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Recreating a Warp-faced Compound Weave with the Jacquard Mechanism -Considering Heizo Tatsumura-

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Recreating of Ancient Fabrics

The technique of how the Warp-faced compound weave was once woven has been the focus of study for many specialists in Japan. It was around 1921 that Heizo Tatsumura began to recreate ancient textiles from the 7th and 8th centuries, found in the Shosoin Repository and the Horyuji Temple. He used the new Jacquard mechanism, which had been imported from France in 1873 with great dexterity. With this mechanism, along with his gifted creativity and inventiveness Tatsumura produced new techniques for the purpose of recreation. The very modern Tatsumura chose the Jacquard mechanism as his tool but at the same time he believed in the importance of always going back to original ancient textiles and to thoroughly research them. His strong conviction to learn from the past became especially important in order to understand and recreate the weaving techniques of the highly intricate warp-faced compound weave which was born in ancient China and lost around the Tang Period (A.D. 618 - 906).

Tatsumura discovered valuable information through his persistence in investigation and his ability to reconstruct the work on the modern Jacquard mechanism shed light on techniques that had been lost. His thinking process and his deep knowledge of ancient methodology gives us insights into how an ancient weaver might have set up and operated his loom. This paper presents speculations on how the warp-faced compound weave was woven in China earlier than the Han and into the Tang periods by gaining inspirations from the methods invented and recreated by Tatsumura on his Jacquard mechanism to reconstruct the complex weave.

By 1924, there were voices stressing the importance of in depth research on the Imperial treasures stored in the Shosoin. The Imperial Museum entrusted Tatsumura with the research and the recreation of those ancient textiles. He started by photographing the original ancient fabric remains, then enlarging the photo to inspect the fibers and the weaves. He also began to identify the dyes. Tatsumura created trial weaves over and over again, repeatedly comparing his trials to the original until he was satisfied with the outcome. As a result of his efforts, he succeeded in elucidating the warp-faced compound weave.

Tatsumura firmly believed the old Chinese saying, "by exploring the old, one is able to understand the new". This philosophy of his has been carried on even today at Tatsumura Textile Company, which he established. The company has been constantly involved in the research and the recreation of ancient fabrics and is faced with new challenges even today. At various times the company researched ancient textile fragments existing in museums worldwide. There were even instances in which Tatsumura Textile Company was requested to help these museums by reproducing

the fabrics as goods to be sold in their shops. In such mass production cases, designs were adjusted to fit the power loom.

The basis in the recreating process is the making of a detailed analysis of the original textile including the reeling and the spinning of the thread. Pattern cards for the Jacquard Mechanism are made and re-made through the process of groping with the structure of the original textile fragments. Threads of a suitable type which in the past had been imported from China, are now produced in Japan. Threads used in the original ancient textiles were not equally smooth in all areas. Today, thread selection starts from the production of suitable raw silk and reeling is done by conscientiously creating thick and thin areas within the single thread.

Tatsumura discovered that ancient silk used in the warp-faced compound weave was only half degummed during the process of dyeing. For this purpose, presently natural ash solution is used in the processing, to get a similar quality to that of the ancient silk. Enlarged photos showed that these threads were slightly twisted in z direction and again, threads were developed to fit this criterion. Chemical dyes were carefully selected to recreate the original colors and the trial weaves were repeated with this dye until the finished work was good enough in Tatsumura's eyes so as to employ natural dyes for the threads used in the final project.

The Recreating Project of 1998

Tatsumura Textile Company's project of 1998 recreates the warp-faced compound tabby silk with warps in three colors. The original textile named *Bird and Animal Motifs Encircled with Pearl Roundel on Purple Ground* (Illustration I-a), is preserved in the Shosoin repository. This project was carried out in a similar manner to that of Tatsumura's past researches.

A photograph was taken of the original textile fragment in the Shosoin in order to analyze the weave. Then the photo was enlarged to four times its original size. Through a careful inspection of each colored thread and by counting the number of woven threads in the photo, the design of the fabric was transferred on to grid paper (Illustration IV-a). A single grid represented the single warp that was visible on the surface. One warp out of the three warp threads was used to make the pattern. The grid was colored according to the color of the surfaced warp. Disintegrated portions of the textile were indicated by a unique identifiable color to separate it from the intact areas. By studying the squares of the grid in the weft direction, specialists determined that each square of the pattern was four warps in the stepped outlines of the motifs. By counting the threads in the warp direction, craftsmen found that two identical units of wefts were always woven. Each square of the pattern has two wefts that control the patterns in the stepped outline of the motif.

