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NAVSEA 0941-014-8013

WESTERBEKE DIESEL

MODEL 14088

ENGINE SERVICE MANUAL

DEPARTMENT OF THE NAVY

NAVAL SEA SYSTEMS COMMAND

WESTERBEKE

WESTERBEKE CORPORATION
MYLES STANDISH INDUSTRIAL PARK
150 JOHN HANCOCK ROAD, TAUNTON, MA 02780-7319

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DSA 700-71C-9054	26' M.W.B.	138	OSA, Columbus, Ohio
N00024-73-C-0270	26' M.W.B.	80	Uniflite, Inc.
N00104-73-C-0830	26' M.W.B.	50	SPCC - Mechanicsburg
N00104-74-C-0825	26' M.W.B.	50	SPCC - Mechanicsburg
N00024-75-C-2041	26' M.W.B.	80	Uniflite, Inc.
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N00024-78C-2355	26' M.W.B.	26	Uniflite, Inc.
N00104-79-C-2732	26' M.W.B.	86	SPCC - Mechanicsburg
N00024-80-C-2060	26' M.W.B.	104	Mason Boats Ltd.
N00104-81-C-2076	26' M.W.B.	102	SPCC - Mechanicsburg

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It is hereby certified that NAVSEA 0941-014-8010 to be provided under the above contracts has been approved by the approval data shown above.

J. H. WESTERBEKE CORPORATION
Avon, Massachusetts 02322

LIST OF EFFECTIVE PAGES

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IMPORTANT

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INTRODUCTION

This manual describes the operation, adjustment and maintenance of the Westerbeke Whaleboat Marine Diesel Engine and is designed to be a guide for those concerned with the operation and maintenance of these diesels. This engine incorporates a basic engine model known variously as 4-99, 4-107 and 4-108. You will notice continual references to these three model numbers throughout the workshop portion of this manual. They are used to distinguish among the three major engineering changes already made to the engine.

The diesel engine closely resembles the gasoline engine inasmuch as the mechanism is essentially the same. Its cylinders are arranged above its closed crankcase, its crankshaft is one of the same general type as that of a gasoline engine; it has the same sort of valves, camshaft, pistons, connecting rods and lubricating system and reverse and reduction gear.

There it follows to a great extent, that it requires the same treatment as that which any intelligent and careful operator would give to a gasoline engine and that gross negligence such as running the engine short of oil, with sludged oil, dirty filters, or with water boiling will have the same expensive consequences.

The diesel engine does differ from the gasoline engine however, in the method of handling and firing its fuel. Carburetor and ignition system are done away with and in its place is a single component - the Fuel Injection Pump - which performs the functions of both.

Unremitting care and attention at the factory have resulted in an engine capable of many hundreds of hours of service. What the manufacturer cannot control however, is the treatment the product will receive in service. This part rests with you.

Whenever service parts are ordered, always give complete description and part numbers with engine model and serial number; as an example:

'Please supply:

For Whaleboat Marine Engine No. ED7153480
10 of 15559 Oil Filter Cartridge'

The engine number is stamped on the starboard side of the engine on the forward end of the Camshaft Chamber and on the port side of the engine near the fuel pump.

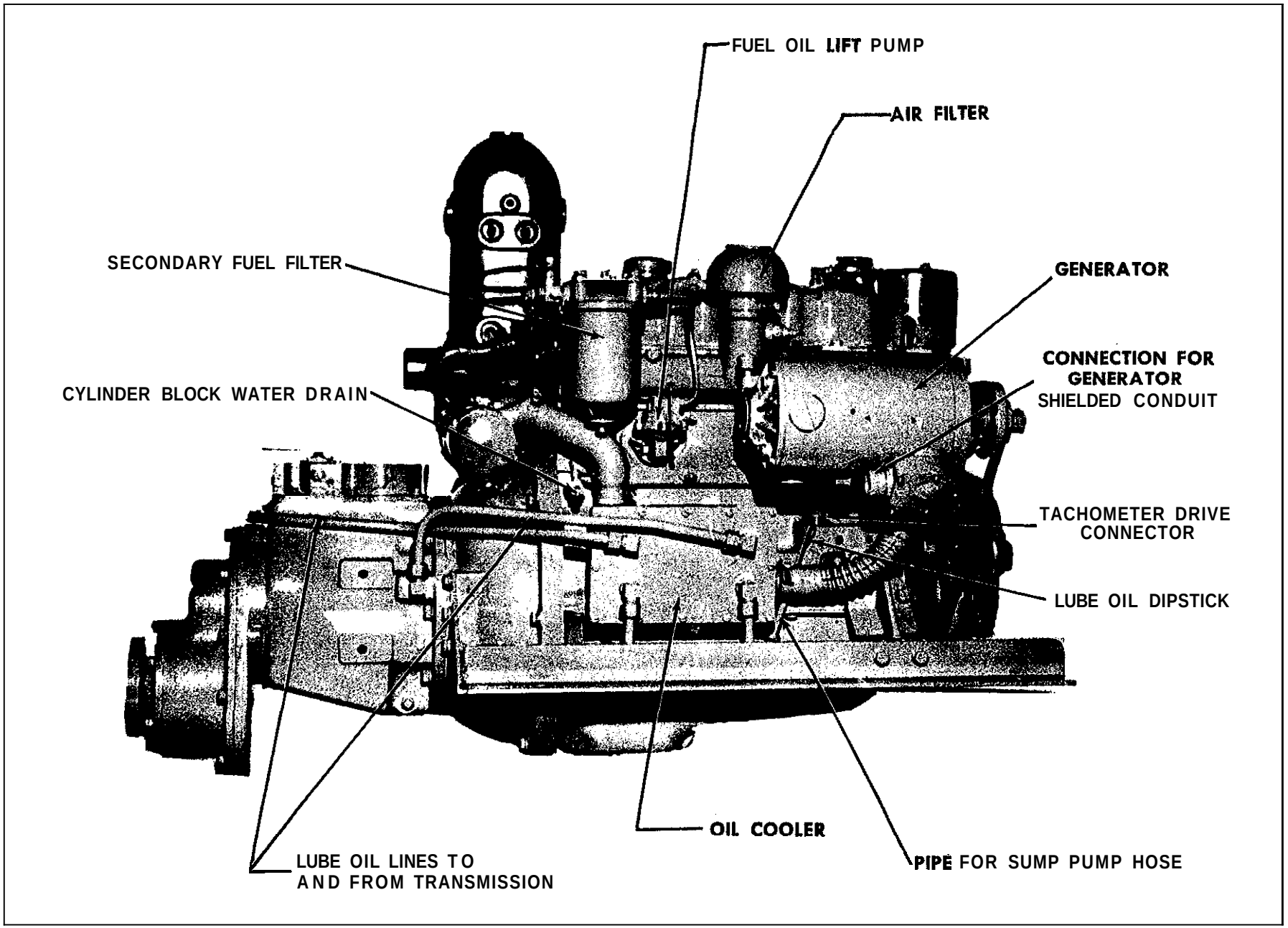


Fig. 1–Starboard Side of Model Four-107

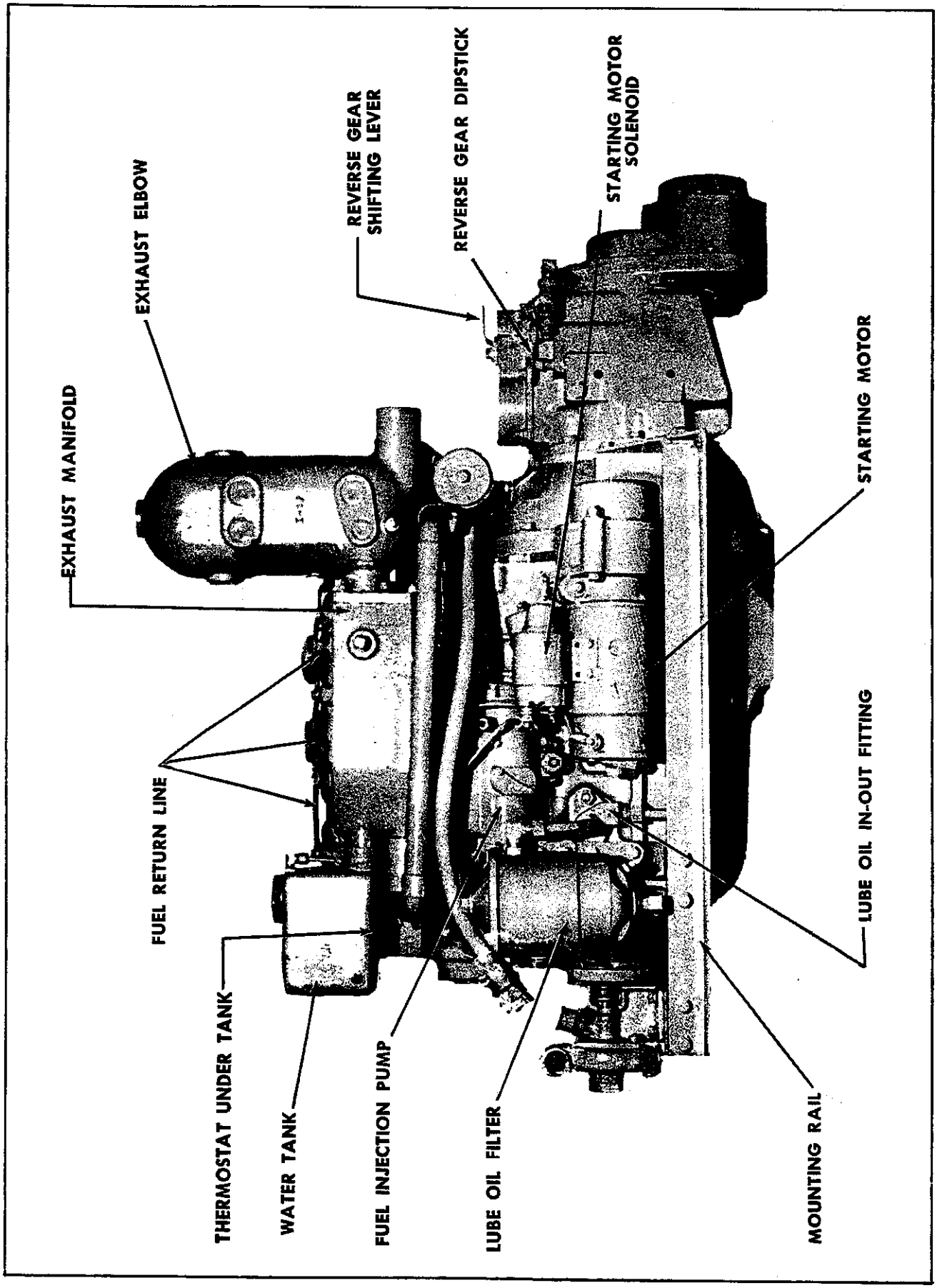


Fig. 2–Port View of Engine

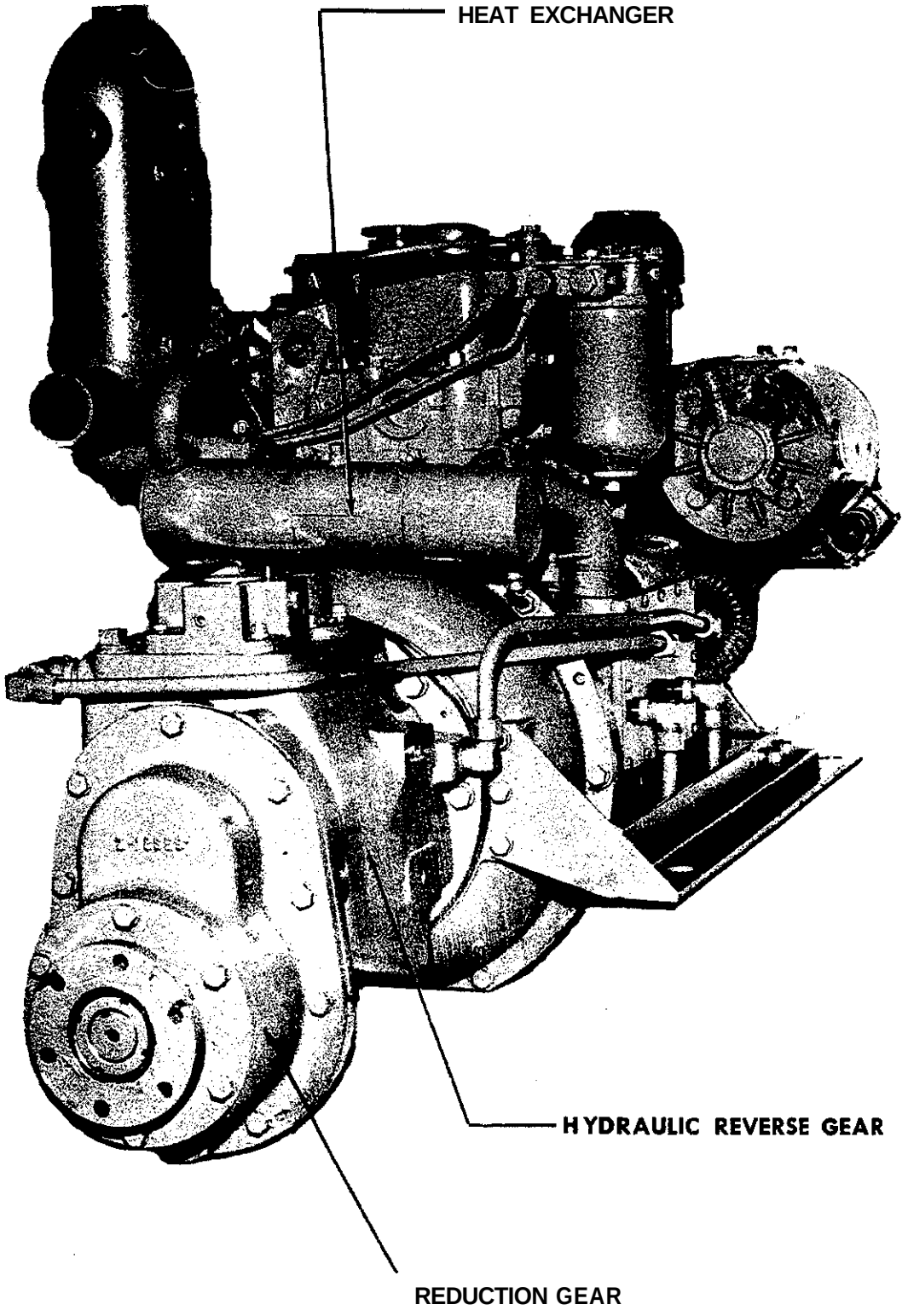


Fig. 3–Rear Starboard View Looking at Transmission

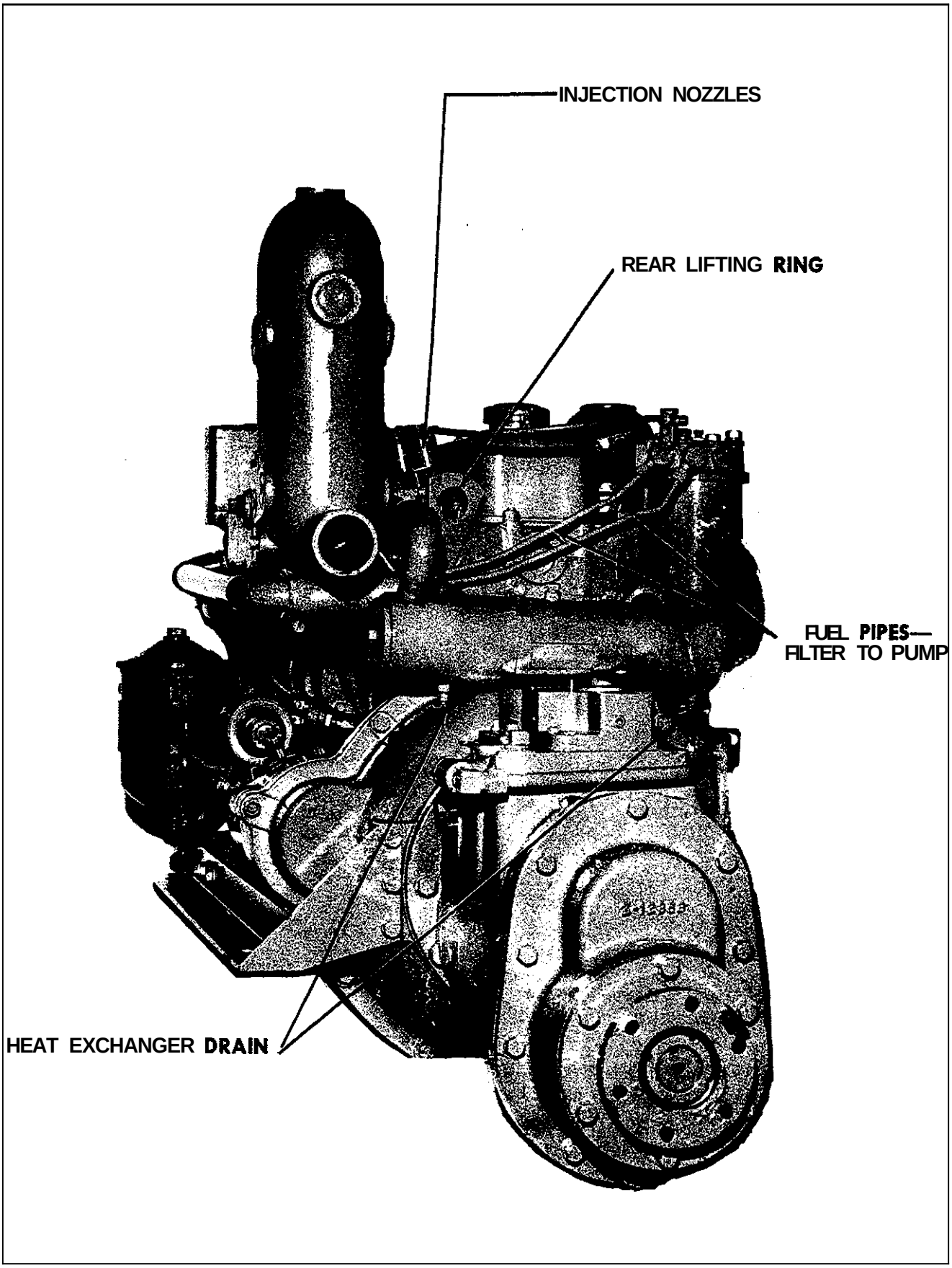


Fig. 4—Rear Port View Looking at Transmission

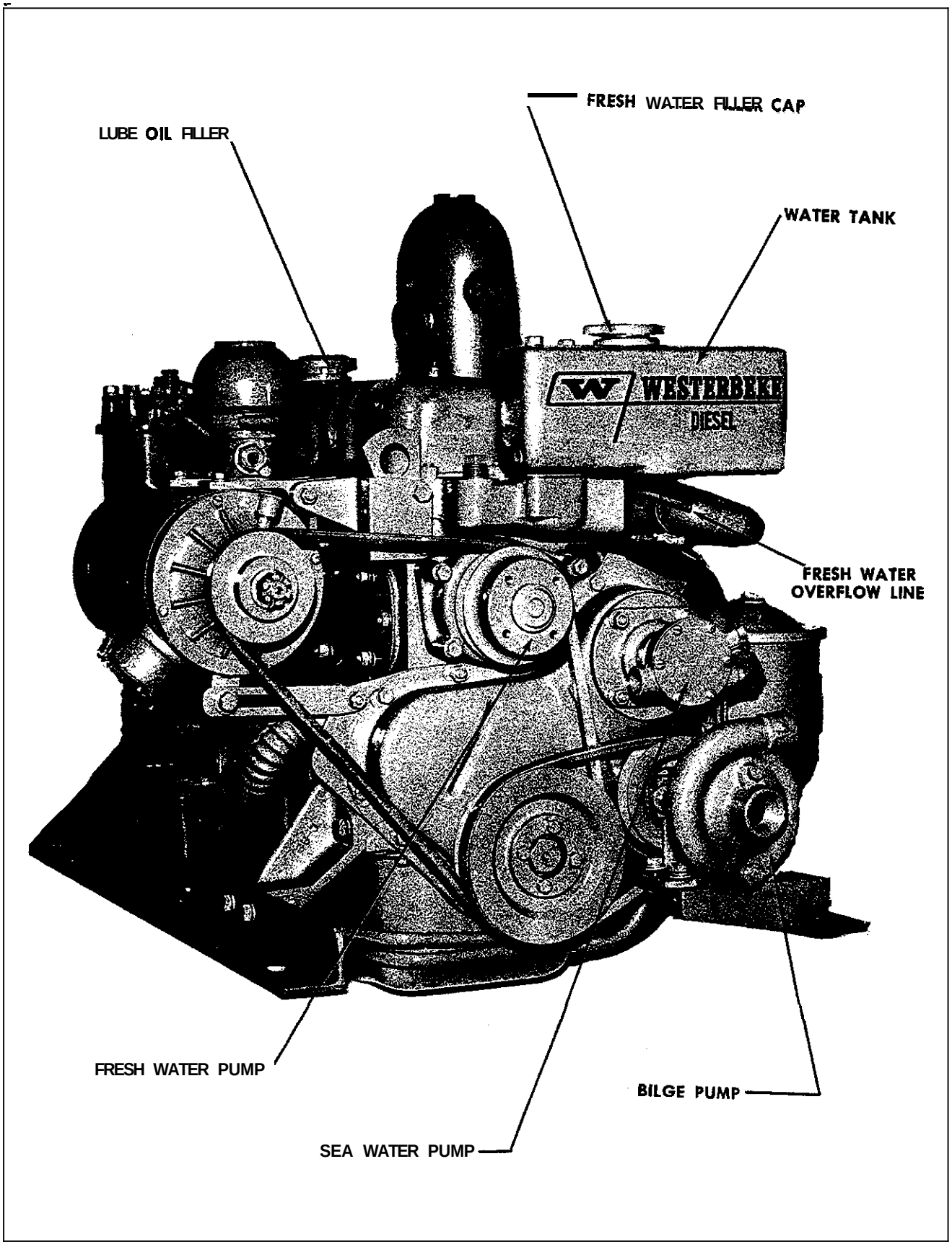


Fig. 5–Front Starboard View of Engine

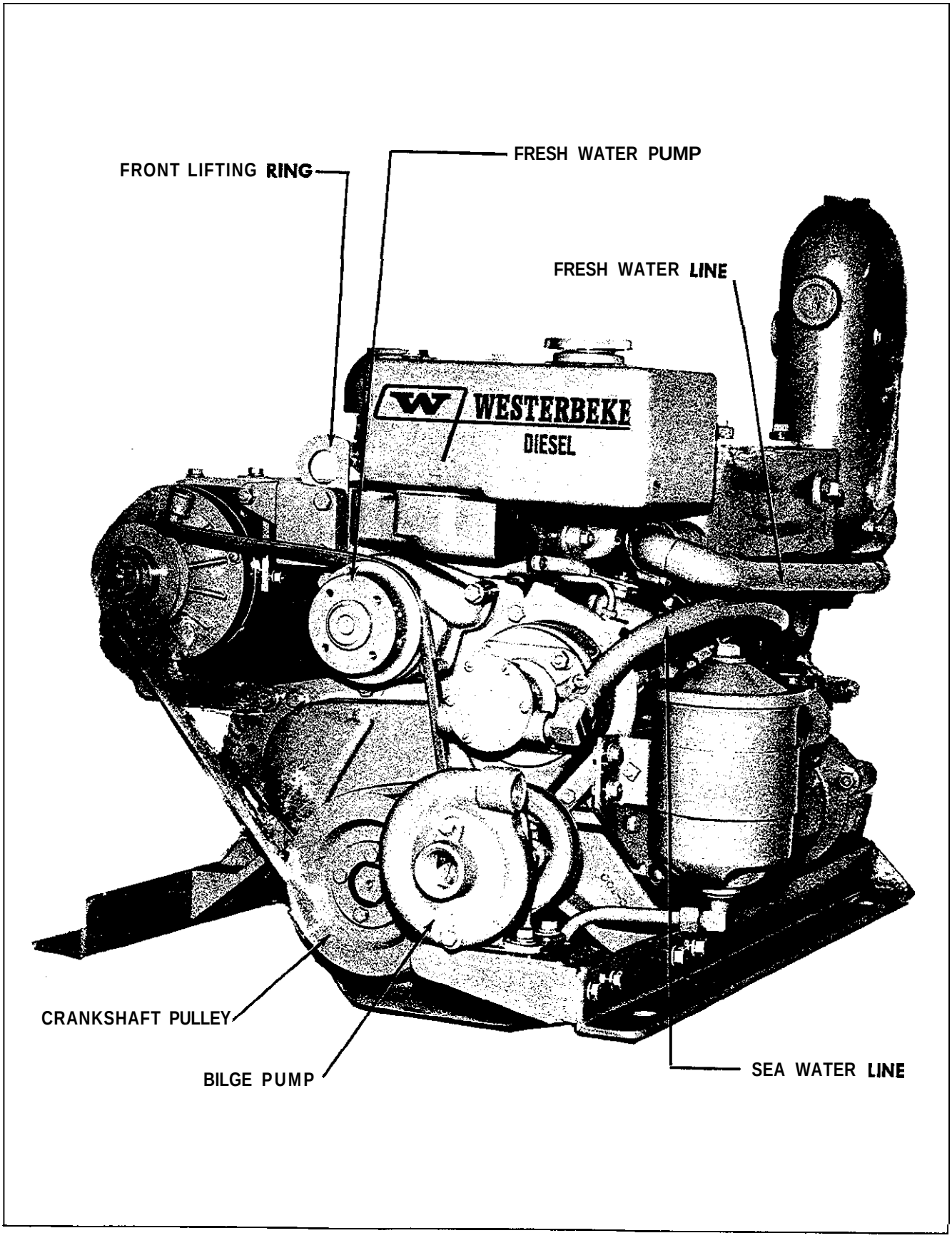


Fig. 6–Front Port View of Engine

INSTALLATION

FOREWORD

Since the boats in which these engines are used have been designed by engineers of the U.S. Navy, every detail of the engine installation is provided for in the plans, and checked by U.S. Naval Inspectors.

The following outline of general procedure is included because it is valuable in explaining the functions of each component, the reasons why, the precautions to be watched, and the relationship of the installation to the operation of the engine.

There are details of the installation which should be checked periodically, and regarding which the operator should have a thorough understanding to insure good operating conditions for the engine, and to insure correct procedure in servicing the engine.

INSPECTION OF SHIPMENT

The engine is shipped from the factory mounted upon heavy skids and properly crated. Accessory equipment is shipped in a separate small box, usually packed with the engine crate. Immediately upon arrival, the shipment should be inspected for possible accidental damage in transit and for any possible shortage in parts and equipment. Before accepting any shipment from the transportation company, check with the packing list and if any shortage or damage is noted. file claim with the agent before accepting shipment, reporting same to the shipper.

Inspect the engine for loose nuts or screws. Transportation frequently loosens things on a new engine, on account of gasket shrinkage.

Tighten down cylinder head. This should be done before starting the engine, and again while it is hot after running for a few hours. Start at center of head, then work out toward sides and ends, taking one-half turn on each nut. Repeat the process in the same order until all nuts are tight. Refer to page E 9.

RIGGING AND LIFTING

The engine is fitted with two lifting rings, designed so that the engine may be lifted without damoge. Location of these is shown in Fig. 4 and 6. Rope or chain slings should be attached to the rings and the engine lifted by means of a tackle attached to this short sling. The lifting rings have been designed to carry the fullweight of the engine, therefore ouxiliory slings ore not required or desired.

The general rule in moving engines is to see that all equipment used is amply strong and firmly fixed in place. Move the engine a little at a time and see that it is firmly supported. Eliminate possibility of accidents by avoiding haste. Do not lift from the propeller coupling, or pry against this with crowbar, as you may distort the coupling.

In some cases it may be necessary to lift the engine in other than the regular horizontol position. -It may be that the engine must be lowered endwise through a small hatchway which cannot be made larger. If the opening is extremely restricted it is possible to reduce to some extent the outside clearances such os generator, cooling piping, water tank, filters, mounting lugs,, etc. This accessory equipment should be removed by a competent mechanic and special care should be taken to avoid damage to any exposed ports or the entrance of dirt where openings have been made. The ports which have been removed should be returned to position as soon as the restricted opening has been passed.

In case it is necessary to hoist the engine either front end upwards or reverse gear end upwards the attachment of slings must be done very carefully to avoid the possibility of domoge to the parts on which the weight may come. It is best if special rigging work be done by someone experienced and competent in the handling of heavy machinery.

ENGINE BOLTS

It is recommended that 1/2" lag bolts, preferably of bronze, be used through theengine supporting brackets. Bolt holes are drilled 9/16". Log screws are less preferred because their hold on the wood is weakened every time they are moved whereas the lag bolt stays in position and the nut on top is used to tighten the engine down or is removed to permit the engine to be lifted. The bolt itself stays in position at all times, as a stud, and the bond between the bolt and the wood is not weakened by its removal.

PROPELLER COUPLING

rach Westerbeke Diesel engine is regularly fitted with a suitable coupling for connecting the propeller shaft to the engine.

The coupling must not only transmit the power of the engine to turn the shaft, but must also transmit the thrust either ahead or astern from the shaft to the thrust bearing which is built into the reduction gear housing of the engine. This coupling is very carefully machined for accurate fit.

For this engine model, with 2.16:1 drive ratio, the propeller half coupling is bored for 1-3/8" shaft. The coupling has keyway with set screw, and a square key is supplied with loose equipment shipped for the engine.

The forward end of the propeller shaft hasa long straight keyway. Any burrs should be removed from the shaft end. The coupling should be a light drive fit on the shaft and the shaft should not have to be scraped down or filed in order to get a fit. It is important that the key be properly fitted both to the shaft and the coupling. The key should fit the side of the keyway very closely, but should not touch the top of the keyway in the hub of the coupling.

If it seems difficult to drive the coupling over the shaft, the coupling can be expanded by heating in a pail of boiling water. The face of the propeller coupling must be exactly perpendicular to the centerline or axis of the propeller shaft.

PROPELLER

The type and size of propeller is indicated in Navy Specifications, selected to fit the application, and based upon boat tests. To utilize the full power of the engine, and to achieve ideal loading conditions, it is desirable to use a propeller which will permit the engine to reach its full rated speed of 2400 rpm on full throttle. This can be determined only by actual trials of the pilot model.

ALIGNMENT OF ENGINE

The engine must be properly and exactly aligned with the propeller shaft. No matter what material is used to build a boat it will be found to be flexible to some extent and the boat hull will change its shape to a greater extent than is usually realized when it is launched and operated in the water. It is therefore very important to check the engine alignment at frequent intervals and to correct any errors when they may appear.

Misalignment between the engine and the propeller shaft is the cause of troubles which are blamed often on other causes. It will create excessive vibration, loss of power and speed, excessive bearing wear, rapid shaft wear and will, in many cases, reduce the life of the hull by loosening the hull fastenings. A bent propeller shaft will have exactly the same effect and it is therefore necessary to be very careful that the propeller shaft itself be perfectly straight.

It is recommended that approximately 1/2" be allowed for the use of shims between the engine mounting feet and the engine bed. It is also recommended that the top of the engine bed be fitted with a steel plate or angle iron to prevent the shims from sinking into the wood under pressure. A perfect alignment is not easy to achieve. It is the result of careful, painstaking effort and the reward in the way of a smooth running installation is well worth the effort. Before starting the work of alignment a number of shims should be cut, these shims should be in various thicknesses so that the motor can finally be set at exactly the right elevation. Temporary shims may be cut from hard wood and used to obtain the preliminary alignment. These temporary shims can then be replaced by permanent cat iron or sheet metal shims which will exactly fit the space between the underside of the mounting lugs and the top part of the engine bed.

The engine should be moved around on the bed and supported on the screwjacks or shims until the two halves of the couplings can be brought together without using force and so that the flanges meet evenly all around. It is best not to drill the foundation for the foundation bolts until the approximate alignment has been accurately determined. One-half inch diameter lag bolts should be used for the hold-down bolts.

Never attempt a final alignment with the boat on land. The boat should be in the water and have had an opportunity to soak up somewhat so that it is as near as possible to its final water form. It is best to do the alignment with the fuel and water tank about half full and all the usual equipment on board. Take plenty of time in making this alignment and do not be satisfied with anything less than perfect results. The alignment is correct when the shaft can be

slipped backwards and forward into the counterbore very easily and when a feeler gauge indicates that the flanges come exactly together at all points. The two halves of the propeller coupling must be parallel within .002 inch. If an .003" feeler gauge con be inserted, alignment is unsatisfactory.

Another way to check the flange alignment is to use slips of paper for indicating shims. Alignment is satisfactory when the same pull is required to remove all pieces of paper when the coupling flanges are brought together.

In making the final check for alignment the engine half coupling should be held in one position and the alignment with the propeller coupling tested with the propeller coupling in each of four positions, rotated 90 degrees between each position. This last test will also check whether the propeller half coupling is in exact alignment on its shaft. Then, keeping the propeller coupling in one position the alignment should be checked rotating the engine half coupling to full position each 90 degrees from the next one.

The engine alignment should be rechecked after the boat has been in service for one to three weeks and if necessary the alignment remade. It will usually be found that the engine is no longer in alignment. This is not because the work was improperly done at first, but because the boat has taken some time to toke its final shape and the engine bed and engine stringers have probably absorbed some moisture. It may even be necessary to re-align at a further period.

The coupling should always be opened up and the bolts removed whenever the boat is hauled out or moved from the land to the water. The flexibility of the boat often puts a very severe strain on the shaft or the coupling or both when it is being moved. In some cases the shaft has actually been bent by these strains. This does not apply to small boats that are hauled out of the water when not in use, unless they are dry for a considerable time.

EXHAUST SYSTEM

The exhaust manifold is a one-piece casting, water cooled to which is attached at the after end an exhaust Goose Neck elbow. This elbow has a connection to take the cooling sea water after it posses through the heat exchanger and then it is directed for cooling the exhaust pipe.

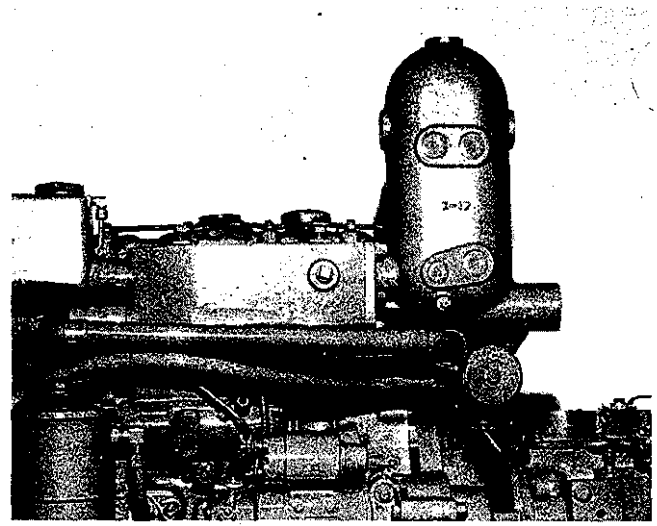


Fig. **8–Exhaust Manifold and Elbow**

The exhaust goose neck is attached to the aft end of the exhaust manifold, with an exhaust flange gasket between the end of the manifold and the flange of the goose neck. The rear end of the exhaust goose neck has a cast round surface over which an exhaust hose is connected and clamped, and the exhaust hose continues back to connect with tubing which carries exhaust line gases and exhaust line cooling water overboard.

The Exhaust Goose Neck is internally water jacketed for cooling, and the water for cooling is supplied by the sea woter pump through the heat exchanger. The cooling water enters into the exhaust goose neck at a 3/4" pipe thread hole in the center section, and fills the internal cavities and is allowed to flow out of internal openings in the aft end of the goose neck and the cooling water and exhaust gases are carried out overboard. There is an internal dam or wall that prevents water from flowing back into the exhaust manifold that could cause internal damage to the engine. There is an 1/8" pipe thread drain hole on the bottom of the casting.

The exhaust pipe must be of sufficient size to handle the exhaust gases from the engine properly. The size of the pipe should never be made smaller than the opening on the exhaust elbow.

INTAKE SCOOP AND PIPING

Intake scoop and piping for the sea woter pump must be provided. Use 1" scoop and 1" piping from scoop to pump, reducing to 3/4" at pump inlet. Hose is not satisfactory for this intake line, unless it is non-collapsible reinforced hose.

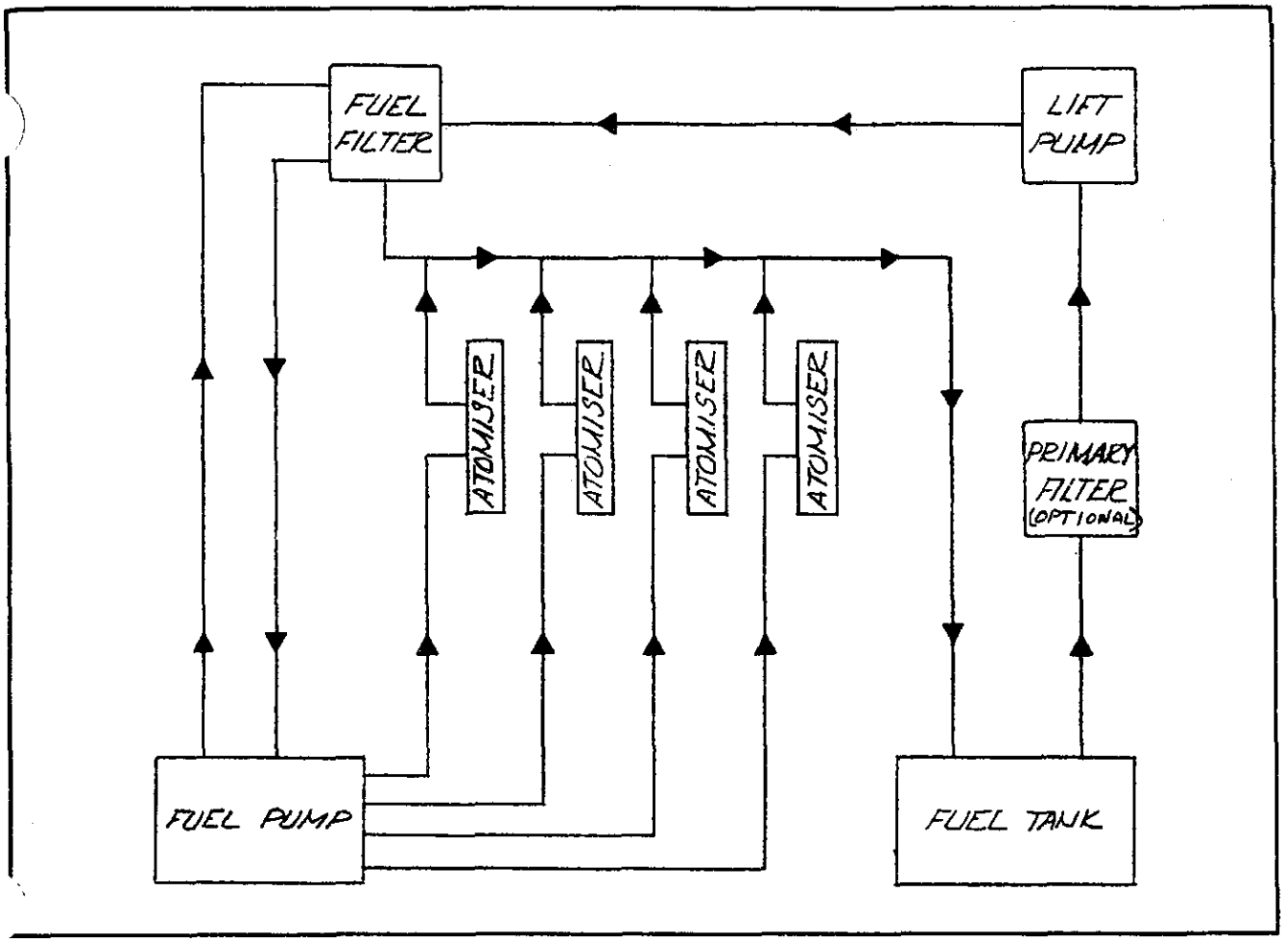


Fig. 9–Fuel System Diagram

COOLING WATER PIPING

The Westerbeke Four-107 Diesel is fresh water cooled, utilizing what is known as a "closed system" wherein the fresh water is circulated by a centrifugal pump through a circuit consisting of engine cylinder block, exhaust manifold, oil cooler and heat exchanger. The heat exchanger is in turn cooled by the sea water pump.

FUEL SUPPLY

To insure satisfactory operotion, a Diesel engine must have a dependable supply of clean fuel oil. For this reason, cleanliness and care are especially important at the time when the fuel tank is installed, because dirt left anywhere in the fuel lines or tank will certainly cause fouling of injector nozzles when the engine is started for the first time.

In the Westerbeke Diesel fuel system, an excess of fuel oil is supplied to the iniection pump by fuel lift pump and the oversupply which is not required for iniection to the engine is returned to the fuel tank.

A fuel filter is mounted on the engine between the fuel lift pump and the injection pump. It contains a replaceable cartridge (see Maintenance Schedule). An optional primary fuel filter/water separator may be installed between the fuel tank and the fuel lift pump. Connection for the fuel supply line is on the fuel lift pump which has a hand primer required for filling the fuel supply lines and the filters, and for purging the system of air when the engine is started for the first time, or whenever the system has been opened for any reason.

FUEL PIPING

The use of extra large copper tubing is desirable. We recommend 3/8" O.D. brass annealed copper tubing together with flared tube fittings, both for the supply line and the return line. Run the tubing in the longest pieces obtainable to avoid the use of unnecessary fittings and connectors. The shut off valve in the line be-

tween the fuel tank and engine should be of the fuel oil type, and it is important that all joints be free of pressure leaks.

Keep fuel lines as far as possible from exhaust pipe for minimum temperature, to eliminate "vapor lock".

It is possible to use standard brass pipe and fittings; however, when standard straight pipe with threaded connections on standard fittings are used, there is always the complication of difficulties due to the number of joints which must be kept tight in service and which may be loosened by vibration. Do not use copper or brass pipe with the soldered type of fittings on a fuel line installation. Tubing with flared fittings is best.

The fuel piping leading from the tank to the engine compartment should always be securely anchored, to prevent chafing. Usually thecopper tubing is secured by means of copper straps. The final length next to the engine should have a loop in the tubing to prevent the possibility of a break caused by metal fatigue from normal engine movement.

COLD STARTING EQUIPMENT

For cold weather operation, a "Spray" Priming System cold starting aid is supplied. This is recommended for use at temperatures below +40° F., as it provides quick starting and thus saves the battery.

Mounting screws and 10 feet of nylon tubing are packaged with loose shipping equipment.

1. Nozzle: The nozzle should be installed in the intake manifold in the hole provided. Installation of nozzle in such position to discharge into a single cylinder should be avoided.
2. Main Unit: Select mounting location where temperature does not exceed 190° F. and as close to nozzle as possible, as greoter efficiency is achieved by keeping fluid line short. The main unit should be installed on the bulkhead rather than directly onengine.
3. Actuator: Select suitable location on or near instrument panel. Drill center hole 13/16" diameter and screw holes 3/16" diameter. Attach with #6 round head screws included. Apply decal below bottom on clean surface.
4. Connections: A tube is run from the actuator to tube protruding from top of main unit. The starting tube goes between discharge nozzle and clear tube protruding from bottom of main unit.

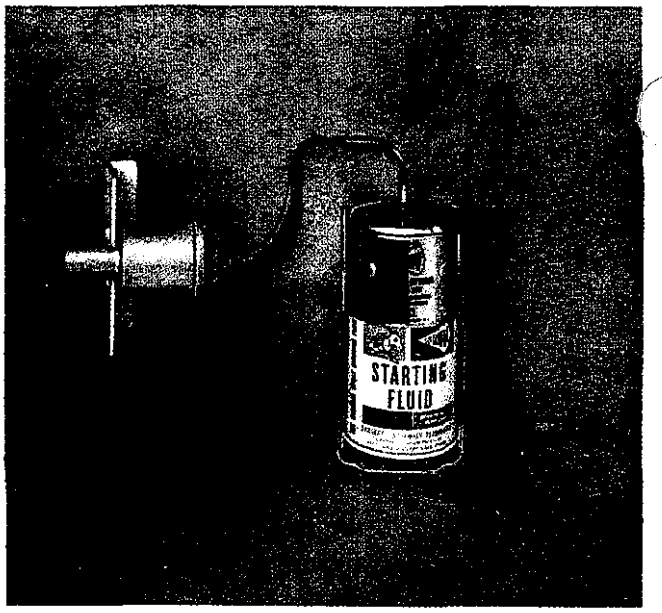


Fig. 10–Spray Starting System

5. Tubing: Cut black tubing with sharp knife or shears, not diagonal cutters, os this may close the hole. Joints are made by pushing clear plastic tube over end of black tube about 3/4", that has been previously wiped clean with laquer thinner. Lacquer thinner, also aids as lubricant for inserting black(tubing. Hold clear tube protruding from bottom of main unit firmly in one hand. The slide brass sleeve to center of joint. This sleeve must not be pulled over joint without holding clear tube or unit will be damaged. All tubing should be properly supported to avoid excess vibration and contact with the exhoust system.

STARTING FLUID: The spray priming system is designed to function with Spray Starting Fluid made by Spray Products Corp. and is available under Federal Stock Number 6850-823-7861.

ELECTRICAL SYSTEM

All electrical accessories on the engine operate on an ungrounded 24 volt system. Engines were originally equipped with a Delco-Remy generator rated at 500 watts (24 volt, 18 amperes) which is no longer in production. Since 1976 this has been replaced with a Motorola alternator. The connections with the Delco generator should be completed as indicated on the wiring diagram on the next page. The connections with the Motorola alternator should be as indicated on the wiring diagram on page Q.16.

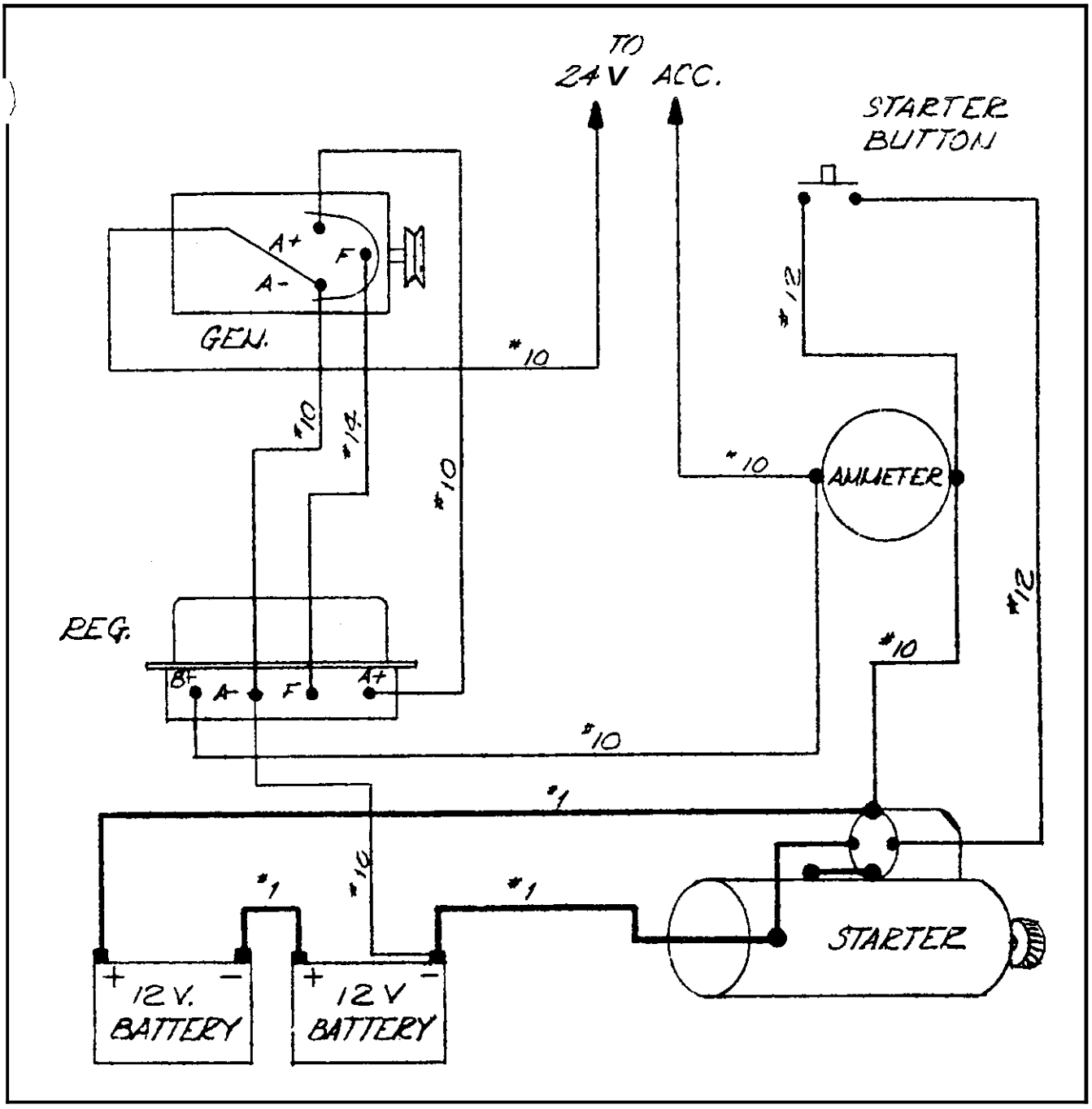


Fig. 11–Wiring Diagram
(Delco-Remy Generator)

Solenoid relay starting switch is mounted on cranking motor. One cable from the battery should be connected to one terminal of the solenoid switch and the other battery cable should be grounded to the cranking motor as indicated. Plan the installation so as to locate the battery as close as possible to the cranking motor, to keep the battery cables short so that the heavy current will not hove to pass through an unnecessary long length of cable, with corresponding current loss.

The current and voltage regulator (supplied with loose equipment) is to be mounted off the engine, in a vertical position, terminals down, connected as shown in the wiring diagram, to the ammeter and the battery. Leads are also indicated from the regulator to the generator, and these wires should be enclosed in metal conduit. Coupling for this conduit is supplied on the generator as shown in Fig. 1.

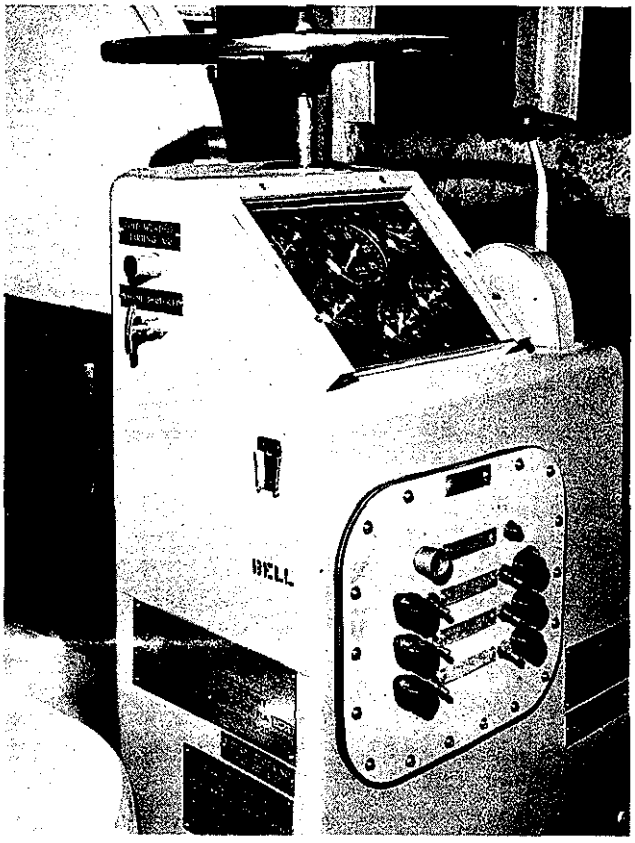


Fig. 12–Instrument Panel

INSTRUMENT PANEL

The instrument panel, shown in Fig. 12 has instruments mounted in a panel plate, which is mounted on the bulkhead. The following instruments are included:

The tachometer is the largest instrument. This indicates a continuous reading in crankshaft revolutions per minute, and is driven from the camshaft at 1/2 crankshaft speed. The take-off shown in Fig. 2 is located under generator, connected with the tachometer head by a length of sheathed cable.

The oil temperature gauge, is connected by capillary tubing with its recording element inserted in 1/2" I.P.S. tapped hole at the bottom of the oil pan.

The water temperature gauge, is connected by capillary tubing with its recording element inserted in 1/2" I.P.S. tapped hole in front of cylinder head.

The oil pressure gauge should be connected to the take-off fitting on the side of the block. Use 1/4" tubing, anchored with tape to prevent chafing, and with either a loop in the tubing at the engine end, or a short section of flexible hose tube, to prevent possibility of breakage due to metal fatigue from normal engine movement.

The ammeter shows the rate of charge or discharge from the battery. Connect it as shown in wiring diagram on previous page.

The hydraulic gear oil pressure should be connected at the 1/4" IPS tapping on left side of reverse gear as shown in detail "C" on installation drawing.

CONTROLS

All parts of the control mechanism should be strong and sturdy and a short as possible. Allow plenty of travel on all levers for full operation without lost motion.

Hydraulic Control Lever: On the hydraulic transmission a small lever operatestheselector valve, located on top of the transmission housing. In the installation this is connected for remote control by a flexible sheather cable leading to control quadrant at pilot station.

The control lever on transmission has three stop positions with detents corresponding to Forward, Neutral and Reverse. Control cable should not be led through any sharp bends, and the section at engine end should be securely supported on the engine, rather than off the engine. After linkage is completed, check the installation for full travel, making sure that when the control quadrant is in forward position the control lever on transmission is on the forward detent, or against the stop pad on cover plate.

TABULATION OF ENGINE INSTRUMENTS – CONTRACTOR SUPPLIED

PART NAME	MANUFACTURER	MFRS. PART #	RANGE
Tachometer	Stewart Warner	531-R	0-2500 RPM
Engine Oil Pressure	Stewart Warner	360-AD	0-80 Lbs.
Gear Oil Pressure	Stewart Warner	360-BX	0-300 Lbs.
Fresh Water Temperature	Stewart Warner	361-L - 72"	60-240°
Ammeter	Stewart Warner	359-L	30-0-30°
Engine Oil Temperature From Cooler	Stewart Warner	361-A - 72"	100-270°

STARTING ENGINE THE FIRST TIME

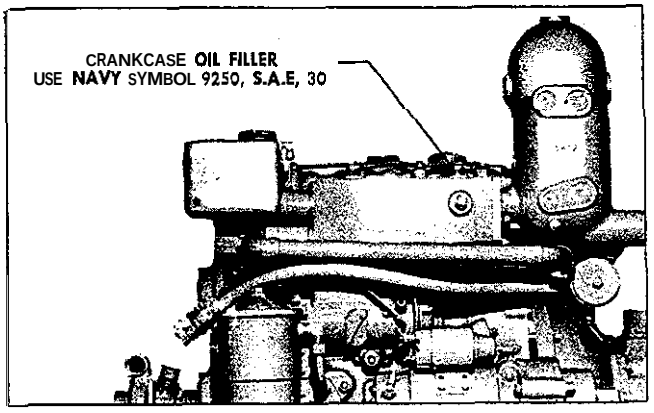


Fig. 13–Location of Crankcase Oil Filler

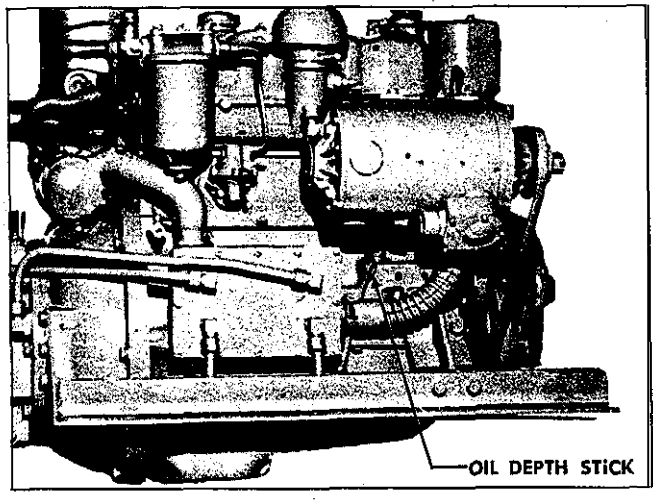


Fig. 14–Location of Oil Depth Gauge

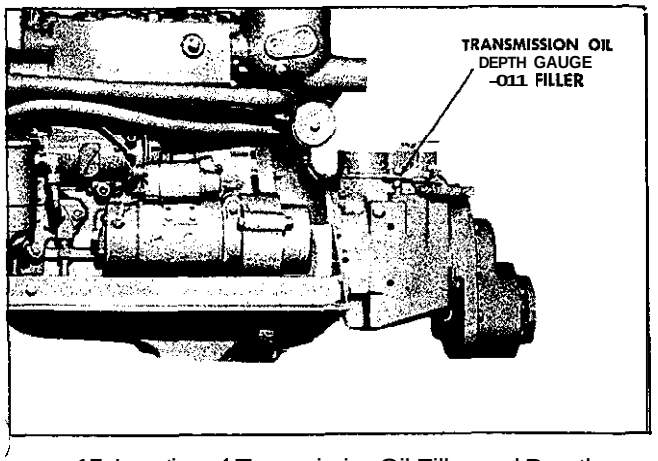


Fig. 15–Location of Transmission Oil Filler and Breather

The engine is shipped "dry", thot is with lubricating oil droined from cronkcose and transmission. The following items should be checked methodically before storting engine thefirsttime.

Check Lubricating Oil in Engine: Fill crankcose with Diesel lubricating oil, S.A.E. 30, to the high level mark on depth stick. Use Specification MIL-1-90008, symbol 9250.

Check Lubricating Oil in Transmission: The clutch and reverse gear ossernbly is o separate unit and carries its own lubrication. Fill housing through filler tube to high level mark on depth gouge with oil of S.A.E. No. 30 viscosity. (Navy symbol some as for cronkcose oil).

Check Fuel Supply: Fill the fuel tonks with clean Diesel fuel oil – open valves in fuel lines. Use Navy Spec. MIL-F-16884 Fuel Oil.

Check Fresh Water Supply: Fill fresh woter expansion tank with clean woter or anti-freeze solution up to about one inch from top of tank.

Check Storage Batteries: Moke sure thot storage batteries ore filled with woter level ot least 3/8" obove the plates, and fully charged, to be copoble of the extra effort thot rnoy be required on first start. Proper specific gravity is 1.220 - 1.280. Make sure thot cable connections are clean and tight.

Priming the Fuel System: In the case of o new engine or on engine that has been standing idle for any length of time, it is importont thot the fuel system be "bled". A typical fuel system is shown in Fig. 17.

To bleed the system, proceed as follows: Loosen the air vent screw (A) on the top of the control gear housing.

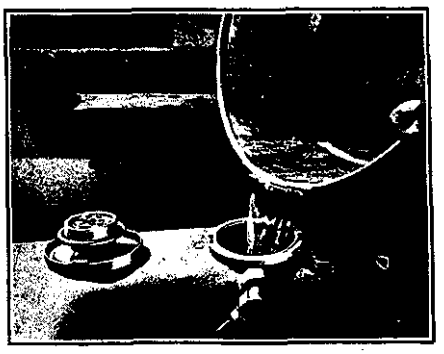


Fig. 16 - Fill Fresh Water Tank

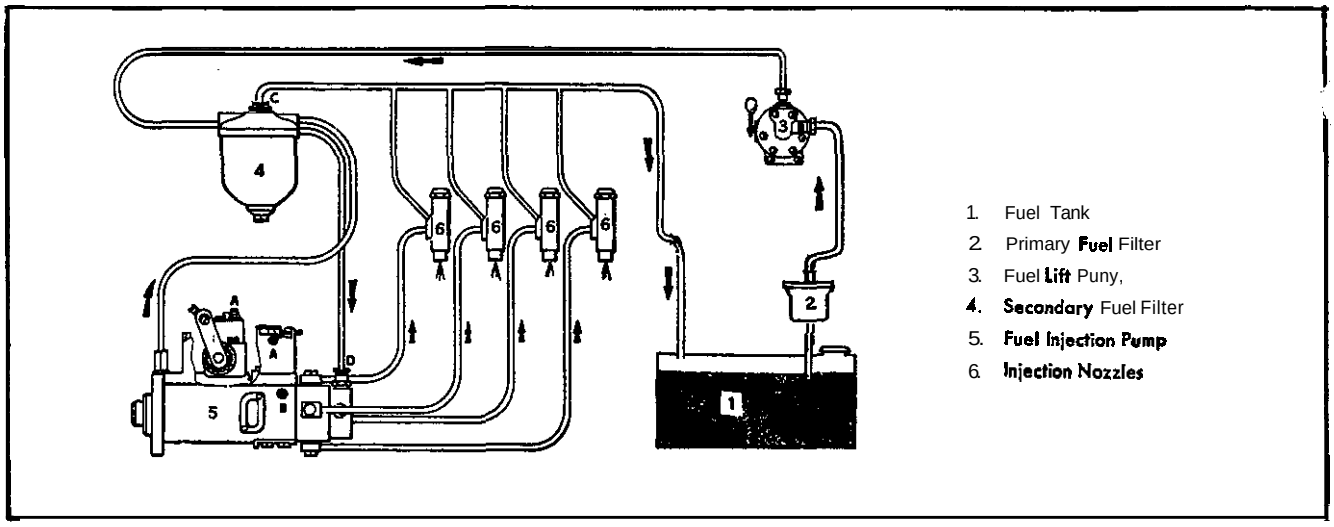


Fig. 17-- Fuel System

Loosen one of the two hydraulic head locking screws (B) on the side of the pump body.

Unscrew by two or three turns, the vent plug on top of the secondary fuel filter (C).

Operate the priming lever of the fuel lift feed pump and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order:

1. Filter cover vent screw (C).
2. Head Locking Screw (B).
3. Governor vent screw (A).

Loosen the pipe union nut (D) at the pump inlet. operate the priming devise and retighten when oil, free from air bubbles, issues from around the threads.

Loosen the unions at the nozzle ends of two of the high pressure pipes.

Set the throttle at fully open position and make sure that the "stop" control is in the "run" position.

Turn the engine until fuel oil, free from air bubbles, issues from both fuel pipes.

Tighten the unions on the fuel pipes, and the engine is ready for starting.

It should be noted that if the cam on the camshaft driving the fuel lift pump is on maximum lift, then it will not be possible to operate the hand primer. If such a condition arises, then the engine should be turned until the hand primer can be operated.

Final Check-Over: Make a careful overall inspection. See that no loose tools or parts are left lying on or near the engine.

Starting the Engine: If the engine is warm and has only been stopped for a Little while, with the reverse gear lever in neutral, place the throttle in the fully open position and engage thestorting motor with the starter switch.

COLD STARTING AID

Operating Instructions:

1. Remove cop and button from can of Spray Starting Fluid. Lift handle of main unit. Hold can in vertical position and insert with lifting and twisting motion to insert spout of can into fluid tight "O" ring seal. **Do** Not **Force!** Push handle down into position and the Sproy Priming System is ready for use.
2. When ready to start, push actuator button a full stroke while counting to five (this is equivalent to five seconds), and release. Now continue storting procedure in usual manner. If engine falters after starting, actuator button can be pushed again a partial stroke to provide injection of a minute amount of Spray Starting Fluid to effect smooth operation. Storting procedure may be modified to use longer or shorter injection period depending on conditions.
3. Spray Starting Fluid moy be kept in Spray Priming System under any circumstances, and a can, even if empty, should always be in the Spray Priming System to prevent drawing dirt into the spray nozzle.

DAILY ROUTINE BEFORE STARTING ENGINE

1. Check Fuel Supply. Best time to fill fuel tank is at end of day's operation, to prevent condensotion from forming in the tank.
2. Check Water Level in fresh water tank. Note: An air space of about 2 inches below top of tonk is normal.
3. Check Lubricating Oil Levels in engine and transmission. Do not overfill. The crankcase oil level can be checked with the engine either idling or stopped. Transmission oil level can be checked only with engine stopped.
4. Make visual inspection for loose connections, loose nuts, leaks, etc. Wipe off any oil or dirt.

HOW TO START THE ENGINE

1. Put Clutch in Neutral; move fuel stop to wide open position; and open throttle about 30%.
2. Press starter button. Never operate the cranking motor continuously for more than 15 seconds; then allow a two minute cooling period.

The engine should start with a few revolutions of the crankshaft if it has good compression and if it is getting fuel. If it does not start, check for leaks in the fuel lines or at filter gaskets, and make sure the filters are full of fuel.

WHEN ENGINE STARTS

1. Check Oil Pressure Immediately. Normal oil pressure is 40-45 lbs. at operating speeds; 10-20 pounds when idling.
2. Check Sea Water Flow. Look for water at exhaust outlet. Do this without delay.
3. Recheck crankcase Oil Level. After the engine has run for 3 or 4 minutes, subsequent to an oil change or new installation, stop the engine and check the crankcase oil level. This is important to make sure that the oil required to fill the engine's internal oil passages and oil filter is compensoted for.

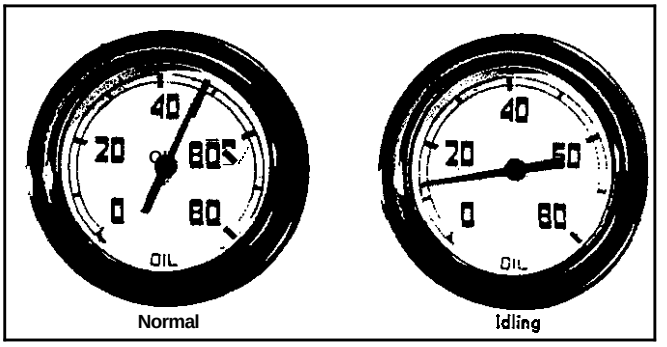


Fig. 19–Oil Pressure Readings

4. Recheck Transmission Oil Level. (This applies only subsequent to an oil change or a new installation). In such case, stop the engine after running for a couple ofminutes at 1000 rpm with one shift into forward and one into reverse, then add ail as necessary.
5. Warm-up Instructions: As soon as possible engage the forward clutch and run the engine at 800-900 rpm until the fresh water temperature gauge registers 130-150° F. Best procedure is to warm up the engine with the boat securely moored, and propeller turning under power. Otherwise, get the boat under way, but at reduced speed until temperature and pressure gauges show proper readings.
6. Prolonged Idling: When required to run engine below 800 rpm for aprolonged time, increase speed to 1200 rpm for at least three minutes every half hour to accelerate oil circulation, and thus to eliminate conditions favorable to sludge and carbon formation.
7. Reverse Operation: Always reduce speed when shifting gears. However, when the reverse gear is engaged, it will carry full engine load.

HOW TO STOP ENGINE

1. Move throttle lever to idle position.
2. Pull shut-off knob.

Note: Whenever convenient, it is desirable to run the engine at idle speed for a few minutes before shutting it off. This permits the water circulation to dissipate excess heat from the metal masses gradually. This is also a good time to check ail level and to refill fuel tank, at end of day's run.

MAINTENANCE OF EQUIPMENT IN COLD WEATHER

Certain maintenance operations must bechecked more carefully in cold weather. For instance, the thermostats and water temperature control must be maintained so that the engine is warmed up as quickly as possible and remains at normal temperature during operation.

Absence of air in fuel lines is especially important in cold weather starting. Bleed the system if required.

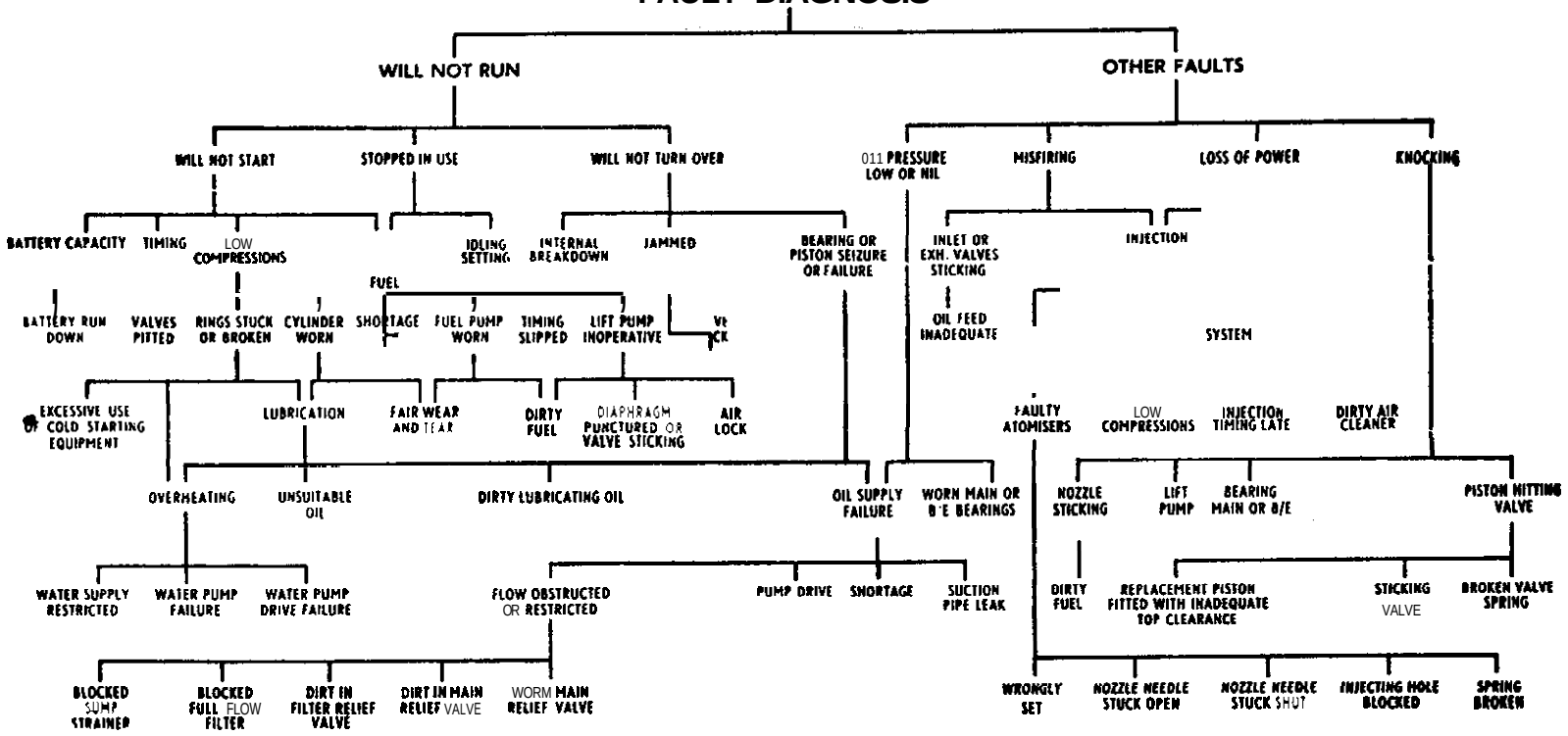
Fuel filters must be checked more often, particularly the primary stage filter, to remove all the moisture and condensation separated from the fuel, otherwise this may freeze and stop the fuel flow.

Lubricating oil must be watched more carefully during cold weather to be sure that dilution is not building up in the crankcase, since despite all precautions there may be occasions when small amounts of raw fuel will condense and wash down the cylinder walls. This is most likely to occur in engines that do not operate for extended periods at comparatively high speed, and temperatures in the crankcase do not reach a point where these heavy ends offuel and other contaminants are disposed of.

OPERATING PRECAUTIONS

1. Never run engine with water or anti-freeze solution boiling.
2. Do **not** put cold water in on overheated engine. It may crackcylinder head, block or manifold.
3. Keep intake silencer free from lint or oil.
4. Do not run engine at high speed without **load.**
5. Never race a cold engine.
6. Keep the engine and its **accessories** clean. Look for loose connections and loose bolts as you clean.
7. Keep the fuel clean. Handle it with extreme care, because water and dirt in fuel cause more trouble and service interruptions than any other factor. Use clean containers in transferring it. Use of a funnel with 200 mesh wire screen is recommended.
8. Do not allow fuel to run low, because fuel intake may be uncovered long enough to allow air to enter the system, resulting in lost time required for priming.
9. Do not be alarmed if temperature gouges show a high reading following a sudden stop after engine has been operating at full load. This is caused by the release of residual heat from the heavy metal masses near the combustion chamber. Prevention for this is to run engine at idle for a short period before stopping it. High temperature reading after a stop does not necessarily signal alarm against restarting. If there is no functional difficulty, temperatures will quickly return to normal when engine is operating.

FAULT DIAGNOSIS



The main value of this chart is to help maintenance staff to consider any engine fault with which they are confronted, in a logical and organised manner. Prevention is better than cure, but if the fault has not been prevented, find it on this chart and follow it back to its cause.

FAULT FINDING

Difficult Starting.

No Fuel at Injection Nozzles:

(a) No fuel in tank.
(b) Fuel lift pump not working.
(c) Loose connections in the fuel system.
(d) Air in the fuel system (Trace from suction side).

Go over the whole of the above ond make sure that the iniection nozzles ore fully primed ond working correctly.

Engine Not Being Turned Over Fast Enough. (Particularly in cold weather).

(a) Lubricating oil too thick.
(b) Battery not fully chorged. Fit fully chorged battery.
(c) Engine "gummy" duetostonding in the cold.

Injection Nozzles Faulty.

Test nozzle by removing it from the cylinder head.

Disconnect pipes on other nozzles while making this test.

Sticking Valves.

Trouble with sticking valves may be due to overheating, the result of choked injection nozzles, or the use of unsuitable lubricating oil.

Test the iniection nozzles as recommended on page P.6 and cleon them if necessary.

The lubricating oil used should be ofonopproved type.

Sticking Rockers.

If the rockers stick, the cause moy be: the wse of unsuitable oil, shortage of oil, or sludging. Use only oil of on approved type. If there is a shortoge of lubricant, the passages and pipes to ond from the comshoft reducer should be checked.

Fuel Oil.

It is essential to use cleon fuel oil free from water, dirt or sond. The recommended specification for fuel is given on page B.11. Providing cleon fuel is used, no trouble should be experienced with the fuel system, but dirty oil will leod to trouble due to choked pipes, choked filters, damaged fuel pump and injection nozzles. If the engine tends to run well for a short period ond then to die oway or stop oltogether, the fuel system should immediately be suspected.

The trouble may be due to the lift pump not working properly, to a loose pipe joint allowing air to get into the fuel system, to a dirty fuel filter, or a choked fuel pipe. Thepre-filter should be cleaned by washing in clean fuel oil, but the finol filter should not need attention more than once in 250 hours, when a completely new filter element should be fitted. If the conditions lead to dust or contominotion of the fuel, decrease the mointenonce intervol.

Air Cleaner.

In accordance with periodical attentions, cleon the filtering gauze in kerosene or fuel oil.

For mointenonce instructions, see "Filters."

DO AND DO NOT

DO KEEP THE ENGINE CLEAN.

DO keep this book where it is conveniently accessible.

DO pay particular attention to lubrication.

DO use only approved grades of lubricating oil.

DO use only GENUINE FACTORY PARTS.

DO keep all bolts and nuts tight.

DO eliminate all air from the fuel system and keep all fuel oil unions AIR-TIGHT.

DO examine engine oil level in sump daily and replenish if necessary.

DO completely change oil in accordance with periodical attentions.

DO renew element in lubricating oil filter in accordance with periodical ottentions.

