PULP AND PAPER INDUSTRY OF JAPAN

February 1947

(No.) R1640

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison, Wisconsin
In Cooperation with the University of Wisconsin

Summary

Wood pulp mills in Japan Proper (Hokkaido, Honshu, Kyushu, Shikoku) at wars' end numbered about 90, and machine-paper mills about 275. Most of the mills are small and outmoded, with certain notable exceptions. Eight pulp mills are classified as manufacturers of rayon pulp, and the remainder produce pulp of the groundwood, sulfite, kraft, and soda types. Of about 500 paper machines, about 100 are Fourdriniers of the ordinary type and the remainder are cylinder or Yankee or modified types. The centuries-old hand-made paper industry is not described in this report.

More than one-half of the total production of pulpwood and nearly one-half of the wood pulp produced in Japan during the 10-year period up to 1945 was concentrated in Karafuto. The loss of this area, coupled with the loss of imports of both pulpwood and wood pulp, considerably reduces the raw material available to the paper industry and other users of pulp. The loss of these facilities was especially severe with respect to chemical paper pulp of the sulfite and kraft types. Sulfite pulp is the only chemical pulp formerly made in large volume in Japan, but 65 percent of the 1930-1940 production of this pulp was made in Karafuto. Nearly all of the kraft pulp was made in Karafuto during the same period, but by 1945 a considerable portion of the rated productive capacity for kraft was located in Japan Proper. Most of the capacity for the production of rayon pulp and mechanical pulp was located in Japan Proper. Soda pulp was produced in Japan Proper and Formosa. Mills producing this pulp are numerous but small and inefficient.

Production of all types of pulp in the peak year of 1941 was 1,408,000 short tons, of which 77 percent was paper pulp, and 23 percent was rayon pulp grade. Production of all types of pulp in 1945 was only about 18 percent of the 1941 production. The chief reasons for low production were shortages of coal, chemicals, and wood. The production of paper and paperboard in 1941 was about 1,670,000 tons.

The rayon pulp industry displayed a singular growth in recent prewar years, and, in general, mills producing this pulp are among the most modern in Japan. Domestic production of rayon pulp expanded from an estimated 4,000 tons in 1932 to more than 325,000 tons in 1941, but as production did not meet demands, Japan depended heavily on imports of this type of pulp. Production of rayon pulp in 1945 was only 11,400 tons or about 5 percent of the rated productive capacity of remaining rayon pulp mills.

Report No. R1640

PULP AND PAPER INDUSTRY OF JAPAN

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The manufacture of pulp and paper in Japan originated over 1,000 years ago, and for centuries before paper was known to the Western world the highly developed art of producing high-quality hand-made papers was practiced. To present day Western peoples, the manufacture of pulp and paper by hand methods was and is nothing more than a quaint household industry. The development in the 80's of methods of utilizing wood fiber for paper led to the introduction of foreign-style paper to Japan and in turn to the development of the domestic machine-paper industry of recent years. The advent of the machine-paper industry came in 1872 with the formation of a joint stock company, the Oji Seishi Kabushiki Kaisha (Oji Paper Manufacturing Company). This was the first company in Japan to produce European or "foreign style" paper as distinguished from hand-made or "Japan paper." The natives of Japan accepted the foreign style papers as supplemental to, rather than a replacement for, the conventional hand papers, and the machine industry enjoyed a moderate growth for a number of years. Commercial significance on a world scale was attained for the first time under the impetus of shortages caused by the World War of 1914, resulting in the development of a domestic pulp and paper industry which in 1940 was the largest in the Orient and which placed Japan among the leading pulp and paper producing nations of the world.

The proper use of wood resources in Japan is extremely important to the existence of its population because of the high concentration of people per unit area of its land and the great dependence on such forest products as fuel, charcoal and lumber. Industries converting wood to pulp consume much less wood than certain other wood-using industries such as lumber and charcoal; the consumption of wood by pulp mills has not exceeded about 15 percent of the total wood consumption in any year.

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[1]The material here reported was obtained by the author in 1946 on assignment to the Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, Tokyo. Acknowledgement is made to Lt. Col. W. E. Cohen, Australian Scientific Mission, and Lt. M. L. Markell,Jr., U.S.A., for assistance in the preparation of this report.

[2]Maintained in cooperation with the University of Wisconsin, Madison, Wis.

Early pulp mills were located chiefly on the island of Honshu, but because of the abundant supply of desirable coniferous woods in northern lands, much of the new production capacity moved to Hokkaido and Karafuto. Owing to the ever-increasing demands of the paper industry, a considerable portion of pulp requirements was met by importation, but by expanding pulp producing facilities Japan attained virtual self-sufficiency in paper pulp by 1938. In the Thirties, the rayon industry emerged as another large consumer of pulp and its needs were at first imported because Japan had neither the capacity nor the industrial technique to produce quality rayon pulp. Soon after 1933, the domestic production of rayon pulp was developed and exhibited a phenomenal growth until 1941. The sulfite and groundwood pulp processes were the first to be extensively used in Japan. Kraft pulp was originally made in Karafuto, and the manufacture of kraft and soda pulps was not developed in Japan Proper until about 1938. Soda pulp was produced in numerous small and inefficient mills, which yielded an inferior and non-uniform grade of pulp. As in the United States, straw is used chiefly in making paper boards and is processed by cooking with lime. Although some waste paper was deinked, it was usually converted into paper board without special chemical treatment. In addition to wood fiber, other fibers used for special purposes include cotton, hemp, flax, rice, or wheat straw, and the inner bark of branches of certain plants of the mulberry family. These fibers are used in small quantities to prepare a large number of special papers.

Wood

Of estimated forest resources of 67 billion cubic feet in Japan Proper (Hokkaido, Honshu, Kyushu, and Shikoku), about 19.2 billion cubic feet in Old Japan (Honshu, Kyushu, and Shikoku), and about 8.5 billion cubic feet in Hokkaido are composed of wood species commonly used for pulping. The preferred species are the spruce and fir (yezomatsu and todomatsu) which grow abundantly in Hokkaido, and the red and black pines (akamatsu and kuromatsu) of Old Japan. Other species used for pulping include beech and hemlock.

The volume of wood consumed for pulp manufacture was approximately 120 million cubic feet annually for a 7-year period up to 1944. The consumption of pulp wood by locality is shown in figure 1. More than one-half of the total pulp wood used in Japan during the 10-year period up to 1945 was concentrated in Karafuto. Not all of the wood was pulped in Karafuto, and many mills on the other islands were dependent upon this peninsula for a source of high-quality pulp wood. The loss of Karafuto to the Russians, coupled with the loss of imports of both pulp wood and wood pulp greatly reduced the raw material available to the paper industry and other users of pulp. A severe shortage of both pulp wood and wood pulp therefore resulted.

Attempts are being made to make up present pulp wood deficiencies through the use of sawmill wastes. In some cases, pulp mill operations have been integrated with sawmill operations to use slabs and edgings from lumber manufacture for pulping. Special small chippers with adapters to fit small miscellaneous material are sometimes used to reduce this wood to chip form. The bark of pulp wood is removed chiefly by hand, although the larger mills have drum-barking equipment. The logs are slashed after peeling and the largest sometimes reduced in size by a splitting device.

Present requirements for pulp wood to supply remaining pulp mills are affected by factors other than rated capacity, such as the ability of mills to consume wood despite present shortages of coal, chemicals and other necessities. Future needs therefore are best considered in terms of past production and modified according to current shortages. From the standpoint of remaining pulp productive capacity, although a maximum output of nearly 900,000 short tons was attained in Japan Proper in 1941, an estimated production of 600,000 tons, which approximates a past 7-year average, appears to be the maximum reasonable possibility after bomb damage is repaired, assuming adequate supplies of coal, wood and chemicals to be available. In addition, wood requirements are, of course, dependent on the proportions of the various pulps made. On the basis of rated pulp mill capacity, the percentage capacity for each type of pulp has been estimated and if conversion factors for the calculation of wood volume per ton of pulp are applied to the assumed maximum production, the wood requirements would be over 70 million cubic feet annually. It should be emphasized that this estimate is given as a sample condition and that because of various shortages and altered emphasis on certain products the actual production is not likely to coincide with the indicated rated capacity of mills. Production of pulp wood has been hindered by reluctance on the part of pulp mill operators to use less desirable wood species such as the hardwoods in mixture with long-fibered coniferous woods. A notable exception to this has been in the production of rayon pulp; for this product, beech in some proportion is considered advantageous. Technical advances for increasing the yield of pulp per unit volume of wood also appeared to be lacking.

Pulp

The yearly average volume of wood pulp available (production plus imports) for consumption by the paper, rayon yarn, staple fiber, and other chemical industries of Japan for the years 1935 to 1942 was approximately 1,350,000 short tons. About 250,000 tons of this amount were obtained by importation. Nearly 45 percent of the average domestic production and about 36 percent of the total pulp available for this 7-year period had Karafuto as its source; small amounts were produced in Korea and Formosa. The production of all types of wood pulp and the magnitude of imports are illustrated in figure 2. Although the over-all dependency on importation has not averaged over 21 percent of the total for the years 1930 to 1940, an individual consideration of paper pulp and rayon pulp reveals the past dependency on imports of rayon pulp and the near self-sufficiency in paper pulp. This is illustrated in figures 3 and 4. Production of wood pulp in Japan by locality is given in figure 5.

The loss of Karafuto is greater from a consideration of pulp types than is indicated from theover-all loss of tonnage because production in Karafuto was mostly of the important chemical pulps, notably sulfite and kraft. This is typified by a breakdown of pulp production by types for Japan Proper, Karafuto, Korea, and Formosa for the year 1941 given in figure 6. The rise and decline of production of chemical paper pulp, mechanical pulp, and rayon pulp since 1930 are shown in figure 7. In the peak production year of 1941, a total of 1,407,993 short tons consisted of 619,132 tons of chemical paper pulp, 462,402 tons of mechanical pulp, and 326,459 tons of rayon pulp. Total pulp production for 1945 was only 255,657 tons, or about 18 percent of the 1941 production and about 25 percent of the rated production capacity of remaining mills. Principal reasons for low production are shortages of coal, chemicals, and wood, and to a lesser degree, bomb damage. Data on the production of pulp by types for 1945 and the rated productive capacities are given in the accompanying tabulation.

Type of pulp	Rated productive capacity (Jan. 1946)		1945 production	
	Percent of total	Short tons	Short tons	Percent of capacity
Mechanical	52	499,900	125,907	25
Sulfite	15	145,760	101,348	70
Rayon	24	230,600	11,422	5
Kraft	5	53,200	15,225	29
Soda	4	40,000[a]	1,755	4
TOTAL	100	969,460	255,657	

[a]Estimate.
Source: Oji Paper Mfg. Co. Ltd.

