Modernization of Technology and Labor in Pre-War Japanese Electrical Machinery Enterprises

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1. Introduction

In the West, recognition of the usefulness of electricity and its widespread social applications emerged in the 1860s. Electricity was utilized for communications, illumination, electric power, and transport. For these purposes apparatus such as electrical machinery, telegraph equipment, electric light bulbs, electric motors, and electric trams was manufactured. Machinery production for the generation and transmission of electricity (generators, transformers, and installations for the distribution of electricity) was also initiated in the same period. The manufacture and utilization of electrical machinery exerted a large influence on industry, one which extended to social life in general. Moreover, in view of the sudden rise at this time of new industries like steel and chemicals, the years from the 1870s to the First World War are sometimes called the period of the "Second Industrial Revolution." In Japan, progress was characterized by an overlapping of the "First Industrial Revolution," which developed around the cotton manufacturing industry, with the "Second Industrial Revolution," which brought about the expansion of heavy industries.

The first electric machine produced in Japan was one for telegraphy. Modernization of communications was an urgent priority for the Meiji Government, which aimed at administrative and military modernization. As early as 1872 it had the well known craftsman-turned-technician, Hisashige Tanaka, produce a Henry telegraph machine. Following this, in 1873, a Manufactory was set up under the Kobusho (Public Works Ministry), and here the production and repair of telegraph equipment and machines began. Foreign engineers directed production at the Kobusho Manufactory, and many Japanese telegraph engineers were trained under their leadership. Kibataro Oki, who later founded the Meikosha, was one of these, and he made a big contribution to domestic production of telephones and switchboards.

Furthermore, the indigenous production of electric generators began in the 1880s. Shoichi Miyoshoi constructed an Edison-type
DC generator in 1885 and used it for incandescent electric lamps. Miyoshi was also a product of the Manufactory of the Public Works Ministry, and becoming independent in 1883, he began the manufacture of electrical machines and equipment. Then in 1895 the Tokyo Electric Light Company built the first Japanese centralized thermal generating station in Tokyo’s Asakusa district. The 200-kilowatt, 2,200-volt single-phase AC generator installed there was one of those built by the Ishikawajima Shipyards. The Ishikawajima yards began the production of electrical machinery after the Sino-Japanese War (1894–95) and constructed an electric machinery plant in 1896, going into full production after the employment of Kosuke Okamoto as Chief Engineer responsible for electrical technology and Hatsune Nakano, professor of the Engineering College, as adviser.1 Four of the above-mentioned 200kw electric generators were produced under their leadership. By the end of the 19th century, ships were newly outfitted with electricity even in Japan, and cases of the establishment of electrical machine shops by shipbuilding companies occurred, while the Ishikawajima Shipyards, after producing enough to satisfy its own needs for electrical equipment, also produced for outside purchasers. The single-phase AC generators built in 1896 were relatively large, but functionally they were apparently not inferior to foreign makes.

The light bulb was another electrical product that was manufactured relatively early in Japan. The one who devoted himself to this enterprise was Ichisuke Fujioka, then a professor of the Engineering College (Kobu Daigakko). In 1884, he was sent by the Public Works Ministry to the Electrical Exhibition held in Philadelphia where he observed the most recent results related to electricity. At that time he also visited the New York Electric Light Company, carefully inspected incandescent light bulbs developed by Thomas A. Edison, and observed the production process. After returning to Japan, he gave up his faculty position at the Engineering College and became Chief Engineer of the Tokyo Electric Light Company, taking part in the initial domestic production of incandescent bulbs. Cooperating with Shoichi Miyoshi, the electric machinery maker from the same town (Iwakuni, Yamaguchi Pref.), in 1890 he founded the first specialized electric light bulb manufacturing company, the Incandescent Co., Ltd. (Hakunetsu-sha) which was a subsidiary company of Tokyo Electric Light. By importing a set of production machinery from England, he began the domestic production of electric light bulbs. Japan’s first incandescent light bulbs were produced in August of the same year.
Early production of electric bulbs by the Incandescent Company, however, was on a very small scale, and the cost was inevitably high. As well, technological know-how was inadequate, and the proportion of good products quite low. About June of 1895, the Incandescent Company was marketing 8 and 16 candle bulbs at 60 sen, 24 candle bulbs at 70 sen, and bulbs over 50 candles at one yen apiece, but imported light bulbs were being bought by lighting companies at a little over half that price. Therefore, as a result of appeals from the lighting companies, the Incandescent Company was obliged to lower its delivery price, but this in turn damaged the earning power of the company. In 1896 the Incandescent Company was reorganized as a joint-stock company, but its business results were very poor, and its dividends were between five and eight percent if there were any.

But to entrepreneurs of that time, the production of electrical equipment seemed to be a field of business with a future. The Mitsui Bank bought Hisashige Tanaka's factory in 1893 and turned it into the Shibaura Manufactory. Its first general manager, Raita Fujiyama, actively sought orders for electrical equipment and pushed the factory forward as an electrical machinery maker. This process was by no means smooth, and orders for electrical equipment were slow to increase. Because the business suffered continual losses, the factory was obliged to combine with it the production of other machinery (steam engines and boilers, earthquake-proof smokestacks, railroad bridge beams, etc.). It was not until the latter part of 1900 that the factory managed to change its type of work, getting out of the red and gaining profits with such main products in electrical goods as generators, electric motors, equipment for electric railways and transformers. Because its business situation was gradually improved, in 1904 the Manufactory was reorganized as a joint stock company with a capital of 1 million yen. Its largest stockholders were eminent members of the Mitsui family, and it can be said to have been a direct affiliate of the Mitsui zaibatsu.²

In this way, at the beginning of the 20th century, several competent enterprises appeared in the Japanese electrical machinery industry, and with them at the center, various kinds of electrical equipment were produced. The development of industry occurs as the result of the accumulation of technological skills and labor power in individual enterprises and the competition between them. In the case of the electrical machinery industry, that sort of situation was created in Japan at the beginning of the 20th century. Below, I would like to clarify the position which Japanese enterprises producing electrical
machinery had reached before the Second World War by discussing the state of acquisition and accumulation of technological know-how and labor power.