In this way we are able to appreciate the genius of the ancient craftsman. For programming the lashes that were used for weaving a pattern weft, the ancient craftsman had organized his loom so that he had to set only half the amount of lashes on the draw cords to create the design he wanted. By

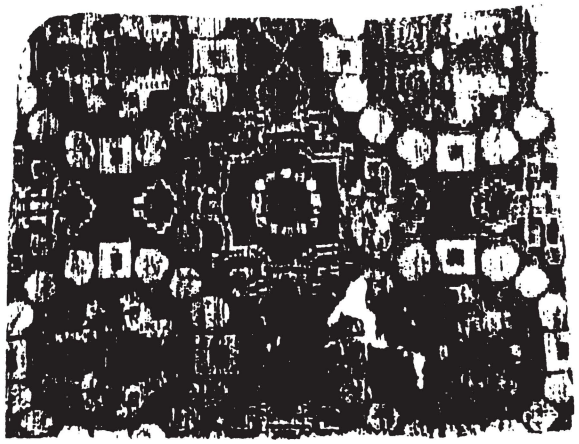


Illustration I-a

Birds and Animal Motifs Encircled with Pearl Roundels on Purple Background

Warp 35.5 cm : Weft 46.0 cm

Eighth Century

Shosoin Repository in Nara, Japan

The design consists of two birds and animals encircled within a pearl roundel. In the roundel a bird and an animal are placed horizontally on the same plain facing each other to create a pair and an identical pair is stacked on top of the other to create a total of four creatures in a roundel. This means that the motif does not repeat itself in the weft direction but the same bird or animal is stacked on top of each other to create a repeat in the warp direction. Four roundels create a unit and in the center of this unit is a sub motif of a curving tendril pattern in the shape of a lozenge.

Statistical data from the selected section of the fabric in the 1998 project

Width of trial cloth :26.8 centimeters

Warp :two 50 denier silk slightly z twisted together in one direction

Count : 122 per centimeter (warps contain three colors and this comes out to about 40 warps per centimeter on the surface of the fabric)

4 decoupures

Weft : 63 denier x 4 (for both binding and pattern wefts)

Count : 8 x 2 (binding and patter) per centimeter

Density of dents on a reed : 20.3 dents per centimeter

Total dents on a reed : 544

Total number of warps : 3,264

Warps with color : 1,088

Necessary number of hooks on the Mechanism : 816

Mechanism with 408 hooks was used (136 hooks per color x 3 colors = 408 hooks). 816 necessary hooks / 408 available hooks = 2.

Han Silk with Design of Chinese Characters of Auspicious Meanings

(CA. Later Han Dynasty AD 25 - 220)

Recreated by Heizo Tatsumura from a photograph

National Museum in New Delhi

Excavated by Sir Mark Aurel Stein from the archaeological site at Loulan.

Statistical data from the second trial in 1982

Width of cloth : 44.5 centimeters (cm)

Warp : two 42-denier silk slightly z twisted together in one direction

Count :132 per centimeter (warps contain three colors and this comes out as 44 warps per centimeter on the surface of the fabric) 1 Decoupure

Weft : four 42-denier silk

Count: : 12.5 per centimeter

Density of dents on a reed : 22 dents per centimeter

Total dents on the reed : 980 (6 warps per dent)

Total number of warps : 5,880

Warps with color :1,960

Necessary number of Hooks on the mechanism :1,960

Mechanism with 936 hooks was used (312 hooks per color x 3 colors = 936 hooks). 1960 necessary hooks / 312 available hooks = 6 plus a leftover amount of 88.