The equipment capacities given appear to be somewhat in excess of that substantiated by pre-war records of the mills in Japan Proper.

Because of the numerous fibrous raw materials used in the production of paper and paper board, no simple factor is available for use in calculating the wood pulp requirements for total paper production. As an illustration, however, the fibrous materials consumed by the Japanese paper industry and the resultant paper products for 1941 might be considered. In that year, 1,211,321 short tons of wood pulp were used in the production of 1,668,765 tons of paper and paper board, which is a proportion of about 0.73 tons of wood pulp per ton of paper and paper board. On this basis, assuming a per capita consumption of paper at the approximate recent pre-war level of about 30 pounds per annum, and assuming a population in Japan of 80 million,

wood pulp requirements of the paper industry would be nearly 880,000 short tons per year. Requirements for rayon pulp for the production of rayon are about 1.17 short tons of pulp per ton of viscose rayon, and about 1.40 tons of pulp per ton of cupra-ammonium rayon ("Bemberg silk").

A location map of pulp mills, including a classification according to approximate productive capacity, is given in figure 8. In summary, these data show that of 93 pulp mills, eight have a capacity of over 30,000 short tons per year; 15 mills have a capacity of 10,000 to 30,000 tons; 30 mills, of 1,000 to 10,000 tons, and 40 mills produce less than 1,000 short tons per year. About 40 percent of the total capacity is concentrated in five mills in Hokkaido.

A. Mechanical Pulp

Over one-half of the remaining pulp capacity is for the production of mechanical pulp. Mechanical pulp, in admixture with unbleached sulfite, is widely used in Japan for papers where permanence is not required, such as newsprint, school books, printing, and a variety of wrapping papers. Wood requirements for the manufacture of groundwood are more exacting than for some chemical processes, and the species which are most suitable for grinding are the spruce and fir (yezomatsu and todomatsu) of Hokkaido. In the central and southern regions where spruce and fir are not available red and black pines (akamatsu and kuromatsu) are used. Pulps produced by the grinding of pine are lower in strength, darker in color, and generally require longer drainage time for water removal in the manufacture of paper. The latter fact has resulted in an appreciable decrease in paper machine operating speeds, particularly in the high-speed machinery generally employed in newsprint manufacture. Little or no hardwood is used in the production of groundwood. It is expected that experiments on the production of hardwood groundwood will be stimulated by severe shortages of the more desirable species. The use of groundwood in paper in as large a proportion as possible is to be encouraged in Japan where wood economy is of prime importance and power is reasonably abundant. The production of mechanical pulp in Japan for 1930 to 1945 is shown in figure 9. Average annual production for 1930 to 1940 was about 360,000 tons, representing about 44 percent of the total production of all types of pulp made during this period. A peak production of 462,420 was reached in 1941. Nearly 88 percent of the groundwood production of recent prewar years was centered in Japan Proper. Since the loss of pulp sources in Karafuto was confined largely to chemical pulps, the result has been a substantial increase in the position of groundwood pulp in comparison with other pulp types. The proportion of groundwood to chemical pulp may be considered as an over-all evaluation of the quality of papers produced, and the increased proportion of groundwood capacity is likely to be reflected in the production of inferior papers. Thirty-five mills are classified as producers of groundwood pulp. The total rated capacity of these mills, disregarding bomb damage, is estimated to be about 500,000 short tons per annum. By far the largest mill is the Tomakomai plant of the Oji Paper Manufacturing Company, Ltd.; this mill has a rated capacity of 191,000 short tons of

groundwood per annum. Two mills have a capacity of more than 30,000 tons per annum, 9 mills from 10,000 to 30,000 tons per annum, and 24 mills fewer than 10,000 tons per annum.

B. Sulfite Pulp

Sulfite pulp is the only chemical pulp produced in large volume for use in paper in Japan, and it is in great demand by the paper industry. It is an important total or partial constituent of such papers as newsprint, printing, bond, document, blueprint, wrapper, and paper bag. Before the war much sulfite pulp was bleached and used in high-quality papers, but, because of the lack of bleaching powder caused by the shortage of salt, the production of bleached sulfite at this time is very small.

Spruce and fir (yezomatsu and todomatsu) are considered superior for sulfite pulping. Because of the availability of these woods and of the raw materials, lime and sulfur, large sulfite pulping facilities were developed in Karafuto and Hokkaido. Sulfite pulp is also produced from red and black pines (akamatsu and kuromatsu) of Honshu and Kyushu, although the sulfite process is not generally considered to be well suited for pulping pine wood. In order to cook pine successfully in Japan and to minimize difficulties caused by resin in the wood, drastic cooking conditions are used. The pulp obtained is inferior in strength and brightness to that obtained from spruce, and the yield of pulp per unit of wood is lower.

The average production of sulfite paper pulp from 1930 to 1940 was about 390,000 short tons. This represents about 48 percent of the total paper pulp for the same period. Much of the prewar production of sulfite pulp was concentrated in five mills of the Oji Paper Manufacturing Company in Karafuto. The dependency upon Karafuto for this type of pulp is shown in figure 10. Over 65 percent of the total domestic production of sulfite pulp during 1930 to 1940 was centered in Karafuto; about 5 percent was produced in Korea. The total rated capacity of remaining mills, disregarding bomb damage, is 145,760 short tons per annum. It is evident that the loss of Karafuto as a source of pulp is particularly severe to consumers of sulfite paper pulp in Japan.

Nine pulp mills are classified as producers of sulfite paper pulp, but a certain amount of this type of pulp is also supplied by rayon pulp mills. The largest mill (Tomakomai, Hokkaido) has a sulfite capacity of 45,360 short tons a year. Four mills have a capacity of from 10,000 to 30,000 tons per annum, and four mills are rated at less than 10,000 short tons per annum. Three mills are situated in Hokkaido, three in Honshu, and three in Kyushu.

C. Rayon Pulp

Wood is the chief source of cellulose for the rayon industry in Japan. Nearly all rayon pulp is produced by the sulfite process with certain modifications in the process as it is used to produce paper pulp. Purification

treatments to increase the alpha-cellulose content of sulfite pulp to the approximate 88 percent required for viscose rayon manufacture include chlorination, alkali treatment, and bleaching.

The rapid growth of the rayon industry of Japan in the years preceding the war resulted in a heavy demand for rayon pulp. Although the production of rayon pulp was expanded at a much greater rate than that of any other type of pulp, domestic production did not keep pace with demand, and Japan depended heavily on imports of this product. The growth of domestic production and the amount of pulp obtained by importation are shown graphically in figure 4. Data on production by locality are given in figure 11. Domestic production reached a peak in 1941 with the manufacture of 325,000 short tons, and imports of rayon pulp reached a high of 325,000 tons in 1937.

Consumption of cellulose by the rayon yarn and staple fiber industries of Japan, which in 1930 was less than 30,000 short tons, increased to a peak of nearly 400,000 tons in 1937. Although consumption of domestic pulp increased considerably each year through 1941, the dominant source was by importation until about 1938, after which consumption of domestic pulp exceeded that obtained by importation. Stimulus to the development of facilities for domestic production arose from the inability of the Japanese to obtain sufficient quantities of rayon pulp by importation in the years immediately preceding 1941. Nearly all of the rayon pulp consumed after 1941 was produced in Japan. Small amounts of cotton were consumed by the rayon industry, but consumption did not exceed 7 percent of the total cellulose used in any year. Cotton, because of its high alpha-cellulosic content, was considered especially desirable in the manufacture of cupra-ammonium rayon, or "Bemberg silk," which is produced by one factory in Kyushu. For the same reason, cotton linters or cotton rags were also used in the manufacture of cellulosic derivatives, such as cellulose nitrate plastics, explosives, lacquer, coatings, films, artificial leather, rocket propellants, and dynamite. The technique in some cases was to produce a tissue paper from alpha-cellulose pulp and cut this paper into pieces of equal size to promote uniform nitration. Wartime effort on the part of the Japanese resulted in the development of techniques of purification of wood pulp to a degree considered suitable for cupra-ammonium rayon, plastics, and explosives, although perhaps inferior to cotton cellulose at the present stage of development.

The wood species used for the production of rayon pulp usually depends on the locality of the mill, although in past years considerable quantities of wood for pulping were shipped from Karafuto to mills on Honshu and Kyushu. Spruce and fir (yezomatsu and todomatsu) are the chief species used in Hokkaido, and mills in Honshu and Kyushu use chiefly red pine (akamatsu), black pine (kuromatsu), and beech (buna). Although little or no hardwood is used in the production of paper pulp in Japan, the use of up to 40 percent beech is considered desirable in the manufacture of rayon pulp by certain mills. Rayon pulp produced in Japan was generally considered inferior and of less uniform quality than pulps obtained by importation. During prewar years, imported pulp was usually employed to produce high-grade rayon for the export market, while the domestic production was used to supply Japan's home needs for rayon yarn and staple fiber.

Domestic production of rayon pulp in Japan began in Karafuto as recently as 1932. Small amounts of pulp were obtained from Korea after 1936, but production in Japan Proper did not begin until about 1938. In 1941 Karafuto and Korea contributed less than one-third of the total. The extremely rapid growth of this industry in Japan Proper is thus illustrated. From a consideration of the strong situation of rayon pulp facilities in Japan Proper, the present reduced capacity of the rayon industry, and the shortage of caustic soda for rayon manufacture, the remaining equipment capacity for rayon pulp manufacture appears to be in excess of the capacity of rayon plants to consume pulp. Assuming no imports of wood pulp, rayon pulp mills may be in a position to furnish the pulp requirements of the rayon industry and in addition to supply a certain tonnage of bleached or unbleached sulfite pulp to the paper industry.

Pulp mills producing rayon pulp are in general among the largest and most modern in Japan. The eight pulp mills in Japan Proper listed below are classified as producers of rayon pulp.

District or prefacture	Company	Mill	Rated annual capacity short tons
Hokkaido	Kokusaku Pulp Industrial Co. Ltd.	Asahikawa	61,600
Yamaguchi	Sanyo Rayon Pulp Co. Ltd.	Iwakuni	34,520
Akita	Tohoku Shinko Pulp Co. Ltd.	Akita	28,000
Miyagi	Tohoku Shinko Pulp Co. Ltd.	Ishinomaki	28,000
Toyama	Kokoku Rayon Pulp Co. Ltd.	Toyama	26,880
Miyazaki	Japan Pulp Industrial Co. Ltd.	Obi	22,400
Niigata	Hokuetsu Paper Mfg. Co. Ltd.	Niigata	20,160
Aichi	Toyo Spinning Co. Ltd.	Inuyama	8,960
		Total =	230,520

Aggregate equipment capacity after reconversion or repair of bomb damage is about 230,000 tons per year and this total was nearly achieved by these mills in 1941. Production for 1945 in Japan Proper was only 10,900 tons, or about 5 percent of remaining capacity. The scarcity of sodium hydroxide and coal for both pulp and rayon manufacture are the chief causes for the low production in 1945.

