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ENDOGENOUS TECHNOLOGY AND SOCIETY IN JAPAN

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This paper is being circulated in a pre-publication form to elicit comments from readers and generate dialogue on the subject at this stage of the research.

INTRODUCTION

The History of Science and Technology

Scientific technology entered a new stage in Japan after the influx and assimilation of Western scientific technology, from the end of the 19th century. The technological base that existed up to that time, and received and nurtured Western technology as it entered Japan, is what we call Japan's endogenous technology. Of course, the development of this endogenous technology required contact and exchange with various cultures--including the West--for its own development. This is borne out in Nihon kagaku gijutsu shi (Asahi Shimbunsha, 1961), a general outline of the level and nature of the endogenous technology in Japan which was the prerequisite for Japan's rapid modernization. That volume concludes with the statement, "[The three distinctive factors of Japanese endogenous technology] we have pointed out are, then, the craftsmanship of Japanese technology; historically speaking, the importance of the transmission of Buddhism from the continent; and the arrival of Western civilization."

The history of endogenous science, which is so closely related to endogenous technology, has long been regarded in this manner. The most general treatment of this subject is to be found in the series, Meiji-zen Nihon kagaku-shi sosetsu (The history of science in pre-Meiji Japan) edited by the Nihon gakushi-in. In the table of contents of the first part of Nihon kagaku-shi sosetsu, nempyo (A general introduction and chronological table of the history of Japanese science, Nihon gakujutsu shinkokai, 1968), a volume of that series, "The Development of Endogenous Science in Japan" is divided as follows: 1) Science in ancient Japan, the early centuries; 2) The period of Chinese influence, first through Korea, later directly, from the 6th through 16th centuries; and 3) The period of Western influence, from the middle 16th to late 19th century--(a) early Western studies; (b) the Dutch influence; (c) influences from various Western nations.

This division into periods of differing influences is the general method in the study of the history of science. However, in the study of the history of technology, the means of organizing the various factors contributing to the development of technology presents a slightly different problem. If, for example, the subject of the history of technology is limited to production, we can define "technology" as the means by which goods are produced, through the combination of labour and labour methods. Thus, the important divisions of the study will be tools, their application, organization of the labour force, and the application of tools by the labour force. While the history of science is the study of the principles and forces that are applied in the production process, the history of technology is the study of the means of application itself. It is the attempt to trace the development of technology through history by investigating the different applications of the unchanging principles and forces of science.

It is important to recognize that technology develops in response to the requirements of human society. But those requirements are complex and diverse; and technology does not always meet them in their entirety. Technological development has in addition an internal logic of its own, which can limit the ability of technology to meet those social requirements, or can, on occasion, produce new social needs. There is, finally, a need to understand the mutually restrictive nature of this relationship between the requirements of society and technological development. Furthermore, though it is clear that technology develops in response to the development of production, a qualification is necessary. The development of production can be measured by the social value ascribed to the final product, which is the result of a given amount of labour and a given amount of time. In principle, the development of technology can also be measured in this fashion. However, a special feature of technological development is that it is linked to increases in the social value placed on articles it contributes to the production of.

If we hold to the above definition of technology, it is apparent that there can be no general history of technology, at least in the field of the history of technology. For, as in the case of production technology, the technology exists as a distinct and independent entity within each industry. Nevertheless, these independent technologies are linked, and can be generalized, because they share a similar role in the production process itself, and a common relation to labour. For this reason, it is necessary to compile a general history of technology together with and in addition to the histories of the various technologies of different industries.

The clarification of these points is necessary for the purpose of properly discussing the special features of Japanese endogenous technology with respect to the problems of the history of technology. Because the detailed treatment of the technologies of each industry is far beyond the scope of this paper, in the discussion that follows, we will limit ourselves to a consideration of a few specific problems.

I. THE DEVELOPMENT OF ENDOGENOUS TECHNOLOGY AND STATE CONTROL - TECHNOLOGY AND SOCIETY PRIOR TO THE MID-18TH CENTURY

An extensive study is generally required to cover the subject of the development of endogenous technology. Endogenous technology here will thus be discussed within the context cited at the beginning of this paper. Viewed from the standpoint of the standard of endogenous technology, an examination from the 17th century onward will be most appropriate. The mid-18th century marks an epoch in view of the various aforementioned problems related to technology, namely, technology and social organizations and technology and state control as a basic framework. Broadly speaking, the demarcation is based upon the difference between an era when state control over principal technology existed and an era when it began to decline.

The period from the end of the 16th century to the 17th century had a dual significance in the history of technology. First, some endogenous technology had reached a totally new standard due to the absorption of foreign technology. This was seen in the technology pertaining to, for example, weaving, metallurgy, firearms, ceramics, etc. Second, other endogenous technology had independently attained a new standard owing to the intensification and re-examination of endogenous technology without the direct influence of foreign technology. This was seen in agriculture and fishing as well as in architecture. Of these, the technology which was closely related to state control belonged to the former category, as can be seen briefly in the following.

The metallurgical method called "Blowing from the South" (Nanban-buki) predominated at the beginning of the 17th century. It is said that its name derived from the fact that it was taught by an European from the South. Nanban-buki is a method of separating silver-containing lead from silver-containing copper. Cupellation (<u>Haifuki</u>) separated silver from silver-containing lead. Both Nanban-buki and supellation should be referred to as separation-smelting methods of leaded silver and copper. The principle had already been introduced to the Iwami Silver Mine from China via Hakata in the middle of the 16th century. Nanban-buki, on the other hand, was introduced to the urban manual industry in Sakai and Osaka.

At the beginning of the 17th century, these two methods were unified and became the most common method of smelting silver and copper, which was called either Nanban-buki or cupellation. The basic process of copper smelting, which consisted of ore crushing, ore tempering, initial blowing, and full blowing, was the outcome of endogenous technology that existed prior to the 16th century. Rough copper produced according to this method was the processing material used for the Nanban-buki process.

In the 17th century, rough copper produced at mines in various regions was sent to Osaka. <u>Ōsaka-shi Shi</u> [Osaka city history] gives the following outline:

> Rihei, the son of a Kyoto copper dealer Riuemon Soga, was adopted by Masatomo Sumitomo. In 1630 (Kan-ei 7), he moved to 1-chōme, Awaji-chō, Osaka, and established a copper-blowing operation under the name of Izumiya at Awaji-cho as well as at Suzuki-dani. His copper-blowing business prospered and he exported processed copper to foreign countries. In 1938 (Kan-ei 15), after examining the background of long-established copper merchants, the Bakufu selected 22 copper merchants to transact with the Dutch and Chinese at Nagasaki. Of these, 12 were residents of Osaka such as Rihei Izumiya and Kyuzaemon Osakaya, 5 from Sakai, 2 from Kyoto, and one each from Wakayama, Bungo, and Nagasaki. As can be seen, authorized copper merchants lived in various regions. Due to the fact that copper manufacturing was restricted to Osaka, among the 22 merchants those who did not do blowing bought copper sticks manufactured by blowers in Osaka for export, and sent these to Nagasaki. Moreover, blowers and other merchants who wished to be engaged in foreign trade conducted their transactions under the name of an authorized member of the copper merchants' guild (<u>Dōya-Nakama</u>).

In February of 1638 the Shimabara Insurrection (Shimabara no Ran) was finally suppressed. This was one year before the inauguration of the policy of national isolation (Sakoku). The Bakufu was quick to formulate the copper merchants' guild in the interim, and it let the Osaka copper merchants who were at the same time copper blowers monopolize the manual production of copper sticks, the silver and copper separation method, and the metallurgical method of Nanban-buki. Although this meant that copper merchants and copper blowers obtained a privilege, it also meant that the Bakufu established its monopolistic control over the metallurgical technology of Nanban-buki.

The matchlock gun, which was first brought to Japan by a Portuguese in 1543, was already being manufactured in the following year not only at Tanegashima, but also at the temple town of Negoro-ji, and at Kunitomo village, Ōmi. About the same time, it was also being manufactured in such places as Fudai in Bungo, Yamaguchi in Nagato, and Odawara in Sagami. Fernand Mendez Pinto, a Portuguese traveller, came to Japan repeatedly from 1544. When Pinto came to Japan in 1556, he left a report which stated that upon hearing that there were as many as 30,000 guns at Fuchū alone in the domain of Ōtomo, Bungo Province, he was so surprised that he questioned a merchant, who then replied that the total number of guns in Japan amounted to 300,000. The production of guns, which were in great demand by the warring lords; developed rapidly on the basis of endogenous technology relating to sword and steel manufacturing. Furthermore, the adoption of the gun completely changed military tactics in Japan. Due to the adept application of new tactics, the state of constant warfare ended and unified regimes were established by such leaders as Nobunaga Oda, Hideyoshi Toyotomi, and Ieyasu Tokugawa.

Guns continued to be manufactured in the areas centering around Sakai and Kunitomo in Ōmi, even after the 17th century began. Their manufacture, however, was placed under strict control. At Kunitomo, Ōmi, for example, gun manufacturing was placed under Bakufu control in 1607 with the issuance of a set of regulations containing eight articles. According to the regulations, gunsmiths were prohibited from moving to other provinces, and the method of mixing gunpowder had to remain a secret among the village officers. There were four officers and 40 gunsmiths involved in gun manufacturing in Kunitomo. Bakufu control not only established a monopoly on technology, but also gave those involved various privileges such as exemption from various taxes and permission to use a surname and wear a sword.

