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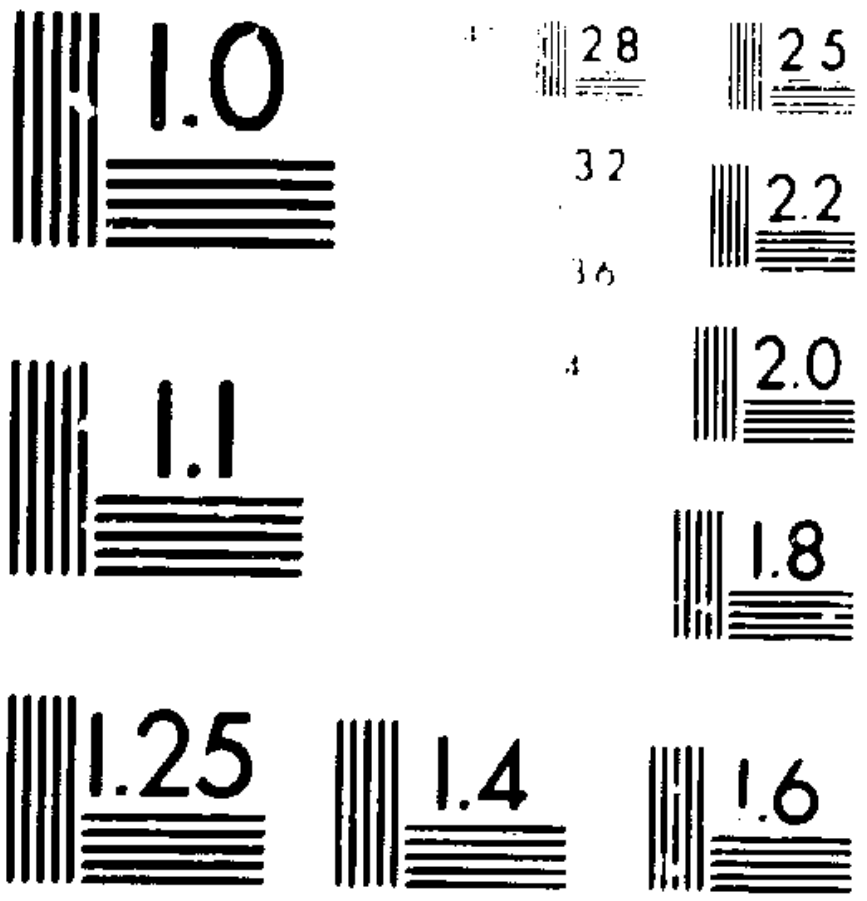

13299

Distr.
LIMITED

ID/WG.410/1
29 November 1983

ENGLISH

United Nations Industrial Development Organization

National Workshop on Technology
Transfer Policies and Planning

Kuala Lumpur, Malaysia, 12 - 14 December 1983

JAPANESE EXPERIENCE IN ELECTRICAL/ELECTRONICS INDUSTRY: CASE STUDY*

Prepared

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V.83-64446

1. Introduction

Modern Japan started with Meiji Restoration in 1868. Soon after that, transfer of technology from abroad began in many fields including electrical industry. Brief historical overviews will be given in the following Sections.

Characteristic features in the period 1868-1940s are that:

- Almost every technology had to be imported from abroad.
- Substantial education and training were carried out in phase.

Additional features in the period 1950s to date are that:

- There have been significant improvements and adaptation of the imported technologies.
- Nation-wide quality control was achieved successfully.

It should be noted here that the government policies and incentives played an important role in every aspect of the development.

2. Electric Power Technology

2.1 Pre-Meiji period

Before Meiji Restoration, Japan was closed to the outside world, with only opening in Nagasaki where the Dutch people could stay and trade. In 1765 the word erekiteri seiritei (electricity) appeared in a Japanese book, and in 1776 an ingeneous Japanese succeeded in constructing a gadget (after a Dutch model) which produced electricity by friction.

2.2 Development before 1900

Electric power industry as we know now started in 1886 when Tokyo Electric Lamp Company was established. There was a heated AC/DC dabate in 1889, and the AC proponent won. In 1891, there existed 11 companies lighting 26,237 lamps, and the government regulations on them were established in the hands of local authorities. In 1892, the first hydraulic power station was built in Kyoto.

Nationwide uniform rulings were established in 1893, but by that time an unhappy situation had already been developed in that the eastern part of Japan had 50 cycles per second while the western part had 60 cycles per second, importing generating machinery from Germany (AEG) and America(GE), respectively.

