

Technicians and Scientists in the Edo Period

1. Introduction

Many researches and surveys have been made on the subjects of the industrialization of Japan after the opening of the country during the Meiji Era, and on the advancement of manufacturing and industrial technology in Japan up to the end of the 20th century, making the subjects widely known. However, elucidation concerning the history of the development of the industrial technology during the period of seclusion in the Edo Period is far from being sufficient domestically and internationally. Even today, many people view the development of the scientific and manufacturing technologies during the Edo Period with a negative image or sense of stagnation.

I would like to introduce in this report, one of the organizations of the various skilled laborers in the Edo Period as an example, and at the same time, make comments on the subject of the Japanese manufacturing technology from the point that Japan was able to walk the road to becoming a country with a remarkable industrial technology after entering the Meiji Era, which was unprecedented in the world, only because science, technology and manufacturing in Japan had already risen to the equivalent level of the developed nations in the West by the latter half of the Edo Period.

2. Research Project “Inventions in the Edo Period”

From the year 2001, “Research on the Systemization of Materials on Science and Technology at the dawn in Japan” (AKA, “The inventions in the Edo Period”) has been commenced as a Monbu Kagakusho Grants-in-Aid for Scientific Research on priority areas. This large-scale research project aims to reveal the true picture of the “inventions in the Edo Period”. The project deals mainly with documents on the activities that had taken place in the fields of science and technology in our country during the Edo Period, and the data on many types of measuring instruments, astronomical instruments, medical instruments, firearms, electronic generators, telescopes, glasses, clocks, and mechanism (*karakuri* or [gimmick](#)), as being the materials to understand the science and technology of the premodern Japan from both aspects of knowledge and practice.

I am a member of one of the research groups, the “Comprehensive Research on the Internal and External Specialty Collection”. Kazuyoshi Suzuki of the National Science Museum stated in regards to the significance of this research projects as follows: “By revealing evidence and proof of our high level scientific technology and splendor of [manufacturing](#) in the Edo Period, I hope that the modern Japanese people be proud

and confident of themselves.”

The first “Inventions in the Edo Period” International Symposium was held in Kanazawa City in Ishikawa Prefecture, in May 2002. Figure 1 is the title page of the symposium pamphlet. Professor Josef Kreiner of the University of Bonn, director of the Institute of Japanese Studies, delivered a keynote speech entitled, “Research on Japan and the Establishment of the Japanese Collection in Europe”. Here is a brief introduction of his speech from the aspect of cultural and technological exchange between Japan and Western Europe before the Meiji Era. ⁽¹⁾ From the 17th century to the 19th century, the Japan Boom had hit various areas in Europe, and the knowledge and products of Japan, such as *Urushi* (japan) ware, armors, Japanese kimonos, tea, medical herbs, ceramic ware, folding screens, Japanese paper, architecture, paintings, and stage art had diffused throughout Europe. The Royalties and aristocrats in Europe competed in collecting Japanese products of arts and crafts, as a symbol of status, and stored them in their Treasure Manors. According to Professor Kreiner, not only the royalties, but also the commoners attempted to take Japanese items into their living spaces. In one town in Europe, the Japanese kimono became such a big fashion that a notice was sent out to the townspeople stating that “the Kimono is prohibited when attending church on Sundays”. It first began with the Ryukyu lacquer ware, and this gold lacquer technology of Japan had greatly surprised the European craftsmen. Ukiyoe had a deep impact on many painters of the period, and everybody knows that the use of color on the Japanese ceramic ware, such as the Arita-yaki led to the birth of the Meissen ware. Listening to the professor’s lecture made me realize the splendor of the Japanese culture and the manufacturing technologies that were particular to Japan in the Edo Period. I also hoped for another big Japan boom during the 21st century.

3. Wood Turners in the Edo Period Established the Foundation for the Industry of Manufacture

The forest area in our country still dominates 67% of the national land today (2000 Forestry Agency Statistics), and Japan has fostered woodwork culture from the olden days. Today, even with a heavy usage of materials such as metals and plastics, most of the Japanese people still prefer wood for tableware and residential spaces. The physical factors for the deep desire for woodwork are not only the rich woodland and the changes in the seasonal climate, but most importantly, that the Japanese people disliked the rust on metals caused by the hot and humid summer.

I would like to point out below that the wood turners, who actively raced through the

mountains throughout Japan during the Edo Period, had structured the foundation for the manufacturing industry of Japan.