Weaving technology deserves equal attention. The weaving industry of Nishijin, Kyoto, enjoyed the highest endogenous technological standards. The weaving technology which had been passed down in the guild of valets (Otoneri-za) developed into the Nishijin weaving industry due to the incorporation of weaving technology brought to the port city of Sakai from China. The Nishijin weaving industry made tremendous progress upon entering the 17th century. Imported Chinese yarn was used to weave such fabrics as gold brocade, satin damask, satin, crepe, fine twill, and figured gossamer. The most important factor in the manufacture of these fabrics was the introduction of the Chinese yarn-plying machine with eight spindles, (Hacchō-nenshiki), which is said to have changed the manufacturing process from piece dyeing to yarn-dyeing. Moreover, the manufacture of velvet was begun in the same manner as in Holland. The leading position of Nishijin weaving was due to the nature of the raw materials used, advanced weaving technology, and the refinement of its products. This, however, also meant that Nishijin was closely related to the Bakufu and the feudal lords. Thus those on the Six-Member Council (Nishijin Kokunin Shū) who represented the major manufacturing concerns were not only permitted to use a surname but also were granted land during the Kan-ei and Genroku eras (1624-1703). (The six professions were figures weaver, silk merchant, weaver, brocade weaver, fabric dealer, and caretaker of units and measurements.) They were the ones in charge of producing ceremonial costumes for the families of successive shoguns.

During the 1670s at the latest a fabric dealers' guild for the transaction of major products was formulated in Nishijin. In 1745 a guild for tall-loom weavers was approved consisting of seven groups, namely, crane (Tsuru), Turtle (Kame), Pine (Matsu), Bamboo (Take), Plum (Ume), Gossamer (Sha), and Longevity (Ei). The tall loom was indispensable to the weaving of figured fabrics, as the conventional flat loom was not adequate. The manufacturing of figured fabrics began at the end of the 16th century. The formation of guilds and the possession of privileges show that the de facto technological monopoly was transformed by the Bakufu into a de jure technological monopoly. As will be discussed later, the approval of the tall-loom weavers' guild was triggered directly by tall-loom weaving technology finding its way to the countryside and by the provincial weaving industry beginning to prosper as a result of this technology drain.

The technology pertaining to metallurgy, gun manufacturing, and weaving was not only influenced by foreign technology in the 15th and the 16th centuries, but also became subject to the central power and came to be organized into a system of privileged technological monopoly. There was, of course, some imported technology which never took root in the developmental process. The method of amalgam treatment is a case in point. Amalgam treatment as a method of smelting silver was used at the Sado silver mine in the 1620s and the 1630s. This, however, was discontinued before long because the production of mercury required for this method had declined so much that imported mercury was needed, and this could not be obtained because of the policy of national isolation. Copper and wooden printing types introduced from Korea were other examples of discontinued items. In the first half of the 17th century, books such as the imperial publications of the Keichō era (Keichō choku han) (1596-1614) were widely published by this method. Type printing, however, declined drastically after that and conventional woodblock printing revived. Type printing was not suitable for the printing of a large number of copies, and this is considered the reason for the decline.

The development of agricultural technology was totally different. The following was the pattern of Small Farmer production:

> Petty farmers whose labor was based upon a monogamous small family unit exerted themselves in the cultivation of wet rice on a small and closed plot of farmland, using manual tools. They tried to develop further productivity with labor-intensive methods and massive fertilizer application of so that they could gain greater production per unit of cultivated field.

The development trend of agricultural technology can be understood in the same way.

This trend, however, is very general and further study shows that the mid-17th century marked a turning point. Viewed from the history of technology, it was from this time onward that the above form was established. Previously, large-scale farm management by patriarchal landlords with serfs and tenants as their principal labour remained the rule, together with the developing petty farm management. Patriarchal large farm management was not simply intact, but was, in fact, more dominant, as is clearly revealed by the agricultural records (Nō-sho)

Seiryō-ki [An Account by Seiryō], whose seventh volume is called Shinmin Kangetsu-Shū [A collection of lessons for the people], is considered to be the oldest agricultural record in Japan; it was written during the 1620s and the 1630s. The volumes as a whole pertain to the life and military records of Seiryō Doi, a feudal warlord, and the seventh volume pertains to an agricultural report drafted by his retainer, Sōan Matsu-ura. Although it was more an agricultural report than an agricultural record, its importance lies in the fact that it was based upon farmer-samurai, who used to be referred to as armoured farmers.

There is another report compiled on the basis of an agricultural survey conducted by a fief government. The Kaga fief conducted a survey as a part of the enforcement of a revised law which was promulgated at the time of the fief-government reform. The survey was compiled as Kusadaka Hyakkoku Kaisaku Nyūyō Jimba Shirabe [A survey record of necessary men and horses for the cultivation which yields one hundred koku] in 1657. Although the survey was conducted for each county, only the records pertaining to Tonami County in Ecchū and Nōbi County in Kaga are left. According to the records, patriarchal large-farm management predominated in Tonami County, while in Nōbi County petty farming had developed in view of the coexistence of patriarchal large-farm management and small-farm management.

These historical data reveal that patriarchal management had reached its peak in the first half of the 17th century, and that it had begun to disintegrate. The change naturally did not come about all at once throughout Japan, and it came later for the less-developed regions. Consequently, agricultural records written in the less-developed regions were still based upon patriarchal management. An authentic agricultural record entitled Aizu Nōsho [An agricultural Record of Aizu] was written by Yojiuemon Sase of Aizu, Mutsu, in 1684. The record systematically described the type of farm management prevalent in the Aizu region. The systematization, however, was made on the basis of production technology adopted by patriarchal farms, partially because the Sase family was one of the most representative of the patriarchal farm owners at that time.

The agricultural technology of patriarchal farm management placed more emphasis upon cattle plowing than did that of small farms. Moreover, it tended to increase productivity through the cultivation of larger acreage per given unit of labour rather than increase production per unit of cultivated field.

The period from the mid-17th century onward was truly the period when the production technology of petty farming was formulated and developed. It must be remembered that a certain accumulation of knowledge was necessary for the emergence of agricultural records as guides to agricultural technology. The fact that farmers had an objective interest in farm production and technology is evidenced by the emergence of agricultural records. These were mainly written by prosperous farmers (Jinushi) who directly managed their own farmland, employing apprentices and labourers of their own families (Jinushi Tezukuri). The fact that agricultural records began to be written, however, is significant in terms of the history of technology.

The first agricultural record of this nature is the one written by the Kitamura family of Tochi-no-o Village in Izumi. Tōza Oboe Nikki [Current memorandum diary], written from 1673, contains the records on the conditions of farm management by a landed farmer. It shows together with dates the planting order of cotton (which cannot be planted repeatedly on the same field indefinitely), the amount and proportion of purchased fertilizer to be given to rice, cotton, indigo plants, and tobacco, and the labour allocation of menial workers and apprentices. This type of record and an interest in agriculture are prerequisites for the appearance of guidebooks on agriculture.

One of the best examples of this type of agricultural guide is Hyakushō Denki [Biography of a peasant] which was written by an upper-class farmer living in Nishi-Mikawa during a period estimated to be from 1680 to 1682. This guide reveals the way of cultivating rice, wheat, various grains, vegetables, water plants, and plants for food in time of dearth by using raw sewage, manure, and green manure crops as well as purchased fertilizer made of dried sardines. Moreover, it explain the preparation of such crops into edible forms and describes the functions of a hand mill, a loom, a spinning wheel, etc. The reason that this guide deserves special attention among other agricultural guides is that it contains many descriptions of farm tools. It states that "the most necessary farm tools throughout the year of all the tools used by peasants are a hoe [Kuwa] and a sickle [Suki]." The guide, therefore, not only teaches the manufacture of different hoes and sickles according to the type of soil and the nature of the work, but also gives instruction on choosing the right kind of hoe and sickle for each purpose. Drawing examples from the regions of Chūgoku, Gokinai, and Ōmi, the guide-book discourages the use of cattle and horses for ploughing. The only section that covers ploughing with cattle and horses limits it to tilling a field in preparation for transplanting young rice plants, and shows in detail how to handle the relevant tools.

Furthermore, it should be noted that this book gives a detailed explanation of irrigation implements and tools. It shows how to make a sweep and a sweep well bucket. It not only explains the structures of a waterwheel, a keel wheel (Ryukotsu-sha), and other pumping implements but also gives a comparative evaluation regarding its pumping efficiency. It is thus certain that Hyakushō Denki compiled all the available agricultural and related technology of the time. And because of this, this guidebook is considered to be the one which was aimed at systematizing the technology of small farmers.

