

TECHNICAL MANUAL AND PARTS LIST

WESTERBEKE

15 hp Mini-Diesel Engine MODEL FOUR-60

Publication Number 16521

Issue Date June 1, 1972



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INTRODUCTION

This manual describes the operation, adjustment and maintenance of the Westerbeke Model Four-60 Marine Diesel Engine, and is designed to be a guide for those concerned with the operation and maintenance of these diesels.

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

Therefore, it follows to a great extent that a diesel engine requires the same preventive maintenance as that which any intelligent and careful 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 a "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. Carburetor and ignition systems are done away with and in their place is a single component – the Fuel Injection Pump – which performs the functions of both.

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

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

Please supply:

For Four-60 Marine Diesel Engine No. 3870

10 of 11951 LUBE OIL FILTERS

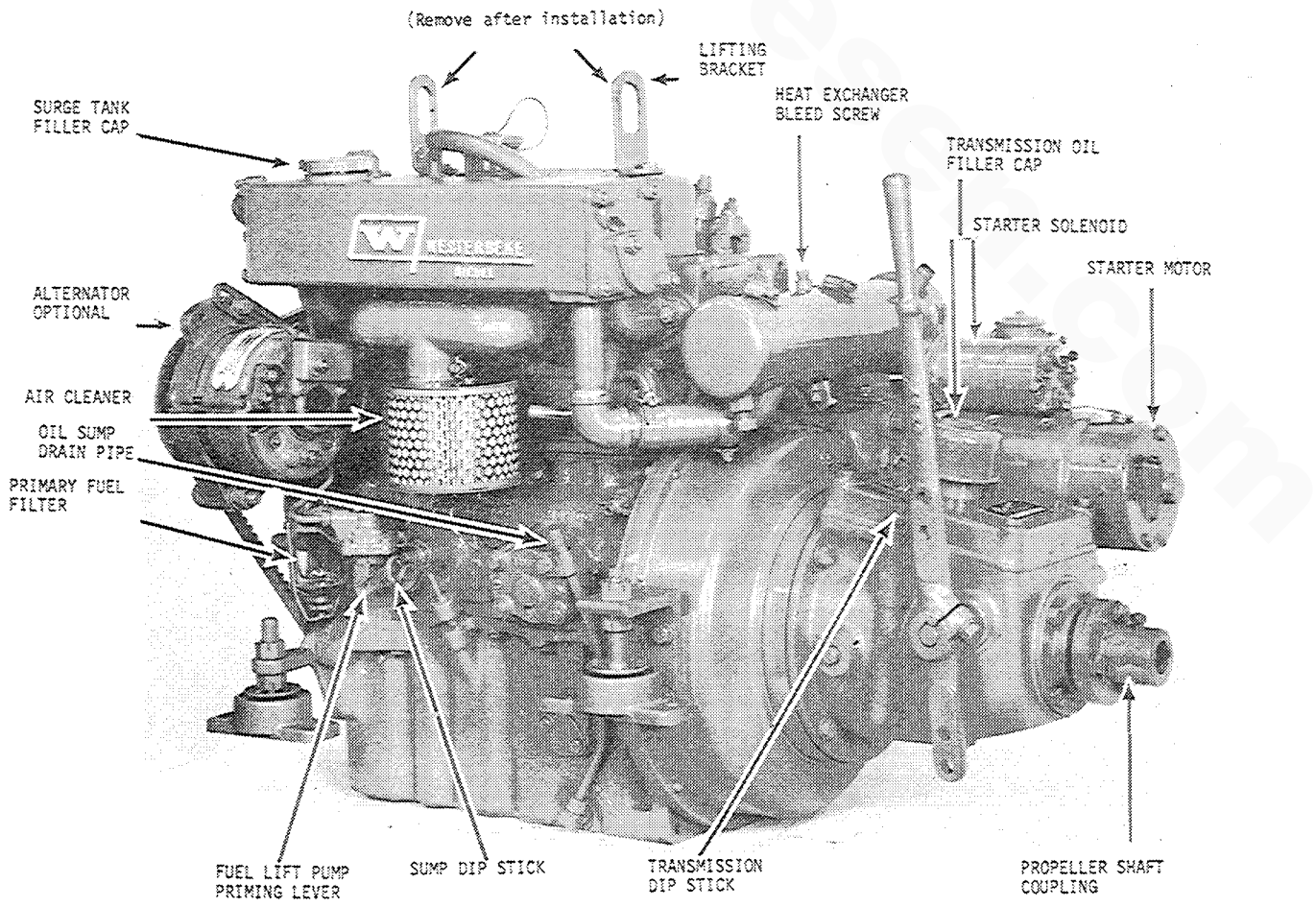
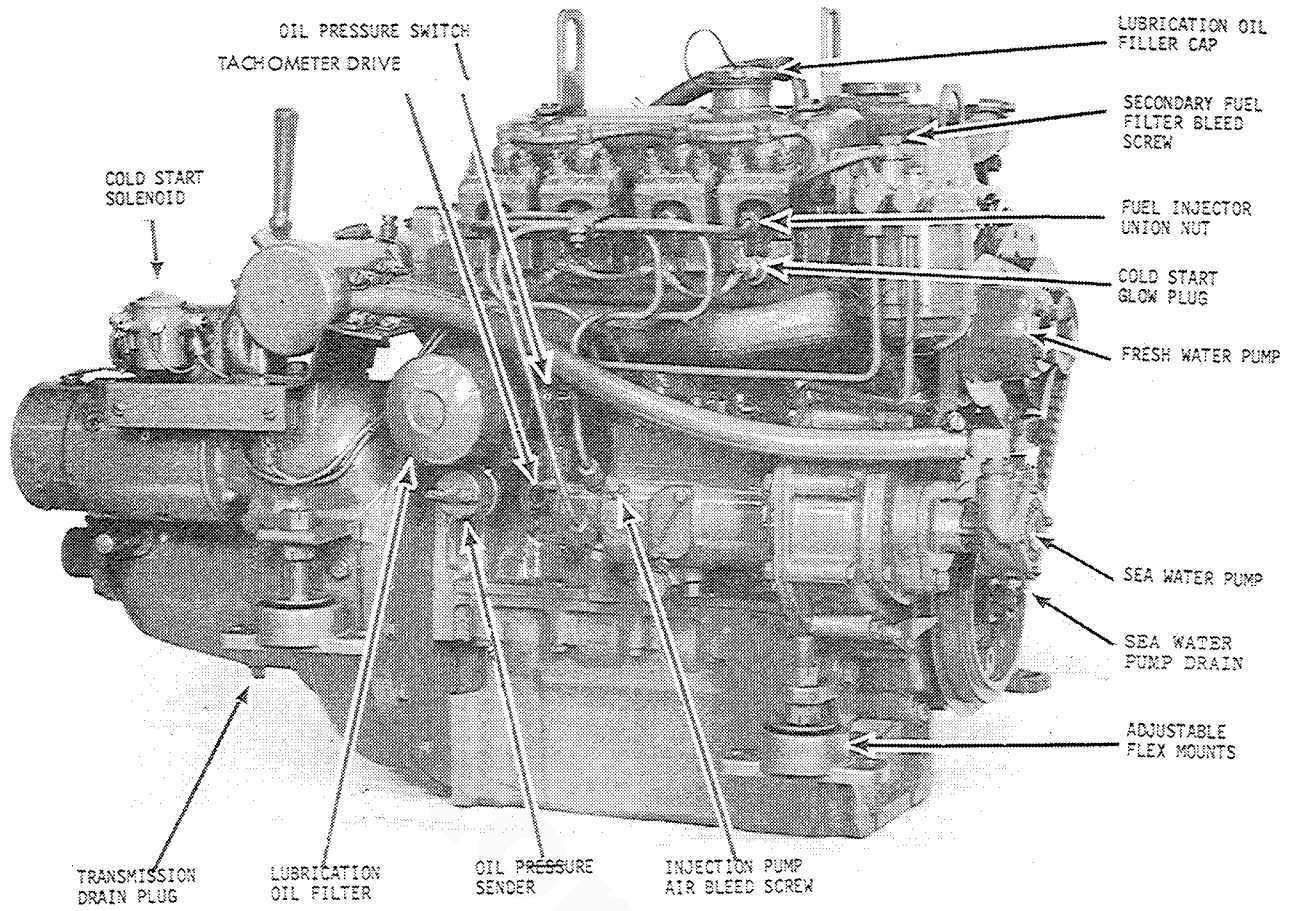
The serial number is stamped on the name plate affixed to the exhaust manifold.

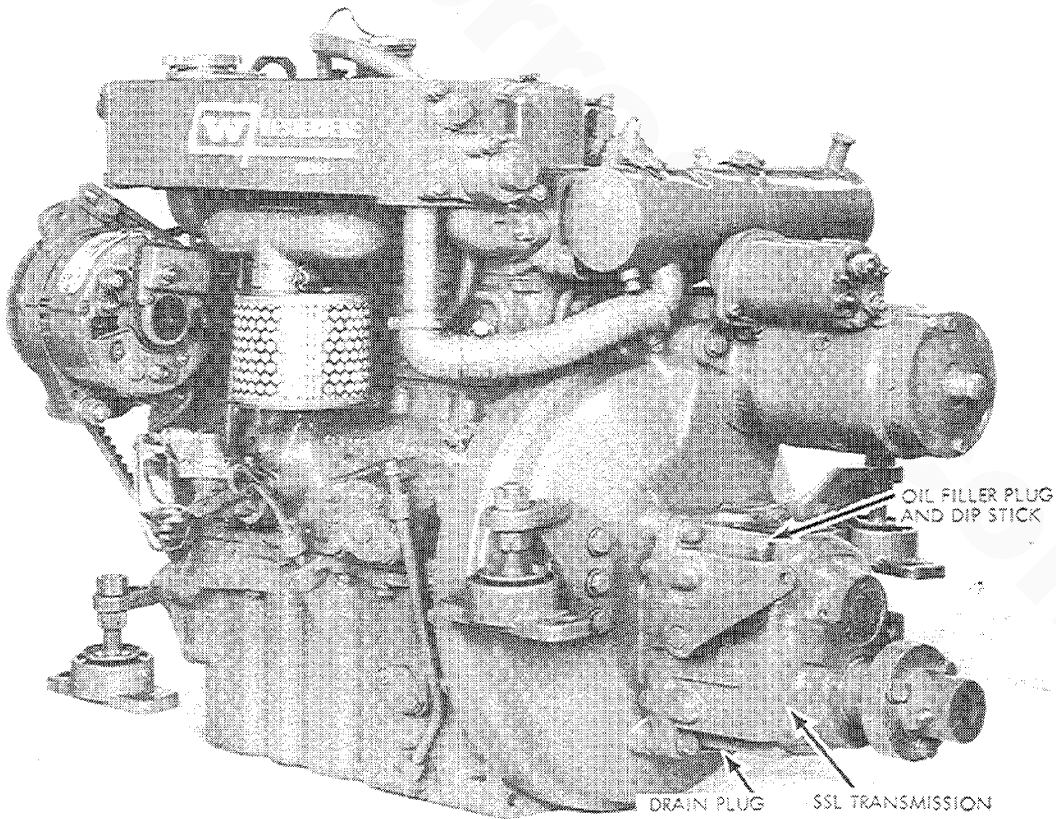
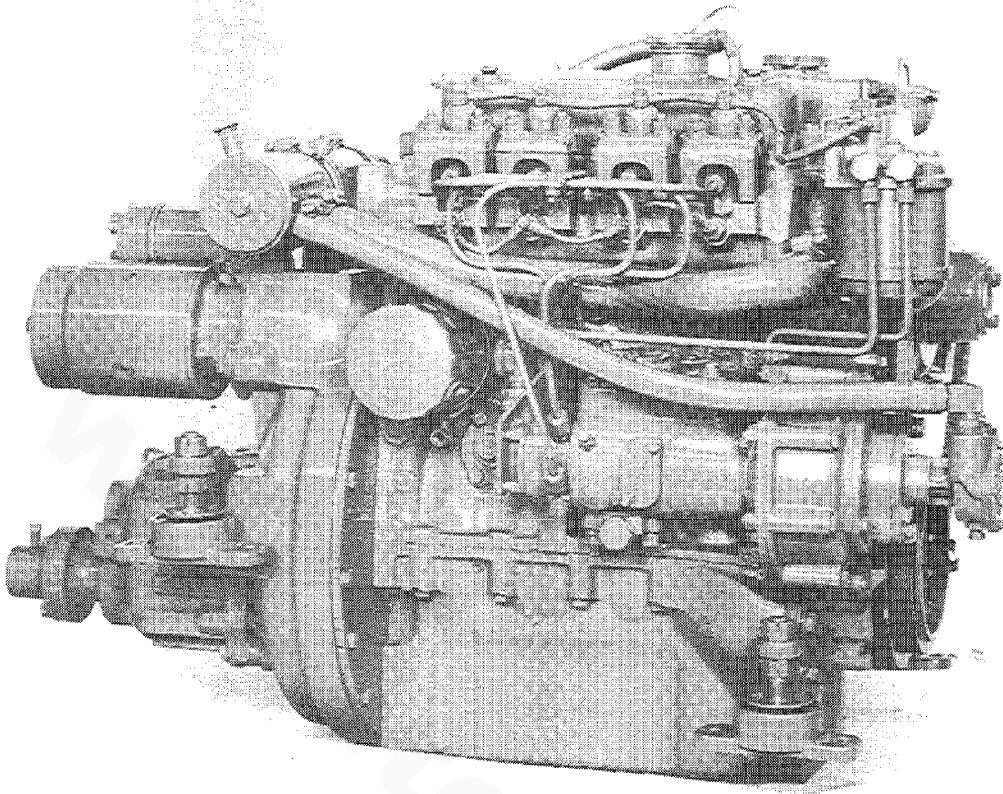
WESTERBEKE MODEL FOUR-60

15 h. p. Mini Diesel Engine

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STARBOARD AND PORT VIEWS-FOUR 60/SSL

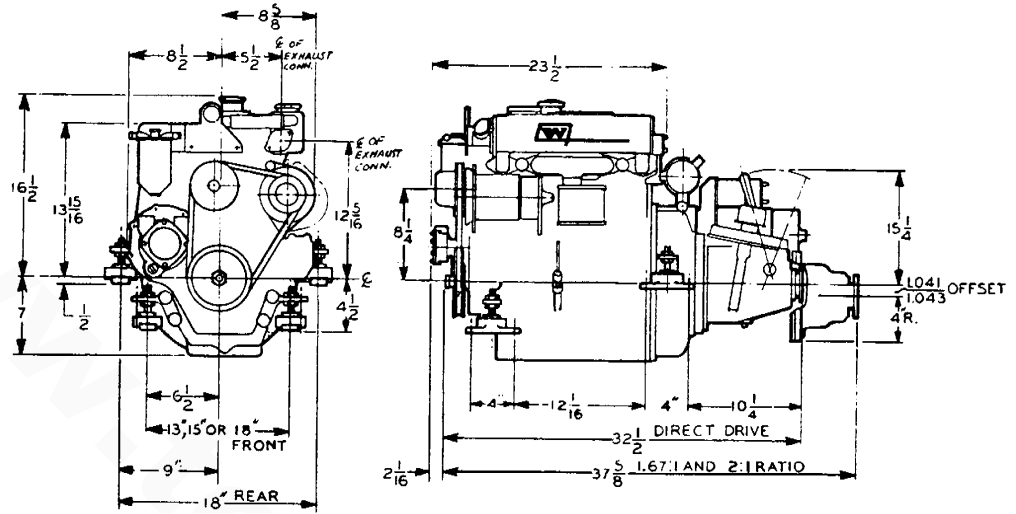
Photos above show the SSL Transmission which was designed for the Four-60 Diesel. The gear is available in two Ratios, 1.3:1 and 2:1.

Its small size and moderate offset greatly increases installability of Four-60 by decreasing length to 30 inches and reducing depth below propeller shaft line to 4 3/4 inches.

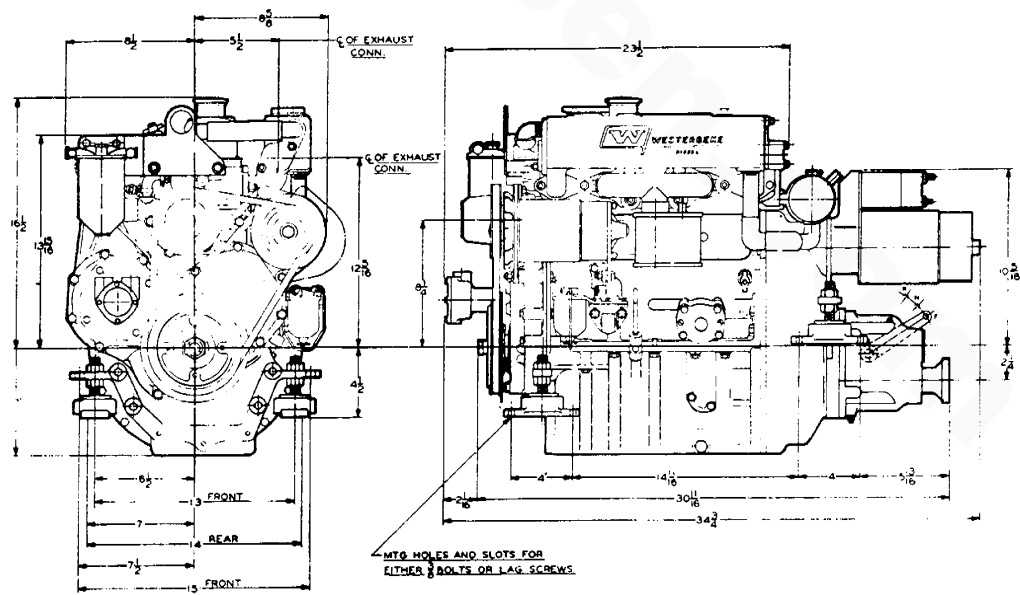
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INSTALLATION DRAWINGS



Four-60/SAO Reverse and Reduction Gear



Four-60/SSL Reverse Gear

DIESEL ENGINE

Number of cylinders	4.
Compression ratio	23·6 : 1.
Bore	2·477 to 2·4785 in. (62·915 to 62·941 mm.).
Stroke	3·0 in. (76·2 mm.).
Capacity	57·9 cu. in. (948 c.c.).
Idling speed	600 r.p.m.
Maximum governed light running speed	2,750 r.p.m.
Maximum speed under load	2,500 r.p.m.
Torque	38 lb. ft. (5·32 kg. m.) at 1,750 r.p.m.

Pistons and rings

Piston ring groove clearance:		
No. 1—compression	·0025 to ·0045 in. (·062 to ·113 mm.).
Nos. 2 and 3—compression	·0015 to ·0035 in. (·038 to ·097 mm.).
Nos. 4 and 5—oil scraper	·0015 to ·0035 in. (·038 to ·097 mm.).
Piston ring fitted gap:		
No. 1—compression	·010 to ·015 in. (·254 to ·381 mm.).
Nos. 2 and 3—compression	·007 to ·012 in. (·178 to ·305 mm.).
Nos. 4 and 5—oil scraper	·007 to ·012 in. (·178 to ·305 mm.).
Piston to bore clearance (at bottom of skirt)	·0031 to ·0037 in. (·787 to ·940 mm.).

Gudgeon pins

Fit in piston	·00025 in. (·0063 mm.) slack, to ·00015 in. (·0038 mm.) tight.
Clearance in small-end bush	·0001 to ·0005 in. (·0025 to ·0127 mm.).

Connecting rods

Length between centres	5·75 in. (146·05 mm.).
Side clearance on crankshaft	·006 to ·010 in. (·152 to ·254 mm.).

Crankshaft and bearings

Journal diameter	2·0005 to 2·001 in. (50·813 to 50·825 mm.).
Crankpin diameter	1·7505 to 1·7510 in. (44·462 to 44·475 mm.).
Main bearing clearance	·001 to ·0027 in. (·025 to ·068 mm.).
Big-end bearing clearance	·001 to ·0027 in. (·025 to ·068 mm.).
Crankshaft end-float	·002 to ·003 in. (·051 to ·076 mm.).

Camshaft and bearings

Bearing clearance	·001 to ·002 in. (·025 to ·051 mm.).
Camshaft end-float	·003 to ·007 in. (·076 to ·178 mm.).

Timing chains and wheels

Camshaft drive	Duplex roller chain.
Injection pump drive	Simplex roller chain.
Injection pump chain wheel bearing liner:		
Inside diameter (finished in position)	1·75025 to 1·75075 in. (44·456 to 44·469 mm.).
Clearance on hub	·001 to ·002 in. (·025 to ·051 mm.).

GENERAL DATA — continued

Valve mechanism

Valve opens } with .020 in. (.508 mm.) valve rocker clear-
 Valve closes } ance
 Valve seat angle
 Valve seat face width
 Valve stem to guide clearance
 Valve rocker clearance—cold
 Valve lift
 Valve stand-down

Inlet	Exhaust
5° B.T.D.C. 30° A.B.D.C. 45° .075 in. (1.906 mm.)	45° B.B.D.C. 5° A.T.D.C. 45° .075 in. (1.906 mm.)
.0015 to .0025 in. (.038 to .062 mm.)	.002 to .003 in. (.051 to .076 mm.)
.012 in. (.305 mm.)	.012 in. (.305 mm.)
.276 in. (7.01 mm.)	.276 in. (7.01 mm.)
.018 to .038 in. (.457 to .965 mm.)	.018 to .038 in. (.457 to .965 mm.)

Valve springs:

Free length
 Fitted length—valve closed
 Fitted length—valve open
 Load to compress to fitted length—valve open

Inner	Outer
1.672 in. (42.471 mm.)	2.047 in. (52 mm.)
1.165 in. (29.6 mm.)	1.328 in. (33.746 mm.)
.889 in. (22.576 mm.)	1.052 in. (26.746 mm.)
28.7 lb. (13 kg.)	43 lb. (19.5 kg.)

Rocker shaft diameter
 Rocker shaft to bush clearance
 Tappet diameter

.5615 to .5625 in. (14.263 to 14.288 mm.).
 .0005 to .002 in. (.013 to .051 mm.).
 .81125 to .81175 in. (20.606 to 20.618 mm.).

Flywheel and starter ring

Number of teeth on starter ring
 Starter ring fitting temperature

94.
 200 to 230° C. (392 to 446° F.).

Oil pump

Rotor end-float
 Rotor lobe clearance

.003 in. (.076 mm.) maximum.
 .004 in. (.102 mm.) maximum.

Oil pressure relief valve

Spring free length
 Spring fitted length
 Load to compress spring to fitted length

2.86 in. (72.64 mm.).
 2.156 in. (54.77 mm.).
 13.5 lb. (6.127 kg.).

Oil pressure

Idling speed
 Normal running speed

15 lb./sq. in. (1.05 kg./cm.²).
 50 lb./sq. in. (3.52 kg./cm.²).

COOLING SYSTEM

Fan belt

Depth
 Width (outside)
 Angle of 'V'
 Lateral movement (measured at the vertical run)

$\frac{37}{64}$ in. (10.72 mm.).
 $\frac{1}{2}$ in. (12.7 mm.).
 40°.
 1 in. (25 mm.).

Thermostat

Opening temperature
 Fully open temperature

79 to 84° C. (175 to 183° F.).
 94 to 96° C. (201 to 205° F.).

Water pump spindle

Interference fit in hub
 Interference fit in vane

.0015 to .0028 in. (.038 to .071 mm.).
 .001 to .0023 in. (.025 to .058 mm.).

GENERAL DATA—continued

FUEL SYSTEM

Diesel models

Lift pump	A.C.—YE type.
Main filter	C.A.V. bowl-less.
Injection order	1, 3, 4, 2.
Static injection timing	16° B.T.D.C.

Injection pump

Type	DPA 3248530.
Roller to roller dimension	1.962 in. (49.84 mm.).
Governor link length	2.087±.039 in. (53±1 mm.).

Injectors

Nozzle	BDN.O.SPC.6389.
Nozzle holder	BKB.35S.5237.
Opening pressure	135 atmospheres.
Needle lift6 to .75 mm.

Torque Wrench Settings

Cylinder head nuts .. .	60 ft. lbs.
Injector clamp nuts .. .	15 ft. lbs.
Rocker bracket nuts .. .	25 ft. lbs.
Flywheel bolts .. .	40 ft. lbs.
Main bearing bolts .. .	70 ft. lbs.
Connecting rod bolts .. .	35 ft. lbs.
Injector nozzle nuts .. .	50 ft. lbs.

Electrical System

Nominal voltage .. .	12 volts (negative ground)
Battery (NOT supplied with engine)	
Terminal voltage .. .	12 volts
Recommended capacity .. .	130 ampere hours
Generator .. .	negative ground
Capacity .. .	14 amperes
Voltage .. .	12 V. D. C.
Alternator (optional)	
Capacity .. .	55 amperes
Voltage .. .	12 V. D. C.

TRANSMISSIONS

Four-60 Gear Options

SAOD .. .	Direct Drive
SA002 .. .	2:1 RG
SAOV .. .	1.29:1 RG
	1.67:1 RG
	2:1 RG
SSL-13 .. .	1.3:1 RG
SSL-20 .. .	2:1 RG

INSTALLATION

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INSTALLATION

FOREWORD

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 ensure good operating conditions for the engine and correct procedure in servicing the engine.

INSPECTION OF SHIPMENT

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

FOUNDATION FOR ENGINE

A good engine bed contributes much towards the satisfactory operation of the engine. The engine bed must be of rigid construction and neither deflect or 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 not only support the engine firmly in the exact position but 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 fibreglas 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 fibreglas "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".

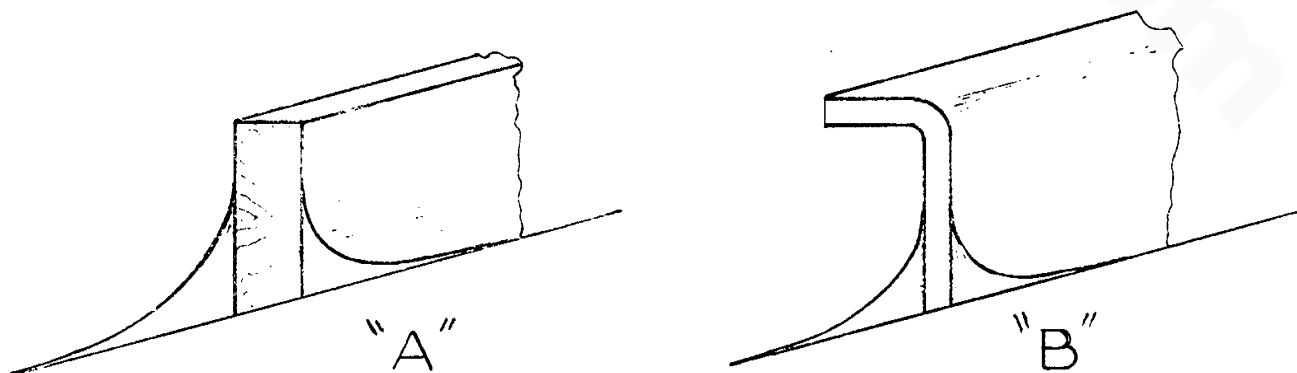


Fig. 1. Bed Design A and B

ENGINE BOLTS

It is recommended that 3/8 inch lag bolts (hanger bolts), preferably of bronze, be used through the engine supporting 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 nuts on top of the lag bolts are used to tighten the engine down or are loosened to permit the engine to be moved. The bolt itself stays in position at all times as a stud and the bond between the bolt and the wood is not weakened by its removal.

PROPELLER COUPLING

Each Westerbeke Diesel engine is fitted with a suitable coupling for connecting the propeller shaft to the engine. The coupling is very carefully machined for accurate fit. The forward end of the propeller shaft has a long, straight keyway and any burrs should be removed from this 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.

If it seems difficult to fit 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 center line or axis of the propeller shaft.

ALIGNMENT

When making the alignment between the engine and propeller shaft half couplings, take plenty of time 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 counter-bore with no interference and when a feeler gauge indicates that the flanges come together at all points. The two halves of the coupling should be parallel within 0.001 inch if possible. However, the maximum allowable tolerance must not exceed 0.001 inch per inch of coupling O. D. In making the final check for alignment, the engine half coupling should be held in one position and the alignment with the propeller half coupling checked in each of four positions 90 degrees apart. Keeping the propeller coupling in one position, the alignment should be checked by rotating the engine shaft half coupling in each of four positions 90 degrees apart.

If initial alignment is accomplished during boat construction or while the boat is still on its cradle, the coupling should be disconnected and all alignment rechecked shortly after launching.

The engine alignment should be re-checked after the boat has been in service for one to three weeks, and if necessary, the alignment re-made. It will usually be found that the engine is no longer in alignment. This is not because the work was improperly done at first, but because the boat has taken some time to take its final shape and the engine bed has probably absorbed some moisture.

NOTE: A fiberglass boat requires the same "Alignment" procedures above as wood or any other material used in boat construction.

EXHAUST LINE INSTALLATION

Exhaust line installations vary considerably and each must be designed for the particular job. Four particular cautions apply:

1. The exhaust line must be designed so that sea water or engine raw water discharge cannot possibly run back into the engine.

2. The exhaust line should be supported so that its weight does not rest on the manifold flange.
3. Use a flexible section preferably of stainless steel at the manifold flange (which should be asbestos-wrapped due to the high temperature) and no less than 12 inches overall length, threaded at each end.
4. The exhaust pipe must be of sufficient size to handle the exhaust gases from the engine properly and should never be made smaller than the opening of the exhaust manifold. The I.D. of the exhaust should be increased 1/2 inch for every ten feet of length beyond the first ten.

ENGINE COOLING SYSTEM

The Westerbeke Four-60 diesel is fresh water cooled, utilizing what is known as a "closed system", wherein the fresh water is circulated by a centrifugal pump through the engine block and head, exhaust manifold, and heat exchanger. The heat exchanger is cooled by the sea water pump.

FUEL PIPING

We recommend 1/4 inch O.D. copper tubing together with suitable fittings, both for the supply line and 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 lock."

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 the flexible rubber hoses supplied.

FUEL SUPPLY (see Fig. 2 for Fuel injection Pump lever control positions)

To ensure satisfactory operation, a Diesel engine must have a dependable supply of clean fuel oil. For this reason, cleanliness and care are especially important at the time when the fuel tank is installed because dirt left anywhere in the fuel lines or tank will certainly cause fouling of injector nozzles when the engine is started for the first time. If a molded tank of fiberglass is used, be certain that the interior is gel-coated to prevent fibres from contaminating the fuel system.

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

Two fuel filters are provided with the engine; one is an integral part of the fuel lift pump (called the Primary Filter), the other mounted on the engine (called the Secondary Filter). The Primary Unit has a bowl and screen, the purpose of which is to trap water and has the advantage that the owner can tell at a glance if water or dirt is collecting in the glass bowl. The Secondary Filter is a replacement element type, the purpose of which is to filter all contaminants before the fuel oil reaches the injection system. Connection for the fuel supply line is on the fuel lift pump which has a hand primer required for filling the fuel supply lines and the filters, and for purging the system of air when engine is started for the first time, or whenever the system has been opened for any reason.

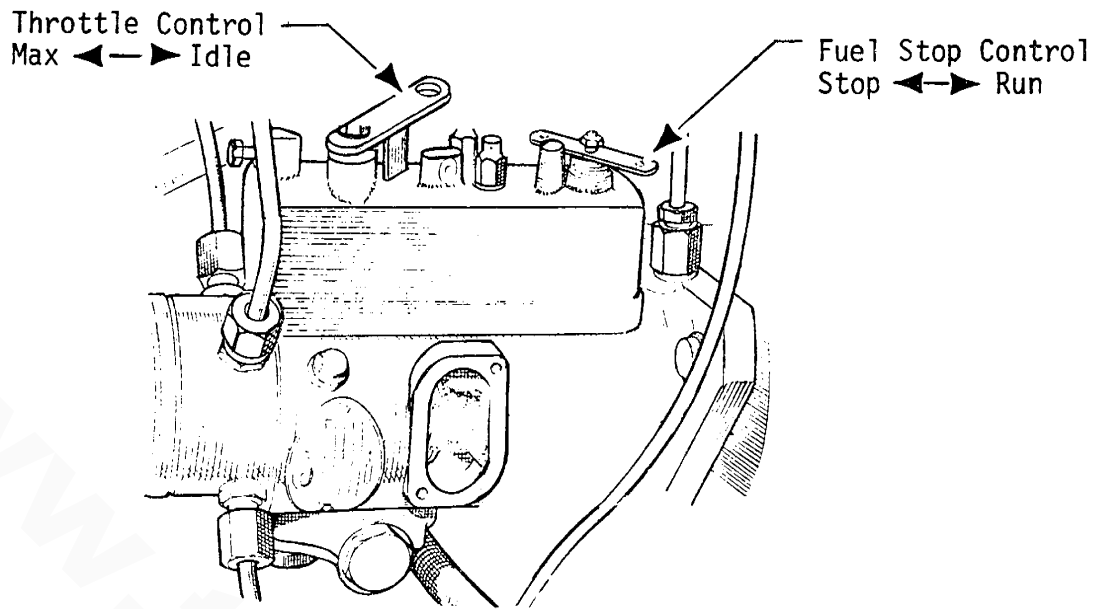


Fig. 2 Fuel Injection Pump Throttle and STOP/RUN Lever Control Positions

NOTE: The fuel injection pump Fuel Stop Control lever should be spring loaded to the run position.

CONTROLS

If manual SAO transmission is used, clutch control may be either Morse type MJ or conventional rod and lever assembly. Type SAO transmissions normally require 25 pounds of effort on the clutch handle or 75 pounds if Morse type cable is connected at the point four inches from the cross shaft. (75 pounds @ 4 inches is reduced again to 25 pounds at the operating station through the leverage ratio of the Morse MJ mechanism.) Whether flexible cable or rod and levers are used, it is imperative that installation be done precisely and in a workmanlike manner. Cable bends must be gradual. Anchor points must be securely fixed to rigid members so that effort put into the clutch handle reaches the clutch cross shaft without lost motion. With rod and lever installations, it is desirable to maintain balance among the several members so that the weight of components does not tend, of itself, to pull the clutch lever from neutral position towards either "Ahead" or "Astern".

SSL Transmission may be used; it is highly efficient, simple in design, and is ideally suited to control by the Model ML Morse single lever control. The necessary cable ends and attaching kits we have designed for this unit are on our list of accessories. (The control and cables should be purchased locally through Morse dealers.) In addition to the throttle and clutch function handled by the ML control, there is also a stop-run lever. These are most easily controlled by Bowdoin wires which should be mounted adjacent to the starter button.

SAO Transmissions require Left-Hand Propellers
 SSL Transmissions require Right-Hand Propellers

ELECTRICAL SYSTEM

All electrical accessories on a standard production Westerbeke Four-60 Diesel Engine operate on a negative grounded 12 volt system. Included with the engine is a 14-ampere generator mounted to the engine. Shown in Fig. 3, is a wiring diagram for a generator and skipper panel, or Fig. 4, a wiring diagram for an optional 55-ampere alternator and Westerbeke All Electric panel.

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

- #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

PREWIRING AND OPTIONS

1. Prewiring

Prewiring includes the installation and wiring of the following devices: alternator, regulator, starting motor, starter solenoid, instrument senders, connecting terminal blocks, pressure and temperature switches, separate key switch panel including the pre-heat function. The cable used to connect the engine and its key switch panel is neoprene jacketed, waterproof, very flexible and meets ABYC standards. This cable includes two #10 conductors for the pre-heat function and two #6 conductors for the ammeter. Chief advantages are pre-wiring will be elimination of wiring mistakes and minimum installation time. The cables are 10 foot lengths to accommodate all installations.

2. All Electric Panel

The Westerbeke all electric panel utilizes an electronic tachometer with a built-in hour meter. Tachometer cables are no longer required. The panel is anodized aluminum, epoxy paint protected, for long lived finish. The marine instruments are an ammeter, water temperature gauge and oil pressure gauge and each instrument is back lighted. This new all electric panel is isolated from ground and may be used with negative ground, positive ground, or isolated ground electrical systems and may be mounted where visible. It must be used with the 55-amp alternator.

3. Factory Installed Engine Alarm System (Optional)

This alarm system, to indicate the existence of high water temperature or low oil pressure, is designed and installed on your Westerbeke diesel at the factory. It consists of an audible alarm to indicate either failure, the alarm being part of the key switch panel. The high water temperature and low oil pressure switches are set for compatibility with the engine. The alarm system is energized by the key switch at the key switch panel and can be de-energized by the same key switch, should the operator wish to turn off the alarm.

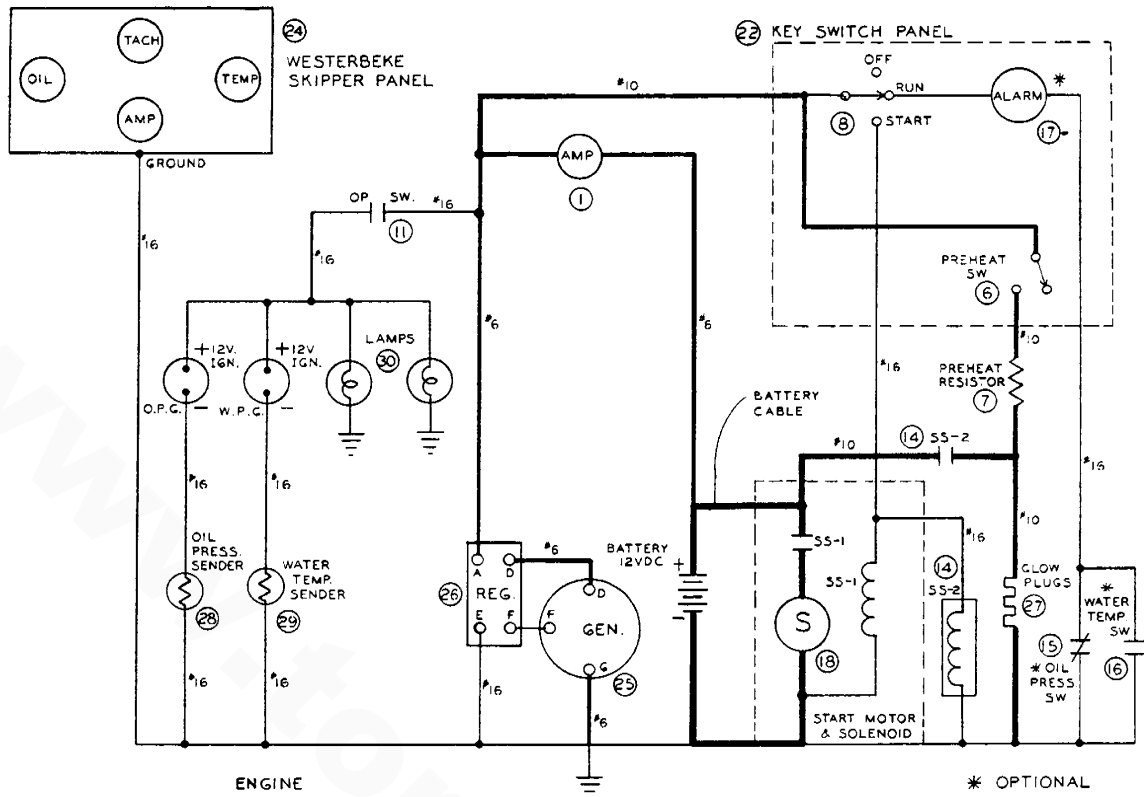


Fig. 3 Wiring Diagram with Generator and Skipper Panel

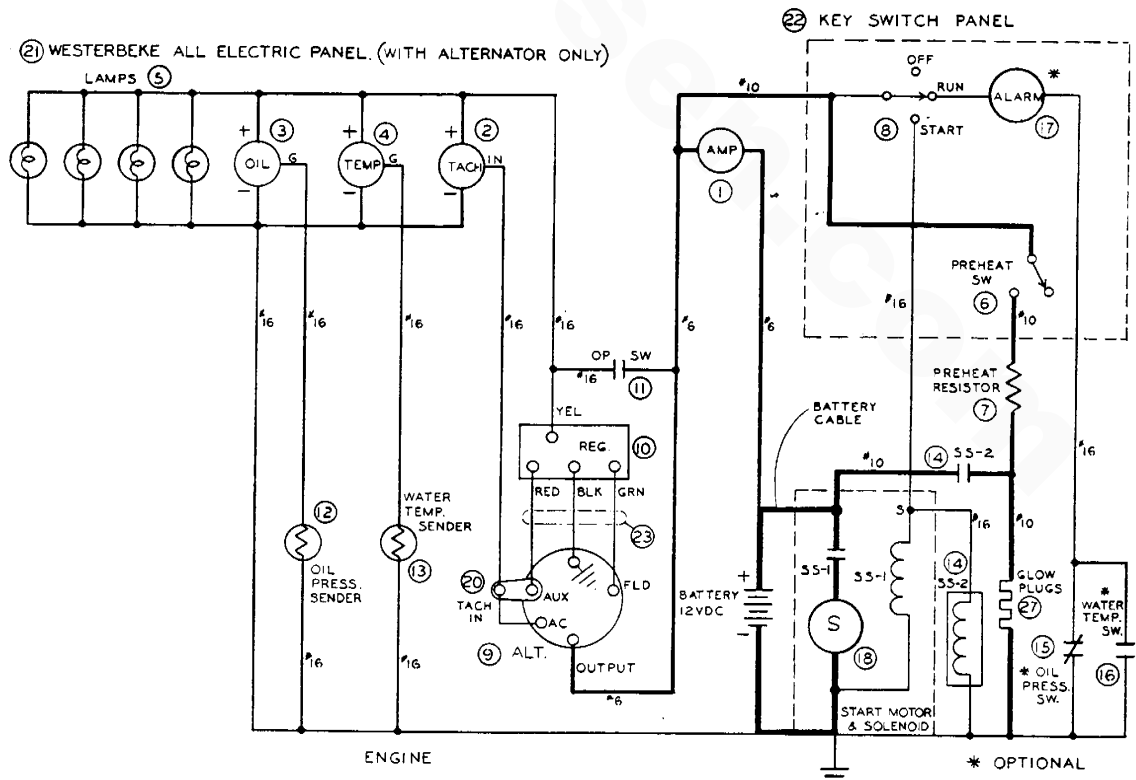


Fig. 4 Wiring Diagram with Alternator and Electric Panel

STARTING AID (Fig. 5)

The starting aid on Westerbeke Four-60 consists of a combustion chamber glow plug preheater which operates by heating the air coming into the combustion chamber. Due to the drop in battery voltage from 12 volts to 9 volts during an engine cranking, four 9-volt glow plugs are used to provide full preheat power during cranking. A resistor is used in the glow plug circuit to prevent burnout of the glow plugs when preheat is used without cranking the engine. A start solenoid is provided in the circuit to bypass this resistor and connect the glow plugs directly across the battery while cranking.

It is most important that the glow plug circuit be wired correctly to prevent burn-out of the glow plugs and provide battery charging.

To start the engine, depress the glow plug PRE-HEAT pushbutton for 30 seconds or longer (depending upon climatic conditions), and then engage the START switch. Both pushbutton and START switches should be released when the engine cranks. If after about 15 seconds cranking time the engine has not started, stop cranking for 15 seconds leaving the PRE-HEAT pushbutton depressed and then engage START switch.

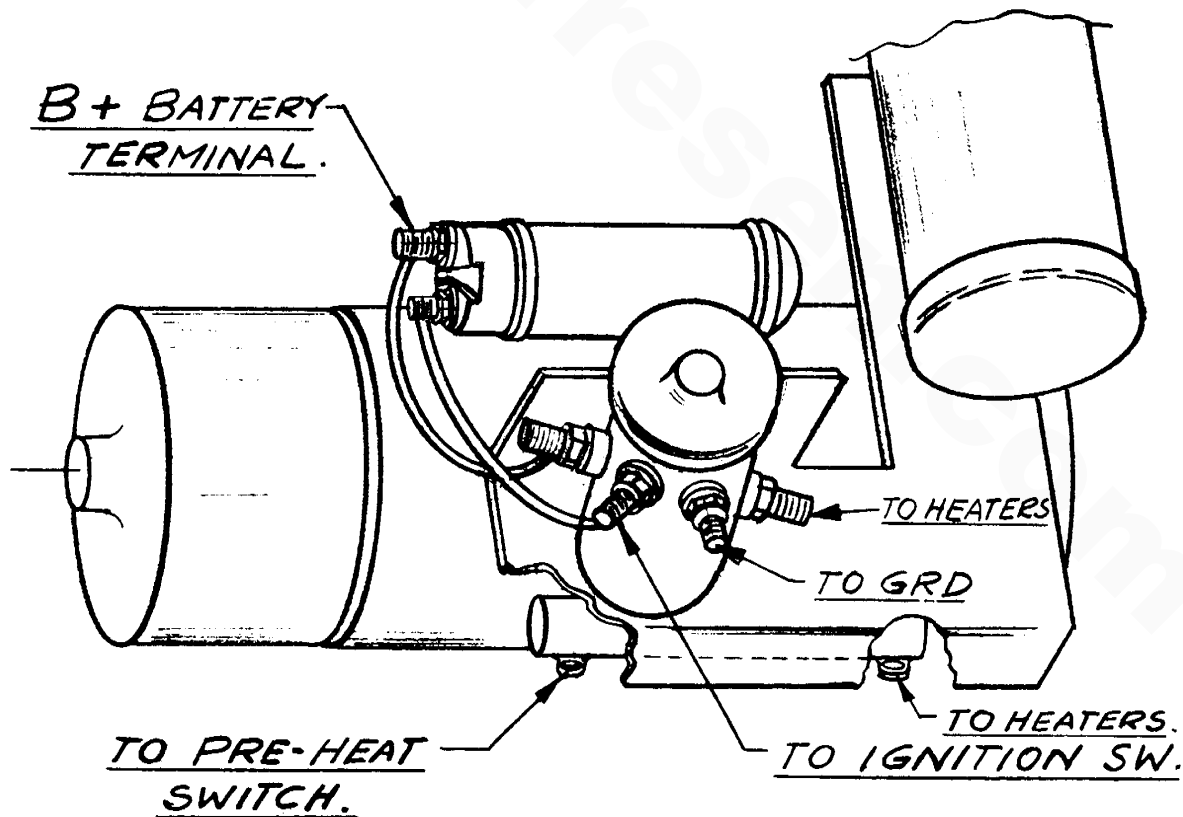


Fig. 5. Starting Aid – Glow Plug Preheat

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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
Chevron Oil Co.	BP Vanellus	10W/30	10W/30	10W/30
	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	Sunfleet MIL-B	10W	20W/20	30
Texaco, Inc.	Ursa Oil Extra Duty	10W	20W/20	30

OPERATION

PREPARATION FOR STARTING ENGINE AFTER INSTALLATION

The engine is shipped "dry", that is, with lubricating oil drained from the crank-case and transmission. The following procedure should be checked methodically before starting the engine for the first time.

