Session IV

Textile Design in Global Context

The Innovative Development of the Jacquard Weaving Machine in Japan

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Abstract

The Jacquard machine is an innovative automatic weaving device traditionally controlled by punching cards. It was invented by Joseph Jacquard and first exhibited at the Paris Exposition in 1801. The machine quickly became popular, mainly around Lyon, France. In Japan, the first Jacquard loom was brought from Lyon to Nishijin by Tsuneshichi Sakura and others in 1873. Since then, the Jacquard loom for Kimono has evolved in its unique way.

Before the introduction of the Jacquard loom, there was already a difference between the European-style draw-loom and the Japanese sorabiki-bata. Therefore, the Jacquard system was adopted carefully in Japan and developed independently. To compare machines and textile designs, we will review patents and utility models related to Jacquard looms, many of which are from the Meiji era (1868 - 1912), to clarify how the European-style Jacquard looms were adapted to fit the Japanese style.

The structure, mechanism, and design methods of the punch card of the Japanese Jacquard differ significantly from the European-style Jacquard looms that are currently widely used in Japan and abroad. In recent years, the computerization of Jacquard looms has progressed, and the punching cards of Japanese and European-style Jacquard looms have been converted into computer data. This allows for an easy comparison of the machine structures and design methods between the two.

By comparing the Japanese and European-style Jacquard looms, we would like to clarify the reasons why the previous generation of engineers further developed the Japanese Jacquard loom and lead it to the development of new fabrics that utilize the strengths of both Japanese, and European-style Jacquard looms.

Keywords: *Jacquard Machine; Textiles; Traditional Craft; Woven Fabric; Kimono*

Introduction

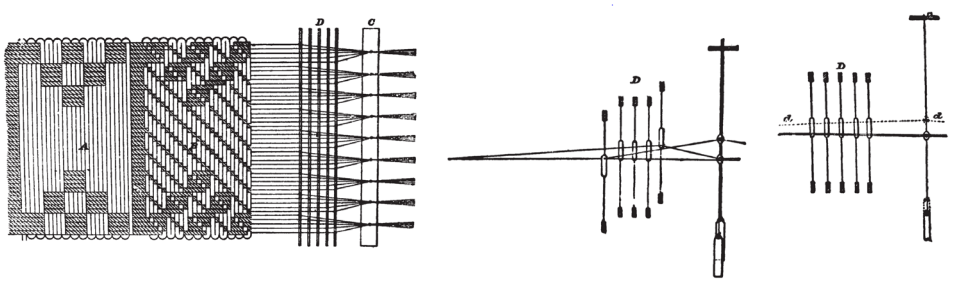
Japanese craftsmen have concentrated on the design and production of narrow fabrics for over a thousand years, since the beginning of the history of the Kimono. Many craftsmen dedicated a lifetime to improving their skills and the mechanisms of the kimono loom. The Kimono culture in Japan is declining, but by exploring the materials, techniques, knowledge and culture cultivated throughout the years, it is possible to see new possibilities and create innovative materials.

Many people would assume that there is no place for traditional weaving looms in the development of today's innovative materials. However, as described by Hagan (1), through examining historical weaving techniques, we can expand our understanding of what is possible in the field. Nonetheless, the speciality looms and other tools needed to research these historical techniques are increasingly more difficult to find due to the focus on fast and cheap manufacturing

of fabrics, which has resulted in a monoculture of looms. In this regard, this study aims to investigate the differences between European- and Japanese-style Jacquard looms and suggest possible opportunities for future research.

The origin of Japanese Jacquard; a comparison between sorabiki-bata and the European drawloom

Prior to the introduction of the Jacquard in Japan, the sorabiki-bata was used by Japanese craftsmen.This loom was similar to the draw-loom used in Europe. To understand the mechanism of the drawloom, first, we need to understand the compound-harness loom. As described by Broudy (2), the compound harness loom consists of two, or sometimes three, sets of harnesses. One set of harnesses is used for the ground weave, and the other set is used for the figured weave. The sets of harnesses are controlled simultaneously by threading the warp yarns through both the first and the second set of shafts. This way of threading results in a single warp yarn passing through one ground weave heddle and multiple warp yarns are threaded in one figure heddle.



A: Cloth woven using only figure harnesses
B: Cloth woven using both figure and ground-weave harnesses.
C: Figure heddles
D: Ground weave heddles

Figure 1: Explanation of the compound harness by Broudy, *The Book of Looms*, 129,130)

The compound-harness loom joins the weave structure and the figured design together, meaning the figured design is part of the texture of the fabric and cannot be separated from it. Although the compound-harness loom allows the weaver countless possibilities in drafting patterns, the size of the figured pattern the weaver can create is determined by the number of harnesses placed in the loom. The drawloom gave this freedom to the weaver by replacing the last set of shafts (C in Fig. 1) for an arrangement where warp threads can be lifted independently.

