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Nº 2

AIR TARGET SYSTEM FOLDER

JAPANESE NONFERROUS METALS

JOINT TARGET GROUP
WASHINGTON, D. C.

SECRET

SECRET

By Authority of
The Commanding General
Army Air Forces

1 MAR. 1945
(Date)
(Initials)

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JOINT TARGET GROUP • WASHINGTON, D. C.
15 January 1945

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The material in this folder is divided into three parts as follows:

GENERAL ANALYSIS

This gives an over-all appreciation of the target system so that the importance of individual targets within the system can be readily evaluated. It also lists the essential details of the main targets in the system.

LOCATION MAP

This shows the location of the principal targets.

DATA ON INDIVIDUAL TARGETS

This is to contain Target Information Sheets and Illustrations and Economic Damage Assessment Reports as issued for individual targets in the system.

Addenda consisting of revised sheets and additional sheets will be issued from time to time. The folder is designed to permit ready substitution or addition of such material.

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Joint Target Group
AC/AS, Intelligence
H. Q. Army Air Forces
Washington 25, D. C.

U. S. GOVERNMENT PRINTING OFFICE 629717

General Analysis

ATSF/NFM 7 Feb. 1945 SECRET

Japanese Non-ferrous Metals

GENERAL ANALYSIS

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FOREWORD

The Japanese Non-Ferrous Metals Industry may be broken down into six main parts as follows:

Part I	Alumina-Aluminum
Part II	Copper
Part III	Zinc
Part IV	Magnesium
Part V	Nickel
Part VI	Lead

A report on Part I Alumina-Aluminum is submitted herewith. Reports on other parts will be prepared later and will be issued as addenda for insertion in this folder.

7 February 1945

Sheet No. ATSF/NFM
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JOINT TARGET GROUP - WASHINGTON, D.C.

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JAPANESE NON-FERROUS METALS

PART I

ALUMINA-ALUMINUM

GENERAL ANALYSIS

SUMMARY

I. CHARACTERISTICS OF THE INDUSTRY

The Japanese aluminum industry consists of three stages, which are considered as separate target systems: alumina production, aluminum reduction, and aluminum and aluminum alloy fabrication. Alumina or aluminum oxide is the product of all alumina plants and is the raw material for the aluminum reduction plants which produce aluminum in ingot form. Fabrication is the production of aluminum and aluminum alloy sheet, forgings, castings and extrusions from aluminum ingot. The fabrication industry is least susceptible to air attack. It will be discussed in a supplement to this study.

The principal importance of the aluminum industry results from the fact that an estimated 82 percent of its output is used in aircraft production. For this reason, it is considered here not as an independent target system but primarily as an alternative method of reducing Japanese air strength.

II. JAPAN'S PRESENT POSITION

A. ALUMINA PRODUCTION

Japan's alumina industry is in a state of transition from the Bayer process, which requires bauxite as a raw material, to other processes which use other types of raw material. Bauxite is available only in the N.E.I.; other materials in the Inner Zone. Shortages due to the shipping stringency have already reduced operations of Bayer process alumina plants to less than 30 percent of capacity. Capacity in non-Bayer alumina plants alone is apparently not yet adequate to meet total requirements, but expansion now under way should correct this deficiency shortly.

B. ALUMINUM PRODUCTION

Japanese annual requirements for aluminum for all purposes are estimated at 208,000 metric tons[1] based on the 1945 Japanese aircraft program. A decline in Japanese aircraft production will, of course, reduce requirements. Even holding production to present levels will bring requirements below 208,000 tons since working inventories can be cut and no further expansion of inventories is required. Current production is believed to be adequate to meet requirements but stocks are probably not greater than necessary operating inventories. Annual capacity exceeds requirements and production by at least 24,000 tons.

III. VULNERABILITY OF INDUSTRY TO AIR ATTACK

A. ALUMINA

Present estimates of capacity indicate that as much as 64 percent of the crucial non-Bayer capacity may be located in five plants in Manchuria, Korea, and Honshu. Since new capacity has been developed rapidly and there may be new plants about which no intelligence is yet available, this degree of concentration may not exist now or will probably decline in the near future. Alumina plants are moderately susceptible to damage by air attack but recuperability time is relatively short so that frequent attack would be required to hold down production. It is believed possible, in addition, to replace or add to capacity by a conversion of cement plants, which would take about five months.

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[1] Based largely on analysis of United States experience. This estimate is in process of revision and is believed to be on the high side.

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TISH SERVICES FOR THE USE OF ALLIED FORCES.

B. ALUMINUM

Aluminum capacity is spread through a number of plants. Twenty plants have been located. Fourteen contain 92 percent of capacity, ten contain 80 percent. A number of plants are difficult to attack: six are located in Manchuria and Korea; as many as seven of the twenty, involving 28 percent of total capacity, are on the Japan Sea and may be beyond the range of carrier-based aircraft, and very difficult for B-29's to attack from present bases.

The production of aluminum in any aluminum reduction plant can be stopped by air attack. If the vital installations, the rectifiers and rectifier transformers, are destroyed, the plant cannot operate until they are replaced--a minimum period of six months, if several installations were destroyed. If a large number of plants were attacked successfully in a short period of time, there is good reason to believe that the recovery period might be at least twice as long. In view of the small area of the vital installations, aluminum plants are especially suitable for low level attack.

C. ALUMINA VS. ALUMINUM

According to present knowledge of non-Bayer alumina plants, production of alumina is concentrated in fewer plants than is production of aluminum. This situation, however, may be due to a lack of recent intelligence regarding new non-Bayer alumina plants.

Aluminum reduction plants are more easily immobilized by aerial bombing than alumina plants, and they are slower to recover. If a number of aluminum plants are attacked within a short period, the recuperability time is markedly lengthened. Until the total number and location of non-Bayer alumina plants is more definitely known, aluminum reduction is the more promising point of attack.

D. ALUMINUM VS. AIRCRAFT

Attacking aluminum as an alternative to attacking aircraft manufacture directly has the disadvantages of, (1) less concentration in production, (2) the location of a number of plants beyond the range either of land-based bombers from our present bases or of carrier-based aircraft, and (3) a lag of five months between loss of aluminum production and reduced front-line aircraft strength. It has the advantages that dispersal is much more difficult, and that recovery time for the aluminum industry, especially if the attack is concerted, is considerably longer.

The start of attacks on aircraft manufacturing raises the issue of what its effect will be on a choice of aluminum as a target system.

If attacks on aircraft manufacture are successful, a resulting excess of aluminum capacity will permit the Japanese to stock-pile aluminum and become relatively invulnerable to later attack. Such a stock-piling, however, is not at all certain. In the first place, attacks on aircraft manufacture may not cut sharply aircraft production for as long as a year. Shipping and power shortages will make Japan reluctant to produce more aluminum than is necessary for current requirements.

Once aircraft has become so dispersed as to be an unrewarding target, aluminum might be the best available alternative method of getting at aircraft.

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ALUMINA INDUSTRY

I. EFFECT OF LOSS OF ALUMINA PRODUCTION ON MILITARY STRENGTH.

A. USE PATTERN

The only use of alumina which is vital to the enemy war economy is as raw material for the aluminum reduction industry. It is also used--probably in relatively small quantities by the Japanese--in abrasives, in ceramics for certain types of fire brick and furnace linings, in chemicals and as a water softnener; but satisfactory substitutes are available for all of these uses. Therefore the effec of loss of alumina production on military strength would be the same as for aluminum, except for the additional time lag of one month, and this subject will be discussed under the *Aluminum Reduction Industry.*

It is estimated that approximately 93 percent of Japanese current annual aluminum production, 194,000 metric tons, is for direct military use. 388,000 metric tons of alumina, or about 91 percent of current annual production, is required to produce this amount of aluminum. Nearly all of the balance of 9 percent is required to produce aluminum for indirect military and industrial use, which is considered necessary to the enemy war economy.

B. EXISTING STOCKS

There is no definite information available on the quantity of alumina in stock. It is believed, however, due to the serious problem the Japanese have had to face in converting their alumina industry to handle low grade raw materials, that stocks, if any, are limited to average working stocks at aluminum plants. These are estimated as one month's supply or a total of 35,000 metric tons.

C. EXPENDITURE RATES

Alumina is needed at the aluminum plants at the rate of about 35,000 metric tons per month. Expenditure rates for the other uses mentioned above is in the realm of pure speculation and relatively unimportant.

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ALUMINA INDUSTRY

II. VULNERABILITY OF PRODUCTION TO AIR ATTACK.

A. INDUSTRIAL PATTERN

1. Shift From Bayer Process

The Japanese aluminum industry, which was initiated in 1934, was built around the Bayer alumina process which is dependent on high grade bauxite of low silica content. Bauxite suitable for this process is now available to the Japanese only from Bintan Island and Malaya. There is evidence as early as 1937, when the development of the Pedersen process was initiated in the plant at Fushun, Manchuria (Target 93.3-32), and later in January, 1941, when an article was published in Tokyo by Dr. Yagi[1], a Japanese scientist, that the Japanese realized this weakness in their position and began making plans to overcome the weakness. Recently there is considerable evidence that these plans have gradually developed into an intensive effort to convert their alumina industry to handle the low grade aluminous raw materials of which they have an adequate supply in Manchuria and North China. There is further evidence that these efforts have been reasonably successful and their alumina industry, if not now fully self-sufficient within their Inner Zone, is rapidly approaching that status.

It is further believed that the Japanese are accomplishing their aim of self-sufficiency in alumina to such an extent that they may be in the process of writing most of the Bayer plants off as losses.[2] The above in addition to the other evidence mentioned herein is supported by the continued increase in Japanese aircraft production.

2. Capacity, Production and Geographic Distribution

Total current alumina capacity is estimated at 571,000 metric tons per annum, of which 232,000 metric tons is in seven Bayer process plants. Total current alumina production is estimated at 424,000 metric tons. The production of the Bayer plants, with the exception of the plant at Takao, has been estimated at no more than 30 percent of capacity because of shortages of bauxite.

The geographic distribution of alumina plants is as follows:

	Number of Plants	Estimated Capacity in Metric Tons
Manchuria	2	72,000
Korea	4	68,000
Honshu	10	311,000
Shikoku	1	20,000
Kyushu	2	60,000
Formosa	1	40,000
	20	571,000

The breakdown of types of production (processes) is as follows:

		Number of Plants	Estimated Capacity in Metric Tons	
Using Bauxite				
Bayer Process				
Honshu	4		132,000	
Kyushu	2		60,000	
Formosa	1		40,000	
Total Bayer		7		232,000

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[1] "*Concerning the Aluminum Industry in Manchukuo and Chosen,*" *Dr. Yagi, Toyo Keisai Shimpo, Tokyo, 25 January 1941, pp. 36-37.*

[2] *See under 'Production Processes - Bayer Process. (Sec. II.B.1.(A)*

Using Shale and Other Low Grade Raw Materials						
Pedersen Process						
Manchuria		1			48,000	
Lime-Sinter Process						
Honshu		2			120,000	
Other plants using low grade raw materials.*						
Manchuria	1			24,000		
Korea	4			68,000		
Honshu	4			59,000		
Shikoku	1	10		20,000	171,000	
Total Non-Bayer			13			339,000
Total All Plants			20			571,000

**NOTE: Process used in these plants is not definitely known. Three or four plants in Manchuria and Korea may be using the Pedersen process. Others may have installed large rotary kilns and be using the lime-sinter process.*

For further details as to capacity, production and location of the individual plants see Map 1, Diagram 2, and Table 1.

3. Concentration

The 10 largest plants include 76.5 percent of capacity; the 14 largest plants, 90.5 percent of capacity. Because of the doubtful value of the Bayer process plants either to the Japanese or as targets the following are considered the five most important plants:

Target Number	Location	Estimated Capacity in Metric Tons	Estimated Production in Metric Tons
90.32- 822	Onoda, Honshu	70,000	70,000
90.29-1690	Itozaki, Honshu	50,000	50,000
93.3 - 32	Fushun, Manchuria	48,000	48,000
84.2 - 1	Konan, Korea	24,000	24,000
93.2 - 200	Antung, Manchuria	24,000	24,000
		216,000	216,000
	Percent of Total Non-Bayer Plants	63.7 percent	64.4 percent

4. Extent of Integration

Elevan of the plants are integrated with aluminum plants and share the same plant compound. These plants would undoubtedly suffer incidental damage as a result of a concerted attack on the aluminum industry. The eleven integrated plants are as follows:

Target Number	Location	Estimated Capacity in Metric Tons	Estimated Production in Metric Tons
	Manchuria		
90.3 - 32	Fushun	48,000	48,000
93.2 -200	Antung	24,000	24,000
	Korea		
84.2 - 1	Konan	24,000	24,000
84.3 - 67	Chinnampo	20,000	20,000
93.2 -201	Yoshi	21,000	17,000
84.4 -208	Genzan	3,000	3,000

	Honshu		
90.12-1100	Omachi	* 8,000	2,400
90.11- 861	Higashi Iwase	20,000	20,000
90.11- 866	Takaoka	* 14,000	4,200
90.5 -1557	Hachinohe	* 10,000	3,000
	Formosa		
91.6 - 3	Takao	* 40,000	32,000
		232,000	197,600
	Percent of Total	40.6	46.5

*Bayer process plants, their integration is of questionable duration.

5. Trends.

The major trend in the alumina industry is the continued increase in non-Bayer in non-Bayer capacity. Current aluminum production requires 416,000 metric tons of alumina. Non-Bayer plants produce only 335,000 tons. The intelligence indicating an early correction of this apparent unbalance together with decline in the production of alumina in Bayer plants is noted below.

June 1944 photography of the plant at Fusbun, Manchuria (Target 93.3-32) shows a very large increase in the alumina plant under construction which may now be completed and in operation. If this is so, alumina production at Fushun is probably very much larger than reported.

Similar expansion of the plant at Antung, Manchuria (Target 93.2-200), is reported.

The two cement plants at Onoda and Itozaki, Honshu (Targets 90.32-822, 90.29-1690), are reliably reported to have been converted to the production of alumina, using the lime-sinter process. These plants are believed to be producing alumina at the annual rate of 70,000 and 50,000 metric tons respectively.

An alumina plant is reported to have been built at Changtien, Shantung Province, China. Rotary kilns, reported as having been moved here from a former cement plant, indicate the lime-sinter process.

The several air photo coverages of the Bayer plant at Takao, Formosa (Target 91.6-3), during the past year show this plant to be receiving bauxite on a hand-to-mouth basis and indicate that this plant is producing at considerably below capacity.

Recent air photography of the three other Bayer plants where NEI bauxite is most likely to be shipped and used--those at Shimizu, Honshu (Target 90.18-1176), and at Kurosaki and Omuta, Kyushu (Targets 90.34-1108 and 90.35-1877)--show little or no activity at these plants with little or no bauxite on hand, and no effort being made to convert them to handle low grade raw materials.

Future changes will work toward increasing or completing Japan's self-sufficiency in alumina. Illustrative of this trend, reports of the following probable future changes have been received:

(a) Increase in the capacity of the Onoda and Itozaki plants (Targets 90.32-822 and 90.29-1690) to a possible 100,000 and 64,000 metric tons respectively by April 1945.

(b) Material increase in the capacity of the Fushun Plant (Target 93.3-32).

(c) Completion of conversion of Yokohama plant (Target 90.17-521) by April, 1945 and the increase of its capacity to 40,000 metric tons.

(d) Increase in the capacity of the plants at Konan and Chinnampo, Korea (Targets 84.2-1 and 84.3-67), and at Higashi Iwase, Honshu (Target 90.11-861).

(e) It is possible that more cement plants may be found to have been converted to alumina manufacture.

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B. PRODUCTION PROCESSES AND PHYSICAL VULNERABILITY

1. Production Processes

The three processes known to be used by the enemy - Bayer Process, Modified Pedersen Process and Soda-Lime-Sinter Process - are graphically described in flow charts Nos. 2,3, and 4 and the notes accompanying same, which will be found in Appendix No. 1.

In each case the primary objective (critical point) has been selected to meet the following requirements:

(a) A point in the process whose destruction or immobilization will stop production in the entire plant.

(b) The point in the process whose equipment will require the longest period to repair or replace.

(c) With due consideration to (a) and (b) above, a point that is readily susceptible to damage or destruction by bombing.

(A) *Bayer Process.* The most important steps or equipment in the Bayer process plant, in the order of their importance, are as follows: digesters, rotary kilns, blowoff tanks and filter presses, precipitators and steam plant. The digesters, filterpresses and precipitators are housed in various types of buildings, the two last requiring relatively large buildings. The blowoff tanks can be outside. The rotary kilns may be partly exposed.

The primary objective in any Bayer process alumina plant is the digester equipment which consists of a number of steel pressure tanks or autoclaves, operating under steam pressure of from 100 to 200 lbs. and a number of pumps usually operated by steam. In addition there is a considerable network of piping connecting the several tanks and pumps with the other plant installations, and a considerable number of valves (some of which are difficult to replace) for the purpose of controlling pressures and the flow of materials. This equipment normally occupies about 80 percent of the floor space of the digester building. The size of the individual digester tanks is variable and not important to the process.

Serious damage to the digester building would stop production in the entire plant.

(B) *Modified Pedersen Process.* The most important steps or equipment in the Pedersen process plant, in the order of their importance, are as follows: electric furnaces, rotary kilns, solution tanks, refining troughs and precipitators, and steam plant.

Only one plant, that at Fushun, Manchuria (Target 93.3-32), is known to be equipped for the Pedersen Process. It is possible, however, that subsequent intelligence may disclose that this process is in use in the plants at Konan, Korea (Target 84.2-1); Antung, Manchuria (Target 93.2-200); and Yoshi, Korea (Target 93.2-201).

The electric furnaces at the Fushun Plant are installed in buildings believed to be reinforced concrete including roofs (Bldgs 30 and 35) If electric furnaces are found at other plants they also will probably be housed in similar substantially constructed buildings. The types of buildings housing the rotary kilns, solution tanks, refining troughs and precipitators, and steam plant are not important to the process and various types may be found. The solution tanks, refining troughs and precipitators require relatively large buildings. The rotary kilns may be partly exposed.

The primary objectives in a Pedersen process plant are the electric furnaces, which, in the Fushun plant, are in batteries of 8 and 12, in single rows in buildings about 240 ft. and 385 ft. in length respectively. The individual furnaces are necessarily large in order to handle the large bulk of raw materials, which, in this plant, is estimated at 24,000 metric tons per month.

Large furnaces are usually spaced about 15 ft. apart. Based on this spacing and the air photography of the Fushun plant the outside dimensions of the furnaces are about 16 by 20 ft. Their height is not known but is probably about 18 ft. overall. Such furnaces are built of fire brick on a steel frame and have a lining which must be resistant chemically to the materials with which the furnace is to be charged. The total thickness of the furnace walls is estimated at about 16 in. For the purpose used the furnaces would operate at a temperature of about 2500°F.

Partial damage to or destruction of the furnace buildings would not stop production in the entire plant as it is believed that undamaged furnaces could continue to operate at a proportionately reduced rate. Total destruction of the transformers would stop production in the furnaces and in the entire plant but it is believed that the Japanese could replace the stepdown transformers fairly quickly.

(C) *Soda-Lime-Sinter Process.* No photo cover is available of any Japanese Lime-Sinter or Soda-Lime-Sinter process plant, and, therefore, intelligence is less definite than for the other two processes. The most important steps or equipment in a Lime-Sinter process plant are the rotary kilns and then in their probable order of importance: the hoppers, conveyors, etc. for handling raw materials; the leaching, filtering and clarifying tanks; the precipitators; and the boiler plant.

The rotary kilns are usually housed in a large building with a ventilated, non-combustible roof supported on a light steel frame, but may be partly exposed. Stacks may be present, but are not always visible, at one end of the kilns. The other equipment in a lime-sinter process plant can be housed in almost any type of building. Those housing the leaching and filtering tanks and precipitators are relatively large.

The primary objectives in a lime-sinter process plant are the rotary kilns. These are large, heavy equipment, usually larger than the kilns used in a Bayer process plant. The individual kilns vary from 6 to 11 ft. in diameter and from 60 to 500 ft. in length--average length about 300 feet. They are constructed of steel boiler plate about 3/4 in. thick and are lined with fire brick. They are equipped with 2 to 6 steel tires, the number depending on the length of the kiln. The thickness of the steel at and near the points where the tires are attacked is built up to about 2 inches.

2. *Physical Vulnerability and Weapon Recommendations*

Most buildings are light and only act as cover. Damage to machinery is therefore the criterion for weapon and fuze selection.

The machinery is moderately vulnerable to H.E. effect. Blast is not very effective and damage will mostly result from direct hits or shock and fragmentation from very near misses. Neither contents, equipment, nor structures are readily combustible and the *use of incendiaries is not recommended.*

The primary objectives differ in the various processes ranging from electric furnaces in the Pedersen process, to digesters (autoclaves) and rotary kilns in the Bayer process, and to rotary kilns in the lime-sinter process. They all have the same degree of vulnerability, however, and will best be damaged by direct hits of meduim size HE bombs. The same size of bombs will also be efficient in creating damage to mechanical conveyors on which the movement of bulky materials depends.

The 250 lbs. G.P. bomb or the 500 lbs. G.P. bomb as alternate will be the most effective weapon and should be fuzed .1 sec. nose and .01 tail.

It must be understood that the above recommendation is general in character and that individual targets may possibly differ from normal. Therefore reference should always be made to the Target Information Sheets for weapon selection and amining points.

C. DURATION OF PRODUCTION LOSS

1. Recuperability of Alumina Plants by Process.

(A) *Bayer Process plants.* Replacement time for digester equipment is about 3 months. All other equipment in the plant except possibly the rotary kilns could be more quickly replaced or repaired. In the event of serious damage to the rotary kilns, production could be continued pending replacement or repairs by shipping the aluminum trihydrate to another plant or to a cement plant for calcination. The boiler plant could be replaced temporarily by a portable contractor's boiler pending repairs.