2. The Acquisition and Accumulation of Modern Technology

(1) The Process of Technological Accumulation in Enterprises with Foreign Capital Tie-ups

At the beginning of the 20th century, the Japanese electrical machinery industry stood at an important turning point. The modernization of Japanese society was promoting electrification in many fields, expanding the national market for electrical machinery and increasing the potential for progress in the electrical machinery industry, but at the same time, also promoting the import of foreign makes which obstructed the development of the indigenous electrical machinery industry. Generally speaking, because products imported from other countries were superior in quality to indigenous products, as well as being lower in price, Japanese enterprises producing electrical equipment were subjected to intense competition from foreign makes in the national market.

At the same time, from the end of the 19th century through the beginning of the 20th, as a general phenomenon, electrical machinery was undergoing rapid technological development. Telephones, invented by Alexander Graham Bell in 1876, at first performed poorly and were unsuitable for general use, but with the subsequent modifications by Thomas Edison and others, their use spread rapidly. And with the improvement of switchboard equipment, telephone networks were constructed as a means of communication within cities and between them. In the field of electric light bulbs, in place of bamboo or cotton filaments, metal filaments came into use, and finally the age of the tungsten light bulb emerged.3 Even in Japan the field of electrical generating equipment grew larger, high-voltage long-distance power transmission came into use, and large-capacity generators, powerful transformers and various kinds of auxiliary equipment were first produced. As a means of transportation, electric trolley cars made their appearance, and as traction engines, electrical locomotives gradually replaced steam locomotives. In the field of prime movers as well, electrification proceeded, and large and small electric motors were produced in great numbers. In the nation’s households as well, waves of electrification surged forward, and electricity-consuming equipment like electric fans, refrigerators and vacuum cleaners even-
ually came into use, along with the rapid dissemination of radios.

The 20th century spawned a veritable "Age of Electricity," and gave birth to many kinds of electrical machinery. Amid such diversification of electrical equipment and its rapid technical advance, Japanese enterprises were able to confront the competitive force of foreign products in terms of quality and price solely by developing the ability to create new products through strengthening and perfecting the power of Japanese capital and technology and by establishing a system of mass production as the result of technological improvement. But soon after its creation, great difficulties were foreseen for this Japanese industry in consolidating such conditions over the short term by its own efforts. In such a situation, some Japanese enterprises sought to create the right conditions by tying up with foreign enterprises.

The world was entering the age of international exchange of capital and technology. In fact, in this period, there were those among the electrical machinery enterprises of Europe and America whose attention was drawn to Japan as the newly industrializing country of the Far East, and who planned the export of capital to this country. For example, the prominent U.S. telephone maker, Western Electric Company, sent its Foreign Department Manager, H.B. Thayer, to Japan in 1896. Western Electric succeeded in selling telephones on the occasion of the Japanese Government's First Telephone Expansion Program. Thayer's purpose in coming to Japan, as well as the arrangement for their delivery, was to examine the possibilities of Japan as a future market for telephones and to sound out the potential for investment of capital. Thayer returned home the following year and reported to his head office that there were bright prospects.

Western Electric planned to establish itself in Japan by forming a joint venture, and as a tie-up partner first chose Kibataro Oki. But these negotiations eventually failed, and as a result Western Electric made Kunihiko Iwadare, who had performed the role of intermediary in negotiations with Oki, their tie-up partner and thus achieved entry into Japan. This was the beginning of Nippon Electric Company, Ltd. (NEC), in 1899. The company was formed with investment of capital by Western Electric in Japan Electric, Ltd., established by Iwadare and others. At its inception, the company's capital was 200,000 yen, and the initial Western Electric holding was 216 of the 400 shares, or 54%. Nippon Electric was the first joint venture with foreign capital in Japan, and it can be said that the fact that the enterprise was an electrical equipment maker was a reflection of the era.

Subsequently, in the field of electric light bulb production too, a
joint venture with foreign capital made its appearance. This was the joint venture formed with capital investment by the integrated American electrical equipment manufacturer, General Electric Company, in Tokyo Electric Co. Ltd. in 1905. The limited partnership Incandescent Company (Hakunetsu Sha) founded by Ichisuke Fujioka and others had been reorganized in 1896 into Tokyo Incandescent Electric Light Bulb Manufacturing Ltd. and changed its name again to the Tokyo Electric Co. Ltd. in 1899. At that time, its capital was 150,000 yen. The intense competition with imported light bulbs, however, continued, and business results showed no turn for the better. The Company, therefore, at its Board of Directors meeting in February of 1904, decided to increase capital by raising 100,000 yen, that is 2000 shares in the form of preferred shares, in order to redeem our obligations, hand, appealing for the cooperation of shareholders, exerted efforts to find new investors. But raising capital in Japan was not successful, so the management group eventually decided to form a joint capital venture with General Electric Company. In 1905, Tokyo Electric increased its capital by 250,000 yen to 400,000 yen, and because 204,000 yen of this increase was allotted to General Electric, that company became the holder of the majority share in Tokyo Electric. The investment in Tokyo Electric was GE's first industrial investment in the Far East. This joint endeavor, moreover, was accompanied by a contract for technological assistance from General Electric to Tokyo Electric, and as the result of this assistance from GE, Tokyo Electric's light bulb production technology was rapidly modernized.

