

FORMOSA

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PETROLEUM FACILITIES OF
FORMOSA

CONFIDENTIAL

PETROLEUM FACILITIES OF

FORMOSA

Prepared by
The Enemy Oil Committee
for the
Fuels and Lubricants Division
Office of The Quartermaster General

February, 1945

C O N F I D E N T I A L

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R E V I S I O N

Arrangements for the preparation and distribution of supplementary information pertinent to this report are contemplated. Request is made that advices concerning corrections and useful addenda for the report be sent to:

Director, Fuels and Lubricants Division
Office of The Quartermaster General
Washington, D. C.

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PETROLEUM FACILITIES OF FORMOSA

1.0 INTRODUCTION

1.1 SCOPE

The purpose of this report is to present all available significant aspects of the petroleum economy and facilities of the island of Formosa, part of the Empire of Japan. The facts and figures are limited by lack of official statistics which have not been published by the Japanese since 1936. All development since that date, and even before, has been considered by them a military secret and accordingly few facts have been made public.

1.2 GEOGRAPHY

1.2.1 Location

Formosa (Taiwan) extends from latitudes 21° 45' to 25° 38' N. and from longitudes 119° 18' to 122° 15' E. With an area, including the Pescadores Islands, of 13,857 square miles, it is a little larger than Holland and more than twice the size of the Hawaiian Islands. Formosa is in the form of an elongated oval having a NNE-SSW axis about 225 miles in length. The breadth, east to west, varies from 60 to 90 miles. It is separated from the Fukien province of the China mainland by the Formosa Strait or the Taiwan Kaikyo, the narrowest width of which is about 90 miles.

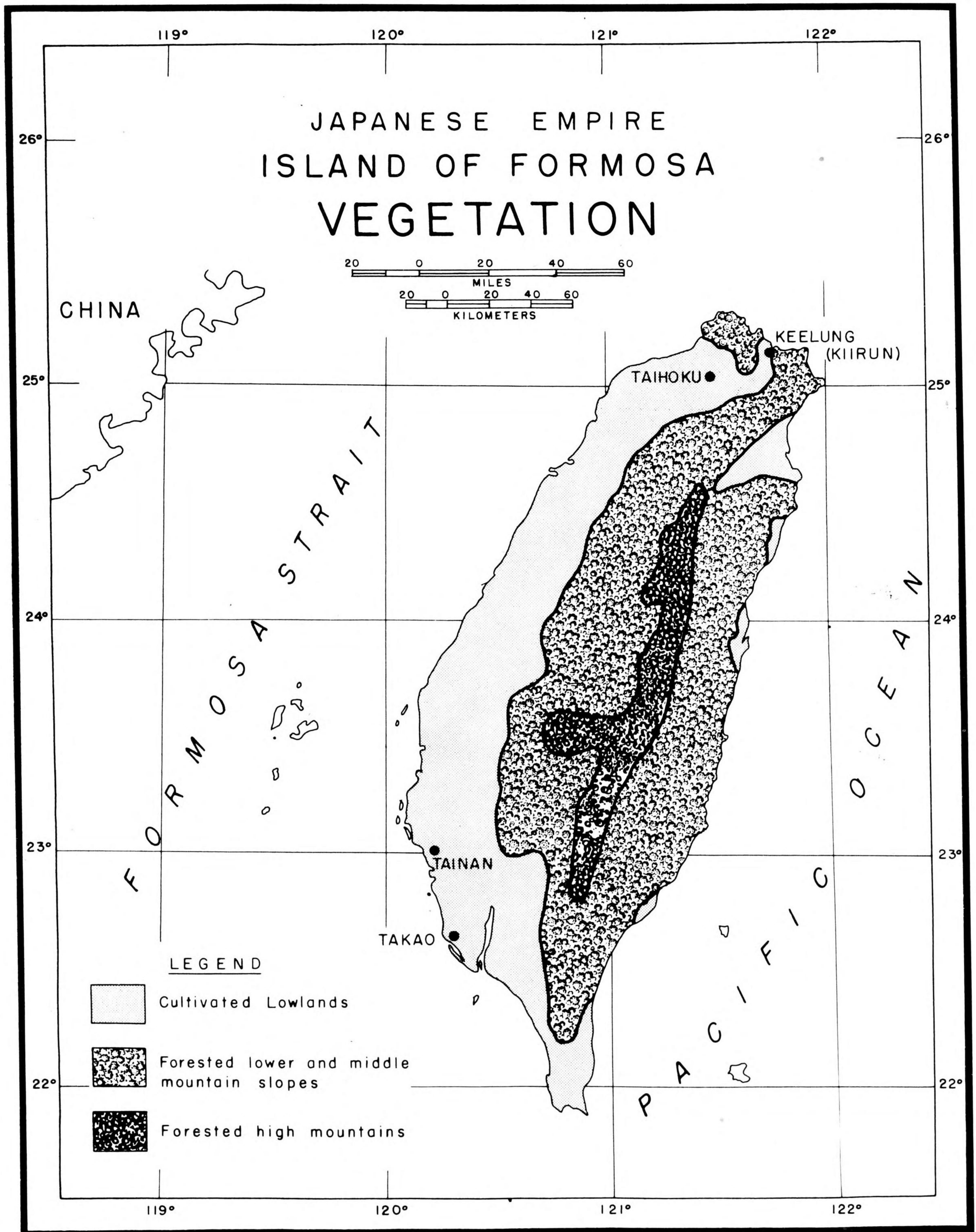
1.2.2 Climate

The island is bisected by the Tropic of Cancer and lies between two branches of the Kuro Siwo or the warm Japanese Black Stream. The climate is sub-tropical. Only in January does the mean temperature fall below 15°C (60°F). In summer, when the southwest monsoon blows, the weather is hot and heavy showers are frequent occurrences. Taihoku, the capital of Formosa and located in the northern part of the island, has a maximum temperature of 99°F and a minimum of 39°F. Rainfall is heavy and well distributed except in the southern area on the west side of the island. There the dry season occurs during the winter months when the northeast monsoon blows. During this period low clouds and rain prevail on the north and east mountainous areas. At Keelung (Kiirun), only 18 miles from Taihoku and previously the foremost harbor of the island, it rains on an average 219 days a year. November is the wettest month in Keelung, but usually is the driest in Tainan at the southern end of the island.

1.2.3 Topography

Formosa, in Portuguese meaning "beautiful island", or Taiwan, either in Chinese or Japanese meaning "terraced bay", has been occupied by Japan since the close of the Sino-Japanese war in 1895 when it was ceded to Japan by the Treaty of Shimonoseki.

A lofty mountain axis situated in the central and eastern parts of Formosa occupies almost two-thirds of the total area of the island. Niitake Yama (Mount Morrison, 13,075 feet) is the highest peak. The east coast is a cliff from 1,500 to 2,500 feet in height. In many places it is almost perpendicular to the ocean. On this side of the island, within 25 miles of the coast, the mountains reach elevations



of 11,000 feet. From these mountains there is a relatively gradual descent to the western coastal plain. This plain, which is 100 miles long N/S and 20 miles wide E/W, is the principal agricultural region of Formosa.

1.2.4 Population

The population as of 1938 was 5,747,000 of which just over 300,000 were Japanese. The remainder are native and Chinese, the latter being largely descendants of Kwangtung and Fukien Chinese. The density of population for Formosa is 372.1 compared to 474.3 per square mile for Japan proper, both being much higher than elsewhere in the Orient. The native aborigines, of which there are one hundred and fifty thousand, are of two classes, the "wild" and the "tame". They have now largely been subdued although occasionally the "wild" break loose and revert to their head-hunting habits. Even the "tame", however, are not sufficiently advanced to be much use as industrial labor. Key positions in social, political and economic life are dominated by the Japanese. Rural conditions are characterized by a high degree of tenancy and low living standards.

1.2.5 Agriculture and Forestry

Formosa has always been more important agriculturally than industrially, although since 1938 great emphasis has been placed on industrial development. The main crops are rice, sweet potatoes, pineapples, sugar and tea. The forest resources are enormous though largely inaccessible. 67% of the island is forested but much of the forested areas lie at elevations of 7,000 to 12,000 feet. Perhaps the most extensive growth and the best known to the world is the camphor tree. The map on page 6 shows the areas of vegetation. The Japanese in Formosa maintain a monopoly on the collection and sale of natural camphor, and also on the production and distribution of alcohol from sugar cane.

1.2.6 Industry

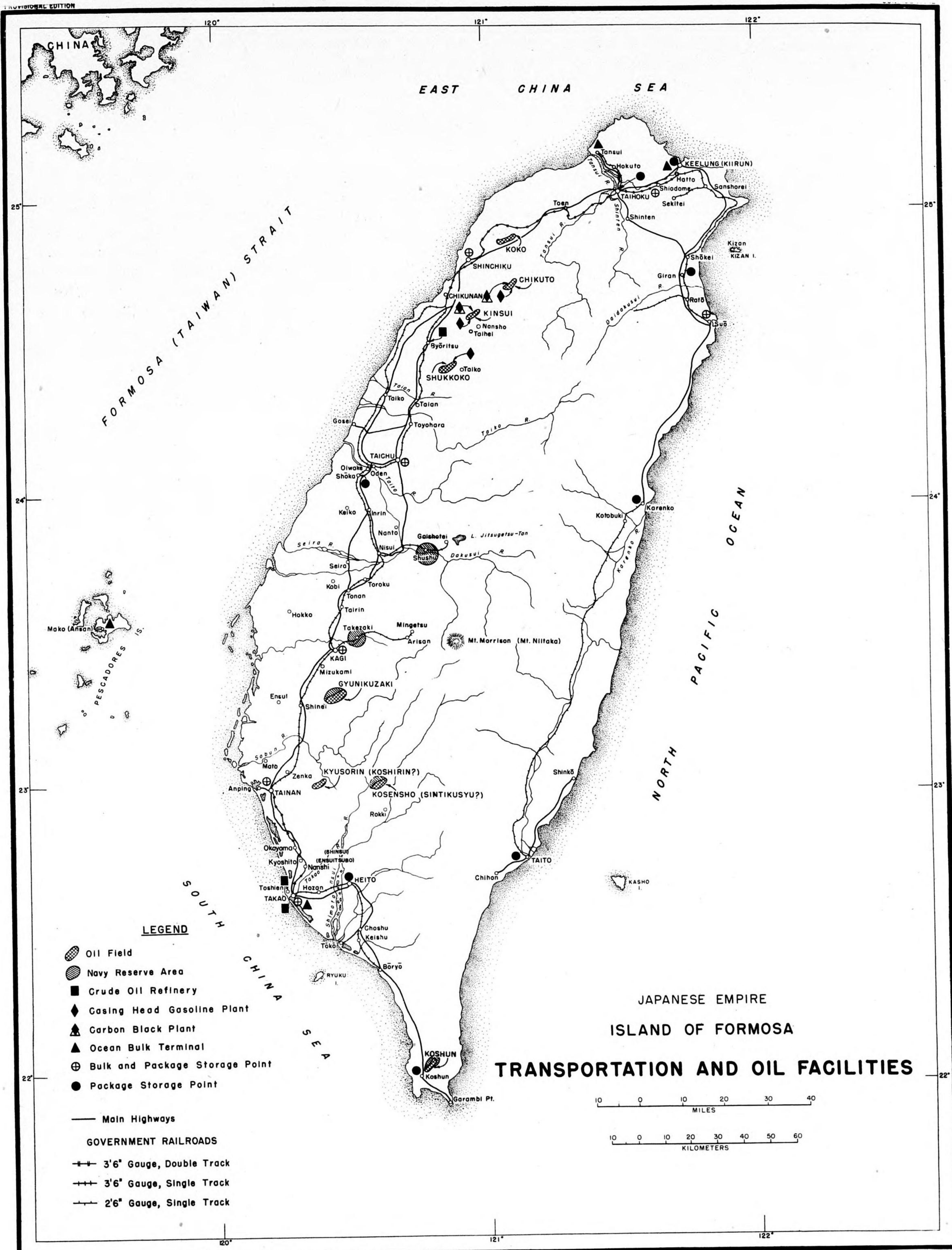
Mining, fishing and the production of petroleum, in that order, are the most important industrial pursuits in Formosa. Coal production in 1938 amounted to 2,145,000 tons; oil 110,000 barrels. Natural gas and carbon black are important adjuncts of the oil fields. Fishing is a part-time occupation and many fishermen are also farmers. The production of alumina, aluminum and alcohol recently has become of considerable importance. Industrial development, taking advantage of short-haul raw materials, includes production of special steel, nickel, ferro-magnesium and phosphates. There is an abundance of water power and hydro-electric power plants are being constructed, but minerals such as iron and bauxite are in deficient supply.

1.2.7 Railroads

Railroads, map on page 8, in Formosa are of three types:

(1) Government railroad of which the main line between Keelung and Takao represents major portion, totals 253 miles; east coast lines from Hatto to Suo and from Karenko to Taito total some 168 miles; branch lines such as Taihoku to Tansui, etc., total about 112 miles. The main line has a coastal and an inland division between Chikunan and Shoka 56 miles long. With double tracking, such as between Keelung and Chikunan in the north and Tainan and Takao in the south, total mileage is just under 1,000. The gauge is 3 feet 6 inches as in Japan. Light weight rails, sharp curves and short crossing loops limit speed and length of trains. The capacity of freight cars is 10 to 12 tons. Rolling stock at the end of 1941 was reported to consist of 220 locomotives, 600 passenger and baggage cars and 8,000 freight cars. Freight carried during the fiscal year ending March 21, 1939 was 7,861,000 metric tons; passengers were estimated at 25,000,000.

8 - INTRODUCTION
 Transportation and oil facilities



(2) Private lines to refinery centers and railway junctions were constructed by sugar, lumber or mining companies chiefly for their own use. Out of approximately 1,600 miles existing in 1939 just over 300 miles were open to public use. The gauge was generally 2 feet 6 inches, although some were 3 feet 6 inches. In 1931 equipment consisted of 251 locomotives, 273 passenger cars, and 15,273 freight cars. The lines usually spread out from the main west coast government line, but difference in gauge generally prevents joint operation.

(3) Pushcar lines consisting of small flat cars pushed by coolies along tracks of 18-inch or 20-inch gauge totaled 645 miles in 1937. Points in the interior and lowlands as well as cane fields are served by this means. Activity is indicated by a report that in 1937 pushcar lines carried 3,302,125 passengers and 457,149 metric tons of freight. No attempt has been made to show these lines on the map.

1.2.8 Roads

The main highway runs north and south along the western agricultural plain. The north-south chain of mountain peaks limits transportation across the island except at the extreme northern and southern ends. A narrow, single lane road runs from Suo to Karenko along the east coast but it is frequently blocked by landslides. Other cross-country traffic is confined to trails or footpaths. Estimated road mileage as of 1938 was as follows:

Road Mileage - 1938

Character of Road	Miles
Unimproved earth and non-surfaced	1,000
Improved earth, sand, clay, gravel, etc.	9,905
Macadam	11
Concrete and asphalt	70
Cement construction	14
T o t a l	11,000

1.2.9 Motor Vehicles

Before the war trucks and busses operating upon some 800 to 1,000 miles of roads constituted an important auxiliary means of transport. A concrete highway ran between Keelung and Taihoku. The north-south prewar highway was interrupted by lack of bridges at certain points. In 1937 motor vehicles on the island were estimated to be as follows:

Motor Vehicles in Formosa, 1937

Kind of Vehicle	Private	Government	Total
Trucks	1,179	121	1,300
Passenger cars	243	245	488
Taxicabs	973		973
Buses	944	495	1,439
Motorcycles	588	162	750
T o t a l			4,950

1.2.10 Rivers

The rivers in Formosa, none of which are more than 90 miles long, are sporadically swift flowing or nearly dry and are of little use as commercial routes, except at their mouths. The lower reaches are often multi-channeled or filled with boulders. The Tansui River is used by small shallow draft lighters or large sampans for traffic to the city of Taihoku. A canal connects the city of Tainan with Anping and there are canals along the Takao waterfront.

1.2.11 Harbors

Keelung (Kiirun) in the north and Takao in the south are the only important natural harbors. Artificial harbors are in process of development at Karenko on the east coast, at Gosei (or Niitaka) and Toshien on the west coast. Takao has, within the past three or four years, been developed tremendously as a major military port and industrial city with many warehouses and storage areas, and has now outstripped Keelung as Formosa's number one port. Both are heavily fortified. At Bako (Mako) in the Pescadores Islands, lying off the west coast of Formosa in the channel between the island and the China mainland, there is also an excellent harbor that is largely given over to the Navy.

1.3 PETROLEUM

1.3.1 Geology

Formosa lies within the petroliferous belt composed of Tertiary strata that extends along the western coasts of southern Sakhalin or Karafuto, Hokkaido, northern Honshu and Formosa. The major structure of this island is that of an anticline with the east limb removed by faulting. The oldest formations exposed in the faulted crest of the anticline occur along the east coast of the island and consist of Pre-Carboniferous strata and crystalline schists. Lying to the westward and forming the west limb of the anticline, are successive belts of Permo-Carboniferous, Cretaceous, Tertiary, Quaternary and Recent strata. There are reversals on the west limb in which petroliferous Tertiary strata are exposed along the crests of sharply folded anticlines. The following table gives the principal anticlinal folds of Formosa:

Principal Anticlinal Folds

Fold	District	General Trend	Length		Width		Dip of Limbs in Degrees	Geological Horizon of Oil Sands	Meters	
			Meters	Feet	Meters	Feet			Meters	Feet
Shukkoko	Shinchiku	NE-SW	5,500	18,150	200-350	660-1,155	35-70	Arisan (Tertiary) Series	500-1,000	1,650-3,300
Kinsui	Byoritsu	NE-SW	2,200	7,260	200-350	660-1,155	10-40	Arisan (Tertiary) Series	500-1,200	1,650-3,960

Information is limited, but the following table gives known facts concerning the stratigraphic column for Formosa:

Stratigraphic Column for Formosa

Age		Division		Description	Thickness
Tertiary	Pliocene	Shokkosan		Loose sand and gravel	750-1,900 m. (2,460-6,215 ft.)
		Byoritsu	Upper Lower	Sandstone and sandy shale Sandstone and sandy shale, oil bearing	2,000-4,100 m. (6,250-13,450 ft.)
	Miocene ?	Arisan	Upper	Sandstone and shale, oil bearing	1,500-5,000 m. (4,920-16,400 ft.)
			Middle Lower	Sandstone and shale, oil bearing Sandstone and shale	
	Eocene	Karisan		Sandstone and shale	1,000-2,000 m. (3,280-6,560 ft.)

The Arisan beds have been divided into lower, middle and upper, all three of which are fossiliferous while the middle and upper contain thin seams of coal and are oil bearing. The lower beds of the Arisan have been classified as Eocene; the age of the middle beds is in doubt; while the upper beds are Miocene. The Byoritsu beds of Pliocene age have been subdivided into upper and lower with the latter being oil bearing. The stratigraphic section on Formosa, therefore, includes sediments of Tertiary age including Eocene, Miocene and Pliocene.

1.3.2 Character of Formosa Crudes

Formosan crude (Shukkoko field) is a wax-bearing naphthene-intermediate-base oil containing almost no sulphur and asphalt but much gasoline and kerosene. Compared to the usual Japanese crudes Formosa oil is rich in paraffin wax. The oils also appear closely related, irrespective of locality or depth, in contrast with Japanese crudes from adjacent areas. The gasoline and naphtha fractions contain a relatively large proportion of the aromatic and naphthenic constituents. The remainder of the crude probably would be satisfactory for the manufacture of gasoline by cracking though prewar the Japanese had no cracking equipment in Formosa.

Analyses of Shukkoko Crudes

	Depth		
	412 m. (1,350 ft.)	550 m. (1,805 ft.)	825 m. (2,700 ft.)
Specific Gravity	0.828	0.874	0.840
Beaumé Gravity	39.40	30.40	37.00
Refractive Index	1.4730	1.4805	1.4805
Dispersion	38.6	38.5	38.4
Pour Point °C	∕ 1.9	∕ 10.3	∕ 6.0
External Appearance	Orange Semi-transparent	Orange Semi-transparent	Light Yellowish Orange Semi-transparent
Color (Lovibond Tintomtr.)	Y 3.8 ∕ R 0.8	Y 9.1 ∕ R 2.0	Y 2.5 ∕ R 0.6
Resin Content (per cent)	22.67	26.00	13.33
Sulphur (per cent)	0.141	0.150	0.135
Paraffin Wax (per cent)	2.877	5.474	4.436

Analyses of Shukko Crudes (Continued)

D e p t h

	412 m.(1,350 ft)	550 m.(1,805 ft)	825 m.(2,700 ft)
Viscosity (Redwood seconds)			
10°C	31.4	45.4	32.8
20°C	29.2	28.2	29.8
30°C	28.2	30.0	29.0
50°C	27.6	28.6	27.6
Viscosity (Saybolt Seconds)			
50°F	33.2	58.0	36.0
70°F	30.2	33.0	31.0
100°F	28.8	30.2	29.4
Distillation Temp. C°			
First Drop	• 57.2°C	46. °C	35.8°C
-50 per cent			
50-75)	0.05	0.05	0.10
75-100)	1.20	0.40	1.50
100-125)	16.85	6.60	10.65
125-150)	37.00	22.55	28.30
150-175) Atmospheric	50.30	36.70	40.00
175-200) pressure	58.02	46.82	47.65
200-225)	65.22	55.40	55.05
225-250)	72.82	64.80	63.70
250-275)	80.67	74.00	73.40
-170)	86.87	81.75	81.83
170-195) 10 mm. Hg.	90.23	87.09	87.10
195-220) pressure	93.86	91.28	92.15
220-245)	96.91	95.44	96.33
Residuum	99.93	99.99	99.86

Yield of Distillate and Spec. Grav.	%	Sp. Gr.	%	Sp. Gr.	%	Sp. Gr.
Gasoline Distillate (to 175°C)	50.30	0.7911	36.70	0.8039	40.00	0.7993
Kerosene Distillate (175-275°C)	30.37	0.8483	37.30	0.8521	33.40	0.8536
Gas-Oil Distillate						
(to 170°C/10 mm. Hg.)	6.20	0.8931	7.75	0.8886	8.43	0.8938
Light Lubricating Oil-Distillate	6.99	0.8683	9.53	0.8649	10.32	0.8672
(170-220°C/10 mm. Hg.)						
Middle Lube Oil Distillate	3.05	0.8246	4.16	0.8294	4.18	0.8257
(220-270°C/10 mm. Hg.)						
Heavy Lube Oil Distillate	3.02	0.8351	4.55	0.8367	3.53	0.8214
(Residuum at vacuum)						

1.3.3 Crude Oil Production

Production data from official Japanese sources, as shown in the table following and on pages 26 and 28, are apparently unreliable. Attention is invited to apparent discrepancies. The production from the Shukko field is greater than the production from all Formosan fields in 1931 and 1933.

The construction of gasoline plants of capacity well above the production shown indicates that the production of casinghead gasoline is in error or that the wells were shut in part of the time. Designated Navy reserves remained unexploited up until about 1937. The important fields of Shukko and Kinsui, brought in around 1924, showed early promise of production of quantities greater than a hundred thousand barrels annually, but crude production statistics remained below fifty thousand barrels until 1940 and casinghead gasoline production below one hundred thousand barrels, although plants with capacity of ten times that quantity have been reported as constructed. Figures for the production of oil and casinghead gasoline

in Formosa, either estimated or as given by official sources, for the years from 1927 through 1941 are given below.

Crude Oil and Casinghead Gasoline Production
(In Barrels)(a)

Year	Crude	Casinghead	Total
1927	143,800	5,030	148,830
1928	137,647	-	137,647 (b)
1929	91,924	-	91,924
1930	85,792	37,716	123,508
1931	38,262	86,408	124,670
1932	34,594	50,596	85,190
1933	35,413	41,370	76,783
1934	40,603	33,891	74,494
1935	50,145	51,903	102,048
1936	37,099	51,311	88,410
1937	36,166	56,566	92,732
1938	37,437	71,997	109,434
1939	36,912	93,667	130,579
1940	50,000	110,000	160,000 (c)
1941	50,000	110,000	160,000 (c)
Totals	905,794	800,455	1,706,249

1.3.4 Imports and Exports

Statistics on imports of petroleum products into Formosa from the East Indies, United States and from Japan Proper were not published after July 1937. Under normal conditions both the Rising Sun Petroleum Company and the Standard-Vacuum Oil Company imported directly but for several years prewar, due to shipping difficulties and other circumstances, SVOC transferred most of its products distributed in Formosa from stocks in Japan. The RSP, however, continued to ship all products with the exception of lubricating oils from the East Indies. The domestic companies shipped stocks by 500 or 1,000 ton coastwise tankers, or in tins and drums by cargo vessels, from Japanese ports to the Formosa ports of Keelung and Takao.

Exports of petroleum products from Formosa are normally small and in 1936 amounted to only 33,770 barrels. As an indication of imports into Formosa in a normal year the following figures published by the Department of Finance, Government of Taiwan and for the year 1936 may be noted:

Petroleum Imports, Formosa, 1936

<u>Products</u>	<u>Barrels</u>	<u>Country</u>	<u>Barrels (d)</u>
Heavy Oil	179,230	Japan	361,478
Gasoline	69,492		
Kerosene	114,970	Netherlands Indies	121,387
Axle Oil	6,189		
Machine Oil	22,896	United States	159,571
Other machine oil	21,553		
All other mineral oils	228,106	From all three	
Grease	23,500	countries (grease)	23,500
	<u>665,936</u>		<u>665,936</u>

(a) Unless otherwise specified, wherever the word "barrels" appears in the report a barrel of 42 U.S. gallons is meant.
 (b) Shukoko only. (c) Estimated.
 (d) Gallons converted to barrels except in case of grease where converted from "kin" to pounds to barrels.

1.3.5 Refining

Prior to the war there was only one crude oil refinery in Formosa. This refinery, with a reported capacity varying between 100 and 250 barrels daily, is located at Byoritsu, and was owned and operated by the Nippon Oil Company who produced from the neighboring oil and gas fields of Shukkoko and Kinsui. At Kinsui there was an old gasoline plant. Commencing in 1930 three modern absorption plants were constructed, one at Shukkoko, a second at Kinsui replacing the old one and a third at Chikuto. The combined capacity is reported in excess of 1,000,000 barrels of gasoline annually. Aerial coverage shows a refinery of uncertain size in process of construction at Takao and another at the new Naval base of Toshien. The Toshien refinery is in an advanced stage of construction and may have a capacity of 5,000 barrels per day.

1.3.6 Distributing

The Nippon Oil Co. and the Mitsubishi Oil Co. had import and storage points at Keelung and Takao, respectively. Nippon also had several interior bulk storage and distributing points for gasoline such as at Shiodome and Kagi. Nippon dealt in all products whereas Mitsubishi imported and distributed largely fuel or diesel and light oil for bunkers or fishing boats. Ogura and Hayama did some kerosene and machine oil business in packages. The two foreign companies were the Rising Sun Petroleum Company (RSP), a subsidiary of the Asiatic Petroleum Company (Royal Dutch Shell) and the Standard-Vacuum Oil Company (SVOC). The RSP had an import point for bulk kerosene and heavy oil at Tansui, gasoline being imported in 78-gallon drums. Latterly gasoline, rather than kerosene, was imported in bulk at Tansui. RSP had storage for packaged goods and drums at Takao and one inland bulk point. The SVOC distributed their products both in packages and in drums with storehouses at Keelung and Takao, ports of import. All companies sold through agencies.