D. Sulfate Pulp

The sulfate or kraft process was adopted in Japan at a time when rapid expansion of the pulp and paper industry was taking place in Karafuto with the result that the modern kraft pulp industry was centered in that peninsula. Before 1939 nearly all of the domestic kraft pulp had Karafuto as its source. No kraft pulp was produced in Korea or Formosa. The average production of kraft pulp in Karafuto, and therefore in Japan, for the years 1930 through 1938 was about 48,500 tons per year which was only about 6 percent of the total paper pulp production for the same period. Imports of kraft pulp during this period averaged about 26,000 tons per year. The production of kraft in Karafuto and Japan Proper is illustrated in figure 12. Production of kraft in Japan Proper expanded from fewer than 11,000 tons in 1939 to a peak of about 25,000 tons in 1942. By the end of the war in 1945, the rated productive capacity of all Japan was 138,349 tons, but the combined capacity of remaining mills in Japan Proper is only 53,220 tons. Thus it is readily seen that the loss of over 60 percent of the kraft pulp capacity, coupled with the loss of imports, is of serious consequence to the kraft paper industry and to industries which require products such as paper containers or multiwalled bags.

The wood species commonly used for kraft pulp are the spruce, fir, red pine, and jack pine. It seems peculiar that the kraft pulp industry, with its flexibility as far as wood requirements are concerned, should have been developed chiefly in the high-quality spruce and fir areas such as Karafuto and Hokkaido, while much of the sulfite pulping was developed in areas where pine woods are the predominant pulp wood.

Remaining kraft mills are operating under difficulties caused by shortages of coal, wood, and salt cake. Since strong and important kraft papers, such as the cement bag paper, were produced largely in Karafuto, the plant equipment and technical background to assume this burden in remaining mills has not yet been acquired. Operations observed in one of the largest kraft mills indicated that cooking procedures were yielding a pulp which would be considered of the semichemical type and which could not readily be prepared for strong papers by the cascades of Kollergangs or edge-runners used as refiners. It is fortunate for the Japanese that his mode of living thus far has not included dependency on large tonnages of containers or grocery bags.

E. Soda Pulp

The soda process in addition to its use in the pulping of wood has also been applied to digestion of straw, grass, bamboo, kozo, mitsumata, bagasse, and other fibrous materials. Nearly any kind of wood is used for soda pulp in Japan, the most important factor apparently being availability. Most of the soda pulp produced in Japan is low in strength, poor in color, and non-uniform, and it is consumed in small amounts in a multitude of papers where strength and quality are not important. Such papers include low-grade toilet tissue, box boards, certain writing papers, and Japanese-style papers, including the hand-made variety. Although well-prepared soda pulp has special characteristics which make it suitable for use in certain papers, the tendency in Japan appears to be to consume the pulp wherever it can be tolerated, rather than because of its special properties.

During the past 8 years, soda pulp was produced chiefly in Japan Proper and Formosa, with a small production in Korea. No soda pulp was produced in Hokkaido or in Karafuto. With one exception, all soda mills are located in the central and southern half of Honshu, in Kyushu, and Shikoku. Because of the small and dispersed nature of the industry, no data are available on production prior to 1938. Total production of soda pulp increased from about 3,000 short tons in 1938 to a high of about 117,000 short tons in 1941. In the latter year, the production was about 11 percent of the total production of paper pulp. About one-third of the 1941 production was centered in Formosa. Soda pulp mills total about 50; thus, in Japan Proper in the highest production year, the average annual production per mill was only about 1,500 short tons. The largest mill has a rated annual capacity of 5,380 short tons.

The production of soda pulp is at a virtual standstill now because of the shortage of caustic soda. The process as practiced in Japan is wasteful of caustic soda, because the size of the mills is so small that recovery of chemical is not feasible. However, given sufficient chemical, these mills are able to contribute to relief of the fiber shortage by pulping straw, grass, bamboo, or other materials which normally would not be used by larger pulp mills.

Paper

To an observer familiar with modern Western methods of producing paper, the Japanese industry appears to be an incredible blend of the reasonably modern with the very old. Many machines are very small in size and low in production, and even hand-made papers seem to be capable of competition with modern machines. This condition is perhaps due in part to the low wage standards of the workers, and, in the case of hand-made papers, to a historical emphasis given to the many special papers incapable of production on modern machinery.

The manufacture of hand-made papers in Japan is a fascinating subject involving a study of the mode of living and culture of the Orient. While it is true that certain of these papers have a singular and distinctive beauty,

their charms have often been exaggerated over the centuries by writers and artists to the point where papers are endowed in terms of attributes usually reserved for humans, such as "masculinity," "dignity," and "sweet temper." Because of the complete dissimilarity of equipment and techniques of manufacture of hand-made and machine-made papers, no detailed description of the industry is given in this report. It may surprise persons familiar with the tedious methods of making hand sheets, however, to note that the production of hand-made papers in Japan in past years was of the order of 30,000 tons per year.

Because the Japanese produced certain papers peculiar to their culture for hundreds of years before machine papers were known to them, the superposition of "foreign-style" paper in relatively recent years resulted in a confusion of classification of the various papers. Originally it was sufficient to distinguish "foreign-style" from "Japanese-style" paper, as the former referred clearly to a wood pulp sheet of doubtful quality, which was machine-made and available in sufficient quantity for consumption by people of moderate means in the form of newspapers, office papers, and wrappings. As machine-made papers became competitive with the classic hand-papers, however, a further subdivision into "machine-made Japanese papers" and "hand-made Japanese papers" was necessary. The classification is thus more dependent on the specific use than the origin of the paper. As an example, a ground-wood and sulfite machine-made toilet tissue may be "foreign style" if sold in the household roll form, or "Japanese style" if converted to the flat packaged sheets often used by the Japanese. A machine-made paper for writing use with the traditional charcoal and brush may be considered "Japanese style" paper, but the same paper applied to office typewriter use would be clearly "foreign style." At one time, papers produced from the inner bark of the mulberry were all hand-made and thus easily distinguishable from "foreign-style" papers, but certain machine techniques were developed to use these long fibers to produce quality papers, and as an example some of these papers were used in the bombing balloons and in the paper money of Japan.

The so-called "foreign-style" papers which constitute most of the total paper tonnage in Japan are made almost entirely from common wood pulps. The types of paper include newsprint, printing, wrapping, coated papers, photographic, bond, ledger, blue print, drawing, cigarette, glassine, condenser, blotter, bank note, bible paper, toilet tissue, wadding, containers, boards, etc. The machinery is orthodox, of the Fourdrinier, cylinder, Yankee, or combination types. Some of the machines were produced in England, the United States, and Switzerland, and the Japanese-built machines in most cases appear to be copied from imported models. Processing or refining equipment usually consists of ordinary beaters and Jordans, and in some cases Kollergangs. A large amount of coated or "art" papers was made before the war, but coating materials are not available or are very scarce at present. Coating is usually done on conventional coating equipment apart from the paper machines. Size-tub equipment was common, but no modern equipment for on-machine coating was observed. Supercalenders are common and are used in the production of glassine and other thin papers having a high gloss. The Japanese excelled in the manufacture of thin special papers such as a hemp paper for use as a silk wrap, high-quality

cigarette paper for the tobacco monopoly and export, and kraft condenser paper as thin as 0.0005 inch. Other special high-quality watermark papers were made for bank note paper for export to China. Since rosin for sizing was largely imported before the war, it is now almost completely unavailable, and this is reflected in the poor water resistance of most papers. Papers made from pine sulfite pulp often had adequate water resistance without the use of sizing, presumably due to natural resins in the wood. Little progress was made in the development of new special papers, or combinations of paper and chemicals for war use, although certain papers are used to a limited extent for artificial leathers or are twisted and used for fabrics. Such recent special papers as moisture-vapor barriers or even wet-strengthened papers appear to be almost nonexistent.

Machine paper mills in Japan number about 275. Of a total of about 500 paper machines somewhat over 100 are Fourdriniers of the conventional type varying in width from about 42 inches to 180 inches, and about 400 machines are of the cylinder, Yankee, or special types varying in width from about 20 inches to 148 inches, with nearly all of the latter group being less than 100 inches wide. A large portion of the paper mills are clustered about the principal cities as may be seen in the location map of paper mills given in figure 13. The largest mill by a considerable margin is the newsprint plant of the Oji Paper Manufacturing Company at Tomakomai, Hokkaido. This mill has ten paper machines, seven of which are 142 inches wide. The Tomakomai mill produces nearly all of the newsprint for Japan, the balance being made by the Kushiro, Yatsoshiro, and Sakamoto mills of the Oji Company. Damage to paper mills due to bomb raids was greater than that suffered by the pulp mills chiefly because of the location of plants. Fire damage to certain mills in the large city areas was great, and this fact, coupled with shortages of coal, pulp, and machine parts, had reduced production to about one-third of prewar. Machine wires and felts, particularly the former, were difficult to obtain immediately after the end of the war. Nearly all of the felts and wires were produced by subsidiaries of the Oji Paper Company. Much of the wire-producing capacity was burned but was quickly repaired in a makeshift fashion. The large and modern Nippon Felt Company was undamaged but is dependent upon foreign sources of wool.