(B) *Pedersen Process plants.* In the Pedersen process, replacement time for the electric furnaces is about six months. All other equipment in this type of plant could be more quickly replaced or repaired. In the event of serious damage to the rotary kilns, production could be continued pending replacement or repairs by shipping the aluminum trihydrate to another plant or to a cement plant for calcination. The boiler plant could be replaced temporarily by a portable contractor's boiler pending repairs.

(C) *Sida-Lime-Sinter process.* The replacement time for rotary kilns is about three months. This is based on the time required to transport the kiln or kilns from another location and set them up. It is known that the Japanese had a considerable excess of cement plants and rotary kilns before the war. If they had to build new kilns from scratch, the replacement time would be longer--4 to 5 months.

Partial production could probably be continued in a lime-sinter plant, in the event of a successful attack, if one or more kilns remained useable.

Of secondary importance in a lime-sinter plant are the hoppers, conveyors, etc., for the handling of raw materials. The bulk of shale and lime required is such that it could not be handled temporarily by manual labor if this equipment were damaged. Damage to or destruction of this equipment would delay production until repairs or replacement could be made.

2. Use of Cement Plants

There is believed to be little, if any, existing unused capacity of alumina to which the Japanese could resort, because of the lack of bauxite and the difficulty of converting the Japanese Bayer process plants (see Note on Bayer process, Appendix I). New capacity could be created, however, and may already have been created by the conversion of cement plants to the Lime-Sinter process.

3. Summary of Duration of Production Loss

The duration of production loss is determined, first, by the replacement time of critical equipment (i.e. 3 months for digester equipment, 6 months for electric furnaces, 3 months for rotary kilns), and, second, by the conversion time of cement plants (which is estimated at about five months).

D. CONCLUSIONS AS TO VULNERABILITY OF ALUMINA PRODUCTION

The various alumina processes are moderately susceptible to bomb damage. Recovery time, however, is fairly short, and frequent attack would be required to hold down production. Cement plants can be converted to the Lime-Sinter process but only after a time lag of five months.

The alumina industry is most vulnerable during early 1945 when bauxite for the Bayer process is no longer available and the capacity of non-Bayer plants is apparently not yet adequate to maintain current aluminum output. Concentration of production in five plants in Honshu, Korea, and Manchuria is thought to be high (63%). However, the uncertainty of information about the changing alumina industry, e.g., the report of two new plants in North China, reduces somewhat the significance of the apparent shortage of capacity and the concentration of capacity in a few plants.

As the Japanese complete their conversion to non-Bayer process plants the increase in capacity and decrease in concentration will make the alumina industry less vulnerable. The desirability of attacking aluminum production by destroying alumina capacity at some later date will depend on the capacity, concentration and location of production at that time.

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ALUMINUM REDUCTION INDUSTRY

I. EFFECT OF LOSS OF ALUMINUM PRODUCTION ON MILITARY STRENGTH.

A. USE PATTERN: REQUIREMENTS

Based on the best available estimates of Japanese aluminum requirements, the uses of aluminum can be broken down as follows:

		Percent of total primary aluminum
Direct Military Uses		93.0
For aircraft production	82.0	
Other Army uses	5.0	
" Navy uses	6.0	
Indirect Military and Industrial Uses		7.0
		100.0

Current use of aluminum by the Japanese in aircraft production, including engines, propellers and spare parts, can be estimated roughly by applying the United States ratio for aircraft output to aluminum input to estimates of Japanese aircraft production. This method yields an estimate of 175,000 metric tons required for the current year, a figure which may be somewhat high. Following is a description of the method:

(1) The ratio of total United States shipments of aluminum fabricated shapes to total empty weight of United States planes was figured for the years 1941-1944.

(2) A study of these ratios revealed that certain allowances would have to be made for difference between United States and Japanese practice, relative size of planes and for the fact that the Japanese aircraft expansion program is about two years later than our own. With these considerations a comparable Japanese ratio was selected and applied to total empty weight of Japanese planes for 1944 to produce total weight of Japanese fabricated shapes for the year.

(3) Secondary aluminum was estimated at 10 percent.

(4) Total Japanese primary aluminum required was figured from total Japanese fabricated shapes minus secondary.

(5) This method produced a figure of 162,000 metric tons of primary aluminum required for aircraft production for 1944. As this was based on an estimated production by Japan of 17,500 combat planes during 1944 it was necessary to revise the estimate of aluminum requirements to make it applicable to the current estimated production of 2000 combat planes per month.

It should be noted that the estimates for Army, Navy, and indirect military and industrial uses are not direct estimates of the Japanese use pattern but are based almost entirely on experience in the United States with the following assumptions:

(1) That the Japanese needs for and uses of aluminum under wartime conditions are essentially the same and proportional to those in the United States.

(2) That the amount of steel available to Japanese consumers of aluminum outside the aircraft industry is the limiting factor in production of arms, munitions, etc., other than aircraft, and that since aluminum exists in a fairly fixed ratio to steel in these products, their production will govern aluminum requirements. Therefore, by multiplying the United States consumption in each of these categories (i.e. Army, Navy, and indirect military and industrial) of aluminum fabricated shapes by the figure representing the percentage that Japanese total steel production is of United States steel production, one arrives at reasonable extimates of requirements of the Japanese Army, Navy, etc.

By this method, the estimated 1944 requriement of aluminum by the Japanese Army in vehicles, ammunition, electronic equipment, artillery, etc., is 10,120 metic tons. The 1944 Japanese Navy requirement of aluminum in ammunition, ship construction, electronic equipment, etc., is 12,155 tons. Indirect military and industrial 1944 uses for de-oxidizing of steel, equipment parts, power transmission lines, etc., are estimated at 16,015 metric tons.

Future requirements will vary with aircraft production. If Japan achieves her planned aircraft production increase in 1945, the rise in aluminum requirements will be substantial, but the rate of increase of aluminum requirements will be less than proportional to the increase in aircraft. If aircraft production is held down or cut because of attacks on aero-engine or aircraft plants, aluminum requirements will decrease, particularly since a stationary aircraft production no longer needs new aluminum for increased working inventories.

B. PRODUCTION AND STOCKS

No independent estimate of production is available. Since there is no evidence than any shortage of aluminum has limited Japanese aircraft production and since capacity is adequate (see Section II), it is believed that production is approximately equal to requirements.

On the other hand, the scarcity of raw materials, shortages of shipping, pressure on electric power supply, and the recent rate of growth forced on the industry has probably prevented any accumulation of a stock pile other than that normally required for operating inventories.

C. TIMING OF EFFECT ON FRONT LINE STRENGTH

Inasmuch as 82 percent of Japanese aluminum is used for aircraft production and very little is known regarding the time factor in connection with the other Japanese uses of aluminum, the discussion here will be limited to the effect on front line aircraft strength.

The 14 largest enemy aluminum reduction plants comprise 92 percent of productio capacity. If any comparable percentage of aluminum production capacity is immobilized by bombing, the effect will be felt by a material reduction in replacements at front line units within a 5 months period which may be broken down as follows:

In stock at aluminum reduction plants and in transit to rolling mills	15 days
From aluminum ingot delivered at rolling mills to finished sheet delivered at aircraft plants	45 days
From sheet delivered at aircraft assembly plants to completed and tested aircraft	60 days
From factory airfield to delivery at the front line	30 days
	150 days

The production and fabrication of sheet has been selected as the limiting factor in the above computation because it has the shortest time factor of the 4 main branches of the so called "pipe line" from aluminum ingot to completed planes. These are, in the order of the time required, sheet, sand castings, extrusions and forgings.

The above estimate is based on American practice and is subject to correction a further intelligence becomes available.

D. CONCLUSIONS AS TO VULNERABILITY

There is no question but that a substantial loss of aluminum production can reduce the aircraft output and hence affect military strength. It is also clear, however, that since the only important, large-scale use of aluminum is in aircraft, an attack on aluminum must be considered only as an alternative to other methods of attacking aircraft. As such an alternative, the aluminum industry, with its advantages and disadvantages, is discussed under Section II D.

ALUMINUM REDUCTION INDUSTRY

II. VULNERABILITY OF PRODUCTION TO AIR ATTACK

A. INDUSTRIAL PATTERN

1. Capcity; Geographic Location

Total current aluminum production capacity is estimated at 232,000 metric tons per annum. Production is estimated to be 208,000 metric tons per annum.

Aluminum is produced by the enemy in 20 plants which are broken down by areas as follows:

	Number of Plants	Estimated Capacity in Metric Tons
Manchuria	2	36,000
Korea	4	36,500
Honshu	11	109,500
Shikoku	1	10,000
Formosa	2	40,000
	20	232,000

Because aluminum reduction requires large quantities of electric energy, plants have been built in areas where electric power is most plentiful, such as Formosa, northern Korea, and southern Manchuria, and, as far as Japan Proper is concerned, in the Tokyo electric supply area. Aluminum plants (like alumina plants) are generally located on the coast.

Five of the Honshu plants plus two of those in Korea, accounting for 20% of total capacity, are on or near the shore of the Japan Sea. It is probable, therefore, that they will be beyond the reach of carrier-based bombers for some time.

All Japanese aluminum plants use the same process - electrolytic reduction of alumina with Soderberg electrodes.

Estimates of the capacity of Japanese aluminum plants have been based on the best ground intelligence available and, for four of the largest plants, on interpretation of adequate air photography.

Photography has shown the capacity of two plants to have been substantially underestimated on the basis of ground intelligence (these were recent installations). It is possible that as further photo coverage is available individual and total capacity estimates will undergo considerable adjustment.

For further details as to capacity, production and location of the individual plants see Map 1, Diagram 2, and Table 1.

2. Concentration

The 14 largest plants include 92 percent of capacity. These, with the cumulative percent of total Japanese capacity, are as follows:

Target No.	Location	Capacity in Metric Tons	Percent of Total Japanese Capacity	Cumulative Percent of Total Japanese Capacity
90.18-1177	Kambara, Honshu	40,000	17.2	17.2
91.6 - 3	Takao, Formosa	20,000	8.6	25.8
91.5 - 61	Karenko, Formosa	20,000	8.6	34.4
93.3 - 32	Fushun, Manchuria	18,000	7.8	42.2
90.9 -1003	Niigata, Honshu	18,000	7.8	50.0
93.2 - 200	Antung, Manchuria	18,000	7.8	57.8
93.2 - 201	Yoshi, Korea	18,000	7.8	65.6

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Target No.	Location	Capacity in Metic Tons	Percent of Total Japanese Capacity	Cumulative Percent of Total Japanese Capacity
90.12-1100	Omachi, Honshu	12,000	5.2	70.8
84.2 - 1	Konan, Korea	12,000	5.2	76.0
90.29- 924	Niihama, Shikoku	10,000	4.3	80.3
90.11- 861	Higashi Iwase, Honshu	8,000	3.4	83.7
90.11- 866	Takaoka, Honshu	8,000	3.4	87.1
90.11-1689	Sasazu, Honshu	6,000	2.6	89.7
90.20-1822	Ogaki, Honshu	6,000	2.6	92.3

3. *Extent of Integration*

Eleven of the aluminum plants are integrated with alumina plants and share the same plant compound, as follows:

Target No.		Estimated Capacity in Metric Tons	Production in Metric Tons
	Manchuria		
93.3 - 32	Fushun	18,000	18,000
93.2 - 200	Antung	18,000	10,000
	Korea		
84.2 - 1	Konan	12,000	12,000
84.3 - 67	Chinnampo	5,000	5,000
93.2 - 201	Yoshi	18,000	18,000
84.4 - 208	Genzan	1,500	1,500
	Honshu		
90.12-1100	Omachi	12,000	12,000
90.11- 861	Higashi Iwase	8,000	8,000
90.11- 866	Takaoka	8,000	8,000
90.5 -1557	Hachinohe	4,000	4,000
	Formosa		
91.6 - 3	Takao	20,000	14,000
		124,500	110,500
	percent of Total	54	53

4. *History and Possible Future Changes*

Production of aluminum by the Japanese was initiated in 1934. Prior to that the Japanese aluminum industry consisted solely of the manufacture of a relatively small amount of aluminum goods from imported ingots, and experimental work. Production of aluminum from 1934 is as follows:

	Metric Tons	
1934 -	700	
1935 -	4,700	
1936 -	7,500	
1937 -	10,500	
1938 -	17,000	
1939 -	23,000	(Approx.)
1940 -	45,000	(Estimated)
1941 -	70,000	(")
1942 -	100,000	(")
1943 -	150,000	(")
1944 -	208,000	(")

The industry was developed around the Bayer process and, as a consequence, was until recently largely dependent on imported bauxite. However, there is evidence even in the earlier years of experimental work in an effort to produce alumina from native low-grade aluminous raw materials. A pilot plant which resulted in the development of the Modified Pedersen process is known to have been in operation at Fushun, Manchuria (Target 93.3-32), prior to 1937. No evidence is available regarding the date of initial development of the soda-lime-sinter process but it was probably between 1939 and 1941. The Soderberg process for aluminum reduction was evidently adopted from the beginning and is used exclusively in Japanese plants.

Definite evidence regarding the construction of individual plants is available for only four plants which are, however, among the largest -- those at Takao, Formosa (Target 91.6-3); Fushun, Manchuria (Target 93.3-32); and at Kamabara and Niigata, Honshu (Targets 90.18-1177 and 90.9-1003).

The original plant at Takao, centering around the two older pot rooms, was begun in 1936 and finished late in 1937. The original plant at Fushun, centering around the two larger pot rooms, was begun about January 1938 and completed late in 1939. The plant at Kambara was begun about March, 1940 and by July, 1941 the first two pot rooms were completed and a third under construction. The plant at Niigata, originally planned for 2 pot rooms, was under construction at the same time as the Kambara plant. It is known that a contract was let to build the plant at Antung, Manchuria, but as of July, 1941 construction was still held up because the Japanese had not been able to furnish the necessary electric equipment.

B. PRODUCTION PROCESS AND PHYSICAL VULNERABILITY

1. Process.

Only one process is in use for the production of aluminum - electrolytic reduction of alumina with Soderberg electrodes. Electroytic reduction is the only process that has been developed successfully for commerical use anywhere. The process as used by the Japanese - spoken of as the Soderberg process - differs from the older electrolytic process only in the type of electrodes used. The process is graphically described in Flow Chart No. 1 and notes accompanying same in Appendix No. 1.

The process consists of dissolving the alumina in a molten bath of synthetic cryolite in the electrolytic pot and electrolyzing it with direct current at 32,000 amperes and about 4.75 volts per pot, the current passing from the Soderberg anode to the carbon lining of the pot which serves as the cathode. The molten aluminum is drawn or syphoned off periodically from the bottom. In the larger Japanese plants the pots are connected in series in "lines" of 132 pots and the direct current is fed to the line at 32,000 amperes, 700 volts. The heat generated by the high amperage current supplied by the mercury-arc rectifiers keeps the elctrolyte molten.

The primary or most essential buildings and equipment in an aluminum reduction plant are the pot rooms, housing the electrolytic pots, the rectifier building, housing the mercury-arc rectifiers and (in Japanese practice) the rectifier transformers, and the open transformer yard, which includes the stepdown transformers, circuit breakers and usually a skeleton steel framework to support the wires, cables and bus bars.

These primary buildings in every aluminum plant will be found in the same arrangement (See accompanying sketch of *Typical Japanese Aluminum Plant Ground Plan* - Illustration No. P1). The rectifier building, which is the primary objective in all aluminum plants, will be found at one end of the long parallel and easily recognized pot rooms, between the pot rooms and the open transformer yard as illustrated in sketch. This should make it possible to locate the primary objective from the air in plants that may not be covered by air photography. In certain of the larger plants this entire installation may be duplicated (See air photography of plants at Fushun, Manchuria, and Takao, Formosa).

2. Layout

(A) *Pot Rooms.* The pot rooms invariably are large, long, one-story buildings from 70 to 180 ft. in width and from 475 to 600 ft. long, usually built on a steel frame and with monitor or saw-toothed roofs for the necessary ventilation (See Illustration P2). Usually there are two but there may be 3 or 4 pot rooms in a group (See air photography of the plants at Kambara, Honshu, and at Takao and Karenko, Formosa). They are always built parallel to each other within the group and from 50 to 60 ft. apart.

(B) *Rectifier Buildings.* Rectifier buildings are long and narrow, averaging 65 to 70 ft. in width. Their length approximates the total overall width of the pot rooms which they serve, and will probably average about 300 ft. (at the plant at Kambara, Honshu, there are 2 rectifier buildings approximately in line serving the 4 parallel pot rooms). All Japanese rectifier buildings will probably prove to be two-story buildings. Those more recently built are probably of reinforced concrete construction including the roof. Rectifier buildings in the older plants do not necessarily have concrete roofs (See older rectifier building at Takao, Formosa (Target 91.6-3)), but even these will probably have a reinforced concrete second floor because of the weight that must be carried thereon. The distance between the rectifier building and the pot rooms ("a" in sketch of typical plant, Illustration P1) is necessarily short. It varies from adjoining to a maximum of about 25 ft. Thus an attack on either part of the installation may be expected to damage the other. One or at most two rectifier buildings will be found at each aluminum plant.

(C) *Transformer Yard.* The distance between the rectifier building and the open transformer yard ("b" in sketch of typical plant, Illustration P1) varies from adjacent to a maximum of about 50 ft. The transformer yard is easily recognizable by the large step-down transformers and circuit breaking equipment, usually be a large skeleton steel structure for supporting wires, cables and bus bars, and by the power line leading thereto.

3. Production Time Factor

The average time required by the enemy to produce aluminum ingot from alumina, including shipment to the fabricating plant is estimated at about one month.

4. Vital Facilities

The vital facilities in any aluminum plant are the mercury-arc rectifiers and the rectifier transformers housed in the rectifier building. Both of these types of equipment are essential to the production of aluminum. Production in any plant would cease immediately if 60 percent or more of the installed units of either type ceased to function. Both types of equipment are easily damaged and both require a long period to replace. This period would increase progressively in the event of a concerted attack as the number of required replacements increased.

The mercury-arc rectifiers are in a single row on the second floor of the two-story rectifier buildings. They are large but delicately adjusted units of industrial electronic equipment whose purpose in the aluminum plant is to convert multi-phase alternating current into a smooth flow of direct current at high amperage. The operating weight of each unit, including water, is from 8 to 15 tons. Mercury-arc rectifiers have no moving parts except the accessory vacuum and water pumps. Their operation is based on the fact that mercury vapor conducts electricity only in one direction between the graphite anodes and the mercury-pool cathode.

A mercury-arc rectifier, of the type known to be in use in the Japanese aluminum industry, consists essentially of a large cylindrical steel tank, from 6 to 8 ft. in diameter and from 4 to 6 ft. in height, in which are inserted from 12 to 18 graphite anodes and a single mercury pool cathode, and in which is maintained an atmosphere of mercury vapor in a very high vacuum. The side walls of the inner (vacuum) tank are of rolled boiler plate from 0.25 to 0.315 in. thick. The side walls of the outer tank (water jacket) are of rolled boiler plate from 0.2 to 0.25 in. thick. The openings in the inner (vacuum) tank where the anodes, excitation anodes, starting anode, and cathode are inserted must be insulated, usually with ceramic bushings, and must be sealed perfectly against the vacuum. These are critical points for damage to the rectifier. Rectifiers are insulated from the floor and are either mounted on ceramic insulators which may be lightly bolted to the floor, or on wheels, as in the Siemens-Schuckert type, which may be of phenolic plastic and serve as insulators.

The largest mercury-arc rectifiers known to be in use in the Japanese Aluminum industry (See the photo of installation in Kambara Plant-Target 90.18-1177 in Illustration P2 and the diagram D1, and also Illustration P3) are exact copies of the German Siemens-Schuckert type and are believed to be exact copies of Siemens-Schuckert model VD100 10, on which detailed Siemens-Schuckert construction drawings are available.

The following pertinent facts and specifications are for this model:

Capacity -	8,000 amperes or 5,600 K.W.
Anodes -	18
Overall height	10.4 ft
Outside diameter	8.9 ft
Operating weight, including water for cooling -	14.88 short tons
Weight without water	12.12 " "
Mounted on 10 inch solid wheels	
(Possibly phenolic plastic for insulation)	
Inner (vacuum) tank	
diameter	8 ft. 3 in.
height	6 ft.
capacity	307.6 cu. ft.
side walls, rolled steel plate,	0.315 in.
Outer tank (water jacket)	
side walls, rolled steel plate	0.2 in.

The multi-phase rectifier transformers are in a single row on the ground floor of the two-story rectifier buildings. They are large units with complex windings (See Illustration P4) whose purpose in the aluminum plant is to furnish alternating current to the rectifiers at the proper voltage (in Japanese practice usually 700 volts) and in the proper number of phases (normally 6). In Japanese practice each transformer furnishes the power to a single rectifier.

Specifications of Japanese rectifier transformers are not available but pertinent specifications of a comparable American transformer are as follows:

Output rating - 6 phase, 8,000 amperes, 700 volts
For operation from: 13,200 Volts, 3 phase, 60 cycle power
Tanks made from boiler plate, 7/16" thick.

Weights per transformer:

Core and coils -	25,000 lbs
Tank and fittings -	27,000 "
Oil -	24,000 "
Total Weight -	76,000 "

5. *Physical Vulnerability of Vital Installations*

The mercury-arc rectifiers and rectifier transformers are both easily damaged by H.E.'s. The rectifiers are large but delicately adjusted industrial electronic units. Any shock which damaged one or more of the numerous insulated vacuum seals would cause a rectifier to cease to function. Any damage which resulted in warping or bending the side wall of the inner (vacuum) tank could probably not be repaired because it would then be very difficult to restore the vacuum seal between the main body of the tank and the anode plate.

In the United States rectifier transformers are installed in a row outside of the rectifier building, presumably because of our fire regulations. Although it is possible that they may be found in this position in some Japanese plants, it is known that they are installed inside, on the ground floor of the two-story rectifier buildings at the five largest enemy aluminum plants: those at Kambara and Niigata, Honshu; Takao and Karenko, Formosa; and at Funshun, Manchuria. This leads to the belief that the inside installation is typical of Japanese practice and that, in all probability, all rectifier transformers will be found inside.