Both the sorabiki-bata and the European drawloom needed two people to operate it, one weaver and one assistant called the drawboy (or sometimes drawgirl) (2). The sorabiki-bata is very similar to the compound-harness loom. It would hold one or two sets of shafts to create the ground weaves, and a drawboy would sit on top of the loom to draw the figured pattern.

In 1605 Claude Dangon of Lyons was believed to have made a simple invention that would place the drawboy on the side of the loom instead of the top of the loom (Fig. 3). This would later be called the European drawloom. The introduction of the comber-board allowed the warp yarns to stay in place.

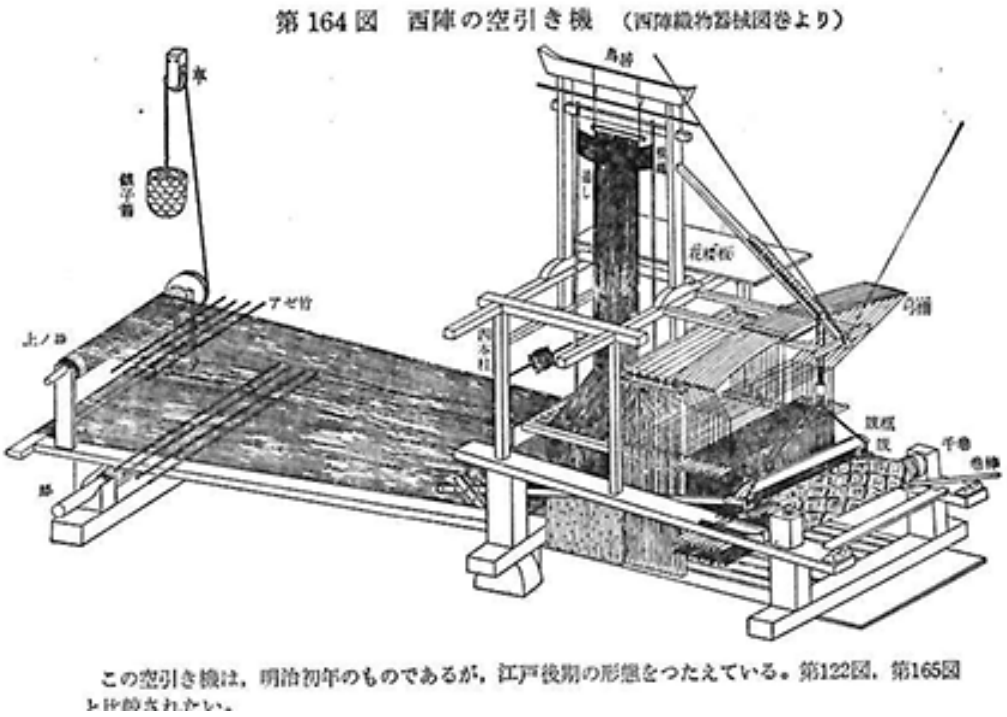


Figure 2: Sorabiki-bata (*Mon-ori no bi to waza*, 231)

The introduction of the Jacquard machine in Japan

The invention of the Jacquard loom was first exhibited at the Paris Exposition in 1801 by Joseph Jacquard (3). This invention would replace the drawboy with a punching card system and therefore reduce the cost of producing fabric.

The first Jacquard loom in Japan was brought from Lyon to Nishijin by Tsuneshichi Sakura and others in 1873 (4). The machine was used to weave fabric for Kimono, the structure, mechanism, and design method of the punch card of the Japanese Jacquard differ significantly from the European-style Jacquard looms that are currently also widely used in Japan and abroad.

Due to the different requirements of fabric structure and size, the Japanese Jacquard developed in a distinctive way since the introduction of the machine. During this period, the Kimono was still the most worn garment in Japan, and because the Kimono required different fabric specifications, the Jacquard consequently developed differently compared to European-style Jacquard.

A Kimono is made out of a long strip of narrow fabric, which requires a loom width of roughly 40 cm. The Kimono is not constructed by cut-and-sew, so the luxury of the garment is not determined by the fit but rather by the quality of the fabric. Another aspect is the fact that textile producers in Japan are historically working as small family businesses. Therefore the size and price of the machine were of great importance. The machine needed to fit in their houses, and Jacquard machines with a low amount of hooks were, although still expensive, more affordable. This also leads to a great diversity of the manufacturing landscape. A lot of independent companies developed their specialty and innovated within their craft.

