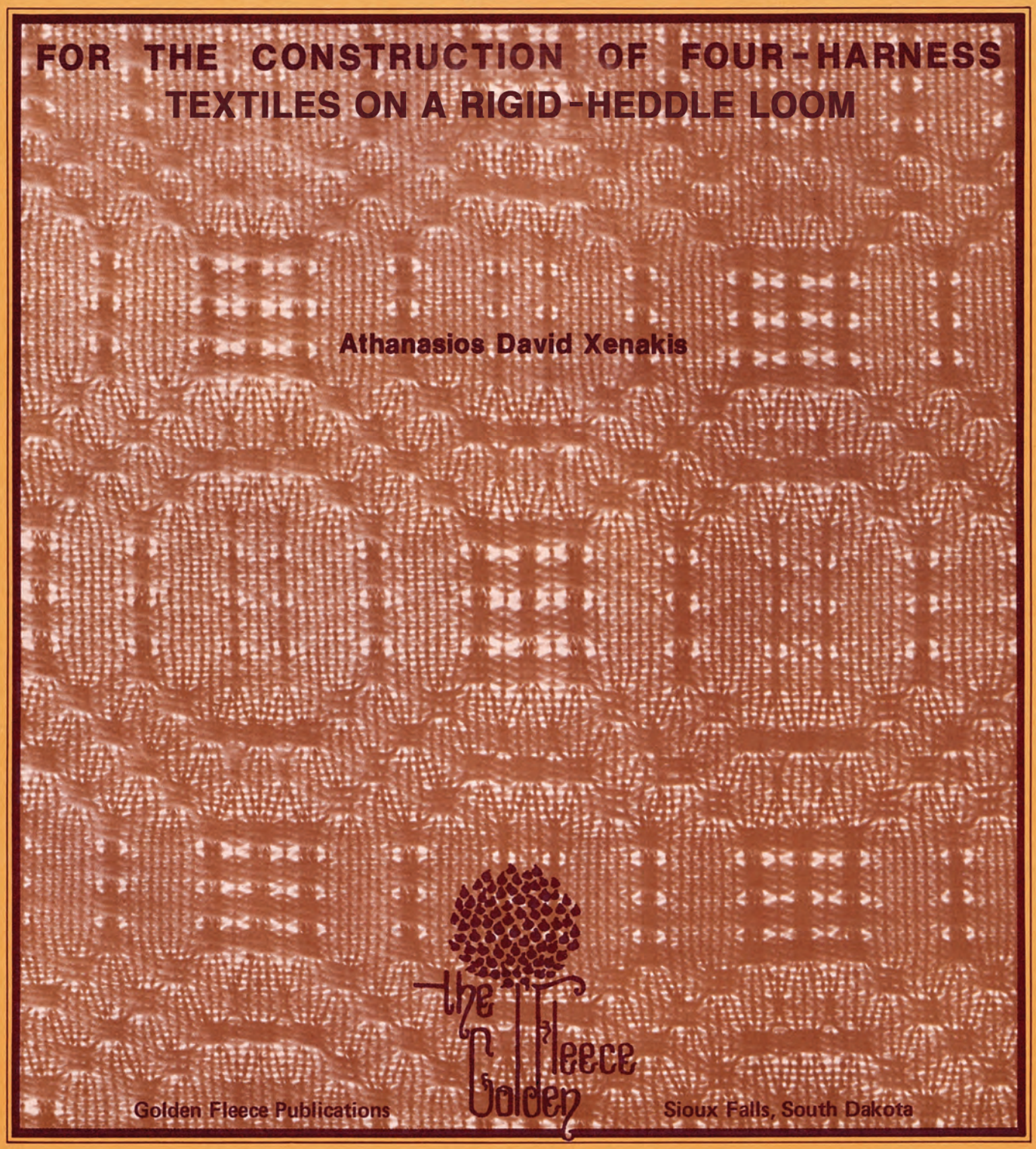
The Xenakis Technique

FOR THE CONSTRUCTION OF FOUR-HARNESS TEXTILES ON A RIGID-HEDDLE LOOM



Athanasios David Xenakis

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WITH NEW FOREWORD BY MADELYN VAN DER HOOGT

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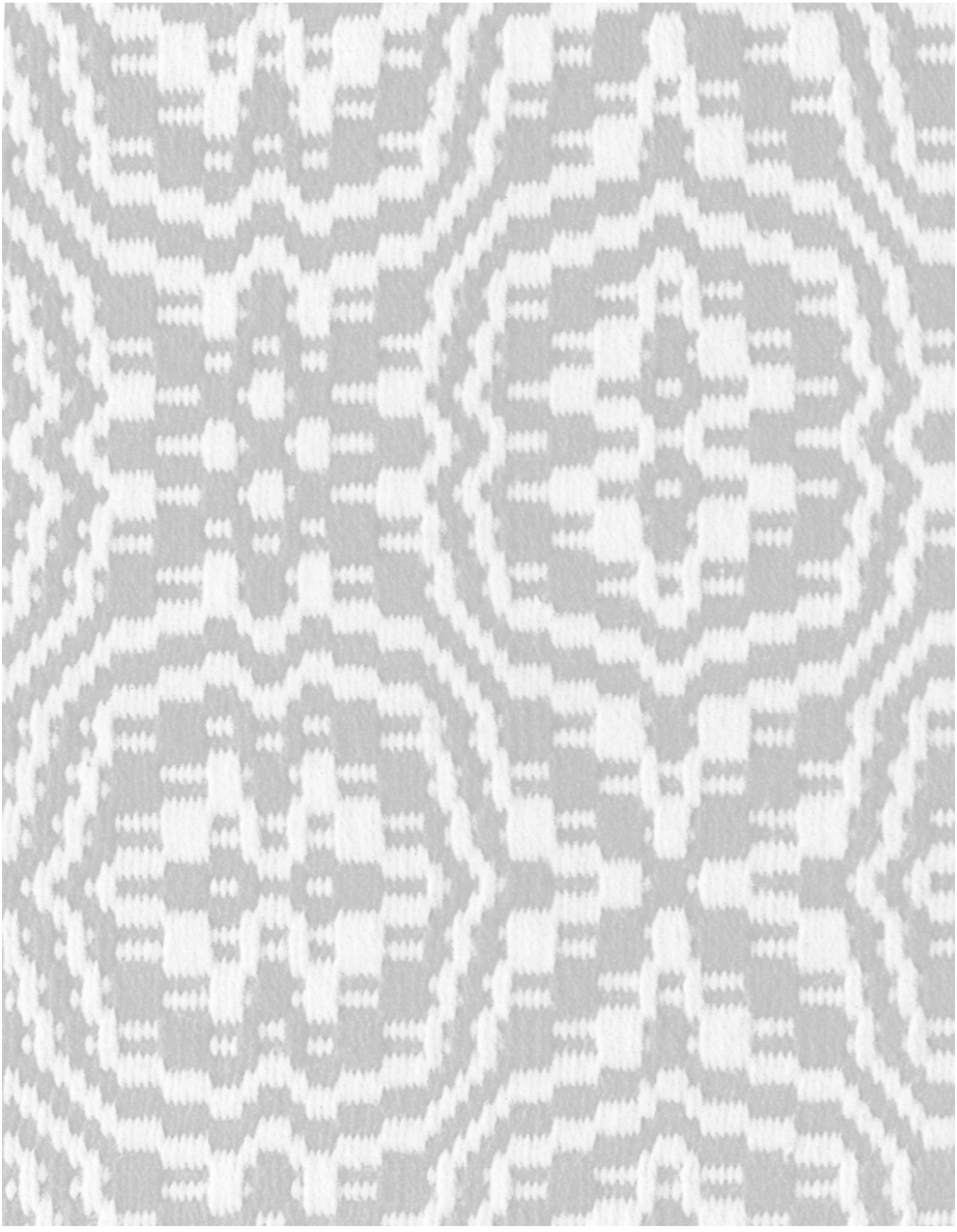
For Elaine and Alexis
And for Elizabeth Zimmermann,
who is a great inspiration for all of us.

Digital edition dedication:
For Madelyn van der Hoogt,
inspired teacher and inspiring friend!

With gratitude to my son, Benjamin,
for shepherding the digital
re-emergence of this book
into the world, and to his wife, Krista,
for her loving proofing
of its words.



Foreword

I met David Xenakis in 1984 at Convergence in Dallas. We had corresponded before that time because we were both members of the Complex Weavers. In those pre-internet years, the Complex Weavers printed a yearly membership booklet that listed every member's address, telephone number, and the looms each of us had (the most important entry). David was listed as having a 12-shaft Glimåkra loom. I was having trouble figuring out how to tie mine up, so I called his phone number. (This was before email and websites and all the miraculous ways you can find each other now. For me, isolated in rural Missouri with, I'm just now remembering, a four-party telephone line, it was nothing short of miraculous to be able to find and talk to another weaver with a problem like mine.)

The late 1970s and early 1980s were a period of great growth in the weaving world. While David was experimenting on the rigid-heddle loom, in the shaft-loom world a lot was happening. Loom manufacturers abounded, drawlooms and dobby looms appeared along with computer weaving programs followed by computer dobbies, and finally even jacquard looms became available to handweavers.

David has a way of understanding how things work that goes beyond words. I remember that he once said to me: "Most of what is in my head is not in words." I cannot even relate to that sentence. Nothing is in my head that isn't in words. David understood how the countermarch system worked and in my first months of knowing him, he taught me how to achieve clean sheds (along with the "why" everything happened). From that time on, I have been learning from him. While he was creating four-shaft structures on the rigid-heddle loom, he was also weaving on shaft looms (lampas, piqué, and more), eventually creating magnificent damask patterns on a drawloom. There are similarities between the patterning methods on a drawloom (one of the most complex looms available to handweavers) and on the rigid-heddle loom (one of the simplest). The slots and long-eyed heddles have much in common, all of which David understood.

I knew all this vaguely, back in the 1980s, and I knew about the *Xenakis Technique for the Construction of Four-Harness Textiles*. I had always been awestruck by the pieces David wove on the rigid-heddle loom, but I was too busy getting looms with more shafts to pay enough attention to how he did them. It's only now, in seeing the revised version of his book and his revived love for the rigid-heddle loom, that I really understand how his three-heddle threading system works. With this book, you can take any four-shaft draft and simply substitute the rigid-heddle threading for each thread on shaft 1, 2, 3, or 4 to weave twills (2/2, 1/3, 3/1), overshot, crackle, Swedish lace, spot Bronson, two-block summer and winter, doubleweave, triple weave, and more.

It is not so easy to see how all this works in the abstract. You have to be able visualize what the slot and hole threads are doing in each of three heddles. It is *much* easier to see how it works by doing it. This book should live beside your rigid-heddle loom at all times. It will be your conversation with David as you work through the samples and the threading orders and the sheds become familiar. Your conversation with David will continue beyond this book since after his twenty-year sojourn into other areas of interest, he is back, he is weaving again, and he is be writing again—welcome to a rigid-heddle Renaissance!

Madelyn van der Hoogt

Athanasios David Xenakis with intermediate weaving class in classroom/showroom;
Golden Fleece, Sioux Falls, South Dakota.

From the Author

The words of Qoheleth, son of David, King of Jerusalem ... "Take anything of which it may be said, 'Look now, this is new'. Already long before our time, it existed. Only no memory remains of earlier times ... "

And so I firmly believe.

There is a commonality in the physical make-up of humans, a sameness of thought, and all are governed in their actions by simple and unalterable physical principles.

The artificer in fibers, for example, knows that regardless of the complexity of the structure he is fashioning, the basis for his structure — and all fiber craft — is the simple principle of friction resistance. Individual fiber against fiber, ply against ply, yarn against yarn. No useful textile may be constructed without that principle and often the excellence of a particular textile may represent an intimate recognition of the ways in which the principle operates.

For all that the recognition may be a sophisticated enunciation of modern physics, the neolithic woman plaiting her rush mats, the weaver of linens in ancient Egypt, the backstrap weaver of the Bedouins — all these have known it as well. Perhaps better, for survival has depended upon such excellences of recognition.

Throughout all of human history, the penetrating intelligence demanded of survivors, and the quest for beauty and excellence have been motive forces in the production of textiles. This production has occupied the talents, time, and ingenuity of countless millions for thousands upon thousands of years — even down to the present day.

Are there, then, artisans so vain that, in the face of this ancient tradition, they may say, "This thing is new."?

I am not so vain.

Yet, in a strange fashion, some forgotten thing has come to me. It is a useful technique for the production of any three-shaft or four-shaft textile on a rigid-heddle loom.

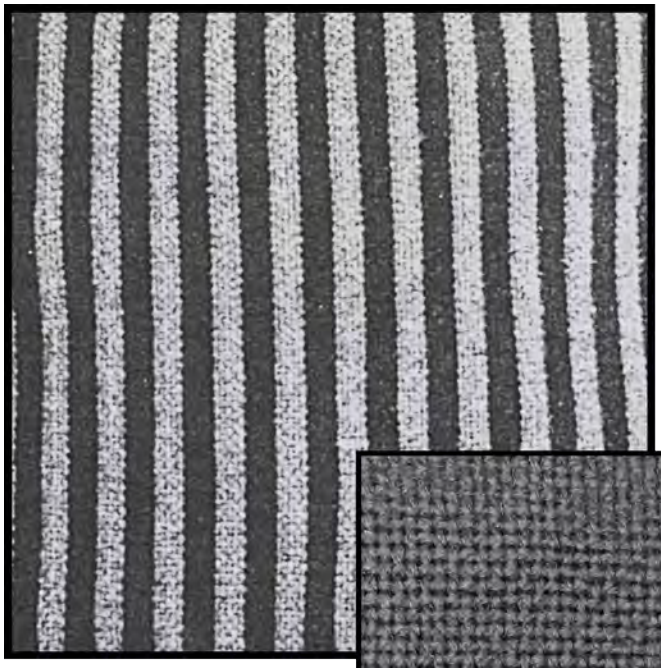
I shall not claim that the invention is my own, but I have rediscovered it from that place where forgotten things lie in wait. And I shall be so bold as to say that, having stumbled upon it, I did recognize it for what it was.

I have found no one who remembers such a technique nor have I found anyone who has heard of such a technique.

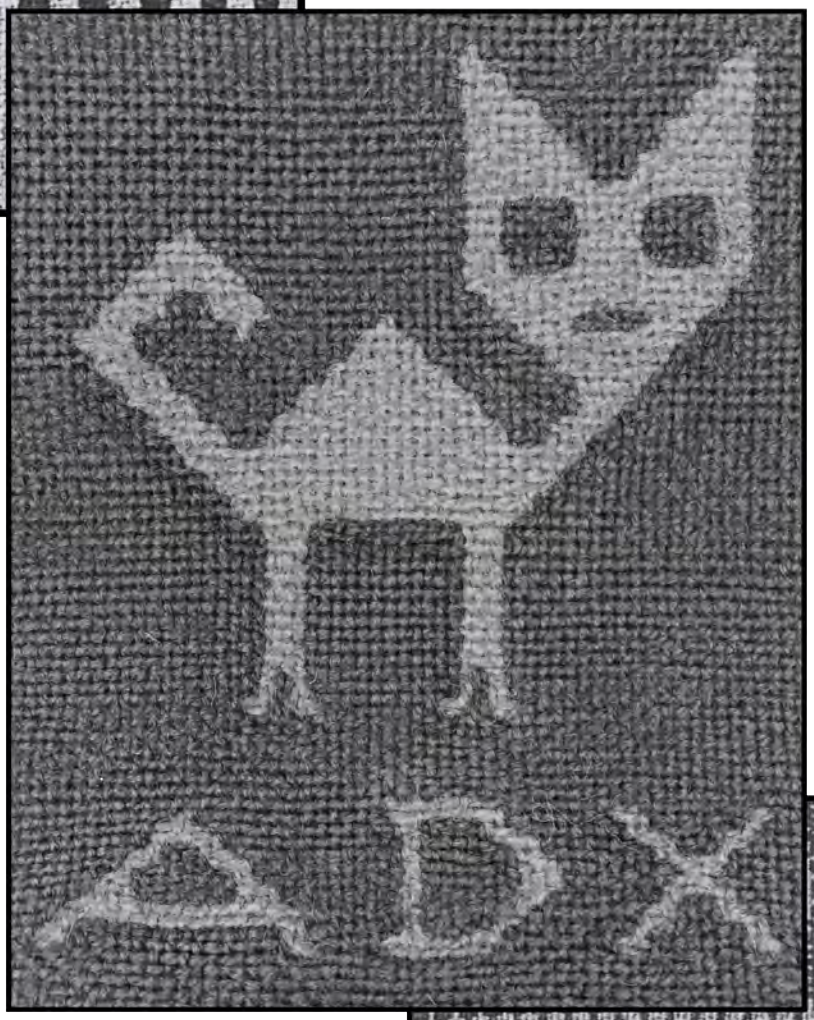
Therefore, after the fashion of an explorer who *discovers* a place that certainly managed to exist before its discovery, I place my name upon my *discovery*.

It shall be known as ***The Xenakis Technique for the Construction of Four-Harness Textiles on the Rigid-Heddle Loom*** until some future Dead Sea scroll will impart to us that Qoheleth's third wife was a famous weaver of coverlets on a loom with many slots and many holes.

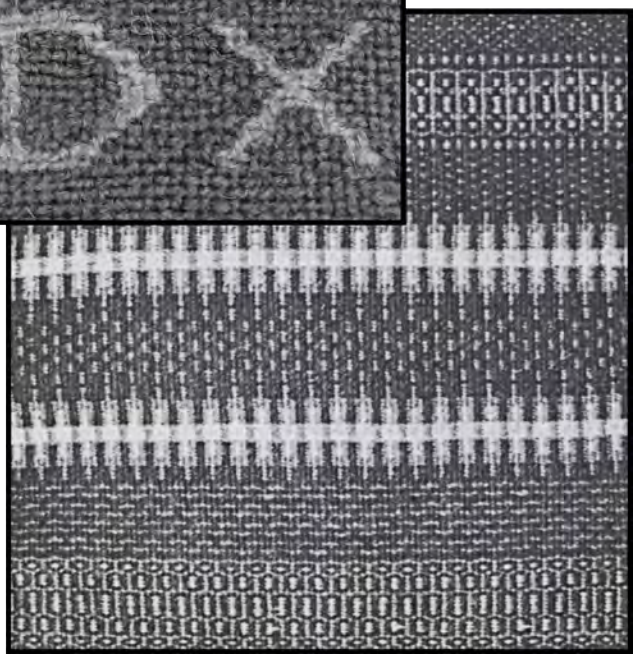
Athanasios David Xenakis
Beresford, South Dakota
February 6, 1978



Sofa pillow in Bedford Cord weave



Peruvian cat and author's initials in Finnweave technique



Floor pillow in Krokbragd

The Loom and the Technique

The rigid-heddle loom often appears to the non-weaver as a toy. A mechanism for weaving, to be sure, but not a grown-up loom.