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Rectifier transformers are encased in a tank of boiler plate, 7/16 in. thick. The transformer coils operate in a bath of highly refined transformer oil of high insulating quality and dielectric strength, which must be kept free from water, air and oxygen. The temperature of the oil in a transformer operating at full load is normally about 55°C above room temperature. The transformer oil is similar to a light household lubricating oil such as "3 in 1." Because of its temperature in operation it can be considered highly inflammable. The transformers, therefore, when installed within the rectifier building, may present a serious fire-hazard.

There are three different types of rectifier transformers as regards the method of cooling used. The differences are of interest because they may affect the vulnerability of the equipment. It is not as yet known which of these types exists in the enemy plants.

In the United States, where the transformers are installed outside, the common practice is to equip them with large cooling radiators outside the tank in which the oil circulates by gravity. The oil-cooled transformer, when installed outside, is highly vulnerable to fragmentation bombs. This type of transformer can be installed inside with forced air circulation but it is more logical that one of the other two types will be found.

The other two types have no radiators. In the one, spoken of as water-cooled, cool water is circulated through a coil of pipe within the oil bath inside the transformer tank. However, the water-cooled type may not be in use as it is subject to short circuiting -- the slightest leak in the water pipes and connections within the tank will cause a short circuit sooner or later and the trouble is not apparent until the short circuit occurs.

The third type, known as forced-oil-cooled, has openings at the top and bottom of the transformer tank to which pipes are fitted, which lead to a heat exchanger. Here the oil is cooled by pumping it continuously to and from the heat exchanger. Where this type of transformer is found the oil can be spilled by breaking the pipes leading to the heat exchanger.

The amount of oil in the latter two types is somewhat less than in the self-cooled type but in any case a considerable tonnage of oil would be involved. Once spilled and ignited, a major fire hazard would be created.

6. Physical Vulnerability of an Aluminum Plant as a Whole

All other equipment in aluminum plants is less vulnerable than the rectifying equipment. Electrolytic pots consist of strong rectangular or round tanks made of steel 1 to 2 in. thick. The tank is usually lined with fire brick and then with a tamped and baked carbon lining 6 to 10 in. thick. They are not easily damaged and those that are damaged can be shorted out of the pot line so that production can be continued in the undamaged pots while repairs are being made to damaged pots and to the building. There are from 250 to 528 pots in a single plant.

The step-down transformers in the open transformer yards are also considered less attractive as a target. They are standard equipment and replacements could probable be made without protracted delay.

Damage to the synthetic cryolite and carbon paste plants would not necessarily stop production of aluminum because the cryolite and carbon paste could be shipped in from another plant pending repairs.

7. Weapon Recommendations

The reinforced concrete building housing the mercury-arc rectifiers and the multi-phase transformers is the primary objective in attacks on Japanese aluminum plants. Since these buildings are usually of fire resistant construction, attack with high explosive weapons alone is recommended.

A preliminary analysis indicates that the AN-M64-500 lb. G.P. bomb will be the most effective weapon on a weight for weight basis in damaging the rectifiers and transformers. The use of 0.1 sec. nose/.025 sec. tail fuzing is recommended to obtain penetration which is necessary for maximum damage, in two-story installations. When primary objectives are located in one-story buildings the use of 0.1 sec. nose/0.01 sec. tail fuzing will be more effective.

The extent of damage will be greatly increased if firing of the transformer oil occurs. The high explosive weapon selected is capable of both rupturing the oil radiators and igniting the released contents. The 500 lbs. G.P., fuzed either .01 tail or .025 tail is also the most effective weapon to cause general damage to equipment other than the primary objectives.

It must be understood that the above recommendation is general in character and that individual targets may possibly differ from normal. Therefore, reference should always be made to the Target Information Sheets for weapon selection and aiming points.

C. DURATION OF PRODUCTION LOSS

1. Unused Capacity Available.

According to the estimates used in this study, the difference between total capacity and production is 24,000 metric tons. This is probably an underestimate of unused capacity. Some technical over-capacity in aluminum may exist in certain plants to allow them to operate wholly on hydro-electric power. If aircraft production is held to its present levels, requirements for aluminum will decrease, as already noted. Excess capacity in aluminum would then be substantially increased.

2. Time Required to Repair or Replace Damaged Facilities

In the event of an attack on a single plant resulting in serious damage to 60 percent or more of either the rectifiers or rectifier transformers (in each rectifier building if there are 2), the immediate results would be as follows:

(a) Direct current power to the pot lines would be cut off.

(b) Assuming the damage was severe enough so that the D.C. power could not be restored within 4 hours, the electrolyte in all the pots would cool and solidify. This would necessitate chipping the electrolyte out of all the 250 to 528 pots and relining them with carbon. This is all hand labor with the assistance of compressed air tools if available. This work would require at least 3 months and full production could not be resumed in less time even though D.C. power were restored earlier. If a sufficient number of rectifiers and rectifier transformers were undamaged, partial production could be resumed in about two months.

The above, however, applies only to the potroom phase of restoring production facilities. Actually full production could not be resumed until the destroyed or seriously damaged rectifying equipment had been replaced and this would require a minimum of six months.

In the event of a concerted attack on the rectifying equipment in enemy aluminum plants, the time required to repair or replace would be greater and would increase progressively with the number of units destroyed. It is reliably estimated that a minimum of 150 mercury-arc rectifiers and 150 rectifier transformers, including installed spares, are in use in the enemy aluminum reduction industry. The time required by the enemy to replace any large number of units of this equipment is not known as it involves the time required to construct the equipment by the Japanese heavy electric industry. Rectifying equipment, especially in the large sizes required for the aluminum industry is highly specialized and is all made to order even in the United States.

The companies which produce about 80% of the mercury-arc rectifiers in the United States estimate that under emergency conditions it would require 29 weeks working at full capacity to produce 150-3600 KW rectifiers and 18 weeks to produce 150 rectifier transformers of comparable size. It is reasonable to believe that the Japanese, with a much smaller heavy electric industry, might require at least double this time. If an attack on the industry were only moderately successful, the recuperability problem would not be nearly as severe, since the Japanese heavy electric industry already produces some rectifiers for expansion purposes. In such a case, overall loss of production might be six months.

3. Available Substitutes & Dispersal Possibilities

It is possible to use wood, magnesium and steel or combinations thereof as substitutes for aluminum in aircraft production. Any major effort to use these materials as substitutes for aluminum in aircraft would involve complete redesign of the aircraft, retooling of aircraft plants and would require a minimum of from 1 to 1½ years before finished planes could be produced in significant quantities. The extent of Japanese research and development along this line is not known. To date little, if any, enemy material has been captured which would indicate such an effort with operational planes.

It is not possible to sub-contract parts of the aluminum process. Dispersal would involve the construction of new plants.

D. CONCLUSIONS AS TO VULNERABILITY

The essential factor in the evaluation of aluminum as a target system is that it is a method of getting at aircraft production and should be considered as an alternative to attacking the aircraft industry directly. As such an alternative, the aluminum reduction industry has several disadvantages.

(a) Production is less concentrated.
(b) A number of plants are out of range of present bases and some are probably not within range of carrier-based aircraft.
(c) There is a lag (although not excessively long) between loss of aluminum capacity and reduced aircraft production.

On the other hand, aluminum has two important advantages.

(a) It cannot be dispersed nearly as effectively as aircraft.
(b) If a concentrated attack could be mounted on a large part of the industry and succeed in destroying vital installations, recovery would be considerably longer delayed than for aero-engine or airframe manufacture (this applies to attack on aluminum reduction, not alumina).

While there is a case for initially attacking aluminum as the primary raw material of aircraft, other factors have led to a decision to attack aircraft manufacture. The question then becomes how will the attack that has been and is being made on the aircraft industry affect evaluation of the aluminum industry as a target system? It is possible that with a cut in aircraft production aluminum might be stockpiled so as to make it invulnerable to later attack. Such a stockpiling, however, is not at all certain. In the first place, even a successful attack on aero-engines will leave large remaining aircraft production. Shipping and power shortages will make Japan reluctant to produce more aluminim than is necessary.

Once aircraft has become so dispersed as to be an unrewarding target, aluminum might be a good alternative method of getting at aircraft.

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Sheet No. ATSF/NFM/ T1
Date 7 February 1945
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TABLE I

JAPANESE NON FERROUS METALS

ESTIMATED CURRENT ANNUAL CAPACITY AND PRODUCTION OF JAPANESE ALUMINUM AND ALUMINA PLANTS AS OF JANUARY 1945

ARRANGED ACCORDING TO ALUMINUM CAPACITY
IN METRIC TONS

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Target No.	Company	Location	Coordinates North	Coordinates East	Aluminum Capacity	Percent of Total	Aluminum Production	Percent of Total	Alumina Capacity	Percent of Total	Alumina Production	Percent of Total
90.18-1177	Japan Light Metals Aluminum Plant	Kambara, Honshu	35°07'	138°37'	40,000	17.24	40,000	19.23				
91.6 - 3	Nippon Aluminum Co.	Takao, Formosa	22°37'	120°17'	20,000	8.62	14,000	6.73	B- 40,000	7.01	32,000	7.54
91.5- 61	Japan Aluminum Co.	Karenko, Formosa	24°01'	121°38'	20,000	8.62	10,000	4.81				
93.3 - 32	Manchuria Light Metals (Aluminum)Mfr. Co.	Fushun, Manchuria	41°50'	123°47'	18,000	7.76	18,000	8.65	48,000	8.41	48,000	11.30
90.9 -1003	Japan Light Metals Co.	Niigata, Honshu	37°54'	139°03'	18,000	7.76	18,000	8.65				
93.2 - 200	*Manchuria Light Metals Co.	Antung, Manchuria	40°07'	124°23'	18,000	7.76	10,000	4.81	24,000	4.20	24,000	5.65
93.2 - 201	*Oriental Light Metals Co.	Yoshi, Korea (Shingishu or Gishu)	39°59'	124°28'	18,000	7.76	18,000	8.65	21,000	3.68	17,000	4.00
90.12-1100	Showa Denko Aluminum, Omachi	Omachi, Honshu	36°29'	137°51'	12,000	5.17	12,000	5.77	B- 8,000	1.40	2,400	0.56
84.2 - 1	Chosen Nitrogen Fertilizer Co.	Konan, Korea	39°50'	127°38'	12,000	5.17	12,000	5.77	24,000	4.20	24,000	5.65
90.29- 924	Sumitomo Aluminum Reduction Plant	Niihama, Shikoku	33°58'	133°17'	10,000	4.31	10,000	4.81				
90.11- 861	Nichiman Aluminum Co.	Higashi Iwase, Honshu	36°45'	137°14'	8,000	3.45	8,000	3.85	20,000	3.50	20,000	4.71
90.11- 866	Nippon Soda Co., Aluminum Plant	Takaoka, Honshu	36°46'	137°01	8,000	3.45	8,000	3.85	B- 14,000	2.45	4,200	0.99
90.11-1689	Kokusan Light Metals Co,Sasazu Plt	Sasazu, Honshu	36°34'	137°13'	6,000	2.59	6,000	2.88				
90.20-1822	*Ibigawa Electro-Chemical Co,Kido/Plt	Ogaki, Honshu	35°22'	136°37'	6,000	2.59	6,000	2.88				
84.3 - 67	Chosen Riken Metals Co.	Chinnampo, Korea	38°43'	125°23'	5,000	2.16	5,000	2.40	20,000	3.50	20,000	4.71
90.5 -1557	Nitto Chemical Co.	Hachinohe, Honshu	40°32'	141°31'	4,000	1.72	4,000	1.92	B- 10,000	1.75	3,000	0.71
90.10-1658	Northeast Aluminum Plant (Nichiman Aluminum Co.)	Koriyama, Honshu	37°24'	140°24'	4,000	1.72	4,000	1.92				
90.25-1726	Osaka Ceramic Industry Cement Co.	Osaka, Honshu	34°38'	135°28'	2,000	0.86	2,000	0.96				
90.17-2034	*Nasu Aluminum Co.	Tokyo, Honshu	35°42'	139°45'	1,500	0.65	1,500	0.72				
84.4 - 208	*Nichiman Aluminum Co.	Genzan, Korea	39°10'	127°26'	1,500	0.65	1,500	0.72	3,000	0.53	3,000	0.71
90.18-1176	Japan Light Metals Alumina Plant	Shimizu, Honshu	35°00'	138°31'					B-100,000	17.51	30,000	7.06
90.32- 822	Onoda Cement Co.	Onoda, Honshu	33°58'	131°10'					70,000	12.26	70,000	16.49
90.29-1690	Asano Cement Co.	Itozaki, Honshu	34°23'	133°07'					50,000	8.76	50,000	11.78
90.35-1877	Toyo Aluminum Co.	Omuta, Kyushu	33°03'	130°27'					B- 36,000	6.30	10,800	2.54
90.34-1108	Japan Aluminum Co.	Kurosaki, Kyushu	33°52'	130°45'					B- 24,000	4.20	7,200	1.70
90.29-1657	Sumitomo Alumina Plant	Niihama, Shikoku	33°58'	133°16'					20,000	3.50	20,000	4.71
90.7 -1759	Kokusan Light Metals	Kurosawajiri, Honshu	39°17'	141°07'					20,000	3.50	20,000	4.71
90.17- 521	Showa Electro-Chemical Co.	Yokohama, Honshu	35°29'	139°40'					16,000	2.80	16,000	3.77
90.27-1648	Asada Alumina Plants	Shikama, Honshu	34°48'	134°41'					3,000	0.53	3,000	0.71
	TOTALS				232,000	100.01	208,000	99.98	571,000	99.99	424,600	100.00
	Percentage of total capacity or production of ten largest plants					80.17		77.88		76.53		79.60
	Percentage of total capacity or production of fourteen largest plants					92.25		91.34		90.53		94.62
	From Bauxite in Bayer Plants								232,000	40.6	89,600	21.10
	From Shales and other low grade aluminous raw materials								339,000	59.4	335,000	78.90

* - The exact locations of these plants are not known. Coordinates are for the towns.
B - Bayer Process Plants

(P)

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JOINT TARGET GROUP, WASHINGTON, D.C.

Sheet No. ATSF/NAM
Date 7 Feb. 1945
Page No. 1

JAPANESE NON-FERROUS METALS, PART I, ALUMINA-ALUMINUM - GENERAL ANALYSIS

APPENDIX NO. 1

PROCESSES IN USE IN THE JAPANESE ALUMINA-ALUMINUM INDUSTRY

DESCRIPTION

The four (4) processes in use in the Japanese alumina-aluminum industry are graphically described in the four (4) flow charts at the end of this appendix.

FLOW CHART NO. 1. SODERBERG PROCESS FOR ALUMINUM REDUCTION

Only the one (1) process is in use in the Japanese aluminum industry. For convenience the manufacture of **synthetic** cryolite is usually associated with the manufacture of alumina. In actual practice fluorspar (CaF_2) is treated with sulphuric acid (H_2SO_4) to produce hydrofluoric acid (HF). Sodium aluminate liquor ($NaAlO_2$) is then drawn from the alumina plant and treated with the hydrofluoric acid to produce synthetic cryolite (Na_3AlF_6) thus eliminating the direct use of alumina and soda ash in this part of the process.

FLOW CHART NO. 2. BAYER PROCESS

This is the standard process for the manufacture of alumina where high grade bauxite of low silica content is available. It cannot be used for lower grade aluminous raw materials or those with a high silica content. Due to the Japanese shipping situation and to the fact that no bauxite of a suitable grade for the Bayer process is available to the Japanese nearer than the Netherlands East Indies, the value of the Bayer process plants to the Japanese war effort and their importance as targets is open to serious question. The Japanese may well be in the process of writing them off, so far as their war effort is concerned, in anticipation of the complete loss of their supplies of bauxite from the NEI. This becomes understandable when considering the fact that, facing the necessity of producing alumina from low grade materials, it is far simpler and easier to convert cement plants, of which Japan had a considerable surplus before the war, to the Lime-Sinter process than it is to convert a Bayer plant to handle low grade materials. Also the conversion of a Bayer plant would require considerable additional plant space because of the necessity of handling a greatly increased bulk of raw materials and it would be very difficult for the enemy to find room for the necessary expansion and rearrangement at some of the compact Bayer plants. It is true that experimental work in an effort to convert the Bayer plants, including a pilot plant at one location, has been reported but, in view of the above, it is believed that the effort will not be carried very far and it is very doubtful whether it will produce satisfactory results.

FLOW CHART NO. 3. MODIFIED PEDERSEN PROCESS

This modification of the Pedersen process was developed by the Japanese for use at the alumina plant at Fushun, Manchuria, for processing native aluminous shale. The use of this process, requiring 10,000 KWH of electric power per ton of alumina, approximately doubles the power required per ton of aluminum. Dr. Yagi[1] states that the total power requirements per ton of aluminum at Fushun are over 50,000 KWH. For this reason the process is suitable only in areas where hydro-power is relatively abundant during the entire year, such as Southern Manchuria and Northern Korea. At present it is definitely known to be in use at the Fushun plant only but may be found in two or three (2 or 3) other plants in the area named. It very probably will not be found in use in the main Japanese Islands.

FLOW CHART NO. 4. THE SODA-LIME-SINTER PROCESS

The soda-lime-sinter process offers the only logical explanation of the reliably reported fact that the two (2) large cement plants at Onoda and Itozaki have been converted to alumina production and are using low grade aluminous raw Material.

---

[1] "Concerning the Aluminum Industry in Manchukuo and Chosen," by Dr. Yagi In Toyo Keizai Shimpo, 25 Jan. 1941, pp 36-37, translated by MID, NY, Report No. 14206, 19 May 1944.

The essential features of the process have been known to the chemical world for years and there is no reason for assuming that it is not known to the Japanese. In fact it was reported in August 1943 as having been studied by several companies and research institutes in Japan since the outbreak of the war. A cement plant can readily be converted to its use without any large drain on strategic materials in about five (5) months. No other known process would be suitable for use in a converted cement plant.

A modification of this process has been used commercially in Norway and Sweden and will shortly be in use in this country. The Process undoubtedly would have been used more and earlier but for the fact there was no need for it. As long as there was an adequate supply of high grade bauxite the Bayer process was preferred.

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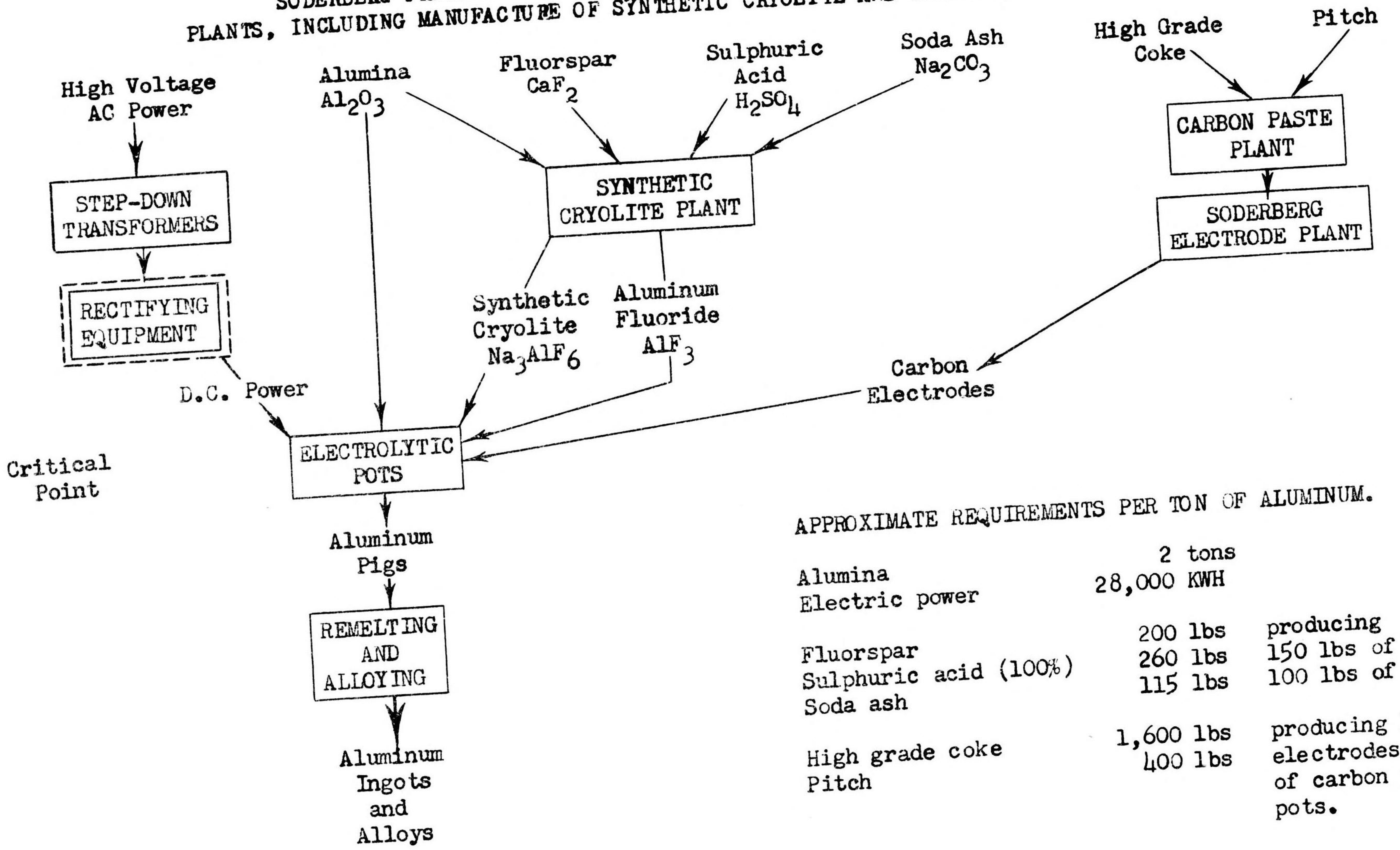
JAPANESE NON FERROUS METALS

FLOW CHART NO. 1 - SODERBERG PROCESS

Sheet No. ATSF/NFM/FC1
Date 7 Feb 1945

SODERBERG PROCESS IN USE IN ALL JAPANESE ALUMINUM REDUCTION PLANTS, INCLUDING MANUFACTURE OF SYNTHETIC CRYOLITE AND CARBON ELECTRODES.



