

# TECHNICAL MANUAL

**WESTERBEKE**

**10TWO & 12B-TWO**

**MARINE DIESEL ENGINES**

**WMD 3 KW - 60 HERTZ**

**WMD 2.4 KW - 50 HERTZ**

**MARINE DIESEL GENERATORS**

PUBLICATION #33403

EDITION TWO

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IMPORTANT

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## INTRODUCTION

### IMPORTANT

THIS MANUAL IS A GENERAL GUIDE TO THE INSTALLATION, START-UP, OPERATION AND MAINTENANCE OF YOUR WESTERBEKE MARINE DIESEL ENGINE. THE INFORMATION IT CONTAINS IS VITAL TO THE ENGINE'S DEPENDABLE, LONG TERM OPERATION.

READ IT !

KEEP IT IN A SAFE DRY PLACE !

KEEP IT HANDY FOR REFERENCE AT ALL TIMES !

FAILURE TO DO SO WILL INVITE SERIOUS RISK, NOT ONLY TO YOUR INVESTMENT BUT YOUR SAFETY AS WELL.

### UNDERSTANDING THE DIESEL....

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 of the same general type as that of a gasoline engine; it has the same sort of valves, camshaft, pistons, connecting rods, lubricating system and reverse and reduction gear.

Therefore, it follows to a great extent that a diesel engine requires the same preventative maintenance as that which any intelligent operator would give to a gasoline engine. The most important factors are proper maintenance of the fuel, lubricating and cooling systems. Replacement of fuel and lubricating filter elements at the time periods specified is a must, and frequent checking for contamination (i.e. water, sediment, etc.) in the fuel system is also essential. Another important factor is the use of the same brand of "high detergent" diesel lubricating oil designed specifically for diesel engines.

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

Unremitting care and attention at the factory have resulted in a Westerbeke engine capable of many thousands of hours of dependable service. What the manufacturer cannot control, however, is the treatment it receives in service. This part rests with you!

### ORDERING PARTS

Whenever replacement parts are needed, always include the complete part description and part number (see separate Parts List). Be sure to include the engine's model and serial number. Also, be sure to insist upon Westerbeke factory packaged parts, because "will fit" parts are frequently not made to the same specifications as original equipment.

### GENERATOR SETS

Westerbeke diesels are used for both the propulsion of boats and for generating electrical power. For generator set applications, all details of this Manual apply, except in regard to certain portions of the Installation, Operation and Maintenance sections. Additional information is provided in the section titled Generator Sets, Section T.

# INSTALLATION

## FOREWORD

Since the boats in which these engines and generators are used are many and varied, details of engine installation are equally so. It is not the purpose of this section to advise boatyards and engine installers on the generally well understood and well developed procedures for installation of engines. However, 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 have a periodic check and of which the operator should have a thorough understanding to insure good operating conditions for the engine and correct procedure for its servicing.

## INSPECTION OF EQUIPMENT

The engine is shipped from the factory mounted securely and properly crated. Accessory equipment is shipped in a separate small box, usually packed with the engine crate.

Before accepting shipment from the transportation company, the crate should be opened and an inspection made for concealed damage. If either visible or concealed damage is noted, you should require the delivering agent to sign "Received in damaged condition". Also check contents of the shipment against the packing list and make sure note is made of any discrepancies. This is your protection against loss or damage. Claims for loss or damage must be made to the carrier, not to J. H. Westerbeke Corporation.

## RIGGING AND LIFTING

The engine is fitted with lifting rings.

Rope or chain slings should be attached to the rings and the engine lifted by means of tackle attached to this sling. The lifting rings have been designed to carry the full weight of the engine; therefore, auxiliary slings are not required or desired.

**CAUTION:** Slings must not be so short as to place the engine lifting eyes in significant sheer stress. Strain on the engine lifting eyes must not be in excess of 10° from the vertical. A spacer bar must be placed between the two lifting eyes, if supported by valve cover studs.

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 horizontal 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 as 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 parts and to avoid dirt entering openings. The parts which have been removed should be returned to position as soon as the restriction 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 damage to the parts on which the weight may bear. 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 bronze or stainless hanger bolts of appropriate size be used through the engine flexible mounts. Lag 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.

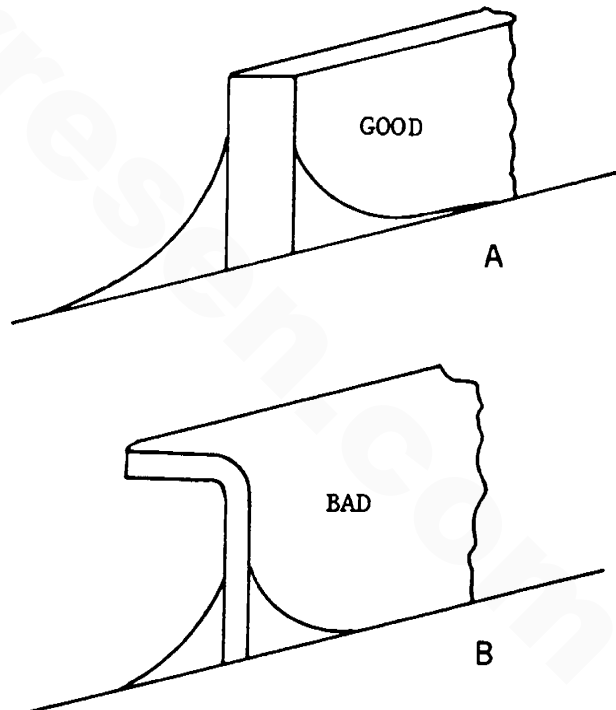
#### FOUNDATION FOR ENGINE

A good engine bed contributes much toward the satisfactory operation of the engine. The engine bed must be of rigid construction and neither deflect nor twist when subjected to the engine weight or the position the boat may have to take under the effects of rough seas. The bed must keep the engine within one or two thousandths of an inch of this position at all times. It has to withstand the forward push of the propeller which is applied to the propeller shaft, to the thrust washer bearing in the engine and finally to the engine bolts and engine bed.

In fiberglass hulls, we recommend that similar wooden stringers as in wooden hulls be formed and fitted, then glassed to the hull securely. This allows hanger bolts to be installed firmly in wood, thus reducing noise and transmitted vibration.

Preformed fiberglass engine beds when used should be of sufficient thickness to properly support the engine and should be well glassed to the hull when installed.

The temptation to install the engine on a pair of fiberglass "angle irons" should be resisted. Such construction will allow engine vibrations to pass through to the hull. Flexible mounts require a firm foundation against which to react if they are to do their job. When possible, follow bed design "A" and avoid bed design "B".



Supports between the bed stringer and extending out from the stringers out to the hull may be required for proper support and to aid in the absorption of vibrations.

#### PROPELLER COUPLING

Each Westerbeke Diesel engine is regularly fitted with a suitable coupling 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 all engine models, a propeller half-coupling, bored to shaft size for the specific order, is supplied. The coupling either has a keyway with set screws or is of the clamping type.

The forward end of the propeller shaft has a 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 varies with the gear ratio and must be selected to fit the application 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 RPM at full throttle under normal load.

#### 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 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 that the propeller shaft itself be perfectly straight.

One particularly annoying result of misalignment may be leakage of transmission oil through the rear oil seal. Check to make sure that alignment is within the limits prescribed.

The engine should be moved around on the bed and supported on the screw-jacks 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.

Never attempt a final alignment with the boat on land. The boat should be in the water and have had an opportunity to assume its final water form. It is best to do the alignment with the fuel and water tanks about half full and all the usual equipment on board and after the main mast has been stepped and final rigging has been accomplished.

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 backward 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 should be parallel within 0.001 inches per inch diameter of coupling (A).

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° between each position. This 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° from the next one.

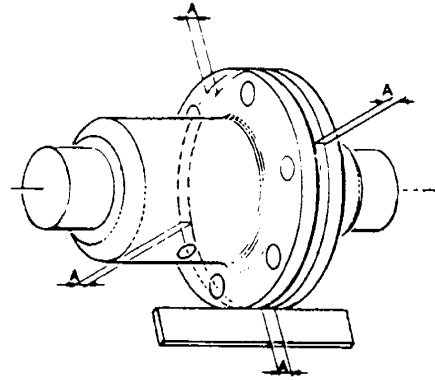
The engine alignment should be rechecked after the boat has been in service for one to three weeks and, if necessary, the alignment remade. It will usually be found that the engine is no longer in alignment. This is not because the work was improperly done at first but because the boat has taken some time to take 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, and during storage in a cradle. 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

Exhaust line installations vary considerably and each must be designed for the particular installation. The prime requirements are to provide an outlet line with a minimum of restrictions and arranged so that sea water, rain water and condensation cannot get back into the cylinders of the engine.

The sea water supply line feeding raw cooling water into the system must be routed so as to prevent a siphoning of raw water through this line into the exhaust system filling the muffler and engine cylinders. This line should be routed at least 12 inches above





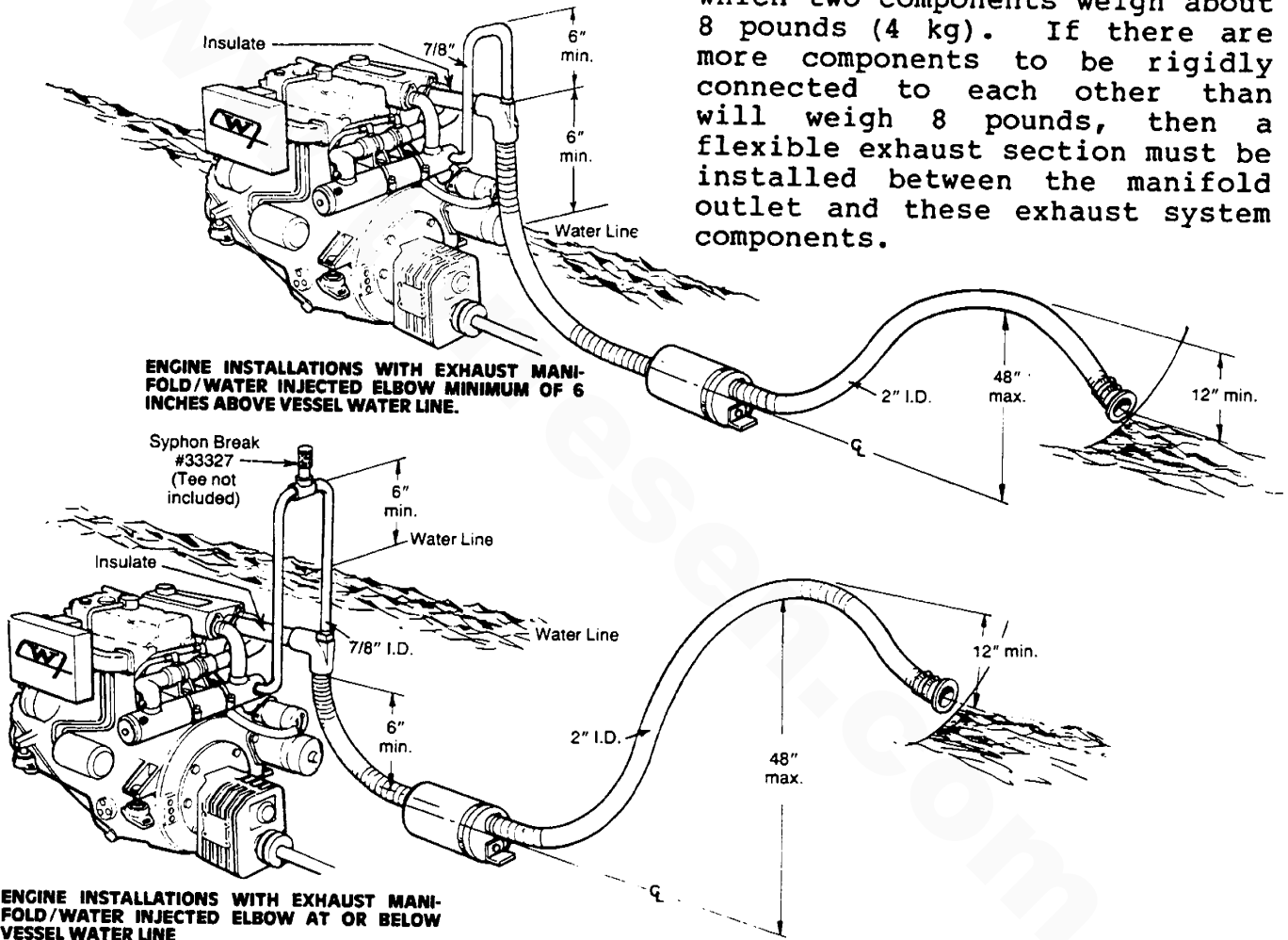
the water line and an anti-siphon break installed at the top of its loop. This loop should be high enough above the water line so as not to be below it at various angles of heel when under sail.

Lines feeding raw cooling water to stuffing boxes, if installed, must be installed so as to prevent siphoning of water back into the engine exhaust and engine cylinders as above.

Most exhaust systems today use a water lift type muffler such as the Westerbeke "Hydro-Hush". In most installations there is a dry, insulated high loop after the engine manifold and before the muffler to prevent water flowing backwards into the engine during cranking.

It is essential not to hang too much weight in the form of exhaust system components rigidly from the engine manifold. Generally, it is permissible to directly connect a pipe nipple and a

water jacketed exhaust elbow, which two components weigh about 8 pounds (4 kg). If there are more components to be rigidly connected to each other than will weigh 8 pounds, then a flexible exhaust section must be installed between the manifold outlet and these exhaust system components.



The exhaust system must be supported or suspended independently of the engine manifold, usually using simple metal hangers secured to the overhead.

All dry portions of the exhaust system can be constructed of common black iron pipe and should be wrapped in suitable insulation material to keep surface temperatures as low as possible.

Many installations use flexible rubber exhaust hose for the water

cooled section of the exhaust line because of the ease of installation and flexibility. Provide adequate support for the rubber hose to prevent sagging, bending and formation of water pockets. The exhaust line must be at least as large an I.D. as the O.D. of the exhaust elbow hose attachment nipple. It should be increased in size by 1/2" I.D. for every 10 feet beyond the first 10 feet.

Always arrange the rubber hose section so that water cannot possibly flow back into the engine. Also make sure that entering sea water cannot spray directly against the inside of the exhaust piping. Otherwise, excessive erosion will occur. The use of brass or copper is not acceptable for wet exhaust systems, as the combination of salt water and diesel exhaust gasses will cause rapid deterioration of this material.

#### MEASURING EXHAUST GAS BACK PRESSURE

Back pressure must be measured on a straight section of the exhaust line and as near as possible to the engine exhaust manifold. The engine should be run at maximum load during the measurement period. Set-up should be as shown below.

1. For normally aspirated engines:

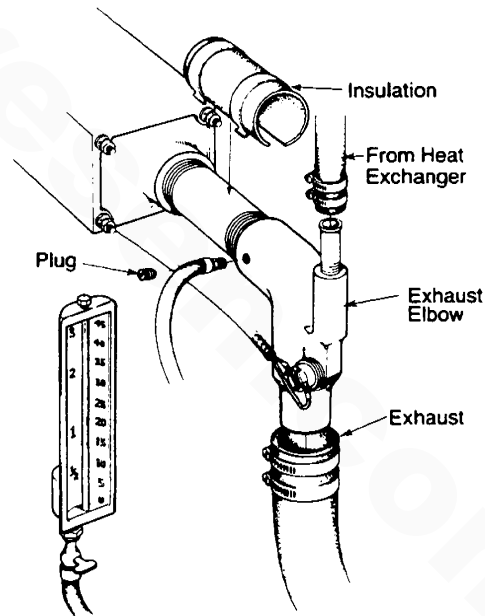
|                      |                     |                     |
|----------------------|---------------------|---------------------|
| <u>Pressure Test</u> | <u>Mercury Test</u> | <u>Water Column</u> |
| 1-1/2" Max PSI       | 3" Mercury          | = 39"               |

2. For turbo-charged engines:

|                      |                     |                     |
|----------------------|---------------------|---------------------|
| <u>Pressure Test</u> | <u>Mercury Test</u> | <u>Water Column</u> |
| 0.75 Max PSI         | 1-1/2" Mercury      | = 19-1/2"           |

#### Checking The Back Pressure

1. Exhaust elbow
  2. Exhaust line
  3. Transparent plastic hose, partly filled with water.
- Measurement "A" may not exceed 39" for normally aspirated engines and 19.5" for turbo-charged engines.



#### WATER CONNECTIONS

Seacocks and strainers should be of the full flow type at least one size greater than the inlet thread of the sea water pump. The strainer should be of the type which may be withdrawn for cleaning while the vessel is at sea. Mount the strainer below the water line to insure self-priming.

Water lines can be copper tubing or wire-wound, reinforced rubber hose. In any case, use a section of flexible hose that will not collapse under suction, between the hull inlet and engine and between the outlet and the exhaust system. This takes up vibration and per-

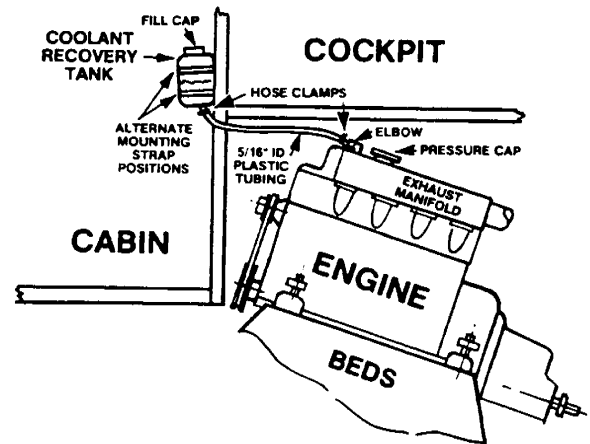
mits the engine to be moved slightly when it is being re-aligned. Do not use street elbows in suction piping. All pipe and fittings should be of bronze. Use sealing compound at all connections to prevent air leaks. The neoprene impeller in the sea (raw) water pump should never be run dry.

#### COOLANT RECOVERY TANK

Your Westerbeke diesel is designed for and supplied with a remote coolant recovery tank. Once the engine has been initially filled via its pressure cap, occasional topping off can be done through the recovery tank. Coolant level can be easily and frequently monitored.

Mount the recovery tank above the engine and inside the cabin where it will always be visible.

Take care that the plastic tubing between the engine and the recovery tank is led so that it will not chafe or kink.



#### FUEL TANK AND FILTERS

Fuel tanks may be of fiberglass, monel, aluminum, plain steel orterne plate. If made of fiberglass, be certain that the interior is gel coated to prevent fibers from contaminating the fuel system. Copper or galvanized fuel tanks should not be used. It is not necessary to mount the tank above the engine level as the fuel lift pump provided will raise the fuel from the tank. The amount of lift should be kept minimum (6 feet being maximum). If a tank is already installed above the engine level, it can be utilized in this position. Great care should be taken to ensure that the fuel system is correctly installed so that airlocks are eliminated and precautions taken against dirt and water entering the fuel.

A primary fuel filter of the water collecting type should be installed between the fuel tank and the fuel lift pump. A recommended type is available from the list of accessories. The secondary fuel filter is fitted on the engine between the fuel lift pump and the injection pump and has a replaceable element.

As the fuel lift pump has a capacity in excess of that required by the injection pump, the return is piped to the fuel tank and should be connected to the top of the tank and the return extended down into the tank.

To insure satisfactory operation, a diesel engine must have a dependable supply of clean diesel fuel. 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 the injector nozzles when the engine is started for the first time.

#### FUEL PIPING

We recommend fuel hose or copper tubing together with suitable 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 between 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 locks".

The fuel piping leading from the tank to the engine compartment should always be securely anchored to prevent chafing. Usually the copper tubing is secured by means of copper straps.

The final connection to the engine should be through flexible rubber hoses.

#### ELECTRIC PANEL

The Westerbeke all-electric panel utilizes an electronic tachometer with a built-in hourmeter (hourmeter only on generators). Mounted on the panel are a voltmeter, water temperature gauge and oil pressure gauge. Each instrument is lighted. The all-electric panel is isolated from ground and may be mounted where visible. It is normally pre-wired.

#### ELECTRICAL EQUIPMENT

Most Westerbeke engines are supplied pre-wired and with plug-in connectors. Never make or break connections while the engine is running. Carefully follow all instructions on the wiring diagram supplied, especially those relating to fuse/circuit breaker requirements.

Starter batteries should be located as close to the engine as possible to avoid voltage drop through long leads. It is bad practice to use the starter batteries for other services unless they require low amperage or are intermittent. In cases where there are substantial loads (from lights, refrigerators, radios, depth sounders, etc.), it is essential to have a complete, separate system and to provide charging current for this by means of a second alternator or "alternator output splitter".

Starter batteries must be of a type which permits a high rate of discharge (Diesel starting).

Carefully follow the recommended wire sizes shown in the wiring diagrams. Plan installation so the battery is close to the engine and use the following cable sizes:

- #1 - for distances up to 8 feet
- #1/0 - for distances up to 10 feet
- #2/0 - for distances up to 13 feet
- #3/0 - for distances up to 16 feet

#### MECHANICAL CONTROLS

The recommended practice is to have the stop-run lever loaded to the run position and controlled by a sheathed cable to a push-pull knob at the pilot station. The throttle lever should be connected to a Morse type lever at the pilot station by a sheathed cable.

The transmission control lever may be connected to the pilot station by a flexible, sheathed cable and controlled by a Morse type lever. The single-lever type gives clutch and throttle control with full throttle range in neutral position. The two-lever type provides clutch control with one lever and throttle control with the other.

Any bends in the control cables should be gradual. End sections

at engine and transmission must be securely mounted. After linkages are completed, check the installation for full travel, making sure that, when the transmission control lever at the pilot station is in forward, neutral and reverse, the control lever on the transmission has moved into the respective position.

Some models do not require a stop cable because they have a fuel run solenoid. Examples of such models are the W58 and the W52 (20KW and 15KW generators).

Check the throttle lever on the injection pump and insure that full movement of the lever is provided by the cable.

# OPERATION

## PREPARATION FOR FIRST START

The engine, for safety reasons, is shipped "dry"...with lubricating oil drained from the crankcase and fluid from the transmission. Therefore, be sure to follow these recommended procedures carefully before starting the engine for the first time.

1. Remove the oil filler cap and fill the sump with diesel oil having an API spec. of CC or better. Refer to the technical data section of this manual for the proper amount of oil the sump should receive.

2. Fill the cooling system with a mixture of antifreeze and fresh water (50-50). The mixture should be strong enough to protect against freezing. Open bleed petcocks to allow air to bleed from the system while it is being filled.

3. Fill the reverse gear to the highest mark on the dipstick with the proper lubricant for the model gear as specified in the Transmission Section of this manual. V-drives must be filled separately.

4. Fill the fuel tank with clean #2 diesel fuel. The use of #1 is permissible but #2 is preferred because of its higher lubricant content.

5. Ensure that the battery is fully charged and the electrolyte level is correct.

## FUEL SYSTEM

The fuel injection system of a compression ignition engine depends upon very high fuel pressure during the injection stroke to function correctly. Relatively tiny movements of the pumping plungers produce this pressure and, if any air is present inside the high pressure line, then this air acts as a cushion and prevents the correct pressure, and therefore fuel injection, from being achieved.

In consequence, it is essential that all air is bled from the system whenever any part of the system has been opened for repair or servicing.

Self-bleeding units need only have the fuel brought to the fuel connection on the engine. The system, when activated, will self-bleed. (The self-bleeding feature of the engine will not bleed the vessel's fuel system from the tank to the engine in all cases.)

## BLEEDING PROCEDURES BY MODEL

Initial Engine Start-up (Engine stoppage due to lack of fuel)

a. Insure that the fuel tank(s) is filled with the proper grade of diesel fuel.

b. Turn the fuel selector valve to "On". Systems with more than one tank insure that fuel returning is going to the tanks being used.

c. Fill any large primary filter/water separator with clean diesel fuel fuel that is installed between the fuel tank and engine.

The above procedures are basic for all initial engine start-ups or for restarting engines stopping due to lack of fuel.

WESTERBEKE W10Two, 3KW, W13, 4.4KW, W21, 7.7KW, W27, 11KW, W33, 12.5KW

These units are self-bleeding.

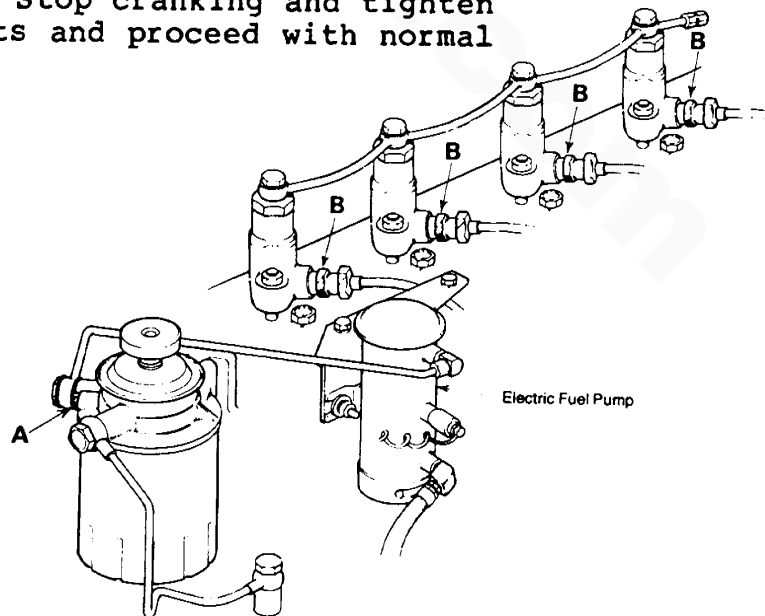
1. Turn the ignition to the ON position (Generators - PREHEAT) and wait 20-30 seconds.
2. Start the engine following normal starting procedures.

WESTERBEKE W52, 15KW, W58, 20KW, W70, 25KW, W100, 32KW

1. Open the bleed screw on the top inboard side of the engine-mounted secondary fuel filter one to two turns using a 10mm box wrench (Bleed Point A). This fuel filter is equipped with a hand-operated priming pump. With the palm of your hand, pump this primer with slow steady pumps until fuel free of air bubbles flows from this bleed screw. Stop pumping and retighten the bleed screw.

NOTE: An electric fuel pump is incorporated in the fuel system on new model units which, when activated by turning the ignition on (Generator - Preheat), will bleed the filter of air through Bleed Point A.

2. With bleed screw A tightened, continue to pump the hand primer (operate the electric fuel pump) several more times so as to bleed and prime the fuel injection pump.
3. Loosen the four injector line attaching nuts at the base of each injector (Bleed Point B) one to two turns with a 16mm open end wrench. Place the throttle in the full open position and crank the engine over with the the starter until fuel spurts by the nut and injector lines. Stop cranking and tighten each of the four nuts and proceed with normal starting procedure.



### PREPARATION FOR STARTING

1. Check water level in expansion tank. It should be 1/2 to 1 in. below the top of the tank when cold. If remote plastic recovery tank is used, the level should be at the cold mark.
2. Check the engine sump oil level.
3. Check the transmission fluid level.
4. See that there is fuel in the tank and the fuel shut-off is open.
5. Check to see that the starting battery is fully charged, all electrical connections are properly made, all circuits in order and turn on the power at the battery disconnect.
6. Check the seacock and ensure that it is open.

### STARTING THE ENGINE (COLD)

1. Check to see that the "stop" lever (if incorporated) is in the "run" position. Place the throttle in the full run position and the gear lever in the neutral position.
2. Engines with keyswitches: Turn the switch to the ON position. This energizes the instrument panel, electric fuel pump and injection pump fuel solenoid.
3. Preheat for 15 to 20 seconds.  
Panels with keyswitches: Push in on the key to activate the preheat and hold in panels with pushbuttons.  
Panels with pushbuttons: Push in on the preheat button to activate preheat and hold it in.  
(Generators: Depress preheat switch and hold.)
4. Start the engine.  
Panels with keyswitches: While continuing to hold the key pushed in for preheat, turn the key to the start position.  
Panels with pushbutton start: Continuing to hold the preheat button in, press the start button.  
(Generators: Continuing to hold preheat depressed, depress start switch.)
5. Start: Once the engine starts, release the keyswitch (push-buttons) and return the throttle immediately to near the idle position (1000 - 1500 RPM).  
Generators: Release the start toggle switch only. Continue to hold the preheat toggle switch depressed until oil pressure shows 20 - 25 PSI, then release the preheat toggle.)

Check for proper oil pressure and insure that there is raw water coolant discharge with the exhaust.

6. If the engine fails to start in 20 to 30 seconds of cranking, discontinue the starting and allow the starter to cool for a



period of time at least twice that used when cranking. Then repeat steps 3 through 5.

**CAUTION:** Excessive cranking can damage the starter as well as fill the exhaust muffler and that portion of the system between the muffler and engine with raw cooling water possibly getting it back into the engine.

#### STARTING THE ENGINE (WARM)

If the engine is warm and has only been stopped for a short time, place the throttle in the partially open position and engage the starter as above, eliminating the preheat step.

**NOTE:** Preheat must be depressed on generator units whenever it is being started.

**NOTE:** Always be sure that the starter pinion has stopped revolving before again re-engaging the starter; otherwise, the flywheel ring gear or starter pinion may be damaged.

Extended use of the cold starting aid beyond the time periods stated should be avoided to prevent damage to the aid.

**NEVER** under any circumstances use or allow anyone to use ether to start your engine. If your engine will not start, then have a qualified Westerbeke marine mechanic check it.

#### WHEN ENGINE STARTS

1. Check for normal oil pressure immediately upon engine starting. Do not continue to run engine if oil pressure is not present within 15 seconds of starting the engine.
2. Check Sea Water Flow. Look for water discharge with the exhaust. Do this without delay.
3. Recheck Crankcase Oil. After the engine has run 3 or 4 minutes, subsequent to an oil change or new installation, stop the engine and check the crankcase oil level. This is important as it may be necessary to add oil to compensate for the oil that is required to fill the engine's internal oil passages and oil filter. Add oil as necessary. Check oil level prior to each day's operation.
4. Recheck Transmission Fluid level. (This applies only subsequent to a fluid change or new installation.) In such a case, stop the engine after running for several minutes at 800 RPM with one shift into forward and one into reverse, then add fluid as necessary. Check fluid level each day of operation.
5. Check Expansion Tank Water Level. This is done stopping the engine and removing the fresh water fill cap from the manifold/expansion tank. (To remove the cap, press down on it with the palm of the hand and twist the cap counterclockwise until

the resistance of the safety stops is felt. Slowly release palm pressure from the cap and allow any pressure built up in the system to escape. Take care not to be scalded or burned by escaping steam or water. Leave the cap in this position until all pressure is released. Then press the cap firmly downward to clear the safety stops and continue turning it until it can be lifted off.

Add coolant as needed to bring the level to within one half inch of the top of the fill neck.

NOTE: Systems with metal remote expansion tanks: Coolant level should be checked at this tank and the level maintained about one half to three quarters full. The fill cap on the engine should not be removed to check the system as coolant will be lost when this cap is removed.

NOTE: Engines equipped with the plastic coolant recovery tank: The level in the tank should be checked and coolant added as needed. The engine fresh water cooling system is filled full when this recovery tank is used and this tank collects coolant from the engine through expansion as the engine reaches operating temperature (170° - 190°F) and returns this coolant to the engine through contraction as the engine cools.

WARNING: The cooling system is pressurized when the engine is at operating temperature or overheated and the pressure in the system must be released with caution as the filler cap is removed. It is advisable to protect the hands against escaping steam or water as the cap is turned.

6. Warm-up Instructions. As soon as possible, get the boat underway, but at reduced speed, until water temperature gauge indicates 130-150°F. If necessary, engine can be warmed up with the transmission in neutral at 1000 - 1500 RPM.
7. Reverse Operation. Always reduce engine to idle speed when shifting gears. However, when the transmission is engaged, it will carry full engine load.

#### STOPPING THE ENGINE

1. Position shift lever in neutral. (Remove load from generator.)
2. Idle the engine for 2 to 4 minutes to avoid boiling and to dissipate some of the heat.
3. Engines equipped with stop handles: Pull the handle out and hold until the engine stops completely.  
Engines stopped by means of the throttle lever: Move the throttle to idle and apply added pressure to move the throttle below idle and in to shut off.  
Engines with keyswitch shut off: Just turn the key off.

NOTE: Be sure to place the stop handles and throttle levers into the run position.

4. Turn off the keyswitch. Some models do not use the stop lever as they are equipped with a fuel solenoid or electric fuel pump which shuts off the fuel supply when the keyswitch is turned to the OFF position.
5. Close the seacock.
6. Disconnect power to system with battery switch.

#### OPERATING PRECAUTIONS

1. Never run engine for extended periods when excessive overheating occurs, as extensive internal damage can be caused.
2. DO NOT put cold water in an overheated engine. It can crack the cylinder head, block or manifold.
3. Keep air intake silencer free from lint, etc.
4. Never Race a Cold Engine as internal damage can occur due to inadequate oil circulation.
5. Keep the engine and accessories clean.
6. Keep the fuel clean. Handle it with extreme care because water and dirt in fuel cause more trouble, and service life of the injection system is reduced dramatically.
7. Do not allow fuel to run low, because fuel intake may be uncovered long enough to allow air to enter the injection system, resulting in engine stoppage requiring system bleeding.
8. Do not be alarmed if temperature gauges 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.

NOTE: Oil and water temperature instruments will remain at or near their last reading when the panel power is shut off with the engine.

## TEN MUST RULES

IMPORTANT

IMPORTANT

IMPORTANT

...for your safety and your engine's dependability.

ALWAYS -

1. Keep this Manual handy and read it whenever in doubt.
2. Use only filtered diesel fuel and check lube oil level daily.
3. Check cooling water temperature frequently to make sure it is 190° or less.
4. Check engine coolant prior to each day's use.
5. Investigate any oil leaks immediately.
6. Check transmission lubricant prior to each day's use.

NEVER -

6. Race the engine in neutral when cold.
7. Run the engine unless the gauge shows proper oil pressure.
8. Tamper with the injection pump.
9. Use cotton waste or fluffy cloth for cleaning or store fuel in a galvanized container.
10. Subject the engine to prolonged overloading or continue to run it if black smoke comes from the exhaust.

## MAINTENANCE

### PERIODIC ATTENTION:

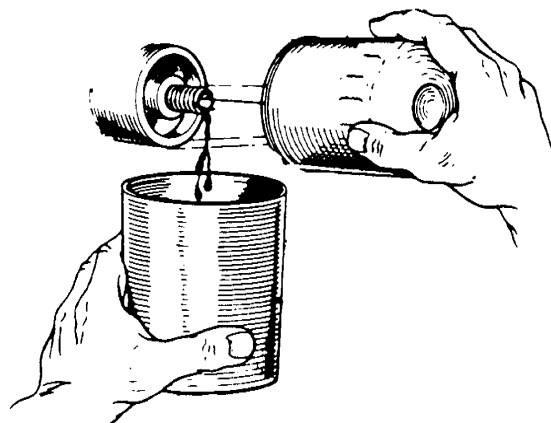
After you have taken delivery of your engine, it is important that you make the following checks right after the first fifty hours of its operation.

Note: Transmissions generally require fluid change after the first 25 to 30 hours of operation. Refer to the Transmission Section of this manual for details.

### FIFTY HOUR CHECKOUT (INITIAL)

Do the following:

1. Retorque the cylinder head bolts.
2. Retorque the rocker bracket nuts and adjust valve rocker clearance.
3. Change fuel filter elements.
4. Change engine lubricating oil and oil filter.
5. Check for fuel and lubricating oil leaks. Correct if necessary.
6. Check cooling system for leaks and inspect water level.
7. Check for loose fittings, clamps, connections, nuts, bolts, vee belt tensions, etc. Pay particular attention to loose engine mounts and engine mount fittings. These could cause mis-alignment.
8. Check conditions of zinc anode in engine heat exchanger.



### DAILY CHECKOUT

Do the following:

1. Check the sea water strainer, if one has been installed.
2. Check water level in cooling system.
3. Check lubricating oil level in sump. Fill to highest mark on dipstick.
4. Check fluid level in transmission. Fill to highest mark on dipstick with proper fluid.

### SEASONAL CHECK-OUT (MORE OFTEN IF POSSIBLE)

Do the following:

1. Check generator, alternator and sea water pump "V" belts for proper tension.
2. Check water level in battery.
3. Change oil in sump. See Note.
4. Replace lubricating oil filter, Figure 2. See Note.
5. Fill sump with diesel lubricating oil to highest mark on dipstick. Refer to Specification page for proper quantity of oil. Do Not Overfill, but be sure the proper amount of oil is placed in the sump. See Note.

**CAUTION:** The use of different brands of lubricating oils during oil changes has been known to cause extensive oil sludging and may in many instances cause complete oil starvation.

6. Start engine and run for 3 or 4 minutes. Stop engine and check oil filter gasket for leaks. Check oil sump level. This is important as it may be necessary to add oil to compensate for the oil that is required to fill the engine's internal oil passages and oil filter. Add oil as necessary. See Note.

#### IMPORTANT NOTE

IT IS MANDATORY THAT THE CHECKS 3, 4, 5 AND 6 BE ATTENDED TO WHEN TOTAL OPERATING TIME REACHES 150 HOURS. IN SOME INSTANCES, THIS TOTAL IS REACHED BEFORE END OF SEASON.

7. Clean Air Filter if supplied. (Most models have an air silencer that does not require cleaning.)
8. Check engine for loose bolts, nuts, etc.
9. Check sea water pump for leaks.
10. Clean primary filter bowl and screen. If filter bowl contains water or sediment, filter bowl and secondary fuel filter need be cleaned more frequently.
11. Replace secondary fuel filter element.
12. Change the fluid in the transmission. Refer to the Transmission Section of this manual for details.

#### WINTERIZATION

1. Fresh Water Cooling System: The use of a 50-50 solution of anti-freeze and fresh water is recommended for use in the fresh water cooling system year round. This solution may require a higher concentration of antifreeze, depending on the area's winter climate.

Should more antifreeze be needed, drain an approximate amount from the engine block and add a more concentrated mixture. Operate the engine to insure complete circulation throughout the system. Recheck.

2. Lubrication System: With the engine warm, drain ALL the lubricating oil from the oil sump. Remove and replace the oil filter; place some paper towels and a plastic bag around the filter to catch the oil while removing it.

When installing the new oil filter, be sure to apply a small amount of oil on the sealing O-ring at the base of the filter. Fill the sump with the correct amount of oil for your engine model. Use an oil with an API Spec. CC. Run the engine and check for proper oil pressure and insure that there are no leaks.

Do not leave old engine lubricating oil in the sump over the winter lay-up period. Lubricating oil and combustion deposits combine to produce harmful chemicals which can reduce the life of internal engine parts.

3. Transmission: Drain the lubricant from your transmission and/or V-drive. Refill with the proper lubricant to the full mark on the transmission dipstick. Run the engine and shift the transmission into forward and reverse one/two times. Stop the engine and check the transmission oil level; add lubricant as needed. Check for leaks.

4. Fuel System: Top off your fuel tanks with #2 diesel fuel. Fuel additives should be added at this time to control algae and condition the fuel. Care should be taken that additives used are compatible

with primary filter/separators used in the system. Change the element in your primary fuel filter/separator if it contains one, and/or clean the separator sediment bowl.

Change the fuel filter elements on the engine and bleed the fuel system as needed. Start the engine and allow it to run for 5 to 10 minutes to insure that no air is left in the fuel system and check for any leaks that may have been created in the fuel system during this servicing, and correct as needed.

5. Sea Water Circuit: Close the thru hull sea cock. Remove the raw water intake hose from the sea cock. Place the end of this hose into a 5-gallon bucket of clean fresh water. Before starting the engine, check the zinc pencil found in the primary heat exchanger on the engine and clean or replace it, if required. Clean your sea strainer, if one is installed on the inside of the hull

Start the engine and allow the raw water pump to draw the fresh water through the system. When the bucket empties, stop the engine and refill the bucket with an antifreeze solution slightly stronger than needed for winter freeze protection in your area.

Start the engine and allow all of this mixture to be drawn through the raw water system. Once the bucket empties, stop the engine. This antifreeze mixture should protect your raw water circuit from freezing during winter lay-up, as well as providing corrosion protection.

Remove the impeller from your raw water pump (some antifreeze mixture will accompany it, so catch it in a bucket). Examine the impeller. Acquire a replacement if needed and cover gasket. Do not replace the impeller back into the pump until the Spring commissioning.

6. With a clean cloth lightly soaked in oil, place it in the opening of the intake manifold so as to block it closed. DO NOT shove the cloth out of sight into the intake manifold. If you cannot see it next Spring, and you attempt to start your engine, you may need the assistance of a servicing dealer. Make a note to remove this cloth prior to start-up. The exhaust through hull can be closed in this same manner.

7. Disconnect the propeller shaft coupling from the transmission. (If the boat remains in the water during winter storage, this need not be done.)

This is a good time to check the security of the coupling to the propeller shaft. Insure also that the coupling set screws are tight and wired so as not to loosen. The engine alignment to the propeller shaft should be checked in the spring when the boat is placed back in the water, and the mast stepped, and the rigging tuned.

8. Controls and Linkage: Check the security of control connections to the engine and transmission. Lubricate these controls and insure that they move freely. Engines with pull-type shut-off levers should be left in the "run" position during winter storage.

9. Starter Motor: Lubrication and cleaning of the starter drive pinion is advisable if access to the starter permits its easy removal. Insure that the battery connections are shut off before attempting to remove the starter. Take care to properly replace any electrical connections removed from the starter.

10. Removing the injectors from the cylinder head and squirting some light lube oil down the injector hole into the cylinders is not necessary for the few months the engine is laid up for the winter. However, if you anticipate a longer lay-up period (12 months +),

please follow through with this procedure. It will prevent the adhering of the piston rings to the cylinder walls. Insure that you have the proper hardware to replace the sealing washers for the injectors and return line connections.

11. Spares: This is a good time to look over your engine and see if external items such as belts or hoses may need replacing, come Spring commissioning. Check over your basic spares kit and order items not on hand, or replace those items used during the winter lay-up, such as filters and zincs.

12. Batteries: If batteries are to be left on board during the winter storage period, insure that they are in a state of full charge and will remain that way, to prevent them from freezing. If not, it would be wise to remove them.

#### LUBRICATING OILS

Lubricating oils are available for Westerbeke Diesel engines which offer an improved standard of performance to meet the requirements of modern operating conditions such as sustained high speeds and temperatures.

Use a good brand of oil that has an API Service Spec of "CC" or better.