After this, in May, 1910, another venture joining a Japanese company with General Electric made its appearance. This was the heavy electrical machinery maker, the Shibaura Manufactory. As noted previously, the predecessor of the Shibaura Manufactory was the Hisashige Tanaka plant, which after coming under the umbrella of the Mitsui Bank in 1883 had followed the path of a specialized electrical machinery maker. This plant was a pioneer among the electrical equipment makers of Japan, but even such a leader-enterprise, in view of the ever-advancing development of electrical equipment technology, was faced with the necessity of forming a technological liaison with General Electric. The Shibaura Manufactory's Managing Director, Jugoro Otaguro, explained the true nature of the tie-up between his company and General Electric in a magazine article as follows:
In Japan as well, the technology for making machines has progressed enormously. People are being sent abroad, and talented men rise continually in this field, but if the situation is compared with that in Europe and America, there is no way we can compete with them yet. The present situation is such that no matter how much we progress, the rate of their progress is that much faster. That is to say, on their side, as well as having the advantages of scale and well developed equipment, their research resources and opportunities are more numerous. These are the most important factors which our entrepreneurs must consider.

According to The 65-Year History of the Shibaura Manufactory (1940), the groundwork for the tie-up between the Manufactory and General Electric had already been laid in 1896, but concrete negotiations were not begun until 1907, and a contract was not actually signed until November 1909. Thus, in 1910, the capital was increased to 2 million yen and about one-quarter of the shares were allocated to General Electric and investors connected with it. At the same time, it was arranged that the Shibaura Manufactory would receive technological assistance from General Electric in the production of electrical machinery.

The greatest benefits in tie-ups with foreign enterprises were the introduction of machinery and plants from the tie-up partner and the rapid raising of technological levels by the acquisition of technological know-how in various fields, as well as the attainment of an advantageous position in competition between enterprises by modernizing their production systems. The process of acquiring new technology was made safe, new products were turned out reliably and productivity could be raised smoothly.

For example, at Nippon Electric, the equipment used at its inauguration had been bought from the factory of Miyoshi Electric which had reached an impasse due to equipment which was too old-fashioned to produce delicate instruments like telephones. After the tie-up, however, the construction of a new factory was begun in 1900. Western Electric's secondhand machinery was installed in this factory, but at the time these machines were the most up-to-date in Japan. Then a master mechanic was dispatched from Western Electric who supervised the process and production methods, tools, etc., with all products manufactured to W.E.'s specifications. About 1907, electric power was introduced, and the machines could be located according to their function. Moreover, blueprints for new products were sent regularly.
from Western Electric and the production processes were reorganized by using them.

At Tokyo Electric, after the tie-up with General Electric, a system aimed at self-sufficiency in electric light bulbs was established. Encountering favorable circumstances after the Russo-Japanese War (1904–1905), the company drew up a plan to increase production to 4000 units per day. All the necessary plant and equipment was ordered from General Electric. In reality, the actual daily production in the first half of 1906 did not reach 4000, averaging only 2500 bulbs, but even so the output was twice what it had been and the benefits of cost reduction were large. Then, in October of 1906, capitalization was increased to 1,600,000 yen at a single stroke and a plan devised to raise the level of self-sufficiency in raw materials and related parts. Previously, there had been deficiencies in the capacity to produce carbon filaments and metal caps, and the shortages had been made up by imports from General Electric, but as a result of the rise in import duties due to promulgation of the Emergency Special Tariff Act in 1904, imported parts became expensive, raising the production cost of light bulbs. Consequently, production machinery with an output capacity of 10,000 carbon filaments per day and a set of metal cap fabricating machinery were imported from General Electric and installed, while self-sufficiency in raw materials was achieved. Thus, light bulbs produced by Tokyo Electric were marketed after October 1906 under the Edison trademark, and the brand impact was so strengthened that their acceptability was raised in the national market.

Concerning the results of the technological assistance agreement with General Electric at the Shibaura Manufactory, the aforementioned *65-Year History of the Shibaura Manufactory* has this to say:

After this agreement had been made, as the first step in the immediate introduction of their technology to our factory, many key personnel dealing with design and production were sent to our counterpart in April 1910, to study their technology and visit their factories, so that we learned a great deal. Afterward we frequently sent trainees to them and occasionally dispatched employees to observe their work in order to maintain technological links.7

In that way, enterprises tied up with foreign enterprises, while receiving the benefits of technological know-how and guidance in modernization as well as plant and equipment from their foreign partners, raised the technological level of electrical machinery production. At that time machinery, which in other countries was second-
hand, was brand new to Japan, and the integrated production system of large American companies (vertical integration) was a novel production method in Japan. Along with the adoption of such new production methods, the frequent dispatch of personnel to the tie-up partner apprised those who led production activities of the state of modern production of electrical machinery, and this was very effective in raising their competence. Generally speaking, the import of plant and equipment from leading industrial countries and the dispatch of technical and supervisory personnel to Europe and America was an effective way of acquiring and nurturing technology for Japanese enterprises. And when enterprises linked to foreign enterprises might make use of such means, they were put in a very favorable position.

