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Relation	



A Modern History of Technology in Japan (I): Synopsis of a Lecture from the Socio-economic Perspective.

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Preface

This is a record of a lecture titled “Comparative History of Technology” which outlines the historical development of industrial technology in the Modern Japan. The lecture has been read by the author at Hiroshima University to the undergraduate students in Japanese language for a period of more than two decades. This record treats with the first half of the lecture; that is, from the early modern times in the late 16th century to the World War II. The second part, that includes the period just after the World War II upto the end of the High Economic Growth phase, will be submitted in the following number of this journal or its successor. The part that describes about the modern economic history of England and Germany as the object of comparison, which was also read in the lecture, has been omitted in this record. The lecture targets at the enrichment of the students’ comprehension on Japan’s experience in its universality and its peculiarity in world history of technology.

In difference with the well-accepted works written or edited by Morris Low¹ that cover also the cultural context, this lecture is solely comprised of the socio-economic perspectives.

This record takes the form of a textbook (in a summarized style) rather than that of a scientific paper. This record gives a list of literature towards

the last of each chapter unlike as it is done in the case of a scientific paper, where sources of quotations are provided in the footnotes on their respective pages. Many tables and illustrations that were cited in the printed materials for the lecture in the Japanese language have not been stated here.

I. Pre-modern Agriculture and Farm Village

Let us begin with a comparison of the agricultural state in the medieval or early modern Japan to that in the Medieval Europe. The condition of Japan could be known through the *Taikô Ken-chi chô* in the last stage of the *Sengoku* (Warring States) period, which was compiled in the late 16th century and the state in the Medieval Europe could be traced, for example, of the 11th century England, through “*Doomsday Books*,” which were compiled in the 11th century during the phase of Norman Conqueror. Autonomy and status of the feudal estates made it difficult for compiling overall statistics for the entire nations and so, only a few exceptional records have been utilized.

At the same time, the difference of the time frame during Medieval times in between Northern Europe (England) and Japan must be taken into consideration. Appearance of the independent peasant family may be regarded as the criteria of Feudalism. The Roman slavery rule in the north

European regions was so superficial that the ancient German clan societies revived through the “Great Germanic Movement” and the independent peasant families got raised without much difficulty. On contrary, in Japan, shift from the slavery system to feudalism was much vaguer. Dissolution of “*Myō*,” as a basic unit of slavery (after the collapse of the ancient despotism), was very slow. The deep-rooted ancient aristocratic powers survived until their elimination by a series of reformation from “*Taikō Ken-chi*” to the establishment of the shogunate power of *Tokugawa* Dynasty.

In English regions, the moist climate belt accompanied with relatively dry summer, required deep plowing and weeding twice a year, i.e., before sowing and after harvesting, both in the fallow season. The English peasants grew wheat, barley, oats, beans and other vegetation, depending upon the natural rainwater. All the nourishment from the surface soil was completely exhausted one time only. Therefore, periodical fallowing was necessary for the recovery of fertility. The Three Field System and the Open Farm System, which was accompanied by the dispersion of the arable land of one peasant family into at least three fields, had been developed.

Contrary to England, in case of Japan, which also belonged to the moist climate belt, but, accompanied with rainy seasons, the peasants

traditionally grew rice (*Oryza Japonica*) on irrigated paddy fields that were enclosed in the levee. In addition to the labor-intensive work of building up the irrigation facilities, seeding culture, transplantation, frequent weeding, control of water supply and harvesting had to be done with *ad hoc* concentration of a great amount of labor force. However, water carried away the nourishment, every year. Hence, serial cultivation did not harm the soil.

Furthermore, we should pay attention to the high harvest productivity of *Oryza Japonica* (about 1,300 grains in one crop), which exceeded that of *Oryza Indica* by approximately three times. *Oryza Japonica* consists of three sub-classes: Non-glutinous rice, Glutinous rice and “*Sen (Tōboshi)*”. The first kind that lacks awn was obtained by doing improvement of a specie over a very long period of time through selective breeding. The usage of the second kind is almost limited to making rice cakes (*Mochi*). The last kind that remains awned was seen only in Southern China, which is of relatively low productivity and that also reduced the total harvest productivity of *Oryza Japonica* in China.

Agriculture, in which instantaneous investment of a large amount of labor (joint work) is needed for jobs like seeding and harvesting, has

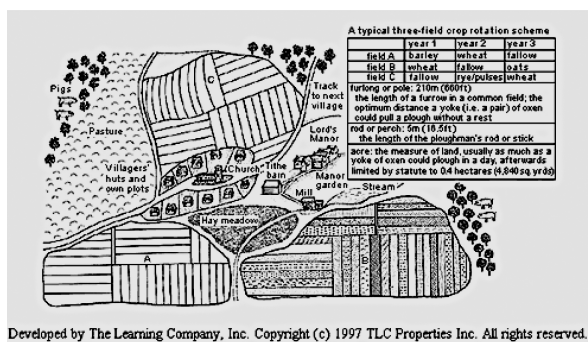


Fig.1, The three-field system

Source: Internet Source (<http://circlesofinnovation.valenciacollege.edu/2014/05/21/infographic-map-of-3-field-system/>)



Fig.2, Rice field.

Source: Internet Source (https://www.city.yotsukaido.chiba.jp/miryoku/smile/rekishi_bunkazai/bunkazai/publication/history/yshakai30kinenshi.html)

a strong cooperative nature. In Medieval times, therefore, agriculture was conducted by rural communities which consisted of individual peasant families that owned arable lands. In many cases, village communities autonomously controlled the joint works necessary for agriculture and also the community life. On the other hand, feudal lords kept common conditions for agricultural production under their control by suppressing peasants with their armed forces, due to which village communities and peasants had to be their subordinates and pay tribute to them. The land lords in West European countries had relatively minor seizures, like pasture ground, forests and water mills (needed for pulverizing wheat, barley and oats into flour). Contrasting them, the land lords of Japan often ruled over the water supply for irrigation. Therefore, they obliged the peasants to pay relatively higher rate of tribute and hence, play control over the villages from remote cities where they were concentrated. However, in West European countries, the relatively weaker rule of the feudal lords upon their peasants had to be supplemented by immediate existence of compulsive power upon villages together with the extra-economical compulsion. Contrary to Japan's case in which *Samurais* had built up many unique cities called *Jōka-machi* around their castles, the lords in Western Europe so often could not leave their own estates and compose the city as their important component.

On the other side, land possession by the peasants on the concentrated irrigated fields which were surrounded by levee was also strong in Japan, unlike as in the case of West European peasants, who often possessed the dispersed fields shaped into belts for their agriculture.

In the medieval time, the city's economy mainly consisted of the commercial activities by craft manufacturers and merchants which were essentially supplementary and external to the rural economy that significantly acquired the greater

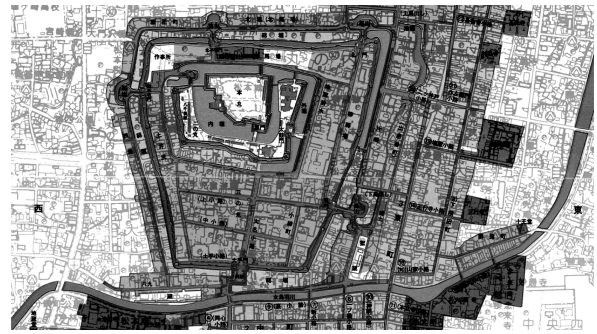


Fig.3, *Jōka-machi* (Matsumoto City)

Source: Internet Source (<https://www.matsumoto-castle.jp/town/know/town-planning>)

part of population and products. However, the monetary system which had been essential in the city economy gradually infiltrated into the nearly self-sufficient rural economy. With dissemination of the monetary system, some peasant families grew prosperous. Differentiated economic status of peasants lead to the fluctuations in community principles and the menace upon the land lord's economic power. In England, the dissolution process of feudalism began much earlier than that in Japan. With the Crusades and the Black Death (plague) in the background, *Commutation* (payment of land rent in currency) was widespread in the late fourteenth and early fifteenth centuries, especially during and after a great peasant revolt, Wat Taylor's Rebellion in 1381. Commutation means the tacit permission by the land lords to the peasants for doing free trade. The case of Japan in this aspect will be examined later.

* * *

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II. Crisis of Japanese Agriculture and Feudalism at the Early Modern Age

1. Crisis of Japanese Agriculture

Industrialization initiated by Industrial Revolution meant that the agricultural population must support (provide the food to) some portion of the total population who worked in some industry and did not engage themselves in any food production. Therefore, rapid growth of productivity in agriculture often preceded Industrial Revolution. In England, Agricultural Revolution was stimulated by the wide diffusion of Norfolk-type Rotation of crops like clover, barley, wheat, and turnip. In this case, the clover and turnip were used as the fodder in winter. The benefits were as follows; (1) the pasture ground for winter and the fallow ground were spared, (2) natural fertilizer was increased with the increase of domestic animals, (3) although deep plowing became necessary, a mechanical plow and seeding were invented. Later, the guano fertilizer imported from Chili was used in addition to domestic animal excrement. Thus, the three-field system completely declined. For such a reorganization of agriculture, the so-called, second “Enclosure Movement” (1760s–1840s) progressed throughout England, in 13.6% of whole territory, whereas the first “Enclosure Movement” covered only 2.76%. Such change in agriculture and farm villages led to a social change, which was rise of capitalism in agriculture. On the other hand, it was traditionally assumed that Japan’s history lacked such an experience and it rushed into the capitalist modern times without any notable growth of productivity in agriculture. However, in 1980s,

such a view was revised with the appearance of several new approaches in historical study which were pioneered by Ôishi, Shinzaburô and others.