By-products and Research

A few of the larger sulfite pulp mills utilize their waste liquor for the production of ethyl alcohol. Although much of the alcohol was made in Karafuto mills, by the end of the war new plants were under construction in Japan Proper. Modern equipment included continuous fermentation equipment. Sulfite waste liquor was also concentrated in crude wooden tanks or in modern multiple effect evaporators to produce a material for use as a binder for charcoal briquettes, as an adhesive for paper, and as a tannin substitute. For use as adhesives the waste liquor was treated with lime to a pH of 4.6 before evaporation to a concentration of about 200 grams per liter. The high percentage of screenings obtained from the sulfite pulping of pines are disposed of chiefly in the production of insulating boards, a common name for which is "Tex-board." The screenings are usually reduced in size in an edge runner and the boards continuously formed on a small filter,

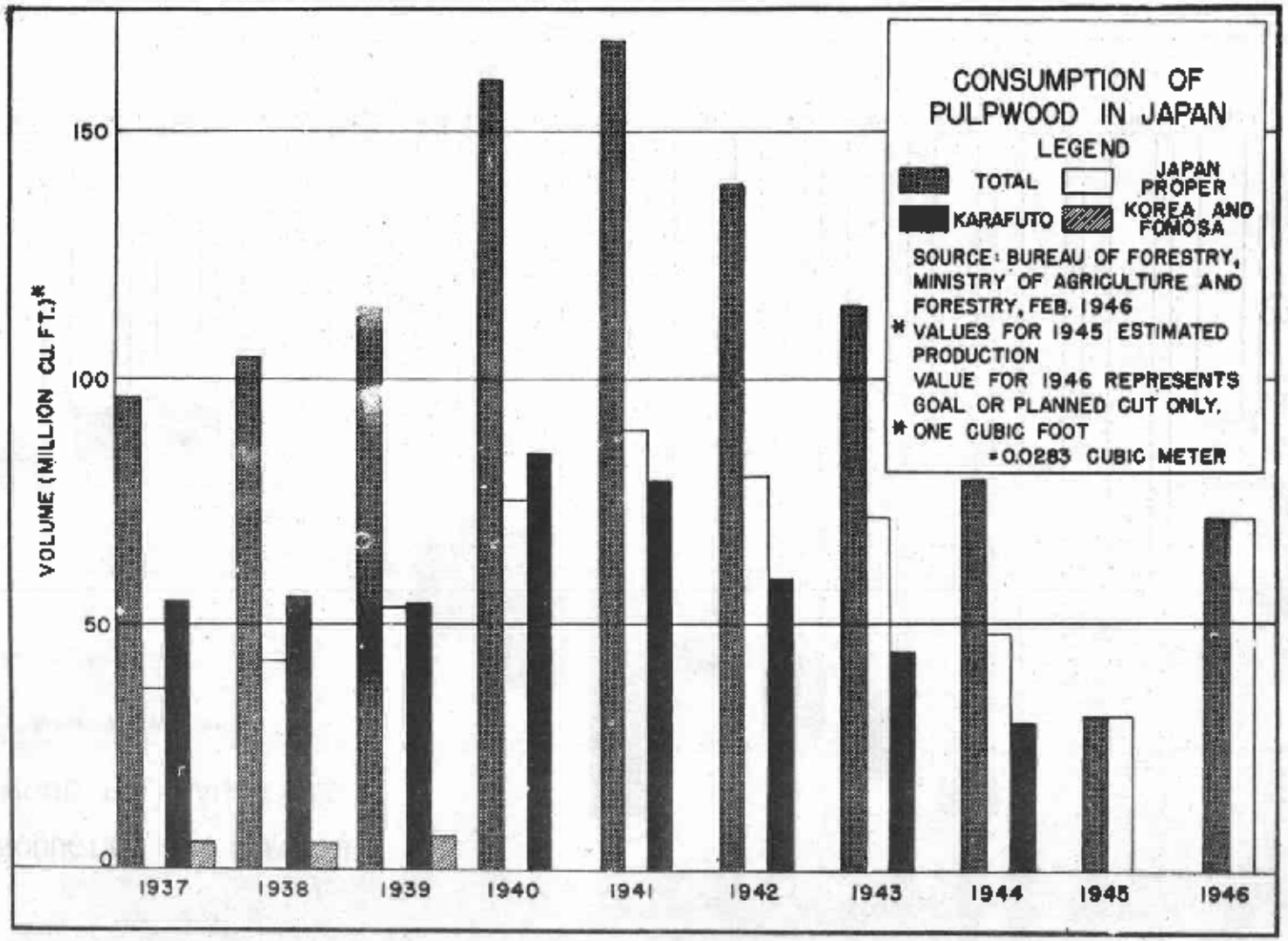
and placed in frames for air or kiln drying. Other related products of perhaps lesser importance include crude rosin from pine stumps which is steam distilled to yield wood rosin and turpentine, the refining of pine root oil for fuel and lubrication, the manufacture of a building brick from coal ashes and lime, and the manufacture of turpentine from sulfite digester vapors.

The most important and most highly developed research on wood products has been in the field of cellulose chemistry as related to the chemical utilization of pulp, particularly for rayon. Principal research efforts related to pulp and paper have been made by the Central Laboratory of the Oji Paper Company, the Institute of Fiber Chemistry at Kyoto Imperial University, Tokyo Imperial University, and other branches of the Imperial universities. Shortages caused by the war have naturally altered the emphasis of study. Much effort appears to be given to the alleviation of salt and fiber shortages. Experiments observed included the continuous electrolysis of sea water in a mercury cell to obtain caustic soda and chlorine for use in pulping. Caustic solutions up to about 20 percent concentration can be made by this method. The hydrogen evolved in the electrolysis was being used for experiments on the production of fertilizer from sulfite waste lignin and rice hulls. It was hoped that the chemicals obtained from the electrolysis could be used in the pulping of straws, woods, and the purification of rayon pulps. Other research efforts were on pulping by the nitric acid method, lignin resins for plastics, sulfite turpentine oil, alcohol produced from artichokes or potatoes, and on pine, beech, and larch for rayon or high-alpha pulps.

Personnel

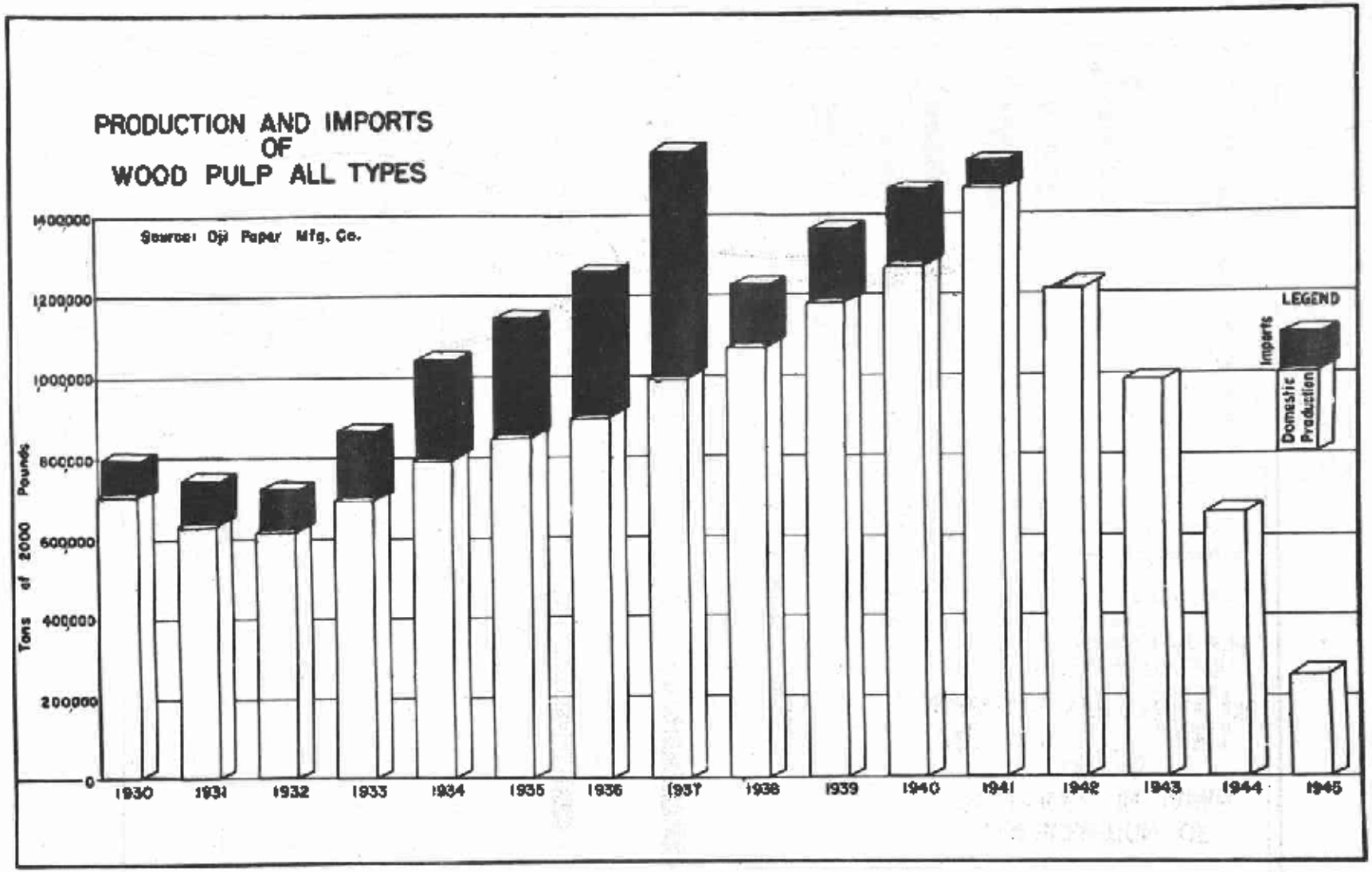
The wage and living standards of Japanese mill workers is very low by Western standards. Labor-saving equipment, conveniences for employees, and safety devices seem to be at a minimum. Female labor is widely used and in an uncommon number of instances the difficult work such as log barking and the hand loading of railroad cars appears to have been assigned to the girls or women, probably because the wage scale for females is lower.

The take-home pay of a typical worker is a confused and vague mixture of several components of which "salary" may be only about one-quarter of the total. Other compensations include such items as "commodity allowance," "residence allowance," "special allowance," "service allowance," and "no absence bonus." In addition, small amounts of fish and rice may be given. A common convenience for employees is the traditional community hot bath which is built for employees at principal mills. The water for this bath is maintained at a high temperature by the use of mill process steam.