1. Remove oil filler cap and fill oil sump with approximately 4.5 U. S. quarts of diesel lubricating oil to the highest mark on the dipstick. Refer to page 18 for an approved lubricating oil. Do not over fill. Select an approved grade listed and continue to use it.

NOTE: Due to the inclination of engine and transmission in the boat, more oil may be required than specified.

2. Remove reverse gear breather cap on SA0 gear or dipstick on SSL gear and fill with S.A.E. 30 lubricating oil to high mark on dipstick. Do not over fill.
3. Fill fresh water cooling system as follows:
 - a. Remove the square head vent screw top of heat exchanger.
 - b. Remove surge tank filler cap and fill the tank (integral with exhaust manifold) with fresh, clean water and/or anti-freeze (refer to Cold Weather Precautions) and when coolant free of air bubbles issues from the vent point, replace and tighten vent screw.
 - c. Fill surge tank to within one inch of top of tank. Replace filler cap.
4. Ensure storage battery water level is at least 3/8 inch 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 with a good grade of water pump grease.
7. Open valves in fuel line and bleed fuel system (refer to Bleeding the Fuel System).

BLEEDING THE FUEL SYSTEM

One possible cause of failure to start, or erratic engine performances is that air may have entered the system, in which case "bleeding" of the system will be necessary.

Before bleeding the system, first ensure that there is an adequate supply of fuel in the tank and that the fuel supply is turned on.

1. Slacken the banjo bolt securing the injectors "fuel return pipe banjo" to secondary fuel filterhead. Operate the priming lever on the lift pump, and when fuel issues from the banjo bolt free of air bubbles, tighten bolt.

NOTE: It will not be possible to operate the lift pump hand priming lever if the cam on the camshaft driving the fuel lift pump is on maximum lift. If such a condition arises operate the cranking motor until the hand primer lever can be used.

2. Slacken the air bleed screw on the fuel injection pump, situated directly above the pump nameplate. Operate the lift pump priming lever, and when fuel flows from the bleed screw free of air bubbles, tighten the bleed screw.
3. Slacken the union nuts at injector end of each of the high pressure pipes (pipes going from the injection pump to each of the four injectors).
4. Position shift lever in neutral.
5. Ensure fuel STOP push-pull control is in full run position. (Push in to run.)
6. Advance throttle to maximum open position. (For maximum fuel flow.)
7. Turn key switch to START position, and when fuel oil free of air bubbles issues from each injector pipe union, tighten union.

TO START ENGINE

1. Position shift lever to neutral.
2. Push fuel stop control into full RUN position.
3. Advance throttle to maximum (to obtain maximum fuel for easier starting).
4. Depress PRE-HEAT pushbutton for approximately 30 seconds or longer, depending on climatic conditions.
5. Turn key switch to START position and hold. Release when engine starts.
6. Immediately upon starting, position throttle to idle setting.

NOTE: Never operate the cranking motor continuously for more than 15 seconds. If engine has not started, stop cranking for 15 seconds leaving the PRE-HEAT pushbutton depressed and turn switch to START position. The engine should start within a few revolutions of the crankshaft if battery is charged and the engine is getting fuel. The cranking motor turning over fast indicates the battery is charged. If battery is charged and engine doesn't start, check fuel system as follows:

- a. Ensure the fuel valve between tank and engine is open.
- b. Ensure the fuel STOP/RUN control lever is in the full RUN position at the stop control lever on the injection pump.
- c. Check for leaks in fuel lines and at gaskets of fuel filters.
- d. Determine if fuel is reaching injectors by performing procedures 3 to 7, "Bleeding Fuel System". If fuel oil doesn't issue from union nuts at injectors, bleed complete system.

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. (This applies after cooling system has been drained or filled for the first time.) Stop engine after engine 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 of 800-900 rpm, until oil pressure gauge indicates approximately 50 psi and water temperature gauge indicates 130-150°F. If necessary, engine 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. Prolonged idling. When required to run engine at idle speed of 600 rpm for a prolonged time, increase speed to 1000 rpm for at least three minutes every half hour to accelerate oil circulation and thus to eliminate conditions favorable to sludge and carbon formation.
8. 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 firmly held in the reverse position since it has no positive overcenter locking mechanism.

TO STOP 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 lack of improper 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 interruptions than any other factor.
8. Do not allow fuel to run low, because fuel intake may be uncovered long enough to allow air to enter the fuel system, resulting in engine stoppage.

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.

COLD WEATHER PRECAUTIONS

1. Precautions against damage by freezing should be taken if the engine is to be left exposed to inclement weather by adding an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor. As these engines are equipped with high temperature thermostats, a permanent type anti-freeze with an Ethylene Glycol Base should be used.
2. Draining Cooling System. Remove the pressure cap from the expansion tank and open the petcock (turn counterclockwise) near the flywheel housing on the fuel hand pump side of the cylinder block.
3. Bleed Cooling System. When filling the cooling system with the correct amount of anti-freeze and/or water for the degree of protection required, remove the square head vent screw on top of the heat exchanger, and when coolant free of air bubbles issues from this vent point, replace and tighten vent screw. Fill the expansion tank to within one inch from top of tank. Start engine and run engine for 3 or 4 minutes. Stop engine and add coolant as necessary.

NOTE: The strength of the anti-freeze solution must be maintained by topping off with the solution as necessary.

4. Fuel filters must be checked more often, particularly the primary filter (glass bowl, water trap, and screen) to remove all the moisture and condensation separated from the fuel, otherwise this may freeze and stop the fuel flow.

POST DELIVERY CHECKOUT

After a customer has taken delivery of his engine, it is advisable in his own interest, that a general check-over of the engine be carried out after the first 50 hours in service.

1. Retorque the cylinder head bolts (refer to Section A. 8, Par. 34 b).
2. Retorque the rocker bracket nuts and adjust the valve rocker clearance (refer to Section A. 7, Par. 15 a and b).
3. Check and adjust if necessary forward drum assembly and reverse band on manual SAO type transmissions. (No adjustment required on the SSL transmission.)
4. Change engine lubricating oil and oil filter.
5. Check for fuel and lubricating oil leaks, and rectify 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. (paying particular attention to loose engine mount fittings which could cause mis-alignment and subsequent problems.)

MAINTENANCE SCHEDULE

DAILY

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 one firm turn.
5. Check lubricating oil level in transmission, fill to high mark on dipstick.

EVERY 50 HOURS

1. Check generator or alternator "V" belt for tension.
2. Check water level in battery.

EVERY 100 HOURS

1. Change oil in sump. Oil may be sucked out of the sump by attaching a suction hose of 3/8 inch I. D. over the outside of the oil sump pipe, located aft of the dipstick.
2. Replace lubricating oil filter.
3. Fill sump with approximately 4.5 U. S. quarts of diesel lubricating oil to high mark on dipstick. Do not over fill. Refer to page 18 for an approved lubricating oil and continue to use it.

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.

4. 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.
5. Change oil in transmission. Use SAE 30, High Detergent Lubricating Oil, Service DG, DM, or DS. Do not overfill.
6. Clean Air Filter.

NOTE: The time period for replacing the air filter depends on operating conditions, therefore, under extremely dirty conditions, the time limits of 250 hours should be decreased. The correct time periods for replacing the filter will greatly assist in reducing bore wear, thereby extending the life of the engine.

EVERY 150 HOURS

1. Check engine for loose bolts, nuts, etc.
2. Check sea water pump for leaks.

EVERY 250 HOURS

1. 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.
2. Replace secondary fuel filter element.
3. Replace air filter.

END OF SEASON SERVICE

When a craft is to be taken out of service for the winter, it is advisable that some measure of protection be afforded the engine.

It is recommended, therefore, that the following procedures be applied immediately after the unit is withdrawn from service:

1. Drain fresh water cooling system by removing the surge tank pressure cap and opening the petcock (turn counter-clockwise) near the flywheel housing on the fuel hand pump side of cylinder block.
2. Remove the hex screw plug on port under side of heat exchange and determine if zinc rod in plug needs replacing. The zinc rod will take care of any electrolysis that may occur between brass and iron components. Insert new zinc rod in plug if necessary and replace plug.
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. Replace drain plug and 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 into cylinder bores 1/8 pint of lubricating oil divided between the 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 just as it was on completion of step (4) above.
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.

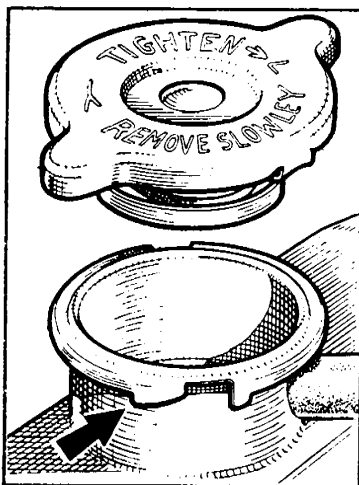


Fig. B2. The Filler Cap Showing One of the Safety Stops

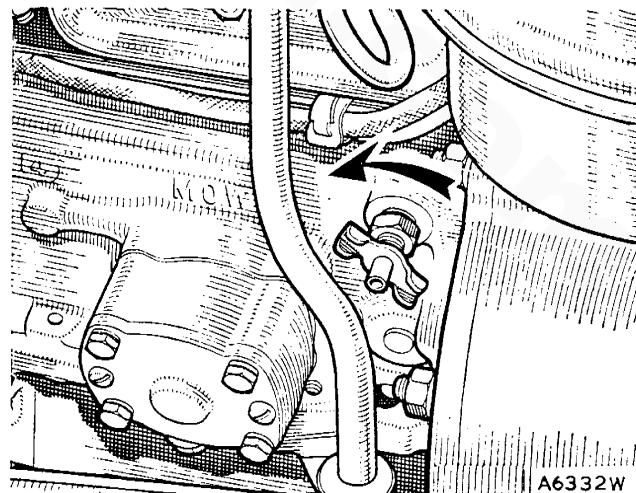


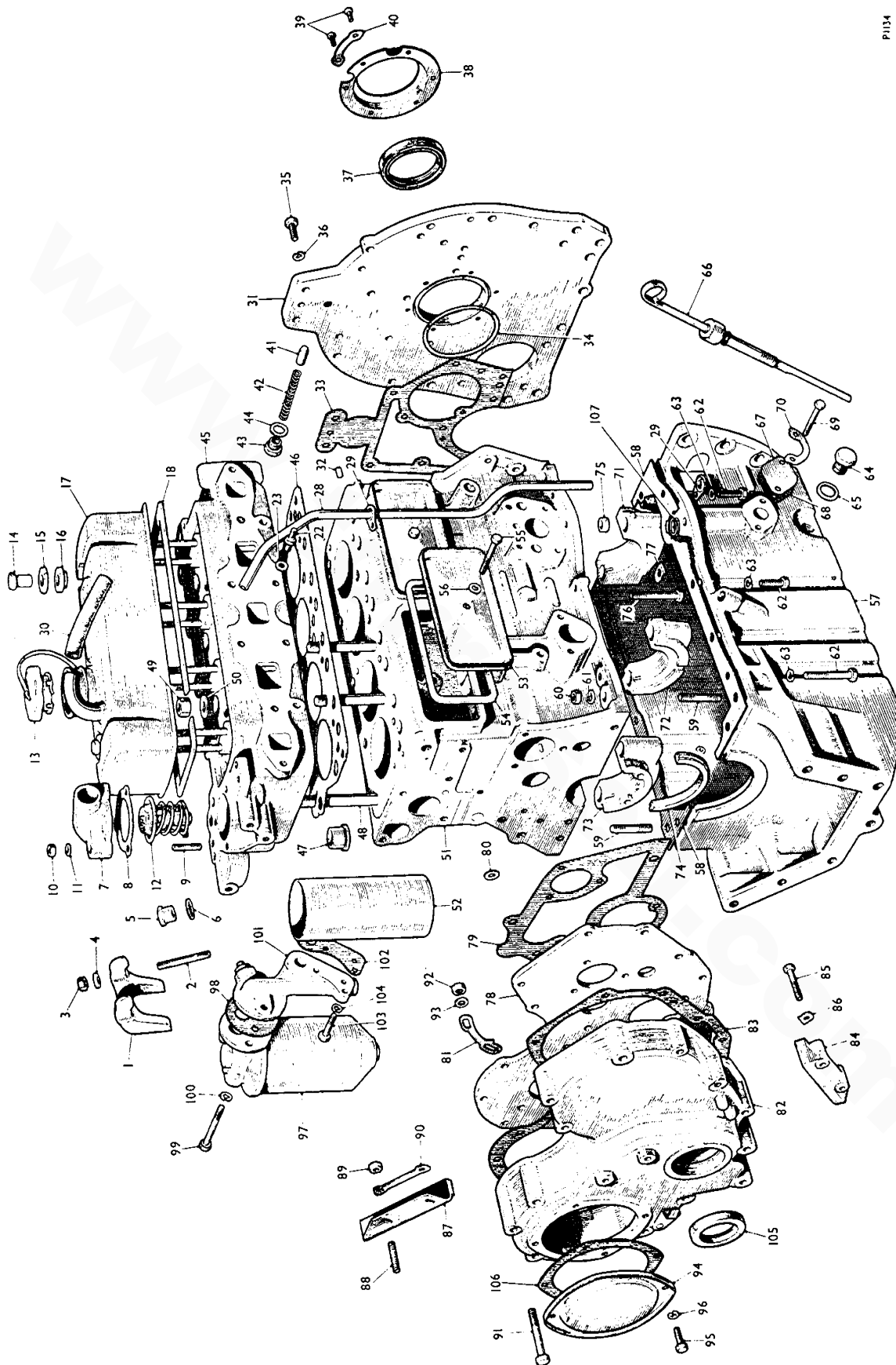
Fig. B3. The Cylinder Block Drain Tap. Turn the tap in the direction of the arrow to open

SECTION A

DIESEL ENGINE

	<i>Section</i>
Camshaft	A.9
Camshaft bearing liners	A.16
Connecting rods	A.12
Crankshaft	A.11
Cylinder head	A.8
Cylinder liners	A.17
Engine back plate	A.10
Engine front plate	A.9
Flywheel	A.10
Lubrication system	A.2
Oil filter—external	A.3
Oil pressure relief valve	A.5
Oil pump	A.4
Oil pump drive	A.6
Oil strainer	A.11
Pistons	A.12
Sump	A.11
Tappets	A.7
Timing chains	A.9
Timing chain tensioners	A.9
Timing chain wheels	A.9
Tractometer drive	A.6
Valves	A.8
Valve rocker clearance—adjusting	A.13
Valve rocker shaft	A.7
Valve seat reconditioning	A.15
Valve timing check	A.14

THE DIESEL ENGINE EXTERNAL COMPONENTS

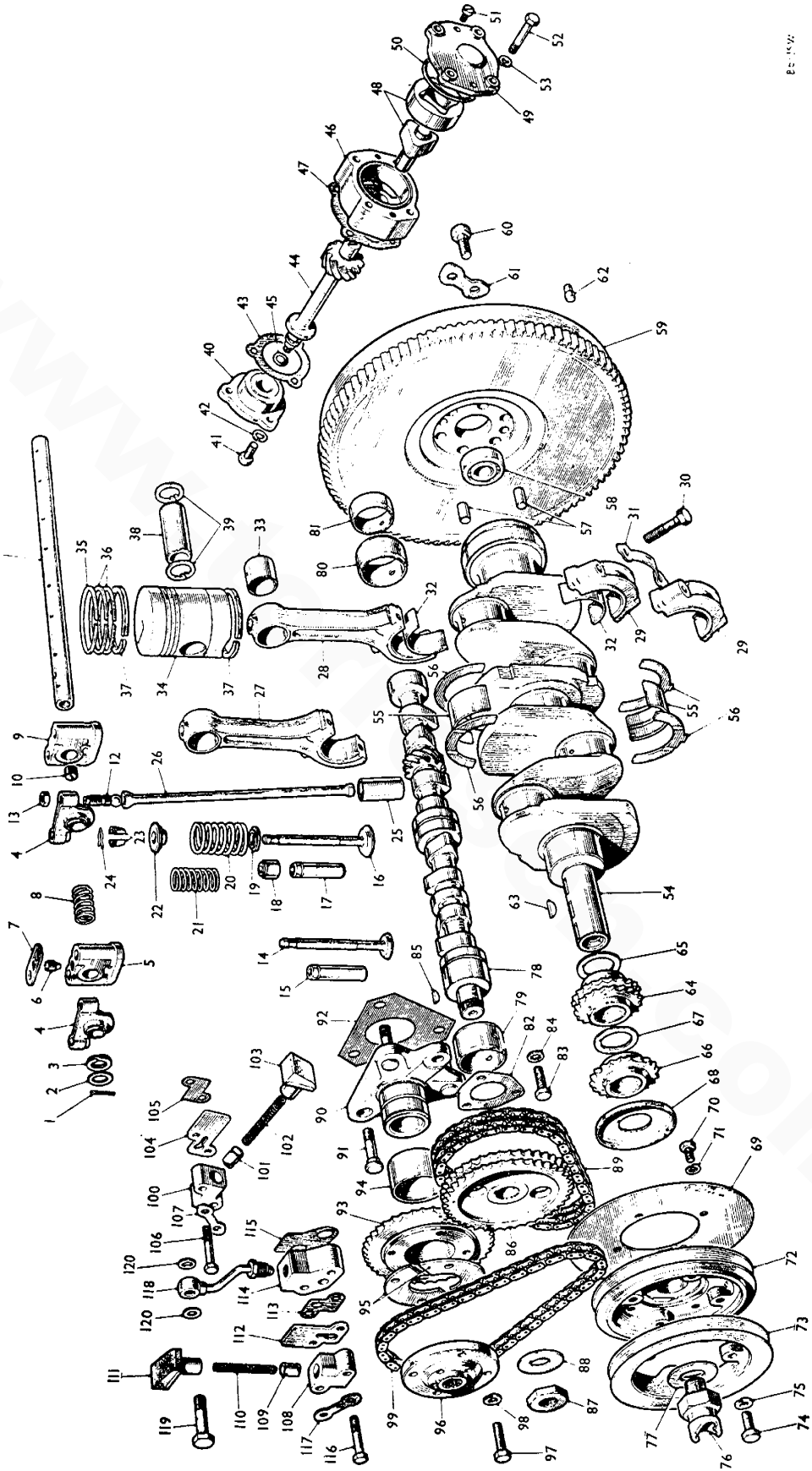


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KEY TO THE ENGINE EXTERNAL COMPONENTS

<i>No.</i>	<i>Description</i>	<i>No.</i>	<i>Description</i>	<i>No.</i>	<i>Description</i>
1.	Clamp for injector.	37.	Oil seal for crankshaft—rear.	73.	Main bearing cap—front.
2.	Stud for clamp.	38.	Housing for oil seal.	74.	Oil seal for front main bearing cap.
3.	Nut for stud.	39.	Setscrew for housing.	75.	Dowel for main bearing cap.
4.	Washer for nut.	40.	Lock washer for setscrew.	76.	Bolt for main bearing cap.
5.	Heat shield for injector nozzle.	41.	Oil release valve.	77.	Lock washer for bolt.
6.	Washer for heat shield.	42.	Spring for valve.	78.	Front plate for engine.
7.	Water outlet elbow.	43.	Cap nut for valve.	79.	Joint washer for front plate.
8.	Joint washer for elbow.	44.	Washer for cap nut.	80.	Joint washer for top fixing hole of front plate.
9.	Stud for elbow.	45.	Cylinder head.	81.	Timing indicator for injection pump.
10.	Nut for stud.	46.	Joint washer for cylinder head.	82.	Timing cover.
11.	Washer for nut.	47.	Combustion chamber insert.	83.	Joint washer for timing cover.
12.	Thermostat.	48.	Stud for cylinder head.	84.	Vibration damper—camshaft chain.
13.	Oil filler cap.	49.	Nut for stud.	85.	Bolt for vibration damper.
14.	Cap nut for rocker cover.	50.	Washer for nut.	86.	Lock washer for bolt.
15.	Cup washer.	51.	Cylinder block.	87.	Vibration damper—injection pump chain.
16.	Rubber bush.	52.	Cylinder liner.	88.	Stud for vibration damper.
17.	Valve rocker cover.	53.	Side cover for cylinder block.	89.	Nut for stud.
18.	Joint washer for rocker cover.	54.	Joint washer for side cover.	90.	Lock washer for nut.
19.	Exhaust manifold.	55.	Bolt for side cover.	91.	Bolt for timing cover.
20.	Inlet manifold.	56.	Washer for bolt.	92.	Nut for bolt.
21.	Joint washer for manifolds.	57.	Oil reservoir.	93.	Washer for nut.
22.	Stud for manifolds.	58.	Joint washer for reservoir.	94.	Cover for injection pump chain wheel.
23.	Washer for stud.	59.	Stud for reservoir.	95.	Setscrew for cover.
24.	Stud for manifolds.	60.	Nut for stud.	96.	Spring washer for setscrew.
25.	Nut for stud.	61.	Spring washer for nut.	97.	Oil filter.
26.	Washer for nut.	62.	Bolt for reservoir.	98.	Joint washer for filter.
27.	Yoke for manifolds.	63.	Spring washer for bolt.	99.	Bolt for filter.
28.	Vent pipe for rocker cover.	64.	Drain plug for reservoir.	100.	Spring washer for bolt.
29.	Bracket for vent pipe.	65.	Copper washer for plug.	101.	Adaptor for filter.
30.	Hose for vent pipe.	66.	Oil dipper rod.	102.	Joint washer for adaptor.
31.	Back plate for engine.	67.	Blanking plate—oil suction drilling.	103.	Bolt for adaptor.
32.	Dowel for back plate.	68.	Joint washer for plate.	104.	Spring washer for bolt.
33.	Joint washer for back plate.	69.	Bolt for plate.	105.	Oil seal—timing cover.
34.	'O' ring for back plate.	70.	Lock washer for bolt.	106.	Joint washer for chain wheel cover.
35.	Setscrew for back plate.	71.	Main bearing cap—rear.	107.	'O' ring for oil suction drilling.
36.	Spring washer for setscrew.	72.	Main bearing cap—centre.		

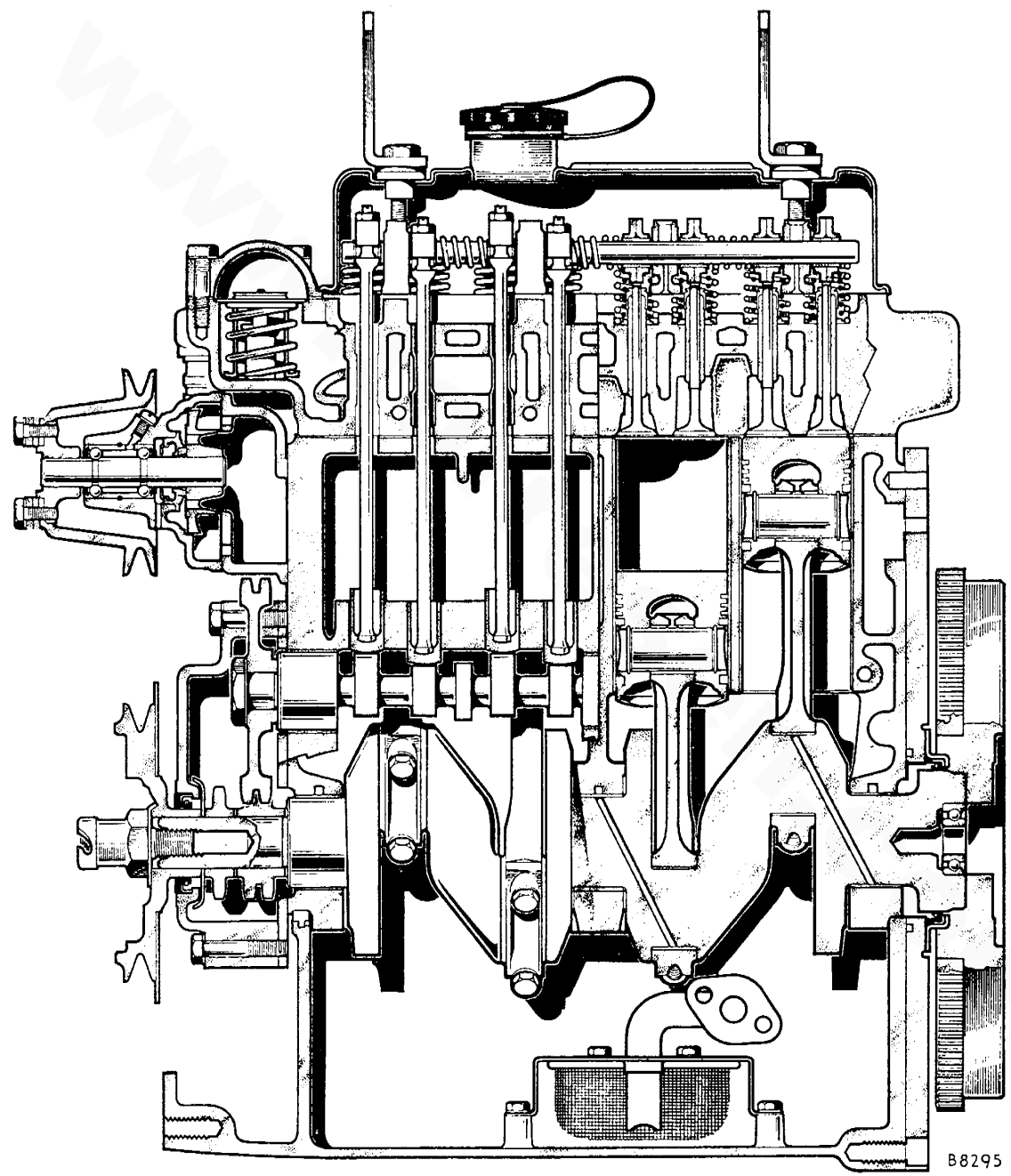
THE ENGINE INTERNAL COMPONENTS



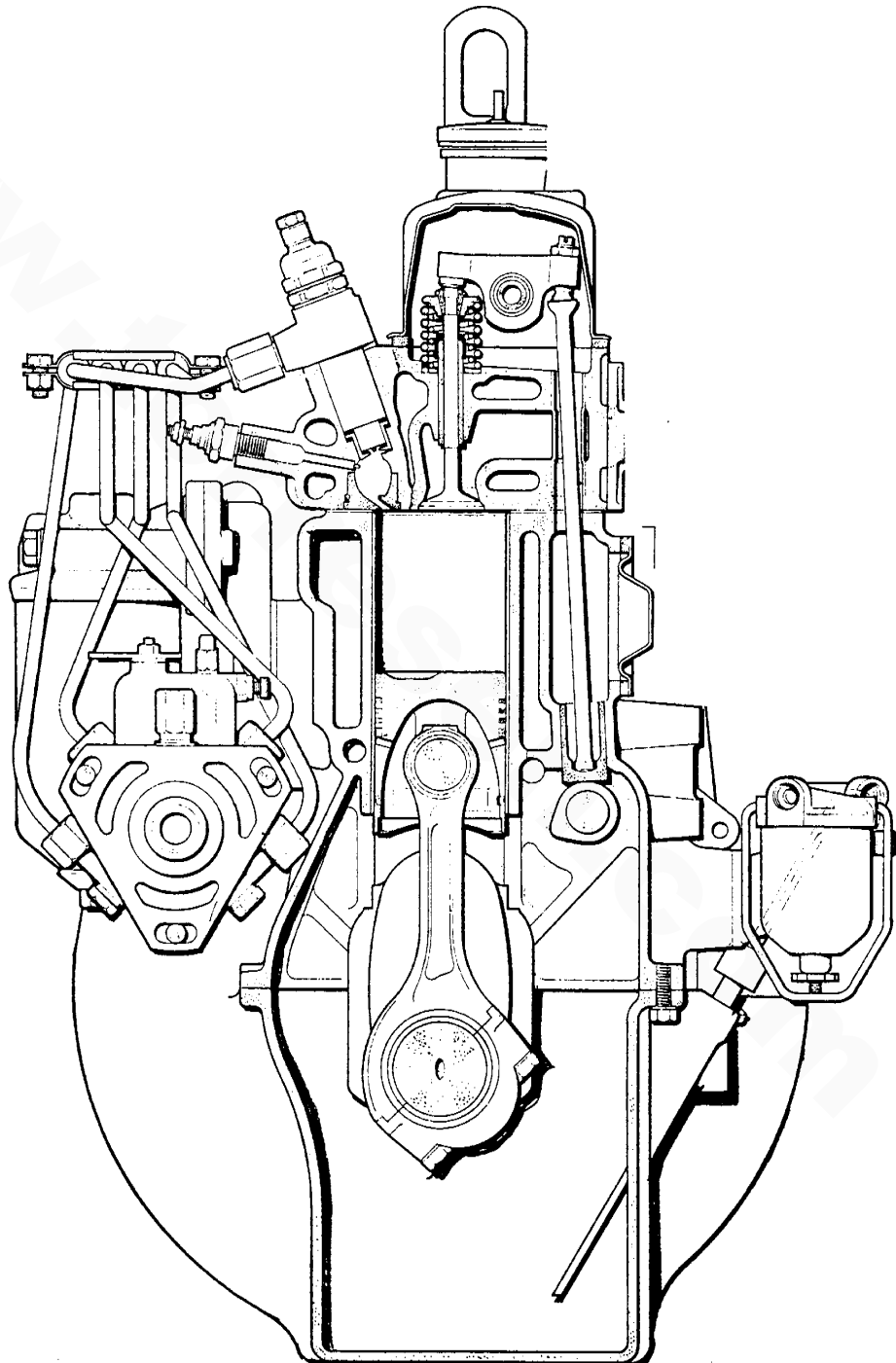
KEY TO THE ENGINE INTERNAL COMPONENTS

No.	Description	No.	Description	No.	Description
1.	Split pin for rocker shaft.	41.	Bolt for housing.	81.	Camshaft bearing liner—rear.
2.	Plain washer for rocker shaft.	42.	Spring washer for bolt.	82.	Locating plate for camshaft.
3.	Spring washer for rocker shaft.	43.	Gasket for housing.	83.	Bolt for locating plate.
4.	Valve rocker.	44.	Tractometer and oil pump drive shaft.	84.	Shakeproof washer for bolt.
5.	Rocker shaft bracket—tapped.	45.	Seal for shaft.	85.	Key for camshaft.
6.	Locating screw for rocker shaft.	46.	Oil pump body.	86.	Camshaft chain wheel.
7.	Plate for rocker shaft bracket.	47.	Gasket for oil pump.	87.	Nut for camshaft.
8.	Spring for rocker shaft.	48.	Oil pump rotor and shaft assembly.	88.	Lock washer for nut.
9.	Rocker shaft bracket—plain.	49.	Oil pump cover.	89.	Chain—camshaft drive.
10.	Screwed plug for rocker shaft.	50.	'O' ring for cover.	90.	Hub for injection pump chain wheel.
11.	Valve rocker shaft.	51.	Screw for cover.	91.	Bolt for hub.
12.	Tappet adjusting screw.	52.	Bolt for oil pump.	92.	Joint washer for hub.
13.	Locknut for adjusting screw.	53.	Spring washer for bolt.	93.	Injection pump chain wheel.
14.	Valve—exhaust.	54.	Crankshaft.	94.	Bearing liner for chain wheel.
15.	Valve guide—exhaust.	55.	Main bearing.	95.	Locating plate for chain wheel.
16.	Valve—inlet.	56.	Thrust washer for crankshaft.	96.	Driving flange for chain wheel.
17.	Valve guide—inlet.	57.	Dowel—flywheel to crankshaft.	97.	Bolt for driving flange.
18.	Oil seal for valve.	58.	Ball race.	98.	Spring washer for bolt.
19.	Valve spring cup—bottom.	59.	Flywheel.	99.	Chain—injection pump drive.
20.	Valve spring—outer.	60.	Bolt—flywheel to crankshaft.	100.	Chain tensioner body—camshaft drive.
21.	Valve spring—inner.	61.	Lock washer for bolt.	101.	Chain tensioner cylinder.
22.	Valve spring collar—top.	62.	Dowel—clutch to flywheel.	102.	Chain tensioner spring.
23.	Valve cotter.	63.	Key for crankshaft.	103.	Chain tensioner slipper head.
24.	Spring clip for valve cotter.	64.	Crankshaft chain wheel—camshaft drive.	104.	Chain tensioner back plate.
25.	Tappet.	65.	Shim for chain wheel.	105.	Joint washer for chain tensioner.
26.	Push-rod.	66.	Crankshaft chain wheel—injection pump drive.	106.	Bolt for chain tensioner.
27.	Connecting rod—Nos. 1 and 3.	67.	Shim for chain wheel.	107.	Lock washer for bolt.
28.	Connecting rod—Nos. 2 and 4.	68.	Oil thrower.	108.	Chain tensioner body—injection pump drive.
29.	Cap for connecting rod.	69.	Timing disc.	109.	Chain tensioner cylinder.
30.	Bolt for connecting rod cap.	70.	Bolt for discs.	110.	Chain tensioner spring.
31.	Lock washer for bolt.	71.	Spring washer for bolt.	111.	Chain tensioner slipper head.
32.	Big-end bearing.	72.	Crankshaft pulley—dynamo drive.	112.	Chain tensioner back plate.
33.	Small-end bush.	73.	Crankshaft pulley—hydraulic pump drive.	113.	Joint washer for chain tensioner.
34.	Piston.	74.	Bolt for hydraulic drive pulley.	114.	Packing block for chain tensioner.
35.	Compression ring—top groove.	75.	Spring washer for bolt.	115.	Joint washer for packing block.
36.	Compression ring—2nd and 3rd grooves.	76.	Starting nut.	116.	Bolt for chain tensioner.
37.	Scraper ring—slotted.	77.	Lock washer for starting nut.	117.	Lock washer for bolt.
38.	Gudgeon pin.	78.	Camshaft.	118.	Oil pipe.
39.	Circlip.	79.	Camshaft bearing liner—front.	119.	Banjo bolt.
40.	Tractometer drive housing.	80.	Camshaft bearing liner—centre.	120.	Washer for banjo bolt.

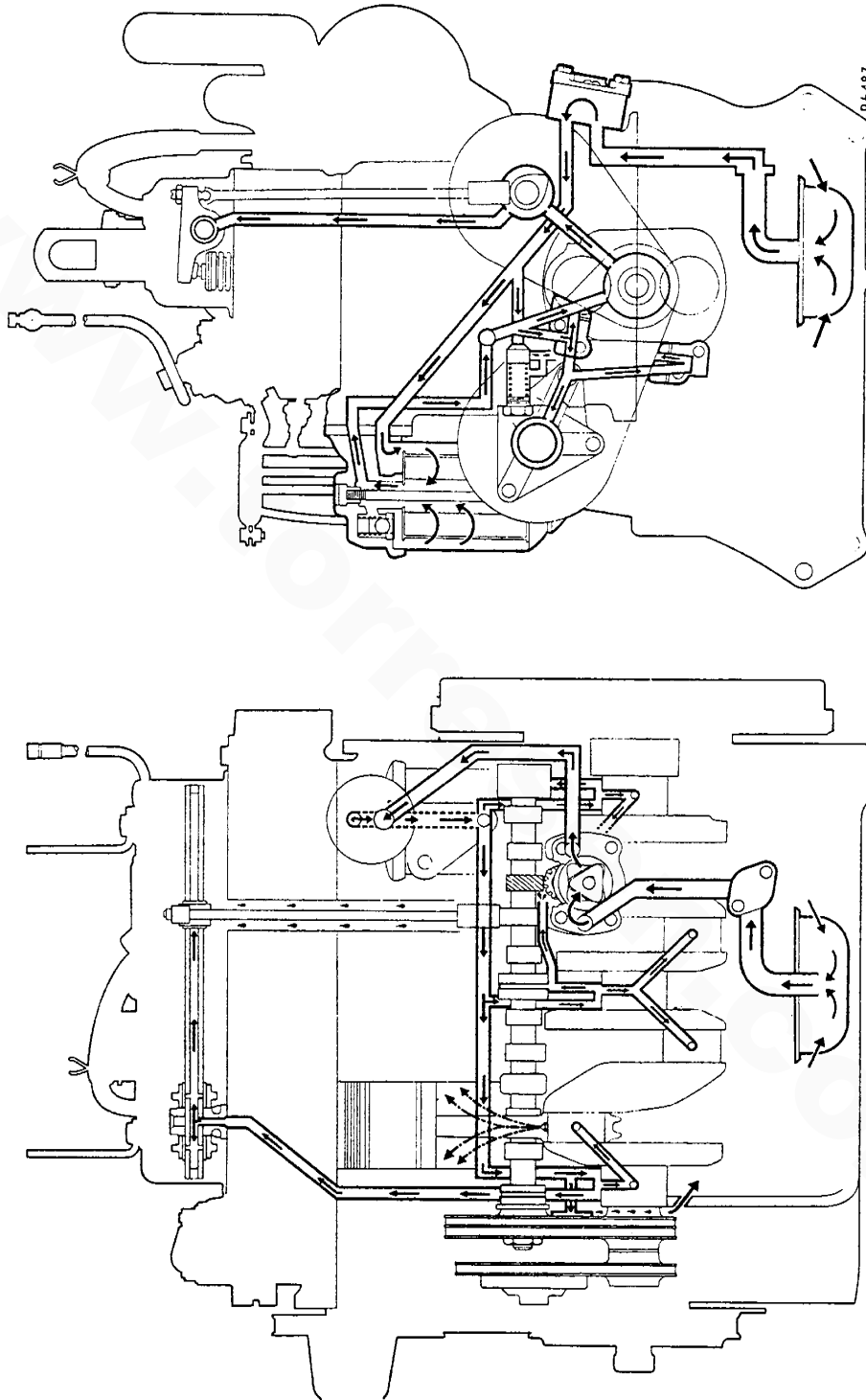
THE ENGINE
(Longitudinal Section)



THE ENGINE
(Transverse Section)



THE ENGINE LUBRICATION SYSTEM



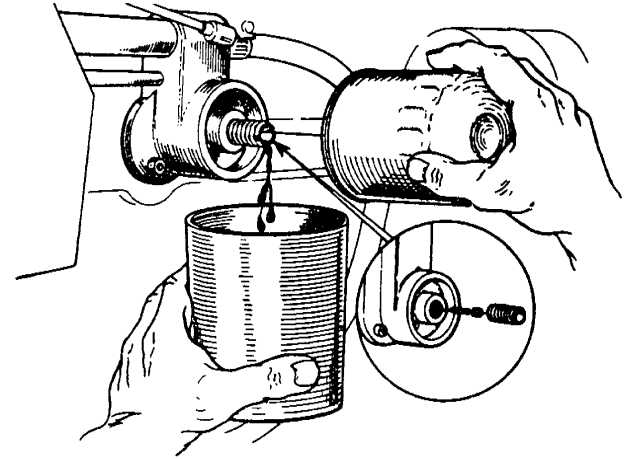
EXTERNAL OIL FILTER

The external filter is of the full-flow type, thus ensuring that all oil in the lubrication circuit passes through the filter before reaching the bearings.

Oil is passed through the filter from the pump at a pressure controlled at 50 lb./sq. in. (3.5 kg./cm.²) by the engine oil pressure release valve.

Should the filter become completely choked due to neglect, a balance valve is provided to ensure that oil will still reach the bearings.

The filter element is removed by unscrewing the case from its base. A small amount of spillage will occur when this is done and a small waste container should be held underneath as the element is unscrewed.



Section A.2

LUBRICATION SYSTEM

The oil supply is carried in the sump and is replenished through a filler aperture in the valve rocker cover.

An eccentric-rotor type oil pump, mounted externally on the left-hand side of the crankcase, is shaft-driven by means of a skew gear on the camshaft. The oil pressure (see 'GENERAL DATA') is controlled by the pressure relief valve fitted in the right-hand side of the crankcase.

In operation, the oil is drawn through a gauze strainer in the sump and reaches the oil pump via drilled passages in the sump and crankcase. The oil passes from the pump to the full-flow filter on the opposite side of the crankcase through a drilling. This same drilling connects with the pressure relief valve.

After passing through the filter the oil enters the main gallery on the right-hand side of the crankcase and is fed to the crankshaft main bearings by branch drillings. The big-end bearings are lubricated from the main bearings through the crankshaft, and a hole in each big-end feeds oil to the thrust side of the cylinder bores.

Oil is fed to the camshaft bearings through passages from the main bearings. A passage from the camshaft centre bearing feeds oil to the camshaft skew gear and a drilling from the camshaft front bearing supplies oil to the cylinder head where further drillings lead to the rocker shaft via the front rocker support bracket. The oil from the rocker gear drains down the push-rod tunnels to the sump.

At the front of the main gallery, oil is fed to the camshaft chain tensioner and the injection pump chain wheel bearing. An oil pipe from the chain wheel hub feeds the injection pump chain tensioner.

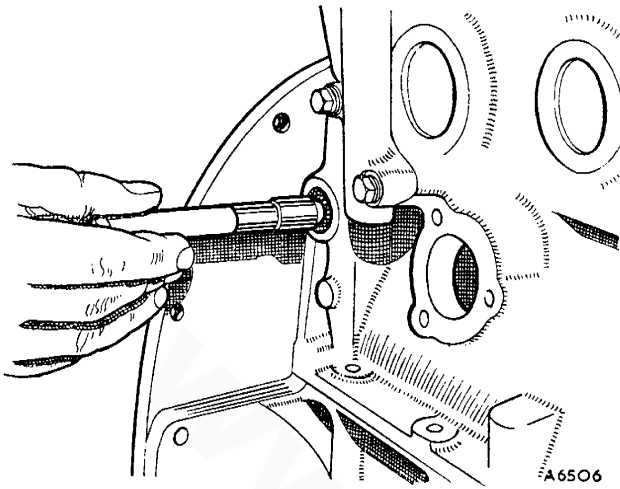


Fig. A.2

Removing the oil pressure relief valve with tool 18G 69

Section A.4

OIL PUMP

Removing

- (1) Remove the four bolts securing the oil pump to the left-hand side of the crankcase and detach the oil pump from the engine.

Dismantling

- (2) Remove the two cover-plate screws and lift off the cover-plate and 'O' ring.

Inspection

- (3) Check the rotor lobe clearance against the figure given in 'GENERAL DATA'.
- (4) Check the rotor end-float against the figure given in 'GENERAL DATA'.

Reassembling

- (5) Reverse the dismantling procedure.

Refitting

- (6) Reverse the removing procedure, with the driving slot in the pump shaft positioned to engage the tongue on the drive.

Section A.5

OIL PRESSURE RELIEF VALVE

Removing

- (1) Unscrew the centre-bolt and remove the oil filter bowl and element.
- (2) Unscrew the relief valve cap nut and withdraw the relief valve spring.
- (3) Remove the plunger, using tool 18G 69.

Inspection

- (4) Check the relief valve spring against the specification given in 'GENERAL DATA'.
- (5) Check the valve seating by applying engineer's blue to the conical valve face and testing for continuous marking. If necessary, lap the valve onto the seat, using tool 18G 69.

Refitting

- (6) Reverse the procedure in (1) to (3), ensuring that the cap nut washer is in a serviceable condition.

Section A.6

TRACTOMETER AND OIL PUMP DRIVE SHAFT

Removing

- (1) Unscrew the centre-bolt and remove the oil filter bowl and element.
- (2) Disconnect the tractometer cable from the angle drive.
- (3) Remove the tractometer drive housing and withdraw the oil seal from the (later type) housing.
- (4) Withdraw the drive shaft, allowing it to rotate to disengage from the camshaft. Slight rotation of the crankshaft may be necessary to allow the drive shaft gear to clear the crankshaft web.

Inspection

- (5) Ensure that the drive shaft is perfectly straight and that the oil pump drive and tractometer square drive are not worn or damaged.

Refitting

- (6) Grease the drive shaft seal and reverse the procedure in (1) to (4), starting with the oil pump drive sufficiently out of line to allow for rotation of the drive shaft as it engages the camshaft.

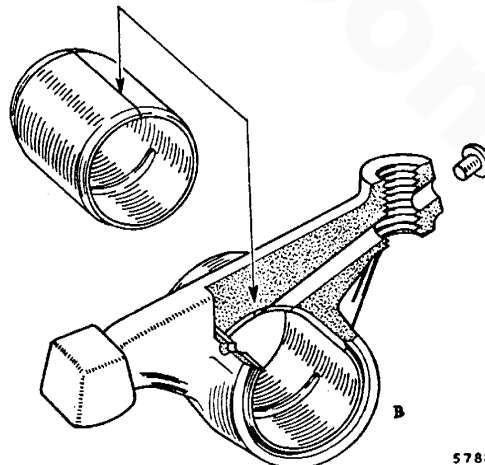


Fig. A.3

When rebushing the forged-type valve rocker ensure that the bush joint is in the position indicated

Section A.7

VALVE ROCKER SHAFT AND TAPPETS

Removing

Valve rocker shaft

- (1) Disconnect the breather pipe from the rocker cover.
- (2) Unscrew the two rocker cover retaining nuts and remove the two engine sling brackets.
- (3) Remove the rocker cover, cup washers, and rubber bushes.
- (4) Remove the eight nuts and spring washers, and the four plates from the rocker shaft brackets, and lift off the rocker shaft assembly.

