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THE PETROLEUM OIL INDUSTRY IN JAPAN

by

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I. INTRODUCTION

Extraordinary development of modern mechanical industry in Japan has required much petroleum. Moreover, the development in internal combustion engines necessitated not only increased production of oil, but also improvement in its properties, thereby resulting in the present development of the petroleum industry.

In order to meet the above conditions, fractions of naturally produced hydrocarbons, suitable for use in modern machinery, were collected and at the same time unsuitable fractions thereof were decomposed, polymerised or refined by solvent to make use of these fractions completely. At the same time research work on coal liquefaction and conversion of animal and vegetable oils into petroleum hydrocarbons was carried on.

As to motor fuel, topping of natural crude oil, decomposition of topped bottom oil, thermal catalytic cracking of naphtha with active acid clay and hydrocracking of naphtha have been effected. A very small quantity of motor fuel has been produced by means of coal liquefaction. The coal liquefaction plants were converted to hydrocracking of petroleum naphtha at the request of the Army and Navy during the war.

As to lubricant oils, low class lubricating oil has been treated by a process in which the distillate from vacuum distillation is treated with sulphuric acid and washed with alkali and warm water. Middle class lubricating oil has been produced by the dewaxing of paraffinic crude oil or by blending high class lubricating oil with low class lubricating oil. High class lubricants have been produced only by the Duo-sol or Furfural solvent refining processes. In case of de-waxing, the Barisol and Acetone-Benzol processes have been adopted. For final refining, the contact re-run process has been adopted.

The conversion of animal and vegetable oils into high class lubricants was planned; the Soap Manufacturing Co. intended to construct a commercial plant, but testing of the product was not completed. Conversion of rubber into lubricating oil, etc. has been accomplished commercially, but good results were not obtained.

II. HISTORY OF THE PETROLEUM OIL INDUSTRY IN JAPAN

It is mentioned in the Nippon Shoki (an ancient Japanese biography), that burning soil and burning water were presented to the Emperor TENJI by the people of ECHIGO in Niigata Prefecture in 668. In 1613, Mr. Nihei MAGARA constructed an oil well at KARAMEGI, Nakakanbara District, Niigata Prefecture. This crude oil was supplied to a simple distillation plant, and light oil was produced and sold. Later, Mr. Yasunojo HIRANO co-operated with Mr. Cynchroton, an American, and constructed an oil well by hand at KUROKAWA, Niigata Prefecture. Even to the present day, this hand sunk oil well has been called a "foreigner's oil well". In 1871 Mr. Shuzo ISHIZAKA founded a modern oil company with a capitalization of ¥30,000. At the same time a rotary drilling system was imported from America. In 1888, the Nippon Oil Co., with capitalization of ¥150,000 was founded by Mr. Hisahiro NAITO. The company imported a cable type drilling machine and installed it at Ogose Shore, NIIGATA. In 1892 the Nagaoka Iron Pipe Company was founded and in 1893 this company laid iron pipe to feed oil from HIOASHIYAMA to oil companies located in the city of NAGAOKA. In 1900 the Nishiyama oil field was developed, and production of oil reached 1739 barrels per day.

In 1900 the International Oil Co., with a capitalization of ¥10 000,000 was founded, and the company constructed a large scale oil refinery near NAOETSU, Niigata Prefecture, for operation on purchased Nishiyama crude oil. In 1911

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the company failed to exploit the Hokkaido oil fields and all of the company's business and property were assigned to the Nippon Oil Company. In 1910 the Nippon Oil Co. obtained 1577 barrels per day of crude oil at NIIZU KARAMEGI, Niigata Prefecture. In 1904 the Nanboku Oil Company was founded and the company installed an oil refinery plant of large scale at HODOGARA, Kanagawa Prefecture to process crude oil imported from foreign countries. Later on, this company was amalgamated with the Takarada Oil Company. In 1914 the Nippon Oil Co. bought a rotary drilling machine and obtained 11,345 barrels per day of crude oil at the Kurokawa oil field, Akita Prefecture.