Nōgyō Zensho [The complete works on agriculture] is well known as another representative agricultural guide written in this period. Yasusada Miyazaki, a former retainer of the Chikuzen fief, wrote this guide in 1697, and it was published by Ryūshi-ken. This guide came to enjoy the best reputation among numerous agricultural guides partially because it was published and circulated widely while most of the other agricultural guides were hand-copied and privately published. Like Hyakushō Denki, this guide was also written on the basis of the writer's great experience, his many accomplishments in agricultural production, and his knowledge of farming in other regions. The important difference between Hyakushō Denki and Nōgyō Zensho lies in the fact that the latter relied heavily on a Chinese tract on agricultural administration entitled Nōsei Zensho [The complete works on agricultural administration] (1639). It is even said that the author intended to systematize Japanese agriculture through the application of knowledge gained from Chinese agriculture. The author, however, stipulated that farming demanded the following conditions: first, a farmer must cultivate farmland which is in proportion to his own assets and status, and second, those things necessary for cultivation are serfs, cattle, and horses. The author's idea of farming can thus be considered to be quite different from that behind Hyakushō Denki, which was far more detailed and concrete in its descriptions of farm and irrigation tools. Consequently, although Hyakushō Denki should be considered the main work on practical agricultural technology, a detailed examination regarding this subject cannot be developed here. At any rate, there was a new development in agricultural technology from the mid-17th century, and it was evidenced by the emergence and the diffusion of these agricultural guides as well as by the improvement of farm tools. The latter can be seen in such things as the diversified hoes as well as in the emergence of teethed threshing tools (Senba-koki) and crop-completing tools. Technological improvements were multifold, ranging from soil improvement through the use of dry rice fields to better water control, fertilizer, weeding, and the increase and improvement of agricultural strains. These technological improvements derived from the small farmers, and it was in the first half of the 18th century that the production technology of small farms was established.

It should be remembered that agricultural technology does not consist of technology pertaining to agriculture alone, but is significantly linked with engineering technology. Viewed from this standpoint, it was prior to the mid-17th century that the area of arable land was greatly increased. Due to the basic policy of increasing agricultural productivity through the development of newly reclaimed rice fields (Shinden-Kaihatsu), engineering technology such as water control and the excavation of irrigation channels emerged. The method of directing a river without opposing the flow of water, which had been a traditional construction method since the 16th century, was perfected and became known as the Kantō school of river direction (Kantō-ryū) at the beginning of the 17th century.

The Kanto method is said to have been initiated by Tadatsugu Ina, a chief treasurer (Kanjō Bugyō) and governor of Kantō (Kanto Gundai). This demonstrates how those who possessed large-scale water-control and irrigation technology at this time were either powerful farmers from the middle ages or retainers of the Bakufu and feudal lords. Gorobei Ichikawa, who excavated the new rice field called Gorobei's New Field in Shinano in the 1620s and the 1630s, was of the former category. An example of the latter was Hyouemon Aoki, a retainer in charge of the development of new fields in Shibata Prefecture who took charge of channel construction and developed about 530 chō [1299 acres] of paddies and about 71 chō [174 acres] of fields at Jōrakuji, Echigo, around 1650. Shigeyasu Naritomi, who contributed greatly to water-control engineering in Kyushu and excavated many channels and new fields, was a retainer of the Saga fief in Hizen.

The number of large-scale excavations of irrigation channels decreased from the middle of the 17th century. Instead; small-scale construction involving existing paddies and fields in order to improve and stablize farm crops became more popular. These projects, were, in many cases, planned and carried out by farmers and merchants. There were again quite a number of large-scale reclamations of new arable land around 1710, but these were done very differently from the previous excavations in the first half of the 17th century. The best example is the reclamation at Shiunji Lagoon in Echigo, which began in 1719. Gonbei Takemae, a miner, requested and carried out drainage construction of the lagoon; the project was financed by his own funds as well as by funds collected from merchants. He ultimately developed approximately 1,996 chō [4892 acres] of fields, called the Newly Reclaimed Shiunji Lagoon Rice Field. The drainage of Inba Marsh was completed in 1724 following a proposal made by the farmers of Hirato Village. The Newly Developed Kōnoike Field which was created from the replacement of the Yodo River, was completed in 1707 and was the most famous reclamation project undertaken by an influential and affluent merchant (Gō-shō).

As can be seen in these cases, the principal technology for the large-scale development of new fields in the 18th century relied upon reclamation by drainage. Such large-scale development had to be pursued by the Bakufu, the fief governments and affluent merchants not only because of the financing but because of the technology involved. Consequently, a new group of engineers who were linked with the Bakufu, fief governments, and affluent merchants emerged. Yasobei Izawa is the most representative of these. Prior to serving the Bakufu in 1722, he had developed Kame Pond in Tatsumi Village, Ki, in 1710. It is presumed that Yasobei grew as an engineer by acquiring and amalgamating diffused, locally developed technology.

One of the characteristics of Yasobei's engineering was the method of drainage clearly revealed in the reclamation at Minuma Tamei New Field in Musashi. He successfully reclaimed approximately 1,300 chō [3186 acres] by excavating a drainage channel about 25 km long. This became a comprehensive project in that an unavoidable irrigation problem arose as a result of the reclamation by drainage. Approximately 60 km of the Minuma Water Channel were newly excavated so that about 12,571 chō [30,811 acres] of rice fields could be irrigated. There was also a canal for boats, with two sluice gates.

Another technique used by Yasobei involved water control. His basic method was aimed at suppressing the flow of river water by the construction of an immense, solid, consecutive embankment; this was seen in the Yado River conservancy and in the Naka River conservancy, which was undertaken to control the Tone River. His method of confronting nature, also observable in his drainage method, became the basis for the technology called the Kishū school of river training (Kishū-ryū), which differed from the Kantō school.

II. DIFFUSION, IMPLANTATION, AND DEVELOPMENT OF TECHNOLOGY - TECHNOLOGY AND SOCIETY FROM THE MID-18TH CENTURY TO THE EARLY MEIJI PERIOD

In many respects the mid-18th century marked a period of transition in Japanese history. This was also true of the history of technology, and the following is an analysis of the transition from the viewpoint of the diffusion of technology and its development and implantation in Japan.

Technology diffusion and its implantation are discussed on the following basis. Sado Shimin Fūzoku Tsuika [An appendum to the customs of the four classes of Sado], written in 1840, states as follows:

> Such devices as syphon drainage, a scoop wheel Dutch suction and hand pumps have been attempted until recently. These, however, often malfunction and cannot keep up with the drainage. There is less trouble and it is more economical and more efficient to set a well-wheel and draw water with a bucket as is done now. There is no better method than this.

The above was written with regard to the Aikawa Silver Mine in Sado. The metallurgical and various mining technologies were in many respects the most representative of endogenous technology, mining technology pertaining to non-ferrous mining such as silver and copper mode up the core, and drainage and ventilation technology was as important as extraction technology, if not more important.

There were two main methods of drainage in the mine pit. One was the excavation of drainage pits. The excavation of large-scale drainage pits had already been undertaken in the 17th century. This method, however, faced limitations when the pit had to be dug farther down into the ground. The problem of pumping out seepage thus became an important issue.

Several interesting points can be gleaned from the account written in 1840. First, the pumping tools used at the Sado Silver Mine will be examined briefly. Drawing water with a bucket was the oldest, most elementary, and most labor-exhausting method of pumping. Syphon drainage was adopted in Sado as early as 1617. Although Scoop-wheel drainage was introduced to Sado in 1634 and used on a trial basis in 1653, it was not adopted. In 1790 the method was taken up again. A hand pump was introduced in 1782. A fundamental change in the method of pumping water in Sado is said to have come about in 1880 when a Cornish pump run by steam engine was adopted.

As can be seen, different pumping tools were introduced continuously. Moreover, it was empirically demonstrated that these tools were economically more efficient. A test run showed that using a scoop wheel introduced by Sōho Suigaku, who was invited from Osaka, was more efficient than syphon drainage. A hand pump was introduced to Sado by Hidemochi Matsudaira, Chief Treasurer, who possessed a so-called Franke Spuit made in Holland. A trial calculation was made and it showed that 1,144 ryō would be saved per year due to decreased labour.

Nevertheless, the 1840 account stated that one of the major pumping methods was to draw water with a bucket because handiworks often malfunctioned and could not be repaired easily. This aptly shows that the prerequisites for the introduction of new technology are a technological foundation and the ability to maintain new tools and methods. Consequently, the process of technological implantation corresponds with what the history of technology reveals, namely, that technology must be seen as having its own specific system.

The second reason for using the method of drawing water with a bucket was that it was economically more advantageous. This economic advantage derived from the quality of labour required for this work. Since the greater part of the expense of drawing water came from labour costs, the more ordinary the quality of labour, the greater its economic advantage. Drainage labourers at the Sado Silver Mine worked like slaves under the control of the bunkhouse system, and the working years of the labourers were so short that prison labour had to be recruited in order to deal with the constant labour shortage.

The introduction of new pumping technology at the Sado Silver Mine appeared to have been unsuccessful. This, however, was not the case in Japan in general, since the system of technological monopoly, as was seen in the previous section, began to decline rapidly from the middle of the 18th century. The following briefly illustrates the conditions of decline.

