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MISCELLANEOUS TARGETS

JAPANESE FUELS AND LUBRICANTS - ARTICLE 1
FUEL AND LUBRICANT TECHNOLOGY

U.S. NAVAL TECHNICAL MISSION TO JAPAN

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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

21 February 1946

RESTRICTED

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

Subject: Target Report - Japanese Fuels and Lubricants, Article 1 - Fuel and Lubricant Technology.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 September 1945.

1. Subject report, dealing with certain aspects of Japanese fuel and lubricant technology outlined by Targets X-09, X-10, and X-38(N) of Fascicle X-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Comdr. G.L. Neely, USNR, assisted by Lt. Comdr. C.S. Goddin, USNR, Lieut. W.H. Mittett, USNR, and Ens. E.R. Dalbey, USNR, interpreter and translator.

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Captain, USN

30700

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JAPANESE FUELS AND LUBRICANTS - ARTICLE 1
FUEL AND LUBRICANT TECHNOLOGY

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

FASCICLE X-1, TARGETS X-09, X-10, AND X-38(N)

FEBRUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

MISCELLANEOUS TARGETS

JAPANESE FUELS AND LUBRICANTS - ARTICLE 1
FUEL AND LUBRICANTS TECHNOLOGY

The U. S. Naval Technical Mission to Japan has investigated several aspects of Japanese fuel and lubricant technology, with particular emphasis on the research of the Japanese Navy, and has reported the findings in detail in nine current reports.

This report presents a brief itemization of aspects of this investigation judged to be of particular interest to the U. S. Navy, and lists a few original Japanese developments on which further study may be warranted.

The significant feature of the Japanese Navy's petroleum policy is the fact that it did not rely upon industry for research and refining. Instead, the Navy built, just before the outbreak of the war, one of the world's largest fuel and lubricant research institutions at OFUNA, and also built and operated two of the largest refineries in Japan. While the Army and private industry carried on independent research, the investigation indicated that the research of the Navy was foremost and, therefore, the referenced and detailed reports on fuels and lubricants present the most advanced technological information in Japan.

Aside from the purely technical aspects of fuel and lubricant development, comments are presented relative to the scientific stature of the Japanese people, and it is concluded that Japanese technical ability has been underestimated.

TABLE OF CONTENTS

LIST OF ENCLOSURES

REFERENCES

Location of Target:

First Naval Fuel Depot, OFUNA, Kanagawa Prefecture.
Third Naval Fuel Depot, TOKUYAMA.
First Naval Technical Depot, YOKOSUKA.
Sasebo Navy Yard, SASEBO, Kyushu.
Kure Navy Yard, KURE.
Army Fuel Research Institute, FUCHU.
The Miike Synthetic Oil Company, OMUTA, Kyushu.
Nissan Ekitai Nenryo K.K., Wakamatsu Plant, WAKAMATSU, Kyushu.
Teikoku Nenryo K.K. (Imperial Fuel Co.) Ube Plant, UBE.
Teikoku Nenryo K.K. TOKYO.
Nihon Hatsudokiyu K.K. (Japanese Motor Co.) UBE.
Imperial Fuel Research Institute, KAWAGUCHI, Saitama Prefecture.
Kyoto Imperial University, KYOTO.
Kyushu Imperial University, FUKUOKA, Kyushu.
The Nippon Oil Company, KUDAMATSU.
Nippon Seiro K.K. TOKUYAMA.
Mitsubishi Resin Oil Factory, SHIMANARA, Nagasaki Prefecture, Kyushu.
Shimabara Alcohol Plant of the Kyushu Regional Fuel Department, SHIMABARA, Kyushu.

Japanese Personnel Interviewed:

A detailed listing of personnel is included in the reports referenced below.

Referenced NavTechJap Reports:

"Japanese Fuels and Lubricants, Article 2 - Naval Research on Aviation Gasoline", Index No. X-38(N)-2.
"Japanese Fuels and Lubricants, Article 3 - Naval Research on Alcohol Fuel", Index No. X-38(N)-3.
"Japanese Fuels and Lubricants, Article 4 - Pine Root Oil Program", Index No. X-38(N)-4.
"Japanese Fuels and Lubricants, Article 5 - Research on Rocket Fuels of the Hydrogen Peroxide-Hydrazine type", Index No. X-38(N)-5.
"Japanese Fuels and Lubricants, Article 6 - Research on Diesel and Boiler Fuel at the First Naval Fuel Depot, OFUNA", Index No. X-38(N)-6.
"Japanese Fuels and Lubricants, Article 7 - Progress in the Synthesis of Liquid Fuels from Coal", Index No. S-38(N)-7.
"Japanese Fuels and Lubricants, Article 8 - Naval Research on Lubricants", Index No. S-38(N)-8.
"Japanese Fuels and Lubricants, Article 9 - Fundamental Hydrocarbon Research", Index No. X-38(N)-9.
"Japanese Fuels and Lubricants, Article 10 - Miscellaneous Oil Technology and Refining Installations", Index No. X-38(N)-10.

INTRODUCTION

The extensive use of oil by the Japanese Navy in far-flung sea and air operations during the early part of World War II, and the reported need for non-petroleum substitutes in the final stages of the war, indicated that a thorough investigation of the fuel and lubricant technology of the Japanese Navy would be of value. Such an investigation would provide the U. S. Navy with an opportunity of gaining a detailed understanding of the manner in which the Japanese Navy conducted its fuel and lubricant research and the progress that it had made in the several fields of common interest. From a purely commercial point of view, the Japanese technology did not hold promise of advances valuable enough to be worthy of extended investigation, as did those of Germany.

A. Personnel of Petroleum Section, U.S. Naval Technical Mission to Japan.

The membership of the Petroleum Section comprised, at the outset, three officers experienced in various phases of petroleum research. These technical investigators were assisted by a language officer who served both as interpreter and translator. During the final period of the investigation, a technical representative of the U. S. Bureau of Mines was added to the Petroleum Section to assist in the investigation of research on the conversion of coal to oil by the Japanese and in the seizure of research equipment. This team, for the most part, worked as a group in order that the experience of each member might be available in the investigation of each plant or technical institution. The reports were also written jointly by the several members of the team.

B. Investigation Procedure.

The Petroleum Section arrived at the Japanese Naval Base, SASEBO, Kyushu, on 24 September 1945, and there organized its itinerary in order to cover the targets pertinent to the purposes of the investigation. It was apparent that the widely scattered locations of the various points to be visited in the Japanese Islands and the inadequate means then available for travelling, billeting, and subsistence made it necessary to utilize a conveyance providing the above essentials. For this purpose an ambulance was obtained and especially fitted out with litters for sleeping, extra racks for drinking water and gasoline, and a trailer for food and miscellaneous gear.

At the outset, the general plan for investigating the technical position of Japan on fuel and lubricant technology deemed of interest to the U. S. Navy was to visit those places where "Intelligence Targets Japan" (DNI) of 4 September 1945, indicated possible findings of interest, supplemented by other locations brought out in connection with investigation of the points of visit. However, when in the course of the investigation it was discovered that the fuel and lubricant research of the Japanese Navy was concentrated at one point, the First Naval Fuel Depot at OFUNA, this "honeybee" plan was abandoned. It was decided, rather, to obtain information on OFUNA in the fullest detail, supplemented by investigations of typical refineries and manufacturing plants wherein the products of research were manufactured for naval and other use. A complete outline of the various targets visited by the Petroleum Section is given in Enclosure (A).

THE REPORT

Part I
FUEL AND LUBRICANT REPORTS
SUBMITTED BY U. S. NAVAL TECHNICAL MISSION TO JAPAN

Other reports submitted by the Petroleum Section of the U. S. Naval Technical Mission to Japan constitute in effect a detailed presentation of practically all of the fuel and lubricant research carried out at the First Naval Fuel Depot, OFUNA, supported by technical data on coal conversion and petroleum refining obtained from typical installations located throughout Japan.

Efforts were made to obtain Japanese research documents whenever warranted and forward them through ATIS to the Washington Documents Center. A list of the documents thus handled is included herein as Enclosure (B). Also submitted, as Enclosures (C) and (D), are lists of samples and equipment seized by the Petroleum Team and forwarded to cognizant government laboratories in the United States.

It is not the purpose of this report to summarize the other nine reports, but rather to present some aspects of the Japanese fuel and lubricant technical position judged to be of special interest to the U. S. Navy. However, in order that the reader may understand the nature of these other reports, the following discussion is presented.

In view of the procedure followed, the reports, in general, are based on the research conducted at OFUNA. The technical files of this extensive research institute, which employed some 3,200 men and comprised over 70 modern buildings, were burned 1 August 1945 by the order of Vice-Admiral N. YAMAGUCHI, the Director of the Depot. It was, accordingly, directed by the the U. S. Naval Technical Mission to Japan that approximately one hundred of the Japanese naval technical personnel return to OFUNA to reproduce from notebooks, personal files, memory, and other sources, reports in English covering all of their research activities during the war period. As these reports were prepared, they were reviewed with the authors by the Petroleum Section, and an effort was made to organize them so that they presented the essential information in orderly form, though time and personnel limitations rendered the preparation of smooth reports out of the question. No attempt was made to reject papers of lesser interest, since one of the chief objects was to provide a complete picture of the full scope of the technical work of the Japanese Navy relative to fuels and lubricants during the war period.

The work carried out at OFUNA embraced the broad field of fuel and lubricant research and testing, with special emphasis on the aviation gasoline program. In the closing years of the war, frantic efforts were directed towards boosting the rapidly dwindling supply of aviation gasoline by production from other sources, such as the manufacture of ethyl alcohol from sweet potatoes and of hydrocarbon fuels from oil obtained by the dry distillation of pine roots.

In order to make the results of this investigation more readily usable, they are presented in a series of ten articles or reports, the titles of which are listed in the References and also in Enclosure (E). The papers prepared by the Japanese technicians are submitted as Enclosures in the pertinent reports. They constitute an integral part of each report and reflect the result of lengthy interrogation. Hence, for complete information on the several technical subjects referred to herein, a study of the detailed reports submitted as Enclosures will be necessary.

Part II
TECHNOLOGICAL POSITION OF JAPANESE NAVY IN REGARD TO FUELS AND LUBRICANTS DURING WORLD WAR II

A. Sources of Supply Before and During War.

It was not one of the purposes of this investigation to obtain statistical information on oil production, storage capacity, or stock position, as such information was or is being collected by other U.S. Government agencies, including the U. S. Strategic Bombing Survey and the G-4 Section of the Supreme Commander for the Allied Powers. Suffice it to say that by the time war with the United States came Japan had accumulated a stock pile in excess of 60,000,000 barrels of crude oil and refined products, and its own production amounted to some 2,500,000 barrels per year. The estimated wartime requirement of the Japanese was some 30,000,000 barrels per year, and the crude refining capacity of Japan in 1941 was about 35,000,000 barrels per year. The Japanese planned to draw upon available inventories after Pearl Harbor until their crude oil requirements for both military and civilian needs could be imported from the Netherlands East Indies, and then behind their rings of defense, produce those products needed to stand off the Allied Forces.

What actually happened was that even though production from Borneo and Sumatra equalled expectations by the middle of 1943, U. S. submarines were so successful in sinking tankers that by 1944, Japan found her stock position rapidly declining and her time schedule for research and development greatly foreshortened. A program of constructing small wooden tankers was next undertaken, but this was impeded by an inability to produce a sufficient number of propulsion engines. By the end of 1944, all the refineries in Japan using imported crudes had ceased continuous operation except the Third Naval Fuel Depot at TOKUYAMA, and early in 1945 charging stock for this depot was obtained by using several Japanese aircraft carriers and one battleship for transporting Netherlands East Indies motor gasoline from SINGAPORE. So desperate was the situation at this time that edible soya bean oil was used as bunker fuel in a battleship sunk in the battle of OKINAWA.

Table I lists very briefly the principal sources of fuels and lubricants for the Japanese Navy during the period 1930 to 1945. The last year of the war is of special interest, since the Japanese were forced to seek fuels and lubricants from nonpetroleum sources such as pine root oil; alcohol from sweet potatoes, vegetable oils, and rubber.

Table I
PRINCIPAL SOURCES OF FUELS AND LUBRICANTS FOR THE JAPANESE NAVY DURING WORLD WAR II

Year	Aviation Gasoline	Motor Gasoline	Kerosene	Aviation Lubricants	Diesel Fuel	Bunker Fuel
1940	1) California Crude 2) Imported Iso-Octane	California Crude	California Crude	Imported Finished Lubricants	Kettleman Hills Distillate	1) California Topped Crude 2) OHA (Sakhalin) Crude 3) Shale Oil
1941	1) California Crude 2) Imported Iso-Octane	California Crude	California Crude	Imported Finished Lubricants	Kettleman Hills Distillate	1) California Topped Crude 2) OHA (Sakhalin) Crude 3) Shale Oil
1942	1) California Crude 2) Imported Iso-Octane	California Crude	California Crude	Imported Finished Lubricants	70% Tarakan (Borneo) Crude 30% Shale Oil	1) Sumatra and Borneo Cracked Residues 2) Shale Oil
1943	1) Borneo and Sumatra Crudes 2) Iso-Octane	Sumatra Crude	Borneo and Sumatra Crudes	Osage and Rhodessa Crudes	1) 10% Tarakan (Borneo) Crude - 30% Shale Oil 2) 90% Tarakan (Borneo) 10% Fischer-Tropsch Liquid	1) Sumatra and Borneo Cracked Residues 2) Shale Oil
1944	1) Borneo and Sumatra Crudes 2) Iso-Octane 3) Alcohol (Training Planes)	1) Sumatra Crude 2) Ethyl and Methyl Alcohol	Borneo and Sumatra Crudes	Osage and Rhodessa Crudes	1) 10% Tarakan (Borneo) Crude - 30% Shale Oil 2) 90% Tarakan (Borneo) 10% Fischer-Tropsch Liquid	1) Sumatra and Borneo Cracked Residues 2) Shale Oil
1945	1) Borneo and Sumatra Crudes 2) Alcohol (Training Planes) 3) Iso-Octane 4) Pine Root Oil (Not used in service) 5) Investigation of Miscellaneous Substitutes as Fuel Sources. (Rubber, Vegetable Oil, etc.)	Ethyl and Methyl Alcohol	Borneo and Sumatra Crudes	1) Osage and Rhodessa Crudes 2) Investigation of Synthetic Oils from Other Sources. (Paraffin Wax, Shale Oil, Vegetable Oil, Rubber etc.)	1) 10% Tarakan (Borneo) Crude - 30% Shale Oil 2) 90% Tarakan (Borneo) 10% Fischer-Tropsch Liquid	1) Sumatra and Borneo Cracked Residues 2) Shale Oil 3) Substitute Fuels, such as Soya Bean Oil 4) Investigation of Pine Root Oil

The production of synthetic oil from coal was disappointing. It reached a maximum rate of some 114,000 tons, which was far below that called for by the Japanese Seven-Year Synthetic Oil Plan. It is of interest that the shale oil works at FUSHUN, Manchuria, produced more oil than the combined production from all coal conversion plants in the Japanese Empire.

B. Refining and Storage Facilities.

The Japanese Navy did not depend upon private industry for fuel supplies, but instead built and operated extensive petroleum refining facilities. This policy of independence started in 1905, after the close of the Russo-Japanese War, when a coal briquetting plant was established at TOKUYAMA. Oil refining by the Navy was started in 1920 with the installation of the first pipestill in Japan at TOKUYAMA. This plant was gradually enlarged to a crude capacity of 9,500 barrels per day. In 1940 construction was started on the Navy's 17,000 barrel per day refinery at YOKKAICHI. In 1941 the various fuel activities of the Navy were designated as Naval Fuel Depots. The Fuel Depots reported to be in existence at the close of the war are listed below:

Naval Fuel Depot	Location	Activity
First	OFUNA, Honshu	Fuel and Lubricant Research.
Second	YOKKAICHI, Honshu	Petroleum Refining.
Third	TOKUYAMA, Honshu	Petroleum Refining.
Fourth	SHINBARA, Kyushu	Coal Mining and Carbonization.
Fifth	HEIJO, Korea	Coal Mining.
Sixth	TAKAO, Formosa	Petroleum Refining.
	NIITAKA, Formosa	Manufacture of Synthetic Lubricants (not completed).
	SHINCHIKU, Formosa	Iso-octane Synthesis, Butanol Fermentation (not completed).
101st	SAMARINDA, Borneo	Crude Oil Production.
102nd	BALIKPAPAN, Borneo	Petroleum Refining.

The YOKKAICHI and TOKUYAMA refineries were complete modern installations and together accounted for some 25% of Japan's total domestic refining capacity. The processes utilized were largely of American origin, although some were based on Japanese naval research. The refining equipment itself was built principally in Japan and compared favorably with that manufactured in America.

During the war the Sixth Naval Fuel Depot was established in FORMOSA to refine East Indies crude, to manufacture iso-octane from butanol or natural gas, and to synthesize lubricants from various waxes and fatty oils. These facilities, except for a butanol fermentation plant, were not completed by end of the war. Fuel depots were also established at SAMARINDA and BALIKPAPAN to produce and refine Borneo oils.

The underground storage facilities of the Japanese Navy were most extensive. Such facilities were inspected at TOKUYAMA and at the Naval bases of KURE and SASEBO. In the main they consisted of large cylindrical or rectangular reinforced concrete reservoirs buried in the hills and completely camouflaged with heavy vegetation. The largest single reservoir inspected was located at SASEBO and had a capacity of about 500,000 barrels. Total bulk storage capacity reported at TOKUYAMA was about 9,000,000 barrels, at the SASEBO Navy Yard 4,000,000 barrels, and at the KURE Navy Yard about 1,000,000 barrels.

Research Facilities.

The fuel and lubricant research facilities were concentrated in 1940-41 at the First Naval Fuel Depot, OFUNA. A complete description of the history and facilities of this institution is given in Enclosure (F). The work at OFUNA was supported by practical engine tests on diesel and aircraft fuels and lubricants at the First Naval Technical Depot at the Yokosuka Navy Yard, on boiler fuels at the Maizuru Navy Yard and on turbine oils at the Hiro Navy Yard near KURE. In addition, research on rocket and gas turbine fuels was carried on at the First Naval Technical Institute, YOKOSUKA, and the Naval Technical Research Institute, TOKYO. A minor amount of research was also sponsored by the Navy at the Imperial Universities of KYOTO, TOKYO, and KYUSHU.

Most of above research work was done by "Engineering" naval officers, who had received commissions after graduating from technical universities. A school also was maintained at OFUNA for training the necessary laboratory technicians and assistants. The quality of the research work at OFUNA was, for the most part, not up to American or German standards. A substantial portion of the work was devoted to duplicating foreign developments and contributed little of original value. This situation is attributed mainly to lack of a sufficient number of highly skilled personnel for the tremendous scope of the work undertaken.

D. Specifications.

The fuel and lubricant specifications of the Japanese Navy are submitted herewith as Enclosure (G). In general, these specifications permitted the use of somewhat lower quality products than those used by the U. S. Navy.

Part III
HIGHLIGHTS OF JAPANESE FUEL AND LUBRICANT TECHNOLOGY

The following itemization presents, in abbreviated form, some of the more significant findings of the Petroleum section relative to the fuel and lubricant technology in Japan, with particular emphasis on the research of the Japanese Navy.

A. Aviation Gasoline.

1. During the war the air arm of the Japanese Fleet used a 92 CFR-M octane number combat aviation gasoline until 1942, at which time the octane number was lowered to 91. This octane requirement was maintained for the balance of the war except during the latter months when the octane number was dropped to 87 for summer grade fuel. Other war-time revisions included increases in the permissible maximum lead content and boiling temperatures.

2. Aviation fuel of 100 octane grade was produced in experimental quantities only.

3. Iso-octane production was low in Japan due to inadequate supplies of C_4 hydrocarbons occasioned by the limited cracking capacity of the small refineries. It has been estimated that the peak annual production of iso-octane did not exceed 80,000 barrels.

4. Most of Japan's iso-octane was synthesized from acetylene produced from calcium carbide, and from butanol produced by fermentation in commercial scale plants erected at KONAN, Korea and YOKKAICHI, Honshu.

5. The Japanese were prevented by the Moral Embargo in 1939 from purchasing American "know-how" on catalytic cracking. A fixed-bed process, utilizing Japanese acid clay catalyst, was developed, but actual produc-

tion of aviation gasoline by this process was very small. No evidence of the application of the fluid catalyst principle in Japan was discovered.

6. The most successful processes for manufacturing high octane blending stock, from the standpoint of volume actually produced during the war, were reported to be hydrogenation of cracked gasoline and hydrocracking of petroleum gas oils. These processes as applied in Japan were developed in the Japanese naval research laboratories.

7. The severe shortage of petroleum in 1945 stimulated intensive research on producing aviation gasoline from a variety of substitute sources, including pine root oil, soya bean oil, rubber, alcohol from sweet potatoes, high and low-temperature tar, camphor, orange peel, birch bark, and pine needles.

8. It was planned to install 36,000 pine root oil retorts in Japan with an annual output of some 2,500,000 barrels of crude oil. By processing fractions of this oil in small catalytic cracking and reforming units an annual output of 400,000 barrels of aviation gasoline (90-92 octane number 0.15 vol % lead) was expected. This program was well under way by end of the war.

9. The use of ethyl alcohol as a blending agent in aviation gasoline was impeded by the insolubility characteristics of 95% alcohol, and the lack of equipment in Japan for manufacturing anhydrous ethyl alcohol.

10. The lack of aviation gasoline for flight, training, and experimental purposes seriously impaired Japan's ability to wage war, especially during the latter part of 1944 and in 1945.

B. Diesel and Heavy Fuel Oils.

1. Japanese diesel fuel specifications included a minimum specific gravity of 0.915, in view of ballasting considerations on submarines.

2. The chief source of submarine diesel fuel during the war was a blend of Tarakan (Borneo) crude oil with 30% of refined shale oil produced at FUSHUN, Manchuria.

3. The Japanese were fully acquainted with the advantages of high cetane fuels and conducted research on 80-100 cetane number stocks with a view to using them in special aviation and torpedo-boat diesel engines.

4. Fischer-Tropsch diesel oil, most of which was obtained from the Miike Synthetic Oil Plant at OMUTA, was utilized by the Japanese Navy by blending with 90% of Tarakan oil, to meet diesel fuel specifications. The Japanese Army used about 50% of the Fischer-Tropsch diesel oil production in Japan as a fuel for diesel engines in tanks.

5. Bunker fuels used by the Japanese Navy were imported principally from California prior to the war, and from Borneo and Sumatra during the war.

6. The Duch East Indies crudes were waxy and had high pour points. The Japanese Navy utilized thermal cracking and the addition of one percent of aluminum stearate during the winter of 1944-45 to lower the pour point to the required level.