The *Edo* Period (1603-1867) can be regarded as the Great Age of Land Development. After the recovery of peace together with the establishment of the shogunate power, the feudal clans were enthusiastic about land development. Later, mainly after 1770s, the merchants-in-contract undertook the development business under the permissions of the lords. The new rice field rapidly got increased. The total amount of rice crop on the official statistics (including some estimations) was increased from 18,505 thousand *koku* (1*koku* is approximately 180 lit.) in 1600 to 32,220 thousand *koku* in 1867. Nevertheless, the total population of Japan remained almost unchanged for approximately 150 years; the population of peasants, craftsmen, merchants and others (except for *Samurais*, clergymen in Buddhism and Shintoism, the population of whom was not compiled officially) was 26,065,425 in 1721, but even in 1846, it remained 26,907,625. The enlargement of rice fields didn’t lead to the population growth. How can we explain such a contradiction?

First of all, we can mention some negative aspects accompanied with the external expansion of arable land; (1) Poor rice field was increased. (2) Some old rice field were left unrealized due to manpower requisition for new rice field development (In this case, the stagnated population growth also worked as a cause). (3) Flood frequently occurred due to the overexploitation and the poor civil engineering constructions for new arable land development, especially that of the water supply facilities. Among such aspects, the problem of so-called “Superannated rice field” is noteworthy. For a very long time, the iron- and manganese-content carried away by water was extracted into the soil and was accumulated to an extent that hydrogen sulfate was generated from the

surface of the soil. Consequentially, the diseases of the rice crops, so-called *Goma-ha-kare-byô* (*Aki-ochi*) or *Nekusare-byô* were frequently prevalent. The first reference to such diseases can be seen in *Aizu-Nôsho* (published in 1684).

A series of the countermeasures protecting crops against these diseases were taken. Agricultural techniques changed since the mid-eighteenth century as follows: (1) Deep plowing cultivation got widespread with utilization of the hoes instead of plows for cultivation. Cows and oxen for plowing were not used anymore. The fields were cultivated by men with the hoes in their hands until the invention and diffusion of the short-bed plow in the second half of nineteenth century. (2) *Ta-boshi* (turning to the dry field), or rice cropping fallows, were broadly utilized. Some portion of rice field was turned for the cultivation of other crops that did not demand much of water, for example, the commodity crops like cotton in Kawachi district near the big city, Osaka. Such a measure encouraged the commercialization of agricultural crops, especially in the outskirts of big cities. (3) It was recommended to make the rice field dry once in the weeding period besides the harvest period (for taking advantage of nitrogen in the soil). Such a measure required some additional capital investment that included civil engineering works for building the drainage facilities (a waterway, a subway drain and others). (4) Improvement of plants by exchange of seeds between the landowners (for example, *Yaroku-mai* invented in the *Obi* clan in Southern Kyûshû), village communities and private organizations (religious one, such as *Fuji-dô*). The *Doi* family in Kurose village near Hiroshima University had been engaged in the improvement of rice crops, by inventing such new sorts of rice seeds as *Gin-bôzu* and *Aki-bôzu*. (5) Usage of artificial fertilizers such as *Hoshika* (fermented sardine), *Abura-kasu* (oil cake extracted from rapeseed) as nitrogen fertilizer exceeding human or animal feces were widespread

throughout Japan. Those fertilizers were purchased in currency by the villages. Thus, the regions producing them economically developed and the monetary economy flew into farm villages together with these commodities. For example, *Kawamo* Village in *Muko* province of *Settsu* district (near today's Kobe city and one of the most economically developed area then) paid 18-20 *monme* of silver (1 *monme* is nearly equivalent to 3.75 grams) for *Hoshika* as early as in 1734. Thus, the peasants' efforts to overcome the crisis and improve the agricultural techniques potentially prepared the future industrialization,² not in terms of the labor productivity, but in terms of the harvest productivity.

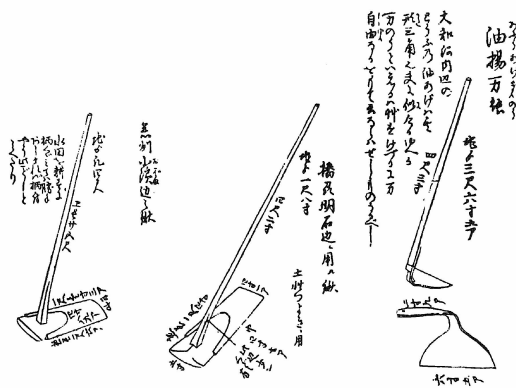


Fig.4, Various kinds of hoes.

Source: Oka, Mitsuo, Inuma Jirô and Horio Hisashi ed. *Inasaku no Gijutsu to Riron (Technology and Theory of Rice Farming.)* Heibonsha 1990. p.231.

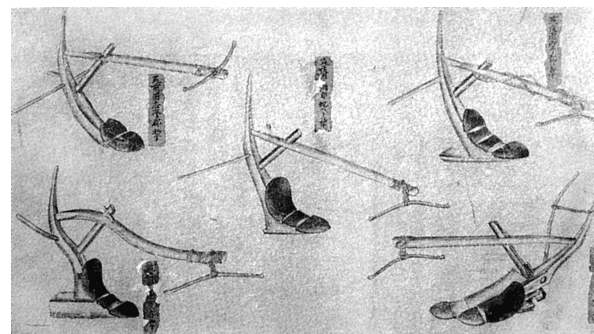


Fig.5, Various kinds of short-bed plows.

Source: *ibid.*, p. 236.

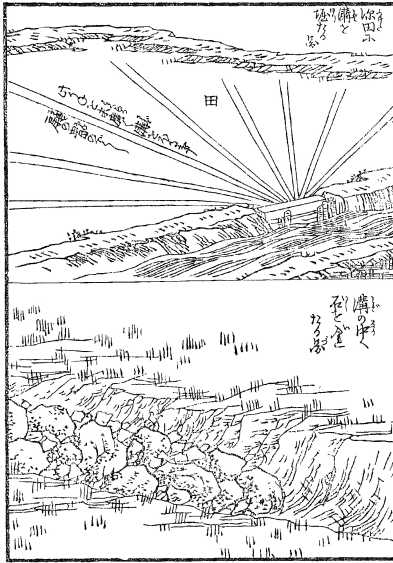


Fig.6, The drainage facilities for making the rice field dry.

Source: *ibid.*, p. 123.

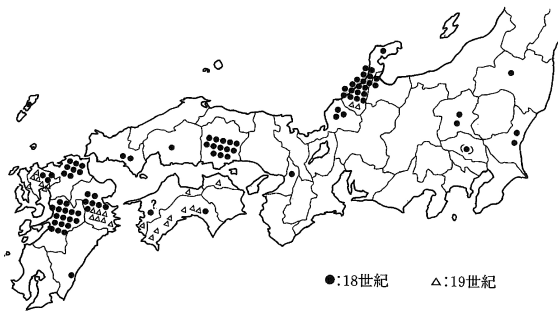


Fig.7, The diffusion of *Yaroku-mai*

Source: *ibid.*, p. 21.

2. The Social Change in Villages

Above-mentioned reforms in agricultural techniques caused wide-spreading and deepening of monetary system into farm villages. Necessary differentiation of peasants took place in Japan also. Prosperous peasants turned *Kôri-gashi* (the usurers) for relatively poor peasants. Due to *Ta-hata Eidai Baibai no Kin* (Act on the eternal prohibition of sales and purchases of arable land), the land ownership was not transferred to them. Therefore, they could not grow as great land owners, but as the usurers for borrowing money on the debtor's lands as *de fact* collateral. In addition, under the prohibition of free cultivation (*Ta-hata Katte Dukuri no Kin*), the prosperous peasants

could not develop commercial agriculture and other businesses freely, except for some food-processing businesses (typically, *Sake*, *Miso*, *Shôyu*) using the surplus rice, wheat and soybeans, which were cultivated without any special permission. Such businesses are often called *Shôya Keiei*.