Tappets

Carry out the procedure in (1) to (4).

- (5) Withdraw the push-rods and label them for assembly in their original positions.
- (6) Remove the two covers from the left-hand side of the engine and lift the tappets out of their housings. The tappets should be labelled to ensure reassembly in their original positions.

Dismantling

Valve rocker shaft

- (7) Remove the grub screw locating the rocker shaft in the front mounting bracket.
- (8) Withdraw the split pins, remove the flat washers and spring washers from the ends of the shaft, and slide the rockers, brackets, and springs from the shaft.
- (9) Remove the screwed plug fitted in one end of the shaft to clean out the oil-way.

Inspection

- (10) Check the rocker bush to rocker shaft clearance against the figures given in 'GENERAL DATA'. If the rockers are of the pressed-steel type, and the bushes are worn, the rockers should be renewed. If the bushes are worn in forged rockers, they should be renewed using tools 18G 226 and 18G 226 A. Fit new bushes with the butt joint positioned at the top of the rocker bore, and drill oil holes in

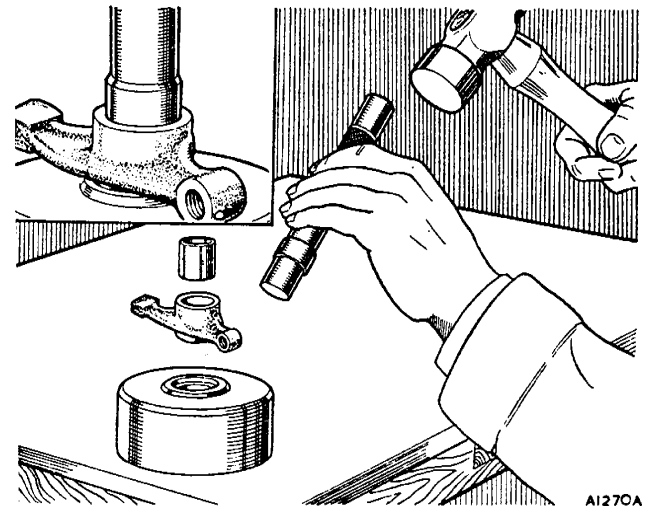


Fig. A.5

Fitting a valve rocker bush using tools 18G 226 and 18 G 226 A

each bush to coincide with the oil-ways in the rocker. If the holes are drilled after fitting, remove the adjuster screw from the rocker and drill through the end plug and bush, using a No. 43, .089 in. (2.26 mm.) drill. Replace the drilled-out plug with a rivet (Part No. 5C 2436) and weld it in position. The second hole in the bush should be drilled with a No. 47, .078 in. (1.98 mm.) drill, and the bush should then be burnish-reamed to the size given in 'GENERAL DATA'.

- (11) Ensure that the push-rods are perfectly straight and that the ends are not damaged.
- (12) Check the diameter of the tappets against the figure in 'GENERAL DATA', and examine the bottom face of the tappets for wear.

Reassembling

Valve rocker shaft

- (13) Reverse the procedure in (7) to (9).

Refitting

Tappets

- (14) Reverse the procedure in (5) and (6).

Valve rocker shaft

- (15) Reverse the procedure in (1) to (4), noting the following points:
 - (a) Tighten the rocker bracket nuts to the torque figure given in 'GENERAL DATA'.
 - (b) Adjust the valve rocker clearance as described in Section A.13.

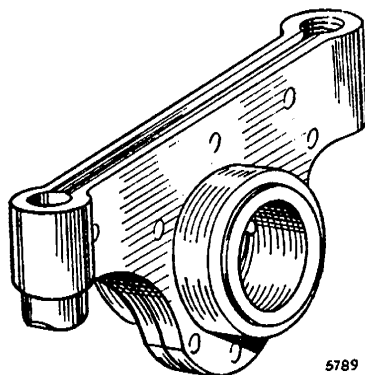


Fig. A.4

The pressed-steel type of valve rocker, which should not be rebushed

Section A.8

CYLINDER HEAD

Removing

- (1) Remove the bonnet and radiator (Section B.3, (1) to (10)).
- (2) Remove the radiator expansion tank.

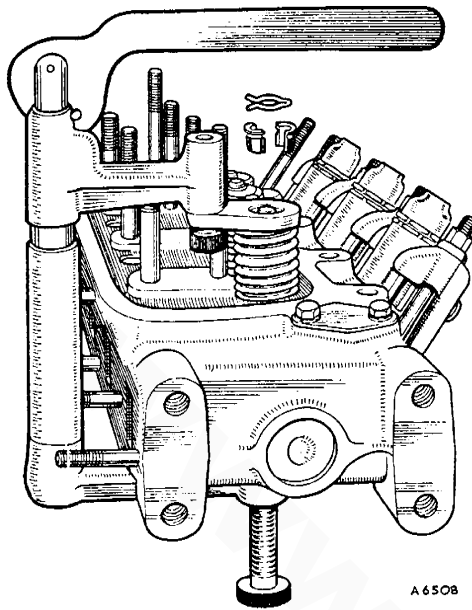


Fig. A.6

Compressing the valve springs with tool 18G 45

- (3) Remove the bowl from the hydraulic filter and drain the system.
- (4) Release and withdraw the suction pipe from the top of the hydraulic reservoir.
- (5) Disconnect the hydraulic pressure pipe union located just above the engine oil filter.
- (6) Release the hydraulic pressure pipe from the bracket on the cylinder head by unscrewing the two nuts and removing the 'U' clamp.
- (7) Remove the three bolts securing the hydraulic pump mounting bracket to the cylinder head.
- (8) Detach the drive belt and remove the hydraulic pump from the engine.
- (9) Remove the exhaust pipe and silencer from the manifold.
- (10) Remove the air cleaner to manifold hose.
- (11) Remove the fuel filter (Section C.5, (1) and (2)).
- (12) Disconnect and remove the fuel return pipe from the injection pump.
- (13) Remove the hydraulic tank (Section M.5, (1) to (9)).
- (14) Disconnect the high-pressure pipes from the injectors.
- (15) Remove the feed and the three connecting links from the heater plugs.
- (16) Remove the rocker shaft and push-rods (Section A.7, (1) to (5)).
- (17) Withdraw the engine breather pipe from the bracket grommets.
- (18) Slacken the water by-pass hose clips.
- (19) Remove the 11 cylinder head nuts and flat washers, and lift the cylinder head off the cylinder block.

Dismantling

- (20) Unscrew the heater plugs from the cylinder head.
- (21) Remove the two nuts and washers securing the exhaust manifold, and the six nuts and washers securing both air and exhaust manifolds, and lift both manifolds away.
- (22) Remove the spill pipe and clamps from the injectors, and withdraw the injectors from the cylinder head, using tool 18G 284 and adaptor 18G 284 P.
- (23) Unscrew the three nuts and remove the water outlet elbow. Ease the outlet elbow gasket off the three studs and withdraw the thermostat.
- (24) Detach the spring clips from the valve cotters and, using tool 18G 45 to compress the valve springs, remove the cotters, the valve spring top collars, the inner and outer valve springs, the valve oil seals, and the valve spring bottom cups.
- (25) Withdraw the valves from their guides, marking them for reassembly in their original positions.
- (26) The combustion chamber inserts can be removed by means of a drift inserted through the injector location in the top of the cylinder head. The lower faces of the combustion chamber inserts are machined after fitting to the cylinder head, and if they are removed the inserts should be labelled to ensure reassembly in their original positions.
- (27) The injector nozzle heat shields can be tapped upwards out of the cylinder head after removal of the combustion chamber inserts.

Inspection

- (28) Check the cylinder head joint face for flatness.
- (29) Ensure that the heater plug drillings in the cylinder head are free of carbon.
- (30) Check the valve springs against the specification in 'GENERAL DATA'.

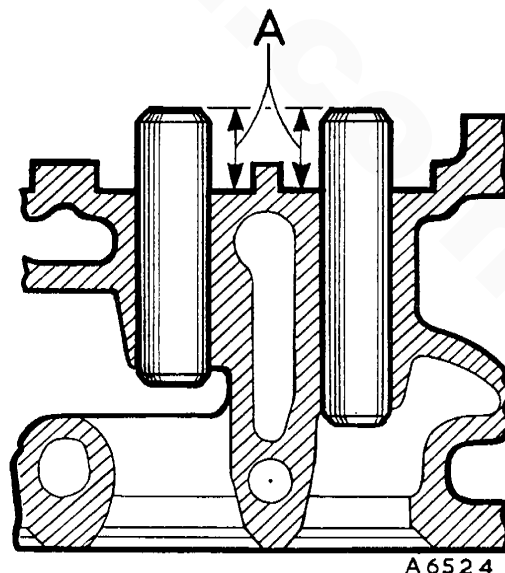


Fig. A.7

The valve guides in position. Dimension (A) should be $\frac{18}{32}$ in. (15 mm.)

- (31) Check the valve stem to guide clearance against the figures given in 'GENERAL DATA'. If new valve guides are fitted, the top face of each guide should be $\frac{1}{16}$ in. (15 mm.) above the valve spring seat surface of the cylinder head.
- (32) Check the valve head stand-down against the figure in 'GENERAL DATA'.

Reassembling

- (33) Reverse the procedure in (20) to (27), noting the following points:
 - (a) Ensure that the joint washer under the flange of each heat shield is in serviceable condition.
 - (b) Check that the lower faces of the combustion chamber inserts are not proud of the cylinder head face.
 - (c) Renew the corrugated washers in the bottom of the heat shields and check the serviceability of the injector to heat shield flange joint washers.
 - (d) Tighten the injector clamp nuts to the figure given in 'GENERAL DATA'.

Refitting

- (34) Reverse the procedure in (1) to (19), noting the following points:
 - (a) Ensure that the cylinder head joint washer is in a serviceable condition and is fitted dry with the side marked 'TOP' and 'FRONT' uppermost.
 - (b) Working in the order shown in Fig. A.9 tighten the cylinder head nuts to the torque figure given in 'GENERAL DATA'.
 - (c) Tighten the rocker bracket nuts to the torque figure given in 'GENERAL DATA'.
 - (d) Adjust the valve rocker clearance (Section A.13).
 - (e) Refill the hydraulic system (Section M.6).
 - (f) Refill the cooling system (Section B.1, (9) to (11) or Section B.6, (6) to (9)).
 - (g) Bleed the fuel system (Section C.8).

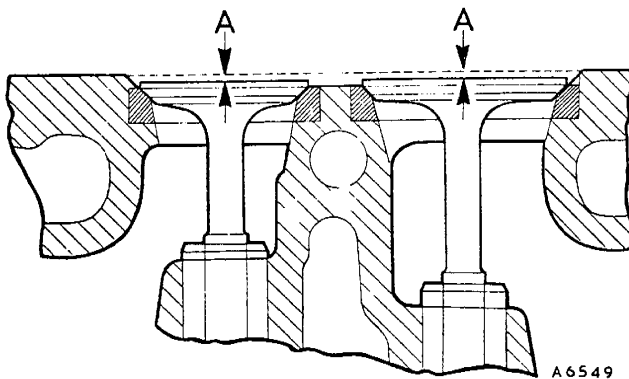


Fig. A.8

The top faces of the valves should stand below the cylinder head face

A = .018 to .038 in. (.46 to .97 mm.)

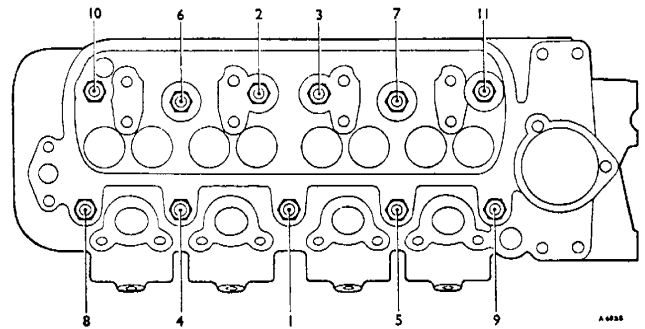


Fig. A.9

Cylinder head nut tightening sequence

Section A.9

CAMSHAFT, TIMING GEAR, AND ENGINE FRONT PLATE

Removing

Timing cover

- (1) Remove the radiator (Section B.3, (1) to (10)).
- (2) Remove the hydraulic pump drive belt.
- (3) Remove the dynamo and drive belt (Section K.5, (2) to (5)).
- (4) Remove the water pump (Section B.4, (3) to (5)).
- (5) Unscrew the starting nut from the front of the crankshaft.
- (6) Unscrew the four bolts and detach the hydraulic drive pulley from the crankshaft pulley.
- (7) Withdraw the crankshaft pulley from the crankshaft.
- (8) Remove the 13 securing bolts and detach the timing cover from the engine.

Injection pump driving chain and tensioner

- Carry out the procedure in (1) to (8).
- (9) Remove the oil thrower from the crankshaft.
- (10) Unscrew the two bolts and remove the injection pump driving chain tensioner.
- (11) Unscrew the four bolts and remove the driving flange from the injection pump chain wheel.
- (12) Detach the two halves of the retaining plate from the face of the injection pump chain wheel.
- (13) Remove the key from the front of the crankshaft and withdraw the injection pump driving chain complete with both its chain wheels.
- (14) Remove any shims fitted on the crankshaft in front of the camshaft driving chain wheel.

Camshaft driving chain and tensioner

- Carry out the procedure in (1) to (14).
- (15) Rotate the crankshaft until the timing marks on both camshaft driving chain wheels are in the position shown in Fig. A.12.
- (16) Unscrew the nut from the end of the camshaft, using tool 18G 98 A.
- (17) Unscrew the two bolts and remove the camshaft driving chain tensioner.

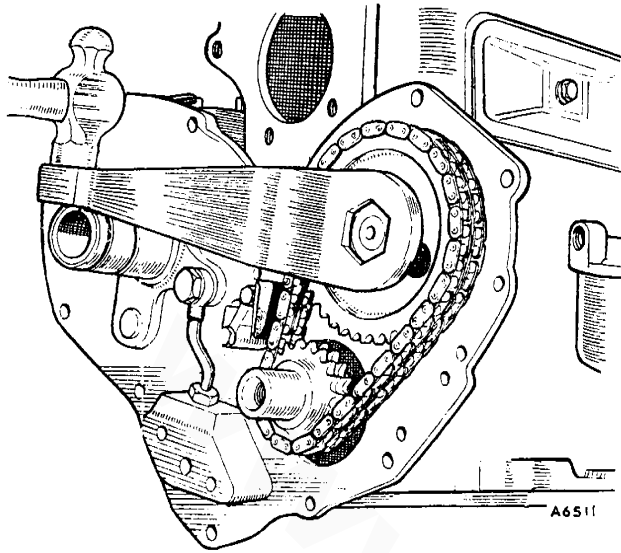


Fig. A.10

Slackening the camshaft nut with tool 18G 98 A

- (18) Withdraw the camshaft driving chain complete with both its chain wheels.
- (19) Remove any shims fitted on the crankshaft behind the camshaft driving chain wheel.

Camshaft

- Carry out the procedure in (1) to (19).
- (20) Remove the valve rocker shaft and tappets (Section A.7, (1) to (6)).
 - (21) Remove the fuel lift pump (Section C.4, (1) to (3)).
 - (22) Unscrew the three bolts and remove the camshaft locating plate.
 - (23) Withdraw the camshaft, allowing it to rotate to disengage from the oil pump drive.

Engine front plate

Carry out the procedure in (1) to (19). The procedure in (20) to (23) (camshaft removal) may also be carried out but is not necessary.

- (24) Disconnect the throttle and stop controls from the injection pump.
- (25) Remove the fuel feed and return pipes from between the injection pump and filter.
- (26) Remove the radiator expansion tank and disconnect the high-pressure pipes from the injectors.
- (27) Disconnect and remove the oil pipe from between the chain tensioner packing block and the injection pump chain wheel hub.
- (28) Unscrew the five bolts securing the front plate to the crankcase and front main bearing cap, and remove the front plate complete with injection pump and high-pressure pipes. Note the separate joint washer at the top fixing hole.

Injection pump chain wheel hub

Carry out the procedure in (1) to (14). The procedure in (15) to (28) may also be carried out but is not necessary.

- (29) Disconnect and remove the oil pipe from between

the chain tensioner packing block and the injection pump chain wheel hub.

- (30) Remove the injection pump (Section C.6, (1) to (3)).
- (31) Remove the chain wheel hub from the front plate.

Inspection

- (32) Examine the crankshaft front oil seal, and renew it if there is the slightest sign of wear or damage.
- (33) Check both chain tensioners. If ovality near the mouth of the body bore is in excess of .003 in. (.08 mm.), the chain tensioner should be renewed; and if the slipper head is badly worn, a new slipper head and cylinder assembly should be fitted to the existing body, provided the body is in serviceable condition.
- (34) Check the clearance between the injection pump chain wheel hub and bearing against the figures in 'GENERAL DATA'.
- (35) Fit the locating plate and chain wheel to the camshaft, and measure the clearance (camshaft end-float) between the locating plate and the face of the camshaft journal. If the end-float is outside the figure given in 'GENERAL DATA', renew the locating plate.

Refitting

Injection pump chain wheel hub

- (36) Reverse the procedure in (29) to (31), noting the following points:
 - (a) After refitting the injection pump driving chain it will be necessary to reset the injection timing as described in Section C.6, (84) to (87).
 - (b) When all fuel system unions have been reconnected, bleed the system as described in Section C.8.

Engine front plate

- (37) Reverse the procedure in (24) to (28) and bleed the fuel system as described in Section C.8.

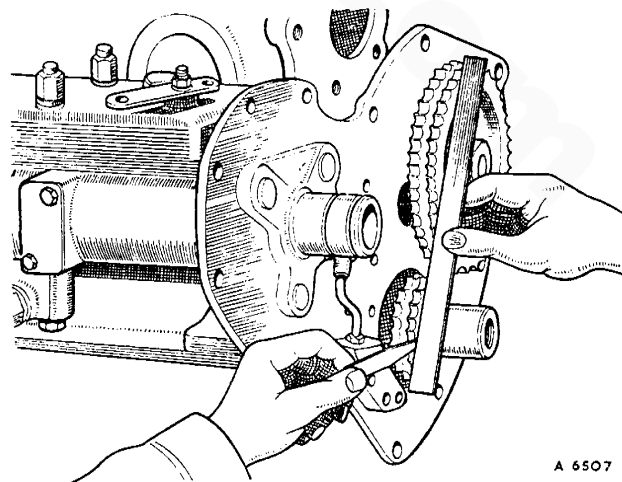


Fig. A.11

Checking the chain wheel alignment with a straight-edge and feeler gauge

Camshaft

- (38) Reverse the procedure in (20) to (23), noting the following points:
- (a) Fit the camshaft retaining plate with its white-metal face towards the camshaft.
 - (b) Bleed the fuel system as described in Section C.8, after the lift pump has been connected into the system.
 - (c) Adjust the valve rocker clearance as described in Section A.13.

Camshaft driving chain and tensioner

- (39) Reverse the procedure in (16) to (19), noting the following points:
- (a) Secure both chain wheels, less chain, to their shafts. Push both chain wheels towards the engine and check the chain wheel alignment by means of a straight-edge across the teeth faces. Increase or decrease the thickness of shims behind the crankshaft chain wheel to position it .005 in. (.127 mm.) rearwards of the camshaft chain wheel.
 - (b) When the driving chain and wheels are assembled to their respective shafts ensure that the timing marks line up as shown in Fig. A.12.
 - (c) To refit the chain tensioner, remove the plug from the base of the tensioner body. Assemble the cylinder and spring into the slipper plunger, and using a $\frac{1}{8}$ in. (3.18 mm.) Allen key, rotate the cylinder in a clockwise direction until it is held in the closed position by the peg inside the plunger. Fit the slipper assembly into the tensioner body, hold the complete assembly in the closed position, and using the Allen key through the hole in the base, rotate the cylinder in a clockwise direction until the helical groove is felt to engage the plunger peg. Still holding the assembly closed, refit and lock the plug in the base of

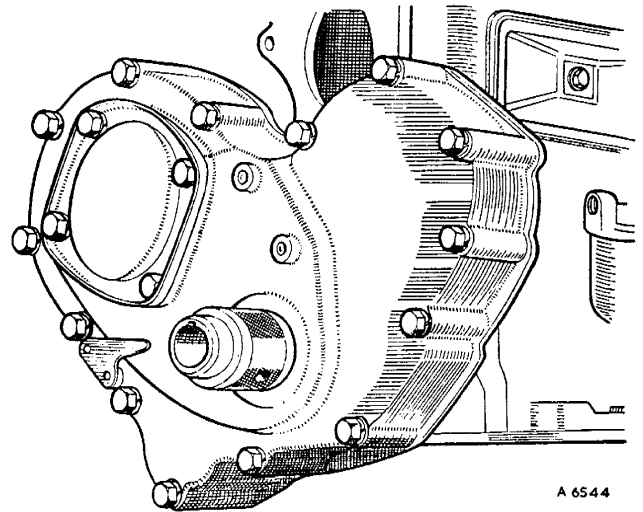


Fig. A.13

Using tool 18G 3 to centralize the timing cover on the crankshaft

the tensioner body and secure the plunger in the closed position by wrapping with wire. After fitting the chain tensioner to the engine, remove the wire.

Injection pump driving chain and tensioner

- (40) Reverse the procedure in (9) to (14), noting the following points:
- (a) Check and adjust the chain wheel alignment as described in (39) (a), but in this case the teeth faces should be in line.
 - (b) The timing marks on both chain wheels and on the injection pump driving flange should be positioned as shown in Fig. A.12 when they are assembled to the engine.
 - (c) Refit the chain tensioner as described in (39) (c).

Timing cover

- (41) Reverse the procedure in (1) to (8), using tool 18G 3 to centralize the timing cover on the crankshaft, and fill the cooling system (Section B.1, (9) to (11) or Section B.6, (6) to (9)).

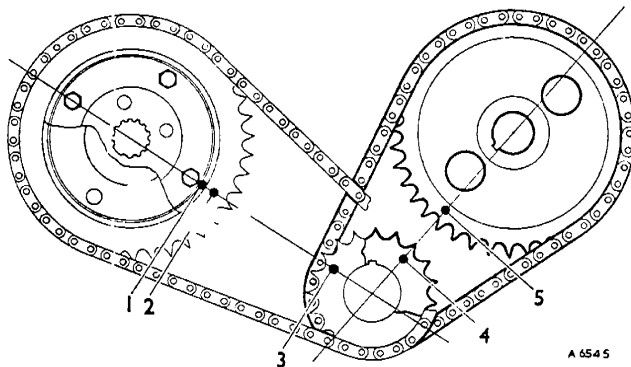


Fig. A.12

Showing the positions of the timing marks when the timing gear is correctly assembled

- 1. Injection pump driving flange.
- 2. Injection pump chain wheel.
- 3. Crankshaft chain wheel— injection pump drive.
- 4. Crankshaft chain wheel— camshaft drive.
- 5. Camshaft chain wheel.

Section A.10

FLYWHEEL AND BACK PLATE

Removing

Flywheel

- (1) Remove the clutch (Section D.2, (1) to (23)).
- (2) Remove the six flywheel to crankshaft bolts and withdraw the flywheel from the two locating dowels.

Back plate

- Carry out the procedure in (1) and (2).
- (3) Unscrew the six bolts and remove the oil seal housing from the back plate.
 - (4) Remove the 12 bolts and withdraw the back plate from the two locating dowels, noting the 'O' ring in the groove in the back plate.

Inspection

- (5) Examine the crankshaft oil seal, and renew it if there is the slightest sign of damage.
- (6) Examine the starter ring teeth for wear or damage. If necessary, remove the starter ring by drilling a hole and splitting it with a hammer and chisel. Heat the new starter ring uniformly to the temperature given in 'GENERAL DATA'; the strip of temperature-indicating paint on the ring will change from pink to grey when the temperature is correct. Fit the starter ring with the tooth chamfer facing away from the flywheel register.

Refitting

Back plate

- (7) Reverse the procedure in (3) and (4).

Flywheel

- (8) Refit the flywheel and tighten the bolts to the torque figure given in 'GENERAL DATA'.
- (9) Reverse the procedure in Section D.2, (1) to (23), noting the points mentioned in Section D.2, (40) (b), (c), and (e).
- (10) Adjust the clutch pedal free movement (Section D.1, (1) to (3)).
- (11) Bleed the fuel system (Section C.8).
- (12) Refill the hydraulic system (Section M.6).

Section A.11

SUMP, CRANKSHAFT, AND MAIN BEARINGS

Removing

Sump

- (1) Drain the sump.
- (2) Remove the radiator (Section B.3, (1) to (10)).
- (3) Raise the front of the tractor and place a support under the gearbox.
- (4) Remove the front axle (Section G.1, (2), (3), (5), (6) and (7)).
- (5) Take the weight of the engine on a crane.
- (6) Remove the clutch (Section D.2, (3) to (16) and (21) to (23)).
- (7) Remove the flywheel and back plate (Section A.10, (2) to (4)).
- (8) Remove the 13 bolts and two nuts securing the sump to the crankcase and remove the sump from the engine, noting:
 - (a) The 'O' ring at the oil pick-up joint.
 - (b) The oil sealing strip at the sump to front main bearing cap joint.

Oil strainer

Carry out the procedure in (1) to (8).

- (9) Unscrew the two bolts securing the oil suction pipe flange to the sump and the two bolts securing the oil strainer bracket to the sump, then remove the oil strainer and suction pipe.

Crankshaft and main bearings

Carry out the procedure in (1) to (8).

- (10) Remove the engine front plate (Section A.9, (2) to (5), (7) to (19), and (25) to (28)).
- (11) Unscrew the connecting rod cap bolts, remove the caps with their bearing halves, and push the connecting rods up the cylinder bores. Connecting rods and caps should be marked to ensure refitting in their original positions.
- (12) Remove the main bearing cap bolts, caps, main bearing bottom halves, and the two half thrust washers positioned on the faces of the centre cap. The main bearing caps, and the crankcase, should be marked to ensure that the caps are replaced in their correct positions.
- (13) Remove the crankshaft, the main bearing top halves, and the two half thrust washers positioned on the faces of the centre bearing housing.

Inspection

- (14) Check the crankshaft journals for wear against the figures in 'GENERAL DATA'.
- (15) Check the crankshaft to main bearing clearance against the figures in 'GENERAL DATA'.
- (16) Check the crankshaft end-float against the figures in 'GENERAL DATA', and adjust the end-float by selective assembly of the thrust washers.

Refitting

Crankshaft and main bearings

- (17) Fit the main bearings and thrust washers to the crankcase and caps, fit the crankshaft and caps to the crankcase; tighten the main bearing cap bolts to the torque figure given in 'GENERAL DATA'.
- (18) Refit the front plate and timing gear by reversing the procedure in Section A.9, (25) to (28), (7) to (19), and (2) to (5), noting the following points:
 - (a) Check the chain wheel alignment as described in Section A.9, (39) (a) and (40) (a).
 - (b) Refit the timing chain tensioners as described in Section A.9, (39) (c).
 - (c) Ensure that the timing marks line up as shown in Fig. A.12.
 - (d) Use tool 18G 3 to centralize the timing cover to the crankshaft.
- (19) Ensure that the connecting rod big-end bearings are correctly located in the rods and caps. Refit the connecting rods to the crankshaft noting that the bolt heads should be towards the camshaft side of the engine, and tighten the bolts to the torque figure given in 'GENERAL DATA'.

Oil strainer

- (20) Fit the oil strainer and suction pipe into the sump, and tighten the suction pipe flange bolts before tightening the oil strainer bracket bolts.

Sump

- (21) Refit the sump to the crankcase and tighten the securing bolts and nuts evenly.

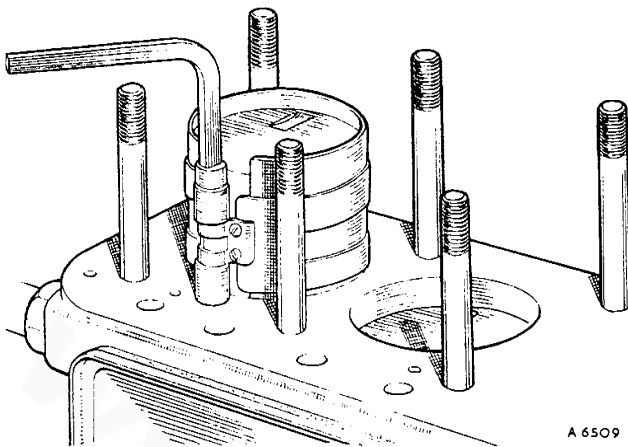


Fig. A.14

Refitting a piston and connecting rod, using tool 18G 55 A to compress the piston rings

- (22) Fit the back plate and flywheel (Section A.10, (7) and (8)).
- (23) Fit the clutch by reversing the procedure in Section D.2, (21) to (23) and (3) to (16), noting the following points:
 - (a) Position the clutch driven plate as described in Section D.2, (40) (b) and (c).
 - (b) Adjust the clutch pedal free movement as described in Section D.1, (1) to (3).
 - (c) When connecting the stop control cable to the injection pump, ensure that the stop lever on the pump has its full range of movement.
- (24) Refit the front axle and radiator by reversing the procedure in Section G.1, (2) to (7) and Section B.3, (1) to (10).
- (25) Bleed the fuel system (Section C.8).
- (26) Refill the hydraulic system (Section M.6).
- (27) Refill the cooling system (Section B.1, (9) to (11) or Section B.6 (6) to (9)).
- (28) Refill the sump.

Section A.12

CONNECTING RODS AND PISTONS

Removing

Connecting rods

- (1) Drain the sump.
- (2) Remove the radiator (Section B.3, (1) to (10)).
- (3) Raise the front of the tractor and place a support under the gearbox.
- (4) Remove the front axle (Section G.1, (2), (3), (5), (6), and (7)).
- (5) Take the weight of the engine on a crane.
- (6) Remove the clutch (Section D.2, (3) to (16) and (21) to (23)).
- (7) Remove the flywheel and backplate (Section A.10, (2) to (4)).
- (8) Remove the sump (Section A.11, (8)).

- (9) Remove the rocker shaft and push-rods (Section A.7, (1) to (5)).
- (10) Remove the cylinder head (Section A.8, (6) to (9), (11) and (12), (14) and (15), and (17) to (19)).
- (11) Unscrew the connecting rod cap bolts, remove the caps with their bearing halves, and withdraw the connecting rods and pistons from the top of the cylinder bores. The connecting rods and caps should be marked to ensure refitting in their original positions.

Pistons

Carry out the procedure in (1) to (11).

- (12) Mark the pistons to ensure correct refitting, remove the circlips, and press out the gudgeon pins to release the pistons from the connecting rods.

Inspection

- (13) Check the big-end bearing to crankpin clearance against the figures in 'GENERAL DATA'.
- (14) Check the connecting rod alignment.
- (15) Check the gudgeon pin clearance against the figures in 'GENERAL DATA'.
- (16) Check the piston ring groove clearance against the figures in 'GENERAL DATA'.
- (17) Check the piston ring gap, in an unworn part of the bore, against the figures in 'GENERAL DATA'.

Refitting

Pistons

- (18) Refit the pistons to the connecting rods, ensuring that the combustion trough in the piston crown is on the opposite side of the connecting rod to the big-end cap.

Connecting rods

- (19) Fit the connecting rods and pistons into the cylinder bores, using tool 18G 55 A to compress the piston rings.

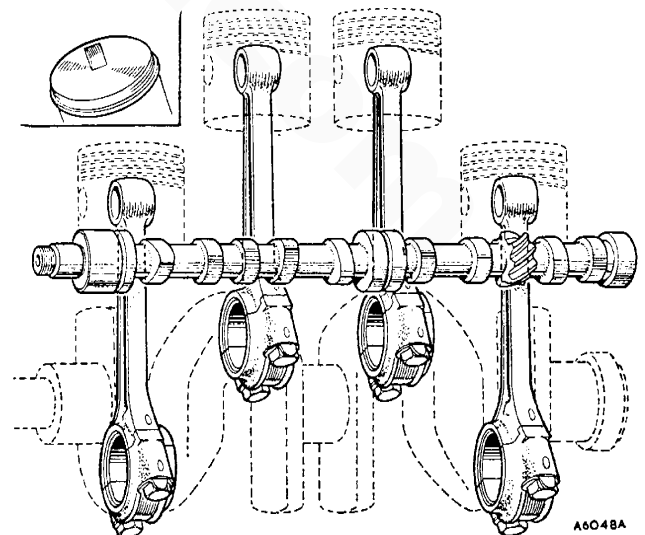


Fig. A.15

The correct assembly of the connecting rods and pistons to the crankshaft

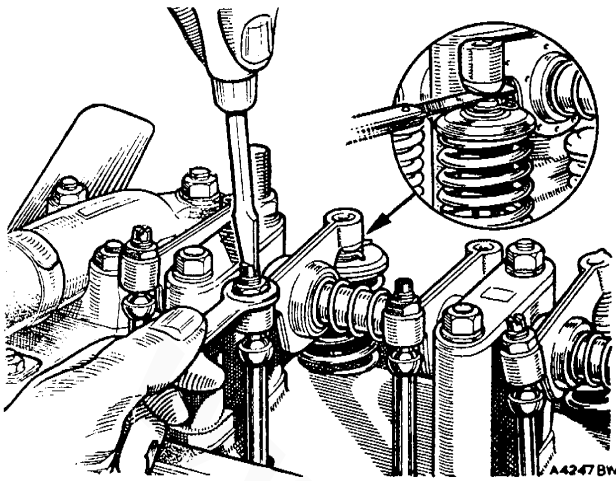


Fig. A.16

Checking and adjusting the valve rocker clearance

- (20) Ensure that the big-end bearings are correctly located in the connecting rods and caps, and fit the connecting rods and caps to the crankshaft with the bolt heads towards the camshaft side of the engine. The combustion troughs in the piston crowns should now be on the opposite side of the engine to the camshaft. Tighten the connecting rod bolts to the torque figure given in 'GENERAL DATA'.

NOTE.—The big-end bearings are offset on the connecting rods, and the rods should be fitted so that the bearings of Nos. 1 and 3 are offset towards the rear of the engine, and the bearings of Nos. 2 and 4 are offset towards the front (see Fig. A.15).

- (21) Refit the cylinder head by reversing the procedure in Section A.8, (17) to (19), (14) and (15), (11) and (12), and (6) to (9), noting the following points:
- (a) Ensure that the cylinder head joint washer is in a serviceable condition and is fitted dry with the side marked 'TOP' and 'FRONT' uppermost.
 - (b) Working in the order shown in Fig. A.9, tighten the cylinder head nuts to the torque figure given in 'GENERAL DATA'.
- (22) Refit the rocker shaft and push-rods by reversing the procedure in Section A.7, (1) to (5), tightening the rocker bracket nuts to the torque figure given in 'GENERAL DATA', and adjusting the valve rocker clearance as described in Section A.13.
- (23) Refit the sump to the crankcase and tighten the securing bolts and nuts evenly.
- (24) Fit the back plate and flywheel (Section A.10, (7) and (8)).
- (25) Fit the clutch by reversing the procedure in Section D.2, (21) to (23) and (4) to (16), noting the following points:
- (a) Position the clutch driven plate as described in Section D.2, (40) (b) and (c).
 - (b) Adjust the clutch pedal free movement as described in Section D.1, (1) to (3).
 - (c) When connecting the stop control cable to the injection pump ensure that the stop lever on the pump has its full range of movement.

- (26) Refit the front axle and radiator by reversing the procedure in Section G.1, (2) to (7) and Section B.3, (1) to (10).
- (27) Bleed the fuel system (Section C.8).
- (28) Refill the hydraulic system (Section M.6).
- (29) Refill the cooling system (Section B.1, (9) to (11) or Section B.6, (6) to (9)).
- (30) Refill the sump.

Section A.13

VALVE ROCKER CLEARANCE

The clearance between the ends of the valve stems and the valve rockers is checked by means of a feeler gauge.

Crank the engine until No. 8 valve is fully open and check the clearance of No. 1 valve which will now be fully closed.

To adjust the clearance, hold the adjusting screw with a screwdriver and slacken the locknut. Rotate the adjusting screw until the clearance between the valve stem and rocker is as given in 'GENERAL DATA'. Hold the adjusting screw against rotation and lock it in position with the locknut. Then re-check the clearance.

Check the remaining rocker clearances by reference to the following table:

- No. 1 valve (ex.) with No. 8 valve fully open.
- No. 3 valve (in.) with No. 6 valve fully open.
- No. 5 valve (ex.) with No. 4 valve fully open.
- No. 2 valve (in.) with No. 7 valve fully open.
- No. 8 valve (ex.) with No. 1 valve fully open.
- No. 6 valve (in.) with No. 3 valve fully open.
- No. 4 valve (ex.) with No. 5 valve fully open.
- No. 7 valve (in.) with No. 2 valve fully open.

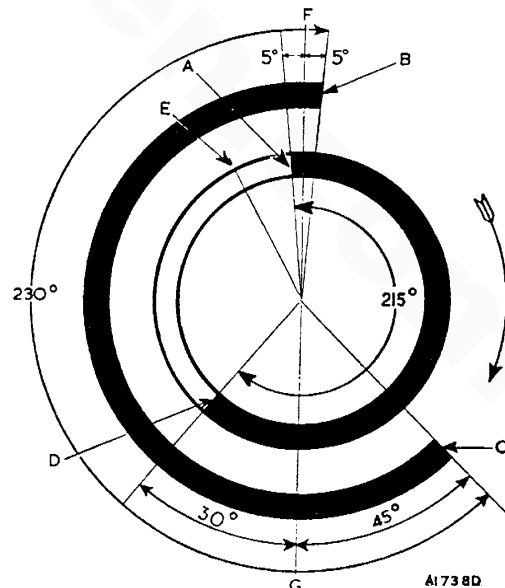


Fig. A.17

Valve timing diagram

- A. Inlet valve opens.
- B. Exhaust valve closes.
- C. Exhaust valve opens.
- D. Inlet valve closes.
- E. Static injection timing, 16° B.T.D.C.
- F. Top dead centre.
- G. Bottom dead centre.

Section A.14

VALVE TIMING CHECK

Set the valve rocker clearance of No. 1 cylinder inlet valve to .020 in. (.51 mm.).

Crank the engine until the exact point at which No. 1 inlet valve is about to open. A clock gauge, with its plunger contacting the valve spring collar, will facilitate this operation.

The timing disc on the crankshaft should now show the 5° B.T.D.C. position in the set of markings identified 1.4.

Reset the valve rocker clearance to the correct running figure (see 'GENERAL DATA').

Section A.15

VALVE SEAT RECONDITIONING

If the valves and seats are not badly pitted, restore them to their original efficiency by lapping with grinding paste.

In the event of severe pitting, reface the valves on a valve grinder to the angle given in 'GENERAL DATA' and reface the valve seats by means of the valve seat cutters shown in Section R. Use the glaze breaker to prepare the seats and then the cutters to clean them up. Remove only as much metal as is necessary to correct the seats and then restore them to their correct width (see 'GENERAL DATA') by the use of narrowing cutters.

If the seats cannot be restored by the recutting process, machine out the seatings to the dimensions given in Fig. A.18 and press special inserts into the cylinder head.

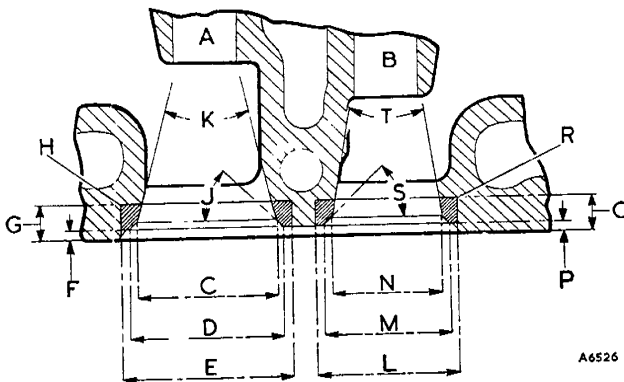


Fig. A.18

Valve seat machining dimensions

Inlet (A)	Exhaust (B)
C. 1.031 in. (26.187 mm.).	L. 1.0375 to 1.0385 in. (26.352 to 26.377 mm.).
D. 1.135 to 1.140 in. (28.83 to 28.956 mm.).	M. .916 to .921 in. (23.266 to 23.393 mm.).
E. 1.2565 to 1.2575 in. (31.915 to 31.94 mm.).	N. .8125 in. (20.638 mm.).
F. .070 to .075 in. (1.78 to 1.9 mm.).	P. .070 to .075 in. (1.78 to 1.9 mm.).
G. .258 to .261 in. (6.55 to 6.63 mm.).	Q. .258 to .261 in. (6.55 to 6.63 mm.).
H. Maximum radius .015 in. (.381 mm.).	R. Maximum radius .015 in. (.381 mm.).
J. 45°.	S. 45°.
K. 30°.	T. 20°.

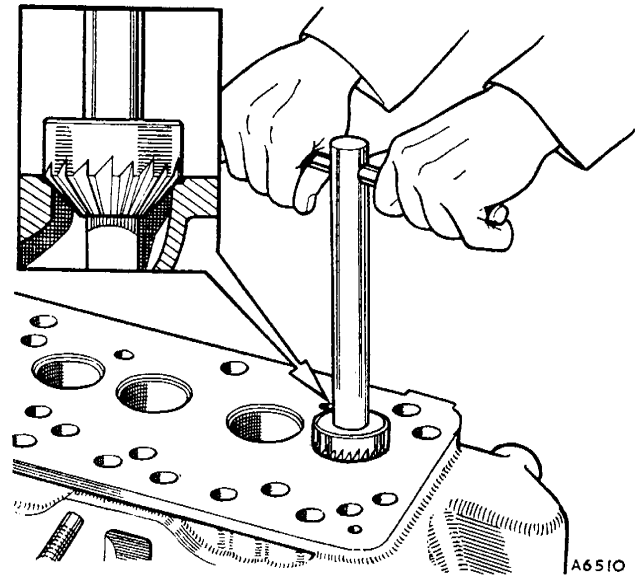


Fig. A.19

Recutting a valve seat with tools 18G 27, 18G 167, and 18G 167 D

Cut new valve seats in the inserts to the dimensions given in Fig. A.18 and ensure that the throat of each insert blends into the throat in the cylinder head.

After reconditioning the valves and seats, check the valve stand-down against the dimensions in 'GENERAL DATA'.

Section A.16

CAMSHAFT BEARING LINERS

Removing

Centre bearing liner

- (1) Insert pilot adaptor 18G 124 K into the front bearing liner from inside the crankcase, and adaptor 18G 124 B into the centre bearing liner from the rear.
- (2) With the body of tool 18G 124 A positioned on the centre screw, pass the screw through the two adaptors already fitted into the bearing liners.
- (3) Place the slotted washer on the flat at the rear of the centre screw and fit the tommy-bar in position behind the slotted washer.
- (4) Tighten up the wing nut to withdraw the centre bearing liner.

Front and rear bearing liners

- (5) Insert adaptor 18G 124 K into the front bearing liner from inside the crankcase.
- (6) With the body of tool 18G 124 A positioned on the centre screw, pass the screw through the adaptor in the front bearing.
- (7) Place the slotted washer on the flat at the rear of the centre screw, fit the tommy-bar in position behind the slotted washer, and tighten up the wing nut to withdraw the front bearing liner.
- (8) Withdraw the rear bearing liner as described in (5) to (7), but using adaptor 18G 124 M.

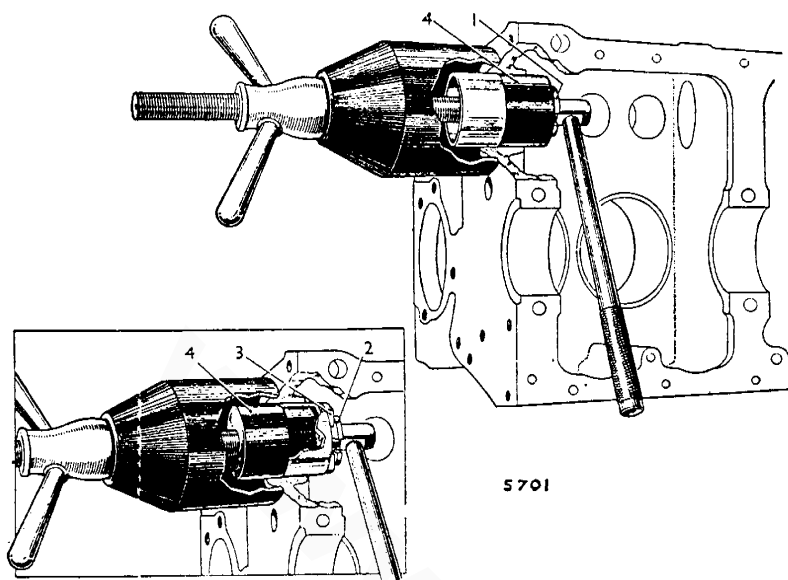


Fig. A.20

Removing a camshaft liner using tool 18G 124 A and adaptor 18G 124 K. The inset shows the liner being replaced

1. Slotted washer.
2. Slotted washer.
3. 'D' washer.
4. Adaptor 18G 124 K.

Fitting new bearing liners

The bearing liners should be so positioned that their oil holes line up with the oil holes in the bearing housings.

