TECHNICAL MANUAL

WESTERBEKE 50
Marine Diesel Engine

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THE WESTERBEKE CORP.

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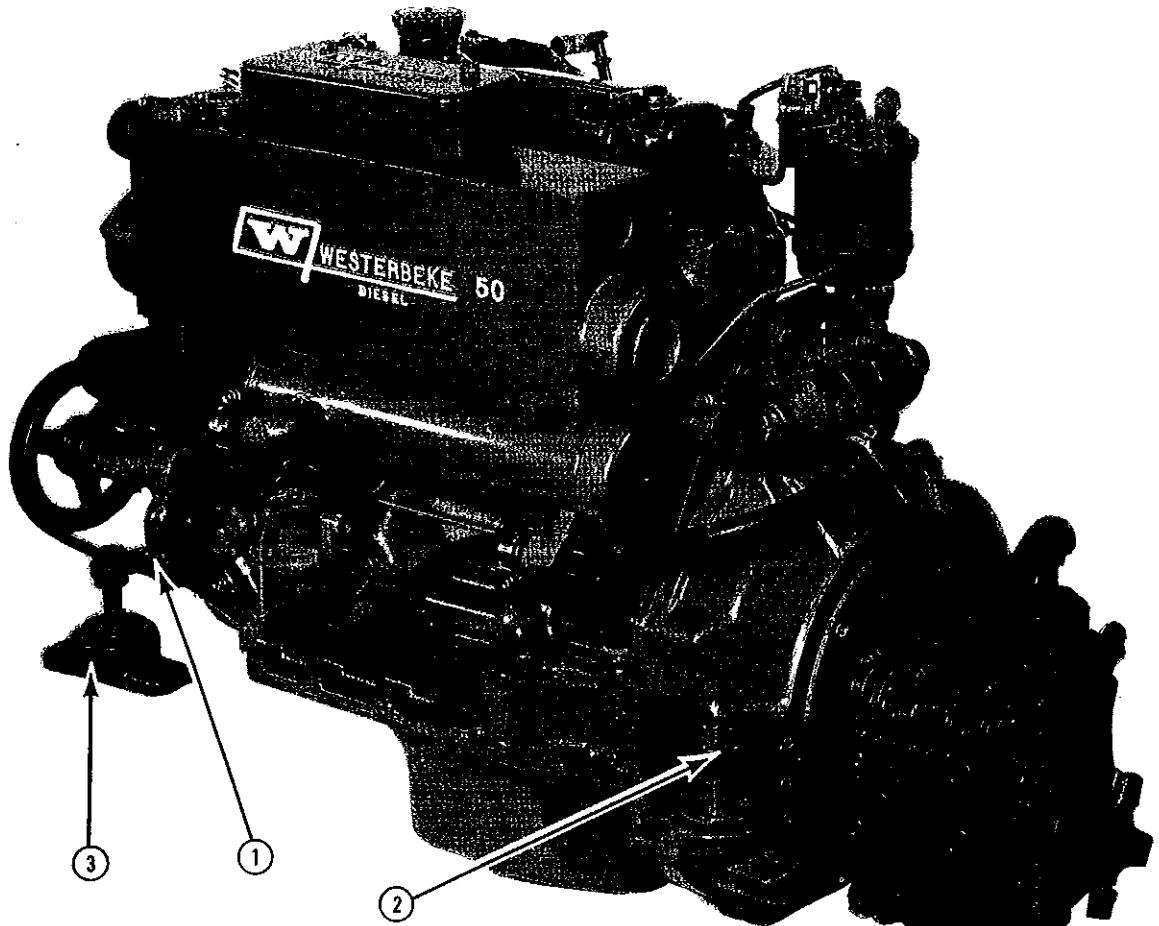
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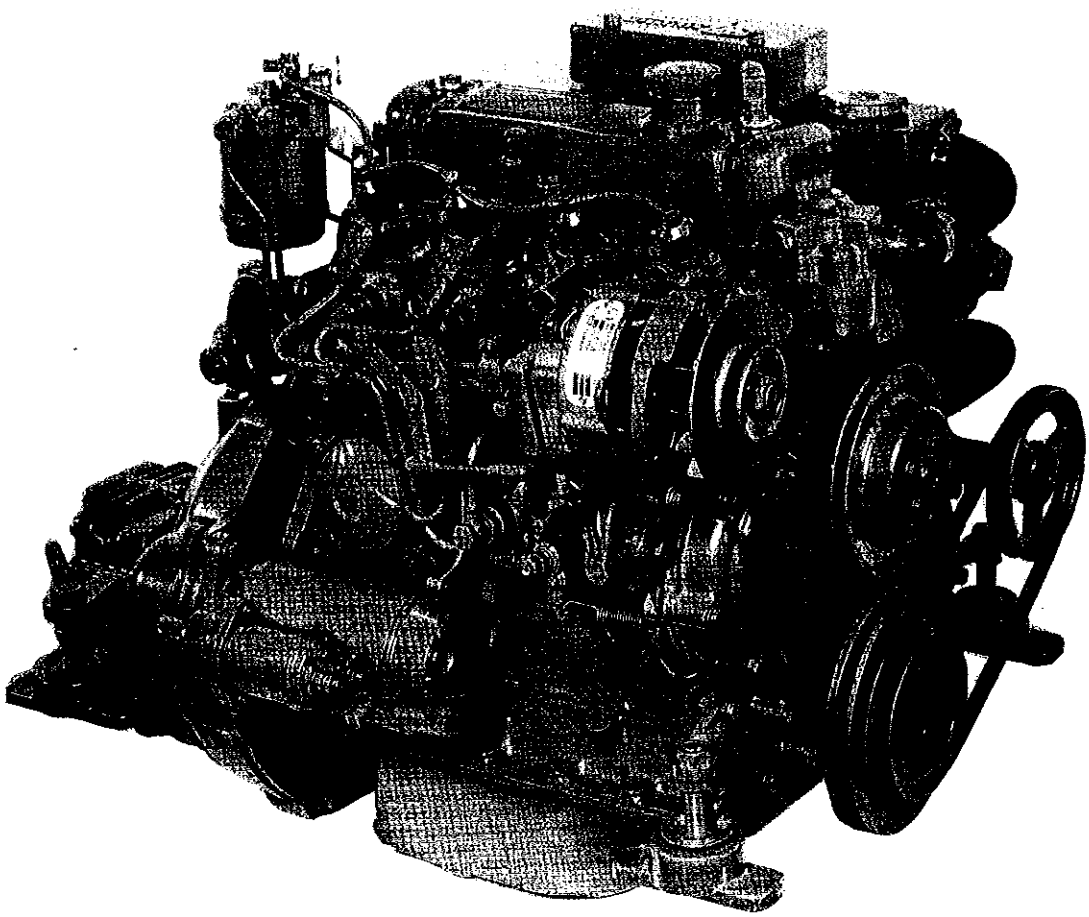


SECTION INDEX

YOUR NOTES

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.

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^{o} 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

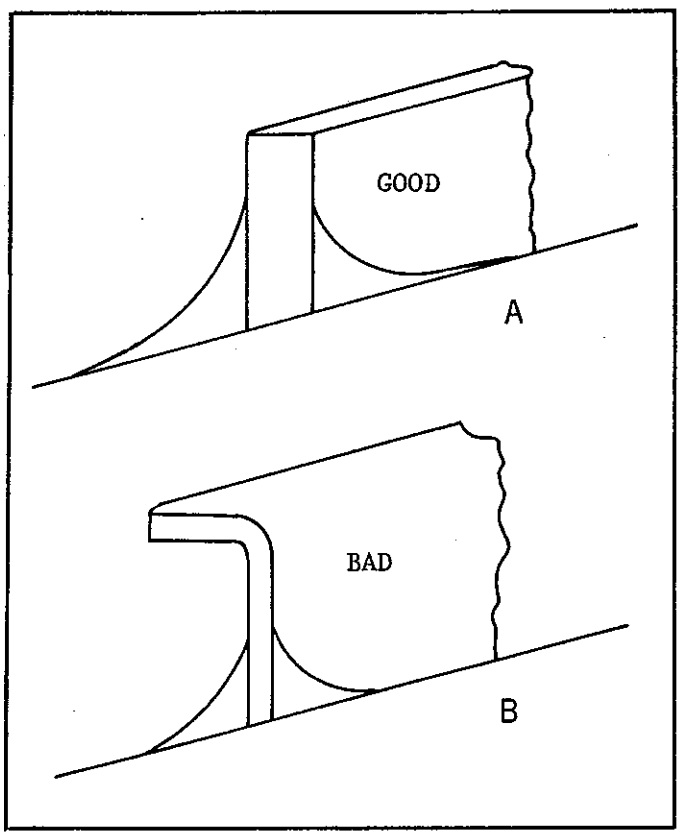
It is recommended that bronze hanger bolts of appropriate size be used through the engine flexible mounts. Lag screws are less preferred because their hold on the wood is weakened every time they are moved, whereas the lag bolt stays in position and the nut on top is used to tighten the engine down or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

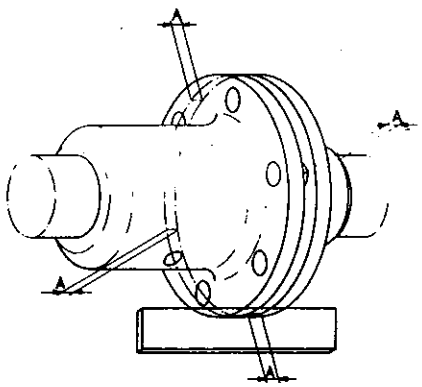
One particularly annoying result of misalignment may be leakage of transmission oil through the rear oil seal. Check to make sure that alignment is within the limits prescribed.

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 in 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 realign at a further period.

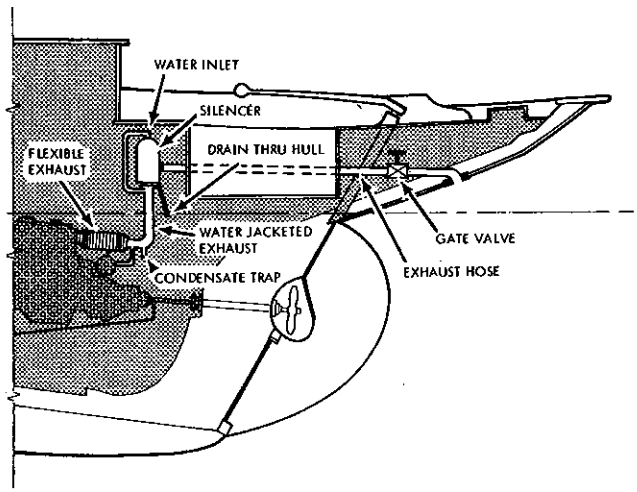
The coupling should always be opened up and the bolts removed whenever the boat is hauled out or moved from the land to the water, and during storage in a cradle. The flexibility of the boat often puts a very severe strain on the shaft or the coupling or both when it is being moved. In some cases the 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.

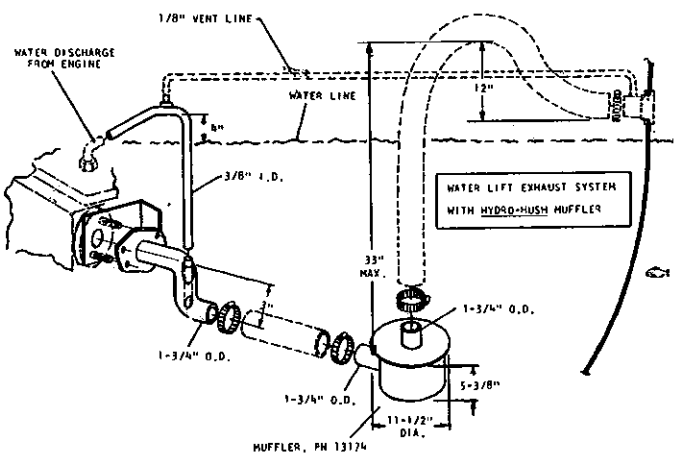
Brass or copper is not acceptable for wet exhaust systems, as the combination of salt water and diesel exhaust gas will

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



WATER LIFT EXHAUST SYSTEM WITH "HYDRO-HUSH" MUFFLER

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

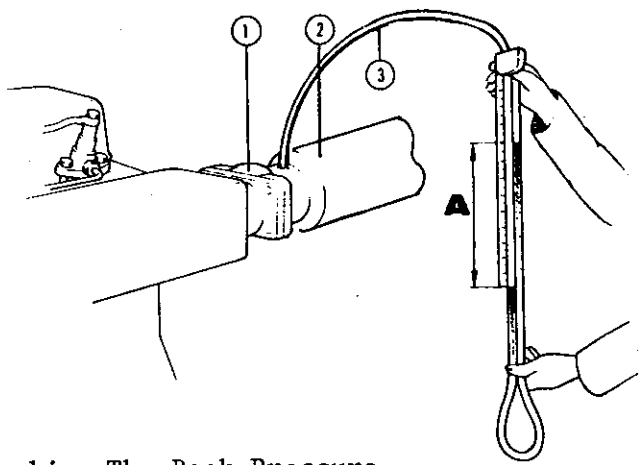
Back pressure must be measured on a straight section of the exhaust line and as near as possible to the engine exhaust manifold. The engine should be run at maximum load during the measurement period. Set-up should be as shown below.

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 realigned. 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 airlocks are eliminated and precautions taken against dirt and water entering the fuel.

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

As the fuel lift pump has a capacity in excess of that required by the injection pump, the 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.

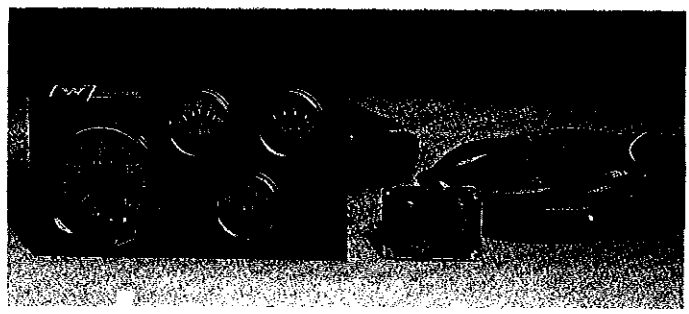
Keep fuel lines as far as possible from exhaust pipe for minimum temperature, to eliminate "vapor locks".

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/ cicuit 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 overfill. 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 overfill.
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.

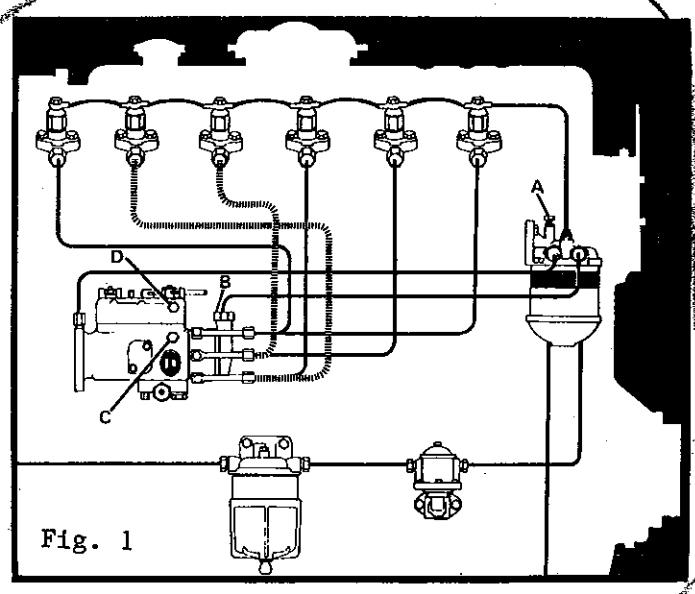


Fig. 1

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

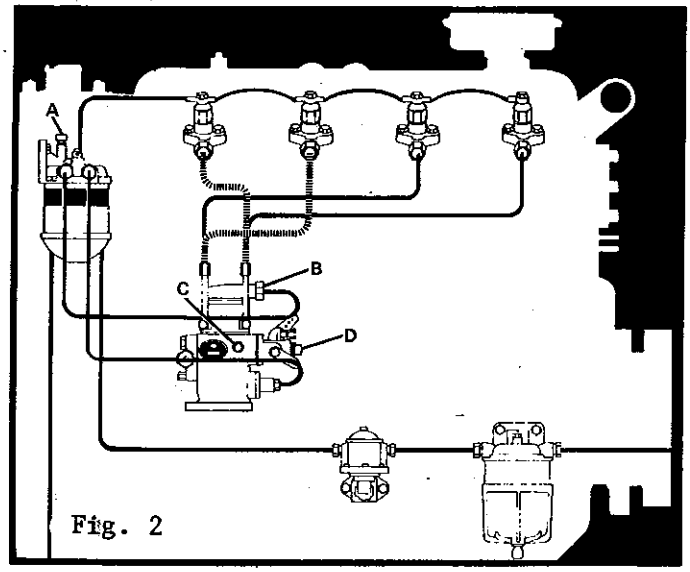


Fig. 2

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

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.

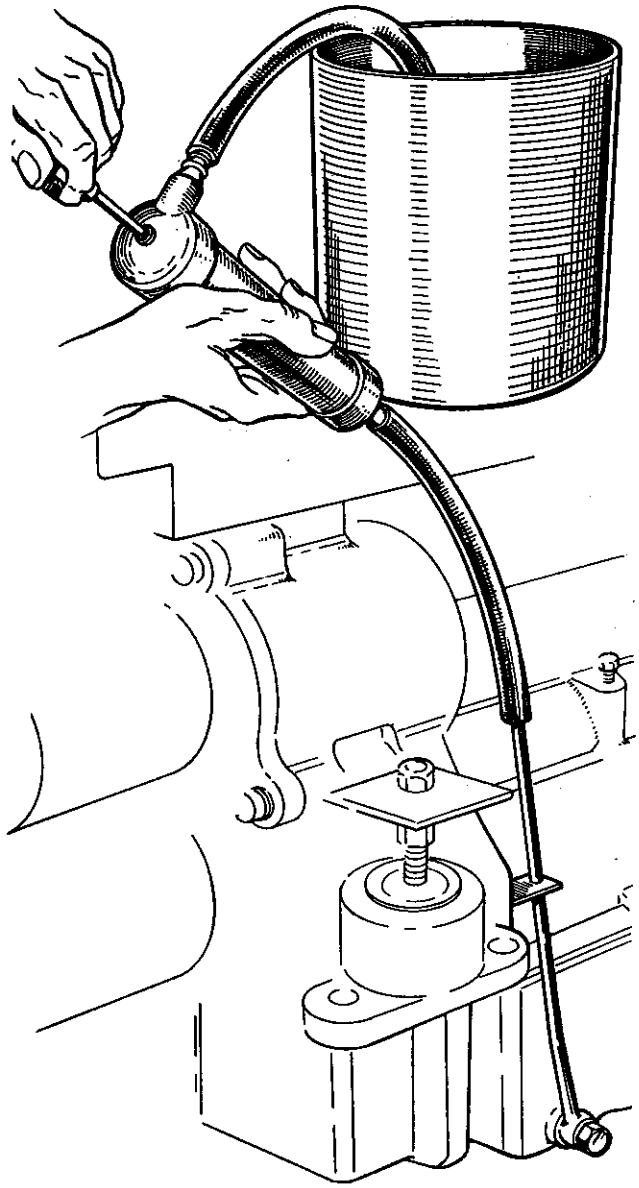


FIGURE 1

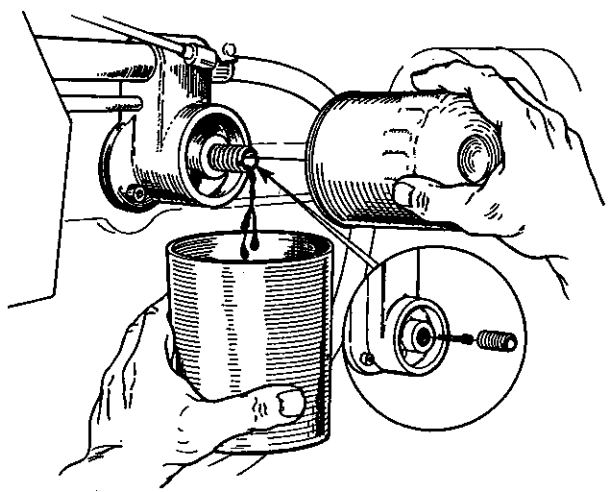


FIGURE 2

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

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.

GENERAL SPECIFICATION DATA

ENGINE – Diesel 1.8 litre	
Type	18V– – – –D
Number of cylinders	4
Bore	3.16 in (80.26 mm)
Stroke	3.5 in (88.9 mm)
Capacity	109.8 in^3 (1799 cm^3)
Injection order	1, 3, 4, 2
Valve operation	Overhead by push-rod
Compression ratio	21.47 : 1
Torque (gross)	79 lbf ft (10.92 kgf m) at 2,400 rev/min
Crankshaft	
Main journal diameter	2.1262 to 2.1270 in (53.992 to 54.012 mm)
Minimum regrind diameter	2.1162 to 2.1170 in (52.742 to 53.762 mm)
Crankpin journal diameter	1.8759 to 1.8764 in (47.64 to 47.65 mm)
Minimum regrind diameter	1.8659 to 1.8664 in (47.39 to 47.40 mm)
Crankshaft end-thrust	Taken on thrust washers at centre main bearing
Crankshaft end-float	0.001 to 0.0055 in (0.025 to 0.139 mm)
Main bearings	
Number and type	5 Steel backed lead indium
Length: Front, centre and rear	1.120 to 1.130 in (28.45 to 28.70 mm)
Intermediate	0.760 to 0.770 in (19.30 to 19.55 mm)
Diametrical clearance	0.001 to 0.0027 in (0.03 to 0.07 mm)
Undersizes	0.010 in (0.25 mm)
Connecting rods	
Type	Horizontally split big-end, plain small end
Length between centres	6.220 to 6.222 in (157.9 to 158.0 mm)
Big-end bearings	
Type	Steel backed lead indium
Length	0.775 to 0.785 in (19.68 to 19.93 mm)
Diametrical clearance	0.001 to 0.0027 in (0.03 to 0.07 mm)
Undersizes	0.010 in (0.25 mm)
Gudgeon pin	
Type	Fully floating with circlip location
Fit in piston	0.0001 to 0.0003 in (0.002 to 0.007 mm) clearance
Fit in connecting rod	0.0002 to 0.0009 in (0.02 to 0.04 mm) clearance
Diameter (outer)	0.9998 to 1.0000 in (25.39 to 25.40 mm)
Pistons	
Type	Aluminium alloy, solid skirt, with open combustion cavity
Clearances:	
Top land	0.0171 to 0.0211 in (0.43 to 0.57 mm)
Bottom land	0.0137 to 0.0172 in (0.35 to 0.44 mm)
Bottom of skirt	0.004 to 0.005 in (0.10 to 0.13 mm)
Oversizes	0.020 in and 0.040 in (0.51 mm and 1.02 mm)
Piston rings	
Compression:	
Type: Top	Chrome-faced
Second	Tapered, cast iron alloy
Width	0.0771 to 0.0781 in (1.96 to 1.98 mm)
Fitted gap: Top	0.012 to 0.017 in (0.30 to 0.43 mm)
Second	0.009 to 0.014 in (0.23 to 0.35 mm)
Ring to groove clearance: Top	0.0025 to 0.0045 in (0.06 to 0.11 mm)
Second	0.0015 to 0.0035 in (0.04 to 0.09 mm)
Oil control	
Type	Slotted scraper
Fitted gap	0.012 to 0.017 in (0.30 to 0.43 mm)
Ring to groove clearance	0.0015 to 0.0035 in (0.04 to 0.09 mm)

Camshaft	
Journal diameters: Front	1.78875 to 1.78925 in (45.43 to 45.44 mm)
Centre	1.72875 to 1.72925 in (43.91 to 43.93 mm)
Rear	1.62275 to 1.62325 in (41.22 to 41.23 mm)
Bearing liner inside diameter (reamed after fitting):	
Front	1.79025 to 1.79075 in (45.47 to 45.48 mm)
Centre	1.73025 to 1.73075 in (43.95 to 43.96 mm)
Rear	1.62425 to 1.62475 in (40.26 to 40.27 mm)
Diametrical clearance	0.001 to 0.002 in (0.02 to 0.05 mm)
End-thrust	Taken on locating plate
End-float	0.003 to 0.007 in (0.08 to 0.18 mm)
Rocker gear	
Rocker shaft diameter	0.624 to 0.625 in (15.85 to 15.87 mm)
Rocker bush inside diameter (reamed in position)	0.6255 to 0.6260 in (15.89 to 15.90 mm)
Tappets	
Type	Bucket
Outside diameter	0.8125 in (20.65 mm)
Length	1.495 to 1.505 in (37.97 to 38.23 mm)
Valves	
Seat angle: Inlet	45°
Exhaust	45°
Head diameter: Inlet	1.434 to 1.439 in (36.42 to 36.55 mm)
Exhaust	1.207 to 1.212 in (30.64 to 30.78 mm)
Stem diameter: Inlet	0.3428 to 0.3433 in (8.71 to 8.73 mm)
Exhaust	0.3422 to 0.3427 in (8.69 to 8.70 mm)
Stem to guide clearance: Inlet	0.0008 to 0.0020 in (0.02 to 0.05 mm)
Exhaust	0.0014 to 0.0026 in (0.03 to 0.06 mm)
Valve lift: Inlet and exhaust	0.384 in (9.75 mm)
Valve: Stand down	0.0445 to 0.0505 in (1.13 to 1.28 mm)
Valve guides	
Length: Inlet and exhaust	2.22 in (56.39 mm)
Outside diameter: Inlet and exhaust	0.5635 to 0.5640 in (14.31 to 14.33 mm)
Inside diameter (reamed after fitting): Inlet and exhaust	0.3441 to 0.3448 in (8.74 to 8.76 mm)
Fitted height above spring seat: Inlet and exhaust	0.55 to 0.56 in (13.9 to 14.2 mm)
Interference fit in head: Inlet and exhaust	0.0005 to 0.00175 in (0.01 to 0.04 mm)
Valve springs	
Free length	1.92 in (48.77 mm)
Fitted length	1.44 in (36.57 mm)
Load at fitted length	82 lbf (37.19 kgf, 364 N)
Load at top of lift	142 lbf (64.4 kgf, 631 N)
Number of working coils	4½
Valve timing	
Timing marks	Dimples on timing wheels, marks on flywheel
Rocker clearance: Running	0.017 in (0.43 mm) cold
Timing	0.024 in (0.61 mm)
Inlet valve: Opens	8° B.T.D.C.
Closes	42° A.B.D.C.
Exhaust valve: Opens	60° B.B.D.C.
Closes	12° A.T.D.C.
Lubrication	
System	Wet sump, pressure fed
System pressure: Running	Between idle and running speed the pressure will vary from 45-85 psi.
Oil pump	Rotor type
Oil filter	Full flow; disposable cartridge type
Oil pressure relief valve	50 lbf/in² (3.52 kgf/cm²)
Relief valve springs: Free length	3 in (76 mm)
Fitted length	2.156 in (54.77 mm)
Load at fitted length	15.5 to 16.5 lbf (7.0 to 7.4 kgf, 69 to 73 N)

FUEL SYSTEM

Fuel injection pump	C.A.V
Type	DPA.3247F180
Injection timing	18° B.T.D.C.
Fuel lift pump	A.C. Mechanical
Fuel injectors	C.A.V. Pintaux
Nozzle type	BDN.OSPC.6651
Nozzle holder type	BKB.35SD.5188
Opening pressure	135 Atm
Main fuel filter	C.A.V.
Type	FS583 6B130
Heater plugs	
Champion	AG32

TORQUE WRENCH SETTINGS

	lbf ft	kgf m	Nm
Cylinder head nuts	75	10.4	102
Rocker bracket nuts	25	3.5	34
Manifold nuts	15	2.1	20
Big-end nuts	35	4.8	47
Main bearing set screws	75	10.4	102
Flywheel bolts	40	5.5	54
Timing cover bolts: ¼ in	14	1.9	19
$\frac{5}{16}$ in	30	4.1	41
Rear plate bolts: $\frac{5}{16}$ in	20	2.8	27
$\frac{5}{16}$ in	30	4.1	41
Camshaft nut	65	9.0	88
Crankshaft bolt	75	10.4	101
Idler gear hub bolt	30	4.1	41
Cylinder side cover set screws	4	0.5	5
Rocker cover nuts	4	0.5	5
Sump bolts	6	0.8	8
Oil filter adaptor	30	4.1	41
Oil pump nuts	16	2.2	22
Oil release valve – domed nut	45	6.2	61
Starter motor bolts	35	4.8	47
Clutch to flywheel	25	3.5	34
Fuel lift pump nuts	12	1.7	16
Injector nozzle nut	50	6.9	68
Injection pump nuts	18	2.5	24
Injector nuts	12	1.7	16
Injection pump driving flange set screws	10	1.4	14
Water pump bolts	17	2.3	23
Water pump pulley set screws	18	2.5	24
Alternator pulley nut	27	3.7	36
Thermal transmitter	16	2.2	22

TRANSMISSIONS

Type SAO Westerbeke/Paragon Manual
Type SAOV with RV10S Vee Drive
Short Profile Sailing Gear
Paragon Hydraulic
Warner Hydraulic
Propeller rotation is left hand except Warner 1.91 to 1

ENGINE MOUNTS

Type	Flexible Adjustable

COOLING SYSTEM

Type	Centrifugal Pump, Thermostat
Thermostat Setting	82C (180F)
Water Capacity (Fresh)	7 Quarts

FUEL INJECTION PUMP HUB

Remove and refit 12.10.26

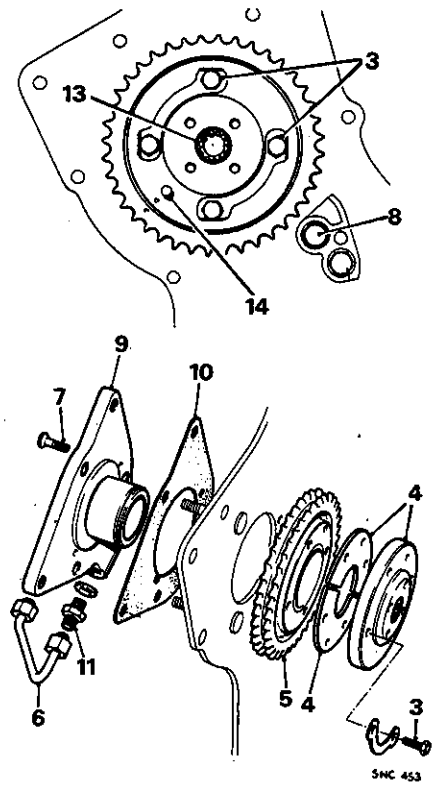
Fuel injection pump gear 1 to 5 and 12 to 18 12.10.25

Removing

1 Remove the timing chain, see 12.65.14.
2 Remove the injection pump, see 19.30.07.
3 Remove the four bolts from the injection pump driving flange.
4 Withdraw the driving flange and collect the two locating half plates.
5 Withdraw the injection pump gear.
6 Remove the injection pump drive oil feed pipe.
7 Remove the countersunk screw from the injection pump hub.
8 Remove the upper bolt from the chain vibration damper.
9 Remove the injection pump hub.
10 Remove the hub gasket.
11 Remove the oil pipe union from the hub.

