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Japanese paper Industry after the Meiji Restoration: How technology helped its growth
Part 2: Pioneers and visionaries

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Preface

Paper manufacturing by paper machines started shortly after the Meiji Restoration. Pioneers and visionaries struggled to make it. As the numbering of chapter is consecutive to Part 1, it starts from Chapter 3.

3. Beginning of paper making in Japan

3.1 Market size of paper in 1800

How much volume of paper was produced in around 1800 in the world? Europe was expanding its economy with technology developed by the Industrial Revolution. China, though stagnated at those days, had once enjoyed civilization of the highest level in the world. Japan nurtured its traditional culture using WASHI, traditional Japanese paper.

There has been a strong regression, almost proportional, between total paper consumption and total GDP in a specified region [1)]. Per capita GDP is available in Maddison Data Base, introduced in part 1, from which that of Europe is estimated, though with some uncertainty. Demographic statistics can be obtained from Wikipedia. Using them, paper consumption or paper market size in a region can be compared as an index as in Table 1.

Table 1 Reginal paper market size estimated as an index at around 1800

	Population		Per capita GDP		Market
	(hundred million)	(Index)	(US dollars in 1990)	(Index)	(Index)
Europe	2.0	6.6	1500-2000	2.6	17
China	4.0	13	600	0.93	12
Japan	0.3	1	641	1	1

Europe had the largest paper market in those days. A person in Europe consumed paper several times, probably three times, as much as one Japanese did. The large demand asked to save manpower and to improve productivity, and urged to develop equipment such as Hollander beater and paper machine. In Japan, on the other hand, jobs were routinely done by hands. Water wheel, which was a key for labor saving, became common late, and it was said to be in the middle of the Edo period.

Then, how was the consumption at around 1900? Europe just finished the Industrial Revolution and the US was exactly in a great progress. Japan was trying to build an industrial structure like one in Europe and America. China was in confusion. Table 2 is made in the same way as Table 1.

Table 2 Reginal paper market size estimated as an index at around 1900

	Per capita GDP	Population	Per capita GDP	Population	Market
	(US dollars in 1990)	(million)	(Index)	(Index)	(Index)
Europe	2658 *1	295 *3	2.25	6.7	15
America	4096 *2	82 *4	3.47	1.9	6.5
Japan	1180	44	1	1	1
China	545	400	0.46	9.1	4.2

*1: 30 countries in Western Europe *2: The US only

*3: Europe except USSR *4: North America

The size of market in Japan at 1900 was probably twice that at 1800. The market size of Europe and that of the US would be 15 times and 6-7 times that of Japan respectively. Paper manufactured in those large markets, using big paper machines, would be cheaper than traditional WASHI made in Japan. It would be a formidable competitor for entrepreneurs in Japan who wanted to manufacture YOSHI with imported paper machines.

As told in Chapter 1, Egypt and Syria had a prosperous paper industry of their own. Then, in the 15th century, European paper of which cost was reduced by improving productivity invaded Islamic market. Egypt lost in the competition and became just a depot for Islamic market. Persia (Iran) which manufactured paper of fine quality in the 14th century, lost market to European paper. In the 19th century, Russian and Indian which installed European paper machines also exported products to Iran. America, on the other hand, positively accepted European technology which was developed in the Industrial Revolution, copied equipment by itself,

nurtured the industry, refined equipment by adding its own developments, and became a leader in the world.

Then, how did Japan do?

3.2 Technology at around 1880

In around 1880, paper machine of a Fourdrinier model was completed. Its width was already 130-inch and operated at a speed of 200 ft per min. Cylinder machine also finished its designing and widely used in America [2]. Paper, which historically had been expensive and used in high society, could be manufactured with lower cost and was becoming a commodity affordable to everyone. Munsell wrote in his Chronology of Paper and Paper-Making published in 1860 as follows [3].