1.3.7 Consumption

The use of quotas to control consumption in Japan and her colonies was instituted by the Government with the Oil Control Law of 1934. The Government authorized permits specifying the quantities of any single product a specific oil company might sell. Quota quantities were not always inclusive of consumption increases and in some instances arbitrary cuts in quotas were made at the expense of the foreign companies. The last normal consuming year was 1937, after which restrictions in quotas became progressively heavier, except for a slight relaxation of quotas in 1939 for the purpose of promoting local industries.

Estimated Civilian Demand, 1937
(in Barrels)

	Gasoline	Kerosene	(a) Light Oils	Fuel or Diesel Oil	Lubricants	Total
Automotive	241,000	-	-	-	15,000	256,000
Fishing Boat and Inland Marine	-	-	30,000	252,000	18,000	300,000
Railway	4,000	-	-	-	5,000	9,000
Utilities and Industrial	2,000	-	-	30,000	28,000	60,000
Agriculture and Farm	-	25,000	4,000	-	1,000	30,000
Household and Lighting	-	100,000	-	-	-	100,000
Totals	247,000	125,000	34,000	282,000	67,000	755,000

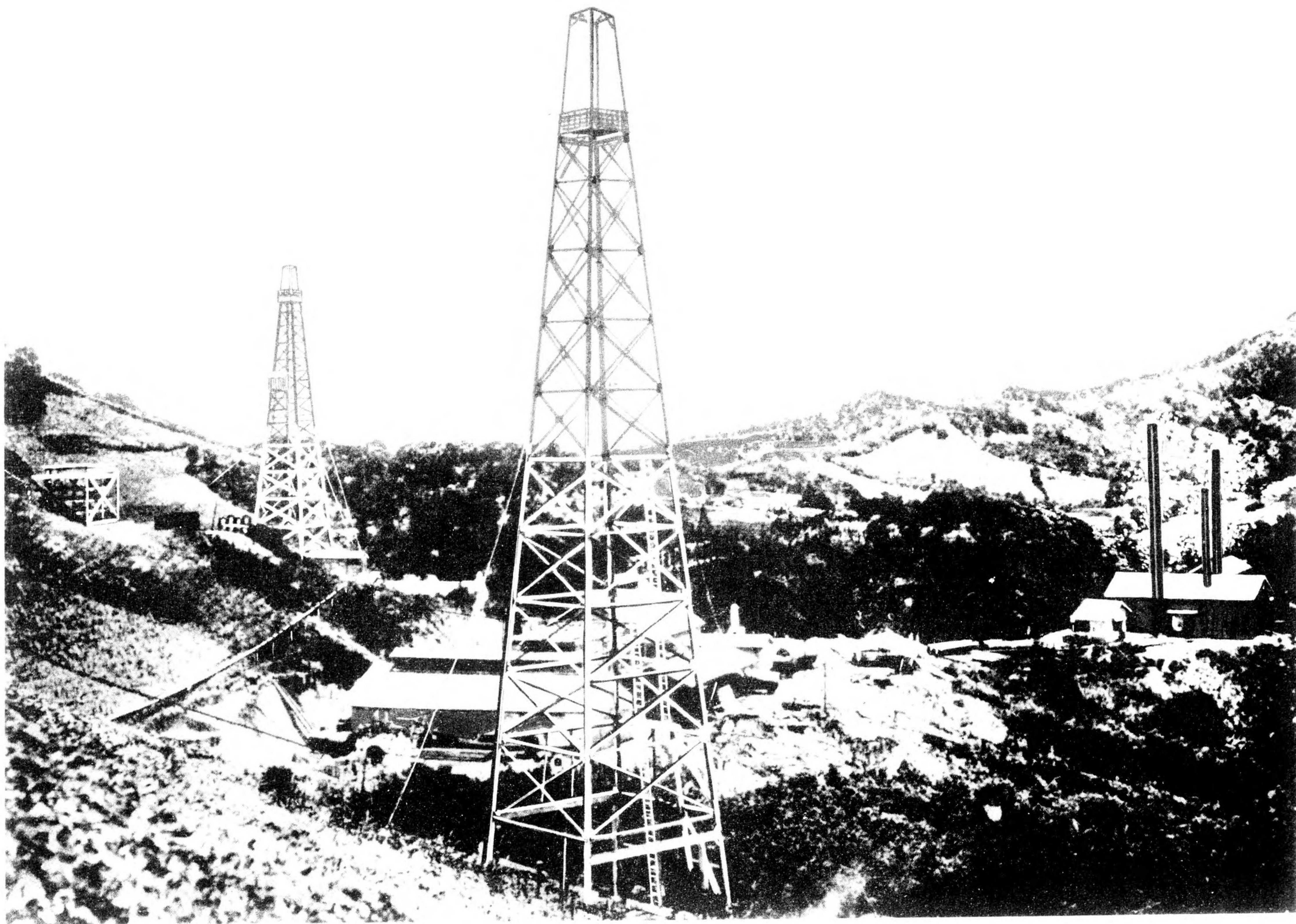
(a) For definition of light oil see page 70, section 4.4.5.

Estimated civilian demand in Formosa, based on authorized quotas for 1937, is given in the table on page 14, and consumption figures, also based on quotas, will be found in the Distributing section, page 54.

1.4 OPERATING COMPANIES

Producing companies operating in Formosa prewar were the Nippon Oil Company (Nippon Sekiyu) and the Formosa Mining Company (Taiwan Kogyo K.K.). After the war commenced in 1941, all producing companies in Japan and elsewhere in the Japanese Empire were amalgamated into one Government controlled company, the Imperial Oil Company. Mitsubishi, Ogura, and Hayama oil companies shared distribution with Nippon although Nippon had by far the lion's share of the Formosa market.

The foreign marketing companies were Standard-Vacuum Oil Company and the Rising Sun Petroleum Company, a subsidiary of the Asiatic Petroleum Company (Royal Dutch Shell). Neither of these companies had any American or British staff in Formosa immediately prewar. SVOC's District Sales Manager was H.T. Dew, Chinese, and at the time war broke out he was in Taihoku where the company maintained a district sales office. The RSP had a sales office in Taihoku managed latterly by a Japanese, and an installation and office at Tansui, also latterly in charge of a Japanese.



VIEW OF KINSUI OIL WELLS

2.0 PRODUCING

2.1 HISTORY OF DEVELOPMENT

Very little is known concerning the history and development of the oil fields in Formosa. They are located in the western part of the island, between the alluvial plains and the foot hills of the mountains, embracing an area 350 kilometers (220 miles) in length, but narrow in width. The Japanese Navy has 30 million tsubo, equalling 24,768 acres (tsubo equals 36 square feet) of possible oil land but prewar exploration did not develop any large reserves, or, if so, they were kept secret. Known oil fields are specifically mentioned by name in this report but Navy reserve areas are covered specifically only where there appears to have been some development. Several reports have referred vaguely to such places as Chuwa (Sho), Hozan (Takarayama), Hakkaryoku, Tsuho, Shobai, Ensuitsubo, Shinsui, Senshuryo and Toshikyaku as being the location of exploratory wells, but with the exception of Ensuitsubo and Shinsui, which appear in parenthesis on map on page 8, these places are not located. One source of information reports that in 1939 only 21 out of 82 petroleum "fields" in Formosa, covering an area approximately equal to the territory reserved by the Navy, were in operation. This unquestionably is an exaggeration and may refer to pools of one or two wells each. Proved reserves are not large.

Designated Navy reserve areas are as follows: (1) around Shushu, Taichu Province (Shushu is on the Nisui-Gaishotei branch railway line). A British report mentions a possible field by the name Tsusho with variants as "? Tsuyo, Tangsian, Tongsian" and "probably in the neighborhood of Shinchiku". It seems more likely this is Shushu as shown on map on page 8. (2) Northeast of Kagi, around the villages of Sokei, Shishito, and Takezaki; (3) in southern Tainan Province around the villages of Rokujukei, Gyunikuzaki, Suiryuto, Sairyo (Nairyo ?) and Chikutoki; (4) in the vicinity of Kosenpo and Takao Province north of Rokki; and (5) near the south tip of the island of Koshun. Specific areas are unknown and even all the villages cannot be located on any map but an attempt has been made to indicate approximate areas on the map on page 8.

Prior to 1942, the oil fields in Japan and Formosa were exploited largely by the Nippon Oil Company with the aid of subsidies granted by the Government-General. In accordance with the provisions of Law No. 73 enacted in 1941, the Imperial Oil Company was established in March 1942, with a capitalization of Yen 250,000,000 to control the nation's oil wells and to take over the interests of Nippon, Asahi, and such other industrial and small private companies as existed prewar.

Exploration and development of petroleum prospects and reserves have always lagged in Japan. This probably is for several reasons: desire to conserve oil in the ground, cheapness of crude and products obtainable from abroad, importance and development of electricity as a source of power. In any case, production has rarely exceeded ten per cent of requirements and despite numerous reports of new areas discovered and new wells, which gush large quantities of oil and gas, official figures of production have not exceeded 2,500,000 barrels in Japan in recent years, and 130,000 barrels in Formosa.

In Formosa drilling and development commenced in 1904 but with the antiquated methods used and the wildness of the territory, production by 1912 had reached a figure of only 473 tons (3,450 barrels). In early years, and even up to relatively recently the Japanese drilled by hand, the so-called "Kadzusa" system. This is a modification of the cable system in which the cable is replaced by strips of bamboo wound on a wheel some 17 feet in diameter. The motor power is supplied by a man running within the wheel, thus turning it over and raising the bit and bailer. The rotary system and the cable system are both used at present, the former apparently now being given preference especially for deep drilling.

Shukkoko (sometimes Shikkoku) in the neighborhood of Byoritsu, Shinchiku Province was the first commercial field discovered and drilled.

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Strategic Considerations

Development in the north at Shukko was commenced in 1904 by the Namboku Sekiyu Kaisha (North-South Petroleum Company), later absorbed by the Hoden Oil Company. Production the first few years was less than 1,000 tons annually and by 1926 appreciable production had just begun. Production from Shukko alone in 1927 was 136,647 barrels but immediately official production figures began dropping off and, despite discovery and exploitation of other fields, production of crude in Formosa has never exceeded 50,000 barrels since 1930.

About 1914 the Kinsui oil and gas field was discovered 10 miles north of Shukko. Gas prospects, particularly, were so good that the Nippon Oil Company immediately constructed a Japanese type of compression plant and in 1930 engaged an American company to construct a modern absorption plant at the field. In 1931, gasoline production from Kinsui officially reached 117,276 barrels but published data show a marked decrease in production immediately thereafter.

Development and further exploitation in Formosa seemed to lag from 1930 until 1937 when Koko and Chikuto oil fields were drilled by the Taiwan Mining Company north of the Kinsui field. In the south, at Gyunikuzaki and Kyusorin districts (Navy reserve areas in Tainan Province), drilling was carried out also in 1937 and oil found. The Japanese had a representative from Schlumberger (electrical well logging company) on the spot in that year, indicating that they were informed as to modern technical developments in the search for oil. Recent air coverage reveals that there are many oil wells northeast of Kagi and in the hills east of Tainan and Shinei.

Subsidies granted by the Government for oil well drilling in Formosa increased from ¥1,005,000 for the fiscal year 1937 to ¥1,280,000 for 1938 and ¥1,742,500 for 1939.(a) Exact figures are unknown for later years but the amounts are known to have increased. After the war began and upon the occupation of the East Indies with their rich petroleum deposits, development in Japan was retarded. There have been numerous recent indications, however, of increasing exploration, development and production in Formosa. Kinsui specifically has been in the radio news as having increased production 30 per cent in the fiscal year 1943/1944, which ends in March, with the drilling of a new well to a depth of 3,800 meters (11,590 feet)(latest record depth), and the continuous flowing of other wells since 1938.

The new structures appear important and with deeper drilling and more intensive exploitation the chances are that production in Formosa may have increased since the war began.

2.2 STRATEGIC CONSIDERATIONS

Value to enemy.- Formosa is strategically located and well developed as a permanent base for Japan. It has spear-headed Japan's military moves and served as a springboard for economic and political penetration into the southern regions. Its Governor General has generally been a naval or military man. The current value of the producing facilities may only be determined when actual present day production and development are known. The quantity of crude oil in the country, prewar, appeared to be small but how much production was deliberately restricted is quite unknown. The production of natural gasoline is a particularly important adjunct today in the manufacture of aviation gasoline.

Considerable material and equipment would be necessary in any case to transport the oil or refined products to ports or places where needed if produced in appreciable quantity of, even 1,000 barrels a day. Prior to the war reliance was on tank cars, but the production then of both crude and casinghead gasoline was less than half this quantity. Plans were once projected to transport crude by tankers to Japan from some port in the vicinity of Byoritsu but, as far as ascertained, they were never carried out.

(a) In the years 1937-1939 the value of the Yen, expressed in U.S. dollars, fluctuated between 28-29 cents.

Possible value to Allies. - The small production credited to Formosa would be of no great value to the Allied forces.

Importance in normal times. - While prior to the war there was no production of consequence in Formosa, the development of crude oil and natural gasoline may be an important item in the future economy of the country after the war.

Wartime use. There is every probability that all oil produced in Formosa is being fully utilized for military purposes. Tanks for its storage are under construction at strategic points.

Effects of damage. - The effectiveness of bombing oil fields is questionable. It is doubtful if the enemy will destroy his own oil wells though he may be expected to destroy pumping equipment, gathering tanks, etc., if occupation seems at all likely.

2.3 GENERAL GEOLOGY

Only two folds appear to be present on the western coastal plain of Formosa. The Kinsui structure on the first line of folding is relatively gentle but the Shukkoko structure on the second line of folding is far steeper. Probably the area of artesian drainage effecting oil accumulation is greater for these folds than for those on the main island of Japan. The sand conditions evidently are far better as much gas is present and the oil is light.

2.4 FORMOSA OIL FIELDS

2.4.1 Chikuto Oil Field

Location - About 40 km. (24 miles) NE of Byoritsu, latitude $24^{\circ} 45' N$, longitude $121^{\circ} 5' E$. The field, in 1937, was from six to eight miles long and two miles wide, with an area of from 12 to 16 square miles. See map on page 8.

Development. - Oil and gas are found at shallow depths. There were four producing zones or horizons (1937) at the following depths: 180 (594 ft.), 300 (990 ft.) 500 (1,650 ft.) and 800 (2,640 ft.) meters. Drilling commenced in 1935 and ten producing wells had been drilled by 1937, utilizing modern drilling equipment. A large drilling program was then scheduled. The field is favorably situated structurally with the axis of the anticline trending in a general NNE direction. This field was exploited by Taiwan Mining Company (Taiwan Kogyo).

2.4.2 Gyunikuzaki (Gyunikuki) Oil Field

Location. - Located in southern Formosa about due north of the Kyusorin anticline and about three-fifths of the way between the cities of Tainan and Kagi, this field is slightly east of the railway station of Shinei where a spur to the coast branches off. Latitude $23^{\circ} 20' N$, longitude $120^{\circ} 10' E$. The area is believed to be considerable, reaching inland toward the mountains and extending almost as far north as the Tropic of Cancer. Assuming it is the designated Navy reserve, it embraces the villages of Rokujukei, Gyunikuzaki, Suiryuto, Sairyoyo and Chikutoki, none of which can be located on any map. A British report states that Gyunikuzaki (Gyunikuki) is "about ten miles south of Kagi; not exactly located" and another reference places Rokujukei as eight miles SE of Kagi and says "possibly identical with Gyunikuzaki". The Taiwan Keizai Nenkan (Economic Journal) published in Tokyo, 1943 mentions that the Shinei wells are named Gyusan Oil Field and places specific location as Banshaso, Gyrikusaki. The similarity with Gyunikuzaki is obvious. The paper further states, "In the same 'gun' (county) is Rokujukai Oil Field at Hakkascho, Rokujukai." It further adds, "Crude oil from both oil fields is conducted by iron tube to Hoshirin." This latter point also cannot be located on any map. Chikutozaki is located by the Taiwan Keizai Nenkan as a separate field in Shinkagun, Nankascho which is farther south and a separate field designated as Kyusorin or Koshirin. See map on page 8.

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Kinsui oil and gas field

Development. - Although a report of an American oil man who was there states that this is a new oil prospect, the development of which started with the drilling of the first well in March, 1937, a brief note in the Journal of the Fuel Society of Japan shows that on April 10, 1932, the third well in this field commenced to emit 5,660,000 cubic feet of gas per day from a depth of 1,300 meters (3,900 feet), about twice the amount of gas given off in the Kinsui field. The latter does not check with Kinsui data. The article further advises that the Nippon Oil Company immediately decided to install a gasoline recovery plant with a daily capacity of 90 kiloliters (567 barrels), the residue gas to be supplied to the sugar refineries in the neighborhood.

The same British report mentioned above gives the following information concerning this field, "About 10 miles south of Kagi; not exactly located. Abundant gas was struck about 1930 at 1,036 meters (3,400 feet) but there were unmanageable quantities of water."

In the Journal of the Fuel Society of Japan, Vol. XIX, August 1940, appears an item stating that, "In the southern part of Taiwan the exploitation of petroleum has been relatively neglected but recently the #4 Chikutozaki well in the Taiwan? (Tainan) Province gushed out oil from shallow stratum and quantity is remarkably increased. This success gives much promise for the future of the oil fields on the south Taiwan."

There is no information on further development nor any record of production, nor is it known definitely that the foregoing refers to the indicated Navy reserve area.

2.4.3 Kinsui Oil and Gas Field

Location. - Kinsui is six miles NE of Byōritsu, latitude 24° 37' N, longitude 120° 55' E. It is east of the inner and main railway which branches at Chikunan and runs through Byōritsu to the south. A small push-car railroad connects the field with the main line. Byōritsu is the unloading and storage point for oil field equipment for Kinsui. See map on page 8 and photographs on pages 16 and 35 to 41.

Geology. - Outcropping strata consisting of sandstone and sandy shale belonging to the Byōritsu beds, form an anticline extending northeast and southwest about 20 kilometers (12-1/2 miles). The beds on both limbs dip 10° to 40°. Gas and oil are found in eight sandstones belonging to the Arisan beds at depths between 500 and 3,000 meters (1,640 and 9,850 ft.).

Development. Discovered around 1914, this field was, in 1937, considered to be by far the most important gas and oil field in Formosa with the limits not known in any direction. Gas output ranges from 30,000,000 to 300,000,000 cubic feet daily but little actual production of oil is reported. The best oil wells in Kinsui contain a large quantity of water. The water problem has been overcome by the use of gun perforators. Very little specifically is known concerning the course of development. Pertinent information as determined is reported chronologically in the following paragraphs:

1914 - Wells Nos. 1, 2, 3, and 4 were drilled to 1,150 feet. No. 1 well was destroyed by a heavy flow of gas and water. The others were abandoned because of water trouble. More than ten million cubic meters (350 million cubic feet) of gas flowed out of well No. 7 from a depth of 518 meters (1,700 feet). This may have been the initial production but it is not certain.

1923 - The fifth well to the south of No. 1 was drilled to 818 meters (2,690 feet) and yielded 1.7 million cubic meters (60 million cubic feet) of gas daily. A gasoline and carbon black plant were installed later near the site of this well.

1929 - September 21, 1929 a gush of natural gas at No. 8 well amounted to 20,000,000 cubic feet per day from which a daily production of 100 koku (one koku =

47.7 U.S. gallons) per day of gasoline was expected. September 1930, natural gas production had risen to 150 million cubic feet per day.

Another report written by K. Ueno in 1939 states that No. 8 well flowed about 4,000,000 cubic meters of gas per day (140,000,000 cubic feet) from a depth of 1,176 meters (3,860 feet). This corresponds with the figure for September 1930. In this connection, production figures as published or announced by the Japanese often were intentionally misleading.

1930 - In 1930 there were reported to be twelve wells (four gas) producing about 300 barrels of oil daily. This report was made by an American engineer constructing the gas plant at Kinsui, and would indicate a production of approximately 100,000 barrels annually. No. 10 gas well was drilled in 1930 to 3,479 feet to produce 100,000,000 cubic feet daily.

1931 - July 1931 daily production as given as 100,000,000 cubic feet of gas from which 5.4 kiloliter (a) (33 barrels) of gasoline was recovered. Capacity of plant was then 90 kiloliters per day. No. 14 gas well was drilled to 3,498 feet.

1932 - September 27, 1932: from No. 12 well natural gas flowed around 300,000,000 cubic feet per day. Nippon Oil Company considering (reported before) extension of gasoline and carbon black plants.

1933 - According to M. Mizuta the Kinsui casinghead gasoline is an excellent aviation gasoline as judged from its composition. Wells Nos. 19 and 21 abandoned.

1934 - Deep test to be conducted. Well No. 12 to be drilled as deep as 4,000 meters. Wells Nos. 20, 22, and 24 to 30 were drilled from 1932 to 1935 and produced gas varying in quantities from 15,000,000 cubic feet to as high as 150,000,000 cubic feet per day.

On July 10th, some 42,500 cubic meters of natural gas flowed from well No. 27 from a depth of 1,182 meters (3,880 feet).

1935 - On April 11th, natural gas flowed from well No. 32 when drilled to 1,750 meters (5,750 feet). The amount was estimated at 50,000,000 cubic feet per day.

1936 - The most important oil news in Japan in 1936 was the completion of well K No. 32, producing daily about 20 barrels of 40° Be., crude, and about 1,000,000 cubic feet of gas at a very high pressure through a 5/8 inch choke at the bottom of 3-inch tubing. The gas contained 0.75 gallons of gasoline per 1,000 cubic feet. The depth was 3,500 meters (11,500 feet). This well was started September 29, 1934 and was brought in August 5, 1936. At the time it was the deepest well in the Far East. The oil company selected the location for the next deep test (well No. 38) and drilling was to start in March 1938. Deeper, richer oil sands were anticipated.

1937 - According to a report by an American oil man engaged in making tests by the Schlumberger machine in Formosa during 1937, there were at that time 32 high pressure gas and oil wells and, from a geological point of view, excellent prospects. It was considered the most important gas and oil field of the period in Formosa. Well No. 33 was being drilled and the depth was then 3,390 feet.

1939 - A report by K. Ueno, appearing in the Journal of the Fuel Society of Japan for June, 1939, has the following to say, "The gas seam in Kinsui is unusual in the oil fields of the island, and enormous resources of oil are believed to exist in a layer at a great depth. A rich gas seam was actually found at a depth of 3,500 meters (11,500 feet) and after suitable measures for restricting the gas pressure were carried out, about 27,000 cubic meters of gas and 3.6 kiloliters (23 barrels) of crude oil gushed out daily for eight months. It is thus promising that large oil resources will be found in the seam 200 to 300 meters (656 to 985 feet) deeper, and the No. 38 well has been newly exploited aiming at a depth of 3,700 to 4,000 meters (12,130 to 13,105 feet).

(a) One kiloliter = approximately 6.3 barrels.

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Kinsui oil and gas field

"The author believes that more than 3,000 million cubic meters of gas will be produced from the Kinsui oil field even though new seams are not discovered in the future. There are many gas seams in the Kinsui oil field, the thickness as well as the content of water varying with the seam, and the gun-perforator will be applied to each well.

"The gas pressure (in pounds per square inch) is almost equal to half the water column (in feet) from the gas seam to the surface of the earth. Therefore, gas gushing from a depth of 1,000 meters (3,280 feet) has a pressure of a little higher than 1,000 pounds per square inch".

1944 - A radio broadcast emanating from Tokyo July 12, 1944, states that production of oil by Kinsui during 1943-44 fiscal year (April to March) exceeded estimated production by 30 per cent. The report continues with the statement that, considering the present rate of production and the fact that other wells have been flowing steadily since 1938, it is believed that a new well drilled in March, which reached the oil strata at 2,500 meters (8,200 feet), will continue to produce great quantities of oil for a long time. Drilling continued to a depth of 3,800 meters (12,464 feet) which set a new record in Japan and for the world (the latter is not correct as several wells have been drilled recently in the U.S. to over 15,000 feet.).

According to K. Ueno in his 1938 report, the present status of gas wells and the distribution of gas sands in the Kinsui oil field are as follows:

Status of Gas Wells at Kinsui, 1939

Well No.	Depth		Daily Gas Quantity Cubic Meters (a)	Water Quantity Kiloliters
	Feet	Meters		
10	4,745	1,438	21,000	34.3
15	Under	repair	161,000	--
20	6,468	1,960	21,300	10.8
24	4,679	1,418	21,300	--
25	4,858	1,472	7,800	17.1
26	5,230	1,585	17,800	2.3
27	4,986	1,511	7,800	35.0
28	4,455	1,350	4,400	95.5
30	4,815	1,459	4,400	1.1
31	4,695	1,423	21,300	34.3
32	11,550	3,500	5,850	0.9
33	3,845	1,165	2,700	--
34	3,845	1,165	7,500	12.6
35	4,676	1,417	350	6.6
36	3,858	1,169	--	--
37	6,353	1,925	--	--
39	5,082	1,540	--	--
Total			305,000	

The following is the distribution of the principal gas sands in the Kinsui oil and gas field:

(a) One cubic meter equals 35.3 cubic feet.

Distribution of Principal Gas Sands, Kinsui Oil and Gas Field

Seam	D e p t h		Presence of Water Sands	Total Production of Gas Cubic Meters	Approximate Thickness	
	Meters	Feet			Meters	Feet
1st	500- 550	1,650-1,815	Present	670,000,000	15	49
2nd	800- 850	2,640-2,805	Present	400,000,000	15	49
3rd	880- 920	2,904-3,036	Present	No production	15	49
4th	950- 980	3,135-3,234	Present	No production	10	33
5th	1,050-1,100	3,465-3,630	Present	300,000,000	15	49
6th	1,150-1,200	3,795-3,960	Not present	730,000,000	5	16
1,400m	1,400-1,500	4,620-4,950	Little water	600,000,000	Thin sands	
1,500m	1,500-1,690	4,950-5,577	Little water	Not collected	Thin sands	
1,800m	1,850-1,920	6,105-6,336	Present	Recently collecting	10	33
2,300m	2,200-2,270	7,260-7,491	Present	Not collected	40	131
3,500m	3,480 below	11,484	Little water	Recently collecting	Not known	

Production.- K. Ueno also advises that the total amount of natural gas which has been produced up to the present (1939) from the Kinsui fields is estimated at 3,000 million cubic meters, one-half of which was treated by gasoline plants, yielding 7,200 kiloliters (45,360 barrels) of gasoline. He also advises that about 10 per cent of the total amount was used in the manufacture of carbon black, and 6,300 tons of carbon black have been produced. The amount of gasoline stated as produced points to an extraordinarily low recovery if the figure is anywhere near correct.

The known production of natural gas in cubic meters and of gasoline in barrels at Kinsui up to 1931 obtained from another source is shown below. Quantities of gasoline produced bear little relationship to volumes of gas, and the chances are that it includes gasoline distilled from crude also produced at this field.

Known Production of Natural Gas and Gasoline at Kinsui

Year	No. of Wells	Natural Gas (In Thousands Cubic Meters)	Gasoline (In Bbls. of 42 U.S. Gals)
1927	1	2,465,517	2,983
1928	1	3,635,350	3,096
1929	1	3,897,482	9,484
1930	2	4,681,216	43,899
1931	2	322,641,329 (a)	117,276

Quality of gas.- The gases from the deeper beds (Kohryukei Series) contain larger quantities of heavy hydrocarbons than those from the Kinsui Series at shallower depths. Gases from upper beds contain larger quantities of oxygen compounds than gases from lower beds, showing the oxidation of the natural gases in the upper beds. The following table, showing quality of gases from Kinsui, is not as informative as it might be, but is the only test that can be found. Based on a production of 15,000 gallons of gasoline per throughput of 50,000,000 cubic feet daily as per refinery output specifications obtained from the contractor, the gases from Kinsui are classified as "wet" (i.e. productive of 0.3 gal. per 1,000 cubic feet). This is not indicated by the volume assigned to heavy hydrocarbons which may include butanes but are probably pentanes and heavier. The gas belongs to the pure hydrocarbon type with little nitrogen. In comparison, the natural gas from Shukkoko belongs to the carbon dioxide type containing more than 30 per cent of carbon dioxide.

