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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Methods of High Frequency Induction Heating and Melting.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. [illegible]5.

1. Subject report, dealing with Target X-37(N) of Fascicle X-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Frank T. Chestnut, U.S. Naval Technician.

C. G. GRIMES
Captain, USN

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RESTRICTED X-37(N)

JAPANESE METHODS OF HIGH FREQUENCY INDUCTION HEATING AND MELTING

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE X-1, TARGET X-37(N)

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

MISCELLANEOUS TARGETS

JAPANESE METHODS OF HIGH FREQUENCY INDUCTION HEATING AND MELTING

Although the Japanese have installed many more high frequency induction furnaces, in proportion to the size and importance of their country, than other countries, they have not used them as effectively or for as varied a field of application as have others. Except for the melting of special metals and alloy steels, the making of tungsten carbides, and one experimental armor plate hardening process, the Japanese apparently overlooked the value of this method of heating in the manufacture of war materials.

With about 18,000 kw of melting capacity reported before the war, Japan added 20,000 additional kw of melting capacity during the war. Less than 700 kw was allocated for experimental work in the field of heating for hardening, surface hardening, or forging operations. Overlooking the war losses and the kilowattage installed by the other Axis countries during the war, (the figures for which are not available) Japan has some 18% of the world's total high frequency melting capacity.

Japan's status in the induction heating field can be said to be dated between 1930 and 1933. The writer introduced the first commercial equipment in 1930, and finds that the technique and type of apparatus used is substantially the same now as then, even though great strides have been reported widely in the patent and trade literature, especially in the U.S. Research and introduction of improvements have been almost nil.

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REFERENCES

Location of Target and Japanese Personnel Interviewed:

1. Mitsui and Co., TOKYO Main Office.
   H. REIZEI, Chief of Machinery Section, Engineering Dept.
   S. ITO, Engineer Machinery Section, Engineering Dept.
2. Tokyo Shibaura Electric Co., MITSUI Main Office and SHIBAURA Main Office, TOKYO, SHIBAURA, YANAGAMACHI, and TSURUMI Works.
   N. MATSUMOTO, Asst. Sales Manager (TOKYO).
   M. OMORI, Engineer in Furnace Department TOKYO).
   H. SEKI, Lawyer (TOKYO).
   K. ITO, Commercial Dept. (TOKYO).
   Y. OKAMURA, Metallurgist (YANAGAMACHI).
   K. YAMAGUCHI, Manager (TSURUMI).
   Y. NIFUMINA, Chief Engineer in Charge of Research (TSURUMI).
   K. SHOBAYASHI, Chief Engineer Metallurgy Dept. (TSURUMI).
   S. WADA, Chief Engineer Metallurgy Dept. (TSURUMI).
3. Tohoku Imperial University, SENDAI.
   Dr. K. HONDA, Past President and Magnetic Expert.
   Dr. T. KUMAGAI, President.
   Dr. H. MASUMOTO, Professor of Physics and Magnetic Expert.
4. TOHOKU KINZOKU KOGYO, SENDAI.
   Dr. H. TAKAGE, President.
   K. SHIMBA, Metallurgist.
   T. YAMAMOTO, Resident Metallurgist.
   C. USHIODA, Engineer on Tungsten Products.
5. Tokyo Imperial University, TOKYO.
   Dr. T. MISHIMA, Professor and Magnetic Expert.
6. Second Naval Technical Institute, Naval Research Laboratory, TOKYO.
   ARAKI, Engineer in Charge of Research.
7. Oki Electric Co., TOKYO.
   Through Shibaura and Nippon Electric Group.
8. Nippon Electrolytic Iron Works, TSURUMI.
   T. MESAKO, Manager.
9. Daido Electric Steel Co., NAGOYA.
   Y. SHIMOIDE, President.
   H. NODA, Superintendent ATSUTA Plant.
   S. NISHIKIORI, Superintendent HOSHIZAKI Plant.
10. TOKAI DENKYOKU KOGYO, NAGOYA.
    G. SAKURAI, Chief of Manufacturing Section.
11. Tokyo University of Engineering, TOKYO.
    Prof. T. TAKEI, Magnetic Expert.
12. Sumitomo Light Metals Co., NAGOYA.
    W. MUKAMOTO, Manager.
13. Sumitomo Metal Industries (Steel Works Inc.), OSAKA.
    S. FURUTA, President and KAWAII, Director of SUMITOMO HONSHA.
    S. YANAGISAWA, General Manager Industry and Manager Steel Works.
    S. HORI, Chief of Research Laboratory.
14. Kawasaki Airplane Co., AKASHI.
    Via Shibaura group, TOKYO, and Sumitomo group, OSAKA.
15. Kure Naval Base.
    Admiral A. YAMAKI
    Capt. (Ord.) S. TAKEBAYASHI
    Lt. Comdr. K. HORIKAWA
    Lt. Comdr. N. HAGIWARA
    Lt. Comdr. T. MORI

16. Nippon Iron and Steel Co. Ltd., TOKYO and YAWATA.
    - M. HIRASE (TOKYO).
    - T. SHIMAMURA, Metallurgist (TOKYO).
    - M. TAKAHASHI (TOKYO).
    - SASABE (TOKYO).
    - T. KITAMURA, Engineer in charge of operations (YAWATA).