In 1918, as the result of the first European war, the import of steel drill pipe was stopped, thereby hindering oil well drilling. The Nippon Kokan Co., Ltd., therefore, was founded for the purpose of manufacturing steel pipe.

In 1921 the Nippon Oil and the Takarada Oil united to form the Nippon Oil Co., ltd. with capitalization of ¥80,000,000. In 1925 agreement on oil field rights in North SAKHALIN was reached in the Russo-Japanese treaty. In 1926 the Kita Karafuto Oil Co., with a capitalization of ¥10,000,000, was founded. In 1930 Borneo Oil Co., with combined capital of Japan and Holland, was founded to start test-drilling of oil fields in Borneo. The Nippon Oil Co. installed a natural gasoline absorption plant and a carbon black works in 1931 at KINSUI, Formosa. In 1934 the Innai oil field, AKITA Prefecture, and the Kokuni and Omonogawa oil fields were exploited. In 1936 the Yabase oil field, AKITA Prefecture, was exploited, and the field proved to be a very good one.

The names and locations of oil refining companies in Japan as of 1 November 1939, are as follows:

Hayama Oil Co.	TOKYO
Nippon Oil Co.	TOKYO
Niizu Oil Co.	NIIGATA
Toyo Oil Co.	OSAKA
Toho Oil Co.	YOKOHAMA
Toyo Shoko Oil Co.	TOKYO
Ogura Oil Co.	TOKYO
Yamabun Oil Co.	OSAKA
Yamagishi Oil Co.	TOKYO
Maruzen Oil Co.	KOBE
Edogawa Oil Co.	TOKYO
Asahi Oil Co.	TOKYO
Aikoku Oil Co.	TOKYO
Aoki Oil Co.	[illegible]
Kyoei Oil Co. (dissolved)	TOKYO
Marusu Oil refinery plant	TOBATA
Mitsubishi Oil Co.	TOKYO
Nippon Oil Co.	KYOTO

The names and locations of oil refining companies still existing as of 1 May 1944, are as follows:

Nippon Oil Co.	(Nippon Oil, Aikoku Oil and Ogura Oil are united).
Maruzen Oil Co.	(Toyo Oil, Toho Oil and Kyushu Oil refinery plant are united)
Koa Oil Co.	

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Mitsubishi Oil Co.

Showa Oil Co. (Asahi Oil, Hayama Oil and Niizu Oil are united).

Taikyo Oil Co. (Yamagishi Oil and Ogura in NIIGATA Prefecture are united).

Nippon Kogyo Co.

Aoki Oil Co.

More recent oil refining plant developments are listed as follows:

Company	Location	Type of Plant	Year Established
Nippon Oil	AKITA	Continuous distillation	1915
Nippon Oil	TSUHUMI	Dubbs Cracking	1924
Nippon Oil	NIIGATA	Cross Cracking	1926
Ogura Oil	TOKYO	Jenkins Cracking	1926
		Schultz Vacuum Distillation 1926	1926
Nippon Oil	NIIGATA	Schultz Vacuum Distillation	1927
Nippon Oil	KUDAMATSU	Cross Cracking	1927
Ogura Oil	YOKOHAMA	Cross Cracking	1927
Mitsubishi Oil	MITSUBISHI	Cross Cracking	1927
Nippon Oil	KUDAMATSU	Foster Pipe Still	1930
Nippon Oil	KUDAMATSU	Saith-Leslie Pipe Still	1930
Mitsubishi Oil	MITSUBISHI	Kellogg Pipe Still	1931
Ogura Oil	YOKOHAMA	Kellogg Pipe Still	1931
Nippon Oil	TSUHUMI	N. N. C. Pipe Still (Nippon Oil Patent)	1932
Yamabun Oil		Badger Vacuum Distillation	1935
Hayama Oil	KANASAKI	Schwertz Cracking	1935
Nippon Oil	TSURUMI	N. N. C. Cracking (Nippon Oil Patent)	1935
Aikoku Oil		N. N. C. Cracking	1937
Aikoku Oil		N. N. C. Pipe Still	1937