7. With regard to incompatibility of fuel oils, shale oil was the most troublesome and blends of shale oil and paraffinic base petroleum oils precipitated in storage. In consequence, indiscriminate blending or mixing of fuels oils was not allowed in the Japanese Navy. It was stated that there were no reports of incompatability problems in the fleet.

C. Lubricants.

1. Lubricating oils obtained from Japanese crudes were of a highly naphthenic nature, and oils suitable for aircraft engine lubrication could be produced only in small yields. This fact necessitated Japanese reliance on imported finished oils or crudes as a source of lubricants during the war.

2. Japanese refineries utilized conventional methods in the refining of lubricating oils. The processes used most extensively were:

(a) Propane de-asphaltizing, Duo-Sol extraction, Barisol dewaxing, and contact re-run refining.
(b) Furfural extraction, acetone-benzene dewaxing, and contact re-run refining.

3. The Japanese Navy initiated extensive fundamental studies of the relationship between chemical structure and lubricant characteristics. It was concluded that structures in which cyclohexane rings are joined in the para position, either by single bonds or by paraffinic chains, are the most suitable for lubricating oils.

4. A satisfactory aircraft engine lubricant was prepared commercially by polymerizing the distillate of cracked paraffin wax in the presence of aluminum chloride.

5. Extensive research and pilot plant studies were undertaken relative to the manufacture of high-grade lubricating oils by the polymerization of cracked or unsaturated fractions of shale oil, Fischer-Tropsch liquid, vegetable oils, rubber, and pine root oil.

6. Anti-oxidants, corrosion inhibitors, and oiliness agents were not used extensively in engine lubricants, although a considerable amount of research on lubricant additives was conducted.

7. A special study was made relative to the use of soya bean phosphatides as additives serving the dual purpose of oxidation inhibitors and oiliness agents, although the findings were not applied to practice.

8. A lubricant of high viscosity index and good stability characteristics was prepared in the laboratory by the co-polymerization of cracked wax distillate, naphthalene, and sulfur.

9. The use of the following special lubricants by the Japanese Navy is of interest:

(a) A special watch oil consisting of a selected fraction of the co-polymerization product of cracked wax and toluene.
(b) An anti-corrosive cylinder oil composed of rapeseed oil compounded with aluminum stearate, triethanol amine, and n-butanol.
(c) An aero-torpedo engine lubricant consisting of polymerized cracked wax distillate plus 1½% aluminum oleate.
(d) An aircraft engine magneto grease containing the soda soap of castor oil, and milled to a smooth texture.
(e) An aluminum stearate type water-proof grease for submarine topside lubrication.

D. Conversion of Coal to Oil.

1. Coal hydrogenation probably was studied more intensively in Japan than in any country of the world except Germany.

2. In attempting to develop the domestic coal hydrogenation technology, the Japanese Navy blocked purchase of the German Bergius hydrogenation patents in order to encourage independence of thought among their own scientists. The Japanese Army, however, carried on negotiations with Germany throughout the war, in an unsuccessful attempt to secure technical information on their coal hydrogenation process.

3. Japan attempted to develop rapidly coal hydrogenation to industrial scale as a war measure, without an adequate background in intermediate scale engineering practice. Only two commercial scale coal hydrogenation plants were installed in the Empire, and oil output from both was insignificant.

4. Japan's main contribution to the Fischer-Tropsch process was Prof. KITA's synthetic iron catalyst, which was used in a section of the TAKIKAWA plant throughout the war.

5. Japan's most successful Fischer-Tropsch plant, the Miike Works, was built directly on the basis of Ruhrchemie patents and all important equipment was of German manufacture.

6. Coal carbonization produced more liquid fuels in the Japanese Empire during the war than coal hydrogenation and the Fischer-Tropsch synthesis combined.

7. All successful coal carbonization installations in Japan were built on foreign designs, especially the Lurgi and Koppers systems. Japanese designed systems were installed but did not operate satisfactorily, and the plants were abandoned.

8. A "Seven Year Plan" was established to achieve an annual production of 1,000,000 kl each of synthetic gasoline and fuel oil by 1943. Actual production of all synthetic fuels in the peak year, 1944, was only about 114,000 kl, divided as follows: Hydrogenation, 700 kl; Fischer-Tropsch Process, 17,800 kl; Low Temperature Carbonization, 95,400 kl.

Part IV
SOME SIGNIFICANT JAPANESE FUEL AND LUBRICANT DEVELOPMENTS OF AN ORIGINAL NATURE

The items referenced below have been selected from the detailed reports of this series ("Japanese Fuels and Lubricants") with the thought that they may be of particular interest to those conducting investigations in these fields and of possible value in future American technological developments.

Subject	Article*	Title	Index No.	Enclosures
Commercial application of process for manufacture of iso-octane from acetylene.	2	Naval Research on Aviation Gasoline	X-38(N)-2	(B)10, (B)11, (B)13, (B)14, and (B)15
Commercial application of process by which terpenes are catalytically converted to aromatics.	4	Pine Root Oil Program	X-38(N)-4	

Subject	Article	Title	Index No.	Enclosures
Commercial production of concentrated (80-85%) hydrogen peroxide using tin-lined and porcelain equipment.	5	Research on Rocket Fuels of the Hydrogen Peroxide-Hydrazine Type	X-38(N)-5	(B)7
Research on development of iron catalysts for Fischer-Tropsch Process.	7	Progress in the Synthesis of Liquid Fuels from Coal	X-38(N)-7	(D)
Fundamental studies relating chemical structure to lubricating oil characteristics.	8	Naval Research on Lubricants	X-38(N)-8	(A), (B)1, and (B)2
Commercial production of lubricants by polymerization of cracked wax distillates, and research on co-polymerization of these distillates with various other materials	8	Naval Research on Lubricants	X-38(N)-8	(A) and (B)10

*Of NavTechJap Report Series "Japanese Fuels and Lubricants".

Part V
GENERAL OBSERVATIONS REGARDING JAPANESE RESEARCH

One of the most impressive attributes of the Japanese is the tremendous importance which they attach to research. In a land severely limited in resources, lavish expenditures of materials and personnel for research were made even to the very last day of the war.

While in peace-time, American, German and British techniques were copied extensively both in laboratories and in refining installations — after the outbreak of the war, the Japanese showed initiative in modifying known methods to suit the changing conditions of raw material supply to produce the final products most needed.

It has been concluded by some investigators that the research and scientific ability of the Japanese is mediocre. This is believed to be a fallacy. It is rather concluded, on the basis of research discussed herein, that their progress has been conspicuous and that within the next few decades Japan may well become one of the foremost technical nations of the world.

It may be of interest to contrast the petroleum research policy of the U. S. Navy with that of Japan. In the United States it was adequate to place the Navy's fuel and lubricant research problems before the industry, and then adopt the specifications of the advanced products available in sufficient quantity for the Navy's needs. This plan maintained the competitive spirit between oil companies and resulted in the Navy acquiring fuels and lubricants of outstanding quality. In Japan, the oil industry was not equipped to handle a job of this magnitude, and it was necessary for the Japanese Navy to establish its own research and manufacture as an essential arm of its fighting force.

ENCLOSURE (A)

ITINERARY OF THE PETROLEUM TEAM OF THE U. S. NAVAL TECHNICAL MISSION TO JAPAN

Date	Place	Target	Activity
2 Oct - 10 Oct	OMUTA, Kyushu	Miike Synthetic Oil Co.	Fischer-Tropsch Process for Conversion of coal to liquid fuel.
11 Oct - 16 Oct	SASEBO, Kyushu	Sasebo Navy Yard.	Underground Storage and Inspection of Japanese Naval Ships.
18 Oct	SHIMABARA, Kyushu	Shimabara Alcohol Plant of the Kyushu Regional Fuel Department.	Production of Alcohol.
23 Oct	FUKUOKA, Kyushu	Kyushu Imperial University.	Research on the Synthesis of Gasoline from Rubber.
24 Oct - 25 Oct	WAKAMATSU, Kyushu	Nissan Ekitai Nenryo K.K.	Low Temperature Carbonization of Coal by Lurgi Process.
27 Oct - 29 Oct	UBE, Honshu	Teikoku Nenryo K.K.	Synthesis of Oil by Low Temperature Carbonization. Hydrogenation Plant Under Construction.
29 Oct - 3 Nov	TOKUYAMA, Honshu	Third Naval Fuel Depot.	Refining of Lubricants used by the Japanese Navy. Second Largest Refinery in Japan.
4 Nov - 5 Nov	KURE, Honshu	Kure Navy Yard.	Underground Storage Facilities.
12 Nov - 25 Feb	OFUNA, Honshu	First Naval Fuel Depot.	Japanese Naval Research on Fuels and Lubricants.
11,18,21, and 28 Jan	KAWAGUCH, Honshu	Imperial Fuel Research Institute.	Research on Preparation of Synthetic Fuels by Coal Carbonization, Hydrogenation, and Fischer-Tropsch Processes.
12 Jan	FUCHU, Honshu	Army Fuel Research Institute.	Japanese Army Research on Fuels and Lubricants.
14-21 Jan	KYOTO, Honshu	Kyoto Imperial University.	Research on Catalysts for Fischer-Tropsch Process.
Nov - Jan	TOKYO, Honshu	Teikoku Nenryo K.K. The Nomura Office U.S.S.B.S.; U.S. Army	Miscellaneous U.S. Government and Japanese Oil Activities.

ENCLOSURE (B)

DOCUMENTS FORWARDED THROUGH ATIS TO THE WASHINGTON DOCUMENTS CENTER

Documents relating to Target Report S-38(N)-1, "Japanese Fuels and Lubricants, Article 1 - Fuel and Lubricant Technology."

NavTechJap No.	Title	ATIS No.
ND26-0012	Work hand book for fuel.	4583

Documents relating to Target Report X-38(N)-2, "Japanese Fuels and Lubricants, Article 2 - Naval Research on Aviation Gasoline."

NavTechJap No.	Title	ATIS No.
[1] ND26-0005.1 to .27	Various reports printed on aviation gasoline.	4576
[2] ND26-0011.1 to .26	Kyushu Imperial University: Technology Report.	4582
[3] ND26-0022	Synthesis of triptane.	4593
[1] ND26-0013.3, .5, .8, .9, .14 .22	Hydrocarbon research.	4584

Documents relating to Target Report X-38(N)-3, "Japanese Fuels and Lubricants, Article 3 - Naval Research on Alcohol Fuel."

NavTechJap No.	Title	ATIS No.
[1] ND26-0006.1 to .10	Research reports on alcohol and its use as fuel.	4577

Documents relating to Target Report X-38(N)-4, "Japanese Fuels and Lubricants, Article 4 - Pine Root Oil Program."

NavTechJap No.	Title	ATIS No.
[1] ND26-0010	Reference on pine-root oil.	4581
[3] ND26-0020	Preparation of aviation gasoline from pine-root oil.	4591
[4] ND26-0018.1 to .2	Miike Company research on pine oil.	4589

Documents Relating to Target Report X-38(N)-6, "Japanese Fuels and Lubricants, Article 6 - Research on Diesel and Boiler Fuel at the First Naval Fuel Depot, OFUNA."

NavTechJap No.	Title	ATIS No.
[1] ND26-0007.1 to .16	Reports on research into diesel and boiler fuels.	4578

ENCLOSURE (B)

Documents relating to Target Report X-38(N)-7, "Japanese Fuels and Lubricants, Article 7 - Progress in the Synthesis of Liquid Fuels from Coal."

NavTechJap No.	Title	ATIS No.
[4]ND26-0008.1 to .76	Research reports on conversion of coal to oil.	4579
[4]ND26-0015.1 to .30	Detail drawing of Miike Synthetic Oil Company.	4586
[4]ND26-0016.1 to .10	Research papers on lubricating oils.	4587
[4]ND26-0017.1 to .4	Research papers on catalysts.	4588
[4]ND26-0018.1 to .2	Miike Company research on pine oil.	4589
[4]ND26-0019.1 to .19	Research on coal to oil manufacture.	4590
[4]ND26-0004.1 to .31	List of selected correspondence between Germany and the Mitsui Company.	4575
[3]ND26-0023.1 to .12	Reports on coal hydrogenation.	4594
[3]ND26-0024.1 to .3	Reports on Fisher-Tropsch process.	4595
[3]ND26-0025.1 to .4	Reports on low-temperature carbonization.	4596
[3]ND26-0021	Explosive combustion of coal dust fuel.	4592
[5]ND26-0026.1 to .32	Research on gasoline synthesis.	4597
[5]ND26-0027.1 to .3	Journal of Society of Chemical Industry.	4598
[5]ND26-0028.1 to .6	Journal of Society of Chemical Industry.	4599
[5]ND26-0029.1 to .15	Journal of Society of Chemical Industry.	4600
[5]ND26-0030.1 to .2	Journal of Society of Chemical Industry.	4601

Documents relating to Target Report X-38(N)-8, "Japanese Fuels and Lubricants, Article 8 - Naval Research on Lubricants."

NavTechJap No.	Title	ATIS No.
[1]ND26-0009.1 to .16	Research reports on lubricating oils.	4580

ENCLOSURE (B)

Documents relating to Target Report X-38(N)-9, "Japanese Fuels and Lubricants, Article 9 - Fundamental Hydrocarbon Research."

NavTechJap No.	Title	ATIS No.
[1]ND26-0013.1 to .22	Hydrocarbon research.	4584

Documents relating to Target Report X-38(N)-10, "Japanese Fuels and Lubricants, Article 10 - Miscellaneous Oil Technology and Refining Installations."

NavTechJap No.	Title	ATIS No.
[1]ND26-0014.1 to .44	Reports on oil technology	4585
[6]ND26-0031.	Shale oil.	4602
[7]ND26-0032.1 to .9	Research papers on catalytic-cracking.	4647

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[1] Obtained at the First Naval Fuel Depot, OFUNA.
[2] Obtained at Kyushu Imperial University, FUKUOKA, Kyushu.
[3] Obtained at the Imperial Fuel Research Institute, KAWAGUCHI.
[4] Obtained at the Miike Synthetic Oil Co., OMUTA.
[5] Obtained at Kyoto Imperial University.
[6] Published at FUSHUN, Manchuria, and obtained at Nihon Seiro K.K., KUDAMATSU.
[7] Obtained at Toa Nenryo K.K., TOKYO.

ENCLOSURE (C)

LIST OF FUEL AND LUBRICANT SAMPLES FORWARDED TO THE U. S. NAVAL ENGINEERING EXPERIMENT STATION OR THE NAVAL RESEARCH LABORATORY

Samples from the Miike Synthetic Oil Co., OMUTA, forwarded to the Naval Research Laboratory, Anacostia, D. C.

NavTechJap Equipment No.	Description	Amount
JE26-0001	Condensed Fischer Oil	3.7 lit
	Motor Gasoline (Fischer-Tropsch)	3.7 lit
	Diesel Oil (Fischer-Tropsch)	3.7 lit
JE26-0002	Paraffin Oil (Fischer-Tropsch)	3.7 lit
	Paraffin Wax, 60°C, min. M.P. (Fischer-Tropsch)	1.5 kg
	Paraffin Wax, 85°C, min. M.P. (Fischer-Tropsch)	1.5 kg
JE26-0003	Spent Fischer-Tropsch Catalyst	1.5 kg
	Catalyst for Removal of Organic Sulfur.	1.8 kg
	Catalyst for Removal of Inorganic Sulfur.	1.8 kg
JE26-0004	Miike Coke	1.5 kg
	Miike Coal	2 kg
	Unreduced Catalyst (Fischer-Tropsch)	1 kg
JE26-0005	Active Carbon Oil (Fischer-Tropsch)	1.8 lit
	Condensed Oil (Fischer-Tropsch)	1.8 lit
JE26-0006	Pine Root Oil	1 lit
	Cracked Pine Root Crude Oil	1 lit
	Pine Root Gasoline	1 lit

Samples from the Mitsubishi Resin-Oil Factory, SHIMABARA, Kyushu, forwarded to the Naval Research Laboratory, Anacostia, D. C.

NavTechJap Equipment No.	Description	Amount
JE26-0007	Turpentine No. 1 (Pine Root Oil Fraction)	500 cc
	Turpentine No. 2 (Pine Root Oil Fraction)	500 cc
	Pine Root Crude Oil.	500 cc
	Pine Tar.	500 cc
	Pine Pitch.	300 gm

ENCLOSURE (C)

Samples taken from the Japanese light cruiser "SAKAWA" and forwarded to the U. S. Naval Engineering Experiment Station, Annapolis, Md.

NavTechJap Equipment No.	Description	Amount
JE26-0003	Heavy Diesel Oil.	5 gal
JE26-0009	Boiler Fuel.	5 gal
JE26-0010	Steam Cylinder Oil.	3 gal
JE26-0011	Turbine and Diesel Lubricating Oil.	1 gal
JE26-0012	No. 8 Grease (Gen. Purpose and Rust Preventive for Aircraft)	10 lb

Samples taken from the First Naval Fuel Depot, OFUNA, and forwarded to the U. S. Naval Engineering Experiment Station, Annapolis, Md.

NavTechJap Equipment No.	Description	Amount
JE26-0013.1	Diesel Fuel	1 lit
JE26-0013.2	Precise Oil No. 1	2 lit
JE26-0014.1	Torpedo Engine Lubricating Oil (for summer use)	200 cc
JE26-0014.2	Precise Oil No. 5	50 cc
JE26-0014.3	Dodecane Polymer (Precise Oil Fraction)	50 cc
JE26-0014.4	Dodecane Polymer (Higher Fraction)	50 cc
JE26-0014.5	Hydrocracked Oil (from Pine Root Oil)	1 lit
JE26-0014.6	Catalytic Cracked Oil (From Pine Root Oil)	150 cc
JE26-0015.1	Aero-Engine Oil (from Rubber)	500 cc
JE26-0015.2	Aero-Engine Oil (from Paraffin)	500 cc
JE26-0015.3	Aero-Engine Oil (from Vegetable Oil)	500 cc
JE26-0015.4	Aero-Engine Oil (from Shale Oil)	100 cc
JE26-0015.5	Motor Oil (from Rubber)	500 cc
JE26-0015.6	Shark Oil (Crude)	500 cc
JE26-0015.7	Squalene (from Shark Oil)	300 cc
JE26-0016.1	Magneto Grease	5 kg
JE26-0016.2	Controllable Pitch Propellor Grease	5 kg
JE26-0016.3	Rocker Arm Grease	5 kg

ENCLOSURE (C)

NavTechJap Equipment No.	Description	Amount
JE26-0016.4	Sea Water Proof Grease	5 kg
JE26-0017.1	Pine Poot Oil (Crude)	1500 cc
JE26-0017.2	Anticorrosive Cylinder Oil	15 lit
JE26-0018.1	Grease for Framework of Aero-Torpedoes	5 kg
JE26-0018.2	Anticorrosive Grease for Interior of Compressed Air Chamber for Aero-Torpedoes.	2 kg
JE26-0018.3	Rocket Fuel Catalyst	1.5 kg
JE26-0018.4	Japanese Acid Clay (Oil Refining at 140°C.)	400 gm
JE26-0018.5	Japanese Acid Clay (Oil Refining at 140°C.)	400 gm
JE26-0018.6	Japanese Acid Clay (Granular)	400 gm
JE26-0018.7	Japanese Acid Clay (Oil Refining at 300°C.)	400 gm
JE26-0018.8	Japanese Acid Clay (for Catalytic Cracking)	400 gm
JE26-0028	Aero-Engine Oil, No. 100	20 lit
JE26-0029	Tea Seed Oil	20 lit
JE26-0030.1-2	Hair Oil	20 lit
JE26-0031	Aero-Engine Oil, No. 140	20 lit
JE26-0032	Aero-Engine Oil, No. 120	20 lit

ENCLOSURE (D)

LIST OF JAPANESE EQUIPMENT AND CATALYSTS FORWARDED TO THE U. S. BUREAU OF MINES, PITTSBURGH, PA.

Equipment from the First Naval Fuel Depot, OFUNA.

NavTechJap Equipment No.	Description	Weight (Estimated)
JE26-0021	Rotary Discharge Valve Assembly.	500 lb
JE26-0022.1-.2	Two High-Pressure Manual Value Assemblies.	15 lb
JE26-0023	High-Pressure Flanged Union Joint Assembly.	25 lb
JE26-0024	High-Pressure Rotating Autoclave Assembly.	150 lb
JE26-0025.1-.2	Two Brass Compression Union Assemblies.	20 lb
JE26-0026	Super-Pressure Autoclave Assembly.	50 lb

Catalyst Sample from the First Naval Fuel Depot, OFUNA.

NavTechJap Equipment No.	Description	Quantity
JE26-0027	One Drum of Hydrocracking Catalyst	150 lb

Fischer-Tropsch Catalyst Samples from Kyoto Imperial University, KYOTO.

NavTechJap Equipment No.	Description	Quantity
JE26-0019.1	Iron Catalyst, Middle Pressure	500 gm
JE26-0019.2	Iron Catalyst, Normal Pressure	500 gm
JE26-0019.3	Ochre Catalyst, Middle Pressure	500 gm

ENCLOSURE (E)

LIST OF ENCLOSURES TO FUEL AND LUBRICANT REPORTS SUBMITTED BY NAVTECHJAP

"Japanese Fuels and Lubricants, Article 2 - Naval Research on Aviation Gasoline", Index No. X-38(N)-2.

Enclosures

(A) "Summary of Aviation Gasoline Research at the First Naval Fuel Depot, OFUNA", prepared (in English) by Engineering Lieutenant Commander H. HOSHIMIYA.

(B) Detailed Japanese Research Reports (in English) on Aviation Gasoline Research at the First Naval Fuel Depot, prepared under the supervision of the Petroleum Section of the U.S. Naval Technical Mission to Japan.