The most epochal event in metallurgical technology was the establishment of the Kagoyama Silver Smelting Work along the Yoneshiro River in remote northern Akita. With the consent of the Bakufu, this was accomplished in 1774 through the collaboration of Osakaya, a member of the copper guild who sent his representative Zenuemon Matsui to Akita fief. Consequently, the technology of Nanban-buki and cupellation was directly transferred to Akita and the separation of silver from copper started there.

Tōbei (Ikkan) of Kunitomo, Ōmi, wrote a book on firearms technology which was entitled Daishō On-Teppo Haritake Seisaku [Procurement and manufacturing of big and small guns]. This instruction book was written so that any country blacksmith could manufacture guns, for it revealed the gun smithery which had been kept secret. How this book spread to various regions and whether or not it was instrumental in the increased production of guns are not certain. But is certain that this book was written with the intention of destroying the existing technological monopoly.

The progress of the Kiryū weaving industry represents the decline of the monopoly on weaving technology. Two Nishijin weavers, Yahei and Kichibei respectively, were invited by a village head who resided near Kiryū and by a Kiryū weaver, and they introduced the tall loom in 1738. This new weaving method spread immediately and by 1741 there were 40 tall looms. By 1743, this method had already taken root in the various areas of northern and western Kōzuke. Figured gossamer produced in Kiryū invaded the Edo and Kyoto markets. Consequently, Nishijin weavers who were threatened by Kiryū's advancement obtained the approval of the Bakufu to form the aforementioned tall-loom weavers' guild in 1745.

Such technological diffusion was not limited to the technology mentioned above. Technological diffusion was pursued by the fief governments, which invited artisans and engineers on the basis of their industrial promotion policies. But attention should also be paid to the fact that there were many cases whereby the implantation of technology was achieved by farmers and artisans bringing back technology to their home towns. The former type can be seen in the case of the fief-government reforms (Hansei Kaikaku) such as those pursued by the Higo fief and the Yonezawa fief. Sericulture, spinning, weaving, the cultivation of lacquer and wax trees, and wax manufacturing and processing technology were diffused and implanted due to fief policies. The aforementioned establishment of the Kagoyama Silver Smelting Work in Akita fief is another example.

There are numerous examples of the latter type. The production of Banshū cotton (Momen) in the Himeji area developed rapidly at the end of the 18th century. Much of the technology for its cultivation was learned and brought back by servants who went to work in the cotton-producing villages in the Osaka area in the middle of the 18th century. Yōsen Sakamoto, a farmer from Suwa, Shinano, observed waterworks and engineering methods in various regions for about 10 years. After returning to his village, he began to improve the water channels in the vicinity in 1785 and excavated not only Takinoyu Dam but also 14 water channels, which took 13 years. Yōsen's improvements led to the development of 300 chō [735 acres] of rice fields. Moreover, it should be noted that because he was aware of the significant correlation between agriculture and the quality of irrigation water, he took measures to improve the water. Tamekichi Katō, the son of a potter in Seto, Owari, lived in Kyushu for several years to learn the technology of Arita porcelain. Upon his return to Seto in 1808, he succeeded in the production of Seto porcelain, and thus was called the restorer of Seto ware. Kumenosuke Yui of the Hosokura Lead Mine in Mutsu worked at various mines as a miner, and when he returned home in 1824 he invented his own metallurgical method of blowing, refining directly from new ore (Nama-buki Hō).

The task of implanting the acquired technology in areas which totally differed socially and geographically from the areas where the technology was originally nurtured was in itself the first step toward technological development, for it was from this that the regional development of technology began.

Let us examine the process of implantation as it applied to the Kiryū weaving industry. . The introduction of tall looms triggered weaving's shift from being farmers' subsidiary work to full-time work in the Kiryū area. Consequently, workers, mainly female operatives for the production of figured crepe, began to be recruited from the farming villages along the Tone River. The system of contract labour was more or less established in the 1750s. At the same time, new fabrics were produced in succession, such as crepe from 1743, gauze from 1745, figured gossamer from 1748, figured crepe from the 1750s, and twill damask and exquisite plain silk from the 1780s. Furthermore, several technological improvements were made during the same period.

One such improvement was the establishment in 1783 of the yarn-plying machine with eight spindles (Haccho Guruma) driven by water power. Although a yarn-plying machine (Nenshiki) had already been used in Nishijin, only a spinning wheel (Tsumugi Guruma) was used in Kiryū. Kichibei Iwase thought of using a waterwheel for yarn-plying and devised a water-powered yarn-plying machine with eight spindles. With the use of the plying machine, Nishijin weavers could handle not only single plying, but also double plying (two single-ply yarns are plied again in the opposite direction.) Kiryū's plying machine, however, was only able to produce single-ply yarn. The production of double-ply yarn in Kiryū did not begin until 1902, when the model factory of Kiryū Yarn-Plying Co., Ltd. decided to adopt western plying machines. Nevertheless, the establishment of the water-powered plying machine contributed greatly to the improvement and development of crepe and entwined crepe because mass production of strong yarn became possible. This model was perfected early in the 19th century by a grandson of Matabei, Yoshio Kasahara, who invented a rotational clock to measure the rotational frequency of plying. It thus, became the prototype of the modern plying machine.

Second, the method of figured weaving was introduced and implanted in Kiryū from Nishijin. One of Nishijin's figured weavers, Hanbei Kosaka, came to Kiryū in 1786 and initiated this method. Shigenojō Kanai, who was trained by Hanbei, began to produce woolen textiles, inventing patterns with the use of dyed yarn. Called "the weaving genius of Awanotani", he established the Council for the Training of Weavers in order to disclose his secret weaving technology. This significant event occurred in the 1810s and the 1820s, when Kiryū weaving entered another developmental stage following the aforementioned development from the 1730s to the 1780s. Masahachi Yamafuji started gold brocade weaving in 1830, Gohei Sanbe started black statin in 1818, Zenuemon Tamagami started pile velvet weaving in the 1820s, and Kiyosuke Yoshida started figured velvet weaving in 1820 and silk crepe weaving in the 1830s. The techniques of these new weaves, excluding silk crepe; were all introduced from Nishijin as a result of either Kiryū weavers going there themselves (Masahachi, Gohei, and Kiyosuke) or inviting weavers to Kiryū from those areas (Zenuemon). It thus becomes clear that Nishijin's technological standards were very high even in this era and that Nishijin had technological leadership. At the same time, attention should be paid to the fact that the independent development of Kiryū weaving technology culminated in the production of silk crepe.

Third, there was progress in the method of dyeing. Centering around the 1790s, dye workers from Nishijin came to Kiryū in succession, and the specialization of the dyeing process took root as was seen in the formation of such guilds as piece dyers, fine-pattern dyers, and yarn dyers. The aforementioned Kiyosuke Yoshida left a secret record of his dyeing techniques, which consisted of 69 variations.

The fourth improvement was the changes in the specialization of weaving and the form of management. The interrelationships found in specialization are shown in Figures 1 and 2. It can be seen that the transfer of the tall loom and Nishijin weaving techniques in the Genbun period (1736-1741) changed the system of specialization greatly. The silk dealers, piece dyers, shuttle makers, weavers, and fine-pattern dyers who made up the the system formed individual guids and worked within their rules on such matters as wage regulation. The contracted weavers and subsidiary weavers shown in the Figure 2 denote the existence of the cottage industry, which seems to have become very prevalent from the 1830s. Thus, according to the application made in 1875 concerning the employment conditions of the weaver, the principal issue pertained to the relationship between the

FIG. 1. The first phase in the 1720s (prior to the Genbun period)

