**Tablet Weaving Structures**
**Theory and History**
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There are a few tablet weaving structures commonly recognized by weavers, including warp twining, doubleface and 3/1 broken twill. Others are known from premedieval and medieval contexts, but are less-often used, and many more structures are possible. In this article, I present a systematic method for classification and analysis of all possible tabletwoven structures. By "structures", I mean only the physical form of the band, regardless of the color patterns that may appear. Decorative color patterns are an essential feature determining the appearance of a tabletwoven band, but they are not a structural component   the structure would be the same even if the warps were all identically colored.

The structure of tablet weaving is determined by five main characteristics:
· the shape or number of holes in the tablets.
· which of the holes contain warp threads.
· the threading direction of the warp.
· the turning pattern.
· whether adjacent tablets are set up the same way.

Each of these will be considered in more detail below.

**Basics**

All of my explanations assume a common frame of reference, the "standard setup" used by most tablet weavers (Fig. 1). This has the weaver sitting at the cloth end of the warp, and the other end attached farther away from the weaver. I also assume that the weaver is looking at the warp from the right side. If you prefer to work in a different arrangement, you may need to make mental adjustments while reading. I use this arrangement because then in diagrams the weaving progresses from left to right, in the direction English-speakers are used to reading. Loom weavers may be used to looking at drafts written in the opposite direction.

Figure 1. Standard position of weaver, warp and tablets. weaver / cloth end warp end
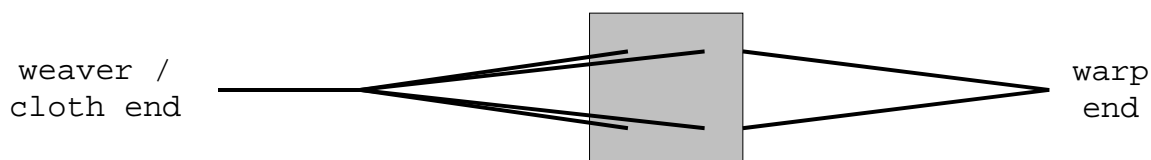
**Tablet Shape**

The vast majority of weaving tablets are square, with four holes, one per corner. Triangular tablets have been found, and there is evidence for the use of six- and eight-holed tablets as well. The structural classification here can be applied to tablets of any shape, but I am only going to work with square tablets in this article since they are universal among modern tablet weavers.

While there are nearly as many schemes for labeling the holes of a tablet as there are weavers using them (or at least authors and manufacturers), I am going to use a particular system in this article. This is the one that seems most logical to me. If you look at the right face of the tablet, the holes of the tablet are labeled A B C D moving in a counterclockwise direction starting with the top hole nearest the weaver (Fig. 2). This arrangement means that when a tablet is turned forward, first the warp in A crosses over the top and is seen, then the warp in B, followed by C and D.

Figure 2. Labels I use for the holes of a tablet, as seen from the right.
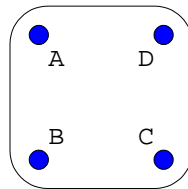
Many (most?) commercial tablets are labeled in a clockwise direction. In that case, just put the labeled face on the left side of the pack instead of the right side so that the AD line is on top. For everything I'm going to talk about here, the only important part is that A is the top hole closest to the weaver, and B is the bottom hole closest to the weaver.

Even 4-hole tablets have two different sets of sheds : the usual single shed created when tablets are used flat, and the paired shed created by tablets on their points. I'm only going to consider tablets used flat, as in Fig. 3a.

Figure 3. Possible sheds created by four-hole tablets used flat (a) or on their points (b).
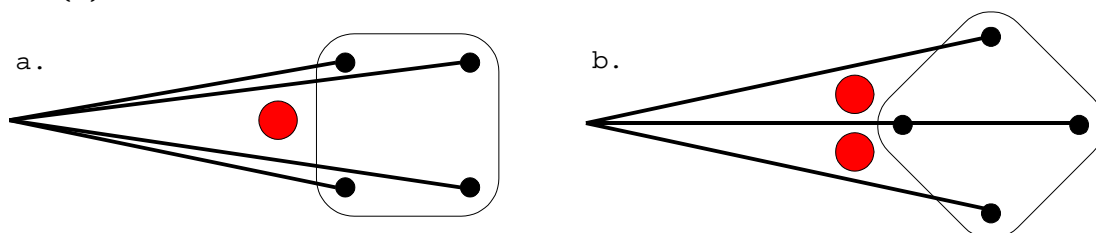
## Tablet Threading

Even with four-hole tablets, there are several possible threading arrangements, since not all holes need to contain warp threads. A four-hole tablet can contain 4, 3, 2 or 1 warp threads, and two arrangements of two threads are possible (Fig. 4).