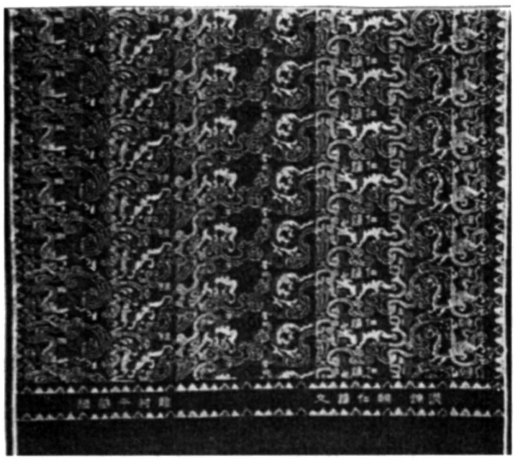


Illustration I-b

using this technique the draw boy used the same lash twice to weave two pattern wefts and this made it simpler for the craftsman when the lashes were programmed on to the draw cords.

In order to reconstruct the weave and the design of the ancient textile, well preserved portions from the original textile fragments were selected and pieced together to form an image of what the original may have looked like. Pattern cards were created from the data derived from this image and a preliminary test was woven. The test was compared with the original and changes were made to bring the test weave even closer to the original. This process was repeated over and over again. In Tatsumura's project of 1998, a pearl roundel containing two birds and two animals was selected as the portion of the fabric to be reproduced (Illustration IV-b).

The subject to be reconstructed was a circular design with the upper half of the motif symmetrical to the lower half. It was calculated that three different colored threads and 272 hooks per color were needed in order to weave the design. This amounts to a total of 816 hooks. It would have been easy to weave a complete design on a 936 hook Jacquard mechanism but Tatsumura decided to choose another method of weaving and to employ a 408 hook mechanism.

The technique used was the "Divided Repeat" or Karikama method and this method was selected in order to preserve the traditional technique of the Nishijin weaver's district in Kyoto. In this method, the design was vertically divided into half at the center of the roundel (816 hooks x ½ = 408 hooks) and two sets of pattern cards for the right half and for the left half of the design were made. In weaving the whole roundel, the weaver raises the needles of the mechanism twice to make a shed for a pattern weft.

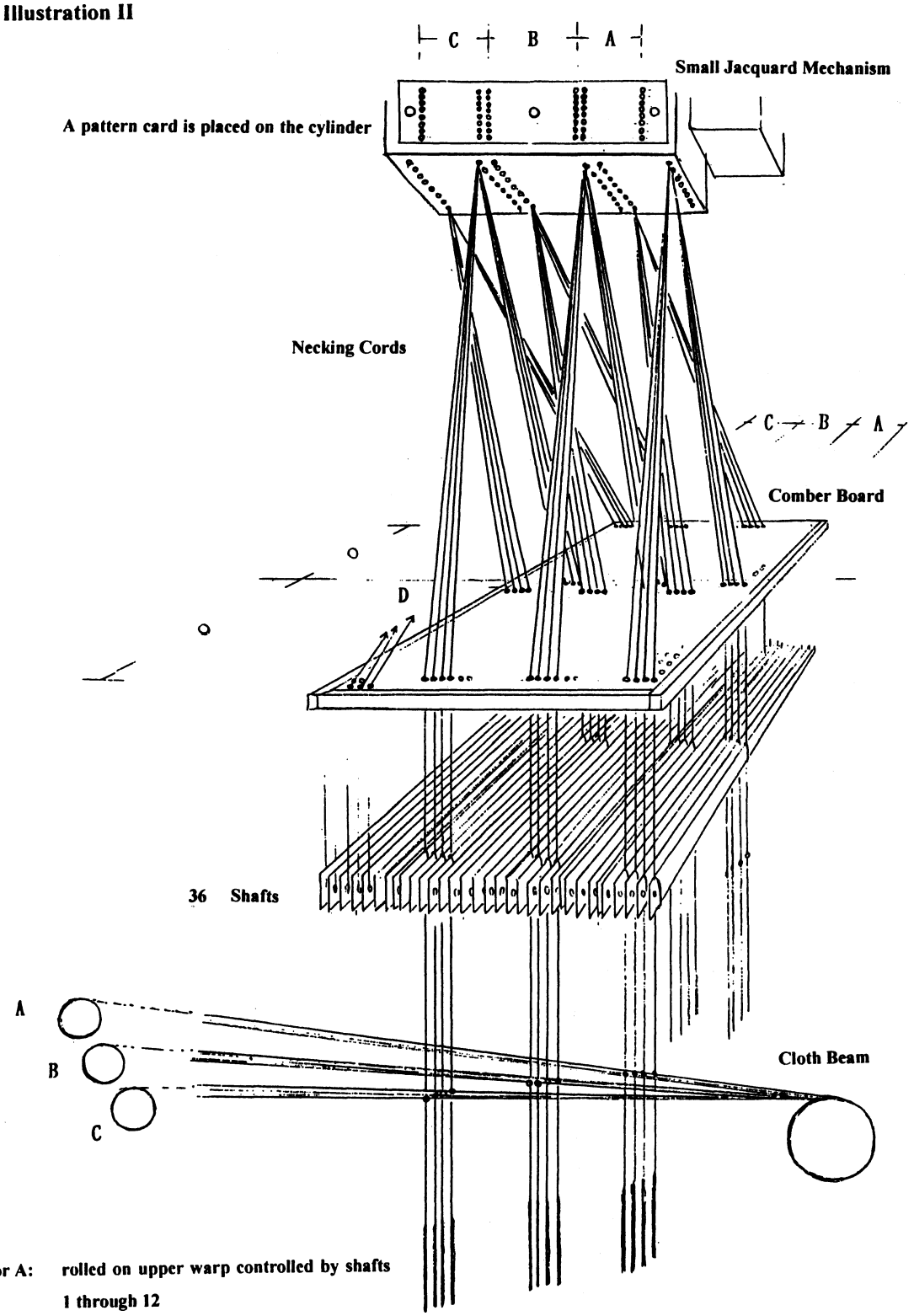
The Divided Repeat (Karikama) method, which raises the needles many times to weave a weft had been used by Heizo Tatsumura around 1935, to recreate a Chinese textile named "*Han Silk with Design of Chinese Characters of Auspicious Meanings*" (Illustration I-b). In this warp-faced compound tabby silk with warps in three colors, six different animals and ten Chinese characters were woven without a repeat. A shuttle traveled seven times to weave the length of the weft to weave this piece.