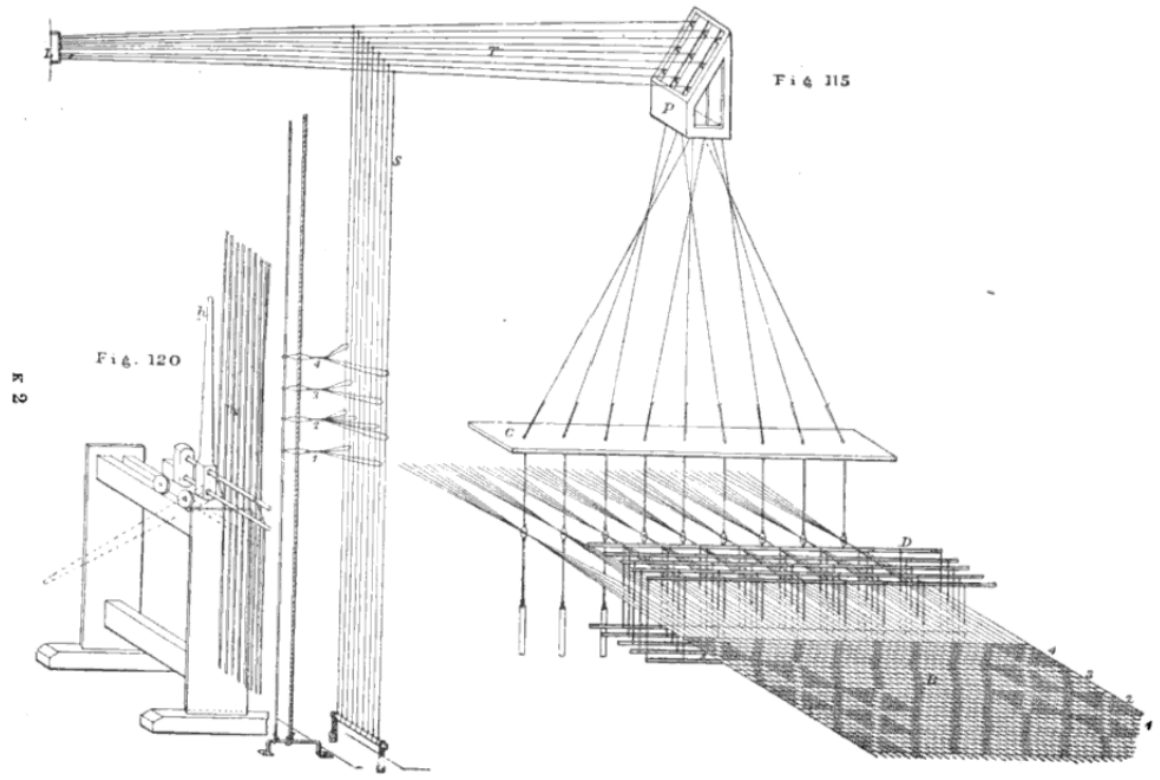


Figure3: European Draw-loom (*The Book of Looms*, 131)

Characteristics of Japanese Jacquard

Even though most textile production has disappeared in Japan, Japanese Jacquard (and sometimes sorabiki-bata) machines can still be found in Tango and Nishijin (Kyoto Prefecture) and Kiryu (Gifu Prefecture). The weavers in these regions focus on the production of detailed narrow width fabric for Obi and Kimono. The Japanese Jacquard machines used by these weavers are a hybrid of the Jacquard machine and a dobby mechanism, similar to the compound-harness drawloom.

The Japanese Jacquard system consists of three components, the Fumise, Boutou and the Jacquard. The warp yarns are threaded through all of the components of the machine. The warp threads pass through the Fumise. Fumise is a dobby mechanism that can push the yarn down to create big motifs which look like embroidery. The Boutou is a dobby mechanism that creates the ground weaves, for example, tweed or a satin weave. Multiple warp threads are threaded together through the Jacquard heddle, allowing the weaver to create figured patterns with a limited number of Jacquard hooks.

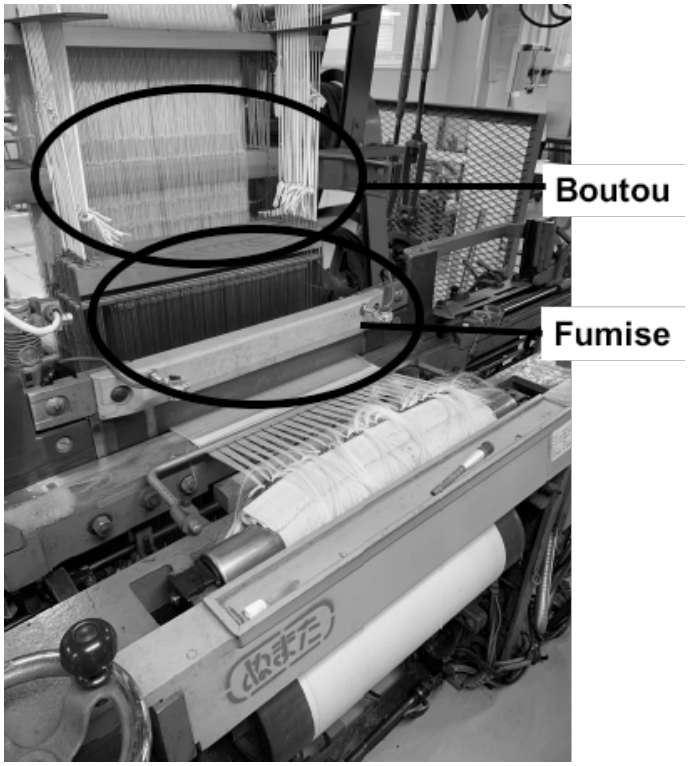


Figure 4: Boutou and Fumise system for Japanese Jacquard (photo taken by the author)