DO check oil flow to rocker arms ond examine the valve springs in accordance with periodical attentions.

DO use only filtered fuel oil. Never tip into the tank o half-empty barrel of fuel oil, the bung of which may have been out for weeks.

DO keep a check on the temperature of the cooling water. It should not be allowed to boil. The normal running temperature is 170°F., but where a pressurised header tank filler cap is fitted then the coolant temperature will be slightly higher.

DO attend immediately to fuel and lubricating oil leaks.

DO grind in valves when necessary.

DO check valve clearance from time to time (.010 in.) with warm engine.

DO tighten cylinder head nuts in correct order (see page E.7).

DO quote engine number when ordering parts.

DO keep essential parts in stock.

DO drain cylinder block if engine is being left idle in frosty weather (drain tap on side of block).

DO make sure that the pressurised filler cap is removed when draining the cooling system.

DO close these drain cocks ond refill with water before attempting to re-start next morning.

DO when in doubt, read this Manual.

DO if the engine is to be laid up for a period of some months, carry out the procedure recommended.

DO NOT neglect the routine ottentions specified in this section.

DO NOT race the engine in neutral.

DO NOT run the engine unless the gauge SHOWS OIL PRESSURE.

DO NOT unnecessarily interfere with any adjustments.

DO NOT break the fuel pump seals remember if broken your Guorantee may be void.

DO NOT continue to run the engine if the cooling water boils.

DO NOT forget to keep the belts adjusted.

DO NOT continue to run the engine if black smoke is coming from the exhaust.

DO NOT if the engine stops without apparent reason, fail to make sure first of all that fuel is reaching the fuel pump.

DO NOT omit to wipe the engine over occasionally with a clean rag.

DO NOT take the fuel pump to pieces.

DO NOT use cotton waste or any fluffy cloth when cleaning.

DO NOT use any but approved brands of lubricating oil.

DO NOT store fuel oil in a galvonisedcontainer.

DO NOT subject any engine to continuous overloading.

DO NOT guess. For additional information contact suppliers of the Marine Craft, or Engine.

FROST PRECAUTIONS

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the water system or where this is not convenient an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

When operating engine at outside temperatures below 32°F., a suitable anti-freeze solution should be used. As these engines are equipped with high temperature thermostats, a permanent type anti-freeze such as etheylene glycol should be used. Alcohol solutions cannot be used successfully, as the alcohol will evaporate, creating a fire hazard, and the engine will run hot.

When draining the water circulating system, the tap on the cylinder block must be opened. This tap is on the camshaft side of the cylinder block, near the flywheel housing.

Where a pressurised filler cop is fitted, this should be removed before draining the cooling system.

When the engine is drained, the fresh water pump is also drained but the rotation of the pump may be prevented by:

(a) locking of the impeller by ice due to the pump hole being blocked by sediment.

(b) locking of the seal through the freezing of globules of moisture between the seal and the gland.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point.

1. Before starting the engine, turn water pump by hand; this will indicate if freezing has taken place. If freezing has taken place. this should free any ice formation.
2. If it is impossible to turn the pump by hand, the engine should be filled with warm water.
3. To ovoid this trouble it is advisable when all water has been drained to run the engine for a few seconds at idling speed, thus dispersing any moisture remaining in the pump.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturers instructions before refilling with normal coolant.

If the foregoing action is taken, no harmful effects should be experienced.

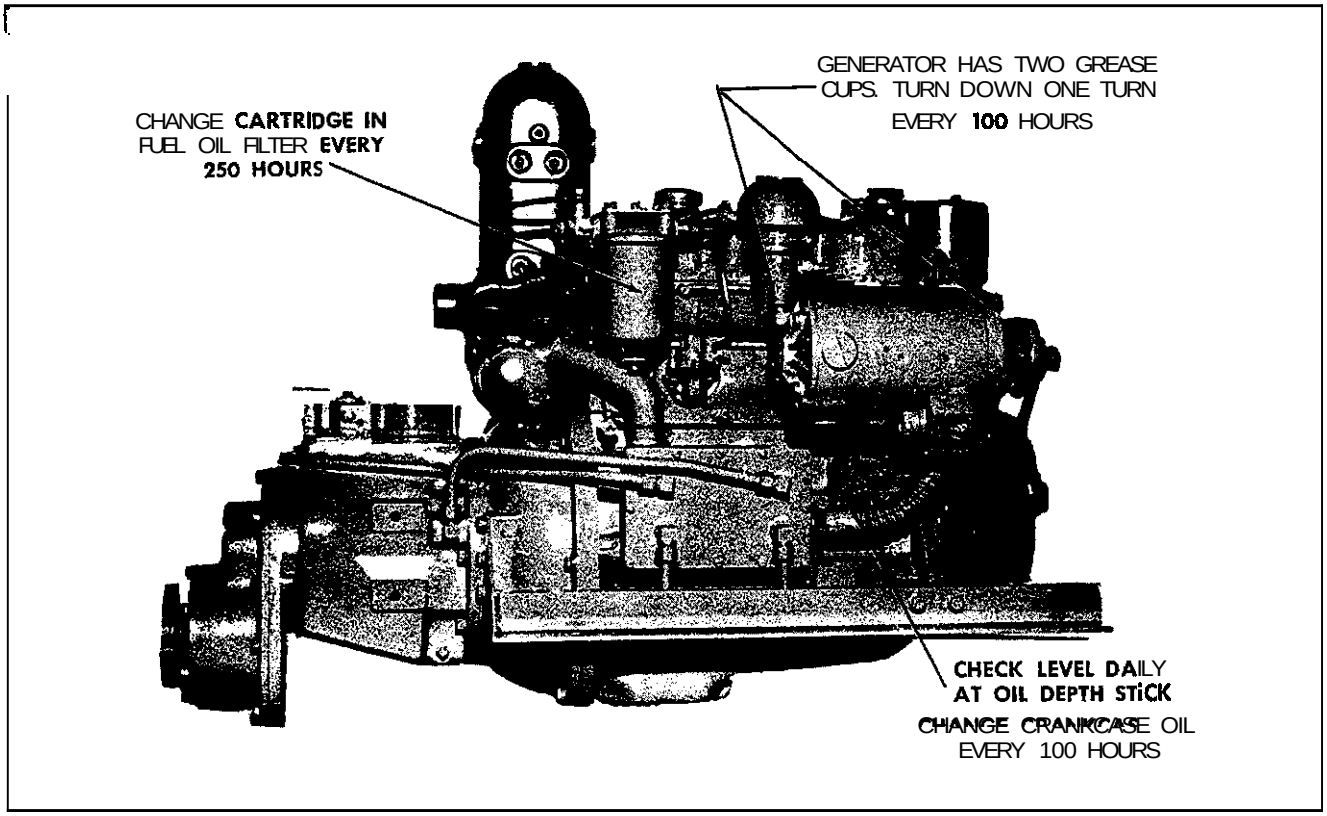


Fig. 21–Poink of Lubrication, Starboard Side

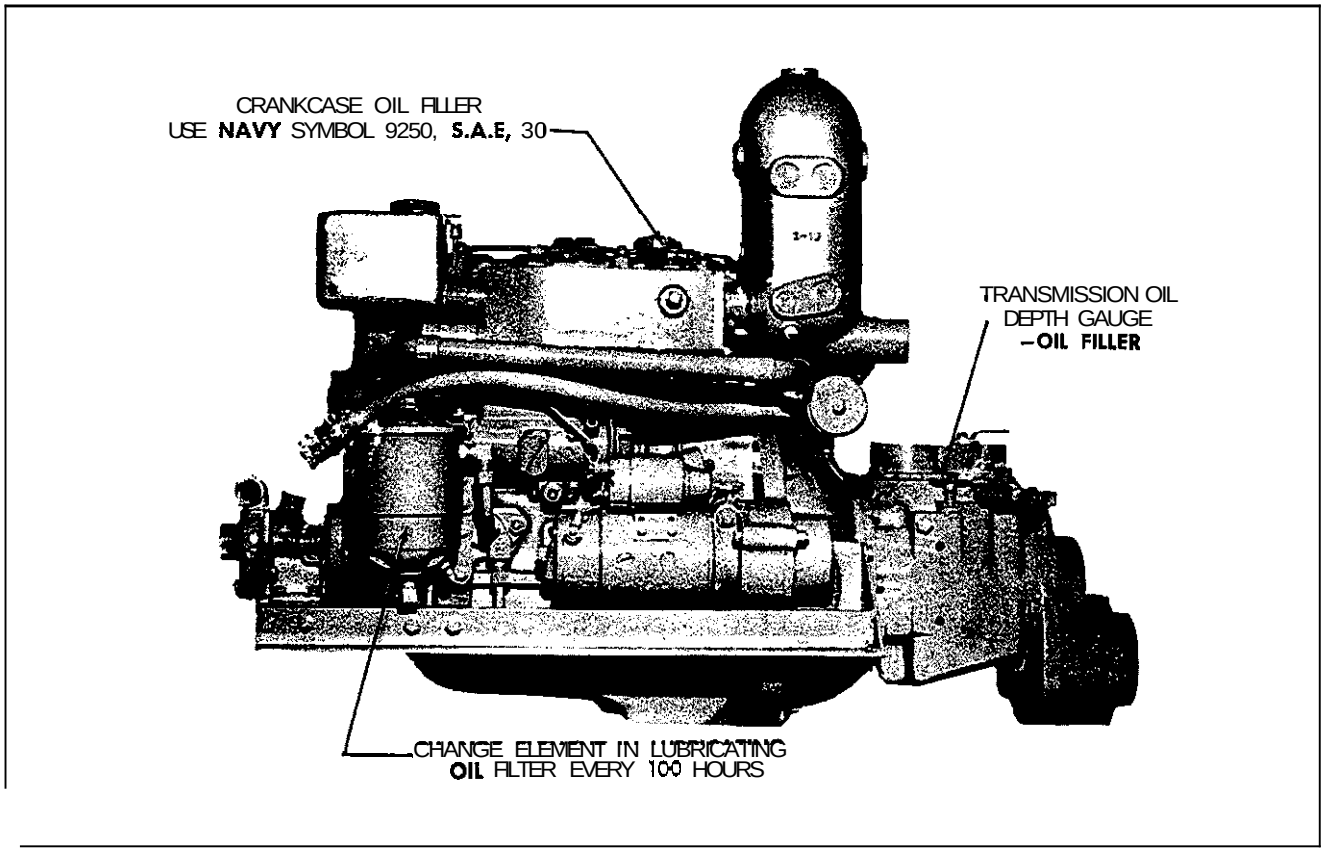


Fig. 22–Points of Lubrication, Port Side

MAINTENANCE SCHEDULE

DAILY

Check sea water strainer, if there is one.

Check water level in cooling system.

Check lubricating oil level in crankcase and transmission

EVERY 50 HOURS

Check "V" belts.

Check water level in batteries. Proper liquid gravity is 1.210 - 1.220.

EVERY 100 HOURS

Change oil in crankcase. Use Navy symbol 9250-oil, S.A.E. 30. Oil may be sucked out of the dipstick tube by attaching a suction hose of 3/8" over the outside dipstick tube.

Change elements in lubricating oil filter.

If equipped with Delco generator turn down two grease cups one firm turn.

EVERY 150 HOURS

Check engine for loose bolts, nuts, etc.

Tighten cylinder head nuts.

Clean air intake silencer.

Check valve clearances and check injector timing.

Check sea water pump for wear, or leaks.

EVERY 200 HOURS

Change oil in transmission.

EVERY 250 HOURS

Wash element in primary fuel oil strainer.

Change element in secondary fuel oil filter. (If fuel contains water or is not clean, filters need to be serviced oftener).

Inspect breathers for crankcase and transmission: wash if necessary.

EVERY 1000 HOURS

Disassemble and clean oil cooler.

Check and adjust valves to correct lash.

Check injector timing.

Check injector spray tips.

Check cylinder walls.

EVERY 2000 HOURS

Check bearings.

Install new piston rings.

Careful examination of entire engine.

If equipped with Motorola alternator check brushes and bearings.

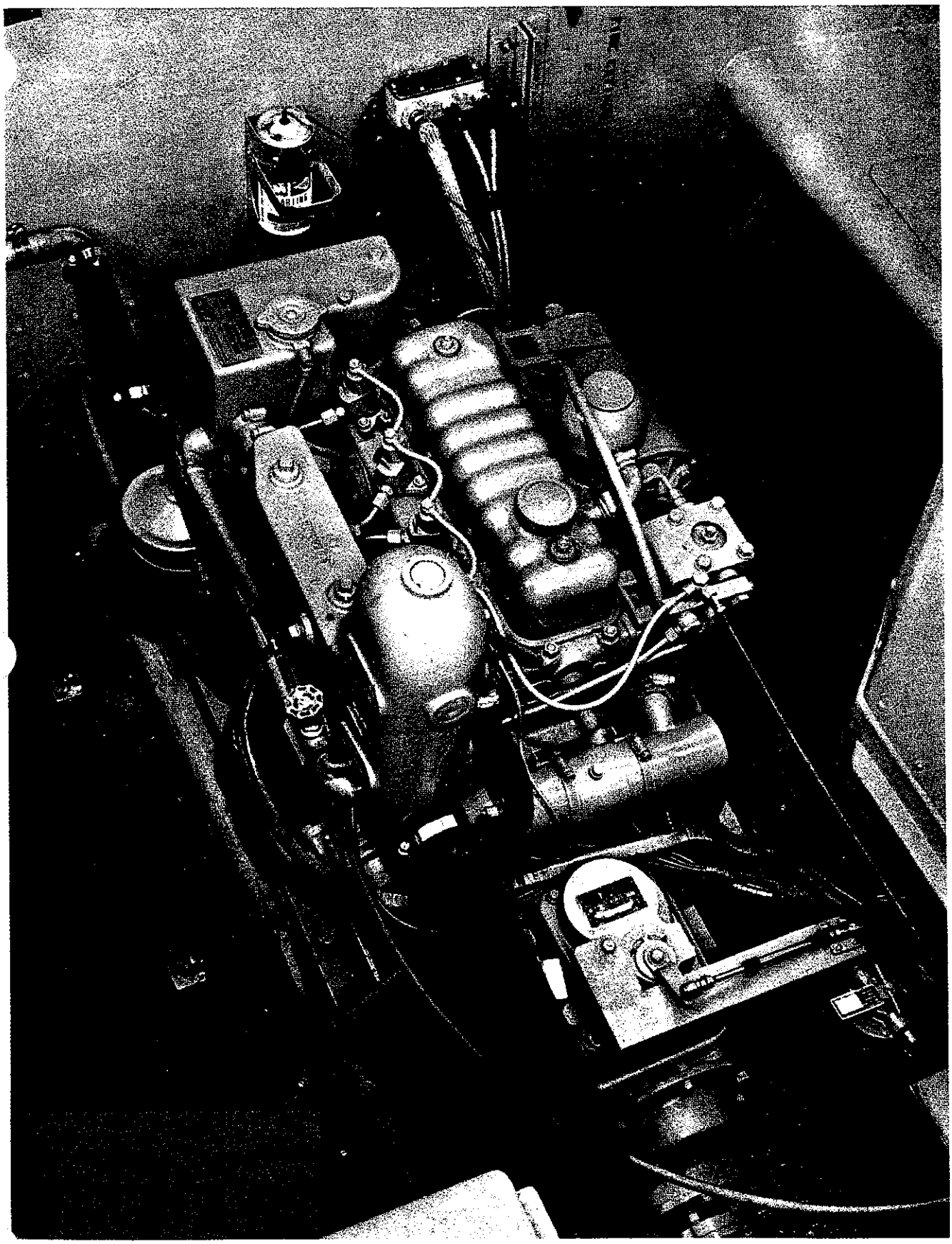


Fig. **22A—Installation** in 26' Motor Whole Boat

FILTER MAINTENANCE

AIR FILTER

The time period for cleaning the air filter depends on operating conditions, therefore, under extremely dirty conditions, the time limits recommended hereafter for cleaning should be decreased.

The correct maintenance of the filter will greatly assist in reducing bore wear, thereby extending the life of the engine.

Remove and wash gauze in cleankeroseneevery **200** hours. An exploded view of the air filter is shown in Fig. **23.**

FUEL OIL FILTERS

Fuel oil filters are provided as well as a dirt trap in the fuel tank.

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

It should be taken out every **500** hours. cleaned, washed in fuel oil and immediately replaced.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer when filling the tank.

The second filter is the primary fuel filter incorporated in the pipe between the fuel tank and the fuel lift pump.

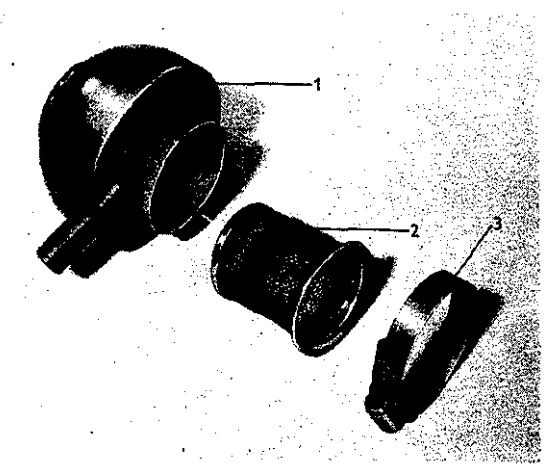


Fig. **23–Exploded** View of Air Filter

1. **Filter Cover.**
2. **Gauze Strainer.**
3. **Filter Securing Clip.**

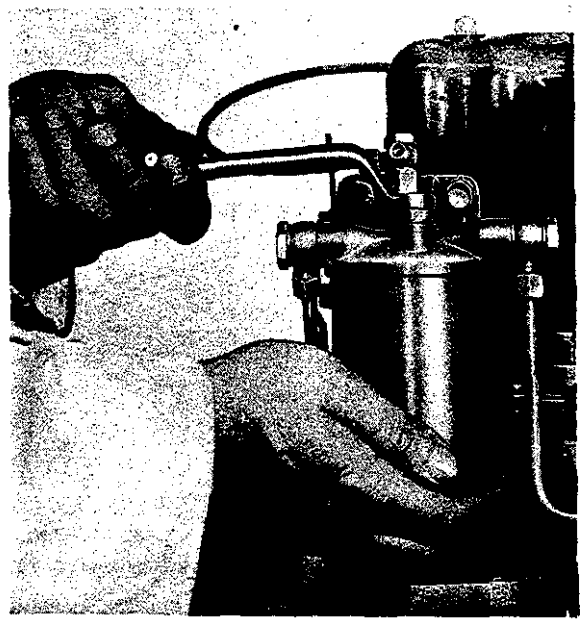


Fig. **24–Removing** Filter Cover krew

This filter should be cleaned every **250** hours unless the condition of the fuel warrants more regular attention.

After cleaning the bowl ensure that a good joint is made between the top of the bowl and the filter body, as leakage of air here may cause air locks in the fuel system.

The third and final filter is a paper element type filter. It is not possible to clean the paper element. It should be renewed every **250** hours.

To renew the element:

1. Unscrew the setscrew in the centre of the cover. (See Fig. **24).**
2. Drop filter bowl clear. (See Fig. **25).**
3. Remove element and discard.
4. Before putting new element in position, clean the filter bowl and inspect the relief valve.
5. Ensure that the rubber joints are in good condition; if not, replace with new joints.

After replacing a filter element, the following procedure should.be adopted in order to remove any air that may be in the fuel system:

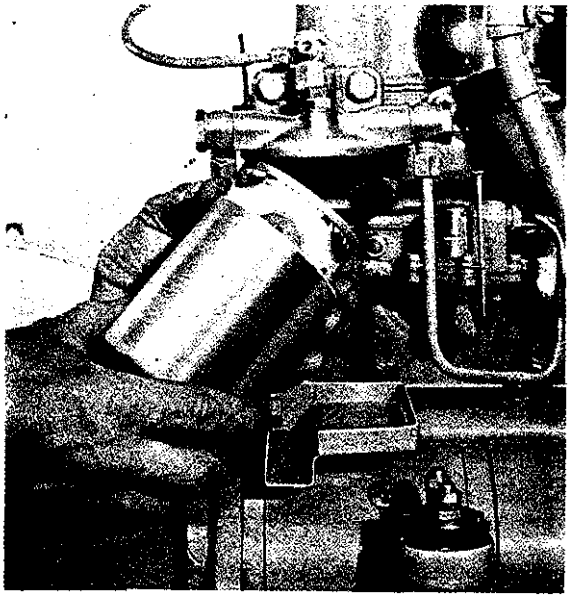


Fig. 25–Dismantling Fuel Filter

1. Unscrew by two or three turns, the vent plug on the top of the filter cover. Operate the priming lever on the fuel lift pump and when fuel, free from air bubbles issues from this venting point, tighten the plug.
2. Loosen the pipe union nut at the fuel pump inlet, operate the priming lever and re-tighten when fuel, free from air bubbles issues from around the threads.

The engine is now ready for starting.

LUBRICATING OIL FILTERS

To insure cleanliness of the lubricating oil, filters are fitted to the engine. If the periodical attentions relating to these filters are carried out, and the correct grade of clean oil isused, a very long life can be obtained from the engine.

The first filter is in the sump and is also a gauze strainer. All the oil must pass through this filter before it reaches the oil pump and is delivered to the bearings.

The second filter is mounted on the side of the cylinder block. The oil passes through this filter after it has left the oil pump and before it reaches the bearings. The element should not be cleaned but renewed every 100 hours.

To remove the element:

1. Unscrew bolt on top of secondary filter.
2. Lift out element from filter and discard.
3. Make sure the rubber case gasket is in good condition. If not, replace with new one when putting in new element.

The cover bolt should be tightened to a torque of 25-30 pounds-foot.

ENGINE OVERHAUL

The following sections contain detailed information relating to the proper operation characteristics of the major components and systems in the engine. Included are disassembly, rework and reassembly instructions for the guidance of suitably equipped and staffed marine engine service and rebuilding facilities. The necessary procedures should be undertaken only by such facilities.

Additional operating characteristics are included in the Operation Section of this manual.

Any replacements should be made only with genuine Westerbeke parts.

CONTENTS SECTION

SECTION A
Engine Description

The 4.108. 4.107 and 4.99 Series Diesel Engines with which this manual is concerned is an indirect injection, four cylinder, four stroke power unit.
The 4.108 and 4.107 has a bore of 3.125 in (79,4 mm) and a stroke of 3.5 in (88.9 mm), and the 4.99 has a bore of 3.0 in (76.2 mm) and a stroke of 3.5 in (88,9 mm).

Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side as viewed from the flywheel end of the engine.

Cylinder Block and Crankcase

The cylinder block is of monobiock construction, cast integrally with the crankcase, it is manufactured from high duty cast iron alloy.

The 4.108 engine is fitted with "dry" type. unshouidered thinwall liners. and the 4.107 and 4.99 engines are fitted with "wet" liners, flanged at the top and sealed at the bottom by two synthetic rubber rings located in the cylinder biock.
Both liner types are centrifugally cast from high duty alloy iron.

Cylinder Head and Valves

The cylinder head is a specially toughened high duty allow casting and is secured to the cyiinder biock by studs and nuts, both are phosphated for increased torque characteristics. The joint between the cyiinder head and block is made from a black composite material and is known as a 'Klinger' type gasket.

Two overhead valves are fitted to each cylinder, push rod operated via the valve mechanism mounted on the head and enclosed by a pressed steel cover. Each inlet valve has a synthetic rubber oil deflecting seal, both inlet and exhaust valves are retained by two springs located between a hardened steel seat and a hardened spring cap secured by split conical collets. All valves operate in unshouldered cast iron guides pressed into the head.

Combustion System

The *'H'* system of combustion is known as the pre-combustion type, being formed completely in the cylinder head, thus giving a flat topped piston with uniform heat distribution. Intimate mixing of the fuel and air over a wide speed range is ensured, which increases the engines performance, efficiency and flexibility. The upper part of the combustion chamber is machined in the cylinder head and is hemispherical in shape: the lower part being formed by an insert in the form of an accurately machined plug located in the cylinder head, this contains the throat connecting the combustion chamber to the cyiinder. Fuel is introduced into this chamber by means of pintle type atomiser nozzles.

Valve Mechanism

The valves are operated by cast iron, mushroom type tappets, located in guides machined in the cyiinder block, through pushrods to forged steel rocker levers with lead bronze lined, steel backed wrapped bushes. Valve clearances are adjusted by means, of a hardened ball ended screw and locknut at the pushrod end of the rocker lever.

Crankshaft

The crankshaft is forged from chrome-molybdenum Steel with four integral balance weights. The 4.108 crankshaft is treated by "Tufftride" process. The rear of the crankshaft is machined to accommodate the lhrust washers which are replaceable, copper lead lined, steel backed, which control the crankshaft end float and are positioned either side of the rear main bearing. An oil thrower and flywheel location flange are also machined at the rear end. while the front end is keyed for a power take oM.

Main Bearings

Three main bearings are provided for the crankshaft and are of the replaceable pre-finished, thin wall, steel backed, aluminium tin lined type. The high duty cast iron bearing caps are dowel located and each is secured by two high tensile steel setscrews locked by tab washers.

Camshaft

The special cast iron alloy camshaft which has chill hardened cams. is mounted in a low position on the right hand side of the cylinder block and supported by three bearings machined directly into the cylinder block. These bearings are pressure lubricated by means of internal drillings and the cams and tappets are splash lubricated.

Connecting Rods and Bearings

The connecting rods are molybdenum alloy steel stampings with 'H' section shank. the big end parting lace is inclined at 45 to the axis of the rod and serraled for cap location. The caps are each secured by two high tensile steel setscrews. The big end bear. ing bores are fitted with replaceable pre-finished thin wall. aluminium-tin lined, steel backed bearings. The small end bores being fitted with bronze lined steel backed bushings.

Timing Gear Arrangement

The camshaft and fuel injection pump are driven by the crankshaft gear via an idler gear. This helical gear train which makes provision lor fuel pump timing adjustments is located on the front face of the cylinder block and enclosed by a pressed steel cover bolted to a steel backplate.

The camshaft and fuel injection pump drive gears are manufactured from spheroidal graphite cast iron. the crankshaft and idler gears being of steel treated by the Sulfinuz or Tufltride process.

Pistons and Piston Pins

The pistons are manufactured from special high silicon aluminium alloy, fitted with three compression rings and one oil control ring above the piston pin and one oil control ring below. The upper oil control ring comprises four laminated segments. The piston pins are of the fully floating type, located axially in the piston by circlips. The piston has a steel insert rolled into the top groove.

Lubrication System

The lubrication of the engine is by full pressure feed from a rotor type oil pump. driven by spiral gears from the camshaft. An oil strainer is fitted on the end of the pump inlet pipe. the pump then delivers the oil via a full flow filter. bolted on the fuel pump side of the cylinder block to the main oil gallery. This gallery is drilled lengthwise through the crankcase. drillings from the main oil gallery to the main bearings and drillings in the main crankshaft journals to the crankpin journals provide the lubrication for the crankshaft. Oil feeds are also taken to the idler gear spigot which maintains an intermittent feed by drillings in the spigot and idler gear to lubricate the timing gear arrangement. and to the centre camshaft bearing where due to special machining on the centre camshaft journal an adequate reduced pressure feed is maintained at the rocker assembly. The oil pump incorporates a pressure relief valve which limits the maximum oil pressure. while the oil filter incorporates a by-pass valve which prevents the engine being starved of oil should the filter element become blocked.

Fuel Injection Equipment

A distributor type fuel injection pump is flange mounted on to a drive housing cast on the left hand side of the cylinder block. It is mounted horizontally at the front of the engine and aear driven via a splined drive shaft The majority of pumps incorporate a mechanical governor and an automatic advance and retard mechanism.

The fuel lift pump is of the diaphragm type mechanical. ly operated by an eccentric on the engine camshaft. via a small pushrod. It is located on the tappet in. spection cover on the right hand side of the engine and is equipped for hand priming.

The injectors are located in an accessible position on the left hand side of the cylinder head.
The nozzles are of the pintle type.
Provision is made lor mounting a fuel filter on either Side of the cylinder head. The filter should be of the paper element type and of approved design.

Cooling System Fresh Water Circuit

A centrifugal type circulating water pump is fitted to the front face of the cylinder block. to assist the water circulation through the cylinder block and head. The water outlet is via a thermostat housing which is cast integral with the cylinder head. the thermostat restricts the flow of water when the engine is cold and brings about a faster warm up. When the water temperature reaches a pre-determined point the thermostat opens and allows normal coolant circulation. The water pump is belt driven from the crankshaft pulley

Tachometer Drive

Provision is made, on the right hand side of the engine, for a drive at half engine speed to be taken from the oil pump spiral gear to a mechanical tachometer.

SECTION B
Technical data

Engine Data

	4.108 and 4.107	4.99
Westerbeke		
Bore (nominal — See Page B.3)	3.125 in (79.37 mm)	3.00 in (76.2 mm)
Stroke	3.5 in (88,9 mm)	3.5 in (88.9 mm)
No. of Cylinders	Four	Four
Cubic Capacity	107.4 in" (1,760 litre)	99 in" (1.621 litre)
Compression Ratio	22 : 1	20 : 1
Firing Order	1, 3, 4, 2.	1. 3, 4, 2.
Cycle	Four-Stroke	Four-Stroke
Combustion System	Indirect Injection	Indirect Injection

Rating Details

	4.99	4.107	4.108
Maximum R Output	34 bhp at 3000 rev/min	37 bhp at 3000 rev/min	37 bhp at 3000 rev/min
Maximum Torque Output	73 lbf ft (10,1 kgf m)	79 lbf (10,92 kgf m)	79 lbf ft (10,92 kgf m)

Recommended Torque Tensions

The following torque figures will apply with the components lightly oiled before assembly: —

	4.107 and 4.99	4.108
Cylinder Head Nuts	42 lbf ft (5.61 kgf m)	60 lbf ft (8.3 kgf m)
Connecting Rod Setscrews	42 lbf ft (5,81 kgf m)	42 lbf ft (5.81 kgf m)
'Main Bearing Setscrews	85 lbf ft (11.5 kgf m)	85 lbf ft (11.5 kgf m)
Flywheel Setscrews	60 lbf ft (8.3 kgf m)	60 lbf ft (8.3 kgf m)
Idler Gear Hub Setscrews	36 lbf ft (4.98 kgf m)	32 lbf ft (4.4 kgf m)
Crankshaft Pulley Setscrews	150 lbf ft (20.5 kgf m)	150 lbf ft (20.5 kgf m)
Injector Securing Nuts	12 lbf ft (1.7 kgf m)	12 lbf ft (1.7 kgf m)

'The lab and shim washers may be discarded where used on earlier engines. but the setscrews must be tightened to the torque loading indicated.

Service Wear Limits

The following "wear limits" indicate the condition when it is recommended that the respective items should be serviced or replaced.

Cylinder Head Warping ... . . Longitudinal	0.006 in (0.15 mm)
Cylinder Head Warping ... ... Transverse	0.003 in (0.08 mm) concave
	0.005 in (0.13 mm) convex
Maximum Bore Wear (when new liners are necessary)	0.006 in (0.15 mm)
Crankshaft Main and Big End Journal Wear	0.001 in (0.03 mm)
Crankshaft Main and Big End Journal Ovality	0.0005 in (0.01 mm)
Maximum Crankshaft End Float	0.020 in (0.51 mm)
Valve Stem Io Guide Clearance ... inlet	0.005 in (0.13 mm)
Valve Stem to Guide Clearance ... exhaust	0.006 in (0.15 mm)
Valve Head Thickness at outer edge	0.025 in (0.64 mm)
Rocker Clearance on Shaft	0.005 in (0.13 mm)
Camshaft Journals — Ovality and Wear	0.002 in (0.05 mm)
Camshaft End Float	0.020 in (0.51 mm)
Idler Gear End Float	0.010 in (0.25 mm)
Valve Head Depth below Head Face inlet and exhaust	0.048 in (1.220 mm)

MANUFACTURING DATA AND DIMENSIONS

The data regarding clearances and tolerances is given for Personnel engaged upon major overhauls.

CYLINDER BLOCK

Total Height of Cylinder Block between Top & Bottom Faces	4.108, 4.107, 4.99	9.936/9.939 in (252,374/252,451 mm)
Parent Bore Dia. for Cylinder Liner	4.108	3.249/3.250 in (82,525/82,550 mm)
Parent Bore Dia. for Cylinder Liner	4.107, 4.99	Wet Liners
Main Bearing Parent Bore	4.108, 4.107, 4.99	2.3950/2.3955 in (60,833/60,846 rnm)
Camshaft Bore Dia. No. 1	4.108, 4.107, 4.99	1.794/1.7955 in (45,568/45,606 mm)
Camshaft Bore Dia. No. 2	4.108, 4.107, 4.99	1.784/1.787 in (45,314/45,390 mm)
Camshaft Bore Dia. No. 3	4.108, 4.107, 4.99	1.776/1.778 in (45,110/45,161 mm)
Tappet Bore Dia.	4.108, 4.107, 4.99	0.562/0.56325 in (14,275/14,307 mm)
Fuel Pump Drive Hub Bearing Bore Dia.	4.108, 4.107, 4.99	1.8125/1.8141 in (46,037/46,078 mm)

Cylinder Liner 4.108

Type	Cast Iron
Inlerference Fit of Liners	Dry — Interference Fit
Inside Dia. of Liner after Finish Boring and Honing	0.003/0.005 in (0,076/0,127 mm)
Height of Liner in relation to Cylinder Block Top Face	3.125/3.126 in (79,375/79,40 mm)
Overall Length of Liner	0.023/0.027 in (0,584/0,686 mm) above
	6.495/6.505 in (164,973/165,227 mm)

Cylinder Liner 4.107 and 4.99

Type		Cast Iron
Inside Dia. of Liner Pre-Finished	4.99	Wet — Push Fit
Inside Dia. of Liner Pre-Finished	4.107	3.00/3.001 in (76.20/76.225 mm)
Thickness of Top Flange	4.99	3.125/3.126 in (79,374/79,4 mm)
Depth of Recess in Block for Liner Flange	4.99	0.3125/0.3145 in (7,937/7,988 mm)
Thickness of Top Flange	4.107	0.3115/0.3135 in (7,912/7,963 mm)
Depth of Recess in Block for Liner Flange	4.107	0.250/0.252 in (6,35/6,4 mm)
Height of Liner in relation to Cylinder Block Top Face	4.107 and 4.99	0.249/0.251 in (6,325/6,375 mm)
Liner Flange Outside Dia.	4.99	0.003 in (0,076mm) Above. 0.001 in (0.025 mm) below
Cylinder Block Top Bore for Liner Flange	4.99	3.618/3.621 in (91,898/91,973 mm)
Clearance Fit of Liner Flange to Block Bore	4.107 and 4.99	3.625/3.627 in (92.075/91,125 mm)
		0.004/0.009 in (0,102/0,229 mm)

Pistons 4.108

Type	Flat Topped
Overall Height (Skirt to Crown)	3.147/3.150 in (79,934/80,010 rnml
Center Line of Piston Pin to Piston Skirt	1.157 in (29,388 mm)
Piston Height in relation to Cylinder Block Top Face	0.002/0.006 in (0,051/0,152 mm) Above
Bore Dia. for Piston Pin	1.06255/1.06275 in (26,989/26,994 mm)
Compression Ring Groove Width—Top	0.0805/0.0815 in (2,045/2,070 mm)
Compression Ring Groove Width—2nd	0.0645/0.0655 in (1,638/1,664 mm)
Compression Ring Groove Width—3rd	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Groove Width—4th	0.126/0.127 in (3,200/3,225 mm)
Oil Control Ring Groove Widih—5th	0.19010.191 in (4,826/4,851 mm)

Note: There is a Steel Insert fitted above the Top Groove

Pistons 4.107 and 4.99

Type	Flat Topped
Overall Height (Skirt to Crown)	3.146 in (79.91 mm)
Center Line of Piston Pin to Piston Skirt	1.344 in (34.14 mm)
Piston Height in relation to Cylinder Block Top Face	0.008510.012 in (0,22/0,30 mm) Above
Bore Dia. for Piston Pin later 4.99 and all 4.107 engines	0.93755/0.93775 in (23,81/23,82 mm)
Early 4.99 engines	0.87505/0.87525 in (22,22/22,23 mm)
Compression Ring Groove Width—Top	0.0801/0.0811 in (2,034/2,06 mm)
Compression Ring Grooves Width 2nd and 3rd	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Grooves Width 4th and 5th	0.190/0.191 in (4,826/4,851 mm)

Piston Rings 4.108

Top—Compression	Parallel Faced
Second and Third Compression	Internally Stepped
Fourth—Oil Control	Laminated Segment
Fifth—Oil Control	Slotted Scraper
Top Compression Ring Width	0.0771/0.0781 in (1,958/1,984 mm)
Ring Clearance in Groove	0.0024/0.0044 in (0,061/0,112 mm)
Second and Third Compression Ring Width	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Fifth Scraper Ring Width	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,063/0,114 mm)
Ring Gap—Top Compression	0.009/0.014 in (0,229/0,356 mm)
Ring Gap---Second and Third Compression	0.009/0.014 in (0,229/0,356 mm)
Ring Gap—Fifth Scraper	0.009/0.014 in (0,229/0,356 mm)

Piston Ring Gaps quoted are measured in a ring gauge of 3.125 in (79,38 mm) bore. In practice lor every 0.001 in (0,254 mm) difference in cylinder bore diameter from gauge size, 0.003 in (0,762 mm) should be allowed.

Piston Rings 4.107 and 4.99 Agricultural and Industrial Engines

Top Compression	Parallel Cast iron
'Second and Third Compression	internally Stepped
Fourth—Oil Control	Chrome Plated Spring Loaded Scraper
Fifth—Oil Control	Slotted Scraper

'4.99 Agricultural engines have taper faced cast iron compression rings fitted in the second and third ring grooves.

Top Compression Ring Width	0.077110.0781 in (1,96/1,984 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Second and Third Compression Ring Width	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Fourth and Fifth Scraper Ring Width	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,064/0,114 mm)
Ring Gap—Compression Rings Chrome Vehicle	0.012/0.017 in (0,30/0,43 mm)
Ring Gap—Oil Control Rings Cast Iron Vehicle	0.009/0.014 in (0,229/0,356 mm)
Ring Gap—Compression Rings Cast Iron Agricultural and Industrial	0.009/0.014 in (0,229/0,356 mm)

Piston Ring Gaps quoted are measured in a ring gauge of 3.000 in (76.20 mm) bore lor 499 engines and 3.125 in (79,38 mm) bore for 4.107 engines. In practice, for every 0.001 in (0,254 mm) difference in cylinder bore diameter from gauge size, 0.003 in (0.762 mm) should be allowed.

Piston Pin 4.108

Type	Fully Floating
Outside Dia. of Piston Pin	1.0625/1.0627 in (26,987/26,993 mm)
Length of Piston Pin	2.673/2.687 in (67,894/68,250 mm)
Fit in Piston Boss	Transition

Piston Pin 4.107 and 4.99

Type	Fully Floating
Outside Dia. of Piston Pin	0.9375 in/0.9377 in (23,812/23,817 mm)
Earlier Engines	0.875/0.8752 in (22,225/22,23 mm)
Fit in Piston Boss	Transition

Small End Bushing 4.108

Type	Steel Backed. Lead Bronze Lined
Length of Small End Bushing	0.935/0.955 in (23,749/24,257 mm)
Outside Dia. of Small End Bushing	1.221/1.222 in (31,013/31,039 mm)
inside Dia. before Reaming	1.0495/1.0545 in (26,657/26,784 mm)
inside Dia. after Reaming	1.06315/1.0632 in (27,004/27,005 mm)
Clearance between Small End Bushing and Piston Pin	0.00045/0.0007 in (0.0114/0,0178 mm)

Small End Bushing 4.107 and 4.99

Type	Steel Backed. Lead Bronze Lined
Length of Small End Bushing	0.865/0.885 in (22,00/22,48 mm)
Outside Dia. of Small End Bushing	
on later 4.99 and ail 4.107 engines	1.06511.066 in (27,05/27,08 mm)
Early 4.99 engines	1.0025/1.0035 in (25,46/25,49 mm)
Inside Dia. after Reaming on later	
4.99 and all 4.107 engines	0.9382/0.93875 in (23,83/23,84 mm)
Early 4.99 engines	0.8757/0.87625 in (22,24/22,26 mm)
Clearance between Small End Bushing and Piston Pin	0.0005/0.00125 in (0,01/0,03 mm)

Note. Bushings to be reamed to suit respective Piston Pins, and are provided with a reaming allowance.

Connecting Rod 4.108

Type	'H Section
Cap Location to Connecting Rod	Serrations, Offset 45" to the Horizontal
Big End Parent Bore Dia.	2.14612.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia.	1.2187511.21975 in (30,956/30,981 mm)
Length from Centre Line of Big End	
to Centre Line of Small End	6.217/6.219 in (157.9121157.963mm)
Big End Setscrew	0.375 in (⅜ in) U.N.F.
Connecting Rod End Float	0.0065/0.0105 in (0,16510,267mm)

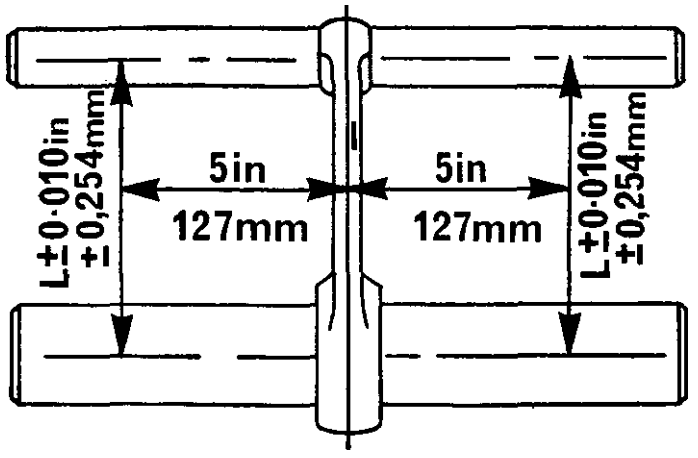
Connecting Rod 4.107 and 4.99

Type	'H' Section
Cap Location to Connecting Rod	Serrations. Offset 45" to the horizontal
Big End Parent Bore Dia.	2.14611.1465 in (54,508154,521mm)
Small End Parent Bore Dia.	
on later 4.99 and ail 4.107 engines	1.062511.0635 in (26,99/27,01 mm)
Early 4.99 engines	1.00/1.001 in (25,4125.43mm)
Length from Centre Line of Big End to Centre Line of	
Small End	6.405/6.407 in (162,69/162,74 mm)
Big End Setscrew	0.375 in (⅜ in) U.N.F.
Connecting Rod End Fioat	
on later 4.99 and all 4.107 engines	0.0065/0.0105 in (0.1610.27 mm)
Early 4.99 engines	0.007510.0105 in (0,19/0,27 mm)

Connecting Rod Alignment 4.108, 4.107, 4.99

Large and small end bores must be square and parallel with each other within the limits of t0.010 in (0,25 mm) measured 5 in (127mm) each side of the axis of the rod on test mandrel as shown in Fig. B.1. With the small end bush fitted, the limit of ±0.010 in (0.025mm) is reduced to 20.0025 in (0.06 mm).

B1



Crankshaft 4.108, 4.107, 4.99

Overall Length	21.125 in (536.575 mm)
Main Journal Dia. Nos. 1 and 2	2.248/2.2485 in (57,099/57,112 mm)
Main Journal Dia. No. 3	2.2475/2.248 in (57,086/57,099 mm)
Main Journal Length No. 1	1.40625 in (35,719 mm)
Main Journal Length No. 2	1.496/1.504 in (37,998/38,202 mm)
Main Journal Length No. 3	1.499/1.502 in (38,075/38,151 mm)
Main Journal Fillet Radii	0.125/0.141 in (3,175/3,581 mm)
Crankpin Dia.	1.9995/2.000 in (50,787/50,800 mm)
Crankpin Length	1.1875/1.1895 in (30,162/30,213 mm)
Crankpin Fillet Radii	0.15625/0.17187 in (5/32/11/64 in) (3,969/4,366 mm)
Surface Finish—All Journals	8-16 micro-in (0.2 - 0.4 micron)
Main Journal and Crankpin Regrind Undersizes	0.010. 0.020. 0.030 in (0.25. 0.51. 0.76 mm)
Oil Seal Helix Dia.	2.21075/2.21175 in (56,153/56.176 mm)
Oil Seal Helix Width	0.050/0.080 in (1,270/2,032 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,102/0,203 mm)
Flange Oia.	3.9985/3.9995 in (101,562/101,587 mm)
Flange Width	0.500 in (12.700 mm)
Spigot Bearing Recess Depth	0.875 in (22.225 mm)
Spigot Bearing Recess Bore	1.250 in (31,750 mm)
Crankshaft End Float	0.002/0.015 in (0,0508/0,381 mm)

Special Nole:

The crankshaft fitted to the 4.108 engine is hardened by the "Tufftride" process.
Special precautions are therefore necessary when regrinding. Only very light cuts should be taken. especially in the region of the fillet radii and adequate cooling should be ensured during grinding operations.

After regrinding the crankshaft it should be crack-detected and de-magnetised. then reireated by the 'Tufftride" process after which the crankshaft should again be crack-detected and de-magnetised. Where facilities are not available to re. harden the crankshaft by this process. a factory replacement crankshaft should be obtained.

Fillet radii and surface finish must be maintained during all crankshaft regrinding. Length of No. 3 main journal not to exceed 1.516 in (38.506 mm) after regrinding. Where necessary use oversize thrust washers to bring crankshaft end float within the correct limits

Crankshaft Thrust Washers 4.108, 4.107, 4.99

Type	Steel Backed—Lead Bronze Faced
Position in Engine	Rear Main Bearing
Thrust Washer Thickness (STD)	0.089/0.091 in (2,261/2,311 mm)
Thrust Washer Thickness (O/S)	0.0965/0.1005 in (2,451/2,553 mm)
Thrust Washer Outside Dia.	3.245/3.255 in (82,423/82,677 mm)
Thrust Washer Inside Dia.	2.590/2.600 in (65,786/66,040 mm)

Main Bearings 4.108, 4.107, 4.99

Type	Pre-finished. Steel Backed. Aluminium Tin Lined
Shell Width	1.245/1.255 in (31,623/31,877 mm)
Outside Dia. of Main Bearing	2.3955 in (60.846 mm)
Inside Dia. of Main Bearing	2.2505/2.2515 in (57,163/57,188 mm)
Running Clearance—Nos. 1 and 2	0.002/0.0035 in (0,051/0,089 mm)
Running Clearance—No. 3	0.0025/0.004 in (0,063/0,102 mm)
Steel Thickness	0.060 in (1.524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Connecting Rod Bearings 4.108, 4.107, 4.99

Type	Pre-finished. Steel Backed. Aluminium Tin Lined
Shell Width	0.870/0.880 in (22,098/22,325 mm)
Outside Dia. of Con. Rod Bearing	2.1465 in (54.521 mm)
Inside Dia. of Con. Rod Bearing	2.0015/2.0025 in (50,838/50,863 mm)
Running Clearance	0.0015/0.003 in (0,038/0,076 mm)
Steel Thickness	0.060 in (1.524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Camshaft 4.108, 4.107, 4.99

No. 1 Journal Length	1.347/1.351 in (34,214/34,315 mm)
NO. 1 Journal Dia.	1.791/1.792 in (45,491/45,517 mm)
No. 1 Cylinder Block Camshaft Bore Dia.	1.794/1.7955 in (45,568/45,606 mm)
No. 1 Journal Running Clearance	0.002/0.0045 in (0,051/0,114 mm)
No. 2 Journal Length	1.250 in (31.750 mm)
No. 2 Journal Dia.	1.781/1.782 in (45,237/45,263 mm)
NO. 2 Cylinder Block Camshaft Bore Dia.	1.784/1.787 in (45,314/45,390 mm)
No. 2 Journal Running Clearance	0.002/0.006 in (0,051/0,152 mm)
No. 3 Journal Length	1.000 in (25.400 mm)
No. 3 Journal Dia.	1.773/1.774 in (45,034/45,060 mm)
No. 3 Cylinder Block Camshaft Bore Dia.	1.776/1.778 in (45,110/45,161 mm)
No. 3 Journal Running Clearance	0.002/0.005 in (0,051/0,127 mm)
Cam Lift	0.266 in (6,766 mm)
Oilways for Rocker Shaft Lubrication	No. 2 Journal

Camshaft Thrust Plates 4.108, 4.107, 4.99

Type	180' Oil Impregnated Sintered Iron
Thrust Plate Outside Dia.	2.555/2.557 in (64,897/64,948 mm)
Cylinder Block Recess Dia. for Thrusf Plate	2.5585/2.5685 in (64,986/65,240 mm)
Clearance Fit of Thrust Plate in Recess	0.0015/0.013 in (0,038/0,330 mm)
Thrusf Plate Inside Dia.	1.500 in (38.100 mm)
Thrust Plate Thickness	0.160/0.162 in (4,060/4,115 mm)
Cylinder Block Recess Depth for Thrust Plate	0.158/0.164 in (4,009/4,166 mm)
Thrust Plate Height in relation to Cylinder Block Face	0.004 in (0.102 mm) above or below
Camshaft End Float	0.003/0.013 in (0,076/0,330 mm)

Valve and Fuel Pump Timing

Refer to later section on timing (page L.1)

CYLINDER HEAD 4.108, 4.107, 4.99

Overall Length of Cylinder Head	20.000 in (508.000 mm)
Overall Depth of Cylinder Head	2.617/2.633 in (66,472/66,878 mm)
Resurfacing Allowance on Cylinder Head Face	NIL—On no account can the cylinder head face be resurfaced.
Pressure for Water Leakage Test	20 lbf/in² (1.4 kgf/cm²)
Valve Seat Angle	45"
Bore in Cylinder Head lor Guide	0.4995/0.5005 in (12,687/12,713 mrn)
Bore in Cylinder Head for combustion Chamber Inserts	1.250/1.252 in (31,750/31,801 mrn)
Depth of Bore in Cylinder Head for Combustion Chamber Inserts	0.373/0.376 in (9,474/9,550 mm)

Combustion Chamber Inserts 4.108. 4.107, 4.99

Outside Dia. of Insert	1.248/1.249 in (31,699/31,724 mm)
Depth of Insert	0.374/0.375 in (9,499/9,525 mm)
Height of Insert in relation to Cylinder Head Face	0.002 in (0.051 mm) above or below
Clearance Fit of Insert in Cylinder Head Bore	0.001/0.004 in (0,025/0,102 mm)
Method of Location in Cylinder Head	By Cylinder Block Face and Expansion Washer

Valve Guides (Inlet) 4.108, 4.107, 4.99

Inside Dia.	0.3145/0.3155 in (7,988/8,014 mm)
Outside Dia.	0.50125/0.50175 in (12,744/12,757 rnm)
Interference fit of Guide in Cvlinder Head Bore	0.00075/0.00225 in (0,019/0,057 mrn)
Overall length of Guide	2.130 in (54.102 mm)
Guide Protrusion Above Top Face of Cylinder Head	0.800/0.815 in (20,320/20,701 mm)

Valve Guides (Exhaust) 4.108, 4.107, 4.99

Inside Dia.	0.3145/0.3155 in (7,988/8,014 mm)
Outside Dia.	0.50125/0.50175 in (12,744/12,757 rnm)
Interference fit of Guide in Cylinder Head Bore	0.00075/0.00225 in (0,019/0,057 mm)
Depth of Counterbore	0.380 in (9.650 mm)
Overall Length of Guide	2.440 in (61.980 mm)
Guide Protrusion above Top Face of Cylinder Head	0.800/0.815 in (20.320/20.701 mm)

Valves (Inlet) 4.108, 4.107, 4.99

Valve Stem Dia.	0.312/0.313 in (7,925/7,950 mm)
Clearance fit of Valve Stem in Guide	0.0015/0.0035 in (0,038/0,089 mm)
Valve Head Dia.	1.410/1.414 in (35,814/35,916 mm)
Valve Face Angle	45"
Valve Head Depth Below Cylinder Head Face	0.028 in (0.711 mm)/0.039 in (0.991 mm)
Overall Length of Valve	4.592/4.608 in (116,637/117,043 mm)
Sealing Arrangement	Rubber Oil Seal

Valves (Exhaust) 4.108, 4.107, 4.99

Valve Stem Dia.	0.3115/0.3125 in (7,912/7,937 mm)
Clearance Fit of Valve Stem in Guide	0.002/0.004 in (0,051/0,102 mm)
Valve Head Dia.	1.191/1.195 in (30,251/30,353 mm)
Valve Face Angle	45"
Valve Head Depth Below Cylinder Head Face	0.021 in (0.53 mm)/0.032 in (0.813 mm)
Overall Length of Valve	4.600/4.616 in (116,840/117,246 mm)
Sealing Arrangement	No Seal fitted to Exhaust Valve

Inner Valve Springs (where fitted)

Fitted Length	1.530 in (38,862 mm)
Load at Fitted Length	28.6 lbf ± 2 lbf (13,0 kgf ± 0.91 kgf)
Fitted Position	Damper Coil to Cylinder Head

Outer Valve Springs 4.108, 4.107, 4.99

Fitted Length	1.780 in (45.212 mm)
Load at Fitted Length	56.0 lbf ± 2.8 lbf (25.4 kgf ± 1.27 kgf)
Fitted Position	Damper Coil to Cylinder Head

Rocker Levers 4.108, 4.107. 4.99

Length between Center Line of Adjusting Screw and Center Line of Rocker Shafi	1.042/1.058 in (26,467/26,873 mm)
Length between Center Line of Rocker Lever Pad and Center Line of Rocker Shaft	1.567/1.583 in (39,802/40,208 mm)
Inside Dia. of Rocker Lever Bore	0.71825/0.71950 in (18,243/18,275 mm)
Outside Dia. of Rocker Lever Bushing	0.7205/0.7215 in (18,301/18,326 mm)
Interference Fit of Bushing in Rocker Lever	0.001/0.00325 in (0,025/0,082 mm)
Finished Inside Dia. of Rocker Lever Bushing	0.6245/0.62575 in (15,862/15,894 mm)
Clearance of Rocker Lever Bushing on Rocker Shaft	0.00075/0.0035 in (0,019/0,089 mm)

Valve Clearances 4.108, 4.107, 4.99

Clearance between Valve Stem Tip and Rocker Lever	0.012 in (0.30 mm) Cold

Rocker Shaft 4.108, 4.107, 4.99

Overall Length of Shaft	14.5625 in (369.887 mm)
Outside Dia. of Shaft	0.62225/0.62375 in (15,805/15,843 mm)
Lubrication	Oil Feed from Cylinder Head through Central Passage to Individual Rocker Levers

Push Rods 4.108, 4.107, 4.99

Overall Length	8.527/8.560 in (216,58/217,42 mm)
Outside Dia.	0.250 in (6,350 mm)

Tappets 4.108, 4.107, 4.99

Overall Length	2.250 in (57.150 mm)
Outside Dia. of Tappet Shank	0.560/0.561 in (14,224/14,249 mm)
Cylinder Block Tappet Bore Dia.	0.562/0.56325 in (14,275/14,307 mm)
Tappet Running Clearance in Cylinder Block Bore	0.001/0.00325 in (0,025/0,082 mm)
Outside Dia. of Tappet Foot	1.245/1.255 in (31,623/31,877 mm)

TIMING GEARS 4.108, 4.107, 4.99

Camshaft Gear

Number of Teeth	48
inside Dia. of Gear Boss	1.750/1.7514 in (44,450/44,486 mm)
Outside Dia. of Camshaft Hub	1.7496/1.7509 in (44,430/44,473 mm)
Transition Fit of Gear and Hub	0.0009/0.0018 in (0,023/0,046 mm)

Fuel Pump Gear

Number of Teeth	48
Inside Dia. of Cylinder Block Bore for Fuel Pump Drive Hub Bearing	1.8125/1.8141 in (46,037/46,078 mm)
Outside Dia. of Fuel Pump Drive Hub Bearing	1.8145/1.8152 in (46,088/46,106 mm)
Interference Fit of Drive Hub Bearing in Cylinder Block Bore	0.0004/0.0027 in (0,010/0,069 mm)
inside Dia. of Fuel Pump Drive Hub Bearing	1.3125/1.3135 in (33,34/33,78 mm)
Outside Dia. of Fuel Pump Gear Drive Hub	1.3105/1.3115 in (33,287/33,312 mm)
Running Clearance of Drive Hub in Bearing	0.0031/0.0051 in (0,079/0,129 mm)
Drive Hub End Float	0.002/0.010 in (0,051/0,254 mm)

Idler Gear and Hub

Number of Teeth	57
Inside Dla. of Gear Boss	1.7187/1.7197 in (43,655/43,680 mm)
inside Dia. of Gear Boss with Bushing Fitted	1.562511.5641 in (39,687/39,728 mm)
Outside Dia. of Gear Hub	1.5612/1.5619 in (39,654/39,668 mm)
Running Clearance of Gear on Hub	0.0003/0.0016 in (0,008/0,041 mm)
idler Gear Width	1.3105/1.3135 in (33,287/33,363 mm)
Hub Width	1.3165/1.3185 in (33,439/33,490 mm)
Idler Gear End Float	0.002/0.007 in (0,051/0,178 mm)

Crankshaft Gear

Number of Teeth	24
inside Dia. of Gear	1.250/1.2512 in (31,750/31,780 mm)
Crankshaft Dia. for Gear	1.250/1.2506 in (31,750/31,756 mm)
Transition Fit of Gear on Crankshalt	0.0006/0.0012 in (0,01510.030 mm)

Timing Gear Backlash

Clearance between Crankshaft/Idler and Camshaft1 Idler Gear	0.0015/0.003 in (0,038/0,076 mm)

LUBRICATING SYSTEM 4.108, 4.107, 4.99

Lubricating Oil Pressure	30160 p.s.i. (2,1/4,2 kgf/cm²) at maximum engine speed and normal working temperature.

Sump

Dipstick Position	Camshaft side of engine opposite No. 2 cylinder
Strainer Location	End of suction pipe to lubricating oil pump.

Typical Sump Capacities

	Imp. pt	U.S. pt	Litre
Refill Capacities—Engine Level			
Standard Sump	7.0	8.4	4.0

Note: The above sump capacities are intended to be used as a guide and actual capacities should be governed by the level indicated on the dipstick.

Lubricating Oil Pump

Type	Rotor Type
Number of Lobes—Inner Rotor	Three or Four
Number of Lobes—Outer Rotor	Four or Five
Method of Drive	By Spiral Gears from the Camshaft

Pump Clearances

Inner Rotor to Outer Rotor	0.0005/0.0025 in (0.013/0.063 mm)
Outer Rotor to Pump Body	0.011/0.013 in (0,28/0,33 mm)
Inner Rotor End Clearance	0.0015/0.0003 in (0.0380,076 mm)
Outer Rotor End Clearance	0.0005/0.0025 in (0.013/0,063 mm)
Inside Dia. of Bore for Pump Shaft	0.500/0.501 in (12,700/12,725 mm)
Outside Dia. of Pump Shaft	0.4983/0.4986 in (12,655/12,664 mm)
Running Clearance. Shaft in Bore	0.0014/0.0027 in (0.036/0.069 mm)

Lubricating Oil Pump Drive Gear

Number of Teeth	12
Inside Dia. of Gear Bore	0.4965/0.4970 in (12.611/12,624 mm)
Outside Dia. of Oil Pump Drive Shaft	0.4983/0.4986 in (12,655/12,664 mm)
Interference Fit of Gear on Shaft	0.0013/0.0021 in (0.033/0.053 mm)
Lubricating Oil Pump Drive Gear Backlash	0.0155/0.019 in (0.394/0.483 mm)

Relief Valve

Type	Spring Loaded Plunger
Pressure Setting	50/65 lbf/in² (3,5/4,6 kgf/cm²)
Length of Plunger	0.9375 in (23.813 mm)
Outside Dia. of Plunger	0.5585/0.5595 in (14,19/14,21 mm)
Inside Dia. of Valve Housing Bore	0.5605/0.5625 in (14,24/14,29 mm)
Clearance of Plunger in Bore	0.001/0.004 in (0.025/0,102 mm)
Outside Dia. of Spring	0.368/0.377 in (9,347/9,576 mm)
Spring — Free Length	1.5 in (38.10 mm)
Spring — Solid Length	0.754 in (19.15 mm)

Lubricating Oil Filter

Type	Full Flow
Element Type	Paper
By-Pass Valve Setting	Opens between 13-17 lbf/in² (0.91-1.2 kgf/cm²) pressure differential
Type of Valve	Spring Loaded Ball
Make	Fram
Model	PH6-PL-MIL
Element, Replaceable	CHO-6PL-MIL

Lubricating Oil

Specification	MIL-L-9000
Grade: for engine	
Normal Use	Symbol 9250, SAE 30
Below 20° Temp.	Symbol 9110, SAE 10
Service	DG or DS
Approximate Capacity (varies with angle	
Crankcase	7 pints

COOLING SYSTEM 4.108, 4.107, 4.99

Type	Water Cooled
Cylinder Block and Head	Thermo-Syhpon Impeller Assisted
Engine Water Capacity	Approx. 10 U.S. quarts

Thermostat

Type	Wax Capsule
Opening Temperature	175-182°F (79,5-83,5°C)
Fully open at	200-205°F (93,5-96°C)
Minimum Travel at Fully Open Temp.	0.3125 in (7.94 mm)

Water Pump

Type	Centrifugal—Belt driven from Crankshaft
Outside Dia. of Shaft for Pulley	0.5905/0.5908 in (14,999/15,006 mm)
inside Dia. of Pulley Bore	0.588/0.589 in (14,935/14,961 mm)
Interference Fit of Pulley on Shaft	0.0015/0.0028 in (0,038/0,071 mm)
Outside Dia. of Shaft lor Impeller	0.498/0.499 in (12,649/12,675 mm)
Inside Dia. of Impeller Bore	0.497/0.4975 in (12,624/12,636 mm
Interference Fit of Impeller on Shaft	0.0005/0.002 in (0,013/0,051 mm'
Outside Dia. of Impeller	3.094/3.125 in (78,588/79,375 mm)
impeller to Body Clearance	0.005/0.025 in (0,127/0,635 mm)
Water Pump Seal Type	Synthetic Rubber—Carbon Faced
Inside Dia. of Seal for Impeller Shaft	0.472 in (11.969 mm)
Outside Dia. of Seal	1.102 in (27.991 mm)
'Water Pump Insert Type	Phosphor Bronze—Surface Finish of Sealing Face to be 12-20 micro-in (0,3-0,5 micron)
Outside Dia. of Insert	1.6241.6245 in (41,250/41,263 mm)
Inside Dia. of Insert Bore in Water Pump Housing	1.625/1.626 in (41,275/41,300 mm)

'Later water pumps are fitted with ceramic faced inserts.

Heat Exchanger (mounted on engine)

Make	Sendure
Type	Liquid to Liquid
Part Number.	1269-3-7

Sea Water Pump

Type.	Single Rubber Impeller
Make	Sherwood
Model Number	F-85
Inlet and Outlet	½ NPT
Capacity	5½ GPM
Drive.	Gear Driven

Fuel

Specification. MIL-F-16884

Fuel Consumption

Rate at Full Speed (25HP at 2400 rpm) . .43 lbs./BHP/Hr

Fuel Filter

Make..	Fram
Model.	FBM-1124APB
Replaceable Cartridge	C-1124APB

Injectors

4.108 Marine & Industrial
4.107 Marine & Industrial

Make	C.A.V.
Holder Type	BKB40SD5224
Nozzle Type	BDN12SD6236
Code Letter	BG
Min. Working Pressure	135 atm (2000 lbf/in² or 140 kgf/cm²)
Setting Pressure	150 atm (2200 lbf/in² or 155 kgf/cm²)

Note: Earlier atomisers bearing the identification code letter 'J' had a setting pressure of 140 atm. When servicing of these atomisers is carried out, they should be reset in accordance with the settings quoted above.

Fuel Lift Pump

Type	AC Delco Diaphragm 'YJ' Series
Spring Colour Code	Green
Method of Drive	From Eccentric on Camshaft via Push rod
Total Stroke of Operating Lever	0.192 in (4.877 mm)
Static Pressure--No Delivery	4-7 lbf/in² (0,28-0,49 kgf/cm²)
Pump to Distance Piece Gasket Thickness	0.018/0.022 in (0,457/0,559 mm)
Distance 'Piece--Lift Pump to Tappet Inspection Cover	0.256 in (6.502 mm)

Fuel Injection Pump

Make	C.A.V.
Type	D.P.A.
Rotation	Clockwise (Viewed from Drive End)
Plunger Dia.	6 mm

	4.108	4.107	4.99
Hydraulically Governed			
Timing Letter	A		A
No. 1 Cylinder Outlet	W		W
Mechanically Governed			
Timing Letter	C	C	C
No. 1 Cylinder Outlet	W	W	W

Static Timing Position

The static timing position varies according to application, but can be obtained by referring to the first group of letters and digits of the fuel pump setting code (stamped on the fuel pump identification plate), i.e..

First Group of Fuel Pump Code	Static Timing B.T.D.C.	Piston Displacement B.T.D.C.	Remarks
EH39, MH26, MH27, PH28, PH30	18'	0.108 in (2.75 mm)	
CH35	19"	0.120 in (3.05 mm)	
PH34	20"	0.134 in (3.40 mm)	
LH23, LH29	20"	0.134 in (3.40 mm)	4.107 engines rated up to and including 2.500 rev/min
LH31	22°	0.160 in (4.06 mm)	4.107 engines rated above 2.500 rev/min
DH19, AH28, BH26	26°	0.226 in (5.74 mm)	

Note: For 4.107 and 4.99 mechanically governed engines rated above 3.000 and 2.500 rev/min respectively. the static timing is altered to 22" B.T.D.C. - piston displacement 0.160 in (4.06 mm). For 4.108 engines prior to engine numbers 108U15973 and 108UD20214, the static timing was 19" B.T.D.C. - piston displacement 0.120 in (3.05 mm). When re. setting these pumps, it is advisable to set at the figures quoted in above table.

For 4.107 industrial engines having a fuel pump coding of PH30 and an idling speed of 1.000 rev/min, the static timing is 21° B.T.D.C. and a piston displacement of 0.147 in (3.73 mm).

Electrical System

Nominal Voltage	24 V.
Type	Ungrounded

Battery (not supplied with engine)

Terminal Voltage	Nominal 24 Volts
Recommended Capacity	130 Ampere Hours

Alternator

Make	Motorola
Model.	MA24-900G
Output	35 Amp
Regulator Model.	TVR24-28G

Generator (no longer available)

Type	Shunt-wound, ungrounded
Make	Delco-Remy
Capacity	500 Watts
Part Number.	1117731
Voltage Regulator Part Number.	1118635

Cranking Motor

Make	Delco-Remy
Part Number.	1107579
Type	Insulated
Enclosure.	Spray Tight
Lock Test.	5.0 volts at 425 amps
No Load Test:	
Maximum Amperes.	85
Volts.	23.5
Minimum Torque	12.5 lb/ft
Direction of Rotation.	Clockwise
Brush Tension.	24 oz. min.

Solenoid Switch for Cranking Motor (Mounted on Cranking Motor)

Make	Delco-Remy
Part Number.	1114301

Transmission

Reverse Gear Make.	Paragon
Model.	P-220L
Type	Hyrdaulic
Lubrication.	Pressure
Operating Oil Pressure	125 lbs.
Oil Specification.	Type A Suffix A Transmission Fluid
Reduction Gear Make.	Paragon
Exact Reduction Ratio.	2.16:1

Propeller Coupling

Bore..	1-3/8"
Keyway	3/8" X 3/16"

SECTION C

APPROVED ENGINE SERVICE TOOLS

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England

PD 1C Valve Guide Remover ond Replacer.

With this tool all valve guides can be removed and replaced provided puller bars areavailable.

PD 1C-1 Puller Bars.

Two bars are supplied for use with PD 1C to suit nominal 5/16" and 3/8" i/d Bore Guide.

38U.3 Piston Assembly Ring

This is an expandable piston assembly ring for Std. and oversize pistons on all type engines.

PD 1C-2 Valve Guide Replacing Stop.

When the valve guide is replaced using one of the above end stops it will ensure that the guide protrudes the correct amount above the top face of the cylinder head.

PD 37 Flywheel Runout-Gauge.

With this tool a check con speedily be made on the alignment of the flywheel, flywheel housing or back plate.

PD 38B Crankshaft Gear, Sprocket, Water Pump and Wafer Pump Pulley Remover.

Engine Type: This is controlled by adaptors available. Details below.

Sprockets or crankshaft gears cannot be removed with this tool when the shaft is in situ.

PD 3852 Crankshaft Gear Remover Adaptor.

This Adaptor is used with PD 38B.

PD 3855 Water Pump Impeller Remover Adaptor.

The Impeller can be removed with ease and safety.

62008 Small End Reaming Fixture.

The correct small end bush reamers must be available to complete the job. Details as follows:

PD 41B Piston Height Gauge.

Used for checking piston height.

PD50-C Cylinder Liner Remover and Replacer.

The following adaptor set must be ordered to complete the operation.

PD 50C-2 Cylinder Liner Remover Adaptor.

Completes PD 50C for removing liners.

PD 155A Small Adjustable Puller.

With suitable adaptors can be used to remove water pump pulley, oil pump drive gears and camshatt gear see adaptor details.

PD 155A-1 Small Adjustable Puller Adaptors.

Removes water pump pulleys.

No. 3 Tension Wrench.

1/2" square drive 25–170 lbs. ft.

316 X Valve Seat Cutter Handle.

This tool is required for operation of all cutters and pilots.

316-10 Valve Seat Cutter Pilot.

This pilot is suitable for all guides that have a nominal 5/16" i/d.

FC 99000 Atomirer Tester.

This is a portable tester fitted with a paper filter element.

7065 Circlip Pliers.

Two types of points are available 1/2" shaft size. 1/2"–1" "B" Shaft size 1"-3".

355 Connecting Rod Alignment Jig.

Enables a quick check to be made on the alignment of connecting rods-various adaptors ore required. See Below.

336 Multi-Purpose Con. Rod Arbor.

Required with the above tool.

PD 336-5 Adaptor.

This adaptor is fitted into the big-end bore when checking the alignment (Thin wall bearings only).

6118 Valve Spring Compressor.

This valve spring compressor has been designed to remove valve springs without removing the cylinder head, provided the adaptors are available.

PD6118-1 Valve Spring Compressor Adaptor.

The adaptor is fitted to one of the rocker shaft securing studs.

PD 130 Fuel Pump Allen Screw Wrench.

Use to remove the Allen screw securing D.P.A. fuel pump.

PD 42B Small End Bush Remover Main Tool.

Enables a new small end bush to be drawn into the small end of con. rod and at the same time will displace the old bush: adaptors are required. See below.

6000C Compression Tester.

See adaptor details.

6000C-5 Compression Tester Adaptor.

This adaptor replaces the atomiser for compression testing.

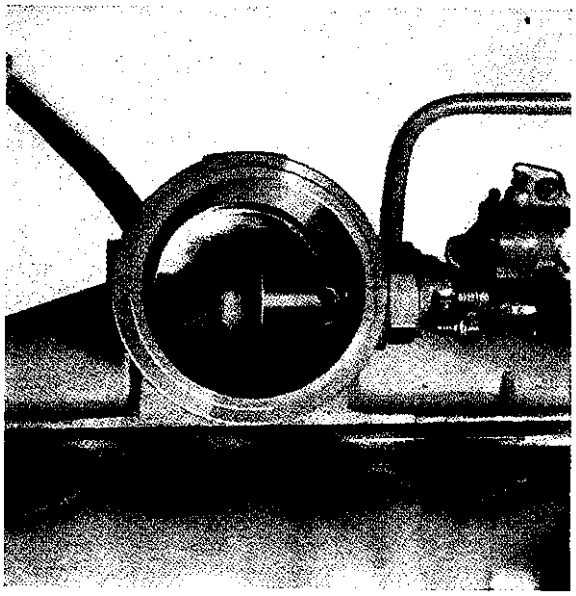
SECTION D
Fault Diagnosis

Fault	Possible Cause
Low cranking speed	1.2.3.4
Will not start	5.6, 7.8, 9.10. 12.13.14.15, 16.17. 18, 19.20.22.31,32.33.
Difficult starting	5, 7, 8, 9, 10.11. 12.13.14.15.16.18.19.20.21.22.24.29.31,32.33.
Lack of power	8.9. 10. 11. 12.13. 14.18. 19.20.21. 22. 23. 24. 25. 26. 27.31. 32. 33.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11.13.14.16.18.19.20.22.23.2425.27.28.29.31.32.33.
Black exhaust	11. 13. 14. 16. 18. 19.20. 22. 24. 25, 27. 28. 29. 31. 32. 33.
Blue/white exhaust	4. 16. 18. 19.20.25.27.31.33.34.35.45.56.
Low oil pressure	4, 36. 37. 38. 39. 40. 42. 43. 44: 58.
Knocking	9. 14. 16. 18. 19, 22. 26. 28. 29. 31. 33. 35, 36. 45. 46. 59.
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26. 28.29.30.33.35.45.59.
Vibration	13, 14, 20, 23, 25, 26 29, 30 33, 45, 47, 48, 49.
High oil pressure	4, 38. 41
Overheating	11. 13. 14. 16. 18. 19. 24. 25, 45.50.51, 52. 53. 54, 57.
Excessive crankcase pressure	25, 31. 33. 34. 45, 55.
Poor compression	11. 19, 25. 28, 29. 31, 32. 33. 34. 46. 59.
Starts and stops	10, 11. 12.

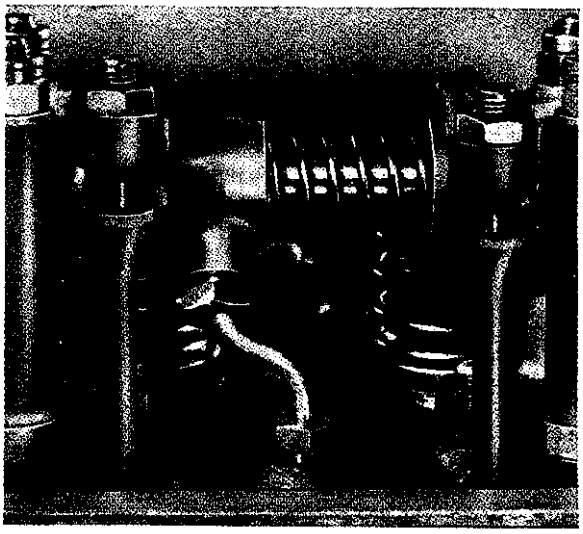
Key to Fault Finding Chart

1. Battery capacity low.
2. Bad electrical connections.
3. Faulty starter motor.
4. Incorrect grade of lubricating oil.
5. Low cranking speed.
6. Fuel tank empty.
7. Faulty stop control operation.
8. Blocked fuel feed pipe.
9. Faulty fuel lift pump.
10. Choked fuel filter.
11. Restriction in air cleaner.
12. Air in fuel system.
13. Faulty fuel injection pump.
14. Faulty injectors or incorrect type.
15. Incorrect use of cold start equipment.
16. Faulty cold starting equipment.
17. Broken fuel injection pump drive.
18. Incorrect fuel pump timing.
19. Incorrect valve timing.
20. Poor compression.
21. Blocked fuel tank vent.
22. Incorrect type or grade of fuel.
23. Sticking throttle or restricted movement.
24. Exhaust pipe restriction.
25. Cylinder head gasket leaking.
26. Overheating.
27. Cold running.
28. Incorrect tappet adjustment.
29. Sticking valves.
30. incorrect high pressure pipes.
31. Worn cylinder bores.
32. Pitted valves and seats.
33. Broken, worn or sticking piston ring/s.
34. Worn valve stems and guides.
35. Overfull air cleaner or use of incorrect grade of oil.
36. Worn or damaged bearings.
37. Insufficient oil in sump.
38. Inaccurate gauge.
39. Oil pump worn.
40. Pressure relief valve sticking open.
41. Pressure relief valve sticking closed.
42. Broken relief valve spring.
43. Faulty suction pipe.
44. Choked oil filter.
45. Piston seizure/pick up.
46. Incorrect piston height.
47. Damaged fan.
48. Faulty engine mounting (Housing).
49. Incorrect aligned flywheel housing. or flywheel.
50. Faulty thermostat.
51. Restriction in water jacket.
52. Loose fan belt.
53. Choked radiator,
54. Faulty water pump.
55. Choked breather pipe.
56. Damaged valve stem oil deflectors (if fitted)
57. Coolant level too low.
58. Blocked sump strainer.
59. Broken valve spring.

