

TECHNICAL MANUAL

WESTERBEKE 60 Marine Diesel Engine

WESTERBEKE WPDS-20 Marine Diesel Generator

Publication #15204

Edition Four

September 1979



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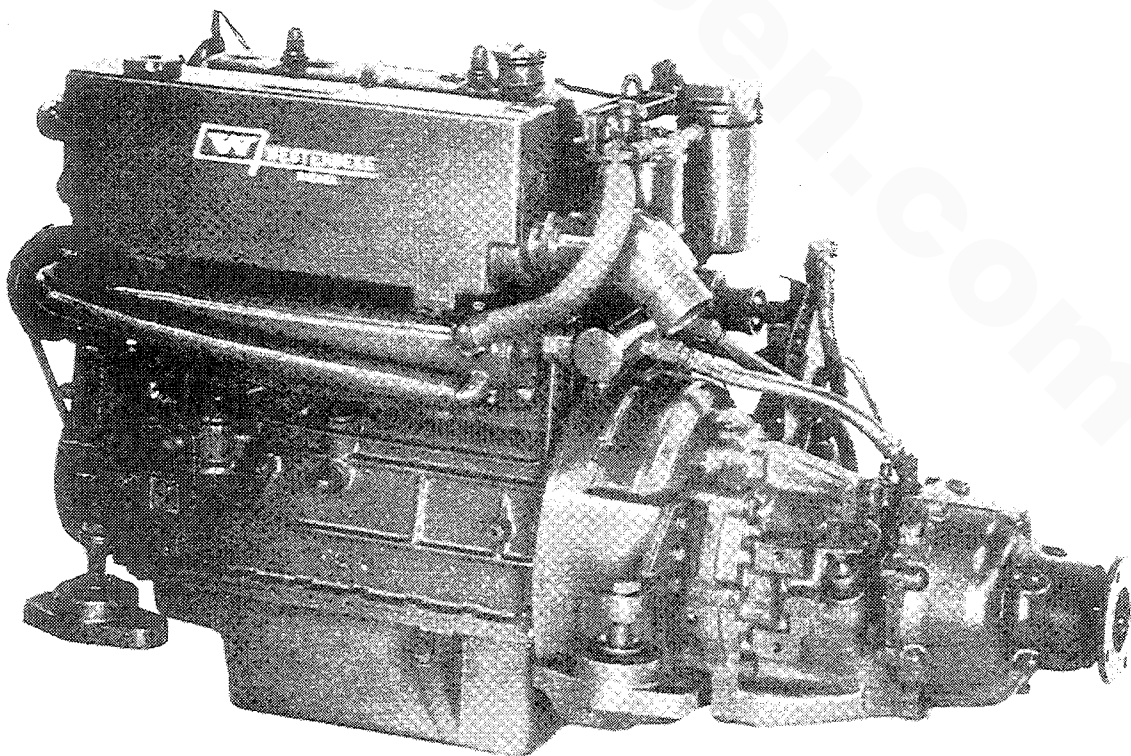
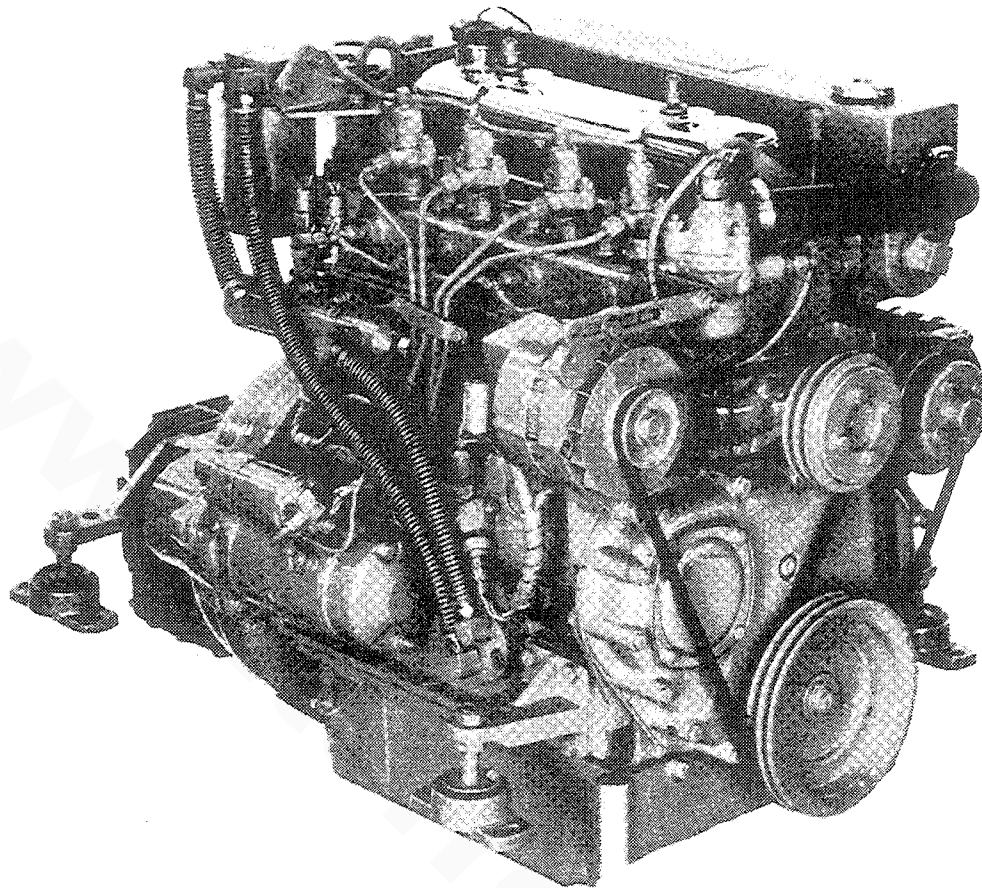
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INTRODUCTION

IMPORTANT

THIS MANUAL IS A DETAILED 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 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 furnished, if not part of this publication). 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.

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INSTALLATION

FOREWORD

Since the boats in which these engines 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

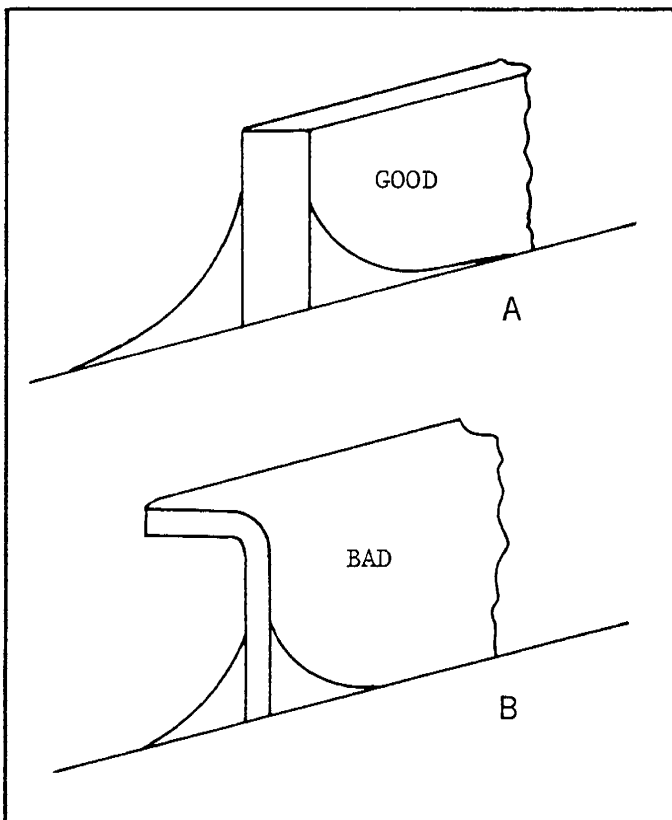
It is recommended that bronze hanger bolts of appropriate size be used through the engine flexible mounts. Lag screws are less preferred because their hold on the wood is weakened every time they are moved, whereas the lag bolt stays in position and the nut on top is used to tighten the engine down or 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.

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".



PROPELLER COUPLING

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

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

For 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 speed 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 align-

ment 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.

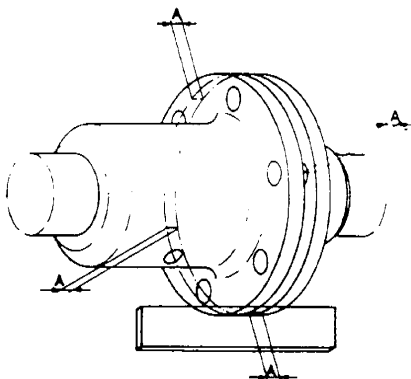
One particularly annoying result of misalignment may be leakage of transmission oil through the rear oil seal. Check to make sure that alignment is within the limits prescribed.

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 tank 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 backwards and forward into the counterbore very easily and when a feeler gauge indicates that the flanges come exactly together at all points. The two halves of the propeller coupling should be parallel within 0.002 inches (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.

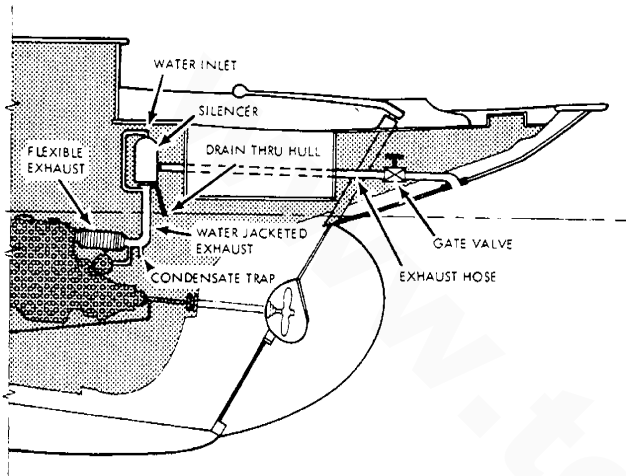
The coupling should always be opened up and the bolts removed whenever the boat is hauled out or moved from the land to the water, and during storage in a cradle. The flexibility of the boat often puts a very severe strain on the shaft or the coupling or both when it is being moved. In some cases the 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 job. The general requirements are to provide an outlet line with a minimum of restrictions and arranged so that sea water, rain water, or condensation cannot get back into the engine. There should be a considerable fall in the line between the exhaust manifold flange and the discharge end. This slope in the pipe makes it difficult for water to be driven in very far by a wave; and a steep drop followed by a long slope is better than a straight gradual slope. Avoid any depression or trough to the line which would fill with water and obstruct the flow of exhaust gas. Also avoid any sharp bends.

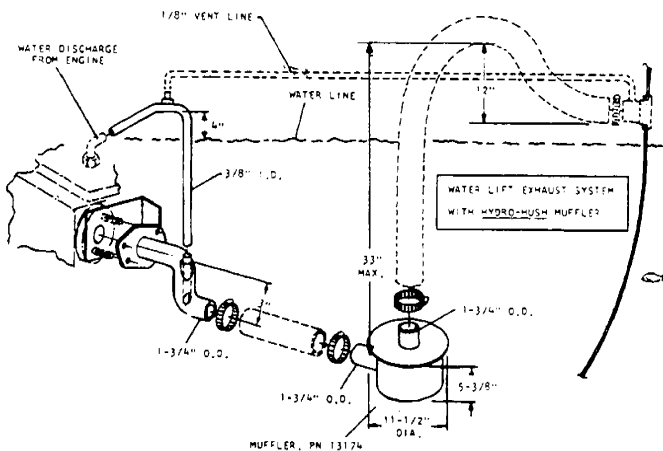
Brass or copper is not acceptable for wet exhaust systems, as the combination of salt water and diesel exhaust gas will

cause rapid deterioration. Galvanized iron fittings and galvanized iron pipe is recommended for the exhaust line. The exhaust line must be at least as large as the engine exhaust manifold flange and be increased in size if there is an especially long run and/or many elbows. It should be increased by 1/2" in I.D. for every 10 feet beyond the first 10 feet.



EXHAUST SYSTEM WITH WATER JACKETED STANDPIPE

To insure vibration doesn't transmit to hull, use a flexible section preferably of stainless steel, no less than 12" overall, threaded at each end and installed as close to the engine as possible. This flexible section should be installed with no bends and covered with insulating material. The exhaust pipe should be properly supported by brackets to eliminate any strain on the manifold flange studs. 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



WATER LIFT EXHAUST SYSTEM WITH "HYDRO-HUSH" MUFFLER

support for the rubber hose to prevent sagging, bending, and formation of water pockets.

Always arrange that water discharge into the rubber hose section is behind a riser or sufficiently below the exhaust flange 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.

MEASURING EXHAUST GAS BACK PRESSURE

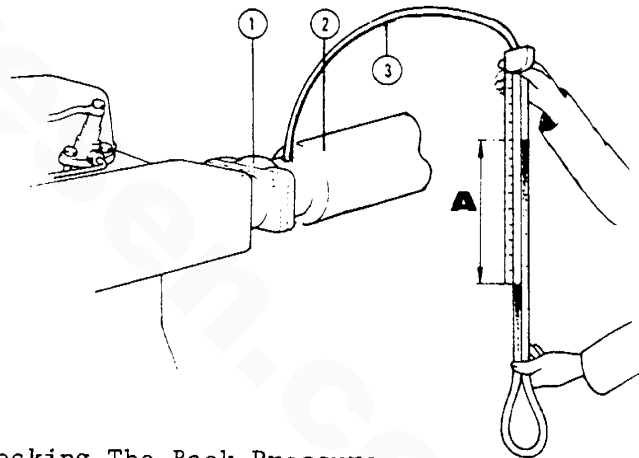
Back pressure must be measured on a straight section of the exhaust line and as near as possible to the engine exhaust manifold. The engine should be run at maximum load during the measurement period. Set-up should be as shown below.

1. For normally asperated engines:

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

2. For turbo-charged engines:

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



Checking The Back Pressure

1. Exhaust pipe flange
2. Exhaust line
3. Transparent plastic hose, partly filled with water. Measurement "A" may not exceed 39" for normally asperated 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.

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 permits the engine to be moved slightly when it's 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.

FUEL TANK AND FILTERS

Fuel tanks may be of fiberglass, monel, aluminum, plain steel or terne 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 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 air-locks 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 overflow is piped to the fuel tank and should be connected to the top of the tank or as near the top as possible.

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 recommended 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.

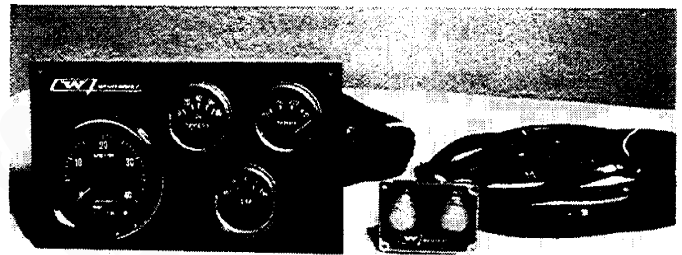
Keep fuel lines as far as possible from exhaust pipe for minimum temperature, to eliminate "vapor locks".

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.

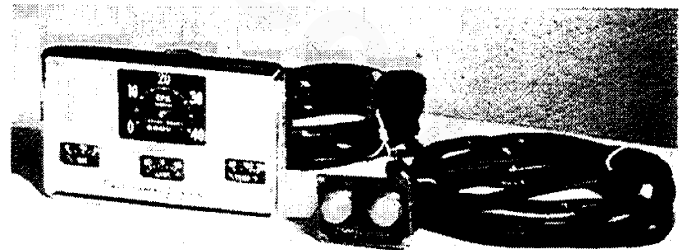
The final connection to the engine should be through flexible rubber hoses.

ELECTRIC PANEL

The Westerbeke all-electric panel utilizes an electronic tachometer with a built-in hour meter. Tachometer cables are no longer required, except for the Skipper mechanical panel. Mounted on the panel are an ammeter, water temperature gauge and oil pressure gage. Each instrument is lighted. The all-electric panel is isolated from ground and may be mounted where visible. It is normally pre-wired.



WESTERBEKE ALL-ELECTRIC PANEL



SKIPPER MECHANICAL TACH PANEL

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 sup-

plied, 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 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 is on the respective detent. Check the throttle control lever and the stop-run lever on the fuel injection pump for full travel.

OPERATION

PREPARATION FOR FIRST START

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

1. Remove oil filler cap and fill oil sump with heavy duty, diesel lubricating oil to the highest mark on the dipstick. See table under Maintenance for an approved lubricating oil. Do not over-fill. Select an approved grade from the listing and continue to use it.
2. If the Reverse Gear has a manual clutch, fill to the highest mark on the dipstick with S.A.E. 30 lubricating oil. You may use the same oil as in the engine.

If Reverse Gear is hydraulic, fill to the highest mark on the dipstick with type A Hydraulic fluid. Do not over-fill.

3. Fill fresh water cooling system only after opening all pet-cocks and plugs until all entrapped air is expelled. On fresh water cooled engines, fill the fresh water cooling system with fresh clean water and/or anti-freeze solution (see Cold Weather precautions in Maintenance Section).

Use a 50-50 anti-freeze solution if cold weather is to be experienced.

Fill surge tank to within one inch of the top. Check this level after engine has run for a few minutes. If trapped air is released, the water level may have dropped. If so, refill tank to within one inch of top and replace filler cap.

4. Ensure battery water level is at least 3/8" above the battery plates and battery is fully charged so that it is capable of the extra effort that may be required on the first start.
5. Fill fuel tank with clean Diesel fuel oil; No. 2 diesel fuel oil is recommended. The use of No. 1 is permissible but No. 2 is preferred because of its higher lubricant content.

NOTE: If there is no filter in the filler of the fuel tank, the recommended procedure is to pour the fuel through a funnel of 200 mesh wire screen.

6. Fill grease cup on water pump, if present, with a good grade of water pump grease.

BLEEDING THE 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. Running out of fuel is a misfortune that also necessitates complete bleeding of the system before the engine can be restarted.

The following instructions for fuel system bleeding apply to typical systems using in-line DPA pumps (shown in Figs.1 and 2).

Before priming and bleeding, insure that the outside of the bleed screws and surrounding area is thoroughly clean to prevent dirt and foreign matter entering the system.

DPA DISTRIBUTOR PUMPS The following priming and venting sequence is applicable to both mechanically and hydraulically governed DPA pumps. The only difference is the physical location on the pump of the governor bleed screw "D" and this is indicated in the appropriate illustration,

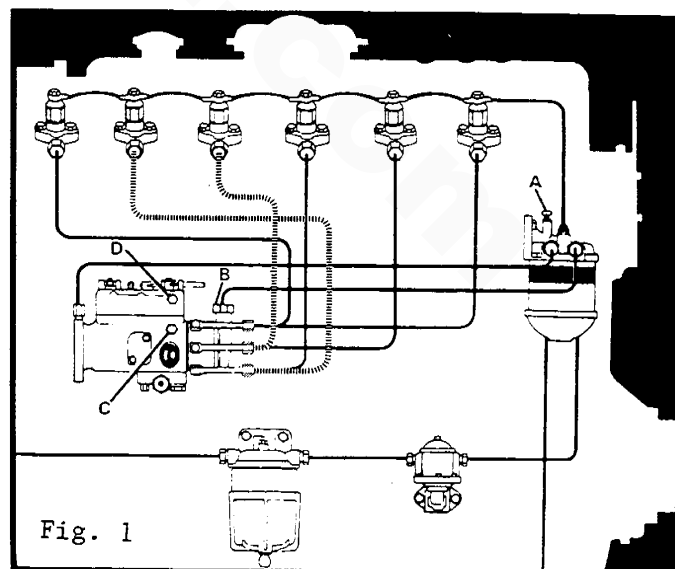


Fig. 1

Fig. 1 for mechanically governed and Fig. 2 for hydraulically governed pumps.

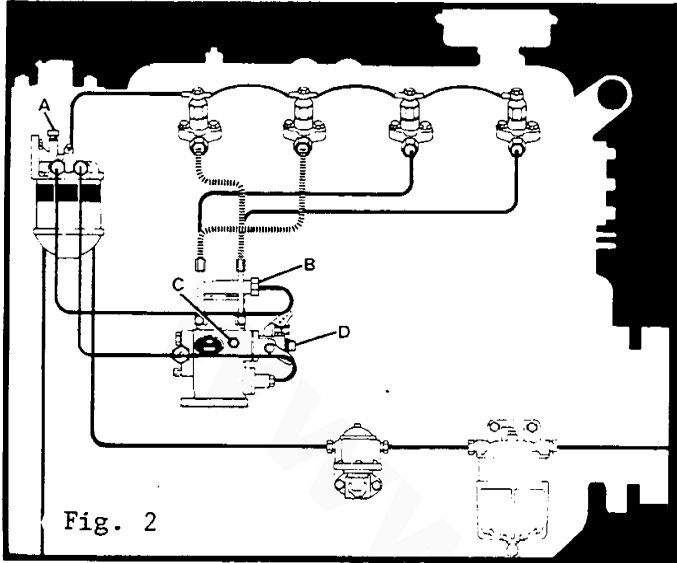


Fig. 2

If the fuel system is fitted with a fuel feed pump, slacken both the filter bleed screw "A" and the injection pump fuel inlet union "B", and operate the hand priming lever of the feed pump until fuel free from air issues from both the vents. Tighten both the vent connections. In a gravity fed fuel system turn on the fuel and carry out the same procedure with the bleed screw and fuel inlet.

Slacken the vent valve fitted to one of the two hydraulic head locking screws "C" and the bleed screw "D" on the governor housing. Operate the hand priming lever of the feed pump, until fuel free from air bubbles issues from the vent "C" and then tighten this bleed screw.

NOTE: The space within the governor housing (vented by screw "D") is normally filled, and its contents lubricated, by fuel oil back-leaked from the pump plungers, the pump rotor and the advance device if fitted. This is the normal way in which this space becomes filled with oil and this can naturally take a long time at feed pump pressures.

However, if the reason that the pump is being vented is because a pipe line or injector or filter element has been changed or serviced or the system has run out of fuel, then the governor housing will still be filled with fuel oil and bleeding by means of the hand priming lever of the feed pump will suffice. In this event, close the governor bleed screw "D" as soon as fuel free from air issues from the vent.

If, however, a new pump has been fitted to the system, then its governor housing will most likely be empty of fuel oil and

bleeding proceeds as follows.

Leave the governor bleed screw "D" slackened. Next slacken any two injector pipe line connections at the injector end. Set the throttle to the fully open position and turn the engine until fuel free from air flows from the unions. Then retighten the loosened injector pipe unions.

Start the engine and run it at fast idling speed until air-free fuel exudes from the governor bleed screw "D". Tighten this screw and stop the engine.

Governing may be erratic during this procedure, therefore stand by to stop the engine should any excessive engine speed develop.

RECOMMENDED SPARES Owners are often in doubt as to the amount of fuel injection equipment spares to carry. A great deal depends upon the use of the craft and its location. General coastal use in well-populated areas is one thing, but voyaging up the Amazon delta, for example, would be quite different and would require a comprehensive spares kit.

Generally speaking, the average boat owner is within relatively easy reach of service centers and requires spares only as insurance against breakdown and for general servicing within the scope of the owner or crew.

A suitable kit for such a purpose would consist of a replacement filter element and a set of sealing and "O" rings for each filter. Spare bleed screws for pumps and filters are also required, for screws are easily lost or damaged in a boat when bleeding the system. A full set of high pressure injection pipes should also be carried, for a fractured or cracked pipe could occur at any time and no patching is possible with these pipes. The correct set of pipes can be obtained from the engine manufacturer's agent or service center and will be supplied already bent to shape and cleaned internally with both ends plugged against the entry of dirt. They will be supplied packed as a set and it is important to keep them this way until required for use. It is vitally important that the internal surface of the pipe is kept scrupulously clean until fitted to the engine.

A spare set of fuel injectors of the right type and correctly set for the particular engine together with a set of the correct seating washers will not only enable defective injectors to be changed when required but will also permit engine use while one set is away being serviced.

Do be careful to check with the engine parts list regarding whether the engine requires injector seating washers or not.

Additionally, spare banjo bolts and washers for back leak pipes and low pressure pipes are handy things to have when a joint starts leaking. Remember no equipment ever breaks down when it is stationary in port. Breakdowns and trouble occur when the equipment is working - and that means at sea!

Do not forget the tools. Always carry the correct spanners for the job - hammers and adjustable wrenches may be all right in some locations, but please, not around your fuel injection equipment on your craft.

HINTS AND TIPS It is essential to stress the need for absolute cleanliness of the fuel at all times. This requirement also extends to methods of operating and servicing the equipment and to precautions about refueling.

A useful hint when changing filter elements is to obtain a polythene bag large enough and strong enough to hold the filter element and put this around the element and filter head before unscrewing the center bolt. Undo the center bolt and allow element, oil and base all to go into the bag. Then empty the bag into a bowl or container large enough for the contents to be separated and the base and sealing rings recovered if required.

Granulated pieces of substance familiar to all cat owners who live in apartments and sold for use in cat litter boxes is ideal for soaking up diesel fuel spilled when venting or removing pipe lines. Put the material down before working on the system.

Barrier creams of the oil-defying kind are useful and make life much easier when removing the grime from hands. Put on the cream before the job is tackled and then dirt, grease and cream are removed together when the job is completed.

In the majority of fueling installations fuel will be supplied through a hose - always wipe the pump nozzle with a clean non-fluffy piece of cloth before use. None of those grubby old swabs, please - they will do far more harm than good. If you spill any fuel on tank, deck or fittings, wipe it off right away. Diesel fuel oil does not evaporate as does gasoline, and if left, will gather dirt and grit, will track everywhere and keep on smelling. Be careful where you put down the fuel tank

cap when refueling - see that it doesn't pick up dirt or grit - this is how quite a lot of dirt gets into the tank.

Avoid dubious sources of fuel. Job lots of unknown origin are not always the bargain they appear to be and fuel injection equipment is expensive to renew when damaged.

WHEN ENGINE STARTS

1. Check Oil Pressure immediately. Normal oil pressure is approximately 50 psi at operating speeds, 15 psi when idling. (Extremely hot engine.)
 2. Check Sea Water Flow. Look for water at exhaust outlet. Do this without delay.
 3. Recheck Crankcase Oil. After the engine has run for 3 or 4 minutes, subsequent to an oil change or new installation, stop the engine and check the crankcase oil level. This is important 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 each day of operation.
 4. Recheck Transmission Oil Level. (This applies only subsequent to an oil change or a 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 oil as necessary. Check oil level each day of operation.
 5. Recheck Expansion Tank Water Level, if engine is fresh water cooled. (This applies after cooling system has been drained or filled for the first time.) Stop engine after it has reached operating temperature of 175°F and add water to within one inch of top of tank.
- WARNING:** The system is pressurized when overheated and the pressure must be released gradually if the filler cap is to be removed. It is advisable to protect the hands against escaping steam and turn the cap slowly counter-clockwise until the resistance of the safety stops is felt. Leave the cap in this position until all pressure is released. Press the cap downwards against the spring to clear the safety stops, and continue turning until it can be lifted off.
6. Warm-up Instructions. As soon as possible, get the boat underway but at reduced speed, until water temp. gauge indicates 130-150°F. If necessary, en-

gine can be warmed up with the clutch in neutral at 1000 rpm. Warming up with clutch in neutral takes longer and tends to overheat the transmission, if partial engagement occurs, which can be detected by propeller shaft rotation.

7. Reverse Operation. Always reduce engine to idle speed when shifting gears. However, when the transmission is engaged, it will carry full engine load.

NOTE: The SAO transmission requires that, when backing down, the shift lever must be held in the reverse position, since it has no positive overcenter locking mechanism.

STOPPING ENGINE

1. Position shift lever in neutral.
2. Move throttle lever to idle position.
3. Pull fuel push-pull STOP control out. (The stop control functions by cutting off the fuel from the fuel injection pump.)

NOTE: Idle engine for a few minutes to dissipate heat gradually before shutdown.

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 cylinder head, block, or manifold.
3. Keep intake silencer free from lint, etc.
4. Do not run engine at high RPM without clutch engaged.
5. Never Race a Cold Engine as internal damage can occur due to inadequate oil circulation.
6. Keep the engine and accessories clean.
7. Keep the fuel clean. Handle it with extreme care because water and dirt in fuel cause more trouble and service in-
8. Do not allow fuel to run low, because fuel intake may be uncovered long enough to allow air to enter the system, resulting in lost time required for priming.
9. Do not be alarmed if temperature 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.

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 fuel oil and check lube oil level daily.
3. Check cooling water temperature frequently to make sure it is 190° or less.
4. Close all drain cocks and refill with water before starting out.
5. Investigate any oil leaks immediately.

NEVER -

6. Race the engine in neutral.
7. Run the engine unless the gauge shows proper oil pressure.
8. Break the fuel pump seals.
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.

YOUR NOTES

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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:

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. Check and adjust, if necessary, the forward drum assembly and the reverse band on manual SA0 and SA-1 transmissions.
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 mount fittings. These could cause mis-alignment.

DAILY CHECKOUT

Do the following:

1. Check 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. Turn down grease cup on water pump, if used, one full turn.
5. Check lubricating oil level in transmission. Fill to highest mark on dipstick.

SEASONAL CHECK-OUT (MORE OFTEN IF POSSIBLE)

Do the following:

1. Check generator or alternator "V" belt for tension.
2. Check water level in battery.
3. Change oil in sump. Oil may be sucked out of sump by attaching a suction hose (3/8" ID) over the outside of the oil sump pipe, located aft of the dipstick. Figure 1. See Note, next page.
4. Replace lubricating oil filter. Fig. 2. See Note, next page.
5. Fill sump with approximately 4.5 US quarts of diesel lubricating oil to high mark on dipstick. Do not over fill. See Note next page.

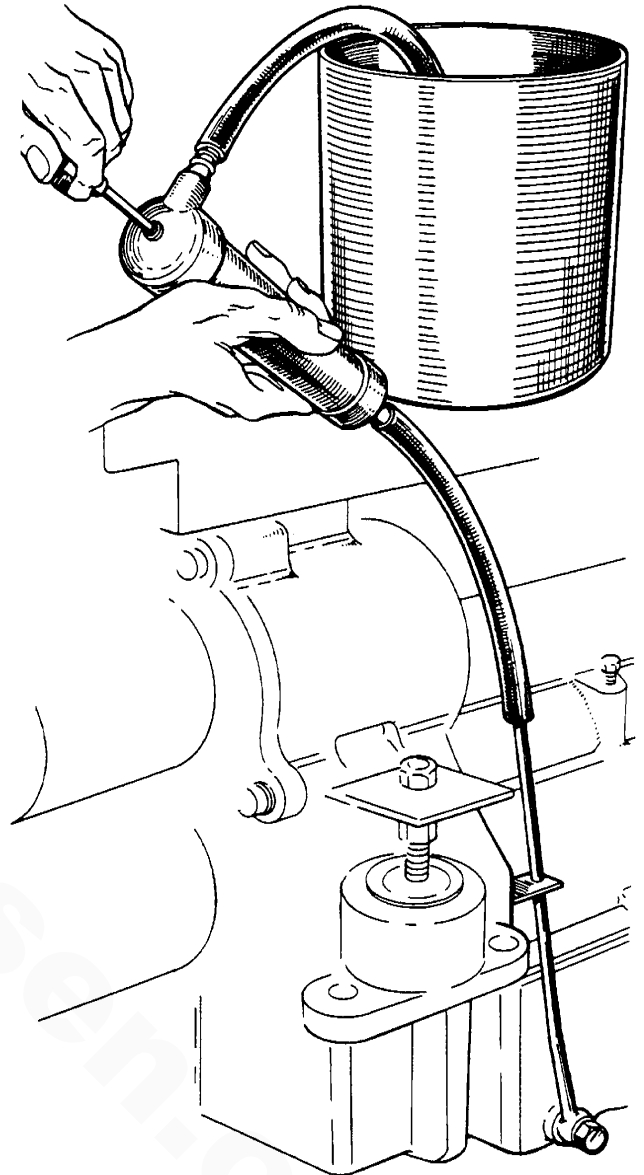


FIGURE 1

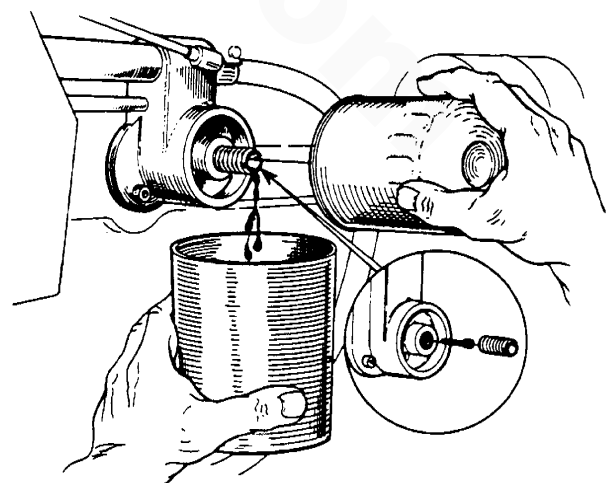


FIGURE 2

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. Change oil in transmission. Use SAE 30, High Detergent Lubricating Oil, Service DG, DM, or DS. Do not overfill. See note below.