There are three types of jacquard setups;

1. **Itoba**

This setup is used to create detailed weaving patterns, primarily patterned weaving. Itoba is the most similar setup to the Western repetitive system. The design methods are also the same. It is suited for weaving a white kimono and garment fabric.

2. **Hitokama matsuba**

The word "Hitokama" means a non-repetitive setup. "Matsuba" is Pine-needles in Japanese and represents the way of threading, as seen in this image. When one hook is raised, the threads on the Boutou, which overlap each other like pine needles, are raised simultaneously so that larger and more complex patterns can be woven. The mechanism of the Boutou is similar to that of a dobby, allowing for ground patterns to be woven. Hitokama matsuba is used often for patterned white kimono fabric.

3. **Hitokama betazashi**

This setup is used for weaving big patterns, with a detailed background weaving, especially for Obi. The Hitokama betazashi is a unique setup because it is the only one that uses the Fumise system. The threading draft shows that one thread goes through both the Boutou and Fumise. This system allows for coloured weft threads to be woven softly, giving it the appearance of embroidery. This setup is often used for weaving Obi

In all three types of weaving machines, the 900-hook setup is still the most popular. Considering that each Jacquard hook has four threads connected to it, it is possible to weave a fabric with 3600 threads. This system makes it possible to weave large patterns with a relatively small jacquard machine, even with the finest silk threads.

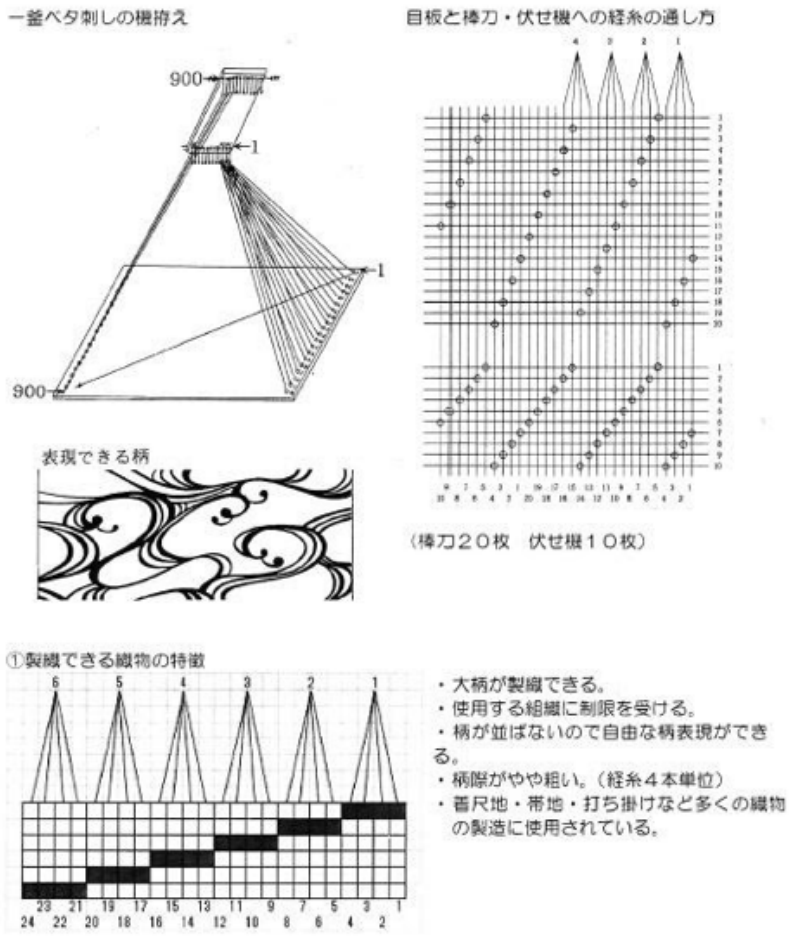


Figure 5: Instruction for Hitokama Betazashi (Text from Kyoto Prefectural Institute for Northern Industry）

The hooking system of both Hitokama matsuba and Hitokama betazashi are significantly different from the European-style Jacquard, which accommodates products that require repetitive patterns over a wide-width weaving loom (1.5-3meters).

Japanese hooking parts are still used today, and the holes of the punching cards allow the metal tools to penetrate them, catch the hooks and then raise them. Western-style Jacquard hooks hold multiple weft threads equally apart, allowing for wide fabrics with repetitive patterns while minimizing the number of hooks.

