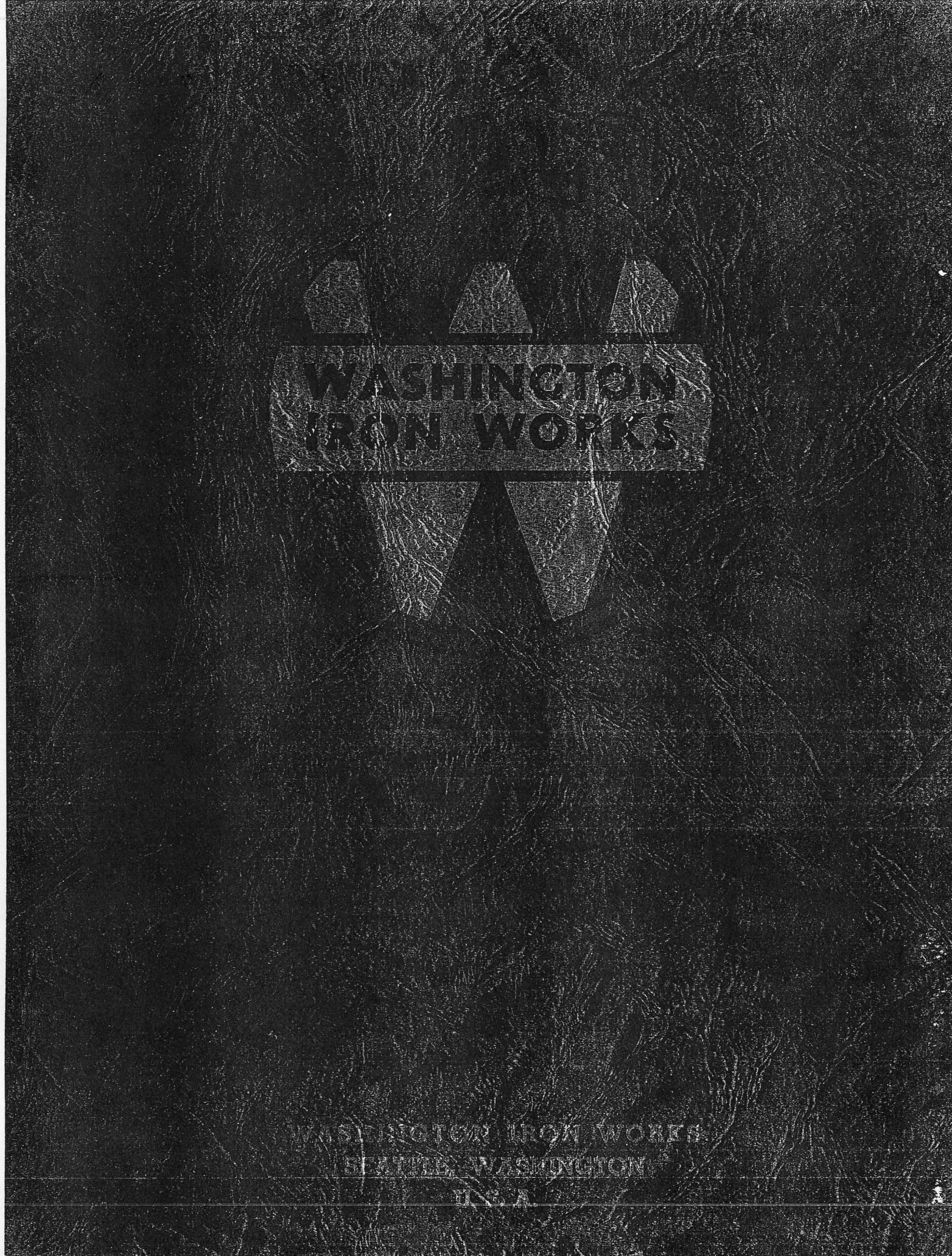


WASHINGTON IRON WORKS
SEATTLE, WASHINGTON
U. S. A.

STATIONARY AND MARINE DIESEL ENGINES

LUBRICATION INSTRUCTION MANUAL

WASHINGTON IRON WORKS
SEATTLE, WASHINGTON
U. S. A.

FOREWORD

Since 1882, the Washington Iron Works has served the needs of industry in supplying heavy duty equipment for logging, mining, marine and allied application.

In 1921, the first Washington Diesel Engine was produced. Since that time hundreds of similar engines have been placed in service from the northern shores of Alaska to the heat of the tropics.