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. The time period for replacing the air filter depends on operating conditions, therefore, under extremely dirty conditions, the seasonal frequency should be increased. The correct time periods for replacing the filter will greatly assist in reducing bore wear, thereby extending the life of the engine.
8. Check engine for loose bolts, nuts, etc.
9. Check sea water pump for leaks.
10. Wash primary filter bowl and screen. If filter bowl contains water or sediment, filter bowl and secondary oil fuel filter need to be cleaned more frequently.
11. Replace secondary fuel filter element.
12. Replace air filter.

END OF SEASON SERVICE

1. Drain fresh water cooling system by removing the surge tank pressure cap and opening all water system petcocks.
2. Remove zinc rod (usually located in heat exchanger) and see if it needs replacing. The zinc rod will take care of any electrolysis that may occur between dissimilar metals. Insert new zinc if necessary.

3. Fill fresh water cooling system with antifreeze of a reputable make. (Refer to Cold Weather Precautions.)
4. Start engine. When temperature gauge indicates 175°F, shut engine down and drain lubricating oil. Remove and replace filter. Fill sump with High Detergent Lubricating Oil.
5. Remove air filter. Carefully seal air intake opening with waterproofed adhesive tape or some other suitable medium.
6. Seal the exhaust outlet at the most accessible location as close to the engine as possible.
7. Remove injectors and spray oil into cylinders.
8. Replace injectors with new sealing washer under each injector. Turn engine slowly over compression.
9. Top off fuel tank completely so that no air space remains, thereby preventing water formation by condensation.
10. Leave fuel system full of fuel.
11. Change fuel filters before putting the engine back in service.
12. Wipe engine with a coat of oil or grease.
13. Change oil in transmission.
14. Disconnect battery and store in fully charged condition. Before storing the battery, the battery terminals and cable connectors should be treated to prevent corrosion. Recharge battery every 30 days.
15. Check alignment.

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.

These oils meet the requirements of the U. S. Ordnance Specification MIL-L-2104B (API Service CC). Any other oils which also conform to these specifications, but are not listed here are, of course, also suitable.

| COMPANY | BRAND | S.A.E. DESIGNATION | | |
|------------------------|-----------------------------|---------------------|----------------------|-----------------------|
| | | 0°/45° ^F | 45°/80° ^F | OVER 80° ^F |
| American Oil Co. | American Supermil Motor Oil | 10W | 20W/20 | 30 |
| BP Canada Limited | BP Vanellus | 10W | 20W/20 | 30 |
| | BP Vanellus | 10W/30 | 10W/30 | 10W/30 |
| Chevron Oil Co. | RPM DELO Multi-Service Oil | 10W | 20W/20 | 30 |
| Cities Service Oil Co. | CITGO Extra Range | 10W | 20W/20 | 30 |
| Continental Oil Co. | CONOCO TRACON OIL | 10W | 20W/20 | 30 |
| Gulf Oil Corporation | Gulflube Motor Oil X.H.D. | 10W | 20W/20 | 30 |
| Mobile Oil Company | Delvac 1200 Series | 1210 | 1220 | 1230 |
| Shell Oil Company | Shell Rotella T Oil | 10W | 20W/20 | 30 |
| Sun Oil Company | Subfleet MIL-B | 10W | 20W/20 | 30 |
| Texaco, Inc. | Ursa Oil Extra Duty | 10W | 20W/20 | 30 |

YOUR NOTES

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ENGINE OVERHAUL

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

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

Any replacements should be made only with genuine Westerbeke parts.

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DESCRIPTION

This high efficiency, naturally aspirated diesel engine is a well-proved power unit of advanced design and incorporates the very latest results of research in diesel engineering techniques. Favorable high power-to-weight ratio with outstanding reliability and the greatest economy in operation are marked features of the engine.

The Westerbeke 60 engine is robustly constructed and manufactured to exacting production standards for withstanding the most arduous duties – inherent Westerbeke qualities which play an important role in reducing routine attention and maintenance to a minimum, while at the same time appreciably extending intervals between major overhauls.

Outstanding features of the design include monobloc construction, a forged alloy-steel crankshaft with 'Tuftride' treated bearing journals, and the Ricardo Comet Mk VB spherical anti-chamber combustion system.

CYLINDER BLOCK AND CRANKCASE

Special cast iron monobloc casting provided with adequate ribs and wide joint flanges, giving a light construction with maximum rigidity. Large capacity water jackets are cast around each bore. There is a closed circuit breathing system fitted

CYLINDER HEAD

Manufactured from special cast iron and secured by twenty-five 7/16 in. (11.1 mm) diameter high tensile steel studs to the cylinder block. Combustion chambers of Ricardo Comet design are incorporated and renewable valve guides are fitted.

CRANKSHAFT

Special alloy steel forging with 'Tuftride' hardened bearing journals. The shaft, which is fully counter-balanced by design and also dynamically and statically balanced, is carried in

three steel-lined reticular tin aluminum shell bearings, 2.478 in. (62.94 mm) diameter giving a total projected area of 10.424 in² (67.24 cm²).

CONNECTING RODS

'I' section heat-treated alloy steel stampings. The big-ends are fitted with steel-backed lead-indium thin shell bearings, 2.248 in. (57.07 mm) diameter, and the small ends with steel-backed lead-bronze alloy bushes, 1.125 in. (28.58 mm) diameter. Total big-end bearing projected area 8.720 in² (56.26 cm²).

PISTONS

Anodized aluminum alloy with solid skirt. Each piston has one chrome-faced compression ring, one taper-faced compression ring, one stepped scraper ring, and one slotted oil control ring. The fully-floating gudgeon pins 1.125 in. (28.58 mm) diameter are located laterally by circlips.

VALVE GEAR

Overhead poppet-type valves are operated by means of flat-faced piston-type tappets and push-rods from the camshaft, which is situated in the engine casing and adjacent to the crankshaft. The inlet valves are manufactured from silicon chromium steel and the exhaust valves from nickel chromium manganese steel. Double coil springs are fitted to each valve.

CAMSHAFT

Steel forging with case-hardened integral cams and supported in three steel-backed white metal bearings.

TIMING GEAR

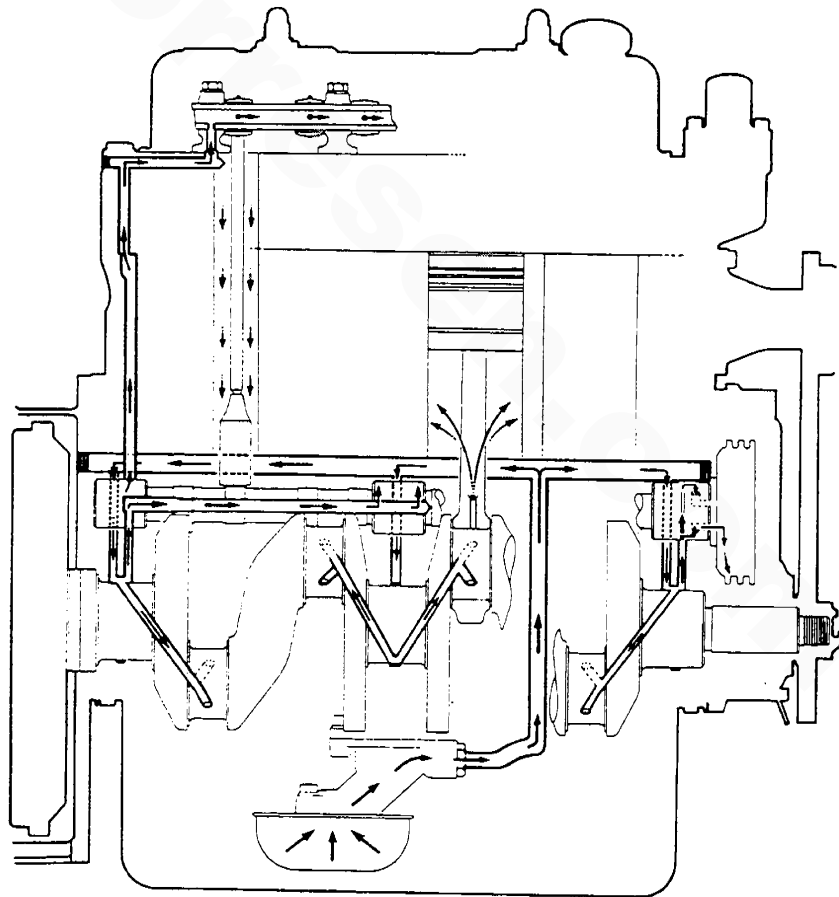
The camshaft and fuel injection pump are chain driven from the crankshaft. Slipper and tensioner units are fitted to ensure smooth working of the timing gear.

LUBRICATION SYSTEM

A full pressure wet sump system is employed. The eccentric-rotor type pressure pump is located within the engine crankcase and driven by helical gears from the camshaft. The pump has a delivery of 2 gal/min (9.1 litres) at 1000 rev/min of engine speed and provides a maximum pressure, controlled by a relief valve, of 50 lbf/in² (3.62 kgf/cm²) to all moving parts. Oil is drawn through a gauze strainer in the sump and before entering the system passes through a detachable external filter of the full flow type. It is then fed to the main, big-end, camshaft and small-end bearings. A restricted oil supply is fed to the valve rockers via the hollow rocker shaft and the returning oil lubricates valve caps, push-rod ends, and tappets.

FUEL INJECTION EQUIPMENT

A distributor-type fuel injection pump incorporating an all-speed mechanical governor is fitted. The pump is driven at half-engine speed from stable idling at approximately 500 rev/min to 3500 rev/min. The diaphragm-type lift pump, which incorporates a hand priming device, is mechanically operated from the engine camshaft and provides fuel to the injection pump under constant pressure. Each injector is fitted with a Pintaux-type nozzle and injects at a pressure of 135 atmos. (138.9 kgf/cm²) (1984 psi).



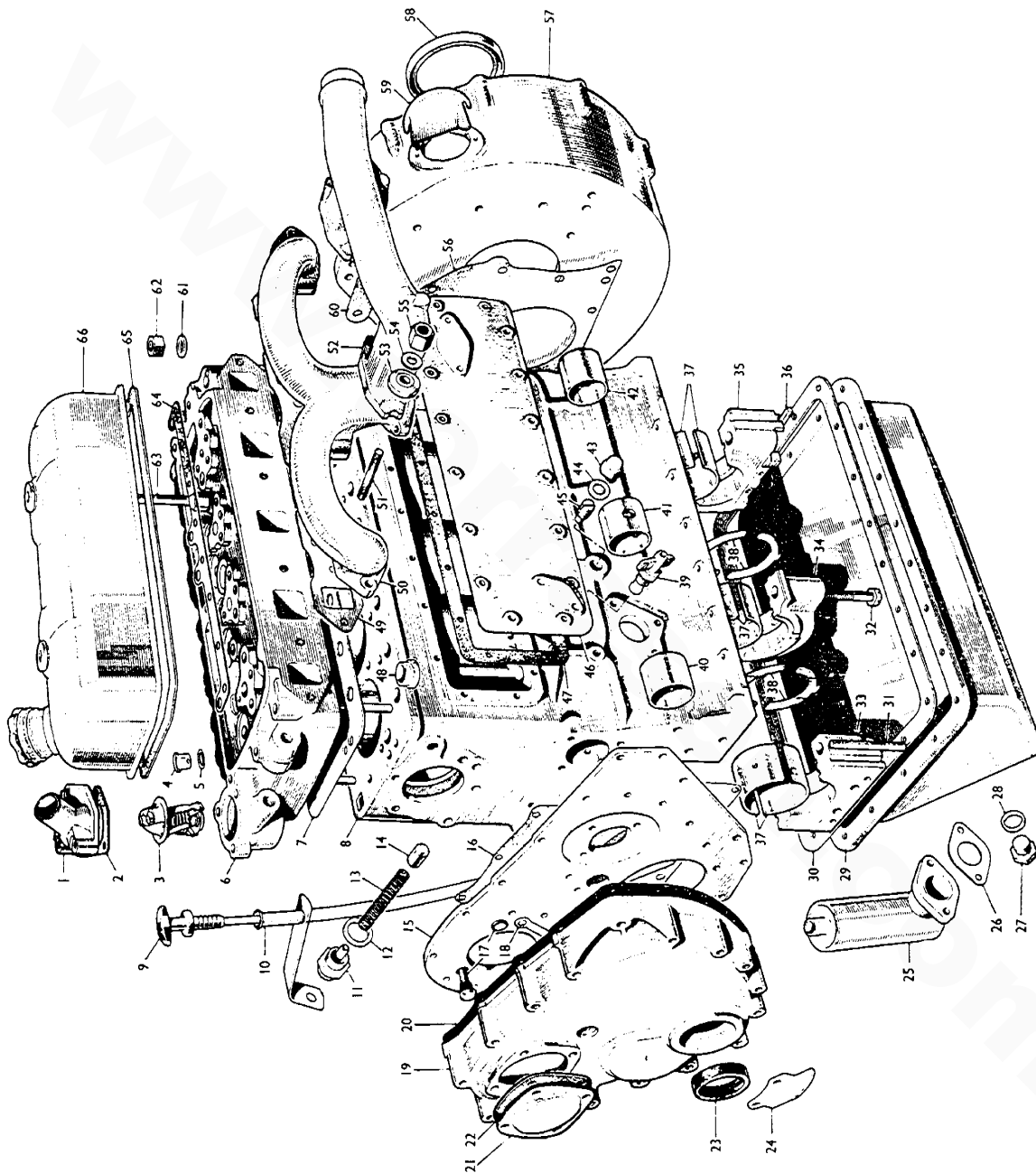
GENERAL DATA

| | | | |
|---|---|-------------------------|--------------------|
| MODEL | Westerbeke 60 | | |
| TYPE | Indirect injection | | |
| Number of cylinders | Four - Vertical | | |
| Bore and Stroke | 3.50 in. (89 mm) x 4.00 in. (101.6 mm) | | |
| Piston Displacement | 154.2 in. ³ (2520 cm ³) | | |
| Compression Ratio | 19.5 : 1 | | |
| Torque | 114.4 lb. ft. (15.81 Kg.m) @ 2,000 RPM | | |
| Continuous Rating | 53 Hp. at 2,500 RPM | | |
| Intermittent Rating | 60 Hp. at 3,000 RPM | | |
| Engine Weight (dry) | 750 lbs. approximately with direct drive | | |
| Oil Pressure: Idling | 15 lb./sq. in. (1.05 Kg./cm ²) | | |
| Normal Running | 50 lb./sq in. (3.52 Kg./cm ²) | | |
| Oil Capacity (including filter) | 7 quarts | | |
| Injection Order | 1, 3, 4, 2 | | |
| Rotation (Engine) | Anti-Clockwise, viewed from flywheel end. | | |
| Cooling Capacity | 12 quarts | | |
| Angle of Installation (max) | 15 degrees | | |
| Camshaft end float | .003 to .006 In. (.076 to .152 mm.) | | |
| Method of adjustment | Renew locating plate | | |
| Chain wheel alignment | Crankshaft and camshaft chain wheel teeth faces in line. Injection pump chain wheel self aligning. | | |
| Method of adjustment | Shims behind crank shaft chain wheel. | | |
| Valve Rocker Clearance (cold): | Inlet | ---- .012 in. (.30 mm.) | |
| | Exhaust | ---- .015 in. (.38 mm) | |
| Valve Timing (with .021 in. (.53 mm.) rocker clearance: | | | |
| | Inlet Valve | open 5° BTDC | closes 40° ABDC |
| | Exhaust Valve | 60° BBDC | 5° ATDC |

Torque Wrench Setting

| | |
|---------------------|----------------------------|
| Cylinder head nuts | 75 lb. ft. (10.37 Kg. m.) |
| Manifold Nuts | 22 lb. ft. (3.04 Kg. m.) |
| Rocker bracket nuts | 25 lb. ft. (3.46 Kg. m.) |
| Big End bolts | 50 lb. ft. (6.9 Kg. m.) |
| Flywheel bolts | 50 lb. ft. (6.9 Kg. m.) |
| Main bearing bolts | 100 lb. ft. (13.82 Kg. m.) |

EXTERNAL COMPONENTS



KEY TO EXTERNAL COMPONENTS

| No. | Description | No. | Description |
|-----|--|-----|--|
| 1. | Water outlet. | 45. | Oil pump locating screw. |
| 2. | Gasket. | 46. | Cylinder side cover. |
| 3. | Thermostat. | 47. | Gasket. |
| 4. | Heat shield for injector. | 48. | Combustion chamber insert. |
| 5. | Washer. | 49. | Manifold gasket. |
| 6. | Cylinder head. | 50. | Exhaust manifold. |
| 7. | Gasket. | 51. | Manifold stud. |
| 8. | Cylinder block. | 52. | Inlet manifold. |
| 9. | Oil dipstick. | 53. | Yoke for manifold. |
| 10. | Dipstick tube. | 54. | Washer. |
| 11. | Plug for oil pressure relief valve. | 55. | Nut. |
| 12. | Washer. | 56. | Gasket for flywheel housing. |
| 13. | Spring. | 57. | Flywheel housing. |
| 14. | Oil pressure relief valve. | 58. | Crankshaft rear oil seal. |
| 15. | Front plate. | 59. | Ventilation cover for flywheel housing. |
| 16. | Gasket. | 60. | Top gasket for flywheel housing. |
| 17. | Bolt for injection pump. | 61. | Washer. |
| 18. | Lock washer for front plate bolts. | 62. | Cylinder head nut. |
| 19. | Timing cover. | 63. | Cylinder head nut and rocker cover stud. |
| 20. | Gasket. | 64. | Push rod locating plate. |
| 21. | Injection pump chain wheel cover. | 65. | Gasket. |
| 22. | Gasket. | 66. | Rocker cover. |
| 23. | Crankshaft front oil seal. | | |
| 24. | Degree plate. | | |
| 25. | Oil separator. | | |
| 26. | Gasket. | | |
| 27. | Sump drain plug. | | |
| 28. | Washer. | | |
| 29. | Sump. | | |
| 30. | Gasket. | | |
| 31. | Sealing plug for front and rear main bearing caps. | | |
| 32. | Main bearing bolt. | | |
| 33. | Front main bearing cap. | | |
| 34. | Centre main bearing cap. | | |
| 35. | Rear main bearing cap. | | |
| 36. | Sealing strip for rear main bearing cap. | | |
| 37. | Main bearings. | | |
| 38. | Crankshaft thrust washers. | | |
| 39. | Water drain tap. | | |
| 40. | Camshaft bearing (front). | | |
| 41. | Camshaft bearing (centre). | | |
| 42. | Camshaft bearing (rear). | | |
| 43. | Cap nut. | | |
| 44. | Washer. | | |

KEY TO INTERNAL COMPONENTS

| No. | Description | No. | Description |
|-----|--------------------------------------|------|--|
| 1. | Rocker shaft. | 69. | Crankshaft pulley. |
| 2. | Plain plug for shaft. | 70. | Oil thrower. |
| 3. | Screwed plug for shaft. | 71. | Crankshaft chain wheel. |
| 4. | Rocker bracket (plain). | 72. | Adjusting shim for chain wheel. |
| 5. | Rocker bracket (tapped). | 73. | Key for crankshaft. |
| 6. | Locating screw for shaft. | 74. | Crankshaft. |
| 7. | Lock washer. | 75. | Connecting rod and cap (Nos. 2 and 4). |
| 8. | Plain washer. | 76. | Connecting rod and cap (Nos. 1 and 3). |
| 9. | Spring washer. | 77. | Little end bush. |
| 10. | Nut. | 78. | Big-end bearing. |
| 11. | Valve rocker. | 79. | Big-end bolt. |
| 12. | Bush for rocker. | 80. | Lock washer. |
| 13. | Adjusting screw for rocker. | 81. | Circlip. |
| 14. | Locknut. | 82. | Gudgeon pin. |
| 15. | Distance piece (centre). | 83. | Piston. |
| 16. | Distance piece (end). | 84. | Compression ring. |
| 17. | Spacing spring. | 85. | Stepped scraper ring. |
| 18. | Spring washer. | 86. | Slotted oil control ring. |
| 19. | Plain washer. | 87. | Flywheel. |
| 20. | Split pin. | 88. | Starter ring. |
| 21. | Valve guide (inlet). | 89. | Dowel. |
| 22. | Valve (inlet). | 90. | Bearing for primary shaft. |
| 23. | Valve guide (exhaust). | 91. | Lock washer. |
| 24. | Valve (exhaust). | 92. | Bolt for flywheel. |
| 25. | Circlip for valve cotter. | 93. | Shaft for oil pump. |
| 26. | Valve cotter. | 94. | Key for shaft. |
| 27. | Valve spring cup. | 95. | Bolt for oil pump. |
| 28. | Oil seal for valve. | 96. | Spring washer. |
| 29. | Valve spring (inner). | 97. | Oil pump body. |
| 30. | Valve spring (outer). | 98. | Oil pump rotors. |
| 31. | Valve spring collar. | 99. | Oil pump cover. |
| 32. | Push-rod. | 100. | Oil strainer. |
| 33. | Tappet. | 101. | Gasket for strainer. |
| 34. | Camshaft. | 102. | Oil delivery pipe. |
| 35. | Key for camshaft. | | |
| 36. | Locating plate for camshaft. | | |
| 37. | Spring washer. | | |
| 38. | Bolt for locating plate. | | |
| 39. | Camshaft chainwheel. | | |
| 40. | Lock washer. | | |
| 41. | Nut for camshaft. | | |
| 42. | Timing chain. | | |
| 43. | Vibration damper for chain. | | |
| 44. | Shim for timing cover centre boss. | | |
| 45. | Screw for damper. | | |
| 46. | Nut. | | |
| 47. | Lock washer. | | |
| 48. | Tensioner for chain. | | |
| 49. | Gasket for tensioner. | | |
| 50. | Bolt for tensioner. | | |
| 51. | Lock washer. | | |
| 52. | Hub for injection pump chain wheel. | | |
| 53. | Gasket for hub. | | |
| 54. | Bearing for chain wheel. | | |
| 55. | Injection pump chain wheel. | | |
| 56. | Internal circlip for driving flange. | | |
| 57. | Injection pump driving flange. | | |
| 58. | Washer for flange. | | |
| 59. | Bolt for flange. | | |
| 60. | Oil feed pipe for hub. | | |
| 61. | Banjo bolt. | | |
| 62. | Washer for banjo. | | |
| 63. | Injection timing pointer. | | |
| 64. | Plain washer. | | |
| 65. | Spring washer. | | |
| 66. | Bolt for pointer. | | |
| 67. | Nut for crankshaft. | | |
| 68. | Lock washer. | | |

ENGINE

Removing

1. Drain fresh water system, refer to "Cooling System",
2. Pump lubrication oil from sump.
3. Disconnect battery cables from engine.
4. Disconnect electrical leads from terminals board.
5. Disconnect fuel pipe clips and fuel pipe from lift pump.
6. Disconnect exhaust pipe from exhaust manifolds.
7. Disconnect stop control from injection pump lever.
8. Disconnect throttle control from injection pump lever.
9. Disconnect propeller shaft coupling from transmission coupling and move shaft back approximately four inches.
10. Remove engine.

VALVE ROCKER SHAFT AND TAPPETS

Removing

1. Remove rocker cover
2. Release the rocker brackets from the cylinder head and lift off the rocker shaft assembly
3. Remove air intake manifold
4. Remove the cylinder side cover with oil separator
5. Withdraw the push-rods
6. Lift out the tappets.

Refitting

Reverse the procedure in 1 through 6 noting:

1. Check cylinder head nut. Torque 75 (refer to Section F , Par. 17b), "Cylinder Head".
2. Torque rocker bracket nuts (25 lb. ft.).
3. Adjust the valve rocker clearance (refer to Page A30 "Valve Rocker Clearance").

CYLINDER HEAD

Removing

1. Drain cooling system (refer to Section D).
2. Disconnect exhaust pipe from manifold.
3. Disconnect stop control from injection pump lever.
4. Disconnect throttle control from injection pump lever.
5. Disconnect electrical lead from temperature sender.
6. Disconnect hose from thermostat housing.
7. Disconnect hose from expansion tank to heat exchanger.
8. Remove fuel pipes from fuel filter.
9. Remove high pressure pipes from injection pump and injectors.
10. Remove fuel return lines from each injector.
11. Disconnect electrical leads from the heater plugs.
12. Remove rocker cover.
13. Remove rocker shaft assembly and withdraw the push rods.
14. Remove combination exhaust manifold/expansion tank, and air intake manifold.
15. Remove the cylinder head nuts, using tool 18G 545 to remove the two which also serve as rocker cover studs.
16. Lift off the cylinder head and push-rod positioning plate.

NOTE: The combustion chamber inserts are a loose fit in the cylinder head. They must be refitted in their original positions because the cylinder head face is machined with the inserts installed.

17. Refitting. Reverse the procedure in 1 to 16, noting:

- a. The cylinder head gasket is marked to ensure correct fitting.
- b. Tighten the cylinder head nuts in the order shown in Fig. 1. Torque 75 lb. ft.
- c. Adjust the valve rocker clearance (see Data).
- d. Bleed the fuel system.

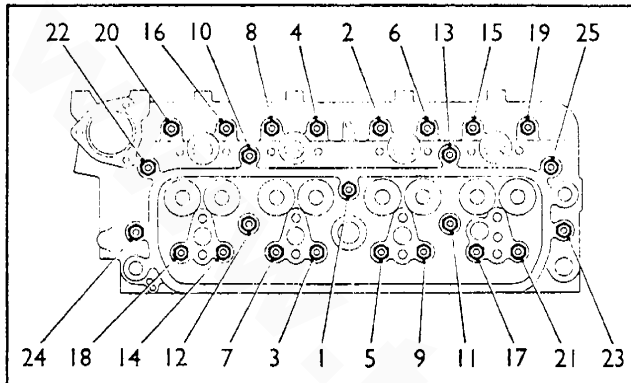


Fig. 1

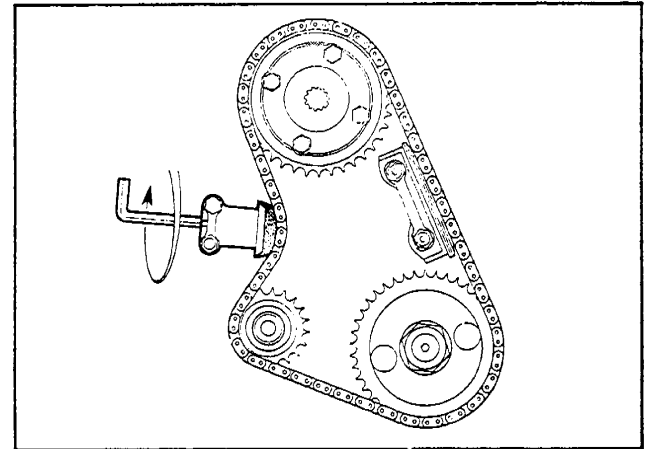


Fig. 2

TIMING CHAIN, CHAIN WHEELS AND CHAIN TENSIONER

Removing

1. Drain cooling system (refer to Section D).
2. Disconnect hoses to salt water pump.
3. Remove four bolts securing salt water pump housing to adapter plate.
4. Remove drive tang between water pump and engine.
5. Remove water pump adapter plate.
6. Slacken alternator mounting and remove belt.
7. Remove alternator.
8. Remove the crankshaft nut, using tool 18G 391.
9. Withdraw the crankshaft pulley, using tools 18G 231 and 18G 231B.
10. Remove alternator mounting bracket and adjustment bracket.
11. Remove the degree plate from the timing cover.
12. Remove the timing cover.
13. Remove the oil thrower from the crankshaft.
14. Retract the chain tensioner slipper as shown in Fig. 2
15. If the chain tensioner alone requires attention, remove it now, but if other components are to be removed leave the tensioner in position.
16. Remove the camshaft nut using tool 13G 98A.
17. Position the chain wheel marks as shown in Fig. 3 then remove the chain tensioner if it requires overhaul.
18. Draw the three chain wheels and chain off their shafts.
19. Refitting. Reverse the procedure in 1 to 18 noting:
 - a. Check and, if necessary, adjust the chain wheel alignment (see Data).
 - b. Assemble the chain wheels and chain to their shafts with the timing marks as shown in Fig. 4
 - c. Release the chain tensioner as shown in Fig. 2
 - d. Ensure that the crankshaft front oil seal is serviceable. If necessary renew the seal, using tools 18G 134 and 18G 134CR.
 - e. Centralize the timing cover using tool 18G 3.

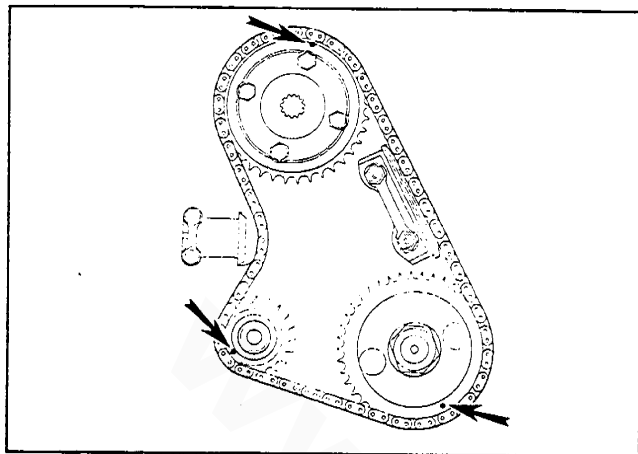


Fig. 3

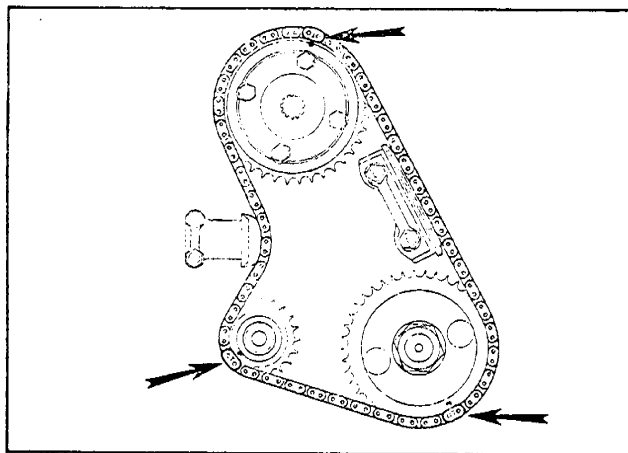


Fig. 4

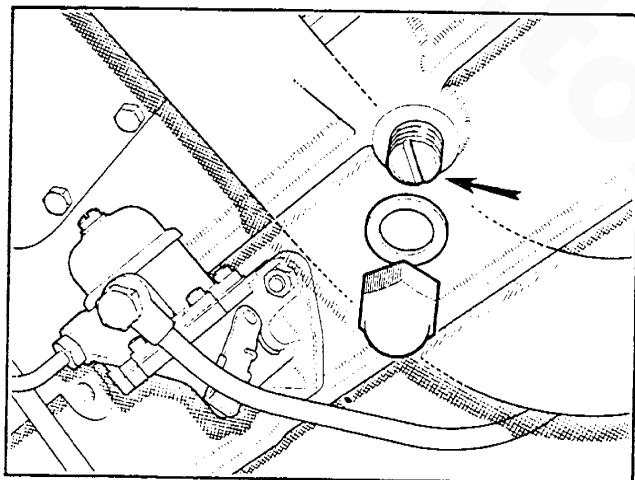


Fig. 5

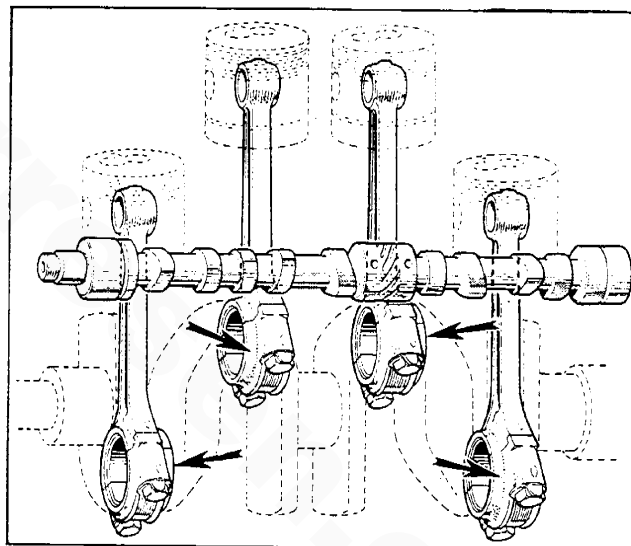


Fig. 6

CAMSHAFT AND FRONT PLATE

Removing

1. Refer to "Timing Chain, Chain Wheels, and Chain Tensioner", Step 1 through 12.
2. Remove the oil thrower from the crankshaft.
3. Retract the chain tensioner slipper as shown in Fig. 2.
4. Remove the camshaft nut, using tool 18G 98A.
5. Position the chain wheel marks as shown in Fig. 3.
6. Draw the three chain wheels and chain off their shafts.
7. Remove the camshaft locating plate.
8. Remove the alternator.