Figure 4. Possible ways to thread a square tablet.
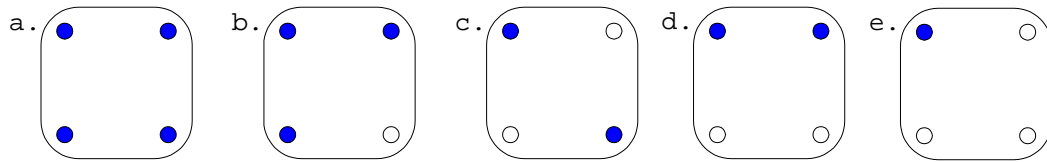


Note that there are two ways to thread a tablet with two warp threads. I'm only going to discuss two of these patterns, a and c, which appear to be the most common in historical finds. I also use examples with one thread per tablet (e) as examples, but these are not really useful for actual weaving.

Threading two adjacent holes creates possibilities beyond the scope of this article, since any woven structure can be created with tablets threaded this way. In any form of weaving, there are four possible arrangements for adjacent warp threads: both on the surface (Fig. 5a), both underneath (Fig. 5c), one above and one beneath, and the reverse (Fig. 5b and d).

Figure 5. All possible sheds can be created using a tablet with two adjacent warp threads.
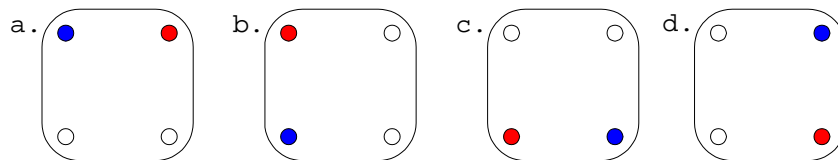
Threading Direction

The warp threads enter the tablet on one side and leave on the other, but with a flat tablet there are two possible directions. Using terms borrowed from spinning, one direction is termed S and the other Z after the directions of their central strokes (Fig. 6).

Figure 6. S and Z threading of tablets from the top and from the right side. From the top, the warp follows the same direction as the central stroke of an S or a Z.
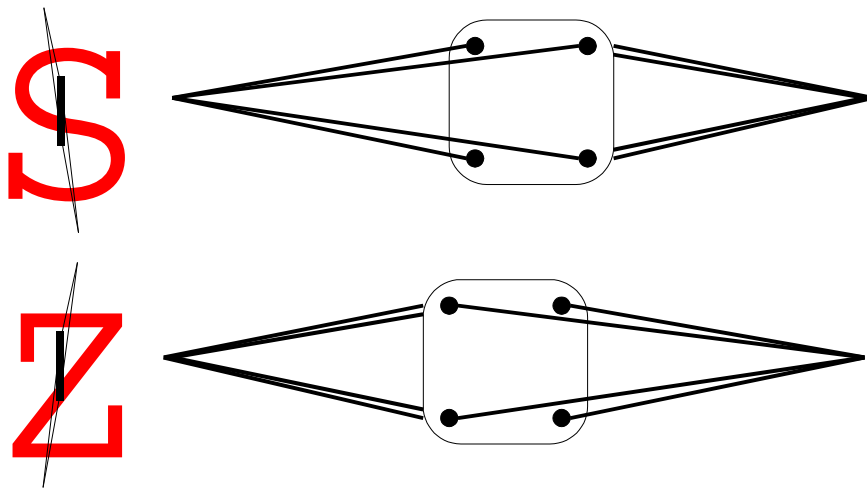


This is the definition used by most weavers and authors, but there are exceptions, so as with tablet labels, always check for the source you are using.