Front and rear bearing liners

- (9) Place the new front bearing liner on the small diameter of adaptor 18G 124 K and insert the adaptor, large diameter first, into the front bearing housing from inside the crankcase.
- (10) With the body of tool 18G 124 A positioned on the centre screw, pass the screw through the adaptor in the front bearing housing.
- (11) Position the larger of the two 'D' washers on the centre screw with the cut-away portion of the washer turned away from the butt joint in the bearing liner.
- (12) Place the slotted washer on the flat at the rear of the centre screw and fit the tommy-bar in position behind the slotted washer.
- (13) Tighten the wing nut to pull the bearing liner into position.
- (14) Fit the rear bearing liner as described in (9), (10), (12), and (13), but using adaptor 18G 124 M.

Centre bearing liner

- (15) Insert pilot adaptor 18G 214 K into the front bearing liner from inside the crankcase.
- (16) Place the new centre bearing liner on the small diameter of adaptor 18G 124 B and insert the adaptor, large diameter first, into the centre bearing housing from the rear.
- (17) With the body of tool 18G 214 A positioned on the centre screw, pass the screw through the two adaptors already positioned in the crankcase.
- (18) Fit the larger of the two 'D' washers onto the centre screw with the cut-away portion of the washer turned away from the butt joint in the centre bearing liner.
- (19) Place the slotted washer on the flat at the rear of the centre screw, fit the tommy-bar in position behind the slotted washer and tighten the wing nut to pull the centre bearing liner into position.

Reaming the bearing liners

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

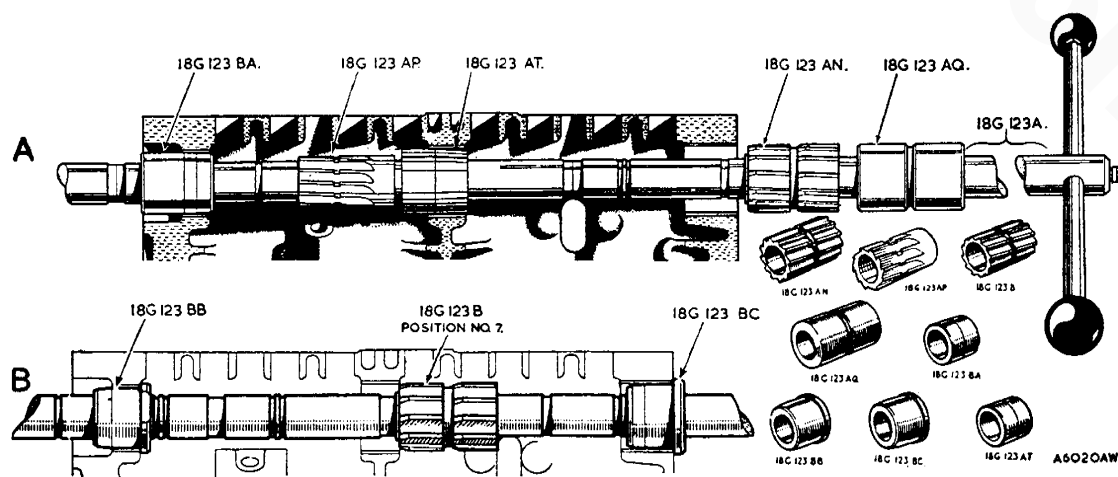


Fig. A.21

The camshaft liner reamer set up to line-ream (A) the front and rear liners and (B) the centre liner

Feed the reamer very slowly. Keep the cutters dry and the cutter flutes free of swarf, preferably with air-blast equipment.

When half-way through each bearing, withdraw the cutter and remove all swarf from both cutter and bearing liner.

When reaming is completed, thoroughly clean all the oil-ways.

Front and rear bearing liners

- (20) Insert pilots 18G 123 AT and 18G 123 BA into the centre and rear bearing liners respectively.
- (21) Place pilot 18G 123 AQ, followed by cutter 18G 123 AN, on the arbor 18G 123 A.
- (22) Pass the arbor through the front bearing and through the pilot in the centre bearing liner. Fit cutter 18G 123 AP onto the arbor and then slide the arbor into the pilot in the rear bearing housing.
- (23) Secure cutter 18G 123 AN in position No. 10, and cutter 18G 123 AP in position No. 7, on the arbor.
- (24) Ream the front bearing liner, clear it of swarf before pilot 18G 123 AQ enters, then ream the rear bearing liner.
- (25) Release the cutters from their positions and withdraw the arbor.

Centre bearing liner

- (26) Insert pilots 18G 123 BC and 18G 123 BB into the front and rear bearing liners respectively.
- (27) Pass the arbor 18G 123 A through the pilot in the front bearing, fit cutter 18G 123 B onto the arbor and slide the arbor into the pilot in the rear bearing liner.
- (28) Secure cutter 18G 123 B in position No. 7 on the arbor and ream the centre bearing liner.
- (29) Release the cutter and withdraw the arbor.

Section A.17

CYLINDER LINERS

The cylinder liners may be bored out to a maximum oversize of .020 in. (.51 mm.). If the liners will not clean up at this figure, remove them through the top face of the cylinder block, using either specialized proprietary equipment, or a power press and a set of adaptors made as shown in Fig. A.22. The necessary pressure when removing old liners is 5 to 8 tons (5080 to 8128 kg.) and when fitting new liners it is 3 tons (3048 kg.).

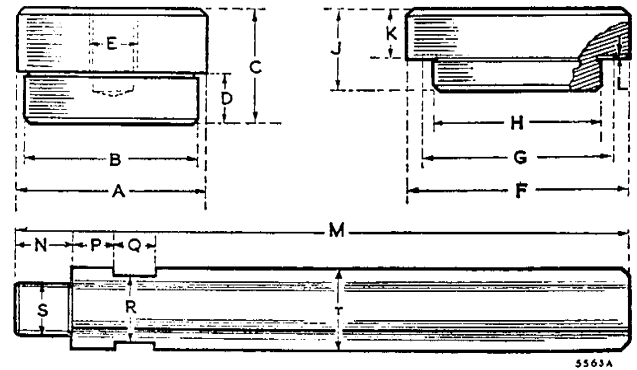


Fig. A.22

Cylinder liner pilots should be made to the above dimensions 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 a temperature of 550° C. (1,020° F.)

Pressing-out pilot

- A. 2.5937 $\begin{smallmatrix} +.005 \\ -.000 \end{smallmatrix}$ in. (65.88 $\begin{smallmatrix} +.127 \\ -.000 \end{smallmatrix}$ mm.).
- B. 2.452 $\begin{smallmatrix} +.000 \\ -.005 \end{smallmatrix}$ in. (62.28 $\begin{smallmatrix} +.000 \\ -.127 \end{smallmatrix}$ mm.).
- C. 1 $\frac{3}{4}$ in. (44.45 mm.).
- D. $\frac{3}{4}$ in. (19.05 mm.).
- E. $\frac{3}{4}$ in. B.S.W. thread.

Pressing-in pilot

- F. 3 $\frac{1}{4}$ in. (82.55 mm.). Two parallel flats to be machined on this diameter, 2 $\frac{1}{8}$ in. (66.68 mm.) apart.
- G. 2 $\frac{1}{4}$ in. (69.85 mm.).
- H. 2.451 $\begin{smallmatrix} +.000 \\ -.001 \end{smallmatrix}$ in. (66.26 $\begin{smallmatrix} +.000 \\ -.025 \end{smallmatrix}$ mm.).
- J. 1 $\frac{1}{2}$ in. (31.75 mm.).
- K. $\frac{5}{8}$ in. (15.87 mm.).
- L. .003 $\begin{smallmatrix} +.002 \\ -.001 \end{smallmatrix}$ in. (.076 $\begin{smallmatrix} +.051 \\ -.025 \end{smallmatrix}$ mm.).

Pilot extension

- M. 10 $\frac{1}{2}$ in. (26.7 cm.).
- N. $\frac{7}{8}$ in. (22.22 mm.).
- P. $\frac{5}{8}$ in. (15.87 mm.).
- Q. $\frac{5}{8}$ in. (15.87 mm.).
- R. 1 in. (25.4 mm.) flats.
- S. $\frac{3}{4}$ in. B.S.W. thread.
- T. 1 $\frac{1}{2}$ in. (31.75 mm.).

Press new liners in from the top face of the cylinder block, leaving the top face of the liner parallel with, and .002 to .005 in. (.05 to .13 mm.) proud of the cylinder block face. Do not machine the top face of the liners.

After fitting, machine and hone the liner bores to the dimension given in 'GENERAL DATA'.

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COOLING SYSTEM

FUNCTIONAL DESCRIPTION

The indirect system of heat exchange cooling is used and consists of a closed fresh water circuit and an open sea water circuit.

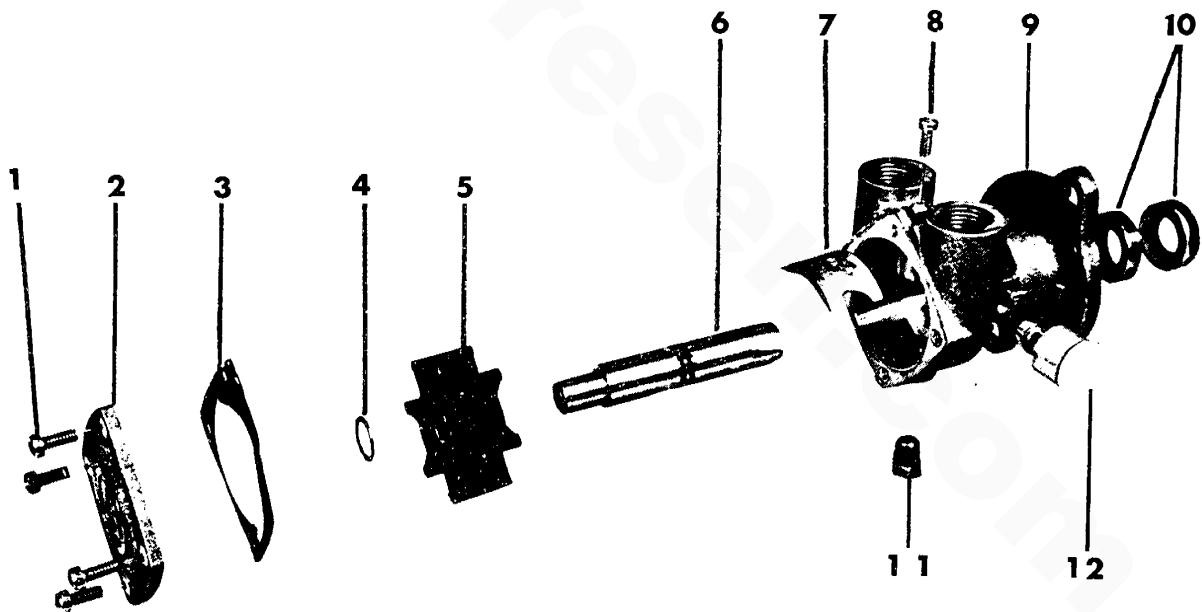
The coolant circulation in the closed circuit is from the combination exhaust manifold and surge tank, through the heat exchanger and engine water jacket, and then returned to the surge tank. Flow is continuous and is assisted by a centrifugal type water pump.

The open circuit uses sea water drawn through a sea-cock and strainer, an engine driven sea water pump passes it through the heat exchanger where it collects heat from the fresh water closed circuit, and finally into the engine exhaust for over-board discharge.

In order that the engine will reach its operating temperature as quickly as possible, a thermostat fitted to the cylinder head will open to allow circulation in the closed circuit when the coolant temperature has reached 175°F.

SEA WATER PUMP (Fig. B1)

This is a self-priming positive displacement rotary pump, with brass case and a single neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate at the top of the impellor housing, producing the pumping action. Before each initial start, turn down grease cup one full turn.



- | | |
|--------------|----------------|
| 1. Screw | 7. Cam |
| 2. Cover | 8. Screw-cam |
| 3. Gasket | 9. Body |
| 4. Snap-ring | 10. Seal |
| 5. Impeller | 11. Plug |
| 6. Shaft | 12. Grease Cup |

Fig. B1. Sea Water Pump

B

THERMOSTAT

Removing:

1. Drain the cooling system so that the coolant level is below the mounting surfaces of the thermostat housing.
2. Loosen clamp securing water hose to thermostat housing.
3. Remove the three retaining nuts securing the thermostat housing to the cylinder head.
4. Lift housing from cylinder head; disconnect water hose.
5. Remove gasket and thermostat.

Inspection:

6. Place thermostat in a bowl of water and heat it slowly. Note the temperature at which the valve commences opening and is fully open, and check this temperature figure in "General Data".

Refitting:

7. Ensure all gasket material is removed from the mounting surfaces.
8. Reverse the procedure in 2 to 5, coating the new gasket with sealer.
9. Fill and bleed cooling system.
10. Start engine and after engine has reached its normal operating temperature, check thermostat housing mounting surface and water hose connection for leaks. Check level of water in surge tank and fill to within one inch from top of tank if required.

FRESH WATER PUMP

DRAINING THE COOLING SYSTEM

CAUTION: As the system is pressurized when hot, the pressure must be released gradually when the filler cap is removed.

1. Turn the cap slowly anti-clockwise until the resistance of the safety stops is felt.
2. Leave the cap in this position until all the pressure is released.
3. Press the cap downwards against the spring to clear the safety stops, and continue turning until it can be lifted off.

Open the cylinder block drain tap located on the left-hand side of the cylinder block by turning it in an anti-clockwise direction.

COLD WEATHER PRECAUTIONS

Water expands when it freezes, and if precautions are not taken, there is considerable risk of bursting the tank or cylinder block. Such damage may be avoided by adding anti-freeze to the water.

Only anti-freeze of the ethylene glycol type incorporating the correct type of corrosion inhibitor is suitable.

1. Drain and flush the cooling system.
2. Pour in the correct quantity of anti-freeze for the degree of protection required (see table).
3. Add water until the level is 1 inch from top of tank.
4. Run the engine until it is hot.
5. Add sufficient water to bring the surface up to the correct working level.
6. Attach a label to the filler neck indicating that anti-freeze has been added.

NOTE: The strength of the anti-freeze solution must be maintained by topping up with solution as necessary.

REMOVING FRESH WATER PUMP (Fig. B5)

1. Drain the cooling system.
2. Slacken the dynamo mounting and adjusting link bolts and disengage the drive belt from the water pump pulley.
3. Unscrew the four bolts and remove the water pump pulley.
4. Slacken the by-pass hose clips
5. Unscrew the four water pump body bolts and withdraw the water pump from the water pump adaptor.

DISMANTLING

6. Using an extractor, withdraw the pulley hub from the spindle.
7. Extract the bearing locating wire through the hole in the pump body and tap out the spindle and bearing assembly.
8. Withdraw the vane from the spindle, using an extractor, and remove the water seal.

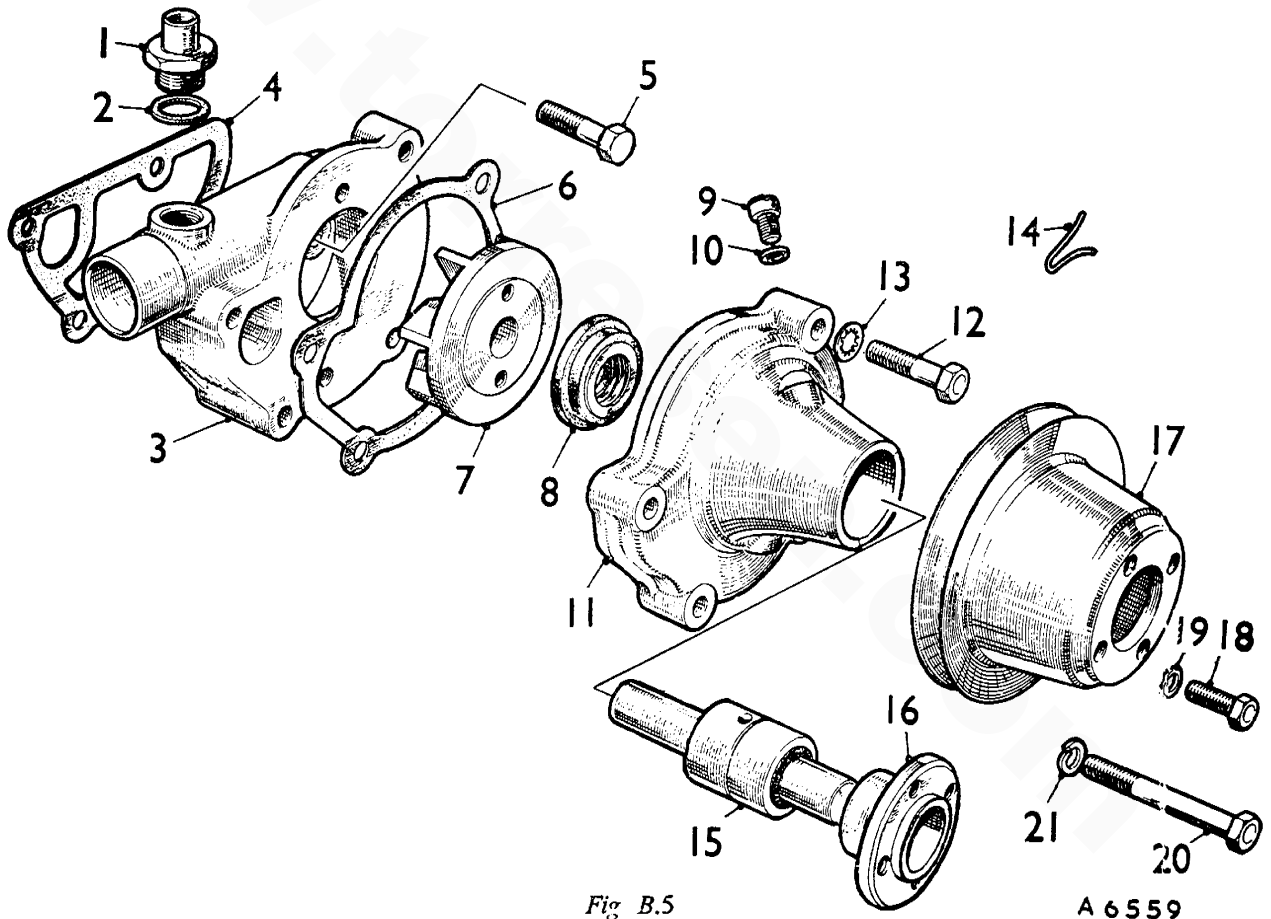


Fig B.5

A 6559

Water pump components

- | | | |
|-----------------------------------|-------------------------------------|-------------------------------------|
| 1. By-pass adaptor. | 8. Seal. | 15. Bearing assembly. |
| 2. Washer for by-pass adaptor. | 9. Set screw for lubricating point. | 16. Hub for pulley. |
| 3. Water pump adaptor. | 10. Fibre washer for set screw. | 17. Water pump pulley. |
| 4. Joint washer for pump adaptor. | 11. Water pump body. | 18. Set screw for pulley. |
| 5. Set screw for pump adaptor. | 12. Set screw for body. | 19. Spring washer. |
| 6. Joint washer for pump body. | 13. Shakeproof washer. | 20. Set screw for body and adaptor. |
| 7. Vane. | 14. Locating wire for bearing. | 21. Spring washer. |

B

INSPECTION

9. Check the interference fit of both the pulley hub and the vane on the pump spindle (see GENERAL DATA). If the fit has been destroyed, renew the components.
10. Ensure that the bearing grease retainers are in good condition.

REASSEMBLING

11. Fit the bearing assembly into the pump body. Ensure that the hole in the bearing coincides with the lubricating hole in the body, and fit the bearing locating wire and the water seal.
12. Press the vane onto the spindle until its face is flush with the face of the body (see Fig. B. 4).
13. Press the pulley hub onto the spindle to the dimension shown in Fig. B. 4.

REFITTING

14. Reverse the procedure in 2 to 5, and fill the cooling system.

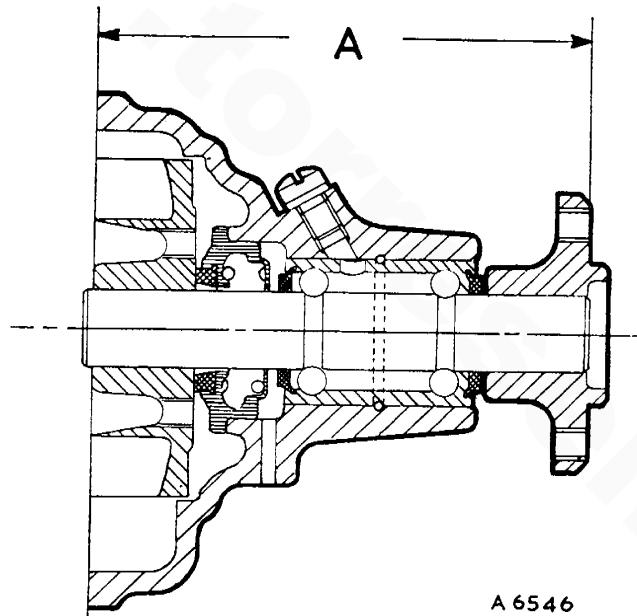


Fig. B4. Water Pump Assembly Dimension

A = 3.961 to 3.981 in. (100.609 to 101.117 mm.).



KEY TO THE INJECTION PUMP COMPONENTS

No.	Description	No.	Description	No.	Description
1.	End plate.	44.	Governor weight.	87.	Control cover.
2.	Locating pin.	45.	Weight retainer.	88.	Control cover vent screw.
3.	Screw for end plate.	46.	'O' ring for drive shaft.	89.	Body for vent screw.
4.	Stud for end plate.	47.	Control bracket.	90.	Washer for vent screw body.
5.	Nut for stud.	48.	Screw for bracket.	91.	Gasket for control cover.
6.	Piston retaining spring.	49.	Tab washer for screw.	92.	Pump body.
7.	Regulating piston.	50.	Governor arm.	93.	Joint washer for pump mounting flange.
8.	Regulating sleeve.	51.	Spring for governor arm.	94.	Drain connection.
9.	Washer for sleeve.	52.	Governor spring.	95.	Washer for connection.
10.	Regulating spring.	53.	Spring guide.	96.	Hydraulic head locking screw.
11.	Spring peg.	54.	Shut-off bar.	97.	Washer for screw.
12.	Transfer pressure adjuster.	55.	Metering valve.	98.	Vented locking screw for hydraulic head.
13.	Sleeve retaining spring.	56.	Linkage hook.	99.	Vent screw.
14.	Filter.	57.	Spring retainer.	100.	Drive hub.
15.	Inlet connection.	58.	Linkage spring.	101.	Drive hub seal.
16.	Washer for inlet connection.	59.	Linkage washer.	102.	Drive shaft screw.
17.	Fuel feed pipe connection.	60.	Pivot ball washer.	103.	Spring washer for screw.
18.	Olive for fuel feed pipe.	61.	Backing washer.	104.	Support washer.
19.	Transfer pump seal.	62.	Linkage nut.	105.	Quill shaft.
20.	Transfer pump rotor.	63.	Keep plate.	106.	Cover plate.
21.	Transfer pump vanes.	64.	Control cover stud.	107.	Gasket for cover plate.
22.	Transfer pump liner.	65.	Tab washer for stud.	108.	Screw for cover plate.
23.	Hydraulic head and rotor assembly.	66.	Nut for stud.	109.	Washer for screw.
24.	Rotor plug.	67.	Washer for nut.	110.	Advance unit housing.
25.	Washer for plug.	68.	Throttle shaft.	111.	Gasket for housing.
26.	Hydraulic head seal.	69.	'O' ring for shaft.	112.	Stud for housing.
27.	Banjo pipe.	70.	Dust cap for shaft.	113.	Cap nut for stud.
28.	Bolt for banjo pipe.	71.	Nut for shaft.	114.	Washer for cap nut.
29.	Washer for bolt.	72.	Washer for nut.	115.	End plug for housing.
30.	Radial connection.	73.	Throttle arm.	116.	'O' ring for plug.
31.	Washer for connection.	74.	Shut-off shaft.	117.	Spring cap for housing.
32.	Adjusting plate—bottom.	75.	'O' ring for shaft.	118.	'O' ring for spring cap.
33.	Adjusting plate—top.	76.	Dust cap for shaft.	119.	Screw for spring cap.
34.	Roller.	77.	Nut for shaft.	120.	Washer for screw.
35.	Roller shoe.	78.	Washer for nut.	121.	Advance piston.
36.	Drive plate.	79.	Shut-off lever.	122.	Outer spring for piston.
37.	Drive plate screw.	80.	Idling stop screw.	123.	Inner spring for piston.
38.	Cam ring.	81.	Locknut for screw.	124.	Hydraulic head locating bolt.
39.	Cam advance screw.	82.	Washer for nut.	125.	Outer 'O' ring for bolt.
40.	Circlip.	83.	Maximum speed stop screw.	126.	Inner 'O' ring for bolt.
41.	Drive shaft.	84.	Locknut for screw.	127.	Washer for bolt.
42.	Thrust sleeve.	85.	Washer for nut.	128.	Non-return valve ball.
43.	Thrust washer.				

OWNERS NOTES

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FUEL SYSTEM (Diesel Models)

C

Section C.3

FUEL TAP

Removing

- (1) Turn the fuel tap off.
- (2) Disconnect the fuel supply pipe and injector spill return pipe from their connections on the fuel tap.
- (3) Drain the fuel tank.
- (4) Unscrew the fuel tap from the fuel tank.

Inspection

- (5) Thoroughly clean the pencil-type filter gauze, attached to the fuel tap, with fuel and a stiff brush.
- (6) Inspect the pipe connections in the fuel tap for damage to the threads and seats.

Refitting

- (7) Reverse the removal procedure in (1) to (4), and bleed the fuel system (Section C.8).

Section C.4

FUEL LIFT PUMP

Removing

- (1) Turn the fuel tap off.
- (2) Disconnect the two fuel pipes from the lift pump.
- (3) Unscrew the two nuts and withdraw the lift pump from the engine.

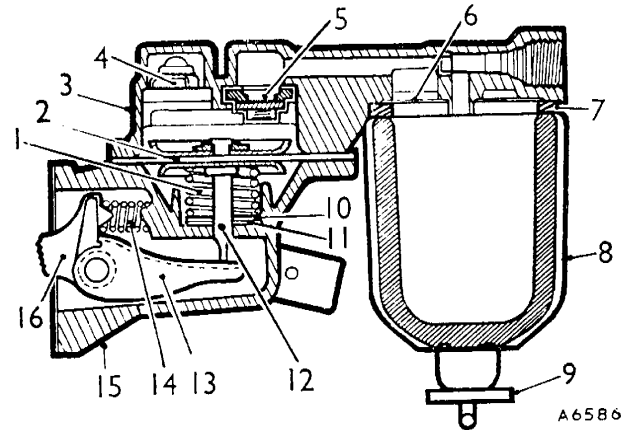


Fig. C.4

Section through the fuel lift pump

- | | |
|----------------------|-------------------------------|
| 1. Diaphragm spring. | 9. Clamp screw. |
| 2. Diaphragm. | 10. Steel washer. |
| 3. Pump cover. | 11. Sealing washer. |
| 4. Outlet valve. | 12. Pull rod. |
| 5. Inlet valve. | 13. Operating link. |
| 6. Filter gauze. | 14. Rocker arm return spring. |
| 7. Sealing ring. | 15. Pump body. |
| 8. Filter bowl. | 16. Rocker arm. |

Dismantling

- (4) Scribe a mark across the pump body and cover joint flanges for location purposes during re-assembly.
- (5) Slacken the clamp screw and remove the pump filter bowl.
- (6) Withdraw the bowl sealing ring and the filter gauze from the pump cover.
- (7) Remove the five screws and separate the cover from the pump body.
- (8) Press the centre of the diaphragm lightly downwards and rotate it through 90° to disengage the pull-rod from the operating link. Withdraw the diaphragm assembly and remove the sealing washer, steel washer, and diaphragm spring from the pull-rod.
- (9) If the rocker arm assembly is to be removed, secure the rocker arm in a vice and tap the face of the pump mounting flange with a soft mallet until the rocker arm pin retainers are dislodged.

Inspection

- (10) Examine the pump body and cover for cracks or damaged threads, and ensure that the faces of the mounting and diaphragm flanges are true.
- (11) Examine the diaphragm for splits or cracks.
- (12) Check the rocker arm pin and linkage for wear or damage.
- (13) Check the operation of the inlet and outlet valves in the pump cover. If they are not serviceable prise the valve assemblies out of the cover with a screwdriver, renew the valve gaskets, and fit new valve assemblies into position. Press the new valve assemblies fully home and stake the cover casting in six places round each valve with a punch.

C

FUEL SYSTEM (Diesel Models)

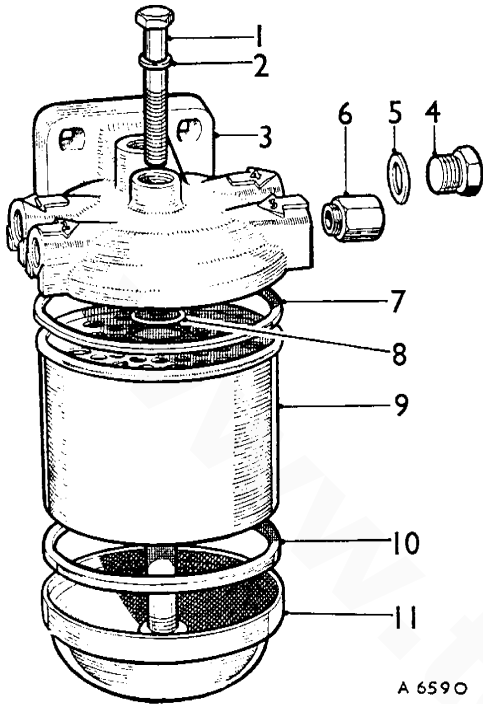


Fig. C.5

Main fuel filter components

- | | |
|----------------------|-------------------|
| 1. Centre bolt. | 7. Sealing ring. |
| 2. Washer. | 8. 'O' ring. |
| 3. Filter head. | 9. Element. |
| 4. Sealing plug. | 10. Sealing ring. |
| 5. Copper washer. | 11. Filter base. |
| 6. Non-return valve. | |

Reassembling

- (14) Reassemble the rocker arm, operating link, and packing washers, onto the rocker arm pin. Place this assembly, and the rocker arm return spring, into position in the pump body and tap two new rocker arm pin retainers into the grooves in the body casting. When the retainers are fully home secure them in position by staking the ends of the grooves.
- (15) Fit the diaphragm spring, steel washer, and sealing washer onto the pull-rod. Insert this assembly into the pump body with the notched flat on the lower end of the pull-rod in line with the slot in the operating link. Press the diaphragm downwards and rotate it through 90° to engage the pull-rod with the operating link.
- (16) Push the rocker arm towards the pump until the diaphragm is level with the body joint flange. Hold the rocker arm in this position, fit the cover to the body with the scribe marks in line, and tighten the five screws evenly.
- (17) Refit the filter gauze, sealing ring, and filter bowl.

Refitting

- (18) Reverse the procedure in (1) to (3), and bleed the fuel system as described in Section C.8.

Section C.5

MAIN FUEL FILTER

Removing

- (1) Disconnect the fuel pipes from the filter head.
- (2) Remove the two bolts from the filter head mounting flange and withdraw the filter from the engine.

Dismantling

- (3) Unscrew the centre-bolt in the filter head and detach the base from the filter.
- (4) Separate the filter element from the filter head.
- (5) Remove the sealing ring from the filter base, and the sealing ring and 'O' ring from the filter head.
- (6) Remove the non-return valve from No. 3 (inlet) connection and the sealing plug from No. 4 (outlet) connection in the filter head.

Inspection

- (7) Examine the filter head and base castings for damaged threads, damaged seal seats, and cracks.
- (8) Check the operation of the non-return valve.

Reassembling

- (9) Reverse the procedure in (3) to (6).

Refitting

- (10) Reverse the procedure in (1) and (2), and bleed the fuel system as described in Section C.8.

Section C.6

FUEL INJECTION PUMP

Removing

- (1) Disconnect the throttle and stop controls, and the fuel feed and return pipes, from the injection pump.
- (2) Disconnect the high-pressure pipes from the injectors.
- (3) Remove the three securing nuts and plain washers and withdraw the injection pump from the engine.

Dismantling

- (4) Disconnect the high-pressure pipes, remove the cover-plate from the side of the pump housing, and drain the fuel oil from the pump.
- (5) Withdraw the quill shaft from the drive hub and check the drive hub end-float by inserting a feeler gauge between the drive hub and pump body. The end-float should not exceed .010 in. (.254 mm.). Excessive end-float can be corrected by renewing the pump body and the governor weight retainer.
- (6) Mount the pump on assembly base 18G 633 A secured in a vice and remove the four high-pressure connections from the hydraulic head.
- (7) Unscrew the nuts and remove the shut-off lever and throttle arm from their shafts. Withdraw the dust cover from each shaft and remove the two nuts and washers securing the control cover.

FUEL SYSTEM (Diesel Models)

- (8) Press the throttle shaft downwards and withdraw the control cover complete with shut-off shaft. Discard the control cover gasket.
- (9) Detach the governor spring from the governor arm and the shut-off bar from the control bracket. Remove the two control cover studs and the small set screw securing the control bracket. Detach the keep plate and lift the control bracket assembly from the pump.
- (10) Disconnect the metering valve from the linkage hook and place the valve in a container of Shell Calibration Fluid 'C' to protect its precision-ground surface.
- (11) Disconnect the linkage hook from the governor arm. Detach the governor arm spring and separate the governor arm from the control bracket.
- (12) Slacken both the spring cap and end plug in the advance unit. Remove the hydraulic head locating bolt complete with its outer 'O' ring, and take care not to lose the non-return valve ball located in the side of the head locating bolt.
- (13) Remove the cap-nut and washer, and withdraw the advance unit from the pump. Detach the inner 'O' ring and washer from the head locating bolt hole, and discard the advance unit gasket.
- (14) Unscrew the spring cap and 'O' ring from the advance unit and withdraw the two springs and the piston. Note the 1 mm. shim inside the spring cap.
- (15) Remove the end plug and 'O' ring from the advance unit.
- (16) Unscrew the cam advance screw from the cam ring, with spanner 18G 646.
- (17) Slacken the fuel inlet connection and remove the screws and studs securing the end plate to the hydraulic head. Lift out the transfer pump vanes and withdraw the transfer pump liner.
- (18) Unscrew the fuel inlet connection and withdraw the regulating valve components in the following order: sleeve retaining spring, nylon filter, transfer pressure adjuster, regulating spring and peg, regulating sleeve with piston and joint washer, and lastly the piston retaining spring.
- (19) Hold the drive hub with tool 18G 659 and, using spanner 18G 634, slacken the transfer pump rotor by turning it in the direction of pump rotation as shown on the pump nameplate.
- (20) Remove the two hydraulic head locking screws, one of which incorporates an air vent valve, and withdraw the hydraulic head and rotor assembly from the pump. Remove the 'O' ring from the groove in the periphery of the hydraulic head.
- (21) Unscrew the transfer pump rotor, but do not allow the pumping and distributing rotor assembly to fall out of the hydraulic head.
- (22) Stand the hydraulic head with the drive plate uppermost. Hold the drive plate with spanner 18G 641 and unscrew the two drive plate screws (see Fig. C.7). Remove the drive plate and top adjusting plate, and withdraw the rollers and shoes from the pumping and distributing rotor.
- (23) Withdraw the rotor from the hydraulic head, remove the bottom adjusting plate, and refit the rotor to the hydraulic head. Immerse the head and rotor assembly in Shell Calibration-Fluid 'C' to protect the working surfaces.
- (24) Withdraw the cam ring from the pump housing, noting the arrow etched on the visible face of the cam ring. This arrow indicates the direction of rotation as shown on the pump nameplate.
- (25) Remove the cam ring locating circlip from inside the pump, using circlip pliers 18G 1004.
- (26) Hold the drive hub with tool 18G 659 and, with torque adaptor 18G 644, unscrew the drive shaft screw from inside the drive hub. Withdraw the drive shaft and governor weights assembly from inside the pump housing.
- (27) Remove the 'O' ring, the weight retainer, weights, thrust washer, and sleeve from the drive shaft.
- (28) Withdraw the drive hub from the pump and remove the spring washer and support washer from inside the drive hub.
- (29) Remove the drive hub oil seal from the pump housing, using tool 18G 658.

Inspection

- (30) Wash all components in Shell Calibration Fluid 'C'; hold the pumping plungers in their bores and blow out the passages in the rotor with compressed air.
- (31) Remove the pumping plungers one at a time and examine them and their bores in the rotor for wear

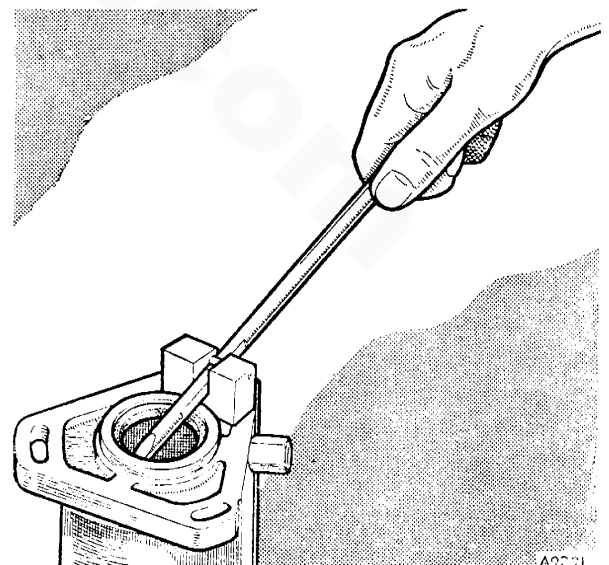


Fig. C.6

Removing the drive hub oil seal, using extractor 18G 658

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Fig. C.7

Holding the drive plate with spanner 18G 641 when unscrewing the drive plate screws

and abrasion. The end of each plunger will be polished where it contacts the roller shoe, and the plungers should be replaced in their original positions.

- (32) Examine the hydraulic head bore and its mating surface on the rotor for wear or scoring. If either of these components or the pumping plungers are worn, renew the rotor and head as a unit.
- (33) Check the cam ring lobes for wear, the plunger rollers for flats, and the roller shoes for freedom in their guides in the rotor.
- (34) Fit the drive plate to the drive shaft and ensure that there is no excessive radial movement on the splines.

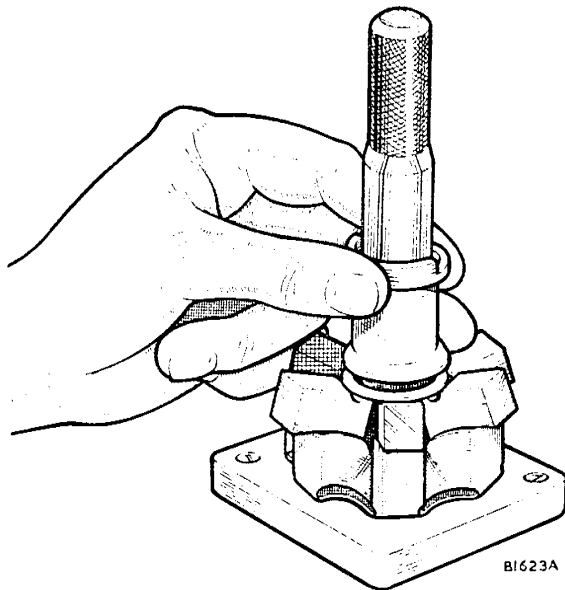


Fig. C.8

Assembling the governor weights, thrust washer, and thrust sleeve into the weight retainer, using tools 18G 661 and 18G 662

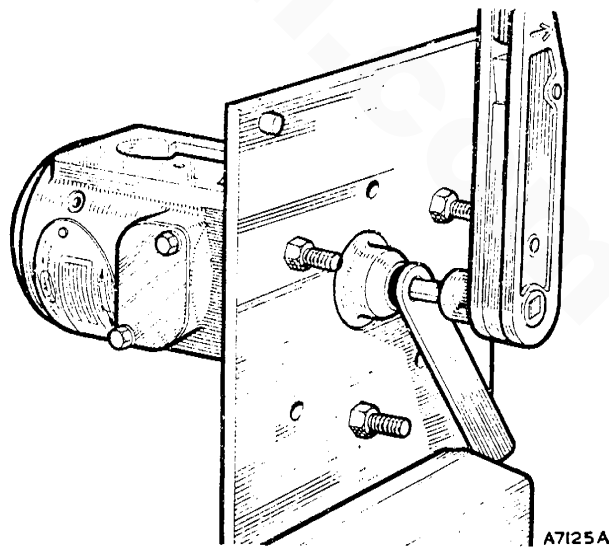


Fig. C.9

Holding the drive hub with drive shaft screw assembly tool 18G 659 while tightening the drive shaft screw with torque adaptor 18G 664 and torque wrench 18G 537

- (35) Check that the transfer pump vanes are a sliding fit in their slots when lubricated with fuel oil.
- (36) Inspect the bore of the regulating valve sleeve for wear and ensure that the valve piston can move freely through it.
- (37) Check all springs for fractures and weakness, and the governor weight retainer, thrust washer, and sleeve for signs of wear.

Reassembling

Rinse the components in clean Shell Calibration Fluid 'C' and assemble them wet.

- (38) Fit a new drive hub oil seal to the pump housing, using tool 18G 663. Insert inspection plug 18G 660 into the oil seal and examine the oil seal; a continuous black line should be visible through the plug.
- (39) Fit the two washers into the drive hub and insert the hub into the hub oil seal.
- (40) Using tools 18G 661 and 18G 662, assemble the governor weights, thrust washer, and sleeve, to the weight retainer (see Fig. C.8). The stepped flange of the sleeve must go away from the thrust washer.
- (41) Slide the governor weight assembly onto the drive shaft, fit protection cap 18G 657 over the drive shaft splines and a new 'O' ring in the groove on the drive shaft.
- (42) Insert the drive shaft and weight assembly into the pump housing and engage the drive shaft splines with the splines in the drive hub. Fit the drive shaft screw and, using tool 18G 659 to hold the drive hub, tighten the screw with adaptor 18G 664 to the torque figure given in 'GENERAL DATA'. Check the drive hub end-float as described in (5).
- (43) Using circlip pliers 18G 1004, fit the cam ring locating circlip against the shoulder in the pump

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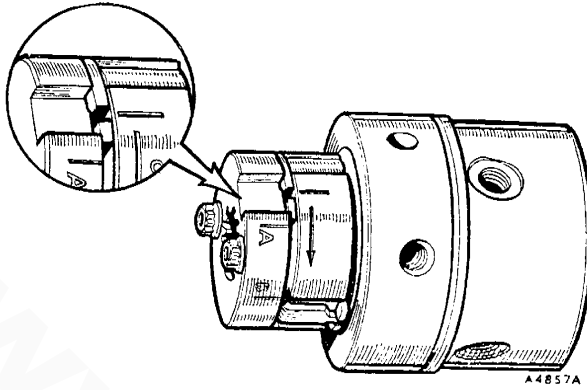


Fig. C.10

Assemble the top adjusting plate and the drive plate with the slots in their peripheries aligned with the scribed mark on the pumping end of the rotor

housing. Place the cam ring in position against the circlip and ensure that the direction of the arrow on the visible face of the cam ring conforms with the direction of the arrow on the pump nameplate. Fit the cam advance screw finger-tight and check the cam ring for freedom of rotation. If the hydraulic head and rotor are being renewed, ensure that the direction of the arrow on the pumping end of the rotor conforms with the direction of the arrow on the pump nameplate.

- (44) Withdraw the rotor from the hydraulic head and fit the top adjusting plate so that the slot in its periphery is in line with the mark on the rotor (see Fig. C.10).
- (45) Fit the drive plate to the rotor with its relieved face next to the top adjusting plate and the slot in the periphery of the drive plate in line with the mark on the rotor (see Fig. C.10). Tighten the drive plate screws lightly and insert the roller and shoe assemblies into their guides in the rotor. Make sure that the contour of the roller shoe ears conforms with the contour of the eccentric slots in the top adjusting plate.
- (46) Fit the bottom adjusting plate, engaging its slots with the lugs on the top adjusting plate, and ensuring that the contour of the eccentric slots matches the contour of the roller shoe ears.
- (47) Insert the rotor assembly into the hydraulic head, then fit and lightly tighten the transfer pump rotor.
- (48) Stand the head and rotor assembly on the bench drive plate uppermost. Fit the relief valve timing adaptor 18G 653 A, preset at 15 atmospheres to high-pressure outlet 'V' on the hydraulic head and connect this assembly to testing machine 18G 109 A (see Fig. C.12).
- (49) Operate the pumping lever of the testing machine and turn the rotor in the normal direction of rotation until the pumping plungers are forced outwards as far as the eccentric slots in the adjusting plates will allow; this is the maximum fuel position. Using tool 18G 656, rotate the adjusting

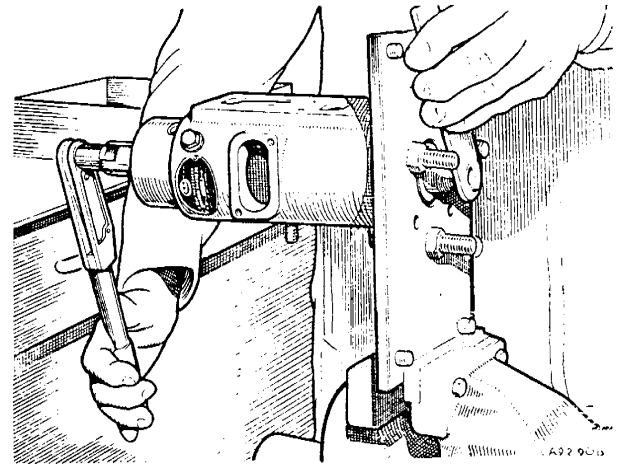


Fig. C.11

Tightening the transfer pump rotor, using torque wrench 18G 536 and tools 18G 659 and 18G 634

plates as necessary to set the roller-to-roller dimension at the figure given in 'GENERAL DATA' (see Fig. C.12). Hold the drive plate with tool 18G 641 and tighten the drive plate screws to the torque figure given in 'GENERAL DATA'. Disconnect the adaptor from the hydraulic head.