The shogunate power tried to reestablish their type of feudalism based upon the principle of "Supreme Proposition of Securing Land Lent in Kind (*Yamada Moritarô*)" i.e. prevention of infiltration of the monetary economy into farm villages; *Kyôho no Kaikaku* (1720's), *Kan-sei no Kaikaku* (1790's) and *Tenpô no Kaikaku* (1830's) were such trials. Through these reforms, the shogunate power repressed peasants' riots and enforced high rate land-lent in kind (rice crops) upon them. In difference with the former two reforms, however, *Tenpô no Kaikaku* was not successful; peasants' riots frequently burst forth and a significant population fled out of villages (some of the refugees turned out to be the notorious *Yakuza*, mainly in the outskirts area of *Edo*). Control upon the commercial activities through *Kabu-nakama* (trade associations) could not help on being abandoned. The dissolution of *Kabu-nakama* led the prosperous peasants to a variety of business opportunities in their villages.

* * *

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III. Transplanting of Modern Technology immediately before and after the Meiji Restoration.

1. "Open Door" and the Crisis of Japanese Feudalism

Spontaneous dissolution process of Japanese feudalism since *Tempô* era (1830s) was accelerated by the pressure from abroad. Commodore of the U.S. Navy, Matthew Calbraith Perry and his fleet, the so-called "Black Ships," came to Japan for the negotiation with the shogunate government for the Japan's Open Door in 1853. In the following year, Japan's government accepted the U.S. request and opened some ports for foreign trade. "Open Door" to European and American countries exposed the contradiction of a closed economy. Shogunate Japan adopted a unique and complicated currency system; The gold currency system (1 *ryô* = 4 *bu* = 16 *shu*) was adopted mainly by *Samurais* and the privileged merchants. On other hand, the silver and copper coins were used by the common people. Each of these systems worked independently from each other. Exchange of currency between the two systems was realized through the exchanging dealers. And then, what makes the matter more complicated is that the gold coin system adopted some silver coins as auxiliary coins. The U.S. negotiators took advantage of such a complicated structure. They succeeded in linking the U.S. currency with the gold coin system of Japan. One U.S. dollar (containing 24 grams of pure silver) was equivalent with three *bu* on the basis of the weight of the pure silver included in the auxiliary coins. However, then, one dollar gold coin contained only 1.5 gram of pure gold, whereas one *ryô* (*Tempô koban*) held 6 grams of pure gold. The U.S. merchants who exchanged their silver coins for Japanese gold coins in Japan could gain much more gold, which was three times as much as that in the U.S. The development of trading with the U.S. and other western countries brought about

outflow of a tremendous amount of gold from Japan.

The *Tokugawa* government and the large clans purchased many naval ships and other armaments from the European countries for the enforcement of defence power. As for the civilian sector, Japan imported a great amount of cotton textile (fabrics and woolen stuff) and exported raw silk and others. Such a deficit in foreign trade furthered the outflow of gold. The shogunate government took a countermeasure against such outflow with the re-coinage. In 1859, the content of pure gold in one *ryô* coin was reduced to approximately 5 grams, but in the following year, it was suddenly and drastically reduced to only 2 grams (*Man-en koban*). Such re-coinage caused rapid rise in prices; 1 *koku* of rice was priced about 93.6 *monme* in 1857, but it was raised to 995.8 *monme* in 1867. Such hyper-inflation caused predicament of poor peasants and disturbance of lord economy. This economic crisis lead to Meiji Restoration.³

2. Transplanting of Western Technology.

Even before the "Black Ships" in 1853, the Opium War in 1840-1842 awakened nationalism among some far-sighted clan lords and several intellectual *Samurais*. One of such lords, *Nabeshima, Naomasa* (*Kansô*) from *Saga* clan took the initiative of building up *Randen-ishibiya Seizôjo* (the Gun Works) in 1842 and *Seiren-kata* (the Refining Works) in 1850. Eventually, they succeeded in building the first reverberator in Japan, the Armstrong artillery guns, the steam boiler for the *Chiyoda-gata* boat and the Steam Boat, *Ryôun maru*. Besides him, Lord *Shimazu, Nariakira* from the *Satsuma* clan ordered to build *Satsuma Shûsei-kan* (the Comprehensive Factory) in 1852. It ran the glasshouse, the pottery works and the machine spinning works (1,800 spindles of Mule and 1848 spindles of Throstle). Immediately after the "Black Ships," only within a year, 225 clans applied to the Tokugawa government to

permit them to cast 1,657 cannon guns. Some blast furnaces were newly built in *Satsuma*, *Nanbu-Kamaishi*, *Komui* and *Ôtara* (of *Sendai*), some reverberators; in *Saga*, *Satsuma*, *Nirayama*, *Mito*, *Hagi*, and *Ôtara* (of *Okayama*), and, some shipyards; in *Yokosuka*, *Mito*, *Saga*, *Satsuma*, *Chôshû*, *Himeji*, *Sendai*, *Fukui*, *Tahara*, *Ôno*, *Tsu*, *Tosa*, etc.

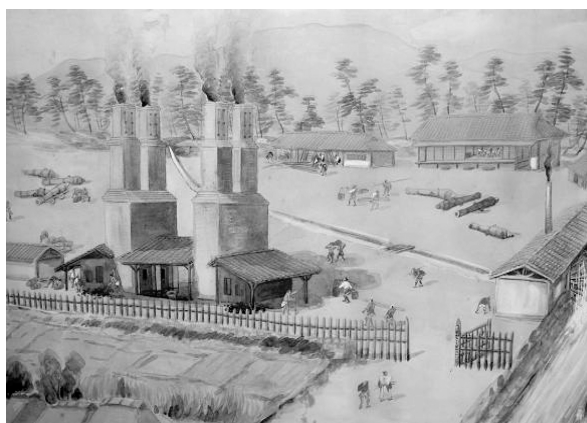


Fig.8, *Saga*, *Seiren-kata* (the Refining Works)

Source: Internet Source (<https://sagajinjya.sagafan.jp/e36923.html>)



Fig.9, *Satsuma Shûsei-kan*. A picture taken in 1872.

Source: Internet Source (<http://www.shuseikan.jp/about/>)

However, their efforts to produce domestically such advanced industrial products were not so successful. Even in the year 1868, only 11 vessels of 45 government's vessels and 12 of 93 clan-owing vessels were built in Japan. The other vessels were imported. The purchasing price amounted to a total of 4,494,000 dollars (government purchase) and



Fig.10, Reverberator in *Nirayama*.

Source: Internet Source (<https://www.city.izunokuni.shizuoka.jp/hansyaro/manabi/bunkazai/hansyaro/pamphlet.html>)

3,336,000 dollars (various clans purchased) with 8,100 *ryô* in Japanese currency. The second place of imported goods was occupied by the cotton textiles – 3,770,000 dollars and then, the woolen fabrics – 3,490,000 dollars in 1867.

What is more important here is that as the fate of “Iron and Arms” which was demanded for military power reinforcement, the efforts to industrialize various weapons and armaments were considerably declined in accordance to the restoration of peace after the end of *Seinan Sensô* (the revolt in *Satsuma* district head by *Saigô, Takamori*, one of the great leaders of *Meiji* Restoration) in 1878. In 1889, the domestic production of the iron and steel satisfied only 18.9% of the domestic demand and only 9.6% (10,665 tons) of the total supply was consumed by the army and navy. The army and navy arsenals were rearranged and unified to only five places (*Osaka* Artillery Arsenal, *Tokyo* Artillery Arsenal, *Yokosuka* Naval Yard, *Onohama* Shipyard and *Akabane* Naval Arsenal). The annual output of steel in *Osaka* Artillery Arsenal, the largest arsenal, was only 2,953.1 tons.

In 1874, even *Osaka*, the most industrialized prefecture, provided hand-made or craft goods like the food processing products (7.8% of all industrial goods), the textiles (7.5%), the pottery (6.2%),

the instruments (6.2%), some sorts of oil (4.3%) and others. Transplanting of modern technology immediately before and after the *Meiji Restoration* could not change the pre-modern economic structure as a whole.

* * *

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IV. Industrial Revolution I—Cotton Spinning Technology: "The Bottom-up Way" or "Top-down Way" of Modernization.⁴

1. Development of Japanese Cotton Industry

Tenpô-no-Kaikaku liberated cotton planting from the Osaka cotton merchants' control. The prosperous peasants began to plant more cotton. The total annual product of cotton crops was increased after the *Meiji Restoration* from 37,800,000 *kin* (1 *kin* \doteq 600g) in 1867 to 88,370,000 *kin* in 1877. The cotton planting was developed in the relatively warm districts; In *Mikawa* 10.5% of total amount of Japanese raw cotton was produced (1877). In *Kawachi* – 8.6%. In *Settsu* – 8.3%. In *Aki* – 5.9%. In *Owari* – 5.8%. In *Hôki* – 4.0%. In *Yamato* – 3.7%. In *Hitachi* –

3.5%. In *Harima* – 3.3%. In *Musashi* – 3.2%. The cotton was spun by human hands (in a cottage style) using only a spinning wheel and a short bar in a hand.