Tablet weaving has the potential to create warp twining in the finished band. If a tablet is turned continually in one direction, the four threads from that tablet will twist together into a cord. This cord is bound to adjacent cords (from other tablets in the pack) by the weft. There are other ways to produce warp twining, but its presence in a band, especially in the selvages, strongly suggests that tablet weaving was used. The direction of twist in the cord can also be described as S or Z. An S-threaded tablet turned forward will create a Z-twined cord, and an S-twined cord if it is turned backward. A Z-threaded tablet will produce an S-twined cord if turned forward, and a Z-twined cord if turned backward (Fig. 7).

Structurally, an S-threaded turned forward is identical to a Z-threaded tablet turned backward. (This is important!)

Figure 7. The relationship between threading direction, turning direction and the resulting cord. Only one hole per tablet is threaded so that the course of the warp on the back of the band (in gray) can be seen.

a. S-threaded, turned forward: Z twining

b. S-threaded, turned backward: S twining

c. Z-threaded, turned forward: S twining

d. Z-threaded, turned backward: Z twining
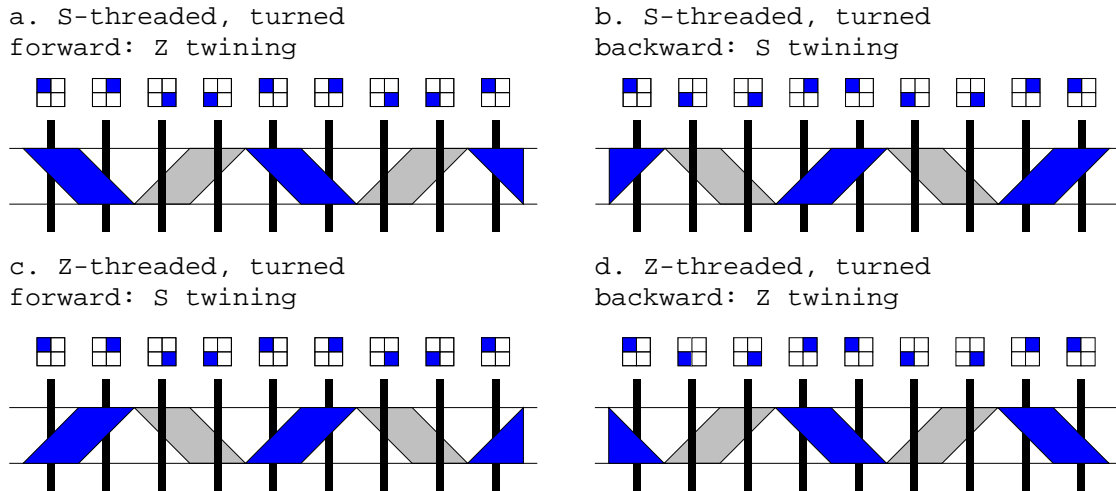
This relationship is possibly the hardest thing for novice weavers to understand, and even experienced weavers occasionally have problems. While working on this article, I came up with a trick for getting smooth diagonal lines. The direction of colored diagonals needs to match the direction of the twining of the cord, but I can never remember how to set up the threads in the tablets to get the desired effect. If you look at the top of a pair of tablets, the change in color sequence between them must follow the same direction as the threading direction of the tablets to give a smooth diagonal color line in the opposite direction (Fig. 8).

Figure 8. Trick for getting smooth diagonals. The color pattern matches the threading direction but gives a diagonal in the opposite direction.

a. S-threaded

b. Z-threaded
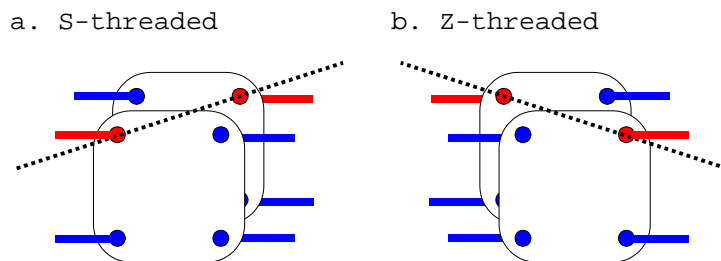
## Turning Pattern

The way the tablets are warped controls the possibilities of a band, while the turning pattern determines what is actually produced. A pack of tablets can be turned either forward or backward. Think bicycle — a forward turn is in the same direction that a bicycle wheel turns when the bike is moving forward (Fig. 9).