(a) New Southwestern Engineering Corporation plant in operation.

Analysis of Gases from Kinsui Oil and Gas Field

Constituents	Kinsui Series (Depth 520 m. or 1,705 ft.)	Kohryukei Series (Depth 818 m. or 2,683 ft.)
CO ₂ and H ₂ S	0.91	0.59
Heavy hydrocarbons	0.15	0.49
O ₂	0.22	0.14
Co	0.13	0.08
CH ₄	96.83	90.25
C ₂ H ₄ (C ₂ H ₆ ?)		4.16
N ₂		4.31
Inert Gases	1.76	
He	0.004	0.006

Gathering system.- A gas pipe line carries the gas to the neighboring towns of Chikunan and Shinchiku. It is used also by sugar refineries in the locality, and by the refinery at Byoritsu. There was also an oil pipe line connecting the field with Byoritsu where the crude oil refinery was located. This refinery also took care of the oil from Shukkoko. Products from the refinery were transported by tank car to Keelung for storage or shipment to Japan and also were distributed elsewhere in Formosa by this means. Gasoline storage capacity in 1930 consisted of five cylindrical tanks with a total capacity of 100,000 gallons.

2.4.4 Koko Oil Field

Location.- This field is some ten miles north of Chikuto, approximately 24° 55' N, 121° 5' E. See map on page 8.

Development.- A wildcat well was drilled in 1937 to a depth of 1,450 meters (4,756 feet) on the anticline trending in the usual NNE direction but somewhat to the west of the Chikuto anticline. Gas was found at 1,250 meters (4,125 feet) and gas and oil at 1,400 meters (4,590 feet). There is no record of further development but, as machine shops and offices were built in 1937 near the village of the same name, the probabilities are that additional drilling has taken place. This field was under exploitation by the Formosa Mining Company.

According to another source, the field at Koko was discovered in 1934 and in early 1936 the wells drilled were producing 29,000,000 cubic feet of gas daily. It is an enterprise of the Nippon Kogyo Co. (Japan Mining Company) a subsidiary of the Nippon Sangyo K.K. (a Yasuda interest in Japan) with a capital of ¥200,000,000 and some eleven subsidiaries such as Kyodo Gyogyo (United Fishery), Nippon Hogei (Japan Whaling Co.), Hitachi Engineering, Hitachi Power, Nissan Jidosha (automobile) Company, etc.

2.4.5 Kosensho (Kosenpo) Oil Field

Location.- Latitude 23° 05' N, longitude 120° 40' E, about 1-1/4 miles NE of Kosen. This field may also be known by the name of Sintikushu which likewise may be spelled Sintikusyu and Shokushu. There is, however, nothing definite that this is one and the same field. The field is not commonly known nor has it been possible to associate the name with any particular village or locality appearing on any map except Kosensho or Kosenpo which is one of the designated Naval reserve areas. A British report mentions this field under the name of Kosen (which merely leaves off the "sho", the designation for village or station) and as being "about 22 miles ENE of Tainan." See map on page 8.

Development.- The following item appeared in the Journal of the Chemical Industry, Japan, for December 1932, "Natural gas gushed out of the No. 25 well at

Sintikusyu when drilled down to 1,883 meters (6,175 feet); gas is reported of good quality and in the amount of 10,863 cubic feet per hour". There is brief mention in the British report that "boring began before 1935 when a second bore hole was begun." Nothing more is known concerning this field.

2.4.6 Koshun Oil Field

Location.- This field is located on the southern tip of Formosa at a place called Koshun, latitude 22° 0', longitude 120° 48' E. See map on page 8.

Development.- No mention has been found of any development taking place in this area.

2.4.7 Kyusorin (Koshirin)(Kashirin ?) Oil Field

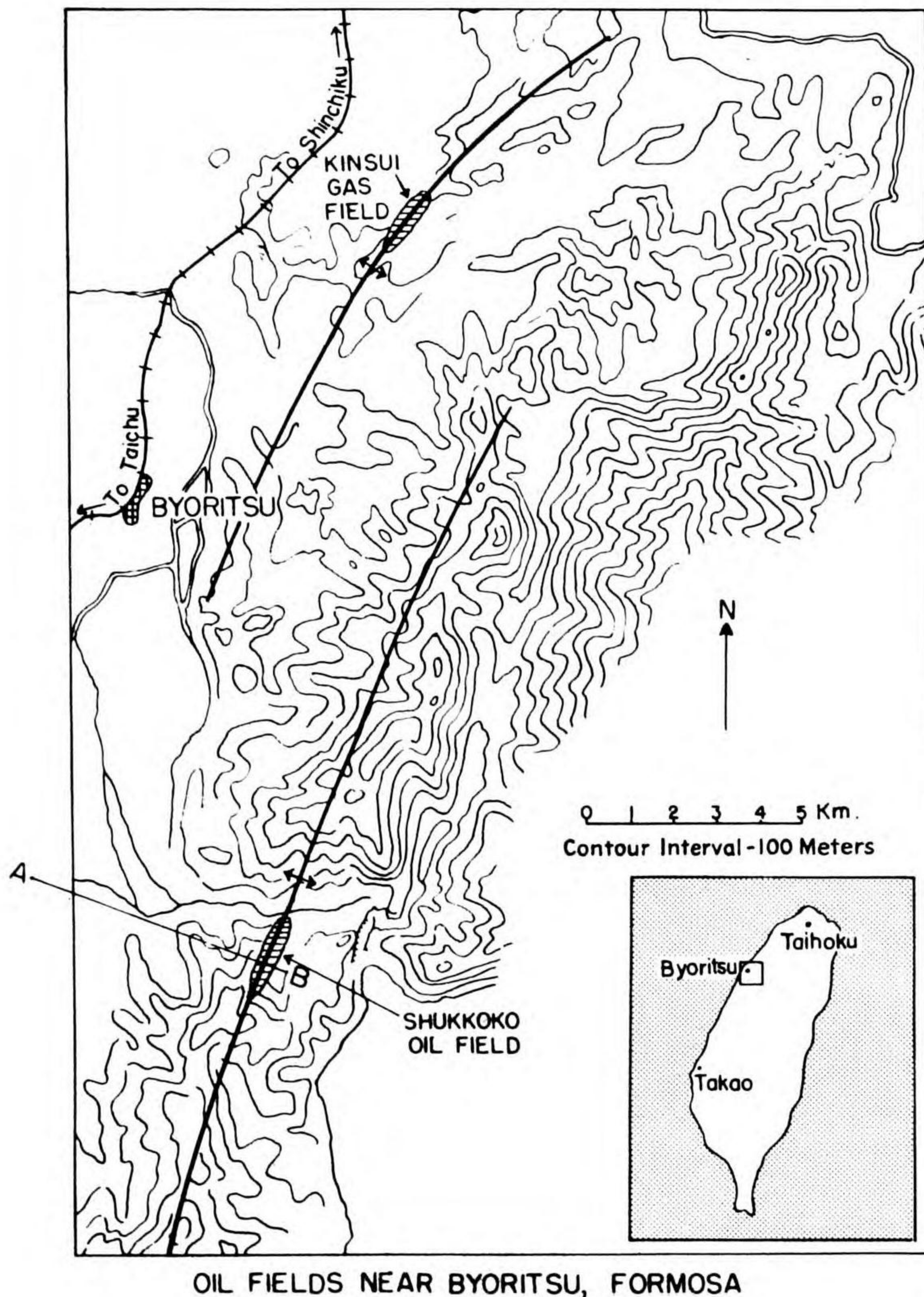
Location.- Located in the southern part of Formosa in Shinkagun, somewhat east and slightly north of Tainan. Approximately 23° 5' N and 120° 10' E. See map on page 8. Kyusorin is not found on any map but has been located as Koshirin, Sachin-sho. A British report states, "Said to be 19 miles NE of Tainan." It probably embraces Chikutozaki in Kanka-sho.

Development.- This is a new development which in 1937 had only one small oil well in production at a total depth of 750 meters (2,450 feet). The area is not exactly defined but is relatively large. A second well completed in February 1937 was dry. Further information is not available but more drilling was contemplated and probably carried out as the Government was making available liberal subsidies covering cost of prospecting. Drilling equipment in use was of the rotary type and very modern.

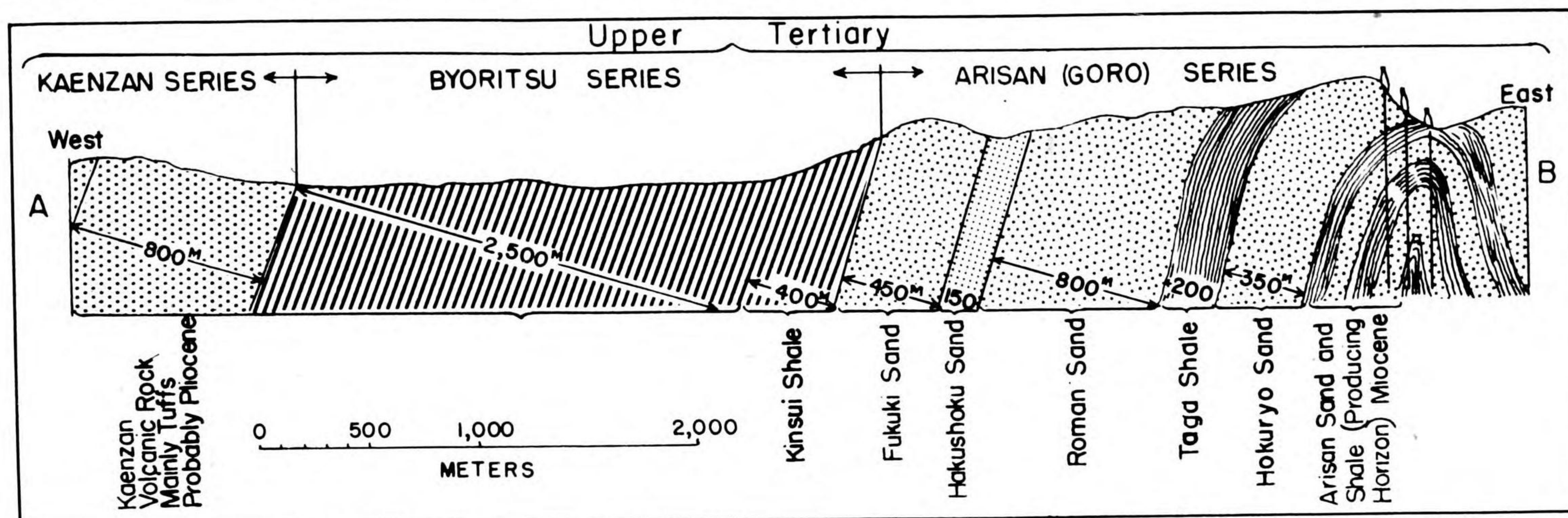
2.4.8 Shukkoko Oil Field

Location.- Located some ten miles south of Kinsui gas field in the province of Shinchiku, six miles southeast of Byoritsu, a town on the inner main north-south railway line that branches at Chikunan. Latitude 24° 37' N, longitude 120° 50' E. See map on page 8, and accompanying topographical sketch of the area.

Development.- This is the oldest of the Formosan oil fields, development having begun in 1904. It occupies an area of 497 acres lying along both banks of the Koro River. Very little information has been found concerning its development. Production probably started about 1924 and the field produced 137,647 barrels in 1927. Production declined rapidly from this field in later years. The Mitsui Company, Tokyo, writing to their San Francisco office, November 20, 1936, makes the following comments concerning the Shukkoko oil field, "Each one of the oil derricks is on a steep mountainside. Oil is obtained from two or three wells. One of these is self-gushing. It does not seem that more can be expected in the future because this field is already old. The earthquake here of last May (1935) seems to have inflicted damage at this field. Two or three wells were abandoned because they were bent by it. It appears that the damage inflicted was



actually greater than was announced at the time." An American oil man in Formosa in 1937 reports small activity and production in the field at that time. It seems possible that in line with deeper drilling practiced elsewhere that this would be tried at Shukkoko and oil production increased.



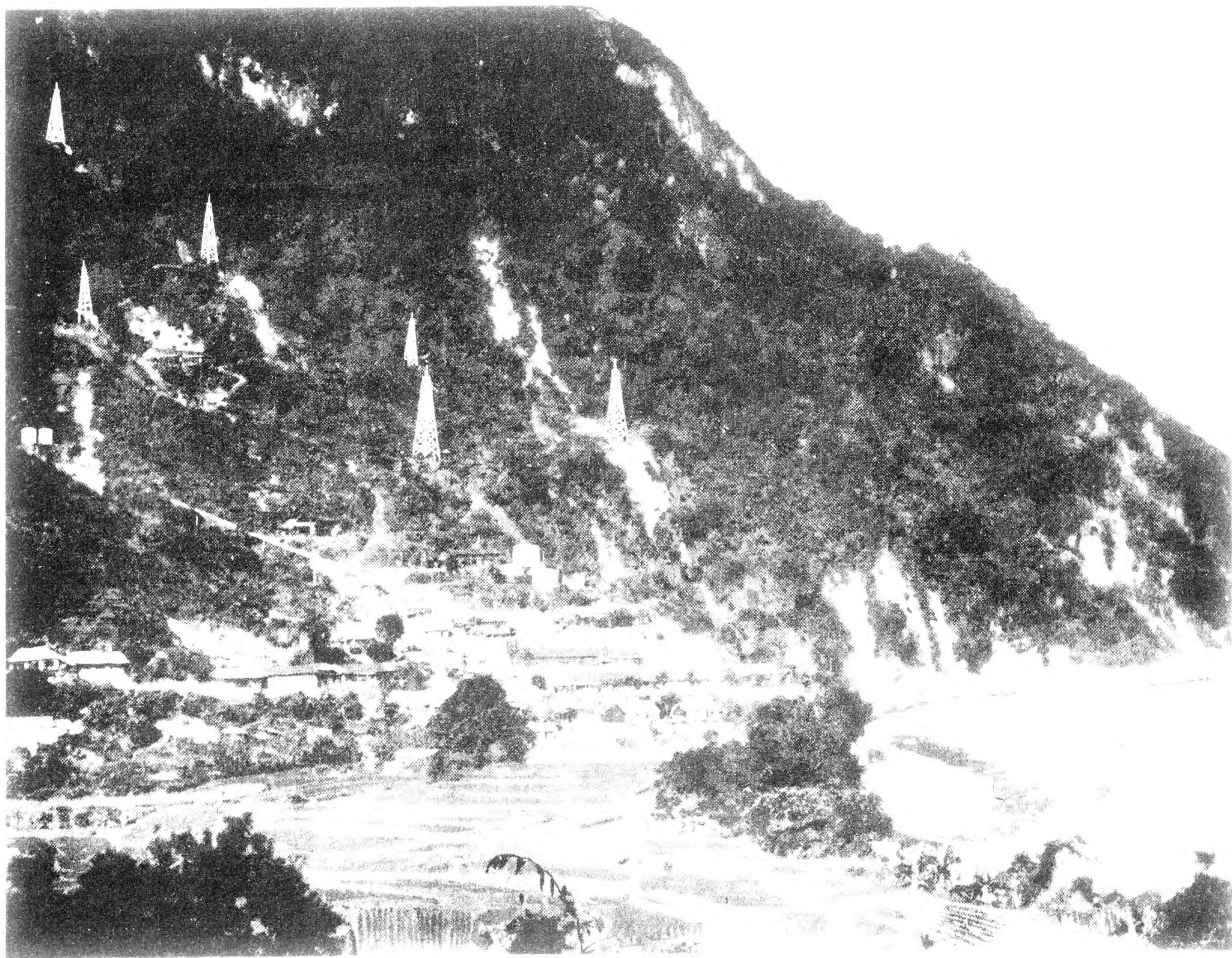
CROSS SECTION OF SHUKKOKO OIL FIELD, BYORITSU, FORMOSA

Geology.- The producing formations in the Shukkoko field are alternating calcareous sandstone and shale of the Arisan (Tertiary) series. The strata form an anticline about 27 kilometers (17 miles) in length dipping 40 to 70 degrees on the east limb and 35 to 60 degrees on the west limb. Six oil sands have been found at depths between 223 and 955 meters (732 and 3,132 feet), the most productive being the 750 meter (2,460 foot) zone. Accompanying geologic cross section prepared originally in Japanese may be tied with sketch of the topography of the area.

Wells.- Many shallow wells appear to have been drilled prior to 1912. Well No. 18 drilled about 1912 and later deepened is said to be one of the best wells in the field and to have produced 53,205 koku (60,300 barrels) from 1918 to 1925. In 1929 the output of the field was reported to be at a rate of 300 to 400 barrels per day. Some of the better wells have had an initial production of more than 1,000 barrels daily. Well data for the Shukkoko field are given in the table below:

Well Data, Shukkoko Oil Field

Well No.	Depth in Feet	Date	Remarks
18	720 Later deepened	1905-1912 1912	Many shallow wells drilled. Drilled by Hoden Oil Company and said to be one of the best wells in the field.
35	2,343	1924	Pumping 110 barrels per day.
36	-	1924	Initial production 1,000 barrels per day.
38	2,482	1926	390 barrels per day.
40	2,554	1927	Initial production 1,600 barrels per day, fell off to 180 barrels pumper.
41	-	1928	Pumping 130 barrels per day.
44	-	1927	Pumping 147 barrels per day.
45	3,280	1927	300 barrels per day.
48	2,650	1928	Initial production 1,000 barrels per day, fell off to 58 barrels per day in January 1929.
49	2,805	1929	Pumping 74 barrels per day.
50	-	1929	Pumping 62 barrels per day.
57	-	1929	Pumping 120 barrels per day.
67	-	1930	Pumping 50 barrels per day.
75	2,640	1935	Initial production 200 barrels per day, later 65 barrels per day.
77	2,772	1935	Initial production 80 barrels per day, later 60 barrels per day.
82	3,215	1938	Producer.



FRANCIS
HARRIS
1911
1911

28 - PRODUCING
Shukkoko oil field

Production.- Production figures for the Shukkoko oil field published by the Department of Commerce and Industry, Tokyo, are as follows (a):

Production of Shukkoko Oil Field

Year	Barrels	No. of Wells	Year	Barrels	No. of Wells
1927	137,647	22	1931	42,840	29
1928	113,585	29	1932	32,846	?
1929	79,845	33	1933	36,282	?
1930	55,838	37	1934	35,079	?

Quality of crude.- See data under heading of Character of Formosa Crudes in Introduction (page 11).

(a) These figures cannot be correlated with individual well production data on page 26.

3.0 REFINING

3.1 INTRODUCTION

Prewar status.- There was but one small crude refinery at Byoritsu in Formosa prewar, an old gasoline plant and possibly three fairly modern absorption gasoline plants which were constructed in 1930 or later (one definitely in 1930 at Kinsui). Production of crude oil which in 1927 was equivalent to 143,800 barrels (largely from the one field at Shukkoko) declined rapidly and in 1939, the last year of record, was only 36,912 barrels. It is not known, however, how much the Japanese had capped production at Shukkoko, nor what production had been developed in other areas. Production of gasoline made from natural gas on the other hand, even from official figures issued prior to the war, showed evidences of increase and the two gasoline plants known to have been constructed to produce 15,000 gallons daily may have been enlarged to turn out three times that quantity. A third plant is said to have been sold through Mitsubishi by the Southwestern Engineering Corporation for erection in Formosa but no trace can be found of it. There is evidence, however, of one plant having been built at Shukkoko. The Petroleum Register, 1938, credits Nippon with having in operation in Formosa one gas absorption plant of 500,000 cubic feet daily capacity (estimated 150 gallons of gasoline per day) and three each of 30,000,000 cubic feet capacity (estimated 9,000 gallons of gasoline per day).

Present situation. - A refinery of large dimension is in an advanced stage of construction at the Naval base of Toshien (near Takao) and another smaller one in a less completed state at Takao itself. The probability is that they were planned to operate on crude oil brought from the East Indies but it may be that crude from oil fields in southern Formosa is now being produced in considerable volume.

The following statistics show estimated capacity of the one crude refinery and the three gasoline plants believed to have been constructed in Formosa:

Estimated Capacity of Formosa Refinery and Gasoline Plants
(In Barrels)

	Byoritsu	Chikuto	Kinsui	Shukkoko	Total Per Year
Crude capacity per day	250				
Gasoline " " "		350	1,050	1,050	
Estimated " " Year	82,500	115,000	345,000	345,000	887,500

3.2 STRATEGIC CONSIDERATIONS

Importance in normal times. - Consumption of petroleum products under normal conditions exceeded by some five times prewar production of crude and natural gasoline. It is uncertain, however, how much production was purposely curtailed or exploitation delayed waiting for the time when Japan would be unable to obtain oil from abroad. Certainly the one small oil refinery at Byoritsu and the gasoline plant at Kinsui was justified by consumption. There is no information whatsoever concerning the amount of gas that may have been developed from Chikuto where a second plant is known to have been erected.

Wartime use. - The indicated development of indigenous crude oil and gas production since 1937 would greatly increase the importance of the plants in Formosa, and account for the construction of two new refineries near Takao, although the latter were more likely intended to operate on crude brought in from the East Indies. With the tremendous development of Takao as an industrial and Naval base, of Toshien

close by as a harbor and storage point for oil, of Karenko industrially, of a new harbor at Gosei, and with the presence of Bako and Keelung as Naval ports, Formosa must have been rated high by the Japanese as a strategical area and an impediment in the approach to Japan proper. Much stress has been placed by the Japanese on the production of butanol (butyl alcohol) from sugar produced in Formosa. Butanol, when dehydrated to butylene, may be alkylated with the iso-butane obtainable from the natural gas which is produced in large volume in Formosa. Thus a component for making aviation gasoline could be prepared in limited quantities for airplanes based on the island.

3.3 BYORITSU OIL REFINERY

Location.- Town of Byoritsu, latitude 24° 30' N., longitude 120° 45' E.

Description.- There is no concrete information relative to the refinery at Byoritsu constructed by the Japan Oil Company to process the Shukkoko oil, but apparently it was small and the usual Japanese type consisting of round pipes set horizontally. Its capacity is reported as varying between 100 barrels (100 koku = 4,770 gallons) and 250 barrels, the latter figure having been accepted for the purpose of this report. Photograph on page 35 indicates the primitiveness of the set-up. Besides making gasoline, kerosene, light oil and fuel oil, it was possible for them to separate the wax contained in the heavy oil by their so-called "perspiration process" or "wet method" and thereby turn out a machine or lubricating oil of fair quality. Nippon Sekiyu or the Nippon Oil Company (same as Japan Oil Company) had a patent in Japan on the process, but it probably was nothing more than the ordinary "sweating" method in which pressed wax was first chilled and then fractionated by controlled melting in "sweating ovens".

In 1937, large and modern factories for making carbon black and artificial rubber were under construction at Byoritsu according to report.

3.4 CHIKUTO GASOLINE PLANT

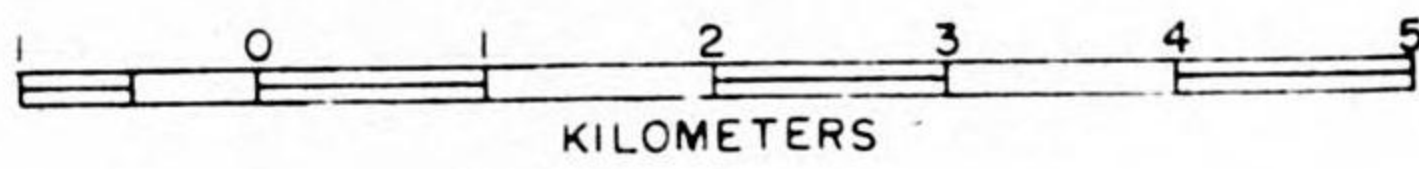
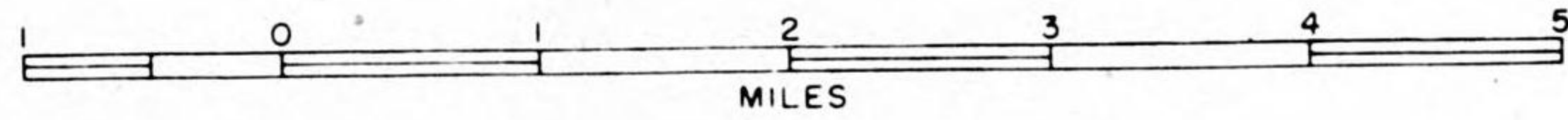
Location.- Latitude 24° 43' N., longitude 121° 5' E.

Description - Information concerning this plant is that it is an exact duplicate of the Kinsui Gasoline Plant erected in 1930. Photograph on page 43, obtained from "A Record of Taiwan's Progress", edition 1936-37, which is about the time that a more intensive development of the oil fields in Formosa was in progress, substantiates this report. Another report of an oil man who was in Formosa in 1937, states that a modern type refinery with cracking unit was in construction at Chikuto at that time. No confirmation has ever been found, and it seems possible that the refinery may have been the gasoline plant which, according to the picture, was still under construction.