APPROXIMATE REQUIREMENTS PER TON OF ALUMINUM.

Alumina	2 tons	
Electric power	28,000 KWH	
Fluorspar	200 lbs	producing 150 lbs of cryolite and 100 lbs of aluminum fluroide
Sulphuric acid (100%)	260 lbs	
Soda ash	115 lbs	
High grade coke	1,600 lbs	producing 1200 lbs of carbon electrodes plus small amount of carbon paste for relining pots.
Pitch	400 lbs	

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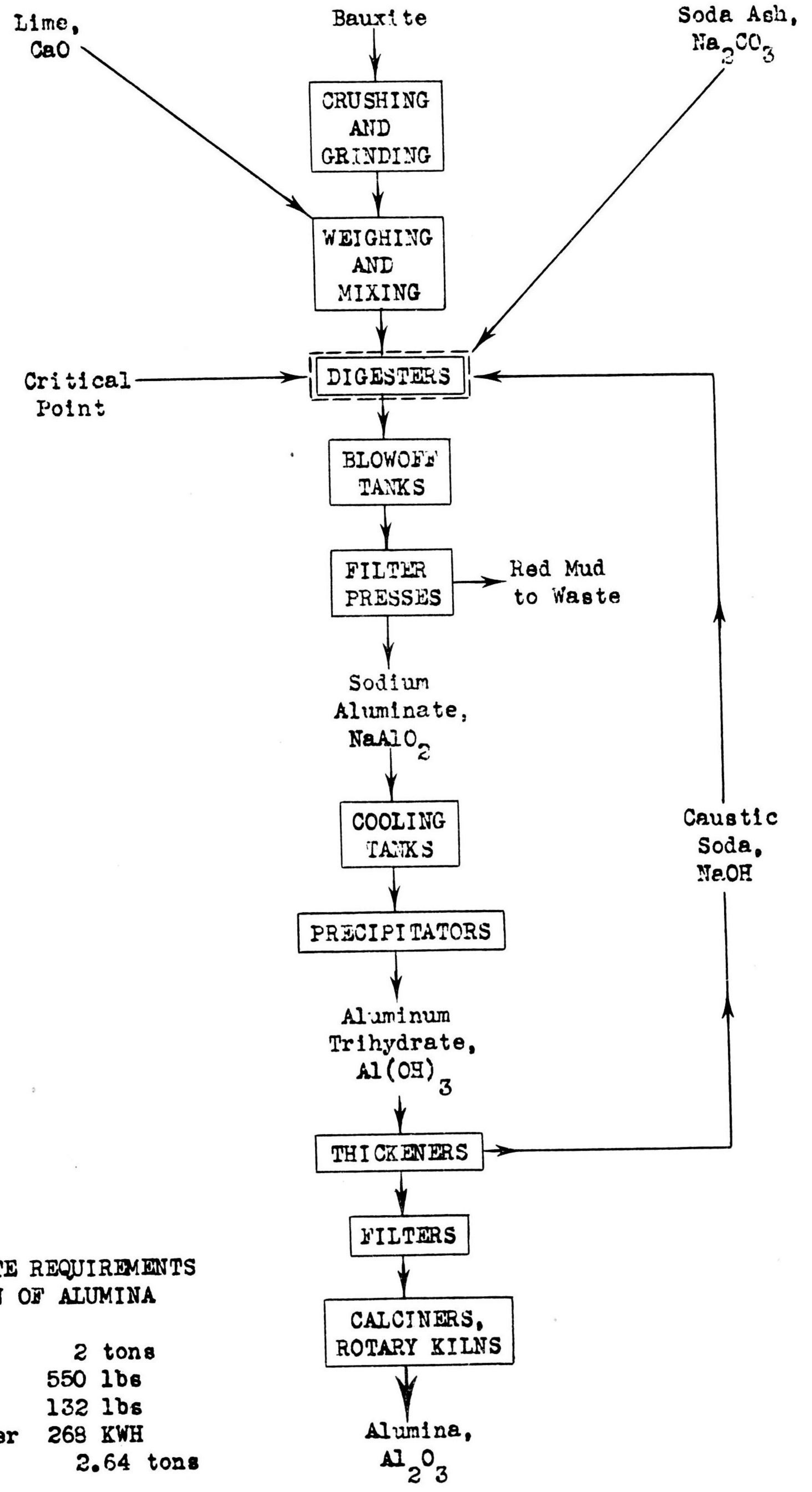
JAPANESE NON FERROUS METALS

FLOW CHART NO. 2 - BAYER PROCESS

BAYER PROCESS IN USE IN JAPANESE ALUMINA PLANTS AT SHIMIZU, TAKAO, OMUTA, KUROSAKI, TAKAOKA, HACHINOHE AND OMACHI.



APPROXIMATE REQUIREMENTS PER TON OF ALUMINA

Bauxite	2 tons
Lime	550 lbs
Soda Ash	132 lbs
Elec. Power	268 KWH
Bit. Coal	2.64 tons

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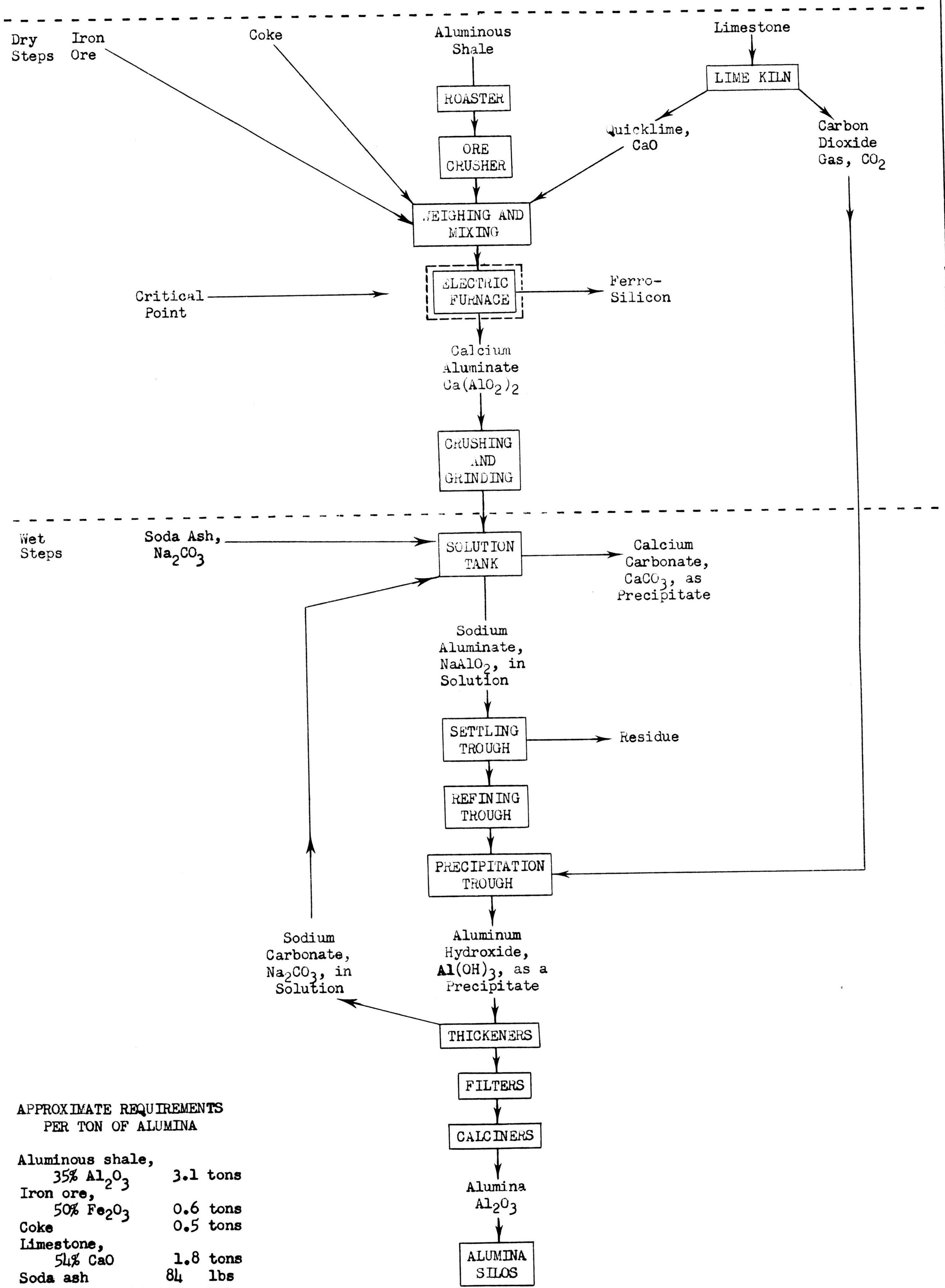
JAPANESE NON FERROUS METALS
FLOW CHART NO. 3 - MODIFIED PEDERSEN PROCESS

Sheet No. ATSF/NFM/FC3
Date 7 Feb 1945

MODIFIED PEDERSEN PROCESS IN USE AT THE ALUNIMA PLANT OF MANCHURIA LIGHTS METALS CO., FUSHUN, MANCHURIA



APPROXIMATE REQUIREMENTS PER TON OF ALUMINA

Aluminous shale, 35% Al_2O_3	3.1 tons
Iron ore, 50% Fe_2O_3	0.6 tons
Coke	0.5 tons
Limestone, 54% CaO	1.8 tons
Soda ash	84 lbs
Elec. power	10,000. KWH
Bit. coal	0.67 tons

Adapted from a translation of an article by Dr. Yagi published in Tōyō Keizai Shimpō (The Oriental Economist), Tokyo, 25 January 1941.

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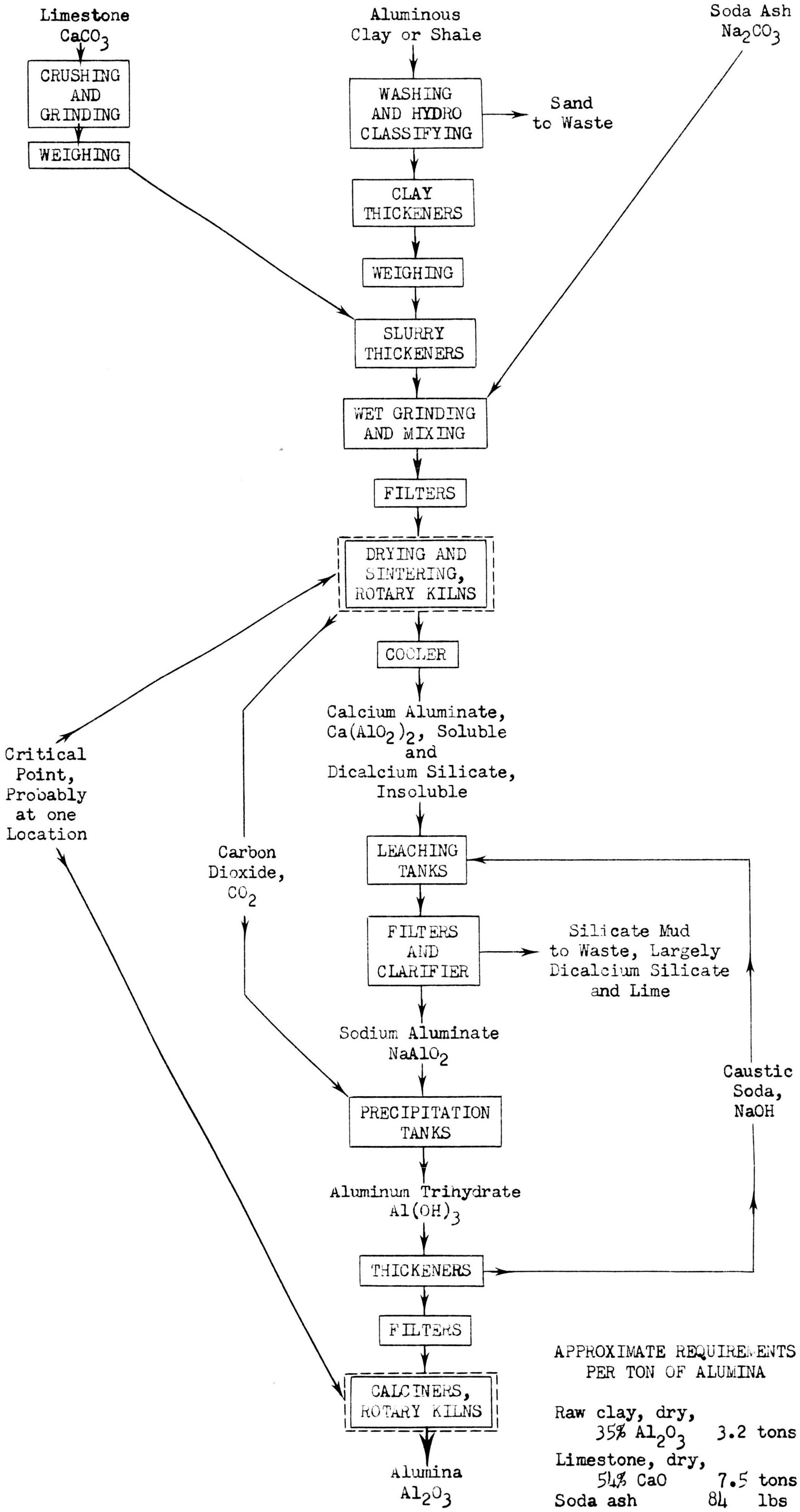
JAPANESE NON FERROUS METALS

FLOW CHART NO. 4 - SODA-LIME-SINTER PROCESS

Sheet No. ATSF/NFM/FC4
Date 7 Feb 1945

SODA-LIME-SINTER PROCESS, SOME MODIFICATION OF WHICH IS IN USE IN THE ALUMINA PLANTS OF ONODA CEMENT CO., ONODA, HONSHU, AND ASANO CEMENT CO., ITOZAKI, HONSHU.



APPROXIMATE REQUIREMENTS PER TON OF ALUMINA

Raw clay, dry, 35% Al_2O_3	3.2	tons
Limestone, dry, 54% CaO	7.5	tons
Soda ash	84	lbs
Elec. power	900	KWH
Bit. coal	2.6	tons

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Date: 7 February 1945

JAPANESE NON FERROUS METALS

DIAGRAM SHOWING PRINCIPAL DETAILS OF CONSTRUCTION OF SIEMENS SCHUCKERT MERCURY ARC RECTIFIER (MODEL VD 10010)

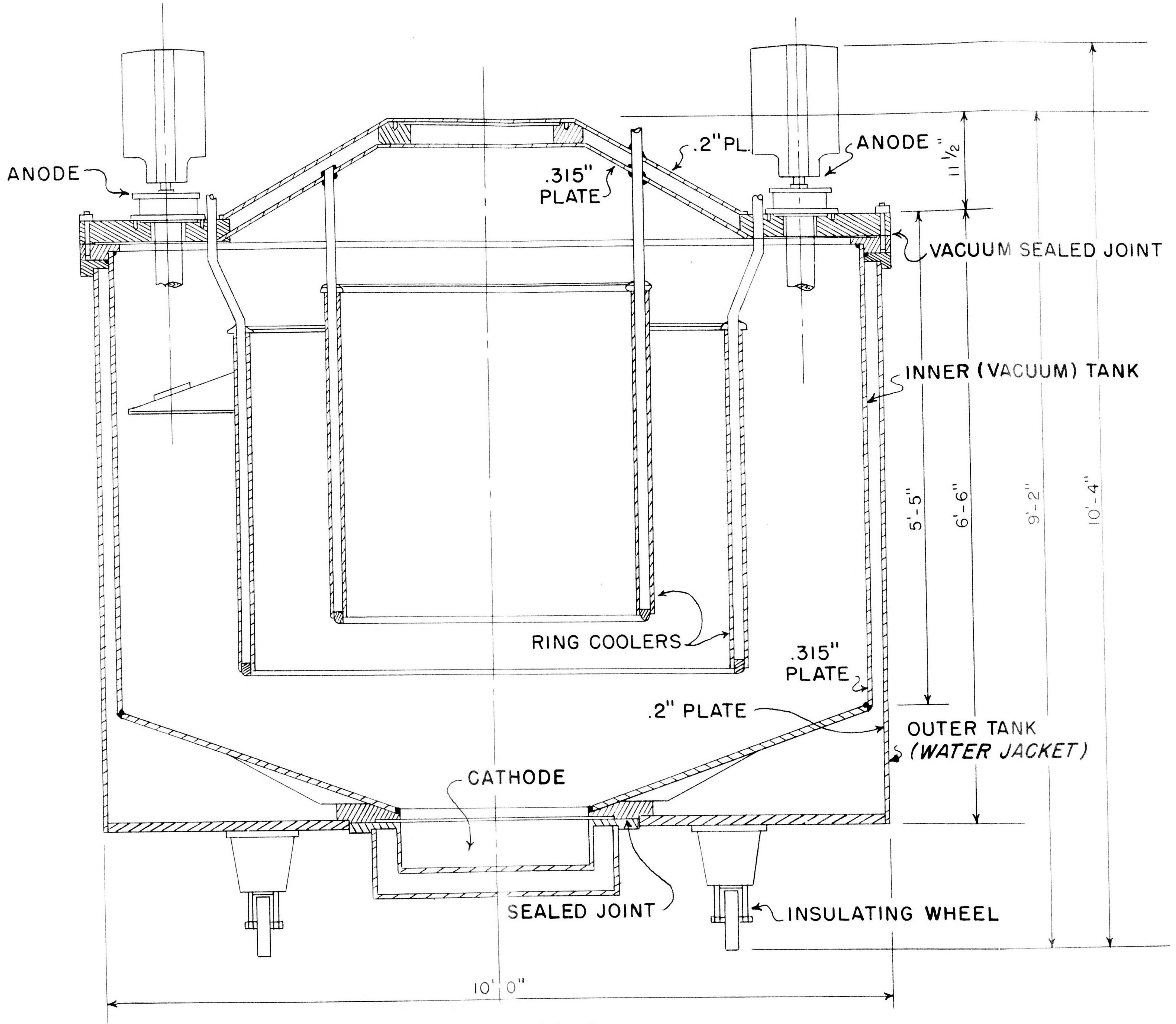

DIAGRAM 1

Drawn from German Siemens-Schuckert construction blue prints of their model VD10010, 18 anode, 5,600 KW rectifier -- belived to be essentially the same model as the rectifiers installed in the plant at Kambara, Honshu, 90.18-1177 (See Illustration No. 2)

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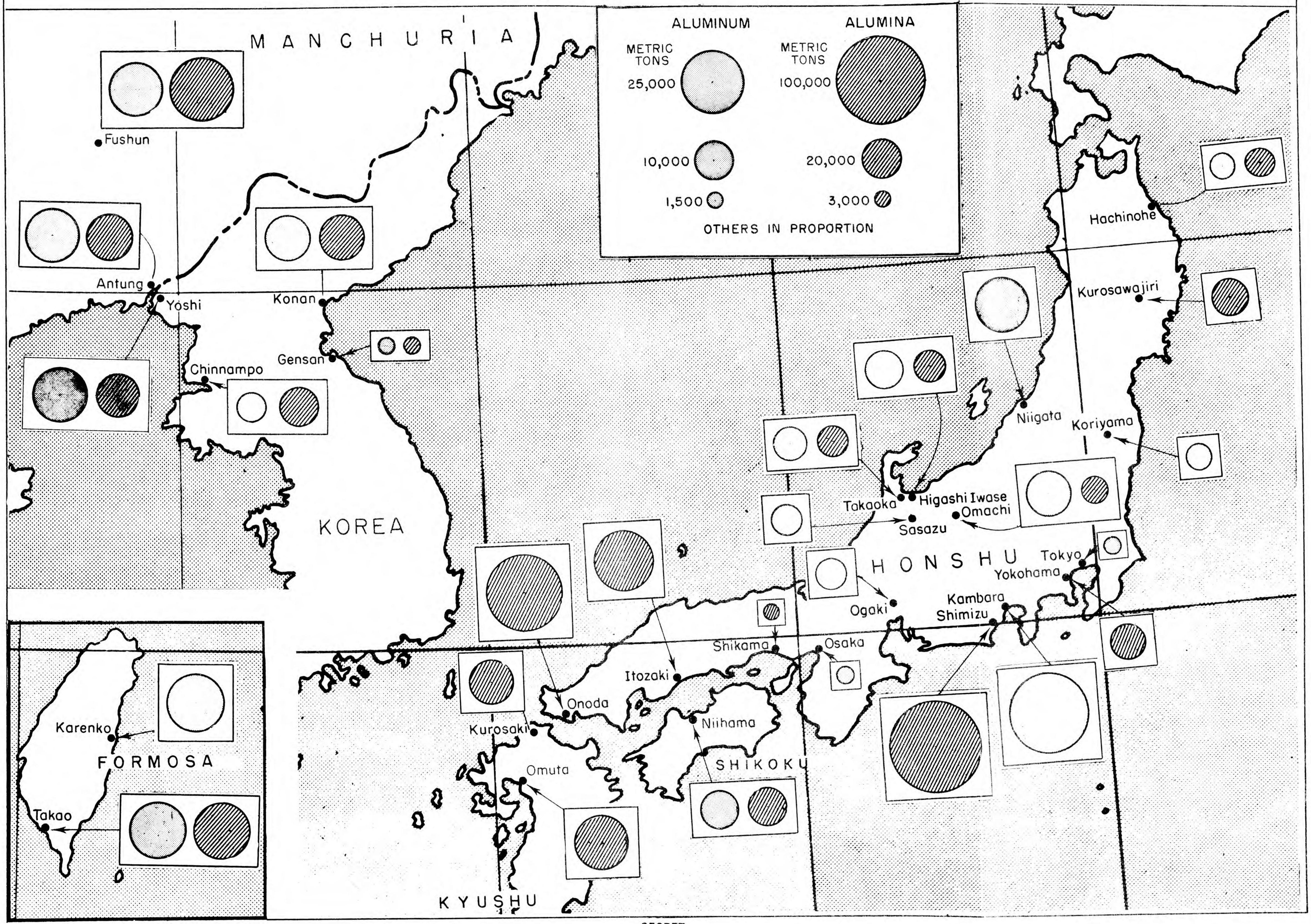
JAPANESE NON FERROUS METALS