Figure 9. Forward and backward quarter turns of a tablet.
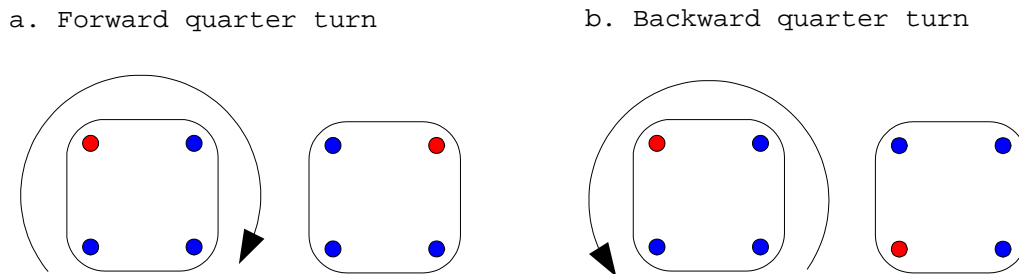


Quarter turns are the most common, but half and whole turns can also be used. Eighth turns may be used if tablets stand on their points and on their flats. Sometimes tablets idle and are not turned at all.

I want to introduce the idea of a "turning unit", a set of any number of turns in any direction and of any size that moves the tablets, creating a new shed, then returns the tablets to their original position. The complement of a turning unit swaps the forward and backward turns, and is structurally identical if done with tablets threaded the opposite way, and a mirror image if done with the same tablets.

Table 1. Some examples of turning directions and their complements. "**f**" and "**b**" denote forward and backward quarter turns, and "**F**" and "**B**" describe half turns.

| | | | |
|---|---|---|---|
| **ffff** | **bbbb** | **ffF** | **bbB** |
| **fffbbb** | **bbbfff** | **ffB** | **bbF** |
| **ffbb** | **bbff** | **FF** | **BB** |
| **fb** | **bf** | **FB** | **BF** |

Turning units are repeated indefinitely. Because of this repetition, **fbbf** is identical to **ffbb** since both will produce the sequence **ffbbffbbffbbffbb**. In practice, bands usually have some interruption in the repeated turning unit, for example to create color patterns in a band.

## Adjacent Tablets

So far I've only talked about single tablets, but tablet weaving with only one tablet would be very boring. Most bands use at least several tablets, and some use hundreds. All could be set up identically, but more often adjacent tables must be different to produce a particular structure. There are two possibilities: difference in threading, and difference in position within the turning unit. Tablet weaving structures are often based around units of two or four adjacent tablets. That gives rise to 3 basic threading possibilities: SSSS, SSZZ and SZSZ. Swapping S and Z would give a mirror image, not an entirely different structure. Similarly, a set of four adjacent tablets could all be in the first position of the turning unit (1111), could be one step out of sequence in the first and second positions by pair (1122), or alternately out of sequence (1212). Tablets can be two steps (a half turn) out of alignment by pairs or alternately: 1133 and 1313. Three steps out of alignment is effectively the same as one step. Four adjacent tablets can also be in all four possible positions in turn (1234).

## Structural Notation

All these traits together can be used to describe tablet-woven structures in an unambiguous way. I've chosen to string together all the descriptors in this order:
1. Number of warp threads
2. Placement of those threads in the holes of the tablet (not necessary for 4-hole structures).
3. Turning sequence
4. Starting positions (by block, either 4 adjacent tablets or minimum necessary).
5. Threading directions (by block, either 4 adjacent tablets or minimum necessary).

Here's an example of a 4-hole structure:
`4-ffff-1111-SZSZ`
This describes a warp-twined band with 4 warps per tablet and alternating S and Z threading.