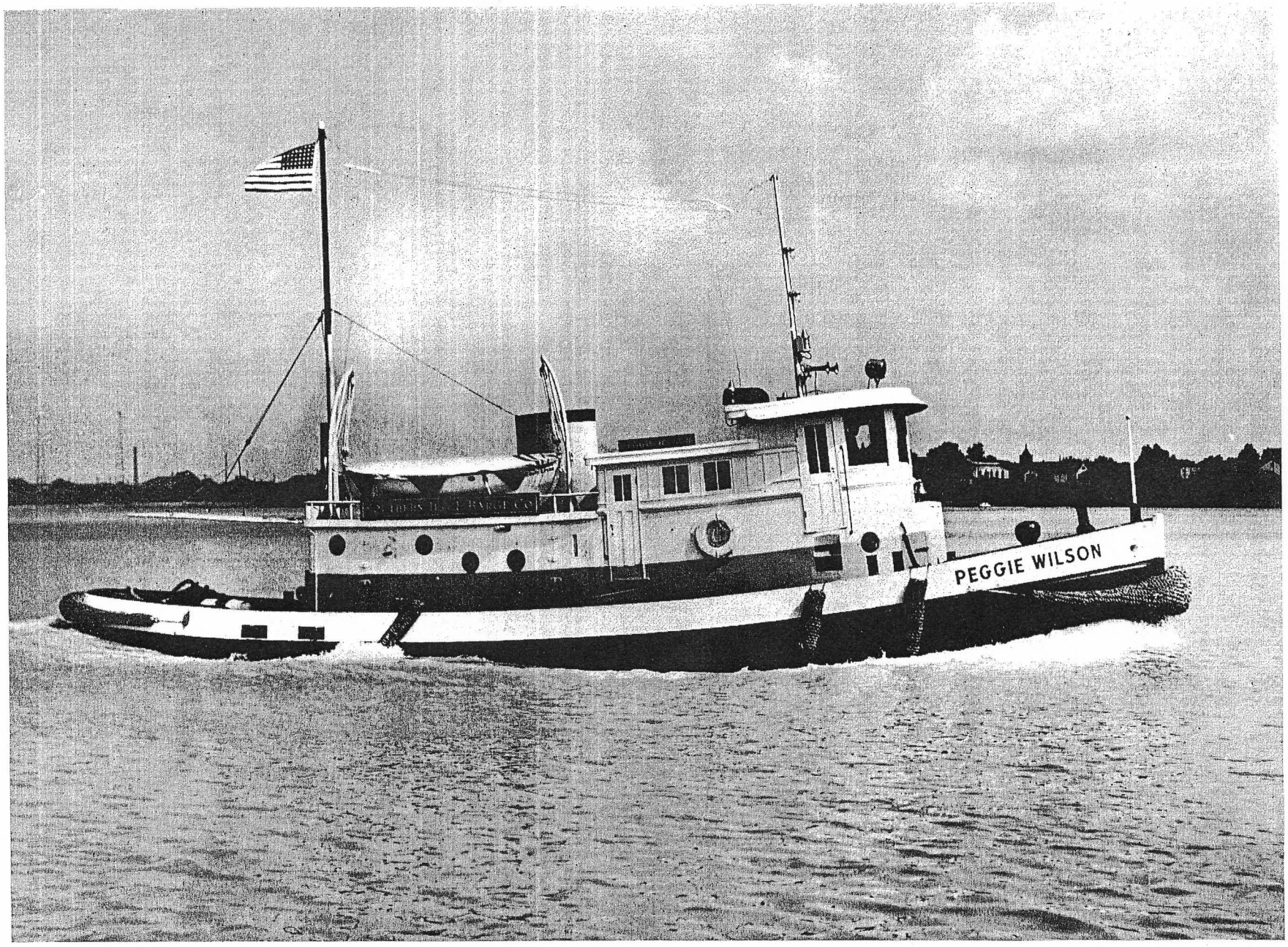
The ever increasing demand for our Diesel Engines is ample significance to the fact we have used every available resource at our command to constantly build in the best manner possible and to assist our customers to obtain the maximum in performance from these engines.

The Diesel Engine is an established and growing factor in the commerce and industry of the world. Economy, reliability, long life and freedom from excessive wear are essential to successful and profitable operation. In attaining these ends there is nothing more important than correct lubrication.

The purpose of this manual is to assist our customers in securing the highest degree of engine efficiency. The following pages are devoted to the care and operation of our oiling system. We urge that you read it thoroughly in order that you will become familar with the requirements of good operating practice.

Because the use of a suitable high quality oil is an important factor in securing effective lubrication and since this selection should not be based on physical specifications alone, we have listed certain products made by the Socony-Vacuum Oil Co. Inc., as an indication of the proper grade and quality for the engine sizes as specified. Other oils however, will work satisfactory in our engines and we only caution operators against products of unknown or inferior quality which may prove costly over the longer period of time.

WASHINGTON IRON WORKS
Seattle, Washington



TUG BOAT PEGGIE WILSON POWERED WITH 8 CYLINDER 10¼ X 13½ DIRECT REVERSING WASHINGTON MARINE DIESEL ENGINE

WASHINGTON DIESEL ENGINES

Being a prime mover, Washington Diesel Engines have a broad field of Service. They are adapted to Industrial and Marine application where power requirements demand an engine of rugged construction with simple as well as conservative operating features. The very best of materials are used in our engines, and this, coupled with the experience of our competent engineering staff enables us to design and build a power unit to meet the most exacting demands in today's commerce and industry. Our engines are not only dependable but economical to operate.

CONDITIONS AFFECTING DIESEL OPERATION

The skill and workmanship used in building our engines to deliver the maximum in dependable power output is of little consequence unless proper attention is given to the needs of certain service requirements. The care and attention given the oiling system and the selection of a lubricating oil especially applicable to Diesel Engines is of paramount importance. To fully appreciate the importance of lubrication and its relation to successful Diesel operation it is essential to have a thorough understanding of the conditions prevailing within the engine cylinders and crankcase.

Washington Diesels are four stroke cycle engines — operating on the true Diesel principle — fuel ignition is accomplished by the heat of compression only and without the aid of hot bulbs or spark plugs. Compression pressures of approximately 360 pounds per square inch is required to create sufficient temperature to ignite the fuel charge. After fuel injection starts and combustion occurs both temperatures and pressures rise very rapidly. This is of short duration, however, and as the engine completes its power stroke they rapidly dissipate themselves. During compression and combustion high pressures and temperatures are generated, which tend to destroy the lubricating oil film on the pistons and cylinder walls. The destruction of this oil film means loss of power through blow-by, loss of compression and metallic contact. In addition to this, the temperatures act to carbonize, vaporize and consume or drive off the lubricant.

Since the lubricating oil is faced with a different but no less severe set of conditions in the engine crankcase, it is evident that the burdens imposed upon the lubricating oil are many. With the pressure system of circulation, the oil is constantly in travel and is broken up into a finely divided mist as it escapes from the cheeks of the main and connecting rod bearings. The oil which travels through the drilled connecting rods to the piston pins is also subjected to piston temperatures which are relatively high and which tend to vaporize and carbonize the lubricant.

