# The Shroud of Turin and the Extra Sheds of Warping Threads. How Hard can it be to Set up a 3/1 Chevron Twill, Herringbone on a Warp-weighted Loom?

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On the 10 May 2020, Mr. Hugh Farey sent me an email. He introduced himself as "a researcher into the weaving of the linen cloth known as the Shroud of Turin". Then he described the size of the Shroud and how it looked. His question to me was this: "*If you had a piece of cloth as described and looked at it closely, could you tell if it was made by a warp-weighted or treadle loom, or would there be no difference?*"

## Introduction

The warp-weighted loom is a vertical loom (Hoffman, 1974, p. 5). "*This loom has a warp beam from which the warp is suspended. The warp is stretched by loom weights made of fired clay or stone, fastened in pairs at the bottom. The warp beam is supported by two up-rights propped against the wall, which are also fitted with supports for the heddle rod"* (Geijer, 1982, p. 30).

On the treadle loom the warp is horizontal (Hoffman, 1974, p.5). Several variations of the treadle or shaft loom arrived in Western Europe during the Middle Ages, in connection with the organized woollen industry (Geijer, 1982, pp. 33–34). "*This technical innovation may have come from the Near East, probably by way of Italy"* (Geijer, 1982, p.34).

The Shroud of Turin is reputed to be the burial cloth of Jesus. " *Sometimes in the middle of the fourteenth century the cloth now known as the 'Shroud of Turin', made its first recorded appearance in Lirey, a small provincial town in the diocese of Troyes, in the north-central France. Troyes lies a short distance southeast of Paris"* (Nickell, 1987, p.11). The Shroud of Turin is a 3/1 herringbone twill (Nickell, 1987, p.35).

"*The repeat of a twill may also be expressed as a numerical ratio, the first figure indicating the number of picks over which an end passes and the second the number of picks under which it passes. Thus 3/1 is a four-end warp twill; 2/2 is a four-end twill binding which is equal on both sides of the weave. If the warp predominates over the weft, it is a warp-face weave. If the weft predominates, the weave is weft-faced"* (Geijer, 1982, p.43).

"*Fabrics of the earliest group, those with woven starting borders, are known in the following constructions: 1) tabby, 2) plain 2/2 twill, 3) chevron twill, and 4) lozenge twill – the last two being derived from plain 2/2 twill"* (Hoffman, 1974, p.183). From late prehistory all chevron and lozenge twills are broken and asymmetrical, and there are never three threads after one another in any shed (Hoffman, 1974, p.187).

So, how hard can it be to set up a 3/1 chevron twill, herringbone pattern, on a warp-weighted loom?

## Methodology

When I decided to try to put up a plain 3/1 chevron twill on the warp-weighted loom, I chose to make one warp for the plain 3/1 chevron twill and one control warp in 2/2 twill on to the same starting border (See Figure 1 and Figures A and B). The Shroud of Turin is woven in linen, but as I was only setting up a test weave to see if it was possible to weave a 3/1 chevron twill on the warp-weighted loom, I decided to use wool for this test weave. The thicker yarn while not influencing the result also made the pattern more visible.

### The starting border

For the warp and the weft of the starting border I used 14/2 worsted yarn. There are 7 warping threads in the starting border. I used a rigid heddle when I made the starting border and warps for this test.

### The warps for the plain 3/1 chevron twill and the 2/2 plain twill

Since I was using 14/2 worsted yarn as weft in the starting border, it was obvious that I would use the same type of yarn in the warps for the plain 3/1 chevron twill and the 2/2 plain twill. I used 14/2 worsted yarn, colour No. 8034 cognac, for the plain 3/1 chevron twill and 14/2 worsted yarn, colour No. 8111 apple green, for the 2/2 plain twill. The weaving of the starting border and producing the warping threads for the two warps (on two upright pegs) were done simultaneously. The weft in the starting border is done at the same time as the warping threads in the warps for the plain 3/1 chevron twill and for the 2/2 plain twill. *Since the weft in the starting border is formed as a loop, it means that every warping thread in the warp for the warp-weighted loom is a double thread, and at the same time there is a double thread in every shed of the starting border* (Hoffman, 1974, pp.109–110).