A 2-hole description is very similar, but you need to specify which holes the warps are in (note, instead of writing AC-AC-AC-AC or BD-BD-BD-BD, I'm just going to write AAAA or BBBB to cut down on length since those are the only two possibilities).
`2-AABB-ffbb-1111-SZSZ`
This is a more complex structure. The first two tablets are threaded through

AC, and the second pair through BD, the turning sequence is ffbb, the tablets all start in position 1, and threading is alternately S and Z.

**Standard Structures**

Having described in detail the five traits of tablet weaving that determine the structure, I can define what I consider to be "standard" structures:
- square tablets used on the flat.
- warped with four threads or with two in opposite corners (two possible starting positions). For two-threaded tablets, the starting position matters (whether the warps are in AC or BD), so blocks AAAA, AABB, ABAB, BBBB can form different structures.
- threaded in blocks of SSSS, SSZZ, or SZSZ.
- turned in repeating units made up of forward and/or backward quarter turns (the first column of Table 1).
- aligned or out of phase in blocks as 1111, 1122, 1212, 1234, 1133, 1313.

Four-hole tablets: 1 warp setups x 3 threading sequences x 4 turning units x 6 alignments =72 structures!

Two-hole tablets: 4 warp setups x 3 threading sequences x 4 turning units x 6 alignments =288 structures!

Because of correspondences between certain setups, not all of these combinations produce unique structures. Once duplicates, mirror images and shifts are eliminated, there are really only 31 structures with 4-hole tablets and 118 using two-hole tablets. Still, that should be enough to keep any weaver out of trouble for quite some time.

(Note that there is no historical documentation for most of these, and as far as I know I'm actually the only one to ever use many of them!)

**Exploring Tablet-woven Structures**

Just reading my explanations probably isn't enough   to fully understand these different structures you really need to try them out. Even after years of tablet weaving, and much thought and study, I still find new aspects of tablet weaving structures.

I put together a "reusable structure analyzer" for tablet weaving. It's simpler than it sounds. Set up a short warp with eight tablets threaded identically with four different colors. Eight tablets is enough to set up two complete four-tablet blocks, but isn' t larg and cumbersome. For ease of comparison, you might

want to use the same colors used in my structure diagrams. Use large, cheap and sturdy yarn. The warp doesn' t need to be very long. Mine is about a foot long. I use cheap bamboo skewers as weft. This allows me to slide the cords apart to examine the internal structure of the weaving, and to slide the cords together to get an idea of what the band would actually look like. After I'm done, I can pull the skewers out and start over. I have another sample warp with two threads per tablet that I use in the same way.

Below are descriptions of the four most common turning units. The associated diagrams are included in the separate figures file.

### ffff (3 4-hole; 11 2-hole)

Warp-twining is familiar to most tablet weavers. The first 4 diagrams demonstrate what happens with a single warp thread starting in each of the four possible positions. The course of each thread on the reverse of the cord is shown in gray. For continuous forward turning, the only difference is the position along the cord of the different warp threads. The same is true for the two possible starting positions of the 2-warp tablets: they are identical but offset. The 2- and 4-warp diagrams are built up from the appropriate 1- hole patterns.

Adding in the other components of structure, for 4-hole tablets threading direction (S and Z) is the only thing that affects the structure. That means that there are really only 3 4-warp basic structures (all called warptwining).

For 2-warp weaves, starting position and threading direction determine structure. Note that 2-AC in position 1 is the same as 2-BD in position 2, and so on. A couple of basic structures are similar in aggregate because they wrap around (1122 = 1221 if repeated across the band) but some that look like they should wrap around don' t because the positions wrap but not the S/Z threading (1122-SSZZ != 1221-SSZZ).

Various examples of warp twining have been used historically, including as selvages on bands with other structures. The very common modern ffffbbbb variant was not used in medieval times, to the best of our current knowledge.

### fffbbb (18 4-hole; 72 2-hole)

There are no synonyms for this turning sequence, and some very odd structures! I don' t know of any medieval or earlier bands using these structures.

**ffbb (10 4-hole; 49 2-hole)**

None of these structures have any warp twining. Instead of determining the direction of twining, the S and Z threading determine the side on which the warps lie (right or left). Because there is no warp twining, all these basic structures can be woven on band looms.