	Subject	Author
	Section I - Manufacturing Methods	
(B)1	Studies on the Dehydrogenation of n-butane.	H. KUMAMOTO
(B)2	Polymerization of Butanes in the Presence of Phosphoric Acid.	H. FUJIMOTO Y. MOMOTARI Y. KAKIUCHI
(B)3	Research on the Production of Iso-Butane.	H. HOSHIMIYA R. OTSUKA S. SHINODA O. HIYATA
(B)4	Synthesis of Isoparaffins.	S. NISHINO
	Part I. Studies on the Synthesis of Isomeric Hexanes.	
	Part II. Studies on the Synthesis of Isododecene.	
(B)5	Isomerization of n-Hexane.	H. HOSHIMIYA M. KATO
(B)6	Studies on the Isomerization of n-Butane.	H. HOSHIMIYA
(B)7	Studies on Materials Resistant to Chlorine Compounds.	H. KAMOGAWA
(B)8	Studies on the Alkylation of Iso-Butane.	H. HOSHIMIYA
(B)9	Studies on the Desulphurization of Gasoline.	H. SAKOTA
(B)10	Studies on the Synthesis of Iso-Octane from Acetylene.	T. YAMAMOTO S. SETO
(B)11	Synthesis of Butene from Acetylene.	T. YAMAMOTO
(B)12	Synthesis of Acetone from Acetylene.	T. YAMAMOTO
(B)13	Studies on the Synthesis of Acetaldehyde without the use of Mercury Catalyst.	T. YAMAMOTO
(B)14	Studies on the Manufacture of Acetylene from Hydrocarbon Gases by Electric Arc.	T. YAMAMOTO T. KONOSU

ENCLOSURE (E)

	Subject	Author
(B)15	Studies on the Separation of Acetylene.	T. YAMAMOTO
(B)16	Studies on Hydrocracking of Oils and Tars.	K. MITSUI M. OWAKI A. MORITA U. SATO K. SONE
	Part I. Studies on Hydrocracking of High Temperature Coal Tar.	K. SONE
	Part II. Studies on Hydrocracking of Low Temperature Coal Tar.	K. SONE
	Part III. Studies on Hydrocracking of Oha Gas Oil.	K. SONE
	Part IV. Studies on Hydrocracking of Omonogawa Gas Oil.	K. SONE
	Part V. Studies on Hydrocracking of Sumatra Kerosene.	K. SONE
	Part VI. Hydrocracking Oha Gas Oil in the Semi- Commercial Hydrogenation Pilot Plant.	K. MITSUI
(B)17	Studies on the Manufacture of Aviation Gasoline from Soya Bean Oil.	N. SAKOTA
(B)18	Studies on the Manufacture of Aviation Gasoline by High Pressure Hydrocracking of Soya Bean Oil.	T. IJIMA S. INABA
(B)19	Studies on Preparing Fuels from Rubber.	H. FUJIMOTO
(B)20	Preparation of n-Heptane and Iso Octane for Standard Fuel.	O. MIYATA
(B)21	Studies on Oil Proof Paints.	H. OKAZAKI
Section II - Service Tests		
(B)22	Engine Tests of Aromatic Hydrocarbons for Aviation Fuel.	T. NAKAYAMA
(B)23	Utility Test of Aromatic Fuels. (Aircraft Engine Tests)	T. KONDO S. SOMA
(B)24	Studies on the Standarization of Aviation Gasoline in War Time	
	Part I. Studies on Standarization of Aviation Gasoline Volatility in War Time.	H. HOSHIMIYA
	Part II. Engine Tests of Aviation Gasoline with Increase Tetra-ethyl Lead Content.	K. TSUNODA
(B)25	Utility Tests of Aviation Gasoline Outside Specification.	T. KONDO S. SOMA

ENCLOSURE (E)

Subject	Author
(B)26 Utility Tests of Aviation Gasoline with Increased Tetra-ethyl Lead Content.	T. KONDO S. SOMA
(B)27 Research on Substitutes for Ethylene Dibromide.	H. HOSHIMIYA
(B)28 Studies on a Method of Testing the Stability of Ethyl Fluid.	T. YAMAMOTO G. ISHIDA
(B)29 Research on Antidetonants of the Aniline Series.	H. HOSHIMIYA
(B)30 Research on Antidetonants of the Selenium Series.	H. HOSHIMIYA
(B)31 Research on Oxygen Compounds as Antidetonants.	H. HOSHIMIYA
(B)32 Studies on the Influence of Moisture on Octane Value.	M. UEHARA
(B)33 Engine Test Methods for Aviation Fuels at OFUNA.	T. NAKAYAMA
(B)34 Low Temperature and Low Pressure Experimental Laboratory.	T. NAKAYAMA T. NAKAMURA
Section III - Engine Combustion Research	
(B)35 Photographic Investigations of Flame Propagation and Detonation in Engine Cylinders.	K. NAKATA
(B)36 Engine Detonation Studies by Piezo-electric Indicator.	K. NAKATA
(B)37 Flame Propagation in Engine Cylinders Studied by the Ionization Method.	K. NAKATA
(B)38 Studies of Slow Oxidation of Hydrocarbons by Absorption Spectra.	K. NAKATA

(C) List of Japanese Documents Pertaining to Gasoline Research obtained from the First Naval Fuel Depot, OFUNA, and Kyushu Imperial University, FUKUOKA. (Forwarded through ATIS to the Washington Document Center.)

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"Japanese Fuels and Lubricants, Article 3 - Naval Research and Alcohol Fuel," X-38(N)-3.

Enclosures

(A) "Summary of the Alcohol Research Program at the First Naval Fuel Depot", prepared (in English) by Engineering Lieutenant Commander T. YAMAMOTO.

(B) Detailed Japanese Research Reports (in English) on the Alcohol Fuel Program at the First Naval Fuel Depot, OFUNA, prepared under the supervision of the U. S. Naval Technical Mission to Japan.

Section I - Fermentation and Synthesis

Subject	Author
(B)1 Studies on the Ethanol Fermentation	T. ASAI K. SHIBAZAKI
(B)2 Research on Alcohol Fermentation	

ENCLOSURE (E)

	Subject	Author
	Part I.	T. UMEMURA S. NAKAMURA
	Part II.	T. UMEMURA Y. NODA
	Part III.	T. UMEMURA Y. NODA
	Part IV.	T. UMEMURA M. TAKAHASHI
(B)3	The Absorption of Inorganic Nutrients in the Alcoholic Fermentation by Yeast.	M. KUNO
(B)4	Studies on the Hydrolysis of Pine Wood.	H. FUJIMOTO
(B)5	Studies on the Butanol Fermentation.	
	Part I.	T. UMEMURA
	Part II.	Y. TAKEDA S. SHIMADA
	Part III.	T. UMEMURA M. TAKAHASHI
	Part IV.	Y. TAKEDA S. SHIMADA
(B)6	The Design of a Simplified Alcohol Distillation Plant.	S. SHIOME
(B)7	Synthesis of Methanol.	S. SENDO
(B)8	Studies on the Production of Higher Alcohols from Cracked Petroleum Gases.	T. ITAKURA
(B)9	Studies on Ethyl Alcohol.	O. MIYATA
(B)10	Synthesis of Butanol from Water Gas.	S. ENDO B. INOUE
Section II - Service Tests		
(B)11	Engine Tests of Alcohol as Aviation fuel.	
	Part I. Studies on the Anti-Knock and Auto-Ignition Properties of Pure Ethyl-Alcohol.	T. NAKAYAMA
	Part II. Studies on the Effect of Blending Agents for Ethyl Alcohol when used as Aviation Fuel.	T. NAKAYAMA
(B)12	Studies on the Utilization of Alcohol for Aviation Fuel.	T. YAMAMOTO
(B)13	The Spectroscopic Investigation of the Mechanism of the Combustion of Alcohol.	Y. MOMOTARI Y. KAKIUCHI
(B)14	Studies on Corrosive Properties of Alcohol Fuels.	Y. MOMOTARI K. HIROMOTO

ENCLOSURE (E)

	Subject	Author
(B)15	Studies on the Prevention of Corrosion of Magnesium and Magnesium Alloy by Methanol.	S. ENDO
(B)16	Studies on Alcohol-Proof Paint.	M. OKAZAKI
(B)17	Alcohol Fuel Utility Test (as Aero-Engine Fuel).	T. KONDO S. SOMA

(C) The Kyushu Regional Fuel Department Alcohol Plant, SHIMABARA, Kyushu - Report by NavTechJap.

(D) List of Japanese Research Reports pertaining to Alcohols from the First Naval Fuel Depot, OFUNA. (Forwarded through ATIS to the Washington Document Center.)

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"Japanese Fuels and Lubricants, Article 4 - Pine Root Oil Program," Index No. X-38(N)-4.

Enclosures

(A) "Summary of the Pine Root Oil Research Program at the First Naval Fuel Depot, OFUNA", prepared (in English) by Chemical Engineering Commander H. FUJIMOTO and Dr. S. KOMATSU.

(B) Detailed Japanese Research Reports (in English) on the Pine Root Oil Program at the First Naval Fuel Depot, OFUNA.

	Subject	Author
(B)1	Design Studies of the Carbonization Apparatus for Pine Roots.	S. SANKA
(B)2	Studies on the Carbonization of Rosin.	M. KUMAMOTO
(B)3	Studies on the Catalytic Reforming of Pine Root Oil.	H. FUJIMOTO
(B)4	Design Studies on the Simplified Treating Process for Pine Root Oil.	S. SANKA
(B)5	Pilot Plant Catalytic Cracking Studies on Sumatra Kerosene and Pine Poot Oil.	H. FUJIMOTO
(B)6	Design of Catalytic Cracking Plant for Pine Root Oil.	T. SHIBAZAKI I. KOIKE I. TAKESHITA
(B)7	Studies on the Manufacture of Aviation Gasoline by High Pressure Hydrocracking of Pine Root Oil.	S. INABA
(B)8	Studies on the Manufacture of Aviation Gasoline by High Pressure Hydrocracking of Pine Rosin.	T. IIJIMA S. INABA
(B)9	Studies on the Composition of Pyroligneous Liquor and its Uses.	N. SAKOTA

ENCLOSURE (E)

	Subject	Author
(B)10	Engine Test of Aviation Gasoline Produced from Untreated Pine Root Oil.	T. NAKAYAMA
(B)11	Utility Test of Pine Root Oil.	T. KONDO S. SOMA

(C) Translation of Pamphlet entitled "Pine Root Oils" and published by the First Naval Fuel Depot, 30 January 1945.

(D) The Mitsubishi Resin Oil Factory, SHIMABARA, Kyushu - Report by NavTech-Jap.

(E) List of Japanese Documents pertaining to Pine Root Oil. (Forwarded through ATIS to the Washington Document Center.)

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"Japanese Fuels and Lubricants, Article 5 - Research on Rocket Fuels of the Hydrogen Peroxide - Hydrazine Type," Index No. X-38(N)-5.

Enclosures

(A) "Summary of the Rocket Fuel Research Program at the First Naval Fuel Depot, OFUNA", prepared (in English) by Chemical Engineering Commander H. FUJIMOTO.

(B) Detailed Japanese Research Reports (in English) on the Rocket Fuel Program at the First Naval Fuel Depot, OFUNA.

	Subject	Author
(B)1	Studies on the Synthesis of $(NH_4)_2S_2O_8$ by PbO_2 Anode.	Y. MOMOTARI H. KADA
(B)2	Studies on Materials for Anti-Corrosive Tubes for producing Hydrogen Peroxide by Hydrolysis of Ammonium-Persulphate.	J. UEDA
(B)3	Studies on the Synthesis of Hydrogen Peroxide from Water Vapour by Electric Discharge Method.	H. FUJIMOTO T. KONOSU Y. MOMOTARI
(B)4	Studies on the Synthesis of Hydrogen Peroxide from a Hydrogen-Oxygen Mixture by Electric Arc Discharge.	H. FUJIMOTO T. KONOSU T. MOMOTARI
(B)5	Research on Organic Stabilizers for Hydrogen Peroxide.	S. ITANI
(B)6	Studies on Metallic Materials for the Manufacturing, Storing and Transporting of Hydrogen Peroxide Solutions.	M. OKAZAKI
(B)7	The Design and Operation of Hydrogen Peroxide concentration Plants at the First Naval Fuel Depot.	S. SHINODA

ENCLOSURE (E)

	Subject	Author
(B)8	Synthesis of Hydrazine.	Y. MOMOTARI S. ENDO T. YAMAMOTO
(B)9	Synthesis of Hydrazine from Urea.	T. YAMAMOTO H. NAKANO
(B)10	Studies on the Combustion of Hydrogen Peroxide and Hydrazine-Hydrate.	M. SHIMO

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"Japanese Fuels and Lubricants, Article 6 - Research on Diesel and Boiler Fuel at the First Naval Fuel Depot, OFUNA," Index No. X-38(N)-6.

Enclosures

(A) "Summary of the Diesel and Boiler Fuel Research at the First Naval Fuel Depot, OFUNA", prepared (in English) by Naval Engineer Dr. I. ITAKURA.

(B) Detailed Japanese Research Reports (in English) on the Diesel and Boiler Fuel Research at the First Naval Fuel Depot, OFUNA, prepared under the supervision of the U. S. Naval Technical Mission to Japan.

	Subject	Author
(B)1	Studies on the Production of Diesel Fuel by Liquid SO_2 Extraction.	T. ITAKURA
(B)2	Studies on the Synthesis of High Cetane Fuel by High Pressure Hydrogenation of Fatty Oil.	H. FUJIMOTO T. IWASE
(B)3	Studies on the Synthesis of Diesel Fuel and its Preparation from Crude Petroleum.	I. ITAKURA
(B)4	Studies on the Application of Fischer Oil.	I. ITAKURA
(B)5	Studies on the Properties of Diesel Fuel Oils.	H. FUJIMOTO
(B)6	Paractical Tests of Substitute Diesel Fuels (Creosote Oil).	M. HIRABE
(B)7	Practical Tests of Copra Oils as Substitute Diesel Fuels.	I. NORITAKE
(B)8	Practical Engine Tests for Substitute Diesel Fuels.	K. HOSOI
(B)9	Engine Test Methods for Diesel Fuels at OFUNA.	I. NORITAKE
(B)10	Preparation of Pure a-Methyl Naphthalene.	O. MIYATA
(B)11	Investigations on the Treatment of Lignite Tar.	T. ITAKURA
(B)12	Studies on the Pour Point Depressant for Wax-Containing Fuel Oils.	I. KAGEHIRA A. WAKANA T. HARA

ENCLOSURE (E)

	Subject	Author
(B)13	Studies on the Solidification of Bunker Fuel Containing Wax.	H. FUJIMOTO
(B)14	Practical Tests of Substitute Boiler Fuels (Copra and Copra Pressed Residue).	I. NORITAKE
(B)15	Studies on Briquetting.	M. KUMAMOTO

(C) List of Japanese Research Reports pertaining to Diesel and Boiler Fuels obtained from the First Naval Fuel Depot, OFUNA, and forwarded through ATIS to the Washington Document Center.

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"Japanese Fuels and Lubricants, Article 7 - Progress in the Synthesis of Liquid Fuels from Coal," Index No. X-38(N)-7.

Enclosures

(A) "Summary of Research on Conversion of Coal to Oil at the First Naval Fuel Depot, OFUNA", prepared (in English) by Naval Engineer Comdr. K. MITSUI.

(B) Detailed Reports (in English) of Research on Conversion of Coal to Oil at the First Naval Fuel Depot, OFUNA, prepared under the supervision of the U. S. Naval Technical Mission to Japan.

	Subject	Author
(B)1	The Thermal Cracking of Phenol under High Pressure Hydrogen.	T. OGAWA K. MITSUI
(B)2	On the Thermal Change of Aromatic Compounds in the Presence of High Pressure Hydrogen.	S. YAMAGUCHI
(B)3	Effect of Size of Coal on Coal Hydrogenation.	T. OGAWA
(B)4	Effect of Viscosity of Paste Oil on Coal Hydrogenation.	T. OGAWA I. TAKAHASHI
(B)5	Effect of Ferric Oxide on Coal Hydrogenation.	T. OGAWA I. TAKAHASHI
(B)6	Effect of Reaction Temperature on the Hydrogenation of Coal.	T. OGAWA I. TAKAHASHI
(B)7	Effect of Reaction Pressure on Hydrogenation of Coal.	T. OGAWA
(B)8	Effect of Reaction Time on the Hydrogenation of Coal.	T. OGAWA
(B)9	Studies on the Hydrogenation of Low Temperature Tar.	T. OGAWA
(B)10	On the Coal Hydrogenation Reaction.	K. MITSUI
(B)11	Experiments on Various Coals Produced In Japan.	T. SUZUKI I. TAKAHASHI
(B)12	Studies on Tar for Paste.	T. YOKOTA

ENCLOSURE (E)

	Subject	Author
(B)13	On the Physical Properties of Paste.	T. SUZUKI R. YUMEN
(B)14	Studies on the Hydrogenation of Mixtures of Aromatic Compounds.	T. SUZUKI
(B)15	Studies on the Properties of Tar from Coal Hydrogenation.	S. KOMATSU K. MITSUI
(B)16	On the Mechanism of Coal Hydrogenation.	T. SUZUKI I. TAKAHASHI
(B)17	Coal Hydrogenation in a Semi-Commercial Pilot Plant.	T. SUZUKI K. MITSUI
(B)18	Studies on Catalysts for Coal Hydrogenation.	K. MITSUI T. OKADA
(B)19	Studies on the Fischer-Tropsch Synthesis.	
	Part I. Activation of Cobalt Catalyst by Hydrogeneration.	J. NAKAI
	Part II. Studies on Iron Catalyst.	J. NAKAI
	Part III. Studies on Liquid Phase Synthesis with Iron Catalyst.	J. NAKAI
(B)20	Studies on Coal.	M. KUMAMOTO
(B)21	Studies on Shaly Coal Tar.	M. KUMAMOTO
(B)22	Studies on Simplified Apparatus for the Carbonization of Shaly Coal.	R. SUSUKI
(B)25	Studies on the Extraction of Coal.	M. KUMAMOTO

(C) List of reports (in Japanese), pertaining to research on conversion of coal to oil, obtained from the First Naval Fuel Depot, OFUNA, and forwarded through ATIS to the Washington Document Center.

(D) Research on the Fischer-Tropsch Process at the Kyoto Imperial University - Report by NavTechJap.

(E) Research Activities of the Imperial Fuel Research Institute at KAWAGUCHI - Report by NavTechJap.

(F) The Coal Hydrogenation Plant at FUSHUN - Report by NavTechJap based on interview with Mr. T. MIYAMA, former Manager of the Fushun Plant.

(G) Miike Synthetic Oil Company - Report by NavTechJap.

(H) Nissan Ekitai Nenryo K.K., Wakamatsu Plant - Report by NavTechJap.

(I) History of the Synthetic Oil Industry in Japan - Report by Mr. N. SHONO, Asst. Chief Engineer of Teikoku Nenryo K.K.

(J) Teikoku Nenryo K.K., UBE Works - Report by NavTechJap.

ENCLOSURE (E)

"Japanese Fuels and Lubricants, Article 8 - Naval Research on Lubricants," Index No. X-38(N)-8.

Enclosures

(A) "Summary of the Lubricants Research Program at the First Naval Fuel Depot, OFUNA", prepared (in English) by Chemical Engineering Captain Dr. I. KAGEHIRA.

(B) Detailed Japanese Research Reports (in English) on the Lubricant Program at the First Naval Fuel Depot, OFUNA, prepared under the supervision of the U. S. Naval Technical Mission to Japan.

	Subject	Author
(B)1	On the Synthesis of Lubricating Oils.	I. KAGEHIRA
(B)2	Studies on the Synthesis of Aero-Engine Oil by Condensation Method.	I. KAGEHIRA A. WAKANA
(B)3	Studies on the Preparation of Aero-Engine Oils from Shale Oil.	I. KAGEHIRA N. IIMURE
(B)4	Studies on the Manufacture of Aero-Engine Oils from Residual Oils by Solvent Extraction.	I. KAGEHIRA N. MATSUO N. IIMURE I. HARA
(B)5	Pilot Plant for Propane-Phenol Solvent Extraction. (Propane Deasphalting and Dewaxing.)	I. KAGEHIRA N. MATSUO I. HARA
(B)6	Pilot Plant for Propane-Phenol Extraction. (Phenol Extraction in Propane Solution.)	I. KAGEHIRA N. MATSUO I. HARA
(B)7	Pilot Plant for High Pressure Solvent Extraction in Propane Solution with High Pressure Methane and Hydrogen.	I. KAGEHIRA N. MATSUO I. HARA
(B)8	Pilot Plant for Acetone-Benzene Dewaxing.	I. KAGEHIRA N. MATSUO I. HARA
(B)9	Explanation of Pilot Plant for Continuous Vacuum Distillation.	N. MATSUO M. OE
(B)10	Studies on the Synthesis of Aero-Engine Oils from Paraffin Wax.	I. KAGEHIRA N. MATSUO E. KOSUGI K. ISHIKAWA M. SUNAZAKI H. NAKAO Y. IKEGAMI
(B)11	Studies on the Composition of Paraffin Wax in Crude Oil.	I. KAGEHIRA H. NAKAO
(B)12	Studies on the Synthesis of Aero-Engine Oil from Fatty Oils.	I. KAGEHIRA A. WAKANA

ENCLOSURE (E)

	Subject	Author
(B)13	Studies of Preliminary Purification of Dry Distillate from Soda Soap.	I. KAGEHIRA N. MATSUO A. WAKANA M. DEHARA
(B)14	Studies on the Synthesis of Aero-Engine Oil by Catalytic Cracking and Polymerization from Fatty Oils.	I. KAGEHIRA N. MATSUO T. SAKURA
(B)15	Studies on the Synthesis of Aero-Engine Oils from Rubber.	I. KAGEHIRA N. MATSUO K. ISHIKAWA N. KOTAKE T. ISHIWATA M. TOYAMA
(B)16	Research on the Preparation of Lubricating Oils from Brown Coal Tar.	I. KAGEHIRA N. MATSUO M. TOYAMA
(B)17	Studies on the Manufacture of Lubricating Oil from Pine Root Oil.	I. KAGEHIRA N. MATSUO T. ISHIWATA
(B)18	A Simplified Method of Reclaiming Used Lubricating Oil.	T. FUJIMOTO
(B)19	Studies on Lubricating Oils for Marine and Aero-Torpedo Engines.	I. KAGEHIRA N. MATSUO M. HIRATA M. MAEDA
(B)20	Studies on Lubricants for Diesel Engines.	I. KAGEHIRA M. HIRATA
(B)21	Studies on Precise Oils.	I. KAGEHIRA N. MATSUO I. HARA
(B)22	Experimental Manufacturing Method for Precise Oils.	N. MATSUO M. HIRATA
(B)23	Studies on Anti-Oxidants for Aero-Engine Oils.	I. KAGEHIRA A. WAKANA N. KOTAKE M. ASAI S. MIYAKE A. MORI
(B)24	Experimental Method for Manufacturing Additive Agents.	N. MATSUO M. HIRATA
(B)25	Engine Tests of Compounded Aircraft Engine Lubricating Oil, Relative to the Influence of Tricresylphosphite and Tricresylphosphate as Additive Agents.	T. FUJIMOTO
(B)26	Engine Test with Proposed Lubricating Oil Addition Agents.	T. KONDO K. SHIMURA

ENCLOSURE (E)

	Subject	Author
(B)27	Studies on the Oiliness Characteristics of Pure Hydrocarbons Based on Static Friction Determination for Steel on Steel.	I. KAGEHIRA M. HIRATA
(B)28	Studies on the Oiliness Characteristics of Stearic Acid, Benzene, and their Derivatives, Based on Static Friction Determinations for Steel on Steel.	I. KAGEHIRA M. HIRATA
(B)29	Studies on Soya Bean Phosphatides as Additives for Lubricating Oils.	I. KAGEHIRA M. HIRATA
(B)30	Studies on Methods of Testing the Oiliness of Lubricating Oil.	I. KAGEHIRA M. HIRATA
(B)31	To Test Lubricants under Extreme Pressure.	F. FUJIMOTO
(B)32	Studies on Additives For Submarine Diesel Engine Lubricants.	I. KAGEHIRA M. HIRATA
(B)33	Studies on a Viscosity Index Improver.	I. KAGEHIRA A. WAKANA I. FUJII
(B)34	Studies on High Frequency Insulating Materials.	A. WAKANA
(B)35	Studies on Pour Point Depressants for Lubricating Oils	I. KAGEHIRA A. WAKANA I. HARA S. MIYATA
(B)36	Research on Lubricating Greases.	
	Part I.	I. KAGEHIRA T. DAN
	Part II.	I. KAGEHIRA T. DAN M. ABE
	Part III.	T. DAN
(B)37	Studies on the Preparation of Anti-Corrosive Cylinder Oil.	K. KAGEHIRA N. MATSUO M. HIRATA T. DAN

(C) List of Japanese Documents Pertaining to Lubricating Oil Research obtained from the First Naval Fuel Depot, OFUNA, and forwarded through ATIS to the Washington Document Center.