RELATIVE CAPACITIES OF JAPANESE ALUMINUM AND ALUMINA PLANTS



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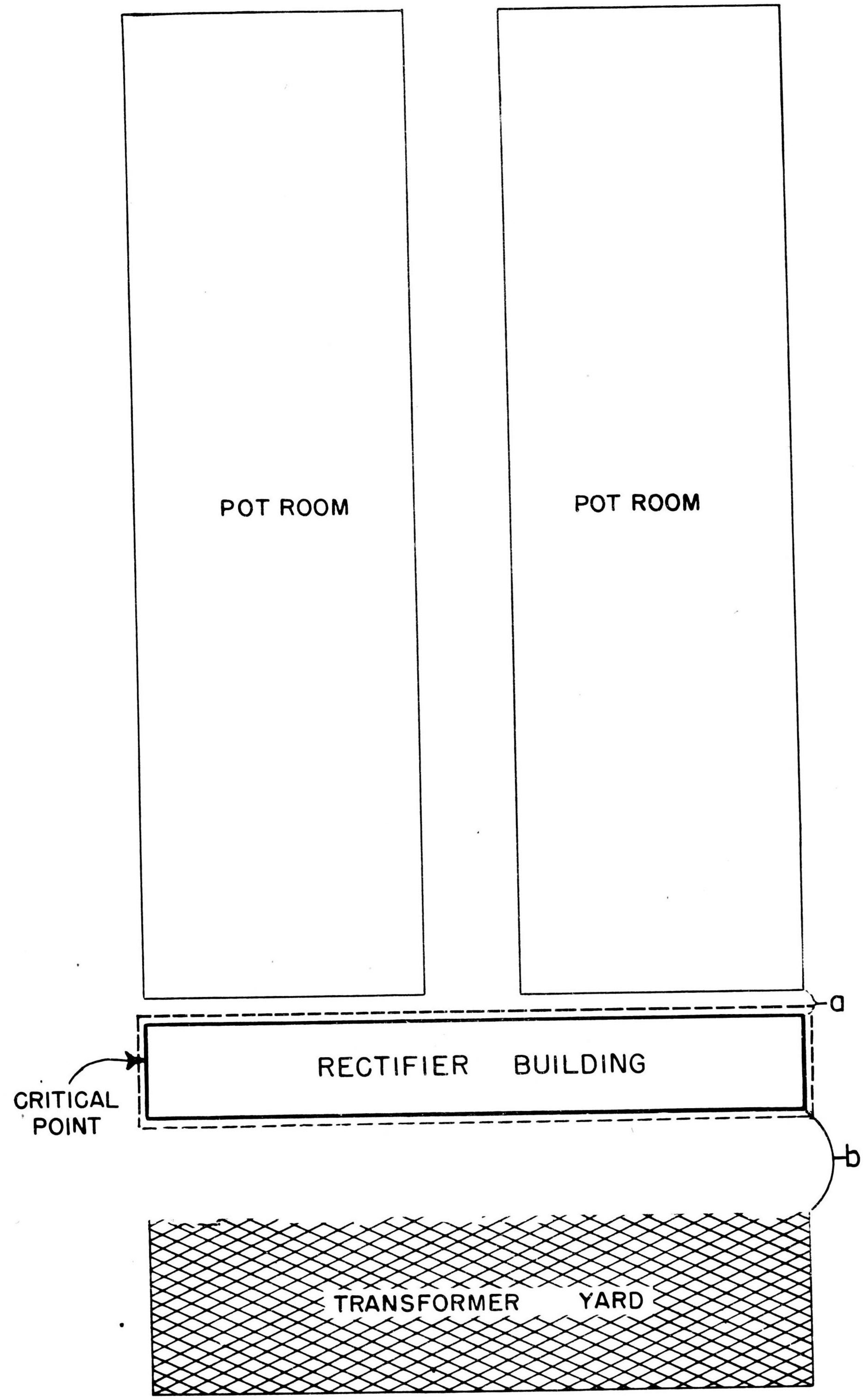
JAPANESE NON FERROUS METALS

GROUND PLAN OF TYPICAL JAPANESE ALUMINUM PLANT



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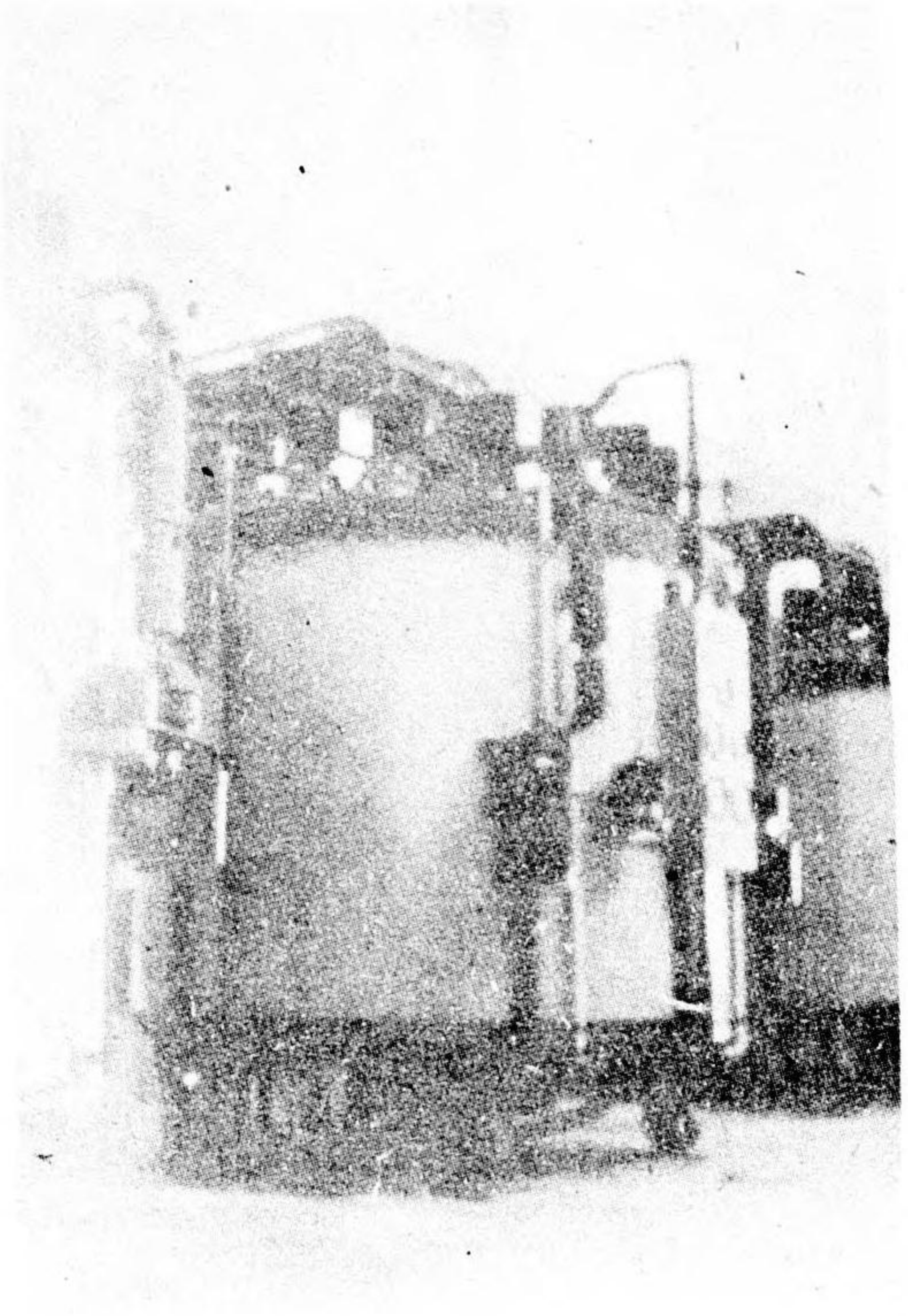
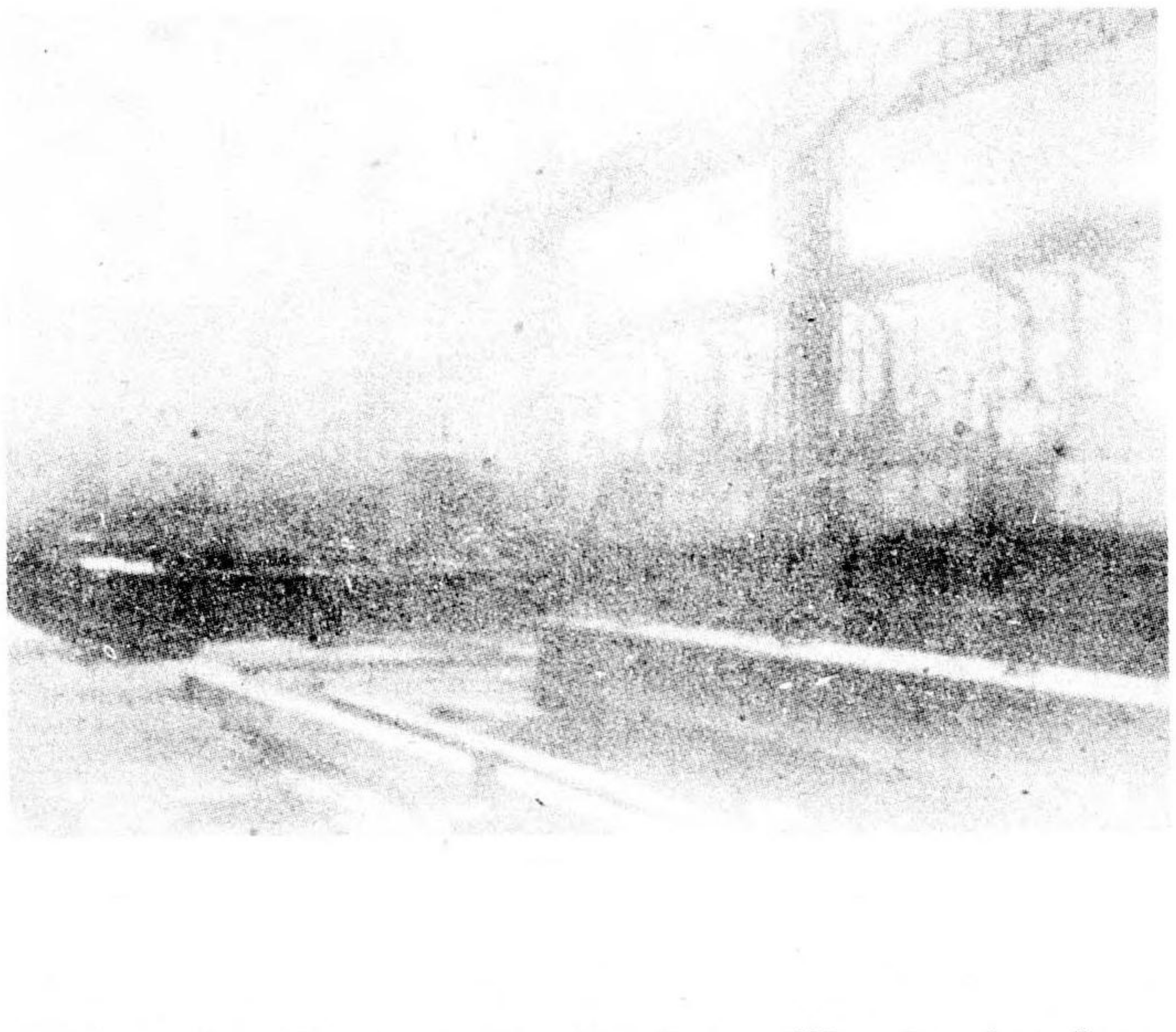
Sheet No.ATSF/NFM/P2
Date 7 Feb. 1945

JAPANESE NON FERROUS METALS
MERCURY ARC RECTIFIERS IN KAMBARA PLANT

Target 90.18-1177 - Aluminum Reduction Plant



8,000 ampere Mercury Arc Rectifier, one of 17 in Kambara plant in 1941. Made in Japan - copied exactly after German Siemens Schuckert type. Overall height, 10 to 11 feet.



Interior view of pot room in Kambara Plant showing construction of building.

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Sheet No. ATSF/NFM/P3
Date 7 Feb. 1945

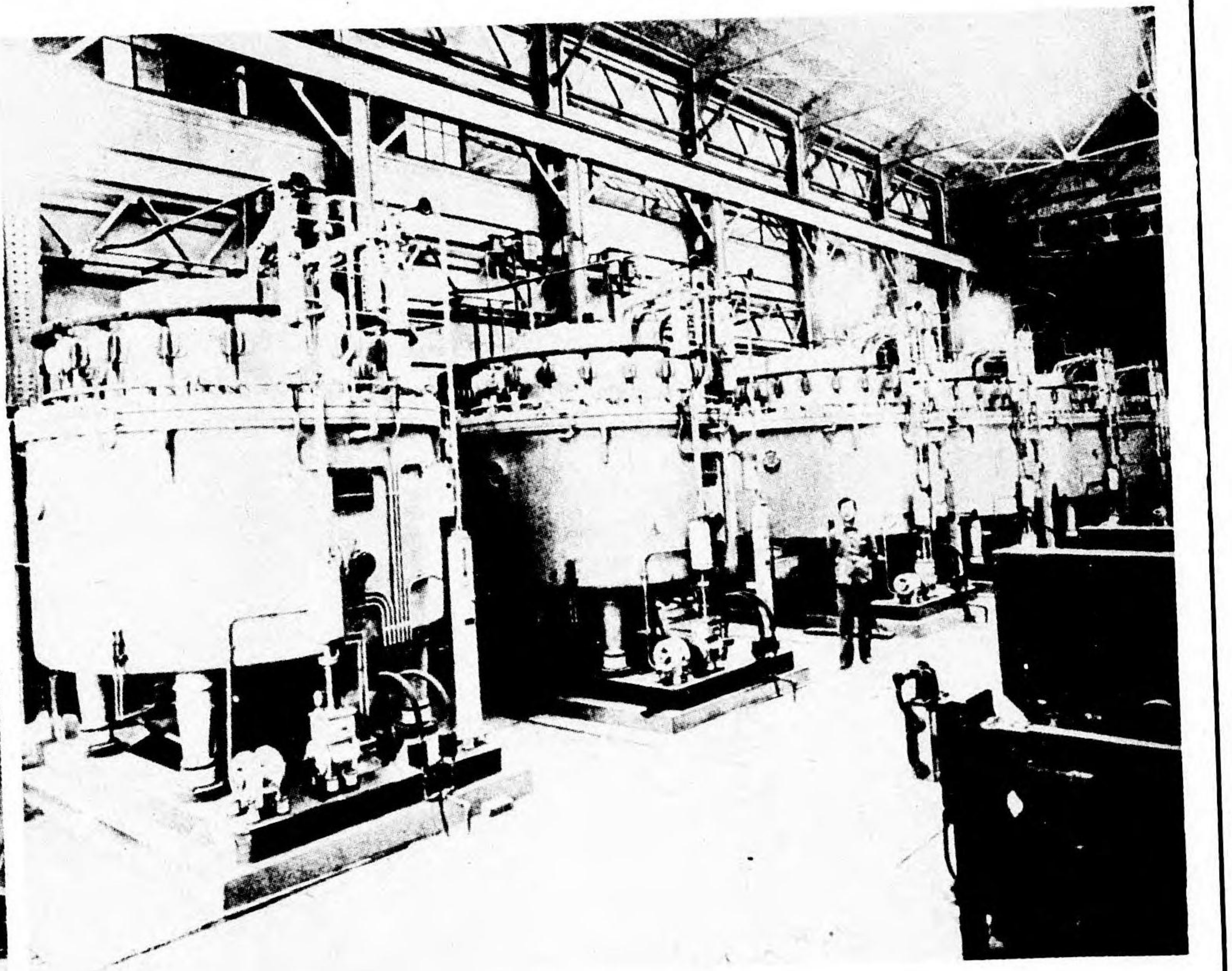
JAPANESE NON FERROUS METALS

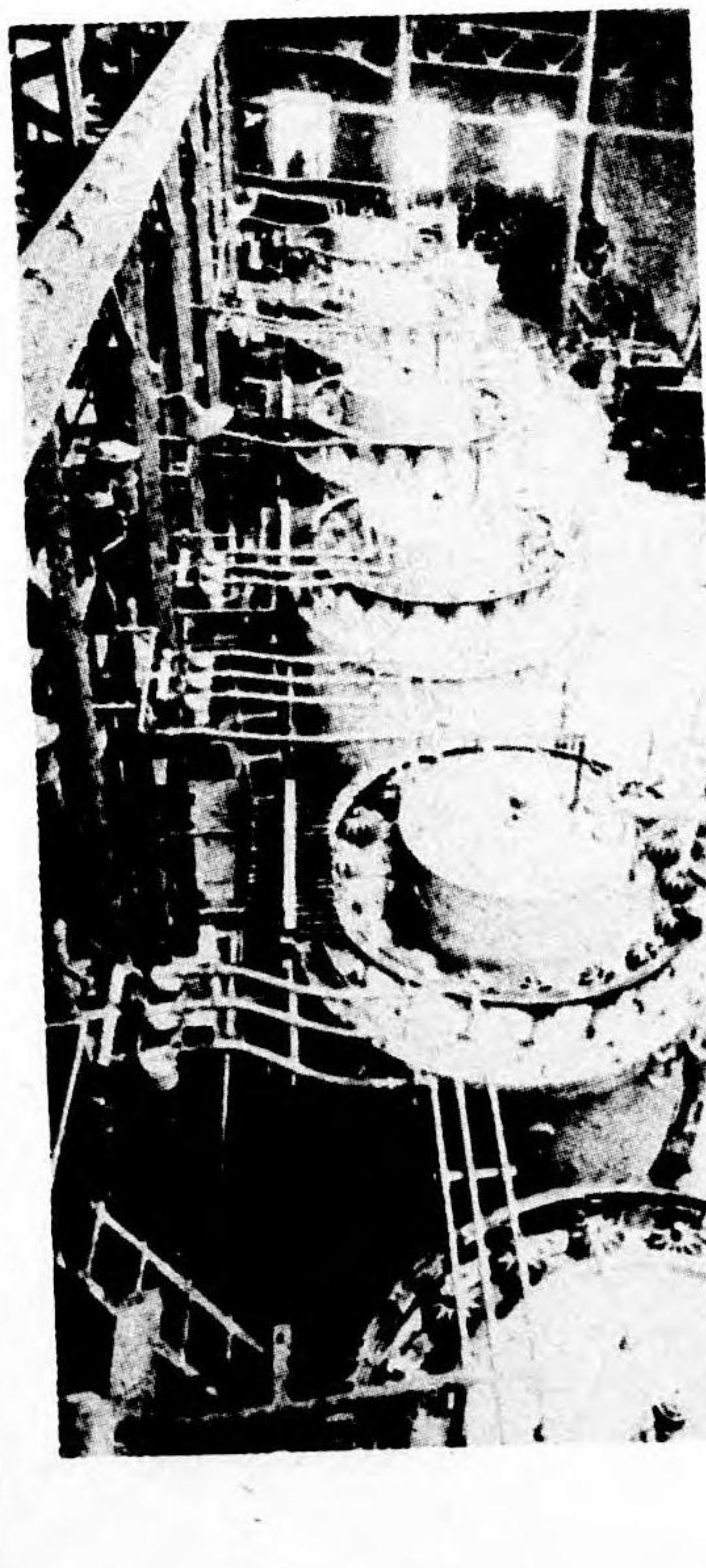
INSTALLATION OF BROWN BOVERI TYPE RECTIFIERS IN JAPANESE ALUMINUM PLANT

30,000--Ampere Rectifier Plant

Photographs show a row of 6 heavy-current mercury-arc rectifiers installed for aluminum industry - output of each unit is 3,000 KW. These rectifiers are provided with controlling grids to make constant-current operation as well as short-circuit protection. The equipment of this plant has been manufactured by Shibaura Engineering Works, Ltd., Tokyo, and more than 70 units of similar large-power mercury-arc rectifiers for use in chemical industry are now being constructed at the same works.