In its simplest form and use it is merely a frame with the ingenious shedding device known as the rigid heddle. The rigid heddle is also referred to by weavers as the *reed*. The reason for this is that it performs the functions of both heddle and batten, and weavers, being human, tend to think of a thing in terms of what it momentarily does or in terms of its resemblance to some other thing.

Alternating threads of warp — also called *ends* — are threaded through the slots and holes of the rigid heddle. When the heddle is in its up position, the hole threads rise above the warp plane and create an opening between the layers of slot and hole threads. Through this opening, a weft yarn — also called a *pick* — is passed. The heddle is then lowered and used as a batten: it is drawn back against the weft yarn so that the weft lies at a perfect right angle to the warps. In so doing, the weft becomes the leading edge of the woven fabric which is known as the *fell*.

With the next step, the heddle is put into its down position. The slot threads are not influenced by the movement of the heddle. The hole threads sink below the warp plane and create another shed with, de facto, the slot threads as the rising warps. The weft is inserted into this new shed and *beaten* into position — parallel and close — to the first weft.

These two weft passes in continuous alternation produce the simplest and most stable of all weave structures, that known as plain weave, or *tabby*. The plain weave wefts pass over one warp then under one warp in the first weft row. In the next, the weft passes under the previous row's over and then over the previous row's under.

The way the weft yarn weaves is called the system of *interlacement* and the possible number of interlacements reaches maximum with these two weft passages. Thus, this simplest-to-produce of all weaves is, from a structural point-of-view, the most stable of all weaves. Each deviation from the 1/1 (over one, under one) system of interlacement means a lessening of structural stability.

Stability, however, is not always of primary importance in a loom-woven textile. A lessening of stability often can mean that a garment fabric will drape more gracefully than a plain weave. Fabrics other than plain weave can be made to wrinkle less easily. Yarns of all types may, in weaves other than plain weave, be displayed to better advantage. Moreover, the possibilities for patterning a plain weave textile, though very great in number, are enormously increased with a departure from plain weave.

The simple reason is that plain weave, as it is usually produced, is a two-warp-two-weft textile. Each alternate warp is either a #1 or #2 — an odd or an even, depending on where the counting starts — and each weft is also an odd or an even passing over all the #l's and under all the #2's or vice versa.

Suppose, for a moment, that the threads could be numbered in sets of four instead of pairs. The implication is that every other pair must be able to be handled in a different fashion than a simple up or down of the rigid heddle. If such a means were found, then the plain weave could still be woven if the four threads were numbered consecutively in an even-odd or odd-even series. If we suppose that the numbering would be 1-2-3-4, the most logical way to begin to think of four threads, then the plain weave would be woven by lifting the 1-3 combination in alternation with the 2-4 combination.

Other combinations occur in four-thread systems. Let us imagine that sheds could be produced by lifting all the #l's and #2's and allowing the weft to pass over the #3's and #4's. Or the reverse. Or perhaps all the #2's and #3's could be lifted to allow the weft to pass over all the #l's and #4's. Or the reverse. Perhaps these pairs of opposites could be lifted in other than an opposite order.

We may suppose, then, that in addition to these six two-thread combinations, we may lift in groups of three or singly. Each set of #l's, #2's, #3's, or #4's in the warp may be lifted alone. Or these groups: 1-2-3, 2-3-4, 1-3-4, & 1-2-4. We have, then, fourteen possible sheds brought into existence just by changing the abstract numbers of some of our warp yarns. If such things were only possible…

They are possible!

We shall, together, do such things and we shall do them, if my recommendation means anything, on a Beka Rigid-heddle Frame Loom manufactured by Beka, Inc., of St. Paul, Minnesota.

There are other looms. If you already own one, then you have this weaver's best wishes. It may be that you own a good one — there are other good ones — but the chances are that you have one that is not so good. In the world of rigid-heddle looms, unlike the world of rigid-heddle weavers, there are many more bad ones than good ones.

You may still weave but you may also have to resign yourself to inconvenience (at the very least) and to sore hands, wounded temper, and a good deal of frustration. All of these come to weavers who will insist on working with cheap, poorly designed, and poorly constructed equipment.

We won't dwell on what constitutes a good loom. I weave on a Beka Loom. I like my loom. It is well designed, well constructed, and very easy to use. I like it, I prefer it, I can in good conscience recommend it to you. Having, in my own mind, disposed of the matter, we will move on.

Threading the loom is next. So many people are frightened of this step.

How do you thread your loom? If you are a beginner and have answered my question with a blank or frightened stare, then please, **PLEASE** go find a weaver who will teach you to do it properly. Once it's been done a few times, dressing the loom — as it is called — becomes an Accomplishment and is no more frightening than learning to play a new piece on the piano.

Whatever system of threading or warping or dressing a loom is used, please bear in mind that more than one heddle will be used and that each thread of warp MUST be positioned precisely in all three heddles.

Yes, I did say three rigid heddles. We'll need, besides, the loom, three narrow pick-up sticks, several shuttles of the *poke* or *stick* type, and a crochet hook — or some such[1] — to draw (or *sley*) the warps through the openings in the heddles.

Three heddles — I should have mentioned that they need to be of identical size — are not really a necessity. A minimum of two is needed. You may, if you wish, read the rest of this section

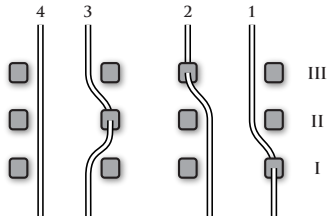
[1] **I have found that the best threading implement is a stainless steel hook from a knitting machine. Before using it, I twist off the small latchet. You may have to use a pliers to slightly narrow the height of the hook. You may also, if you wish, improvise a handle, but I haven't needed one so far.**

(reserving your judgment) before deciding that an alternative I shall mention later on is sufficiently unattractive to warrant the expenditure for the third heddle.

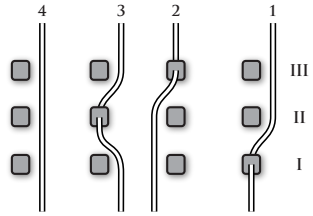
Two of the heddles will be used in the actual weaving or, more precisely, will be used in ways that are familiar. The third will remain in position next to the back beam to be used, either lifting or depressing, as an aid in forming the sheds.

First, it is good to understand that the three heddles, as they relate to the warps, are in absolute alignment. Peering through a slot of the first, daylight must be seen through the *same* slot in the second and third.

With this in mind, study carefully the drawing below.



The differences between the paths followed by each of the numbered warps are obvious. The warps may also be diagrammed this way:



Each way is equally correct. All that is needed is to understand that in all important respects, each way of showing the numbered warps is the same.

Fix the combinations firmly in mind. Heddles I, II, and III are arranged with I closest to the cloth beam, II in the middle, and III next to the warp beam.

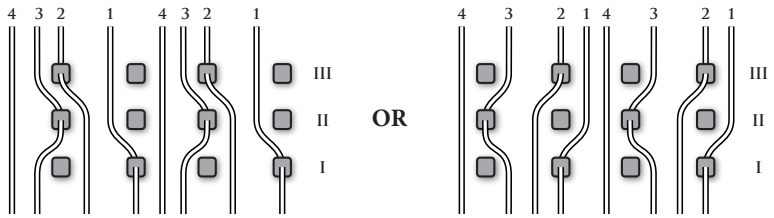
A #1 thread passes through a hole in heddle I and a slot — either to the right or the left — of the *same* hole in heddles II and III.

A #2 thread passes through slots in I and II and through a hole in III either to the right or left of the same slot as in I and II.

A #3 thread passes through a slot of heddle I, a hole — either to the right or the left of the same slot — in heddle II and the same slot in heddle III.

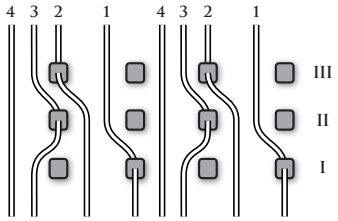
Thread #4 — which, if you are like me, you'll develop an odd attachment for — passes through the same slot in all three heddles.

A threading sequence of eight threads will, in 1-2-3-4 order, look like this:



If three 8-dent heddles (rigid heddles with openings for eight threads in every inch) were being used, these eight threads would comprise one inch of warp width; in three 10-dent heddles, 4/5's of an inch; and in three 12-dent heddles, 2/3's of an inch.

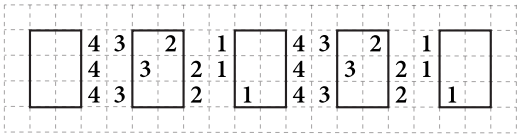
Although both of the previous threadings are workable — not much to prefer between them, really — The one below is probably the easiest, and it is probably most useful to concentrate on one. Please note that there are slight discrepancies in spacing. Looking at the front heddle, there is a single warp in the first slot on the right-hand side and a pair of warps in the slot to its left. This pattern is repeated in the other heddles but at an offset from the first. The net effect is that there are the same number of warps as there are slots and holes in *each* of the heddles.



The drawing is reasonably clear and could be used if only simple threadings are to be used, but when threadings later become more complex and involve hundreds of threads not necessarily in consecutive order, it will be useful to find some way to eliminate the need to draw the many needed holes and wavy lines.

We can use squared paper and impose a system of writing our threading drafts. First draw upon the paper a set of horizontally arranged boxes, each two squares wide and three squares tall and separated from each other by a space of equal size.

Each box of 2 x 3 will represent a hole — the *same* hole — in all three heddles. Each space between the boxes represents a slot in all three. Each horizontal row — though two spaces wide per slot and hole for convenience in writing when one or the other is shared by two warps — is one heddle. The boxes and the spaces between them are three rows high and so represent all the heddles. Using these boxes, we may write a draft of the example above as follows:

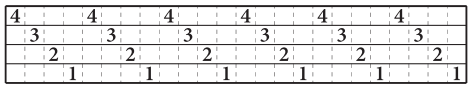


Read each from right to left and compare this simplified draft with the drawings at the top of the page. You should be able to see that they are the same. With practice in using this method, you will be able to see the path taken by each warp through the heddles at a glance.

To avoid confusion, remember to read from right to left and do keep in mind that on our written draft, as in our weaving, warp threads never, NEVER cross each other.

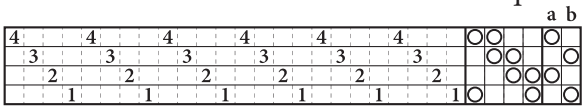
With that thought held firmly in mind, we'll wind a sample warp. Let us, for the purpose of learning this new technique, wind a small warp of 48, 60, or 72 threads — six inches width in, respectively, 8-dent, 10-dent, or 12-dent heddles — and approximately one-and-a-half yards long. Thread the warp through the center six inches of three identical rigid heddles using the threading shown above. Thread in 1-2-3-4 order over and over again until all threads are in place. Then beam the warp and attach the warps in some fashion to the front beam.

We are threaded in 1-2-3-4 order. On a four-shaft loom draft, our 1-2-3-4 (which is called a *straight-draw threading*) would look like this:



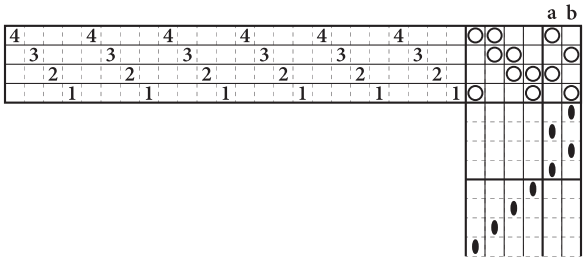
Each horizontal space represents a shaft (referred to in older terminology as a *harness*[§]) which is a horizontal frame with string or wire heddles held between the horizontal legs of the frame. The eye of this heddle holds the warp thread (in exactly the same way that the holes of a rigid heddle hold the warp threads) and successive l's, 2's, 3's, and 4's are in the eyes of heddles on each shaft. A warp thread is threaded through one heddle only and when a shaft is raised, all the threads held by heddles on that shaft rise. When two or more shafts are raised together, all threads on those shafts rise.

At the right (usually) of the threading draft for a shaft loom is a box ruled into squares with circles in some of them This is called the *tie-up*.



Each vertical set of four boxes represents a combination of shafts — or a single shaft — to be lifted. Reading from the right, the first vertical set directs a lift of shafts 1 & 3. The second set directs a lift of 2 & 4, the third 1 & 2, then 2 & 3, etc.

Below, (usually) this combination of lifts are a set of vertical ruled lines giving a set of vertical spaces aligned with the vertical sets in the tie-up box. The vertical spaces have marks in them.



These marks, read from top to bottom (sometimes from bottom to top), indicate the order of the lifts. In the drawing above, the direction calls for the lifting first of 1-3, then 2-4, followed by 1-3, 2-4, 1-2, 2-3, 3-4, and 1-4.

The marks mean, simply, that at any given mark, only the shafts designated in the tie-up box directly above are being lifted.

The first four lifts, assuming the threading to be in 1-2-3-4 order, are our old friends the odds and the evens. A plain weave or tabby fabric would result from repeating those lifts.

Since this means of representing a sequence of lifted threads is in common use, we also will use it but remembering only that our rigid-heddle weaving resembles shaft-loom weaving only in that we are manipulating threads in a numbering system of four. All else being equal, we may not call our weaving *four-shaft* since we have no shafts. ***Construction of four-shaft textiles*** is the closest I've come to an accurate description. Perhaps you'll think of a better one. I hope so: the preposterous name I awarded the technique in the Title and Foreword to this book lacks grace and has to recommend it only its clinical accuracy. Though now I think of it, *four-harness* isn't exactly poetic and sounds more a description of the hitching of horses to a wagon.

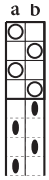
This sequence of lifts below the tie-up box is, by the way, called the *treadling order*. Shaft-loom weavers get their lower extremities into the act by using their feet to push down on levers — or treadles — in the bottom of the loom any one of which can be *tied-up* to lift one or more shafts and thus freeing their

[§] **When this book was written in 1977-1978, *harness* was a common usage. Since that time, the prevailing terminology has come to prefer *shaft* as a more useful term for the heddle frames of a traditional loom. In revising this book for digital realization, the term *shaft* has been substituted for previous instances of *harness* — except for the book's title and a few other places where the change would be awkward.**

hands and minds for, one assumes, the contemplation of higher things.

We, with our rigid heddles in position, must pay attention to what we are doing if we are not to end as the absent-minded shaft-loom weaver who raised all the shafts and wound up with the shuttle in his lap.

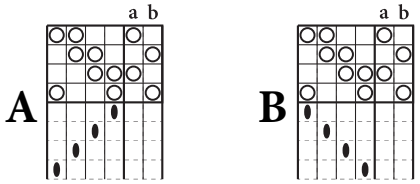
For our first tie-up sequence, let us assume that a heading has already been woven on our sample warp in plain weave and that the alternating lifts of 1-3 and 2-4 have already been discovered to happen by using heddles I and II as one unit in the normal up and down positions. If our assumption is correct, then we will have woven:



Over-Two-Under-Two Twill

Next, we will weave a series of four lifts that will give us the 2/2 twill weave. 2/2 twill is so called because the weft, in every row, passes over two warps and under two warps across. However, it does not cross the same two every time. There is a sideways shift (of the over-two-under-two sequence) of one warp with each succeeding weft pass.

This tie-up gives us the other four warp pairings besides the tabby pairs. The tie-up is standard — you'll soon recognize it as clearly as Constantine recognized the *Chi-Rho* in the sky·



Woven in **A** order (above), weave as follows (Note that if you start weaving on the left with lift order **A**, your weft will be caught by the edge warp every time❧):

1-2 lift: Lift up on heddle III and insert a stick beneath the III threads (the stick is inserted just in front of heddle III but behind heddles I and II). Release heddle III (now push it, and the stick, to the back and out of the way). Place heddle II in *rest* position (suspended on the warp just behind the heddle blocks). Place heddle I on top of the blocks — toward the back of the block — and bring the stick up behind heddle II. Watch the warps that rise as the stick comes up behind heddle II: your shuttle will pass under them. Weave. Push the stick to the back and out of the way.

2-3 lift: Place heddle I in neutral position in front of the heddle blocks. Place heddle II atop the blocks — toward the front of the blocks — and slide the stick forward to just behind the blocks. Weave, and remove the pickup stick.

3-4 lift: Place heddles I & II in neutral position in front of the blocks and bring heddle III forward. Push down lightly on all three heddles. Working just behind the heddle blocks and in front of heddle III, slide a stick under the warps that remain up. You'll see them easily since they are the only warps that are not controlled by the three heddles. Push heddle III and the stick to the back. Now, place heddle II atop the blocks, bring the stick forward. Watch the warps that rise as the stick comes up behind heddle II: your shuttle will pass under them. Weave. Push the stick to the back and out of the way.

1-4 lift: Place heddle I atop the blocks — toward the back of the blocks — bring the stick forward. Weave. Push the stick to the back and out of the way.

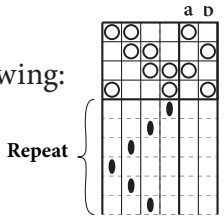
❧ **When the sequence of lifts gives you a shed where the weft from the preceding pick will not catch the edge thread, it may be necessary for you to pass the shuttle between the two edge threads manually. In other words, you may have to manually lift the edge and cause the shuttle to go beneath, or you may have to slightly depress the edge warp in order to have the shuttle pass over it.**

You should see, now, a series of little floats over two warps angling up to the left. Were we purists, we would call our twill in writing 2\2 twill with the slash indicating the direction of the twill diagonal.

Repeat these four lifts continuously and the slant will continue to angle to the upper left. If you weave in the **B** order (opposite page),the slant will reverse (2/2 twill).

Handweavers have traditionally woven their twills to the left and power looms to the right though why this should be, I have no idea.