This Japanese hooking system in use today is called direct Jacquard and can be broadly divided into the following two categories.

1) A type in which the cylinder of an existing Jacquard machine is removed and the needle of the Jacquard machine is directly controlled by the action of a magnet or magnetic material.

2) A type in which the entire structure of the Jacquard machine is changed for direct weaving machines so that the opening operation can be performed directly (Fig. 5, right) (5).

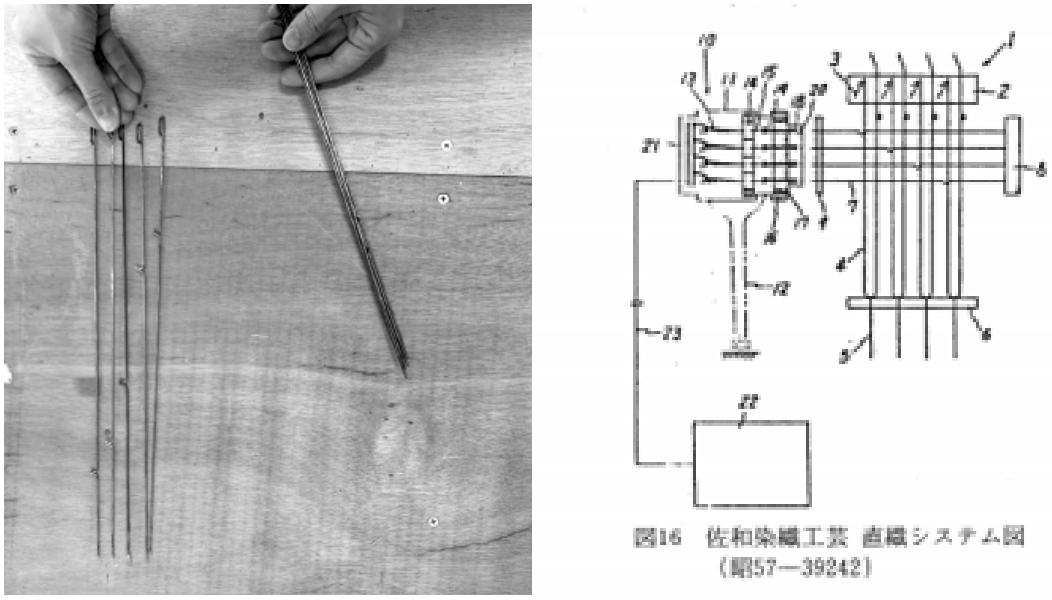


Figure 6: Japanese hooks (Left: Photo taken by the author, Right: Mechanism for Japanese hooks (Tokkyomen yori mita Orijyakādoki no Kaihatsu, 442)

Reconstructing Japanese Jacquard development from the patent archive

Japan's patent system became widespread in July 1885, when the patent ordinance, the predecessor of today's patent law, was enacted. The utility model system was introduced in 1905. After the system was introduced, the number of applications increased significantly (6). In particular, many applications related to the textile industry are found. These supported Japan's industrial development during the Meiji period (1868 - 1912). Among the vast number of patent applications relating to the textile industry, this study focused purely on the development of the Japanese-style Jacquard loom.

Kohei Araki developed the first domestic wooden Jacquard of 100 and 200 hooks in 1877. Araki also manufactured a punched cards machine, which contributed significantly to the development of domestic Jacquard. Later, the Jacquard machine by Hasegawa Masashichi, approved as patent No. 2548 in 1895, is similar to the one developed by Araki. In 1907, a patent for a horizontal needle for Jacquard was granted to Yoshinosuke Fujiya under patent No.11696. Fujiya continued with his invention of the Fujiya style Jacquard machine in 1909 as patent No.17068. The horizontal needle is still used today in the direct Jacquard. It is recognized by Fig. 6 and Fig. 8.