Refitting

12 Reverse the procedure in 5 to 11.
13 Ensure that the circlip is correctly located in its groove in the splined bore of the injection pump driving flange.
14 Fit one of the locating half plates to its groove in the injection pump hub, and position it by inserting a $\frac{7}{32}$ in (5.5 mm) peg through the timing hole in the locating plate and into the timing hole in the gear.
15 Fit the second locating half plate and then fit the driving flange, engaging the driving flange timing hole with the peg.
16 Fit and tighten the driving flange bolts to 10 lbf ft (1.4 kgf m, 14 Nm); ensure that the peg can be withdrawn from the timing hole and lock the bolts with their lockplates.
17 Fit the timing chain, see 12.65.14,
18 Fit the injection pump, see 19.30.07.



OIL PUMP DRIVE SHAFT

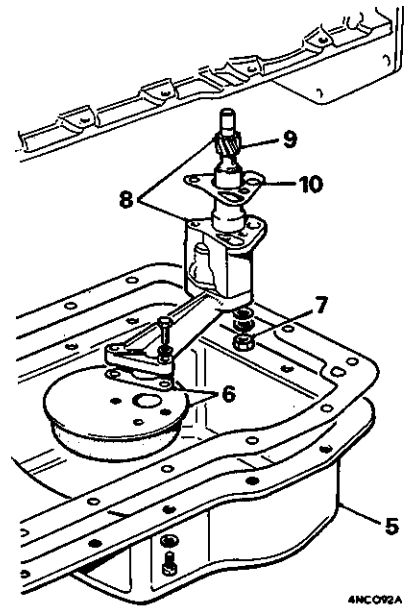
Remove and refit 12.10.30
Oil pump 12.60.26

Removing

1 NA
2 Drain the sump.
3 Disconnect the oil cooler pipe from the LH side of the crankcase.
4 Release the oil pipe clip from the gearbox mounting plate and move the oil pipe aside.
5 Remove the sump.
6 Remove the oil strainer and gasket.
7 Remove the three oil pump securing nuts.
8 Withdraw the oil pump and its drive shaft.
9 Withdraw the drive shaft from the oil pump.
10 Remove the oil pump gasket.

Refitting

11 Reverse the procedure in 1 to 10, tightening the oil pump securing nuts to 16 lbf ft (2.2 kgf m, 22 Nm).



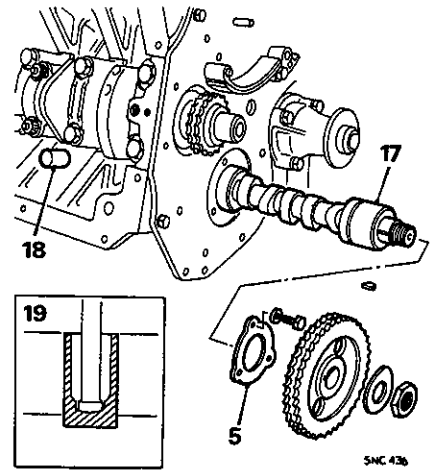
TAPPETS

Remove and refit 12.29.57
Camshaft 1 to 17 and 20 to 32 12.13.02

Service tool: 18G 694

Removing

1 NA
2 Drain the sump.
3 NA
4 Remove the timing chain and the camshaft gear, see 12.65.12.
5 Remove the camshaft locating plate.
6 Remove the fuel lift pump.
7 Remove the rocker cover and gasket.
8 Slacken evenly and remove the eight nuts retaining the rocker shaft brackets.
9 Remove the locking plate from the rocker shaft rear bracket.
10 Remove the rocker shaft assembly and the shim under each centre bracket.
11 Withdraw the push-rods and retain their order for refitting.

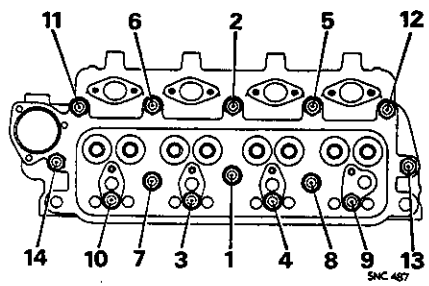


12 Lay the engine on its side with the cylinder head slightly downwards.
13 Withdraw the dipstick.
14 Remove the sump.
15 Remove the oil pump and its drive shaft.
16 Rotate the camshaft to position all the tappets away from their cams.
17 Withdraw the camshaft.
18 Withdraw the tappets and retain their order for refitting.

Refitting

19 Fit the tappets with their open ends towards the cylinder head.
20 Fit the camshaft.
21 Fit the oil pump and its drive shaft, tightening the retaining nuts to 16 lbf ft (2.2 kgf m, 22 Nm).
22 Fit the sump.
23 Fit the dipstick.
24 Place the engine in an upright position.
25 Fit the push-rods.
26 Fit the rocker shaft assembly, noting:
- a Ensure that the shim is fitted under both centre brackets.
- b Fit the locking plate to the rear bracket.
- c Tighten the cylinder head nuts to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown, using tool 18G 694 to reach the centre row.
- d Tighten the rocker bracket nuts to 25 lbf ft (3.5 kgf m, 34 Nm).

27 Fit the fuel lift pump.
28 Fit the camshaft locating plate.
29 Fit the camshaft gear, timing chain, and timing gear cover, see 12.65.12.
NOTE: Do not leave the crankshaft pulley in position.
30 Adjust the valve rocker clearance, see 12.29.48.
31 Fit the rocker cover and its gasket.
32 NA
33 Run the engine for a minimum of 5 miles, 8 km or 15 mins and on return slacken the cylinder head nuts approximately ⅛ of a turn in the sequence shown before retightening them to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown. Check the valve rocker clearances.



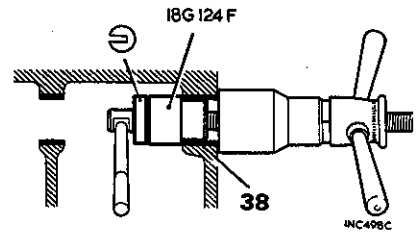
CAMSHAFT BEARINGS

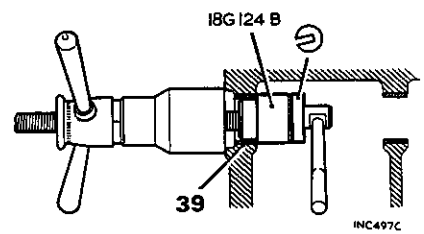
Remove and refit **12.13.13**

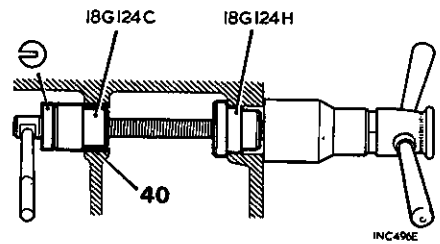
Service tools: 18G 55 A, 18G 123 A, 18G 123 B, 18G 123 E, 18G 123 F, 18G 123 L, 18G 123 T, 18G 123 AB, 18G 123 AC, 18G 123 AD, 18G 124 A, 18G 124 B, 18G 124 C, 18G 124 F, 18G 124 H, 18G 134, 18G 134 CQ, 18G 284, 18G 284 A, 18G 284 AC, 18G 694, 18G 1108, 18G 1195

Removing

1 NA
2 Drain the sump.
3 NA
4 Remove the
5 Remove the flywheel.
6 Remove the crankshaft rear oil seal retainer.
7 Remove the bolts securing the gearbox adaptor plate and pull the adaptor plate off its two locating dowels.
8 Remove the two adaptor plate gaskets.
9 Remove the alternator.
10 Remove the high-pressure pipes from the injectors and pump.
11 Remove the injection pump drive oil feed pipe.
12 Remove the timing chain and the camshaft gear, see 12.65.12.
13 Remove the camshaft locating plate.
14 Remove the chain vibration damper.
15 Remove the bolt securing each front mounting bracket to the crankcase.
16 Remove the two bolts securing the front mounting plate to the crankcase.
17 Lift off the front mounting plate, complete with injection pump, front mounting brackets, chain tensioner stop-pin, and chain tensioner shoe.
18 Remove the fuel lift pump.
19 Withdraw the dipstick.
20 Release the dipstick tube from the cylinder head nut and withdraw the tube from the crankcase.
21 Disconnect and remove No. 1 heater plug.
22 Remove the rocker cover and gasket.
23 Remove the rocker shaft assembly, noting the locking plate on the rear bracket and the shim under each centre bracket.
24 Withdraw the push-rods, retaining their order for refitting.
25 Remove the cylinder head nuts.
26 Lift off the cylinder head.
NOTE: The combustion chamber inserts may drop out of the cylinder head as it is lifted; they **MUST** be refitted in their original positions.
27 Remove the cylinder head gasket.
28 Lay the engine on its side with the cylinder head face slightly downwards.
29 Remove the sump.
30 Remove the oil pump and its drive shaft.
31 Remove the big-end bearing caps and bearing halves.
32 Remove the main bearing caps and bearing halves, using tools 18G 284, 18G 284 A, and 18G 284 AC.
33 Lift out the crankshaft and remove the bearing and thrust washer halves.
34 Withdraw the connecting rod and piston assemblies.
35 Rotate the camshaft to position all the tappets away from their cams.
36 Withdraw the camshaft.
37 Withdraw the tappets and retain their order for refitting.
38 Remove the camshaft front bearing liner, using tools 18G 124 A and 18G 124 F as shown.
39 Remove the camshaft rear bearing liner, using tools 18G 124 A and 18G 124 B as shown.
40 Remove the camshaft centre bearing liner, using tools 18G 124 A, 18G 124 C, and 18G 124 H as shown.







Refitting

NOTE: When fitting each new bearing liner ensure that its oil holes are lined up with those in the crankcase.

41 Fit a new camshaft front bearing liner, using tools 18G 124 A and 18G 124 F as shown.

42 Fit a new camshaft rear bearing liner, using tools 18G 124 A and 18G 124 B as shown.

43 Fit a new camshaft centre bearing liner, using tools 18G 124 A, 18G 124 C, and 18G 124 H as shown.

NOTE: Lightly lubricate the arbor before assembling the cutters and pilots to it.

Feed the reamers very slowly and keep the cutters dry.

Keep the cutter flutes clear of swarf during reaming.

44 Ream the front and rear bearing liners using tools 18G 123 A, 18G 123 L, 18G 123 E (in position '10' on the arbor), 18G 123 AB, 18G 123 B (in position '6' on the arbor), and 18G 123 AC as shown.

45 Ream the centre bearing liner, using tools 18G 123 A, 18G 123 T, 18G 123 F (in position '9' on the arbor), and 18G 123 AD as shown.

46 Ensure that the oil holes of the bearing liners are still lined up with those in the crankcase.

47 Thoroughly clean all swarf from the cylinder block and crankcase.

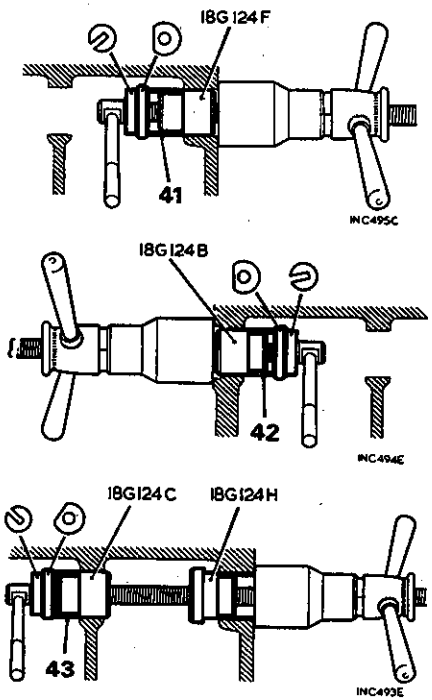
48 Fit the tappets with their open ends towards the cylinder head.

49 Fit the camshaft.

50 Fit the connecting rod and piston assemblies with the combustion cavities on the R.H. side of the engine, using tool 18G 55 A.

51 Fit the crankshaft main bearings, and thrust washers (grooved side towards the crankshaft) to the crankcase.

52 Fit the main bearing caps, noting:
- a Caps Nos. 2 and 4 are each stamped with their number.
- b Fit caps 2, 3 and 4 with the cast word 'FRONT' towards the front of the engine.
- c Using a straight-edge, align the front and rear bearing caps with the front and rear faces of the crankcase.



- d Tighten the main bearing bolts to 75 lbf ft (10.4 kgf m, 102 Nm).

53 Check the crankshaft end-float against the figure in DATA, and fit alternative thrust washers if necessary.

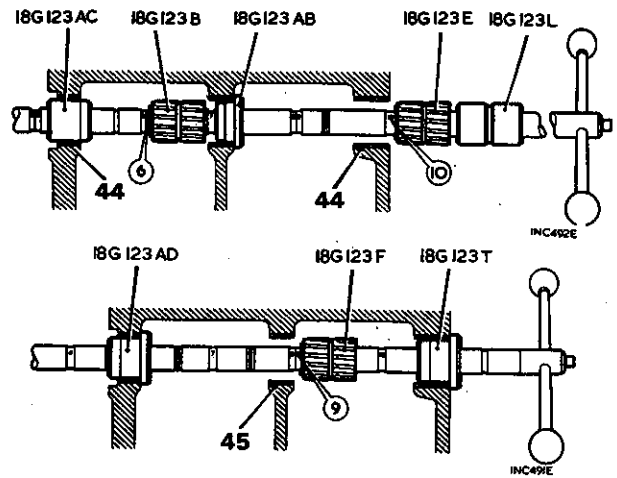
54 Fit the big-end bearings and caps, ensuring that the connecting rod and cap markings are aligned.

55 Tighten the big-end nuts to 35 lbf ft (4.8 kgf m, 47 Nm).

56 Fit the oil pump and its drive shaft, tightening the retaining nuts to 16 lbf ft (2.2 kgf m, 22 Nm).

57 Soak the cork sealing strips in engine oil, then fit them to the front and rear main bearing caps.

58 Fit the sump.



59 Position the front mounting plate assembly on the engine and locate it by fitting the camshaft locating plate bolts and the chain tensioner retaining screw.

60 Fit the two bolts to secure the mounting plate to the crankcase.

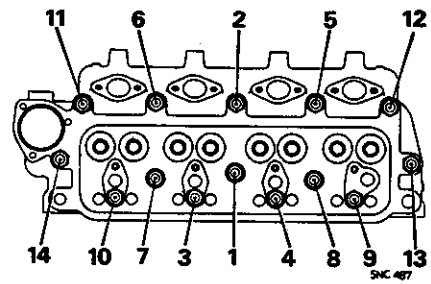
61 Fit the two bolts to secure both front mounting brackets to the crankcase.

62 Fit the chain vibration damper.

63 Fit the camshaft locating plate.

64 Fit the camshaft gear, timing chain, and timing gear cover, see 12.65.12.
NOTE: Do not leave the crankshaft pulley in position.

65 Reverse the procedure in 18 to 27, noting:
- a Fit the cylinder head gasket with the face marked 'TOP' uppermost.
- b Ensure that the combustion chamber inserts are fitted flush with the cylinder head face.
- c Leave the cylinder head nuts finger tight until the rocker shaft assembly has been fitted.
- d Tighten the cylinder head nuts to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown, using tool 18G 694 to reach the centre row.



- e Tighten the rocker bracket nuts to 25 lbf ft (3.5 kgf m, 34 Nm).
- f Adjust the valve rocker clearance, see 12.29.48.
- g Apply Loctite to the bottom of the dipstick tube.

66 Reverse the procedure in 4 to 11, noting:
- a Use tools 18G 134 and 18G 134 CQ to fit the new rear oil seal.
- b Use tool 18G 1108 to protect the seal when fitting the adaptor plate.
- c Tighten the adaptor plate bolts to 30 lbf ft (4.2 kgf m, 41 Nm).
NOTE: Fit the two longer bolts in the two top holes.

d Tighten the oil seal retainer bolts to 20 lbf ft (2.8 kgf m, 27 Nm).
e Tighten the flywheel bolts to 40 lbf ft (5.5 kgf m, 54 Nm).

67 Fit the engine.

68 Run the engine for a minimum of 15 mins and on return slacken the cylinder head nuts approximately ¼ of a turn in the sequence shown before retightening them to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown. Check the valve rocker clearances.

DATA

Camshaft bearing inside diameters (reamed in position):	
Front	1.79025 to 1.79075 in (45.47 to 45.48 mm)
Centre	1.73025 to 1.73075 in (43.95 to 43.96 mm)
Rear	1.62425 to 1.62475 in (40.26 to 40.27 mm)
Crankshaft end-float	0.001 to 0.0055 in (0.03 to 0.14 mm)
Thrust washer thicknesses	0.0885 to 0.0905 in (2.25 to 2.30 mm), 0.091 to 0.093 in (2.31 to 2.36 mm) and 0.0935 to 0.0955 in (2.37 to 2.43 mm)

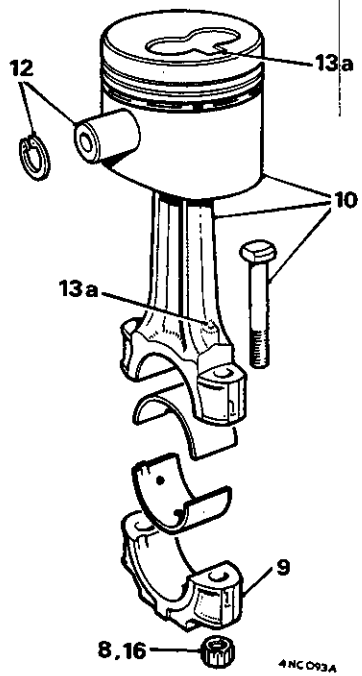
CONNECTING RODS AND PISTONS

Remove and refit 12.17.01

Service tool: 18G 55 A

Removing

1 NA
2 Drain the sump.
3 Drain the cooling system.
4 Remove the cylinder head gasket, see 12.29.02.
5 Disconnect the oil cooler pipe from the L.H. side of the crankcase.
6 Release the oil cooler pipe clip from the gearbox mounting plate and move the oil pipe aside.
7 Remove the sump.
8 Remove the big-end nuts.
9 Remove the big-end caps and bearing halves.
10 Withdraw the connecting rod and piston assemblies.
11 Mark the pistons and connecting rods for reassembly.
12 Remove the circlips and the gudgeon pins and separate the pistons from the connecting rods.



Refitting

13 Reverse the procedure in 8 to 12, noting:
a Assemble the pistons to the connecting rods with the combustion cavities on the oil hole side of the connecting rods.
b If new piston rings are being used ensure that the ring gaps are correct, see 12.17.10.
c Use tool 18G 55 A to compress the piston rings.
d Fit the connecting rod and piston assemblies with the combustion cavities on the R.H. side of the engine.
14 If the connecting rods or piston(s) have been renewed, rotate the crankshaft and measure the amount by which each piston stands proud of the cylinder block face at T.D.C.
15 If piston stand-proud is outside the limits given in DATA, fit suitable alternative piston(s) from the range available.
NOTE: It is not necessary for the pistons in an engine to be of the same height grade.
16 Tighten the big-end nuts to 35 lbf ft (4.8 kgf m, 47 Nm).
17 Reverse the procedure in 1 to 7.

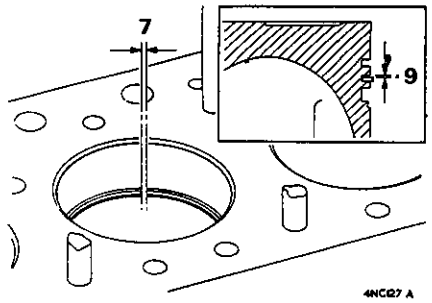
DATA

Piston stand-proud	0.013 to 0.021 in (0.33 to 0.53 mm)

CONNECTING RODS AND PISTONS

Overhaul 12.17.10
Connecting rods 1 to 5 and 10 to 12
Pistons 1 to 9 and 12

1 **NA**
2 Drain the sump.
3 Drain the cooling system.
4 Remove the cylinder head gasket, see 12.29.02.
5 Remove and separate the connecting rods and pistons, see 12.17.01.
6 Remove the rings from the pistons.
7 Check the piston ring gaps, in an unworn part of the cylinder bore, against the figures in DATA. If necessary, increase the gap(s) by filing the end of the ring(s).
8 Fit the piston rings, noting:
  a Fit the oil control ring expander spring first, ensuring that the latch pin enters both ends of the spring.
  b Fit the oil control ring with its gap 180° from the expander latch pin.
  c Fit the second ring with the word 'TOP' uppermost.



9 Check the piston ring groove clearance against the figures in DATA.
10 Check the gudgeon pin clearance in the connecting rod bush (see DATA). If the clearance is excessive, renew the bush, noting:
  a Position the bush with its hole and oil grooves towards the top.
  b Finish-ream the bush to the dimension given in DATA.
11 Ensure that the connecting rod alignment is within the figure given in DATA.
12 Reverse the procedure in 1 to 5.

DATA

Connecting rod alignment	
Maximum out-of-parallel of big-end and little-end	0.004 in per inch (0.004 cm per cm) effective mandrel length
Connecting rod bush	
Clearance on gudgeon pin	0.0002 to 0.0009 in (0.02 to 0.04 mm)
Inside diameter (reamed after fitting)	1.0002 to 1.0007 in (25.41 to 25.42 mm)
Piston rings	
Fitted gap:	
Top compression	0.012 to 0.017 in (0.30 to 0.43 mm)
Second compression	0.009 to 0.014 in (0.23 to 0.35 mm)
Oil control	0.012 to 0.017 in (0.30 to 0.43 mm)
Ring to groove clearance:	
Top compression	0.0025 to 0.0045 in (0.06 to 0.11 mm)
Second compression	0.0015 to 0.0035 in (0.04 to 0.09 mm)
Oil control	0.0015 to 0.0035 in (0.04 to 0.09 mm)

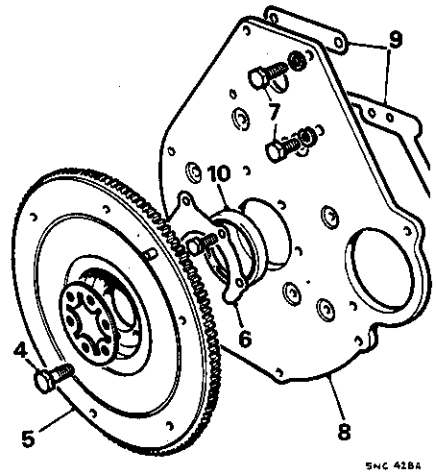
CRANKSHAFT REAR OIL SEAL

Remove and refit 12.21.20
Gearbox adaptor plate 12.53.03
Flywheel 1 to 8 and 15 12.53.07

Service tools: 18G 134, 18G 134 CQ, 18G 1108

Removing

1 **NA**
2 Remove the gearbox.
3 Remove the **damper**
4 Remove the flywheel securing bolts.
5 Lift off the flywheel.
6 Remove the oil seal retainer.
7 Remove the bolts securing the gearbox adaptor plate.
8 Pull the adaptor plate off its two locating dowels.
9 Remove the two adaptor plate gaskets.
10 Remove the oil seal from the adaptor plate.



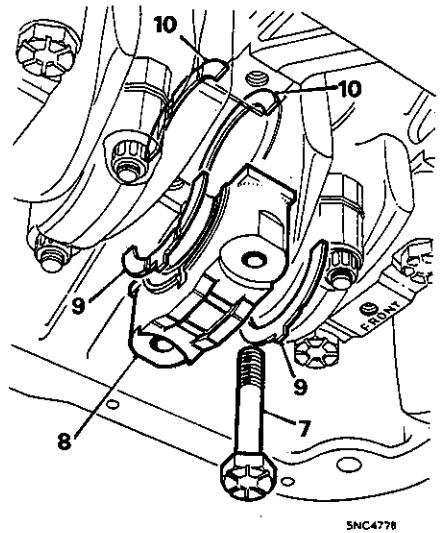
Refitting

11 Fit the new oil seal flush with the rear face of the adaptor plate, using tools 18G 134 and 18G 134 CQ.
12 Reverse the procedure in 1 to 10, noting:
  a Use tool 18G 1108 to protect the oil seal when fitting the adaptor plate.
  b Tighten the adaptor plate bolts to 30 lbf ft (4.2 kgf m, 41 Nm).
  NOTE: Fit the two longer bolts in the two top holes.
  c Tighten the oil seal retainer bolts to 20 lbf ft (2.8 kgf m, 27 Nm).
  d Tighten the flywheel bolts to 40 lbf ft (5.5 kgf m, 54 Nm).

CRANKSHAFT END-FLOAT

Check and adjust 12.21.26

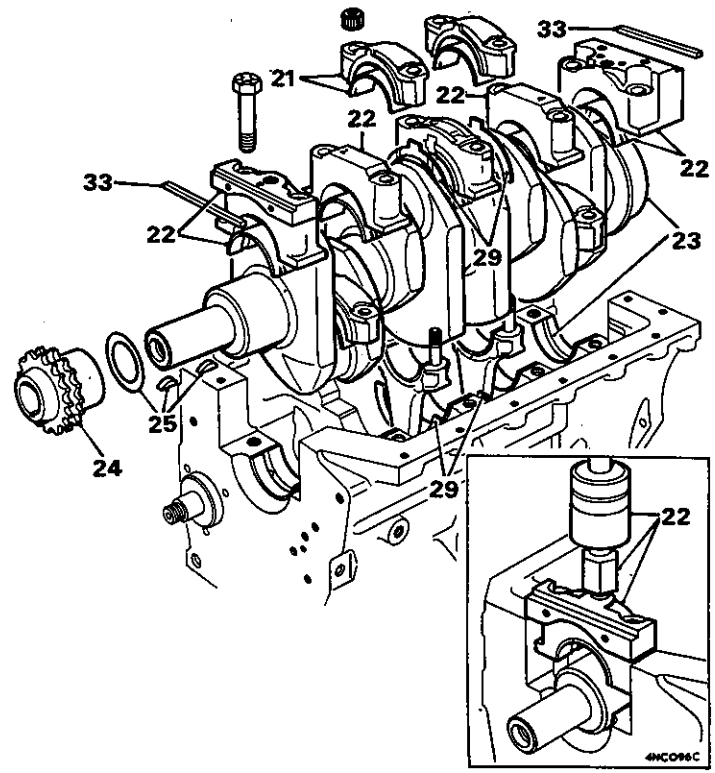
1 NA
2 Check the crankshaft end-float using a dial gauge against the crankshaft pulley bolt. If end-float is outside the limits given in DATA, change the thrust washers as described in the following paragraphs.
3 Drain the sump.
4 Release the oil pipe clip from the gearbox mounting plate and move the oil pipe aside.
5 Remove the sump.
6 Remove the oil pump and its drive shaft.
7 Remove the two bolts from the centre main bearing cap.
8 Remove the centre main bearing cap.
9 Remove the bottom halves of the thrust washers from the cap or crankshaft.
10 Slide the upper halves of the thrust washers around the crank and remove them.
11 Select a set of thrust washers to give the correct end-float (see DATA).
12 Reverse the procedure in 3 to 10, noting:
   a Fit the thrust washers with their grooved sides towards the crankshaft.
   b Fit the main bearing cap with the 'FRONT' mark towards the front of the engine.



   c Tighten the main bearing cap bolts to 75 lbf ft (10.4 kgf m, 102 Nm).
   d Ensure that the end-float is correct after tightening the main bearing cap bolts.
   e Tighten the oil pump securing nuts to 16 lbf ft (2.2 kgf m, 22 Nm).