- (50) Rotate the drive shaft in the pump housing to position the master spline at 12 o'clock. Fit a new 'O' ring to the groove in the periphery of the hydraulic head and align the master spline in the drive plate with the metering valve bore in the hydraulic head. Lubricate the periphery of the hydraulic head and the bore of the pump housing liberally with clean Shell Calibrated Fluid 'C' and assemble the hydraulic head to the pump body.

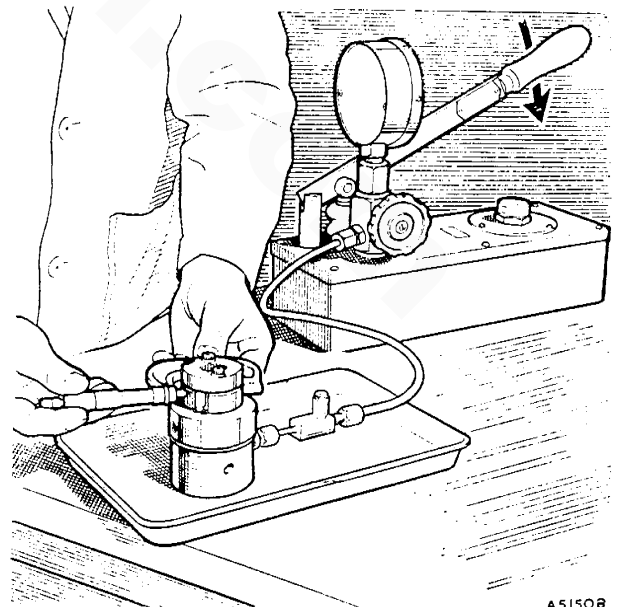


Fig. C.12

Setting the roller-to-roller dimension, using a micrometer and tools 18G 109 A and 18G 653 A

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Fit the two hydraulic head locking screws finger-tight, positioning the screw with the vent valve above the pump nameplate.

- (51) Hold the drive hub with tool 18G 659 and, using spanner 18G 634, tighten the transfer pump rotor to the torque figure given in 'GENERAL DATA' (see Fig. C.11). Fit the transfer pump liner and insert the transfer pump vanes into their slots.
- (52) Ensure that the locating peg is in position 'C' in the pump end plate and seat the piston retaining spring in the bottom of the regulating valve bore.
- (53) Fit a new seal washer to the small-diameter end of the regulating valve sleeve and fit the piston into the sleeve. Insert the regulating spring and peg into the large-diameter end of the sleeve and place the transfer pressure adjuster on the top of the sleeve. Fit the sleeve retaining spring onto the pressure adjuster and pass the filter, small end leading, over the spring and onto the shoulder of the valve sleeve. Insert this assembly, valve sleeve first, into the bore of the end plate and fit the fuel inlet connection and washer.
- (54) Place a new sealing ring in its recess in the hydraulic head face and fit the end plate to the head, engaging the locating peg with the slot in the transfer pump liner. Tighten the end plate screws and studs to the torque figure given in 'GENERAL DATA', then tighten the fuel inlet connection to the torque figure given in 'GENERAL DATA'.
- (55) Using spanner 18G 646, tighten the cam advance screw to the torque figure given in 'GENERAL DATA' and check the cam ring for freedom of rotation.
- (56) Fit new 'O' rings to the advance unit end plug and spring cap, using protection cap 18G 640 to pass the rings over the threads. Screw the end plug finger-tight into the end of the advance unit where the fuel duct enters the bore. Fit the piston into the advance unit, with its counterbored end at the open end of the housing, and place the two springs in position in the piston. Place the 1.0 mm. shim washer inside the spring cap and screw the cap finger-tight into the housing. If the spring cap or end plug are renewed, ensure that the new part has the same identification letter as the component it replaces. Unmarked components should be used to replace unmarked components.
- (57) Fit a new 'O' ring under the head of the hydraulic head locating bolt, using protection cap 18G 639. Position the non-return valve ball in the side of the head locating bolt and fit the bolt to the advance unit. Using assembly cap 18G 647, fit a new inner 'O' ring to the shank of the locating bolt, and place the plain washer on top of the 'O' ring.
- (58) Place a new advance unit joint washer on the pump housing with the straight side of the 'D'-shaped hole at the drive end of the pump; to ensure sealing, this joint washer should be fitted dry. Position the advance unit on the pump, fit a new aluminium and rubber washer to the stud, and fit the cap nut.

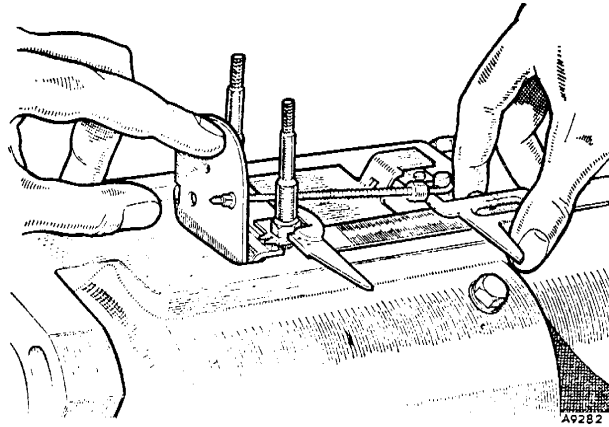


Fig. C.13

Setting the governor link length (the dimension between the metering valve lever pin and the control cover stud) with the vernier held parallel to the axis of the pump

- (59) Tighten the two hydraulic head locking screws, the hydraulic head locating bolt, and the advance unit cap-nut, to the torque figures given in 'GENERAL DATA'. Tighten the advance unit end plug and spring cap to the torque figures given in 'GENERAL DATA'.
- (60) Insert the metering valve into its bore in the hydraulic head.
- (61) Assemble the governor arm, control bracket, and governor arm spring, then fit the assembly to the pump housing, ensuring that the lower end of the governor arm engages the stepped face of the thrust sleeve flange. Fit the keep plate with its open end towards the shut-off bar, and fit new tab washers with their pointed tabs towards the governor arm. Screw in the two control cover studs to the torque figure given in 'GENERAL DATA' and secure them with the pointed tabs.
- (62) Fit the small screw and tab washer to the metering valve end of the control bracket. Tighten the screw to the torque figure given in 'GENERAL DATA' and lock it with the tab washer.
- (63) Assemble the spring retainer, spring, and linkage washer onto the linkage hook. Pass the threaded end of the hook through the governor arm, fit the pivot ball washer and backing washer, and screw on the linkage nut about three turns.
- (64) Press back the spring retainer and attach the linkage hook to the metering valve so that the hook end is turned towards the metering valve.
- (65) Press the governor arm lightly in the direction of the metering valve and, using a vernier gauge held parallel to the pump axis, set the governor link length (see Fig. C.13) to the dimension given in 'GENERAL DATA'. This adjustment is made by slackening or tightening the linkage hook nut.
- (66) Locate the spring guide in hole No. 2 in the governor arm (see Fig. C.14) and connect the governor spring to the guide.

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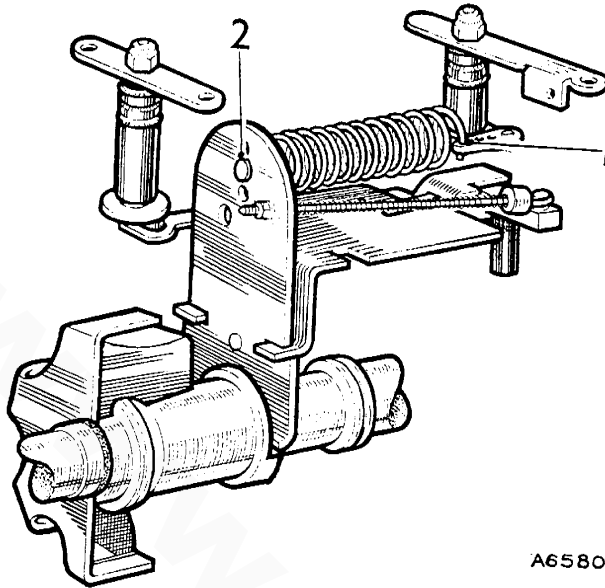


Fig. C.14

Governor spring location

1. Hole No. 1 in the throttle shaft link.
2. Hole No. 2 in the governor arm.

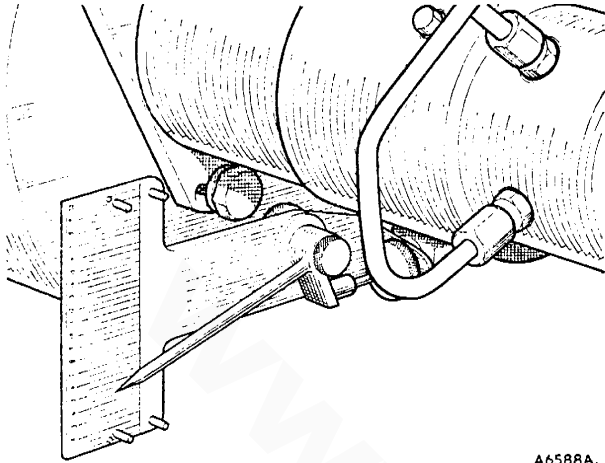
- (67) Insert the plain end of the shut-off bar into the slot in the control bracket and position the shut-off bar under the tab of the control cover locking washer.
- (68) Using protection cap 18G 654, fit new lower 'O' rings to the shut-off and throttle shafts. Fit a new upper 'O' ring to each shaft, using protection cap 18G 665, and pack the groove between the 'O' rings on each shaft with Shell Alvania No. 2 grease.
- (69) Press the shut-off shaft into its bore in the control cover, positioning the eccentric peg close to the edge of the control cover and projecting slightly from the joint face.
- (70) Place a new control cover joint washer in position on the pump housing, engaging the tabs with the slots under the keep plate. To ensure sealing, this joint washer should be soaked in Shell Calibration Fluid 'C' before assembly.
- (71) Connect the free end of the governor spring to No. 1 hole in the throttle shaft link (see Fig. C.14) and press the throttle shaft into its bore in the control cover. Place the control cover in position on its studs, ensuring that the shut-off peg engages the shut-off bar. Pull the shut-off shaft fully home as the control cover is lowered onto the pump housing.
- (72) Fit new sealing washers to the control cover studs, and screw on the stud nuts to the torque figure in 'GENERAL DATA'.
- (73) Place the dust caps on the throttle and shut-off shafts, fit the throttle arm and shut-off lever to their shafts and secure them in position with their nuts and washers.
- (74) Refit the inspection cover to the side of the pump housing and refit the quill shaft.

Testing and adjusting

- (75) The following precautions must be observed when testing the pump:
 - (a) Ensure that the power-driven test bench is set to run in the direction of pump rotation as indicated on the pump nameplate.
 - (b) Ensure that the fuel flow at the pump inlet is not less than 1,000 c.c./min. If this flow cannot be obtained, a maximum feed pressure of 2 lb./sq. in. (.15 kg./cm.²) is permissible.
 - (c) Do not run the pump for long periods at high speed with low fuel output.
 - (d) Do not run the pump for long periods with the shut-off control in the closed position.
 - (e) Ensure that the throttle and shut-off controls are in the fully open position except where stated otherwise.
- (76) Mount the pump on the test bench and connect up the drive.
- (77) Fit radial connections to the four high-pressure outlets in the hydraulic head and connect them, by means of high-pressure pipes to a matched set of test injectors set to open at 175 atmospheres. The pipes should be 6 mm. x 2 mm. x 865 mm. (34 in.) long, and the injectors should have Type BDN.12. SD.12 nozzles mounted in Type BKB.50.SD.19b nozzle holders.
- (78) Using flexible pipes, preferably of the transparent type, connect the injection pump to the test equipment as follows.
 - (a) Fit transfer pressure adaptor 18G 636 in place of the hydraulic head locking screw (not the one with the vent valve), and connect the adaptor to the pressure gauge.
 - (b) Fit the end plate adjuster 18G 690 to the fuel inlet on the pump and connect the adjuster, by means of a 'T' coupling, to both the fuel supply and the vacuum gauge.
 - (c) Connect the pump drain (back-leakage) connection to the measuring glass inlet, and the measuring glass drain cock to the test bench return connection.
- (79) Fit automatic advance gauge 18G 638 B to the advance unit spring cap in place of the small set screw. Set the degree scale to give a zero reading.
- (80) Unscrew the idling and maximum speed stop screws to ensure that the throttle arm has its full range of movement.
- (81) Unscrew the transfer pressure adjuster in the pump end plate to the maximum extent, then screw it in 1½ turns.
- (82) Fill and prime the injection pump as follows:
 - (a) Connect the fuel feed pipe to the drain connection on the pump.
 - (b) Open both the vent screws on the injection pump, turn on the gravity feed, and when test oil free of air bubbles flows from the vent screw on the hydraulic head, close this vent screw. When test oil free of air bubbles flows

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Fig. C.15

Checking the automatic advance, using advance gauge 18G 638 B

- from the control cover vent screw, close this vent screw also.
 - (c) Rotate the pump drive through 180° and repeat the procedure in (b).
 - (d) Fit the feed and return pipes to their respective connections.
 - (e) Slacken the high-pressure pipe unions at the injectors and run the test bench at 100 r.p.m. until oil, free of air bubbles, issues from the injector connections. Tighten the high-pressure pipe unions while the test machine is running.
- (83) Check the oil-tightness of all joint washers, oil seals, and pipe connections, while the pump is running and when stationary. Then carry out the following sequence of tests:

Test 1—Transfer pump vacuum

Run the pump at 100 r.p.m. and turn the test oil feed cock to the 'off' position. The depression registered on the vacuum gauge should reach 16 in. (406 mm.) Hg within 60 seconds maximum. **Do not run the pump for periods exceeding 60 seconds with the test oil supply turned off.** After the vacuum test turn on the test oil supply and with the pump running at 100 r.p.m. air-vent the pump by means of the vent screw on the hydraulic head.

Test 2—Transfer pump pressure

Run the pump at 100 r.p.m. and note the pressure gauge reading. This should be 11 lb./sq. in. (.8 kg./cm.²) minimum.

Test 3—Transfer pump pressure

Increase the pump speed to 800 r.p.m. The pressure gauge reading should now be 50 to .66 lb./sq. in. (3.5 to 4.7 kg./cm.²).

Test 4—Advance setting

With the pump running at 900 r.p.m. set the end plate adjuster to give an advance gauge reading of 2½°.

Test 5—Advance position

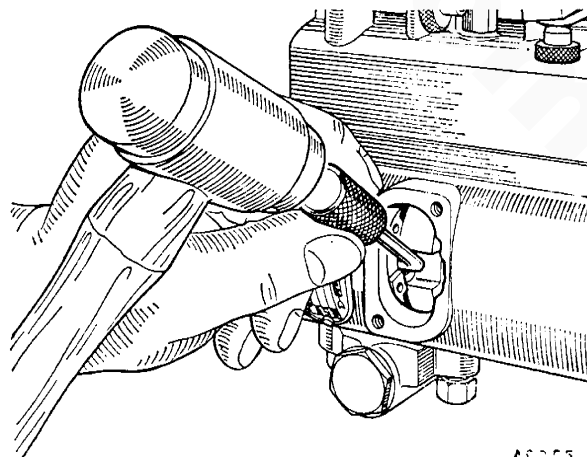
Increase the pump speed to 1,400 r.p.m. The advance gauge reading should now be 3½ to 4½°.

Test 6—Back-leakage

Run the pump at 1,000 r.p.m. and measure the back-leakage in the measuring glass: it should be 5 to 50 c.c. per 100 shot time cycle.

Test 7—Maximum fuel delivery

Run the pump at 1,000 r.p.m. The average delivery for 200 shots from all four test injectors should be 2.9 ± .1 c.c. In arriving at this figure compare the delivery from all injectors to ensure that the difference in output between any two does not exceed .7 c.c. Before taking a reading allow the test oil to settle in measuring-glasses for 15 seconds and allow the glasses to drain for 30 seconds before a fresh test is made. If the fuel delivery is incorrect, turn off the test oil supply and remove the cover-plate from the side of the pump. Slacken the two drive plate screws and turn the pump drive until the slot in the periphery of the top adjusting plate is visible. Using tool 18G 656 engaged in the slot, tap the adjusting plate in the direction necessary to correct the fuel delivery. Movement of the adjusting plate in the direction of normal pump rotation will increase the output, and movement in the opposite direction will decrease output. This adjustment must be carried out very carefully as the amount of movement required will be very small. Tighten the drive plate screws to the torque figure given in 'GENERAL DATA', using torque adaptor 18G 655 A. When tightening the screws, the torque wrench and spanner must be in line (see Fig. C.17). After making the



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Fig. C.16

Adjusting the maximum fuel setting, using maximum fuel adjusting probe 18G 656

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adjustment replace the cover-plate and prime the pump as described in (82). Re-check the fuel delivery and, if necessary, re-adjust the pump output.

Test 8—Maximum fuel delivery check

Decrease the pump speed to 150 r.p.m. The average delivery for 200 shots should now be not less than that obtained in 'Test 7' minus 1.6 c.c.

Test 9—Cut-off operation

Run the pump at 200 r.p.m. with the shut-off lever in the fully closed position. The average delivery for 200 shots should not exceed .5 c.c.

Test 10—Throttle operation

Run the pump at 200 r.p.m. with the throttle arm in the fully closed position and the shut-off lever in the open position. The average delivery for 200 shots should not exceed .5 c.c.

Test 11—Fuel delivery check

Run the pump at 1,250 r.p.m. with both the throttle and shut-off controls in their fully open positions. Record the average delivery for 200 shots.

Test 12—Governor setting

Increase the pump speed to 1,360 r.p.m. and set the throttle arm by means of the maximum speed stop screw to give a maximum average delivery of .8 c.c. per 200 shots; no line should exceed 1.0 c.c. Tighten the stop screw locknut.

Test 13—Fuel delivery check

Reduce the pump speed to 1,250 r.p.m. The average delivery for 200 shots should now be not less than that obtained in 'Test 11' minus .4 c.c.

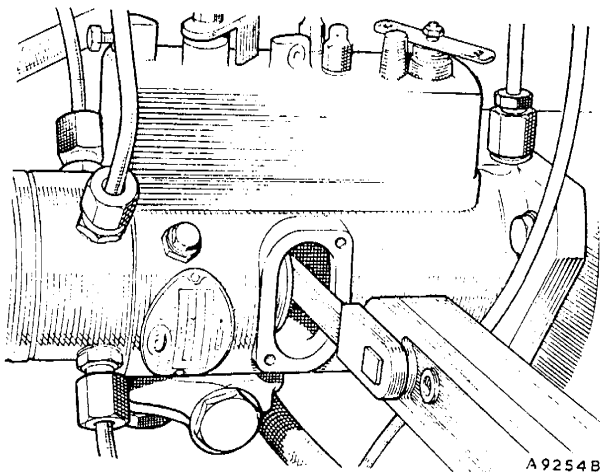


Fig. C.17

Tightening the drive plate screws, using torque wrench 18G 537 and torque adaptor 18G 655 A. Torque wrench and spanner must be in line as shown

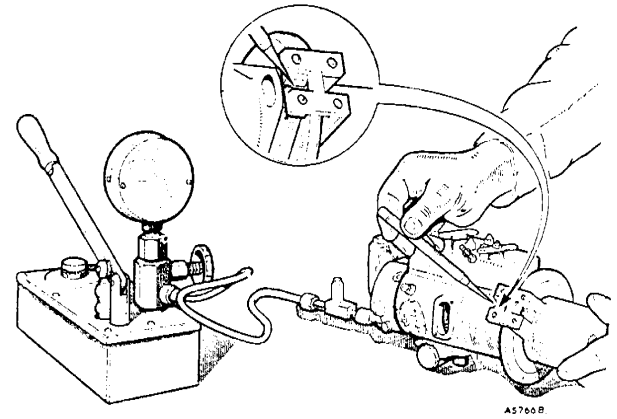


Fig. C.18

Scribing the timing mark on the fuel injection pump flange, using tool 18G 648 A

Test 14—Timing setting

After the foregoing tests have been completed, remove the pump from the test bench and mount flange marking gauge 18G 648 A, preset to 84°, on the pump quill shaft. Using testing machine 18G 109 A and timing adaptor 18G 653 A, apply 100 atmospheres pressure to outlet 'V' in the hydraulic head while rotating the drive hub, by means of the marking gauge, in the direction of normal pump rotation. When resistance is encountered, hold the marking gauge steady on the pump mounting flange and mark the pump by drawing a scribing tool along the guide on the gauge. If necessary, delete the old timing mark from the pump flange before making the new mark. Finally, seal the cover-plate screws on the side of the pump, using wire, a lead seal, and sealing pliers 18G 541, and fit the correct high-pressure connections to the hydraulic head.

Refitting

- (84) Crank the engine until No. 1 piston is at 16° B.T.D.C. on its compression stroke.
- (85) Insert timing gauge 18G 1052 into the injection pump chain wheel hub from the rear, engaging the splines on the tool with those in the driving flange.
- (86) Apply a gentle clockwise (as seen from the rear of the engine) pressure to the gauge to eliminate backlash and line up the timing pointer on the engine front plate with the mark cut in the timing gauge (see Fig. C.19).
- (87) Fit the injection pump, complete with high-pressure pipes, to the engine. Align the pump scribe mark with the timing pointer and tighten the three securing nuts.
- (88) Connect the throttle and stop controls, ensuring that both the throttle arm and shut-off lever on the pump have their full range of movement.

C

FUEL SYSTEM (Diesel Models)

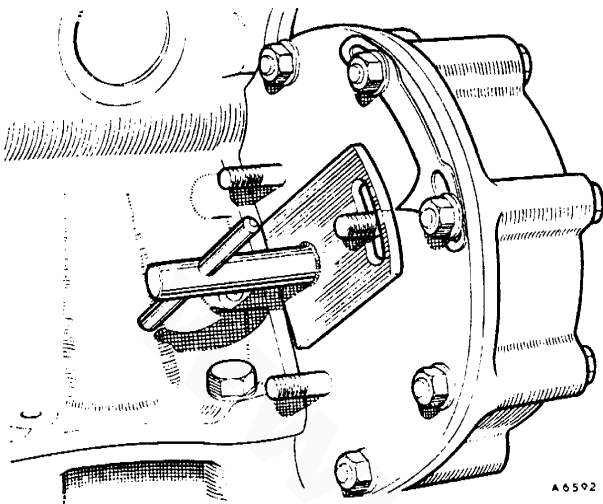


Fig. C.19

Checking the position of the injection pump timing pointer, using timing gauge 18G 1052

- (89) Connect the high-pressure pipes to the injectors, and the fuel feed and return pipes to the injection pump.
- (90) Bleed the fuel system as described in Section C.8.
- (91) Adjust the maximum and idling speeds as described in Section C.9.

Section C.7

FUEL INJECTORS

Removing

- (1) Disconnect the spill and high pressure pipes from the injectors.
- (2) Unscrew the securing nuts and remove the injector clamps.
- (3) Withdraw the injectors, using tool 18G 284 and adaptor 18G 284 P, and plug the injector holes in the cylinder head.

Dismantling

- (4) Mount the injector in dismantling fixture 18G 388.
- (5) Remove the injector cap-nut and the copper joint washer.
- (6) Slacken the locknut, unscrew the spring cap-nut, and remove the copper joint washer, spring, and spindle.
- (7) Unscrew the nozzle nut, using spanner 18G 210, and remove the nozzle body and valve assembly.

Inspection

- (8) Wash all the components thoroughly in clean Shell Calibration Fluid 'C'.
- (9) Examine the spring for signs of weakness, rusting, or fracture, and ensure that the ends are perfectly square. Check the spindle for straightness.
- (10) Ensure that the face of the nozzle holder which contacts the nozzle is perfectly smooth and flat.
- (11) Using cleaning kit 18G 487, thoroughly clean the nozzle body and valve:

Fig. C.20
Clearing the pintle orifice

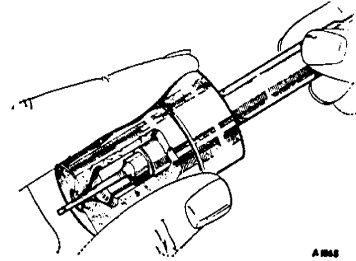
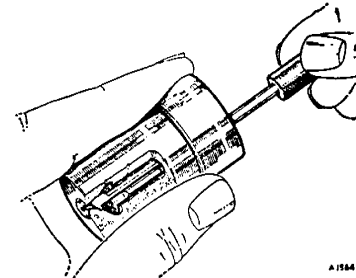


Fig. C.21
Cleaning the annular chamber



- (a) Clean all carbon from the nozzle valve and the outside of the body with the brass-wire brush.
 - (b) Remove all foreign matter from inside the nozzle body by means of the shaped scrapers as shown in the illustrations.
 - (c) Clear the auxiliary spray hole in the nozzle with the probing tool. The wire should be fitted into the tool so that it protrudes only about $\frac{1}{8}$ in. (1.6 mm.).
- (12) Ensure that the lapped pressure face on the upper end of the nozzle is perfectly smooth and flat.
 - (13) Fit the nozzle into adaptor 18G 109 E with the nozzle tip towards the small diameter connection. Attach the adaptor to testing machine 18G 109 A and operate the pumping lever several times, thus clearing the nozzle passages by reverse-flushing.

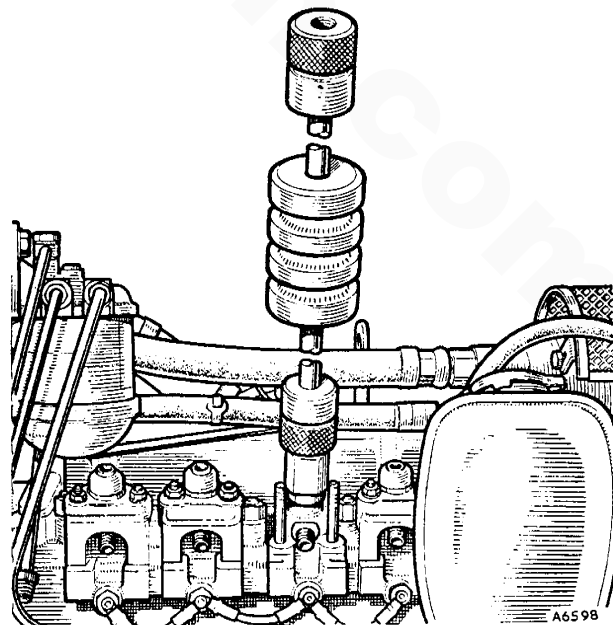


Fig. C.22
Withdrawing an injector, using tool 18G 284 and adaptor 18G 284 P

FUEL SYSTEM (Diesel Models)

C

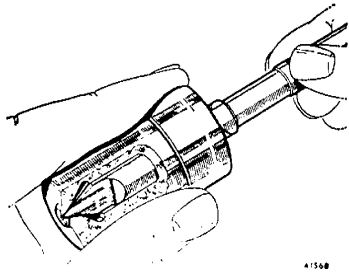


Fig. C.23
Cleaning the
nozzle seat



Fig. C.24
Clearing the aux-
iliary spray hole

(14) In cases where the carbon deposit is particularly hard, it can be softened by boiling the nozzle bodies in a caustic solution:

- (a) Dissolve 2 oz. (56.7 gm.) of caustic soda in 1 pint (.57 litre) of water and add ½ oz. (14.2 gm.) of an ordinary washing detergent.
- (b) Boil the nozzle bodies in the liquid for a minimum of 1 hour and not more than 1½ hours. Do not allow too much water to evaporate, because a concentration of caustic soda above 15 per cent. may cause roughness of the nozzle bore and seat which would make the nozzle unserviceable.
- (c) Wash the nozzles in running water and immerse them in a de-watering oil such as Shell Ensis 254. Remove the surplus oil by draining or with compressed air, then remove the carbon as described in (11) and (13).

(15) Examine the valve seat in the nozzle body through a nozzle microscope. The seat should not be

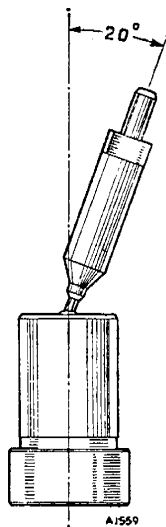


Fig. C. 25

Testing the pintle and orifice for wear. The valve must not tilt at a greater angle than 20° from the body centre-line

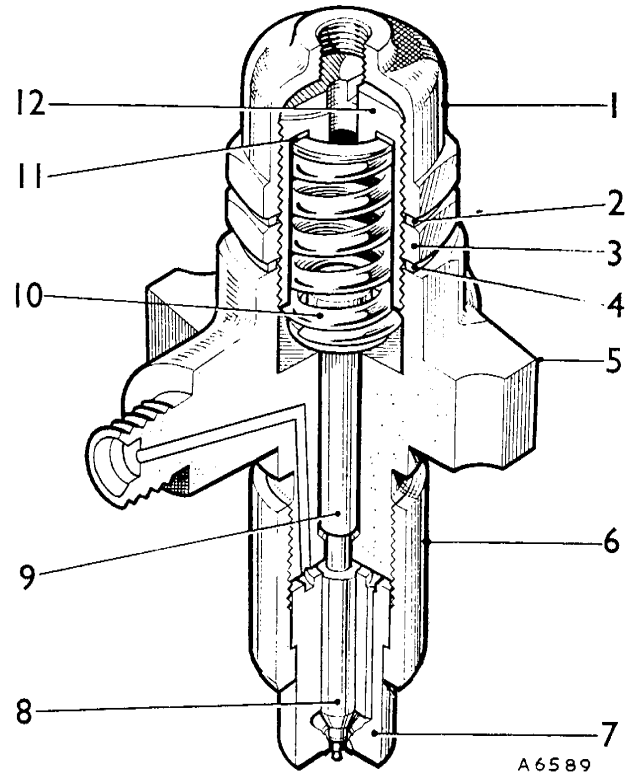


Fig. C.26

Section through a fuel injector

- | | |
|----------------------|---------------------|
| 1. Injector cap-nut. | 7. Nozzle body. |
| 2. Joint washer. | 8. Nozzle valve. |
| 3. Locknut. | 9. Spindle. |
| 4. Joint washer. | 10. Spring. |
| 5. Nozzle holder. | 11. Washer. |
| 6. Nozzle nut. | 12. Spring cap-nut. |

stepped, and should be free from scores and pitting.

(16) Examine the conical surface which forms the seat of the nozzle valve through a nozzle microscope. The most critical part of the conical surface is where it forms an angle with the parallel stem. This angle should be sharp and clearly defined, with no rounding or wear breaking the knife-edge anywhere on its diameter. Check the pintle clearance as shown in Fig. C.25.

(17) If all the components appear serviceable, assemble the injector as described in (32) and (33). Then adjust and test the injector as described in (34) to (43). Provided the wear is not excessive, an unserviceable nozzle body and valve can be reconditioned on a nozzle grinding and lapping machine as described in (18) to (31).

Reconditioning

(18) Select a nozzle lap from those supplied with the machine. The bore diameter varies slightly from one nozzle to another, and the lap chosen should fit the nozzle in the same manner as the nozzle valve to ensure concentricity of the valve seat and nozzle bore after lapping.

C

FUEL SYSTEM (Diesel Models)

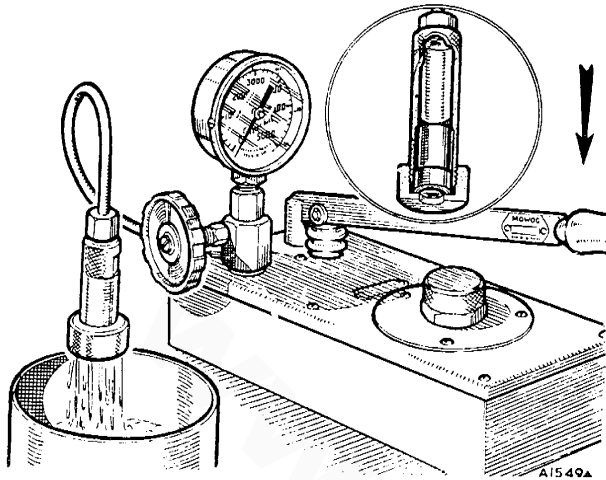


Fig. C.27

Reverse-flushing an injector nozzle with testing machine 18G 109 A and adaptor 18G 109 E. A sectioned adaptor with a nozzle in position is shown inset

- (19) Mount the lap in the lathe of the machine and if the lap is pointed remove the tip to avoid damaging the pintle hole. Grind the conical end to the correct nozzle body seat angle of 59°. Pass the lap slowly backwards and forwards across the grinding-wheel, feeding in the lap very gradually until its conical surface is entirely cleaned up. Inspect the lap under the nozzle microscope and, if the ground surface is rough, dress the grinding wheel and regrind the lap.
- (20) Fit the lap into the lapping chuck of the machine and apply a coating of tallow to the guide surface of the lap for lubrication.
- (21) Apply a small quantity of lapping paste to the tip of the lap, taking care that the paste does not extend to the parallel stem of the lap.
- (22) Start the machine and carefully slide the nozzle over the rotating lap. Oscillate the nozzle on the lap in very short strokes at a rate of 20 to 30 strokes per minute, engaging the nozzle seat with the lap at each stroke. Apply only light pressure to the nozzle and do not allow the nozzle seat to remain in contact with the lap for more than 5 seconds at a time.
- (23) After 30 seconds lapping time withdraw the nozzle, clean the lap, and examine the conical lap tip. There will be a mat surface where the lap has been in contact with the nozzle seat, and in the early stages of lapping this surface may be narrow or have a bright circumferential ring. These markings indicate the extent of the wear on the nozzle seat.
- (24) Reface the lap as described in (19) after every 1½ minutes of lapping time.
- (25) When the seat appears satisfactory after a few seconds' lapping with a freshly ground lap, use fine lapping paste to finish the seat off to a smooth mat surface. Lapping should be kept to a minimum because excessive lapping will allow the nozzle valve

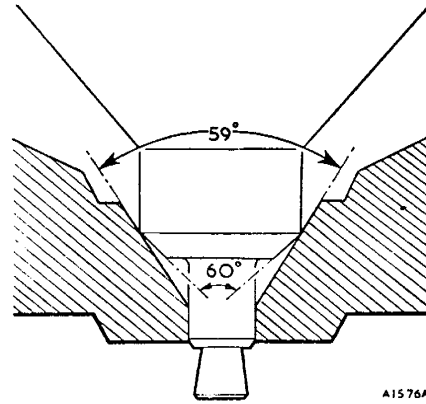


Fig. C.28

Correct nozzle and valve seat angles

to seat in a lower position than the auxiliary spray hole and the nozzle will be useless.

- (26) Reverse-flush the nozzle as described in (13), dry it with compressed air, and make a final inspection under the nozzle microscope.
- (27) Make sure that the grinding-wheel is dressed correctly and adjust the refacing angle of the machine to 60° to suit the nozzle valve.
- (28) Mount the valve in the lathe of the machine and reface the conical seat. Be particularly careful not to damage the pintle end of the valve by allowing it to touch the grinding-wheel, and remove only the absolute minimum of material from the valve seat; just enough to change the colour of the seat, otherwise the nozzle valve lift (needle lift) will be increased. As a guide, there should be no sparks or hiss from the grinding-wheel when refacing the valve. Watch the refacing procedure through a magnifying-glass, focusing on the surface of the seat face away from the grinding-wheel.

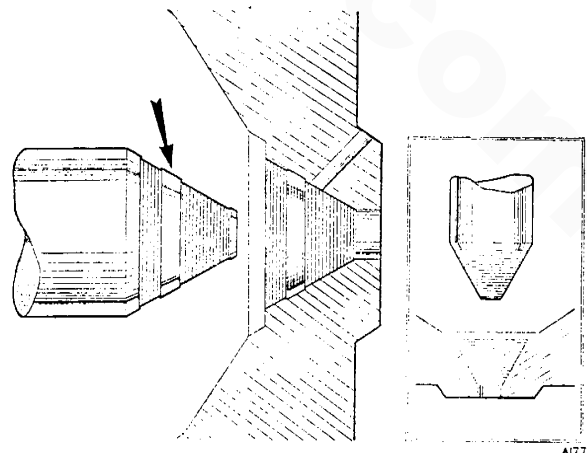


Fig. C.29

Lapping a nozzle seat. The arrow indicates the bright circumferential ring which may be present on the lap in the early stages of lapping. A view of the seat and lap upon completion is shown inset

FUEL SYSTEM (Diesel Models)

- (29) After refacing, inspect the valve under the nozzle microscope.
- (30) If, due to slight distortion or deposits on its guide surface, the valve is found to be a tight fit in the nozzle body, it can be corrected by lapping the guide surface of the valve. Mount the valve in the lapping chuck and lap the guide surface of the valve, using fine lapping paste and one of the collets supplied with the machine. A correctly fitting valve should just slide into the body under its own weight when lubricated with fuel oil.
- (31) After attention to either the nozzle body or valve seats, assemble the valve and body and check the needle lift against the figure in 'GENERAL DATA'. To correct excessive needle lift, lap the joint face of the nozzle body on a surface lapping plate. Be careful not to tilt the nozzle because the joint face must remain true and at right angles to the nozzle axis.

Reassembling

- (32) Wash all the components in clean Shell Calibration Fluid 'C', and assemble the nozzle valve to the nozzle body while both components are immersed in the oil.
- (33) Fit the nozzle holder to dismantling fixture 18G 388 and reverse the procedure in (5) to (7), tightening the nozzle nut to the torque figure given in 'GENERAL DATA'. Then adjust and test the injector as described in (34) to (43).

Adjusting and testing

Back-leakage test

- (34) Connect the injector to testing machine 18G 109 A with the nozzle facing away from the operator and open the check valve to the pressure gauge.
- (35) Operate the pumping lever and observe the pressure at which injection occurs.
- (36) With the injector cap-nut removed adjust the spring cap-nut to give an injection pressure of 170 atmospheres.

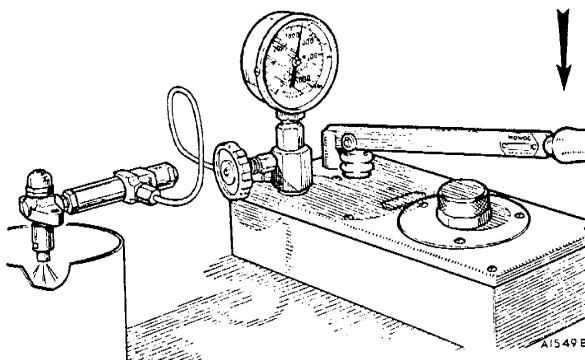


Fig. C.30

Testing an injector for spray, using testing machine 18G 109 A and adaptor 18G 109 B

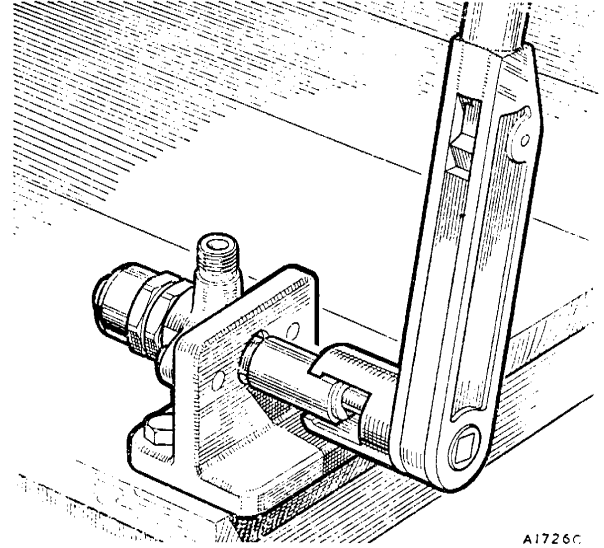


Fig. C.31

Reassembling a fuel injector, using fixture 18G 388, spanner 18G 210, and torque wrench 18G 372

- (37) Operate the pumping lever until the pressure gauge registers 160 atmospheres. Release the lever and time the pressure drop from 150 to 100 atmospheres. For a nozzle in good condition this time should be between 6 and 40 seconds.

Seat tightness test

- (38) Adjust the spring cap-nut to give an injection pressure of 100 atmospheres. Dry the nozzle tip and depress the pumping lever until a pressure of 90 atmospheres is obtained. Maintain this pressure for 10 seconds and examine the nozzle tip for dryness. If in doubt, maintain the 90 atmospheres pressure for 60 seconds while holding a piece of blotting paper below the nozzle tip; the diameter of the wet spot on the paper should not exceed 1/2 in. (13 mm.).

Adjustment and spray test

- (39) Adjust the spring cap-nut to give an injection pressure of 135 atmospheres, tighten the locknut, and re-check the injection pressure. Fit the injector cap-nut and joint washer.
- (40) Connect adaptor 18G 109 B to the testing machine in place of the injector and adjust the adaptor opening pressure to 220 atmospheres.
- (41) Connect the injector to the adaptor and close the check valve to the pressure gauge.
- (42) Operate the pumping lever at about 60 strokes a minute and observe the auxiliary spray. This should be well formed and free from splits or distortions. A slight central core may be disregarded.
- (43) Increase the operating speed to about 140 strokes a minute and observe the main spray. This should be well atomized and free from large splits or distortion. A slight central core may be disregarded.

C

FUEL SYSTEM (Diesel Models)

Refitting

(44) Reverse the procedure in (1) to (3), noting the following:

- (a) Renew both sealing washers on each injector. One washer passes over the nozzle and seals between the nozzle nut and the heat shield flange. The second washer (atomizer seal washer) seals between the nozzle face and the bottom of the heat shield; this washer should be fitted with its two edges downwards.
- (b) Tighten the injector clamp nuts to the torque figure given in 'GENERAL DATA'.
- (c) Bleed the fuel system as described in Section C.8.

- (1) Ensure that the stop control is fully home in the run position and remove the sealing cap from the maximum speed stop screw.
- (2) Run the engine until it has attained its normal running temperature.
- (3) Slacken the locknut and adjust the maximum speed stop screw to set the engine maximum light running speed at 2,750 r.p.m. This will give the engine a maximum governed speed under load of 2,500 r.p.m. Tighten the locknut.
- (4) Fit the sealing cap and seal it with wire and a lead seal, using sealing pliers 18G 541.
- (5) Adjust the idling stop screw to give an idling speed of 600 r.p.m. and tighten the locknut.

Section C.9

MAXIMUM AND IDLING SPEED ADJUSTMENT

Before making either of these adjustments ensure that the engine air cleaner is correctly serviced and fitted.

NOTE.—Adjustment of the maximum fuel setting will alter the pump timing in relation to the mark on the pump mounting flange; therefore, after adjustment of the maximum fuel setting, the mounting flange should be re-marked as described in Section C.6 (83), Test 14.