    Nippon Iron and Steel Co. Ltd., (Continued)
    - S. OKAMOTO (YAWATA).
    - I. KOHIRA, Chief of Steel Production (YAWATA).
    - N. SUNAGA, Chief of Rolling Mill.
17. Naval Air Factory, HIRO.
    - Admiral A. YAMAKI and Staff at KURE.
18. MITSUI SEIKI KOGYO, OKAGAWA
    - F. NOBU, Manager.
    - R. OKAMURA, Engineer and Assistant Manager.
19. Nippon Electric Co., TOKYO and TAMAGAWA.
    - Dr. Y. NIWA - Manufacturing Division and Chief Engineer (TOKYO).
    - M. FUKUSHIMA, Management Dept. (TOKYO).
    - K. KOBAYASHI, Asst. Superintendent (TAMAGAWA).
    - O. ITO, Superintendent (TAMAGAWA).
20. Osaka Arsenal, OSAKA.
    - Via Shibaura and Official Chief of Ordnance (U.S.) groups.
21. FURUKAWA Electric Co., NIKKO.
    - T. KAWAMURA, Casting Engineer.
22. Special Alloy Manufacturing Ci., TSURUMI (SHIBAURA Subsidiary).
    - K. OKAMURA, Metallurgist, Shibaura YANAGAMACHI Works.

LIST OF ENCLOSURES

(A) List of High Frequency Furnace Installations in Japan as Reported to Ajax Electrothermic Corporation (Licensors) Before the War.

(B) Lists of High and Low Frequency Furnace Installations Made in Japan During the War as Reported by the Mitsui and Shibaura Companies.

(C) "Electric Surface Hardening Equipment for Steel Plate" (Supplied by the Shibaura Company).

INTRODUCTION

High frequency induction heating has played an important part in nearly all metallurgical advances since 1916. Its use has reached into almost every branch of industry and research where accurately controlled heat is an essential feature.

The writer was familiar with the history and application of high frequency heating; he had lists (see Enclosures A and B) of all Japanese installations made before the war, and had had previous contact with the principals in Japan who would be making and installing such equipment for new applications. It was felt, therefore, that the opportunity to explore its use by the Japanese for war purposes could be coordinated easily with other investigations.

THE REPORT

A. SUPPLIERS OF HIGH FREQUENCY EQUIPMENT

Although several companies make high frequency furnaces in Japan, the market has been substantially supplied by the Mitsui and Shibaura Companies operating under license by the Ajax Electrothermic Corp., of the United States. The first few units were built by Ajax and sold through the Mitsui Co. as agent. Later, technical information was given to Mitsui and Shibaura, and the equipment was manufactured in Japan on a royalty basis. Competing companies have arisen during the war period and include the Mitsubishi Co., the Hitachi Co., and to a lesser extent the Tokyo High Frequency Furnace Co.

B. TYPES OF EQUIPMENT IN USE

1. Mercury-Hydrogen Spark Gap Converter

These equipments are supplied only by the Mitsui-Shibaura group. Units of 3.15 and 35 KVA are used principally for laboratory and small scale production melting and for making tungsten carbide. There are about 50 of the 35 KVA units, four of the 15 KVA units, and one of the 3 KVA units in Japan. Frequencies range from 20,000 to 60,000 cycles.

These units are designed essentially the same as they are in the U.S., except that the capacitors are of the old oil dielectric type immersed in an oil bath with water cooling coils. Controls are not good and from a casual viewpoint it appears that most of the equipment was operating at reduced loads and poor efficiency.

2. Motor-Generator Operated Equipments

Motor-generator frequency changers supply the bulk of the power for induction heating. They are sold by the Mitsui-Shibaura Companies, the Mitsubishi Co. and the Hitachi Co. Generator designs appear to be similar to those in the U.S. and the equipments as a whole are generally similar to the Ajax designs of 1930-1933. Few improvements since that date have been adopted. Frequency is almost universally 960 or 1000 cycles, although one 300 kw, 3000 cycle machine was brought over from the U.S. for a surface hardening application. There are a few installations using 2000 cycles.

There are some 134 generator operated equipments of the following ratings: (600 kw will melt 2000 lbs of steel per hour)

No. of Units	KW rating
16	60
6	100
41	150
52	300
16	600
3	1100

Note: See Enclosures (A) and (B).

Of the total of 38,00 kw installed it is believed that all but about 600 kw was being used for steel and special alloy melting, with the remainder being used for experimental heating applications for forging and hardening. One other 300 kw equipment was used part time for a hardening experiment.