DATA

Crankshaft end-float	0.001 to 0.0055 in (0.03 to 0.14 mm)
Thrust washer thicknesses	0.0885 to 0.0905 in (2.25 to 2.30 mm) 0.091 to 0.093 in (2.31 to 2.36 mm) and 0.0935 to 0.0955 in (2.37 to 2.43 mm)



CRANKSHAFT

Remove and refit 12.21.33

Service tools: 18G 134, 18G 134 CQ, 18G 284, 18G 284 AC, 18G 1108, 18G 1195

Removing

1 NA
2 Drain the sump.
3 Remove the engine.
4 Remove the damper
5 Remove the flywheel.
6 Remove the crankshaft rear oil seal retainer.
7 Remove the bolts securing the gearbox adaptor plate and pull the adaptor plate off its two locating dowels.
8 Remove the two adaptor plate gaskets.
9 Remove the alternator.
10 Disconnect the high-pressure pipes from the injectors.
11 Remove the injection pump drive oil feed pipe.
12 Remove the timing chain and the camshaft gear, see 12.65.12.
13 Remove the camshaft locating plate.
14 Remove the chain vibration damper.
15 Remove the bolt securing each front mounting bracket to the crankcase.
16 Remove the two bolts securing the front mounting plate to the crankcase.
17 Lift off the front mounting plate, complete with injection pump, front mounting brackets, chain tensioner stop-pin, and chain tensioner shoe.
18 Withdraw the dipstick.
19 Remove the sump.

20 Remove the oil pump and its drive shaft.
21 Remove the big-end bearing caps and bearing halves.
NOTE: If the crankshaft has to be rotated, be careful not to apply any force which could cause damage if a piston touches a valve.
22 Remove the main bearing caps and bearing halves, using tools 18G 284 and 18G 284 AC on the front and rear caps if necessary.
23 Lift out the crankshaft and remove the bearing and thrust washer halves.
24 Remove the crankshaft gear.
25 Remove the crankshaft keys and lift off the shim(s).

Refitting
26 Fit the shim(s), keys and gear to the crankshaft.
27 Fit the crankshaft, main bearings, and thrust washers (grooved side towards the crankshaft) to the crankcase.
28 Fit the main bearing caps, noting:
- a Caps Nos. 2 and 4 are each stamped with their number.
- b Fit caps 2, 3, and 4 with the cast word 'FRONT' towards the front of the engine.
- c Using a straight-edge, align the front and rear bearing caps with the front and rear faces of the crankcase.
- d Tighten the main bearing bolts to 75 lbf ft (10.4 kgf m, 102 Nm).

29 Check the crankshaft end-float against the figure in DATA, and fit alternative thrust washers if necessary.
30 Fit the big-end bearings and caps, ensuring that the connecting rod and cap markings are aligned.
31 Tighten the big-end nuts to 35 lbf ft (4.8 kgf m, 47 Nm).
32 Fit the oil pump and its drive shaft, tightening the retaining nuts to 16 lbf ft (2.2 kgf m, 22 Nm).
33 Soak the cork sealing strips in engine oil, then fit them to the front and rear main bearing caps.
34 Fit the sump.
35 Fit the dipstick.
36 Position the front mounting plate assembly on the engine and locate it by fitting the camshaft locating plate bolts and the chain tensioner retaining screw.
37 Fit the two bolts to secure the front mountig plate to the crankcase.
38 Fit the two bolts to secure both front mounting plate to the crankcase.
39 Fit the chain vibration damper.
40 Fit the camshaft locating plate.
41 Fit the camshaft gear, timing chain, and timing gear cover, see 12.65.12.
NOTE: Do not leave the crankshaft pulley in position.
42 Reverse the procedure in 4 to 11, noting:
- a Use tools 18G 134 and 18G 134 CQ to fit the new rear oil seal.
- b Use tool 18G 1108 to protect the seal when fitting the adaptor plate.
- c Tighten the adaptor plate bolts to 30 lbf ft (4.2 kgf m, 41 Nm).
NOTE: Fit the two longer bolts in the two top holes.
- d Tighten the oil seal retainer bolts to 20 lbf ft (2.8 kgf m, 27 Nm).
- e Tighten the flywheel bolts to 40 lbf ft (5.5 kgf m, 54 Nm).

DATA

Main journal diameter	2.1262 to 2.1270 in (54.01 to 54.03 mm)
Crankpin diameter	1.8759 to 1.8764 in (47.64 to 47.66 mm)
Clearance in bearings (journals and crankpin)	0.001 to 0.0027 in (0.03 to 0.07 mm)
Undersizes (journals and crankpins)	0.010 in (0.25 mm)
Crankshaft end-float	0.001 to 0.0055 in (0.03 to 0.14 mm)
Thrust washer thicknesses	0.0885 to 0.0905 in (2.25 to 2.30 mm), 0.091 to 0.093 in (2.31 to 2.36 mm) and 0.0935 to 0.0955 in (2.37 to 2.43 mm)

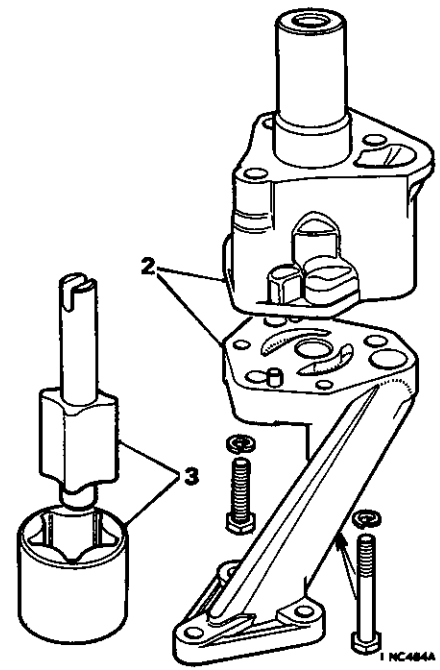
OIL PUMP

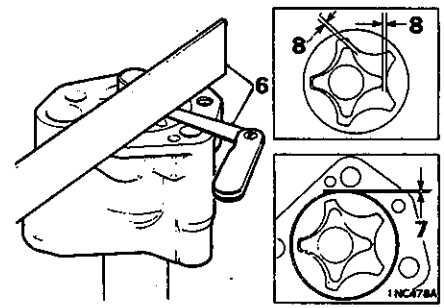
Overhaul **12.60.32**

Dismantling
1 Remove the oil pump, see 12.10.30.
2 Remove the cover from the pump body.
NOTE: The cover is located by two dowels.
3 Remove the rotors from the pump body.

Inspection
4 Clean the components.
5 Fit the rotors to the pump body with the chamfered end of the outer rotor at the closed end of the body.
6 Check the end-float of the inner and outer rotors.
7 Check the outer rotor to pump body diametrical clearance.
8 Check the rotor lobe clearances.
9 Renew the pump assembly if the clearances or end-floats in 6 to 8 exceed the figure given in DATA.

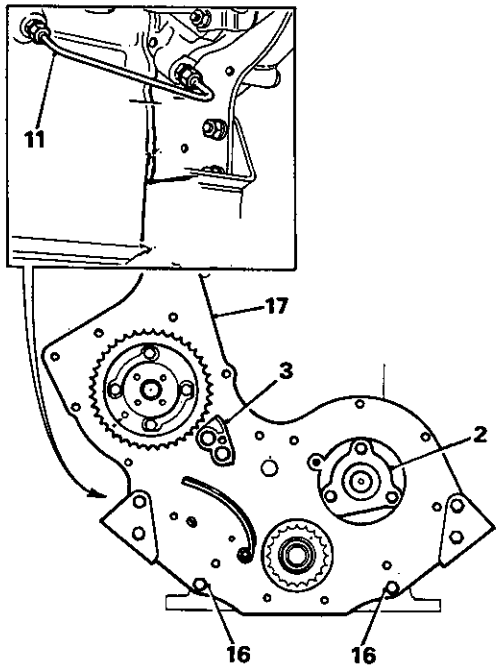
Reassembling
10 Lubricate all components with clean engine oil.
11 Reverse the procedure in 1 to 3, ensuring that the outer rotor is fitted with its chamfer at the closed end of the body.

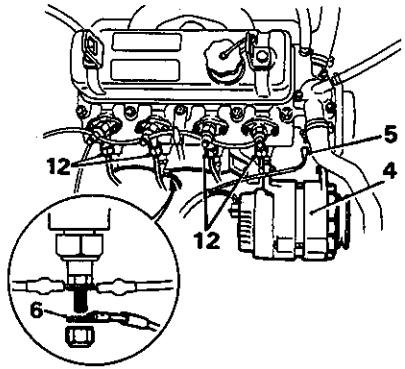




DATA

Outer rotor end-float	0.005 in (0.13 mm)
Inner rotor end-float	0.005 in (0.13 mm)
Outer rotor to pump body diametrical clearance	0.010 in (0.25 mm)
Rotor lobe clearance	0.006 in (0.15 mm)





ENGINE FRONT MOUNTING PLATE GASKET

Remove and refit 12.25.10

Removing

1 Remove the timing chain and the camshaft gear, see 12.65.12.
2 Remove the camshaft locating plate.
3 Remove the chain vibration damper.
4 Remove the alternator.
5 Disconnect the thermal transmitter and move the wiring harness aside.
6 Disconnect the supply lead from the heater plugs.
7 Disconnect the fuel return pipe from the injection pump.
8 Disconnect the fuel supply pipe from the injection pump.
9 Disconnect the stop control cable from the injection pump.
10 Disconnect the throttle cable from the injection pump lever.
11 Remove the injection pump drive oil feed pipe.
12 Disconnect the high-pressure pipes from the injectors.
13 Remove the two bolts and washers securing the front mounting plate to the crankcase.
14 Lift off the front mounting plate, complete with injection pump, front mountings, chain tensioner stop-pin, and chain tensioner shoe.
15
16 NA
17
18 Remove the front mounting plate gasket.

Refitting

19 Fit the front mounting plate gasket.
20 Position the front mounting plate assembly on the engine and locate it by fitting the camshaft locating plate bolts and the chain tensioner retaining screw.
21 Reverse the procedure in 1 to 16, noting:
   a With the throttle cable connected ensure that the injection pump throttle lever is operated through its full range of movement by the throttle pedal.
   b When the stop control cable is connected, ensure that the stop control has sufficient travel
22 Bleed the fuel system, see 19.50.07.

CYLINDER LINERS

Remove and refit 12.25.26

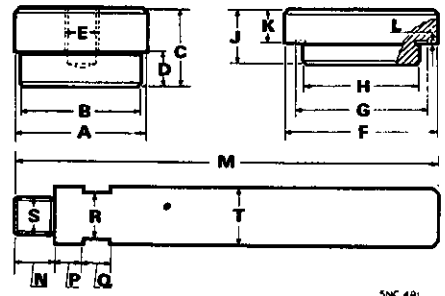
NOTE: If the condition of the cylinder bores is such that they cannot be cleaned up to accept oversize pistons, dry cylinder liners can be fitted (see DATA).

Pilots should be made to the dimensions given, from case-hardening steel and case-hardened.

The pilot extension should be made from 55-ton hardening and tempering steel, hardened in oil, and then tempered at 550°C (1020°F).

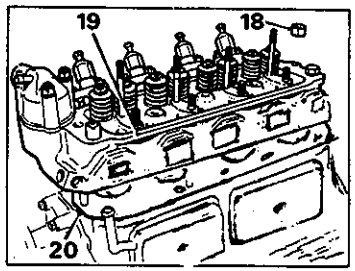
DATA

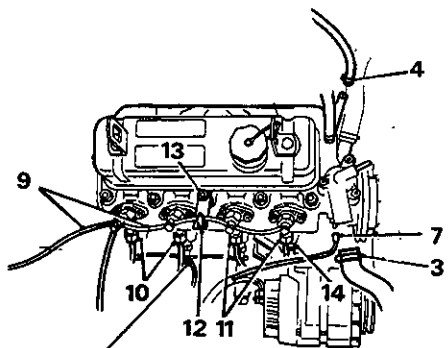
Cylinder block	
Bore: Standard	3.1595 to 3.1606 in (80.25 to 80.28 mm)
Oversize maximum (without cylinder liner)	0.040 in (1.02 mm)
To accept cylinder liner	3.2615 to 3.2620 in (82.84 to 82.86 mm)
Cylinder liners	
Outside diameter	3.2645 to 3.2660 in (82.92 to 82.96 mm)
Bore: Standard (machined after fitting)	3.1595 to 3.1606 in (80.25 to 80.28 mm)
Oversize (maximum)	0.020 in (0.51 mm)

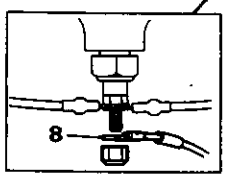


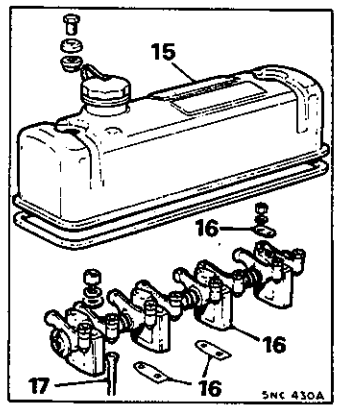
Pilots

Pressing-out pilot:	A.	3.25 $^{-0.005}_{-0.000}$ in (82.55 $^{-0.13}_{-0.00}$ mm)
	B.	3.157 $^{-0.000}_{-0.005}$ in (80.19 $^{+0.00}_{-0.13}$ mm)
	C.	1.75 in (44.45 mm)
	D.	0.75 in (19 mm)
	E.	¾ in B.S.W. thread
Pressing-in pilot:	F.	3.625 in (92.07 mm)
	G.	3.312 in (84.14 mm)
	H.	3.133 $^{+0.000}_{-0.005}$ in (79.58 $^{+0.00}_{-0.13}$ mm)
	J.	1.25 in (31.75 mm)
	K.	0.75 in (19 mm)
	L.	0.015 in (0.38 mm)
Pilot extension:	M.	14.50 in (36.83 cm)
	N.	0.875 in (22.22 mm)
	P.	0.625 in (15.87 mm)
	Q.	0.625 in (15.87 mm)
	R.	Two flats 1 in (25.4 mm) across
	S.	¾ in B.S.W. thread
	T.	1.25 in (31.75 mm)









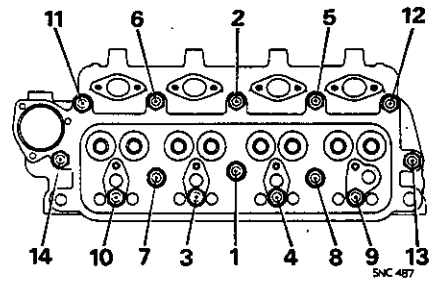
CYLINDER HEAD GASKET

Remove and refit **12.29.02**

Service tool: 18G 694

Removing

1 NA
2 Drain the cooling system.
3 Disconnect the hoses from the water outlet elbow.
4 Disconnect the breather hose from the cylinder side cover.
5
6 NA
7 Disconnect the lead from the thermal transmitter.
8 Disconnect the supply lead from the heater plugs.
9 Disconnect the spill rail and return pipe from the injectors and lay the spill rail aside.
10 Remove Nos. 3 and 4 injector pipes.
11 Remove Nos. 1 and 2 injector pipes.
12 Remove the oil dipstick.
13 Release the dipstick tube from the cylinder head nut and withdraw the tube from the crankcase.
14 Disconnect and remove No. 1 heater plug.
15 Remove the rocker cover and gasket.
16 Remove the rocker shaft assembly, noting the locking plate on the rear bracket and the shim under each centre bracket.
17 Withdraw the push-rods, retaining their order for refitting.
18 Remove the cylinder head nuts.
19 Lift off the cylinder head.
NOTE: The combustion chamber inserts may drop out of the cylinder head as it is lifted; they **MUST** be refitted in their original positions.
20 Remove the cylinder head gasket.



Refitting

21 Reverse the procedure in 1 to 20, noting:
- a Fit the cylinder head gasket with the face marked 'TOP' uppermost.
- b Ensure that the combustion chamber inserts are fitted flush with the cylinder head face.
- c Leave the cylinder head nuts finger tight until the rocker shaft assembly has been fitted.
- d Tighten the cylinder head nuts to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown, using tool 18G 694 to reach the centre row.
- e Tighten the rocker brackets nuts to 25 lbf ft (3.5 kgf m, 34 Nm).
- f Adjust the valve rocker clearance, see 12.29.48.
- g Bleed the fuel system, see 19.50.05.
- h Apply Loctite to the bottom of the dipstick tube.

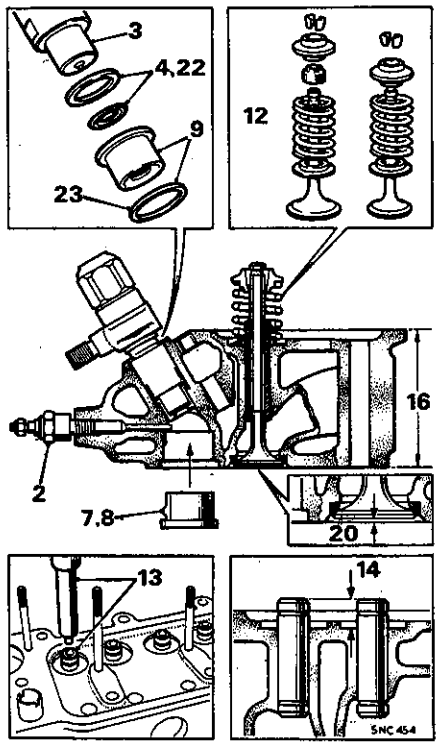
22 Run the engine for a minimum of 15 mins and on return slacken the cylinder head nuts approximately ⅛ of a turn in the sequence shown before retightening them to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown. Check the valve rocker clearances.

CYLINDER HEAD

Overhaul 12.29.19

Service tools: 18G 27, 18G 29, 18G 45, 18G 167, 18G 167 A, 18G 167 B, 18G 167 C, 18G 174, 18G 174 A, 18G 174 B, 18G 174 C, 18G 174 D, 18G 284, 18G 284 P

1 Remove the cylinder head gasket, see 12.29.02.
2 Remove the three remaining heater plugs from the cylinder head.
3 Remove the injectors, using tools 18G 284, and 18G 284 P.
4 Remove the two sealing washers from each injector position.
5 Remove the heater hose from the cylinder head.
6 Remove the manifolds and gasket.
7 Mark the combustion chamber inserts for refitting in their original positions.
8 Remove the combustion chamber inserts, if necessary using a soft drift through the injector holes.
9 Push out the injector heat shields and their sealing washers.
10 Remove the water outlet elbow and its gasket.
11 Lift out the thermostat.
12 Remove the valves and their components, using tool 18G 45.
NOTE: Seals are fitted to the inlet valve guides.
13 If the valve guides are worn (see DATA), press them out in the direction of the valve seats.
14 To fit new valve guides, press them in from the top of the cylinder head until they protrude by the amount stated in DATA. Protrusion is measured from the top of the valve guide to the bottom of the counter bore for the valve spring.
15 Ream new valve guides to the size given in DATA.
16 Check the cylinder head face for flatness and, if necessary, reface the cylinder head without reducing its depth below the figure given in DATA.
NOTE: The combustion chamber inserts must be faced level with the cylinder head.



17 If necessary, reface the valves to the angle given in DATA, removing the minimum of material.
18 If necessary, recut the valve seats in the cylinder head, using the following tools:
a 18G 27 Handle.
b 18G 174 D Pilot.
c 18G 174 A Glaze breaker for inlet seats.
d 18G 174 Cutter for inlet seats.
e 18G 174 B Top narrowing cutter for inlet seats.
f 18G 174 C Bottom narrowing cutter for inlet seats.
g 18G 167 A Glaze breaker for exhaust seats.
h 18G 167 Cutter for exhaust seats.
j 18G 167 B Top narrowing cutter for exhaust seats.
k 18G 167 C Bottom narrowing cutter for exhaust seats.
19 Lap the valves onto their seats, using tool 18G 29.
20 Check the valve stand-down against the figure in DATA. If stand-down is excessive, even with a new valve fitted, renew the valve seat insert(s) and cut their seats.
21 Renew the valve springs if they are not as specified in DATA.
22 Renew the sealing washers for the injectors.
23 Renew the sealing washers for the injector heat shields.
24 Reverse the procedure in 1 to 12.

DATA

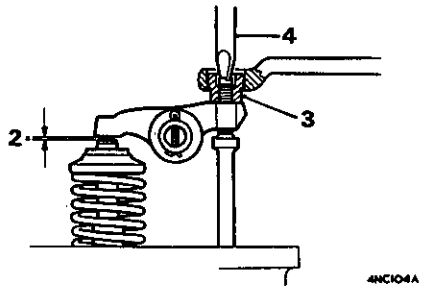
Cylinder head	
Depth after refacing	3.16 in (80.26 mm) minimum
Valve guides	
Inside diameter (reamed after fitting)	0.3441 to 0.3448 in (8.74 to 8.76 mm)
Protrusion (from bottom of counterbore)	0.550 to 0.560 in (13.97 to 14.22 mm)
Valves	
Seat angle	45°
Stand-down	0.0445 to 0.0505 in (1.13 to 1.28 mm)
Stem diameter: Inlet	0.3428 to 0.3422 in (8.71 to 8.73 mm)
Exhaust	0.3422 to 0.3427 in (8.69 to 8.70 mm)
Valve springs	
Free length (approximate)	1 ⅞ in (48.75 mm)
Load when compressed to 1.44 in (36.58 mm)	82 lbf (37.195 kgf, 364N)

VALVE CLEARANCE

Check and adjust 12.29.48

Checking

1 Remove the rocker cover and gasket.
2 Check, and if necessary adjust, the clearance between the rocker arms and valve stems against the figure in DATA, working in the following order:
Check:
No. 1 valve with No. 8 valve fully open.
„ 3 „ „ „ 6 „ „ „
„ 5 „ „ „ 4 „ „ „
„ 2 „ „ „ 7 „ „ „
„ 8 „ „ „ 1 „ „ „
„ 6 „ „ „ 3 „ „ „
„ 4 „ „ „ 5 „ „ „
„ 7 „ „ „ 2 „ „ „



Adjusting

3 Slacken the locknut.
4 Rotate the adjusting screw to set the clearance.
5 Hold the adjusting screw against rotation and tighten the locknut.
6 Fit the rocker cover and gasket.

DATA

Valve rocker clearance (cold) . . . . . 0.017 in (0.43 mm)

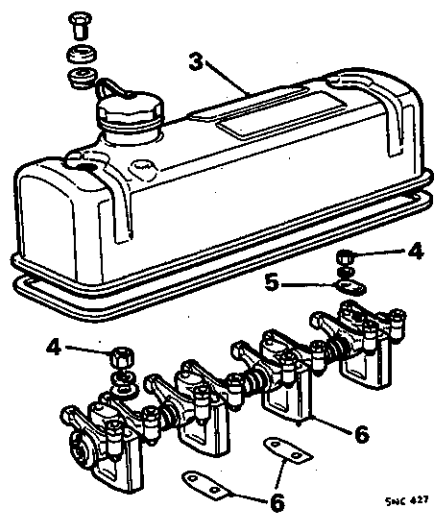
ROCKER SHAFT ASSEMBLY

Remove and refit 12.29.54

Service tool: 18G 694

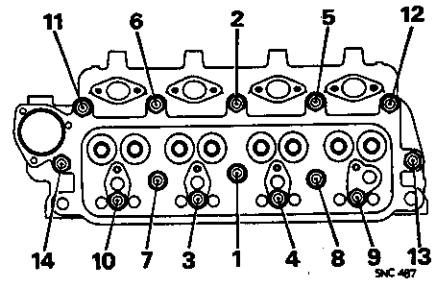
Removing

1 NA
2 Drain the cooling system.
3 Remove the rocker cover and gasket.
4 Slacken evenly and remove the eight nuts retaining the rocker shaft brackets.
5 Remove the locking plate from the rocker shaft rear bracket.
6 Remove the rocker shaft assembly and the shim under each centre bracket.



Refitting

7 Reverse the procedure in 1 to 6, noting:
a Tighten the cylinder head nuts to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown, using tool 18G 694 to reach the centre row.
b Tighten the rocker bracket nuts to 25 lbf ft (3.5 kgf m, 34 Nm).
c Adjust the valve rocker clearance, see 12.29.48.
8 Run the engine for a minimum of 15 mins and on return slacken the cylinder head nuts approximately ¼ of a turn in the sequence shown before retightening them to 75 lbf ft (10.4 kgf m, 102 Nm) in the sequence shown. Check the valve rocker clearances.



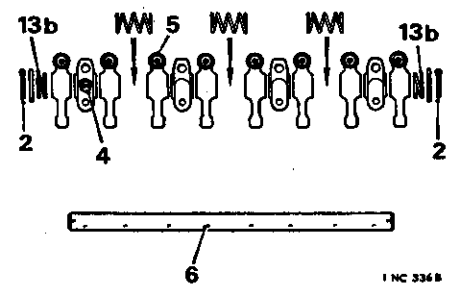
ROCKER SHAFT ASSEMBLY

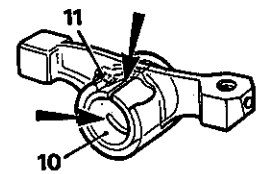
Overhaul 12.29.55

Service tools: 18G 226, 18G 226 A

Dismantling

1 Remove the rocker shaft, see 12.29.54.
2 Remove the split pin from each end of the rocker shaft.
3 Slide the components off the shaft.
4 Remove the locating screw from the rocker shaft rear bracket and remove the bracket.
5 Remove the adjuster screws.





Inspection

6 Clean the oilways of the rocker shaft.
7 Examine the rocker to valve contact faces for wear, and renew the rocker(s) if necessary.
8 Renew the rocker adjusting screws if they are worn or if the threads are damaged.
9 Press out worn rocker bushes, using tools 18G 226 and 18G 226 A.

Reassembling

10 Press in new rocker bushes, using tools 18G 226 and 18G 226 A, and ensuring that the bush joint and oil groove are in the positions shown.
11 Drill a hole in the bush, through the hole in the top of the rocker barrel, using a 1.95 mm drill.
12 Burnish-ream the bush to the dimension given in DATA.
13 Reverse the procedure in 1 to 5, noting:
a The locating screw engages the larger of the two diametrically opposite holes.
b The double-coil spring washers are fitted inside the plain washer at each end of the shaft.

DATA

Rocker shaft diameter . . . . . 0.624 to 0.625 in (15.85 to 15.87 mm)
Rocker bush inside diameter (reamed in position) . . . . . 0.6255 to 0.6260 in (15.89 to 15.90 mm)

OIL PRESSURE RELIEF VALVE

Remove and refit 12.60.56

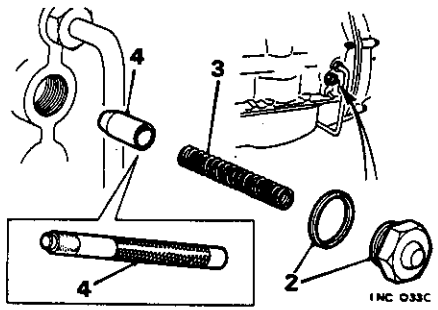
Service tool: 18G 69

Removing

1 NA
2 Remove the valve cap washer from the rear of the L.H. side of the crankcase.
3 Withdraw the spring from the crankcase.
4 Withdraw the valve plunger, using tool 18G 69.

Refitting

5 If the valve plunger is pitted, or is not seating correctly, lap the plunger onto its seating, using tool 18G 69. If lapping fails to correct the fault, renew the plunger and ensure that the new plunger seats correctly.
6 Renew the spring if it is not as specified in DATA.
7 Reverse the procedure in 1 to 4.



DATA

Relief valve spring:	
Free length	3 in (76 mm)
Load when compressed to 2.16 in (54.77 mm)	15.5 to 16.5 lbf (7.0 to 7.4 kgf, 69 to 73 N)

TIMING GEAR COVER OIL SEAL

Remove and refit 12.65.05

Service tools: 18G 98 A, 18G 134, 18G 134 BD

Removing

1 NA
2 Slacken the alternator mounting bolts and remove the fan belt.
3 Remove the water pump pulley.
4 Remove the crankshaft pulley, using tool 18G 98 A.
5 Remove the timing gear cover and gasket.
6 Remove the oil seal from the timing cover.

Refitting

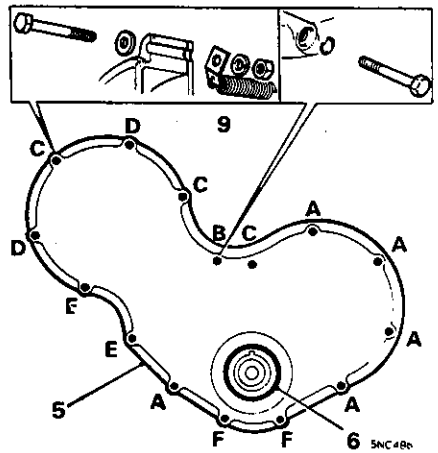
7 Fit the new oil seal to the timing gear cover, using tools 18G 134 and 18G 134 BD.
8 Fit the timing gear cover and gasket, using the crankshaft pulley to centralize the oil seal on the crankshaft.
9 Fit the timing gear cover bolts in the following illustrated positions.

Position	Bolt size
A	$\frac{5}{16}$ in x 1¾ in (44.5 mm) long
B	$\frac{5}{16}$ in x 2 in (50 mm) long

NOTE: An 'O' ring is fitted on this bolt.

