TWENTY-FOUR BLOCKS ON FOUR SHAFTS

1. INTRODUCTION

I first saw a piece woven in crackle in a picture of a small mat, on which there were many colours in a checkerboard design. The colours didn't occur in a plaid or tartan or stripy kind of a way, but rather were scattered here and there.

I located Mary Snyder's book, The Crackle Weave, and made a sample warp to try out her theory and samples. The four-block crackle samples in Monograph 1 are the result of that exercise.

Zielinsky's book on crackle is Volume 8 of the Master Weavers Series published by Leclerc. This publication really changed my approach to crackle, because in it he introduces the concept of there being 8 blocks, and then later goes on to explore a version of crackle that comprises 12 blocks.

Investigation into the mathematics of permutations of three out of four shafts reveals that the actual number of threading units is 24. Some of these are visually indistinguishable until multiple colours in the warp and weft reveal their structural uniqueness. This monograph explores these threading units and devises corresponding systems of treadling units.

Most people think of crackle as a four-block weave on four shafts, as described in Zielinski's Encyclopedia of Hand Weaving:

> "Crackle gives four blocks of pattern with four shafts. Each block is written on a different "unit" of threading.
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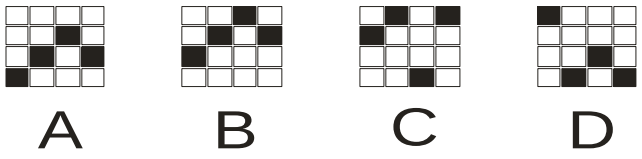
> 
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> Each unit can be repeated any number of times, therefore the blocks of pattern can be of any size. But when joining two blocks, an "incidental" heddle must be inserted to preserve the continuity of the draft."

A point that often confounds weavers when they first experiment with this technique is the need to insert incidentals at the termination of a block of threading units.

I'm unclear what Zielinski meant about "preserving the continuity of the draft". My thinking is that blocks are terminated with a single incidental thread to balance the threading and complete the pointed twill structure of the final unit. In Figure 1, unit A is repeated 3 times:

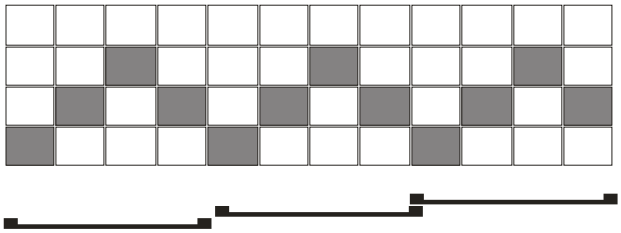

Figure 1: Threading block with three repeats of unit A.

Now we add the incidental at the end and see how this addition "balances" the block and gives it symmetry, Figure 2:

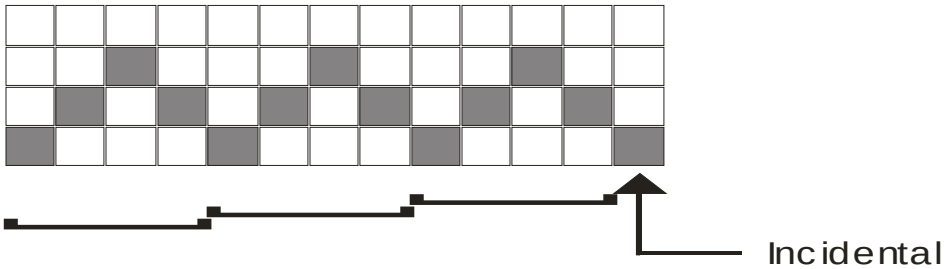

Figure 2: Threading block with incidental added.

The four crackle threading units can be substituted into a "4-block profile threading draft" such as the one shown in Figure 3:

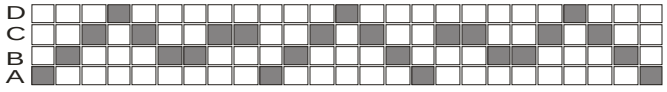

Figure 3: Sample four-block profile threading draft.

The dark squares represent a unit of threading: each dark square on the bottom row represents one repeat of threading unit A (four warp ends), and similarly for B, C, and D. When the draft shows a change from one block to

another, an incidental will be inserted to terminate the final unit. Figure 4 is the draft with arrows showing where the incidentals need to be inserted.

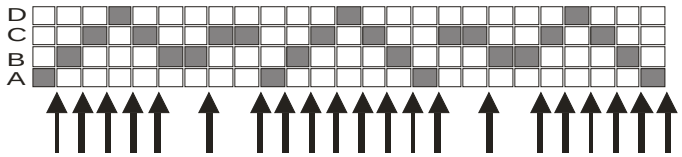

Figure 4: Sample profile draft with incidentals noted.