The melting units were being used for making special steels, magnet steels, tool steels, stainless steels, corrosion and heat resisting alloys, medium or hardener alloys for brass melting, carbides, and the like. During the war many furnaces were making manganese steels for ordnance parts.

Generator controls are inferior to those used today in the U.S. Tirrill type voltage regulators are used almost exclusively. Field reduction controls and oil switches are used as the main load breaks. The furnaces are connected to the busses generally by sliding contacts which wear, arc, and overheat. A few flexible lead connectors are used but no water cooled leads such as are favored in the U.S. were found. Capacitor switches approach, but do not accomplish an actual improvement (a cascade switching control is referred to). No water-cooled capacitors, busses or generators were discovered.

Capacitors were of the old oil dielectric type immersed in an oil bath with water cooling tubes in the oil bath. No individual cooled pyranol filled units were in use. Most of the capacitors were of the relatively low KVA 10 mfd. type, although some appeared to be of the 30 KVA, large bulk tank type, as supplied by the Germans.

Furnace coils were of the same electric design as those used in the U.S., i.e. two and four section reverse wound coils. However, the coils are not nearly as rigidly supported and often give way and become distorted under the effect of the expanding furnace linings. Most coils appeared to be anchored to the guides only at every fourth or fifth turn, and the number of guides was less than are used in the U.S.

The furnace structural members are of (magnetic) mild steel generally, for the larger furnaces, and are shielded by 8mm copper plates. U.S. practice is to make the structural members of non-magnetic materials and to avoid the necessity of the copper shields.

None of the "lift coil" furnaces, so popular in the U.S., have been sold in Japan, and very little brass melting is being done by high frequency.

The Japanese apparently do not "push" their furnaces to get average full load conditions, and as a result, their melting periods are unduly long and their efficiencies are low. At one installation it was reported that power consumption per metric ton of steel melted was 800 kwh measured at the generator terminals. 660 kwh would have been about normal for the particular furnace cited.

Furnace linings used in Japan are made differently from those commonly employed in the U.S. The most general practice in Japan is to coat the furnace coil with the usual thin protective liner (sometimes omitted), add two layers of mica (sometimes omitted), then tamp in a moist refractory material between the mica and an iron template or form. For basic linings a mixture of 90-95% of dead burned magnesite is mixed with 5-10% of alumina. About 3% by weight of molasses is added to the mixed material. After tamping in place, the lining is slow-baked for about 12 hours, after which the form is removed and a wash heat of iron is superheated in the lining to sinter it. Sometimes 10% by weight of sodium silicate is used instead of the molasses, and linings are made about the same way as the basic linings, with silica sand wetted by sodium silicate. In some instances the coil proper is lined with brick instead of the mono liner heretofore described. At the Daido Steel Co. the linings used for the five ton furnaces are brick next to the coil, with the silica and sodium silicate mix for the main refractory. With this lining some 30 heats of tool steel can be made. In the one and two ton furnaces the acid and basic linings last for 40-70 heats and in the smaller furnaces (600-1000 lb) the linings are good for 80-120 heats. At the Daido plant power consumption is about 700 kwh per metric ton of steel melted (measured at the motor terminals)

Furnace sizes range to 5 tons, which is about the same as U.S. practice. In Europe furnaces of 8-10 tons have been built under Ajax license. For the class of steel generally melted by high frequency, the smaller furnaces are more desirable.

In Japan there is a tendency to use the high frequency furnace for lower grades of steel than in the U.S.; in some instances it is being used, or is under consideration, for ordinary and alloy cast iron.

3. Vacuum Tube Converter

So far as could be learned the Japanese have not used vacuum tube equipment for either induction or dielectric heating applications. There was some indication that they were being studied, but no equipment could be located.

4. Quenched Spark Gap Converter

Two pieces of equipment of the quenched spark gap type were located. They were built by the Tokyo High Frequency Furnace Co. and were rated at 35 KVA. Frequencies were estimated to be around 300,000 cycles. One piece of equipment at the Special Alloy Mfg. Co. at TSURUMI was in poor condition and appeared not to have been used for some time. Another piece of equipment at the plant of the Mitsui Seiki Kogyo in OKAGAWA was said to be operating, but it was reported that it took 90 minutes to melt 5 kg of cast iron. It was further reported that, when the equipment was installed, the melting time was 45 minutes. Since a good 35 KVA mercury-hydrogen gap converter furnace will easily melt 17 lbs of steel in 45 minutes, it must be assumed that the quenched gap equipments in Japan are poorly designed and that maintenance is not sufficient to keep them in good operating condition.

5. Inverted Rectifier Equipments

The Japanese have done no work whatsoever on this type of equipment, so far as could be learned.

6. Low Frequency Coreless Induction Heating

Normal or commercial power line frequencies of 50 and 60 cycles have been used for heating the tires of locomotive car wheels for expanding and removing them. So far as could be learned, such frequencies are not used for annealing operations in general, nor for the heating of chemical vats and process equipment.

