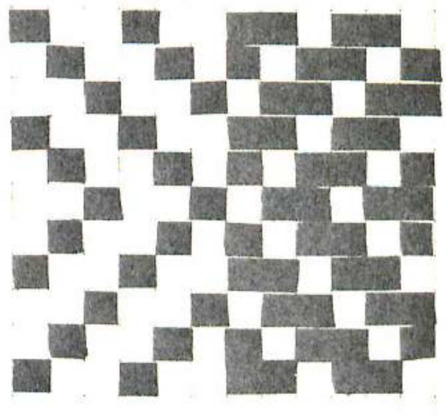
Balanced twill $\frac{2}{2}$ /



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

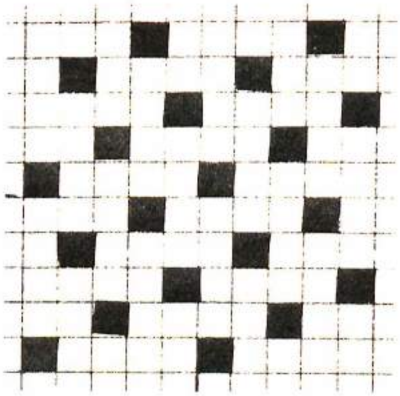


Weft twill $\frac{1}{3}\frac{2}{2}$ /

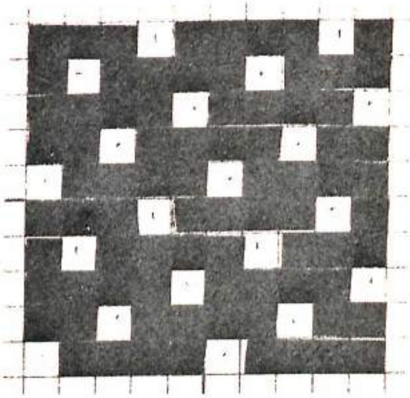


Warp and weft twill combination.

Plate 14. The fundamental constructions.



Weft satin 5-leaf.

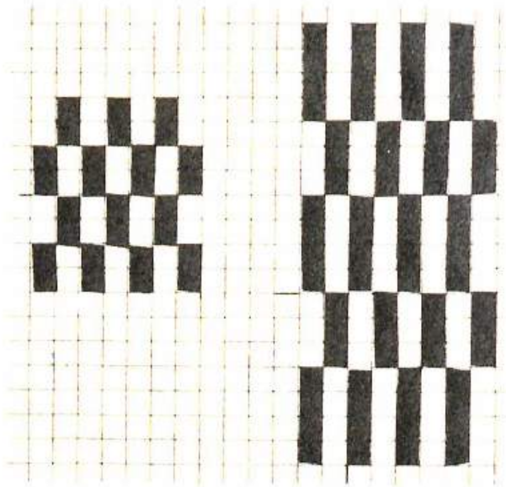


Warp satin 5-leaf.

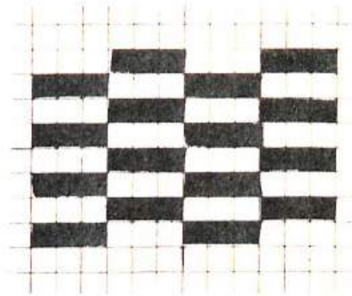
Warp satin 12-leaf.

Plate 15. The fundamental constructions.

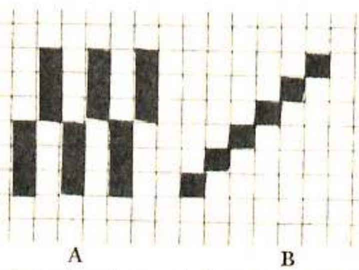
Modified and Composite Weaves



Warp or cross ribs.



Weft or long ribs.



Figured ribs, developed by placing a rib unit A in a twill formation B.

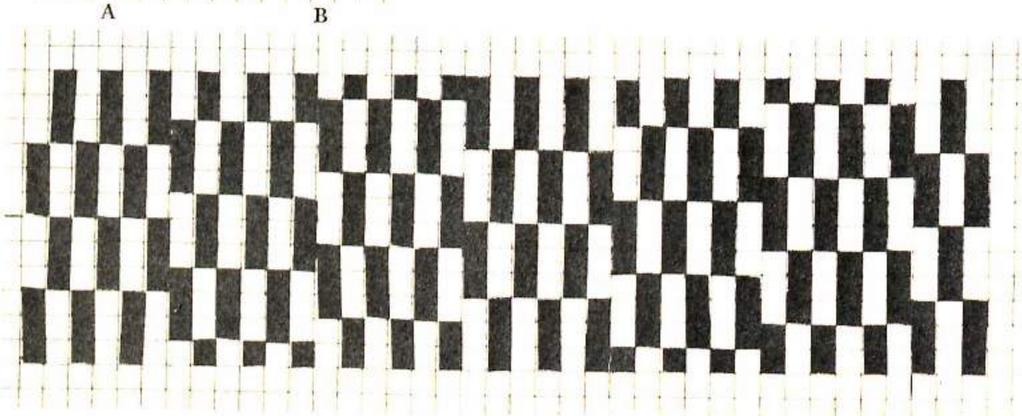
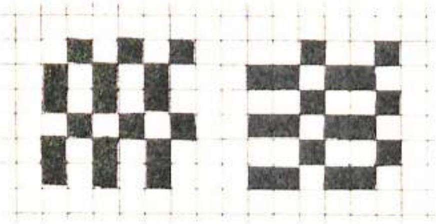
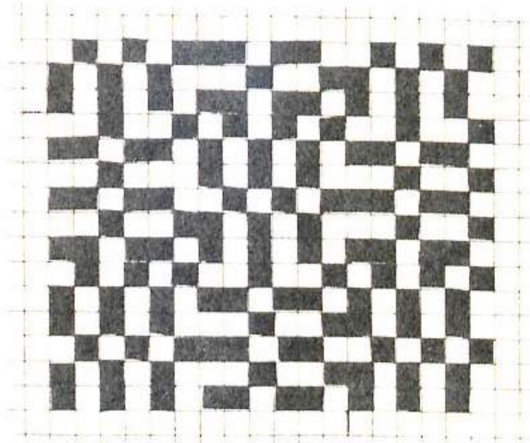


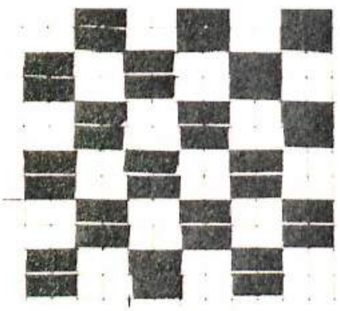
Plate 16. Modified and composite weaves.



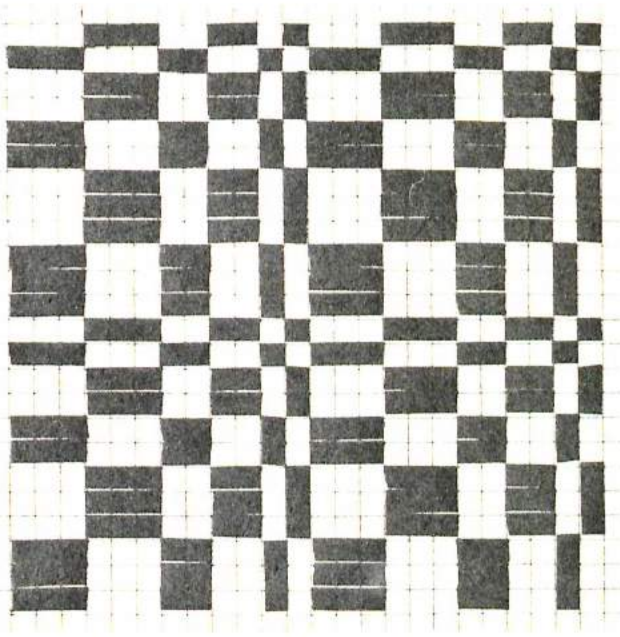
A B



Combination ribs, developed by combining A and B.



Basket weave.

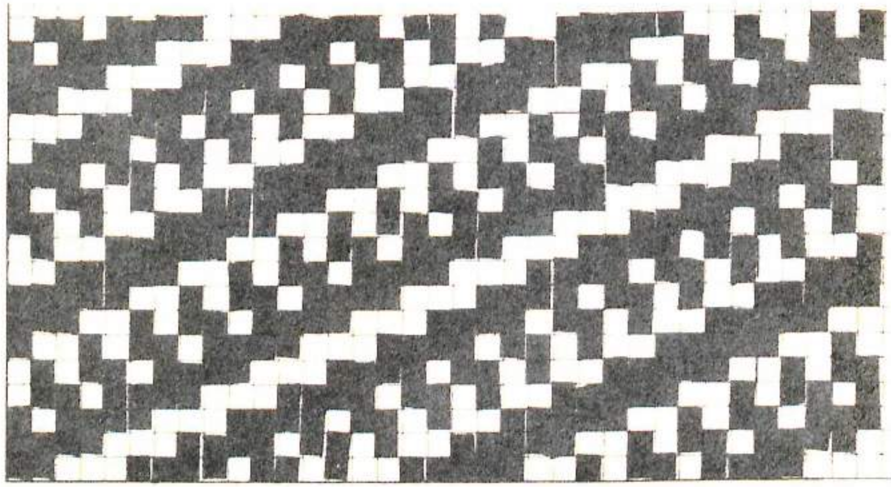


Basket weave.

Plate 17. Modified and composite weaves.

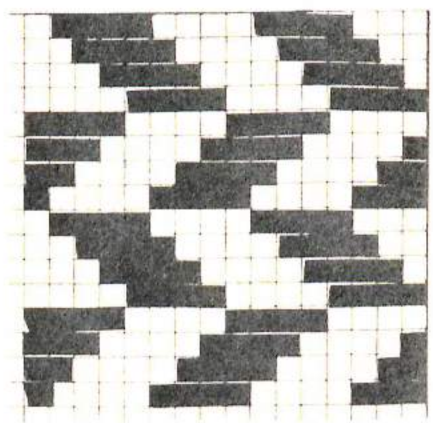
A. $\frac{3}{2}$

B. $\frac{2}{1}$



Interlocking twill, developed from A and B.

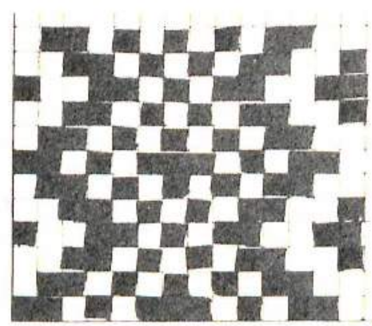
Steep twill.



Reversed twill.

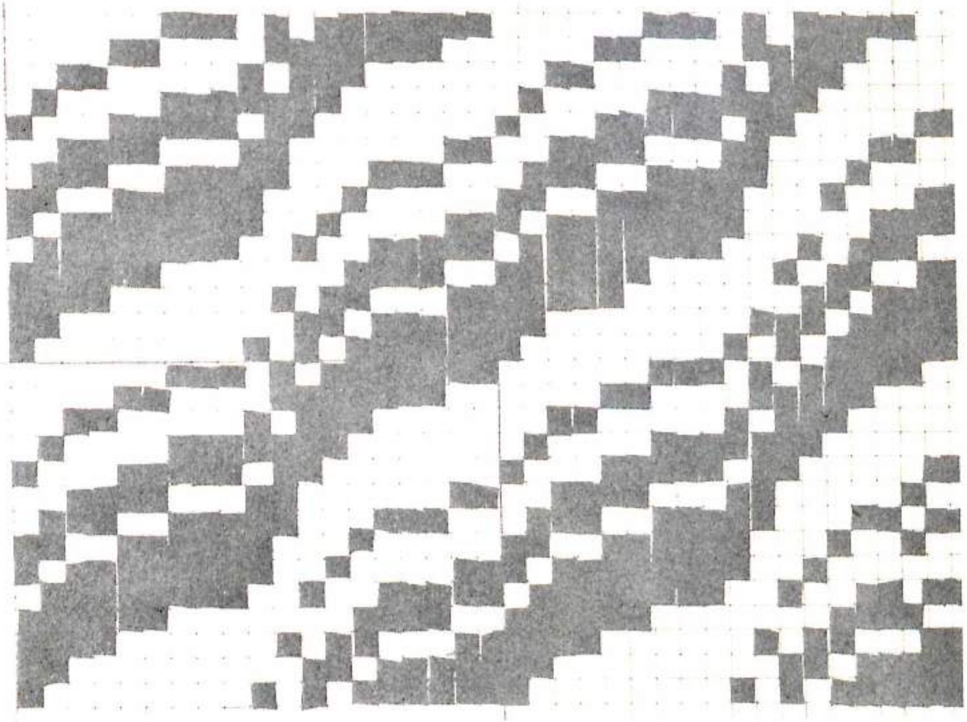
Offset twill.

Herringbone or pointed twill.

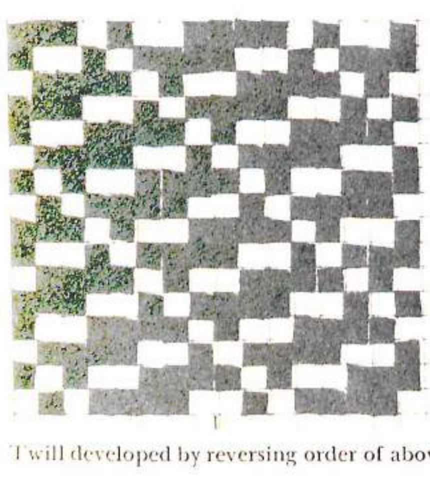


Twill pointed in warp and filling.

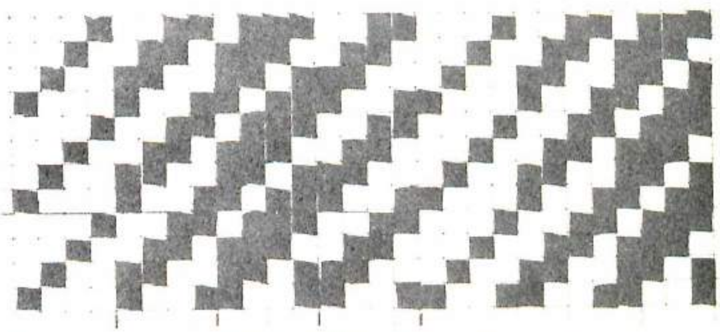
Plate 18. Modified and composite weaves.



Undulating twill.

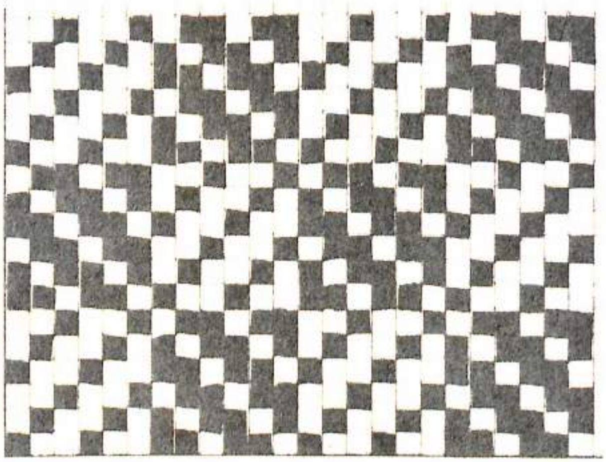


Twill developed by reversing order of above section.

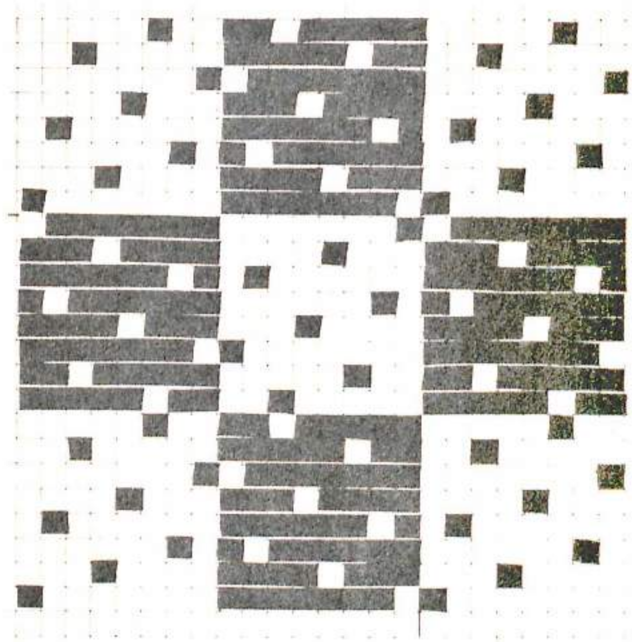


Twill shade, achieved by adding tying points to original unit.

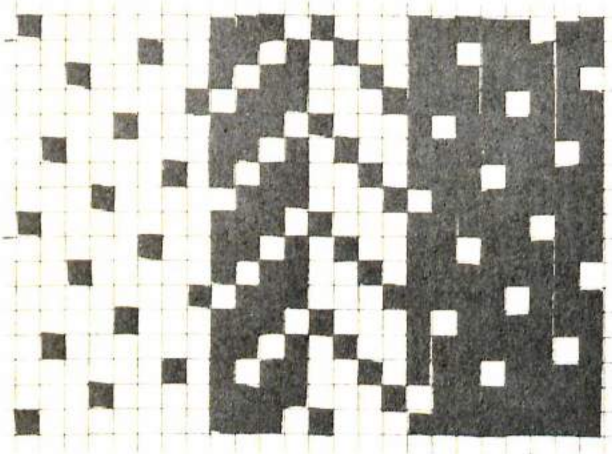
Plate 19. Modified and composite weaves.



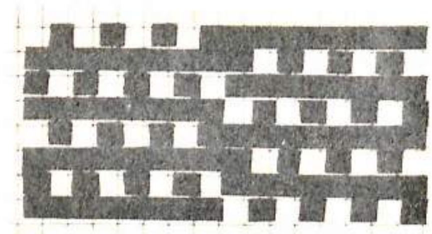
Checkerboard damask: combination of warp and weft twill.



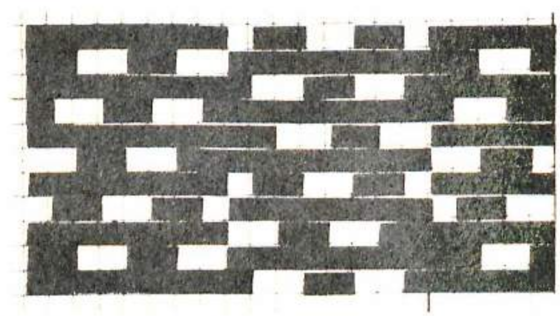
Combination warp and weft satin.



Combination weave: weft satin, warp twill, weft twill, warp satin.

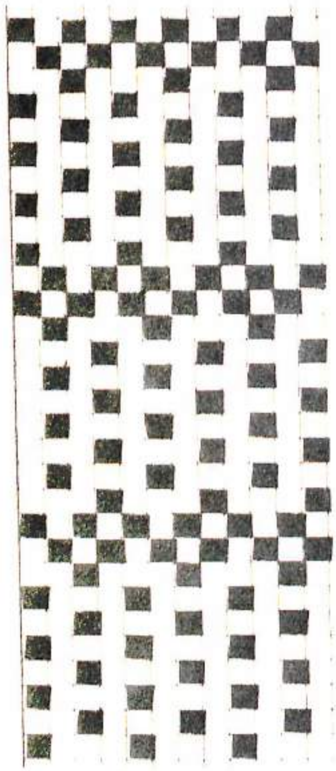


Warp cord in plain weave.

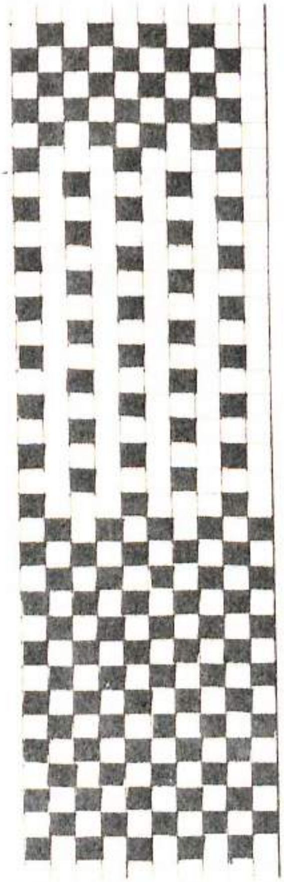


Warp cord in $\frac{2}{2}$ twill.

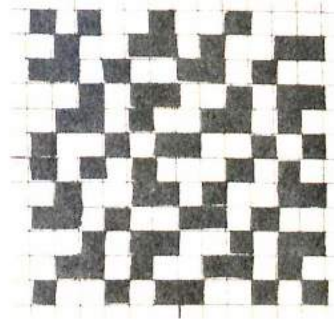
Plate 20. Modified and composite weaves.



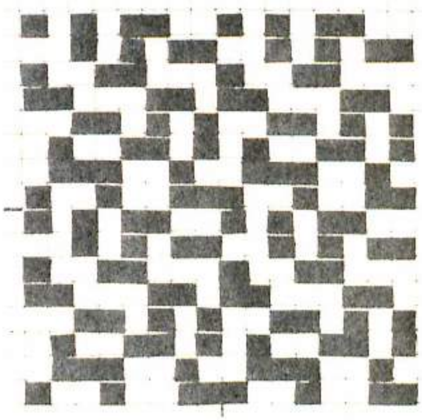
Weft cord in plain weave.



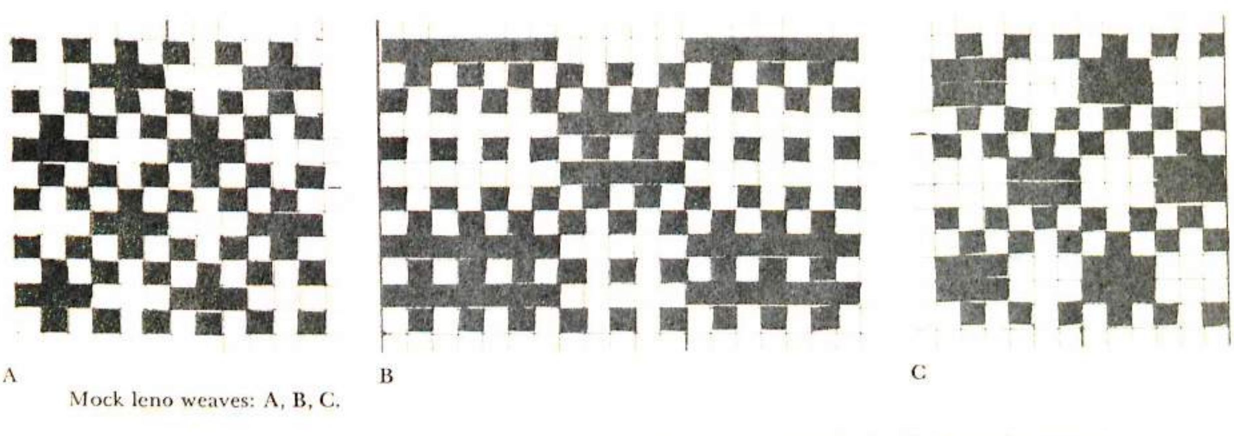
Plissé weave in plain weave.



Crêpe weave.



Crêpe weave.

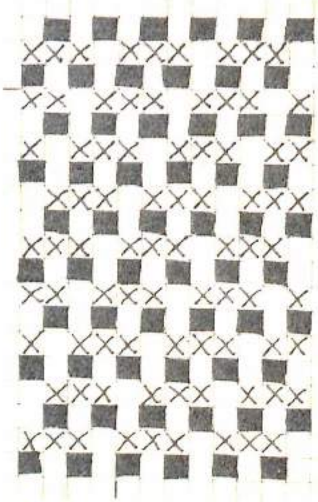


A B C

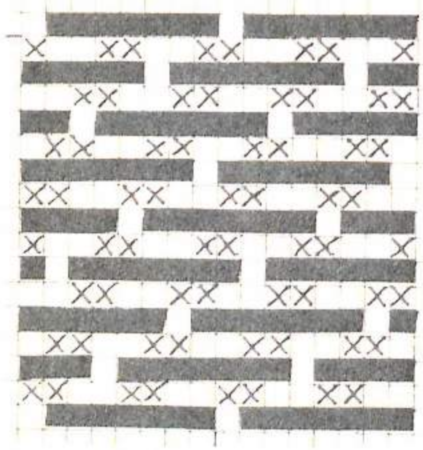
Mock leno weaves: A, B, C.

Plate 21. Modified and composite weaves.

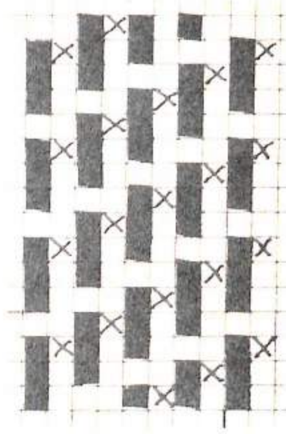
Back filling fabrics: A, B, C.



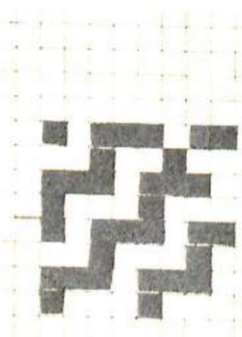
A: Front plain weave, back $\frac{3}{1}$ twill.



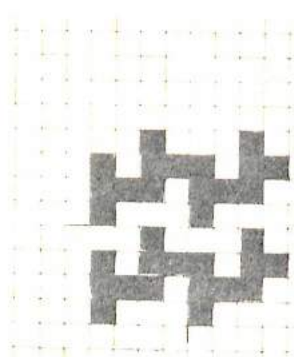
B. Front twill $\frac{7}{1}$, back twill $\frac{2}{2}$.



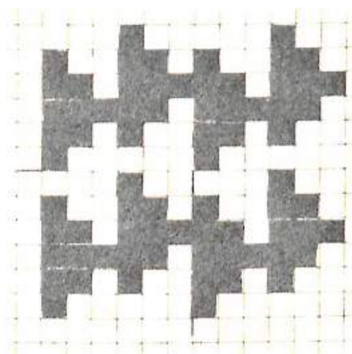
C. Back warp fabric: front $\frac{3}{1}$ twill, back $\frac{1}{3}$ twill.



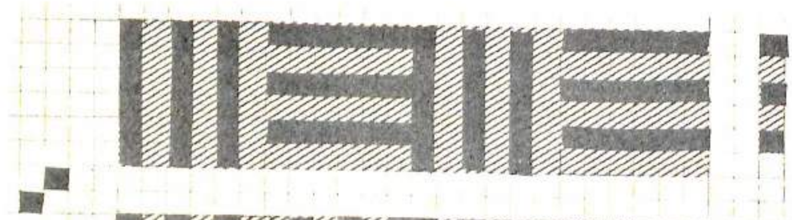
Double weave, plain weave closed on both sides forming a tube, or tubular weave.



Double weave, plain weave open on one side; can be unfolded for double width.

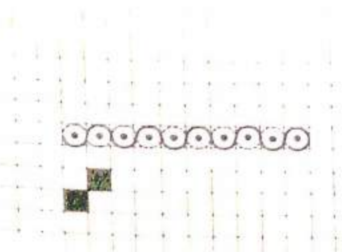


3-layered plain weave; can open to triple width.

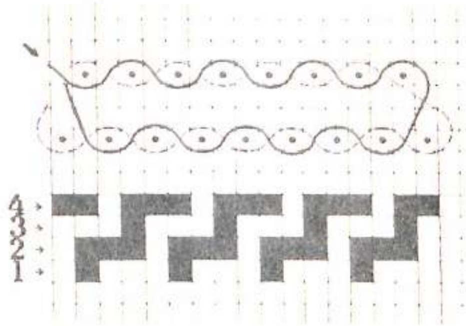


Color effect: plain weave with alternating two colors in warp and weft.

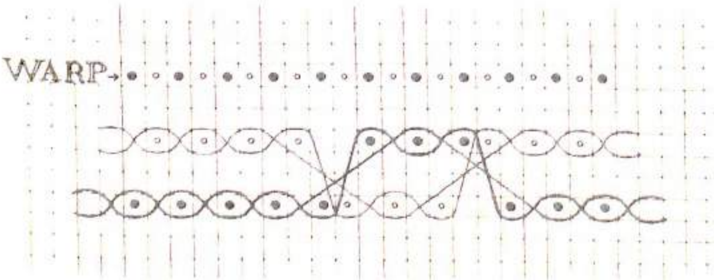
Plate 22. Modified and composite weaves.



Plain weave: cross section and draft.



Tubular weave: cross section and draft.



Cross section of double cloth in contrasting colors, interlocked for pattern effect.

Double cloth closed on one side only, to open to double width: cross section and draft.

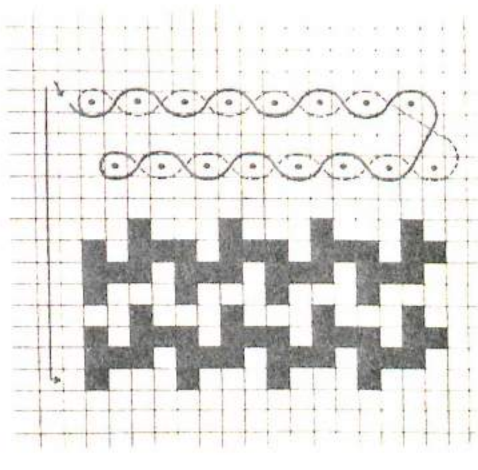
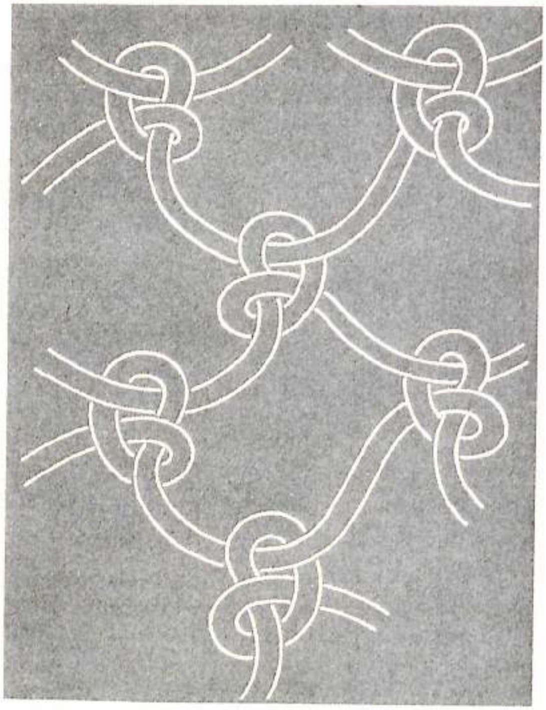
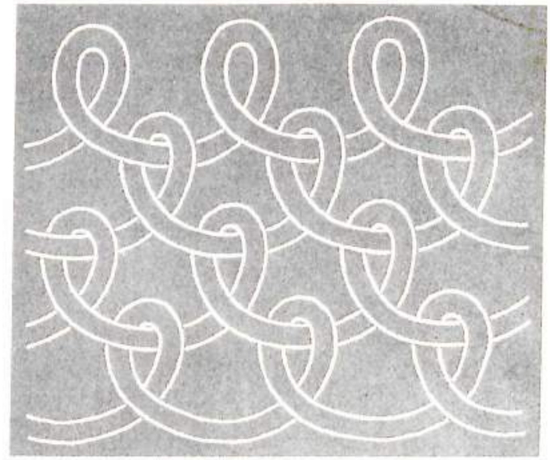


Plate 23. Modified and composite weaves.

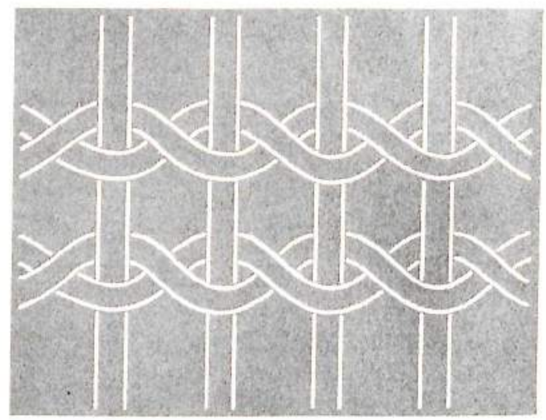
Early Techniques of Thread Interlacing



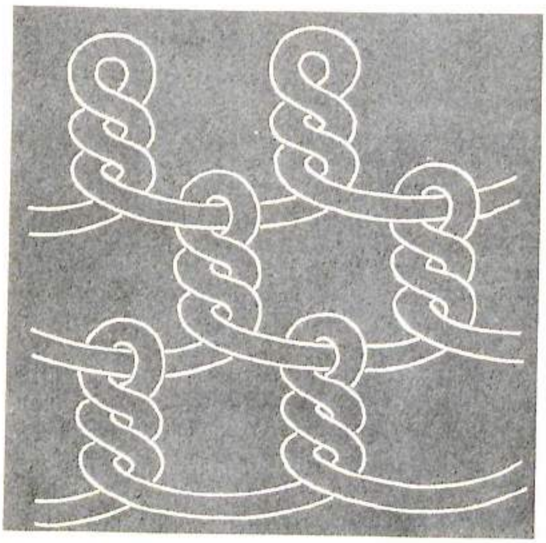
Knotted net, pre-Columbian (after Junius Bird). It is also the so-called Lake-dwelling knot, Neolithic, Robenhausen, Switzerland.



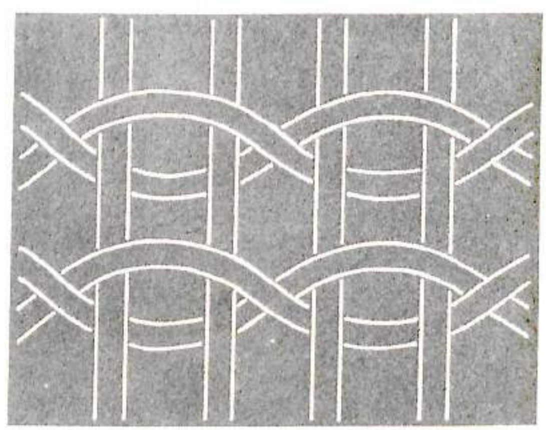
Looping, knotless net, Neolithic Switzerland.



Twining.

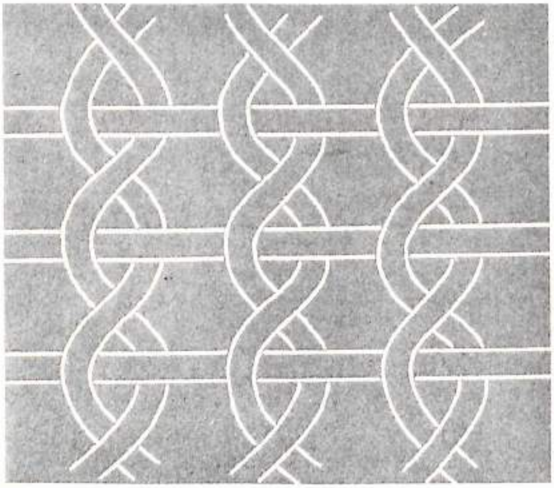


Looping, developed from knotless net.