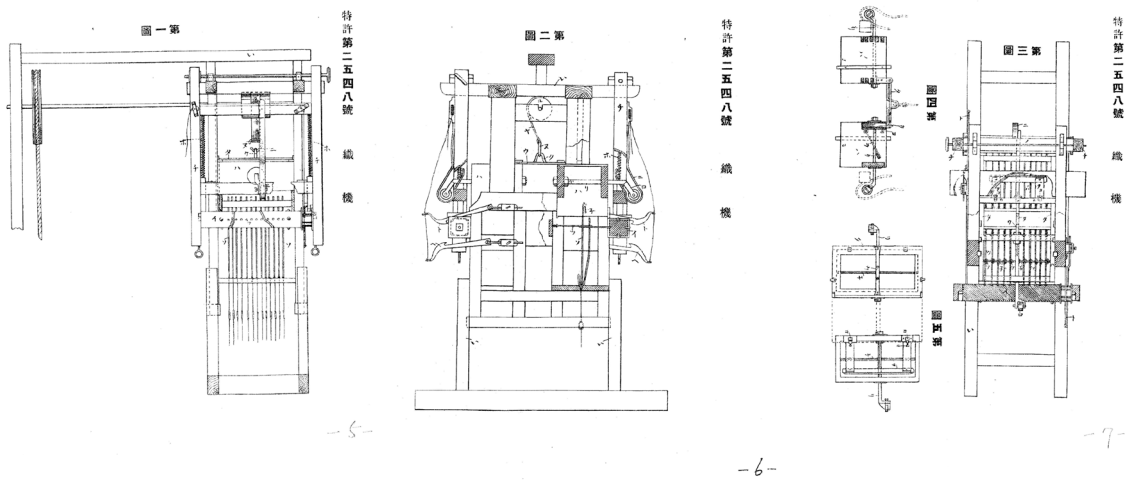


Figure 7: Patent No.2548 by Masashichi Hasegawa shows the early Japanese jacquard system

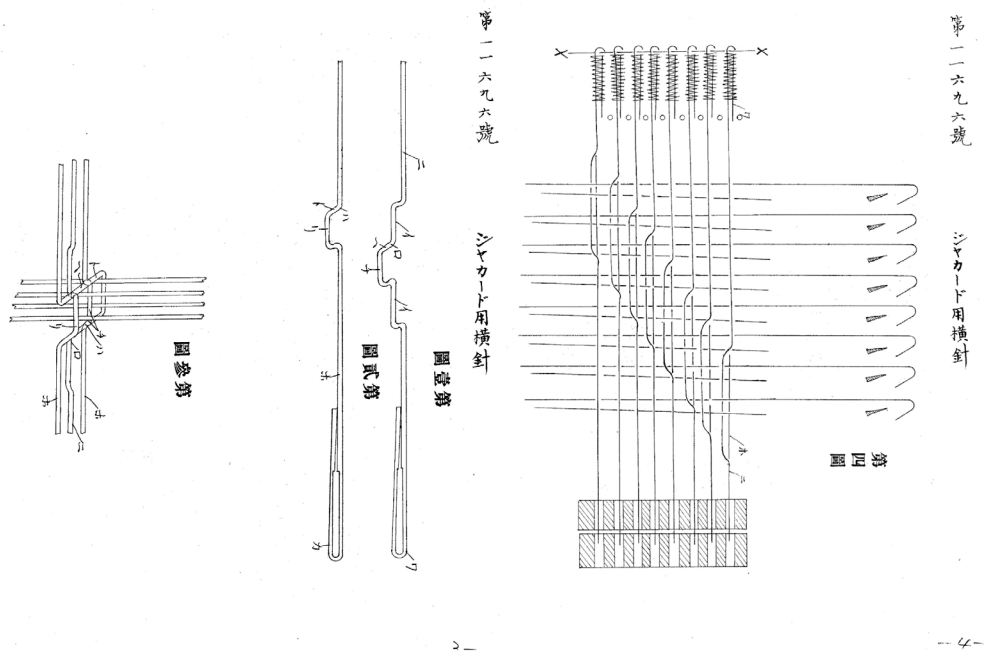


Figure 8: Patent No.11696 by Yoshinosuke Fujiya shows the early horizontal needles by steel

The development of the Jacquard system goes hand-in-hand with the development of the power loom. Several pre-war patents relating to power looms list inventions by Sakichi Toyoda and Michio Suzuki. The two men, both later well known for car manufacturing, have much in common. Both were born in Shizuoka Prefecture and were involved in manufacturing looms as carpenters in their youth. Later, as inventors and entrepreneurs, they founded and grew automatic loom manufacturers. The technology they originally invented for automatic looms was later developed to create some of the world's leading car manufacturers, TOYOTA and SUZUKI. At the Textile Machinery Pavilion attached to the Automobile Pavilion in the Toyota Commemorative Museum of Industry and Technology, it can be seen how Sakichi Toyoda devoted himself to the manufacture of automatic looms.

The outstanding performance of the looms of the two companies is widely proven by the fact that "TOYOTA" made a contract to transfer the patent right of the G-type automatic loom in 1929 at the request of Pratt Brothers in England and "SUZUKI" developed the sarong loom in 1930 and exported it to Southeast Asia. The power loom, which was initially completely made of wood, then evolved to a combination of wood and steel and finally, the whole machine was made out of steel. In addition to the mechanism of Jacquard, this shows that Japan had already at this time cultivated sufficient resources to develop metal materials and power equipment (7).