Historical applications for the 4-hole version include favorites of recreationists, including both doubleface and 3/1 twill. Pebble weave and Hochdorf weave are included in the 2-hole structures. The methods used to produce color changes in the doubleface, 3/1 twill and Hochdorf weaves all create warp twining, and so are diagnostic of tablet weaving. Pebble weave was traditionally not woven on tablets, and color changes do not involve warp twining.

Some of the 2-hole structures can't be woven as is without 4-hole selvages: 2-AAAA-ffbb-1111-SSSS pulls out every other weft, effectively creating a half-turn instead of quarter-turn structure unless the selvages catch the weft threads. Early examples sometimes used one selvage tablet on its point (see Fig. 3) to create a solid edge.

**fb (0 4-hole; 3 2-hole)**

The only structures that don't involve unattached warp threads are the 2- hole patterns starting with threads in the BD holes. These again have no warp twining, and can be duplicated with band looms. One of the structures is plain weave (tabby). In 4-hole weaving, fb is mixed with ffff to create patterns of floats for the Snartemo weave. The 4-hole fb structures have internal interwoven warps, but surface floats.

**Color changes**

The interest in many actual tablet-woven bands is provided by color and/or structure changes. While color-arrangement is outside the scope of this discussion, the methods commonly used for color change may also produce structure changes. Normally either the turning direction of one or more tablets is reversed, or the tablet is flipped or twisted about its vertical axis and keeps the same turning direction. This takes advantage of the principle that an S-threaded tablet turned forward is identical to a Z-threaded tablet turned backward and vice versa (Fig. 10). Either method produces a longer or shorter float than usual.

Figure 10. Equivalent of reversing and flipping tablets.
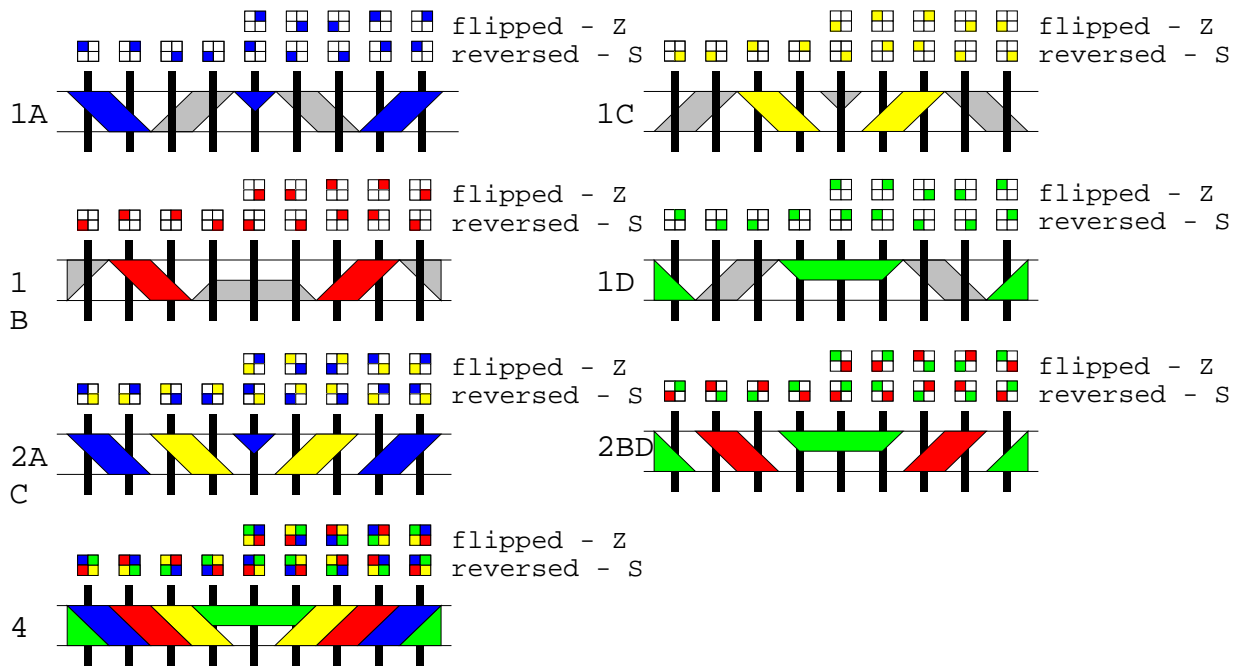