IF THE FRONT PLATE IS NOT TO BE REMOVED, OMIT 9 AND 16.

NOTE: The front plate must be removed to renew the chain vibration damper.

9. Remove the timing chain tensioner.
10. Disconnect the throttle and stop controls, and the throttle return spring, from the injection pump.
11. Disconnect the fuel feed and return pipes from the injection pump.
12. Disconnect the high pressure pipes from the injection pump.
13. Remove the lubricating oil feed pipe from the crankcase and injection pump chain wheel hub.
14. Remove the front plate complete with injection pump.
15. Remove the cylinder side cover.
16. Drain and remove the sump.
17. Release the oil delivery pipe from the crankcase.
18. Remove the dowel screw shown in Fig. 5 and withdraw the oil pump and strainer.
19. Remove the rocker cover.
20. Remove the rocker shaft.
21. Withdraw the push-rods.
22. Lift out the tappets.
23. Withdraw the camshaft.
24. Refitting. Reverse the procedure in 1 to 23 as necessary noting:
 - a. Before tightening any of the front plate bolts, fit all bolts which pass through the front plate into the cylinder block to ensure correct positioning of the front plate.
 - b. Check the camshaft end-float against the figure in Data.
 - c. Check the chain wheel alignment (see Data).
 - d. Assemble the chain and chain wheels to their shafts with the timing marks as shown in Fig. 4 .
 - e. Release the chain tensioner slipper as shown in Fig. 2.
 - f. Ensure that the crankshaft front oil seal is serviceable. If necessary renew the seal, using tools 18G 134 and 18G 134CR.
 - g. Centralize the timing cover with tool 18G 3.
 - h. Refer to Data for torque wrench settings.
 - i. Adjust the valve rocker clearance (see Data).
 - j. Bleed the fuel system.

OIL PUMP, CONNECTING RODS AND PISTONS

Removing

1. Remove engine.
2. Remove valve rocker shaft and tappets.
3. Remove cylinder head.
4. Remove the big-end caps.
5. Withdraw the connecting rods and pistons upward.
6. Refitting. Reverse the procedure in 1 to 5, noting:
 - a. The cylinder head gasket is marked to ensure correct fitting.
 - b. Refer to Data for torque wrench settings.
 - c. Fit the connecting rods with their offsets as shown in Fig. 6 , using tool 18G 55 A to compress the piston rings.
 - d. Tighten the cylinder head nuts in the order shown in Fig. 1 .
 - e. Adjust the valve rocker clearance (see Data).
 - f. Bleed the fuel system.

FLYWHEEL HOUSING, FLYWHEEL AND BACKPLATE

Removing

1. Take weight off rear of engine with sling attached to rear lifting eye.
2. Remove rear mounting brackets from transmission housing.
3. Remove nut securing each rear mounting bracket to flexible mount.
4. Close inlet and outlet sea water cocks. Disconnect raw water from transmission oil cooler (hose between oil cooler and heat exchanger).
5. Disconnect battery cable leads from starter motor.
6. Disconnect shaft cable or rod and clips from transmission shift lever.
7. Disconnect coupling between transmission and propeller shaft and move shaft back approximately four inches.
8. Remove bolts and lock washers securing transmission to bellhousing. Pull transmission straight back and firt away from engine.
9. Remove Starter Motor.
10. Remove Flywheel Housing. Remove bolts and lock washers (front of housing and rear of backplate) securing housing to backplate. Pull housing from the backplate two locating dowels.
11. Remove Damper Plate. (Hydraulic Transmission) Remove the socket head screws securing damper plate to flywheel.
12. Remove Flywheel. (Hydraulic Transmission) Knock-up the tabs of the star washer and remove the bolts securing flywheel to the crankshaft. Pull flywheel from crankshaft.
13. Remove Gear Drive Plate and Flywheel. (Manual Transmission) Knock-up the tabs of the star washer and remove bolts securing drive plate and flywheel to the crankshaft. Remove star washer. Pull drive gear and flywheel from crankshaft.
14. Remove Backplate. Remove bolts and lock washers securing backplate to cylinder block and pull backplate from the cylinder block two locating dowels.
15. Remove gasket from cylinder block face.
16. Remove oil seal (if damaged, pressed fit).

To View and Overhaul

Examine the flywheel starter ring gear teeth for damage or wear, and replace ring gear if required. The fitting of a new ring requires special workshop equipment for heating the ring evenly to shrink it onto the flywheel. With special workshop equipment available proceed as follows:

17(a). Place the flywheel in a suitable container of clean cold water and support the assembly in the container by positioning four metal blocks under the ring gear.

Arrange the flywheel assembly so that it is partly submerged in water with the ring gear uppermost. The complete ring must be above the water line and it's recommended that the bottom face of the ring be approximately 1/4 in. above water level.

Heat the ring gear evenly around its circumference using oxy-acetylene welding equipment, thus expanding the ring, which will allow the flywheel to drop away from the ring gear. Lift out the ring gear and completely dry it off.

(b) Ensure that the face of the flywheel and new ring gear are clean and free from burrs.

(c) Heat the new ring gear to the approximate temperature, refer to "General Data". Fit the ring gear over the flywheel with the lead in on the teeth facing the front of the flywheel and allow the ring to cool at room temperature.

18. Clean the face of the cylinder block, crankshaft, backplate, flywheel housing and flywheel.

19. Check that the two locating dowels in the cylinder block face are free from burrs.

20. Check the backplate for flatness. Examine the backplate two dowels locating holes for the cylinder block dowels are free from burrs. Examine the two locating dowels in the backplate for the alignment of the flywheel housing are free from burrs.
21. Position the flywheel housing over the backplate locating dowels, checking alignment of locating holes and dowels. Ream and fit oversize dowels if required.

To Install

It is most important that the backplate, flywheel and flywheel housing be correctly aligned with the crankshaft.

22. Install oil seal if removed.
23. Install new gasket to cylinder block face.
24. With the two flywheel housing locating dowels installed in the backplate. Install the backplate to the cylinder block gasket with cylinder block dowels in the backplate locating holes. Secure with bolts and lock washers.

Alignment of Backplate

25. Secure the dial test indicator gauge with the base of the gauge to the crankshaft. Set the plunger of the gauge against the vertical face of the backplate. Turn crankshaft and check that the face of backplate is at right angles to crankshaft axis. This facing should be within inches (total indicator reading) of being at right angles to crankshaft axis.

All adjustments to bring the backplate within the limit must be on the backplate and under NO CONDITIONS must the rear face of the cylinder block be interfered with.

26. Fitting Flywheel. (Hydraulic Transmission)
 - a. Install flywheel on crankshaft flange and secure flywheel to crankshaft with star washer and bolts.
 - b. Bend over tabs of star washer.
 - c. Fitting Damper Plate. (Hydraulic Transmission)
 - d. Secure damper plate to flywheel with sockhead screws.
27. Fitting Flywheel. (Manual Transmission)
 - a. Install the flywheel gear drive plate and star washer to crankshaft and secure with bolts. Bend over tabs of star washers.
 - b. Secure base of the dial test indicator to the backplate adjust gauge so as to set gauge plunger against vertical machined face of flywheel. Press crankshaft one way, to take up end float, and turn flywheel. The run out on the flywheel face should be within 0.002 in.

Install and Align Flywheel Housing

28. Locate the flywheel housing on the backplate two locating dowels and secure housing to backplate (from front of housing and rear of backplate) with set bolts and lock washers.
29. Attach indicator gauge base to flywheel, adjust the indicator gauge plunger against the flat machined face of the flywheel housing. Turn crankshaft checking that this face is perpendicular to crankshaft axis. The limit for this facing is 0.006 in. (total indicator gauge reading) of being at right angles to the crankshaft axis.
30. With indicator gauge base still attached to flywheel, set plunger of gauge to interior of bored hole in flywheel housing. The limit for this is 0.010 in. (total indicator gauge reading).

CRANKSHAFT

Removing

1. Remove engine.
2. Remove flywheel housing, flywheel and backplate.
3. Remove timing chain, chain wheels, and chain tensioner.
4. Pump lubrication oil from sump.
5. Remove sump.
6. Release the oil delivery pipe from the crankcase.
7. Remove the dowel screw shown in Fig. 5 , and withdraw the oil pump.
8. Remove the big-end caps and separate the connecting rods from the crankshaft.
9. Remove the main bearing caps, using tools 18G 284 and 18G 284 AJ.
10. Lift out the crankshaft and collect the main bearing and thrust washer halves.

Refitting

11. Reverse the procedure in 1 to 35 noting:
 - a. Refer to Data for torque wrench settings.
 - b. Check crankshaft end-float against the figure in Data.
 - c. Before tightening any of the front plate bolts, fit all bolts which pass through the front plate into the cylinder block to ensure correct positioning of the front plate.
 - d. Check the chain wheel alignment (see Data).
 - e. Assemble the chain and chain wheels to their shafts with the timing marks as shown in Fig. 4 .
 - f. Release the chain tensioner slipper as shown in Fig. 2.
 - g. Ensure that the crankshaft front oil seal is serviceable. If necessary renew the seal, using tools 18G 134 and 18G 134 CR.
 - h. Centralize the timing cover, using tool 18G 3.
 - i. Ensure that the crankshaft rear oil seal is serviceable. If necessary renew the seal, using tools 18G 134 and 18G 134 CQ.
 - k. Use tool 18G 554 to align the clutch plate.
 - l. Bleed the fuel system.

CYLINDER HEAD

1. Detach the spring clips from the valve cotters.
2. Remove the valves and their components, using tool 18G 106.
3. Renew the valve springs if they are not as specified in Data.
4. If the valve guides are worn, drive them out through the upper face of the cylinder head. Fit new valve guides through the ports and drive them in to the position shown in Data.
5. Ream the guides to the dimensions given in Data.
6. If necessary, regrind the valves to the angle given in Data and reface the valve seats with the tools listed in 'SERVICE TOOLS'.
7. Lap the valves onto their seats, using tool 18G 29.
8. Check the valve head stand-down (see Data). If stand-down is excessive, even with a new valve fitted, machine the cylinder head (see Data) and fit valve seat inserts. Inserts should also be fitted if normal refacing will not restore the seats.
9. Renew the valve stem oil seals, and reassemble the valve components to the cylinder head as shown in Fig. 1.

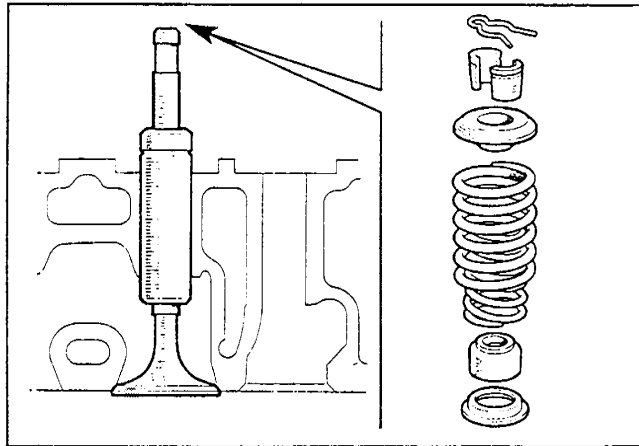


Fig. 1

Data

Valve springs

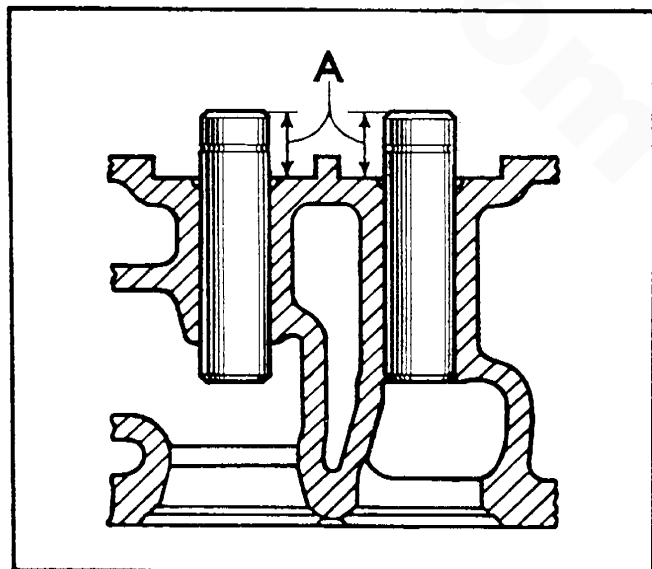
| | | | | | | |
|---------------------------------|----|----|----|----|----|----|
| Free length | .. | .. | .. | .. | .. | .. |
| Fitted length | .. | .. | .. | .. | .. | .. |
| Pressure (valve closed) | .. | .. | .. | .. | .. | .. |
| Working coils | .. | .. | .. | .. | .. | .. |
| Wire diameter | .. | .. | .. | .. | .. | .. |
| Core diameter | .. | .. | .. | .. | .. | .. |

| Inner | Outer |
|--------------------------------------|---|
| 2.187 in. (55.55 mm.) | 2.5 in. (63.5 mm.) |
| 1.5 in. (38.1 mm.) | 1.703 in. (43.26 mm.) |
| 23 to 25 lb. (10.43 to 11.34 kg.) | 56.5 to 60.5 lb. (25.63 to 27.44 kg.) |
| 7½ | 5½ |
| .104 in. (2.65 mm.) | .156 in. (3.96 mm.) |
| .75 to .765 in. (19.05 to 19.43 mm.) | 1.125 to 1.140 in. (28.58 to 28.96 mm.) |

Valve guides

Fitted position

A = $.75 \pm_{.016}^{.00}$ in. ($19.05 \pm_{.4}^{.00}$ mm.)

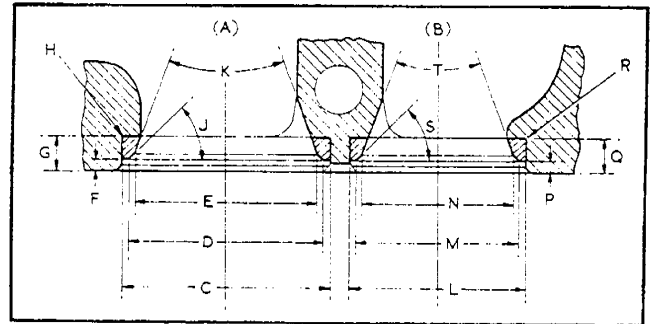


| | |
|---|--|
| Length: Inlet | 2.14 in. (54.36 mm.) |
| Exhaust | 2.5 in. (63.5 mm.) |
| Inside diameter: Inlet (reamed in position) | .3438 to .3443 in. (8.733 to 8.745 mm.) |
| Exhaust (reamed in position) | .3433 to .3438 in. (8.720 to 8.733 mm.) |
| Outside diameter: Inlet and exhaust | .5645 to .5650 in. (14.34 to 14.35 mm.) |
| Oversize guides | .5735 to .5740 in. (14.567 to 14.580 mm.) |
| Valves | |
| Seat angle: Inlet and exhaust | 45° |
| Seat face width: Inlet | .195 ± .0025 in. (4.953 ± .063 mm.) |
| Exhaust | .199 ± .0025 in. (5.055 ± .063 mm.) |
| Head diameter: Inlet | 1.557 to 1.562 in. (39.55 to 39.67 mm.) |
| Exhaust | 1.307 to 1.312 in. (33.20 to 33.32 mm.) |
| Stem diameter: Inlet and exhaust | .34175 to .34225 in. (8.68 to 8.69 mm.) |
| Lift: Inlet and exhaust | .39 in. (9.9 mm.) |
| Stand-down: Inlet and exhaust | .020 to .030 in. (.508 to .762 mm.) stand-down |

Valve seat inserts

Cylinder head machining dimensions:

| Inlet (A) | | Exhaust (B) | |
|-----------|--|-------------|--|
| C. | 1.6615 to 1.6625 in. (42.20 to 42.23 mm.) | L. | 1.4215 to 1.4225 in. (36.11 to 36.13 mm.) |
| D. | 1.540 to 1.545 in. (39.12 to 39.24 mm.) | M. | 1.300 to 1.305 in. (33.02 to 33.15 mm.) |
| E. | 1.46 in. (37.08 mm.) | N. | 1.22 in. (30.99 mm.) |
| F. | .090 to .095 in. (2.29 to 2.41 mm.) | P. | .090 to .095 in. (2.29 to 2.41 mm.) |
| G. | .278 to .281 in. (7.06 to 7.14 mm.) | Q. | .278 to .281 in. (7.06 to 7.14 mm.) |
| H. | Max. radius .015 in. (.38 mm.) | R. | Max. radius .015 in. (.38 mm.) |
| J. | 45° | S. | 45° |
| K. | 40° | T. | 40° |



TIMING CHAIN TENSIONER

1. If ovality near the mouth of the tensioner body bore exceeds the figure given in Data renew the complete chain tensioner.
2. If the slipper head is worn, renew the slipper head and cylinder assembly.

Data

| | |
|--|-----------------------------|
| Permissible ovality of tensioner body bore | .003 in. (.076 mm.) maximum |
|--|-----------------------------|

INJECTION PUMP CHAIN WHEEL

1. If the chain wheel bearing requires renewal (see Data), remove the driving flange from the chain wheel.
2. Press out the old bearing and press in a new bearing from the chamfered end of the chain wheel bore.
3. Finish the bore of the new bearing to the size given in Data.
4. Fit the driving flange to the chain wheel with the master spline and timing mark in the relative positions shown in Fig. 1. Position the flange so that its securing bolts are central in the adjusting slots.

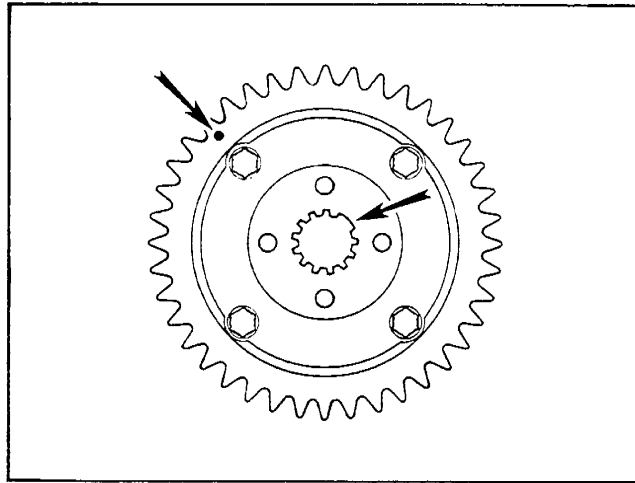


Fig. 1

Data

| | |
|---|---|
| Chain wheel bearing bore (finished in position) | 1.75025 to 1.75075 in. (44.46 to 44.47 mm.) |
| Clearance on chain wheel hub | .001 to .002 in. (.03 to .05 mm.) |

OIL PRESSURE RELIEF VALVE

1. Unscrew the plug shown in Fig. 1 and withdraw the relief valve spring.
2. Remove the valve cup, using tool 18G 69.
3. If the valve cup to seat contact is unsatisfactory, lap the valve cup onto its seat with tool 18G 69.
4. Renew the valve spring if it is not as specified in Data.
5. Reassemble the components to the crankcase.

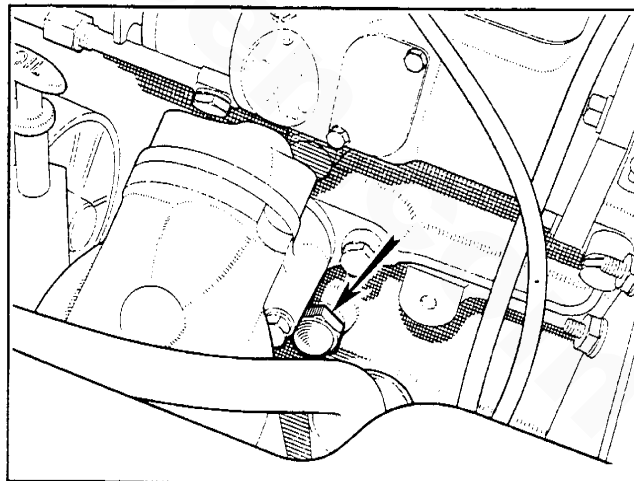


Fig. 1

Data

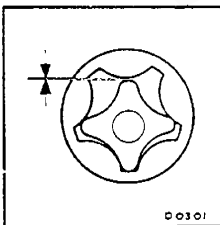
| | |
|---|---|
| Free length of oil pressure relief valve spring | 3 in. (76.2 mm.) |
| Operating pressure | 50 to 55 lb./sq. in. (3.52 to 3.87 kg./cm. ²) |

OIL PUMP

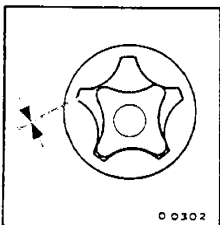
1. Remove the pump cover.
2. Check the rotor end-float against the figure in Data. Excessive end-float can be corrected by lapping the pump body face.
3. Check the diametrical clearance between the outer rotor and the pump body against the figure in Data. Renew the rotors, or pump body, or both, as necessary to correct excessive clearance.
4. Check the rotor lobe clearance (in two positions) against the figure in Data. Renew the rotors if clearance is excessive.
5. Reassemble the components, ensuring that the chamfered end of the outer rotor is innermost in the pump body.

Data

Oil pump rotor end-float -005 in. (-13 mm.) maximum
 Outer rotor to body diametrical clearance -010 in. (-25 mm.) maximum
 Rotor lobe clearance:



.. .. . -008 in. (-2 mm.) maximum



.. .. . -006 in. (-15 mm.) maximum

FLYWHEEL

1. If the teeth on the starter ring are worn or damaged, remove the starter ring by drilling a hole and splitting the ring across the hole with a hammer and chisel.
2. Heat the new starter ring uniformly to the temperature given in Data; the strip of temperature-indicating paint on the ring will change from pink to grey at the correct temperature.
3. Fit the starter ring with the tooth chamfer facing away from the flywheel register.

Data

Starter ring fitting temperature 200° to 230° C. (392° to 446° F.)

CAMSHAFT BEARING LINERS

1. Withdraw the front bearing liner, using the tools shown in Fig. 1.

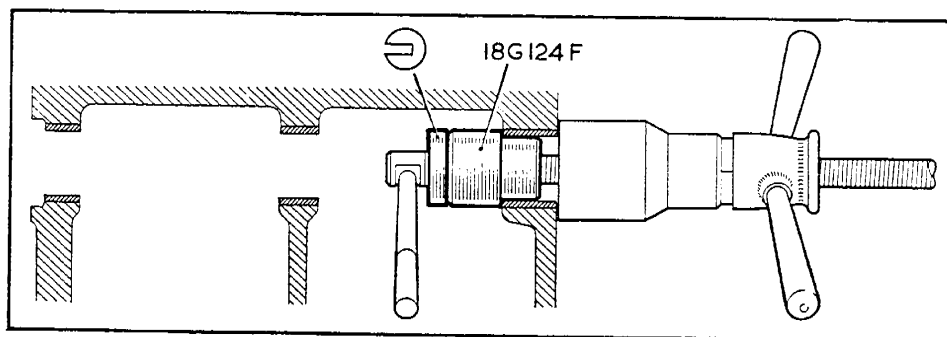


Fig. 1

2. Withdraw the rear bearing liner, using the tools shown in Fig. 2.

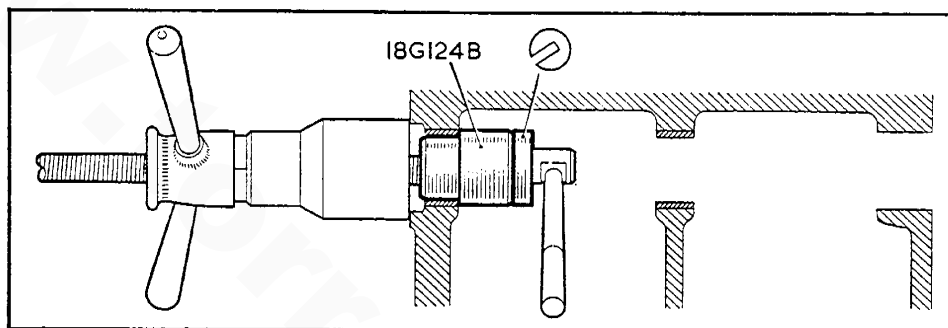


Fig. 2

3. Withdraw the centre bearing liner, using the tools shown in Fig. 3.

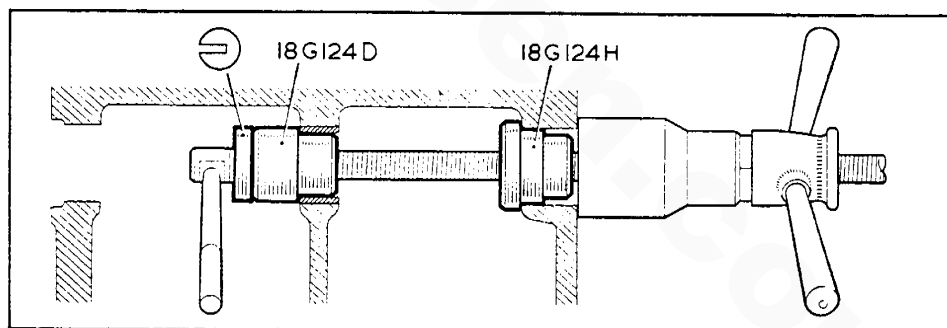


Fig. 3

4. Fit a new front bearing liner, using the tools shown in Fig. 4, and lining up the oil holes in the liner with those in the crankcase.

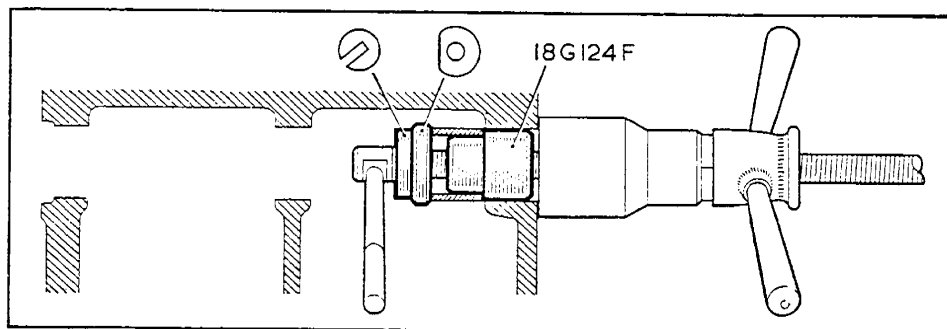


Fig. 4

5. Fit a new rear bearing liner, lining up the oil holes and using the tools shown in Fig. 5.

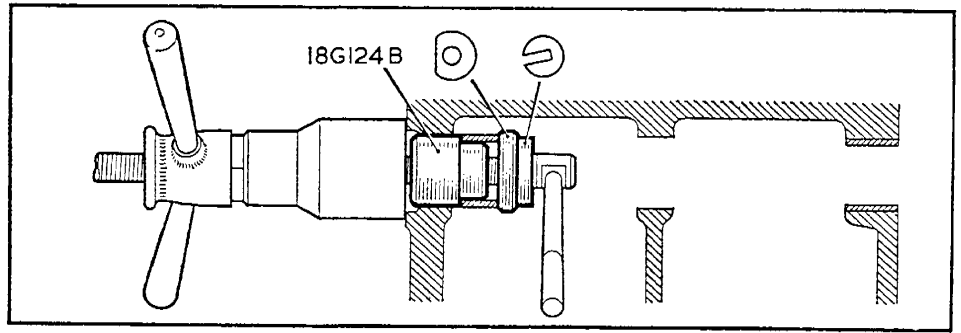


Fig. 5

6. Fit a new centre bearing liner, lining up the oil holes and using the tools shown in Fig. 6.

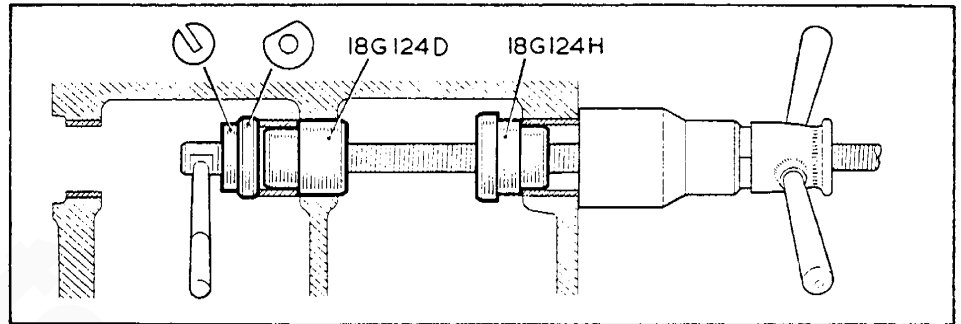


Fig. 6

7. Ream the front and rear bearing liners, using the tools shown in Fig. 7.

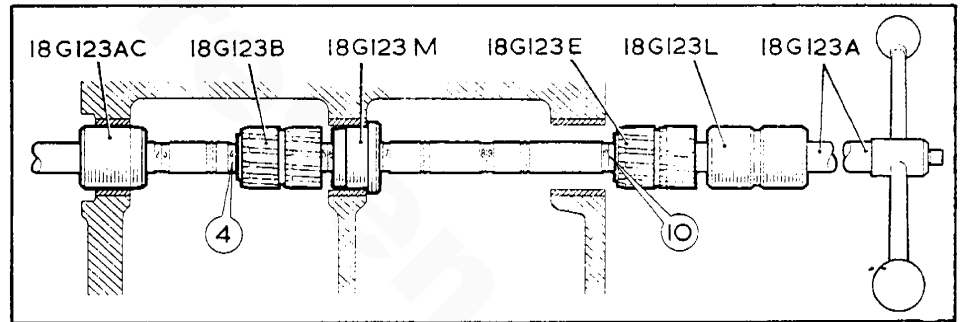


Fig. 7

8. Ream the centre bearing liner, using the tools shown in Fig. 8.

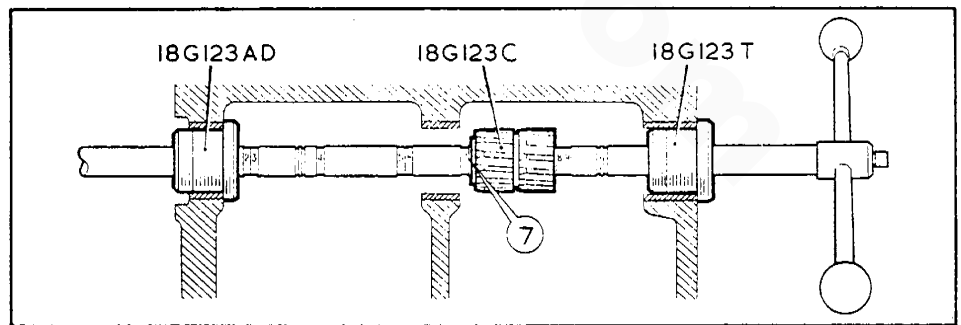


Fig. 8

Data

| | | | | |
|-------------------------------------|----|----|----|---|
| Camshaft journal diameters: Front.. | .. | .. | .. | 1-78875 to 1-78925 in. (45.43 to 45.45 mm.) |
| Centre | .. | .. | .. | 1-74875 to 1-74925 in. (44.42 to 44.43 mm.) |
| Rear .. | .. | .. | .. | 1-62275 to 1-62325 in. (41.22 to 41.23 mm.) |
| Clearance in bearings | .. | .. | .. | .001 to .002 in. (.03 to .05 mm.) |
| End-float | .. | .. | .. | .003 to .006 in. (.076 to .152 mm.) |

CONNECTING ROD AND PISTON

1. Separate the piston from the connecting rod.
2. Check the gudgeon pin clearance in the little-end bush against the figure in Data. If the clearance is excessive, renew the little-end bush.
 - a. Position the new bush with its joint on the cap side of the connecting rod as shown in Fig. 1.
 - b. Finish-ream the bush to the size given in Data.
3. Check the piston ring groove clearance and the piston ring gap against the figures in Data. Renew the rings, or piston and rings, as necessary.
4. Assemble the piston to the connecting rod with the combustion cavity and oil jet hole in line as shown in Fig. 2.