Concerning the influence of the "Open Door" in mid 1850s, *Shimazu, Nariakira*, one of the greatest and far-sighted clan lords in those days said, "What is most terrible is neither a warship nor a cannon, but only cotton cloth." Following his instructions, the *Shimazu* family of *Satsuma* founded *Sakai Spinning Mill* in 1870 and *Kagoshima Spinning Mill* in 1872. Before them, however, as early as in 1867, the former privileged merchant of *Tokugawa* Dynasty, *Kashima, Manpei* also founded his own mill, *Kashima Spinning Mill*. These three mills were often called *Shiso san bôseki* (Three Founders of Machine Spinning).



Fig.11, Cotton spinning in Meiji era.

Source: Internet Source (<http://www.wul.waseda.ac.jp/TENJI/virtual/farsari/42.jpg>)

In addition to these three Founders, the new government built two state pilot-plants in Aichi and Hiroshima Prefectures in 1881-1882 and developed the policy to promote *Jukki-bô*, the "10 Basic Cotton Mills," by inducing the private investors to construct modern cotton spinning mills through a policy of the no-interest-lent of machines for 10 years from the government. Nevertheless, these early efforts were not successful. Each of them had only 2,000 spindle-scale. The most of the water

mills introduced in those days were not suitable for the unstable water resources of Japan which had the high-water seasons in a year. And then, the most important is the inadequacy of the East Asian kind of cotton fiber (short and hard) to the Mule spinning machines and the Throstle frames. The yarn of the short and hard cotton fiber very often snapped with such machines.

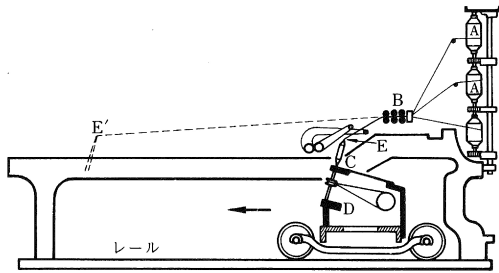


Fig.12, The Mule spinning machine.

Source: Unno, Fukuju ed., *Gijutsu no Shakai-shi 3: Seiô Gijutsu no Inyû to Meiji-Shakai (A Social History of Technology 3: Transplanting of Western Technology and the Society in Meiji Era.)* Yûhikaku, 1982. p.153.

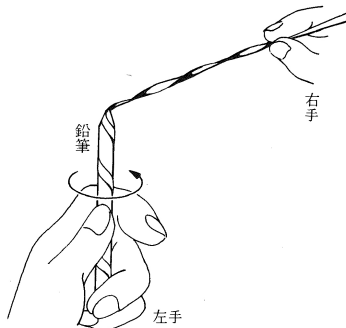


Fig.13, Twisting action of the Mule machine.

Source: *ibid.*, p.154.

Contrary to such failure with the Mule spinning machines and the Throstle frames, *Gaun, Tokimune*, an independent inventor outside the establishment, succeeded in mechanical spinning of such short and hard cotton fiber. He said, “I am never willing to learn Western-style of designs. I am quite satisfied with my own designs.” His invention, the so-called *Gara-bô* spinning mills, gained high reputation in the First National Industrial Exposition in 1877. Gottfried Wagener,

a government advisor, admired it as “the best invention in this Exposition.” In this spinning machine, a roller pulls up a yarn from a rotating tin cylinder that is full of raw cotton and which is lifted to some extent with the movement of the yarn. *Gara-bô* was spread all over the cotton-cultivating districts (Shizuoka, Aichi, and Osaka). It supported the small manufactures ran by prosperous peasants, many of which had set up the *Gara-bô* machines inside a boat, the so-called *Funa-ya* (works-in-boat), in order to be saved from the influence of the water level changes.

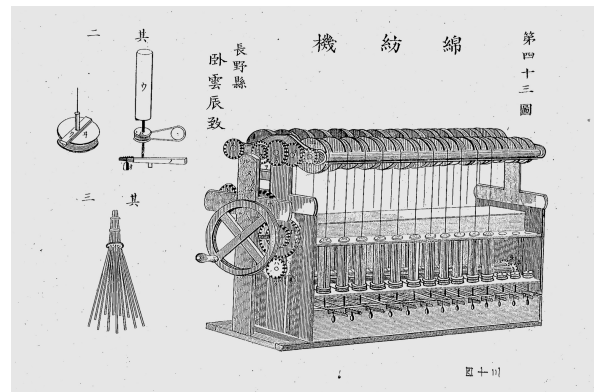


Fig.14, *Gara-bô* spinning mill

Source: Internet Source (https://www.ndl.go.jp/exposition/data/R/908r.html#EXHIBIT_1)

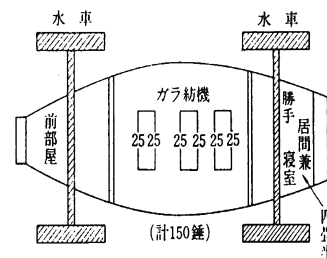


Fig.15, *Funa-ya* (works-in-boat) with *Gara-bô* machines.

Source: Unno ed., *op. cit.*, pp.142, 143.

On the other hand, *Shibusawa, Ei-ichi*, the outstanding organizer of modern business in Japan and then, President of the First National-patented Bank, made great efforts of capital procurement for the *Yunyū Bōatsu*, the prevention of dependence upon the imported textile. He succeeded in gathering capital from the former lords (National Bond for Feudal Salary) and the wholesale merchants of raw cotton and cotton yarn in Osaka (250,000 yen) and established *Osaka Bōseki-Gaisha* (*Osaka Cotton-spinning Company*) in 1882, which built their own factory in *Shikan-jima*, a factory equipped with 15,000 spindles and the steam power in the following year. *Shibusawa* adopted the Ring spinning machine on the recommendation by the young talent, *Yamabe Takeo* who was asked by *Shibusawa* to research on the machine spinning suitable for Japanese raw cotton, while he stayed in Great Britain for the study of political economy. The company achieved a great success. After that success, many private companies with more than 10,000 spindles of the Ring machines operated by the steam engines were established one after another. Their share in the sales markets exceeded half of the demand as early as in 1891. They pressured *Gara-bō* manufacturers. This means “the Historical Defeat of the Bottom-up Way” of Japanese capitalism. Some of the grass-roots capitalists, i.e. the former prosperous peasants whose potential growth as modern capitalists was denied, took part in *Jiyū-Minken Undō*, i.e. Liberal and Democratic Movement, and took a series of the opposing actions to the *Meiji* absolutism.

The rapid expansion of cotton spinning industry lead to the rapid increase of raw cotton demand. Whereas 55% of the demand was satisfied with the domestic raw cotton in 1887, that ratio was reduced to 25% only two years later, in 1889. In this year, 68% of the demand was satisfied with the imported cotton with short and hard fiber, similar to the domestic kind, from China. However, the cotton spinning manufacturers developed the

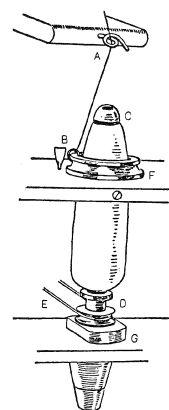


Fig.16, Principle of the Ring machine.

Source: *ibid.*, p.158.



Fig.17, *Sangen-ya* factory of *Osaka Bōseki-Gaisha*

Source: *ibid.*, p.144.

unique *Kon-men* (cotton-mixture) technique to mix the East-Asian raw cotton with the long and soft fiber-kind cotton introduced from India and America for keeping high quality and for being able to compete with the English cotton textile goods. And then, to make the transportation cost low, they attempted to use home-country ships against the monopoly of British Pacific Ocean Steamship Company. Under the slogan, “Cheap raw cotton, cheap goods,” *Nihon Yūsen*, a shipping company, and *Bōseki-Rengō-kai*, a business circle of cotton spinning manufacturers, pioneered the route directly to Bombay (recently known as Mumbai) for the purchase of Indian raw cotton in 1893, using a steam ship named, *Hiroshimamaru*, eventually after the trouble with the British

government, then the ruler of the colonial India (the so-called “Bombay Cotton-shipping Case”). Thus, young Japanese capitalism entered into confrontation with Britain in East-Asian market from its very beginning.

2. Silk Manufacture and Japanese Capitalism

Silk reeling industry was developed as peasant's side job in the relatively cool districts like Shinshû and the Northern Kantô. They used very simple tool for reeling, the so-called, *Zaguri*, which was used till 1894 as the major tool. The prosperous peasant-landowner began to manage sericulture and serici-paper works from the lasting days of the shogunate period. After the success of the governmental pilot-plant, *Tomioka Seishijô*, which introduced mechanical silk reeling, many small, local capitals (especially in Shinshû and Kiryû) rushed into this industry. However, in the case of silk reeling, the mechanization could not exclude hand-work. Therefore, the manufacturers had to depend upon the cheap labor that was comprised of the girls. Moreover, silk-textile industry depended on peasant's side job except for large cities like Kyoto. In this meaning, the silk industry had a pre-modern character as a whole, which was not so attractive for the bankers and large investors even then. However, it can be said that the turnover of prosperous peasants to the capitalists succeeded exceptionally in this industry. After the so-called *Matsukata Deflation* for overcoming the inflation caused by the civil wars which led the economic depression, it became difficult to found new companies and factories in this industry (1882-).