Wood turners were the craftsmen who cut down trees such as the horse chestnut trees, beech trees, and zelkoova trees, and then using manual turners, created wooden products such as bowls and trays. The word wood turners cover four types of craftsmen, namely the turners, wooden ladle makers, lacquerers, and drawing box makers. Most of the wood turners had left the village and entered into the deep mountains to follow their business of woodcrafts. When good lumber had depleted, they would immigrate to a new land. In other words, they were wandering people.

Figure 2 is a photo of the manual turner (taken from the History of Eigenj-cho, Wood Turner Edition, Lower volume ⁽²⁾). There is a steel nail at the right side edge where the wood is fixed and turned. The turner is operated by 2 persons. One person holds the rope with both hands and turns the turner by pulling on the rope, and the other person shapes the wood with turner plane, which is a type of chisel (steel stick of different shapes on a handle).

The turning technology in Japan is thought to have already existed during the Nara Period, however, it was during the Edo Period when the status of the wood turners became secured and a large-scale ruling system was established to provide special privileges, such as the freedom to travel and exemption from labor. The Tsutsui-shrine in Hirutani, and the Takamatsu-palace in Kimigahata, both located in Eigenji town in Shiga Prefecture, controlled and governed the group of wood turners from Tohoku (East-North region) to Kyushu (Kyushu island in south). The fore-mentioned two places had founded the status of the wood turners as parishioners (Ujiko), and so they traveled all around Japan to collect the first crop fee and the subscription fee from the wood turners in exchange of distributing amulets and providing official guarantees. Records of levy travels are found in the “List of Parishioners (Ujiko-kari-cho)”. The “List of Parishioners” of Hirutani, a record from 1647 to 1893 in 34 books, and the “List of Parishioners” of Kimigahata, a record from 1694 to 1873 in 53 books, still exist today. The two books from Hirutani and Kimigahata were organized and edited into the “History of Eigenji Town, Wood Turner Edition” ⁽²⁾, which was published last year.

Figure 3 shows the photos of the amulets and official guarantee with the chrysanthemum crest that were distributed at the Tsutsui-shrine ⁽²⁾. The chrysanthemum crest with 16 petals, which is the symbol of Japanese emperor, is engraved on amulets following a legend that it was the Imperial Prince Koretaka that became the first of the wood turners after entering into the mountain in Eigenji town in Heian Period. Figure 4 shows in a graph the number of times each town and village

was recorded in each volume of the two books according to prefectures. The higher the graph is, the longer the wood turners had performed their duties as the parishioners. Incidentally, the number of names recorded in the book in the year around 1726 was approximately 1,500 persons. As it can be seen in Figure 4, the distribution of wood turners under the jurisdiction of Eigenji town spread from Tohoku to Kyushu totaling 36 prefectures. The 10 prefectures of Hokkaido, Aomori, Iwate, Ibaraki, Chiba, Toyama, Ishikawa, Saga, Kagoshima, and Okinawa have no record of wood turners, however, it does not necessarily mean that wood turners did not exist in these prefectures. Ishikawa and Toyama, in particular, had their unique system for wood turners, not requiring the control from Eigenji town.

During the Edo Period, over 2000 wood turners had traveled in the mountainous areas throughout Japan, with their turners and saws, seeking good quality wood. They had manufactured bowls and trays used in the daily lives of the people with their outstanding skills. They had formed a large-scale group of craftsmen centering in the Eigenji town in Shiga Prefecture. These are the facts that should be noted in the manufacturing history of Japan. It is easily inferred that the turning technology and delicate craftsmanship demonstrated by the wood turners to the villagers throughout Japan had widely influenced the manufacturing and processing of the toothed wheel and cam that are necessary for the improvement of agricultural machines and loom, even influencing the processing of metals later.

Figure 5 shows the scene of bowl making using the two-person turner. This two-person turner was used for the manufacturing of products of various sizes, starting with a small seal impression, tinwork, up to the processing of the large bronze bell. Figure 6 shows the scene of making the tobacco pipe using the Archimedian drill, which is the tool to bore holes. The turner and the Archimedian drill are the lathe and boring machine of the modern time, and they were used during the Edo Period for manufacturing processes of many different items. Brass gear of precision used for bed clocks appeared in the latter part of Edo Period, and they must have also been manufactured using the turner and the Archimedian drill along with rasps. Figure 7 shows the back of the main body of the bed clock that was manufactured in the latter half of the Edo Period. The large toothed wheel in the center is the count wheel determining the number of clocks striking from 9 to 4 (The temporal hour system was prevalent amongst Japanese people during the Tokugawa period, in which the daytime and nighttime were divided into 6 equal-divisions, from 9 to 4), and the toothed wheel on the bottom right is a stop work for winding the spring. They are both of brass, manufactured beautifully with precision.