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Company	Location	Type of Plant	Year Established
Osaka Mineral Oil		Badger Vacuum Distillation	1937
Toyo Oil	TSURUMI	Badger Vacuum Distillation	1937
Ogura Oil		Barisol Dewaxing Process	1937
Toyo Shoko		Barisol Dewaxing Process	1938
Niitsu Oil		Schwartz Cracking	1938
Asahi Oil		Badger Vacuum Distillation	1938
Hayama Oil	KAWASAKI	Badger Vacuum Distillation	1939
Toho Oil		Badger Vacuum Distillation	1939
Toa Nenryo		Topping Pipe Still	1939
Hayama Oil	KAWASAKI	Duo-sol Process	1939
		Contact Re-run Process	1939
Maruzen Oil		Barisol Dewaxing Process	1939
		Contact Re-run Process	1939
		Duo-sol Process	1939

Note: The above companies were established before 1944.

A table showing oil refining plants provided with comparatively modern equipment follows:

Location of Plant	Name of Co.	Feature of Plant
KASHIWAZAKI, Niigata Pref.	Nippon Oil Co.	Gasoline, Paraffin Pipe Still.
NIIGATA Pref.	Nippon Oil Co.	Schultz Vacuum Distil. Paraffin, Cross Cracking Distillation, Cold-settling, Dewaxing.
TSUCHIZAKI, Niigata, Pref.	Nippon Oil Co.	Cold-settling Dewaxing, N.N.C. Pipe Still.
TSURUMI, Kanagawa Pref.	Nippon Oil Co.	Dubbe Cracking, N.N.C. Pipe Still N.N.C. Cracking.

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Location of Plant	Name of Co.	Feature of Plant
KUDAMATSU, Yamaguchi Pref.	Nippon Oil Co.	Cross Cracking, Foster Pipe Still, Smith-Leslie Pipe Still.
TOKYO	Ogura Oil Co.	Jenkins Cracking, Schultz.
		Vacuum Distillation.
YOKOHAMA	Ogura Oil Co.	Schultz Vacuum Dist. Kellogg Pipe Still, Cross Cracking.
KAWASAKI	Mitsubishi	Kellogg Pipe Still, Cross Cracking.
KAWASAKI	Hayama Oil Co.	Heckmann Vacuum Distillation, Schwartz Cracking Topping Distillation, Vacuum Distillation, Badger Vacuum Distillation Barisol, Duo-Sol, Contact Re-run.
KANAGAWA Pref.	Toho	Heckmann Vacuum Distillation, Badger Vacuum Distillation.
KANAGAWA Pref.	Aikoku	N.N.C. Pipe Still, N.N.C., Cracking.
TOKYO	Edogawa Refinery	Heckmann Vacuum Distillation.
TOKYO	Asahi Oil Co.	Heckmann Vacuum Distillation, Badger Pipe Still.
NIIGATA	Niizu	Heckmann Vacuum Distillation.
		Schwartz Cracking
OSAKA	Maruzen	Barisol, Duo-sol.
		Contact-Rerun, Heckmann Vacuum Distillation, Cracking.
		Contact-Rerun, Heckmann Vacuum Distillation, Cracking.
OSAKA	Toyo	Heckmann Vacuum Distillation Badger Pipe Still.
KANAGAWA Pref.	Toyo Shoko	Badger Pipe Still.
OSAKA	Yamabun	Badger Pipe Still.

III. PRODUCTION OF OIL

A. Origin of Oil in Japan

Petroleum oil consists of a mixture of various hydrocarbons, a very small quantity of compounds of oxygen, sulphur and nitrogen, and other

inorganic substances. Miscellaneous theories on the formation of oil have been discussed among scholars. These are mainly divided into the inorganic origin theory, as represented by carbide origin theory, and the organic origin theory which is further divided into the vegetable origin theory, the animal origin theory, and the sapropolite origin theory. Japanese scholars have adopted the animal origin theory and sapropolite origin theory to explain the formation of oil in Japan, which theory assumes that marine animals are buried and that decomposition, polymerisation, etc., are effected by means of pressure and heat during long periods to form the present petroleum oil. This presumption has also been tested experimentally. In 1888 Mr. Engler obtained oil by the dry distillation of fish. Dr. K. KOBAYASHI has proved that the above decomposition of marine animals could easily be carried out at atmospheric pressure in the presence of acid clay. Dr. Y. TANAKA ascertained the presence of aliphatic acids such as palmitic, stearic, etc., in Japanese crude oils. All oil strata in Japan belong to the tertiary aqueous rock.