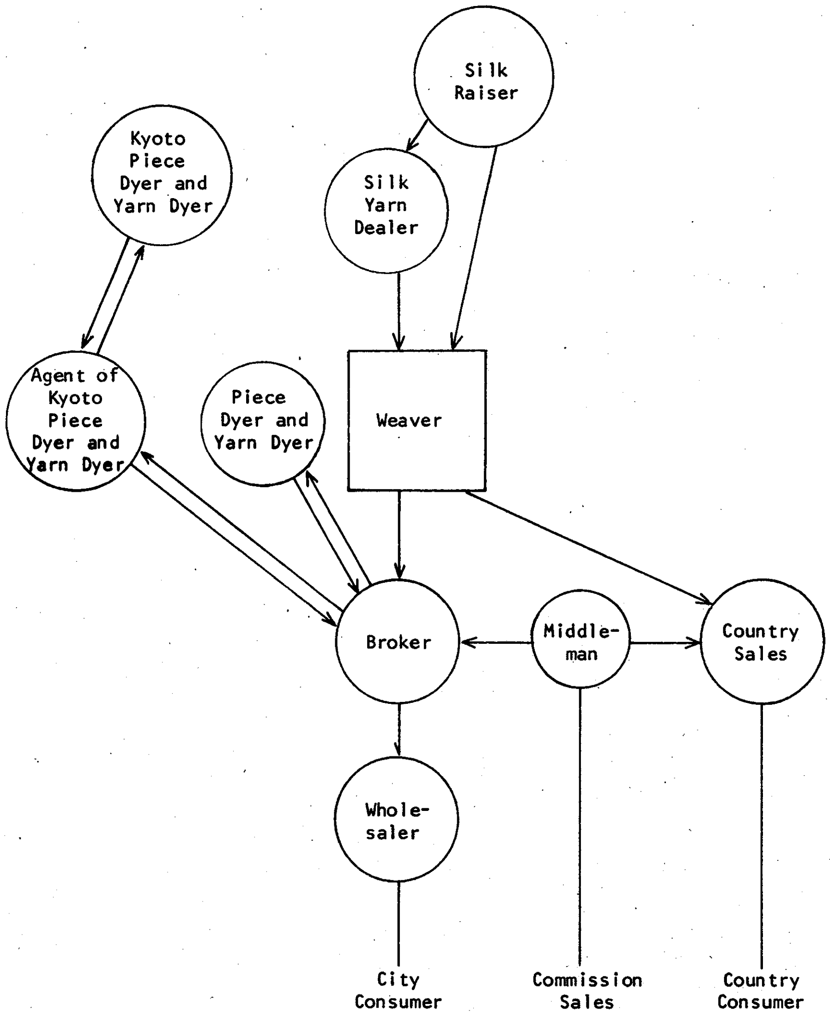
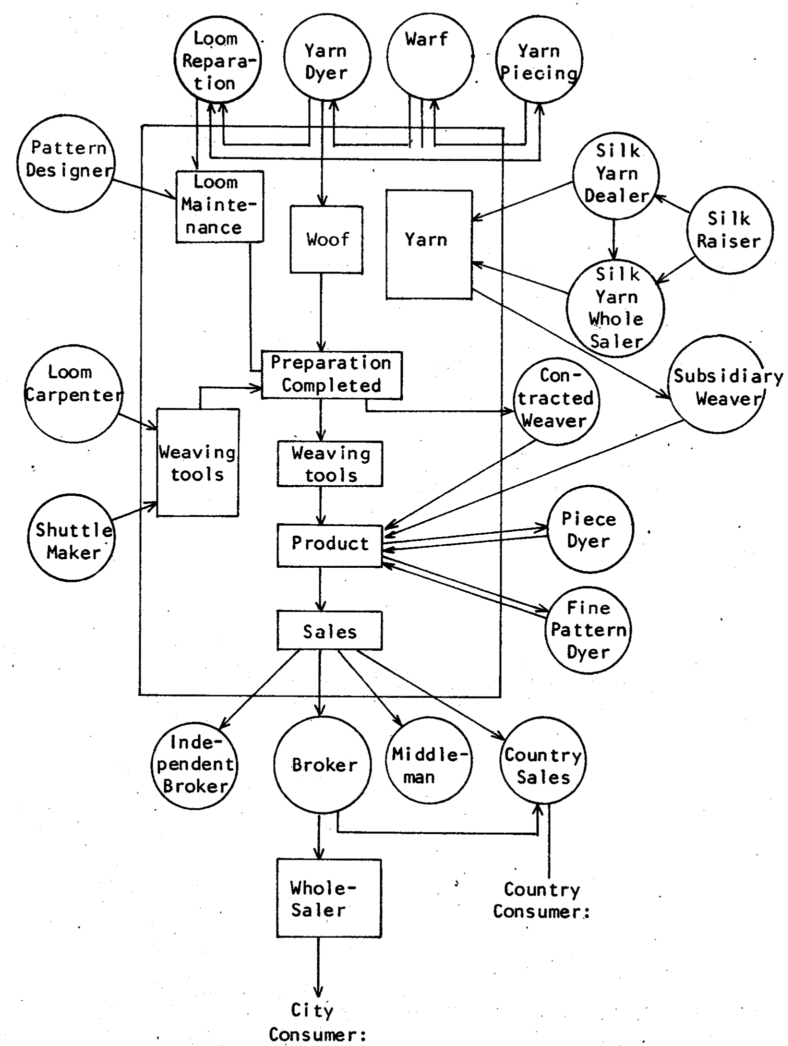


FIG. 2. The second phase in the 1830s (after the Genbun period)



professional weavers and the weavers of the cottage industry.

From the end of the Tokugawa period and into the Meiji period, the Kiryū weaving industry made changes due to the impact made by the opening of the ports. The usage of western dyes (1865) and the production of figured fabric and cotton crepe with the use of imported cotton yarn (1860) were the first innovations. Jacquard looms (figured fabric) were introduced from Nishijin (1877) and the other looms came soon after: "bang" looms (splashed pattern, 1883), dobby looms (polka dot pattern, 1886), and piano-machine looms (figured brocade, 1886). The power loom, however, was not adopted immediately after its trial run in 1872. It was adopted in 1889 by Japan Textile Co. Ltd., which was established in 1887 on the basis of the previously founded manufacturing mill of Seiai-sha (1880) and Crepe Weaving Co. Ltd. (1882). Although both mills relied upon the waterwheel and a steam-driven engine as their principal power sources, Japan Textile Co. Ltd. in 1900 adopted an electric engine for its supplementary power instead of the waterwheel.

According to the company record written in 1907, however, power looms were used for actual operations only by Kiryū Textile Co. Ltd. (previously Japan Textile Co. Ltd.) and the Prefectural School of Kiryū Weaving (previously the technical continuation school attached to Yamada First Higher Elementary School founded in 1893). This technical continuation school together with Kiryū Weaving Training Center established by the Kiryū Produce Co. Ltd. in 1877 were the forerunners of the technical training institutions. The tall loom was the most prevalent type of loom used at this time, and the stall loom which was a "western loom with four poles" was only used by a fraction of the weavers. This was because

> domestically produced power looms were so imperfect in their structure and device that production efficiency was low and they were not yet suitable for the production of exquisite fabrics which were woven through the application of traditional techniques.

The number of power looms in the Kiryū area increased rapidly from 1907, because electricity from the Watarase Hydroelectric Company became available in 1908 and because there were managerial improvements in the textile industry. Moreover, the completion of the Murata-type power loom by Heisaku

Murata of Kiryū and others in 1915 contributed greatly to the prevalency of power looms. In 1916, there were 1,004 power looms in Yamada County alone, an increase of 6.6 times over the number of power looms in use in 1905.

The above are the major points regarding the technological development of Kiryū weaving. As can be seen, the technological leadership of Nishijin weaving was more or less consistent throughout its history. The Nishijin weaving industry was able to maintain its technological leadership despite the economic threat imposed by the local industries such as Kiryū weaving. It can be said that Nishijin made technological improvements because of the economic threat and thus was able to maintain its leadership. It was Nishijin that sent trainees abroad immediately to acquire western weaving technology and imported western looms when the Meiji government put forth its industrial protection and promotion policies. The developmental standard of Nishijin weaving technology was represented by the figured brocade that was perfected at the end of the Tokugawa period. This cloth was made with a technique that produced figured horizontal patterns by pulling woof yarns of varied colors with the sawtooth-filed-fingernails. This technique reveals the apex of endogenous weaving technology in Japan and presents many problems to be pursued.

Together with figured brocade, the invention of the clockwork device played another important role. This device, which was used from 1831, is said to have suddenly increased spinning efficiency ten-fold. The influence caused by its emergence was as follows according to <u>Nishijin Tengu Hikki</u> [Long-nosed goblin's notes on Nishijin] (1845):

> A clockwork spinning wheel was devised and put to use about twenty years ago. As a result of this, Nishijin silk weaving is said to have lost its conventional pattern of relationships. Moreover, the income of spinners and figured weavers in Nishijin had decreased.
> Why is this so?
> It costs about 600 <u>mon</u> per month to rent a clockwork spinning wheel with 12 spindles. In addition to the monthly rental, a two-month deposit of 1,200 <u>mon</u> must be paid in advance. The spinning business has turned into a money-making venture. Since a clockwork wheel can finish five days' work of manual spinning in a day, spinners no longer have the yarn to spin and therefore have little to do. Wages for clockwork spinning are half those

of manual spinning. On the average, however, the income is not any greater. In the third month, spinners cannot pay the rental and the clockwork wheel thus is taken away. [Several passages omitted.]

There are many wives of clothing and other merchants in the Nishijin area who are secretly saving much money using the clockwork wheel. The reason is as follows:
It costs about 1 ryō 2 bu to get a new clockwork spinning wheel with 12 spindles. These wives own these wheels with the consent of their husbands. Since they don't have to worry about the rental fees, weavers give more work to these amateur spinners even if they are not so good at the work. The professional spinners have less work. Those who don't have children, however, can be hired either by weavers on a daily basis or by spinners for a six-month period. Those who have children cannot do the same, and become more destitute. Consequently, although the clockwork wheel is convenient, it causes daily financial problems. The clockwork wheel, thus, is not good for professional spinners and for the wives of figured weavers. Moreover, silk merchants who can send out yarn to be spun by clockwork wheel can surely be satisfied with manual spinning.

Clockwork, thus, should be abolished at the cost of those who are prosperous so that smaller operators can be saved.

The author of this book is said to be Sagaminosuke Izeki, one of those on the Six-Member Council of Nishijin. Clockwork could handle five times the amount of work as manual spinning and reduced the cost by half. The amount of yarn to be spun, however, was limited in two ways, namely, by the supply of raw material and by the demands of the weavers. Taking the rental fees into account, clockwork ultimately was less advantageous. Moreover, since manual spinners lost their jobs, it caused poverty to those in the lower classes. The production capacity of weaving did not match that of clockwork spinning at the time. Thus clockwork spinning, in fact, could not fit into the production process of weaving.