In addition to the above burden the oil becomes contaminated with by-products of combustion and unburned fuel which work past the piston. These influences all tend to reduce the lubricating value and chemical stability of the lubricating oil. The sum of the factors mentioned, namely, heat, rapid circulation in the presence of hot gases, and since heat results from both compression and combustion, it is evident that some means of escape or dissipation must be available, i.e., the cooling water and lubricating oil, otherwise the engine would soon destroy itself. The heat which reaches the engine crankcase may raise the oil temperature to as much as 100°F. above atmospheric, and contaminants indicate the influences which the lubricating oil must resist satisfactorily if it is to be dependable in the course of supplying lubrication, cooling and protection to the internal moving parts of the engine.

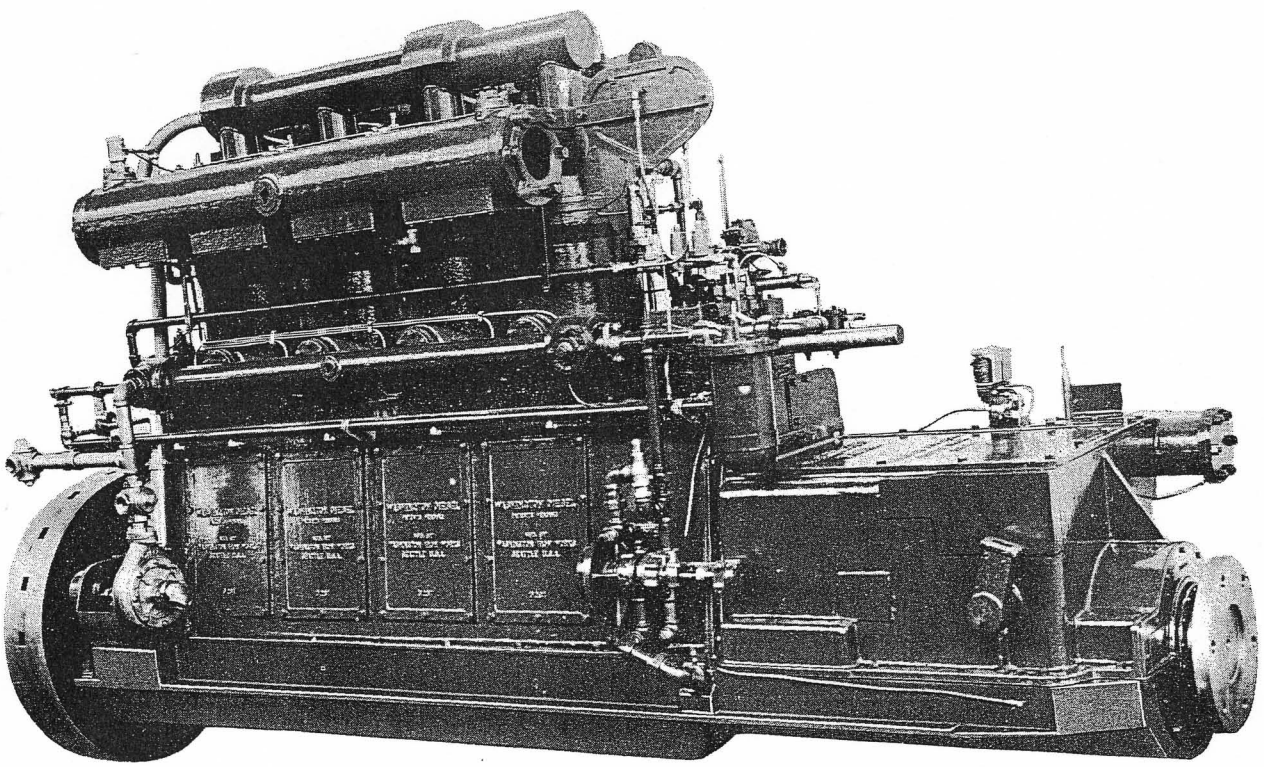
EFFECT UPON PERFORMANCE

It should be evident to the reader that lubrication has an important effect upon the daily economy of the engine. To substantiate this simpley consider the fact that power loss and wear are largely influenced by the effectiveness of lubrication. The amount of wear in turn controls the daily oil consumption and consequently the cost of the lubricant. The amount of time consumed to properly service the engine daily also affects its economy since it affects the cost of each brake horsepower developed.

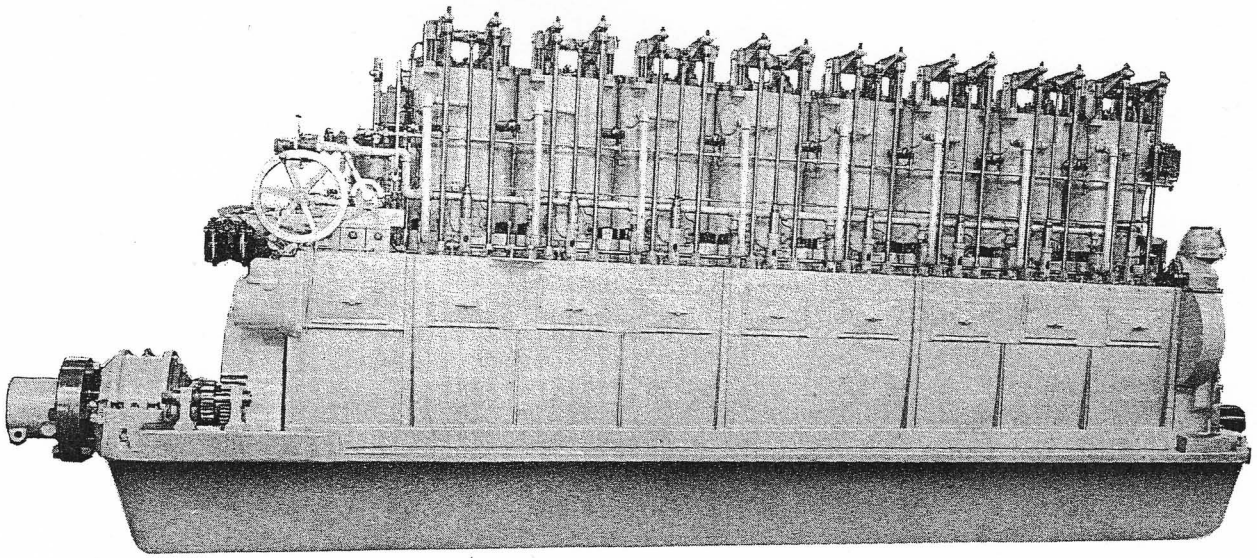
The performane of an engine is decidely off standard when lubrication is sub-standard. This is evident in the response to throttle, hence, flexobility is lowered. The ability of the engine to function properly under overload conditions, and the response to speed control, or governing may likewise be affected and reduce the standard of performance of the engine.