2.3 Education and training in the Meiji era

The Miniatry of Education established an educational institution in 1871, inviting Henry Dyer (1848-1918) and other eight British teachers. It started education in 1873, and its name changed into Technological College. There were seven Departments, including that of

Telegraph, which actually covered all areas of Electrical Engineering. Unification of education and research, and the combination of theory and practice were eminent features of the College. Indeed, it is said to have been a grand experiment for the British teachers themselves.

While in early years all power generating machines were imported from abroad, at a power plant built in 1896, boilers, steam engines, and generators were those designed by the graduates of the Technical College and made by Ishikawajima Shipbuilding Company. In 1925, however, in power supply companies, only about 10% of steam turbines, 10% of generators (over 1 MW) and 0% of boilers were made in Japan.

2.4 Development in the 20th Century

In 1907, rulings on high voltage power lines were made, and in 1908 both the lowering of the price and lending of in-house wiring contributed to the rapid growth of the electric power industry, no more limiting the consumption to only the affluent households.

The first survey of hydraulic power potential was carried out in 1910, the second survey in 1918-22. Under the Electric Industry Law established in 1911, more than one company were permitted to operate in the same area, but the Great Depression brought about the merger of companies in the thirties.

In 1926, the power generation was at the level of 2.5 GW, ten times as much as that in 1911.

Federation (a kartel) of Electric Power Companies was established in 1932 under the revised law. The third survey was done in 1937.

Policy of national control was announced in 1936 and took the form of one company (established in 1939) for generation and transmission and 9 companies (established in 1942) for distribution.

This control was abolished after the war and 9 power companies privately owned and privately operated were established in 1951. Next year, however, a government-sponsored company responsible for the development of new power resourses was established. Also a system of wide-area cooperation was established in 1958.

Atomic power generation in Japan started on 1963-10-26, at an experimental power station. It belonged to the Atomic Energy Research Institute, first established in 1955 as a non-profit private organization and made a public corporation in 1956 under a law. Japanese Atomic Power Generation Company was established in 1957 and its first power plant started practical operation in 1966 with output of 125 MW. The basic technology was imported from British GE, but they encountered many difficult problems to adapt to the Japanese environment. The second plant began operation in 1970, its technology being imported from American GE. Domestication rate was 35% and 51%, respectively, for those plants but it soon exceeded 90% for later plants and now it is almost 99%. At present, there are 24 atomic power plants with total output capacity of 17,177 MW.

2.5 Technology transfer in electric power industry

Until around 1940, the technologies in electrical industry were almost all imported from advanced countries of America and europe. Thus Toshiba (then Shibaura) got a licance in 1909 from GE, Mitsubishi Electric in 1922 from Westinghouse. Fuji Electric was established in 1923 by Furukawa Electric joint with Siemens of Germany. Hitachi did not have any such arrangements with a specific company abroad.

The transfer of technology went rather smoothly, mainly because there were sufficient number of competent engineers and technicians to absorb and adapt the imported technologies to the needs of the country.

2.6 Training in electrical technology

Besides universities and colleges, vocational schools have been very instrumental in supplying good technicians to the industry. The school system in the latter category took form in 1920 by Vocational Schools Ordinance. In 1922 there were 66 disciplines in this system, including mechanical engineering and electrical engineering.

The following two points are worth noting here:——

- Mechanical engineers/technicians are even more responsible than electrical engineers/technicians for the design and manufacture of electric power machinery.
- Both electric power technologies and electric communications technologies were dealt with in the same department of electricity,

distinction in subjects being sometimes made between "strong electricity" and "weak electricity".

Between 1938 and 42, a great expansion of the higher technical school system was made, in which electrical field got 1365 per year among the total of 7560. In 1945 the number of students entering this field was 2592 among the 13,802. Expansion of technical schools was also phenomenal in the period 1938-42, increased number of electrical technology students counting 3620 per year among 16,090.

After the war, the school system changed into so-called 6-3-3-4 system. In 1956, there were departments of electricity, electric power, and electric communications in the technical high schools. In the period of 1958-59, among the increased number 10,000 of annual entrants, the share of those three disciplines was 5000, exceeding 4000 of the mechanical engineering. In "Doubling Plan of National Income" in the period 1960-65, the increase in the number of annual entrants into electrical disciplines was 32,695 among the total of 85,000.