The correlation between the decline of technological monopoly and technological development can be seen in the case of the Rōzan Silver Smelting Work. Many improvements and constant efforts were made there to attain more purified silver after separation and to increase silver production through resmelting the residue created during the process of initial smelting. As a result, a complicated and elaborate work process had been worked out by the beginning of the 19th century. The process, based upon Nanbanbuki and cupellation, exhibited the highest standard of metallurgical technology. Since this has already been discussed in another paper, the details are omitted here.

Technological improvements made in metallurgy upon entering the 19th century were, of course, not limited to those at Rōzan alone. How to cope with the poor quality of ore and how to overcome the financial difficulties of mine management were major tasks for each metal mine. The following methods were devised and pursued: a massive blowing method at the Sado Silver Mine (1816), a covered blowing method at the Ani Copper Mine (1831), and a silver gauging method (1818) and a direct blowing method (1824) at the Hosokura Lead Mine. Mining workers who knew the characteristics of their mines devised these improvements as they modified and applied methods used at other mines to suit their own mines.

These endogenous metallurgical methods were replaced ultimately by the following western methods: a cyanide process for gold and silver and pyrometallurgy in the 1900s and a converter from 1907 for copper. But the mining technology that is indivisible from metallurgy presented a slightly different pattern. It was again impossible to avoid confusion caused by the introduction of western technology. The riots at the Ikuno Silver Mine in 1869 and the Sado Silver Mine in 1875 occurred as a result of the chaos brought about by the introduction of western technology. The Meiji government overcame the crisis through either the suppression or alleviating these riots and forcefully promoted the modernization of production. The method of ore transport was improved as early as 1868 in Sado through the installation of railways and a hoisting machine. In 1879, drainage was improved again in Sado by the installation of a steam-driven pump. From 1887 to 1896, the lighting in the pits was changed to a metal hand lamp. The introduction of powder blasting came about from 1877 to 1886. This method was commonly used in many mines throughout Japan.

In this way, the endogenous mining technology was improved in many respects. The introduction and the actual usage of a rock drill, however, did not come about until it was adopted by the Ani Mine in 1882. Together with the introduction of various types of rock drills, its usage spread to other mines. According to a survey conducted on the 35 most representative mines in Japan, the value of using a rock drill as compared with manual extraction was as follows:

> The quantity of ore extracted per worker with the use of a drill as against the index of 1.00 for the manually extracted quantity was 1.10 in 1907, 3.62 in 1912 and 5.72 in 1917.
>
> The output with the use of a drill as against the index of 1.00 for the quantity of manual output was 0.02 in 1907, 0.19 in 1912, 0.47 in 1917, and 1.28 in 1922.

The above shows that the technological supremacy of a drill was established in the latter half of the 1910s and that its use, in terms of quantity, became predominant in the 1920s. Approximately 40 years were needed from its introduction before it reached wide usage. This was not due to financial reasons in view of the fact that the rapid introduction in the 1910s came about "despite the progressively serious recession in mining" and that "the usage of machinery increased." There was an underlying problem of labour organization as can be seen in the problem of bunkhouse workers and directly employed workers. The manual-extraction method was inseparably linked with the endogenous labour organization of metal miners. The persistent reliance upon the manual method throughout the Meiji period can be seen in the report compiled by the Ani Mining Office under the Bureau of Mining, the Ministry of Engineering.

The agrarian production technology from the middle of the 18th century onward made great progress, especially regarding commercial agricultural production and the agricultural processing industry. The development in sericulture and reeling was especially remarkable. The following is stated in Meiji-Zen Nippon Sangyō Gijutsu-shi [Technological history of pre-Meiji sericulture in Japan] concerning the outline of sericultural technology in the Tokugawa period:

> Concerning silkwork breeding technology:
>
> (1) The systematic separation, heteromorphic selection, and crossing which are done now were, in reality, already pursued in the Tokugawa period and a species with high utility value was raised.
> (2) Technology regarding the cultivation of breeding cocoons and the protection of breeding silkworms and other related production methods were developed and good breeding silkworks were produced.
> (3) Not only spring breeding silkworms, but also summer and autumn breeding silkworms were produced.

(4) The importance of geography and weather phenomena was recognized and areas most suitable environmentally were chosen for sericulture.
(5) The basis concerning the appraisal of breeding silkworms established in the Tokugawa period is still used at present.

Concerning the cultivation technology of the mulberry:

(1) Mulberry plantations were set up in accordance with the conditions in Japan, and the technology of mulberry cultivation in all aspects was advanced. The technological standard, therefore, was not so different from what is available at present.
(2) More than 60 kinds of mulberry trees were cultivated to achieve highly productive sericulture.
(3) A seeding method with high utility value was devised and applied to sericulture.
(4) Taking various purposes into consideration, uniquely Japanese cultivation and harvesting methods were devised. Thus a high technological standard was achieved.

Concerning sericultural technology:

(1) Various types of methods of raising silkworms ranging from natural to cool raising, warm raising, intermediate raising, and even-temperatured raising were devised in order to improve the raising methods.
(2) Methods of raising silkworms fed on whole leaves, whole sprouts, crushed sprouts, and shredded leaves were devised.
(3) The basis of not only spring silkworms, but also uniquely Japanese summer and autumn silkworms was technologically established.
(4) Standards of temperature treatment such as natural urge and horizontal urge were established.
(5) Early, intermediate, and late mulberry cultivation was pursued and much attention was paid to the quality of mulberry leaves. The amount of leaves to be fed and the frequency of feeding were also standardized.
(6) Extremely detailed technological care was followed regarding mulberry feeding, sand removal, hybernation and protection during gathering, ventilation, and other sanitary conditions.
(7) Temperature control with the use of a thermometer which differed from European technology was invented.

Concerning the silk reeling technology:

(1) Independent development suitable for the conditions of Japanese sericulture was developed together with reeling procedures and tools. The technology, in terms of its basic principles, was developed to the point whereby there was little difference from that which presently exists.
(2) Technology related to pupae killing and cocoon drying such as sun drying, dry killing, and steam killing was devised.

(3) Technology related to cocoon killing, fiber searching, fiber tying, and threading was developed.
(4) Uniquely Japanese technology of small spindles and re-reeling was developed.
(5) Starting from a primitive spinning method that developed into improved hand spinning and then treadle spinning, the idea of treadle mechanical spinning was added at the end of the Tokugawa period. Thus the technology in principle was already not too different from the present technology.
(6) Raw-silk manufacture in this period was suitable for diversified fabric and string weaving. From the middle of the 1850s, raw-silk manufacturing technology was so advanced that raw silk was exported.

The above remained the same up to early Meiji. The research on sericulture technology based upon modern science and its actuation progressed rapidly from early Meiji. The Meiji government established Tomioka Spinning Factory in Tomioka, Jōshū, in order to transfer European spinning technology as part of the measures adopted to improve Japanese raw silk. Furthermore, in 1874, a sericulture research center was established in Naito Shinjuku Experiment Station which was under the control of the Industrial Promotion Bureau of the Ministry of Internal Affairs.

There appears to be no problem regarding specific techniques and the characteristics of technology. Viewed from the history of technology, however, the following should be pointed out:

First, the production of breeding silkworms held a specialized position in the sericulture and spinning industry. Its specialized position was not due to its geographical environment, but to a decisive factor — the Bakufu granted it a privilege. Nobutatsu silkworms of Fukushima were the best available in the middle of the Tokugawa period, and Fukushima was thus the most famous area for sericulture in Japan. Its reputation as a chief producer of silkworms derived from the Bakufu's granting it an authorization based upon its authorization system which had started in 1774. The authorization was granted because of a strong request which had been made by producers for several years, and it meant that the superior sericulture technology of this area came to be possessed as a priviledge.

Second, sericulture and reeling management were linked on the level of individual farmers until about 1840. Consequently, the mulberry cultivation capacity and the sericulture capacity of each farmer restricted the reeling capacity, and vice versa. Raw silk produced in this form was distributed to local weavers in the vicinity. Local weaving was able to flourish as a result.

Third, around 1840 the local weaving industry was developed enough to absorb nearby sericulture and reeling farmers as their principal producers of raw material. The amount of yarn sent up to Kyoto began to decline rapidly. At the same time, raw-silk wholesalers began to reorganize the sericulture and reeling farmers. This appeared in a form which functionally divided the farmers involved in sericulture from those involved in reeling. Wholesalers bought up cocoons, and thus the cottage industry, which forced the reeling farmers to become wage workers, developed rapidly. This trend corresponded to the development of the local weaving industries. Upon completion of the reeling using their homemade cocoons, reeling farmers then continued reeling using advanced cocoons from the wholesalers. Mutual restriction of the sericulture capacity and the reeling capacity thus diminished and their was further development of sericulture and reeling. The technology of sericulture and reeling thus was incorporated into the pattern of the cottage industry.

Fourth, there was no division between mulberry cultivation and sericulture. The independent management of mulberry plantations and silk raising was not possible financially. This was because of the changed demand-and-supply relationship due to the increased quantity of silk yarn from the sudden development of the sericulture and reeling industry, and because wholesalers only paid the minimum price. Consequently, silk-raising and reeling farmers as well as their technology were under the control of wholesale merchants.