C. SPECIFIC APPLICATIONS INQUIRED ABOUT

1. Ferrous Metal Melting

As pointed out under items 1 and 2 of Part A, substantially all of the high frequency equipment in Japan is used for ferrous metal melting. The exceptions noted will be described in the following items of this section.

2. Non-ferrous Metal Melting

As a general rule, it is believed that non-ferrous metals are not as widely melted by high frequency in Japan as in the U.S. Exceptions are in the mints and in plants where the hardener additions for non-ferrous melts are made. None of the lift coil type furnaces for miscellaneous brass melting have been reported or seen in use.

3. Magnesium Melting

Although a non-ferrous metal magnesium usually is separately reported. It was thought that the Japanese might be using the high frequency furnace for making or for melting this metal. At the Furukawa Electric Industries plant at NIKKO it was stated that an aluminum alloy containing 20 to 30% of a mixture of copper, manganese, and magnesium was being melted in 650 lb charges in a high frequency furnace. There was no evidence that the magnesium alloys in general were being melted this way.

4. Tungsten Carbide Manufacture

The double carbide of tungsten and cobalt was being made in high frequency furnaces at the Special Alloy Manufacturing Co plant at TSURUMI. Mercury-hydrogen spark gap converter equipment had been tried, but was not in operating condition. The tungsten, cobalt, and carbon constituents were packed in a graphite container which in turn was packed in a clay container with "crystal" graphite heat insulation. The graphite container was then heated to 2000° C to form the desired carbide. The material thus formed was allowed to cool down, after which it was reground to powder form, shaped, pressed, and sintered in a hydrogen atmosphere resistance furnace. No sintering was being done by high frequency.

5. Centrifugal Casting

No indication could be found that the Japanese were using high frequency melting and centrifugal casting for making their gun barrels. Except experimentally, it is believed that no castings are being made by the centrifugal process.

6. Vacuum Furnaces

It was reported that several experimental vacuum melting furnaces had been made using the converter type equipment as a power source, but that no commercial size or generator operated vacuum melting furnaces had been made. The converter operated units were of the external coil, silica tube type and were not arranged for pouring the charge in the vacuum. Many parties showed interest in vacuum furnace designs, apparently having read about them in U.S. or foreign literature.

7. Forging Applications

The writer was able to locate only one application of the use of high frequency heating for forging. This was at the Osaka Arsenal where a 5 to 6 inch diameter, 3/4 inch wall, steel tube was heated 3 inches back from the end to a temperature of 880-900° C for an upsetting operation. The heating pattern was not graduated, the full temperature being attained for the full 3 inches. Several heaters were connected in parallel, each drawing 40-60 kw from the 300 kw, 1000 cycle supply source. Efficiency was said to be 40% overall, with a motor generator efficiency of 80%.

The Mitsui-Shibaura representatives said that induction heating for forging was not popular because of the cost, but this might be questioned. Power costs in Japan were said to be 2 to 3 sen per kwh which, even at the old rate of 2 yen to the dollar, would make the power cost but 1 to 1½ cents per kwh. It is believed, rather, that the average Japanese has not yet found out that while the first cost and power cost may be high, the total cost per unit of production is lower on account of time and material savings, and reduction of rejects. The Mitsui-Shibaura people said that they expected the use of induction heating for forging to increase.

8. Hardening and Surface Hardening

This is another application which did not get under way in time to aid the Japanese war effort. Only four applications could be located.

At the Osaka Arsenal it was said that converter type equipment had been used experimentally to harden the noses of armor piercing shot. The shot was said to be about one inch in diameter, heated and hardened about one inch back from the point. No details were available except that the heating time was 30 seconds and the frequency 50,000 cycles. A deep case hardening could be obtained under these conditions.

The Osaka Arsenal also sponsored other tests at SHIBAURA-TSURUMI, where an experimental equipment was set up for hardening the surface of armor plate. The Tsurumi equipment comprised a "U" shaped yoke of 8mm silicon steel laminations, having legs 7 inches high by one inch wide and 22½ inches long. The two legs were 4 inches apart center to center. Each leg was wound with 6 turns of 3/4 inch diameter copper tubing flattened to about one-half inch. The two coils were connected in series to a 200 kw, 1000 cycle, 600 volt power source. The coils proper were 27 inches long. The core pieces were interspersed at 2 inch intervals with 3/8" brass spacers which were adapted for water cooling.

The plate to be surface hardened was passed under the ends of the yokes at a spacing of about 10mm. Since the edges of the plate had a tendency to get hotter than the surface, a continuous water spray was applied to hold the edge temperature down. As the plate surface emerged from under the second leg of the yoke, it was quenched by a slot jet about 3 inches from the second yoke leg. Water pressure on the jet was said to be 45 lbs per square inch. Power factor of the combination was said to be 20%.