Use the following chart to select the proper viscosity of oil for your Westerbeke engine.

| Ambient Temperature | Viscosity       |
|---------------------|-----------------|
| Above 80° F         | SAE 30 or 10-30 |
| 30 - 80° F          | SAE 20 or 10-30 |
| Below 30° F         | SAE 10 or 10-30 |



## ENGINE OVERHAUL

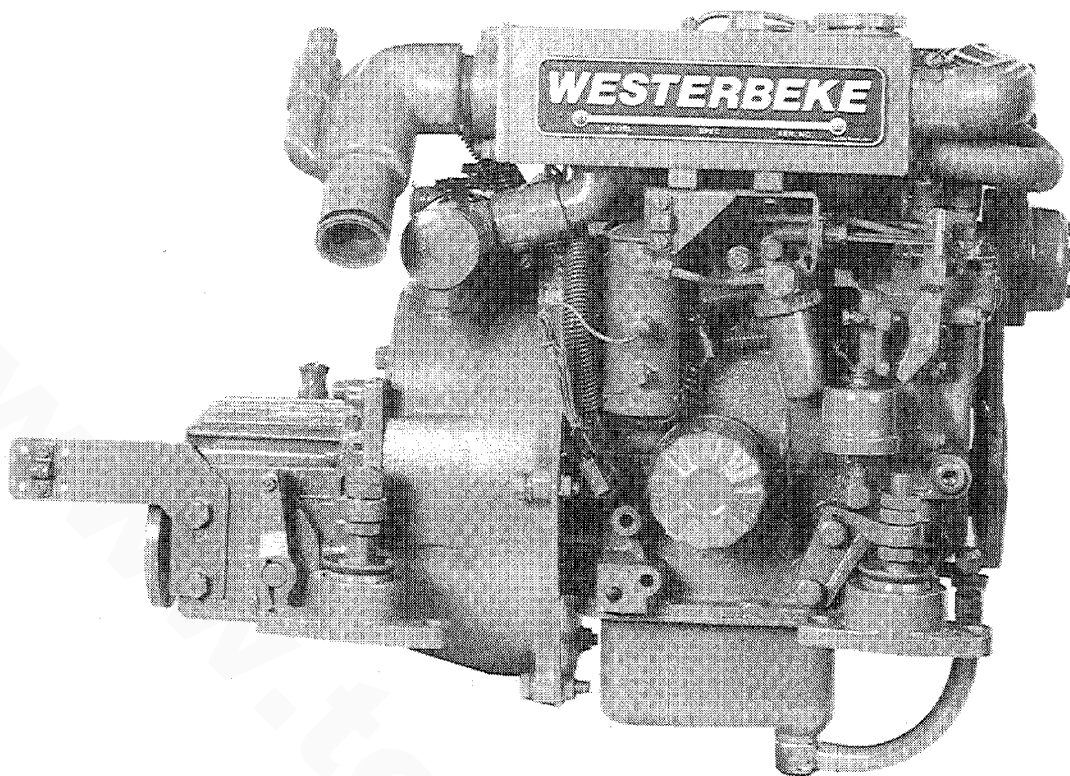
The following sections contain detailed information relating to the proper operation characteristics of the major components and systems of the engine. Included are disassembly, rework and reassembly instructions for the guidance of suitably equipped and staffed marine engine service and rebuilding facilities.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

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

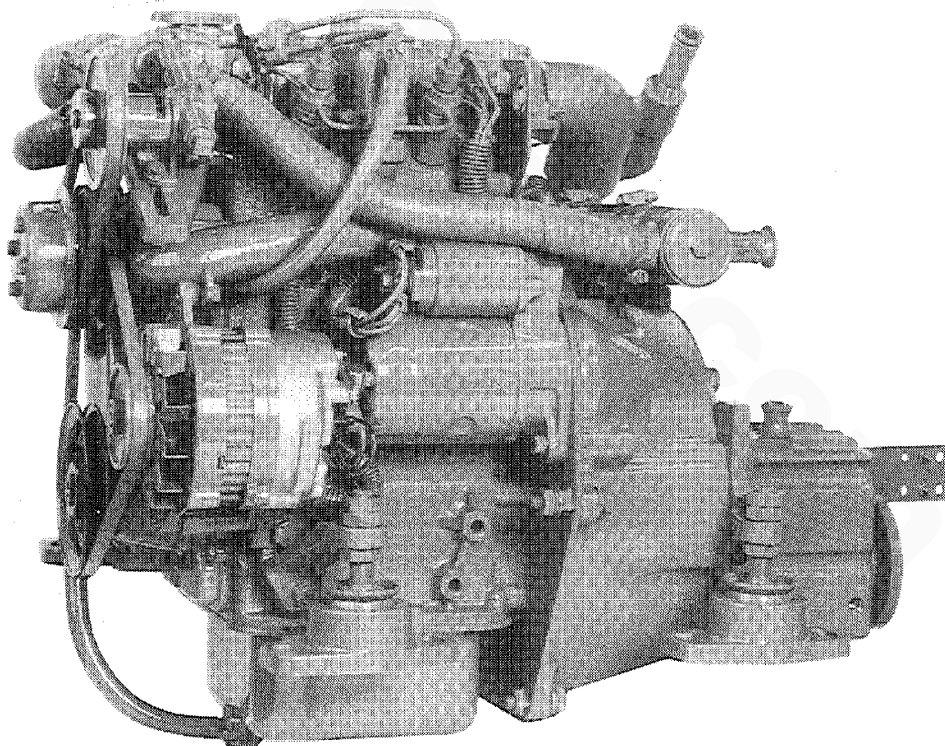
Any replacements should be made only with genuine Westerbeke parts.

|                             |    |
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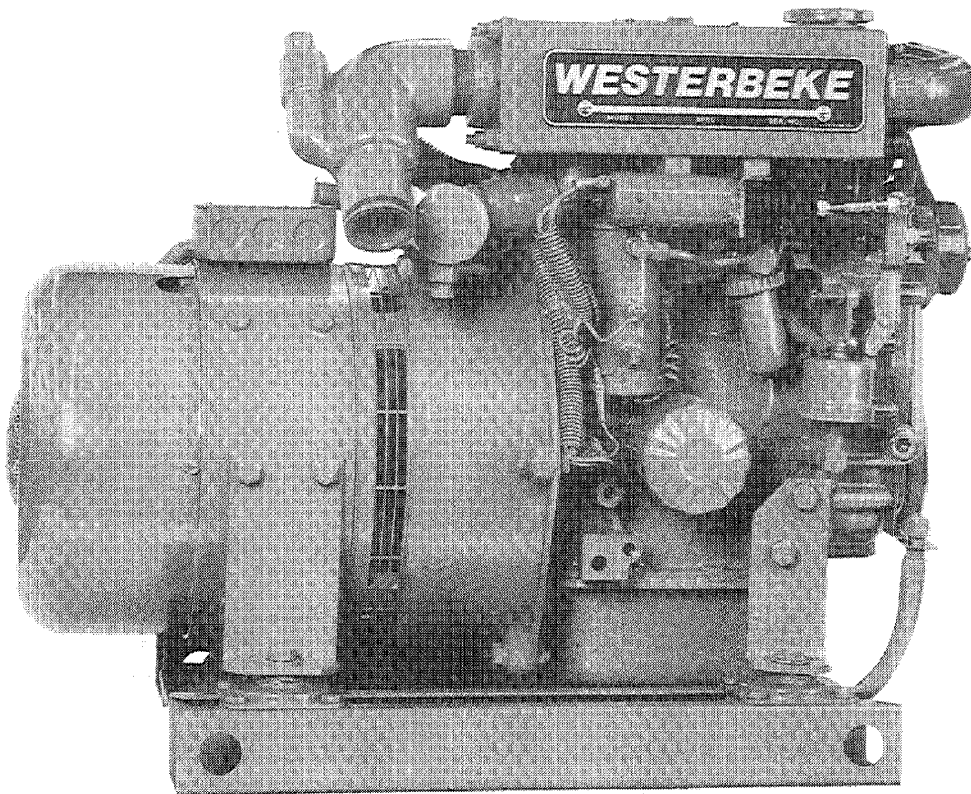
[www.torresen.com](http://www.torresen.com)



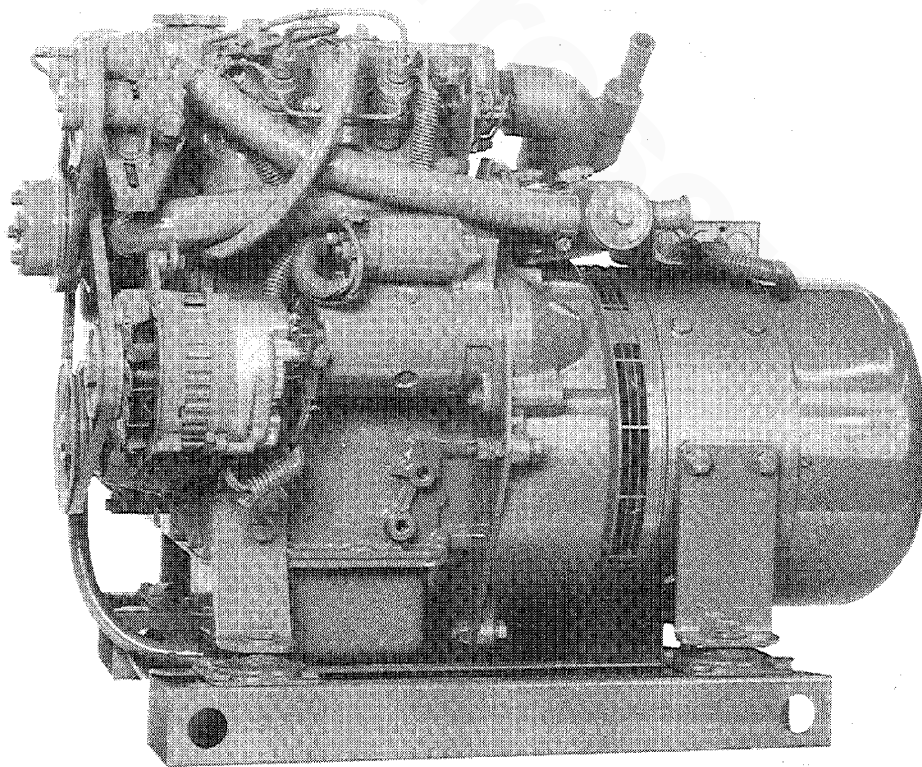
Right Side



Left Side



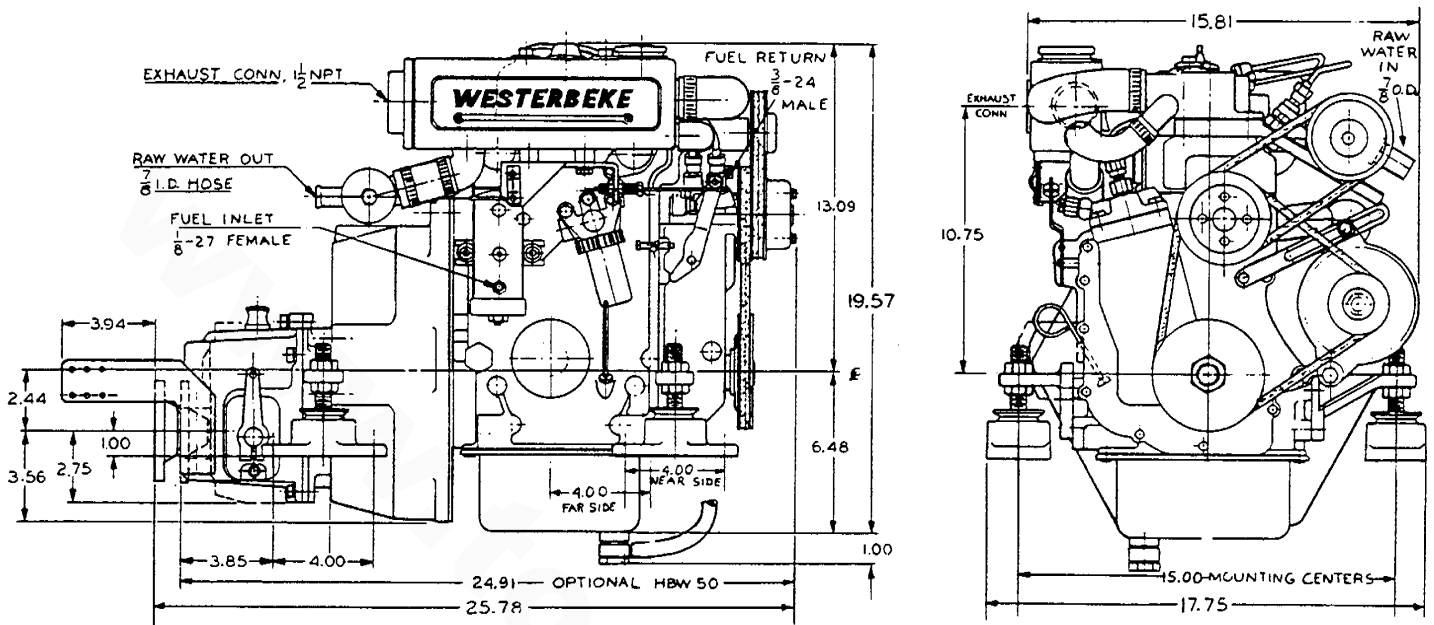
Right Side



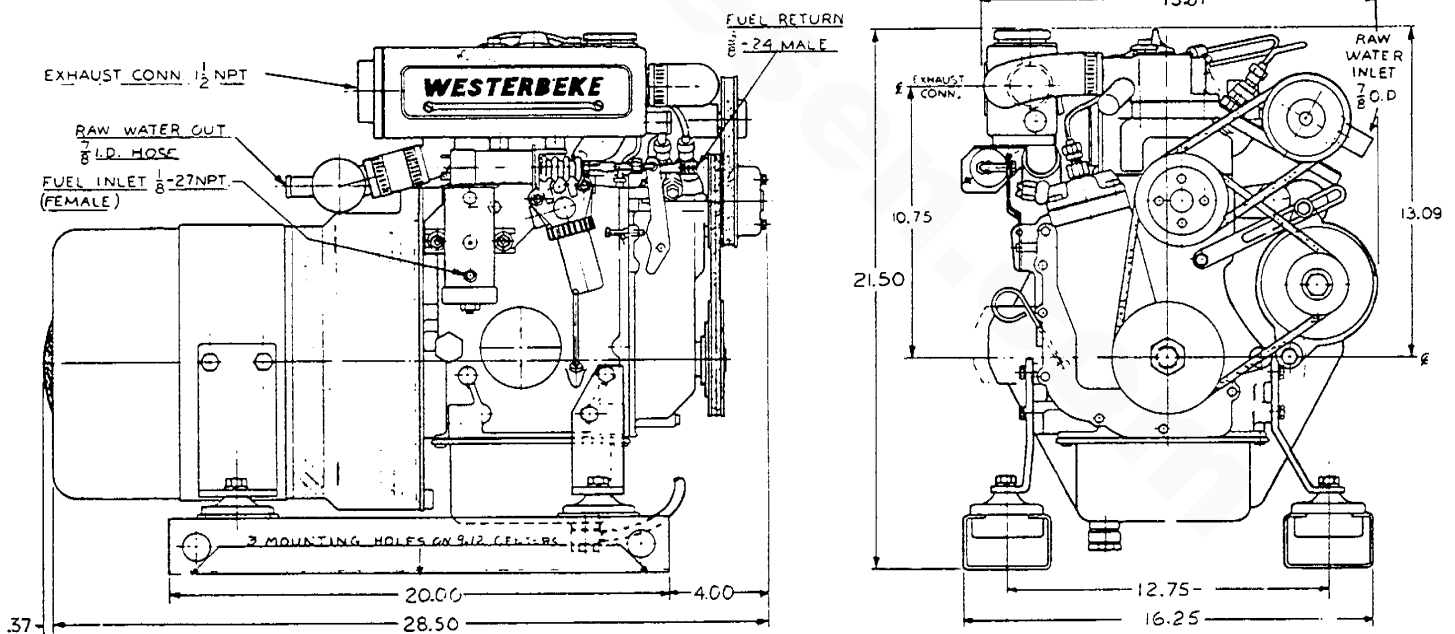
Left Side

DIMENSIONAL DRAWINGS

Westerbeke 10Two & 12B-Two



2.4 KW & 3 KW GENERATOR



Dimensions are subject to change.

## ENGINE NUMBER

1. The engine serial number is stamped on the I.D. plate attached to the exhaust manifold.
2. The engine serial number is stamped as shown below.

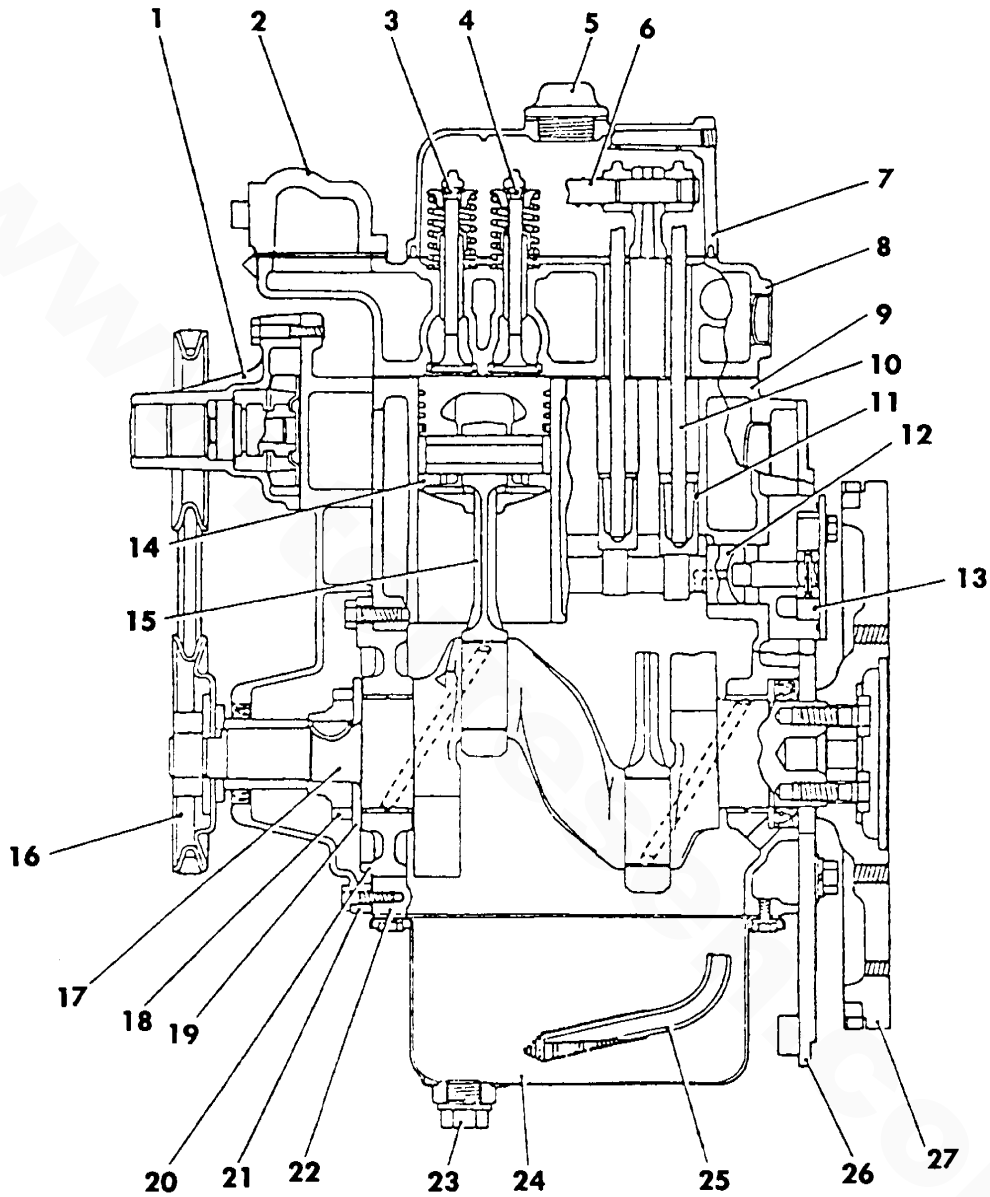
Engine number 1001 - C000

The engine block serial number will also be found stamped in the block on a flange just below the number two injector.

The generator serial number is found stamped in the outside housing of the generator on the left side when viewed from the front of the engine.

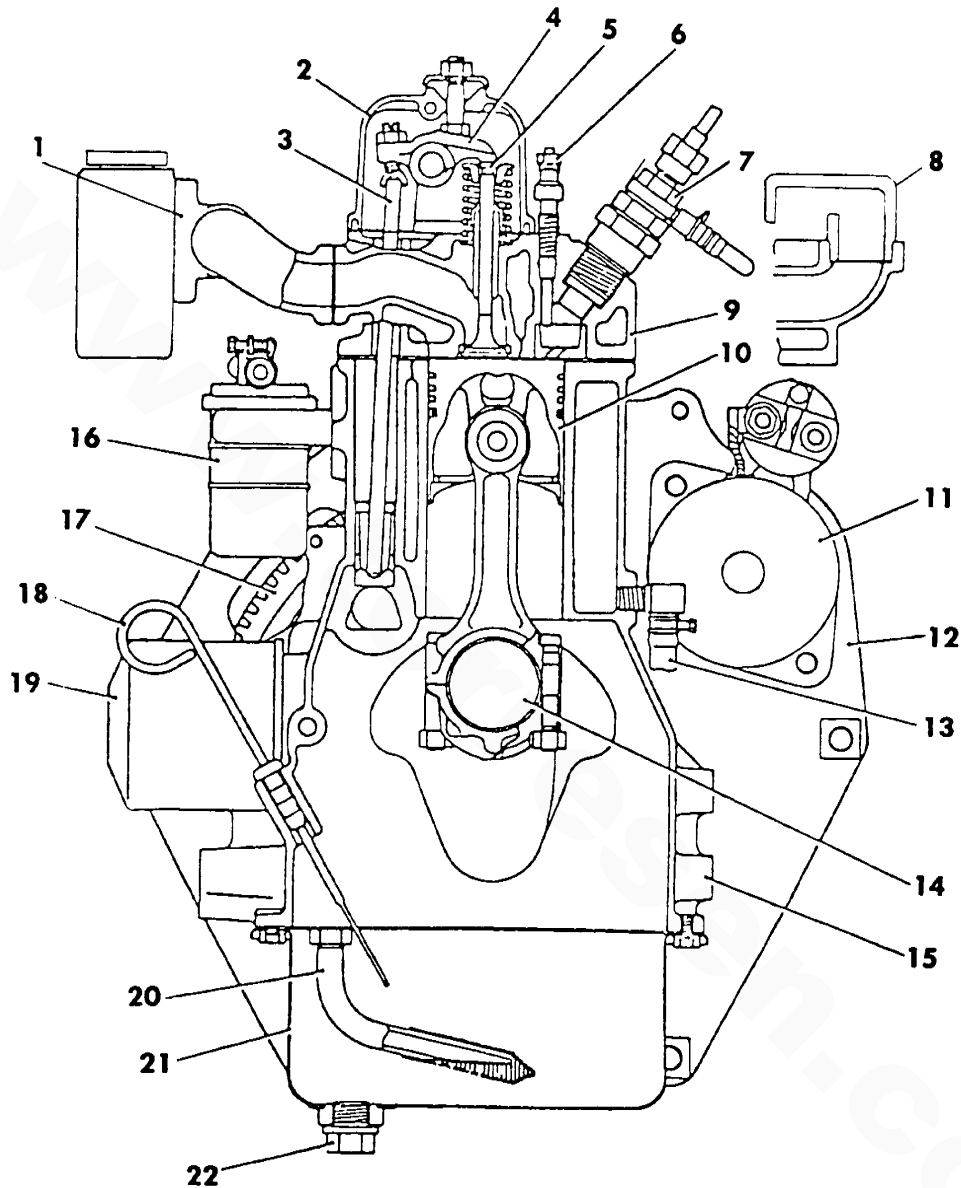
SECTIONAL VIEWS OF ENGINE

1. Longitudinal cross section



- |                      |                       |                           |
|----------------------|-----------------------|---------------------------|
| 1. Fresh water pump  | 10. Push rod          | 19. Crankshaft plate      |
| 2. Water outlet fit. | 11. Tappet            | 20. Front bearing housing |
| 3. Exhaust valve     | 12. Camshaft          | 21. Gear case             |
| 4. Intake valve      | 13. Oil pump          | 22. Oil drain plug        |
| 5. Oil filler cap    | 14. Piston            | 23. Oil pan               |
| 6. Rocker arm shaft  | 15. Connecting rod    | 24. Oil screen            |
| 7. Rocker cover      | 16. Crankshaft pulley | 25. Rear plate            |
| 8. Cylinder head     | 17. Crankshaft        | 26. Flywheel              |
| 9. Cylinder block    | 18. Crankshaft gear   |                           |

2. Lateral cross section



- |                     |                      |                     |
|---------------------|----------------------|---------------------|
| 1. Exhaust manifold | 9. Cylinder head     | 16. Fuel filter     |
| 2. Rocker cover     | 10. Piston           | 17. Ring gear       |
| 3. Push rod         | 11. Starter          | 18. Oil level gauge |
| 4. Rocker arm       | 12. Rear plate       | 19. Oil filter      |
| 5. Exhaust valve    | 13. Water drain hose | 20. Oil screen      |
| 6. Glow plug        | 14. Crankshaft       | 21. Oil pan         |
| 7. Nozzle holder    | 15. Cylinder block   | 22. Oil drain plug  |
| 8. Intake pipe      |                      |                     |



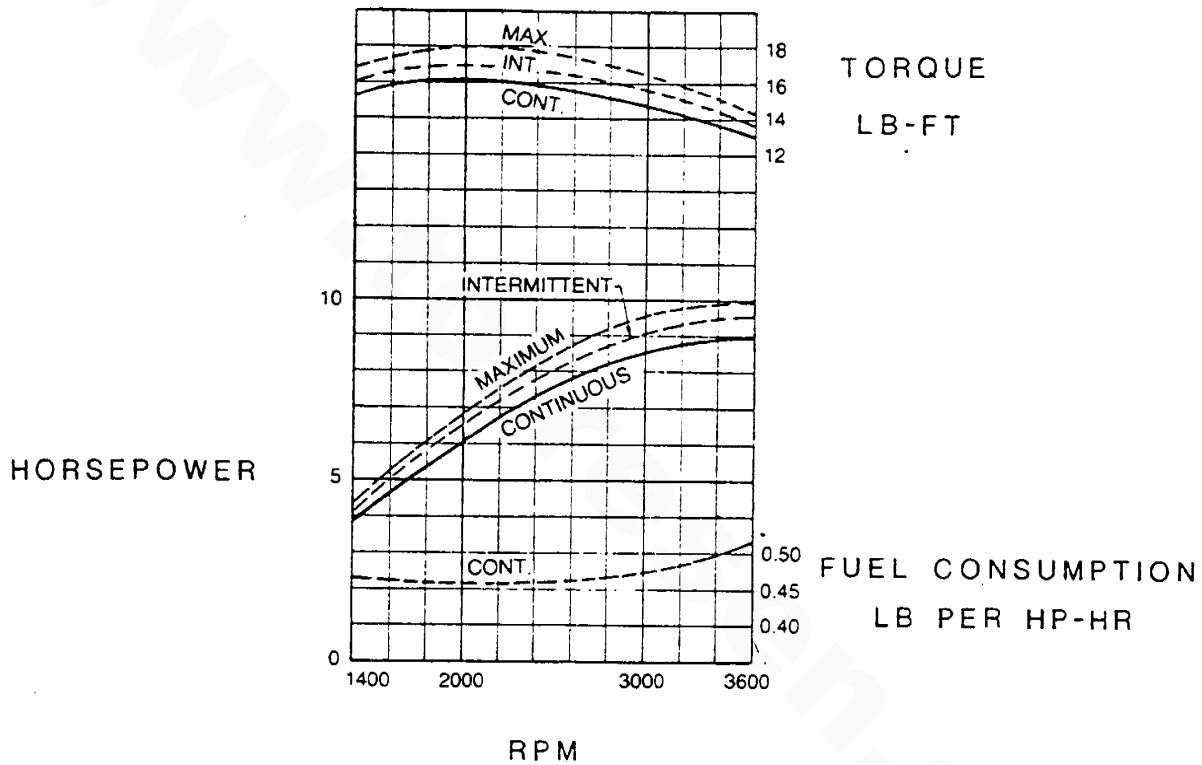
GENERAL SPECIFICATIONS

|   |  |
|---|--|
| Type                                    | Vertical, 4 cycle, OH, water cooled.                                     |
| Combustion Chamber                      | Swirl type chamber   |
| Number of Cylinders                     | 2  |
| Bore x stroke                           | 65 mm (2.56 in.) x 68 mm (2.68 in.)                                      |
| Total Displacement                      | 451 cc (27.52 ci)  |
| Compression Ratio                       | 25:1   |
| Firing Order                            | 1 - 2  |
| Engine Performance                      | 9.5 HP at 3000 RPM - 10 Two Model<br>12.0 HP at 3600 RPM - 12B-Two Model |
| Dry Weight                              |  |
| Propulsion                              | 205 Pounds   |
| Generator                               | 308 Pounds   |
| Fuel                                    | #2 Diesel Fuel   |
| Fuel Injection Pump                     | Bosch M. Type  |
| Governor                                | Centrifugal weight type  |
| Nozzle                                  | Throttle type  |
| Fuel Injection Pressure                 | 160 kg/cm <sup>2</sup>   |
| Lubrication System                      | Forced Lubrication (trochoid pump)                                       |
| Oil Pump                                | Trochoid Type  |
| Engine Oil Capacity Limit (upper-lower) | 2.8 liters - 1.8 liters  |
| Cooling Water Capacity                  | Approx. 1.6 liters (in engine proper)                                    |
| Starter                                 | Solenoid operated, overrunning clutch cranking type. 12V - 0.9 KW        |
| Alternator                              | 12 Volt - 35 amp   |
| Glow Plug                               | Sheathed plug (quick heat type)  |

PERFORMANCE CURVES

This performance shows the values under standard ambient conditions (atmospheric pressure 760 mmHg, temperature 20° C, humidity 65%).

**10 Two and 12B-Two Propulsion Engine**



**WMD 3 KW Generator Model 60 Hertz  
WMD 2.4 KW Generator Model 50 Hertz**

| Electrical Characteristics |         |         | Ratings |       |      |      | Deratings |                                       | Engine | Start  |
|----------------------------|---------|---------|---------|-------|------|------|-----------|---------------------------------------|--------|--------|
| Model                      | Volts   | Amps    | Hertz   | Phase | Wire | P.F. | KW        |                                       | RPM    |        |
| 3.0-612                    | 120     | 25      | 60      | 1     | 2    | 1.0  | 3.0       | 3.5% each 1000 ft. above sea level.   | 1800   | Remote |
| 3.0-613                    | 120/240 | 25/12.5 | 60      | 1     | 3    | 1.0  | 3.0       | 1% for each 10° F above 85°F ambient. | 1800   | Remote |
| 2.4-512                    | 220     | 10      | 50      | 1     | 2    | 1.0  | 2.4       | 10% for continuous duty.              | 1500   | Remote |

Troubleshooting

Causes and remedies for general engine trouble are listed as follows.

| SYMPTOMS & PROBABLE CAUSE                     | REMEDY   |
|---|--|
| <b>Hard Starting</b>                          |  |
| (1) Slow cranking                             |  |
| (a) Viscosity of engine oil high              | Use oil of lower viscosity   |
| (b) Battery discharged                        | Charge battery   |
| (c) Battery is old                            | Replace battery  |
| (d) Poor connection of battery terminal       | Clean terminals and cable connectors   |
| (e) Faulty starter                            | Overhaul or replace starter  |
| (f) Faulty starter Bendix drive               | Check starter amperage draw. Replace or repair starter if necessary                    |
| (2) Injection system trouble                  |  |
| (a) Air in fuel system                        | Allow system to self bleed   |
| (b) Fuel filter clogged                       | Replace fuel filter element  |
| (c) Injector pressure low                     | Adjust injector pressure   |
| (d) Nozzle injection failure                  | Clean or replace nozzle  |
| (e) Lack of pressure from injection pump      | Overhaul or replace injection pump   |
| (f) Injection timing too early                | Check and adjust injection timing<br>Propulsion 25° B.T.D.C.<br>Generator 25° B.T.D.C. |
| (3) Engine                                    |  |
| (a) Lack of compression                       |  |
| 1) Improper valve clearance                   | Adjust valve clearance   |
| 2) Incorrect contact of valve seat            | Lap valves to head   |
| 3) Seizure of valve stem                      | Replace valve and valve guide  |
| 4) Valve spring broken                        | Replace valve spring   |
| 5) Leakage from cylinder head gasket          | Replace gasket   |
| 6) Piston ring sticking                       | Replace piston and piston ring   |
| 7) Worn piston rings and cylinder             | Repair as needed   |
| (b) Glow plug burned                          | Replace glow plug  |
| (c) Insufficient operating time for glow plug | Adjust time per temperature. Check connections and solenoid                            |
| (d) Incorrect setting of throttle lever       | Set to starting position full open   |
| (e) Governor spring out of position           | Correct spring   |

| SYMPTOMS & PROBABLE CAUSES | REMEDY |
|----------------------------|--------|
|----------------------------|--------|

Lack of Power

- |   |   |
|---|---|
| (1) Lack of compression                     | See "Lack of Compression" under "Hard Starting"     |
| (2) Improper adjustment of injection system |   |
| (a) Improper injection timing               | Adjust injection timing                             |
| (b) Injectors misfiring                     | Overhaul or replace injectors                       |
| (c) Low injector pressure                   | Check injector nozzle, and adjust injector pressure |
| (3) Lack of fuel                            |   |
| (a) Air in fuel system                      | Check connections and fuel tank                     |
| (b) Filter clogged                          | Replace filter                                      |
| (c) Fuel tank contaminated                  | Clean tank and replace filters                      |
| (4) Lack of intake air                      | Check air intake for obstruction                    |
| (5) Overheating                             |   |
| (a) Lack of cooling water                   | Replenish water (check for leaks)                   |
| (b) V-belts loosened                        | Adjust or replace                                   |
| (c) Heat exchanger clogged                  | Clean   |
| (d) Improper injection timing               | Correct injection timing                            |
| (e) Lack of engine oil                      | Replenish engine oil (check for leaks)              |

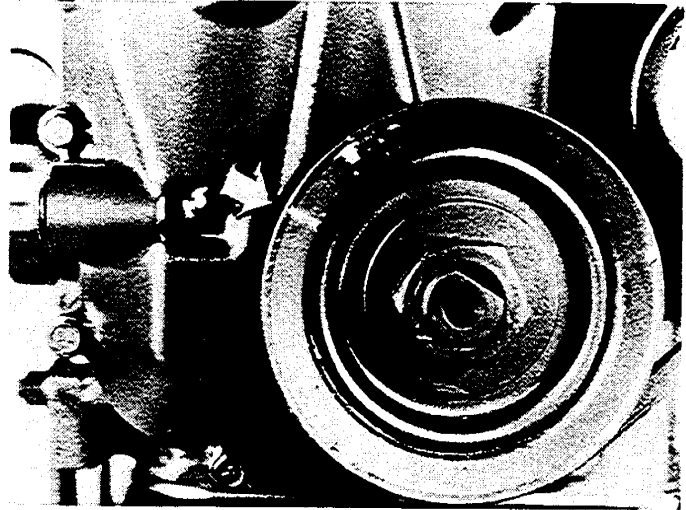
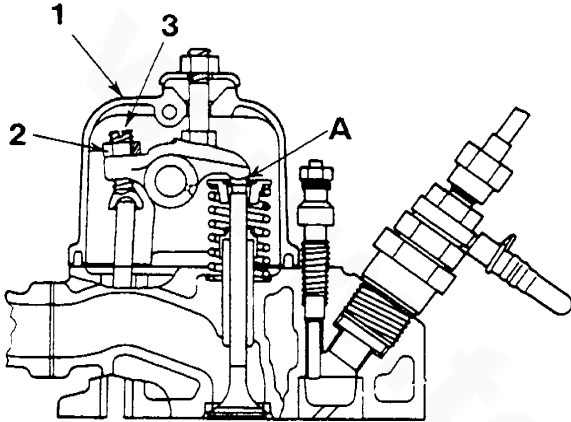
Excessive Oil Consumption

- |   |                                    |
|---|------------------------------------|
| (1) Oil leakage                                 |                                    |
| (a) Faulty oil seals                            | Replace oil seals                  |
| (b) Gear case gasket damaged                    | Replace gasket                     |
| (c) Gear case bolts loosened                    | Tighten bolts                      |
| (d) Drain plug loosened                         | Tighten plug                       |
| (e) Oil pipe connector loosened                 | Tighten connector bolt             |
| (f) Rocker cover gasket damaged                 | Replace gasket                     |
| (g) Rocker cover bolts loosened                 | Tighten bolts                      |
| (2) Oil up                                      |                                    |
| (a) Piston ring end gaps incorrectly positioned | Correct ring positions             |
| (b) Connecting rod tilted or distorted          | Replace connecting rod             |
| (c) Wear of piston ring                         | Replace ring                       |
| (d) Wear of piston and cylinder                 | Replace piston and rebore cylinder |
| (3) Oil down                                    |                                    |
| (a) Faulty stem seal                            | Replace stem seal                  |
| (b) Wear of valve and valve guide               | Replace valve and valve guide      |

| SYMPTOM  | REMEDY   |
|--|--|
| Noise or Abnormal Sound                          |  |
| (1) Crankshaft or main bearing                   |  |
| (a) Excessive wear of bearing                    | Replace bearing and grind crankshaft               |
| (b) Excessive wear of crank-<br>shaft            | Grind to proper undersize                          |
| (c) Bearing melted                               | Replace bearing and check oil line                 |
| (2) Connecting rod and connecting<br>rod bearing |  |
| (a) Wear of connecting rod<br>big end bearing    | Replace bearing and grind crank pin                |
| (b) Wear of crank pin                            | Grind crank pin                                    |
| (c) Connecting rod bent                          | Straighten or replace                              |
| (3) Piston, piston pin and piston<br>ring        |  |
| (a) Wear of cylinder                             | Rebore cylinder to oversize, and<br>replace piston |
| (b) Wear of piston pin                           | Replace piston pin                                 |
| (c) Seizure of piston                            | Replace piston                                     |
| (d) Piston ring worn or<br>damaged               | Replace piston ring                                |
| (4) Valve mechanism and other                    |  |
| (a) Wear of camshaft                             | Replace camshaft                                   |
| (b) Excessive valve clearance                    | Adjust valve clearance                             |
| (c) Wear of timing gear                          | Replace gear                                       |
| (d) Wear of water pump<br>bearing                | Replace bearing                                    |

### ADJUSTMENT OF VALVE CLEARANCE

- (1) Remove the rocker cover #1, loosen the rocker arm lock nut #2, and, while turning the adjusting screw #3, measure and adjust the valve clearance with a thickness gauge between the valve stem and rocker arm position A.

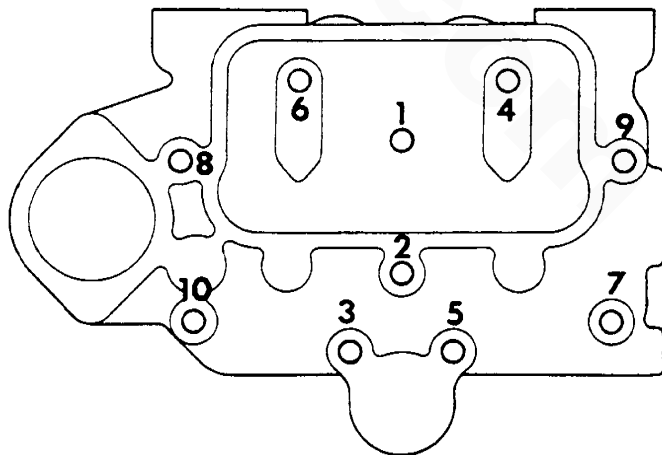


- (2) With the No. 1 cylinder at TDC on compression stroke, adjust the clearance of the intake and exhaust valves of the No. 1 cylinder. Then, with the No. 2 cylinder at TDC on compression stroke, adjust the clearance of the intake and exhaust valves of the No. 2 cylinder.
- (3) To position the No. 1 cylinder for TDC of compression stroke, align the timing mark on the gear case with that on the crankshaft pulley. Position No. 2 cylinder at TDC of its compression stroke by rotating the crankshaft 170°.
- (4) After the adjustment, securely tighten the rocker arm nut while holding the adjusting screw from rotating.

Note: The cylinder head holddown bolts should be torqued before the valve adjustment is made.

Valve Clearance (both intake and exhaust) - engine cold:

0.25mm



CYLINDERHEAD BOLT TIGHTENING TORQUE:

Note: The cylinder head bolts, when being torqued, should be broken free one-quarter to one-half turn, then torqued to the value given and in the proper order as shown.

Tightening Torque:

25.3 - 28.9 lb-ft.

3.5 - 4.0 kg-m.

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## CONSTRUCTION AND SERVICING OF CYLINDER HEAD

### Cylinder Head

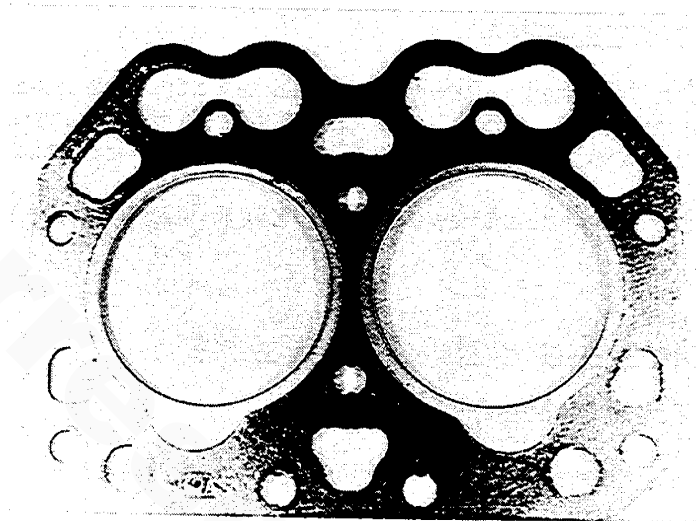
The cylinder head is made of a cast iron and has great rigidity and excellent cooling property. It is of the overhead valve type and the intake port and exhaust port are of cross-flow type, and the valve seats and guides are replaceable.

Swirl chamber and glow plug are provided at the left-hand side of the head to insure complete fuel combustion and better engine starting.

### Cylinder Head Gasket

The cylinder head gasket is made of air-tight and durable material and has stainless steel grommets in the cylinder bore area. The gasket is coated with sealant on both sides except where the cylinder bore periphery is to prevent oil and water leakage; therefore, no gasket sealant is needed during assembling.

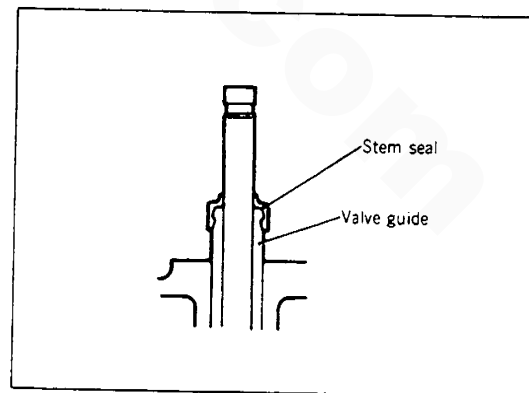
An engine model mark is stamped on the upper side of the gasket (cylinder head side) to help insure proper positioning.



### Valve and Valve Spring

The intake valve has a large diameter head to increase the intake efficiency. Both the intake and exhaust valves are steel and the exhaust valve has a welded special heat-resistant steel head to withstand a higher heat. The upper part of the valve guide is provided with a valve stem seal to prevent oil leakage into the cylinder.

The valve spring is made of a high-rigidity valve spring steel. The spring, spring retainer and retainer lock of the intake valve are identical to those of the exhaust valve.





### Combustion Chamber

The combustion chamber is of a swirl chamber type. The swirl chamber is made of a heat-resisting steel and is pressed into the cylinder head. The swirl chamber should not be disassembled because it is machined with the head after being pressed into the cylinder head.

### Rocker Arms and Rocker Shaft

Rocker arms are made of a special cast iron. Rocker shaft is made of bar steel and the surface is cemented. Oil to the rocker arms and rocker shaft is supplied through the rocker cover oil hole.

### Rocker Cover

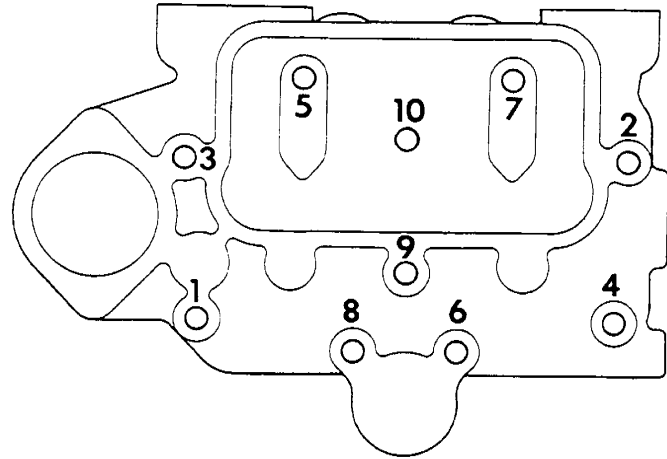
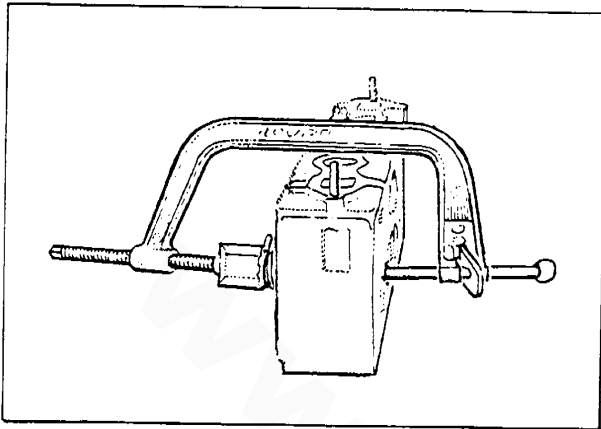
The rocker cover is made of aluminum die-cast and the upper part is provided with an oil passage to supply oil to the rocker section via a supply tube from the front cam bearing.

The cover is also provided with a fill port for engine oil.

### Servicing the Cylinder Head

#### Disassembly

- (a) Remove the exhaust manifold.
- (b) Remove the oil pipe from the cylinder head.
- (c) Remove the fuel return line.
- (d) Remove the fuel injection lines from the injectors.
- (e) Remove the injectors.
- (f) After removing the glow plug lead wire, remove the glow plug.
- (g) Remove the rocker cover.
- (h) After removing the rocker shaft holddown bolts, remove the rocker arms, rocker shaft and rocker support assembly. After removing the rocker assembly, pull out the push rods.
- (i) Loosen and remove the cylinder head bolts in the illustrated order.



(j) Remove the head gasket, etc.

(k) Using a valve spring compressor, compress the valve spring and remove the retainer, spring and valve. Keep the removed valves and related parts in order by each cylinder.

### Inspection

#### CAUTIONS:

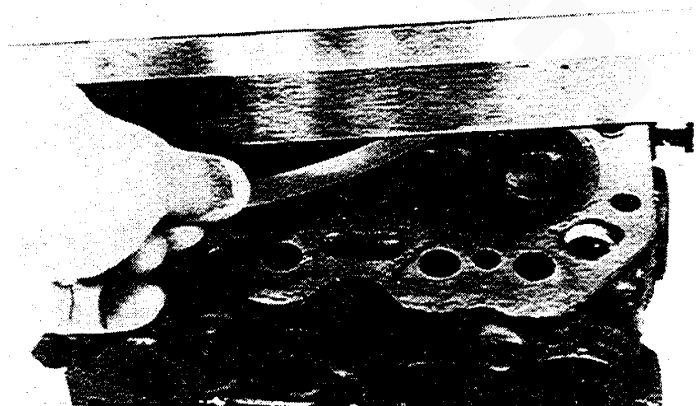
1. Check the cylinder head for visible water leakage or damage before cleaning.
2. Prior to inspection and repair, clean each part carefully and remove oil, scale, carbon and paint.
3. Clean oil holes with compressed air and make sure they are not clogged.

### Cylinder Head

Check the cylinder head for cracks, damage and water leakage before cleaning.

Make sure the oil passage is not clogged.

Check the bottom of the cylinder head for any warpage. Check as illustrated using a straight edge and thickness gauge.

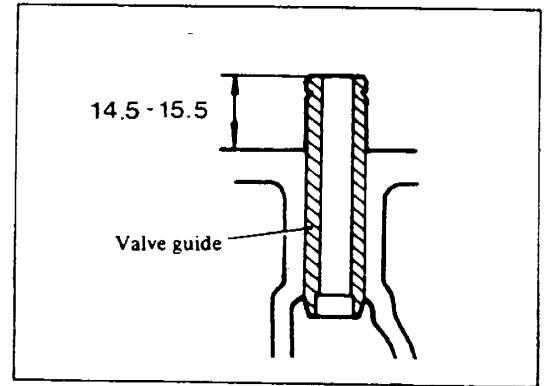


Valve Guide

Check the clearance from valve stem to valve guide and, if it exceeds the service limit, replace the valve guide and valve. When replacing a valve with its stem worn, also replace the valve guide.

To replace the valve guide, use a press and remove the worn guide by pressing it out from the underside of the head out through the top.

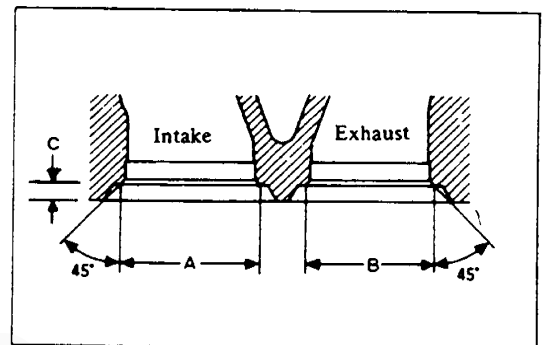
To install a new guide, press it into the cylinder head from the upper side obtaining the illustrated dimension. After installing the valve guide, check the valve stem to guide clearance and, if the clearance is less than the standard value, ream the guide to achieve the desired clearance.



Valve Seat

Check the valve seat for any damage and incorrect contact, and, if defective, correct as illustrated. After correcting, lap the valve and seat with lapping compound.