4. No New Product Law (Kyoho Reforms) and the Patent System during the Edo Period

Counter-reactions to the prosperous years beginning with the Tokugawa Shogunate to the end of the Bunka/Bunsei Era, the years of Yoshimune, the 8th Shogun of Tokugawa, (reigned: 1716-1745) experienced a serious stagnation in business. Yoshimune banned various luxuries, known as the Kyoho reforms. One of the rulings was the banning of the manufacturing of new products, known as the “No New Product Law”. Figure 8 shows the text of the No New Product Law (as taken from the collection of laws in Kanei and Kyoho eras) that was declared in 1721. This No New Product Law was frequently put into effect in the years thereafter. Guilds of craftsman and merchants, numbering over 90, were formed, where they watched each other to check that the law was honored. Yoshimune had also ordered the guilds to report to the magistrate’s office when offenders were found.

In the past, controversy existed over the discussion on the impact of this No New Product Law on the development of the manufacturing technology in Japan. Many reports found stated that one of the factors in the stagnation in the industry during the Edo Period was this No New Product Law. On the other hand, along with the development of researches and investigations into the scientific technology and industrial technology, it has become more widely accepted that after the enactment of the No New Product Law, a variety of inventions had taken place in the field of industrial technology.

Yoshimune had declared the No New Product Law in order to correct the trend of excessive luxury and to re-establish the Shogunate economy. At the same time, he had encouraged domestic products. Each feudal clan and magistrate’s office issued a “stock” to the invention of townspeople to guarantee the inventor’s exclusive right on the product. It was during the 1750s that the “stock”, which is the beginning of the patent system, had appeared. For example, the feudal clan of Takamatsu began to work on the improvement of the technical skill of sugar manufacturing, leading to the success in producing white sugar. The clan also established a sugar market place in Osaka. The authority also gave permission to Tozaemon Nakajima who was a farmer and the inventor of powdered konnyaku in Mito, to set up a konnyaku (paste made from the arum root) market place and approved the right of monopoly in 1776. Each clan granted permissions to open product markets and rights of monopoly as a privilege to new technical developers ⁽³⁾.

In this way, the No New Product Law had not really caused stagnation in industries. Instead, the development of specialty products by feudal clans had taken place years

hereafter and the domestic market had revived its liveliness.

Next, I would like to state my personal opinion on the relationship between the No New Product Law and the development of the scientific technology of Japan. I would like to focus on the exception of the No New Product Law (Fig. 7), which banned inventions and new ideas. New products for shows, divine services and festivals (according to the proclamation made later) were excluded from the scope of the law. Inventions and ideas involved in entertainment, such as the Karakuri wooden puppet used for shows and for festivities were not restricted by this No New Product Law. As a result, the No New Product Law had brought into life creative masters of Karakuri, who were interested in scientific technology.

5. Versatile Scientific and Technical Experts: Masters of Karakuri in Edo Period

If I must point out 3 famous masters of Karakuri during Edo, they will be; 1. Hanzo Yorinao Hosokawa (1741-1796) who published “An Illustrated Anthology of Karakuri” and who was involved in the calendar reform during the Kansei Period, 2. Hisashige Tanaka (1799-1880), AKA Karakuri Gizaemono, a native of Kurume and creator of the greatest masterwork of the Karakuri wooden puppet named “Yumiiri Douji (archer puppet)” and the “myriad year clock”, later became the founder of Toshiba, 3. Benkichi Ono (1800-1871) has been called the Da Vinci of Kaga, and he had expertise in, not only the Karakuri puppets, but also in mathematics and medicine. What the three masters held in common were that they were brought up in the environment of manufacturing, showed interests in variety of things, and after reaching adulthood, they had avidly absorbed the most advanced science of the West that came in through Nagasaki. They became versatile scientific and technical experts with great knowledge in mathematics, astronomy, chemistry, and medicine, and even after reaching the age of 50, they had never lost their insatiable ambition ⁽⁴⁾.

Figure 9 shows the “archer puppet” (Hisashige Tanaka, from Toyota Collection), which is known to be the best of the Edo Karakuri. Figure 10 is the greatest creation of the Japanese clock, the “myriad year clock” (owned by Toshiba Inc., displayed at the National Science Museum). (Full photo of the myriad year clock is the photo of the model recreated for the 100th anniversary of foundation of Toshiba, partially remodeled by the writer).