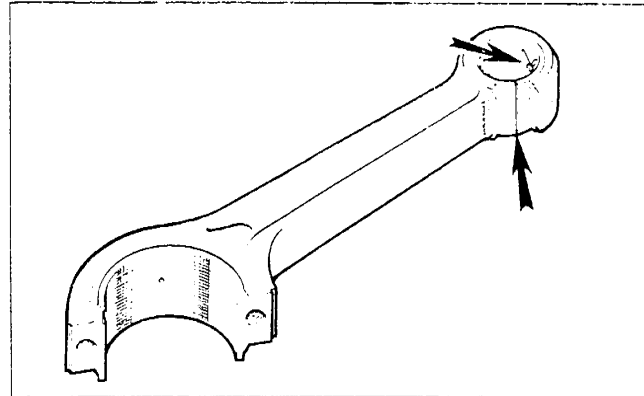


Fig. 1

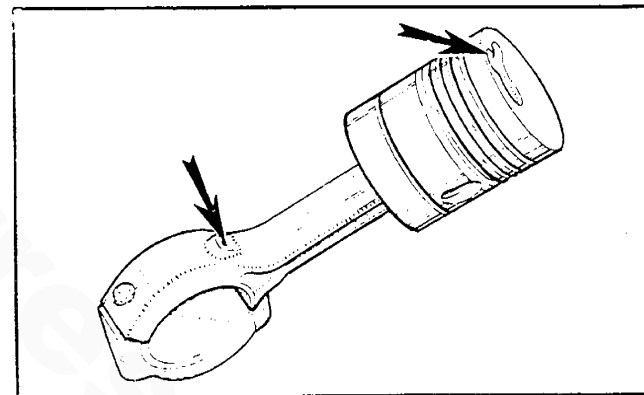


Fig. 2

Data

Gudgeon pins

| | | | | | | | | |
|-----------------------|----|----|----|----|----|----|----|---|
| Diameter | .. | .. | .. | .. | .. | .. | .. | 1-1248 to 1-1250 in. (28-57 to 28-58 mm.) |
| Fit in piston | .. | .. | .. | .. | .. | .. | .. | ·0003 in. (·008 mm.) clearance to ·0001 in. (·003 mm.) interference |
| Fit in connecting rod | .. | .. | .. | .. | .. | .. | .. | ·0005 to ·0012 in. (·013 to ·030 mm.) clearance |

Little-end bushes

| | | | | | | | | |
|--------------------------------------|----|----|----|----|----|----|----|--|
| Inside diameter (reamed in position) | .. | .. | .. | .. | .. | .. | .. | 1-1255 to 1-1260 in. (28-588 to 28-60 mm.) |
|--------------------------------------|----|----|----|----|----|----|----|--|

Pistons and rings

| | | | | | | | | |
|---------------------------|----|----|----|----|----|----|----|---------------------------------------|
| Ring/groove clearance: | | | | | | | | |
| Top and 2nd (compression) | .. | .. | .. | .. | .. | .. | .. | ·0026 to ·0046 in. (·066 to ·117 mm.) |
| 3rd (stepped scraper) | .. | .. | .. | .. | .. | .. | .. | ·0026 to ·0046 in. (·066 to ·117 mm.) |
| 4th (slotted scraper) | .. | .. | .. | .. | .. | .. | .. | ·0025 to ·0045 in. (·064 to ·114 mm.) |
| Ring gap: Top | .. | .. | .. | .. | .. | .. | .. | ·014 to ·019 in. (·36 to ·48 mm.) |
| Remainder | .. | .. | .. | .. | .. | .. | .. | ·010 to ·015 in. (·25 to ·38 mm.) |

CYLINDER BORES

1. If the cylinder bores cannot be cleaned up at the maximum oversize given in Data bore them to the dimension given for fitting cylinder liners.
2. Press in the cylinder liners and then bore them to the standard bore size.

Data

| | | | | | | |
|------------------------------|----|----|----|----|----|--|
| Standard cylinder bore | .. | .. | .. | .. | .. | 3-4995 to 3-501 in. (88-89 to 88-93 mm.) |
| Oversizes: First | .. | .. | .. | .. | .. | .010 in. (.254 mm.) |
| Second (maximum if lined) | .. | .. | .. | .. | .. | .020 in. (.508 mm.) |
| Third | .. | .. | .. | .. | .. | .030 in. (.762 mm.) |
| Bore size for fitting liners | .. | .. | .. | .. | .. | 3-642 to 3-6425 in. (92-507 to 92-520 mm.) |

CRANKSHAFT

Data

| | | | | | | |
|--------------------------------------|----|----|----|----|----|---|
| Crankshaft journal diameter | .. | .. | .. | .. | .. | 2-4785 to 2-4790 in. (62-95 to 62-96 mm.) |
| Clearance in main bearings | .. | .. | .. | .. | .. | .0015 to .003 in. (.038 to .076 mm.) |
| Crankpin diameter | .. | .. | .. | .. | .. | 2-2480 to 2-2485 in. (57-099 to 57-112 mm.) |
| Clearance in big-end bearings | .. | .. | .. | .. | .. | .002 to .0035 in. (.051 to .089 mm.) |
| Undersizes (journals and crankpins): | | | | | | |
| First | .. | .. | .. | .. | .. | .010 in. (.254 mm.) |
| Second | .. | .. | .. | .. | .. | .020 in. (.508 mm.) |
| Third | .. | .. | .. | .. | .. | .030 in. (.762 mm.) |
| Fourth | .. | .. | .. | .. | .. | .040 in. (1-016 mm.) |
| End-float | .. | .. | .. | .. | .. | .002 to .003 in. (.051 to .076 mm.) |

INJECTION PUMP

Removing

1. Disconnect the battery and remove the engine cover panel.
2. Remove the high-pressure pipes from the pump and injectors.
3. Disconnect the throttle return spring from the pump.
4. Disconnect the throttle and stop controls from the pump.
5. Disconnect the delivery and return pipes from the pump.

6. Remove the three securing nuts and withdraw the injection pump and quill shaft from the engine.

Refitting

7. Reverse the procedure in 1 to 6, noting:
 - a. Time the injection pump to the engine as described in Data.
 - b. Bleed the fuel system.
 - c. Adjust the maximum and idling speeds as described in Data.

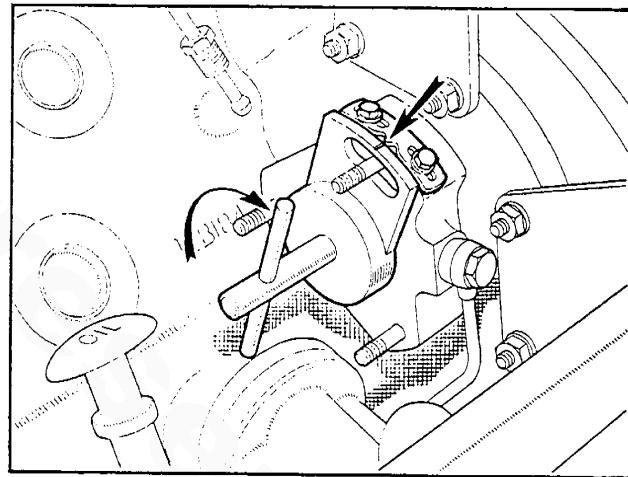
Data

Injection timing 25° B.T.D.C.

Method of adjustment:

1. Position No. 1 piston 25° B.T.D.C. compression (mark on front face of crankshaft pulley and degree plate on timing cover).
2. Fit tool 18G 698 in place of the injection pump, apply gentle clockwise pressure to eliminate chain slack and set the timing pointer in line with the mark on the tool as shown.
3. Position the master spline in the pump drive hub in line with the master spline in the driving flange. Fit the quill shaft and injection pump to the engine, lining up the mark on the pump flange with the timing pointer.

25° B.T.D.C.



Governed speed:

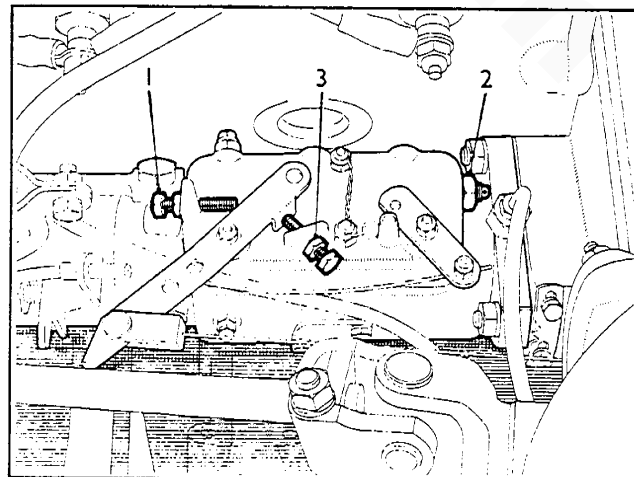
Maximum (light running) 3,700 r.p.m. (this gives a maximum speed under load of 3,500 r.p.m.).

Idling 500 r.p.m.

3,700 r.p.m. (this gives a maximum speed under load of 3,500 r.p.m.).
500 r.p.m.

Method of adjustment (engine at normal running temperature and air cleaner serviced):

1. Adjust the maximum speed stop screw (1) to give an engine speed of 3,700 r.p.m. Tighten the locknut, fit the sleeve and seal it with wire and a lead seal using tool 18G 541.
2. Stop the engine and unscrew the anti-stall screw (2) until it is out of contact with the governor arm.
3. Start the engine and adjust the idling stop screw (3) to give an engine speed of 450 to 500 r.p.m.
4. Screw in the anti-stall screw until a slight speed increase is noticed, then unscrew it one-third of a turn.
5. Readjust the idling stop screw to give an engine speed of 500 r.p.m. and tighten the locknut.
6. Test the anti-stall screw setting by running the engine at 3,000 r.p.m. and releasing the throttle:
 - a. If the engine stalls, screw in the anti-stall screw slightly and re-test.
 - b. If the engine deceleration is sluggish, unscrew the anti-stall screw slightly and re-test.



7. Tighten the anti-stall screw locknut and check the operation of the stop control.

Note.—After every adjustment of the anti-stall screw ensure that the idling speed is controlled by the idling stop screw and not by the anti-stall screw.

INJECTORS

Removing

1. Disconnect the battery and remove the engine cover panel.
2. Disconnect the spill rail from the injectors.
3. Disconnect the high-pressure pipes from the injectors.
4. Remove the securing nuts and withdraw the injectors, using tools 18G 284 and 18G 284 P.

Refitting

5. Renew the atomizer seal washers, fitting the new washers as shown in Fig. 1.
6. Reverse the procedure in 1 to 4, tightening the securing nuts to the figure given in Data.
7. Bleed the high-pressure pipes.

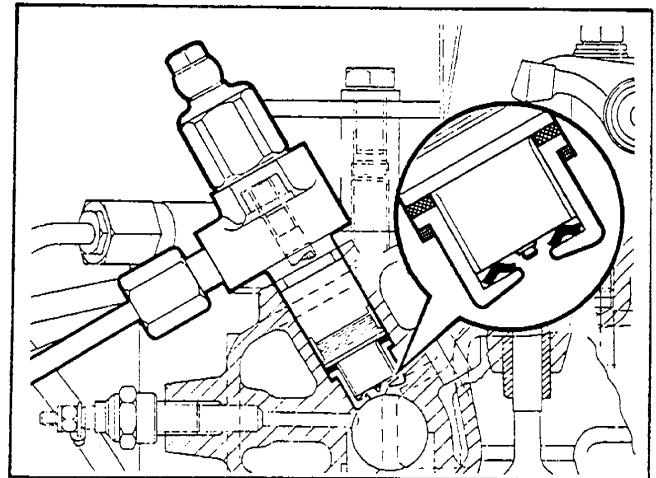


Fig. 1

Data

Torque wrench setting for injector securing nuts . . . 12 lb. ft. (1.7 kg. m.)

LIFT PUMP

Removing

1. Disconnect both pipes from the lift pump and seal the end of the pipe from the tank to prevent siphoning.
2. Disconnect the priming cable from the pump.
3. Remove the two securing nuts and withdraw the pump.

Refitting

4. Reverse the procedure in 1 to 3 and bleed the fuel system.

VALVE ROCKER CLEARANCE (Fig. C. 3)

The correct clearance between the valve rockers and stem is given in "General Data".

1. Unscrew the rocker cover nuts (1) and lift off cover.
2. Check the clearance at the position illustrated and the order as follows:

Check No. 1 valve with No. 8 fully open
Check No. 3 valve with No. 6 fully open
Check No. 5 valve with No. 4 fully open
Check No. 2 valve with No. 7 fully open
Check No. 8 valve with No. 1 fully open
Check No. 6 valve with No. 3 fully open
Check No. 4 valve with No. 5 fully open
Check No. 7 valve with No. 2 fully open

3. Adjust if necessary, by loosening the locknut (2) and turning adjustment screw (3) until the clearance is correct.
4. Hold the screw against rotation and tighten the locknut. Refit the rocker cover, checking that its gasket is serviceable.

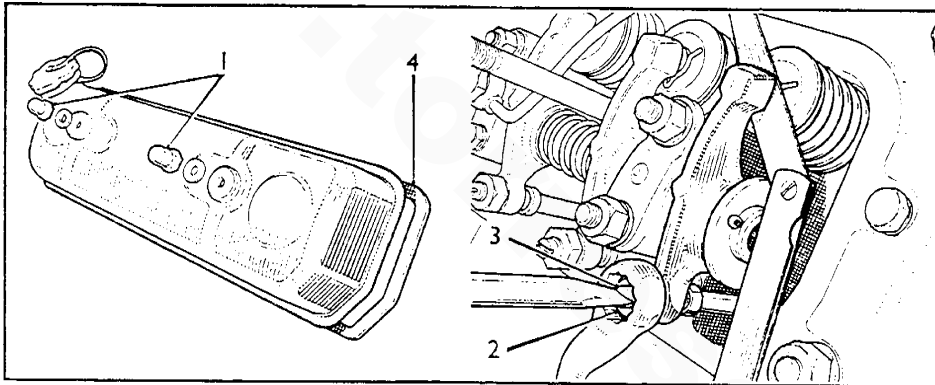


Fig. C. 3. Valve Rocker Clearance

OIL FILL CAP (Fig. C. 4)

The oil fill cap (1) incorporates an air filter which cannot be cleaned. Fit a new cap at the recommended interval.

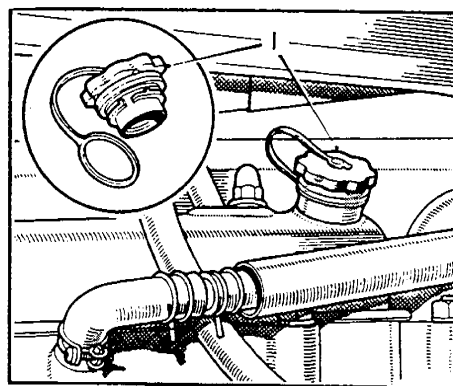


Fig. C. 4. Oil Fill Cap

AIR INTAKE SILENCER

The air intake silencer is located behind the heat exchanger and exhaust manifold. The intake is covered by a metal screen which does not have to be replaced. Depending on operating conditions check to see the screen is clear when performing maintenance checks. If clogged it will impair proper engine operation. Clean screen with fuel oil and lint free cloth.

LUBRICATING OIL DIPSTICK

The engine oil pan contains a boss on either side of the engine to accept the dipstick assembly. The opposite side contains a plug. Depending on your application they may be reversed if desired.

LUBRICATING OIL LINES

Note the positioning of the lines before removing them for any service as they must be replaced exactly as originally installed. If reversed the filter will not function as it is designed to pass and filter in only one direction.

SERVICE HINTS

1. When replacing the heat exchanger or if you should have to remove the air intake silencer it is easier to remove the exhaust manifold assembly with these attached rather than each part individually.
2. The zinc is located on the bottom of the heat exchanger at the forward end of the engine.
3. The rear most petcock on the heat exchanger is the raw water drain and the one forward of that is the fresh water.

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OTHER OVERHAUL

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SECTION Q

Q.2

MARINE ENGINE ELECTRICAL SYSTEM

ACTIVATION BY FUEL PRESSURE (Push Button Start)

This system is supplied on all four and six cylinder Westerbeke engines beginning January 1975. Basically, the system is very simple and eliminates the need for a separate switch position to activate the engine alarm system, when supplied.

Starting is accomplished by operation of the start push button which causes the starting motor to crank.

Once the engine is running, fuel pressure developed in the low pressure side of the fuel injection pump operates a fuel pressure switch. Voltage is then applied to the alarm system (if supplied) and to the alternator for excitation and for all instruments.

When the engine is stopped, fuel pressure drops and the fuel pressure switch removes voltage from these devices.

When an engine is supplied with a pre-heating device, the device is energized by a separate push button.

NOTE: It is important that your engine installation includes fuses or circuit breakers, as described under "Ownership Responsibility" on the wiring diagram supplied with your engine.

SECTION Q

**ACTIVATION BY FUEL PRESSURE
(PUSH BUTTON START)**

Q.3

WIRING DIAGRAM

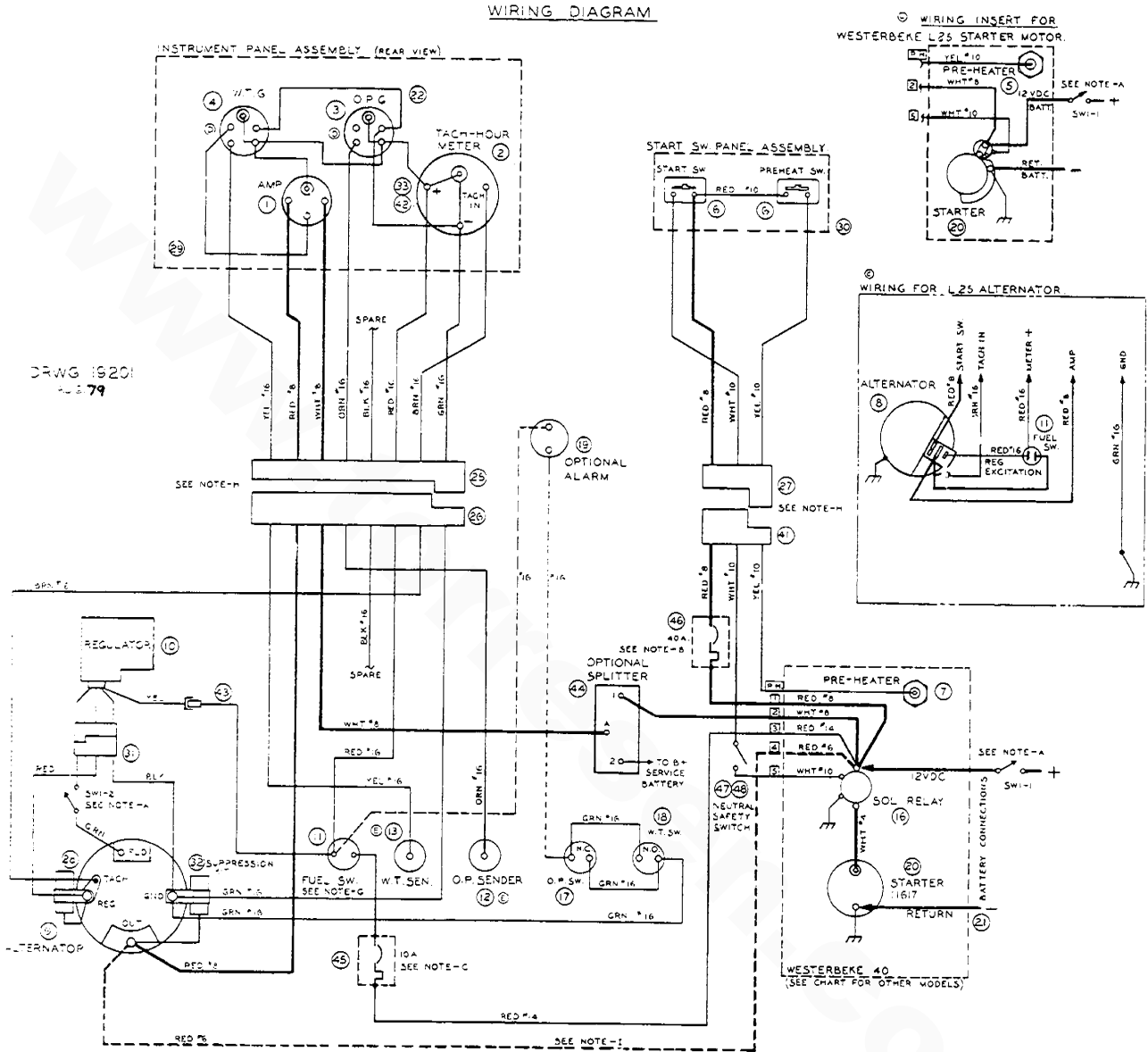
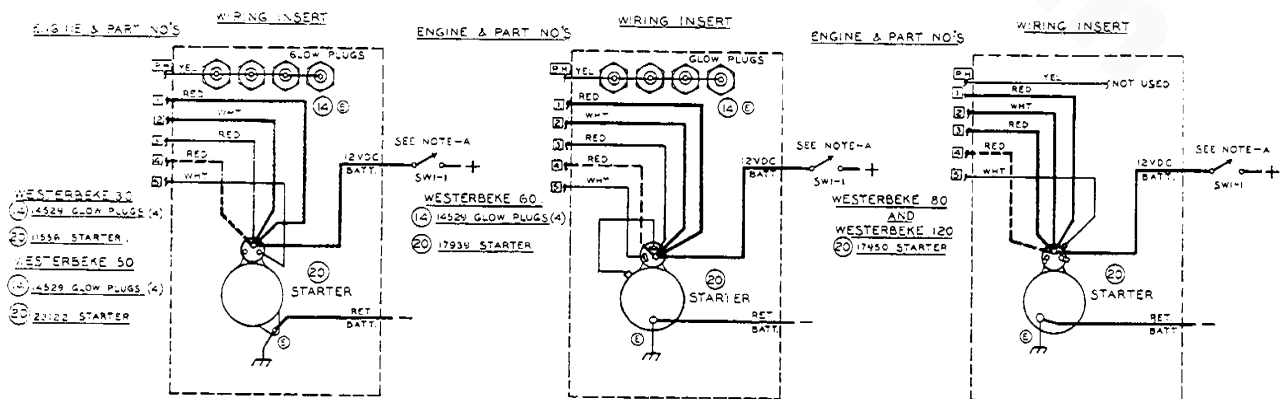


CHART FOR STARTER MOTORS AND HEATERS



Marine Engine Electrical System

ACTIVATION BY LUBE OIL PRESSURE (Keyswitch Start)

This system is supplied on all 4 and 6 cylinder Westerbeke diesels produced prior to January 1975. Operation is very simple. Putting the start switch in the Run position energizes an alarm system (when supplied). Returning the start switch to Off position de-energizes the alarm.

Turning the start switch to Crank position operates the starting motor and starts the engine. Upon starting, the start switch is released to the Run position.

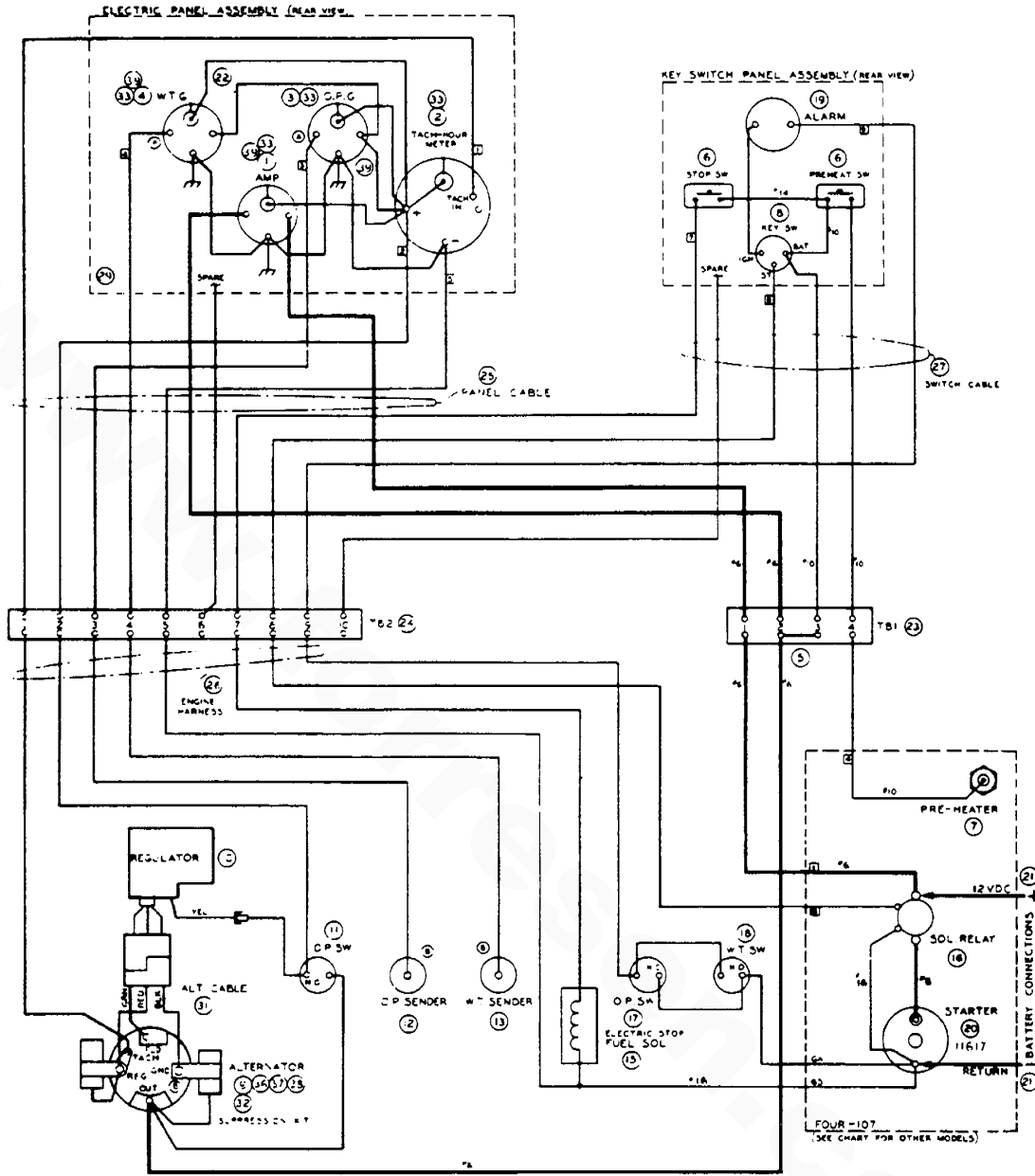
When the engine develops oil pressure, voltage is supplied to the alternator for excitation and to all instruments. Whenever the engine stops, loss of oil pressure removes voltage from these devices.

When an engine is furnished with a pre-heating device, it is energized by a separate push button at the key switch panel.

When an engine is furnished with an electric stop solenoid, it is energized by a separate push button at the key switch panel.

NOTE: It is important that your engine installation includes fuses or circuit breakers, as described under "Owner's Responsibility" on the wiring diagram supplied with your engine.

**ACTIVATION BY LUBE OIL PRESSURE
(KEYSWITCH START)**

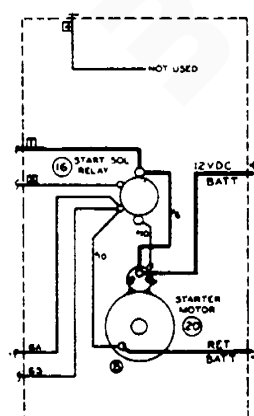
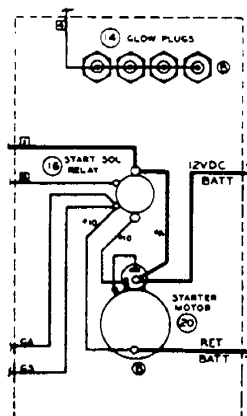
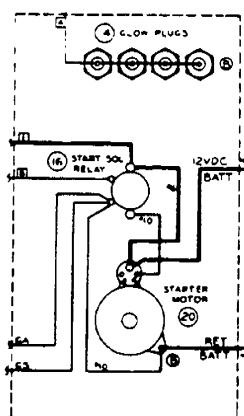
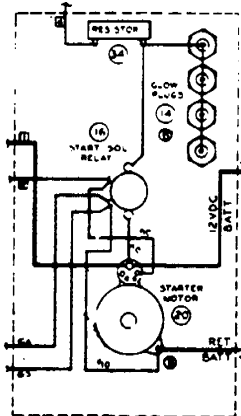


FOUR-6C

FOUR-91

FOUR-154

FOUR-230 & SIX-346



Drawing No. 15245

YOUR NOTES

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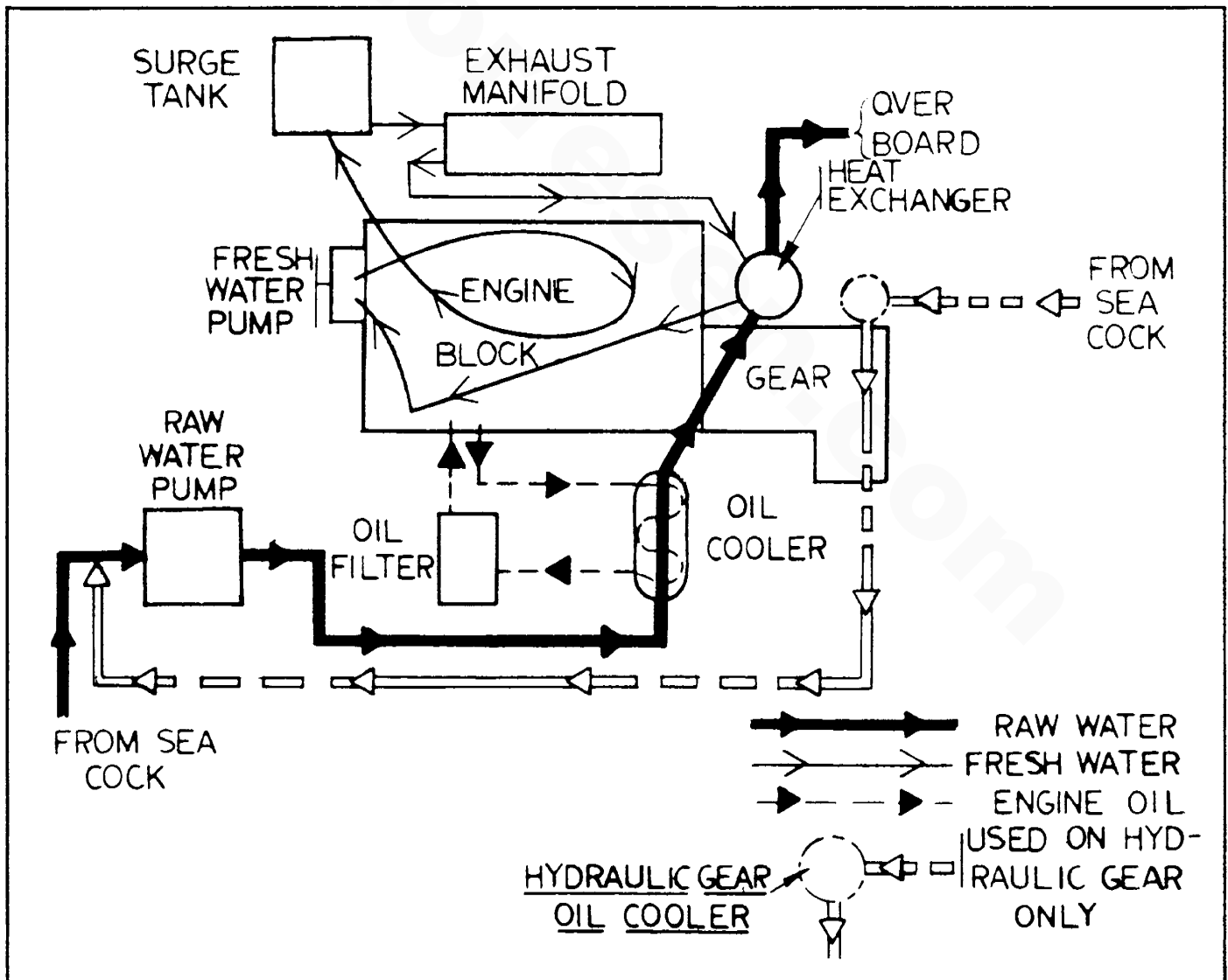
COOLING SYSTEM (EXTERNAL)

1. DESCRIPTION

The 4 and 6 cylinder marine diesel engines are equipped with a fresh water cooling system. Transfer of heat from the fresh water (closed system) circuit to the sea (raw) water is accomplished by a heat exchanger, similar to an automobile radiator. It differs because raw water, not air, cools the engine's fresh water. An unrestricted fast-flowing stream of sea water flows through the tubes of the heat exchanger while the fresh water flows rapidly under low pressure around the tubes of the heat exchanger. The raw water and fresh water never mix so the water cooling passages in the engine stay clean.

2. FRESH WATER SYSTEM

Heat rejected in combustion, as well as heat developed by friction is absorbed by the fresh water. The fresh water flows from the expansion tank to the heat exchanger; here it is cooled and discharged into the lower part of the cylinder block, where it is circulated through the block and cylinder head by means of a centrifugal fresh water pump. Openings in the water jacket around the cylinder bores connect with corresponding openings in the cylinder head, where the fresh water circulates around the valves and fuel injectors. When the engine reaches its operating temperature, the fresh water then passes out through the thermostat into the expansion tank and the circuit repeats.



R2

3. SEA WATER SYSTEM

The engine is indirectly cooled by the unrestricted fast-flowing stream of sea water which absorbs the heat from the freshwater via the heat exchanger. This raw water is picked up from the sea by a powerful neoprene impeller sea water pump, and passes through the oil cooler to the heat exchanger. After passing through the heat exchanger (and transmission oil cooler if installed), the raw water is then piped overboard.