SECTION E
Cylinder Head



E I

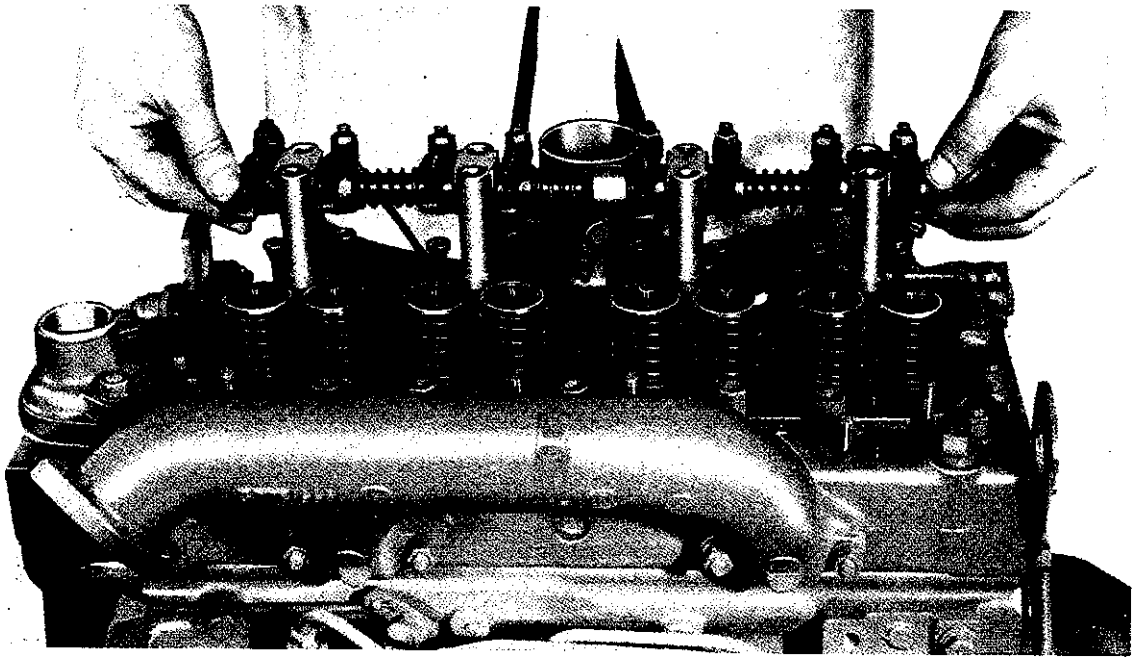


E2

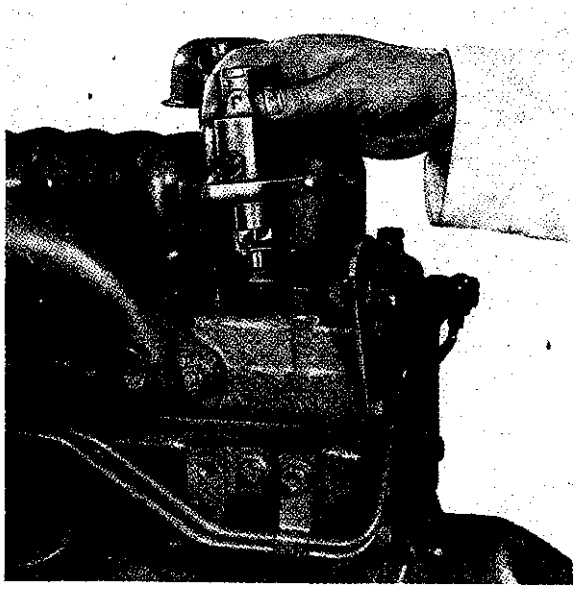
Before commencing to overhaul the cylinder head ensure that all joints, gaskets and any other parts expected to be required are available.
Remove any external components from the vicinity of the cylinder head cover. atomisers and fuel pump.

To Remove the Cylinder Head

1. Completely drain the cooling system.
2. Disconnect the battery terminals.
3. Remove the securing nuts and detach the exhaust pipe from the exhaust manifold. Blank off the end of the exhaust pipe to prevent entry of any foreign matter.

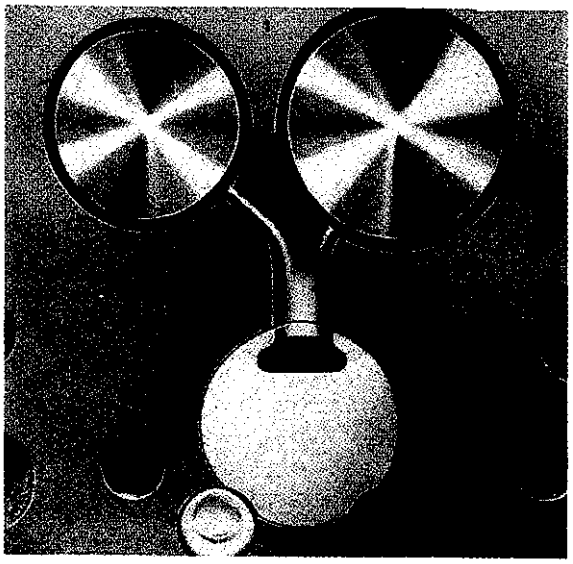


E3



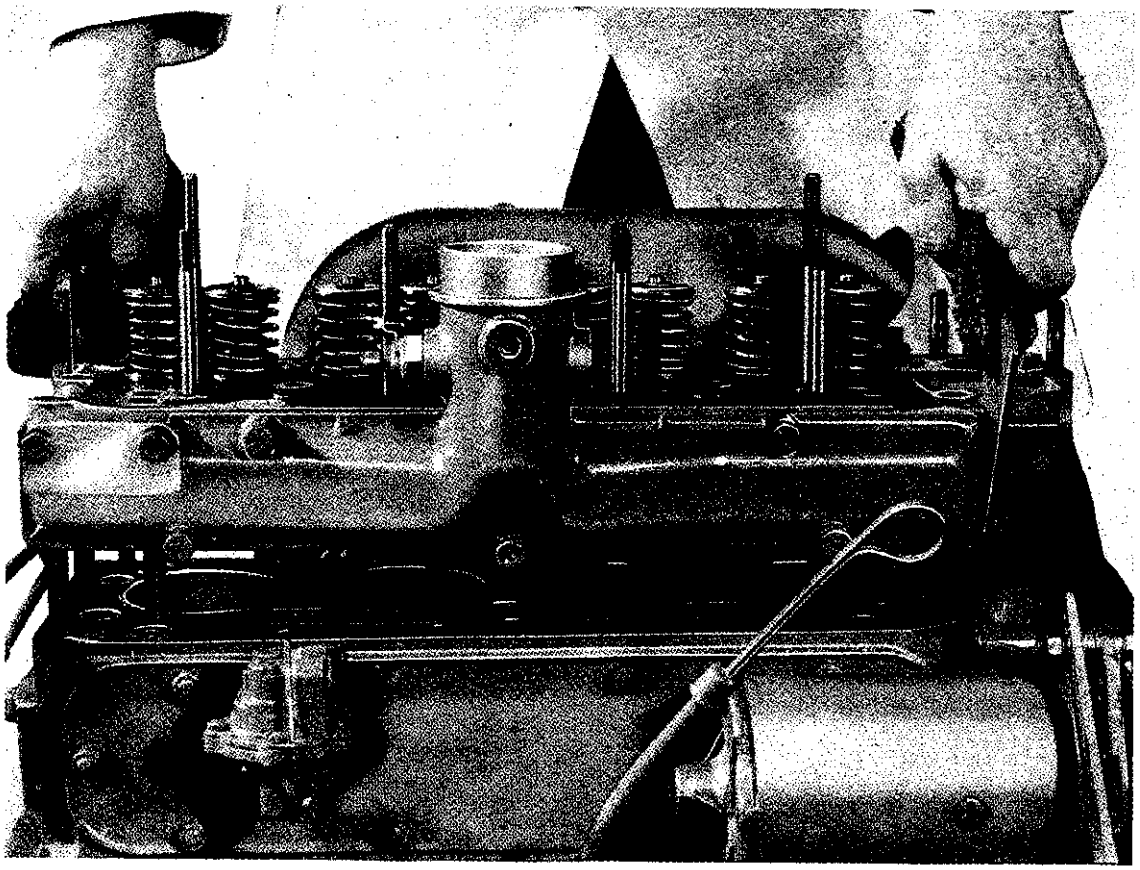
E4

4. Uncouple the water outlet connection on the front of the cylinder head.
5. Remove the air cleaner and place somewhere level ready for servicing.
6. Disconnect the fuel pipe and electrical connection to the starting aid located in the induction manitold. (Refer to Fig. E.l).

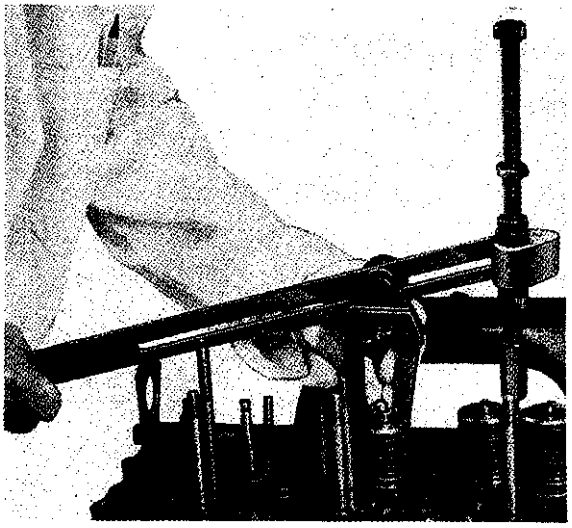


E6

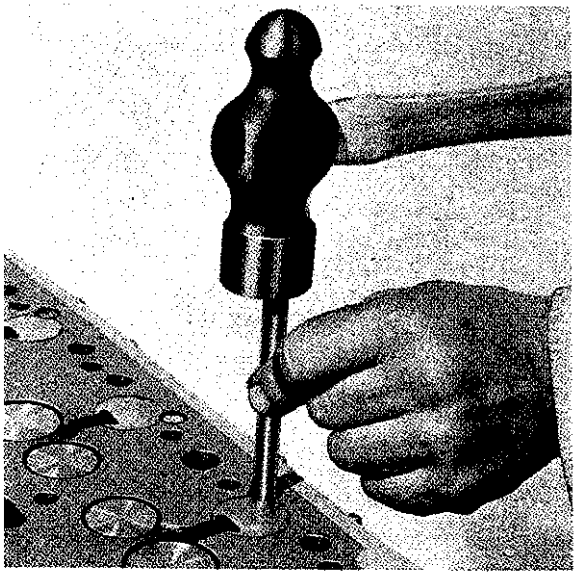
7. Remove the cylinder head cover together with the breather pipe.
8. Unscrew the oil feed pipe to the rocker shaft at the cylinder head end. (Refer to Fig. E.2 for its location).
9. Remove the eight rocker shaft bracket securing nuts evenly and remove the rocker shaft complete with the oil feed pipe. (Refer to Fig. E.3).



E5



E7



E9

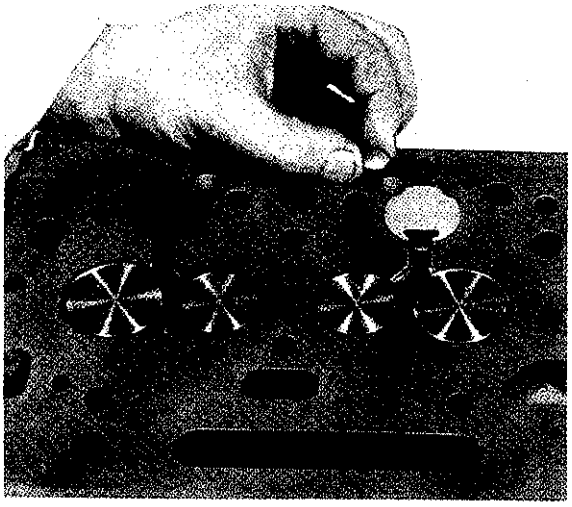
10. Remove the eight push rods and place somewhere safe (possibly in the cylinder head cover) to avoid the possibility of any being accidentally bent.
11. Unscrew the small banjo bolts on the tops of the atomisers and remove the leak-off pipe by unscrewing the union on top of the fuel filter.
12. Remove the low pressure fuel pipes between the fuel filter and the fuel pump, remove the fuel filter alter disconnecting the feed pipe from the lift pump, blank off all pipes and ports to prevent ingress of foreign particles.
13. Remove the four high pressure fuel pipes from the fuel pump to the injectors. Blank off fuel pump outlet ports.
14. Remove the injector securing nuts and carefully remove the injector. (Refer to Fig. E.4).
    Blank off the exposed ports on the injectors.
15. Uncouple the alternator adjusting link.
16. Remove the cylinder head securing nuts and lift off the cylinder head complete with inlet and exhaust manifolds. (Refer to Fig. E.5).

NOTE: On 4.99 and 4.107 engines. to prevent liner movement should the engine be turned with the cylinder head removed. it is suggested that the linen are held in position by suitable tubing placed over two of the cylinder head studs and locked with nuts and washers.

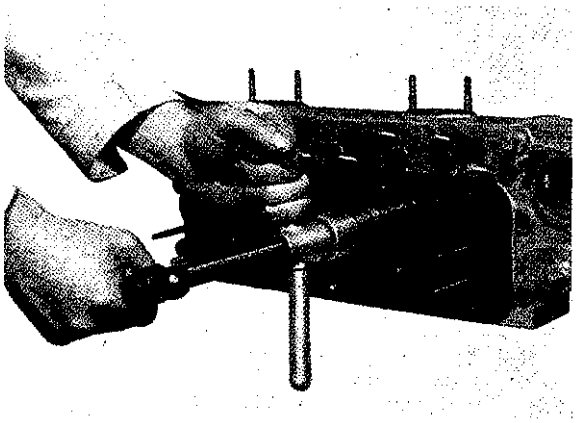
To Remove the Valves

All valves are numbered. The cylinder head is marked with corresponding numbers. (Refer to Fig. E.6).

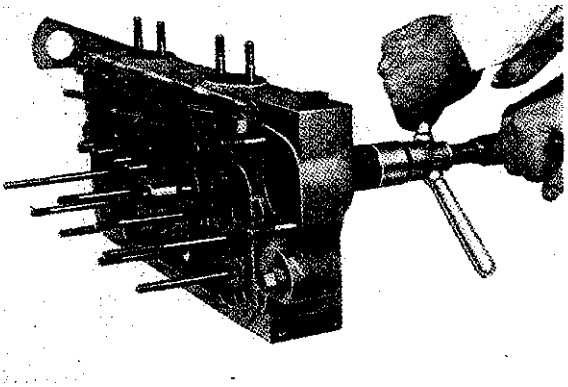
1. Remove collets by compressing the valve springs as shown in Fig. E.7.
2. Remove the spring caps, springs, seals (where fitted) and spring seats. Remove valves.



E8



E10



E11

COMBUSTION CHAMBER INSERTS

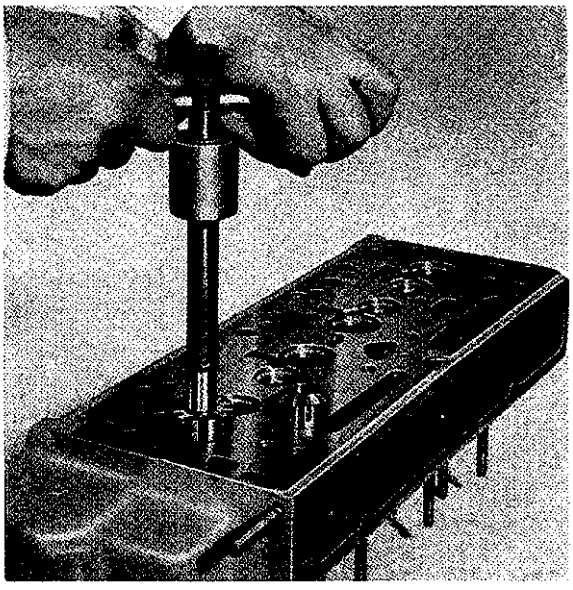
These can be gently tapped out of their locations by means of a short length of curved bar through the injector ,bore. When refitting they must be located by means of expansion washers in the recesses provided. as shown in Figs. E.8 and E.9.

Cleaning

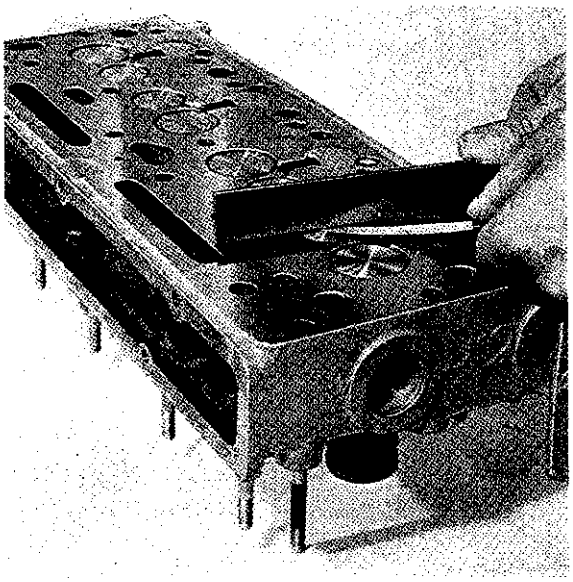
Remove any carbon from the cylinder head.
If the water jacket within the cylinder head shows signs of excessive scale, then a proprietary brand of de-scaling solution may be used. if possible the cylinder head should be tested for water leakage after such treatment at the pressure given on Page B.7.

VALVE SPRINGS

It is advisable to fit new valve springs whenever the engine undergoes a major overhaul. Where a top overhaul only is being carried out the springs should be examined, paying particular attention to squareness of ends and pressures developed at specific lengths, the details of which can be found on Page B.8.



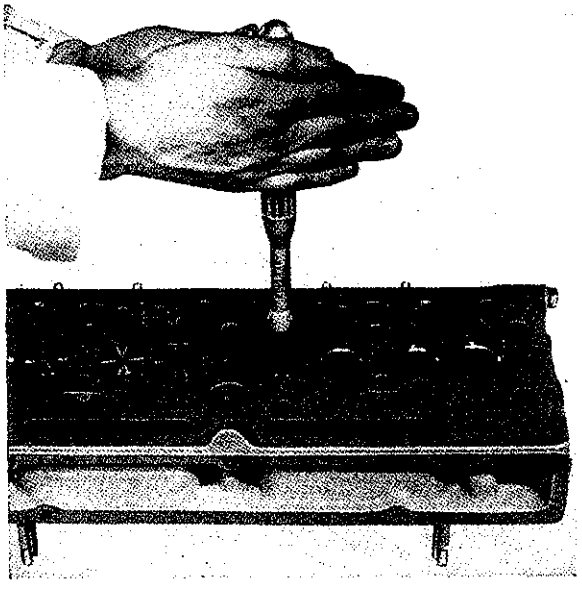
E12



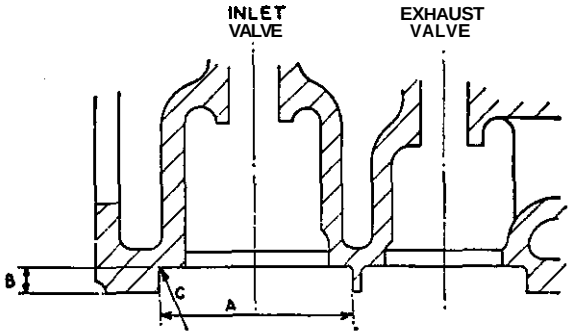
E13

VALVE GUIDES

The worn guides should be removed either by means of a press and a suitable "dolly" or the valve guide removal tool shown in Fig. E.lO.
Before fitting the new guides remove any burrs from the cylinder head parent bores, then smear the bores with clean oil and either press in the new guides or pull them in by means of the tool shown in Fig. E.ll. until the guide protrusion above the head top face is that quoted on Page B.7.
NOTE: Special care should be exercised during this operation as the guides. being made of cast iron. are therefore comparatively brittle.



E14



E15

Inlet
A—1.530 in to 1.531 in
B—0.3125 in to 0.3175 in
C—0.015 in chamfer at 45" (Max.)

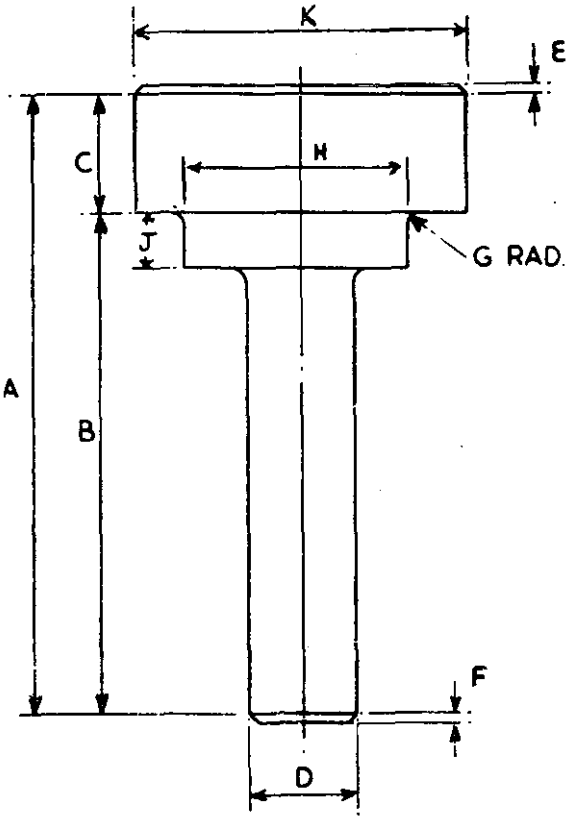
Exhaust
A—1.296 in to 1.297 in
B—0.3125 in to 0.3175 in
C—0.015 in chamfer at 45 (Max.)

VALVES AND VALVE SEATS

The valves should be checked in their respective guides for wear and replaced if wear has taken place. (ensure that the wear is in fact on the valve stem and not in the guide bore before replacing the valve).
The valve and valve seat faces should be reconditioned in the normal way using specialised equipment or with grinding compound, according to their condition. A valve seat (hand operated) cutting tool is shown in Fig. E.12. Valves should always be refitted to their original seats and any new valve fitted should be suitably marked to identify its position if removed at a later date. (Refer to Fig. E.6 for illustration of valve numbering)
Before refitting the valves it should be ascertained whether the valve head depth relative to the cylinder head face is within the limits given on Page B.8. This depth can be checked, as shown in Fig. **E.13,** by placing a straight edge across the face of the cylinder head. then by careful selection of feeler gauges measuring the distance between the straight edge and the head of the valve.
Where this depth exceeds the maximum limit and even the fitting of a new valve does not reduce this depth below the maximum limit. then the remedy is to fit a valve seat insert. the procedure for this is given in detail commencing on this page.
When refacing valves or valve seats care should be taken to see that only the minimum amount of metal necessary to obtain a satisfactory seat is removed, and that as narrow a valve seat as possible is maintained.

Hand Grinding

When grinding or lapping-in valves make certain that all signs of pitting are removed from the seats.



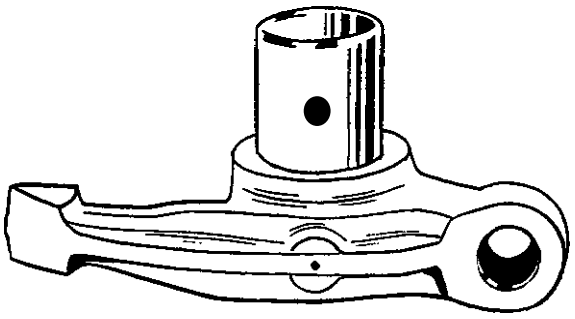
E16

Material EN32A Case Hardened and Ground

Inlet Dimensions
A—2.75 in
B—2 in
C—0.75 in
D—0.309 in to 0.310 in
E—1/16 in at 45
F—1/16 in at 45
G—1/32 in Radius
H—1.238 in to 1.239 in
J—0.222 in to 0.225 in
K—1.523 in to 1.533 in

Exhaust Dimensions
A—2.75 in
B—2 in
C—0.75 in
D—0.309 in to 0.310 in
E—1/16 in at 45
F—1/16 in at45
G—1/32 in Radius
H—1.018 in to 1.019 in
J—0.222 in to 0.225 in
K—1.287 in to 1.297 in

After all the valves have been lapped in the valve head depths relative to the cylinder head face should be checked to ensure that they are within the limits given on Page B.8.



E17

VALVE SEAT INSERTS

Valve seat inserts are not fitted to production engines. but may be fitted in service.
When fitting inserts ensure that only genuine Westerbeke parts are used.
In order to fit these inserts proceed as follows:

1. Fit new valve guides as described on Page E.4.
2. Using the new valve guile bore as a pilot, machine the insert recess in the cylinder head face to the dimensions shown in Fig. E.15.
3. Remove all machining swarf and thoroughly clean the insert recess (removing any burrs which may be present).
4. Using the valve guide bore as a pilot once again press the insert home with the inserting tool, this tool is shown fully dimensioned in Fig. E.16.
   NOTE: The insert must not under any circumstances be hammered in, neither should any lubrication be used.
5. Visually inspect to ensure that the insert has been pressed fully home. i.e. is flush with the bottom of the recess.
6. Recut the valve seat at an included angle of 90 (which will give the normal 45 seat) until the valve head depth reaches the minimum limit which is given on Page B.8. Lightly lap the valve to its new seat.

To Dismantle the Rocker Shaft Assembly

1. Remove the retaining circlips from each end of the rocker shaft.
2. Withdraw the rocker levers. springs and support brackets from the rocker shaft.
3. Unscrew the oil feed pipe from the banjo and remove the banjo. (When refitting this feed pipe it Should be noted that the end of the pipe locates the banjo position on the shaft).

Examine the rocker bushings and shaft for wear. The rocker levers should be an easy fit on the rocker shaft without excessive side play.
New rocker levers are supplied complete with bushing fitted and reamed to size.
NOTE: When fitting new bushes ensure that the oil feed holes are in alignment before pressing home. and when pressed fully home that the holes coincide. (Refer to Fig. E.17).

To Re-Assemble the Rocker Shaft Assembly

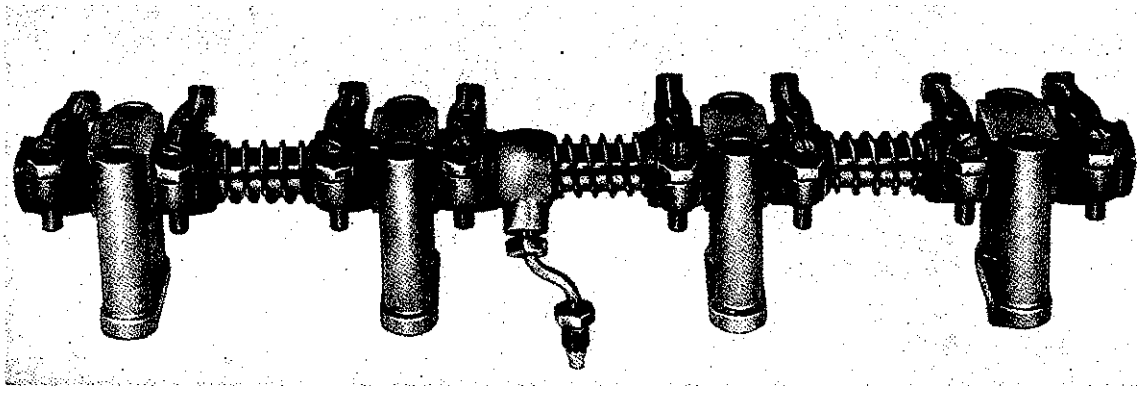
1. Refit the oil feed banjo and locate with the feed pipe.
2. Refit the rocker levers, springs and support brackets in the opposite order to which they were removed. Lightly oil the components during reassembly and ensure that each rocker lever does not bind on the shaft. The assembly should now be as shown in Fig. E.18.

PUSH RODS

Check the push rods for straightness. if any are bent then fit new replacements.

To Refit the Valves

Lightly oil the valve stems to provide the initial lubrication.
Replace valves, springs. spring plates. washers, collars and collets, taking care that the numbers on the valves correspond to the numbers stamped adjacent to the valve seat (see Fig. E.6)



E18

NOTE: Valve springs incorporate a damper coil and care should be taken to ensure that this damper coil is to the bottom of the spring, i.e., nearest the cylinder head when fitted.
Inner valve springs are not required for engines rated at 3,000 revlmin and below.
4.108 and **4.99** marine diesel engines are fitted with rubber sealing rings on inlet valves only.
All latest **4.107** and **4.99** marine diesel engines incorporate oil deflectors on both inlet and exhaust valves.
In the case of earlier **4.107** and **4.99** marine diesel engines which incorporate rubber sealing rings on the inlet valves only, oil deflectors should be fitted to both inlet and exhaust valves after the valve assembly has been dismantled. With this arrangement, a different valve spring seating washer is required for exhaust valves.
a different valve spring seating washer is required for exhaust valves.
Where a groove is cut on the inlet valve stem. a rubber Sealing washer should be fitted in addition to the deflector to stop the latter from becoming canted on the stem.
Oil deflectors should not be fitted to **4.99** vehicle and **4.108** engines.

CYLINDER HEAD GASKET

Always use a new cylinder head gasket. Ensure that the correct type is used.

4.108 Engines

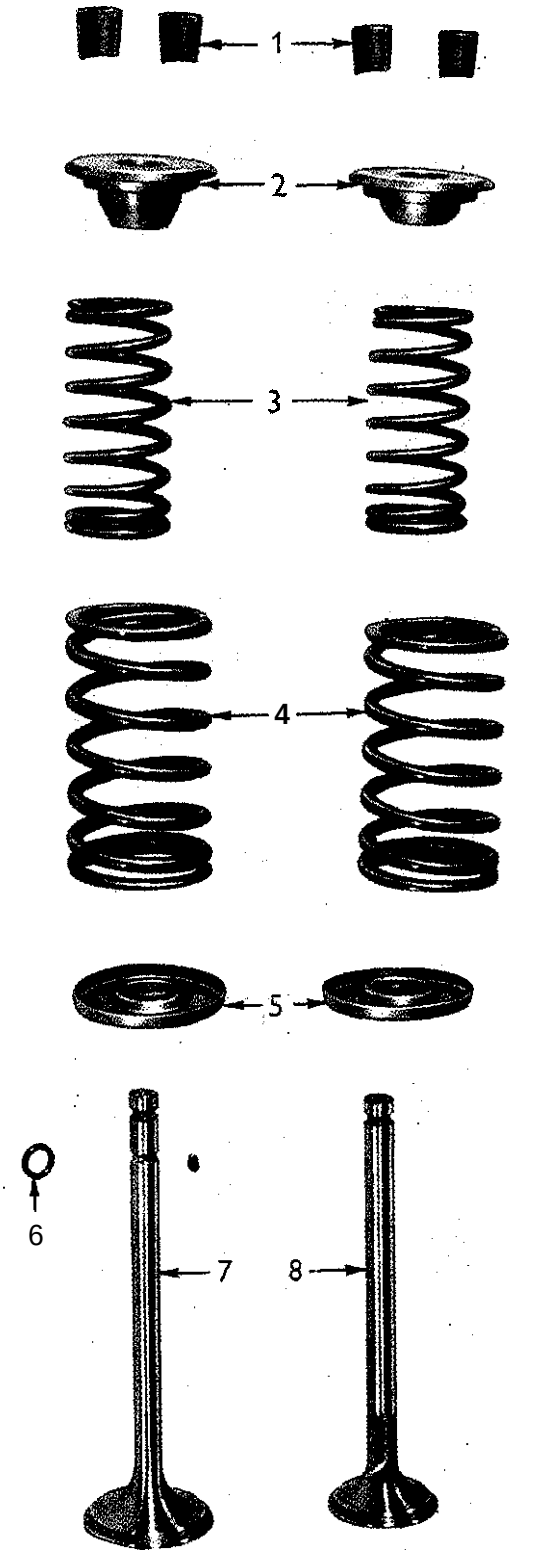
With this engine. the gasket is made of a black composite material and is known as the Klinger type. It MUST be fitted DRY and on no account should sealing compound be used.
It is very important that the gasket is placed correctly. otherwise the steel beading may be nipped between the cylinder head face and the top of the liner.

4.107 and 4.99 Engines

These engines use a steel laminated gasket.

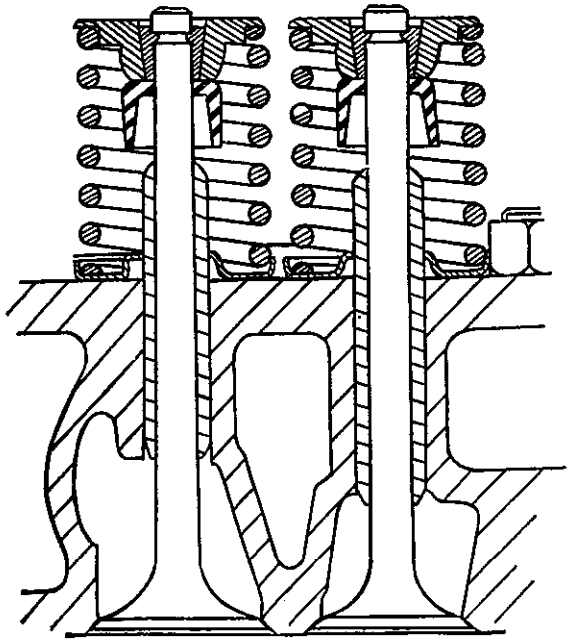
To Refit the Cylinder Head

1. Place the cylinder head gasket carefully in position on the cylinder block top face (the gasket is marked "TOP FRONT to indicate how it should be fitted). (Refer to Fig. E.22).
2. Lower the cylinder head into position on top of the gasket ensuring that it lays perfectly level.
3. Lightly lubricate both cylinder head studs and nuts with engine oil, then tighten the nuts progressively in three stages in the sequence shown in Fig. E.23 to the torque given on page B.2. This final torque tightening stage should be repeated to ensure that no loss oi tension has taken place on any studs earlier in the sequence.

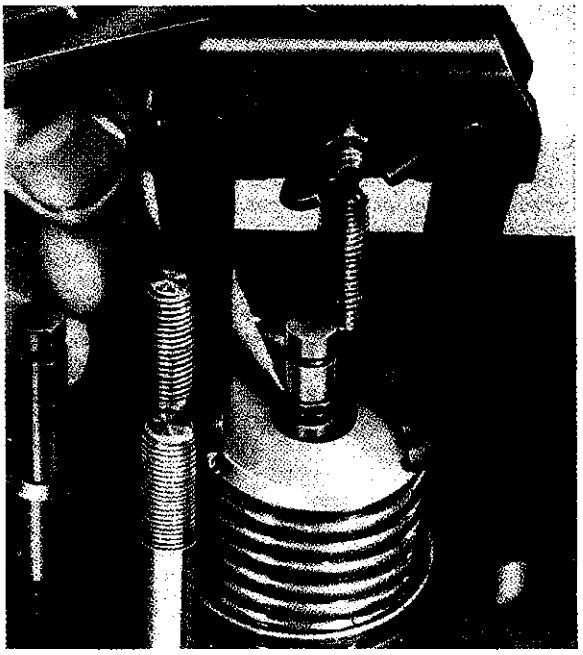


E19

1. **Retaining Collets**
2. **Spring Caps**
3. **Inner Valve Springs**
4. **Outer Valve Springs**
5. **Spring Seating Washers**
6. **'O' Sealing Ring (Inlet Valves only)**
7. **Inlet Valve**
8. **Exhaust Valve**

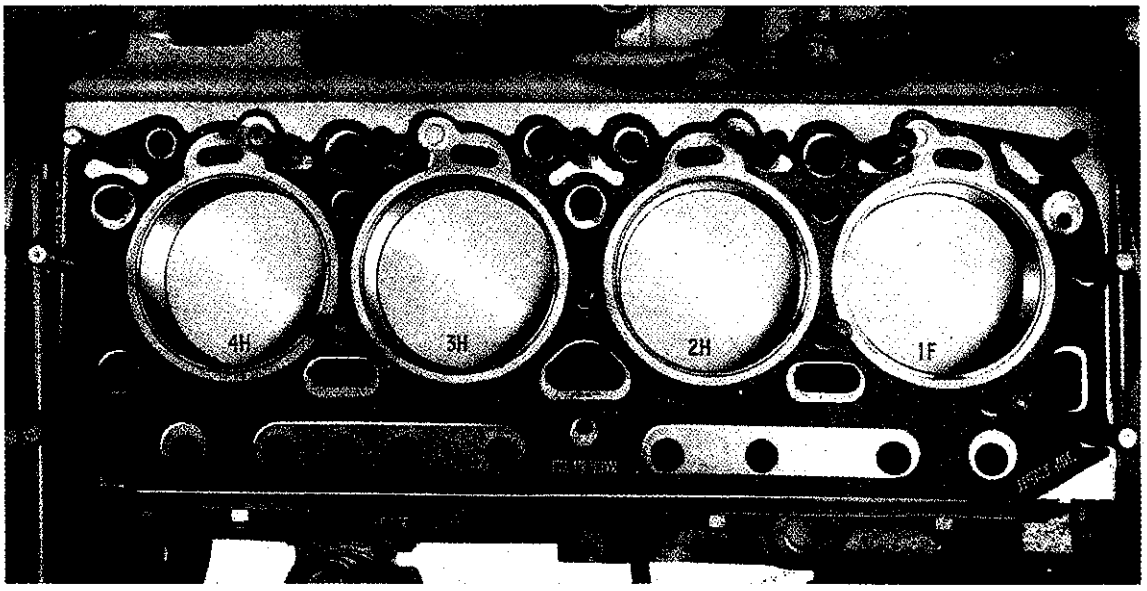


E20

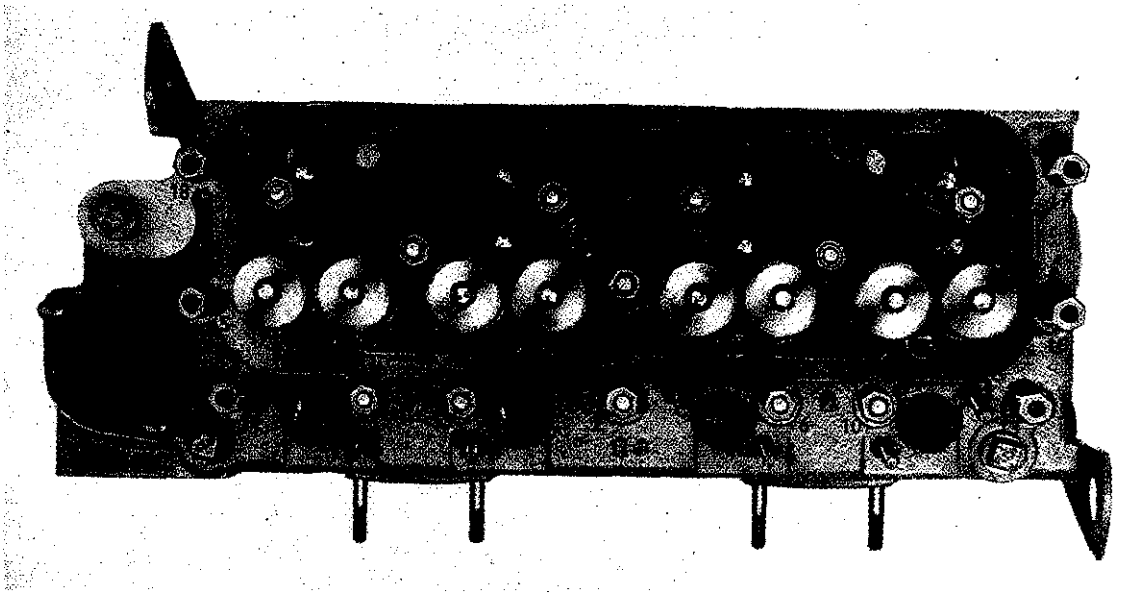


E21

4. Fit the push rods in their locations then carefully fit the rocker shaft assembly, noting that the valve adjusting screw ends locate in their respective push rod cups and the oil feed to the rocker shaft is located correcily.
5. Locate the oil feed pipe nut just finger tight at this stage, then evenly tighten the rocker shaft bracket securing nuts to a torque of 12 . 15 lbf it (1,7 · 2 kgf m) now tighten the oil feed pipe nut.
   When correctly located the oil feed pipe will be as shown in Fig. E.2.
   NOTE: If the oil feed pipe nut is tightened before the rocker shaft bracket securing nuts, the pipe will either be strained or the olive pulled off the feed pipe.
6. Adjust the. valve clearances to 0.012 in (0.3 mm) as follows: —
   Turn the engine so that the valves of No. 1 cylinder are in the position of 'valve overlap', i.e., the period between the opening of the inlet valve and the closing of the exhaust valve. In this position, adjust the clearances of No. 4 cylinder valves: similarly. with the valves of No. 3 cylinder in the overlap position. adjust the valves of No. 2 cylinder. With valves of No. 4 in the overlap position, adjust the valves of No. 1 cylinder and finally with valves of No. 2 cylinder in overlap position, adjust valves on No. 3 cylinder.
7. Replace the alternator adjusting link and tension the "V" belt (Refer to Page N.l).



E22



E23

8. Replace the injectors (Refer to Page P.7) but do not tighten the securing nuts.
9. Replace the leak off pipe assembly and four high pressure fuel pipes to the injectors. Tighten the injector securing nuts.
10. Replace the fuel oil filter and the low pressure tuel pipes between filter and lift pump and filter and fuel pump.
11. Reconnect the electrical and fuel supplies lo the starting aid.
12. Reconnect the exhaust pipe to the manifold.
13. Reconnect the water outlet connection at the front of the cylinder head.
14. Fill the cooling system with clean water ensuring the drains are closed. Check for water leaks.
15. Bleed the air trom the fuel system as described on Page P.8).
16. Reconnect the battery.

Starting the Engine

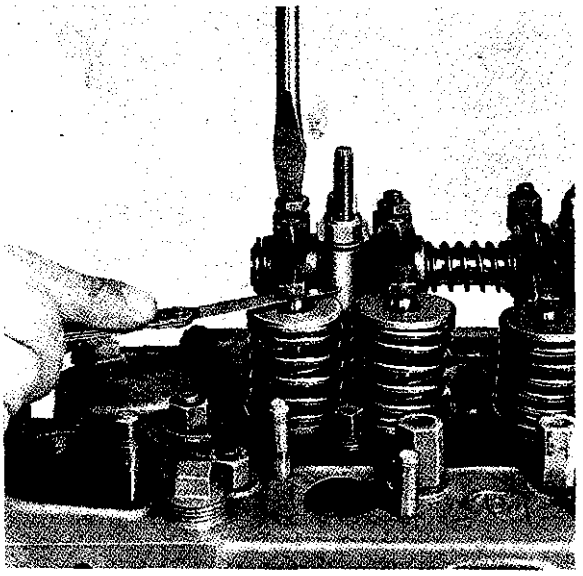
Proceed as instructed on Page P.II, with the engine running at a fast idle check that the oil pressure is satisfactory and that the oil reaches the rocker assembly and oozes gently trom the rocker levers at this speed.

After the engine has been thoroughly warmed up it should be shut down, the rocker shaft removed and the cylinder head nuts checked, so that any loss of torque tension can be corrected by tightening the nuts to the torque given on Page B.2 and in the order shown in Fig. E.23.

Replace the rocker shatt as previously described and set the valve clearances to 0.012 in (0.30 mm) COLD. Start engine and check oil flow to rocker levers. if satisfactory refit cylinder head cover and air cleaner. Finally check for oil leaks and rectify immediately if any are visible.

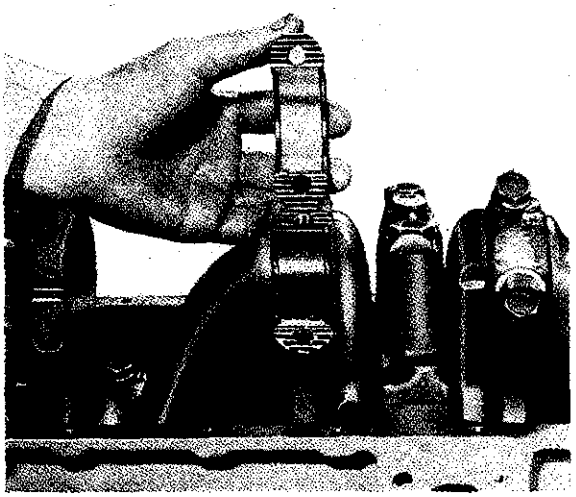
NOTE for 4.108 Engines Only

I is essenlialthat **r head nuts** are re-torqued to **i0 lbf ft (8,3 kgf m) after the first 6 to 12 hours with the engine** hot and in **the sequence** shown in Fig. E.23.

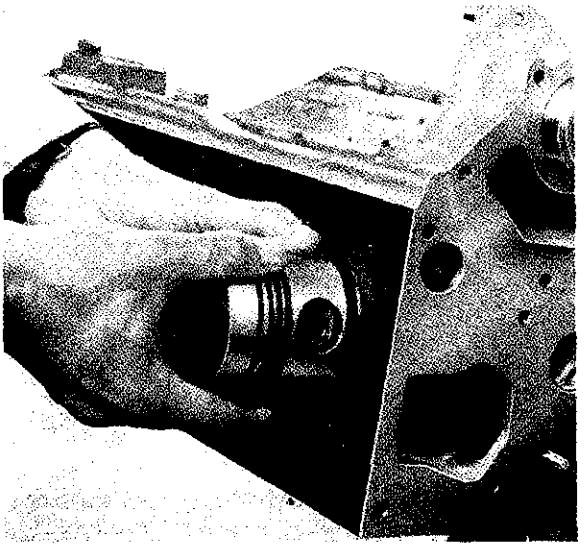


E24

SECTION F
Pistons and Connecting Rods



F1



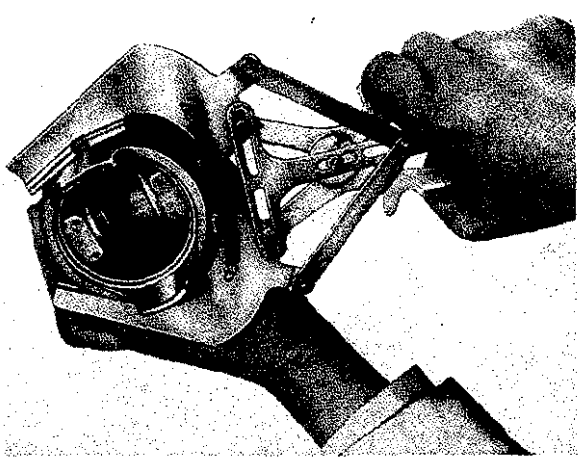
F2

To Remove Pistons and Connecting Rods

1. Remove the cylinder head assembly. (Refer Io Page E.I)
2. Remove the oil sump. (Refer to Page M.1).
   NOTE: Any ridges or carbon deposits around the top of the cylinder bores should be removed with a suitable scraper before piston removal is attempted.
3. Rotate the crankshaft until one pair of big ends are at bottom dead centre, then remove their respective connecting rod cap securing bolts.
4. Remove the connecting rod caps and bearing shells. (Refer to Fig. F.I).
   NOTE: If the bearing shells are serviceable, they should be suitably marked to identify them to their Original locations.
5. Push the pistons and connecting rods carefully out through the top of the block and remove as shown in Fig. F.2.
6. Rotate the crankshaft through 180' to bring the remaining pair of big ends to bottom dead centre and repeat removal operations.
   When piston removal has been carried out keep each piston and rod assembly separate, each to each as marked. Mark the pistons on the crown (before removing the piston pin) to indicate the **'FRONT'** in relation to the 'FRONT' marking cast on the connecting rods.

To Remove Pistons and Rings from the Connecting Rods

1. Remove the piston rings from each piston, using a suitable piston ring tool, such a tool is shown in Fig. F.3.
   NOTE: The laminated segments or spring loaded rings fitted in the fourth ring groove should be removed by hand.
   With 4.108 pistons there is a steel insert rolled into the top ring groove during piston manufacture. It should be regarded as an integral part of the piston and no attempt should be made to remove



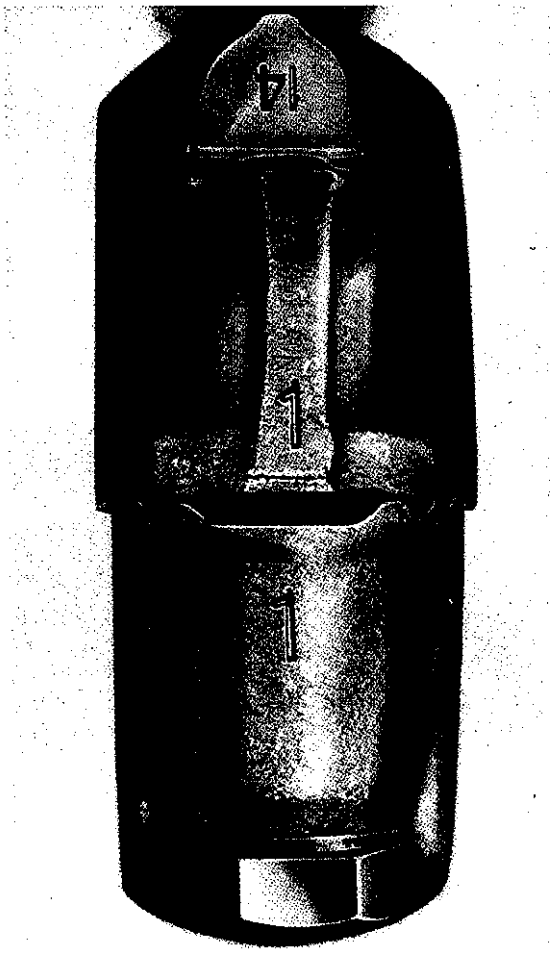
F3

it from its location.
2. Remove the circlip retaining the piston pin and push out the piston pin to release the connecting rod.

NOTE: Should difficulty be experienced in removing the piston pin, warm the piston in a suitable clean liquid (usually water) to a temperature of 100—120°F. (40—50°C). this will then enable the pin to be pushed out quite easily.

Inspection

1. Examine the pistons for scoring and any signs of groove damage.
2. Check the clearance of the piston rings in their respective grooves by placing the ring outer face into the groove and a suitable sized feeler between the ring and groove face.
   NOTE: Ail ring gaps, ring groove clearances etc.. are given in the Technical Data Section on Pages A.5 and A.6.
3. Check the fitted gaps of the piston rings. bearing in mind that in worn cylinder bores these gaps should be checked at the bottom of the bore.
4. Check the fit of the piston pin in the small end bushing, if excessive, replace the small end bushing.
5. To renew the small end bushing remove the old one by means of a suitable press and 'dolly'. Press in the new bushing, ensuring that the oil holes coincide when fitted. Ream out the new bushing to suit the piston pin, then check the rod for parallelism and twist. (Refer to Page A.7).
6. Examine the big end bearing shells tor any signs of wear or pitting.

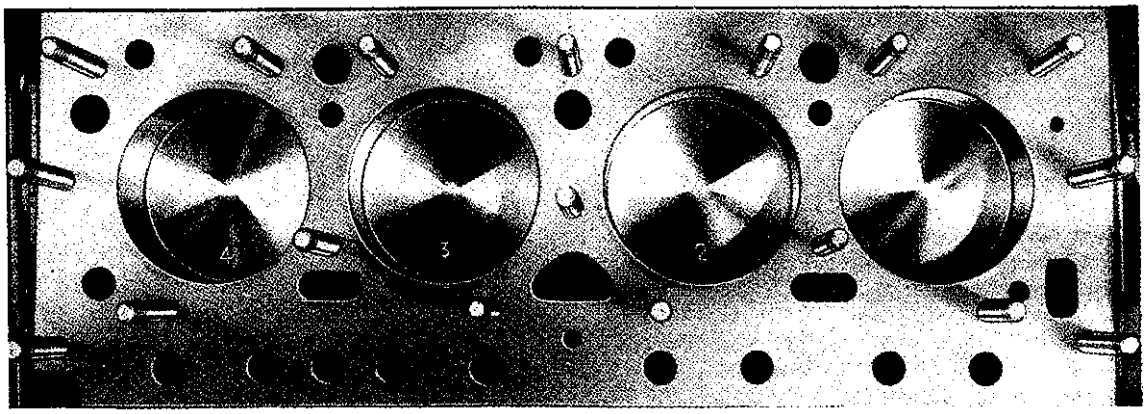


F4

To Refit the Pistons to the Connecting Rods

If the original pistons are to be refitted they must be re-assembled to the same connecting rods. i.e. No. 1 piston to No. 1 connecting rod assembly. Refer to Figs. F.4 and F.5 for location of piston and rod numbering. Any new components titled should be numbered the same as those which they replace.

1. Warm the piston in a suitable clean liquid to a temperature of 100 — 120°F (40 — 50°C) which will enable the piston pin to be easily pushed into the piston bore when the piston and rod have been correctly aligned.
2. Place No. 1 piston onto its head, noting the position of the mark previously made to indicate the "FRONT.



F5

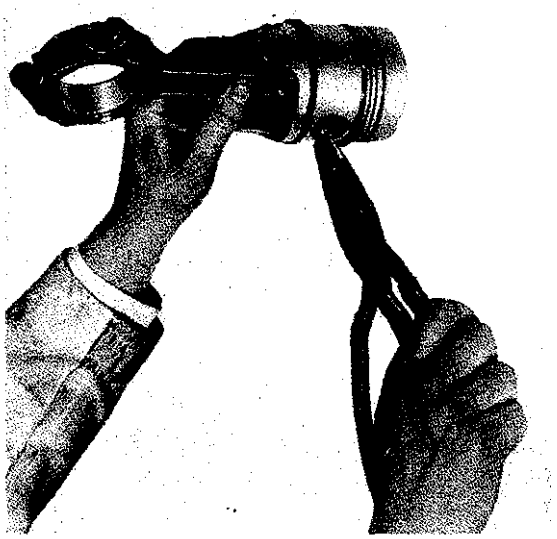
3. Hold No. t connecting rod with the small end between the piston pin bores so that the word "FRONT" cast on the rod is towards the same side.
4. Push the piston pin into the piston thus locating the connecting rod in position.
5. Fit the two retaining circlips ensuring that they locate correctly in their recesses. (Refer to Fig. F.6).
   NOTE: If the engine has been in service tor some considerable time it is advisable to fit new circlips. even if the old ones do not appear to be strained or damaged.
6. Repeat this procedure for the three remaining pistons and connecting rods.

Fitting the Piston Rings

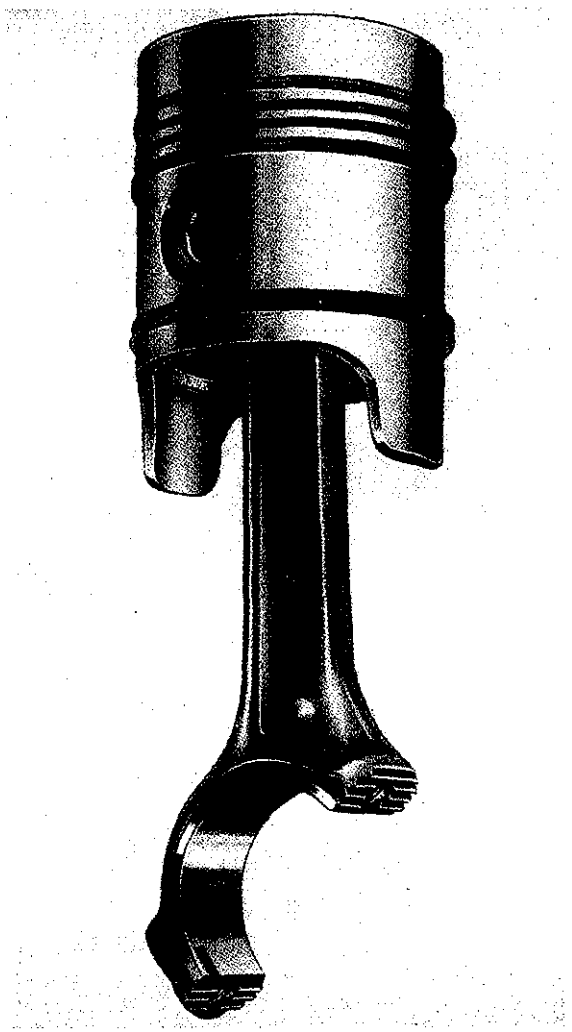
Fit piston rings to the piston. Rings vary according to engine type and application as follows: reading from the top of the piston.

4.108 Engines

1. Plain parallel faced compression.
2. Internally stepped compression.
3. Internally stepped compression.
4. Laminated segment oil control.
5. Slotted scraper.



F6



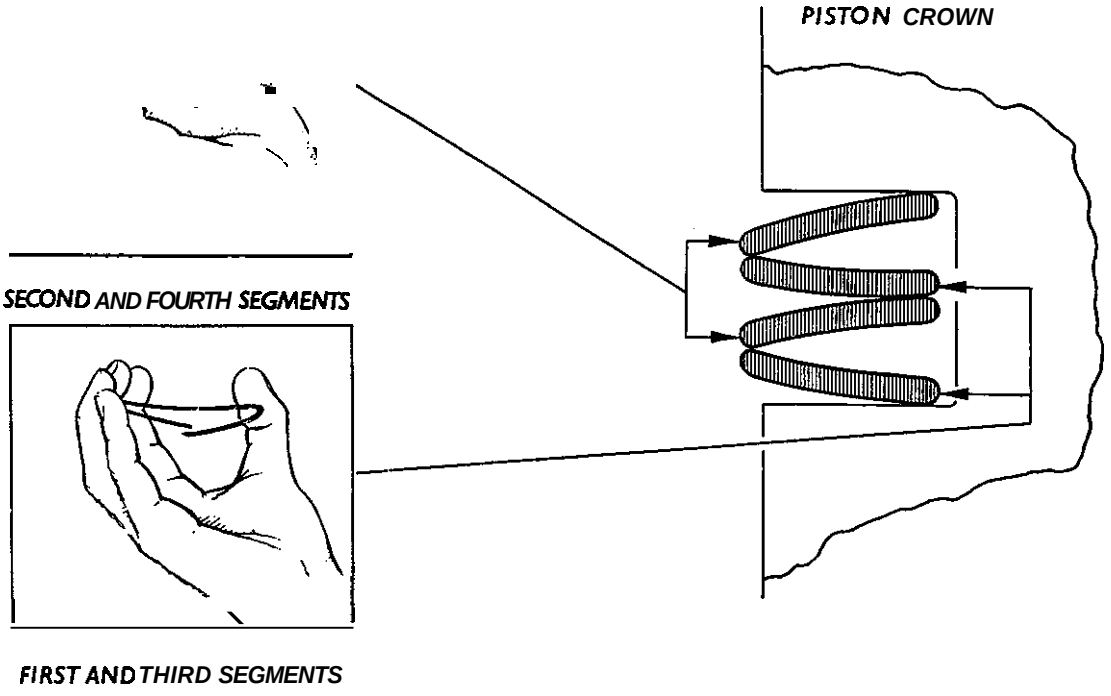
F7

4.107 and 4.99 Marine and Industrial Engines rated at 3000 r.p.m. or below.

1. Plain parallel faced compression.
2. Internally stepped compression.
3. Internally stepped compression.
4. Laminated segment oil control.
5. Slotted scraper.

After an appropriate period of service. when indications of piston ring and/or cylinder bore wear may become apparent, a replacement ring pack has been made available for fitting exclusively to 4.99 service engines and includes a taper faced ring for fitting in

NOTE: All the rings quoted above except the laminated and spring loaded type may be fitted by means of an expanding tool of the type shown in Fig. F.3. These rings, being made of cast iron are therefore comparatively brittle, so when fitting care should be taken not to expand any ring more than is necessary to just clear the piston.

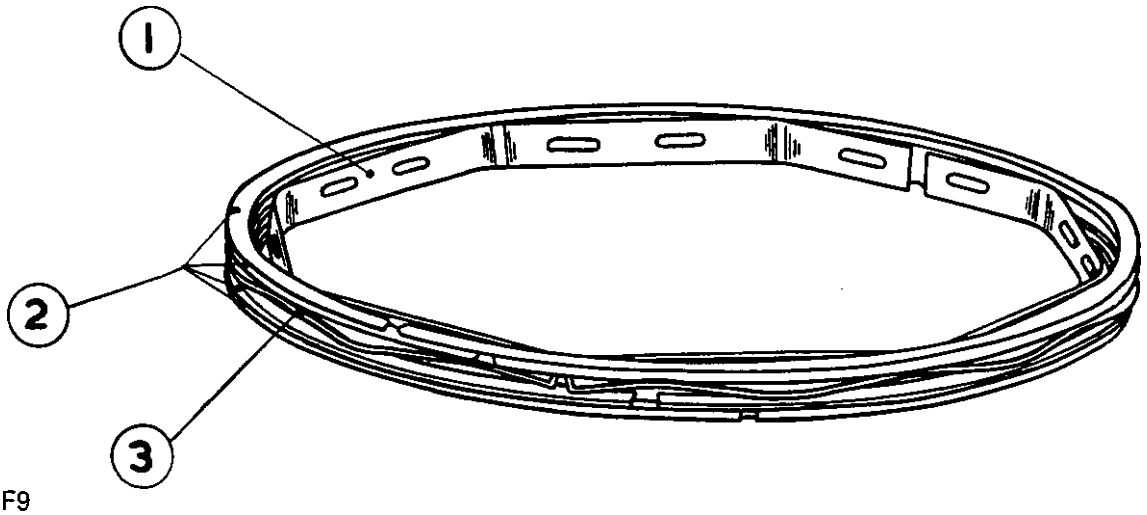


F8

Laminated Segment Rings

The procedure for fitting the laminated type is different. in as much as the ring comprises four separate segments, these may be fitted by hand in the following sequence with the piston crown uppermost:—

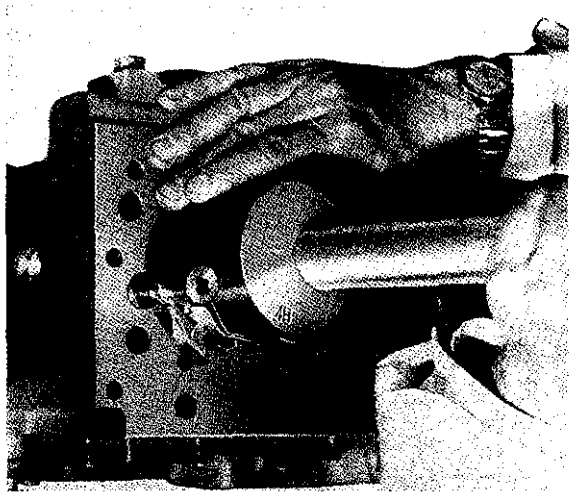
1. Fit the first segment to the piston so that when held horizontally between the thumb and fingers and radially compressed the ring ends point downwards (see Fig. **F.8).**
   Place this ring on the bottom face of the fourth ring groove with the gap over the piston pin bore.
2. Fit the second segment on top of the first, so that when compressed as described above the ends point upwards. Position the gap at 180° to that of the first segment.
3. Fit the third segment as in (1) above with the gap immediately above the gap of the first segment.
4. Fit the fourth segment as in (2) above with the gap immediately above the gap of the second segment. If all the segments have been fitted correctly then they will be positioned as shown above.



F9

The gaps of the remaining rings should be staggered alternately along the piston pin axis.
Liberally lubricate the rings in their grooves and see that they can move freely in their locations. this does not apply to the laminated type in the fourth groove, which if correctly fitted should not move freely due to the outward pressure of the top and bottom segments on the ring groove walls.
When all the rings have been fitted, they should be as shown in Fig. F.8.

Always ensure that internally stepped or taper faced rings are correctly fitted. They are marked TOP or BTM (bottom) to ensure correct replacement.
The top compression and slotted oil control rings may be fitted either way up.



F10

Spring Loaded Scraper Ring

When fitting the chrome plated spring loaded scraper ring. (see Fig. F.9). the following procedure should be adopted: —

1. Fit internal expander (1).
2. Fit two rail rings (2) at the bottom of the groove.
3. Fit spiral ring (3).
4. Fit two top rail rings (2).

When fitting rail rings, the gaps should be staggered.

To Fit Piston and Connecting Rod Assemblies

Before fitting the piston and connecting rod assemblies to their respective cylinder bores. thoroughly clean and liberally coat each bore with clean engine oil.

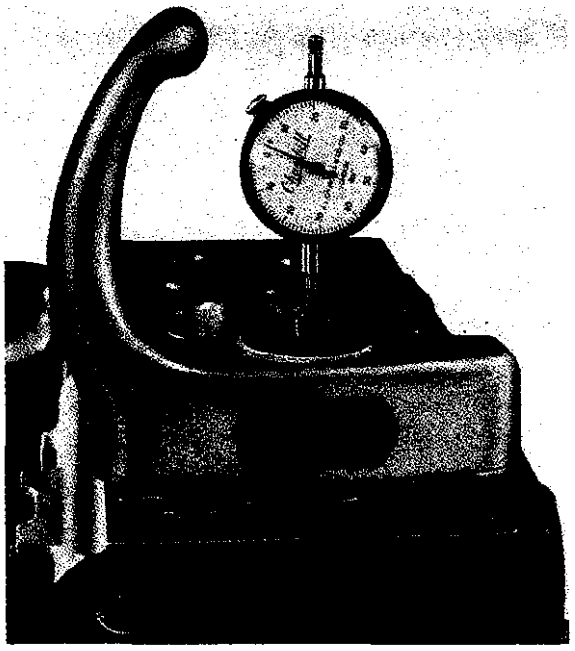
1. Turn the engine until ihe crankpins of say numbers 1 and 4 cylinders are at bottom dead centre.
2. Using a suitable ring clamp of the type shown in Fig. F.lO, carefully compress the rings of No. 1 piston and hold in this position.
3. With the word 'FRONT' on the connecting rod facing the front of the engine. insert the rod carefully into No. 1 cylinder bore.
   NOTE: The cylinders are numbered 1, 2, 3, 4 starting from the front (water pump) end of the engine. It is extremely important that these components (marked as shown in Figs. F.4 and F.5). are returned to their original locations.
4. The piston head may be gently tapped with the shaft of a hammer as shown in Fig. F.10 until all the rings have entered the cylinder bore.
5. Draw the rod towards the crankpin, place the top half bsaring shell in position locating the tag in the machined slot and liberally oil. draw the rod onto the crankpin.
6. Fit the lower half bearing shell to the connecting rod cap, locating the tag in the machined slot, liberally oil and fit the cap to the crankpin, ensuring that the numbers on the rod and cap coincide as shown in Fig. F.4.
7. Fit the two connecting rod securing bolts and lighten evenly to the torque quoted on Page **8.2.**
   NOTE : Locking tabs are not fitted to these bolts.
8. Repeat this procedure for No. 4 piston and connecting rod assembly.
9. Rotate the crankshaft to bring numbers 2 and 3 crankpins to bottom dead centre.
10. Repeat procedures **2** — 7 to fit the two remaining assemblies.
11. Refit the lubricating oil sump. (Refer Page M.4).
12. Refit the cylinder head assembly. (Refer Page E.7).

Fitting New Pistons

With new 4.108 and 4.107 pistons a machining allowance is provided on the crown of the piston to enable the necessary material to be removed by means of a lathe so that when fitted the piston height above the cylinder block top face will be within the iimits quoted on Page 8.3.
To determine the exact amount to be removed from the piston crown, the piston. connecting rod and bearing assembly will have to be fitted to its respective cylinder bore as previously described, and the piston height above the cylinder block top face measured with the particular piston at top dead centre. This piston height can be measured by means of a piston height gauge of the type shown in Fig. F.11. Repeat for each new piston to be fitted and mark each piston with the number of the cylinder bore it will belong to. (not on the top as any marking here wiii be removed by the machining). When each piston has been skimmed it should be checked again when finally refitted lo ensure that any new piston fitted is now within the limits quoted. Once the piston height is correct mark any such piston on the crown with the number of its respective bore. (Refer to Fig. F.5).

It will of course be appreciated that grade F pistons are suitable lor topping to give other grades where these are not to hand,

After fitting pre-topped pistons, the distance between the cylinder block lace and piston crowns should be checked to ensure the limit is as already quoted (See Fig. F.II).



F11

SECTION G
Cylinder Block and Liners

CYLINDER LINERS (4.108 ENGINES)

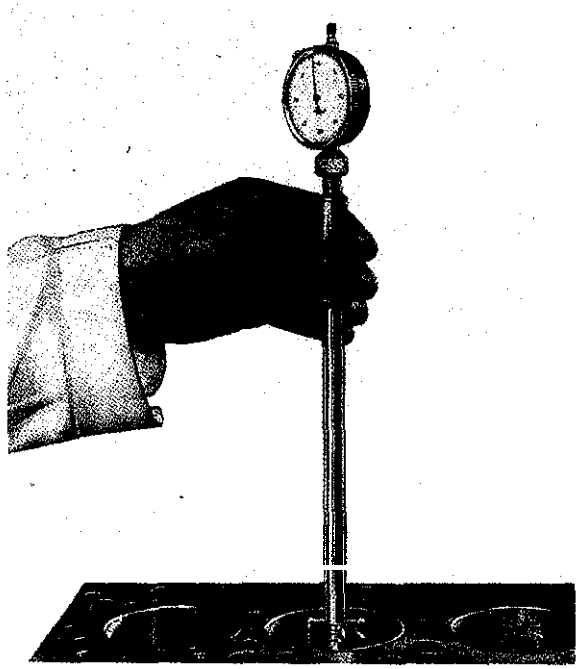
The cylinder liners fitted to the **4.108** series engines are centrifugally cast alloy iron, they are an interference fit in the cylinder block parent bore and of the thinwall dry type.

Reboring of these liners is not possible and new liners should be fitted when a rebore would normally be considered necessary.

Dimensional checks of the cylinder bore are carried out by means of the gauge tool shown in Fig. G.l

When checking liners each one should be measured in three positions — top, centre and bottom: the readings being taken parallel and at right angles to the centre line of the cylinder block giving six readings for each cylinder bore.

When checking the fitted internal bore of a new thinwall liner it is advisable to allow a period of time to elapse for the liner to settle.



G1

To Renew Cylinder Liners

1. Remove all the various comopents from the cylinder block. (Refer to the appropriate sections for details of their removal).
2. Using a shouldered metal disc slightly smaller on the outside diameter than the parent bore diameter and a suitable Dress. Dress the liners carefully out through the top of the cylinder block.

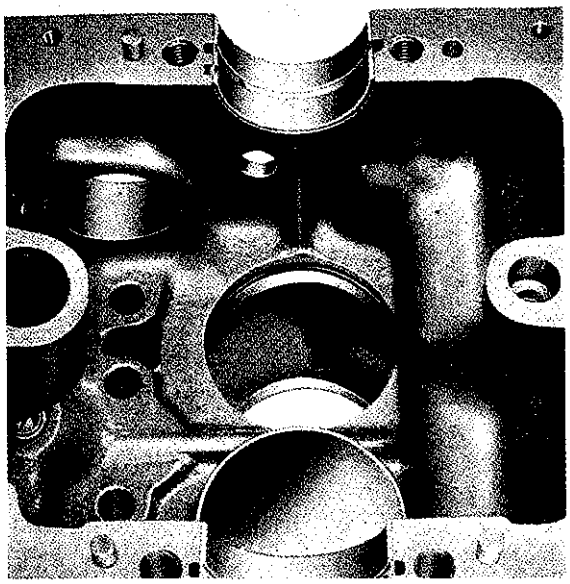
   NOTE: Support the block locally in the area of the top of the liner.

3. Lightly lubricate the outside of the liner with clean engine oil ready for fitting.
4. As the liner must protrude above the cylinder block top face and not be pressed fully home when fitted correctly, a solid stop washer should be available designed to give the correct liner protrusion.
   NOTE: The limits for liner protrusion are given on page 8.3 and may be checked as shown in Fig. G.2.
5. Press the liner into the bore progressively until it reaches the solid stop washer.
6. Bore and finish hone the liners to the dimension quoted on Page 8.3.
   NOTE: Where boring equipment is mounted on the top face of the cylinder block fit a parallel plate between the boring bar and cylinder block face. Such a plate should be thicker than 0.027 in (0.686 mm).
7. Re-assemble the engine components to the cylinder block. (Refer to the appropriate sections for assembly of these)

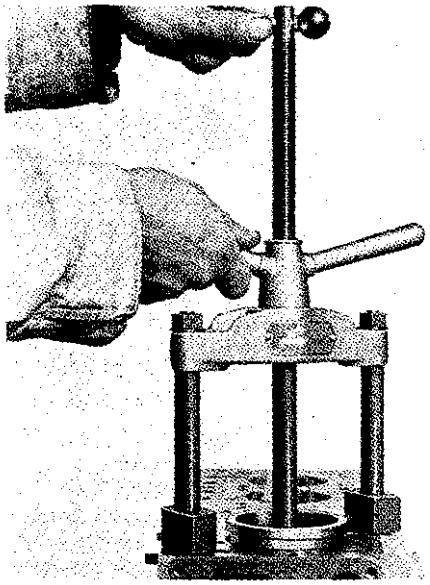
CYLINDER LINERS (4.107 and 4.99)

Cylinder liners fitted to **4.107** and 4.99 engines are of the centritugal cast iron wet type. They have flanges at the top and are sealed at the bottom by means of two rubber sealing rings which fit in machined recesses in the cylinder block.

G2



G3



G4

Earlier 4.99 engines had only one sealing ring at the bottom of the liner.

4.107 and 4.99 cylinder liners have pre-finishsd bores. Under normal circumstances, the liner would only need to be renewed during major overhaul, but should it be necessary to remove the liner for any other reason, this can be carried out without removal of the crankshaft.

If at any time, the cylinder iiners are removed and these same liners are to be refitted, then before they are removed from the cylinder block, they should be suitably marked so that they may be refitted to their original parent bore and in the same position in that bore, that is, thrust side of the liner to the thrust side of the cylinder block.

To Renew Cylinder Liners

Remove all components from cylinder block.

Remove liners using a suitable liner removing tool (see Fig. G.4).

Once the liner has cleared the rubber sealing rings in the cylinder block, the liner can be removed by hand.

Remove any corrosion and burrs which may be present at the inner ends of the landings.

Renew the rubber sealing rings in the grooves at the bottom lands.

To ease fitting of the liners when the rings have been placed in position, smear the liners with soft soap or soapy water.

Place liner in position and press home by hand, ensuring that the rubber sealing rings remain in their grooves (see Fig. G.5).

The liners are a push fit and no force is required.