Z M 72107 P

FIG. 1



Z K 72108 F

FIG. 2

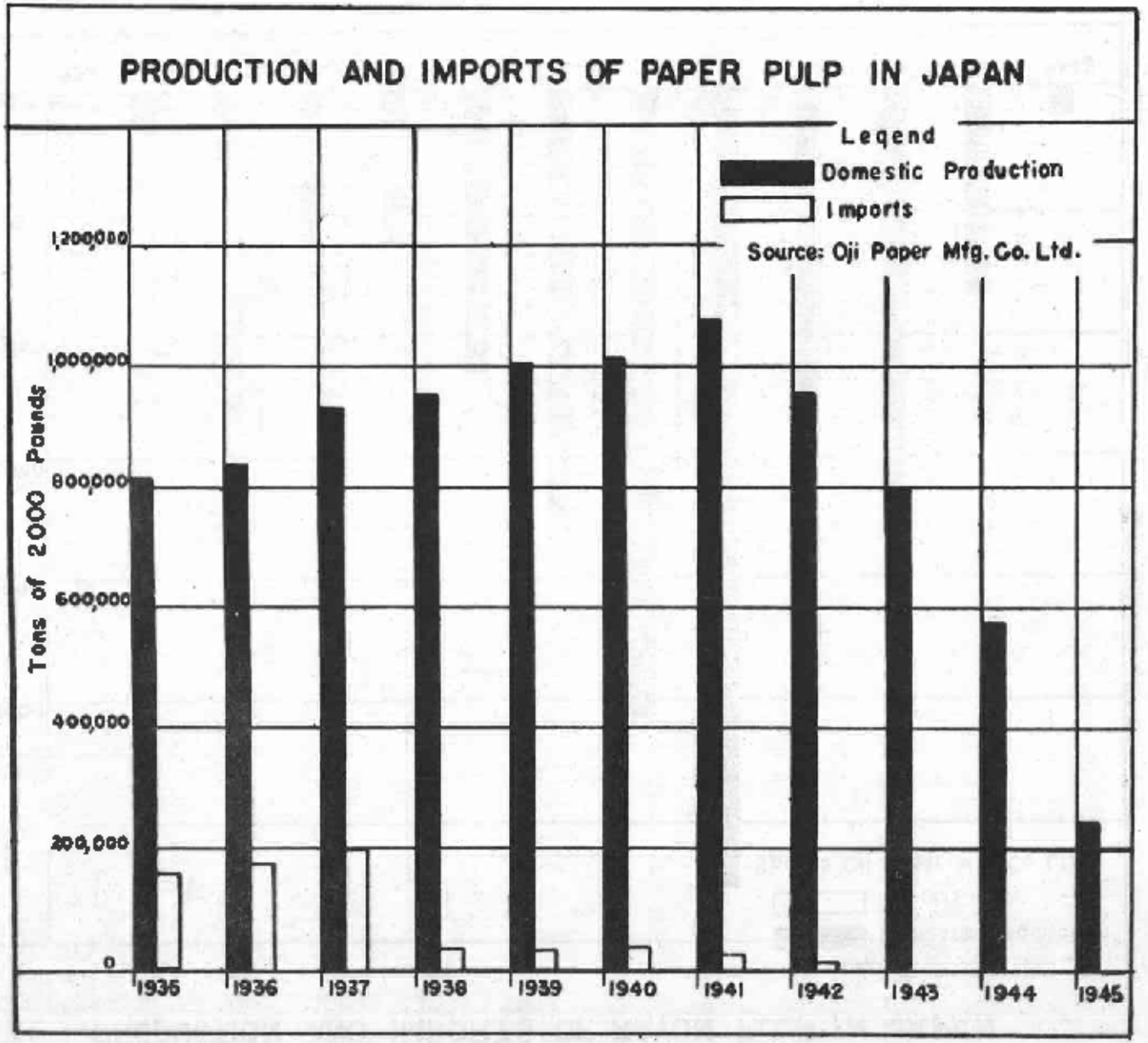
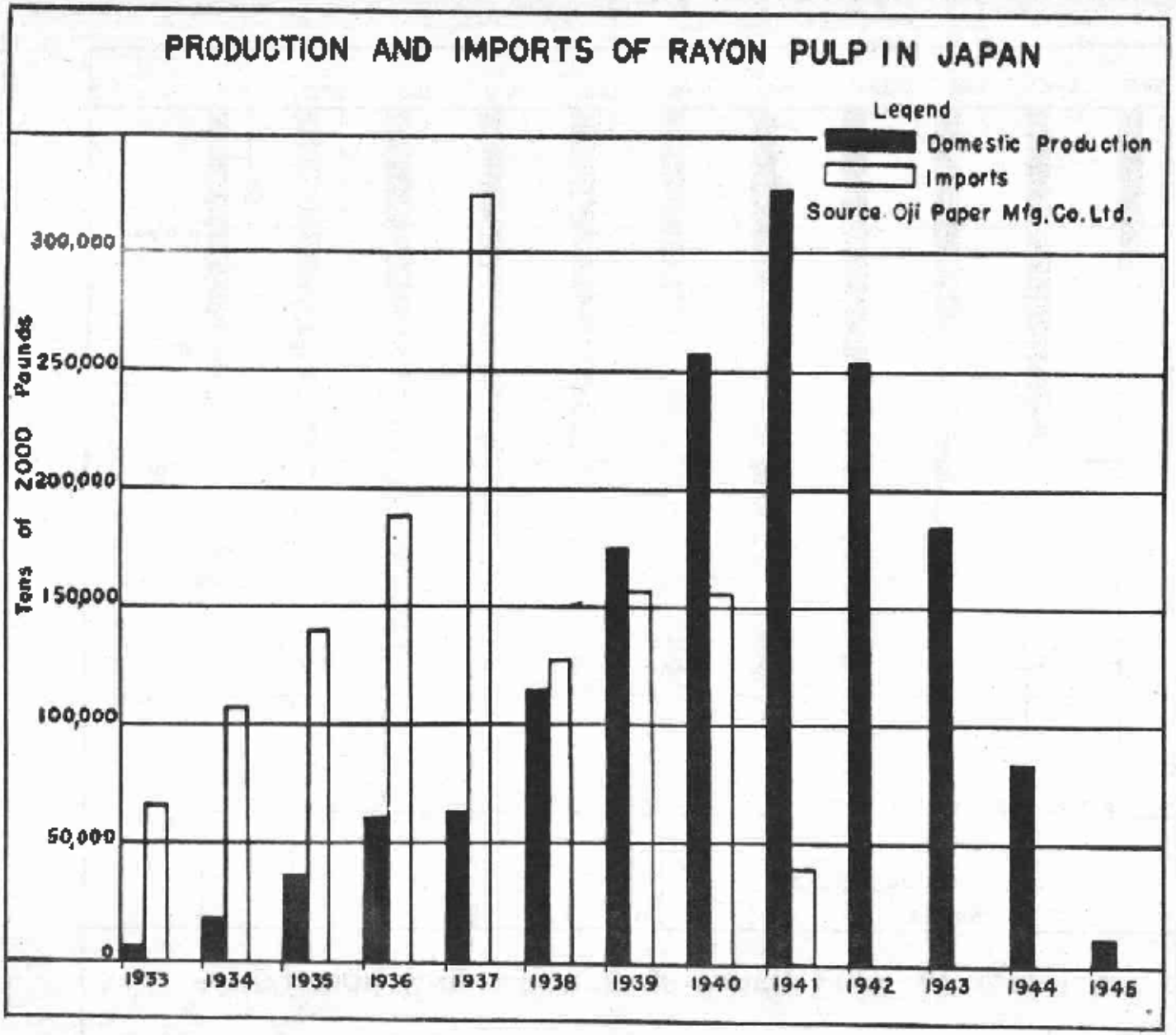
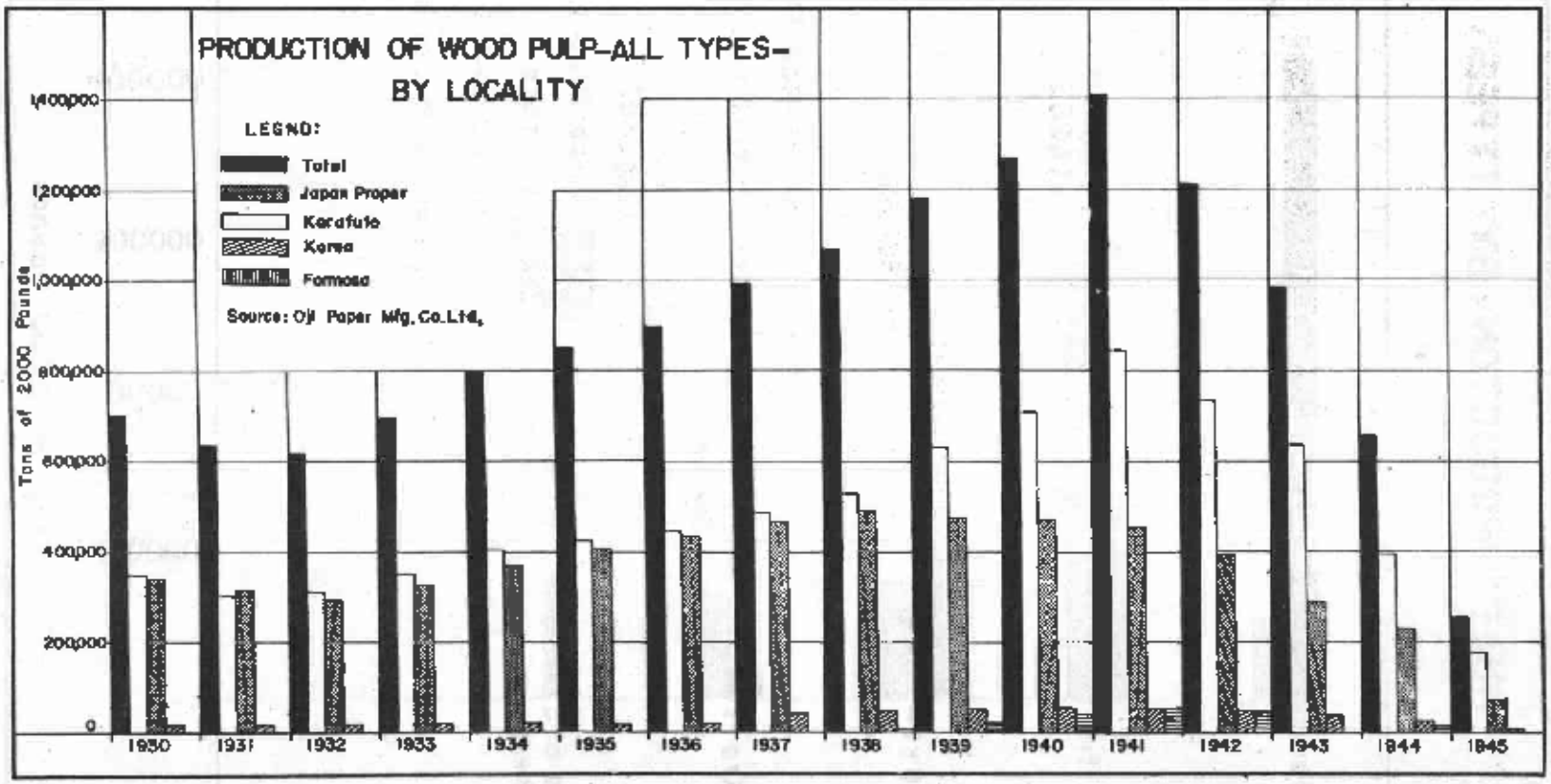

PRODUCTION AND IMPORTS OF PAPER PULP IN JAPAN
Legend
Domestic Production
Imports
Source: Oji Paper Mfg. Co. Ltd.
Tons of 2000 Pounds
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945