(D) The Japanese Motor Oil Company, Nihon Hatsudokiu K.K., UBE, Yamaguchi Prefecture - Report by NavTechJap.

ENCLOSURE (E)

"Japanese Fuels and Lubricants, Article 9 - Fundamental Hydrocarbon Research," Index No. X-38(N)-9.

Enclosures

(A) "On the Physical Properties of Some Pure Hydrocarbons", prepared (in English) by Dr. S. KOMATSU of the First Naval Fuel Depot, OFUNA.

(B) "Data on the Thermal Cracking of Pure Hydrocarbons", obtained from Professor A. IBUKI of Kyoto Imperial University.

(C) List of Japanese Documents pertaining to Hydrocarbon Research obtained from the First Naval Fuel Depot, OFUNA, and forwarded through ATIS to the Washington Documents Center.

* * * * *

"Japanese Fuels and Lubricants, Article 10 - Miscellaneous Oil Technology and Refining Installations," Index No. X-38(N)-10.

Enclosures

(A) List of Documents in Japanese Pertaining to Research on Miscellaneous Oil Technology at the First Naval Fuel Depot, OFUNA, forwarded through ATIS to the Washington Document Center.

(B) Detailed Reports (in English) of Research on Miscellaneous Oil Technology at the First Naval Fuel Depot, OFUNA.

	Subject	Author
(B)1	Studies on Acid Clay.	H. FUJIMOTO
(B)2	Entrainment and Plate Efficiency of Bubble-Cap Rectifying Columns.	T. YOKOYAMA

(C) "Development of Catalytic Cracking in Japan" by N. NAKAHARA, President of Toa Nenryo K.K.

(D) "The Petroleum Industry in Japan" by J. AOKI and G. NARA of The Shun Nomura Office.

(E) Nippon Oil Co., Kudamatsu Plant - Report by NavTechJap.

(F) The Third Naval Fuel Depot, Tokuyama Refinery - Report by NavTechJap.

(G) The Nippon Seiro K.K., Tokuyama Plant - Report by NavTechJap.

ENCLOSURE (F)

ENCLOSURE (F)

D E S C R I P T I O N

O F T H E

F I R S T N A V A L F U E L D E P O T

O F U N A

ENCLOSURE (F)

LIST OF ILLUSTRATIONS

* * * * *

LIST OF APPENDICES

ENCLOSURE (F)

DESCRIPTION OF THE FIRST NAVAL FUEL DEPOT, OFUNA

HISTORY

The First Naval Fuel Depot, located in OFUNA, Kanagawa Prefecture, was officially established on 21 April 1941. This Depot was devoted exclusively to research, process development, and practical testing of fuels and lubricants. Previously, the research activities and pilot plant studies had been conducted at the Tokuyama Naval Fuel Depot, and the practical product testing had been performed at the Naval Aviation Technical Depot, YOKOSUKA (later the First Technical Depot). The Depot at OFUNA was established by the Navy so as to centralize all Naval activities pertaining to this particular field at one independent plant.

The aviation fuel and lubricating oil research department of the Naval Aviation Depot was first transfered to OFUNA and reestablished on 27 May 1938, as the Experimental Department of the Naval Fuel Depot. It was then considered desirable to move the research department of the TOKUYAMA Naval Fuel Depot to OFUNA. This transition was begun in June 1939 and completed in March 1940. In April 1941, the independent organization known as the First Naval Fuel Depot was officially established, and it continued operation until 15 August 1945.

BUILDINGS AND GROUNDS

The First Naval Fuel Depot occupies an area of approximately 100 acres and is located about a mile and a half from OFUNA Station. A map of the Depot is included as Appendix (I), and a panoramic view is shown in Figure 1(F). There are a total of 74 buildings within the grounds. Of these, 37 were devoted exclusively to technical work, while the remainder were used for office space, shops, storage, and other related facilities. Nearly all of the laboratories were solid structures built of steel and concrete. The 37 buildings mentioned above provided nearly nine acres of floor space for laboratories, pilot plants, and test apparatus.

Included herein as Figures 2(F) to 20(F) are photographs of some units of the research equipment of the Depot. Although these photographs show only a portion of the equipment, they are indicative of the type of research conducted at OFUNA. Detailed descriptions of all items of equipment are given in the technical reports submitted by the Japanese personnel attached to the First Naval Fuel Depot. These reports are included as Enclosures in the NavTechJap Reports, Index Nos. X-38(N)-1 to -10, inclusive.

The Depot suffered no bomb damage and was never exposed to bombing attacks; however, elaborate preparations had been taken to protect key points from possible damage. Two extensive underground shelters had been built as well as several smaller ones. The buildings containing files, records, and communication centers were carefully protected. The only wooden laboratories on the premises were torn down in June 1945 to minimize the fire hazard.

An extensive cave building program was started in the fall of 1944. Nine large caves to be used primarily for storage of raw materials and equipment were built on or near the Depot during the last year of the war. A series of underground laboratories were also started but were not completed. There were to be ten individual and connected laboratory rooms in one large cave. Some of the individual laboratories had been completed and were being used at the termination of the war. Photographs of the outside view of one of the caves and an underground laboratory are shown in Figures 2(F) and 3(F), respectively.

ENCLOSURE (F)

Although not directly subjected to bombing attacks, the increasing number of bombings on nearby cities during the final months of the war made it necessary for the Depot to be more and more self-sufficient. An example of the extent of this self-sufficiency is indicated by the fact that in 1945 it was found necessary to set aside a building for the manufacture of laboratory glassware, since all commercial sources had been destroyed.

PERSONNEL AND ORGANIZATION

As originally established, the First Naval Fuel Depot consisted of a Research Department and an Experimental Department, in addition to the departments concerned with general affairs, accounts, and medical treatment. The Research Department was responsible for both research and pilot plant studies pertaining to fuels and lubricants, and the Experimental Department was concerned with full scale tests of fuels and lubricants.

As time progressed it was apparent that the Japanese engineering design facilities were inadequate, and it became increasingly difficult to transfer the application of laboratory results to pilot plant stage and also to full scale design for the Naval Refineries at YOKKAICHI and TOKUYAMA. To meet this need, the Chemical Engineering Department was established in April 1944.

Each of the departments described above was broken down into sections, the nature of which varied with changes of emphasis in research activity. A detailed itemization of the organization as it was at the termination of the war is shown in Appendix II.

When first organized in April 1941, there was a staff of 45 and a worker complement of 1,000 men employed at the Depot. The first Superintendent of the Depot was Rear-Admiral Hiromitsu YANAGIHARA. By October 1943 the staff had increased to 120 men, and there were 1940 workers. At this time Vice-Admiral Aiki OBATA was appointed as Superintendent. He remained in this capacity until 1 May, 1945, when he was relieved by Vice-Admiral Nobusuke YAMAGUCHI. At the end of the war there were 3,210 men employed at the First Naval Fuel Depot, and of this number, 410 composed the staff.

Aside from the department heads, most of the key research personnel attached to the Depot had commissions in the Japanese Navy as engineering specialists. A breakdown of the classification of the heads of departments and sections connected with the technical activities is as follows: 6 Naval Officers (1 Vice-Admiral, 3 Captains, 1 Commander, 1 Lt. Commander), 12 Engineering Naval Officers (1 Captain, 2 Commanders, 7 Lt. Commanders, 2 Lieutenants), 3 civilian engineers, and one civilian chemist.

WARTIME RESEARCH

Detailed discussions of the wartime research projects investigated at the First Naval Fuel Depot are included in the NavTechJap reports referenced herein. These projects covered a wide field of application and present a comprehensive picture of the quality and scope of Japanese research activity. The personnel directing this research were competent chemists and chemical engineers, although there appeared to be a scarcity of skilled assistants and technicians.

About 30 patents were granted to the First Naval Fuel Depot during the war. A complete list of these and other patents held by the Depot is given in Appendix III.

ENCLOSURE (F)

Figure 1(F)

PANORAMIC VIEW OF THE FIRST NAVAL FUEL DEPOT, OFUNA

ENCLOSURE (F)

Figure 2(F)
ENTRANCE TO THE MAIN UNDERGROUND RESEARCH LABORATORY

ENCLOSURE (F)

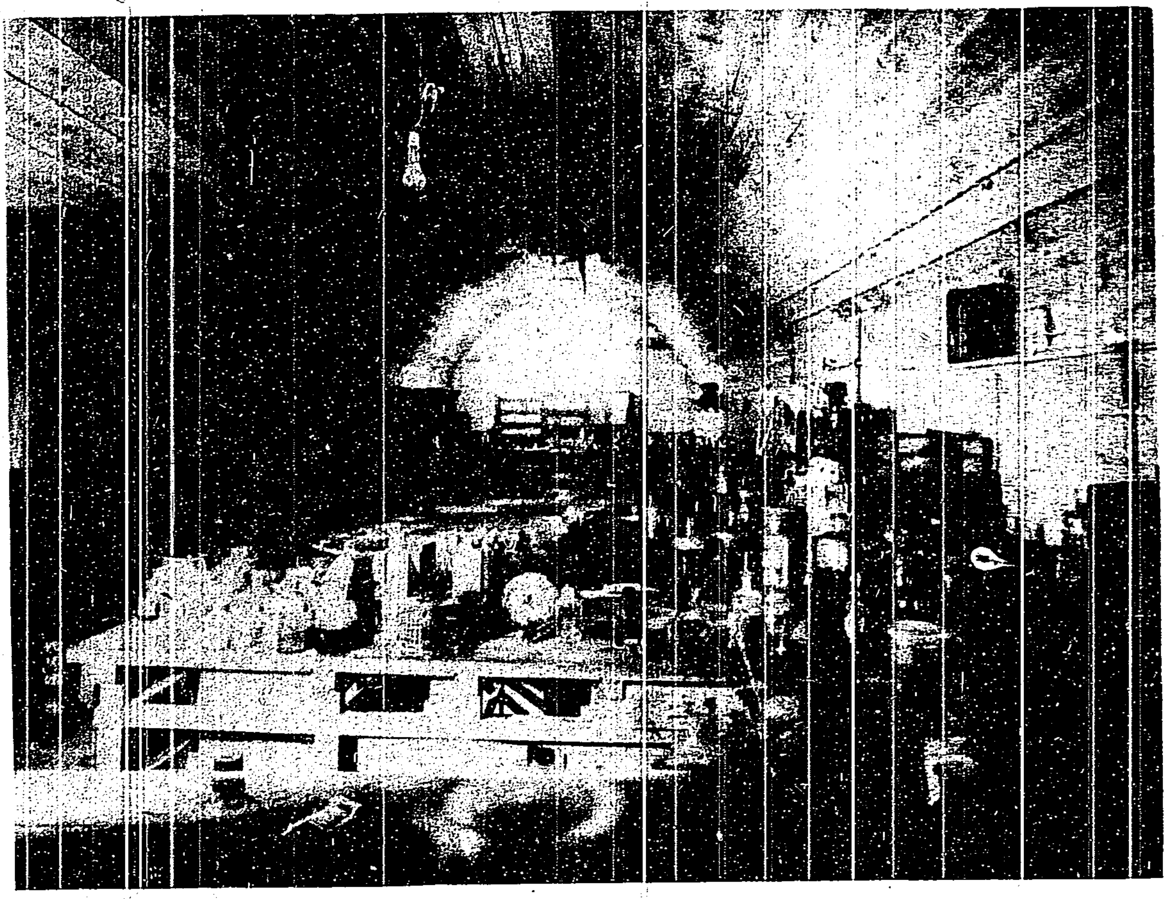


Figure 3(F)
A TYPICAL UNDERGROUND RESEARCH LABORATORY

ENCLOSURE (F)

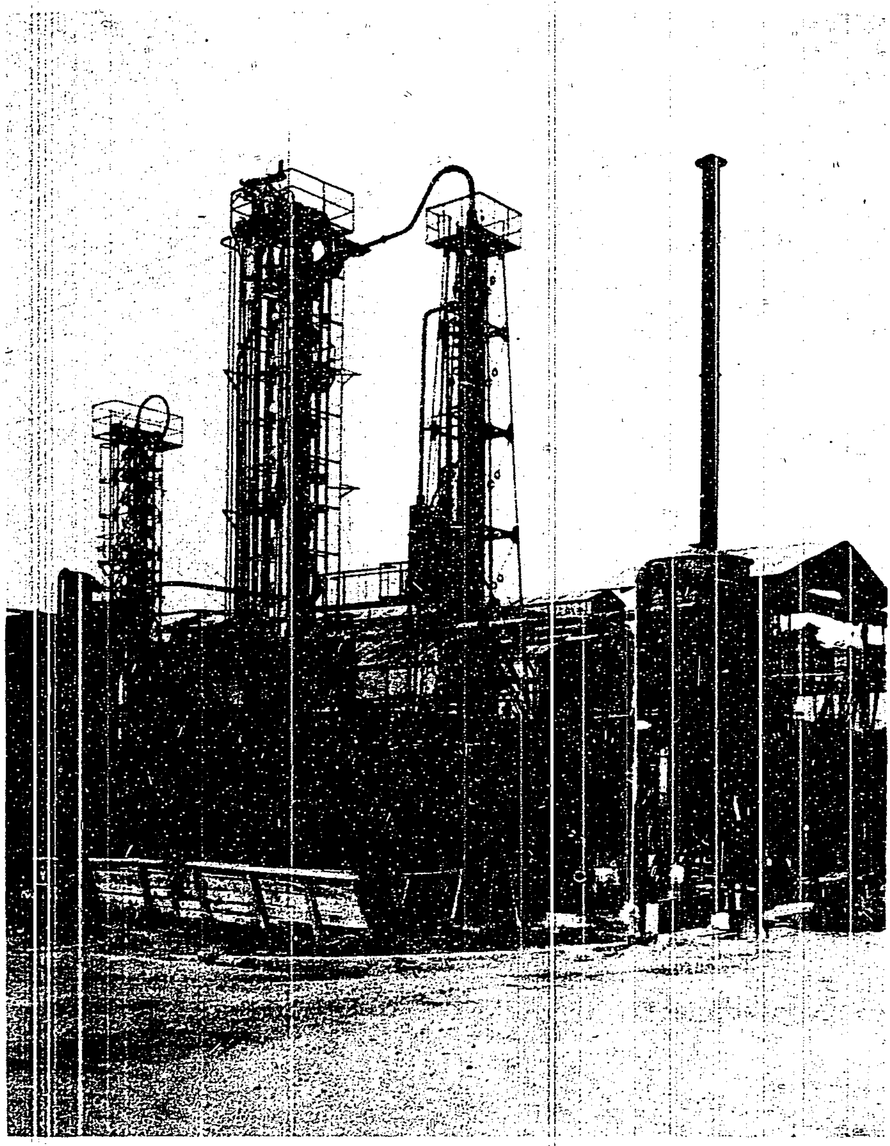


Figure 4(F)
CONTINUOUS CRUDE OIL DISTILLATION UNIT
(Sixty barrels per day capacity)

ENCLOSURE (F)

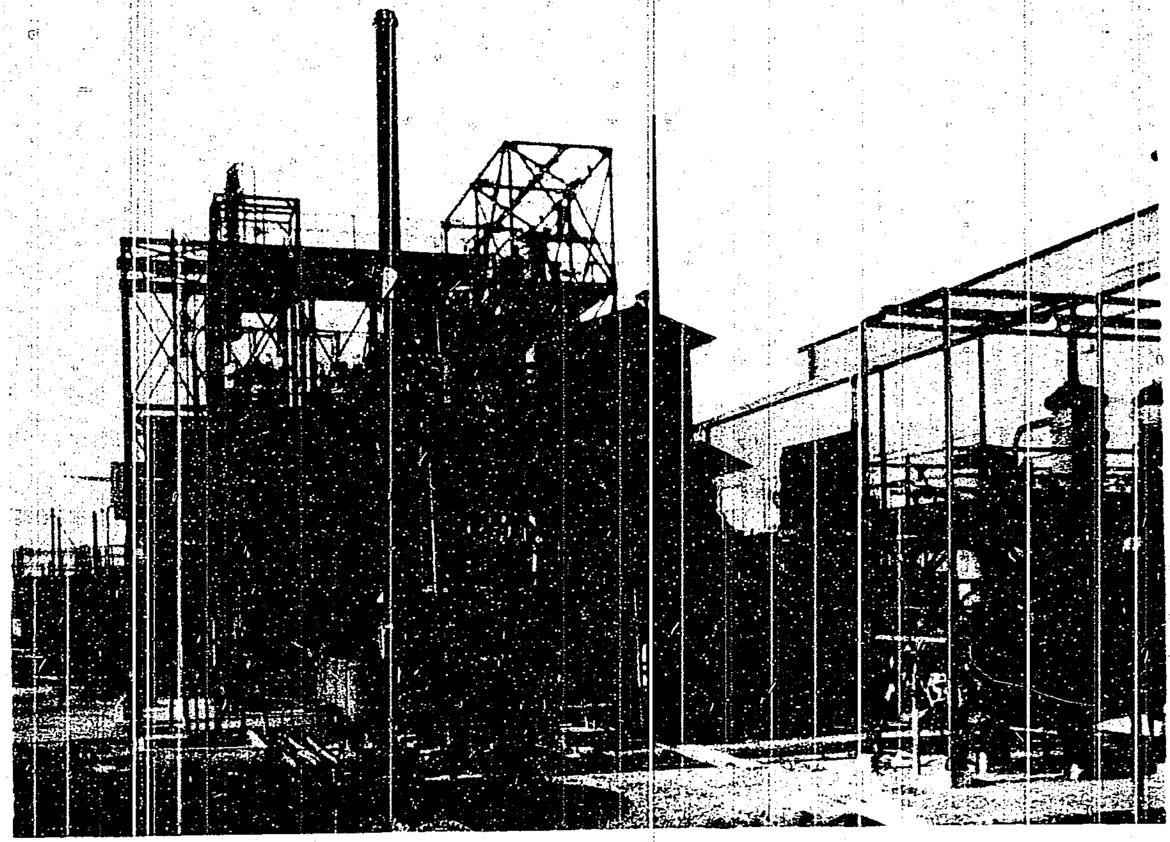


Figure 5(F)
CATALYTIC CRACKING PILOT PLANT
(Twenty-five barrels per day charge capacity)

ENCLOSURE (F)

Figure 6(F)

REACTION CHAMBERS, HEAT EXCHANGERS AND GAS SEPARATORS OF THE 200 ATMOSPHERE COAL HYDROGENATION PILOT PLANT

ENCLOSURE (F)

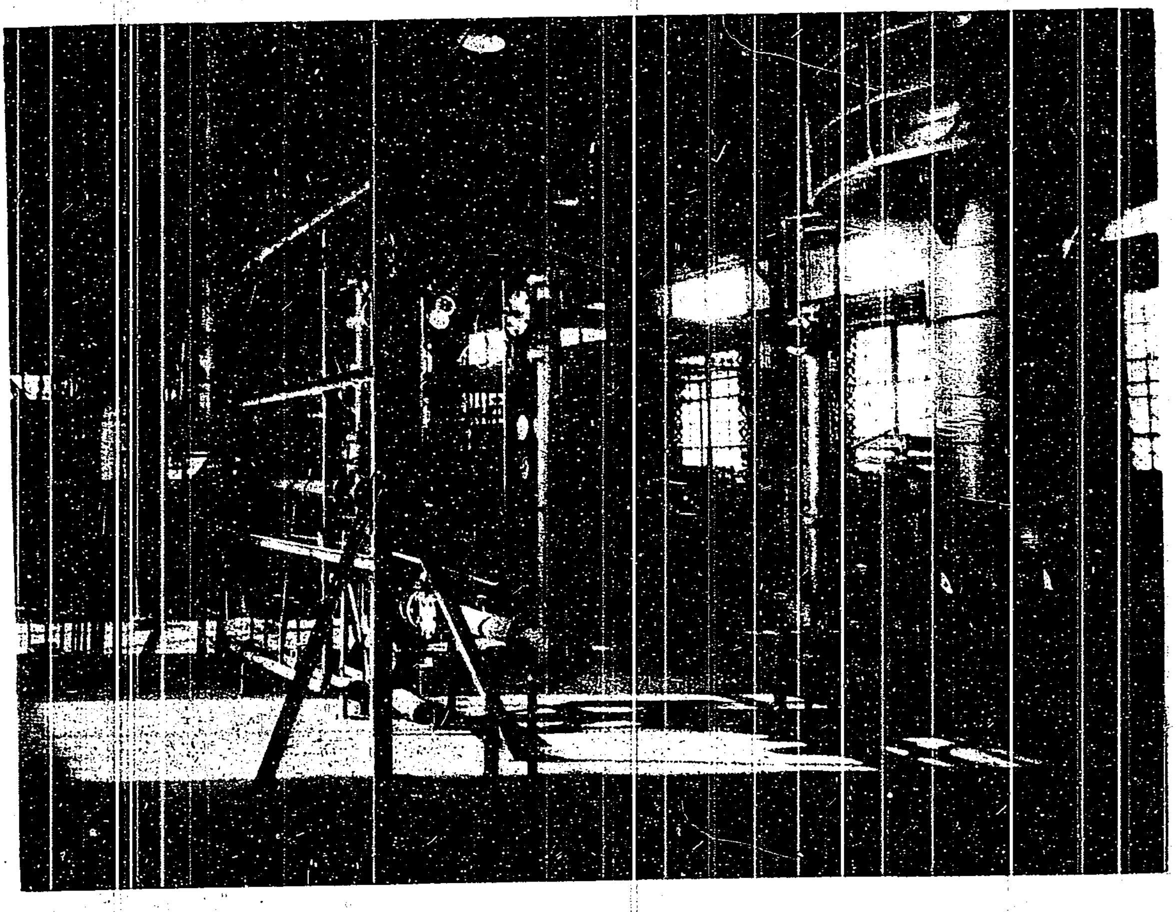


Figure 7(F)
PILOT PLANT APPARATUS FOR MANUFACTURE OF ACETYLENE BY THE ELECTRIC-ARC CRACKING OF METHANE

ENCLOSURE (F)