"In a little more than a quarter of a century, the machines have entirely superseded the diminutive hand-mills which sparsely dotted the country, and gigantic establishments have risen up in their places. Paper-mill villages, and banking institutions even, have grown out of this flourishing branch of industrial art, and we behold with satisfaction and amazement, what has been brought about by the aid of a commodity so insignificant in the eyes of the world as linen and cotton rags."

Regarding pulping of wood, it started a little late. Keller invented groundwood process in the 1850s. Alkaline pulping by Burgess was in the 1860s. Sulfite process was of some use in the 1880s. Newsprint ~~paper~~ made of groundwood pulp and sulfite pulp appeared in market in the 1890s. The latter half of the 1800s was a period in which wood pulp was replacing old rag pulp.

3.3 Pioneers in the early days of the Meiji era

Right at that time, the Meiji Restoration (1868) occurred and Japan strived toward introducing social structure in Europe and America and technologies they developed. Paper (YOSHI) making was one of them, and a first paper machine was imported in 1872. Some economists were interested in and reviewed the history of technology transfer occurred in Japan in details. Followings are an excerpt from them [5), 6)].

Having looked technologies overseas, entrepreneurs and venture capitalists made moves. Abiko summarized a story from "Nippon Shigyou Souran" published in 1937 by Oji Paper Co. [5)].

Yasubei Momotake, the first pioneer, accompanied Hirofumi Ito, who later became a Prime Minister, and visited America in 1870. He was overcome with paper machines and realized that they would be needed. Promising to buy one, and coming back, he managed to get capital from 10 merchants in Osaka, got permission from Osaka government and offered a prospectus. The total expenditure was 40,000 yen. But his venture failed. It was said that the machine did not arrive. He, still having a dream, asked K.R. Mackenzie, an English man, to deal with the job of importing a paper machine. The price of the machine was 25,000 yen, one forth was a down payment and the rest would be paid after the machine arrived at Japan.

How much is 25,000 yen in the 1880s in real money in 2020? It is not easy to evaluate, and it may be several hundred million yen, quite a big money for venture capital.

Then, Momotake financially broke, and his business was transferred to Horai-sha. It invited Joichiro Majima to manage the business, who was proficient in English. He was twenty-three years old and his salary was 100 yen per month, as much as that of a top manager of a large company.

Horai-sha was not successful and transferred the business to Majima. Then, publishing newspaper became a boom, and his business was relieved. When a boom finished in 1885, Majima closed his business in Osaka. Later, he came back to paper business and became a key person of the industry again, which will be introduced later.

The case of another start-up, Yuko-sha, was studied by Abiko [5)]. Yuko-sha made an agreement with Thomas Waters at the English Consulate for building a mill with a paper machine. As building a house with bricks was not known in Japan, many troubles happened. It completed in 1873. The paper machine made by Ann Firston in Britten which Waters ordered in 1872 arrived in 1874. It took three weeks to deliver, as such a huge equipment had never been unloaded at Yokohama Port yet. The price of the machine was 25,000 yen in total, and would be paid by five instalments. The last installment was supposed to be after paper was manufactured on the machine. Happily, it was paid. The machine started operation in May 1874.

John Rogers, an English man, was invited to train Japanese operating staff. Some of Japanese staff were under twenty years old, who later became key persons in machine operation. A salary Rogers got was 200 yen per month, quite a good pay foreign instructors received. In spite of difficulty in communication, Rogers worked very faithfully and his staff responded sincerely. It was reported that Rogers worked faithfully, day and night, and helped Japanese staff make big progress. His staff founded a union called "Rogers Union" to remember his service and goodness.

Nao-saburo Ono, one of his staff, wrote a document memorizing his instructions. It is very precious and reserved in Paper Museum at Oji, Tokyo. Followings are a part of his document translated in English.