Notice that an incidental is added at the right edge of the draft – not as a transition between blocks, but for the purpose of balance and symmetry.

A similar approach can be taken using 24 blocks. A 24-block profile draft could look something like this:

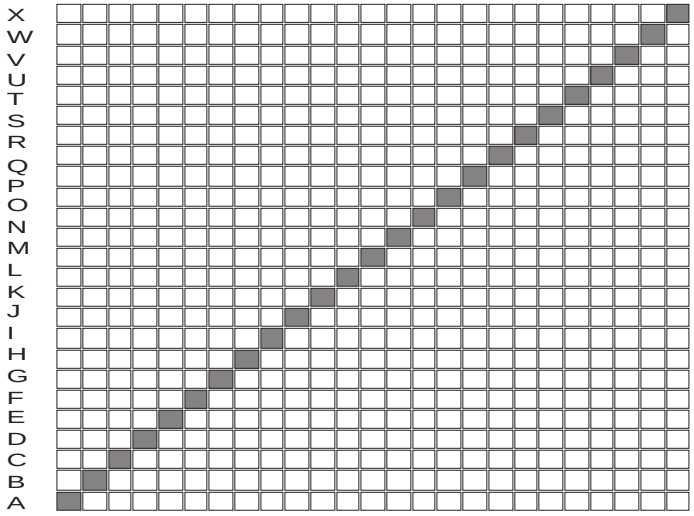

Figure 5: Sample 24-block profile threading draft.

This, the simplest possible 24-block profile threading draft, samples each of the 24 blocks. Each shaded square represents five warp ends – four for the threading unit and one for the incidental. To sample this design would require a minimum of 120 warp ends, allowing for only a single repeat of each unit per block. So it is evident that designing for 24 blocks needs room.

2. THREADING UNITS

With a four-shaft loom, there are four ways to select just three of those shafts:

(1,2,3) (1,2,4) (1,3,4) (2,3,4).

Figure 6: Combinations of three shafts out of four.

Once these 4 groups of three shafts have been identified, there are 6 ways that each of them can be put in order. Thus there are 24 arrangements or permutations:

(1,2,3)*	(1,2,4)	(1,3,4)	(2,3,4)*
(1,3,2)	(1,4,2)	(1,4,3)	(2.4.3)
(2,1,3)	(2,1,4)	(3,1,4)	(3,2,4)
(2,3,1)	(2,4,1)	(3,4,1)*	(3,4,2)
(3,1,2)	(4,1,2)*	(4,1,3)	(4,2,3)
(3,2,1)	(4,2,1)	(4,3,1)	(4,3,2)*

Figure 7: Permutations of three shafts out of four.

These permutations are the basis of 24 threading units. Each becomes a more typical crackle threading unit when the middle number is repeated, and the incidental is included; for example, (1,2,3) yields the four-thread unit [1,2,3,2,], and including the incidental produces [1,2,3,2,1]. Here is a list of the twenty-four threading units expressed in this notation:

[1,2,3,2,1]*	[1,2,4,2,1]	[1,3,4,3,1]	[2,3,4,3,2]*
[1,3,2,3,1]	[1,4,2,4,1]	[1,4,3,4,1]	[2.4.3,4,2]
[2,1,3,1,2]	[2,1,4,1,2]	[3,1,4,1,3]	[3,2,4,2,3]
[2,3,1,3,2]	[2,4,1,4,2]	[3,4,1,4,3]*	[3,4,2,4,3]
[3,1,2,1,3]	[4,1,2,1,4]*	[4,1,3,1,4]	[4,2,3,2,4]
[3,2,1,2,3]	[4,2,1,2,4]	[4,3,1,3,4]	[4,3,2,3,4]

Figure 8: List of 24 threading units with incidentals (not in threading order).

Notice how this way of using five ends to designate the units allows each unit to be read from left to right or from right to left – a useful fall-out of the reflective symmetry that the units now have. The incidental can be either

the first or the last end of the unit, which facilitates threading from either direction. The incidental is not used when a unit repeats within a block, but only when changing to a different block or at the selvedge.

Listing the 24 threading units, as was just done, is straightforward; but putting them in an order that can be threaded for weaving is another matter. It requires that no adjacent units start on the same shaft, and it also requires that adjacent units will not create weft floats over more than 3 ends. Once such a sequence is obtained, the units can be labelled, but such labelling is arbitrary and there are several ways it can be done. Figure 9 is one way.