If the above mentioned factors, namely, economy and engine performance, are up to standard the engine is reliable and dependable. However, if either one or both should be below standard engine reliability and dependability are affected also. Since one of the fundamental requirements of a modern Diesel is its ability to deliver economically, the power for which it has been installed, it should be remembered that it is utterly impossible to construct an engine which will resist indefinitely the effects of inferior lubrication. With improper oiling, wear increases rapidly and damage to many of the internal working parts is inevitable. Should this occur, the engine must necessarily be stopped as will all operations which depend upon its power.

The delivery of continuous, reliable power will be largely the result of regular conscientious attention to the needs of the lubrication system and such attention is unquestionably one of the best safeguards against shutdown.



WASHINGTON 4 CYLINDER 10¼ X 13½ REVERSE GEAR TYPE MARINE DIESEL ENGINE



WASHINGTON 8 CYLINDER 14½ X 18 DIRECT REVERSING MARINE DIESEL ENGINE

WASHINGTON DIESEL LUBRICATING OIL REQUIREMENTS

The lubricating oil requirements of our engines is essentially the same as that of other engines in the same class and service. It is, however, important that the oil be of the type specifically adapted to service in Diesel Engines, as brought out in the discussion on page 5. The operators of our engines have access to many so called Diesel Engine lubricating oils on the market today, all of which are obviously not of the same quality and suitability; therefore it is our purpose to assist our customers in selecting an oil possessing those characteristics so essential to satisfactory service.

We readily appreciate that operators of our engines do not have the means or experience necessary to conduct tests to determine the suitability of an oil for Diesel Service and must necessarily rely upon the integrity and experience of their supplier. Much has been said regarding physical specifications and their relation to lubricating oil selection. We prefer to outline what the owner is entitled to expect in terms of service and value from correct high quality lubricating oil.

Service Qualities

In expressing the characteristics most desired in lubricating oil to assure fully efficient service in the engine such qualities as film strength, chemical stability, freedom from objectionable material and resistance to the formation of carbon deposits are of paramount importance. Consequently we urge our operators to select an oil of proven service qualities before placing it in use. If difficulty is experienced respecting any of the above qualities, we suggest the lubricating oil be investigated and a new grade installed if necessary, since it would not be good economy to pay for and not receive the performance to which you are entitled.

Selection of Lubricant

In providing our operators with a specific guide or indication of the quality considered saticfactory, we are listing below an oil made by the Socony-Vacuum Oil Company, Inc., which is correct for all engine sizes and operating conditions except as specified below:

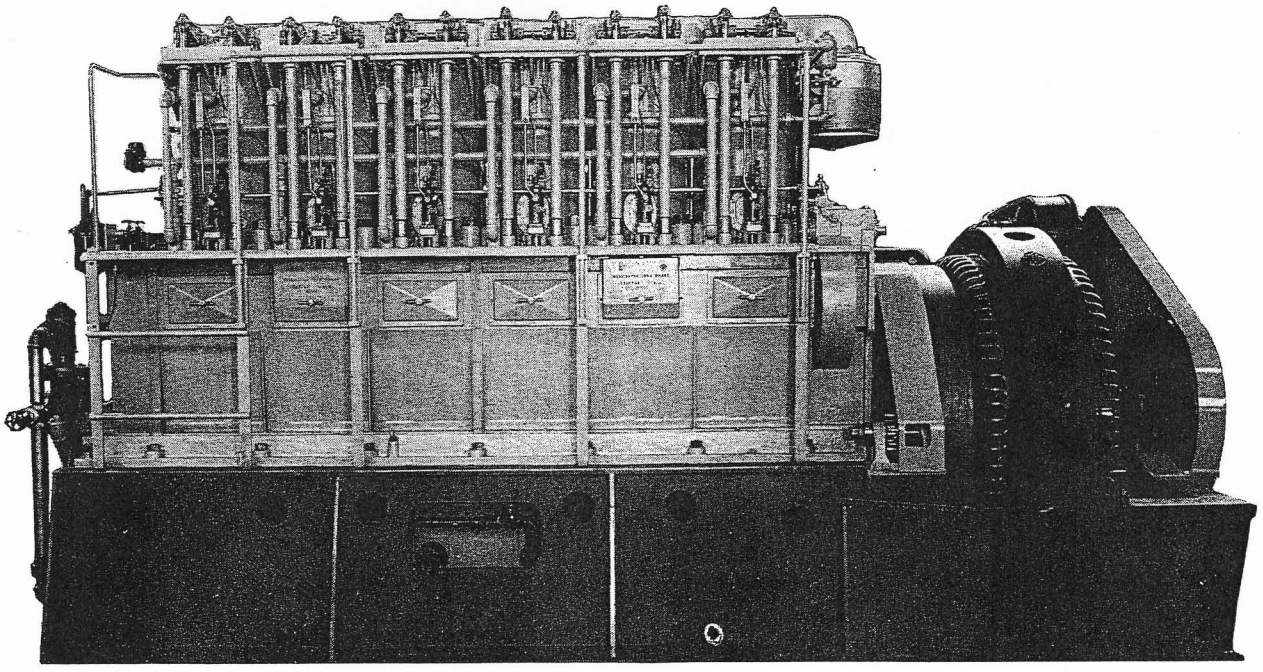
Industrial Engines

All Sizes.....Gargoyle D.T.E. Oil No. 3

Marine Engines

All Sizes.....Gargoyle D.T.E. Marine Oil No. 3

NOTE: When engine is subjected to severe or unusual atmospheric or load conditions, special engineering consideration should be given to the selection of the proper lubricant.