"Machine tenders should pay attention to every part of the machine. When noticing something unusual, or hearing unusual noise, even very small one, check it immediately. When the drive slows down, a part of old felt soaked with dissolved rosin should be pasted on it. Before starting operation, cylinder dryers should be warmed up for a couple of hours, and a stock chest should be well agitated. Then the wire should be washed completely, a dandy roll is set and washed, a couching roll is washed, and then wet felts are also washed. --------"

Seki, who collected the document, made a comment on it in 1948 as follows. "For those who already have some experience in machine operation, there is not anything new. It, however, would be laborious to instruct routine operations precisely to operators and it would not be easy for operators to work exactly as instructed."

What was business then? It was reported "demand was so small that paper was stacked in a warehouse. An order from the Ministry of Finance was some help. Then newsprint boom in 1877 relieved a lot" [5]. The market was not matured yet, and was far less than what entrepreneurs imagined.

Okuda listed paper companies established in the 1870s and paper machines they had in Table 3 [8].

Table 3 Paper companies and their paper machines in the early days of the industry

Company	Founded	Start Operation	Country of Maker	Machine and Wire Width
Yoko-sha	Feb. 1872	June 1874	England	Fourdrinier 54 in
Shoshi-kaisha	Nov. 1872	June 1875	England	Fourdrinier 76 in
Majima Seishisho	April 1874	Oct. 1875	England	Fourdrinier 54 in
Papier fabrik	1873	Jan. 1876	Germany	Fourdrinier 54 in
Mita Seishisho	Dec. 1874	Oct. 1875		Cylinder mold
Insatukyoku Shoshibu	Feb. 1874	1878	England	Cylinder mold 57 in
Kobe Seishisho	Feb. 1876	Mar. 1877	USA	Fourdrinier 72 in

They were private companies except one at the sixth from the top in Table 3, and Japanese paper industry grew by itself, not by control of the government, though orders from the government in early days were very helpful. As old rag was a main pulp source, all mills listed in Table 3 located in suburban areas. As mills required a lot of water, it was not easy to get a water-right big enough for operation in such locations. Kamiyama reviewed the troubles in details [6].

3.4 Paper machines of those days

As in Table 3, five machines were a Fourdrinier model, of which width was in the range from 48-inch to 78-inch, and one was a cylinder machine, of which width was 57-inch. The largest machine in the world at that time was 100-inch wide, and ran at 100 ft per min [9]. Fig. 1 is a picture of a typical paper machine at around 1870 [2].

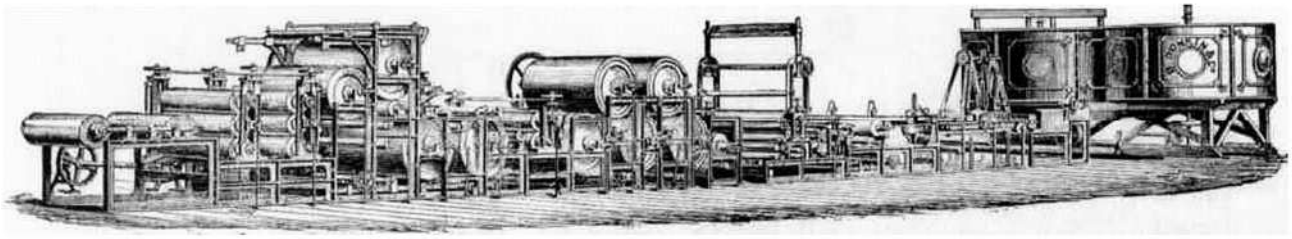

Fig. 1 Picture of typical paper machine at around 1870

Then, what did Yuko-sha's machine look like? Its specification was as follows [6].