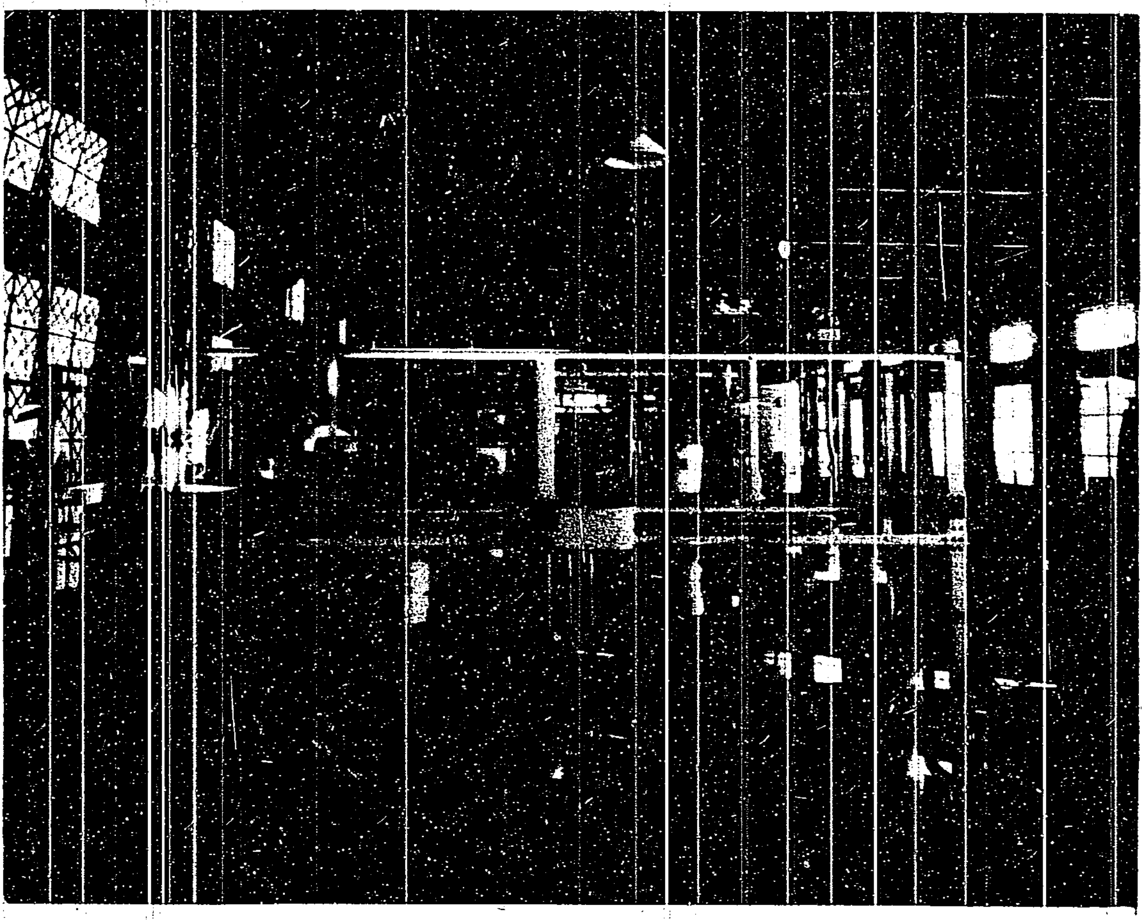


Figure 8(F)

PILOT PLANT FOR STUDYING THE EXTRACTION OF COAL WITH BASIC OIL FROM SHALE

ENCLOSURE (F)

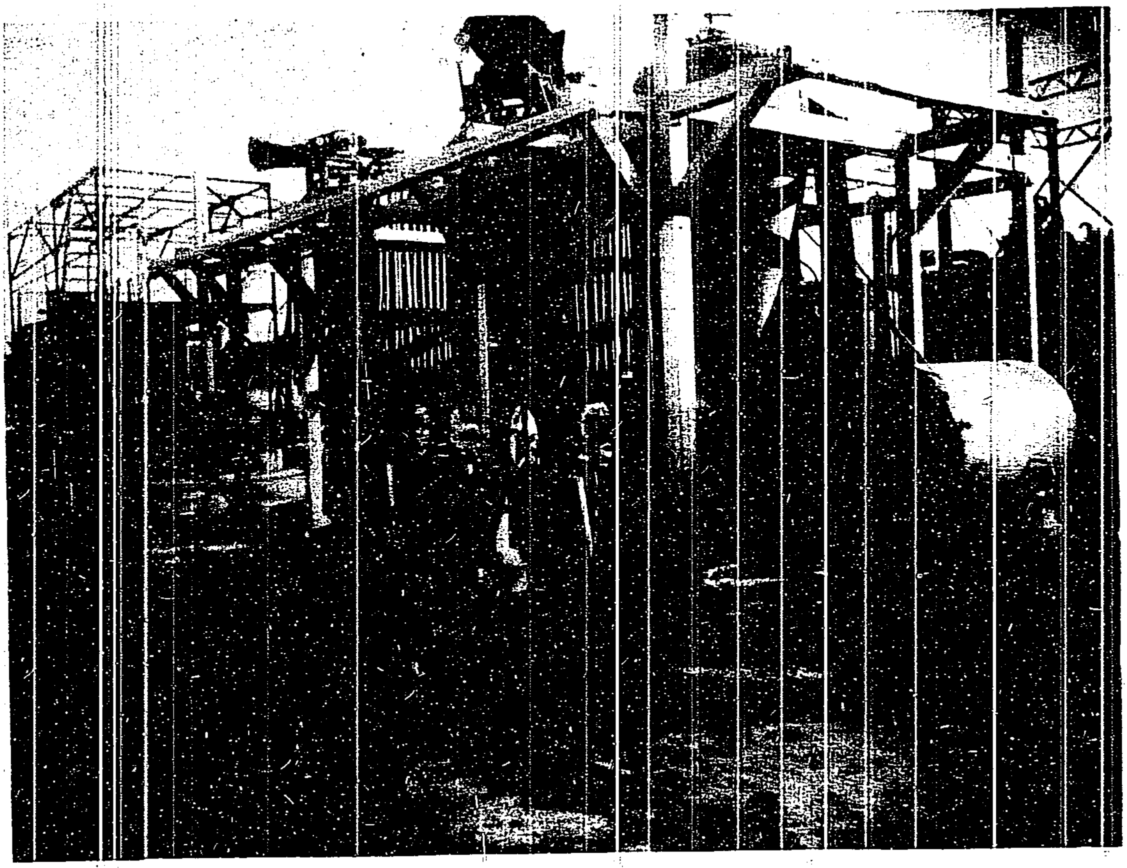


Figure 9(F)

PILOT PLANT FOR HYDROLYSIS OF WOOD

(Twelve kilograms of wood per day capacity)

ENCLOSURE (F)

Figure 10(F)
ACETONE-BENZOL DEWAXING PILOT PLANT
(Fifty liters of oil per day charge capacity)

ENCLOSURE (F)

Figure 11(F)

PINE ROOT CARBONIZATION RETORTS DESIGNED FOR RURAL INSTALLATION

ENCLOSURE (F)

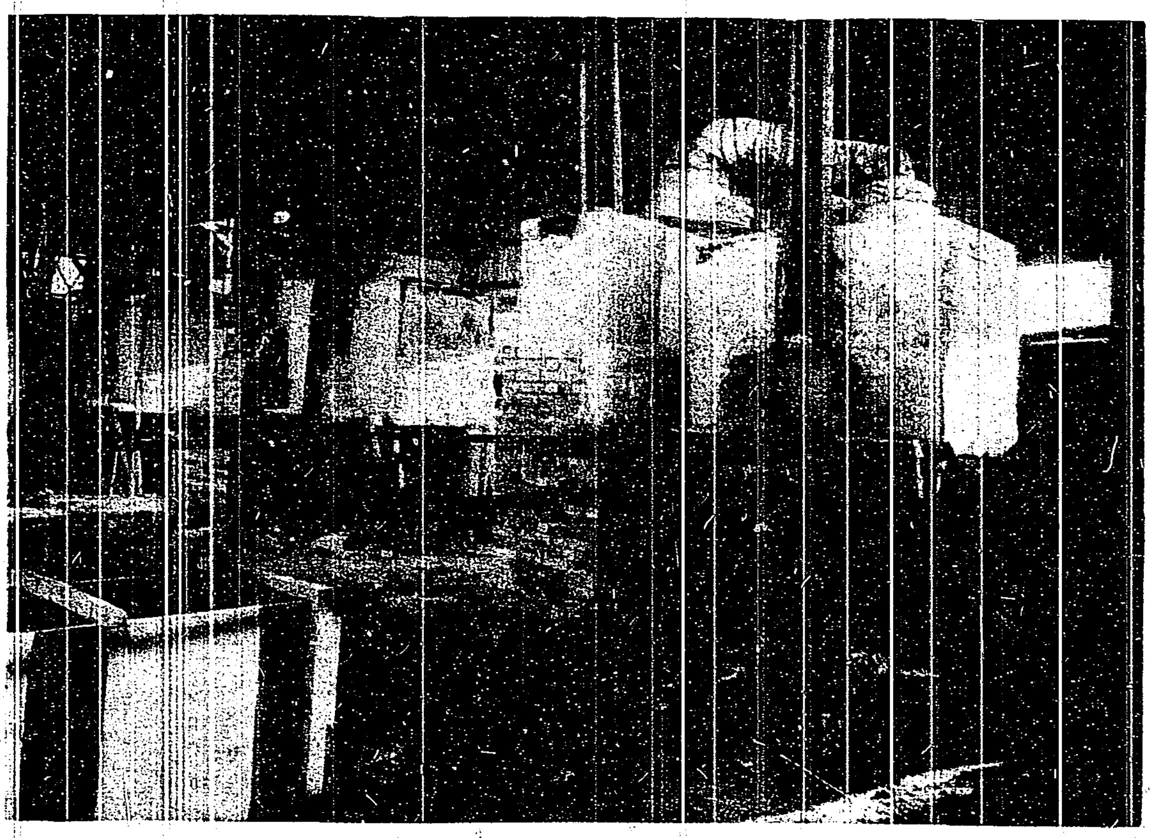


Figure 12(F)

SIMPLIFIED PINE ROOT OIL CATALYTIC REFORMING UNIT
DESIGNED FOR RURAL INSTALLATION

ENCLOSURE (F)

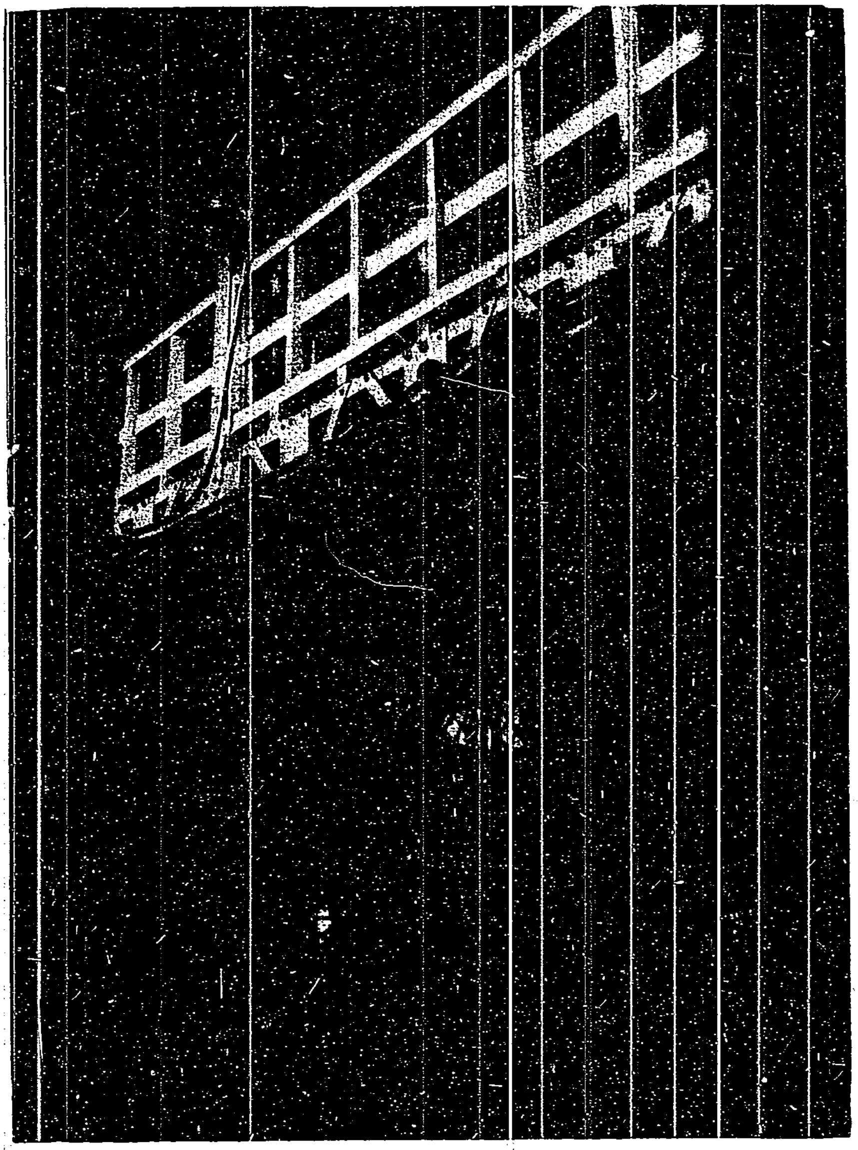


Figure 13(F)

VACUUM DISTILLATION COLUMNS
FOR PREPARATION OF 80% HYDROGEN-PEROXIDE

ENCLOSURE (F)

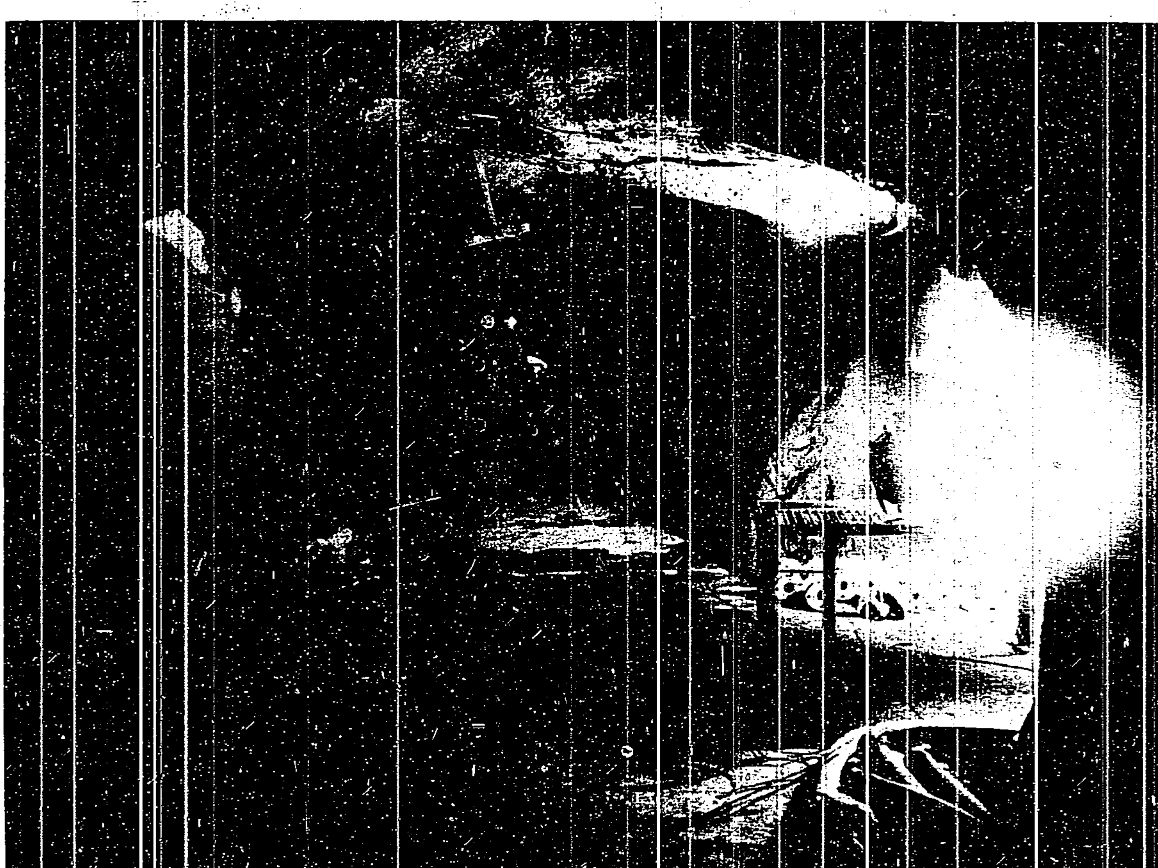


Figure 14(F)
UNDERGROUND TIN-LINED TANKS
FOR STORAGE OF 80% HYDROGEN-PEROXIDE

ENCLOSURE (F)

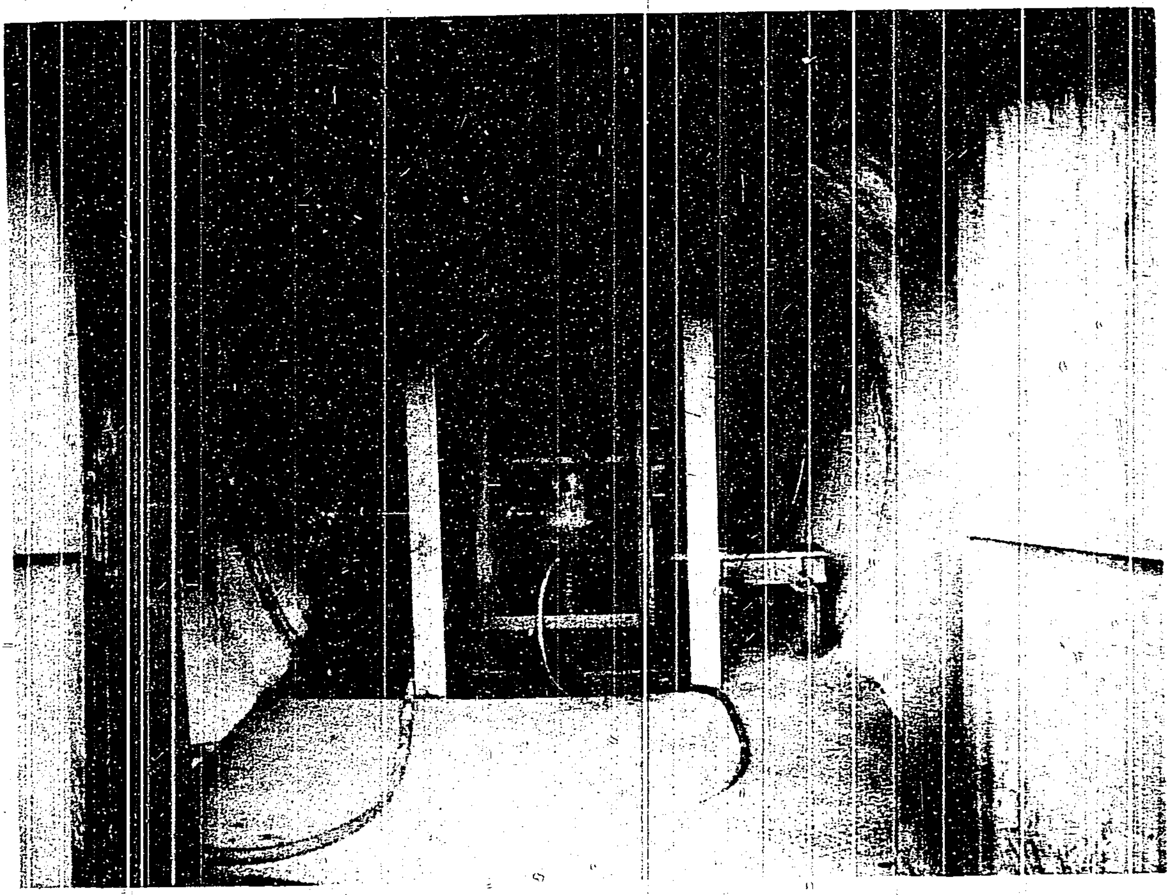


Figure 15(F)

EXPERIMENTAL APPARATUS FOR STUDYING THE COMBUSTION OF HYDROGEN-PEROXIDE AND HYDRAZINE TYPE ROCKET FUELS

ENCLOSURE (F)

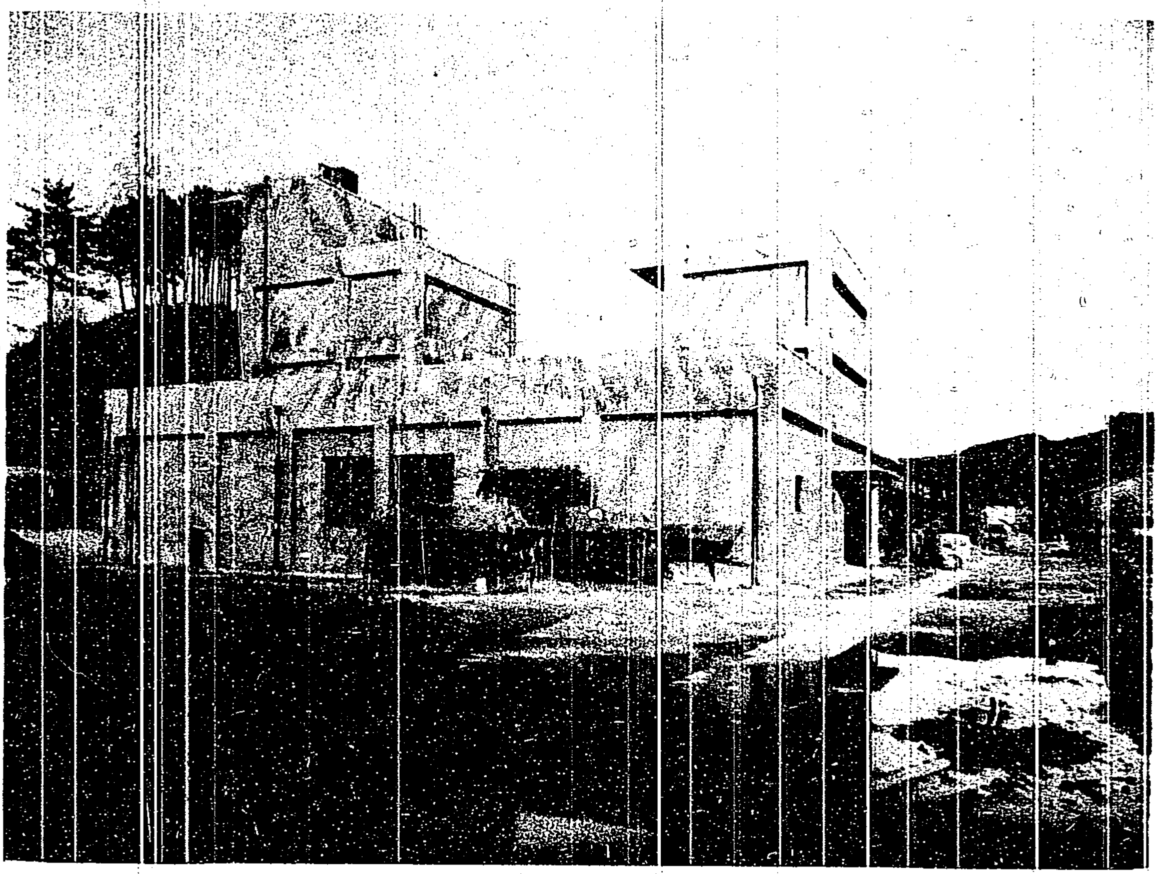


Figure 16(F)
FULL-SCALE AIRCRAFT ENGINE FUEL TEST CELL

ENCLOSURE (F)