SAO TRANSMISSION

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SAO TRANSMISSION

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 OF SAO TRANSMISSION

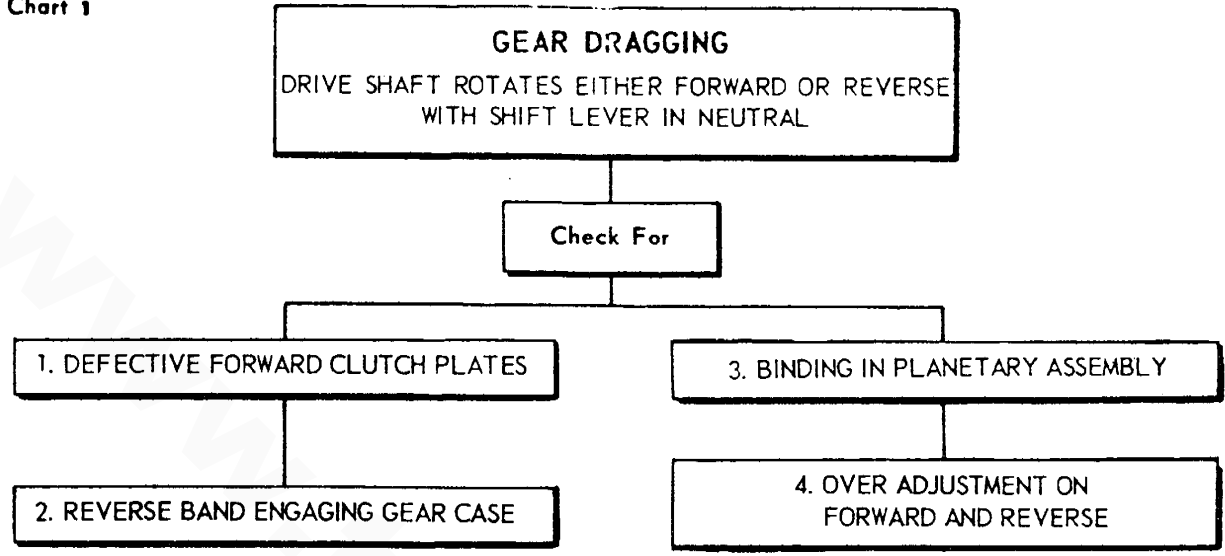
As in any servicing operation, cleanliness is a must and all rules for good workmanship apply. Some of these rules are as follows:

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

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

TROUBLE SHOOTING CHARTS

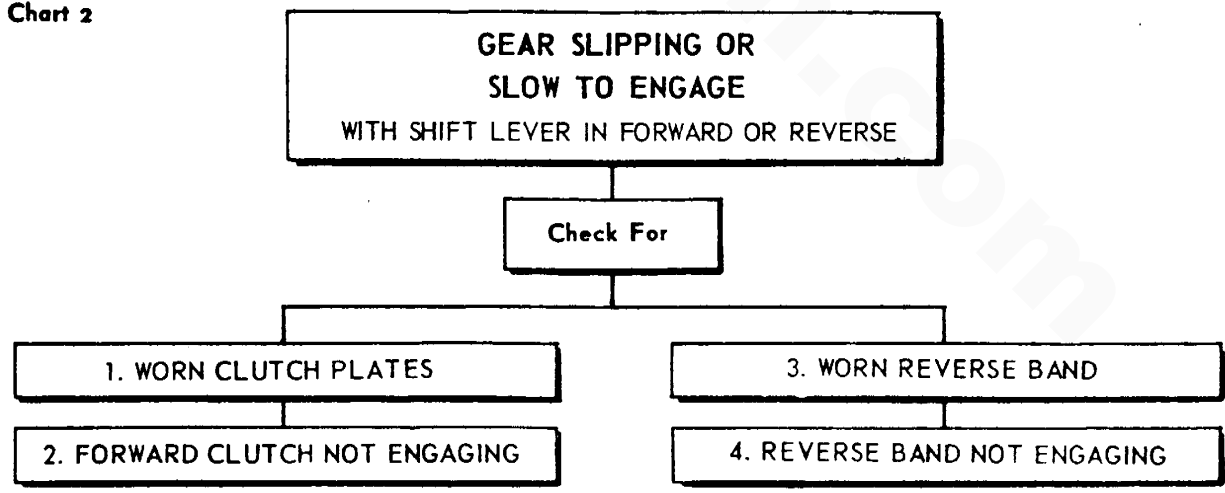
Chart 1



REMEDY

- | | |
|--|--|
| <ol style="list-style-type: none"> 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: <ol style="list-style-type: none"> a. Bearings and gears worn excessively in gear case. Replace necessary parts. | <ol style="list-style-type: none"> 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. |
|--|--|

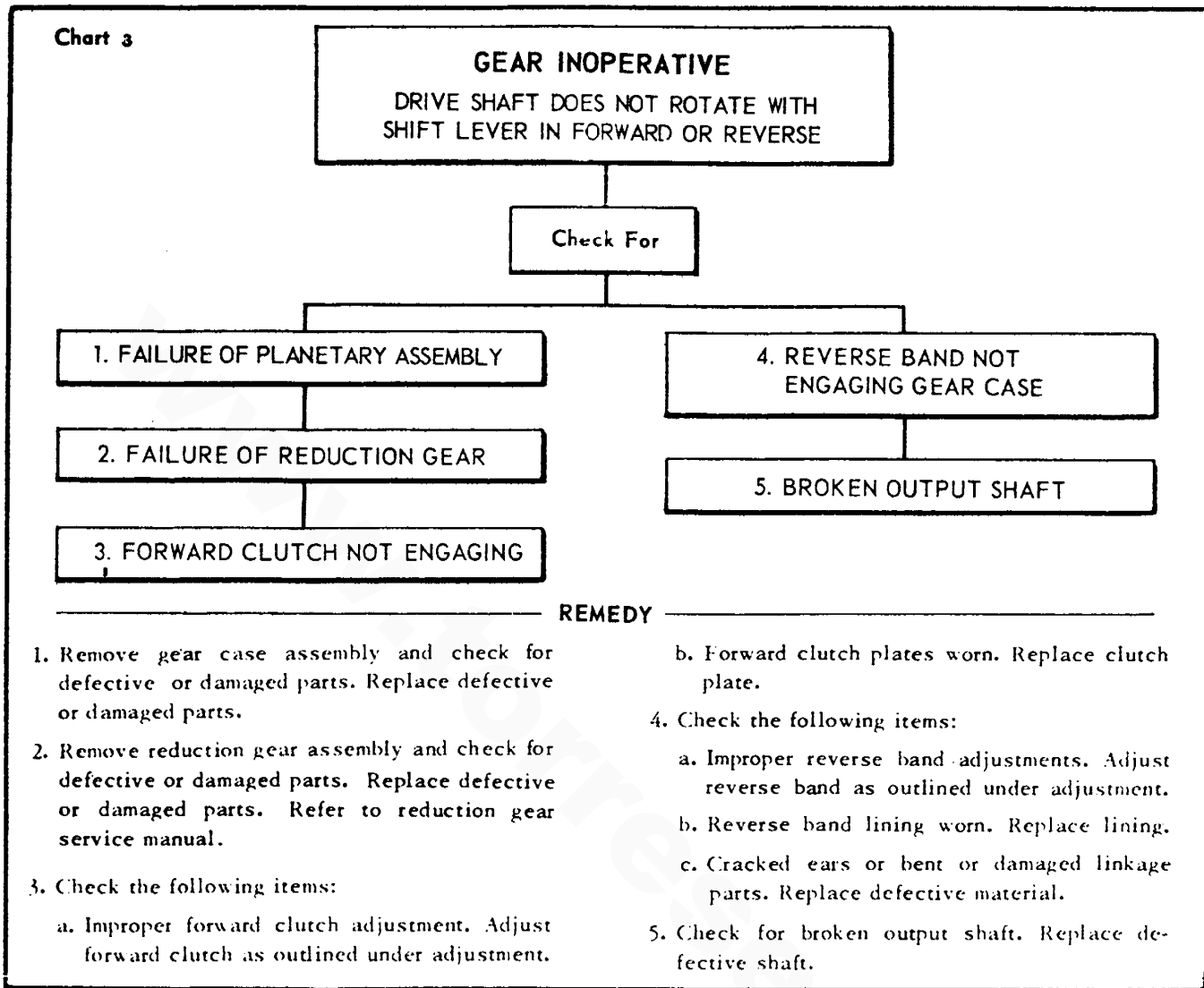
Chart 2



REMEDY

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. Remove forward clutch plates and check for wear. Replace if worn excessively. 2. Improper forward clutch adjustment. Adjust as outlined under adjustment. | <ol style="list-style-type: none"> 3. Remove reverse band and check for wear. Replace lining if worn below rivets. 4. Improper reverse band adjustment. Adjust as outlined under adjustment. |
|---|--|

TROUBLE SHOOTING CHART



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

REMOVAL OF REDUCTION GEAR ASSEMBLY FROM REVERSE GEAR HOUSING IF INSTALLED

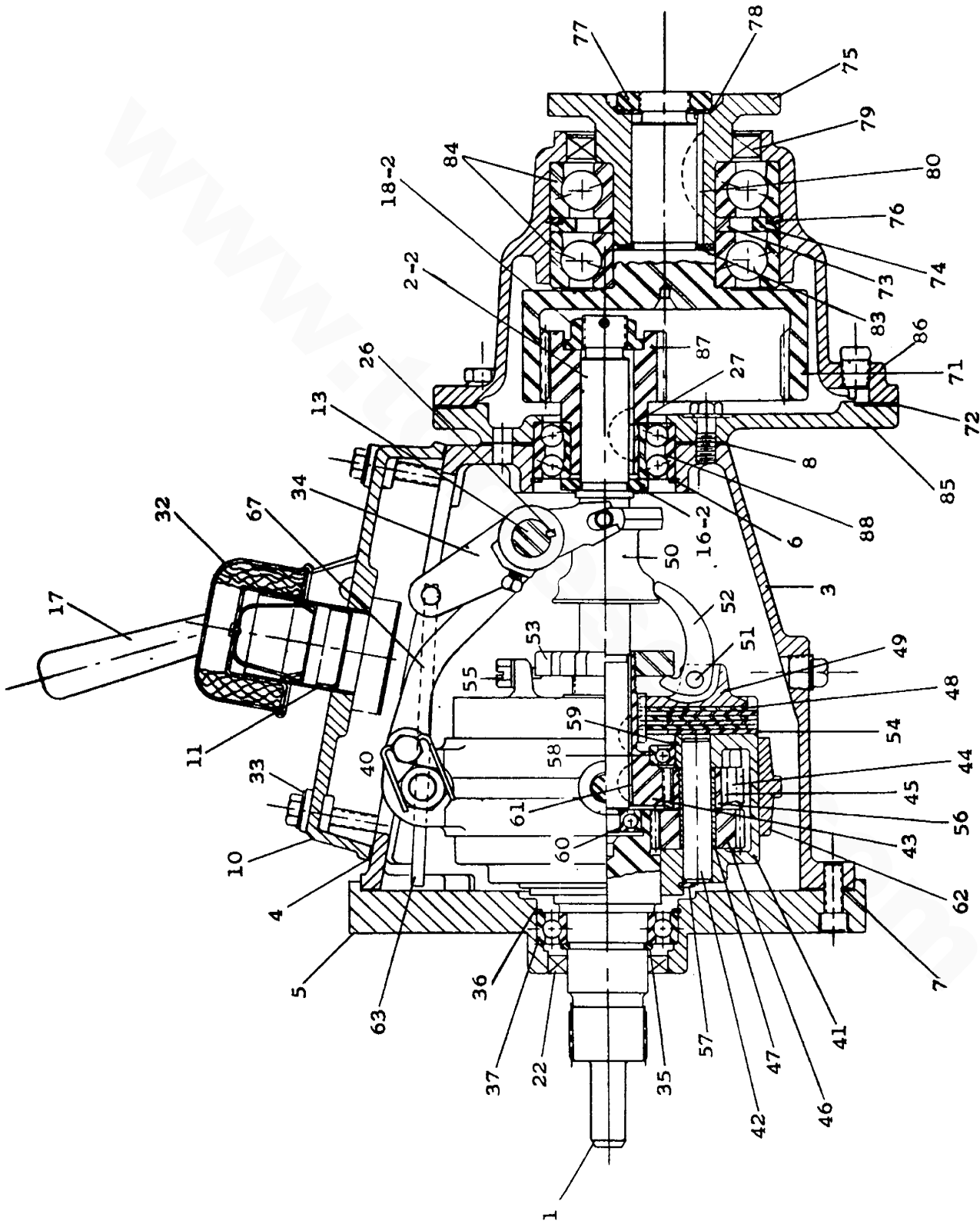
NOTE: Remove the reverse gear with reduction gear attached as a complete unit before draining oil, to avoid fouling the bilges.

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

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

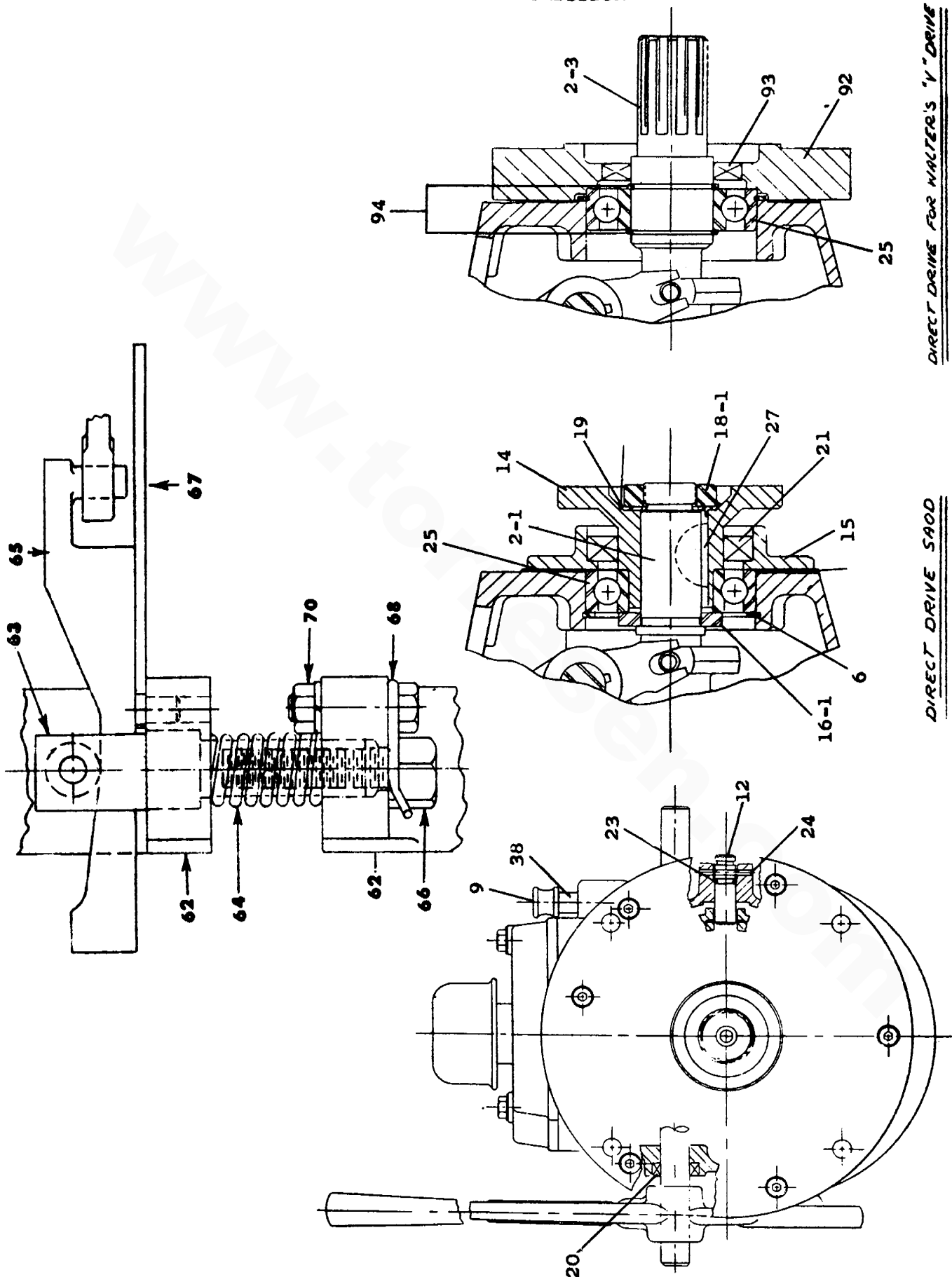
TYPE SAO TRANSMISSION

Cross Section of 2:1 Reduction Gear Shown



DRAWING NO. 13914

TYPE SAO TRANSMISSION



DIRECT DRIVE FOR WALTER'S 'V' DRIVE

DIRECT DRIVE SAOD

REMOVAL OF REVERSE GEAR HOUSING ASSEMBLY FROM ENGINE

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

REMOVAL OF GEAR CASE ASSEMBLY FROM REVERSE GEAR HOUSING

REDUCTION MODEL

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

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

DIRECT DRIVE UNIT (perform procedures 1 through 6 above)

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

DISASSEMBLY OF GEAR CASE

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

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

INSPECTION

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

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

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

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

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

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

ASSEMBLY OF GEAR CASE

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

NOTE: Use same dummy shaft as used in disassembly.

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

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

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

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

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

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

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

ASSEMBLY OF REVERSE GEAR CASE IN REVERSE GEAR HOUSING

REDUCTION MODEL

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

DIRECT DRIVE UNIT

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

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

ASSEMBLE TRANSMISSION TO ENGINE

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

ASSEMBLY OF REDUCTION GEAR ASSEMBLY TO REVERSE GEAR HOUSING ASSEMBLY

NOTE: Refer to reduction gear assembly and disassembly procedures.

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

ADJUSTMENTS

1. With the transmission secured to the engine, replace all water lines, etc. However, do not connect the shifting linkage until all of the adjustments have been made and are satisfactorily tested.
2. After securing the propeller half coupling to the gear half coupling, check the alignment.
3. The transmission should be filled with new oil as specified. Be certain to replace any oil that was removed from the engine.
4. 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:

1. Back out the lock screw (55) until the dog on the end of the lock screw is clear of the hole in the pressure plate (49).
2. Rotate the screw collar (53) to the right until the lock screw (55) is opposite the next hole in the pressure plate (49).
3. Tighten the lock screw 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.

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

1. Loosen the lock nut (70) on the inside of the upright ear at the top of the reverse band.
2. Tighten the adjusting nut (66) 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. Replace gasket (4), cover (10) and secure to reverse gear housing with capscrews and cover seals. The transmission is ready for a preliminary test which may be done at dockside.
5. Check all of the mooring lines before continuing the test.
6. With the engine running at idle speed, shift the transmission into forward and reverse noting how well the transmission responds.
7. 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 (55) and rotating the screw collar (53) to the right until the next hole in the pressure plate (49) 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.

REDUCTION GEARS

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

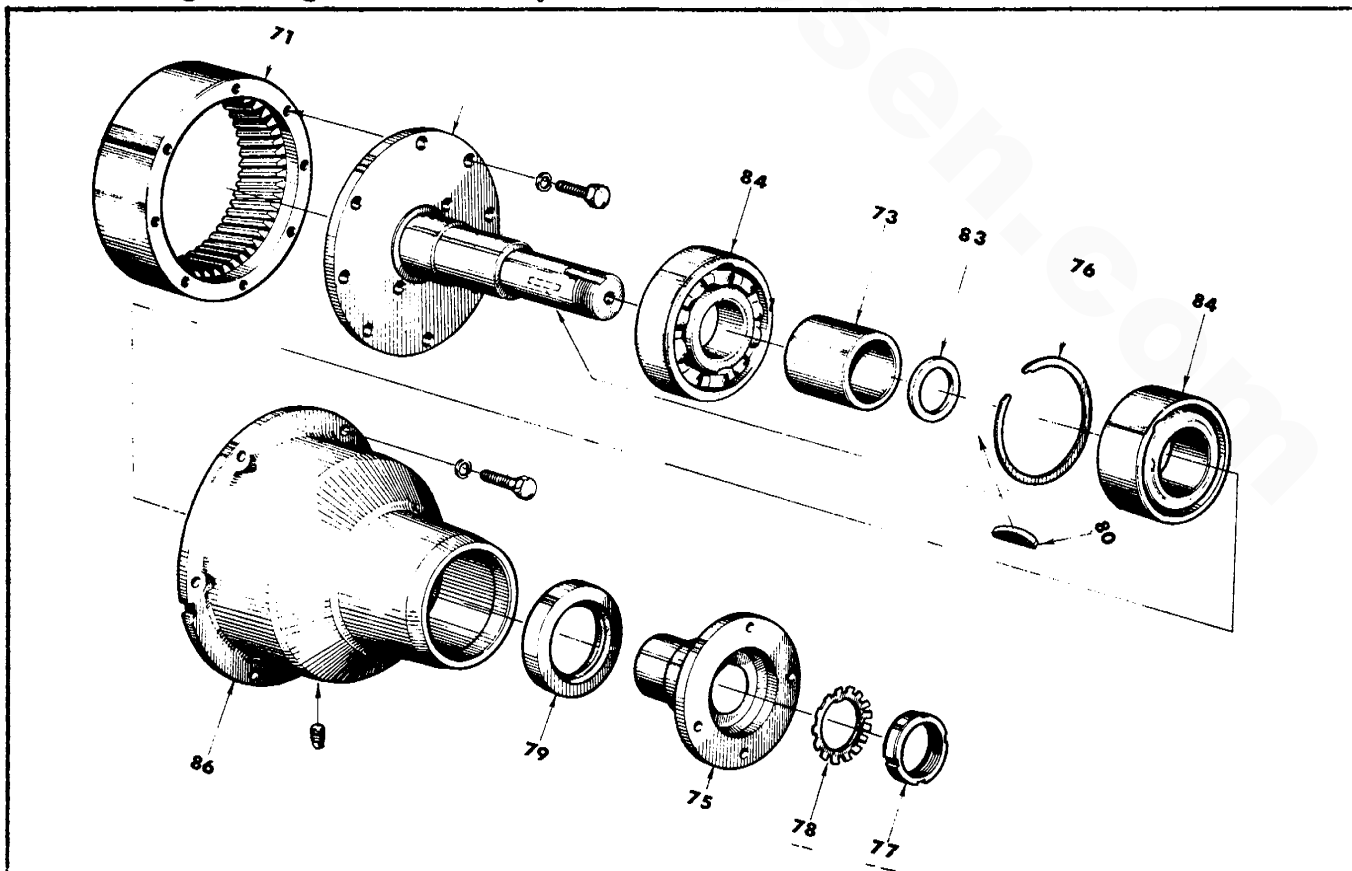
All parts should be thoroughly cleaned before inspection. Parts showing excessive wear should be replaced.

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.



OWNERS NOTES

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MODEL SS TRANSMISSION

Model SS Transmissions are made for both right and left handed engines. As fitted to model Four-60 Diesel Model SSL is used. It is suited to a left hand engine and turns a right hand propeller. It is available in two ratios:

Model SSL - 13 (1.3 : 1 Ratio)

Model SSL - 20 (2 : 1 Ratio)

It is differentiated from the Model SSR - 20 (For right handed engines) by having the clutch lever on the left hand side. It is also notable that when fitted to Model Four-60 the water pump is omitted from the high speed shaft of the transmission.

SSL TRANSMISSION

The SSL Transmission is designed and built for marine use. The three position hand lever (optional) operates the gear to give ahead, neutral or astern action. With the shift lever mounted in the normal slant position, the transmission is in FORWARD gear when the shift lever is moved aft or in REVERSE when shift lever is moved forward.

SSL is available in 2 ratios 1.3:1 or 2.1. The propeller turns a right hand gear which is the opposite direction to that of the engine.

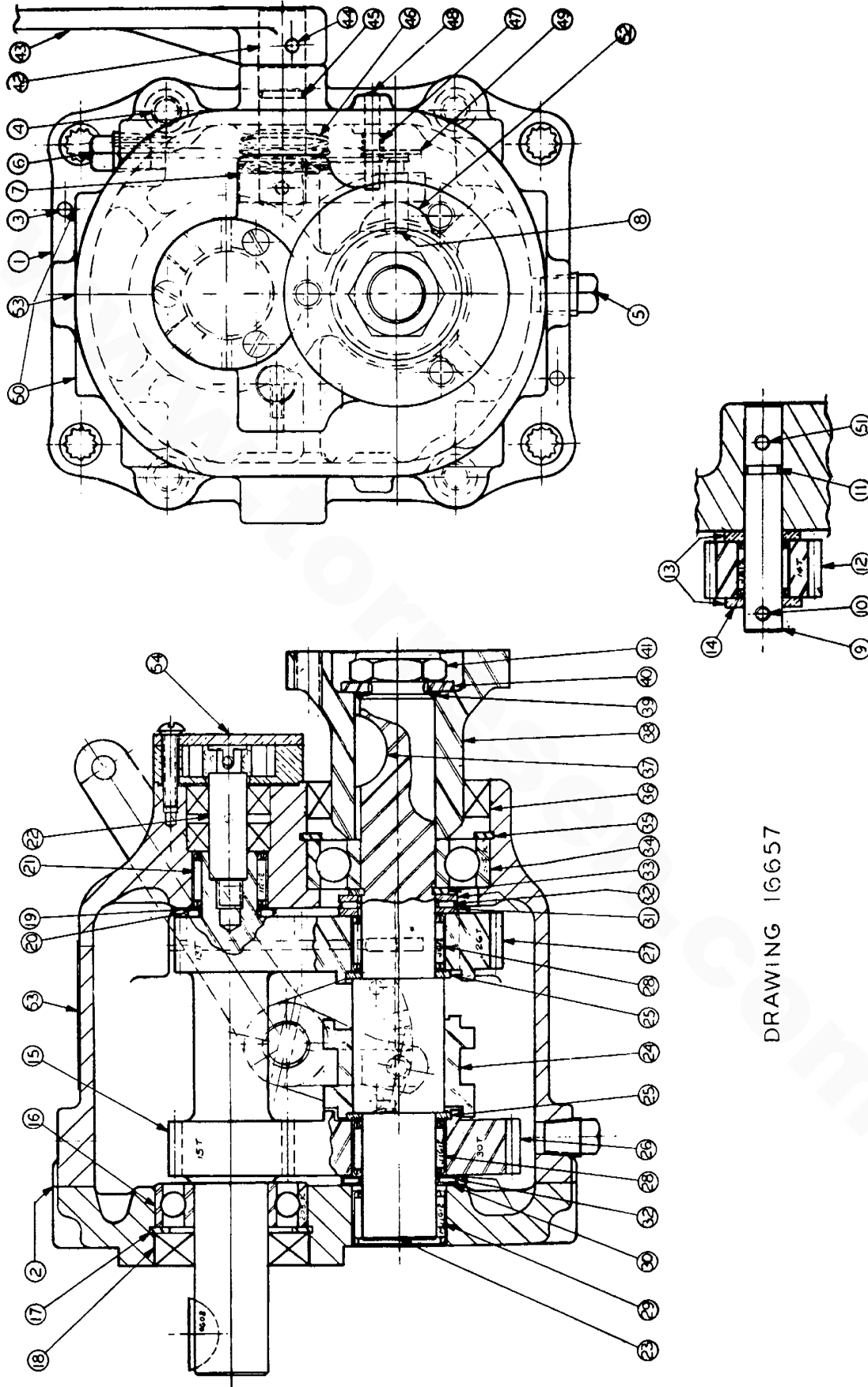
No adjustments are required. The only maintenance is to check the lubricating oil level and change the lubricating oil at time periods specified.

REMOVAL OF SSL REVERSE GEAR ASSEMBLY FROM ENGINE

1. Disconnect shift cable from transmission.
2. Remove the capscrews and lockwashers, securing the drive shaft half coupling to the propeller half coupling.
3. Slide propeller shaft back away from drive shaft.
4. Remove the capscrews and lockwashers securing reverse gear housing to flywheel housing adapter plate
5. Slide reverse gear housing straight back approximately three inches until shaft clears adapter plate and lift reverse gear housing assembly clear of engine.
6. Drain oil from reverse gear housing.

DISASSEMBLY PROCEDURES

1. Remove waterpump (54). - Not applicable on Model Four-60
2. Remove Woodruff key from reverse gear engine shaft.
3. Remove four capscrews securing front end plate (1) to housing.
4. Remove front plate (1) containing bearing (16), snap ring (17), seal (18), bearing (23). Protect seal by tape over key slot in shaft.
5. Lift out shaft (15) which has pump shaft (22) screwed into rear end. Bearing (20) and race (19) are now removable.
6. Remove race (30), bearing (32), gear (26) containing bearing (28), and washer (25).
7. Drive forward pin (48) into box, using flat end punch.
8. Rotate arm (43) to rear, allowing dog (24) to move forward and off shaft. Remove shoe (52).
9. Remove nut (41), washer (40), O-ring (39), coupling (38), and key (37).
10. Support housing on front face. Press shaft (23) forward out of bearing (34).
11. Remove snap ring (33) from shaft. Remove washers (31), bearing (32), gear (27) containing bearing (28), and washer (25).
12. Knock out pin (44). Remove handle (43), slide shaft (42) into housing. Remove detent plate (49), springs (47), and spring washers (46).
13. Drive pin (51) into shaft (9) with flat end punch.
14. Remove shaft (9) with associated gear (12), washers (13), bearings (14), pin (10), and O-ring (11).
15. Remove bearings, seals, snap rings from respective housings and gears as necessary. Press seals and bearings with suitable tools. Do not use hammer.
16. Reassemble in reverse order, replacing seals, gaskets, and O-rings. Be sure to protect input shaft seal by covering input shaft keyway with tape or something similar.
17. Align propeller shaft half coupling to reverse gear assembly half coupling



DRAWING 16657

Cross Section: SSL TRANSMISSION

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PARTS LIST

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NOTES ON USING THIS PARTS LIST

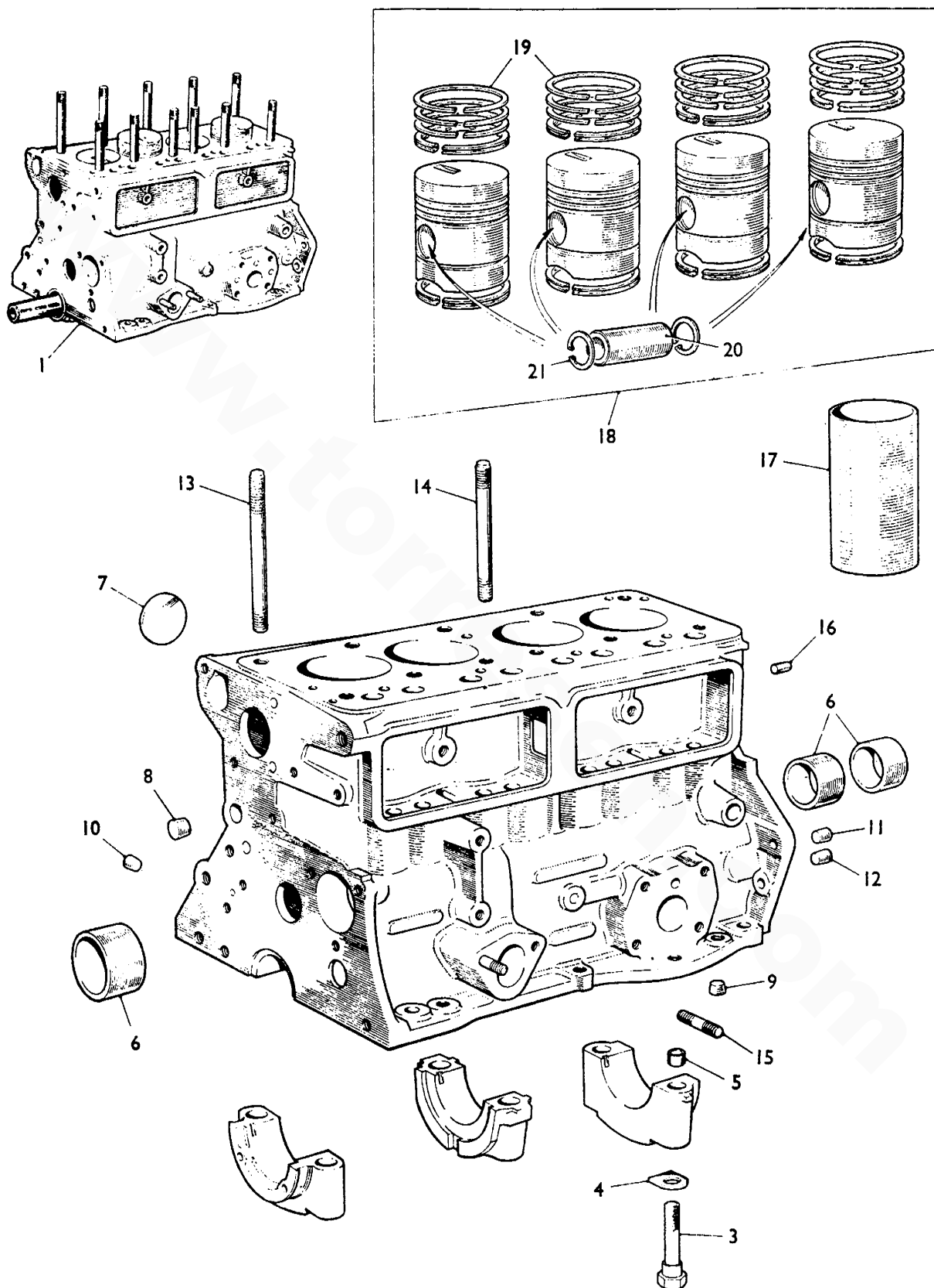
1. Unit of issue for all linear commodities is inches (not feet or yards).
2. Start looking in the contents -- if you cannot find any item, check miscellaneous page.
3. Please -- Report errors and omissions to us via speed letter.
(Attention: John H. Westerbeke, Jr.)

MODEL FOUR-60

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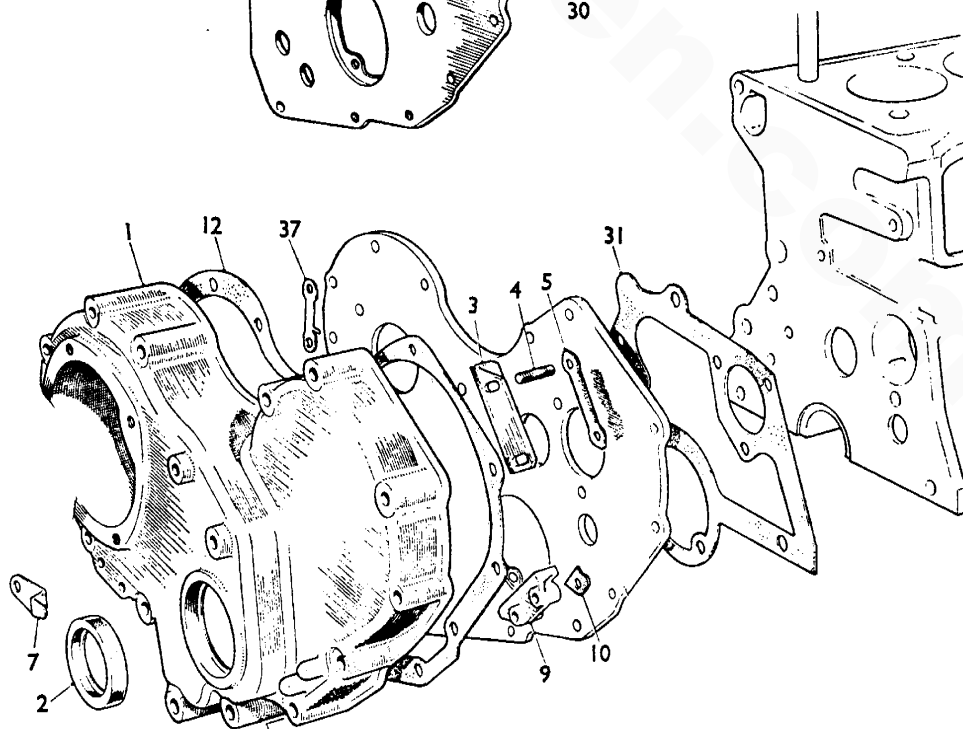
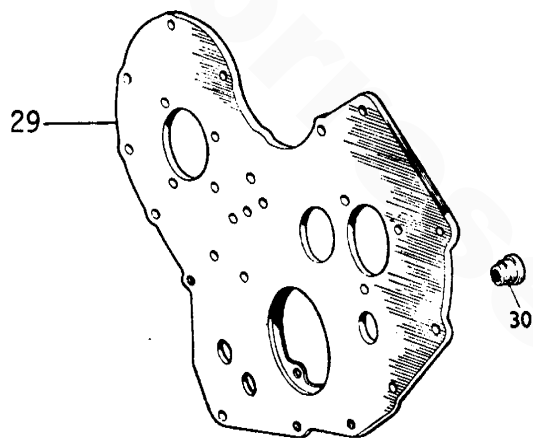
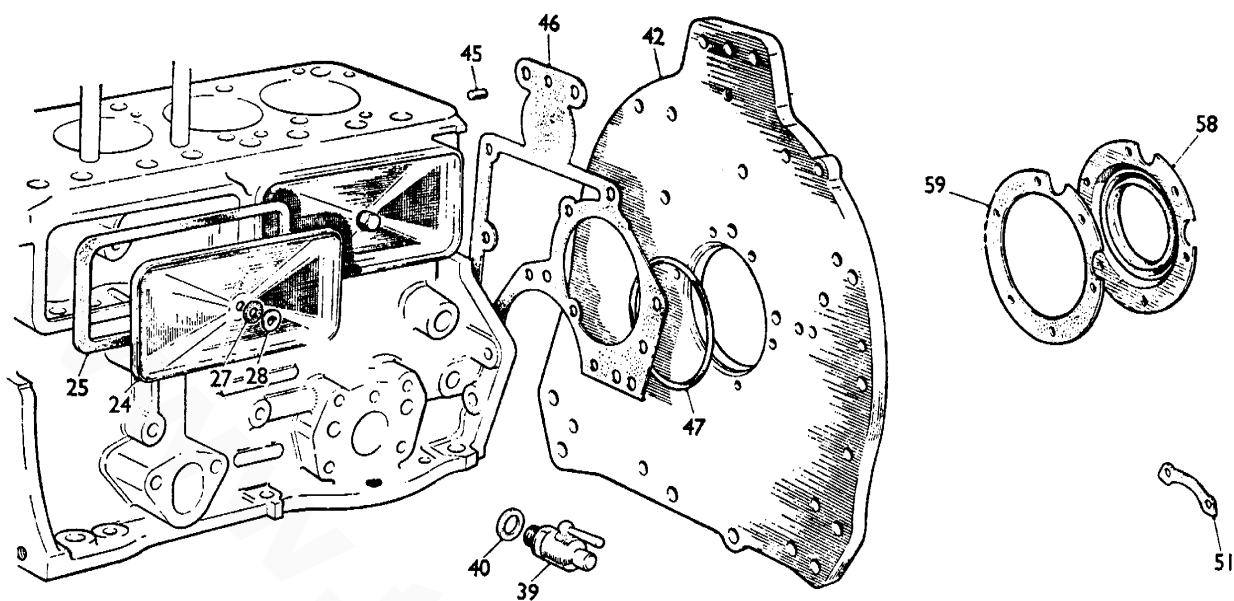
FOUR 60: BLOCK (INTERNAL)



FOUR 601 BLOCK (INTERNAL)

REF	PN	NAME	REMARKS
1-1	12991	ENGINE	LESS FLYWHEEL/BACKPLATE/SUMP/MANIFOLDS
1-2	15452	BLOCK	ASSEMBLY
3	15392	BOLT	MAIN BEARING CAP
4	15489	LOCKWASHER	
5	15306	DOWEL	MAIN BEARING CAP
6	15451	LINER	CAMSHAFT BEARING
7	14553	COREPLUG	
8	14593	PLUG	CRANKCASE OIL GALLERY
9	15481	PLUG	OIL RELEASE VALVE PASSAGE
10	15434	PLUG	CHAIN TENSIONER AND OIL PUMP GEAR FEED
11	14433	PLUG	OIL PUMP GEAR FEED - REAR FACE
12	15347	PLUG	MAIN OIL FEED - REAR FACE
13	15490	STUD	CYLINDER HEAD - LONG
14	15491	STUD	CYLINDER HEAD - SHORT
15	15492	STUD	FUEL PUMP
16	15439	DOWEL	BACKPLATE
17	15346	LINER	
18-1	15449	PISTON ASSY	SET OF FOUR - STANDARD
18-2	15450	PISTON ASSY	SET OF FOUR - .010" O/S
19-1	15453	RING SET	FOR ONE PISTON - STANDARD
19-2	15454	RING SET	FOR ONE PISTON - .010" O/S
20	15396	PIN	PISTON
21	15469	RING	PISTON PIN RETAINING

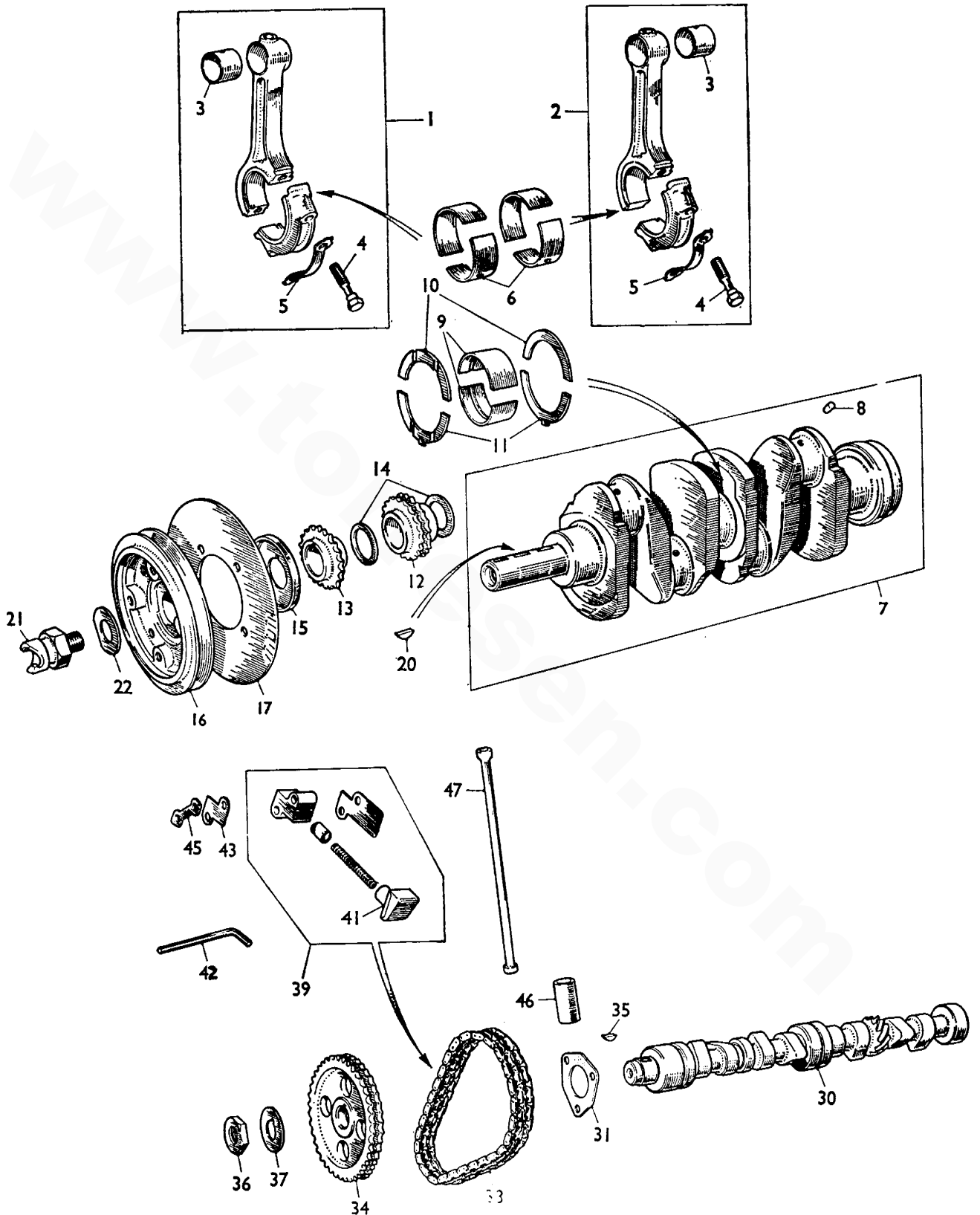
FOUR 60: BLOCK (EXTERNAL)



FOUR 601 BLOCK (EXTERNAL)

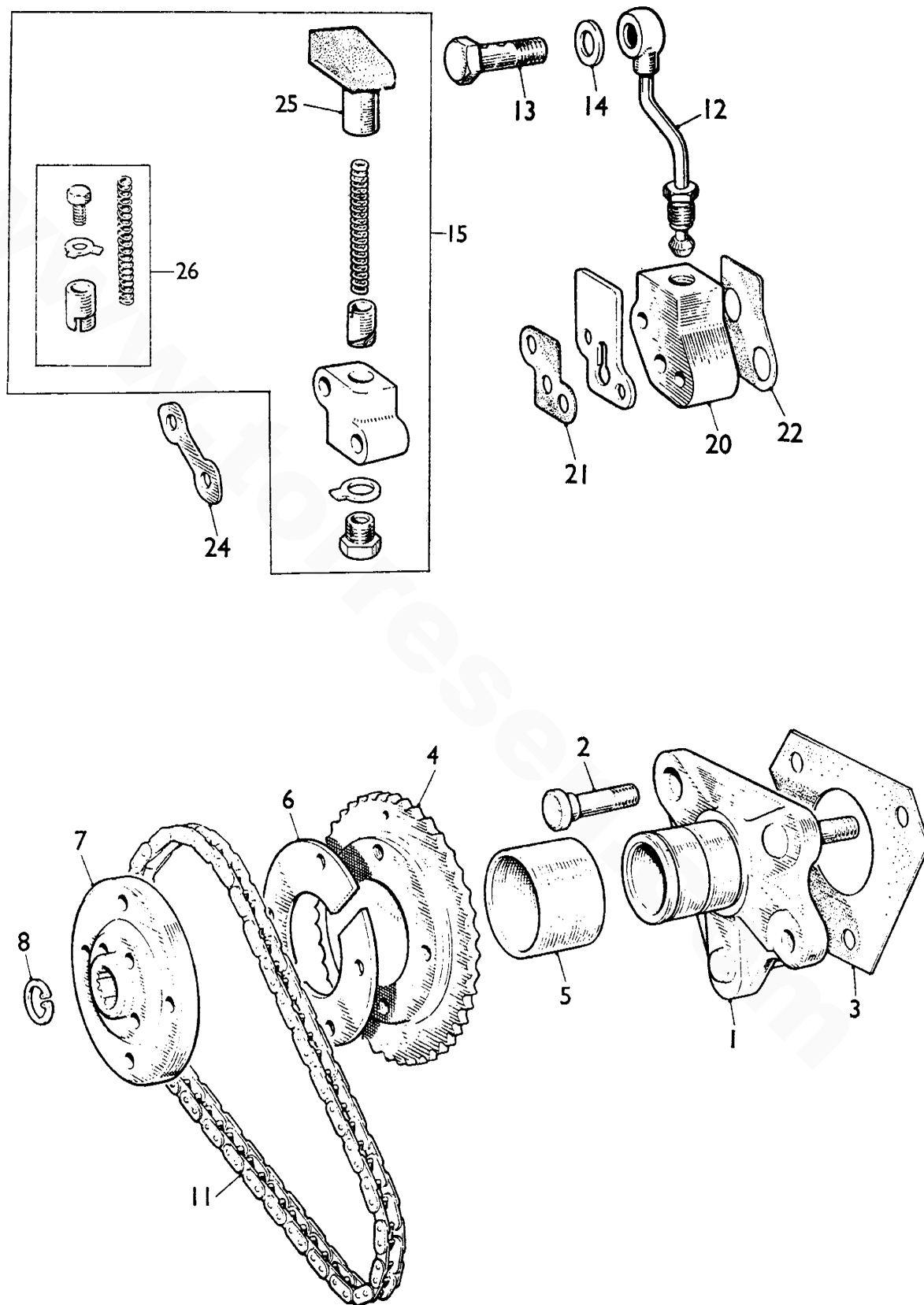
REF	PN	NAME	REMARKS
1	15390	COVER	TIMING
2	14643	SEAL	OIL
3	15349	DAMPER	INJECTION PUMP DRIVE CHAIN
4	15496	STUD	DAMPER
5	15350	LOCKWASHER	
7	15351	INDICATOR	TIMING
9	15410	DAMPER	CAMSHAFT DRIVE CHAIN
10	15407	LOCKWASHER	
12	15391	GASKET	TIMING COVER TO FRONT PLATE
24	13526	COVER	CYLINDER SIDE
25	14562	GASKET	
27	14564	BUSHING	
28	14563	WASHER	
29	15397	PLATE	FRONT
30	15348	DOWEL	TAPPED
31	15385	GASKET	FRONT PLATE TO CRANKCASE
37	15395	INDICATOR	INJECTION PUMP TIMING
39	15465	PETCOCK	CYLINDER BLOCK WATER DRAIN
40	15483	WASHER	
42	13887	BACKPLATE	
45	15439	DOWEL	BACKPLATE TO BLOCK
46	15394	GASKET	BACKPLATE TO BLOCK
47	15474	O-RING	BACKPLATE TO BLOCK
51	15355	LOCKWASHER	
58	15420	SEAL	INCLUDES COVER
59	15403	GASKET	