C	$\frac{5}{16}$ in x 2 in (50 mm) long
D	$\frac{5}{16}$ in x 2¼ in (57 mm) long
E	¼ in x 1¾ in (44.5 mm) long
F	¼ in x 1¾ in (31.75 mm) long

10 Reverse the procedure in 1 to 4, tightening the crankshaft pulley bolt to 75 lbf ft (10.4 kgf m, 102 Nm).



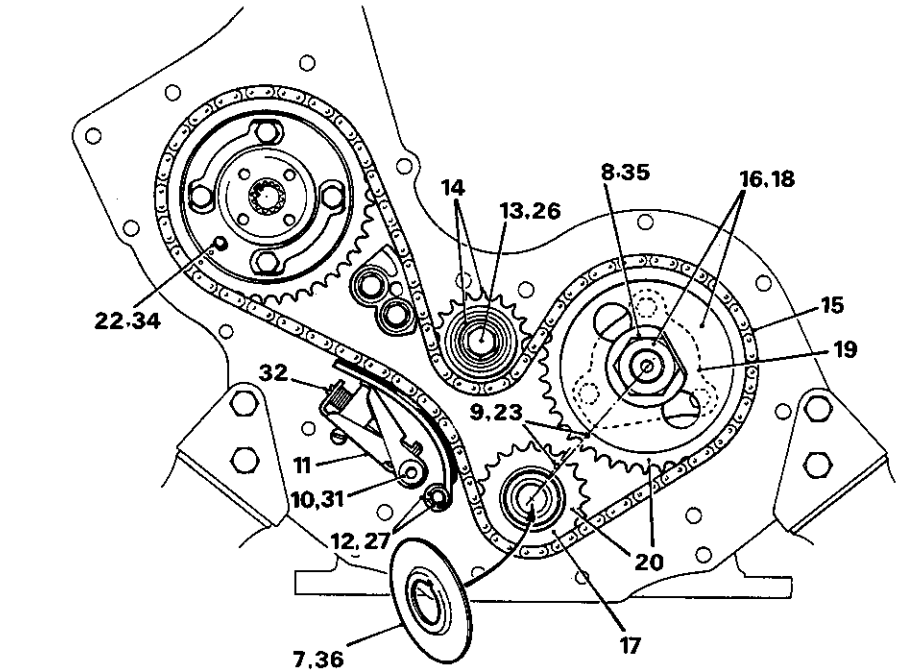
TIMING CHAIN AND GEARS

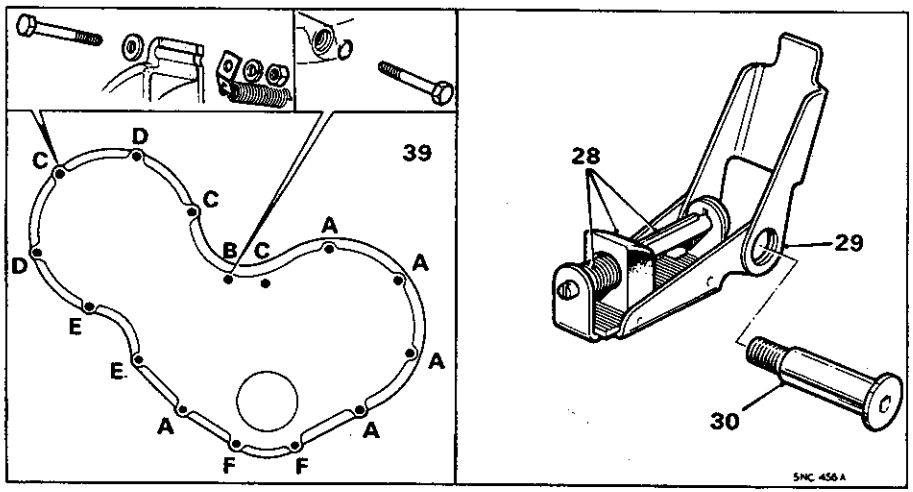
Remove and refit 12.65.12
Timing chain tensioner 1 to 14, 16 to 19, 34 to 40, and 43 to 47 12.65.28
Timing chain 1 to 14, 16 to 22, 29 to 41, and 43 to 47 12.65.14

Service tools: 18G 98 A, 18G 134, 18G 134 BD

Removing

1 NA
2 Drain the cooling system.
3 Slacken the alternator mounting bolts and remove the fan belt.
4 Remove the water pump pulley.
5 Remove the crankshaft pulley, using tool 18G 98 A.
6 Remove the timing gear cover and gasket.
7 Remove the crankshaft oil thrower.
8 If the camshaft gear is to be removed, slacken the camshaft nut using tool 18G 98 A.
9 Rotate the crankshaft until the timing marks are positioned as shown.
10 Hold the chain tensioner and chain together by hand and remove the tensioner retainer screw.
11 Lift away the chain tensioner.





12 If the chain tensioner shoe is to be renewed, remove the circlip from the pivot pin and lift off the shoe.
13 Remove the idler gear bolt.
14 Lift away the idler gear and its hub.
NOTE: The idler gear hub is located by a roll-pin dowel.
15 Remove the timing chain.
16 Remove the camshaft nut and gear.
17 Remove the crankshaft gear.

Refitting

18 Fit the camshaft gear and secure it with its nut.
19 Check the camshaft end-float against the figure in DATA. If end-float is excessive, remove the camshaft gear and renew the camshaft locating plate.
20 Fit the camshaft gear and crankshaft gear to their shafts.
21 Place a straight-edge across the tooth face of the gears and check their alignment; the crankshaft gear face should be rearward by the amount stated in DATA. If necessary, add or remove shims behind the crankshaft gear to set the alignment as near as possible to the DATA figure.
22 Position the injection pump gear with its timing hole at approximately 7 o'clock and insert a $\frac{7}{32}$ in (5.5 mm) peg through the hole to engage the hole in the engine front plate.
23 Position the camshaft gear and crankshaft gear with their timing marks in the positions shown.
24 Fit the timing chain and place the idler gear (without its hub) in position on the chain.
25 Adjust the position of the chain, without rotating the gears, to permit the idler gear hub to be fitted without chain slack between the idler and its adjacent gears.
NOTE: The idler gear hub is located by a roll-pin dowel.
26 Fit the idler gear bolt and tighten it to 30 lbf ft (4.1 kgf m, 41 Nm).
27 Fit the chain tensioner shoe and circlip to the pivot pin.
28 Fit the spring, pressure block, and centre pin to the chain tensioner body. Compress the spring and rotate the centre pin 180° to retain the compressed position.
29 Fit the pressure lever to the chain tensioner with the lever legs forward of the tensioner body, i.e. the tensioner body will contact the engine front plate when fitted.
30 Fit the retaining screw through the pressure lever and tensioner body.
31 Fit the compressed chain tensioner and tighten its retaining screw.
32 Rotate the centre pin 180° to release the tensioner.
33 Ensure that the timing marks are still correctly positioned.
34 Remove the peg from the injection pump gear.
35 Tighten the camshaft nut to 65 lbf ft (9 kgf m, 88 Nm).
36 Fit the crankshaft oil thrower with its dished side towards the gear.
37 Renew the timing gear cover oil seal, using tool 18G 134 and 18G 134 BD.
38 Fit the timing gear cover and gasket, using the crankshaft pulley to centralize the oil seal on the crankshaft.
39 Fit the timing cover bolts in the following illustrated positions.

Position	Bolt size
A	$\frac{5}{16}$ in x 1¾ in (44.5 mm) long
B	$\frac{5}{16}$ in x 2 in (50 mm) long

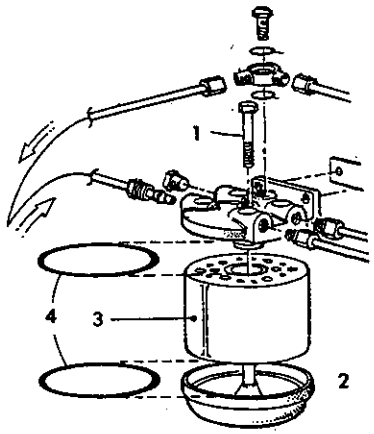
NOTE: An 'O' ring is fitted on this bolt

C	$\frac{5}{16}$ in x 2 in (50 mm) long
D	$\frac{5}{16}$ in x 2¼ in (57 mm) long
E	¼ in x 1¾ in (44.5 mm) long
F	¼ in x 1¼ in (31.75 mm) long

40 Reverse the procedure in 1 to 5, tightening the crankshaft pulley bolt to 75 lbf ft (10.4 kgf m, 102 Nm).

DATA

Camshaft end-float	0.003 to 0.007 in (0.08 to 0.18 mm)
Timing gear alignment	Crankshaft gear 0.005 in (0.13 mm) rearward of camshaft gear



FUEL FILTER ELEMENT

Remove and refit 19.25.07

Removing

1 Support the filter base and unscrew the centre bolt in the filter head.
2 Detach the filter base.
3 Remove the element, using a twisting motion.
4 Remove the seals from the filter base and filter head.

Refitting

5 Clean the filter base.
6 Reverse the procedure in 1 to 4, using a new element and seals.
7 Bleed the fuel system, see 19.50.07.

HYDRAULIC TYPE ONLY

INJECTION PUMP

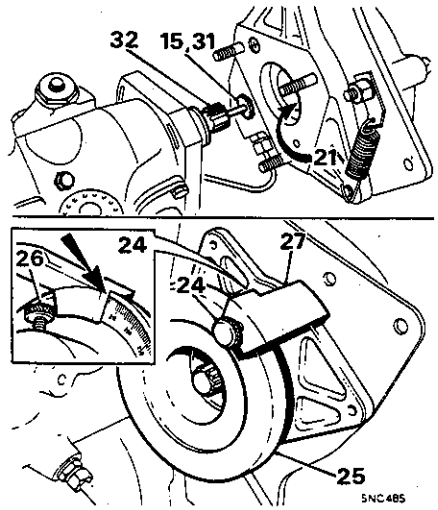
Remove and refit 19.30.07

Timing – check and adjust 1 to 16 and 21 to 38 19.30.01

Service tools: AMK 9990, MS 67 A

Removing

1 Slacken the alternator mounting bolts and remove the fan belt.
2 Remove the alternator.
3 Disconnect the fuel return pipe from the injection pump.
4 Disconnect the fuel supply pipe from the injection pump.
5 Disconnect the stop control cable from the injection pump.
6 Disconnect the throttle cable from the injection pump
7 Disconnect the lead from the **fuel pressure switch**
8 Remove the injection pump stop lever return spring.
9 Remove Nos. 3 and 4 injector pipes.
10 Remove Nos. 1 and 2 injector pipes.
11 Remove the three nuts and washers securing the injection pump and withdraw the injection pump from the engine.
NOTE: The lower nut also secures the anchor bracket for the stop lever return spring.
12 Withdraw the injection pump torsion bar.
13 Remove the injection pump gasket.
14 – 20 **NA**



Refitting

21 Rotate the crankshaft until the master spline in the injection pump drive is in the 12 o'clock position.
22 Insert timing pin AMK 9990 into the timing hole in the gearbox adaptor plate. The hole is situated below the sump flange on the RH side.
23 Maintain a light pressure on the timing pin and rotate the crankshaft in the normal direction of rotation until the timing pin engages the timing hole in the flywheel. The master spline in the injection pump drive should now be in the 8 o'clock position when viewed from the rear.
24 Assemble the long scribing guide of tool MS 67A to the tool body, set it on the 204° position and lock it with its knurled screw.
25 Insert the assembled tool into the injection pump position on the engine, engaging the injection pump drive splines.
26 Slide the body of the tool along its centre bar until the body engages the injection pump drive gear hub. Lock the centre bar with the knurled screw.
27 Apply gentle clockwise (viewed from the rear) pressure to the tool and check that the scribed line (timing mark) on the drive gear hub lines up with the scribing guide of the tool. If necessary, scribe a new mark.
28 Remove tool MS 67A.
29 Remove timing pin AMK 9990.
30 Fit the injection pump gasket to the drive gear hub.
31 Fit the torsion bar into the drive flange on the engine.
32 Position the injection pump drive shaft so that its master spline lines up with that on the drive flange.
33 Fit the injection pump drive shaft over the end of the torsion bar and **VERY GENTLY** engage the drive shaft splines with the drive flange splines.
34 Push the injection pump as far into position as possible and fit the spring anchor bracket, washers, and nuts.
35 Progressively tighten the three nuts to pull the injection pump fully into position, ensuring that the timing marks on the pump and drive flange are aligned.
36 Reverse the procedure in 1 to **10**
37 Bleed the fuel system, see 19.50.07.

LIFT PUMP

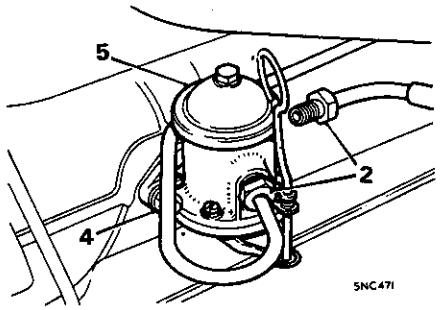
Remove and refit **19.45.09**

Removing

1 NA
2 Disconnect the two pipes from the lift pump.
3 Plug the supply pipe from the fuel tank.
4 Remove the securing nuts and washers.
5 Remove the lift pump and gasket.

Refitting

6 Reverse the procedure in 1 to 5.
7 Bleed the fuel system, see 19.50.07.

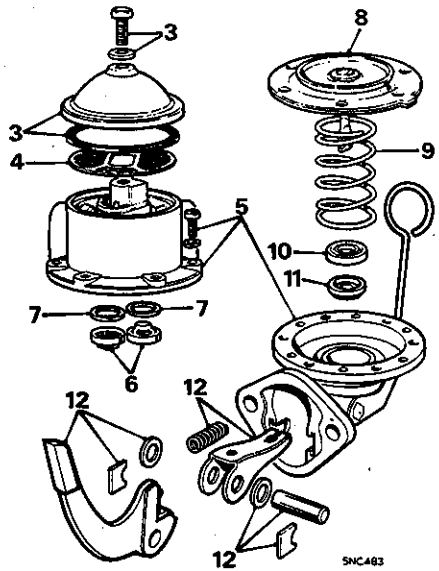


LIFT PUMP

Overhaul **19.45.16**

Dismantling

1 Remove the lift pump, see 19.45.09.
2 Scribe a reassembly mark across the body joint flanges.
3 Remove the domed cover and sealing ring.
4 Remove the filter.
5 Remove the securing screws and separate the top and bottom halves of the pump.
6 If the valves require renewing, lever them out carefully.
7 Remove the valve gaskets.
8 Press the diaphragm downwards, rotate it through 90° and withdraw it.
9 Lift out the diaphragm spring.
10 If the diaphragm rod seal is to be renewed, carefully withdraw the seal retainer.
11 Lift out the seal.
12 If the rocker arm pin or linkage is to be renewed, secure the rocker arm in a vice and tap the face of the pump mounting flange to dislodge the rocker arm pin and its components.



Reassembling

13 Renew any components which are worn or damaged.
14 Reverse the procedure in 1 to 12, noting:
   a If the diaphragm spring is renewed, ensure that the new spring is of the same colour as the original.
   b If the valves are renewed, ensure that they are fitted to operate in the correct directions and staked in.

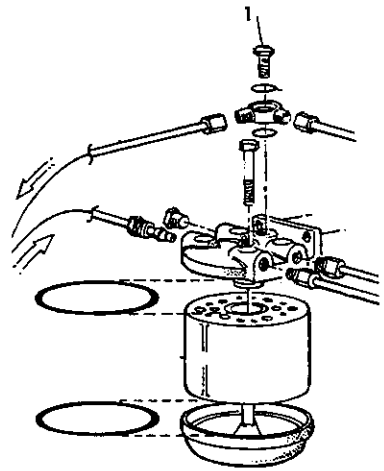
NOTE: The inlet port is indicated by an arrow on the pump body.

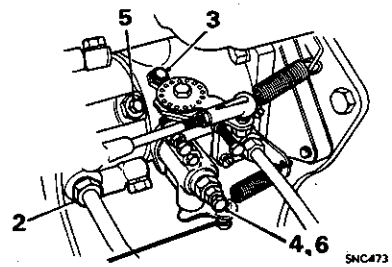
FUEL SYSTEM

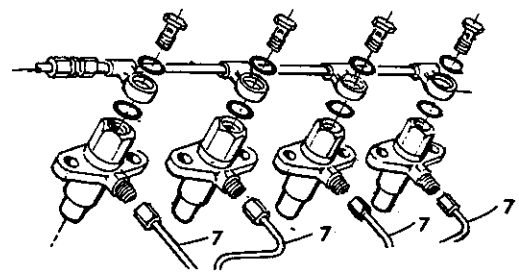
Bleeding **19.50.07**

NOTE: After renewing the fuel filter element it will only be necessary to bleed the fuel filter as described in 1 and 2, provided that the engine has not been cranked while the filter is dismantled.

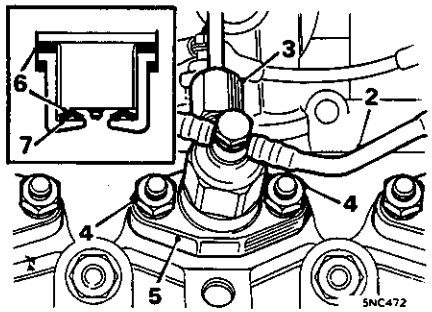
1. Slacken the bleed screw at banjo fitting in the fuel filter head. Operate the lift pump by means of its priming lever and, when the fuel flowing from the screw is free of air bubbles, tighten the screw.
2. Slacken the union nut at the injection pump end of the fuel feed pipe. Operate the lift pump, and when the fuel flowing from the union is free of air bubbles, tighten the nut.
3. Slacken the air bleed screw on the fuel pressure switch adapter. Operate the lift pump and when the fuel flowing from the bleed screw is free of air bubbles, tighten the screw.
4. Slacken the air bleed screw on the injection pump governor housing. Operate the lift pump until the fuel flowing from the bleed screw is free of air bubbles, leave the bleed screw slack.
5. Slacken the air bleed screw on the injection pump high-pressure banjo bolt. Operate the starter motor with full throttle in the full run position and when the fuel flowing from the high-pressure bleed screw is free of air bubbles, tighten the bleed screw.
6. Continue cranking the engine with the starter motor to expel any air trapped in the governor and when the fuel flowing from the governor housing bleed screw is free of air bubbles, tighten the bleed screw.
7. Slacken the union nut at the injector end of any two high-pressure pipes. Operate the starter motor with throttle in the full run position and when the fuel flowing from both pipes is free of air bubbles, tighten both union nuts.







8. Start the engine and allow it to run until it is firing on all cylinders or repeat step 7 if necessary.
9. Note:
   If difficulty in starting occurs, the sea water intake valve must be closed to prevent filling of the exhaust system with sea water. Immediately when the engine starts, open the sea water intake valve to prevent damage to the pump and engine.



INJECTORS

Remove and refit **19.60.01**

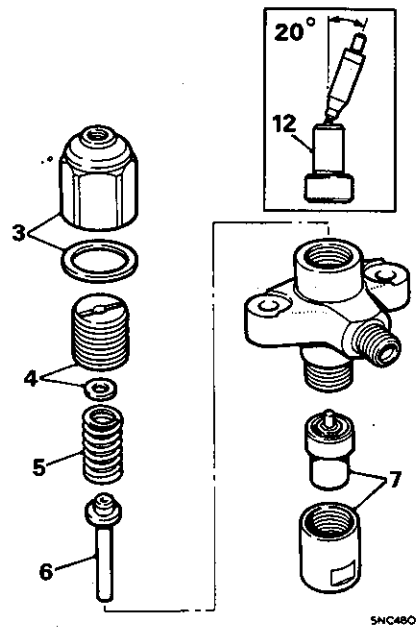
Service tools: 18G 284, 18G 284 P

Removing

1 NA
2 Disconnect the spill rail from the injectors.
3 Disconnect the high-pressure pipes from the injectors.
4 Remove the nuts and washers securing the injectors.
5 Withdraw the injectors, using tools 18G 284 and 18G 284 P if necessary.
6 Remove the two sealing washers from each injector position.

Refitting

7 Fit two new sealing washers to each injector position, fitting the smaller washer as shown.
8 Reverse the procedure in 1 to 5, tightening the injector securing nuts to 12 lbf ft (1.7 kgf m, 16 Nm).
9 If more than two injectors have been removed, crank the engine with the starter motor and bleed at least two of the high-pressure pipes.



INJECTORS

Overhaul **19.60.08**

Service tools: 18G 109 A, 18G 109 B, 18G 109 E, 18G 210, 18G 388, 18G 487

1 Remove the injectors, see 19.60.01.
2 Mount the injector in tool 18G 388.
3 Remove the cap nut and sealing washer.
4 Remove the spring cap and shim.
5 Remove the spring.
6 Lift out the spindle.
7 Remove the nozzle nut and nozzle, using tool 18G 210.
8 Renew the spring if it shows any sign of weakness or distortion.
9 Renew the spindle if it is not perfectly straight.
10 Clean the nozzle and valve, using kit 18G 487.
11 Reverse-flush the nozzle, using tools 18G 109 A and 18G 109 E.
12 Renew the nozzle assembly if the pintle clearance allows an angle of more than 20° when checked as shown.
13 If necessary, restore the nozzle and valve seats to the angles given in DATA.
14 Check the needle lift against the figure in DATA.
15 Reverse the procedure in 2 to 7, tightening the nozzle nut to 50 lbf ft (6.9 kgf m, 68 Nm).
16 Test and set the injectors to the specification given in DATA, using tools 18G 109 A and 18G 109 B.
17 Fit the injectors, see 19.60.01.

DATA

Auxiliary hole diameter	0.2 mm
Needle lift	0.70 to 0.75 mm
Nozzle seat angle	59° 0′
Valve seat angle	60° 0′

Testing

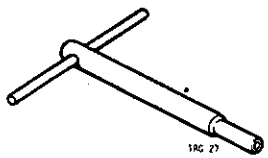
TEST		NOZZLE SET TO OPEN AT	ADAPTOR (18G 109 B) SET TO OPEN AT	STROKES PER MINUTE	REQUIREMENTS
Spray	Auxiliary	135 Atm	220 Atm	60	Spray free of distortions. Slight core permissible.
	Main	135 Atm	220 Atm	140	Spray free of distortions. Slight core permissible.
Seat tightness		100 Atm	–	–	Dry nozzle after 10 seconds at 90 Atm pressure
Back-leakage		160 to 170 Atm	–	–	Initial pressure 160 Atm. Time for pressure drop from 150 to 100 Atm to be between 6 and 140 seconds
Final setting		135 Atm*	–	–	–

* Add 5 Atm when setting new injectors or after fitting new springs.

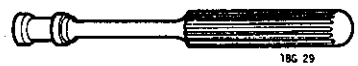
SERVICE TOOLS

All Service Tools mentioned in this Manual must be obtained direct from the tool manufacturers:

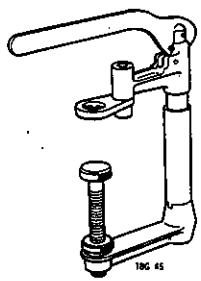
Messrs V L Churchill & Co. Ltd.
PO Box No. 3
London Road
Daventry
Northants NN11 4NF
England



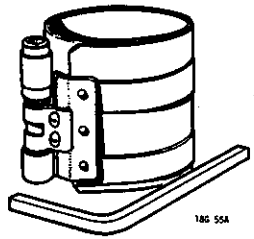
18G 27 Valve Seat Cutter and Pilot Handle



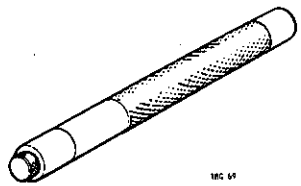
18G 29 Valve Grinding-in Tool



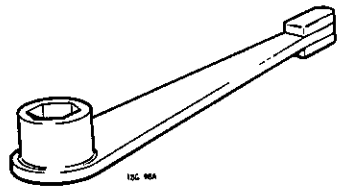
18G 45 Valve Spring Compressor



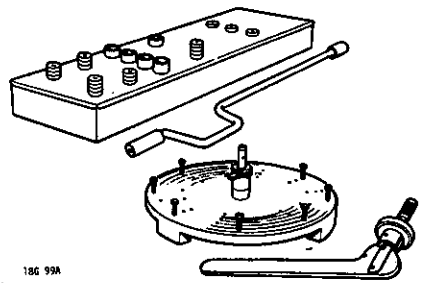
18G 55A Piston Ring Compressor



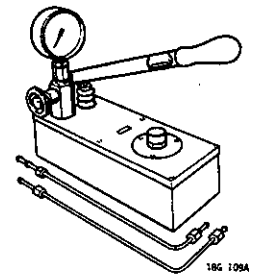
18G 69 Oil Pump Release Valve Grinding-in Tool



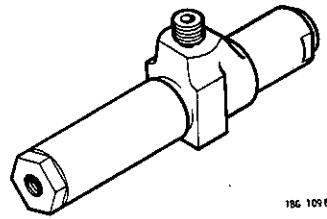
18G 98 A Starting Nut Handle



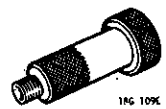
18G 99 A Clutch Assembly Gauging Fixture



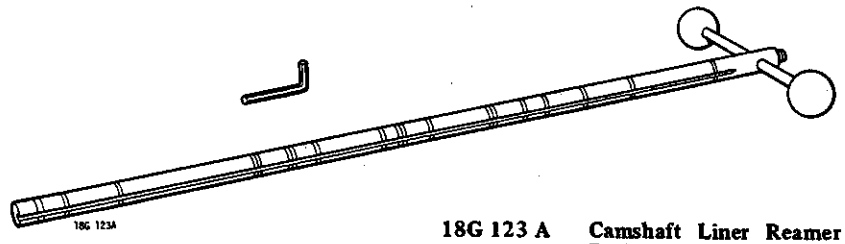
18G 109 A Injector Nozzle Testing Machine



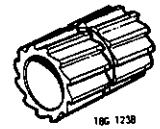
18G 109 B Injector Nozzle Testing – Adaptor



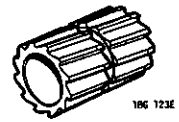
18G 109 E Injector Nozzle Reverse Flush – Adaptor



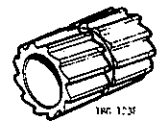
18G 123 A Camshaft Liner Reamer – Basic Tool



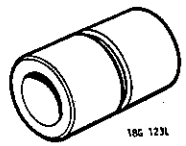
18G 123 B Camshaft Liner Reamer Cutter



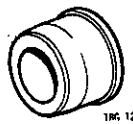
18G 123 E Camshaft Liner Reamer Cutter



18G 123 F Camshaft Liner Reamer Cutter

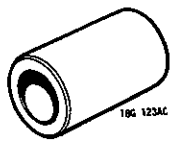


18G 123 L Camshaft Liner Reamer Pilot

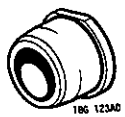


18G 123 T Camshaft Liner Reamer Pilot

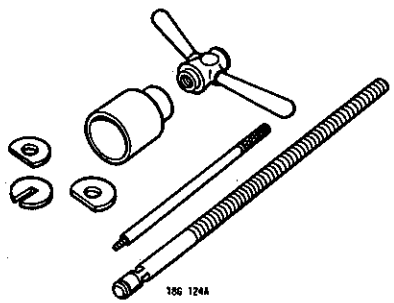
18G 123 AB Camshaft Liner Reamer Pilot



18G 123 AC Camshaft Liner Reamer Pilot

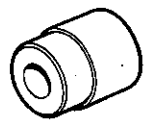


18G 123 AD Camshaft Liner Reamer Pilot

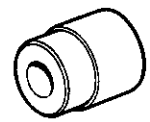


18G 124 A Camshaft Liner Remover/Replacer – Basic Tool

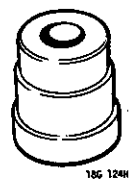
18G 124 B Camshaft Liner Remover/Replacer – Adaptor



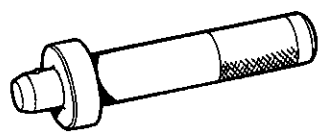
18G 124 C Camshaft Liner Remover/Replacer – Adaptor



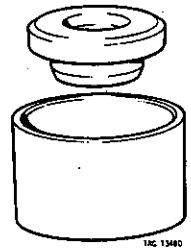
18G 124 F Camshaft Liner Remover/Replacer – Adaptor



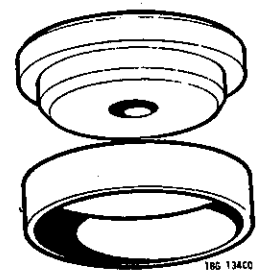
18G 124 H Camshaft Liner Remover/Replacer – Adaptor



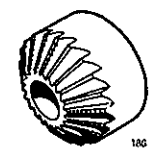
18G 134 Bearings and Oil Seal Replacer – Basic Tool



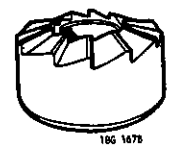
18G 134 BD Timing Case Oil Seal Replacer – Adaptor



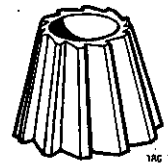
18G 134 CQ Crankshaft Rear Oil Seal Replacer – Adaptor



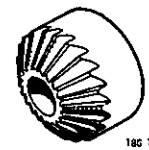
18G 167 Valve Seat Finishing Cutter



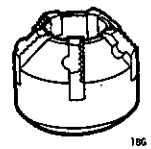
18G 167 B Valve Seat Narrowing Cutter – Top



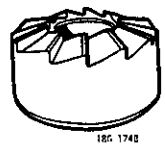
18G 167 C Valve Seat Narrowing Cutter – Bottom