A steel plate of 0.5 C, 1.5 Ni, 1.0 Cr, 0.5 Mn, 0.3 Si, less than 0.03 P and S, balance Fe, having dimensions of 24 inches inside by 2 inches thick, when passed through the machine at the rate of 1mm per second, was said to have a surface hardness of 700 Vickers about 1/4 inch deep on a 350 Vickers base. Hardness pattern was regulated by speed of travel. While the Shibaura people thought the method practicable, it was not adopted by the Army or Navy. (See print marked Enclosure (C) attached to this report.)

The Shibaura Co. also made some experiments at their FUCHU plant for the surface hardening of crankshafts. These had not progressed very far.

One 300 kw, 3000 cycle, surface hardening equipment was sold by the Olin Crankshaft Co., of Cleveland, Ohio, through the Okura Co. in Japan to the Kawasaki Airplane Co. It was learned from the Shibaura and Sumitomo representatives that this equipment probably was located at the AKASHI plant of the Kawasaki Airplane Co., near KOBE. The plant was visited, but since it was badly bombed and no Japanese personnel were available, no information was obtained.

9. High Temperature

Investigation at the Tokai Denkyoku at NAGOYA, where carbon and graphite materials are made and processed, disclosed that high frequency had not been used to process carbon brushes and spectroscopic graphite products. No other high temperature applications were uncovered except the making of carbide metal products.

10. Low Frequency Coreless Induction Heating

As previously stated, the only use of 50 and 60 cycle coreless induction heating appears to be for the applying and removing of railroad car wheel tires.

ENCLOSURE (A)

LIST OF HIGH FREQUENCY FURNACE INSTALLATIONS IN JAPAN AS REPORTED TO AJAX ELECTROTHERMIC COMPANY (LICENSORS) BEFORE THE WAR.

Firm	Date Reported	No Equips.	Instal. No.	KW
Sumitomo Copper & Steel Tube Works, OSAKA	7/5/29	1		150
Tobata Factory, TOKYO	7/11/32	1	4	300
Daido Elec. Steel Co., NAGOYA	3/11/32	1	5	150
Sumitomo Steel Works, OSAKA	8/18/30			100
Nihon Kinzoku Co. Ltd.	5/29/33	[illegible]	10	150
Kaigun Hiko Kosho (Navy Aeroplane Fac.) HIROSHIMA	5/17/34	1	13	150
Zoheikyoku (The Mint), OSAKA	8/17/33	1	14	300
Kaigun Sasebo Koshu (Naval Arsenal) SASEBO	8/17/33	1	15	60
Mitsubishi Mining Co.	3/1/34	1	16	150
The Mint, OSAKA	3/1/34	1	17	300
Second Inst. Nippon Steel Co. MURORAN, HOKKAIDO	5/17/34	1	18	300
Sumitomo Copper Co.	9/5/34	1	19	300
Kobe Steel Co.	9/5/34	1	20	300
Nippon Denkai Steel Co.	9/5/34	1	21	300
Rikageku Kogo Co.	9/5/34	1	22	150
Sumitomo Copper Co.	11/28/34	1	23	300
Nippon Special Metal Co.	11/28/34	1	24	150
Tokyo Kozai Kaisha	11/28/34	1	25	60
Special Steel Co.	11/28/34	1	26	300
Nippon Chisso Kaisha Ltd.	3/7/35	1	32	300
Nippon Kokan K., Ltd.	3/7/35	1	33	150
Nippon Tokushuko G.K.	3/31/36	1	40	600
Honkeiko Baitetsu Kaisha	3/31/36	1	41	150
Tohoku Kinzoku Kogyo K.K.	3/31/36		42	100
Nippon Chisso Minamata Works	4/29/36	1	45	150

ENCLOSURE (A), continued

Firm	Date Reported	No Equips.	Instal. No.	KW
Daido Steel Works	11/28/39	2	102	1100
Furukawa Electric Industrial Co.	4/29/36	1	46	300
Sumitomo Metal Undustrial Co.	4/29/36	1	47	300
Military Arsenal	7/21/36	1	49	300
Chosen Chisso K.K.	7/21/36	1	50	300
Sumitomo Kinzoku K.K. Nippon Chisso K.K. Nobeoka	7/21/36	1	52	300
Tsugami Works	7/21/36	1	53	100
Rikagaku Kogyo K.K.	1/6/37	2	54	300
Rikagaku Kogyo K.K.	1/6/37	1	55	150
Nippon Soda K.K.	1/6/37	1	56	300
Kure Naval Yard	1/6/37	1	57	60
Nippon Kako K.K.	3/9/37	1	58	150
Nippon Seitetsu K.K.	3/9/37	1	59	600
Komatsu Works	3/9/37	1	60	300
Nippon Seiren K.K.	4/5/38	1	87	300
Akita Mokuzai K.K.	4/5/38	1	88	300
Sumitomo Cable Works	4/5/38	1	89	150
Ube Chisso K.K.	4/5/38	1	90	60
Okura & Co.	9/19/39	1	Ohio#2	
Tokushu Gokin Kogu K.K.	12/5/38	1	91	35 kva
Fujikoshi Kozai K.K.	12/5/38	1	92	35 kva
Hattori Tokei-Ten	12/5/38	1	93	35 kva
Kyoto Imperial Univ.	12/5/38	1	94	1.5 kva
Kenki Keiki Shikenjo	12/5/38	1	95	1.5 kva
Mitsubishi Dockyard	12/5/38	1	96	.5 kva
Nippon Tokushuko K.K.	12/5/38	2	97	600
Mint	12/5/38	1	98	300
Taika Denkiyakin K.K.	12/5/38	1	99	300
Tokyo Denki K.K.	12/5/38	1	100	150