FIG. 3



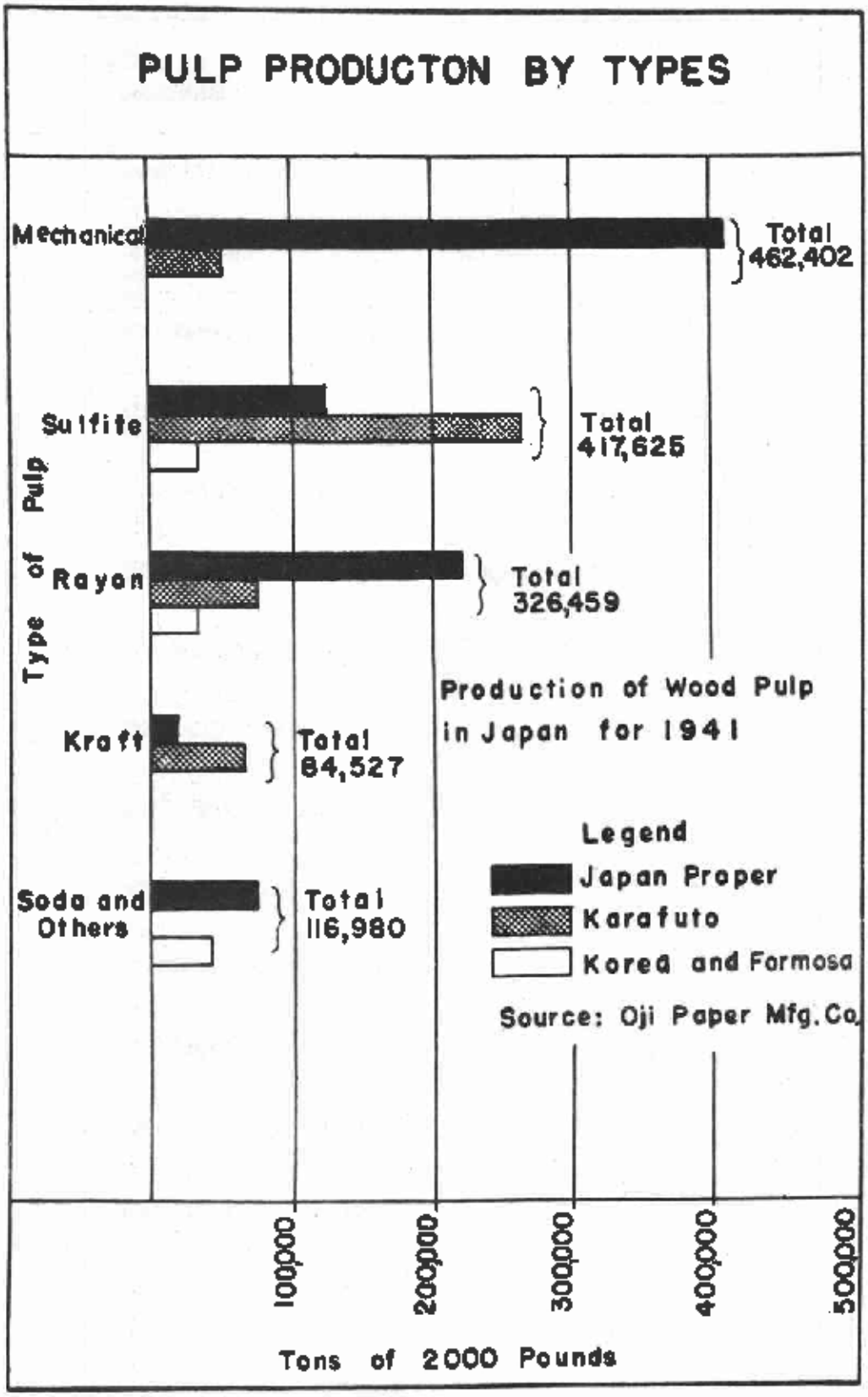
Z M 78110 F

FIG. 4



Z M 72111 F

Fig. 5



Z M 72112 F

FIG. 6

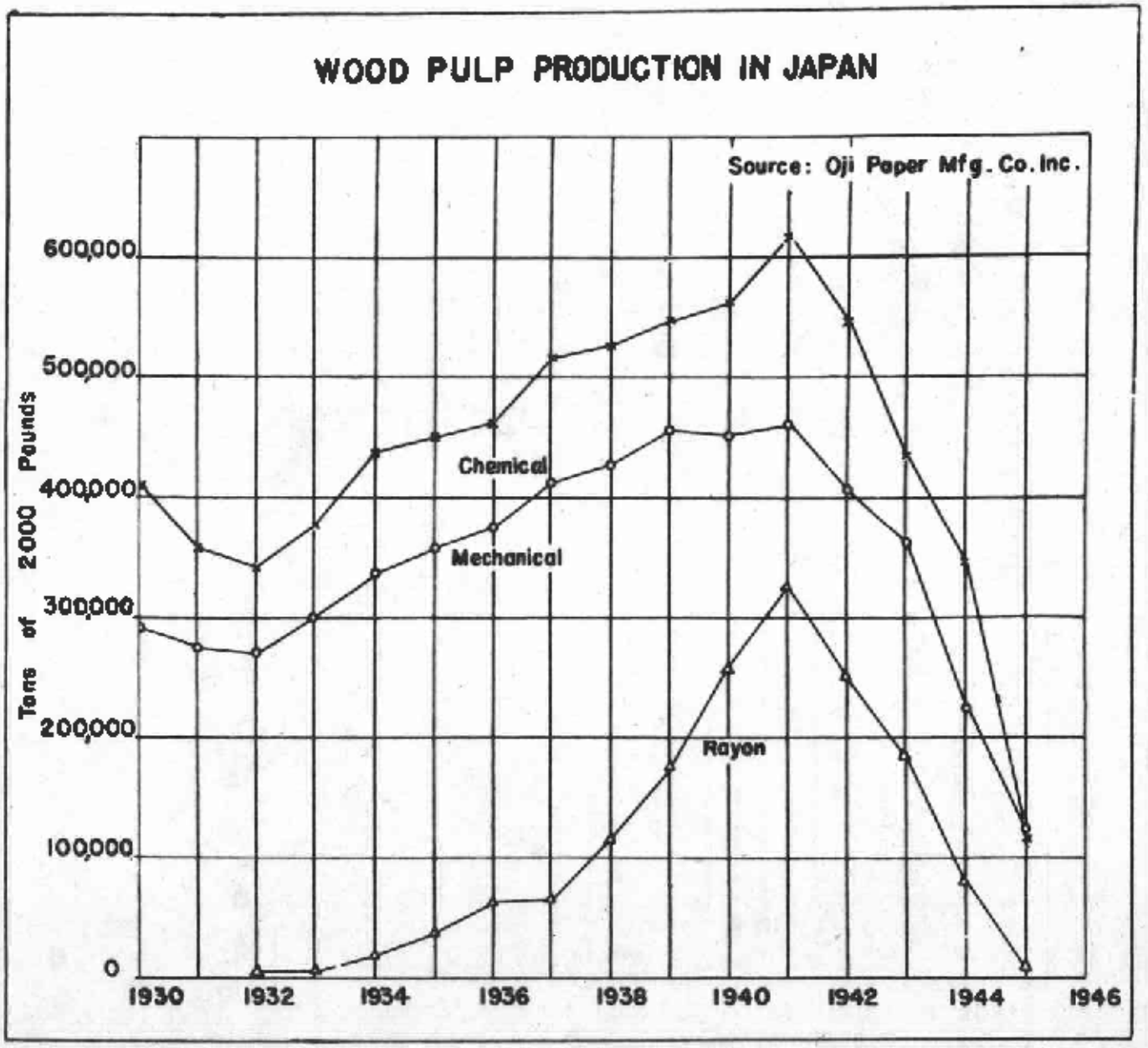
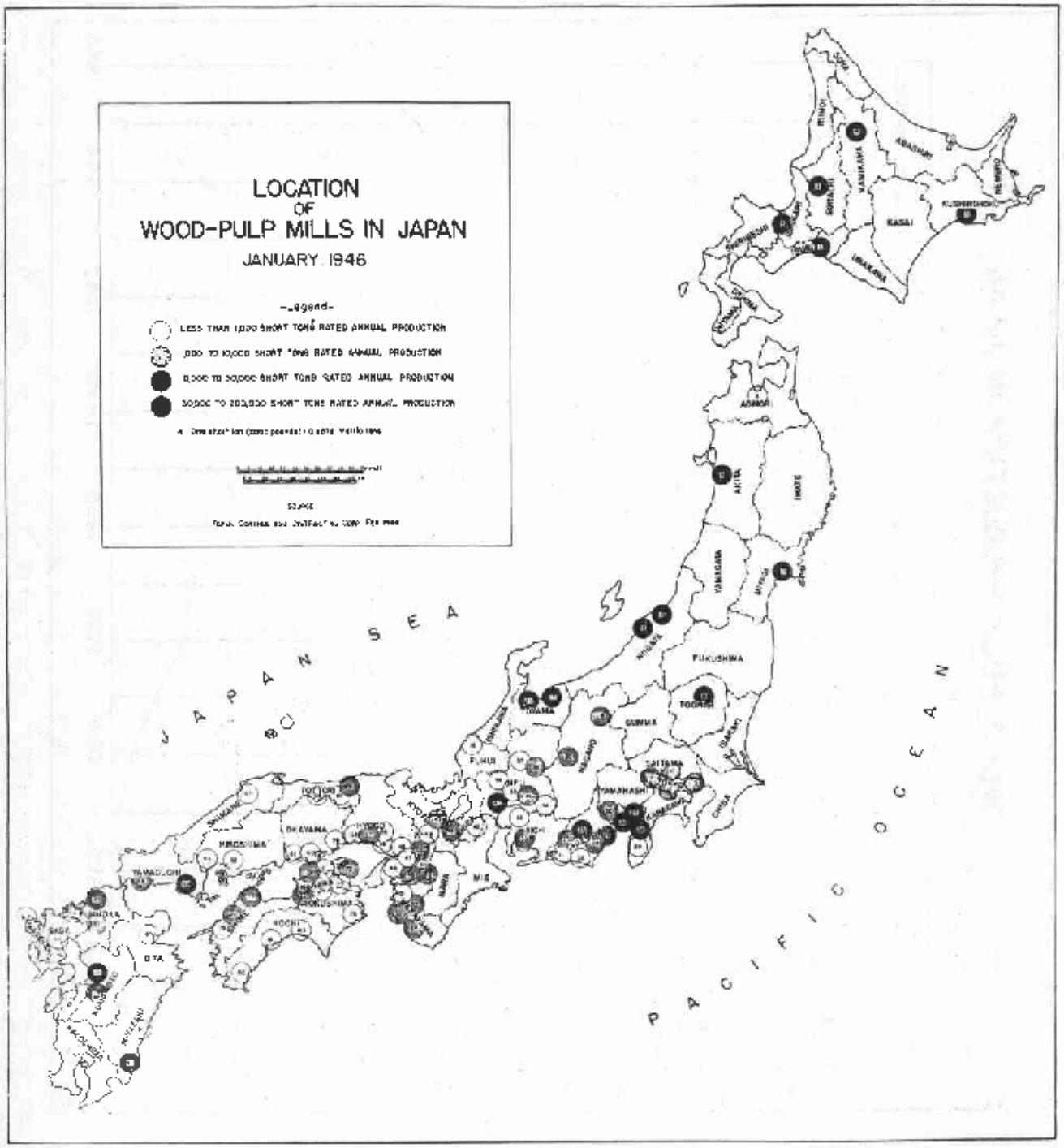