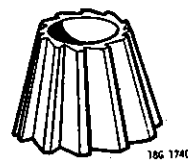
18G 174 Valve Seat Finishing Cutter



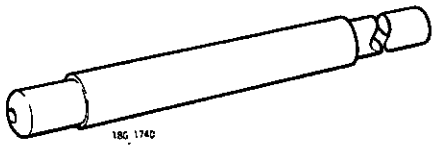
18G 174 A Valv Seat Glaze Breaker



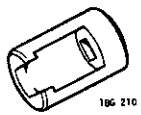
18G 174 B Valve Seat Narrowing Cutter – Top



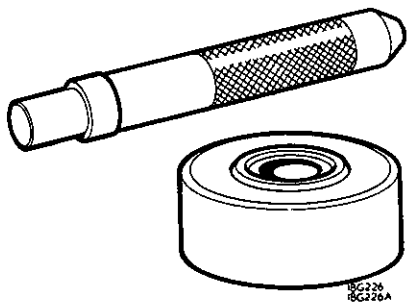
18G 174 C Valve Seat Narrowing Cutter – Bottom



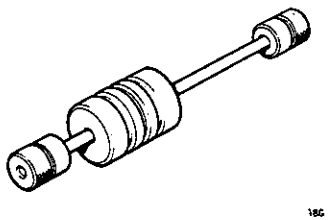
18G 174 D Valve Seat Cutter Pilot



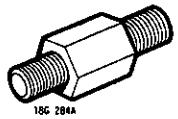
18G 210 Injector Nozzle Nut Spanner



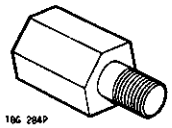
18G 226 } Valve Rocker Bush
18G 226 A } Remover/Replacer



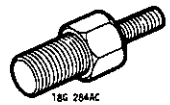
18G 284 Impulse Extractor – Basic Tool



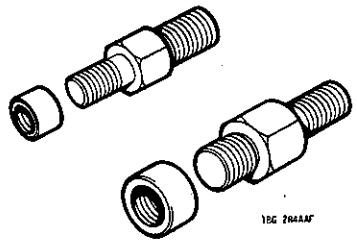
18G 284 A Main Bearing Cap Remover – Adaptor



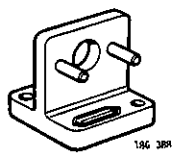
18G 284 P Injector Remover – Adaptor



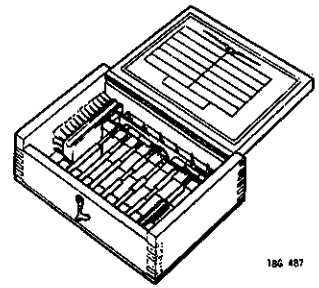
18G 284 AC Main Bearing Cap Remover – Adaptor



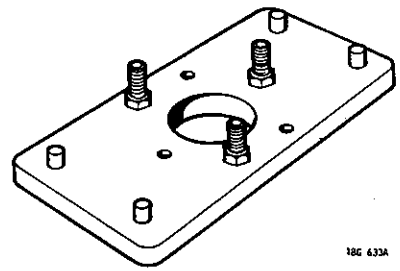
18G 284 AAF Crankshaft Spigot Bush Remover – Adaptor



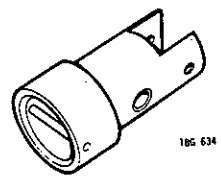
18G 388 Injector Dismantling Fixture



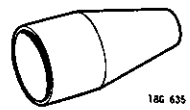
18G 487 Injector Nozzle Cleaning Kit



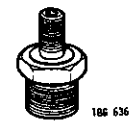
18G 633 A D.P.A. Assembly Base



18G 634 Assembly Box Spanner

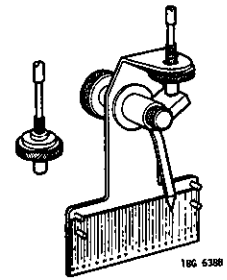


18G 635 Hydraulic Drive Shaft Protection Cap

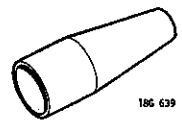


18G 636 Transfer Pressure – Adaptor

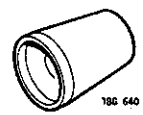
18G 637 Assembly Rod



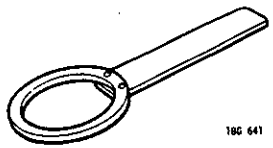
18G 638 B Automatic Advance Gauge



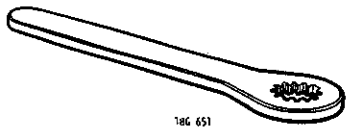
18G 639 Head Locating Fitting Protection Cap



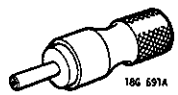
18G 640 Automatic Advance Plug Protection Cap



18G 641 Assembly Drive Plate Spanner

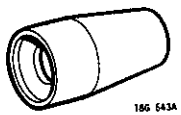


18G 651 Drive Shaft Holding Tool

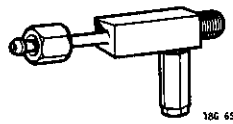


18G 691 A Pilot Guide

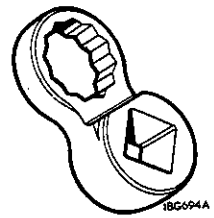
18G 1195 Clutch Plate Centralizer



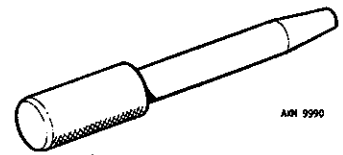
18G 643 A Metering Valve Pinion Protection Cap



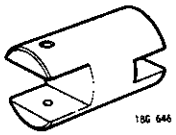
18G 653 A Relief Valve Timing – Adaptor



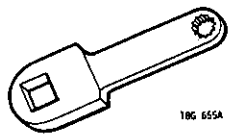
18G 694 A Cylinder Head Nut – Crowfoot Wrench (Special) – Alternative Tool 18G 694



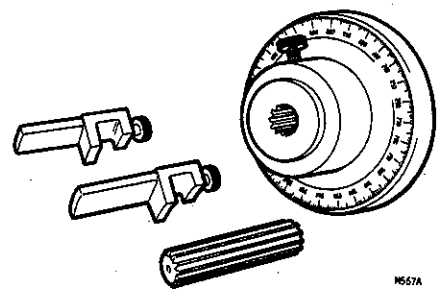
AKM 9990 Timing Pin



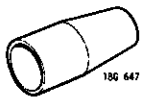
18G 646 Torque Spanner Socket



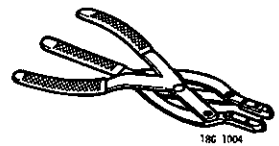
18G 655 A Drive Plate Screw Torque – Adaptor



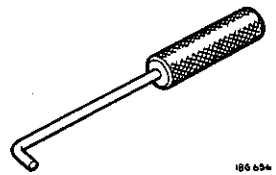
MS67A Injection Timing Gauge



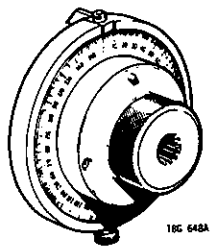
18G 647 Assembly Cap



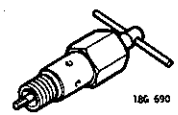
18G 1004 Circlip Pliers – Small



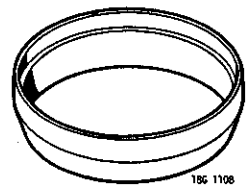
18G 656 Maximum Fuel Adjusting Probe



18G 648 A Universal Flange Marking Gauge



18G 690 End Plate Adjuster



18G 1108 Crankshaft Rear Oil Seal Protector Sleeve

OTHER OVERHAUL

CONTENTS SECTION PAGE

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.

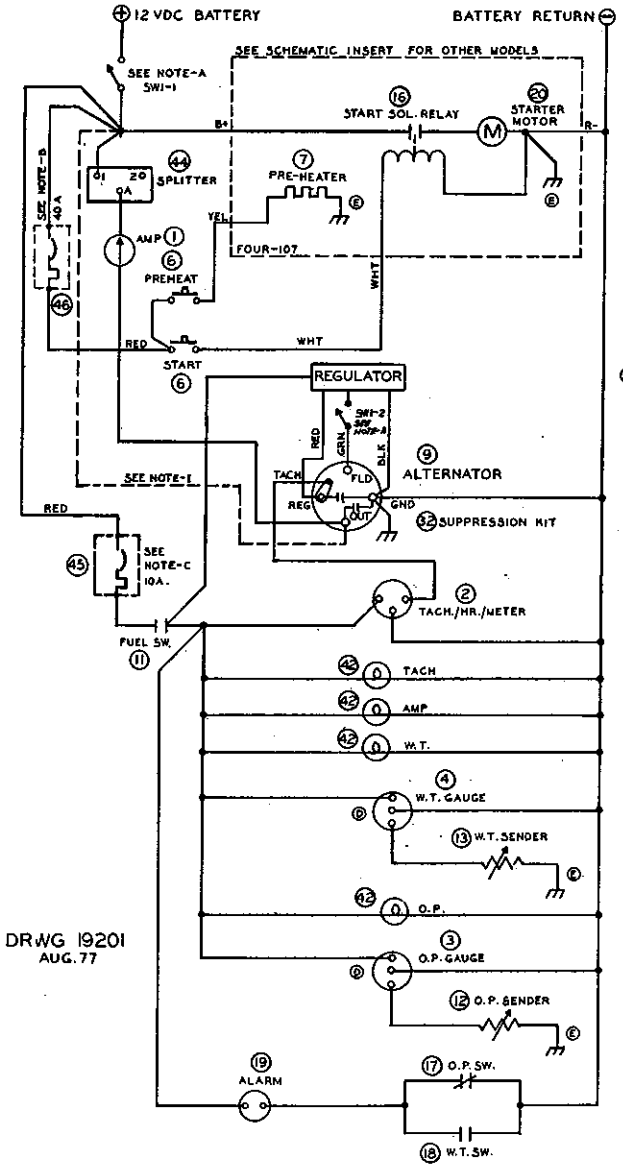
Starting is accomplished by operation of the start push button which causes the starting motor to crank.

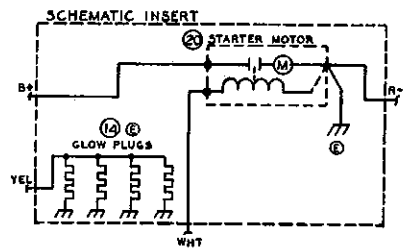
Once the engine is running, fuel pressure developed in the low pressure side of the fuel injection pump operates a fuel pressure switch. Voltage is then applied to the alarm system (if supplied) and to the alternator for excitation and for all instruments.

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 preheating 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.





WESTERBEKE 30, 50 & 60

WESTERBEKE 80 & 120 } WITHOUT GLOW PLUGS.

NOTES ON OWNER'S RESPONSIBILITY.

Ⓐ AN ON-OFF SWITCH MUST BE INSTALLED IN THIS LINE TO DISCONNECT THE STARTER CIRCUIT FROM THE BATTERY IN AN EMERGENCY & WHEN LEAVING THE BOAT. 12VOLT DIESEL ENGINE STARTERS TYPICALLY DRAW 200 TO 300 AMPS WHEN CRANKING. THE DURATION OF INDIVIDUAL CRANKING CYCLES SHOULD NOT EXCEED 30 SECONDS. A SWITCH WITH CONTINUOUS RATING OF 175 AMPS AT 12 VDC WILL NORMALLY SERVE THESE FUNCTIONS, BUT SUCH A SWITCH MUST NEVER BE USED TO "MAKE" THE STARTER CIRCUIT. ADDITIONALLY THE SWITCH MUST HAVE A SECOND POLE WITH A 5 AMP CONTINUOUS RATING TO SWITCH THE ALTERNATOR FIELD. WITHOUT THIS SECOND POLE DAMAGE WILL OCCUR TO THE ALTERNATOR IF THE SWITCH IS OPENED WHILE THE ENGINE IS RUNNING.

Ⓑ A 40 AMP FUSE OR BREAKER (SLO-BLOW PREFERRED) MUST BE INSTALLED IN THIS LINE.

Ⓒ A 10 AMP FUSE OR BREAKER (SLO-BLOW PREFERRED) MUST BE INSTALLED IN THIS LINE.

Ⓓ WARNING; SENDER CONNECTION; CONTACT WITH B+ MAY DAMAGE SENDER.

Ⓔ SENDER & HEATER RETURNS ARE THROUGH ENGINE BLOCK.

Ⓕ FOR WIRING OF AUXILLARY ALTERNATORS SEE THE FOLLOWING DIAGRAMS:
MOTOROLA 85 AMP, 11232
MOTOROLA 120 AMP, 11231
LEECE-NEVILLE 55 AMP, 16585
LEECE-NEVILLE 105 AMP, 16614

Ⓖ IF ADDITIONAL PRESSURE SWITCHES ARE REQ'D TO START BOAT ACCESSORIES, A FLEXIBLE HOSE MUST BE RUN FROM THE FUEL PRESSURE MANIFOLD TO A NEARBY BULKHEAD AND ALL PRESSURE SWITCHES MOUNTED AT THE BULKHEAD, INCLUDING THE FUEL SWITCH PRESSURE SWITCH SUPPLIED.

Ⓜ APPLY SILASTIC OR TIGHT WOUND PLASTIC ELECTRICAL TAPE AROUND CONNECTORS CONNECTED.

Ⓘ THIS CONDUCTOR INSTALLED WHEN PANEL IS NOT ORDERED.

ACTIVATION BY FUEL PRESSURE
(PUSH BUTTON START)

WIRING DIAGRAM.

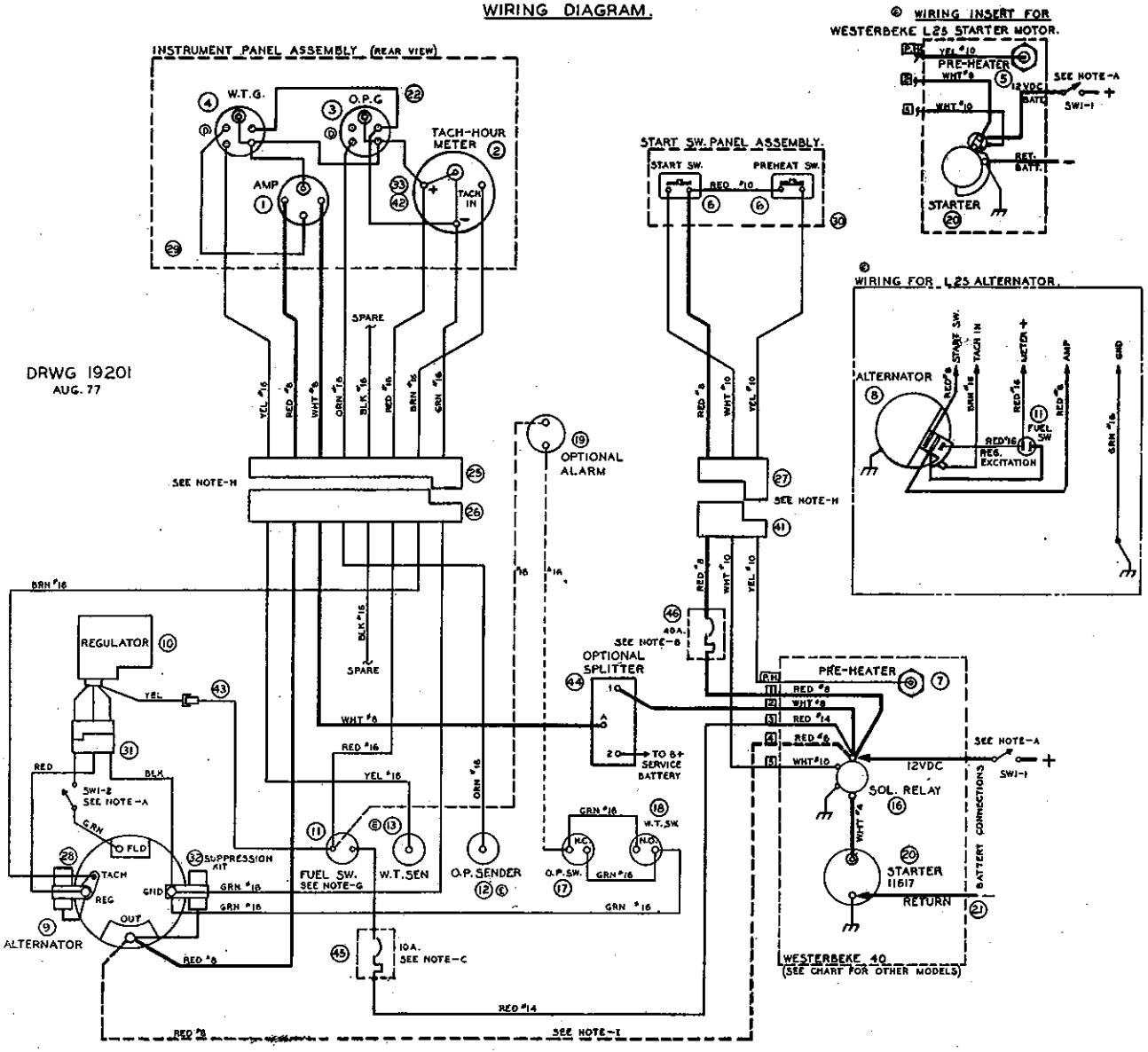
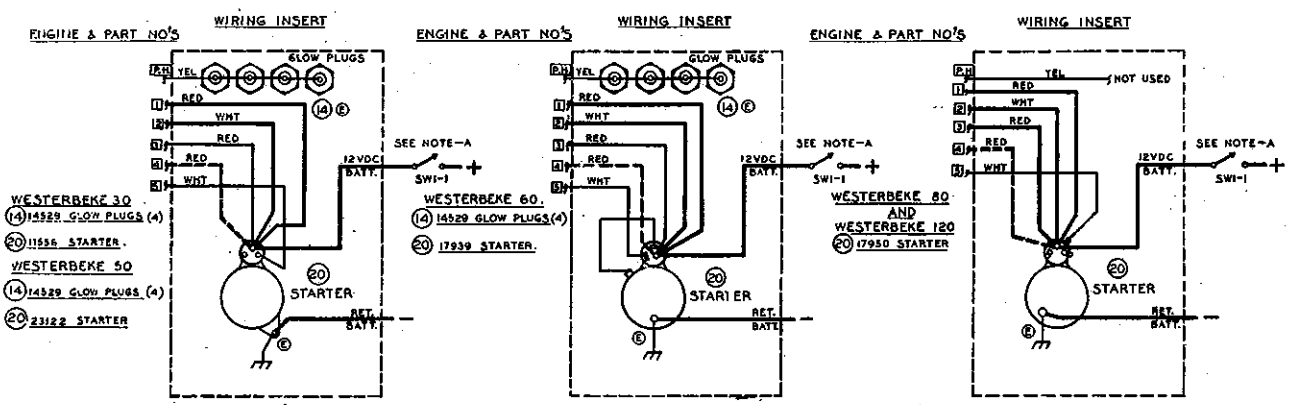


CHART FOR STARTER MOTORS AND HEATERS.



COOLING SYSTEM (EXTERNAL)

1. DESCRIPTION

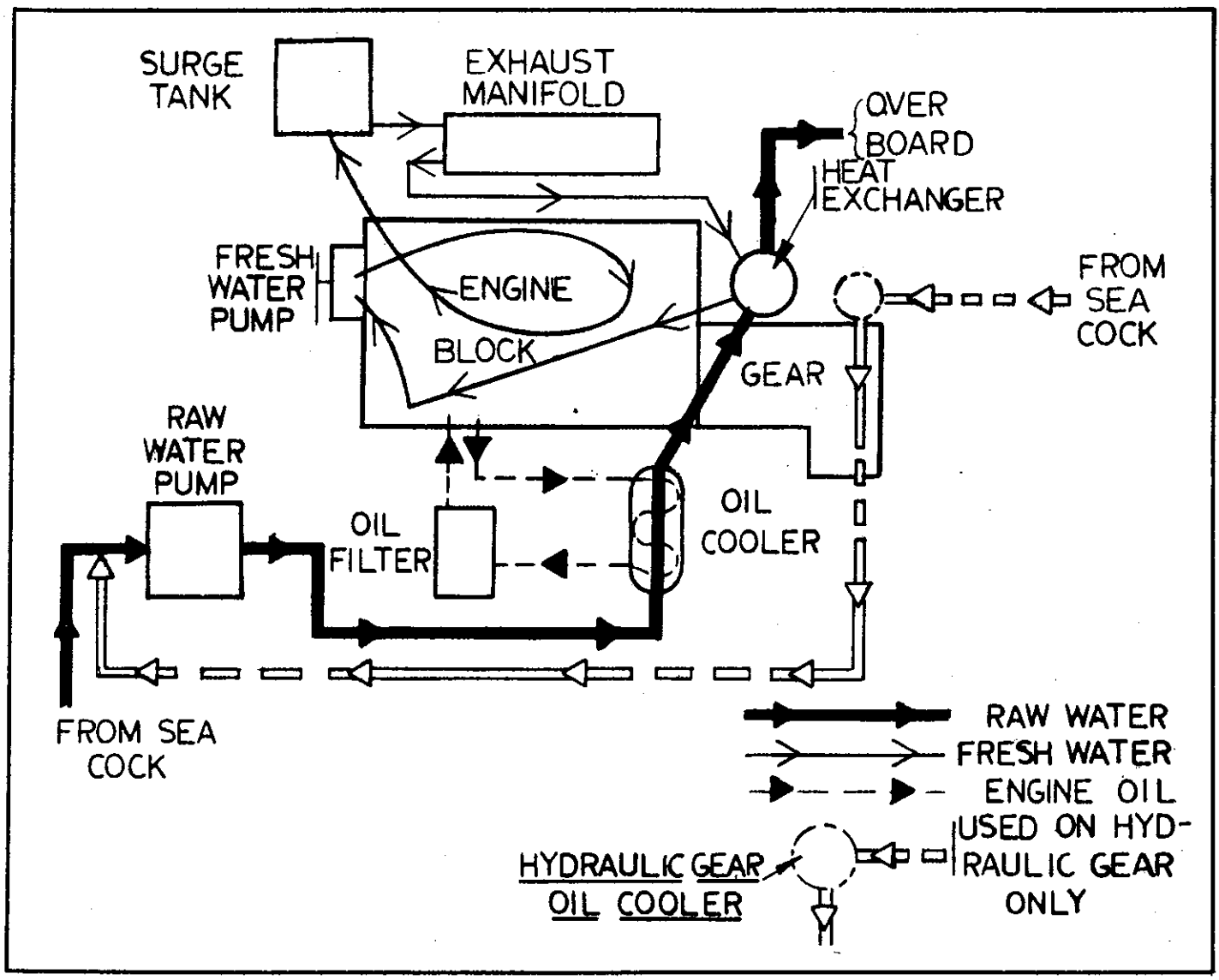
Marine Diesel Engines are equipped with a fresh water cooling system. Transfer of heat from the fresh water (closed system) circuit to the sea (raw) water is accomplished by a heat exchanger, similar to an automobile radiator. It differs because raw water, not air, cools the engine's fresh water. An 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.

3. SEA WATER SYSTEM

The engine is indirectly cooled by the unrestricted fast-flowing stream of sea water which absorbs the heat from the fresh



water 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 is mounted under the surge tank and is belt driven from the crankshaft pulley. The water pump is a self-priming, 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 petcock on left hand side of cylinder block below the air filter, and the fresh water drain petcock on bottom left side of heat exchanger. (Turn petcocks counter-clockwise to open.)

6. FILLING COOLING SYSTEM

Ensure the petcock on left hand side of cylinder block and petcock on bottom of heat exchanger is closed. (Turn clockwise to close.)

Open air vent petcock on top of heat exchanger. Remove fill cap on top of expansion tank and pour coolant into system until coolant free of air bubbles issues from vent petcock. Close air vent petcock on top of heat exchanger and completely fill system to within one inch from top of tank.

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 TEXACO Regal Starfak No. 2 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 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.

TRANSMISSIONS

YOUR NOTES

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

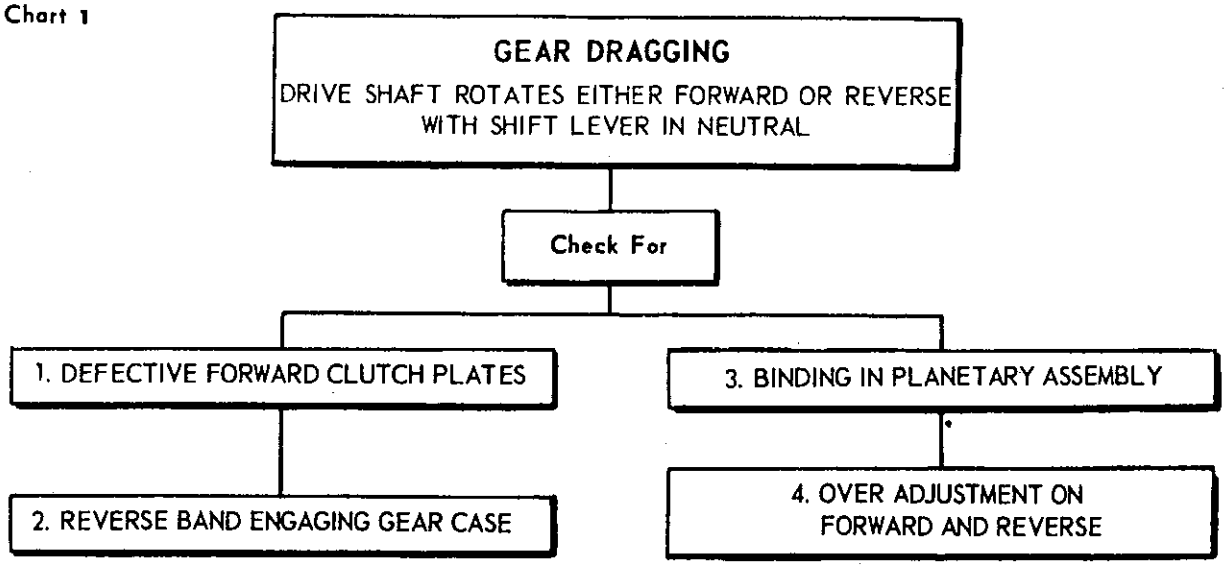
As in any servicing operation, cleanliness is a must and all rules for good workmanship apply. Some of these rules are as follows:

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 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.

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

TROUBLE SHOOTING CHARTS

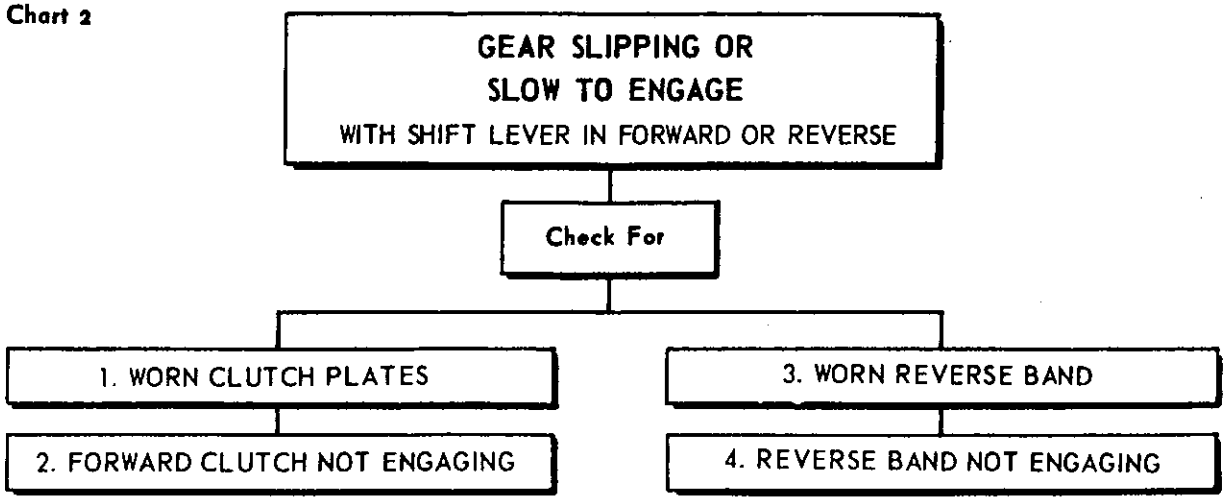
Chart 1



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



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

Chart 3

GEAR INOPERATIVE
DRIVE SHAFT DOES NOT ROTATE WITH SHIFT LEVER IN FORWARD OR REVERSE

Check For

1. FAILURE OF PLANETARY ASSEMBLY
2. FAILURE OF REDUCTION GEAR
3. FORWARD CLUTCH NOT ENGAGING
4. REVERSE BAND NOT ENGAGING GEAR CASE
5. BROKEN OUTPUT SHAFT

REMEDY

1. Remove gear case assembly and check for defective or damaged parts. Replace defective or damaged parts.
2. Remove reduction gear assembly and check for defective or damaged parts. Replace defective or damaged parts. Refer to reduction gear service manual.
3. Check the following items:
   a. Improper forward clutch adjustment. Adjust forward clutch as outlined under adjustment.
   b. Forward clutch plates worn. Replace clutch plate.
4. Check the following items:
   a. Improper reverse band adjustments. Adjust reverse band as outlined under adjustment.
   b. Reverse band lining worn. Replace lining.
   c. Cracked ears or bent or damaged linkage parts. Replace defective material.
5. Check for broken output shaft. Replace defective shaft.