1. First I wove 4 cm of the starting border. Then I started to make the warping threads for the plain 3/1 chevron twill by taking the loop formed by the weft of the starting border and carried it approximately 2 meters over to the right peg and dropped the loop down onto the peg (See Figure A).
2. I went back to the starting border and made a new shed in the starting border by using the rigid heddle. Then I took the next loop formed by the weft of the starting border and carried it approximately 2 meters over to the left peg and dropped the loop down onto the peg.
3. I made and dropped in total three loops down onto the left peg (See point B and Figure A) before I dropped the next loop down onto the right peg (See point A and Figure A).
4. In total I produced ten double warping threads on the right peg and 30 double warping threads on the left peg (See Table 1). Then I wove 4,5 cm of the starting border and started to produce the warping threads for the warp of the 2/2 plain twill.
5. The warp for the 2/2 plain twill is made in the traditionally way of making a warp for the warp-weighted loom (Hoffman, 1974, p 109–110). I follow the same procedure as described in point A and point B. The great difference being that this time, I dropped every second loop of warping threads down onto the left peg and down onto the right peg (See Figure B).
6. When I had produced the warp for the 2/2 plain twill, I had 20 double warping threads dropped on the left peg and 20 double warping threads dropped on the right peg. I then wove the last 4,0 cm of the starting border (See Table 1).

| **The distribution of threads** | **3/1** | **In %** | **2/2** | **In %** |
|---|---|---|---|---|
| Double back threads | 10 | 25 | 20 | 50 |
| Double front threads | 30* | 75 | 20 | 50 |
| Total | 40 | 100 | 40 | 100 |

Table 1. Distribution of double warping threads for the 2-2 plain twill and for the 3-1chevron twill on the warp-weighted loom. 30* - Ten of these threads are in the extra shed.

## Attaching the warp onto the warp-weighted loom

1. After I had woven the last 4,0 cm of the starting border, I chained the warping threads and stitched the starting border onto the beam on my warp-weighted loom (Olsen, 2014, pp.64–67).
2. After I had stitched the starting border onto the beam, (containing one warp for the plain 3/1 chevron twill and one warp for the 2/2 plain twill), I unchained the warping threads and distributed the threads into one row of warping threads in the back of the shed rod and into one row of warping threads in front of the shed rod. Then I tied the warping threads to the weights (Olsen, 2014, pp.68–71).
3. After the warping threads were tied to the weights I crocheted one spacing cord for the warping threads in the back row of the shed rod, and one spacing cord for the warping threads in front of the shed rod (Olsen, 2014, pp.72–73). I did not heddle the warping threads onto the shed rod and I did not cut the warping threads in two, down by the floor.
4. the warps were now in position on the loom and I could start to pick up the threads for heddle rod 2 for the plain 3/1 chevron twill. When picking up the warping threads for heddle rod 2, I followed the tie-up for the 3/1 chevron twill (See Figure G).
5. After picking up the threads for heddle rod No. 2, I heddled rod 2 and control the heddling to check that all the warping threads are connected to the correct heddle rod. (Olsen, 2014, pp.96–101).
6. Then I picked up the warping threads for rod 1 and heddled rod 1(Olsen 2014, pp.102–103).
7. Then I started to pick up the warping threads for heddle rod 3 and heddled rod 3, and checked the heddling. Heddle rod 3 is the last heddle rod for a twill set-up on a warp-weighted loom (Olsen, 2014 pp.104–105).
8. I followed the same procedure as described in points J-M when I picked up the threads and heddled the rods for the 2/2 plain twill. I picked up the threads following the tie-up for the 2/2 twill (See Figure H).
9. When I had put up both the warps I made sure that all the three heddle rods could be moved back and forth, one at a time. Then I checked that all the sheds appeared behind each heddle rod, and that there were no unheddled warping threads in the two warps (See Figure C).
10. Now I was ready to start weaving the 3/1 chevron twill (See Figure C).

## The weaving process

1. The first test weave for the 3/1 chevron twill went well. I wove with two sheds, and two weft threads, one thin and one thick (See Figure D).

2. The second test weave on the set-up for the plain 3/1 chevron twill also went well. Here I focused on to weaving with the shed towards me, and not the shed towards the wall (See Figure E). I wove with one single weft thread.
3. When I had finished the two test weaves for the 3/1 chevron twill I wove a plain 2/2 twill weave on the control warp (See Figure F).