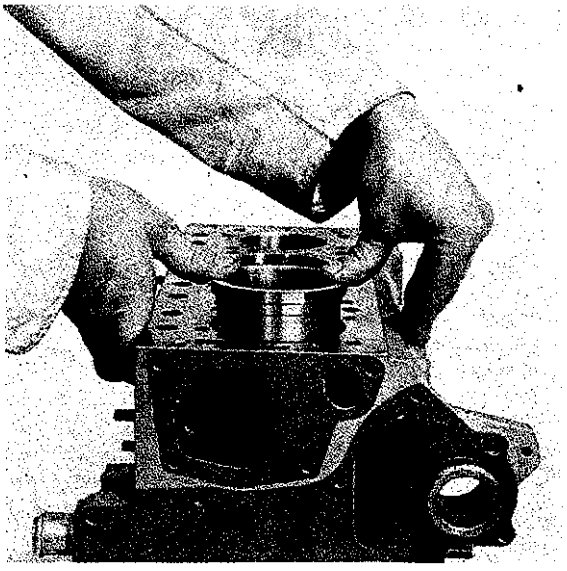
After fitting the iiners, the cylinder block should be water tested at a pressure of 20 lbf/in² (1,4 kgf/cm²).

Re-assemble engine as required and to instructions given far the various components.

Note: If engine is overheated, it could have an adverse affect on the liner sealing rings.

All 4.107 and later 4.99 engines have four small holes drilled along the fuel pump side of the cylinder block. each one breaking through into the area between the two sealing rings at the bottom of each cylinder liner. These holes permit any coolant which may have leaked past the upper sealing ring to escape thus relieving the bottom sealing ring of any pressure above it and preventing coolant from entering the engine sump.

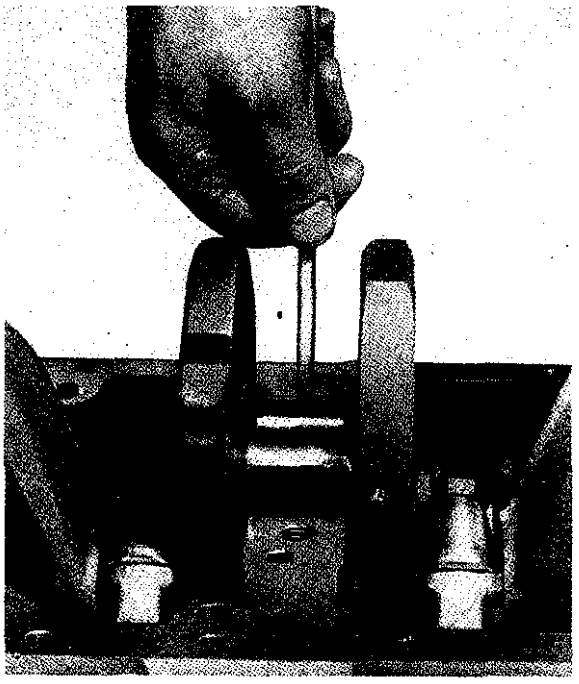
In the case of a new engine, or where cylinder liners and/or sealing rings have been fitted, it is possible that a slight leakage of coolant could occur from these holes. This should ease as the liners and sealing rings settle down after the initial period of running, but where difficulty is experienced. then the use of BARSEAL in the cooling system (in accordance with the manufacturers instructions) is approved.



G5

SECTION H

Crankshaft and Main Bearings



H1

Description

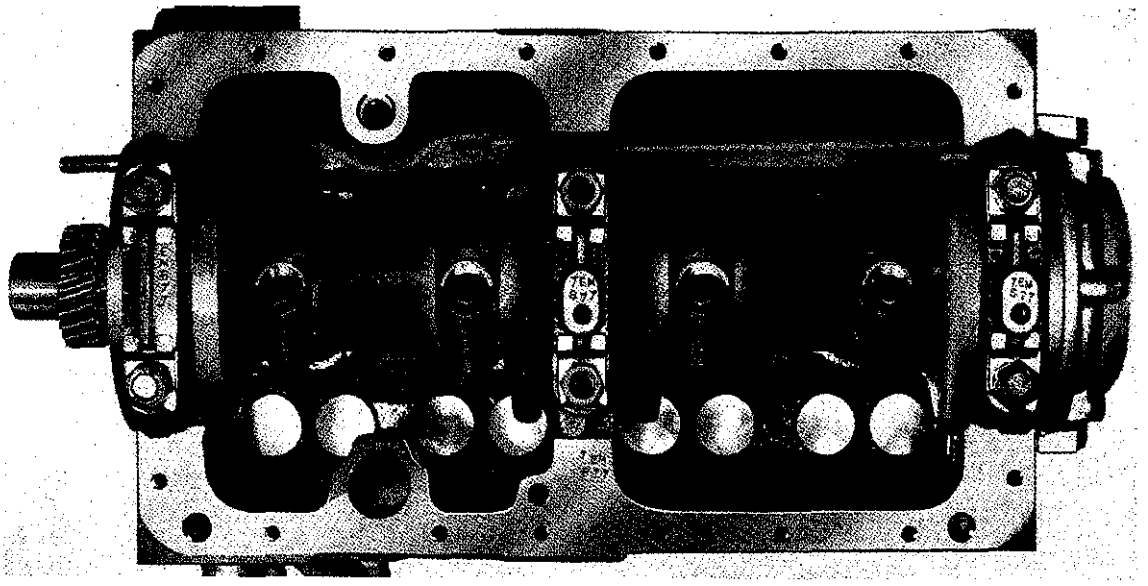
The crankshaft runs in three pre-finished replaceable thinwail, steel backed, aluminium tin-lined bearings. Crankshaft end float is controlled by thrust washers located either side of the rear main' bearing. 0.0075 in (0.19 mm oversize) thrust washers are available which if used on one side of the rear main bearing only will reduce crankshaft end float by 0.0075 in (0.19 mm) and by 0.015 in (0.38 mm) if used on both sides The limits for the crankshaft end float are given on Page B.6.

The main bearing caps are numbered and are not interchangeable. The main bearing shells are located by means of tabs which locate in slots in the bearing housings.

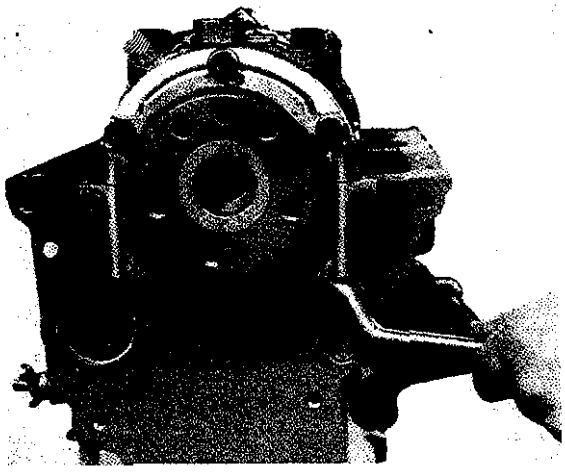
NOTE: Before renewal of the main bearings is attempted make absolutely certain that the correct replacements are available, reference to the relevant parts list will ensure this, but for identification purposes the new bearings should have an annular groove machined in the inner (bearing) face along the centre line of the feed holes, when the bearings are correctly located these feed holes will correspond exactly with those machined in the cylinder block.

On later 4.107 and 4.99 engines. the annular oil groove in the main bearing parent bore (cylinder block and bearing cap) has been deleted. Adequate lubrication is maintained by repositioning the oil feed holes radialiv in the shell bearings and continuing to machine the annular groove in the bearing on the centre line of these feed holes.

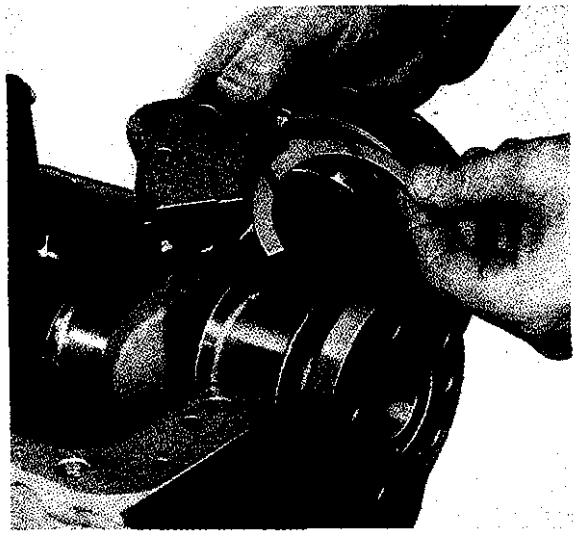
These later type shell bearings may be used on both early and later type engines, whereas the early type of shell bearings must NOT on any account, be fitted to later engines where the annular groove in the main bearing parent bore has been deleted.



H2



H3

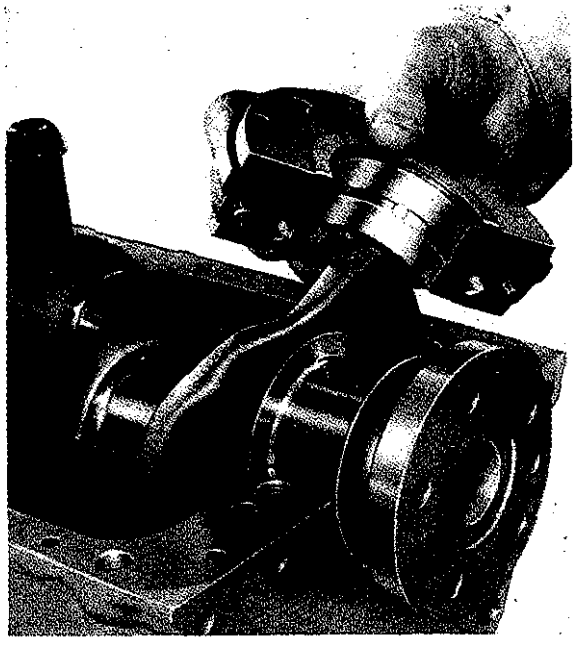


H4

To Renew Main Bearings and Thrust Washers

Removal of the main bearings and thrust washers can be carried out without removing the crankshaft by the following procedure: —

1. Remove the engine from its application.
2. Remove the sump and suction pipe assembly.
3. Slacken the setscrews which secure the main bearing caps.
4. Remove completely one of the main bearing caps and remove the bearing sheil from the cap.
5. Remove the top half of the bearing sheil by pushing it, on the opposite side to the one having the locating tag, with a suitable strip of wood and rotating it on the crankshaft as shown in Fig. H.1.
6. Inspect the bearing shells and if replacements are necessary continue by lightly lubricating and inserting the new top half bearing shell, plain end first, into the side having the tag location.
7. Rotate the bearing sheil on the crankshaft until it locates correctly with the tag in the machined slot.
8. Locate the lower half bearing sheil in the main bearing cap, liberally lubricate and refit.
9. Tighten the two securing setscrews to positively locate the bearing shells then slacken a turn or two.
10. Repeat items 3—8 for the remaining two bearings. NOTE: To enable the rear main bearing cap to be removed, first remove the two oil seal housing setscrews as shown in Fig. H.3.
11. Finally tighten the main bearings to the torque given on Page B.2.



H5

Renewal of the thrust washers is accomplished by carrying out the following procedure: —

1. Remove the two setscrews securing the two rear main bearing oil seal half housing as shown in Fig. H.3.
2. Remove the rear main bearing cap securing setscrews.
3. Remove the rear main bearing cap and from it the two lower half thrust washers. (Refer Fig. H.4).
4. The single upper half thrust washer is removed by rotating it with a thin piece of wood until it can be lifted out of its recess.
   NOTE: The new thrust washers should be lightly lubricated before fitting. The steel faces of the lower thrust washers should face inwards towards the bearing cap. (Refer Fig. H.5), the steel face of the upper thrust washer should also face inwards.
5. Locate the upper thrust washer half as shown in Fig. H.6, place the lower halves either side of the rear main bearing cap as described and refit the cap.
6. Tighten the setscrews evenly and finally to the torque given on Page 8.2.

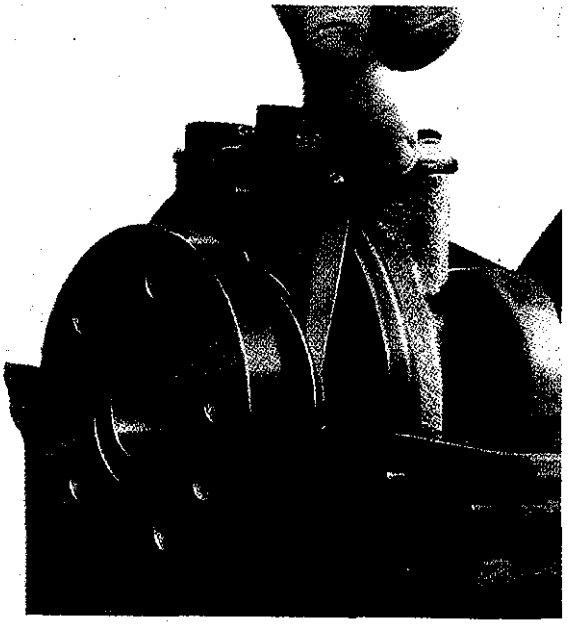
7. Check that the crankshaft end float is within the limits given on Page B.6 by means of feeler gauges as shown in Fig. H.7. If incorrect, oversize thrust washers are available to give an overall reduction of 0.015 in (0.38 mm). (Refer to Page H.2).
8. Refit the two setscrews securing the rear main oil seal half housing.
   NOTE: If any leakage of oil is apparent from this seal then new seals should be fitted to the half housings as described under the heading "Crank-. shaft Rear End Oil Seal" or fit a new assembly.
9. Refit the suction pipe assembly and sump.

To Remove the Crankshaft

To remove the crankshaft it will be necessary to remove the engine.

1. Remove the starter motor, flywheel and flywheel housing.
2. Remove the crankshaft front pulley. timing case cover. timing gears and fuel pump drive hub. (Refer to Page K.l for details of their removal)
3. Remove the securing setscrews (also any studs fitted) and remove the timing case back plate.
4. Remove the sump and lubricating oil pump complete with suction and delivery pipes. (Refer to Page M.l for removal of these).
5. Remove all the connecting rod setscrews, connecting rod caps and bearing shells. (Refer to Page F.1).
   NOTE: All the bearing shells should be marked to indicate "top" or "bottom" and number of the rod assembly.
6. Unscrew the main bearing caps.

H6



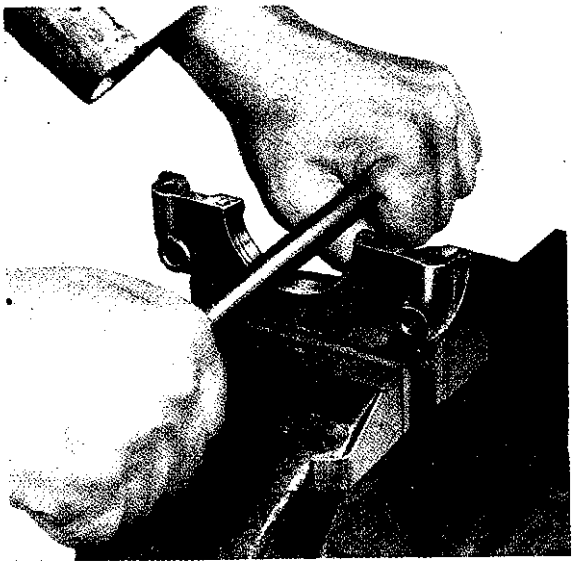
H7

   NOTE: The rear seal half housing securing setscrews will require removal to enable the rear main bearing cap to be removed. (Refer to Fig. H.3).
7. Lift out the crankshaft and place where it is not likely to be damaged ready for inspection.
8. Remove the top half main bearing shells.
9. Finally. remove the top half oil seal housing.

To Refit the Crankshaft

1. First ensure that crankshaft oilways are clear.
2. Place the three top bearing shells in position then oil liberallv with clean engine oil.
   NOTE: Unless a new set of main bearings is being fitted, those removed must be returned to their original locations.
3. Place the crankshaft in position.
4. Locate the upper thrust washer in position as shown in Fig. H.6.
5. Fit the three lower bearing shells, oil, and fit the three main bearing caps in their respective locations.
   NOTE: Ensure at this stage that the two lower thrust washer halves are positioned correctly either Side of the rear main bearing cap when it is fitted.
6. Check the main bearing setscrews prior to fitting for signs of stretch or thread damage. Where damage or any doubt exists fit new replacements.
7. Fit the setscrews then tighten evenly to the torque tension given on Page B.2.
8. Check that the crankshaft can be rotated freely. if satisfactory check the crankshaft end float by means of feeler gauges as shown in Fig. H.7. Should it not be within the limits quoted on Page B.6, then oversize thrust washers are available to give the necessary adjustment. (Refer to Page H.2).

9. Fit new sealing strips to the rear main bearing oil seal housings and refit the housings as described under the heading "Crankshaft Rear End Oil Seal" on Page H.4.
10. Liberally oil the crankpins, locate the connecting rod bearing shells, again ensuring their correct relative positions, then fit the connecting rod caps as described on Page F.5. The crankcase should now be as shown in Fig. H.2.
11. Refit the lubricating oil pump complete with suction and delivery pipes. (Refer to Page M.4).
12. Refit the sump using new seals and gaskets. (Refer to Page M.1).
13. Refit the timing case back plate. fuel pump drive hub, timing gears, timing cover and crankshaft front pulley. (Refer to later text commencing on Page K.l for their reassembly.
14. Refit and correctly align the flywheel housing as described in Section J.
15. Refit the flywheel and starter motor.



H8

CRANKSHAFT REAR END OIL SEAL

This sealing arrangement consists of two half housings bolted around the rear of the crankshaft. The bore of these housings is machined to accommodate a rubber cored strip which, in conjunction with a right hand helix machined between the thrust collar and the flywheel mounting flange to the dimensions given on Page B.6, acts to return the surplus oil reaching the seai. The two half housings fit over this helix and the contact of the sealing strips with the crankshaft prevents leakage beyond this point.

NOTE: When traces of oil become apparent from behind the flywheel and a faulty rear oil seal is suspected, first ensure that the crankcase is breathing normally. Any build up in crankcase pressure could cause oil to be forced past the rear sealing arrangement. If crankcase pressure is normal and new seals require to be fitted the following procedure should be adopted with the crankshaft in position.

1. Set up a half housing in the vice with the seal recess uppermost.
2. Settle approximately 1 in (25 mm) of the strip. at each end. into the ends of th? groove ensuring that each end of the strip projects 0.010/0.020 in (0.25/0.50 mm) beyond the half housing joint face.
3. With the thumb or finger press the remainder of the strip into the groove, working from the centre. then use any convenient round bar to further bed in the strip by rolling and pressing its Inner diameter as shown in Fig. H.8. This procedure takes advantage of the friction between the strip and the groove at the ends to compact the rope, while ensuring that the projections of the end faces of the rope remain as set.
4. Fit the sealing strip to the other half housing in a similar manner.
5. Remove all traces of the old gasket from the cylinder block rear face and fit a new gasket treated with a suitable sealing compund.
6. Lightly coat the faces of the housing with a suitable sealing compound.
7. Spread a film of graphite grease over the exposed inside diameter surface of the strip.
8. Assemble the half housings around the crankshaft rear journal and fasten together by the two setscrews (See Fia. H.31.
9. Swivel the complete seal housing on the shaft to bed in the strips, and to establish that the assembly turns on the crankshaft.
10. Bolt the seal housing in position on the block and the rear main bearing cap then finally tighten the securing setscrews.

SECTION J
Flywheel and Housing

Alignment of the Adaptor Plate, Flywheel Housing and Flywheel.

It is most important that the adaptor plate, flywheel housing and flywheel be correctly aligned with the crankshaft. If the plate and housing have been removed as is necessary for a complete overhaul, the greatest care must be taken on replacement to insure accuracy of alignment. The appropriate procedure is as follows:

See that the faces of both the rear of the cylinder block and the adaptor plate are perfectly clean and free from burrs.

Secure the adaptor plate to the cylinder block with set-screws and spring washers.

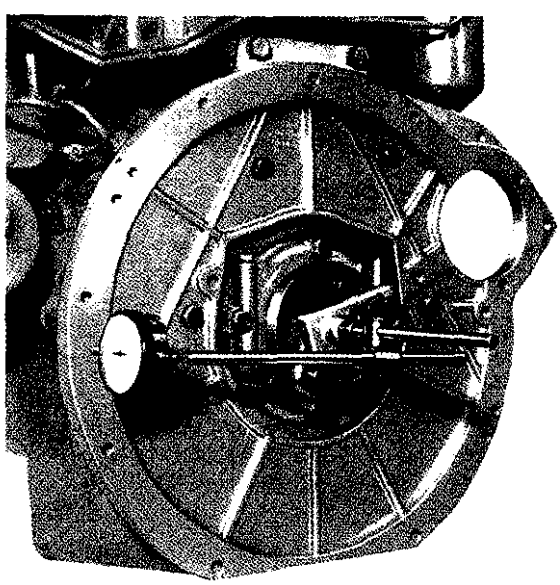
Alignment of the Adaptor Plate Face.

Secure the base of an indicator gauge to the flange of the crankshaft.

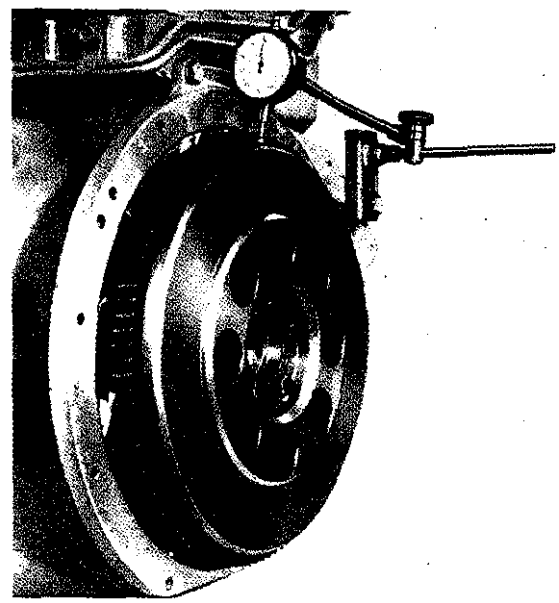
Set the needle of the gauge against the vertical face of the adaptor plate (See Fig. J1).

Turn the crankshaft and check that this face is perpendicular to the crankshaft axis.

Flywheel housing face should be within a limit of .006 total indicator reading of being truly at right angles to the crankshaft axis.



J1



J2

All adjustments to bring the adaptor plate within the limits must be on the adaptor plate and under NO CONDITIONS must the rear' of the cylinder block be interfered with.

When the adaptor plate is properly aligned to the above limits, tighten the setscrews evenly.

Ream the dowel holes and fit the correct length and size of dowels.

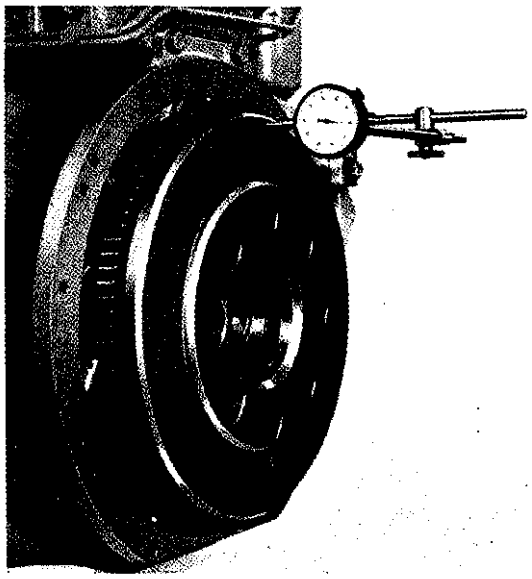
Fitting Flywheel and Checking Alignment.

With the flywheel and crankshaft flange perfectly clean and free from burrs, place the flywheel on the crank-shaft flange.

Insert the setscrews complete with tab washers into the flywheel holes and tighten evenly.

Secure the base of the indicator gauge to the adaptor plate. With the flywheel at top center, set the needle of the gauge on the periphery at T.D.C. See Fig. J2.

Turn the crankshaft and check the indicator, the flywheel should run true within .012 in. total indicator reading.

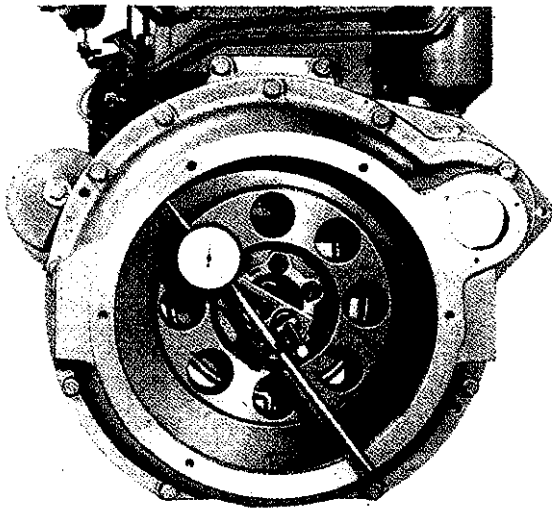


J3

With the base of the indicator gauge still bolted to the adaptor plate adjust the indicator so as to set the needle against the vertical machined face of the flywheel. See Fig. J3.

Again turn the crankshaft and check the indicator, the flywheel should be within .0005" per inch of flywheel diameter (total indicator reading) of being truly at right angles to the crankshaft axis.

When the flywheel is correctly aligned, lock the securing Setscrews by means of the tab washers.



J4

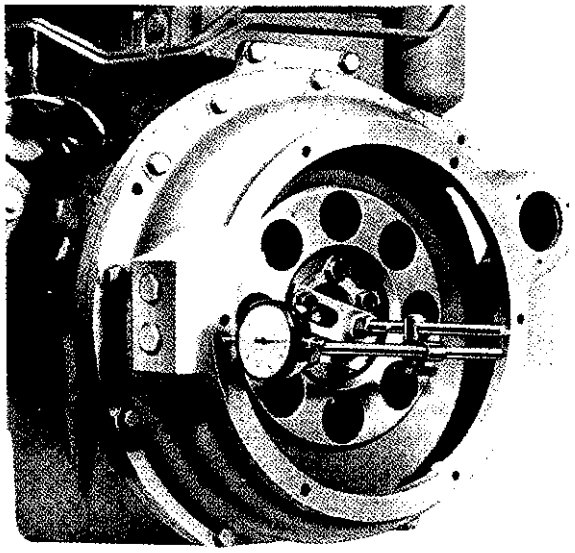
See that the face of the housing is perfectly clean and free from burrs.

Secure the housing to the adaptor plate with setscrews and spring washers, but not overtight so as to allow adjustment.

Attach the indicator gauge to the flywheel centre and set the needle of the gauge to the interior of the bored hole in the flywheel housing (See Fig. J4).

Turn the crankshaft and check that this hole is truly central. The housing is adjusted until the bored hole is central.

The hole in the housing should be truly central with the crankshaft within a limit of .006 (total indicator reading).



J5

Alignment of the Flywheel Housing Face.

With the base of the indicator gauge still bolted to the flywheel centre, adjust the indicator so as to set the needle against the vertical machined face of the flywheel housing, and again turning the crankshaft, check that this face is perpendicular to the crankshaft axis (See Fig. J5).

The limits for this facing are the same as those given for the adaptor plate facing. When the housing is properly aligned to the above limits, tighten the securing setscrews evenly.

Ream the dowel holes and fit the correct length and size dowels.

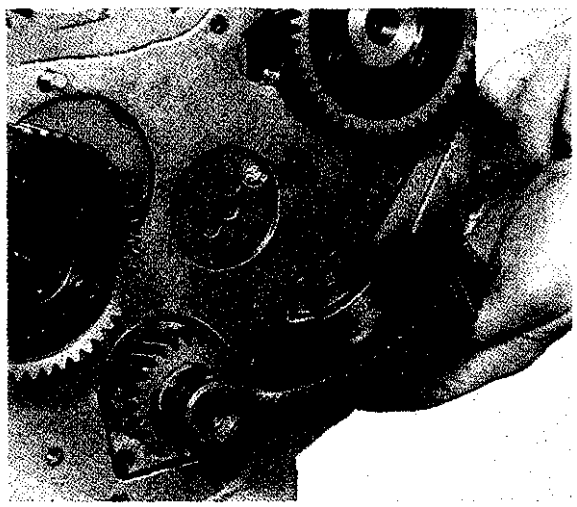
CHANGES TO TM 0941-014-8010

Installation of Flywheel Ring Gear

Care should be exercised in replacing flywheel ring gears. Too high a temperature (above 1500°F) during replacement installation may leave the steel ring gears fully annealed. If a press of sufficient capacity (about 10 tons) is available, ring gears should be installed without heating. When using a press, a suitable jig should be fabricated to ensure proper distribution of pressure around the gear circumference. If a press is not available ring gears will then have to be installed by heating.

The correct installation procedure is to support the ring gear, chamfered side up on a solid flat surface. Heat the ring gear in an oven to 4000 F. for about 20 minutes. If an oven is not available rest the ring gear on a flat metal surface and heat the gear uniformly with an acetylene torch, keeping the torch moving around the gear to avoid hot spots. Direct the flame against the inside diameter of the gear avoiding the gear teeth. The ring gear should not be heated over 400° F unless it cannot be installed at that temperature; excessive heat will destroy the original heat treatment causing premature failure of the ring gear. Under no circumstances should the gear temperature exceed 500° F. Heat indicating crayons, which melt at a predetermined temperature, may be utilized when a torch must be used to heat the ring gear. When sufficiently heated, place the ring gear on the flywheel with the chamfered side up and tap in place against the shoulder on the flywheel.

SECTION K
Timing Case and Drive



K1

To carry out the following procedure it is assumed that either working space exists with the engine 'in place' or it is removed from the application.

To Remove the Timing Case Cover

1. Slacken alternator mounting bolts, release the adjusting arm setscrew and remove the alternator drive belt.
2. Remove the crankshaft pulley retaining setscrew or dognut and withdraw the pulley which is a keyed fit on the crankshaft.
3. Remove the securing setscrews and nuts from the timing case and carefully remove the cover, taking care not to catch the rubber lip of the oil seal on the crankshaft pulley locating key.

To Renew the Crankshaft Front Oil Seal

1. Using a suitable dolly and press, remove the oil seal from the timing case cover by pushing out through the front.
2. Locate the new seal in position so that the lip faces inwards.
3. Press in the new seal from the front until it just butts against the seal retaining lip, giving local Support to the cover as the seal is pressed home.

To Refit the Timing Case Cover

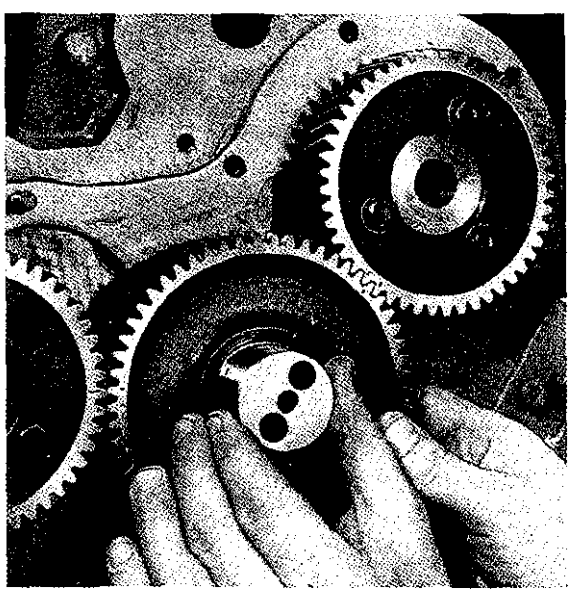
1. Using a new gasket, lightly coated with a suitabie Sealing compound, place the lront cover in position taking care not to damage the rubber lip of the oil seal on the crankshaft pulley key.
2. Loosely fit the front cover securing setscrews and nuts.
3. Fit the crankshaft pulley to centraiise the seal. then tighten the securing setscrews and nuts.
4. Fit the crankshaft pulley retaining setscrew or dog. nut and tighten to the torque given on Page B.2.
5. Refit the "V" belt and tension as described on Page N.1.

To Remove the Idler Gear and Hub

1. Remove the timing case front cover as previously described in this section.
2. Tap back the locking tabs and unscrew the two idler hub securing setscrews.
3. The setscrews, idler gear and hub may now be removed together as shown in Fig. K.1.
4. Clean and thoroughly examine the gear and hub lor signs of excessive wear. cracks, pitting, etc.

To Refit the Idler Gear and Hub

1. After ensuring that the oilways in the hub and gear are clear, hold the gear in position with the timing marks correctly aligned.



K2

NOTE: If the cylinder head assembly has not been disturbed, then the cylinder head cover and rocker shaft should be removed in order to allow the camshaft to be turned to facilitate the aligning of the timing marks.

2. Insert the hub as shown in Fig. K.2 so that the holes in the hub and the cylinder block are in alignment and secure with the two setscrews.

NOTE: Clearance is provided in the setscrew holes of the idler gear hub, to provide the necessary backlash adjustment for the timing gears.

3. Using the adjustable idier gear. backlash between both crankshaft gear/idler gear and camshaft gear/idler gear should be set within the range given on Page 8.9 with the gears held together in order to take up the effect of bearing Clearance. Backlash may be checked by the use of feeler gauges as shown in Fig. K.3.
4. When the backlash has been correctly set, finally tighten the idler gear hub securing setscrews to the torque given on Page B.2.
5. Check the idler gear end float as shown in Fig. K.4 the limits are given on Page B.9.
6. Lock the idler gear hub securing setscrews with the tabwashers.

NOTE: The timing gears when correctly set should appear as shown in Fig. L.1.

7. Refit the timing case front cover. etc.. as previouslv detailed in this section.

K3

To Remove the Fuel Pump Gear

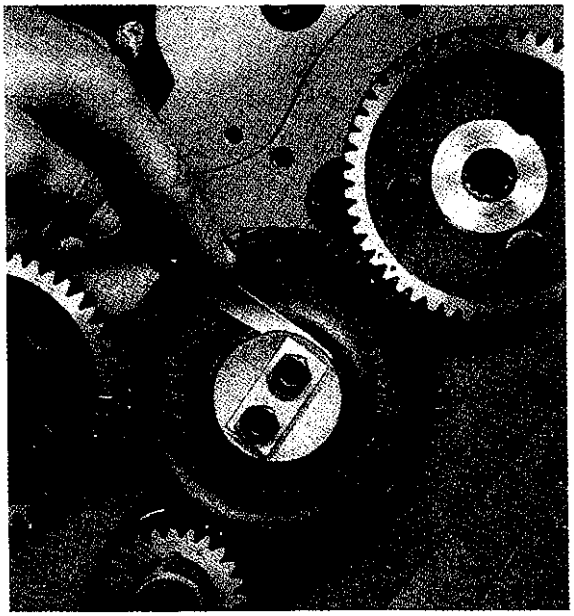
1. Remove the timing case front cover.
2. Remove the idler gear and hub.
3. Remove the three securing setscrews and ease the gear from its location on the fuel pump driving hub.
4. Examine the gear for signs of excessive wear. cracks, pitting. etc.

To Remove the Camshaft Gear

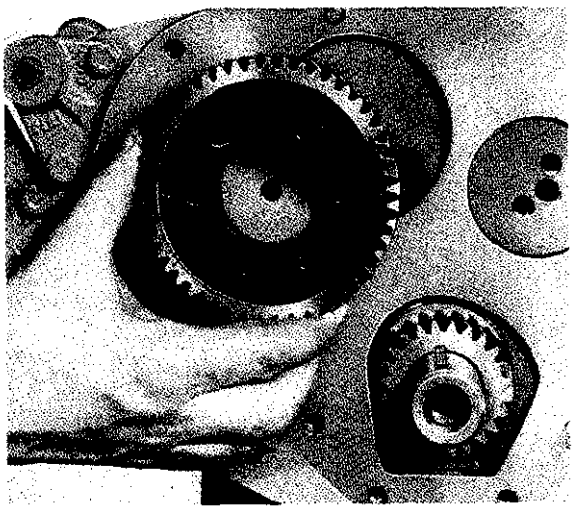
1. Remove the timing case front cover.
2. Remove the three securing setscrews and ease the gear away from its location.
3. Examine the gear for signs of excessive wear. cracks. pitting, etc.

To Refit the Camshaft Gear

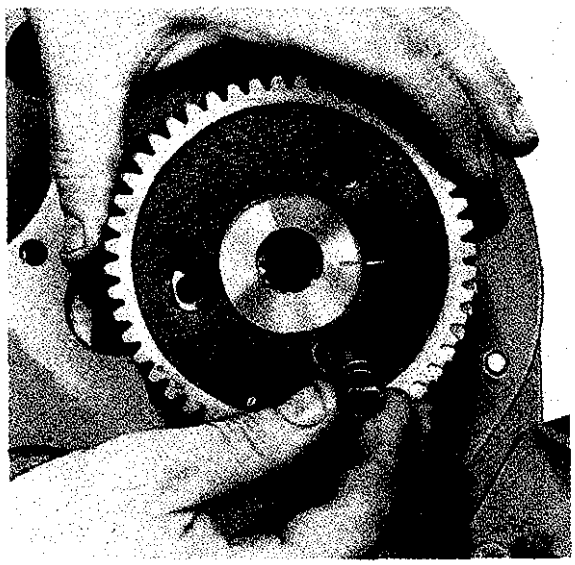
1. Remove the idler gear and hub, cylinder head cover and rocker shaft (if not previously removed).
2. Refit the gear to the camshaft ensuring that the 'D' marks on the gear and camshaft hub respectively align as shown in Fig. K.5.
3. Refit the three securing setscrews and tighten lo a torque of 19—21 lbf ft (2.6—2.9 kgf m).
   NOTE: Only the plain (non-slotted) holes in the camshaft gear are to be used and these will align with the tapped holes on the camshaft hub when the 'D' marks are in alignment.
4. Refit the idier hub and gear, timing case front cover. etc., as previously detailed in this section.



K4



K5



K6

To Refit the Fuel Pump Gear

1. Refit the fuel pump gear so that the timing marks on the gear and hub respectively are in alignment as shown in Fig. K.6.
2. Refit the three securing setscrews and tighten to a torque of 19—21 lbf ft (2.6—2.9 kgf m).
3. Refit the idler gear and hub. timing case front cover. etc.

To Remove the Fuel Pump Drive Hub

1. Remove the timing case front cover and fuel pump gear.
2. Remove the low and high pressure fuel pipes from the fuel (injection) pump.
3. Remove the fuel pump securing setscrews and withdraw the pump.
4. Remove the drive hub locating circlip and withdraw the drive hub from its bearing (Refer Fig. K.7).
5. Examine the drive hub also the bearing in which it runs for signs of excessive wear, surface cracks. pitting etc.

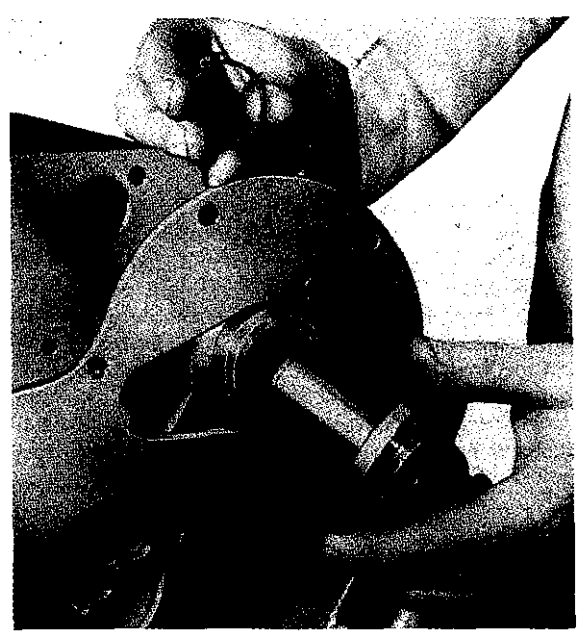
NOTE: The bearing is an interference fit in the cylinder block and replacement is carried out by means ot a suitable dolly and puller or press if the block is completely stripped, the new one being fitted in the reverse manner.

To Refit the Fuel Pump Drive Hub

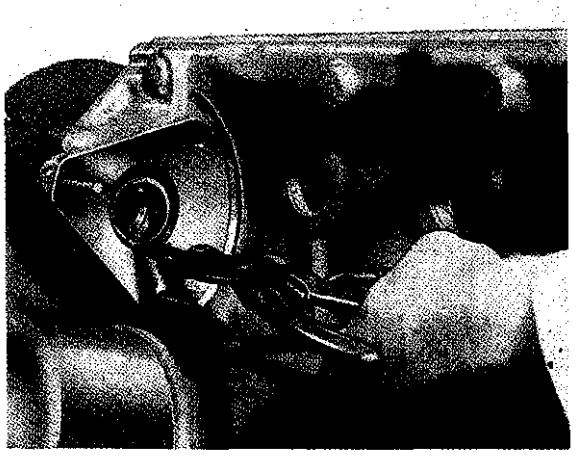
1. Replace the drive hub in the bearing and locate with the circlip as shown in Fig. K.8.
2. Check the drive hub end float by means of feeler gauges placed between the front face of the bearing and the rear lace of the drive hub. The end float limits are given on Page B.9.
3. Refit the fuel pump as detailed on Page P.4.
4. Refit the low and high pressure fuel pipes to the fuel pump.
5. Refit the fuel pump drive gear, idler gear and hub. timing case front cover etc.

To Remove the Timing Case Back Plate

1. Remove the timing case front cover and timing gears.
2. Remove the fuel pump and drive hub.
3. Remove the securing setscrews and studs (where fitted).



K7



K8

4. Lift the timing case back plate clear from the camshaft hub and crankshaft gear.
   NOTE: The crankshaft gear is an interference fit on the crankshaft. Should its removal become necessary. then this can be accomplished by the use of a suitable puller.

To Refit the Timing Case Back Plate

1. Fit the timing case back plate to the cylinder block using a new gasket and suitable sealing compound.
2. Refit any studs removed and secure with the setscrews.
3. Refit the fuel pump drive hub and fuel pump.
4. Refit the timing gears, timing case front cover etc.

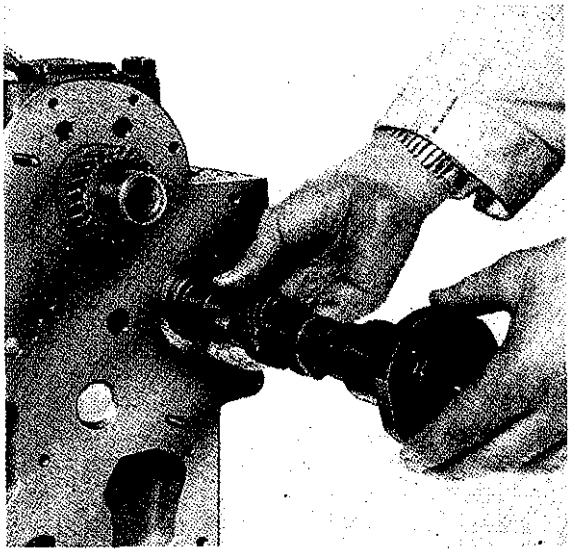
To Remove the Camshaft and Tappets

To remove the camshaft it may be necessary to remove the engine from the application and place in a suitable dismantling stand where it can be turned upside down. The purpose of this is to prevent the tappets from falling out of their locations when the camshaft is removed. if, however, it is not possible to turn the engine over in this manner, then this problem may be overcome by attaching suitable clips (when the tappet inspection cover has been removed) to each tappet to hold them in their locations when the camshaft is withdrawn from the block.

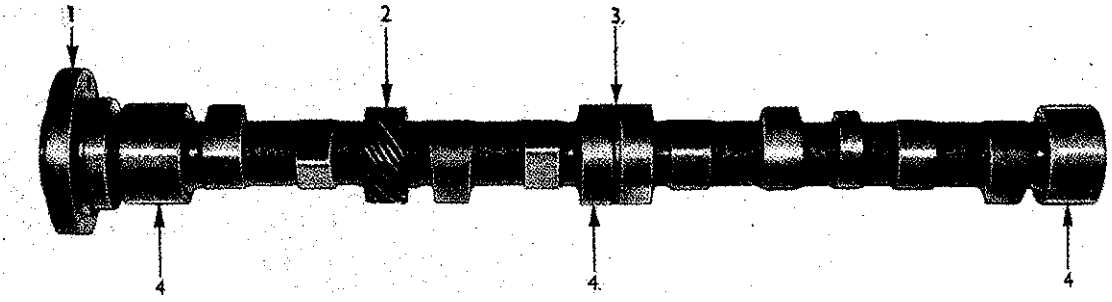
1. Remove the engine from the application and mount in a suitable dismantling stand (where available) correct way up.
2. Remove the cylinder head cover, rocker shaft and push rods.
3. Remove the timing case front cover and timing gears.
4. Remove the fuel lift pump. tappet inspection cover and fuel lift pump operating push rod.
5. Turn the engine over so that the sump is now uppermost.
   NOTE : At this stage if it is not possible to turn the engine over then the tappets should be lifted to the too of their locations and secured with suitable clips.
6. Remove the sump and lubricating oil pump assembly. (Refer to Page M.1 for details of their removal).
7. Remove the timing cover back plate as previously detailed, this will show the camshaft and thrust plates as illustrated in Fig. K.13.
8. Ease the camshaft out from the block and catch the two thrust plates as they come out of their recess in the cylinder block.
9. Withdraw the camshaft as shown in Fig. K.9 taking care to ensure that the cams and journals are not damaged during this operation.
10. The tappets may now be removed by lifting them out of their locations (Refer to Fig. K.11) or by removal of the retaining clips if the engine is still the normal way up.
11. Examine camshaft and tappets for signs of excessive wear. surface cracks, pitting etc.

To Refit the Tappets and Camshaft

1. If the tappets have been removed liberally lubricate them with clean engine oil and return to their respective locations. Secure with clips (if applicable).
2. Carefully refit the camshaft into the cylinder block exercising the same care as used during its removal.

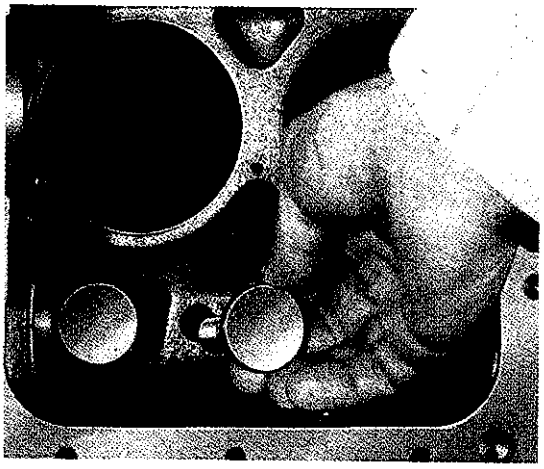


K9



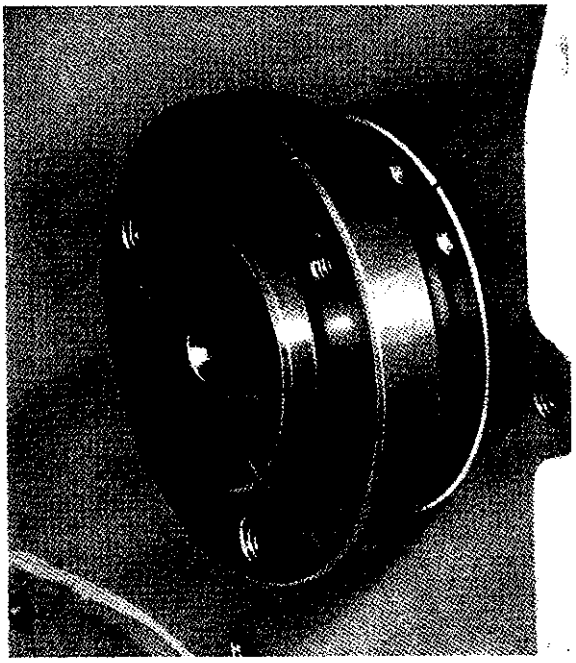
K10

1. Drive Hub
2. Lubricating Oil Pump Drive Gear
3. Groove for reduced oil pressure feed to Rocker Shaft
4. Bearing Journals

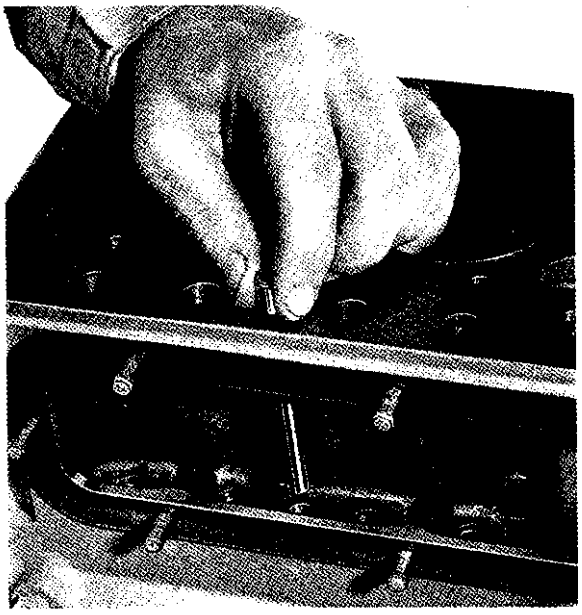


K11

K12



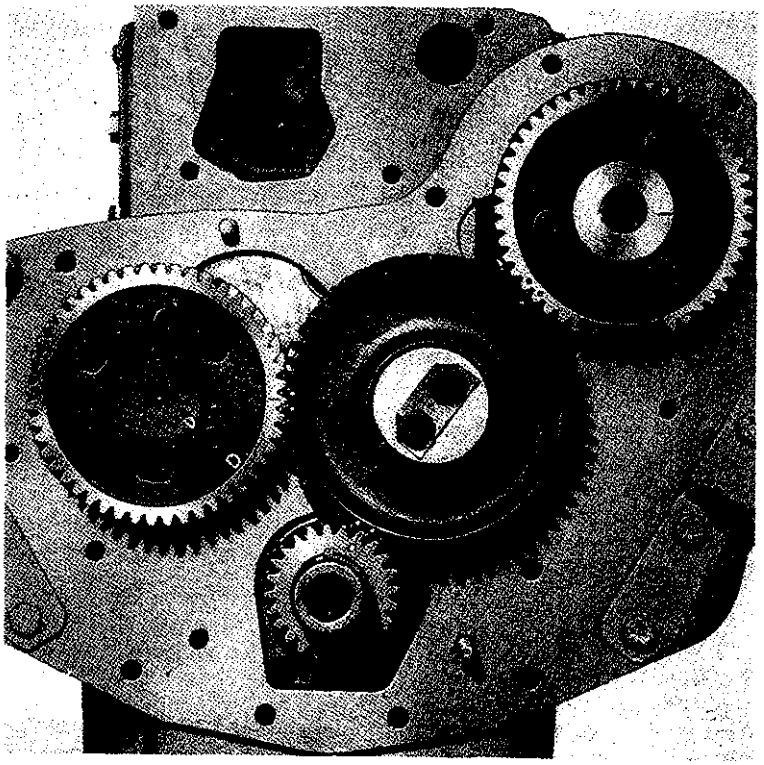
K13



K14

3. Before the camshaft is pushed fully home locate the two thrust plates (Refer to Fig. K.12) (one of which locates on the dowel in the recess) in position, either side of the camshaft hub. when correctly located the camshaft can be pushed fully home and will appear as in Fig. K.13.
4. Refit the timing case back plate as previously described.
5. Refit the lubricating oil pump assembly and sump as described on Pages M.I and M.4.
6. Turn the engine over so that the cylinder block top face or cylinder head (if fitted) is uppermost.
7. Refit the timing gears, timing case front cover etc.. as previously detailed.
8. Refit the fuel lilt pump operating push rod (Refer to Fig. K.14), tappet inspection cover. (alter removing any retaining clips) and fuel lift pump. Refer to Fig. P.9.
9. Re-assemble the remainder of the engine components in accordance with the instructions given for each in the relevant part of this section.

SECTION L
Timing



L1

General

As timing gears are employed, the factory setting remains constant. It is also worth remembering that the removal of the cylinder head in no way effects either the fuel pump or the valve timing.

TIMING MARKS

When the engine is originally timed at the factory. certain marks are stamped on the gears, so that if for any reason the engine timing has to be disturbed, then to reset to the original timing is quite straight forward.

To Reset the Engine to the Original Timing

Before commencing the retiming procedure it is assumed that (a) the camshaft. fuel pump and idler gears have all been removed, and (b) the camshaft is free to turn by hand. (If the cylinder head assembly is still in position, it is advisable to remove the injectors and rocker shaft to facilitate the retiming operations).

1. Turn the engine until the keyway in the front of the crankshaft is uppermost as shown in Fig. L.I (This will bring Nos. 1 and 4 pistons to T.D.C.)

2. Fit the camshaft gear to its hub ensuring that the 'D' marks are correctly aligned. (Refer to Fig. K.51. Secure with the three setscrews.

3. Similarly, fit the fuel pump gear to the fuel pump drive hub ensuring that the stamped timing marks align as shown in Fig. K.6. Secure with the three setscrews.

4. Replace the idler gear so that the double dots on the idler gear are matched to the single dot on the crankshaft gear and single line (or dot) on the camshaft gear, while the single dot on the idler gear matches with the double dots on the fuel pump gear. These timing marks when correctly positioned will appear as shown in Fig. L.1.

5. Locate the idler gear with the hub and the two securing setscrews using a new tabwasher.

6. Backlash adjustment should be carried out as described under the heading 'To Refit the Idler Gear and Hub.

Checking Fuel Pump Timing—See Page P.5

Checking Valve Timing

To check the valve timing proceed as follows:

1. Turn the crankshaft until the valves of No. 4 cylinder are 'on overlap.
2. In this position set the valve clearance of No. 1 inlet valve to 0.039 in (1 mm).
3. Turn the engine slowly in the normal direction of rotation until the clearance of No. 1 inlet valve is just taken up. (In this condition it will just be possible to rotate No. 1 inlet valve push rod between the thumb and the forefinger).
4. Nos. 1 and 4 pistons will now be at T.D.C. if the timing has been correctly set.

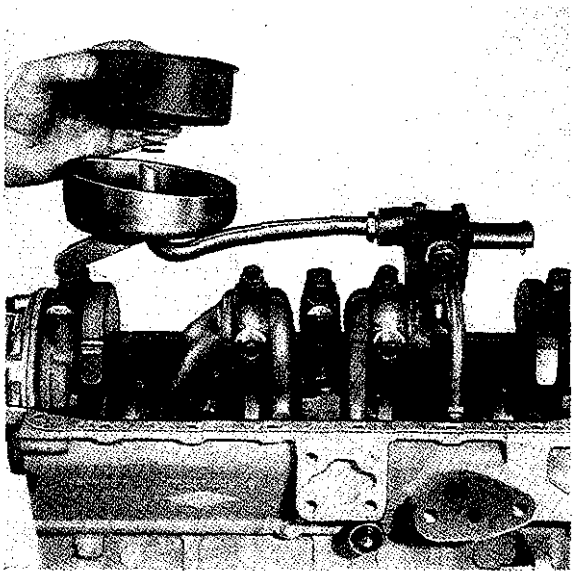
NOTE: No adjustment is provided for valve timing. should the timing be incorrect and the camshaft gear has been correctly fitted lo the camshaft hub. the error will probably be due to incorrect alignment of the original timing marks on the drive gears. Recheck as detailed on Page L.1.

When valve timing is originally set and checked during production a timing tolerance of plus or minus 2 (flywheel) degrees is allowed for item (4) above. When the timing has been correctly set, do not forget to reset No. 1 inlet valve clearance to the correct figure.

check T.D.C.

NOTE: When the timing has been reset, great care should be exercised when first turning the engine. for should the timing be incorrectly set. even by only one tooth. there is the possibility that a valve head will strike the piston crown.

SECTION M
Lubrication System



M1

The importance of correct and clean lubrication cannot be stressed too highly and all references to engine oil should be taken to mean lubricating oil which falls within the specification given in the appendix. Care should be taken to ensure that the oil chosen is that specified for the climatic conditions under which the engine is operated.

THE LUBRICATING OIL PUMP

The oil pump fits into a machined bore in the clyinder block and is located by means of a screw locked by a tab washer. (Refer to "Engine Photographs" for its location).

The oil pump is driven through spiral gears from the camshaft, on the other end of the drive shaft is pressed and pinned a four lobed rotor. This rotor meshes with and drives a five lobed rotor which is free to rotate within the cast iron pump body.

NOTE: Lengtli of oil pump set screw is critical. If replaced by a longer unit, oil pump shaft will lock and gear failure will result.

To Remove the Sump

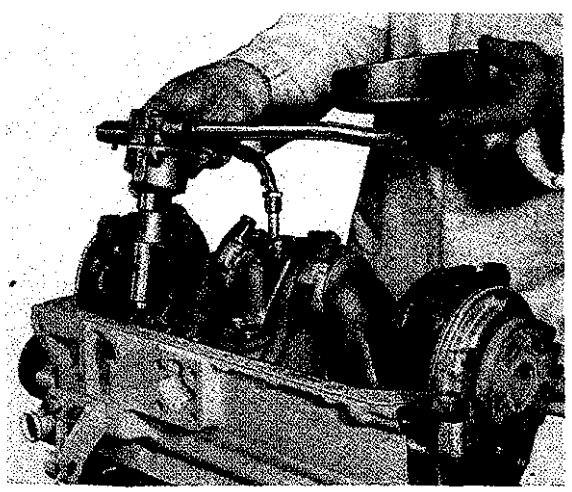
1. Remove the sump drain plug and drain the oil.
2. Remove the dipstick. sump securing setscrews and remove the sump.

To Refit the Sump

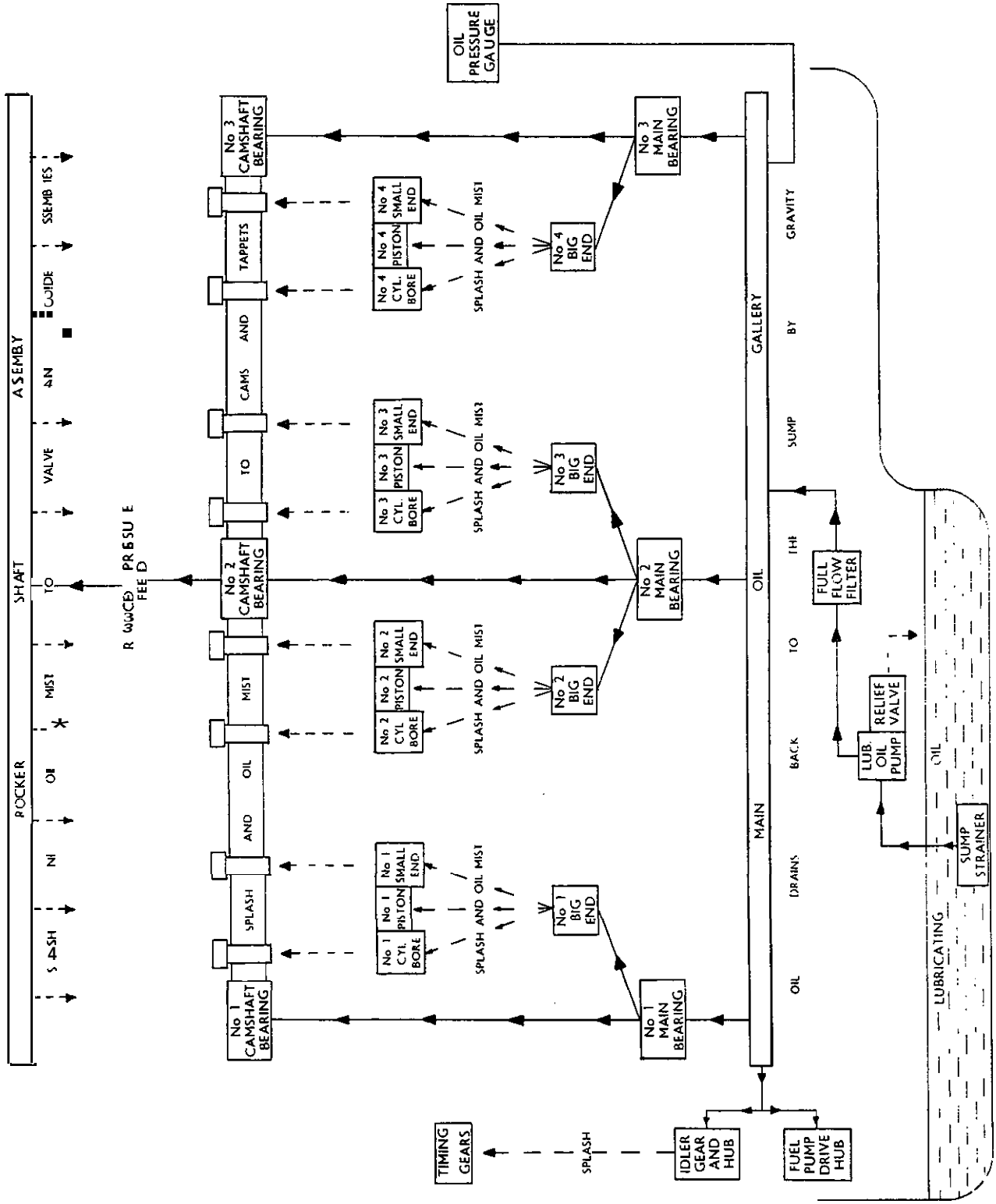
1. Lightly apply a coating of a suitable sealing compound to the crankcase and sump faces, position the gaskets so that all the holes align.
   NOTE: When the gaskets are being placed in position it is important that the mitred ends go right up into the recesses in the front and rear main bearing caps.
2. Lightly apply a coating of sealing compound to the cork strips. then press these strips into [he grooves provided in the main bearing caps.
3. Place the sump in position and fit all the retaining setscrews, tighten evenly.
4. Replace the dipstick and sump drain plug, then refill with clean new oil of an approved grade to the correct level. Do not overfill.

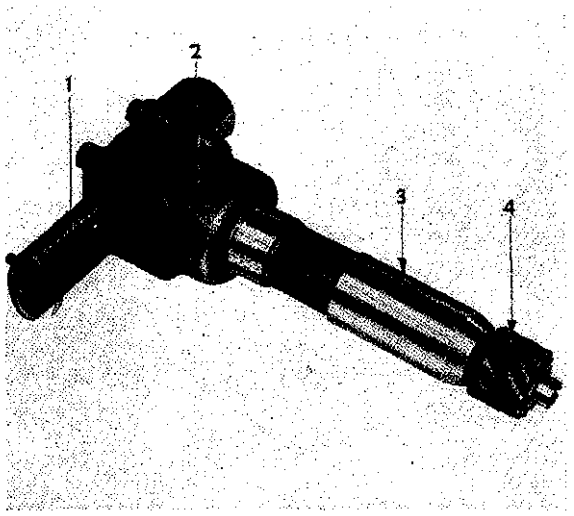
To Remove the Oil Pump

1. Drain the engine oil and remove sump.
2. Remove the strainer from the end of the lubricating oil suction pipe. (Refer to Fig. M.l).
3. Unscrew the delivery pipe securing nut to the cylinder block and the setscrew securing the suction pipe assembly to the rear main bearing cap.



M2


ROCKER SHAFT ASSEMBLY
SPLASH
OIL MIST
VALVE GEAR ASSEMBLIES
PRESSURE FEED TO
No 1 CAMSHAFT BEARING
No 2 CAMSHAFT BEARING
No 3 CAMSHAFT BEARING
SPLASH AND OIL MIST
TAPPETS AND CAMS
No 1 CYL. BORE
No 1 PISTON
No 1 SMALL END
No 1 BIG END
No 2 CYL. BORE
No 2 PISTON
No 2 SMALL END
No 2 BIG END
No 3 CYL. BORE
No 3 PISTON
No 3 SMALL END
No 3 BIG END
No 4 CYL. BORE
No 4 PISTON
No 4 SMALL END
No 4 BIG END
No 1 MAIN BEARING
No 2 MAIN BEARING
No 3 MAIN BEARING
OIL PRESSURE GAUGE
MAIN OIL GALLERY
DRAINS BACK TO SUMP BY GRAVITY
FULL FLOW FILTER
LUB. OIL PUMP
RELIEF VALVE
SUMP STRAINER
LUBRICATING OIL
TIMING GEARS
SPLASH
IDLER GEAR AND HUB
FUEL PUMP DRIVE HUB



M4

1. Relief Valve Housing
2. Rotor Housing
3. Hole for Locating Screw
4. Pump Drive Gear

4. Tap back the tab washer locking the location screw and support the lubricating oil pump assembly (if the engine is the normal way up), while the locating screw is removed.
5. Remove the lubricating oil pump assembly from the cylinder block as shown in Fig. M.2.

To Dismantle the Oil Pump

1. Remove the delivery and suction pipes. The pump will now be as shown in Fig. M.4.
2. Withdraw the drive gear by means of a suitable puller.
3. With the pump suitably held in a vice. (using protective clamps) remove the four securing set-screws and remove the end cover assembly.
   N.B. This end cover assembly also incorporates the pressure relief valve housing.
4. Withdraw the drive shaft complete with inner rotor.
   N.B. It is advisable not to remove this inner rotor from the shaft as this item is not available as a separate pan (See later note).
5. Withdraw the outer rotor.

Inspection

1. Inspect for signs of wear, cracks, pitting, etc.

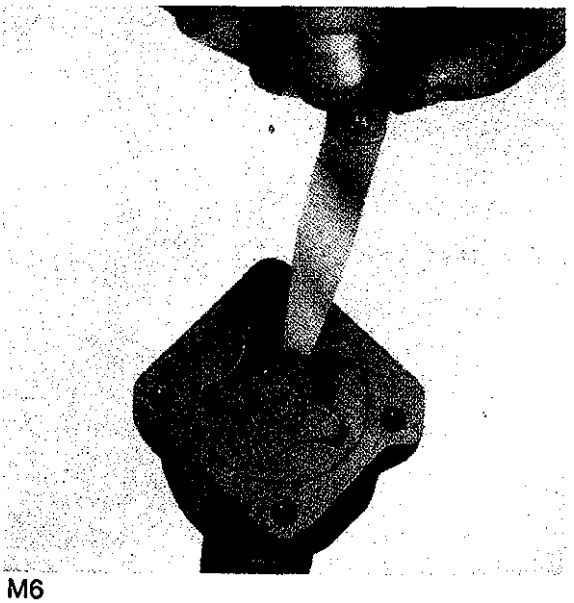
M5

2. Install the drive shaft complete with inner rotor, then the outer (driven) rotor ensuring that the face which carries the chamfered edge enters the pump body first (Refer, Fig. M.5), now carry out the three following dimensional checks.

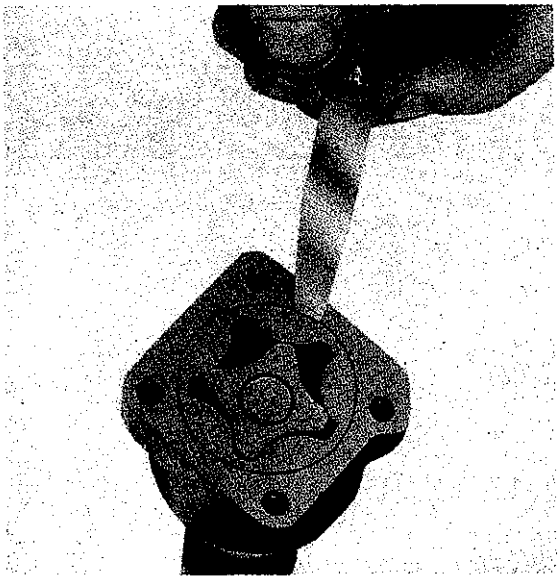
   (a) Check the clearance between the inner and outer rotors. (Refer Fig. M.6).

   (b) Check the clearance between the outer rotor and the pump body (Refer Fig. M.7).

   (c) Check the clearance between the rotors and the end cover assembly using a straight edge and feeler gauges (Refer Fig. M.8).



M6



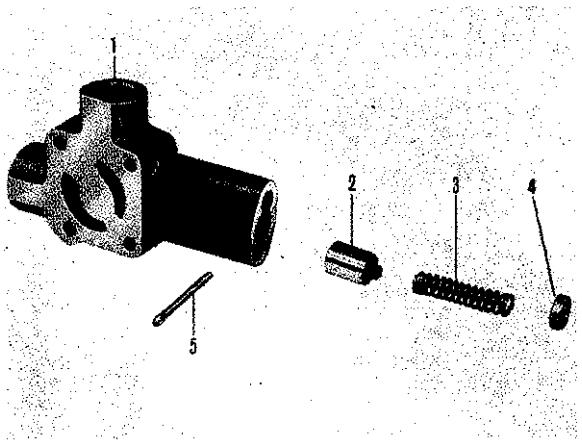
M7

NOTE: The relevant clearances for these dimensional checks are given on Page B.10, they are the clearances applicable to a new pump and are intended to be used as a guide. Should a lubricating oil pump be worn to such an extent that it adversely effects the working oil pressure. then a replacement pump should be obtained.

To Re-Assemble the Oil Pump

1. Insert the outer rotor ensuring that the face which carries the chamfered edge enters the pump body first. (Refer Fig. M.5).

M8



M9

1. Outlet to Main Oil Filter
2. Relief Valve Plunger
3. Plunger Spring
4. Spring Cap
5. Retaining Cotter Pin.

2. Insert the drive shaft complete with inner rotor into the pump body.

3. Replace the end cover assembly and fit the four Securing setscrews. Ensure correct positioning so that the suction and delivery pipes will locate correctly.

4. Press the oil pump drive gear onto the shaft.

5. Finally rotate the pump by hand to ensure that it turns quite freely.

To Refit the Oil Pump

1. Refit the suction and delivery pipes, do not tighten the pipes at this stage.

2. Place the lubricating oil pump assembly in position, locate with the securing screw and lock it with the tab washer.

3. Tighten the delivery pipe at both ends, refit the Setscrew securing the suction pipe assembly.

4. Tighten the suction pipe at the pump end then refit the strainer on the end of the suction pipe.
NOTE: The strainer which fits on the end of the Suction pipe should be thoroughly cleaned in suitable cleaning fluid before being refitted. It is good practise to remove this strainer and clean it thoroughly on every occasion when the sump is removed.

5. Replace the sump as previously detailed and Secure with the setscrews.

6. Fill the sump to the correct level with clean oil of an approved grade.

NOTE: Caution should be exercised when restarting the engine, as it will take a moment or two for the oil pump and pipes to prime, therefore the engine speed should be kept to a minimum until either the gauge shows satisfactory pressure (where fitted) or the oil pressure warning light is extinguished.

The most satisfactory way to prime the iubricating oil pump is to motor the engine for approximately 10/20 seconds before any attempt is made to start the engine.

OIL PRESSURE RELIEF VALVE

The oil pressure relief valve is contained in a housing integral with the oil pump end cover, which is secured to the rotor housing by four setscrews. This relief valve controls the maximum oil pressure by allowing a spring loaded plunger to move and bypass excess oil back to the sump when the pre-determined spring pressure given on page B.10 is exceeded.

To Dismantle the Oil Pressure Relief Valve

1. Drain the engine oil from the sump.
2. Remove the sump securing setscrews and carefully remove the sump.
3. Continue as for removing the oil pump as previously detailed.
4. Remove suction and delivery pipes.
5. Remove the four securing setscrews and remove the end cover assembly.
6. Remove the cotter pin from the end of the housing and withdraw the spring cap, spring and plunger. An exploded view of the assembly is shown in Fig. M.9.
7. Thoroughly clean the parts, inspect for wear or damage and renew if necessary.

To Re-Assemble the Oil Pressure Relief Valve

1. Replace the plunger, spring and spring cap then secure with the cotter pin.
2. Secure to the iubricating oil pump body by means of the four setscrews.
3. Continue as detailed for refitting the lubricating oil pump.

OIL PRESSURE

Always ensure that with the engine running, oil pressure is registering on the gauge or the oil pressure warning light is extinguished.
Pressures do vary according to climatic conditions and even between individual engines, but the oil pressure range at normal working speed and temperature is given on Page B.9. The pressure will drop whilst the engine is idling and also a slight drop will be experienced when the oil is hot, this is quite normal. If. however, the oil pressure is suspected of being too high or to0 low then reference to the possible faults listed under these headings given on Page D.1, may prove helpful.

NOTE: Whenever the oil pressure reading is questionable, use a direct reading, mechanical oil pressure gauge attached directly to engine oil gallery on block.

LUBRICATING OIL FILTERS

To ensure cleanliness of the iubricating oil a sump strainer and a main full flow type of oil filter are fitted. The sump strainer consists of a gauze wire container which is fitted over the end of the lubricating oil pump suction pipe. All oil must pass through this strainer before it reaches the oil pump.

SECTION N

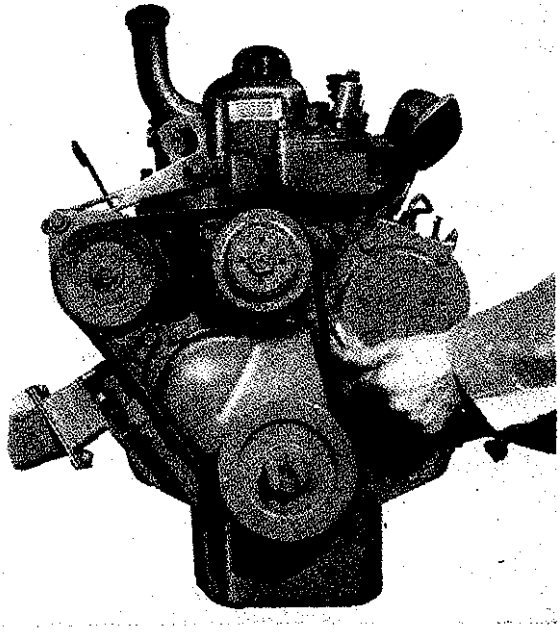
nal oling System

ALTERNATOR BELT

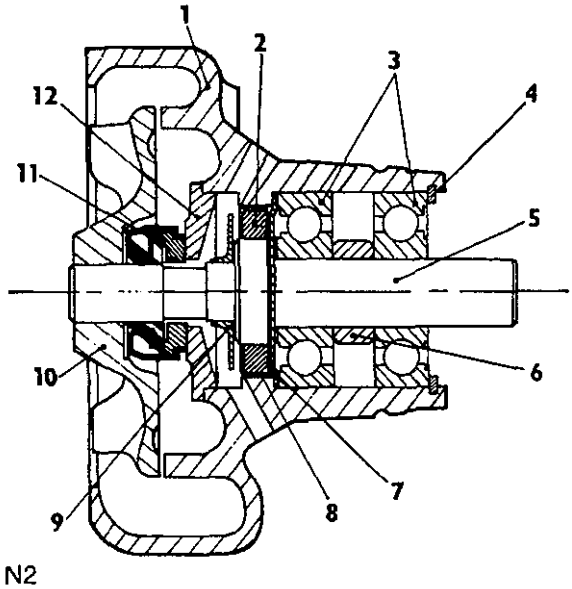
To Adjust the Alternator Belt

Alternator belt adjustment is achieved by altering the position of the alternator as detailed below.

1. Slacken the alternator adjusting lever setscrew.
2. Slacken the two alternator-to-bracket mounting bolts.
3. Move the alternator either towards or away from the engine to either slacken or tighten the belt.
4. Lock in the desired position by tightening the alternator adjusting lever setscrew.
5. Check the tension, if correct. the tension is such that without undue pressure. the thumb applied midway between the water pump and crankshaft pulleys can depress the belt approximately $\frac{3}{8}$ in (10 mm) as shown in Fig. N.1.