Figure 17(F)
FULL-SCALE AIRCRAFT ENGINE TEST STAND

ENCLOSURE (F)

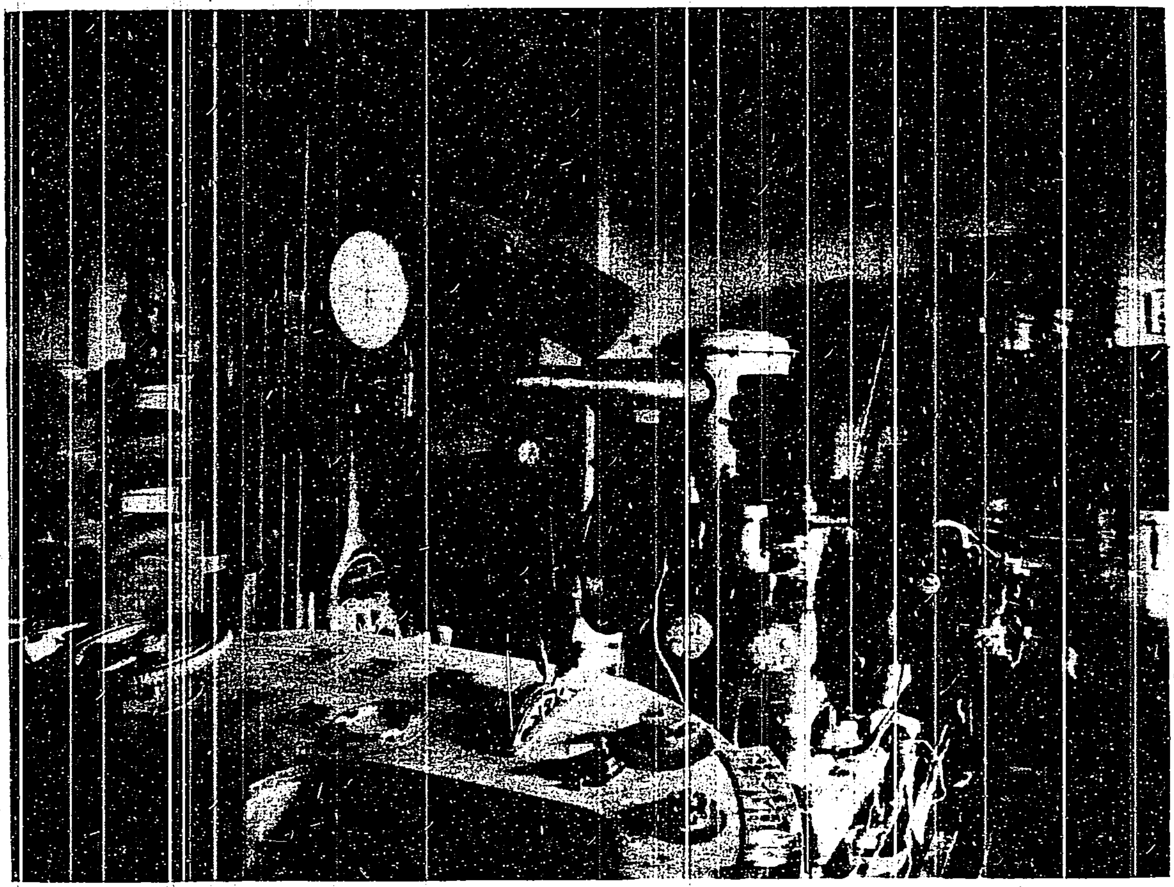


Figure 18(F)
"KINSEI-4" TYPE SINGLE-CYLINDER, VARIABLE COMPRESSION, COUNTER-BALANCED, AIRCRAFT TEST ENGINE

ENCLOSURE (F)

Figure 19(F)

ENTRANCES TO LOW-TEMPERATURE LOW-PRESSURE COLD ROOMS FOR AIRCRAFT FUEL AND LUBRICANT RESEARCH

ENCLOSURE (F)

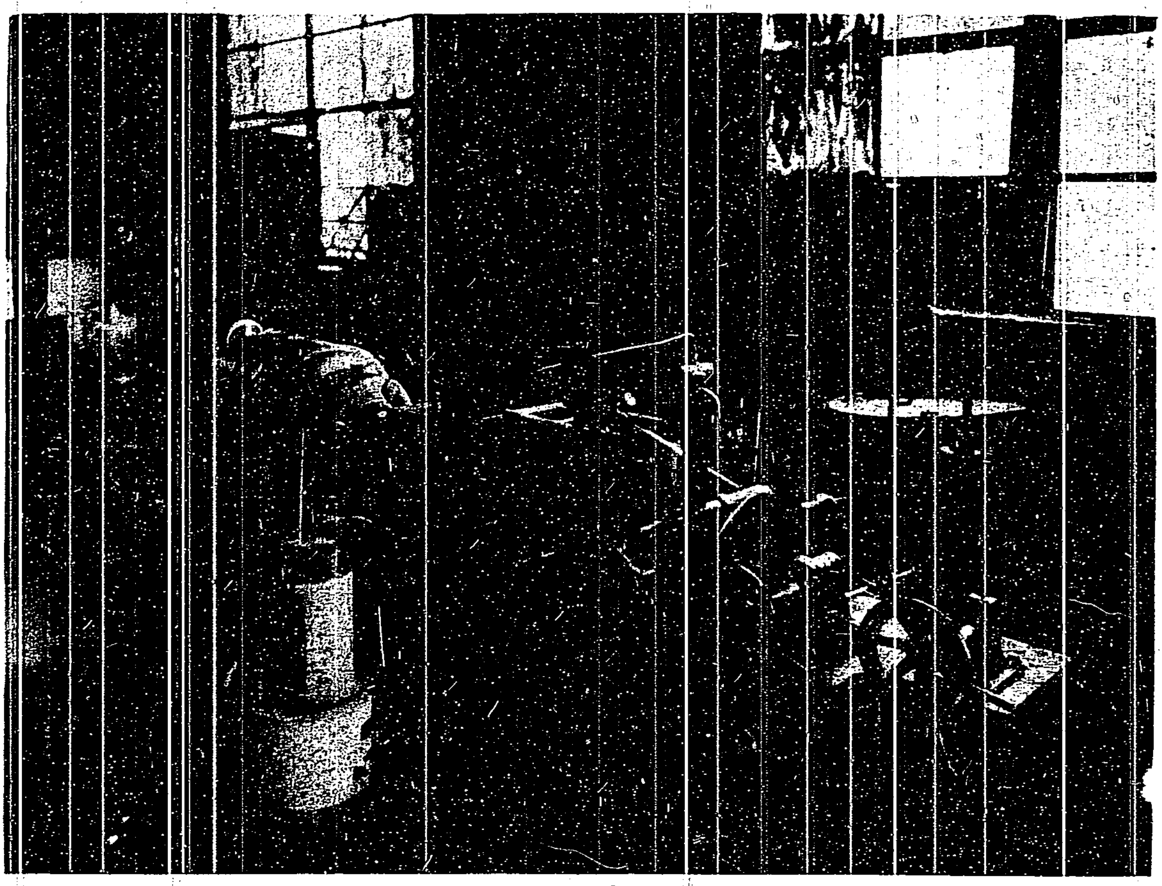
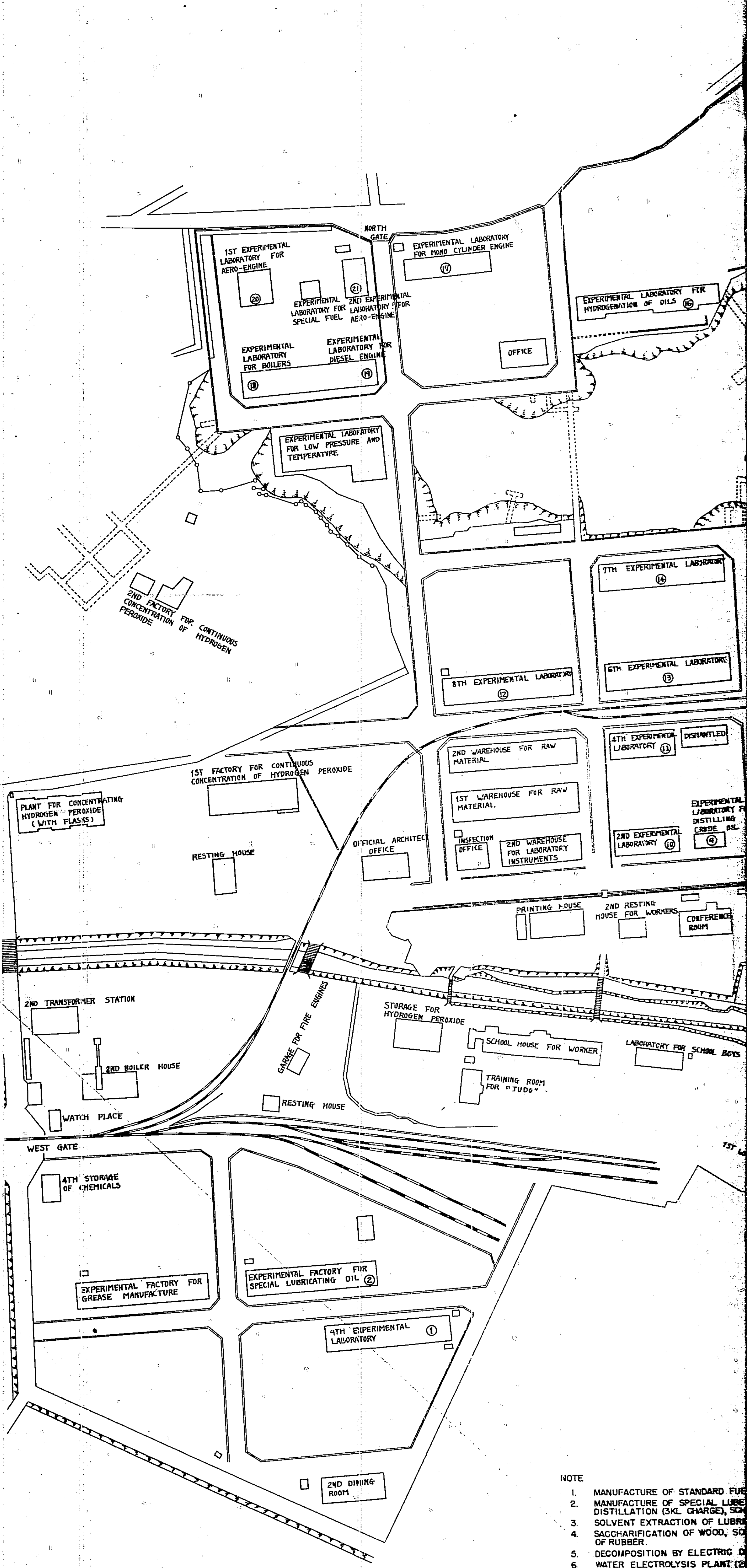


Figure 20(F)

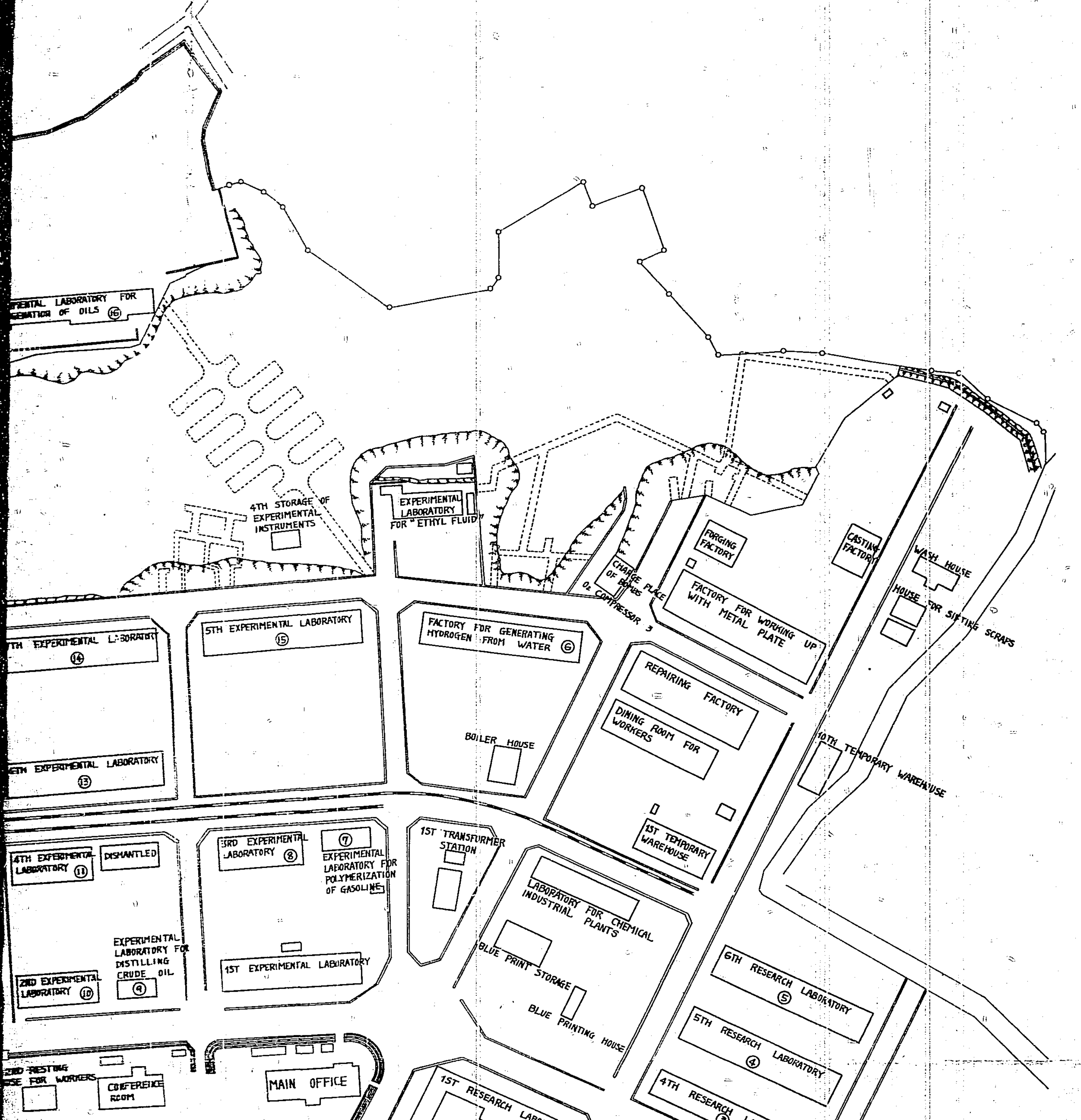
MACHINE FOR TESTING THE OILINESS CHARACTERISTICS OF LUBRICANTS

RESTRICTED



NOTE

1. MANUFACTURE OF STANDARD FUE
2. MANUFACTURE OF SPECIAL LUBE DISTILLATION (3KL CHARGE), SCH
3. SOLVENT EXTRACTION OF LUBRI
4. SACCHARIFICATION OF WOOD, SO OF RUBBER.
5. DECOMPOSITION BY ELECTRIC D
6. WATER ELECTROLYSIS PLANT (2
7. POLYMERIZATION OF GASOLINE
8. SMALL CATALYTIC CRACKING P
9. CRUDE OIL DISTILLATION UNIT.
10. SO_2 EXTRACTION.
11. MANUFACTURE OF LUBRICATING O
12. MANUFACTURE OF CATALYSTS, HI
13. HYDRATION OF ACETYLENE.
14. SYNTHESIS OF AVIATION GASOL
15. CATALYTIC AND THERMAL CRAC
16. SEMI-COMMERCIAL PLANT FOR
17. COMBUSTION RESEARCH UNDER
18. KAMPON TYPE BOILER.
19. 31 TYPE MONO-CYLINDER DIESE CYLINDER DIESEL ENGINE.
20. AIRCRAFT ENGINE TEST STAN
21. TESTING ROCKET FUELS.



ANUFACTURE OF STANDARD FUELS.
ANUFACTURE OF SPECIAL LUBE, CRACKING PARAFFIN WAX, HEKKMANN TYPE VACUUM STILLATION (3KL CHARGE), SCHULTZ TYPE VACUUM DISTILLATION (300 L AND 500 L).
LVENT EXTRACTION OF LUBRICATING OILS.
CCHARIFICATION OF WOOD, SOLVENT EXTRACTION OF COAL AND DISTILLATION F RUBBER.
ECOMPOSITION BY ELECTRIC DISCHARGE AND SYNTHESIS OF VINYL-METHYL ETHER.
ATER ELECTROLYSIS PLANT (200M³ HYDROGEN PER HOUR).
OLYMERIZATION OF GASOLINE.
MALL CATALYTIC CRACKING PILOT PLANT.
RUDE OIL DISTILLATION UNIT.
O2 EXTRACTION.
ANUFACTURE OF LUBRICATING OILS.
ANUFACTURE OF CATALYSTS, HIGH-PRESSURE HYDROGENATION AUTOCLAVES.
YDRATION OF ACETYLENE.
YNTHESIS OF AVIATION GASOLINE BY ISOMERIZATION AND ALKYLATION.
ATALYTIC AND THERMAL CRACKING PILOT PLANT.
EMI-COMMERCIAL PLANT FOR LIQUEFACTION OF COAL (60 KL/M).
OMBUSTION RESEARCH UNDER HIGH-PRESSURE, LUBRICANT TESTING ENGINE.
AMPON TYPE BOILER.
1 TYPE MONO-CYLINDER DIESEL ENGINE AND 61 TYPE HIGH-SPEED MONO-CYLINDER DIESEL ENGINE.
IRCRAFT ENGINE TEST STAND (FULL SCALE).
ESTING ROCKET FUELS.

U.S. NAVAL TECHNICAL MISSION TO JAPAN	RESTRICTED
LAYOUT MAP – 1st. NAVAL FUEL DEPOT, OFUNA.	
29 Nov. 1945	PLATE I	X-38(N)-1

ENCLOSURE (F)

APPENDIX (II)

ORGANIZATION CHART OF THE FIRST NAVAL FUEL DEPOT

15 August, 1945

SUPERINTENDENT Vice Adm. YAMAGUCHI	
DEPARTMENT OF GENERAL AFFAIRS	
DEPARTMENT OF FUEL RESEARCH Capt. SASAKI Advisor, Dr. KOMATSU	Section 1 - ROUTINE WORK Eng. Lt. Comdr. MOMOTARI Engineering Officers 11 Technicians 1 Workers 45
	Section 2 - COAL AND DRY DISTILLATION Eng. Comdr. FUJIMOTO Engineering Officers 4 Technicians 0 Workers 15
	Section 3 - DIESEL AND BUNKER OIL Eng. ITAKURA Engineering Officers 2 Technicians 1 Workers 37
	Section 4 - CRACKING AND PINE ROOT OIL Eng. Comdr. FUJIMOTO Engineering Officers 16 Technicians 10 Workers 99
	Section 5 - HYDROGENATION Eng. Lt. Comdr. YAMAMOTO Engineering Officers 15 Technicians 2 Workers 72
	Section 6 - BLENDING GASOLINE Eng. Lt. Comdr. YAMAMOTO Engineering Officers 6 Technicians 0 Workers 56
	Section 7 - FERMENTATION Eng. Lt. Comdr. UMEMURA Engineering Officers 8 Technicians 1 Workers 44
	Section 8 - LUBRICANTS Eng. MATSUO Engineering Officers 6 Technicians 2 Workers 44

DEPARTMENT OF FUEL RESEARCH (continued)	Section 9 - DOPES Eng. Lt. Comdr. WAKANA Engineering Officers 2 Technicians 0 Workers 23
	Section 10 - GREASES Eng. Lt. Comdr. DANN Engineering Officers 3 Technicians 0 Workers 7
	Section of EXPERIMENTAL MANUFACTURE Eng. MATSUO Engineering Officers 6 Technicians 5 Workers 203
	Section of INSPECTION AND PLANNING Eng. Capt. KAGEHIRA Engineering Officers 3 Technicians 3 Workers 38
	Section of GENERAL AFFAIRS Lt. Comdr. UEMATSU Engineering Officers 6 Technicians 1 Workers 46
DEPARTMENT OF PROCESS ENGINEERING Capt. MIYAZAWA	Section 1 - DESIGN Eng. SHIBASAKI Engineering Officers 7 Technicians 5 Workers 128
	Section 2 - PROCESS ENGINEERING Eng. Lt. Comdr. SANKA Engineering Officers 15 Technicians 1 Workers 55
	Section 3 - MATERIALS Comdr. KATABUCHI Engineering Officers 6 Technicians 1 Workers 24
	Section 4 - REPAIRING Eng. SHIBASAKI Engineering Officers 4 Technicians 5 Workers 207
	Section of CONCENTRATION OF H_2O_2 Eng. Lt. Comdr. YAMAMOTO Engineering Officers 15 Technicians 2 Workers 121

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DEPARTMENT OF PROCESS ENGINEERING (continued)	Section of GENERAL AFFAIRS Comdr. KATABUCHI Engineering Officers 4 Technicians 2 Workers 27
DEPARTMENT OF FUEL EXPERIMENT Capt. SASAKI	Section 1 - AVIATION GASOLINE Eng. Comdr. NAKATA Engineering Officers 8 Technicians 1 Workers 63
	Section 2 - DIESEL FUEL Capt. NORITAKE Engineering Officers 2 Technicians 0 Workers 18
	Section 3 - LUBRICATION Eng. Lieut. FUJIMOTO Engineering Officers 2 Technicians 1 Workers 18
	Section 4 - SAMPLING Eng. Lieut. SONODA Engineering Officers 4 Technicians 4 Workers 52
	Section of GENERAL AFFAIRS Capt. NORITAKE Engineering Officers 1 Technicians 1 Workers 33
DEPARTMENT OF FINANCE	
DEPARTMENT OF MEDICINE	

ENCLOSURE (F)

APPENDIX (III)

JAPANESE PATENTS HELD BY THE FIRST NAVAL FUEL DEPOT

Patent No.	Date	Subject
No. 43758	21 Oct. 1922	A manufacturing method of liquid fuel from coal.
No. 65661	10 Sept. 1925	A method for transforming fatty oils to petroleum oil and the simultaneous dry distillation of shale rock.
No. 68856	8 July 1926	Improvement of the method for the dry distillation of shale rock.
No. 70770	21 Jan. 1926	A method of manufacturing naphthalene which contains no sulphur.
No. 70804	24 Jan. 1926	A dehydration method for oils.
No. 73117	26 Aug. 1926	A method of manufacturing transformer oil, having a high flash point and low viscosity.
No. 79898	18 Jan. 1928	A method for refining petroleum pitch.
No. 80842	7 Mar. 1928	A method for the liquefaction of coal.
No. 80928	13 Mar. 1928	A method of manufacturing paints for ships' bottoms.
No. 82025	5 June 1928	A method of denaturing ethyl alcohol.
No. 82580	16 July 1928	A method of manufacturing hydrogen and carbon monoxide from methane.
No. 83198	11 Sept. 1928	A method of improving the properties of lubricating oils.
No. 88565	2 Oct. 1930	A method for the dry distillation of coal.
No. 88905	28 Dec. 1930	A method of preparation for some important liquids from coal tar and mineral oil.
No. 95140	24 Mar. 1932	A method of manufacturing hydrogen from hydrocarbons.
No. 96461	29 June 1932	Preparation of useful liquids from coal.
No. 96772	29 July 1932	Preparation of some important liquid hydrocarbons from coal tars, pitch, asphalt, bitumen, etc.
No. 97032	23 Aug. 1932	Recovering of oil from waste liquid containing oil.
No. 97569	30 Sept. 1932	Washing of coal.
No. 97962	26 Oct. 1932	High pressure charge pump.
No. 98957	9 Jan. 1933	Decomposition of gaseous hydrocarbons.
No. 99729	23 Feb. 1933	Improved centrifuge.