If the valve seat surface recedes more than the service limit, replace the cylinder head. The receding of the valve seat surface can be checked by measuring the installed height of the valve spring.



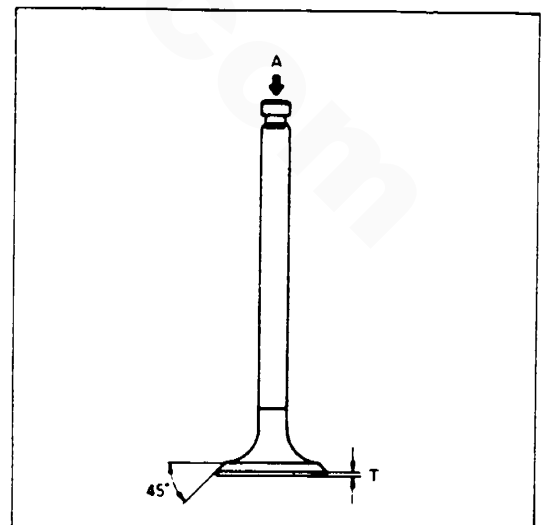
**CAUTION:** Check the valve guide for any wear before correcting the valve seat. If necessary, replace the guide.

| Amm  | Bmm  | Cmm |
|------|------|-----|
| 23.7 | 21.7 | 2.5 |

Valve

If the thickness (T) of the valve head exceeds the service limit, replace the valve.

If the top end (A) of the valve stem (surface in contact with the rocker arm) is worn or dented, repair or replace.

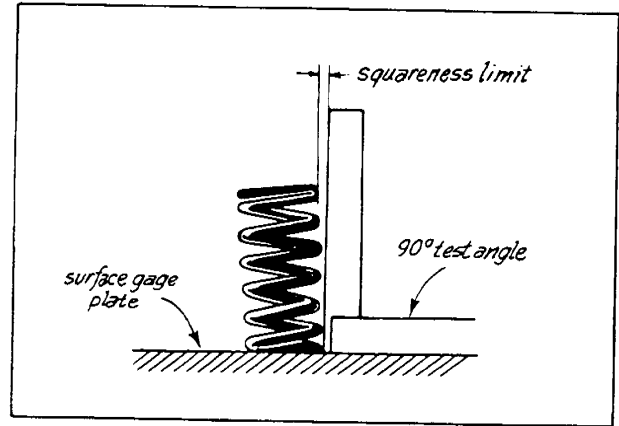
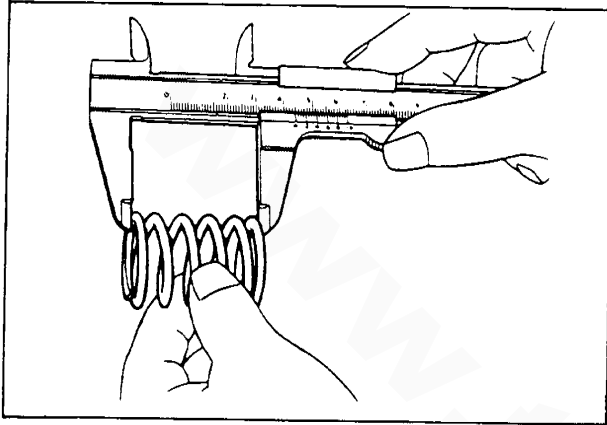


### Valve Spring

Check for cracks and damage.

Measure the free length and load of the spring; if defective, replace.

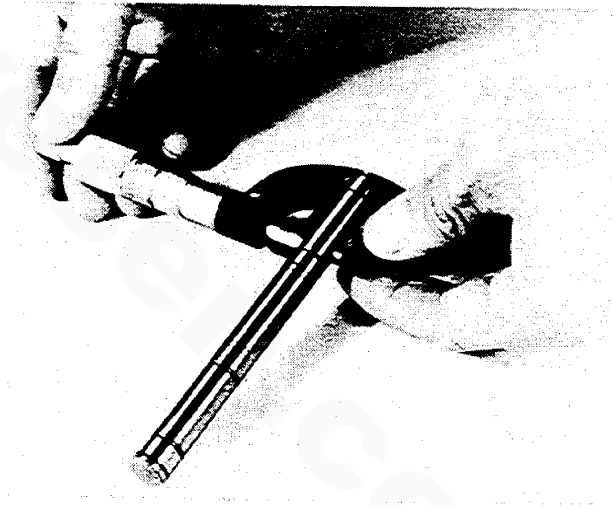
Check the squareness of the spring; if excessively tilted, replace.



### Rocker Arms and Rocker Shaft

If the rocker arm part in contact with the valve is excessively worn or damaged, replace. Also check the adjusting screw, and if the surface in contact with the push rod is excessively worn, replace.

Check the I.D. of the rocker arm bushing and the O.D. of the rocker shaft (rocker arm installation area), and if the clearance is excessive, replace the rocker arm assembly.



### Push Rod

Check the push rod for bending and wear at both ends, and if defective, replace.

### Assembly and Adjustment

#### CAUTION:

1. Clean thoroughly each assembly part prior to assembly.
2. When assembling, apply oil to sliding and rotating parts.

Securely install the valve stem seal into the valve guide.

Note: The valve stem seal is not re-usable.

Coat the valve stem with engine oil and insert it into the valve guide. Then install the retainer with the red-painted end of the valve spring at the retainer side, compress the spring with a spring compressor, and install the retainer lock.

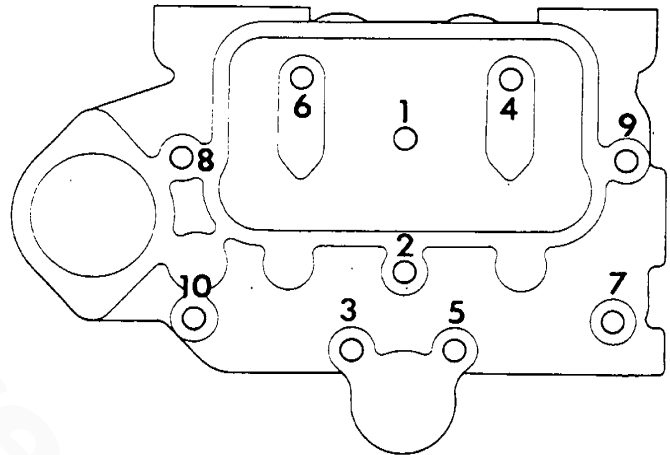
Install the rocker arm, rocker shaft and rocker bracket. When installing, apply engine oil to the bore of the rocker arm bushing.

The cylinder head gasket is coated with sealant and there is no need of applying any additional sealant.

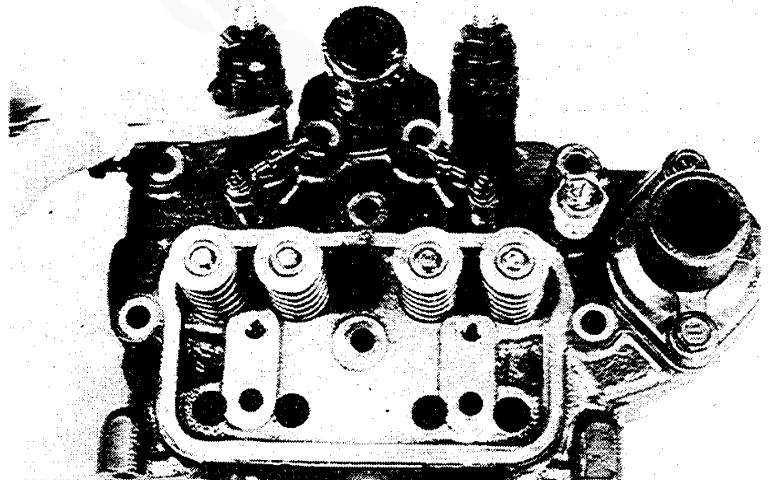
Tighten the cylinder head bolts in the illustrated order to the specified torque.

Install the rocker arm and shaft assembly on the top of the cylinder head, and tighten the bolts to the specified torque.

Install the glow plug and tighten to the specified torque.



Install the nozzle holder gasket, and install and tighten the nozzle holder assembly to the specified torque.

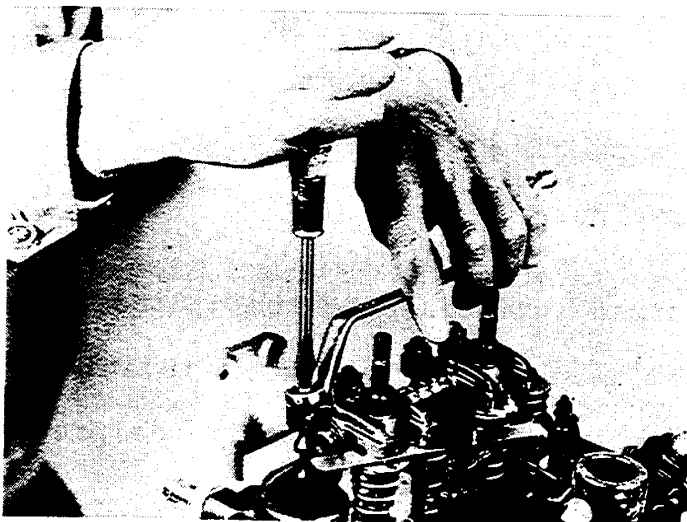


**CAUTION:**

1. Replace the gaskets and washers with new ones, and apply sealant to specified areas.
2. When installing the injectors, do not turn the body side but turn the retaining nut.

Install the glow plug lead wire.

Adjust the valve clearance. With the piston of each cylinder at the top dead center of compression stroke, insert a feeler gauge between the valve stem tip and the rocker arm face and adjust to the specified clearance (cold) by use of the adjusting screw.



## CRANKCASE

### Construction of Crankcase

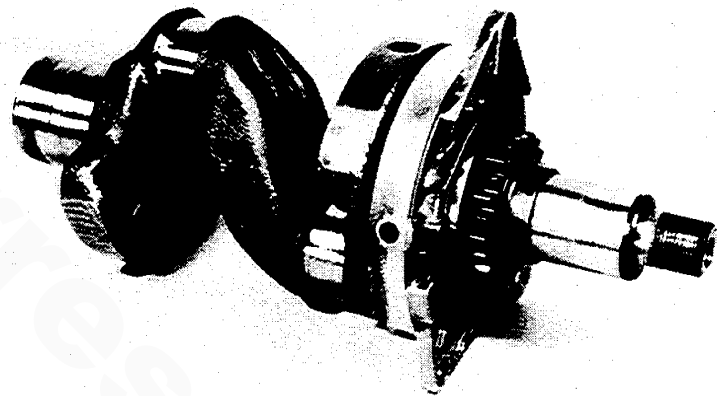
#### Crankcase

The crankcase is of the full-jacket type, made of cast iron alloy and formed integral with the cylinders.

The main bearing is of the bushing type, made of special copper alloy with back metal and is flash-plated. The crankshaft thrust is received and maintained by the front bearing housing.

#### Crankshaft

The crankshaft is a high carbon steel precision forging, and the main bearings and connecting rod journals are induction-hardened to increase the wear resistance. The balancer is formed integral with the crankshaft.



#### Flywheel and Ring Gear

The flywheel is designed to provide a great inertial efficiency and to minimize torque variation. The ring gear is shrink-fitted to the flywheel, and gear teeth are induction-hardened to increase their resistance to wear.

#### Piston, Piston Pin and Piston Ring

The piston is made of special light alloy and is elliptic and tapered (getting smaller upward) to provide the best contact with the cylinder bore.

The piston pin is a hollow, special alloy steel pin and is carburized throughout the surface. The piston pin is pressed into the connecting rod and fixed by use of a special fitting tool.

Each piston is provided with four piston rings, three compression rings and one oil ring. No. 1 ring and oil ring are hard chrome-plated on the surface in contact with the cylinder.

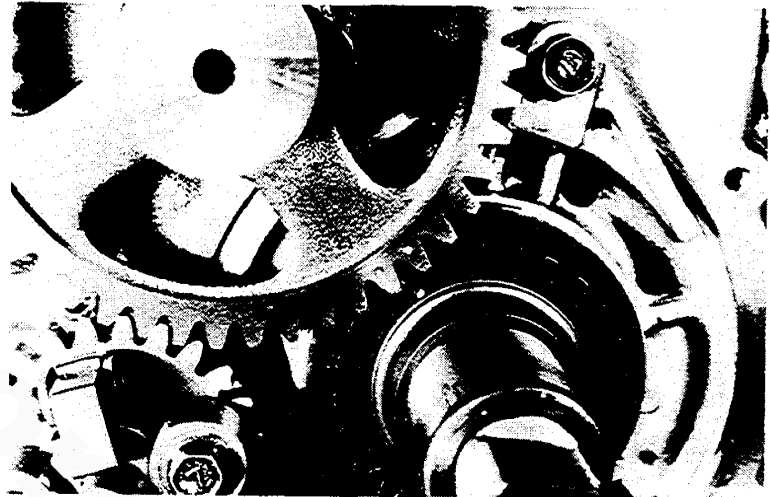
### Connecting Rod

The connecting rod is a high carbon steel forging, and the rod is of I-section and the big end is of horizontally split construction to increase rigidity.

The piston pin is pressed into the small end of the rod. The connecting rod bearing is made of special copper alloy with back metal and is flash-plated.

### Timing Gears

All the timing gears are spur gears. The camshaft gear is driven by the crankshaft gear and the governor gear is driven by the camshaft gear.



### Camshaft

The camshaft is a high carbon steel forging and is formed integral with the cam for the injection pump, and the cam lobes and journals are induction-hardened.

The camshaft is supported in machined holes in the crankcase. The front journal is provided with an oil hole to supply oil intermittently to the cylinder head and rocker arms.

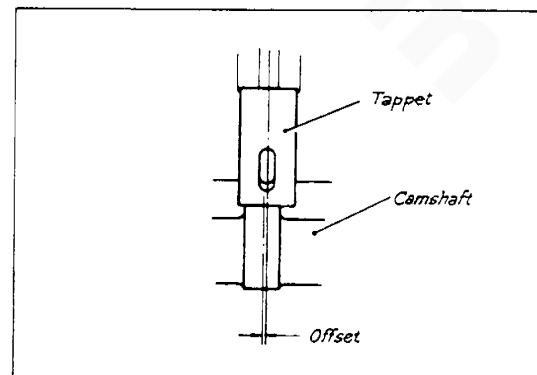
Camshaft thrust is received by the front side of the crankcase and by a surface provided in the timing gear front cover.

The rear end of the camshaft is provided with a slot to drive the oil pump.

### Tappet and Push Rod

The tappet is tubular and is surface-treated on the bottom surface and the rod receiving area. The tappet is installed offset from the cam center and revolves as the cam rotates, thus preventing uneven wear of the bottom of the tappet.

The push rod is made of bar steel and both ends are specially hardened.





### Oil Pan

The oil pan is made of sheet metal and is provided with an oil drain hose attached to the sump oil drain boss.

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## DISASSEMBLY, AND INSPECTION OF CRANKCASE

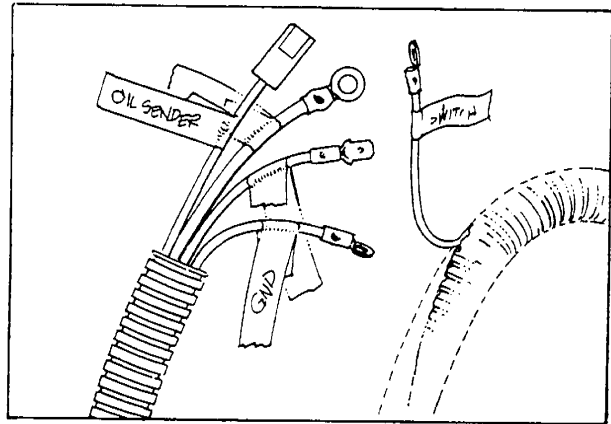
### Electrical System

Remove engine electrical harness complete. Mark leads for proper reassembly.

Remove 35 amp DC alternator and drive belt.

Remove starter motor.

Remove the glow plugs.



### Cooling System

Remove sea water pump, mounting bracket, thermostat housing, thermostat, pump drive belt, hoses and primary heat exchanger.

Remove exhaust manifold with idle stop control (fuel solenoid assembly - generator model).

### Fuel System

Remove electric fuel pump and engine mounted fuel filter assembly.

Remove high pressure liner from injection pump to injectors.

Remove fuel return line from injectors and to injection pump.

Remove injectors and sealing washers.

### Cylinder Head

Remove rear lifting eye and rocker box cover with oil supply line.

Remove rocker arm assembly and push rods.

Remove cylinder head hold down bolts and lift cylinder head from block.

Lift tappets out of block with use of a magnetic pencil.

Remove the oil pan and gasket.

Remove transmission, damper plate and bellhousing (generator - see generator section).

Remove the flywheel and backplate.

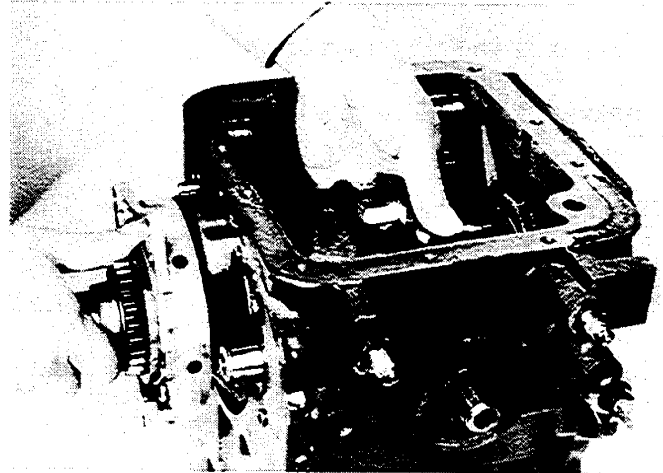
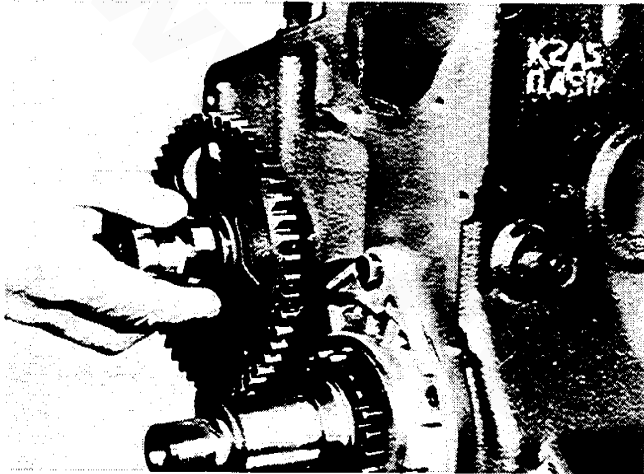
Remove the oil pump.

Loosen the front crankshaft pulley nut, and remove the front pulley.

Remove the front gear case cover and gasket.

After removing the governor weight assembly, remove the snap ring, and then the governor gear.

Draw the camshaft and gear from the crankcase.



Remove the sleeve, crankshaft gear and plate.

Remove the connecting rod caps, and draw the pistons and connecting rod assembly through the top of the block. Keep the rod caps and bearings in order by cylinder so that there will be no mixing. (Mark the rod and cap on one side).

Remove the front bearing housing from the crankcase.

Draw out the crankshaft from the crankcase hole. Be careful not damage the main bearing.

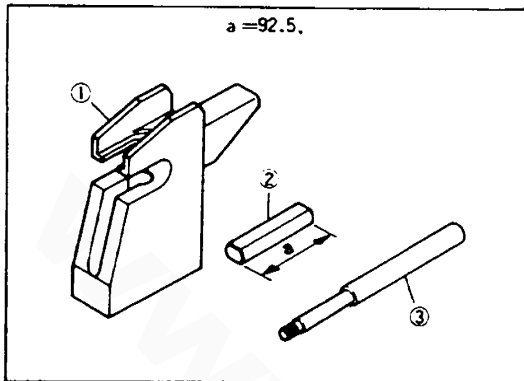
#### Disassembly of Piston and Connecting Rod

Set the piston and connecting rod assembly on the body of a special tool as illustrated, insert the push rod of the tool into the piston pin hole, and remove the piston pin by pressing it out with the aid of a hydraulic press. Do not use the guide of the tool when removing the piston pin.

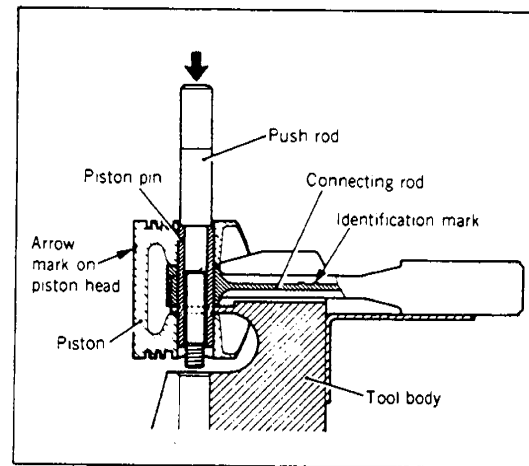
#### CAUTION

1. Be sure to use hydraulic press when removing the piston pin. Do not attempt to hammer it out. If an excessive pulling force is required to remove the piston pin due to adhesion, replace it with a new one. Do not apply the load of more than 3,000 kg (6,600 lbs.) to the pin setting tool.

- When setting the piston and connecting rod on the tool body, be sure that the small end of the connecting rod is placed properly on the receiving area of the tool body.



1. Body
2. Guide
3. Push rod



## Checking

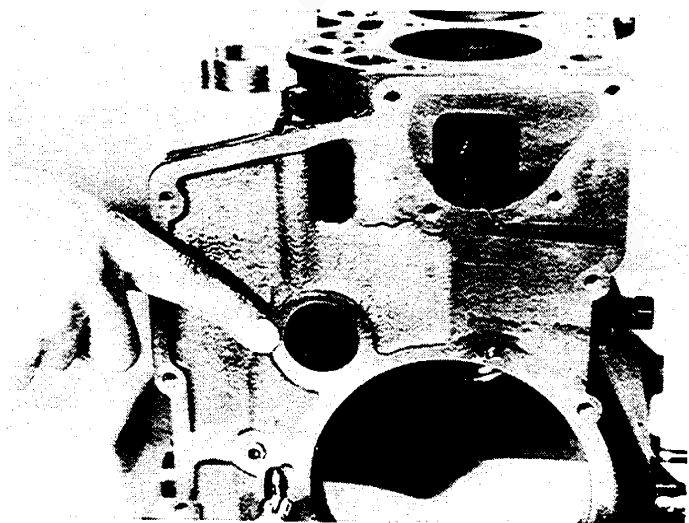
### CAUTION

- Check the crankcase for signs of water leakage, oil leakage and damage before cleaning it.
- Prior to inspection and repair, clean each part and remove the dust, oil, carbon deposits and water scale.
- Clean the oil galleries by applying compressed air and be sure that the holes are not clogged and are clean and unobstructed.

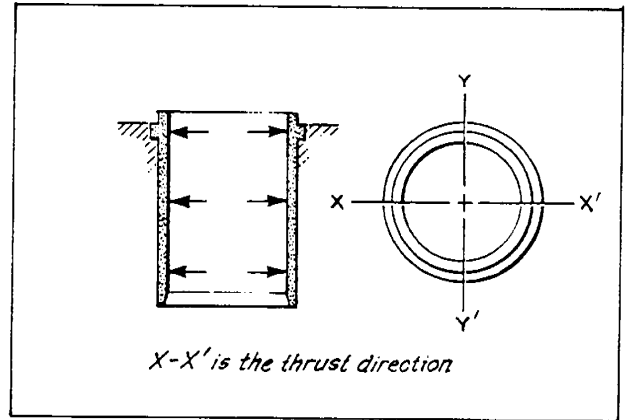
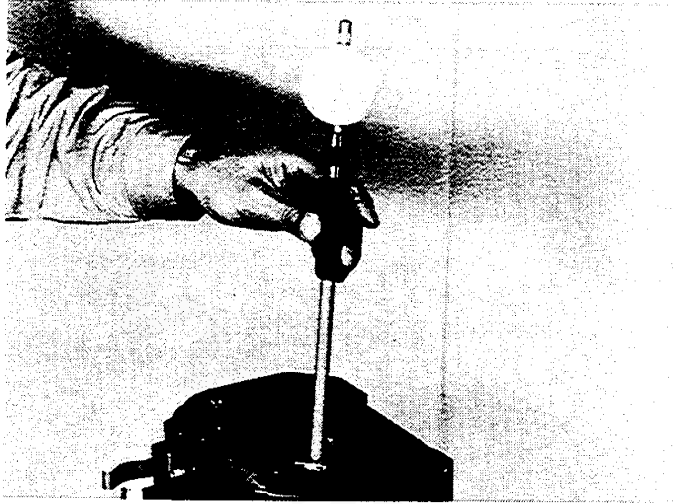
## Crankcase

Check the crankcase for cracks and damage. If defective, replace the crankcase.

Check the water jackets for presence of water scale and rust, and clean as needed.



Using a cylinder gauge, measure the cylinder bore at three different places in X and Y directions, and if necessary, rebore the cylinders to oversize or replace the block if beyond repair.

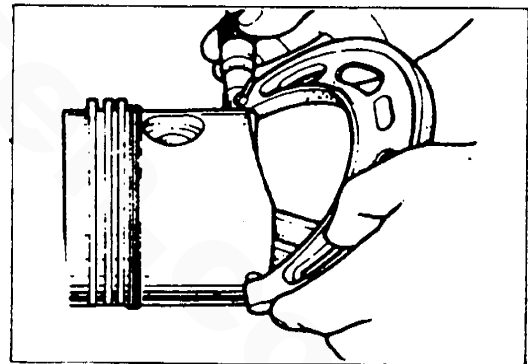


### Piston, Piston Pin and Piston Ring

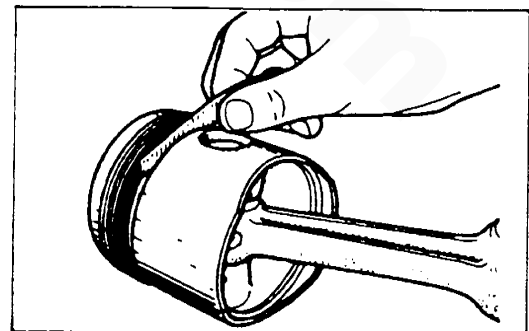
Check the piston for evidence of seizure, streaks and wear, and if defective, replace.

Measure the O.D. of the piston, and if excessive wear is found, replace. If the piston to cylinder wall clearance is excessive, rebore the cylinder to the next oversize or replace the piston. The piston O.D. should be measured at the lower part of the skirt across the thrust faces.

When an oversize piston is used, finish the cylinder bore oversize as well. First, measure the outside diameter of the oversize piston to be used (diameter in the thrust direction at the lower part of the piston skirt), rebore the cylinder so that the clearance between the piston and the cylinder wall will be the value specified in the data section, and finally cross finish by honing.

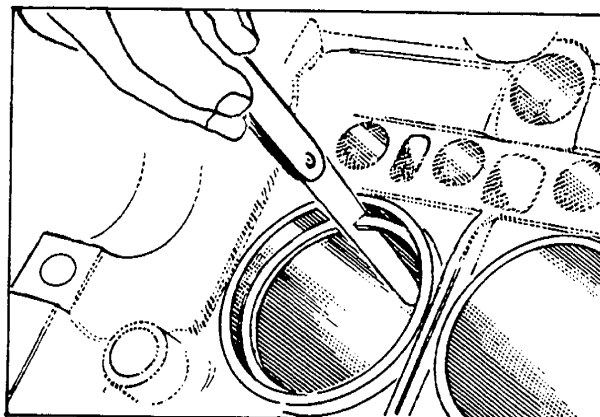
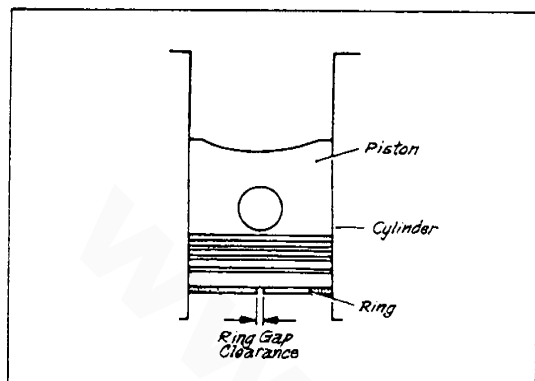


Measure the piston ring side clearance, and if necessary, replace the ring. If the clearance is still excessive with a new ring, replace the piston.



Measure piston ring end gap, and if the end gap is excessive, replace the ring.

To measure, push the ring with a piston into the least worn part (skirt) of the cylinder as illustrated, and measure the end gap using a feeler gauge.

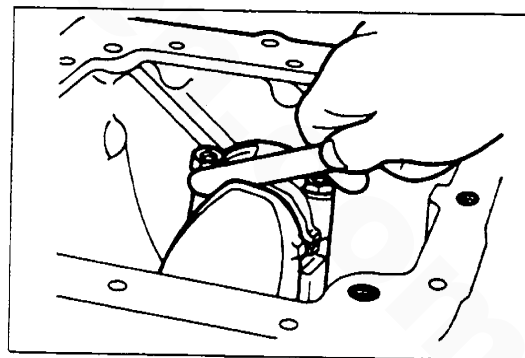
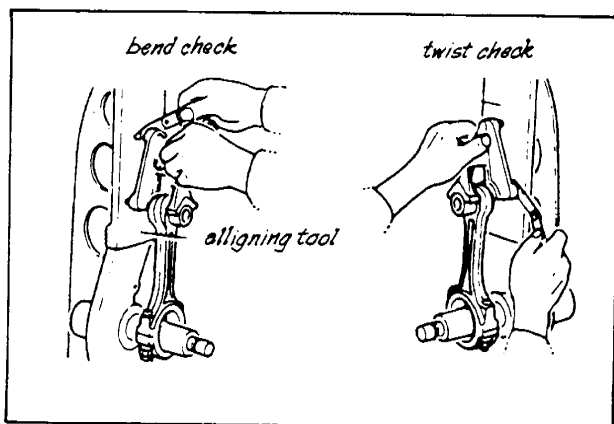


If the clearance between the piston pin and piston or the bore of the small end of the connecting rod is excessive, replace the piston pin assembly or connecting rod assembly.

### Connecting Rod

Using a connecting rod aligner, measure the bend and distortion of the rod, and if excessive bend or distortion is found, repair or replace.

After installing the connecting rod on the crankshaft, measure the thrust clearance, and if the clearance is excessive, replace the rod assembly.

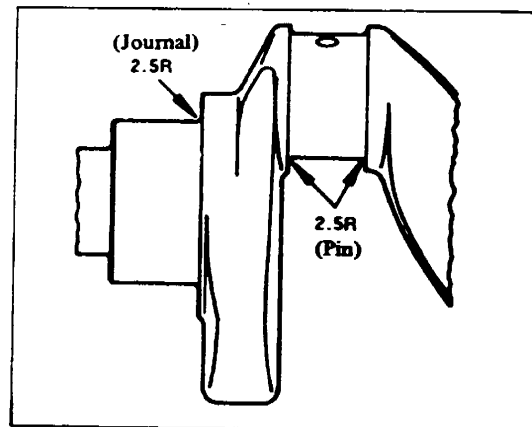


### Crankshaft

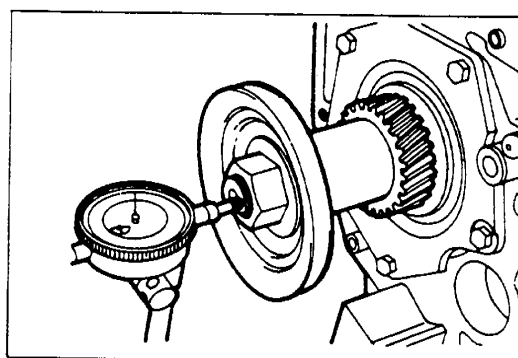
Check the crankshaft journals and pins for damage and seizure. Also measure the crankshaft O.D., and if wear is excessive, finish the crankshaft to the next undersize and replace the main bearing and connecting rod bearing with new parts of the same undersize.

**CAUTION**

Correct the bend before grinding the crankshaft. Finish each fillet to the illustrated R.



Measure the crankshaft end play, and if it exceeds the specified value, replace the front main bearing housing. To measure the end play, install the crankshaft and main bearing housing, install the gear, sleeve and pulley, tighten the nut, and then apply a dial gauge to the end of the crankshaft.



**Main bearing and connecting rod bearing**

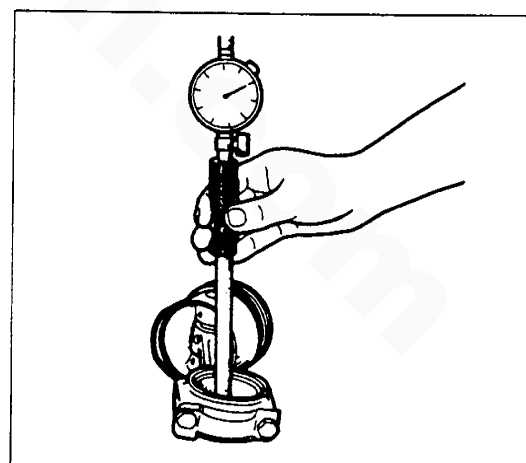
Check the bearing surface for flaking, melting, seizure and incorrect contact, and if defective, replace.

With each main bearing and connecting rod bearing installed in the crankcase, bearing housing and connecting rod, measure the I.D. of the bearings.

Then, measure the O.D. of the crankshaft journals and pins and calculate the oil clearance.

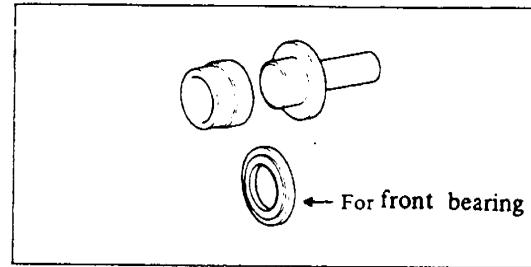
If the oil clearance is not within the specifications, replace the bearing.

If the standard oil clearance is not obtained even with the new bearing, grind the crankshaft undersize and install a bearing of the same undersize.



To replace the main bearing, use the special tool, Bearing Installer, Part Number 33742.

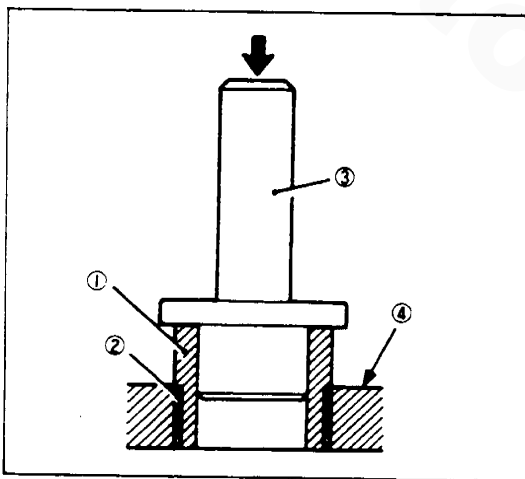
- (1) To remove the main bearing, install the guide ring to the installer body as illustrated. To pull the main bearing out of the bearing housing, push it from the front side to the rear side. To remove the main bearing at the rear of the crankcase, remove the oil seal, and then push the bearing inward from the rear side of the crankcase.



Bearing Installer

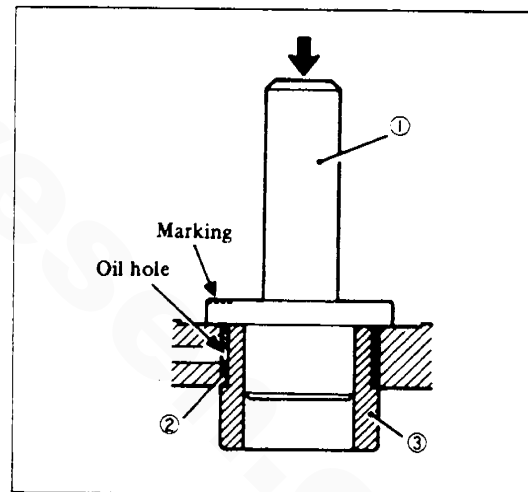
- (2) To install the main bearing, assemble the main bearing installer body and guide ring as illustrated and press in the bearing in the same direction of removal.

Since the front bearing is to be installed 2.5mm inside from the reference surface at the bearing installation side, use the furnished tool adapter ring.



- |                      |   |
|----------------------|---|
| 1. Guide ring        | 4. Bearing housing (front)<br>or crankcase (rear) |
| 2. Main bearing      |   |
| 3. Bearing installer |   |

Removing the Main Bearing



- |                      |               |
|----------------------|---------------|
| 1. Bearing installer | 3. Guide ring |
| 2. Main bearing      |               |

Installing the Main Bearing

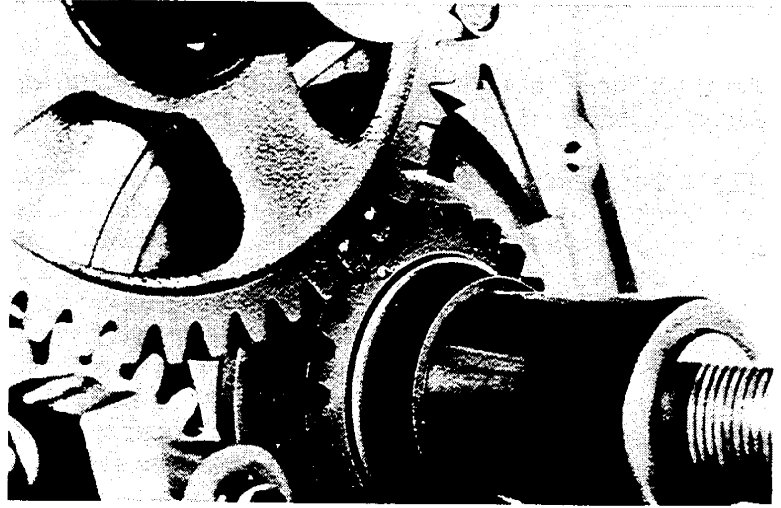
**CAUTION**

1. Install the main bearing so that the oil hole of the bearing aligns with that of the crankcase. Set the oil hole position of the main bearing to the mark line stamped on the collar of the installer body, and then press the bearing in while aligning the oil hole with that of the crankcase. After setting, do not turn the tool or bearing. Be sure that the butting part of the main bearing is in the illustrated position.
2. Before installing the bearing, apply engine oil to the outside surface of the bearing. Be sure to use a press to install the bearing. Install the bearing squarely.



### Timing Gears

Check each gear for incorrect wear and damage, and if defective replace.



### Camshaft

Measure the clearance between the camshaft journals (both front and rear) and the shaft hole in the crankcase, and if the clearance is excessive, replace the camshaft or crankcase.

If the cam face is damaged or the cam lobe is worn in excess of the service limit, replace the camshaft.

Check the slot for driving the oil pump for any wear, and if the wear is excessive, replace.

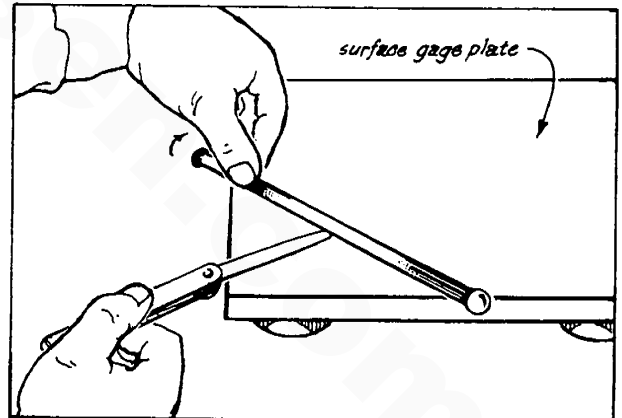
### Tappet

Check the bottom of the tappet (the surface contacting the cam), and replace the tappet if the bottom is excessively cracked, spalled or streaked.

### Push Rod

Replace if the wear at both ends is excessive.

Place the push rod on a surface plate and measure the bend in the center, and if it is excessively bent over the standard value, repair or replace.



## ASSEMBLY AND ADJUSTMENT

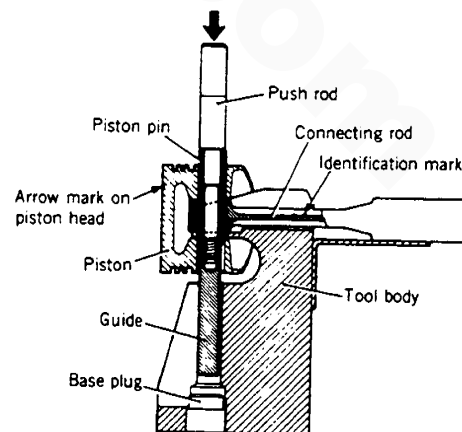
### CAUTION

1. Clean each part thoroughly. Especially clean carefully oil holes, bearings, bearing lower holes and inner wall of cylinders.
2. Be careful not to mix nuts and bolts. Metric and S.A.E. bolts are used on various engine assemblies.
3. During assembly, recheck clearances and insure parts are being assembled in their proper order and facing in the correct direction in relation to the engine block, e.g., pistons, piston rings, bearings and bearing caps.
4. Apply lubricating oil to moving parts during assembly. Insure that moving parts, when assembled on the engine, rotate or slide and are not subject to binding or excessive tension.
5. If there are mating marks scribed during disassembly, reference them correctly for assembly.
6. Use new gaskets, lockwashers, o-rings, etc.
7. Tighten the bolts and nuts on important parts of engine to specified torques using a reliable torque wrench.
8. Use liquid sealants when required on nuts, bolts and gaskets. Refrain from using tape sealants.

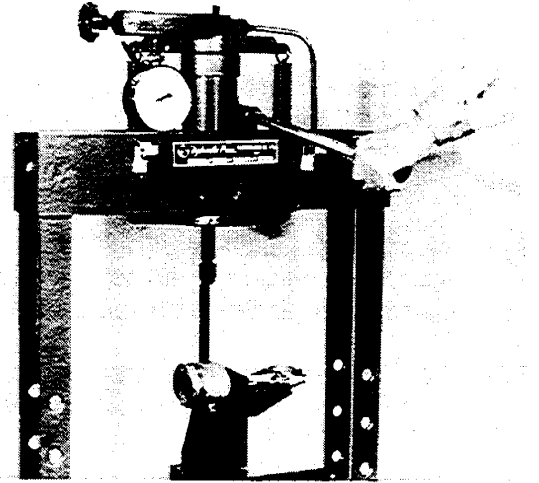
### Assembling of Piston and Connecting Rod

Assemble the piston and connecting rod in the following manner using the special tool Piston Pin Setting Tool, Part Number 33582.

1. Insert the piston pin into the push rod of the tool and screw the guide fully into the push rod.
2. Insert the push rod, piston ring and guide assembled in the preceding paragraph, into the piston pin hole of the piston and further into the small end of the connecting rod. Make sure that the front mark (arrow) on the top of the piston and the identification mark of the connecting rod face in the same direction. Apply engine oil sufficiently to the piston pin surface and inside the small end of the connecting rod.



3. Set the piston, connecting rod and tool assembled in the preceding paragraph, to the tool body. To set, align the notch of the guide with that of the body and insert the assembly into the tool body. Then turn the guide 90 degrees. After setting, be sure that the small end of the connecting rod securely rests on the receiving part of the tool body. Also check that the front mark (arrow) on the top of the piston and the identification mark of the connecting rod are facing upward.
4. With the piston set on a hydraulic press, press the piston pin into the piston. The hydraulic pressure should be between 500 -1500 kg (1100 - 1300 lbs). If the pin requires a greater or lesser pressure, replace the connecting rod or piston and pin assembly. The pin is pressed into a prescribed position by the guide. After the installation is completed, turn the push rod 90 degrees, align the notch of the guide with that of the tool body, and remove the piston and connecting rod assembly from the tool body.



#### CAUTION

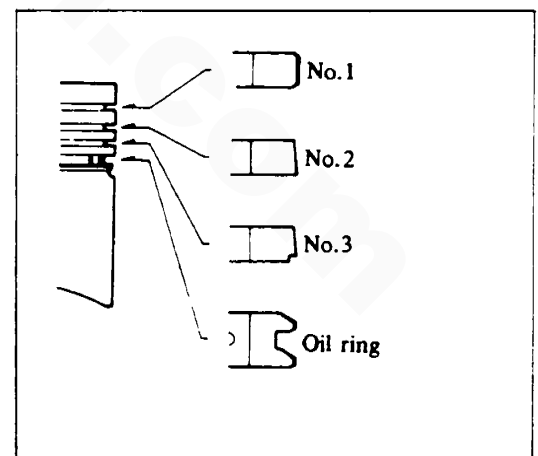
After installing the piston and connecting rod, verify that the piston pin is equally pressed in against the center of the rod. If the pin has been installed unequally, correct it. In such a case, check the tool.

#### Installation of Piston Rings

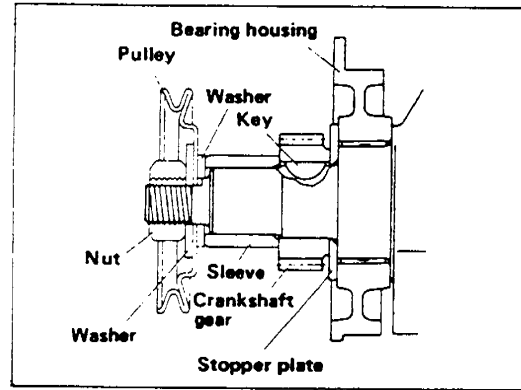
Since piston rings differ in shape from one another, they must be installed as illustrated paying attention to the position and direction. They must be installed so that the manufacturer's mark and size mark face the top of the piston.

Insert the crankshaft into the crankcase. Apply engine oil to the main bearings and journals, and take care not to damage the main bearing.

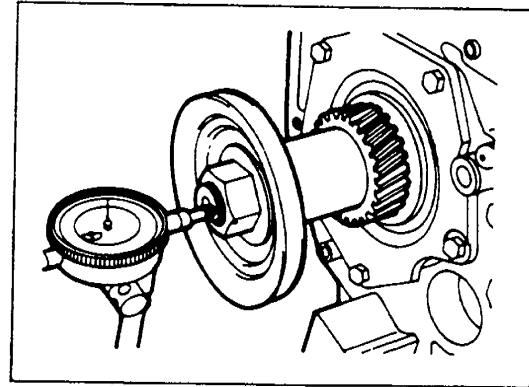
Install the front bearing housing.