The oil cooler conducts heat away from the bearings and other friction surfaces by the lubricating oil, which is circulated by the oil pressure pump and cooled by the flow of sea water through the tubes of the oil cooler. When the engine is equipped with a water cooled transmission for a hydraulic or RB sailing gear the sea water is also circulated through the tubes of a transmission oil cooler, and then piped overboard. In this sense both the engine oil cooler and transmission oil cooler are heat exchangers.

4. SEA WATER PUMP

The water pump may be belt driven or mounted on the front of the timing cover and driven from the fuel pump gear. The water pump is a selfpriming, positive displacement rotary pump, with a brass case and a neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate in the impeller housing, producing the pumping action.

NOTE: As the water pump contains a neoprene impeller, on no account should it be run in a dry condition. Always carry a spare impeller and gasket.

5. DRAIN COOLING SYSTEM

Remove the pressure cap from expansion tank and open the petcock on the side of the cylinder block behind the starter motor, and the fresh water drain petcock on the bottom of the heat exchanger. (Forward petcock) Turn petcocks counter-clockwise to open.

6. FILLING COOLING SYSTEM

Ensure that the petcock on the side of the cylinder block and the petcock on the bottom of the heat exchanger are closed. Turn clockwise to close. Remove fill cap on top of expansion tank and pour coolant into system to one inch from the top of the tank. Start engine and run until normal operating temperature is reached. Stop engine, carefully remove the cap and add coolant as required.

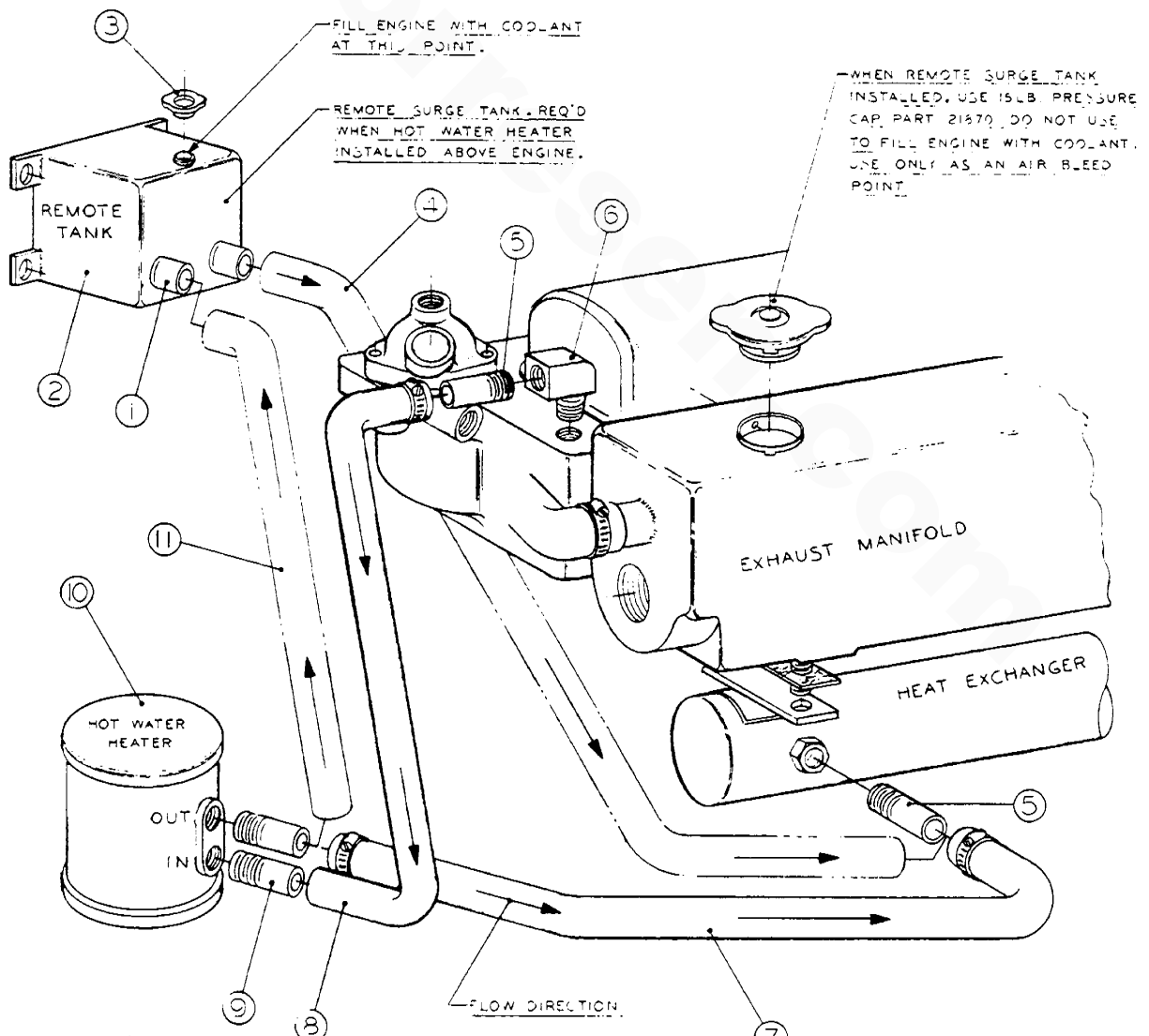
7. IMPELLER REPLACEMENT

- a. Remove front end cover and gasket.
- b. Remove impeller.
- c. To replace the neoprene impeller coat the impeller and impeller chamber with a good grade water pump grease only.
- d. Align impeller key way with shaft key. Care should be taken that the impeller blades all lie in the same direction relative to the rotation of the pump, i.e., blades trailing.
- e. Secure end cover and gasket with four screws and lockwashers.
- f. In the event of wear being present on end cover, the cover may be reversed.

8. THERMOSTAT

- a. Drain cooling system (approximately two quarts).
- b. Remove the nuts retaining the thermostat housing to the cylinder head and lift up housing.
- c. Lift out thermostat.

- d. Test the opening temperature by placing the thermostat in the water. Raise to the temperature stamped on bottom of thermostat.
 - e. If thermostat fails to open, fit new thermostat. Allow the temperature to cool. If it sticks open, renew new thermostat.
 - f. Install thermostat with new gasket and secure thermostat housing to cylinder head.
 - g. Replace coolant, remove, or if system was drained, fill expansion tank to within one inch from top of tank with clean fresh water and a suitable corrosion inhibitor or antifreeze solution.
 - h. Start engine and run until normal operating temperature is reached. Stop engine, carefully remove expansion tank filler cap and add coolant as required.
9. REMOVE SEA WATER PUMP (Timing cover mounted)
- a. Remove hoses from pump.
 - b. Remove the four bolts securing pump to adapter plate, and pull pump away from plate.
 - c. Remove drive tang between water pump coupling and fuel pump drive gear.
 - d. To replace the pump, reverse the procedure above, using sealing compound. (Rector seal or its equivalent on inlet and discharge hose connections to prevent air leaks. Secure with hose clamps).
10. ENGINE HOT WATER HEATER INSTALLATION



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TRANSMISSIONS

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TYPE SA1 MANUAL

Description

The Westerbeke-Paragon manually operated reverse gear units consist of a multiple disc clutch and a planetary reverse gear train. These units are self contained and are independent of the engine lubrication system.

Operation

On the forward drive, the reverse gear case and multiple disc clutch are locked together as a solid coupling. The multiple disc clutch is locked or clamped by the pressure produced when the shift lever is moved to the forward position. Thus the propeller shaft turns in the same direction as the engine.

The reverse drive is obtained by clamping the reverse band around the reverse gear case which contains the planetary reverse gear train. The reverse band is clamped when the shift lever is moved to the reverse position. The reverse motion is then obtained by driving through the gears thus turning the propeller shaft opposite to the engine rotation.

With the shift lever in the neutral position the multiple disc clutch and the reverse band are unclamped and the planet gears run idle and the propeller shaft remains stationary.

It is desirable to start the engine with the transmission in neutral, thus avoiding moving the boat in either direction. It is recommended that the shifting be done at speeds below 1000 RPM and preferably in the 800 RPM range or lower to prolong the life of the engine, transmission and of the boat.

Lubrication

It is recommended that SAE 30 oil be used for lubrication. The quantity of oil depends upon the angle of installation as well as the reduction model. The level should be maintained at the high mark on the dipstick. The level should be checked periodically to ensure proper operation.

The number of hours that can be run between oil changes varies with the operating conditions. Under normal conditions, the oil should be changed every 100 hours or each season, whichever is shorter.

Model and Serial Numbers and Part Numbers

The model numbers and serial numbers are on the name plate on the cover of the transmission. The parts lists accompanying the exploded views are intended only to identify the parts in regards to disassembly and assembly and are not intended to be used to identify parts by number. To order parts, refer to the part numbers and names as given in the above mentioned parts lists.

TROUBLE-SHOOTING

The accompanying 'trouble-shooting' charts should be studied and the suggestions carried out prior to any disassembly to determine as best as possible what the trouble may be. Also, the exploded views and the accompanying discussions should be carefully read and understood so that any or all of the service work as indicated from the trouble-shooting charts may be carried out properly.

DISASSEMBLY OF TRANSMISSION

As in any servicing operation, cleanliness is a must and all rules for good workmanship apply. Some of these rules are as follows:

1. Use only clean fluid in any cleaning or washing of parts.
2. Use only clean oil for lubrication when pressing parts together
3. Never use a hammer to drive ball bearings in place.

4. Never press a ball bearing so that the force is carried through the balls.
5. Use only properly sized wrenches in removing or securing nuts and capscrews.
6. Replace gaskets and "O" rings with new material.
7. Work on a clean bench and protect gear teeth and oil seal surfaces from nicks and scratches.

REMOVAL OF REDUCTION GEAR ASSEMBLY FROM REVERSE GEAR HOUSING

NOTE: To facilitate removal of the transmission from the engine, it is simpler to remove the reduction gear assembly first. Make certain that all of the oil is removed from the reverse and reduction unit before removal is attempted.

1. Remove capscrews and lockwashers around flange of reduction gear housing.
2. Strike gear half coupling flange with soft mallet to break reduction gear unit from reduction adapter plate. Slide entire reduction unit straight back approximately 3 inches until reduction unit clears reduction drive gear and lift reduction unit clear of reverse gear housing assembly.

NOTE: Refer to reduction gear service manual for disassembly and assembly of reduction unit.

REMOVAL OF REVERSE GEAR HOUSING ASSEMBLY FROM ENGINE

1. Remove capscrews and lockwashers from flange of cover (4) and remove cover.
2. Remove capscrews and lockwashers that secure reverse gear housing (60) to front end plate (58) or timing gear cover.

3. Slide entire reverse gear housing straight back approximately 3 inches until housing is clear of engine gear (92) and lift reverse gear housing assembly clear of engine.
4. Remove pilot roller bearing (95) from engine gear (92) if it remains on engine gear.
5. Remove front end plate (93) from transmission.
6. Remove engine gear (92) from engine, following engine manufacturer's recommendation, only if necessary to replace.
7. If necessary to replace, remove oil seal (94) from front end plate

REMOVAL OF GEAR CASE ASSEMBLY FROM REVERSE GEAR HOUSING

REDUCTION MODEL

1. Remove screw (81) from arm of yoke (79) and remove ball joint (80) and lockwasher (82) from eye of link on reverse band assembly.
2. Loosen capscrews in yoke and remove crossshafts (78) from sides of housing being careful not to damage oil seals (68) in housing.
3. Remove yoke (2) from operating sleeve assembly (40) through cover opening in housing.
4. Remove reverse band assembly from gear case assembly from front of housing.

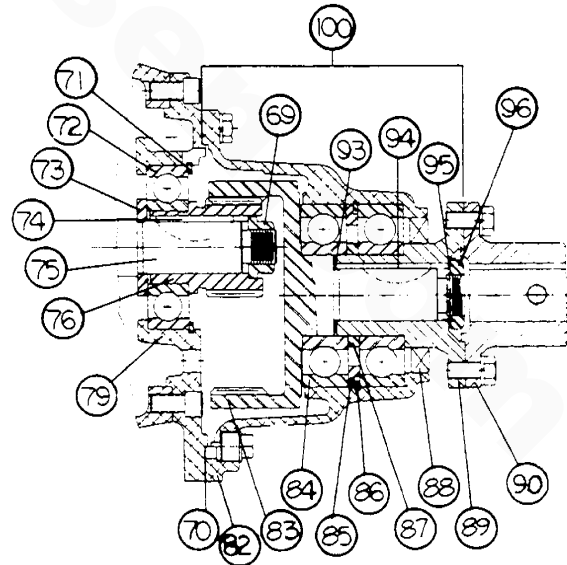
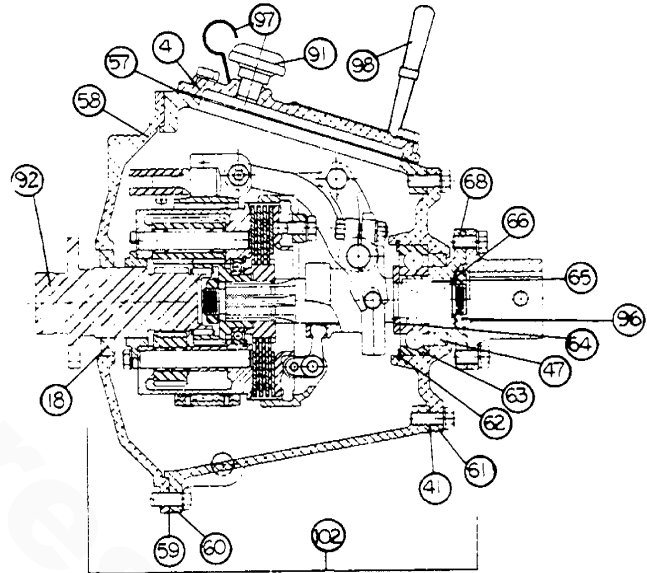
NOTE: On older reverse bands using the drag link, it will be necessary to remove the pins that anchor the reverse band to the housing before removing reverse band from housing.

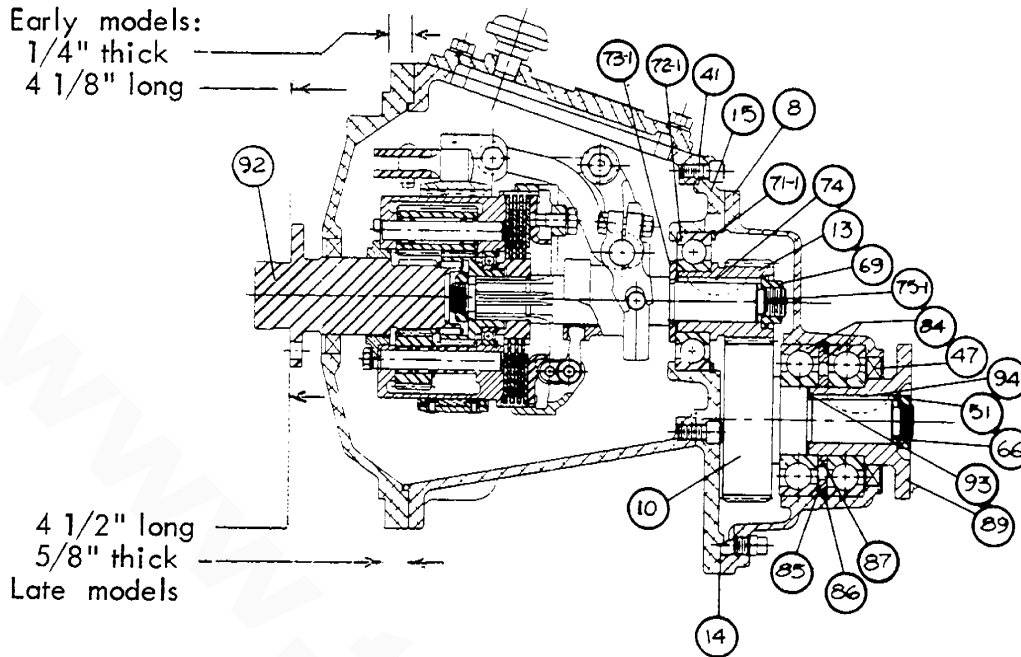
5. Remove cotter pin from reverse gear tailshaft and remove reverse gear tailshaft nut (69).
6. Support reverse gear housing face down so that gear case may drop free approximately 2 inches.
7. Press on reverse gear tailshaft until tailshaft is free of reduction drive gear (76).
8. Lift reverse gear housing straight up until housing clears tailshaft.
10. Remove capscrews that secure reduction adapter plate (79) to reverse gear housing and remove reduction adapter plate, ball bearing (72) and reduction drive gear (76) from reverse gear housing.
11. Press ball bearing (72) and reduction drive gear (76) from reduction adapter plate (79) and press ball bearing from reduction drive gear.

NOTE: When disassembling direct drive units, use the following procedure.

12. Bend tang of lockwasher (66) away from locknut (96) and remove from reverse gear tailshaft by holding gear half coupling (68) with spanner wrench.
13. Support reverse gear housing face down so that gear case may drop free approximately 2 inches.
14. Press on reverse gear tailshaft until tailshaft is free of gear half coupling. Lift reverse gear housing straight up from gear case assembly until housing clears tailshaft.
15. Remove capscrews and lockwashers that secure direct drive plate (61) to reverse gear housing (60) and remove direct drive plate (61) ball bearing (63) and gear half coupling (68) from reverse gear housing (60).

16. Press gear half coupling (68) from ball bearing (63) and press ball bearing from direct drive plate (61).
17. If necessary to replace, remove oil seal (47) from direct drive plate (61).





DISASSEMBLY OF THE REVERSE BAND-TOGGLE OPERATED TYPE

1. Remove screw (55), nut (58) and lockwasher (57) that secures brace (56) to ear of reverse band (51).
2. Remove cotter pin (54) from ear of reverse band and remove pin (53) that holds short lever (52) in forked ear of reverse band. Remove short lever.
3. Remove locknut (50) from adjusting screw (44) and remove adjusting screw and assembled levers from reverse band.
4. Remove adjusting nut (50) from adjusting screw.
5. Remove cotter pins (47) from ends of pins in assembled levers and disassemble link (48), adjusting bolt (44) and pins (46).

CAUTION: Do not disassemble link (48) or (61) or disturb setting of jam nut.

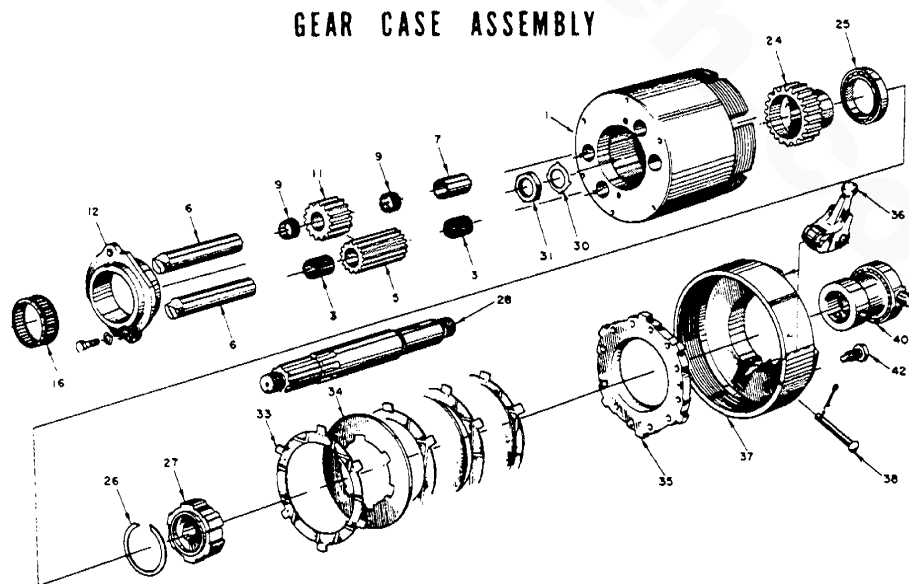
6. If necessary to re-line reverse band, remove rivets holding reverse band lining to reverse band.

DISASSEMBLY OF GEAR CASE

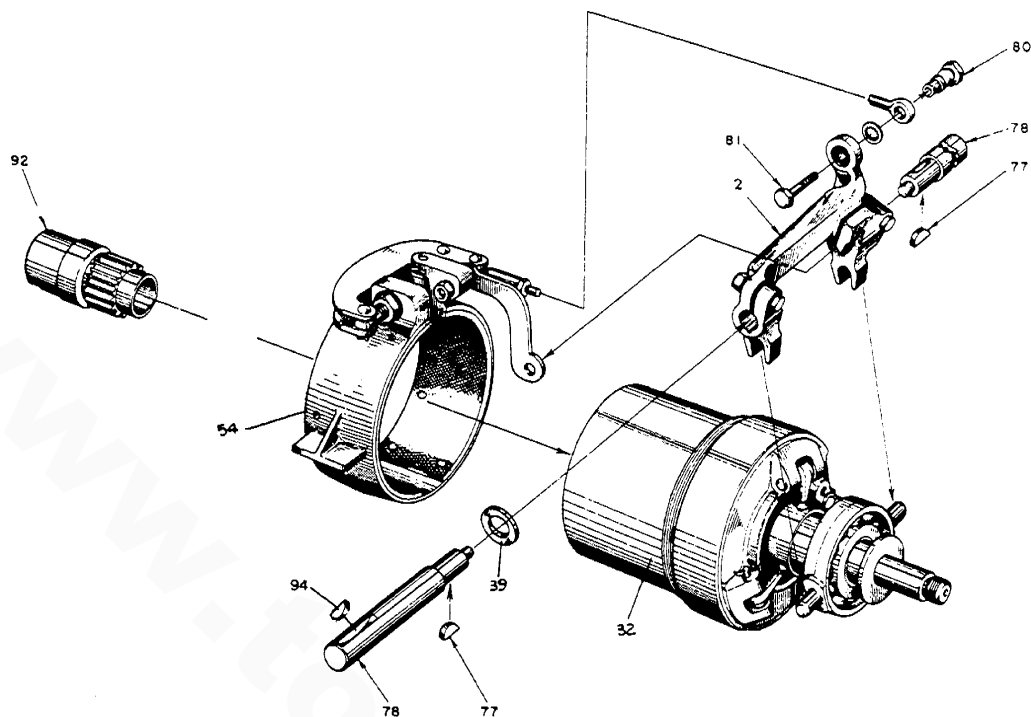
1. Remove thrust washer (73) from end of reverse gear tailshaft on reduction units and Woodruff key (74) seal washer and thrust washer (64) from end of tailshaft on direct drive units.
2. Remove lockscrew (42) and lockwasher (41) from screw collar (37) and remove screw collar from gear case by **unscrewing**. Lift operating sleeve assembly (40) from tailshaft when removing screw collar.
3. If finger assembly (36) seems loose or worn, remove from screw collar (37) by removing cotter pins (39) and finger pins (38).
4. Lift pressure plate (35) and clutch plates (34) and (33) from end of gear case.
5. Bend tang of lockwasher (30) away from sides of locknut (31) inside propeller gear (24) and remove locknut and lockwasher while clamping reverse gear tailshaft.

S.6

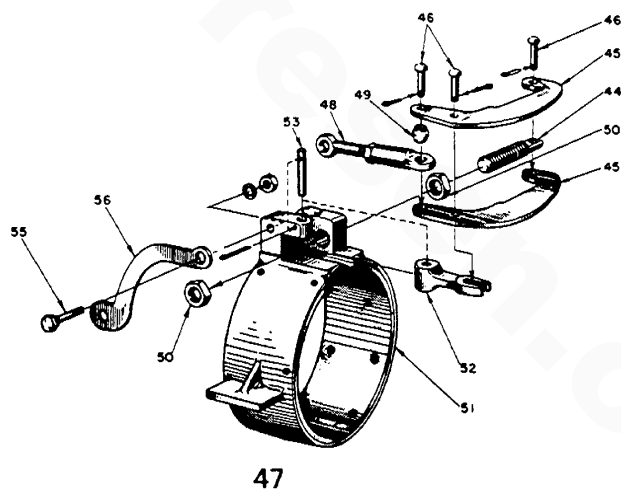
6. Properly support gear case on clutch plate carrier (27) and press tailshaft (29) or (28) from propeller gear (24) and clutch plate carrier (27). Lift clutch plate carrier from gear case.
 7. Remove case ball bearing retaining ring (26) from groove in gear case.
 8. Remove capscrews (14) and lockwashers (13) from case roller bearing race (12)
 9. Remove case roller bearing retaining rings (15) from case roller bearing race (12) and remove case roller bearing (16) from race.
 10. Before removal of the short or long pinions is attempted, first inspect the gear teeth for indication of wear. Also, rotate each pinion to check for rough spots during rotation. If further inspection or replacement is necessary, proceed with the disassembly. However, do not disassemble unless required.
 11. Drive pinion shaft (6) of one of the short pinions (11) from threaded end of gear case approximately 1/2 inch. Push pinion shaft on through with dummy shaft. Push dummy shaft until centered in short pinion (11) and short pinion spacer (7). Remove short pinion and dummy shaft from inside of gear case.
 12. Remove remaining short pinions from gear case.
- The propeller gear (24) can be pressed from the case ball bearing (25) at this time.
13. Remove long pinions (5) using dummy shaft as in removing short pinions.
 14. Remove thrust pads (2) from inside gear case (1).



ASSEMBLY OF REVERSE BAND AND YOKE TO GEAR CASE ASSEMBLY



TOGGLE OPERATED REVERSE BAND ASSEMBLY STANDARD



YOUR NOTES

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TYPE SAO MANUAL

DESCRIPTION

The Westerbeke Paragon manually operated reverse gear units consist of a multiple disc clutch and a planetary reverse gear train. The units are self contained and are independent of the engine lubrication system.

OPERATION

On the forward drive, the reverse gear case and multiple disc clutch are locked together as a solid coupling. The multiple disc clutch is locked or clamped by the pressure produced when the shift lever is moved to the forward position. Thus the propeller shaft turns in the same direction as the engine.

The reverse drive is obtained by clamping the reverse band around the reverse gear case which contains the planetary reverse gear train. The reverse band is clamped when the shift lever is moved and held in the reverse position. The reverse motion is then obtained by driving through the gears thus turning the propeller shaft opposite to the engine rotation.

With the shift lever in the neutral position the multiple disc clutch and the reverse band are unclamped and the planet gears run idle and the propeller shaft remains stationary.

It is desirable to start the engine with the transmission in neutral, thus avoiding moving the boat in either direction.

It is recommended that the shifting be done at speeds below 1000 RPM and preferably in the 800 RPM range or lower to prolong the life of the engine, transmission and of the boat.

TROUBLE SHOOTING

The trouble shooting charts below and on the next page should be studied and the suggestions carried out prior to any disassembly to determine as well as possible what the trouble may be. Also, the exploded views and the accompanying discussions should be carefully read and understood so that any or all of the service work as indicated from the trouble shooting charts may be carried out properly.

DISASSEMBLY

As in any servicing operation, cleanliness is a must and all rules for good workmanship apply. Some of these rules are as follows:

1. Use only clean fluid in any cleaning or washing of parts.
2. Use only clean oil for lubrication when pressing parts together.
3. Never use a hammer to drive ball bearings in place.
4. Never press a ball bearing so that the force is carried through the balls.
5. Use only properly sized wrenches in removing or securing nuts and cap-screws.
6. Replace gaskets and "O" rings with new material.
7. Work on a clean bench and protect gear teeth and oil seal surfaces from nicks and scratches.

NOTE: Remove the reverse and reduction gear as a complete unit before removing the oil to avoid fouling the bilges.

TROUBLE SHOOTING CHARTS

Chart 1

GEAR DRAGGING
DRIVE SHAFT ROTATES EITHER FORWARD OR REVERSE
WITH SHIFT LEVER IN NEUTRAL

Check For

1. DEFECTIVE FORWARD CLUTCH PLATES

3. BINDING IN PLANETARY ASSEMBLY

2. REVERSE BAND ENGAGING GEAR CASE

4. OVER ADJUSTMENT ON
FORWARD AND REVERSE

REMEDY

- 1. Forward clutch plate warped and sticking. Remove and replace clutch plates.
- 2. Improper reverse band adjustment. Adjust reverse band as outlined under adjustment.
- 3. Check the following items:
 - a. Bearings and gears worn excessively in gear case. Replace necessary parts.

- b. Engine gear bearings worn excessively, causing misalignment of engine shaft. Replace necessary parts. Check misalignment of engine gear.
- 4. Over-adjustment of either forward and reverse or both will result in loss of neutral. Check and readjust as outlined under adjustment.

Chart 2

**GEAR SLIPPING OR
SLOW TO ENGAGE**
WITH SHIFT LEVER IN FORWARD OR REVERSE

Check For

1. WORN CLUTCH PLATES

3. WORN REVERSE BAND

2. FORWARD CLUTCH NOT ENGAGING

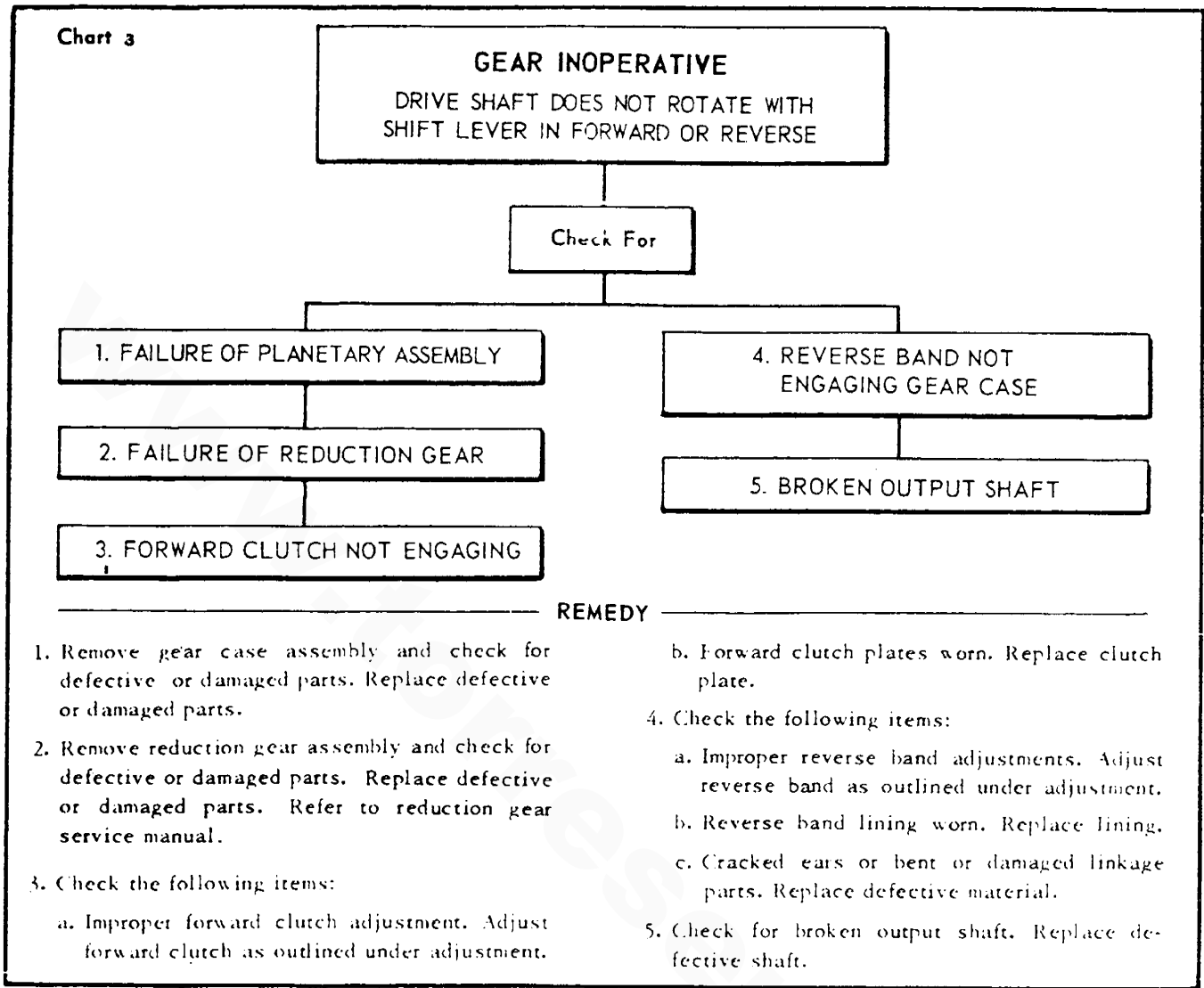
4. REVERSE BAND NOT ENGAGING

REMEDY

- 1. Remove forward clutch plates and check for wear. Replace if worn excessively.
- 2. Improper forward clutch adjustment. Adjust as outlined under adjustment.

- 3. Remove reverse band and check for wear. Replace lining if worn below rivets.
- 4. Improper reverse band adjustment. Adjust as outlined under adjustment.