N1



N2

1. Pump Body
2. Seal
3. Shaft Bearings
4. Retaining Circlip
5. Pump Shaft
6. Spacer
7. Flange — Oil Seal Retaining
8. Retainer — Oil Seal
9. Flange — Water Pump Thrower
10. Impeller
11. Seal
12. Insert

6. If the tension is correct tighten the two alternator-to-bracket mounting bolts.

NOTE: When a new belt is fitted, it is advisable to recheck the adjustment after only a comparatively short running period. This is to allow for the initial stretch which is common to new belts. once this initial stretch has taken place the belt may be checked in accordance with Operator Instructions.

To Remove the Alternator Belt

1. Slacken the alternator adjusting lever setscrew.
2. Slacken the alternator-to-bracket mounting bolts.

3. Pivot the alternator towards the cylinder block.
4. Turn the engine slowly by hand and work the alternator belt off the water pump pulley.
5. The belt can now be lifted from the alternator and crankshaft pulleys and removed from the engine.
6. Examine the belt for signs or fraying or cracks in Ihe rubber and renew if necessary.

To Refit the Alternator Belt

Refitting the belt is just a reversal of the removal operations. Adjust the belt tension as previously detailed under the heading "To Adjust the Alternator Belt".
If a new belt has been fitted refer to the note given after the details on fan belt adiustment.

N4

To Remove the Water Pump

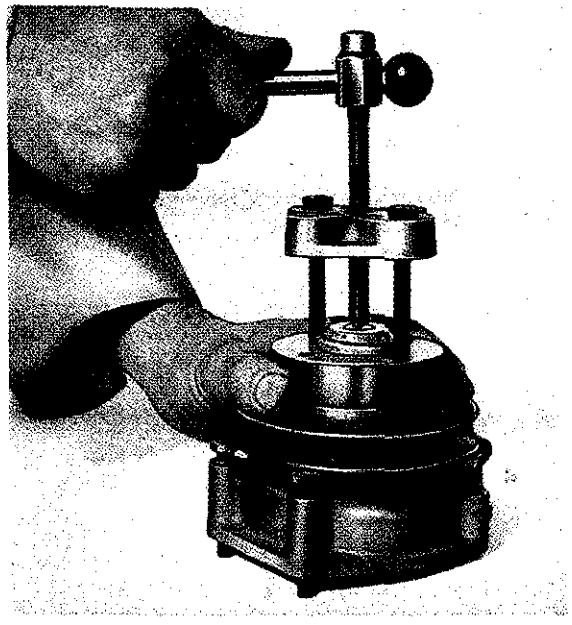
Slacken generator securing setscrews and remove driving belt.

Unscrew the four setscrews securing the water pump and backplate to cylinder block.

Remove water pump and back plate.

To Dismantle the Water Pump

1. Remove the pulley securing nut or circlip (where fitted).



N3

2. Remove the water pump pulley by means of a suitable puller, the holes in the pulley face may be utilised for this purpose (Refer to Fig. N.3).
3. Press the shaft out of the pump body from the pulley end complete with water pump thrower, insert. seal and impeller.
4. Remove the impeller from the pump drive shaft by means of a suitable puller or press.
5. Remove the bearing retaining circlip then using a suitable mandrel press the two shaft bearings complete with spacer out through the front of the pump body.
6. Remove the felt seal and retaining flanges.

Inspection

1. Examine the pump body for cracks, corrosion or any other damage. Renew where necessary.
2. Examine the shaft and bearing assembly for wear or corrosion. Renew where necessary.
3. Examine the water thrower flange for damage or corrosion. Renew where necessary.
4. Examine the water pump seal and insert for excessive wear. scoring or cracks on the sealing faces. Renew where necessary.
5. Remove rust and scale from the impeller and examine for excessive corrosion or other damage. Renew where necessary.
6. Examine the pump pulley for signs of cracks. corrosion or any other damage. Renew where necessary.

To Re-Assemble the Water Pump

(Refer to Fig. N.2)

1. Insert the oil seal retainer (8) and oil seal (2) followed by the oil seal retaining flange (7).

2. Fit the two bearings (3) and spacer (6) onto the shaft (5) and pack the space between the two bearings approximately % full of high melting point grease.
3. Press the bearings and shaft assembly into the pump body, impeller end first and locate with the circlip (4).
4. Press the water thrower flange (9) into position on the drive shaft.
5. Thoroughly clean the insert recess and drain hole in the pump body.
6. Lightly coat the inner diameter of the insert recess and outside diameter of the insert with grade "AVV" Loctite.
7. After removing any traces of oil or grease from the insert, press it fully home. Remove all traces of Surplus Loctite.
   NOTE :—Special care must be taken during this operation not to mark the face upon which the seal registers.
8. Place the carbon-faced seal (11) on the drive shaft so that this face registers with the insert face.
9. Press the impeller onto the shaft over this seal until the clearance given on Page A.13 exists between the back face of the impeller and the pump body. This clearance can be checked as shown in Fig. N.4.
10. Press the pulley fully onto the shaft and fit the securing nut or circlip (where applicable).

    NOTE :— 4.108 Engines Only. When the pulley is originally pressed onto the shaft during production a pressure of 2½—3 ton/in² is required. Therefore it is recommended that if the pulley interference on the shaft is such that a substantially reduced pressure will press the pulley back onto the shaft. then a replacement pulley and/or shaft should be fitted.

To Refit the Water Pump

1. Fit the backplate followed by the water pump to the cylinder block using new gaskets lightly Coated with suitable sealing compound.
2. Secure the water pump assembly to the cylinder block with the four setscrews.
3. Refit the alternator belt and adjust to the correct tension.

THERMOSTAT

To Remove the Thermostat

1. Drain the coolant from the engine block.

N5

2. Remove expansion tank or thermostat housing (whichever is applicable).
3. Lift out thermostat, as in Figure N5.

To Test the Thermostat

1. immerse the thermostat in a suitable container of water and slowly heat. An accurate thermometer should be available to check the temperature of the water as it rises.
2. Note the temperature at which the valve in the unit commences to open. This temperature should be as stamped on the unit by the manufacturers.
3. If the unit does not function properly then a replacement thermostat will be required, as no adjustment of these units is possible.

To Replace the Thermostat

Replacing the thermostat is a reversal of the removal procedure. A new gasket should be fitted between the thermostat housing and the water outlet connection.

SECTION P
Fuel System

FUEL OIL FILTERS

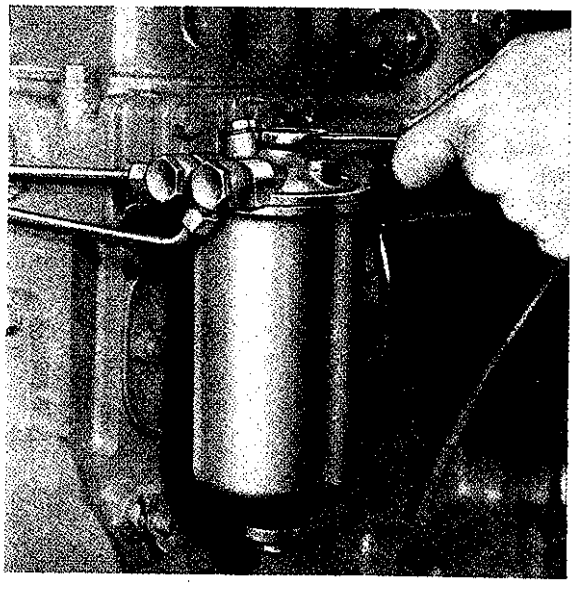
The element in this filter is of the paper type and therefore no attempt should be made to clean it. Its life will be governed by the quality and condition of the fuel passing through it, but under average conditions the element should be renewed in accordance with the recommendations in Operator Section. This period would naturally be reduced if it was apparent from the condition of the element if removed and inspected, that conditions warranted it.

To Renew the Filter Element

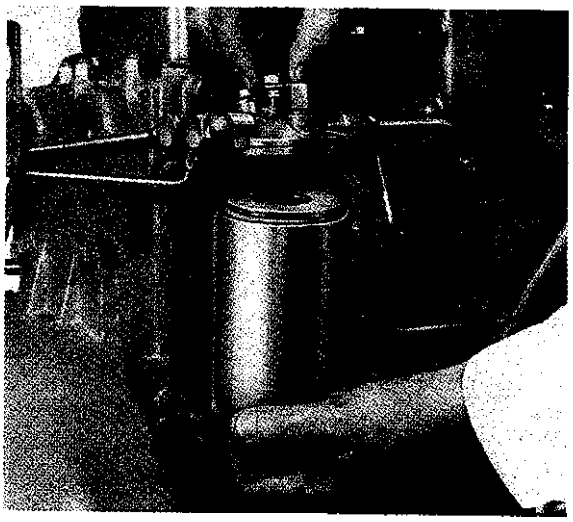
1. Unscrew the filter bowl securing bolt in the centre of the headcasting. Refer to Fig. P.S.
2. Lower the filter bowl clear as shown in Fig. P.6 then discard the fuel therein together with the old element.
3. Inspect the sealing rings and replace if damaged in any way.
4. Place the new element in position inside the filter bowl and Offer up the bowl firmly and squarely so that the top rim of the filter bowl locates centrally against the sealing ring in the filter head casting.
5. Hold in this position while the securing bolt is located and screwed home.

   NOTE : If the sealing rings are in good order and the bowl is located correctly, no excessive tightening will be required to obtain a leak proof seal.
6. Prime the fuel system as detailed on Page P.8.

   NOTE : Some filter bowls have a drain plug fitted. in this case the relevant manufacturers service literature should be consulted.



P5

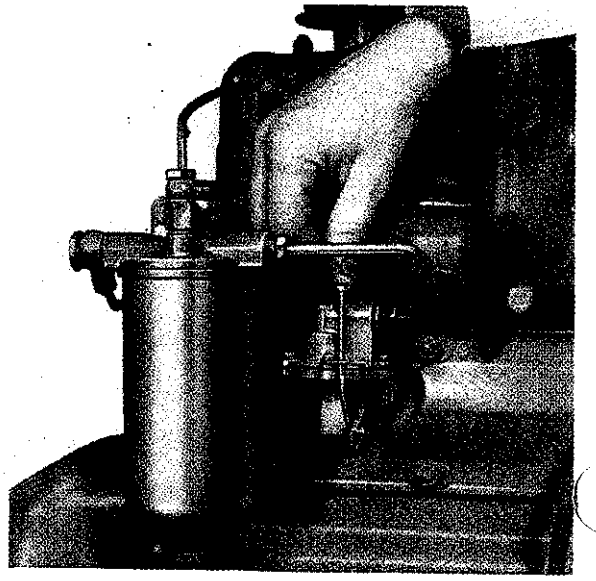


P6

FUEL LIFT PUMP
Testing the Pump in Position

1. Disconnect the outlet pipe (lift pump to filter) leaving a free outlet from the pump.
2. Rotate the engine and note if there is a well defined spurt of fuel from the outlet port once every two engine revolutions.

   NOTE: As an alternative the pump may be operated by means of the hand primer as shown in Fig. P.7, which should give the same result every time the priming lever is operated. However should the engine happen to have stopped in such a position that the eccentric operating the lift pump is in the maximum lift position, then it will not be possible to operate the hand primer properly. If such a condition arises the remedy is to rotate the engine one complete revolution.



To Remove the Lift Pump

1. Disconnect the pipes from the inlet and outlet ports. Seal the ends of the pipes to prevent the entry of foreign matter.
2. Remove the two nuts and washers holding the pump to the tappet inspection cover. Withdraw the pump, spacer and gaskets.

To Dismantle the Lift Pump

1. Before dismantling. make a file mark across the two flanges for locution purposes when the pump is being re-assembled.
2. Remove the five cover screws and separate the two main castings. then remove the diaphragm assembly from the lower half by turning the diaphragm through 90" in either direction.

   NOTE: The diaphragm and pull rod assembly is a permanent assembly and no attempt should be made to separate the parts.
3. Remove the retaining clip from one side of the pump body and push out the rocker arm retaining pin. Withdraw the rocker arm, etc.. from the body.
4. Prise out the valves with a screwdriver or other suitable tool.

Inspection

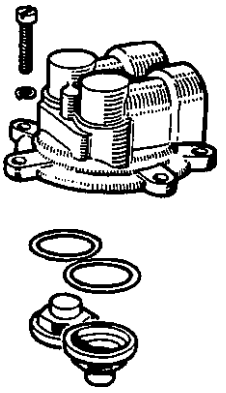
1. Check the diaphragm assembly and renew if the material is split or checked, or if serious wear is apparent in the link engagement slot.
2. The diaphragm spring should be replaced if faulty or corroded. A new spring should have the same color identification (Refer to Page 8.11).
3. Replace the valves unless they appear to be in perfect condition.
4. Examine the rocker arm, operating lever, rocker arm retaining pin and rocker arm return spring lor wear. Replace any parts where necessary.
5. Replace all joints. seals and washers as routine procedure.
6. Examine upper and lower castings for wear or distortion. Slight distortion of flanges can be remedied by grinding the flange face to restore flatness.

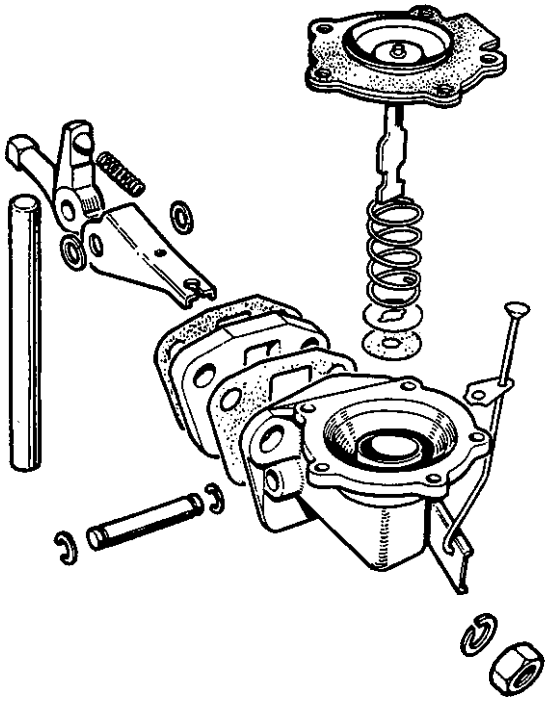
To Re-Assemble the Lift Pump

Examine the casting and ensure that there is sufficient material to provide a sound staking when new valves are fitted.

Clean the valve recesses to allow the new valves to be correctly fitted.

1. insert a new valve gasket in each valve recess.
2. Place the new valves in the recesses. The valve in the inlet port should be fitted with the spring outwards (i.e., towards the diaphragm flange) and the valve in the outlet port fitted in the reverse position.
3. Press the valves home with a suitable piece of tubing. approximately 9/16 in (14.29 mm) inside diameter and ¾ in (19.05 mm) outside diameter.





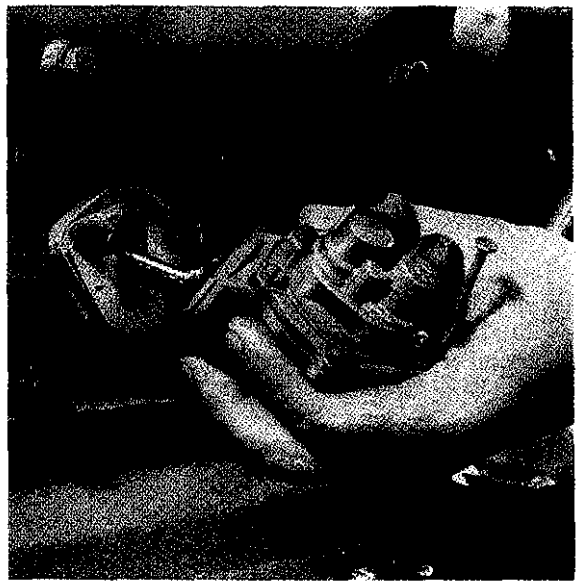
4. Stake the casting in six places (between the original stakings) round each valve. with a suitable punch.

   NOTE: Valves fitted to earlier lift pumps were held in position with a retaining plate and two screws. On no account should attempts be made to stake the valves of this earlier type pump.

5. Place the rocker arm retaining pin in the appropriate hole in the lower casting and push through until it protrudes slightly inside.
6. Fit one packing washer and link into the casting moving the pin in slightly to retain them.
7. Fit the rocker arm and return spring and retain by moving the pin in further, ensuring that the spring seats correctly.
8. Fit the remaining packing washer, then push the rocker arm retaining pin through the link, washer and casting until the ends protrude equally beyond the outside of the casting.
9. Retain by securing with the two clips
10. Insert the new rubber sealing washer followed by the steel seating washer and diaphragm return spring.
11. Place the diaphragm assembly over the spring with the pull rod downwards, locating the top of the spring in the diaphragm protector washer.
12. Now position the pull rod so that the flat notcheo blade has one of its thin edges facing the rocker arm. Press downwards on the diaphragm assembly and twist it through 90° in either direction, this action will engage and retain the pull rod in the fork of the link.
13. Operate the rocker arm against the diaphragm spring pressure until the diaphragm is level with the body flange.
14. Place the cover assembly in position and line up the file marks made on the flanges prior to dismantling.
15. Still holding the diaphragm level with the body flanges, fit the five flange securing screws, tighten evenly and securely.

To Refit the Fuel Pump

1. Fit the spacer using a gasket on either side.
2. Enter the pump operating lever into the recess in the tappet inspection cover as shown on Fig. **P.9** and secure with the two nuts and washers.
3. Reconnect the low pressure fuel pipes to the inlet and outlet ports.



P9

FUEL INJECTION PUMP

Description

The fuel injection pump, is of the D.P.A. distributor type. It is a precision built unit incorporating a simple hydraulic governor or alternatively one of the mechanical flyweight type depending upon the application to which the engine is fitted.

To Remove the Fuel Injection Pump

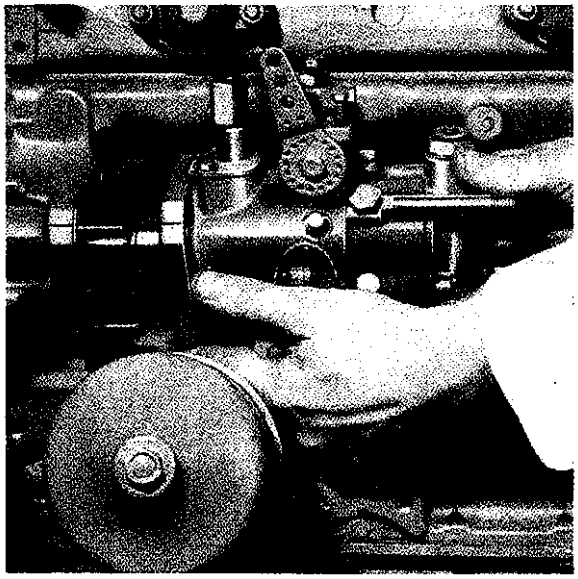
1. Remove the four high pressure pipes between the pump and the injectors and blank off all ports to prevent the ingress of foreign particles.
2. Remove the low pressure fuel pipes from the inlet and outlet connections and blank off all ports.
3. Disconnect the stop and throttle controls and their return Springs.
4. Remove the two nuts and the socket headed set. screw which secure the fuel pump to the mounting flange together with their spring and plain washers.
5. Carefully withdraw the fuel pump from its mounting.

To Refit the Fuel Injection Pump

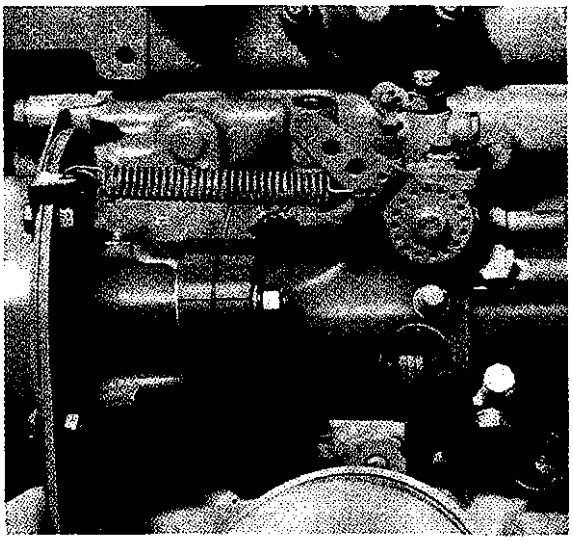
1. Replace the fuel pump mounting flange gasket (where necessary).
2. Fit pump as shown in Fig. P.8 ensuring that the master spline on its quill shaft is correctly positioned to engage with the female splines within the fuel pump drive hub.

   NOTE: This master spline ensures that the pump will only locate in the drive hub in one position for timing purposes. Further, when fitting the mechanically governed injection pump which uses a separate quill shaft, the noticeably shorter, splined end is fitted in the injection pump.

3. When the splines are in correct alignment the pump can be pushed in until the mounting flanges meet and the securing nuts and setscrew with their washers can be fitted.
4. Before tightening, align the timing marks scribed on the fuel pump mounting flanges as shown in Fig. P.II. Tighten the setscrew and nuts.
5. Refit the low pressure pipes to the inlet and outlet connections.
6. Refit the high pressure fuel pipes.
7. Reconnect the throttle and stop controls together with their return springs.
8. Prime the fuel system with fuel oil as detailed on Page P.8
9. Fuel pump timing can be checked as detailed in the following text.



P10



P11

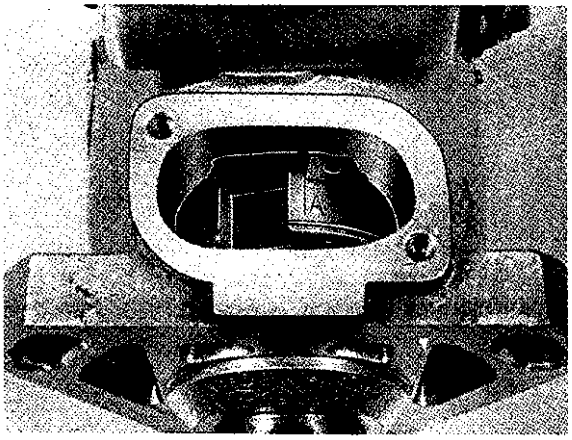
FUEL INJECTION PUMP TIMING

Reference should be made to the details given on Page L.l covering engine timing. if this timing sequence has been followed regarding the timing gears and the timing marks on the mounting flanges are correctly aligned as shown in Fig. P.II, then the fuel pump timing should be correct.

A further check is possible and utilises the internal timing marks within the pump body. To be able to see these marks necessitates the removal of the inspection cover.

On the fuel pump rotor inside the fuel pump, are a number of scribed lines, each one bearing an individual letter. A timing circlip, one end of which has a straight edge is positioned inside the pump body and is preset so that when the appropriate scribed line on the fuel pump rotor aligns with the straight end of the circlip. it denotes commencement of injection (static timing) see Fig. P.12.

NOTE: On earlier pumps. the timing circlip had a scribed line on one end and on these pumps, the scribed line on the fuel pump rotor should be aligned with the scribed line on the circlip.



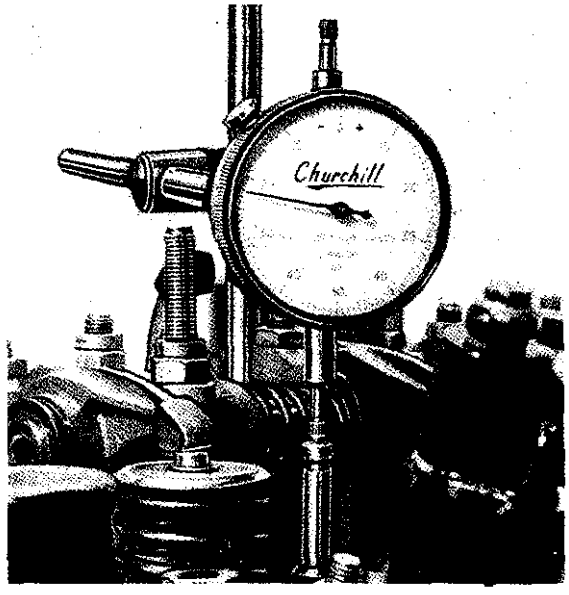
P12

CHECKING FUEL PUMP TIMING

1. Ensure that the fuel pump is correctly fitted with the scribed line on the mounting flange aligning with the adjacent mounting flange on the cylinder block (see Fig. P.II).
2. Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke.
3. Remove the cylinder head cover.
4. Slacken the valve adjusting screw on No. 1 exhaust valve Sufficiently to allow the rocker lever to be moved to one side and the push rod removed. rotate the rocker lever on the shaft, so that the valve spring cap is accessible for using the valve spring compressor.
5. Remove the collets, spring cap and springs from No. 1 exhaust valve and allow the valve to rest on the top of the piston.
6. With the aid of a dial indicator in contact with the end of the valve now resting on No. 1 piston, it will be necessary to position the crankshaft so that the piston will be 0.120 in (3,05 mm) B.T.D.C. this being the equivalent of 19' on the engine flywheel. Refer Fig. P.13.

   To do this, turn the crankshaft in the opposite direction to normal rotation, approximately an eighth of a turn and then forward until the required position is registered on the indicator. This enables the backlash in the timing gears to be taken up.

   NOTE: The above setting is for 4.108 marine engines. For other applications and engines see Page B.12.
7. Remove the inspection plate on the fuel pump enabling the rotor to be seen (Fig. P.12).
8. With No. 1 piston at the static timing point on its compression stroke, the scribed line on the rotor marked 'A' (for hydraulically governed engines) or 'C' (for mechanically governed engines) should align with the straight edge or scribed line on the timing circlip.
9. If the timing is incorrect proceed by either :—
   (a) making any necessary adjustments by means of the holes in the fuel pump gear. they are Slotted enabling the drive shaft to be turned relative to the gear when the securing setscrews are slackened. (Refer to Fig. K.6) or
   (b) by slackening the two nuts end socket headed Setscrew which secure the fuel pump to the mounting flange and turning the pump body in the direction required.
10. When the fuel pump timing has been set, turn the engine against the normal direction of rotation once again to the appropriate piston displacement to check that the squared end of the circlip is now aligned with the line on the rotor.
11. When the fuel pump timing has been correctly set, slowly turn the engine to T.D.C. in the normal direction of rotation, remove the indicator and refit the valve springs.
12. Refit the push rod and reset the valve clearance.



P13

NOTE!

Refer also to Service Bulletins No. 11, 21 and 29 for additional data on the fuel injection pump.

Maximum Speed Setting

The maximum speed screw (5) is set and sealed by the manufacturers and must not be altered or tampered with in any way, unless factory authority is first Obtained and any adjustments necessary are carried out by experienced personnel. As with all seals on the pump unauthorised removal may render the guarantee void.

The maximum no load speed may vary according to the application to which it is fitted, reference may be made to the code number stamped on the fuel pump data plate. The last four numbers in the code indicate the maximum no load engine speed, therefore in the case of the following example it would be 4480 rev/min. Code Example EH39/1200/0/4480.

NOTE : If the fuel pump data plate is damaged or defaced so as to make it impossible to read accurately. or if there is no code stamped on the plate you are advised to contact your nearest C.A.V. Distributor, or Westerbeke.

NOTE : The engine must not be allowed to operate at a Speed in excess of that specified or severe damage may occur.

INJECTORS

General

When replacing injectors in the cylinder head, it is essential that a new, correct type copper washer is fitted between the nozzle body and cylinder head.
The first symptoms of atomiser trouble usually come under one or more of the following headings :—

1. Misfiring.
2. Knocking in one (or more) cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption.

Testing for Faulty Injector

If an injector is suspected of being faulty, try this method to isolate it.

Loosen the union nut at the injector end of the high pressure fuel pipe. If each injector is isolated in turn in this way. (with the engine running at approximately 1.000 rev/min) tightening each union nut firmly before proceeding to the next, then the faulty injector, when isolated in this manner, will have little or no effect on the running.

Warning

Great care should be taken to prevent the hands or face from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

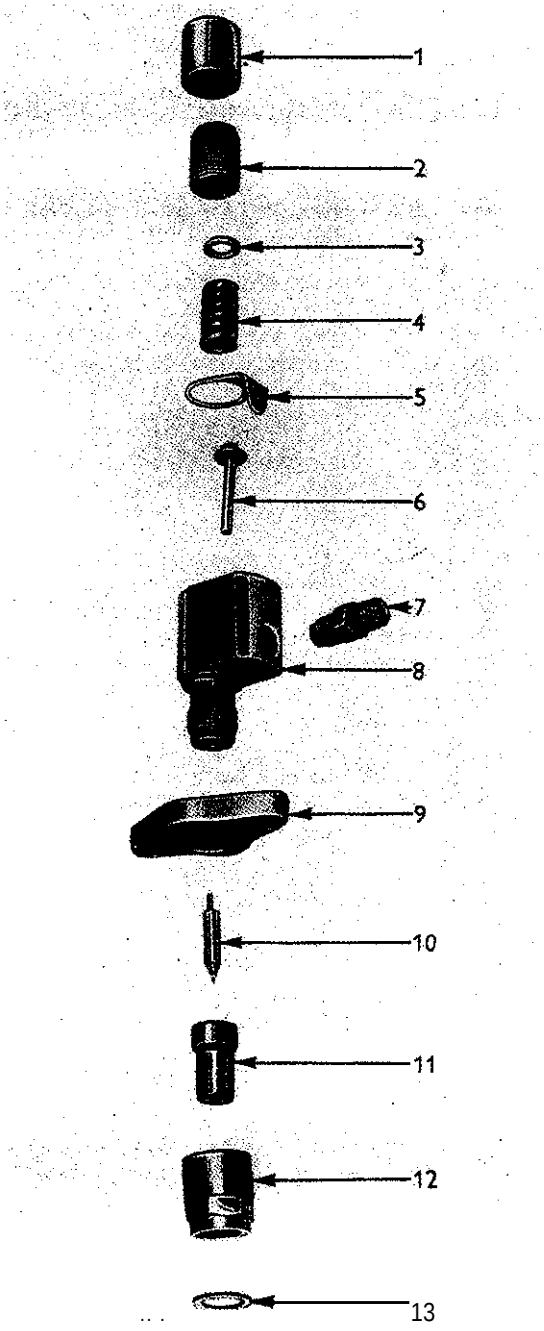
Injector Pressures

Details of holders and nozzle types together with pressure settings are given on Page B.12.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT AN INJECTOR TESTING PUMP OF THE TYPE ILLUSTRATED. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF INJECTORS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

Injector Identification

Injectors can be identified by code letters stamped on a tab washer fitted under the spring cap nut (see Fig. P.16) or alternatively, the code is stamped on the injector body. Details of codings can be found on Page B.12.



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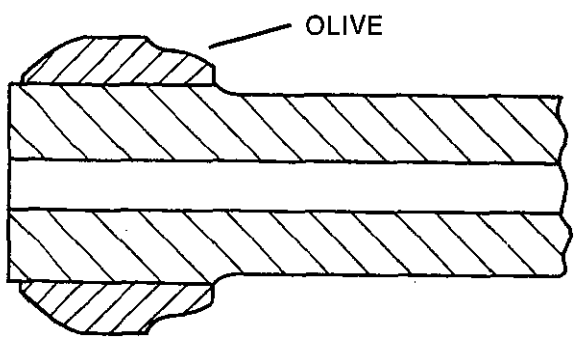
1. Capnut
2. Spring cap
3. Shim washer
4. Nozzle spring
5. Identification tab washer
6. Spindle
7. Fuel inlet union
8. Nozzle holder body
9. Securing flange
10. Nozzle needle
11. Nozzle body
12. Nozzle capnut
13. Copper sealing washer

Fuel Pipes (High Pressure)

When replacing the fuel pipes it should be noted that no two pipes are the same, each is formed to suit an individual injector position. This is important when ordering a replacement pipe, as each one has a different part number.

For standardization purposes, high pressure fuel pipes assemblies are now supplied with olives fitted as shown in Fig. P.17. The earlier type pipe assemblies with olives fitted in the reversed position are still satisfactory.



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The pipes should be clean. (wash in clean fuel oil and biow through the fine bore with compressed air if there is any doubt), the oiives at each end should not be split or unduly compressed, otherwise leakage will result and a new pipe will be needed.

Ensure when fitting. that the pipe fits squarely at both ends and that the union nuts are tightened firmly but not over-tightened.

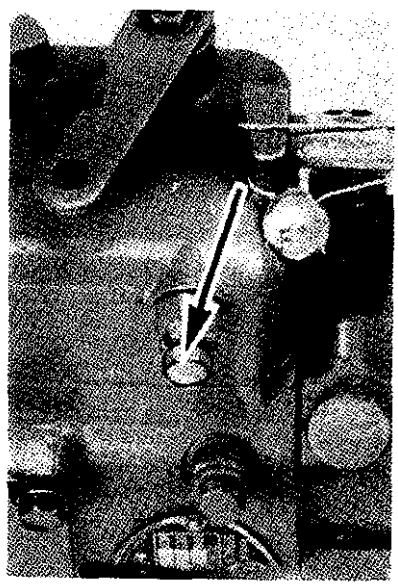
Priming the Fuel System

The air must be vented from the fuel system whenever any part of the system between the fuel tank and injection pump has been disconnected for any reason. or when the system has been emptied of fuel.

No attempt must be made to start the engine until the injection pump has been filled and primed as serious damage can be caused to the pump due to lack of lubrication.

The method of priming detailed below. ensures that only fuel which has passed through the paper filter element can reach the interior of the pump.

1. Slacken the air vent valve on the top of the control gear housing on hydraulically governed pumps (refer Fig. P.15) or on the front of the governor housing on mechanically governed pumps (refer Fig. P.18).
2. Slacken the vent valve fitted on one of the two hydraulic head locking screws
3. Slacken the vent screw on the top of the fuel filter
4. Operate the priming lever on the fuel feed pump (Refer to Fig. P.7) and when fuel. free from air bubbles, issues from each venting point, tighten the screws in the following order :—
   1. Filter cover vent screw.
   2. Head locking screw vent valve.
   3. Governor cover vent valve.
5. Slacken the pipe union nut at the pump inlet. operate the priming lever and retighten when fuel oil, free from air bubbles issues from around the threads.
6. Siacken the unions at the injector ends of two of the high pressure pipes.
7. Set the throttle at the fully open position and ensure that the "stop" control is in the "run" position.
8. Turn the engine until fuel oil, free from air bubbles. issues from both fuel pipes.
9. Tighten the unions on both fuel pipes. and the engine is ready for starting.



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Priming Procedure after Changing a Filter Element

1. With the vent screw on the filter cover removed. and the union at the filter end of the return pipe (filter to tank) slackened, operate the feed pump priming lever until oil, free from air bubbles, issues from the filter cover vent.
2. Replace the vent plug, and continue to operate the priming lever until oil, free from air bubbles. issues from around the threads of the return pipe union.
3. Tighten the return pipe union.
4. Slacken the union at the filter end of the filter to injection pump feed pipe, and operate the priming lever until oil, free from air bubbles, issues from around the union threads.
5. Tighten the feed pipe union. The pump and filter are now filled and primed and ready for further service.

OTHER

CONTENTS

ELECTRICAL SYSTEM

Earlier engines were equipped with Delco-Remy electrical accessories operating on a nominal 24 volt system. The generator and voltage regulator have been replaced with a Motorola alternator and regulator.

STORAGE BATTERY

Terminal voltage must conform to the 24-volt svstem. and the batterv may be either four 6-volt units in series or two 12-volt units. Recommended capacity is 130 ampere hours, minimum. For cable sizes refer to table on Page 24. Batteries are not supplied with the engine.

BATTERY MAINTENANCE

Check electrolyte level once a week. Make sure that storage batteries are kept filled with fluid level approximately 3/8" above the plates, and fully charged. Proper specific gravity for full charae is 1.220-1.280. Add pure water (preferably-distilled) as necessary' to each cell. If impossible to obtain distilled water, use rain water or clean fresh water which is free of minerals. Do not overfill, and be sure the vents are kept open in filler caps: these are for the escape of gas from the electro-chemical action. Keep the terminals clean and the connection clamps tight. Smearing the battery posts and cable terminals with light grease after tightening the connections will help prevent corrosion.

500-WATT GENERATOR

This is identified as assembly part number 1117731, a direct current,, insulated system, 24-volt 18-amp. unit. It is atwobrush. 4 pole, shunt wound, voltage and current regulated generator, "circuit" type, driven at twice engine speed, with cut-in speed at 800 enaine rpm. Rotation is CW when v'iewed from the-drive end. The construction includes fungicidal and corrosion treatment.

The generator is hinge mounted on the starboard side of the engine, front end, and driven with a v-belt from the crankshaft pulley, this same belt also driving the fresh water pump. Adjustment of the belt tension is regulated by an adjustment strap anchored to the timing gear case housing.

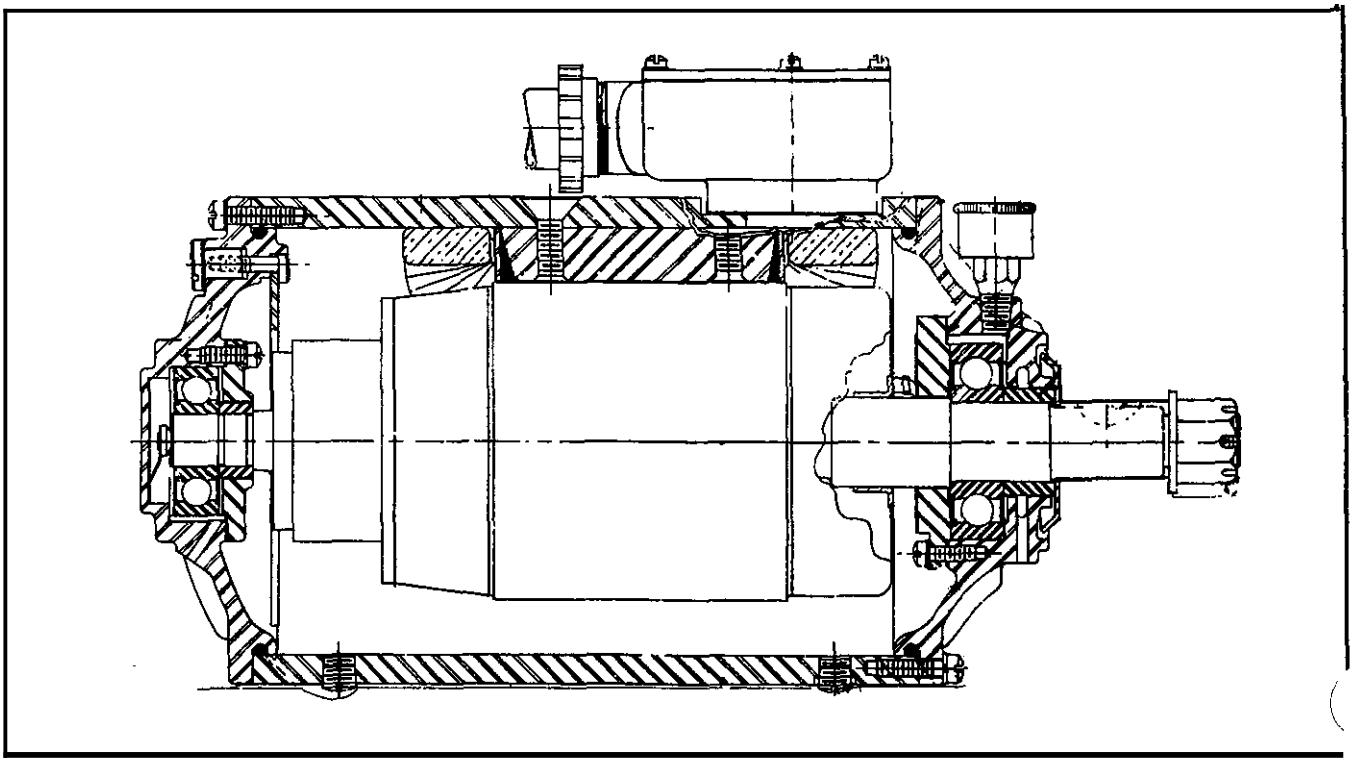


Fig. 117–Generator Assembly

The armature is supported by double sealed ball bearings at the drive end and the commutator end. The commutator end bearing is protected from water by a special cover and gasket. Water sealing at the drive end is by a special assembly that is replaceable from outside the generator. Inspection of the commutator can be made by removing a special gasket sealed inspection plug in the generator frame. Terminal outlets are housed in and protected by a special receptacle provided for sheathed conduit with a 1-1/8-18 thread coupling. Wires leading from generator to regulator correspond to Battery, Armatureand Field terminals. A capacitor on the output lead reduces radio interference. The generator output is regulated by the current settings of the current and voltage regulator.

GENERATOR MAINTENANCE

This moy be divided into two sections, normal maintenance required to assure continued operation of the generator, and the checking of inoperative units. A periodic inspection should be made of the charging circuit. Make it a rule to do it every time the lubricating oil is changed. Keep all connections clean and tight. Preventive maintenance includes the following:

1. Lubrication - The ball bearing used in this generator should be lubricated by turning the grease cups down one full turn every time the lubricating oil is changed. Use ball bearing grease to refill grease cups when required. Never oil commutator.

2. Inspect condition of generator drive belt for tightness, cracks, fraying or other signs of deterioration. Replace belt if badly worn. Adjust belt tension as necessary to prevent possibility of slipping, by means of the adjusting strap on generator mounting. The tension is correct when the vee-belt can be depressed a distance equal to the thickness of the belt ,when thumb is pressed against the center of the span.

3. Visually inspect all wires for signs ofbreaks. abrasion spots caused by rubbing, also for signs ofoverheatingorcorrosion. Repair or replace any faulty wiring at once.

4. Visually and by feel inspect all terminals and connections for cleanliness and tightness. Also inspect for shorts or grounds.

5. Inspection -The commutator end framemust be removed for periodic inspection of brush and commutator condition. If the commutator is rough, out of round or has high mica, or the brushes show excessive wear, the generator must be disassembled. The armature must be turned down on a lathe and the mica undercut. Worn brushes should be replaced.

6. Brushes will wear from use and must be replaced when they get too short. Inspect each for .length, condition of pigtail, and freedom of movement in brush holder. Brush tension should be approximately 28 ounces. This can be checked with a spring gauge, and correction can be made by bending the brush spring as required. If the brush spring shows evidence of overheating (blued or burnt) do not attempt to readjust it, but install a new one. Overheating will cause a spring to lose its temper. If the brushes ore worn down to less than half their original length, they should be replaced. The length of a new brush is 15/16". Use a brush seating stone for abrasive to seat the new brushes to the curve of the commutator, and blow out all dust with compressed air after the brushes are seated.

7. After replacing the end frame, clean the exterior of the generator.

GENERATOR DISASSEMBLY

At regular intervals the generator should be disossembled for a thorough cleaning and inspection of all parts. Never clean the armature or fields in any degreasing rank using heated vapors or by dipping in any degreasing solution, since these may damage the insulation. These parts may be cleaned by brushing with clean spirits or kerosene. The sealed ball bearings should be inspected and replaced if necessary. All wiring and connections should be checked. Rosin flux should be used in making all soldered connections. Acid flux must never be used on electrical connections.

CHECKING INOPERATIVE GENERATOR

Several conditions may require removal of the generator from the engine and further checking of the generator, as follows:

1. No output
2. Unsteady or low output
3. Excessive Output
4. Noisy generator

1. No output - Remove cover and check commutator bors or a loose connection. Burned bors, with other bars fairly clean, indicate open circuited coils. If brushes appear to be making good contact with commutator and commutotor appears normal, use test points and a test light to locate trouble as follows (leads must be disconnected from generator):

   a. Check field for open circuit. The lamp should light when one test point is placed on FIELD terminal and the other on the field frame or any convenient ground. If it does not light, the circuit is open. If the open is due to a broken lead or bad connection, it can be repaired, but if the open is inside one of the field coils, the coil must be replaced.

   b. If the field is not open, check for shorted field by connecting a battery of the specified voltage and an ammeter in series with the field circuit. Field draw at 24 volts should be .85-.89 amperes. Excessive current draw indicates a shorted field.

   NOTE: If a shorted field is found, check the regulator contact points since a shorted field may have permitted excessive field current which would have caused contact point to burn. Clean or replace parts as required.

   c. If trouble has not yet been located, disassemble generator and check armature. brush holders, and field circuits. Repair or replace parts as required.

2. Unsteady or Low Output - Check as follows:

   a. Check drive belt tension

   b. Check brush condition.

   c. Inspect commutator for roughness(grease and dirt, high mica, out-of-round! or burned bars. With any of these conditions the commutator must be turned down in a lathe and the mica undercut. In addition, with burned bars which indicate open circuit, the open circuit condition must be eliminated orthearmature replaced.

3. Excessive Output - This condition may result from:

   a. Improper voltage setting.

   b. Defective voltage regulator unit.

   c. Short circuit between the charging circuit and field circuit, in the generator, or regulator, or wiring.

   d. Poor ground connection at regulator.

   e. High battery temperature which reduces the resistance of the battery to charge so thot it will accept a high charge rote even though the voltage regulator is set normal.

   If the trouble is not due to high battery temperature, determine the cause by opening the field circuit (breaking field lead between generator and regulator) with the generator operating at 'medium speed. If the output drops off, the regulator is at fault and it should be inspected for high settings or short circuits.

4. Noisy Generator - Noisy generator may be caused by loose mounting, loose drive pulley, worn or dirty bearings, or improperly seated brushes.

   To set brush neutral setting, remove end cover plate to expose two brush plate attaching screws. Loosen enough to permit shifting of the brush plate. Place a thin ridged strip of material (small rule will work) between brush and brush holder so that the strip will extend through the inspection hole. Connect one side of a battery to the "A" receptacle of the generator and ground the other side of the battery to any convenient ground on the generator. Locate brushes in a neutral position, disconnect battery and mark position of inserted strip on side of the inspection hole.

Shift brush plate ahead (direction of armature rotation) until the inserted strip is 3/32"-1/8" ahead of neutral marking on side of inspection hole. At this point. 3/32-1/8" on the field frame is equivalent to 1/8 to 1/4 commutator bar of movement.

INSTALLATION CAUTION

After the generator is reinstalled on the engine or at any time after leads have been disconnected and then reconnected to the generator, the generator must be repolarized. This can be done in the following manner:

Disconnect the lead from the FIELD terminal of the regulator and momentarily touch this lead to the BATTERY terminal of the regulator. This allows a momentary surge of current to flowthroughthe generator field windings in the proper direction. Failure to do this may result in severe damage since reversed generator polarity causes vibration, heavy arcing and burning of the relay contact points.

GENERATOR REGULATOR

Since the generator used on these engines operates on what is known as a two-wire or insulated (non-grounded) system, the regulator is of a type to conform to this system. The regulator is mounted off the engine.

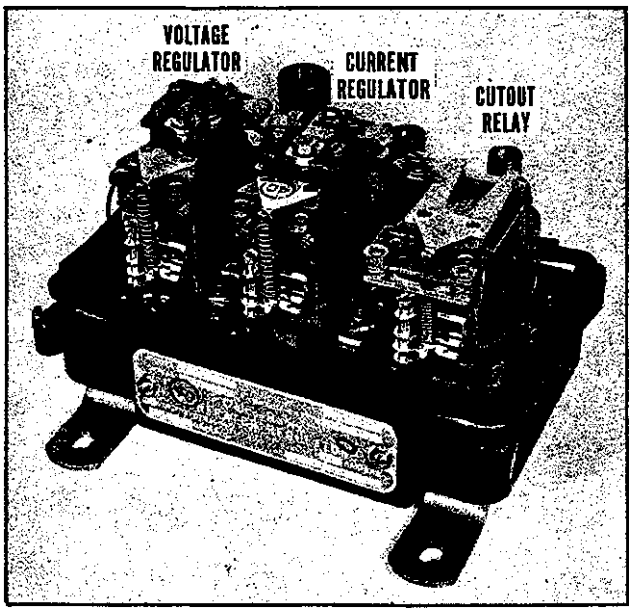


Fig. 118--Generator Regulator

The regulator shown in Fig. 118 consists otfour units: an actuating relay, a circuit breaker relay, a current regulator and a voltage regulator, all mounted in a single receptable with cover, and connected to the generator and battery as shown in wiring diagram, page 20.

The actuating relay and circuit breaker relay function together to close the circuit between the generator and battery when the generator voltage is sufficient to charge the battery. They open the circuit when generator voltage falls below battery voltage when engine is stopped or idling so that the battery will not discharge through the generator. .The current regulator is a current limiting devise which preventsthegeneratorfrom exceeding its specified maximum. The voltage regulator is a voltage limiting devise which prevents the system voltage from exceeding a specified maximum, thus causing a tapering charge rate to the battery as it approaches full charge and protecting electrical units from excessive voltage. The Delco-Remy testspecification number is 2120.

The test specifications are as follows:

Cutout & Actuating Relay • Closing Voltage

Range 25-27 volts — Adjust to 26.0 volts

Voltage Regulator Setting

Range 28.0-29.5 volts — Adjust for 28.5 volts

Current Regulator Setting

Range 16-20 amps — Adjust for 18 amps.

Voltage Regulator Air Gap.	.084 in.
Current Regulator Air Gap.	.084 in.
Circuit Breaker Air Gap.	.042 in.
Circuit Breaker Point Opening.	.040 in.
Circuit Breaker Back Air Gap	.008 in.
Actuating Relay Air Gap	.037 in.
Actuating Relay Point Opening	.037 in.
Actuating Relay Back Air Gap	.008 in.

Actuating and Circuit Breaker **Relays** - Description: The actuating and circuit breaker relays operate together to perform the same function as the cutout relay on other regulators. When the actuating relay operates it 'actuates' or causes the circuit breaker relay to operate. The circuit breaker relay then functions to close or openthecircuitbetween the generator and battery.

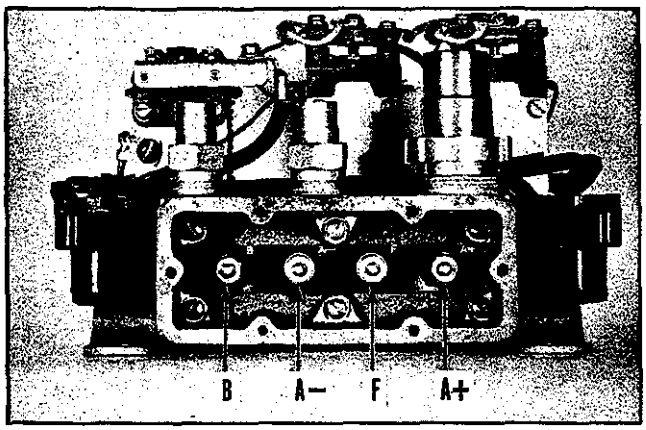
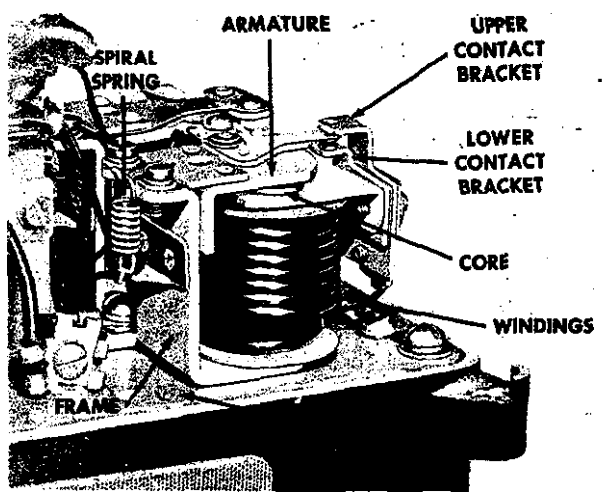


Fig. 119–Regulator Terminals

The actuating relay (Fig. 119A) contains two windings and an upper and a lower set of contact points. One of the windings is a series winding of a few turns of heavy wire (shown in solid lines in Fig. 119C) which is connected into the charging circuit. The second winding is a shunt winding consisting of many turns of fine wire (shown in dotted lines), which. in series with o resistor, is shunted across the generator. One or the other set of contact points is olwoys closed excepting when the armature is in motion between the two extreme armature positions.

The circuit breaker relay (Fig. 119B) contains a shunt winding (shown in dotted lines, Fig. 119C) on a core above which is an armature with two heavy duty contact points. Beneath these are two stationary contact points. One of these is connected through the regulator to the generator insulated terminal, and the other is connected to the battery through the wiring circuit.



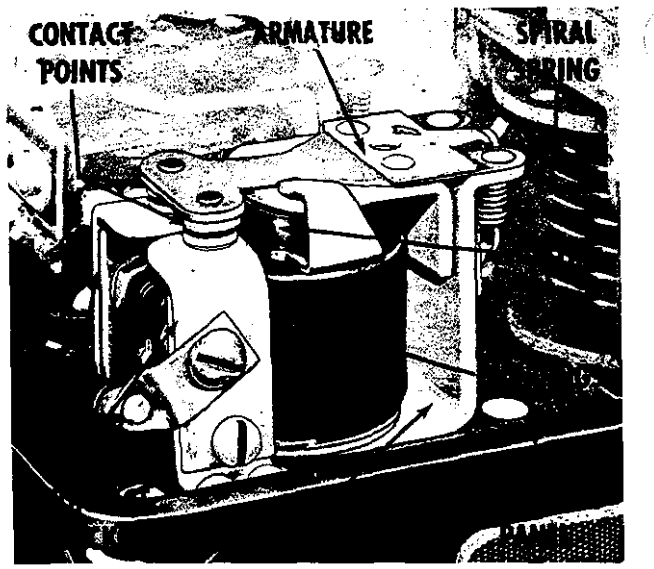


Fig. 119B–Circuit Breaker

When the generator is not operating, this actuating relay ormatureisheldintheupper position by the tension of a spiral spring so that the upper contact points are closed and the lower conta points are open. When the generator begins to operate, a magneticfield builds up in the actuati relay shunt winding. When the voltoge reache the value for which the relay is adjusted, the ma netism is sufficiently strong to pull the armatu down towards the core causing the upper conta points to open and the lower contact points close.

Closing of the lower contact points connects the circuit breaker relay shunt winding (Shown in dotted lines) across the generator. This creates a strong magnetic field which pulls the circuit breaker relay armature down so that its points close completing the circuit between the generator and the battery.

During the small fraction of a second that the circuit breaker relay points are closing, generator voltage is impressed across the entire circuit breaker relay shunt winding. This causes a very rapid relay action.

When the circuit breaker contact points have closed the major part of the winding is shunted across the generator by means of a connection to the relay armature. Thismannerofconnecting the winding assures better relay operation, since any shock or vibration which mightcause the actuating relay p i n t to bounce open will not cause the circuit breaker relay points to open as long as the actuating relay upper contact points do not close

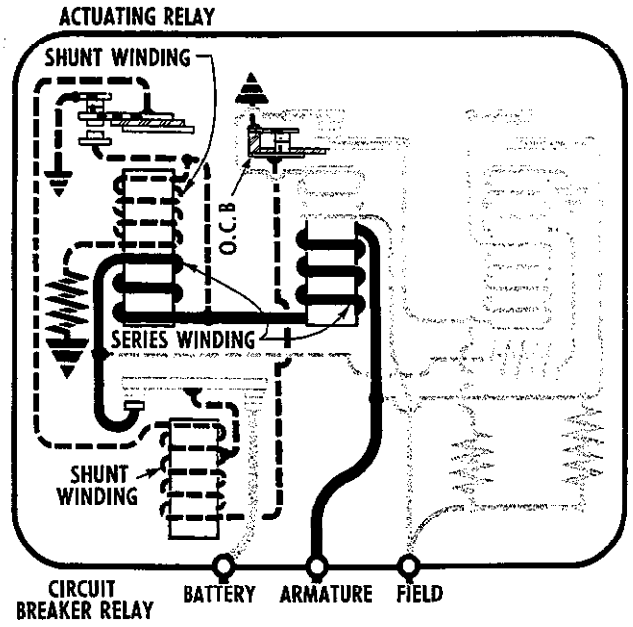


Fig. **119C–Wiring** Diagram **of Actuating Relay** and Circuit **Breaker** Relay

When the generator voltage drops below battery voltage current flows from the battery to the generator. This reverses the flow of current through the actuating relay serieswinding (shown in solid lines, Fig. 119C). As a result, the series winding (solid lines) and the shunt winding (dotted lines) no longer help each other, but become magnetically opposed. The resultant magnetic field becomes too weak to hold theactuating relay armature in the lower position. The armature spring tension opens the lower points and closes the upper points. The upper contact points, in closing, connect the insulated end of the circuit breaker relay winding to ground. This causes the upper part of the circuit breaker relay shunt winding (dotted lines) to magnetically oppose the lower part so that the resultant magnetic field becomes too weak to hold the circuit breaker armature down. The armature is releasedand the spring tension opens the points. This design of relay provides rapid and positive relay action.

Voltage Regulator - Description: The voltage regulator (See Fig. 120 and **123)** contains two windings assembled on a single core. One of these is a shunt winding consisting of many turns of fine wire, which in series with a resistor, is shunted across the generator. The circuit is thus **subject** to generator voltage at all times. The second winding is an accelerator winding consisting of many turns of fine wire, which in series with a resistor, is connected between the field side of the contact points and ground. The windings and core are assembled into a frame. Above the core is an armature and a stationary point which are identical in construction to those used on the current regulator.

When the generator voltage reaches the value for which the voltage regulator is adjusted, the magnetic field produced by current in the shunt winding, plus that created by the current in the accelerator winding, overcomes the armature spring tension, pulling the armature down and thus separating the voltage regulator contact points. Separation of the points diverts the field current through a resistorwhich isconnected across the points. The increased resistance of circuit reduces the field current and the generator voltage. The reduction in generator voltage in turn results in a loss of magnetic strength in the shunt winding. When the contacts open, the flow of current through the accelerator winding is cut off, causing a reduction in the total magnetic strength of the core. This weakens the magnetic field strength of the core so that the armature spring pulls the armature up, causing the contact points to close. This re-establishes the original circuit and permits the generator voltage to increase. The preceding cycle is then repeated at the rate of about **50** to **150** times a second, thus limiting the generator voltage to a predetermined maximum.

Limiting the generator voltage in this manner protects voltoge-sensitive units in the electrical system and causes the charging current to the battery to taper off as the battery approaches full charge.

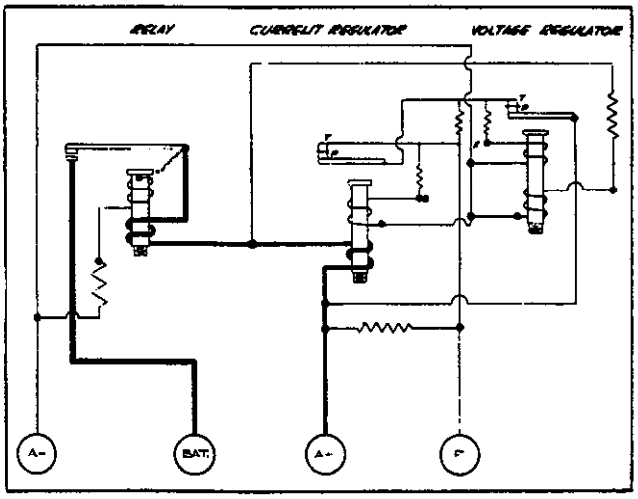


Fig. **120–Regulator Wiring Diagram**

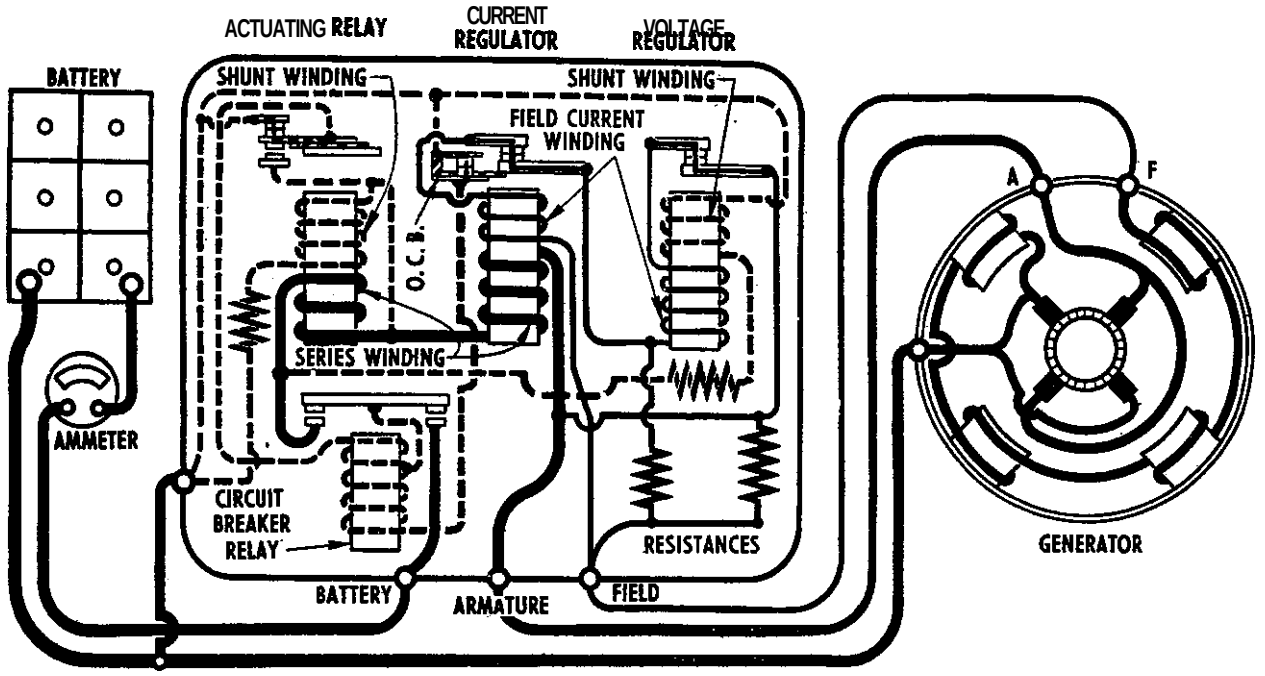


Fig. 121–Generator Circuits

Current Regulator - Description: The current regulator contains two windings on the same core – a series winding and an accelerator winding. The series winding consists of a few turns of heavy wire, and it is connected into the charging circuit so that the full generator output passes thru it. The winding consists of many turns of fine wire and, in series with a resistance, is connected between the field coil side of the contact points and ground.

The core and windings are assembled into a frame, similar to that of the voltage regulator (Fig. 123). A flat steel armature is attached to the frame by a hinge so that it is just above the core. The armature contains a contact point which is located just beneath a stationary contact point. When the current regulator is not operating the spiral spring tension holds the armature away from the core so that the armature contact point and stationary contact point are not touching. The stationary contact point is assembled into a flat spring which rises slightly above the fiber mounting bracket when the contact points are together. This arrangement permits awiping action between the points as they close and open which assures better contact between them.

The instantaneous current flows from the field ground in the generator to the regulator ground, where several paths for current flow are available. One path through a resistance unit, returns to the insulated side of the field coils, to complete the circuit. The accelerator windings on both the current and voltage regulator units are in parallel and the inductive flow thru these windings opposes the magnetic effect of the working windings. This increases the rate of armature vibrations, resulting in an exceptionally smooth-operating regulator.

The current regulator is adjusted tooperatewhen the generator output reaches its specified maximum. When this output is reached, the magnetic field created by the current flow through the series winding, plus that created by current in the accelerator winding is sufficient to overcome the armature spring tension. The armature is pulled down toward the winding core, and the points are separated. As soon as the contact points open, the field current is diverted through a resistor which is connected across the points. Inserting a resistance in the generator field circuit in this manner reduces the generator field current, which in turn reduces the generator output. The reduction in generator output causes a decrease in the magnetic field strength of the current regulator series winding.

In addition to the regulating resistance in series with the field coils, a parallel **resistance** is used to absorb some of the inductive energy produced when the regulator contact points open. Inductive voltage, of course, causes current to continue to flow in the same direction as the original current flow. Thus, when the contacts open, the generator field coils becomethesource of the supply and the current must be traced from this point.

REGULATOR MAINTENANCE

1. Mechanical **checks** and adjustments (air gaps, point openings) must be made with the battery disconnected.

   CAUTION: The cutout relay contact points must never be closed by hand with the battery **connected** to the regulator. This would **cause** a high current to flow thru the units and would seriously damage them.

2. All voltage checks must be mode with the **regulator** on open circuit (battery **disconnected**). Voltage and current regulator **checks** must be made at specified speed (2000 engine rpm, corresponding to 4000 generator **rpm**).
3. The regulator must be in operating position when electrical settings are checked and **adjusted,** and it must be stabilized **at operating temperature.** Failure toobservethese rules will cause serious errors in checking and **adjusting** voltage regulator settings.
4. After any tests or regulator adjustments requiring leads to be disconnected, the generator must be **repolarized,** as covered on page Q.4. This must be done after leads are reconnected, but BEFORE ENGINE IS STARTED.

Service - Circuit Breaker Relay: Three **adjustments** are required, air gap, point opening and closing voltage.

AIR GAP - The air gap should be measured between thearmatureandthecenter ofthecore with the points just touching. Place fingers on the two sides of the ormoture and push down until the points just touch to measure the air gop (Fig. 122A). Adjust by loosening the fourscrews attaching the two lower contact brackets and raise or

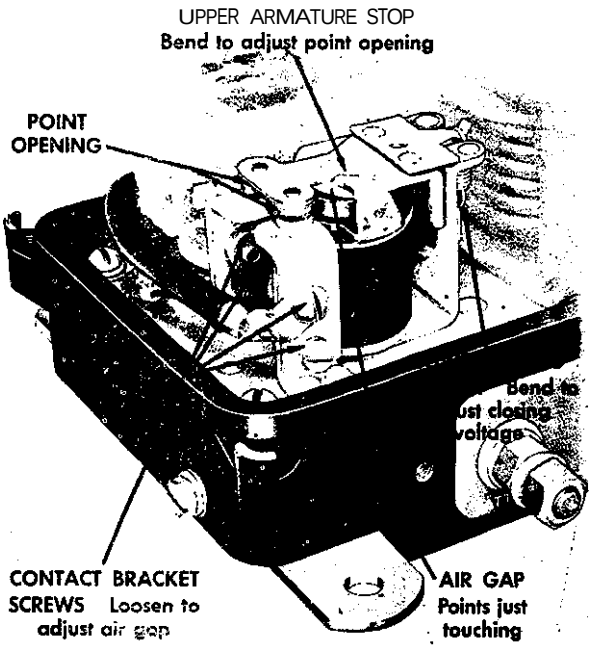


Fig. **122**—Circuit **Breaker** Relay **Adjustments**

lower as required (Fig. 122B). Be sure the points are in accurute oiignmentand tightenscrewsafter adjustment. BOTH SETS OF POINTS MUSTCLOSE SIMULTANEOUSLY.

POINT OPENING - The point opening is **measured** with ihe points open and, (Fig. 122) ond **adjusted** by bending the upper armature stop (Fig 122C).

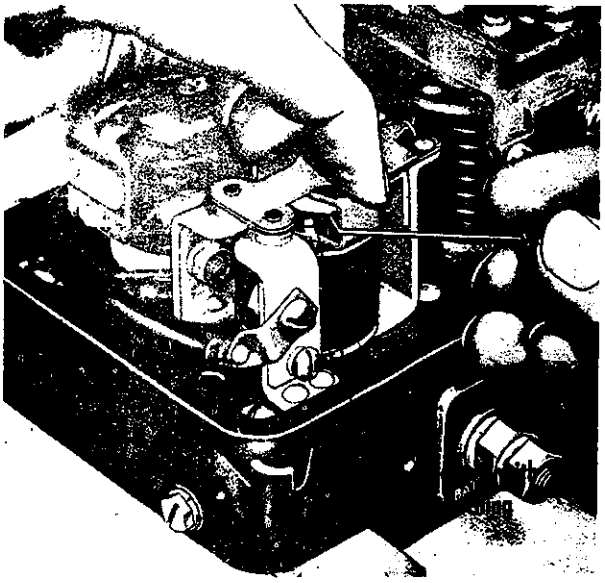


Fig. 122A Checking Air Gap on Circuit Breaker Relay

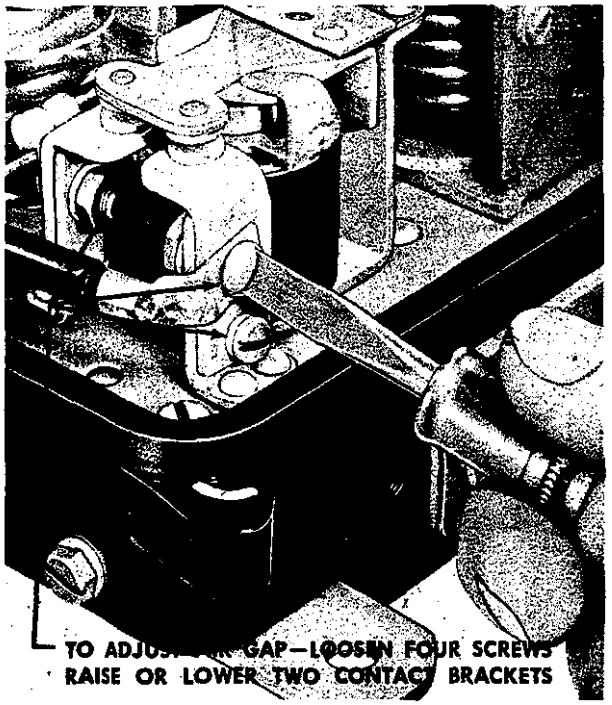


Fig. 1229–Adjusting Air Gap on Circuit Breaker Relay

CLOSING VOLTAGE - To check the closing voltage of the circuit breaker relay, the regulator must be connected in the proper manner to the generator. Do not connect a battery to the regulator; the regulator BATTERY terminal must be disconnected. Hold the actuating reloy armature down by hand to open the actuating relay upper contact points, and close theactuating relay lower contact points. A voltmeter should be connected from the regulotor ARMATURE terminal and the ground screw at the end of the regulator and the lead must be disconnected from the BATTERY terminal of the regulator (Fig. 122D). Slowly increase generator speed and note the voltage at which the circuit breaker relay points close. Bend the lower spiral spring hanger to adjust the closing voltage (Fig. 122E). Bend the hanger up to decrease or down to increase the closing voltage.

After each change of adjustment and before taking the closing voltage reading, reduce generator speed and open the voltage regulotor points momentarily. This will cause the voltage to drop so that the effect of residual magnetism in the relay core is nullified. Then allow the voltage regulator points to close and slowly increase generator speed to check relay closing voltage. It may be necessary to repeat this operation several times in order to get on accurate check of the relay closing voltage.

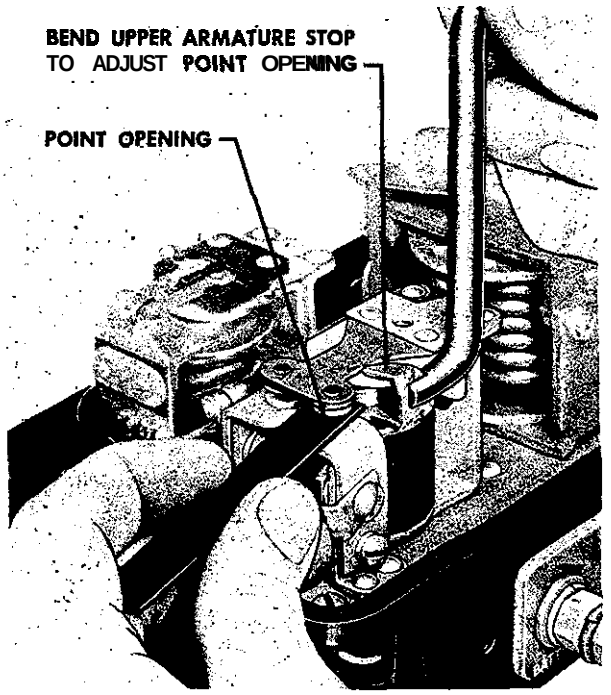


Fig. 122C–Checking and Adjusting Point Opening on Circuit Breaker Relay

SEALING VOLTAGE: The sealing voltage is the voltage at which the armature seals against the winding core. If the difference between closing voltage and the sealing voltage is not within limits (see pg. Q.4) adjust by decreasing the air gap to decrease the difference or increase the air gap to increase the difference.

Service - Actuating Relay: Three checks and adjustments ore required on the actuating relay: air gap, point openingandoperating voltage (Fig. 122F).

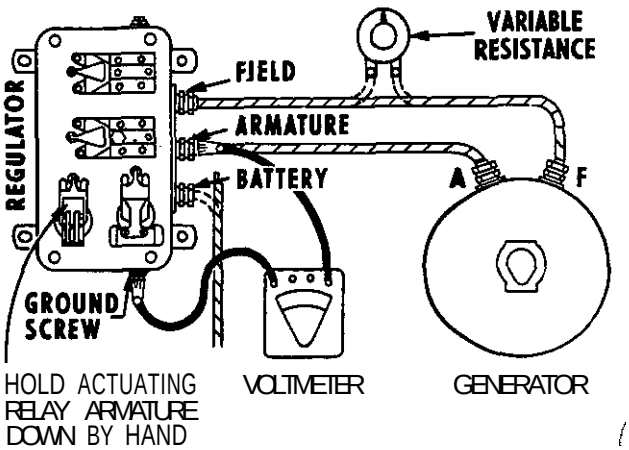


Fig. 122D–Voltmeter Connections to Check Closing Voltage of Circuit Breaker Relay

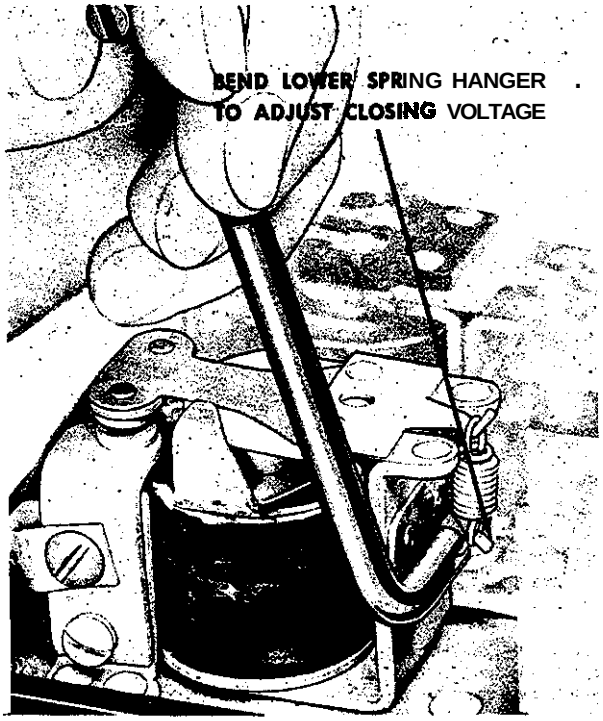


Fig. **122E—Adjustment** of **Circuit Breaker Relay** Closing **Voltage**

AIR GAP - The air gap should be measured between the armature and the center of the core (not residual pin in armature) with the lower contacts just touching (Fig. 122G). Place finger on the center of the armature to push the armature down when measuring air gap; do not push down on the flat springs which support the contacts. Adjust by loosening the two screws which attach the stationary contact and raise or lower the support as necessary. Be sure support is square on mounting bracket and tighten attachingscrews securely after adjustment is complete.