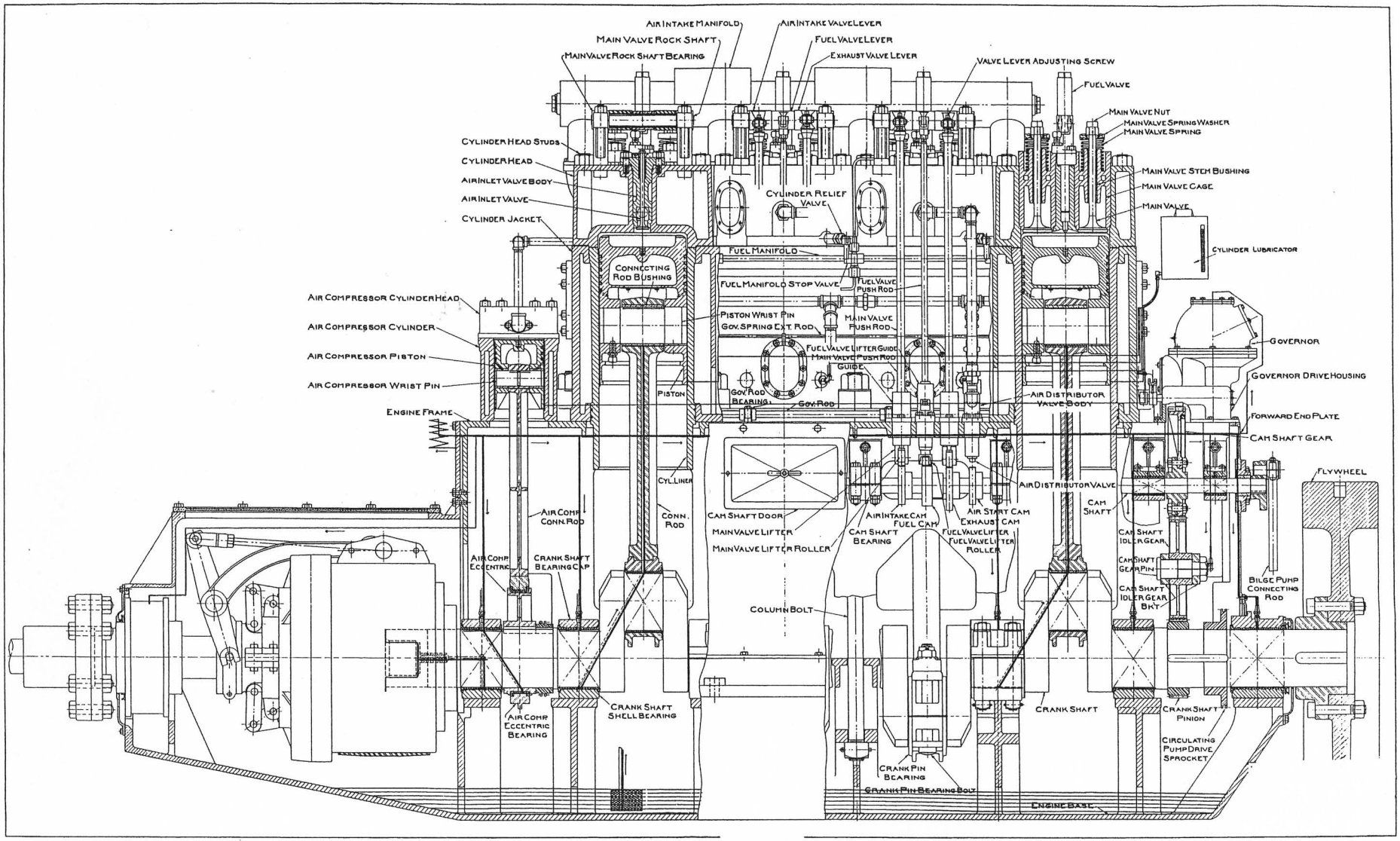
WASHINGTON 6 CYLINDER 12¾ X 16 INDUSTRIAL ENGINE DRIVING A. C. GENERATOR

DESIGN OF WASHINGTON OILING SYSTEM

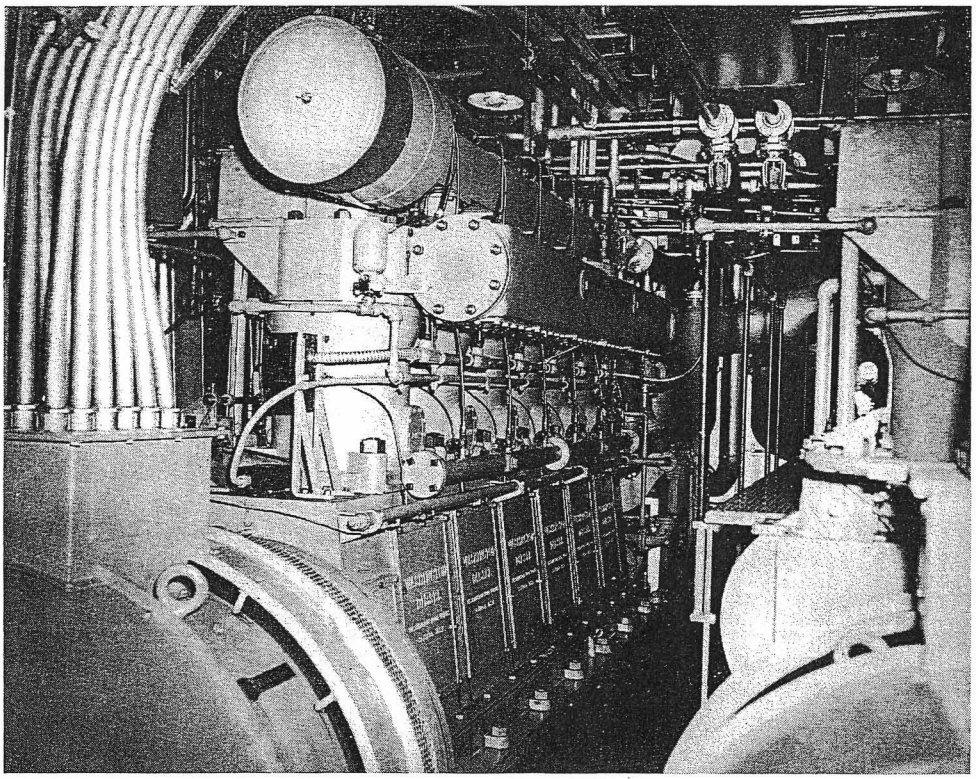
The function of the full pressure circulation system, which is used on all Washington Diesel Engines, is two fold in that it supplies every working part within the engine with a copious supply of oil at all times and also acts to carry away from these working parts temperatures generated from motion and induced from combustion, The main oil supply is located in a service tank outside the engine base from which the pressure pump draws oil forcing it through a filter and oil cooler and into the main oil header from which leads run to each of the main bearings. The oil still under pressure travels from the main bearings through holes drilled in the crankshaft to the lower connecting rod bearings, and into the connecting rods leads to the wrist pin bearings. A scavaging pump transfers the oil from the engine base back to the main oil supply tank completing the cycle.