3. Communication Technology

3.1 Early history

When Commodore Perry came over in 1854 onboard the "black ship", to advise the Shogunate government of Japan to open the country to outside world, he brought a telegraph equipment as a gift to the Shogun. Right after the Meiji Restoration, in 1896, a telegraph line opened between Tokyo and Yokohama. When Ministry of Technology was established in 1870, the Office of Telegraph was among its four Offices. Next year a training shop was established in the Office.

Tokyo-Kobe telegraph line opened in 1872. Manufacture of telegraph equipment started in 1874, and Tanaka Factory (now Toshiba Company) started its operation in 1875. An engineer, dispatched to 1873 Vienna World Fair, had studied the technology there and by 1887 he could produce 1000 such equipments (at half the price of imported ones).

Bell invented telephone in 1876, and the next year it was brought over to Japan, actual usage being started in the same year between the Ministry of Technology and the Ministry of Royal Family. Tokyo Central Telegraph Office opened in 1878, and in the same year the Ministry of Technology started to build a prototype of Bell telephone equipment. In 1881, Oki succeeded in making a domestic telephone equipment in a private company.

It is to be noted here that the Meiji government, after observing the European state of the art, adopted a policy of establishing educational institution first and then plants and firms, so that enough human resources would be available when the demand arose.

Iwatare, an 1882 graduate from the Technological College, studied electrical technology at Edison Co. (now GE) from 1886 to 88, and after serving at an electric power company, came to found Nippon Electric Company (NEC) in 1899. It was helped by the Western Electric Co. of the U.S.A.

Fuji Denki was established in 1923 as stated before, and its communications industry division became a separate company (now Fujitsu) in 1935.

3.2 Government policy

In 1885, the Ministry of Technology was abolished and the newly established Ministry of Post, Telegraph and Telephone took over the communications part of the job. The Cabinet decided in 1889 that the operation of telephone communication network be carried out by the government and the production of equipments be done by private companies. Telephone exchange operation started in 1890 in the Tokyo and the Yokohama areas and between the two areas. Long-distance call between Tokyo and Kyoto became possible in 1896.

Although telephone subscriptions increased tremendously, it was not considered usual to find a telephone set in a typical household not in a priviledged status until the end of the World War I..

In 1949, the Ministry of Post, Telegraph and Telephone were divided into two Ministries, and in 1952 one of them became NTT(Nippon Telegraph and Telephone Public Corporation). KDD(Kokusai Denshin Denwa = International Telegraph and Telephone) Company was created in 1953. The NTT carried out three five-year plans in succession (1953-57, 1958-62, 1963-67) and it improved the telephone communication both quantatively and qualitatively.

3.3 Wireless communications and broadcasting

In 1896, the next year of Marconi's invention, the research in wireless tele-communications started in Japan, and Choshi Wireless Station was established in 1908.

Radio broadcasting started in 1925 by NHK(Nippon Hoso Kyokai) but it was in 1951 that private broadcasting companies began operation.

Transistor was invented at Bell Telephone Laboratories in 1948. Five years later, Sony started production of transistors and in 1957 it was exporting 70% of transistor radios it produced to the U.S.A.

In 1953, TV broadcasting started in Japan. Exportation of color TV sets to the U.S.A. began in 1964. It is interesting to note that the high rate of growth entailed the change in labor market in electrical/electronics industry from male-dominated skilled labor to

female unskilled labor demand, so that the wage of female workers went up considerably.

3.4 Data communications

Under the laws enacted in early 1950s, NTT and KDD have a monopoly on the use of telecommunication facilities for the transmission of messages of other parties as a business and on the use of such facilities to provide other types of communication services for other parties.

In 1971, Public Electric Communication Law was revised to give a legal basis for data communications, and private companies can now use data communication circuits for business under certain restrictions.

In around 1980, MPT(Ministry of Posts and Telecommunications) responded to requests from various quarters by issuing two orders relating to:

(1) nearly total liberalization of communication circuits for use in data processing, and

(2) establishment of a system enabling small and medium enterprises to conduct communication services.

MPT has also been active in upgrading data communications as an important infrastructure of the society. Projects in this respect were:

— development of standard protocol,

— studies on database utilization technology,

— studies on data communication oriented language,

— studies on problems in network formation,

— development of comprehensive security system for data communications.