(2) The Process of Technological Accumulation in Enterprises Practicing “Self-Reliance in Technology.”

Within Japan during this period, however, there were enterprises which, in the rapid development and progress of electrical machinery technology from the end of the 19th century into the early part of the 20th, without relying on technical tie-ups with specific foreign enterprises, gathered business resources from within and outside the country and developed their own products which could compete with foreign products, managing to continue and develop their businesses. And their numbers were certainly not small. What made the existence of such enterprises possible was the demand for a great variety of electrical equipment in the country and the high growth rate of the market for it. And among such enterprises there were managers and companies which fostered a strong sense of rivalry in the competition with foreign enterprises and companies tied to foreign capital, and deliberately advocated “self-reliance in technology.” As representative of this kind of entrepreneur in the Meiji and Taisho periods (1868–1926), we can cite Kibataro Oki of Oki Electric and Namihei Odaira of Hitachi Engineering Works. As people who pushed the Japanese electrical machinery industry forward, their names are far more famous in Japan than those of the managers of enterprises with foreign ties.

Kibataro Oki was born in Hiroshima Prefecture in 1848. As a young man, he learned the craft of the silversmith, but at the age of 27 he moved to Tokyo and entered the Manufactory of the Public Works Ministry as an underworker. Shortly after that he was promoted to the rank of Junior Engineer (gishu), and in 1878 joined the team making Bell telephones at the Manufactory, enjoying the opportunity
to become familiar with the mechanisms of the latest communication equipment. Believing in the future of equipment using electricity, he left government service and founded Meikosha in 1881. At this plant, along with telegraph and telephone instruments, medical appliances which were just coming into use were produced and orders from customers filled.

The greatest demand for telegraph equipment was for military field telegraphs. Meikosha succeeded in copying German models; because these worked effectively, they were accepted by the army, and the Company succeeded in getting large orders for them. With telephones as well, the progress from direct lines linking two points to lines between multiple points was made possible in the 1890s by the use of exchanges, and as a result the demand for telephones increased rapidly. In addition, Meikosha, apart from the previously mentioned medical apparatus, made a variety of electrical equipment such as electric buzzers, lighting conductors, incandescent lights, arc lamps, galvanometers, resistance meters and batteries. Kibataro Oki renamed Meikosha in 1889, calling it the Oki Electrical Machinery Plant. Building a modern factory at Kyobashi in Tokyo in 1894, he began mass-production of electrical equipment, giving priority to telegraph and telephone equipment.

Then, as mentioned above, Western Electric tried to form a tie-up with Oki Electrical Machinery in 1898, but when that failed, the joint enterprise Nippon Electric was formed the next year. After that, Oki Electrical Machinery and Nippon Electric engaged in intensive competition in producing and marketing telephones and exchange equipment. Kibataro Oki nourished a sense of rivalry with Nippon Electric, and taking a stand in favor of indigenous products, worked to prevent the import of foreign products. Nippon Electric responded to this, and on the occasion of tenders from the Communications Ministry for telephones and switchboards, the two companies made ever-lower bids. For instance, a 55-yen Solid-Back Magnetic Telephone quickly dropped to the 20-yen level, and a bid of less than half the original price was said to have been proffered for a switchboard. Oki Electrical Machinery was the only purely Japanese telephone and switchboard maker at the time, and as a result of Kibataro Oki’s entrepreneurial skill, the Company maintained a high level of capability in technological development and production, so that it was able to compete on an even footing with Western Electric and Nippon Electric.8

The other Japan-centered entrepreneur, Namihei Odaira, was born
in Tochigi Prefecture in 1874. After graduating from the Electrical Engineering course of Tokyo Imperial University in 1900, he joined the partnership firm, Fujita-gumi, and worked at the Kosaka Mine as chief electrical engineer. His main work at the Kosaka Mine was the hydroelectric system, but this work included everything from design to construction of spillways, transformer substations, generating stations, electric railways, electric lighting facilities, etc. After this he changed employers, moving to the Hiroshima Hydroelectric Company and the Tokyo Electric Light Company, and with the latter participated in building the Komabashi Power Station on the Katsura River. The output of this power station was 15,000 kilowatts, and it was designed to deliver 55,000 volts of electricity to the Waseda Transformer Station in Tokyo, a distance of 80 kilometers. The construction of the generator plant for generation and transmission of such large output and high voltage required the importing of components from abroad and guidance from foreign engineers.

Odaira keenly regretted this reliance on electrical equipment and technology from Europe and America. He had consistently favored the domestic production of electrical machinery, and on this occasion his desire for domestic capability was reinforced. In 1906, Odaira was approached by a newly rising entrepreneur of the day, Fusanosuke Kuhara, and joined his company as an engineer at the Hitachi Mines of Kuraha Mining. Kuhara is reported to have said at the time, “I want to make use of your talents in all the electrical work necessary for the development of the mines.” Accordingly, the electrical machinery repair shops set up at the Hitachi Mines, although intended for the repair of equipment used in the mines, also contributed to the realization of Odaira’s vision concerning the domestication of electrical machinery production.9