For cylinder wall lubrication oil is supplied through a mechanical lubricator mounted on the forward end of the engine. Oil is delivered to each cylinder through a lead line to the side of the cylinder walls, where the oil is distributed by the piston rings to the upper wall area, excess oil is drained back into the engine base through oil holes provided in the oil scraper ring grooves.

On page 9 a typical layout of the oil piping is shown. Familiarity with the details of this piping and other parts of the oiling system is essential to obtaining high efficiency from the system and in carrying on regular service requirements.



OILING SYSTEM ON WASHINGTON MARINE DIESEL REVERSE GEAR TYPE



DUAL WASHINGTON MARINE INSTALLATION DRIVING D. C. GENERATOR

REQUIREMENTS OF ENGINE OILING

Oil Supply

Before starting the engine the main service tank should be checked to see that the oil level is in the proper position in the gauge glass, and fresh oil added if needed to bring the level up to ¾ full. If the engine is started with insufficient oil it may prove damaging to the engines within a matter of minutes. It should be a daily habit with the operator to check the oil level and to open the drain valve in the bottom of the tank daily to draw off any water or sludge which may have accumulated there. *If for any reason the pressure gauge fails to register, the engine should be stopped at once to avoid damage and an investigation should be made to determine the cause and its elimination.*

Oil Pressure

The oil pressure gauge should also be checked frequently as it indicates the functioning of the oiling system. When the engine is cold the oil pressure gauge will read from 30 to 40 pounds. This, however, will drop down to 15 or 20 pounds as the engine warms up, and will remain at this reading.

Crankcase Oil Temperature

Oil temperatures should be checked frequently at the outlet on the scavenging pump before it is delivered to the main supply tank. On Marine Engines where salt water is used for cooling, the circulating water temperature should not exceed 120°F. Temperature at the water outlet. Temperatures above this will cause a precipitation of salts in the circulating wate rsystem and promote the formation of deposits or scale which will in turn interfere with proper engine cooling. Lubricating oil temperatures should run between 135 and 140° F. when taken at the above specified location. This

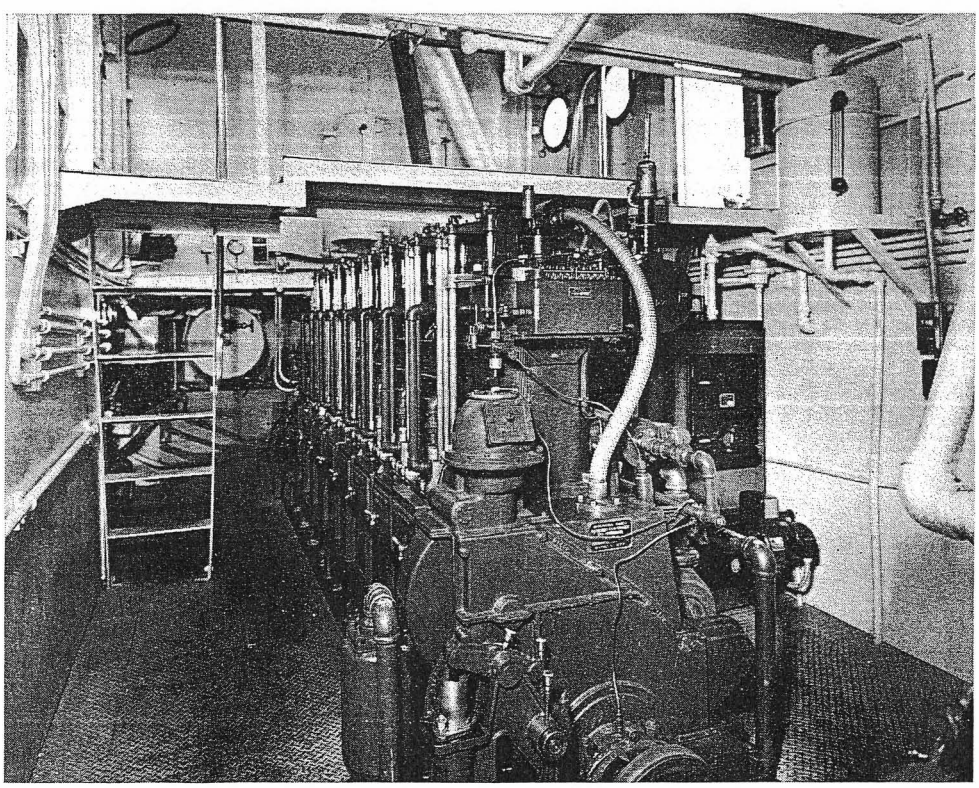
applies to Marine as well as Industrial Engines. Since oil temperature is influenced by speed, load, engine cooling, air temperatures, and the function of the oil cooler, we wish to point out that any one, or a combination of these, may produce a change in temperature.