Communication services provided by NTT are:—

- DDX = new data netework services, of which
  - — circuit switched service started in 1979,
  - — packet switched service started in 1980.
- public data communication services, of which
  - — DEMOS-E (Dendenkosha Multiaccess On-line System - Extended) started in 1971,
  - — DRESS (Dendenkosha Realtime Sales-management System) started in 1970.
  - — miscellaneous data communication services, including emergency medical information systems, automatic cash payment systems for city and regional banks, etc. have started.
- INS (Information Network System), an integrated system of electronic communication and data processing, transmitting voice, data, images and patterns, just started on an experimental basis in the Mitaka area of Tokyo.

Services provided by KDD are:—

- VENUS-P (International Subscribers' Data Service)
- ICAS (International Computer Access Service).

4. Computer Technology

4.1 Relay computers and vacuum-tube computers

In the beginning, there was an enthusiasm in developing relay computer based on the theory of Boolean algebra. Thus Electro-Technical Laboratory (ETL) of the government built in 1952 ETL-Mark I and in 1955 ETL-Mark II, and Fujitsu built FACOM 100 in 1954 and a commercially successful FACOM 128 in 1956.

There are only two cases of vacuum-tube machines which were actually built and put to practical use for some time. One is FUJIC completed in 1957 and the other is TAC completed in 1959.

4.2 Parametron computers

A unique logical element "parametron" was invented in 1954 by a (then) graduate student. It proved to be cheap and stable. Quite a number of parametron computers were built:—

MUSASHINO-1, PC-I in 1958

HIPAC 101, NEAC 1101, 1102 in 1959

HIPAC 103, NEAC 1201 in 1961

Some of them were commercially successful and contributed much to show the great power of computers to the potential users.

4.3 Transistor computers

Electro-Technical Laboratory took a lead again in building transistor computers ETL-Mark III in 1957 and ETL-Mark IV in 1958. It stimulated major manufacturers toward production of commercial computers based on the technology of ETL-Mark IV. Thus in 1959 HITAC 301 and NEAC 2201 were born and developed into HITAC 201 and NEAC 2203 respectively. In 1961 FACOM 222, 241 and OKITAC 5080 were born and in 1963 they developed into FACOM 231 and OKITAC 5090. Since 1960 on, TOSBAC 2100, 3000, ..., 4200 were developed in succession.

4.4 License agreements

Since IBM had basic patents indispensable for the production of computers, 15 Japanese companies, including 6 mainframe makers, made a contract with IBM in 1960 on the license of those patents.

In spite of the early start on the transistor computer as described in 4.3, the Japanese manufacturers felt a great gap between them and the American counterparts in system construction as well as the software technology and the peripheral equipments. The reasons were attributed to the lack of military demands and the smallness of the market. Anyway, in order to bridge the gap, there occurred in the period 1961 to 64 a series of technical know-how license agreements, namely,

Hitachi with RCA,

Mitsubishi with TRW,

NEC with Honeywell Information Systems,

Oki with Univac (Sperry Rand),

Toshiba with GE.

Only Fujitsu was an exception. Also Hitachi's HITAC 5020 (1965) was a successful product of their original design, which in a sense turned out to be a parallel to the IBM 360 series.

4.4 Government policy on technological developments

The Japanese government made policy decisions to promote the information technology from an early stage. Thus, under the initiative of the MITI (Ministry of International Trade and Industry), the two laws were enacted in 1950s:

- Law Concerning Temporary Measures for the Promotion of the Machinery Industry (1956), and
- Law Concerning Temporary Measures for the Promotion of the Electronics Industry (1957).

JEIDA (Japan Electronics Industry Development Association) was created in 1958 as a non-profit organization responsible for the coordination and cooperation between companies in the electronics industry.

FONTAC project (1962-64) was the first government-subsidized project to produce a large-scale computer. F, O, N in the name came from Fujitsu, Oki, and NEC, respectively. Although the project produced only a tolerable model, it contributed much to the development of high technology in each of the participating companies.

Super-high-performance computer project (1966-72) was the second such project, aimed at out-performing the IBM 360. ETL of MITI was in charge of the basic design and eight manufacturers including Hitachi, NEC and Fujitsu participated.

In 1971, the two above-mentioned laws were consolidated into the Law Concerning Temporary Measures for the Promotion of Specified Electronic and Specified Machinery Industries (Specified Industries Law).

R & D project for the pattern information processing system lasted from 1971 to 1980. It was divided into three steps:

—Basic research and development of devices and meterials,

—Development and evaluation of pilot models of recognition equipments for characters, figures, substances and voices,

—Trial manufacturing and test of the whole system.