Tatsumura's Success in Recreating the Warp-Faced Compound Weave

For Tatsumura, the key to his success in recreating the warp-faced compound weave on the Jacquard mechanism was his idea to divide the warp threads by color to be rolled on the individual back beams of the loom. The bottom section of Illustration II gives a side view of the three different colors of the warp threads being divided onto the three warp beams.

In the illustration, each back beam is named A, B and C according to the individual color of the warp to which it corresponds. This division of warp colors continues on to the intersection of the warp thread and the heddles, through a vertical system stacked on top of each other with the shaft topped

Illustration II



Color A: rolled on upper warp controlled by shafts 1 through 12

Color B: rolled on middle warp controlled by shafts 13 through 24

Color C: rolled on lower warp controlled by shafts 25 through 36

D: cords that come from the shafts connecting to the small Jacquard mechanism installed in front of the main mechanism

by the comber board and with the pattern cards on the cylinder above it. Each area on the mechanism is labeled A, B and C according to the color of the corresponding threads it controls.

Turning now to the 36 shafts, these are the shafts that lift to make the sheds for the basic structure--plain weave. The first twelve shafts (shaft no. 1 through 12) are connected to warp A and thus control the warps with color A. The second set of twelve shafts (shaft no. 13 through 24) control warp B with color B thread and the last set of twelve shafts (shaft no. 25 through 36) belong to warp C with color C thread. Threading the warps followed the traditional warp order of colors of the ancient warp-faced compound weave. The warp order of colors placed in a line reads as: ABCCBAABC. This particular warping order with the last and first thread colors of neighboring units being the same and the direction of returns is characteristics of the ancient warp-faced compound weave.

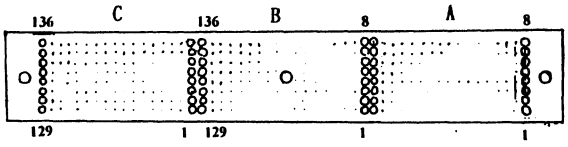
With this set up, the even and odd numbered shafts are raised alternately which is very practical in producing the plain weave. It is constructed of a single set of three warps strung together. In China, shafts for the ground weave were installed in front of the draw cords. In Japan, by following this draw loom tradition, a small sub system (60 hook mechanism) separately placed in front of the main system operates to alternately raise the eighteen odd or even numbered shafts for weaving the plain weave on the Jacquard mechanism. If the sub system is not used, pattern cards for the binding weft of the plain weave must be inserted between each pattern weft card, in which case the number of pattern cards held by the main system will be double the amount of a separate system.