The “archer puppet” classified into Zashiki Karakuri, karakuri puppets produced for individual amusement, is an automatic puppet made of wood. The puppet picks up the four arrows placed on a table one by one, and shoot them to a mark placed 2 meters away. If the arrow hits the mark, the doll joyfully goes to fetch the next arrow. The

moving power is the phosphor bronze spring, and the 6 groups of cam and lever moves the 11 strings. With the minimal movement of the face, it expresses the seriousness in aiming the mark, and the joy when the arrow had hit the mark. From the 17th century to the beginning of the 20th century, a large number of automata (automatic dolls) were created in West Europe. The principle structure of the Japanese Karakuri puppets is the same, however, the expressive method to the audience greatly differs. Japanese Karakuri puppets are unique in expressing their emotions.

The “myriad year clock” in Fig. 10 exhibits topnotch artwork with its cloisonné decorations. Nevertheless, here I would like to introduce the work as that which exhibits a high manufacturing technology of precision (processing and metallurgical technologies) and high standards of horology, astronomy, and mechanism. The myriad year clock has 6-sided faces. The first face is like the western type of clock using the mechanism from Switzerland, the second is the Warigoma type automatic rotation hour plate commonly seen in Japanese clocks, and the 6th plate is the hour plate with lunar surface device, which provides the phases of the moon and the date. Other faces express the seven days of a week and the oriental zodiac. Furthermore, on the top of the clock, there is a planetarium, which shows the rotation of the sun and the moon above the map of Japan. The power moving the clock consists of 2 groups of 4 phosphor bronze springs, and the movement of the Swiss clock on the first face leads to the movement of the **hours** and minutes for all other hour plates, and the movement of the sun and the moon is realized with a metallic mechanism structure. In this way, the “myriad year clock” utilizes an extremely high level mechanism, created with the combination of science, technology and expertise.

In the latter years of the Edo Period, the Karakuri puppet dolls, or wooden robots, had established themselves as the culture of Japan. Hisashige Tanaka must have known that the automatons in Western Europe were metallic made automatic puppets capable of conducting the exactly same movements as human beings. Even though he had possessed an extremely precise metallic processing skill as seen in the “myriad year clock”, he had created the “archer puppet” all in wood, not only for its outer appearance, but also for the inner structure. Karakuri puppets are not created to realize movements that are exactly the same as those of human beings, but are created so that the movements and expressions of the puppets differ subtly according to the environment (climate, location) and the mood of the puppeteer and the audience.

Robotics, that were fostered by the Shibai Karakuri (theater puppet), Zashiki Karakuri (room puppet), and Parade Float Karakuri (carriage puppet) in the Edo Period, had led the Japanese people to love robots. The number of industrial robots in

Japan used today still dominates the majority of the robots used in the world. Robot contests are held throughout Japan with avid participation by children and adults ⁽⁶⁾. Let it be known in the world that robots make use of the features of inter-personal relationships as exhibited in the Karakuri puppets, so that the robots can be accepted at ease by all the people in the world, leading to the creation of robots that will contribute to the happiness of human beings. Here may exist the new direction for the manufacturing in Japan.

6. Conclusion

The wood turner group, controlled by Eigenji town, existed from the beginning of the Edo Period to the 1880s. In modern times, they must have taken up the role of the creation, accumulation, and diffusion of the skills of the town factory or small and medium size corporations that support the manufacturing of Japan. Their contribution to the development of manufacturing in Japan today is immense.

The Japanese industry has not been able to break out of the difficult times after the collapse of the bubble economy. Currently, Japan is quite similar to the Kyoho time in the Edo Period, experiencing a sluggish economy after being accustomed to extravagance and with the government taking expanded measures. Yoshimune had proclaimed the “No New Product Law” which on the surface, seemed outrageous, however, at the same time he encouraged the down-to-earth development of specialty products by each clan and re-established the industrial economy. Furthermore, the “No New Product Law”, as a result, brought into life many “masters of Karakuri” who can be considered as all-around scientific technologists, and also fostered robotic particular to Japan. What is equivalent to the “No New Product Law” in this modern time? “Good quality products at a low price” is the cardinal rule for the market economy. However, as a result, it has led to the age of heavy consumption. We have reached the time where there is a need to bring out measures that will promote changes to the “manufacturing of products for long-term use, energy conserving, and to put importance on environmental issues.”