ENCLOSURE (F)

Patent No.	Date		Subject
No. 101999	17 July	1933	Decomposition of tar in the complete gasification of coal.
No. 103427	27 Oct.	1933	Complete gasification of coal.
No. 103921	30 Nov.	1933	High Pressure stop valve.
No. 105588	2 Apr.	1934	Decomposition of carbon dioxide and gaseous hydrocarbons.
No. 109263	24 Oct.	1934	Synthesis of aromatic hydrocarbons such as benzene and toluene from acetylene.
No. 109413	2 Nov.	1934	Method of separating acetylene gas.
No. 109412	5 Nov.	1934	Preparation of formaline and formic acid from methane.
No. 108434	12 Nov.	1934	Preparation of raw material for synthetic rubber containing isoprene and compounds similar to isoprene.
No. 110026	29 Mar.	1935	Method of producing bunker oil containing coal.
No. 110728	13 May	1935	Synthesis of diformic-peroxide hydrate from methane.
No. 111614	19 July	1935	Production of bunker fuel containing coal.
No. 113705	12 Dec.	1935	Automatic pressure reducing pump.
No. 120618	7 June	1937	Synthesis of peroxides from higher hydrocarbons.
No. 122099	7 Oct.	1937	Aviation gasoline from coal tar.
No. 122579	4 Nov.	1937	Production of bunker fuel containing coal.
No. 125244	6 June	1938	Method of improving the cetane number of diesel fuels.
No. 127201	7 Nov.	1938	Synthesis of aromatic hydrocarbons from acetylene.
No. 128995	27 Feb.	1939	Fractionating column for hydrocarbon gases.
No. 128813	15 Feb.	1939	Production of ashless coal.
No. 129493	29 Mar.	1939	Electric discharge tube.
No. 137461	18 July	1940	Total gasification of coal.
No. 134770	13 Feb.	1940	Fractionating column for acetylene.
No. 134649	8 Feb.	1940	Production of diesel oil from oils, waxes, and fatty acids.
No. 165732	26 July	1944	Acetylene separator.
No. 155090	23 Feb.	1943	Method of gas separation.

ENCLOSURE (E)

Patent No.	Date		Subject
No. 155714	30 Mar.	1943	Separating apparatus for removing traces of acetylene from gases.
No. 141116	20 Jan.	1941	Fractionating column for hydrocarbon gas separation.
No. 149983	14 Apr.	1942	Liquefaction of coal by solvent extraction.
No. 154802	29 Jan.	1943	Liquefaction of coal by solvent extraction.
No. 157155	19 June	1943	n-Hydrocarbons from aliphatic ketones.
No. 166282	10 Aug.	1944	Solvent extraction of coal.
No. 149984	14 Apr.	1942	Method of distillation for heavy oil.
No. 153748	16 Nov.	1942	Separation of unsaturated hydrocarbons from cracked oils.
No. 148223	13 Feb.	1942	Continuous distillation of crotonaldehyde.
No. 143892	3 June	1941	Synthesis of lubricants for aeroplanes and automobiles.
No. 146652	17 Nov.	1941	Method of improving lubricating oils.
No. 160368	26 Nov.	1943	Synthesis of high grade lubricants.
No. 143893	3 June	1941	Treating method of oil sludge.
No. 144363	5 July	1941	Method of improving diesel oils.
No. 146053	10 Oct.	1941	Treating method of oil sludge.
No. 157156	19 June	1943	Production of coal binding material from asphalts.
No. 164862	14 July	1944	Method of separating carbonecous matter from heavy bituminous oil.
No. 139913	20 Nov.	1940	Synthesis of alcohols from unsaturated hydrocarbons.
No. 140032	27 Nov.	1940	Synthesis of higher alcohols from unsaturated hydrocarbons.
No. 140581	18 Dec.	1940	Synthesis of alcohols from unsaturated hydrocarbons.
No. 144180	21 June	1941	Apparatus for producing acetaldehyde from acetylene.
No. 149231	16 Mar.	1942	Acetaldehyde from acetylene.
No. 150950	4 June	1942	Acetaldehyde from acetylene.
No. 138948	5 Oct.	1940	Method of producing low pour point castor oil.
No. 157900	23 July	1943	Synthesis of pure a-methyl naphthalene.
No. 167502	13 Oct.	1944	Synthesis of ethyl chloride.

ENCLOSURE (F)

PATENTS WHICH HAVE BEEN USED COMMERCIALLY

Patent No.	Date		Subject
No. 118760	13 Jan.	1937	High-temperature-pressure terminal.
No. 134650	8 Feb.	1940	Cetane from whale wax.
No. 129971	3 May	1939	Methods for hydrogenation of oils.
No. 168035	30 Oct.	1944	Synthesis of pour point depressants for lubricants.
No. 164476	15 June	1944	Method of treating oil sludge.
No. 166284	10 Aug.	1944	Synthesis of n-paraffin hydrocarbons from aliphatic ketones.

ENCLOSURE (G)

ENCLOSURE (G)

SPECIFICATIONS OF FUELS AND LUBRICANTS FOR THE JAPANESE NAVY

THE FIRST NAVAL FUEL DEPOT

August 1945

Prepared For and Reviewed With
U. S. Naval Technical Mission to Japan

December 1945

ENCLOSURE (G)

TABLE OF CONTENTS

ENCLOSURE (C)

I - GASOLINE

A. Aviation Gasolines

Aviation Base Gasoline
Date - 1937

General: It consists of hydrocarbons and shall be clear, white, free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Anti-knock value
   87 octane No. .... (T.E.L. 0.085 vol%) min
   92 octane No. .... (T.E.L. 0.1 vol%) min
3. Distillation (°C)
   I. B. P. .... 60 max
   10% point .... 80 max
   50% point .... 105 max
   90% point .... 150 max
   97% point .... 170 max
   Sum of 10, 50 and 90% point .... (°C) 260 min
4. Reid vapor pressure .... 0.6 Kg/cm^2 max
5. Sulphur* .... 0.1% max
6. Unsaturates (absorbed by 85% sulphuric acid) .... 100% max
7. Freezing point (°C) .... -50 max

*When no sulphur is detected by qualitative analysis the test for sulphur may be omitted.

* * *

87# Aviation Base Gasoline
Date - 1939

General: It is the same as the aviation base gasoline specification except for the following:

Anti-knock value
87 octane No. .... (T.E.L. 0.085%) min

* * *

70# Aviation Gasoline
Date - 1939

General: It consists of hydrocarbons and benzene or alcohol and shall be clear, water white or pale yellow, and free from water and suspended matter, conforming to the following requirements:

1. Reaction .... neutral
2. Anti-knock value .... 70 octane No. min
3. Reid vapor pressure .... 0.6 Kg/cm^2 max
4. Distillation (°C)
   I. B. P. .... 60 max
   10% point .... 80 max
   50% point .... 105 max
   90% point .... 150 max
   97% point .... 170 max

ENCLOSURE (G)

5. Sulphur* .... 0.1% max
6. Unsaturates** (absorbed by 85% sulphuric acid) .. 1.0% max

*When no sulphur is detected by qualitative analysis, the test for sulphur may be omitted.
**In the case of alcohol blended gasoline: absorbed by 85% H_2SO_4: Vol% of alcohol+1.0% max.

<u>Note</u>: To prepare this gasoline, blending with benzene or alcohol must satisfy the following requirements:

1. Blending material: No. 1 or No. 2 benzene conforming to Japanese naval specification or absolute alcohol conforming to Japanese naval specification.
2. Blending limit - benzene .... 30 vol% max
   abs. alcohol .... 20% max
3. Pour point or cloud point, (°C) .... -45 max

* * *

85# Aviation Gasoline
Date - 1937

<u>General</u>: It consists of hydrocarbons and tetra-ethyl lead and shall be clear, blue, free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Anti-knock value .... 85 octane No. min
3. Distillation (°C)
   - I. B. P. .... 60 max
   - 10% point .... 80 max
   - 50% point .... 105 max
   - 90% point .... 150 max
   - 97% point .... 170 max
   - Sum of 10, 50 and 90% point (°C) .... 260 min
4. Reid vapor pressure .... 0.6 Kg/cm^2 max
5. Sulphur .... 0.1% max
6. Content of tetra-ethyl lead .... 0.085 vol% max
7. Unsaturates (absorbed by 85% sulphuric acid) .... 1.0% max
8. Freezing point (°C) .... -50 max

* * *

91# Aviation Gasoline
Date - 1942

<u>General</u>: It is the same as the 85# aviation gasoline specification except for the following:

1. Anti-knock value .... 91 octane No. min
2. Content of tetra-ethyl lead .... 0.1 vol% max

* * *

92# Aviation Gasoline
Date - 1943

<u>General</u>: It is the same as the 85# aviation gasoline specification except for the following:

ENCLOSURE (G)

1. Anti-knock value .... 92 octane No. min
2. Content of tetra-ethyl lead .... 0.1 vol% max

* * *

<u>70# Aviation Cracked Gasoline</u>
Date - 1941

<u>General</u>: It consists of hydrocarbons and shall be clear, water white or pale yellow, free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Anti-knock value .... 70 octane No. min
3. Distillation (°C)
   - I. B. P. .... 60 max
   - 10% point .... 80 max
   - 50% point .... 105 max
   - 90% point .... 150 max
   - 97% point .... 170 max
4. Reid vapor pressure .... 0.6 Kg/cm^2 max
5. Sulphur .... 0.1% max
6. Unsaturates (absorbed by 85% sulphuric acid) .... 6.0% max

* * *

<u>80# Aviation Cracked Gasoline</u>
Date - 1941

<u>General</u>: It is the same as the 70# aviation cracked gasoline specification except for the following:

1. Anti-knock value .... 80 octane No. min
2. Content of tetra-ethyl lead .... 0.1 vol% max

* * *

B. <u>Motor Gasolines</u>

<u>No. 1 Motor Gasoline</u>
Date - 1937

<u>General</u>: It shall be clear water white, free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Distillation (°C)
   - I. B. P. .... 70 max
   - 10% point .... 95 max
   - 50% point .... 145 max
   - 90% point .... 200 max
   - 97% point .... 220 max
3. Sulphur - Straight-run gasoline .... none
   - Cracked gasoline .... 0.2% max
4. Unsaturates* (absorbed by 85% sulphuric acid)
   - Straight-run gasoline .... 1.0% max
   - Cracked gasoline .... 6.0% max

*In the case of mixed gasoline consisting of straight-run and cracked gasoline the content of sulphur should be less than the calculated value based on the mixed volume ratio and the maxima of each.

ENCLOSURE (G)

No. 2 Motor Gasoline
Date - 1941

General: It shall be free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Distillation (°C)
   - 10% point .... 85 max
   - 50% point .... 150 max
   - 90% point .... 210 max
   - 97% point .... 225 max
3. Sulphur .... 0.3% max

Previous specification: It consists of 90% of No. 1 motor gasoline and 10% of absolute alcohol. (Date - 1937. Revised - 1941)

* * *

No. 3 Motor Gasoline
Date - 1941

General: It consists of 80% of No. 2 motor gasoline and 20% of absolute alcohol and shall be free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Distillation (°C)
   - 10% point .... 100 max
   - 50% point .... 160 max
   - 90% point .... 210 max
   - 97% point .... 225 max
3. Sulphur .... 0.3% max

* * * * *

II - KEROSENE

No. 1 Kerosene
Date - 1942

General: It consists of straight-run kerosene. It shall be clear, water white, or light purple, having no combustion residue and free from water and suspended matter. It shall also conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity, (15/4°C) .... 0.83 max
3. Flash point. (°C) .... 25 - 30
4. Distillation (°C)
   - I. B. P. .... 90 min
   - 10% point .... 150 max
   - 50% point .... 200 max
   - 90% point .... 250 max
   - 97% point .... 275 max
5. Unsaturates (absorbed by 85% sulphuric acid) .... 1.0% max

ENCLOSURE (G)

No. 2 Kerosene
Date - 1935

General: It shall be colorless or light yellow, having no combustion residue and free from water and suspended matter. It shall also conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity, (15/4°C) .... 0.81 max
3. Flash point, (°C) .... 20 min
4. Distillation (°C)
   - I. B. P. .... 150 max
   - 10% point .... 175 max
   - 50% point .... 205 max
   - 90% point .... 250 max
   - 97% point .... 275 max
5. Unsaturates (absorbed by 85% sulphuric acid ..... 6.0% max

* * *

No. 3 Kerosene
Date - 1939

General: The consumption of the wick shall not be marked after burning this kerosene in a lamp for seven hours, and it shall produce no soot when used. It shall also conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity .... 0.825 max
3. Flash point (°C) .... 115 min

Note: A. S. T. M. Lamp Test.

* * * *

III - GAS OIL

Gas Oil
Date - 1935

General: It shall be clear, free from water and suspended matter and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.87 max
3. Flash point (°C) .... 30 min

Note: Established in 1935

* * * * *

IV - HEAVY OIL

No. 1 Heavy oil
Date - 1939

General: It shall be suitable for diesel engine fuel, free from harmful dust on the injection apparatus, and conform to the following requirements:

ENCLOSURE (G)

1. Water .... 0.5% max
2. Reaction .... neutral
3. Specific gravity (15/4°C) .... 0.95 max
4. Flash point (°C) .... 80 min
5. Viscosity at 0°C .... 500 S.U.S. max
6. Sediment .... 0.05% max
7. Sulphur .... 0.5% max
8. Ash .... 0.05% max
9. Conradson's carbon .... 5% max

* * *

No. 2 Heavy Oil
Date - 1939

General: It shall be suitable for diesel engine fuel, free from harmful dust on the injection apparatus, and conform to the following requirements:

1. Water .... 0.1% max
2. Reaction .... neutral
3. Specific gravity (15/4°C) .... 0.85 min
4. Flash point (°C) .... 65 min
5. Viscosity (Redwood No. 1 sec) at 30°C .... 30 min
6. Sediment .... 0.01% max
7. Sulphur .... 1.0% max
8. Ash .... 0.01% max
9. Conradson's carbon .... 0.5% max
10. Cetane No. .... 45 min
11. Pour point (°C) .... -5 max
12. Calorific value, (cal/g) .... 10,000 min

* * *

New No. 2 Heavy Oil
Date - 1942

General: It consists of Tarakan oil and shale or Fischer oil, shall be suitable for diesel engine fuel and free from harmful dust on the injection apparatus, and conform to the following requirements:

1. Water .... 0.2% max
2. Reaction .... neutral
3. Specific gravity (15/4°C) 0.915 (0.005)
4. Flash point (°C) .... 65 min
5. Viscosity (Redwood No. 1 sec) at 30°C .... 30 min
6. Sediment .... 0.05% max
7. Sulphur .... 1.0% max
8. Ash .... 0.05% max
9. Pour point (°C) .... -5 max
10. Calorific value (cal/g) .... 10,000 min
11. Conradson's carbon .... 2.0% max
12. Cetane No. .... 38 min

* * * * *

ENCLOSURE (G)

V - BUNKER FUEL

Bunker Fuel
Date - 1939

General: It shall be suitable for bunker fuel, free from dust or sediment harmful to the burner. It also shall conform to the following requirements:

1. Water .... 0.5% max
2. Reaction .... neutral
3. Specific gravity (15/4°C) .... 0.96 max
4. Flash point (°C) .... 80 min
5. Viscosity (Redwood No. 2 sec) at 0°C .... 2000 max
6. Sulphur .... 3.0% max

* * * * *

VI - BENZENE

No. 1 Benzene
Date - 1935

General: It consists of benzene, toluene and xylene, being suitable as a blending fuel for aviation gasoline, and shall be clear, water white and free from water and suspended matter. It shall also conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.870 - 0.885
3. Sulphur .... 0.25% max
4. Freezing point (°C) .... -7 max
5. Distillation (°C)
   - 60% point .... 100 max
   - 80% point .... 120 max
   - 95% point .... 160 max
   - 98% point .... 170 max

Color test by sulphuric acid: After shaking a mixture of 90 cc of the sample and 10cc of 90% sulphuric acid, the acid layer shall not be darker than pale yellow in color.

* * *

No. 2 Benzene
Date - 1935

General: It shall conform to the requirements shown in the specification for No. 1 Benzene, except for the following:

1. Freezing point (°C) .... -15 max

* * * * *

VII - ALCOHOL

Alcohol
Date - 1937

General: It shall be suitable for blending with gasoline and shall conform to the following requirements:

ENCLOSURE (G)

1. Purity .... 99 Wt% min
2. Specific gravity (15/4°C) .... 0.797 max
3. Distillation .... Distillate at 78 - 80°C
4. Reaction .... neutral

Solubility: This alcohol shall form a clear solution when mixed with distilled water in any proportions at room temperature.

* * * * *

VIII - METHANOL

No. 1 Methanol
Date - 1943

General: It shall be clear, water white and free from suspended matter, and conform to the following requirements:

1. Purity .... 99 Wt% min
2. Specific gravity (15/4°C) 0.796-0.799
3. Reaction .... neutral

Note: It shall be stored in a steel vessel with a date label.

* * *

No. 2 Methanol
Date - 1943

General: It shall be clear, water white and free from suspended matter, and conform to the following requirements:

1. Purity .... 90 Wt% min
2. Specific gravity (15/4°C) .... 0.82 max
3. Reaction .... neutral or weakly acidic

* * *

A-Methanol
Date - 1943

General: It consists of 75 vol% of No. 1 Methanol and 25 vol% of water. It shall be suitable for aviation gasoline and conform to the following requirements:

1. Pruity .... 69.5 Wt% min
2. Specific gravity (15/4°C) .... 0.872 - 0.877
3. Reaction .... neutral

* * * *

B-Methanol
Date - 1943

General: It consists of 50 vol% of No. 1 Methanol and 50 vol% of water. It shall be suitable for aviation gasoline and conform to the following requirements:

1. Purity .... 43.5 Wt% min
2. Specific gravity (15/4°C) .... 0 927 - 0.931

ENCLOSURE (G)

3. Reaction .... neutral

Remark: Anti-corrosive dope (pottassium chromate) must be added to it just before use in following proportions: 20 g of dope per 200 liters of alcohol.

* * * * *

IX - ETHYL FLUID

Ethyl Fluid
Date - 1937

General: Ethyl fluid to be used as an anti-knock material for aviation gasoline shall be a blue clear liquid and free from suspended matter. It shall conform to the following requirements:

1. Components:
   Tetraethyl lead - 60 Wt% min, 64 vol% min
   Ethylene dibromide - 32 Wt% min, 25 vol% min

2. Lead susceptibility: When this fluid is added to a mixture of 70 vol% of iso-octane and 39 vol% of normal heptane, the anti-knock values of the mixture shall be as follows:
   90 octane No. min 0.1 vol% tetra-ethyl lead added.
   87 octane No. min 0.1 vol% ethyl fluid added.
   Naval-sub-standard fuel "N-1" may also be used, and, in this case, the anti-knock value of this fuel shall be as follows:
   89 octane No. min. 0.1 vol% ethyl fluid added.

3. Containers: The container shall be metallic, clean, and capable of storing ethyl fluid for prolonged periods. The volume and the weight of the container must be clearly marked.