Japanese crude oil contains mainly naphthene base hydrocarbons and i called naphthene base oil.

B. Distribution of Oil Fields in Japan

The oil fields in Japan are distributed from Sagara oil field in SHIZUOKA Prefecture through NAGANO, NIIGATA and AKITA to HOKKAIDO, extending across the Southern and Northern districts like the backbone of an animal. These oil fields are classified into (1) oil fields in NIIGATA Prefecture, (2) oil fields in AKITA Prefecture and (3) oil fields in HOKKAIDO. Properties of crudes from these districts are given in the following table.

Properties of Japanese Crude Oils

Name of Crude Oil	Color	Pitch (%)	Paraffin (%)	Degrees ($^{\circ}$Bo)	Flash pt($^{\circ}$C)	Remarks
KUBIKI (NIIGATA)	Dark green	4.0	0.847	37.2	10.5	Contains about 30% of gasoline, light oil and kerosene respectively.
OOSHI (NIIGATA)	Green Red Opaque	1.0	2.11	35.0	55.0	Contains almost no gasoline, 50% of light oil, and about 40% of kerosene. Flash pt. is high.
KOSHIYA (NIIGATA)	Beautiful red, transparent	1.0	less than 0.5	41.7	less than 0	Contains 45% of gasoline, 15% of light oil, and about 25% of kerosene. Excellent quality.

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Name of Crude Oil	Color	Pitch (%)	Paraffin (%)	Degrees (^{0}Be)	Flash pt(^{0}C)	Remarks
NISHIYAMA Light (NIIGATA)	Dark green Opaque	3.0	0.158	27.3	60.0	Contains little gasoline and about 35% of heavy oil. Used as raw material for lubricant oil.
NISHIYAMA Heavy (NIIGATA)	Dark green Opaque	2.5-3.5	0.864	30.1	26.0	Contains 30% of gasoline 25% of light oil and about 30% of kerosene, is the best crude oil in Japan. The bottom oil is used as raw material for paraffin and lubricant oil.
NISHIYAMA IRIWADA Deep Stratum (NIIGATA)	Conc. green by reflected ray yellow brown by passed ray		1.23	42.2	less than 20 below zero	Contains about 43% of gasoline, 18% of light oil, about 24% of kerosene and about 1% of paraffin. Excellent paraffin base crude oil.
NISHIYAMA TAKEMACHI (NIIGATA)	Black green transparent		3.319	40.0	Below zero	Has high content of gasoline and a small quantity of pitch. The pour pt. of light oil component is elevated owing to high paraffin content.
HIGASHIYAMA (NIIGATA)	Black brown Opaque	6.0	0.691	27.6	26.5	Contains 15-20% of gasoline and 45-50% of kerosene. The bottom oil is raw material for paraffin and also suitable for heavy cylinder oil.
[illegible]O (NIIGATA)	Black brown Opaque	6.0	0.337	27.5	37.0	Contains 10-15% of gasoline and light oil can also be manufactured.