- Machine length: 9.4 m
- Wire width: 180 cm
- No.1 press felt length: 7.6 m
- No2 press felt length: 5.5 m
- Dryer: 5 drums, 90 cm in diameter
- Calender: one stack of seven rolls
- Dandy roll: 170 cm in width, 54 cm in peripheral length
- Beater: 2 sets
- Pump: 18 cm

Let us compare it to a paper machine of Fig. 1. The Yuko-sha's machine had five dryers which might be set in two stages as in Fig. 1. It was not equipped with a size press and after dryers which the machine in the picture had. It had one stack of calender of seven rolls, while the picture had two sets. The total machine length was about 10 m, and that of the wire part was 4.7 m calculated from the document by Naosaburo Ono, while the machine in the picture had a wire of 5-6 m in length, estimated by the size of dryer. It was operated at a velocity of about 13 m per min. for ordinary bond paper, which was about a half of that of the fastest paper machine in those days. The Yuko-sha's machine was smaller than one in the picture, probably three forth of it, and might look like one in the picture.

Fig. 2 is a picture of a paper machine which started operation in 1875 at Oji Mill, Oji Paper Co. It is listed in Table 3, the second from the top under the old name of Shoshi-kaisha.

Its specification was as follows [10].

- Supplier: James Bertram of Scotland
- Wire: 78 in x 30 ft
- Table roll: 1 and 13/16 in
- Couch roll: Top 17 and 1/2 in (jacket roll), Bottom 11 and 5/8 in (bronze roll)
- Press: two sets, Top 13 and 1/2 in (bronze roll), Bottom 14 and 1/4 in (rubber roll)
- Dryers: 12 drums of 36 in, 1 drum of 48 in
- Calender: two stacks of 3 rolls and 4 rolls
- Reel : 4 rolls driven parallel by belt with gear transmission

The machine, 76-inch wide, was larger than that of Yuko-sha, 54-inch wide, and had more dryers, 13 drums in total, and could be operated at a faster speed. A leaving dry web was silted to two parts, cut to sheets and was stacked up by two operators by hand at the end.

At the beginning, the Ministry of Finance had a papermaking section which was soon transferred to private sector. The papermaking section, however, built three cylinder machines, by copying an imported cylinder machine listed in Table 3 at the fifth from the top, in the period from 1879-1884. They were the first domestically made machines. The substitution to imported machines, however, did not last and 12 machines which started operation until 1893 were all imported. Then, two cylinder-machines were domestically made in 1894.

The trend of domestically made machine became common after the World War I and many domestic makers offered cylinder machines as well as Fourdrinier machines. The point is that Japan wanted to copy a machine at around 1880 and was capable enough to do it. Its technique and talent were later succeeded to domestic machine makers.

3.5 Visionaries of the first generation

Kamiyama listed foreigners invited to instruct machine operation. Rogers was one of them. The others were Bottomley, McFarlane, Lehmann, Ottomar Eksner and shoe (?). They worked in mills listed in Table 3.

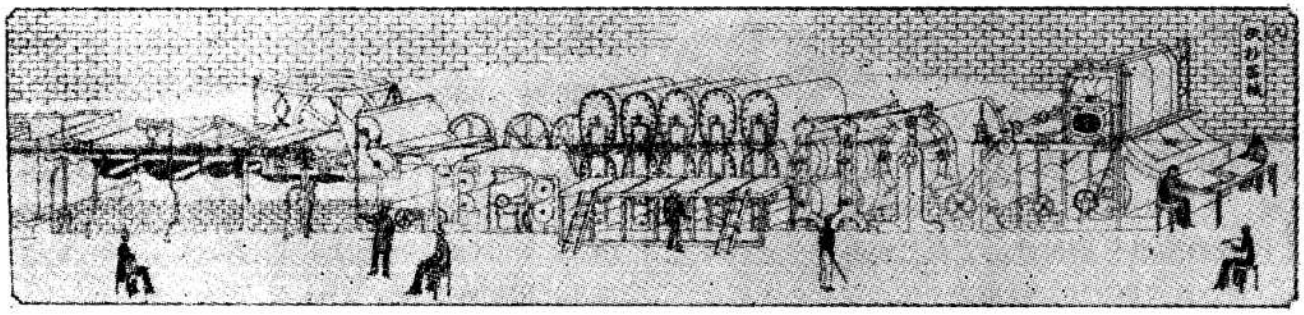

Fig. 2 Picture of the first paper machine of Shoshi-kaisha

Then, invitations ended there, and they were dismissed in a couple of years, suggesting that machines could be operated well by only Japanese.