## Results

As I had anticipated before I started the test, I was weaving with two sheds on the set-up for the 3/1 chevron twill. The first test weave ended in a beautiful double weave with an eyelet pattern on the front side of the weave (towards me) (See Figure 2), and with a warp-faced weave on the back side of the weave (the side of the weave pointing towards the wall) (See Figure 3). The thinnest weft is the most visible on the front side of the weave and travels over six warping threads (three double warping threads) and under two warping threads (one double warping thread). The most visible weft thread (in apple green colour) also passes over the second weft thread (purple), which passes over the two last warping threads of the group of six warping threads, on the front side of the weave. The purple weft thread is not very visible on the front side of the weave. The binding points for the purple weft threads are to the right for the binding points for the green weft threads on the front side of the weave. The purple warping threads are one row below the green warping threads on the front side of the weave (See Figure D and Figure 2).

On the back side of the eyelet pattern (the weaving side towards the wall), the weave is a clearly warp-faced weave, were the eyelet pattern effects are hardly visible. The warping threads dominates the back side of the weave, on the points in the weave where the eyelet pattern effect is most visible on the front side of the weave. The apple green weft is hardly visible on the back of the weave. It travels over two warping threads (one double) and under six warping threads (three double warping threads ). The purple weft thread travels under two warping threads (one double) and over six warping threads (three double). The purple weft thread passes over the green weft thread. The binding point for the green weft thread is to the right for the purple weft thread (See Figure D and Figure 3).

During the second test weave on the set-up for the 3/1 chevron twill I concentrated the weaving on the shed facing me. The result was a new beautiful double weave. The front side (towards me), shows a plain 3/1 chevron twill weave (See Figure E and Figure 5), where the weft is passes over six warping threads (three double warping threads) and under two warping threads (one double warping thread). On the back side of the weave, (the side towards the wall) the warp thread passes over three weft threads and under one weft thread (See Figure E and Figure 4). The weft passes over two warping threads (one double warping thread) and under six warping threads (three double warping threads).

The control weave on the set-up for the 2/2 plain twill, is as expected an even side plain 2/2 twill, where the weft goes over and under two warping threads on both sides of the weave (See Figure F and Figure 6 and 7).

## Discussion

First I want to give a reply to Mr. Hugh Fareys question: " *If you had a piece of cloth as described, and looked at it closely, could you tell if it was made by a warp-weighted or treadle loom, or would there be no difference?"* The answer to that question is: *Yes, I could tell if it was woven on a warp-weighted or treadle loom, because there are several clues to look for." (*Author, 2020).

1. In a cloth woven as a plain 3/1 twill the weft goes over three warping threads and under one warping thread (Geijer, 1982, p.42, fig c and p. 43).
2. In all the 2/2 twills I have woven on my warp-weighted looms (I own two warp-weighted looms) the weft travels over two warping threads and under two warping threads. This is because I always use double warping threads in my warps and in my starting border (Hoffman, 1974, p. 110; Hansen, 1978, pp.48, 54, 56).
3. My experience is that there are three main set-ups for weaving twill on the warp-weighted loom (Olsen, 2014, p.94).
4. From the set-up for the 2/2 plain twill you can for instance weave a 2/2 broken weft chevron twill (Olsen, 2014, p.83).
5. From the set-up for the 2/2 large diamond lozenge twill and from the set-up for the 2/2 small diamond lozenge twill you can for instance weave a 2/2 broken warp chevron twills as a herringbone pattern and the hounds tooth pattern (Hansen, 1978, p.53, Olsen, 2014 pp.86–87).
6. All the patterns mentioned in points 3-5 are broken and not symmetrical, and all lozenge and chevron twills from prehistorical times are also broken and asymmetrical (Hoffmann, 1974, p.187; Geijer, 1982, p.56)
7. In a 3/1 chevron twill woven on a treadle loom the weft passes over three single warping threads and under 1 single warping thread. It is an even-faced fabric and not a double weave or a double cloth. The Shroud of Turin is not woven as a double weave.