TROUBLE SHOOTING CHART



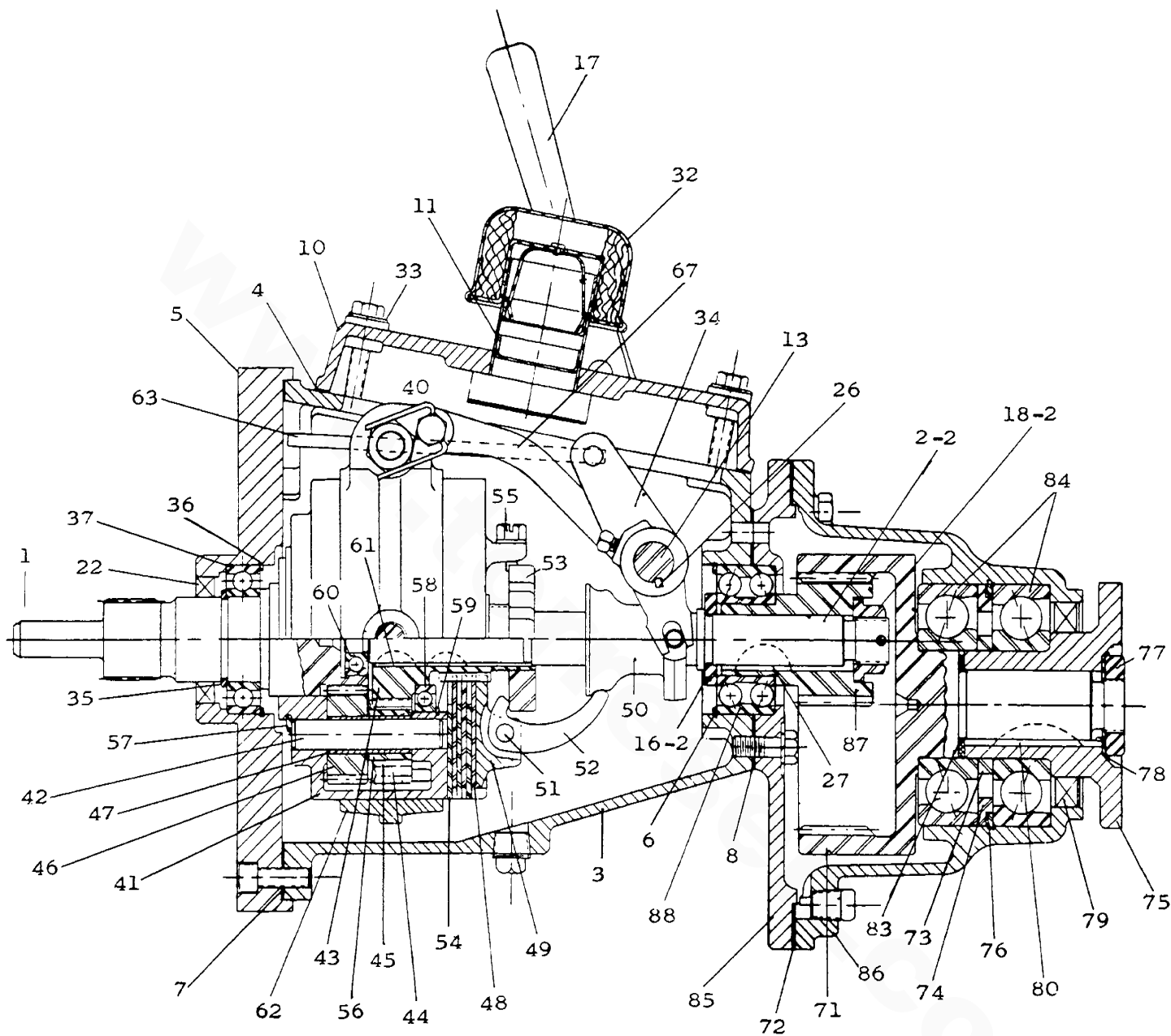
NOTE: Disassembly need be carried out only as far as is necessary to correct those difficulties which interfere with proper marine gear operation.

REMOVAL OF REDUCTION GEAR ASSEMBLY FROM REVERSE GEAR HOUSING IF INSTALLED

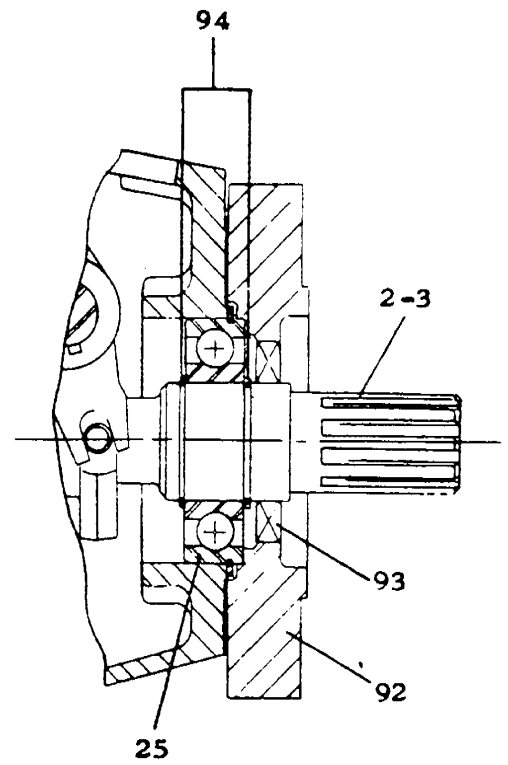
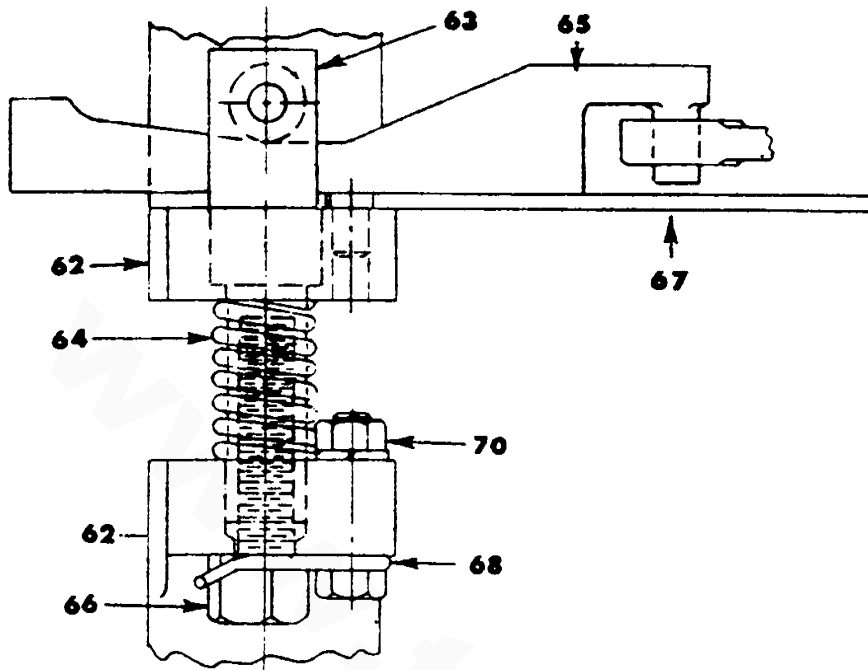
NOTE: Remove the reverse gear with reduction gear attached as a complete unit before draining oil, to avoid fouling the bilges.

1. Remove starter motor
2. Disconnect propeller half coupling and slide back approximately 4 inches.
3. Remove capscrews securing reverse gear to bellhousing.
4. Strike gear half coupling flange with soft mallet to break reverse gear from bellhousing. Slide entire reverse and reduction gear streight back approximately 3 inches until reverse gear clears bellhousing and lift units clear of engine.

(Refer to "Reduction Gear" section of manual for disassembly and assembly of reduction unit.)

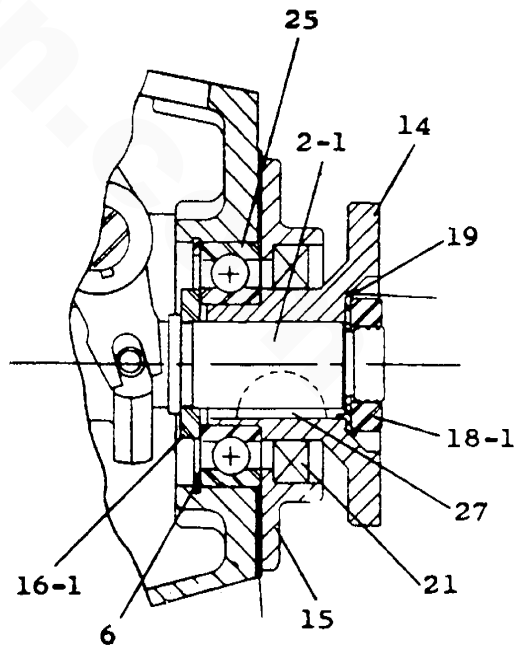
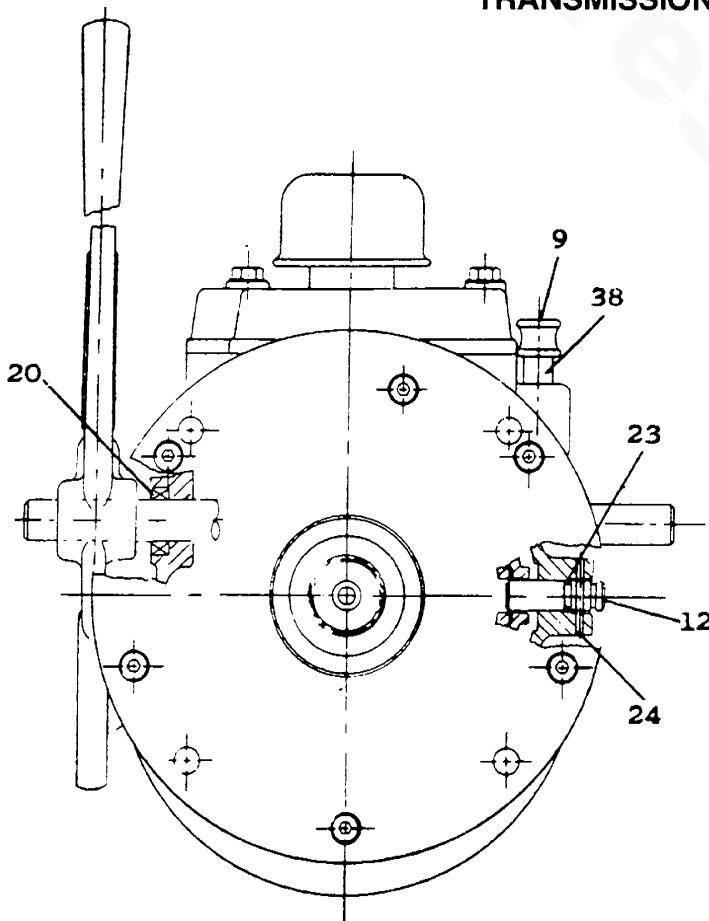


**SA0 MANUAL
TRANSMISSION**



SAO MANUAL TRANSMISSION

DIRECT DRIVE FOR WALTER'S "V" DRIVE



DIRECT DRIVE SAOD

REMOVAL OF REVERSE GEAR HOUSING ASSEMBLY FROM ENGINE

1. Remove capscrews and lockwashers that secure reverse gear housing (3) to front end plate (5).
2. Slide entire reverse gear housing (3) straight back approximately 3 inches until housing is clear of front plate engine gear (1) and lift reverse gear housing assembly clear of front plate (5).
3. Remove pilot roller bearing (60) from front plate engine gear (1) if it remains on gear.
4. If necessary to replace front end plate (5), oil seal (22), or bearing (37) proceed as follows:
 - a. Remove capscrews and lockwashers securing front end plate (5) to engine flywheel housing.
 - b. Slide front end plate (5) straight back approximately two inches until front plate engine gear (1) is clear of flywheel housing, and lift clear of engine.
 - c. Remove retaining ring (36), bearing (37), retaining ring (35) and oil seal (22).
 - d. Replace new oil seal and bearing if required.

REMOVAL OF GEAR CASE ASSEMBLY FROM REVERSE GEAR HOUSING

REDUCTION MODEL

1. Remove four capscrews, cover seals (33), cover (10), and gasket (4) from reverse gear housing (3).
2. Through cover opening in reverse gear housing (3), remove nut (70), lockwasher and screw, securing adjustment nut lockspring (68) to ear of brake band assembly (62). Remove lock spring.
3. Remove adjustment nut (66) from reverse cam (65). Remove reverse cam (65) from eye in yoke (34) and slide out reverse cam (65) from reverse cam slide assembly (63).
4. Remove cross shaft (13) from reverse gear housing (3) as follows:
 - a. Loosen the two capscrews securing the yoke (34) to the cross shaft (13).
 - b. With small end of housing toward mechanic, slide cross shaft (13) from left to right being careful cross shaft doesn't come in contact with operating sleeve bearing (50), or Woodruff key (26) in cross shaft under yoke arm (34) isn't forced against cross shaft oil seal (20) in right side of housing. Remove the two Woodruff keys from cross shaft.
 - c. Slide cross shaft out of housing and remove brace (67) and lift yoke (34) from operating sleeve (50).
5. On dipstick side of housing remove roll pin (24) securing brake band locking pin (12) that secures brake band to housing. Remove locking pin and inspect "O" ring (23) and replace if damaged.
6. Slide brake band (62) from gear case assembly (41) and remove band from front of housing.
7. Remove cotter pin and nut (18-2) from reverse gear tailshaft (2-2).
8. Support reverse gear housing (3) with front end down so that gear case (41) may drop free approximately two inches.
9. Press on reverse gear tailshaft (2-2) until tailshaft is free of reduction drive gear (87).
10. Lift reverse gear housing (3) straight up until housing clears tailshaft (2-2).

11. Remove capscrews and lockwashers that secure reduction adapter plate (85) to reverse gear housing (3).
 - a. Remove reduction adapter plate with attached bearing (88) and reduction drive gear (87).
 - b. Press bearing with drive gear from adapter plate.
 - c. Press bearing from drive gear.

DIRECT DRIVE UNIT (perform procedures 1 through 6 above)

12. Bend tang of lockwasher (19) away from locknut (18-1) and remove nut from reverse gear tailshaft (2-1), by holding gear half coupling (14) with spanner wrench. Remove lockwasher.
13. Support reverse gear housing (3) face down so that gear case may drop free approximately 2 inches.
14. Press on reverse gear tailshaft (2-1) until tailshaft is free of gear half coupling (14). Lift reverse gear housing (3) straight up from gear case assembly (41) until housing clears tailshaft (2-1).
15. Remove capscrews and lockwashers that secure direct drive plate (15) to reverse gear housing (3).
 - a. Remove direct drive plate (15) with attached bearing (25) and gear half coupling (14) from reverse gear housing (3).
 - b. Press gear half coupling from bearing.
 - c. Press bearing from drive plate.
 - d. If necessary to replace, remove oil seal (21) from direct drive plate.

DISASSEMBLY OF GEAR CASE

1. Remove thrust washer (16-2) and retainer ring (6) from end of reverse gear tailshaft on reduction units, and Woodruff key (27), seal washer (6) and thrust washer (16-1) from end of tailshaft on direct drive units.
2. Remove lockscrew (55) and lockwasher from screw collar (53) and remove screw collar from gear case by unscrewing. Lift operating sleeve assembly (50) from tailshaft when removing screw collar.
3. Lift pressure plate (49) and clutch plates (48) and (54) from end of gear case.
4. Properly support gear case on clutch plate carrier and press tailshaft (2-1) or (2-2) from propeller gear (43) and clutch plate carrier. Lift clutch plate carrier from gear case.
5. Remove case ball bearing retaining ring (59) from groove in gear case.
6. Remove capscrews (14) and lockwashers (13) and case bushing (23) from gear case.
7. Before removal of the short or long pinions is attempted, first inspect the gear teeth for indication of wear. Also, rotate each pinion to check for rough spots during rotation. If further inspection or replacement is necessary, proceed with the disassembly. However, do not disassemble unless required.
8. Drive pinion shaft (20) of one of the short pinions (22) from threaded end of gear case approximately 1/2 inch. Push pinion shaft on through with a dummy shaft.
9. Push dummy shaft until centered in short pinion (46) and short pinion spacer (56). Remove pinion shaft (42) from front end of gear case.
10. Remove remaining short pinions (46) from gear case.
11. Press propeller gear (43) from the case ball bearing (58).
12. Remove long pinions (44) using dummy shaft as in removing short pinions.

NOTE: Bushings are pressed into the long and short pinions.

INSPECTION

All parts should be thoroughly cleaned before inspection. Parts showing excessive wear should be replaced.

1. Ball and roller bearings should be examined for indication of corrosion and pitting on balls or rollers and races.
2. Long and short pinion bushings should be examined for wear.
3. Pinion shafts should be examined for wear or "brinelling".
4. Long and short pinion spacers should be examined for wear.
5. Long and short pinion bore diameters should be examined for wear.
6. All gear teeth should be examined for "pitch line pitting", uneven wear pattern or excessive wear.
7. All shafts should be examined for wear on splines and shoulders.
8. Clutch plates should be examined for flatness, roughness, indicating of excessive heating and wear or peening of driving lugs.
9. Clutch plate carrier should be examined for wear and peening of lugs and splines.
10. Examine all oil seals for rough or charred lips.
11. Reverse band links, pins, etc. should be examined for wear or bending.
12. Reverse band lining should be examined for wear.

NOTE: Lining should be replaced before rivets come in contact with gear case.

13. Gear case should be examined for wear from reverse band linking, short or long pinions wearing into inside faces or wear in clutch plate slots on threaded end.
14. Screw collar and finger assembly should be examined for wear.
15. Pressure plate should be examined for wear.
16. All old gaskets should be replaced.
17. Operating sleeve assembly should be examined for wear.
18. Engine gear should be examined for wear on oil seal surfaces, case roller bearing race, pilot bearing race and gear teeth for "pitch line pitting", uneven wear or excessive wear.

NOTE: When uneven gear teeth wear has been noticed, check engine gear for eccentricity. Maximum eccentricity at pilot bearing race is .005 inches.

19. Where special vibration dampers are used as flexible couplings, check springs and splines for wear.

ASSEMBLY OF GEAR CASE

1. If pinion gears (45) and (46) bushings (21), and pinion shafts (42) were removed from gear case (41), assembled as follows:
 - a. Insert dummy shaft into long pinion (44).

NOTE: Use same dummy shaft as used in disassembly.

- b. Insert four bushings (21) equally spaced around dummy shaft to center shaft in gear; then assemble remaining bushings.

NOTE: Smear dummy shaft with cup grease to prevent bushings from dropping out. Install bushing spacer (56) in gear next to first row of bushings.

- c. Lay gear case (41) on side and insert long pinion (44) in case to align with hole in outer row.

- d. Insert pinion shaft (42) plain end first, into unthreaded end of gear case and push through pinion as far as rear wall of gear case, forcing out the dummy shaft.
 - e. Remove dummy shaft, and start pinion shaft into rear wall of case. Do not drive pinion shaft all the way into gear case until all shafts are inserted.
 - f. Assemble remaining long pinions in gear case.
 - g. Using dummy shaft, insert short bushings (47) into short pinion (46) in same manner covered in paragraphs a and b above. With short pinion, use pinion spacer (56).
 - h. Insert short pinion (46) into gear case, pinion toward front of case, to line up with hole in inner row and insert pinion shaft (20) as described in d above.
 - i. Assemble remaining short pinions in gear case.
2. Assemble case bushing (23) to gear case with edges of race in line with flats on pinion shafts. Replace lockwashers (13) and capscrews (14).
 3. Insert propeller gear (24) through rear of gear case in mesh with long pinions.
 4. Press case ball bearing (58) into gear case and onto propeller gear by supporting entire assembly on propeller gear inside front end of gear case. Make certain that case ball bearing is seated properly on propeller gear and into gear case. Install case ball bearing retaining ring (59) in groove in gear case next to case ball bearing.
 5. Press clutch plate carrier (27) onto reverse gear tailshaft (2-1) or (2-2).
 6. Align splines on reverse gear tailshaft and press tailshaft through propeller gear until propeller gear is seated against the clutch plate carrier already on tailshaft. Support the entire assembly on propeller gear inside front end of gear case during pressing operation.
 7. Place Woodruff key (61) on end of tailshaft inside propeller gear.
 8. Install clutch plates in clutch plate cavity in rear of gear case starting first with bronze clutch plate (54) and alternating steel plate (34) and bronze clutch plate.
 9. Install pressure plate (49) on top of last bronze clutch plate in clutch plate cavity.

NOTE: Make certain that all plates ride freely and that no binding is apparent during assembly.

10. Assemble finger assembly (52) to screw collar (53) using finger pins (51) and securing with cotter pins.
11. Thread screw collar (53) onto gear case assembly (41) approximately half of the thread length.
12. Place operating sleeve assembly (50) onto tailshaft. Position ball ends of finger assembly over sleeve assembly.
13. Continue screwing screw collar onto gear case (41) until finger assembly will snap over center and lock into position against the shoulder of the pressure plate (49).
14. Push operating sleeve assembly (50) forward until finger assemblies are free.
15. Place lockwasher over end of lockscrew (55) and thread lockscrew into one hole near edge of screw collar (53). Rotate screw collar until dog on end of lockscrew lines up with closest hole in pressure plate.
16. On reduction tailshafts, install retaining ring on reverse gear tailshaft making certain that retaining ring is seated properly in groove in reverse gear tailshaft.

CAUTION: The forward clutch is not properly adjusted at the end of this assembly. Proper adjustment is made after installation in boat is complete. Follow instructions as outlined under section on adjustments.

ASSEMBLY OF REVERSE GEAR CASE IN REVERSE GEAR HOUSING

REDUCTION MODEL

1. Place new gaskets (8), (7), and (4) on front, rear, and top of reverse gear housing (3).
2. If removed for replacement, install new oil seals (20) in cross shaft holes in housing.
3. Support gear case assembly (41) on propeller gear (43) inside front end of gear case so that reverse gear housing (3) will not rest on face when lowered over gear case assembly.
4. Lower reverse gear housing (3) over gear case assembly with reverse gear tailshaft (2-2) protruding through bore in rear of housing.
5. Place thrust washer (16-2) with counter-bored side down over reverse gear tailshaft (2-2). (Make certain that thrust washer seats properly on shoulder of retaining ring (6) on tailshaft (2-2).)
6. Press reduction drive gear (87) into ball bearing (88).
7. Place new gasket (8) on reverse gear housing (3) and press reduction drive gear (87) and ball bearing (88) on reverse gear tailshaft (2-2) until ball bearing is seated against thrust washer (16-2). Thread on reverse gear tailshaft nut (18-2).
8. Press reduction gear adapter plate (85) over ball bearing and secure with necessary bolts.
9. Install reduction gear crescent (74).
10. Tighten all capscrews. Tighten reverse gear tailshaft nut (18-2) until cotter pin can be installed through castellation in nut and hole in reverse gear tailshaft.
11. Install cotter pin and bedn ends over nut.
12. Place new gasket (72) on reduction adapter plate (85).
13. Install brake band assembly (62) onto gear case assembly (41) in reverse gear housing.
14. With reduction adapter plate (85) facing mechanic, insert yoke (34) through cover opening in housing placing forked arms of yoke over pins of operating sleeve assembly (50). Ensure part number of yoke is facing mechanic.
15. Align and hold hole in brace (67) on inside right hole in yoke and push cross shaft through yoke and brace to left side of housing.
16. Pull cross shaft out from right side of housing approximately one inch and insert Woodruff key in cross shaft to the right of each yoke hole to position yoke to cross shaft.
17. Secure yoke to cross shaft by tightening the two cap screws in yoke.
18. Slide reverse cam (65) through reverse cam slide assembly (63) and in hole in arm of yoke (34).
19. Position pin in brake band (62) in hole in brace (67).
20. Replace and tighten adjustment nut (66) to reverse cam slide assembly (63).
21. Secure lock spring (68) over adjustment nut (66) with screw, lockwasher and nut (70).

DIRECT DRIVE UNIT

22. After paragraph 4 above place thrust washer (16-1) over reverse gear tailshaft. Place seal washer (6) over reverse gear tailshaft against thrust

- washer and install Woodruff key (27) in keyway in tailshaft.
23. If removed for replacement, press new oil seal (21) into direct drive plate (15). Press ball bearing (25) into direct drive plate.
 24. Place direct drive plate, oil seal and ball bearing assembly on suitable support and press gear half coupling (14) into oil seal (21) and ball bearing (25) until gear half coupling is seated against ball bearing. Care must be taken not to damage oil seal during assembly.
 25. Align direct drive plate and gear half coupling up with key in reverse gear tailshaft and press together until ball bearing is seated against thrust washer (16-1).
 26. Place lockwasher (19) over reverse gear tailshaft with tang in keyway in gear half coupling and thread locknut (18-1) on reverse gear tailshaft.
 27. Install lockwashers and capscrews in holes in direct drive plate and bolt to reverse gear housing.
 28. Tighten all capscrews. Tighten locknut (18-1) and bend up one tang on lockwasher (19) over locknut.
 29. Continue with paragraphs 13 through 20.

ASSEMBLE TRANSMISSION TO ENGINE

1. If front end plate (5) was removed from reverse gear housing (3) or engine flywheel housing proceed as follows:
 - a. Replace oil seal (22) or bearing (37) if necessary.
 - b. Slide engine gear (1) into flywheel housing damper spline.
 - c. Align mounting holes in front end plate (5) with holes in flywheel housing and secure with lockwashers and capscrews.
 - d. After installing on engine, check engine gear for runout. Maximum eccentricity is .005 inches at pilot roller bearing.
2. Insert two studs three inches long in two opposite bolt holes in front end plate (5).
3. Check to be certain that pilot roller bearing (60) is properly installed in propeller gear inside gear case.
4. Start reverse gear housing (3) over the two studs and slide housing over engine gear (1) right up against flywheel housing. It may be necessary to rotate gear case slightly to properly mesh teeth on engine gear and short pinions in gear case.
5. Install lockwashers and capscrews in holes around flange of housing.
6. Remove the two studs and install remaining lockwashers and capscrews. Tighten all capscrews.

ASSEMBLY OF REDUCTION GEAR ASSEMBLY TO REVERSE GEAR HOUSING ASSEMBLY

NOTE: Refer to reduction gear assembly and disassembly procedures.

1. Install two studs 3 1/2 inches long in two opposite holes in reduction adapter plate.
2. Position reduction gear assembly over studs with oil drain plug at bottom and slide onto reduction drive gear. It may be necessary to rotate reduction ring gear slightly to properly mesh gear teeth.
3. Install lockwashers and capscrews around flange of reduction gear housing and tighten uniformly.

YOUR NOTES

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SA1 AND SA0 MANUAL CLUTCH ADJUSTMENTS

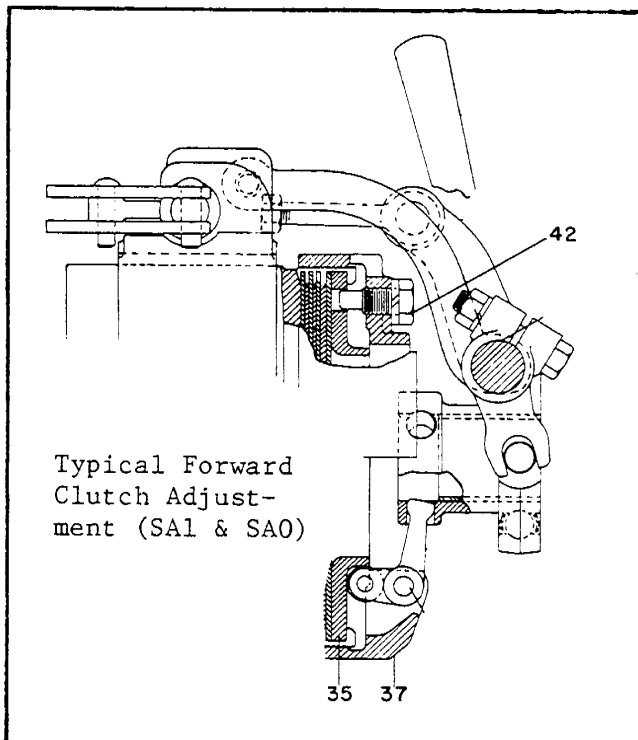
With the transmission secured to the engine, replace all water lines, etc. However, do not connect the shifting linkage until all the adjustments have been made and are satisfactorily tested:

Before securing the propeller half coupling to the gear half coupling, check to make certain that the couplings do not run out more than .002 inches with respect to each other. Study section "Alignment to Engine" on Pages 14 and 15 of Technical Manual.

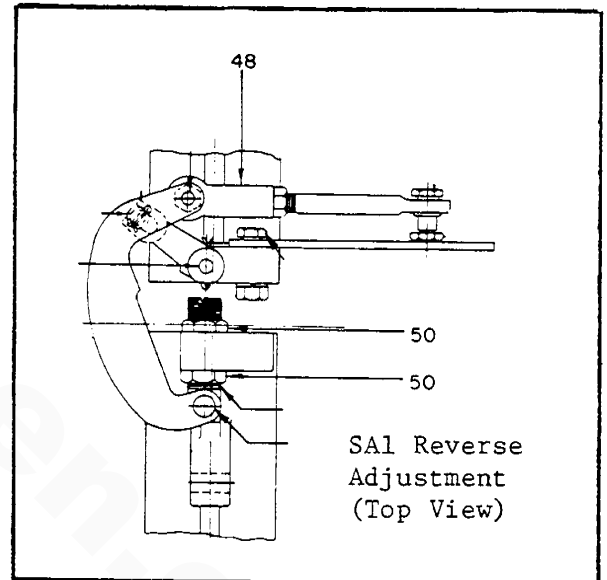
The transmission should be filled with new oil as specified under lubrication.

The transmission can be partially adjusted before the engine has been run. However, a complete running test is necessary to satisfactorily determine whether the adjustments have been properly made.

The preliminary adjustments for the forward drive are made as follows: remove reverse cover plate, rotate pressure finger assembly and screw collar (37) until lock screw (42) is up and facing you. Then, working carefully to avoid dropping either screw or tools into clutch housing --

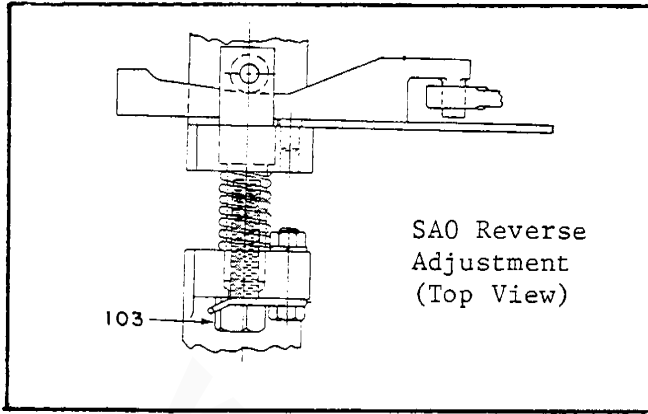


1. Back out the lockscrew (42) until the dog on the end of the lockscrew is clear of the hole in the pressure plate (35).
2. Rotate the screw Collar (37) to the right until the lockscrew (42) is opposite the next hole in the pressure plate (35).
3. Tighten the lockscrew making certain that the dog on the end properly enters the hole in the pressure plate.
4. Continue this until a decided effort is required to shift into forward (approximately 26 foot pounds).



The preliminary adjustments for the reverse drive are made as follows:

1. Loosen the locknut (50) on the inside of the upright ear at the top of the reverse band.
2. Tighten the adjusting nut (50) on the outside of the ear until both nuts are again tight against the ear of the reverse band.
3. Repeat until a decided snap is required to shift into reverse.
4. Do not tamper with adjustment of link (48).
5. For Four-99s and early Four-107s there was a cam operated reverse adjustment. Simply turn screw head (103) clockwise one flat at a time until satisfactory reverse engagement is obtained (see Figure 3).



Replace the cover on the reverse gearhousing. The transmission is ready for a preliminary test which may be done at dockside.

Check all of the mooring lines before continuing the test,

With the engine running at idle speed, shift the transmission into forward and reverse noting how well the transmission responds.

If the transmission does not engage in one or both of the forward or reverse positions further dockside adjustments are necessary. Continue the adjustments as outlined above until the transmission will engage in both forward and reverse drives.

A complete running test is necessary to determine that the transmission is properly adjusted. The transmission should not slip or "break" away under full power conditions in the forward drive and should hold in reverse under all normal reversing conditions.

If further adjustments are necessary, continue the adjustments as outlined above until satisfactory operation is reached. It should be noted however that the adjustments should be carried out only until satisfactory operation is reached since it is possible to over-adjust the transmission. If the transmission is over-adjusted it will be more difficult to shift into forward and reverse and the parts will be heavily stressed and subject to early fatigue failure. Therefore, once the preliminary adjustments have been made, only a very small amount of adjustment will be necessary for either forward or reverse. Usually, an adjustment of a half a step on the forward, or at the most, a full step is required for full adjustment. Only a very small adjustment is required for the reverse drive.