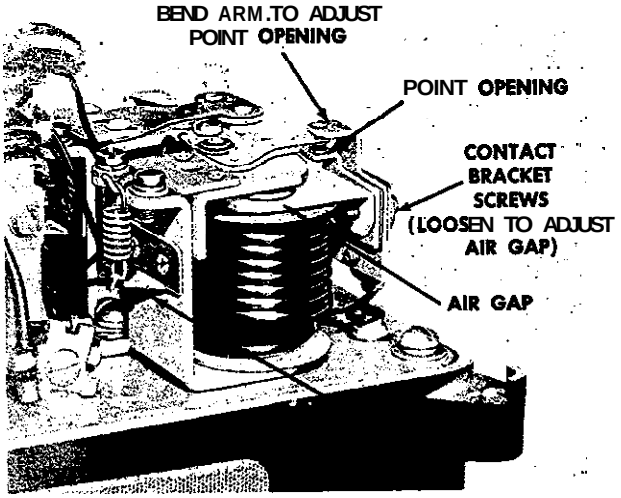


Fig. **122F—Adjustments Required** on **Actuating Relay**

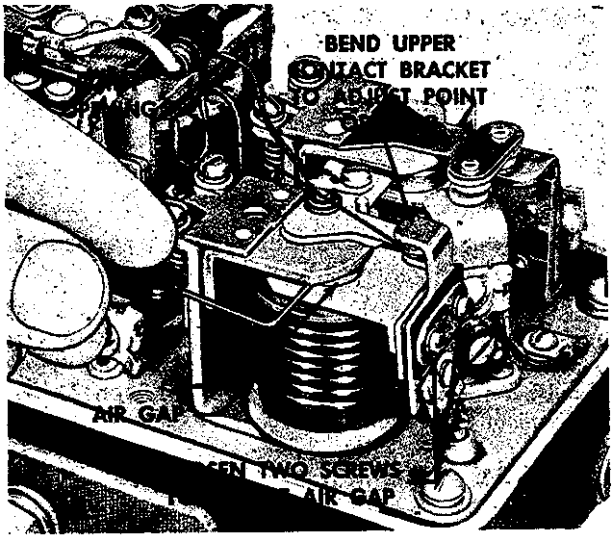


Fig. **122G—Actuating** Relay Air **Gap** and Point Opening **Checks and Adjustments**

POINT OPENING - Check point opening of lower contact points with upper contact points just touching. Place finger on the center of the armature, push down until upper points open, release until upper points just touch (Fig. 122G). Then measure point opening. Adjust by bending the flot spring which supports the uppercontactonthearmature.

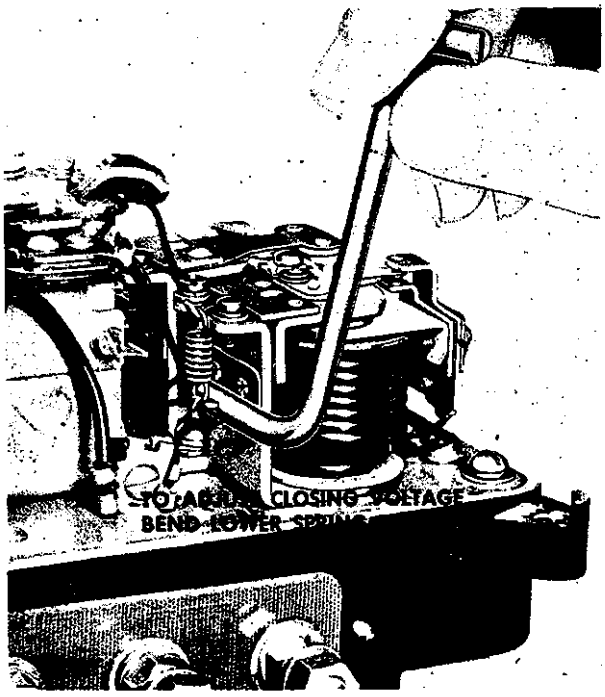


Fig. 122H—Adjustment of **Actuating** Relay Closing **Voltage**

OPERATING VOLTAGE - Connect a voltmeter from the regulator ARMATURE terminal to the ground screw on the end of the regulator. Slowly increase the generator speed and note the voltage at which the actuating relay closes. This will be indicated by a sharp click procuced as the circuit breaker contacts close in response to the closing of the actuating relay lower contacts. To adjust the closing voltage. bend the lower spiral spring hanger (Fig. 122H). Bend down to increase the closing voltage and up to decrease the closing voltage. After each change of adjustment, and before taking closing voltage reading, reduce generator speed and open the voltage regulator points momentarily. This will cause the voltage to drop so that the effect of residual magnetism is nullified. Then allow the voltage regulator points to close and slowly increase generator speed to check relay closing voltage. It may be necessary to repeat this operation several times in order to get on accurate check of the relay closing voltage. (If a variable resistor is used in the field circuit to control voltage during testing, the generator should be cycled before each reading by reducing the voltage below 6 volts).

Service - Voltage Regulator: Two checks and adjustments are required on the voltage regulator – Air gap and voltage setting – per specifications on page Q.4.

Air Gap - Measure the' air gap between the armature and the part of the core next to the residual pin (not between armature and residual pin). To measure, press down on the contact screw to make sure it is bottomed, and check the air gap with a feeler gauge, see Fig. 123. To adjust, loosen the lock nut and turn the contact screw (Fig. 124). The easiest method is to insert the proper size feeler gauge, loosen the lock nut, and with downward pressure on the screwdriverturn the contact screw to set for .084" air gap. Tighten the lock nut after adjustment.

Note: When installing. a new fibre insulator bracket assembly (which includes the flat spring) the flat spring tension should be checked and adjusted if 'necessary. If it is excessive, there will be no wiping action between the points and the point wear will be more rapid than normal. If it is too low, point bouncing and considerable arcing are apt to occur. To make sure the flat spring has the proper tension, first check and adjust the regulator voltage setting (see following paragraph). Then with the regulator points

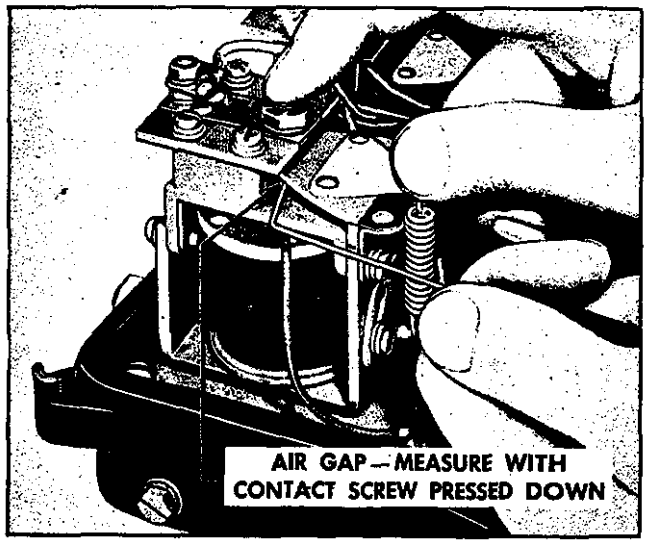


Fig. 123–Checking Air Gap on Voltage Regulator with hire Gouge

closed, note flat spring position. It should be up off the fiber insulator. If it is not, the spring is too strong and it can be weakened by running a dull edged tool across the crease of the flat spring. Minimum spring tension should be two ounces, and this is measured by holding the armature down and pulling up on the end of the flat spring with a spring scale to see what pull is required to raise the flat spring off the fibre

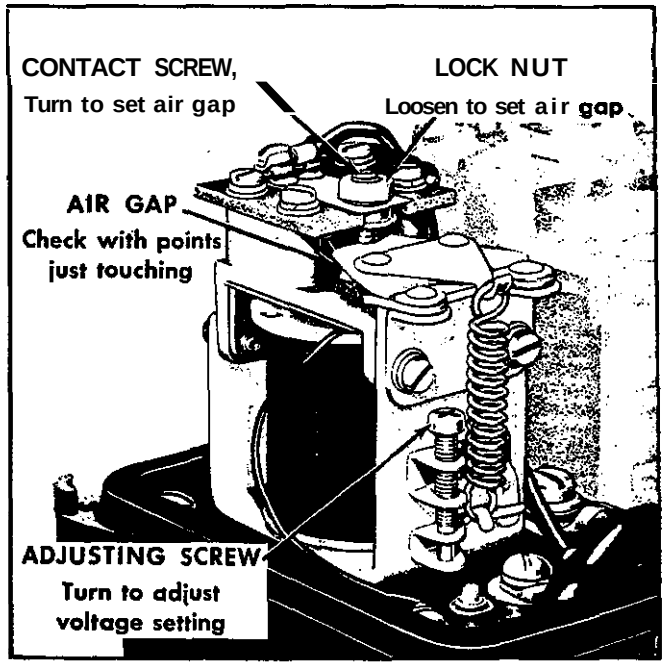


Fig. 124–Adjustments Required on Voltage Regulator are Air Gap and Voltage Setting Adjustments, on Current Regulator are Air Gap and Current Setting

insulation. If less than two ounces is required, 'ncrease the tension by prying, lightly under one side and then the other side of the crease in the spring.

VOLTAGE SETTING - Connect a voltmeter between the ARMATURE A- and A. terminals. Lead must be disconnected from the regulator BATTERY terminal. With the generotor operating at full speed (2000 engine rpm or 4000 generator rpm) and the regulator at operating temperature, note the voltage setting. Correct range is 28.0 - 29.5 V. Adjust for 28.5 volts. To adjust the voltage setting, turn the adiusting screw shown in Fig. 124, which regulates the tension of the spiral spring. Increasingthespring tension increases the voltoge setting. After each change of adjustment cycle the generator by momentarily opening the voltage regulator points by hand before taking thevoltoge reading. This eliminates residual magnetism in the core of the regulotor and assures o true adiustment.

Service — Current Regulator: Two checks and adjustments are required on the current regulator, air gap and current setting. Since these ore similar to those described for the voltoge regulator, refer to the some illustrations, Figures 123 and 124.

AIR GAP - The correct air gap for the current regulator is .084", end the adjustmentprocedure. is the same os outlined for the voltage regulotor on previous page.

CURRENT SETTING -To check the current regulator setting it is necessary to drive thegenerator at full speed (engine at full throttle) and to keep the voltage regulator from operating. This may be accomplished by removing the regulotor cover and placing a jumper lead across the voltage regulator contact points, which will prevent the voltage regulotor from operating. Then remove the regulator BATTERY lead and connect an accurate ammeter in series between BATTERY terminal of regulator and the battery. Then with engine running at full speed, read the current output in omperes. Be sure to remove the jumper from voltoge regulator immediately after the test.

Correct range is 16 - 20 omperes. If the output is in this range, the adiustment is satisfactory. If not in this range, adjust to 18 amperes. To adjust the current regulator setting, turn the adjusting screw shown in Fig. 124, which regulates the tension on the spirol spring. Increasing the tension will increase the current setting.

MOTOROLA ALTERNATOR SYSTEMS

INSTALLATION

GENERAL

CAUTION: OBSERVE PROPER POLARITY WHEN INSTALLING ALTERNATOR OR BATTERY. GROUND POLARITY OF BATTERY AND GROUND POLARITY OF ALTERNATOR MUST BE THE SAME. REVERSE POLARITY WILL DESTROY THE RECTIFIER DIODES IN ALTERNATOR.

NOTE: Battery should be disconnected when installing alternator to minimize the possibility of personal injury. Disconnect grounded cable first.

AS A PRECAUTIONARY MEASURE, DISCONNECT BATTERY TERMINAL WHEN CHARGING BATTERY. CONNECTING CHARGER IN REVERSE WILL DESTROY THE RECTIFIER DIODES IN THE ALTERNATOR.

The requirements of the alternator mechanical installation are several: (1) solid vibration free attachment of the mounting bracket to the engine and alternator to the mounting bracket, (2) correct belt alignment, and (3) protection from spray, and from engine exhaust system heat.

Hardened steel flat washer should be substituted for spring lock washers on bracket and alternator as mounting hardware. Flat washers tend to provide and retain greater surface tension while lock washers, under vibration, wear the metal away and lose their locking ability. Lock washers should be used against steel surfaces.

ALTERNATOR PULLEY ALIGNMENT

Correct belt alignment is essential for maximum alternator and belt service life. The center line of all pulleys related to the alternator drive must be within 1/32" of true center, Figure 69.

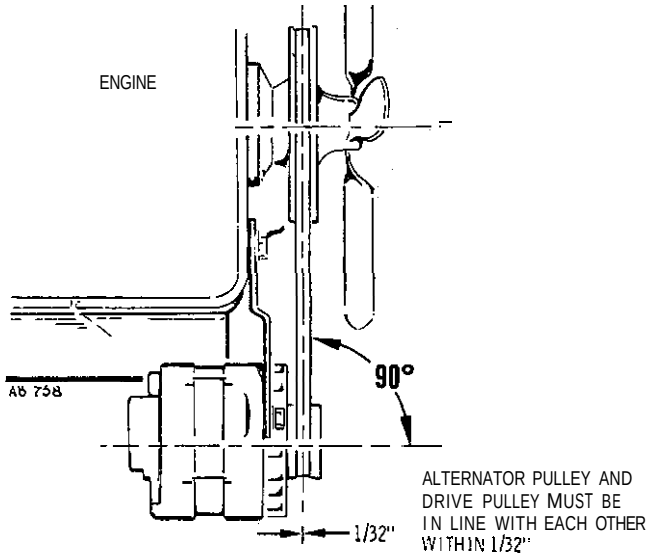


FIG. 69 ALTERNATOR BELT ALIGNMENT

Tighten pulley nut to 40 - 50 foot pounds. Tighten drive belts by applying pressure to the alternator front housing only. Do not apply pressure to the rear housing or stator. Set belt tension to engine manufacturer recommendations. If this information is not available, tighten belts to the point where the alternator fan cannot be turned by hand.

MAINTENANCE

GENERAL

Due to alternator design and construction, very little, if any, maintenance is required in normal usage: however, proper tension and condition of drive belts should be checked regularly. Periodic inspection of brushes and bearingsshould be made after approximately 50,000 miles (or 1500 hours in industrial or agricultural applications) under normal operating conditions.

BRUSH INSPECTION

On most Motorola alternators, brush removal for inspection. easily be accomplished without special tools or alternator removal, Figure 75. If the brushes are not oil soaked or crack have smooth contact surfaces, and are at least 3/16" long, they may be reused. Refer to applicable alternator service manual for specific brush removal details.

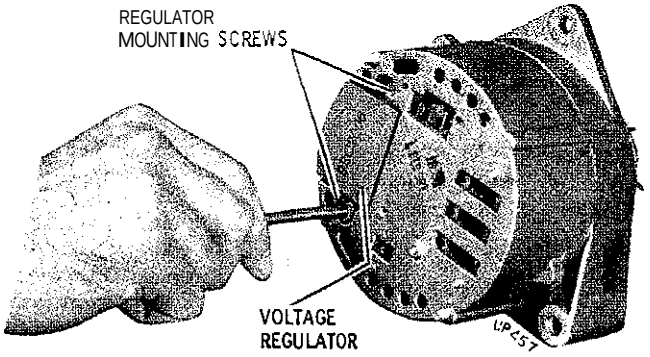


FIG. 75 BRUSH ASSEMBLY REMOVAL

BEARING INSPECTION

Front and rear ball bearings are of the sealed type to provide long and trouble-free performance. However, it is recommended that the bearings be inspected after about 50,000 miles operation. If any unusual looseness or noise is noted, the bearingsshould be replaced to insure maximum service life from the alternator. Refer to alternator repair manual for specific bearing removal instructions.

TROUBLESHOOTING & SERVICE DIAGNOSIS

BATTERY

The vehicle storage battery circuit represents a continuous, although variable, electrical load to the alternator. If the circuit, positive or negative, is opened or broken while the alternator is charging, the loss of the battery will result in the charging voltage rising to unsafe levels.

High voltage will damage the alternator and regulator and may damage other electrical accessories or instruments.

TEST PRECAUTIONS

DO NOT under any circumstances, short FIELD terminal of alternator to ground.

DO NOT disconnect voltage regulator while alternator is operating.

DO NOT disconnect load (alternator output lead) from alternator while the alternator is operating.

DO NOT remove alternator from car without first disconnecting the grounded battery cable. If battery must be removed, disconnect grounded battery cable. If battery must be removed, disconnect grounded cable first.

The following rule applies to all alternator charging systems:

AUTION: IF A BATTERY IS BEING INSTALLED. MAKE CERTAIN THAT HE N POLARITY OF THE BATTERY AND THE IFC O OF THE ALTERNVAT I \F THE A REVERSE POLARIT WILL DES C Y RECTIFIER)DES IN THE ALTE! ATOR

TEST EQUIPMENT REQUIRED

Typical equipment required for general electrical in-vehicle testing of the alternator and voltage regulator should include meters that provide the following scales:

VOLTS AMPERE TESTER, SUN ELECTRIC MODEL 24
Volts OC: 0 - 40
Ampere DC: -10 to +100

N PILE. Sun Electric Y-20 cr qu ., capable of 0 to 600 ampere load. ntrolled t erating knob

12 VOLT TEST LAMP, May be home-made with 3 to 15 candlepower lamp in a socket. with two 3' test leads provided with alligator clips.

OHMMETER, Any commercial type, like a Simpson 260 or equiv.

BATTERY HYDROMETER, any commercial type, with temperature correction scale, or Motorola Electronic Battery Tester 7BT1181W.

SORTMENT OF JUMPER LEADS, 2.4.6 and 10 feet in ngth, with alligator clips attached to the ends. Make with good quality No. 10 wire.

TESTING PROCEDURES

Alternators and voltage regulators should be tested on the vehicle, using circuit conductors and accessories that are a permanent part of the system.

Before actual in-vehicle testing commences, the charging system and battery must be checked to eliminate possible difficulty, as follows:

The battery rnust be at least 75% full charged and properly secured in the carrier. Ordinary storage batteries may be checked with a hydrometer (1.240 Sp. Gr.), Motorola Battery Tester model 7BT1181W or other special testers. Since maintenance free batteries usually do not contain vent caps, a hydrometer cannot be used to evaluate battery condition. In these cases, the Motorola battery tester and other special testers may be used. The carrier must not place excessive physical strain on the battery.

Wires and cables rnust be free of corrosion with cable supporting clamps to reduce a strain on battery posts.

All leads, junctions, switches and panel instruments that are directly related to the charging circuit must be good enough to provide proper circuit control.

The inspection of the alternator drive system should include the following:

Engine driving and alternator driven pulleys must be capable of transmitting required energy from the engine output shaft to the alternator.

The alternator drive belt must be properly adjusted and in good condition, free of grease or oils that may induce slipping under load.

Some of the more common causes of charging system malfunctions are covered in the chart below.

SYMPTOM NO. 1 - ALTERNATOR FAILSTO CHARGE CHECK FOR:

A. Alternator belt loose.
B. Open or high resistance in charging or ground return circuit or battery connections.
C. Excessively worn, open or defective brushes.
D. Open excitation resistor.
E. Open isolation diode.
F. Regulator inoperative.
G. Open rotor (field coil).

SYMPTOM NO. 2 - LOW OR UNSTEADY CHARGING RATE CHECK FOR:

A. Alternator belt loose.
B. Intermittent or high resistance charging or ground return circuit or battery connections.
C. Excessivelv worn. stickv or intermittent brushes.
D. Faulty regulator.
E. Shorted or open rectifier diode.
F. Grounded or shorted turns in rotor (field coil).
G. Open, grounded or shorted turns in stator.

SYMPTOM NO. 3 - EXCESSIVE CHARGING RATE

(as evidenced by lights and fuses burning out frequently, battery requires too frequent refilling)

CHECK FOR:
A. Make certain all connections on alternator and regulator are tight.
B. Regulator faulty.

SYMPTOM NO. 4 - NOISY ALTERNATOR CHECK FOR:

A. Defective or badly worn belt.
B. Misaligned belt or pulley.
C. Loose pulley.
D. Worn bearings.
E. Shorted rectifiers.

NOTE: Refer to applicable alternator service manual for specific test and troubleshooting information.

ELECTRONIC VOLTAGE REGULATOR

The Motorola all-electronic transistorized voltage regulator is an electronic device using no mechanical contact: or relavs to perform the onlv necessary regulation on the alternator system.

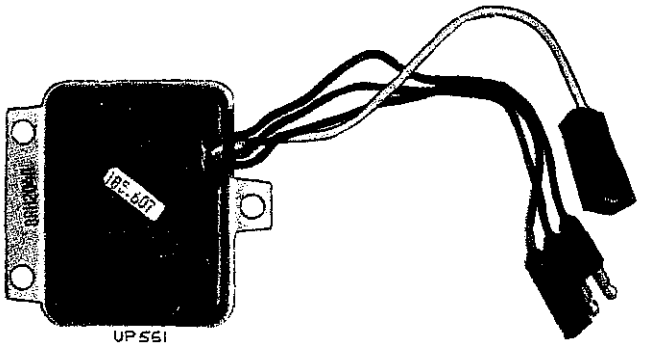


FIG. 67 TYPICAL MOTOROLA TRANSISTORIZED VOLTAGEREGULATOR

Thetypical regulator shown in Figure 67 has been filled with an encapsulating material to cover and protect the semiconductors from the environmental conditions thev will encounter in normal use. The electronic circuitry should not reauire re-adjustment and the reliabilitv of the semi-conductors permits this encapsulation.

The prime purpose of the regulator is to maintain constan system output voltage under all speed and load conditions his is e as si voltage will damage c i l mp and er Either mechanical or electronic regulators may be used with an alternator; however, modern electronic units are used almost exclusively since they provide superior overall performance.

The typical electronic regulator functions like a solid-state switch which constantly monitors system voltage, Figure 68. When the voltage tends to drop, the switch closes and energizes the alternator field winding to increase the output. When the system voltage tends to rise, the regulator switch opens and de-energizes the field circuit to decrease the voltage. For a more detailed description of regulator theory and operation, refer to "Electronic Regulator Theory" Manual, 25-139.

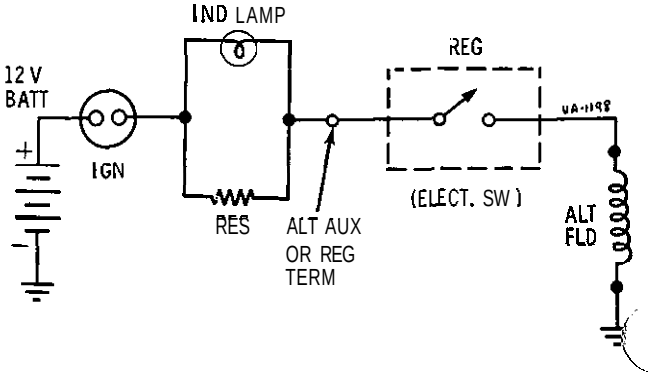
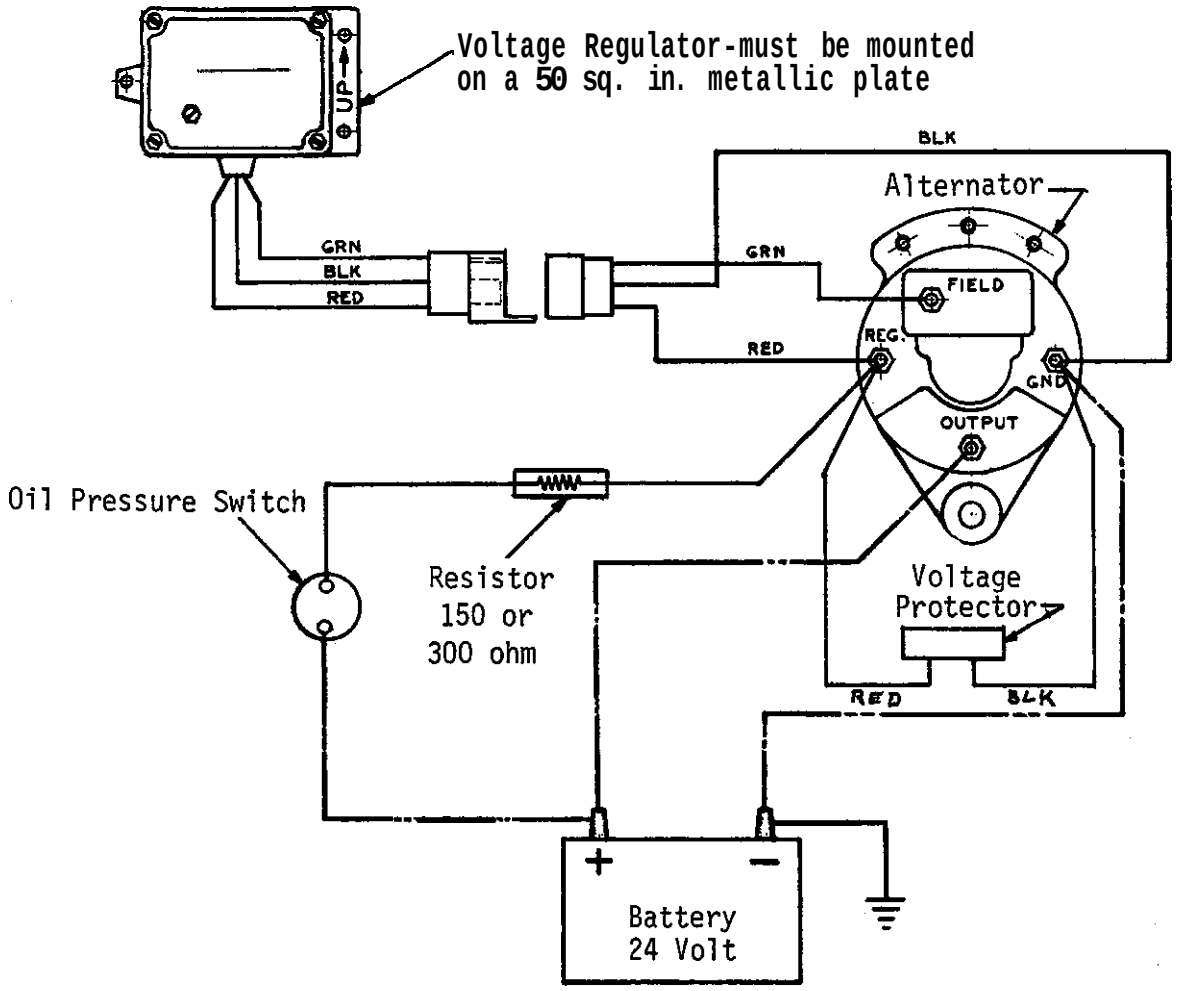


FIG. 68 SIMPLIFIED REGULATOR CONTROL CIRCUIT

Q.16

ELECTRICAL SYSTEM USING MOTOROLA 24VDC 35AMP ALTERNATOR



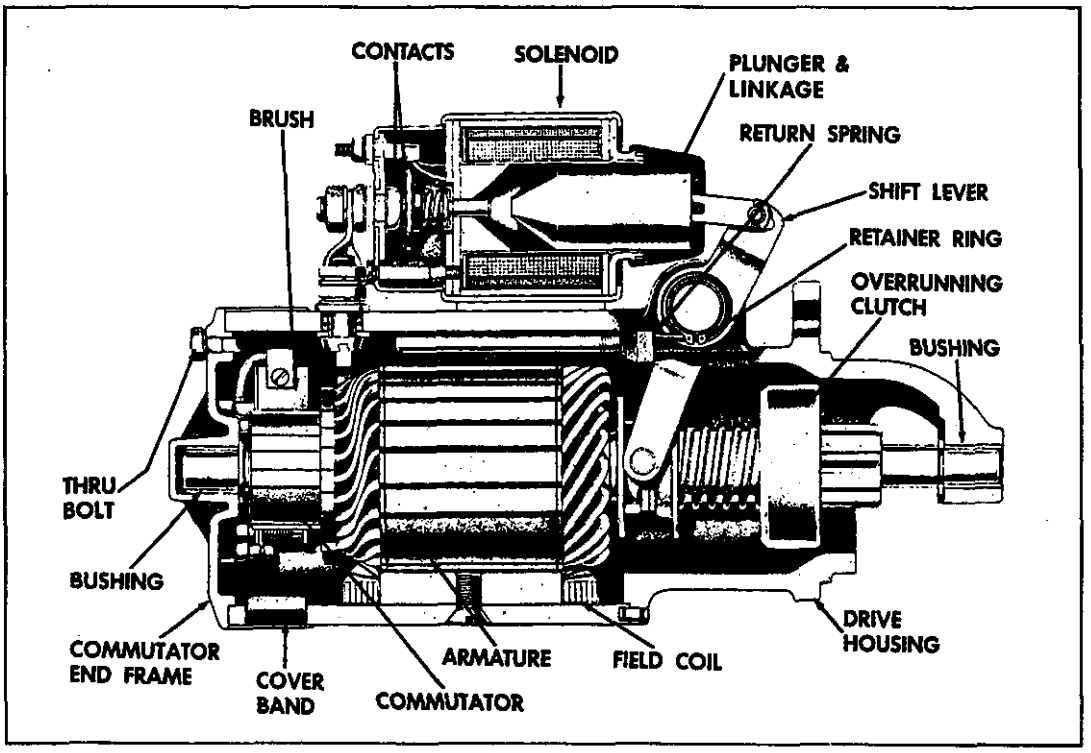


Fig. **125–Sectional** View **of Cranking Motor**

CRANKING MOTOR

The cranking motor used on this engine (Delco-Remy Model 1**107579)** is grounded type, operating on nominal 24 volts, corresponding to the generator circuit. It is a 4 pole, 4 brush, insulated unit, with rotation C.W. as viewed from drive end. The armature shaft is supported on bronze bushings, with wick oilers.

Fig. **125** shows a sectional view and illustrates the solenoid-operated overrunning clutchasused in this cranking motor.

The overrunning-clutch is designed to provide positive meshing and demeshing of the drive pinion and ring gear. The overrunning clutch cranking motor uses a shift lever which slides the clutch and drive pinion assembly along the armature shaft so that it can be meshed and demeshed as required. The clutch transmits torque from the cranking motor armature to the engine flywheel but permits the drive pinion to overrun, or run faster than, the armature after the engine is started.

This protects the armature from excessive speed during the brief interval that the drive pinion remains in mesh after the engine starts.

The overrunning clutch (Fig. **126);** consists of a sleeve shell assembly which is splined internally to match splines on the armature shaft. Thus, both the shell and sleeve assembly and the armature shaft must turn together. A pinion and collar fits loosely into the shell, and the collar is in contact with four hardened steel rollers which are assembled into notches cut in the inner face of the shell. These notches taper inward slightly so that there is less room in the end away from the rollers than in the end where the rollers are shown. The rollers are spring loaded by small plungers.

When the shift lever shown in Fig. **125** is operated the clutch assembly is moved endwise along the armature shaft so that the pinion meshes with the flywheel ring gear. If the teeth should butt instead of mesh, the clutch spring compresses so that the pinion is spring loaded against the ring gear teeth. Then when the armature begins to rotate meshing takes place at once.

Completion of the shift lever movement closes the cranking motor switch so that the armature, begins to rotate. This rotates the shell-and-(sleeve assembly, causing the rollers to jam tightly in the smaller sections of the shell notches.

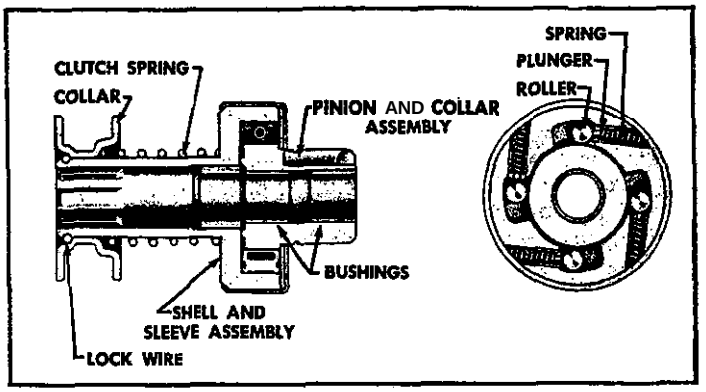


Fig. 126–Overrunning Clutch

The rollers jam between the pinion collar and the shell so that the pinion is forced to rotate with the armature and crank the engine.

This protects the armature for the brief instant that the starter switch is pressed. Opening the cranking circuit releases the shift lever, causing the lever spring to pull the overrunning clutch drive pinion out of mesh with the engine flywheel ring gear. A slot in the shift lever provides for instantaneous releose of the switch ontact points as they open the cranking circuit. therwise, the momentary delay in the action of the solenoid would result in burned contacts.

When the engine begins to operate, it attempts to drive the cranking motor ormature, through the pinion, faster than the armature is rotating. This causes the pinion to rotate with respect to the shell so that it overruns the shell and armature. The rollers are turned back toward the larger section of the shell notches where they are free, and thus permits the pinion to overrun.

CRANKING MOTOR LUBRICATION

Every 300 hours of operation, remove pipe plugs from commutator and drive ends and fill with 8-10 drops of engine oil.

When the motor is disassembled for any reason, lubricate as follows.

1. Oil wicks should be saturated.
2. Bushings should be coated with a small amount of grease lubricant such as Delco-Remy Lubricant 1860954 (Moly #1).
3. The armature shaft should be coated lightly with Delco-Remy Lubricant No. 1960954, (Moly #1).
4. The drive assembly should be wiped clean.

   CAUTION: Do not clean in any degreasing tank or with grease dissolving solvents; this will dissolve the lubricant in the clutch mechanism.
5. The overrunning clutch requires no lubrication.
6. Avoid excessive lubrication.

TROUBLESHOOTING THE CRANKING CIRCUIT

Several checks, both visual and electrical should be made in a defective cranking circuit to isolate trouble before removing any unit. Many times a component is removed only to find it is not defective after making reliable tests. Therefore, before removing a unit in a defective cranking system, the following checks should be made:

BATTERY: To determine the condition of the battery, check as outlined on page

WIRING: Inspect the wiring for frayed insulation or other damage. Replace any wiring that is damoged. Inspect all connections to the cranking motor, solenoid, ignition switch and battery, including all ground connections. Clean and tighten all connections and wiring as required.

SOLENOID SWITCH: Inspect all control switches and the ignition switch, to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, repair or replace the bypassed switch.

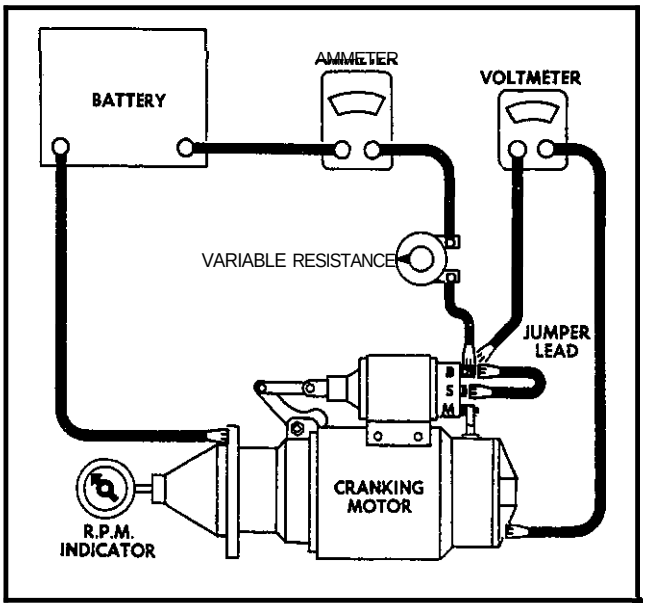


Fig. 127 - No Load Ted Hookup

MOTOR: If specified battery voltage con be measured at the motor terminal of the cranking 'motor, allowing for some voltage drop in the circuit and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

CRANKING MOTOR TESTS

With the cranking motor removed from the engine, the armature should be checked for freedom of operation by turning the pinion. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoe screws will cause the armature to drag and it will not turn freely. The motor should bedisassembled immediately. However, if the armature does operate freely, the motor should be given a no-load test before disassembly.

Never operate the cranking motor more than 30 seconds at a time without pausing to allow it to cool for at least two minutes. Overheating, caused by excessive cranking will seriously damage the cranking motor.

NO-LOAD TEST

Connect the cranking motor in series with a fully charged battery of 24 volts, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as shown in Fig. 127 from the motor battery terminal to the motor frame. An r.p.m. indicator is necessary to measure armature speed. Obtain the specified voltage 'by varying the resistance unit. Then read the current draw and the armature speed with the following specifications:

Volts	23.5
Minimum Amperes	70
Maximum Amperes	130
Minimum R.P.M.	6500
Maximum R.P.M.	13000

Interpret the test results as follows:

1. Rated current draw and no-load speed indicate normal condition of the cranking motor.

2. Low free speed and high current draw indicate:

   a. Too much friction – tight, dirty or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.

   b. Shorted armature. This can be further checked on a growler after disassembly.

   c. Grounded armature or fields. Check further after disassembly.

3. Failure to operate with high current draw indicates:

   a. A direct ground in the terminal or fields.

   b. "Frozen" bearings (this should have been determined by turning the armature by hand.)

4. Failure to operate with no current draw indicates:

   a. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

   b. Open armature coils. Inspect the armature for badly burned bars after disassembly.

   c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. Low no-load speed and low current draw indicate:

   a. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.

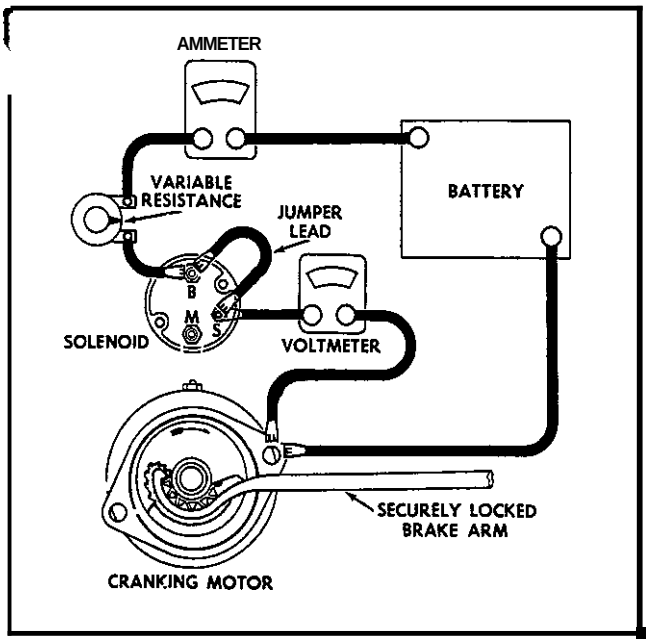


Fig. 128--Resistance Test Hookup

6. High free speed and high current draw indicate: shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

RESISTANCE TEST

This test requires equipment as illustroted in Fig. 128 with the pinion securely locked so that it cannot rotate. A variable resistance with o high current capacity should be used. When 5 volts are applied the current should fall in the range of 375 min. amps to 435 max. amps.

DISASSEMBLY

If the motor does not perform in accordance with specifications it will need to be disassembled for further testing of the components. Normally the cranking motor should be disassembled only so far as is necessary to make repoir or replacement of the defective parts. As a precaution it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Following are general instructions for disassembling the exposed shift lever cranking motor:

1. Remove the solenoid from the field frame and linkage.
2. Remove the thru-bolts and the commutator end frame.

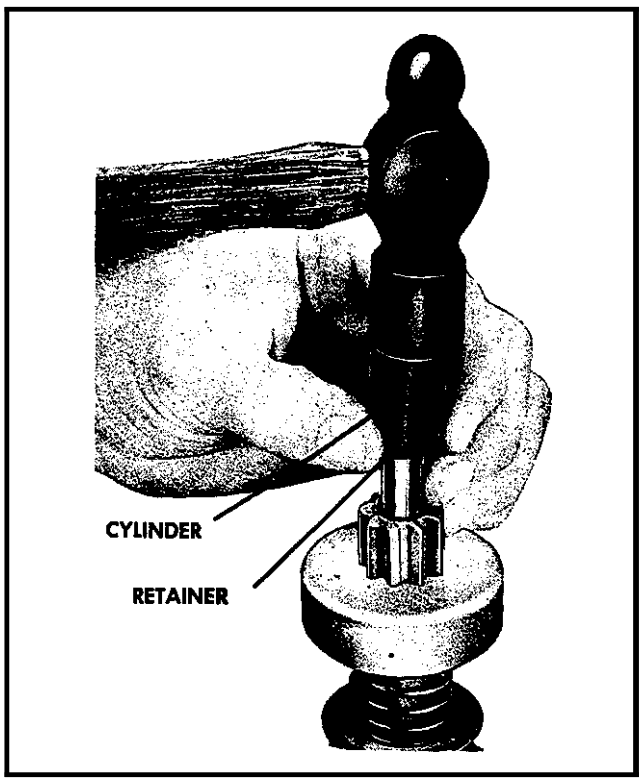


Fig. 129–Removing Retainer from Snap Ring

3. Remove the field frame from the armature and drive housing assembly.
4. Separate the armature and pinion from the drive housing and linkage.
5. Remove the pinion from the armature by sliding a metal cylinder onto the shaft, with a hammer striking the metal cylinder against the retainer, drive the retainer towards the armature core and off the snap ring. See Fig. 129.
6. Remove the snap ring from the groove in the armature shaft.
7. Remove the drive assembly from the armature shaft.

CLUTCH DISASSEMBLY

Roll type clutches (Figures 126 and 130) are designed to be serviced as a complete unit, therefore do not disassemble. Replace if necessary. Do not wash in solvent.

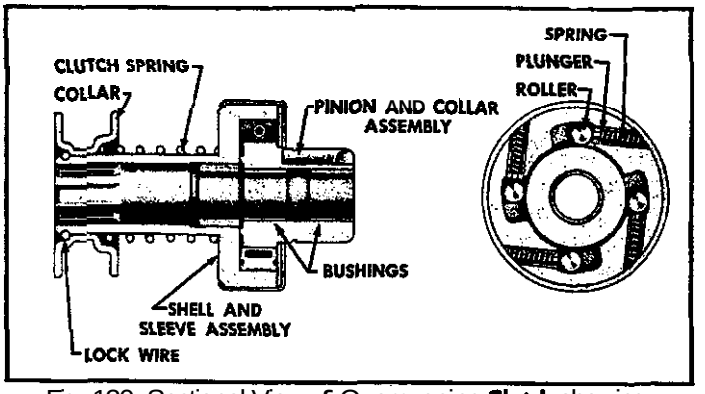


Fig. 130–Sectional View of Overrunning Clutch showing details of construction and Location of Rollers in Clutch

COMPONENT INSPECTION AND REPAIR

A. Brushes and brush holders – Inspect the brushes for wear. If they are worn down to one-holf their original length, when compared with a new brush, they should be replaced. Moke sure the brush holders are clean and the brushes are not binding in the holders. The full brush surfaceshould ride on the commutator with proper spring tension of 64 ounces minimum to givegood, firm contact. Brush leads and screws should be tight and clean.

B. Armature – The armature should bechecked for short circuits, opens and grounds.

1. Short circuits are located by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature. The steel strip will vibrate on the area of the short circuit. Shorts between bars ore sometimes produced by brush dust or copper between the bars. Undercutting the insulation will eliminate these shorts.

2. Opens – Inspect the points where the conductors are joined to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not fully burned, resolder the leads in the riser bars and turn the commutator down in a lathe. Then undercut the insulation between the commutator bars 1/32".

3. Grounds in the armature can be detected by the use of a test lomp and prods. If the lamp lights when one test prod is placed on the commutator and the other test prod on the armature core or shaft, the armature is grounded.

If the commutator is worn, dirty, out of round, or high insulation, the commutator should be turned down and undercut as previously described.

C. Field Coils – The field coils should be checked for grounds and opens using a test lamp.

1. Grounds – Disconnect the field coil ground connections. Connect one test prod to the field frame and the other to the field connector. If the lamp lights the field coils are grounded and must be repaired or replaced.

2. Opens – Connect test lamp prods to end of field coil leads. If the lamp does not light, the field coils are open.

If the field coils need to be removed for repair or replacement, a pole shoe spreader and pole shoe screwdriver should be used. Care should be exercised in replacing the field coils to prevent grounding or shorting them as they are tightened in place. Where the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

REASSEMBLY

1. Place the clutch assembly on the armature shaft.

2. To facilitate replacing the snap ring and retainer on the armature shaft:

a. Place the retainer on the armature shaft with the cupped surface facing the snap ring groove.

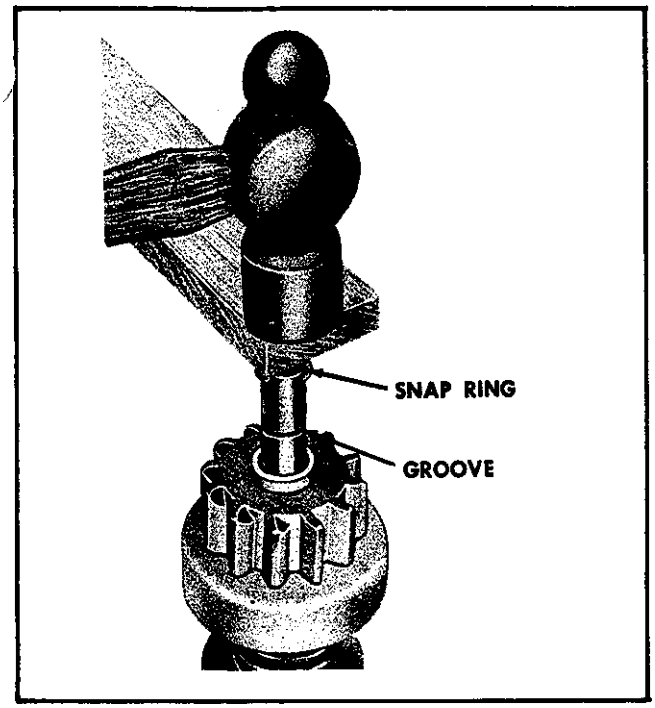


Fig. 131–Forcing Snap Ring over Shaft

b. Place the snap ring on the end of the shaft. With a piece of wood on top of it, force the ring over the shaft with a light hammer blow (Fig. 131) then slide the ring down into the groove.

c. To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze the retainer and washer together with pliers (Fig. 132).

d. Remove the washer.

3. Refer to disassembly procedure and follow in reverse to complete the reassembly.

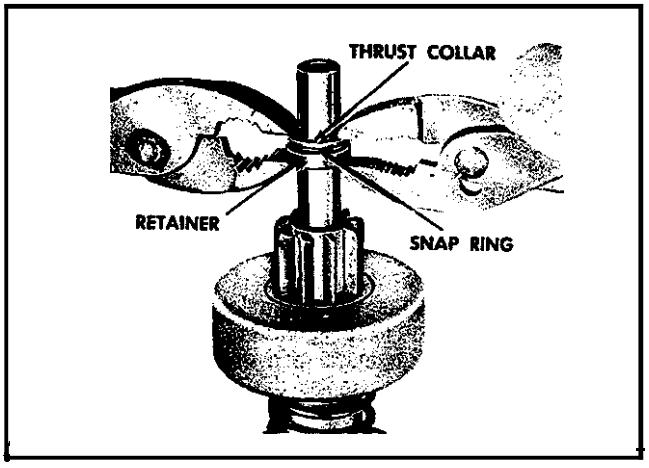


Fig. 132–Forcing Retainer over Snap Ring

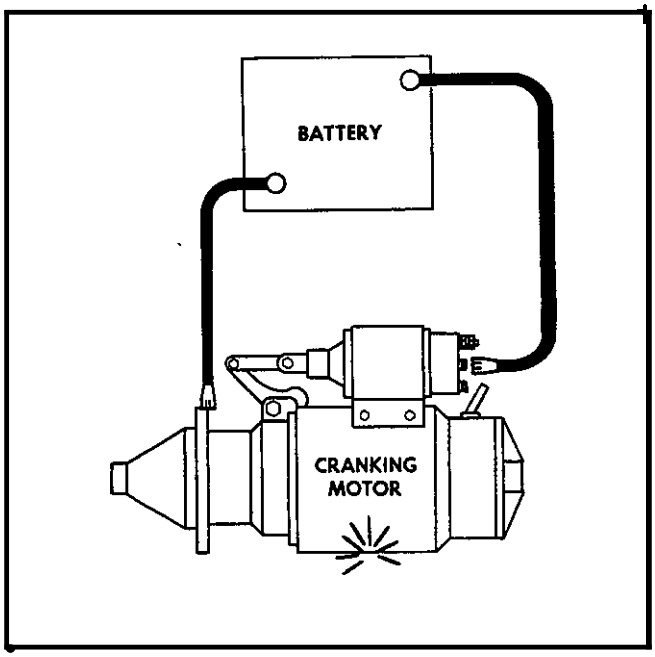


Fig. 133–Connections for Checking Pinion Clearance

PINION CLEARANCE

Pinion clearance should be checked after reassembly of the motor to insure proper adjustment. To check pinion clearance follow the steps listed below.

1. Disconnect the motor field coil connector from the solenoid motor terminal and INSULATE IT CAREFULLY.

2. Connect a battery of 24 volts, from the solenoid switch terminal to the solenoid frame. (Fig. 133).

3. MOMENTARILY flash a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. This will shih the pinion into cranking position and it will remain so until the battery is disconnected.

4. Push the pinion back towards the commutator end to eliminate slack movement.

5. Measure the distance between pinion and pinion stop. This clearance should be .010 to .140 (Fig. 134).

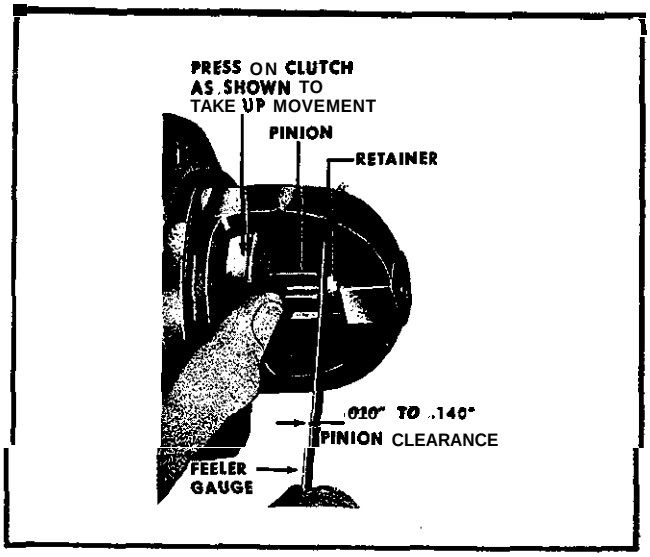


Fig. 134—Checking Roller Clutch Pinion Clearance

Adjust the pinion clearance by loosening th screw on the serrated shaft lever linkage and moving it forward or backward. Press on clutch as shown in Figure 134 to take up movement.

SECTION R

COOLING SYSTEM (EXTERNAL)

This engine is fresh water cooled, utilizing what is known as a "closed system", wherein the cooling water is circulated from the water or surge tank (mounted over the thermostat at the front end of cylinder head) through the exhaust manifold jacket into the heat exchanger (mounted over the flywheel housing). Cool fresh water leaves the heat exchanger and flows through the dual oil cooler to the cylinder block connection on the starboard side, where it is circulated thru the block and cylinder head by means of a centrifugal fresh water pump. The fresh water then passes out through the thermostat into the surge tank and the circuit repeats. See Fig. 99.

The heat rejected in combustion, as well as heat developed by friction, is absorbed by the fresh water coolant moving through the heat exchanger, which has a flow of sea water exchanger mounted on the engine. Within the heat exchanger, which has a flow of raw or sea water through its jacket and around the fresh water passages, the heat is continuously and rapidly transferred to the sea water flowing through it. the same as the heat from an automobile engine is carried away by air flowing through the radiator.

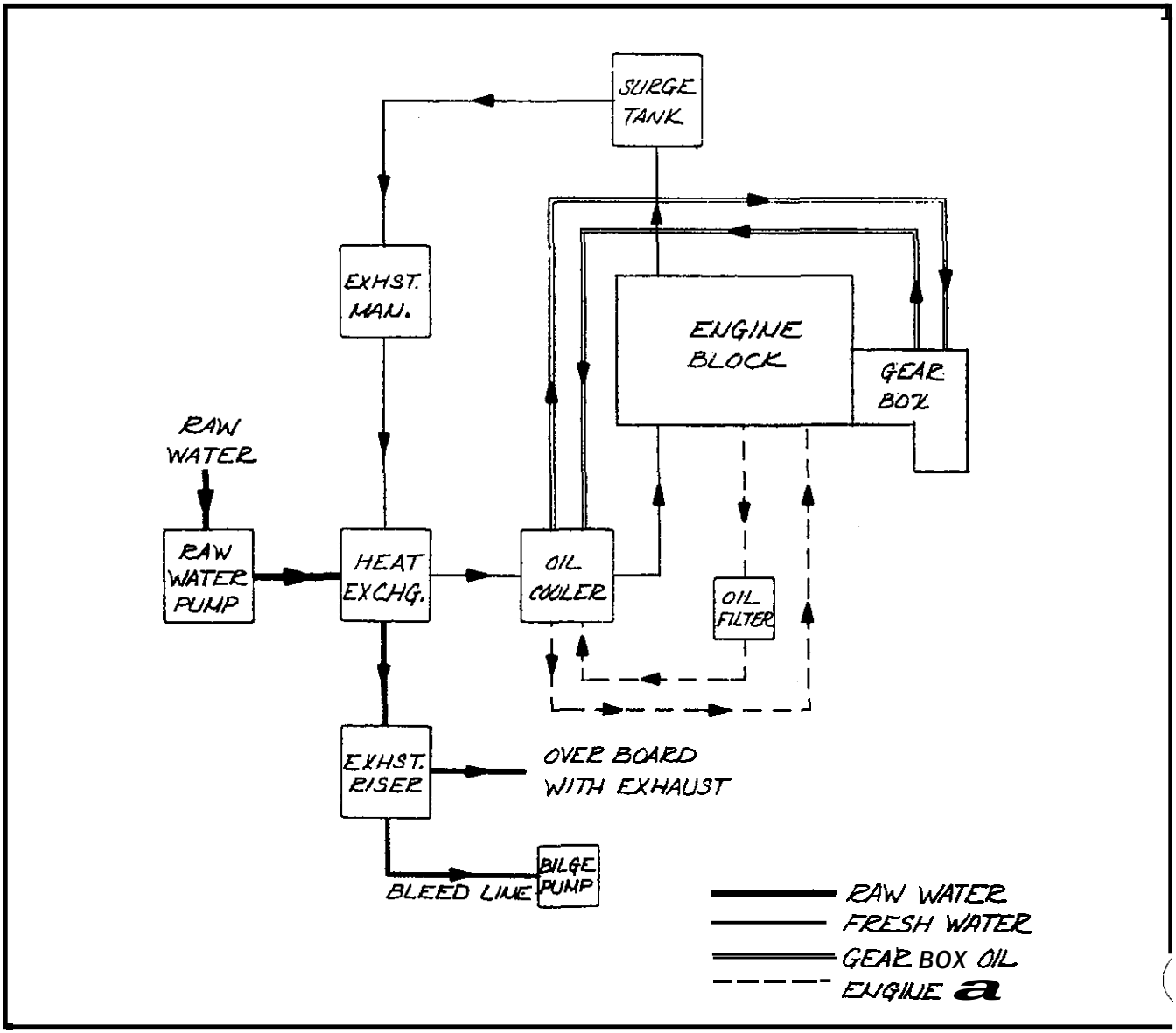


Fig. 99–Wafer System Diagram. Also showing Oil Flow to Coolers

Heat is also conducted away from the bearings and other friction surfaces by the lubricating oil, which is circulated by a pressure pump and cooled by the flow of fresh water through the dual oil coolers, one for the engine and one for the transmission. In this sense, both of the oil coolers are also heat exchangers.

The high velocity flow in this closed system provides close control of operating temperature throughout the engine, eliminating hot spots. The system may be filled with anti-freeze solution, for operating in cold weather.

SEA WATER PUMP

This is a self priming, positive displacement, rotary pump, with brass case and a single neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate at the top of the impeller housing, producing the pumping action. Before each initial start coat the impeller and impeller chamber with Texaco Regal Starfak No. 2 Grease only. The sea water pump has a rated capacity of 5-1/2 GPM at 1500 RPM pump speed. Inlet and outlet are tapped 3/8" NPT.

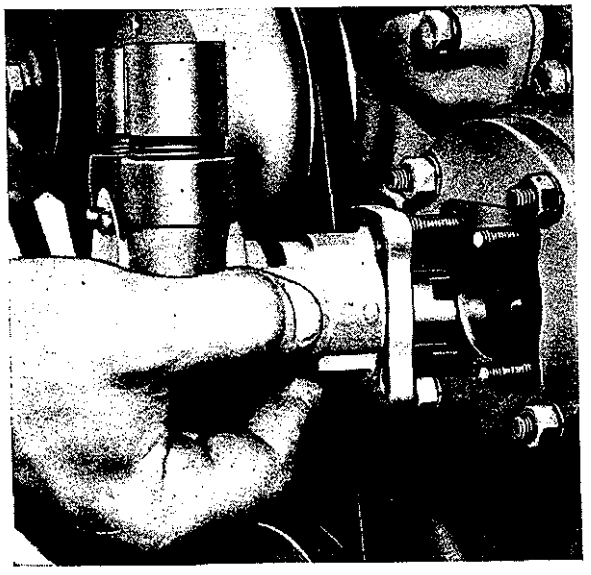


Fig. 101–Removing Sea Water Pump

To Remove Pump

Uncouple inlet and outlet connections.

Remove the four nuts, thereby enabling the pump to be lifted away from the timing case. See Fig. 101.

The pump may be replaced by reversing the above procedure.

Dismantling

To dismantle the pump, proceed as follows:

Remove front end cover.

Remove impeller.

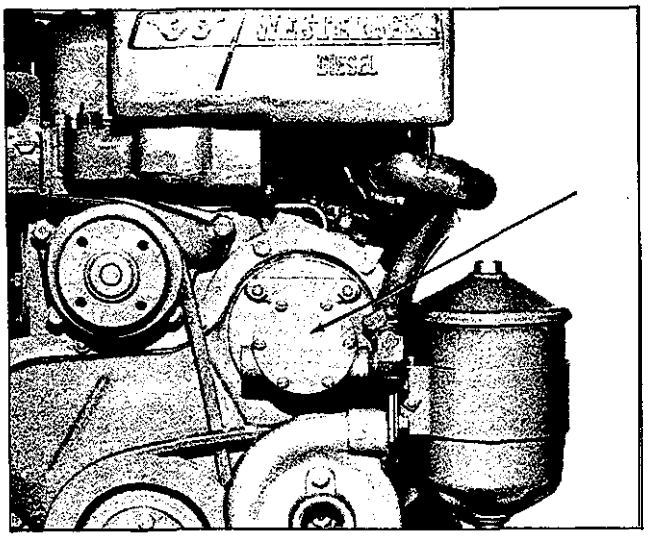


Fig. 102–Sea Water Pump Cover Plote

A suitable Press may be used to Dress out the impeller shaft together with the'water pump bearing.

The cam in the impeller housing may thenbe detached by removing the single screw.

Remove seal in impeller housing.

Remove mechanical seal and seat.

Inspect and clean all parts and replace with new if necessary.

To re-assemble the sea water pump, the reverse order of the above procedure should beadapted, care being taken when replacing the neoprene impeller that the blades all lay in the same direction relative to the rotation of the pump, that is. the blades trailing.

When reassembling coat the impeller and housing with Texaco Regal Starfax No. 2 grease.

Important Note:

As the sea water pump contains a rubber neoprene impeller, it should never be run in a dry condition. If the engine is to be laid up for any period the water pump should be packed with Texaco Regal Starfax No. 2 Grease. This can be done by removing the six cover screws and end plate. See Fig. 102.

SECTION S

TRANSMISSION

PARAGON HYDRAULIC TRANSMISSION - MODEL "P220"

DESCRIPTION

The Paragon Hydraulic transmission, model P220 as used on this engine is a self contained unit, independent of the engine lubrication oil and oil pressure system. The unit consists of a pressured oil system, a hydraulically actuated multiple-disc clutch for the forward drive and a hydraulically actuated reverse band which clamps a planetary reverse gear train for the reverse drive. Cooling is provided by an external oil cooler, mounted on the engine, which utilizes the engine fresh water for cooling.

OPERATION

Pressured oil for the operation of the transmission is provided by an internal gear type pump mounted inside of the transmission. The internal gear type pump or oil pump is driven continuously by the engine thus providing pressured oil for the operation of the transmission during any running of the engine. From the pump, the pressured oil is delivered through the external oil cooler to the relief valve and to the control valve where, depending upon the control valve setting, the pressured oil can be directed either to the forward drive or to the reverse drive.

The pressured oil is maintained at a constant pressure by means of a relief valve. At engine speeds over 1000 RPM, the pressured oil will be approximately 125 P.S.I. and at idle speeds the pressure may be as low as 60 P.S.I. Pressure slightly above or below these valves may be encountered, due to variance in the relief valves.

By shifting the control lever to the forward position, the pressured oil is directed to the multiple disc clutch piston. This clamps the multiple disc clutch and the planetary reverse gear case together as a solid coupling, which rotates in the same direction as the engine rotates.

The reverse band is clamped by shifting the control lever to the reverse position which directs the pressured oil to the reverse piston, thus engaging the reverse band around the planetary gear case. This causes the planetary gears to rotate, driving the output shaft or propeller shaft opposite to engine rotation.

With the control lever in the neutral position, the pressured oil is prevented from entering either the multiple disc clutch piston or the reverse band piston. Therefore the planetary gears run idle and the propeller shaft remains stationary.

ROTATION DESIGNATION

Since there are several methods used to designate the rotation of an engine, the following explanation shall be used to determine the rotation of an engine so far as all Paragon hydraulic transmissions ore concerned.

Regardless of whether the transmission is attached to the flywheel end or the anti-flywheel end of the engine, ALWAYS view the transmission and/or engine from the transmission or output end. Therefore, when viewed from the transmission end, an engine that rotates "clockwise", "standard" or "right hand" will be known as a Right hand rotating engine and an engine that rotates "counterclockwise". "opposite" "left hand" will be known as a Left hand rotating engine.

It is important when assembling the P220 transmission to properly determine the rotation of the engine. Notes taken during disassembly as to the location of the reverse band adjusting screw, the position of the reverse band linkage and location of the rotation note on the front end plate will be very useful when reassembling the transmission. Remember, ALWAYS VIEW THE TRANSMISSION AND ENGINE FROM THE TRANSMISSION END.

The right hand and left hand sides of the transmission are also determined in the above manner. That is, they are determined when viewing the unit from the output end.

PART NUMBERS AND ORDERING

The parts list accompanying the exploded views are intended only to identify the parts in regard to disassembly and assembly for this technical manual and are not intended to identify parts by number. To order parts, refertothe complete parts list section in the back section of this book.

ALWAYS GIVE MODEL NUMBER AND SERIAL NUMBER OF TRANSMISSION WHEN ORDERING PARTS.

TROUBLE SHOOTING

The trouble shooting charts on the following pages should be studied and the suggestions carried out prior to any disassembly, to determine as best as possible what the trouble may be. Also, the exploded views and the accompanying discussions should be carefully read and understood, so that any or ail of theservice work as indicated from the trouble shooting charts may be carried out properly.

It is desirable to start the engine with the transmission in neutral, thus avoiding moving the boat in either direction. Should the engine stall during shifting or in forward or reverse, return the control lever to the neutral position before restarting the engine.

It is not necessary to race the engine to obtain good shifting characteristics, as the design of the transmission is such that the operation of the forward and reverse drive is nearly instantaneous with the moving of the control lever, even at very low engine speeds. It is recommended that shifting be done at speeds below 000 RPM and preferably in the 800 RPM range, to prolong the life of the engine, transmission, and of the boat. While NOT recommended as a continuous method, EMERGENCY shifts may be made at higher engine speeds.

LUBRICATION

The model P220 transmission is a self contained unit, independent of the engine lubricating systems. The unit is lubricated by pressure and splash from its own oil. The type of oil recommended is the same as for the engine, symbol 9250, SAE 30.

The quantity of oil depends upon the angle of installation, os well as the reduction model. The level must be maintained at the high mark on the dipstick and should be checked periodically to ensure satisfactory operation.

When filling for the first time or refilling after an oil change, check the level after running for a few minutes to make certain that the oil cooler and the various passages are full. If necessary. refill to the high mark on the dipstick to ensure proper operation of the transmission.

The oil in the transmission should be changed every 100 hours, or each season under normal conditions, when the engine oil is changed. However the number of hours that can be run between oil changes varies with the operating conditions. Drain plugs are located at the bottom of the reverse gear housing and the reduction gear housing.

MODEL AND SERIAL NUMBER

Each reverse gear has a model number and a serial number. These numbers are on the name plate, located on the cover of the transmission.

TROUBLE SHOOTING CHART

Chart 1

GEAR INOPERATIVE

DRIVE SHAFT DOES NOT ROTATE WITH SELECTOR VALVE IN FORWARD OR REVERSE

Check For

1. LOW OIL PRESSURE
2. HIGH OIL TEMPERATURE
3. REVERSE BAND NOT ENGAGING PLANETARY GEAR CAGE
4. FAILURE OF PLANETARY ASSEMBLY
5. FAILURE OF REDUCTION GEAR

REMEDY

1. Check the following items:

   a. Low oil supply. Add oil, refer to lubrication.

   b. Faulty oil gauge. Replace gauge. Oil gauge slow to register, air or obstruction in oil gauge line. Clean and bleed oil gauge line.

   c. Plugged oil lines or passages. Clean lines or passages.

   d. Oil pressure relief valve scored and sticking. Remove relief valve. Clean valve and valve tore in control valve housing with crocus cloth to free valve, or replace.

   e. Defective pistons and oil distributor seal rings. Replace seal rings.

   f. Defective oil pump. Check for wear, and replace if necessary.

2. Check the following items:

   a. Low oil supply. Add oil, refer to lubrication.

   b. Low water level in cooling system. Add water, and check for leaks.

   c. Plugged raw water inlet screen. Clean screen.

   d. Collapsed or disintegrated water inlet hose. Replace hose.

   e. Air leak in cooling water suction line. Replace suction line.

   f. Raw water pump impeller worn or damaged. Replace impeller.

   g. Clogged or dirty oil cooler element. Remove and clean.

3. Check the following items:

   a. Reverse band lining worn out. Replace lining.

   b. Defective reverse piston "O" ring. Replace "O" ring.

4. Remove gear case assembly, and check for defective or damaged parts. Replace defective or damaged parts.

5. Remove reduction gear assembly and check for defective or damaged parts. Replace defective or damaged parts.

TROUBLE SHOOTING CHART

Chart 2

GEAR DRAGGING
DRIVE SHAFT ROTATES EITHER FORWARD OR REVERSE WITH SELECTOR VALVE IN NEUTRAL POSITION

Check For

1. **DEFECTIVE FORWARD CLUTCH PLATES**
2. **BINDING IN PLANETARY ASSEMBLY**

REMEDY

1. Forward clutch plates warped and sticking. Remove clutch plates and replace.

2. Check the following items:

a. Bearings and gears worn excessively in gear case. Replace necessary parts.

b. Input shaft bearings worn excessrvely, causing misalignment of input shaft. Replace necessary parts.

Chart 3

GEAR SLIPPING OR SLOW TO ENGAGE
WITH SELECTOR VALVE IN FORWARD OR REVERSE POSITION

Check For

1. **LOW OIL PRESSURE**
2. **WORN FORWARD CLUTCH PLATES**

REMEDY

1. Low oil pressure. See Chart 1, item 1.

2. Remove forward clutch plates and check for wear. If worn excessively, replace clutch plates.

TROUBLE SHOOTING CHART

Chart 4

INTERNAL AND EXTERNAL LEAKS

Check For

1. WATER IN LUBRICATING OIL
2. EXCESSIVE OIL IN ENGINE CRANK-CASE OR FLYWHEEL HOUSING
3. OIL ON EXTERIOR OF MARINE GEAR
4. LOSS OF OIL FROM TRANSMISSION

REMEDY

1. Check the following items:
   a. Hole in oil cooler element permitting water to seep into oil compartment. Replace oil cooler element.
   b. Oil cooler gaskets. Check gaskets and replace.
2. Defective front end plate oil seal. Replace oil seal.
3. Check for damaged gaskets. Replace gaskets.
   a. Oil seeping from breather. Check for too. high oil level.
   b. Defective rear end oil seal. Replace oil seal.
4. a. See Chart 4, Item #1.
   b. Check for defective gaskets and seal.

DISASSEMBLY OF TRANSMISSION

As in any servicing operation, cleanliness is a must and all rules for good workmanship apply. Some of these rules are as follows:

1. Use only clean fluid in any cleaning or washing of parts.
2. Use only clean oil, when pressing parts together.
3. Never press a ball bearing so that the force is carried through the balls.
4. Never use a hammer to driveball bearings. neddle roller bearings or oil seals in place.
5. Use only properly sized wrenches in removing or securing nuts and capscrews.
6. Replace gaskets and "O" rings with new material.
7. Work on a clean bench and protect gear teeth and oil seal surfaces from nicks and scratches.
8. Lubricate the lips of new oil seals with clean, light grease applied with a soft brush before installing on the running surface.

Before removing the transmission from the engine, disconnect all control cables, and oil lines to the cooler. The propeller half coupling should be disconnected and slid back approximately 4 inches. Remove the dipstick from the housing and drain all of the lubricating oil before removing the transmission to avoid spilling the oil in the boat.

DISASSEMBLY NEED BE CARRIED OUT ONLY AS FAR AS IS NECESSARY TO CORRECT THOSE DIFFICULTIES WHICH INTERFERE WITH PROPER FUNCTIONS OF THE TRANSMISSION.

REMOVAL OF REDUCTION GEAR ASSEMBLY FROM THE REVERSE GEAR ASSEMBLY

NOTE: To facilitate removal of the transmission from the engine, it is easier to remove the reduction gear assembly first. Make certain that all of the oil is removed from the reverse and reduction units before removal is attempted.

1. Remove capscrews and lockwashers around flange of reduction gear housing.
2. Strike gear half coupling flange with a soft mallet to break reduction gear unit from the reduction adapter plate. Slide entire reduction unit straight back approximately 3 inches until reduction unit clears reduction drive gear and lift reduction unit clear of reverse gear assembly.

DISASSEMBLY OF REDUCTION GEAR

1. Remove oil drain plug (39) from bottom of reduction gear housing (58) and drain oil from unit. Make certain that all lubricating oil is removed from reverse gear unit.
2. Remove capscrews (107) and lockwashers (108) from flange of reduction gear housing and slide entire reduction gear straight bock approximately 3 inches until reduction gear clears reduction drive pinion.
3. Bend tang of lockwasher (47) away from locknut (48). Remove locknut using suitable wrench and lift lockwasher from shaft. Remove coupling washer (46).
4. Remove gear half coupling (106) with gear type puller or by supporting entire assembly under flange of gear half coupling and press against shaft to force coupling from assembly.
5. Remove six capscrews (44) and washers (43) and remove oil seal retaining rear plate (42).
6. Suppbrt reduction gear housing so that output shaft and gear (51) and (38) can drop free approximately 2 inches and press output shaft and gear from reduction gear housing.
7. Press ball bearing (40) from housing.
8. If necessary to replace, remove oil seal (45).

REMOVAL OF COMPLETE TRANSMISSION ASSEMBLY FROM ENGINE

1. Remove six bolta'and washers from around flange of reverse gear housing.
2. Slide entire reverse gear assembly straight back approximately 3 inches until transmission is clear of engine.

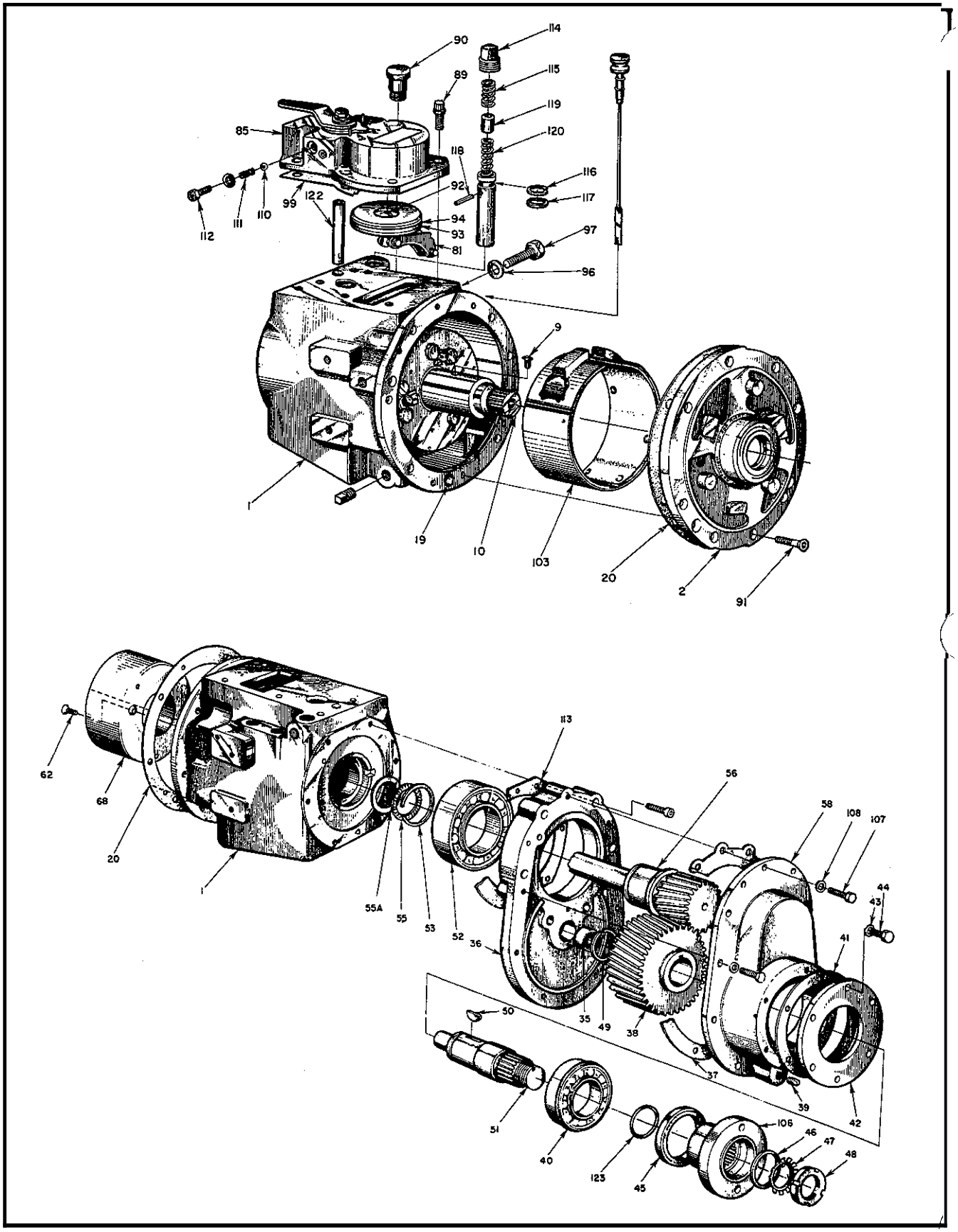


Fig. 151–Complete Assembly

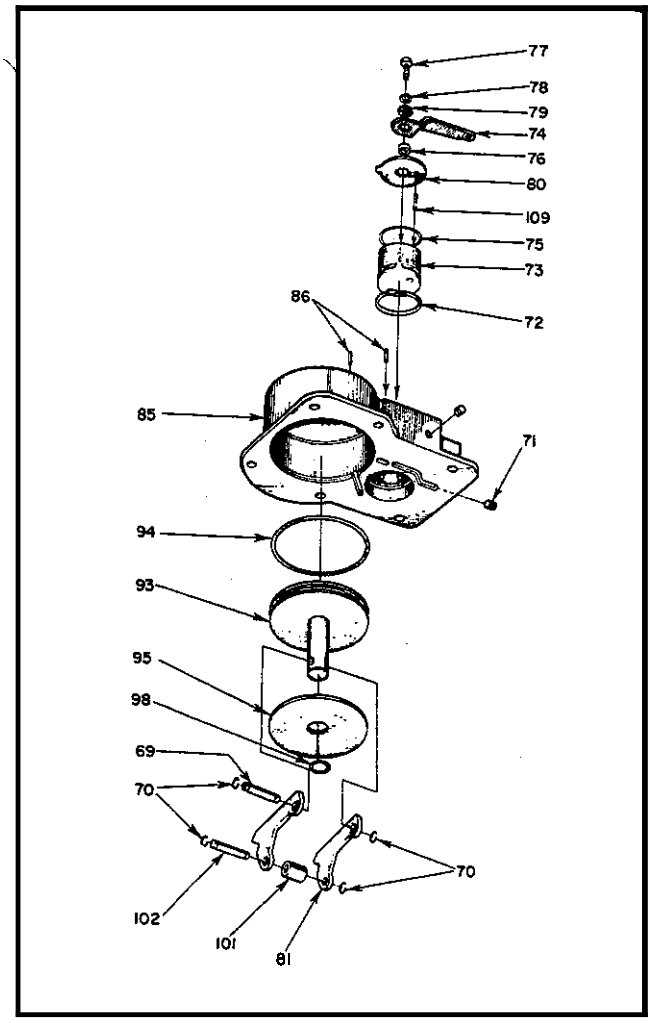


Fig. 152-Cover Assembly

DISASSEMBLY OF COVER

FIGURE 152

1. Remove six socket head bolts (89) around flange and cover.
2. Lift cover (85) from top of reverse gear housing assembly by rotating slightly. This will leave the reverse piston (93) and assembled linkage remaining on the reverse gear housing assembly.
3. Remove reverse band support screw (97) and back out approximately 1 inch.
4. Lift reverse piston (93) and assembled linkage from top of reverse gear assembly.