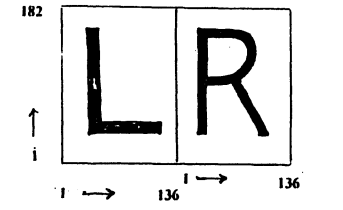
The comber board is divided into three sections A, B and C, corresponding to the colors, A, B, C. The diagram of the loom in Illustration II shows the three sections from front to back. The first and the last four threading of the two repeats are shown passing through the holes of the comber board in the sequence of the style used in the Nishijin weaver's district in Kyoto. In this project, the threading direction is worked from the left front corner backward as shown in each area. Each necking cord is equivalent to a four-warp pattern step.

Each pattern card placed on the cylinder is also divided into three sections corresponding to the warp areas and colors, A, B, C. Each card carries a total of 408 holes to match the number of hooks, which are then divided equally among the three sections. Thus each section carries 136 holes and the rows of eight holes repeat 17 times across the card in each of the sections A, B and C (Illustration III-a). The direction in which the grid paper is drawn and the order the pattern cards are punched along with the order of lacing the pattern cards, all follow the reverse method (Illustration III-b).

Our warp-faced compound weave was woven face up because it is easier to lift a single warp out of the group of three than two. We suspect the ancient weavers did the same for this reason. There are several reasons why the warp threads are divided by color. The Jacquard mechanism in most cases has been used in Nishijin weavers district for the traditional patterned textiles woven with supplementary wefts.

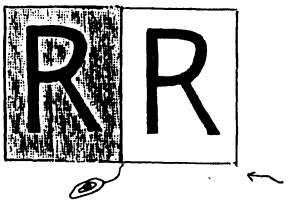
Pattern Card **Illustration III-a**



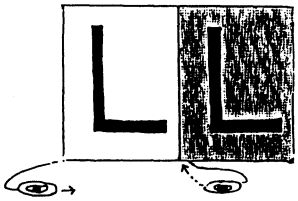


Divided Repeat (Karikama) Technique

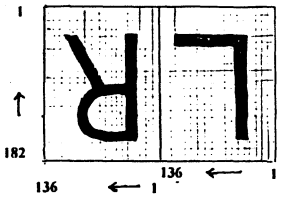
The Warp-faced Compound weave is woven with the front side up.



The shuttle of the patterning weft is brought to the center to rest.



Next the shuttle is brought through to the left selvage. The moves so that one half of the two repeats is always not woven. The shuttle movement is from right to center, center to left, left to center and center to right. RL -LR



The order of the pattern card is reversed with the last card inserted in the front.

Point Paper Plan **Illustration III-b**

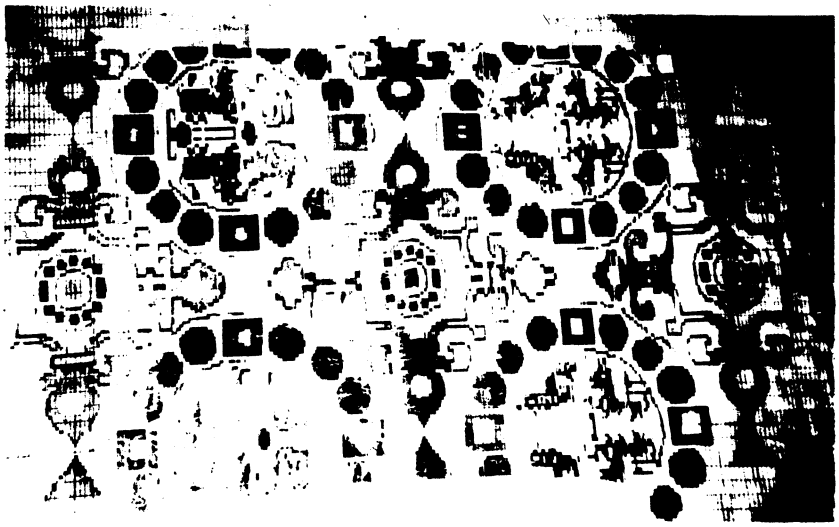


Illustration IV-a

A fabric design reconstructed on grid paper from a photo of an ancient textile fragment stored in the Shosoin.