FOUR 60: CRANKSHAFT - CAMSHAFT - ROD



REF	PN	NAME	REMARKS
1	15342	ROD	RH - NO 2 & 4 CYLINDERS
2	15345	ROD	LH - NO 1 & 3 CYLINDERS
3	15343	BUSHING	
4	15311	BOLT	
5	15344	WASHER	
6-1	15447	BEARING	CONNECTING ROD - STANDARD
6-2	15448	BEARING	CONNECTING ROD - ,010" U/S
7	15332	CRANKSHAFT	
8	15440	PLUG	
9-1	15445	BEARING	MAIN - STANDARD
9-2	15446	BEARING	MAIN - ,010" U/S
10	15412	THRUSTWASHER	UPPER
11	15413	THRUSTWASHER	LOWER
12	15389	GEAR	CAMSHAFT DRIVE
13	15333	GEAR	INJECTION PUMP DRIVE
14	14654	WASHER	PACKING - GEARS
15	15296	SLINGER	
16-1	15334	PULLEY	STANDARD
16-2	15069	PULLEY	ACCESSORY - 1 GROOVE - 6" OD - A SECTION
17	15335	DISC	TIMING
20	14446	KEY	
21	14613	NUT	
22	14574	LOCKWASHER	
30	15387	CAMSHAFT	
31	15307	PLATE	CAMSHAFT LOCATING
34	15388	GEAR	CAMSHAFT
35	14531	KEY	
36	14540	NUT	
37	14544	LOCKWASHER	
38	14542	CHAIN	CAMSHAFT DRIVE
39	15476	TENSIONER	CHAIN
41	14435	HEAD	TENSIONER
42	15475	WRENCH	ALLEN
43	14506	GASKET	TENSIONER TO FRONT PLATE
45	14507	LOCKWASHER	
46-1	15302	TAPPET	STANDARD
46-2	15303	TAPPET	,010" O/S
47	15326	PUSHROD	

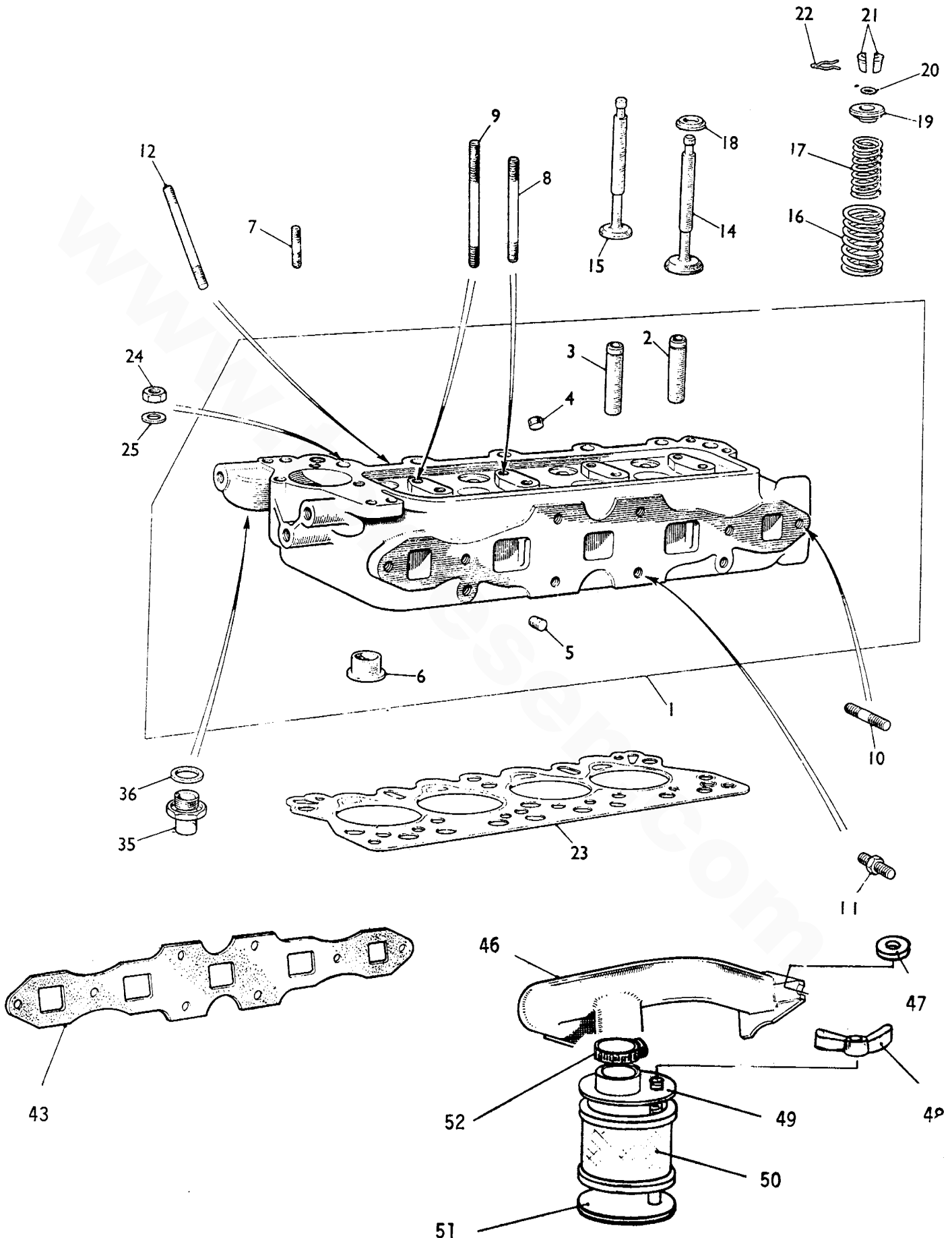
FOUR 60: INJECTION PUMP DRIVE SYSTEM



FOUR 60: INJECTION PUMP DRIVE SYSTEM

REF	PN	NAME	REMARKS
1	15360	HUB	
2	15361	BOLT	
3	15362	GASKET	HUB TO FRONT PLATE
4	15363	GEAR	INJECTION PUMP DRIVE
5	15436	BUSHING	
6	15364	PLATE	TWO HALVES
7	15365	FLANGE	
8	15429	RING	RETAINING
11	15366	CHAIN	INJECTION PUMP DRIVE
12	15398	LINE	OIL - TENSIONER
13	15367	BOLT	BANJO
14	15485	WASHER	BANJO BOLT
15	15336	TENSIONER	CHAIN - ASSEMBLY
20	15368	BLOCK	
21	14506	GASKET	TENSIONER TO FRONT PLATE
22	15369	GASKET	BLOCK TO FRONT PLATE
24	14507	LOCKWASHER	
25	14435	HEAD	TENSIONER
26	14509	KIT	REPAIR - CHAIN TENSIONER

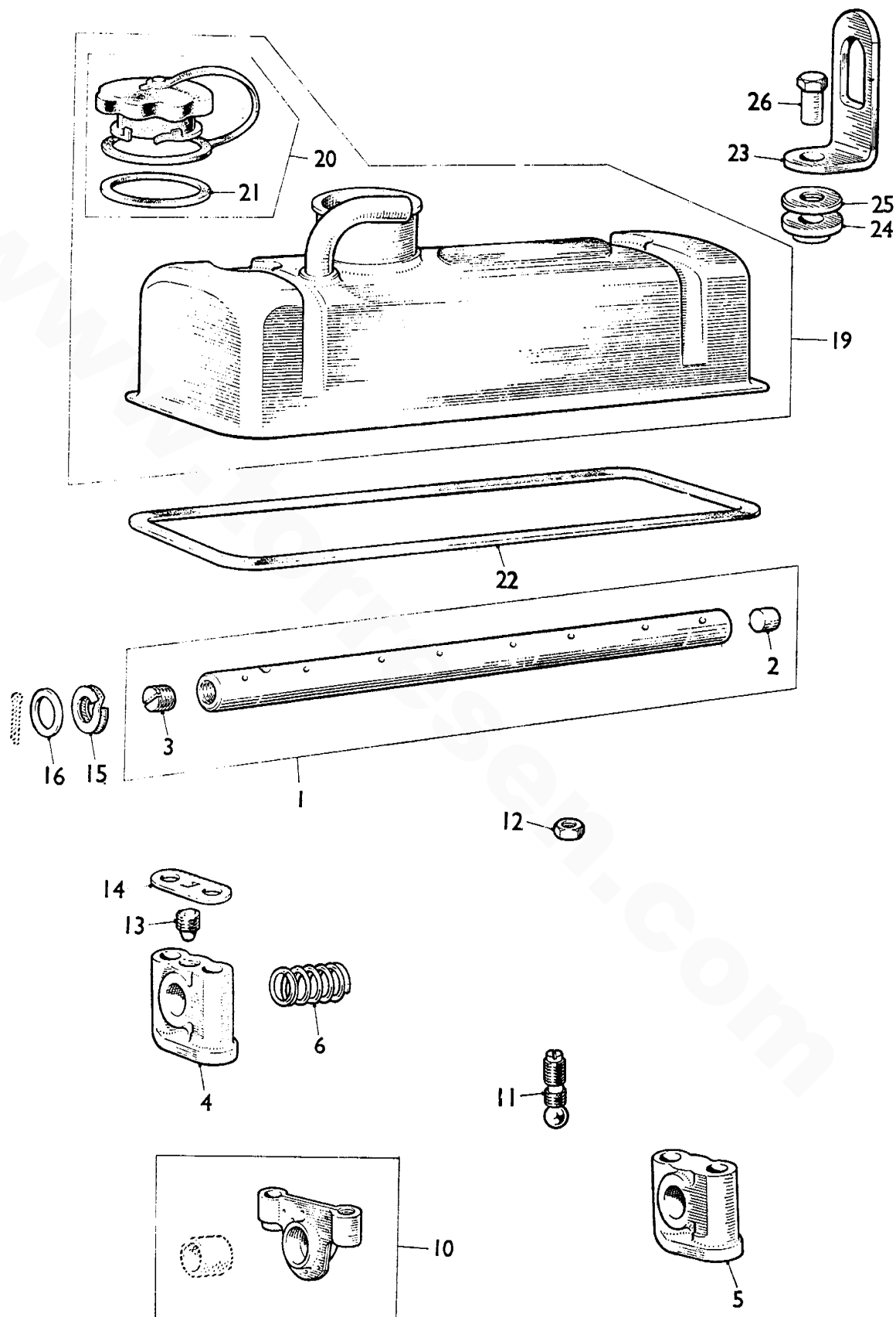
FOUR 60: CYLINDER HEAD



FOUR 60: CYLINDER HEAD

REF	P	NAME	REMARKS
1	15316	HEAD	ASSEMBLY INCLUDING VALVE GUIDES
2-1	15319	GUIDE	INLET VALVE - STANDARD
2-2	15320	GUIDE	INLET VALVE - ,010" O/S
3-1	15317	GUIDE	EXHAUST VALVE - STANDARD
3-2	15318	GUIDE	EXHAUST VALVE - ,010" O/S
4	14433	PLUG	
5	14597	PLUG	
6	15321	INSERT	COMBUSTION CHAMBER
7	15432	STUD	THERMOSTAT HOUSING
8	15495	STUD	ROCKER BRACKET - SHORT
9	15493	STUD	ROCKER BRACKET - LONG
10	15430	STUD	INLET AND EXHAUST MANIFOLD
11	15322	STUD	INLET AND EXHAUST MANIFOLD - HEX
12	15431	STUD	INJECTOR CLAMP
14	15323	VALVE	INLET
15	15324	VALVE	EXHAUST
16	15325	SPRING	VALVE - OUTER
17	15417	SPRING	VALVE - INNER
18	15419	CUP	VALVE SPRING - BOTTOM
19	15418	CUP	VALVE SPRING - TOP
20	15411	SEAL	
21	15320	COTTER	VALVE
22	15321	CLIP	COTTER RETAINING
23	15408	GASKET	CYLINDER HEAD
24	14445	NUT	CYLINDER HEAD STUD
25	14443	WASHER	
35	15383	ADAPTOR	THERMOSTAT BYPASS
36	15422	WASHER	
43	15374	GASKET	MANIFOLD
46	15083	MANIFOLD	INTAKE
47	15441	WASHER	MANIFOLD CLAMPING
48	15076	WINGNUT	
49	15072	COVER	TOP
50	15075	FILTER	AIR
51	15073	COVER	BOTTOM
52	11405	CLAMP	

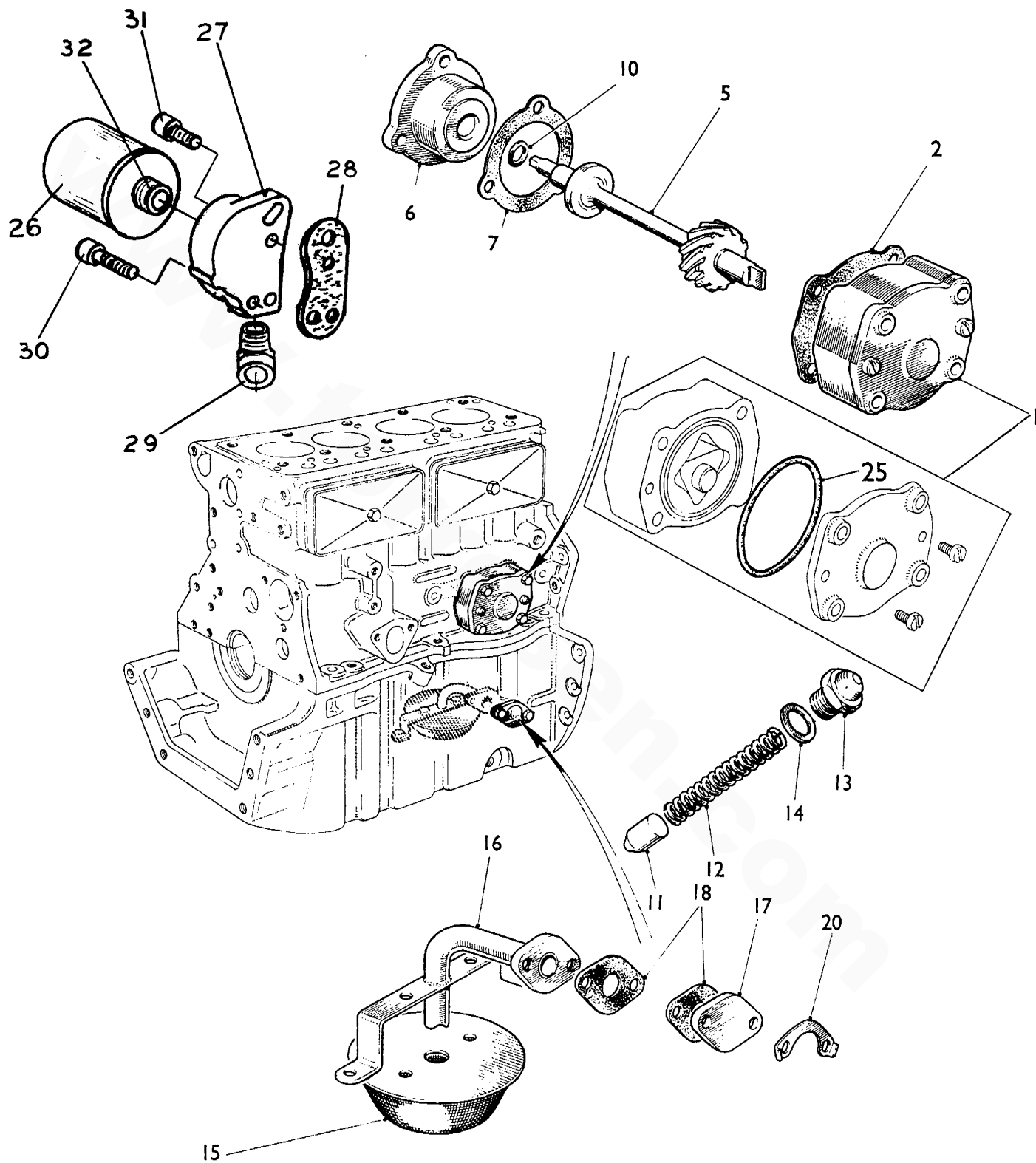
FOUR 60: ROCKER SHAFT - VALVE COVER



FOUR 601 ROCKER SHAFT - VALVE COVER

REF	PN	NAME	REMARKS
1	15304	SHAFT	ROCKER
2	14555	PLUG	PLAIN
3	14646	PLUG	THREADED
4	15461	BRACKET	1 PER ENGINE - TAPPED
5-1	15459	BRACKET	2 PER ENGINE - PLAIN
5-2	15460	BRACKET	1 PER ENGINE - WITH OIL HOLE
6	15487	SPRING	
10	15401	ROCKER	
11	15400	SCREW	TAPPET ADJUSTING
12	15488	NUT	LOCKING
13	14481	SCREW	LOCATING
14	15310	PLATE	ROCKER SHAFT BRACKET
15	15305	WASHER	SPRING
16	15486	WASHER	PLAIN
19	15399	COVER	VALVE - ROCKER
20	14515	CAP	OIL FILL
21	14516	WASHER	
22	15315	GASKET	VALVE COVER
23	15309	BRACKET	LIFTING
24	14808	BUSHING	
25	15299	WASHER	
26	14807	SCREW	

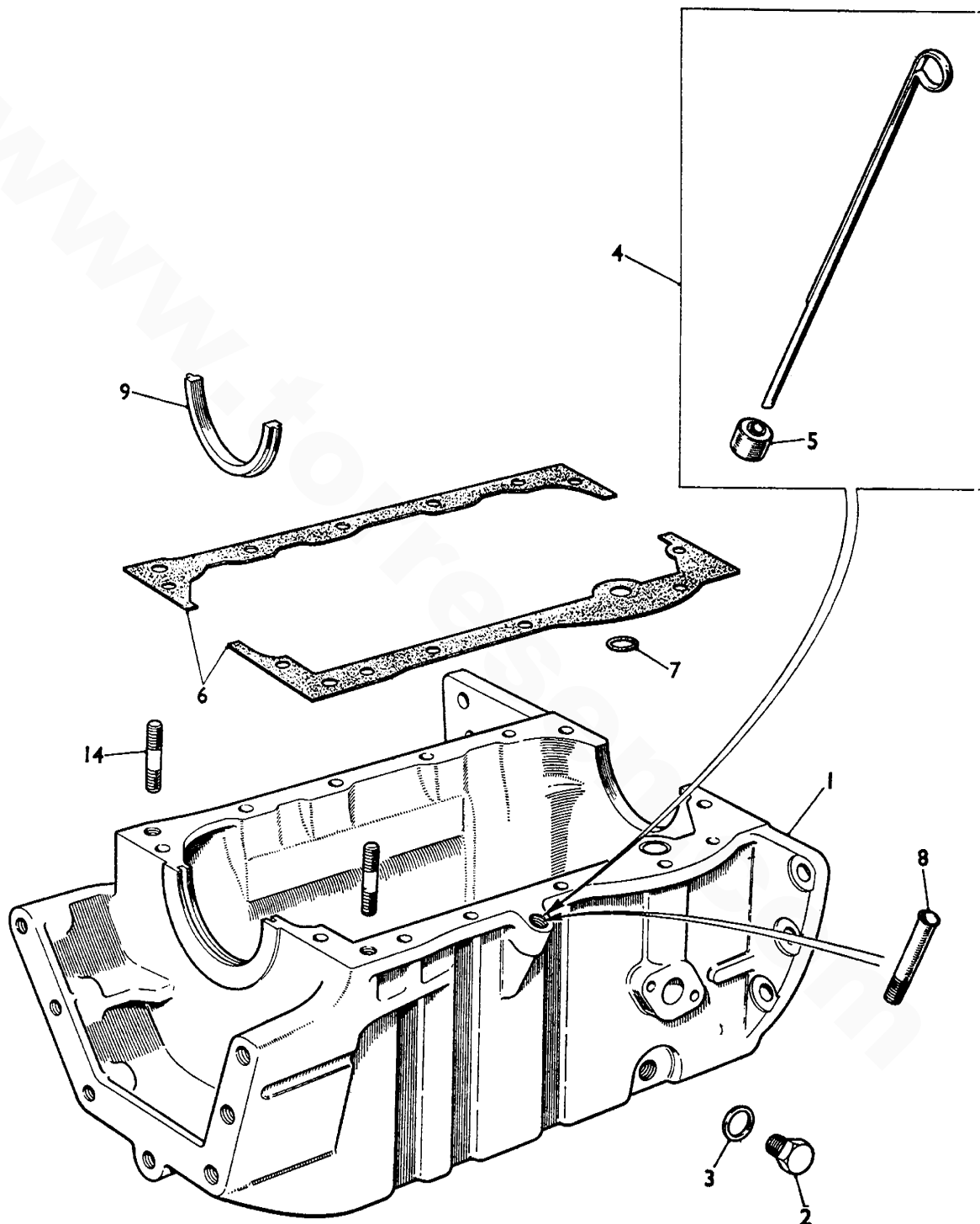
FOUR 60: LUBE OIL PUMP - STRAINER - FILTER



FOUR 60: LUBE OIL PUMP - STRAINER - FILTER

REF	PN	NAME	REMARKS
1	15339	PUMP	OIL
2	15340	GASKET	PUMP TO CRANKCASE
5	15404	SHAFT	
6	15405	HOUSING	TACHOMETER DRIVE SHAFT
7	15341	GASKET	
10	15406	SEAL	
11	14550	VALVE	OIL RELIEF
12	14549	SPRING	
13	14608	NUT	
14	14528	WASHER	COPPER
15	15312	STRAINER	OIL
16	15356	TUBE	OIL SUCTION
17	15314	FLANGE	OUTER
18	15416	GASKET	
20	15482	LOCKWASHER	
25	15471	O-RING	OIL PUMP COVER TO BODY
26	11951	FILTER	LUBE OIL - SCREW IN TYPE
27	13698	ADAPTER	
28	15353	GASKET	LUBE OIL BOSS
29	11984	ELBOW	
30	16633	SCREW	LONG
31	16632	SCREW	SHORT
32	13610	NIPPLE	

FOUR 60: LUBE OIL SUMP

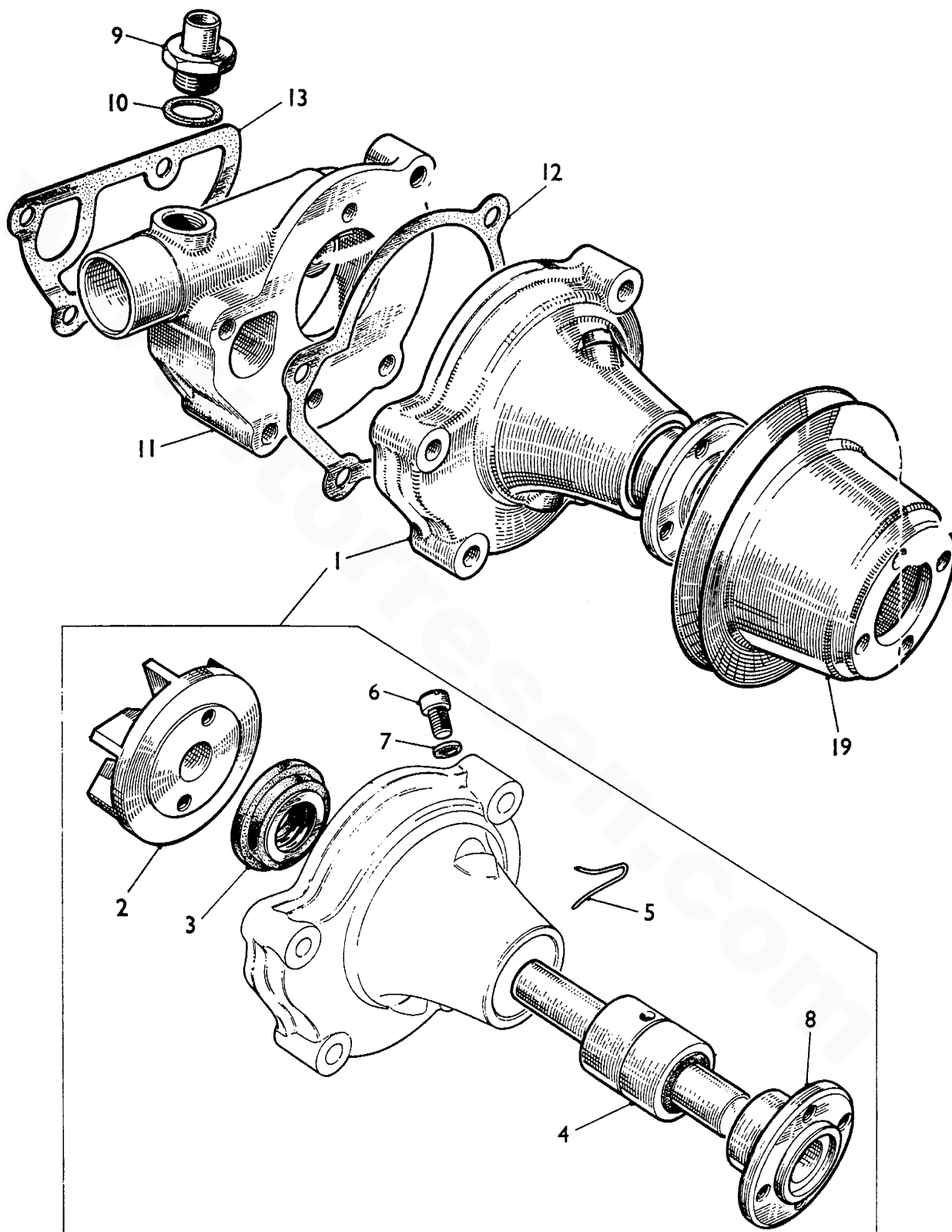


FOUR 60: LUBE OIL SUMP

REF	PN	NAME	REMARKS
1	15084	SUMP	
2	15462	PLUG	DRAIN
3	14453	WASHER	
4	15357	DIPSTICK	
5	15421	BUSHING	
6	15455	GASKET	SUMP TO BLOCK
7	15499	RING	
8	15435	TUBE	DIPSTICK
9	15386	SEAL	OIL - SUMP TO FRONT MAIN BEARING
14	15433	STUD	

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FOUR 60: FRESH WATER PUMP

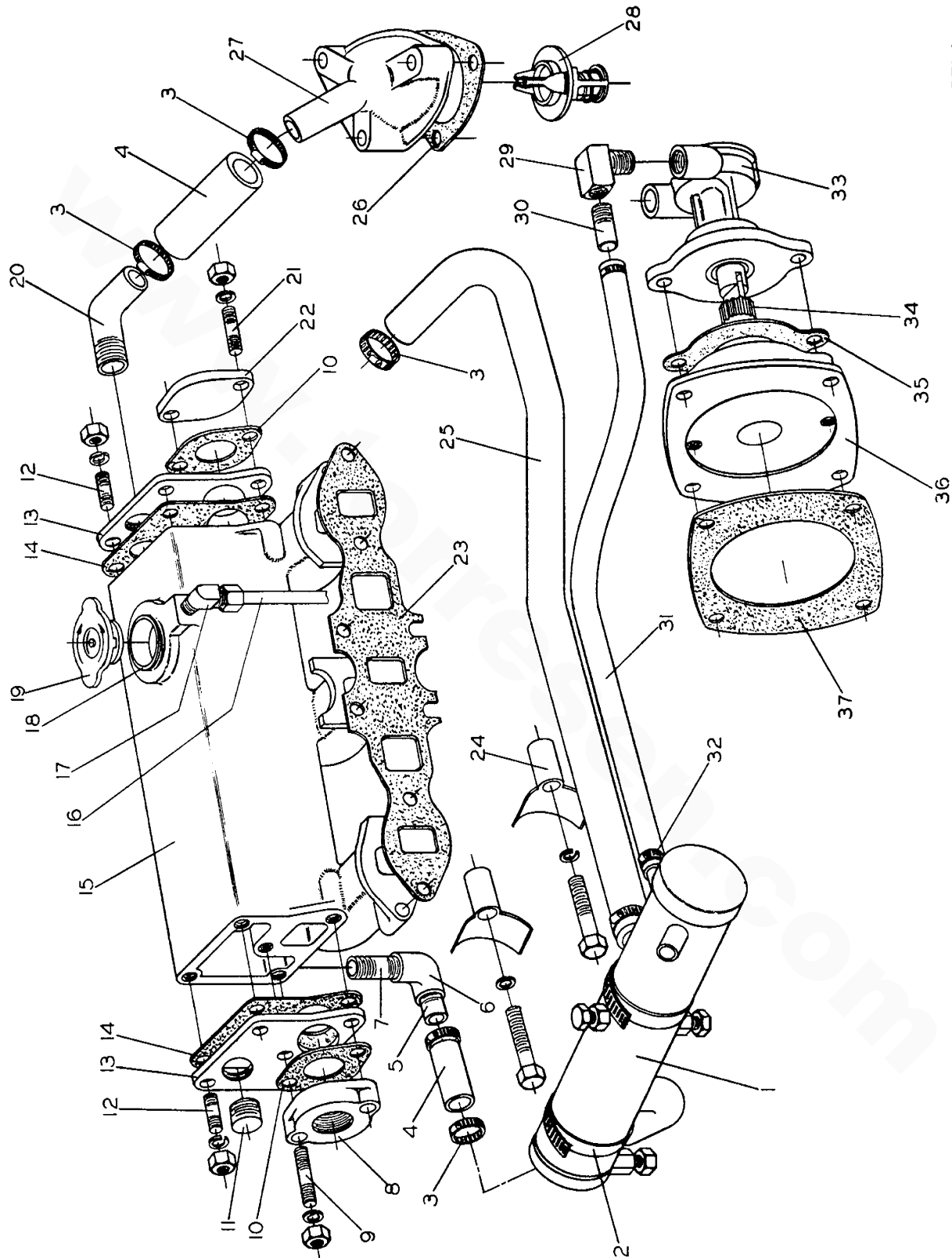


FOUR 601 FRESH WATER PUMP

REF	PN	NAME	REMARKS
1	15409	PUMP	FRESH WATER - COMPLETE
2	15379	IMPELLER	
3	15463	SEAL	
4	15415	BEARING	
5	15313	WIRE	BEARING LOCATING
6	15497	SCREW	LUBRICATION POINT
7	15484	WASHER	FIBRE
8	15380	HUB	WATER PUMP PULLEY
9	15383	ADAPTER	THERMOSTAT BYPASS
10	15422	WASHER	
11	15414	ADAPTER	WATER PUMP TO BLOCK
12	15381	GASKET	PUMP TO ADAPTER
13	15382	GASKET	ADAPTER TO BLOCK
19	15378	PULLEY	WATER PUMP

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FOUR 60: COOLING SYSTEM

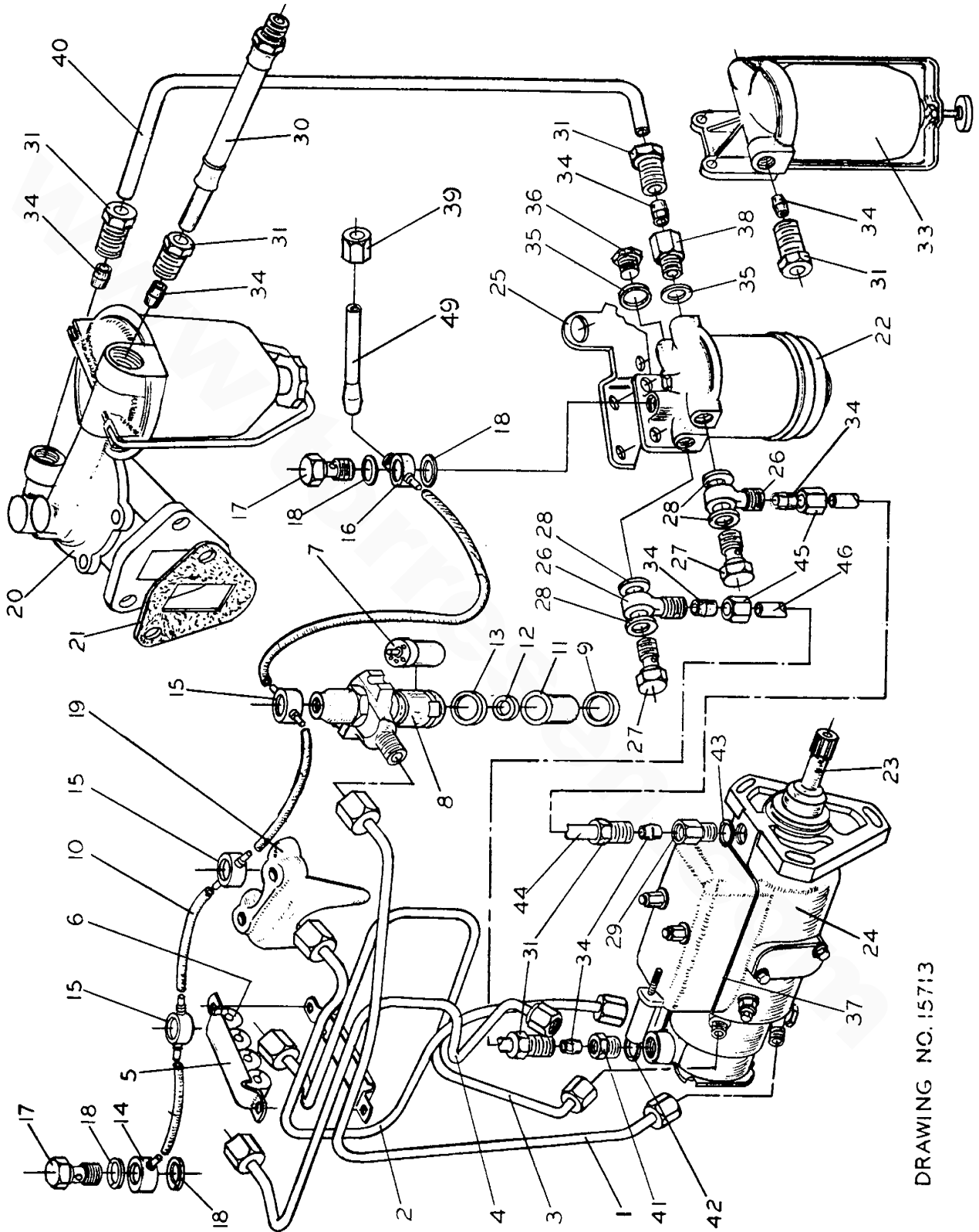


DWG NO.15714

FOUR 60: COOLING SYSTEM

REF	PN	NAME	REMARKS
1	15055	EXCHANGER	
2	11505	CLAMP	
3	11405	CLAMP	HOSE
4	11779	HOSE	
5	11254	NIPPLE	HOSE
6	16434	ELBOW	
7	13554	NIPPLE	
8	15057	FLANGE	EXHAUST
9	12272	STUD	EXHAUST FLANGE
10	15058	GASKET	EXHAUST FLANGE
11	16433	PLUG	
12	11928	STUD	MANIFOLD END PLATE
13	15094	PLATE	MANIFOLD END
14	15096	GASKET	MANIFOLD END PLATE
15	15056	MANIFOLD	EXHAUST
16	11500	TUBING	
17	13329	ELBOW	
18	11751	NECK	FILLER
19	11499	CAP	PRESSURE
20	13603	ELBOW	
21	11930	STUD	EXHAUST PORT PLATE TO COVER
22	15059	PLATE	EXHAUST FLANGE PORT
23	15374	GASKET	EXHAUST MANIFOLD TO HEAD
24	12092	BRACKET	HEAT EXCHANGER
25	12221	HOSE	MOLDED
26	11860	GASKET	THERMOSTAT HOUSING
27	15329	HOUSING	THERMOSTAT
28	15473	THERMOSTAT	
29	13338	ELBOW	
30	13519	NIPPLE	HOSE
31	11517	HOSE	
32	11344	CLAMP	SEA WATER HOSE
33	15098	PUMP	SEA WATER
34	13697	DRIVE	SEA WATER PUMP
35	13700	GASKET	SEA WATER PUMP TO ADAPTER
36	13696	ADAPTER	SEA WATER PUMP TO PLATE
37	15438	GASKET	PUMP ADAPTER TO TIMING COVER

FOUR 60: FUEL SYSTEM

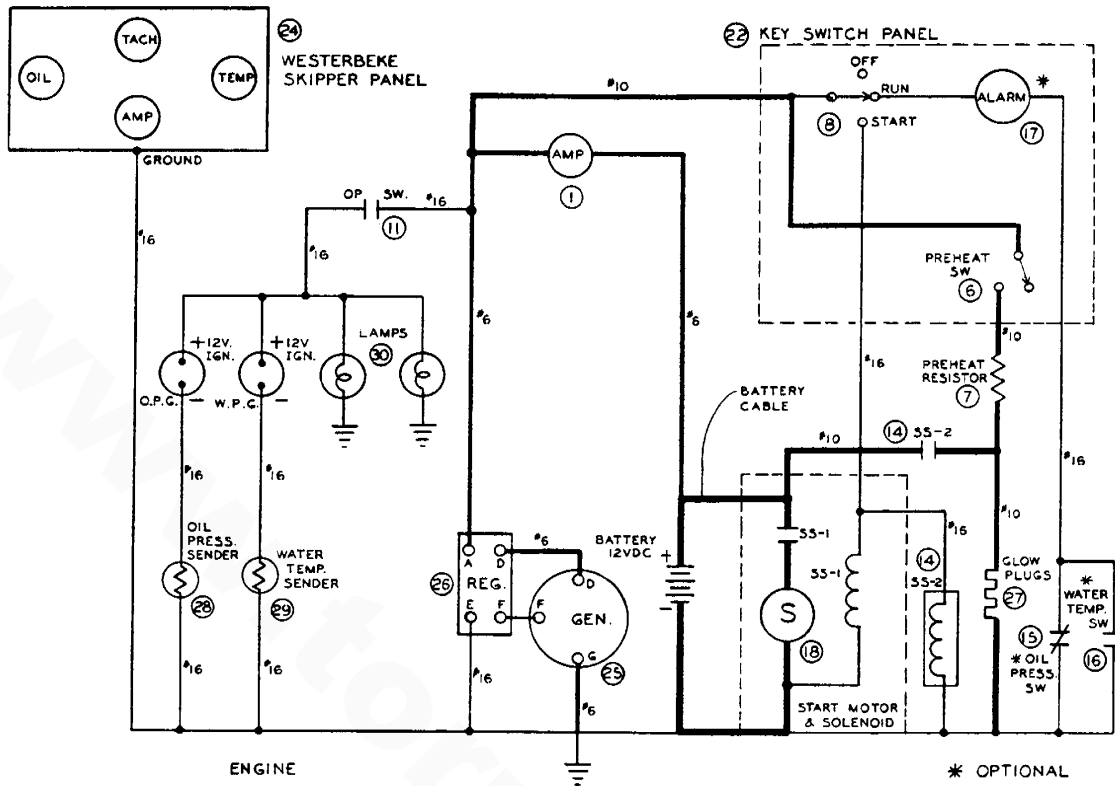


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FOUR 60: FUEL SYSTEM

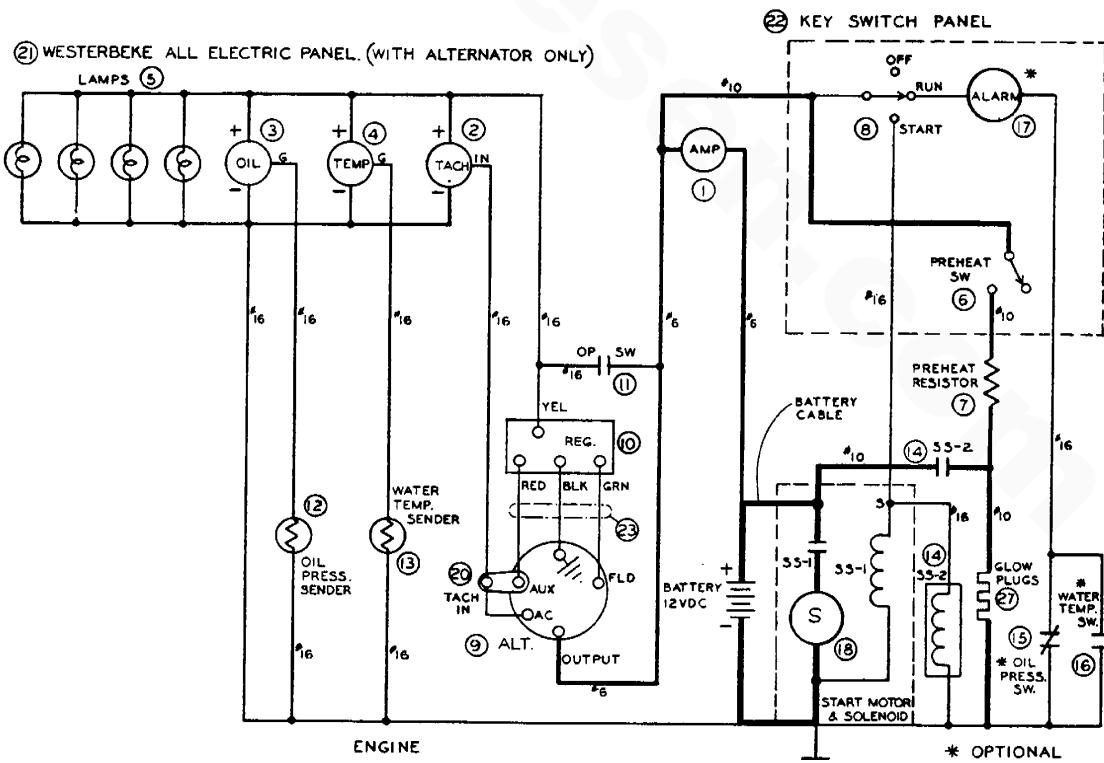
REF	PN	NAME	REMARKS
1	15370	LINE	#1 INJECTOR
2	15371	LINE	#2 INJECTOR
3	15372	LINE	#3 INJECTOR
4	15373	LINE	#4 INJECTOR
5	14492	CLAMP	
6	14493	BUSHING	
7	14548	NOZZLE	INJECTOR
8	15393	INJECTOR	COMPLETE
9	14463	WASHER	HEAT SHIELD
10	15480	LINE	RETURN - PLASTIC
11	14462	SHIELD	HEAT
12	14464	WASHER	INJECTOR SEALING
13	14490	WASHER	INJECTOR HOLDER
14	15424	BANJO	SINGLE PUSH-ON
15	15423	BANJO	DOUBLE PUSH-ON
16	15468	BANJO	DOUBLE PUSH-ON/THREADED
17	11935	BOLT	BANJO
18	11943	WASHER	BANJO BOLT
19	15328	CLAMP	INJECTOR HOLDER
20	15358	PUMP	FUEL LIFT - COMPLETE
21	15308	GASKET	LIFT PUMP TO BLOCK
22-1	15426	FILTER	FUEL - COMPLETE
22-2	11703	ELEMENT	FUEL FILTER
22-3	15478	SEAL	FUEL FILTER COVER
23	15477	SHAFT	INJECTION PUMP DRIVE
24	15359	PUMP	FUEL INJECTION - COMPLETE
25	15071	BRACKET	FUEL FILTER MOUNTING
26	11941	BANJO	
27	12350	BOLT	
28	12522	WASHER	
29	15502	ADAPTER	FUEL RETURN
30	11920	LINE	FUEL INLET
31	11596	NUT	FUEL INLET AT LIFT PUMP
33-1	11784	FILTER	FUEL - GLASS BOWL
33-2	11598	FILTER	FUEL - METALIC BOWL
33-3	13762	ELEMENT	PRIMARY FUEL FILTER - AC 'T60'
33-4	13761	ELEMENT	PRIMARY FUEL FILTER - FRAM 'F1104M'
34	11597	FERRULE	
35	15500	WASHER	PLUG
36	14664	PLUG	
37	15503	GASKET	INJECTION PUMP COVER
38	14662	VALVE	FILTER - NON RETURN
39	16707	NUT	FUEL OUTLET AT FILTER
40	16677	LINE	LIFT PUMP TO FILTER
41	14671	BUSHING	FUEL INLET AT FILTER
42	14670	WASHER	
43	15501	WASHER	
44	16678	LINE	INJECTION PUMP TO FILTER
45	16676	NUT	
46	16679	LINE	FILTER TO INJECTION PUMP
49	16706	FITTING	FUEL LINE