Fifth, an efficient and immediate technological reaction at the time of the opening of the ports was not observable in the areas which had highly developed reeling. Rapid technological development was achieved in areas that possessed a certain independent technological development but that were not inclined toward becoming independent weaving areas. In other words, the silk-reeling industry which was not under the control of merchants involved in weaving was able to achieve rapid development in view of the new expansive market that arose as a result of the opening of the opening of the ports. The reeling industry in Suwa, Nagano, is a case in point, and Genjiro Manufacturing presents the most representative figure of this type.

The above five points must be added to the characteristics stated in Meiji-Zen Nippon Sangyō Gijutsu-shi, which otherwise aptly describes the apex of the endogenous sericultural technology without being marred by such factors as regional and class differences.

IV. CONCLUSION - CHARACTERISTICS OF THE DEVELOPMENT OF TECHNOLOGY

The conditions of the formation and development of endogenous technology have been seen through several examples. It is nearly impossible at present to make a generalization regarding the standard of endogenous technology. Viewed from the standpoint of "Technology and Society", however, it seems probable that first, as far as the state of technology is concerned, although regional characteristics existed in each production technology, the level of technology was relatively equalized. It can be stated that this equalization was brought about rapidly after the mid-eighteenth century. What were the reasons for this state of equalization?

Producers naturally had a strong desire for production, which provided the foundation for equalization. Their zeal was epitomized in literature which recorded their own production process. This not only marked a starting point which put various technologies in relative perspective, but also helped produce competent personnel who were able to improve production methods through the use of skills which they had acquired through wide travel. Such personnel in the field of handicrafts have already been discussed. With regard to agriculture, many outstanding farmers emerged in various regions.

Equalization was not achieved solely through the diffusion of technology by producers. Much of it was, in fact, due to the emergence and propagation of technological literature. Upon entering the eighteenth century, the number of agricultural records and guides increased. Professor Toshio Furushima and others categorized the writers of these texts into four types. The first type were Confucian Scholars or literati; the second type local bureaucrats (samurai) who were in change of civil administration and high ranking village officials (Mura-yakunin); the third type were made up of farmers; and the fourth type was characterized by Nagatsune Ōkura who led a unique life as a writer of agricultural books. From our point of view, it seems more appropriate to subdivide the second type into samurai and farmers, whereby the latter would be grouped with the third type. Attention must be paid to the fact that writers of agricultural books belonging to the third type emerged throughout Japan and that their books played important roles in the improvement of agricultural technology in their respective regions. In addition, special attention will be paid to be emergence of Nagatsune Ōkura, who comprised the fourth type of writer.

Nagatsune, who was borne the fourth son of a farmer in the town of Hita-Kuma, Bungo Province was first apprenticed to a wax wholesaler (Ki-rō Tonya) in Hita-Kuma. After leaving his home province at about the age of twenty, he acquired skills in sweet potato cultivation while he was traveling through various parts of Kyushu. He subsequently traveled to Osaka in 1796 and while he engaged in sugar manufacturing and acted as an agent for the transaction of seedlings and farm tools, he began to write such books as Nōka Eki [For the farmers' benefit]. Prior to his relocation in Edo in 1825 he traveled widely to the provinces of Shimo-osa, Shimotsuke, Echigo, Tando, Hokuriku, Ki-i and others, observing and recording the various farm tools and the manner in which outstanding farmers managed their farms. The information was published in a book entitled Nōgu Benri-ron [A theory on serviceable farm tools] and others. After moving to Edo, his status as an agricultural writer was more or less established and he not only made suggestions to the Bakufu but also responded to questions from various fief governments. In 1830 he started a sugar factory, and the cultivation of sumac for the Tanaka fief, Suruga Province. He was then invited by the Tawara fief, Mikawa Province to act as a Produce Collection Official (Sanbutsu Toritate), at which time he gave instructions on the cultivation of sumac, paper mulberries and candle rushes. He was also involved in increasing the productivity of such manufacturing industries as paper, tatami mats, earthern dolls and sugar. His active career in the Tawara fief was made possible due to the recommendation and co-operation given by Kazan Watanabe. In view of the fact that Kazan committed suicide at the time of the imprisonment of a number of pro-western scholars, Nagatsune moved to Okazaki. In 1842 he was invited by Tadakuni

Mizuno to act as an industrial promotion official for the Hamamatsu fief and took charge of industrial promotion policies. In 1845 he resigned from his post and moved to Edo because Tadakuni fell from power. Nagatsune was devoted to the development of farm production which centered around the three aspects of technological improvement, cultivation of commercial products and the processing of farm products. He regarded poverty and destitution on the part of the farmers as a problem derived from lack of the necessary agricultural technology for agricultural management. He worked to solve the problems faced by farmers in a positive manner and thus he was quite different from Sontoku Ninomiya and others who viewed technology as a problem of farmer's mind and knowledge. The influence of Nagatsune was very great and apart from the aforementioned fiefs, retainers of such fiefs as Mito, Morioka, Takada and Tsu also sought his instruction. It is said that Kazan, Nampo Ōta, Geki Hakura, Kindai Tōjō, Heihachirō Ōshio, and others were among his circle of acquaintances. Much could be drawn from the life of Nagatsune. However, the main point to be made here is that the need for technology and the level of technology was so great at the time that Nagatsune, with his interest in technology, was able to become active as an agricultural leader and literati.

The growth of literature on technology was also observed in other fields. Approximately eighty books on sericulture were published throughout the Edo Era. Among them, Shinsen Yōzan Hisho [A new treasured book on sericulture] written by Yozaemon Tsukada of Shiojiri Village, Shinano in 1757 was very popular as it was a compilation of sericultural technology existent up to that time in the regions ranging from Shinshū to Kantō and Tōhoku. It is said that more than 3,000 copies were published. In addition, three books — Yōzan Suchi [Indispensable knowledge on sericulture] (Tomonao Yoshida, 1794), Yōzan Hiroku [A confidential document on sericulture] (Morikuni Uegaki, 1803) and Yōzan Kinu-Burui [Silk sieves on sericulture] (Jūbei Narita, 1813) — were all written by silk raisers who were influenced by Chinese technology through books on sericulture (Nōsō Shūyō [A compilation of mulberry agriculture] and others). There existed great interest in adopting new technology from the imported Chinese literature of sericulture because the domestic sericultural technology had stagnated.

Literature concerning mining and other industries which contributed greatly to the equalization of technology was also published. Here, the problem of educational standards must be taken into consideration, for relatively high standards are required in order for technological literature to fulfill its function.

The history of mass education is very important in this respect. It was in the middle of the eighteenth century that the masses, particularly farmers, became interested in education, knowledge and information. Corresponding to this demand, educational agents and publications increased. As a result of this trend, technological literature also increased. Another factor to be noted is that the content of education was so highly unified that there was little room for the emergence of deep-rooted local characteristics. This naturally contributed to the equalization of technology, and cultural centralization.

The third reason for the equalization of technology is a result of the political system. That various fiefs were intent on their industrial promotion policies through the introduction of technology has been stated. The problem here goes beyond their individual policies, for the system of the Bakufu and the fief was a unique feudal system with a centralized structure under a shogun, who restricted the independent control of individual lords. This characteristic was not only pertinent to the political system but also to the economic system. Major agricultural products and the produce of each locality had to be either directly sent to the three major cities (Edo, Ōsaka and Kyōto) or indirectly channeled into the market network which ultimately reached the three major cities. The entire market, moreover, was further delineated due to the isolation policy of the Bakufu.

It was this structure that made it possible for the shogunate to establish monopolistic control over major technologies. Due to the same structure, however, monopolistic control over various technologies declined rapidly as productivity and the economy developed. Contacts, exchange and tension with different cultures are indispensable elements for the development of technology. Thus it is probable that the very deprivation of these elements was an important factor which strengthened the tendency for the dissolution of technological monopoly.

Second, we must ask what were the conditions and the characteristics of endogenous technology prior to the existence of such a tendency toward equalization. As far as the developmental trend of endogenous technology is concerned, it led to the reinforcement of labour intensity. In agriculture, the management of farms by outstanding farmers aptly illustrates this point. Figured brocade, a labour intensive technology in weaving, and the predominant method of drawing water from a mine with a bucket are only a few of the many cases on this point. Needless to say, the reinforcement of labour intensity corresponded to the formation of artisans' guilds and small farmers' organizations as labour organizations.

Therefore, when a technological improvement contrary to the trend of reinforced labor intensity was introduced, it was immediately opposed by the labour group affected. The reaction on the part of Monya, one of those on the Six-Member Council of Nishijin, with regard to the "clockwork" (Zenmai) device epitomizes this tendency.