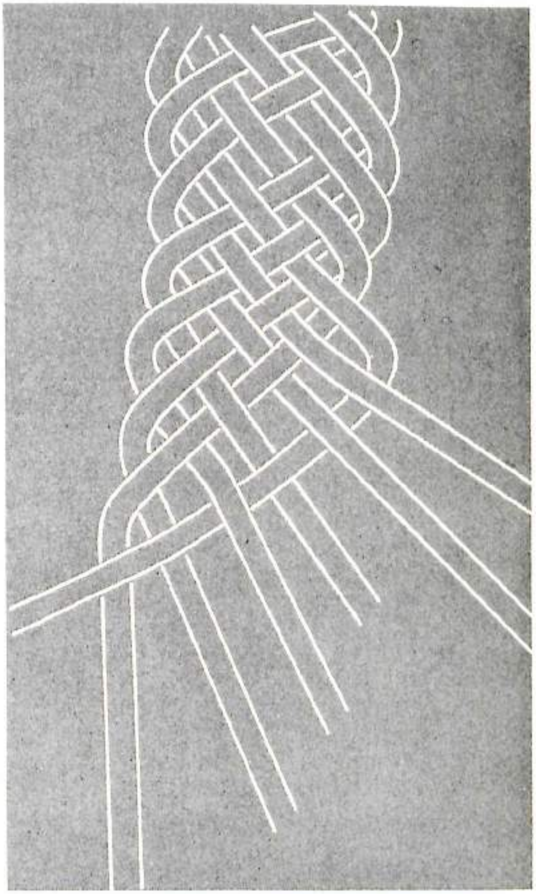


Twining.

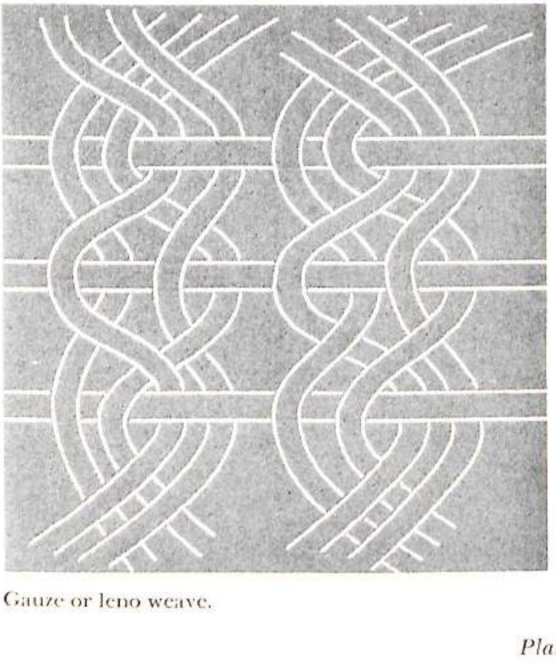
Plate 24. Early techniques of thread interlacing.



Gauze or leno weave.

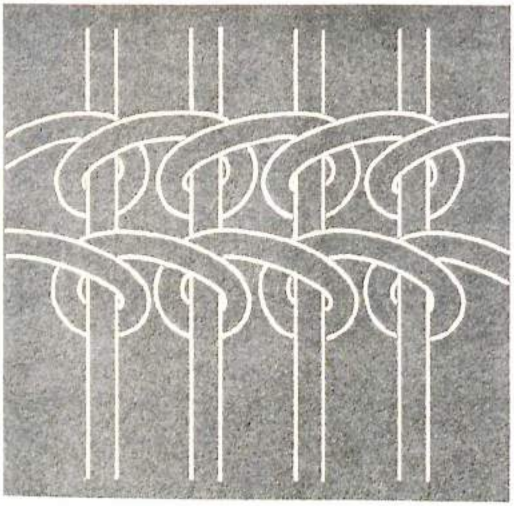


Braid of the early Nazca period (after Lila M. O'Neale).

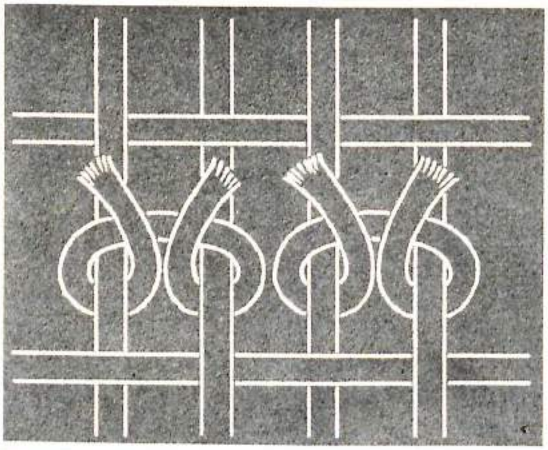


Gauze or leno weave.

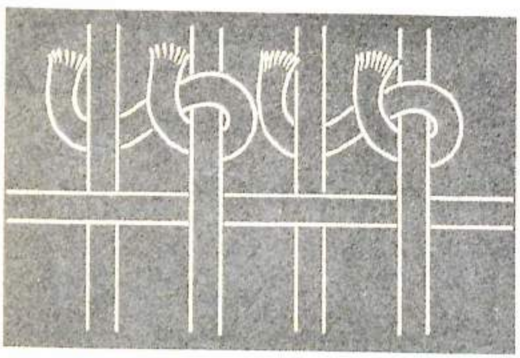
Plate 25. Early techniques of thread interlacing.



Soumak.



Turkish rug knot.



Persian rug knot.

Plate 26. Early techniques of thread interlacing.

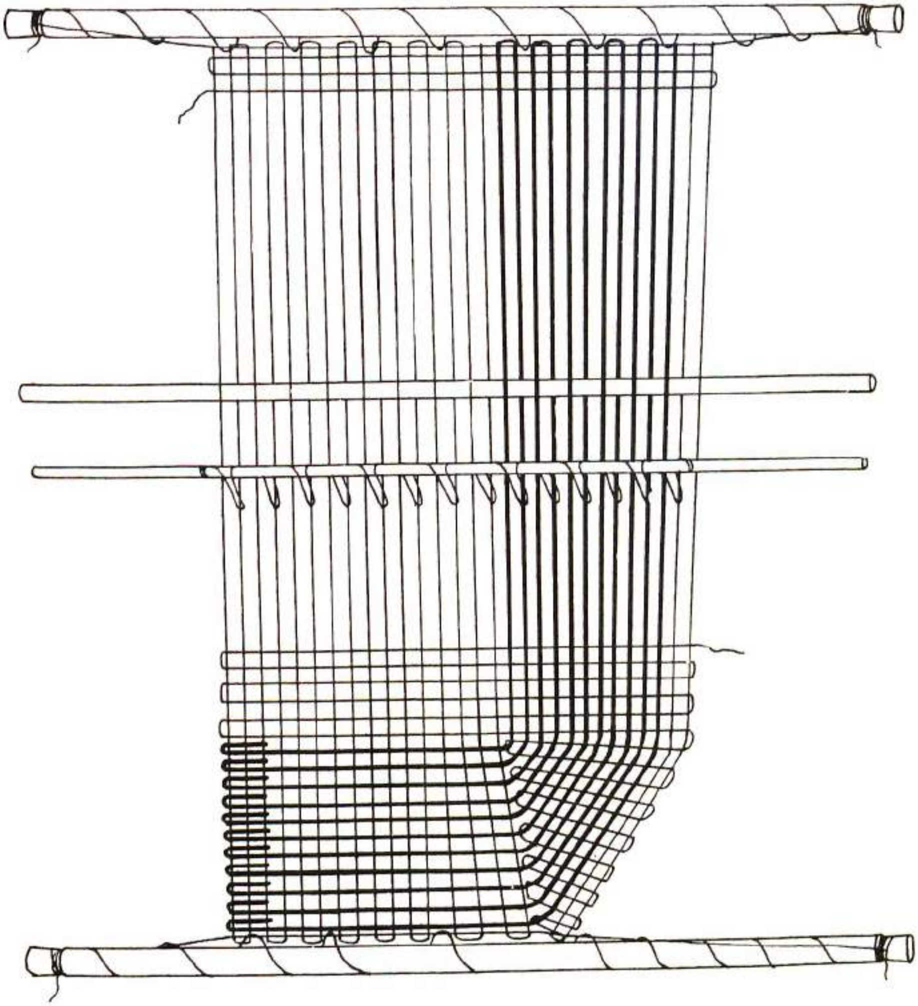


Plate 27. Loom, Santa Ana Hueytlalpan (after Bodil Christensen).

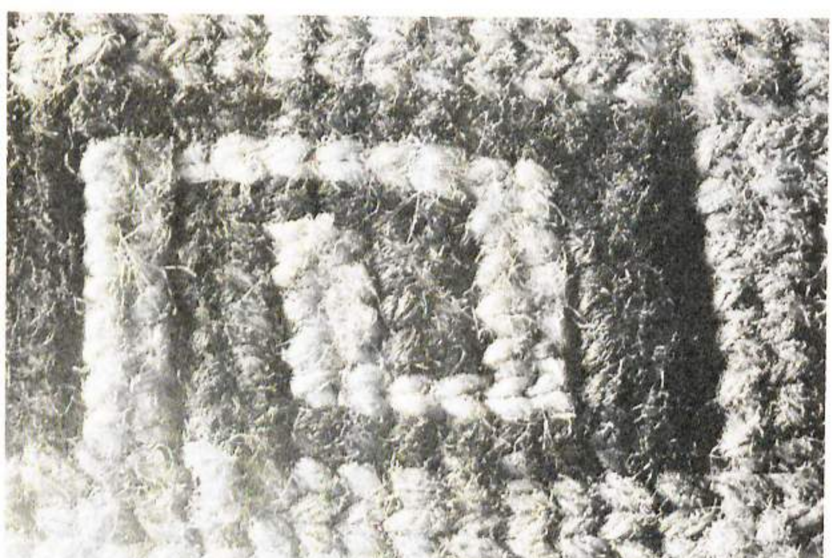


Plate 28. Twining, Admiralty Islands.

Plate 29. Shaped shirt, ancient North Chile.

Plate 30. Netting, Coptic, 5th century.

Tactile Sensibility

Plate 31. Braid, Nazca culture, Peru.

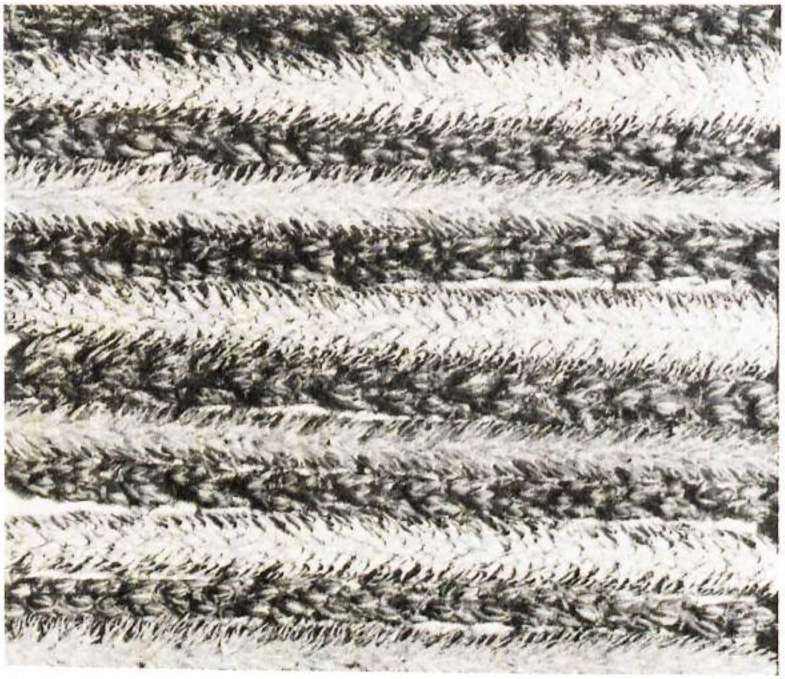
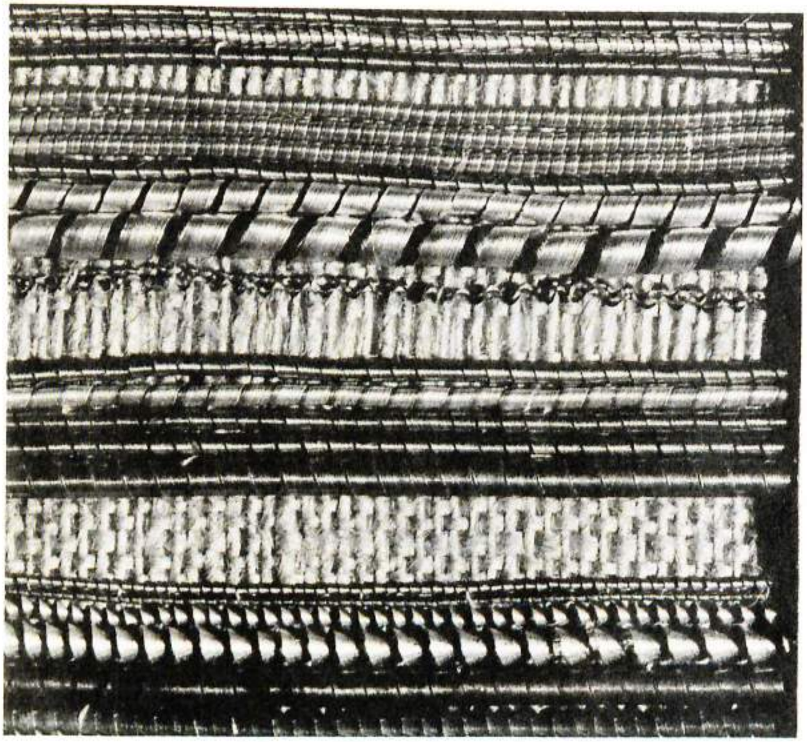


Plate 32. Study made with grass.

Plate 33. Study made with metal shavings.



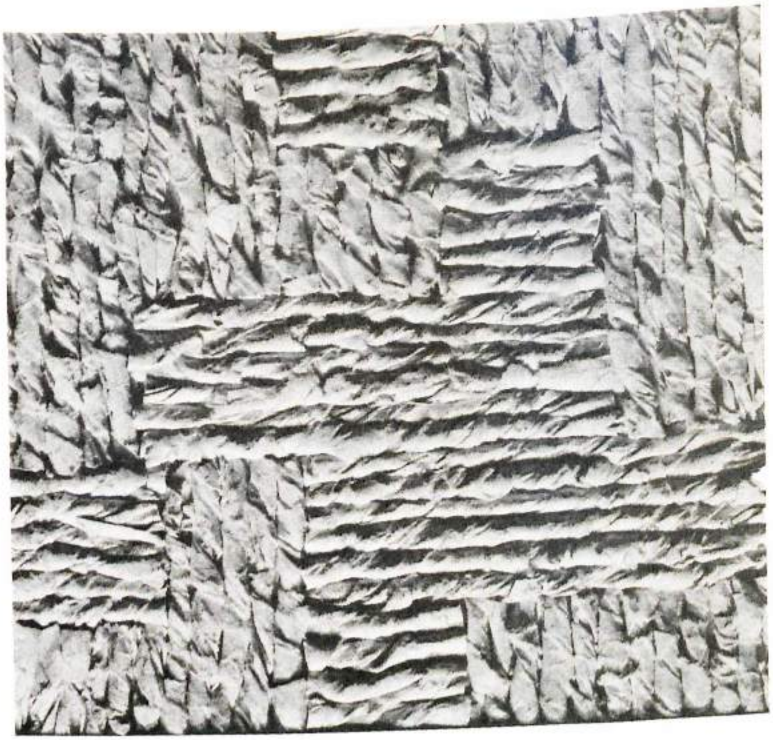


Plate 34. Study made with twisted paper.

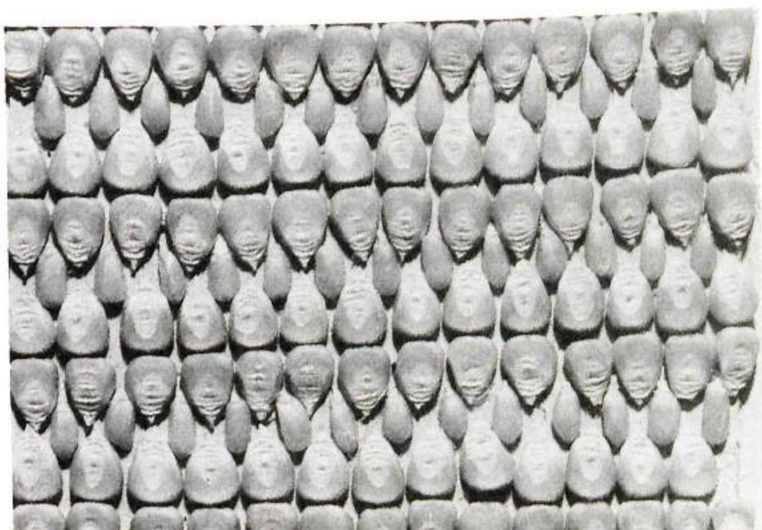


Plate 35. Study made with corn kernels.

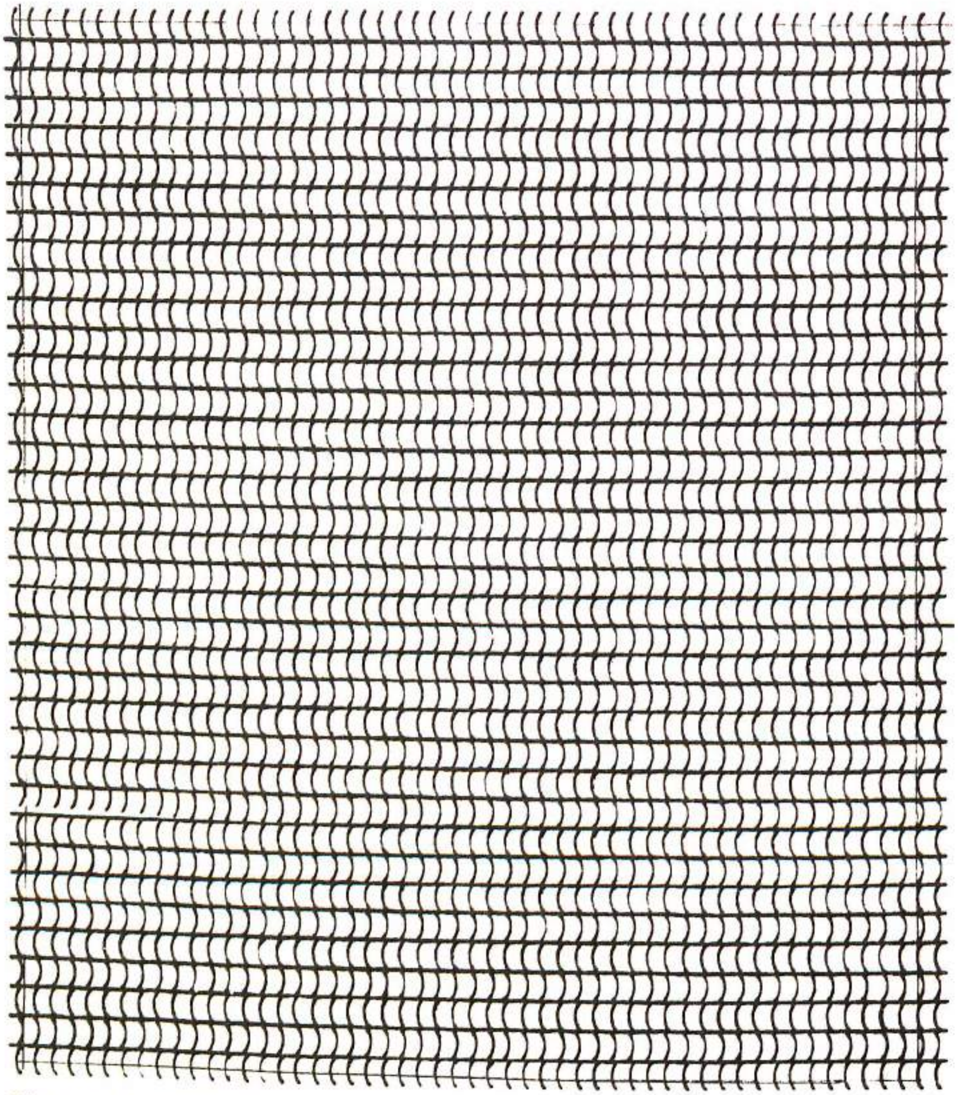
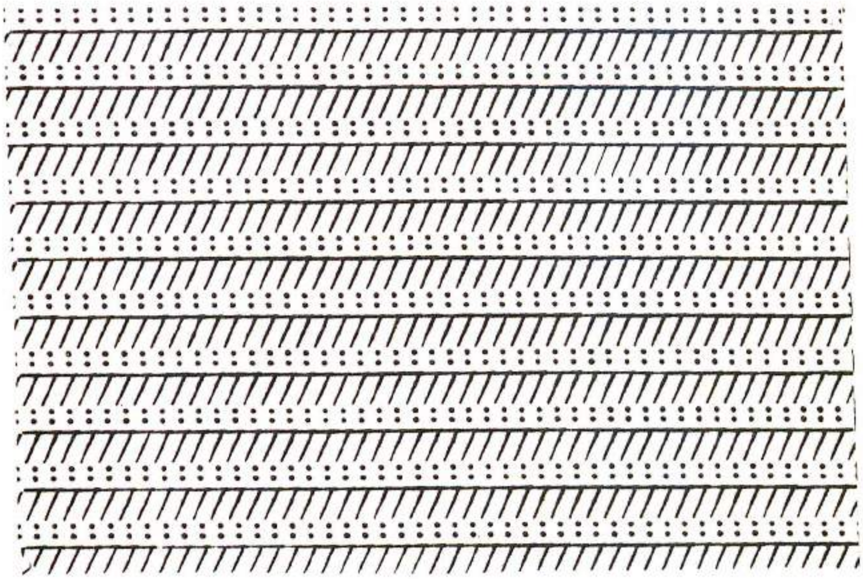


Plate 36. Study made on the typewriter.



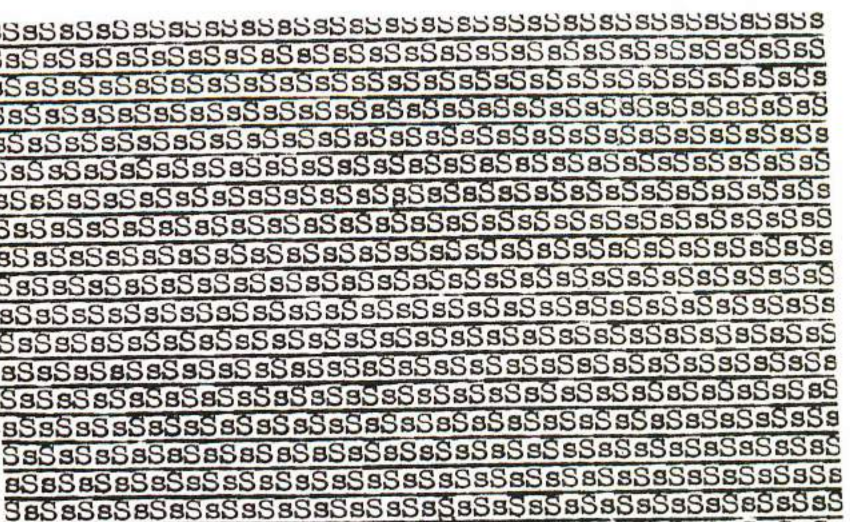
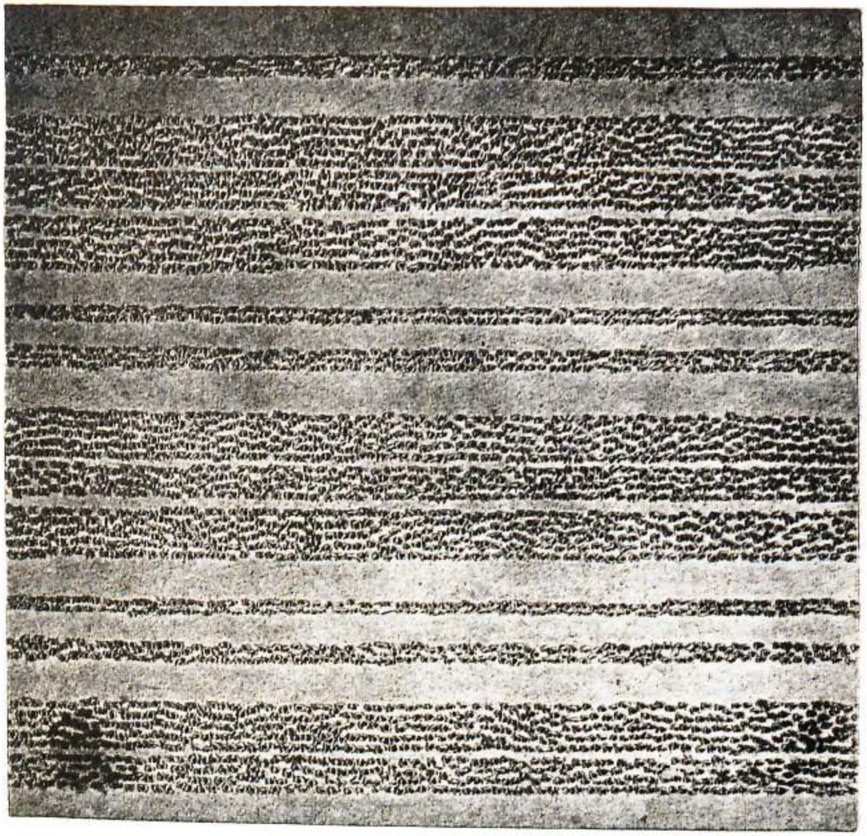


Plate 37. Studies made on the typewriter.



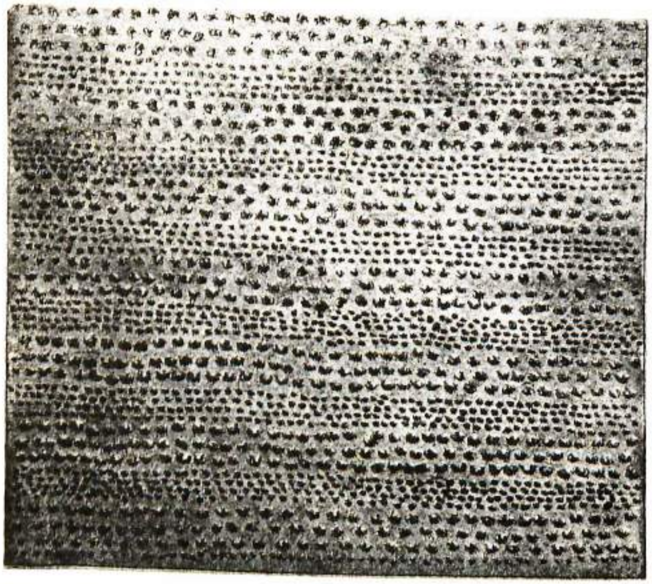
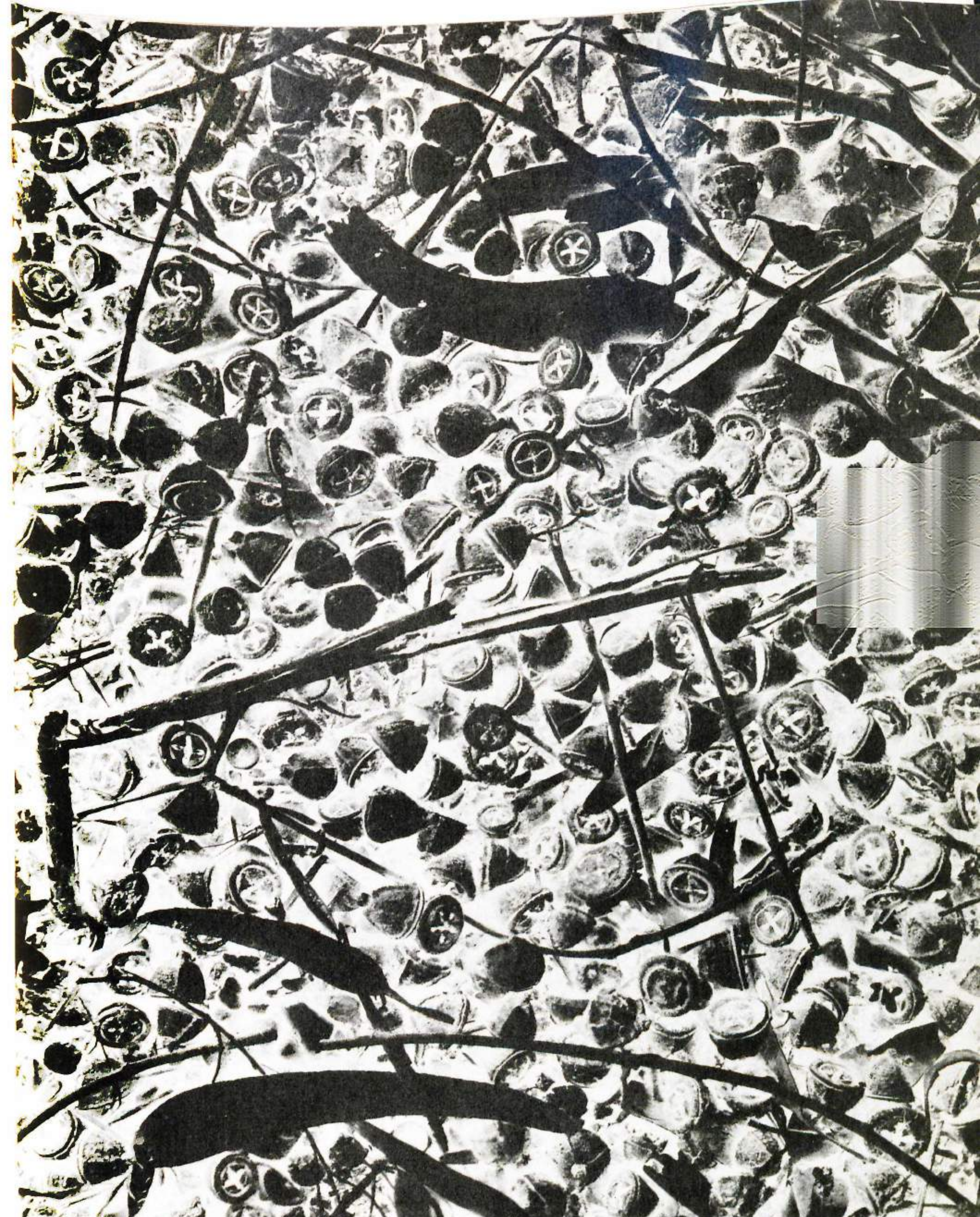


Plate 38. Studies made by puncturing paper.

Plate 39. Arrangement made by nature as contrast to arrangement made by design. Charles Eames.



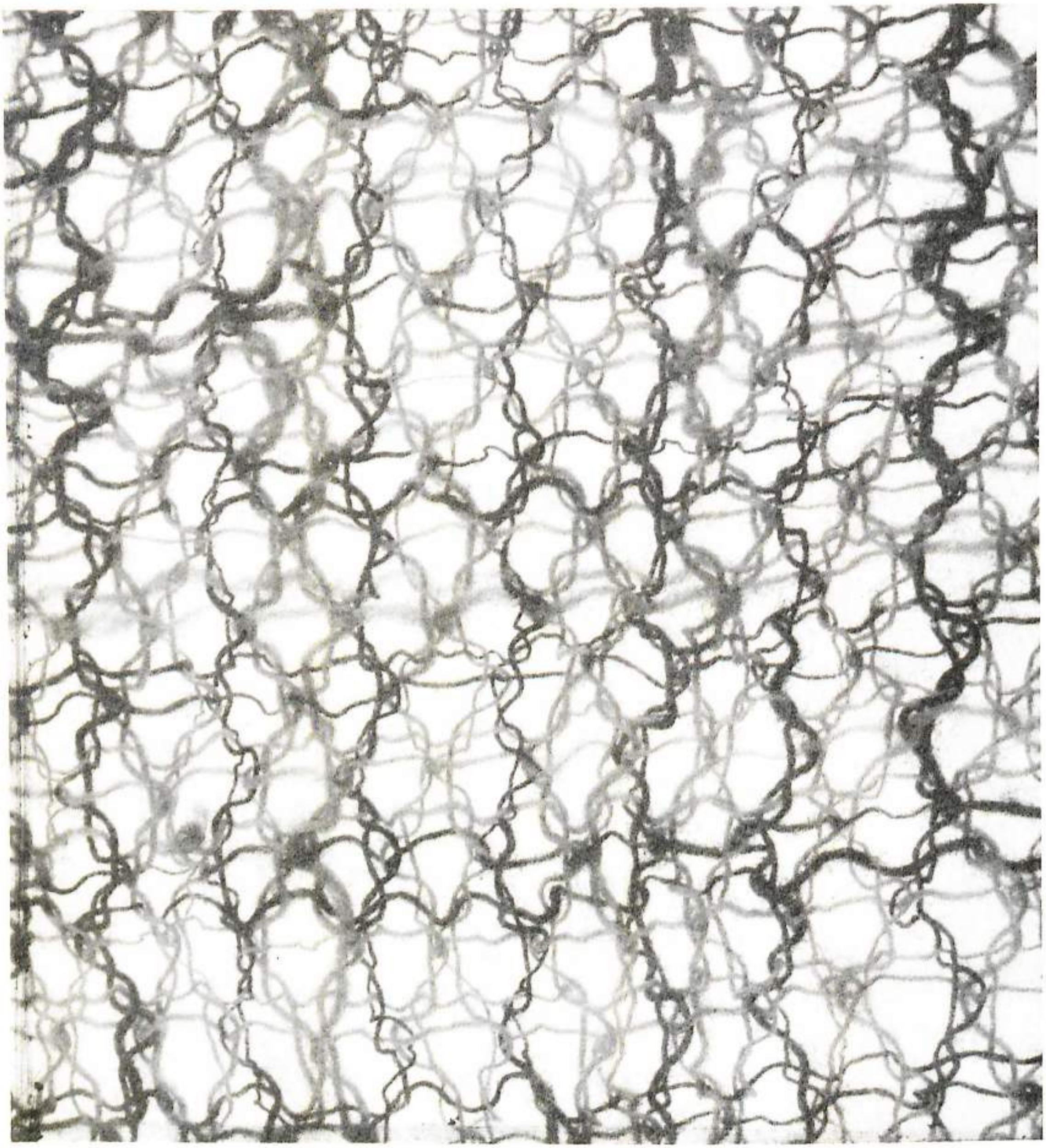


Plate 40. Lace, ancient Peru.