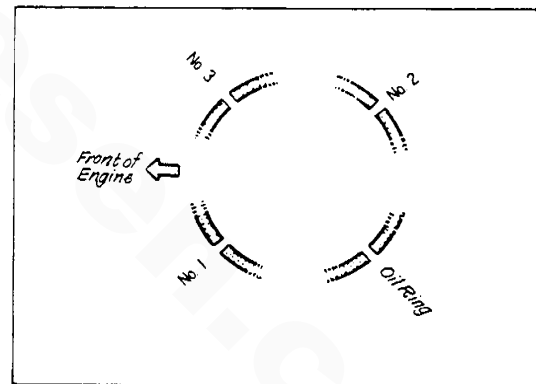
Install the crankshaft plate, crankshaft gear and sleeve. Install the crankshaft plate with the chamfered side directed toward the rear of the engine, crankshaft gear with the stepped side directed toward the front of the engine, and sleeve with the chamfered square end toward the front of the engine.



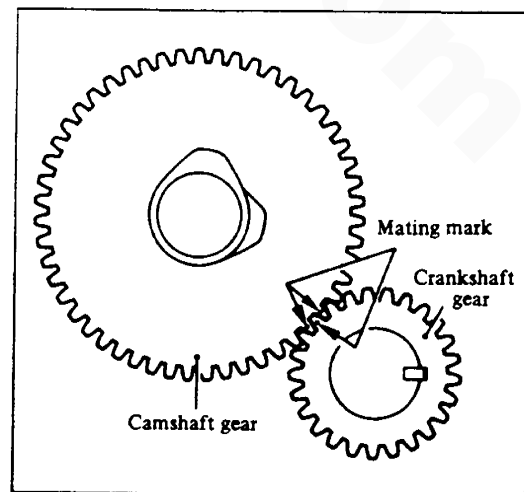
Temporarily install the sleeve stopper, washer and crankshaft pulley, and after tightening the nut, check the crankshaft end play. If the end play is excessively larger than the specified value, recheck the bearing housing. Also verify that the crankshaft gear and sleeve are properly installed. After checking the end play, loosen the nut and remove the pulley and washer.



Insert the piston and connecting rod assembly into the cylinder, install the connecting rod cap, and tighten to the specified torque. Insert the bolts at the connecting rod side and tighten the nuts from the cap side. When inserting the piston, use a piston ring compressor and be sure that the front mark (arrow) on the piston head and the identification mark on the connecting rod are directed toward the front of the engine. Also make sure that each piston ring end gap is not in the direction of thrust of the piston or in line with the piston pin and that the adjacent ring end gaps are at least 90 degrees apart.



Key the camshaft gear to the camshaft and insert the camshaft into the crankcase. Make sure that the mating mark of the crankshaft gear aligns with that of the camshaft gear as illustrated. Apply oil to the bearing surfaces when installing.



Install the governor gear, and install a snap ring onto the shaft. Then install the governor weight assembly and sliding shaft.

Install the gear case (with governor linkage assembled). In this case, attach a gasket coated with a good brand of sealant to the gear case before installation.

Install the crankshaft pulley. Do not forget to install the crankshaft spacer stopper washer and crankshaft pulley washer. (Insure these washers maintain their positions when installing and tightening the front pulley nut.) Torque the front pulley nut to the proper specification.

Install the oil pump assembly.

Install the backplate.

Install the flywheel and tighten the bolts to the specified torque.

Install the oil screen and oil pan.

Insert the tappets.

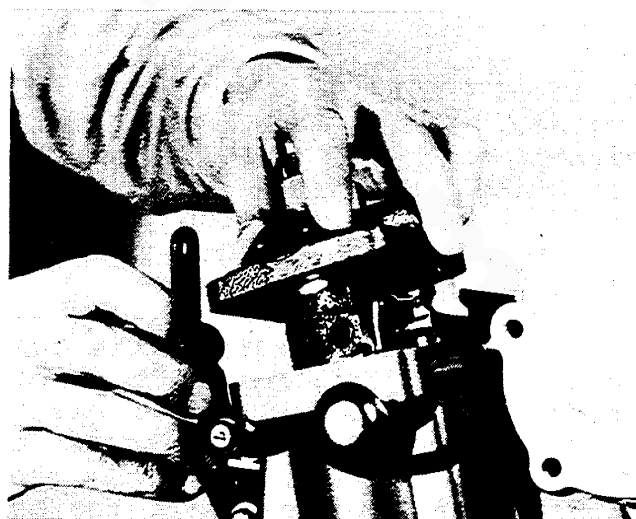
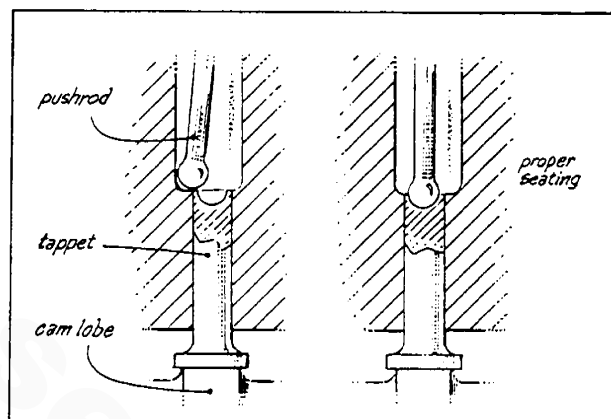
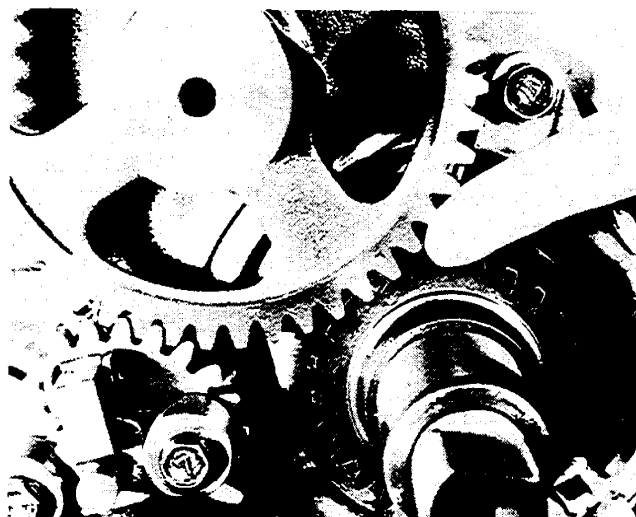
Insert the push rods into the tappet hole center.

Install the cylinder head assembly. (See "Cylinder Head Assembly".)

Install the injection pump assembly and fuel lines. (See "Fuel System".)

Install the oil filter. If the oil pressure switch and oil pressure sender have not been installed yet, apply sealant to their threads and install them. (Use the proper socket for installing the oil pressure switch.)

Install the fuel filter assembly and electric fuel pump.



Install the fresh water pump and drive pulley.

Install the starter and alternator. (See "Electrical System".)

Install the alternator belt. Adjust the tension of the belt by adjusting the alternator.

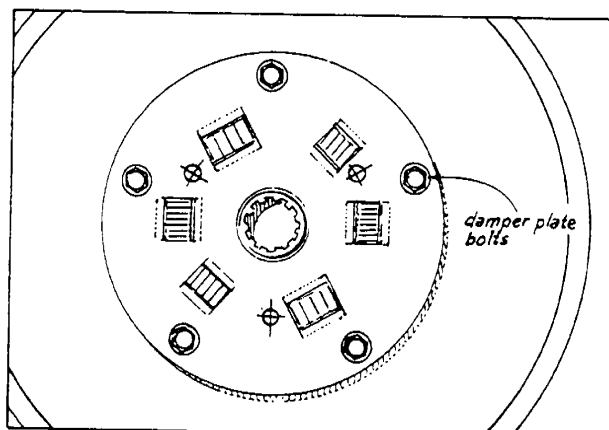
Install the thermostat, housing, sea water pump, bracket and drive belt.

Install the primary heat exchanger, manifold and related hoses.

Attach the idle stop assembly (generator - fuel run solenoid).

Reinstall wiring harness. Insure harness is properly supported and protected from chafing and heat.

Install the damper plate, adapter and transmission. (Generator units: refer to text on generator removal and installation.)

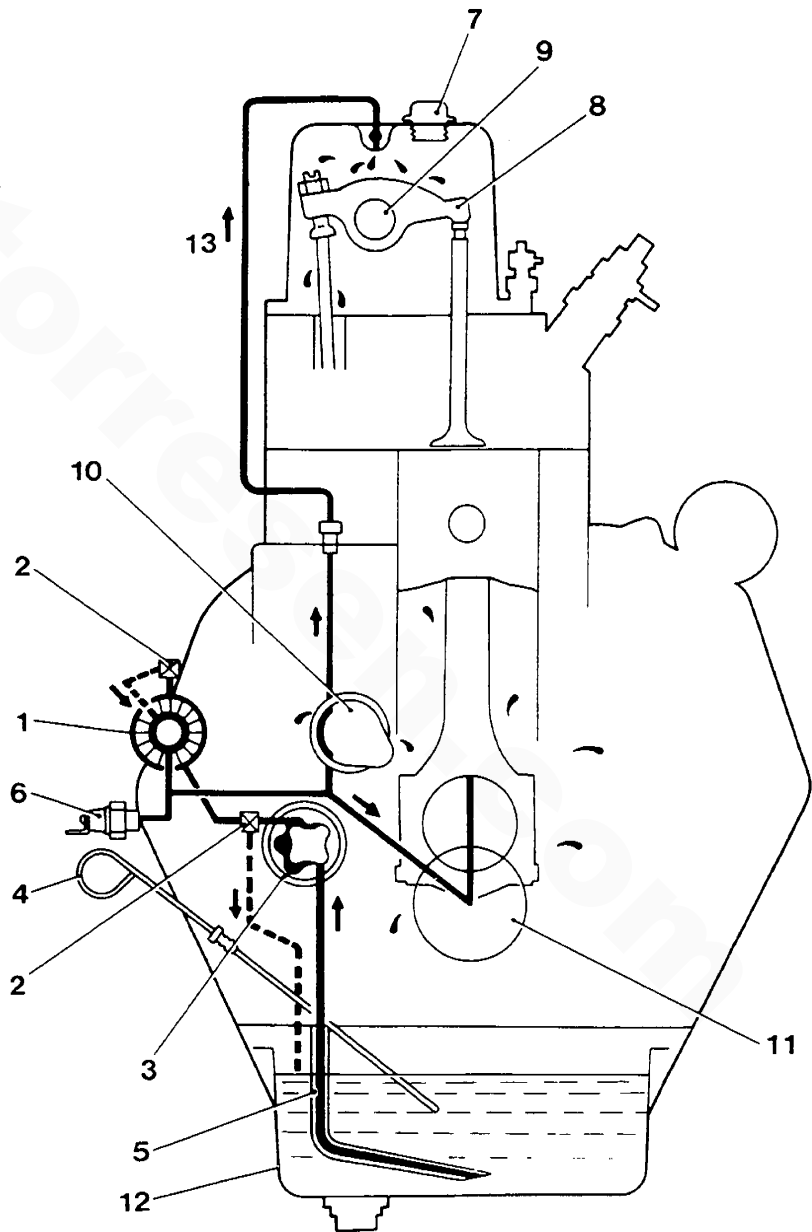


LUBRICATION SYSTEM

General

The lubricating system is of full-force type using a trochoid gear pump with a full-flow oil filter. The oil pump is driven through the Oldham's coupling located at the rear end of the camshaft. The oil from the oil pump is regulated by a check valve, filtered by the cartridge type oil filter and supplied to each part of the engine through oil galleries in the engine block.

- 1. Oil Filter
- 2. Relief Valve
- 3. Oil Pump
- 4. Dipstick
- 5. Pickup Line
- 6. Oil Pressure Switch
- 7. Oil Fill Cap
- 8. Rocker Arm
- 9. Rocker Shaft
- 10. Camshaft
- 11. Crankshaft
- 12. Sump
- 13. Oil Line to Rockers



## Engine Oil

- (1) Engine oil to be used  
Use HD engine oil (heavy-duty oil, API spec of CC), and change the oil every 100 hours of operation (initially at 50 hours).
- (2) Changing of engine oil

To change the engine oil, warm up the engine. Shut it down and then remove the oil drain hose from its support bracket at the front of the engine. Two wrenches are needed to do this one to hold the fitting on the hose and the other to unscrew the securing cap. Lower the hose into a container large enough to hold the oil and allow the sump to drain. A pump may be used to draw the oil out through this hose. When the sump is completely drained, reposition the drain hose on its support bracket and replace the hose cap/plug and tighten securely.

Refill the engine oil sump with the correct amount of oil as specified in the data section of this manual.

NOTE: Check the oil level reading on the oil sump dipstick. Allow a few minutes after adding the new oil for it to settle into the oil sump.

## Oil Filter

The oil filter is an easy-to-handle cartridge type filter with the filter body and element formed integral.

If the element has been contaminated or clogged and the oil pressure difference before and after the element has become more than about 1 kg/cm<sup>2</sup>, the built-in relief valve opens to allow the oil to flow to each part of the engine without passing through the oil filter element. Therefore, it is important to check and change the oil regularly. The filter interior requires no cleaning. The filter must be replaced with a new one every 100 hours of operation (initially at 50 hours).

### Removal and Replacement of Oil Filter

If it is difficult to remove the filter by hand, use a special tool (commercially available) or wrap a V-belt around it.

To install, tighten the oil filter fully by hand.

Tightening torque: 1.1 to 1.3 kg-m

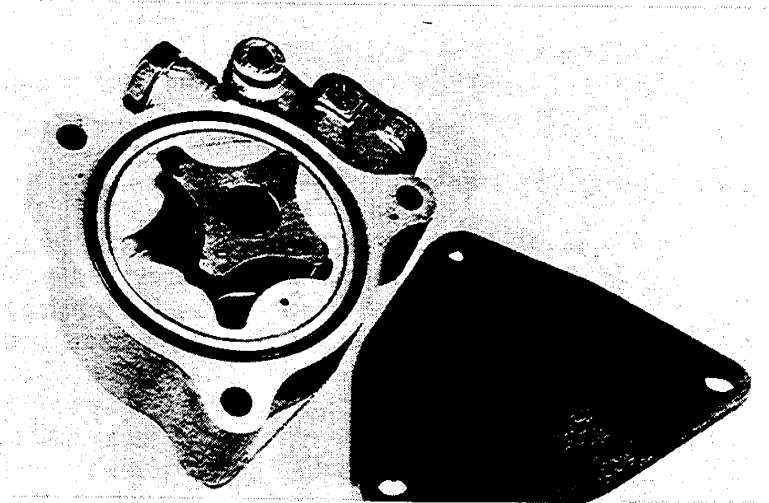
Confirm that the O-ring is properly fitted in the O-ring groove. Apply a thin coat of engine oil to the O-ring. Prior to installing the filter on the engine, run the engine after filling with oil and check for pressure and leaks. Check the oil level after shutting the engine off and add oil to bring the level up to the full mark as needed.



### Oil Pump

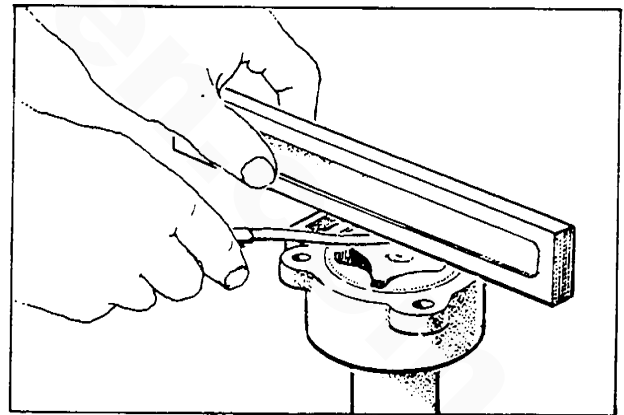
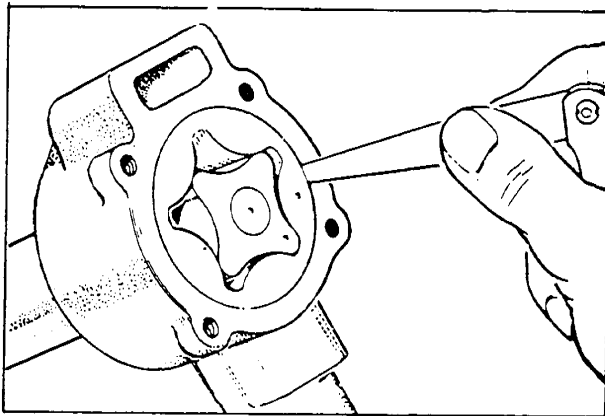
The oil pump is of trochoid type and is mounted at the rear of the crankcase. The oil filter is attached to this oil pump.

The oil pump incorporates a relief valve which, when the delivery pressure becomes more than  $3.5 \text{ kg/cm}^2$ , relieves excess pressure by passing oil back into the oil sump.



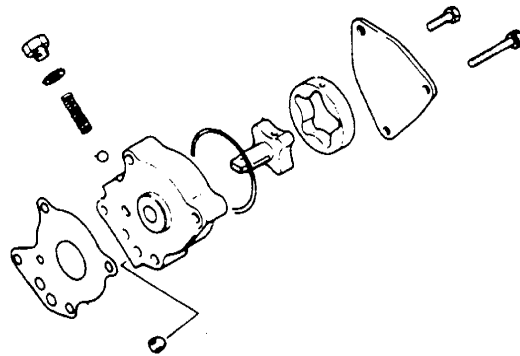
When disassembling and reassembling the oil pump, pay attention to the following items.

- (1) Apply engine oil to the rotating parts before assembling.
- (2) After assembling, check that the pump shaft turns smoothly.
- (3) Measure the clearance between the outer rotor and the pump body using a feeler gauge, and if the clearance is excessive, replace the rotor assembly or the pump body or both.
- (4) Measure the clearance between the outer and inner rotors using a feeler gauge, and if the clearance is excessive, replace the rotor assembly.



- (5) To check the clearance between the rotor and cover, insert the rotor into the pump body and apply a straight edge across the body face. If the clearance does not conform to the standard, replace the rotor assembly or body.

- (6) Assembling the oil pump
- (a) Install the rotor assembly in the oil pump body.
  - (b) Install the oil pump shaft to the crankcase with its lug properly fitted in the slot in the camshaft.
  - (c) Replace the O-ring with a new one and install the pump cover. Apply oil to the O-ring and install it squarely on the O-ring groove.



#### Oil Pressure Switch

The oil pressure switch is located at the rear right side of the crankcase and, when the lubricating system pressure becomes lower than 18 to 23 PSI during normal operation, this switch operates an alarm buzzer. When the alarm sounds, check the oil pressure and water temperature gauges on your instrument panel.

NOTE: The alarm can also be activated by an overheat switch which will activate the alarm should the operating temperature of the engine reach 205° F.

Should the oil pressure be low, stop the engine and investigate.

Check the oil pressure switches, and if they do not meet the specifications, replace them.

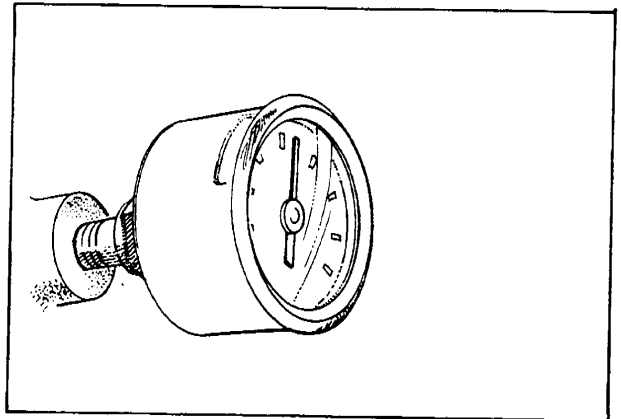
NOTE: Generator units have a two-prong oil pressure and water temperature switch which interrupts the circuit for the fuel run solenoid when tripped, thus shutting down the generator automatically.

### Checking Oil Pressure

1. Warm up the engine.
2. Remove the oil pressure sender and connect a mechanical oil pressure gauge instead.
3. Set the engine speed at 3000 RPM and measure the oil pressure. If the oil pressure is less than the specification, check the lubricating system.

Oil pressure:

Greater than  $3.5 \text{ kg/cm}^2$   
( $50 \text{ lb/in}^2$ ) at 3000 RPM



NOTE: Insure proper oil is being used that meets temperature requirements and the A.P.I. Spec of CC or better.

## FUEL SYSTEM

Fuel from the fuel tank is brought to the engine by the aid of an engine-mounted electric fuel pump. (Note: A filter/water separator is recommended to be installed in the fuel supply line between the fuel tank and the connection to the electric fuel pump.) Fuel passes through the electric pump to the engine-mounted fuel filter and then to the high pressure injection pump. The injection pump delivers the fuel through high pressure lines to each injector. The injectors spray the fuel into the engine's combustion chambers where it ignites. Fuel not used is returned to a fitting on the injection pump where it combines with unused fuel from the injection pump and is returned to the fuel tank.

### Fuel Filters (Engine Mounted)

The fuel filters are easy to handle cartridge type and constructed of paper.

One filter element is located in the base of the electric fuel pump and the other is located in the filter housing adjoining the electric pump. (Note: Both elements should be replaced after the initial 50 hours of engine operation and then every 200 hours or once a season as needed.)

### Changing the Fuel Filters

The fuel filter element located in the electric fuel pump can be removed by undoing the base of the pump. A 17 mm wrench 5 mm thick should be used to undo the base. Turn the base clockwise to replace. (Fuel will spill from the pump when the base is removed so be prepared to catch it.) Remove the base and filter element. Install the new element, insure the sealing gasket in the base cover is in good condition and the round magnet is in the center of the cover when reinstalling.

The filter element in the cartridge is a paper type and to remove it, unscrew the knurled retainer ring and drop the ring and lower housing off the filter bracket. (Fuel will spill from the housing, so be prepared to catch it.) The filter element is then withdrawn from the filter bracket. Two O-rings are located in this bracket and should be replaced as needed. One seals the lower housing and the other seals and holds the filter element in place.

Replace the filter element and the lower housing and retainer ring and tighten the retainer ring.

Caution: When threading the retainer ring onto the bracket, take care not to cross thread it. It should thread easily onto the bracket until the lower housing contacts the sealing O-ring. Hand tighten only.

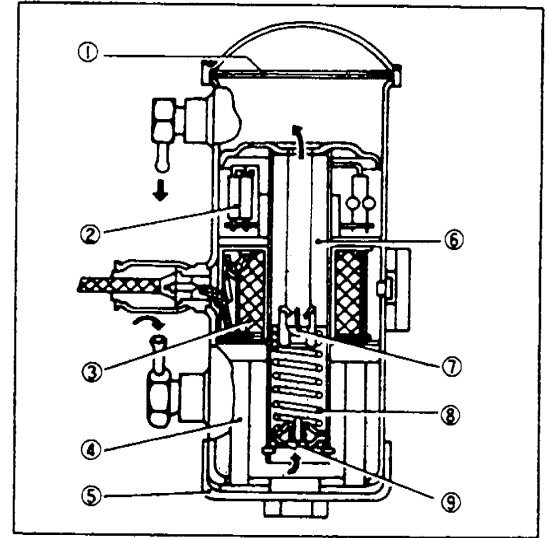
Bleed the air from the electric fuel pump and this filter cartridge by simply turning on the keyswitch (generator - depress preheat switch) for 30 to 40 seconds, then start the unit and check for leaks.

Fuel Pump

In a solenoid-operated (transistor type) 12 volt DC fuel pump, the reciprocating motion of the pump plunger is controlled by a transistorized circuit.

The oscillator section incorporates transistors, diodes and resistors.

When the transistor circuit is closed and the solenoid coil is excited, a sucking force acts on the plunger forcing it down against the spring force and the fuel, pushing up the delivery valve, that leads into the plunger. When the transistor circuit is opened, the plunger is pushed back upward by the spring force, forcing the fuel out of the outlet port, and at the same time, the inlet valve opens and the fuel enters the lower chamber.



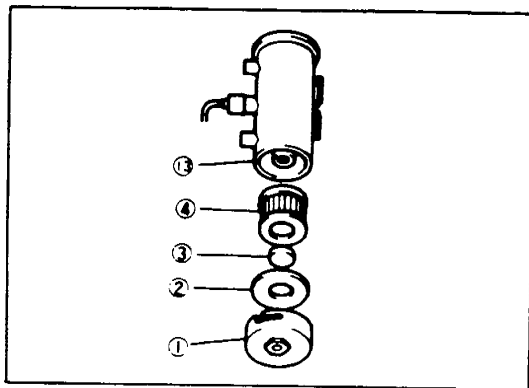
- |                   |                  |
|-------------------|------------------|
| (1) Diaphragm     | (6) Plunger      |
| (2) Oscillator    | (7) Outlet valve |
| (3) Solenoid coil | (8) Spring       |
| (4) Filter        | (9) Inlet valve  |
| (5) Filter cover  |                  |

Fuel Pump

Disassembly and Reassembly of the Electric Fuel Pump for Cleaning

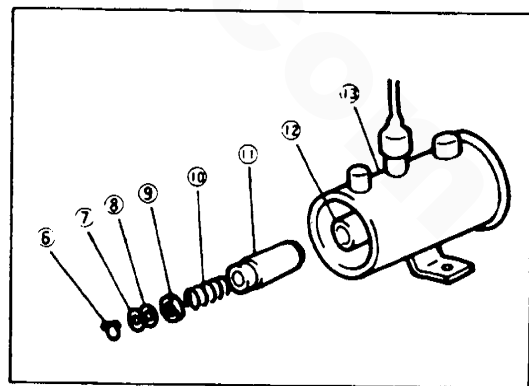
Since this transistorized fuel pump is of a totally enclosed type, only the cover, filter and plunger assembly require cleaning.

Using a 17 mm wrench, remove the cover (1) as illustrated. Then, the cover gasket (2), magnet (3) and filter (4) can be removed from the pump body.



- |                  |            |
|------------------|------------|
| (1) Cover        | (4) Filter |
| (2) Cover gasket | (13) Body  |
| (3) Magnet       |            |

Removal of Filter



- |                     |                     |
|---------------------|---------------------|
| (6) Spring retainer | (10) Plunger spring |
| (7) Washer          | (11) Plunger        |
| (8) O-ring          | (12) Plunger tube   |
| (9) Valve           | (13) Body           |

Removal of Plunger

Replace the filter as needed.

Check the cover gasket, and if damaged, replace it. Clean the magnet and cover thoroughly.

To remove the plunger, first remove the spring retainer (6) from the plunger tube (12). Then remove the washer (7), O-ring seal (8), valve (9), plunger spring (10) and plunger (11) from inside the tube. Wash these parts in clean diesel oil and remove the oil and other contaminants using compressed air.

**CAUTION: THE TUBE (12) HAS VERY SMALL WALL THICKNESS. BE CAREFUL NOT TO DEFORM THE TUBE DURING REMOVAL OF THE PLUNGER AND THE RELATED PARTS.**

**CAREFULLY HANDLE THE PLUNGER TO PREVENT IT FROM BEING DENTED OR OTHERWISE DAMAGED.**

#### Assembling

- (1) To assemble, install the plunger, plunger spring, valve, O-ring and washer in that order, and finally secure them with the retainer so that they will not come out.
- (2) Install the filter element, and then the magnet and gasket in the base cover and tighten the cover with a 17 mm wrench to the ends of the slotted stop.

#### Servicing and Checking the Electric Fuel Pump

##### (1) Changing the Filter

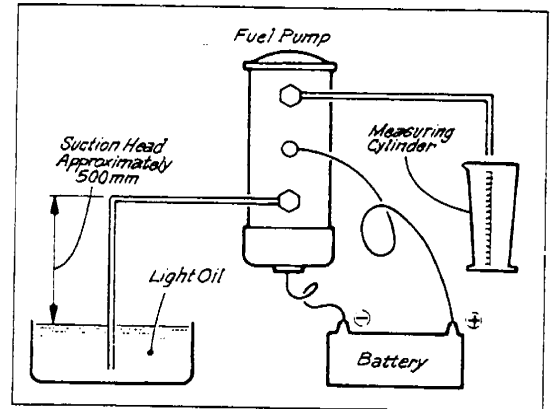
After the first 50 hours of operation and thereafter every 200 hours, remove the lower cap of the pump using a 17 mm wrench and replace the filter element.

##### (2) Checking the Electric Fuel Pump Operation

Turn on the ignition switch (generator - preheat). The pump should produce a clicking sound. If the pump does not produce any operating sound, check with a DC voltmeter to determine that 12 volts is being supplied to the pump. If 12 volts is being supplied to the pump and the pump still does not make any operating sound, replace the fuel pump assembly. If 12 volts is not present at the pump, check the unit circuit breaker, electrical connections and switch.

(3) Checking the Discharge Rate of the Fuel Pump

Check the discharge rate as illustrated. The pump must deliver over 200 cc (.422 pints) of fuel in 15 seconds.



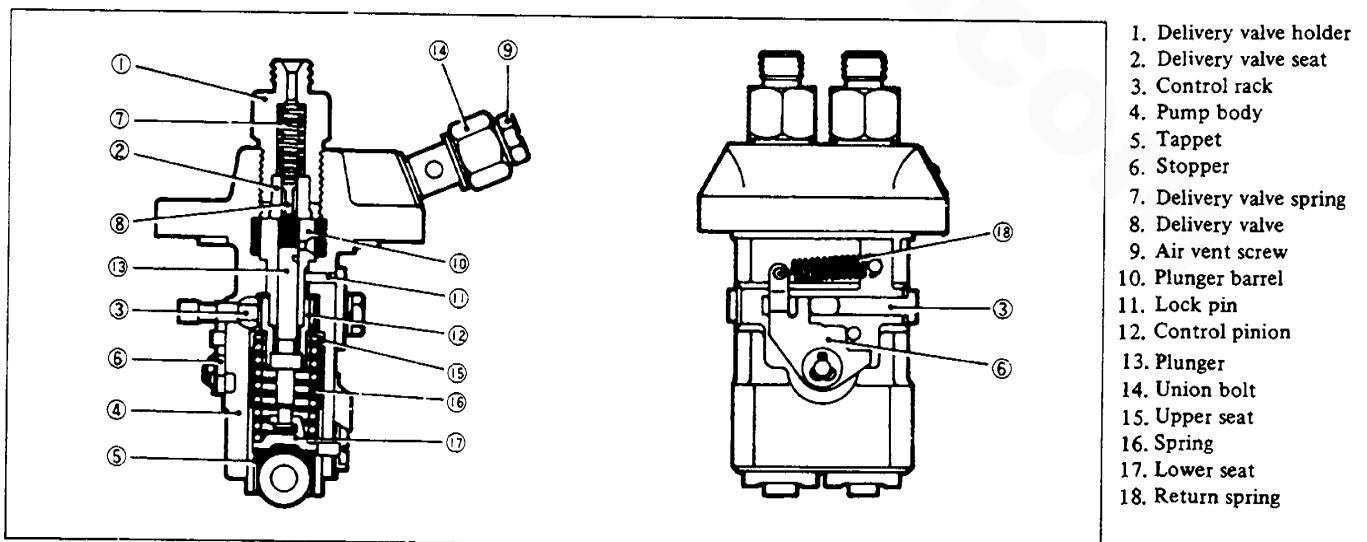
Fuel Injection Pump

This fuel injection pump is a double-barrel pump installed in the cylinder block and consists of pump element (plunger assembly), delivery valve, tappet and smoke set device. The pump is mounted at the front right side of the cylinder block and delivers the fuel under pressure when the pump cam rotation pushes the plunger up which reciprocates through a fixed stroke.

(1) Control of Injection Rate

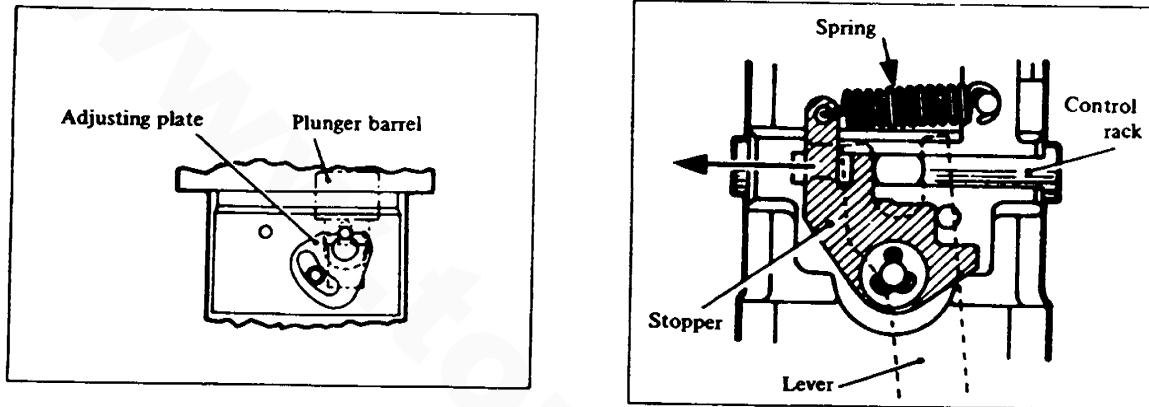
The fuel injection rate is increased or decreased by changing the relative position of the plunger lead and plunger barrel. The plunger is rotated by the control pinion installed on the outer periphery of the plunger barrel.

The lower flange of the plunger fits in the slit of this pinion, and the rotation of the pinion is transmitted directly to the plunger. This control pinion is driven by engine power through the camshaft, governor weights operated through centrifugal force, governor sleeve and throttle linkage. Therefore, when the fuel rack moves to the right, the amount of fuel injected decreases, and when the fuel rack moves to the left, the fuel increases.



(2) Smoke Set

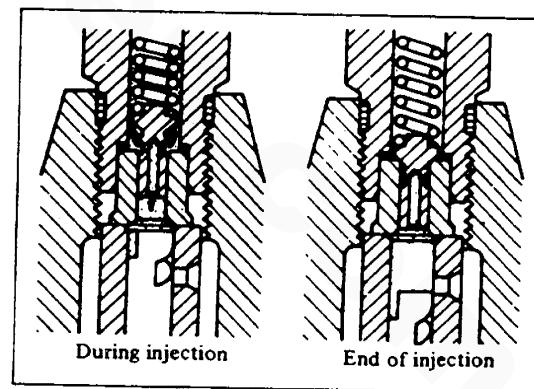
A smoke set is installed to control the maximum fuel injection rate. The stopper is held by a spring in the illustrated position. This position is the smoke set position. To start a cold engine, the throttle lever is pulled fully toward the maximum number of rotation and the control rack is moved by the governor lever in the direction of the arrow overcoming the spring force of the stopper thus causing excessive injection. The fuel injection rate between the two barrels is adjusted by the plunger barrel which rotates on the adjusting plate with cam mechanism located on the opposite side of the control rack.



(3) Delivery Valve

In addition to the function to deliver the fuel into the injector line after the fuel pressure has increased sufficiently high, the delivery valve has another important function to prevent "after-drip" from the nozzle tip after completion of injection.

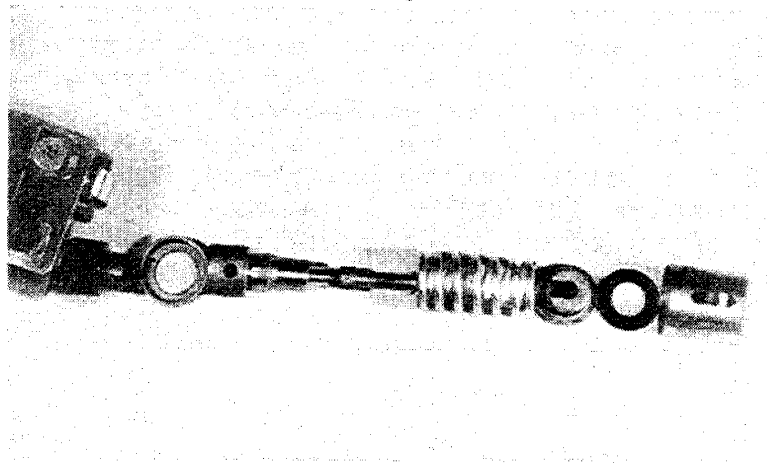
When the fuel pressure above the plunger has dropped at the completion of injecting, the delivery valve piston moves to close the delivery valve seat, but at that time, the compressed fuel still remains in the line which results in the after-drip from the nozzle tip. To prevent this after-dripping, the delivery valve piston sucks back the fuel remaining in the injection line before the delivery valve is seated, thus reducing the fuel pressure in the injector line almost to zero.





### Disassembly of the Fuel Injection Pump

- (1) Remove the fuel injection lines and return lines.
- (2) Loosen the injection pump mounting bolts and lift the pump assembly out of the engine block. Position the throttle arm about half open to position the fuel rack ball joint at the notch in the block for removal.



- (3) Record the thickness and quantity of pump adjusting shims in order to facilitate adjustment at the time of reassembly.
- (4) Disassembly of the Fuel Pump

#### CAUTION:

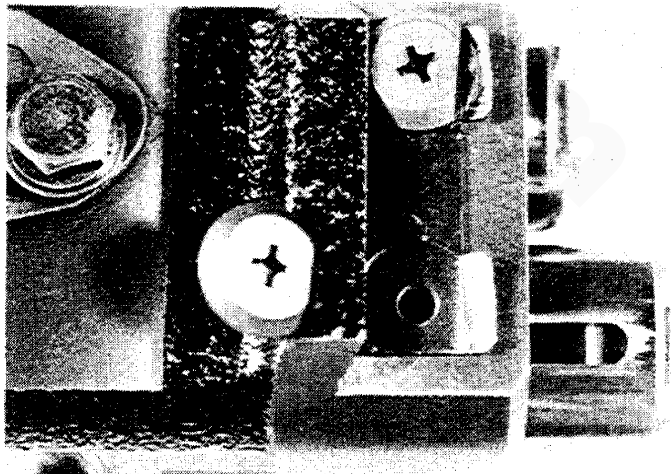
Do not recklessly try to disassemble the fuel injection pump. Pump adjustment requires a test bench and acquired skill. Avoid disassembly and adjustment of the pump when this equipment and knowledge are not available.

Before disassembling, close the fuel inlet and outlet and clean the exterior of the pump.

Fill a container with clean diesel oil and put disassembled parts in it.

Keep in order the disassembled parts except those to be replaced so that they may be reassembled in their original positions and that no mixing with other parts will occur.

- (a) Remove the delivery valve holder. Take out the valve spring, valve and O-ring.
- (b) Take out the gasket and valve seat.

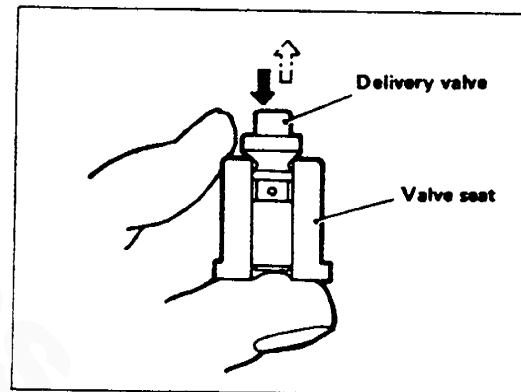


- (c) Straighten the tappet guide pin lock plate, push in the tappet slightly, pull off the guide pin using a needle nose pliers and take out the tappet.
- (d) Remove the spring and upper seat.
- (e) Remove the pinion.
- (f) Draw out the plunger barrel upward from the pump housing. Keep the removed plunger barrels and plungers in sets. (Never mix plunger and barrel assemblies.)
- (g) Remove the cotter pin, washer, return spring and smoke set, and pull out the control rack.

### Examination

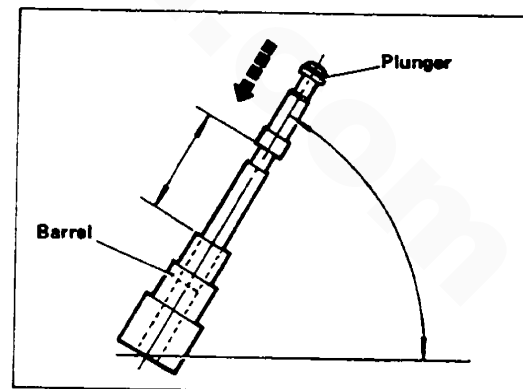
#### (1) Delivery Valve Seat

Check the contact surface of the delivery valve seat, and if not showing good contact, replace the delivery valve. The delivery valve should show a slight resistance when being withdrawn from the valve body when the other hole is closed off with one's finger.



#### (2) Plunger Barrel

Check the plunger for seizure, damage and rust. Also check that the plunger slides smoothly when it is lubricated with diesel fuel and inserted into the barrel. If the plunger is found not to slide smoothly into the barrel, replace the assembly. The repair of the plunger is not permitted; it must be replaced.

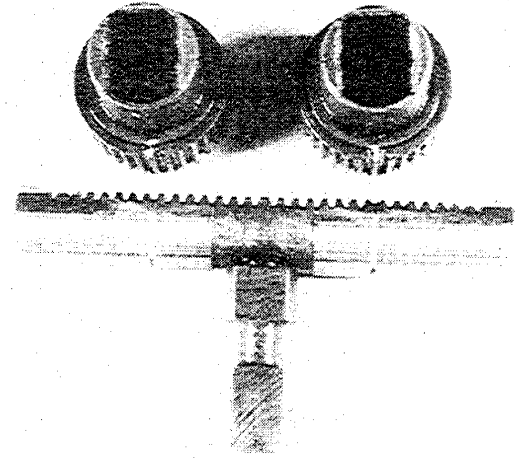


(3) Control Rack and Pinion

Replace the rack and pinion whose teeth are worn or damaged.

(4) Tappet

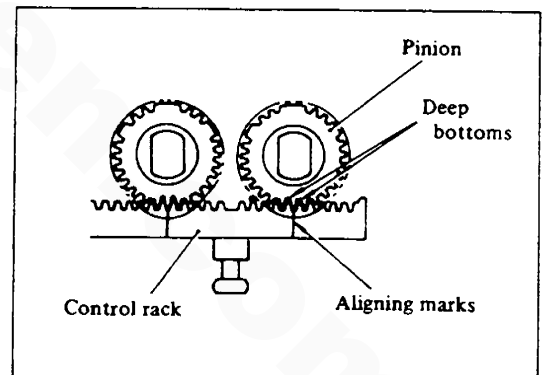
Check the outer periphery of tappet, roller and shaft for wear and damage, and if defective, replace.



Reassembly

(1) Partial Assembly of Fuel Injection Pump Assembly

- (a) Insert the plunger barrel with the notch properly aligned with the dowel pin of the pump housing.
- (b) Install the O-ring to the delivery valve holder.
- (c) Install the spring seat gasket and valve assembly to the valve holder, and temporarily install this to the pump housing. Be sure to install the O-ring properly.
- (d) Install the control rack.
- (e) Assemble pinions to the control rack with their center deep teeth properly aligned with the aligning marks on the control rack respectively.
- (f) Install the spring upper seat and spring.
- (g) Assemble the plunger and spring lower seat, and install the assembly with the mark "L" on the plunger flange facing the control rack side.

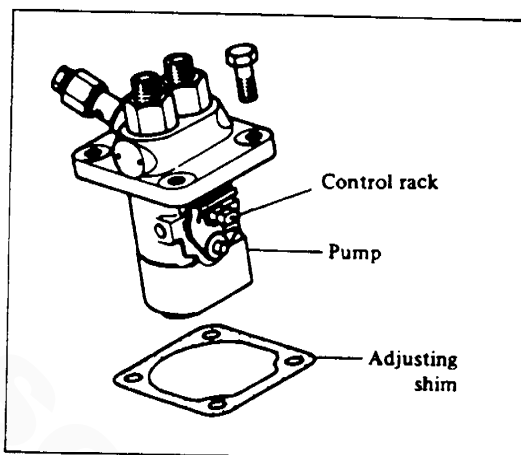


- (h) Insert the tappet (pay attention to the shim inserted), align the tappet guide hole with the dowel pin hole of the housing and insert the tappet guide pin. Before inserting the tappet guide pin, attach the lock plate and bend it to lock after the guide pin is installed.
- (i) Install the smoke set stopper, return spring and washer, and install a cotter pin.
- (j) Tighten the delivery valve holder to 30 lb/ft.



(2) Installation and Adjustment of Fuel Injection Pump

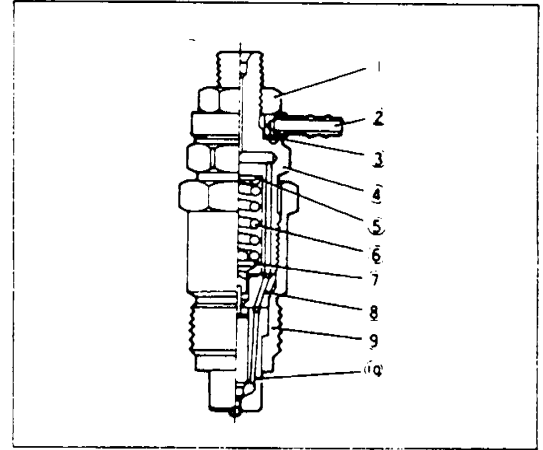
- (a) To install the pump assembly, use the same thickness adjusting shim under the pump as removed. Confirm that the projection of the control rack fits properly in the forked end of the governor lever. The shim is available in nine types from 0.2 mm (thickness) to 1.0 mm in increments of 0.1 mm.



- (b) Connect the fuel feed hose and bleed the injection pump by turning on the keyswitch or depressing the preheat switch (generators).
- (c) Confirm the injection timing. First remove the delivery valve holder, and after pulling out the delivery valve and spring, install the delivery valve holder only. Turn the crankshaft so as to bring #1 piston coming up on its compression stroke. The injection time is the moment when the fuel flowing from the outlet port of the valve holder stops flowing. Compare this moment to the timing mark on the crankshaft pulley on the front cover mark. If the standard injection timing cannot be obtained, adjust by increasing or decreasing the thickness of the adjusting shim. As the shim thickness changes 0.1 mm, the injection timing changes about 1°. Where the above operation cannot be done, the adjustment may be made without removing the valve and spring. In this case, remove injection line #1 at the injector side and slowly turn the crankshaft pulley nut with a wrench. The injection timing is the moment when the fuel appears and swells at the end of the pipe, and this is about 1° later than the normal injection timing. The injection timing must be checked when the plunger is in the smoke set position, that is, full open throttle.