In reality, the repair of machinery was the first step toward the manufacture of machinery. At the time, the electric motors at the Hitachi Mines were almost all made in the United States, but the way in which machines were used at the mines was extremely rough, and within less than a year many of them were scorched black. The nominal repairs that had to be made were so total that the work was not much different from building them again from scratch. For example, while repairing electric motors, methods of manufacture and so on were studied, and acquired with confidence. In 1910 “steel sheet presses were bought from England, and with all of the design and working drawings being done themselves, three 5 HP electric motors” were built.10 These motors were used at the Hitachi Mines.
At that time, the general situation was that large-capacity, high-voltage electrical machinery and equipment depended mainly on imports, while small-capacity, low-voltage units were usually ordered from Japanese manufacturing plants. The products of the Hitachi Engineering Works were predominantly of small capacity and low voltage at first, but Odaira purposefully assembled young engineers graduating from the universities and formed a technological coterie, so that the propensity to develop new products at the Works grew stronger. For example, receiving an order in 1911 from the Hitachi Mines for a 275 HP 3600 rpm electric motor for ventilation, they produced it, and this was one of the largest electric motors made in Japan at that time. Even at Hitachi, "because it turned at high speed, its manufacture was very difficult," but it was completed in August of the next year and delivered. This electric motor was baptized at the Hitachi Engineering Works as Product No. 1, and was worthy of commemoration.

Enterprises promoting "the domestication of technology," of which the Hitachi Engineering Works was foremost, were most conspicuously active in the period of the First World War (1914–18). Because the import of various kinds of electrical equipment for which foreign countries had been relied on in the past was stopped during this period, orders poured into Japanese companies, and the domestic production of large-capacity, high-voltage electrical equipment proceeded rapidly. At the Hitachi Engineering Works, generators of a capacity up to 6000 KVA were produced, and in electric motors, as well as units of large capacity, high-speed units like the 3600 rpm motor were turned out. Transformers of the 66,000 and 77,000 V class with capacities of several thousand KVA were delivered to a chemical fertilizer company and others. In 1916, the company was called upon by the Electrical Testing Station of the Ministry of Communications to make a 350,000 V experimental transformer, and at the end of the following year, after much effort, it was completed. Such new products "were all designed either by following materials in books or magazines, or by sketching the external appearance of models imported from abroad."11

Taking the opportunity afforded by this cessation of imported foreign makes, Japanese enterprises manufacturing electrical machinery expanded the range of their products and raised their technological levels. Their technological standards, however, did not immediately reach those of Europe and the United States. Concerning the technological level at the Hitachi Engineering Works in this period, the
company history says that "looking at the quality of the products, it cannot be disputed that there were many deficiencies such as inadequacy of design, lack of skill in production, mismatches of raw materials, and as a result, delays in production deadlines." For example, the above-mentioned 350,000 V experimental transformer delivered to the Electrical Testing Station of the Communications Ministry underwent its formal test for acceptance in June of 1917, but it could not attain the required capacity, and only after many more attempts did it finally come up to the standard in November of that year.

Japanese enterprises manufacturing electrical equipment, whether those with foreign capital tie-ups or those practicing "technological nationalism," were alike in using the method of raising technological levels by importing plant and equipment and recruiting and training capable men. But in the matter of strengthening their ability to develop technology, the latter were obliged to exert greater efforts than the former. The enterprises following the principle of domestic generation of technology, in the final analysis, were obliged to compete with imports and the products of companies affiliated with foreign enterprise by improving the quality of their own products and reducing their costs by nurturing their own ability to develop technology. At the Hitachi Engineering Works, in order to improve their capabilities in technology and production, a Research Section was set up in 1918 and was given "in conjunction with research, the responsibility of solving the urgent problem of ensuring the continuing improvement of products." Accordingly, the Research Section repeatedly negotiated with the Design Department and worked for the improvement of technology and products. For instance, tests concerning the rating of fuses, experiments with commutation in direct current dynamos, testing of electric fans, and copper wire testing were entrusted to them and carried out. Without such trials and research, there could have been no improvement in the quality of domestically produced electrical equipment nor any reduction in costs. Or to put it another way, the indigenous enterprises which benefited from these trials and research thus established the conditions under which they could compete with companies affiliated with foreign enterprises.

The production systems of enterprises advocating "technological nationalism," however, were by no means perfect. For example, Oki & Co. (Oki Electrical Machinery's name after 1896) produced a common battery-type switchboard as its most advanced model in 1907 and delivered it to the Ministry of Communications, but it was reported that, "the main components were all assembled from im-
ported parts.” And even at the Hitachi Engineering Works, during the First World War, large orders were received, but it was recorded that there was “a tendency for production to be upset by delays in the delivery of castings and copper materials from outside as the supply of raw materials was interrupted.” These “technological nationalistic” enterprises were enthusiastic about the development of new products to compete with the imports and the products of companies with foreign affiliations, but in the acquisition of raw materials and parts to produce them rationally and efficiently, they had not yet established an adequate system.

3. The Formation and Growth of the Working Strata and the Modernization of Factory Management

(1) The Origins of Workers and Their Technical Training

Because the modern electrical machinery industry was entirely foreign to Japan, the skills necessary to produce electrical goods had somehow to be taught to the operatives. There were instances of enterprises teaching the workers they employed directly, and other cases where men who had been employed by an enterprise and acquired those skills themselves hired a coterie of apprentices and taught them the skills. The latter method is hard to envision nowadays, but in the Meiji and Taisho periods it was often used. By this method, apprentices were trained, and skilled workers (oyakata) with a number of workers under them were employed by enterprises. Under the two-layered employment system whereby those employed directly by the enterprise were also employers of subordinates, the system by means of which part of the production activities of the enterprise was divided up, known as the oyakata seido (gang boss system), was used in several Japanese industries before the War. In the electrical machinery industry, too, this system was utilized by some enterprises actively. I will cover the actual composition of the oyakata seido in enterprises producing electrical equipment in the next section, but here I would like to explain the origins of technically-skilled workers in the electrical machinery industry.