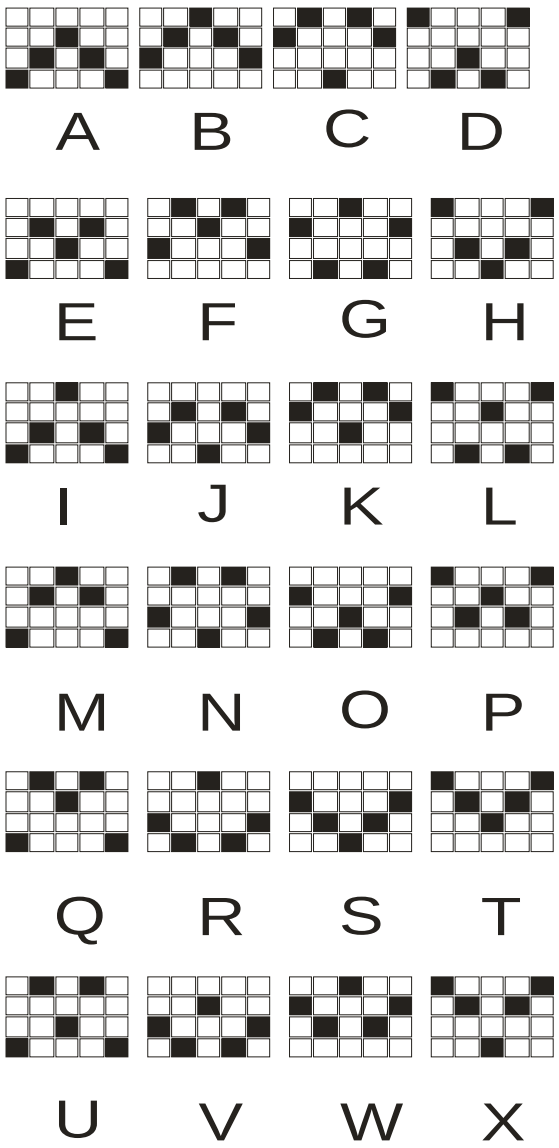

Figure 9: Ordered sequence of 24 threading units.

This ordering of the threading units no weft floats over more than three warp ends. If the sequence is altered by omitting or re-arranging some units, then every block-to-block edge needs to be examined for floats of four or more, otherwise erratic edges between the blocks can be a great distraction to the over-all unity of the design. Some publications advocate the insertion of another "incidental" to tack down a long float. Sometimes the reader is advised to leave out an end if it duplicates the last end of the previous block. These measures leave some blocks narrower and others wider and this has a substantial impact on the unity of the design and the regularity of the profile draft that was used.

Here are some tips for using fewer than 24 blocks:

1. A,B,C,D are the units commonly used in four-block crackle.
2. Q,R,S,T are the flipped images of A,B,C,D, and using these eight blocks will maintain a true plain weave structure. Other combinations of eight units may result in loss of the ability to weave plain weave.
3. Using the A through L is a good selection for 12-block crackle as all edges meet properly, including the edge between unit L and unit A.
4. You can use any number (n) of consecutive blocks from this list in a pointed twill type of profile design. But if your profile wraps through the blocks and positions the "nth" block next to the first block there may be a problem.

Colour/texture/grist variations in the warp create a variety of effects. End-and-end arrangements of yarns contrasting in one or more of these three aspects, are particularly suitable for this structure.

3. TREADLING UNITS

Having covered the threading of 24 blocks of crackle on a four-shaft loom, we now turn our attention to devising treadling blocks that will utilize the threading blocks to greatest advantage.

First the tie-up, shown in Figure 10. Like four-block crackle, the 24-block version uses a standard six treadle 2/2 twill tie-up for four shafts:

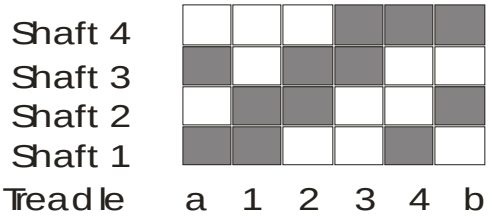

Figure 10: Standard 2/2 twill tie-up for four shafts and six treadles.

The dark squares represent falling shafts. The outer left and right treadles (a and b) are known as the tabby treadles, and they are the two combinations of two non-adjacent shafts (a lowers 1&3), (b lowers 2&4). The four middle treadles lower two adjacent shafts: treadle 1 lowers shafts 1&2; treadle 2 lowers shafts 2&3; treadle 3 lowers shafts 3&4; treadle 4 lowers shafts 4&1.