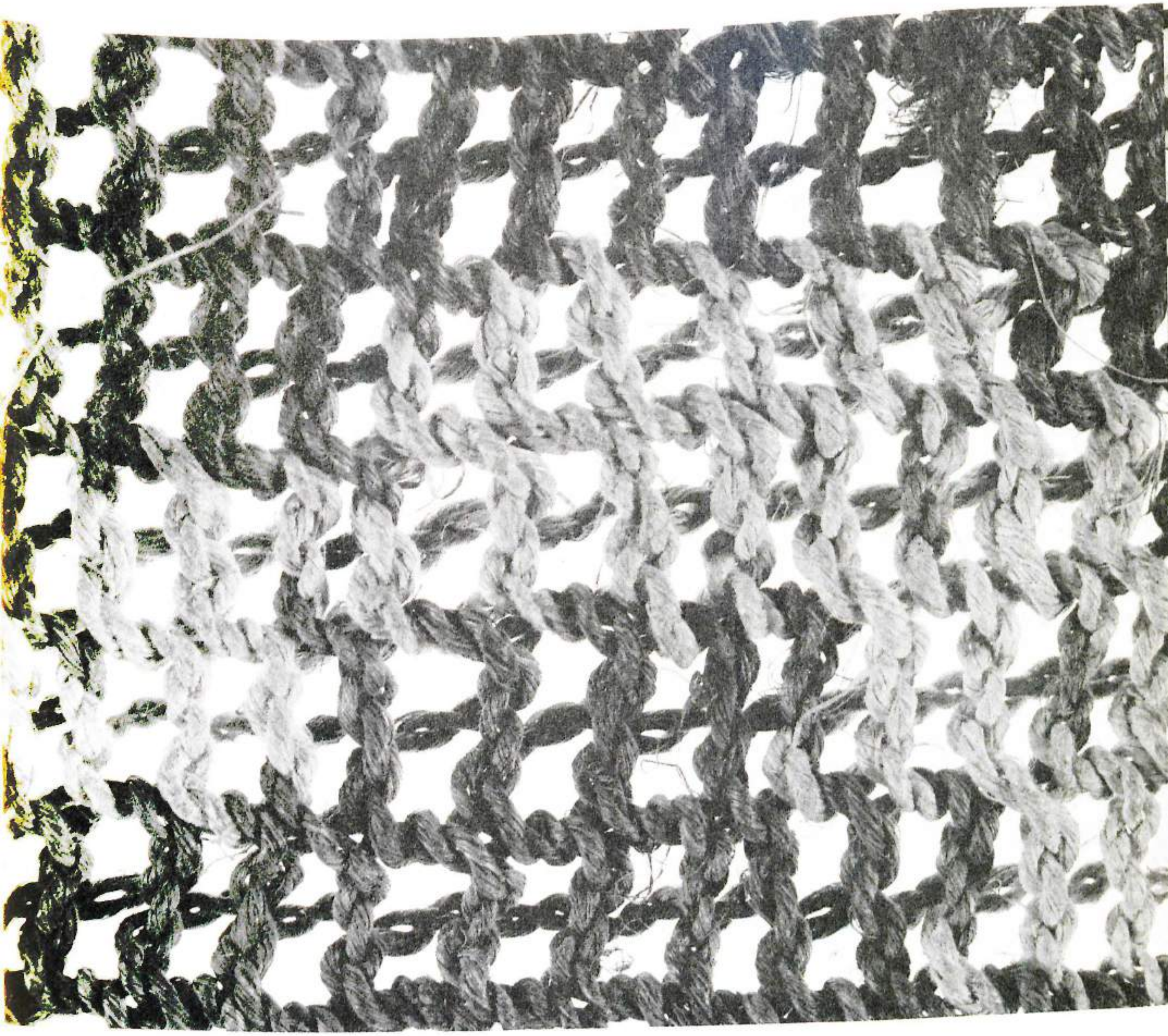


Plate 41. Detail of ancient looped bag, Salta, northern Argentina.

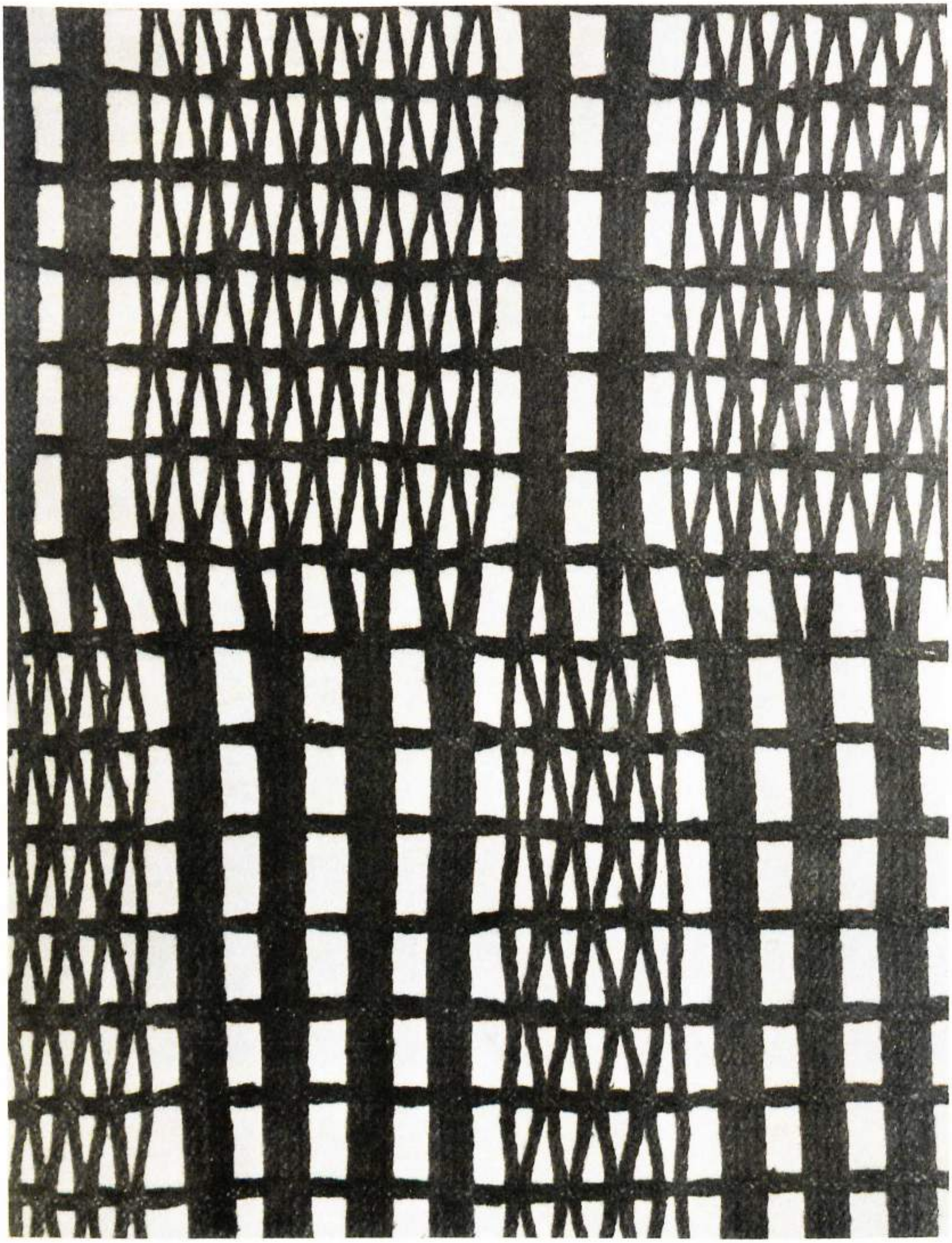


Plate 42. Study in twining. Nina Pattek, 1965.

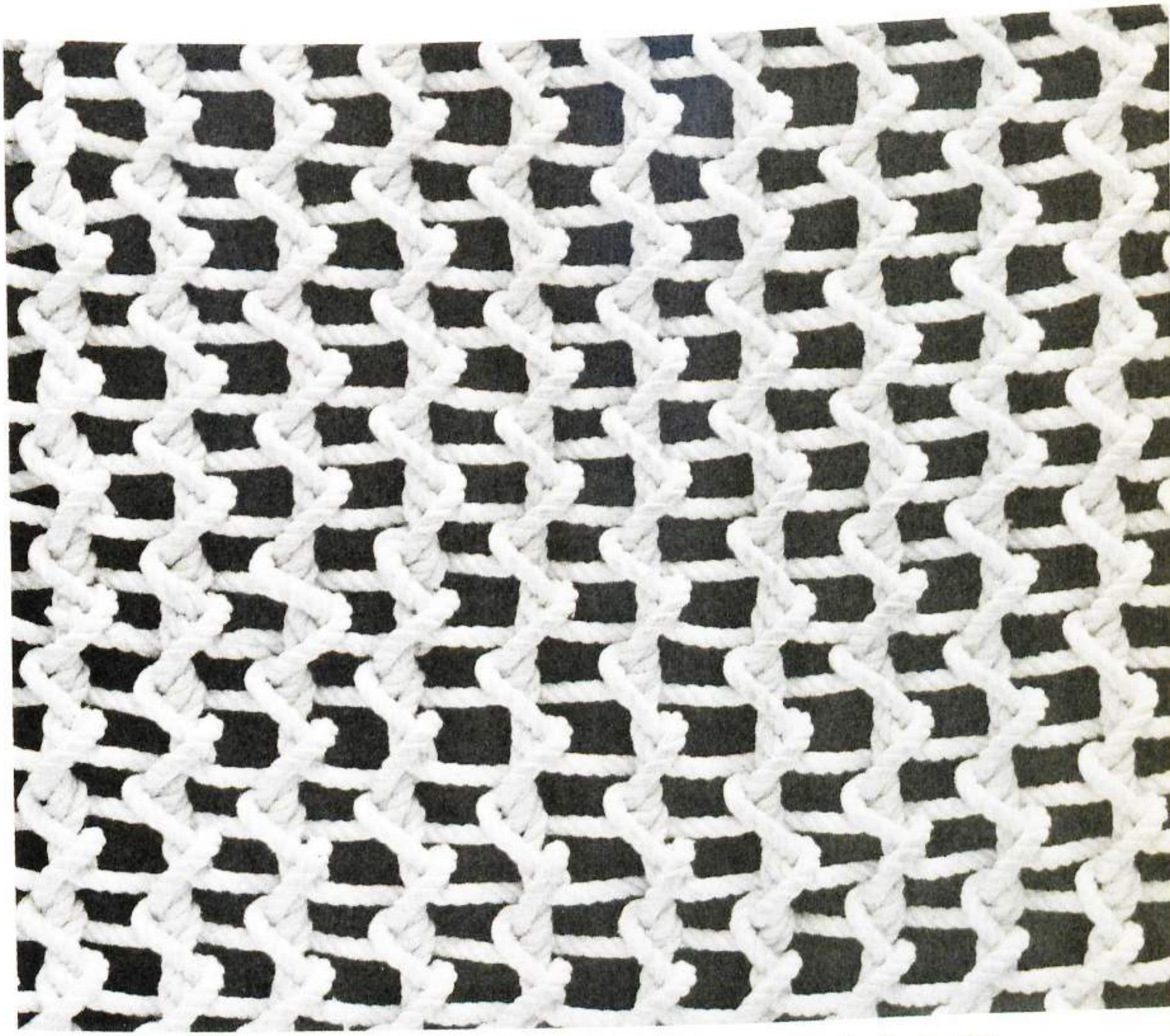


Plate 43. Detail of screen in looping technique. Dorothy Cavalier Yanik, 1962.

Plate 49. Casement material, widely spaced leno bands. Jack Lenor Larsen.

Plate 44. Mexico: Tarascan lace.

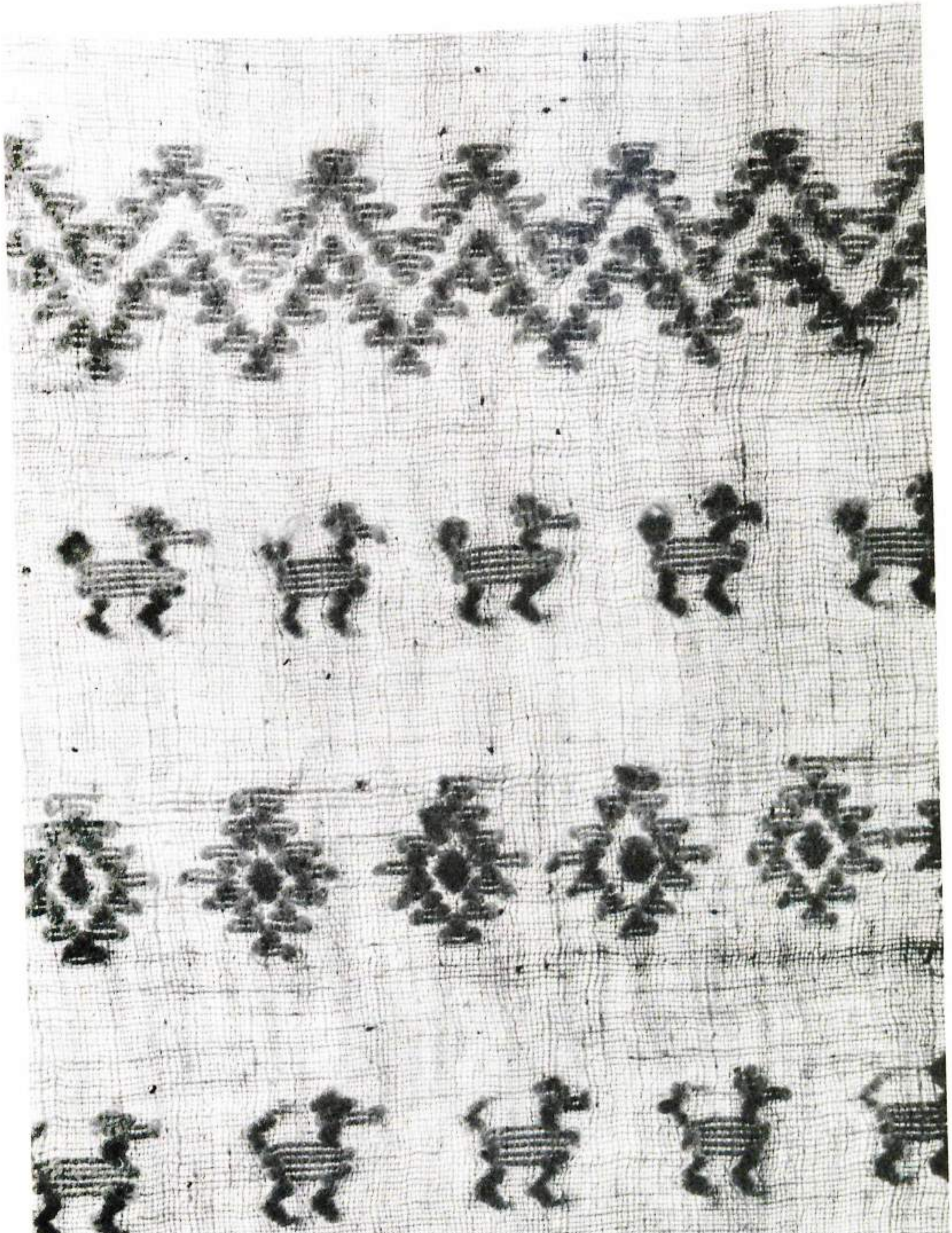


Plate 45. Mexico: Chiapas inlaid technique.

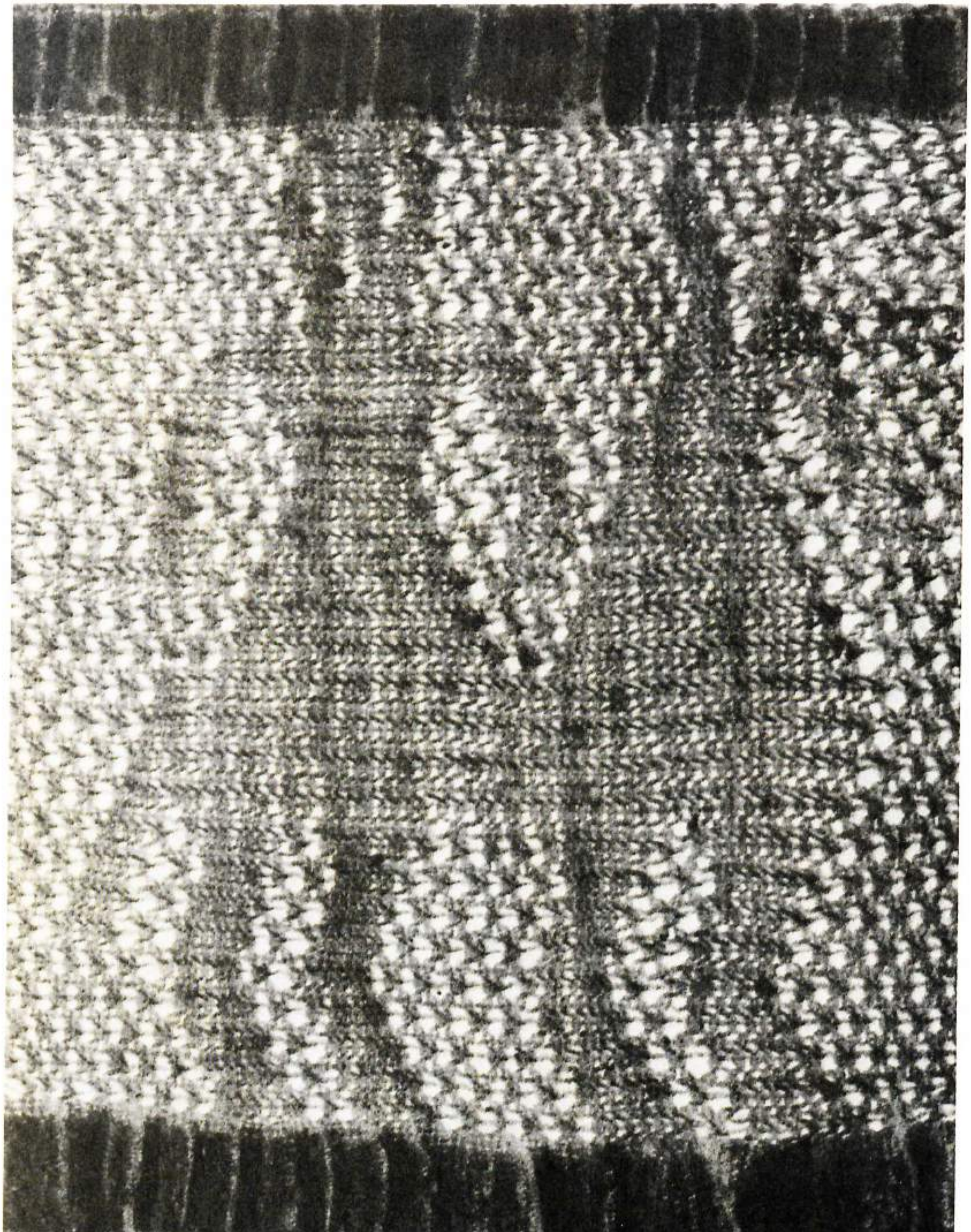


Plate 46. Mexico: lace (detail).

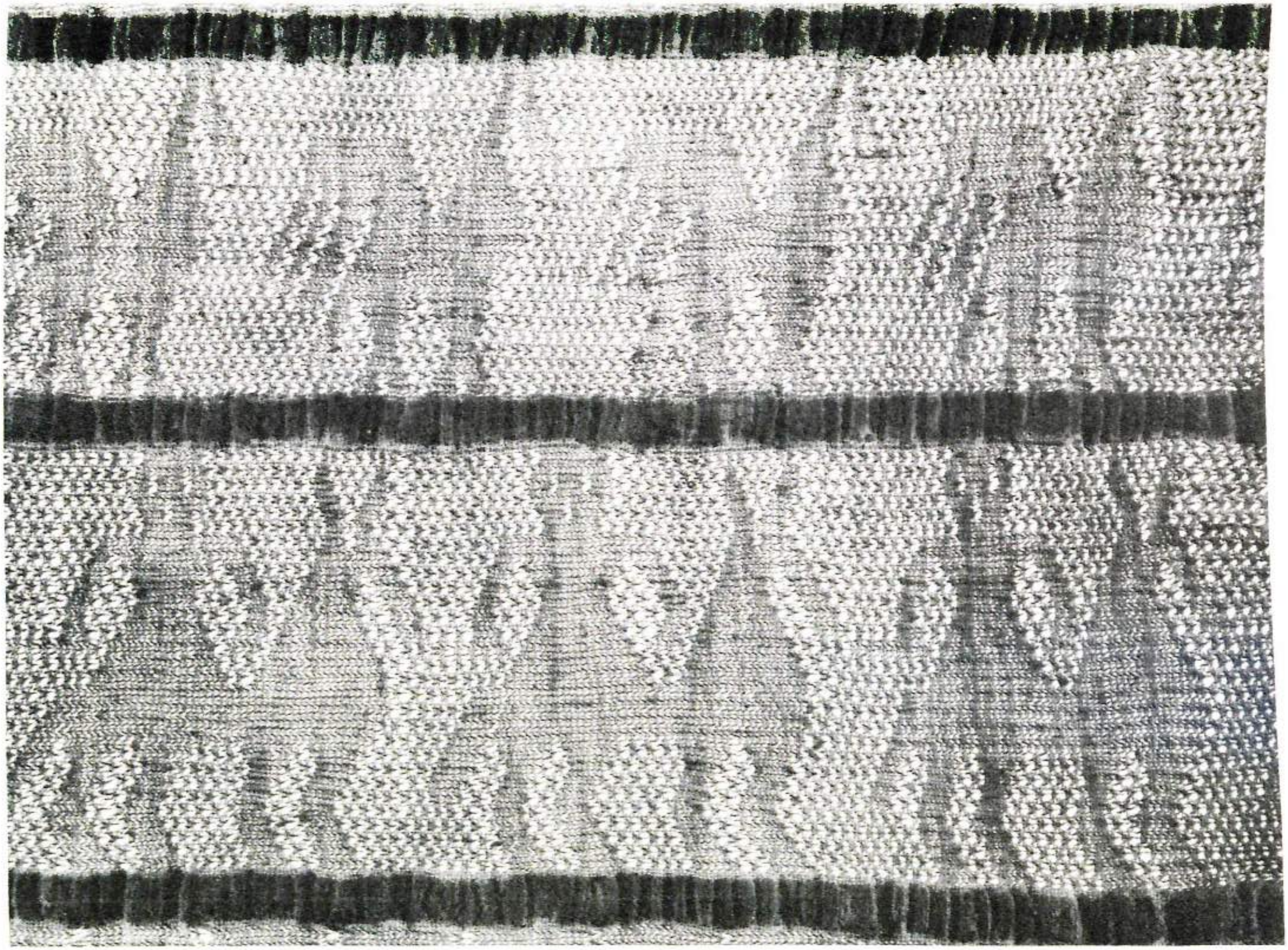


Plate 47. Mexico: lace.

Plate 49. Casement material, widely spaced leno bands. Jack Lenor Larsen.

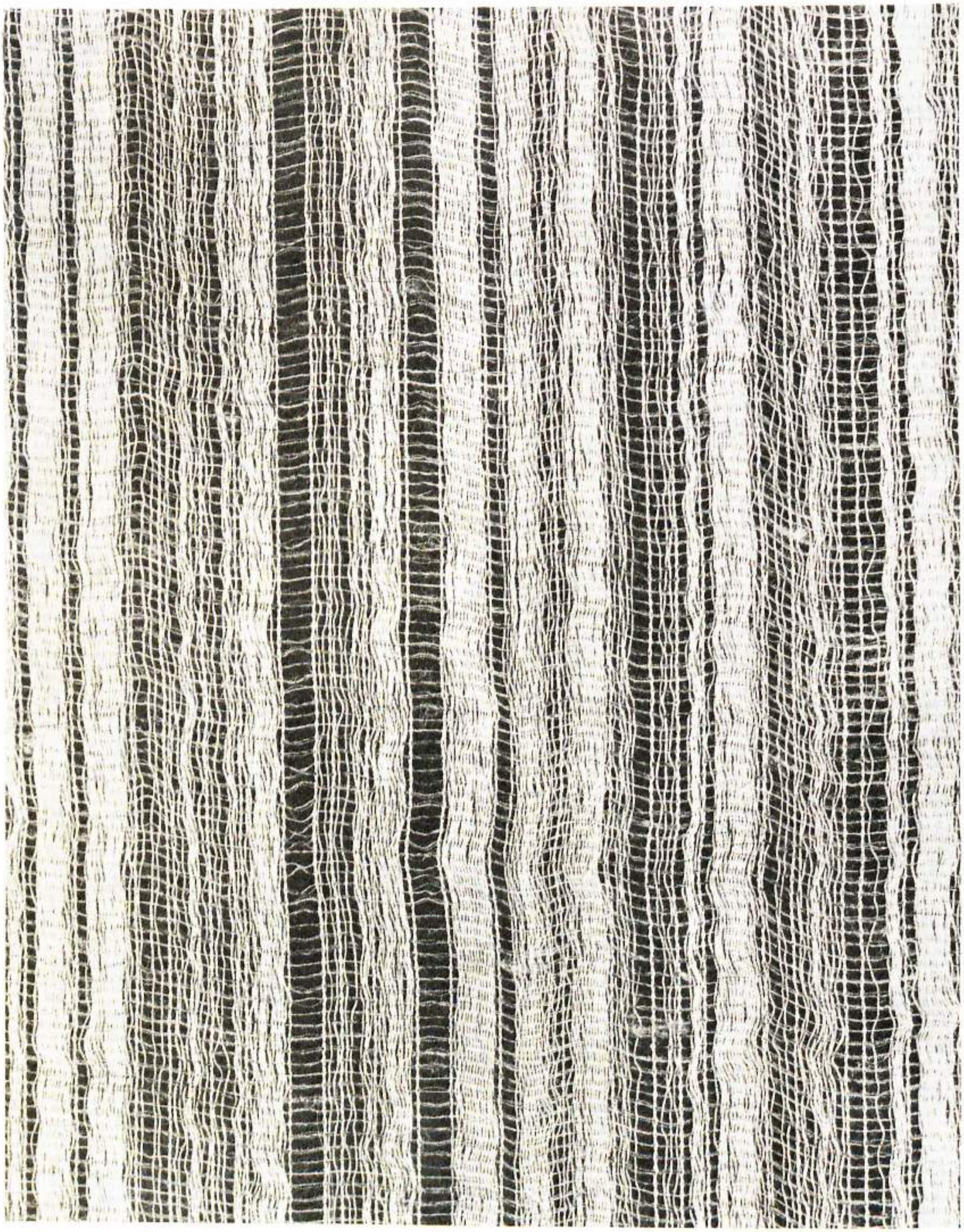


Plate 48. Casement material, plain weave, leno reinforced. Jack Lenor Larsen.

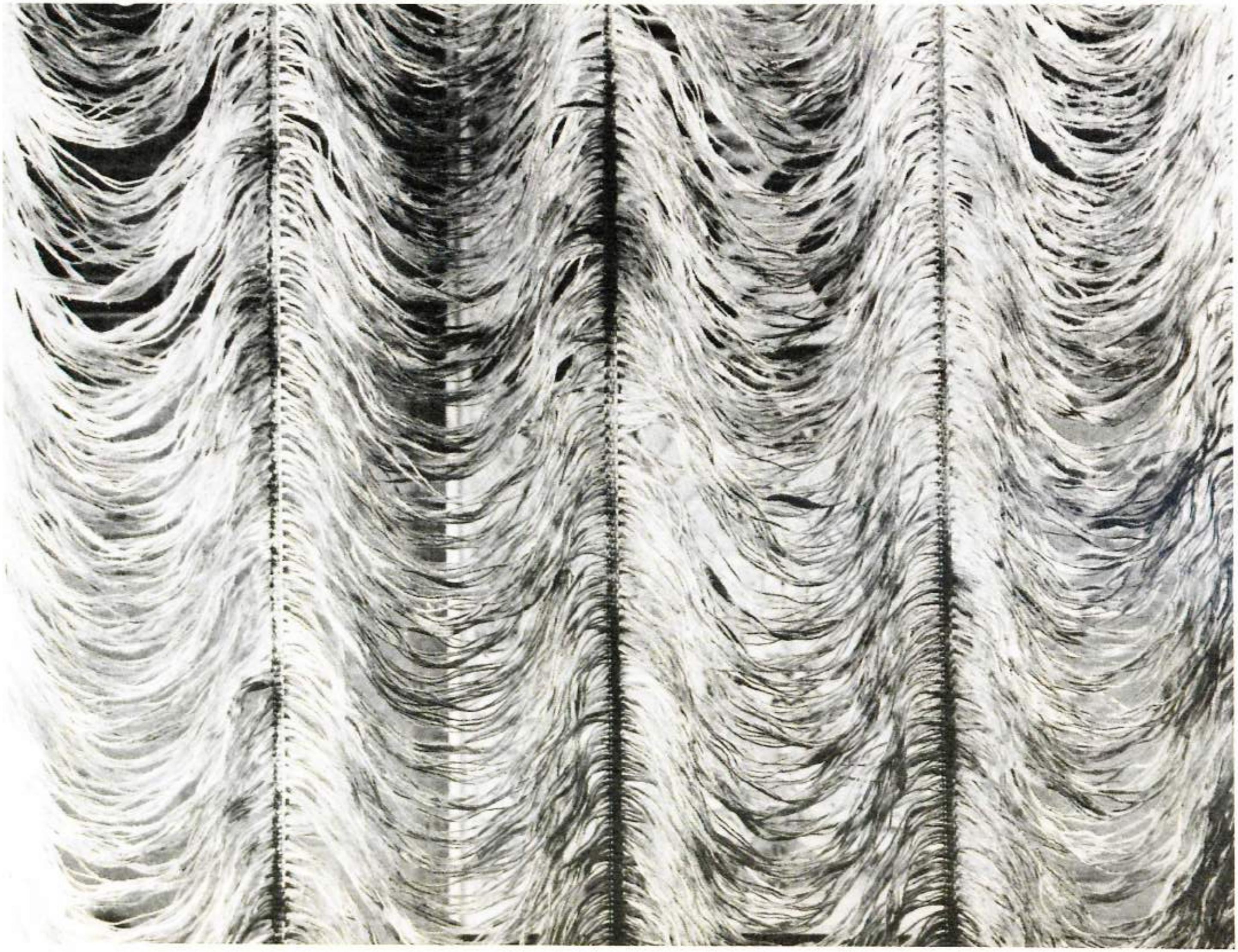


Plate 49. Casement material, widely spaced leno bands. Jack Lenor Larsen.

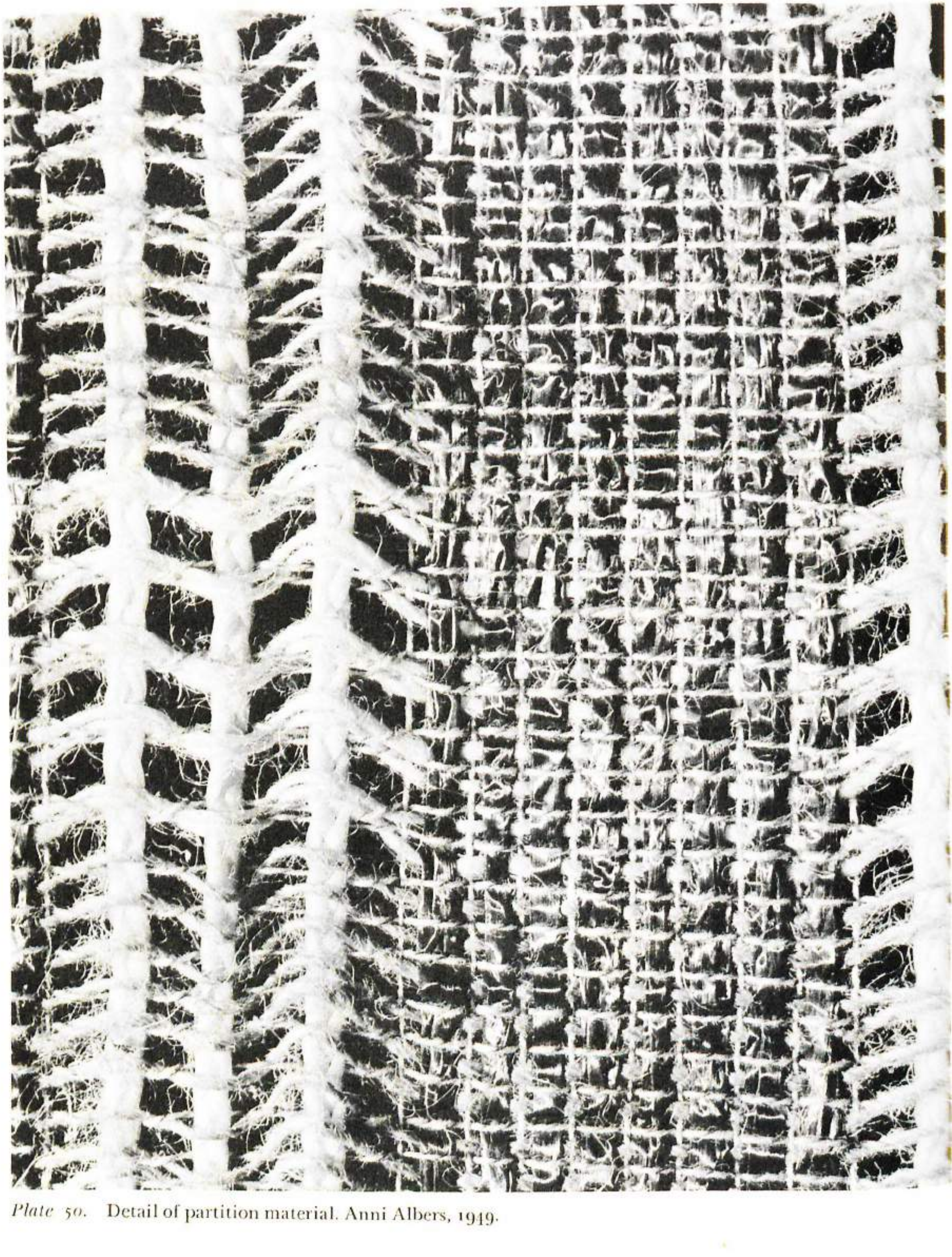


Plate 50. Detail of partition material. Anni Albers, 1949.