Concerning the ways in which enterprises developed workers skilled in electrical machinery, an engineer at a certain electrical equipment factory states as follows in the Shokko Jijo (Factory Workers’ Conditions):

As Japanese industry has only a short history, it has been very difficult to obtain skilled and competent workers. Skilled workers,
moreover, being proud of their skills, often have the bad habit of laziness. In particular, within the production of electrical machinery begun in recent years, coil-winding work is not like other jobs, and in such new tasks workers from other fields cannot be used easily. As a result, much difficulty has been encountered in the training of workers for the new jobs, and in the attempt to train educated ones, we tried to hire students facing financial difficulties who wanted to become workers, but there was not one in ten who succeeded and the program ended in almost complete failure. They found en route that they couldn’t endure the work, and when their strength would not stand up to it, they quit because their perseverance was limited. Sons of iron-casters and carpenters were slow in comprehending and took a great deal of time, but many succeeded.16

From such records, we can discern that one group of workers in electrical machinery making in Japan was newly formed from the offspring of those in other trades like casters and carpenters who received their training at their own enterprises. With the expansion of electrical machinery manufacturing, each enterprise came to train operatives in specialized technical areas on the shop floor in an organized way. For example, concerning the beginning of technical training at the Shibaura Manufactory, the 65-Year History of the Shibaura Manufactory has this to say:

In particular, in operations at our plant, work such as that related to winding coils differs from operations at most mechanized factories, and the work is quite unique in its production methods, so we cannot acquire skilled workers in this field from other plants. Therefore, at our company, there is no way to proceed except by training laymen in these operations. At first, while layman operatives helped with the work, they were made to learn it gradually. But as the factory was expanded, it became necessary to train them systematically. Finally in 1913 an Operatives Training Center was set up in the Coil-Winding Factory, and coil-winding methods were taught to newly employed male operatives.17

In 1915, a Training Section was established in the Engineering Department, absorbing the Operatives Training Center of the Coil-Winding Factory. And this was the first section to take charge of skill development at the Shibaura Manufactory. At the same company, in the same year, female workers were employed and trained in wire insulation work, and after completing their training were put to work
as operatives. This was the first use of female workers at the Shibaura Manufactory, but after this the number of female workers increased and they were used for a wider range of jobs.

Workers in the electrical machinery industry, however, were not only in work categories like coil-winding peculiar to electrical equipment making. Because electrical machines are basically machines, workers participating in machine manufacture, the so-called tekko (metal-workers, mechanics, machinists), were hired in considerable numbers. Among these were those in occupations such as forge-men (smiths), bending workers, foundry-men (casters), lathe-men, fabricators, finishers, wood-workers and painters. From among these, lathe-men, fabricators and finishers were in occupations that had not previously existed, so a new strata of workers was formed by those obtaining these skills after the Industrial Revolution. In contrast, smiths, bending workers, founders, wood-workers and painters made up a strata based on craft-like skills from the period before the appearance of modern industry. Forge-men were originally blacksmiths; bending workers had been copper potters; founders, metal-casters; wood-workers, carpenters; and painters, craftsman painters. But as social strata they were all newly formed workers in the wake of industrialization.

When these tekko were to be newly trained, the apprenticeship system was brought into play. This was a system which, employing young men as apprentices, instructed them in skills by man-to-man methods for fostering skills which had been widely practised before the advent of modern society. Tekko was an occupational category from the period after the Industrial Revolution, but their skills were at first nurtured by the apprentice system.

The above-mentioned Shokko Jijo points out that there were two kinds of apprenticeship systems for tekko at the turn of the century.18 The first type was for "apprentices who were directly recruited by the factory and had no special master-follower relationship with a designated skilled worker, but while assisting the workers in the factory received their instruction and practised their occupation." In this case, the enterprise rarely designated a particular skilled worker to train the apprentice. The second type was for an apprentice "who had a master-follower relationship with a particular skilled worker before coming to the factory, and who was hired by the factory as an assistant to this worker." In this case, the apprentice usually lived in the house of this worker, his oyabun (boss).

Apprentices in either case were "usually between 14 or 15 years of
age and 20,” but with regard to wages, could be paid or unpaid. When they received wages, “the first kind of apprentice was paid his wages, if any, directly by the factory, but for the second kind of apprentice, the oyabun first received them and afterward passed them on to the apprentice. Because this kind of apprentice usually lived in the boss’s house and was given his food and clothes by the boss, the latter deducted the cost of these things from the wages received for the apprentice, and paid the remainder to the apprentice.” Apprentices were usually assistant workers, and in matters of wages did not receive the consideration due a grown man. Furthermore, the second kind of apprentice was bound to the master in an even more inferior position.

But there were problems in the first kind of apprenticeship system as well. At the time, there was a tendency for this kind of apprentice to increase in number, but in most cases they were not given special masters. And even when they were, they were not given adequate instruction, and were not trained effectively under the purported apprenticeship system. So the apprentices who did master the techniques to some extent and became able to do the work anyhow, then found that rather than staying on as an apprentice in that factory, they could work as an artisan at another factory for a larger wage. As a result, a situation arose in which no few “apprentices, without finishing their term, freely moved to other factories and became so-called watari-shokko (migrant journeymen).”