Oil Filter

A large metal edge oil filter is standard equipment on Washington Engines. The functioning of this unit in keeping the oil clean is of paramount importance. Therefore, it is essential to keep this filter in excellent working condition at all times. The exterior surface of the filter screen should be cleaned out at intervals not exceeding six hours. The clockwise turning of the filter handle will drive a scraper around the face of the screen removing any accumulation of material lodged there. A general indication that the element is becoming clogged is the reduction in oil pressure. Located at the bottom of the filter case is a drain plug which should be removed weekly to permit draining of any sludge or foreign deposits. The filter element should be removed at periods not exceeding sixty days and should be thoroughly cleaned. Refer to Parts Manual for instructions.

Mechanical Lubricator

On Marine and Industrial Engines a mechanical lubricator is located on the forward end of the engine for supplying lubricating oil to the cylinders. A lead line runs to each side of the cylinder walls. When the engine leaves the factory the feeds to the cylinder are left well open purposely to supply an ample amount of oil to the cylinders during the run-in period. After proper run-in these feeds should be cut down to a delivery rate of from six to eight drops per minute per line. The lubricator should be maintained at better than half full at all times with the same type of oil as used in the engine circulating system.



WASHINGTON DIESEL MODEL 8-R-13-320 H.P. INSTALLED IN TUG BOAT

Oil Change Periods

Where conditions of operation are normal and oil of suitable quality is used with proper attention given the filtering element, a drain period of 300 hours is suggested. On installations where an efficient centrifuge is employed, this period may be increased to 500 operating hours. It is advisable, however, to confirm this practice through chemical and physical analysis of the oil. With abnormal conditions such as overloading the engine, ineffective filtering element and with dirty operating conditions, the drain period should not be extended over 200 operating hours. This, however, is influenced by the above mentioned circumstances and in extreme cases a drain period of 100 hours may be necessitated. The reader is referred to that section covering purification of Diesel Lubricating Oil on page 13. A thorough understanding of the effects of various purification methods is essential to efficient operation and we urge our operators to familiarize themselves with this practice because regular oil changes, in accordance with operating conditions is most essential to good lubrication.

Drains should always be made when the engine is warm as this permits removal of troublesome deposits before they have an opportunity to precipitate out. The inside of the engine crankcase, and the screen on the scavenging pump should be cleaned at regular intervals; this applies also to the crankcase breathers. We suggest this be done once per month, or at intervals consistent with good operating economy.

Factors Influencing Satisfactory Lubrication

A resume of preceding chapters indicates that the satisfactory performance of lubricants is affected by the following: Cooling water temperature, air intakes and filters, rate of oil feed to cylinders, equal balance of load on each cylinder and avoidance of overload except where it is impossible to do so. We urge our users to familiarize themselves with good practice policies which result in satisfactory performance, and extended service over an indefinite period of time.

ACCESSORY PARTS

Marine Engine Thrust Bearings

Tapered Roller-Thrust Bearings are used on most marine installations, although a Babbit Collar Thrust Bearing was used on older models. All Tapered Roller Thrust Bearings are lubricated from the main engine circulating system, while the Babbit Collar Thrust Bearing is lubricated from the mechanical lubricator mounted on the forward end of the engine. We recommend a feed of ten drops per minute to this bearing. The same oil which is used for the engine cylinders is satisfactory.

Water Pumps

Rotary Type Water Pumps are used on Washington Marine Engines. The pump bearings are grease lubricated and require a water pump grease. For this application we recommend Gargoyle Grease A.A. No. 4, applied through the grease cup on the pump housing. To service this unit the operator should give this cup one turn every three or four hours in order to keep an adequate supply of lubricant in the water pump bearings.

Air Compressors On Engine

The compressor is of our own manufacture. The same grade of lubricating oil used in the engine will be satisfactory for service in the compressor.

Air Cleaners

The Air Clearners are furnished at customer's preference, therefore servicing should conform to manufacturer's instructions.

Exhaust & Inlet Valves

Before starting the engine and during operation the valves should be lubricated at eight hour intervals using Mobil Upper Lube applied by oil can. This highly concentrated lubricant provides a protective film against wear and assists in keeping valve stems free of objectionable deposits. When applied this lubricant should be used sparingly.

Reverse Gears

Three types of Reverse Gears are used on our Marine Diesel Engines. On the larger size old model engines these are of our own manufacture and are so designed as to withstand hard usage indefinitely. This type consists of the clutch type gear mounted on a through stub shaft which forms the backbone to hold the drum assembly in line and to keep wear to a minimum. The gears are of the spur type made from large sized nickel steel blanks. These gears are mounted on heavy duty bronze floating bushings, running on hardened and ground pins. Lubrication of these gears is provided by oil bath in the gear drum. This system is independent of the engine Oiling System and therefore requires checking about once a week. The oil level should be maintained at 1/3 full at all times and fresh oil should be added when necessary to maintain this level. The fill plug is located at the after end of the drum. The lubricating oil requirements of this gear necessitate the use of a lubricant such as Gargoyle Compound No. 4, which is of the correct body and possesses the required characteristics. On the smaller type Marine Diesels, we use Joes Husky Revers Gear. This gear is so mounted that couplings located at each end may be removed for inspection. To lubricate this gear, it is necessary to first throw the lever to the forward position, then remove the small plug in the edge of the flange and force in about two guns of Gargoyle Compound No. 4, which possesses the required characteristics for service in this unit. Servicing should be made about once a week.

All late model engines have the reverse gear and clutch completely enclosed and lubricated from the engine lubricating system.

Lubricating Oil Purification

The subject of oil purification when treated singularly and in detail is space consuming, more so than space in this manual will permit; therefore, it is our purpose to give a brief outline of the several methods involved as a general guidance to users of Washington Diesel Engines.