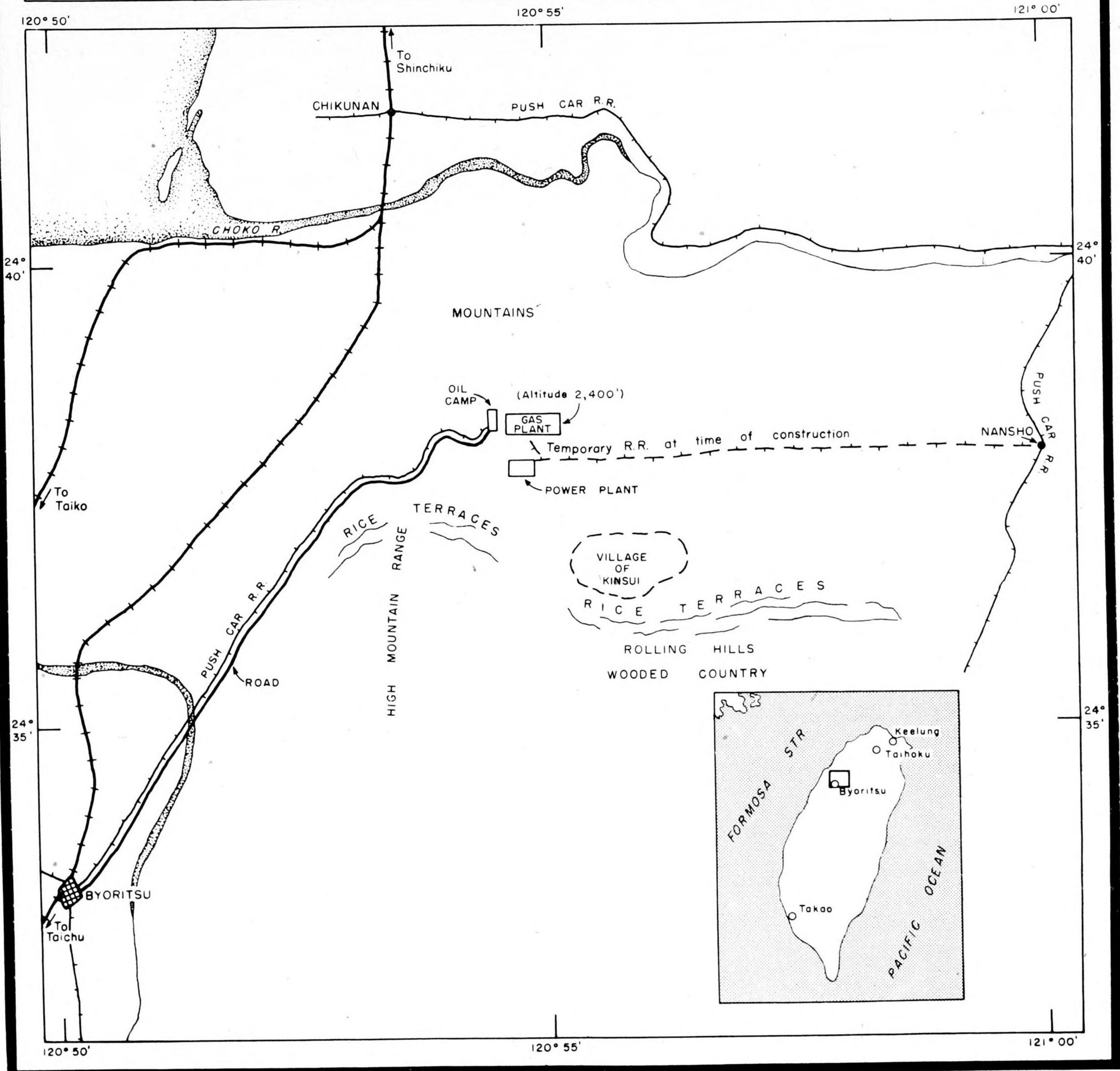
3.5 KINSUI GASOLINE PLANT

Location.- 24° 35' N. latitude, 120° 55' E. longitude, some seven miles in the hills to the northeast of the town of Byoritsu and away from the main railway running from Keelung to Takao, 13 miles south of the town of Shinchiku. The elevation of the plant is 2,400 feet. A temporary railway coming from the east, starting from a small town the name of which may be Nansho, some 12 miles inland from Byoritsu, appears to have been laid at the time of construction but the information is somewhat obscure. A reporter who was at Kinsui in 1937, mentions only the push car light railway. The somewhat winding push car light railway in question, constructed through a gap in the hills, connected the oil camp at Kinsui with Byoritsu. There appears, also, according to a report pertaining to the date that the plant was constructed, to have been a road entering through the same gap into the plant in 1930. Any approach to the plant from the north or west, because of the mountains, would be most obscure but the plant is easily visible approaching either from the south or

JAPANESE EMPIRE
ISLAND OF FORMOSA
SKETCH OF KINSUI GASOLINE PLANT



(Approximate Scales)



the east. Between Byoritsu and the plant there is a river over which the light railway crosses on a crude bridge. The river at that point is 400 feet wide. Like most of the Formosan rivers, or mountain streams, it is practically dry in the dry season and a torrent in the wet. See sketch of location with respect to Byoritsu, map on page 31.

Description.- Prior to the erection of the modern plant in 1930, the Nippon Oil Company had their own compression and absorption system plant at the field, which was probably erected about 1926. See photograph on page 37. The modern plant, see photograph on page 39, was constructed by the Southwest Engineering Corporation under the supervision of their own engineer who was on the spot from June to December 1930. Immediately afterwards the annual production jumped to 117,276 barrels (according to Chitani in a paper entitled "Petroleum Resources of Japan" read before the American Association of Petroleum Geologists and printed in Vol. 18, No. 7, July 1934) though this figure is not substantiated by official statistics. See page 13.

The plant, shipped from the United States (one of three such refineries said to have been sold to Mitsubishi for use in Formosa), consisted of a complete distillation unit, three absorbers together with pumps and turbines, heat exchangers, and condensers, and a complete stabilizer unit with a normal capacity of 30,000 gallons of gasoline per day. The capacity of the plant, according to report, was 50,000,000 cubic feet of gas per 24 hours.

A succeeding report states that the plant, as originally installed, could produce only 15,000 gallons daily, but that subsequently sufficient maintenance and replacement equipment was bought by Mitsubishi from companies other than Southwestern to make it possible to increase each plant's production to 45,000 gallons of gasoline per day. This would be equivalent, approximately, to 1,000 barrels daily although even one such plant of 15,000 gallons (approximately 350 barrels daily) would be sufficient to care for the total quantity of casinghead gasoline credited to Formosa in 1941, i.e., 110,000 barrels annually.

At the time of erection, the refineries were not equipped to produce high-octane gasoline but what the Japanese have done in the meantime is unknown. Iso-butane used in making aviation gasoline is an important fraction in natural gas. Much stress in broadcasts has been laid on the production of butanol or butyl alcohol in Formosa from sugar for the preparation of aviation gasoline. The Japanese could, by dehydrating butanol to butylene and subsequently alkylating with the iso-butane available from the natural gas, make a desirable component for use in the preparation of aviation gasoline.

Gas for this plant, in 1930, came from four of twelve wells drilled in its approximate vicinity. The plant was equipped to bottle butane gas. It was located on the side of a hill and in its construction a cut and a fill had to be made. There were five cylindrical tanks with a total capacity of 100,000 gallons for gasoline storage. The boiler and electric plant was located 400 yards south of the main plant.

In 1938, the Navy considered the establishment of a Fischer-Tropsch plant at the Kinsui field to make liquid fuels from the natural gas in that territory but there is no evidence that construction was ever carried out.

3.6 SHUKKOKO GASOLINE PLANT

Location.- 24° 25' N. latitude, 120° 51' E. longitude.

Description.- There is reported to be a casinghead plant at Shukkoko. From the photograph on page 45 it might well be a plant of 45,000 gallons daily capacity, which ties up with a report from another source that a new refinery of Nippon Oil Company with annual crude capacity of 350,000 barrels was projected at Taiko, a small village just SE of Shukkoko. There has never been any confirmation. It is, however, support for the theory that production from this field is larger than shown by official figures.

3.7 TAKAO OIL REFINERY

Location.- Aerial reconnaissance late in 1944 disclosed that a refinery and tank farm is being constructed on the edge of the lagoon at Takao, four miles SE of the harbor mouth. The land on which the installation is being erected has been formed by dredging the lagoon which, at this end and for over two miles from deep water, is only three feet deep. Latitude 22° 37' N., longitude 120° 16' E.

Description.- There is little yet to go on but the aerial coverage as per photograph on page 49 showed the following construction:

- 1 pipe distillation furnace,
- 1 fractionating tower,
- 1 cooling tower,
- 7 large oil storage tanks,
- 10 small rerun tanks.

There were also a number of small miscellaneous buildings, considerable material and supplies and signs of considerable activity. In October 1944, there was no evidence of pipe lines between installations, the storage tanks were not roofed, and, in general, there was no appearance of the refinery being ready for use in the near future.

3.8 TOSHIEH OIL REFINERY

Location.- This plant is under construction at the NE end of small hill, three miles NE of Toshien Harbor, latitude 22° 42' N., longitude 120° 18' E. It covers an area of about 5,300 x 2,250 feet. Approximate position has been indicated on the map margin, page 60. This map was completed before aerial photograph of the refinery to be found on page 51 was made available.

Description.- Facilities appear to include boiler and power house; control house, pipe furnace, thermal cracking unit, probable lubricating oil vacuum unit and filter house, probably pumphouses, and control equipment houses, cascade-type cooling tower. There are several groups, one of 10 and the other 20 rerun tanks average 30 feet in diameter. There are 5 earth-revetted tanks of 120 feet diameter at the base of the hill on the East side of the area already completed and bases for 13 similar tanks are under construction in the same area. These tanks are probably for crude and refined oil storage. There is a coal pile 600 feet x 450 feet, which would indicate an intention of operating the refinery on coal. There are numerous miscellaneous buildings and piles of material visible and two H-shaped buildings of large dimension at either end of the plant assuming it is all one unit. Seven structures, ranging from 105 feet x 90 feet to 90 feet x 65 feet, may house small storage tanks. A railroad line runs adjacent to north end of plant area and a spur enters the area from the southwest.

Capacity is uncertain but might be estimated at between 3,000 and 5,000 barrels daily. Storage when complete might easily have a capacity of 1,500,000 barrels.

There are uncertain indications of pipe lines approaching the plant along the railway coming from the direction of Tainan, which might indicate that it is planned to operate the refinery on oil from fields such as Gyunikuzaki, or the closer ones of Kyusorin and Kosensho. Oil from these fields may also be transported by rail tank cars to the storage tanks located in close proximity to the railway. It seems probable that the intention is to supply the Navy based at Toshien with products from this refinery. On map, page 60, are shown location of auxiliary tanks near the harbor, and there is a railway spur close by.

3.9 CARBON BLACK

Location.- Kinsui, Chikuto, Gyusan and Bochirin.

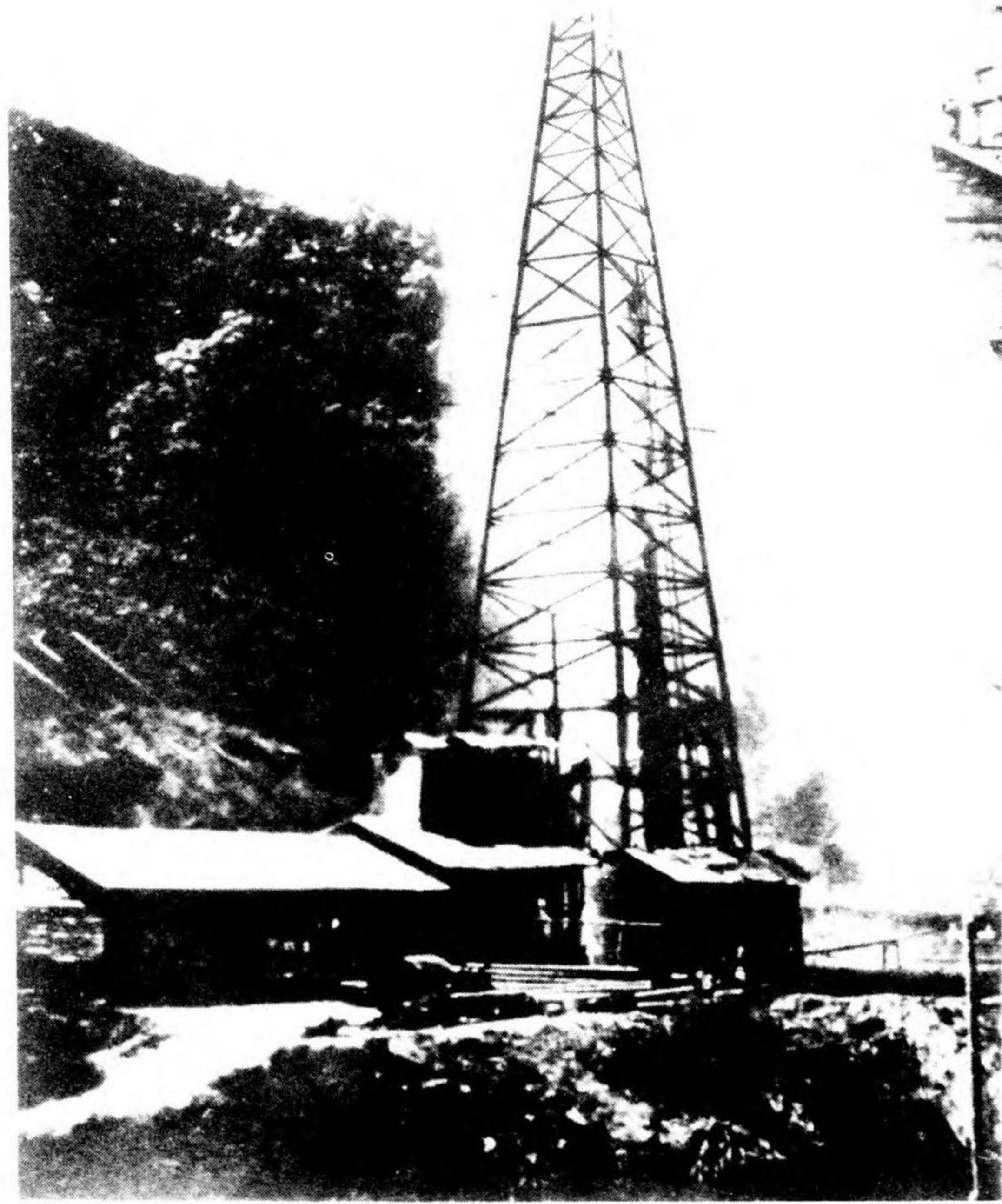
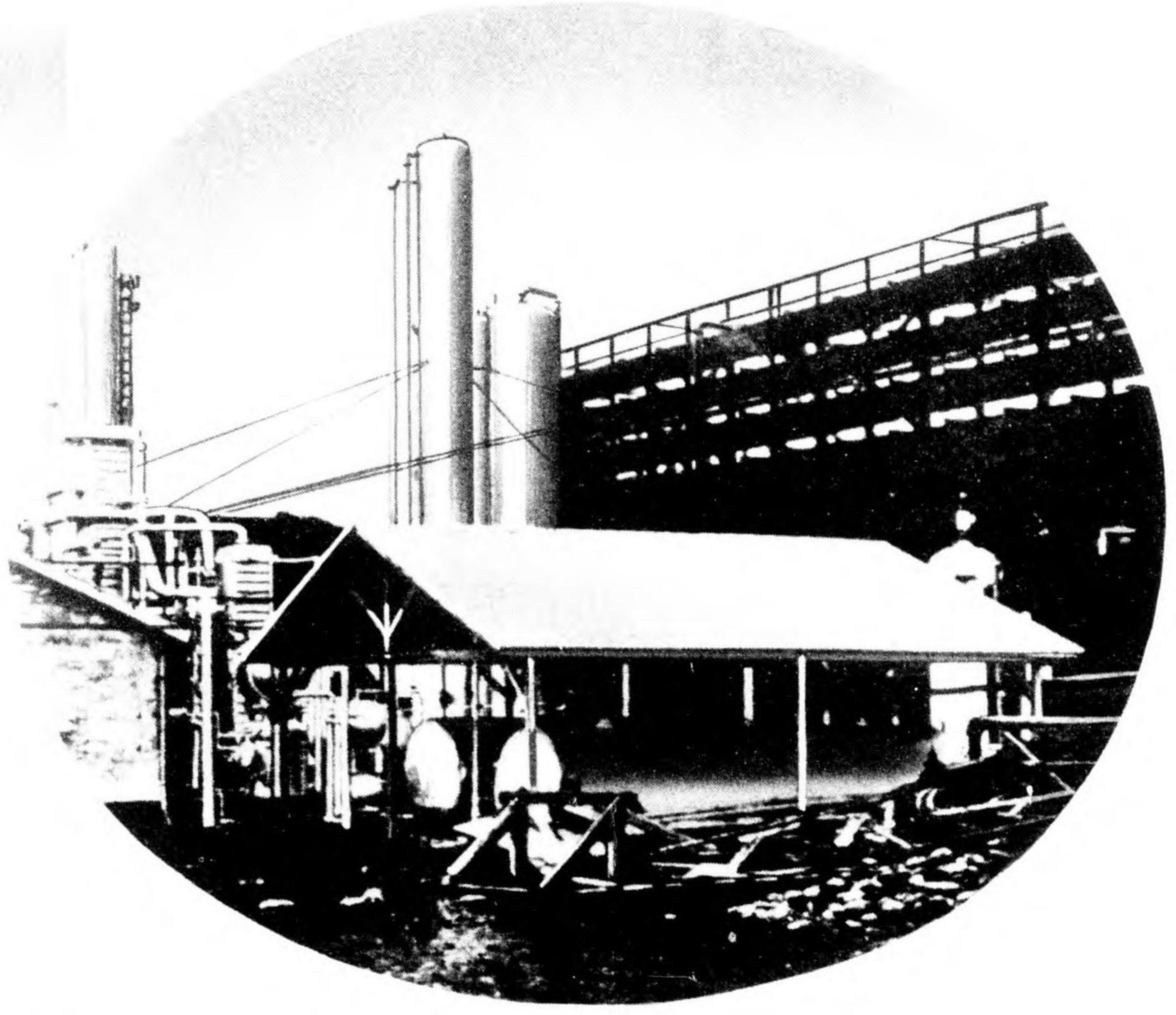
Kinsui plant.- The plant is installed at Taihei near the Kinsui oil and gas fields, and is situated on a plain surrounded by three hills, therefore, comparatively free from winds. After the raw gas has passed through the gasoline plant, there remains 98% of CH₄ (methane) which is used in making the carbon black. A modern plant utilizing the American channel type machine system and capable of burning 2,500,000 cubic feet of gas per day was constructed here in 1930 by the Nippon Oil Company. This plant is reported to make some 25 per cent of the carbon black required by Japan for making rubber tires. In 1932, the production was 4,000 pounds daily or some 750 tons annually while in 1939 reported output had attained a figure of 2,250 tons per year. The plant is significant by its rows of low, saw-tooth roofs, marked by constant smoke. See photograph on page 47. A second carbon black plant has also been reported in this district but never confirmed.

Chikuto plant.- The Taiwan Mining Company had a plant at Chikuto which according to report had an output of only 400 tons in 1939, although it had been 2,000 tons in 1937. Output is dependent upon gas available but also upon demand. A second plant is reported to have been constructed at Chikuto by the Nippon or Japan Oil Company with a capacity of 330 tons annually or only one ton per day.

Gyusan and Bochirin plants.- The Japan Oil Company is reported also to have constructed small plants at these two unlocated points with a capacity of 150 and 670 tons annually respectively.

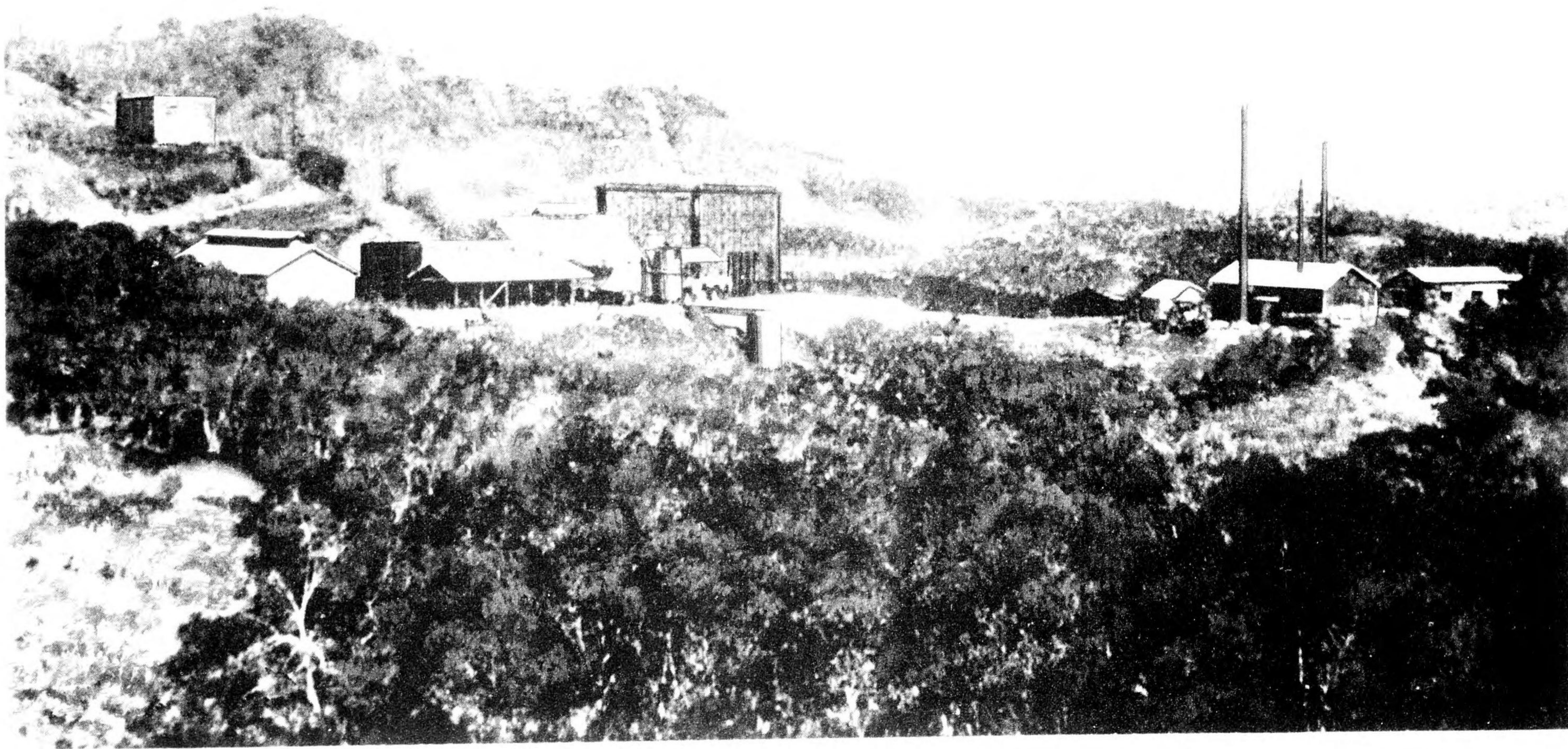
Value to enemy.- For many years Japan imported carbon black from the United States but with the discovery of natural gas began to make her own. However, the supply from this source is reported to be only about one-third of her needs. Acetylene gas is a substitute raw material from which an inferior grade is made that may also be used for compounding with rubber in automobile tires to increase durability. Japan has a sufficiency of soft carbon black. It is the hard carbon black type, more ideally suitable for tire manufacture, of which she may still be deficient.

Due to the relatively simple equipment required, carbon black plants, if damaged by enemy action, may easily be restored.



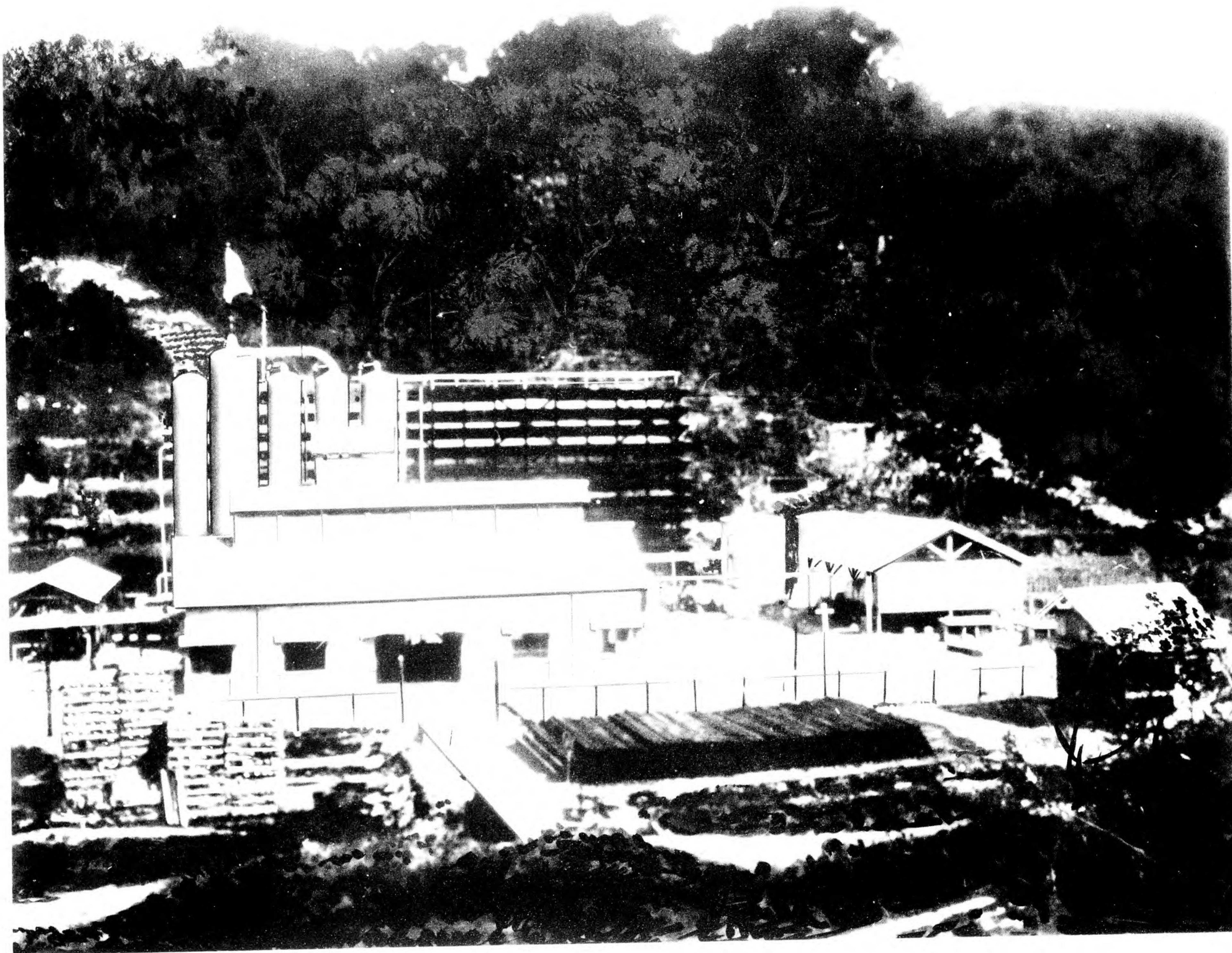
VARIOUS VIEWS OF BYORITSU AND KINSUI

- TOP: VIEW OF BYORITSU OIL REFINERY
- IN CIRCLE: GASOLINE PLANT AT KINSUI
- BOTTOM: SCENE AT KINSUI SHOWING NATURAL GAS SPURTING FROM WELL