WOOD PULP PRODUCTION IN JAPAN
Source: Oji Paper Mfg. Co. Inc.
Tons of 2000 Pounds
600,000
500,000
400,000
300,000
200,000
100,000
0
Chemical
Mechanical
Rayon
1930
1932
1934
1936
1938
1940
1942
1944
1946

FIG. 7



Z M 72114 F

FIG. 8

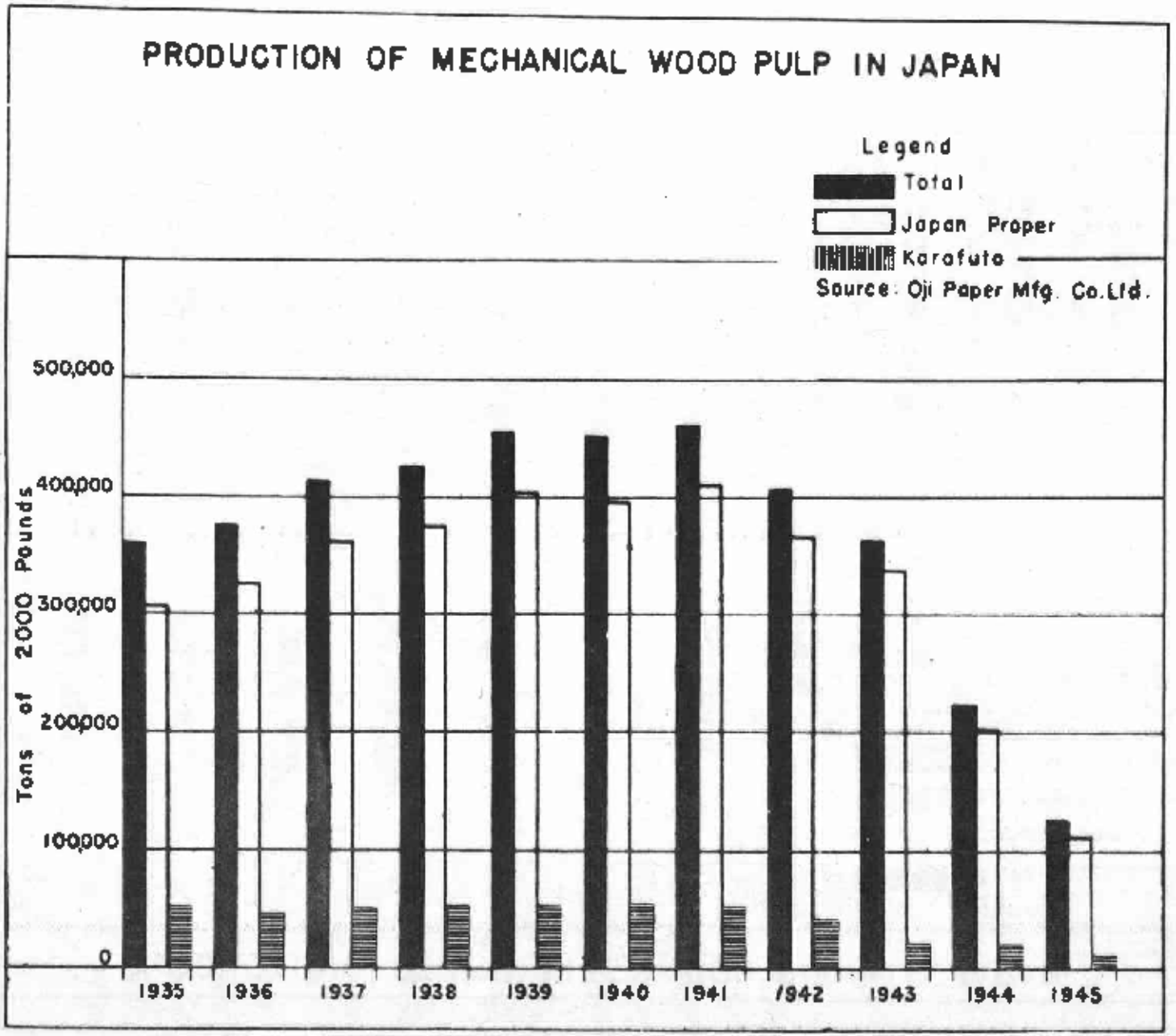

PRODUCTION OF MECHANICAL WOOD PULP IN JAPAN
Legend
Total
Japan Proper
Karafuto
Source: Oji Paper Mfg. Co.Ltd.
Tons of 2000 Pounds
500,000
400,000
300,000
200,000
100,000
0
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945

FIG. 9

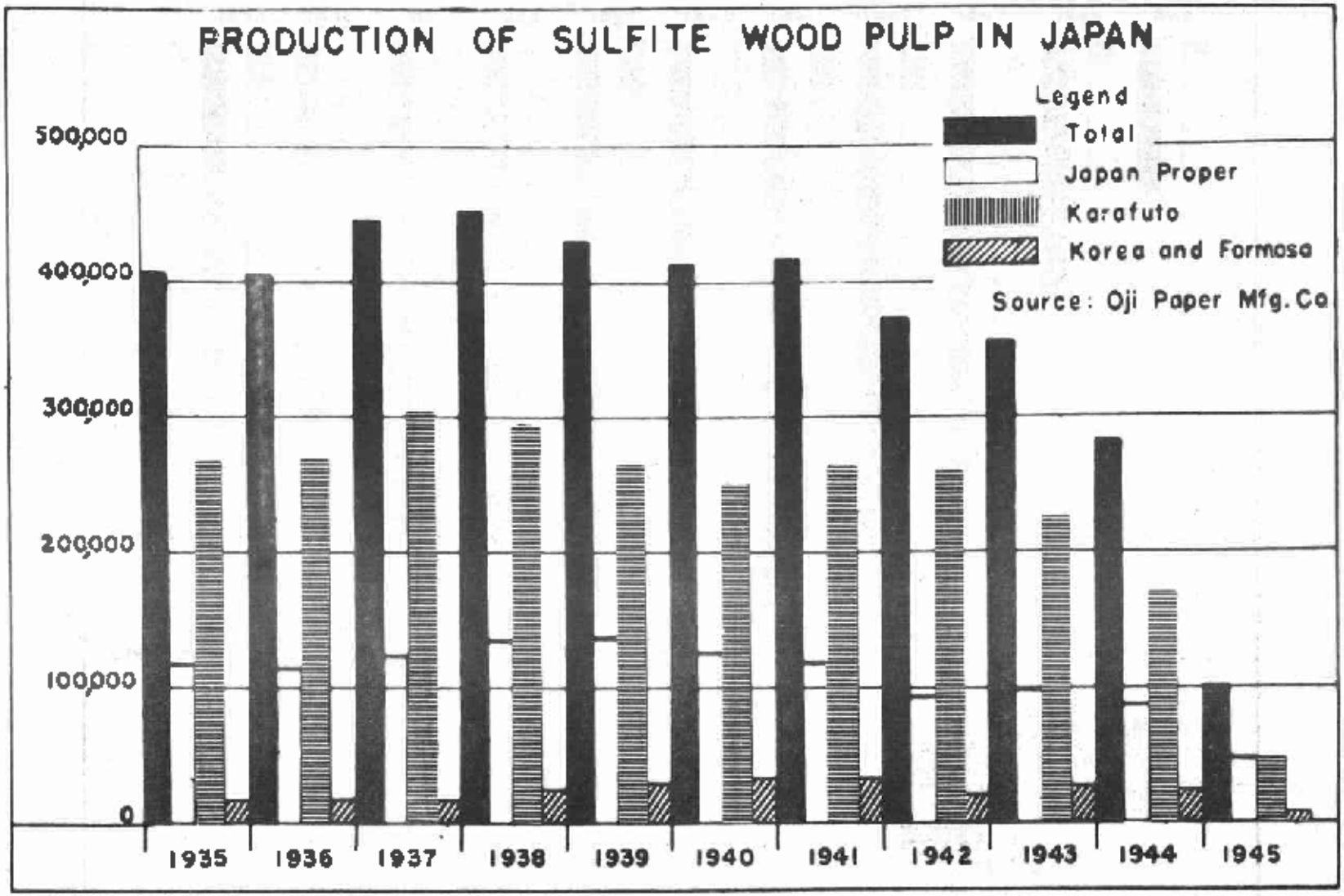

PRODUCTION OF SULFITE WOOD PULP IN JAPAN
Legend
Total
Japan Proper
Karafuto
Korea and Formosa
Source: Oji Paper Mfg. Co
500,000
400,000
300,000
200,000
100,000
0
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945