On the forward drive, a full step of adjustment is as outlined above or is made by loosening the lock screw (42) and rotating the screw collar (37) to the right until the next hole in the pressure plate (35) can be lined up under the lock screw. A half a step is made by taking the lock screw out of the hole that it is in and placing it in the hole adjoining it in the screw collar. Then rotate the screw collar to the right until the next hole in the pressure plate is lined up under the dog of the lock screw. Make certain that the lock screw enters the hole properly or it will bind up the forward clutch.

When the transmission is properly adjusted, replace the cover and secure all external bolts and fasteners. Before replacing the shifting linkage, check to make certain that it operates freely and does not bind or drag. Replace the linkage on the transmission shift lever and secure properly.

WHEN CLUTCH SLIPPING IS NOTICED, STOP AND ADJUST AT ONCE.
 PROPER ADJUSTMENT WILL MAINTAIN YOUR CLUTCH FOR YEARS,
 BUT A SLIPPING CLUTCH MAY DESTROY ITSELF, CAUSING COSTLY
 REPAIRS.

SA1 AND SA0 REDUCTION UNITS

DESCRIPTION

The Westerbeke/Paragon reduction gears consist of an internal ring gear and a drive gear that offers a variety of reduction ratios.

ADJUSTMENTS

There are no adjustments necessary to maintain the reduction gears in proper running condition.

DISASSEMBLY OF REDUCTION UNIT

NOTE: Disassembly need be carried out only as far as necessary to correct those difficulties which interfere with proper marine gear operation.

Remove reverse and reduction gear as a complete unit before removing the oil to avoid fouling the bilges.

1. Remove oil drain plug from bottom of reduction gear housing (86) and drain oil from unit. Make certain that all lubricating oil is removed from reverse gear unit.
2. Remove capscrews and lockwashers from flange of reduction gear housing and slide entire reduction unit straight back approximately 3 inches until reduction unit clears reduction drive pinion.
3. Bend tang of lockwasher (78) away from locknut (77). Remove locknut using suitable wrench and lift lockwasher from shaft.
4. Remove gear half coupling (75) with gear type puller or by supporting entire assembly under flange of gear half coupling and press against shaft to force coupling from assembly.
5. Support reduction gear housing so that flanged shaft assembly can drop free approximately 2 inches and press flanged shaft assembly from reduction gear housing.
6. Remove retaining ring (76) from groove next to ball bearing (84) inside reduction gear housing and press ball bearing from housing.
7. If necessary to replace, remove oil seal (79).
8. Remove Woodruff key (80) from flanged shaft and remove seal washer (74) and spacer (73).
9. Press ball bearing (84) from flanged shaft using two holes in flange.
10. Remove capscrews and lockwashers from rim of flanged shaft and remove ring gear (71) from flanged shaft.

INSPECTION

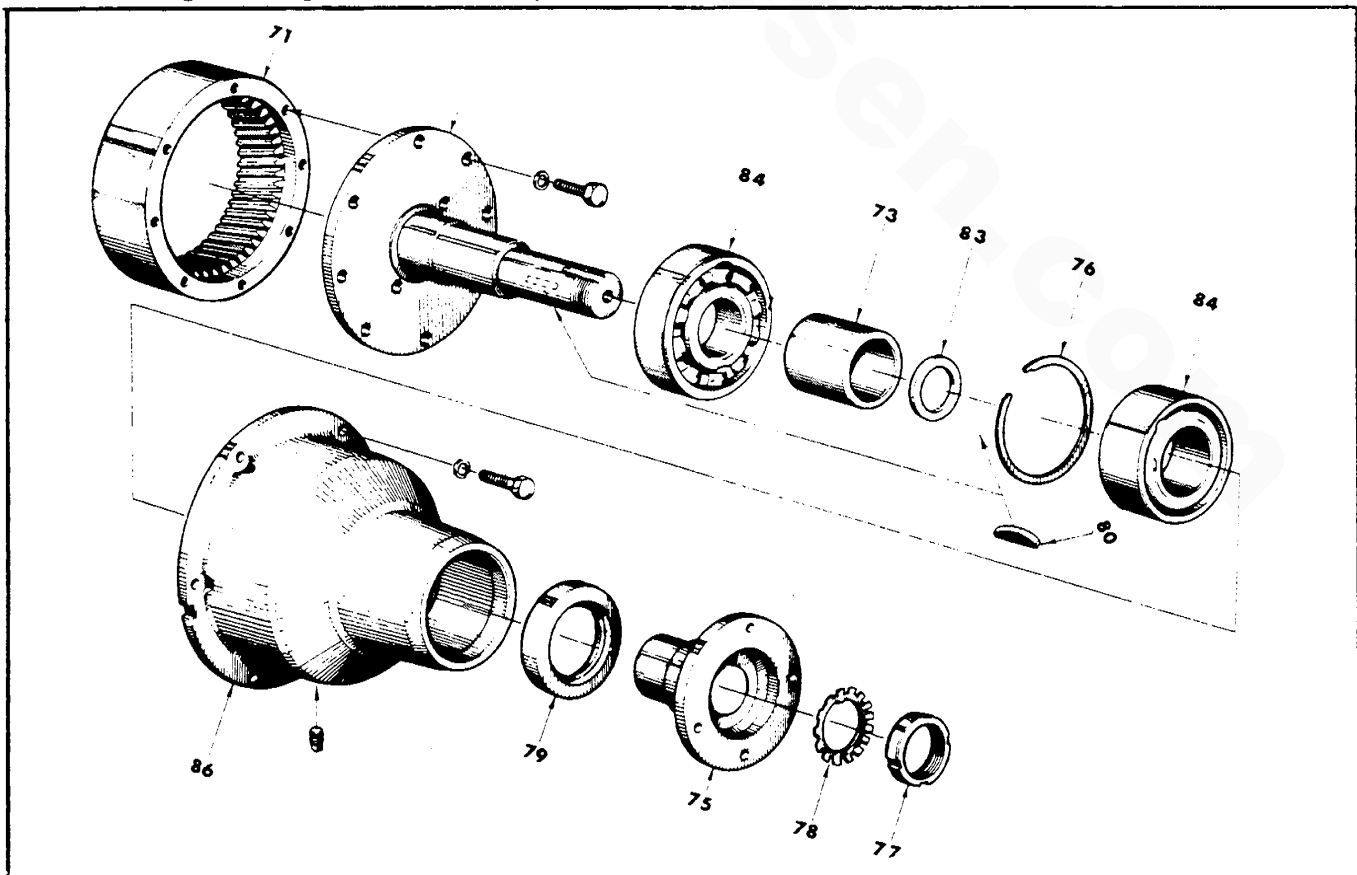
All parts should be thoroughly cleaned before inspection. Parts showing excessive wear should be replaced.

1. Ball bearings should be examined for indications of corrosion and pitting on balls and races.
2. All gear teeth should be examined for "pitch line pitting", uneven wear pattern or excessive wear.
3. Examine oil seal for rough or charred lips.
4. Retaining rings should be checked for burrs or deformities.
5. All gaskets should be replaced.

ASSEMBLY OF REDUCTION UNIT

1. Replace oil drain plug into reduction gear housing (86).
2. Press ball bearing (84) into reduction gear housing (86) and install retaining ring (76) into groove next to ball bearing.

3. If removed for replacement, press new oil seal (79) into reduction gear housing.
4. Place flanged shaft over ring gear (71) and line up holes in flange with those in ring gear.
5. Place lockwasher over capscrew and insert capscrew into hole in flanged shaft and secure flanged shaft to ring gear.
6. Press ball bearing (84) onto flanged shaft. Place spacer (73) over shaft next to ball bearing and place seal washer (74) over shaft next to spacer.
7. Install Woodruff key (80) into keyway in flanged shaft.
8. Place reduction gear housing over small end of flanged shaft and start ball bearing (84) on flanged shaft into bore in housing by tapping housing with a soft mallet.
9. Turn unit over with small end of housing down and press on center of flanged shaft until spacer (73) is seated against ball bearing (84) in reduction housing.
10. Support unit on inside of flanged shaft with large end of unit down and press gear half coupling (75) onto shaft end and into ball bearing until coupling is seated against ball bearing. Care must be taken to line up keyway in coupling and key in shaft before pressing together.
11. Place lockwasher (78) over end of flanged shaft with tang on inside of lockwasher in slot on flanged shaft. Place locknut (77) onto shaft and secure using suitable wrench.
12. Bend one tang of lockwasher into slot on locknut.
13. Install two studs 3 1/2 inches long into two opposite holes in reduction adapter plate.
14. Position reduction gear assembly over studs with oil drain plug at bottom of housing and slide onto reduction drive gear. It may be necessary to rotate reduction gear slightly to properly mesh gear teeth.
15. Install lockwashers and capscrews around flange of reduction gear housing and tighten uniformly.



TYPE RB — FREEWHEELING

The Volvo Penta reduction-reverse gear, type RB, has a built-in reduction gear, with reduction ratio 1.91:1. Engagement "Ahead" or "Astern" takes place by means of self-adjusting cones which are held in the engaged position partly with the help of the propeller thrust.

When engaging "Ahead", the output shaft is moved with its cone so that it meshes with the front cone. When "Astern" is engaged, the output shaft is moved backwards and meshes with the inner cone which operates via an intermediate gear. The direction of rotation of the output shaft will therefore be reversed. In the neutral position the cone is held by the locking plunger in such a position that there is clearance between the cone and the gear wheel.

Reduction-reverse gear with ratio 1.9 :1 has a separate oil changer and is watercooled.

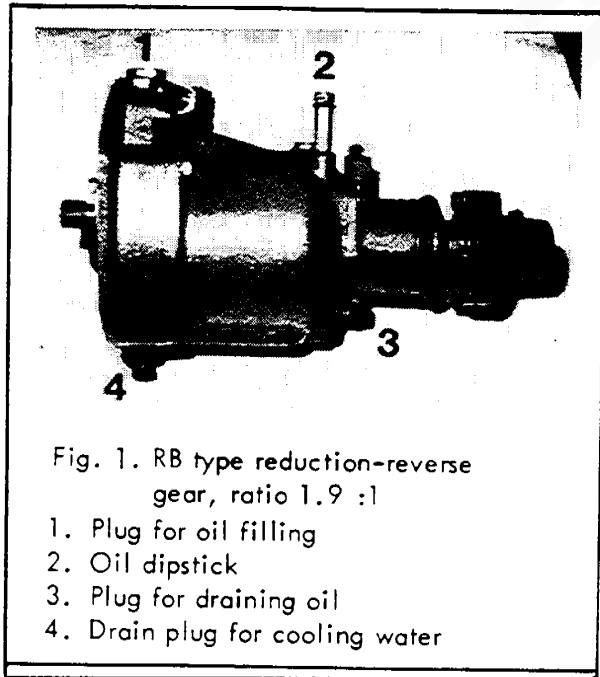


Fig. 1. RB type reduction-reverse gear, ratio 1.9 :1

1. Plug for oil filling
2. Oil dipstick
3. Plug for draining oil
4. Drain plug for cooling water

REPAIR INSTRUCTIONS - REMOVING

The repair instructions refer to Fig. 2 for ratio 1.9 :1.

1. Disconnect the cooling water connections (ratio 1.9 :1). Remove the propeller shaft and push it aft.
2. Remove the bolts holding the reverse gear to the engine and pull the reverse gear carefully aft, without breaking, so that it is released from the engine.
3. Remove the bolt (12) and pull off the coupling flange (10). Also lift off the rubber protector (18). The key (15) need not be removed.
4. Remove the reverse gear lever from the control shaft (1). Then remove the cover (2). Pull out the control shaft (1) and the eccentric stud (9) (note the position of the stud which has marked sides).
5. Remove the bolts which secure the reverse gear housing (32) to the casing (33). Part the casing from the housing by means of light blows with a mallet.
6. Remove the bolts (22) and take out the shaft (17) with the sleeve (20).
8. Remove the bolts (23) and the washer (24). Place one of the bolts (23) in the center hole of the support bearing (27) and pull off the gear wheel (30). If the ball bearing (29) is to be removed from the gear wheel, remove the bolts (25) and the ring (26) after which the ball bearing is pressed out.
9. Lift out the cone (28).
10. Remove the gear wheel (31) with bearing (34) from the housing (33). For the reduction-reverse gear with ratio 1.9 :1, removing is made easier by tapping carefully on the bevelled side of the gear wheel (31),
11. See Fig. 2. Remove the bolts (38). The flange (44) need not be removed from the shaft. Press out the shaft (42) together with the cover (43) and the ball bearing. Pres-

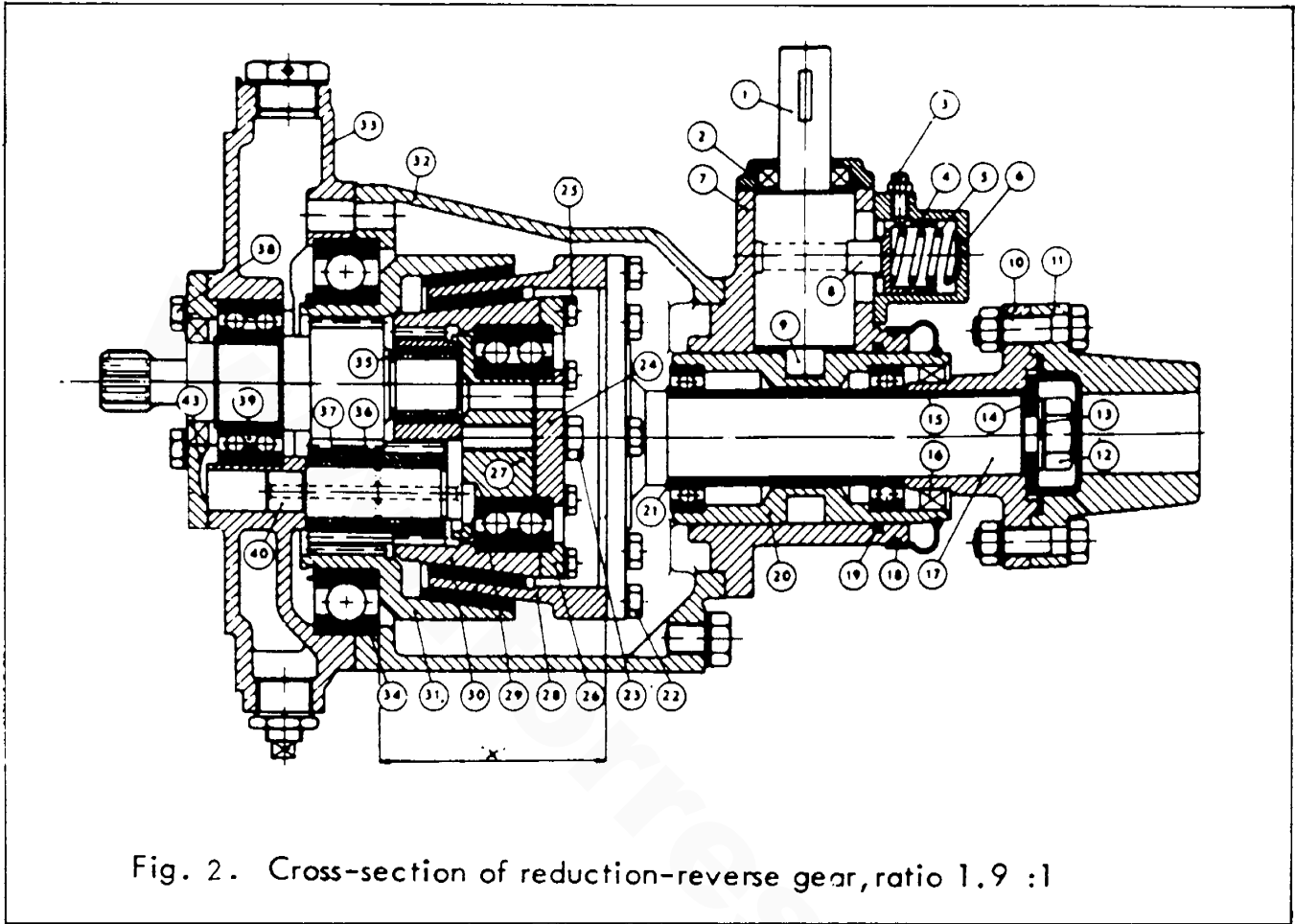


Fig. 2. Cross-section of reduction-reverse gear, ratio 1.9 :1

sure is applied to the shaft journal for the bearing (35). Take care to ensure that the needle bearing (35) is not damaged. Protect the bearing from dirt and place it so that it will take up the same position again when being fitted.

12. Drive out the shaft (40) with the gear wheel (37) and the bearing (36). With regard to taking care of the bearings, see point 11.
13. See Fig. 2. Removal of flange (44) and bearing (3) from the shaft (42) should be done in a press after the locking flange has been removed. Pressure must not be applied to the outer circumference of the flange (44).

INSPECTION

Before the reverse gear is refitted, all its com-

ponents should be carefully cleaned. At the same time inspect the parts and replace those that are worn. Fit new gaskets, O-ring and spring washers. Check carefully to see that all sealing rings are undamaged.

See Fig. 2. Friction lining wear on the gear wheel (31), which is most subjected to wear, is compensated for by increasing the thickness of the shim (21) as follows: Place the cone (28) in the gear wheel (31) and measure the distance "X" shown in Fig.4. The amount by which the measurement "X" is less than 85mm (3.35") determines how much the thickness of the shim (21) shall be increased. For example, if the distance measures 83mm (3.29"), then a 2mm (0.08") thick shim should be fitted. If the wear is so great that the measurement "X" is less than 81mm (3.19"), then the worn parts must be replaced. The friction linings in the gear wheel and cone are not interchangeable.

1. Fit the bearing (36) and the gear wheel (37), also press the shaft into the housing.
2. Fit the gear wheel (31) with bearing (34) into the housing (33).
3. See Fig. 2. Fit together the shaft (42), bearing (39), cover (43) and the flange (44) into one unit. The ball bearing (39) is fitted so that the recess on one side of the bearing (Fig.7) faces opposite the teeth on the shaft (42). If the sealing ring in the cover (43) shows the least sign of damage or if it has been removed from the cover, it should be replaced by a new one. A protecting sleeve should be used to prevent damage to the sealing ring by the passage of the keyway in the shaft (42).
4. See Fig. 2. Fit the shaft unit into the housing (33). Take care to ensure that the gear wheel on the shaft (42) meshes with both gear wheels (37 and 31).
5. See Fig. 2. Fit the needle bearing (35).
6. Fit the cone (28) in the gear wheel (31).
7. Fit together the bearing support (27), bearing support (27), bearing (29), cover (24) and the gear wheel (30) into one unit and and tighten on the cover (24). The ball bearing is fitted so that the recess one side of the bearing faces away from the teeth on the gear wheel (30). The bearing support (27) and the washer are fitted so that the middle through hole comes upwards.
8. Place the unit in the cone (28).
9. Fit the shaft (17) and the sleeve (20) onto the cone (28).
10. Fit the reverse gear housing (32) over the assembled parts and tighten it onto the housing (33).
11. Fit the rubber protector (18) and the coupling flange (10). Before fitting check that the bolt (12) is well tightened and that the key (15) is properly bedded down in its keyway in the shaft (17).

12. Fit the flange (9), shaft (1), locking plunger (8), sleeve (4), spring (5) and the plunger housing (6). Oil the parts liberally before fitting. The flange (9) is fitted so that its sides marked "O" follow the longitudinal direction of the engine. Fit the reverse gear lever and check the movements of the lever from neutral to "Ahead" and "Astern" positions respectively, which should be equi-distant. If the movement in one direction is appreciably more than in the other direction, this is to be adjusted by turning the flange (9). This is shaped such that the center of the rectangular portion is offset in relation to the center of the cylindrical portion (guide). If the flange is fitted so that the projecting side faces forwards, the movement of the reverse gear lever from the "Ahead" position to "Neutral" is decreased. If the flange is turned half a turn so that the projecting side faces aft, the movement of the lever from "Neutral" to the "Astern" position is decreased.

Then check that the reverse gear engages in both the "Ahead" and "Astern" positions.

13. Fit the reverse gear to the engine. Regarding the reverse gear with ratio 1.9 :1, fitting is facilitated if the rubber bushings on the driving studs (45) as well as the holes for these in the engine flywheel, are carefully coated with talc.

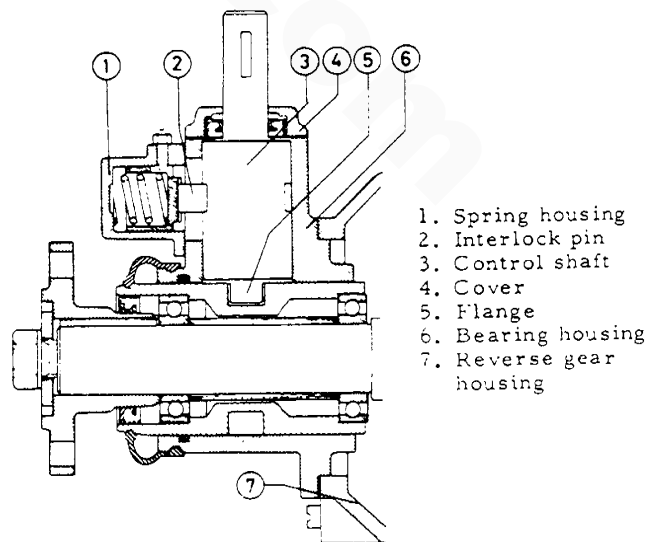


Fig. 3. Rear section of reverse gear

1. Set the reverse gear lever in the neutral position.
2. Remove the bolts which hold the bearing housing (6, Fig. 3) to the housing (7). Pull the bearing housing aft several millimeters (this is facilitated by carefully engaging the lever), insert a knife between the sealing surfaces and loosen the basket carefully so that it remains in contact with only one of the sealing surfaces.
3. Turn the bearing housing to the desired position and tighten down the housing.

If the keyway on the shaft is in such a position after being moved round that the reverse gear lever cannot be fitted, the shaft and flange are turned as follows: On the shaft there is only one keyway so that both

the lever retainer and the shaft must be turned.

- a. Remove the spring housing (1, Fig. 3) and lift out the locking plunger (2).
- b. Remove the cover (4) without pulling it off the shaft.
- c. Lift the shaft (3) with cover (4) from the housing and turn the shaft 180° (half a turn). Turn also the flange (5) half a turn and fit the shaft.

4. Refit the parts.

If the remote control for the RB reduction-reverse gear is fitted, it may not be done in such a way that a constant pressure operates on the reverse gear control components. In both "Ahead" and "Astern" positions the remote control device must be completely unloaded so that the propeller thrust can maintain the cones in the reverse gear in the engaged position.

DATA

| | |
|---------------------------|-----------------------|
| Type | Volvo Penta RB 1.9 :1 |
| Ratio "Ahead" | 1.9 :1 |
| Ratio "Astern" | 1.73:1 |
| Lubricating system | Circulation type |
| Oil capacity, approx..... | 0.5 liter (1 quart) |
| Oil grade | Service DS |
| Oil viscosity | SAE 20 |
| Oil change | Every 100 hours |
| Propeller type | Left-hand thread |
| Weight, approx..... | 28 kg (61 lb.) |

II. INTRODUCTION

Transmissions have been designed for smooth operation and dependability in marine use. The transmission is self-contained, having an oil pressure system and oil supply completely separated from engine lubricating oil systems.

Transmission oil under pressure is used to engage a forward or reverse drive. The for-

ward drive is through a multiple disc clutch arrangement, while the reverse drive utilizes a reverse clamp band and planetary gear train. The transmission oil is circulated and cooled through a separate external oil cooler core, which is in turn cooled by the engine water. Paragon transmissions are furnished with either direct drive or reduction gears. Gear reduction ratios and corresponding model identification numbers are listed in Section I, under "SPECIFICATIONS".

III. INSTALLATION

A. The installation instructions below are for use when the original transmission has been removed for servicing and must be re-installed, or when the transmission unit is to be adapted as non-original equipment to a marine engine.

B. It is important that the engine and transmission rotations are matched. The direction of rotation of an engine is defined in this manual as the direction of rotation of the engine crankshaft as viewed from the output end of the transmission. A clockwise rotation of the engine is a right hand rotation and a counterclockwise rotation of the engine is a left hand rotation.

A letter "R" or "L" appearing on the transmission serial number plate illustrated in Section I, "SPECIFICATIONS", indicates whether the transmission is for use with a right or left hand rotating engine.

C. The hydraulic transmission is attached to the engine in the following manner:

1. Insert two 3-1/2" studs in opposite transmission mounting holes in the engine adapter plate.
2. Place the transmission against the studs so that the studs go through two of the matching holes in the transmission housing flange.
3. Slide the transmission along the studs toward the engine so that the spline on the shaft at the front of the transmission enters the matching splined hole in the engine vibration dampener.

4. Install and tighten four bolts with lockwashers through the transmission housing flange into the engine adapter plate. Remove the 3-1/2" studs, install and tighten the two remaining bolts with lockwashers through the transmission housing flange.

D. The transmission and propeller shaft coupling must be carefully aligned before the propeller shaft is connected to the transmission, in order to avoid vibration and consequent damage to the transmission, engine, and boat hull during operation. To align the coupling, move the propeller shaft, with attached coupling flange, toward the transmission so that the faces of the propeller shaft coupling flange and transmission shaft coupling flange are in contact. The coupling flange faces should be in contact throughout their entire circumference. The total runout or gap between the faces should not exceed .002" at any point. If the runout exceeds .002", reposition the engine and attached transmission by loosening the engine support bolts and adding or removing shims to raise or lower either end of the engine. If necessary, move the engine sideways to adjust the runout or to align the coupling flange faces laterally. Tighten the engine support bolts and recheck the alignment of the coupling before bolting the coupling flanges together. Connect the coupling flanges with bolts, lockwashers, and nuts.

E. Connect the oil cooler lines to the transmission.

F. Connect the shift control cable from the cockpit control station to the transmission control valve lever, shown in Figure on page 5. Place the transmission control valve lever in the neutral position and

GENERATOR TROUBLESHOOTING

PREPARATION

A few simple checks and a proper troubleshooting procedure can locate the probable source of trouble and cut down troubleshooting time.

1. Check all modifications, repairs, replacements performed since last satisfactory operation of set to be sure that connection of generator leads are correct. A loose wire connection, overlooked when installing a replacement part could cause problems. An incorrect connection, an opened circuit breaker, or a loose plug-in printed circuit board are all potential malfunction areas to be eliminated by a visual check.
2. Unless absolutely sure that panel instruments are accurate, use portable test meters for troubleshooting.
3. Visually inspect components on VR²¹. Look for dirt, dust, or moisture and cracks in the printed solder conductors. Burned resistors, arcing tracks are all identifiable. Do not mark on printed circuit boards with a pencil. Graphite lines are conductive and can cause short circuits between components.

The question and answer troubleshooting guide which follows, gives a step-by-step procedure for checking the generator components. Refer to Figure 22 for an electrical schematic of the generator and voltage regulator connections.

TROUBLESHOOTING PROCEDURES

This troubleshooting information is divided into tables, A, B, C, and D as follows:

- A. No build up of AC output voltage.
- B. AC output voltage builds up, but is unstable.
- C. AC output voltage builds up, but is high or low.

D. AC output voltage builds up, but field breaker trips.

To correct a problem, answer the question of the step either YES or NO. Then refer to the step number in the answer column and proceed to that step next.

Letters A through P in the Test Procedure column refer to detailed procedures in the Adjustments and Tests section, pages 8-15.

| TABLE A. No Build Up of AC Output Voltage | Yes | No | Test Proc. |
|---|-----|----|------------|
| 1. Is Field Breaker CB21 on control panel ON? | 2 | 3 | |
| 2. Connect jumper wire across terminals of Field Breaker, CB21. Does AC output voltage build up? If voltage builds up REPLACE FIELD BREAKER. | — | 4 | |
| 3. Push to reset Field Breaker. Does AC output voltage build up? If voltage builds up but is high, low, unstable, or causes tripping of Field Breaker, refer to Tables B, C, or D. | — | 4 | |
| 4. Disconnect alternator stator leads 1 & 2 from TB21-1 and TB21-2 on VR22. Is reference voltage across 1 & 2 20 VAC or more? | 14 | 13 | |

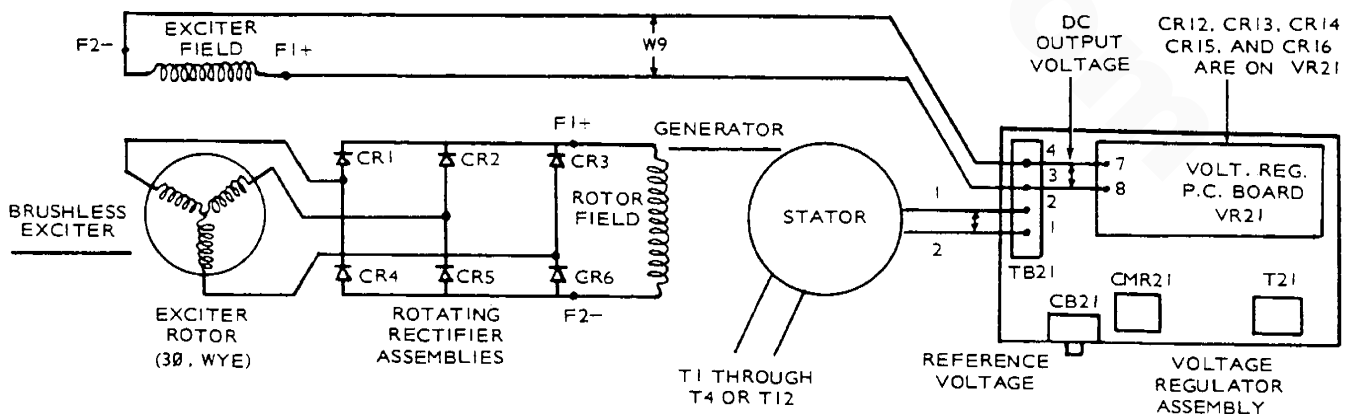


FIGURE 22. GENERATOR-REGULATOR ELECTRICAL SCHEMATIC

| TABLE A. (continued) | Yes | No | Test Proc. |
|---|-----|----|------------|
| 5. Is exciter field voltage across F1+ and F2- on endbell terminal block 7.0 VDC or more? If not, check wiring harness W9 from end bell to VR22 terminals 3 and 4. | 6 | — | |
| 6. Is brushless exciter stator (field) winding OK? | 7 | — | K |
| 7. Are diodes CR1, CR2, CR3, CR4, CR5, CR6 in rotating rectifier assemblies OK? Check all diodes - more than one may be defective. | 8 | — | F |
| 8. Are brushless exciter rotor windings OK? | 9 | — | L |
| 9. Is generator rotor field winding OK? | 10 | — | M |
| 10. Are generator stator windings OK? | 11 | — | N |
| 11. Is commutating reactor CMR21 OK? | 12 | — | I |
| 12. Is reference transformer T21 OK? | 18 | — | J |
| 13. Flash exciter field. Is reference voltage across 1 and 2 now 20 VAC or more? | 14 | 5 | E |
| 14. Reconnect generator leads 1 & 2 to TB21-1 and TB21-2 on VR22. Does reference voltage build up? | — | 15 | |
| 15. Is regulator DC output voltage across VR21-7 and VR21-8 7 VDC or more? See Figure 22. | 5 | 16 | |
| 16. Are SCR's CR13 and CR16 OK? | 17 | — | H |
| 17. Are diodes CR12, CR14, and CR15 OK? | 18 | — | G |
| 18. Replace voltage regulator PC board (VR21) | — | — | P |

| TABLE B. AC Output Voltage Builds Up, But Is Unstable | Yes | No | Test Proc. |
|---|-----|----|------------|
| 1. Are there any loose or broken wires or connections on voltage regulator assembly VR22? | — | 2 | |
| 2. Is W9 (exciter field) wiring harness from VR22 to End bell OK? | 3 | — | |
| 3. Does adjustment of Damping Control R27 potentiometer on VR21 result in stable voltage? | — | 4 | A |
| 4. Replace PC Board VR21. | — | — | P |

CAUTION Do not replace the printed circuit board until the trouble not on the PC board has been located and corrected to avoid damage to new PC board.

| TABLE C. AC Output Voltage Builds Up, But is High or Low | Yes | No | Test Proc. |
|--|-----|----|------------|
| 1. Is set running at correct RPM? (See appropriate engine manual to set RPM) | 2 | — | |
| 2. Does adjustment of Voltage Adjusting knob for R22 on VR22 result in correct output voltage? | — | 3 | A |
| 3. Does adjustment of potentiometer R26 on VR21 result in correct output voltage? | — | 4 | A |
| 4. Is correct voltage reference V4 to V1, V2, or V3 on VR21 being used? Refer to Figure 6. | 5 | — | |
| 5. Are generator output leads properly connected? Refer to Figure 6. | 6 | — | |
| 6. Replace voltage regulator, PC board VR21 | — | — | P |

CAUTION Do not replace the printed circuit board until the trouble not on the PC board has been located and corrected to avoid damage to new PC board.

| TABLE D. AC Output Voltage Builds Up, But Field Breaker Trips | Yes | No | Test Proc. |
|--|------------|-----------|-------------------|
| 1. Does AC output voltage build up to 140% or more of rated voltage before Field Breaker trips? | 2 | 7 | — |
| 2. Are there any loose or broken wires or connections on VR22? | — | 3 | |
| 3. Is diode CR15 on VR21 OK? | 4 | — | G |
| 4. Are T21 windings and connections OK? | 5 | — | J |
| 5. Are generator stator leads properly connected? Refer to Figure 6. | 6 | — | — |
| 6. Replace VR21. | — | — | P |
| 7. Are diodes CR1, CR2, CR3, CR4, CR5, CR6 in rotating rectifier assemblies OK? Check all diodes - more than one may be defective. | 8 | — | F |
| 8. Is brushless exciter stator winding OK? | 9 | — | K |
| 9. Is generator rotor field winding OK? | 10 | — | M |
| 10. Is brushless exciter rotor OK? | 11 | — | L |
| 11. Are generator stator windings OK? | 6 | — | N |

ADJUSTMENTS AND TESTS — REFERENCE LIST, pages 8-15.