Injector Nozzle

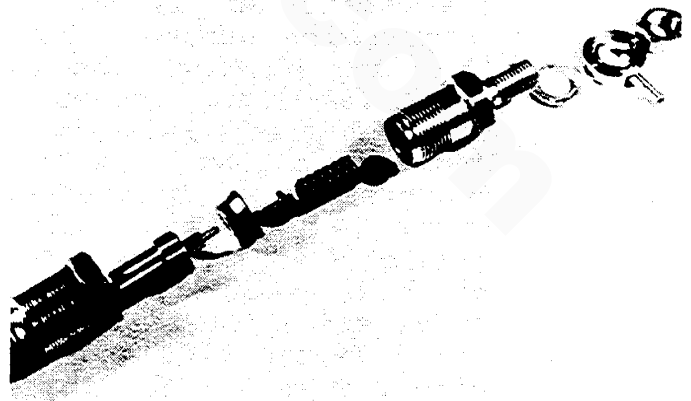
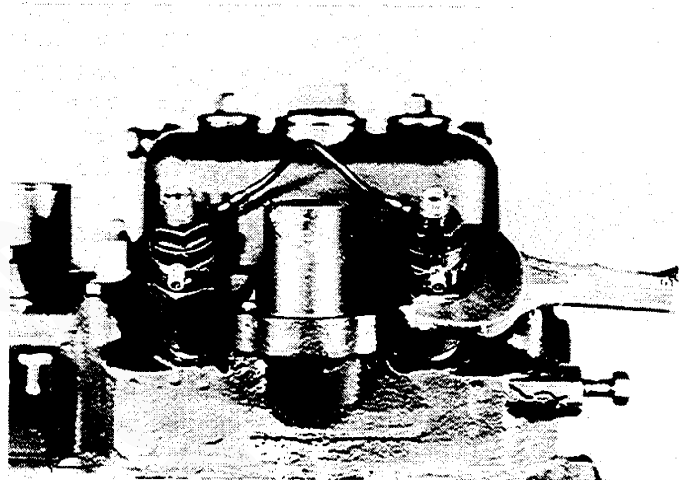
The fuel from the fuel injection pump passes through the fuel passage in the nozzle holder body and is injected through the nozzle into the combustion chamber. The excess fuel at the nozzle flows through the nozzle holder, the upper nipple and the return line and returns to the fuel tank.



- |                |                  |
|----------------|------------------|
| 1 Hexagon nut  | 7 Pressure pin   |
| 2 Packing ring | 8 Distance piece |
| 3 Washer       | 9 Retaining nut  |
| 4 Body         | 10 Nozzle        |
| 5 Shim washer  | 11 Flange        |
| 6 Spring       |                  |

Disassembly of the Injector

- (1) Remove the return line from the injector upper attachment.
- (2) Remove the fuel injection line from the injector.
- (3) Loosen the injector nut and remove the assembly.
- (4) Disassemble the nozzle holder assembly in the following manner.
  - (a) With the retaining nut held in a vice, remove the nozzle holder using a wrench on the nozzle holder body. When holding the retaining nut in the vice, use an aluminum or copper plate between the nut and the vice.
  - (b) Remove the shim, pressure ring, flange, pressure pin and distance piece.



- (c) Take out the nozzle from the retaining nut. If the nozzle is too hard to remove, lightly tap it with a wooden piece and remove, taking care not to damage the needle valve.

### Inspection

Check the nozzle for incorrect contact and damage, and if defective, replace the nozzle assembly.

Check the pressure spring for damage.

### Assembly of Nozzle and Injector Assembly

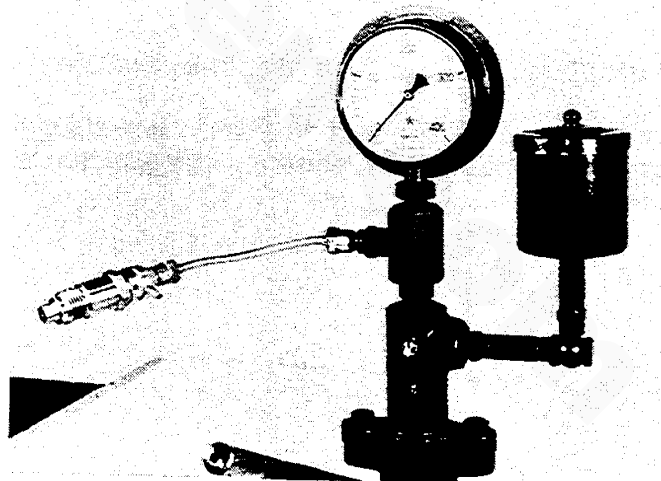
**CAUTION:** Before assembling, put the parts in diesel oil and clean them well. DO NOT wipe the cleaned parts with cloth. When installing the nozzle holder body and retaining nut, be sure to tighten them to the specified torque. Insufficient torque will cause poor compression. If torqued excessively, the nozzle needle will drag, affecting injection performance.

- (1) Install the nozzle assembly, spacer and pressure pin to the retaining nut.
- (2) Install the shim, spring and flange in the body and install them to the above-mentioned retaining nut and torque the retaining nut to the specification.
- (3) Tighten the nipple gasket and nipple.

### Injection Test

#### (1) Injection Start Pressure Test

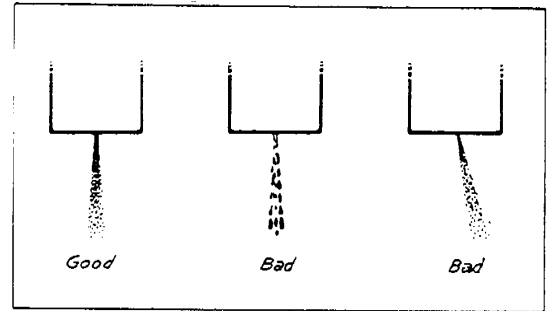
- (a) Measure the injection start pressure using a nozzle tester, and if out of standard, make adjustment to obtain the specified pressure by increasing or decreasing the adjusting shims. Adding shims increases the pressure and reducing shims decreases the pressure.



- (b) As the thickness of the adjusting shim changes 0.1 mm, the pressure changes about 10 kg/cm<sup>2</sup>. To change the shim, hold the retaining nut with a vice and remove the pump body with a wrench. Tighten the retaining nut to the specified torque.

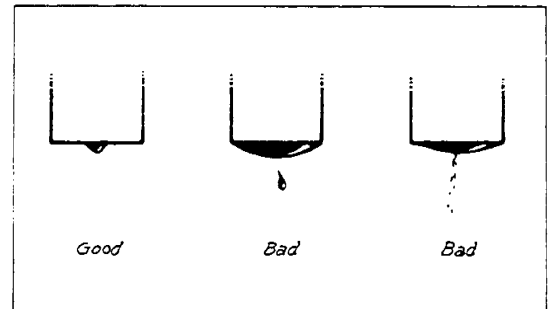
(2) Injection Test

The chattering test (intermittent small amount injection test) is considered as passed if intermittent clearcut injection with sound is obtained when the tester lever is slowly operated. In this case the injection must be straight in the same direction as the nozzle axis. Spray in different directions or in several lines is not acceptable. Also a large coarse spray is not acceptable.



(3) After-drip Test

In the preceding chattering test, if the fuel collects on the tip of the nozzle and dripping occurs after injection, the nozzle must be replaced because it is defective. A very small amount of fuel may collect on the nozzle tip. This is caused by chattering and, therefore is not a defect.



(4) Spray Condition Test

When the tester lever is operated fast (about 200 strokes per minute), the fuel must be sprayed in fine mist straight in the direction of the nozzle axis. Coarse spray is not acceptable.

Installation of the Nozzle Holder Assembly

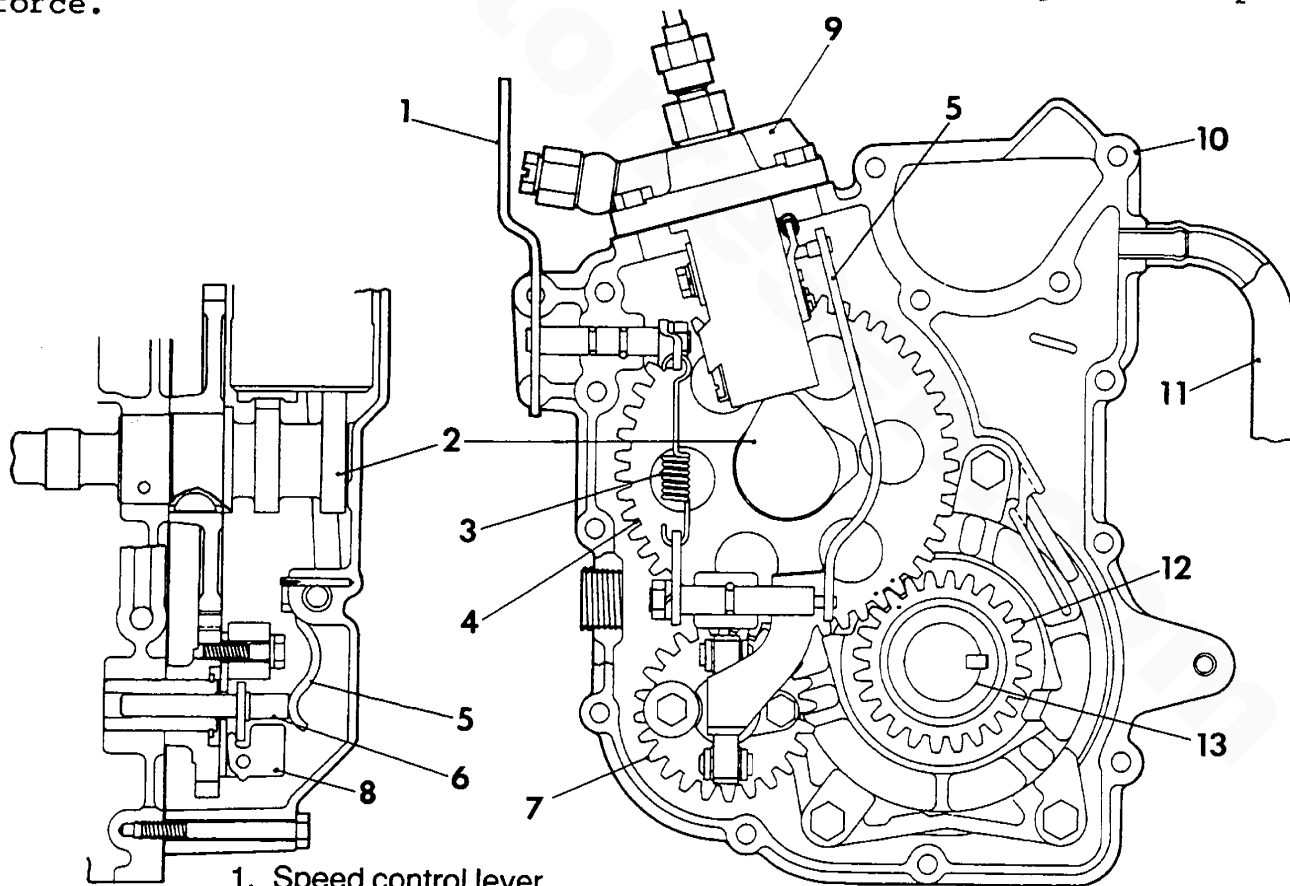
Install the nozzle holder assembly to the cylinder head and tighten to the specified torque. Replace the nozzle holder gasket with a new one.

GOVERNOR SYSTEM

General

The governor functions to keep the engine running at a constant speed by balancing the centrifugal force acting on the governor weights and the governor spring tension. As the engine speed increases, the governor weights (8) open to move the sliding shaft (6) forward and the control rack of the injection pump is moved by the governor lever (5) in the direction of reducing the fuel injection rate. At the same time the governor spring (3) is pulled by the governor lever (5) until the spring force is balanced with the centrifugal force of the governor weights, thus maintaining the constant engine speed.

If the speed control lever (1) is pulled toward HIGH SPEED, the governor spring (3) is pulled and the governor control rack is moved by the governor lever (5) toward increasing fuel injection rate to increase the engine speed which is kept constant when the centrifugal force of the governor weight is balanced with the governor spring force.



- |                        |                             |
|------------------------|-----------------------------|
| 1. Speed control lever | 8. Governor weight breather |
| 2. Camshaft            | 9. Injection pump           |
| 3. Governor spring     | 10. Gear case               |
| 4. Cam gear            | 11. Air breather pump       |
| 5. Governor lever      | 12. Crankshaft gear         |
| 6. Sliding shaft       | 13. Crankshaft              |
| 7. Idle gear           |                             |

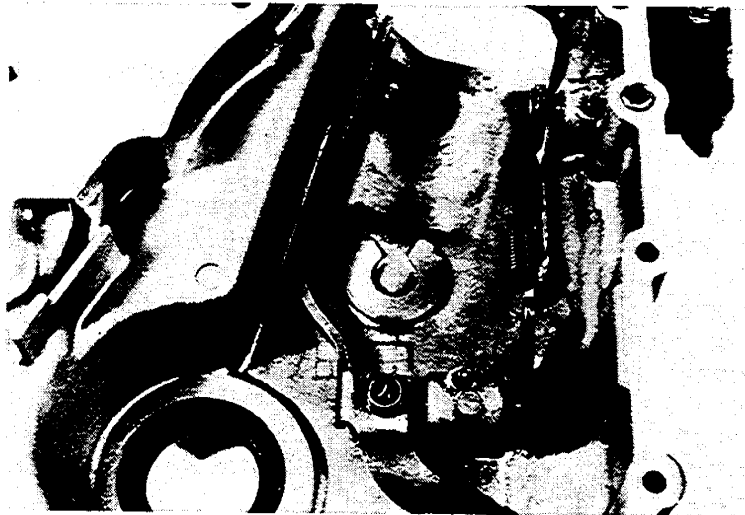


### Governor Lever

#### Construction of the Governor Lever

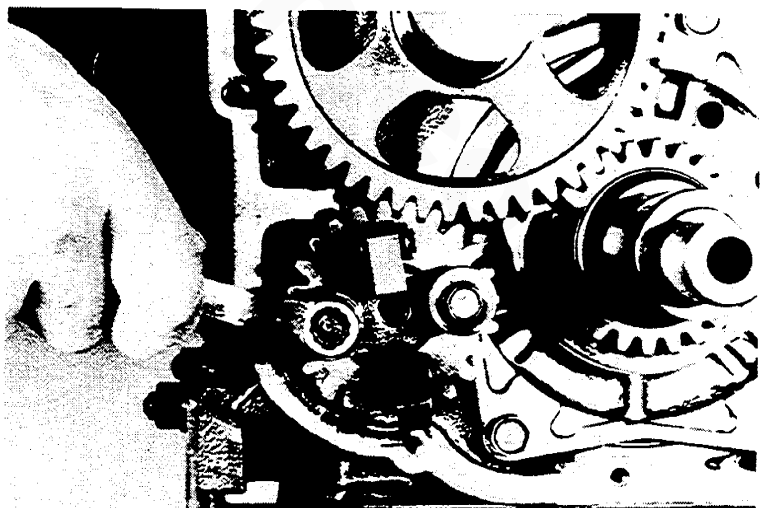
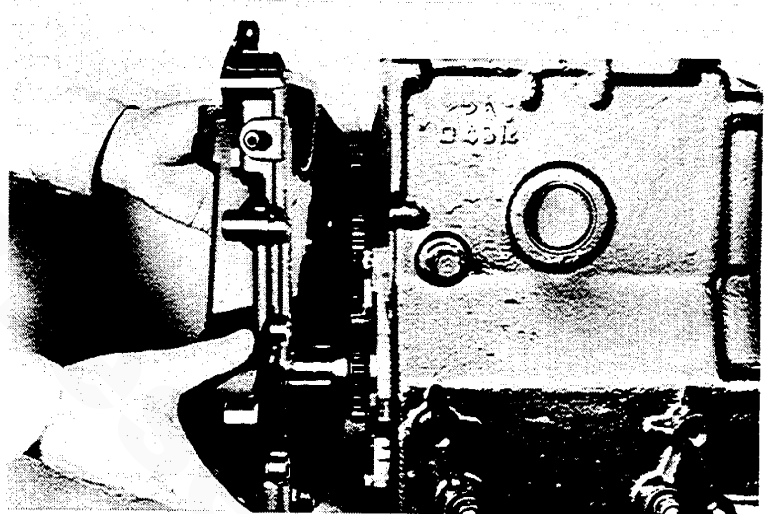
The governor lever is built inside the gear case, one end of the lever in contact with the injection pump control rack and the other end with the governor weight sliding shaft.

The lever is held at the center by a shaft which is fitted to connect the shaft with the control lever.



#### Disassembly

- (1) Remove the alternator belt. (See "Cooling System".)
- (2) Remove the crankshaft pulley nut, then the pulley.
- (3) Remove the fuel injection pump. (See "Fuel Injection Pump".)
- (4) Remove the gear case bolts, then the gear case.
- (5) Remove the governor spring.
- (6) Remove the nut, washer and spring lever, and remove the throttle control lever from the gear case.
- (7) Remove the nut, washer and spring lever, then the governor lever set bolt, and remove the governor lever.
- (8) Remove the governor weight assembly and sliding shaft from the pump camshaft.



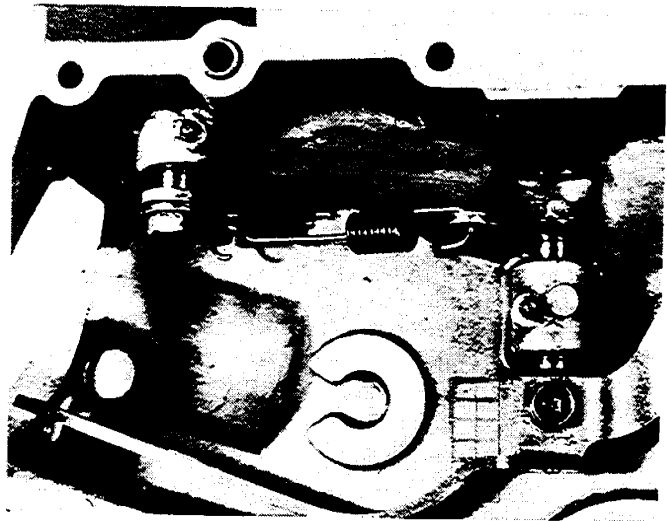
## Inspection

### (1) Governor Lever

Check the connections of the governor lever with the sliding shaft and with the control rack and, if defective, replace.

### (2) Governor Spring

Check the spring for deterioration and breakage, and if defective, replace. Do not stretch the spring.

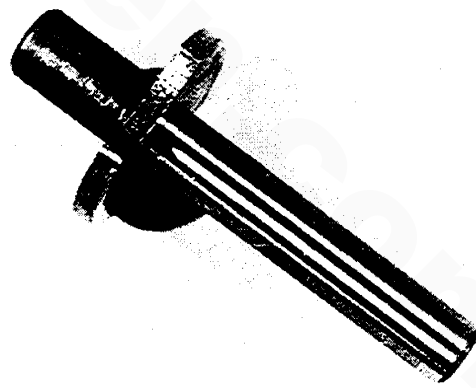
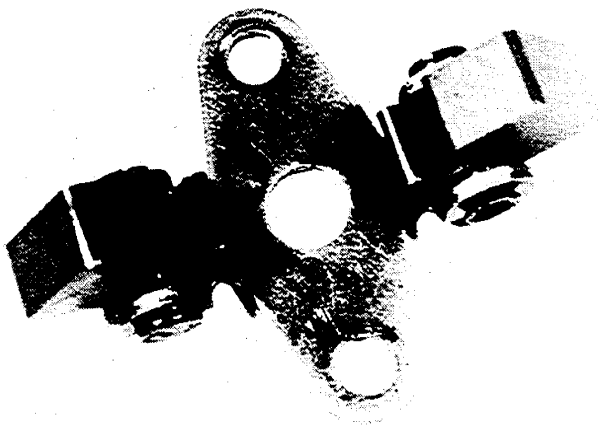


## Governor Weight

The governor weight is installed on the governor gear in mesh with the cam gear. In order to improve the governor regulation, the sliding shaft is provided with a stopper.

The governor gear is fitted in the gear shaft on the crankcase side and is retained by a snap ring.

The shaft is made hollow to receive the sliding shaft.



## Disassembly

The governor weight can be disassembled by the same procedures as for the governor lever.

### Inspection

#### (1) Governor Assembly

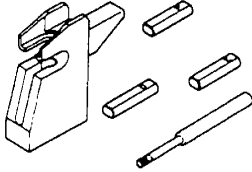
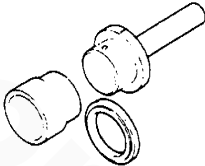

- (a) Check the weight for wear and damage, and if defective, replace.
- (b) Check the operating part of the sliding shaft for damage and see if the operation is smooth. If defective, replace.

### Reassembly

For reassembling, reverse the order of disassembly, and after the reassembly is completed, check that the operation is smooth.

MAINTENANCE

Special Tools

| Tool No. | Tool Name   |   | Use   |
|----------|---|---|---|
| 33582    | Piston pin setting tool   |    | For drawing out or press-fitting piston pin.  |
| 33742    | Bearing installer   |    | For drawing out or press-fitting main bearing, with ring adapter for front bearing. |
| 33584    | Compression gauge adapter (Straight type) without check valve (5/8-18 UNF thread for gauge) |  | For testing compression. Mounts in place of glowplug.                               |
| 33781    | Compression gauge with built-in check valve   |   | For testing compression.  |

In addition to the above, the following are needed: Common service tools, bearings, puller, valve seat cutter, valve guide installer, oil filter wrench and other measuring instruments.

## OVERHAULING PROCEDURE

### Judging When to Overhaul the Engine

Usually the overhauling time of the engine is determined by reduced engine power, decreased compression pressure and increased fuel and engine oil consumption.

But the reduced engine power may be caused not only by the trouble of the engine itself but also by damaged nozzle or improper adjustment of the injection pump. For this reason, it will be most advisable to take a compression check of the engine before undertaking major overhaul.

However, the decrease in compression pressure is caused by many factors and it is not so easy to find which factor is the cause. Therefore, the cause for trouble should be determined on the basis of records of regular inspection and maintenance.

If the trouble is caused by the wear of the cylinder and piston, the following symptoms will appear.

- 1) Reduced engine power and decreased compression pressure
- 2) Increased fuel consumption
- 3) Increased consumption of lubricating oil
- 4) Poor engine starting
- 5) Increased noise from engine parts

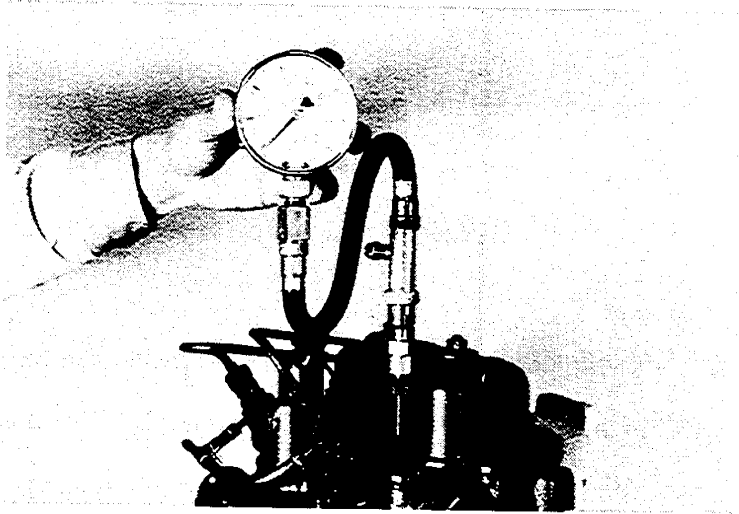
Usually, two or more of the above symptoms appear at the same time. Symptoms 2) and 4) are caused by excessive fuel injection, improper injection timing and plunger and nozzle wear, and they are also seriously affected by electrical system trouble such as faulty battery, alternator, starter and glow plug. Therefore, in order to determine the overhauling time of the engine, it is recommended to use as a guide the decrease of the compression pressure due to the wear of the cylinder and piston and at the same time to take into consideration the oil consumption and other items.

The compression pressure is the source of the explosive power of the diesel engine, and without sufficient compression pressure, complete combustion cannot be achieved even if other parts of the engine are normal.

In order to determine the overhauling time of the diesel engine, it is important to measure the engine compression pressure regularly. Since the compression pressure varies with engine RPM, check the speed also. The engine RPM can be measured at the front end of the crankshaft.

### Measuring Compression Pressure

- (1) Remove the glow plug from the cylinder whose compression pressure is to be measured.
- (2) Install a pressure gauge adapter in the screw hole of the glow plug and connect a pressure gauge.
- (3) Turn the engine over with the starter and when the engine speed has become stabilized, record the engine speed and pressure gauge.
- (4) Measure the compression pressure of other cylinders in the same manner.



**CAUTION:** It is wrong to judge the status of the other cylinder by measuring only one cylinder. Be sure to measure both cylinders.

### Judgement of Engine Condition by Compression Pressure

- (1) When the engine is new, the compression pressure is a little high because of the close fit between mating parts, but after that, the pressure decreases gradually as the parts get worn.
- (2) When the compression pressure has decreased below the acceptable limits, the engine should be overhauled.

### Judgement by Increased Consumption of Engine Oil

If the engine oil consumption has increased by about 50% more than the standard consumption (as 100%), the engine should be overhauled.

### Cautions in Overhauling

Disassemble the engine taking the following precautions. The order of disassembling and reassembling may be different depending on the change of specifications.

- (1) Carefully check for visible problems prior to disassembling or cleaning because some faults may not be found after disassembling or cleaning.
- (2) Drain all water, oil and fuel before disassembling.

- (3) Clean or wash the exterior of the engine.
- (4) Use proper tools and observe the order of disassembling. Keep disassembled parts in proper order and protect as necessary. Also take special care to prevent the fuel system parts from being contaminated by dirt or dust.
- (5) Do not disassemble or remove the parts that require no disassembly.

Assemble the engine taking the following precautions.

- (1) Prepare all necessary parts for reassembling.
- (2) Clean or wash the parts and apply oil as needed.
- (3) Check all gaskets, washers and oil seals and replace them with new ones.
- (4) Be sure to install in proper directions and positions (see dowel pins, mating marks and specified directions). When tightening torque is not specified, tighten evenly to an ordinary torque. Apply a sealant where specified.
- (5) After completion of reassembly, re-check for abnormality. Prepare for starting the engine. Run the engine at idle sufficiently for test run.

SPECIFICATIONS AND SERVICE LIMITS

|  | <u>STANDARD<br/>VALUE</u>    | <u>SERVICE<br/>LIMIT</u>     |
|--|------------------------------|------------------------------|
| 1. Compression pressure (320 RPM)  | 32kg/cm <sup>2</sup>         | Approx. 26kg/cm <sup>2</sup> |
| 2. Difference of compression pressure between cylinders (max.)                           | 2.5kg/cm <sup>2</sup>        |                              |
| 3. Order of fuel injection   | 1 - 2                        |                              |
| 4. Fuel injection timing (BTDC of compression stroke when started at smoke set position) | 25°                          |                              |
| 5. <u>Cylinder Head</u>  |                              |                              |
| a. Bottom surface distortion   | 0.05mm/less                  |                              |
| b. Valve guide I.D.  | 6.6mm                        |                              |
| c. Valve seat angle  | 45°                          |                              |
| d. Valve seat width  | 1.5 - 1.8                    |                              |
| e. Valve seat sinkage  |                              | -1 mm                        |
| 6. Valve Clearance (engine cold)   | 0.25mm                       |                              |
| 7. <u>Valve</u>  |                              |                              |
| a. Stem O.D.   | 6.6mm                        |                              |
| b. Clearance between stem and guide (intake)   |                              | 0.10mm                       |
| c. Clearance between stem and guide (exhaust)  |                              | 0.15mm                       |
| d. Seat face angle   | 45°                          |                              |
| e. Valve head thickness (margin width)   | 1mm                          |                              |
| 8. <u>Valve Spring</u>   |                              |                              |
| a. Free length   | 44mm                         |                              |
| b. Installed load/height   | 10.0±0.5kg/37.6mm            | -15%                         |
| c. Squareness  | 2.0°                         | 3°                           |
| 9. <u>Rocker Arm</u>   |                              |                              |
| a. Clearance between rocker arm and shaft  | 0.04mm                       | -0.2mm                       |
| 10. <u>Crankcase</u>   |                              |                              |
| a. Cylinder I.D.   | 65mm                         | +0.95mm                      |
| b. Tolerance on oversize cylinder bore   | 0 - 0.03mm for each oversize |                              |
| c. Taper of cylinder bore  | within 0.01mm                |                              |



|  | <u>STANDARD<br/>VALUE</u>    | <u>SERVICE<br/>LIMIT</u> |
|--|------------------------------|--------------------------|
| <b>11. <u>Piston</u></b>                 |                              |                          |
| a. Type                                  | Solid type                   |                          |
| b. Material                              | Aluminum Alloy               |                          |
| c. O.D. (skirt end)                      | 64.95mm                      |                          |
| d. Piston to cylinder wall clearance     |                              | 0.3mm                    |
| e. Oversize available                    | 0.25, 0.50, 0.75mm           |                          |
| <b>12. <u>Piston Pin</u></b>             |                              |                          |
| a. Type                                  | Semi-floating                |                          |
| b. Piston to pin clearance               |                              | 0.08mm                   |
| c. Press-in load with connecting rod     | 500 - 1500kg                 |                          |
| <b>13. <u>Piston Ring</u></b>            |                              |                          |
| a. No. of rings: Compression             | 3 (No. 1 chrome-plated)      |                          |
| Oil                                      | 1 (chrome-plated)            |                          |
| b. Ring side clearance                   |                              |                          |
| Compression No. 1                        |                              | 0.3mm                    |
| No. 2                                    | 0.03 - 0.08mm                | 0.2mm                    |
| No. 3                                    | 0.03 - 0.08mm                | 0.2mm                    |
| Oil ring                                 | 0.03 - 0.07mm                | 0.2mm                    |
| c. Ring end gap                          | 0.20 - 0.50mm                | 1.5mm                    |
| <b>14. <u>Connecting Rod</u></b>         |                              |                          |
| a. Type                                  | Forged, I-beam               |                          |
| b. Bend and distortion                   |                              | 0.15mm or less           |
| c. Big end thrust clearance              | 0.1 - 0.35mm                 | 0.5mm                    |
| <b>15. <u>Connecting Rod Bearing</u></b> |                              |                          |
| a. Type                                  | Kelmet metal with back metal |                          |
| b. Oil clearance                         | 0.035 - 0.050mm              | 0.15mm                   |
| c. Undersize                             | 0.25, 0.50, 0.75mm           |                          |
| <b>16. <u>Crankshaft</u></b>             |                              |                          |
| a. Type                                  | Fully counterbalanced        |                          |
| b. Bend                                  |                              | 0.05 mm or less          |
| c. End play                              | 0.1 - 0.3mm                  |                          |
| d. Journal O.D.                          | 54mm                         | -0.95mm                  |
| e. Pin O.D.                              | 42mm                         | -0.95mm                  |
| f. Undersize finish dimensions           |                              |                          |
| Journal U.S. 0.25                        | (standard value - 0.25)      | -0.040                   |
|  |                              | -0.055                   |
| U.S. 0.50                                | (standard value - 0.50)      | -0.040                   |
|  |                              | -0.055                   |
| U.S. 0.75                                | (standard value - 0.75)      | -0.040                   |
|  |                              | -0.055                   |

|                    |   | <u>STANDARD<br/>VALUE</u>                            | <u>SERVICE<br/>LIMIT</u>                |
|--------------------|---|--|---|
| g. Pin             | U.S. 0.25   | (standard - 0.25)                                    | -0.035                                  |
|                    |   |  | -0.050                                  |
|                    | U.S. 0.50   | (standard - 0.50)                                    | -0.035                                  |
|                    |   |  | -0.050                                  |
|                    | U.S. 0.75   | (standard - 0.75)                                    | -0.035                                  |
|                    |   |  | -0.050                                  |
| <br>               |   |  |   |
| 17.                | <u>Main Bearing</u>                               |  |   |
| a.                 | Type  | Kelmet metal with back metal                         |   |
| b.                 | Oil clearance                                     | 0.029 - 0.090mm                                      | 0.15mm                                  |
| c.                 | Undersize   | 0.25, 0.50, 0.75mm                                   |   |
| <br>               |   |  |   |
| 18.                | <u>Crankshaft Plate</u>                           |  |   |
| a.                 | Thickness   | 4 ± 0.1mm  |   |
| <br>               |   |  |   |
| 19.                | <u>Camshaft</u>                                   |  |   |
| a.                 | Drive method                                      | Gear   |   |
| b.                 | Clearance between journal and cylinder block hole |  | 0.15mm                                  |
| c.                 | Cam lobe diameter (both intake and exhaust)       | 25.59mm  | -1.0mm                                  |
| d.                 | Cam lobe diameter (pump cam)                      | 44.00mm  | -1.0mm                                  |
| <br>               |   |  |   |
| 20.                | <u>Tappet</u>                                     |  |   |
| a.                 | Clearance between tappet and cylinder block hole  |  | 0.15mm                                  |
| <br>               |   |  |   |
| 21.                | <u>Push Rod</u>                                   |  |   |
| a.                 | Bend  |  | 0.3mm or less                           |
| <br>               |   |  |   |
| LUBRICATION SYSTEM |   |  |   |
| 1.                 | <u>Quantity of Engine Oil</u>                     | 2.8 liters (upper limit)<br>1.8 liters (lower limit) | excluding<br>.3 liters in<br>oil filter |
| 2.                 | <u>API Service Spec.</u>                          | API spec. CC or better                               |   |
| 3.                 | <u>Viscosity</u>                                  |  |   |
| a.                 | Summer: 20°C or higher                            | SAE 30 or 10W-30                                     |   |
| b.                 | Spring, fall: 5° - 20°C                           | SAE 20 or 10W-30                                     |   |
| c.                 | Winter: 5°C or lower                              | SAE 10W-30   |   |

|  | <u>STANDARD<br/>VALUE</u> | <u>SERVICE<br/>LIMIT</u> |
|--|---------------------------|--------------------------|
| <b>4. <u>Oil Pump</u></b>                        |                           |                          |
| a. Type  | Trochoid type             |                          |
| b. Check valve opening pressure                  | 3.5kg/cm <sup>2</sup>     |                          |
| c. Clearance between outer rotor and body        |                           | 0.30mm                   |
| d. Clearance between outer rotor and inner rotor |                           | 0.25mm                   |
| e. Clearance between rotor and cover             |                           | 0.25mm                   |
| <b>5. <u>Oil Pressure Switch</u></b>             |                           |                          |
| a. Generator: normally open                      | 18 - 23 PSI (to close)    |                          |
| b. Propulsion: normally closed                   | 18 - 23 PSI (to open)     |                          |

**FUEL SYSTEM**

|                                      |  |
|--------------------------------------|--|
| <b>1. <u>Fuel</u></b>                | #2 diesel fuel   |
| <b>2. <u>Fuel Filter Type</u></b>    | Filter paper type cartridge                                    |
| <b>3. <u>Fuel Pump</u></b>           |  |
| a. Type                              | Electromagnetic type   |
| b. Delivery rate                     | 200cc or more (15 sec., 12V) free flow                         |
| <b>4. <u>Fuel Injection Pump</u></b> |  |
| a. Model                             | ND-PFR2M   |
| b. Fuel injection rate               |  |
| Smoke set (SS)                       | 1800 RPM 17+1mm <sup>3</sup> /st                               |
| At start set (MS)                    | 150 RPM 27+5mm <sup>3</sup> /st                                |
| Difference between cylinders         | 2mm <sup>3</sup> /rev. cyl. or less standard                   |
| <b>5. <u>Nozzle</u></b>              |  |
| a. Type                              | Throttle   |
| b. Model                             | ND-DN4SD24   |
| c. Injection start pressure          | 160 +10 kg/cm <sup>2</sup> 150kg/cm <sup>2</sup> or less<br>-0 |

**GOVERNOR**

|                |                         |
|----------------|-------------------------|
| <b>1. Type</b> | Centrifugal weight type |
|----------------|-------------------------|

STANDARD  
VALUE

SERVICE  
LIMIT

COOLING SYSTEM

1. Fresh Water Pump

- a. Type Centrifugal impeller type
- b. Water Temperature Switch (normally closed) 205°F ±5° (to operate)

2. Sea Water Pump

- a. Type Positive displacement  
G.P.M. at 3000 RPM  
G.P.M. at 1800 RPM (at discharge from exchanger)

ELECTRICAL SYSTEM

1. Starter

- a. Type Solenoid-operated overrunning
- b. Output-voltage 0.9KW - 12VDC
- c. Direction of rotation Clockwise as viewed from pinion side
- d. No-load terminal voltage 11.5VDC
- e. No-load current 60A or less
- f. No-load speed 6500 RPM or more
- g. Pinion gap 0.5 - 2.0mm

2. Alternator

- a. Voltage 12VDC
- b. Current 35 amp
- c. Regulator (Internal IC type) 14.4VDC ±0.3V
- d. No-load output  
Terminal voltage 13.5VDC  
Current 7 amp  
Speed 1300 RPM or less
- e. Load output  
Terminal voltage 13.5VDC  
Current 30 amp or greater  
Speed 2500 RPM or less

3. Glow Plug

- a. Type Sheathed quick heating type
- b. Rated current 10.5V
- c. Resistance 0.16 ohms (at normal temperature)

TABLE OF TIGHTENING TORQUES

|                                 | <u>Kg-m</u> | <u>lb-ft</u> |
|---------------------------------|-------------|--------------|
| Cylinder head bolt (M8)         | 3.5 - 4.0   | 25 - 29      |
| Rocker cover nut (M8)           | 0.5 - 0.7   | 4 - 5        |
| Connecting rod cap nut          | 3.2 - 3.5   | 23 - 25      |
| Flywheel bolt (M10)             | 6.5 - 7.0   | 46 - 51      |
| Crankshaft pulley nut (M24)     | 15.0 - 20.0 | 108 - 144    |
| Oil filter                      | 1.1 - 1.3   | 8 - 9        |
| Nozzle holder                   | 5.0 - 6.0   | 36 - 43      |
| Nozzle holder and retaining nut | 6.0 - 8.0   | 43 - 58      |
| Glowplug                        | 1.5 - 2.0   | 11 - 15      |

UNLESS OTHERWISE INDICATED

Grade 6T

|               |            |         |
|---------------|------------|---------|
| 6mm bolt/nut  | 0.7 - 1.0  | 5 - 7   |
| 8mm bolt/nut  | 1.6 - 2.3  | 12 - 17 |
| 10mm bolt/nut | 3.2 - 4.7  | 23 - 24 |
| 12mm bolt/nut | 5.6 - 8.2  | 41 - 59 |
| 14mm bolt/nut | 7.7 - 10.5 | 56 - 76 |

Grade 8T and 8.8

|               |             |          |
|---------------|-------------|----------|
| 6mm bolt/nut  | .8 - 1.2    | 6 - 9    |
| 8mm bolt/nut  | 1.8 - 2.7   | 13 - 20  |
| 10mm bolt/nut | 3.7 - 5.5   | 27 - 40  |
| 12mm bolt/nut | 6.4 - 9.5   | 46 - 69  |
| 14mm bolt/nut | 10.4 - 14.0 | 75 - 101 |

Grade 5 capscrew

|          |             |         |
|----------|-------------|---------|
| 1/4 UNC  | 1.2 - 1.5   | 9 - 11  |
| 1/4 UNF  | 1.5 - 1.8   | 11 - 13 |
| 5/16 UNC | 2.5 - 2.8   | 18 - 20 |
| 5/16 UNF | 2.9 - 3.2   | 21 - 23 |
| 3/8 UNC  | 3.7 - 4.6   | 28 - 33 |
| 3/8 UNF  | 4.1 - 4.8   | 30 - 35 |
| 7/16 UNC | 6.1 - 6.8   | 44 - 49 |
| 7/16 UNF | 6.9 - 7.6   | 50 - 55 |
| 1/2 UNC  | 9.4 - 10.1  | 68 - 73 |
| 1/2 UNF  | 10.1 - 11.1 | 73 - 80 |

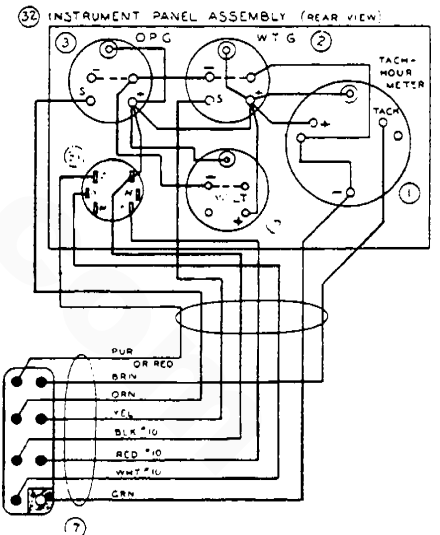
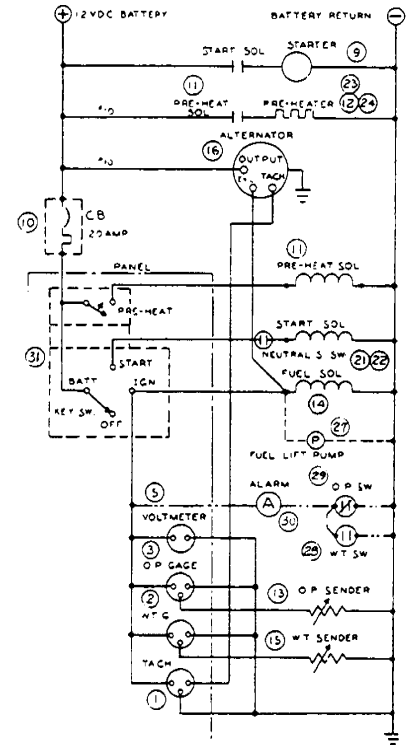
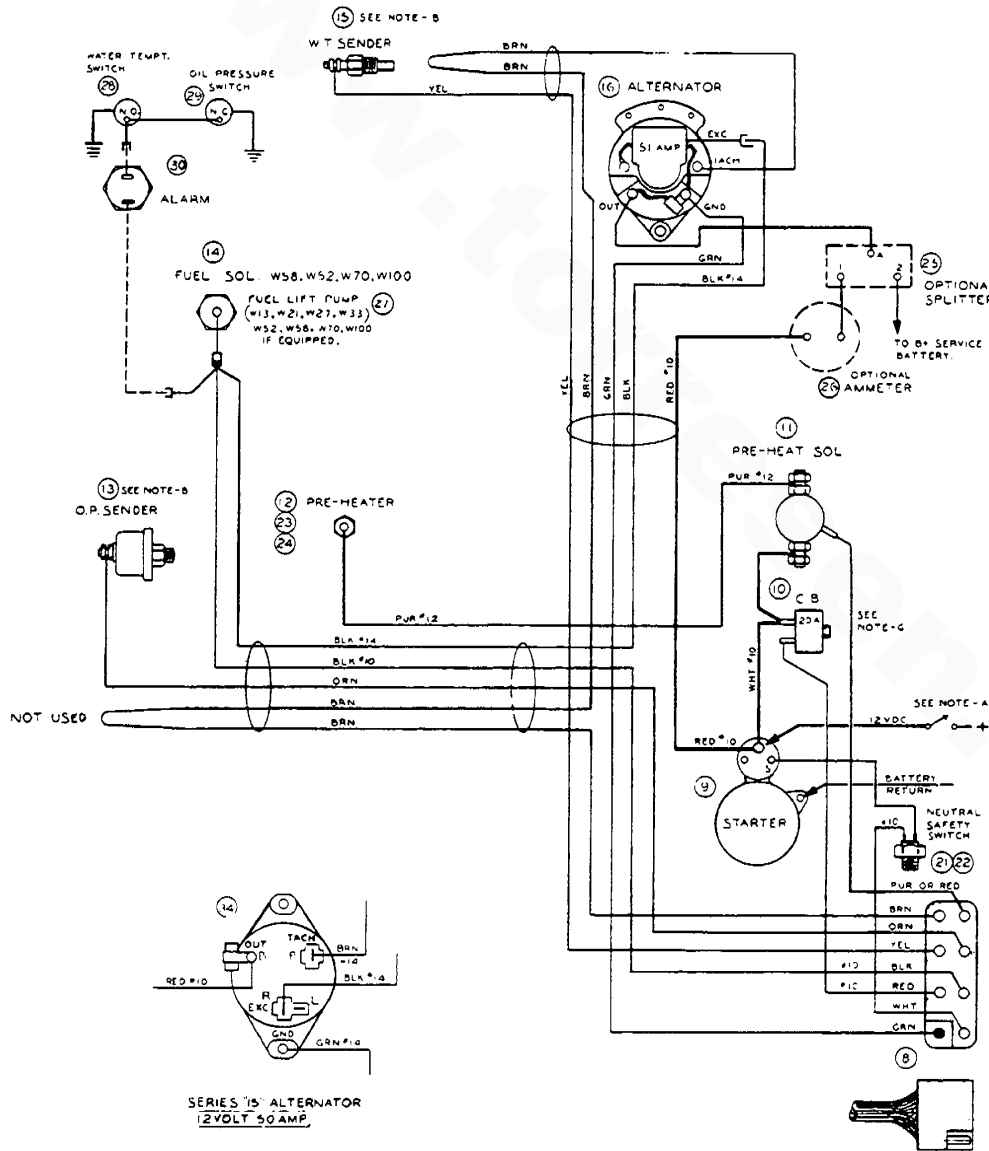
## OTHER OVERHAUL

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ACTIVATION BY KEYSWITCH

SCHEMATIC DIAGRAM

WIRING DIAGRAM



## MARINE ENGINE ELECTRICAL SYSTEM

### ACTIVATION BY KEYSWITCH

Turning the ignition switch ON activates the instrument panel. (The oil and water temperature gauges will zero, the voltmeter will indicate battery voltage and the hourmeter will start to record time. The alarm buzzer should sound. The electric fuel pump will start to operate.

Pushing the key will activate the preheat circuit. This closes a solenoid on the engine with an audible click and supplies 12 volts to the engine glow plugs. Preheat as needed for weather conditions. A noticeable voltage drop will indicate on the voltmeter when the preheat circuit is activated.

Continuing to preheat, turn the key to START. This energizes the starter and turns the engine over. Once the engine starts release the keyswitch. It should spring back to the ON position and pop out of the preheat position.

The voltmeter should indicate a charge from the alternator 13.5 - 14.5 volts. The oil pressure and the alarm buzzer should shut off. Oil pressure opens the oil pressure switch in the alarm circuit shutting off the alarm. The water temperature switch operates the opposite. It closes when an overheat condition exists and the operating temperature of the engine reaches 205° F and sounds the alarm. The tachometer will register engine speed as it takes impulses from the alternator as it charges. If the alternator does not produce a charge, the tachometer will not operate. The hourmeter will continue to record time. The hourmeter is on a separate 12 volt circuit.