Having mastered both sequences, try out the following:



Here you have zigs and zags. And, belying the commonness of its use, an attractive, useful, and satisfying weave. In some ways, this back-and-forth structure of the twill is more fun to do since you can leave the sticks in for three picks as the twill changes direction.

You will have noticed that, at the point of change there is no duplication of the 1-4 lift, or, later, the 1-2 lift. When more than one repeat of the sequence is woven, the 1-2 and 1-4 lifts are shared by the two lifts above and below them. Once in a while, a pattern — for a certain effect — will direct that these two *pivot* points be duplicated. You may try it if you wish but on our sample warp, the result is very liable to look like an error across the width of the fabric.

Probably nothing is ever truly an error. Just as this special effect can be useful, it is worthwhile to note that an error — in the words of America's premier knitter-designer, the late Elizabeth Zimmermann — when repeated, becomes a pattern. Which, were one of a philosophical turn of mind, might be the key to whole new vistas of thought. Think about it: at the very least, the regular repetition of an error indicates persistence.

Your pardon, a freely associating mind hath led us astray.

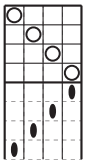
Over-Three-Under-One Twill

There are two other kinds of twill possible with four-thread manipulation. These are the 1/3 and 3/1 twill. The numbers indicate, respectively, over-one-under-three and over-three-under-one, with the same sideways shift by one warp in succeeding weft rows.

2/2 twill, as might be imagined, looks the same on both sides of the fabric and so is called a balanced twill. 1/3 and 3/1 twill, being but two ways of describing the same kind of interlacement (if a 3/1 twill fabric is turned over, a 1/3 twill is seen on the other side), are both unbalanced twills with a strong weft emphasis on the side with the float over three warps and an equally strong warp emphasis on the reverse side of the fabric. Neither twill in its pure form is particularly stable and an all-over fabric will have a tendency to curl. The curl will be *selvedge*[1] toward selvedge with the weft-dominant side tending to concave.

There are ways to counteract any drawbacks in the fabric and we will discuss some of those later in this book. In the meantime, they'll do little harm to the little warp upon which we are working such wonders.

The 3/1 twill is the simpler of the two weaves to accomplish on a rigid-heddle loom and uses the following tie-up and lift sequence:



[1] **The edge of your weaving, the place where the weft turns.**

Over-Three-Under-One Twill

In the first shed, all of the #l's are lifted. In the next, all the #2's, etc.

Weave as follows:

Lift 1: Place heddle I atop the shed block. Weave.

Lift 2: Place heddles I & II in neutral position just in front of the shed block. Place heddle III atop the shed block. Weave.

Lift 3: Place heddle II atop the shed block. Weave.

Lift 4: Place all three heddles beneath the shed blocks. Weave.

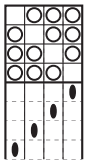
Having repeated the sequence of lifts several more times, a heavier looking twill has formed.

I like this one. It's fun to weave: the sheds are easy to find, the floats over 3 are big and easy to see, and the only problem you might have is a tendency to beat just a bit too hard. Be gentle with this one until you can make the twill lines run up a perfect 45° angle.

This twill also angles up to the left unless the lifts are made in reverse order.

Over-One-Under-Three Twill

The last of the four-shaft twills, the 1/3 twill, uses the following tie-up and treadling sequence:



The lifts are made in groups of three. You know all of these already, do you not? Each group of three is simply a group of two plus one more. For the trepid among us, we'll give directions.

Lift 2-3-4: Place heddles II and III in neutral position behind the shed blocks and push them back. Place heddle I beneath the shed blocks. Weave.

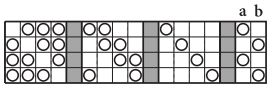
Lift 1-3-4: Place heddles I and II in neutral position in front of the shed blocks (you may need to manually support them). Place heddle III beneath the shed blocks. Weave.

Lift 1-2-4: Place heddle I in neutral position in front of the shed blocks (push heddle III back as far as it will go). Place heddle II beneath the shed blocks. Weave.

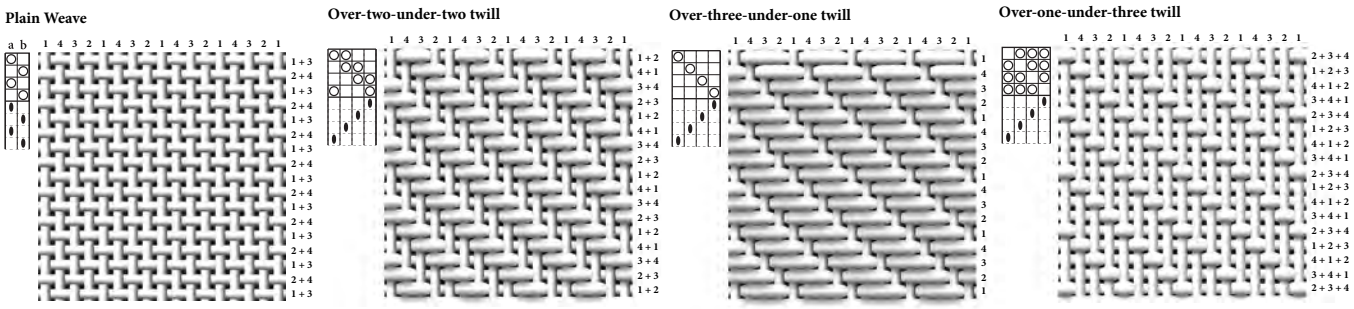
Lift 1-2-3: Place heddles I, II, and III atop the shed blocks. Weave.

These four lifts, in order, again produce a left-slant twill and may be woven in reverse sequence to reverse the twill line.

If we were to make a listing in tie-up form of what we are now able to do with four threads, it would look like this:



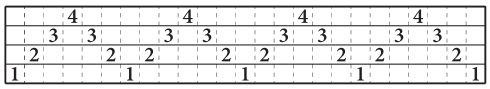
In terms of the primary fabric types, these are the four basics: they are plain weave and the three twills. Here are drawn representations of the four:



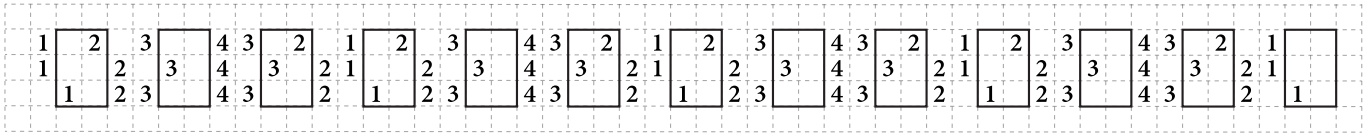
There are fourteen lifts relevant to four-shaft textiles. No more, no fewer.

What is important to know is that, no matter how the loom is threaded, the mechanical operations for lifting the numbered threads remain the same. The loom may be threaded, say, 1-2-1-4-1-2-1 instead of 1-2-3-4 and the same sheds result with the important consideration that the woven fabric may or may not be a twill or even a plain weave. That consideration gives us a wonderful freedom for we are able to infinitely vary our threading. The combination of these two aspects plus a third — the lift sequence — has, then, at a single stroke, transformed our simple two-way loom into a marvelously complex and sophisticated device.

We need not thread our loom consecutively. This threading, for example, which contains the pivot feature we met in our previous acquaintance with lift sequences, could be written for four-shaft loom:



and threaded in our three rigid heddles this way:



With what results?

We know that a 1-2-3-4 threading woven in the 2/2 twill sequence that begins with the 1-2 lift produces a left-slanting twill line. We could reason that since a reversal of the lifting order reverses the twill slant, a reversal in the threading would accomplish the same thing.

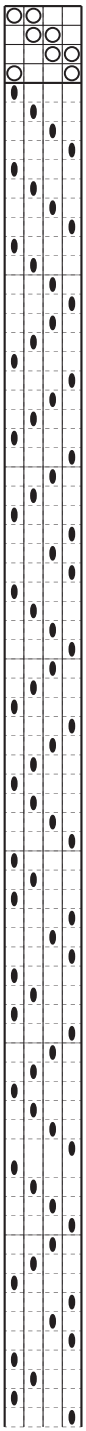
But there are two *directions* in the same threading. And, amazingly, by lifting in the normal 2/2 twill sequence, the twill lines will run in two directions. A reversal of the lifting sequence will reverse both directions and give us the miracle of a series of little diamonds.

It is not quite magic but it is a piece of legerdemain that will, if your first diamond twill is at hand in the form of a small sample, delight you. I promise it!

Woolen scarf, solid weft-faced bands on both sides woven in Moorman technique (see Bibliography)

Woolen scarf, extended point twill detail

Woolen scarf in stitched double plain weave



And, as yet, we've only considered the normal lift sequence and its reverse. What if we lifted in the complex sequence shown in the left margin of this page? We would have small, medium, and large-sized diamonds all at once.

May I wager that, on the longest warp your loom will hold, you could not exhaust the possibilities inherent in this one threading and our sequence of lifts and their reverse order? Your pardon: the wager was sneaky and I shall not hold you to it, for the exhaustion is not possible. The time has not yet come in all of human history when no more possibilities were left to try. Which is not to say that you should spend an inordinate amount of time being awed by the size of the number of permutations. We daily live on the edge of such infinities, do we not? In weaving as in, say, chemistry, there are hundreds of easily recalled situations which lead to numbers larger than the mind can grasp.

The very subject of twills is so large that I intend, forthwith, to cease any attempt to deal with it. Further information on twills and their structure must be sought in one of the excellent books in the bibliography of this book. I have marked with an * those which I consider vital to any serious handweaver. May you receive from their authors as much valuable instruction as I have!

As a matter of fact, now that you are properly introduced to the simple mechanics of four-shaft textiles, a great many books that formerly were not relevant to you as a rigid-heddle frame loom weaver are now within your scope and use.

There are a few limitations which I'll attempt to summarize as they pertain to this technique.

First is the matter of heddle cost. Three rigid heddles — or two more than you probably purchased with your loom — are expensive. Not so expensive by any appreciable factor as even the smallest four-shaft loom, but more expensive than none at all. Yet, for that relatively small cost, a great world of weaving becomes available which almost makes the cost unworthy of mention.

As a matter of fact, there is a method of getting by with only two rigid heddles . You'll recall I mentioned it early on?

Heddle III can be replaced with a stick and a set of string heddles of the doupe variety. These doupe heddles can be tied and inserted for a bare fraction of the cost of a rigid heddle. It is a perfectly serviceable way of handling threads and is the same shedding mechanism used on less developed looms of, say, the backstrap type. Any book with information on that kind of loom will show how the technique is used. Doupes and stick function as well as a rigid heddle but are not, in my mind, as easy to use. Moreover, a tidy, threaded loom with rigid heddles or shafts is a lovely thing and I find the sight of this stringy paraphernalia unappetizing.

Please do not misunderstand. Lacking a third rigid heddle, I would use the stick and doupes without hesitation and appetizing be damned. But since there has been, thus far, no need…

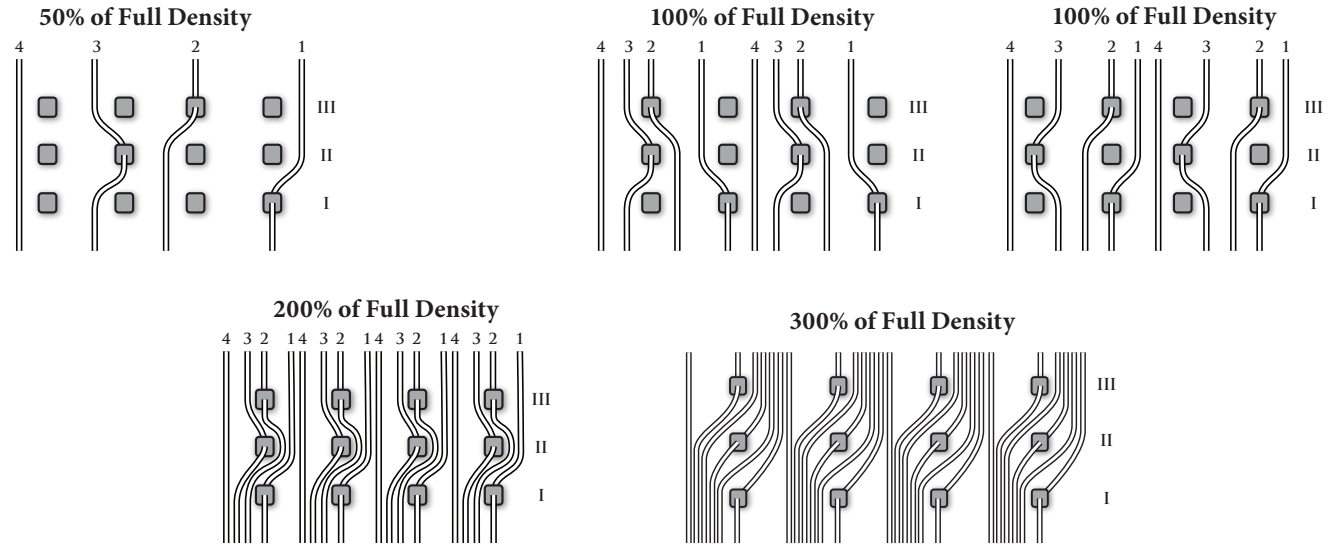
Here are some thoughts on the speed of fabric production. This technique will feel awkward to you at first — what new thing doesn't? — but a remarkable facility will come with very little practice.

Yes, of course it is slower to weave on a rigid-heddle loom than on a shaft loom. But after all, it is *not* a shaft loom. It was never intended to be a shaft loom and it never will be. A dedicated frame loom weaver from South Dakota has managed to work out a method of weaving four-shaft textiles on the frame loom, and we shouldn't expect the dear loom to be more than it is.

If speed of production is important to you, then the rigid-heddle frame is probably not the loom for you. But do, please, be prepared for a comparatively major economic outlay. My grandmother used often to say that one receives just what one pays for. If speed is desired, then speed will be paid for. Nothing wrong with it, just be prepared.

The most important limitation is a technical one and has to do with warp density, or the number of warps threaded through the rigid heddle in a given width.

This very important consideration is usually expressed as, say 10 EPI or *ends per inch*. There are, at the time of this writing❧, two sizes of rigid heddle available from Beka, Inc.: a No. 8 and a No. 10. Using two together in our normal straight draw threading, we can thread, essentially, 4 EPI or 5 EPI (or half the filled density of one heddle of the size being used) in each of heddles I and II for an effective overall density of 8 EPI or 10 EPI as this drawing of 100% of Full Density shows:



We can also halve that to achieve one-quarter of each density and by using two heddles, achieve 50% of full density for both (upper left of drawing).

Using more than one heddle will also allow us to achieve 200% density, and with three heddles, it is even possible to thread 300% density. With an injudicious choice of warp and weft yarn size, there is a tendency, in these more crowded threadings, for the areas with three warps in a slot to look too much squeezed together. But with care, with consideration for yarn size, and with proper washing and finishing, the crowded effect disappears.

❧ **When this book was written in 1977-1978, the Beka Looms, Inc. company of St. Paul, MN, (with whom the author was closely associated, and who later served as distributors for the first printing of *The Xenakis Technique*) sold a very limited range of loom sizes and heddle densities. To the original 8 EPI and 10 EPI models were later added a 12 EPI. This greatly assisted in being able to use many more kinds and sizes of yarns. Within a few years of this book's appearance, several loom companies, most notably the Willow Tree Loom Company of Lincoln, AK, began manufacturing their Gypsy Moth series of looms, larger looms on floor stands with a beater assembly containing a reed, and heddles made of wooden frames on which were stretched short-length TexSolv heddles. Such a construction solved forever the problem of limited densities on a rigid-heddle loom. It should be noted that these were no longer rigid-heddle looms in the strictest sense of the term, but the shedding mechanism was no longer static with respect to warp density. The only change was that the beating mechanism was transferred to a steel reed instead of to the *rigid* heddle.**

There are other things to be considered about these two greater density threadings: they are at their maximum efficiency in a straight-draw threading. The introduction of a point threading means that, due to the presence of the pivot thread, the overall density is reduced by one thread for every point of reversal. Thus, if there were two pivot threads in a group of twenty (or one inch worth in two #10 heddles), the warp density in that inch would be reduced to 18 EPI.

This seems to me to be a useful device for the weaving of finer tabby fabrics and for slightly heavier herringbone weaves and diamond twills. But twill diamonds and herringbones, beautiful weaves of themselves, are not always wanted. Also, by extending this point-threading principle a bit further as it applies to the maximum density threadings, it can be seen that twill skip blocks (used in overshot weaving which will be covered later in this book) are pretty much out of the question unless a fabric of greatly mixed densities is wanted. It is impossible to thread, say, a 1-2-1-2-1-2-1-2 combination at a density greater than the filled density of one of the rigid heddles being used.

A third consideration has to do with threadings of the three-shaft type. (We'll deal with three-shaft weaves later.)

A three-shaft straight-draw threading would be 1-2-3-1-2-3. Its most efficient threadings, due to the absence of the #4 thread, are either 75% of the filled density of one of the heddles being used, or twice that (150%). These percentages would give, then, warp densities of 6 EPI and 12 EPI in a No. 8 heddle and 7.5 EPI (actually 7 EPI in one inch and 8 EPI in the next) and 15 EPI in a No. 10 heddle. Normal 8 and 10 EPI threading densities are also possible but require that the count be made over a two-inch space and divided in half.

12 and 15 EPI would be extraordinarily useful densities but there is a drawback. On a three-shaft straight-draw threading, simple tabby is not possible. These useful densities must, then, be limited to three-shaft weaves.

A three-shaft point threading (1-2-3-2-1-2-3-2) can be threaded to maximum density with ease, or it may be threaded to the normal density of the size heddle being used. Three-shaft point threadings are extremely useful for some weaves and the simple tabby may be woven since every other thread is an even or an odd.

Lesser densities are possibilities for weft-face weaves (weaves in which the warp is completely covered by the weft) and for the weaving of bulky yarns. 5 EPI is possible using two No. 10 heddles. 4 EPI and 6 EPI in two No. 8 heddles are good for bulky yarns since the holes in a No. 10 heddle are too small for bulky yarns.