ENCLOSURE (A), continued

Firm	Date Reported	No Equips.	Instal. No.	KW
Tokyo Imperial University	11/28/39	1	101	35
Navy	11/28/39	1	103	300
Sumitomo Metal	11/28/39	1	104	60
Special Alloy Co.	2/2/40	1	105	35
Tokyo Electric Co.	2/2/40	1	106	35
Japan Metal Industrial Co.	2/2/40	1	107	600
Japan Steel Co.	2/2/40	1	108	600
Kawasaki Ship Yard	2/2/40	1	109	300
Tohoku Imperial University	2/2/40	1	110	60
Mitsui	9/23/40	1	111	300
Mitsui	9/23/40	1	112	300
Mitsui	9/23/40	1	113	300
Mitsui	9/23/40	1	114	300
Mitsui	9/23/40	1	115	300
Mitsui	9/23/40	1	116	150
Mitsui	9/23/40	1	117	150
Mitsui	9/23/40	1	118	150
Mitsui	9/23/40	1	119	150
Mitsui	9/23/40	1	120	35
Mitsui	9/23/40	1	121	35
Mitsui	9/23/40	1	122	35
Mitsui	9/23/40	1	123	35
Mitsui	9/23/40	1	124	35
Mitsui	9/23/40	1	125	35
Mitsui	9/23/40	1	126	35
Mitsui	9/23/40	1	127	35
Mitsui	9/23/40	1	128	35
Mitsui	9/23/40	1	129	3

ENCLOSURE (B)

LIST OF HIGH AND LOW FREQUENCY FURNACE INSTALLATIONS MADE IN JAPAN DURING THE WAR AS REPORTED BY THE MITSUI AND SHIBAURA COMPANIES

(Delivered during 1941 - 1945)

Tokyo Shibaura Electric Co.,
Nihonbashi, Tokyo
19 November, 1945

Part I - HIGH FREQUENCY ELECTRIC FURNACE

Shop No.	Name of Customer	Capacity of Furnace
207388	South Manchuria Railway Co., Fushun Colliery	150 kwa
207470	Showa Steel Works, Manchuria	150 kw
207510	Nippon Electric Co., TOKYO	150 kwa
207538	Mitsubishi Heavy Industry Co.	35 kva
207600	Mitsubishi Heavy Industry Co.	35 kva
207625	Nippon Electric Co., TOKYO	35 kva
207651	Ohata Copper Drawing Co.	35 kva
207658	Nippon Metal Industry Co., TOKYO	35 kva
304161	Own Use	300 kw
209560	Tohoku University, SENDAI	35 kva
209536	Nissan Chemical Industry Co.	35 kva
209535	Nakajima Aircraft Co., TOKYO	35 kva
207733	Nissan Automobile Mfg. Co., YOKOHAMA	35 kva
207745	Nippon Steel Tube Co.	60 kw
209605	Tohoku University, SENDAI	35 kva
209610	Tohoku University, SENDAI	35 kva
209616	Tohoku University, SENDAI	35 kva
209625	Oki Electric Co., TOKYO	60 kw
209626	Oki Electric Co., TOKYO	35 kva
209670	Electric Smelting Co.	150 kw
209671	Electric Smelting Co.	35 kva
209700	Maruko Tool Works	300 kw
209720	Haneda Machine Co.	35 kva