The purpose of purification is two fold; first, to maintain the lubricating oil in a clean and stable condition, and secondly to obtain a maximum in horsepower hours per gallon. Such treatment also assists in keeping the interior of the engine in a clean condition by removing objectionable material before it reaches the precipitation point. There are many points involved when consideration is being given to purification methods, and we suggest the operator refer to the maker for literature covering the features of their particular system.

Centrifugal Separation

The principle of this method involves separation by the difference in specific gravity between the oil and impurities which it contains. This difference is greatly magnified by the centrifugal force which produces separation. This method has important advantages because large quantities of oil can be treated quickly.

Filtration

This method has as its basic principle the removal of impurities from the lubricating oil by passage through an element or elements. There are many filters and reclaimers on the market whose mechanical details vary widely. These may be considered as falling into two general classes; namely, those whose elements are of the cotton waste, bag or edge types, and those whose elements consist of activated clay. For details surrounding these types the reader is referred to the maker.

Batch Setting

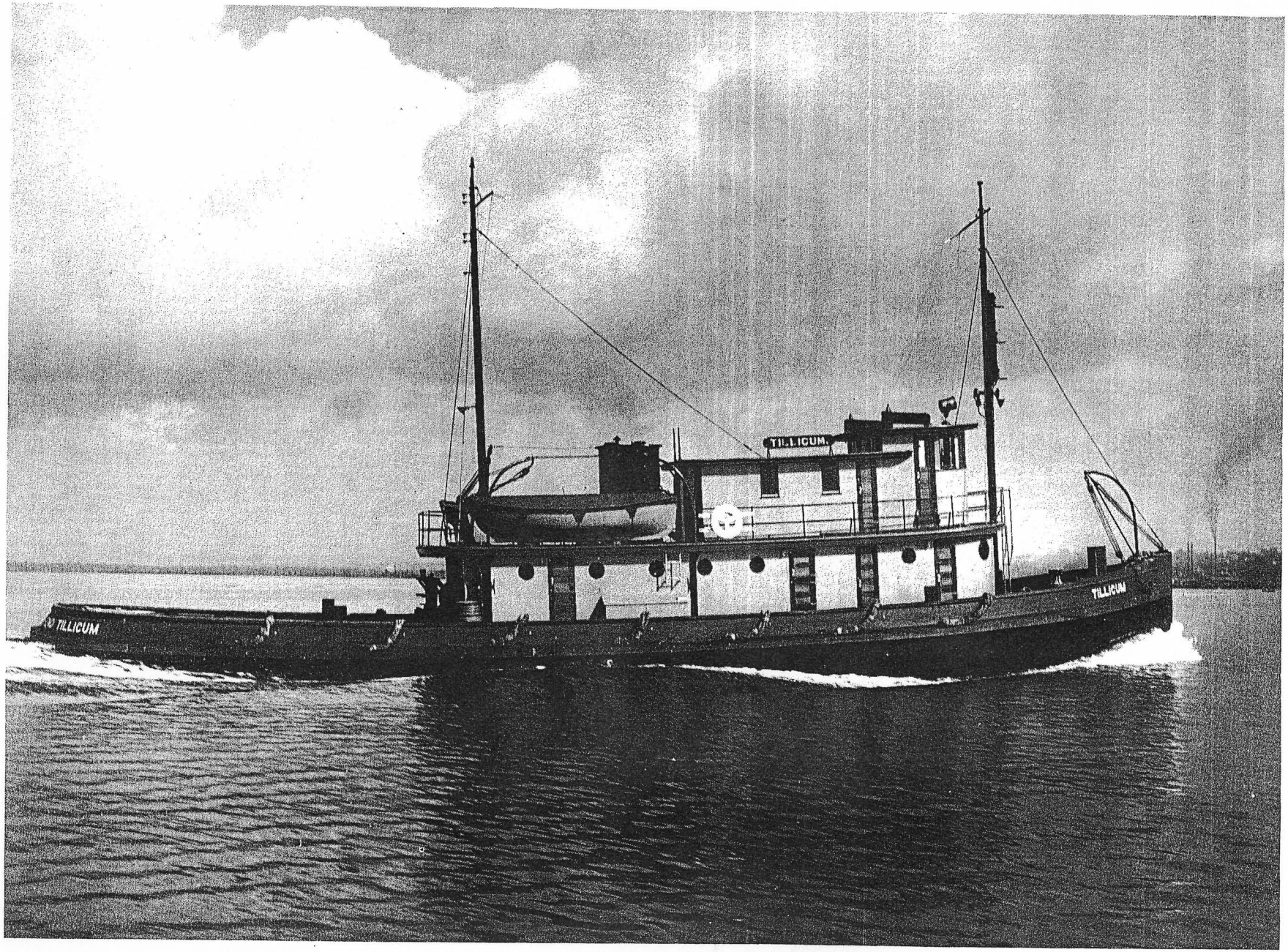
Separation in this method is secured through the difference in specific gravities between the oil and impurities it contains plus the action of gravity. However, this method requires a period of absolute quiet; therefore, it is of little value aboard ship. It will not permit separation of fuel dilution, fine impurities or restore the original color to the oil.

Diesel Engine Fuels

The subject embracing Diesel Fuels is one of considerable importance and while we treat the subject briefly we want to emphasize to our users the need for using fuels of established quality and suitability.

There are many written specifications covering these fuels, some of which may be satisfactory while others may not be. Since the use of poorly selected fuels can result in the formation of objectionable deposits we urge our users to consult with their supplier when considering the purchase of Diesel Fuels, in order to obtain a fuel having the required characteristics.

Our experience has indicated that such fuels as Mobilfuel Diesel possess the proper characteristics for use in our engines. This fuel is marketed throughout the country by the Socony-Vacuum Oil Company, Inc., and its various affiliated companies. Other fuels, if used, should have equal characteristics.



TUG BOAT TILLICUM POWERED WITH 6 CYLINDER 14½ X 18 DIRECT REVERSING WASHINGTON DIESEL ENGINE