The development of technology which accompanies such reinforced labor intensity is supported economically by low wages which are based upon the state of the labor organizations. Problems pertaining to the standard of wages must be said to be inherent. For example, silk-reeling manufacturers in Hachiōji decided not to send silk yarn to Kyoto from about 1830 because Hachiōji weaving had been established. At about the same time, the weaving industry of Kokura duck cloth was established in Suwa, Shinano. It was a cottage industry whereby the Kokura duck cloth manufacturers leased out looms and materials to weavers. It is said that there were as many as 2,500 looms. The raw material for Kokura duck cloth, however, was not produced in Suwa, but was sent from Mikawa. Thus it was in the regions of Echizen, Edo and Kansai that Kokura duck cloth was sold after having been processed in Suwa. The trends observed in both Hachiōji and Suwa reveal the initial process of the dissolution of fundamental divisional relationships under the shogunate system, and the establishment of an independent division of labor. The processing industries which began to take root in

Suwa at that time were cottage industries. Moreover, as far as the relationship between raw materials, processing and markets was concerned, the economic foundation which allowed for the emergence of such processing industries derived from low wages. The weaving industry, supported by low wages, was a prerequisite for the development of the textile industry in Suwa. When the ports were opened, the weaving industry was transformed rapidly into the silk-reeling industry in Suwa. The low wages, however, remained a constant.

Production activities were pursued on the basis of labor organizations. Thus it was natural that the technological leadership in relation to the production technology concerned rested with the foremen in the case of artisans' guilds, with the distributing dealers in the case of cottage industries and with the landholders in the case of the landholder-tenant farmer relationship. It is obvious that this furthered labor intensity during the process of technological development.

This, however, does not mean that production workers were used and discarded in an inhuman manner. Rather it was necessary to maintain the immediate production workers as a result of the development of technology, which was clearly seen in mining technology. The Akita fief began its experimental research on silicosis when miners at the Araya Mine suffered from it. At the Ōmori Silver Mine, Iwami, Seiji Miyatabashira of Kasaoka, Bicchū was invited in order for him to attempt preventive measures through the use of medicated vapor and masks. Measures against exhaust fumes and for the installation of ventilation were adopted by many mines. Although the technology of labor maintenance is not directly related to production technology, special attention should be paid to it in view of its significance.

As far as the development of technology is concerned, it was not possible to completely surpass the urban handicraft industries which took the technological lead in this field. This is aptly revealed by the fact that the weaving industry in Kiryū consistently adopted technology from Nishijin. It should be stated that a centralized technological structure existed throughout the process of technological equalization. Furthermore, it can be stated that this process paved the way for the introduction of modern industrial technology.

Lastly, the characteristics of technological development must be explained. It was extremely difficult under the circumstances to question the scientific basis upon which technology was upheld. If modern scientific technology develops and evolves on the basic of the immediate promotion of labor productivity it must be pointed out that the pattern of technological development in Japan certainly diverged greatly from this.

Moreover, it was difficult for the basis of endogenous technology in Japan to be re-grasped. This can be pointed out in relation to construction and surveying. The timber allotment (Ki-wari) technology was the fundamental endogenous technology of construction. The timber allotment technology had been secretly passed down; it was Masanobu Hirauchi who compiled it into five volumes entitled Shōmyō [Discernment of an artisan] in 1608. From the middle of the eighteenth century many books on timber allotment were published. Although the literature pertaining to this technology disclosed treasured skills, the progress of the timber allotment technology was hindered as a result of these books. The timber allotment technology was based upon the experiences of the artisans who continued to study and improve it. Publication of manuals, however, negated creativity and the timber allotment technology degenerated into a rote method.

Construction and engineering works had to rely upon the technology of standard norms. As far as construction technology was concerned, the skills relating to standard norms declined from the seventeenth century and there was absolutely no progress. With regard to surveying technology, the onset was marked by a book entitled Jingo Ki [An account of eternity] (Mitsuyoshi Yoshida, 1627). The endogenous technology was developed through the adoption of Dutch surveying technology. From the 1630s to the 1640s, a systematic technology of surveying was started by Chōzaemon Higuchi of Nagasaki and others, and from the 1720s to the 1730s many surveying books were published. As a result of the introduction of the triangulation method from China, a book on surveying was published. The book, however, turned out to be one with calculation methodology written by a mathematician omitting any reference to surveying methods.

In addition, there existed a great imbalance from the viewpoint of systematized technology. On one hand, there were examples similar to the case of drawing water at the mines which revealed that introduced measures relating to tools and implements never took root as technology. On the other hand, despite the development of processing technology such as to be found in metallurgy, mining, weaving, silk-reeling and sericulture, the technological production of the raw materials themselves neither developed nor did it correspond to the development of processing technology.

Thus, we may summarize this imbalanced development as "Japanese technology being characteristically handicraft-oriented." Was technology in Japan thus far discussed so stagnant that it could not have developed any further? Was there only technological devastation? Did western technology introduced in abundance in the Meiji Period play the role of a savior for the endogenous technology? These questions still remain unanswered, and when the lives of such persons as Yūgaku Ōhara and Naozō Nakamura are taken into consideration, these questions become even more pertinent.

Yūgaku Ōhara was born in 1797. He left his adopted family in 1814 and wandered throughout various provinces. He came to Osabe Village, Katori, Shimotosa in 1835 and began an independent movement for the rationalization of agricultural production. The major points of his instruction were as follows: to nurture rational and planned farm work in agricultural production, to keep the management scale at an appropriate level, to shorten the cultivation period required for rice crops, to give instructions on planting in checkrows and rough planting and to recommend the usage of homemade manure. His instructions on agricultural technology, in fact, did not exhibit any innovations. They had not only been stated in previously published agricultural guides, but also practiced in other regions. Nevertheless, the significance of Yūgaku rested on the fact that he did not limit agricultural problems to simply problems of technology, but aimed at solving various problems which underlied technological development. He helped establish a credit union financed by real estate and carried out the rearrangement of farmland in order to reorganize densely populated villages into scarcely populated villages. He aimed at solving these underlying factors of agricultural production which also restricted the development of production technology. Yūgaku committed suicide in 1858 after being reprimanded by the Bakufu. Although his theories also fell into disrepute, his aim, in the perspective of technological history, was to re-establish conventional agriculture.

Such attempts were possible only for a man like Yūgaku who had unique experiences, thoughts and abilities. In the same agrarian society, there were not a few people among the outstanding farmers, who devoted themselves to the improvement of agricultural technology. The best representative of them is Naozō Nakamura.

Naozō Nakamura was born in 1819 at Nagahara Village, Yamato. His family is said to have been destitute at the time. He first studied moral philosophy (Shin-gaku). In 1863, he began to study comparative yielding by gathering various rice species from each region. As a result of this study, he was able to adopt the Ise Nishiki species and recommend it around 1864 or 1865. After the establishment of the Meiji government, he was appointed a government official. He went to Akita, Miyagi and other prefectures to give guidance on agriculture. After he died in 1882, his comparative cultivation method was carried on at the government experiment agency established in early Meiji, at Naito Shinjuku Experiment Station and at other similar stations in Akita and other prefectures. According to professor Toshio Furushima,

> New agriculture confronts a discrepancy between the methodology of German-style chemical analysis and that of conventional agricultural writers. As far as cultivation experiments with emphasis upon the field for crops are concerned, however, continuity from the traditional empiricism is clearly observable.

Naozō's attempt, therefore, was epochal in the sense that he filled the gap between tradition and experimentation.

Consequently, we can say that endogenous technology took its own course in its independent development. Viewed from the standpoint of modern scientific technology, endogenous technology developed as far as possible on a given scientific basis, and finally reached a point whereby the particularistic scientific basis was about to be re-examined. However, there is no way of knowing about the prospects it would have enjoyed from that point onwards, for it was soon confronted with the exogenous technology from the west. The historical research necessary to consider the possibilities of an endogenous technology in isolation from western influences is, at this time, almost totally lacking.

NOTES

Voluminous literature on the history of technology has been referred to in order to compile this report. In particular, the following books have been helpful:

Meiji Izen Nippon Kagaku-shi [Pre-Meiji science history of Japan] (Gakushi-in, ed., Nippon Gakujutsu Shinko-kai), Volumes on General Remarks, A Chronological Table, Engineering Works, Construction, Agriculture, Sericulture, The Manufacture of Arms, Applied Chemistry, Fishing and Forestry.

Nippon Kagaku Gijutsu-shi [The history of science and technology in Japan] (Asahi Shimbun-sha, ed., Asahi Shimbun-sha, 1962).

Nippon Kagaku Gijutsu-shi Taikei [An outline of the history of science and technology in Japan] 25 vols. (Nippon Kagaku-shi Gakkai, ed., Dai-ichi Hōki Shuppan, Ltd.).

Edo Kagaku Koten Sōsho [Classic library of edo science] (Kunio Aoki and others, ed., Kowa Shuppan). More volumes are being published in this series.

Nippon Nōsho Zenshū [The complete works on agriculture in Japan] (Tatsuo Yamada and others, ed., Nōsangyoson Bunka Kyōkai). More volumes are being published in this series.

Nippon Kagaku Koten Zensho [The complete classical works on science in Japan] (Hiroto Saegusa and others, ed., Asahi Shimbun-sha).

Kiryū Orimono-shi [The history of Kiryū textiles] 3 vols. (Kiryū Orimono Dōgyō Kumiai, 1940), and other histories of various industries.

Hirano-son shi [The history of Hirano village] (Hirano Murayakuba, ed., Hirano Mura Yakuba, 1932) and other works on local histories.