The circuit is protected by a circuit breaker located on the engine. Any time excessive current flows, the circuit breaker will trip. This is a manual reset breaker which must be reset before the engine will operate electrically again.

**CAUTION:** The builder/owner must ensure that the instrument panel, wiring and engine are installed so that electrical devices cannot come in contact with sea water.

The latest information regarding your engine's electrical system is included on the wiring diagram shipped with the engine. Be sure to study this wiring diagram and all notes thereon.

### GLOW PLUG

A glow plug is provided in each combustion chamber in order to ensure smooth engine starting during the cold weather.

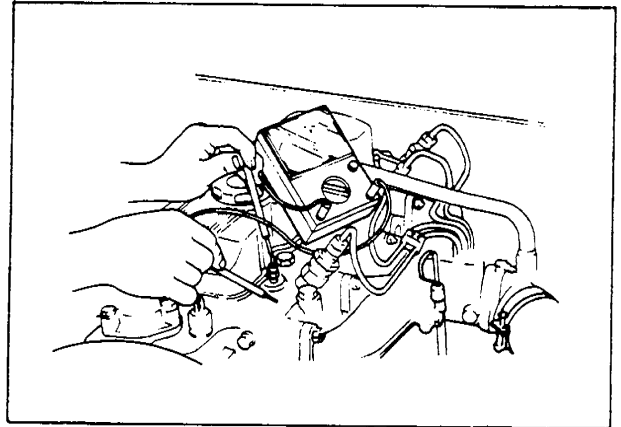
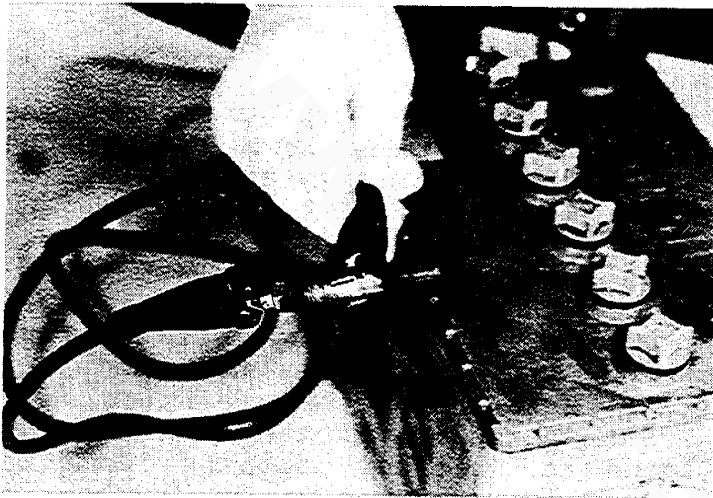
The tip of the glow plug glows red hot when energized on preheat.



When 12 volts positive is connected to the glow plug terminal and the negative to the sheathing, the glow plug tip should glow red-hot. To check, energize 2 to 4 times for about 30 seconds each. Do not energize too long because it will damage the plug.

If the glow plugs installed on the engine take too long to glow red-hot, one of the glow plugs is shorted. Usually the glow plug takes about 25 seconds or less to glow red-hot.

A glowplug can be checked for an open circuit fault by using a circuit tester and checking the continuity between the positive terminal on top of the glowplug and the cylinder head. If there is no continuity, the glowplug should be replaced.



VOLTMETER

The voltmeter can be a useful instrument in determining the status of your electrical system and warn you when an abnormality occurs. The voltmeter will indicate differently, depending when the readings are taken.

Fully charged batteries that are in a static state should read between 12.3 and 12.6 volts on the dial. The term static means that the battery has not been charged or discharged for at least 2 hours. If the reading is between 11 and 11.5 volts, then the battery is about half discharged and should be charged to insure its usefulness. If the engine is started and the needle does not go up, this would indicate that no charge is being delivered to the battery.

When the battery is being charged, the needle should be between 12.6 and 13 volts. The needle may move up to about the 14.6 volt range toward the end of the charge cycle, at which time the needle drops back to the 12.6 to 13 volt range, as voltage regulation controls this function. If the battery voltage exceeds 15 volts, this indicates that the battery is being overcharged and will damage the battery if left unchecked. The voltage regulator is most likely at fault.

When the battery is being charged, (having electrical loads placed upon it and no charging current applied), it is normal for the needle to indicate between 11.4 and 12.6 volts.

## TACHOMETER

The tachometer is operated by pulses generated from any one of the alternator phases. The pulse frequency is determined by the rotational speed of the alternator rotor. The rotor speed is dependent upon the engine crankshaft speed and the **RATIO** of the alternator pulley to the crankshaft pulley. The tachometer in an instrument panel is calibrated by Westerbeke for the standard alternator; if an optional alternator (i.e., 90 amp) is used to operate the tachometer, the calibration should be checked. Also, when a tachometer is replaced, the new instrument must be calibrated.

### CAUTION

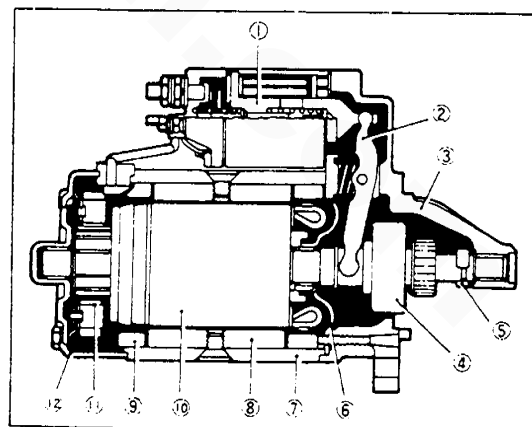
WHEN CALIBRATING THE TACHOMETER, USE A PHILLIPS SCREWDRIVER WITH AN INSULATED SHAFT.

1. Use a motor tester with an RPM indicator, another tachometer or a strobo-tach to determine the speed of the crankshaft turning.
2. Remove the plastic plug and flatwasher located on the rear of the tachometer.
3. Insert an insulated Phillips screwdriver into the calibration control slot and slowly turn counterclockwise to increase the RPM reading, clockwise to decrease reading (direction of screw as viewed from the rear of the tachometer case). An accurate calibration setting is more easily achieved at the higher side of the dial scale.
4. Replace plastic plug and flatwasher.

## STARTER

The starter is a DC series motor with a solenoid-operated pinion, which is smoothly moved by magnetic switch operation into and out of mesh with the flywheel ring gear.

It is made up roughly of a motor which generates power, an overrunning clutch which transmits the torque and prevents the overrunning after the engine starts, and a magnetic switch which moves the pinion into mesh with the ring gear and sends the load current to the motor.



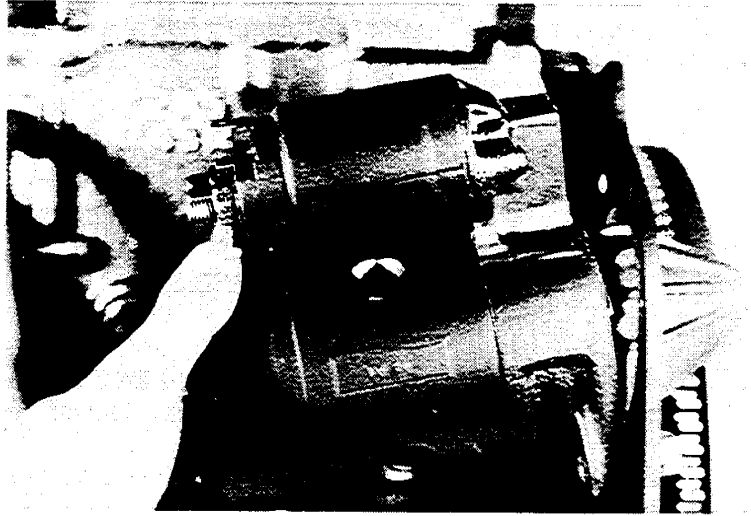
- |                        |                  |
|------------------------|------------------|
| 1. Magnetic switch     | 7. Yoke          |
| 2. Shift lever         | 8. Pole          |
| 3. Front bracket       | 9. Field coil    |
| 4. Over running clutch | 10. Armature     |
| 5. Stop ring           | 11. Brush        |
| 6. Center bracket      | 12. Rear bracket |

The stationary part consists of yoke, pole piece, field coil, front bracket, center and rear brackets and magnetic switch, and the rotating part consists of armature and over-running clutch.

The magnetic switch is made up of an iron core, plunger and connector coil, and the plunger and clutch are connected with a lever.

#### Disassembly

- (1) Turn the battery switch off or remove the ground terminal from the battery.
- (2) Remove the wires from B terminal and S terminal.
- (3) Remove the mounting nut, then the starter.



#### Checking

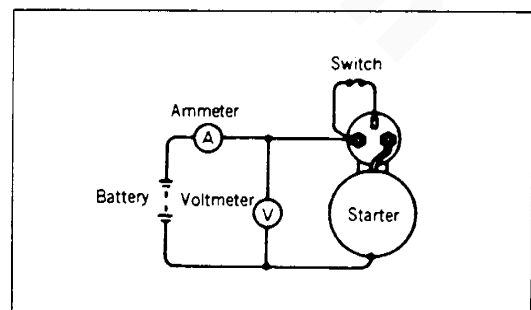
**CAUTION:** It is not necessarily a starter problem if the engine does not start even when the starter switch is depressed. The trouble may rest with the solenoid, circuit breaker, battery or engine itself. Therefore, check the circuit for starting without removing the starter, and if no abnormality is found, then remove it from the engine and test it.

#### (1) Checking of Starter Circuit

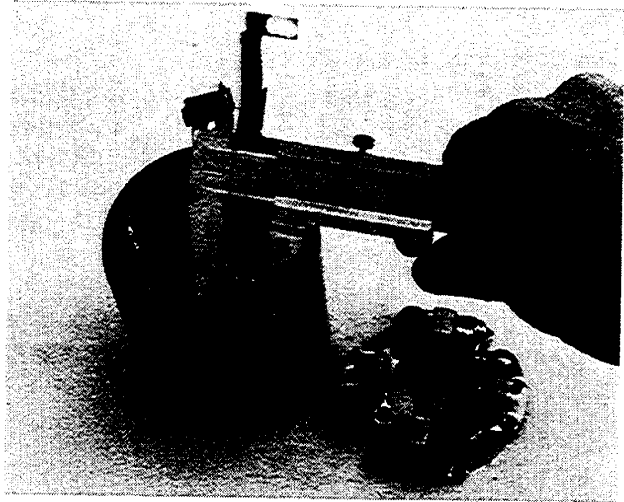
- (a) Battery state of charge
- (b) Battery connections clean and tight (battery switch ON)
- (c) Circuit breaker test
- (d) Proper size wire to starter
- (e) Good ground connection
- (f) Proper size battery (45 amp hour minimum)

#### (2) No-load Test

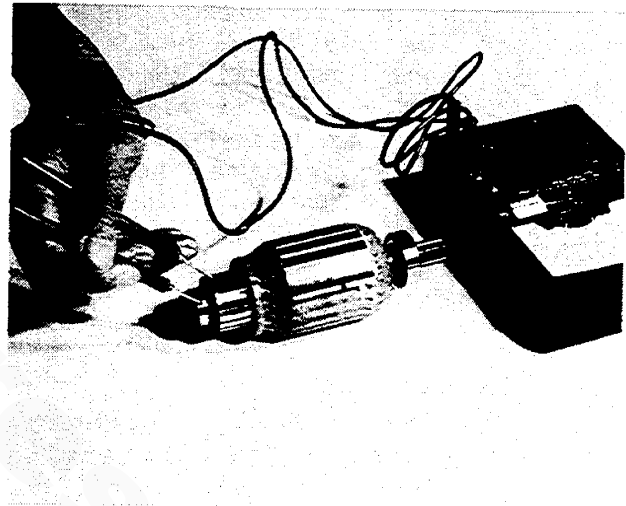
If the starter and battery are connected as illustrated and when the switch is closed, the starter will rotate. It is judged as normal if the starter rotates smoothly at the speed stated below. If any abnormality is found in this test, check in accordance with the following procedures.



- (a) Checking of brushes  
Check the brushes and the insulated condition of brush holders on the pressure (+) side of the brush spring.



- (b) Checking of armature  
1) Check for short circuit using a growler tester.  
2) Check grounding. There should be no continuity between the commutator and the armature shaft.  
3) Check commutator. Check undercut depth and roughness.



### (3) Checking of Field Coil

Check for grounding. There should be no continuity between one end (brush) of the coil and yoke. (In this case, the shunt coil grounding wire will be disconnected.)

Check for disconnection. There must be continuity at both ends of coil (between brushes).

Check condition of installation. If the pole piece and coil are loosened or damaged, replace them as yoke assembly. (The pole piece is caulked to the yoke.)

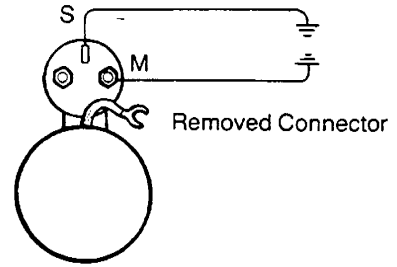
Check the solenoid. If the pinion fails to move out into mesh with the ring gear, check the solenoid in the following manner.

- (a) Continuity test  
Continuity must exist between the terminals (S) and (M) and between the terminal (S) and body. If the resistance is zero, it means the solenoid is defective and must be replaced.

(b) Pull-in Test

The pull-in coil is judged as normal if the plunger is attracted and the pinion comes out when the battery is connected between the solenoid terminals (S) and (M).

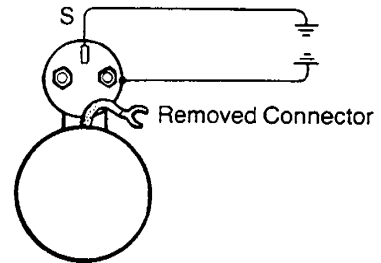
**CAUTION:** Do not apply voltage continuously for more than 10 seconds.



(c) Holding Test

With the battery connected between the solenoid terminal (S) and the body, pull out the pinion by hand as far as the pinion stopper. If the pinion does not return when released, the holding coil is considered normal.

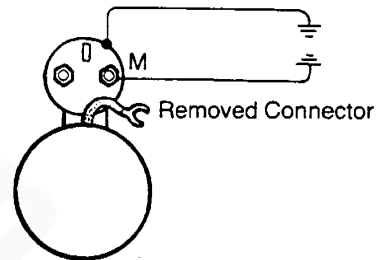
**CAUTION:** Do not apply voltage continuously for more than 10 seconds.



(d) Return Test

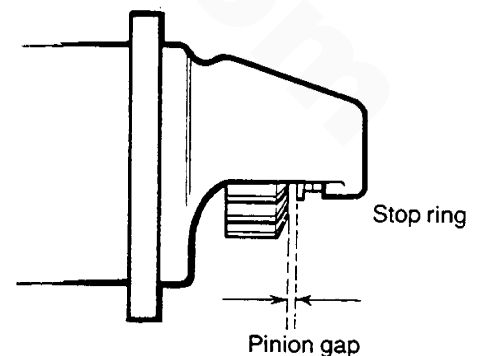
With the battery connected between the solenoid terminal (M) and the body, pull out the pinion by hand as far as the pinion stopper. If the pinion returns immediately when released, both coils are considered as normal.

**CAUTION:** Do not apply voltage continuously for more than 10 seconds.



(5) Checking of Pinion Gap

If the battery is connected between the solenoid terminal (S) and the starter body, the pinion will jump out and stop. In such a state, push the pinion lightly back toward the armature and measure the gap between the pinion and the stop ring. (Measured value of pinion gap should be 0.5 -2.0 mm.)



To adjust the clearance, increase or decrease the number of fiber washers on the solenoid mounting surface. Increasing the washers decreases the amount of clearance.

CAUTION: Avoid applying voltage continuously for over 20 seconds to prevent overheating of the solenoid.

In this test, after reassembling, if the pinion fails to jump out or if the pinion gap is too big or too small, faulty shift lever, improper installation of plunger spring or faulty solenoid is possible.

### Reassembly

For reassembling, reverse the order of disassembling.

CAUTION: In the installed position of the starter, the starter shaft must be exactly in parallel with the axis of center of the engine. The starter must be securely installed so it will not move when starting the engine. If the tightening is insufficient or if any foreign substance exists on the mounting surface, the bracket may be broken or cocking of the starter may occur. Insure the mounting surfaces are clean.

The starter performance largely depends on the wiring and battery. Use proper size wire for the distance between the battery and the starter and tighten the terminals securely.

### ALTERNATOR

#### CAUTION:

DO NOT USE A HIGH-VOLTAGE TESTER SUCH AS A MEGGER; OTHERWISE A DAMAGED DIODE RESULTS.

DURING HIGH-SPEED OPERATION OF THE ENGINE, DO NOT DISCONNECT THE POSITIVE OR NEGATIVE TERMINAL OF THE BATTERY FROM THE (A) TERMINAL OF THE REGULATOR. A VOLTAGE SURGE WILL OCCUR THAT WILL DAMAGE ALTERNATOR DIODES SHOULD THESE CONNECTIONS BE OPENED.

DO NOT RUN THE ENGINE WITH THE LEAD DISCONNECTED FROM THE (B) TERMINAL OF THE ALTERNATOR. THE INTERNAL REGULATOR VOLTAGE COIL WILL BE DAMAGED.

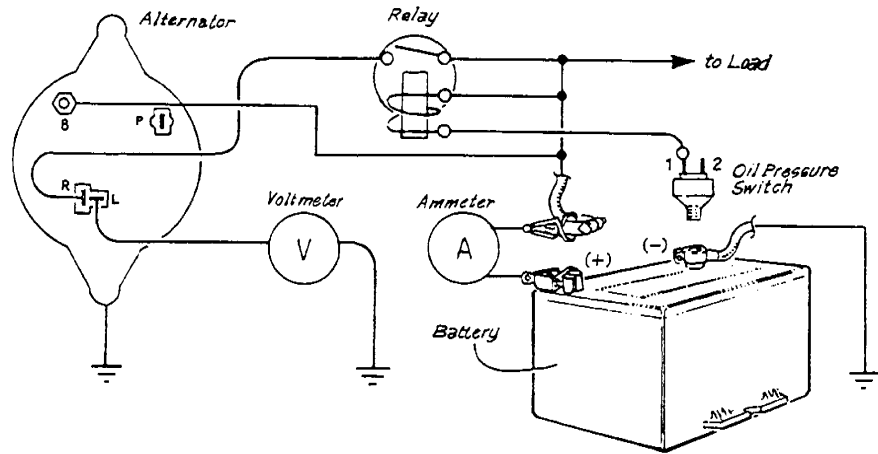
WHEN MAKING A RAPID CHARGE OF BATTERY USING A QUICK CHARGER, BE SURE TO DISCONNECT THE BATTERY CABLES; OTHERWISE DAMAGED ALTERNATOR DIODES WILL RESULT.

WHEN USING A STEAM CLEANER, BE CAREFUL NOT TO ALLOW DIRECT CONTACT OF STEAM WITH THE ALTERNATOR.

The charging system consists of an alternator with internal voltage regulator, engine mounted circuit breaker, battery and connecting wires. Because of the use of IC's (integrated circuits), the electronic voltage regulator is very compact and is built in the rear bracket of the alternator.

Charging Voltage Test

1. Turn keyswitch off on marine engines or disconnect the oil pressure switch wire on generator sets.
2. Disconnect cable from positive (+) terminal of battery and connect an ammeter in series between the cable and positive (+) terminal of the battery.



3. Connect a voltmeter between terminal (L) of alternator and ground. Check to ensure that the voltmeter reading is zero. If the pointer of the voltmeter deflects (a voltage present), a defective alternator or wiring is suspected.
4. Turn keyswitch on or connect the oil pressure switch terminal to ground, but do not start the engine. The voltmeter reading should be considerably lower than the battery voltage. If the voltmeter reading is much the same as the battery voltage, a defective alternator is suspected.
5. With the ammeter terminals short-circuited, start the engine.

CAUTION:

MAKE SURE THAT WHEN THE ENGINE IS STARTED, NO STARTING CURRENT IS APPLIED TO THE AMMETER.

6. Remove the short circuit across the ammeter terminals and increase the engine speed immediately to approximately 2,000 to 3,000 rpm. Take the ammeter reading.
7. If the ammeter reading is 5A or less, take the voltmeter reading without changing the engine speed (2,000 to 3,000 rpm). The reading is the charging voltage.

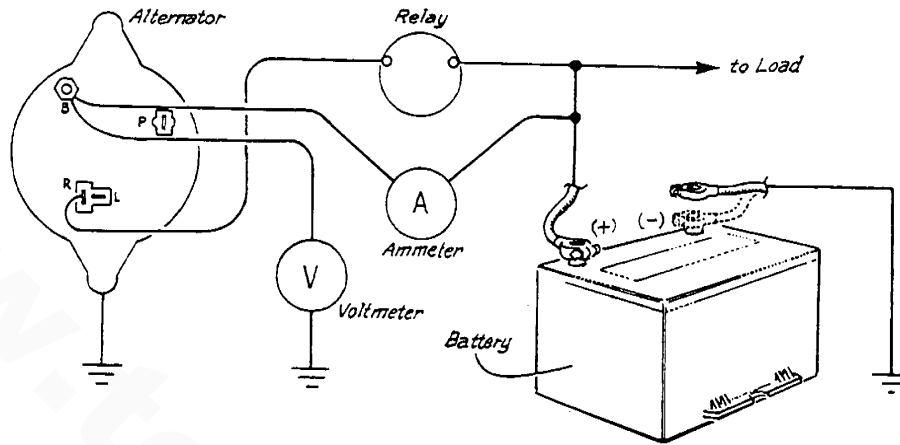
NOTE: Since the electronic voltage regulator is a temperature compensation type, the charging voltage varies with temperature. Therefore, the temperature around the rear bracket of the alternator must be measured and the charging voltage corrected to the temperature.

| Description                       | Standard value                 |
|-----------------------------------|--------------------------------|
| Charging voltage                  | 14.4 $\pm$ 0.3V at 20°C (68°F) |
| Temperature compensation gradient | -0.1V/10°C (50°F)              |

8. If the ammeter reading is more than 5A, continue to charge the battery until the reading falls to less than 5A or replace the battery with a fully charged one. An alternative method is to limit the charging current by connecting 1/4 ohm (25W) resistor in series with the battery.

Output Test

1. Disconnect the battery ground cable.
2. Disconnect the cable from terminal "B" of alternator and connect an ammeter between terminal "B" and this cable.
3. Connect a voltmeter between terminal "B" (+) and ground (-).
4. Set the engine tachometer.



Note: The RPM is that of the alternator. The pulley ratio (alternator vs. crank pulley) is 1.78 to 1. All readings are at 13.5 VDC.

5. Connect battery ground cable to battery. The voltmeter should indicate the battery voltage.
6. Start the engine.
7. Turn on the 12 volt accessories equaling the amperage output of the alternator, accelerate the engine to the specified speed (2000 to 3000 RPM) and measure the output current. The output current should be close to alternator maximum output.

| Output current     | 1300 RPM | 2500 RPM | 5000 RPM |
|--------------------|----------|----------|----------|
| Cold 20° C (68° F) | 7 amp    | 30 amp   | -        |

Disassembly

1. After removing the three through bolts, insert a screwdriver between the front bracket and stator. While prying it, remove the front bracket and rotor.  
NOTE: If the screwdriver is inserted too deep, the stator coil might be damaged.
2. Hold the rotor in a vise and remove the pulley nut. Then remove the pulley, fan, spacer and seal. Next, remove the rotor from the front bracket and remove the seal.
3. Unsolder the rectifier from the stator coil lead wires and remove the stator assembly.



NOTE: Make sure that the solder is removed quickly (in less than five seconds). If a diode is heated to more than 150°C (310°F), it might be damaged.

4. Remove the condenser from terminal "B".

5. Unsolder the plates "B" and "L" from the rectifier assembly.

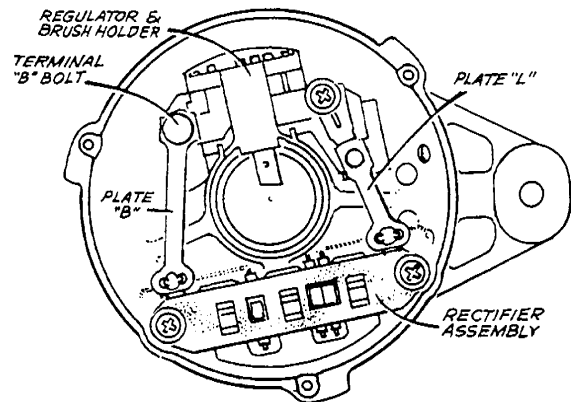
6. Remove the mounting screw and "B" terminal bolt and remove the electronic voltage regulator and brush holder. The regulator and brush holder cannot be separated.

7. Remove the rectifier assembly.

8. Brush and brush spring replacement.

When only a brush or brush spring is to be replaced, it can be replaced without removing the stator, etc. With the brush holder assembly raised as shown, unsolder the pig-tail of the brush.

NOTE: If the terminals "L" and "B" of the rectifier assembly are bent, damage might result to the rectifier molding. Therefore, the plates "B" and "L" should be gently bent at the center.

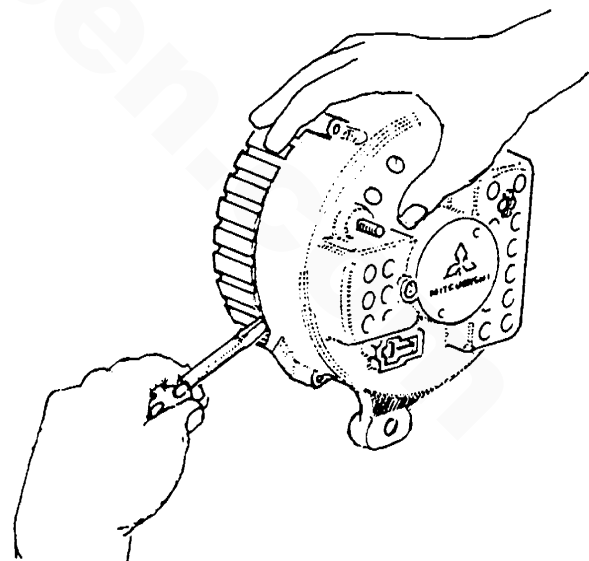


Alternative method for disassembling the stator winding, brush-holder/regulator unit and the integrated circuit/diode rectifier assembly from the rear bracket.

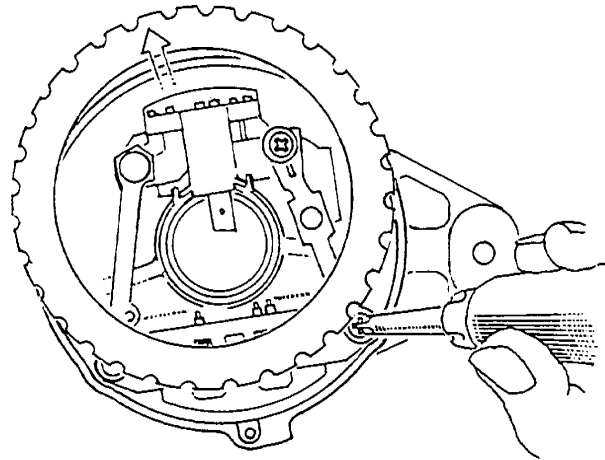
Once the front bracket and rotor assembly are separated from the rear half of the alternator:

1. Insert a flat-bladed screwdriver between the stator core and the edge of the rear bracket on the same side as the brush-holder. Raise this side of the stator core away from the bracket so as to open a gap of about 1/2 inch. BE CAREFUL NOT TO ALLOW THE SCREWDRIVER BLADE TO ENTER FAR ENOUGH TO TOUCH THE STATOR WINDING.

2. Maintaining the 1/2 inch gap, insert the screwdriver between the stator core and the bracket on the rectifier side and move the stator laterally towards the brush-holder for a distance of 1/2 to 3/4 of an inch without lifting it from the bracket.



3. Insert a #2 Philips screwdriver through this opening and remove the two screws holding the rectifier.
4. Remove the nut anchoring the "B" terminal bolt and the capacitor mounted thereto on the outside rear of the bracket. Then remove the third Philips screw holding the brush-holder to the bracket.
5. Carefully withdraw stator, brush-holder and rectifier from the rear bracket as one loosely connected unit.



With the bracket out of the way, it is easy to unsolder the stator winding leads from the rectifier quickly to avoid heat damage to the diodes and I.C. chips. It is also easier to renew brushes because there is no need to bend the connecting plates between the brush-holder and the rectifier and possible damage the rectifier molding.

When reversing this procedure, make sure that the stator winding leads are gently pushed back (from possible contact with the rotor body) after seating the stator into the rear bracket.

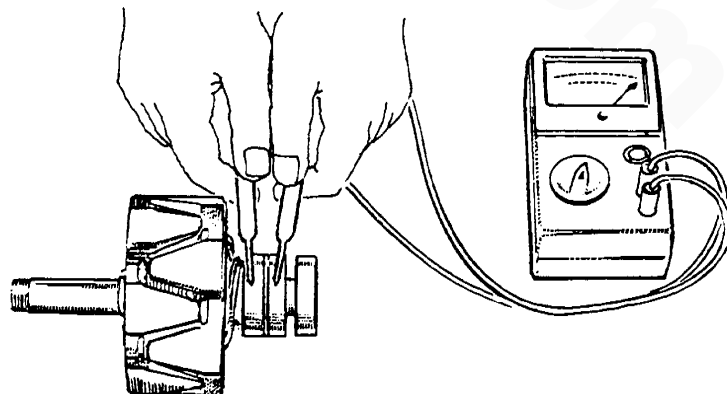
Inspection

Rotor Assembly

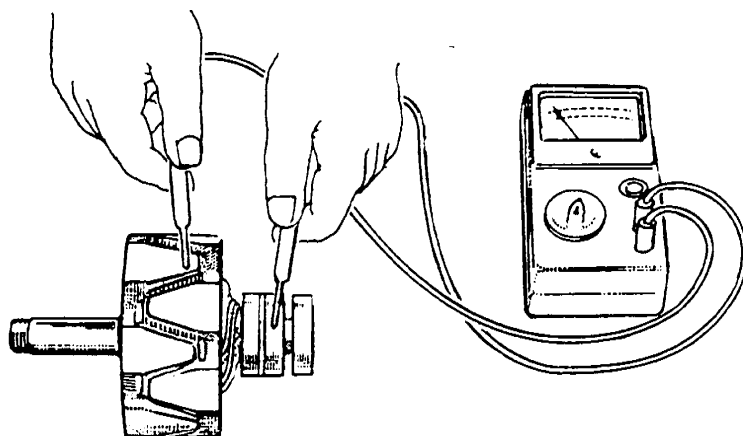
1. Check the outside circumference of the slip ring for dirtiness and roughness. Clean or polish with fine sandpaper, if required. A badly roughened slip ring or a slip ring worn down beyond the service limit should be replaced.

| Description    | Standard value<br>mm (in.) | Service limit<br>mm (in.) |
|----------------|----------------------------|---------------------------|
| Slip ring O.D. | 33 (1.2992)                | 32.2 (1.2677)             |
| Runout         | 0.03 (.0012)<br>or less    | 0.2 (.008)                |

2. Check for continuity between the field coil and slip ring. If there is no continuity, the field coil is defective. Replace the rotor assembly.

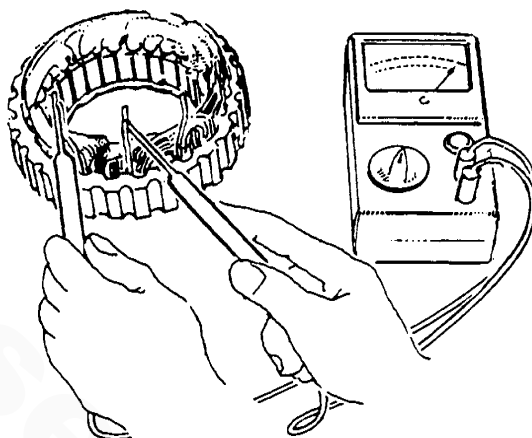


3. Check for continuity between the slip ring and shaft (or core). If there is continuity, it means that the coil or slip ring is grounded. Replace the rotor assembly.

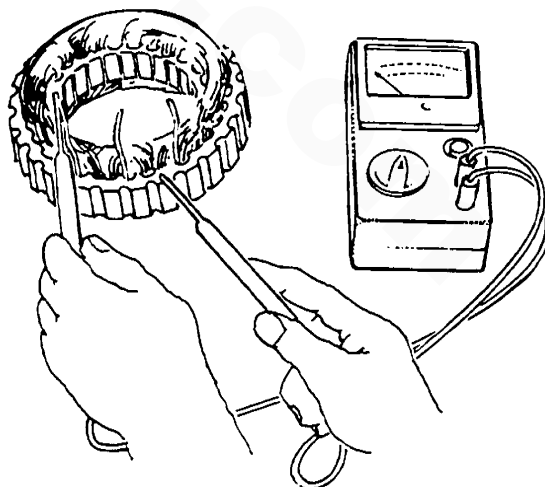


### Stator Assembly

1. Check for continuity between the leads of the stator coil. If there is no continuity, the stator coil is defective. Replace the stator assembly.



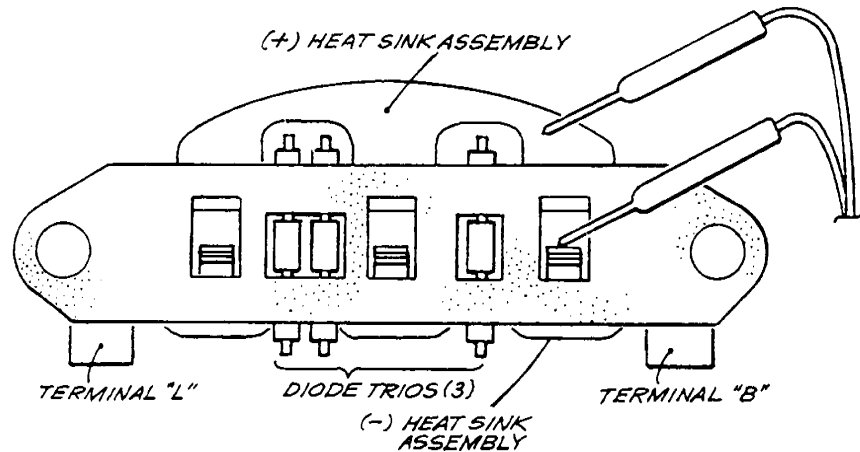
2. Check for an open circuit between the stator coil leads and the stator core. If there is continuity, the stator is grounded and must be replaced.



Rectifier Assembly

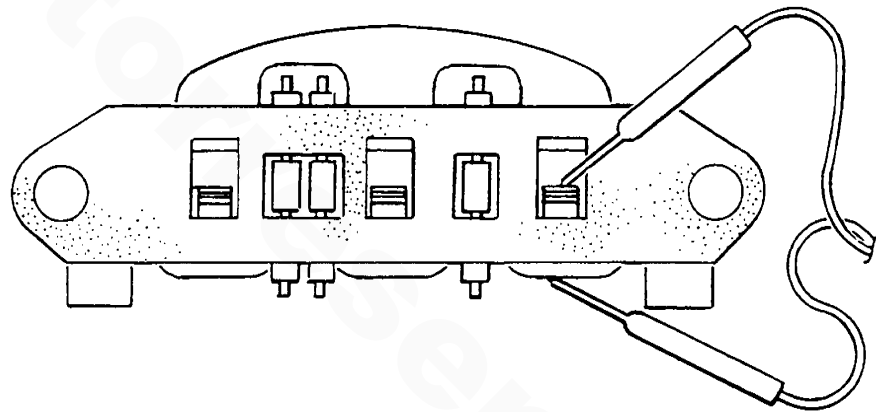
(+) Heatsink Assembly Test

Check for continuity between the (+) heatsink and stator coil lead connection terminal with an ohm meter. If there is continuity in both directions, the diode is short-circuited. Replace the rectifier assembly.



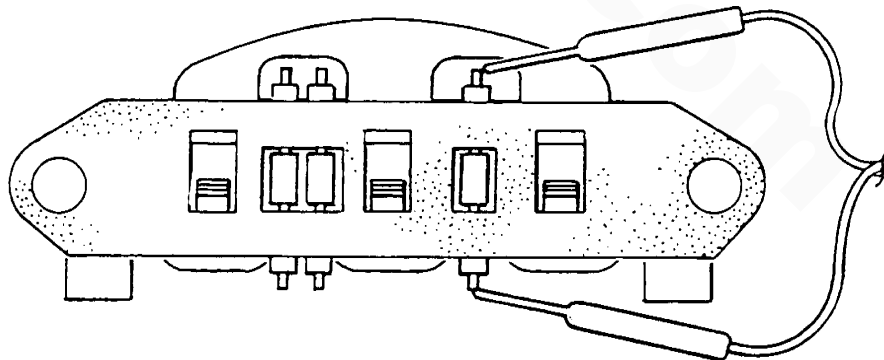
(-) Heatsink Assembly Test

Check for continuity between the (-) heatsink and stator coil lead connection terminal. If there is continuity in both directions, the diode is short-circuited. Replace the rectifier assembly.



Diode Trio Test

Using an ohm meter, check the three diodes for continuity in both directions. If there is either continuity or an open circuit in both directions, the diode is defective. Replace the rectifier assembly.



Brush and Brush Rig

1. Check the length of the brush. A brush worn down to the service limit line should be replaced.

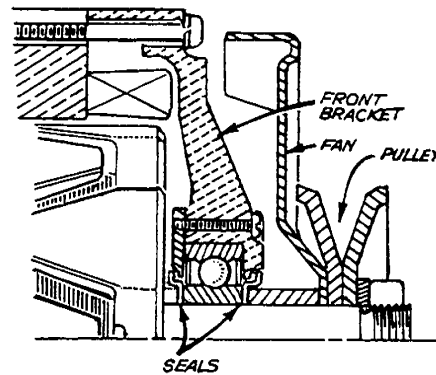
| Description          | Standard value                   | Service limit    |
|----------------------|----------------------------------|------------------|
| Length of brush      | 18 mm (.709 in.)                 | 8 mm (.315 in.)  |
| Load of brush spring | 3.04 to 4.22 N<br>(.7 to 1 lbs.) | 2.06 N (.5 lbs.) |

2. Check the brush spring pressure to make sure the brush moves smoothly in the brush holder.

Reassembly

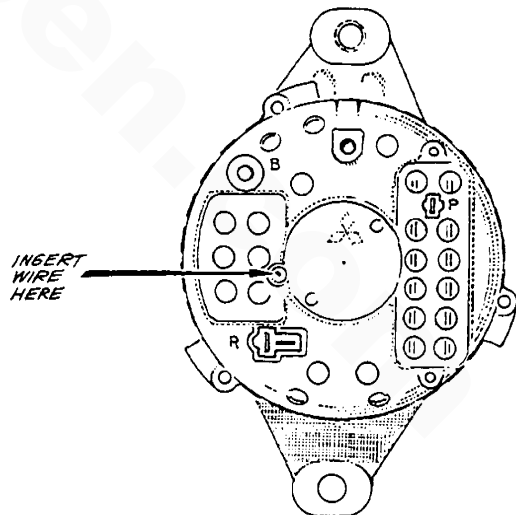
Reverse the disassembly procedure but pay special attention to reassembly of the following.

1. Install seals in front and rear of the front bearing as shown.



2. To install the rotor assembly in the rear bracket, push the brushes into the brush holder, insert a wire to hold them in raised position, and then install the rotor.

NOTE: After installation, remove the wire.



SERVICE BULLETINS

Please refer to the Service Bulletin Section at the rear of the manual as there are several that relate to the electrical system.

## COOLING SYSTEM (EXTERNAL)

### 1. DESCRIPTION

Westerbeke marine diesel engines are equipped with fresh water cooling. Transfer of heat from engine fresh water to sea water is accomplished by a heat exchanger, similar in function to an automotive radiator. Sea water flows through the tubes of the heat exchanger while fresh water flows around the tubes. The sea water and fresh water never mix with the result that the cooling water passages in the engine stay clean.

### 2. FRESH WATER CIRCUIT

Heat rejected during combustion, as well as heat developed by friction, is absorbed by the fresh water whose flow is created by a fresh water circulating pump. The fresh water flows from the engine through a fresh water cooled exhaust manifold, a heat exchanger, in most cases an oil cooler, and returns to the suction side of the fresh water circulating pump. The flow is not necessarily in this order in every model. When starting a cold engine, most of the external flow to the heat exchanger is prevented by the closed thermostat. Some amount of by-pass is maintained to prevent overheating in the exhaust manifold. As the engine warms up, the thermostat begins to open up allowing full flow of engine fresh water through the external cooling system.

### 3. SEA WATER CIRCUIT

The sea water flow is created by a positive displacement neoprene impeller pump (gear pump in certain special cases). Normally the pump draws sea water directly from the ocean via the seacock and sea water strainer. Sometimes a transmission oil cooler, or perhaps a V-drive, will be piped on the suction side of the sea water pump. Generally, it is better to have as few devices on the suction side of the sea water pump as possible to preclude priming difficulties. Usually sea water flows directly from the discharge of the sea water pump to the heat exchanger sea water inlet. After passing through the tubes of the heat exchanger, the sea water may enter a transmission oil cooler, if present and if sea water cooled. Ultimately, the sea water enters a water injected, wet exhaust system, the most popular type of exhaust system in use. In the case of larger engines the sea water flow is divided prior to entering the exhaust systems so that a portion is used to cool the exhaust system. Full sea water flow would create unnecessary exhaust back pressure.

### 4. SEA WATER PUMP

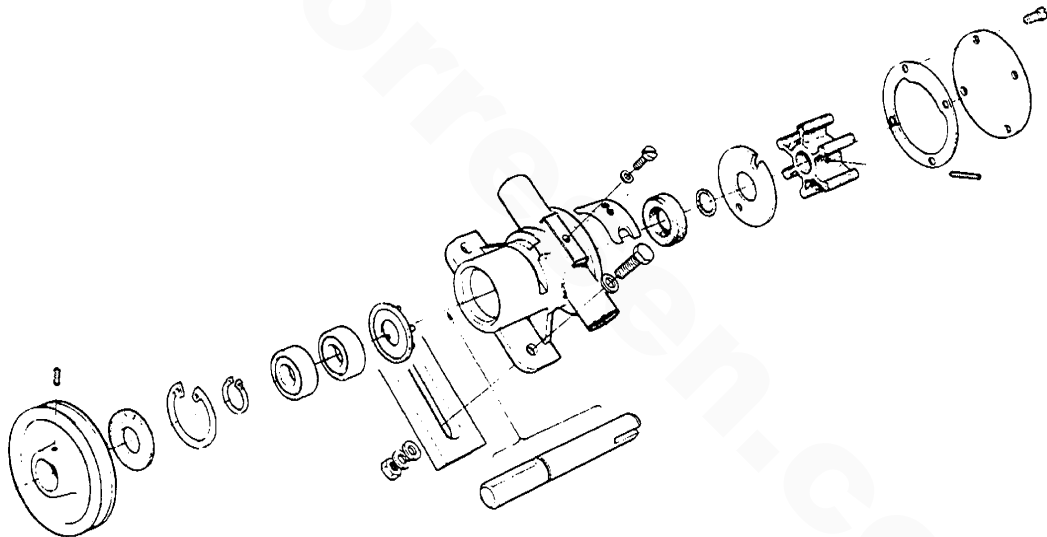
The sea water pump is self priming and positive displacement. It is a rotary pump with a non-ferrous housing and a neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate within the impeller housing, producing the pumping action. On no account should this pump be run dry. There should always be a spare impeller and impeller cover gasket aboard.

#### 5. SEA WATER PUMP #32617 IMPELLER REPLACEMENT

The following instructions are general and indicative only. Specific instructions where applicable may be packaged with your replacement impeller.

- (a) Remove the four screws and washers that hold the front cover to the pump body. Remove the cover and gasket.
- (b) Grasp the impeller hub with a pair of pliers and withdraw the impeller.
- (c) Apply a small amount of petroleum jelly to impeller blade ends of new impeller. Line up impeller hub screw with slot in pump shaft and insert impeller into pump until flush with cover mounting surface.
- (d) Immerse the new gasket in water for a moment before installing. Install the gasket, cover, screws and washers.

Note: No sealant is needed on the cover gasket for proper sealing. In you intend to reuse the cover gasket, immerse it in water until reassembly of the cover. The gasket will shrink when dried out.



#### 6. SEA WATER PUMP #32617 - SEAL REPLACEMENT

- (a) Remove the pump from the mounting bracket and remove the drive pulley.
- (b) Remove the front cover and impeller as above. Remove the cam and inner wear plate.
- (c) Remove the plastic bearing shield from the pulley shaft end of the pump with the aid of a small screwdriver. Push through the small recess in the outer circumference of the shield and pry it out. With snap ring pliers, remove the large outer snap ring positioned in the pump body.

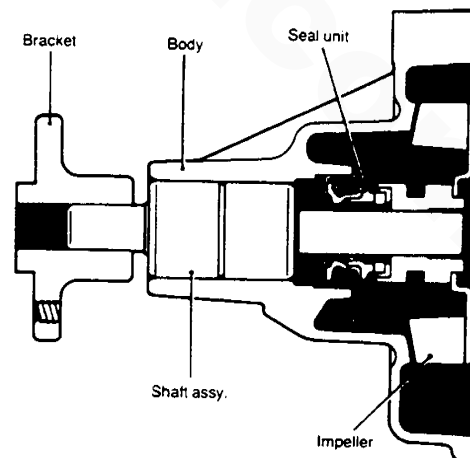
- (d) Support the pump and with a soft dowel that fits into the slot of the shaft. Carefully press the shaft out of the pump. (Press away from the impeller bore.) In most instances the bearings, plastic spacer and O-ring will come out with the shaft. If the bearings remain in the pump when pressing out the shaft, be sure to support the bearings by the inner race.
- (e) Reach in from the impeller bore side and withdraw the seal with needle nose pliers. Clean the seal area.
- (f) Apply a liberal amount of petroleum jelly to the seal lip and then dip the seal in water and press the seal squarely into the seal bore, lip facing the impeller bore. Use the inner wear plate to position the seal flush with the impeller bore inner surface.
- (g) Apply lubricant to pump shaft and bearings outer surface. Position plastic spacer and O-ring on shaft. Press bearings and shaft assembly on outer race of bearings. Take care to see that the shaft passes through the seal without damaging it. Press the shaft assembly in until it bottoms in the pump body. Rotate the shaft to insure it is free.
- (h) Replace the large outer snap ring and plastic bearing shield.
- (i) Replace the inner wear plate and cam. Apply a small amount of sealant to the cam inner surface and the screw holding screw. The inner wear plate, if worn or grooved, can be reversed.
- (j) Replace the impeller as described in #5.