Photographs show actual installation of 30,000-A mercury-arc rectifiers for an aluminum plant in Japan





Total capacity of installation	18,000 kW
Total ampere of installation	30,000 A
Number of sets	3
Kilowatt per set	6,000 kW
D. C. Voltage	0 to 600 V
Rating of transformer	6,940 kVA ; 3,330 V
Number of rectifiers	6
Ampere per rectifier	5,000 A
Number of anodes per rectifier	18
Number of phases	6
Frequency	60 cycles per second
Type of anode insulation	Mycalex seal
Operation	full automatic

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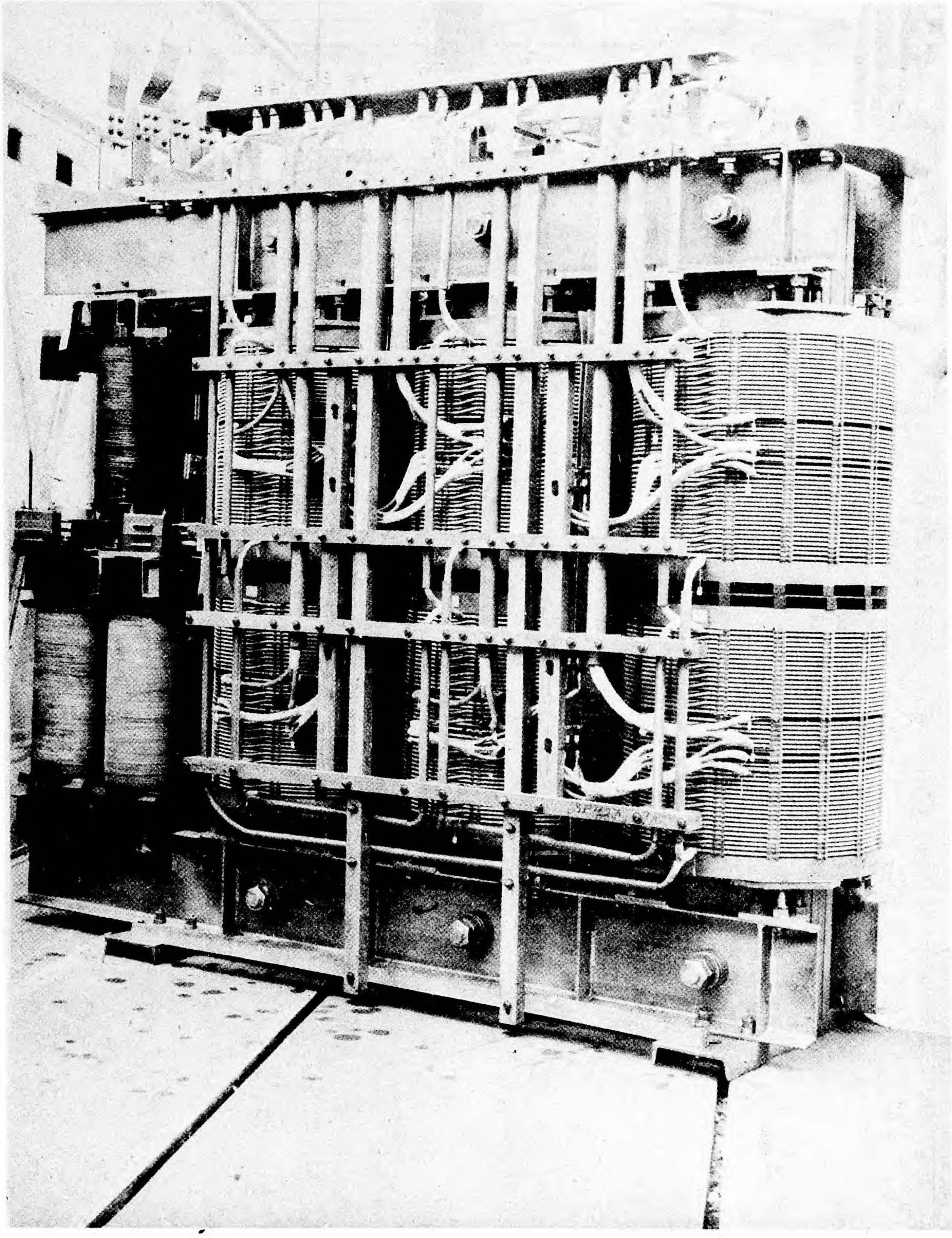
Date 7 Feb. 1945

JOINT TARGET GROUP, WASHINGTON, D.C.
JAPANESE NON FERROUS METALS

AMERICAN RECTIFIER TRANSFORMER INTERIOR ASSEMBLY



This entire assembly is inclosed in a steel tank made from 7/16" boiler plate and operates in a bath of transformer oil.

Weights -	Core and coils	25,000 lbs.
	Tank and fittings	27,000 lbs.
	Oil	24,000 lbs.
	Total Wt.	76,000 lbs.

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Location Map

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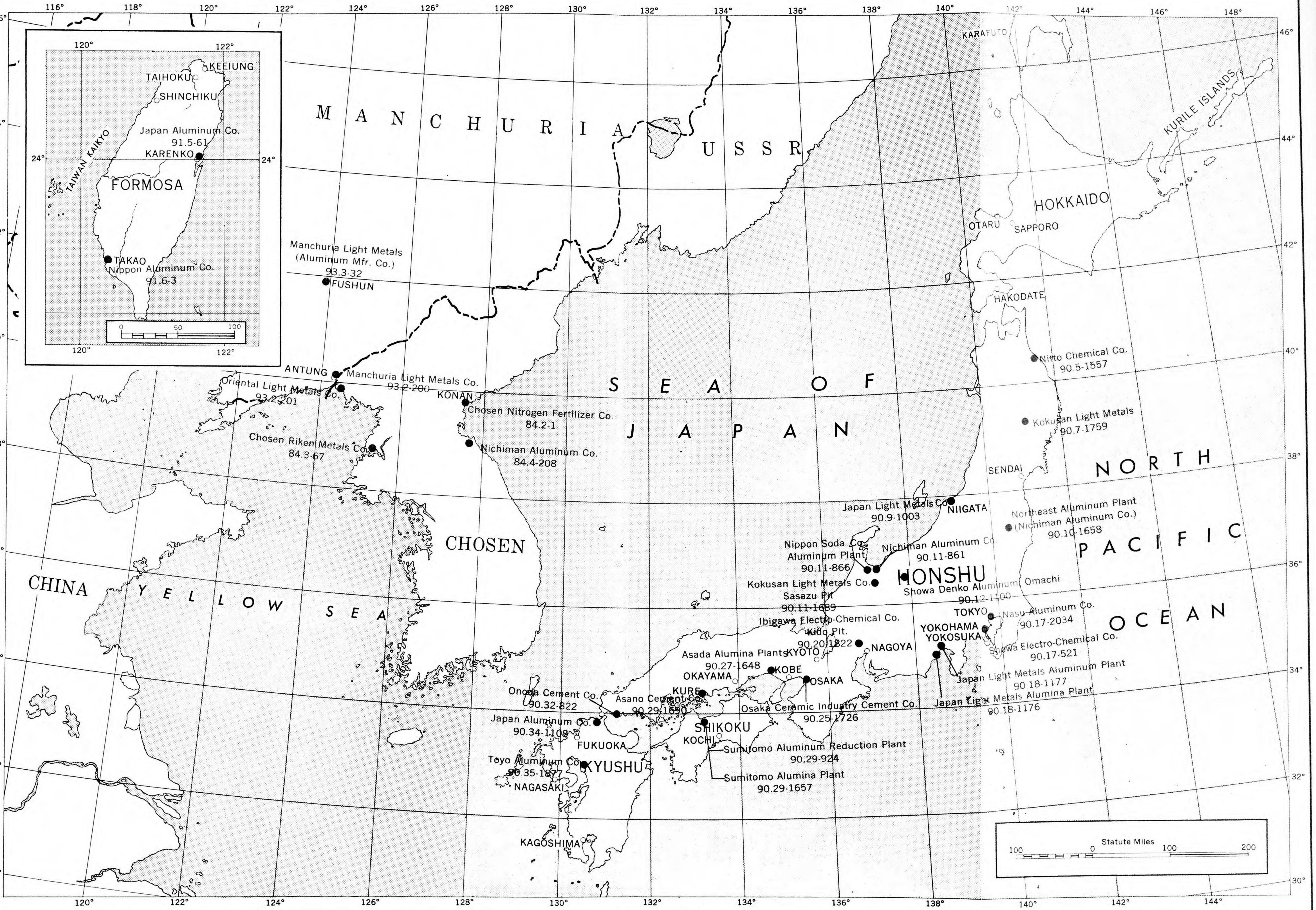
AIR TARGET SYSTEM FOLDER - JAPANESE NON-FERROUS METALS

GENERAL LOCATION MAP

SHEET NO. ATSF/NFM/MI
DATE 7 FEB 1945
PAGE NO. 1 (1 PAGES)



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SOIL CONSERVATION SERVICE
WASHINGTON D.C. 1945

Prepared at the direction of the Commanding General, Army Air Forces,
Aeronautical Chart Service, by the U.S. Coast and Geodetic Survey,
Washington, D.C. for AC AS Intelligence.
January 1945

Target Material

Sheet ATI/I/NFM
Date 18 January 1945
Page No. 1 (1 page)

Joint Target Group, Washington, D. C.

AIR TARGET INDEX — JAPANESE WAR
PART I — SYSTEM INDEX

NON-FERROUS METALS

Target Name	Place Name	Target Number
Asahi Electro-Chemical Co.	Tokyo (Japan)	90.17-212
Asano Cement Co., Itozaki Plant	Itozaki (Japan)	90.29-1690
Chosen Nitrogen Fertilizer Co. (1)	Konan (Korea)	84.2-1
Chosen Riken Metals Co.	Chinnampo (Korea)	84.3-67
Furukawa Copper Refinery	Kiyotaki (Japan)	90.13-811
Furukawa Copper Smelter	Honzan (Japan)	90.13-810B
Hulutao Lead & Zinc Smelter	Hulutao(Manchuria)	93.3-187
Japan Mining Co. Smelter	Chinnampo (Korea)	84.3-68
Japan Light Metals Co.	Niigata (Japan)	90.9-1003
Japan (Showa) Electro-Chemical Co.	Yokohama (Japan)	90.17-521
Japan Light Metals, Alumina	Shimizu (Japan)	90.18-1176
Japan Light Metals, Aluminum	Kambara (Japan)	90.18-1177
Japan Aluminum Co.	Karenko (Formosa)	91.5-61
Korea Refining Co.	Choko (Korea)	84.6-116
Kokusan Light Metals Co.	Sasazu (Japan)	90.11-1689
Manchuria Light Metals Co., Fushun Plt	Fushun (Manchuria)	93.3-32
Manchuria Magnesium Industry	Yingkou(Manchuria)	93.3-34
Mitsubishi Copper Refinery	Osaka (Japan)	90.25-697
Mitsui Electrolytic Zinc Refinery	Omuta (Japan)	90.35-1261
Mitsui Zinc Distillery	Omuta (Japan)	90.35-1260
Mitsui Zinc Smelter	Hikoshima (Japan)	90.34-1847
Nichiman Aluminum Co.	Higashi-Iwase (Japan)	90.11-861
Niihama Copper Concentrating Mill	Niihama (Japan)	90.29-925
Nippon Aluminum Co.	Takao (Formosa)	91.6-3
Nippon Aluminum Co.	Kurosaki (Japan)	90.34-1108
Nippon Soda, Odera Refinery	Odera (Japan)	90.10-1666
Nippon Soda Co., Aluminum Plant	Takaoka (Japan)	90.11-866
Onoda Cement Co.	Onoda (Japan)	90.32-822
Riken Metal Co., Ube Plant	Ube (Japan)	90.32-922
Saganoseki Copper Works	Saganoseki (Japan)	90.33-1328
Showa Denko Aluminum, Omachi	Omachi (Japan)	90.12-1100
Sumitomo Alumina Plant	Niihama (Japan)	90.29-1657
Sumitemo Aluminum Reduction Plant	Niihama (Japan)	90.29-924
Toyo Aluminum Co.	Omuta (Japan)	90.35-1877

(1) See "Chemical Industry".

NON-FERROUS METALS

JOINT TARGET GROUP, WASHINGTON, D. C.
TARGET LOCATION SHEET

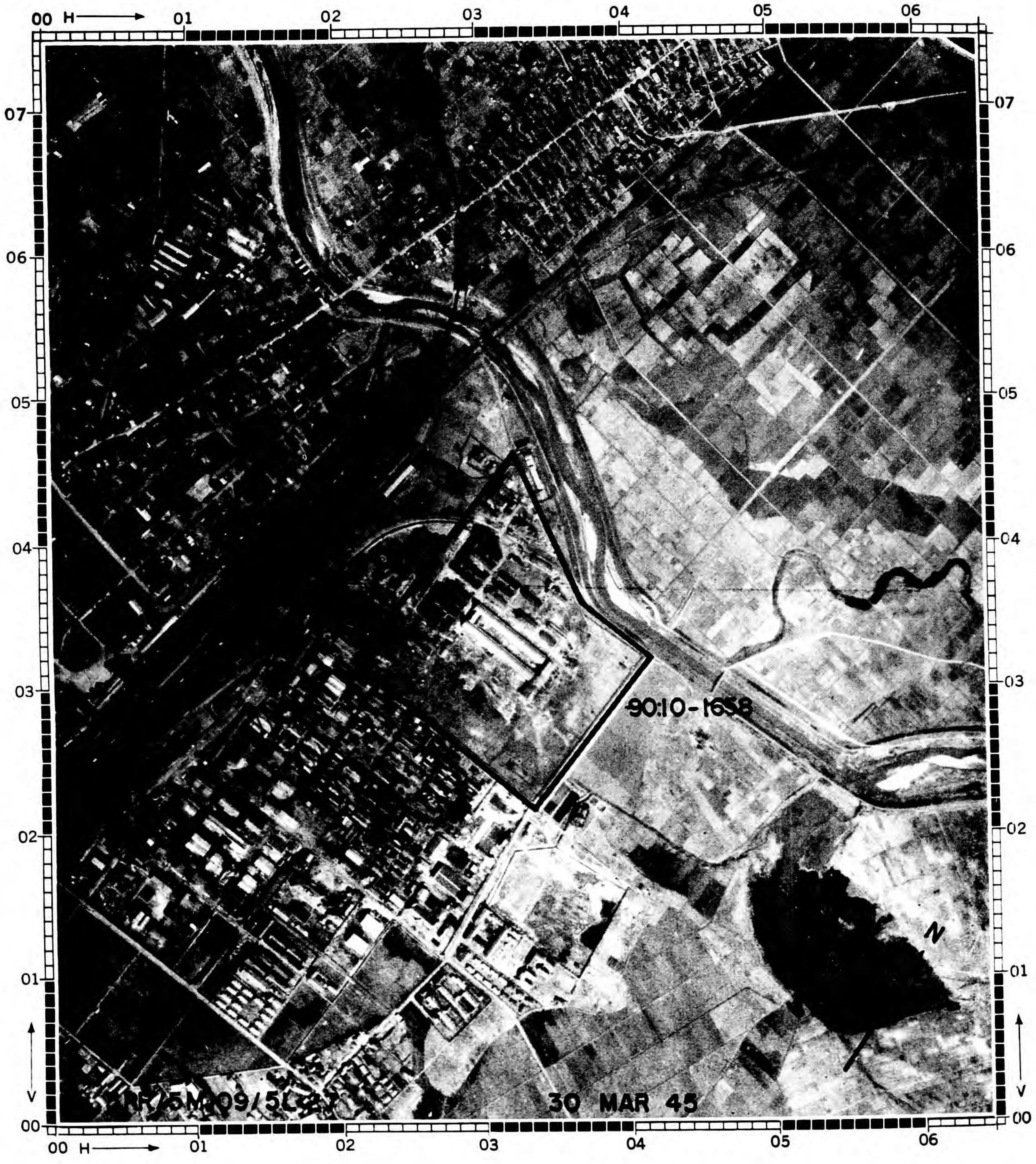
NORTHEAST ALUMINUM PLANT
KORIYAMA JAPAN

SHEET No. . . . . .90.10-1658—TL
DATE. . . . . .19 May 1945
TARGET No. 90.10-1658
CATEGORY
Bsc. Proc. Ind.—Non-Ferrous Metals
COORDINATES . . . .37°24′N 140°24′E
ALTITUDE . . . . .748 feet

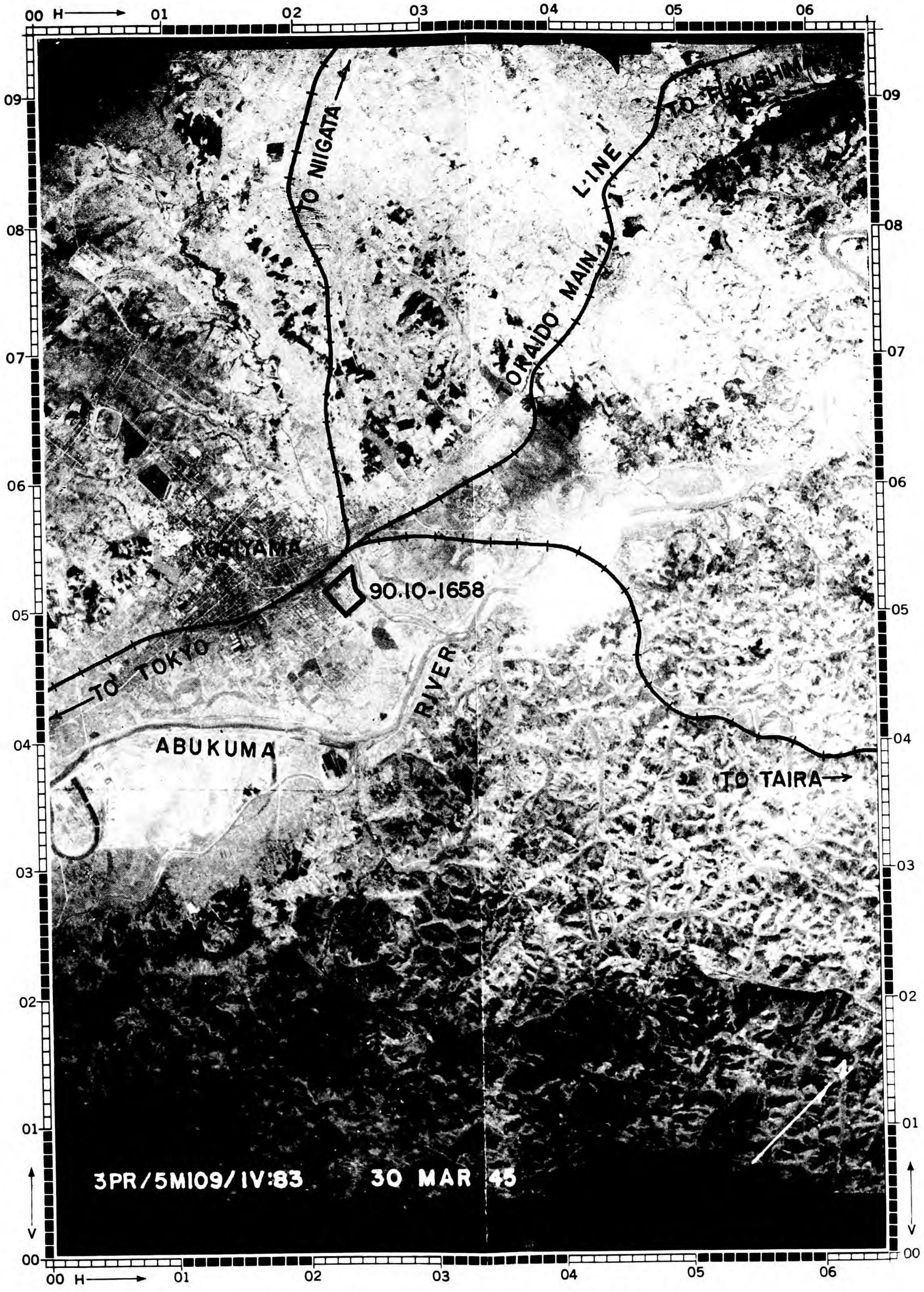
SIGNIFICANCE:

Important aluminum reduction plant. Considerably larger than reported in Bsc Proc Ind, Non-Ferrous Metals, before air photography was available. Estimated annual capacity 10,000 metric tons, about 4 per cent of total Japanese capacity. Plant reported seriously damaged by 21st B.C. on 13 April 1945. Damage to pot rooms believed to be minor with no damage to critical rectifier building.

Holders of Joint Target Group Folders should insert this sheet in Air Target System Folder: Japanese Non-ferrous Metals.



LARGE SCALE ILLUSTRATION—SCALE APPROX.: 1:9,300



SMALL SCALE ILLUSTRATION—SCALE APPROX.: 1:61,500

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TARGET LOCATION SHEET

SUMITOMO ALUMINUM REDUCTION PLANT

NIIHAMA JAPAN

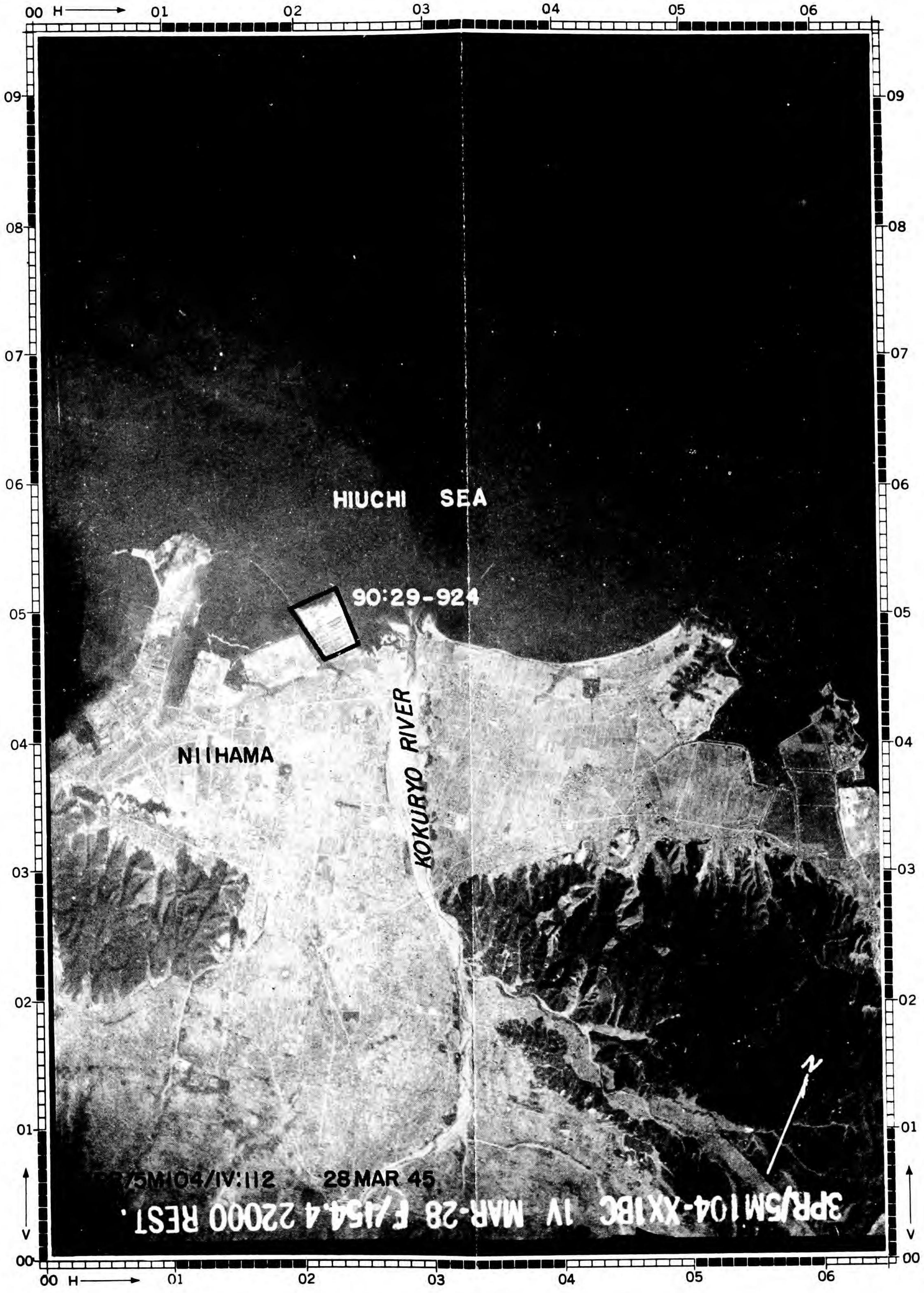
SHEET No. . . . . 90.29-924—TL
DATE. . . . . 18 May 1945
TARGET No. 90.29-924
CATEGORY. . . . . . . Bsc. Proc. Ind.-NFM
COORDINATES. . . . . 33°58'N 133°17'E
ALTITUDE. . . . . 15 feet

Holders of Joint Target Group Folders should insert th sheet in Air Target System Folder: Japanese Non-Ferrous Metals.