Having examined the possibilities at hand and several possible solutions — all of which seem to be less than ideal — let us pretend to philosophical fortitude and accept the fact that we may weave on warp densities of 4, 5, 6, 8, 10, 16, and 20 EPI❧ with more or less success and on other densities for special purposes. Having accepted this, our marvelous creativities will have received a resounding swat on the *derriere* and will rise to the challenge of creativity within given parameters. Perhaps 'twere best so: undisciplined art is, at best, disturbing and at worst, meretricious.

❧ **To these numbers may now be added the possibilities inherent in a 12 EPI rigid-heddle.**

For all weave structures, the size of yarn is of paramount importance and particularly so given the limitations with which we are faced on the rigid-heddle loom.

Do you know how to determine whether a yarn will work well at a given density in 50-50 — weft shots equal warp density — plain weave?

Take the yarn and wind it around a ruler. The number of times it will wind around half an inch is a rule of thumb for the density of an inch of warp in the heddle. Half an inch?

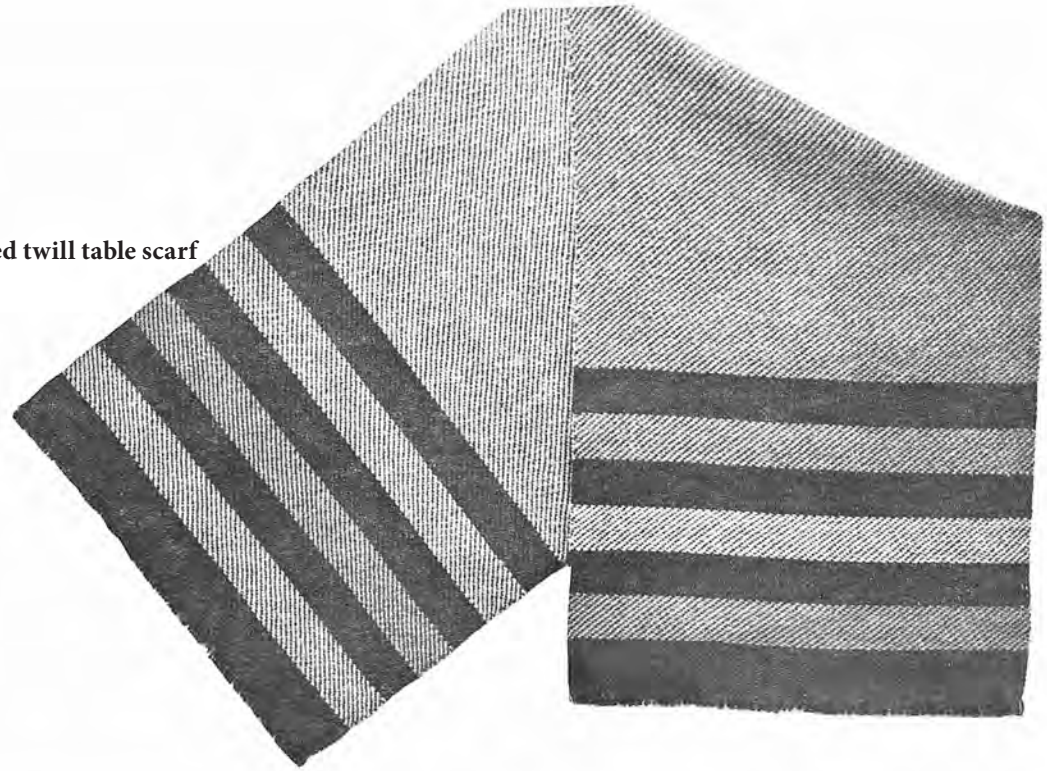
Quite so. In this warp cross-section drawing, from dotted line to dotted line, the weft (which we'll assume to be the same size yarn as the warp) passed through the warp plane — or *interlaced* — exactly four times (which is same number of warps). The warps, to accommodate the weft, need to have between them a minimum space equal to the size of one weft. If the yarn wound around the ruler four times in one-half inch, then the remaining half inch can be assumed to have been an accounting for the size of the weft yarns. If it happens that the warp and weft yarns are of a different size, the same principle can be extended by winding one of each yarn to be used together around the ruler for the full inch.

The principle can be further extended to take into account different systems of interlacement.

Take, for example, this drawing of 2/2 twill. From dotted line to dotted line, the twill weft interlaced only twice as opposed to four times in plain weave. Thus, the warps in a 2/2 twill can be set closer together by 50% than the plain weave warp assuming the yarns to be the same size as they were for the plain weave.

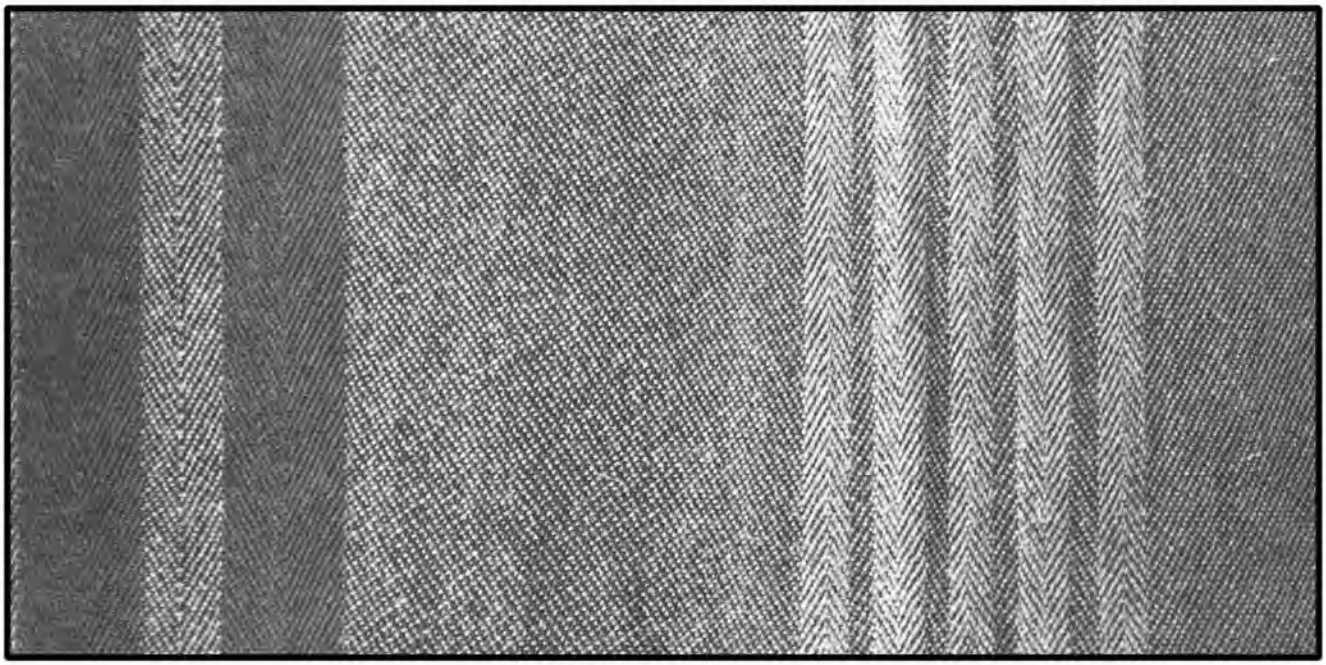
These are simple rules of thumb and fairly workable. There are the usual number of exceptions to the rules of which only experience can bring knowledge. Even so, you'll find that you gain that experience rapidly.

Plain weaves can be woven more openly than the method just described would seem to indicate but, though yarn is compressible — some yarns more than others — textiles are seldom as pleasing if they are woven too closely. Those words *too closely* have a variety of meanings to a variety of people. Close in a linen place mat is more acceptable than close in a woolen scarf. It all, you see, depends upon personal taste and the use for which the textile is intended. So, let your intelligence and good taste guide you and, for heaven's sake, force yourself to weave a small sample before committing yourself to a warp that will not give you anything but unpleasantness, an unsatisfactory fabric, and the waste of perfectly good yarns.



Three-shaft double-faced twill table scarf

Three-shaft twill table scarf showing bands of 2/1 and 1/2 twill

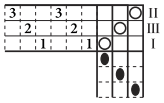


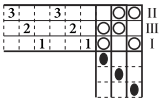
II. The Weaves and the Weaver

Up to this point, we have not discussed textiles constructed on three shafts. Handweavers, for reasons having to do with a commonly used loom called the *counterbalanced*, have not seemed much inclined to use the major three-shaft weaves.

There are, on three shafts, two possible twills. These are the 2/1 and its upside-down version, the 1/2. Both of these surround us — literally! — for it is the 2/1 twill that is called the *jeans* twill and is the weave structure commonly used for cotton denim.

These twills both have some of the disadvantages of the 1/3 & 3/1 twills. They are unbalanced weaves making them problematic on a counterbalanced loom, having a tendency to curl until they are finished. The threading is 1-2-3 in straight-draw order.

The lifts for 2/1 twill are: 

The lifts for 1/2 twill are: 

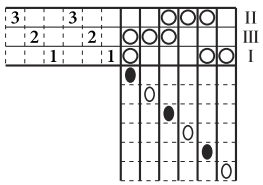
An interesting aspect of these weaves on a rigid-heddle loom is that heddle III is not necessary. After threading heddles I and II in the usual way, and before beginning to weave, place both heddles beneath the shed blocks and insert a stick behind heddle II under the No. 2 threads (the 2's are the only slot threads in the sequence and will be the only threads up when heddles I and II are down). During the weaving, the combination of this stick and the two heddles will give all six of the lifts quite easily.

A point threading (1-2-3-2-1-2-3-2-1) may also be used in these weaves and with the same lifts. Note that in a point threading, true plain weave may be woven in the usual way since every other thread is either an odd (1 or 3) or an even (2). The straight-draw threading produces, when handling the heddles in the way usual for a tabby weave on four shafts, an odd over-two-under-one in one weft row and over-one-under-two in the next. It is not a tabby weave and the 1 and 3 threads will *rib* together. The fabric is not unpleasant but could as easily be produced with one heddle by simply omitting threads from the usual slot-hole sequence.

> *(Had you always thought of that as an error? If so, pretend great wisdom in the face of all critics and tell them that you were REALLY weaving a three-shaft rib weave with one rigid heddle. Your erudition will astound, your technical skill and ingenuity will be a source of amazement to all.)*

There is a lovely weft-faced weave from, tradition has it, Norway, which uses a three-shaft point threading and the 1/2 twill lifts. The weave is called *Krokbragd* and the use of several colors in several sequences will produce intricate color patterns of great charm. For details of this weave, I refer you to *The Techniques of Rug Weaving* by the brilliant British author-weaver Peter Collingwood.

Another dazzling effect (to weaver and non-weaver alike) that can be achieved with the six lifts and a straight-draw threading is the double-faced three-shaft twill. Thread in the normal way using a slightly more open sett. Then, using two colors of weft (shown as dark and light oval symbols in the drawing below), lift in the following sequence:



Beaten properly, a fabric with each side showing the floats of a 2/1 twill and one side showing a different color than the other is the result. As Mary Atwater observed, "This always causes much excitement."

The variety of the four-shaft weaves always leaves me a little bewildered and wondering where I should begin. There is so *much*!

The straight draw threading is, I suppose, the logical place for a beginning. Possible on the straight-draw threading are (among other things):

(1) Plain weave — lifts 1-3, 2-4

(2) 2/2 twill — lifts 1-2, 2-3, 3-4, 1-4

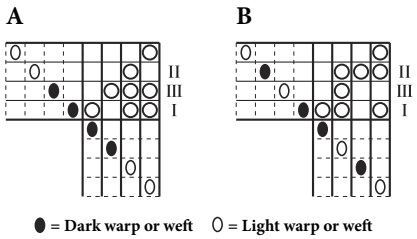
(3) 3/1 twill — lifts 1, 2, 3, 4

(4) 1/3 twill — lifts 1-2-3, 2-3-4, 1-3-4, 1-2-4

(5) Double-faced 3/1-1/3 twill, which is similar in principle to the double-faced three-shaft twill — lifts 1, 2-3-4, 2, 1-3-4, 3, 1-2-4, 4, 1-2-3 and a plethora of pebble weaves, vertical herringbones, cord weaves, rib weaves, crepe weaves, basket weaves, and what have you.

(6) Double faced 3/1 - 2/2 twill (same principle as other double-faced twills but with floats over two on one side and floats over three on other) ... lifts 1-4, 4, 1-2, 1, 2- 3, 2, 3-4, 3

The most stunning of all the weaving techniques possible on the straight-draw threading is that of the double plain weave. On our rigid-heddle loom, we can accomplish this weaving *tour de force* easily in at least two ways:



Both of these will deliver a double plain weave fabric and the use of A or B, for the weaving of simple double cloth, will produce nearly identical results. The two methods are useful for other techniques which are based on the weave. One is more effective in one technique, the other in another.

Among the important techniques which use the double weave are the weaving of the two layers of fabric with a single shuttle. The shuttle passes from upper layer to lower layer and back again at one of the selvedges. The result is a fabric that, when taken from the loom, unfolds to twice the width of the fabric as it was on the loom.

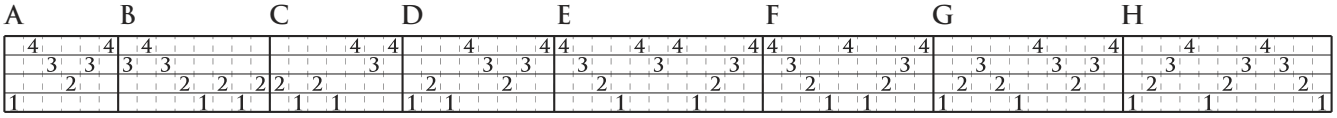
By extending the same technique, a completely seamless tubular weave is easily possible.

By changing the lift sequence for A to 3(o), 4(o), 1-3-4(●), 2-3-4(●) and for B to 3(o), 1-3-4(●), 4(o), 1-2-4(●), the fabric layers reverse themselves: what was top becomes bottom, and vice versa.

There are, besides, several techniques, some loom-controlled, some hand-controlled, which use one or the other of the threadings to produce a merging of the two fabrics at specified points to form a design. The finished weaving shows a light design on a dark background on one side and an identical dark-on-light design on the other side. Some of the hand-controlled techniques are called double weave pick-up of which specialized forms are called *single pick-up*, *Mexican pick-up,* and *Finnweave*. The names designate the several ways of producing this interesting fabric.

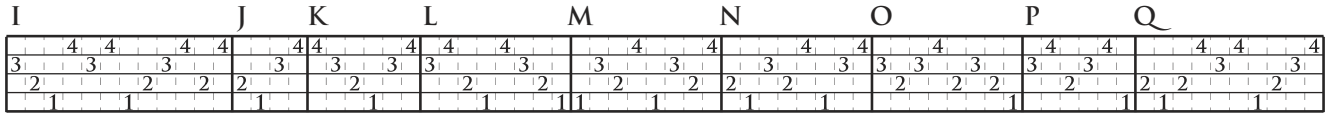
To make things even more interesting, I have also included a method for weaving, on three rigid heddles, three separate cloth layers at one time (page 45).

The point threading with its many permutations brings us to another series of weaves based on pivoting the *direction* of the threading. The following, **A** through **H** are a sampling of such threadings:



These are known as *birdseye*, *rosepath*, or simple *diamond twill*, although there are many names and many modifications. These weaves all use one or another of the lift sequences for the four-shaft twills with as many variations in lifting as there are in the threading.

The straight-draw and the point, in their next stage of development, undergo modifications with skips and breaks in the threading and lifting orders. **I** through **Q**, below, are examples:



Plain weave on these threadings becomes, at times, impossible, and the fabrics grow in complexity. And grow and grow and grow! There is an entire class of weaves based on warp groupings, other classes of weaves which alternate *blocks* of plain weave with two-thread or four-thread ribs (M's & O's) and skips (mock leno) and spots (Bronson weave) and floats (crackle weave, summer-winter weave, overshot). Other weaves build in strategically placed points of instability to produce an opening in the fabric.

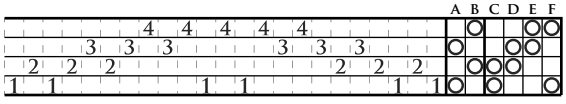
Simple Overshot

It is at this point that we arrive at a weaving system that produces one of the most spectacular weaves ever conceived. It is a fabric derived from a 2/2 twill threading and is known by a variety of names each of which describe some aspect of the weave. Its best-known name and, generically, its most appropriate is *overshot,* or sometimes *Colonial Overshot*. To a non-weaver, that word will sound as though a hunted animal has been too thoroughly killed.

The weave, also called variously as *monk's belt*, *poor man's damask*, *diamond brocade*, etc., is technically a brocade. It is a tabby fabric which uses also an extra weft called the pattern weft which floats over, under, and through the basic plain-weave fabric to produce a vast variety of designs. Mechanically, it is quite simple to produce. The twill lifts are alternated with the plain-weave lifts. The twill lifts, because of the threading, produce the pattern, the plain-weave weft weaves normally and weaves the basic structure.

The workings of the weave compared to the complexity of its appearance are almost absurdly simple. These will be child's play for you in view of your now-expert knowledge of the 2/2 twill.