References

- (1) Inventions in the Edo Era Office (Supervisory Section). The first “inventions in the Edo Period” international symposium documents. National Science Museum (2002).
- (2) Town History Editing Committee (2001). Eigenji town history, wood turner edition. (Vol. 1 and 2) Eigenji Town.
- (3) Tetsuo Tomita (Jan. 25, 1995). Patent news. International Trade and Industry Research Committee.
- (4) Toshihiko Kikuchi (1988). Illustrated reference book, technology in the Edo Period. (Volume 1 and 2). Kowa.
- (5) Ryoichi Suematsu (2000). Robot loving Japanese ① “Japan, kingdom of robots”. Architect, Japanese Architectural Society Tokai Branch, 7, 4.
- (6) Ryoichi Suematsu (2001). Robot loving Japanese ④ “Robot contest that attracts younger generation”. Architect, Japanese Architectural Society Tokai Branch, 4, 4.
- (7) Ryoichi Suematsu (2001). Robot loving Japanese ⑥ “Future of Robotics”. Architect, Japanese Architectural Society Tokai Branch, 10, 4.

“Technicians and Scientists in the Edo period” Figures



Fig.1 The pamphlet of the first international symposium on Inventions in the Edo Period



Fig.2 Manual Turner (Hirutani Wood Turner Reference Library)



Fig.3 Seal and wooden amulet (Hirutani shrine)

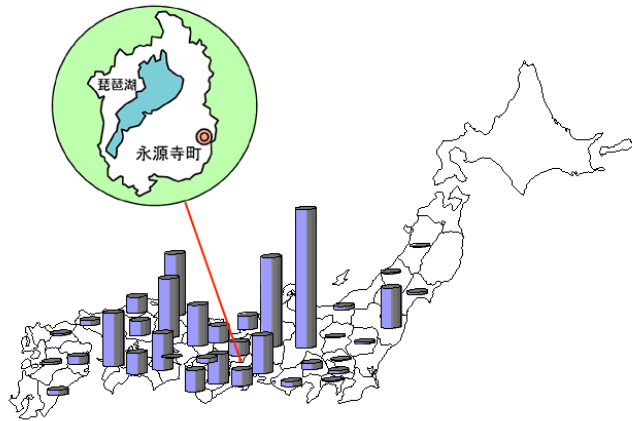


Fig.4 Distribution of areas of activity of the wood turners controlled by Eigenji town



Fig.5 Scene of wood turners at work using a turner: Wakoku-shoshoku-ezukushi (occupations in Japan expressed in pictures) (1685)⁽³⁾



Fig.6 Scene of drilling a hole by a tobacco pipe maker using the Archimedean drill: Imayo Shokunin-zukushi Uta-awase (1821)⁽³⁾

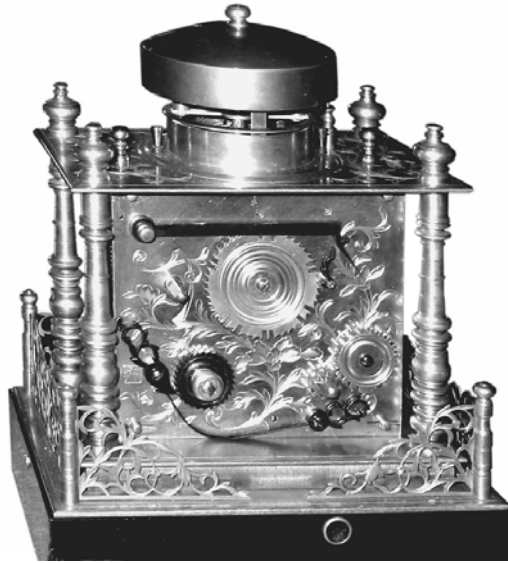


Fig.7 Brass gear of precision processing (photo taken by the writer)

Bed Clock created by Shigenori in the latter part of Edo Period (backside) Toyota Collection

享保六丑年七月

一 惣て新規之儀、器物織物之類
一切仕出候事可為無用候

(中略)

見せ物等之儀ハ新規之事不致候てハ
如何候間、此段ハ可為格別事

御触書寛保集成より抜粹

Fig.8 The No New Product Law ordained in 1721

Taken from the collection of laws in Kanei and Kyoho eras



Fig.9 “Archer Puppet” by Hisashige Tanaka, Toyota Collection (photo taken by the writer)



Fig.10 “Myriad Year Clock” by Hisashige Tanaka, owned by Toshiba, exhibited in National Museum(Top photo: model, bottom right: second face, bottom left: sixth face, bottom center: upper celestial globe. Photos taken by the writer)