Following the foreigners, two Japanese, Masanori Onodera and Ichiro Murata, were listed as key persons in the industry. They had a chance of studying in the US [6].

Onodera (born in 1845) visited the US in 1870, accompanying his master, and stayed there in Holyoke, Massachusetts to learn paper making at a paper company named Holbrook (?). He became a leading expert of paper machine operation as his carrier and was invited to mills one after another [11].

What was Holyoke? Followings are an excerpt from Wikipedia [12]. It located adjacent to Springfield, and along Connecticut River. After the Holyoke Canal System completed in 1849, many mills, especially paper mills, started up, using its hydro-power. The size of population in 1860 was 6000, and it increased to 60,000 in 1920. It was exactly what Munsell wrote in his book and was cited in Chapter 3.3. Onodera stayed at one of mills there (Holbrook ?), and learned paper making, that contributed his later carrier. Holyoke was later visited by Japanese, Tamaoki in 1888 and Nishi in 1925. When Nishi visited, writing paper was still made from rags, cooked with lime.

Murata, the other key person, also studied at Holbrook in Holyoke, and came back to Japan in 1877, and became a vice president of a company, Mita Seishisho

The period of years from 1870 to 1900 was a transition period from rags to wood pulp in the world. As Hudson River Company told in its website [14], the company was established in 1865, and produced groundwood pulp in 1868, first in America, and 70 tons of it in 1877. When the patent by Voelter expired in 1888, equipment makers came into the market and the output of groundwood pulp surged, while rag paper was still manufactured in Holyoke. It is interesting to know whether Murata had information on wood pulp. In 1887, Murata joined in establishing Fuji-Seishi, and became the second president. Fuji-Seishi built a mill based on wood pulp, not rags, using softwood in Fiji area.

Following Onodera and Murata, Kamiyama listed Majima and Ohkawa [6]. Majima, who was introduced in Chapter 3.3 and had closed his paper business in Osaka, was invited to Fuji-Seishi as a mill manager in 1887. He traveled Europe and America for a year, observed what was going on there and advised a way Japanese paper industry should move in to the company president in 1889. He began to use softwood abundant in Fuiji area, succeeded in making groundwood pulp, and manufactured newsprint and printing paper with it. The company grew to be the largest in Japan in 1898. The decision of manufacturing wood pulp was a turning point of the industry.

Then, Majima took a new course of life. He quitted Fuji-Seishi and started his own paper company near Osaka in 1893. The mill had two cylinder machines (72 in) which were supplied from domestic makers and one rotary digester. He ordered another two cylinder machines (64 in) in 1898. The business looked to be promising, but failed in the depression after 1907. The rest of his life was unfortunate. It may be understood that he was interested in paperboard as his new venture, which was increasing demand in Osaka area. Anyway, Majima was distinctive in the early days of Japanese paper industry.

Heisaburo Ohkawa was introduced in the History of Oji Paper Co. as follows. "In 1879, Ohkawa visited the US at the age of 20, and learned paper making. After coming back, he used rice straw instead of rags for making newsprint and saved a lot of cost." His carrier will be introduced in details later in Part 3 and Part 4. He worked in five mills in Holyoke, one of which was Holbrook.

In 1884, he was interested in sulfite pulp and visited Europe and America. After testing in lab, he set up a sulfite pulp mill at Keta in Kiso area, abundant with good softwood. It took years to have know-how for manufacturing sulfite pulp. Though Japanese could copy a cylinder machine right after they saw it, a plant like sulfite process which involved chemical reactions seemed to be difficult to operate. As sulfite pulp was now at hand, an integrated mill which had two kinds of pulp, sulfite and groundwood, and paper machines became a standard model in Japan. With that model, Japanese paper industry expanded vigorously at a yearly growth rate of about 10%. The details will be reviewed in Chapter 5. The work by Ohkawa will be also introduced there.