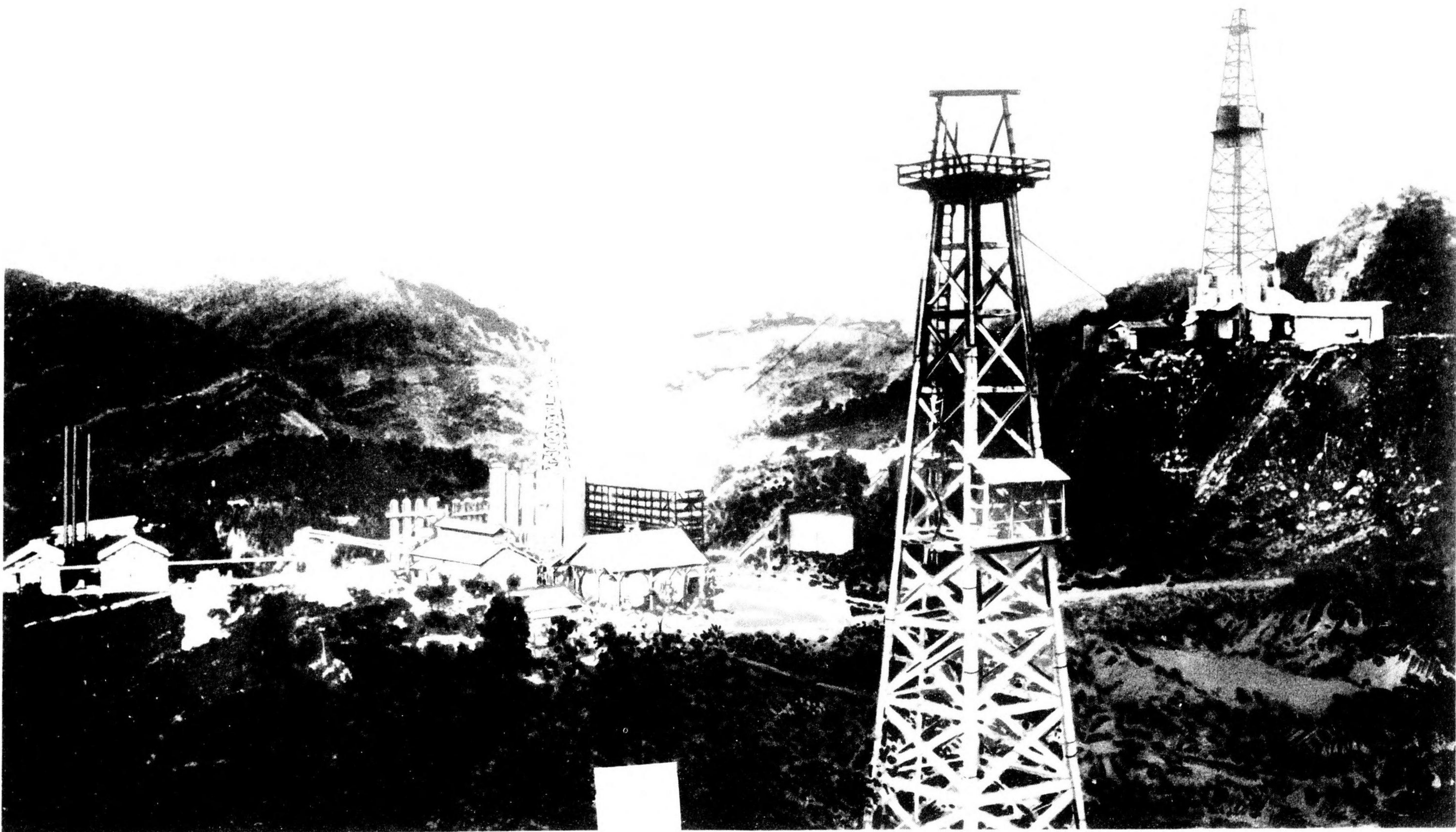


VIEW OF KINSUI GASOLINE PLANT BEFORE 1930

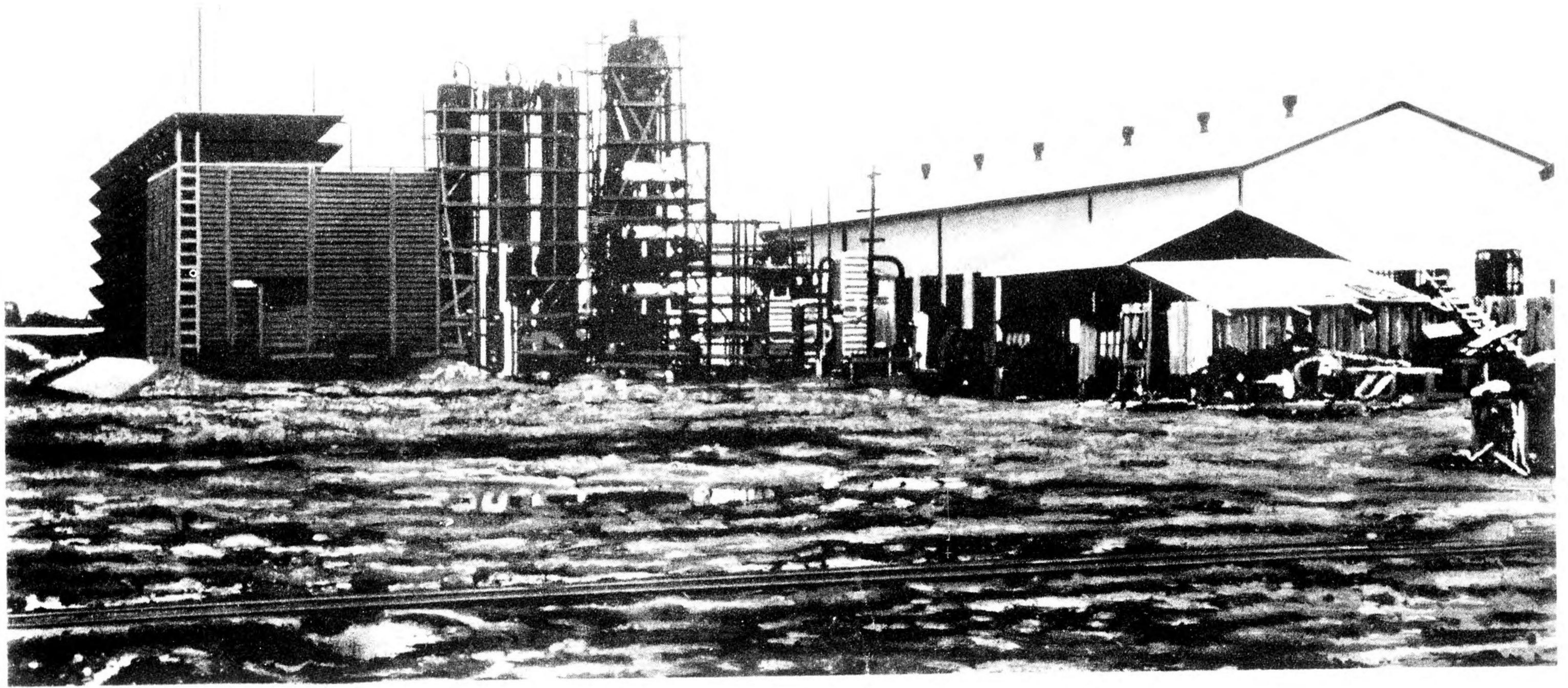
REFINING
Kinsui Gasoline plant



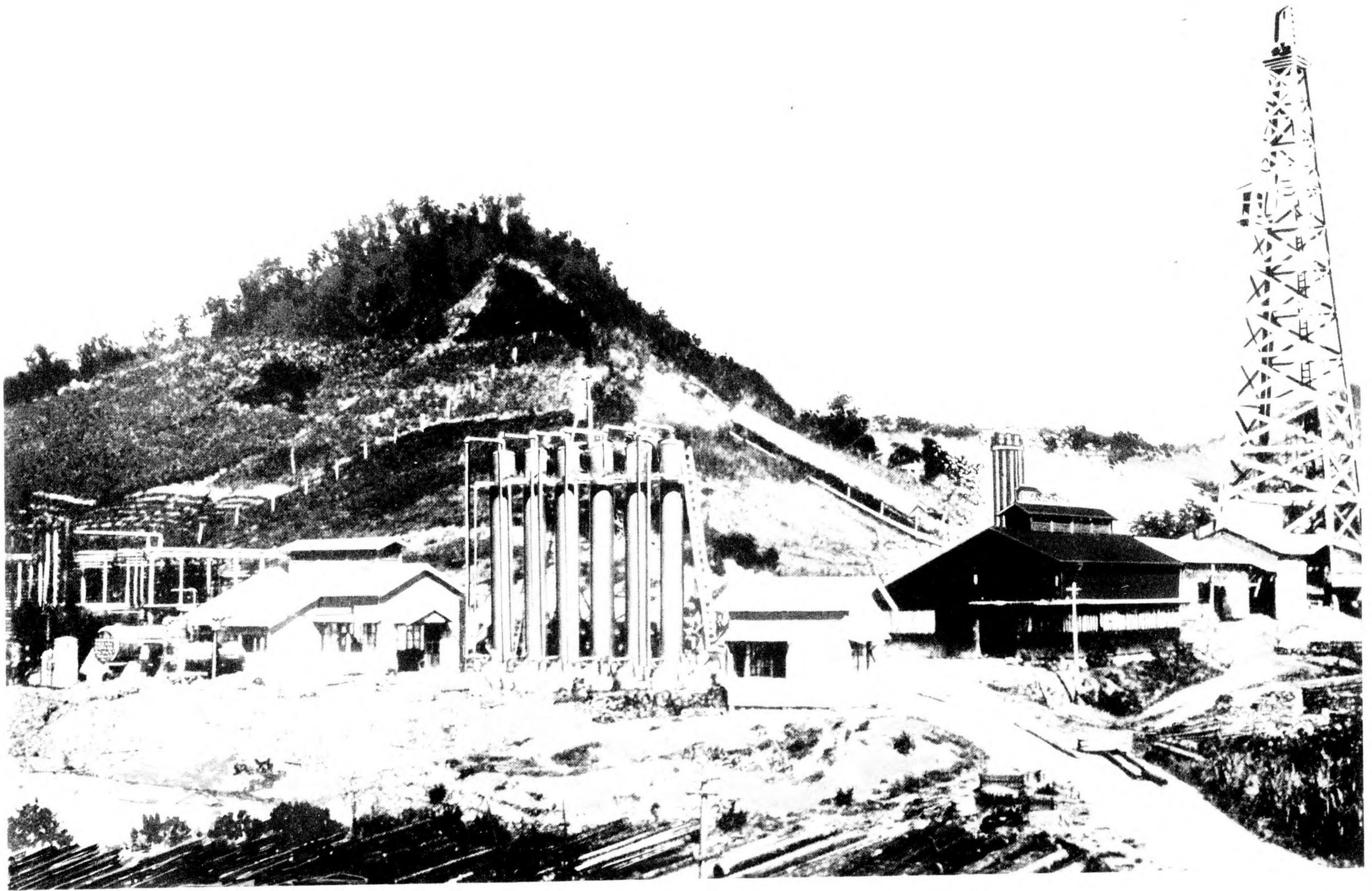
CLOSE UP VIEW OF THE KINSUI GASOLINE PLANT, CONSTRUCTED 1930



DISTANT VIEW OF THE KINSUI GASOLINE PLANT AND OIL FIELD

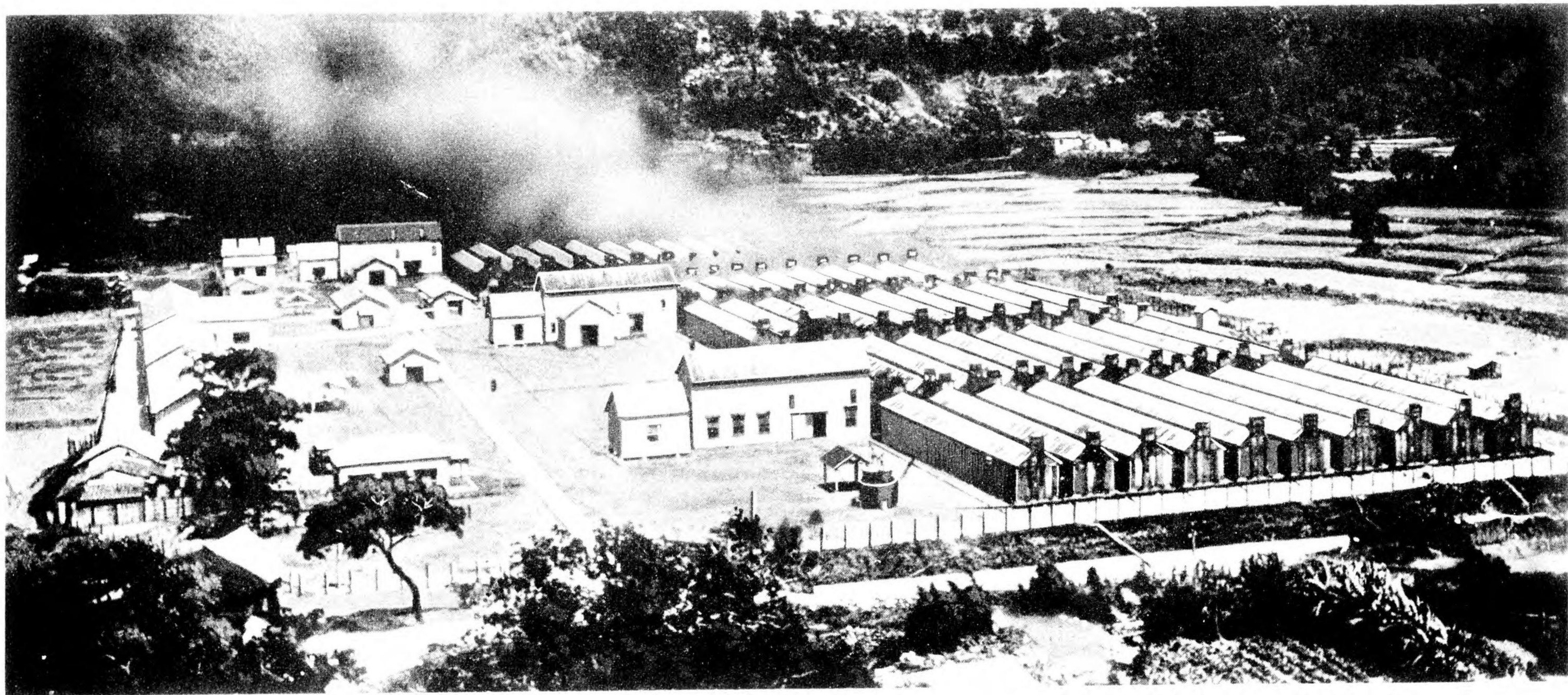


VIEW OF CHIKUTO GASOLINE PLANT IN PROCESS OF CONSTRUCTION

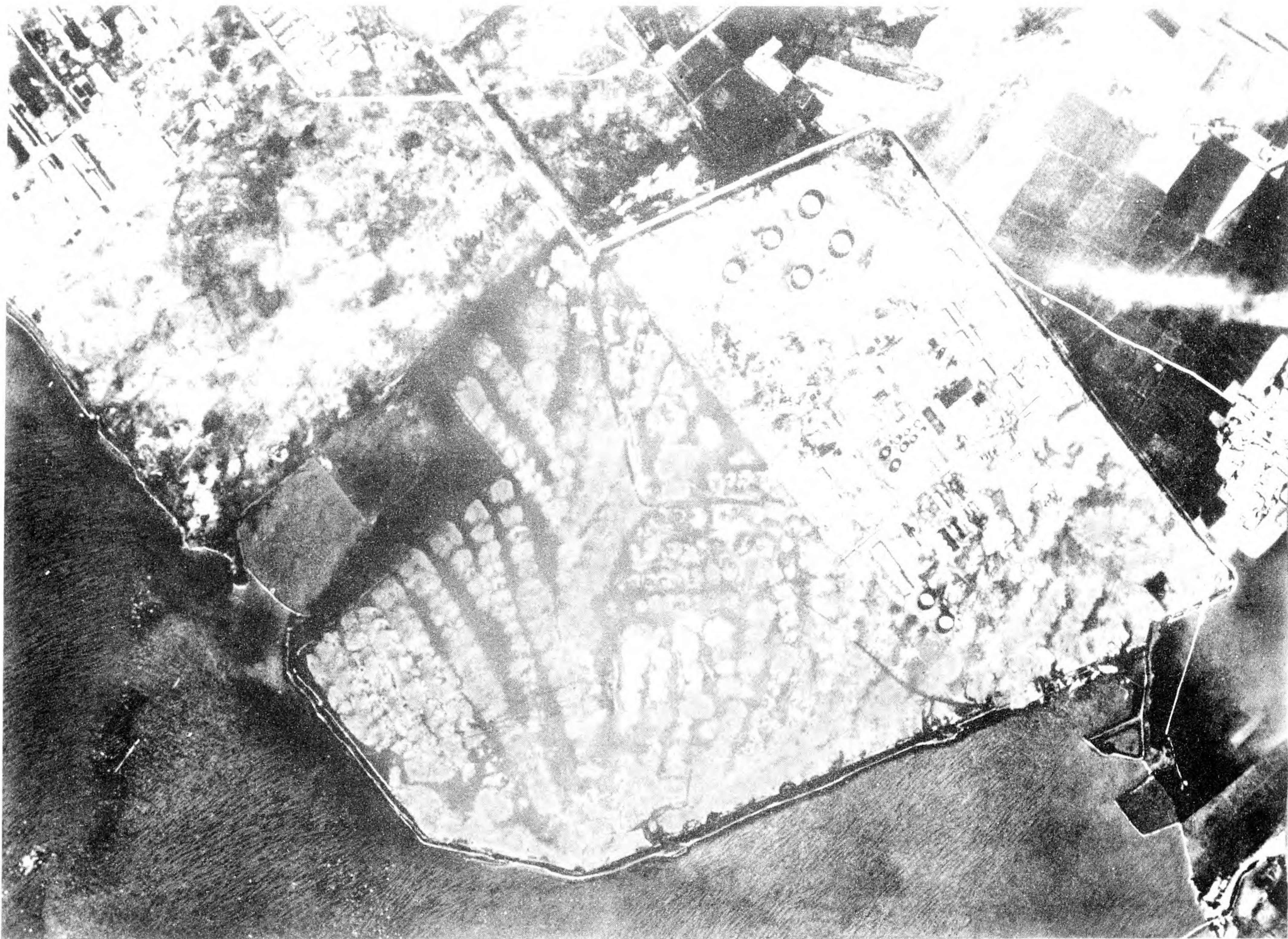


VIEW OF SHUKKOKO GASOLINE PLANT

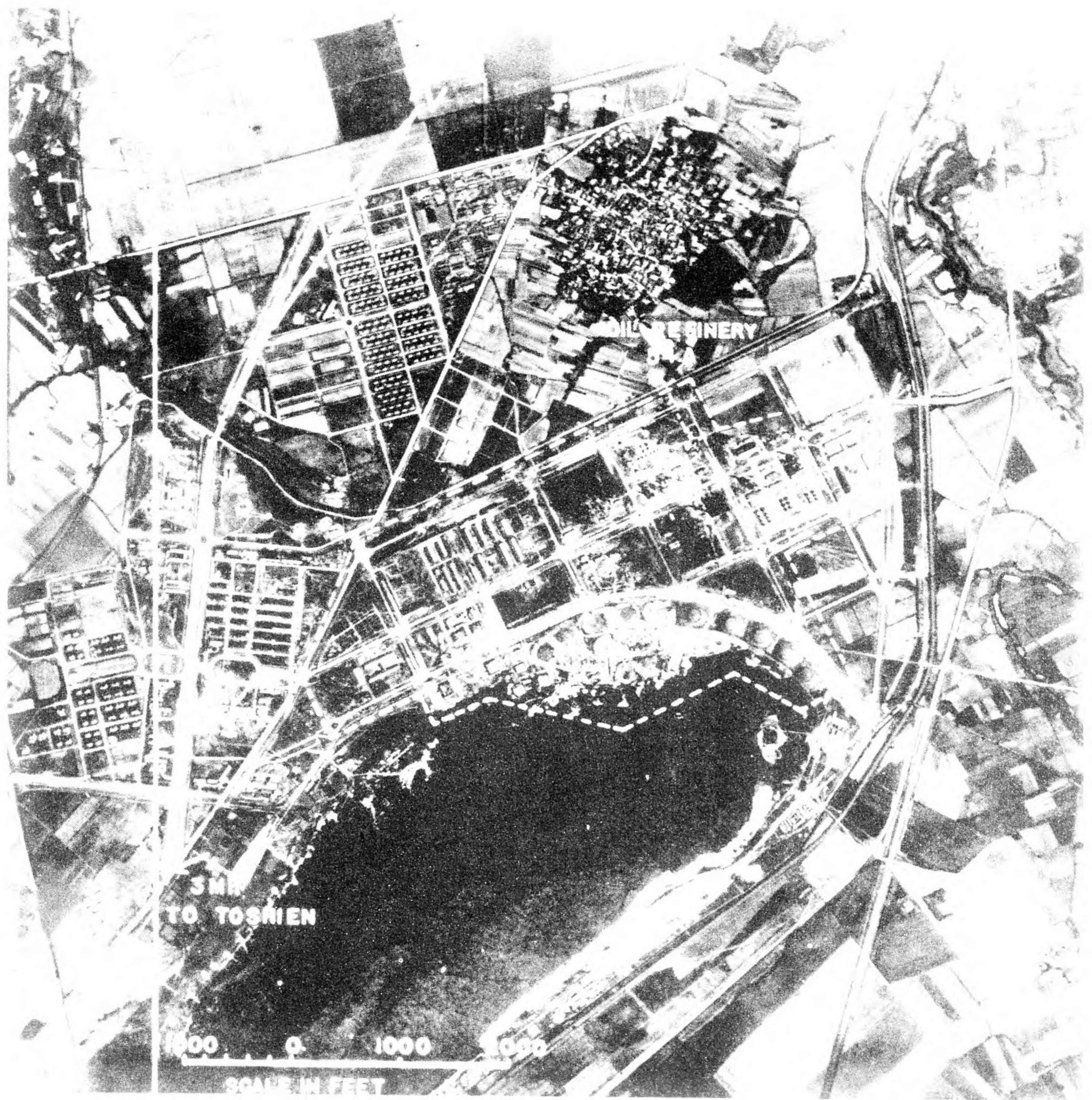
REFINING
Shukoko gasoline plant



VIEW OF KINSUI CARBON BLACK PLANT



AERIAL VIEW OF NEW REFINERY UNDER CONSTRUCTION LATE 1944 AT TAKAO



AERIAL VIEW OF OIL REFINERY UNDER CONSTRUCTION AT TOSHIE

4.0 D I S T R I B U T I N G

4.1 I N T R O D U C T I O N

4.1.1 G e n e r a l

The domestic companies consisting of Nippon, Mitsubishi, Ogura and Hayama had the larger part of the market for petroleum products in Formosa, and of these the Nippon Oil Company did the **biggest** share. The Standard-Vacuum Oil Company and the Rising Sun Petroleum Company were the only other distributors of oil in this area and, with the exception of lubricating oil, the RSP had the major share of the remainder of the business.

Nippon Oil Company had an installation at Keelung, stocks for which came from the oil and gas fields and the refineries in the neighborhood of Byoritsu, and also from Japan; Mitsubishi had fuel oil storage at Takao and transshipped from Tsurumi; the RSP had an installation at Tansui (Tamsui) to which point products were shipped directly from the East Indies by tanker; while Standard normally imported its products in packages either from Hongkong or Japan.

4.1.2 S t r a t e g i c C o n s i d e r a t i o n

With Japan's lack of any substantial indigenous production, either in Japan proper or Formosa, and with no synthetic production in Formosa at all, the matter of storage is particularly important to the military and civil operations of the enemy. Civil consumption in Formosa today is probably extremely small and limited to the lube oil needs of essential industries, and perhaps to agricultural or fishing purposes, assuming there is some leeway in the availability of locally produced stocks not required by the military.

Any damage to stocks in storage or to storage facilities, because of the growing difficulties of replenishment and distances from source, can have a serious effect on the enemy's operations. The priority of oil storage in Formosa to bombing, therefore, is exceptionally high.

Some attempt has been made to conceal new storage being erected at Toshien, either underground or above ground, but the effort at camouflaging surface tanks at relatively small and easily detected places like Keelung, Takao and Tansui should not make them difficult targets.

4.1.3 C o n s u m p t i o n

Consumption of petroleum products in Formosa, never very high, commenced to decline under quotas and a rationing system starting soon after the outbreak of war with China in 1937. Restrictions became progressively greater as time passed. Gasoline was largely used for taxis, buses and trucks; kerosene for illuminating and small engines needed in agriculture; heavy oil or fuel and diesel, and also light oil, by fishing boats; while lube oils were required for automotive purposes, the powered boats, sugar centrals, railways, and the few industries of which Formosa boasted. Sales figures are not available for all the companies but sales quotas granted by the Taiwan Government General to the oil companies are representative of consumption and are shown in the following table for the years 1937, 1938 and 1939. Quotas which were cut too sharply in 1938 were increased in 1939 in line with government policy to try to develop Formosa industrially.

Petroleum Products Sales Quotas - Formosa (a)

	<u>1 9 3 7</u>			<u>1 9 3 8</u>			<u>1 9 3 9</u>		
	<u>G a s o l i n e</u>								
	<u>Kilo-</u> <u>liters</u>	<u>Barrels</u>	<u>Percent</u>	<u>Kilo-</u> <u>liters</u>	<u>Barrels</u>	<u>Percent</u>	<u>Kilo-</u> <u>liters</u>	<u>Barrels</u>	<u>Percent</u>
SVOC	5,056		12.89	4,130		12.90	4,506		11.98
RSP	8,302		21.18	6,788		21.20	7,384		19.63
Nippon	25,855		65.93	21,102		65.90	25,730		68.39
	<u>39,213</u>	247,042		<u>32,020</u>	201,726		<u>37,620</u>	237,006	
	<u>K e r o s e n e</u>								
SVOC	2,985		15.08	1,981		13.92	2,604		13.02
RSP	3,909		19.75	2,558		17.98	3,364		16.82
Domestic Cos.	<u>12,898</u>		<u>65.17</u>	<u>9,691</u>		<u>68.10</u>	<u>14,032</u>		<u>70.16</u>
	<u>19,792</u>	124,690		<u>14,230</u>	89,649		<u>20,000</u>	126,000	
	<u>F u e l o r D i e s e l O i l</u>								
RSP	11,264		25.14	9,601		26.90	9,016		23.40
Domestic Cos.	<u>33,549</u>		<u>74.86</u>	<u>26,093</u>		<u>73.10</u>	<u>29,518</u>		<u>76.60</u>
	<u>44,813</u>	282,322		<u>35,694</u>	224,872		<u>38,534</u>	242,764	
	<u>L u b e O i l</u>								
SVOC	768		7.22	652		6.92	700		6.21
RSP	346		3.25	310		3.29	336		2.98
Domestic Cos.	<u>9,528</u>		<u>89.53</u>	<u>8,468</u>		<u>89.79</u>	<u>10,232</u>		<u>90.81</u>
	<u>10,642</u>	67,045		<u>9,430</u>	59,409		<u>11,268</u>	70,988	
	<u>L i g h t O i l s (b)</u>								
Domestic Cos.	5,400	34,020	100	4,860	30,618	100	5,000	31,500	100
TOTAL	1937:	755,119	barrels	1938:	606,274	barrels	1939:	708,258	barrels

4.2 OCEAN TERMINALS

The seaboard petroleum facilities of Formosa, located at Keelung, Takao and Tansui, are of limited size and importance. Nothing of a definite and specific nature is known regarding the Nippon's installation at Keelung. Mitsubishi's plant at Takao, originally constructed in 1927, is shown by air coverage photographs to have been enlarged, or more likely there has been new construction by other oil companies.

(a) Kilolitres converted to barrels of 42 U.S. gallons on basis of conversion factor of 6.3 barrels.

(b) For definition of "light oil" see page 70, section 4.4.5.

4.2.1 Keelung

General.- This is an important port and likewise a Naval base on the northern end of Formosa, latitude 25° 9' N., longitude 121° 44' E. See map on page 56, and aerial photograph on page 57. The inner harbor is narrow but has been well developed and the docks near the railway yards on the side opposite the town proper will accommodate at least six 10,000 ton vessels. There are large, well constructed warehouses or custom sheds erected on these particular concrete docks. There are also docks on the opposite side of this arm of the harbor and adjacent to the town itself which are not so well developed, but probably are used by naval vessels for loading supplies. A "dangerous-goods" storage warehouse area for package goods was located on the western side of Gyucho, adjoining a dock and coal yard area.