#### 7. SEA WATER PUMP #32617 - SHAFT AND BEARING REPLACEMENT

If shaft and bearing replacement become necessary, it is recommended that the pump be replaced.

#### 8. FRESH WATER PUMP

The water pump is a centrifugal impeller type and is installed at the front top of the crankcase. The pump shaft is supported on maintenance-free double-row radial ball bearings which are greased and sealed.





### Disassembly

- (a) Drain the cooling water. (The drain plug is located on the right-hand side of the crankcase.)
- (b) Remove the water hose.
- (c) Remove the alternator and sea water pump belts.
- (d) Remove the pulley.
- (e) Remove the water pump assembly.

### Inspection

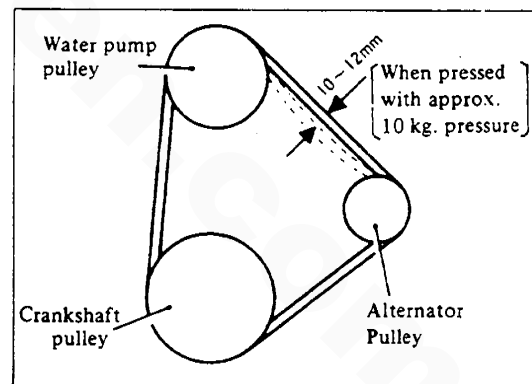
- (a) Check the parts for cracks, damage and water leakage, and if defective, replace.
- (b) Check the rotating condition of the impeller and shaft. If they make noise or do not rotate smoothly, replace them as an assembly.
- (c) Check the fan (if equipped) for cracks and damage, and if defective, replace.
- (d) Check the belts for elongation and cracks due to deterioration, and if defective, replace.

### Reassembly

For reassembling, reverse the order of disassembly. The alternator belt adjustment can be made in the following manner.

#### (a) Adjustment of Alternator Belt

The alternator belt should deflect 10 to 12 mm deep when pressed at the center point between the water pump pulley and the alternator or alternator pulley. Adjust the alternator belt tension by moving the alternator. After adjustment, securely tighten the pivot bolt and adjusting arm bolt.



## 9. ENGINE FRESH WATER

It is preferable to fill your engine with a 50% antifreeze-water mixture. This precludes the necessity of draining coolant in the winter. Since most antifreezes contain preservative agents of one kind or another, rusting within the engine is minimized. Also, the antifreeze mixture boils at a higher temperature than water, giving cooling system "head room".

When draining the engine, open the pressure cap first to relieve the vacuum created by draining.

#### 10. FILLING THE FRESH WATER SYSTEM

It is very important to completely fill the fresh water system before starting the engine. It is normal for air to become trapped in various passages so all high points must be opened to atmosphere to bleed entrapped air. When an engine is started after filling with coolant, the system may look deceptively full until the thermostat opens. At this time when water flows through the external cooling circuit for the first time, pockets of air can be exposed and rise to the fill point. Be sure to add coolant at this time.

After a number of seasons' use of the engine, water scale and rust may occur in the block water jacket and exchanger, resulting in considerable reduction of cooling efficiency. Therefore, it is necessary to flush the cooling system once every two or three years.

**CAUTION:** Adhere to the manufacturer's instructions when using the additive. Do not mix different brand products. Be sure to put the proper amount of antifreeze in water and agitate well before adding it to the cooling system. Do not use a concentrated antifreeze solution.

#### 11. THERMOSTAT

Generally, thermostats are of two types. One is simply a choking device which opens and closes as the engine temperature rises and falls. The second type has a by-pass mechanism. Usually this is a disc on the bottom of the thermostat which moves downward to close off an internal by-pass passage within the head. Both types of thermostats, from 1980 onwards, have a hole punched through them to serve as a by-pass while the engine is warming up. This prevents overheating in the exhaust manifold during engine warm-up. Replacement thermostats must be equal in this design characteristic.

When replacing a thermostat, be sure that it is rotated so as to not strike the thermostat housing, projections inside the head, temperature senders or temperature switches which may be installed close to the thermostat. Also insure the by-pass hole is not blocked by any part of the housing.

A thermostat can be checked for proper operation by placing it in a pan of cold water and then raising the temperature of the water to a boil. The thermostat should open noticeably (with travel on the order of 1/4" - 1/2") and be fully opened when the water is boiling.

#### 12. WATER TEMPERATURE SWITCH

The water temperature switch is located in the thermostat housing at the front of the cylinder head. This switch will close on a propulsion at 205° F to activate an alarm buzzer and on a generator engine it will open to de-energize the fuel run solenoid to shut the engine off.

### 13. WATER TEMPERATURE SENDER

The water temperature sender is located in the thermostat housing at the front of the cylinder head. It senses the temperature of the water flowing through the thermostat and electrically transmits this reading to a water temperature gauge in the engine instrument panel.

### 14. TRANSMISSION OIL COOLER

Certain transmissions require oil cooling. In these cases, the transmission oil cooler is usually cooled by sea water.

Normally, sea water enters this cooler after exiting the heat exchanger, but not always.

## **TRANSMISSIONS**

## HBW SHORT PROFILE SAILING GEAR

### DESCRIPTION

#### 1. BRIEF DESCRIPTION

The Type HBW Short Profile Sailing Gears are equipped with a positively driven, mechanically operated helical gearing system. The servo-operated multiple-disc clutch requires only minimum effort for gear changing, making the transmission suitable for single-lever remote control via a rod linkage, Morse or Bowden cable.

The torque transmission capacity of the clutch is exactly rated, preventing shock loads from exceeding a predetermined value and thus ensuring maximum protection of the engine.

The transmission units are characterized by low weight and small overall dimensions. The gearbox castings are made of a high-strength, corrosion-resistant aluminum alloy, chromized for improved sea water resistance and optimum adhesion of paint.

The transmissions are immersion-lubricated. Maintenance is restricted to oil level checks (see "Maintenance").

#### 2. GEAR CASING

The rotating parts of the HBW transmission are accommodated in an oil-tight casing divided into two halves in the plane of the vertical axis. Amply dimensioned cooling ribs ensure good heat dissipation and mechanical rigidity.

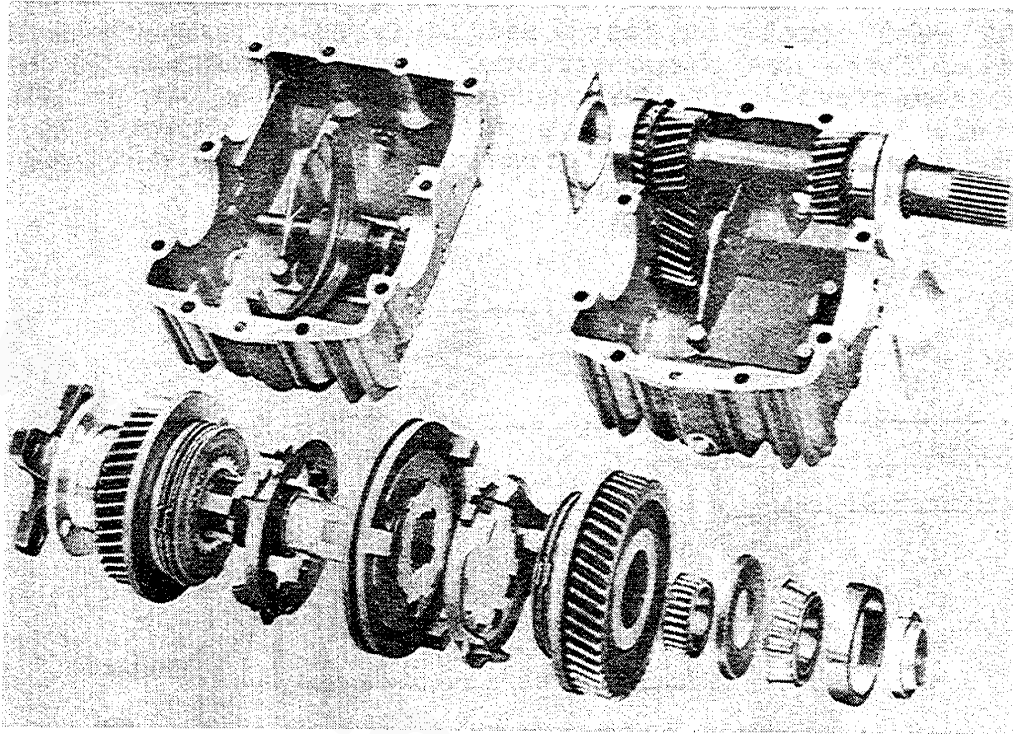
An oil filler screw with dipstick and an oil drain plug are screwed into the gear casing. The filler screw is provided with a breather hole.

The shaft for actuating the multiple-disc clutch extends through a cover on the side of the gear casing.

#### 3. GEAR SETS

The transmission is equipped with shaved, casehardened helical gears made of forged low-carbon alloy steel. The multi-spline driving shaft connecting the transmission with the engine is hardened as well.

The driven shaft (propeller side) of the transmission is fitted with a forged coupling flange, except on the V-drive model.



#### 4. MULTIPLE-DISC CLUTCH INCLUDING OPERATION - POWER TRAIN

The engine torque is applied to the input shaft (36) in the specified direction of rotation and, IN SHIFTING POSITION A (forward), via gear (44), the frictionally engaged clutch discs (51 and 52) to the external disc carrier (57) and from there via the guide sleeve (59) to the output shaft (66).

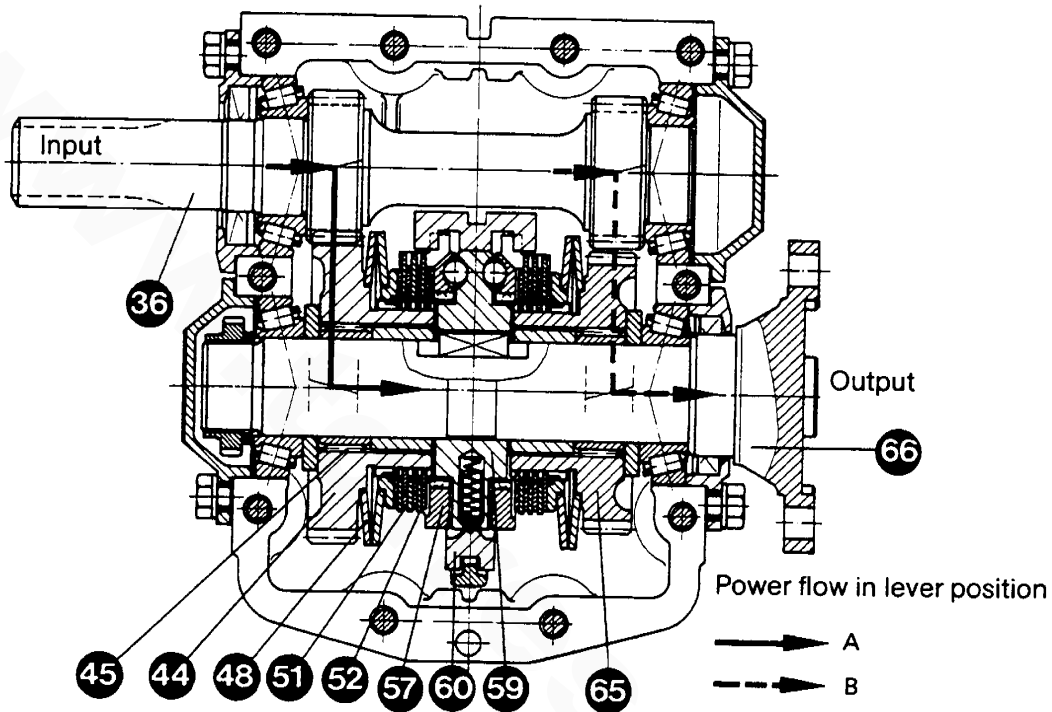
IN SHIFTING POSITION B (reverse), the torque is transmitted from the input shaft (36) via intermediate gear (26), gear (65), clutch discs (51 and 52) to the external disc carrier (57), the guide sleeve (59) and the output shaft (66).

#### - FUNCTION

The transmission uses a positively driven, mechanically operated multiple-disc clutch system mounted on the output shaft.

The thrust force required for obtaining positive frictional engagement between the clutch discs is provided by a servo system. This essentially comprises a number of balls which, by the rotary movement of the external disc carrier, are urged against inclined surfaces provided in pockets between the guide sleeve and the external disc carrier and in this manner exert axial pressure. The thrust force and, as a result, the transmittable friction torque are thus proportional to the input torque applied. Due to the cup springs (48) supporting the clutch disc stack and a limitation of the range of axial travel of the external disc carrier (57), the thrust force cannot exceed a predetermined value.

The actuating sleeve (60) is held in the middle position by spring-loaded pins. To initiate the shifting operation, the actuating sleeve (60) need merely be displaced axially by a shifting fork until the arresting force has been overcome. Then the actuating sleeve (60) is moved automatically by the spring-loaded pins, while the external disc carrier, which follows this movement, is rotated by the frictional forces exerted by the clutch discs, and the shifting operation is completed as described above.



## 5. SHAFT BEARINGS

Both the input and the output shafts are carried in amply dimensioned taper roll bearings.

The intermediate gear and the movable gears are carried in sturdy needle roller bearings.

## 6. SHAFT SEALS

External sealing of the input and output shafts is provided by radial sealing rings. The running surface on the shafts is casehardened.

## 7. LUBRICATION

The transmissions are immersion-lubricated. The bearings are generously supplied with splash oil and oil mist.

## INSTALLATION

### 1. DELIVERY CONDITION

For safety reasons, the gearbox is NOT filled with oil for shipment. The actuating lever is mounted on the actuating shaft.

Before leaving the factory, each transmission is subjected to a test run with the prescribed ATF oil. The residual oil remaining in the transmission after draining acts as a preservative and provides reliable protection against corrosion for at least 1 year if the units are properly stored.

### 2. PAINTING THE GEARBOX

ALWAYS COVER THE RUNNING SURFACES AND SEALING LIPS OF THE RADIAL SEALING RINGS ON BOTH SHAFTS BEFORE PAINTING. Make certain that the breather hole on the oil filler screw is not closed by the paint. Indicating plates should remain clearly legible.

### 3. CONNECTION OF GEARBOX WITH ENGINE

A torsio-elastic damping plate between the engine and the transmission is to compensate for minor alignment errors and to protect the input shaft from external forces and loads. Radial play should be at least 0.5 mm.

### 4. SUSPENSION OF ENGINE-GEARBOX ASSEMBLY IN THE BOAT

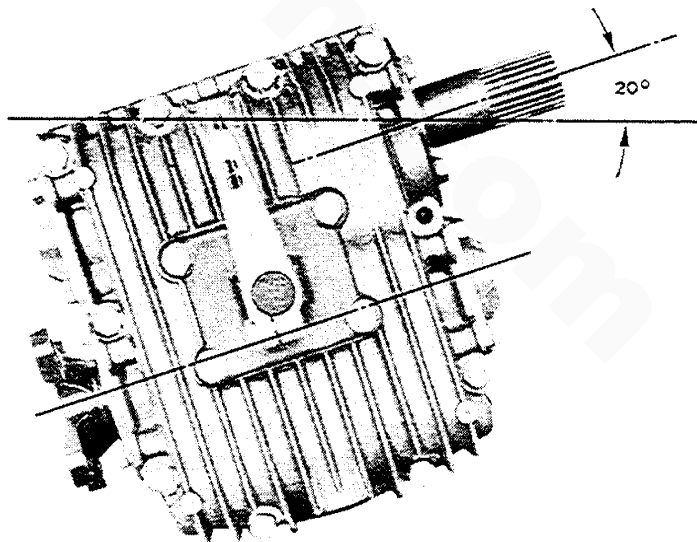
To protect the gearbox from detrimental stresses and loads, provision should be made for elastic suspension of the engine-gearbox assembly in the boat or craft.

The oil drain plug of the gearbox should be conveniently accessible.

### 5. POSITION OF GEARBOX IN THE BOAT

The inclination of the gearbox unit in the direction of the shafts should not permanently exceed an angle of 20 degrees (15 degrees for the V-drive model). (See illustration.)

The gearbox can also be mounted with the output shaft in the UPWARD position. Interchange the oil dipstick and the oil drain plug in this case.





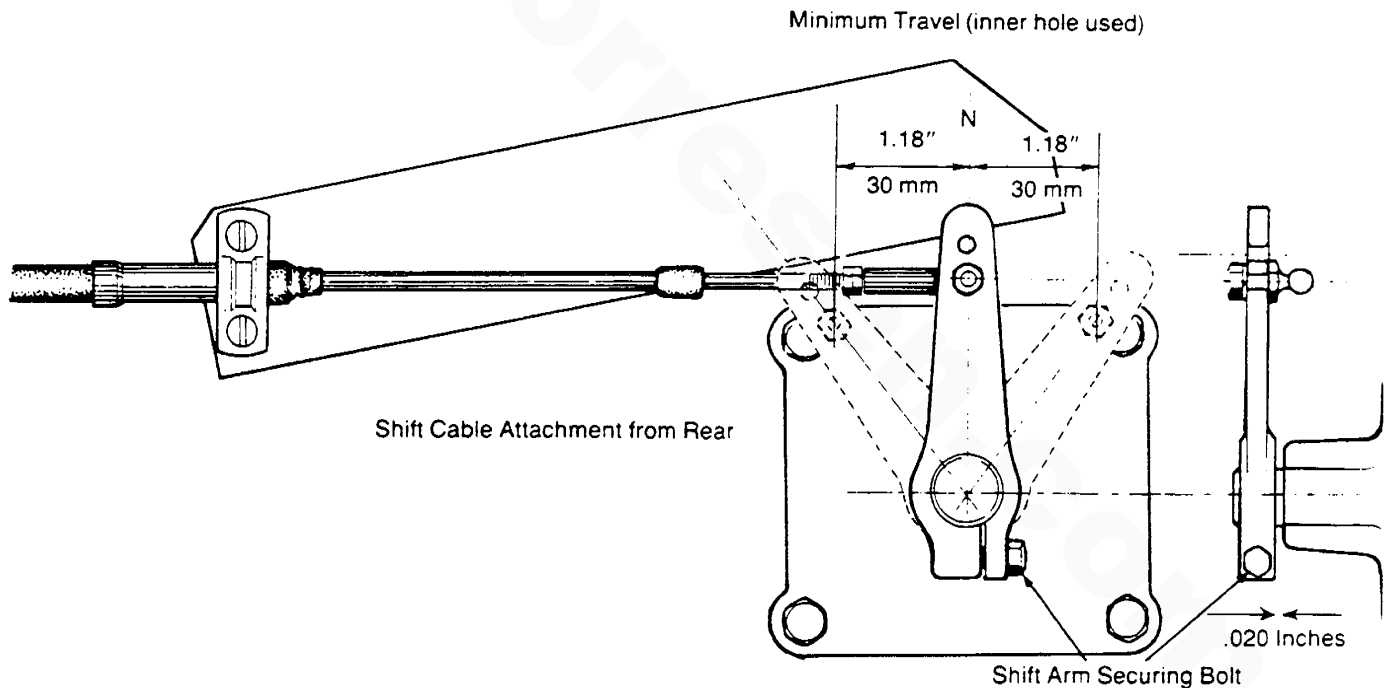
6. OPERATION OF GEARBOX

The adjustment of the shift lever on the transmission when attaching the shift control cable to it, is of prime importance to ensure proper clutch engagement and long service life for the transmission.

The control cable, when attached to the transmission shift arm ball joint connector, should be attached so as to be at a 90° angle with the lever and transmission in the neutral position. (Ref. Illustration.)

The transmission shift arm can be rotated on the transmission side cover shifting shaft by loosening the securing bolt (13mm) and rotating the shift arm to produce the 90° angle between the arm and the shift cable when the transmission is in neutral. Insure that there is at least .020 inch clearance between the shift arm and the shift cover before retightening the securing bolt.

The shift cable and pedestal control must allow the transmission shift arm to move from the neutral position into the forward or reverse engagement a MINIMUM of 1.37 inches (35mm) when the outermost ball joint attachment hole is used on the shift arm, or 1.18 inches (30mm) when the inner is used. Use of the inner attachment hole is preferred. (Ref. Illustration.)



Failure to properly adjust the shift arm and cable to produce the MINIMUM shift arm travel required for clutch engagement will result in clutch slippage and eventual failure.

Adjusting the shift arm and shift cable to produce shift lever movement greater than the minimum is recommended.

Movement at the shift arm preferably should be 1.5 to 2 inches of arm movement into the forward and reverse position. Cockpit controls must be of a design that will allow for this desired cable travel.

This shift lever travel should be verified at initial commissioning, and periodically thereafter (at least once a year).

When shifting the transmission from the controls in the vessel's cockpit, it should be done smoothly and without hesitation (dump it into gear).

The position of the shift cover plate underneath the actuating lever is factory adjusted to ensure proper operation of the transmission and is sealed with Loc-Tite (orange). Therefore, do not loosen the 4 capscrews. Removal or disturbing of this cover will void all warranty responsibilities by Westerbeke.

When installing the gearbox, make certain that shifting is not impeded e.g. by restricted movability of the cable or rod linkage, by unsuitably positioned guide sheaves, too small bending radius, etc.

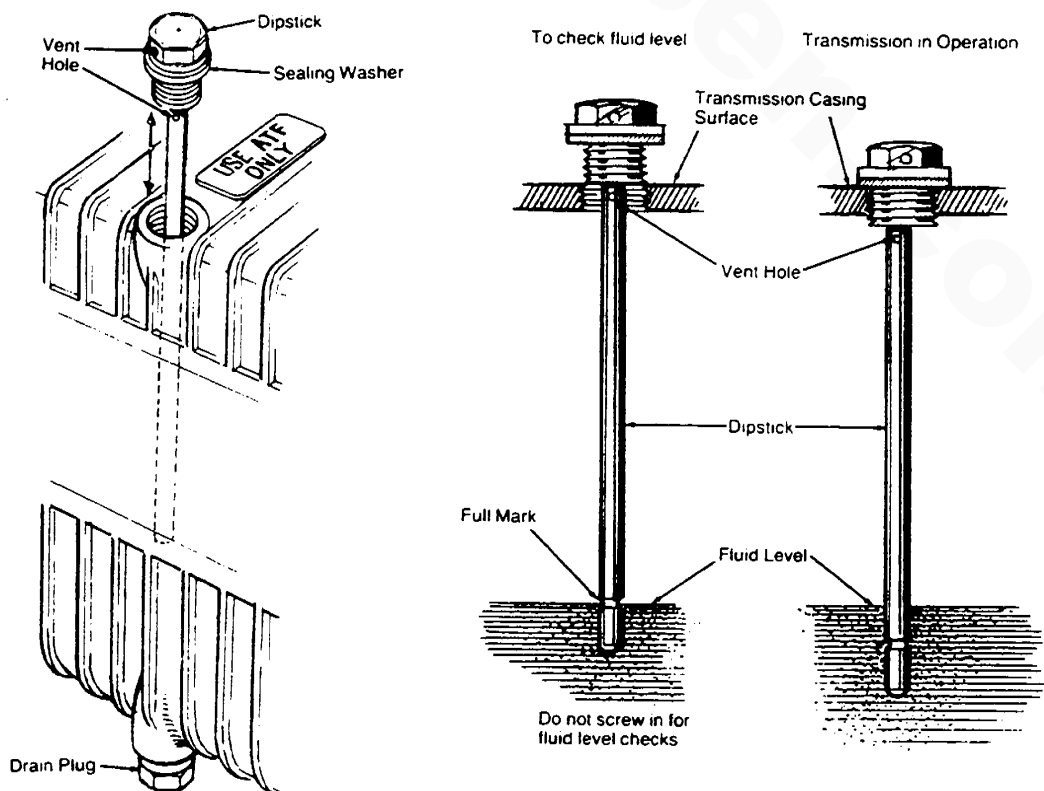
## 7. ENGINE-GEARBOX COMPARTMENT

Care should be taken that the engine-gearbox compartment is properly ventilated.

### OPERATION

#### 1. INITIAL OPERATION

Fill the gearbox with automatic transmission fluid. The fluid level should be the index mark on the dipstick (see illustration).



To check the fluid level, just insert the dipstick; DO NOT SCREW IN. Retighten the hex screw with the dipstick after the fluid level check. Do not omit the o-ring seal.

## 2. OPERATING TEMPERATURE

The maximum permissible temperature of the transmission fluid is 130°C. If this temperature is to be exceeded, an optional oil cooler is available.

## 3. OPERATION OF GEARBOX

The zero position of the operating lever on the control console must coincide with the zero position of the actuating lever on the transmission. Shifting is initiated by a cable or rod linkage via the actuating lever and an actuating cam. The completion of the gear changing operation is servo-automatically controlled.

Gear changing should be smooth, not too slow, and continuous (without interruption). Direct changes from forward to reverse are permissible, since the multiple-disc clutch permits gear changing at high RPM, including sudden reversing at top speeds in the event of danger.

## 4. OPERATION WITHOUT LOAD

Rotation of the propeller without load (freewheeling), e.g. while the boat is sailing, being towed, or anchored in a river, as well as idling of the engine with the propeller stopped, will have no detrimental effects on the gearbox.

Locking of the propeller shaft by an additional brake is not required, since locking is possible by engaging the reverse gear. DO NOT sail while engaged in forward.

## 5. LAY-UP PERIODS

If the transmission is not used for periods of more than 1 year, it should be COMPLETELY filled with fluid of the same grade to prevent corrosion. Protect the input shaft and the output flange by means of an anticorrosive coating if required.

## 6. PREPARATION FOR RE-USE

Drain the transmission of all fluid and refill to the proper level with the prescribed fluid.

## MAINTENANCE

### 1. TRANSMISSION FLUID

To ensure trouble-free operation of the clutch, use only automatic transmission fluid (ATF).

Under no circumstances should the fluid contain any additives such as molybdenum sulphite.

We recommend commercial Automatic Transmission Fluid (ATF), Type A or Dexron II.

## 2. FLUID QUANTITY

HBW 5 approximately 0.4 liter  
HBW 10 approximately 0.6 liter  
HBW 20 approximately 0.8 liter  
HBW 50 approximately 0.3 liter  
HBW 100 approximately 0.35 liter  
HBW 150 approximately 0.55 liter  
HBW 150V approximately 1.0 liter  
HBW 220 approximately 0.75 liter  
HBW 250 approximately 0.75 liter  
HBW 360 approximately 1.40 liter  
HBW 360A approximately 1.50 liter  
HBW 400 approximately 2.00 liter  
HBW 450 approximately 1.80 liter

Use the index mark on the dipstick as a reference.

## 3. FLUID LEVEL CHECKS

Check the fluid level in the transmission daily. Correct fluid level is the index mark on the dipstick (see item 1 under OPERATION). Always use the same fluid type when topping up.

## 4. FLUID CHANGE

Change the fluid for the first time after about 25 hours of operation, then at intervals of at least once per year.

## 5. CHECKING THE CABLE OR ROD LINKAGE

The cable or rod linkage should be checked at shorter time intervals. Check the zero position of the operating lever (on the control console) and of the actuating lever (on the gearbox) on this occasion. The minimum lever travel from the neutral position to the operating positions (0-A = 0-B) should be 35 mm for the outer and 30 mm for the inner pivot point. Make certain that these minimum values are safely reached. Check the cable or rod linkage for easy movability (see item 6 under INSTALLATION).

## 6. OVERHAUL

Disassembly of the transmission in the field is not recommended. If an overhaul or repair is needed, the work should be done by Westerbeke or an authorized Westerbeke service center.

## BW TRANSMISSIONS

These manual transmissions rotate opposite to the engine when in forward gear. Shifting effort is very low. The input power on the BW3 is transmitted to the output shaft by helical spur gears when in forward. In reverse this task is taken over by a high performance roller chain. The unit also incorporates a servi cone-type clutch. The BW7 and BW12 transmit their power with casehardened helical gears and in reverse there is an intermediate gear. The reversing process on these is carried out by a servo double disc system.

### LUBRICATION

1. Fill the transmission with 20 to 40 SAE weight engine oil, the same as is used in the engine.
2. Oil capacity  
BW3 approximately 0.35 liter  
BW7 approximately 1.0 liter  
BW12 approximately 1.0 liter
3. Check the oil level daily with the engine stopped. The level must be between the upper and lower dipstick marks when the dipstick is completely screwed/inserted into the housing.
4. Change the oil initially after the first 30 hours, thereafter every 250 hours, once per year minimum. The BW7 and BW12 have a drain plug for oil removal. Oil may also be removed by suction through the dipstick tube, where oil is added.
5. Operating oil temperature must not exceed 120°C (250°F).

### OPERATION

1. Normal shifting should be done below 1500 RPM.
2. The BW3 may be locked in reverse when sailing or freewheeled in neutral.
3. The BW7 and BW12 may be locked in either forward or reverse when sailing or freewheeled in neutral.

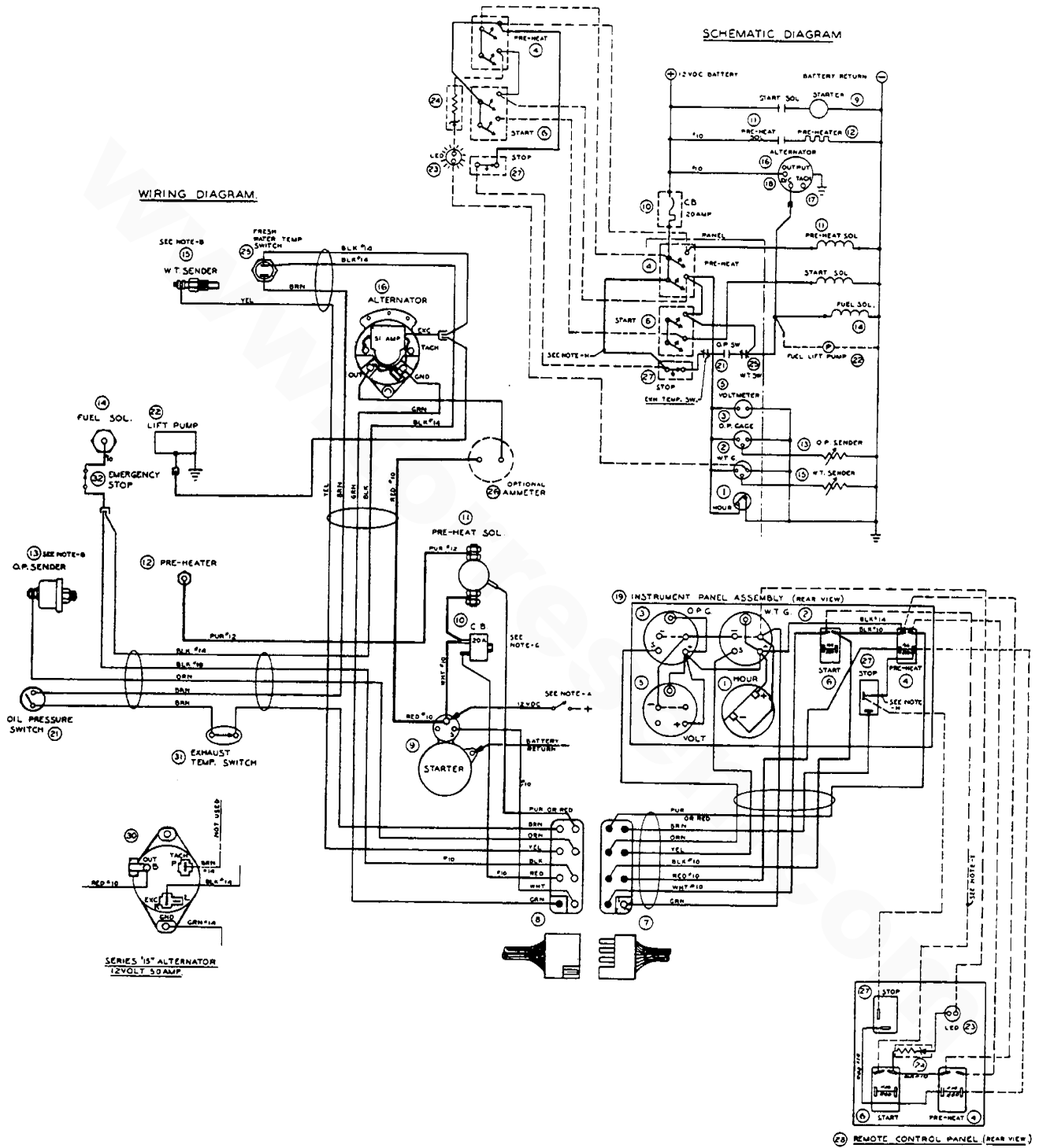
### SERVICE

1. Never loosen the shift lever cover screws, except in the course of qualified servicing, as this upsets a critical adjustment.
2. Disassembly of the transmission in the field is not recommended. If an overhaul or repair is needed, the work should be done by Westerbeke or an authorized Westerbeke service center.

## GENERATOR SETS

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| Generator - 3KW (60 Hz) and 2.4KW (50 Hz).....   | 130  |

MANUAL STARTER DISCONNECT (TOGGLE SWITCHES)



MANUAL STARTER DISCONNECT (TOGGLE SWITCHES)

GENERAL:

This manually controlled series of Westerbeke marine diesel generators is equipped with toggle switches on the engine control panel and, optionally, at remote panels. The following instructions and methods of correcting minor problems apply only to such toggle switch controls.

All three switches are momentary contact type and serve the following functions:

1. Preheat: The PREHEAT/DEFEAT toggle switch is a double pole, single throw switch. The switch serves two purposes: preheating the engine for easy starting and defeating or bypassing the engine protective oil pressure switch. The defeat function activates the fuel run solenoid, instrumentation, alternator excitation, electric fuel pump and supplies DC voltage to the start switch.
2. Start: The START toggle switch is a double pole, single throw switch. The switch, when depressed, supplies 12 volt DC power to the starter solenoid, energizing the starter to start the engine.
3. Stop: The STOP toggle switch is a single pole, single throw, normally closed switch. This switch provides power to the fuel run solenoid, instrument cluster and alternator excitation, after the oil pressure switch has closed upon starting. Opening of this switch opens the power circuit to the fuel run solenoid, thus stopping the flow of fuel to the engine and stopping the engine.

ENGINE OPERATION:

1. Preheat: Depress the PREHEAT switch. This will activate the instrument panel gauges and lights. The fuel run solenoid will be activated, drawing the throttle arm into the run position. The preheat solenoid will close and supply voltage to the glow plugs. The electric fuel pump will be activated. Hold the preheat switch depressed 15 to 60 seconds, depending on ambient temperature.
2. Start: Continuing to hold the PREHEAT switch depressed, depress the START switch. This will energize the starter solenoid, engaging the start. Once the engine fires and starts to run, release the START switch only. Continue to hold the PREHEAT switch depressed until the engine oil pressure reaches 25 PSI, then release it.
3. Stop: Depress the STOP switch and hold it until the engine stops completely. (Remove any load from the generator before



stopping it.) The STOP switch opens the circuit to the fuel run solenoid, de-energizing it, moving the throttle arm into the shut off position, stopping the engine.

#### REMOTE ENGINE OPERATION:

For remote operation of the generator system, the same three switches are used. The PREHEAT and START switches are connected in parallel with the local panel switches and serve the same functions as in the local panel. The STOP switch is in series with the local panel STOP switch, and serves the same functions as in the local panel. The generator may be stopped from local or remote positions. The green indicator light in the remote panel signals that the engine has started and to release the START switch only. Hold the PREHEAT depressed for a few more seconds to allow oil pressure to rise.

#### AC GENERATORS:

Once the diesel generator sets have been placed in operation, there is little or no control adjustment required by the A.C. Generator. When starting the generator, it is always a good plan to switch off all A.C. loads, especially large motors, until the engine has come up to speed and, in cold climates, starts to warm up. These precautions will prevent damage by unanticipated operation of A.C. machinery and prevent a cold engine from being stalled.

TROUBLESHOOTING

MANUAL STARTER DISCONNECT (TOGGLE SWITCHES)

CIRCUIT PROTECTION:

The engine control system is protected by a 20 amp manual reset circuit breaker located on the engine as close as possible to the power source.

Manual Control (toggle switch) troubleshooting.

| <u>Problem</u>   | <u>Probable Cause</u>   | <u>Verification</u>  |
|--|---|--|
| Preheat depressed, no panel indications, fuel solenoid, electric fuel pump and preheat solenoid not energized. | Battery switch or power not on<br><br>20 amp circuit breaker tripped        | Check switch and/or battery connections.<br><br>Reset breaker if opens again, check preheat solenoid circuit and "run" circuit for shorts to ground. |
| Start switch depressed, no starter engagement.   | Connection to solenoid faulty   | Check connection.  |
|  | Faulty switch   | Check switch with ohmmeter.  |
|  | Faulty solenoid   | Check that 12 volts present at solenoid connection.  |
|  | Loose battery connection  | Check battery connection.  |
| Start depressed, panel indications OK. Start solenoid OK. Fuel solenoid not functioning.                       | Low batteries   | Check battery charge state.  |
|  | Poor connections to fuel solenoid. Defective fuel run solenoid. (P/N 23041) | 1. Check mechanical positioning of fuel solenoid for plunger bottoming.<br>2. Manually check movement of fuel run solenoid plunger and throttle arm. |
| No ignition, cranks, does not start. Fuel solenoid energized.  | Faulty fueling system   | 1. Check for fuel to generator system.<br>2. Check for air in fuel system. Allow system to self-bleed.<br>3. Fuel lift pump failure.                 |

|   |  |   |
|---|--|---|
| No ignition, cranks, does not start. Fuel solenoid energized. | Faulty fueling system  | 4. Filters clogged. (Replace filters and allow system to self-bleed by depressing PREHEAT switch only.  |
| Failure to stop.  | Fuel solenoid (P/N 23041) return spring  | Stop engine by manually moving the throttle lever to shut off. That failing, shut off fuel and air. Check fuel solenoid linkage and repair for free movement. |
|   | Stop switch failure  | Stop engine by depressing emergency stop switch on engine or manually moving throttle to shut off. Test switch with ohmmeter.                                 |
|   | Fuel injection pump failure  | Depress emergency shut-off switch on engine. Stop engine by opening the high pressure injector lines at the injectors & stop air intake.                      |
| Engine stops.   | Low oil pressure or overheated   | Check oil, fresh water and sea water cooling.   |
|   | Low oil pressure switch fails to close   | Check for satisfactory operation with switch bypassed. Check with ohmmeter.   |
|   | High water temperature switch opens at too low a temperature.                                  | Same as above.  |
|   | 20 amp circuit breaker tripping.   | Same as above.  |
|   | High exhaust temperature switch open at too low a temperature                                  | Same as above.  |
|   | Emergency stop switch or stop switch in panel defective and opening fuel run solenoid circuit. | Check operation of switch with an ohmmeter.   |

|                       |                                |   |
|-----------------------|--------------------------------|---|
| Engine stops.         | Switch and wiring              | Inspect all wiring for loose connections and short circuits.  |
| Not charging battery. | Alternator drive               | Check drive belt and its tension. Be sure alternator turns freely. Check for loose connections. Check output with voltmeter. Insure 12 V present at regulator terminal. |
| Battery runs down     | Oil pressure switch            | Observe if gauges and panel lights are activated when engine is not running. Test the oil pressure switch.  |
| Battery runs down     | High resistance leak to ground | Check wiring. Insert sensitive (0-.25 amp) meter in battery lines. (Do not start engine.) Remove connections and replace after short is located.                        |
|                       | Low resistance leak to ground  | Check all wires for temperature rise to locate fault.   |
|                       | Alternator                     | Disconnect alternator at output, after a good battery charging. If leakage stops. Remove alternator and bench test. Repair or replace.                                  |

TECHNICAL DATA

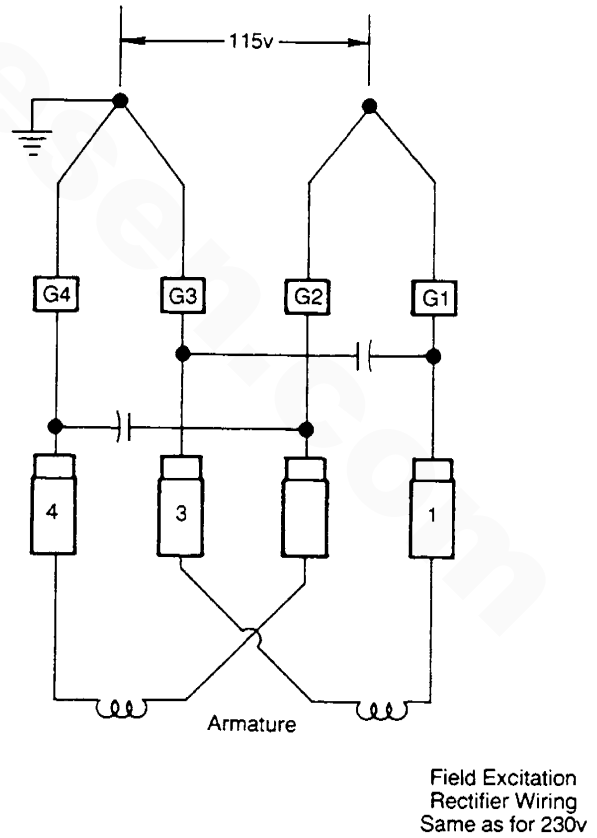
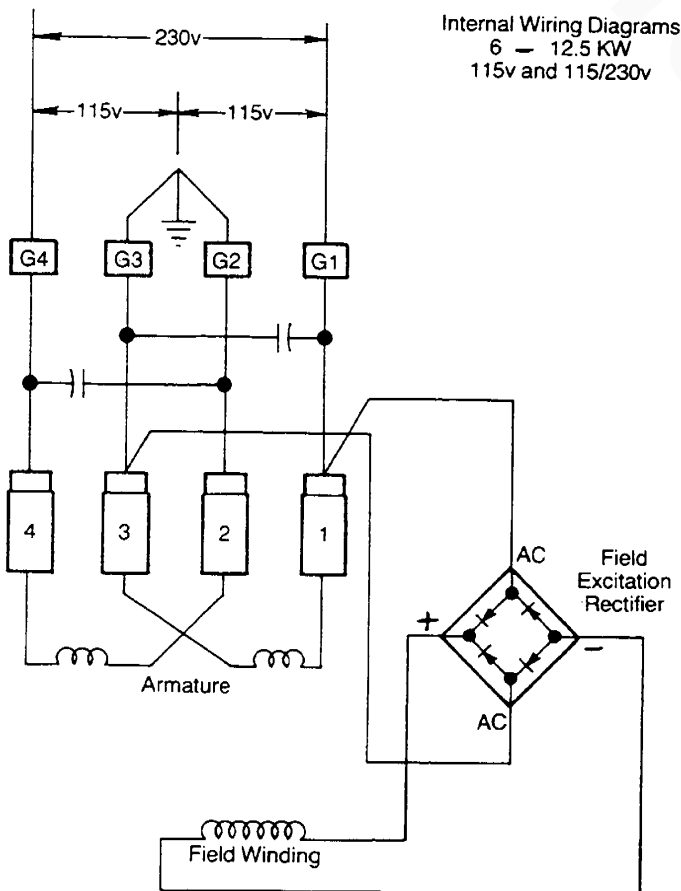
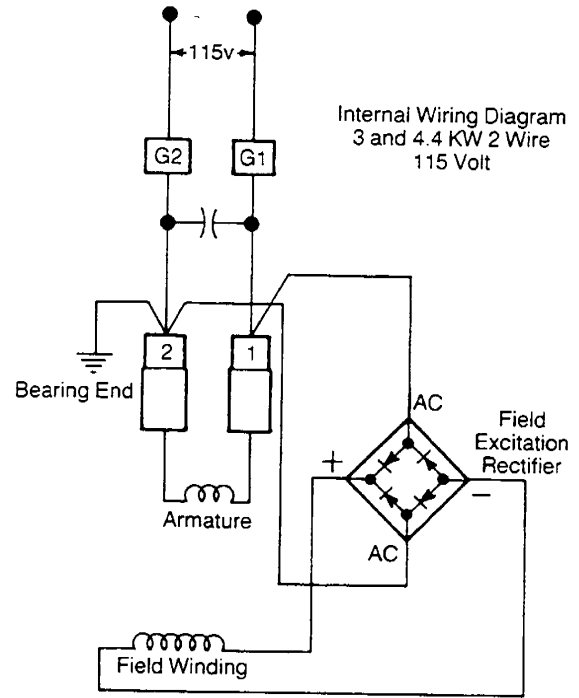
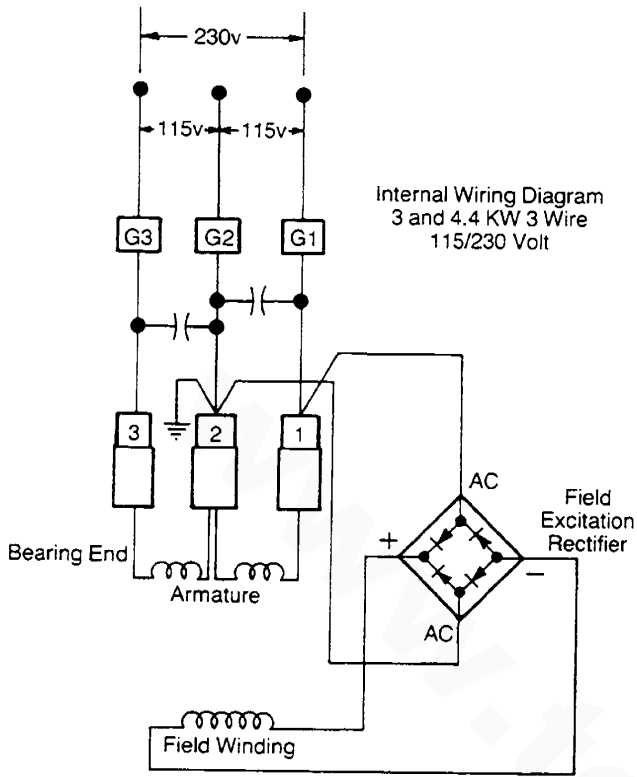
|        |                    |                     |
|--------|--------------------|---------------------|
| 3.0 KW | 115 VAC            | 25.0 AMP at 115 VAC |
| 4.4 KW | 115 VAC            | 34.7 AMP at 115 VAC |
| 6.0 KW | 115 or 115/230 VAC | 25.7 AMP at 230 VAC |
| 6.5 KW | 115 or 115/230 VAC | 27.0 AMP at 230 VAC |
| 7.7 KW | 115 or 115/230 VAC | 33.5 AMP at 230 VAC |
| 8.0 KW | 115 or 115/230 VAC | 34.0 AMP at 230 VAC |
| 11.0KW | 115 or 115/230 VAC | 46.0 AMP at 230 VAC |
| 12.5KW | 115 or 115/230 VAC | 52.0 AMP at 230 VAC |

Frequency 60 Hertz Standard  
(50 Hertz available at reduced rating)

RPM 1800 - 60 Hertz  
1500 - 50 Hertz

Voltage  
Normal 115 VAC 230 VAC  
Maximum - No load 132 VAC 264 VAC  
Minimum - Full load 108 VAC 216 VAC

Excitation Voltage 115 VAC (output voltage)



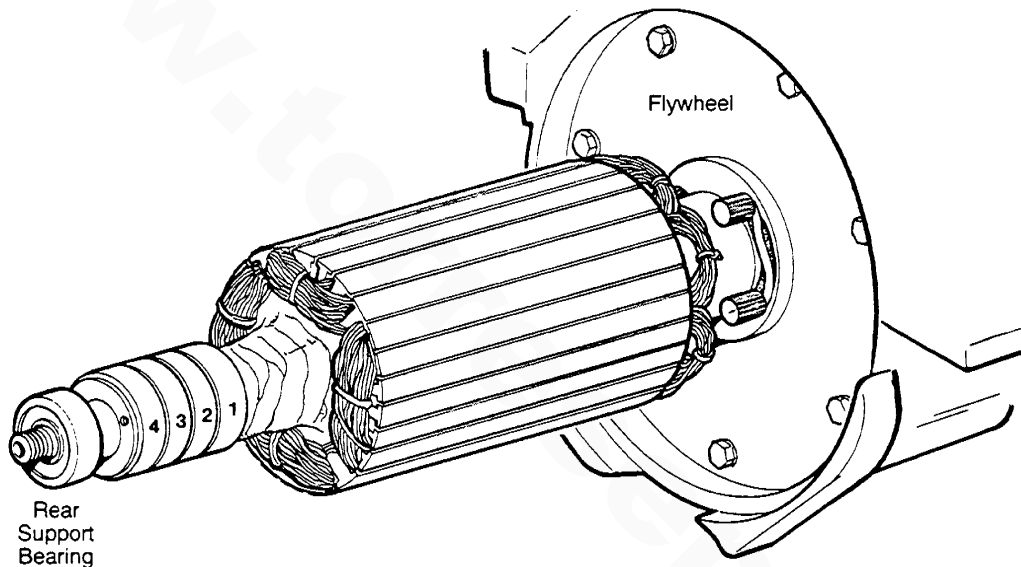
GENERAL TROUBLESHOOTING

|                      |          |
|----------------------|----------|
| MODELS 3 KW - 12.5KW | 60 Hertz |
| 2.4 KW - 9.4KW       | 50 Hertz |

No Electrical Output

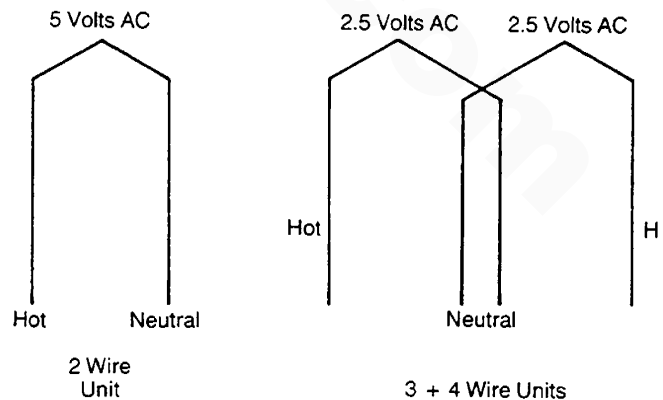
1. Remove load from generator and verify no output directly at generator output leads with voltmeter.
2. Check for proper electrical connections. Refer to Internal Wiring diagrams.