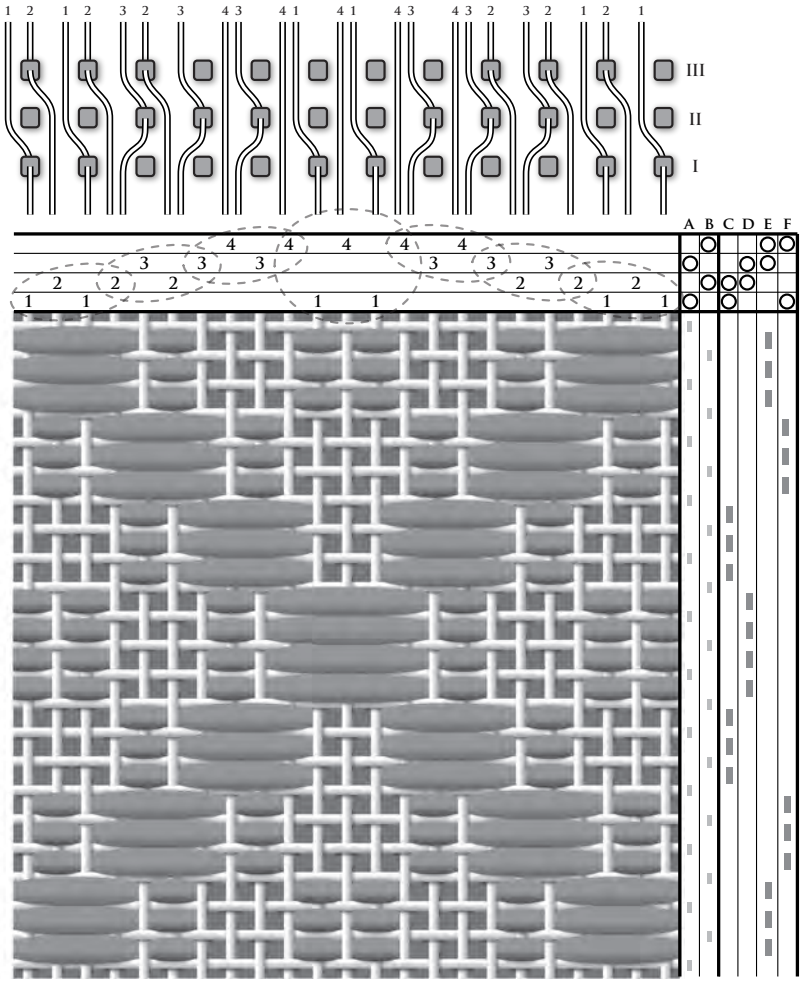
Let us suppose that we wind a tiny warp — only 23 warp ends and of sufficient length to allow us to weave about five or six inches — and thread our loom in what will look like a hiccuping and drawn-out point threading:



After threading, wind two shuttles. One shuttle will hold yarn the same as, or similar to, the warp yarn. The yarn for the second — *pattern weft* — shuttle should be lofty — or compressible — and about twice the thickness of the warp yarn.

First, weave a heading in plain weave by alternating lifts A and B and weaving with the first shuttle. We are now ready to begin weaving this wonderfully satisfying fabric.

Open first lift "E". Lift E is the 3-4 lift which means that the shuttle and pattern weft passes over all the #1 and #2 threads. Thus, moving toward the center from either selvedge, we find a float over four threads, a visible warp, another tiny float over one warp, four more warps which have been skipped, another float over one warp, and another visible warp. The latter is the exact center warp, the pivot thread for the entire group of twenty-three warps and the float pattern on either side of it is a mirror image of the other side.



Now weave whichever tabby shot is next with the first shuttle. We have found our first *block* in the weave. A block is a way of grouping warp threads to provide pattern capability across the whole piece of weaving. That sounds complex, I know, but have patience: you'll understand it very soon.

Our block is the place where the pattern thread floated over the group of four warps. There are two such places on our little weaving and if we remember the threading, we'll see that they are the same block. Having found our block, we will follow the ancient instructions for weavers of these fabrics to *tromp as writ* or to *weave as drawn in*.

The first block was *drawn in* to the rigid heddles as four threads. Thus we should weave lift E two more times (each time followed by a tabby shot) since overshot is, theoretically, a *fifty-fifty* weave (a weave in which there are the same number of tabby shots in an inch as there are warps in an inch).

In actual practice, the weave doesn't always work out to fifty-fifty because yarns are so very different in size and loftiness. What we will do is weave E a couple of more times. Between each of the lifts of E, a tabby shot must be woven to hold the pattern shot in place and to simultaneously construct the tabby fabric upon which we are superimposing the overshot pattern. What we really want to do is square the block which, in a perfect case, means that ***we weave the number of threads in the block minus 1***: we'll weave the same E plus tabby again and again (the number of times will possibly differ with each weaver) until the floats over four warps form a squarish area. Do be very careful of that, won't you? If the block is not squared in any attempt to *weave as drawn in*, the floats will look like areas that have been squashed, or else they will look too elevated.

In weaving the same shed (with alternate tabby shots, of course), you'll have noticed that the pattern shuttle does not *catch* the edge warp when it re-enters the shed. It is a minor problem and means that the shuttle must enter the shed from the top or the bottom of the shed between the first two warps. Do, please, get in the habit of noticing whether the weft is going to catch or not. Otherwise, your edge overshot float will vanish like a snowman in the Sahara. The plain-weave wefts will catch every time.

We've woven the first block. Actually, we've woven all the blocks in some fashion. But we have woven the block upon which our attention was focused, the block which is the *opposite* of the lift we are using.

Next, since the blocks always follow each other in twill succession, we'll open either the D shed or the F shed. It will be, in nearly all cases, one or the other and after opening the two to see, you'll understand that F is the correct lift to use. When we say twill *succession*, we don't really know whether the lifts are moving in their normal sequence or the reverse. What we need to look for, in determining which direction is correct, is another float just to the right or left of the last float in the completed block and overlapping it by one warp. If we have been concentrating on the left-side float of the first block, we must see in the next block, another float (perhaps of a different size) just to the right above the last lift of the first block.

We've determined that F is correct: weave a pattern weft in the F shed, beat it back, and examine it.

The float over block one has vanished and the area with the float has moved three warps away from the edge. There is also a tiny float over one warp on each side of the large float — one warp away — and a set of visible warps in the center.

Look closely at the new block and notice that it does overlap the first block by one thread. 2/2 twills overlap by a thread, do they not? All we are really doing is weaving larger twill floats with a tabby to stabilize the weave. If you'll study the threading, you'll see that the overlap is caused by a sharing of a warp in exactly the same manner that two twill wefts share a warp.

There is a telltale sign of the common threads of the blocks on either side of the pattern block float. One warp in from the edge, the pattern weft jumped over the #2 thread that was still affected by the 1-4 lift (F) and on the inner side of the pattern float, jumped over the #3 thread (which is part of the 3-4 block) which was also affected by the F lift. These floats over one warp are called *half-tones*. There may be more than one of them, depending upon the size of the blocks, and as the weaving progresses, you'll discover that there will be half-tones above, below and on each side of the floats of the main pattern blocks.

Now weave block two (lift F) square with tabby between each pattern shot.

The C shed is next. Open it, weave a pattern weft, beat, look.

The new block's float has moved toward the center and overlaps block two by one warp. Excellent!

There is a half-tone over the #4 warp which is the exact center of the warp, one other half-tone on the selvedge sides of the two block floats (over the #3 threads in block two), and visible warps on each selvedge. Weave block three square with tabby.

Open lift D. Weave the first shot of pattern weft in this block, and look closely. Notice that the fourth block's float is in the exact center of the warp and is over five warp threads instead of four. For a block with a pivot, an odd number of threads is needed or else our overshot weaving could not be made to look symmetrical. We could omit a thread or we can add one to make an odd number. One way, the center block is smaller than the others, the other way, larger. It has to be one way or the other and whichever choice is made, it is largely a matter of taste—and also consideration for the proportions of the overall pattern. I added a warp for this draft. You, if you wish, may subtract.

Since the block float is wider by one warp than the other blocks, we'll probably need to weave one or two more pattern shots to make the block square.

Oops! A moment, please. There are other floats over one warp in the first block area on each side of the fabric. No, these are not half-tones. Half-tones occur only at each side of the pattern block. These little specks of pattern weft are called *accidentals*. Accidentals occur when there is a thread affected by the lift in areas of the weave other than the block areas adjacent to the pattern block. Look at the threading, think about the lift being used, and you'll see why they happen. They occur because the block in which the accidental occurs shares a warp with the dominant-for-the-row pattern block.

We have now woven our fourth block square. What next?

Next we remember that our blocks follow each other in twill succession. If we, having now woven lift D follow with lift E, the pattern block will shift back to the first block and there will be no overlapping of the fourth and first. We remember, then, that the fourth block contains a pivot thread and so, from D, we must reverse our order. C is, then, the next correct lift. Weave it square with tabby and follow with F and finally E.

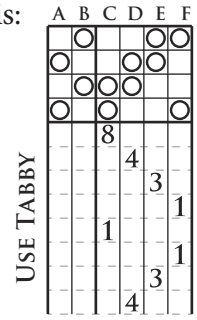
Step back and take a look at what you've done (stylized drawing on page 27). Can you believe the complex appearance of this weave?

Examine it. There are areas of solid color in the pattern yarn (these are the block floats and are sometimes called *skips*), areas of mixed color in the half-tones and accidentals, and areas of solid tabby fabric where there is a reverse skip (or, a skip on the fabric's underside).

If you have been good children and have faithfully woven with me the little warp of twenty-three threads in the draft, you will have learned more about overshot weaving than a great many handweavers with four-shaft looms ever bother to figure out. It is too simple to look up a pattern, thread it, lift in the sequence given, and not think. Thinking is always good, don't you agree?

Besides, it is far more enjoyable to do one's own thinking, and also not to be forever losing one's place on a piece of paper. Knowing what you now know, you should be able to sit at any loom threaded to any overshot draft, find the edge block, and weave off the piece with nary a written word.

Still and all, until sureness and self-confidence come, it will be useful to know how to interpret the written directions that usually accompany a pattern. You'll often see tie-up and treadle instructions that look like this one. In most overshot directions, the presence of the tabby shots between the pattern shots is assumed. At best, an instruction to *Use Tabby* will be given near the beginning of the lift sequence. The lift sequence will look something like this:



Interpreted in the weaving, lift 1-2 is made eight times *with tabby* (which is what *Use Tabby* means) then 2-3 is made four times, lift 3-4 three times, etc.

The tabby, you see, would merely take up space and look untidy and confusing. Leaving the tabby out of the actual weaving, by the way, is sometimes done. The fabric is interesting to look at with its undulations of warp and weft, but is extraordinarily unstable.

This would be an appropriate place for me to mention a weaving practice of many weavers which I use. Did you in your weaving sometimes forget which tabby was next? I thought as much. I solve the problem by arranging things so that the tabby shuttle runs behind the pattern shuttle. I also arrange that whenever I am about to do the 1-3 lift, my tabby shuttle is to the right of the fabric. If I momentarily forget which is next, I note which side my shuttle is on and never even look at the warp. If it is on the left, the heddles go down; if on the right, the heddles go up. The reverse of this would work just as well. You'll discover which you prefer. Once you've gotten such a system developed for yourself, stick to it and you'll find that your weaving will never show errors such as two tabby shots in the same shed — something that, with weaves such as overshot, is all too easy to do.

There is another way to weave overshot which produces a heavy fabric in two colors with no tabby background showing — in fact, you may find that a plain-weave weft isn't really necessary. The technique is not common but is interesting as an experiment which you might wish to perform on your little overshot sample warp. The procedure is as follows:

Wind a third shuttle with a yarn similar to your pattern yarn but in a different color. You'll be weaving with three shuttles.

Find the edge block — which on our sample warp is made by the 3-4 lift. Weave the first pattern shot with your previously used pattern yarn. Now, before weaving the tabby, open the opposite lift — the opposite of 3-4 is 1-2 — and weave the second pattern yarn. Follow with a tabby shot. Repeat these three shots in order until the block is squared, follow with the next block (lift 1-4 and its opposite 2-3) and the next (lift 1-2 and its opposite 3-4) and the next (lift 2-3 and its opposite 1-4).

You'll have woven a piece of weft-faced fabric with the pattern blocks and accidentals showing up as usual but with all the background showing up as opposite floats in a second color. Beaten properly, the tabby background will have vanished to be replaced completely with the second pattern yarn.

Forgive if, for a moment, I digress.

By carrying this principle backwards to a simpler fabric, the 2/2 twill, an interesting color effect can be achieved by using two wefts — each a different color — and weaving the 2/2 twill on opposites. Lift in the following order: 1-2, 3-4, 2-3, 1-4, 3-4, 1-2, 1-4, 2-3 and alternate the two shuttles. You'll find amazing diagonal lines of color happening and these may be influenced by modifications in the threading and the lifting sequence. The effect is so spectacular and so simple that I cannot think why more of this technique isn't done.

End of digression.

We come now to a problem that may prove to be one of the delightful challenges that will confront us daily as we weave on the rigid-heddle loom.

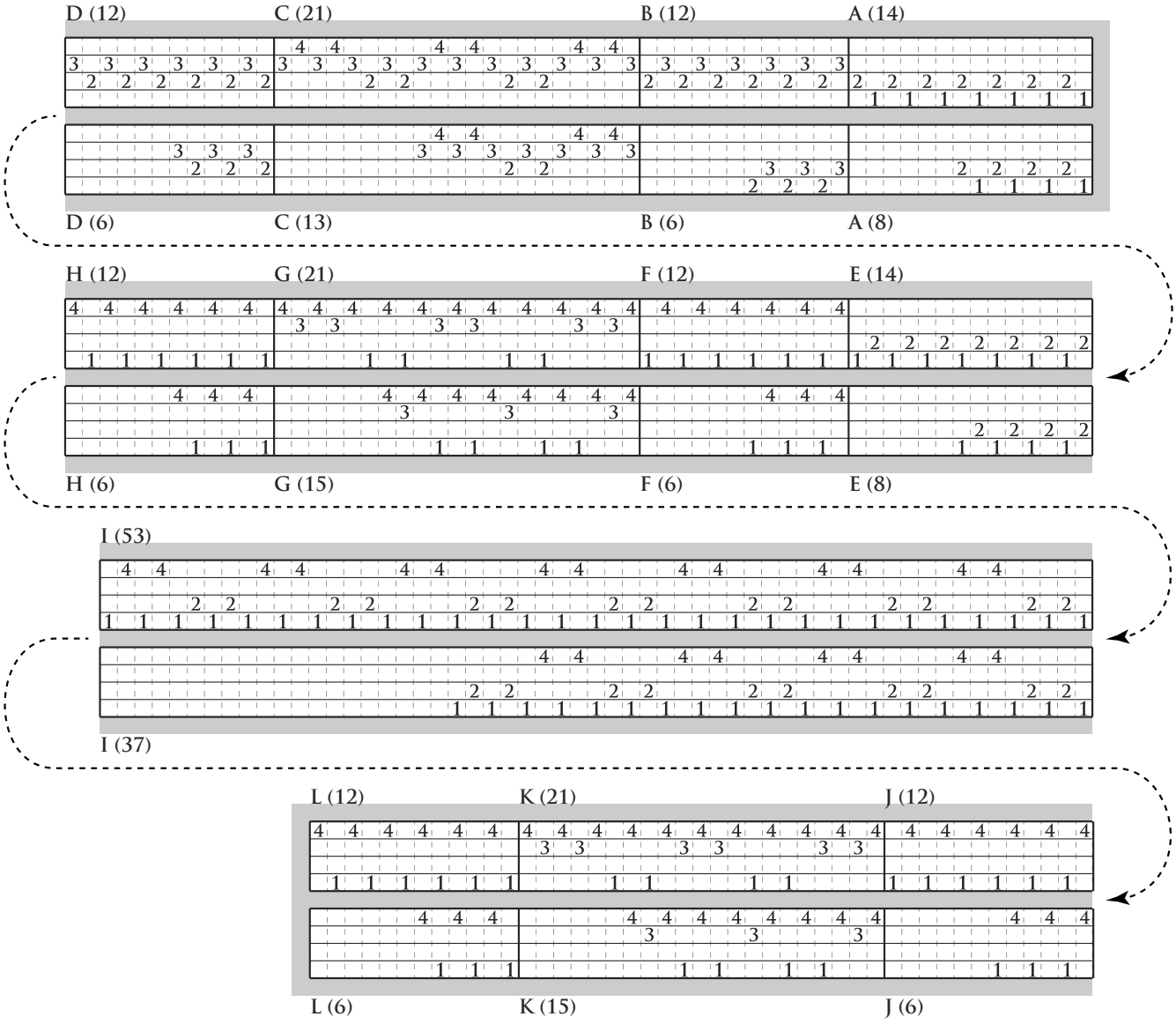
Overshot patterns are usually woven at a much finer warp density than our rigid-heddle looms permit. What this means is that an overshot float at a density of 30 EPI can go over fourteen warps and still be slightly less than half-an-inch in length. A float over fourteen threads at a warp density of 10 EPI means a float nearly an inch-and-a-half long. For wall hangings, say, such a float may be permitted, but for any fabric that will be touched, handled, and used, 1.4" is too long, and will snag and pull and eventually look sad and stringy.

Some of the old patterns routinely use floats of such length and they are patterns of such loveliness that it seems a shame not to be able to use them.

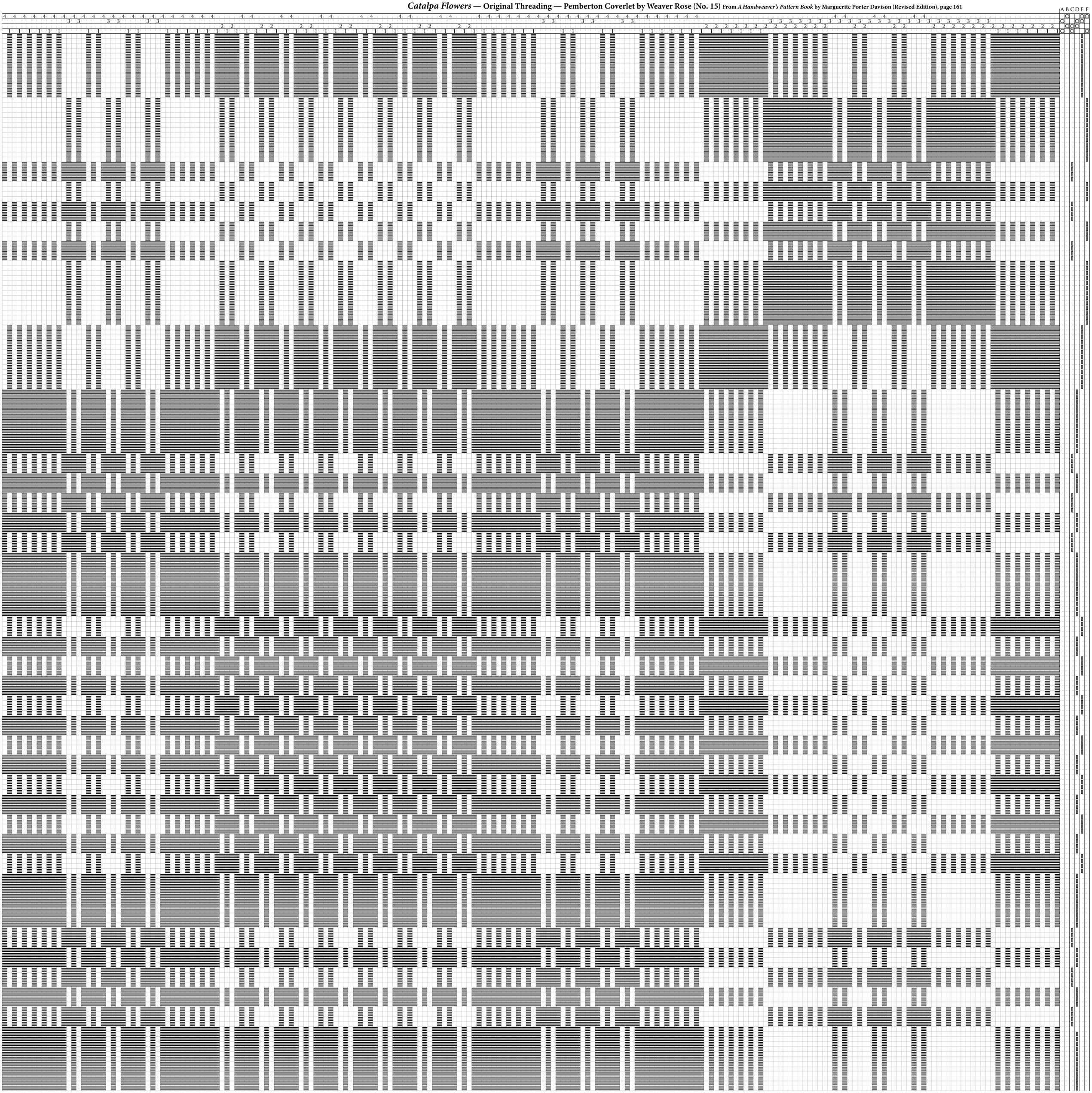
One solution that suggests itself is to take courage in hand and rescale an entire pattern. There will be, of this practice, a few critical souls who will harp on the purity of the original patterns. When confronted by such critics, we will smile sweetly and say that we surely do respect the ancient patterns and that our intention is not to violate them but to bring them again to life after they have languished unwoven for so long in their pristine purity.