* * * * *

X - LUBRICATING OILS

A. Aero-Engine Oils

Aero-Engine Oil No.120
Date - 1941

General: It shall be suitable as an aero-engine oil and conform to the following requirements:

1. Specific gravity (15/4°C) .... 0.92 max
2. Flash point (°C) .... 200 min
3. Viscosity at 200°F, S.U.S. 115-125
4. Viscosity index .... 90 min
5. Conradson's carbon .... 1.5% max
6. Ash .... 0.02% max
7. Pour point (without additives) (°C) .... -5 max
8. Saponification value .... 1.5 max
9. Acid value .... 0.1 max
10. Stability (British Air Ministry Oxidation Test)
    Conditions of oxidation:
    Sample 45cc
    Velocity of blown air .... 15 litres per hour
    Blowing time of air .... two 6 hr periods

ENCLOSURE (G)

Temperature of oil .... 200°C
Viscosity ratio .... 2.0 max
Carbon residue after oxidation .... 2.5% max

* * *

Aero-Engine Oil No.80
Date - 1941

General: The oil shall be adequate for aero-engine oil and shall conform to the following requirements:

1. Specific gravity (15/4°C) .... 0.90 max
2. Flash point (°C) .... 200 min
3. Viscosity at 200°F .... 75-85 S.U.S.
4. Viscosity index .... 90 min
5. Conradson's carbon .... 1.0% max
6. Ash .... 0.02% max
7. Pour point (without additives) (°C) .... -15 max
8. Saponification value .... 1.0 max
9. Acid value .... 0.1 max
10. Stability (British Air Ministry Oxidation Test)
    Conditions of oxidation:
    Sample 45cc
    Velocity of blown air .... 15 litres per hour
    Blowing-time of air .... two 6 hr periods
    Temperature of oil .... 200°C
    Viscosity ratio .... 2.0 max
    Carbon residue after oxidation .... 2.5% max

* * *

B. Cylinder Oils

No. 1 Cylinder Oil
Date - 1935

General: It shall be suitable for the lubrication of internal engines and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.965 max
3. Flash point, (°C) .... 250 min
4. Viscosity (Redwood No. 1) at 100°C .... 98 sec min
   At 150°C .... 38 sec min
5. Ash .... 0.05% max
6. Animal or Vegetable oil .... none

* * *

No. 2 Cylinder Oil
Date - 1935

General: It shall be suitable for the lubrication of internal engines and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°) .... 0.926 max
3. Flash point (°C) .... 180 min

ENCLOSURE (C)

4.	Viscosity (Redwood No. 1) at 30°C	450 - 500 sec
	At 50°C	160 - 180 sec
	At 100°C	40 - 50 sec
	At 150°C	30 - 40 sec
5.	Ash	0.025% max
6.	Pour point (°C)	2.0 max
7.	Animal or Vegatable oil	none

* * *

No. 3 Cylinder Oil
Date - 1942

General: It shall be suitable for the lubrication of air compressor cylinders and conform to the following requirements:

1.	Reaction	neutral
2.	Specific gravity (15/4°C)	0.94 max
3.	Flash point (°C)	220 min
4.	Viscosity (Redwood No. 1) at 50°C	260 - 280 sec
	At 100°C	50 sec min
5.	Ash	0.01% max
6.	Pour point (°C)	-10 max
7.	Volatility, % wt loss (6 hrs at 135°C)	0.06 max
8.	Conradson's carbon	0.2% max
9.	Animal or Vegetable oil	none

* * *

No. 4 Cylinder Oil
Date - 1943

General: It shall be suitable for the lubrication of marine-torpedo engines and conform to the following requirements:

1.	Reaction	neutral
2.	Specific gravity (15/4°C)	0.90 max
3.	Flash point (°C)	200 min
4.	Viscosity at 210°F, S.U.S.	90 - 105
5.	Viscosity index	90 min
6.	Pour point (°C)	-15 max
7.	Conradson's Carbon	0.1% max
8.	Saponification value	1.5 max
9.	Acid value	1.0 max

* * *

No. 5 Cylinder Oil
Date - 1943

General: It shall be suitable for the lubrication of aero-torpedo engines and conform to the following requirements:

1.	Reaction	neutral
2.	Specific gravity (15/4°C)	0.91 max
3.	Flash point (°C)	200 min
4.	Viscosity at 210°F, S.U.S.	90 - 105
5.	Viscosity index	90 min
6.	Pour point (°C)	-30 max
7.	Conradson's carbon	1.0% max

8. Saponification value .... 4.0 max
9. Corrosion (Cu strip test 3 hrs) .... non-corrosive

* * *

C. Turbine Oils

No. 1 turbine Oil
Date - 1935

General: It shall be suitable for the lubrication of turbines and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) 0.88-0.94
3. Flash point (°C) .... 170 min
4. Viscosity (Redwood No. 1) at 30°C .... 250 - 430 sec
   At 50°C .... 90 - 150 sec
   At 80°C .... 45 sec min
5. Pour point (°C) .... 0 max
6. Corrosion .... non-corrosive
7. Volatility, % wt loss (6 hrs at 135°C) .... 1.0 max
8. Conradson's carbon .... 0.3 max
9. Animal or Vegetable oil .... none
10. Acid value .... 0.1 max
11. Emulsion test - demulsibility .... 20 min
    Water content in oil after test .... 2% max
12. Stability
    Black sludges after heating at 160°C for 12 hours shall not be formed.
    Sample 20cc
    Oil to be steamed until volume is doubled
    Standing temp. after steaming .... 20°C
    Calculation: Demulsibility :: $\frac{\text{Oil separated (cc) x 5}}{\text{Time (min) for separating 20cc of water}}$
    (Comparable to A.S.T.M. Steam Emulsion Test)

* * *

No. 2 Turbine Oil
Date - 1935

General: It shall be suitable for the lubrication of turbines and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) 0.88-0.94
3. Flash point (°C) .... 190 min
4. Viscosity (Redwood No. 1) at 30°C ....500 - 650 sec
   At 50°C .... 160 - 220 sec
   At 80°C .... 60 sec min
5. Pour point (°C) .... 0 max
6. Corrosion .... non-corrosive
7. Volatility, % wt loss (6 hrs at 135°C) .... 0.8 max
8. Conradson's carbon .... 0.6% max
9. Animal or Vegetable Oil .... none
10. Acid value .... 0.1 max

ENCLOSURE (G)

11. Emulsion test - demulsibility .... 20 min
Water content in oil after test .... 2% max
12. Stability: There shall be no black sludge formed after heating at 160°C for 12 hours.

* * *

No. 3 Turbine Oil
Date - 1937

General: It shall be suitable for the lubrication of refrigerating machines and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) 0.86-0.94
3. Flash point (°C) .... 170 min
4. Viscosity (Redwood No. 1) at 30°C .... 120 - 180 sec
At 50°C .... 60 - 80 sec
5. Ash .... 0.025% max
6. Pour point (°C) .... -25 max
7. Volatility, % wt loss (2 hrs 100°C) .... 2.0 max
8. Animal or Vegetable oil .... none

* * * * *

XI - SPECIAL LUBRICATING OILS

A. Precise Oil

No. 1 Precise Oil
Date - 1943

General: It shall be suitable for various precise machines in aircraft and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.92 max
3. Viscosity (Redwood No. 1) at 10°C .... 145 sec max
At 30°C .... 60 sec min
4. Pour point (°C) .... -50 max
5. Corrosion .... non-corrosive
6. Volatility, % wt loss (5 hrs at 100°C) .... 0.3 max
7. Saponification value .... 0.2 max
8. Acid value .... 0.1 max

* * *

No. 2 Precise Oil
Date - 1943

General: It shall be suitable for various precise machines in aircraft and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.92 max
3. Viscosity (Redwood No. 1) at 10°C .... 250 sec max
At 30°C .... 90 sec min
4. Pour point (°C) .... -45 max
5. Corrosion .... non-corrosive
6. Volatility, % wt loss (5 hrs at 100°C) .... 0.3 max

ENCLOSURE (G)

7. Saponification value .... 0.2 max
8. Acid value .... 0.1 max

* * *

No. 3 Precise Oil
Date - 1943

General: It shall be suitable for the lubrication of magnetic generators in aircraft and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.92 max
3. Viscosity (Redwood No. 1) at 10°C .... 600 sec max
   At 30°C .... 150 sec min
   At 50°C .... 65 sec min
4. Pour point (°C) .... -40 max
5. Corrosion .... non-corrosive
6. Volatility, % wt loss (5 hrs at 100°C) .... 0.2 max
7. Saponification value .... 0.2 max
8. Acid value .... 0.1 max

* * *

No. 4 Precise Oil
Date - 1943

General: It shall be suitable for precise machines in the marine-torpedo and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.92 max
3. Viscosity (Redwood No. 1) at 10°C .... 600 sec max
   At 30°C .... 150 sec min
4. Pour point (°C) .... -40 max
5. Corrosion .... non-corrosive
6. Volatility, % wt loss (5 hrs at 100°C) .... 0.2 max
7. Saponification value 0.3-0.5
8. Acid value .... 0.1 max

* * *

No. 5 Precise Oil
Date - 1943

General: It shall be suitable for precise machines in the aero-torpedo and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.92 max
3. Viscosity (Redwood No. 1) at 10°C .... 600 sec max
   At 30°C .... 150 sec min
4. Pour point (°C) .... -60 max
5. Corrosion .... non-corrosive
6. Volatility, % wt loss (5 hrs at 100°C) .... 0.2 max
7. Saponification value .... 0.7 max
8. Acid value .... 0.1 max

ENCLOSURE (G)

B. Hydraulic Oils

No. 1 Hydraulic Oil
Date - 1943

General: It shall consist of refined hydrocarbons suitable for the hydraulic apparatus of aircraft, and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.92 max
3. Flash point (°C) .... 130 min
4. Viscosity (Redwood No. 1) at 10°C .... 145 sec max
   At 30°C .... 60 sec min
5. Pour point (°C) .... -50 max
6. Corrosion .... non-corrosive
7. Saponification value .... 0.2 max
8. Acid value .... 0.1 max

* * *

No. 2 Hydraulic Oil
Date - 1943

General: It consists of castor oil and butanol. It shall be suitable for the hydraulic apparatus of aircraft and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) .... 0.875 min
3. Flash point (°C) .... 32 min
4. Viscosity (Redwood No. 1) at 0°C .... 120-150 sec
   At 30°C .... 45 sec min
5. Pour point (°C) .... -50 max
6. Corrosion .... non-corrosive
7. Acid value .... 0.2 max

* * *

C. Anti-Corrosive Cylinder Oils

Anti-Corrosive Cylinder Oil
Date - 1943

General: It shall be suitable as the anti-corrosive agent for aero-engine cylinders, and conform to the following requirements:

1. Reaction .... slightly basic
2. Viscosity (Redwood No. 1) at 30°C .... 1000 sec max
   At 50°C .... 350-420 sec
3. Pour point (°C) .... 5 max

* * *

D. Castor Oil

Castor Oil
Date - 1935

General: The oil shall be clear, pale yellow, free from suspended matter

ENCLOSURE (G)

and conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) 0.958-0.97
3. Flash point (°C) .... 240 min
4. Viscosity (Redwood No. 1) at 50°C .... 500 sec min
5. Pour point (°C) .... -10 max
6. Iodine value 80-87
7. Saponification value 170-190
8. Solubility test .... completely soluble

Conditions of test,
Solvents each to be used individually:
85% alcohol, density 15/4°C 0.835
92.5% acetic acid, density 15/4°C 1.069
Amount of solvent ... 15cc for 5cc of sample oil
Temperature .... 90°C
Time of contact .... 10 minutes

* * *

<u>Reclaimed Castor Oil</u>
Date - 1935

<u>General</u>: The oil shall be clear, pale yellow and free from suspended <u>matter</u>. It shall also conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) 0.97-0.985
3. Flash point (°C) .... 340 min
4. Viscosity (Redwood No. 1) at 50°C .... 500 sec min
5. Pour point (°C) .... -10 max
6. Iodine value 73-87
7. Saponification value 170-100
8. Free fatty acid .... 1.5% max

* * *

E. <u>Rape Oils</u>

<u>Bleached Rape Oil</u>
Date - 1935

<u>General</u>: The oil shall be clear, pale yellow and free from suspended <u>matter</u>. It shall also conform to the following requirements:

1. Reaction .... neutral
2. Specific gravity (15/4°C) 0.913-0.916
3. Viscosity (Redwood No. 1) at 50°C .... 110 sec min
   At 90°C .... 50 sec min
4. Ash .... 0.025% max
5. Pour point (°C) .... -5 max
6. Iodine value 96-105
7. Saponification value 170-178
8. Free fatty acid .... 0.6% max

ENCLOSURE (G)

Rape Oil
Date - 1935

General: The oil shall be clear, pale yellow or light orange yellow. It shall also conform to the following requirements:

1. Specific gravity (15/4°C) 0.912-0.918
2. Pour point (°C) .... -5 max
3. Saponification value 170-190
4. Free fatty acid .... 3% max

* * * * *

XII - GREASE

No. 1 Grease
Date - 1943

General: It is composed mainly of a calcium soap or fatty acid and refined mineral oil. It shall be of uniform texture and suitable for the lubrication of ball and roller bearings. It shall also conform to the following requirements:

1. Consistency .... 190 ± 20 at 25°C
2. Dropping point (°C) .... 90 min
3. Anount of mineral oil .... 65% min
   Characteristics
   Flash point (°C) .... 130 min
   Viscosity (Redwood No. 1) at 30°C .... 50 sec min
4. Free alkali .... 0.2% max
5. Ash .... 4% max
6. Water content .... 2.5% max
7. Volatility, 100°C for 8 hrs .... 4% max
8. Corrosion .... non-corrosive

* * *

No. 2 Grease
Date - 1943

General: It is composed mainly of a calcium soap of fatty acid and refined mineral oil. It shall be of uniform texture and suitable for the lubrication of ball and roller bearings. It shall also conform to the following requirements:

1. Consistency .... 250 ± 20 at 25°C
2. Dropping point (°C) .... 85 min
3. Amount of mineral oil .... 70% min
   Characteristics
   Flash point (°C) .... 130 min
   Viscosity (Redwood No. 1) at 30°C .... 50 sec min
4. Free alkali .... 0.2% max
5. Ash .... 3.5% max
6. Water content .... 2.0% max
7. Volatility, 100°C for 8 hrs .... 4% max
8. Corrosion .... non-corrosive

ENCLOSURE (G)

No. 3 Grease
Date - 1943

General: It is composed mainly of a calcium soap of fatty acid and refined mineral oil. It shall be of uniform texture and suitable for the lubrication of ball and roller bearings. It shall also conform to the following requirements:

1.	Consistency	310 ± 20 at 25°C
2.	Dropping point (°C)	80 min
3.	Amount of mineral oil	75% min
	Characteristics	
	Flash point (°C)	130 min
	Viscosity (Redwood No. 1) at 30°C	50 sec min
4.	Free alkali	0.2% max
5.	Ash	3.0% max.
6.	Water content	1.5% max
7.	Volatility, 100°C for 8 hrs	4% max
8.	Corrosion	non-corrosive

* * *

No. 4 Grease
Date - 1943

General: It is composed mainly of a calcium soap and refined mineral oil. It shall be of uniform texture and suitable for the lubrication of fuselage ball and roller bearings, torpedo main engines, or general machineries. It shall also conform to the following requirements:

1.	Appearance	paste like
2.	Consistency	250 ± 20 at 25°C
3.	Dropping point (°C)	80 min
4.	Amount of mineral oil	80% min
	Characteristics	
	Flash point (°C)	160 min
	Viscosity (Redwood No. 1) at 30°C	130 sec min
5.	Free alkali	0.2% max
6.	Free fatty acid	0.5% max
7.	Ash	2.5% max
8.	Water content	2.0% max
9.	Sediment	0.1% max
10.	Corrosion	non-corrosive
11.	Stability	Pass Test*

*When the sample is heated to 100 ~ 105°C for 3 hours its colour shall not change and there shall not be any separation of oil or soap.

* * *

No. 5 Grease
Date - 1943

General: It is composed mainly of an aluminium soap of fatty acids and refined mineral oil. It shall be of uniform texture and suitable for the lubrication of variable pitch propellers and other high-loaded rubbing parts. It shall conform to the following requirements:

1. Appearance .... ductile and viscous semi-liquid

ENCLOSURE (G)

2. Consistency .... 360 ± 20 at 10°C
3. Dropping point (°C) .... 40 min
4. Amount of mineral oil .... 88% min

Charasteristics

Flash point (°C) .... 200 min
Viscosity at 210°F, S.U.S. .... 115 min
Viscosity index .... 70 min
Conradson's carbon .... 1.05% max
5. Free alkali .... 0.2% max
6. Free fatty acid .... 1.0% max
7. Free fat .... 0.5% max
8. Ash .... 1.5% max
9. Water content .... 0.5% max
10. Sediment .... 0.1% max
11. Corrosion .... non-corrosive
12. Stability .... Pass Test*

*When the sample is heated at 100 ~ 105°C for 3 hours, the colour shall not change and there shall not be any separation of oil or soap.

* * *

No. 6 Grease
Date - 1943

General: It is composed mainly of a mixture of a sodium soap with an aluminium or calcium soap of fatty acids and refined mineral oil. It shall be of uniform texture and suitable for the lubrication of comparatively high loaded rabbing parts such as the side valves of aero-engines, gears, etc. It shall also conform to the following requirements:

1. Appearance .... semi-liquid paste
2. Consistency .... 350 ± 20 at 25°C
3. Dropping point (°C) .... 65 min
4. Amount of mineral oil .... 90% min

Characteristics

Flash point (°C) .... 200 min
Viscosity at 210°F, S.U.S. .... 100 min
Viscosity index .... 70 min
Conradson's carbon .... 1.05% max
5. Free alkali .... 0.2% max
6. Free fatty acid .... 0.5% max
7. Free fat .... 0.5% max
8. Ash .... 1.5% max
9. Water content .... 0.5% max
10. Sediment .... 0.1% max
11. Corrosion .... non-corrosive
12. Stability .... Pass Test*

*When the sample is heated at 100 ~ 105°C for 3 hours, the colour shall not change nor shall there be any separation of oil or soap.

* * *

No. 7 Grease
Date - 1943

General: It is composed mainly of a sodium soap of fatty acid and refined mineral oil. It shall be of uniform texture and suitable for the lubrication at moderately high temperatures of rubbing parts such as aircraft generators, of magnetic generators, special generators, motors, etc. It shall also conform to the following requirements:

1.	Appearance	paste like
2.	Consistency	240 ± 20 at 25°C
		170 min at -20°C
3.	Dropping point (°C)	150 min
4.	Amount of Mineral oil	70% min
	Characteristics	
	Flash point (°C)	170 min
	Viscosity (Redwood No. 1) at 30°C	300 sec min
	Pour point (°C)	-30 max
	Conradson's carbon	0.3% max
5.	Free alkali	0.2% max
6.	Free fatty acid	0.1% max
7.	Free fat	0.5% max
8.	Ash	3.0% max
9.	Water content	0.5% max
10.	Sediment	0.1% max
11.	Corrosion	non-corrosive
12.	Stability	Pass Test*

*When the sample is heated at 100 ~ 105°C for 3 hours, the colour shall not change nor shall there be any separation of oil or soap.

* * *

No. 8 Grease
Date - 1943

General: The grease shall be of mineral oil nature and suitable as an anti-corrosive lubricant for aircraft and other general machineries. It shall also conform to the following requirements:

1.	Appearance	paste like
2.	Reaction	neutral
3.	Consistency	220 ± 50 at 25°C
4.	Dropping point (°C)	40 min
5.	Acid value	0.1% max
6.	Saponification value	1.5% max
7.	Ash	0.02% max
8.	Water content	0.1% max

* * *

No. 9 Grease
Date - 1943

General: It is composed mainly of an aluminium soap of fatty acid and refined mineral oil. It shall be of uniform texture and suitable for the frame work of the aero-torpedo.

1.	Appearance	viscous semi-liquid
2.	Viscosity at 210°F, S.U.S.	1000 ~ 2000
3.	Consistency	280 ± 20 at -40°C
4.	Amount of mineral oil	92% min

Characteristics of mineral oil:

ENCLOSURE (G)

	Flash point (°C)	200 min
	Viscosity at 210°F, S.U.S.	60 ~ 70
	Viscosity index	80 min
	Pour point (°C)	-40 max
	Conradson's carbon	1.0% max
5.	Free alkali	0.2% max
6.	Free fatty acid	1.0% max
7.	Free fat	0.5% max
8.	Ash	1.0% max
9.	Water content	0.5% max
10.	Sediment	0.1% max
11.	Corrosion	non-corrosive
12.	Stability	Pass Test*

*When the sample is heated at 100 ~ 105°C for 3 hours, the colour shall not change nor shall there be any separation of oil or soap.

* * *

No. 10 Grease
Date - 1943

General: It is composed mainly of an aluminium soap of fatty acid and refined mineral oil. It shall be of uniform texture and suitable as an anti-corrosive material for the chamber of the aero-torpedo. It shall also conform to the following requirements:

1.	Appearance	paste like
2.	Consistency	310 ± 20 at 25°C
3.	Dropping point (°C)	85 min
4.	Amount of mineral oil	85% min
	Characteristics	
	Flash point (°C)	200 min
	Viscosity at 210°F, S.U.S.	60 ~ 70
	Viscosity index	80 min
	Conradson's carbon	1.0% max
5.	Free alkali	0.2% max
6.	Free fatty acid	1.0% max
7.	Free fat	0.5% max
8.	Ash	1.0% max
9.	Water content	0.5% max
10.	Sediment	0.1% max
11.	Corrosion	non-corrosive
12.	Stability	Pass Test*

*When the sample is heated at 100 ~ 105°C for 3 hours, the colour shall not change and there shall not be any separation of oil or soap.

ENCLOSURE (G)

XIII - COAL

	Burning test			Proximate composition (%)				Hardness	Slack coal
	Degree evap. kg water 1 hr	Ash + Clinker (%)	Clinker (%)	H_2O	Ash	Fixed C	Total S	(%)	(%)
Standard Briquette	10 min	10.0 max	4.0 max	2.5 max	10.0 max	70.0~ 78.0	1.0 max	50.0 min	
Briquette No. 1	10 min	10.0 max	4.0 max	1.5 max	8.0 max	72.0~ 78.0	1.0 max	50.0 min	
Briquette No. 2	8 min	15.0 max	4.0 max	3.5 max	15.0 max	57.0~ 63.0	2.0 max	50.0 min	
Lamp coal No. 1	10 min	10.0 max	4.0 max	1.5 max	5.0 max	78.0 min	1.0 max		25.0 max pass through the sigve of 1 $inch^2$
Lamp coal No. 2	8 min	15.0 max	4.0 max	4.0 max	15.0 max	45.0 min	2.0 max		10.0 max pass through the sigve of 1 $inch^2$
Lamp coal No. 3	6.5 min	20.0 max	5.5 max	4.0 max	20.0 max	40.0 min	3.0 max		10.0 max pass through the sigve of 1 $inch^2$

<u>Slack coal</u>
<u>Date - 1939</u>

H_2O (%)	5.0 max
Volatile matter (%)	25.0 min
Fixed carbon (%)	40.0 min
Ash (%)	25.0 max
Total sulphur (%)	3.0 max
Calorific value (cal/gr)	6,000 min

* * *

The following specification, established in 1918, was temporarily adopted.

	Burning test			Proximate composition (%)				Hardness
	Degree evap. kg water 1 hr	Ash + Clinker (%)	Clinker (%)	H_2O	Ash	Fixed C	Total S	(%)
Briquette No. 1	10 kg	8.0 max	2.0 max	1.5 max	8.0 max	75.0 min	1.0 max	50.0 min
Briquette No. 2	9 kg	15.0 max	3.0 max	2.5 max	15.0 max	60.0 min	2.0 max	50.0 min