NOTE: Generator armature slip rings and brush rigs are numbered from inboard at the windings or flywheel end outward toward the rear support bearing.



2A. Residual Voltage Check

Disconnect field leads from bridge rectifier. (Note position of leads on rectifier (+) to (+) and (-) to (-).) Operate the generator and check AC output (no load on generator). Measure voltage between neutral lead and hot lead(s).



2-wire unit                      5 Volts AC (Hot lead to neutral)  
 3 and 4 wire unit    2.5 volts AC (each hot lead to neutral approximate)

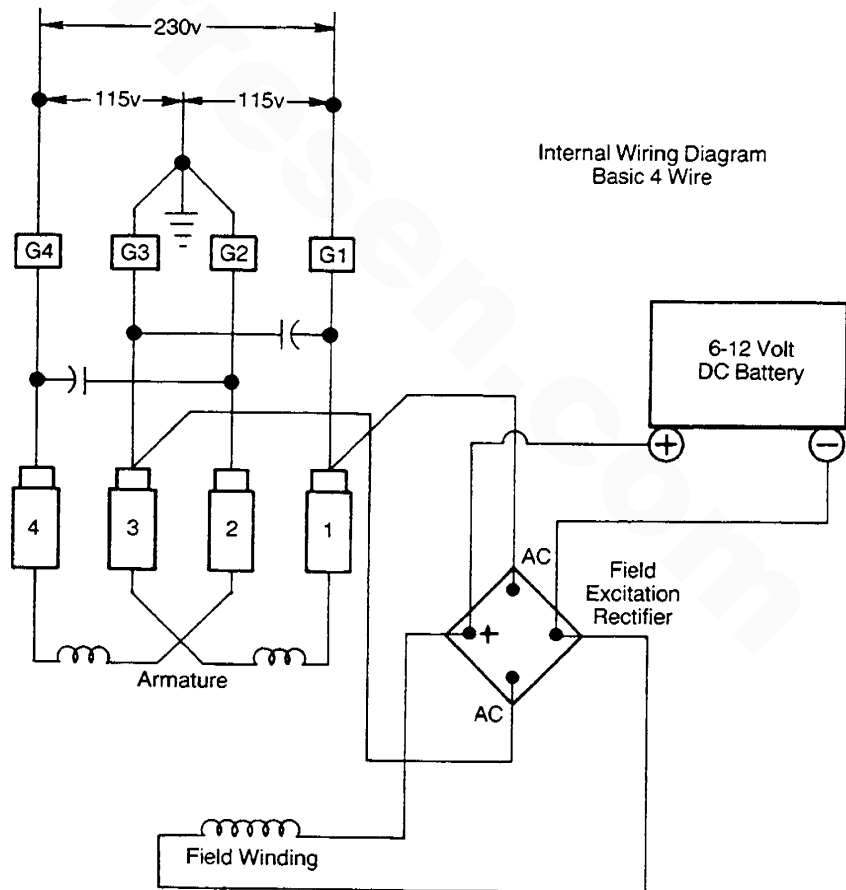
Residual Voltage checks O.K. You can assume the rotating armature and brush rig are O.K. The generator problem lies in the rectifier and/or field coils.

Residual voltage not present. Check brush rig and static capacitors. Check rotating armature resistance values and continuity check found elsewhere in this manual.

3. Test operation of generator by by-passing bridge rectifier. Apply 12 volts DC to field leads on bridge rectifier (+) to (+) and (-) to (-). Run generator (no load). Measure voltage output at generator leads. Generator output with 12 volts DC excitation to the field coils should be 50 to 70 Volts AC. If 50 to 70 volts AC is produced, this should indicate that the generator is O.K., and that the bridge rectifier is defective.
4. If no voltage is produced, check the static capacitor(s) that it is not shorted to ground. If found faulty, remove connection from output terminal at brush rig and repeat Step #3.
5. Flash Field Coils

Units may lose their residual magnetism from extended storage, rough handling during installation or disassembly and assembly for installation, etc., requiring the field coils to be excited with 6 to 12 volts DC to restore the magnetism to the generator. This is done in the following manner:

Stop the engine and remove the generator end bell cover. This will expose the cooling fan, brush rig assembly and rectifier. Check internal wiring; refer to figure. The positive (+) lead from the field coils is connected





to the positive marked terminal on the rectifier and the negative (-) lead from the field coils is connected to the opposite UNMARKED terminal on the rectifier. Using jumper leads with insulated alligator clips, connect 6 to 12 volts DC battery positive to the positive of the rectifier and negative to the UNMARKED terminal of the rectifier for approximately 10 seconds. This should restore magnetism to the stationary field coils. (Be careful not to connect DC voltage to the AC terminals on the rectifier, as this will damage the rectifier.)

Remove the alligator clip connections; replace the end bell cover and operate the generator and check AC output voltage.

6. Check for a short or open in the rotating armature or in the stationary field coils.

ROTATING ARMATURE (RESISTANCE VALUES)

|                      |  |
|----------------------|--|
| 3.0 & 4.4KW (2-wire) | 1 ohm or less slip ring to slip ring     |
| 3.0 & 4.4KW (3-wire) | 1 ohm or less between slip rings 1 and 3 |

NOTE: No continuity should be found between slip rings (1 & 2) and (2 & 3) on the 3-wire unit. (If so, an internal short in the armature winding exists.) Replace the armature.

|                                |   |
|--------------------------------|---|
| 6.5, 7.7, 8.0, 11.0 and 12.5KW | 1 ohm or less between slip rings (1 & 3) and (2 & 4). |
|--------------------------------|---|

NOTE: 3- and 4-wire units: There should be no continuity found between slip rings (1 & 2), (2 & 3) and (3 & 4). If continuity is found, an internal short exists between these windings and the armature should be replaced.

NOTE: All units: There should be no continuity found between any of the slip rings and the armature's central steel shaft. If continuity is found, the windings are shorted to the shaft and the armature should be replaced.

Rotating armature slip rings are numbered from inboard of the generator flywheel end outward to the rear support bearing. When referring to 2, 3 and 4-wire units, these are the number of generator output leads being connected to the load. You will find on the 11.0 and 12.5KW units that there are 8 leads coming from the brush rig and are combined for a total of 4 output leads. The number of wires can also be related to the number of slip rings on the rotating armature.

FIELD COIL RESISTANCE (TOTAL)

|                  |           |     |
|------------------|-----------|-----|
| 3.0 & 4.4KW      | 32.5 ohms | +5% |
| 6.5, 7,7 & 8.0KW | 22.2 ohms | +5% |
| 11.0 & 12.5KW    | 14.2 ohms | +5% |

NOTE: There should be no continuity found between the field coils and the generator body.

## 7. Replacement of Field Coil(s)

Field coils are connected in series and the resistance value given above in this text is the total of the four field coils. To determine the resistance value of one, divide by four. Each field coil has a mounting position on the generator housing and cannot be interchanged with another field coil.

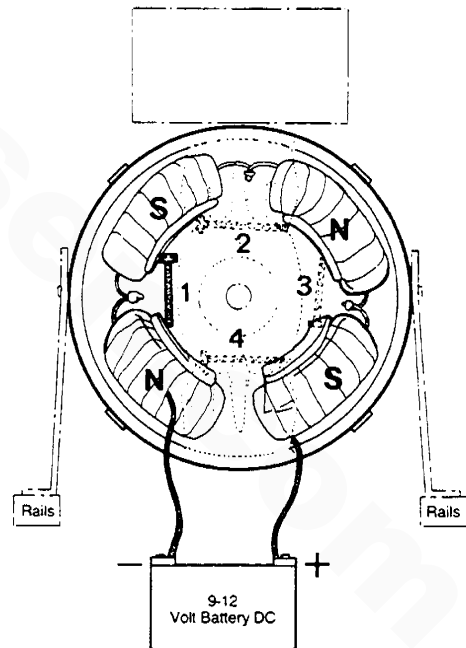
When installing a replacement field coil(s), the installer must insure that the coil is correct for the mounting position in the housing and will have the correct polarity when excited with 9 - 12 volts DC.

The field coil shoes that hold the coil securely to the generator housing are held in place by bolts that must be properly tightened when the coil and shoe are installed to the generator housing. When connecting the coils in series insure the butt connections are good and secure and positioned away from rotating parts.

To insure the field coils have been positioned properly in the generator housing and will have the correct polarity, the following test must be made before reassembly of the generator.

- (1) Connect a 9 - 12 volt DC battery to the leads off the coils that would normally be connected to the (+) and (-) connectors of the bridge rectifier. These leads are unmarked and the polarity in their connection to the DC battery is not important. NOTE: When removing the leads from the battery and reconnecting them to the bridge rectifier, you should maintain the same polarity as used in this test, plus lead to (+) on rectifier and negative to unmarked (-) connection on rectifier.

- (2) With a 3 inch iron bolt or its equivalent, place this bolt between each adjoining field coil shoe. It should be held in place by the magnetic attraction set up between the coil/shoes by the 9 - 12 volts excitation of the field coils. Should this fail to happen between any of the four adjoining coils/shoes, then an incorrect coil is installed and must be removed and the correct one installed; otherwise the generator when assembled will not produce proper voltage.



Low Voltage Output

1. Verify voltage output at generator output leads with load applied to generator; check no load condition also. Check voltage at the load. Check rating for generator and verify load with amp probe at output leads. Check all connections to insure they are clean and secure. Insure that the wire size carrying the voltage to the load is of sufficient size so as not to produce a voltage drop.

NOTE: Beware of motor starting loads and the amperage draw placed on the generator from these types of loads. Generally, the amperage draw of a motor at start up will be 3 - 5 times the amperage needed when running.

2. Check generator with Hertz meter:

No Load Hertz            61 - 61.5 (51 - 51.5)

No Load Voltage        131 - 135 Volts (Generator Cold)

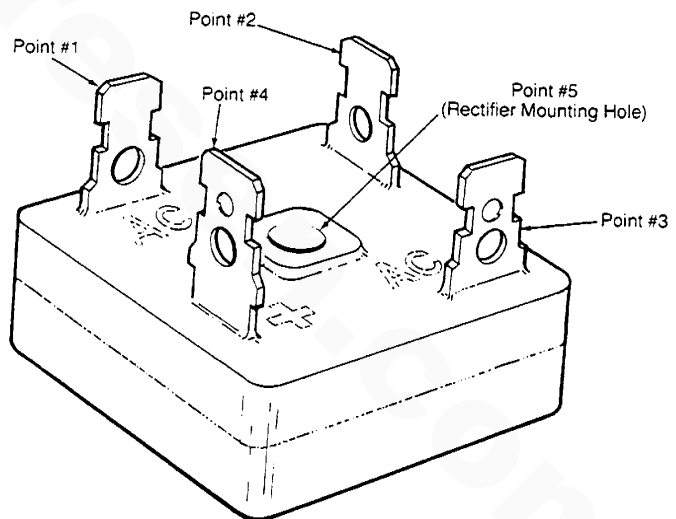
No Load Voltage        126 - 130 Volts (Generator Hot)

3. Test Bridge Rectifier:

Bridge rectifier may be faulty and should be checked as follows.

- (1) Set ohmmeter scale on Rx1 (+DC) zero the meter.

- (2) Connect the (+) lead from the meter to Point #4, with the (-) lead from the meter momentarily contact points #1, #2, #3 and #5. No deflection of the needle should occur showing infinite resistance.



- (3) Remove the (+) lead from Point #4 and connect the (-) lead to Point #4 and with the (+) lead, momentarily touch Points #1, #2 and #3. Points #1 and #3 should show an 8-ohm resistance  $\pm 2$  ohms. Point #2 should show a 40-ohm resistance  $\pm 5$  ohms.
- (4) Touch Point #5 with the (+) lead, no deflection of the needle should occur. IF THE RECTIFIER FAILS ANY OF THE ABOVE TESTS, IT IS DEFECTIVE AND SHOULD BE REPLACED.

4. Check field coil resistance as per specification given in A-6.
5. Insufficient cooling of the generator. Ambient air entering the generator should not exceed 104°F (40°C).  
Operating efficiency of the generator decreases as the ambient air temperature entering the generator end bell increases above 104°F. Generators in confined areas may require the ducting of cool outside air into the compartment and directed toward the inlet at the generator end bell.
6. Check condition of brushes for wear and contact with slip rings on armature. Insure brushes are not sticking in holders.

#### High Voltage Output

1. Verify voltage at generator output leads.  
No load voltage 126 - 130 volts (Generator Hot)  
61 - 61.6 Hertz  
(51 - 51.5 Hertz)
2. Check internal wiring of generator leads attached to brush rig and leads from brush rig feeding AC to bridge rectifier. Refer to Internal wiring schematics. These internal wiring diagrams are applicable to related 50 Hertz units as well.

## YOUR NOTES

[www.torresen.com](http://www.torresen.com)

## 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.

# SERVICE BULLETIN

DATE: 6/15/79

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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# SERVICE BULLETIN

DATE: 5/6/74

BULLETIN NUMBER: 69

MODEL: All Marine Generators and Marine Engines

SUBJECT: Exhaust System Failures

When engine sea water is fed into an exhaust system so that the full stream strikes a surface, erosion may cause premature failures.

Proper design of either a water jacketed or a water injected ("wet") exhaust system to prevent this problem requires that the sea water inlet be positioned so that the entering stream of water does not strike a surface directly. Also, the velocity of the entering sea water stream should be as low as possible which is achieved by having inlet fittings as big in diameter as possible.

In addition to the above design considerations, it is usually advantageous to divide the sea water flow at the point of entry to the exhaust system so that only a portion of it enters the exhaust system. The remainder is normally piped directly over the side. The proper proportion of the sea water flow to pass through the exhaust system can only be determined by trial and error. The goal is to prevent excessive exhaust temperatures with the least amount of sea water.



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# SERVICE BULLETIN

DATE: 4/4/83

BULLETIN NUMBER: 82

MODEL: All

SUBJECT: Battery Recommendations

| MODEL         | BATTERY AMPERE HOURS | VOLTAGE   |
|---------------|----------------------|-----------|
| W7, WPD4      | 60-90                | 12 V.D.C. |
| W10Two, 3KW   | 90-125               | 12 V.D.C. |
| W13, 4KW      | 90-125               | 12 V.D.C. |
| W21, 7.7KW    | 90-125               | 12 V.D.C. |
| W27, 11KW     | 90-125               | 12 V.D.C. |
| W33, 12.5KW   | 90-125               | 12 V.D.C. |
| W30           | 125-150              | 12 V.D.C. |
| W40, WPD10-15 | 125-150              | 12 V.D.C. |
| W50           | 125-150              | 12 V.D.C. |
| W52, 15KW     | 125-150              | 12 V.D.C. |
| W58, 20KW     | 125-150              | 12 V.D.C. |
| W60, WBO-20KW | 150-170              | 12 V.D.C. |
| W70, 25KW     | 170-200              | 12 V.D.C. |
| W80, 30KW     | 170-200              | 12 V.D.C. |
| W100, 32KW    | 200 minimum          | 12 V.D.C. |
| W120, 45KW    | 200 minimum          | 12 V.D.C. |

The ampere hour range shown is minimum. There is no real maximum.



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# SERVICE BULLETIN

DATE: September 18, 1975

BULLETIN NUMBER: 87

MODEL: All Marine Engines

SUBJECT: Alternator Output Splitter

GENERAL DESCRIPTION: The splitter is a solid state device which allows two batteries to be recharged and brought to the same ultimate voltage from a single alternator as large as 120 amp and, at the same time, isolates each battery so that discharging one will have no effect on the other. Charging rates are in proportion to the batteries' voltage (state of discharge). This method precludes the necessity, and even the desirability, of a rotary switch for selecting which battery is to be charged. It also assures that ships services cannot drain the engine starting battery.

## INSTALLATION:

1. Mount splitter on a metal surface other than the engine, preferably in an air stream if available. Do not install near engine exhaust system. Install with cooling fins aligned vertically.
2. Be sure to use a wire size appropriate to the output of the associated alternator. In full power systems number 4 wire is recommended from the alternator to the splitter and from the splitter to the batteries.
3. Connect the alternator output terminal to the center splitter terminal.
4. Connect one splitter side terminal to one battery (s).
5. Connect the other splitter side terminal to the other battery (s).
6. When the splitter is installed, both batteries will see a charging voltage 8/10 volts less than usual. This voltage can be regained, if desired, by connecting the regulator wire directly to the alternator output terminal instead of the regulator terminal.

TEST INFORMATION: When the engine is not running, the side splitter terminals should read the voltage of the respective battery. The center splitter should read zero voltage.

With the engine running and alternator charging, the side splitter terminals should read the same voltage which should be the voltage of the regulator or somewhat less. The center splitter terminal should read .82 volts higher than the readings of the side terminals.

Continued.....



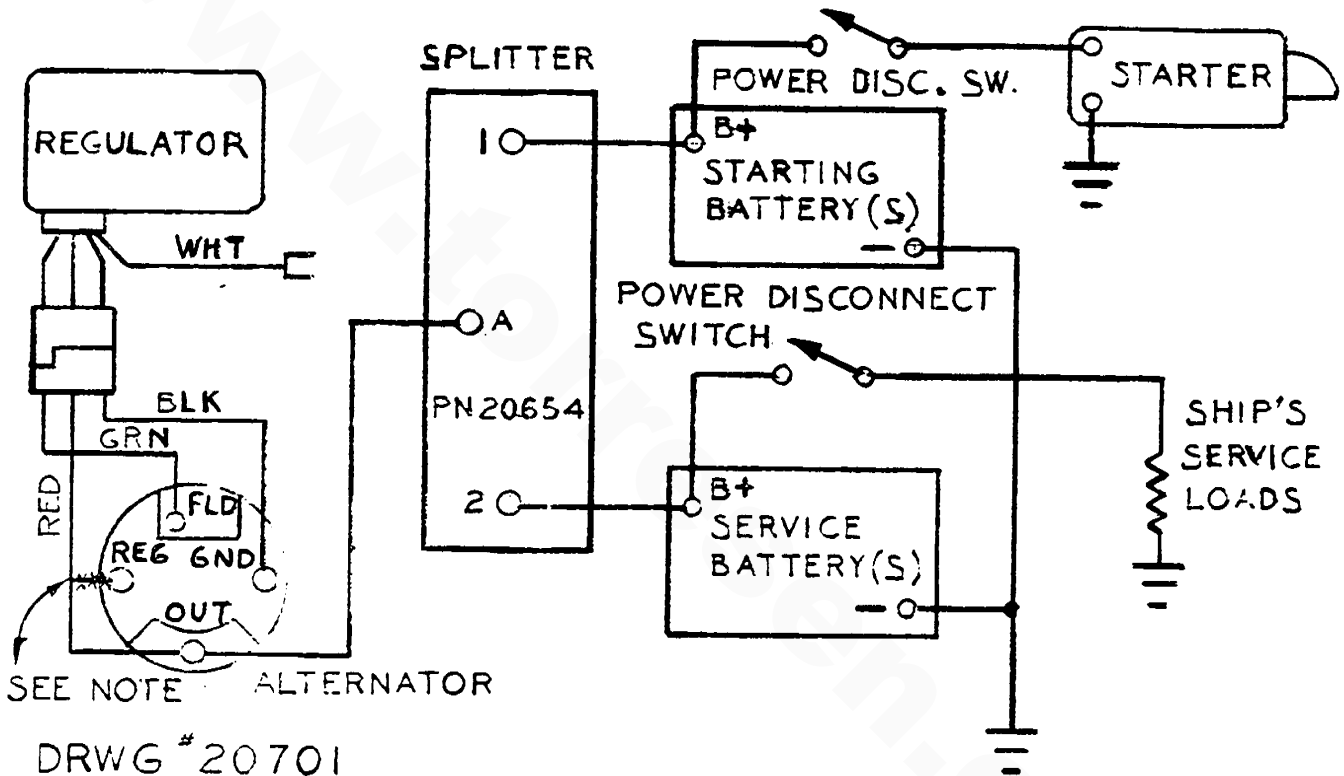
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SERVICE BULLETIN #87 (Continued)  
(Alternator Output Splitter)

This unit is sealed for maximum life and is not repairable.

BYPASSING SPLITTER: In the event of failure, batteries may be charged directly from alternator by connecting either splitter terminal #1 or #2 to terminal A, bypassing the splitter itself. This should not be done simultaneously for both batteries unless they are, and will remain at, the same voltage (state of charge).



NOTE: On Alternators which have an isolation diode between their output and regulator terminals, such as the Motorola units used with most WESTERBEKE engines, the regulator wire should be removed from the REG terminal and reconnected to the OUTPUT terminal as shown. The diode in the splitter will provide an equivalent voltage drop.

# SERVICE BULLETIN

DATE: April 28, 1976

BULLETIN NUMBER: 92

MODEL: All

SUBJECT: Troubleshooting Water Temperature and Oil Pressure Gauges

Given a presumably faulty gauge indication with the instrument panel energized, the first step is to check for 12 VDC between the ign. (B+) and neg. (B-) terminals of the gauge.

Assuming there are 12 volts as required, leave the instrument panel energized and perform the following steps.

1. Disconnect the sender wire at the gauge and see if the gauge reads zero, the normal reading for this situation.
2. Connect the sender terminal at the gauge to ground and see if the gauge reads full scale, the normal reading for this situation.

If both of the above gauge tests are positive, the gauge is undoubtedly O.K. and the problem lies either with the conductor from the sender to the gauge, or with the sender.

If either of the above gauge tests is negative, the gauge is probably defective and should be replaced.

Assuming the gauge is O.K., proceed as follows. Check the conductor from the sender to the sender terminal at the gauge for continuity.

Check that the engine block is connected to ground. Some starters have isolated ground terminals and if the battery is connected to the starter (both plus and minus) the ground side will not necessarily be connected to the block.

If the sender to gauge conductor is O.K. and the engine block is grounded, the sender is probably defective and should be replaced.



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# SERVICE BULLETIN

DATE: May 20, 1980

BULLETIN NUMBER: 110

MODEL: All

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<br>Volts | Total Length<br>of wire in<br>feet | MAXIMUM CURRENT |    |    |    |    |    |     |
|-----------------|------------------------------------|-----------------|----|----|----|----|----|-----|
|                 |                                    | 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  | 3  | 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   |



**J. H. WESTERBEKE CORP.**

AVON INDUSTRIAL PARK, AVON, MASS. 02322 · (617) 588-7700  
CABLE: WESTCORP, AVON · TELEX: 92-4444

# SERVICE BULLETIN

DATE: May 6, 1982

BULLETIN NUMBER: 114

MODEL: All Marine Engines

SUBJECT: Domestic Water Heater Installation  
Using Westerbeke FLOWCONTROLLER

Principle: There are two 7/8" hose connections at the end of the manifold which provide a parallel flow of engine cooling water to and from the heater. These connections are part of the FLOWCONTROLLER which assures a flow of hot water through the heater at all times and yet precludes excessive restriction of engine cooling water flow caused by the heater - all simply and automatically.

Installation: Remove the returnbend which normally connects the 7/8" hose spuds on engines as shipped from the factory. Connect these spuds to the heater with 7/8" ID wire inserted hose. The spud marked "out" indicates the flow from the engine and the spud marked "in" indicates the flow returning to the engine.

Hoses should rise continuously from their low point at the heater and to the engine so that trapped air will rise naturally from the heater to the engine. If trapped air can rise to the heater, then an air bleed petcock must be installed at the higher fitting at the heater for bleeding the air while filling the system. Avoid loops in hose runs which will trap air.

If any portion of the engine cooling water circuit to or from the heater rises above the engine's own pressure cap, then the pressurized remote expansion tank must be installed in the circuit to be the highest point. The tank kit Part Number is 24177. Install the remote expansion tank in a convenient location such as a sail locker for ease of checking fresh water coolant level.

The cap on the engine mounted expansion tank/manifold should not be opened once the system is installed and filled.

The hose connection from the heater to the remote expansion tank should be routed and supported so as to rise continuously from the heater to the tank enabling any air in the system to rise.

FLOWCONTROLLER kits are available for retro-fit to late 1980, 1981 and 1982 Westerbeke marine engines which employ the "two-pass" exhaust manifold. The kit numbers are:

Kit #32276 for engines whose exhaust manifold is on the left side of the cylinder head (W21, RD60, W27, RD80, W33).

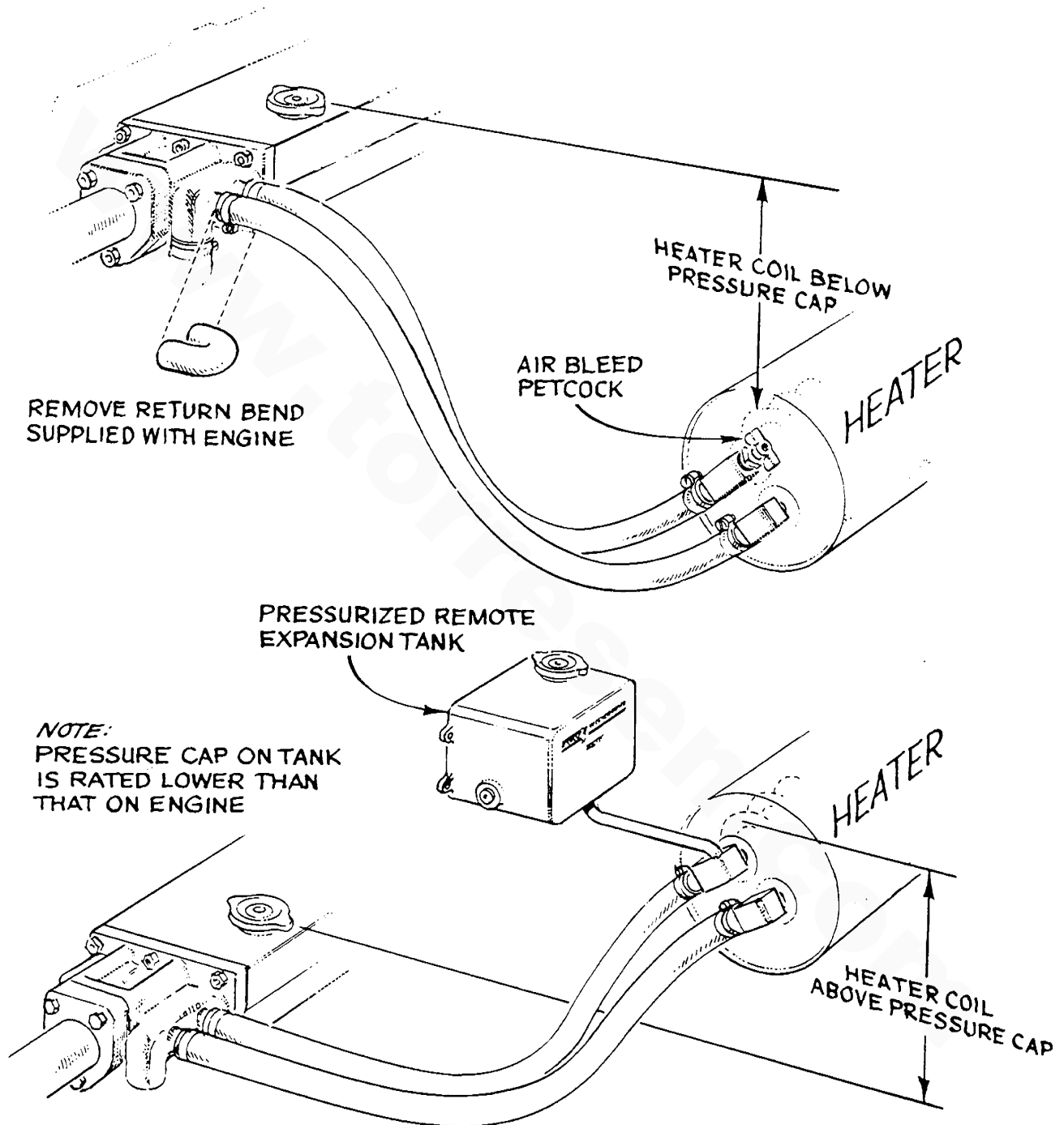
Kit #32274 for W13 and Kit #32275 for W52 and W58 engines whose exhaust manifold is on the right side of the cylinder head.



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## HEATER BELOW ENGINE



## HEATER ABOVE ENGINE

# SERVICE BULLETIN

DATE: August 14, 1983

BULLETIN NUMBER: 125

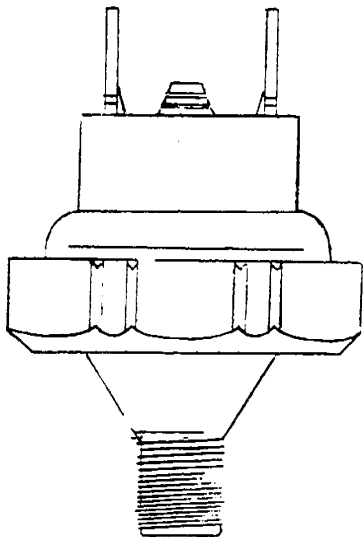
MODEL: All (Propulsion & Generators)

SUBJECT: Oil Pressure Switches

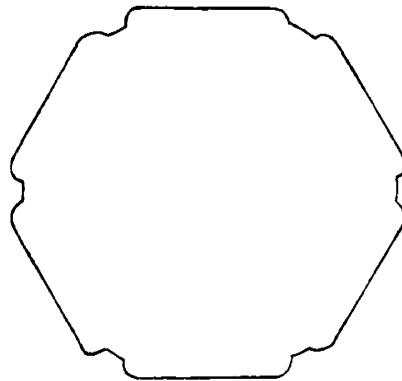
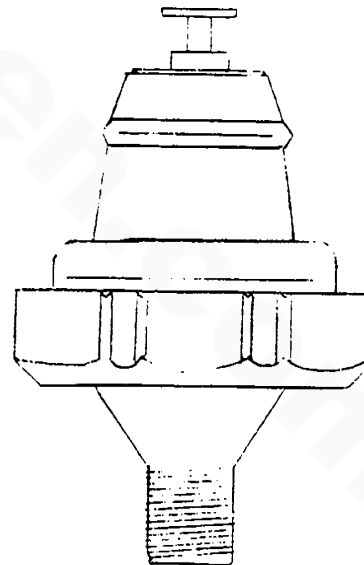
When removing and installing oil pressure switches of the type illustrated below, care should be taken to use the correct type socket specifically designed to correctly fit the metal circumference of these switches.

The correct socket can be acquired through well-known tool manufacturers such as Snap-On, New Britain, Cromwell, Proto and others. The use of channel lock pliers, vise-grips or pipe wrenches is not advised, in that they may cause damage to the seal between the metal body and the plastic center insert, resulting in a leak and/or switch failure.

DUAL PRONG



SINGLE PRONG



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# SERVICE BULLETIN

DATE: August 25, 1983

BULLETIN NUMBER: 127

MODEL: 3.0, 4.4, 7.7, 11.0 & 12.5KW Generators

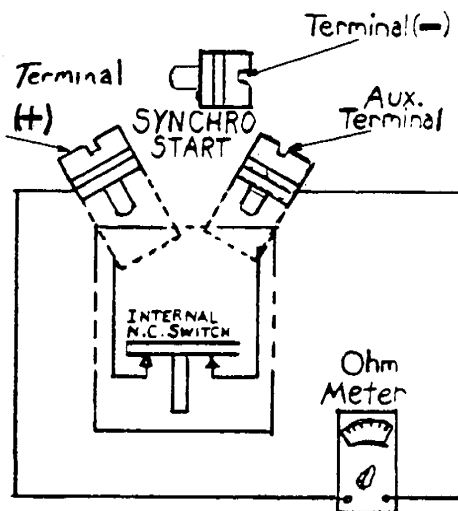
SUBJECT: Fuel Shut-Off solenoid #23041 - Adjustment

Should it be necessary to disturb the mounting of a fuel shut-off solenoid for unit maintenance or repair, or to replace a failed solenoid, the following procedure must be observed when replacing the solenoid on the generator:

With the solenoid de-energized and attached to its mounting bracket, (4.4 - Mounting Clamp), the solenoid plunger should be manually bottomed in the solenoid and the throttle arm manually moved to the run position so as to be within .010 - .020 inches of contacting the throttle stop screw. The linkage connecting the throttle arm and solenoid plunger should then be connected and adjusted to maintain these positions when the solenoid is electrically energized with the preheat switch on the instrument panel.

(NOTE: On 4.4KW generators the solenoid's position may have to be changed by moving it fore or aft under the mounting clamp that holds it against the air intake silencer to properly install and adjust the connecting linkage to the throttle arm.)

(Figure A)



## MANUAL CHECK

Check the operation and bottoming of the fuel solenoid, plunger manually by doing the following:

1. Connect an ohmmeter across the + terminal and vacant auxiliary terminal on the back of the fuel solenoid. (Figure A.)
2. With the fuel solenoid in the stop position, 0-1 ohms resistance should be found across these two terminals.
3. Manually moving the throttle arm into the run position and bottoming the fuel solenoid plunger, a resistance of about 15 to 30 ohms should then register on the meter indicating that the plunger has bottomed against the internal switch de-energizing the pull in windings.

Failure to insure manually that the fuel solenoid operates as described above will result in the failure of the solenoid when operated electrically. (The fuel solenoid may fail within 30 seconds if the plunger does not bottom when electrically energized.)



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When operated electrically by use of the preheat switch on the instrument panel, the fuel solenoid plunger should move smoothly and rapidly into the solenoid with no binding or hesitation, drawing the throttle arm into the run position .010 - .020 inches off the throttle stop screw as the plunger bottoms in the fuel solenoid.

(NOTE: The throttle arm stop screw is adjusted and wired/sealed at the factory to allow the throttle arm to move to the proper no load speed and voltage for the generator. Further adjustment should not be needed. Tampering with this stop screw without proper written authorization may affect the generator's warranty.)

# SERVICE BULLETIN

DATE: December 6, 1983

BULLETIN NUMBER:133

MODEL: W10Two, W13, W21, W27, W30, W33, W40, W50, W52, W58, W70,  
W80, W100, W120 (All Related Generators)

SUBJECT: Zinc Pencil - #11885

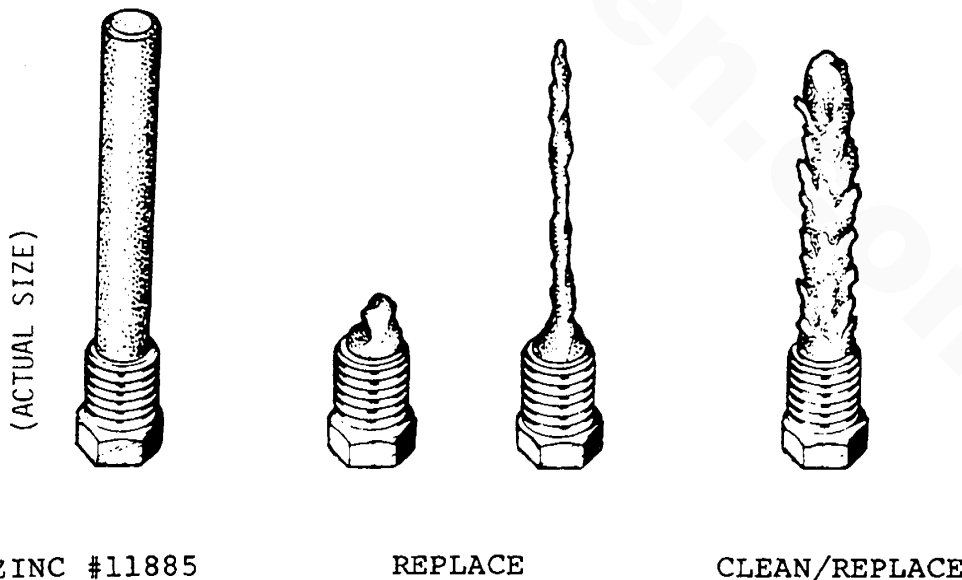
A zinc pencil PN 11885 is located in the sea water cooling circuit of all primary heat exchangers on the above models. The purpose of the zinc pencil is to sacrifice itself to electrolysis action taking place in the salt water cooling circuit. This zinc pencil should be periodically checked by unscrewing it from its mounting boss on the exchanger. For the location of the zinc on your model, refer to the cooling system section of your parts manual. Replace the zinc pencil as inspection dictates. (Refer to Illustration A.)

Should material be flaking off the zinc, it should be scraped clean, or be replaced by a good solid zinc pencil.

If it appears that a lot of material has been flaking off the zinc, then it is advised that the end cap of the exchanger be removed, and the flaked material be cleaned from that area of the exchanger. A new end cap gasket should be on hand in case it is needed when replacing the end cap.

Refer to Service Bulletin #84 when removing end caps made of rubber.

## ILLUSTRATION A



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# SERVICE BULLETIN

DATE: December 28, 1983

BULLETIN NUMBER: 134

MODEL: 3KW, 4.4KW, 7.7KW, 11KW & 12.5KW (Related to 50 Hertz Units)

SUBJECT: Fuel Solenoid - PN 23041

Fuel solenoid adjustment and operation as outlined in Service Bulletin #127 should be verified as part of the pre-start-up inspection (commissioning) of the generator.

During installation, the adjustment of the fuel solenoid may be affected, due to handling and positioning of the unit in the vessel's hull.

Periodic inspection of the solenoid's operation is also recommended at the initial 50-hour servicing and every 200 hours thereafter.

NOTE: The flexible rubber boot covering the solenoid must not be removed, as this helps protect the plunger from contaminants and aids in withdrawal of the plunger when the solenoid is de-energized.

Periodically examine the plunger to ensure that it is clean. Generally no lubrication is needed on this plunger.

Periodic lubrication is needed on the ball joint connection between the plunger and the throttle arm.



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# SERVICE BULLETIN

DATE: April 3, 1984

BULLETIN NUMBER: 137

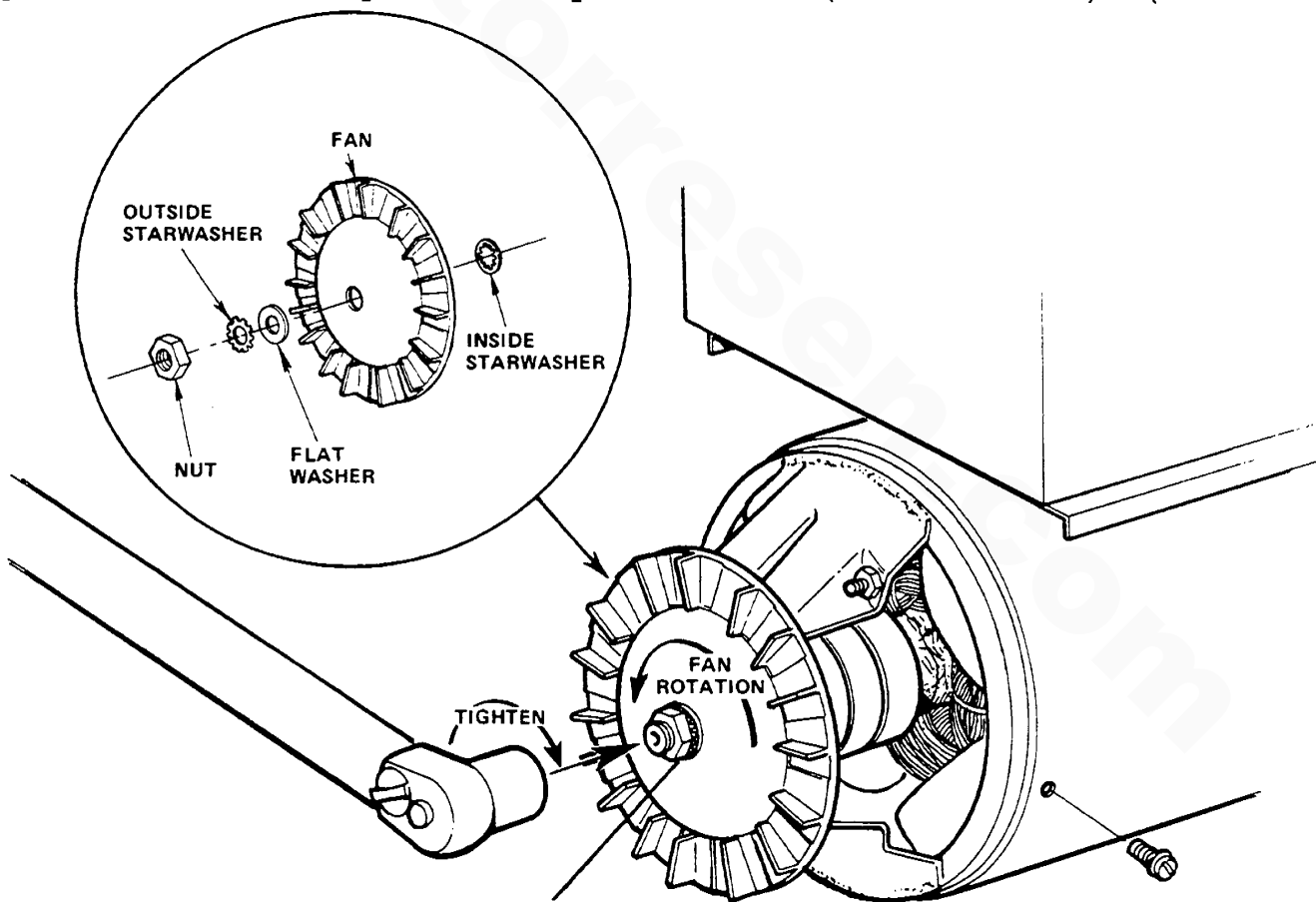
MODEL: 3KW, 4.4KW, 7.7KW, 8KW, 11KW, 12.5KW (Also related 50 Hertz Units)

SUBJECT: Cooling Fan Securing Nut

Generator units must have proper air circulation while running to provide for combustion air for use by the engine and for cooling the generator unit (minimum 250 C.F.M. all units through 12.5KW for generator end cooling).

The fan on the back end of the above model generators plays an important part in moving air through the generator for cooling. In installations where surrounding air is limited, outside air should be ducted to the area of the screened end bell inlet to provide this needed air for cooling and combustion as well.

The security of the generator fan holddown nut should be checked at installation (commissioning), at the initial 50-hour servicing of the generator unit and periodically thereafter (200-300 hours). (FIGURE A)



Cooling Fan  
Securing Nut

FIGURE A

Securing Nut Torque - 25 lb/ft.

over.....



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The cooling fan securing nut should be tight enough so that when force is applied to rotate the fan by pushing on the outer edge and blades with the palm of your hand (protect the hand with a cloth or glove), you should be able to turn the generator and engine without the fan slipping on the shaft. If properly torqued and fan still slips, replace the lockwashers.

Recirculation of generator cooling air through the generator must be avoided. The generator compartment ventilation must be sufficient to prevent generator air recirculation.

Insure that the screened endbell inlet and the screened discharge slots at the flywheel are not obstructed, preventing good air circulation through the generator while it is running.