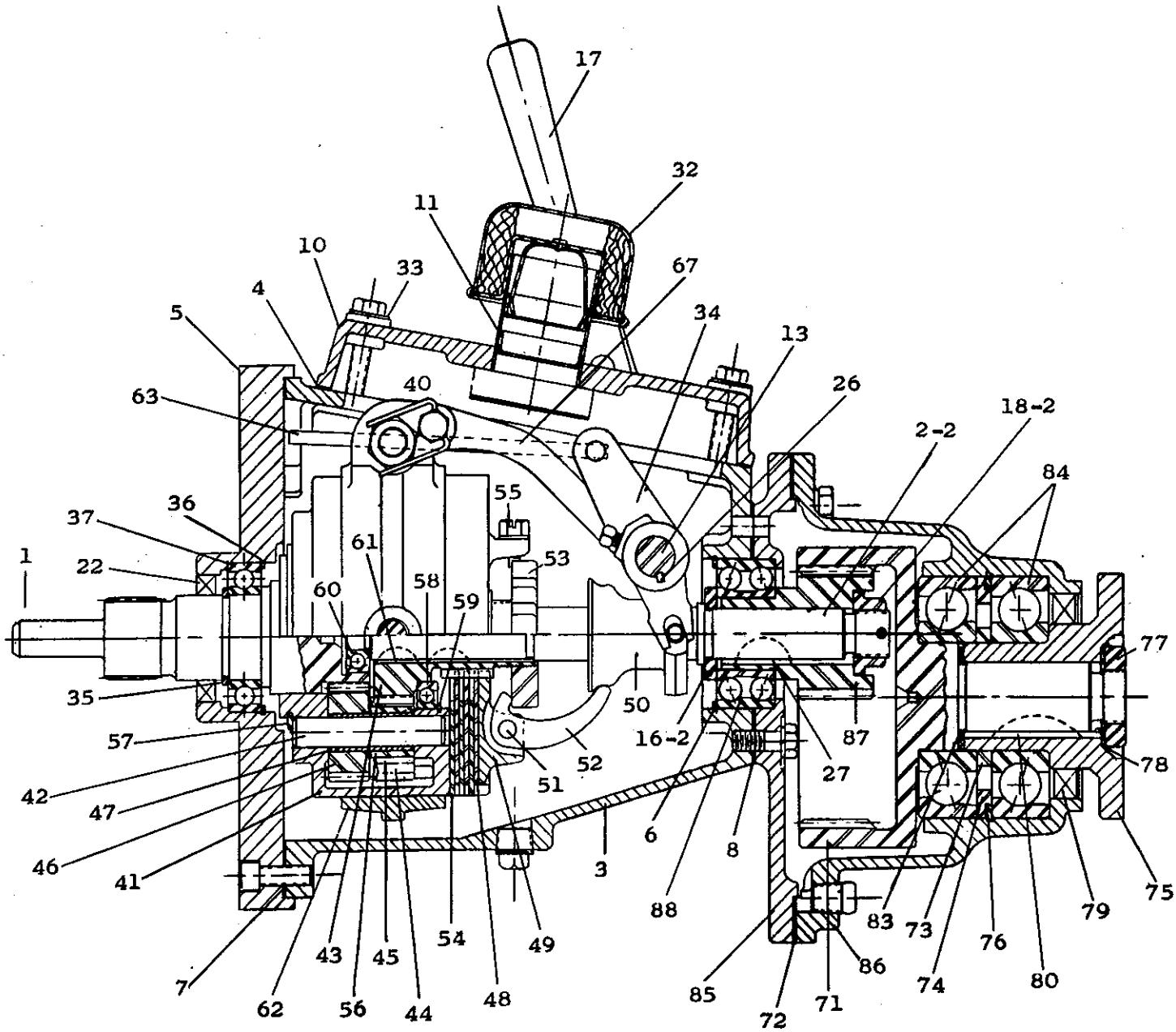
NOTE: Disassembly need be carried out only as far as is necessary to correct those difficulties which interfere with proper marine gear operation.

REMOVAL OF REDUCTION GEAR ASSEMBLY FROM REVERSE GEAR HOUSING IF INSTALLED

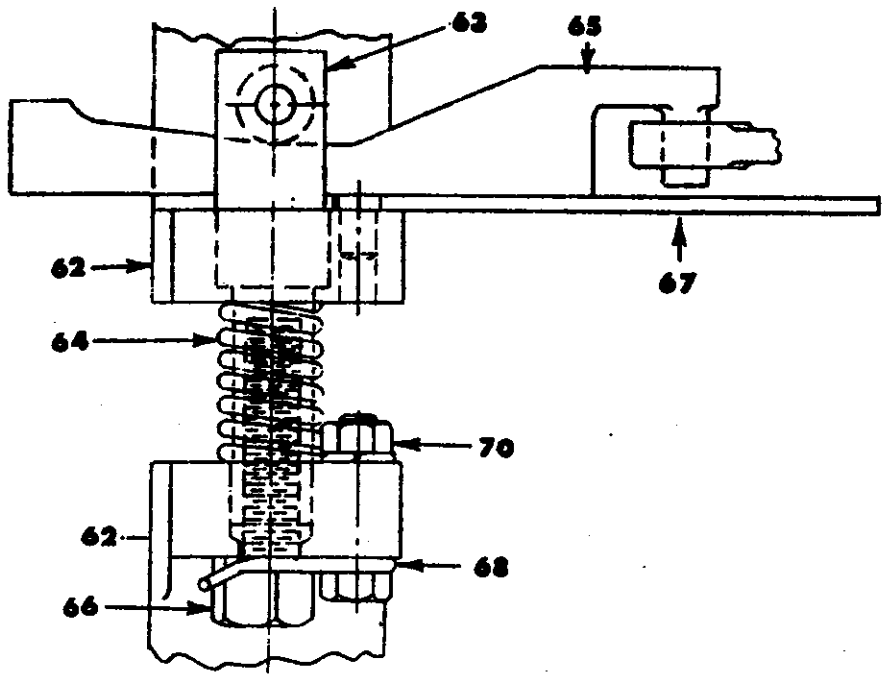
NOTE: Remove the reverse gear with reduction gear attached as a complete unit before draining oil, to avoid fouling the bilges.

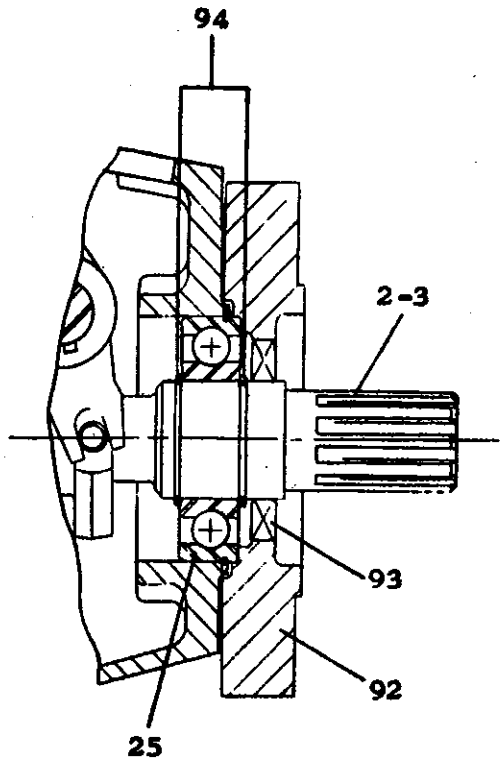
1. Remove starter motor
2. Disconnect propeller half coupling and slide back approximately 4 inches.
3. Remove capscrews securing reverse gear to bellhousing.
4. Strike gear half coupling flange with soft mallet to break reverse gear from bellhousing. Slide entire reverse and reduction gear streight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



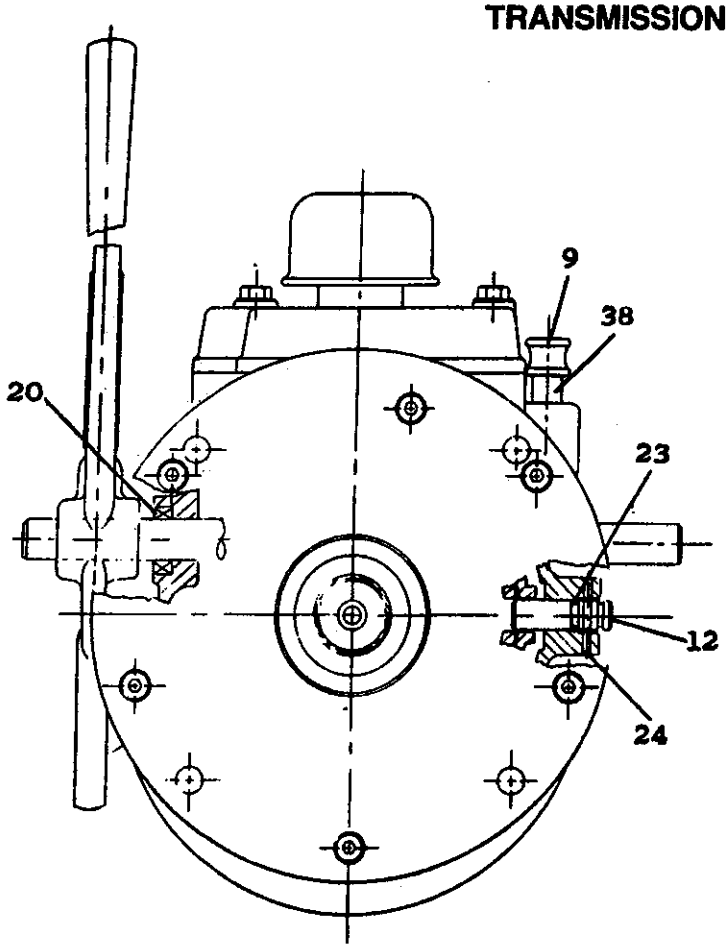
SA0 MANUAL
TRANSMISSION

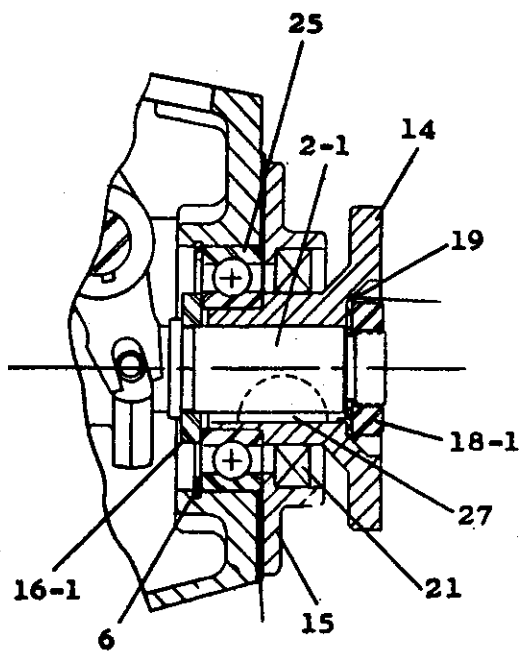




DIRECT DRIVE FOR WALTER'S "V" DRIVE

SA0 MANUAL TRANSMISSION





DIRECT DRIVE SA0D

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 centerec 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", unever 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

SA1 AND SA0 MANUAL CLUTCH ADJUSTMENTS

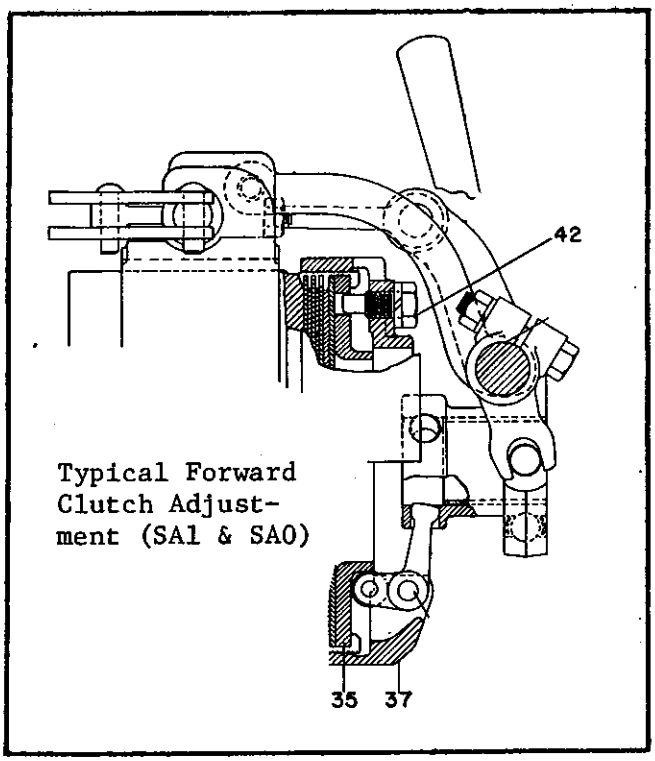
With the transmission secured to the engine, replace all water lines, etc. However, do not connect the shifting linkage until all the adjustments have been made and are satisfactorily tested.

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 --



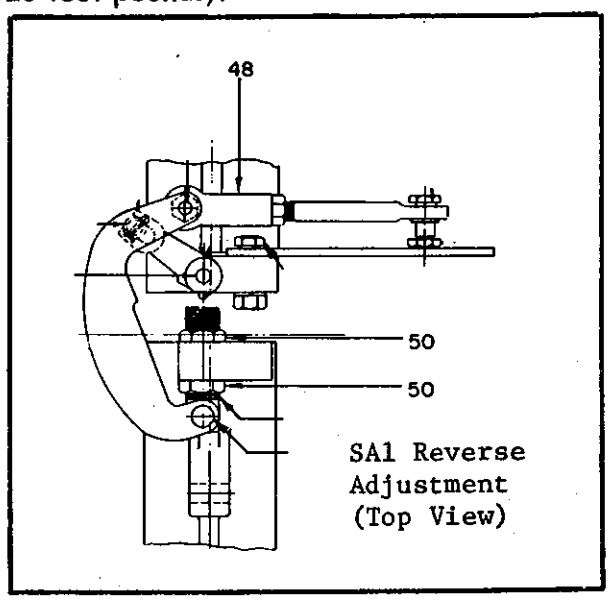
Typical Forward Clutch Adjustment (SA1 & SA0)

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).



SA1 Reverse Adjustment (Top View)

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

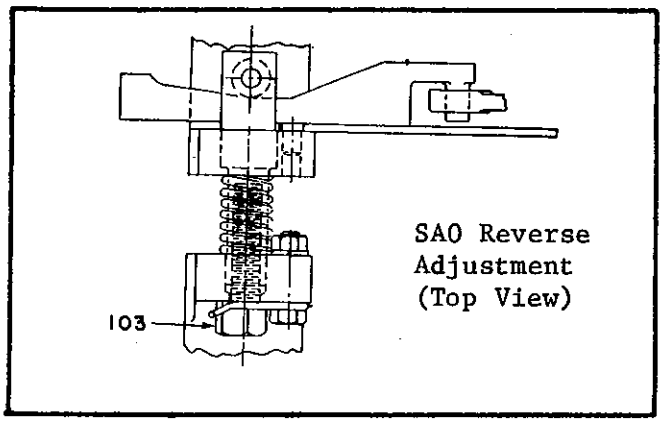
1. Loosen the locknut (50) on the inside of the upright ear at the top of the reverse band.

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).



SAO Reverse Adjustment (Top View)

Replace the cover on the reverse gear housing. 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 lockscrew (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 lockscrew. A half a step is made by taking the lockscrew 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 lockscrew. Make certain that the lockscrew 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

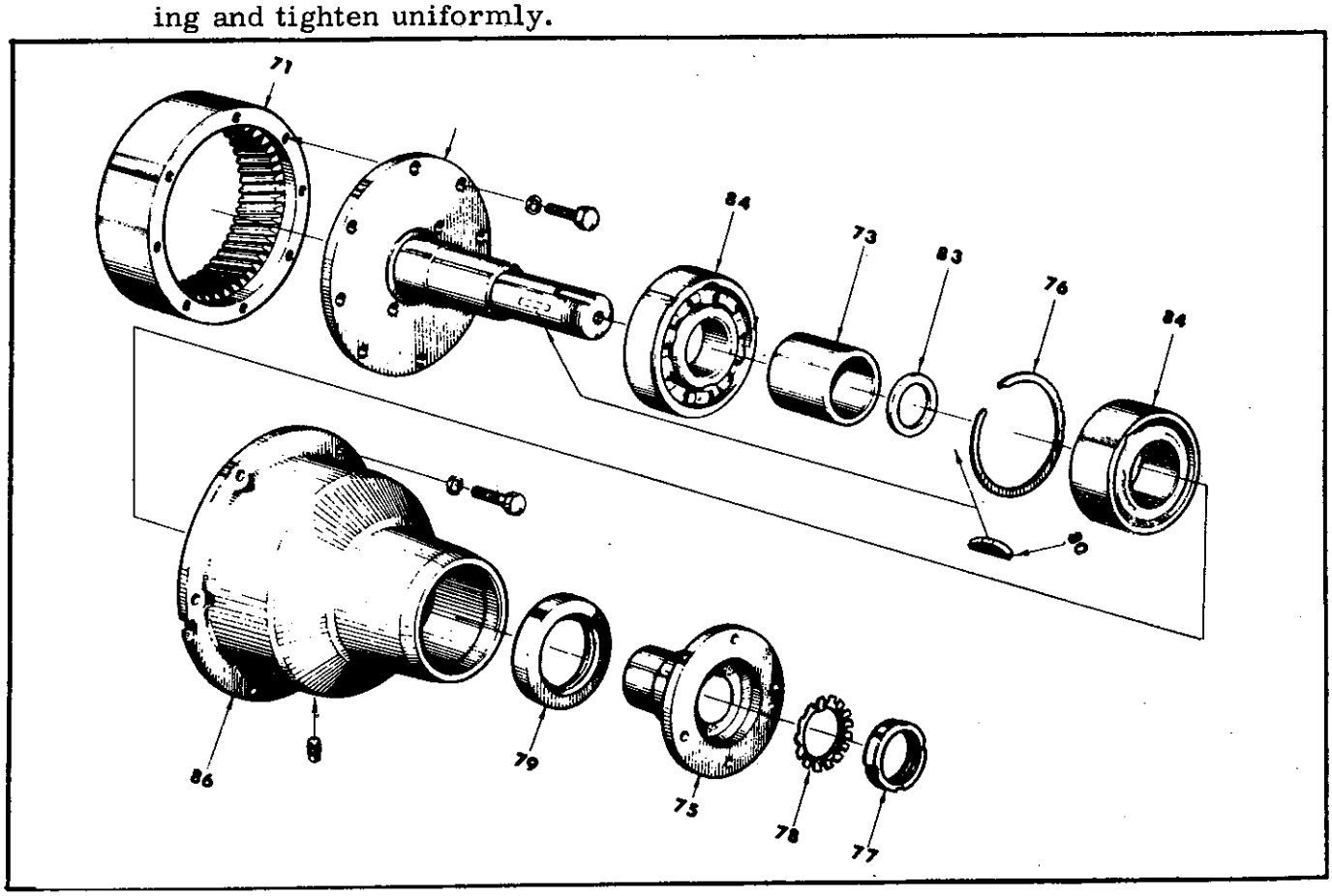
All parts should be thoroughly cleaned before inspection. Parts showing excessive wear should be replaced.

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.



PARAGON P-21 SERIES HYDRAULIC

I. SPECIFICATIONS

A. Description Chart

MODEL	REDUCTION RATIO	DIRECTION OF ROTATION
P21L	DIRECT	ALL LEFT HAND AS VIEWED FROM THE OUTPUT END OF THE TRANS-MISSION
P22L	1.5:1	
P23L	2:1	
P24L	2.5:1	
P25L	3:1	

B. Model and Serial Numbers

Each reverse gear has a model number and a serial number. These numbers are on the name plate, located on the housing of the transmission.

MODEL AND SERIAL NUMBER CHART

DIRECT DRIVE MODEL AND SERIAL NUMBERS

P21- L 5J-1234

- P2 - Gear Size
- 1 - Direct Drive
- L - Left Hand Rotation Unit
- 5J-1234 - Transmission Serial No.

REDUCTION GEAR MODEL AND SERIAL NUMBERS

P 23 L 5J-5678

- P2 - Gear Size
- 2, 3, 4, 5 — Reduction Gear Size
- 1.5:1, 2.0:1, 2.5:1, 3.0:1 — Reduction Gear Ratio
- L - Left Hand Rotation Unit
- 5J-5678 - Transmission Serial No.

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 forward 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 reinstalled, 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

adjust the shaft control cable length until the cockpit control station hand lever is in the neutral position. Move the cockpit control hand lever to forward and reverse positions several times while observing the transmission control valve lever motion. The transmission control valve lever should move fully into forward or reverse position when the hand lever is moved into forward or reverse position, and should return exactly to the neutral position when the hand lever is in the neutral position.

G. Remove the oil dipstick, shown in Figure on page 5, and fill the transmission with Type A transmission fluid to the mark on the dipstick. Replace the dipstick in the transmission housing.

IV. OPERATION

Principle of Operation

The transmission forward and reverse drives are operated by transmission oil under pressure. An internal gear type oil pump delivers the transmission oil, under pressure, to the external oil cooler. The transmission oil is returned, still under pressure, to the oil distribution tube and relief valve. The relief valve maintains the oil pressure by remaining closed until the oil pressure reaches 60 PSI. When the control lever is shifted to the forward position, oil under pressure is delivered to the multiple disc clutch piston, which moves to clamp the clutch discs and planetary reverse gear case together. The discs and case then revolve as a solid coupling in the direction of engine rotation. The reverse drive is engaged by shifting the control lever to the reverse position, so that oil under pressure is delivered to the reverse piston. The reverse piston moves to clamp the reverse band around the planetary gear case, preventing the planetary gear case from moving but allowing the planetary gears to revolve to drive the output or propeller shaft in a direction opposite to the rotation of the engine. With the control lever in the neutral position, pressurized oil is prevented from entering the clutch piston or reverse band piston and the propeller shaft remains stationary.

Starting Procedure

1. Always start the engine with the transmission in NEUTRAL to avoid moving the boat suddenly forward or back.

2. When the engine is first started, allow it to idle for a few moments. Stop the engine and check the transmission oil level. Add oil if necessary to bring the oil level up to the mark on the transmission dipstick.

NOTE

ON SUBSEQUENT START-UPS, THE TRANSMISSION OIL LEVEL MAY BE CHECKED BEFORE RUNNING THE ENGINE, WHEN ENGINE OIL IS CHECKED.

3. Start the engine again, with the transmission in NEUTRAL, and allow the engine to warm up to operating temperature.

4. Shift the transmission into FORWARD or REVERSE as desired. If the engine should stall when the transmission is shifted to FORWARD or REVERSE, place the transmission in NEUTRAL before restarting the engine.

   It is recommended that shifting be done at speeds below 1000 RPM, and preferably in the 800 RPM, or idle engine range, to prolong the life of the engine, transmission, and boat. EMERGENCY shifts may be at higher engine speeds, but this is not a recommended practice.

V. MAINTENANCE

A. Lubrication

The Models P200, P300 and P400 transmissions are self-contained units, independent of the engine lubricating systems. The units are lubricated by pressure and by splash from its own oil. The type of oil recommended is "Transmission Fluid, Type A", commonly used for automatic transmissions in automobiles.

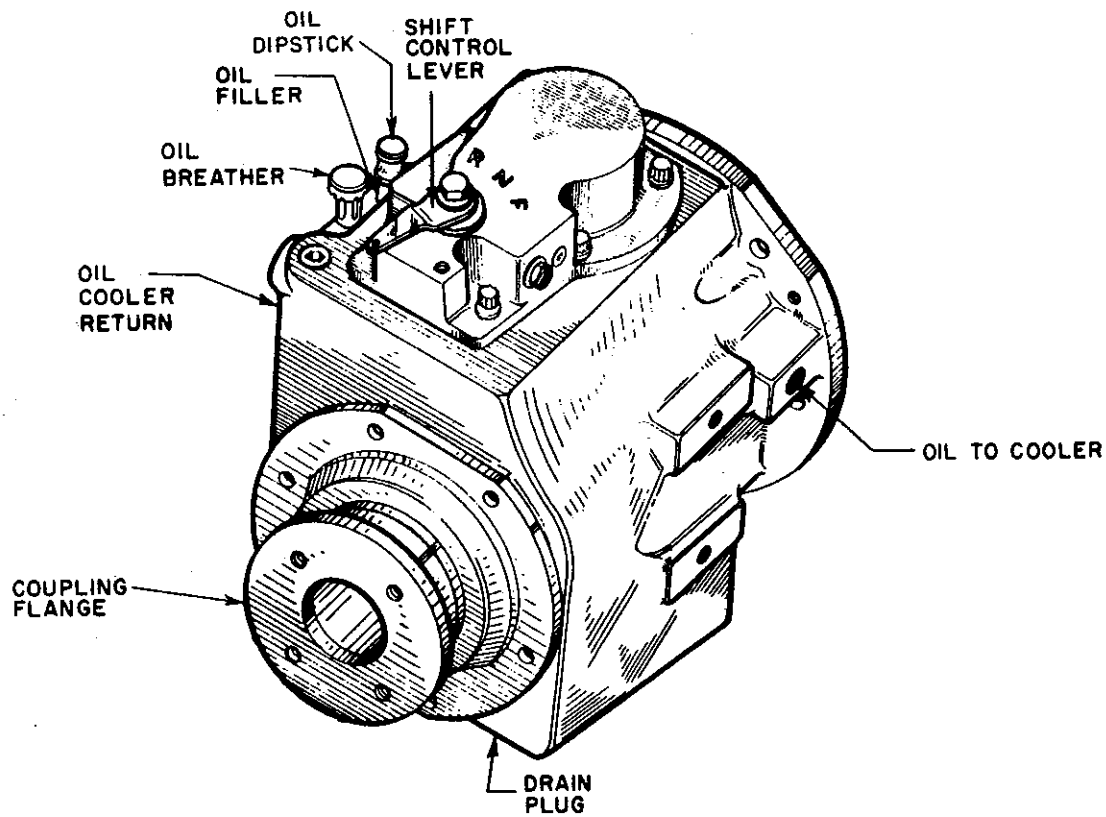
The quantity of oil depends upon the angle of installation, as well as the reduction model. The level must be maintained at the mark on the dipstick and should be checked periodically to ensure satisfactory operation.

When filling for the first time or refilling after an oil change, check the level after running for a few minutes to make certain that the oil cooler and the various passages are full. If necessary, refill to the mark on the dipstick to ensure proper operation of the transmission. The transmission oil level should be checked each time the engine oil level is checked, before running the engine.

The oil in the transmission should be changed every 100 hours, or each season under normal conditions. However, the number of hours that can be run between oil changes varies with the operating conditions. Drain plugs are located at the bottom of the reverse gear housing and the reduction gear housing.

B. Adjustments

No adjustment is necessary for the FORWARD drive multiple disc clutches, and the reverse band is self adjusting to compensate for lining wear, so that no external reverse band adjustment is necessary.



C. Trouble Shooting Chart

PROBLEM	POSSIBLE CAUSES AND METHODS OF CORRECTION	
GEAR INOPERATIVE		
Drive Shaft does not operate with selector valve in forward or reverse.	1. Low Oil Pressure.	a. Low oil supply. Add oil, refer to lubrication.
		b. Faulty oil gauge. Replace gauge. Oil gauge slow to register, air or obstruction in oil gauge line. Clean and bleed oil gauge line.
		c. Plugged oil lines or passages. Clean lines or passages.
		d. Oil pressure relief valve scored and sticking. Remove relief valve. Clean valve and valve bore in control valve housing with crocus cloth to free valve, or replace.
		e. Defective pistons and oil distributor seal rings. Replace seal rings.
		f. Defective oil pump. Check for wear, and replace if necessary.
	2. High Oil Temperature	a. Low oil supply. Add oil, refer to lubrication.
		b. Low water level in cooling system. Add water, and check for leaks.
		c. Plugged raw water inlet screen. Clean screen.
		d. Collapsed or disintegrated water inlet hose. Replace hose.
		e. Air leak in cooling water suction line. Replace suction line.
		f. Raw water pump impeller worn or damaged. Replace impeller.
		g. Clogged or dirty oil cooler element. Remove and clean
	3. Reverse Band not engaging Planetary Gear Cage.	a. Reverse band lining worn out. Replace lining.
		b. Defective reverse piston "O" ring. Replace "O" ring.
	4. Failure of Planetary Assembly.	Remove gear case assembly, and check for defective or damaged parts. Replace defective or damaged parts.
	5. Failure of Reduction Gear.	Remove reduction gear assembly and check for defective or damaged parts. Replace defective or damaged parts.

PROBLEM	POSSIBLE CAUSES AND METHODS OF CORRECTION	
GEAR DRAGGING Drive Shaft rotates either forward or reverse with Selector Valve in neutral position.	1. Defective forward Clutch Plates.	Forward clutch plates warped and sticking. Remove clutch plates and replace.
	2. Defective forward Clutch Piston Release Spring.	Forward clutch piston release spring broken or weak. Replace spring.
	3. Binding in Planetary Assembly.	a. Bearings and gears worn excessively in gear case. Replace necessary parts. b. Input shaft bearings worn excessively, causing misalignment of input shaft. Replace necessary parts.
GEAR SLIPPING OR SLOW TO ENGAGE With Selector Valve in forward or reverse position.	1. Low Oil Pressure.	See "Gear Inoperative", (1).
	2. Worn forward Clutch Plates.	Remove forward clutch plates and check for wear excessively, replace clutch plates.
	3. Reverse Band not engaging Gear Case.	See "Gear Inoperative", (3).
INTERNAL AND EXTERNAL LEAKS	1. Water in Lubricating Oil.	a. Hole in oil cooler element permitting water to seep into oil compartment. Replace oil cooler element. b. Oil cooler gaskets. Check gaskets and replace.
	2. Excessive Oil in Engine Crankcase or Flywheel Housing.	Defective front end plate oil seal. Replace oil seal.
	3. Oil on Exterior of Marine Gear.	a. Oil seeping from breather. Check for too high oil level. b. Defective rear end oil seal. Replace oil seal.
	4. Loss of Oil from Transmission.	a. Check for defective gaskets and seal.