* * *

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Fig.18, A silk-reeling manufacture.

Source: *ibid.*, p.203.

Technology.) Tôyô-Keizai Shipô sha, 1961.

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V. Industrial Revolution II— Establishment of the heavy industries and their military-related character

1. *Nisshin Sengo-Keiei* (Postwar State Management after the Sino-Japanese War)

A brilliant talent of *Kôza-ha*, *Noro, Eitarô* once characterized Japanese Industrial Revolution that it consisted of the relatively independent two phases; “Lancashire-type Industrial Revolution of light industries” and “Birmingham-type Industrial Revolution of the heavy industries” which continuously followed after the former. The Industrial Revolution of the heavy industries was promoted not on the basis of the indigenous accumulation of capital, but on the basis of a great

sum of the compensation from the *Qin* Dynasty that the Japanese government obtained as the result of Sino-Japanese War (1894-1895). Japan gained totally 231,500,000 taels; 200,000,000 taels as “Compensation for military-recovery,” 1,500,000 taels as “Redemption for the Defense Expense in *Weihai-wei (Ikai-ei)*” and 30,000,000 taels as “Remuneration for Rendition of *Liáodông (Ryôtô)* Peninsula.” The total sum was worth 38,080,000 GB pounds or 360,000,000 yen (for three years of National Budget). Treasurer, *Matsukata, Masayoshi* took advantage of this opportunity for the policy-set, the so-called, *Nisshin Sengo-Keiei* (Postwar State Management).

The main target of *Nisshin Sengo-Keiei* was to reinforce the military forces in preparation for the future, possible war with Russia that was in confrontation with Japan after the Sino-Japanese War and to promote the heavy industries which could support the newest and powerful military armament. To attain such goals, the Japanese government took such vital measures as follows: (1) The imperial Army newly established 6 new infantry divisions (total of 12 infantry divisions), 2 divisions of cavalrymen and artillerymen and the Imperial Navy constructed a large fleet consisting of six 10,000-ton class steel-covered battleships. (2) In 1896, Imperial Parliament adopted to spend a total of 4,095,700 yen for foundation of a giant steel works, which was realized as *Yahata State Iron & Steel Works* (to be mentioned later). (3) The railway (to be mentioned later) and the telegraphic communication networks were largely expanded. (4) The army and navy arsenals were enlarged. (5) Navigation Encouragement Act and Shipbuilding Encouragement Act were adopted for the sake of promotion of marine transportation and shipbuilding: 66% of Governmental Grant-in-aid for Shipbuilding was delivered to *Mitsubishi*, and 26 % – *Kawasaki*) in 1896.

The establishment and stabilization of the modernized financial system to promote

the industries and the international linkage of Japanese economy were also the main object of *Nisshin Sengo-Keiei*. Several semi-governmental investment banks were founded one after another; *Nihon Kangyô Ginkô* (Japan Bank for Promotion of Industries) for long-term loans on the real estate mortgage in 1897, *Nô-kô Ginkô* (Banks for Agriculture and Industry) in 1897, *Hokkaido Takushoku Ginkô* (Colonial Bank for Development of Hokkaido) in 1900 and *Nihon Kôgyô Ginkô* (Industrial Bank of Japan) for long-term loans on valuable securities mortgage in 1902.

The gold standard currency was established (0.75g of pure gold as 1 yen) in 1897 in the place of the gold-silver double standard currency system established in 1870, in accordance with sharp fall or instability of silver price in Eastern Asia due to the large scale outflow of silver from China for the compensation to Japan (being afraid of flowing-out of silver, the government didn't stamp large silver coins after this currency reform). For the establishment of the stabilized foreign trade account, the Bank of Japan entrusted the assurance of Japanese foreign trade settlements to the Bank of England on Japanese gold the Bank of England secured. Thus, Japan succeeded in participation into the world economy.

2. The Development of the Heavy Industries.

Yahata State Iron & Steel Works: The coke-blast furnaces with capacity of 160 tons with a hot wind blower were built (Before then, *Kamaishi* blast-furnace capacity was only five tons at first, and then enlarged to 25 tons). The 25 ton-class open-hearth furnaces with the electric charging machine were equipped, which expelled completely the reverberators and the crucible furnaces which were then studded at various places. The 10 ton-class Bessemer converters were utilized as auxiliary refining furnaces. As for the raw material supply, iron ore from *Kamaishi* and *Kamaishi-pig* iron were quickly replaced with imported ore from

China and Southeast Asia.

Steel making technology was widespread to private firms (Relatively small steel makers only with an open-hearth furnace or an electric-arc furnace using Indian-pig iron and the US scrap iron).



Fig.19, The opening ceremony of *Yahata State Iron & Steel Works*.

Source: Internet Source (<https://trc-adeac.trc.co.jp/html/image/4020605100/4020605100100010/3-2-3-1-1.jpg>)

Ship building: Building of a huge commercial cargo and passenger ship, *Hitachi-maru* (6,200 tons, 2,000 horsepower, and mild steel armored) was completed in 1898 in *Mitsubishi's Nagasaki Shipyard*. That was monumental as an example announcing the full acquisition of modern ship-building engineering by Japanese engineers and shipyard workers. Moreover, in 1887, an engineer, *Miyahara, Jirô*, invented *Miyahara-type* tuberos boiler so efficient by adopting the curved pipes absorbing the swelling and shrinkage of the pipes (Later, however, the Japanese boiler market was monopolized by *Babcock & Wilcox Co.*)

Railway: Thanks to the fund-raising activities by *Shibusawa, Ei-ichi* and his colleagues, several private railroad companies were founded based upon concentration of capital from the former lords and the privileged merchants; Japanese Railway



Fig.20, *Hitachi-maru*

Source: Internet Source (https://blogs.yahoo.co.jp/bonbori098/GALLERY/show_image.html?id=19039951&no=0)

Company (from Tokyo to Aomori) was founded in 1881, the *San-yô Railway Company* – in 1888, the *Kyûshû Railway Company* – in 1888 and the *Hokkaido Colliery Railway Company* – in 1889. However, the development of the private railways seems to have been so slow for the government that hurried to build the railway network all over the territory. The government denied the spontaneous development of the private railroad and purchased the private railway facilities since 1887 under the guideline, the so-called “Revived Principle of Government-building Trunk Lines,” established by *Inoue, Masaru*, Director of Department of Railroad.

The railway between Ôtsu and Kyoto was constructed by Japanese only, without any help and advice from the engineers dispatched to Japan from European countries and America. Although in those days, the locomotives had to be imported, they ran on the railway of Japanese construction.

Machinery: *Shibauro Engineering Works* (today's *Toshiba*) manufactured a 1,300-horsepower steam engine in 1896 for *Kanegafuchi Bôseki (Kanebô)*. However, the age of steam engines was so short in Japan and, as early as in 1910, the age of the turbine began. Besides factory engines, *Kobe Factory* of Department of Railroad constructed a 1B1 type steam locomotive by Japanese only in 1893 (However, the establishment of the systematic domestic production began only in 1912).

In 1905, *Ikegai Iron Works* tried to copy

the lathes made in the United States. However, the establishment of the systematic domestic production could not be seen before WWII.

Mines: *Mitsui Miike* Colliery, *Takashima* Colliery, *Ikuno* Silver Mine and *Sado* Gold Mine were disposed to the *Mitsubishi* group. *Besshi* Copper Mine was owned by the *Sumitomo* family since the shogunate period. *Ashio* Copper Mine was purchased by *Furukawa, Ichibei*. Such mining businesses were prosperous in accordance with the development of industrialization and exportation and, then, became the roots of the conglomerates, i.e. the so-called *Zaibatsu*.

3. The Establishment of Japanese Capitalism

Japanese capitalism in its earliest days was composed of the following sectors: (1) the flourishing cotton spinning industry which was rapidly developed upon the investments from the former feudal ruler class; (2) the relatively large silk reeling industry as one of the most important export industries, in which the growth and turnover of the prosperous peasants to the modern capitalists can be seen exceptionally; (3) the foreign trade businesses and heavy industries such as the marine transportation, the trading companies, the coal mines, the copper mines and the ship-building yards which were organized by *Zaibatsu*, the semi-feudalistic privileged merchants; (4) the large-scale governmental industries, such as the Army and Naval arsenals and *Yahata* State Iron & Steel Works; and (5) the poor farming villages which was not modernized and remained as it was in the pre-modern times, as the main supplier of the cheap labor power to the modernized industries. Immediately after the completion of their own type of the Industrial Revolution, Japanese capitalism entered into a serious confrontation with the European and American advanced countries about the Asian markets due to its essential dependence upon the latter as the sales markets of their industrial products and the purchase market of the

raw materials, in spite of the dependence upon the European and American markets as the sales markets of their silk, copper, coal, tea leaves and others and the purchase market of the advanced manufacturing machines and industrial equipment.

* * *

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VI. Development of Industrial Technology in the Inter-war Period.