Nippon.- The Nippon Oil Company's plant (map page 56) is located halfway up the south slope of Kyushi-Zan hill overlooking the railway yards alongside Gyucho-Ko basin or arm in the Inner Harbor. At the plant north of Gyucho-Ko there are six oil tanks with capacity estimated approximately as follows:

Details of Tankage, Keelung

Number	Capacity Each Metric Tons	Total Capacity	
		Tons	Barrels
1	8,000	8,000	56,000
2	4,000	8,000	56,000
1	3,000	3,000	21,000
2	2,000	4,000	28,000
6		23,000	161,000

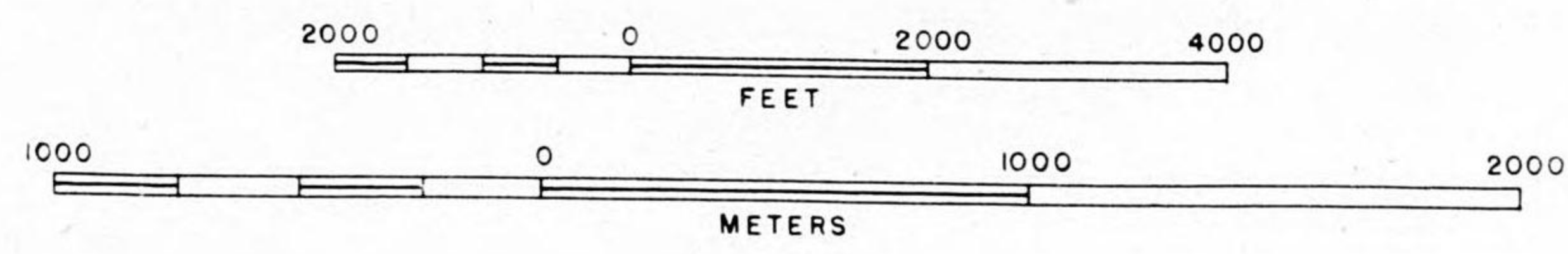
This checks somewhat with the files of one of the foreign oil companies which gives total commercial storage in 1938 of the native companies operating in Formosa, inclusive of Takao and elsewhere, as 38,500 tons or roughly 250,000 barrels.

A 1935 report places four small fuel oil tanks near wharf just south of Gyucho-Ko, and credits underground tanks with having been constructed in the side of the hill south of Nippon's plant mentioned on some maps as Hill No. 246, as well as on Kyushi-Zan to the northeast and far back of Gyucho-Ko. In addition, the report says there may be submarine storage tanks. It has been suspected by one source that there may be 250,000 barrels capacity in such hidden storage in the Keelung area. In support of there being such hidden storage in the neighborhood of Gyucho-Ko it is quoted that Keelung harbor regulations provide that "the firing of salutes must be carried out some place outside Gyucho-Ko". The same source reports storage tanks near the main wharves, as indicated on map on page 56, but another source advises not having seen any tanks in this locality.

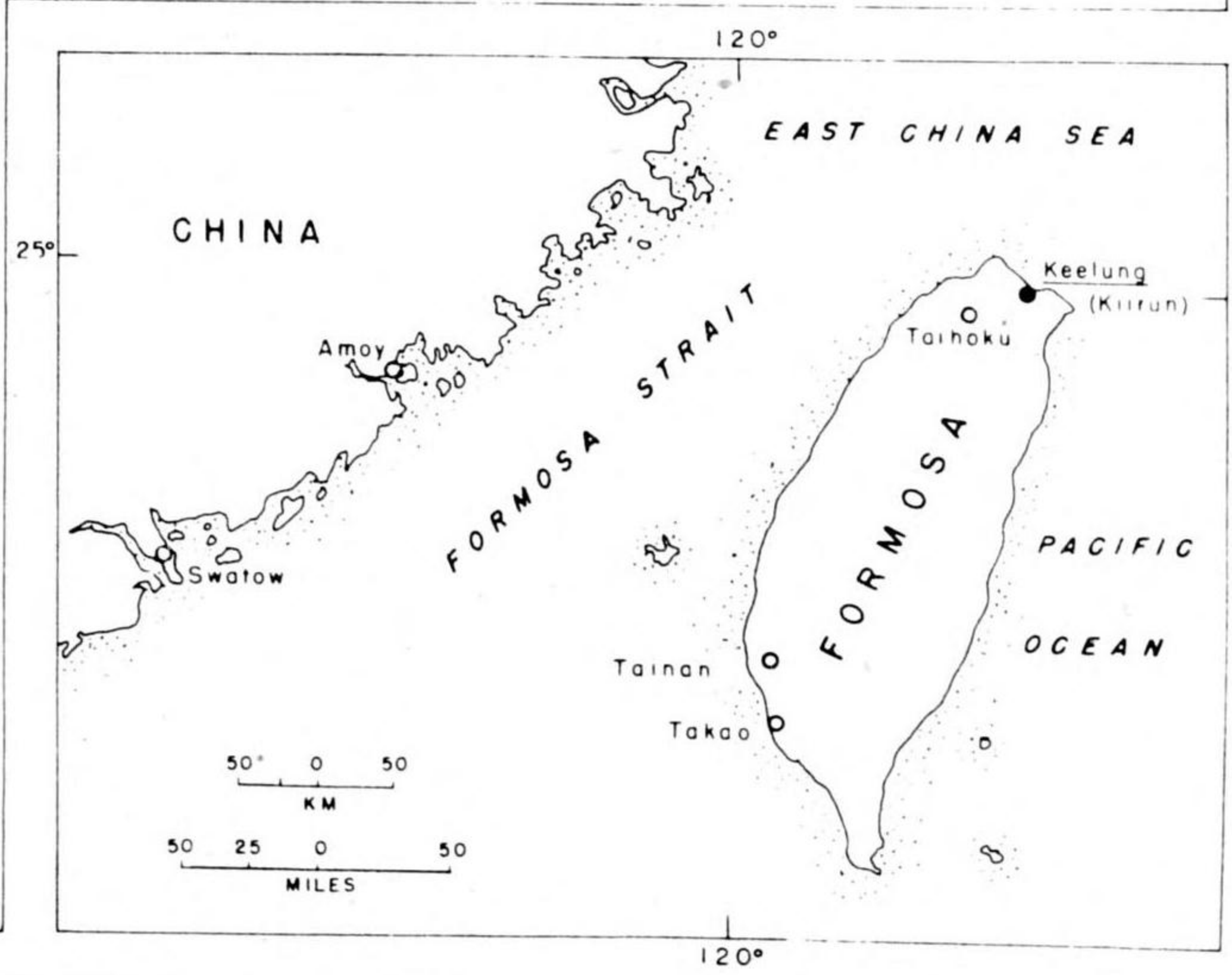
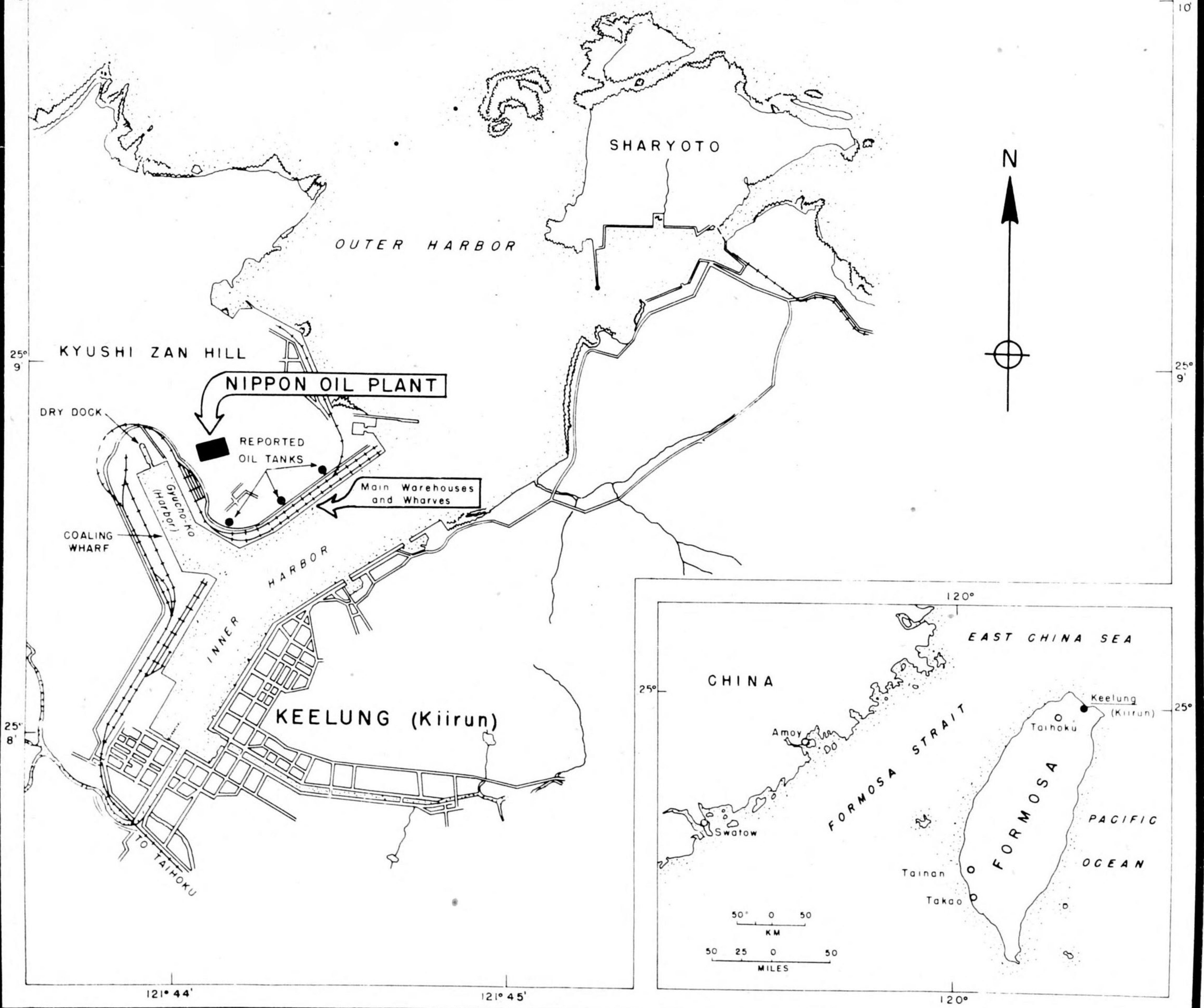
A further report, emanating from a source who visited Formosa in 1930, advises that the Japanese Navy had 12 storage tanks with a total capacity of approximately 20,000 to 25,000 barrels of gasoline at a point situated SSE of the harbor and shielded from sight of town by a low hill though plainly visible from a point four miles south of the city. It is possible that about that time (1930), either Nippon or Mitsui Bussan Kaisha (the latter at one time distributed diesel oil in Formosa as agents for the General Petroleum Company, subsidiary of Socony-Vacuum Oil Company) may have had storage on this side of the harbor and the city of Keelung and that the authorities, for strategic reasons, may have made them evacuate. There has been no late report of storage in this locality;

The above is given as evidence of the conflicting information concerning Nippon's and Naval storage at Keelung and how exceedingly difficult it is to evaluate it properly. Very recent aerial coverage of the Keelung locality shows no visible tankage anywhere except that of Nippon as originally constructed at the hillside plant

JAPANESE EMPIRE
ISLAND OF FORMOSA
PORT OF KEELUNG (KIIRUN)



East China Sea





AERIAL PHOTOGRAPH OF PORT OF KEELUNG

above Gyucho-Ko and possible underground storage at the southwest end of the Inner Harbor. The map of the port of Keelung on page 56 shows the location of three reported oil tanks between the northwest wharves and the hillside, but there is nothing in the picture that in any way indicates presence of oil storage either above or below ground at this point.

There is no clear explanation of how fuel oil or other products were discharged and stored in the tanks in question, particularly on account of the strict harbor regulations the Japanese had for the mooring and discharging of tankers. It seems doubtful if a tanker would have been permitted to go alongside and discharge by pipe line at any point in the inner harbor, and whether a satisfactory shoreside mooring point was available in the outer harbor is unknown. It is, possible, of course, that oil was transferred to barges from a tanker moored at a buoy in the outer harbor but there has never been any indication or report of the use of barges for this purpose.

Railway sidings were available on the level space between the hillside plant of Nippon's and Gyucho-Ko and it seems probable that oil from the oil refinery at Byoritsu and the gasoline plants at Kinsui, Shukkoko and Chikuto would be unloaded from tank cars and stored at the plant. On the other hand, production was not very large and distribution may have been directly to the market or via the bulk plant at Shiodome, halfway between Keelung and Taihoku.

There are no buildings at the hill plant and its lofty position and inaccessibility by road makes it improbable that Nippon had a can factory and filling house for kerosene and gasoline there. It has always been understood that distribution for the local market was almost entirely from the Shiodome bulk plant.

Foreign companies.- Of the foreign companies only the Standard-Vacuum Oil Company had any appreciable leased storage for package goods at Keelung. This storage area had been reduced greatly in recent years.

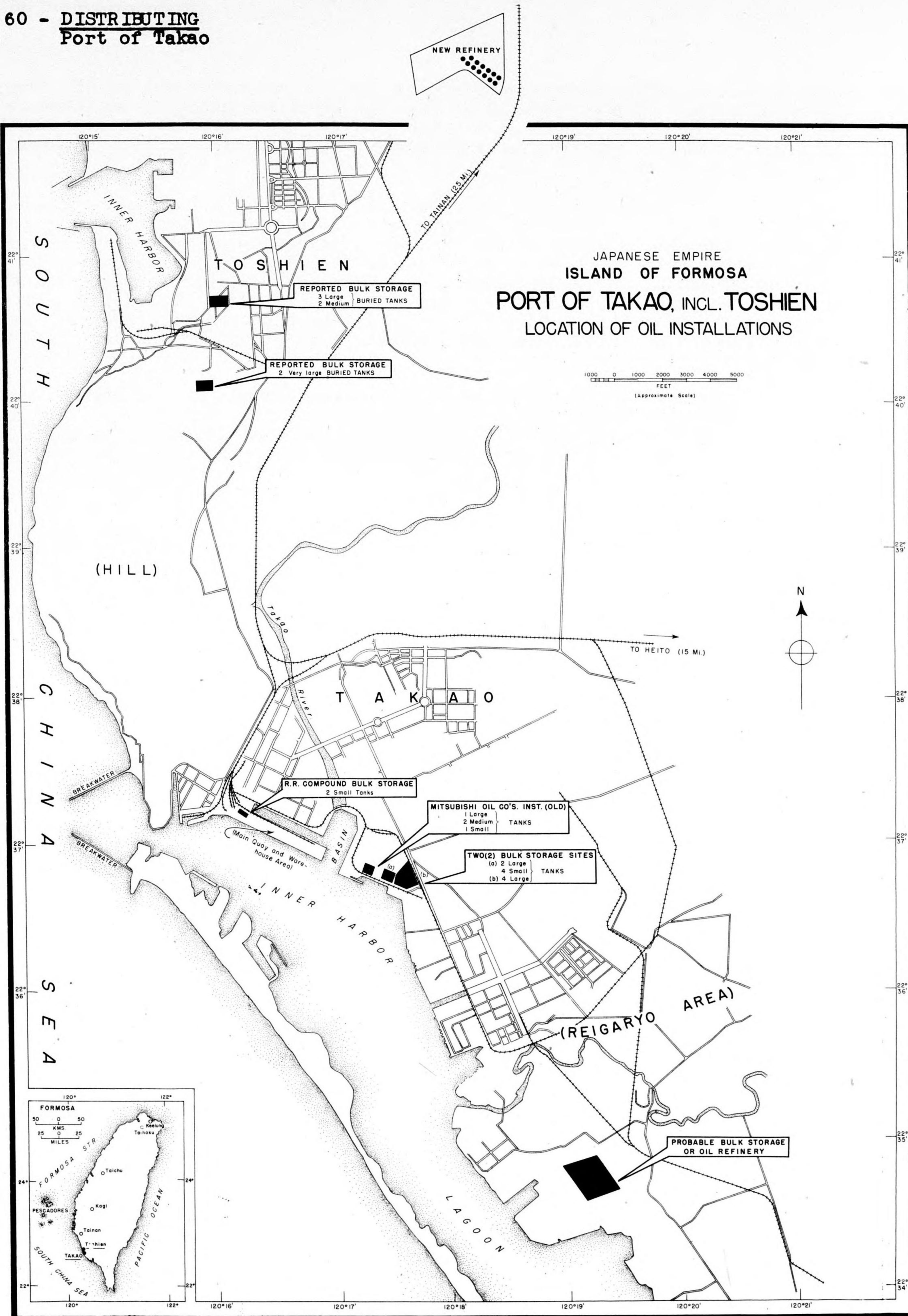
4.2.2 Takao

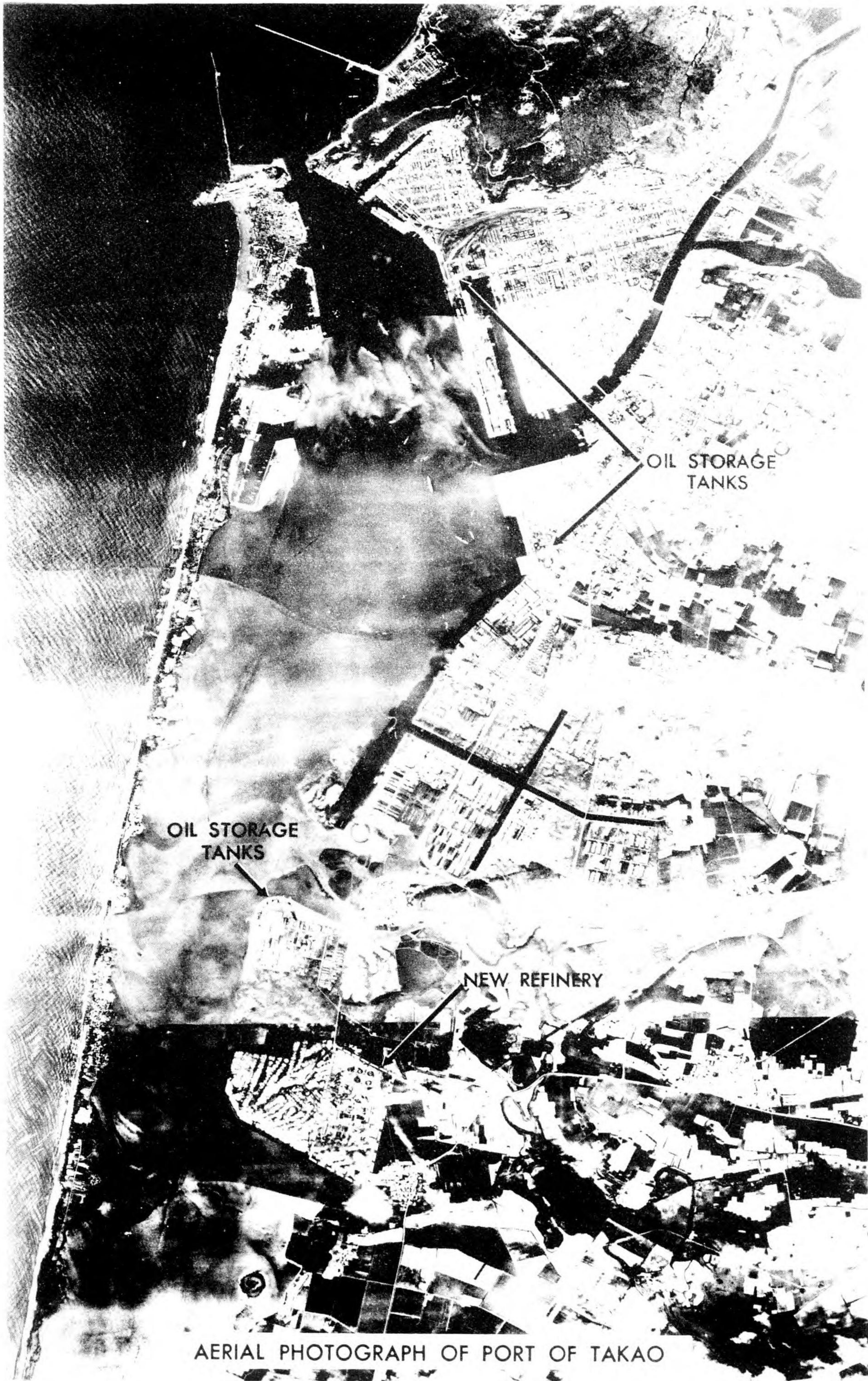
General.- Takao, latitude 22 37' N., longitude 120 16' E., during the past few years has been developed into a major industrial city and military port covering in area half a dozen times again the size of the original city, which at one time was confined mostly to the space between the Takao River and South China Sea. The Naval headquarters for Formosa, formerly at Bako (Mako) in the Pescadores Islands, has been transferred to Takao and a new Naval base with petroleum storage tanks is under construction at Toshien near Takao. Aluminum, cement, brick, chemical plants, sugar refineries and alcohol plants, and many warehouses have been constructed there. Air coverage in December 1943 and later, as shown by the photographs on pages 49 and 61, shows what has been considered to be a small oil refinery, and tank storage of 250,000 barrels capacity, under construction. This plant is further mentioned under storage on page 74.

Nippon.- Nippon did not have large bulk storage at Takao, but it seems quite certain that they would have small tankage near one of the railway stations to which tank cars from the north would be routed and unloaded and products stored for local distribution in this important market; or else they may have constructed one of the plants described under the heading of "Other", page 63. There is reported to have been small bulk storage in the dangerous-goods warehouse area used by the oil companies on the east side of the railway in the northern outskirts of Takao, as indicated later under "Foreign Companies".

Mitsubishi.- In 1927 Mitsubishi Shoji Kaisha constructed four fuel oil tanks at Takao with a total capacity of 9,070 tons (approximately 57,000 barrels) designed to supply both heavy and light oil. See map on page 60, plan on page 64, and prewar photograph on page 65.

Recent aerial photograph shows, through the camouflage, that there now might be one more tank at this site, possibly of 2,000 tons capacity. The fourth tank of 60 ton capacity in the original installation was located on the pier, but evidently has been moved as it can no longer be found on the recent aerial photograph. There





AERIAL PHOTOGRAPH OF PORT OF TAKAO

are, however, two tanks at the yards much farther West and somewhat East of the customs compound; their size is perhaps 100 tons each (630 barrels).

An eight-inch pipe line, submerged at the Takao River basin crossing, carried oil from the tanks to railway loading stand and originally, at least, appears to have served as means of unloading tankers from piers by means of a floating pipe line. Later, certain berths along the east side of the basin are understood to have been especially equipped for tankers while fueling facilities were also available on the main wharf. The Takao River basin, formerly much shallower, now appears to be capable of handling vessels of most sizes. The pipe line was four inches in diameter beyond the pier to the 60 ton tank at the railway yards.

Other.- Near Mitsubishi's plant to the East there are now two separate storage sites, shown as (a) and (b) on map on page 60, which may or may not belong to Mitsubishi but probably are plants which were constructed by other oil companies some time about or after 1939. There is no information concerning this storage other than aerial coverage and interpretation. This credits Mitsubishi with now having 14 storage tanks at Takao in an area the size of 2,300 x 1,200 feet. The tanks have diameters ranging from ten to 120 feet, mostly well camouflaged. There are also 14 buildings ranging in size from 50 x 20 feet to 200 x 60 feet, as well as certain miscellaneous buildings.

The plant marked (a) is separated from Mitsubishi's by an industrial plant which is reported as a carbonic acid plant. There are at least two large tanks of the size (in appearance) of the 7,000 ton tank at plant (a), and four smaller tanks which might be placed at approximately 1,000 and 500 barrel capacity, two of each, respectively. It is not certain that these tanks are used for oil storage. See remarks on page 74. There are, likewise, a number of buildings varying in size as indicated above.

Adjacent to this plant and on an area marked (b), which appears to have much vacant space, are four large tanks with considerable space in between, as well as a number of miscellaneous buildings. These have been described in the aerial photograph interpretation report as "holders for natural gas piped from gas fields to North located just East of oil tanks," but they have more the appearance of two very large, say 120 feet diameter or 12,000 tons (80,000 barrels), oil tanks and two 7,000 ton (45,000 barrel) oil tanks.

There is no satisfactory information by which storage at Takao may be accurately calculated, but roughly estimated, storage as described above, including the two tanks at the railway yards, total 415,000 barrels as itemized below:

Estimated Tankage, Takao

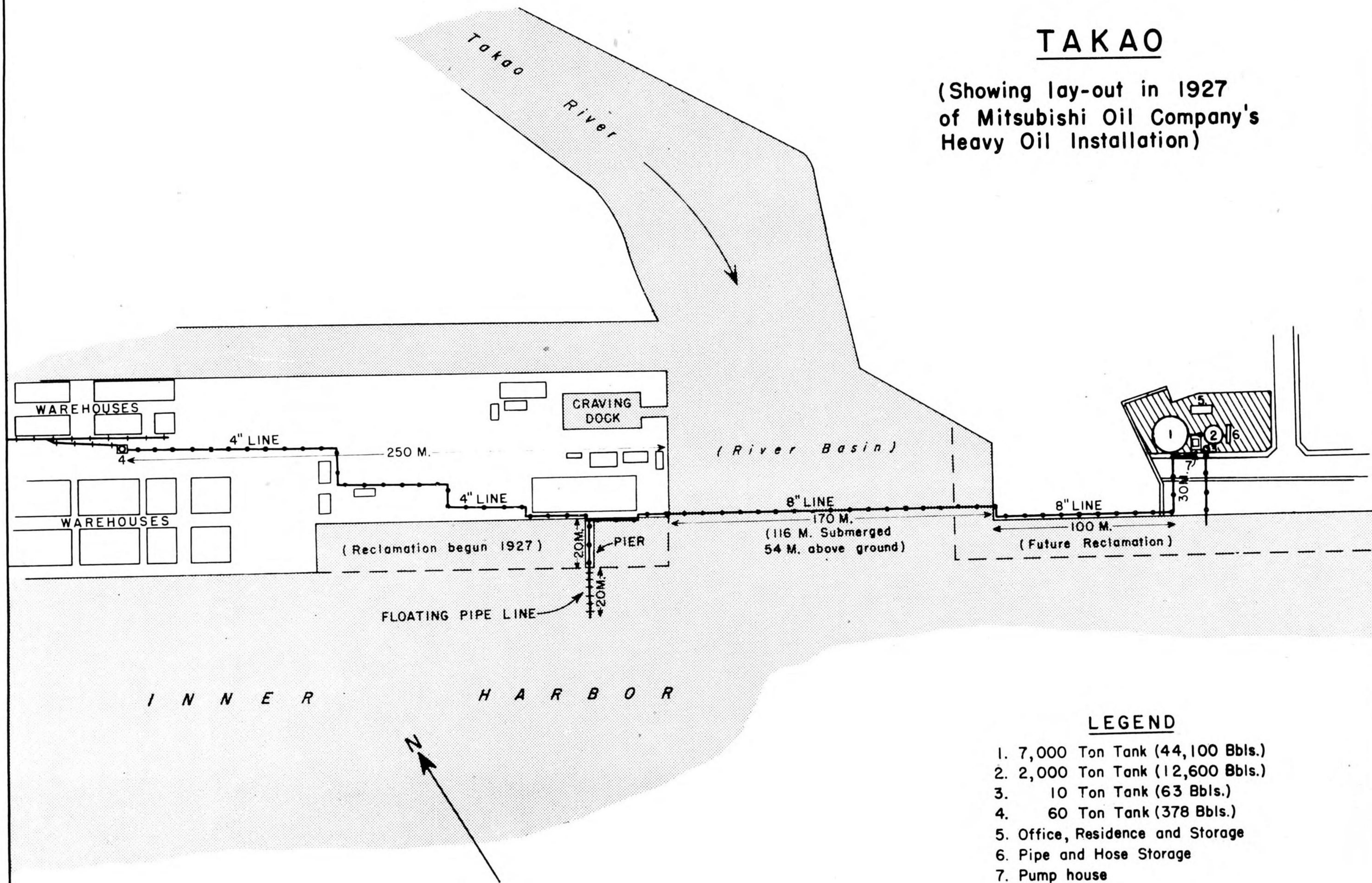
Number of tanks	Total (Barrels)
2 - 80,000 barrels	160,000
5 - 45,000 "	225,000
2 - 12,600 "	25,200
2 - 1,000 "	2,000
2 - 630 "	1,260
2 - 500 "	1,000
1 - 63 "	63
16 - Total	414,523

See map on page 60 which was drawn on the basis of this data and such deductions as it has been possible to make from air-coverage photographs.