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Name of Crude Oil	Color	Pitch (%)	Paraffin (%)	Degrees (°Be)	Flash pt(°C)	Remarks
NANOKAICHI (NIIGATA)	Conc.green black Opaque	10.5	0.117	18.8	103.0	Excellent machine oil can be manufactured from the heavy component. The pour pt. of crude oil is less than -20°C.
NIIZU (NIIGATA)	Black brown Opaque	12.5	0.395	18.2	114.0	The pour pt. is less than 20°C. No gasoline and light oil components. Raw material for kerosene, transformer oil and lubricant oil.
NIIZU KUMAZAWA (NIIGATA)	Black	10.0	0.156	18.10	102	The pour pt. is less than -20°C. Suited for manufacture of lubricant oil.
KATTE (AKITA)	Black Opaque	5.8	1.867	32.7	25	Contains gasoline, kerosene and light oil. Suitable as raw material for cylinder oil.
KINSHOZAN (AKITA)	Black Opaque	13.5	0.277	18.7	63	Suitable as raw material for light oil, kerosene, lubricant oil and asphalt.
MICHIKAWA (AKITA)	Black Opaque	36.1	Trace	13.9	121	Is raw material for kerosene, heavy oil and lubricant oil. Asphalt can be obtained.
KUROKAWA (AKITA)	Black Opaque	24.0	0.319	16.1	88	Lubricant oil, light oil and asphalt can be obtained.
TOYOKAWA (AKITA)	Black Opaque	30.7	0.32	14.7		Represents Japanese asphalt base crude oil. Suitable for manufacture of lubricating oil and light oil. 37% of asphalt can be obtained.

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Name of Crude Oil	Color	Pitch (%)	Paraffin (%)	Degrees (°Be)	Flash pt(°C)	Remarks
KATSURANE (AKITA)	Blue Black	9.0	0.983	34.0	less than 15	A mixed base crude oil.
ASAHIGAWA (AKITA)	Black Opaque	20.0	0.542	21.2	30	Suitable for manufacture of gasoline, kerosene, light oil and lubricating oil. Raw material for asphalt.
DOYOMIGAWA (AKITA)	Black Opaque	15.0	0.502	20.7	51	Contains 20% of gasoline, 20% of light oil and 28% of kerosene. Suitable for manufacture of lubricating oil and asphalt.
HANEKAWA (AKITA)	Blue Black Opaque	5.6	2.108	32.0	23	Contains much paraffin, about 22% of light oil and about 20% of kerosene. Raw material for lubricating oil.
ISHIKARI (HOKKAIDO)	Blue Black Opaque		1.313	43.1	less than zero	Contains about 45% of gasoline and comperatively rich in paraffin.
SAGARA (SHIZUOKA)	Blue Green Transparent		1.192	42.0	-9	High content of gasoline and light oil.

C. Amount of Japanese Crude Oil Production

The crude oil production (barrels) in Japan (including FORMOSA) from 1930 to 1936 is as follows:

1930	2,048,564 barrels
1931	1,966,007
1932	1,627,253
1933	1,455,186
1934	1,820,479
1935	2,249,198
1936	2,539,311

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The crude oil production in various districts in Japan is listed as follows:

Prefecture	Barrels
NIIGATA	797,176
AKITA	529,105
HOKKAIDO	92,018
SHIZUOKA	163
NAGANO	151
YAMAGATA	119
Total	1,418,732

The crude oil produced in various oil fields in Japan from January to June, 1935 is shown as follows:

Oil Field	Production (bbls.) Jan.-June	Per Day
NISHIYAMA, Niigata	146,255	794
NIIZU, Niigata	117,900	647
NAKANO OGUNI, Akita	141,859	794
TOYOKAWA, Akita	86,980	476
ASAHIKAWA, Akita	65,878	363
HIGASHIYAMA, Niigata	37,453	204
OHOMO, Niigata	27,811	159
YURI, Akita	22,359	125
ATSUMA, Hokkaido	26,215	147
ISHIKARI, Hokkaido	15,628	85
NIPPON OGUMI, Akita	11,877	65
INNAI, Akita	177,607	976
ASAHI INNAI, Akita	44,174	250

IV. SUPPLY-DEMAND AND RELATION OF OIL IN JAPAN

A. Consumption of Oil

About 1926 Japan's demand for petroleum was 20% fulfilled by Japanese crude oils and 80% by imported oils. These imported oils included both refined and crude oils. As the production of Japanese crude oils did not increase in proportion to the demand, the ratio to the imported oils became smaller. By 1936 only about 10% of the demand was met by Japanese crude oils. Thus, in 1936, the demand of oil for civilian use in Japan was 3,119,000 tons per annum, while the production of Japanese crude oil was about 320,000 tons and imports of refined oil amounted to 1,811,000 tons, and of imported crude oil, 1,048,000 tons per annum.