The patent applications did not limit to the development of the loom itself but also included fabric designs. Heizo Tatsumura was born in Osaka in 1876, and after the death of his grandfather at the age of 16, he left Osaka to follow his uncle's advice to become a Kimono merchant in Nishijin. In 1894, after researching the technology of weaving, he became an owner of a weaving company himself at the young age of 18 (8). His uncompromising spirit of producing the finest and most artistic products led him to create many new techniques using the Jacquard weaving machines, which quickly became popular in Nishijin. In his thirties, Heizo gained fame by acquiring a number of patents and utility models, including the Takanami weave and the Kouketsu weave. From Patent No.4060, Takamani weave is a double-woven fabric. It uses low-twist silk yarn for top cloth and high twist silk yarn for the bottom cloth as weft. After steaming, it causes the back weft to re-twist, causing the two separate pieces to rise and the bound pieces to sink. This structure is effective for Patterned fabric to make the pattern more 3D.

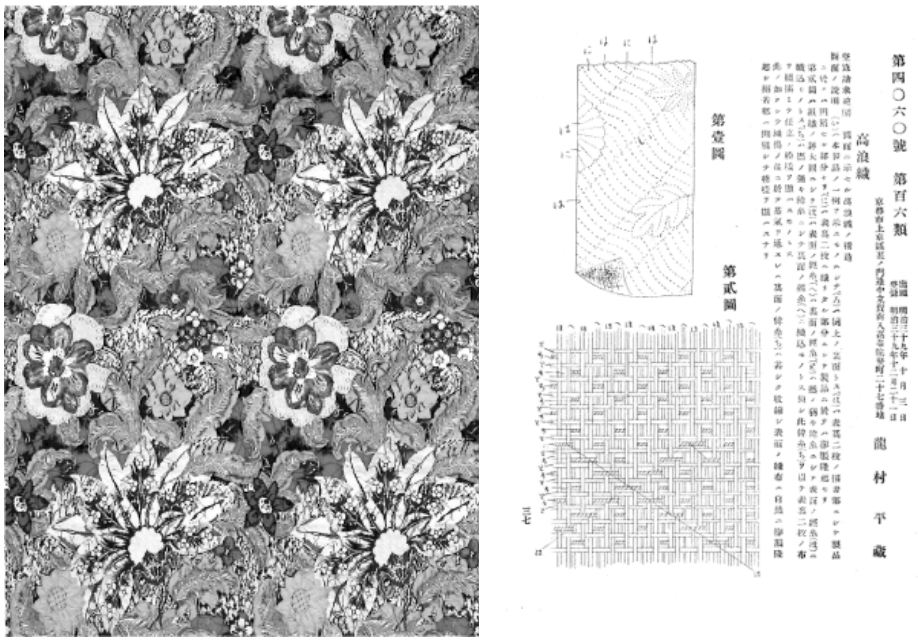


Figure 9: Patent No.4060 by Heizou Matsumura shows the “Takanami weave”(Left: images from(*Syodai Tatsumura Heizou Ori no Sekai*, 20), Right from Patent online Library)

In order to create beautiful Obi, Tatsumura developed many techniques as shown through numerous patent applications. His deep interest in textiles led him to spend his life restoring ancient fabric and creating high-end Obi to tapestry presented to the imperial royal family (9).

The initial focus of this research was to find patents relating to the development of the Jacquard machine itself, but in the patent archives, much more documentation was found that informs the development of the Japanese Jacquard, such as the automation and high-quality design for Obi. Toyota’s invention shows how woven machines’ automation was globally competitive. Also, like

Heizou Tatsumura, textile producers were eager to make luxurious woven fabric, because the Kimono and Obi are equally important as Western jewelry. In comparison with other textile related machines, such as machines for yarn making and winding, the Japanese Jacquard machine can be said to have been developed in Japan. The Japanese Jacquard machine's originality was based on its high machinery development and high textile quality, which were based on Kimono fabric.

Digitization of Jacquard machine

In recent years, the computerization of Jacquard looms has greatly progressed and changed all aspects of Jacquard design and weaving. A considerable number of Japanese Jacquard looms today operate with a Direct Jacquard system, even though there was a delay in the adaptation of computers in the craft of weaving. It was said that the reason for this delay was due to the fear of the punching card craftsmen losing their jobs, and therefore losing the knowledge that is needed to create the punching cards. This highly specialized craft is considered essential in the divided labor system that is common in Japan's industry.

The Direct Jacquard is the system adopted by most Japanese weavers today and is the digital translation of the punched card. Although the system is digital now, there is no significant change in the design process. This can also be seen in the software used for the Direct Jacquard system.

The structure of the Japanese weaving machine, which uses a Boutou and a Fumise, is mechanically simple but it is complicated to operate and understand. Every warp yarn passes through multiple heddles throughout the loom, so the designer needs to achieve a comprehensive understanding of the interconnectedness of the whole system. Even though the software itself is simple, it is difficult to use in practice because of the complicated setup. Ultimately, a specialist equivalent to a traditional punched cards craftsman would be needed, even after digitalization.

In Kyoto, the Kyoto Municipal Institute of Industrial Technology and Culture made software for the Japanese Jacquard system. The worldwide format for Jacquard files is called Jc5, but Japanese Jacquard also use Cgs and CgsⅡ.