- A. VOLTAGE CALIBRATION ADJUSTMENT
- B. VOLTAGE STABILITY ADJUSTMENT
- C. BATTERY CHARGE RATE ADJUSTMENT
- D. VOLTAGE REGULATOR CHECKOUT
- E. FLASHING THE FIELD
- F. TESTING ROTATING RECTIFIERS
- G. TESTING OUTPUT BRIDGE DIODES
- H. TESTING SCR'S
- I. TESTING REACTOR
- J. TESTING REFERENCE TRANSFORMER
- K. TESTING EXCITER STATOR
- L. TESTING BRUSHLESS EXCITER ROTOR (ARMATURE)
- M. TESTING GENERATOR ROTOR
- N. TESTING GENERATOR STATOR
- O. WIRING HARNESS CHECK
- P. VR21 REPLACEMENT

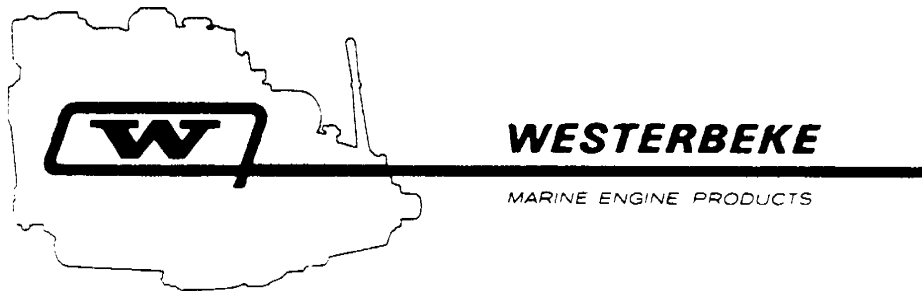
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SERVICE BULLETINS

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.

V2



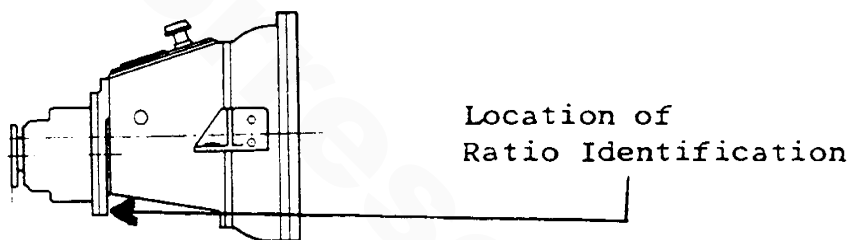
SERVICE BULLETIN #16

SUBJECT: Reduction Gear Ratio Identification

MODELS: Westerbeke-Paragon Model SA

To identify the reduction gear ratio on SA transmissions, look for digits marked on the back side of the adapter plate.

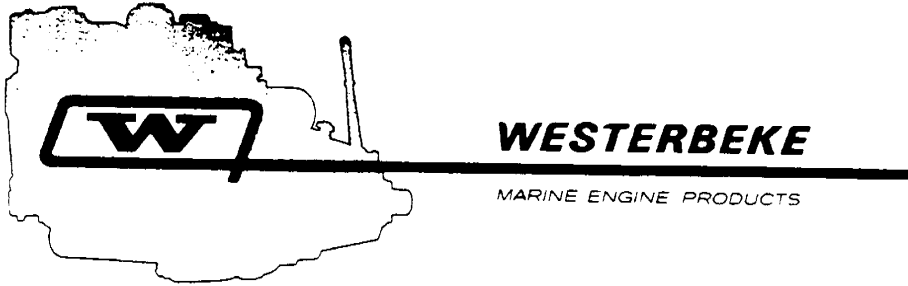
See Drawing Below



These digits represent the following ratios:

| <u>DIGITS</u> | <u>RATIO</u> |
|---------------|--------------|
| R015 | 1.5:1 |
| R020 | 2:1 |
| R025 | 2.5:1 |

9/3/68



SERVICE BULLETIN #20

MODEL: ALL ENGINES

SUBJECT: CONNECTING PRESSURE SENSING DEVICES TO OIL GALLERIES

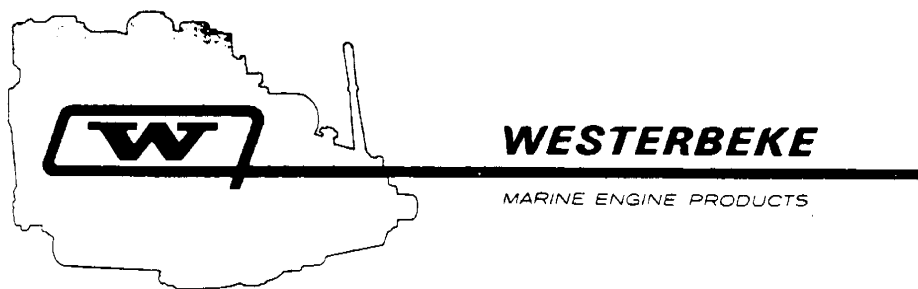
Oil pressure sensing devices, such as senders and switches, must never be connected directly to any oil gallery of an engine. The reason is simply that continued engine vibration causes fatigue of the fittings used to make such a connection. If these fittings fail, the engine loses its oil pressure and very quickly siezes.

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.

6/15/69

#11967

V4



SERVICE BULLETIN #69

Subject: Exhaust system failures

Models: All marine generators and marine engines

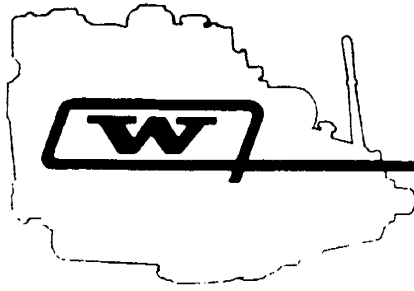
When engine sea water is fed into an exhaust system so that the full stream strikes a surface, erosion may cause premature failures.

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 sea 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.

PN 19149

May 6, 1974



WESTERBEKE

MARINE ENGINE PRODUCTS

SERVICE BULLETIN #72

MODELS: ALL

SUBJECT: NON-INTERCHANGEABILITY BETWEEN MANUFACTURERS OF GAUGES AND SENDERS

In recent years we have purchased gauges and senders from four different manufacturers.

In no case may the gauge of one manufacturer be used with the sender of another manufacturer. In some cases the wiring of either or both the gauge and the sender varies by manufacturer.

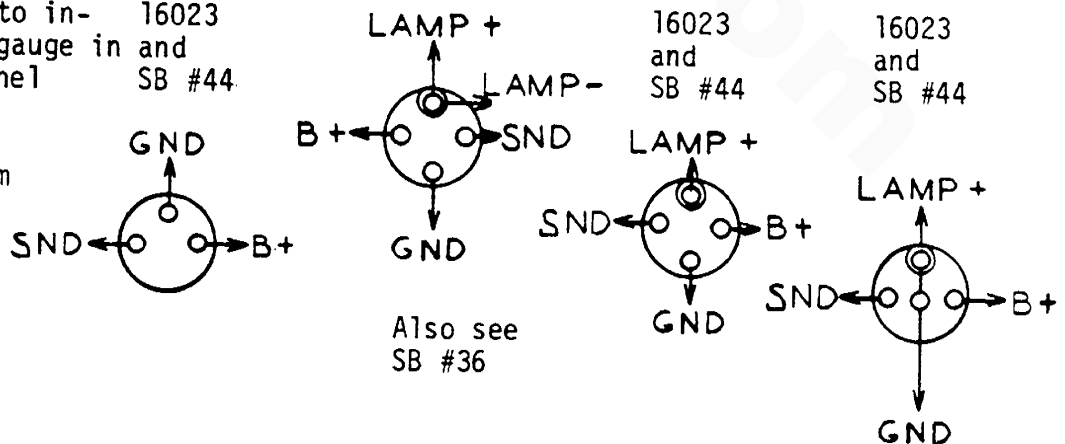
Thus it becomes important, when ordering a replacement gauge or ordering a replacement sender, to order a matched set or to know conclusively who the manufacturer is.

Ammeters are electrically interchangeable.

| | <u>STEWART-WARNER</u> 2" DIA CASE | <u>VDO</u> 2 3/8" DIA CASE | <u>FARIA</u> 2" DIA CASE | <u>NOVOX</u> 2" DIA CASE |
|---------------------|--------------------------------------|-------------------------------|-----------------------------|-----------------------------|
| Ammeter | 11581 | 11931 | 16550 | 19165 |
| Oil pressure gauge | 11544 | 11914 | 16548 | 19166 |
| Oil pressure sender | 11542 | 11916 | 16551 | 19167 |
| Water temp. gauge | 11545 | 11913 | 16549 | 19168 |
| Water temp. sender | 11543 | 11915 | 16552 | 19169 |

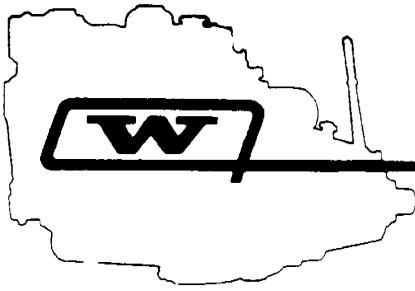
Adapter ring to install 2" dia gauge in and 2 3/8" dia panel cut-out
16023 and SB #44

Wiring diagram



5/29/74

PN19190



WESTERBEKE

MARINE ENGINE PRODUCTS

SERVICE BULLETIN #78

ISSUED: January 24, 1975

SUBJECT: Thermostats

MODEL: Four and six cylinder engines

DISTR: Distributors, Dealers, and Manufacturers

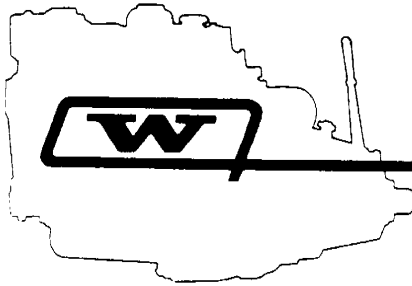
Basically there are three thermostats in use for our various four and six cylinder engines. The thermostat which is used in the Four-107 may not be used anywhere else.

The thermostat used in the Four-60, Four-91, and Four-154 is interchangeable across that range.

The thermostat used in the Four-230 and the Six-346, both VD and 98 series, is different from the thermostat above in that it has a movable bottom part which seals against the lower thermostat housing. Therefore, it is not interchangeable.

A list of correct part numbers follows:

| <u>Engine models</u> | <u>Part number</u> |
|----------------------|--------------------|
| Four-107 | 11698 |
| Four-60,-91,-154 | 18136 |
| Four-230, Six-346 | 17926 |



WESTERBEKE

MARINE ENGINE PRODUCTS

SERVICE BULLETIN #81

REISSUED: October 3, 1975
 SUBJECT: Hydro-Hush Muffler Installation
 MODEL: A11
 DISTR: A11

The diagram on the reverse side shows a proper installation of the Hydro-Hush stainless steel muffler.

Make sure installation is such that water cannot enter engine at any angle of heel or pitch.

Muffler remains approximately twenty-five percent full of water after engine is shut down with maximum thirty-three inch lift used.

Muffler must be installed as close to fore-aft centerline of boat as possible.

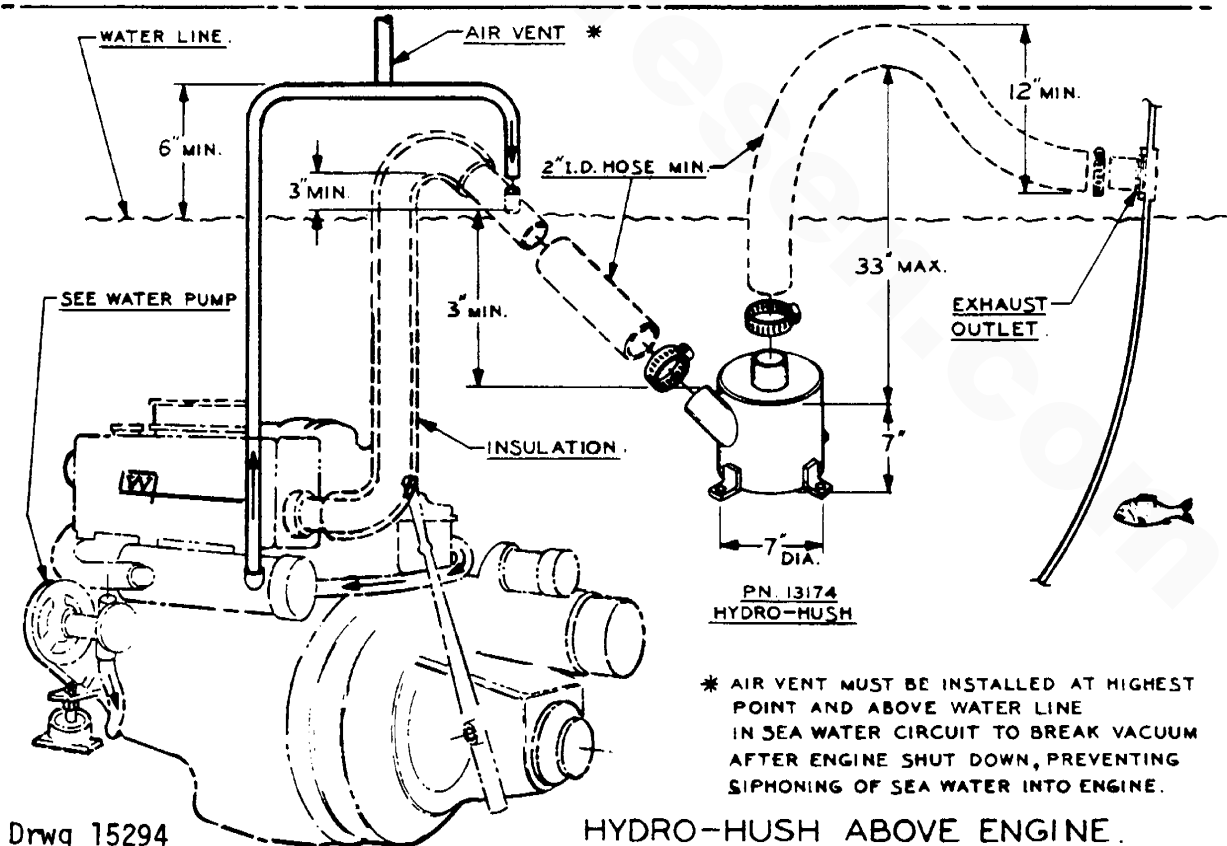
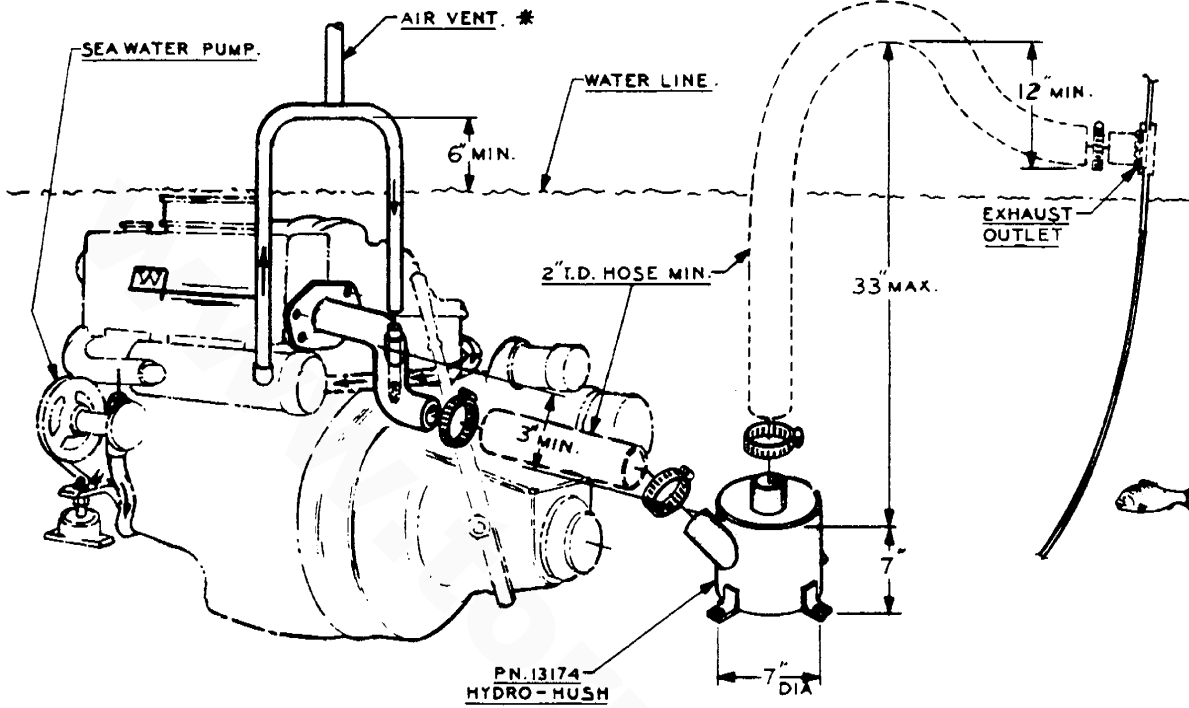
There must be an unblocked vent to atmosphere at the high point of the sea water circuit (where it passes above the waterline) to break the vacuum which would encourage siphoning through the sea water circuit upon engine shutdown. Such siphoning would fill the engine with sea water through its exhaust. Pipe the air vent with approximately 3/16 copper tubing to discourage water flow through it when the engine is running. If water flows through the air vent when the engine is running, pipe it over the side or into the transom exhaust outlet. But be sure it will drain upon engine shutdown and function properly as a siphon break by venting the sea water circuit to atmosphere.

Use as few right angle fittings as possible. If there is any question as to back pressure, check your engine manual.

Exhaust line diameters indicated are minimums. Refer to engine manual for specifics regarding run lengths and sizes greater than indicated.

The installation tips given are to be used as a guide only. We cannot be responsible in any way for muffler installation. We presume basic understanding of good marine practice on the part of the installer.

HYDRO-HUSH BELOW ENGINE.



Drwg 15294

HYDRO-HUSH ABOVE ENGINE.



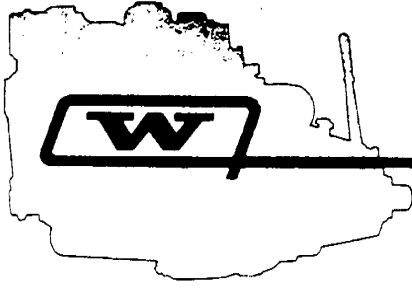
SERVICE BULLETIN #82

REISSUED: May 21, 1979
 SUBJECT: Battery Recommendations
 MODEL: A11
 DISTR: Owners, Distributors, Dealers, Manufacturers

BATTERY RECOMMENDATIONS

| <u>MODEL</u> | <u>BATTERY AMPERE HOURS</u> | <u>VOLTAGE</u> |
|--------------------------------|-----------------------------|----------------|
| Vire, 7 Horsepower, gasoline | 40-60 | 12 V.D.C. |
| W-7, 7 Horsepower, diesel | 60-90 | 12 V.D.C. |
| W-10, 10 Horsepower, diesel | 90-125 | 12 V.D.C. |
| Four-60, 15 Horsepower, diesel | 90-125 | 12 V.D.C. |
| W-20, 20 Horsepower, diesel | 90-125 | 12 V.D.C. |
| W-30, 25 Horsepower, diesel | 125-150 | 12 V.D.C. |
| L25, 25 Horsepower, diesel | 125-150 | 12 V.D.C. |
| W-40, 37 Horsepower, diesel | 125-150 | 12 V.D.C. |
| WPDS-15, 15 Kilowatt, diesel | 125-150 | 12 V.D.C. |
| W-50, 41 Horsepower, diesel | 125-150 | 12 V.D.C. |
| W-60, 53 Horsepower, diesel | 150-170 | 12 V.D.C. |
| WPDS-20, 20 Kilowatt, diesel | 150-170 | 12 V.D.C. |
| W-80, 75 Horsepower, diesel | 170-200 | 12 V.D.C. |
| W-120, 115 Horsepower, diesel | 200 minimum | 12 V.D.C. |

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



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MARINE ENGINE PRODUCTS

SERVICE BULLETIN #84

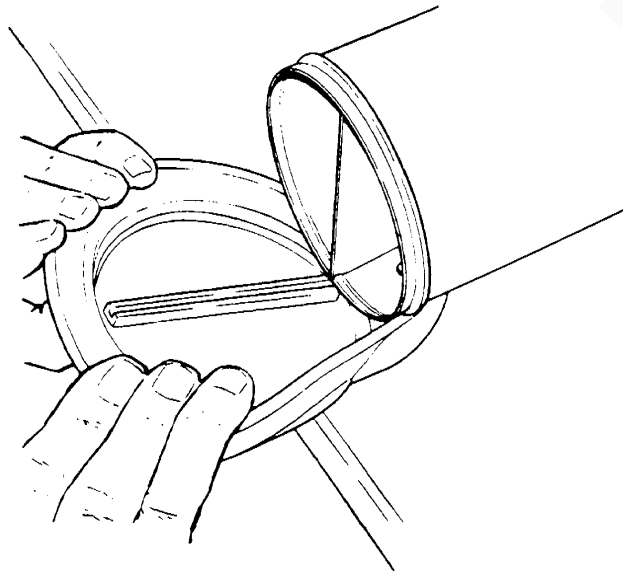
ISSUED: September 4, 1975
SUBJECT: Heat Exchanger Rubber End Cap
MODEL: A11
DISTR: Distributors, Engine Shipments

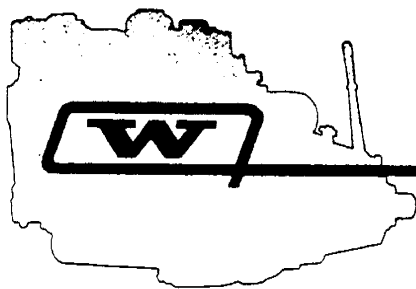
Many heat exchangers supplied on our various products incorporate a molded rubber end cap to facilitate inspection of the tubes.

There have been occasions on which engine overheating has been caused by the improper positioning of this rubber end cap.

It is absolutely essential that the molded channel running across the inside of the cap be positioned over the baffle of the heat exchanger, according to the drawing below.

In any cases of engine overheating where such a rubber end cap is used, it should be checked for proper positioning along with other routine troubleshooting.




WESTERBEKE

MARINE ENGINE PRODUCTS

SERVICE BULLETIN #87

ISSUED: September 18, 1975
 SUBJECT: Alternator Output Splitter
 MODEL: All Marine Engines
 DISTR: Distributors, Shipments

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).

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

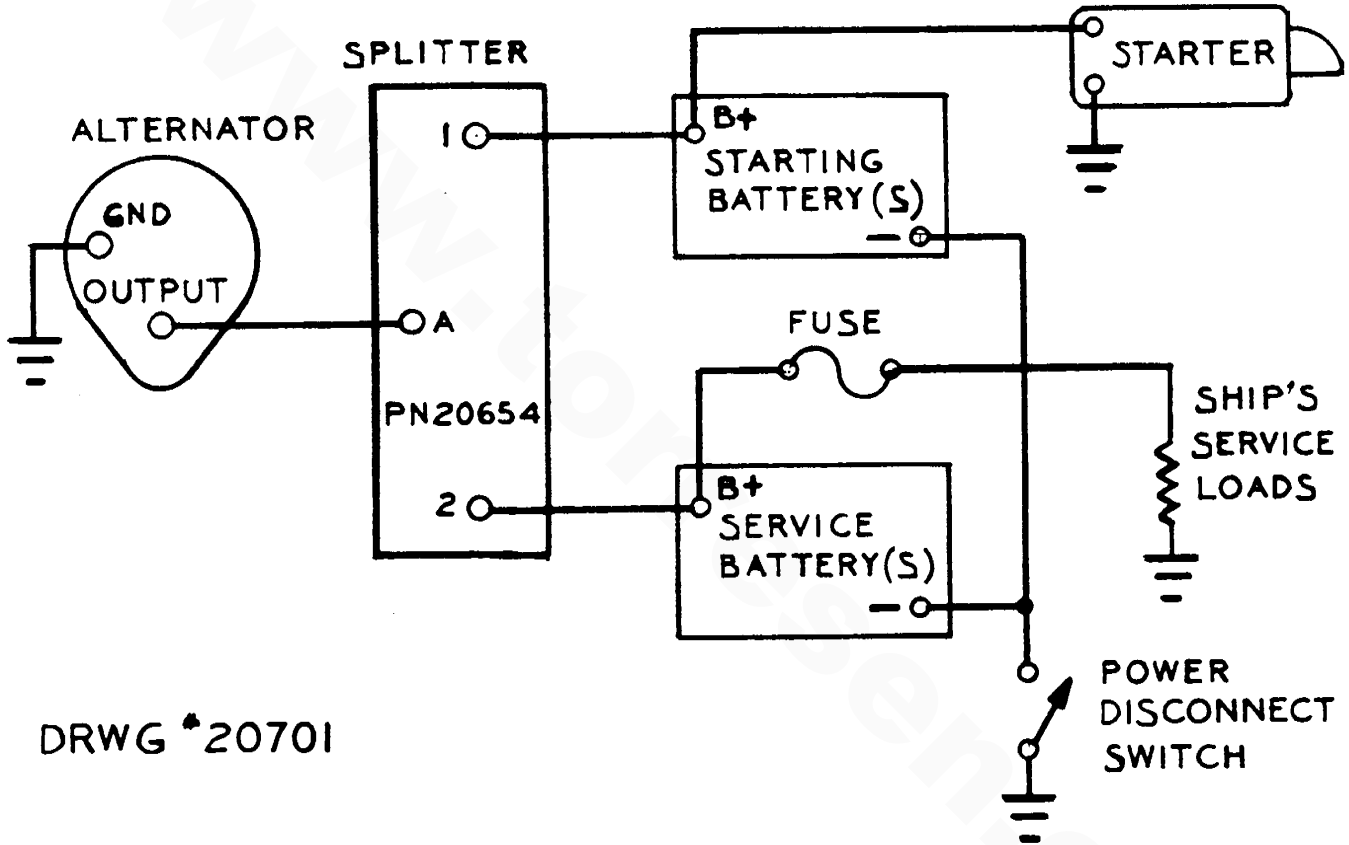
With the engine running and alternator charging, the side splitter terminals should read the same voltage which should be the voltage of the regulator or somewhat less. The center splitter terminal should read .82 volts higher than the readings of the side terminals.

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

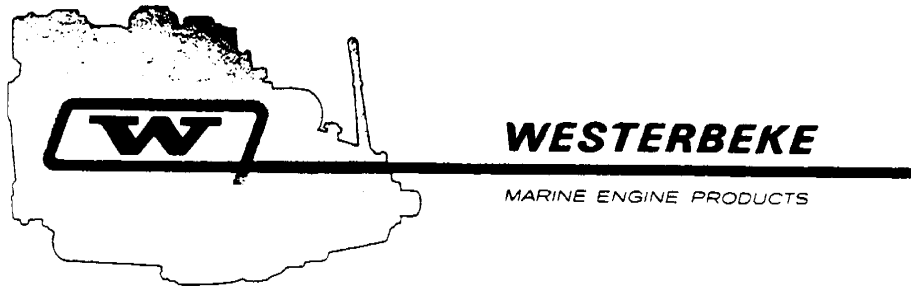
Continued-Reverse Side

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

BY-PASSING 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).



DRWG *20701



SERVICE BULLETIN 92

ISSUED: April 28, 1976

SUBJECT: Troubleshooting Water Temperature and Oil Pressure Gauges

MODELS: All

DISTR: Distributors, Shipments

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 is 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 OK 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.

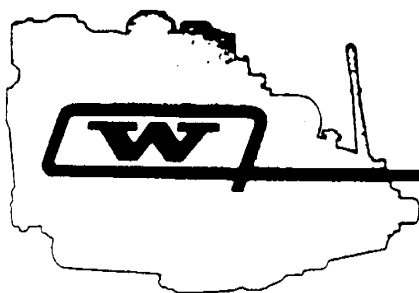
Assuming the gauge is OK, proceed as follows. Check the conductor from the sender to the sender terminal at the gauge for continuity.

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 OK and the engine block is grounded, the sender is probably defective and should be replaced.

P/N 21616

4/28/76

**WESTERBEKE**

MARINE ENGINE PRODUCTS

SERVICE BULLETIN 94

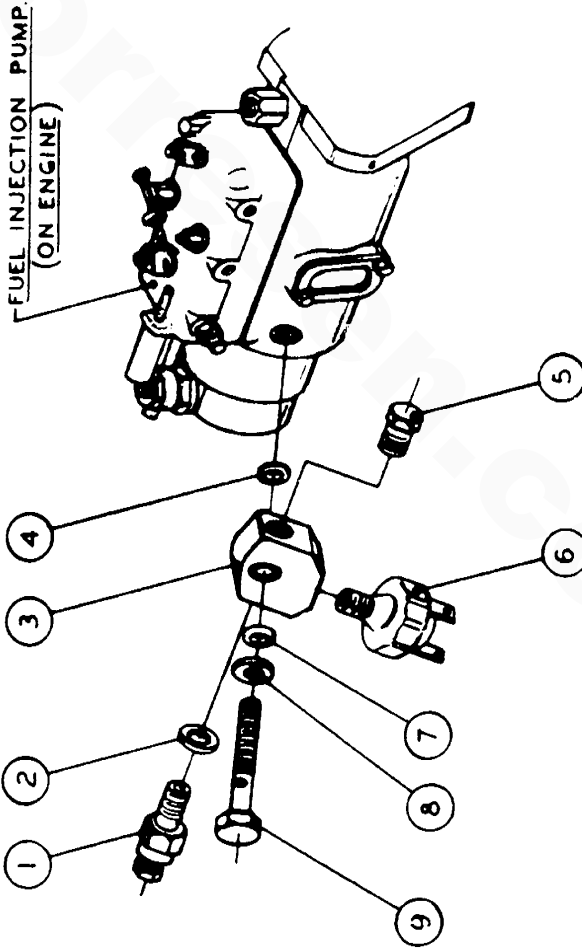
ISSUED: September 9, 1976
SUBJECT: Fuel Pressure Switch Installation
MODEL: A11
DISTR: Distributors, Shipments

Overleaf is a parts list and an illustration showing the proper installation of the fuel pressure switch used on most of our engine products.

P/N 21564

9/9/76

| DATE | REVISED | REVISION RECORD | AUTH | DR | CR |
|------|---------|-----------------|------|----|----|
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| ITEM | 19187 | 19442 | 19320 | 11383 | 11615 | 19321 | 19185 | 19261 | 19204 | PART NO. | DESCRIPTION | QTY |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|----------------------|-----|
| | | | | | | | | | | | HEX HD. SCREW | 1 |
| | | | | | | | | | | | FLAT WASHER | 1 |
| | | | | | | | | | | | O" RING 7/16 O.D. | 1 |
| | | | | | | | | | | | FUEL PRESSURE SWITCH | 1 |
| | | | | | | | | | | | PLUG | 1 |
| | | | | | | | | | | | O" RING 9/16 O.D. | 1 |
| | | | | | | | | | | | ADAPTER | 1 |
| | | | | | | | | | | | COPPER WASHER | 1 |
| | | | | | | | | | | | SCREEN ASSY (BLEED) | 1 |
| | | | | | | | | | | | | |

| | | |
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| TOLERANCES UNLESS NOTED | J.H. WESTERBEKE CORP. AVON, MA. 02322 | |
| DECIMAL | SCALE NONE | DRAWN BY B.J.S. |
| FRACTIONAL | | APPROVED BY |
| ANGULAR | | |
| TITLE INSTALLATION DWG, FUEL PRESS SWITCH TO A FUEL INJECTION PUMP | | |
| DATE 9-9-76 | DRAWING NUMBER 21743 | |

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