B. Oils Imported to Japan

1. Crude oil for manufacture of gasoline. In 1923 the Nippon Oil Co. imported crude oil for the first time from California through the Mitsui Bussan Co. The oil was Long Beach crude of 24° Be supplied by the General Oil Co. Thereafter 25° Be and 30° Be crude oils were imported from the Associated Oil Co. and Union Oil Co., respectively. Of gasoline that was manufactured, 25% came from these oils. In 1927 the Nippon Oil Co. imported 25° Be Kiwood crude oil produced by the Rio Grande Oil Co. and containing more than 30% of gasoline. In 1931 Kettleman crude, which contained more sulphur than Kiwood crude, and had a 40% yield of gasoline, was purchased at a comparatively cheap price. The Asano Bussan Co. also imported

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Kettleman crude from the Standard Oil Co. in California. Thus, the crude oil imported into Japan was mainly Kettleman. Quanities were also imported from Equador for manufacture of gasoline and light oil. Poza Rica crude oil was imported from Mexico. The above crudes were mainly used for manufacture of automotive gasoline.

Midway Sunset, Olinda Brea, San Joaquin Valley and Wilmington crudes were imported for the purpose of manufacturing aviation gasoline. Gulf Coastal crude was also imported for the same purpose.

2. Crude for manufacture of lubricating oil. Coalinga, Fosc Creek, Miri, Round Mountain, and other crude oils were imported for the purpose of manufacturing lubricating oils.

V. OIL REFINING PROCESSES

A. Crude Stills

Most of the oil refinery plants of large scale have adopted pipe-stills for continuously distilling crude oil. In 1930 the Nippon Oil Co. constructed a Foster Pipe-still at the Kudamatsu Oil refinery plant for distilling crude oil. A Smith-Leslie Pipe-Still was also constructed there. A pipe-still patented by the Nippon Oil Co. was installed at the Tsurumi Oil Refinery Plant of the same company in 1932 and at the Aikoku Oil Co. in 1937.

B. Cracking Units

In 1924 the Nippon Oil Co. constructed a Dubbs cracking system at the Tsurumi Oil Refinery. Gross units were installed at the Niigata Oil Refinery of the Nippon Oil Co. in 1926, at the Kudamatsu Oil Refinery of the Ogura Oil Co. in 1931, and at the Kawasaki Oil Refinery of the Mitsubishi Oil Co. in 1931. In 1926 a Jenkins unit was constructed at the Tokyo Oil Refinery of the Ogura Oil Co. In 1933, a Cyro unit was constructed at the Navy Tokuyama Refinery for research purposes. Schwartz units were constructed at the Kawasaki Oil Refinery plant of the Hayama Oil Co. in 1935 and at the Niizu Oil Co. in 1938. The Nippon Oil Co. constructed a N.N.C. system in April 1935. The Aikoku Oil Co. also adopted the N.N.C. system.

C. Vacuum Distillation Units

Vacuum distillation plants have been adopted in this country as follows:

Schwartz (Continuous)	Nippon Oil Co.	in 1927
	Ogura Oil Co.	in 1926
Heckmann (Continuous)	Maruzen Oil Co.	in 1929
(Batch)	Edogawa Oil Refinery Plant	in 1929
	Hayama Oil Co.	in 1931
M. H. (Batch) (Improvement of Heckmann)	Niizu Oil Co.	in 1931
Kellogg (Continuous)	Mitsubishi Oil Co.	in 1932
	Ogura Oil Co.	in 1937
Badger (Continuous)	Osaka Oil Refinery Plant	in 1937
	Toyo Oil Co.	in 1937
	Toyo Shoko Oil Co.	in 1938
Cubro (Continuous)	Hayama Oil Co.	in 1937

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D. Lubricating Oil Refining

The most common process of refining lubricating oils consists of washing the distillate with concentrated sulphuric acid, caustic soda solution, and warm water, and heating in a large iron tank to clarify the oil. In recent years the Sharples Centrifuge has been used in large plants for sulphuric acid washing. Acid oil obtained from distillates of high viscosity tends to emulsify and water can not easily be separated therefrom after washing with caustic soda solution. Accordingly, after the concentrated sulphuric acid washing, active acid clay is used instead of caustic soda washing to effect deoxidation and decoloration at the same time. The active acid clay is one which is obtained by activating acid clay with hydrochloric acid or sulphuric acid and has a decolorizing power of 2.5 to 3 times that of acid clay. If the crude oil contains paraffin, it must be completely dewaxed.