1. Development of electrification and electric engineering industries

It is often said that although the age of the steam engines in Japan was delayed for nearly one century than that in England, the age of electricity came to Japan simultaneously with some advanced European countries. Under the so-called “War of Currents,” in which the problem which current – direct or alternating – is suitable for power transmission was fiercely discussed, the choice of technology in each country influenced the further economic growth of that country. The former “World’s Factory,” Great Britain, which left many direct current transmissions, was relatively delayed in electrification and thus made way for the newly rising countries like Germany and Russia in this aspect (the Age of Uneven Development). Japan

successfully could ride on the tide of the three-phase alternating current that was eventually accepted all through the world.

The rapid growth of electrification of national economy in Japan was quite amazing. As early as in 1887, two electric power plants, *Asakusa* Power station of *Tokyo* Electric Lamp Company and *Nakanoshima* Power Plant of *Osaka* Electrical Lamp Company which adopted the three-phase alternating current for the first time in Japan, both in the two largest cities, entered into operation. Following them, the first hydro-power plant in Japan, *Keage* Municipal Power Plant, was constructed in Kyoto in 1892. The first power plant for mining electrification was built in the *Kosaka* Mine in 1895. The first urban stations for general purpose were constructed in *Kôriyama* and *Hiroshima* in 1899, each of which had voltage of 11,000v. and the power transmission line exceeding 10 miles. The first thermal power station equipped with steam turbines was built at *Sen-ju* in Tokyo in 1906. Each of the four turbines had 1,500hps, and then, in the following year (1907), a large-scale hydro power station, *Katsuragawa-Komahashi* Hydro-Power Station (55,000v power transmission of 70km) was built.

However, what is the most striking and historical event was the construction of the First *Inawashiro* Hydroelectric Power Plant in 1915;



Fig.21, *Asakusa* Power station

Source: Internet Source (<https://tanken.com/tokyodento.html>)

It generated 37,500kW in one year and had the high-voltage (115,000v) power transmission line for providing electricity to Tokyo in spite of a long distance from there (220km). Successively, *Tatsushima* Power Plant on the river *Azusa-gawa* was constructed 200km far from Yokohama in 1923, which had 154,000v power transmission line. In the following year (1924), a contract on mutual purchase of electric power between *Tokyo* Electric Lamp Company and *Daidô* Electric Power Company was concluded. This means that the electric power network in the eastern part of Japan and that in the western part were connected with each other.

After the establishment of Army and Navy Fuel Arsenals in 1939, the petroleum fuel was

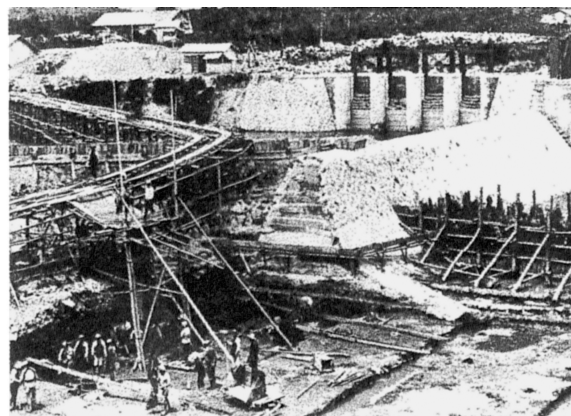


Fig.22, The First *Inawashiro* Hydroelectric Power Plant under the construction and after the completion.

Source: Yamazaki, Toshio and Kimoto, Tada-aki, [Shinban] *Denki no Gijutsu-shi (A History of Electric Engineering)*. [New Version]. Publisher Ohm, 1992. P.316.

delivered first of all to the Army and the Navy. In accordance with the decrease in the men labor power due to a large-scale conscription, the woman labor power and the Korean compulsorily moved to Japan were introduced into the coal pits. For the sake of economy and rational distribution of fuel, the Imperial Parliament passed Act of State Control on Electricity in 1939, which was aimed at the unified control of totally 1,500 km super-electric network all over the territory by a semi-governmental enterprise, *Nihon Hassôden Kabushiki Gaisha* (*Nippatsu*: Japan Power Generation and Transmission Co.) *Nippatsu* took the policy for increase of hydro-power potentials to economize the coal.

Such a rapid electrification was encouraged by the rapid growth of the electrical engineering companies which were blessed with the investment and provision of advanced technology from the foreign big enterprises; *Shibaura* Engineering Works tied up with the General Electric Co. in 1909. *Mitsubishi* Electric Engineering Corporation which just became an independent firm from *Mitsubishi* Shipbuilding only in 1921, tied up with Westinghouse in 1923. In the same year, *Furukawa* Zaibatsu established *Fuji* Electric Engineering Co. Ltd., as a joint venture with the Siemens Group.

The vertical shaft water mills and the dynamos were produced domestically for the first time in 1918. The water-cooled transformer was first produced domestically in 1925. The 154kV oil breaker was manufactured by *Hitachi* and *Shibaura* in 1926. The first domestically assembled electric locomotive (EF-52 type) began to work in 1928. Almost all items of electric engineering shifted to domestic production by 1936.

2. The Formation of the Four Major Manufacturing Districts

Electrification liberated the location of factories from the geographical limitation that they had to be near to the collieries, water resources or

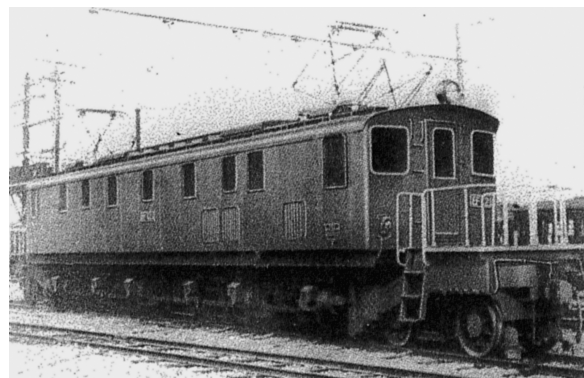


Fig.23, EF-52 type electric locomotive

Source: *ibid.*, p. 318.

other fuel resourcing places. In the Inter-war Period in Japan, the rapid electrification encouraged the formation of the major manufacturing districts.

Keihin Manufacturing District: The large seashore zone in Tsurumi and Kawasaki areas between Tokyo and Yokohama was reclaimed by *Asano, Sô-ichirô* (completed in 1924). There became concentrated many heavy industrial facilities; *Asano* Cement Co., *Nippon* Steel Pipe Co. (which introduced a German-made blast furnace exceptionally for the private steel works in those days,) *Tsurumi* Steel and Shipbuilding Works (subsidiary to *Asano Zaibatsu*), *Ishikawa-Jima* Shipyard, *Kawasaki* Heavy Industries Ltd., *Tsurumi* Petroleum Refining Plant of *Nihon* Oil Co., *Kawasaki* Petroleum Refining Plant of *Mitsubishi* Oil Co Ltd. and others.

Hanshin Manufacturing District: In the area between Osaka and Kobe, there were concentrated steel making, copper-refining, light metals and other works, many of which were subsidiary to *Sumitomo Zaibatsu*, such as *Sumitomo* Steel Works and *Sumitomo* Copper Refinement Works. Besides them, a number of small or medium-sized manufactures of metal-fabricating, ship-building, machine tool, electric engineering and other works were also located.

What is striking in this manufacturing district is the frequent outbreaks of public nuisance cases; The chlorine gas from *Osaka* Alkali Co.(in

1906/07), the soot and smoke from *Sumitomo Copper Refinement Co.* and *Nihon Cotton Spinning Co.* (in 1914), those from *Aji-gawa Higashi Power Station* and *Kasugade Power Station* of *Osaka Electric Lamp Co.* (in 1919/20) annoyed the citizens around there.

Chûkyô Manufacturing District: There used to be concentrated many consumer goods industry such as textile, pottery and clocks around the city of Nagoya. Immediately after WWI, even while the other districts suffered from scarcity of electricity, this district had some surplus potential of electricity supply. Therefore, *Daidô Steel Works*, *Nihon Insulators Ltd.*, *Toyota Automatic Loom Works, Ltd.* and others were located there.

Kita-Kyûshû Manufacturing District: In accordance with its Third Enhancing Plan adopted in 1916, the productive potential of *Yahata Iron & Steel Works* was enlarged. With the main target of secondary use of the common resources, waste and/or the derivatives, *Asahi Glass Co. Ltd* and other chemical plants were built around *Yahata Works*. In *Makiyama Plant* of *Asahi Glass*, the ammonia soda process was introduced for the first time in Japan.

3. Rise of Chemical Industry

Besides the rapid electrification, the rapid growth of the new chemical industries also characterizes the successful industrial development of Japanese economy in the Inter-war Period. During and after the Industrial Revolution, acid and alkali, the basic chemical products in those days were provided by the three major chemical companies; *Nihon Seimi* (in Onoda City), *Osaka Ryûsô* and *Osaka Alkali*.