ENCLOSURE (B), continued

Shop No.	Name Of Customer	Capacity of Furnace
209759	Own Use	35 kva
209910	Akita Steel Mfg. Co.	300 kw
209933	Kobe Iron Works, Ltd., KOBE	300 kw
209958	Toho Steel Co.	300 kw
209991	Fujita	35 kva
210166	Toho Industry Co.	35 kva
210186	Sanwa Alloy-Metal Co.	300 kw
375103	Osaka Military Arsenal	60 kw
350241	Navy Department	300 kw
350261	Kure Naval Arsenal	300 kw
207781	Mitsui Ship Building Co.	35 kva
303990	Tohoku Metal Industry Co.	150 kw
209714	Own Use	35 kva (2)
209804	Kushu Electric Railway Co.	300 kw
209929	Nakajima Aircraft Co.	35 kva
209906	Toyo Bearing Co.	35 kva
209939	Maruko Tool Works	35 kva
350183	Yokosuka Naval Arsenal	300 kw
351164	Naval Technical Research Institute	35 kva
350337	Yokosuka Naval Arsenal	150 kw
304760	Waseda University, TOKYO	35 kva
209537	South Manchuria Railway Co.	35 kva
209730	Nippon Stainless Steel Co.	600 kw
209811	Nippon Metallurgical Industry Co.	35 kva
209930	Kawasaki Ship Building Co.	600 kw
209962	Mukden Arms Mfg. Co.	300 kw
209993	Tokyo Screw & Nut Mfg. Co.	150 kw
209997	Nakajima Aircraft Co.	150 kw
210100	Nippon Soda Co.	300 kw

ENCLOSURE (B), continued

Shop No.	Name of Customer	Capacity of Furnace
209998	Sampo Copper Drawing Co.	300 kw
210017	Osaka Special Steel Co.	300 kw
210129	Yuasa Metal Industry Co.	35 kva
210130	Yuasa Metal Industry Co.	100 kw
306100	Tokyo Technical University	60 kw
209915	Nippon Nitrogenous Fertilizer Co.	300 kw
210181	Daido Steel Mfg. Co.	600 kw (2)
210182	Daido Steel Mfg. Co.	1100 kw
210239	Nakajima Aircraft Co.	35 kva
210251	Sumitomo Metal Industry Co.	600 kw
210253	Hokushin Electric Machine Co.	100 kw
210254	Mitsui Mining Co.	15 kva
350886	Kokura Military Arsenal	150 kw
215632	Tsugami Ataka Co.	150 kw
218645	Santoku Industry Co.	150 kw
210261	Nippon Special Steel Co.	600 kw (2)
210340	Kobe Steel Works, Ltd.	150 kw
210342	Chuo Electric Industry Co.	150 kw
210350	Central Bank of Manchuria	300 kw
215620	Daido Steel Mfg. Co.	150 kw
210460	Sumitomo Metal Industry Co.	150 kw
210495	Formosa Iron Works, Ltd.	300 kw
210496	Nippon Valve Co.	150 kw
215760	Nippon Special Co.	60 kw
216210) 216211)	Sumitomo Metal Industry Co.	150 kw
215898	Mitsubishi Heavy Industry Co.	35 kva
215990	Sumitomo Machine Co.	150 kw
215992	Own Use	60 kw
376219	Sagami Military Arsenal	60 kw

ENCLOSURE (B), continued

Shop No.	Name of Customer	Capacity of Furnace
375666	Sagami Military Arsenal	150 kw
215900	Own Use	35 kva
215941	Sumitomo Metal Industry Co.	35 kva
307118	Nagoya Imperial University	35 kva
307301	Commerce & Industry Department	35 kva
307317	Morioka Technical College	35 kva
216273	Fujikura Electric Cable Co.	35 kva
216320	Nippon Metal Industry Co.	60 kw
216054	Furukawa Electric Industry Co.	300 kw
210240	Taika Mining Co.	600 kw
216430	Mitsubishi Heavy Industry Co.	35 kva
351170	Naval Technical Research Institute	100 kw
216250	Toyo Bearing Co.	60 kw
216210	Sumitomo Metal Industry Co.	150 kw
216140	Nippon Metal Industry Co.	600 kw
216868	Sumitomo Metal Industry Co.	300 kw
216170	Nippon Aluminum Co.	300 kw
216270	Own Use	150 kw
216285	Kato Machine Works	150 kw
216591	Nippon Stainless Steel Co.	600 kw
216610	Kawasaki Heavy Industry Co.	600 kw
216611	Manchuria Casting Co.	300 kw
216710	Nippon Stainless Steel Co.	600 kw
216755	Furukawa Electric Industry Co.	300 kw
350337	Yokosuka Naval Arsenal	150 kw

Part II - LOW FREQUENCY ELECTRIC FURNACES

Shop No.	Name of Customer	Capacity of Furnace
207677	Nippon Nitrogenous Fertilizer Co.	80 kw (2)
207710	Nippon Spelter Co.	60 kw
207715	Ohata Copper Drawing Co.	80 kw (2)
209575	Osaka Metal Co.	60 kw (2)