Let us use, for example, the coverlet pattern by the great American handweaver William Henry Harrison "Weaver" Rose which is called *Catalpa Flowers*. On the page following this one is a diagram of the pattern floats for a partial repeat of this pattern as it was woven by Weaver Rose. Glance at it before reading further.

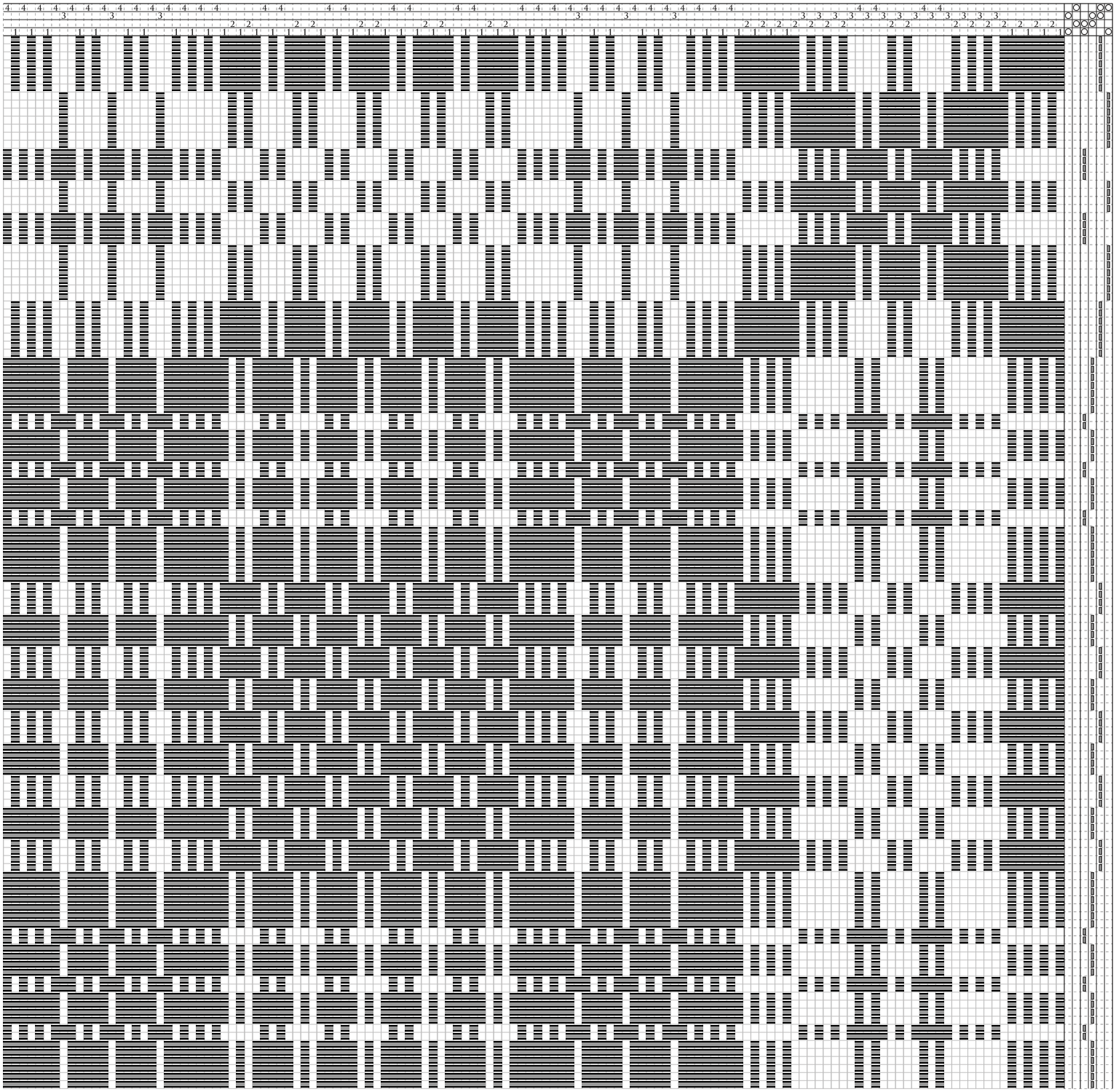
The following is a comparison of the original threading and an adaptation I made of it. (A woven example of *Catalpa Flowers* is shown on the back cover of this book.) The upper four lines are the original pattern, the lower four are my adaptation.



Catalpa Flowers **— Original Threading — Pemberton Coverlet by Weaver Rose (No. 15)** **From *A Handweaver's Pattern Book* by Marguerite Porter Davison (Revised Edition), page 161**



***Catalpa Flowers* — Adapted and Condensed Threading — Pemberton Coverlet by Weaver Rose (No. 15)** From *A Handweaver's Pattern Book* by Marguerite Porter Davison (Revised Edition), page 161

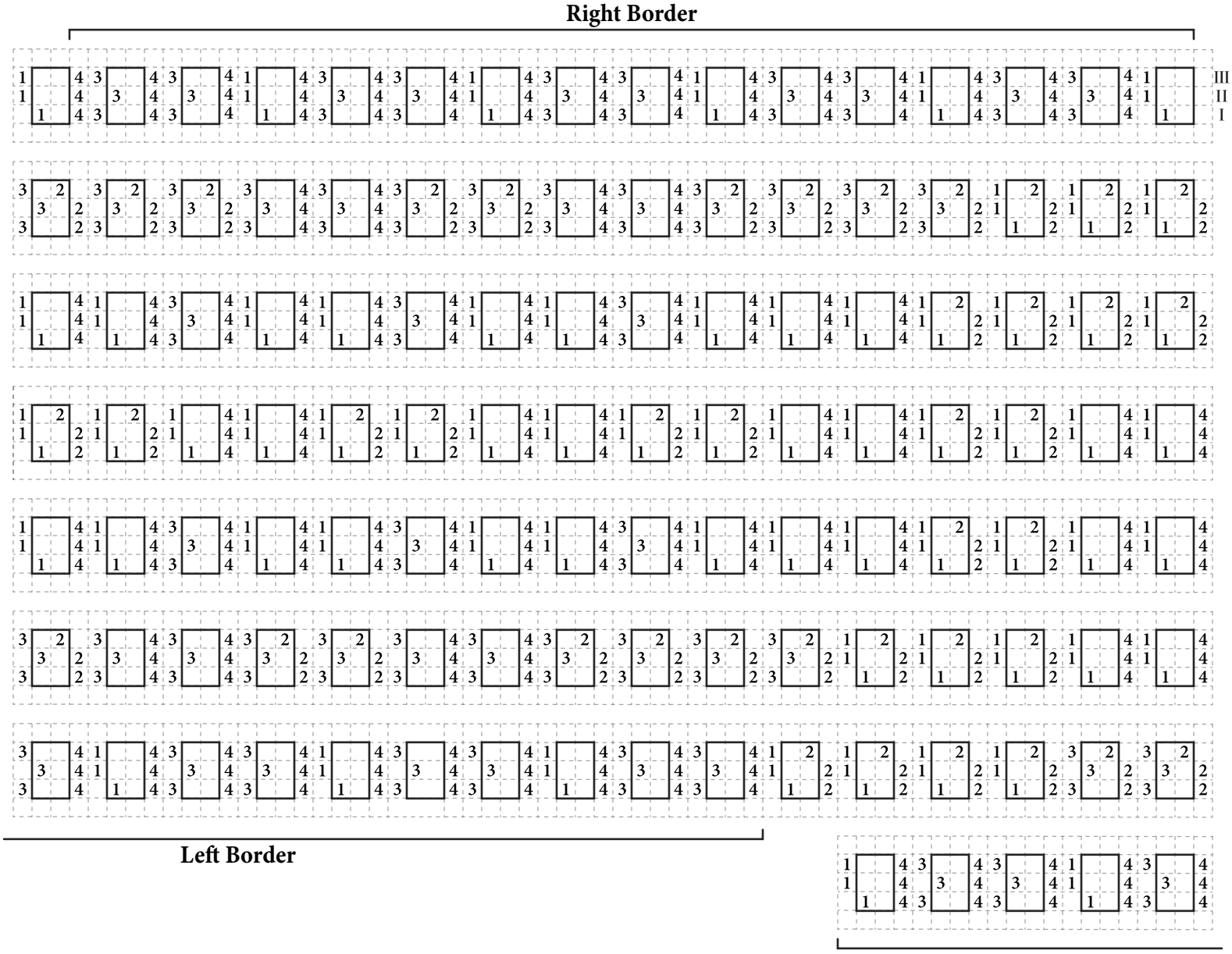


Catalpa Flowers (modified)

233 total ends @ 10 EPI = 23.3″ width

163 ends (without border) @ 10 EPI = 16.3″

This draft was used to weave the fabric shown on the back cover of this book.



The threading pattern, as can be seen, is long and complex and contains a number of blocks that would have a pattern weft float over twelve or fourteen warps.

Let us begin by setting our ground rules.

> *First*: Whenever we reduce the size of one block, we will reduce, as nearly as possible, all other blocks by the same percentage of reduction. Fudging will, I assure you, be required!
>
> *Second*: Let there be a maximum float size of over eight warps (which will be 1" in length at 8 EPI and .8" in length at 10 EPI).

Thus, in the first section of the original, we have a float of fourteen whenever the 3-4 lift is made. We will reduce it to the maximum size of eight threads in the adaptation, or one more thread than 50% since we need to retain an even number of threads in the block. The next section has, in the original, twelve threads and by reducing it 50%, we arrive at six. In the third section, the original contains twenty-one threads with, among them, several pivots. Reducing this section by 50% would destroy the peculiar configuration of the threading and the best we can do is to omit the last seven threads in the section. In any case, there are no long floats which would otherwise be of concern.

The next sections present no problems. The following section is an example of one way we might have handled the third section: two threads, each in the nature of a pivot, have been removed from the three 4-3-4-3-4 groups.

Next comes a 50% reduction followed by the big central *checkerboard* of the central motif. It would have been simplicity itself to have ended my adaptation eight threads earlier than I did and to have then arrived at pretty close to 50%. But I really *like* that center section and by adding those eight threads, I was indulging myself by allowing myself to break my own first rule. Well, no one ever said that we had to be so hide-bound that we couldn't enjoy ourselves a bit, did they?

The page which follows the diagram of the original contains a diagram of the adaptation.

Having made our adaptation, we have solved only part of the problem. We have altered the size of the blocks and, having done so, have messed up the original lifting sequence. Thankfully, we are all now weavers with the knowledge of the *weaving as drawn in* principle and can find our way out of the problem with only minor adjustments to our thinking.

A few words now on something that close study of the original draft, specifically the treadle instructions might reveal: were your yarns able to provide an absolutely balanced weave and you were to follow the treadle instructions exactly, you would find that weave would look squashed and truncated compared to the diagram on page 32. The reason is that the original draft was simply recorded from a woven cloth and not from an exact count of the numbers of warps in the blocks.

Herein is contained a lesson. Never trust the directions for lifting given with an overshot pattern. The directions are those that the original weaver used, and the yarns you are using may not weave the same as the yarns he used. On the original, there is the instruction to *square* a float over fourteen by weaving it eight times. No doubt in the yarns originally used, eight times was sufficient to square, but in different yarns, the same squaring might be arrived at by weaving the same block sixteen or even eighteen times. The correct number will be determined by **your** yarns and **your** eyes.

Consequently, if I were to draw for you the pattern as originally directed, there would be, on the paper, a

truncation effect that was probably not present in the original weaving. When I composed my own adaptation, I used as a basis the theoretical fifty-fifty nature of the weave. When comparing the two, keep these ideas in mind. The two should still give you some idea of how the lift sequence was changed by the adaptation.

I should also explain about the threading diagram which follows the two drawings. It is a threading diagram of the modified *Catalpa Flowers* and is shown in the photograph on the back cover of this book. It contains the central motif (sections F through L) with, on each side, a section of A through E. Flanking both of these is a thirty-thread border which seemed more pleasant in theory than in practice. Really, it is rather ho-hum but it does contain a lot of #4 threads. This whole threading diagram contains 233 warps which, sleyed at 10 EPI, almost exactly fill up a 24" Beka loom. The design was woven to be a hanging and so the width of the border is wider than necessary. Were two or three pieces being woven to be pieced together, there would be no need for the border.

Let us return to the point: when necessary, I believe that it is permissible to scale down the great overshot patterns to fit our needs. All that is needed is an intelligent understanding of the process and a sensitivity to the originals. May you enjoy the overshot weaves as much as I do!

If we are to speak of intelligence, we are offered a splendid opportunity to exercise ourselves with another kind of weave called the *Summer and Winter* weave. The origins of the name are obscure and having woven a piece of this fabric, you may decide that its name derives from the predominantly light on one side, predominantly dark on the other side, reversibility of the fabric.

This weave is a closer weave than the overshot and has a maximum float size of over three warps. It is, as a four-shaft textile, somewhat limited since it is a two-block weave as opposed to the overshot which was a four-block weave.

The problem offered to us is that of ease of weaving. We know how the lifts normally operate and that the tabby lifts (1-3 against 2-4) are the easiest of all fourteen lifts since they remain the closest to the original method of handling the loom.

The common practice, in four-shaft weaving, is to weave the two blocks on threadings of 1-3-2-3 (or multiples of these) and 1-4-2-4 (or multiples). If we look closely at these two blocks, we'll see that every other thread is not the odd-even-odd-even combination with which we are familiar but arrange themselves so that the tabby must be woven by alternating the 1-2 and 3-4 lifts.

Weaving tabby in this manner is perfectly possible on our loom but does require some changing of sticks before every shed. Why not rethink the threading in terms of our own loom?

If, then, we substitute a threading of 1-2-3-2 and 1-4-3-4 for the two blocks, we still have the same block/thread relationships except that the tabby is restored to the 1-3 and 2-4 lifts which are ever so much more pleasant to weave.

Having done this much rethinking, we must rethink the threading for any given pattern and reinterpret the lifting sequence. All of which sounds ever so complicated but will, in practice, make the weaving smooth and effortless.