In the Inter-war Period, some chemical industrial complexes were also formed in accordance with the growth of the new chemical industries. **(1) The Ômuta District** near *Mitsui Miike Colliery*: there alizarin, naphthalene and other organic-synthesized chemical goods were

produced from the exhausted tar and benzenes and others were produced from the exhausted gas from the colliery. Electrochemical factories using the electricity from *Ôyodo River Hydroelectric Power Plant* of *Kumamoto Electricity Co.* provided the carbide, which was processed to ammonium sulfate through lime-nitrogen by Frank-Caro Process introduced by *Fujiyama Jô-ichi*. **(2) Niihama District** (in Shikoku Island): There sulfuric acid industry was developed depending upon the sulfate iron ore from the *Sumitomo Besshi Copper Mine* and the sulfurous acid gas from refinement process of copper. Electric refinement of the metals such as gold, silver, high purity copper, nickel, selenium and palladium was widely adopted there. **(3) Hokuriku District:** There, surplus hydroelectric power was effectively utilized for a variety of electrochemical processes: The plants of *Chû-Etsu Electric Industry*, *Hokkai Electrochemical*, *Tôa Chemical Synthesis Industry Co.*, *Ôji Paper Manufacturing*, *Nihon Soda Co.*, *Shin-Etsu Chemical Co.*, *Niigata Electric Industry*, *Nissan Chemical Industries*, *Shôwa Denkô Co. Ltd.* and others were located around there. Among them, the plants of *Nihon Soda Co.* and *Shôwa Denkô* supplied a large amount of chemical fertilizer (ammonium sulfate) which was increasingly demanded after *Kome-Sôdô (Riot for Rice)*. **(4) The Western Part of Setouchi District:** the traditional chemical industries of cement, acid and soda were located there using the coal and lime in Ube and Onoda areas.

Among such a remarkable development of various chemical industries, the rapid growth of *Nihon Chisso-Hiryô Kabushiki-Kaisha (Japan Nitrogen Fertilizer Ltd.)* established by a young venture capitalist, *Noguchi, Jun* (exactly – *Shitagau*) in 1908 is notable. *Noguchi* adopted Frank-Caro Process for ammonia production and purchased the patent of nitrogen fixation method in 1921, with which the lime-nitrogen was effectively synthesized as the intermediate chemical goods

for ammonia production. His company advanced into Korean Peninsula in 1927 to obtain cheap electricity and cheap labor power; they developed *Bu-Jongang* River, constructed a huge hydro-power station and a large-scale chemical industrial complex named *Hung-nam* Complex. In accordance with the move of the production base of chemical fertilizer (ammonium sulfate) to Korea, the products from their main plant, *Minamata* Plant, were diversified since 1928. They adventurously adopted polymer chemical processes. In 1932, an engineer, *Hashimoto, Hikohichi* invented a unique method for reactivation of the mercury catalyst for the synthesis of acetylene from which acetic acid was produced. The acetic acid induced products such as acetate rayon, safety glass and polyvinyl-alcohol fiber became the major products of this company. They also engaged in the production of the vinyl chloride since 1941.



Fig.24, The calcium cyanamide reactors in *Minamata* factory of *Nihon Chisso-Hiryō Kabushiki-Kaisha*

Source: Internet Source (<https://tanken.com/tisso.html>)

After the second half of 1930s, *Kanebō*, *Kurashiki Ken-shoku*, *Tōyō Rayon* and other textile manufacturers engaged in the synthesis of various synthetic fibers. *Nihon Tire*, *Nihon Carbide*, *Nihon Kasei*, *Mitsui* and *Sumitomo* affiliated manufacturers and others engaged in synthetic rubber.



Fig.25, A general view of *Hung-nam* Complex.

Source: Internet Source (<https://gogogoda.amebaownd.com/posts/6060003>)

4. The Development of the Machine Industries as an *Achilles' Tendon* to Japanese Capitalism

The automobile industry lead the magnificent development of mechanical engineering in the 20th century's world history, especially in the United States. For the first time in Japanese history, *Tokyo Automobile Works* domestically manufactured their own automobile, *Takury-gō*. However, that company came to a deadlock soon after the beginning of the sales of their automobiles. Following them, *Kai-shin sha* Co. assembled only six or seven cars of their own *DAT* type (powered 10 horsepower and equipped with 2 water-cooled vertical cylinders and a three-step speed changer) in their small works with only about 30 machine tools. *Tokyo Gas and Electric Co.* assembled the tracks specified for the army use since 1917. Such manufacturers producing the army tracks

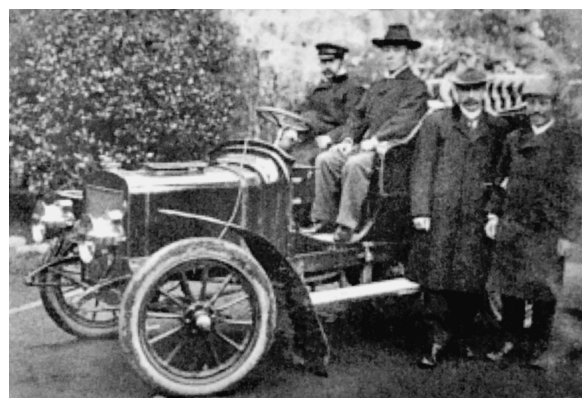


Fig.26, *Takury-gō*.

Source: Internet Source (<https://minkara.carview.co.jp/userid/952383/blog/41785624/>)

was continuously promoted by the Military-using Automobile Manufacturer Protection Act.

Ishikawa-Jima Shipyard assembled the automobiles in cooperation with a British automobile company, Wolseley Co. in 1920, which was the earliest instance of the cooperation with a foreign company. However, the prime cost was so expensive as more than 10,000 yen. After Wolseley, the U.S. Ford Company and General Motors Co. advanced into the Japanese automobile market in 1925. Japan Ford Co. built the *Yokohama Midori-machi* Factory. In 1926, Japan General Motors Co. was founded. They built their own *Osaka* Factory. Around these factories, the local repair works and the manufacturers of the parts, such as *Tobata Casting Co.* were developed.

In 1930s, many manufacturers entered into the automobile industry with the expectation about the increase in the military demand for the tracks being sent to the Chinese front; *Tôyô* Cork Industry Co. (later, *Mazda*), the Engine Manufacturing Co. (later, *Daihatsu*), *Mitsubishi Kobe* Shipyards and *Toyota* Automatic Loom Works, Ltd. For the sake of security keeping (at least nominally) and the promotion of the domestic army track production, Automobile Industry Act adopted in 1936 limited the automobile assembly business to domestic manufacturers. After such measures adopted, *Toyota* and *Nissan* monopolized the production of the private cars. However, a part of the material, many of machine tools and tools were continuously imported. For example, *Nissan* constructed a factory on the basis of the blueprint and the capital equipment purchased from Graham Page Ltd.

Not only the automobile industry, but also many other machine industries depended upon the imports as the major supplier of advanced mechanical equipment such as shipbuilding equipment, heavy industrial machines, Arsenal's equipment and electric machines. On the other hand, the small casting works were clustered in Kawaguchi, Kuwana, Tobata, Sakai and other

cities. Most of them hired only one cupola and the technology there remained craftwork level. However, among them, an outstanding entrepreneur, *Ayukawa, Yoshisuke*, later the founder of the *Nissan* conglomerate, introduced advanced then technology such as the electric furnaces and the electric annealing furnaces in Tobata in 1920. Beside, an engineer and entrepreneur, *Utsunomiya, Tokutarô* succeeded in the domestic production of drills in 1923. However, the domestic manufacturing of pits and cutters succeeded only in 1929. The weak development and the dependence upon the import of the machine industries became an *Achilles' tendon* to Japanese capitalism.

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VII. Organization of Research and Development in Pre-war Japan

1. Impact of World War I

After Japan's participation in World War I (then, the European Great War) in 1914, Japanese national economy suffered from the scarcity of medicine, dyestuff, fertilizer and other chemical products, most of which had been imported from Germany. In order to take the effective countermeasures against the serious shortage of

chemical goods, especially chemical fertilizer, the government established *Ad hoc* Board of Investigation on Chemical Industry in November of 1914. While this board was reorganized and renamed to *Ad hoc* Nitrogen Laboratory in May of 1918 and, at last, *Tokyo* State Industrial Research Institute in 1928, they finally succeeded in industrialization of Haber process in 1929. Such long-time efforts eventually bore a fruitful result; They invented their own, effective way of ammonia synthesis.

On the basis of the contribution from *Sumitomo Zaibatsu* (21,000yen) for the development of substitute special steel, Second Section of *Ad hoc* Physical and Chemical Laboratory affiliated to *Tôhoku* Imperial University was founded in April of 1916. After the war, the laboratory was reorganized to an independent Steel Laboratory in 1919 and was renamed as Metallic Material Laboratory in 1922, which played the significant role as a center of material sciences based upon quantum dynamics.

In 1917, *Nihon Kôgaku* Company Ltd. (now *Nikon* Co.) was founded on the basis of the investment from the Imperial Navy for the substitute development of optical lens which were then imported mainly from Germany.