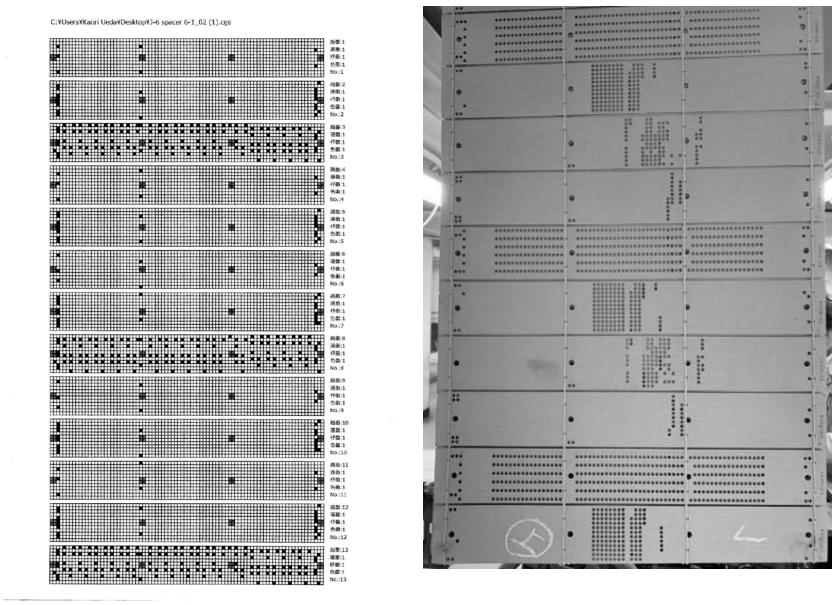


Figure 10: This is a CGSⅡ file for the Japanese Jacquard system (images taken by the authors)

Conclusion

In this article, we have described the history of Jacquard weaving in Japan. Before the introduction of the Jacquard loom, there was already a difference between the European-style draw-loom and the Japanese sorabiki-bata. Fabrics produced for Kimono and Obi had different requirements and therefore, the Jacquard looms also developed according to the conditions needed to produce the fabric. The reasons for the different uses of these looms can be found within the narrow-width fabric size, family businesses and the demand for detailed luxuriously woven fabrics.

The initial focus of this study was to find patents relating to the development of the Jacquard machine itself, but in the patent archives, much more documentation was found that informs the development of the Japanese Jacquard, such as the automation and high-quality design for Obi.

150 years after the introduction of Jacquard machines in Japan, the punching cards have now been replaced, and software can be used to design textiles with the Jacquard loom. The use of software allows for unique opportunities for designers worldwide to work with Japanese Jacquard looms because the design is no longer tied to a specific location. While in other countries looms were optimized for fast and low-cost production, which has resulted in a monoculture of looms, Japanese Jacquard looms were developed to weave detailed and complex fabrics, where every weaving mill specialized and created their own techniques.

The development of the Japanese Jacquard machine has currently stopped. There is a decline in the demand for the Kimono, but the machines are still primarily used to produce traditional Japanese textiles. However, we notice there is a lack of specialist setups in other countries. Building on our research on the history of Japanese Jacquard weaving, we are now looking to the future, and investigating how the unique situation and diverse landscape can be used to aid in the development of for example smart textiles.

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Notes

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Author Biographies

Dr. Kaori Ueda

Based in Kyoto, Kaori Ueda is a fabric designer and researcher, specialized in woven fabric. She graduated from the Royal College of Arts in 2007, specializing in woven textile design. After that, Ueda moved back to Japan, and currently, she is working in Kyoto Saga University of Art, as an associate professor for Textile Design. During her work, she started to research the history of traditional textile design in Japan.

In addition to theoretical research, Ueda is using practice-based design research. Starting in 2017, she got the opportunity to research 'Tango Chirimen' through KAKENHI grants. Through her research, she was attracted to the quality of old chirimen fabric and realized how unique and beautiful the fabric is. She started her research history of looms and the difference between European countries and the Japanese Kimono industry. Through the research of Chirimen, she met Milou Voorwinden and started research on the Jacquard machine.

Milou Voorwinden

Milou Voorwinden is a textile researcher, designer, and artist specialising in weaving. Currently, she works as a jacquard designer and runs her textile design and research studio in the Netherlands. Her passion translates into her primary practice: three-dimensional textiles.

Promoting innovative ways of using traditional weaving methods, Voorwinden brings in contemporary digital tools and gives us a fresh and colorful look at the technique. Ultimately, it is her main goal to rediscover, renew, and re-apply the age-old methods.

In 2019 Voorwinden received the talent development grand of the creative industries fund NL. During this period, she travelled with Kaori Ueda to Kyotango to collaborate with weaving mills and develop new methodologies for designing with Japanese Jacquard looms.