WARNER HYDRAULIC

DESCRIPTION

Westerbeke Four-107 Engines are also furnished with Warner hydraulic direct drive and reduction gear assemblies.

The direct drive transmission consists of a planetary gear set, a forward clutch, a reverse clutch, an oil pump, and a pressure regulator and rotary control valve. All of these are contained in a cast iron housing along with necessary shafts and connectors, to provide forward, reverse and neutral operation. A direct drive ratio is used for all forward operation. In reverse, the speed of the output shaft is equal to input shaft speed, but in the opposite direction. Helical gearing is used to provide quieter operation than can be obtained with spur gearing.

Oil pressure is provided by the crescent type pump, the drive gear of which is keyed to the drive shaft and operates at transmission input speed to provide screened oil to the pressure regulator.

From the regulator valve the oil is directed through the proper circuits to the bushings and anti-friction bearings requiring lubrication. A flow of lubricant is present at the required parts whenever the front pump is turning and it should be noted that supply is positive in forward, neutral and reverse conditions.

The unit has seals to prevent escape of oil.

Both the input and output shafts are coaxial, with the input shaft splined for the installation of a drive damper, and the output shaft provided with a flange for connecting to the propeller shaft.

CONTROL LEVER POSITION

The position of the control lever on transmission when in forward should be shifted to the point where it covers the letter "F" on the case casting, and is located in its proper position by the poppet ball. The Warranty is cancelled if the shift lever poppet spring and/or ball is permanently removed, or if the control lever is changed in any manner, or repositioned, or if linkage between remote control and transmission shift lever does not have sufficient travel in both directions. This does not apply to transmissions equipped with Warner Gear electrical shift control.

LUBRICATION

The properties of the oil used in the transmission are extremely important to the proper function of the hydraulic system. Therefore, it is extremely important that the recommended oil, automatic transmission fluid (ATF), Type "A" be used.

PROCEDURE FOR FILLING TRANSMISSION WITH OIL

When filling the transmission, oil should be added until it reaches the full mark on the dipstick. The quantity of oil depends upon the angle of the installation. The unit should be turned over at engine idle speed for a short time in order to fill all circuits, including the cooler and cooler piping.

PROCEDURE FOR CHECKING OIL LEVEL

The oil level should be checked immediately after shutting off engine and sufficient oil added to again bring the transmission oil level to the full mark on the dipstick assembly. The dipstick assembly need not be threaded into the case to determine the oil level. It need only be inserted into the case until the cap or plug rests on the surface surrounding the oil filler hole.

The transmission should be checked periodically to assure proper oil level, and oil should be added if necessary.

CHANGING OIL

It is recommended that the transmission oil be changed once each season. After draining oil from the unit, the removable oil screen should be thoroughly cleaned before refilling the transmission with the recommended oil (ATF) Type "A".

REDUCTION GEAR BOX

The reduction gear box operates in conjunction with the direct drive unit. The reduction gear box consists of a planetary gear set which reduces the input revolutions to a fixed ratio.

It is recommended that all installations using a reduction gear have a suitable locking device or brake to prevent rotation of the propeller shaft when the boat is not under direct propulsion. If the marine gear is not in operation and the forward motion of the boat causes the propeller shaft to rotate, lubricating oil will not be circulated through the gear because the oil pump is not in operation. Overheating and damage to the marine gear may result unless rotation of the propeller shaft is prevented.

Except in an emergency, shift from forward to reverse drive through neutral at engine speeds below 1000 rpm to prevent damage to the engine, or marine gear.

SHORT PROFILE SAILING GEAR

1. Description

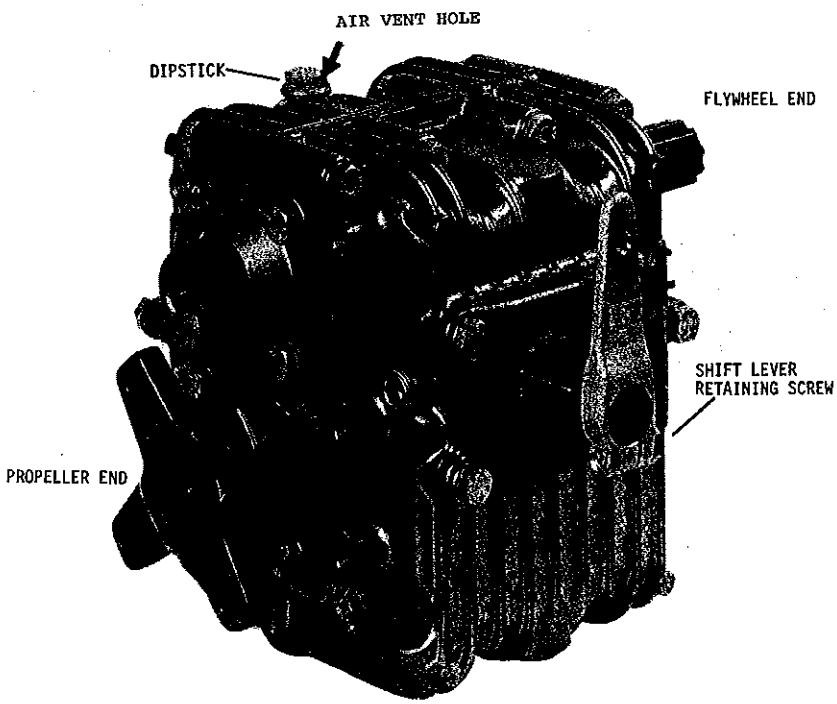
1.1 Brief description

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

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

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

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



1.2 Gear casing

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

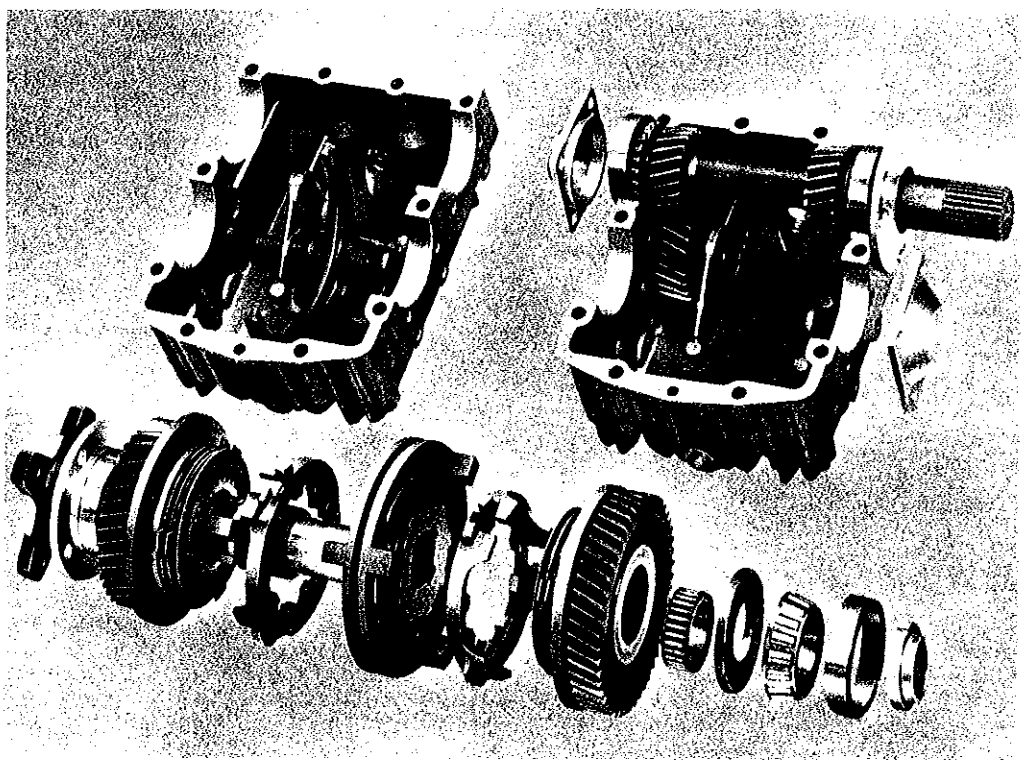
An oil filler screw with dipstick and an oil drain plug are screwed into the gear casing. The filler screw is provided with a breather hole.

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

1.3 Gear sets

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

The driven shaft (propeller side) of the transmission is fitted with a forged coupling flange.



1.4 Multiple-disc clutch including operation – power train

The engine torque is applied to the input shaft (36) in the specified direction of rotation and, **in shifting position** A (see item 1.2), via gear (44), the frictionally engaged clutch discs (51 and 52) to the external disc carrier (57) and from there via the guide sleeve (59) to the output shaft (66).

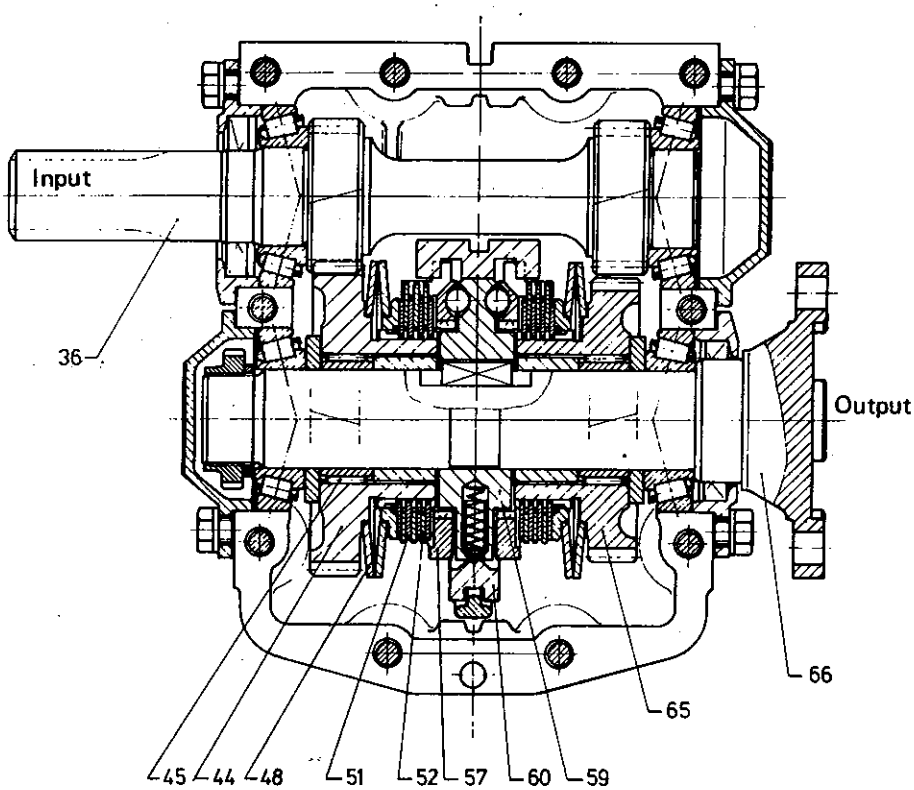
In shifting position B (see item 1.2), the torque is transmitted from the input shaft (36) via intermediate gear (26), gear (65), clutch discs (51 and 52) to the external disc carrier (57), the guide sleeve (59) and the output shaft (66).

– Function

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

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

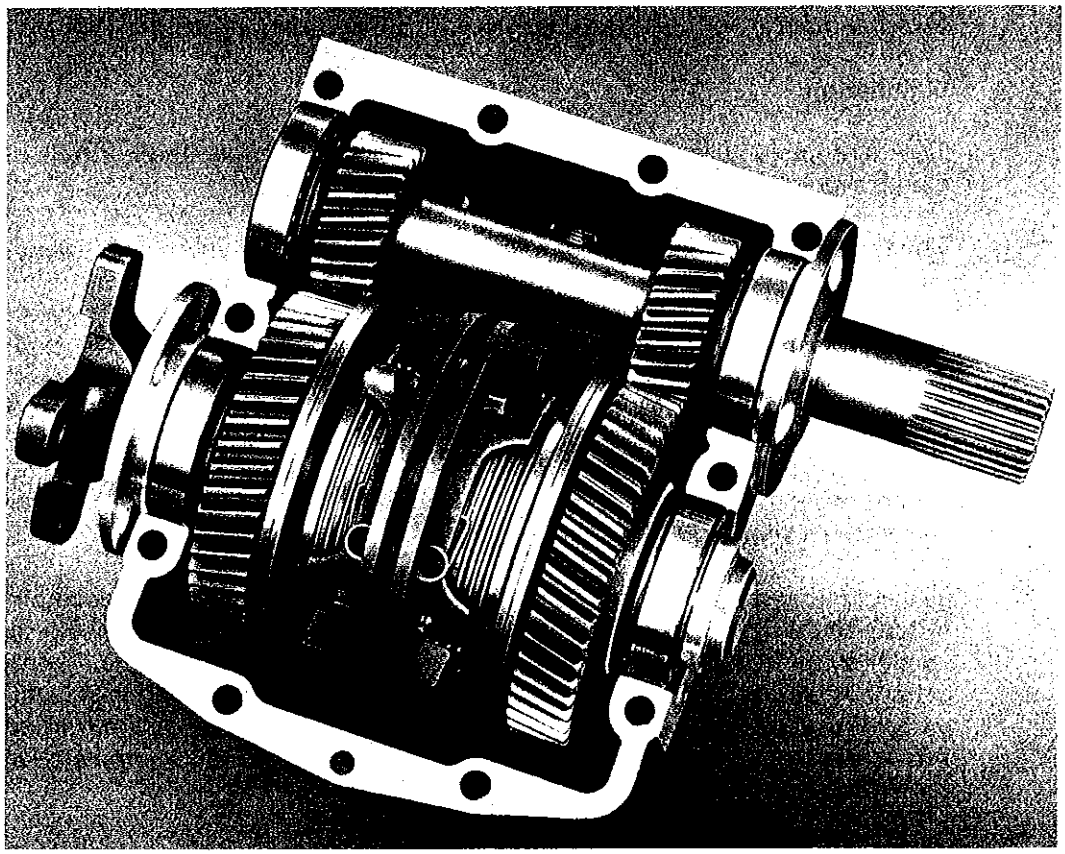
The actuating sleeve (60) is held in the middle position by spring-loaded pins. To initiate the shifting operation, the actuating sleeve (60) need merely be displaced axially by a shifting fork until the arresting force has been overcome. Then the actuating sleeve (60) is moved automatically by the spring-loaded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



1.5 Shaft bearings

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

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



1.6 Shaft seals

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

1.7 Lubrication

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

2. Installation

2.1 Delivery condition

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

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

2.2 Painting the gearbox

Before painting the gearbox, take care to remove any oil films by means of suitable agents (e.g. HST safety cleansing fluid).

Always cover the running surfaces and sealing lips of the radial sealing rings on both shafts before painting. Make certain that the breather hole on the oil filler screw is not closed by the paint. Indicating plates should remain clearly legible.

2.3 Connection of gearbox with engine

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

2.4 Suspension of engine-gearbox assembly in the boat

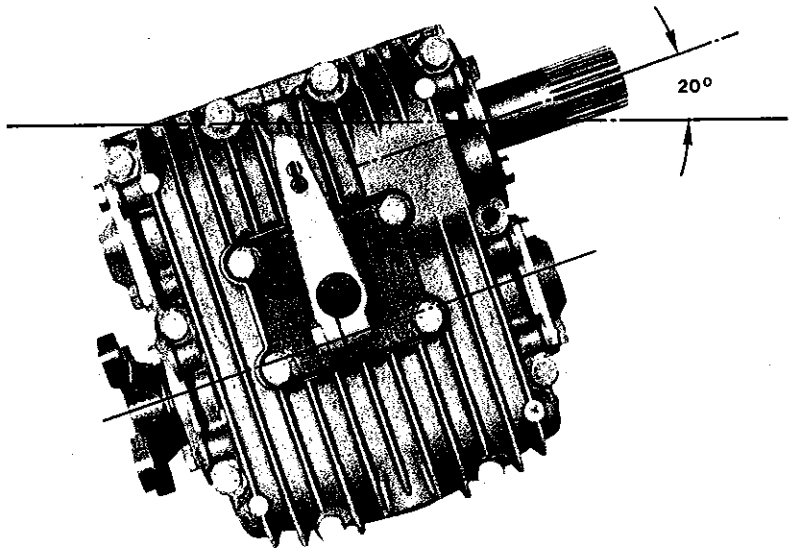
To protect the gearbox from detrimental stresses and loads, provision should be made for elastic suspension of the engine-gearbox assembly in the boat or craft.

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

2.5 Position of gearbox in the boat

The inclination of the gearbox unit in the direction of the shafts should not permanently exceed an angle of 20 degrees (see illustration).

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



2.6 Operation of gearbox

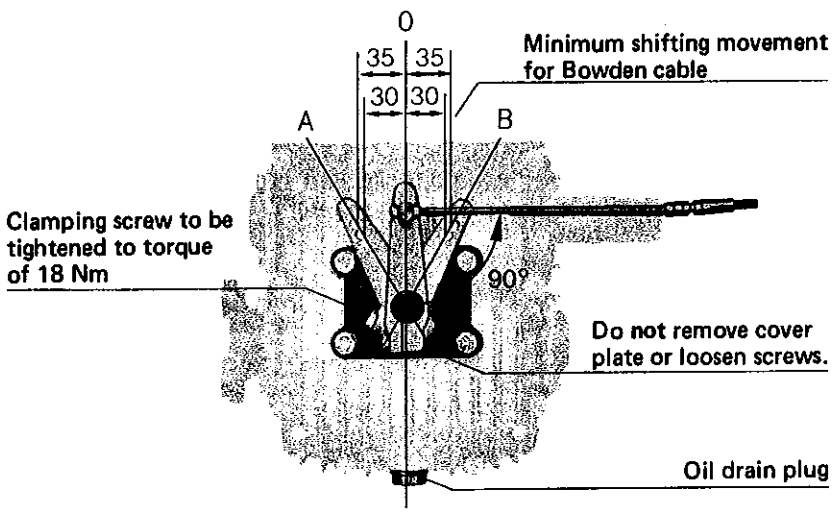
Gear changing requires only minimum effort. The gearbox is suitable for single lever remote control. Upon loosening the retaining screw, the actuating lever (see illustration) can be moved to any position required for the control elements (cable or rod linkage). Make certain that the lever does not contact the actuating lever cover plate (9): the minimum distance between lever and cover should be 0.5 mm.

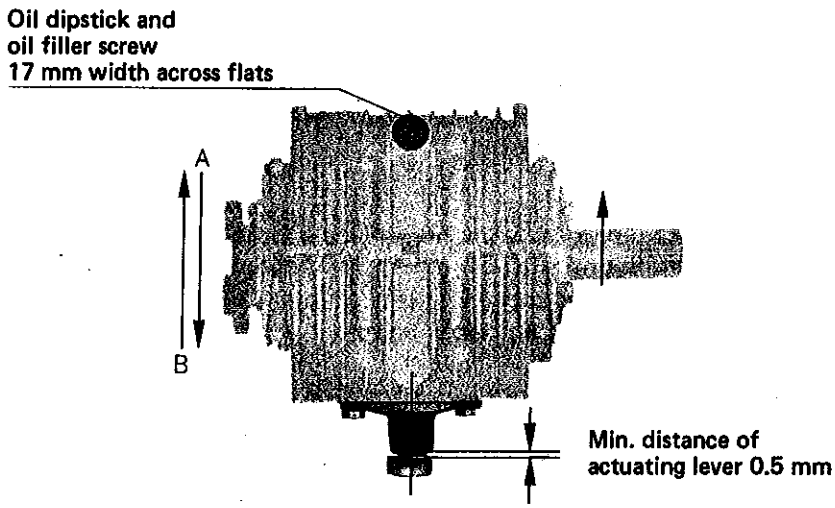
The control cable or rod should be arranged at right angles to the actuating lever in the neutral position of the lever.

The shifting travel, as measured at the pivot point of the actuating lever, between the neutral position and end positions A and B should be at least 35 mm for the outer and 30 mm for the inner pivot point.

A larger amount of lever travel is in no way detrimetal.

However, if the lever travel is shorter, proper gear engagement might be impeded which, in turn, would mean premature wear, excessive heat generation and resulting damage.





The position of the cover plate underneath the actuating lever is factory-adjusted to ensure equal lever travel from neutral position to A and B.

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

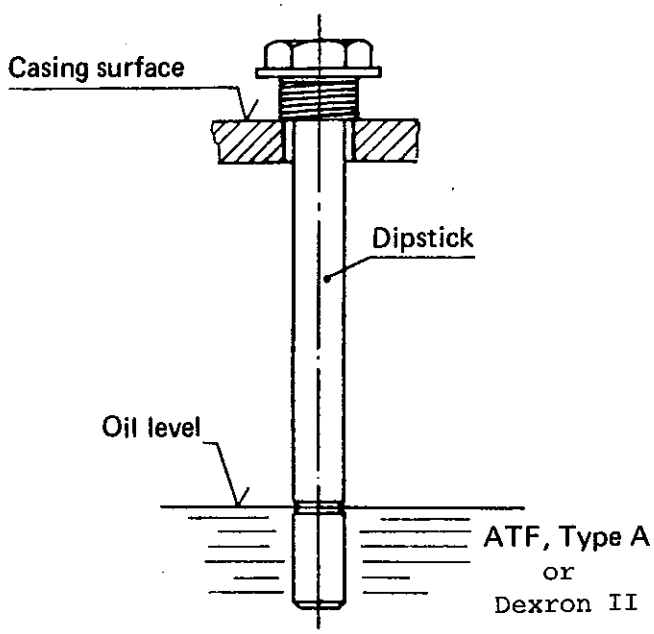
2.7 Engine-gearbox compartment

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

3. Operation

3.1 Initial operation

Fill the gearbox with oil of the recommended grade (see items 4.1 and 4.2). The oil level should be the index mark on the dipstick (see illustration).



Correct readings up to 20° inclination in direction of shafts

To check the oil level, just insert the dipstick, do **not screw in.** Retighten the hex screw with the dipstick after the oil level check.

3.2 Operating temperature

The max. permissible temperature of the transmission oil is 130 °C.

3.3 Operation of gearbox

Shifting is **initiated** by a cable or rod linkage via the actuating lever and an actuating cam. The completion of the gear changing operation is **automatic** and cannot be influenced by external control. The actuating lever is mounted on an actuating shaft and fixed by means of a retaining screw.

Gear changing should be smooth, not too slow, and continuous (without interruption). The multiple-disc clutch permits gear changing at high engine rpm, including sudden reversing at top speeds in the event of danger.

3.4 Operation without load

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

Locking of the propeller shaft by an additional brake is not required, since locking is possible by engaging the reverse gear.

3.5 Lay-up periods

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

3.6 Preparation for re-use

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

4. Maintenance

4.1 Transmission oil

To ensure trouble-free operation of the clutch, only use oil of the recommended type.

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

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

4.2 Oil quantity

HBW 5 approx 0.4 ltr
HBW 10 approx 0.6 ltr
HBW 20 approx 0.8 ltr
Use the index mark on the dipstick as a reference.

4.3 Oil level checks

Check the oil level in the transmission daily. Correct oil level is the index mark on the dipstick (see item 3.1). Always use the same oil grade when topping up.

4.4 Oil change

Change the oil for the first time after about 25 hours of operation, then at intervals of at least 1 year.

4.5 Checking the Bowden cable or rod linkage

The Bowden cable or rod linkage should be checked at shorter time intervals. The minimum lever travel from the neutral position to operating positions (0—A = 0—B) should be 35 mm for the outer and 30 mm for the inner pivot point. Make certain that these minimum values are safely reached. Check the cable or rod linkage for easy movability (see item 2.9).

4.6 OVERHAUL

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

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.

WESTERBEKE
ENGINE PRODUCTS

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

WESTERBEKE
ENGINE PRODUCTS

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.

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WESTERBEKE
MARINE ENGINE PRODUCTS

SERVICE BULLETIN #72

MODELS: ALL

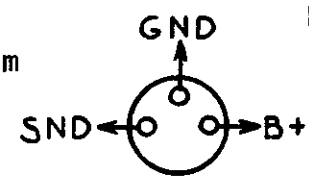
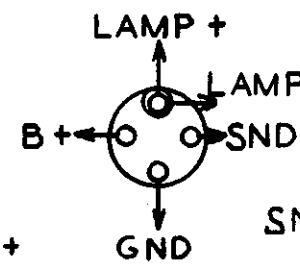
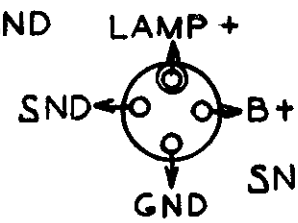
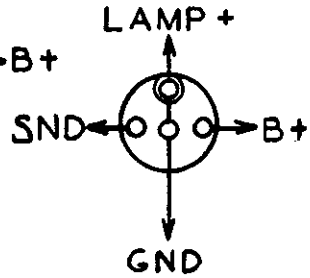
SUBJECT: NON-INTERCHANGEABILITY BETWEEN MANUFACTURERS OF GAUGES AND SENDERS

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.

	STEWART-WARNER 2" DIA CASE	VDO 2 3/8" DIA CASE	FARIA 2" DIA CASE	NOVOX 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 2 3/8" dia panel cut-out	16023 and SB #44		16023 and SB #44	16023 and SB #44
Wiring diagram		 Also see SB #36		

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WESTERBEKE
ENGINE PRODUCTS

SERVICE BULLETIN #76

REISSUED: August 27, 1975

SUBJECT: Proper Bleeding Procedure for Hydraulically Governed Fuel Injection Pumps, Incorporating an Engine Anti-stall Device

MODELS: W-30 (All); W-50 (If fitted with this type pump)

DISTR: Distributors, Engine Delivery

An anti-stall device is incorporated on fuel injection pumps fitted to the Four-91 engines. This device is located on top of the fuel pump governor housing, just beneath the air vent bleed screw. In fact, the bleed screw and anti-stall device are a complete assembly incorporating parts #1, #2, and #3 as shown on the diagram.

The anti-stall device has a spring loaded pin which comes in direct contact, with the top end of the fuel injection pump (metering valve) preventing rapid upward movement of the metering valve to the fuel cutoff position, during rapid engine deceleration. Rapid deceleration or rapid retarding of the throttle without this device installed would normally cause engine stalling and/or stoppage.

It should be noted here that under normal bleeding procedures, it is only necessary to bleed the bleed screw #5 shown on the diagram.

However, if excessive air entering the injection pump makes it necessary to bleed screw #1 in the diagram during the fuel pump bleeding procedure, when loosening or tightening the bleed screw #1, two wrenches should be used. One is to loosen the bleed screw and one is to hold the anti-stall device body #2 to prevent it from turning and upsetting the adjustments. If during the bleeding procedure screw #2 shown in the diagram is inadvertently turned in or clockwise during bleeding the result will be excessive engine RPM which cannot be controlled by retarding the throttle.