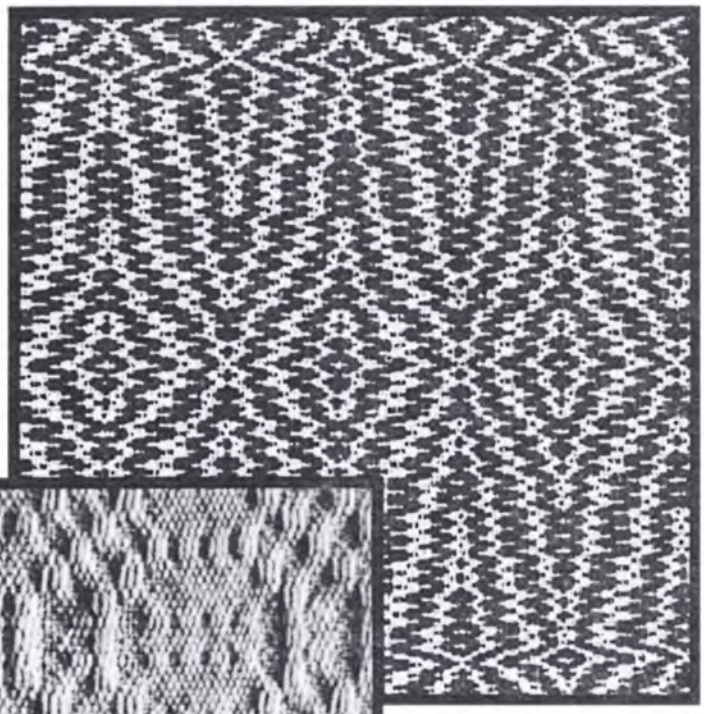
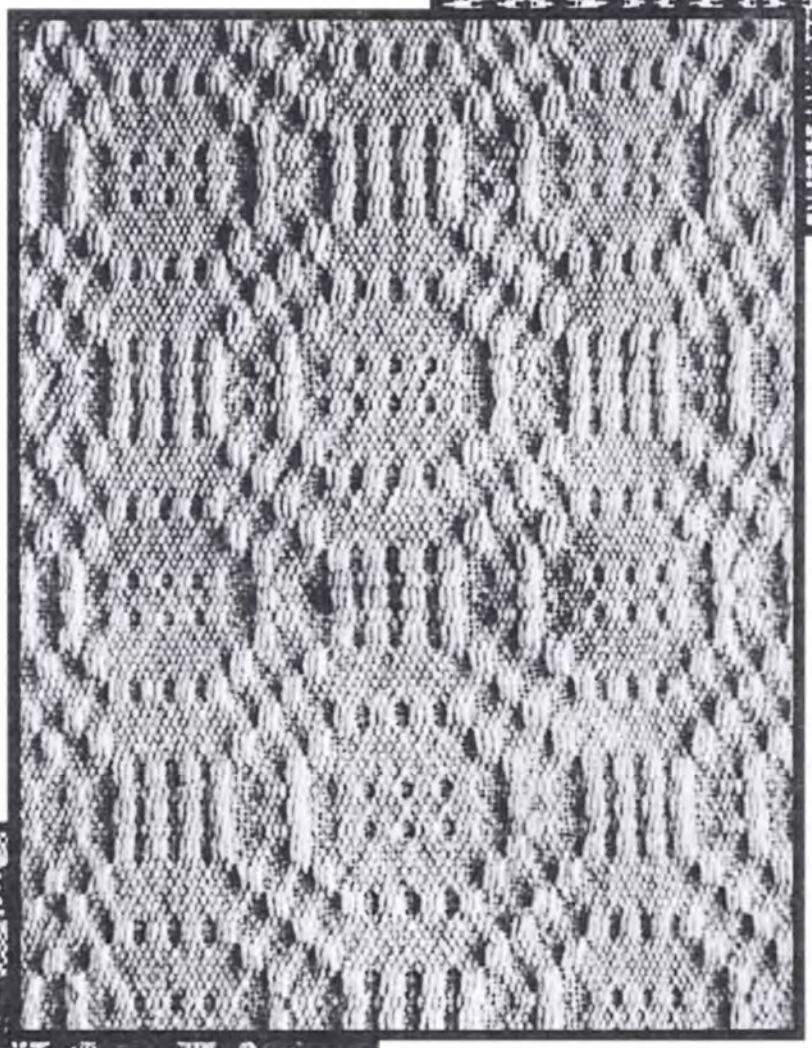


Table runner in Crackle Weave — scoured silk warp and tabby, silk chenille pattern weft



Shawl in silk and alpaca (detail from front cover)

Honeycomb weave on overshot threading

More useful to the four-shaft loom and consequently to us, is the delightful *Crackle Weave*. The crackle weave was named — for its resemblance to the crackle effect in certain ceramic glazes used on hand-made pottery — by the late and much-admired American weaver and teacher Mary M. Atwater.

Crackle weave is woven in much the same way as overshot with pattern weft alternating with plain weave wefts. Its threading system is a little different — though it is still based on 2/2 twill, but in a point configuration — and it is woven *as drawn in* only after a good bit of experience.

When weaving your first crackle weave piece, follow the lift and threading orders pretty carefully. When it becomes more clear to you that the pattern block being woven is actually (though not so apparently) proceeding in the same fashion as overshot, you'll be the undisputed master of still another technique.

The crackle weave has no long floats to concern us and many lovely patterns are available to use as runners, curtain fabrics, pillows, etc.

There are, besides those listed, hundreds of other weaves and patterns, almost without end, that may be woven quickly and easily on our rigid-heddle loom.

The books listed in the bibliography will give you much more information.

It is quite probable that the four-shaft books, thinking as they do in terms of the four-shaft loom, will give technical information and instruction that may have to be rethought and adapted for greater ease of weaving on our own rigid-heddle loom, and it may be that, having adapted, we may begin to venture down pathways that are the peculiar pathways of our very special loom.

Do not be afraid to rethink the structure of any weave. Do not hesitate to redesign the threading of a pattern so that the lift arrangements for the loom are more convenient.

You may, as I have found once or twice, discover that certain configurations of fabric may be more easily woven upside down.

Take a lift series such as that used for the 1/3 twill, for example. We know that we can manipulate this series of lifts but we also know that by lifting the *blanks* instead of the ***o's*** (which will have the efffect of turning the fabric upside down on the loom), we can weave more quickly and easily. There may not be as much satisfaction in the doing but to deny oneself the right-side up view of a lovely fabric for the comparatively short time it takes to weave it, is better than denying it altogether. That is better, by far, than spending an unnecessary and less-enjoyable amount of time producing it.

This weaving technique is very new. I have attempted to fathom it in the short time it has been my personal possession and have found, already, some wonderful things. Now, having done what I could of the initial work, I turn the technique over to you in the full awareness that very great discoveries are soon to be made by the application of many minds and many talents.

The thought of these discoveries fills me with great excitement and prompts in me the hope that I may hear of some of them at least.

In the meantime, I wish you good weaving in peace and health!

❧ David Xenakis

III. Commonly Used Threading Drafts

In this concluding section, I have sketched a few of the many drafts which are commonly used in four-shaft weaving. Along with the conventional drafts, I have included a possible method for threading the rigid-heddle loom.

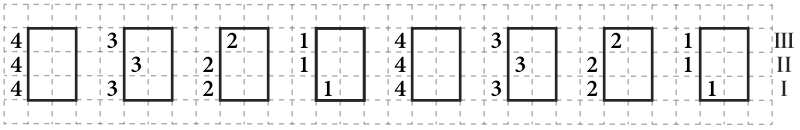
In some cases, I have given the draft for a weave, and have followed with a suggested modification for ease of weaving on the rigid-heddle loom.

I have also included the lift sequences for certain weaves particularly when a threading adaptation requires that the lift sequence be changed to conform to the adaptation.

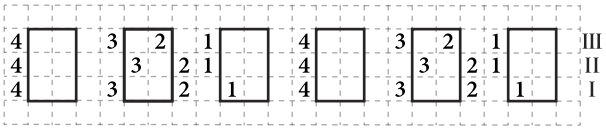
In some cases, I have given a variety of warp densities for a single threading (see four-shaft straight-draw threading and diagrams). When I have given such a variety of densities, I have labeled each with a number followed by a percentage sign. The percentage designates the relationship between the given density and the number of threads required to fill completely one rigid heddle of the size being used. For example, a written percentage such as 150% indicates either a density of 12 EPI for an eight-dent rigid heddle or 15 EPI for a ten-dent rigid heddle. For the size being used, 100% will be taken to mean the size description of the rigid heddle being used (either 8 EPI or 10 EPI).

Four-Shaft Straight-Draw Threading

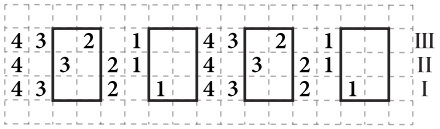
50%



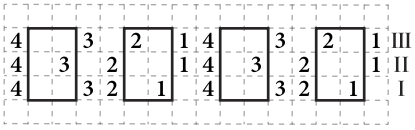
75%



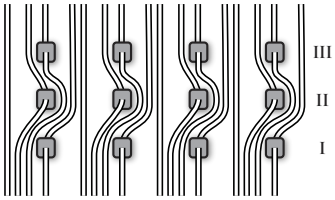
100%



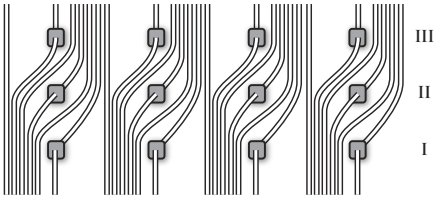
110%



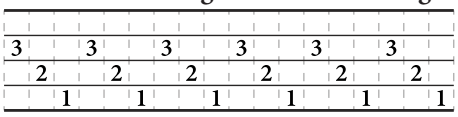
200% of Full Density



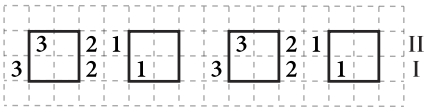
300% of Full Density



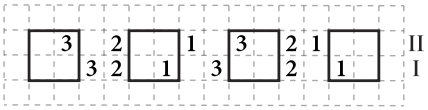
Three-Shaft Straight Draw Threading



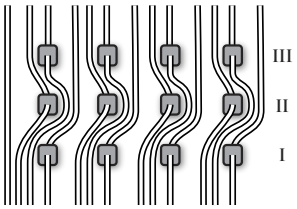
75%



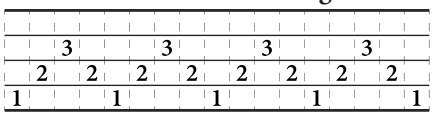
100%

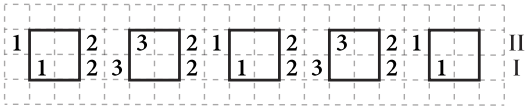


150%

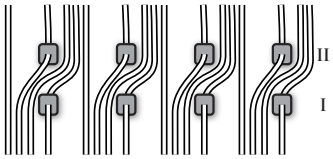


Three-Shaft Point Threading

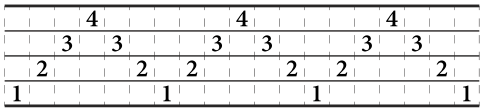


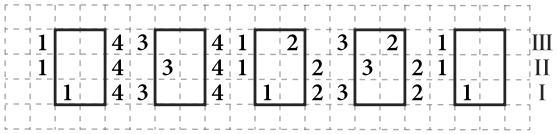


200% of Full Density

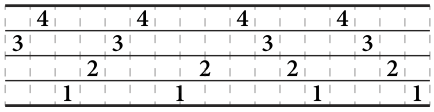


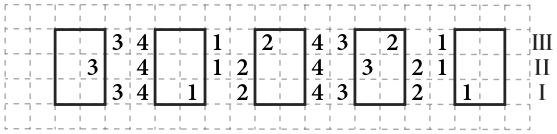
Four-Shaft Point Threading



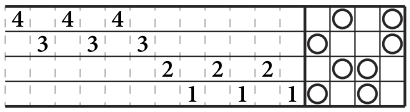


Four-Shaft Broken Twill





Two-Block Monk's Belt

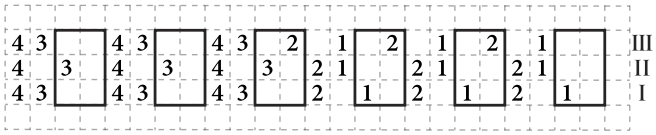


Weave *As Drawn In* with alternating tabby and pattern wefts

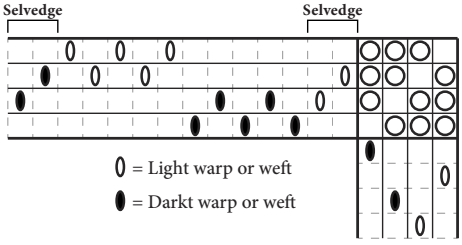
Tabby

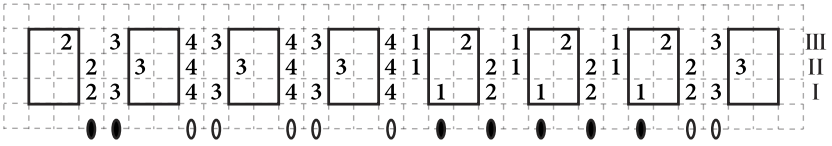
Block A

Block B

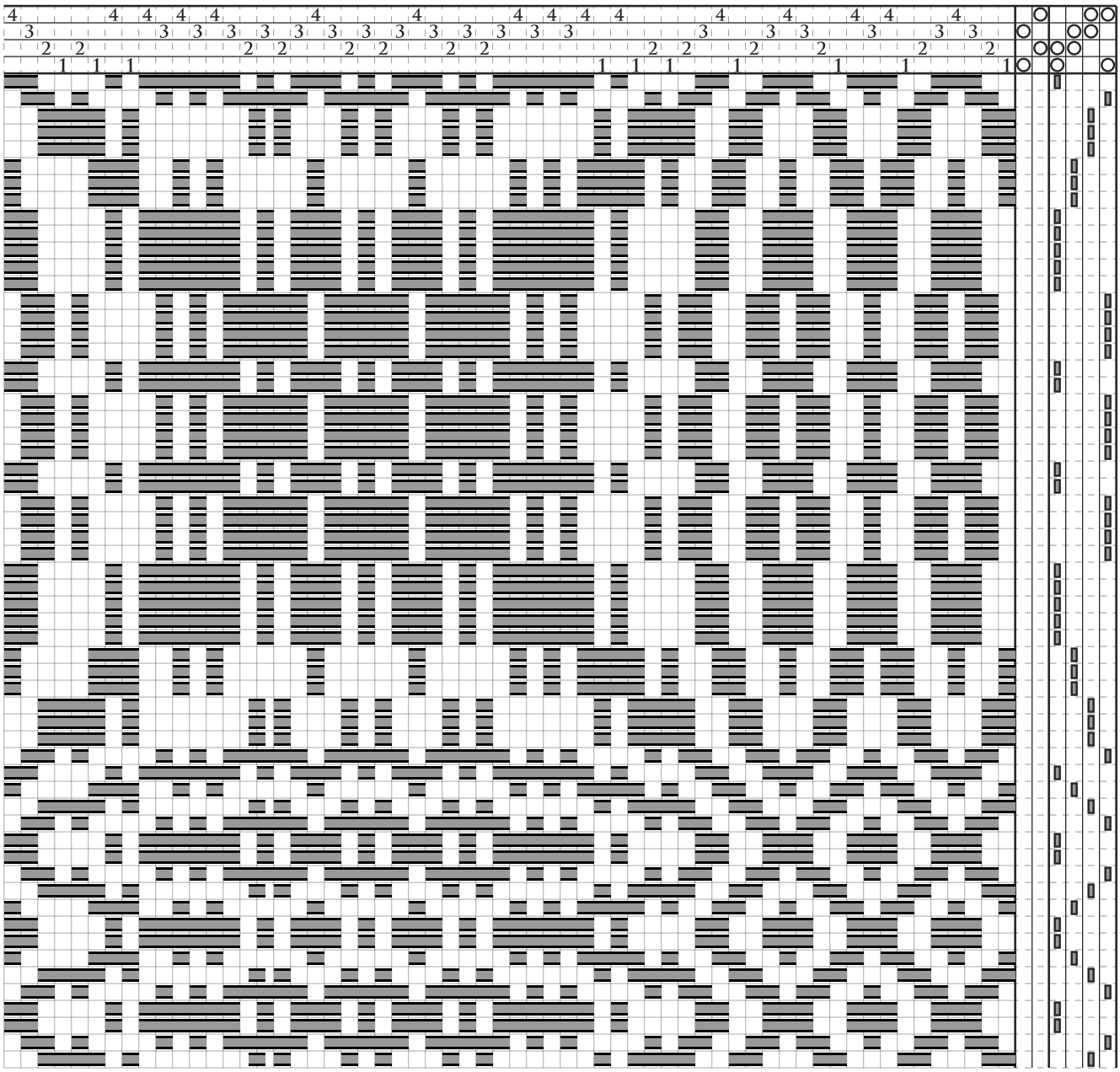


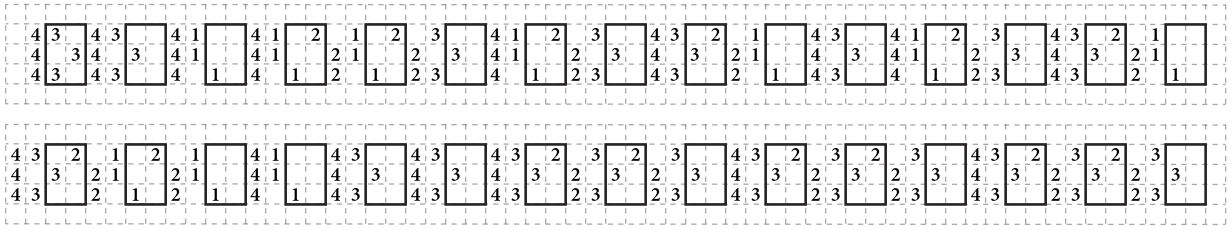
Bedford Cord (Five-Thread Adaptation)



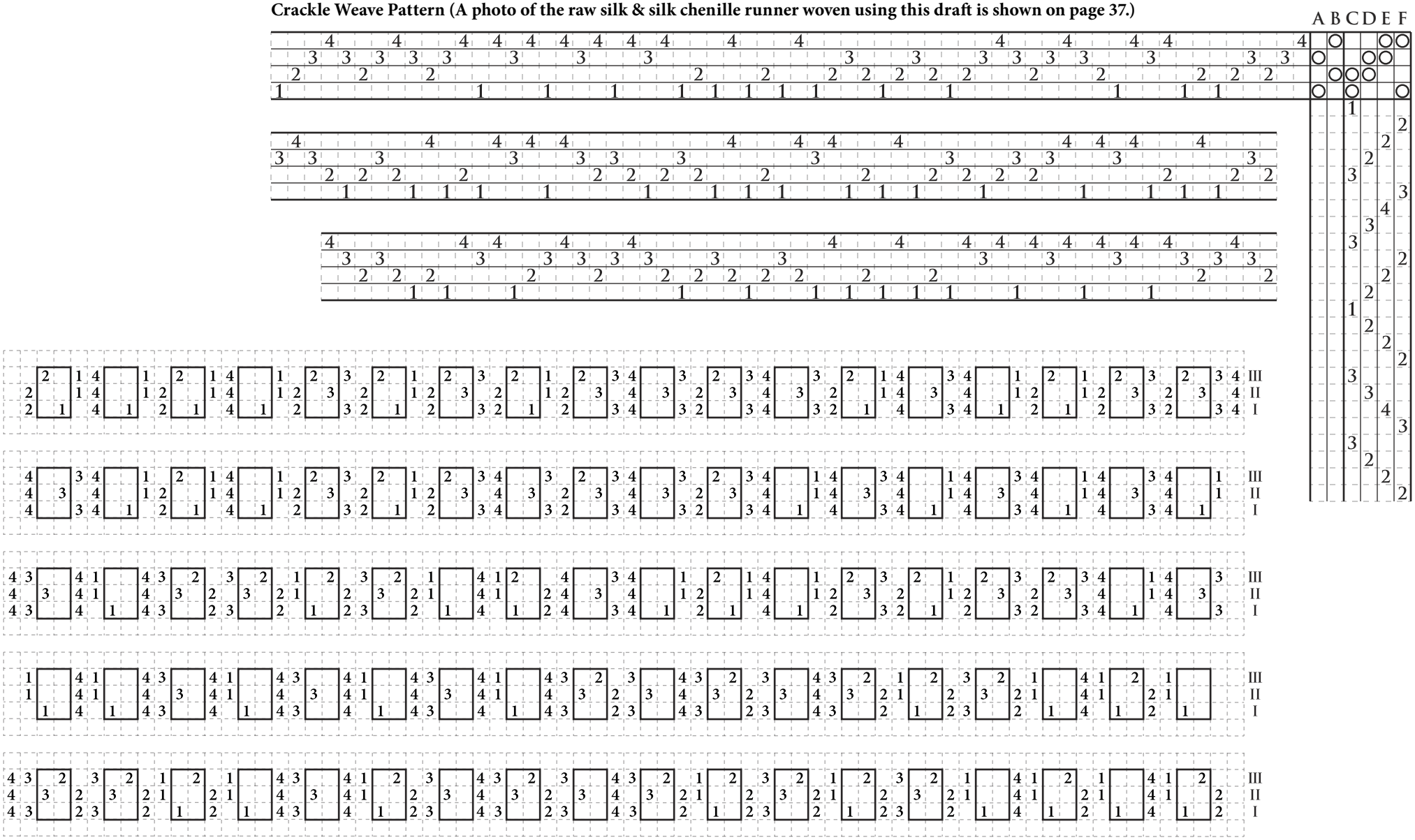


Example of Small Overshot Pattern (with Rigid-Heddle Threading Diagram)

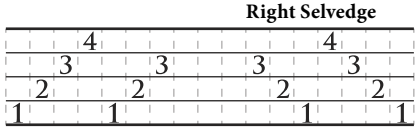




Crackle Weave Pattern (A photo of the raw silk & silk chenille runner woven using this draft is shown on page 37.)