NOTE: Make notation of position of linkage i.e. to which side levers (81) are attached.

5. Remove reverse piston "O" ring (94) from groove in reverse piston (93).
6. Remove retaining ring (70) from end of reverse piston shaft pin (69) and remove reverse piston shaft pin (69) from reverse band lever (81) ond reverse piston shaft. Remove retaining ring (70) from other end of reverse piston shoft pin.
7. Remove piston backup plate (95) from reverse piston shaft and remove "O" ring (98) from groove in bore in piston backup plate.
8. Remove retaining ring (70) from end of reverse band roll pin (102) and remove reverse band roll pin from levers (81) and reverse band roll (101). Remove retaining ring (70) from other end of reverse band roll pin.
9. Remove capscrew (112) from cover (85) and remove detent spring (111) and remove ball detent (110).
10. Remove control valve retaining ring (72) from counterbore on under side of cover (85).
11. Remove assernbled control valve from top of cover by pulling on control lever (74).
12. Remove capscrew (77). lockwasher (78) and plain washer (79). Remove control lever (74), control lever bushing (76) and control lever pawl (80) from control valve (73).
13. Remove control valve "O" Ring (75) from groove in control valve (73).
14. It is not necessary to remove control lever pin (109) in control valve for further servicing. However, if control valve pin has become damaged and needs replacing, it may be removed by gripping with a plier and twisting.
15. Unless damaged, it is not necessary to remove control lever pins (86) and pipe plugs (71) from cover.

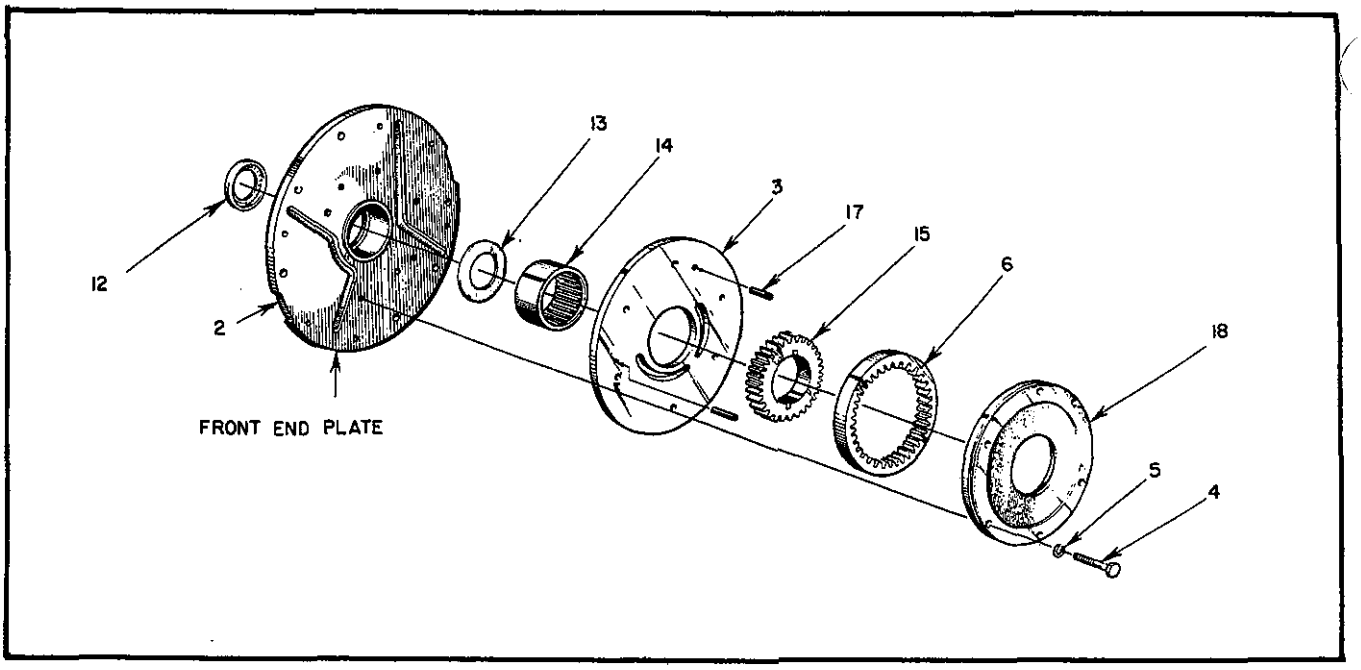


Fig. 153–Front End Plate and Pump

DISASSEMBLY OF FROM END PLATE AND PUMP

FIGURE 151 and 153.

1. Remove six flat-head socket capscrews (91) around flange of front end plate assembly.

NOTE: To assure proper assembly, make notation of direction of cast arrow on front end plate before removing front end plate (Fig. 151).

2. Place assembly tool T-4689 over splined end of engine gear (10) to protect oil seal during removal of front end plate.
3. Lift front end plate assembly, figure 151, from housing assembly taking care not to damage front oil seal in front end plate.
4. Remove pump drive key (9) from engine gear (10).
5. Remove six capscrews (4) and six lockwashers (5) from pump housing (18), figure 153.
6. Remove pump port plate (3) from front end plate. Care must be taken not to damage pump housing pins (17).
7. Remove pump port plote (3) from pump housing and remove inner pump gear (15) and outer pump gear (6) from cavity in pump housing.
8. It is not necessary to remove two pump pins (17) from pump housing (18) for further servicing. However, if pump housing pins, have become damaged and reauire replacing, they may be removed by $ripping with a plier and twisting.
9. Unless damaged and they require replacing, do not attempt removal of roller bearing (14) and front end plate thrust washer (13) from front end plate.
10. Unless damaged and it requires replacing, do not attempt removal of oil seal (12) from front end plote. If necessary to remove oil seal for replacement, take care not to damage roller bearing (14) and front end plate thrust washer (13).

REMOVAL OF GEAR CASE ASSEMBLY FROM REVERSE GEAR HOUSING

FIGURE 154

1. Remove reverse band (103) from gear case inside reverse gear housing.
2. Support reverse gear housing face down on engine gear.

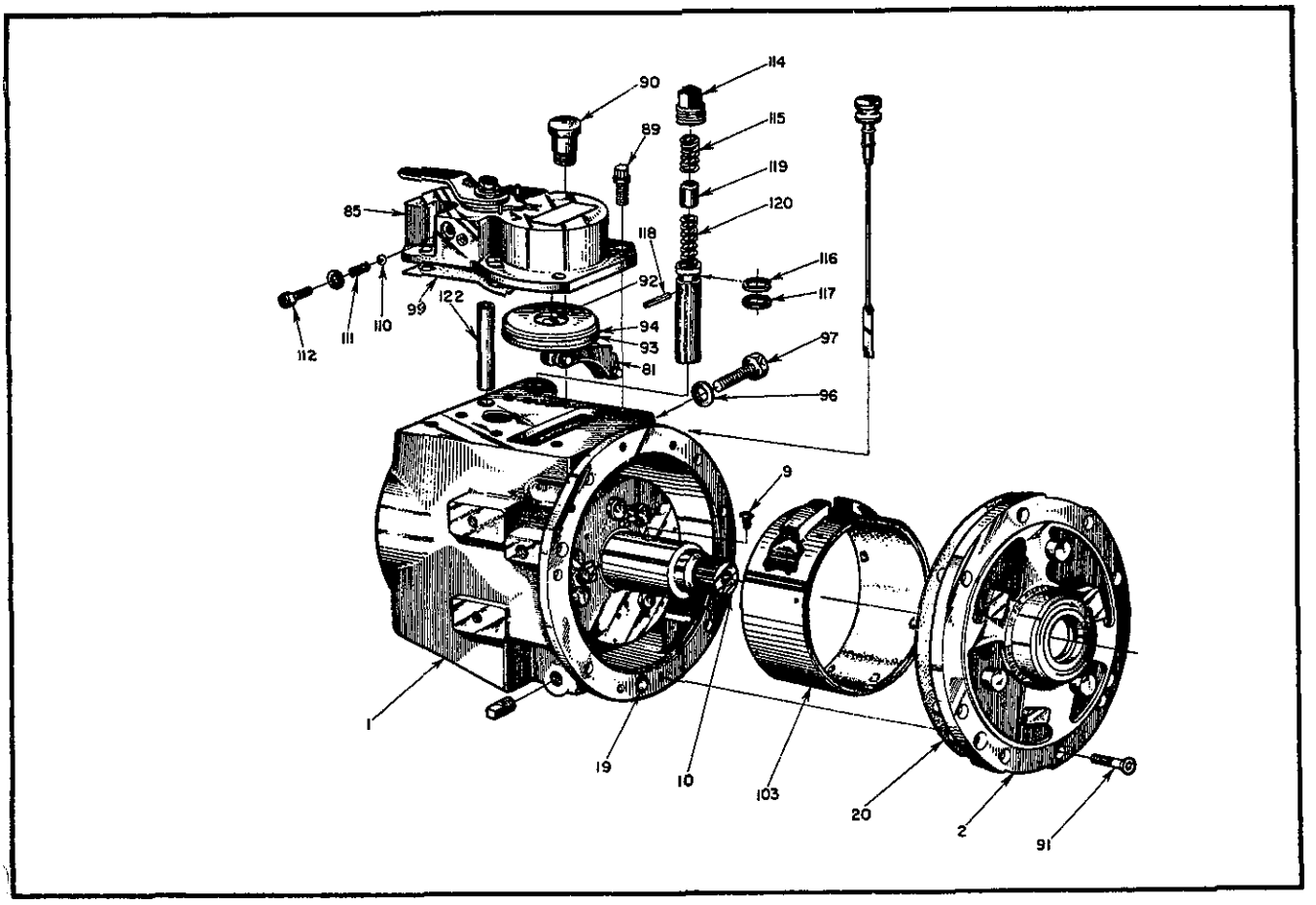


Fig. 154—Reverse **Gear** Housing

3. Remove socket head capscrews that secure reduction adapter plate (36) to reverse geor housing (1). Lift reduction adapter plate (36), ball bearing (52) and reduction pinion tailshaft (56) assembly straight up until reduction pinion tailshaft end is clear of housing.

4. Press ball bearing (52) and reduction pinion shaft (56) from reduction adapter plate (36).

5. Remove retaining ring (53) from reduction pinion tailshaft (56) and press ball bearing (52) from reduction pinion tailshaft.

6. Remove needle thrust bearing (55) and bearing race (55A) from counterbore in rear of reverse gear housing.

7. Lift reverse gear housing straight up from gear case assembly until housing clears gear case assembly.

8. Unless damaged and in need of replacing, do not remove oil suction tube (79), oil distributor tube (122). baffle (68). reverse band housing pin (100). 1/4" pipe plug for oil drain, capscrew (97) and brass washer (92) from housing. If necessary to replace, make note of location of each to aid re-assembly.

9. Remove all old gaskets from reduction adapter plates, cover and housing.

DISASSEMBLY OF GEAR CASE

FIGURE 155

1. If necessary to replace, remove oil distributor seal rings (54) from ring grooves in screw collor (61).

2. Bend sides of screw collar clip (66) away from head of lockscrew (67) and remove lockscrew and clip from screw collar (61).

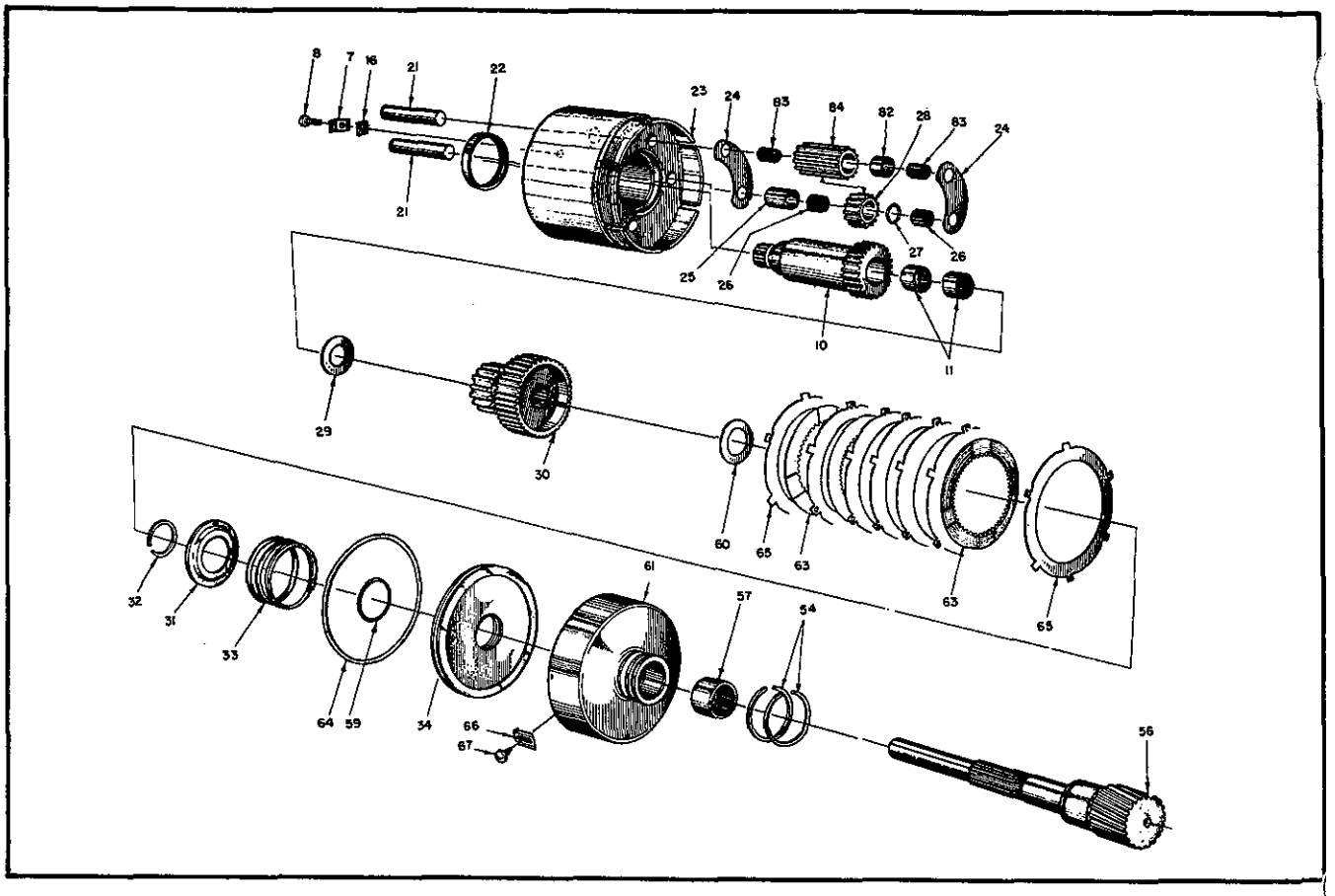


Fig. 155–Disassembly ot Gear Case

3. Using spanner wrench T-4391, remove screw collar (61) from end of gear case (23) while clamping gear case.

4. Remove retaining ring (32). spring retainer (31) and spring (33) from screw collar. Remove forward piston (34) from screw collor by topping open face of screw collar on wooden surface.

5. Remove "O" rings (64) and (59) from outside and inside diameters of piston.

6. If necessary to replace, remove screw collar needle bearing (57) from screw collar.

7. Lift clutch plates (65) and (63) from end of gear case.

8. Remove propeller gear thrust washer (60) from counterbore in propeller geor.

9. Remove propeller geor (30) and engine gear thrust washer (29) from inside of gear case.

10. Bend sides of case clip (7) away from head of capscrew (8) and remove capxrew (8). case clip (7) and pinion shaft locking tab (16) from gear case (23).

11. Drive pinion shaft (21) from one of short pinions (28) from threaded end of gear case approximately 1/2 inch. Push pinion shaft on through with dummy shaft T-4725 until dummy shah is centered in short pinion. Remove short pinion and dummy stud from gear case (23). Remove pinion shaft and short pinion spacer (25) from gear case.

12. Replace dummy shaft with pinion shaft (21) and remove remaining short pinions.

13. Remove engine gear (10) from inside gear case (23).

14. Remove long pinions (84) from gear case, using T-4724 as in #11 above. Remove thrust pads (24) from inside gear case.

15. Do not remove engine gear roller bearings (11) unless damaged and replacement is necessary.
16. Do not remove gear case needle bearing (22) unless necessary to replace.

DISASSEMBLY OF RELIEF VALVE
FIGURE 154

1. Remove relief valve pipe plug (114) and relief valve holdown spring (115) from reverse gear housing (1).
2. Using long nose pliers remove relief valve ossembly.
3. Do not remove snap ring (116) or "O" ring (117) unless damaged and replocement is necessary.
4. Hold relief valve body in vice. Depress relief valve plug (119) with screwdriver until relief volve pin (118) moy be removed from side of relief volve body.
5. Remove relief valve plug (119) and relief valve spring (120) from relief valve body.

REASSEMBLY OF TRANSMISSION

INSPECTION

All parts should be thoroughly cleaned before inspection. Parts showing excessive wear should be replaced.

1. Ball and roller bearings should be examined for indications of corrosion and pitting on balls or rollers and races.
2. Long and short pinion rollerbearingsshould be examined for wear.
3. Pinion shafts should be examined for wear or "brinelling" (wear on pinion shaftcaused by rollers).
4. Long and short pinion thrust pads, roller spacers and short pinion spacers should be examined for wear.
5. Long and short pinion bore diameter should be examined for wear.
6. All gear teeth should be examined for "pitch line pitting", uneven wear pattern or excessive wear.
7. All shafts should be examined for wear on splines and shoulders.
8. Clutch plates should be examined for flatness, roughness, indication of excessive heating and wear or peening of driving lugs.
9. Clutch plate carrier should be examined for wear and peening of involute splines.
10. Examine all "O" rings for cuts, flattening or evidence of rolling.
11. Examine all oil seals for rough or charred lips.
12. Oil pump parts should be examined for wear.
13. Reverse band links, pins and adjusting screw should be examined for wear or bending.
14. Reverse band lining should be examined for wear.

NOTE: Lining should be replaced before ,rivets come in contact with gear case.

15. Gear case should be examined for wear from reverse band lining, short or long pinions wearing into inside face or wear in clutch plate slots on threaded end.
16. Oil distributor seal rings should be examined for wear on outside diameter and on side away from pressure.
17. Screw collar should be examined for wear where oil distributor seal rings run.
18. All retaining rings should be examined for burrs or deformities.
19. All old gaskets should be replaced.
20. All oil passages should be checked to make certain that they are clear.
21. External oil lines and fittings from cooler to transmission should be examined to see that they are clear and not damaged.
22. Engine gear should be examined for wear on oil seal surface, roller bearing races and gear teeth for pitch line pitting, uneven wear or excessive wear.

23. Vibration dampers should be checked at springs and splines for wear.

24. Check relief valve plug and relief valve body for scoring or burrs.

ASSEMBLY OF GEAR CASE

FIGURE 155

1. Press gear case needle bearing (22) into gear case (23), using bearing assembly tool T-4602.

2. Assemble long pinions (84) and roller bearings (83) and thrust pads (24) etc., asfollows:

   (a) Place long pinion (84) on one end on thrust pad (24) and insert dummy shoft T-4724 into long pinion.

   (b) Insert four roller bearings (83) equally spaced around dummy shaft to center shaft in pinion; then assemble remaining rollers in first row. Thirty-two roller bearings complete one row. Install long pinion bearing spacer (82) over dummy shaft next to first row of roller bearings, then assemble second row of roller bearings.

NOTE: Smear dummy shaft with cup grease to prevent rollers from dropping out. Use extreme care when handling assembled pinions to prevent roller bearings from dropping out during assembly, into gear case.

   (c) Lay gear case (23) on side and insert long pinion (84) with dummy shoft and roller bearings in gear case from threaded end of case. Long pinion should align with one hole in outer row of pinion shaft holes. Insert thrust pad (24) between long pinion and front wall of gear case. Note that each thrust pad aligns with one hole on outer row and one hole on inner row of pinion shoft holes and that the curvature of thrust pad follows curvature of geor case.

   (d) Insert pinion shaft (21), plain end first, into unthreaded end of gear case and push through thrust pad and pinion as far as rear wall of gear cose, forcing out dummy shoft.

   (e) Remove dummy shaft, insert second thrust pod (24) between long pinion and rear wall of gear cose and start pinion shaft into rear wall of gear case. Do not drive pinion shaft all the way into geor case until all shafts are inserted.

   (f) Assemble remaining long pinions into gear case.

3. Press first engine gear roller bearing (11) into engine gear (10) using bearing assembly tool T-4603. Install second engine gear roller bearing into engine gear using T-4670.

4. Install engine geor (10) with assembled engine gear roller bearings into gear case (23) from threaded end of gear cose, meshing teeth on engine gear and long pinions alreody assembled into gear case. The splined end of the engine gear should pro truoa from the front end of the gear cose.

5. Assemble short pinion (28) and roller bearings (26) etc., as follows:

   (a) Place short pinions (28) on one end on flat surface and insert dummy shaft T-4725 into short pinion.

   (b) Insert four roller bearings (26)' equally spaced around dummy shaft to center shaft in pinion; then assemble remaining rollers in first row. Thirty-two roller bearings complete one row.

   Insert short pinion bearing spacer (27) over dummy shaft next to first row of roller beorings, then assemble second row of roller bearings.

NOTE: Smear dummy shaft with cup grease to prevent rollers from dropping out. Use extreme care when handling assembled pinion to prevent roller bearings from dropping out during assembly into gear cose.

   (c) Line up thrust pad (24) olready in gear case and insert pinion shaft (21), plain end first, into unthreaded end of geor case, through thrust pad so that pinion shaft protrudes approximately one inch into gear case. Place short pinion spacer (25) over end of protruding pinion shoft.

(d) Smear ends of roller bearings with cup grease.

(e) Insert short pinion assembled with roller bearings, etc., into gear case, meshing teeth on short pinion and long pinion already in gear case. Line short pinion over pinion shaft and short pinion spacer already in gear case and push pinion shaft through short pinion as far as rear wall of geor cose, forcing out dummy shaft.

(f) Remove dummy shaft, line up second thrust pad (24) already in gear case and start pinion shaft into rear wall of gear case. Do not drive pinion shaft all the way into gear cose until all shafts are inserted.

(g) Assemble remaining short pinions into gear case.

6. Align slots in each pair of pinion shafts so that slots face each other and are parallel. Insert pinion shaft locking tab (16) into slots in pinion shaft. Make certain that the pinion shafts and pinion shaft locking tabs are seated against geor case. Place cose clip (7) over top of pinion shaft locking tab lining up holes with threaded holes in gear case and formed end of case clip over edge of locking tab toward center of gear case. Install capscrew (8) and secure tightly. Bend pre-formed end of case clip up oround head of copscrew.

7. Install engine geor thrust wosher (29) on engine geor (10) from threod end of geor case.

8. Instoll propeller geor (30) into geor case from threod end of the geor case meshing the geor teeth of the propeller geor with the short pinions olreody in the gear case.

9. Install propeller geor thrust wosher (60) in counterbore of propeller gear.

10. Install steel clutch plates (65) and bronze clutch plates (63) in clutch plote cavity in threaded end of gear cose as follows:

(a) Place one steel clutch plate (65) with lugs in notches of gear case and place one bronze clutch plate (63) over teeth on clutch plote carrier.

(b) Install remaining bronze clutch plotes (63) and steel clutch plates (65) alternating bronze ond steel until all ore in ploce.

NOTE: Make certain that oll clutch plotes ride freely on their respective lugs and that no binding is apparent during assembly.

11. Press screw collar needle bearing (57) into screw collar (25) using bearing assembly tool T-4671.

12. Install "O" rings (64) and (59) to outside diameter and inside diometer of forward piston (34).

13. Install forward piston with "O" rings into screw collar (61). Lubricate "O" ringsurfaces of screw collor with light oil beforeinstolling forward piston into screw collor.

NOTE: Use core in installing forward piston as not to roll or damage "O" rings on internal threads in screw collar.

14. Instoll screw collar spring (33). spring retainer (31) and retaining ring (32) in screw collor.

15. Clamp geor cose in vice with engine geor protruding down. Place screw collor with assembled forward piston, screw collor spring, spring retainer, retaining ring and screw collor needle beoring and screw down collor using spanner wrench T-4391. Screw collor should be tightened until threaded holes in periphery of screw collor line up with drilled holes in gear cose.

16. Line up screw collar clip (66) over one threaded hole in screw collar with lip over edge of screw collar. Install lockscrew (67) and tighten until two sides of lockscrew head are parallel with sides of clip. Bend pre-formed sides of clip up oround heod of lockscrew. Add second lockclip and lockscrew.

17. Instoll two oil distributor seal rings (54) in ring grooves of screw collar.

NOTE: Use core in expanding oil distributor seal rings when installing so as not to break rings.

18. Up-end geor cose assembly and ploce on end of engine geor.

ASSEMBLY OF GEAR CASE IN REVERSE GEAR HOUSING

FIGURE **154**

1. Assemble oil suction tube (19) in hole in flange of reverse gear housing (1) using suction tube assembly tool T-4672.

2. Insert oil distributor tube (122) in hole in top of reverse geor housing, making certain that tube is seated in bottom of hole and is below top surface of reverse gear housing.

3. Install baffle (68) into reverse gear housing (1) until bock side rests on bosses in back of reverse geor housing. Fasten with flat head socket copscrews (62).

4. Instoll reverse bond housing pin (100) into drill boss on inside of housing near elongated slot in top.

5. Place new front end plate gosket (20), cover gosket (94) and rear housing gosket (113) on reverse gear housing. Note that front gosket (20) holds reverse band housing pin (100) in housing.

6. Turn oil distributor rings (54) in screw collor (61) so that gaps of rings ore together ond are facing up.

7. Take reverse geor housingossembly, (figure 154) and place over gear case assembly, (Figure 155). Start housing bore overscrew collar. Ease oil distributor rings into chamfer on bore of reverse geor housing with gentle rocking motion. Do not force rings into housing or rings may break. Lubricote bore in housing before installing to ease assembly.

8. Place needle thrust bearing race (55A) ond needle thrust bearing (55) on top of screw collor. Make certain that engine geor thrust wosher (29), propeller gear thrust washer (60), thrust beoring race (55A) and needle thrust bearing (55) ore lined up properly.

9. Press reduction pinion tailshaft (56) into boll beoring (52). Install retoining ring (53) in place.

10. Press needle thrust bearing (35) into reduction adopter plote (36).

11. Press reduction adapter plate assembly, Figure 154 over reduction pinion tailshaft assembly, Figure 154.

12. Install complete reduction adapter plate onto housing ossembly. Instoll six socket head copscrews in reduction odapter plote (36). Use two reduction odopter plote seals in two uppermost holes under head of copscrews.

13. Place new gosket (37) on reduction odapter plote.

COVER ASSEMBLY

FIGURE **152**

1. Install pipe plugs (71) into cover (85). Install two control lever pins (86) into top of cover (85).

2. Assemble one control lever pin (109) to top of control valve (73).

3. Assemble control volve "O" ring (75) to groove at top of control valve (73).

4. Place control valve lever **(74)** over control valve lever pin on control valve.

5. Instoll control lever bushing (76) into control lever pawl (80).

6. Install control lever (74) onto control lever bushing.

7. Assemble plain washer (79). lockwasher (78) and capscrew (77) in hole of control lever bushing (76) ond into thread hole in control lever.

8. Instoll assembled control valve into cover (85) from topside of cover, so that the point on the control lever pawl is pointed ot neutral position. Lubricote bore of cover before installing control valve to aid in installing. Core must be taken not to damoge "O" ring during assembly. Assemble control valve retoining ring (72) to control valve from underside of cover.

9. Make certain that control lever and control valve rotate freely.

10. Install ball detent (110) into hole in side of cover and rotate control valve until ball detent drops into detent in control valve.

11. Install detent spring (111) on top of ball detent in cover. Install seal wosher and capscrew (112) and tighten capscrew. Rotate control volve to make certain that ball detent operates smoothly in forward, neutral and reverse.

12. NOTE: The following items may be assembled together at this time; however, DO NOT assemble into cover at this time.

13. Assemble retaining ring (70) to one end of reverse band roll pin (102). Install reverse band roll pin through hole in short leg of one reverse band lever (81). Place reverse band roll (101) over end of reverse band roll pin and install second reverse band lever (81) over end of reverse band roll pin (102). Make certain that both levers are installed so as to line up. Install retaining ring (70) over end of reverse band roll pin.

14. Assemble retaining ring (70) to end of reverse piston shaft assembly Figure 152. Install reverse shaft pin through hole in long leg of one reverse bond lever (81), through hole in reverse piston shaft (92) and through hole in long leg of one reverse band lever (81), through hole in reverse piston shaft (92) and through hole in long leg of second reverse band lever (81). Assemble retaining ring (70) to end of reverse piston shaft pin (64).

15. Install reverse piston "O" ring (94) into groove in O.D. of reverse piston (93).

NOTE: DO NOT assemble into cover at this time.

RELIEF VALVE ASSEMBLY

FIGURE 154

1. Place relief valve spring (120) in relief valve housing (121). Place relief valve plug (119) on top of spring in relief valve housing (121).

2. Clamp relief valve housing (121) in vise with relief valve plug up. Depress relief valve plug with screwdriver until relief valve pin (118) can be pushed through holes in relief valve housing (121).

3. Install relief valve pin (118) in relief valve housing (121) and relax pressure on relief valve plug until plug holds pin in place.

FRONT END PLATE AND PUMP ASSEMBLY

FIGURE 153

1. Press oil seal (12) into front end plate (2) from front face or outside face of front end plate.

2. Press front end plate thrust washer (13) into front end plate, using assembly tool T-4673 until properly seated against bottom of bore.

3. Press roller bearing (14) into front end plate using assembly tool T-4602.

4. Install two pump housing pins (17) into pump housing (18).

5. Install outer pump gear (6) into cavity of pump housing (18).

6. Install inner pump gear (15) into cavity of pump housing (18) meshing teeth with outer pump gear.

7. Place pump port plate (3) over pump housing (18) with unchamfered sidetoward pump housing, lining up over pump housing pins (17) already in pump housing, and press together.

8. Line up pump housing pins (17) protruding through pump port plate (3) with holes in front end plate and bolt together using six lockwashers (5) and six capscrews (4).

TRANSMISSION ASSEMBLY

FIGURE 151

1. Install pipe plug into drain hole of housing. Drain hole is located on the right hand side near the bottom of the housing.

2. Install relief valve assembly into reverse gear housing. Assemble relief valve retaining ring (116) and "O" ring (118). Make certain that relief valve is seated properly. Assemble relief valve holddown spring (115) and pipe plug (114).

3. After final adjustments have been made, install breather (90) and dipstick (104).

4. Install brass washer (96) and screw (97) to threaded-through hole in pad on side of housing.

5. Assemble reverse bond (103) to gear case inside housing so that lugs on reverse band are up ond in line with reverse band support screw. Position reverse band support screw so that lug on reverse bond con rest against it.

6. Install pump drive key (9) in hole in engine gear. Line up sides of pump drive key with engine gear.

7. Place assembly tool T-4689 over splined end of engine gear to protect oil seal during front end plate assembly.

8. Line up keyway in inner pump gear in front end plate assembly (figure 153) with pump drive key in engine gear. Slide front end plate assembly over engine gear until front end plate is seated properly against housing, engaging pump drive key with keyway in inner pump gear.

9. Rotate front end plate assembly to line up six bolt holes with reverse gear housing. Note that front end plate assembly can be located in one of two positions; i.e., up for right rotation or up for left rotation. As the transmission is always viewed from the transmission or output end, the plate should be assembled with words "Use For Left Rotation" being up.

10. Install six flat-head socket capscrews (91) to front end plate assembly and reverse gear housing and tighten securely.

11. Install assembled reverse piston and linkage (figure 152) into opening in top of reverse gear housing as follows:

(a) Back off reverse band support screw (97) until reverse band can be rotated past end of reverse band support screw.

(b) Rotate reverse band until reverse band roll on assembled linkage can pass between lug on reverse band and reverse band housing pin in housing.

(c) Slip reverse band roll over squoredend of lug on reverse band and hooknotches of reverse band lever over reverse band housing pin in housing.

(d) Insert screwdriver through opening in top of housing and rotate reverse band lug against reverse band roll. This will cause the reverse piston and piston back-up plate to drop down against the top of the housing.

NOTE: Hook reverse bahd lever on reverse band housing pinon righthand side of housing.

(e) Tighten reverse band support screw.

12. Place cover and assembled control valve (figure 152) over reverse piston assembled to reverse gear housing, and line up bolt holes in cover with those in reverse gear housing.

13. Press down on cover, engaging reverse piston in cavity in cover. Care must be taken not to damage "O" ring on reverse piston during assembly. Lubricate bore in cover prior to assembly with light oil.

14. Install six ferry head capscrews (89) in cover and tighten securely.

ASSEMBLY OF COMPLETE TRANSMISSION ASSEMBLY TO ENGINE

1. Install two studs in opposite side holes in engine adopting piote on engine so studs protrude opproximately 3-1/2 inches.
2. Start reverse gear assembly over sfuds ond slide entire assembly up ogoinst engine, engaging spline on engine gear in splined hole of vibration damper on engine.
3. Install four 7/16"-14 x 1-3/4" attaching bolts and washers in holes around flange of reverse gear housing.
4. Remove studs and install remaining two bolts ond washers.

ASSEMBLY OF REDUCTION GEAR ASSEMBLY TO REVERSE GEAR ASSEMBLY

1. Replace oil drain plug (39) into reduction gear housing (54).
2. Press boll beoring (40) with snap ring into reduction gear housing (58).
3. Press output shaft and geor (51) into reduction gear housing.
4. Instoll oil seal (45) into rear end plate (42).
5. Assemble rear end plate and seal to reduction housing. Instoll six lockwashers (43) and capscrews (44) in rear end plote holes and tighten securely.
6. Instoll "O" ring (123) over spline on output shoft against bearing shoulder of shoft.
7. Support unit on inside of shaft with large end of unit down and press splined gear half coupling (106) onto shaft end until coupling is seated ogainst ball beoring.
8. Place coupling wosher (46) over end of shoft, insert lockwasher (47) with tang on inside of lockwasher in slot on shaft. Place locknut (48) onto shoft and secure using suitable wrench.
9. Bend one tong of lockwasher into slot on locknut.
10. Install two studs 3-1/2 inches long into two opposite holes in reduction adopter plate.
11. Position reduction gear assembly overstuds and slide onto reduction drive gear. It may be necessary to rotate reduction gear slightly to properly mesh gear teeth.
12. Install lockwashers (108) and rapscrews (107) around flange of reduction gear housing and tighten uniformly.

ADJUSTMENTS

With tronsmission secured to the engine, replace all oil lines, etc. Before securing the propeller half coupling to the gear half coupling, check to make certain that the couplings do not run out more than .002 inches with respect to each other.

The transmission should be filled with new oil as specified under "Lubrication".

The forward clutch is direct acting and hos sufficient travel to compensate for wear. Therefore. there are no adjustments for the forward drive.

No adjustment is necessary for either the neutral or reverse. A large spring provides positive retraction of the forward piston and the reverse piston stroke and band linkageeliminates any adjustments on the reverse.

SERVICE BULLETINS

The following Bulletins contain supplementary and updated information about various components and service procedures which are important to the proper functioning of your engine and its support systems.

You should familiarize yourself with the subjects and make sure that you consult the appropriate Bulletin(s) whenever your engine requires service or overhaul.

v.2

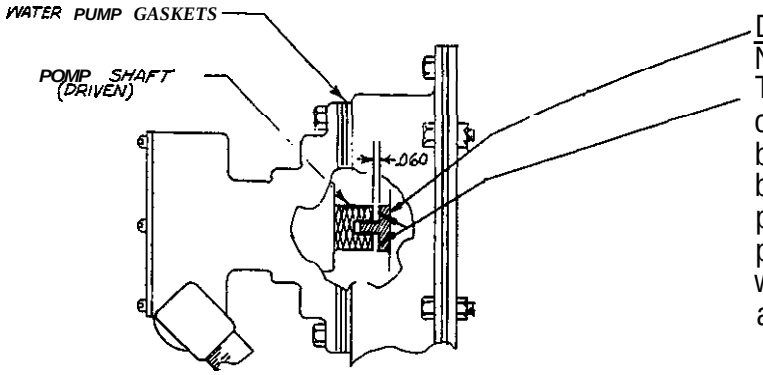
SERVICE BULLETIN

DATE: September 17, 1976 *BULLETIN NUMBER:* 10

MODEL: Westerbeke 40 and WPDS 10-15

SUBJECT: Sea Water Pump Clearance and Alignment

Clearance:
Adequate longitudinal clearance between the sea water pump shaft and the driving shaft is established by the use of multiple pump gaskets. The number of gaskets required can vary from 1 to 4. Enough gaskets must be used so that the shaft ends do not mate. See figure 1.



NOTE:
The application of liquid or paste type Prussian blue (at points indicated by arrows) will give positive indications of pump drive contact which will require the use of additional gaskets.

If the proper clearance is not maintained, the sea water pump shaft will force the fuel pump drive hub against its bushicg. The bushing will seize to the drive hub and rotate in its housing. Bushing wear and loss of oil pressure will result.

When replacing the sea water pump be sure that the same number of gaskets is replaced and there is the required clearance.

Alignment:
Alignment is just as critical as clearance. The latest 1/2" pump intentionally has no pilot because the location of the timing cover itself is not precise. To assure that the pump shaft is axial with the driving shaft, install the pump with the four nuts just snugged. WITH THE FUEL STOPLEVER OFF, crank the engine for a few seconds. If the nuts have not been overtightened, the drive tang will cause the pump to align itself. It is best to deliberately offset the pump against its studs so you can visually verify movement of the pump as it centers itself during cranking. The nuts should then be tightened. This procedure must be repeated anytime the pump is loosened.

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PIN: 16742

SERVICE BULLETIN

v.3

DATE: April 23, *1968* *BULLETIN NUMBER:* 11

MODEL: Westerbeke 40 and WBDS 10-15

SUBJECT: Instructions for Replacing Injection Pump Drive Hub Bushing (#0050323)

1. Remove c/s Pulleys
2. Remove water pump
3. Remove timing cover
4. Mark idler gear and fuel pump gears before removing fuel pump gear (This is very important in order to retain proper relation of gears and eliminate re-timing of engine).
5. If fuel pump hub bushing is worn as suspected, gear and bushing will pull right out of block.
6. Remove quill shaft from injection pump (splined pump drive shaft).
7. Remove gear from drive hub
8. Remove hub bushing retaining circlip
9. If bushing is frozen on hub, tighten forward end of bushing in vise and drive hub of bushing with brass drive taking care not to damage female splines in hub
10. Place hub flange on top of vise and with small brass punch knock out drive key from hub
11. Clean hub shaft with crocus cloth or similar material. Pre-oil and fit new bushing. Check that bushing rotates freely. Replace circlip.
12. Clean bushing hole in block
13. With plastic or similar soft headed mallet drive newly assembled bushing in place hitting squarely on center until it has definitely bottomed out against block.

Continued

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WESTERBEKE SERVICE BULLETIN **#11** (Continued)

14. After bushing is in place recheck for free rotation of hub making sure no binding is evident

15. Line up master spline of drive hub with master spline of fuel pump drive

16. Replace fuel pump drive shaft by passing it through drive hub until it enters into pump drive. When shaft comes up against fuel pump drive it may be necessary to hold a slight finger pressure against drive shaft and rotate slightly left and right until shaft enters pump drive. (NOTE: On drive shaft longer portion mates in drive hub)

17. After shaft is in place (using a brass or similar hammer) drive the water pump drive key into hub

18. Reinstall pump drive gear making suie gear teeth are matched (same as on removal)

19. Line up corresponding scribe marks on drive hub and drive gear then **install** and tighten 3 drive gear bolts.
NOTE: If scribe marks are not properly aligned timing will be **off.**

20. Reinstall timing cover

21. Reinstall pulleys

22. When installing Sherwood pump refer to attached bulletin. (Service bulletin **#10)**

SERVICE BULLETIN

v.5

DATE: 6/15/69 *BULLETIN NUMBER:* 20

MODEL: All Engines

SUBJECT: Connecting Pressure Sensing Devices to Oil Galleries

Oil pressure sensing devices, such as senders and switches, must never be connected directly to any oil gallery of an engine. The reason is simply that continued engine vibration causes fatigue of the fittings used to make such a connection. If these fittings fail, the engine loses its oil pressure and very quickly seizes.

Such pressure sensing devices must be bulkhead mounted and connected to the oil gallery using an appropriate grade of lubricating oil hose. Any fittings used to connect the hose to the gallery must be of steel or malleable iron. Brass must not be used for this purpose.

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V.6

SERVICE BULLETIN

DATE: June 15, 1969 *BULLETIN NUMBER:* 21

MODEL: Westerbeke 40

SUBJECT: Replacing Injection Pump Drive Hub Part Number 12632

NOTE: When replacing the drive hub the new hub will have no timing mark scribed on it. For this reason the following procedure must be adhered to step by step. When the procedure is completed and before replacing the timing cwer, a new mark is to be punched on the drive hub to coincide with the existing scribe mark on the fuel pump drive gear.

1. Remove the small cwer on side of injection pump.
2. Turn engine in direction of rotation (clockwise looking aft). Use a socket and long bar on crankshaft nut and turn by hand.
3. While turning shaft, look into opening in injection pump. It will be noted that pump rotor has a series of letters on it with a scribe mark beneath each letter. It will also be noted that there is a large snap ring visible through the opening.
4. Rotate the shaft until the scribe mark for the letter "C" lines up with the edge of the lower end of the snap ring. (There is also a letter "G" on the rotor -- do not confuse it with "C".)
5. At this point #1 piston is at 22° before top dead center.
6. Remwe crank shaft pulleys (when removing the crankshaft nut, if the shaft is moved before removing the pulley, reset the letter "C" with the snap ring in the pump).
7. Remwe water pump.
8. Remwe timing cover
9. Mark the idler gear and fuel pump gear.(This is very important in order to retain proper relation of gears and eliminate complete engine retiming.)
10. Remwe fuel pump gear from drive hub.
11. Obtain three (3) 5/16" fine threaded bolts about 3" long threaded all the way. These are to be threaded into the holes on the drive hub and turned in against the front plate to pull the hub and bronze bushing out of the block as an assembly. (Note: Tighten bolt equally in sequence to prevent galling the bronze bushing in the block.)

Continued

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SERVICE **BULLETIN** #21 - **Continued**

REPLACING INJECTION PUMP DRIVE HUB

12. When the hub and bushing are **removed** pull out the pump splined drive shaft which will now be visible.

13. Remove circlip from old hub and transfer bushing to new hub using new circlip.

14. With plastic or similar soft headed mallet drive assembly back into block hitting squarely on center until it has definitely bottomed out against block.

15. After bushing is in place, recheck for free rotation of hub making sure no binding is evident.

16. Line up master spline of hub with master spline of fuel pump drive.

17. Replace fuel **pump** drive shaft by passing it through drive **hub** until it enters into pump drive. When the shaft comes up against fuel pump drive it may be necessary to hold a slight finger pressure against the drive shaft and rotate slightly left or right until shaft enters ***pump*** drive.

NOTE: ON DRIVE SHAFT, LONGER SPLINSD **END** MATES INTO DRIVE **HUB.**

18. **Rotate** hub until letter "C" is back on scribe **mark.**

19. Re-install drive gear making sure letter "C" is lined up before securing bolts.

20. Remark hub to correspond with mark on gear.

21. Using soft headed **hammer** insert water pump drive key into hub until it bottoms out.

22. Install timing gear cover, pulley, and water pump.

23. Put **cover** back on injection pump and bleed pump using procedure in manual.

V.8

SERVICE BULLETIN

DATE: November 3, 1970 *BULLETIN NUMBER:* 31

MODEL: Westerbeke Diesel Model Four-107 (Whaleboat)

SUBJECT: Lubricating Oil System Modification

PURPOSE: To reverse lube oil direction through system thereby utilizing high pressure by-pass valve in lube oil filter.

APPLICABILITY: All referenced engine models whose lube oil fitting, located at oil attachment boss on engine, bears the casting number B-120.

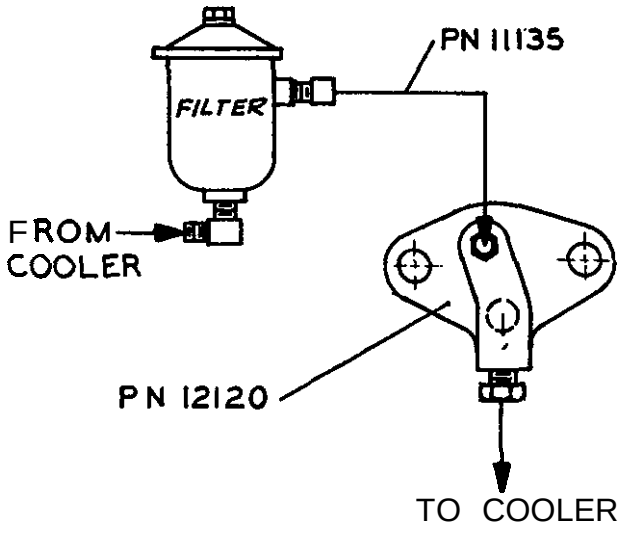
PROCEDURE:

1) Remove existing fitting and oil line between fitting and lube oil filter.

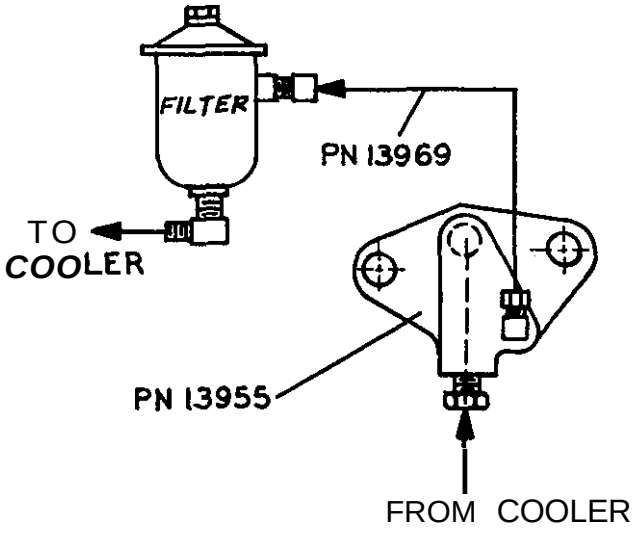
2) Using new gasket, ferrules, and elbow provided, install new fitting and oil line.

PARTS REQUIRED:
2 - 13333 Ferule
1 - 13955 Fitting, oil lines to boss
1 - 13969 Line, lube oil
1 - 11616 Gasket, fitting
1 - 13335 Elbow

OLD CIRCUIT



NEW CIRCUIT



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SERVICE BULLETIN

v.9

DATE: June 22, 1976 BULLETIN NUMBER: 93

MODEL: All

SUBJECT: Adjusting Paragon P200 Series Reverse Band

If the boat moves forward when the gear is in neutral at proper idle speed, the reverse band may be out of adjustment. When adjusting, be very careful not to get reverse band too tight or it will burn out. If the boat goes backwards when in neutral, it may be too tight.

The following adjustment procedure should only be carried out when it is not possible to obtain the service of an authorized Paragon transmission service dealer.

To Adjust:

On the outside left side of the gear there is a bolt in the mounting pad. Under its head are 1 to 3 washers. Remove one washer. This should stop forward boat movement. But under NO circumstances use fewer than one washer nor more than three.

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V.10

SERVICE BULLETIN

DATE: March 4, *1977* *BULLETIN NUMBER: 98*

MODEL: Westerbeke Four-107 Whaleboat

SUBJECT: Electrical System Change

Delco generator #11667 and regulator #11669 are no longer in production and are being replaced by:

Motorola alternator #21566 and

Motor regulator #21611

This alternator is driven from the engine's crankshaft pulley at a speed ratio of 2.19:1 with an output of 840 watts at 24 VDC.

See diagram and parts list overleaf.

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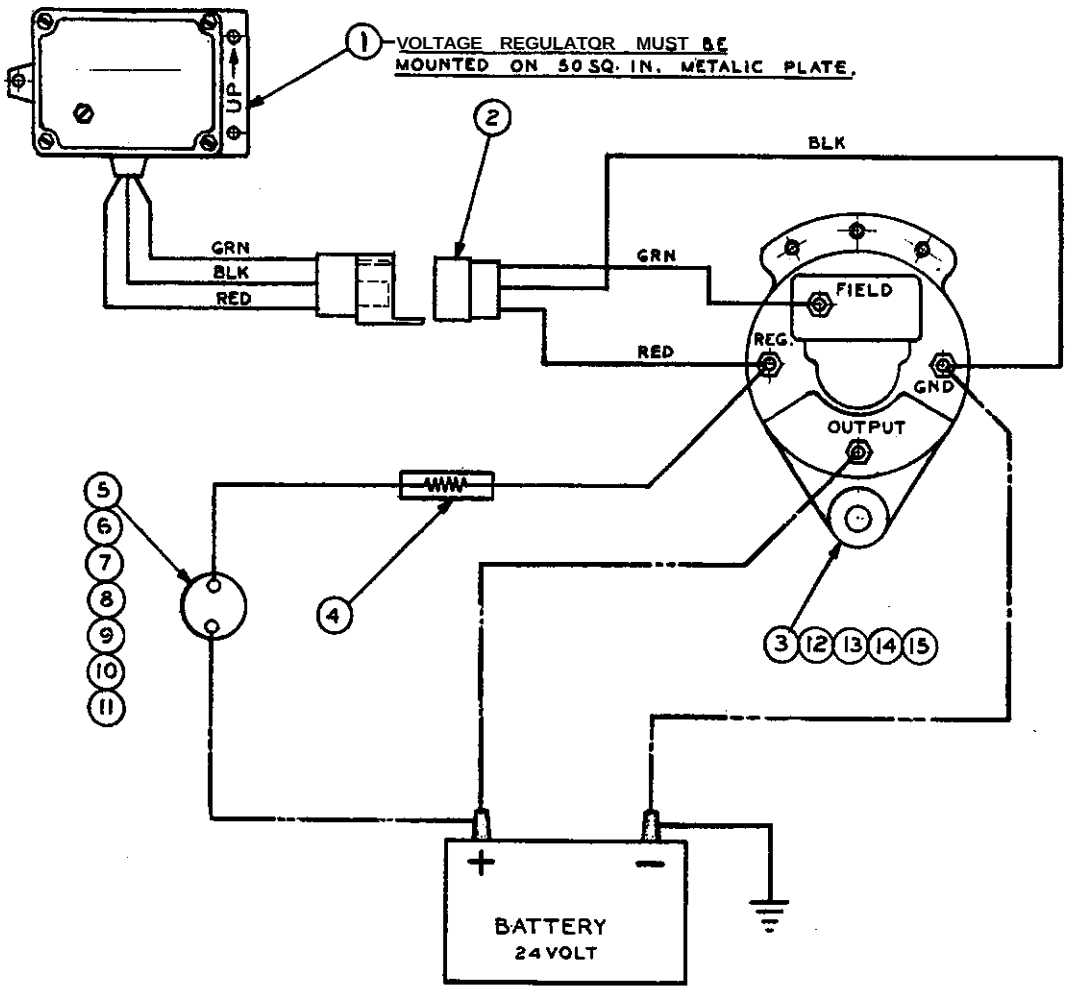

ITEM	PART NO.	DESCRIPTION	QTY
15		BELT	1
14	11548	PULLEY	1
13	11125	STRAP	1
12	12060	BRACKET	1
11	11492	NIPPLE (STEEL)	1
10	13328	ELBOW 90°	1
9	15122	ELBOW 45°	1
8	11981	HOSE	1
7	11615	PLUG	3
6	11969	MANIFOLD	1
5	11383	SWITCH, OIL PRESSURE	1
4	22120	RESISTOR. 150 OHM	1
3	21566	ALTERNATOR. 24V. 35AMP	1
2	22119	CABLE ASSY.	1
1	21611	REGULATOR. 24 VOLT	1

TOLERANCES (UNLESS OTHERWISE SPECIFIED)	J. H. WESTERBEKE CORP. AVON, MA. 02322	
DECIMAL ±	MODEL FOUR-107WB	SCALE NONE
FRACTIONAL ±	TITLE ELECTRICAL SYSTEM USING 4VOLT, 35AMP. MOTOROLA ALT.	
ANGULAR ±	DATE 2-16-77	DRAWING NUMBER 22121

V.12

SERVICE BULLETIN

DATE: May 20, 1980 *BULLETIN NUMBER:* 110

MODEL: A11

SUBJECT: Ammeter Wire Sizes

Ammeters may be installed in conjunction with any Westerbeke marine diesel engine or diesel generator set. The range of the ammeter must be appropriate for the maximum output of the alternator.

Additionally, the wire size for the alternator output circuit, including the ammeter, varies with the total length of that circuit. The table below shows the maximum current that can be carried various total distances by various wire sizes, to and from source to load.

WIRE SIZE TABLE

System Volts	Total Length of wire in feet	MAXIMUM CURRENT (AMPS) 35	40	55	60	70	85	120
12	1 to 5	12	12	12	8	8	8	6
12	5 to 10	10	10	8	6	6	6	4
12	10 to 20	6	6	6	6	3	2	1
12	20 to 30	6	4	4	2	1	1	1
12	30 to 40	4	2	2	1	1	0	0
24	1 to 5	14	14	12	12	10	10	8
24	5 to 10	12	12	10	10	8	8	6
24	10 to 20	10	8	8	6	6	4	4
24	20 to 30	8	6	6	4	4	4	2
24	30 to 40	6	6	4	4	2	2	0
32	1 to 5	14	14	12	12	10	10	8
32	5 to 10	12	12	10	10	8	8	6
32	10 to 20	10	8	8	6	6	4	4
32	20 to 30	8	6	6	4	4	4	2
32	30 to 40	6	6	4	4	2	2	0

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PARTS LIST

NOTES ON USING THIS PARTS LIST

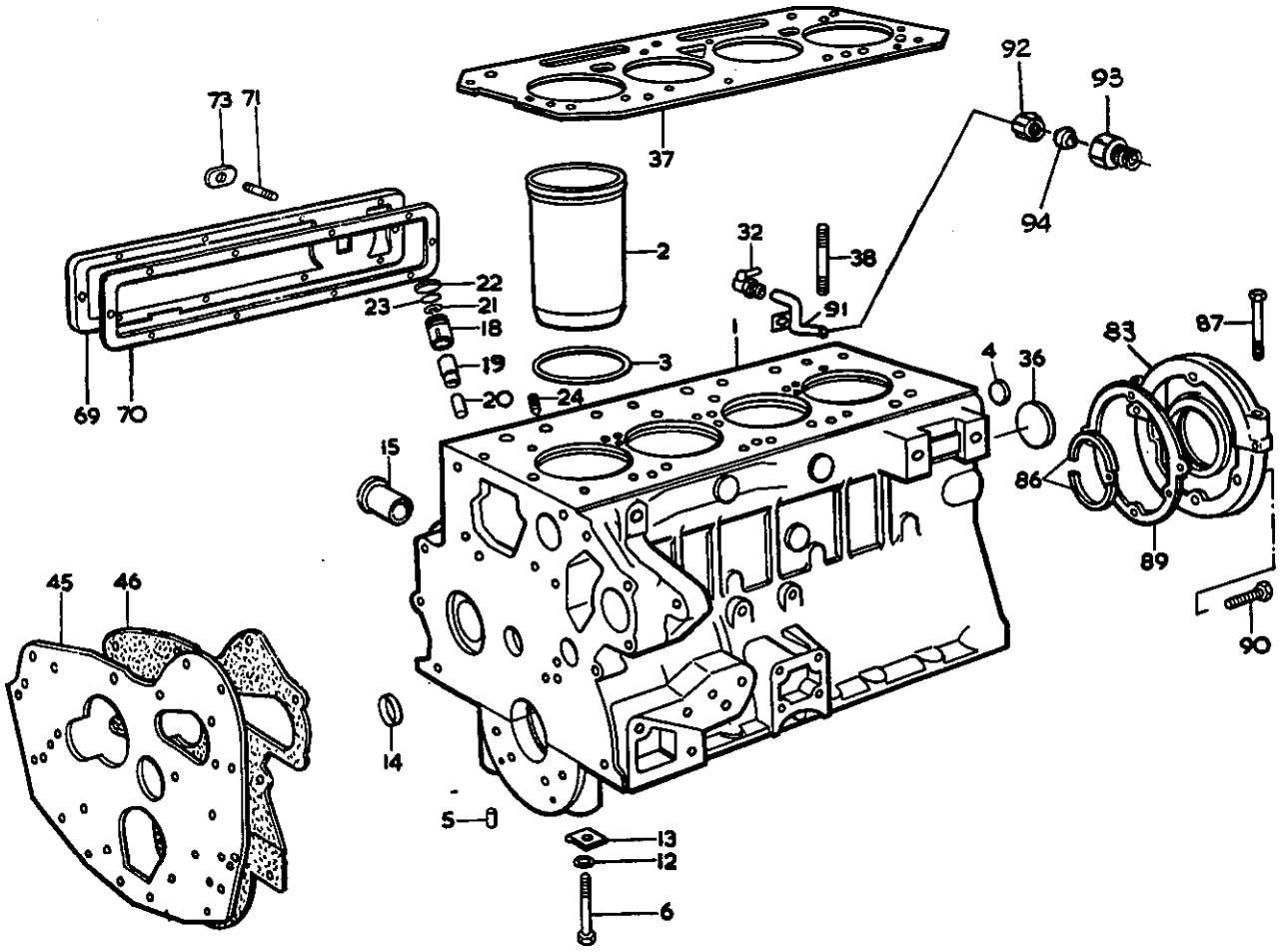
1. Unit of issue for all linear commodities is inches (not feet or yards).

2. To find the part number of a serviceable component:

   a) In the contents, find the page number of the system of which the component is most logically a member.
   b) On the illustration corresponding to that page number, find the specific illustration of the component and note the reference number.
   c) Go to the facing partslist and find the reference number. The part number, name, description, and quantity required follows.

3. There are three series of serial numbers in use and they are identified by a prefix stamped as part of the serial number in the block. They are 107Uxxxxxx, 108Uxxxxxx, and EDxxxxxx. References are made in the parts list to these codes.

FCUR 107 WHALEBOAT SPEC - CYLINDER BLOCK

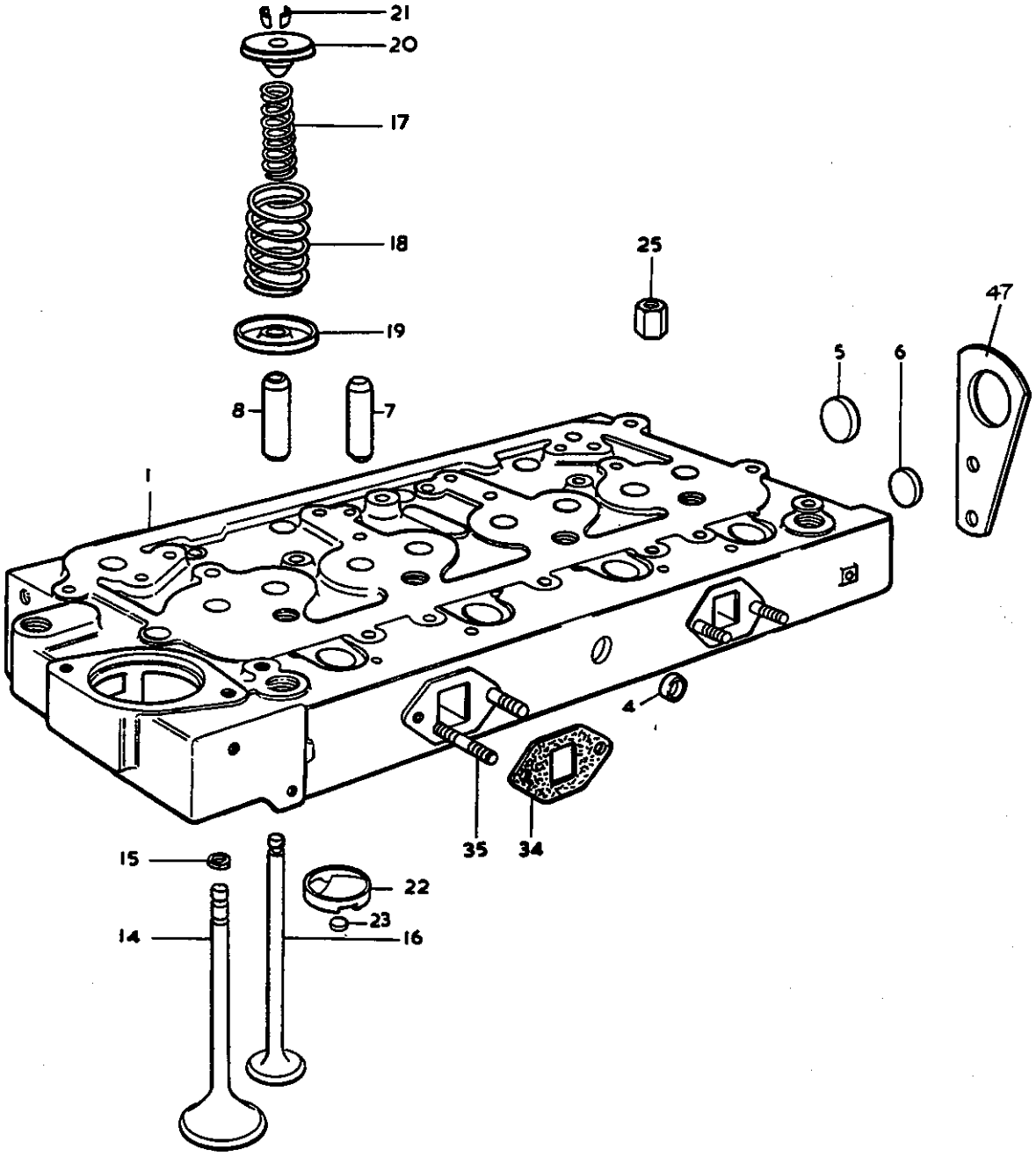


Drawing No. ***13905***

FCUR 107 WHALEBOAT SPEC - CYLINDER BLOCK

REF	PN	NAME	REMARKS	QUAN
1	30870	ENGINE	BLOCK & HEAD ASSEMBLY	1
2- 1	12600	LIMER	S/N 107U	4
2- 2	19990	LINER	S/N 108U 5 ED	4
3	12565	RING	LINER SEALING S/N 107U	8
4	12452	FLUG	BLOCK WATER JACKET	1
5	12380	DOWEL		6
6	12469	BOLT		6
7	12454	PLUG	EXPANSION S/N 108U & ED	5
8	19978	PLUG	BLOCK DRAIN S/N 108U & ED	1
11	19992	FLUG	BEARER FACINGS S/N 108U & ED	2
12	12623	SHIM		6
14	12456	FLUG	EXPANSION FRONT & REAR	2
15	12371	CONNECTOR		1
18	12485	SLEEVE	TACH DRIVE	1
19	14686	BEARING	TACH DRIVE	1
20	12484	SHAFT	TACH DRIVE	1
21	12363	SNAPRING	TACH DRIVE	1
22	19994	CAP	TACH DRIVE	1
23	12619	WASHER	TACH DRIVE	1
24	12464	PLUG	ALTERNATE DIPSTICK POSITION	1
32- 1	13970	FETCOCK	S/N 107U BLOCK DRAIN	1
32- 2	13341	PLUG	S/N 108U & ED BLOCK DRAIN	1
36	12458	PLUG	REAR CAMSHAFT CHAHSER	1
37- 1	12400	GASKET	HEAD S/N 107U	1
37- 2	20020	GASKET	HEAD S/N 108U & ED	1
38- 1	14743	STUD	SHORT TO S/N 107U7023705	18
38- 2	12615	STUD	LONG FROM S/N 107U7023705	18
38- 3	19965	STUD	S/N 108U & ED	18
45	12656	PLATE	MOUNT TIMING COVER	1
46	12406	GASKET		1
69- 1	12685	COVER	S/N 137U ALL TO 108U47977	1
69- 2	20029	COVER	S/N 108U47978 ON & ED	1
70	12666	GASKET		1
71	12498	STUD		10
73	12652	WASHER		10
83	12334	HOUSING		1
86	11993	SEAL		2
87	12356	BOLT		2
89	12661	GASKET		1
90	12475	BOLT		6
91	14825	LINE	UATER DRAIN S/N 107U	1
92	12432	NUT	WATER DRAIN S/N 107U	1
93	12377	CONNECTOR	UATER DRAIN S/N 107U	1
94	12415	FERRULE	UATER DRAIN S/N 107U	1

FOUR 107 WHALEBOAT SPEC - CYLINDER HEAD - VALVES

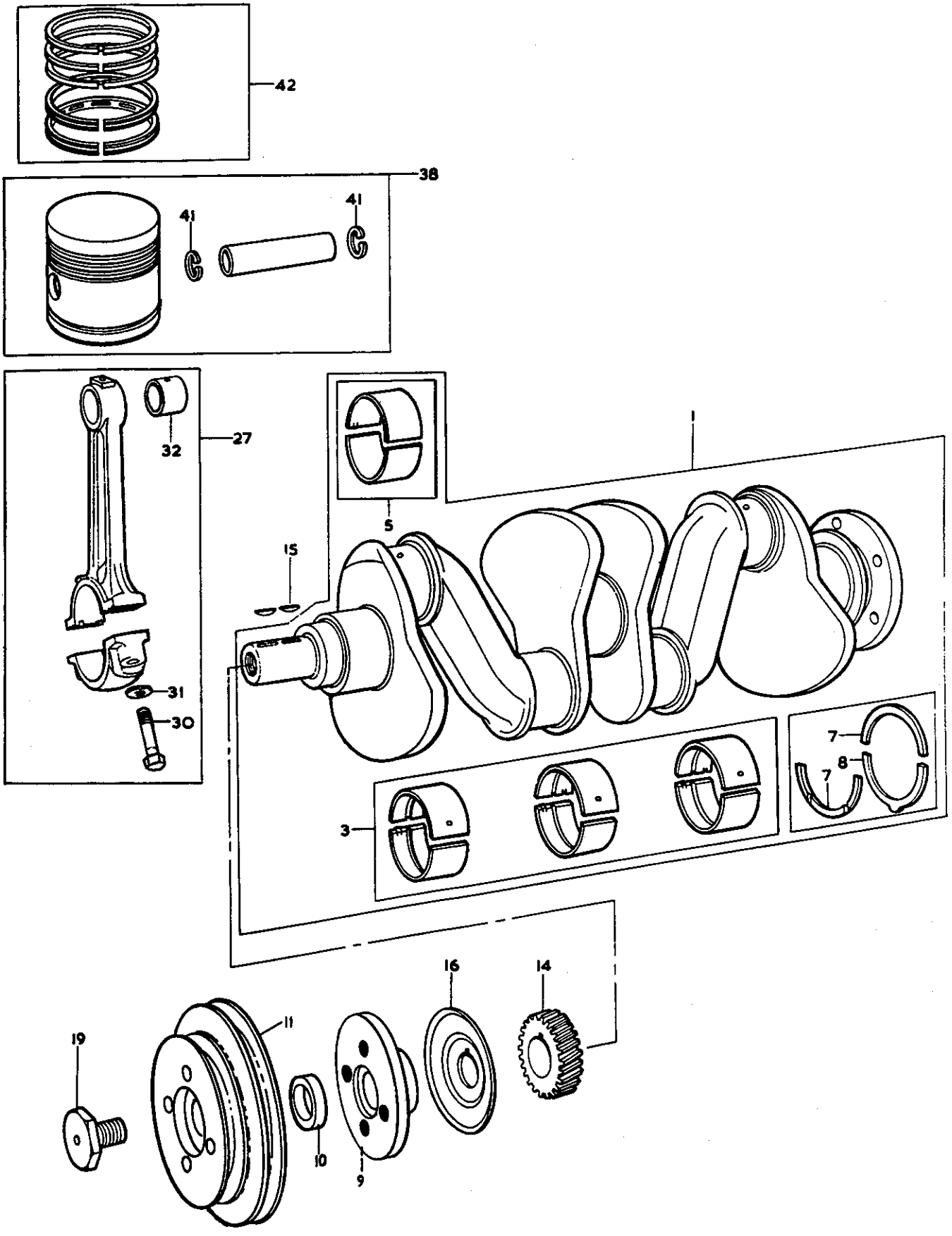


Drawing No. 13904

FOUR 107 UHALEBOAT SPEC - CYLINDER HEAD - VALVES

REF	PN	NAME	REMARKS	QUAN
1- 1	12340	HEAD	ASSEMBLY S/N 107U	1
1- 2	19939	HEAD	ASSEMBLY S/N 108U & ED	1
2	19979	PLUG	HEAD-TOP-S/N 108U & ED	3
3	19956	PLUG	HEAD-TOP-S/N 108U & ED	4
4	12452	PLUG	HEAD-SIDE	1
5	12454	PLUG	HEAD-REAR	1
6	12455	PLUG	HEAD-RFAR	1
7	12629	GUIDE	INLET	4
8	12628	GUIDE	EXHAUST	4
14- 1	12509	VALVE	INTAKE-NO GROOVE-FROM S/N 107U7101102	4
14- 2	12511	VALVE	INTAKE-O-RING GROOVE TO SN 107U7101102	4
15- 1	12635	DEFLECTOR	FOR INTAKE VALVE 12509	8
15- 2	14696	C-RING	FOR INTAKE VALVE 12511	4
16	12510	VALVE	EXHAUST	4
17	12608	SPRING	INNER S/N 107U	8
18- 1	12609	SPRING	OUTER S/N 107U	8
18- 2	19960	SPRING	S/N 108U & ED	8
19	12536	SEAT	VALVE SPRING	8
20- 1	12360	CAP	EXHAUST VALVE SPRING	4
20- 2	14687	CAP	INTAKE VALVE SPRING	4
21	12378	COTTER	PAIR	8
22- 1	12682	INSERT	COMBUSTION CHAMBER	4
22- 2	19999	SEPT	INTAKE VALVE S/N 108U & ED	4
22- 3	19997	SEAT	EXHAUST VALVE S/N 108U & ED	4
23	12542	WASHER		4
25- 1	12421	NUT	HEAD-LONG S/N 107U	6
25- 2	14831	NUT	HEAD-SHORT NS 107U	12
25- 3	20005	NUT	HEAD-LONG S/N 108U & ED	6
25- 4	14445	NUT	HEAD-SHORT S/N 108U & ED	12
34	11653	GASKET		
35- 1	12496	STUD	SHORT	
35- 2	14810	STUD	LONG	2
47	12546	PLATE		1

FOUR 107 WHALEBOAT SPEC - CRANKSHAFT - ROD - PISTON

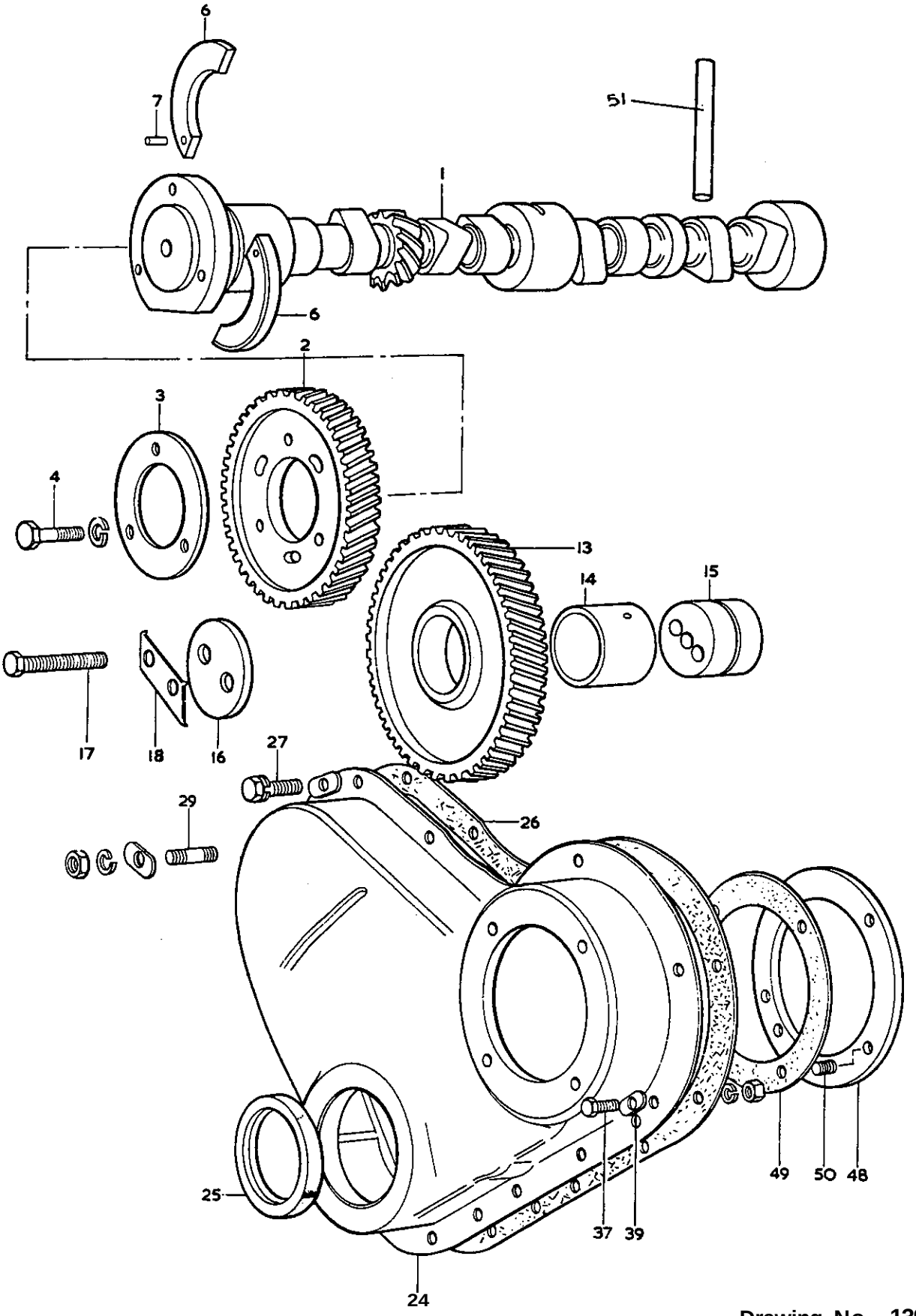


Drawing No. 13903

FOUR 107 WHALEBOAT SPEC - CRANKSHAFT - ROD - PISTON

REF	PN	KAME	REMARKS	QUAN
1- 1	12341	CRANKSHAFT	ASSEMBLY SIN 107U	1
1- 2	23115	CRANKSHAFT	ASSEMBLY SIN 108U & ED	1
3- 1	12342	BEARING	MAIN-KIT-STD	1
3- 2	12349	GEARING	MAIY-KIT-. 010 UNDER	1
3- 3	12370	FEARING	MAIN-KIT-. 020 UNDER	1
3- 4	12373	BEARING	MAIY-KIT-. 030 UNDER	1
5- 1	12343	BEARING	ROD-KIT-STD	1
5- 2	12414	BEARING	ROD-KIT-.010 UNDER	1
5- 3	12423	BEARING	ROD-KIT-.020 UNDER	1
5- 4	12519	BEARING	ROD-KIT-.030 UNDER	1
7- 1	14707	UASHER	THRUST-STD	2
7- 2	19969	WASHER	THRUST-.007 OVER	AR
8- 1	12537	WASHER	THRUST-STD	1
8- 2	19968	WASHER	THRUST-. 00M OVER	AR
9	12633	ADAPTER		1
10	11857	WASHER		1
11	12099	PULLEY		1
14	14719	GEAR	CRANKSHAFT	1
15	12408	KEY		1
16	12383	SLINGER		1
19	12613	SCREW	PULLEY RETAINING	1
27- 1	12344	ROD	CONNECTING ASSEMBLY S/N 107U	4
27- 2	19935	ROD	CONNECTING ASSEMBLY S/N 108U & ED	4
30	12348	BOLT	CONNECTINS ROD	8
31	20645	TABUASHER		8
32- 1	12594	BUSHING	CONNECTING ROD S/N 107U	4
32- 2	19986	BUSHING	CONNECTING ROD S/N 108U & ED	4
38- 1	12908	PISTON	ASSEMBLY S/N 107U	4
38- 2	19938	PISTON	ASSEMBLY S/N 108U & ED	4
41- 1	12573	SNAPRING	PIN RETAINING S/N 107U	8
41- 2	19984	SNAPRING	PIN RETAINING S/N 108U & ED	8
42- 1	12905	RING SET	NEW LINER S/N 107U	4
42- 2	12906	RING SET	WORN LINER S/N 107U	4
42- 3	19937	RING SET	STD S/N 108U & ED	4