## Conclusions

Tablet-woven structures can be described completely and unambiguously using five criteria:

1. Number of warp threads
2. Placement of those threads in the holes of the tablet (not necessary for 4-hole structures).
3. Turning sequence
4. Starting positions (by block, either 4 adjacent tablets or minimum necessary).
5.  Threading directions (by block, either 4 adjacent tablets or minimum necessary).

A systematic analysis of basic structures using limited combinations of the above criteria reveal that even if duplicates and mirror images are removed, there are large numbers of possible structures (31 using 4-hole, and 118 with 2-hole tablets), and if color patterns are included the possible arrangements are nearly overwhelming. Although these include only a subset of the available combinations, this level of complexity is not expressed in either documentable historic or modern tablet weaving (Table 2). I hope that the classification described here provides a framework for analysis of existing bands and a source of inspiration for tablet weavers.

## Table 2. Historical Overview

This table does not include bands which I could not analyze from descriptions or photographs, nor does it include bands in more complex structures (which will be the subject of a later paper). Most known historical tablet weaving is in one of a small subset of possible structures; large classes of structure (most notably fffbbb) are not known from any medieval or earlier finds.

### 4-ffbb-1111-SSSS: doubleface
**Time**: throughout
**Place**: throughout
**Notes**: one of the two doubleface structures
**Catalog**:
- Datgen, Germany (Hansen 1990)
- Moscevaja Balka, 8th c. (Ierusalimskaja and Borkopp 1996)
- England, 10th c., seal tag (Collingwood 1996)
- two silk seal tags, England, late 12th c. (Henshall 1964)
- bands from London, 14-15th c. (Crowfoot et al. 1992)

### 4-ffbb-1111-SZSZ: doubleface
**Time**: throughout
**Place**: throughout
**Notes**: one of the two doubleface structures
**Catalog**:
- Egypt, 10th c. (Collingwood 1996)
- Gondar tapestries, Ethiopia, 1600-1800 (Collingwood 1996)
- Jerusalem garter, European, 1649 (Collingwood 1996)

### 4-ffbb-1212-SSZZ (= 4-ffbb-1234-SSSS): doublefaced 3/1 twill
**Time**: throughout
**Place**: throughout
**Notes**: more complex doublefaced weave with diagonal pattern structure
**Catalog**:
- Evebo, Mammen, Elisenhof, Durham, Birka (Hansen 1990)
- Poland, 3-4 th c. (unpatterned; Collingwood 1996)
- Norway, 6th c. (earliest patterned example; Collingwood 1996)
- Ft. Miran, Central Asia, AD 800 (Collingwood 1996)
- Witgarius, AD 876 (Collingwood 1996)
- patterned ground weave for brocaded bands from Birka, Sweden, 9-10th c (Geijer 1980)
- St. Cuthbert, AD 916 (Collingwood 1996)
- St. Ulrich, AD 973 (Collingwood 1996)
- patterned ground weave for a brocaded silk band, early 10th c., Durham,

England (Crowfoot 1939)
- St. Donats, Arlon, Belgium (Collingwood 1996)
- Sicily, 12th c. (brocaded; 300 tablets, 78 cm wide) (Collingwood 1996)
- silk seal tag, England, late 12th c. (Henshall 1964)
- Scottish seal tag, 1196 (Collingwood 1996)
- band from London, 14th c. (Crowfoot et al. 1992)

### 4-ffff-1111-SSSS: warp twining
**Time**: probably throughout
**Place**: probably throughout
**Notes**: bands tend to twist, better for tubular tablet weaving
**Catalog**:
- wristband on Anglo-Saxon woman' s dress (Crowfoot 1952)
- tubular silk seal tag, 13th c. England (Henshall 1964)
- tubular bands, 14th c. London (Crowfoot et al. 1992)