Foreign companies.- Neither the SVOC nor RSP had bulk storage at Takao, but rented warehouse space in a large and new warehouse project, accessible to the railway and bordering on the Takao River, some two miles or more north of the harbor.

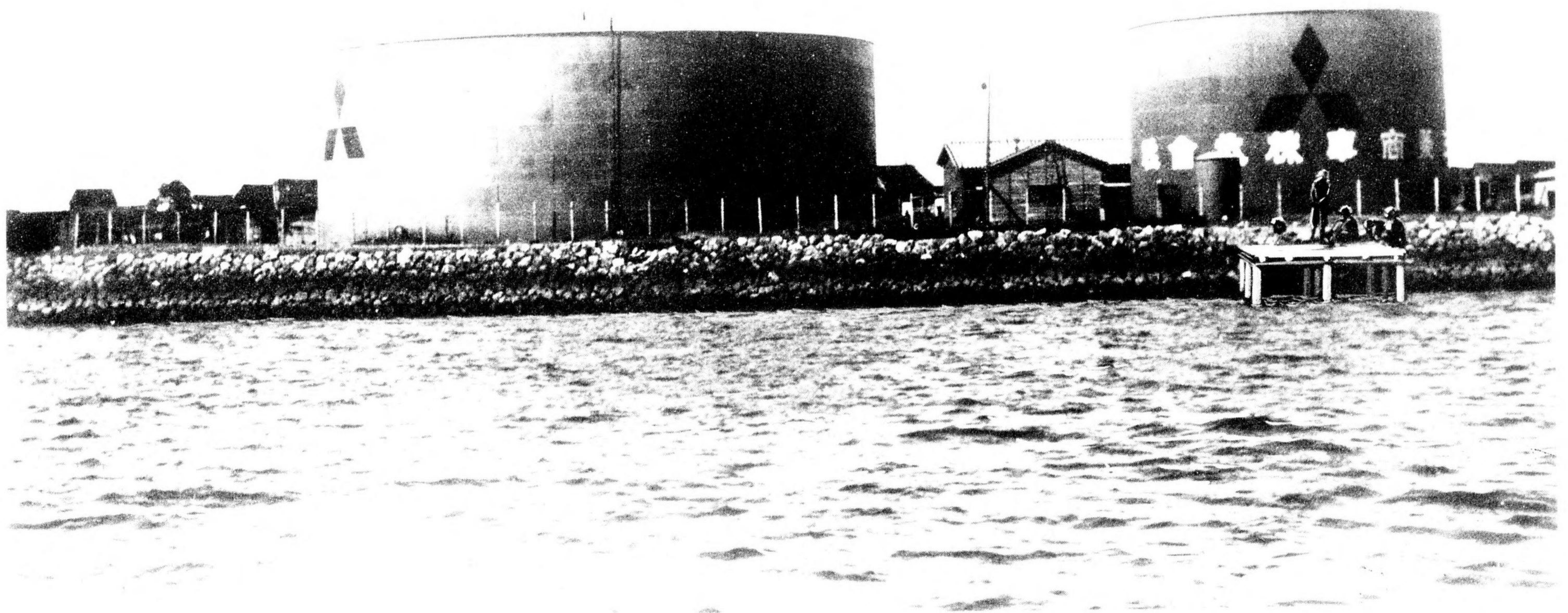
TAKAO

(Showing lay-out in 1927
of Mitsubishi Oil Company's
Heavy Oil Installation)



LEGEND

- 1. 7,000 Ton Tank (44,100 Bbls.)
- 2. 2,000 Ton Tank (12,600 Bbls.)
- 3. 10 Ton Tank (63 Bbls.)
- 4. 60 Ton Tank (378 Bbls.)
- 5. Office, Residence and Storage
- 6. Pipe and Hose Storage
- 7. Pump house



VIEW OF MITSUBISHI PLANT AT TAKAO AS CONSTRUCTED 1927

4.2.3 Tansui Installation

Location.- Tansui (Tamsui) the only bulk terminal or coastal installation in Formosa owned by the RSP was located at the mouth of the shallow Tansui River, latitude 25° 10' N., longitude 121° 25' E. See map on page 68.

General.- Tansui was, at one time, an important port in trade with China, but the bar at the mouth of the harbor prevented vessels over two or three thousand tons from using it, and the increasingly shallow depth of the river up to Taihoku, the capital, aided in reducing it to a point of little importance. It is at the end of a railroad branch running from Taihoku which is ten miles NNW. The only industry of any note was the installation maintained by the RSP.

Port facilities.- Tankers or vessels of over 11 feet draft had to partially unload into lighters outside of the bar. Maximum draft at L.W.S. 11 feet 0 inches; L.W.N. 12 feet 0 inches; minimum depth L.W.S. 11 feet 6 inches; L.W.N. 11 feet 6 inches. There was a berth alongside the installation at which vessels of maximum length of 316 feet could tie up. No tank lighters were available but about fifteen privately owned lighters of approximately 15 tons each were available for packaged oils. Case oil (which just prewar was a rarity) could be discharged on to the jetty at about 500 cases per hatch per hour. Bulk kerosene was discharged at the rate of 100 tons per hour through an eight-inch line into a tank of 21,250 barrel capacity while diesel oil was unloaded through a 6-inch pipe line at the rate of 120 tons per hour and stored in a tank of 8,640 barrel capacity. There was also a 60 ton (430 barrel) filling tank for diesel oil. Gasoline was imported in 65 Imperial gallon drums brought in as deck cargo. With changing conditions, the tank formerly used for storing kerosene was converted to the storage of bulk gasoline and kerosene was imported in tins and drums. There were no bunkering facilities. A tin factory capable of manufacturing 45,000 5-gallon tins per month (based on a 40-hour week) did not operate for several years prewar because of lack of tin plate. Large quantities of drums (5000/6000) used for importing either kerosene or gasoline and also local distribution were stored in the compound. Warehouses covered an area of 14,200 square feet, and had a capacity of 198,800 cubic feet. See layout plan and map on page 68.

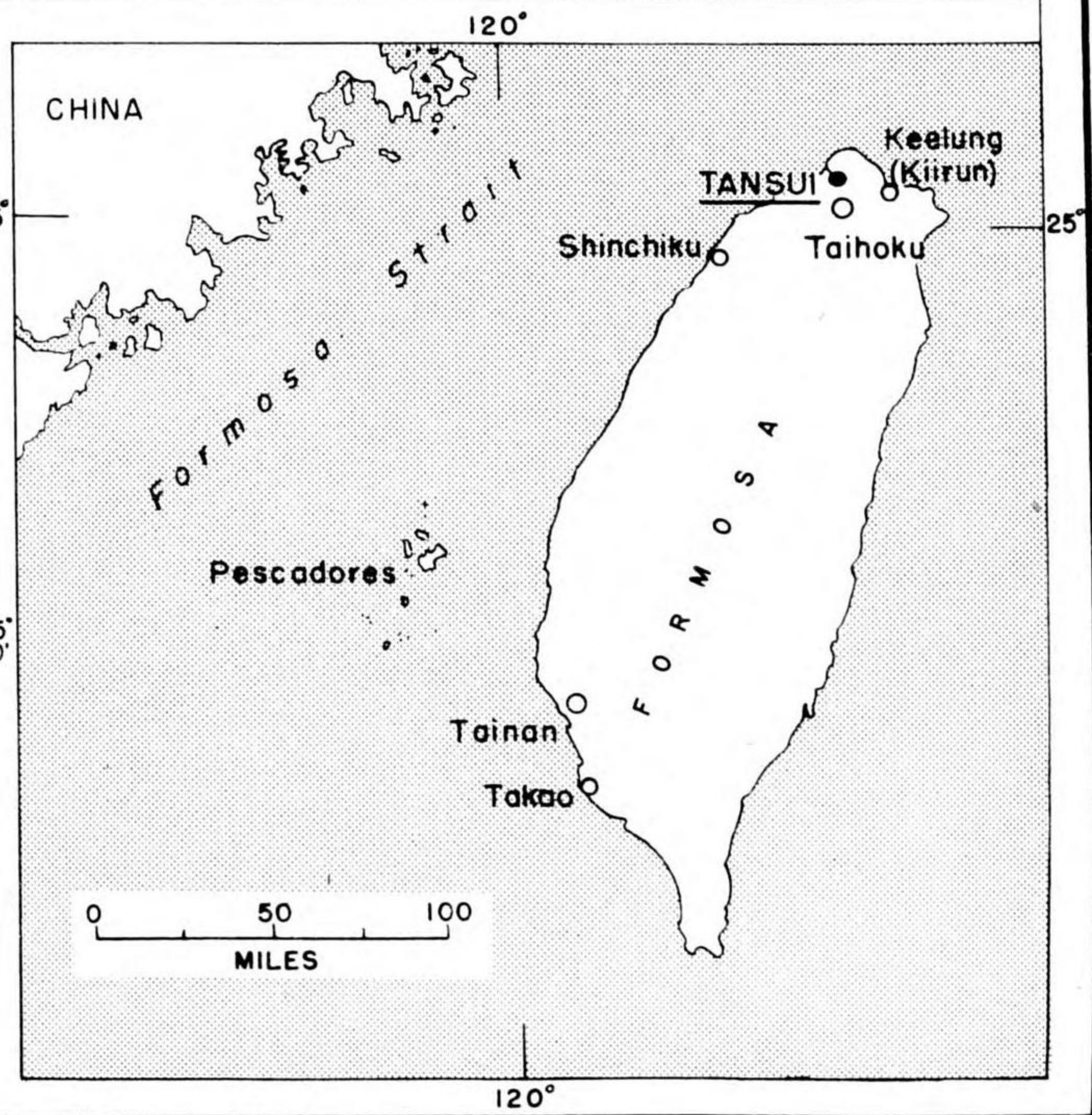
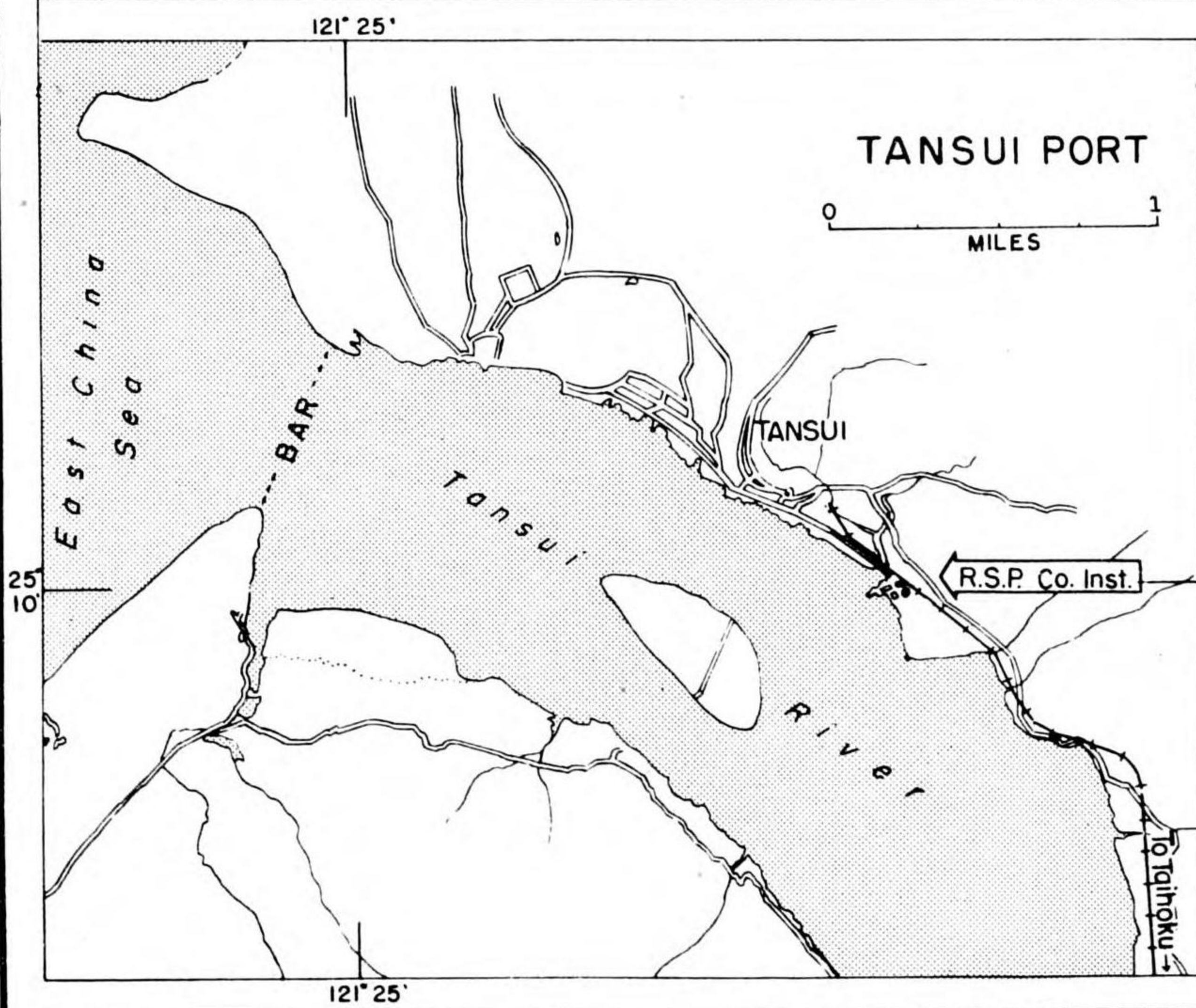
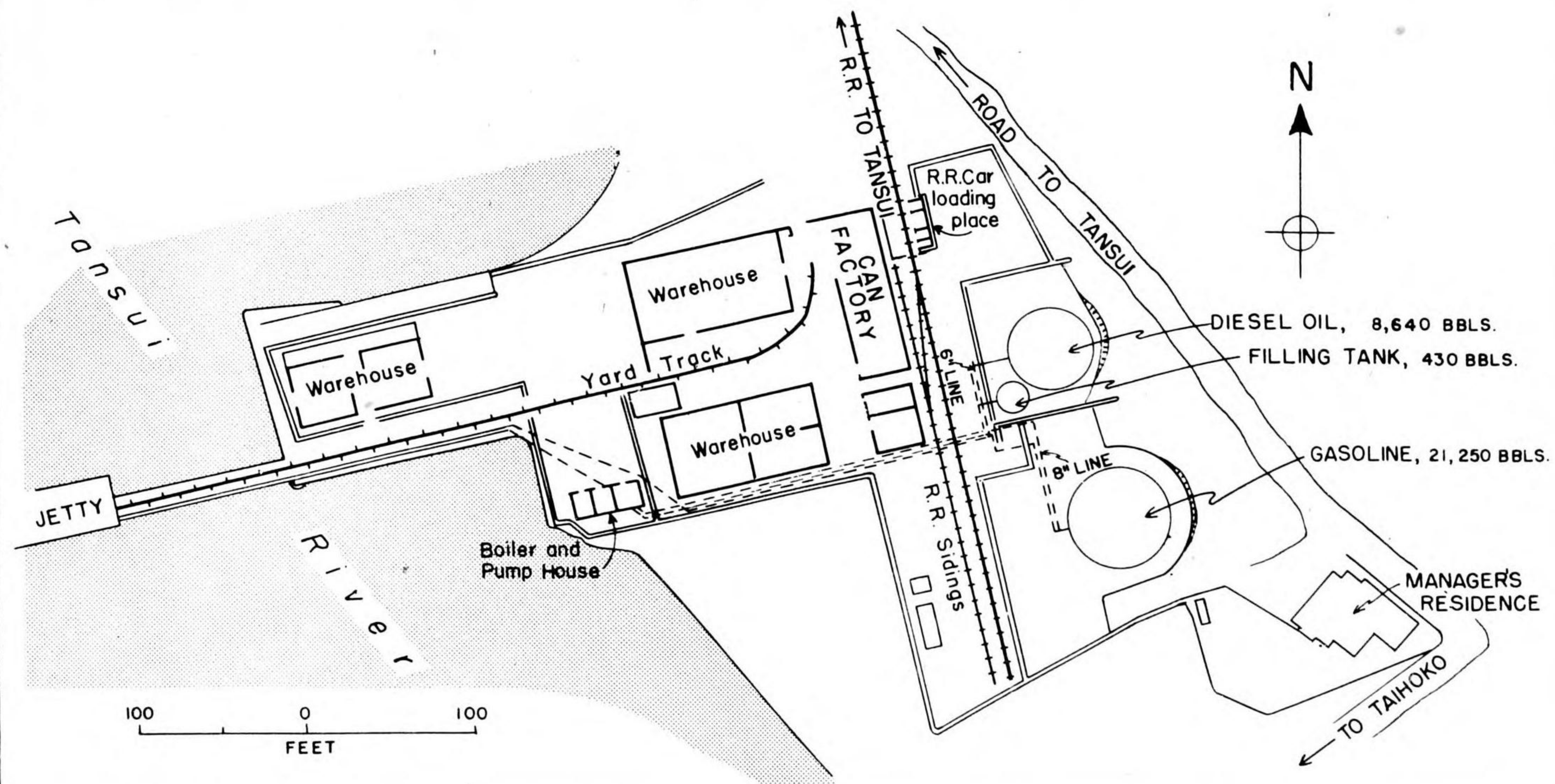
4.3 INLAND STORAGE FACILITIES

Nippon.- Specific information on inland storage facilities of the Nippon Oil Company is not available. This company is known to have had an inland terminal, bulk shipping point and tank truck loading rack for gasoline at Shiodome, a town on the railway and main highway about half way between Taihoku and Keelung. From here gasoline (and perhaps kerosene), transshipped from Japan and primarily stored at Keelung, was distributed to inland points or to the large consuming area around Taihoku. Drums, with which a considerable portion of the trade was latterly supplied, were filled there and there was a small mixing plant for adding the necessary alcohol admixture to the gasoline as required by law.

Nippon also had other inland storage tanks, owned either by themselves or their agents, to which supplies were shipped from Keelung, Shiodome or the refinery at Byoritsu. There are no data but it seems probable that this company might have had bulk storage at such important points as Maruyama between Taihoku and Hokuto; Schinchiku, military center and airport; Taichu; Kagi, a main distributing center; Tainan, large military base and second largest city of Formosa; and Takao. Fifty cylindrical tanks at Schinchiku reported in October 1944 as being buried are believed to be alcohol tanks and not oil tanks. Two small fuel oil tanks are known to be located at Suo, a fishing center with a basin for fishing boats and the only port in northeast Formosa. It is doubtful if there would be storage for bulk elsewhere on the east coast, such as at Karenko or Taito, in view of the roughness of the ocean, lack of good harbors except the small artificial one at Karenko, and general inaccessibility except by sea. Distribution in this area is believed to have been either by drums or tins. Storage is reported at most of the airfields but it is believed that this consists of dumps of drums.

Foreign companies.- At Kagi the Rising Sun Petroleum Company had bulk storage consisting of one 25-ton gasoline and one 28-ton kerosene tank. It is possible

JAPANESE EMPIRE
ISLAND OF FORMOSA
TANSUI INSTALLATION
RISING SUN PETROLEUM CO, LTD.
(ROYAL DUTCH SHELL)



their agents may have owned bulk tankage for either kerosene or diesel oil elsewhere but this is uncertain. Package storage warehouses owned or leased by RSP agents existed, prewar, at important points such as Taihoku, Keelung, Giran, Karenko, Taito, Koshun, Toko, Heito, Takao, Tainan, Kagi, Toroku, Shoka, and Shinchiku. The agents of the SVOC had storage warehouses at most of these same points for distribution of gasoline, kerosene, and lubricating oil in packages to retailers and consumers.

4.4 RETAIL MARKETING

4.4.1 Gasoline

Outside of Taihoku and Takao there were no modern gasoline service stations with gasoline filling and lubrication service. Small drive-in filling stations were, also, not numerous in Formosa and the needs of taxis and trucks were served by sidewalk or curb pumps having approximately 500 or 1,000 gallon underground tanks, or by portable pumps (sometimes called bruettes) with a tank of capacity ranging between 80 and 150 gallons. Nippon had a tank truck or two on the island, but generally pumps were filled from the usual 55 U. S. gallon galvanized iron so-called investment drum, the black one-way drum of the same size or the RSP's large 78 U.S. gallon (65 Imperial gallons) drums used for both importing the product and inland distribution.

Brands.- The quality of products was once important to the buyers but as restrictions became more rigid the consumer was glad to get anything. Nippon sold Bat Brand; the RSP sold Black Shell; while SVOC marketed Pegasus or the Flying Red Horse, as it is perhaps better known abroad. Premium grades of Red Shell and Socony Motor Gasoline, formerly distributed by the foreign companies, were largely off the market by 1940. From 1938, all the domestic companies used the same brands which, in Taiwan, were Aka Komori and Kuro Komori, meaning Red and Black Bat respectively.

Rationing.- On January 1, 1938, after which, under military commandeering and rationing, a decrease would be registered, there were in all Formosa, as per table on page 9, a total of 4,950 motor vehicles.

The ticket rationing system put into force July 1, 1938, was calculated on allotting to consumers, on the average, about four-fifths of normal requirements. Private cars were required to get along on 1.75 gallons per day, taxis on 3.6 gallons, buses on 4.2 gallons, and trucks on 5.6 gallons. This, however, was only the commencement of the rationing system and by September 1, 1941, when it was decreed that no more gasoline could be used in motor cars, only official cars continued to operate on gasoline.

4.4.2 Kerosene

Kerosene was distributed in 5-gallon tins, but, at a later date, with the scarcity of tin plate, was likewise sold as bulk in drums. The retail shops operated by natives sold the oil to customers who brought bottles, tins or whatever containers were available for their requirements.

Brands.- Brands for kerosene which originally, when sold in tins, were important as registering quality, especially to the native (largely of Chinese extraction) became unimportant when sold in bulk. Under normal conditions Blue and White Bat were the premium and second grade kerosenes, respectively, of the native companies; Shell, and Anchor or Tank those of the RSP, and Comet and Cock, those of the SVOC. Taipo, a kerosene of 35.1 Beume gravity, was specially sold in Formosa by Nippon for the cheaper native demand. Brands common to all domestic companies became Ao Fujisakura, Shiro Fujisakura and Cha Fujisakura from about 1938. These may be translated, Blue, White and Tea color Fuji Cherry.

4.4.3 Heavy Oil

Fuel or diesel oil was distributed in second-hand tins or in old one-way drums and was consumed almost entirely by fishing boats. A coupon rationing system was instituted for this product, as for gasoline, and there was a progressive decrease in sales due to the increased commandeering of fishing boats for special military service--especially during the southern drive in the war with China that ended in 1939 with the taking of Canton. Nippon, Mitsubishi (with storage at Takao) and RSP supplied the heavy oil; RSP imported diesel quality only.

Brands.- Brands were largely unimportant and not in common usage although the RSP sold diesel oil in tins under the brand of Black Anchor.

4.4.4 Lubricating Oil

Lubricating oils, particularly the oils of the foreign companies, were sold in small retail packages or 5-gallon tins to the small consumers or motor car operators and in 50-gallon drums to large consumers such as sugar centrals. The known quality of the foreign company brands made these products always in demand whereas the cheapness of the domestic so-called machine oils gave these latter oils the major share of the market. There were no sales restrictions other than sales quotas given distributing companies.

Brands.- Native brands were numerous while SVOC and RSP largely sold Mobile and Shell respectively.

4.4.5 Light Oil

A so-called neutral oil under 28° Beaume gravity produced by the Japanese refiners in considerable quantity rightfully belongs under this category. This oil was in demand by the smaller fishing boats with diesel or semi-diesel (hot bulb) engines of low horsepower.

A low-grade kerosene or power oil, classified statistically as light oil, was supplied by both the domestic and the foreign companies to farmers operating small engines used for agricultural purposes, such as pumping water, as an insecticide and for harvesting.

Brands.- Brands commonly marketed in Formosa were:

SVOC	Socony Engine Fuel oil latterly called Cock.
RSP	Shell Power Oil.
Nippon	No Hatsu, Ao Zensho
Ogura	Kisha

4.5 SUBSTITUTES FOR GASOLINE

4.5.1 Alcohol

General.- Formosa has been Japan's most important source of ethyl alcohol for industrial purposes and remained so until the construction, in 1937, of numerous anhydrous ethyl alcohol plants in Japan proper, and the capture, in 1942, of the Philippines and the East Indies, both large potential sources of ethyl alcohol made from sugar cane and molasses.

The plants constructed in Japan were designed to operate, and did operate pre-war, on potatoes, sweet potatoes and waste sulphite liquor as raw materials, but it is

questionable whether, in the light of apparent food shortage, potatoes are so much used today for making alcohol.

The Japanese Empire, and areas now under its control, has been credited with having constructed and having available for operation 119 ethyl, 21 methyl and 19 butyl alcohol plants. Of this number there are reported to be 20 ethyl alcohol plants in Formosa and 5 butyl alcohol plants but no methyl alcohol plants.

Ethyl alcohol.- Ethyl alcohol is probably not used so much today in Japan as a motor fuel or for admixture with gasoline for consumption as a motor fuel but as a solvent and in the manufacture of smokeless powder and synthetic rubber. In Formosa compulsory blending of 5% alcohol with gasoline was instituted on July 1, 1938 and gradually increased until April 1940, when the required admixture became 20%. There was talk of this becoming 30% eventually but by September 1, 1941, there had been no change. On September 1, the use of gasoline for motor cars, except specially approved or military, was prohibited.

Before 1937 ethyl alcohol was exported to China, Hongkong, Macao, Manchuria, the Kwantung Leased Territory and Japan, but as the war progressed the major portion went to Japan for use as indicated above. Production was as follows:

Production of Ethyl Alcohol in Formosa (a)

<u>Year</u>	<u>U. S. Gallons</u>
1932	3,862,434
1933	3,756,614
1934	3,941,799
1935	5,000,000
1936	4,708,990
1937	Not available
1938	9,285,714
<hr/> <hr/> Total	<hr/> <hr/> 30,555,551

The following list of commercial ethyl alcohol plants is made up from two reports on the subject, one mainly from the Sugar Yearbook for 1940, published in Japanese, and the other by a private individual acquainted with the subject, who had visited the country and knew something of the plans and accomplishments of the Japanese in developing alcohol production. Source One's production is based on 1934 figures of daily production with an additional quantity as new production. Figures are daily capacities in terms of absolute alcohol. Annual capacity may be reckoned on the basis of 250 days operation though this is variable depending upon conditions. No attempt has been made to coordinate the two estimates of production and the quantities might be considered as minimum and maximum.

Commercial Ethyl Alcohol Plants - Formosa

Factory Name	Town and Area	Province	Company	Daily Capacity (U.S. Gallons)	
				Source One	Source Two
Ako	Heito-shi, Heitogun	Takao	Taiwan Seito	14,765	14,966
Kyoshito #1 & #2	Nanshi, Okayamagun	Takao	Taiwan Seito	7,000	30,680
n.a.	Kyoshito	Takao	Formosan Development Co.		5,260
Takao	Takao City	Takao	Takao Alcohol Company (Takao Shusei Kaisha)	12,572	2,173
n.a.	Takao City	Takao	Ensuiko Seito Kaisha		12,295
n.a.	Takao City	Takao	Formosan Development Co.		5,132

(a) Absolute and 95 per cent.