8. The distribution of warping threads in front of and in the back of the shed rod on the warp-weighted loom is very important when it comes to weaving on a warp-weighted loom (See Table 1 and Table 2). *To keep the loom in balance during the weaving process is of vital importance*. If you do not keep the loom in balance, the loom will be in danger of falling forward each time you move one of the heddle rods back and forth when you are changing from one shed to the next during the weaving process (Geijer, 1982, p.30). You keep the loom in balance by using the same amount of weights in front of and in the back of the shed rod. All the weights have to have the same specific weight (to keep the loom in balance) and to keep the tension in the fabric even through the whole weaving process.
9. Table 1 shows that for the set-up for the 3/1 chevron twill there are ten double warping threads behind the shed rod and 30 double warping threads in front of the shed rod. When it comes to the 2/2 plain twill there are 20 double warping threads behind the shed rod and 20 double warping threads in front of the shed rod. It means that when I weave a 3/1 chevron twill on the warp-weighted loom, the loom will be imbalanced during the weaving process. When I weave a 2/2 plain twill on the warp-weighted loom, the loom will be balanced (See Figures 8 and 9).
10. Table 2 shows the same as Table 1, this time in single warping threads.
11. To keep the loom in balance during the test, I had to use extra weights on the warping threads at the back of the shed rod for the plain 3/1 chevron twill. Because of this extra weight, these threads got extra tension during the weaving process, which effected the quality of the weave (See Figure 9).
12. When I had put up the 3/1 chevron twill (the shed rod and three heddle rods) and started to weave the first test weave, I had the normal shed as I would have when I weave a 2/2 twill weave on a warp-weighted loom and one extra shed. I also had problems with getting even and nice selvages. When I wove the same shed twice after each other, (like 0, 0 or 1, 1) I had to use two different kind of thickness of wefts, so that the wefts would not get entangled and disappear into each other.
13. There is no doubt that I had to deal with a double weave when I was weaving the 3/1 chevron twill. Normally, you cannot weave in the same shed, twice directly after each other. If you take the weft from the left side of the weave, through the shed and over to the right side of the weave, and back again from the right to the left, without changing the shed, there will be no weft left in the shed. In the two test weaves for the 3/1 chevron twill I could weave 0, 0, 1, 1, 2, 2, 3, 3 because I used both sheds one after another, for each rod I was using. One of the most interesting discoveries during this experiment, is that I got two extra sheds and an double weave by setting up one single warp on to the loom. To get a double weave you normally make two warps and put them on top of each other in the loom.

14. The reason why I had the extra sheds in the set-up for the plain 3/1 chevron twill with one single warp, is because the heddle rods who are threaded opposite of each other. In all the three main set-ups for the 2/2 twills on the warp-weighted loom, the shed rod (rod 0) and heddle rod *2* are always threaded opposite of each other, and heddle rod number 1 and heddle rod number 3 are always threaded opposite of each other (Olsen, 2014, p.94). When it comes to the treading system for the plain 3/1 chevron twill on the warp-weighted loom, it is the shed rod (rod 0) and heddle rod 3 which are threaded opposite of each other, and heddle rod 1 and heddle rod 2 which are threaded opposite of each other (See Figures C and G).

| **The distribution of threads** | **3/1** | **In %** | **2/2** | **In %** |
|---|---|---|---|---|
| Single back threads | 20 | 25 | 40 | 50 |
| Single front threads | 60* | 75 | 40 | 50 |
| Total | 80 | 100 | 80 | 100 |

Table 2. Distribution of single warping threads for the 2-2 plain twill and for the 3-1 chevron twill on the warp-weighted loom. 60* - Twenty of these threads are in the extra shed.

## Conclusion

"*The weave of the cloth of Turin is a three-to-one twill, striped in the herringbone pattern"* (Nickell, 1987, p.35). It is a 3/1 chevron twill, herringbone pattern, which means that the weft goes over three single warping threads and under one single warping thread. It means that the The Shroud of Turin is a single weave cloth.

When I wove the plain 3/1 chevron twill on my warp-weighted loom, the weft passed over six single warping threads (3 double warping threads) and under two single warping threads (1double warping thread), Since the shed rod and heddle rod nr 2 are not threaded opposite of each other, I got one extra shed in the weave, while weaving the 3/1 chevron twill, which means that I was weaving a double weave.

My test results, as I have described them in this article, tells me that the Shroud of Turin cannot have been woven on a warp-weighted loom. The Shroud of Turin must have been woven on a treadle loom.

## Acknowledgement

First I want to thanks Hugh Farey for asking me about the Shroud of Turin. Thanks to Mr. Farey I have found new and beautiful patterns and set-ups for the warp-weighted loom, as a satin with 5 rods,  and I have learned and discovered a lot through this experiment.

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