SIGNIFICANCE:

One of the largest aluminum reduction plants under Japanese control—considerably larger than reported in ATSF/NFM. Probably accounts for about 8.5 per cent of total Japanese capacity. Reported in full production. On the basis of inadequate photography, it is believed the plant includes some fabrication and possibly rolling of duralumin sheet.

LARGE SCALE ILLUSTRATION—SCALE APPROX.: 1:61,500



SMALL SCALE ILLUSTRATION—SCALE APPROX.: 1:24,600

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JOINT TARGET GROUP, WASHINGTON, D. C.
TARGET LOCATION SHEET

RIKEN METAL CO., UBE PLANT
UBE JAPAN

SHEET 90:32-922–TL
DATE................ 25 May 1945
TARGET 90:32-922
CATEGORY........... Bsc. Proc. Ind.–Non-Ferrous Metals
COORDINATES .... 33°57′N 131°14′E
ALTITUDE .... 10 feet

Holders of Joint Target Group Folders should insert this sheet in Air Target System Folder: Japanese Non-Ferrous Metals.

SIGNIFICANCE:

Largest magnesium plant in Japanese Inner Zone. Estimated annual capacity 5,000 metric tons. Sea water and magnesite are both believed to be used as raw materials.

LARGE SCALE ILLUSTRATION–SCALE APPROX.: 1:10,000

SMALL SCALE ILLUSTRATION–SCALE APPROX.: 1:64,000

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JOINT TARGET GROUP, WASHINGTON, D. C.
TARGET LOCATION SHEET

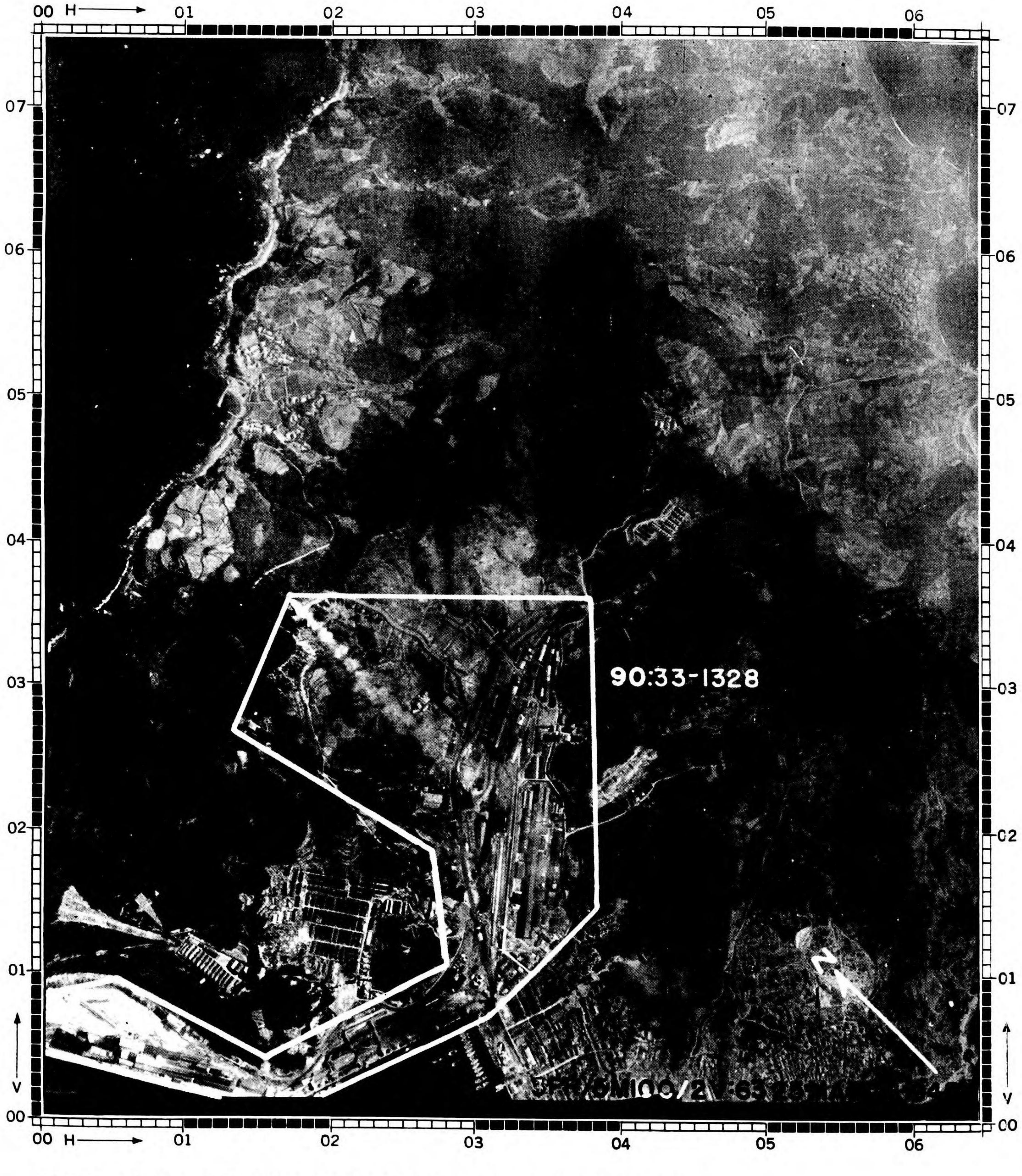
SAGANOSEKI COPPER WORKS
SAGANOSEKI JAPAN

SHEET No. 90:33-1328–TL
DATE................25 May 1945
TARGET No. 90:33-1328
CATEGORY...........Bsc. Proc. Ind.– Non-Ferrous Metals
COORDINATES ....33°15′N 131°53′E
ALTITUDE ....50 feet

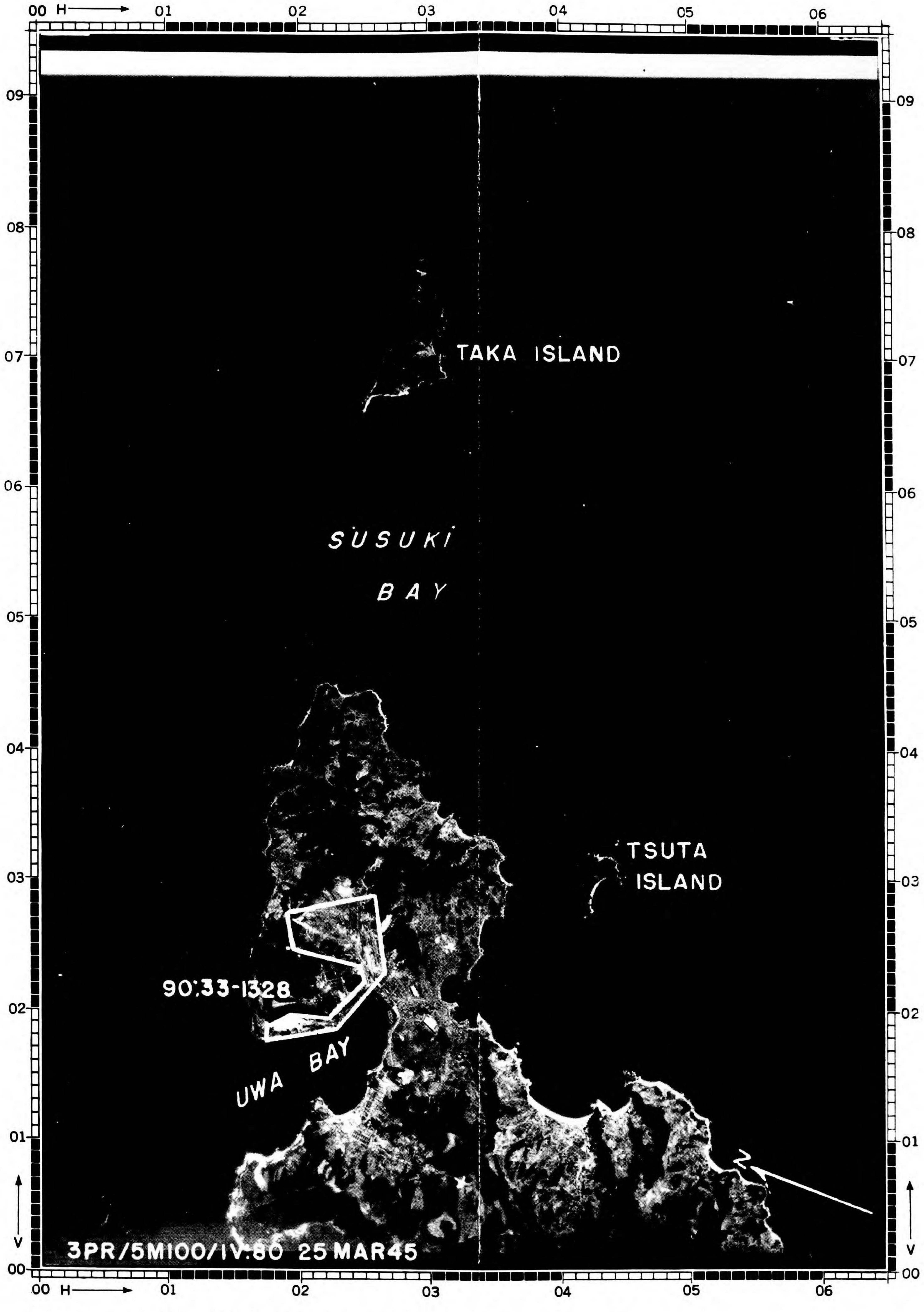
Holders of Joint Target Group Folders should insert this sheet in Air Target System Folder: Japanese Non-Ferrous Metals.

SIGNIFICANCE:

One of the largest Japanese smelters and refineries. Copper, lead, and zinc are the principal products, with less important output of gold, silver, and sulfuric acid. Lead and zinc concentrates believed to be imported from Korea. Most copper ore believed to be from local mines.



LARGE SCALE ILLUSTRATION—SCALE APPROX.: 1:14,000



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Sheet No. 90.34-1108-TI
Date 10 Jan. 1945
Page No. 1 (1 pages)

JOINT TARGET GROUP, WASHINGTON, D.C.
TARGET INFORMATION SHEET

Obj. Folder 90.34
Obj. Area 90.34
AAF Target No. 90.34-1108
NAME OF TARGET NIPPON ALUMINUM CO.

Place Kurosaki
Category Non-Ferrous Metals

Lat.: 33° 52'N
Long: 130° 45'E
Alt.: 20 feet

ALL PREVIOUS SHEETS CANCELLED

SIGNIFICANCE

Medium sized alumina plant. Rated seventh in capacity among Japanese controlled plants. Estimated 1944 capacity, 24,000 metric tons, about 5 per cent of Japanese total. 1944 production believed to be at capacity. Bayer process used with Bauxite from NEI. Reported to supply alumina to Japan Aluminum Co. plant at Karenko, Formosa (TARGET 91.5-61).

LOCATION

On reclaimed land on S shore at W end of Hon Harbor (Dokai Bay). The Japan Iron Works, Yawata Plant (TARGET 90.34-28) is about 6,500 feet to the E. The compound is bounded on the S by multiple RR tracks, on the W by an inlet, and on the N by the harbor.

DESCRIPTION AND LAYOUT

(Refer to Illustration No. 90.34-1108 P3). The target area is long and irregular in shape, extending about 3100 feet N-S and about 1200 feet E-W at its longest dimensions. It includes about 50 acres, about 30 per cent built-up. The bauxite storage areas (1 and 2) are estimated, as of 18 June 1944, to contain about 18,000 metric tons, dry weight, sufficient for about 4.5 months full operation.

CONSTRUCTION & VULNERABILITY

Buildings appear to be of light construction, steel or possibly wood framed. Eave heights are probably not over 30 feet. Buildings are one-story, short span.

Monitor type pitched roofs are used throughout, with light covering of corrugated iron or asbestos or wood sheathing.

PRIMARY OBJECTIVES

Leaching and digester buildings (5)

WEAPON RECOMMENDATIONS

Instructions with regard to weapons will usually be given in Field or Operational Orders, but in the absence of such specific instructions and to assist Planners in formulating such orders the following information is given:

An attack with H.E. weapons alone is recommended. A preliminary analysis indicated that the following weapon would be most effective:

AN-M57 250-lb G.P. bomb fuzed .1 sec. nose/.025 sec. tail.

Since the autoclaves in the digester building are the primary objectives, the smallest bomb which will successfully destroy them is the most efficient one. The AN-M64 500-lb G.P. bomb fuzed .1/.025 is recommended as an alternate weapon but its effectiveness is not much different than that of the 250-lb bomb.

Attack with I.B.'s is not recommended since the primary objectives cannot be destroyed by fire.

CAMOUFLAGE, DECOYS AND SMOKE SCREENS

Photography of 18 June 1944 shows some evidence of disruptive painting.

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TARGET NO. 90.34-1108

APPROX. COORDINATES 33° 53' N 130° 46' E

PHOTOGRAPHED 18 JUNE 1944

NIPPON ALUMINUM CO.
KUROSAKI JAPAN

0 2000 4000 6000 FEET
0 ½ 1 MILE
1:32 000 APPROX.

ILLUSTRATION NO. 90.34-1108 P1

ISSUED SEPTEMBER 1944

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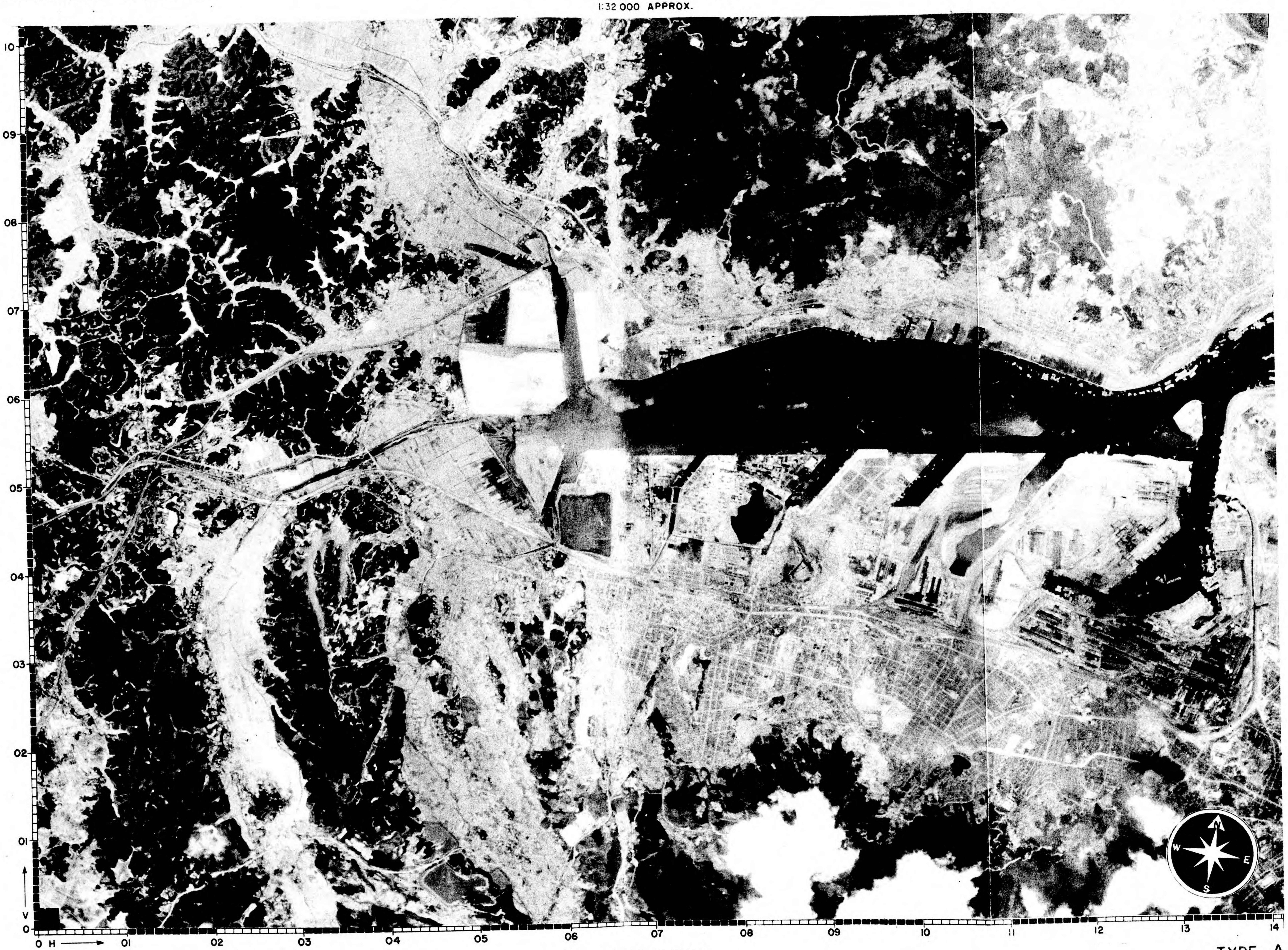

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TYPE A

JOINT TARGET GROUP
WASHINGTON, D. C.

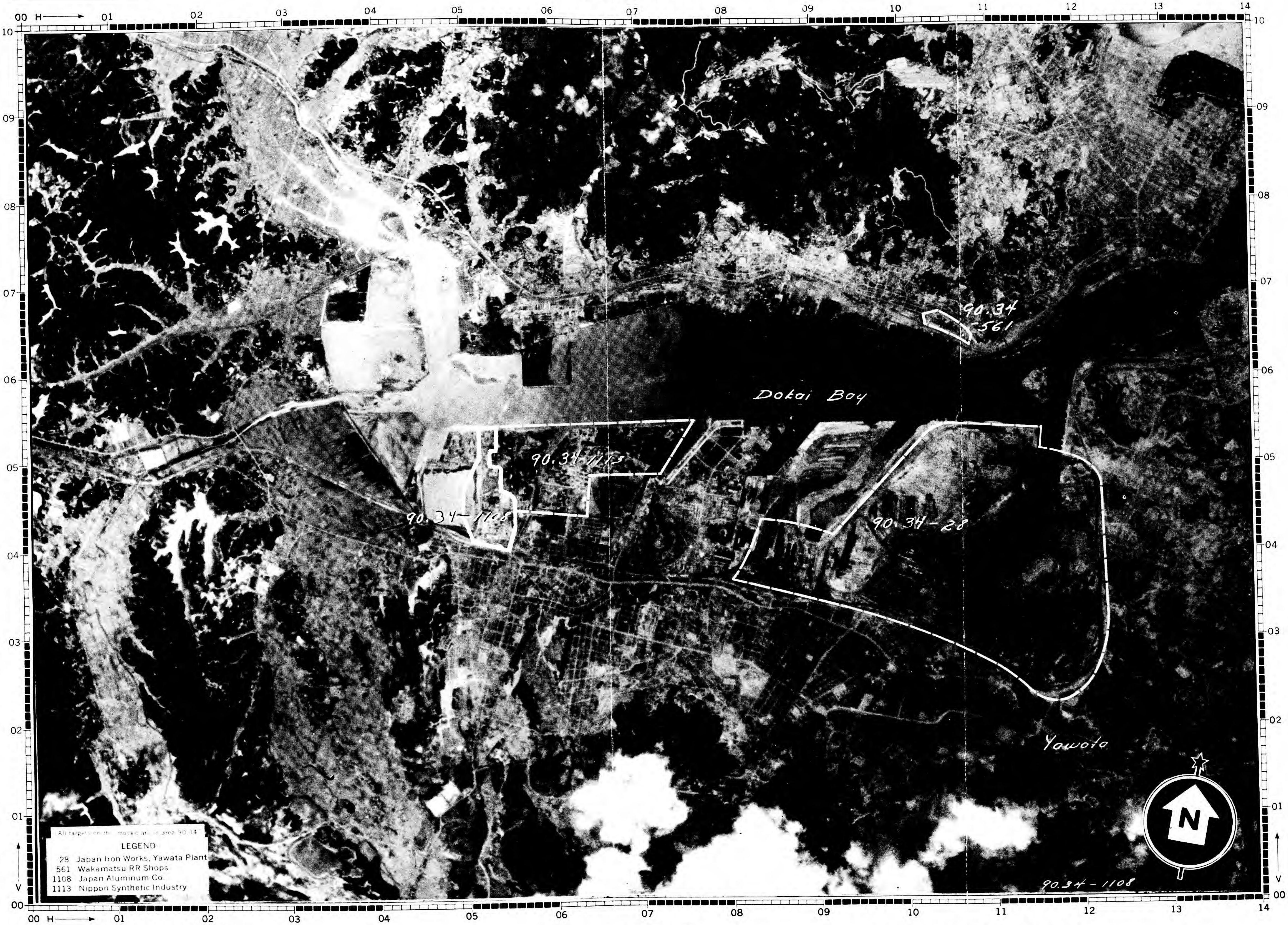
NIPPON ALUMINUM CO.
KUROSAKI JAPAN

0 2000 4000 6000 FEET
0 ½ I MILE
I:32 000 APPROX.