It is not certain if Onodera and Murata had information on wood pulp, while they stayed at

Holyoke. Then, Majima and Ohkawa really understood that wood pulp would replace rag pulp, and led the industry to that way. How many years were they behind the world trend? I would say it was less than ten years.

Onodera, Murata and Ohkawa learned paper making in Holyoke. Walsh brothers arranged the deals. Who were they? It is from Wikipedia. Thomas Walsh and John Walsh established a trading company in Yokohama and then in Kobe. They exported cotton rags to the US, Holyoke being one of the destinations, and their business was profitable. In 1876, they started paper making in Kobe with equipment imported from the US. Their mill is listed at the bottom of Table-3. They quitted the business in 1897 and their mill was transferred to a Japanese.

3.6 Paper mills in the US at around 1890

In 1888, Tamaoki who learned under Rogers went to the US to buy a paper machine. He visited ten mills there and made a report, which described their equipment, pulp resources, products, and manpower and their pays [19)]. The original consisted of 19 sheets of WASHI (traditional Japanese paper) on which he wrote with sumi (Japanese ink). It is reserved in Paper Museum in Oji, Tokyo.

Though the details are skipped, mills were operated in many different ways. Water wheels were used more often than steam engines, and electric motors were not available yet. Paper mills which produced wood pulp were not major yet, and their types of pulp were mostly groundwood and few sulfite pulp. Newsprint was yet to come. In those days, Majima and Ohkawa were interested in wood pulp, Majima in groundwood and Ohkawa in sulfite, in Japan, a long way from the US. They definitely had correct information and had a spirit of entrepreneur.

The equipment Tamaoaki bought were: one Fourdrinier machine (84-inch) by Winchester, one rag cutter, three beaters, one Jordan, one engine of 250 HP and two boilers. They costed 35,000 dollars.

In the next issue (Part 3), the expansion of the industry will be reviewed.

References

1) Kiyoaki Iida: JAPAN TAPPI Journal Vol.69, No.8, p.68 (2015)
2) Kiyoaki Iida: JAPAN TAPPI Journal Vol.68, No.6, p.38 (2014)
3) Joel Munsell: Chronology of paper and paper-making, ALBANY: J. MUNSELL, 78 STATE STREET. 1864
4) Kiyoaki Iida: JAPAN TAPPI Journal Vol.67, No.11, p.84 (2013)
5) Shoichi Abiko: Research Paper No.14 (2008.12), Tokyo Collage of Transport Studies
6) Tsuneo Kamiyama: Economic Studies No.130 (2004), Meiji Gakuin University
7) Jhoichiro Majima, Wikipedia
8) Masanobu Okuda: JAPAN TAPPI Journal Vol.10, No.62 p.20 (1956)
9) Haunreiter, K.J.: 200th Anniversary of the Paper Machine, TAPPI JOURNAL, Vol.80, No.10, p.93
10) Itsuki Nishi: JAPAN TAPPI Journal Vol.32, No.5, p.2 (1978)
11) Masataka Onodera, Wikipedia
12) Holyoke, Wikipedia
13) Kiyoaki Iida: JAPAN TAPPI Journal Vol.68, No.4, p.65 (2014)
14) Kiyoaki Iida: JAPAN TAPPI Journal Vol.67, No.11, p.84 (2013)
15) Fujio Suyama: JAPAN TAPPI Journal Vol.27, No.10, p.3 (1971)
16) Thomas Walsh, Wikipedia
17) Thomas James Waters, Wikipedia
18) Yoshikuni Seki: Journal of the Japanese Technical Association of the Pulp and Paper Industry Vol.2, No.4, p.35 (1948)
19) Tadakatsu Omi: JAPAN TAPPI Journal Vol.23, No.8, p.11 (1969)