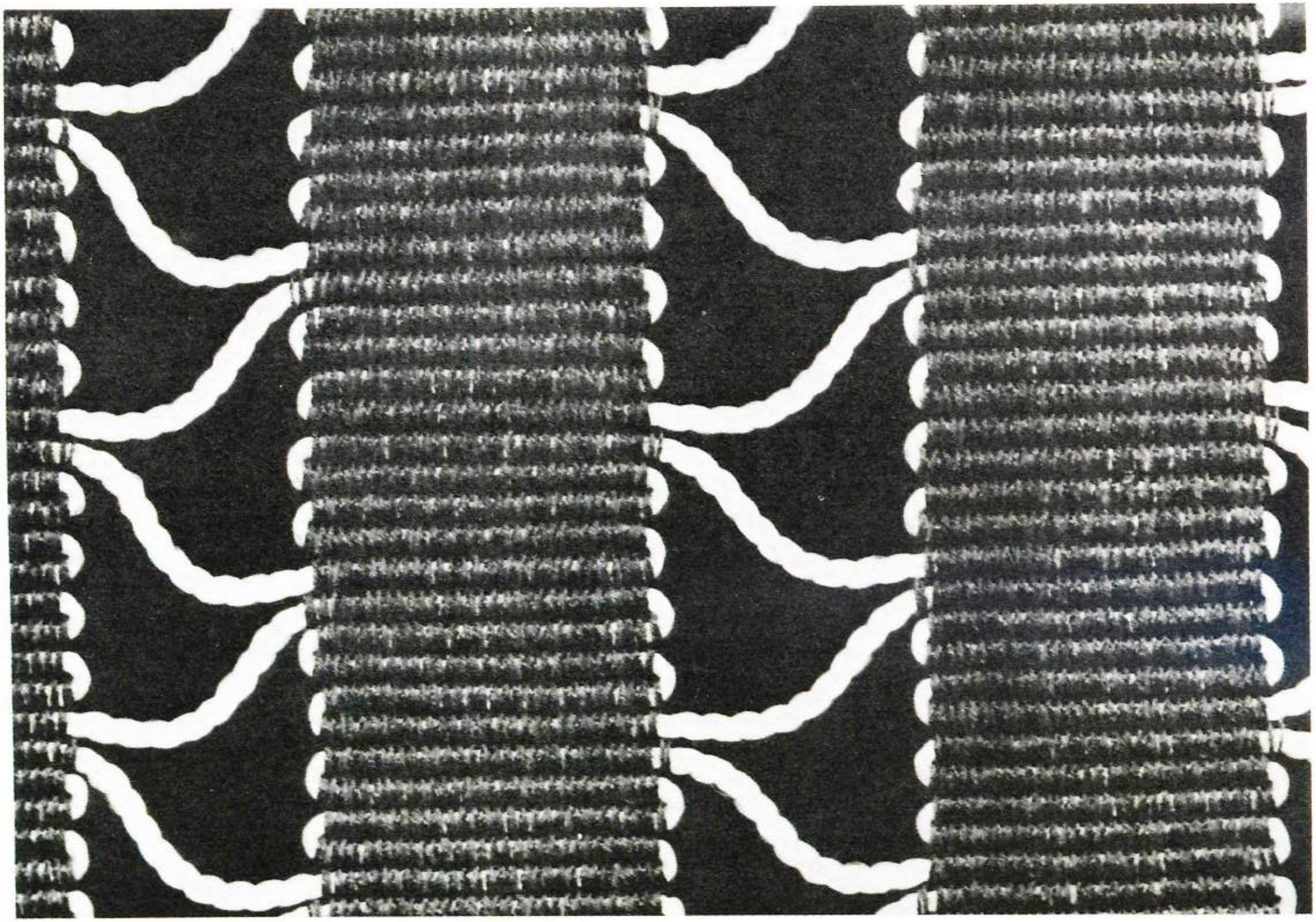


Plate 51. Partition material. Anni Albers, 1949.

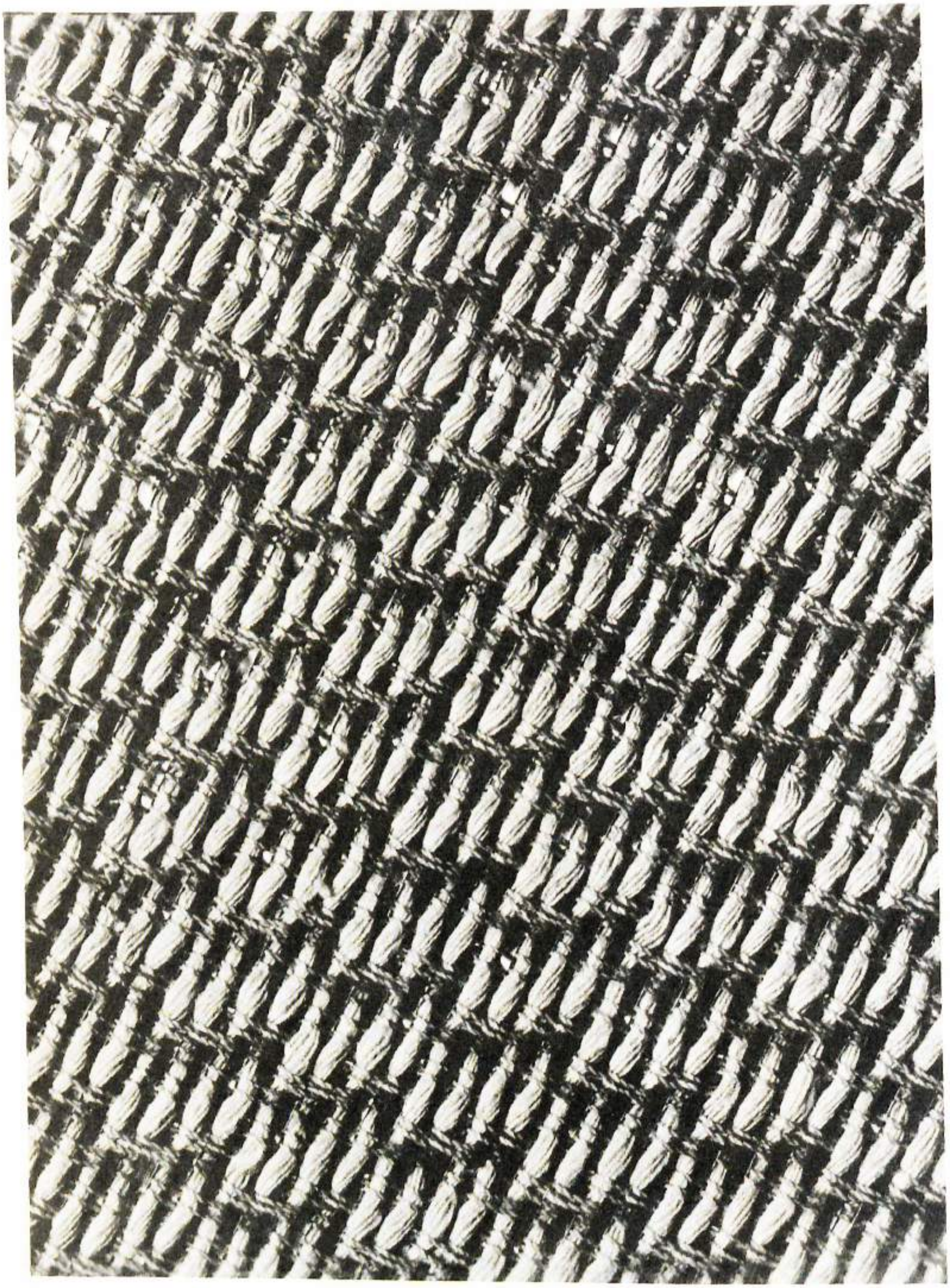


Plate 52. Drapery material, offset twill. Anni Albers, 1946.

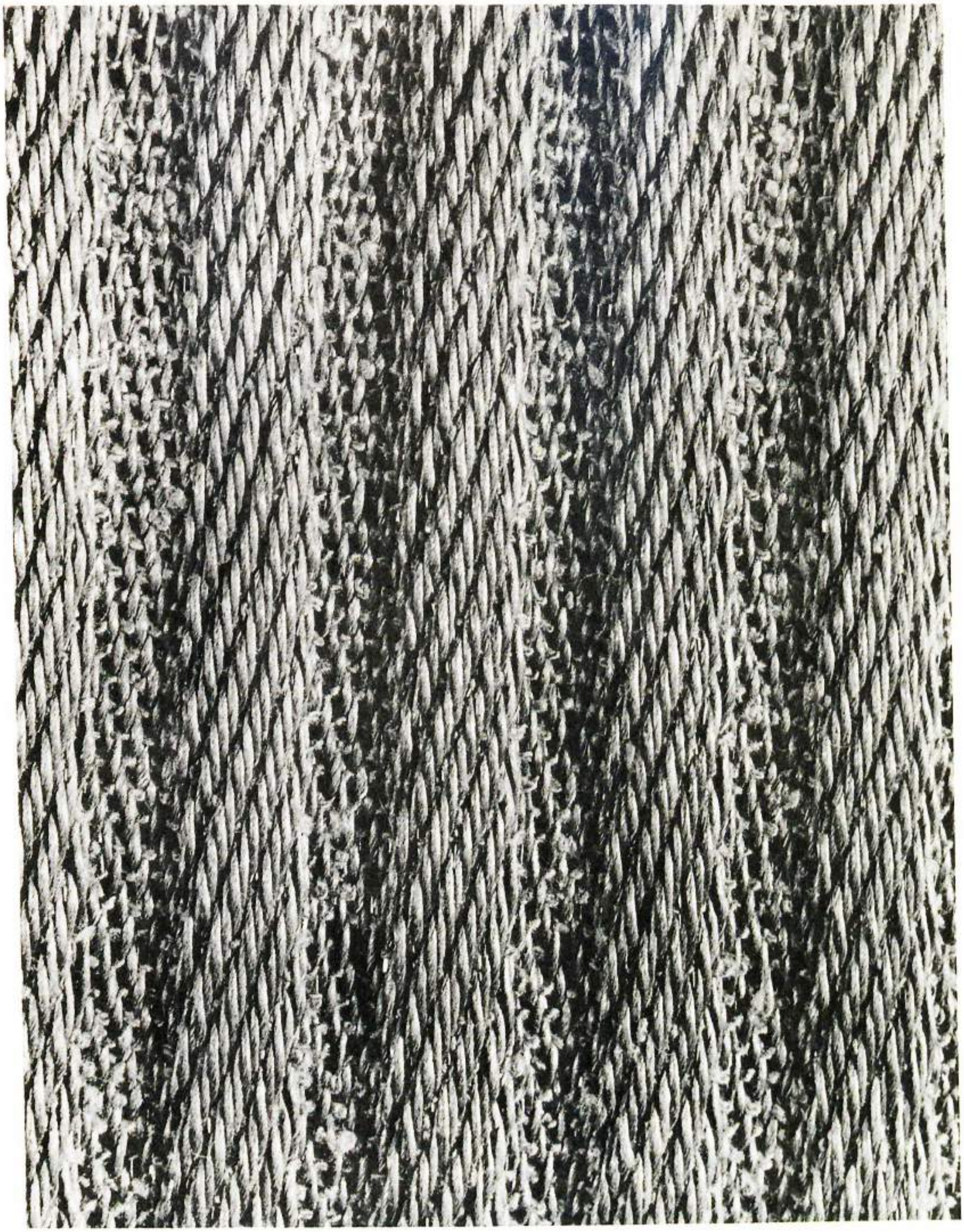


Plate 53. Upholstery material, corded weave. Anni Albers, 1949.

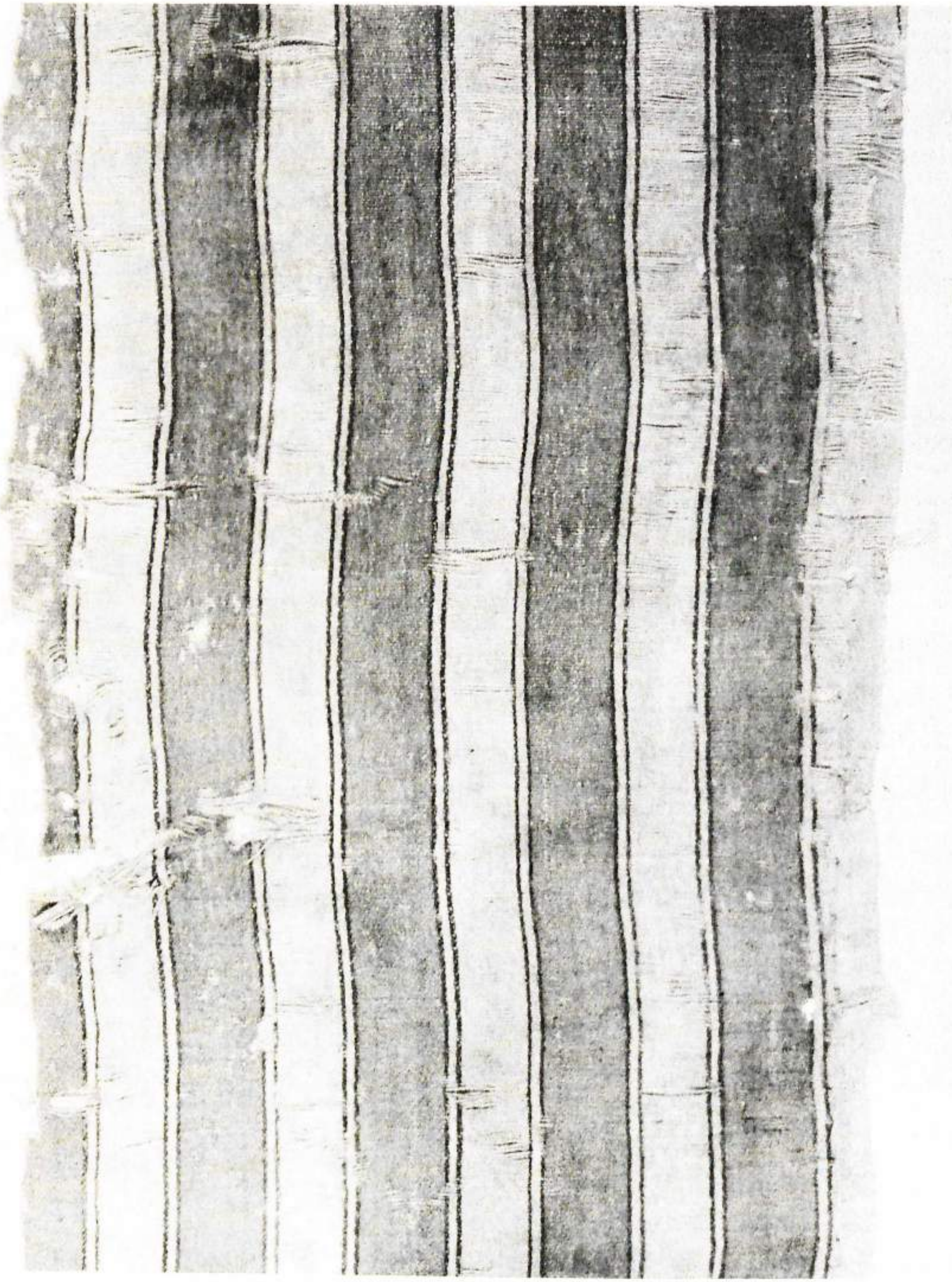


Plate 54. Stripes in satin weave, Egypto-Arabic, 10th–12th century.

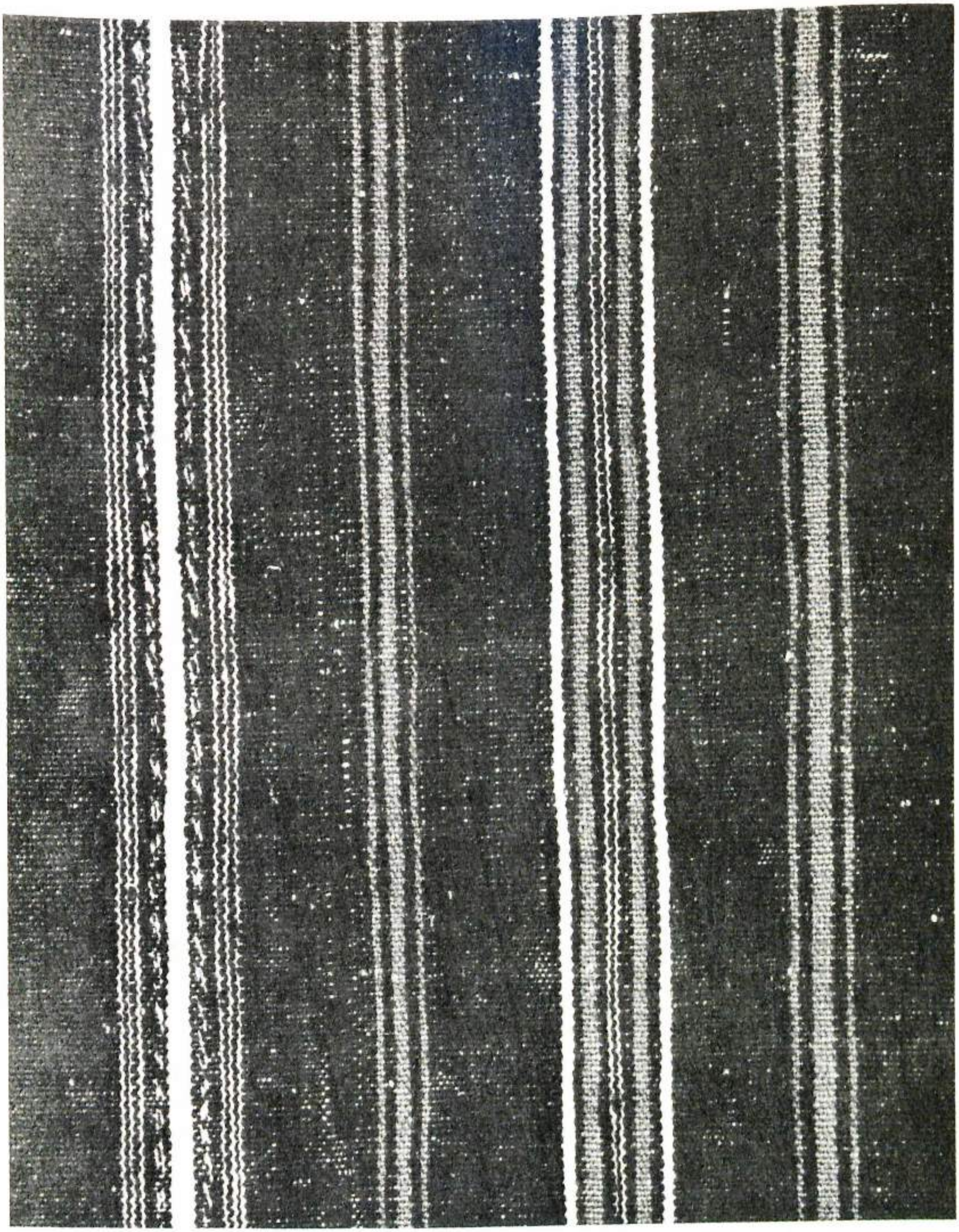
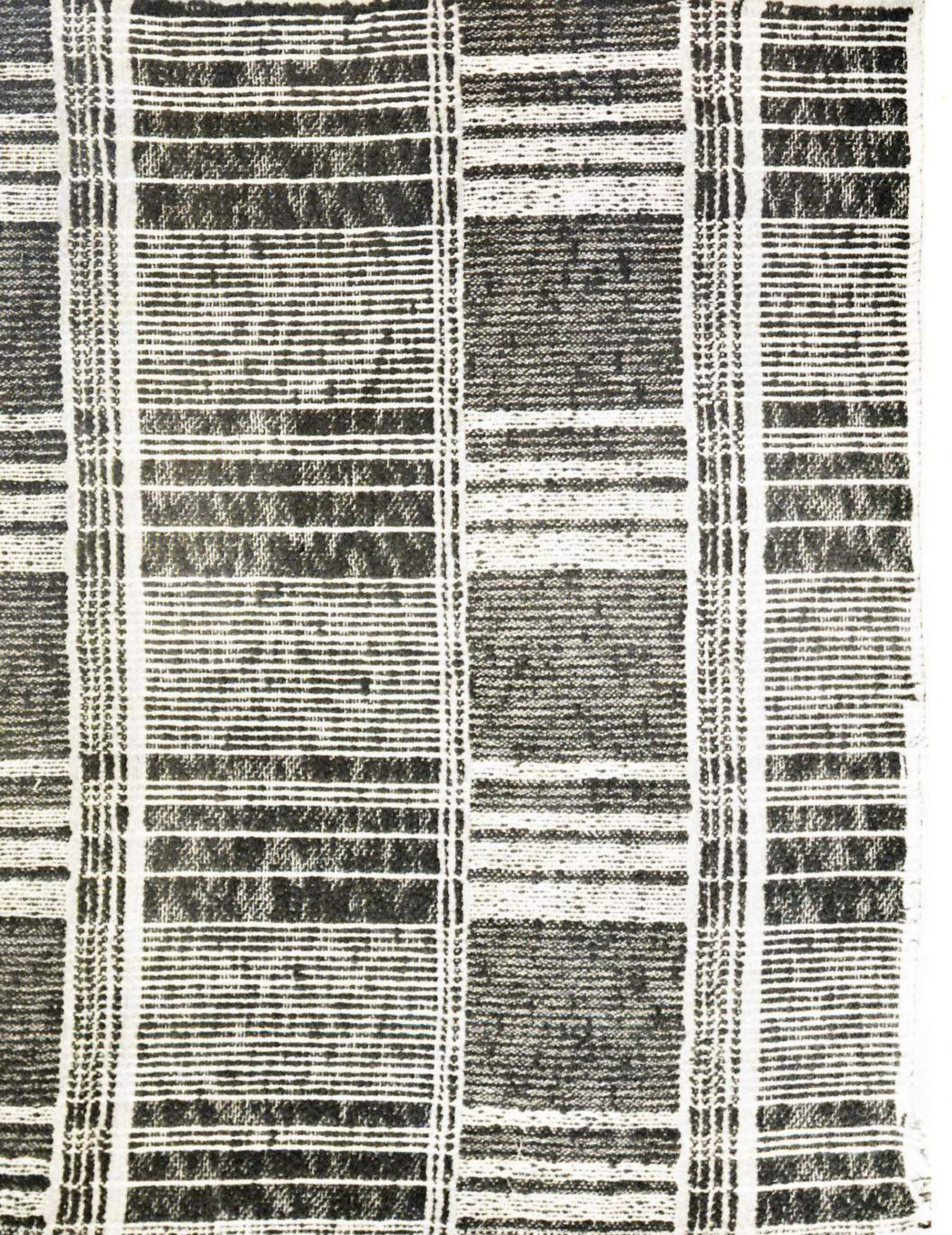


Plate 55. Detail of striped cloth, United States, early 19th century.



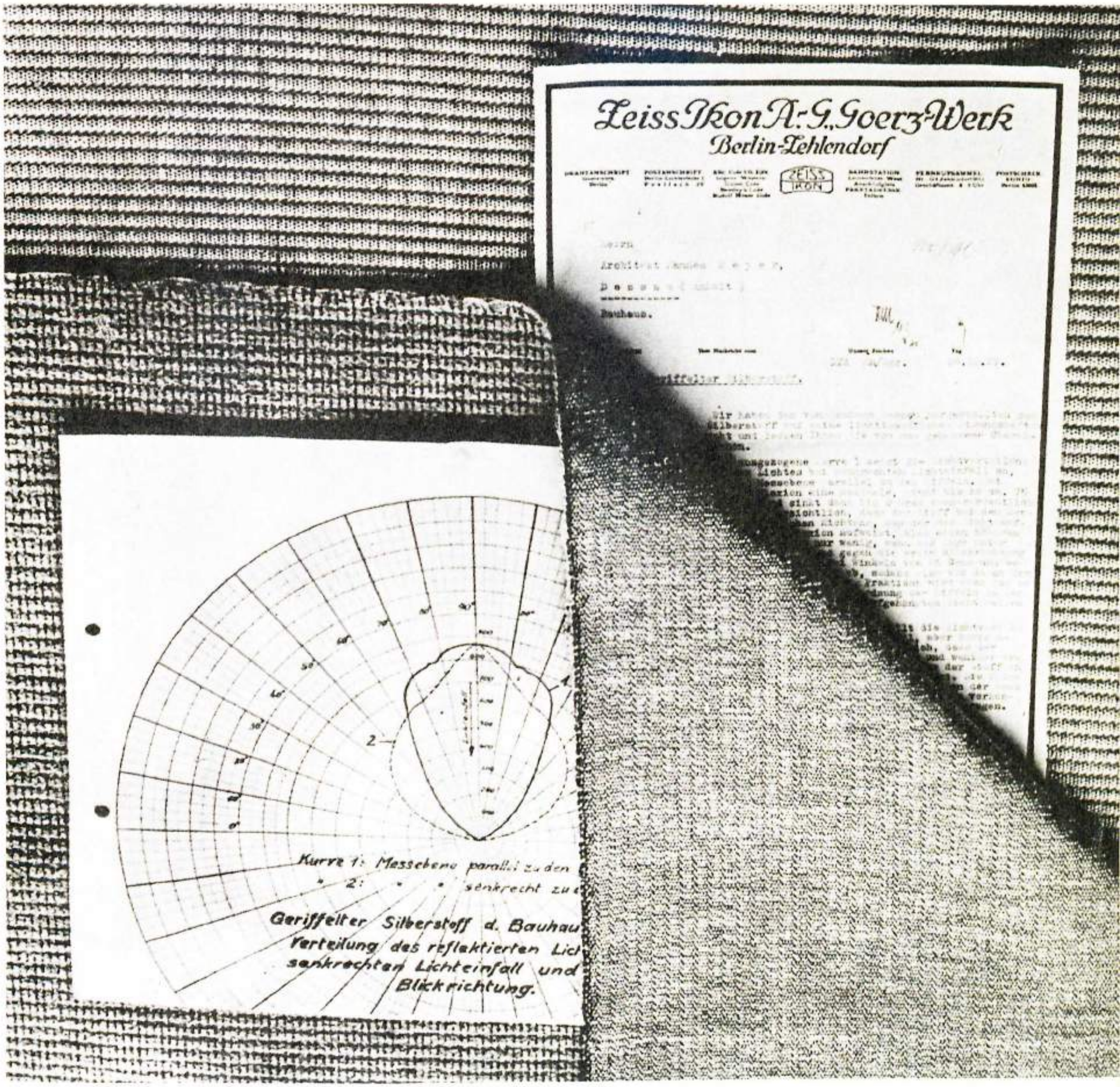
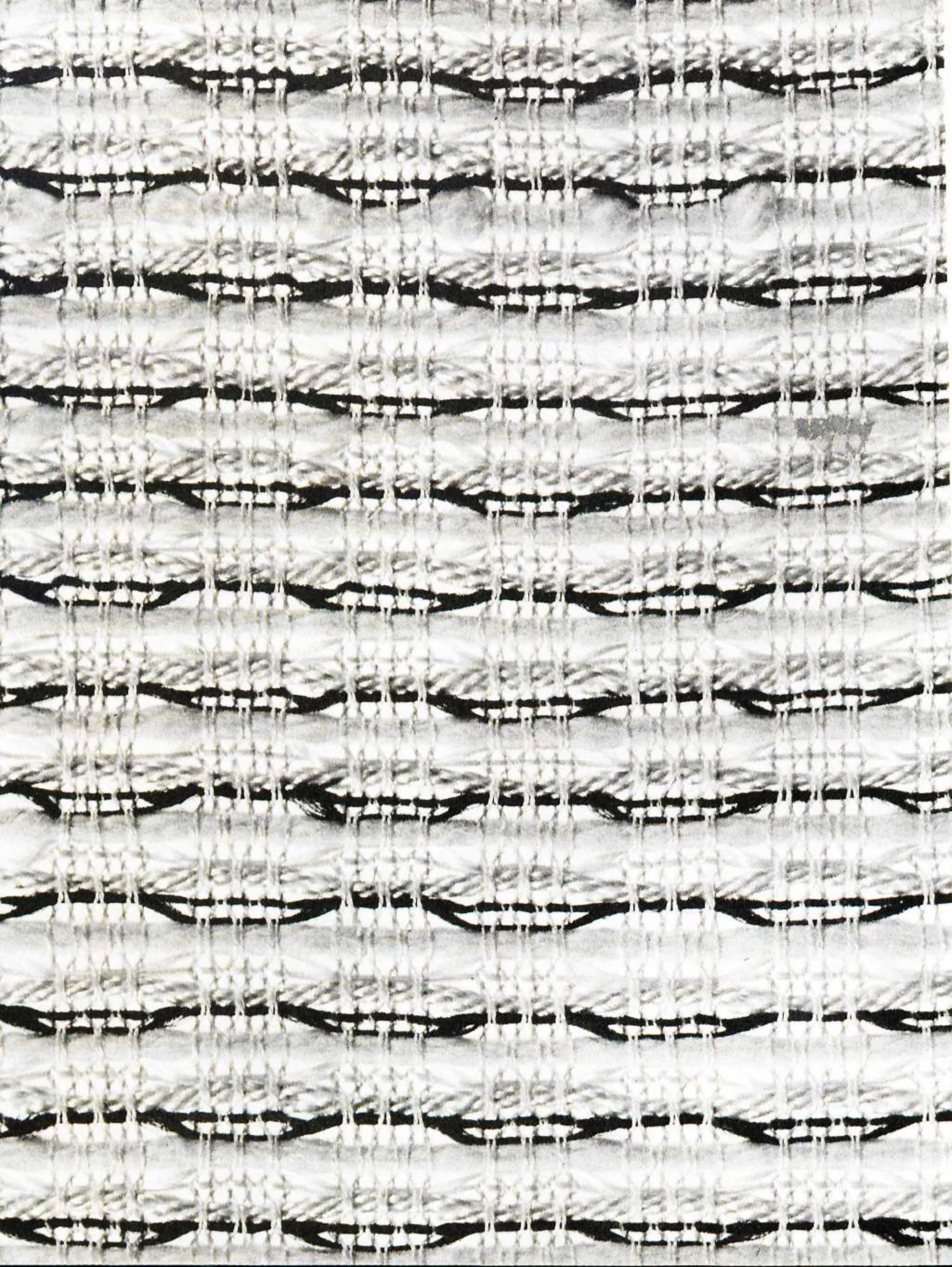


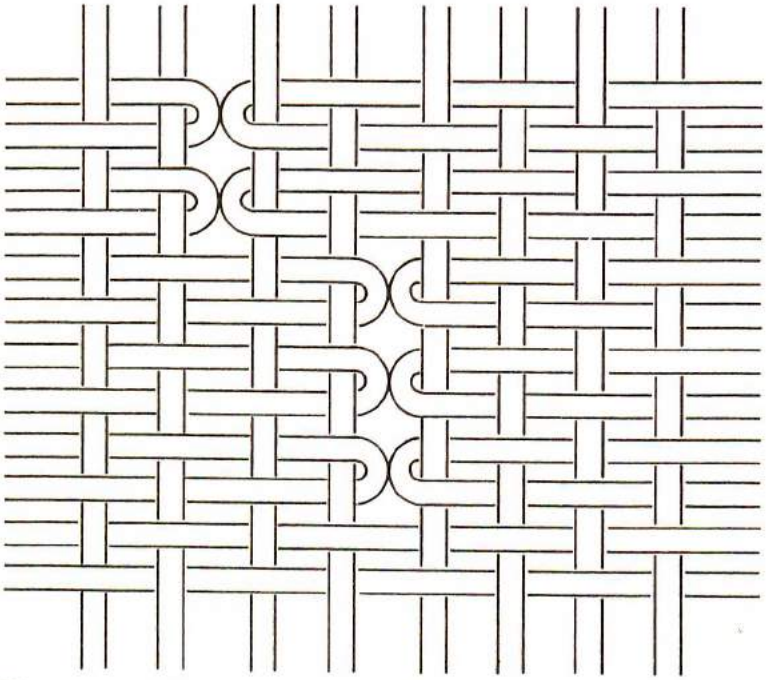
Plate 57. Sound-absorbing wall material, with diagram indicating light reflection. Anni Albers, Bauhaus period, 1929.

Plate 56. Striped twill weave, Norway, ca. 1940.

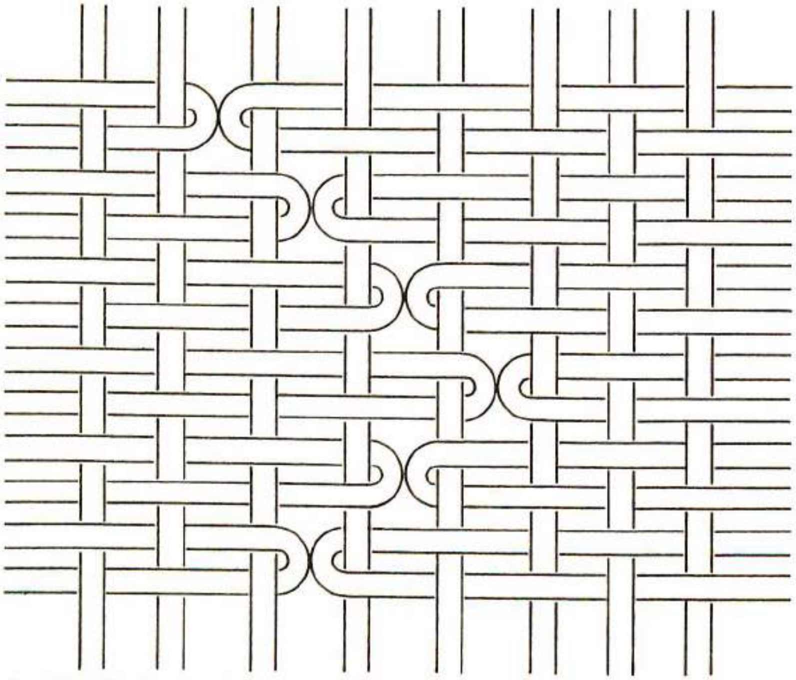


Tapestry

Plate 58. Leno weave. Anni Albers, Bauhaus period.

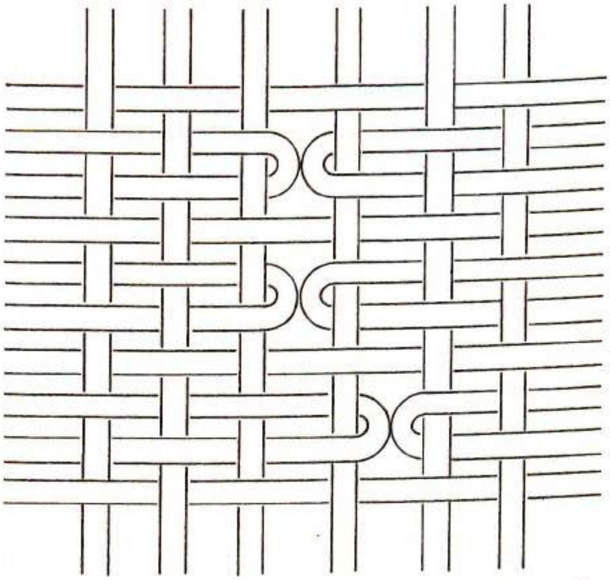


Slit tapestry or Kelim technique.

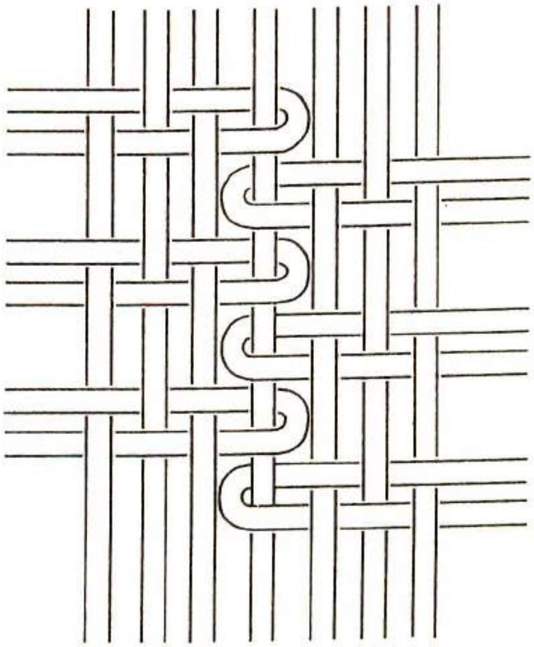


Avoiding slits by avoiding verticals.

Plate 59. Tapestry constructions.