In the past, craftsmen employed a piano machine to punch pattern cards and for every supplementary weft that created a traditional pattern weave; a card had to be punched. The craftsmen naturally picked up a design on the grid paper by following individual colors. For this reason when a craftsman punched a card, naturally it was easier to divide the sections by color on a pattern card. It was also a natural line of thought for Tatsumura to divide the warp threads by color instead of rolling everything on a single beam to solve the problem of threads becoming tangled among the highly dense warps during the weaving process. It also solved the problem of tension since the back beams equalized the different pulling forces that occurred during weaving. In the following section, I would like to show that on an experimental primitive loom this method of division also worked to simplify the weaving of the warp-faced compound weave and that perhaps this gives us an insight into how an ancient weaver produced this illusionary weave on his draw loom.

Experiments on the Primitive Loom and Concluding Remarks

My original purpose for researching the weaving method of the warp-faced compound weave on the Jacquard mechanism was to look for a solution on how to weave with an extremely dense warp. By applying Tatsumura's approach, my aim was to gain an understanding of how the ancient weaver had avoided this problem.

In order to experience the workings of the draw loom in person, I recreated Tatsumura's solution on an experimental primitive loom (Illustration V). His method led me to separate the draw cords by each color of the warps. Specialists until recently have always experimented by collecting all of the draw cords into a single tower to centrally control the movement of the loom. But my experiment of separating the draw cords according to warp color shows that each draw cord makes a clear shed for a pattern weft in the closely spaced warps. With this method, the patterning parts on each cord are light in weight, which lightens the burden off of the draw boy when pulling the draw cords.

Dividing the draw cords by their warp colors also suited the color order of the ancient weave. I experimented with warps of four colors and then six colors on the primitive loom. As previously mentioned, the color orders of the threads were lined in the weave so that the first and the last threads in the neighboring units of four or six colors were always the same colors and were woven with at least two warps in each pattern step. In other words, in the case of warps with four colors, the threads are lined so that the order looks as follows: ABCDDCBAABCDD etc. so that only half the number of draw cords are needed to control the two end colors (A and D), compared to the colors in between. My experiment shows that with lesser draw cords to pull to create the design it is easier to manipulate the cords for pulling up the warps and also to program them with lashes. Lesser numbers of draw cords makes process simpler and practical in programming the active motif in the design such as its outlines.