FIG. 10

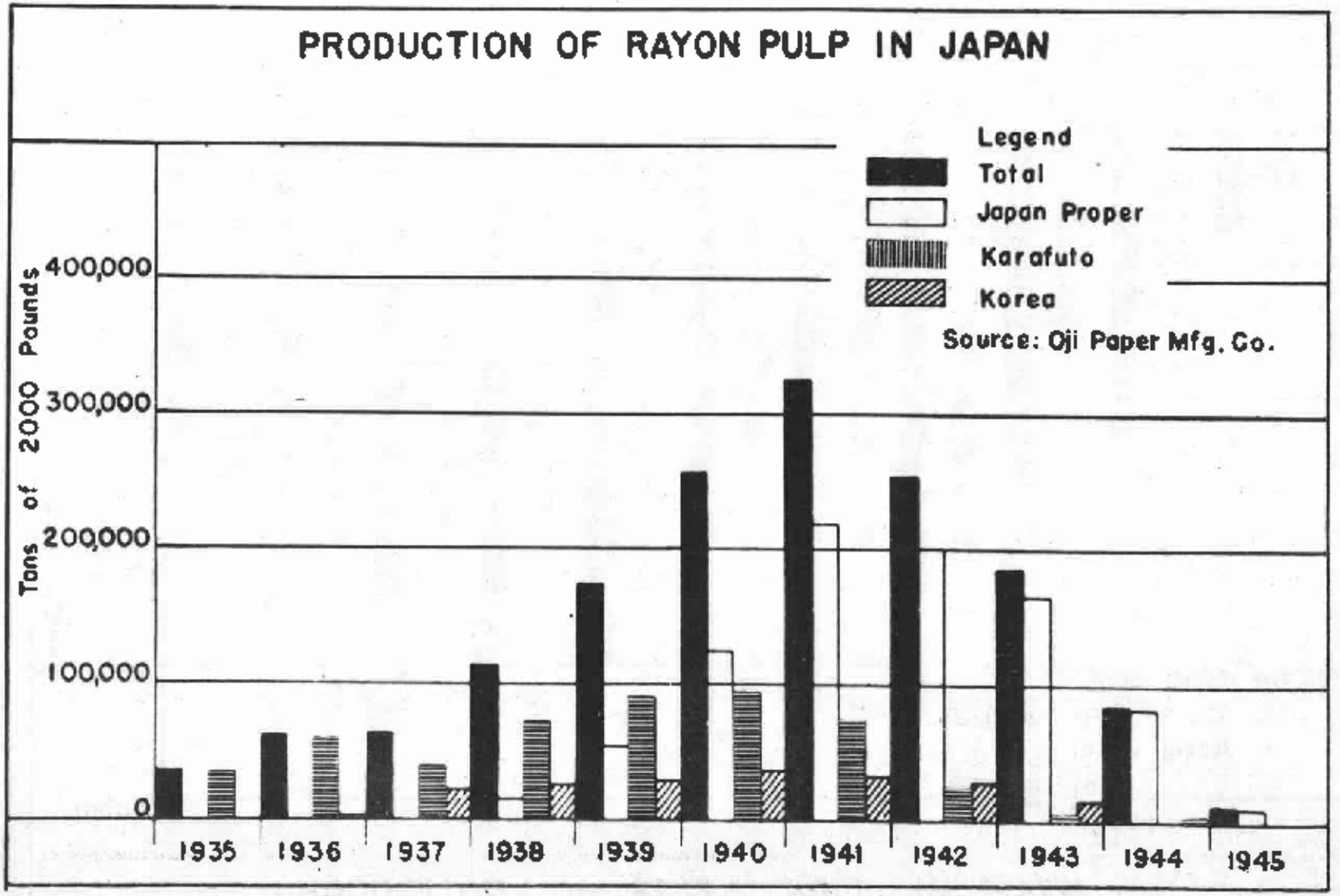

PRODUCTION OF RAYON PULP IN JAPAN
Legend
Total
Japan Proper
Karafuto
Korea
Source: Oji Paper Mfg. Co.
Tons of 2000 Pounds
400,000
300,000
200,000
100,000
0
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945

Fig. 11

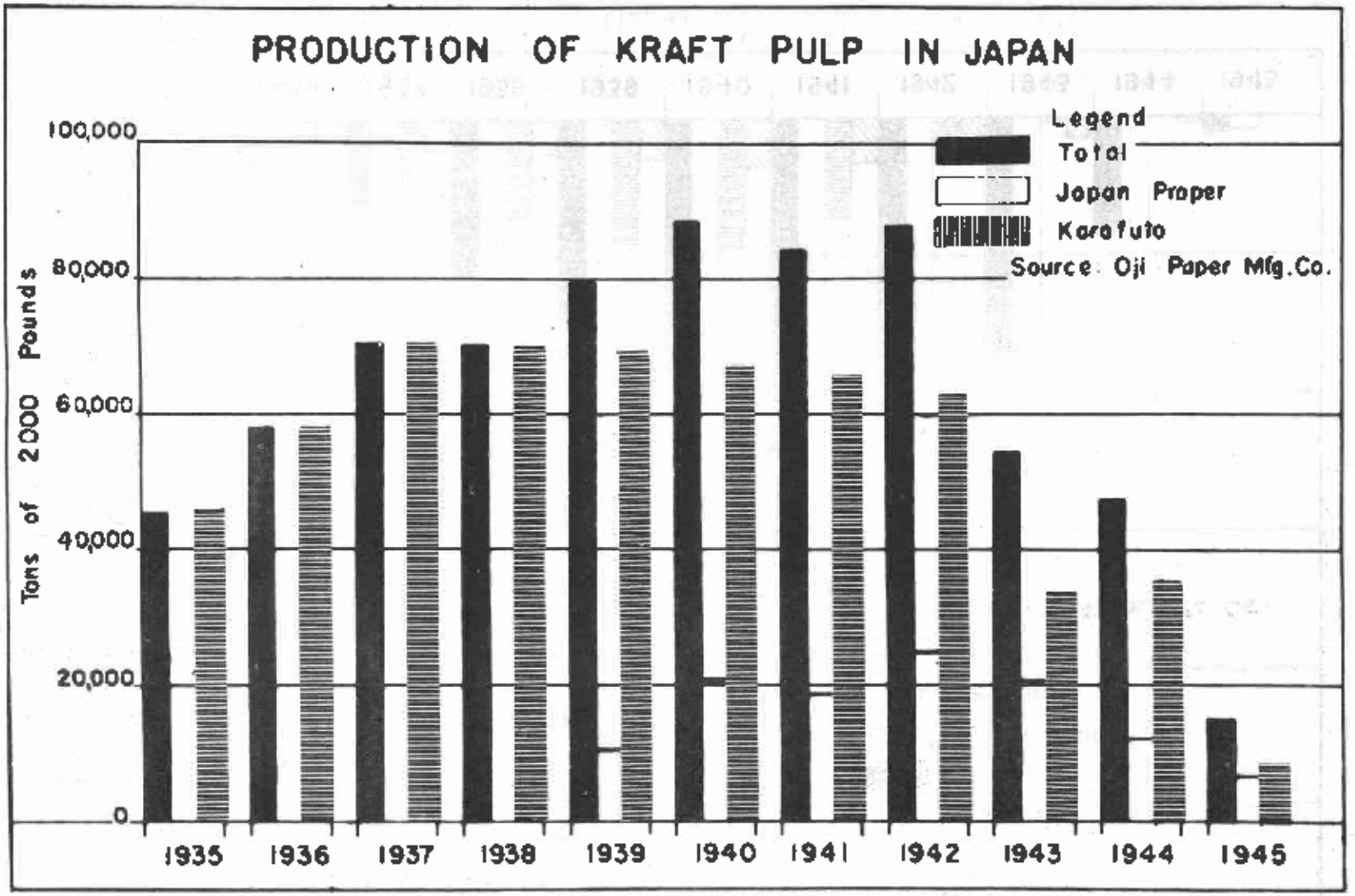

PRODUCTION OF KRAFT PULP IN JAPAN
Legend
Total
Japan Proper
Karafuto
Source Oji Paper Mfg.Co.
Tons of 2000 Pounds
100,000
80,000
60,000
40,000
20,000
0
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945

Fig. 12

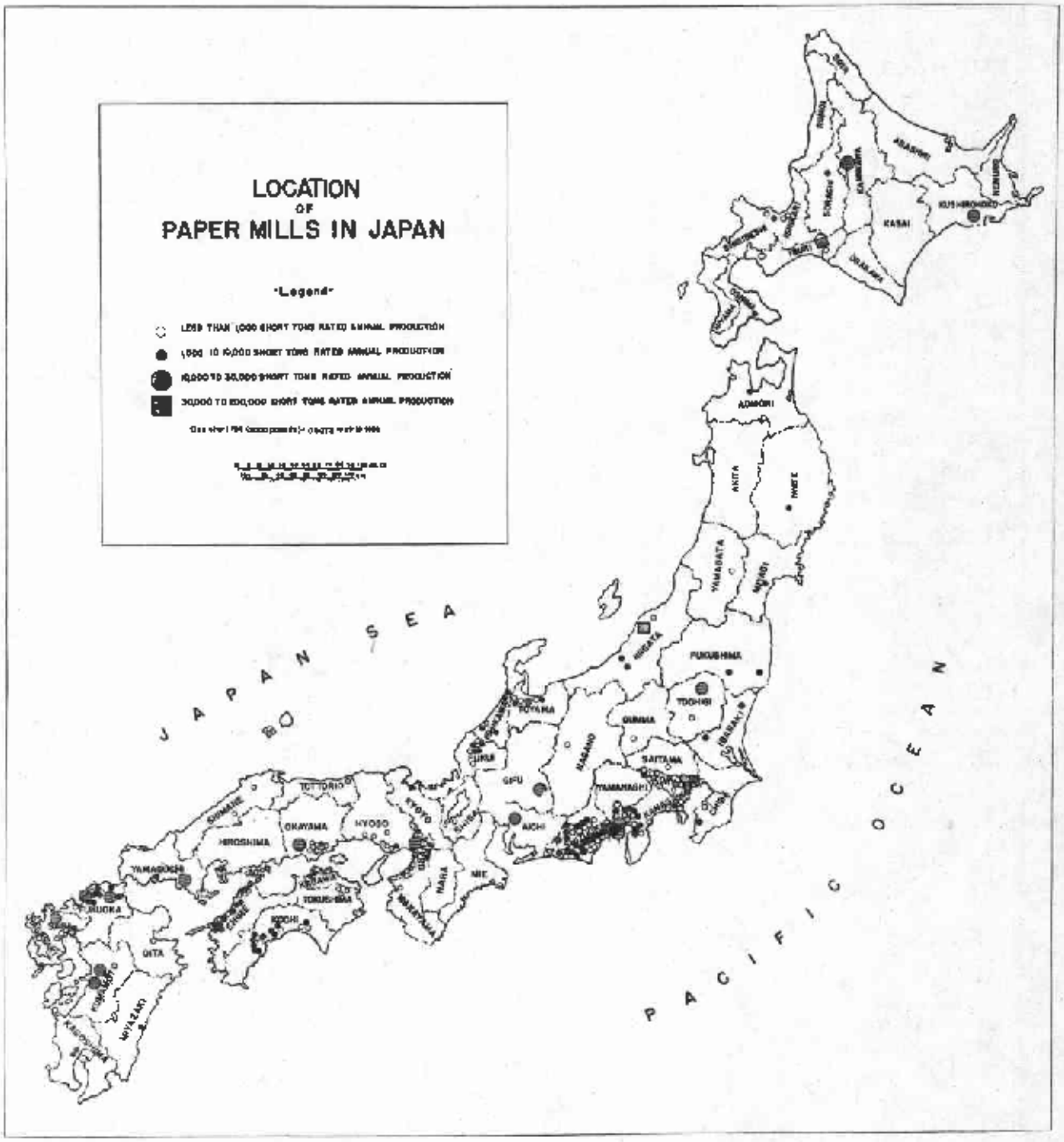

LOCATION
OF
PAPER MILLS IN JAPAN
"Legend"
JAPAN SEA
PACIFIC OCEAN
HOKKAIDO
AOMORI
AKITA
IWATE
YAMAGATA
MIYAGI
FUKUSHIMA
NIIGATA
TOYAMA
GUNMA
TOCHIGI
SAITAMA
GIFU
NAGANO
YAMANASHI
AICHI
SHIZUOKA
TOTTORI
SHIMANE
OKAYAMA
HIROSHIMA
HYOGO
KYOTO
SHIGA
NARA
MIE
YAMAGUCHI
TOKUSHIMA
KOCHI
OITA
MIYAZAKI

Fig. 13