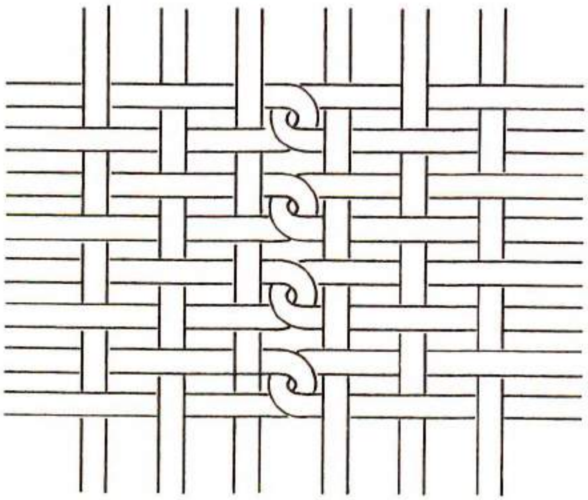


A method of avoiding slits: plain weave alternating with design threads. Also called inlaid technique.

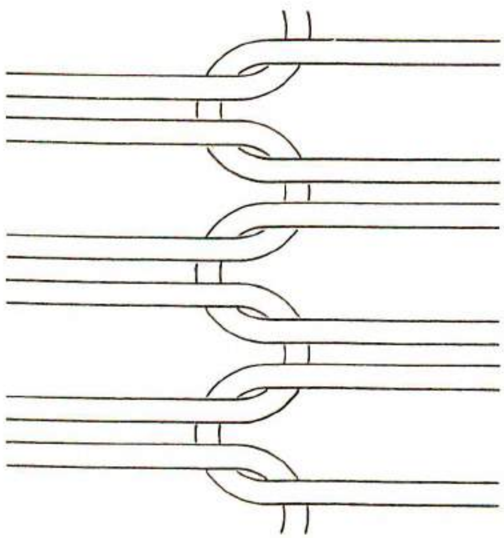


Sectional wefts turned around the same warp thread.

Plate 60. Tapestry constructions.



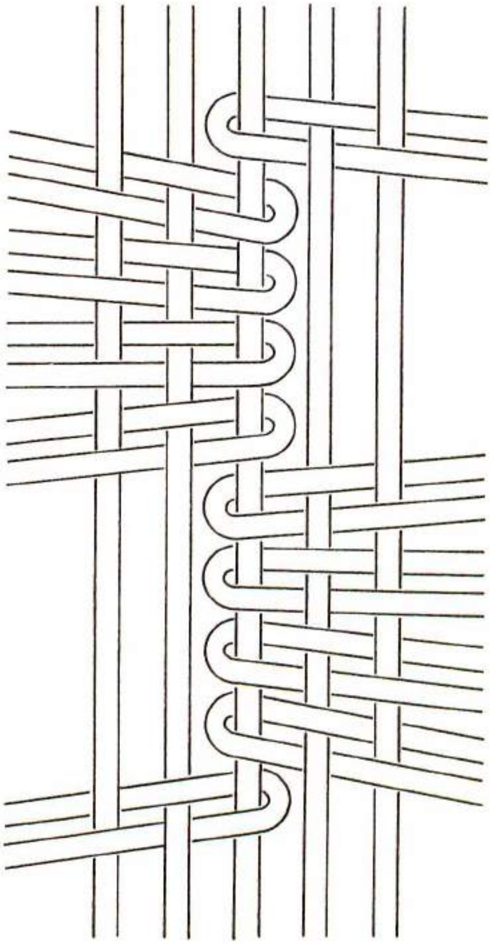
Interlocking wefts.

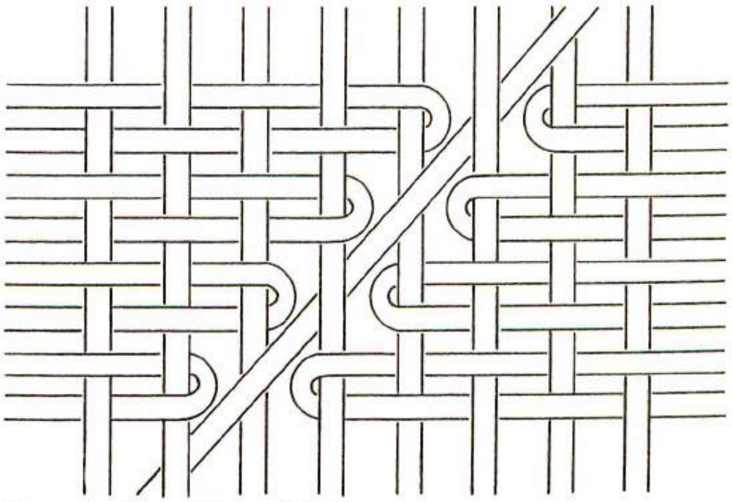


Interlocking wefts around two threads.

Plate 61. Tapestry constructions.

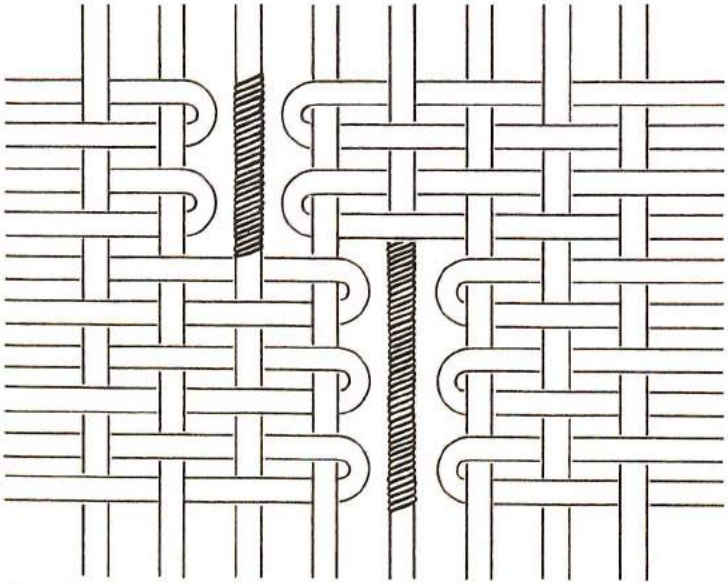
Groups of sectional wefts turning around the same warp thread. Also called brick-interlocking. (Peru.)



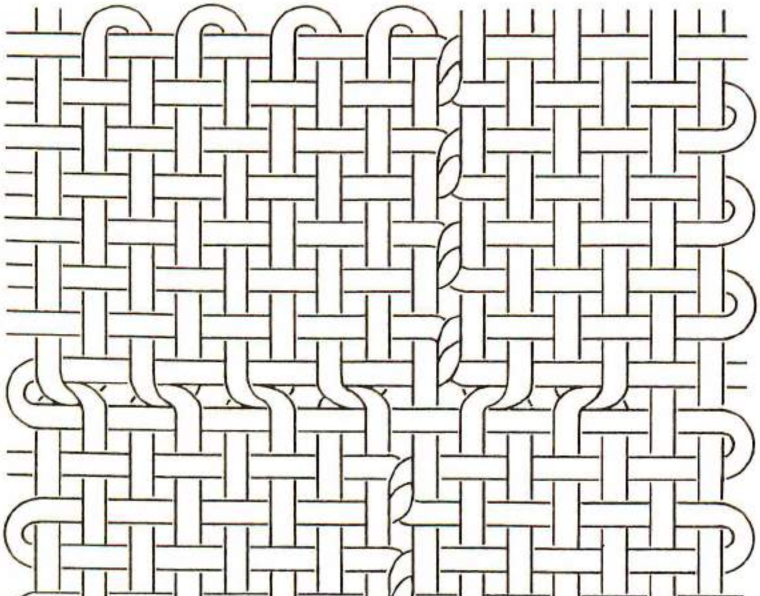


Diagonal outline of design. (Peru.)

Plate 62. Tapestry constructions.



Slit tapestry with wrapped warp to outline design. (Peru.)



Interlocking warp and weft. (Peru.)

Plate 63. Tapestry constructions.

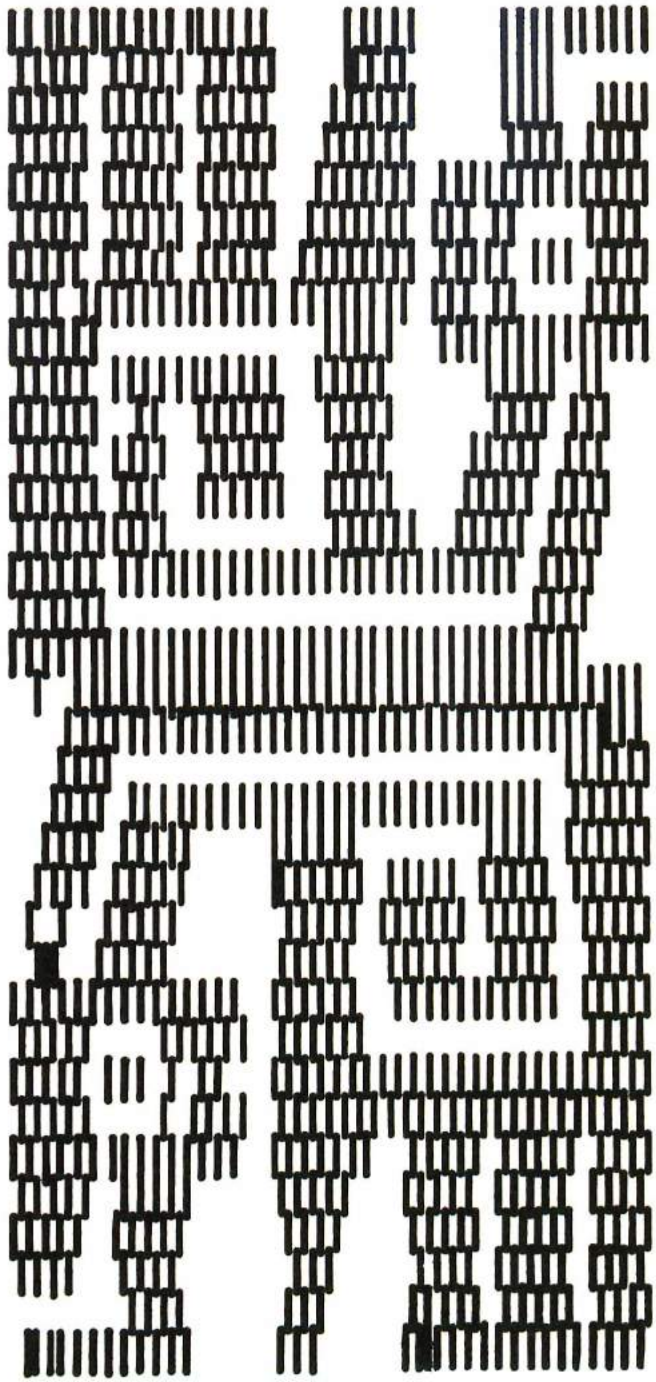


Plate 64. Diagram of warp position in a fabric of ca. 1600 B.C., showing double image of a bird with upraised head and neck. Huaca Prieta, Chicama Valley, Peru.

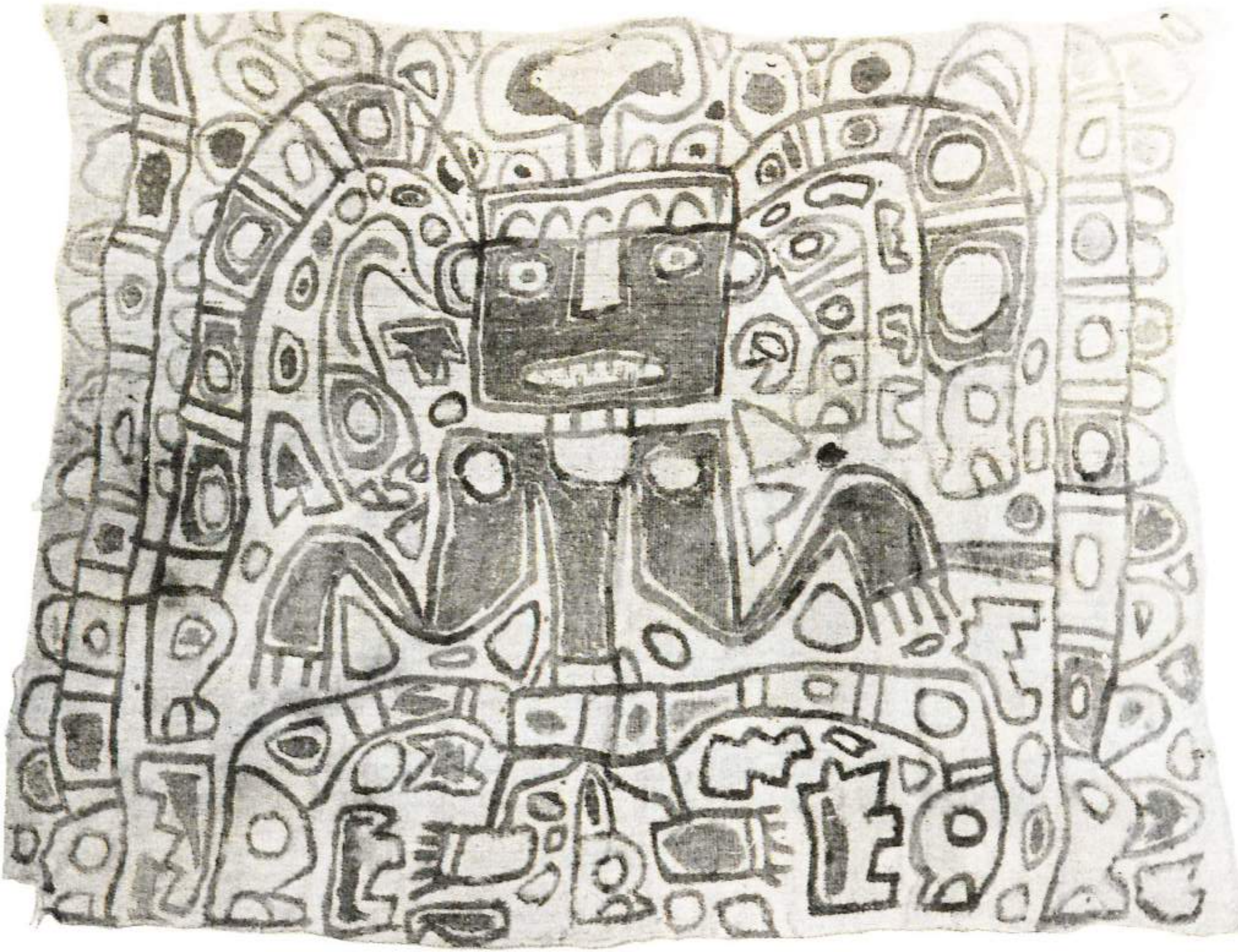


Plate 65. Peruvian painted textile, Chancay, central coast, 1100–1300 A.D.

Plate 66. Chilkat ceremonial blanket, twining technique.

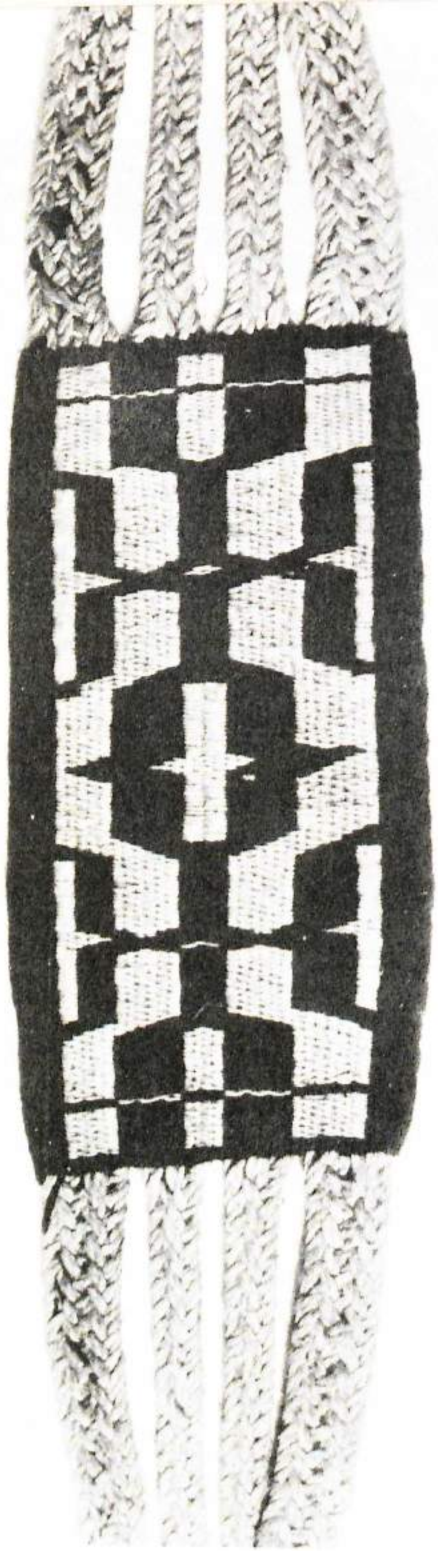


Plate 67. Soumak technique, work of the Ainu, Japan.

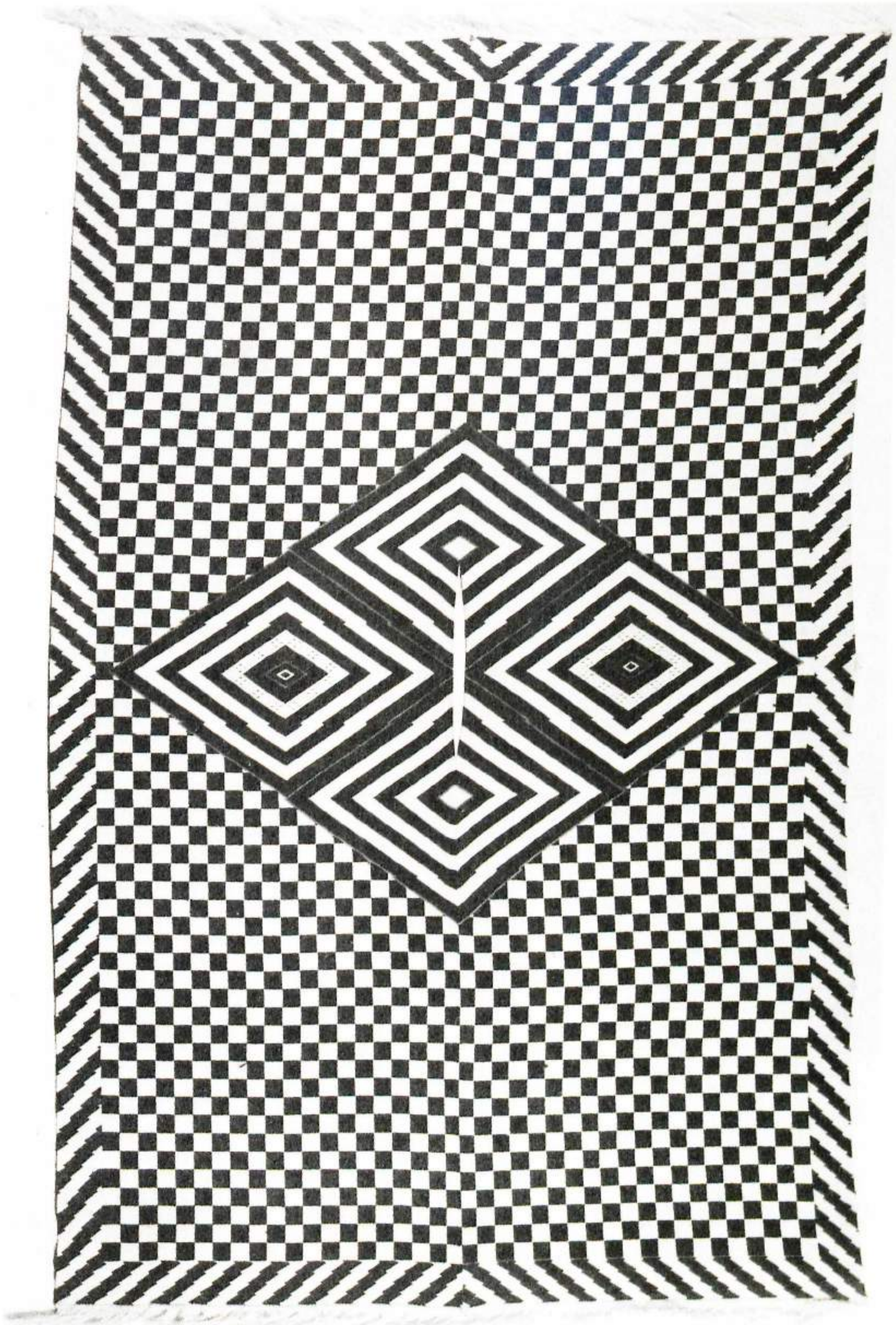


Plate 68. Mexican serape, tapestry technique, Querétaro.

Plate 69. Pile cloth of the Bushongo, Congo.

Plate 70. Coptic tapestry fragment, 5th–6th century.

Plate 71. Coptic textile, 5th–6th century. Tapestry-woven band set in looped cloth.

Plate 72. Coptic weaving.

Plate 73. Coptic head, tapestry, 5th–7th century.

Plate 74. Coptic head, tapestry, 3rd–4th century.

Plate 76. Coptic textile, looped weave.

Plate 75. Coptic head, looped weaving.

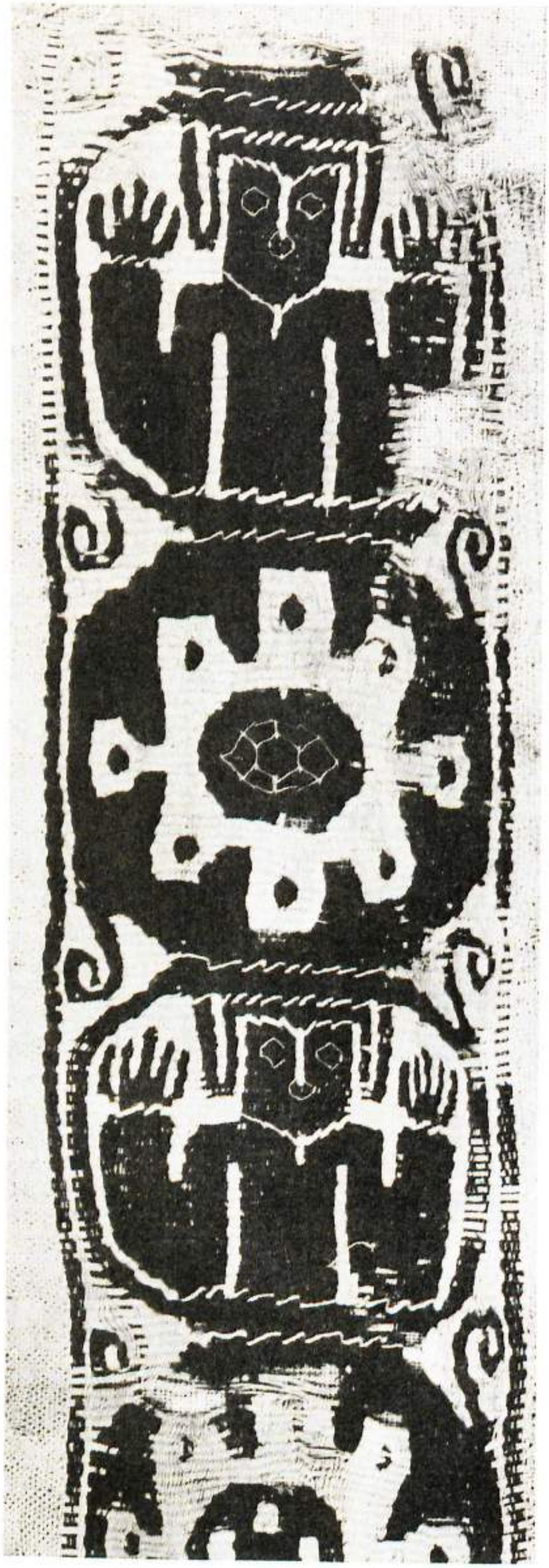


Plate 77. Coptic textile, 6th–7th century.

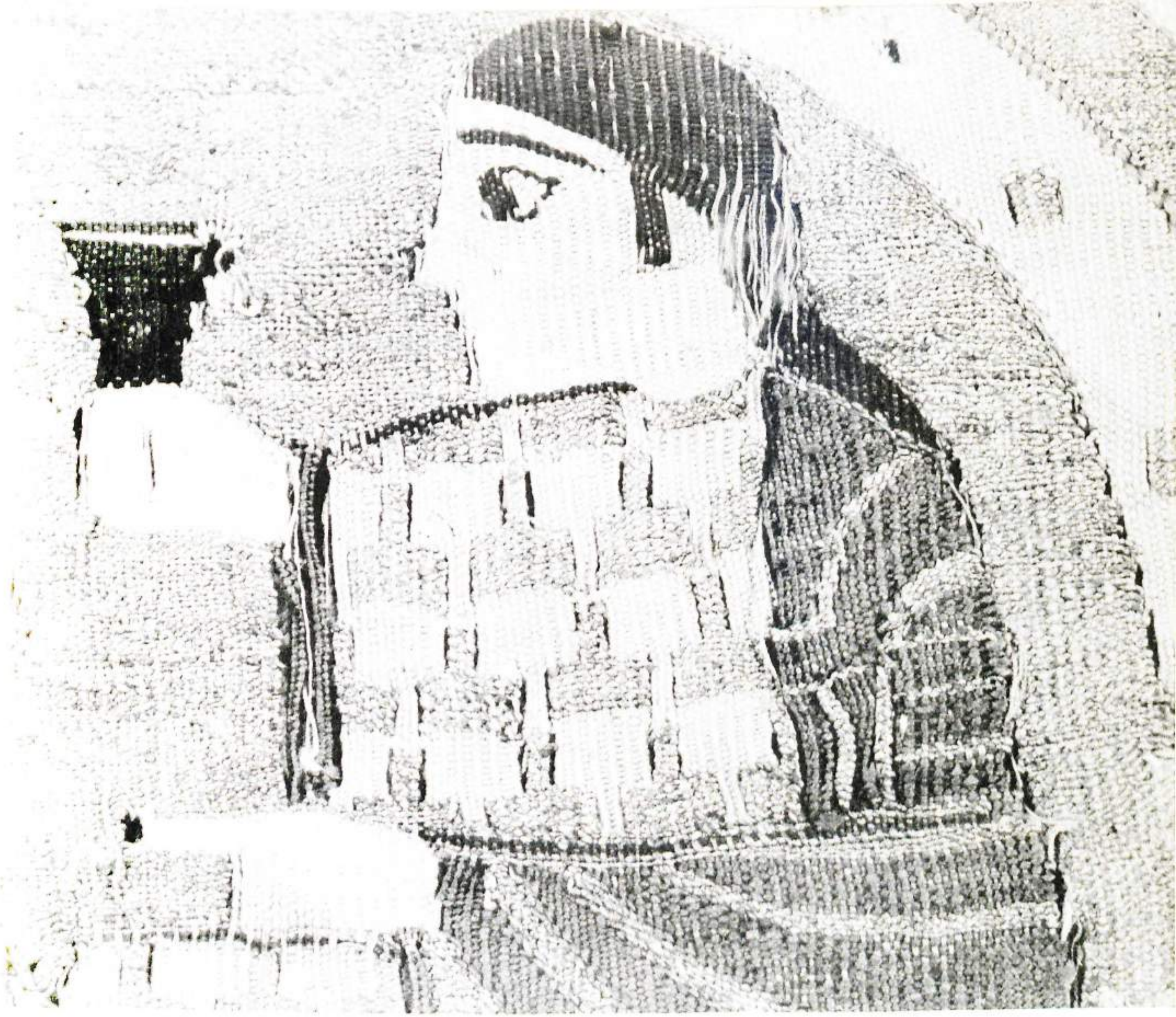


Plate 78. Slit tapestry, Hispano-Moresque, 13th–14th century.

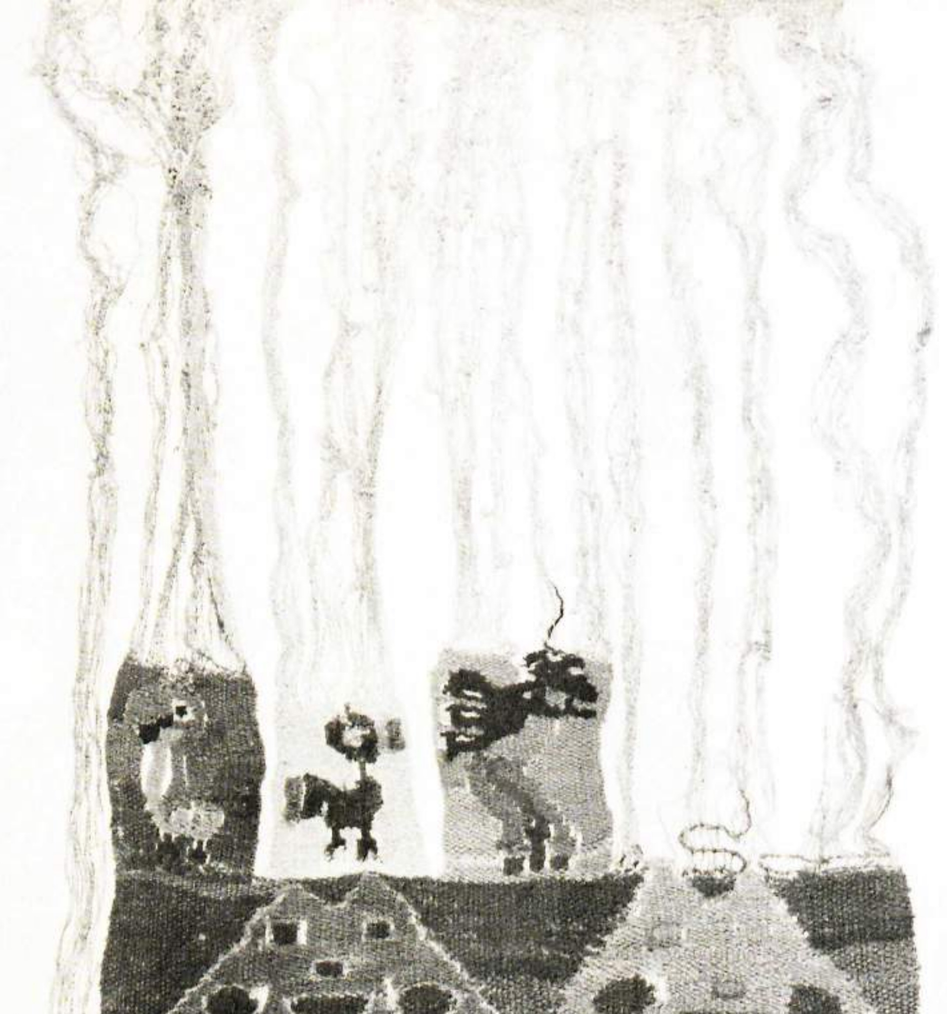


Plate 79. Peruvian sampler.

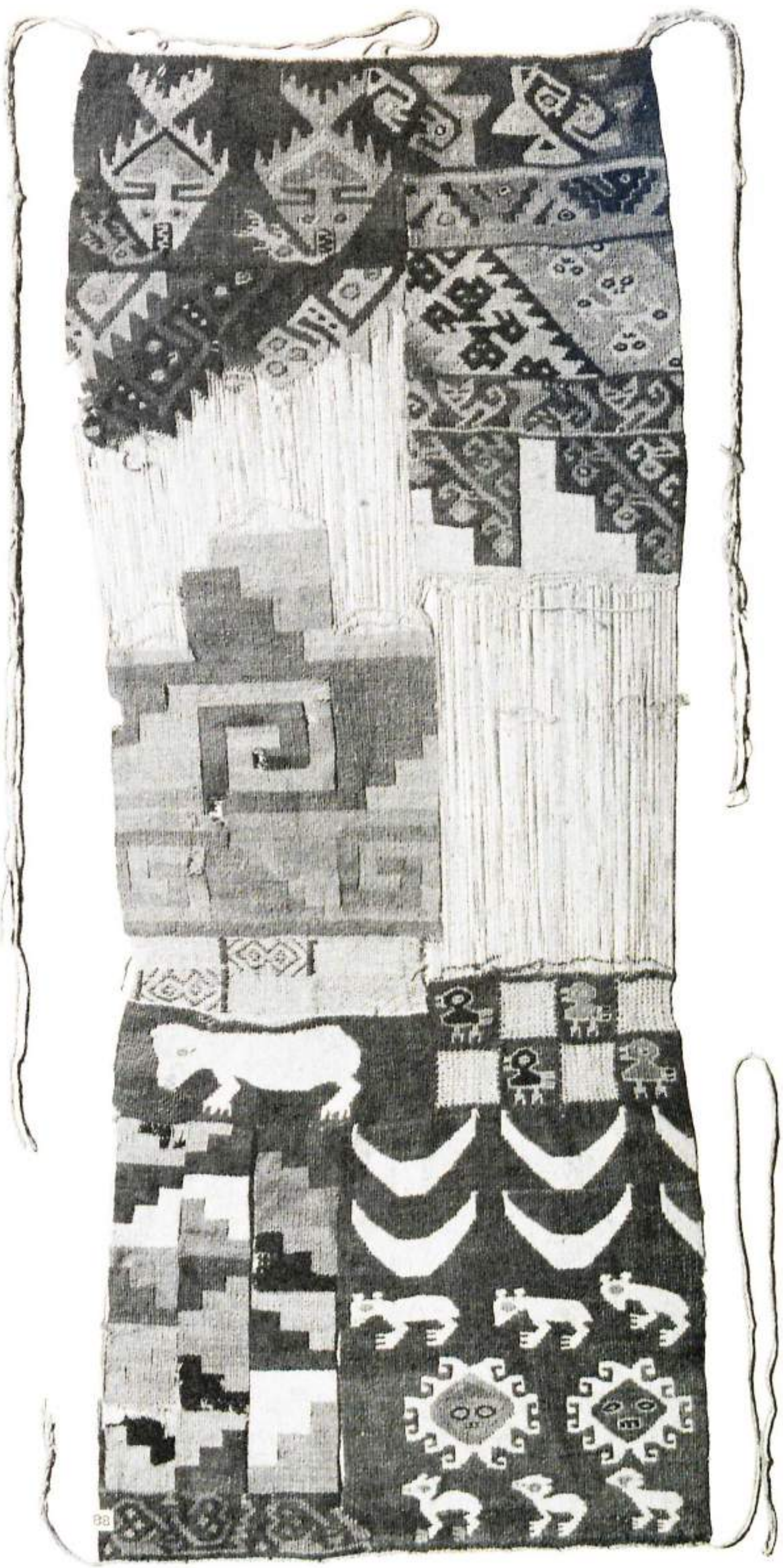


Plate 80. Peruvian sampler.