FOUR 107 UHALEBOAT SPEC - TIMING SYSTEM - CAMSHAFT

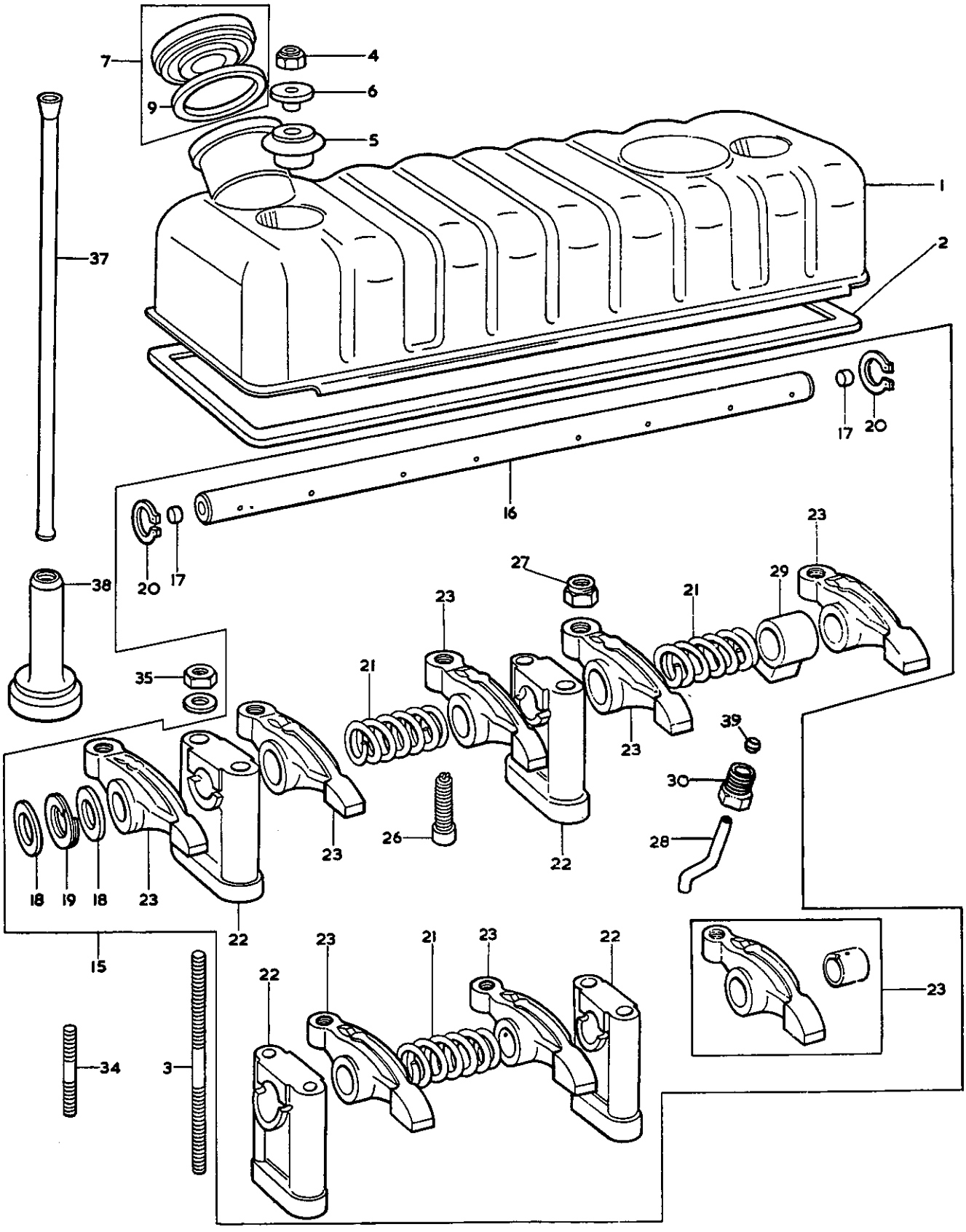


Drawing No. 13902

FOUR 107 WHALEBOAT SPEC - TIMING SYSTEM - CAMSHAFT

REF	PN	NAME	REMARKS	QUAN
1	12605	CAMSHAFT		1
2	12597	GEAR		1
3	12625	PLATE		1
4	12474	BOLT		3
6	12654	PLATE		2
7	12440	DOWEL		1
13	12689	FEAR	IDLER WITH BUSHING	1
14	14685	BUSHING	FOR IDLER GEAR	1
15	12388	HU3		1
16	12551	PLATE		1
17	12481	BOLT		2
18	12541	TABUASHER		1
24	12678	COVER	TIMING	1
25	12456	SEAL	TIMING COVER	1
26	12658	GASKET	TIMING COVER	1
27	12474	BOLT		8
29	12493	STUD		1
37	12471	BOLT		4
39	13536	WASHER		3
48	12626	PLATE		1
49	12636	GASKET		2
50	12500	STUD		4
51	12460	PUSHROD	FUEL LIFT PUMP	1

FOUR 107 WHALEBOAT SPEC - ROCKER SHAFT

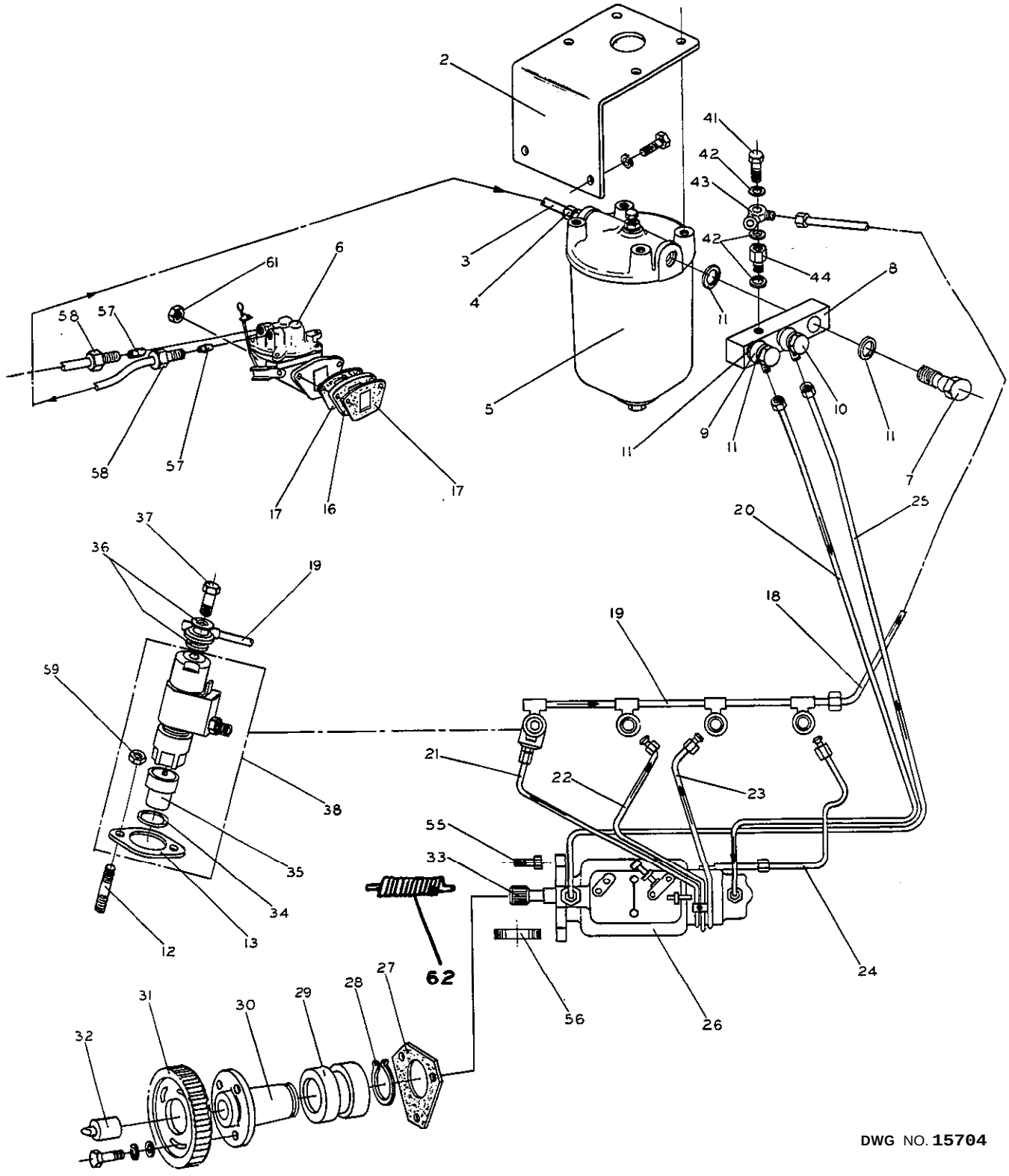


Drawing No. 13901

FOUR 107 WHALEBOAT SPEC - ROCKER SHAFT

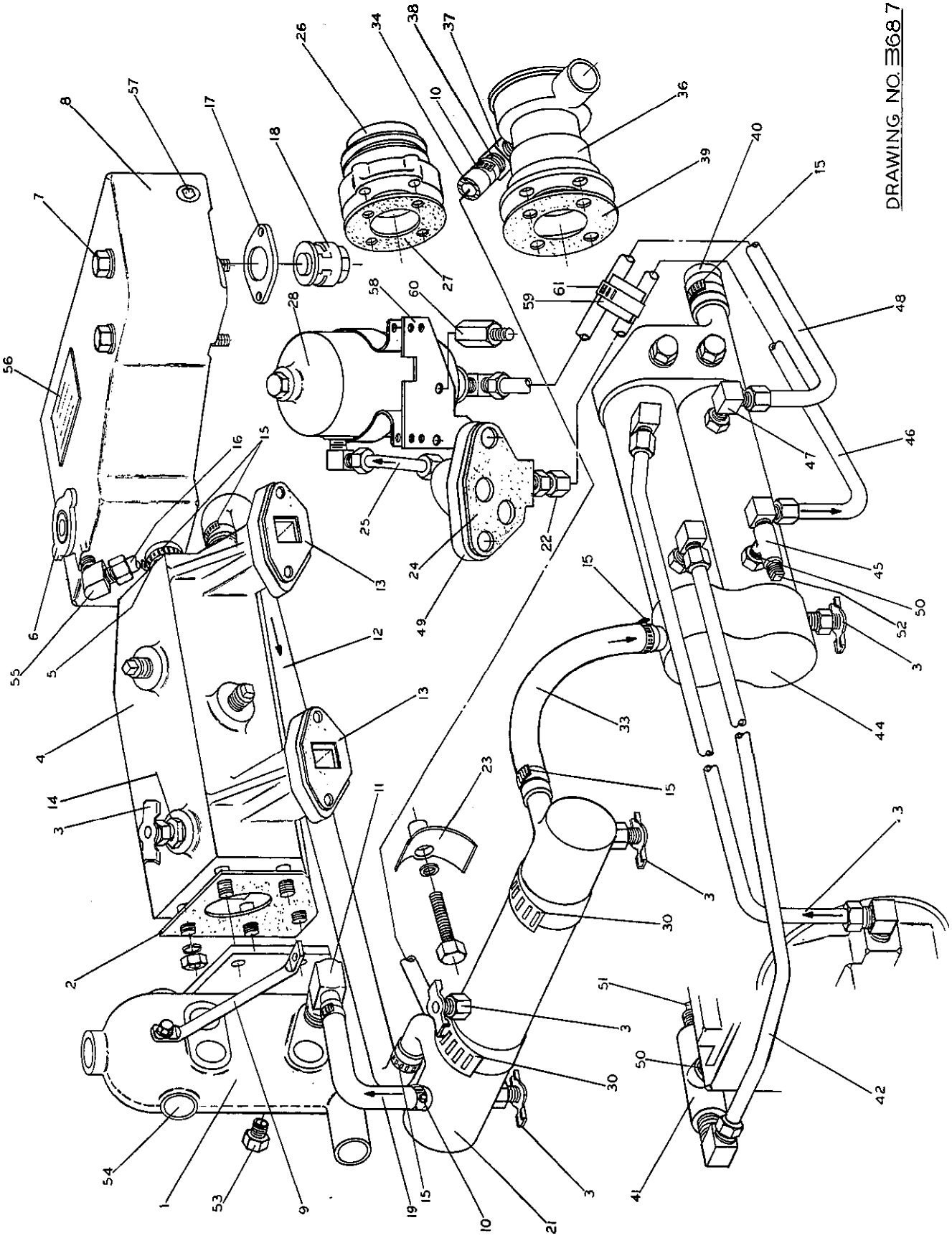
REF	PN	NAME	REMARKS	QUAN
1	12681	COVER	ROCKER	1
2	12404	GASKET	ROCKER COVER	1
3	12494	STUD	LONG 4-1/2 IN	2
4	12429	NUT		2
5	12467	SEAL		2
6	12535	YASHER		2
7- 1	14709	CAP ASSY	SMALL 1-3/4 DIA TO S/N 107U7106766	1
7- 2	12567	CAP ASSY	LARGE 2-3/8 DIA	1
9	14713	GASKET		1
15	12336	SHAFT	COMPLETE ASSEMBLY	1
16	12335	SHAFT	ROCKER WITH PLUGS	1
17	12446	PLUG		2
18	12525	WASHER		4
19	12539	UASHER		2
20	12362	SNAPRING		2
21	12488	SPRING		3
22	12358	BRACKET		4
23	12333	ROCKER		8
26	12462	BOLT		8
27	12433	NUT		8
28	12637	LINE	HEAD TO ROCKER SHAFT	1
29	12372	CONNECTOR	OIL FEED TO ROCKER SHAFT	1
30	12419	NUT		2
34	12499	STUD	SHORT 3-5/8 IN	6
35	12434	NUT		8
37	12607	ROD		8
38	12606	TAPPET		8
39	12413	FERRULE		2
40	12331	BUSHING	ROCKER	8

FOUR 107 WHALEBOAT SPEC - FUEL SYSTEM



REF	PN	NAVE	REMARKS	QUAN
2	12116	BRACKET	FUEL FILTER MOUNTING	1
3	12150	LINE	LIFT PUMP TC FUEL FILTER	1
4	13336	CONNECTOR	FUEL LINE TO FUEL FILTER	1
5- 1	11614	FILTER	FUEL-FNGINE POUNTED	1
5- 2	16418	ELEMENT	FUEL FILTER	1
6- 1	11700	PUMP	LIFT-COMPLETE-2 STUD	1
6- 2	12575	KIT	LIFT PUPP REPAIR	1
6- 3	16443	PUMP	LIFT-COMPLETE-4 STUD	1
7	11126	BCLT	BANJO-FUEL MANIFOLD TO FILTER	1
8	11124	MANIFOLD	FUEL	1
9	11941	BANJO		2
10	12350	BOLT	BANJO	2
11	12522	LASHER	BANJO	6
12- 1	12501	STUD	LONG	4
12- 2	12495	STUD	SFCRT	4
13	12653	FLANGE	INJECTOR MOUNTING	4
16	12379	SPACER	2 STUD LIFT PUMP TO BLCCK	1
17- 1	12670	GASKET	2 STUD LIFT PUMP TO BLOCK	2
17- 2	16245	GASKET	4 STUD LIFT PUMP TO BLCCK	1
18	33749	LINE	LEPK OFF INJECTCR TO FILTER	I
19	13517	LINE	LEPK OFF BETWEEN INJECTORS	1
20	14813	LINE	FILTER TO INJECTION PUMP	1
21	12641	LINE	INJECTCR 1	1
22	12645	LINE	INJECTOR 2	1
23	12646	LINE	INJECTOR 3	1
24	12647	LINE	INJECTOR 4	1
25	14814	LINE	INJECTION PUMP TO FILTER	1
26- 1	14680	PUMP	INJECTION-MECHANICAL TC 107U6037-MAPINE	1
26- 2	14678	FLMP	INJECTION-MECHANICAL FROM 107U6037	1
27	12402	GASKET	INJECTION PUMP TO BLCCK	1
28- 1	12364	CIRCLIF	HUB 12632	1
28- 2	31323	CIRCLIP	HUB 20004	1
29- 1	12332	BEARING	HUE 12632	1
29- 2	31324	REARING	ASSEMBLY-HUB 20004	1
29- 3	31322	BUSHING	HUB 29004	1
30- 1	12632	HUB	TO 107U46015	1
30- 2	20004	tUB	FRCM 107U46015	1
31	19989	GEAR	▮NJECT▮ON PUMP DRIVING	1
32	12614	SHAFT		1
33	14744	SHAFT	INJECTION PUMP DRIVING	1
34	11945	LASHER	INJECTOR	4
35	12694	NOZZLE	INJECTOR	4
36	11943	WASHER	BANJO	8
37	11935	BOLT	BANJO	4
38	11701	INJECTOR		4
41	12351	BOLT	BANJO	1
42	11944	'WASHER	BANJO	3
43	11936	BANJO		1
44	12634	VALVE	CCECK-FUEL FILTER	1
55	12561	ECLT	INJECTION PUMP MOUNTING	1
56	12497	STUD	INJECTION PUMP MOUNTING	2
57	11597	FERRULE		1
58	11596	ALT		1
59	12268	NUT	INJECTCR MOUNTING	8
b1	12269	NUT	LIFT PUCP MOUNTING	AR
62	14674	SPRING	FUEL SHUTOFF LEVER	1

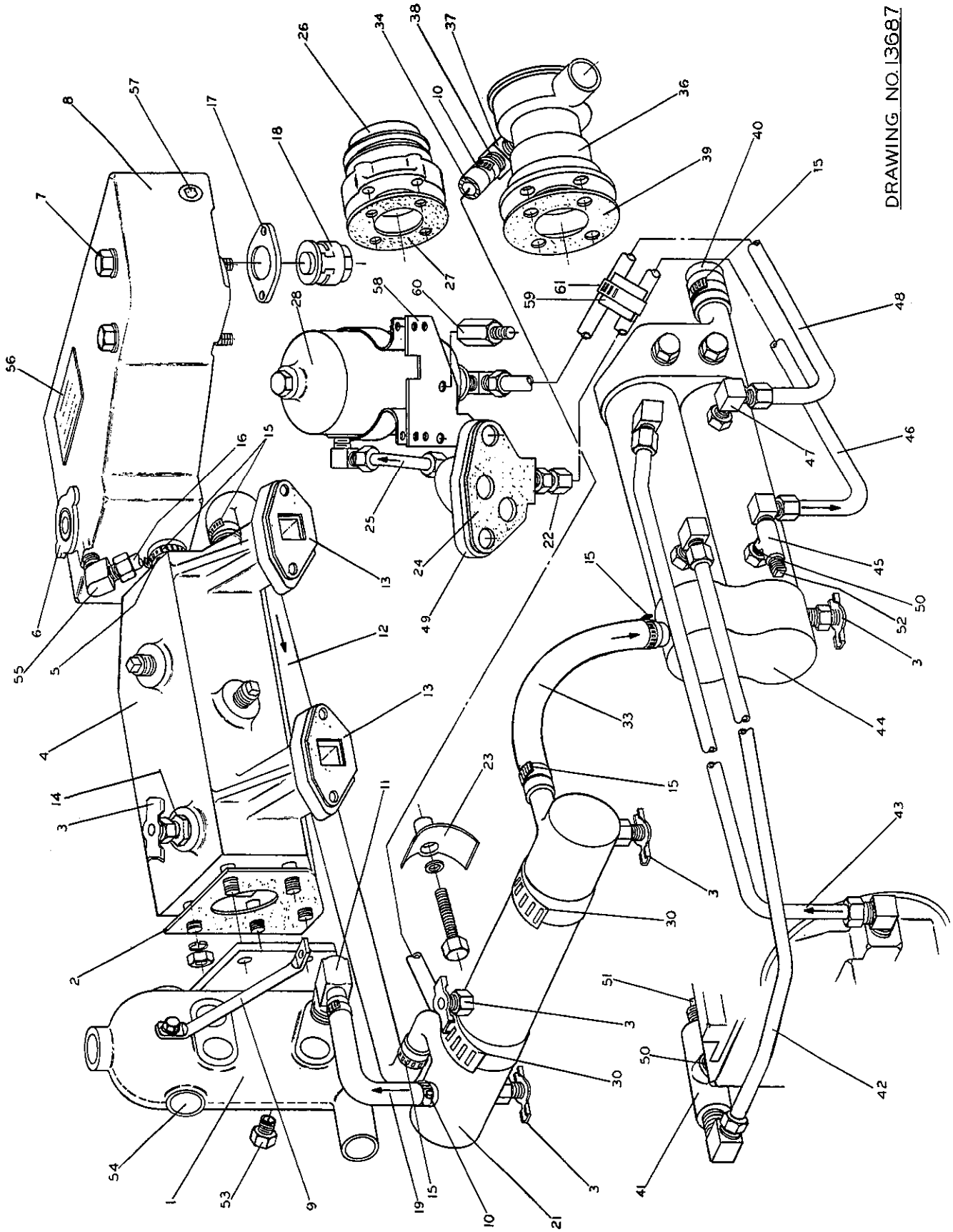
FOUR 107 WHALEBOAT SPEC - COOLING SYSTEM



FCUR 107 WHALEBOAT SPEC - COOLING SYSTEM

REF	PN	NAME	REMARKS	QUAN
1	15017	RISER	EXHAUST-SEA WATER JACKETED	1
2	12667	GASKET	EXHAUST MANIFOLD FLANGE	1
3	11471	PETCOCK		6
4	12411	MANIFOLD	EXHAUST-FRESH UATER JACKETED	1
5	11501	HOSE	FRESH UATER-INCHES REQUIRED	2
6	11499	CAP	PRESSURE	1
7	14832	SCREU	EXPANSION TANK	2
8	14073	TANK	FRESH UATER EXPANSION	1
9	13131	BRACKET	EXHAUST RISER	1
10	11341	CLAMP	HOSE	4
11	11128	ELBOW	EXHAUST RISER SEA UATER IYLET	1
12	13825	HOSE	FORPED-FRESH WATER	1
13	11653	GASKET	EXHAUST MANIFOLD TO HEAD	2
14	11612	BUSHING	PETCOCK MOUNT I N HEAD AND MANIFOLD	2
15	21878	CLANP	HOSE	8
16	11500	TUBING	EXPANSION TANK OVERFLOW INCHES REQUIRED	8
17	12663	GASKET	THERMOSTAT	1
18	24688	THERMOSTAT		1
19	11656	HOSE	FORMED-SEA UATER	1
21	14156	EXCHANGER	HEAT-FRESH UATER TO SEA UATER	1
22	13334	CONNECTOR	LUBE OIL LINE TO ADAPTER	1
23	12092	BRACKET	HEAT EXCHANGER	2
24	12669	GASKET	LUBE OIL ADAPTER TO BLOCK	1
25	13969	LINE	LUBE OIL ADAPTER TO FILTER	1
26- 1	12935	PUMP	FRESH UATER S/N 107U	1
26- 2	20035	PUMP	FRESH UATER S/N 108U & ED	1
27	12673	GASKET	FRESH UATER PUMP TO PLATE	1
28- 1	11613	FILTER	LUBE OIL	1
28- 2	15559	ELEMENT	LUBE OIL FILTER	1
29	12503	STUD	LUBE OIL ADAPTER TO BLOCK	1
30	11505	CLAMP	HEAT EXCHANGER TO BRACKET	2
33	11648	HOSE	WIRE INSERTED-FRESH UATER INCHES REQD	7
34	11517	HOSE	HEATER-SEA UATER INCHES REQUIRED	24
36	16423	PUMP	SEA UATER 1/2 I N IMPELLER	1
37	13338	ELBOW		1
38	13519	NIPPLE		2
39	11143	EASKET	SEA UATER PUMP TO TIMING COVER	1
40	13846	HOSE	FORMED FRESH UATER	1
41	11723	TEE		1
42- 1	13127	LINE	GEAR OIL COOLER TO PARAGON TRANSMISSION	1
42- 2	14234	LINE	GEAR OIL COOLER TO WARNER TRANSMISSION	1
43- 1	14078	LINE	PARAGON TRANSMISSION TO GEAR OIL COOLER	1
43- 2	14233	LINE	WARNER TRANSMISSION TO GEAR OIL COOLER	1
44	12985	COOLER	GEAR & LUBE OIL-FRESH UATER COOLED	1
45	11651	TEE		1
46	14080	LINE	LUBE OIL COOLER TO ADAPTER	1
47	13335	ELBOW		9
48	14079	LINE	LUBE OIL FILTER TO COOLER	1
49	13955	ADAPTER	LUBE OIL LINES TO BLOCK	1
50	11650	NIPPLE		2

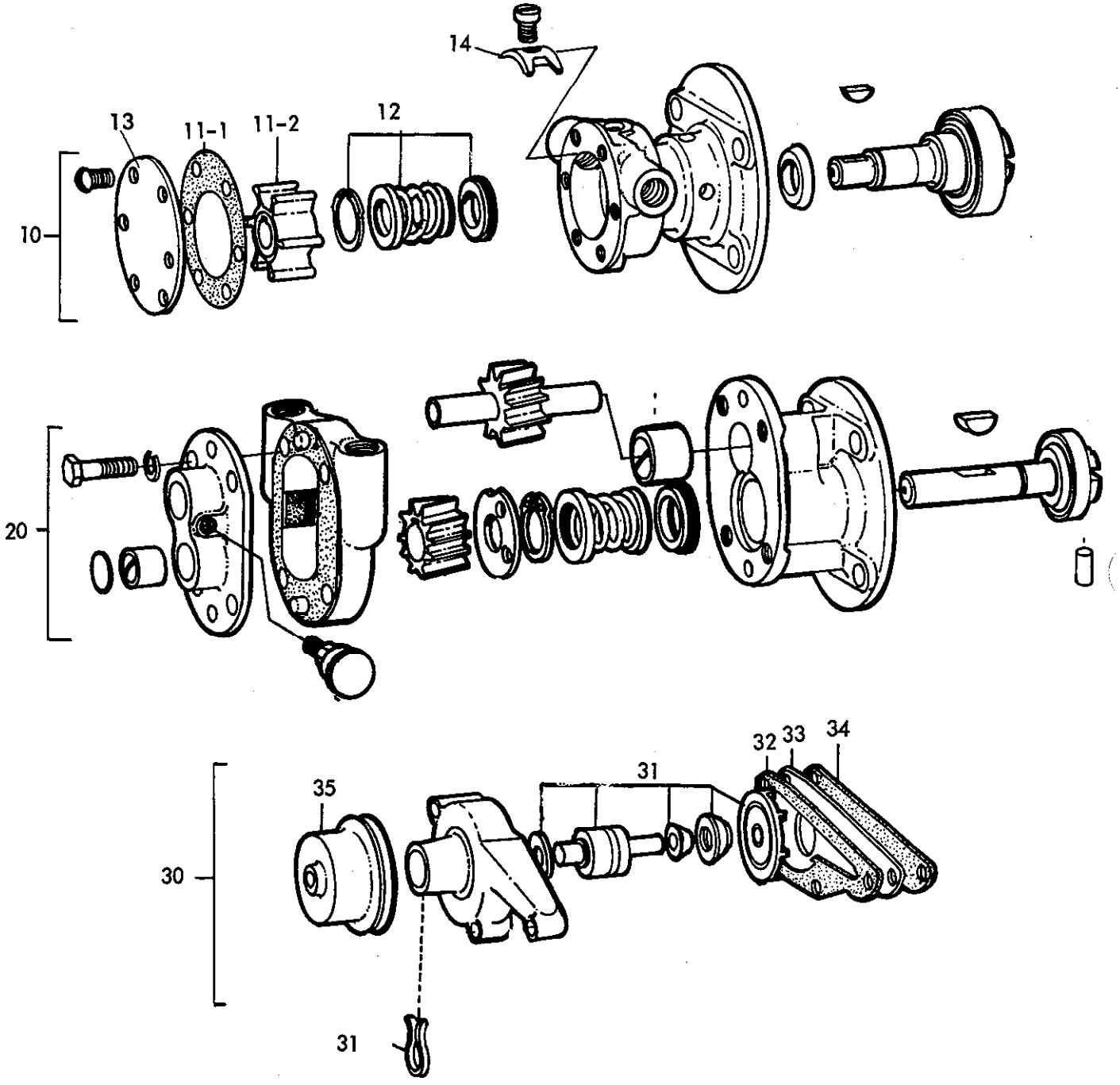
FOUR 107 WHALEBOAT SPEC - COOLING SYSTEM



FCUR 107 WHALEBOAT SPEC - COOLING SYSTEM

REF	PN	NAME	REMARKS	QUAN
51	11724	PLUG	TRANSMISSION OIL	1
52	11494	PLUG	OIL COOLER	1
53	11724	PLUS	EXHAUST RISER DRAIN	1
54	11755	PLUG	EXPANSION	10
55	13329	ELBOW	EXPANSION TANK OVERFLOW	1
56	11156	NAMEPLATE		1
57	11752	PLUG	EXPANSION TANK CORE	2
58	11119	BRACKET	LUBE OIL FILTER	1
59	11148	SUPPORT	OIL LINE	1
60	11121	STUD	LUBE OIL FILTER BRACKET TO BLOCK	3
61	11386	CLAMP	OIL LINE SUPPORT	1

FOUR 107 WHALEBOAT SPEC - WATER PUMPS

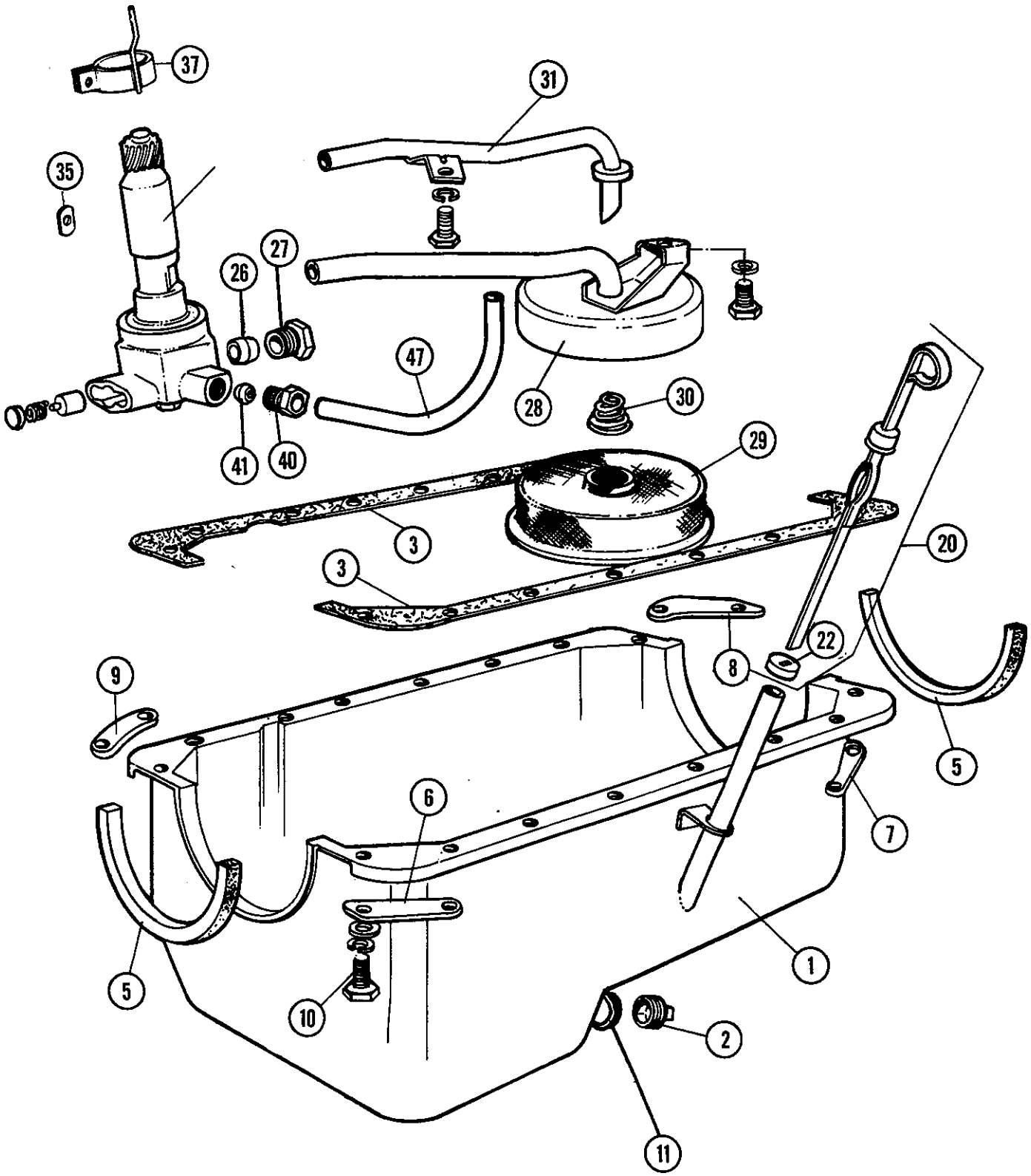


Drawing No. 13556

FOUR 107 WHALEBOAT SPEC - WATER PUMPS

REF	PN	NAME	REMARKS	QUAN
10- 1	11020	PUMP	3/8 RUBBER IMPELLER-NLA USE 16423 PUMP	1
10- 2	16423	PUMP	1/2 RUBBER IMPELLER	1
11- 1	15153	GASKET	PUMP 16423	1
11- 2	11418	IMPELLER	PUMP 16423	1
11- 3	11906	KIT	IMPELLER REPLACEMENT PUMP 11020	1
12- 1	14774	SEAL	PUMP 11020	1
12- 2	18159	SEAL	PUMP 16423	1
13- 1	12918	COVER	PUMP 11020	1
13- 2	18171	COVER	PUMP 16423	1
14- 1	12916	CAY	PUMP 11020	1
14- 2	18152	CAM	PUMP 16423	1
20	11658	PUNP	BRONZE GEAR-COMPLETE ONLY	1
30- 1	12935	PUYP	FRESH WATER WATER COMPLETE-S/N 107U	1
30- 2	20035	PUMP	FRESH WATER COMPLETE-S/N 108U & ED	1
31- 1	12932	KIT	PUMP 12935 REBUILD	1
31- 2	19933	KIT	PUMP 20035 SEBUILD	1
32	12673	GASKET	PUMP TO PLATE	1
33	12655	FLATE	PUMP TO BLOCK	1
34	12674	GASKET	PLATE TO BLOCK	1
35- 1	12459	PULLEY	PUMP 12935	1
35- 2	19987	PULLEY	PUMP 20835	1

FOUR 107 WHALEBOAT SPEC - LUBE OIL SUMP

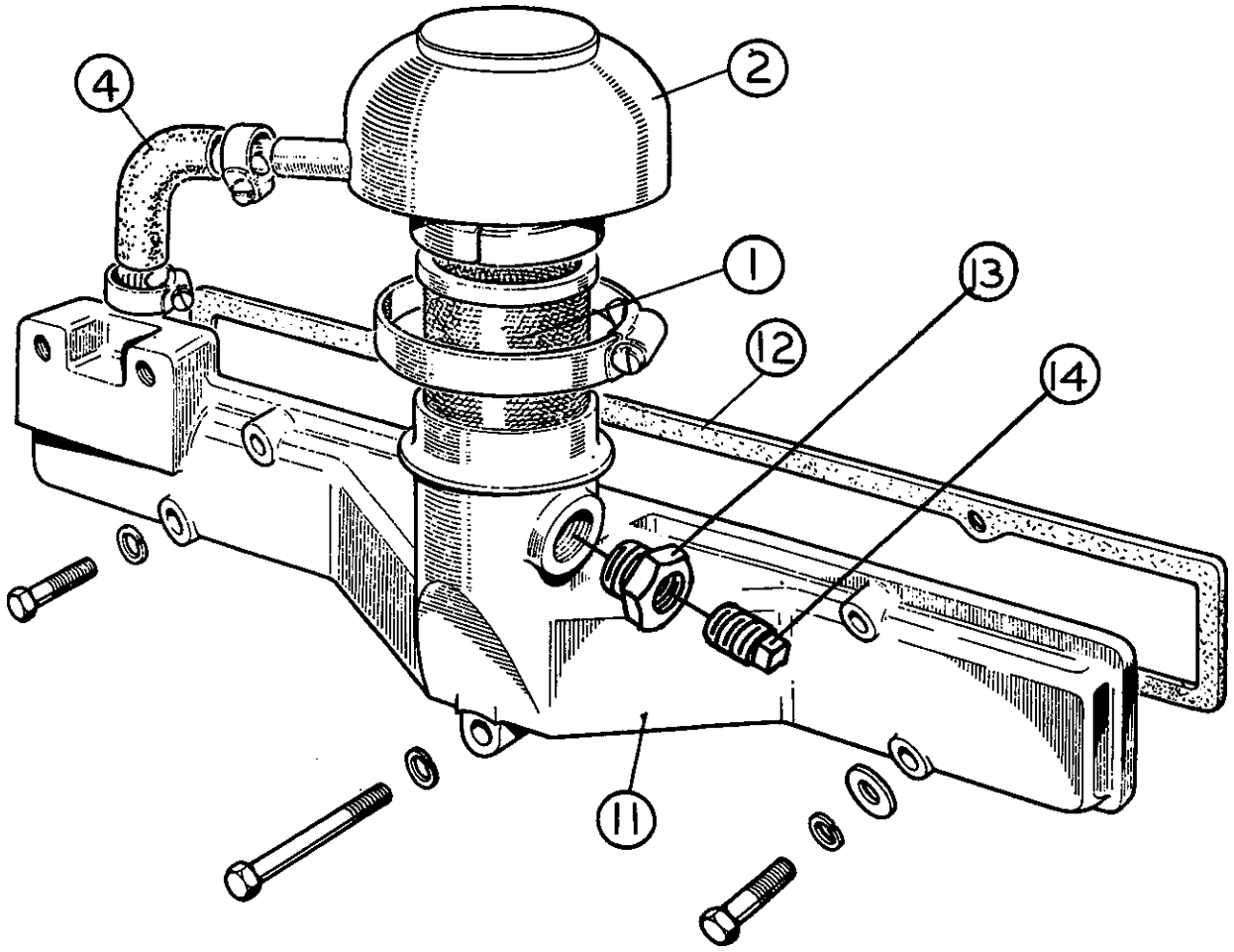


Drawing No. 13900

FCUR 107 WHALEBOAT SPEC - LUBE OIL SUMP

REF	PN	NAME	REMARKS	QUAN
1	12680	SUMP		1
2	13951	FLUG	DRAIN SUMP	1
3	12659	GASKET	SUMP-LEFT AND RIGHT	1
5	12407	GASKET		2
6	12547	PLATE	STIFFENER	1
7	12548	FLATE	STIFFENER	1
8	12549	FLATE	STIFFENER	1
9	12550	FLATE	STIFFENER	1
10	12473	SCREU		16
11	13952	WASHER	SLCP DRAIN PLUG	1
20	12612	DIPSTICK		1
22	14816	WASHER		1
26	19950	FERRULE	SCCTIOK PIPE	1
27	20006	NUT	SUCTION PIPE	1
28	12651	PIPE	ASSEMBLY	1
29	12686	STRAINER		1
30	12491	SPRING		1
31	21834	TUBE	SIFHON	1
35	20017	TABUASHER	BODY LOCATION SETSCREW	1
36	12692	FUMP	LUBE OIL-COMPLETE	1
37	19973	LINE	LUBE OIL FEED TC D/GEAR SPRAY	1
40	19952	NUT	LUBE OIL DELIVERY LINE	2
41	19951	FERRULE	LUBE OIL DELIVERY LINE	2
47	12442	LINE	LUBE OIL DEL▮VERY LINE	1

FOUR 107 UHALEBOAT SPEC - INTAKE MANIFOLD

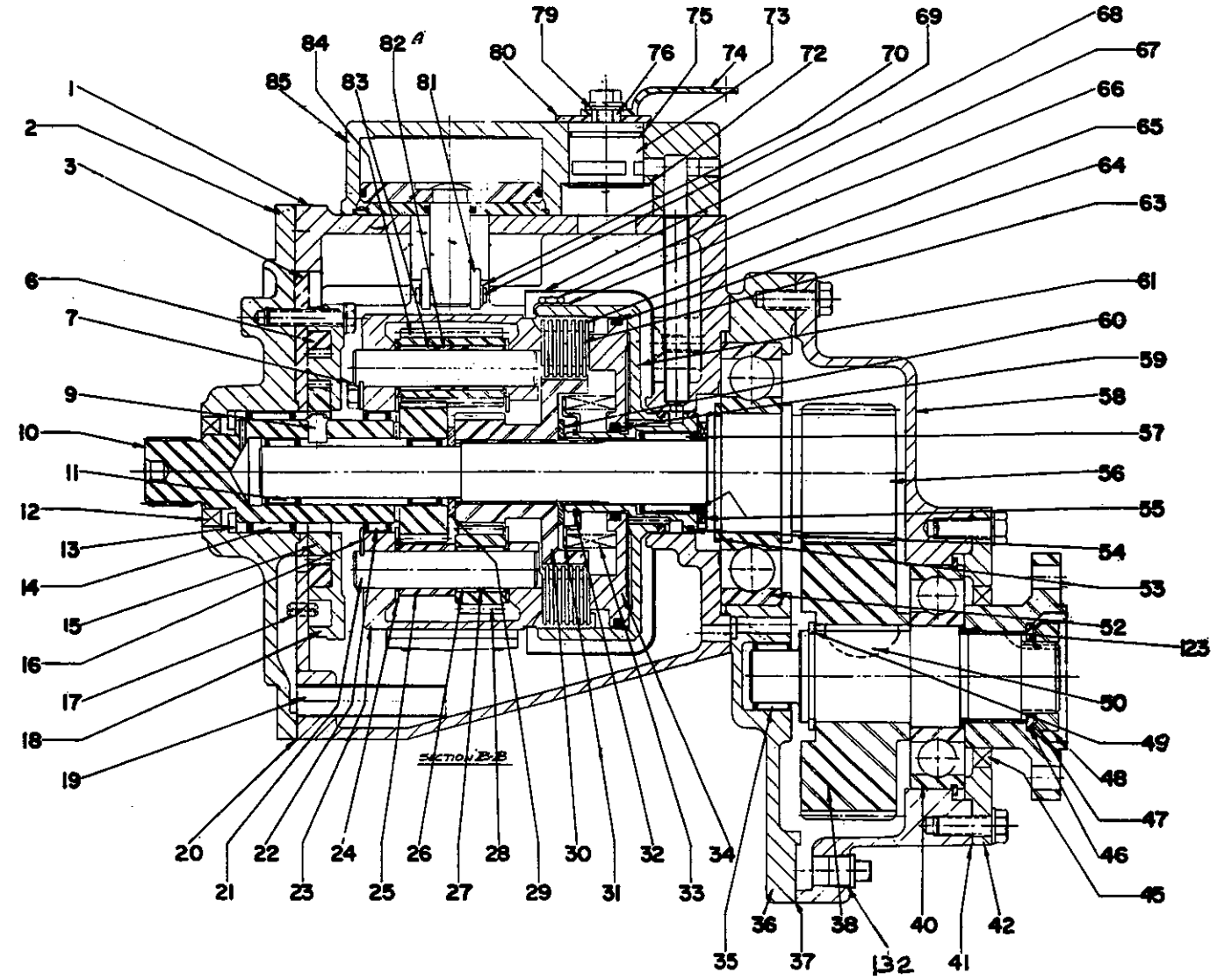


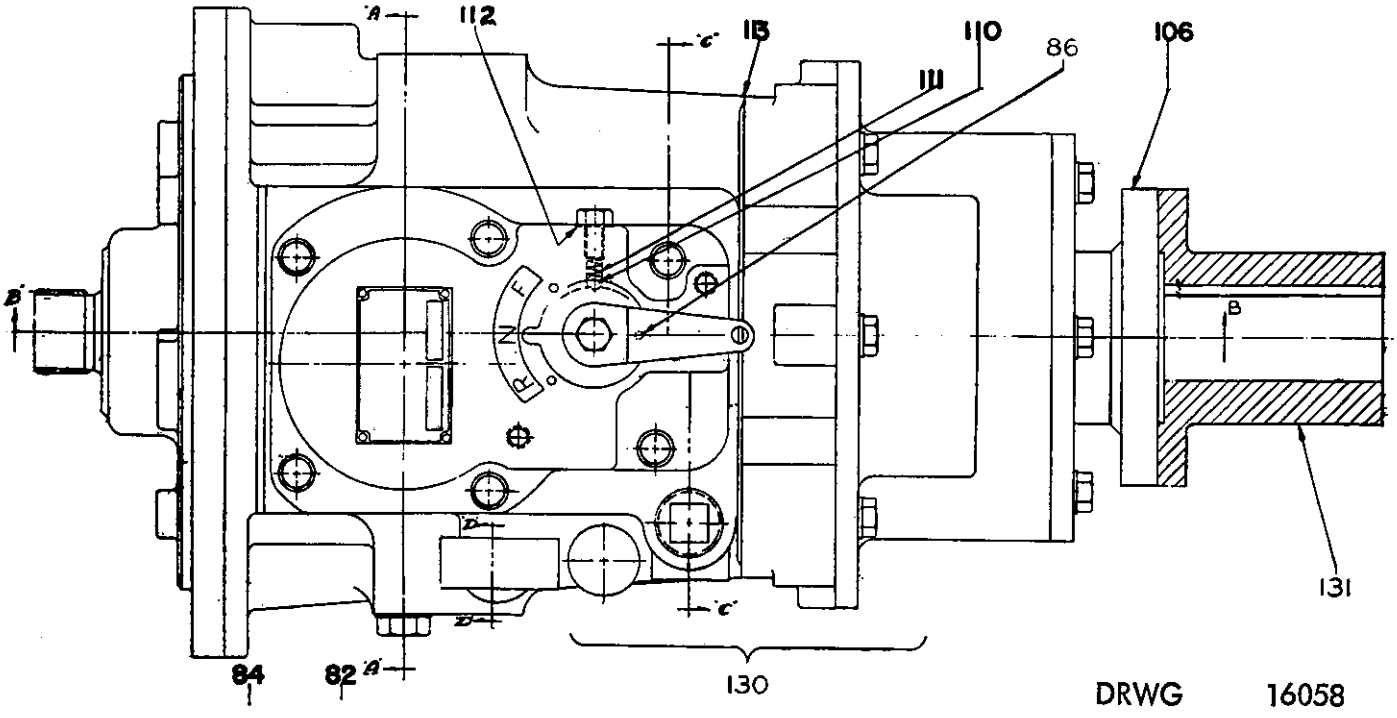
Drawing No. 13569

FOUR 107 UHALEBOAT SPEC - INTAKE MANIFOLD

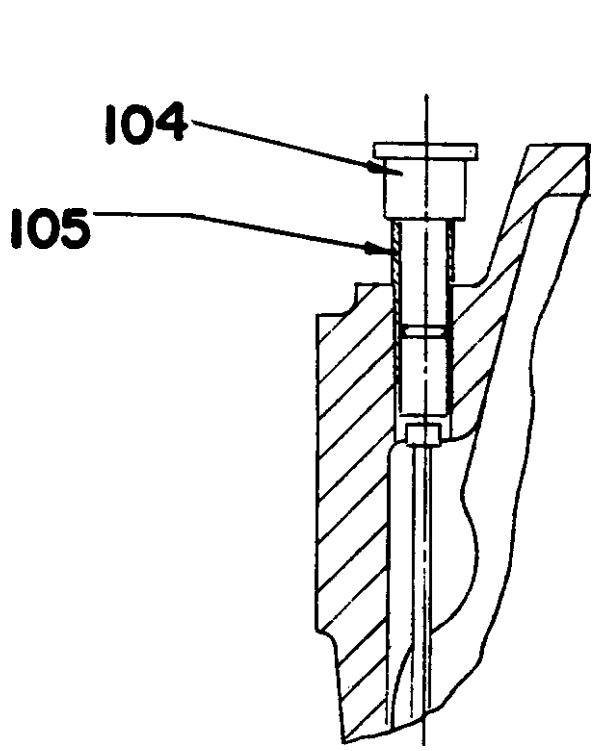
REF	PN	NAME	REMARKS	QUAN
1	12556	FILTER		1
2	12683	COVER		1
4	12639	ELBOW	BREATHER	1
11	12688	MANIFOLD		1
12	20021	GASKET		1
13	13392	BUSHING		1
14- 1	11615	PLUG		1
14- 2	11688	AID	STARTING-ETHER TYPE	1

FOUR 107 WHALEBOAT SPEC - TRANSMISSION - PARAGON

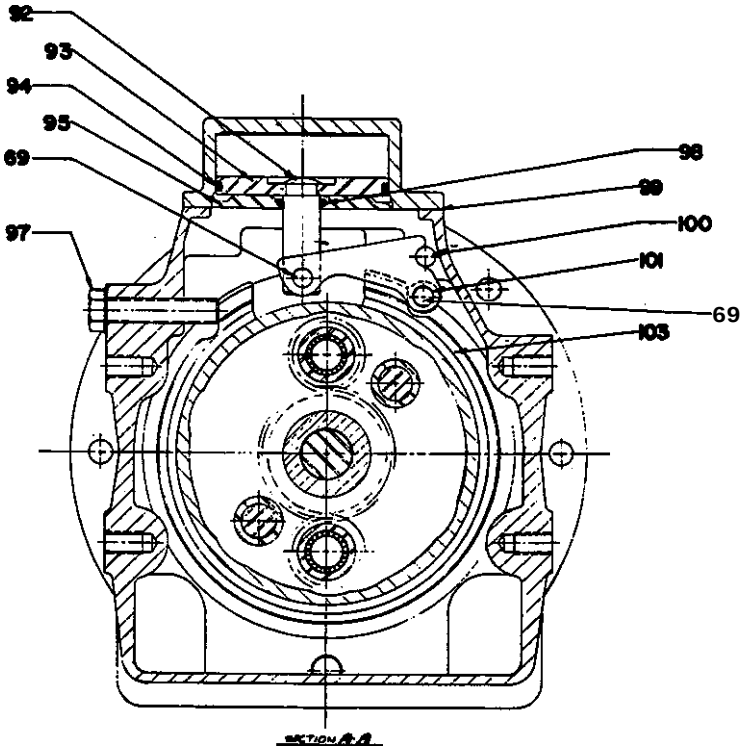


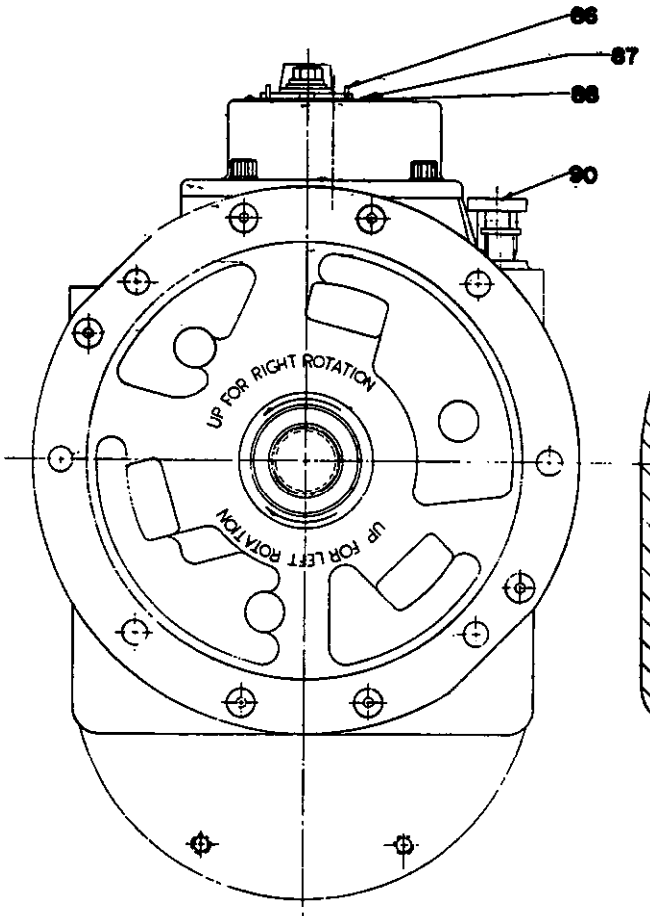


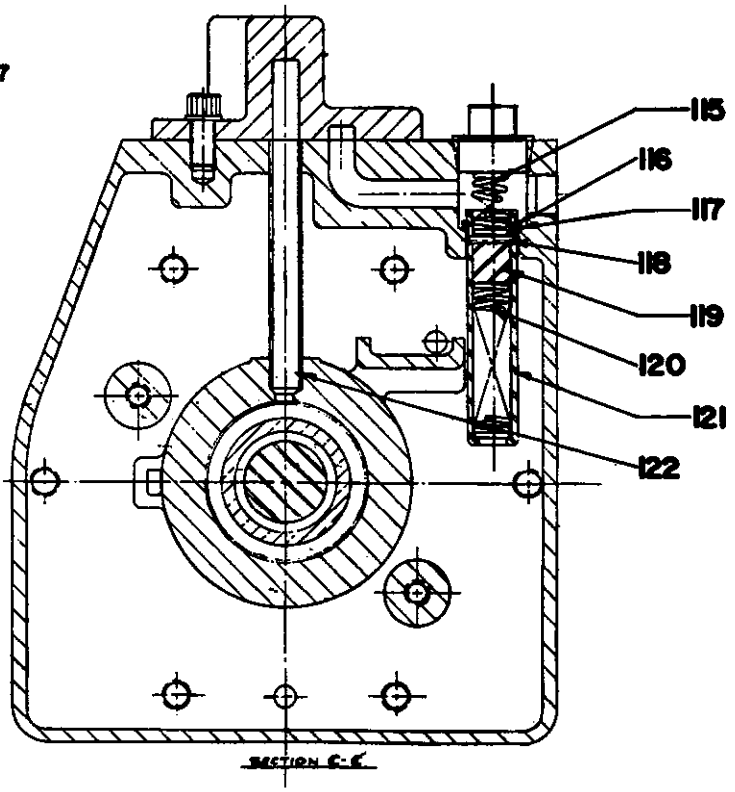
FOUR 107 WHALEBOAT SPEC - TRANSMISSION - PARAGON



SECTION D-D







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FOUR 107 WHALEBOAT SPEC - TRANSMISSION - PARAGON

REF	PN	NAME	REMARKS	QUAN
1- 1	16235	HOUSING	TRANSMISSION-TO SERIAL 6A1	1
1- 2	16227	HOUSING	TRANSMISSION-FROM SERIAL 6A1	1
2- 1	16234	FLATE	FRONT-TO SERIAL 6A1	1
2- 2	16226	PLATE	FRONT-FROM SERIAL 641	1
2- 3	16237	PLATE	FRONT PLATE ASSEMBLY-TO SERIAL 6A1	1
2- 4	16229	FLATE	FRONT PLATE ASSEMBLY-FROM SERIAL 6A1	1
3	16220	PLATE	PUMP-PORT-TO SERIAL 6A1	1
6	16107	GEAR	OUTER-PUMP	1
7	16153	CLIP	CASE	2
9	16122	KEY	PUMP	1
10- 1	16151	GEAR	DRIVE	1
10- 2	16152	GEAR	DRIVE GEAR ASSEMBLY	1
11	16139	BEARING	DRIVE GEAR	2
12	16150	SEAL	OIL-FRONT PLATE	1
13	16131	UASHER	THRUST-FRONT PLATE	1
14	16132	BEARING		1
15	16134	GEAR	■NNER-PUMP	1
16	16137	TAB	SHAFT LOCKING	2
17	16135	PIN	PUMP HOUSING-TO SERIAL 6A1	1
18- 1	16225	HOUSING	PUMP-TO SERIAL 6A1	1
18- 2	16133	HOUSING	PUMP-FROM SERIAL 6A1	1
18- 3	16219	PUMP	ASSEMBLY-TO SERIAL 6A1	1
18- 4	16230	FUMP	ASSEMBLY-FROM SERIAL 6A1	1
19	16130	TUBE	SUCTION	1
20	16236	GASKET	FRONT PLATE	1
21	16136	SHAFT	PINION	4
22	16128	BEARING	CASE-NEEDLE	1
23- 1	16162	CASE	GEAR	1
23- 2	16165	CASE	ASSEMBLY	1
24	16114	PAD	PINION THRUST	1
25	16155	SPACER	SHORT PINION	2
26	16116	BEARING	SHORT PINION-ROLLER	1
27	16110	SPACER	SHORT PINION BEARIYG	2
28- 1	16113	PINION	SHORT	2
28- 2	16140	PINION	ASSEMBLY-SHORT	2
29	16141	WASHER	THRUST-DRIVE GEAR	1
30	16195	GEAR	PROPELLER	1
31	16196	RETAINER	SPRING	1
32	16164	RING	RETAINING	1
33	16198	SPRING	SCREY COLLAR	1
34	16194	PISTON	FORWARD	1
35	16139	FEARING	ROLLER	1
36	16202	FLATE	REDUCTION ADAPTER	1
37	16206	GASKET	REDUCTION GEAR HOUSING	1
38	16210	GEAR	OUTPUT GEAR AND SHAFT ASSEMBLY	1
40	16102	BEARING	BALL-REDUCTION HOUSING	1
41	16208	GASKET	REAR END PLATE	1
42	15205	PLATE	REAR END	1
45	15127	SEAL	REAR END PLATE	1
46	15214	WASHER	COUPLING	1
47	16169	LDCKYASHER	BALL REARING	1
48	16168	AUT	BALL BEARING-LOCK	1
49	16209	RING	RETAINING-OUTPUT SHAFT	1

FOUR 107 WHALEBOAT SPEC - TRANSMISSION - PARAGON

REF	PN	NAME	REMARKS	QUAN
50	16101	KEY	OUTPUT SHAFT	1
52	16103	EEARING	BALL-REDUCTION	1
53	16157	RING	RETAINING-BALL BEARING	1
54	16108	RING	PISTON-OIL DISTRIBUTOR	2
55- 1	16217	BEARING	THRUST-TAILSHAFT-NEEDLE	1
55- 2	16218	RACE	THRUST-TAILSHAFT BEARING	1
56	16163	TAILSHAFT	REDUCTION PINION	1
57	16144	BEARING	NEEDLE-SCREW COLLAR	1
58	16203	HOUSING	REDUCTION GEAR	1
59	16126	O-RING	FORWARD PISTON-INNER	1
60	16232	WASHER	THRUST-PROPELLER GEAR	1
61- 1	16193	COLLAR	SCREU	1
61- 2	16197	COLLAR	SCREW COLLAR ASSEMBLY	1
63	16143	PLATE	INNER CLUTCH	6
64	16117	O-RING	FORWARD PISTON-OUTER	1
65	16142	PLATE	OUTER CLUTCH	7
66	16124	CLIP	SCREU COLLAR	2
67	16123	LOCKSCREW	SCREU COLLAR CLIP	2
68	16154	BAFFLE		1
69	16171	PIN	ROLL	1
70	16118	RING	RETAINING-REDUCTION BAND ROLL	1
72	16146	RING	CONTROL VALVE RETAINING	1
73- 1	16212	VALVE	CONTROL-TO SERIAL 6A1	1
73- 2	15223	VALVE	CONTROL-FROM SERIAL 6A1	1
73- 3	16178	VALVE	CONTROL VALVE ASSY-TO SERIAL 6A1	1
73- 4	16231	VALVE	CONTROL VALVE ASSY-FROM SERIAL 6A1	1
74	16159	LEVER	CONTROL	1
75	16145	C-RING	CONTROL VALVE	1
76	16160	BUSHING	CONTROL LEVER	1
79	16167	WASHER		1
80	16158	PAUL	CONTROL LEVER	1
81	16181	LEVER	REVERSE BAND	2
82	16111	SPACER	LONG PINION BEARING	2
83	16115	REARING	ROLLER-LONG PINION	1
84- 1	16112	PINION	LONG	2
84- 2	16138	PINION	LONG-PINION ASSEMBLY	2
85- 1	15211	COVER	TO SERIAL 6A1	1
85- 2	16224	COVER	FROM SERIAL 6A1	1
86	16166	PIN	CONTROL LEVER	3
87- 1	16119	SCREU	NAMEPLATE-TO SERIAL 6A1	4
87- 2	16120	SCREU	NAMEPLATE-FROM SERIAL 6A1	4
88- 1	16161	NAMEPLATE	TO SERIAL 6A1	1
88- 2	16233	NAMEPLATE	FROM SERIAL 6A1	1
90	16176	BREATHER		1
92	16180	SHAFT	REVERSE PISTON	1
93- 1	16186	PISTON	REVERSE PISTON AND SHAFT ASSEMBLY	1
93- 2	16185	PISTON	COMPLETE REVERSE PISTON ASSEMBLY	1
94	16174	O-RING	REVERSE PISTON	1
95	15170	PLATE	PISTON BACKUP	1
97	16221	SCREU	BRAKE BAND	1
98	16175	C-RING	PISTON BACKUP PLATE	1
99- 1	15177	GASKET	COVER-TO SERIAL 6A1	1
99- 2	15228	GASKET	COVER-FROM SERIAL 6A1	1

FOUR 107 UHALEBCAT SPEC - TRANSMISSION - PARAGON

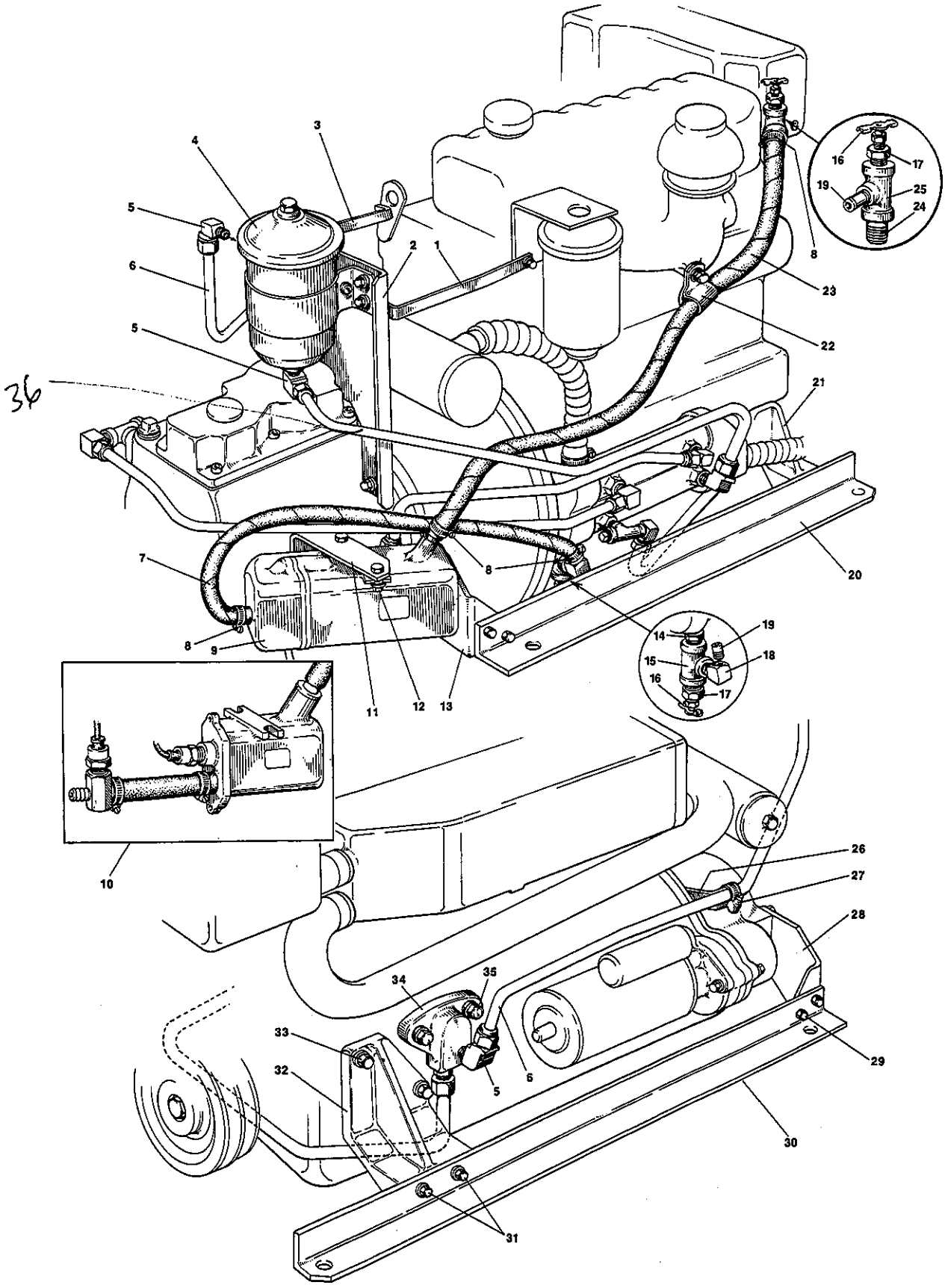
REF	PN	NAME	REMARKS	QUAN
100	16173	PIN	REVERSE GEAR HOUSING	1
101	16172	RCLL	REVERSE BAND	1
103- 1	16183	BAND	REVERSE BAND ASSEMBLY	1
103- 2	16184	EAND	REVERSE-WITHOOT LINING	1
103- 3	16104	LINING	REVERSE BAND-OME PAIR	1
103- 4	16100	RIVET	REVERSE BAND LINING	12
104- 1	16187	CIPSTICK	ASSEMBLY-TO SERIAL 6A1	1
104- 2	16216	DIPSTICK	ASSEMBLY-FROF SERIAL 6A1	1
104- 3	16190	HANDLE	DIPSTICK-TO SERIAL 6A1-NLA	1
104- 4	16215	HANDLE	DIFSTICK-FROM SERIAL 6A1	1
104- 5	16188	ROD	DIPSTICK-TO SERIAL 6A1-NLA	1
104- 6	16238	ROD	DIPSTICK-FROM SERIAL 6A1	1
104- 7	16129	C-RING	DIPSTICK	1
104- 8	16192	COLLAR	DIFSTICK-TO SERIAL 6A1	1
104- 9	16189	DECAL	DIPSTICK-TO SERIAL 4A1	1
104-10	16191	BLSHING	CIFSTICK-TO SERIAL 642-NLA	1
105	14889	TUBE	DIPSTICK	1
106	16213	COUPLING	GEAR HALF	1
110	16147	BALL	DETENT-TO SERIAL 6A1	1
111	16148	SPRING	DETENT-TO SERIAL 6A1	1
112	14888	SEAL	DETENT CAPSCREU-TO SERIAL 6A1	1
113	16121	CASKET	HOUSING-GEAR	1
115	16199	SPRING	RELIEF VALVE HOLD DOWN	1
116	16201	RING	RETAINING-RELIEF VALVE	1
117	16149	C-RING	RELIEF VALVE	1
118	16109	FIN	RELIEF VALVE	1
119	16105	PLUG	RELIEF VALVE	1
120	16106	SPRING	RELIEF VALVE	1
121	16200	HOUSING	RELIEF VALVE	1
122	16182	TUBE	DISTRIBUTDR	1
123	16126	C-RING		1
130	11721	GEAR	COMPLETE TRANSMISSION	1
131	23700	COUPLING	PRCPELLER HALF 1-3/8 PORE	1
132- 1	16156	SEAL	RECUCTION ADAPTER PLPTE 3/8 ID	1
132- 2	33593	SEAL	REDUCTION ADAPTER PLATE 1/2 ID	1

WESTERBEKE MODEL 14088 SPEC B WHALEBOAT ENGINE

SPEC B, INTRODUCED IN OCTOBER 1985. RELOCATES OR MODIFIES THE FOLLOWING COMPONENTS IN ORDER TO REDUCE ENGINE OVERALL WIDTH AND LENGTH: MOUNTING RAILS LUBE OIL FILTER, BLOCK HEATER AND ALTERNATOR .THE ILLUSTRATION AND PARTSLIST FOLLOWING IDENTIFY NEW PARTS CREATED BY SPEC B FOR SERVICE PURPOSES.

J. H. WESTERBEKE CORP.
AVON INDUSTRIAL PARK, AVON, MASS. 02322 · (617) 588 7700
CABLE: WESTCORP, AVON · TELEX: 92 4444

WESTERBEKE MODEL 14088 SPEC B WHALEBOAT ENGINE



WESTERBEKE MODEL 14088 SPEC B WHALEBOAT ENGINE

REF	PN	NAME	REMARKS	QUAN
1	35331	STRAP	RIGHT FILTER BRACKET SUPPORT	1
2	35318	BRACKET	LUBE OIL FILTER	1
3	35321	STRAP	LEFT FILTER BRACKET SUPPORT	1
4	11613	FILTER	LUBE OIL	1
5	13335	ELBOW	COMPRESSION	4
6	35324	LINE	BLOCK OIL ADAPTER TO FILTER	1
7	21516	HOSE	WIRE INSERTED-INCHES REQUIRED	26
8	11341	CLAMP	HOSE 8	4
9	21911	HEATER	WATER JACKET	1
10	35393	HEATER	WATER JACKET-REMOTE THERMOSTAT	1
11	35322	BRACKET	HEATER	1
12- 1	31555	CAPSCREW	5/16NC X 1	2
12- 2	31759	WASHER	FLAT 5/16	2
12- 3	31758	LOCKWASHER	5/16	2
12- 4	31756	NUT	5/16NC	2
13	13256	MOUNT	REAR RIGHT	1
14	33766	NIPPLE	REDUCER 3/8NPT TO 1/4NPT	1
15	11723	TEE	3/8NPT	1
16	11471	PETCOCK		2
17	13717	BUSHING	REDUCER 3/8NPT TO 1/8NPT	
18	13338	ELBOW	3/8NPT STREET 90	
19	13519	NIPPLE	HOSE	2
20	35320	RAIL	RIGHT	1
21	13099	MOUNT	FRONT RIGHT	1
22	13760	CLAMP	SUPPORT HEATER HOSE	1
23	21516	HOSE	WIFE INSERTED-INCHES REQUIRED	30
24	33765	NIPPLE	1/2NPT CLOSE	1
25	11651	TEE	1/2NPT X 3/8NPT X 3/8NPT	1
26	24117	BRACKET	SUPPORT OIL LINE	1
27	17298	CLAMP		1
28	13257	MOUNT	REAR LEFT	1
29- 1	31605	CAPSCREW	3/8NC X 1	4
29- 2	31764	LOCKWASHER	318	4
29- 3	31762	NUT	318NC	4
30	35319	RAIL	LEFT	1
31- 1	31655	CAPSCREW	7/16NC X 1	4
31- 2	31770	LOCKWASHER	7/16	4
32	13100	MOUNT	FRONT LEFT	1
33- 1	31681	CAPSCREW	7/16NF X 1-114	4
33- 2	31770	LOCKWASHER	7/16	4
34- 1	13955	ADAPTER	OIL LINES TO BLOCK	1
34- 2	12669	GASKET	ADAPTER TO BLOCK	1
35- 1	31681	CAPSCREW	7/16NF X 1-1/4	1
35- 2	31770	LOCKWASHER	7/16	2
35- 3	31772	NUT	7/16NF	1
35- 4	12503	STUD	7/16NF X 1-9/16	1
36	35325	LINE	OIL FILTER TO COOLER	1

WESTERBEKE MODEL 14088 SPEC B WHALEBOAT ENGINE

REF	PN	NAME	REMARKS	QUAN
		NOTE	ALL REFERENCES ARE TO NAVSEA MANUAL 0941-014-8013 WITH CHANGE 3	
			PAGE X.17-19 DELETE THE FOLLOWING REF	
25	13969	LINE	OIL ADAPTER TO FILTER	1
48	14079	LINE	OIL FILTER TO COOLER	1
58	11119	BRACKET	OIL FILTER	1
60	11121	STUD		3
			PAGE X.29 DELETE THE FOLLOWING REF	
22	12103	RAIL	LEFT	1
29	12131	BRACKET	BILGE PUMP	1
33	13101	RAIL	RIGHT	1
			PAGE X.17 CHANGE THE FOLLOWING REF TO	
19	21516	HOSE	WIRE INSERTED-INCHES REQUIRED	8
			PAGE X.23 CHANGE THE FOLLOWING REF TO	
1	35304	SUMP	3/4UNF DRAIN PLUG-FROM AUG 85	1
2	35305	PLUG	SUMP DRAIN 3/4UNF	1
11	35306	WASHER	SUMP DRAIN PLUG 35305	1
			PAGE X.27 CHANGE THE FOLLOWING REF TO	
3	35323	ALTERNATOR	35AMP-24VDC-NEG GND-SPEC B	1
13	35338	STRAP	ALTERNATOR ADJUSTING-SPEC B	1
			PAGE X.34 CHANGE THE FOLLOWING REF TO	
131	34546	COUPLING	PROPELLER HALF 1 IN BORE	