The Navy established Naval Aircraft Research Laboratory in 1918, which was reorganized to Naval Research Institute of Technology in 1923 and played the important role in development of electronics engineering.

The government established Munitions Bureau affiliated to Cabinet in April of 1918, which was the first governmental agency for the wartime mobilization planning in Japan.

2. *Riken* (Institute of Physical and Chemical Research)

A prominent chemist, *Takamine, Jôkichi*, then the Chair of *Ad hoc* Board of Investigation on Chemical Industry, submitted his proposition

to the government, appealing the inevitability of the establishment of an enormous, comprehensive research institute modeled on German Physikalisch-Technische Reichsanstalt (PTR), tentatively named *Kokumin Kagaku Kenkyû-jo* (the National Institute for Scientific Research). He wrote, “(Japan) shall keep a position among the most advanced countries in the world... We shall widely extend the market for the our products and get the wealth of the world.” His proposition was eventually accepted and *Rikagaku Kenkyû-jo* (shortened *Riken*; Institute of Physical and Chemical Research) was established in Tokyo in March of 1917 as a juridical foundation. The government financed 2million yen, a large variety of the private companies contributed totally 2.2million yen and the Emperor donated 1 million. Having gathered excellent scientific talents from all over Japan, *Riken* achieved remarkable successes; The colleagues of *Riken* issued 2,004 scientific papers written in Japanese and 1,164 papers written in European languages from 1917 to 1945. They obtained approximately 800 domestic patents and 200 foreign patents, and especially, a prominent physicist, *Nishina, Yoshio* who pioneered nuclear physics in Japan engaged so actively in experimental work. His laboratory finally constructed one of the largest cyclotrons in those days. *Nishina* Laboratory in *Riken* was involved in Japan’s atomic bomb project named as “*Ni-gô*” after the initial letter of his surname.

As a countermeasure against the temporary financial difficulty in the depression after WWI, the third Director, Baron *Ôkôchi, Masatoshi* attempted to make their own research funds by selling their own inventions: Vitamin A, Synthetic Sake, the measurement instruments, the medicines and others. He established even a dealer company, *Rikagaku Kôgyô Co.* (1927) and other companies for this purpose. Such companies were increased one after another and eventually composed a conglomerate, the so-called, *Riken Konzern*.

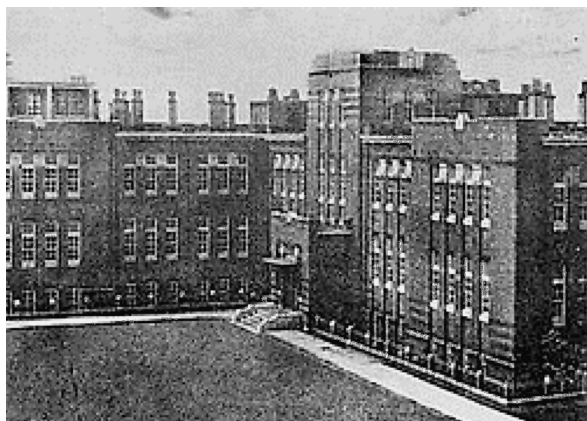


Fig.27, The head office of *Rikagaku Kenkyū-jo*

Source: Internet Source (<https://ja.wikipedia.org/wiki/E7%90%86%E5%8C%96%E5%AD%A6%E7%A0%94%A9%B6%E6%89%80>)

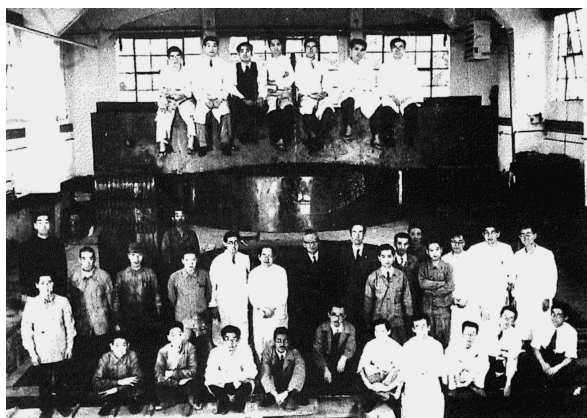


Fig.28, The completion of the electromagnet for the large cyclotron at *Riken*.

Source: Tamaki, Hidehiko and Ezawa, Hiroshi ed., *Nishina Yoshio*, Misuzu Pub.,1991.From the pages of photos

3. Mobilization to Devastation

For the sake of invitation of foreign investment, the government held a large-scale business meeting, *Bankoku Kōgyō Kaigi* (World Engineering Conference) in October of 1929, inviting various foreign entrepreneurs, investors and engineers. Although this attempt failed in its main purpose, the *Sangyō-shingikai* (Deliberative Council on Industrial Problems), which was established as one of the consequence of this Conference, played a significant role in the spread of the Japanese style of employment system (the life-time employment, on-the-job training and the seniority system), the scientific management

methods and the promotion of the industrial standardization and the industrial rationalization movement.

Also in that year (1929), Technical High Schools in Tokyo and Osaka were promoted to *Tokyo* and *Osaka* Institutes (universities) of Technology. At the same time, some state universities were newly found. And then, following Department of Scientific Industrial Research of UK as a model, Japan Society for the Promotion of Science was established with the government fund of 20 million yen, which distributed grants-in-aid for the scientific research useful for the state and controlled the research activities of various groups and scientists through Research Committees organized within the Society. Since that moment, some grant-in-aid systems or subsidy systems for the promotion of scientific research were piled up complicatedly. In 1939, Ministry of Education established Grant-in-Aid for Scientific Research (3 million yen) mainly for the fundamental research. In May of 1941, Cabinet Decision, “The Outline of New Establishment of Science and Technology” was issued to systematize the mobilization of scientific talents and research potentials. As more serious the governmental finance became in accordance with the progress of the war, the government founded a new system, *Kenkyū Tonarigumi* (Research Groups) in 1943 in attempt to obtain the scientific fruits only from grouping the scientists without any expenditure.

It is often said that the R&D efforts to make the atomic bomb, the radar (half developed), the homicide ray and others bore no fruitful result except for the cultivation of penicillin and the development of technique of the science administration. However, so-called “*Invisible Colleges*” formed through the relatively free scientific exchanges between the mobilized scientists in the *Kenkyū Tonarigumi* and others had some positive influence for the Post-war flourishing of scientific and industrial research, especially in

the field of the properties of matter based upon quantum dynamics. In addition, we must take into consideration that some Japan's industrial potentials remained not so destroyed. In spite of heavy loss and damages upon the consumer-goods industry and others by the U.S. air raids, the capacity of some industries such as the thermal power generation, the lime nitrogen production, the pulp manufacture and the iron & steel works remained not so lost. Those had been the basic conditions for the post-war economic recovery.

[to be continued]

* * *

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Notes

- 1 See, Morris Low, *Science and the Building of a New*

Japan. Palgrave-Macmillan, 2005; Morris Low ed., *Building a Modern Japan: Science, Technology, and Medicine in the Meiji Era and Beyond*. Palgrave-Macmillan, 2005; Morris Low, Shigeru Nakayama and Hitoshi Yoshioka, *Science, Technology and Society in Contemporary Japan*. Cambridge University Press.

- 2 The modern agricultural sciences was transplanted from Western countries in Meiji era (*'Nôji-shiken-jô'* i.e., the Laboratories of Agriculture were established in various places throughout Japan). However, such efforts were not so fruitful. On the other hand, the actual knowledge of *Rô-nô* (the Old Farmers) who were trained before the introduction of Western knowledge and *Nô-sho* (guidebooks for farming) published before the *Great Restoration* were still useful.
- 3 How should we understand the political essence of the Meiji Restoration? This topic was the main target in the “Great Debate on Japanese Capitalism” in 1930's. Here, in this lecture, following the view of the *Kôza-ha* (The group of historical and economic researchers who contributed to or were inspired by the *Nihon Shihonshugi Hattatsu-shi Kôza* [the *Lectures on the History of Japanese Capitalism*] in 7 volumes published by Iwanami Shoten in 1932-1933), we suppose its essence in the establishment of a unique kind of absolutism accompanied with the strong urge for modernization of the country on the basis of self-dissolution of the feudalism.
- 4 Recently, in the study of economic history of Modern Japan, more pluralistic and compound understanding of Japanese modern economy has obtained increasing support (as for such a new current, see, for example, Meiji-Ishin Gakkai ed., *Kôza: Meiji-Isin*. Vol.8: *Meiji-Ishin no Keizai Katei [A Course on the Meiji Restoration*. Vol 8, *Economic Process behind the Meiji Restoration*] Yûshi-sha, 2010; Sakane Yoshihiro and Mori Ryôji ed. *Nihon no Keizai Hatten wo Dô Toraeru ka? [How Should We Understand the Economic Growth of Japan?]* Seibun-dô, 2019). This text doesn't follow such a recent development of the study in the economic history of modern Japan sufficiently. Therefore the following parts have some limitation.