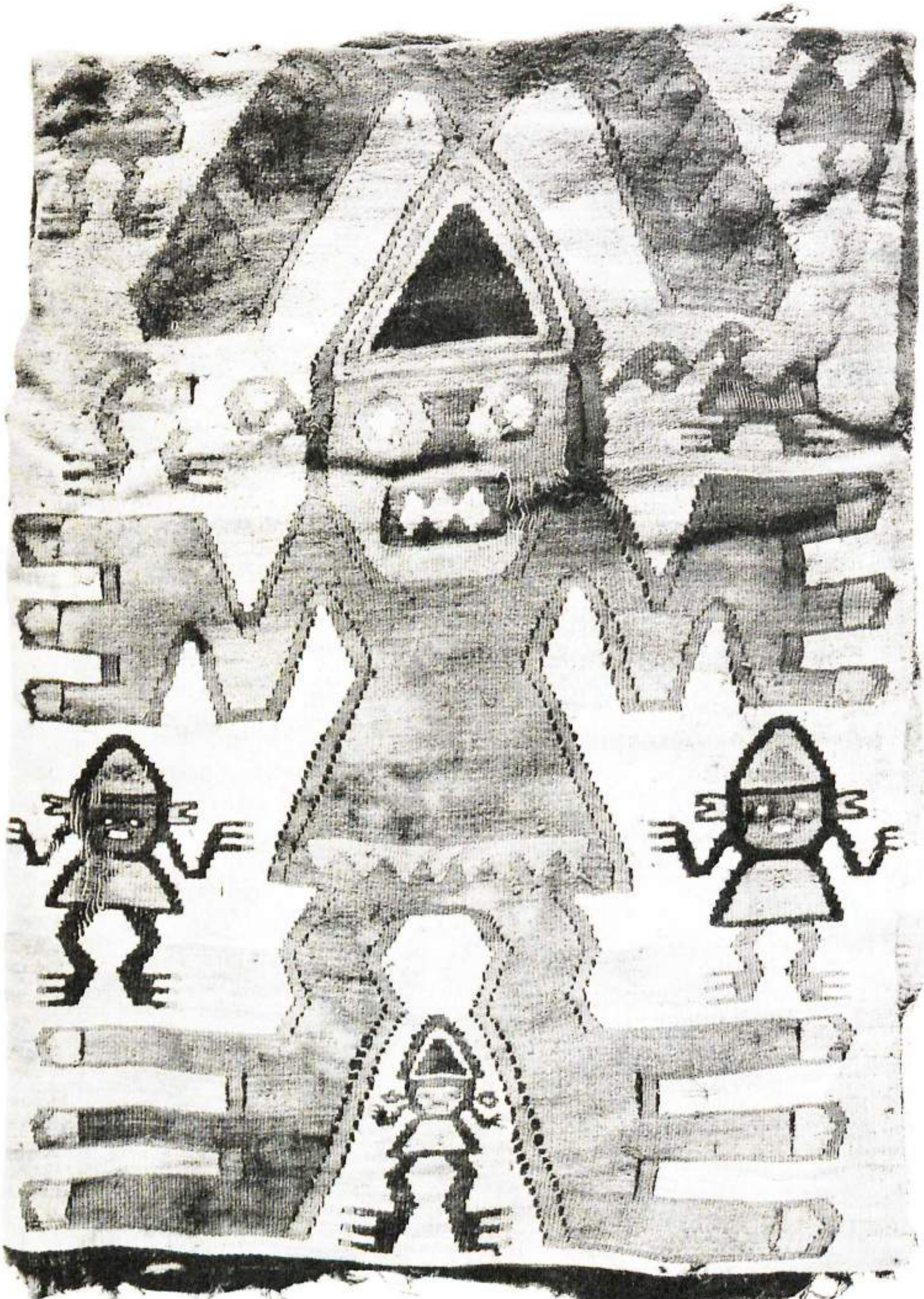
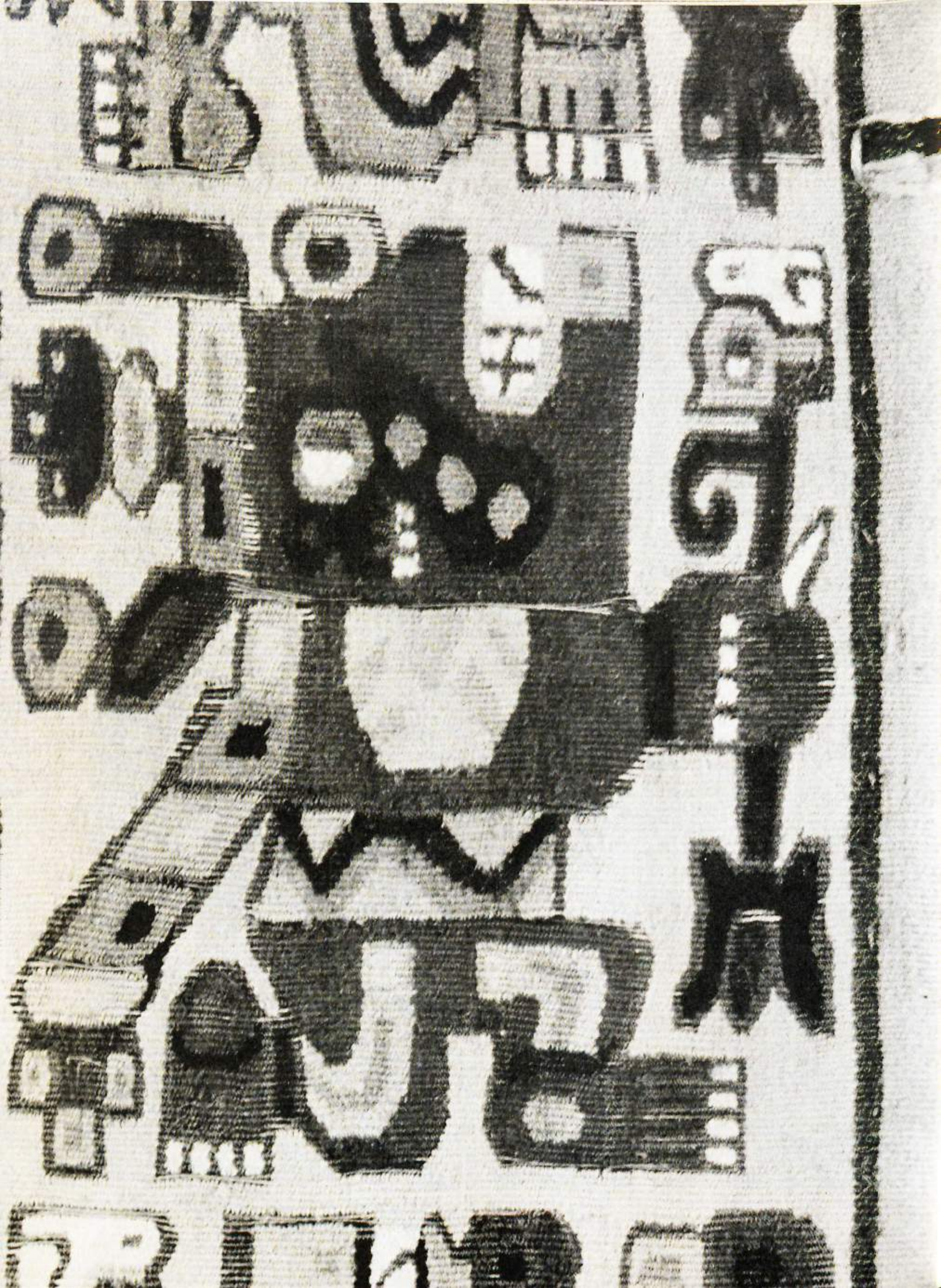


Plate 81. Tapestry weave, Chimu, Peru.

Plate 82. Tapestry detail, Middle Ica, Peru.



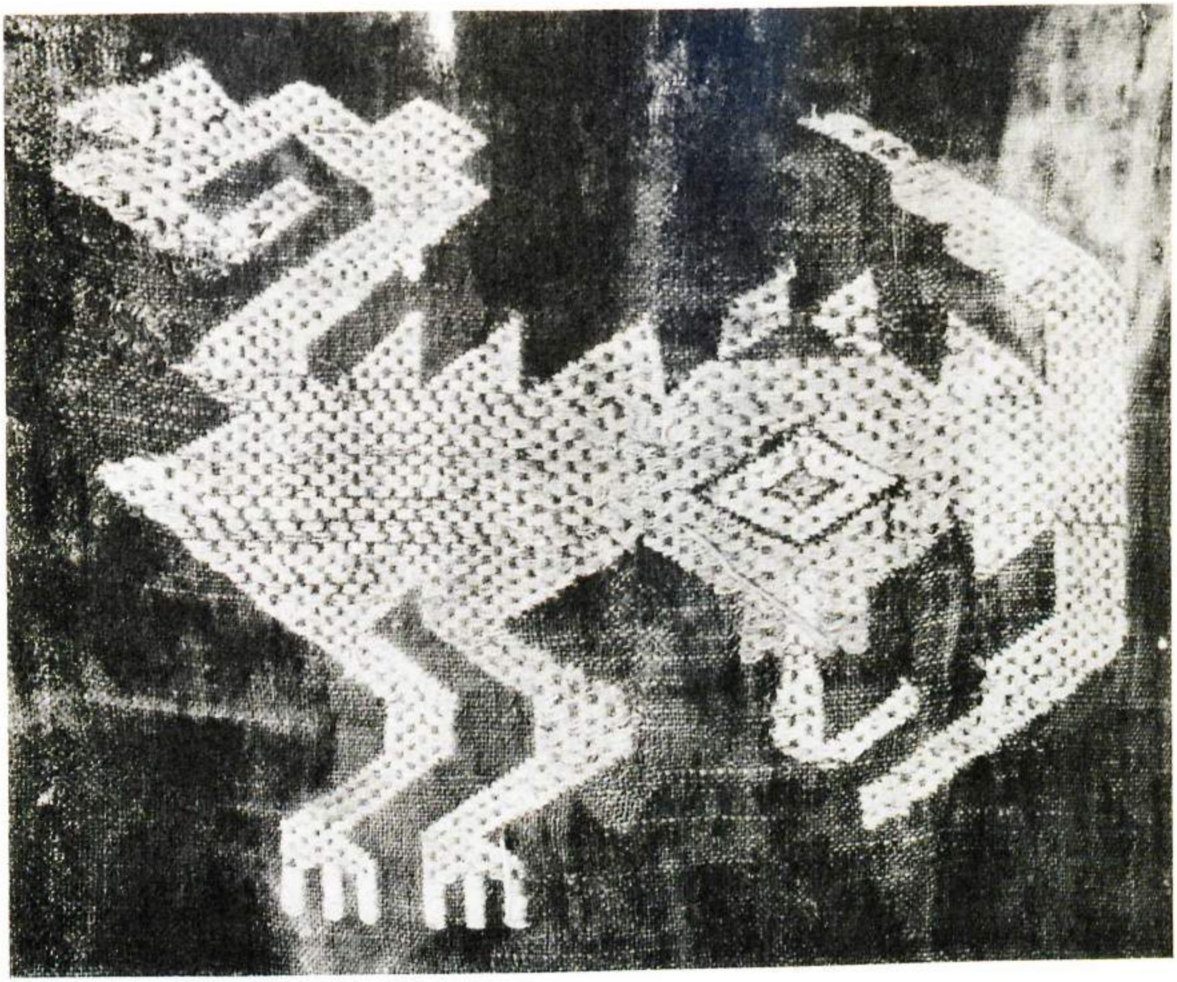


Plate 84. Inlaid technique, Peru.

Plate 83. Tapestry detail, Tiahuanaco, Peru.

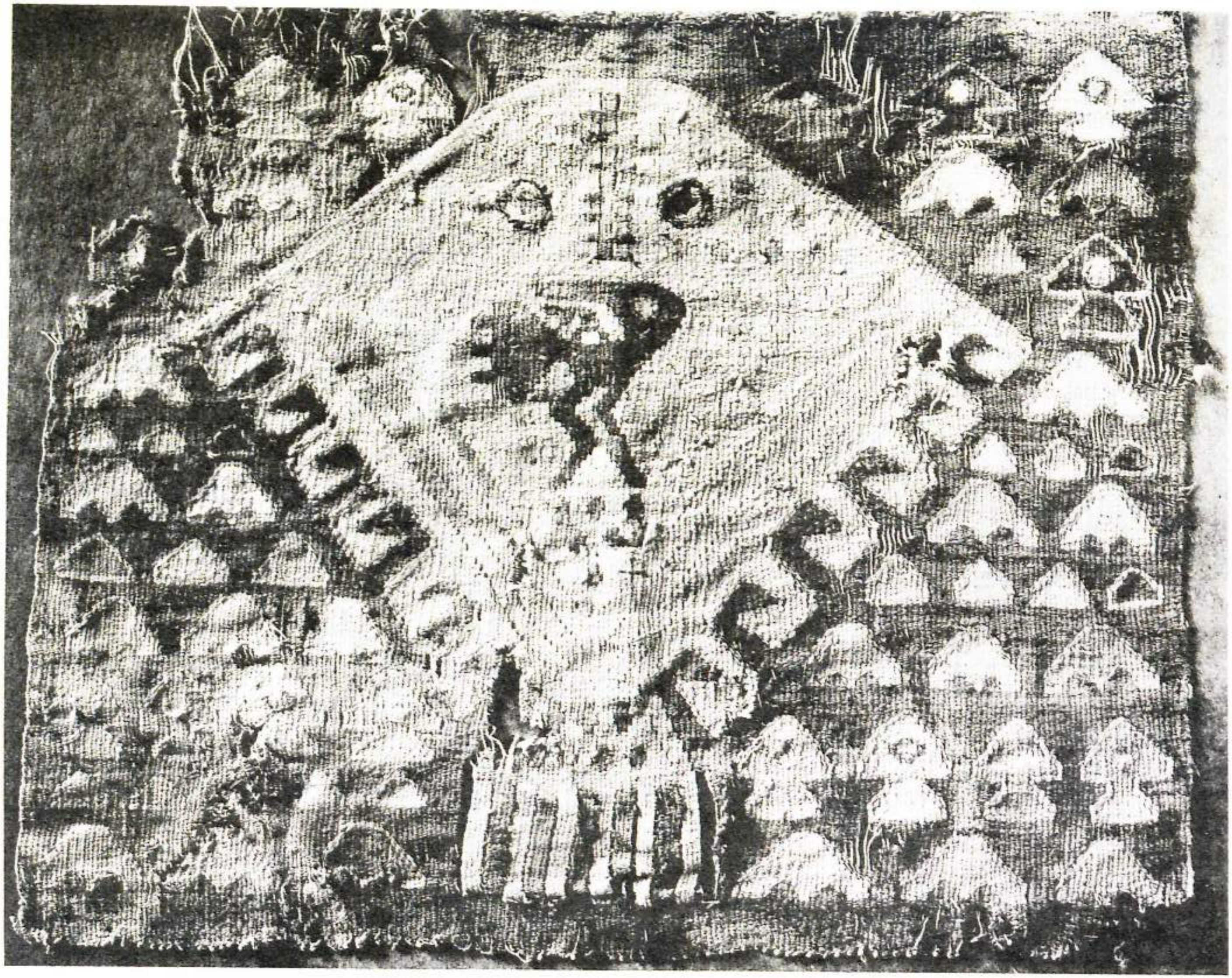


Plate 85. Tapestry, Pachacamac, Peru.

Plate 86. Interlocking weave, Paracas (?), Peru, before 500 A.D.

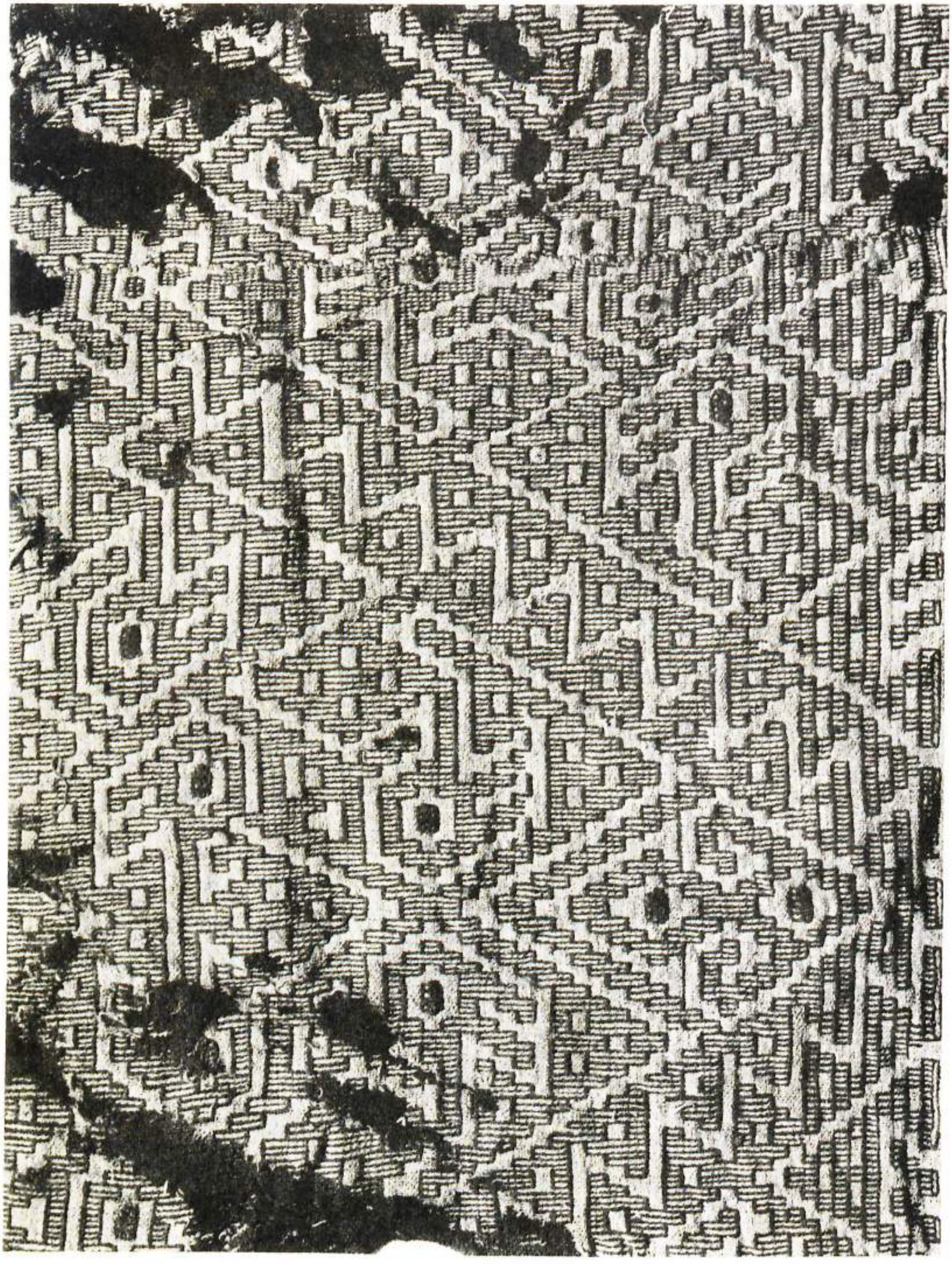


Plate 87. Double cloth, Pachacamac, Peru.

Plate 88. Triple cloth, Peru.

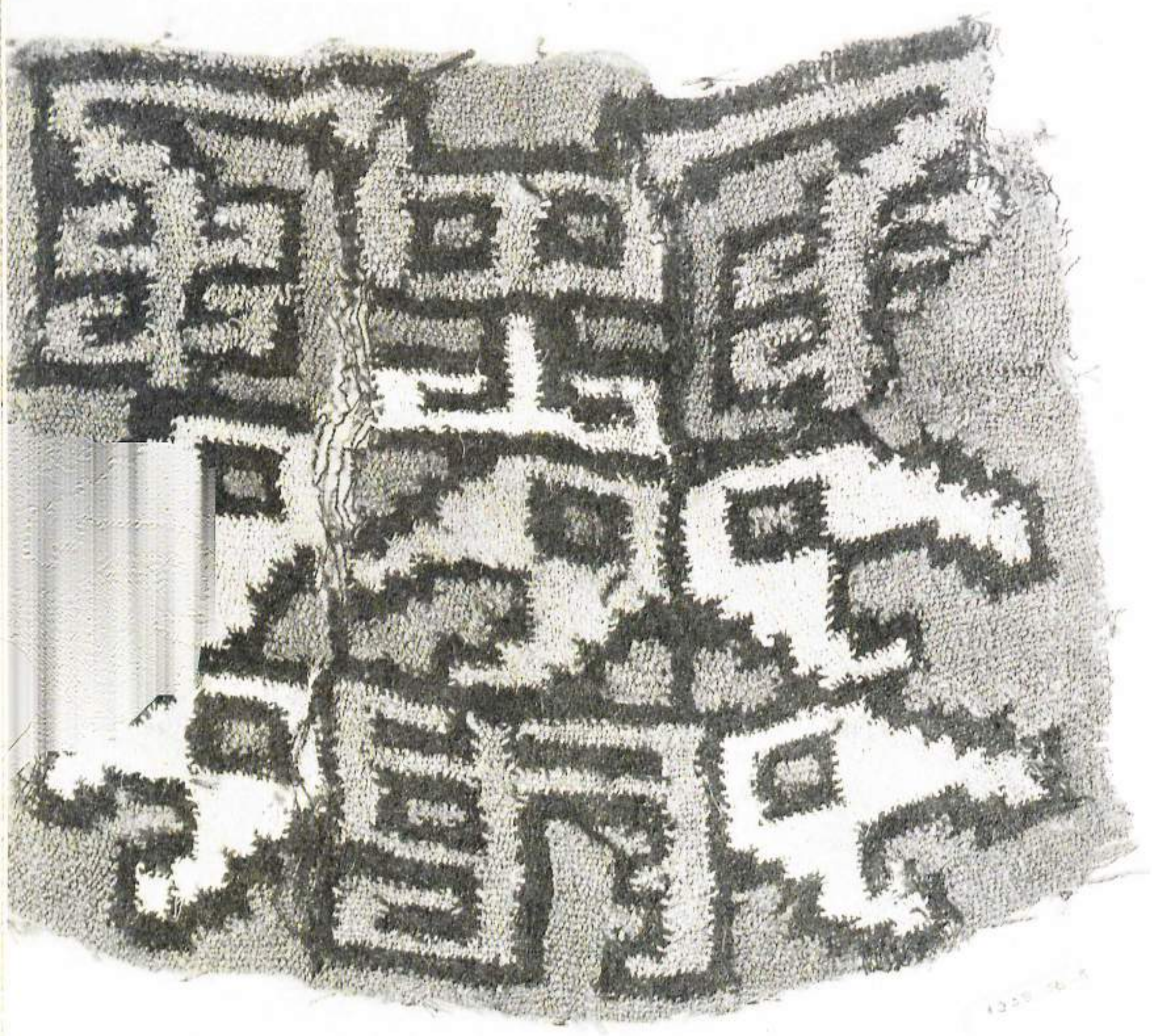


Plate 89. Tapestry with interlocking warps, Nazca, Peru, ca. 600 A.D.

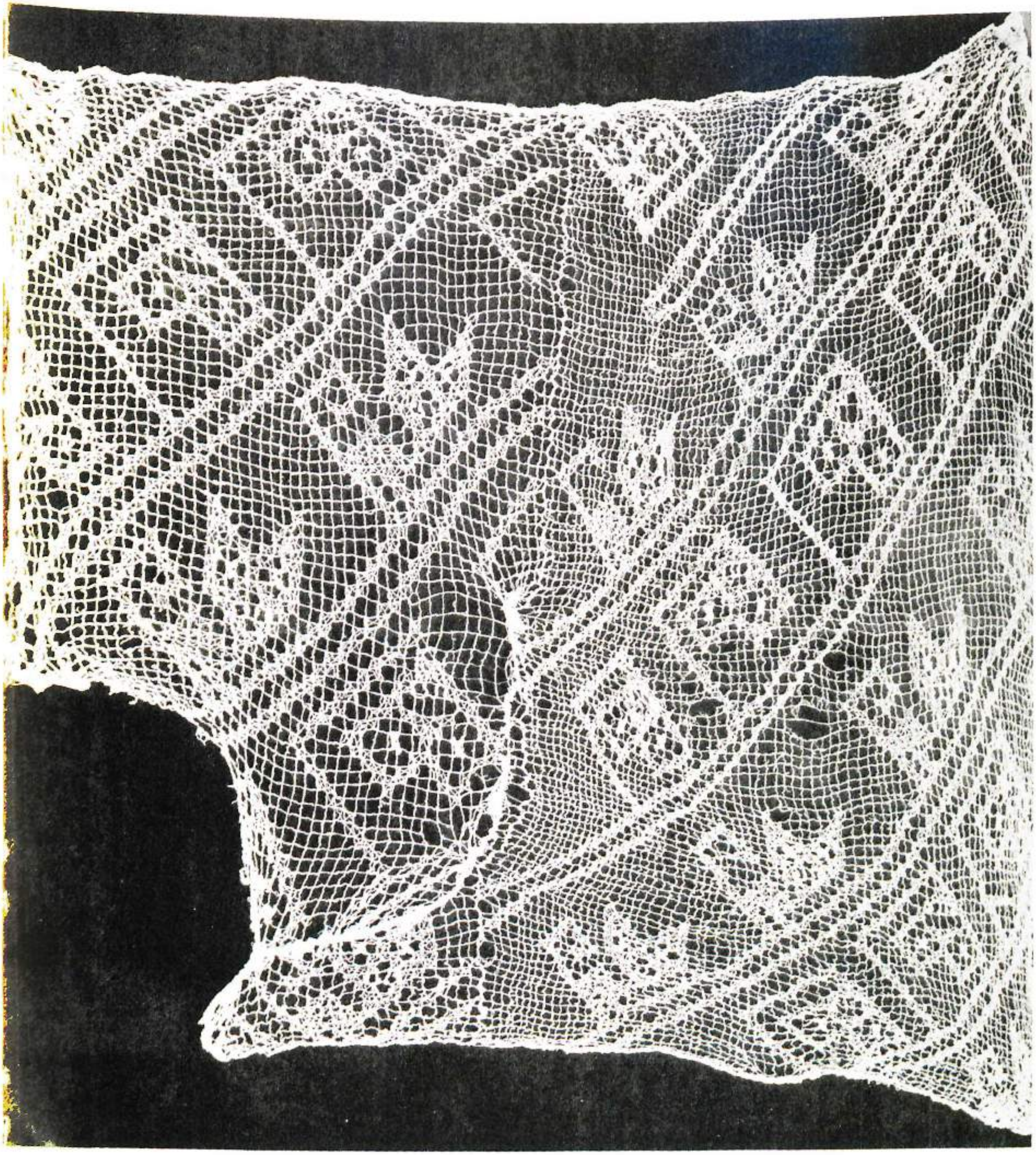


Plate 90. Lace headcloth, Peru, 1400–1550 A.D.

Plate 91. Detail of tapestry, Norway, 18th century.

Plate 92. Tapestry, Franco-Flemish (Arras or Tournai), 15th century.

Plate 93. Detail of rug, Persian, 16th century.

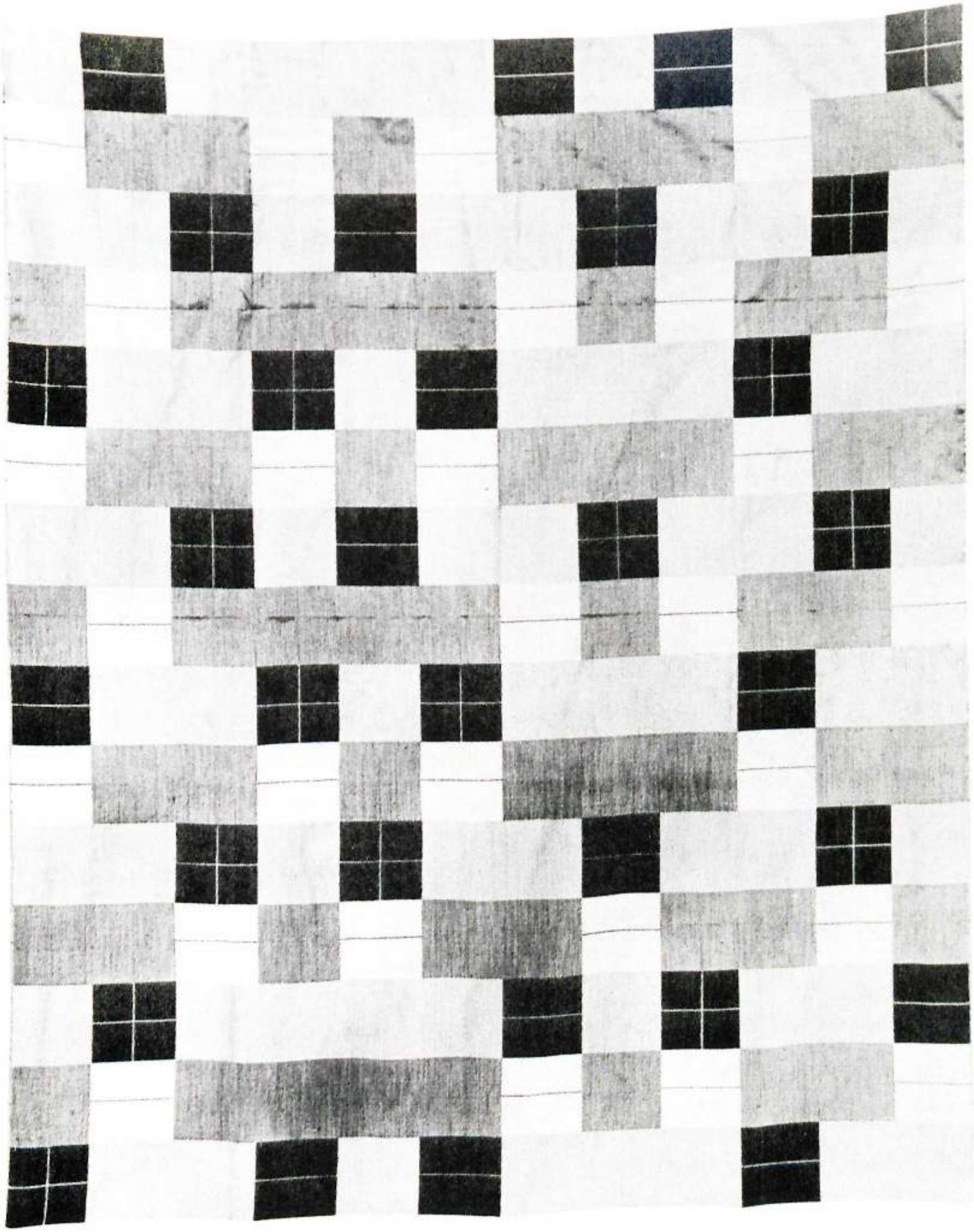
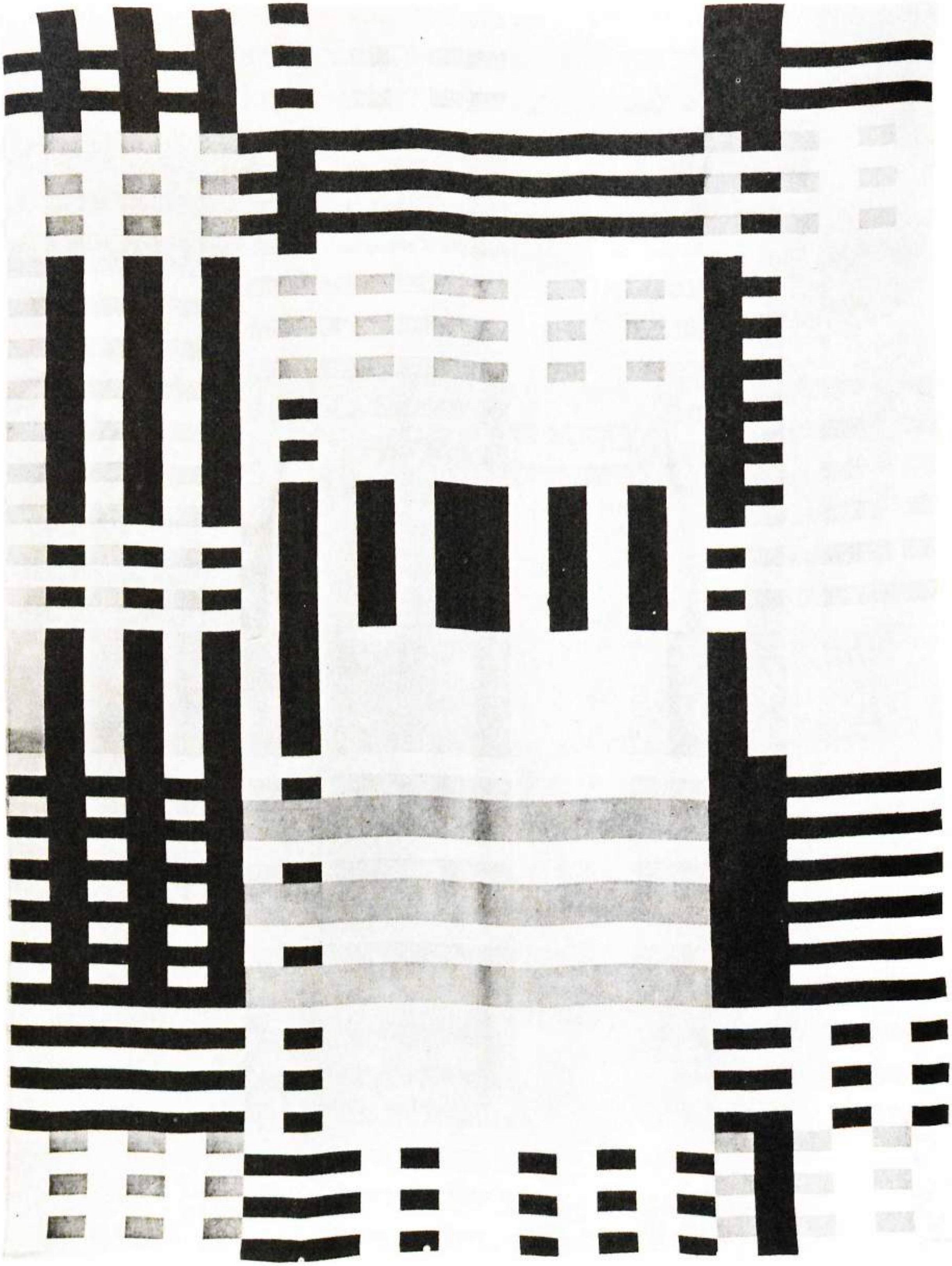


Plate 94. Wall hanging, double weave. Anni Albers, 1927.