These watari shokko, in the period of the rise of the Japanese machine industry, having no specific boss (oyakata) and wandering from factory to factory, were veritable “stray sheep.” In this case “sheep” did not imply “gentleness;” originally they were aggressive. Because at the time the recruitment of workers “usually depended on introductions by current workers or advertising on billboards, etc.,” opportunities were not scarce for watari shokko to be hired by the companies. And because among skilled workers there was a custom to move from factory to factory, honing their skills, the “adherence rate” was generally low (i.e. the turnover rate was high). The company side, however, gradually reformedit the apprenticeship system and improved skill development, decreasing the opportunities for skilled workers to become watari shokko. After the 1910s, large enterprises in Japan adopted the “in-plant apprentice” system. And because this system got rid of the dependence on the old watari shokko and made it possible to nurture essential workers within the company, in due course it became the mainstay of the Japanese skill-developing
system.19

(2) The Modernization of Plant Management: The Decline of the Oyakata System

In the Japanese electrical machinery industry, from the end of the 19th century into the early 20th, the above-mentioned oyakata seido (gang-boss system) was in operation, and there were enterprises which implemented a system of production based on the guidance and supervision of oyakata. For example, at Nippon Electric, in the ten or so years from 1899 to about 1910, a system called "kumi-uketori" (group contract system) was used, and this was one type of oyakata seido. Under this system, various work such as the production of parts and assembly of machines was contracted out to designated oyakata. For instance, the boss of the wood-working shop contracted for telephone boxes, the brass-founder oyakata for mouthpieces, and so on. The oyakata who had a contract with the company would then choose the artisans or workers necessary for the job and hire them, putting them to work in the Company's factory.20

By using this oyakata seido, the Company was able to avoid the responsibility of directly hiring all the workers necessary for the manufacture of electrical equipment, training them, and posting and directing them. And because the appraisal of each man's work and payment of their wages was left to the oyakata, the company did not find it necessary to handle personnel or labor management for all of the employees. The Company signed a contract with the oyakata and paid the contract price in exchange for the goods, so that all that was required was consignment of the products. In the development of business management, however, this oyakata seido gradually revealed some disadvantages, and its abolition became necessary.

The greatest problem of the oyakata seido was that it could not keep pace with the progress of production. For example, in conjunction with changes in demand and progress of technology, the Company promoted the development of new products, but this led to diversification of the types of machines made in the factory and complications in the production process. But since the oyakata bosses had signed separate contracts with the Company, they did not make any attempt to communicate among themselves. Therefore, disruptions and delays in production occurred.

Problems arose not only in the management of production, but also in labor management. Along with product diversification and technological progress, the production process became complicated,
and new tasks multiplied, but the oyakata could not uniformly evaluate the work of the artisans or operatives by communicating with each other and decide on suitable wages for each job. The wages for different workers became unbalanced, and because in addition the oyakata, bosses tried to keep wages of their workers low in general, the dissatisfaction of the workers grew, and sometimes developed into fierce conflicts.

Due to that situation, the Company embarked on a reform of the system. The Company placed secretaries hired directly under the oyakata, and had them arrange the records of workers' tasks and accurately calculate the remuneration for each worker. Next, the Company took over the payment of wages directly to the workers based on these calculations. Previously, the oyakata had calculated the wages for their workers and made the payments, but now the Company acted as proxy in this responsibility. Work contracts between the Company and oyakata continued, but the wages paid by the Company to the workers were deducted from the contract price.

Then Output and Inspection sections were set up, and production control and inspection functions were taken over by the Company. In the factory, the sphere of control of the oyakata gradually diminished, while the sphere of direct production control and labor management by the Company grew larger. In 1910, Nippon Electric did away with the traditional oyakata seido, and began to produce electrical equipment under a system of direct supervision by the Company. The earlier shokunin (artisans) became known as shokko (operatives, factory hands), and stood in a relationship of direct employment by the Company. The oyakata lost their former authority to hire, put to work, pay wages, fire and supervise production of the workers, and became responsible for guidance and supervision of workers in restricted aspects of each function. The new title of gocho (foreman) was given to the oyakata. Thus the business structure of top management, office, technical department and factory, and the modern factory management system of factory director, division head, department chief, section chief and foreman were created. (Figure 1) In 1910, when the oyakata seido was abolished, the number of employees at Nippon Electric was 106 white collar and 584 blue collar workers, or 690 altogether.

The dissolution of the oyakata seido at Nippon Electric, however, was relatively early in Japan. At another company, which like Nippon Electric was producing telephones and switchboards, Oki Electric (in 1912 Oki Electric Co. Ltd. was established, and in 1917 merged with
Oki and Co.), this kind of contracting system was carried on until the latter half of the 1920s. At Oki, this production system was called the *renge ukeoi-sei* (joint-contract system).21

The essential feature of this system was the payment of a prescribed daily wage when those working on the floor did not have a contract, but when there was a contract, without using the daily wage system the *kumi-cho* (*oyakata*) made a production contract with the Company and received payment of the relevant contracted wages in a lump sum, distributing them to the workers according to their output. In the manufacture of electrical equipment, specialized processes such as founding, turning, forging and painting are necessary, and for these operations, skilled artisans were present at Oki Electric and took charge of supervising each work. In those days, the skills required for each of these operations were taught in an apprentice-like system, and at the top was a *kumi-cho* who directed the operatives under him. When the Company produced a new kind of machine, it let out new contracts to the *oyakata*, drawing on their skills, and by utilizing the old personal relationship between *oyakata* and *totei* (gang boss and apprentice or underling), it tried to reduce the production time, ensure good quality, and minimize costs. In the *Oki Denki Hyaku-
nen no Ayumi (The 100-Year History of Oki Electric), this feature is described as follows:

When a complicated drawing was delivered and a contract made for production, the craftsmanship of the artisans would solve its complexities. Because craftsman-like skills were evaluated in terms of the contract wages, their indomitable spirit (high morale) was aroused. Their satisfaction and pride in being able to produce goods not inferior to foreign products using a single drawing was rewarded. This accumulation of specialized skills was Oki Electric’s strength and without doubt was an element in preserving the stronghold of Japanese indigenous technology.22

This production system, however, was essentially one of genba makase (laissez-faire, leaving it up to those on the shop floor), and there were problems in the raising of overall factory output. This was because, if even one group’s production of parts was late, a machine could not be completed, and if tolerances of parts were exceeded, the unit could not be completed satisfactorily. At Oki Electric, in the latter half of the 1910s, skilled men graduated from the Training Center for Communications Officials, and engineers who graduated from the colleges and higher technical schools were hired on a fixed-term basis, and the situation in the workshops in which “old skilled masters” trained under the earlier apprentice system were at the helm was gradually changing. In particular, engineers from the colleges argued that production methods should be modernized by making design drawings more sophisticated and by modifying jigs and tools. This trend toward modernization was realized when Oki Electric signed a technical agreement with the British General Electric Company in 1926 and began the indigenous production of automatic switchboards.23

Oki Electric constructed a factory to specialize in the production of automatic switchboards in Shibaura, Tokyo, in 1927, and here it adopted the modern production system used in England, giving up joint-contract system methods. At this factory, not bound by previous customs, operatives with knowledge and skills based on scientific principles were gathered, the old occupational system was not used internally, and automatic switchboards were produced under the leadership of Japanese engineers who had been sent to England and English engineers who had come to Japan. After this, at Oki Electric this kind of modern system of production management was adopted at other plants, and the “genba makase” production system gradually
disappeared.

4. Concluding Remarks

The process of modernization of plant management has been examined in terms of the breakdown of the oyakata and sub-contracting systems at Nippon Electric and Oki Electric and their replacement by scientific and systematic methods of production control, and as we can gather from these examples, from about 1910 into the 1920s, in order to keep up with increasing output and the manufacture of new products, the former oyakata-style production methods were done away with and those based on a new system of supervision by the companies themselves were put into practice. In order to increasingly produce technically-sophisticated electrical equipment efficiently, and in order to realize better quality, rather than genba makase (leaving it up to those on the shop floor), direction by supervisors and engineers with scientific knowledge and techniques became indispensable. This modernization was begun by Nippon Electric, an enterprise tied to foreign concerns, and soon spread to others. In the Japanese electrical machinery industry, along with the accumulation of technological know-how and labor power, there was also a change in organization (the supervision system) to a more functional one.

Because heavy electrical machinery was ordered in separate units and was not amenable to mass production, however, in this sector even after the 1930s skilled workers in production shops had to be relied on for their technological know-how. The accumulation of technological know-how, labor power and the modernization of production methods went hand in hand, and in the manufacture of electrical equipment, this progress did not come about at one time or in one place only.

Notes

2. The first President of the Board, Morinosuke Mitsui, was head of one of the 11 Houses of Mitsui.
3. Drawn tungsten filaments were developed by W. Coolidge of General Electric in 1910, making the production of low-cost tungsten light bulbs possible. In Japan, too, under the technical
guidance of G.E., conversion was made from pressed to drawn wire filaments.

4. Concerning the manner of W.E.'s entry to Japan, see *Nippon Denki KK Nanaju-nen Shi* (The 70-Year History of Nippon Electric Co. Ltd.), 1972, p. 24ff. Material in this article concerning Nippon Electric comes in great part from this source.

5. The capital tie-up of Tokyo Electric with General Electric was completed quickly because Ichisuke Fujioka, one of the founders, and G.E.'s current representative in Japan, J.R. Geary, knew each other well. *Tokyo Denki KK Goju-nen Shi* (The 50-Year History of Tokyo Electric), 1940, p. 97. Information in this article concerning Tokyo Electric owes much to this source.


7. *Shibaura Seisaku-sho Rokuju-nen Shi* (The 65-Year History of Shibaura Manufactory), 1940, p. 55. The material concerning the Manufactory in this article comes largely from this work.

8. Japanese makers, however, were always in the shadow of the top companies of Europe and North America in product development. If we single out telephone switchboards, common battery-type boards were initially from the Western Electric Company of the United States. Oki and Company produced supplementary switchboards of this kind and supplied them to the Communications Ministry.


10. Ibid., p. 12.
11. Ibid., p. 29.
12. Ibid., p. 21.
13. Ibid., p. 28.
15. *Hitachi Seisaku-sho Shi 1*, p. 20.
16. *Shokko Jijo* was the report on an investigation concerning *shokko* (factory workers) in various sectors of industry by the Ministry of Agriculture and Commerce, printed in 1903. Here, the three volumes of *Shokko Jijo* edited by Takao Tsuchiya and published by the Seikatsu-sha in 1947 are used. The comments quoted are from Vol. 3, pp. 267–8.


18. The following information is derived from the above-mentioned version of *Shokko Jijo* edited by Tsuchiya, Vol. 2, p. 36ff.


21. For more details concerning the following, see ibid., p. 18ff.


23. As the technology was advancing, enterprises practicing “technological nationalism” were also obliged to introduce technology from foreign countries for new, high-quality products. This, however, meant the purchase of new technology without any accompanying capital tie-ups.

Translated by Donald W. Burton