Commercial Ethyl Alcohol Plants - Formosa (Continued)

Factory Name	Town and Area	Province	Company	Daily Capacity (U.S. Gallons)	
				Source One	Source Two
n.a.	n.a.	Tainan	Monopoly Bureau		7,632
Kobi #1	Kobi-gai, Kobi	Tainan	Dai Nippon Sugar Mfg.Co.	16,200	30,680
n.a.	Kagi	Tainan	Monopoly Bureau		3,169
Nansei	Mizukami-sho Kagi-gun	Tainan	Meiji Sugar Mfg. Co.	16,000	30,680
Santo	Rokkyaku-sho Toseki-gun	Tainan	Meiji Sugar Mfg. Co.	1,177	1,177
Soya	Mato-gai, Sobun gun	Tainan	Meiji Sugar Mfg. Co.	2,128	2,128
Shinei	Shinei-gai	Tainan	Ensuiko Sugar Mfg. Co.	9,053	9,540
Keiko	Keiko-gai Inrin-gun	Taichu	Meiji Sugar Mfg. Co.	1,720	1,720
Nanto	Nanto-gai, Nanto-gun	Taichu	Meiji Sugar Mfg. Co.	2,049	2,049
Keishu	Keishu-sho Hokutogun	Taichu	Ensuiko Sugar Mfg. Co.	1,177	1,177 ^a
Shinchiku	Shinchiku-shi	Shinchiku	Dai Nippon Sugar Mfg.Co.	1,131	1,131
Taichu #1 & #2	Taichu-shi	Taichu	Dai Nippon Sugar Mfg.Co.	3,574	23,760
	Shoka	Taichu	Niitaku Seito Kaisha		3,304
	Kotobuki	Karenko	Ensuiko Seito		1,000
Total Daily Capacity				88,546	189,653

Source One shows the names and cane manufacturing capacities of a half dozen additional plants and advises that they may produce alcohol. These are listed hereunder as they do not appear to be a duplication of any plants which Source Two has in first list over those of Source One. Capacity estimates, in the absence of other data, are based on the size of plant.

Additional Plants Which May Produce Ethyl Alcohol - Formosa

Factory Name	Town and Area	Province	Company	Estimated Capacity
Kibi	Kizan-gai, Kizan gun	Takao	Formosan Development Co.	5,000
Sankanten	Eiko-sho, Niitoyo-gun	Tainan	Taiwan Seito Kaisha	2,000
Wanri No.1 and No. 2	Zenka-sho, Shinka-gun	Tainan	Taiwan Seito Kaisha	3,000
Kagi	Tairin-sho, Kagi-gun	Tainan	Dai Nippon Sugar Mfg. Co.	5,000
Kokko	Hokko-gai, Hokko-gun	Tainan	Dai Nippon Sugar Mfg. Co.	10,000
Gannai No.1 and No. 2	Ensui-gai, Shinei-gun	Tainan	Ensuiko Sugar Mfg. Co.	5,000
Total Additional Capacity of Source One				30,000

Butyl alcohol.- The Japanese have laid considerable stress on the use of butyl alcohol or butanol as a source of octanes for aviation gasoline. It may be made from sweet potatoes, from cane and beet sugar, molasses or acetylene. Indications are that in Formosa the fermentation process is the chief source of butyl alcohol.

The Japanese claim to have their own process for making butanol into aviation gasoline. Ordinarily, normal butanol as produced by fermentation is converted to isobutanol by isomerizing with a catalyst. Subsequently three steps are required: dehydration of iso-butanol to iso-butylene; polymerization of the iso-butylene to diisobutylene, an octene; and finally hydrogenation of the unstable octene to iso-octane which is stable.

(a) Both sources show capacity as not available, estimated as same size as Santo. The equivalents of terms in locations are, gai--town; shi--city; sho--station, village; gun--county; shu--province.

The extent of Japan's plans for butanol production is unknown but recent indications are that Japan may now be producing an aviation gasoline component from butanol. The process, in its technological application, is complicated and under conditions of access to the highly aromatic type petroleum resources in the Netherlands East Indies, large production may be discounted. Japan, has always had in mind self-sufficiency at home and plans are projected far ahead. A broadcast in 1944 from Japan advises that the Taiwan Sugar, the Meiji Sugar, the Nitto Development, and the Ensuiko Sugar Manufacturing companies of Taiwan have formed themselves into a cooperative unit called the Taiwan Synthetic Fuel Manufacturing Company, capitalized at ¥5,000,000 to manufacture iso-octane from butanol. The broadcast states that "though very little time has elapsed since conversion of the facilities of these companies to the manufacture of iso-octane and also many improvements need to be made in technique", and goes on, encouragingly to its listeners, to say that, "it is believed that a new aviation fuel company will be established to put Taiwan on a self-sufficiency basis".

The locations of the butyl alcohol plants in Formosa and their capacity for production are somewhat uncertain. The list below should, be considered in this light and production figures largely an estimate:

Butyl Alcohol Plants - Formosa

District	City or Town	Company	Raw Materials Used	Annual Capacity (U.S. Gallons)
Tainan	Kagi	Formosan Development Co.	Sweet potatoes	145,310
	Kagi	Formosa Seito Company	Sweet potatoes	1,429,614
Takao	Kyoshito	Formosa Seito Company	Cane molasses	143,100
	Takao	Formosan Development	Cane molasses	994,083
	Takao	Formosa Shusei	Sweet potatoes	239,000
	n.a.	Formosa Yuki Gosei	Acetylene	239,000
Total				3,190,107

4.5.2 Charcoal

The use of charcoal in generators has been encouraged in Japan for years and subsidies were paid to car owners who converted and installed gasogenes. It took time for the public to give up the hope of being able to obtain gasoline and only a few cars were converted and these experimentally. Later, when conversion might have been made, it was difficult to get the equipment. There was also a heavy commandeering of good motor cars and trucks by the military in 1939 and 1940. Eventually buses not operating on mountainous routes were largely converted to charcoal, but in certain instances were permitted to operate on gasoline or bottled gas over the more mountainous stretches where the power generated by charcoal was insufficient. In 1938 charcoal production in Formosa amounted to 53,000 metric tons.

4.5.3 Bottled Gas

Some bottled gas, as put up in cylinders at the gasoline plant at Kinsui, was consumed but nothing is known concerning the scale of consumption nor the conversion of motor vehicles in Formosa to this means of propulsion.

4.6 SUMMARY OF OIL STORAGE IN FORMOSA

Commercial storage: Northern Formosa, native.- Nippon's prewar storage capacity was largely at Keelung but some was upcountry and at oil fields. Capacity at Keelung has been estimated at 161,000 barrels. At Byoritsu, in 1930, on the railway south of the town, there were reported to be eight or nine 500-barrel tanks used for tank car

shipments of gasoline to Keelung and elsewhere. At the Kinsui gasoline plant there were, according to the same report, six tanks of 10 x 40 feet, estimated as containing 2,250 barrels in total. There are no indications regarding field and refinery storage elsewhere but it would be safe to assume a figure of 15,000 barrels. At the Shiodome bulk plant storage may be calculated at 1,500 barrels. Bulk storage of agents of the native companies at upcountry distributing points may be estimated at 1,000 barrels.

Commercial storage: Pescadores Islands.- Oil stores for fishing vessels are reported to be located about 200 yards northeast from the three piers in front of Makyu (town) on the north shore of Jukokuwan or bay. There is no indication of size, and the capacity may be considered as included with Navy storage below.

Commercial storage: Takao.- Later interpretation of aerial coverage on the two plants in proximity to Mitsubishi's oil storage depot mentioned on page 63 and shown on map on page 60 as sites (a) and (b) credits plant (a) with being a gas works reported as making poison gas. Facilities are now reported to be 2 covered tanks 90 feet in diameter, 3 tanks 55 feet in diameter, 2 tanks 40 feet in diameter, 1 building 60 feet x 50 feet, and several small miscellaneous buildings. There is no need to change the total storage capacity from that given in the table on page 63 but a doubt has been cast on the use of the above mentioned tanks for storage of petroleum products. There is nothing new concerning the 4 tanks on site (b).

Latest photographs taken in October 1944 of the new refinery at Takao show storage tanks still under construction. There is little evidence that the refinery is nearing completion. The ten small rerun tanks of either 25 feet or 30 feet in diameter might have a total capacity between 25,000 and 30,000 barrels but there are no signs of pipe lines. This and the potential storage capacity for bulk is not being taken into account at this time but merely recorded for future guidance.

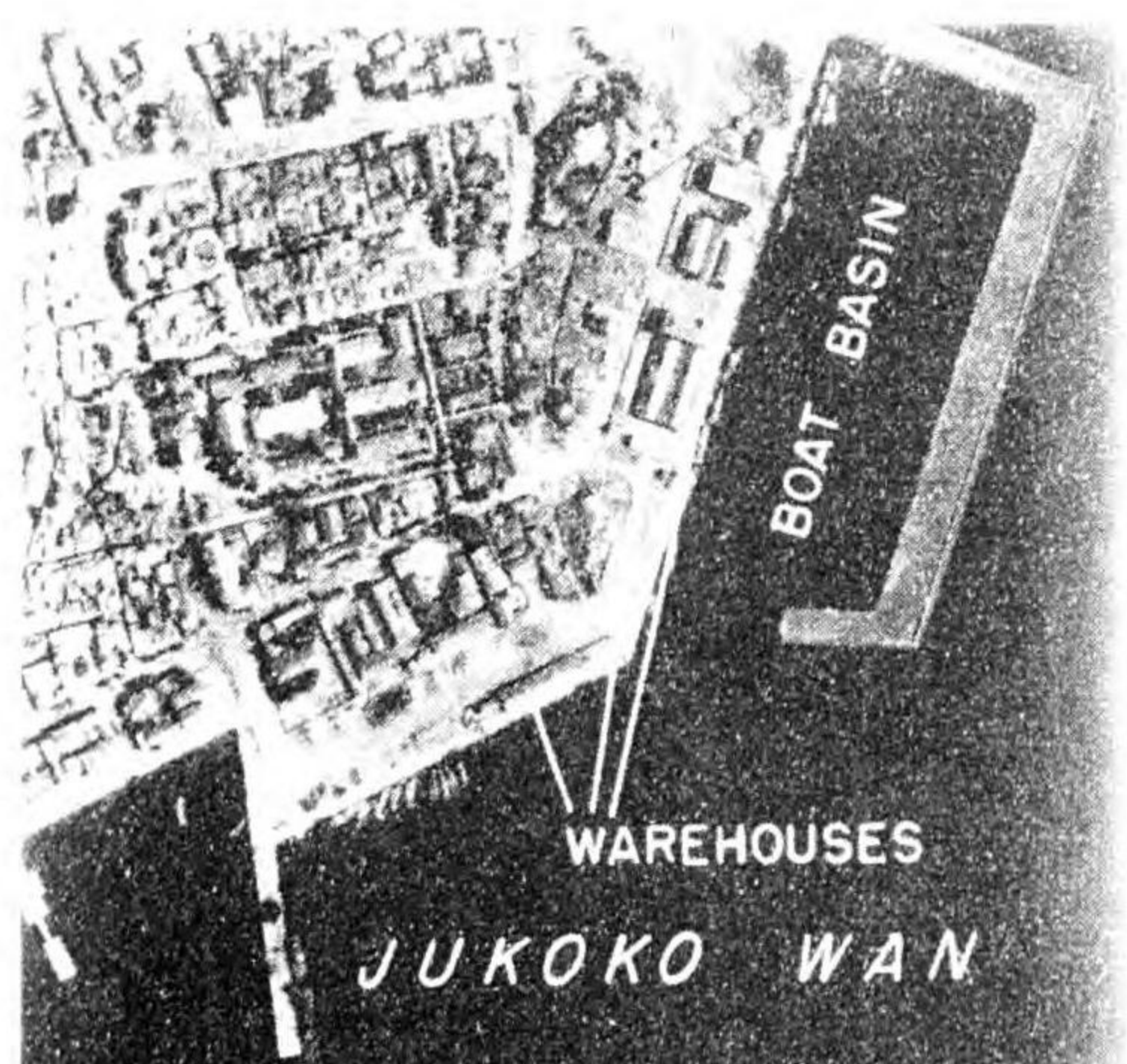
Commercial storage: Tansui and inland foreign.- According to layout on page 68 bulk storage of RSP at Tansui totaled 30,320 barrels. The only other bulk storage of RSP or agents is at Kagi where there are two tanks with capacity of 500 barrels.

Naval storage: Keelung.- There is no place in the vicinity of Keelung or on the island of Sharyoto in the harbor where storage tanks, other than Nippon's can be found nor even any likely spot where they might be buried. As it would be likely for the Navy to have their own bulk storage for fuel and diesel oil at this important harbor the original estimate of Naval storage at Keelung of 250,000 barrels is left unchanged but it should now be considered as doubtful.

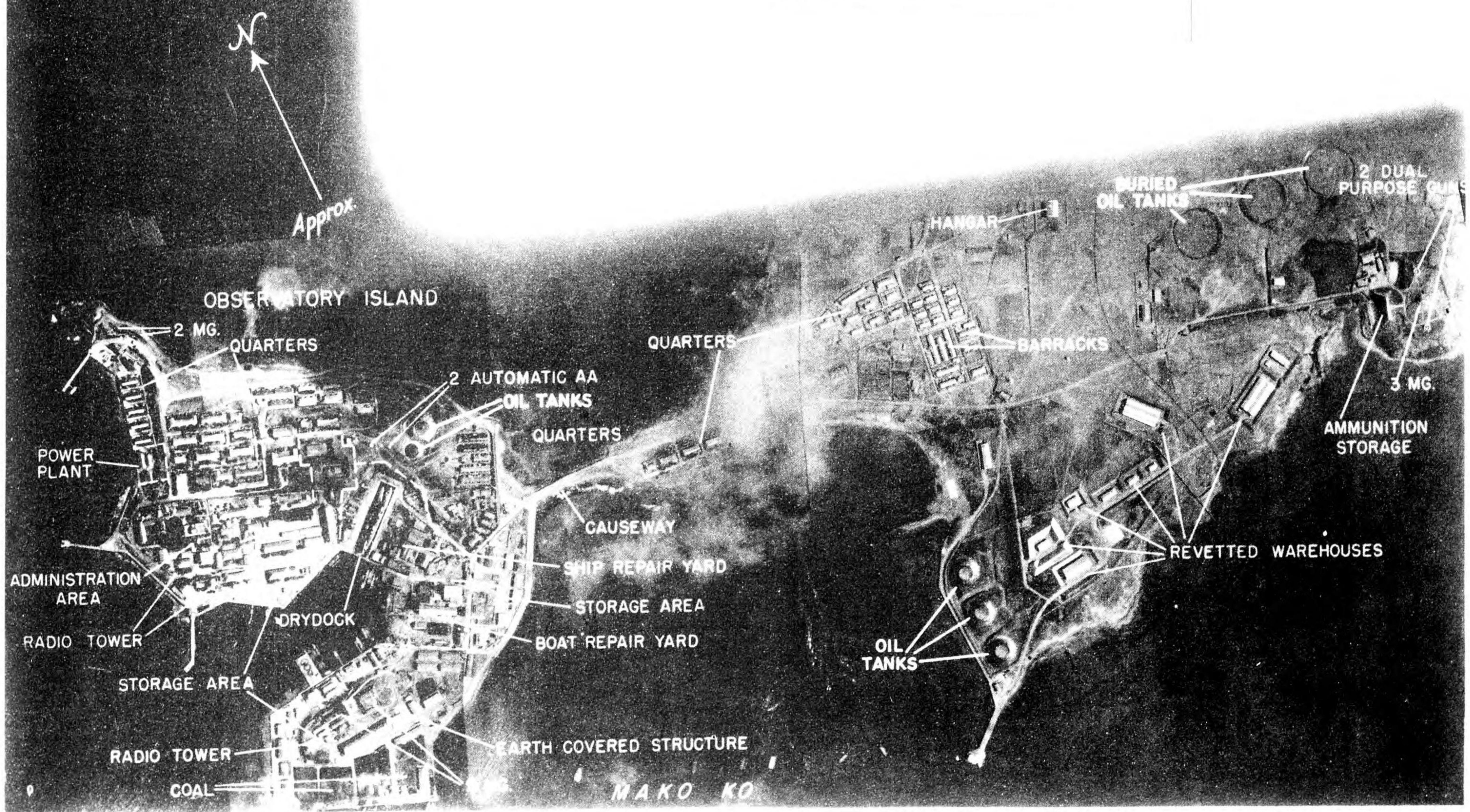
Naval storage: Bako, Pescadores Islands.- Naval storage at Bako, also known as Mako and Makyu in the Pescadores, has been placed at 280,000 barrels. At the Ansan Naval Base, located on an island in Bako Bay, there are two small fuel tanks but on a large area to the southeast to which the island is joined by a causway, there are reported to be three large earth-covered fuel tanks near the bunkering pier on the coast, and three larger (240 feet in diameter) underground or buried tanks further inland. See aerial photograph taken in October 1944 on page 75.

Naval storage: Toshien, near Takao.- At Toshien, five miles north of Takao and seven miles SSE of Okayama, a new Naval harbor, town and refinery has been constructed. Reports show that indications of tankage already constructed and to be built should be capable of storing between 1,500,000 and 2,000,000 barrels of oil. Five storage tanks out of a possible 18 under construction at the refinery have been completed. These are 120 feet in diameter and assuming they are standard 42 feet high, their capacity is approximately 80,000 barrels each. There are 30 rerun tanks averaging 30 feet in diameter. Their total capacity may be estimated in round figures at 100,000 barrels. Total present capacity may be estimated (late 1944) as roughly 500,000 barrels.

Two buried fuel storage tanks of 225 feet in diameter are to be found in the valley on the slope of Ape Hill (separating Takao and Toshien) 1.6 miles SSW of the



AERIAL PHOTOGRAPH OF
UNDERGROUND OIL STORAGE
ANSAN NAVAL BASE
PESCADORES ISLANDS



DISTRIBUTING
Ansan Naval Base, Pescadores Islands

traffic circle in the newly built town of Toshien. There is a possibility, however, that these may be water reservoirs. Another group of five probable fuel oil storage tanks are located 3,750 feet SW of the traffic circle. The three larger tanks are of 130 feet in diameter, and the two smaller ones of 40 feet diameter. They are flush with the ground level and are, therefore, probably buried. A low wall surrounds each installation. See map on page 60.

Naval storage: Toko.- This port has been spoken of as a possible Naval re-fueling base but there are no details as to storage tanks or capacity.

Estimated Bulk Storage Capacity in Formosa
(Not including potential storage under construction in late 1944)

	Location	Company	Barrels (42 U.S. Gallons)
Prewar Commercial	Tansui	RSP	30,320
	Upcountry	RSP Agents	500
	Keelung	Nippon	161,000
	Shiodome	Nippon	1,500
	Upcountry	Nippon Agents	1,000
	Byoritsu	Nippon	5,000
	Kinsui	Nippon	2,500
	Chikuto, Koko, Shukkoko, elsewhere Takao	Nippon and Taiwan Kogyo Mitsubishi	15,000 56,763
Prewar Military	Keelung	Navy	250,000
	Bako, Pescadores	Navy	280,000
Total			803,583
Later con- struction	Takao Toshien	Mitsubishi and Other	357,760
		Imperial Oil Co., (?)	500,000
		Navy (2 x 225 ft.)	300,000
		(3 x 130 ft.)	270,000
		(2 x 40 ft.)	20,000
Total			1,447,760
Grand Total			2,251,343

APPENDIX 1

CONVERSION FACTORS USED IN THIS REPORT

The conversion factors given below have been approved by the Enemy Oil Committee and are those commonly used for general calculations.

Basis.- One metric ton of 1,000 kilograms is divided by the volume of one barrel (159 liters) multiplied by the density of the oil at 60° F (15.5° C). This reduces to the factor of 6.3 divided by the density of the oil.

<u>Product</u>	<u>Bbls/Metric Ton</u>
Propane	12.4
Butanes	11.0
Natural Gasoline	9.16
Aviation Gasoline	8.5
Motor Gasoline	8.5
Motor Bensol (90 per cent)	7.2
Ethyl Alcohol	8.0
Methyl Alcohol	8.0
Kerosene	7.9
Diesel Oil	7.2
Lube Oils	7.0
Residual Fuel	6.5
Paraffin Wax (a)	7.5
Asphalt	6.0
Synthetics (b)	8.0
Shale Oil	7.0
All products average (b)	7.5
Crude Oils (c)	7.0

(a) The factor of 7.5 bbls./ton of wax appears to be the best figure for the wax dissolved in oil. The density of solid wax varies with the melting point from about 0.88 to 0.95, and averages about 7.0 bbls./metric ton.

(b) Does not take into account liquefiable gases.

(c) Gravity of crudes vary considerably. In view of the variation from field to field it usually will be preferable to use field gravities when available.

A P P E N D I X 2

LOCATION OF PLACE NAMES REFERRED TO IN THE FORMOSA REPORT

Confusion in transliteration of Chinese characters and differences in pronunciation between the Chinese and Japanese, variation in spelling in English and differences in what a place is called locally are a few of the difficulties encountered in locating specific places.

The following list contains geographic names referred to in this report, giving common variants in spelling (indicated in parentheses), and showing location by latitude and longitude coordinates. Certain places, mostly small villages with a variation in spelling that cannot be checked, have not been located on any map but as they may be helpful and possibly can be recognized by someone especially familiar with the locality they have been included in the report and marked with a question mark. Words underlined are terms frequently used in making Formosa place names derived either from Chinese or Japanese, and their meaning is indicated.

<u>Name</u>	<u>Location</u>	
	<u>Latitude N</u>	<u>Longitude E</u>
Anping	23° 00'	120° 09'
Ansan	23° 33'	119° 34'
Bako (Mako)(Makyo)	23° 34'	119° 32'
Bochirin?		
Byoritsu (Byoritu)	24° 34'	120° 49'
Chikunan (Tikunan)	24° 41'	120° 48'
Chikuto	24° 45'	121° 5'
Chikutoki (Chinkutozaki, Chikutokaku)?		
Chuwa (sho)?		
Eiko-sho?		
Ensui	23° 20'	120° 20'
Ensuitsubo	22° 44'	120° 20'
Formosa (Taiwan)	- Between 21° 55' and 25° 21'	119° 18' and 122° 15'
<u>Gai</u> - town		
Gaishotei	23° 50'	120° 50'
Giran	24° 45'	121° 45'
Gosei (Niitaka)	24° 15'	120° 32'
<u>Gun</u> - county		
<u>Gunto</u> - Archipelago		
Gyuchō Ko	25° 08'	121° 44'
Gyunikuzaki (Gyunikuki) (Gyusan) (Gyrikusaki)?	23° 20'	120° 28'
Gyuzan?		
Hakkasho ?		
Hakkaryoku?		
Hatto	25° 07'	121° 44'
Heito	22° 41'	120° 27'
Hokko	23° 34'	120° 15'
Hokkaido Island	- Between 41° 30' and 45° 30'	139° 45' and 145° 50'
Honshu Island		
Hoshirin?		
Hozan (Takarayama)?		
Kagi	23° 29'	120° 26'
<u>Kaikyu</u> - strait		
Karafuto (Sakhalin)	Between 46° and 50°	142° and 145°
Karenko (Kwaren Ko)	24° 00'	121° 38'
Kashirin (Koshirin)? (Kusorin)	23° 1'	120° 25'
Keelung (Kiirun)(Kirun)	25° 08'	121° 44'

<u>Name</u>	<u>Location</u>	
	<u>Latitude N</u>	<u>Longitude E</u>
Keiko gai	23° 58'	120° 28'
Keishu (Keisyū)	22° 28'	120° 30'
Kizan	24° 55'	121° 55'
Kinsui	24° 37'	120° 28'
Ko-harbor		
Kobi (Aobi)	23° 42'	120° 26'
Koko	24° 53'	121° 4'
Koshiryō (Koryū)?		
Koshun (Kōsyūn)	22° 00'	120° 45'
Kosenshō (Kosenpo) (Kosen)	23° 05'	120° 33'
Kotobuki	23° 52'	121° 30'
Kyoshitō	22° 46'	120° 17'
Kyusorin (Kashirin) (Koshirin)	23° 1'	120° 25'
Mato gai	23° 12'	120° 15'
Mizukami	23° 27'	120° 20'
Mount Morrison (Niitaka Yama)	23° 28'	120° 55'
Nairyō (Sairyō)?		
Nanka sho?		
Nanshi (Okayama gun)(Nansi)	22° 44'	120° 18'
Nanshō	24° 35'	120° 55'
Nanto	23° 55'	120° 40'
Niitaka Yama (Mount Morrison)	23° 28'	120° 55'
Nisui	23° 48'	120° 35'
Okayama	22° 48'	120° 16'
Pescadores Islands (Hoko Shoto, Boko Gunto) - Between	23° 11' and 23° 54'	119° 15' and 119° 36'
Rokki (Rokkiri)	22° 59'	120° 35'
Rokkyaku?		
Rokukukei? (Rokujukai)?		
Sairyō (Nairyō)?		
Sakhalin (Karafuto) Between	46° and 50°	142° and 145°
Senshuryō?		
Shi - city		
Shiodome	25° 03'	121° 40'
Shinchiku (a town, also a province)	24° 52'	120° 57'
Shinei (Sin-ei)	23° 18'	120° 18'
Shinka (gun)		
Shinsui	22° 46'	120° 25'
Shishitō?		
Sho-station, village		
Shobai?		
Shoka (Syokwa)	24° 06'	120° 33'
Shoto-Archipelago		
Shu-province		
Shukkoko (Shikkoko)	24° 25'	120° 51'
Shushu (Shusho)	23° 50'	120° 46'
Sintikushyū (Shukushu)?	23° 0'	120° 30'
Sokei?		
Suiryutō?		
Suo	24° 35'	121° 52'
Taichū	24° 08'	120° 42'
Taihei (near Kinsui)	24° 35'	120° 52'
Taihoku	25° 03'	121° 31'
Taiko (village at Shukkoko)	24° 24'	120° 50'
Tainan	23° 00'	120° 12'
Tairin	23° 36'	120° 26'
Taitō	22° 46'	121° 08'
Taiwan (Formosa) - Between	21° 45' and 25° 38'	119° 18' and 122° 15'
Taiwan Strait (Taiwan Kaikyū)		
Takao	22° 37'	120° 16'
Takao River	22° 37'	120° 19'

Location of place names

<u>Name</u>	<u>Location</u>	
	<u>Latitude N</u>	<u>Longitude E</u>
Takezaki (Takesaki)	23° 30'	120° 33'
Tansui (Tamsui)	25° 10'	121° 27'
Tansui River	25° 10'	121° 25'
Toku (Tokō)	22° 27'	120° 27'
Toroku	23° 42'	120° 32'
Toshien	22° 40'	120° 17'
Toshingaku ?		
Tsuho ?		
Tsusho (Tsuyo, Tangsian, Tongsian) ?		
Tsurumi	35° 29'	139° 42'
Yama - mountain		
Zenka	23° 8'	120° 16'

APPENDIX 3

SOURCES OF PORT AND HARBOR MAPS FOR FORMOSA

Maps of ports and harbors having importance for petroleum handling in Formosa are not reproduced in this report, inasmuch as qualified persons have ready access to detailed charts published by the Hydrographic Office, Bureau of Operations, Navy Department at Washington and charts of the British Admiralty. For convenience, references are given here to maps of various ports. In the following list HO designates the Hydrographic Office.

<u>Port</u>	<u>Chart No.</u>	<u>Title</u>
Keelung	HO 2500	Northern part of Taiwan (Formosa), Auran Hakuchi to Soo Wan
	HO 1908	Kiirun Ko (Keelung Harbor)
Pescadores Islands	HO 2558	Pescadores Island (Hoko Retto)
	HO 2641	Hatto Retto (Rover Group)
	HO 2506	Pescadores Island (Hoko Retto), Inner Anchorages
Takao	HO 2488	Takao Ko; Toapanraa Byochi
	HO 3203	West Coast of Taiwan (Formosa) and Pescadores Channel (Hoko Suido) Plan: Anpin Ko
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