The treadling sequences will be expressed using these treadle numbers. So when a treadling sequence such as {2ab} is given it is read from left to right, and woven with three weft picks:

Pick 1	Treadle 2	Shafts 2&3 lowered;
Pick 2	Treadle a	Shafts 1&3 lowered;
Pick 3	Treadle b	Shafts 2&4 lowered.

The six treadles (a,1,2,3,4,b) can be grouped into three sets of countersheds: a&b, 1&3, and 2&4. If a countershed occurs once in two picks then warp float length is 1; if a countershed occurs once in three picks then warp float length is 2; and if a countershed occurs once in four picks then warp float length is 3. The stability of the fabric is so improved by this attention to float length that maintaining a maximum float length of 3 is something I have adhered to rigorously in my research. In devising systems of treadling

I wanted to be sure that the weaving would not be compromised structurally and aesthetically by undesirable long floats.

The shortest possible treadling sequence is 2 opposites treadled alternately, also called treadling on opposites (Figure 11).

{ab}	{ba}
{13}	{31}
{24}	{42}

Figure 11: Treadling on opposites.

These six two-treadle sequences of weaving on opposites each produce a pseudo-plain weave. Since the threading units no longer always have odd and even shafts alternating, no treadling will produce plain weave in every block (on a four-shaft loom). The countershed treadling units produce plain weave in 8 of the threading blocks, and a form of basket weave in the other 16.

Some may wonder why there are six countersheds listed – why is {ab} different from {ba}? The reason is that this distinction is required to develop the full set of treadling sequences. Then using multiple shuttles of weft which have colour/texture/grist variations, the difference becomes apparent.

These 2-treadle units weave a very stable textile, with maximum warp floats over just one weft pick. But the short floats result in undramatic textiles when compared to treadling sequences that allow longer floats.

We will first devise a treadling system that produces maximum warp floats over two picks of weft. This is achieved by adding a single treadle to one of the six countershed pairs. The added treadle can't be one of the two in the pair, so that leaves the other four as candidates. So each of the six countershed pairs combined with one of four other possible treadles means there will be 24 possible units, as listed in Figure 12.

{1ab}	{1ba}
{2ab}	{2ba}
{3ab}	{3ba}
{4ab}	{4ba}
{a13}	{a31}
{213}	{231}
{413}	{431}
{b13}	{b31}
{a24}	{a42}
{124}	{142}
{324}	{342}
{b24}	{b42}

Figure 12: List of 24 three-pick treadling sequences (not in weaving order).

As was the case with the 24 threading blocks, obtaining this list is less of a problem than putting it into an order so that when woven the transitions between the blocks don't introduce the long warp floats that we have tried so hard to avoid. Figure 13 arranges the 24 treadling sequences in an order that accomplishes this, with maximum warp floats of two both within blocks and between them:

A	{a13}	M	{a31}
B	{142}	N	{324}
C	{4ba}	O	{2ba}
D	{b13}	P	{b31}
E	{124}	Q	{342}
F	{2ab}	R	{4ab}
G	{a24}	S	{a42}
H	{231}	T	{413}
I	{3ba}	U	{1ba}
J	{b24}	V	{b42}
K	{213}	W	{431}
L	{1ab}	X	{3ab}

Figure 13: Ordered sequence of 24 three-pick treadling units.

These treadling sequences are units that are treadled repeatedly as necessary to achieve the proportions desired. Just as for the threading blocks, treadling blocks can be arranged according to a block profile treadling draft for 24 blocks.

Figure 14 is another set of treadling sequences, this time with four picks each, producing warp floats over three picks:

A	{a1a3}	M	{a3a1}
B	{1412}	N	{3234}
C	{4b4a}	O	{2b2a}
D	{b1b3}	P	{b3b1}
E	{1214}	Q	{3432}
F	{2a2b}	R	{4a4b}
G	{a2a4}	S	{a4a2}
H	{2321}	T	{4143}
I	{3b3a}	U	{1b1a}
J	{b2b4}	V	{b4b2}
K	{2123}	W	{4341}
L	{1a1b}	X	{3a3b}

Figure 14: Ordered sequence of 24 four-pick treadling units.

Many other variations of treadling can be devised. All of the four-block sequences documented in Monograph 1 *Crackle Weave Sampler* can be adapted to 24 blocks. Each set of treadling sequences invites exploration with colour, texture and grist of weft yarn.

Two blankets woven in 24-block crackle are shown on the following page. The blanket in Figure 15 was woven on a warp threaded end-and-end in brown and gold, and treadled using the units in Figure 13 with three colours rotating (navy, light blue, turquoise). The blanket in Figure 16 was woven on the same warp, and treadled using the units in Figure 14 in three colours rotating (red, pink, red, brown).