Again ETL played a key-role and nine manufacturers including NEC, Fujitsu, Hitachi and Toshiba participated.

R&D project for VLSI technology was carried out from 1976 to 1979. It was aimed at IBM's "Future System". Five partipating companies, NEC, Toshiba, Fujitsu, Hitachi and Mitsubishi jointly organized the "VLSI Technology Research Association". ETL was the leader and NTT (Nippon Telegraph and Telephone Public Corporation) cooperated.

In 1978, as the 1971 Specified Industries Law expired, a new Law Concerning Temporary Measures for the Promotion of Specified Machinery and Information Industries (Machinery and Information Industries Promotion Law) was established. Underlying this law was the concept of "mechatronics", machinery and information industries being considered an integrated entity.

R&D project for basic technologies of the next generation computer system lasted from 1979 to 1983. The emphasis was on basic software for the 4th generation computers and input/output technologies for the Japanese language. Oki, Sharp, and Mitsubishi joined the five companies in the VLSI project, and they organized the Computer System Basic Technology Research Association.

The fifth-generation computer project has just started and the international cooperation is solicited. It is to explore the potential of future computers with a rather far horizon in view.

4.5 Other government actions

Committee on the Information Industry of the Industrial Structure Council published an interim report in 1974 on computerization and information industry and made several recommendations about the necessary measures. It produced another report in 1981. Those reports had a considerable influence on the government actions.

JECC (Japan Electronic Computer Co.) was formed in 1961 to provide Japanese manufacturers with funds necessary to sell their products on a rental basis while securing enough resources for development. The money comes from the Development Bank.

IPA (Information-Technology Promotion Agency) started in 1970 under a law (IPA Law), in order to promote the development of software technology and the dissemination of generally applicable software products.

Examples of the appropriation of the MITI budget for computerization, besides the development projects already mentioned, are:

- Optical Telemetering Control System Development Plan (1979-86),
- Health Care System Development Plan (1978-82),
- security measures for data processing service.

About the tax measures, the following should be mentioned. In 1979, a revision of the taxation system was made which permits to set aside as a tax-free reserve up to 50% of the income from sales of general-purpose software. A 1982 revision was designed to encourage the introduction of high-performance remote data-processing equipments. As another measure, there is a system of reserve funds to offset losses incurred by cancellation of the rental contract with JECC.

Government actions on data communication have already been described in Section 3.4, and so there is no need of repeating it here.

4.6 Education in information technology

In response to the MITI request, the Ministry of Education organized a Committee on the Information Processing Education in 1969. It produced a final report in 1972, supplemented by four reports of its subcommittees. They provided the main plan of action and the necessary guidelines for the Ministry as well as universities and colleges.

There were two mainstays in the report, one the creation of specializing departments and the other the information-processing education of the students at large. Both lines were followed enthusiastically. The author would like to stress here the importance of the second mainstay — the general education —, because it contributes a great deal to the successful use of computers in quite a wide range of fields, not by a handful of "specialists" but by a large number of common people in each field.

As for the use of computers in scientific research, a great role was played by a policy of installing a large-sized computer in each of the seven major national universities for the common use of all reserch workers of Japan. Some of them are now connected by communication lines, and each one has many satellite centers in nearby universities and colleges.

Training in high schools started with a recommendation in 1969 on the promotion of information-processing education in high schools. It consisted of three parts:—

- "promoting departments" should be established in technological high schools and commercial high schools,
- "information-processing training center" should be established in each prefecture for the common use of vocational high schools,
- selected teachers in vocational high schools should be trained in teaching information processing.

Actions along these lines were taken seriously and the result is a good supply of middle-class human resources with adequate background and familiarity in computer technology.

5. Final Remarks

Reviewing the Japanese experiences in electric/electronic industry, one is led to the conclusion that:

> By far the most important factor in the success of technology transfer is the human resource.

Therefore in the national policy, the highest priority should be given to the education. Universities and colleges are important of course. But even more important is the education of the mass. Hence the basic education of everybody must come first, and then vocational education to bring up technicians and clerks next.

If a developing country finds a difficulty in securing enough number of competent teachers, then use of high technology products such as video-tapes and micro-computers may be worth serious consideration. At first sight, they may appear to be too costly. But if they can achieve what is not easily achieved by other means, then they will turn out to be reasonably cheap.

The author should be very happy if this short summary of the Japanese experiences in the selected fields could serve as a source of useful hints in formulating national policies of Malaysia.

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