In recent years, refining plants for the manufacture of high class lubricating oils by means of solvents have been installed because of the development of aircraft. The Showa Oil Co. and Maruzen Oil Co. adopted refining processes in which the furfural process, Duo-sol process, Barisol dewaxing process and contact re-run process are combined to form one plant. In 1942 the Showa Oil Co. and Maruzen Oil Co. commenced the manufacture of aviation lubricating oil. A Japanese crude oil highly suited for refining of high class lubricants by means of solvent refining is Omonogawa crude oil from AKITA Prefecture. The viscosity index of this crude oil is about 85-90.

Two processes for solvent refining lubricating oils are used in Japan. One is Duo-sol refining, Barisol dewaxing, and contact re-run refining.

The Navy used a propane de-asphalting process, propane dewaxing, and active acid clay refining, but good results were not obtained.

The Nippon Oil Co. used a process in which the furfural extraction and propane de-asphalting were combined. In April, 1945, the Army constructed the Marifu Oil Refinery of 2,000 bbl/day in YAMAGUCHI Prefecture. This plant, later destroyed by bombardment, planned to refine Liliku crude oil produced in Sumatra by means of the Duo-sol process. A flow chart for the plant is given by Figure 1(D).

The conversion of animal and vegetable fatty acid into high class lubricating oils has been earnestly studied in Japan. Plants based on this conversion were constructed and pilot plant products were produced. However, at the termination of the war the refined oil was not produced on commercial scale. The Nippon Tokushu Oil Co. adopted a process in which condensation of benzol and paraffin was utilized. The Nippon Fatty Co. adopted a process in which fatty acid, after hydro-cracking, is condensed in the presence of aluminium chloride. The Miyoshi Chemical Engineering Co. adopted a process in which fatty acid, after saponification with alkali, is condensed in the presence of aluminium chloride. The Miyoshi Chemical Engineering Co. adopted a process in which fatty acid, previously heat treated, was decomposed and polymerized in the presence of active acid clay, and the product thus obtained was hydrogenated to yield refined oil. The best result was obtained when oxidation inhibitor was added to this oil. Dr. Yuzaburo MAOAI, a professor at Tokyo Imperial University, studied the last mentioned process for many years. A 7,000 KL/year plant based on this process was completed at AMAGASAKI, HYOGO and was under test operation at the termination of the war. The product obtained from the pilot plant was used for the 16,435 km. non-stop flight in MANCHUKUO under the auspices of the Asahi Newspaper. In this flight lu-

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bricant consumption was 4-5 gm hp/hour at maxium horse power, and 0.9 gm hp/hour at the normal cruising output. This showed that the oil from the above pilot plant was excellent in every respect. Test results of this lubricant are as follows (wherein the oil was obtained from Nagai's synthetic oil to which was added blending oil obtained from naphthenic base petroleum oil and organic metallic salt inhibitor):