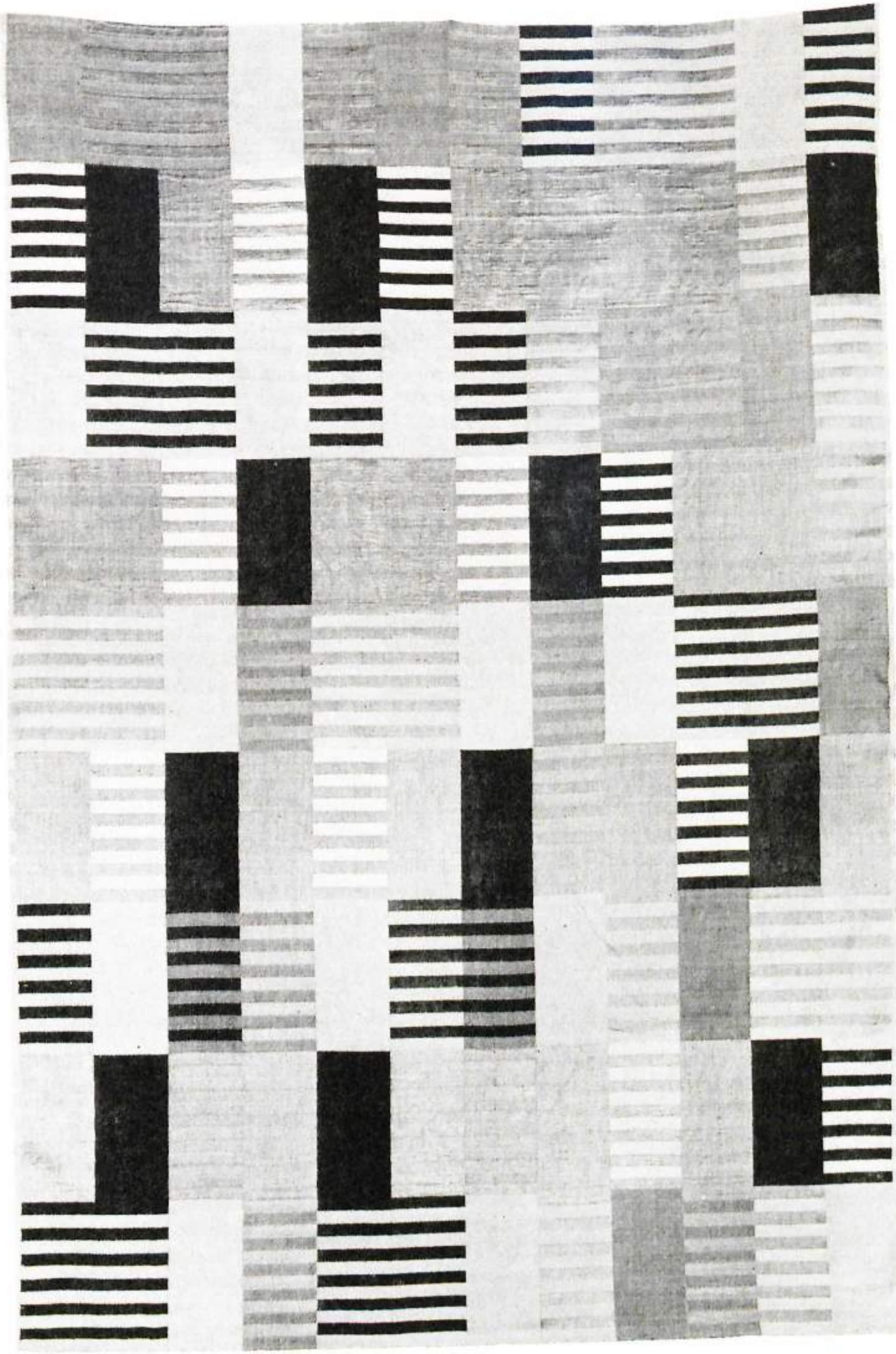
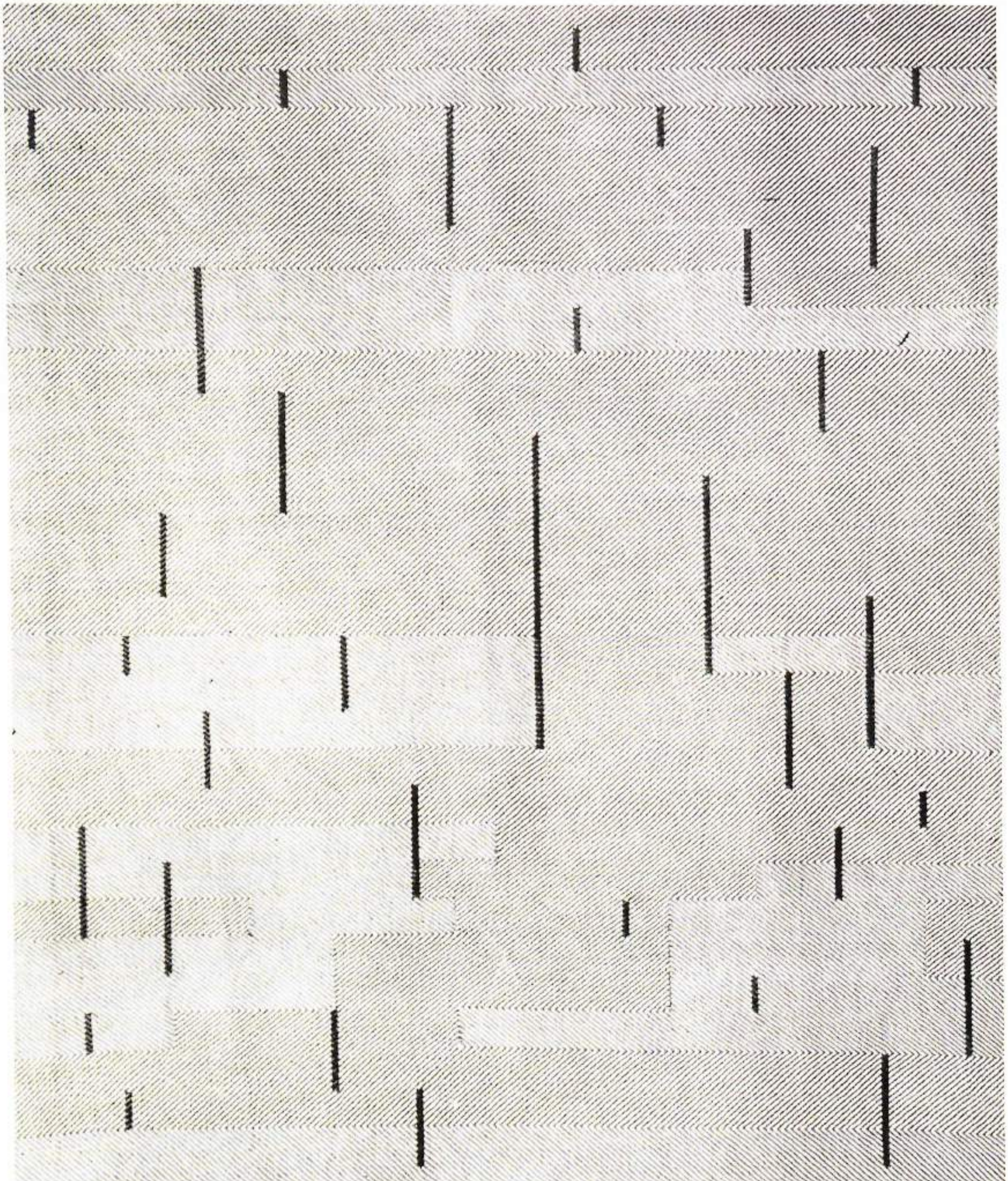


Plate 96. Wall hanging, three-ply weave. Anni Albers, 1927.

Plate 95. Wall hanging, Jacquard weaving. Anni Albers, 1925.



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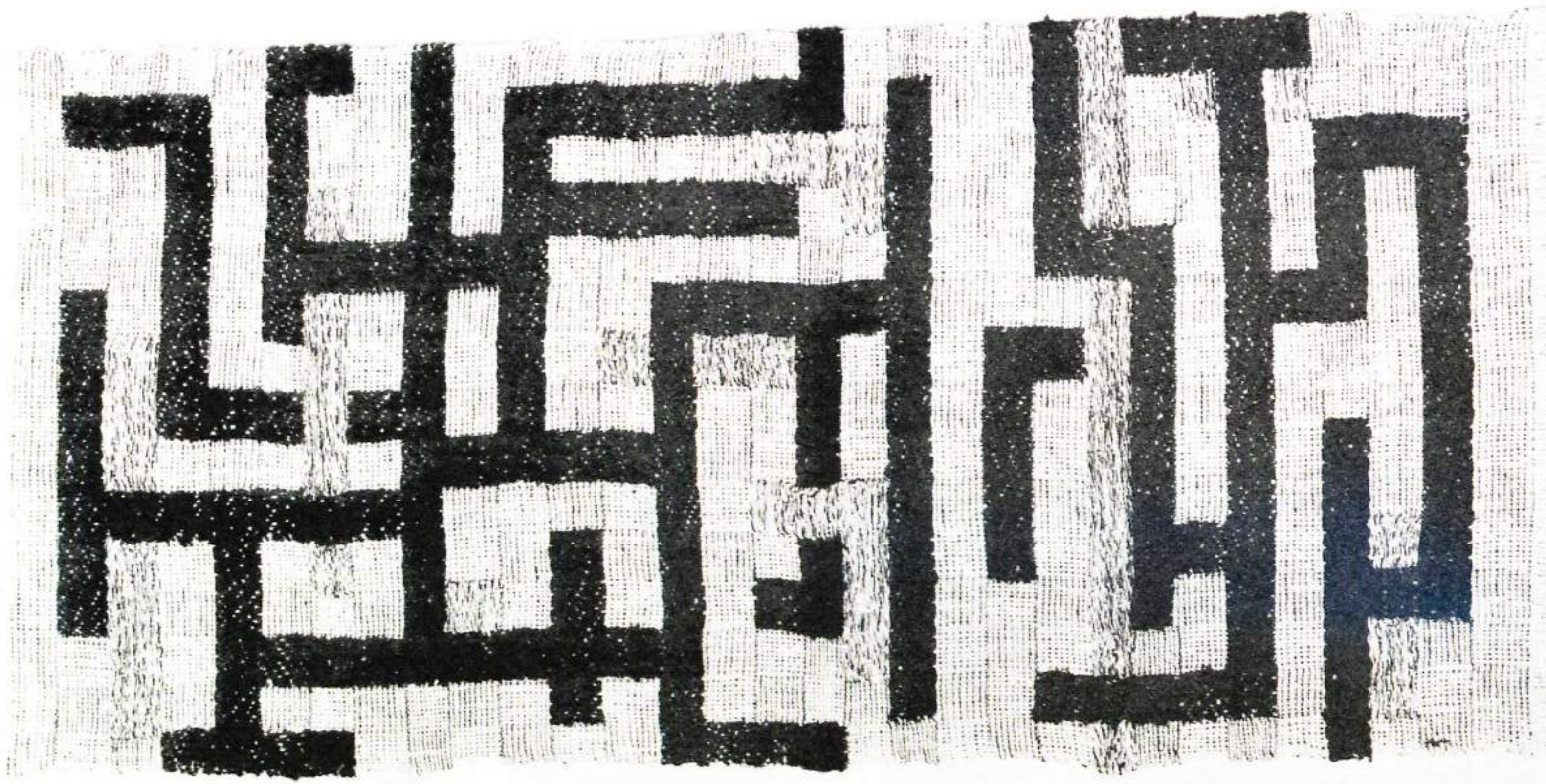

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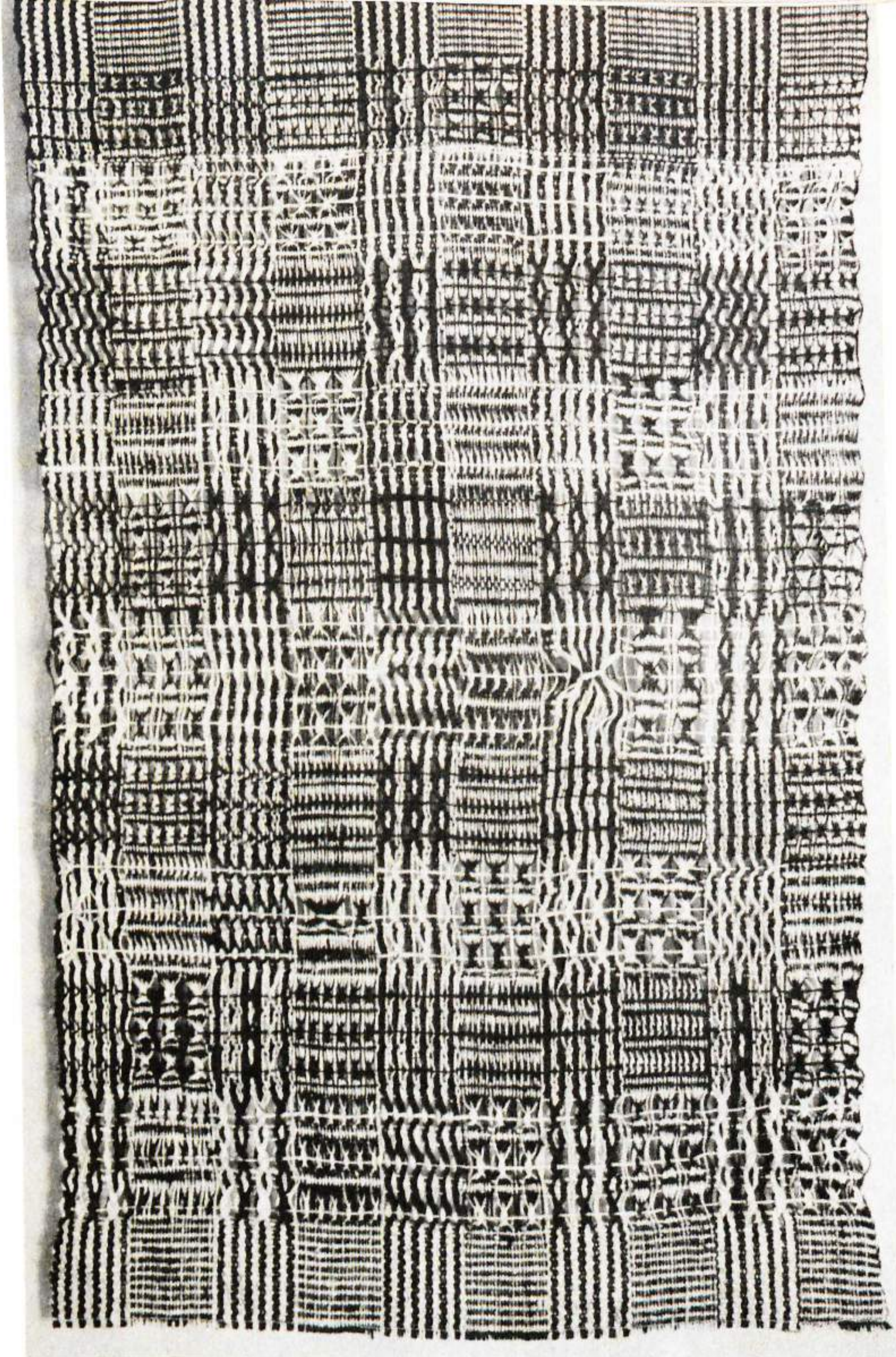
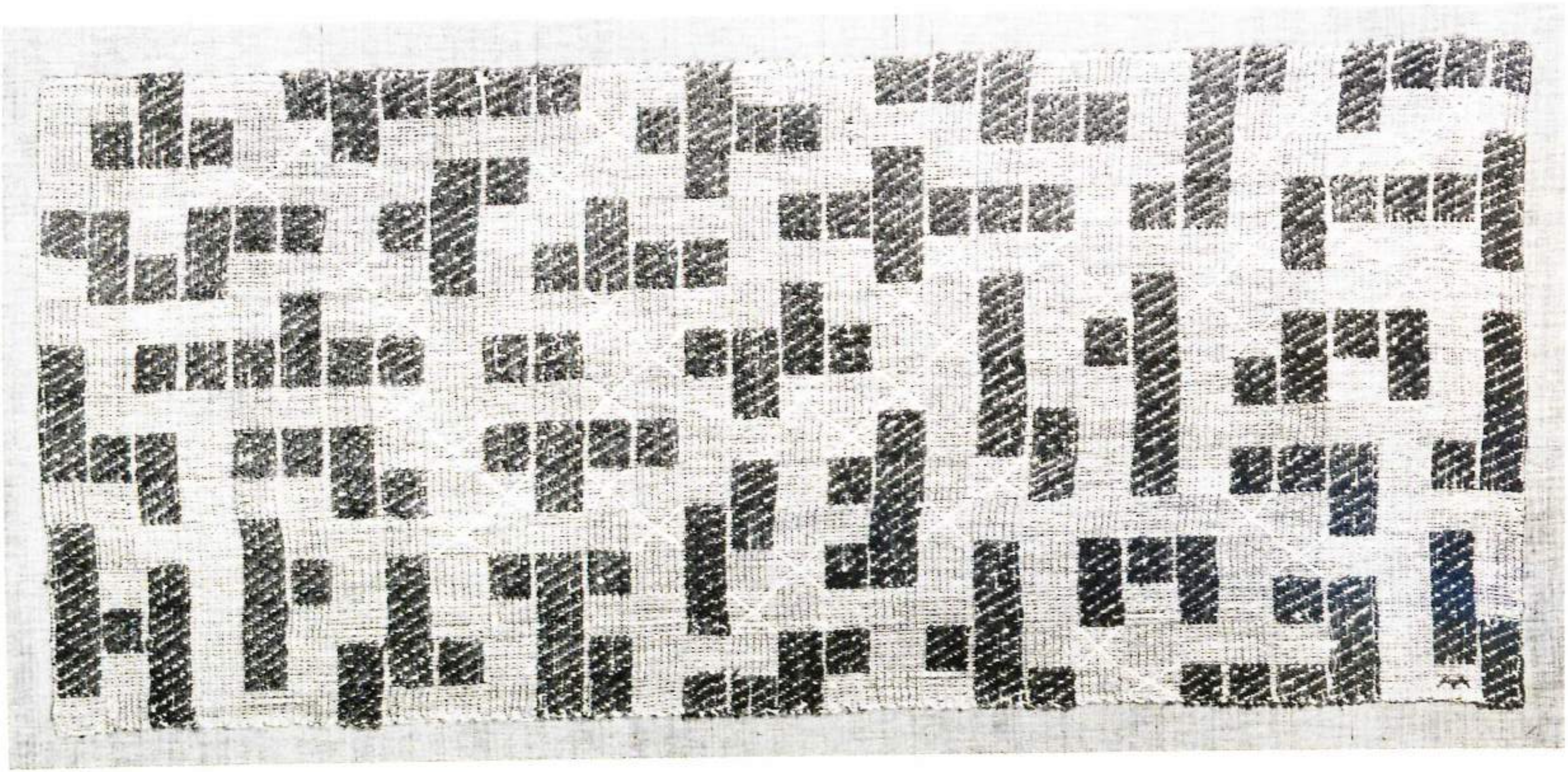


Plate 99. Tapestry with leno weave. Anni Albers, 1950.



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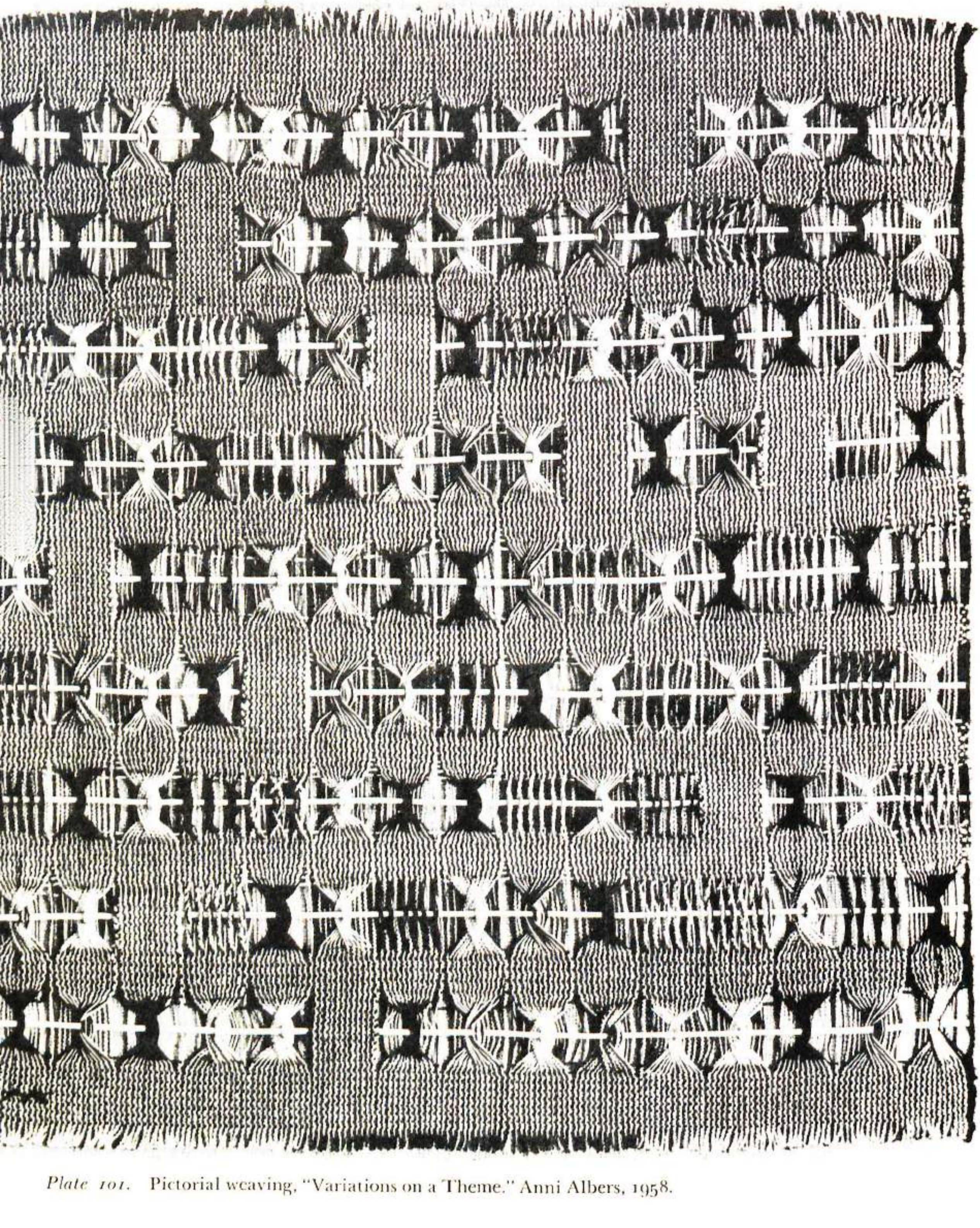
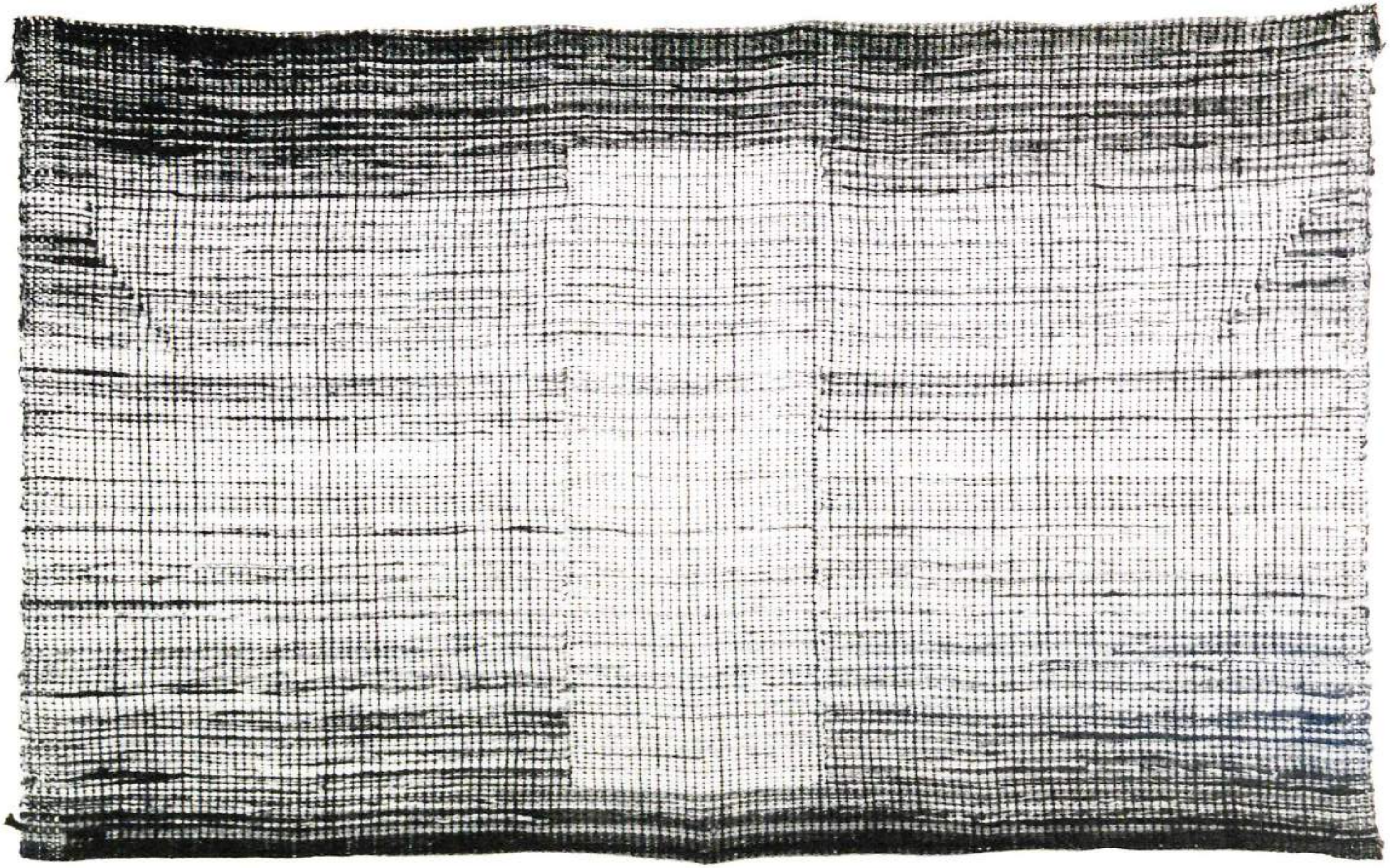


Plate 101. Pictorial weaving, "Variations on a Theme." Anni Albers, 1958.



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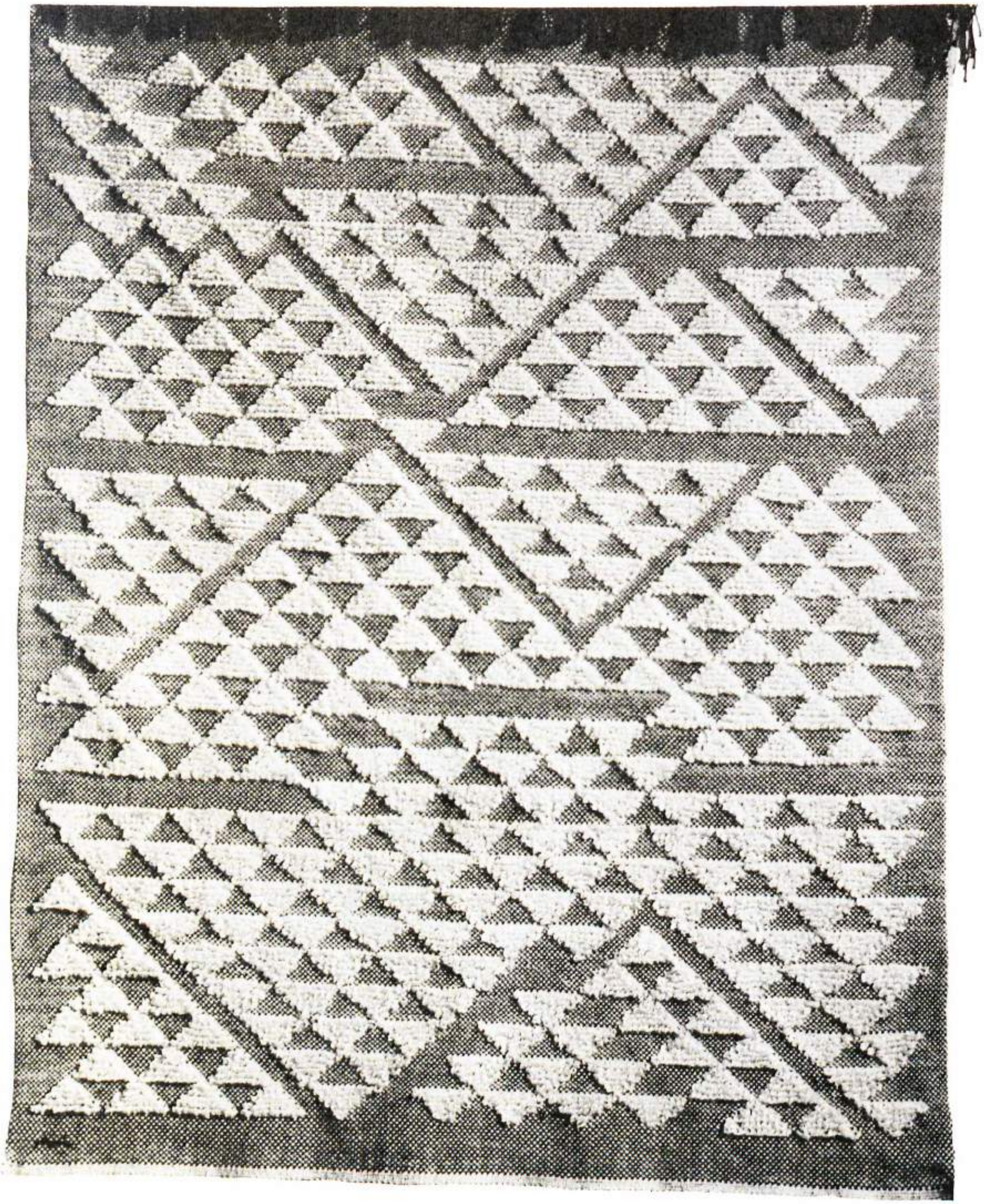
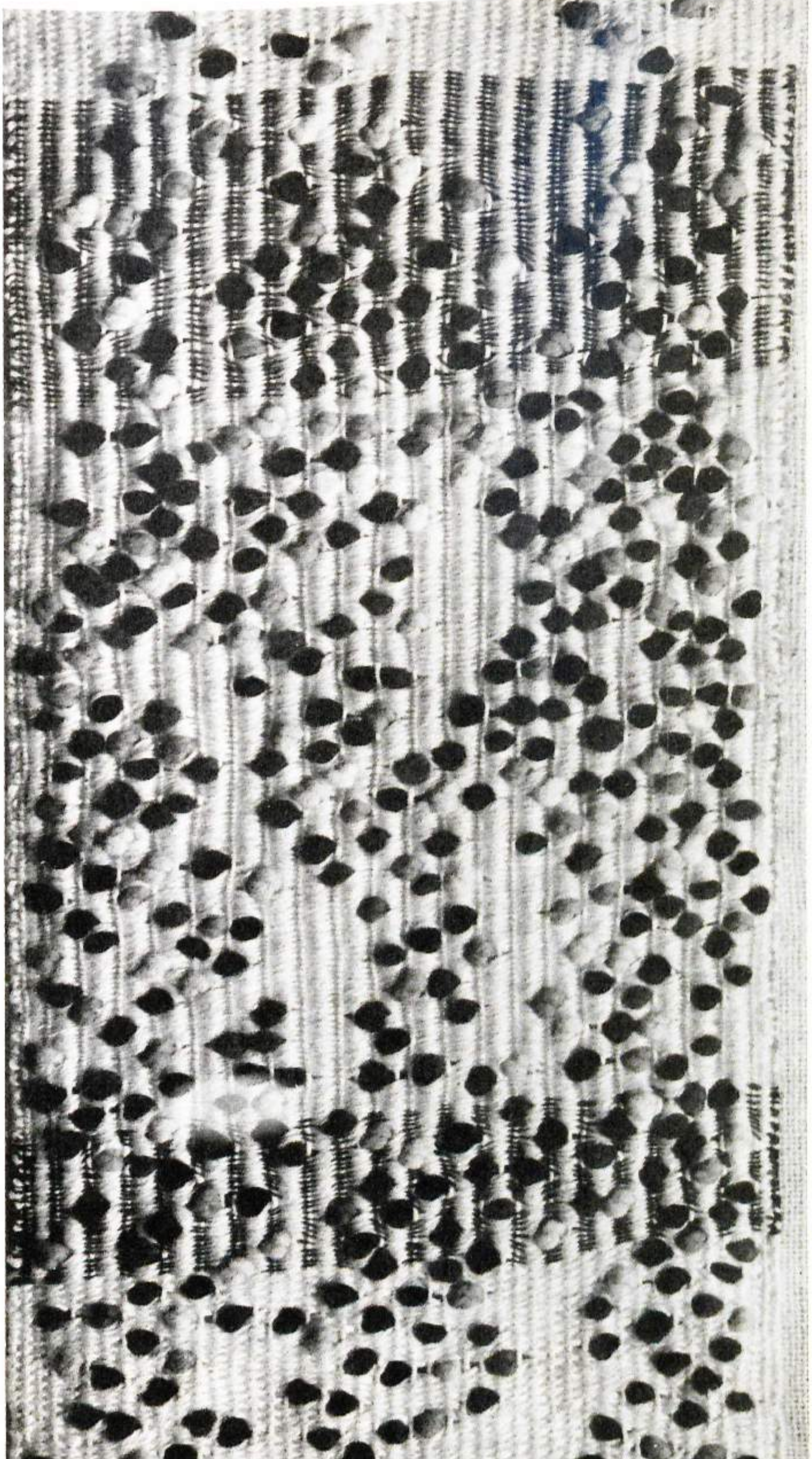


Plate 103. Vicara rug. Anni Albers, 1959.

Plate 104. Pictorial weaving, "Dotted." Anni Albers, 1959.