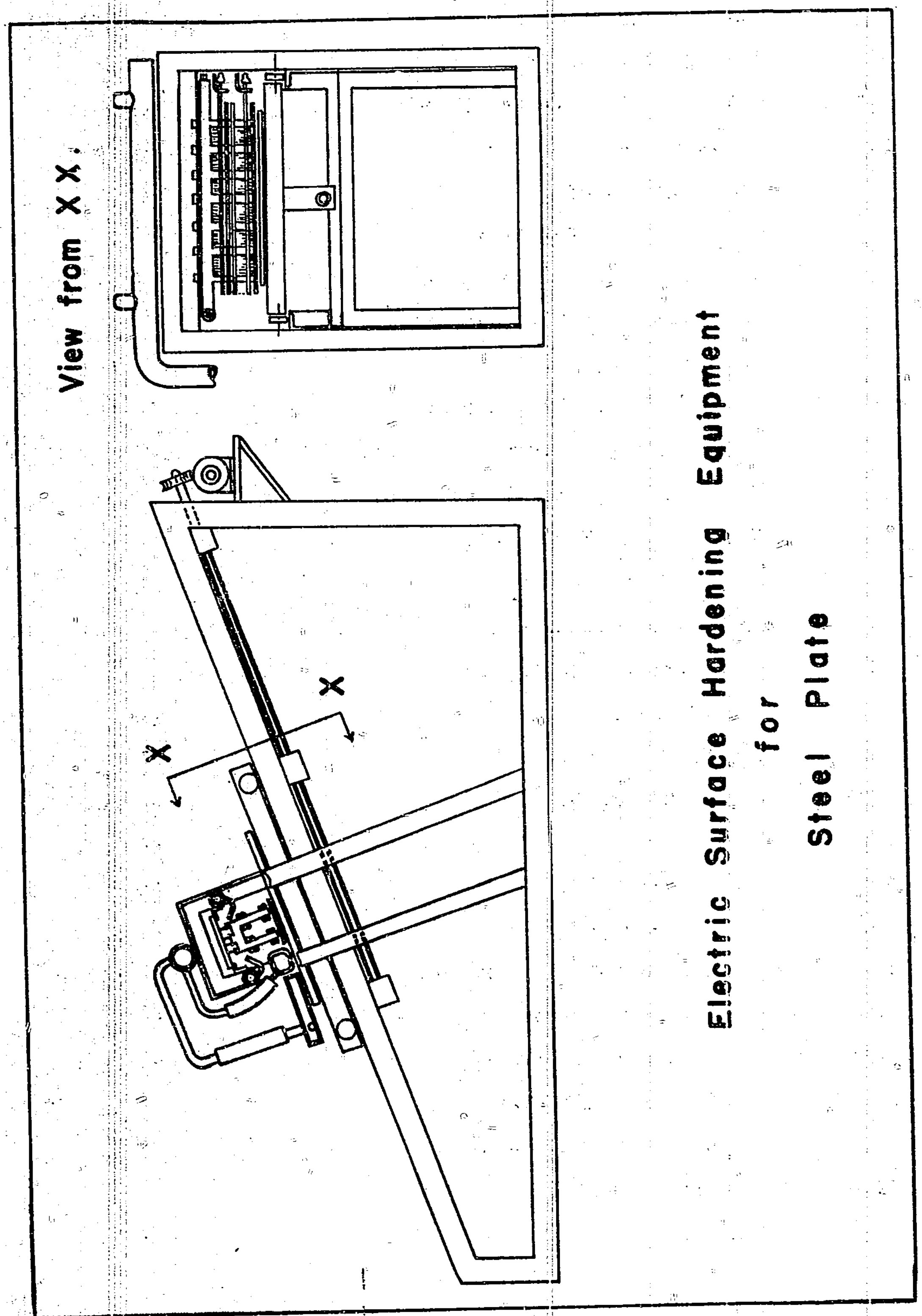
ENCLOSURE (B), continued

Shop No.	Name of Customer	Capacity of Furnace
375020	Kokura Military Arsenal	80 kw
209849	Sumitomo Metal Industry Co.	60 kw
350181	Yokosuka Naval Arsenal	80 kw
350241	Navy Department	60
209999	Sampo Copper Drawing Co.	80
209876	Toyosaki Copper Drawing Co.	60
210121	Nishikawa Copper Drawing Co.	60
210150	Nippon Mining Co.	120 (3)
216169	Sumitomo Metal Industry Co.	120 (2)
375029	No. 1 Military Arsenal of Tokyo	120
210147	Riken Rolling Mill Industry Co.	80
210220	Nippon Steel Works, Ltd.	80
210250	Mitsui Mining Co.	80
210341	Mitsubishi Mining Co.	80 (2)
210436	Sampo Copper Drawing Co.	80
351251	Hiro Naval Arsenal	80
215687	Oki Electric Co.	60
215770	Mitsui Mining Co.	80 (5)
376237		60
270390	Tokyo Bolt & Nut Co.	80
270388	Second Sedosha	80 kw
270387	Sumitomo Metal Industry Co.	80 (2) kw
270389	Arai Copper Drawing Co.	80 kw
270045	Sampo Copper Drawing Co.	80 kw (7)
216865	Sumitomo Metal Industry Co.	60 kw (2)
217127	Toyosaki Copper Drawing Co.	80 kw

Part III - HIGH FREQUENCY ANNEALING FURNACE

	Own Use	300 kw

ENCLOSURE (C)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Electric Surface Hardening Equipment
for
Steel Plate