Table I(D)
NAGAI OIL COMPARISON TABLE

Oil Tested		Viscosity				Carbon After Oxidation (%)	Increase of Hydrogen
		Centistokes		Index	Ratio at 100°F		
		210°F	100°F				
Phillips*		26.03	460.1	82.2	1.54	2.602	1.952
Gulf Pride*		25.84	463.6	80.4	1.60	2.190	1.722
City Service*		26.06	454.8	83.6	1.58	2.490	1.634
Nagai's Oil**	BO 5/I 0	24.88	317.9	106.6	1.41	0.820	0.634
	BO 5/I 0.01	24.82	317.5	106.6	1.23	0.532	0.234
	BO 5/I 0.05	24.88	317.9	106.6	1.16	0.470	0.224
	BO 0/I 0.10	24.82	317.4	106.6	1.16	0.472	0.216
	BO 10/I 0	24.79	325.6	104.6	1.28	0.850	0.712
	BO 10/I 0.01	24.76	324.1	104.9	1.24	0.598	0.400
	BO 10/I 0.05	24.76	323.7	105.0	1.17	0.524	0.334
	BO 10/I 0.10	24.73	323.7	104.9	1.16	0.536	0.346
	BO 15/I 0	24.73	330.6	103.3	1.35	0.926	0.724
	BO 15/I 0.01	24.73	330.2	103.4	1.25	0.706	0.504
	BO 15/I 0.05	24.79	330.1	103.7	1.19	0.600	0.399
	BO 15/I 0.10	24.82	330.4	103.7	1.18	0.588	0.406

*(made in America)
**BO - Blending Oil
I - Inhibitor
For example, BO 5/I 0.01 indicates that 5% blending oil and 0.01% inhibitor were added.

ENCLOSURE (D)

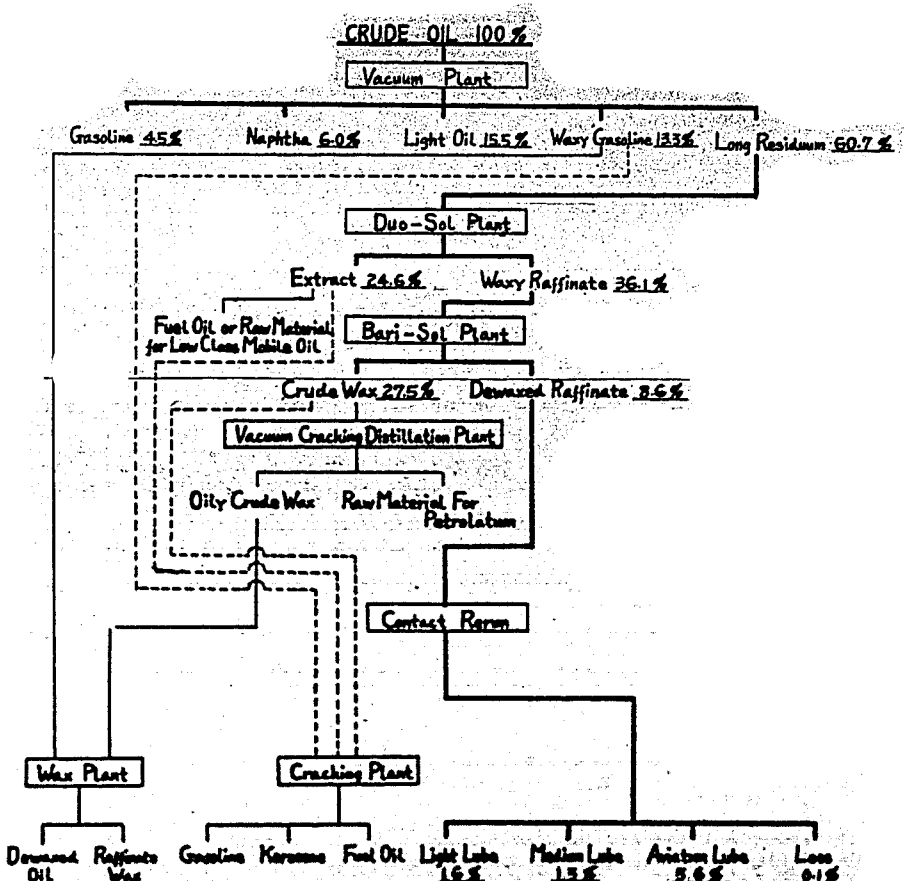

Figure 1 (D)
FLOW SHEET FOR REFINERY OPERATING ON CRUDE OIL PRODUCED IN LILIKU SUMATRA
PLANT CAPACITY: CRUDE OIL 3000 KL/DAY