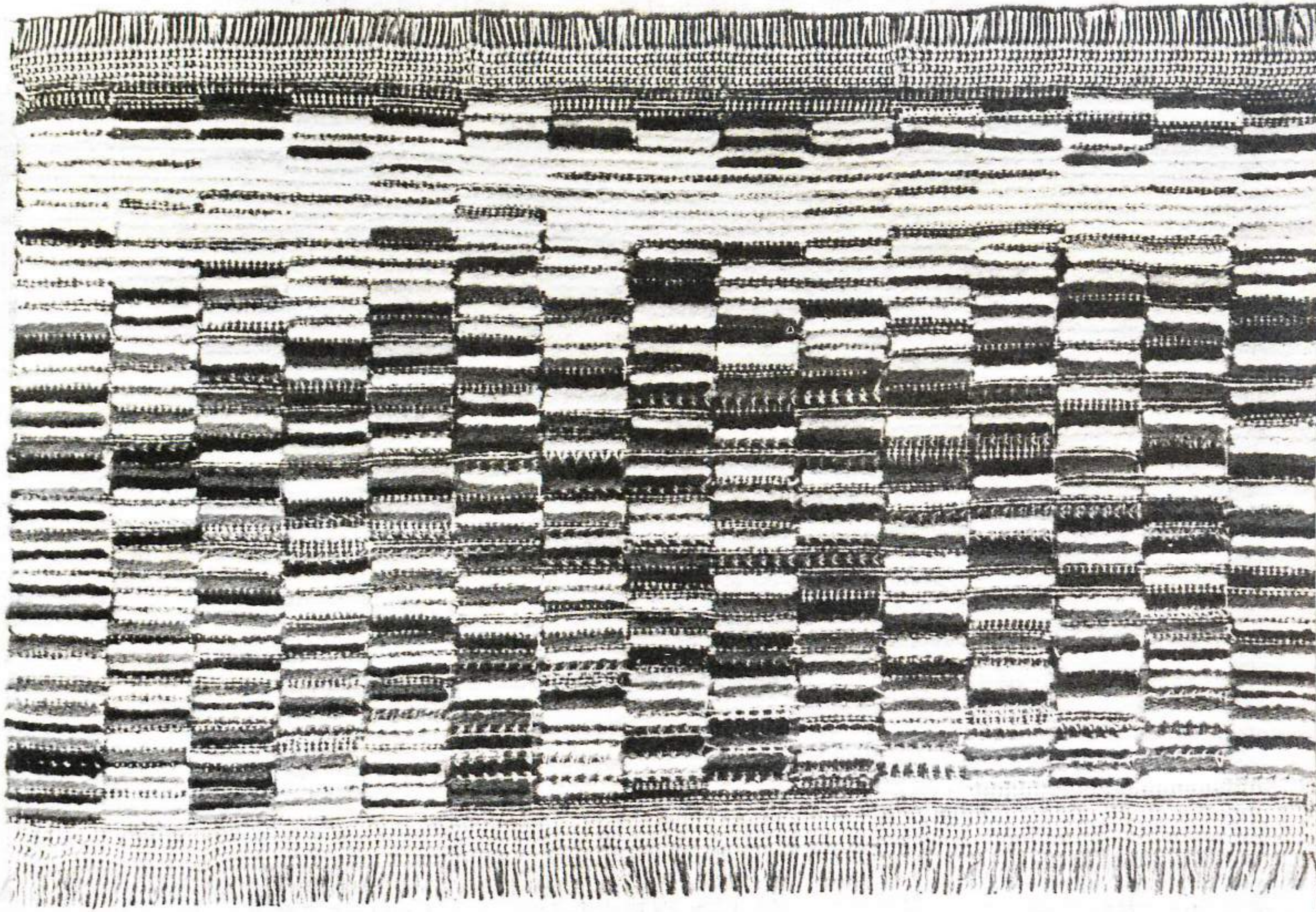
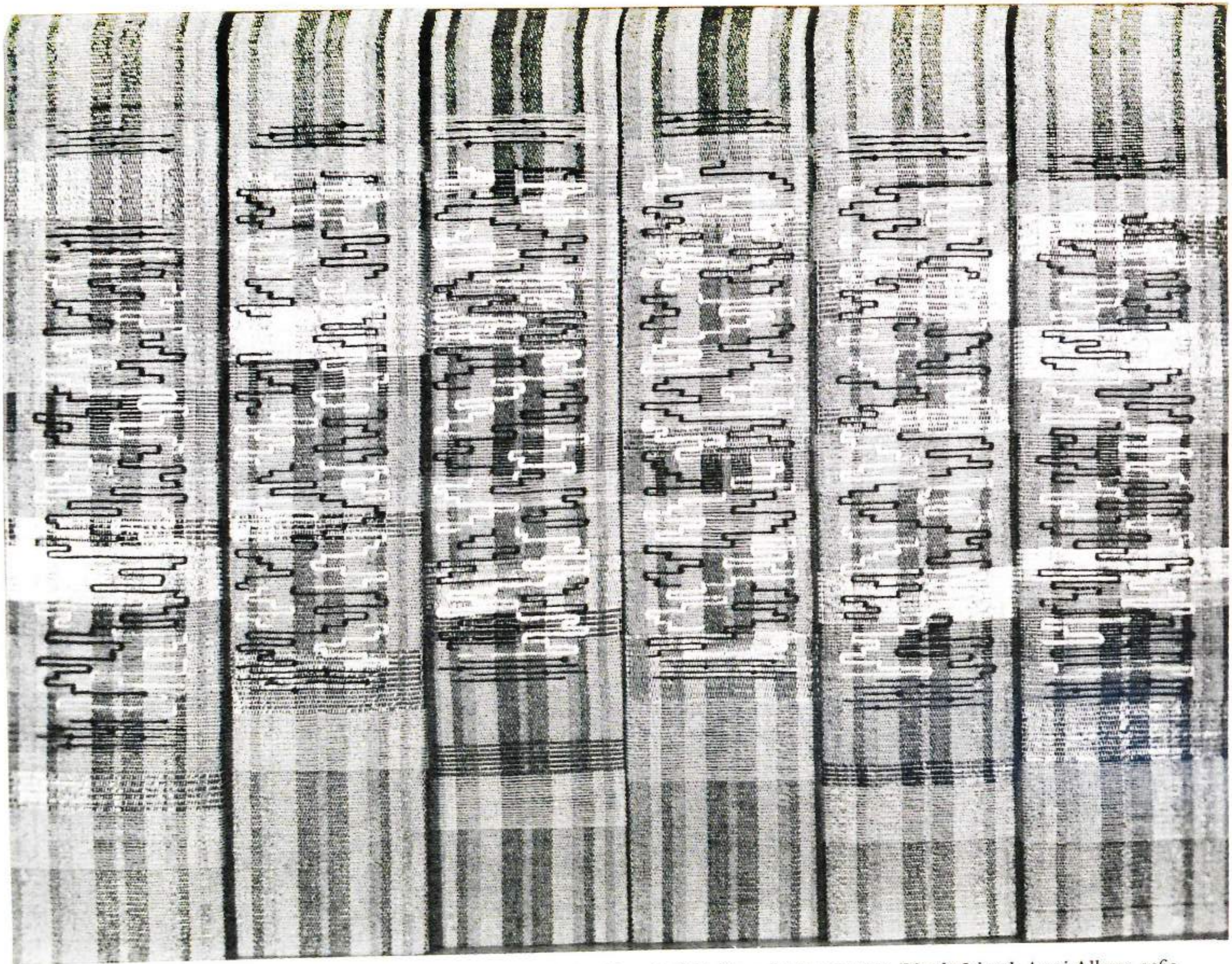


Plate 105. Pictorial weaving, "North Westerly." Anni Albers, 1957.



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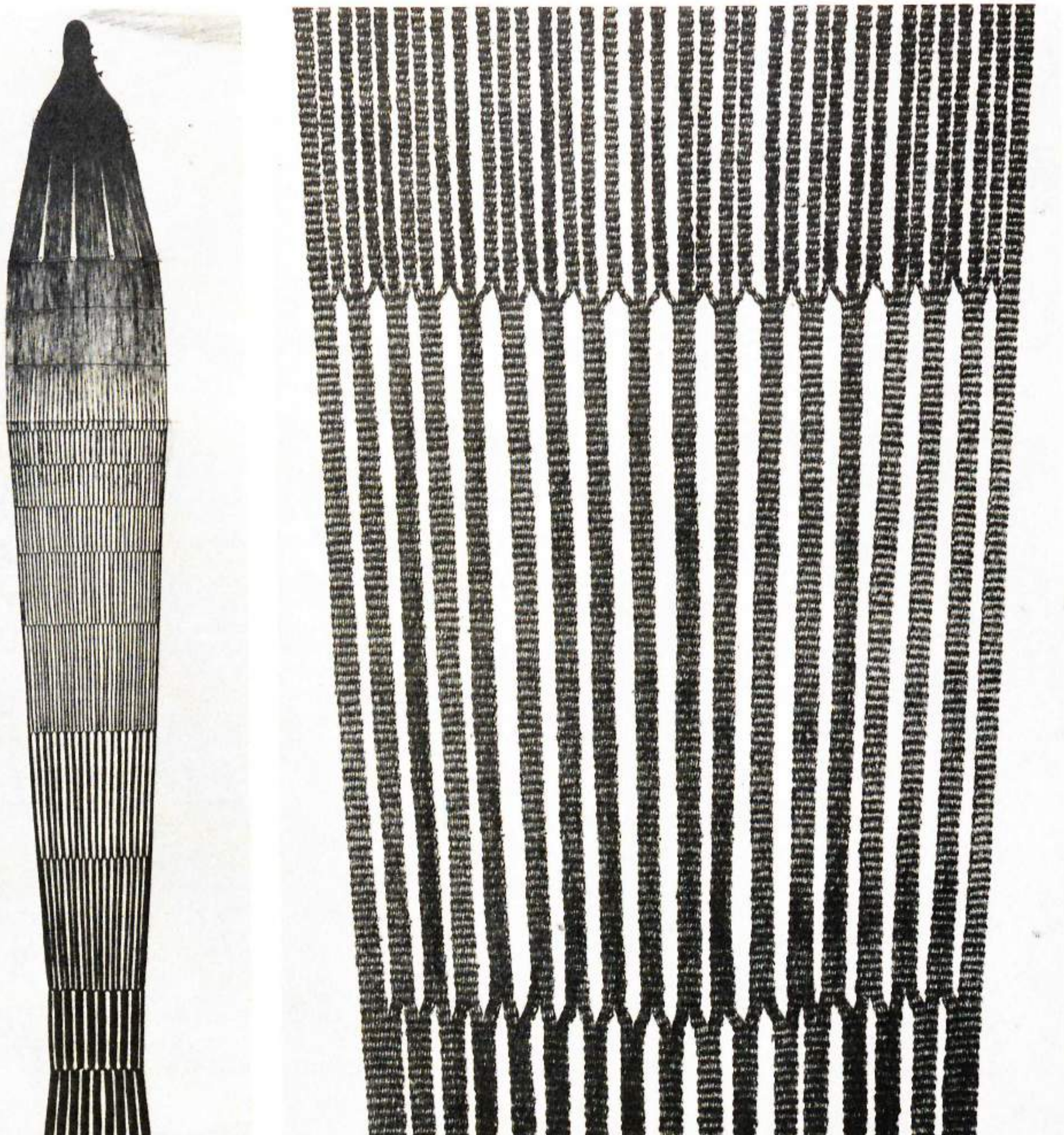
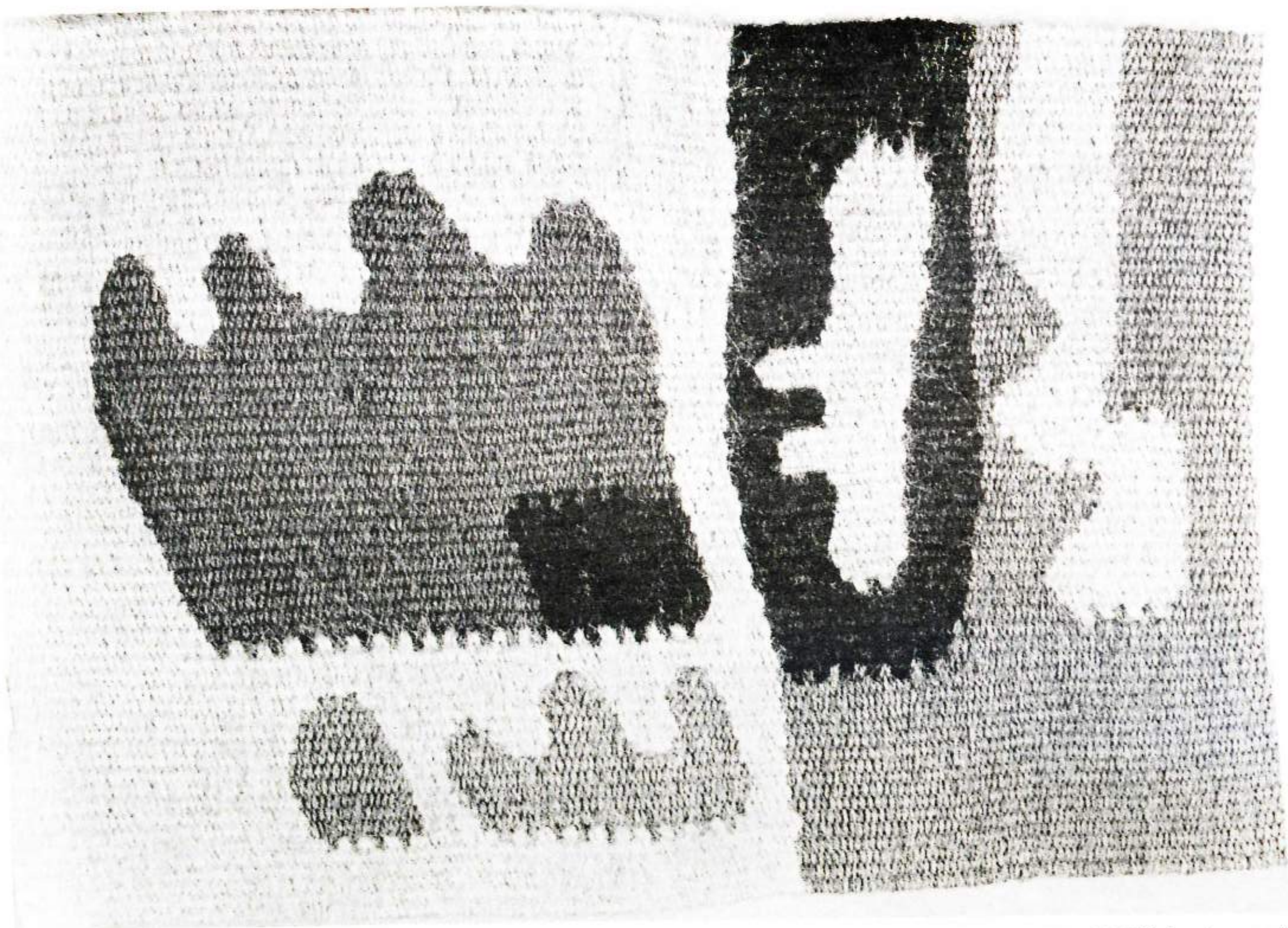


Plate 107. "Dark River" (complete work and detail). Lenore Tawney, 1962.



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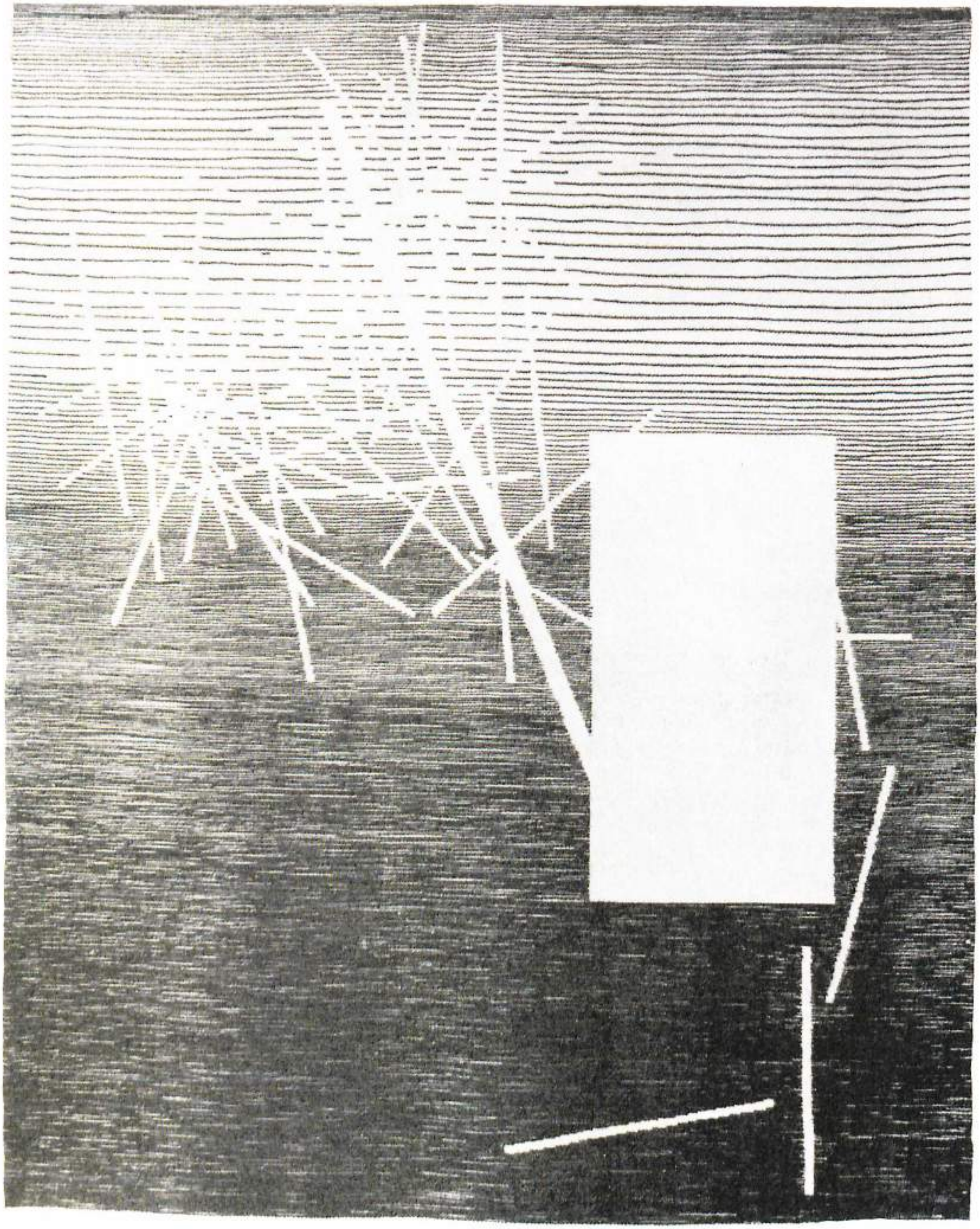
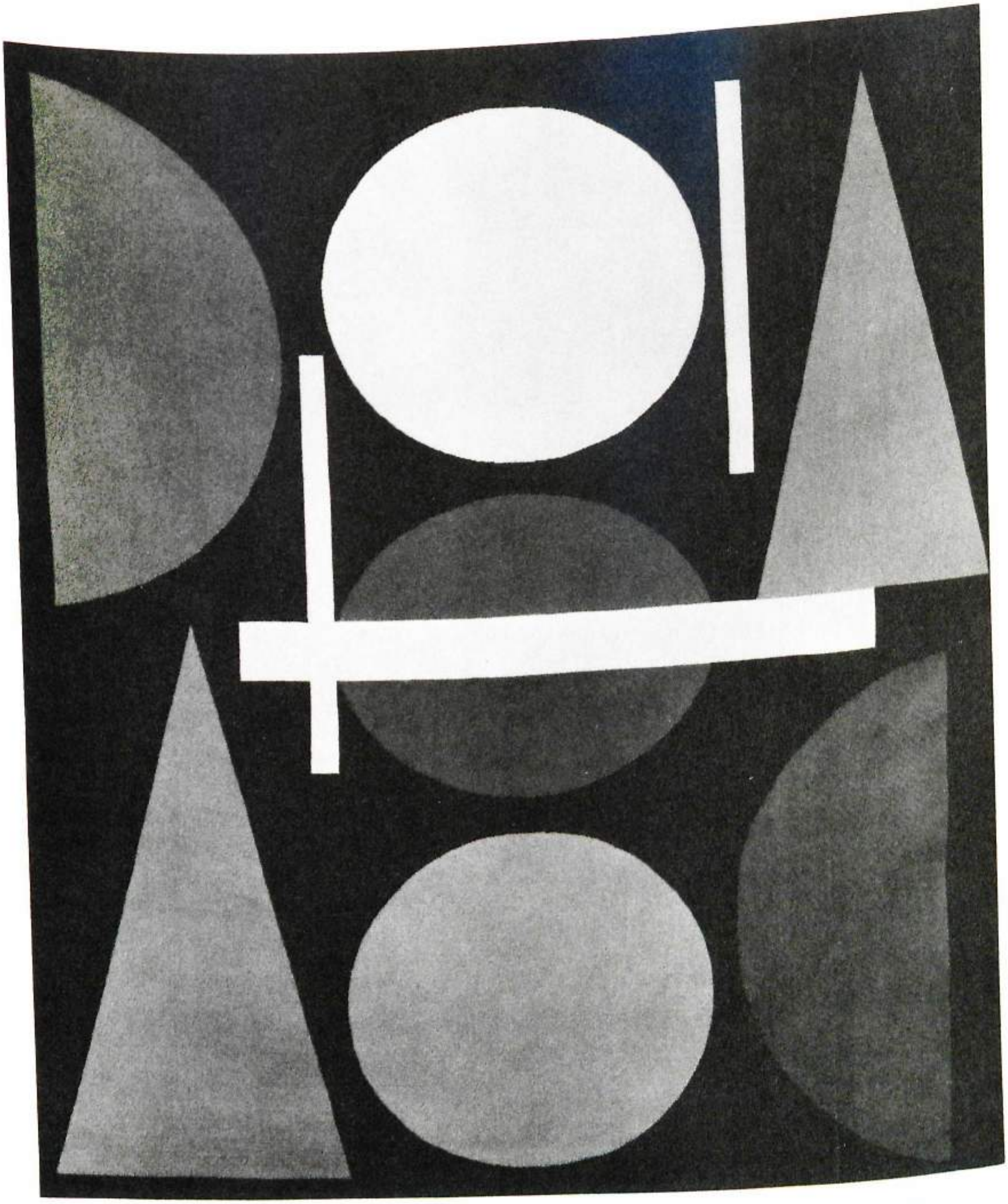


Plate 109. Tapestry, "La Férule." Michel Seuphor, 1960.



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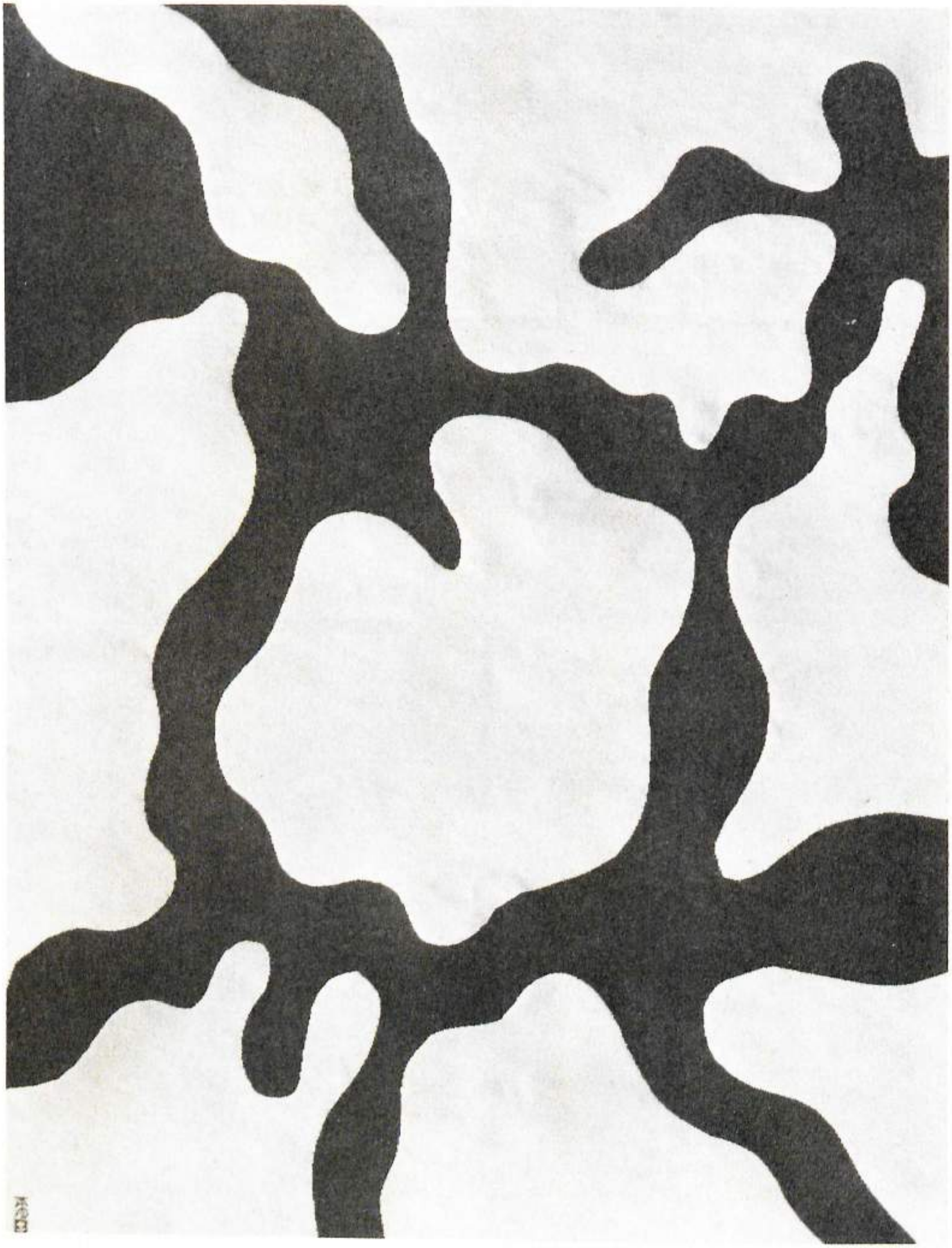

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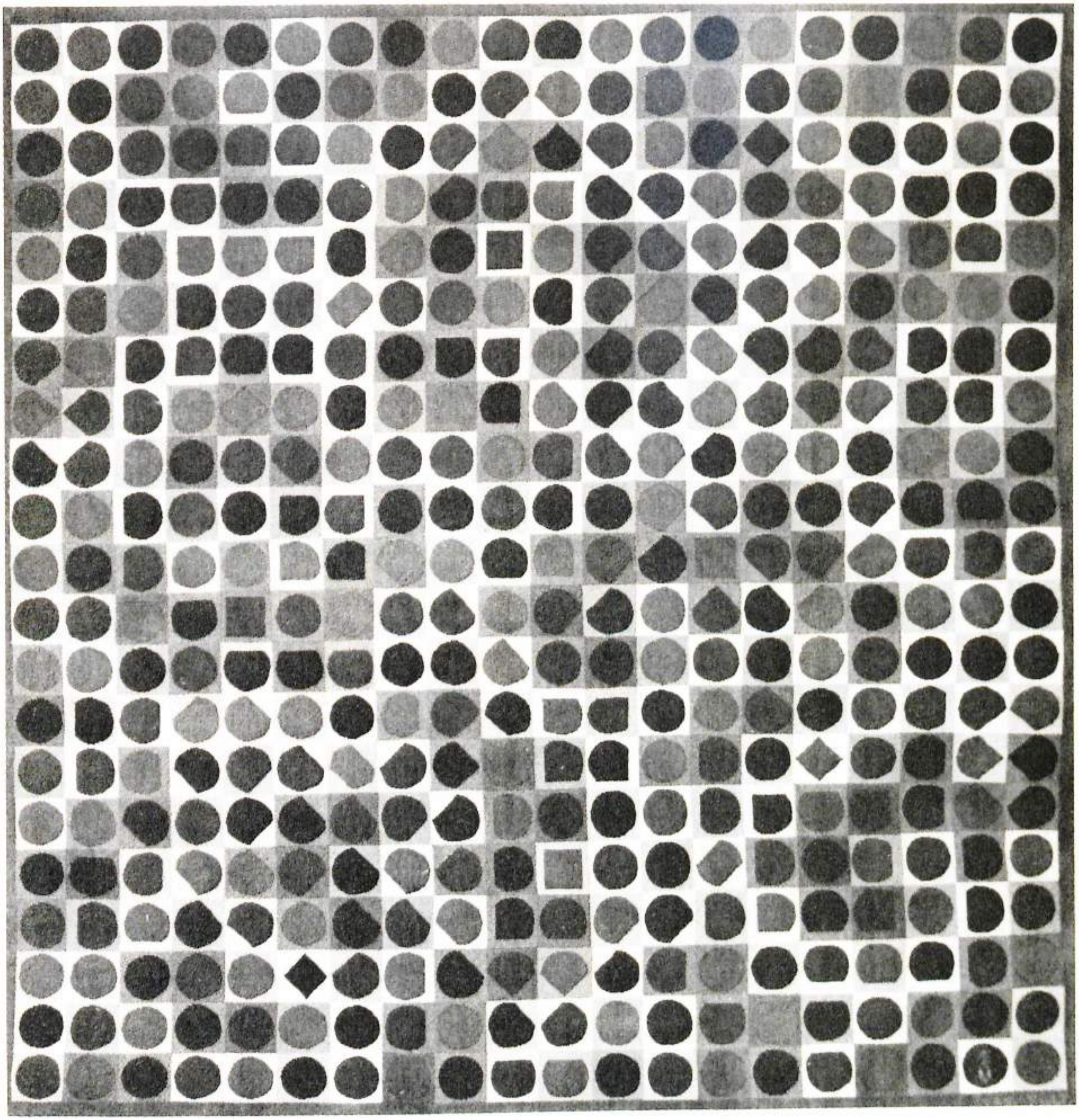

Plate 112. Tapestry, "Cassiopée." Victor Vasarely, 1963. (Atelier Tabard Aubusson.)

Acknowledgments

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Thus I am glad to thank Mr. and Mrs. Jean Arp; Dorothy Cavalier Yanik; Jack Lenor Larsen; Nina Pattek; Michel Seuphor; and Lenore Tawney for permission to show their works. To Charles Eames I owe his discerning photograph of a piece of nature; to Junius Bird the unequaled diagram of the earliest work shown in this book as well as his comments on it; to Crimilda Pontes and Sybil Wilson I owe help on my drawings.

To the publishers of the *Encyclopædia Britannica* I am grateful for permission to quote myself from a signed article I wrote for them; and to the Carnegie Institution of Washington for the use of Bodil Christensen's diagram showing a unique method of shaping a weaving. My thanks for photographs from their files go to the American Museum of Natural History; the Art Institute of Chicago; the British Museum; the Brooklyn Museum; the Busch-Reisinger Museum, Harvard University; the Chicago Natural History Museum; the Cone Mills Corporation; the Cooper Union Museum for the Arts of Decoration; the Detroit Institute of Arts; the Galerie Denise René, Paris; Meiji-Shobo Ltd., Kanda, Tokyo; the Metropolitan Museum of Art; the Minneapolis Institute of Arts; the Museum of Modern Art; the Museum für Völkerkunde, Basel; the Peabody Museum, Harvard University; the Rijksmuseum voor Volkenkunde, Leiden, Netherlands; the University Museum, University of Pennsylvania; and the Yale University Art Gallery.

To the *Ciba Review* I owe special thanks for permitting me to reproduce some of their photographs.

And here I should also name my husband, whom I mentioned gratefully earlier: Josef Albers.

— A. A.

Plate Credits

Plate 1. Earliest known representation of a loom. Predynastic Egyptian pottery, ca. 3400 B.C. Courtesy: *Ciba Review*, No. 16, December 1938.

2. Loom from Bougainville Island. Courtesy: Museum für Völkerkunde, Basel.

3. Greek warp-weight loom. From an Athenian lekythos, ca. 560 B.C. Courtesy: The Metropolitan Museum of Art (Fletcher Fund, 1931), New York.

4. Peruvian weavers at work on back-strap loom. From a Mochica pottery vessel, 600–1000 A.D. Copyright: British Museum, London.

5. Back-strap loom (diagram) of the type used in Peru. Courtesy: The American Museum of Natural History, New York.

6. Okinawa loom, Japan. A transitional loom with back strap and foot treadle. From *A Study of Okinawan Textile Fabrics*, by Toshio and Reiko Tanaka, copyright © 1952 by Meiji-Shobo Ltd., Kanda, Tokyo. Reproduced by permission.

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27. Loom, Santa Ana Hueytlalpan. After Bodil Christensen: "Otomi Looms and Quechquemitls from San Pablito, State of Puebla, and from Santa Ana Hueytlalpan, State of Hidalgo, Mexico," *Notes on Middle American Archaeology and Ethnology*, No. 78. Courtesy: Carnegie Institution of Washington.

28. Twining, Admiralty Islands, diagram and photograph. From C. Nooteboom: "Quelques Techniques de Tissage des Petites Îles de la Sonde" (Mededelingen van het Rijksmuseum voor Volkenkunde, No. 3), copyright © 1948 by Rijksmuseum voor Volkenkunde, Leiden, Netherlands. Reproduced by permission.

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75. Coptic head, looped weaving. Collection: Norman Ives. Photo: Robert Perron.

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106. Ark panels for Temple B'Nai Israel, Woonsocket, Rhode Island. 5′4″ x 7′. Anni Albers, 1962. Photo: John Hill.

107. "Dark River" (complete work and detail). 13′6″ x 28″. Lenore Tawney, 1962. Collection: Museum of Modern Art, New York; Greta Daniel Fund. Courtesy: the artist. Photo: Ferdinand Boesch.

108. Tapestry, "Formes Biologiques." Design by Jean Arp, woven by Sophie Täuber-Arp, 1926. Courtesy: Mr. and Mrs. Jean Arp. Photo: Etienne Weill.

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110. Tapestry, "Nue aux Cercles Rouges." 77″ x 62½″. Auguste Herbin, 1959; Atelier Tabard Aubusson, 1963. Courtesy: Galerie Denise René, Paris.

111. Tapestry, "Ramure." 78″ x 51½″. Jean Arp, 1961–1962; Atelier Tabard Aubusson. Courtesy: Galerie Denise René, Paris.

112. Tapestry, "Cassiopée." 93″ x 89″. Victor Vasarely, 1963; Atelier Tabard Aubusson. Courtesy: Galerie Denise René, Paris.

1899	Born in Berlin, Germany
1922–1930	Student at Bauhaus in Weimar and Dessau. Bauhaus Diploma
1933–1949	Assistant Professor of Art, Black Mountain College, North Carolina
1937	Became citizen of the United States of America
1950–	Free-lance work, New Haven, Connecticut
1961	Gold Medal of American Institute of Architects in the Field of Craftsmanship
1962	Citation, Philadelphia Museum College of Art
1964	Tamarind Lithography Workshop Fellowship
1965	DABA Citation, The Decorative Arts Book Award
1972	Received honorary Doctor of Fine Arts from The Maryland Institute College of Art
1973	Received honorary Doctor of Laws from York University, Toronto, Ontario

Author of:

ANNI ALBERS: ON DESIGNING (Pellango Press, 1959; Wesleyan University Press, 1962; paperback, 1971)
ANNI ALBERS: ON WEAVING (Wesleyan University Press, 1965; paperback, 1974)
PRE-COLUMBIAN MEXICAN MINIATURES (Praeger, 1970)

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California State University and Colleges

Anni Albers

In this book, Anni Albers develops the thoughts on the history and design of weaving which she put forward in her collection of essays *On Designing,* published in 1959. Although *On Weaving* is not meant to be a technical reference book, it conveys a fundamental understanding and appreciation of the craft, both to the textile expert and to the interested layman, and is written in uncomplicated language, illustrated with clear diagrams.

In chapter 5 Anni Albers says: 'Though elaborations are usually thought to be an advance stage of work, they are often an easy expansion from basic concepts. Intricacy and complexity are not, in my mind, high developments. Simplicity, rather, which is condensation, is the aim and the goal for which we should be heading. Simplicity is not simpleness but clarified vision – the reverse of the popular estimate.'

This methodically intellectual approach has been applied in the composition and writing of this book and has enabled the author with her expert knowledge to condense into a small space the very quintessence of designing woven fabrics and the many facets and intricacies of this craft. But at the same time Anni Albers is able to excite and inspire the reader's imagination and unravel the romantic story of weaving.

The technical side, which includes tapestry and carpet weaving, weaves and their derivatives, cloth constructions and materials is extremely well documented with drawings and photographs. The artist-designer will find delight in the many black-and-white and coloured illustrations of ancient and modern weaving.

This is a book which will be of the greatest interest and a most welcome addition to libraries, historians, art colleges, textile designers and interior designers. In fact any one connected with textiles.

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