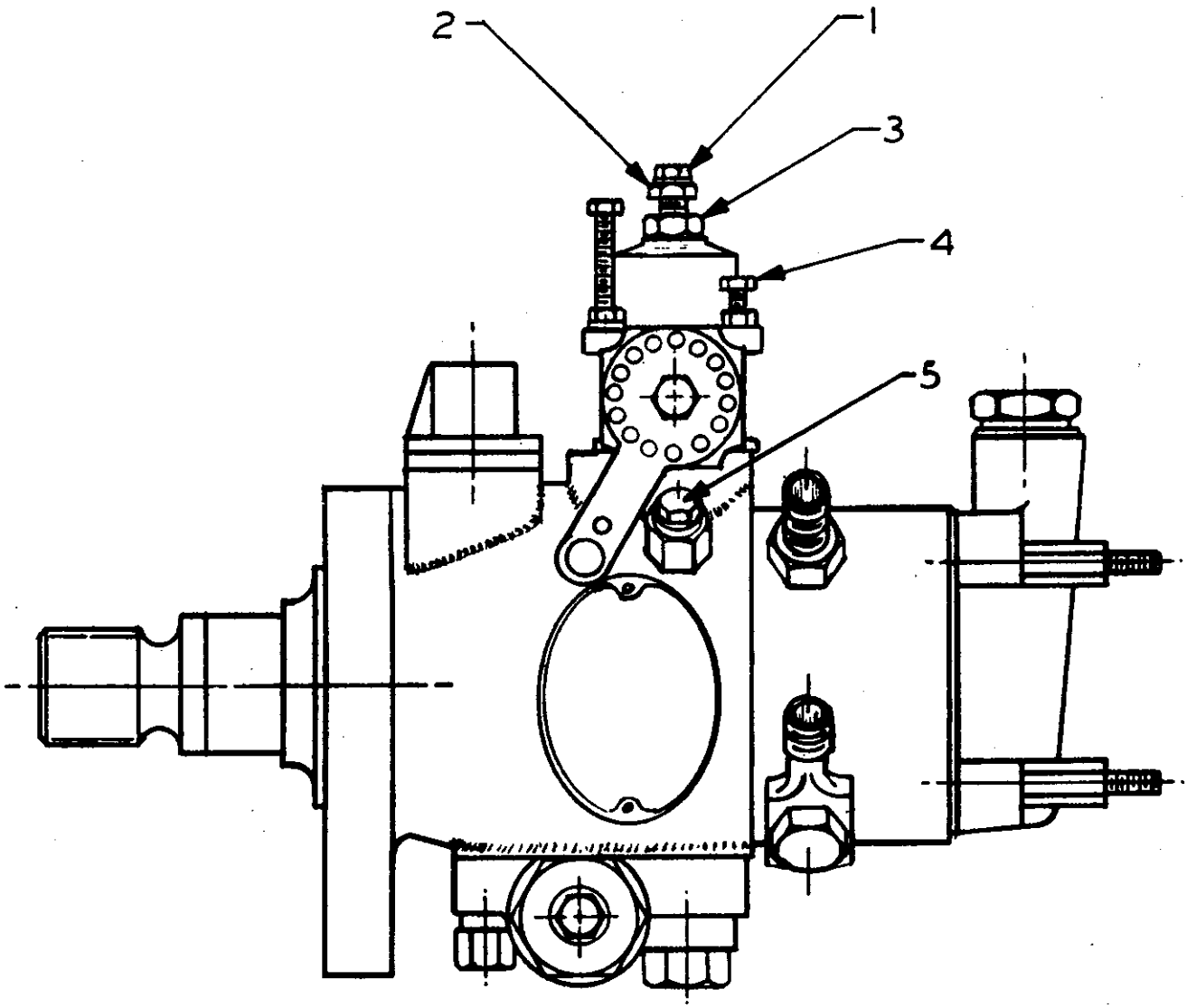
If the adjustment of the anti-stall device has been disturbed or when installing a replacement pump, the procedure for resetting it is as follows:

1. Loosen the locknut (#3) sufficiently to enable the anti-stall device body (#2) to be unscrewed two complete turns.
2. Set engine idle speed with idling stop screw (#4) to 800 RPM.
3. Turn the anti-stall device body (#2) clockwise until there is a barely perceptible increase in the idling speed. Now hold device body (#2) with wrench and tighten locknut (#3).
4. Accelerate the engine to maximum no load RPM and return the throttle rapidly to the idling position. Should the period of return from maximum RPM to idling RPM speed exceed three seconds, this is an indication that the device has been screwed in too far. However, should engine stalling occur, this is an indication that the device

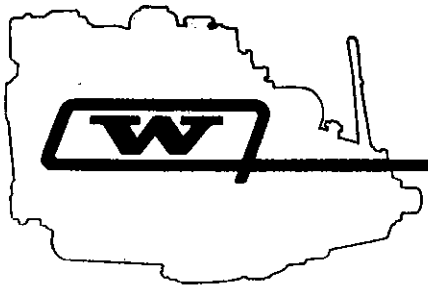
SERVICE BULLETIN #76 con't.

has not been screwed in far enough. In either case, re-adjustment should be made accordingly.

CAUTION: Use extreme caution when tightening the locknut or the bleed screw because the "threaded boss" that the assembly is screwed into is pressed into the governor housing. It is not an integral part. Therefore, if it is loosened or turned through over-torquing, replacement of the complete governor housing may become necessary.



On all prewired engines dating from early 1975 onwards bleed screw (#5) has been relocated to the opposite side of the fuel injection pump.



WESTERBEKE

MARINE ENGINE PRODUCTS

SERVICE BULLETIN #81

REISSUED: October 3, 1975

SUBJECT: Hydro-Hush Muffler Installation

MODEL: All

DISTR: All

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.

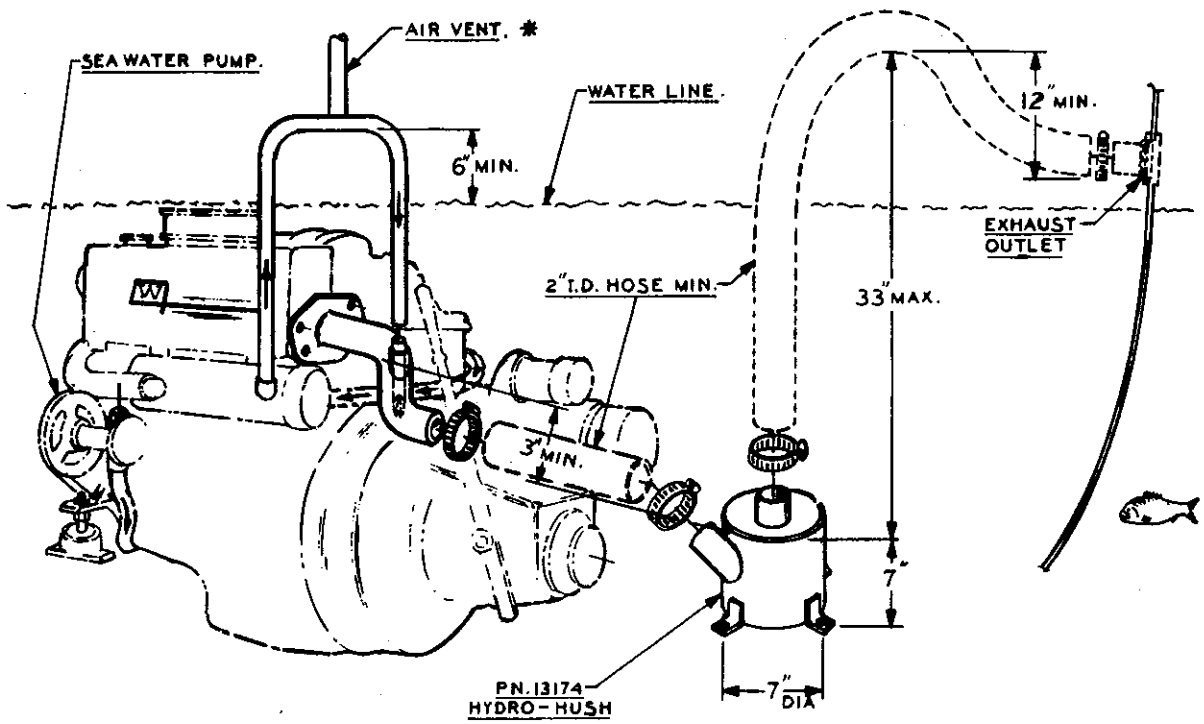
There must be an unblocked vent to atmosphere at the high point of the sea water circuit (where it passes above the waterline) to break the vaccuum which would encourage siphoning through the sea water circuit upon engine shutdown. Such siphoning would fill the engine with sea water through its exhaust. 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 transon 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.

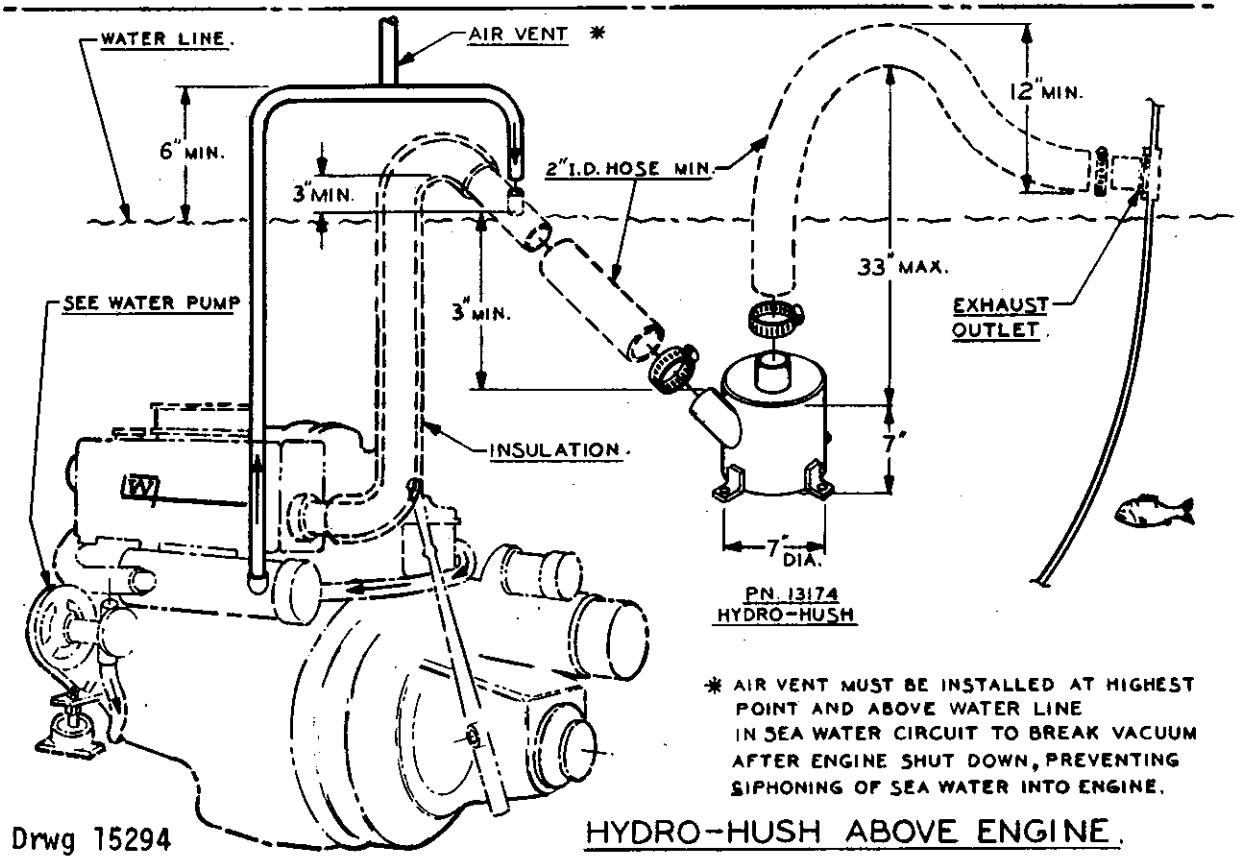
Use as few right angle fittings as possible. If there is any question as to back pressure, check your engine manual.

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.





* AIR VENT MUST BE INSTALLED AT HIGHEST POINT AND ABOVE WATER LINE IN SEA WATER CIRCUIT TO BREAK VACUUM AFTER ENGINE SHUT DOWN, PREVENTING SIPHONING OF SEA WATER INTO ENGINE.

Drwg 15294

HYDRO-HUSH ABOVE ENGINE.

WESTERBEKE
ENGINE PRODUCTS

SERVICE BULLETIN #82

REISSUED: May 21, 1979

SUBJECT: Battery Recommendations

MODEL: All

DISTR: Owners, Distributors, Dealers, Manufacturers

BATTERY RECOMMENDATIONS

MODEL	BATTERY AMPERE HOURS	VOLTAGE
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.

WESTERBEKE
ENGINE PRODUCTS

SERVICE BULLETIN #84

ISSUED: September 4, 1975

SUBJECT: Heat Exchanger Rubber End Cap

MODEL: All

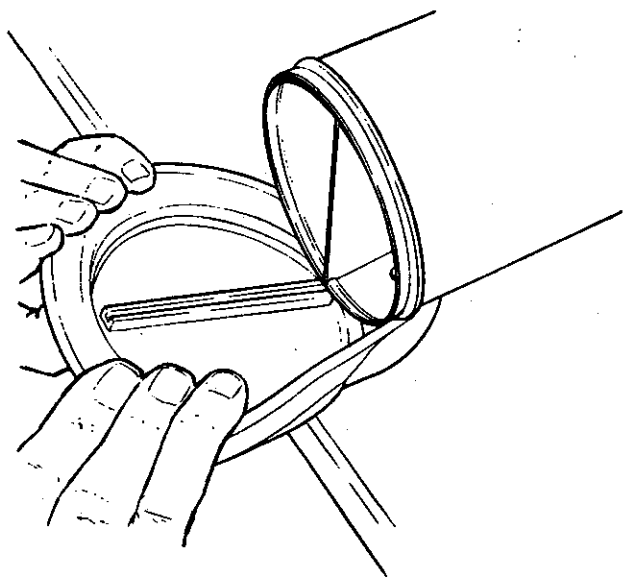
DISTR: Distributors, Engine Shipments

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 trouble-shooting.



WESTERBEKE
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).
6. When the splitter is installed, both batteries will see a charging voltage 8/10 volts less than usual. This voltage drop can be regained, if desired, by connecting the regulator wire directly to the alternator output terminal instead of the regulator terminal.

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

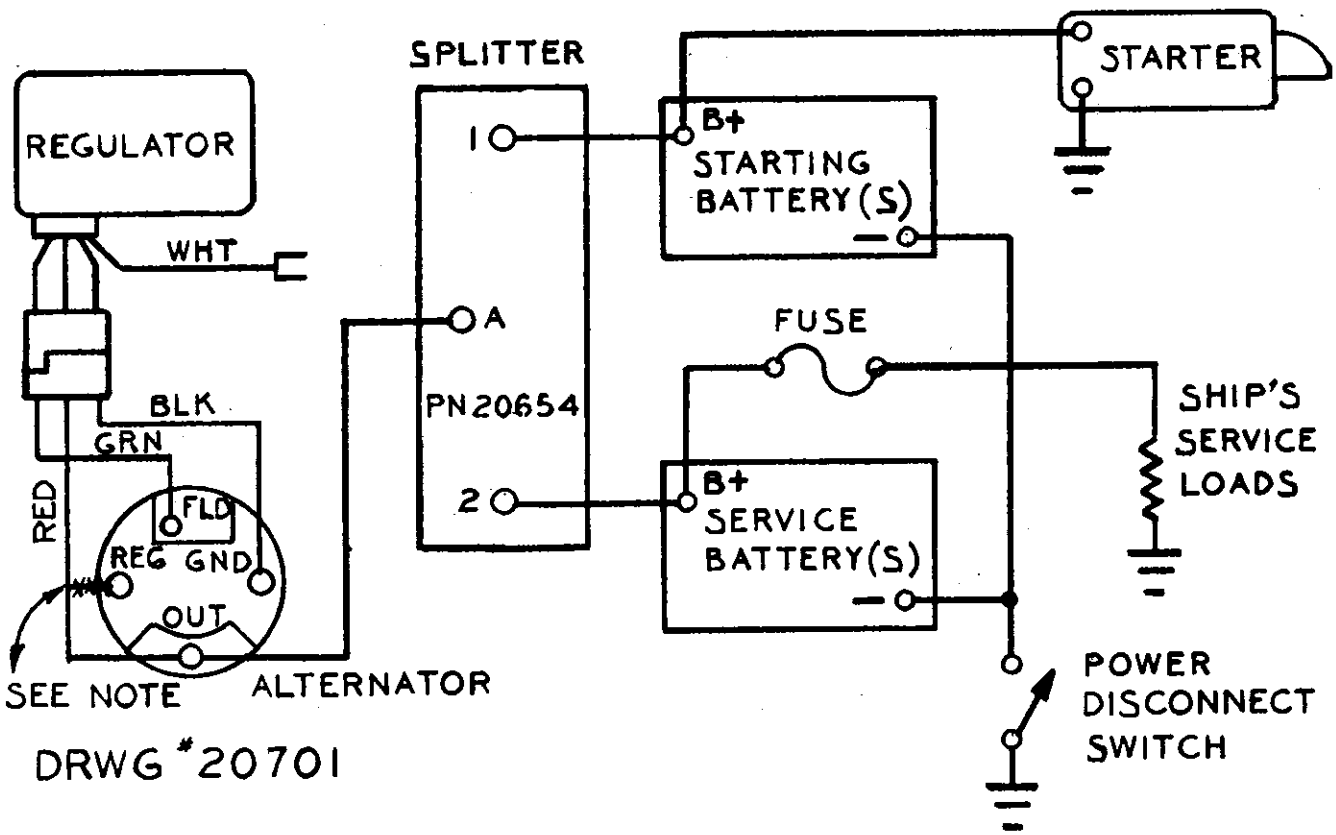
With the engine running and alternator charging, the side splitter terminals should read the same voltage which should be the voltage of the regulator or somewhat less. The center splitter terminal should read .82 volts higher than the readings of the side terminals.

Continued.....

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

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

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.)



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

WESTERBEKE
ENGINE PRODUCTS

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 gague 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
ENGINE PRODUCTS

SERVICE BULLETIN 94

ISSUED: September 9, 1976

SUBJECT: Fuel Pressure Switch Installation

MODEL: All

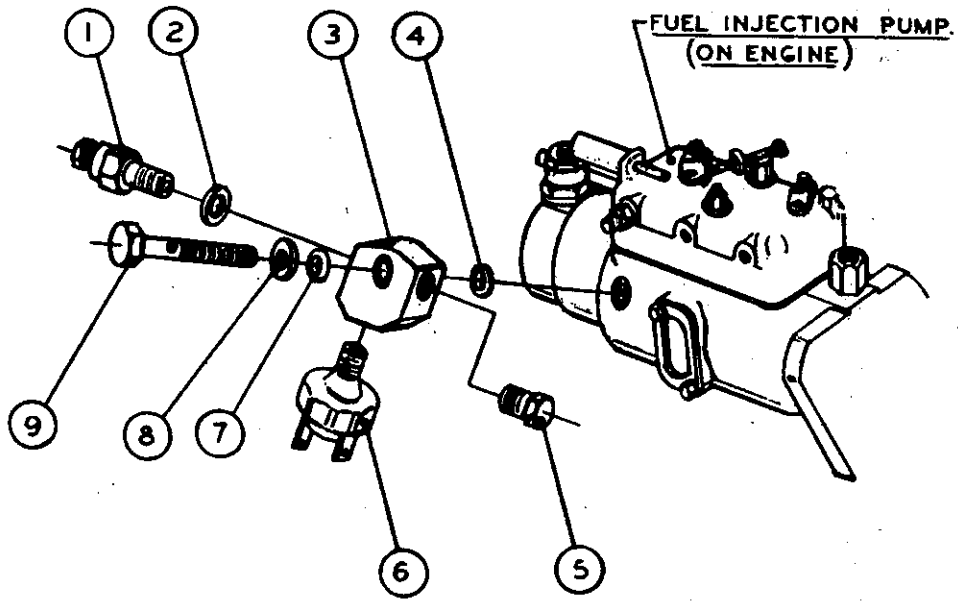
DISTR: Distributors, Shipments

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

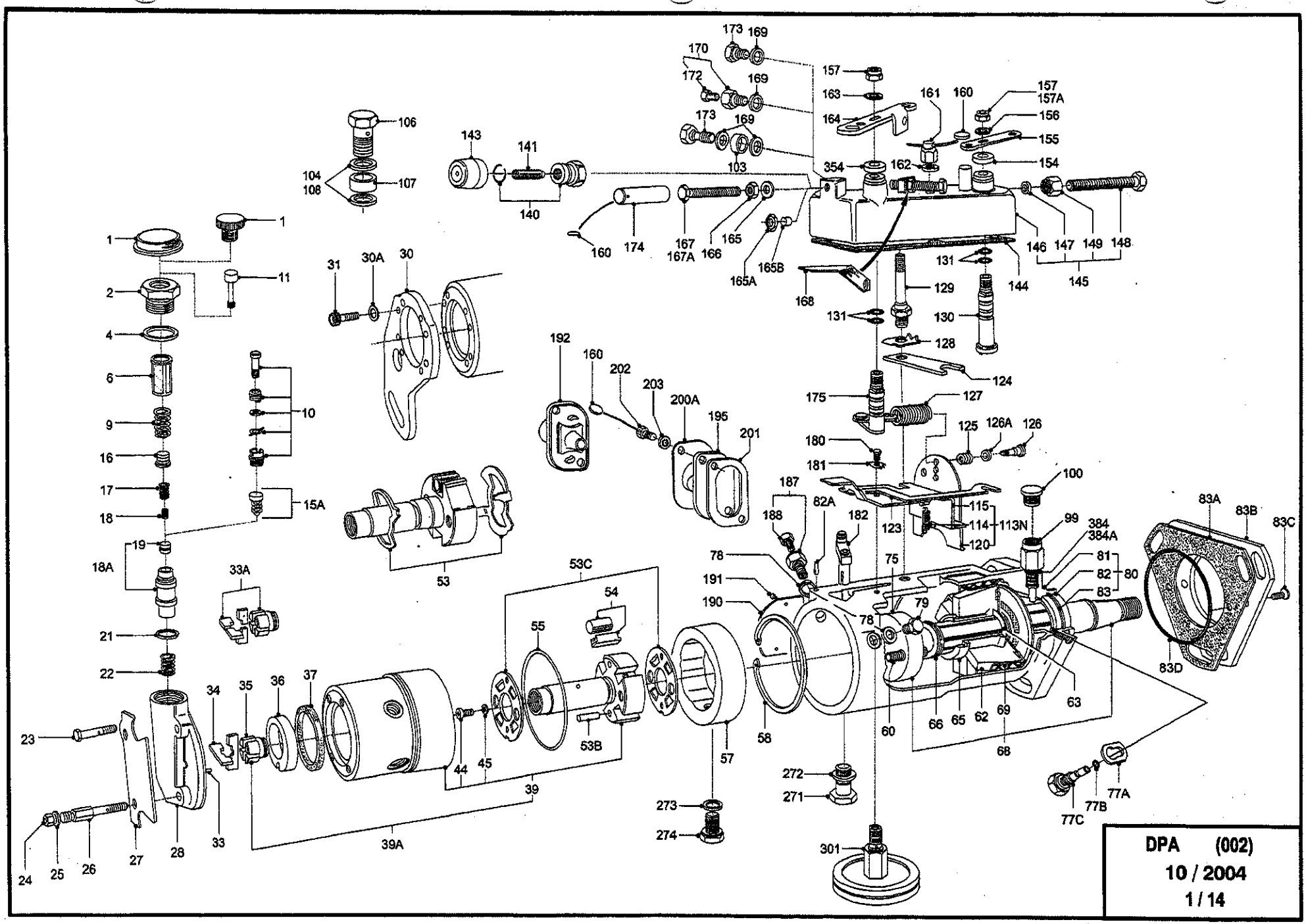
DATE	SYM	REVISION RECORD	AUTH	DR	CK



ITEM	PART NO.	DESCRIPTION	QTY
9	19187	HEX HD. SCREW	1
8	19442	FLAT WASHER	1
7	19320	"O" RING 7/16 O.D.	1
6	11383	FUEL PRESSURE SWITCH	1
5	11615	PLUG	1
4	19321	"O" RING 9/16 O.D.	1
3	19185	ADAPTER	1
2	19261	COPPER WASHER	1
1	19204	SCREW ASS'Y (BLEED)	1

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

V.15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SERVICE BULLETIN

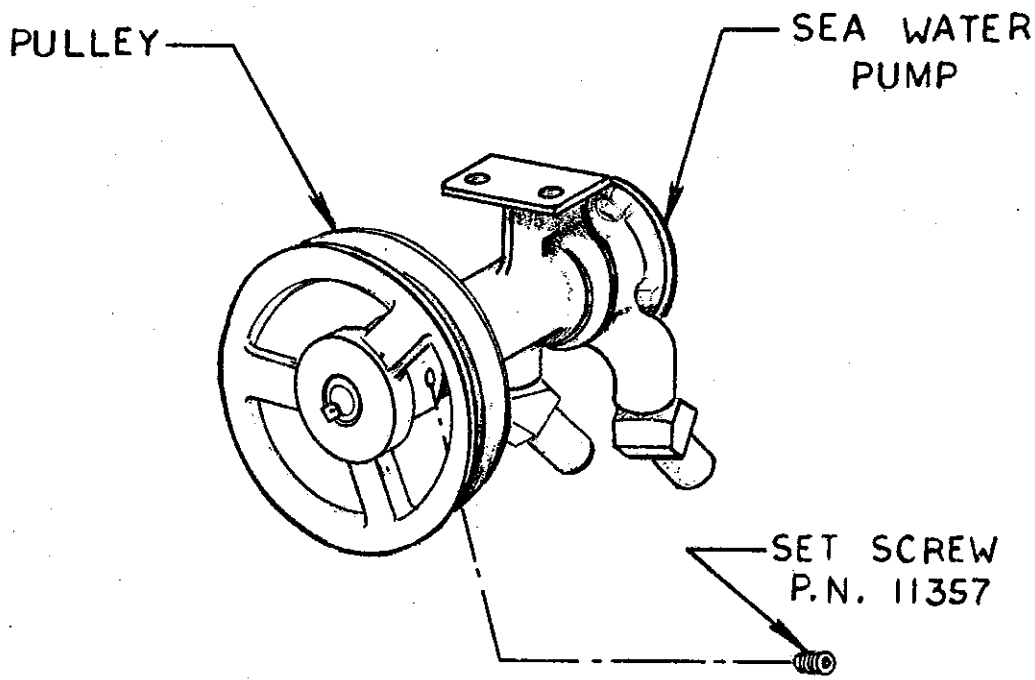
DATE: January 22, 1980 *BULLETIN NUMBER:* 104

MODEL: Westerbeke 30 and 50

SUBJECT: Sea Water Pump Pulley Set Screw P.N. 11357

The sea water pump pulley on the Westerbeke 30 and 50 engines is keyed to the sea water pump shaft and locked in position with a heat treated 5/32" Allen head set screw, Westerbeke P.N. 11357.

Particular attention should be paid to this set screw at the time of commissioning of the engine and during regular servicing of the engine. Ensure that it is tight. If not, remove the set screw and apply a good locking liquid to the set screw threads and reinstall and tighten with the aid of a 5/32" Allen wrench.



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P/N: 24293

SERVICE BULLETIN

DATE: May 1, 1980 *BULLETIN NUMBER:* 107

MODEL: All Models

SUBJECT: Thermostats

Beginning approximately May, 1980, thermostats supplied by the factory have a by-pass hole sufficient to allow adequate water flow through the exhaust manifold, head, and block, during engine warm-up.

This flow is mandatory, especially in the case of marine engines and generator sets which have significant load applied soon after start-up.

We strongly recommend that only genuine WESTERBEKE thermostats be used in WESTERBEKE products to assure proper design in this regard.

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SERVICE BULLETIN

DATE: 7 July 80 Reissued *BULLETIN NUMBER:* 95

MODEL: All

SUBJECT: Domestic Hot Water Heaters

Principle

The heater is connected in series with the engine's freshwater circuit. This allows full water flow for maximum heat transfer to the heater. The series installation also avoids several potential pitfalls of installations in which the heater is in parallel with either the engine's by-pass or its internal freshwater circuit.

The only potential disadvantage of a series installation is flow restriction due either to a restrictive heater design, a large engine water flow (such as models W58, W80, W120), or a combination of both.

Installation

The shorter the length of piping to and from the heater, the better. The elevation of the heater should assure that the top of its internal coil is no higher than the engine pressure cap. If the heater must be higher than this at any heel angle, then the optional remote fill tank must be installed to be the highest point of the circuit.

Piping between the engine and heater should rise continuously from the heater to the engine so that trapped air will rise automatically from the heater to the engine. If trapped air can rise to the heater, then a petcock or other convenient method of bleeding that air is a necessity.

Study the attached sketches. A convenient place to interrupt the engine cooling circuit is between the thermostat housing outlet and the exhaust manifold inlet. This is also the hottest water available. CAUTION: While most owners want the hottest water available, it is possible for scalding water or even steam to come from the faucets.

Since the heater is in series with the engine cooling water, any other convenient point of the circuit can also be interrupted for heater installation.

Some engine/heater combinations require that a "by-pass" nipple be installed in parallel with the heater. This is required to maintain an adequate fresh water flow for cooling capability. The table below shows the minimum diameter of "by-pass" nipples in these situations:

MODEL	HEATER SENDURE	ALLCRAFT	RARITAN
W30			3/8" NPT
W40			3/8" NPT
W50			1/2" NPT
W58	1/2" NPT	1/2" NPT	3/4" NPT
W80	1/2" NPT	1/2" NPT	3/4" NPT
W120	1/2" NPT	1/2" NPT	3/4" NPT

Please see sketches on overleaf.

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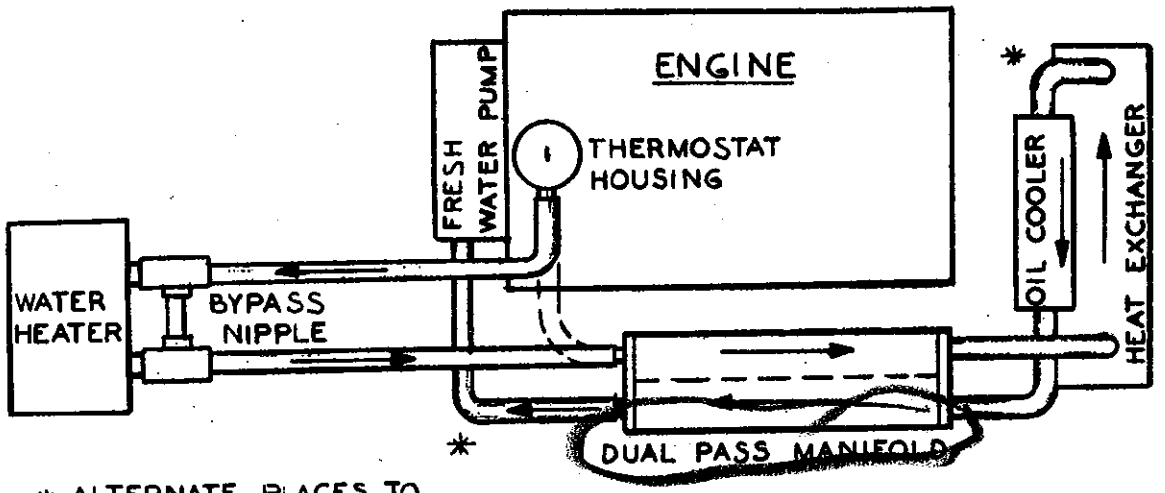
P/N: 21814



* ALTERNATE PLACES TO INTERRUPT CIRUIT AND CONNECT HEATER IN SERIES.