### 4-ffff-1111-SSSS + 4-fb-1111-SSSS: Snartemo; fourcolored diagonal patterns with floats
**Time**: Migration/Viking periods
**Place**: Scandinavia
**Notes**: elaborate 4-colored weave, not widespread
**Catalog**:
- Snartemo, 6th c. (Hansen 1990, Collingwood 1996)
- Ovre Berge, Norway (Collingwood 1996)
- Leksand, Sweden, ?10th c. (Nockert 1983, Hansen 1990, Englund 1994)

### 4-ffff-1111-SSSS with reverses: Egyptian diagonals; bicolored patterns with broken diagonal stripes
**Time**: Viking thru early Middle Ages
**Place**:
**Notes**: not Egyptian!
**Catalog**:
- Masku, Finland, 10-11th c. (Collingwood 1996)
- Kaukola, Finland, 11-13th c. (Hansen 1990, Collingwood 1996)
- Sicily, 12th c. (Collingwood 1996)

### 4-ffff-1111-SSZZ: warp twining
**Time**: probably throughout
**Place**: probably throughout
**Notes**: simple, band lays flat, but not well-represented in historic material
**Catalog**:
- band from London, 14th c. (Crowfoot et al. 1992)

## 4-ffff-1111-SZSZ: warp twining

**Time**: throughout

**Place**: throughout

**Notes**: most common form of tablet weaving, simple and the band lays flat; used alone, as ground weave for brocades, and as edges on more complex structures

**Catalog**:

- ground weave for brocaded bands throughout (Hansen 1990)
- North European warp-twined starting borders, Iron Age (Hald 1980, Hansen 1990, Collingwood 1996)
- Coptic, 6th c. (Collingwood 1996)
- tabletwoven fringe from Maaseik, Belgum, early 8th c. (Budny and Tweddle 1985).
- ground weave for many brocaded bands from Birka, Sweden, 9-10th c (Geijer 1980, Englund 1994)
- Orkney, Viking era ( with 2-AAAA-ffff-1111-SZSZ; Collingwood 1996)
- ground weave for 3 brocaded silk bands, early 10th c., Durham, England (Crowfoot 1939)
- ground weave for brocaded silk bands 11-14th c., south Germany and Austria (MüllerChristensen 1977).
- ground weave for late 13th c. band from London (Crowfoot et al. 1992)
- ground weave for brocaded linen & silk seal tag, 15th c. England (Henshall 1964)

## 2-BBBB-fb-1111-SSSS: plain weave, tabby

**Time**: tabby is ubiquitous, using many methods of production

**Place**: tabby is ubiquitous, using many methods of production

**Notes**: Hald (1980) believes many tabby bands could have been woven on tablets, since the method of production cannot usually be identified from the band

**Catalog**:

- Danish Bronze Age (Hald 1980, Collingwood 1996)
- 6th c. band from Laceby, plain weave on front; patterning method produces long floats on back (Crowfoot 1956)
- Speyer Cathedral, Germany, 9-10th c.; has reversals, floats (Collingwood 1996)
- early 14th c. band from London (Crowfoot et al. 1992)

## 2-ABAB-ffbb-1133-SSSS: Hochdorf weave, sometimes called pebble weave

**Time**: 6-8th c.

**Place**: Europe

**Notes**: similar structures not necessarily made on tablets are very common in central Asia, eastern Europe, and South America

**Catalog**:
- Celtic chieftain burial from Hochdorf, 6th c. BCE (Knudsen 1994, Banck-Burgess 1999)
- band from Chelles, France, 7-8th c. (van Epen 1997)

## 2-AAAA-ffff-1111-SZSZ
**Time**: Viking
**Place**: Orkney
**Notes**: one known example
**Catalog**:
- Orkney, Viking era (Collingwood 1996)

## 2-AAAA-ffff-1212-SSSS
**Time**: primarily Migration/Viking
**Place**: northern Europe
**Notes**:
**Catalog**:
- Vestrum, Norway, AD400 (Collingwood 1996)
- Snartemo, 6th c. (Collingwood 1996)
- bands from Viking-age Götland (Nockert and Knudsen 1996)
- band from Bramble Bottom, England, 13th c. (Crowfoot 1954)

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