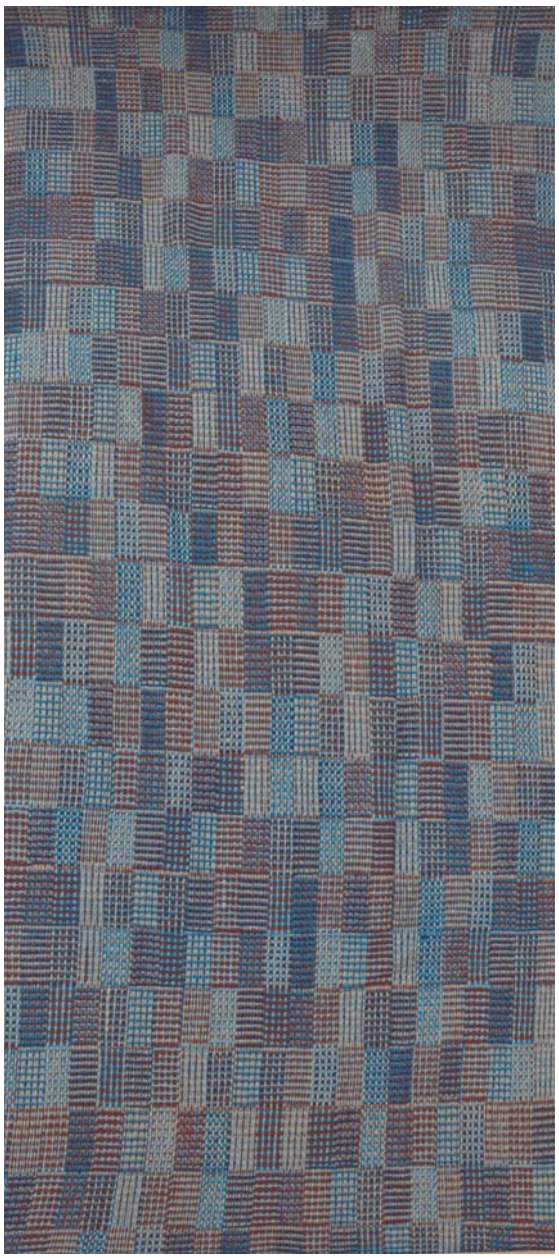

Figure 15: Three-pick treadling

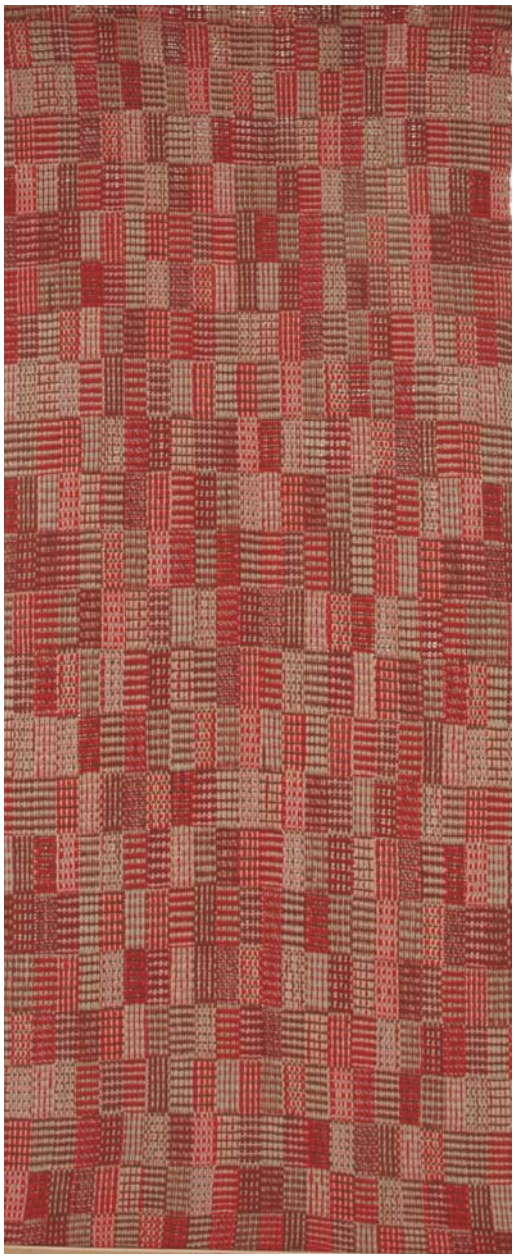

Figure 16: Four-pick treadling