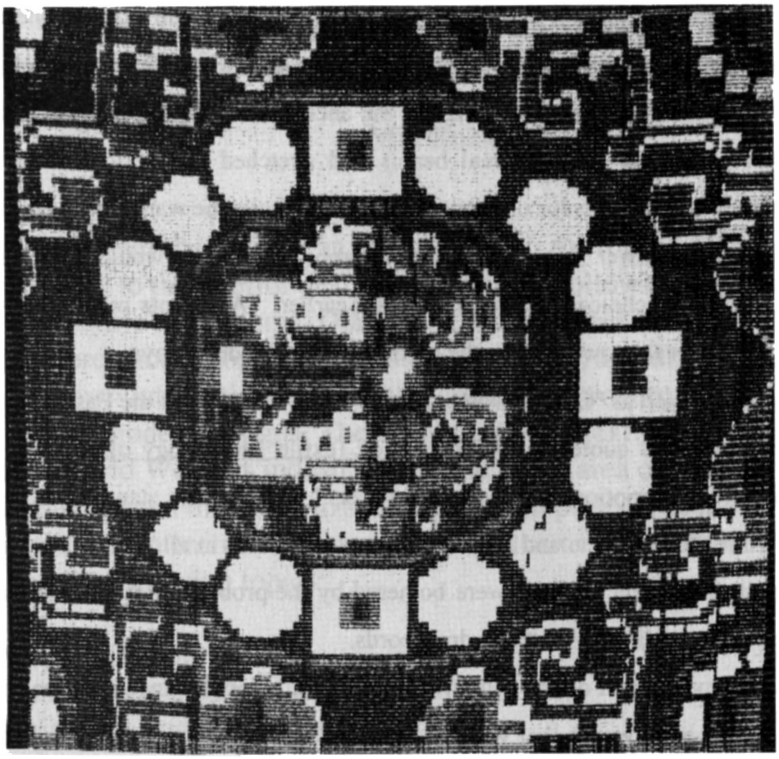
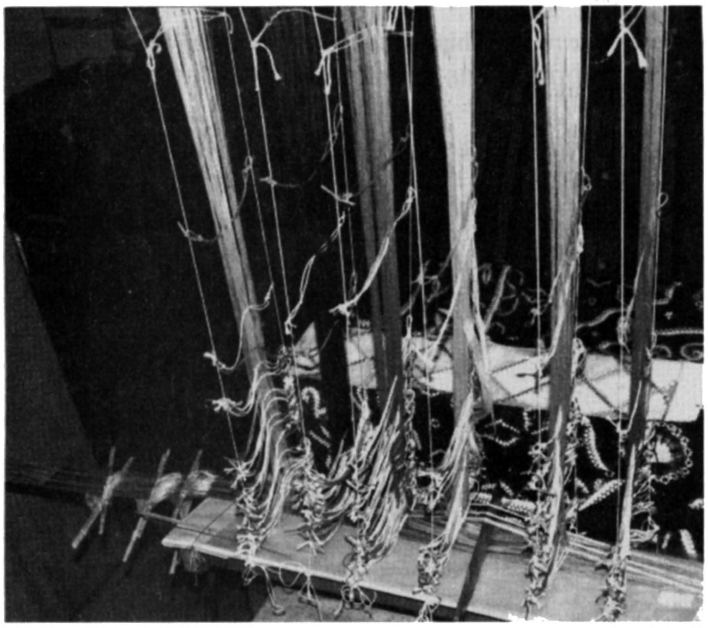
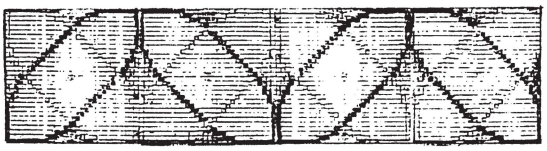


Illustration IV-b

Illustration V





Design on the grid paper Total grid: 120 x 30 One grid represents 2 warps.

The experimental loom for the warp-faced compound (2/1) twill with warps of 6 colors. The loom has no reed. Three harnesses for the twill weave are put in front of the six individual draw cords. Each draw cord has 30 lashes.

The Total number of warp: 1,440
(Warp with color: 240)
in 52-54mm width

Warp: polyester sewing machine thread (No. 60)
Count: 267~244/cm (45~46/cm on the surface)

Weft: Cotton covered polyester sewing machine thread
Count: 8/cm (binding & pattern wefts)

Prints showing daigrams of looms from existing Chinese draw looms and from Japanese draw looms, which have been replaced by the Jacquard mechanism, provide us with examples of single-tower looms. But for the above mentioned reasons, my image of the ancient Chinese draw loom consists of individual colored warp threads rolled on individual beams and stretched tightly for a rather long distance. Draw cords for each individual color of warps were placed above the warp threads. Even in the case when a single large-scale tower was used, most probably draw cords would have been set separated by their warp colors for technical reasons mentioned earlier. Assistants may have worked with sticks to create the sheds under the towers when the cords are lifted by draw boys.

Chinese literary works such as "Ode to Women Weavers" by Wang Yi of the Eastern Han was also written during this period and is quoted in the History of Textile Technology of Ancient China. Wang Yi gives a comprehensive description of the draw loom as, "...two towers standing facing each other" and the ode ends, "while they travel to and fro, they know no tiredness at all." It is hard to think from such an expression that the ancient weavers were bothered by the problem of the dense warps or the problem of the weight in order to lift the warps by draw cords.

Needless to say, my experiment on the primitive loom is not a definite answer to the weaving method for the warp-faced compound weave that was used more than one thousand two hundred years ago. By thinking from a weaver's point of view, of which I am one, this method is practical and logical enough as a consideration and perhaps it will help illustrate the whole picture of how the warp-faced compound weave was woven in the ancient past. The relationships of color threads in the warp order and its activity in the pattern still remains a topic for future study.

(Translated by Naomi Nagano)

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