RESTRICTED

ILLUSTRATION No. . . . **90.34-1108 P2**
DATE. . . . . **29 April 1945**
TARGET No. **90.34-1108**
COORDINATES. . . **33°53'N 130°46'E**
PHOTOGRAPHED. . . . . **18 June 1944**

Holders of Joint Target Group Folders should insert this sheet in Air Target System Folder: Japanese Non-Ferrous Metals with other 90.34-1108 material.



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RESTRICTED

May be taken into the air if data is trimmed off

TARGET NO. 90.34-1108

NIPPON ALUMINUM CO.
KUROSAKI, JAPAN

ILLUSTRATION NO. 90.34-1108 P3

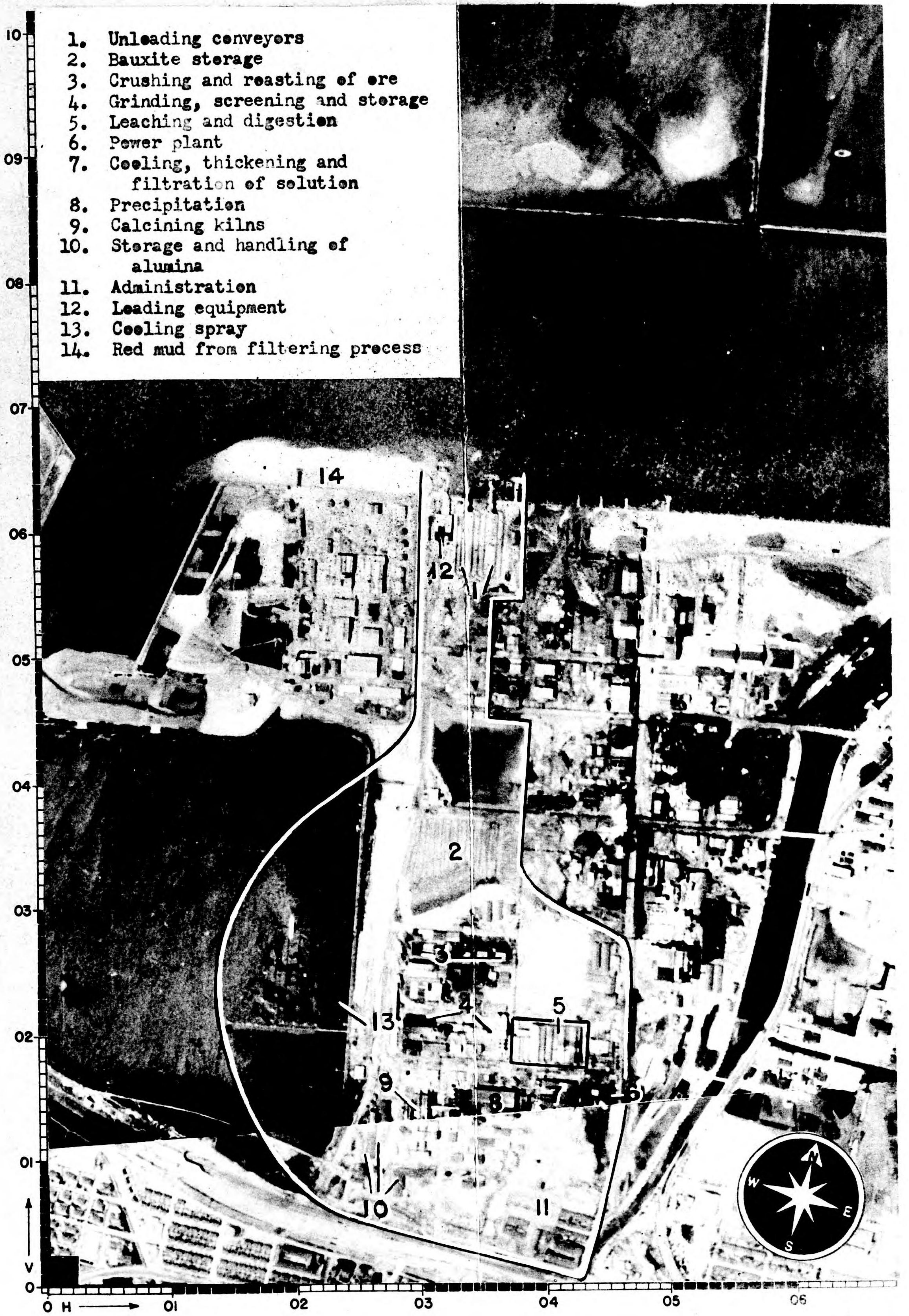
APPROX. COORDINATES 33° 52'N 130° 45'E

ISSUED OCTOBER 1944

PHOTOGRAPHED 18 JUNE 1944

CONFIDENTIAL

0 500 1000 1500 2000 2500 3000 FEET
0 1/4 1/2 MILE
1:6000 APPROX.



1. Unloading conveyors
2. Bauxite storage
3. Crushing and roasting of ore
4. Grinding, screening and storage
5. Leaching and digestion
6. Power plant
7. Cooling, thickening and filtration of solution
8. Precipitation
9. Calcining kilns
10. Storage and handling of alumina
11. Administration
12. Loading equipment
13. Cooling spray
14. Red mud from filtering process

AC/AS, INTELLIGENCE

CONFIDENTIAL

TYPE B
C5-2604, AF

TARGET NO. 90.34-1847

APPROX. COORDINATES 33° 56'N 130° 54' E

PHOTOGRAPHED 18 JUNE 1944

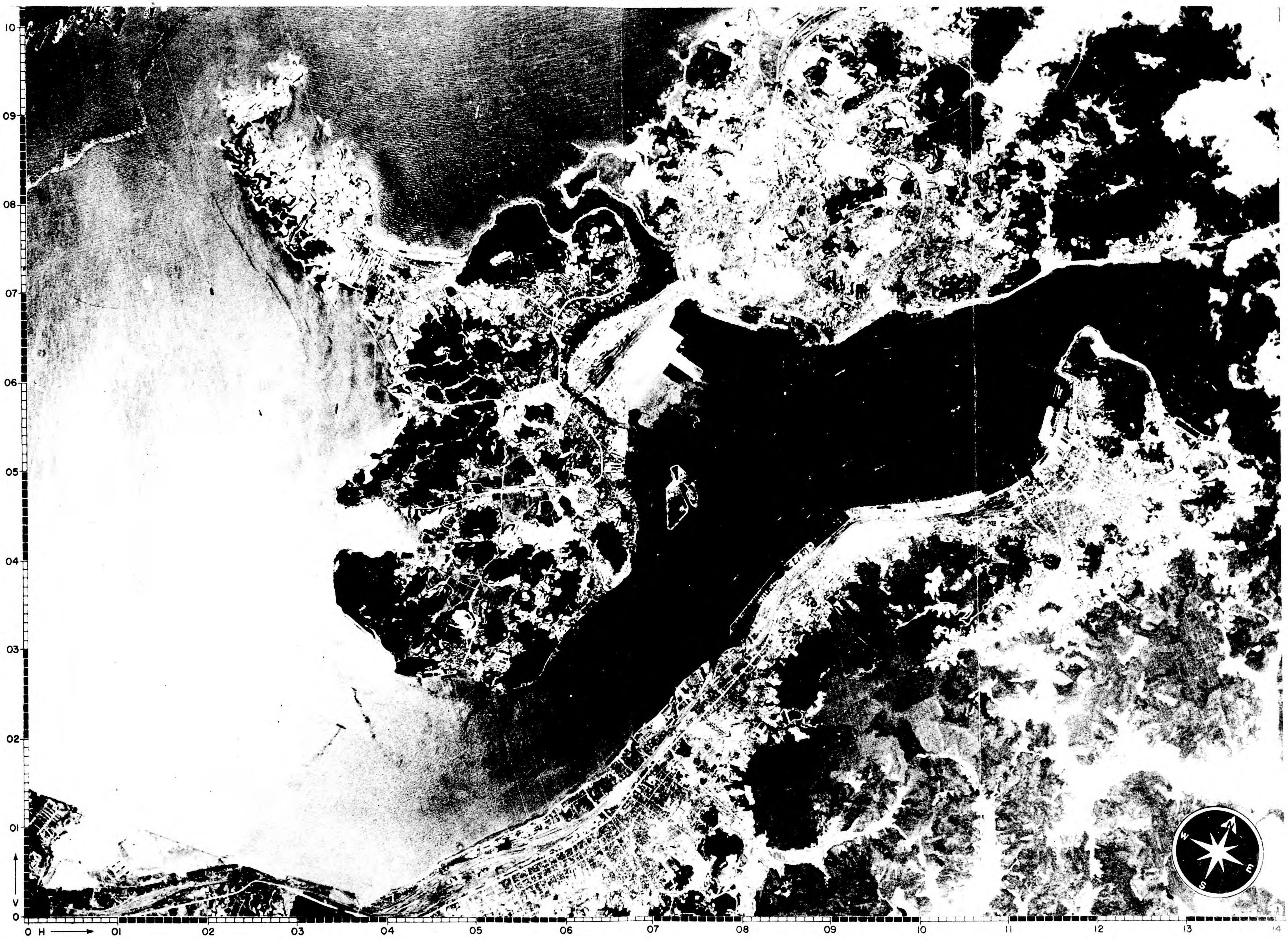
MITSUI ZINC SMELTER
HIKOSHIMA JAPAN

0 2000 4000 6000 FEET
0 1/2 1 MILE
1:32 000 APPROX.

ILLUSTRATION NO. 90.34-1847 P1

ISSUED OCT 1944

CONFIDENTIAL



AC/AS, INTELLIGENCE

CONFIDENTIAL

TYPE A

TARGET NO. 90.34-1847

APPROX. COORDINATES 33° 56'N 130° 56' E

PHOTOGRAPHED 18 JUNE 1944

MITSUI ZINC SMELTER
HIKOSHIMA JAPAN

0 2000 4000 6000 FEET
0 1/2 1 MILE
1:32 000 APPROX.

ILLUSTRATION NO. 90.34-1847 P2

ISSUED OCT 1944

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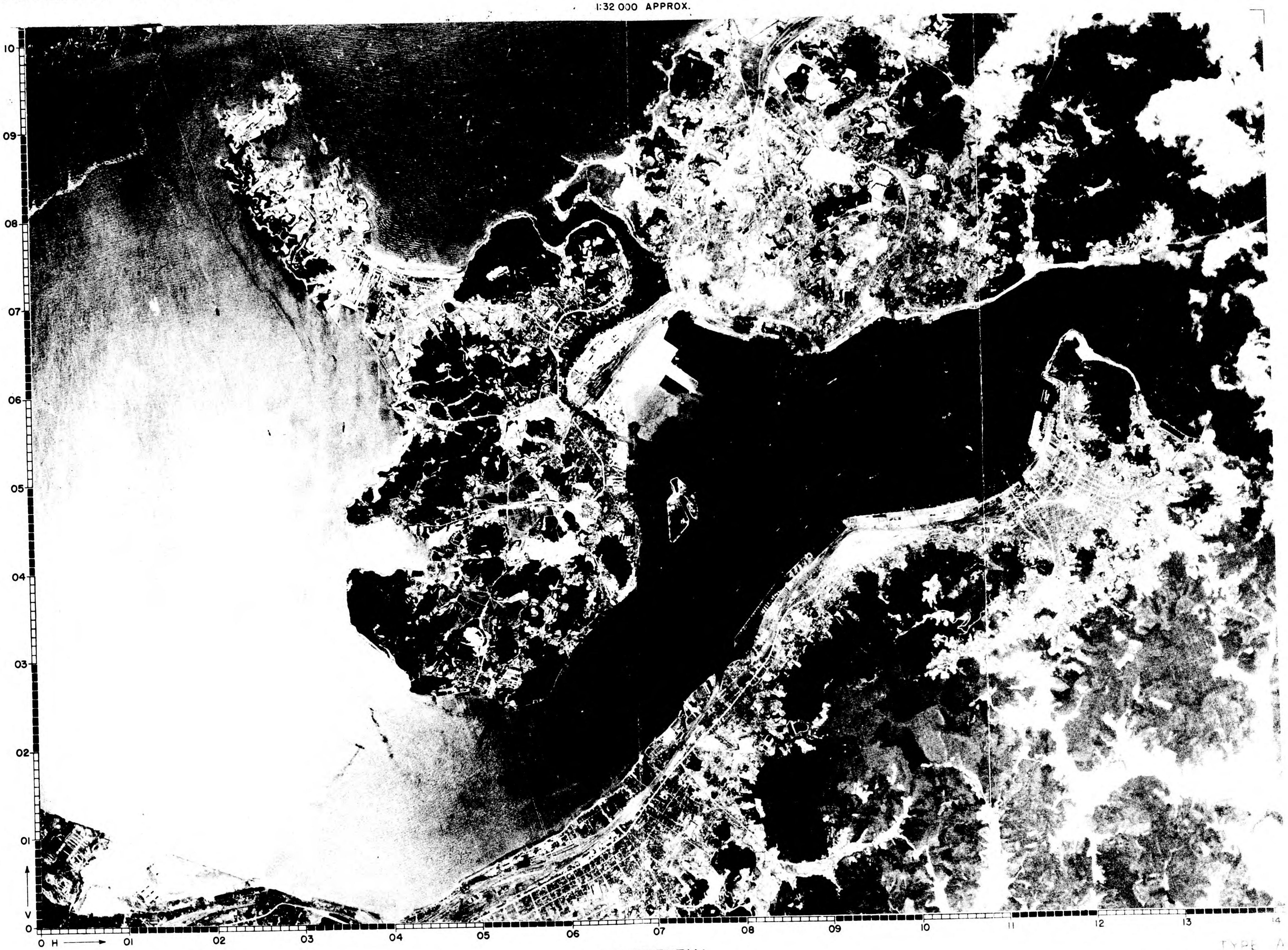

AC/AS, INTELLIGENCE

CONFIDENTIAL

TYPE A

TARGET NO. 90.34-1847

APPROX. COORDINATES. 33° 56'N 130° 54'E

PHOTOGRAPHED 18 JUNE 1944

MITSUI ZINC SMELTER
HIKOSHIMA JAPAN

ILLUSTRATION NO. 90.34-1847 P3

ISSUED OCT 1944

CONFIDENTIAL

0 500 1000 1500 2000 2500 3000 FEET
0 1/4 1/2 MILE
1:6000 APPROX.

AC/AS, INTELLIGENCE

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TYPE B
C5-2604, AF

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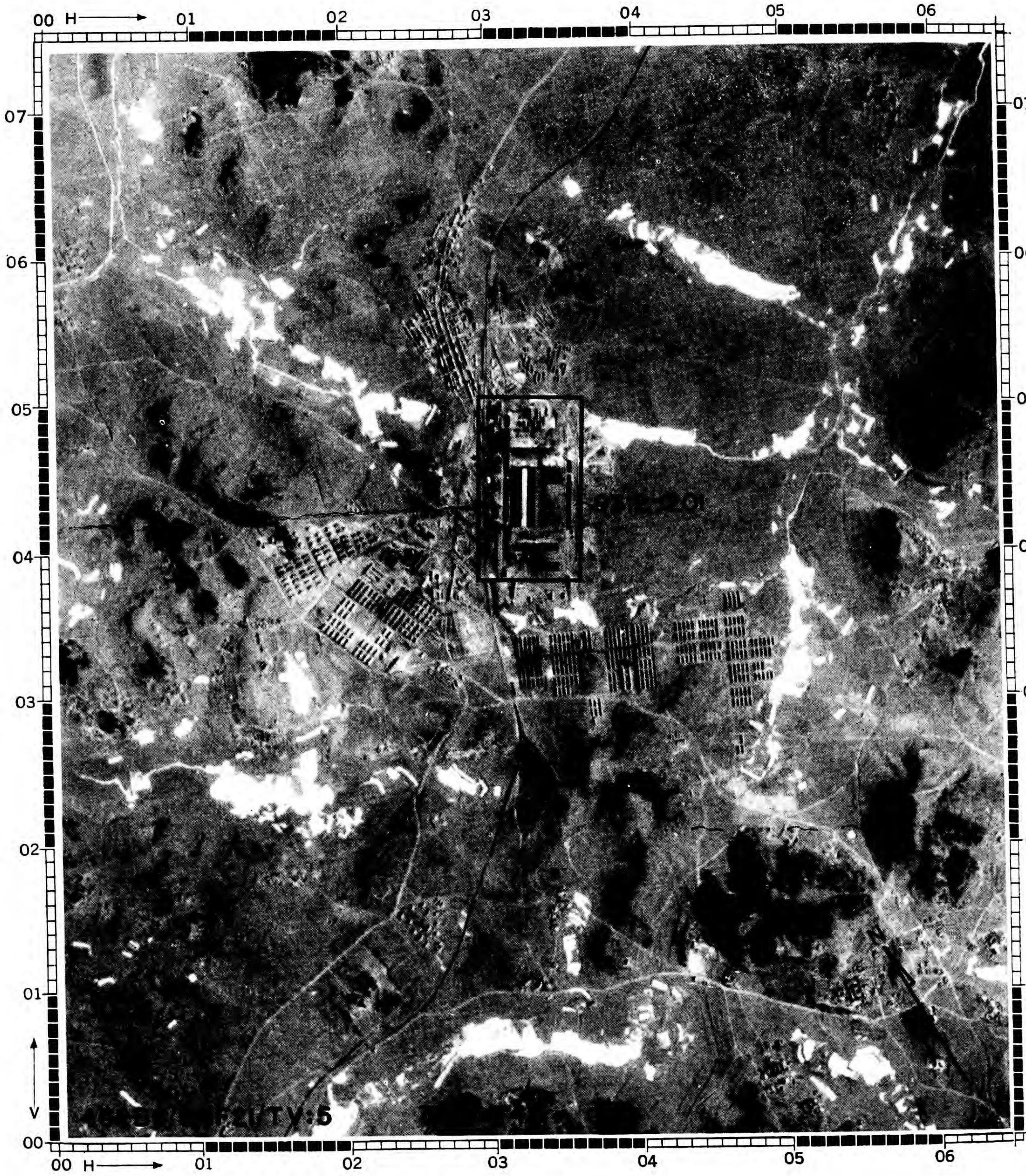
JOINT TARGET GROUP, WASHINGTON, D. C.
TARGET LOCATION SHEET

ORIENTAL LIGHT METALS CO.
YOSHI KOREA

SHEET	93:2-201–TL
DATE	25 May 1945
CATEGORY	Bsc. Proc. Ind.–NON-FERROUS MTLS.
COORDINATES	39°58′N 124°27′E
ALTITUDE	82 feet

SIGNIFICANCE:

Large aluminum reduction plant, an important link in Japan's effort to produce aluminum on the mainland from native raw materials. On the basis of inadequate photography and conflicting ground intelligence, this plant appears to have 4 pot lines and a possible annual capacity of 40,000 metric tons. Alumina probably from Fushun, Manchuria (93:3-32) and Tangshan, Hopeh, China.



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SMALL SCALE ILLUSTRATION–SCALE APPROX.: 1:130,500

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CG Eleventh Air Force	1	55
CG U.S.S.T.A.F.	1	56
CG Eighth Air Force	1	57
CG M.A.A.F.	1	58
CG Fifteenth Air Force	1	59
CNO (OP-16-V-S)	6	60-64, 266
CinCPac	5	65-69
ComAirPac: Carrier Divisions 1 each =	16	70-85
All Carriers 1 each =	98	86-183
Other units 1 each =	43	184-226
Total =	157	
ComAirNorSols	5	227-231
ComThird Fleet	5	232-236
ComFifth Fleet	5	237-241
ComSeventh Fleet	1	242
ComFirst Carrier Task Force, Pac	1	243
ComSecond Carrier Task Force, Pac.	1	244
ComFltAir, West Coast (OinC)	1	245
ComFltAir, Alameda (OinC)	1	246
ComFltAir, Seattle (OinC)	1	247
Commander, Navy No. 169	2	248-249
Commander, Navy No. 3233	2	250-251
ComForward Area, CenPac	2	252-253
Commander, Navy No. 3254	2	254-255
ComPhilippineSeaFron	2	256-257
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CG U.S.S.T.A.F.	1	56
CG Eighth Air Force	1	57
CG M.A.A.F.	1	58
CG Fifteenth Air Force	1	59
CNO (OP-16-V-S)	6	60-64, 266
CinCPac	5	65-69
ComAirPac: Carrier Divisions 1 each =	16	70-85
All Carriers 1 each =	98	86-183
Other units 1 each =	43	184-226
Total =	157	
ComAirNorSols	5	227-231
ComThird Fleet	5	232-236
ComFifth Fleet	5	237-241
ComSeventh Fleet	1	242
ComFirst Carrier Task Force, Pac	1	243
ComSecond Carrier Task Force, Pac.	1	244
ComFltAir, West Coast (OinC)	1	245
ComFltAir, Alameda (OinC)	1	246
ComFltAir, Seattle (OinC)	1	247
Commander, Navy No. 169	2	248-249
Commander, Navy No. 3233	2	250-251
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Commander, Navy No. 3254	2	254-255
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