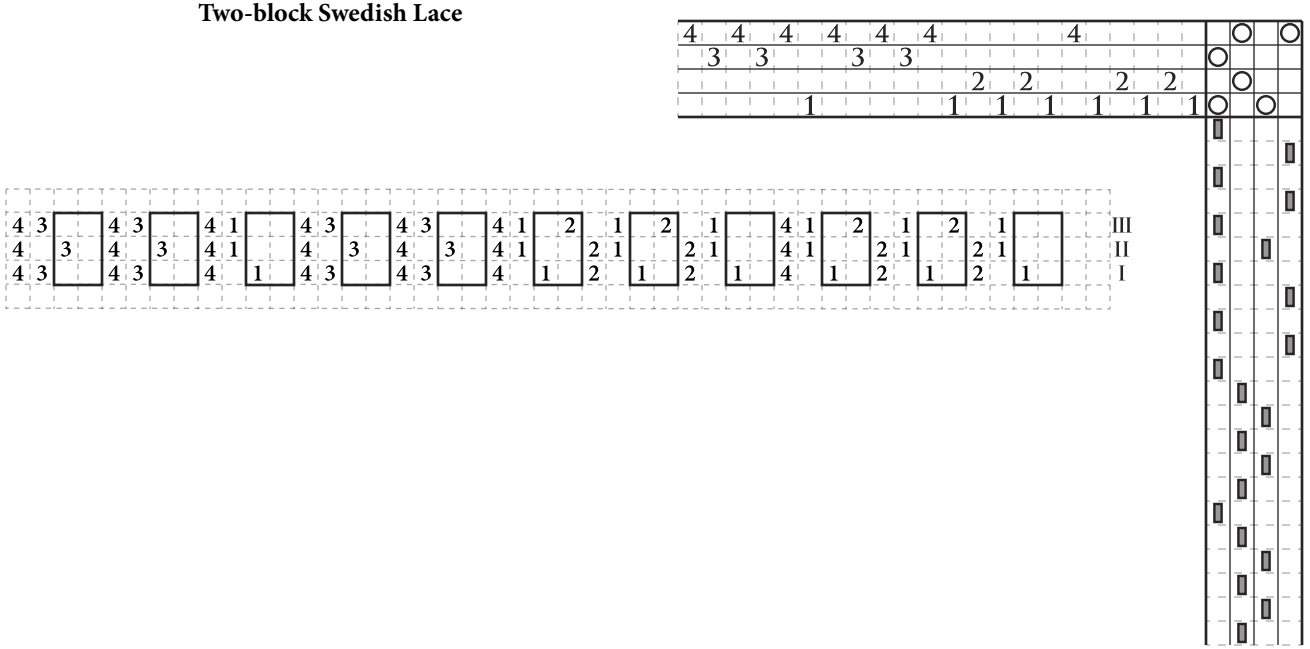


The tie-up shows the lift sequences used to weave the runner in the photograph.
The runner also contains seven selvedge threads on each side threaded according to this draft:

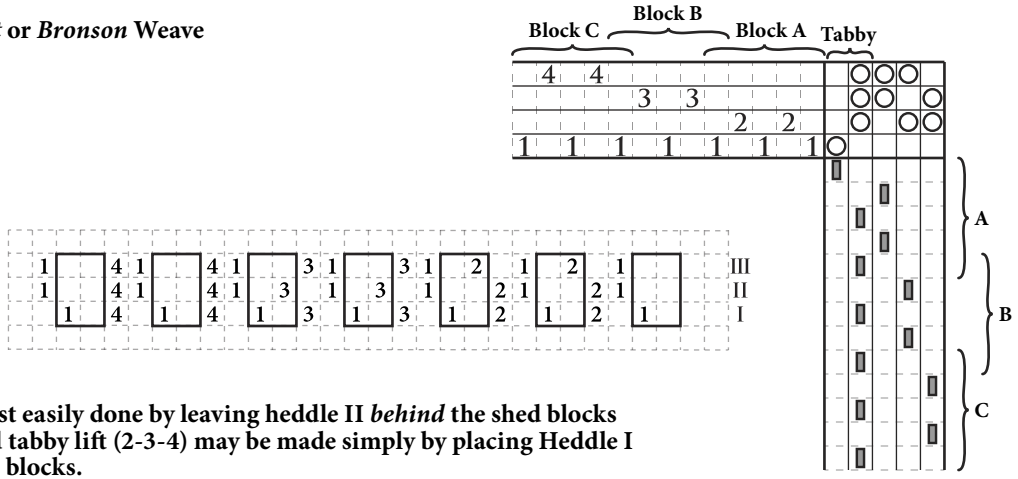


The entire pattern (including fourteen selvedge warps) totals 192 ends: sleyed at 10 EPI, the width is 19.2".

Two-block Swedish Lace



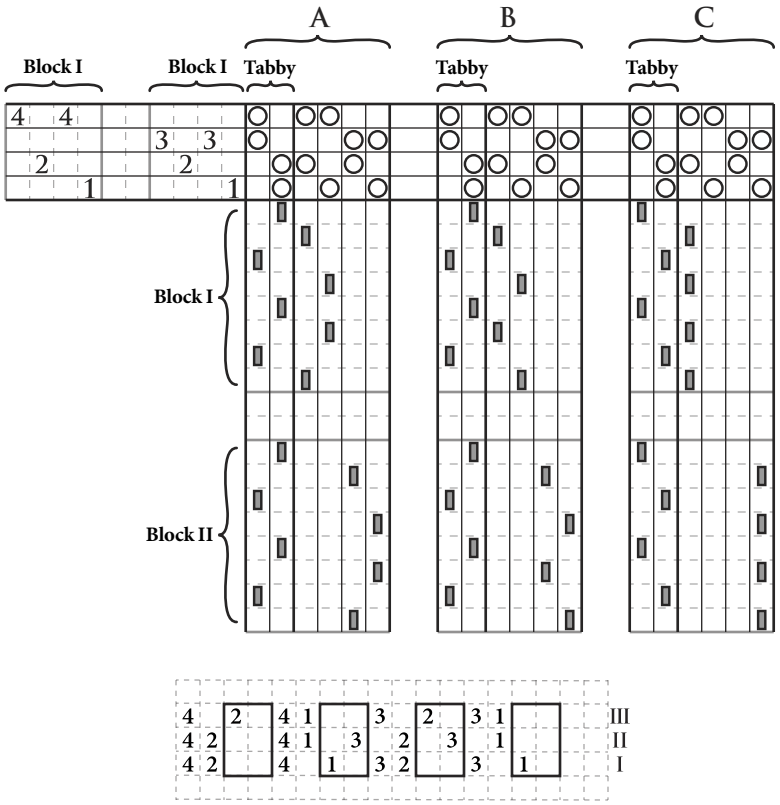
Three-block *Spot* or *Bronson* Weave



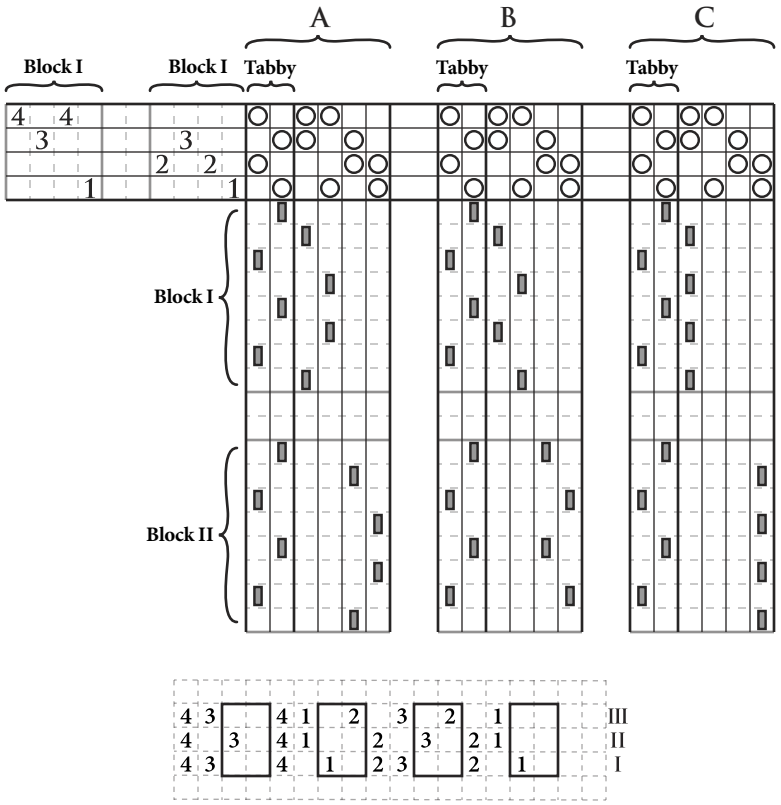
This weave is most easily done by leaving heddle II *behind* the shed blocks so the the second tabby lift (2-3-4) may be made simply by placing Heddle I beneath the shed blocks.

Two-block Summer & Winter weave

Four-shaft Convention



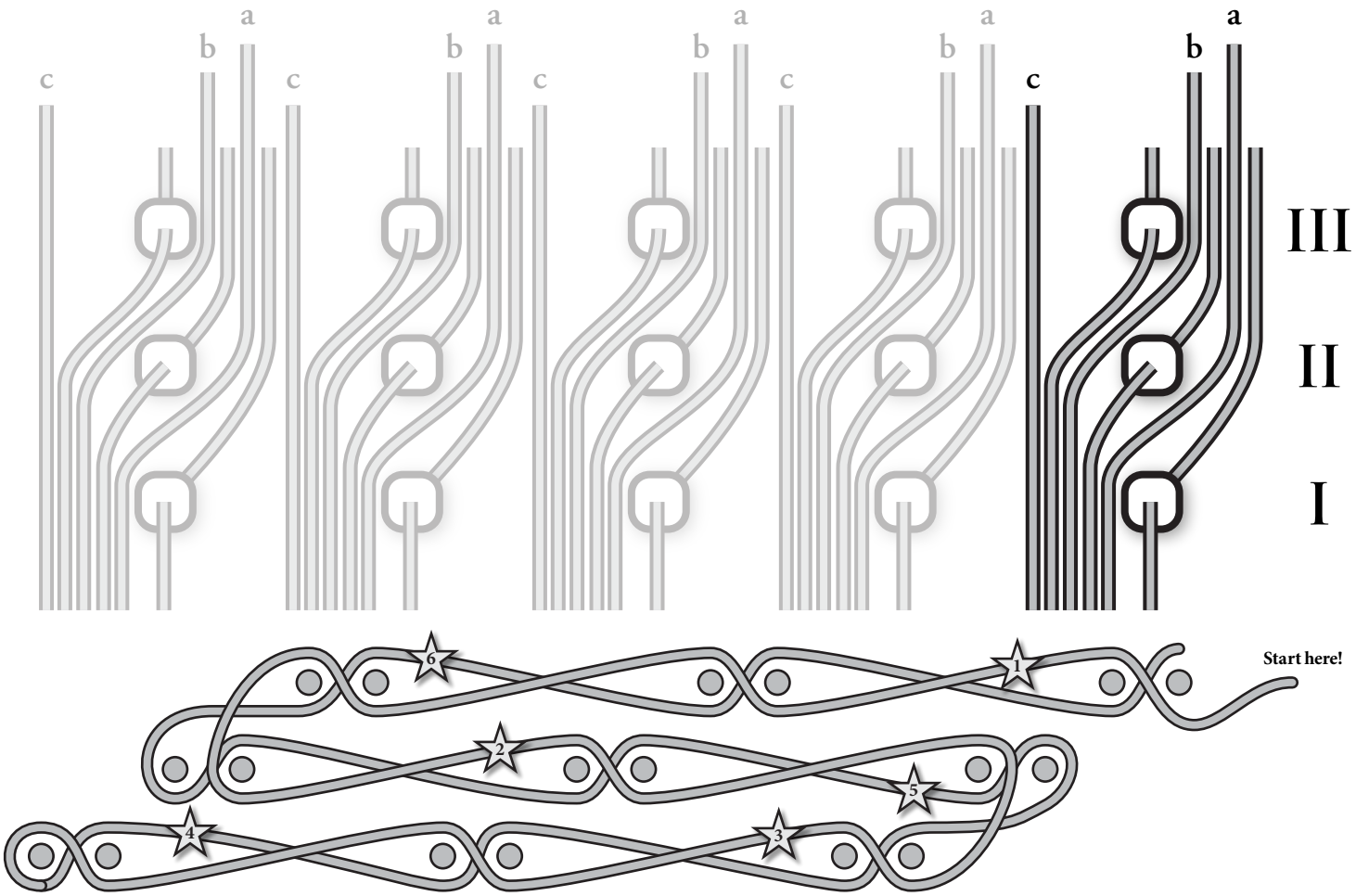
Rigid-heddle Adaptation



Above are shown two charts for the Summer & Winter weave. One uses the conventional shaft threading. The other is the adaptation mentioned in the text of this book.

With each chart are three list sequences which will produce very different results. (Note that the odd-numbered lifts are the tabby, and the even-numbered lifts are those of the pattern weft.) Lift set (A) is the most common of the sequences for the weave and will give a fabric woth the pattern weft in pairs. (B) is a weaving of the pattern wefts singly, or in *non pairs*. (C) is called the *overshot* method.

Triple-width weaving on a rigid-heddle loom



Notes:

1) This threading will provide triple density. In other words, if it is threaded as shown using, say, three 8-dent heddles, the density per inch will be 3 x 8 = 24 epi.

2) In the event that plain weave overall is needed for a heading, all three heddles up or down can be used together. This is probably not a good idea if triple-width weaving is intended.

3) When you put all three heddles in down position, notice that there are three threads in every slot. You can place 3 or 4 picks of plain weave in scrap yarn behind the three heddles—beaten to the back of the loom—so that you can see them in precise order. Now, you will need to place two pick-up sticks behind the heddles. These sticks only need to be placed once and can be left in place throughout the weaving. They will slide easily past each other and should be left as far back as possible until they are needed to help make a shed.

I have marked the slot warp associated with heddle I (that which, with heddle I, weaves one layer of the fabric) as **a**, that associated with heddle II as **b**, and that with heddle III as **c**. (Notice that the very first slot does not have a **c** slot warp for obvious reasons.)

With the three heddles in down position, pick up all the warps across that are marked as **a**. In all the slots except the first and the last, **a** is the center of the three slot warps. It is the first in the very first slot on the right, and there is no **a** in the last slot on the left. Slide this stick to the back and leave it there until it is needed to form a shed. This will now be referred to as stick **a**.

Place the second stick by picking up all the **a** and **b** slot warps. In all the slots except the first on the right, these will be the center and left of the three in each slot. The two in the very first slot belong to the picked-up group. There are no **a** and **b** warps in the last slot. Slide this stick to the back. Notice that it slides beneath the first. Leave this stick at the back until it is needed to form a shed. This will now be referred to as stick **b**.

Weaving triple-width fabric:

1) I have placed a cross-section diagram below the warping chart so that you can see the passing of the weft across the fabric six times to produce separate fabric layers joined only at the edges. Repeating these six passes will give you a fabric that will unfold, when taken from the loom, to three times the width of the fabric on the loom. In other words, if your weaving was 24" wide on the loom, it will unfold to 6′ wide off the loom.

2) Until you are sure of yourself, begin this weaving with more-than-usual care. The sheds will not always be very obvious or very high. Be sure you know what the shed is: a mistake involving, say, passing over a single warp—maybe somewhere in the center of your work—that should have been passed under will mean that your triple width fabric will stick together. Don't worry. There are ways to fix such things, but they are inconvenient. Care in weaving will avoid those problems later. Once you are sure of yourself, you can begin to weave with more speed.

3) Some of the sheds are made by lifting one or more heddles and then sliding one or other of the sticks forward to make the shed. Watch the shed form as the stick moves forward to just behind the heddles: your shuttle needs to go under those slot warps that the stick has raised for you. Once finished placing the weft, slide the stick back until it is needed again.

4) Take care with your tensioning at the place where the weft turns around an inner edge. Try to place it so the the inner folds will look as much like the rest of the fabric as possible.

5) **To weave**:

- ☆ 1. Place heddle I on the blocks, weave from right to left.
- ☆ 2. Place heddles I & II atop the blocks, bring stick **a** forward, weave.
- ☆ 3. Place heddles I, II, & III atop the blocks, bring stick **b** forward, weave.
- ☆ 4. Place heddles III in down position (manually support the other two), weave.
- ☆ 5. Place heddle I atop the blocks, bring stick **b** forward, weave.
- ☆ 6. Heddles in neutral, bring stick **a** forward, turn it on its side, weave.

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Four-shaft draft space — Three-heddle threading diagram draft space