FOUR 60: ELECTRICAL SYSTEM



WITH GENERATOR AND SKIPPER PANEL

DRWG 13706



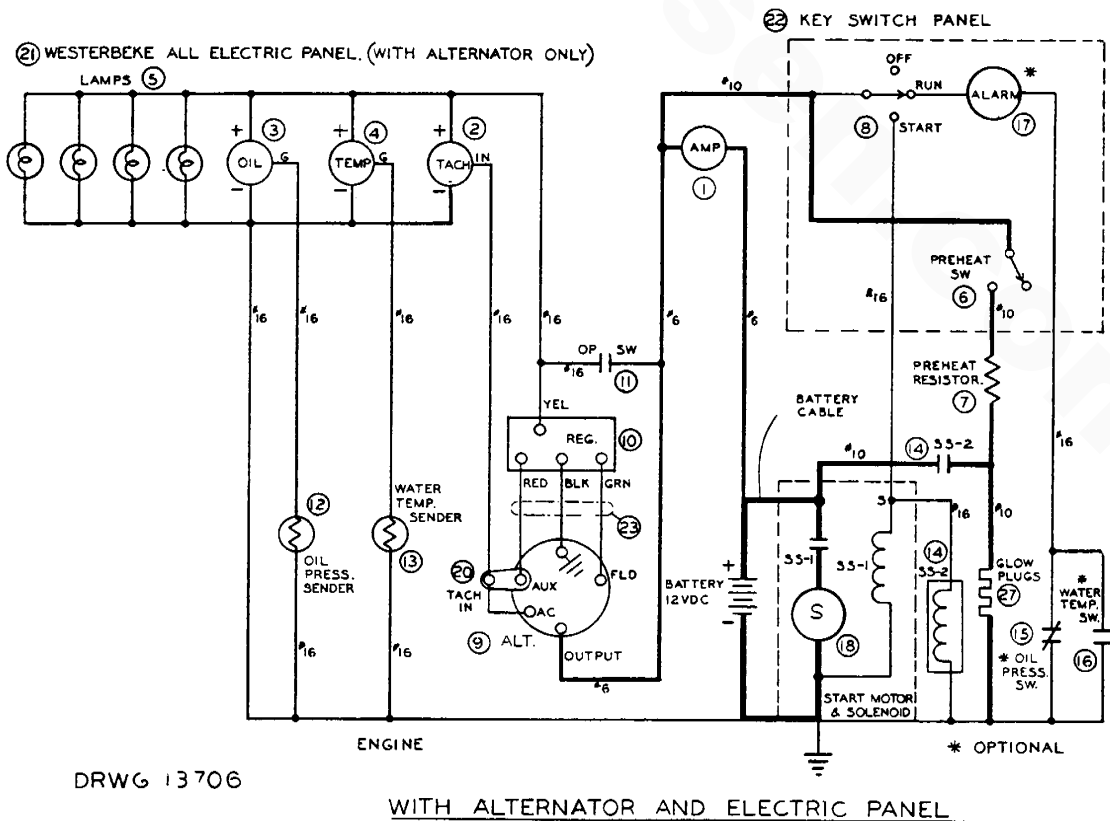
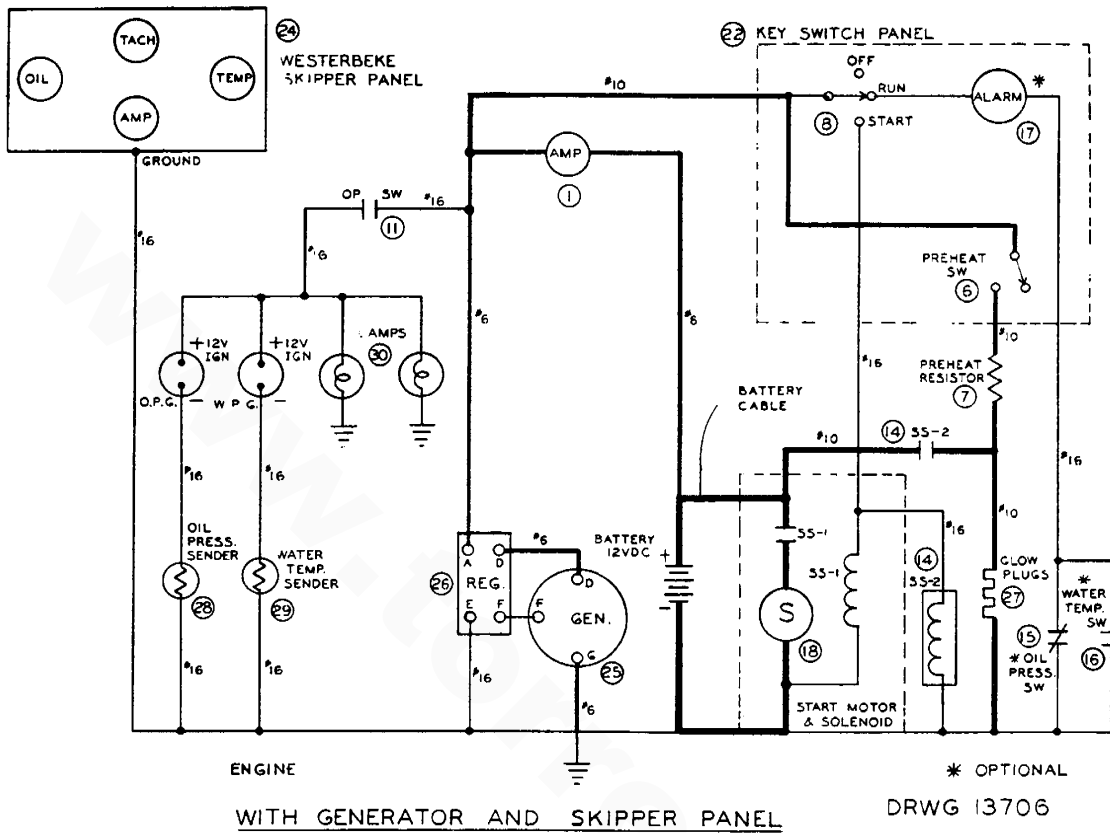
DRWG 13706

WITH ALTERNATOR AND ELECTRIC PANEL

FOUR 60: ELECTRICAL SYSTEM

REF	PN	NAME	REMARKS
1-1	11931	AMMETER	2 3/8" OD - ELECTRIC PANEL
1-2	16550	AMMETER	2 1/32" OD - ELECTRIC PANEL
2-1	11917	TACHOMETER	ELECTRIC PANEL
2-2	16456	TACH CABLE	4' - FOR 3/4"-27 TPI TACH DRIVE THREAD
2-3	16457	TACH CABLE	6' - FOR 3/4"-27 TPI TACH DRIVE THREAD
2-4	16458	TACH CABLE	8' - FOR 3/4"-27 TPI TACH DRIVE THREAD
2-5	16459	TACH CABLE	10' - FOR 3/4"-27 TPI TACH DRIVE THREAD
3-1	11914	GUAGE	PRESSURE - 2 3/8" OD - ELECTRIC PANEL
3-2	16548	GUAGE	PRESSURE - 2 1/32" OD - ELECTRIC PANEL
4-1	11913	GUAGE	TEMPERATURE - 2 3/8" OD - ELECTRIC PANEL
4-2	16549	GUAGE	TEMPERATURE - 2 1/32" OD - ELECTRIC PANEL
5-1	11432	LIGHT BULB	14 VOLT
5-2	12961	SOCKET	LAMP - 2 3/8" OD GUAGES
6	11957	SWITCH	PREHEAT
7	13710	RESISTOR	PREHEAT
8	11956	KEYSWITCH	STARTING
9-1	11546	ALTERNATOR	55AMP - 12VDC - NEG GND
9-2	11548	PULLEY	11546 ALTERNATOR
9-3	13859	BELT	11546 ALTERNATOR
9-4	13701	BRACKET	11546 ALTERNATOR MOUNTING
9-5	11125	STRAP	ADJUSTING - 11546 ALTERNATOR
9-6	11670	WIRE	11546 ALTERNATOR EXICATION
10	11550	REGULATOR	ALTERNATOR
11	11383	SWITCH	OIL PRESSURE - ALTERNATOR FIELD
12-1	11916	SENDER	11914 OIL PRESSURE GUAGE - UNGROUNDED
12-2	16551	SENDER	16548 OIL PRESSURE GUAGE - GROUNDED
13-1	11915	SENDER	11913 WATER TEMP GUAGE - UNGROUNDED
13-2	16552	SENDER	16549 WATER TEMP GUAGE - GROUNDED
14	11489	SOLENOID	PREHEAT
15	11552	SWITCH	OIL PRESSURE - ALARM SYSTEM
16	11396	SWITCH	WATER TEMPERATURE - ALARM SYSTEM
17	13355	ALARM	
18-1	11556	STARTER	9,25" HOUSING LENGTH
18-2	16762	STARTER	7,50" HOUSING LENGTH
20	12959	TACH KIT	ELECTRIC TACHOMETER TO ALTERNATOR
21-1	12317	PANEL	ALL ELECTRIC
21-2	16023	RING	2 1/16" OD GUAGE TO 2 3/8" PANEL CUTOUT
22	13368	PANEL	KEYSWITCH
23	11549	CARLE	ALTERNATOR TO REGULATOR
24-1	11693	PANEL	SKIPPER - MECHANICAL TACHOMETER
24-2	13707	NUT	TACH CABLE TO TACH DRIVE
24-3	13868	GUAGE	OIL PRESSURE - REPLACEMENT - 11693 PANEL
24-4	12883	TACHOMETER	REPLACEMENT - 11693 PANEL
24-5	13682	GUAGE	WATER TEMP - REPLACEMENT - 11693 PANEL
24-6	11970	AMMETER	REPLACEMENT - 11693 PANEL
25-1	13789	GENERATOR	14AMP - 12VDC - NEG GND
25-2	15479	BRUSH	SET OF 2 - 13789 GENERATOR
25-3	15466	STRAP	ADJUSTING - 13789 GENERATOR

FOUR 60: ELECTRICAL SYSTEM

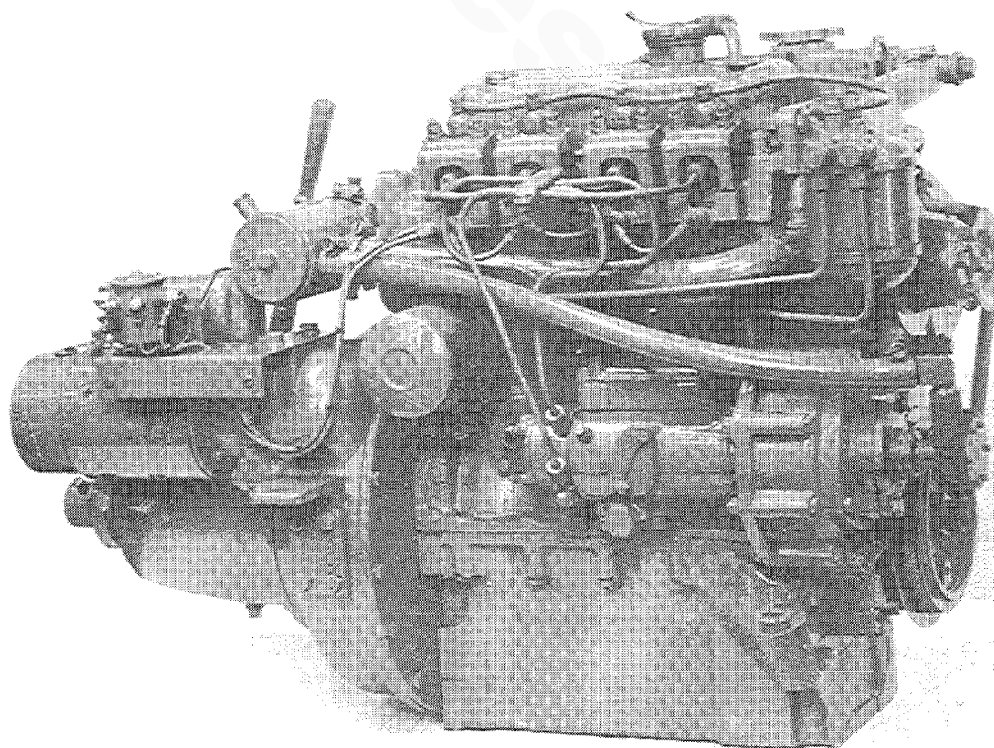
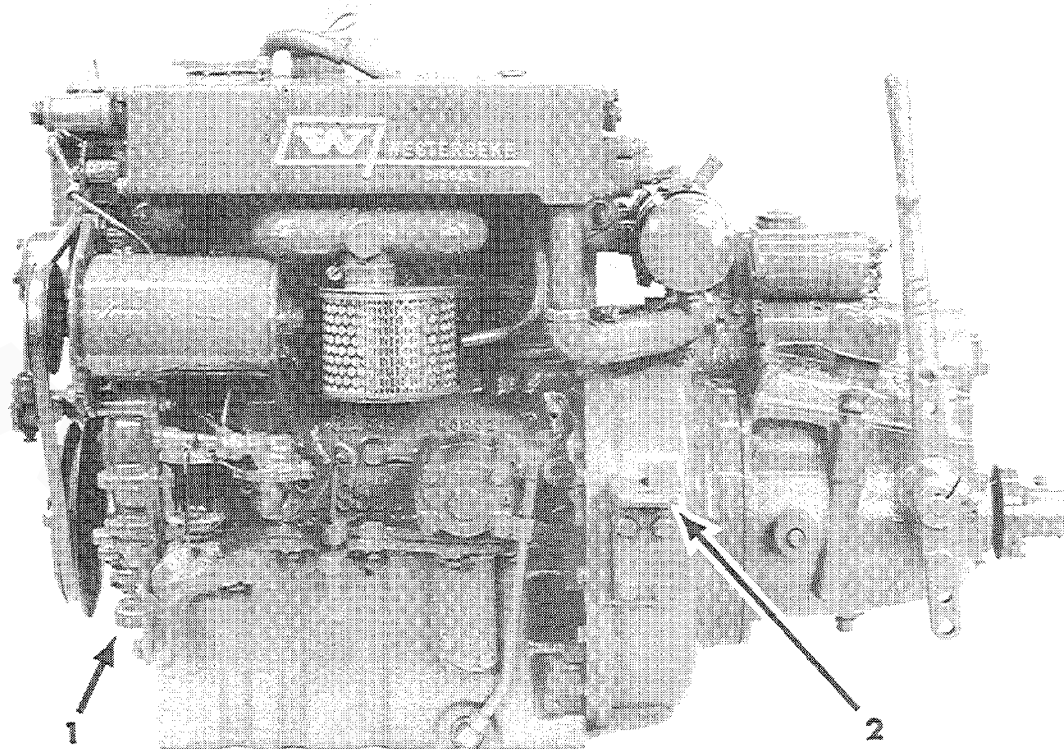


FOUR 601 ELECTRICAL SYSTEM

REF	PN	NAME	REMARKS
25-4	15425	PULLEY	13789 GENERATOR
25-5	15375	WASHER	13789 GENERATOR PULLEY
25-6	15377	STUD	13789 GENERATOR TO ADJUSTING STRAP
25-7	15376	BRACKET	13789 GENERATOR MOUNTING
25-8	15472	BELT	13789 GENERATOR
26	13790	REGULATOR	13789 GENERATOR
27	15464	GLOW PLUG	9 VOLT
28	11542	SENDER	OIL PRESSURE - 11693 SKIPPER PANEL
29	11543	SENDER	WATER TEMPERATURE - 11693 SKIPPER PANEL
30	11692	SOCKET	11693 SKIPPER PANEL - LAMP

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FOUR 60: MOUNTS

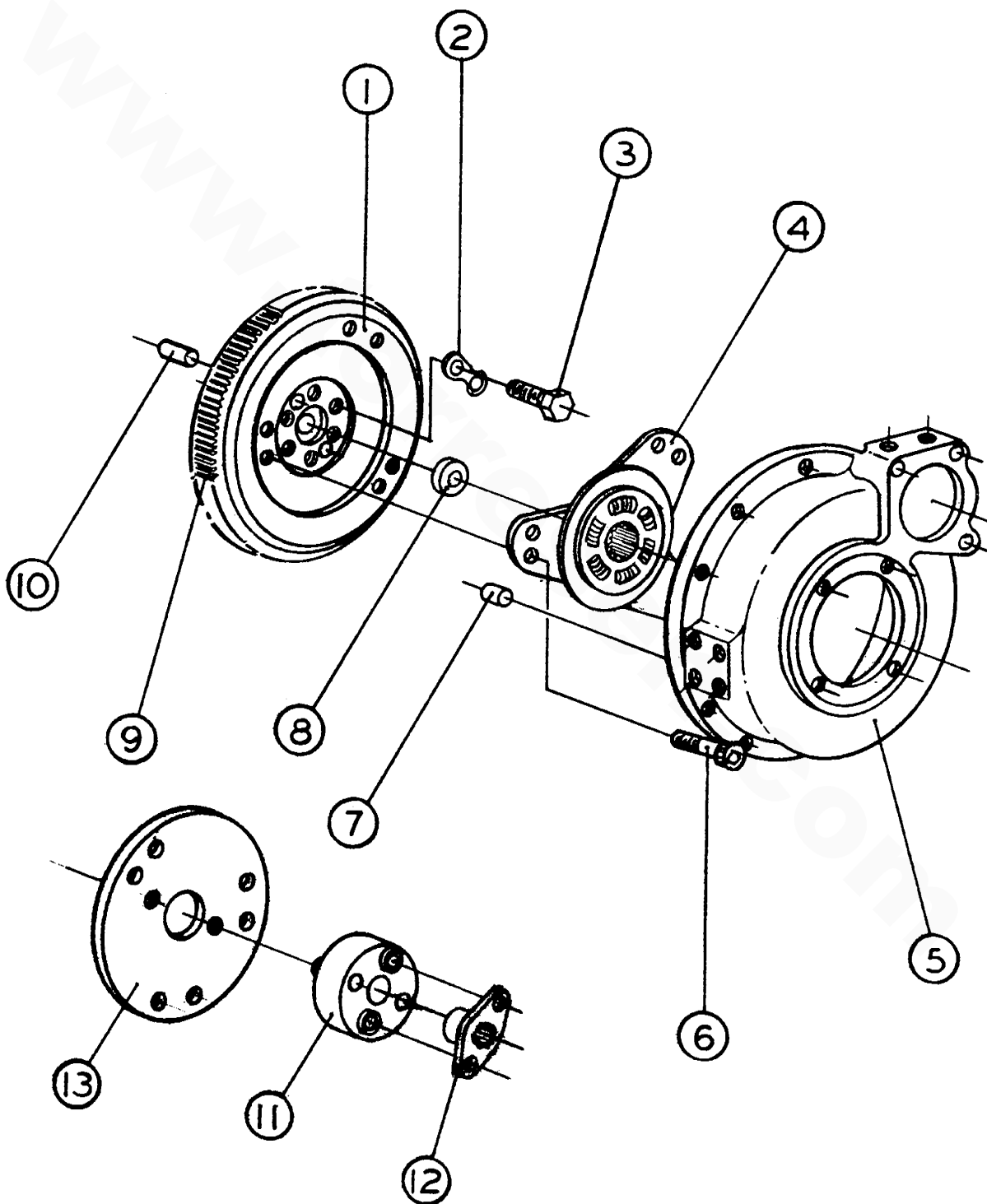


FOUR 60: MOUNTS

REF	PN	NAME	REMARKS
1	15060	MOUNT	FRONT LEFT & RIGHT
2-1	12275	MOUNT	REAR LEFT & RIGHT - SIDE HOUSING PAD
2-2	16040	MOUNT	REAR LEFT & RIGHT - FOR TYPE SS TRANSMISSION
2-3	11687	ISOLATOR	USED WITH ALL MOUNTS

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FOUR 60: BACK END ARRANGEMENTS

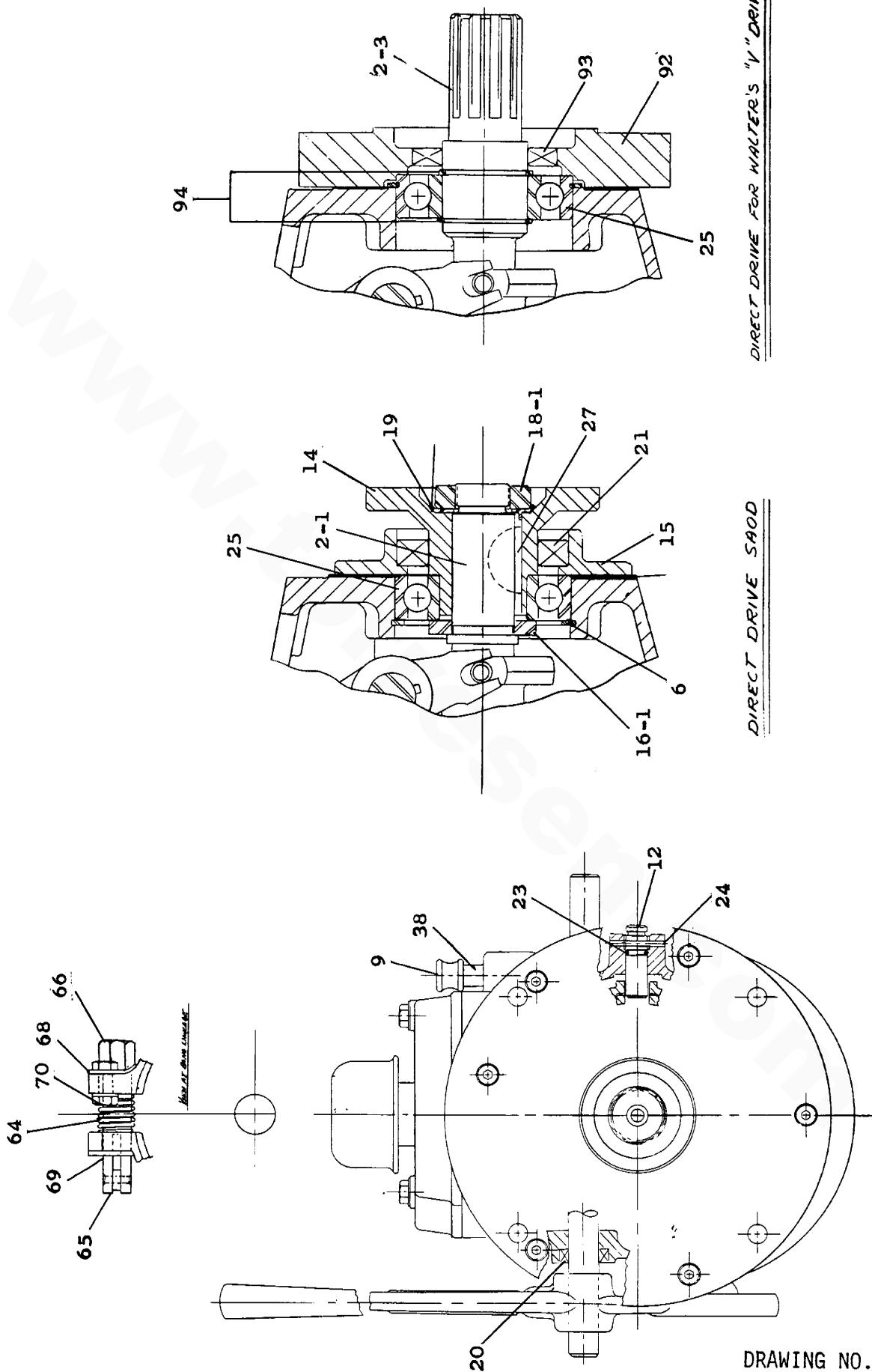


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FOUR 60: BACK END ARRANGEMENT

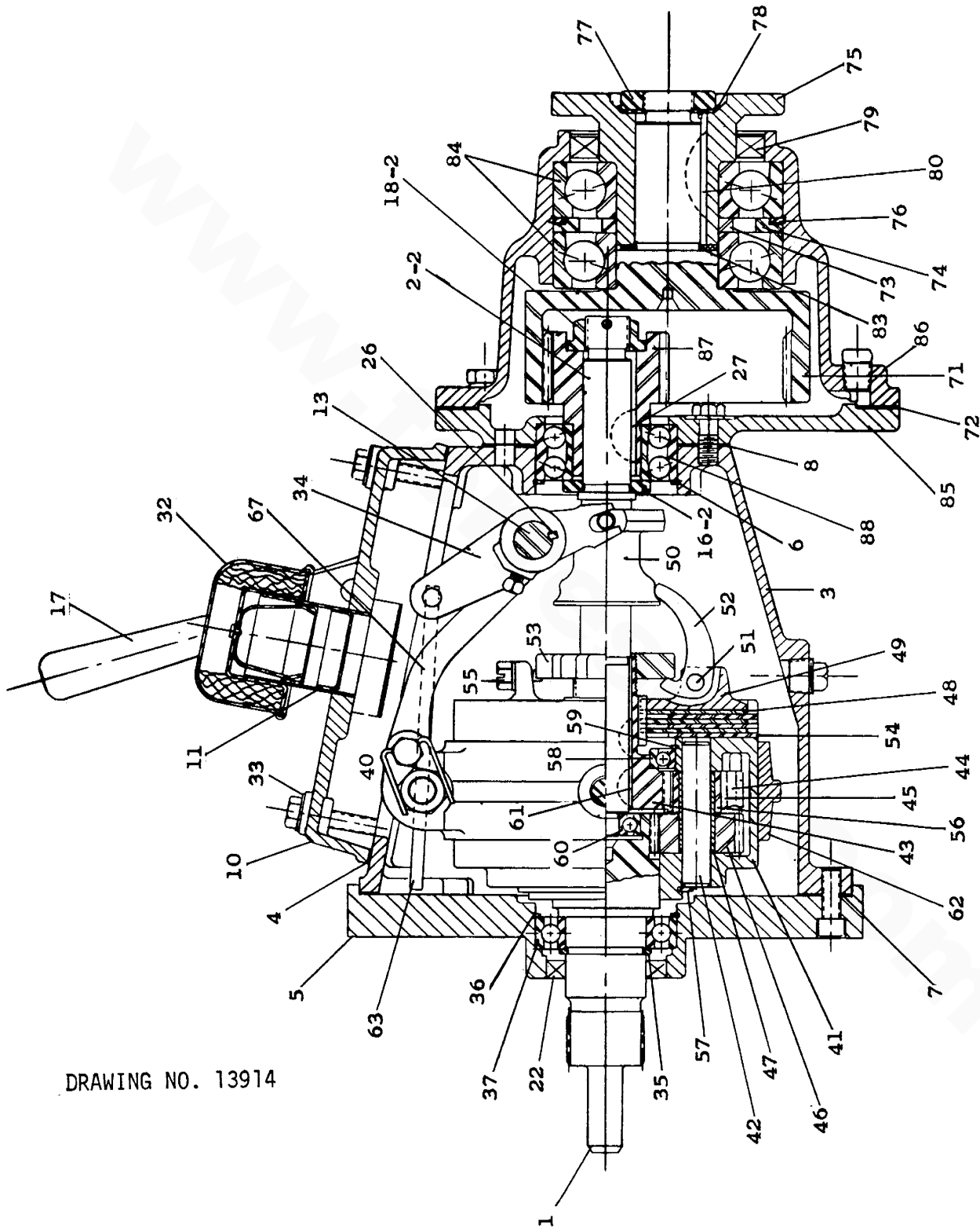
REF	PN	NAME	REMARKS
1	15080	FLYWHEEL	EXCLUDES RING GEAR
2	15338	LOCKWASHER	FLYWHEEL BOLT
3	15494	BOLT	FLYWHEEL TO CRANKSHAFT
4-1	15064	DAMPER	TYPE SAØ TRANSMISSION
4-2	16024	DAMPER	FREEWHEELING SAILING TRANSMISSION
5-1	15090	HOUSING	TYPE SAØ TRANSMISSION
5-2	16399	HOUSING	FREEWHEELING SAILING TRANSMISSION
5-3	16508	HOUSING	TYPE SS TRANSMISSION
6	13555	SCREW	DAMPER TO FLYWHEEL
7	11955	DOWEL	HOUSING TO BACKPLATE
8	13704	BUSHING	SAØ TRANSMISSION SHAFT SUPPORT
9	11315	RING GEAR	FORWARD RING GEAR NOT USED
10	14437	DOWEL	FLYWHEEL TO CRANKSHAFT
11	16441	DAMPER	RUBBER - TYPE SS TRANSMISSION
12	13416	COUPLING	DRIVE DAMPER TO DISC
13	16366	DISC	DRIVE - TYPE SS TRANSMISSION

TYPE SAO TRANSMISSION



DRAWING NO. 13915

TYPE SAO TRANSMISSION



DRAWING NO. 13914

TYPE SAØ TRANSMISSION

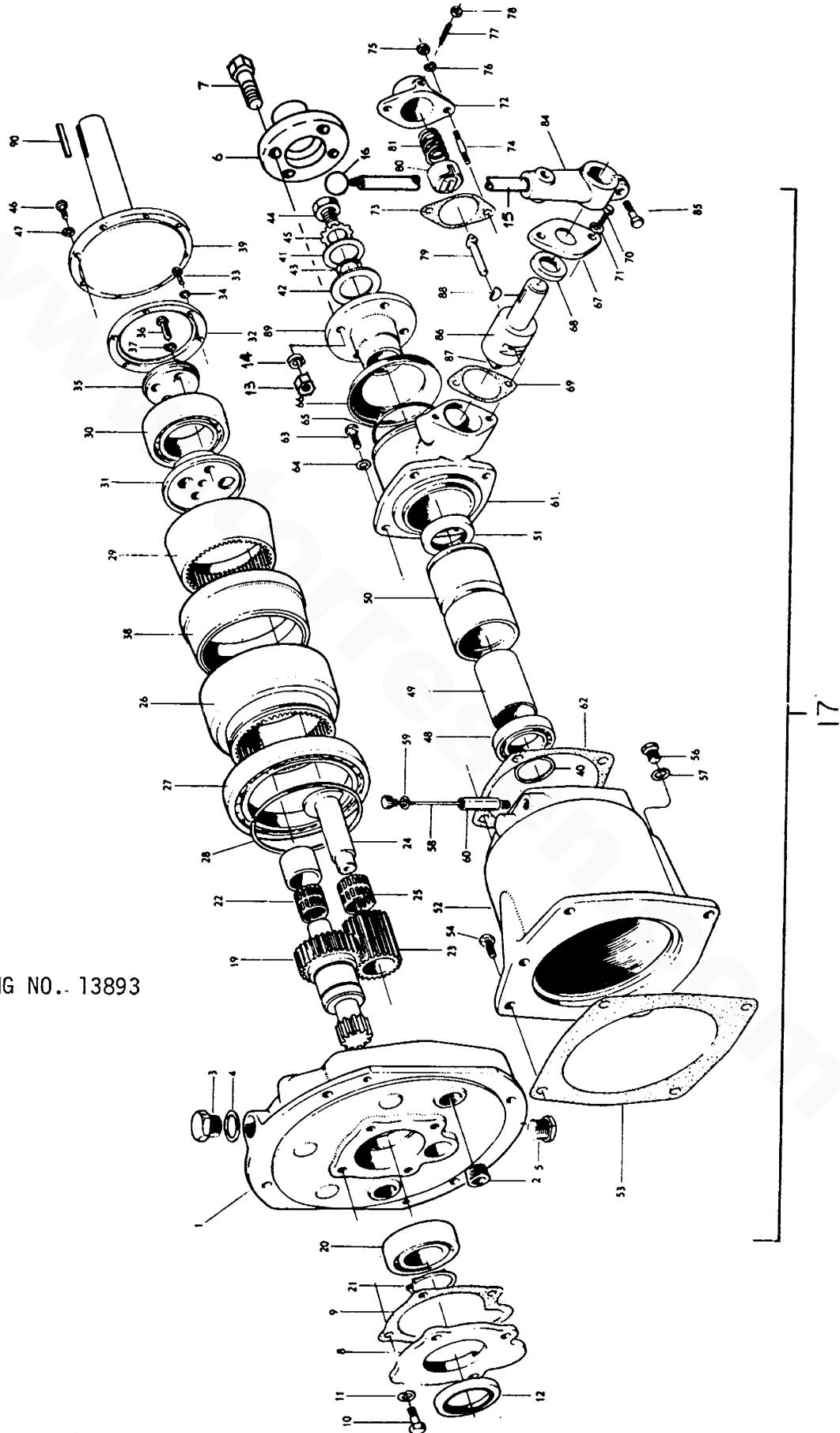
REF	PN	NAME	REMARKS
1	14894	GEAR	ENGINE
2-1	14857	TAILSHAFT	REVERSE GEAR
2-2	14858	TAILSHAFT	REVERSE GEAR
2-3	14899	TAILSHAFT	
3	14891	HOUSING	REVERSE GEAR
4	14868	GASKET	HAND HOLE COVER
5	14892	PLATE	FRONT END
6	14373	RING	RETAINING - REVERSE GEAR HOUSING
7	14893	GASKET	REVERSE GEAR HOUSING - FRONT
8	14876	GASKET	REAR - REVERSE GEAR HOUSING
9	14895	DIPSTICK	ASSEMBLY
10	14867	COVER	HAND HOLE
11	14883	TURE	FILLER
12	14879	PIN	BRAKE BAND LOCK
13	14861	CROSS SHAFT	
14	14863	COUPLING	GEAR HALF
15	14864	RETAINER	OIL SEAL
16-1	14865	THRUSTWASHER	REVERSE GEAR TAILSHAFT
16-2	14866	THRUSTWASHER	REVERSE GEAR TAILSHAFT
17	14852	LEVER	
18-1	14377	NUT	REVERSE GEAR TAILSHAFT
18-2	14323	NUT	REVERSE GEAR TAILSHAFT
19	14875	LOCKWASHER	REVERSE GEAR TAILSHAFT
20	14884	SEAL	OIL CROSS SHAFT
21	14885	RETAINER	OIL SEAL
22	14896	SEAL	FRONT PLATE
23	14886	ORING	
24	14887	PIN	ROLL
25	14882	BEARING	BALL - REVERSE GEAR HOUSING - REAR
26	14316	KEY	WOODRUFF - CROSS SHAFT
27	14848	KEY	WOODRUFF - REVERSE GEAR TAILSHAFT
32	14880	BREATHER	
33	14888	SEAL	COVER
34	14862	YOKE	ASSEMBLY
35	14903	RING	RETAINING - ENGINE GEAR
36	14898	RING	RETAINER - FRONT PLATE
37	14898	BEARING	BALL - ENGINE GEAR
38	14889	TURE	DIPSTICK
40	14890	BAFFLE	COVER
41	14834	CASE	GEAR
42	14842	SHAFT	PINION
43	14836	GEAR	PROPELLER
44	14837	PINION	ASSEMBLY - LONG
45	14840	BUSHING	PINION
46	14838	PINION	ASSEMBLY - SHORT
47	14841	BUSHING	PINION
48	14845	PLATE	STEEL - CLUTCH
49	14846	PLATE	PRESSURE
50	14847	SLEEVE	OPERATING
51	14849	PIN	FINGER
52	14851	FINGER	
53	14854	SCREW	COLLAR
54	14855	PLATE	BRONZE - CLUTCH
55	14859	LOCKSCREW	PRESSURE PLATE
56	14871	SPACER	SHORT PINION

TYPE SAØ TRANSMISSION

REF	PN	NAME	REMARKS
57	14874	RING	RETAINING - PINION SHAFT GEAR CASE
58	14877	BEARING	BALL - GEAR CASE
59	14373	RING	RETAINING - GEAR CASE BALL BEARING
60	14881	BEARING	BALL - PILOT
61	14844	KEY	WOODRUFF - REVERSE GEAR - TAILSHAFT
62	14850	BAND	BRAKE
63	14860	SLIDE	REVERSE CAM
64	14870	SPRING	
65	14853	CAM	REVERSE
66	14856	NUT	
67	14869	BRACE	
68	14872	LOCKSPRING	
69	14878	PIN	
70	14873	NUT	
71	14299	GEAR	INTERNAL
72	14321	GASKET	
73	14333	SPACER	
74	14337	SPACER	
75	14357	COUPLING	
76	14375	SNAPRING	
77	14378	NUT	
78	14379	LOCKWASHER	
79	14390	SEAL	OIL
80	14352	KEY	
83	14334	SEAL	WASHER
84	14396	BEARING	BALL
85	14835	PLATE	REDUCTION ADAPTER
86	14309	HOUSING	REDUCTION GEAR
87	14839	GEAR	REDUCTION DRIVING
88	14843	BEARING	BALL - REDUCTION ADAPTER PLATE
92	14900	PLATE	ADAPTER
93	14901	SEAL	OIL
94	14902	RINGS	RETAINING - TAILSHAFT

FREEWHEELING SAILING GEAR - MANUAL - 1.9:1

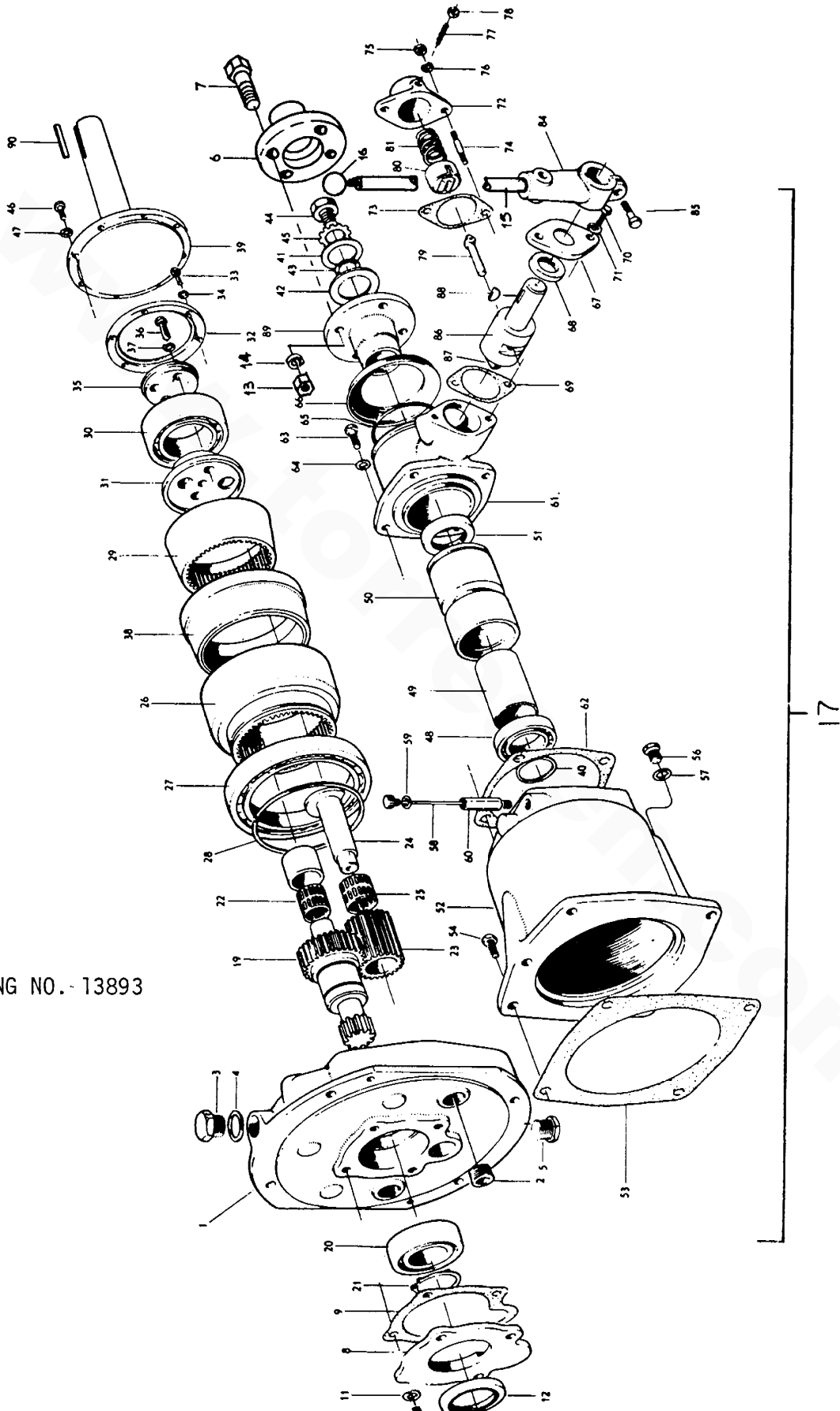
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FREE WHEELING SAILING GEAR - MANUAL - 1,9:1

REF	PN	NAME	REMARKS
1	14212	ADAPTER	
2	14211	PLUG	
3	14172	PLUG	
4	14205	GASKET	
5	14170	PLUG	
6-1	11645	COUPLING	BORED 1"
6-2	13974	COUPLING	OTHER THAN 1" BORE - SPECIFY
7	14228	BOLT	
8	14177	COVER	
9	14178	GASKET	
10	14224	BOLT	
12	14202	SEAL	
13	14232	NUT	
15	11643	LEVER	
16	11644	KNOB	
17	11642	GEAR	COMPLETE
19	14209	GEAR	
20	14165	BEARING	
21	14216	LOCK	
22	14204	BEARING	
26	14206	GEAR	
27	14168	BEARING	
28	14217	LOCK	
29	14181	GEAR	
30	14166	BEARING	
31	14179	SUPPORT	
32	14199	LOCK	
33	14221	BOLT	
35	14180	WASHER	
36	14229	BOLT	
38	14193	CONE	
39	14183	SHAFT	
40	14163	SHIM	
41	14208	WASHER	
42	14169	WASHER	
43	14167	O RING	
44	14207	BOLT	
45	14160	WASHER	
46	14223	BOLT	
48	14162	BEARING	
49	14184	SPACER	
50	14182	SLEEVE	
51	14201	SEAL	
52	14175	HOUSING	
53	14173	GASKET	
54	14226	BOLT	
55	14240	WASHER	
56	14159	PLUG	
57	14157	WASHER	
58	14203	DIPSTICK	
59	14158	GASKET	
60	14194	NIPPLE	
61	14176	HOUSING	
62	14174	GASKET	
63	14226	BOLT	

FREEWHEELING SAILING GEAR - MANUAL - 1.9:1

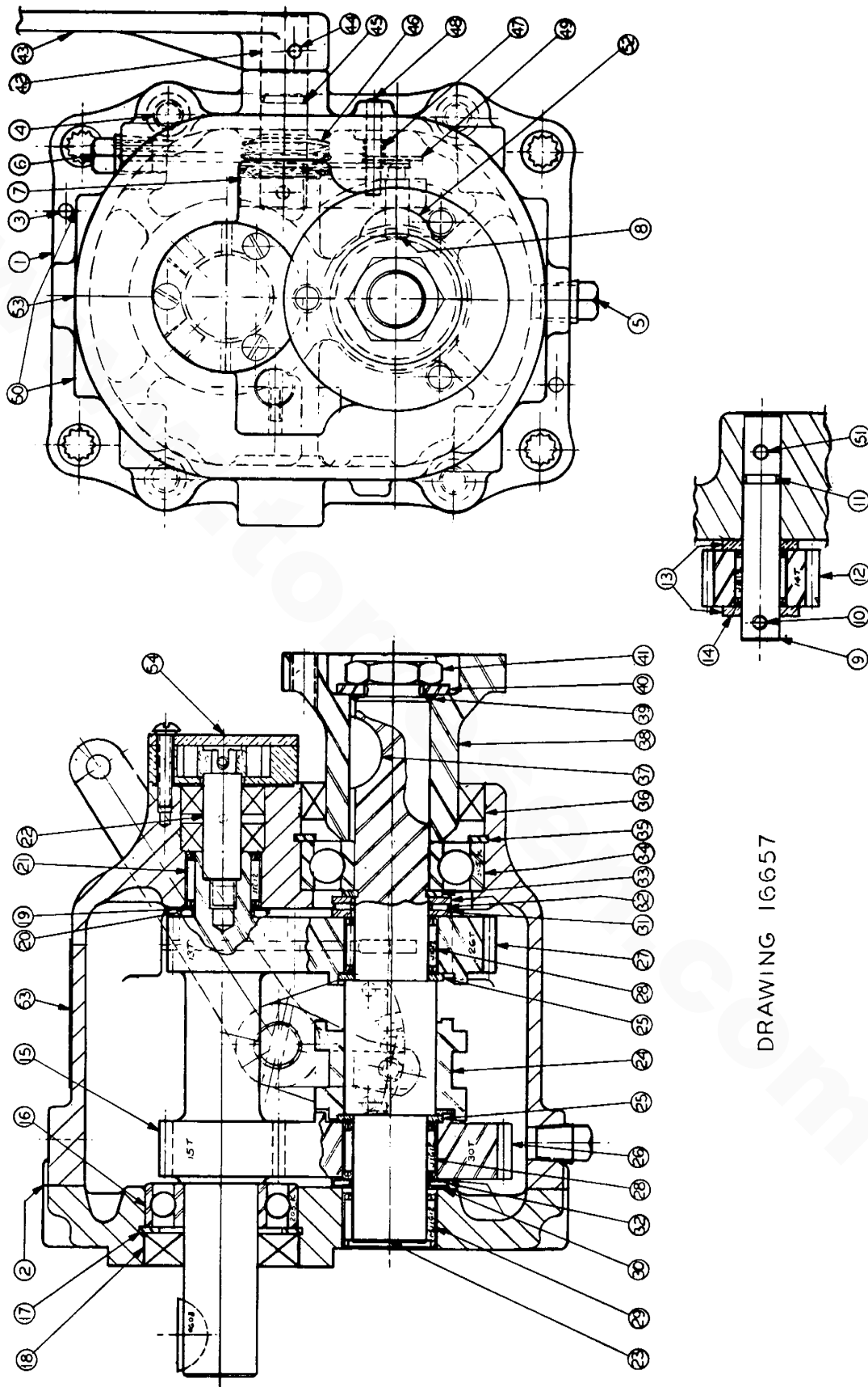


DRAWING NO.- 13893

FREE WHEELING SAILING GEAR - MANUAL - 1,911

REF	PN	NAME	REMARKS
65	14220	O RING	
66	14195	COVER	
67	14196	FLANGE	
68	14200	SEAL	
69	14197	GASKET	
70	14222	BOLT	
72	14190	HOUSING	
73	14197	GASKET	
74	14219	BOLT	
75	14230	NUT	
77	14218	BOLT	
78	14230	NUT	
79	14188	PIN	
80	14189	SLEEVE	
81	14191	SPRING	
84	14171	ARM	
85	14224	BOLT	
86	14186	SHAFT	
87	14187	PIN	
88	14215	KEY	
89	14185	COUPLING	
90	14214	KEY	

TYPE SSR AND SSL MANUAL TRANSMISSION

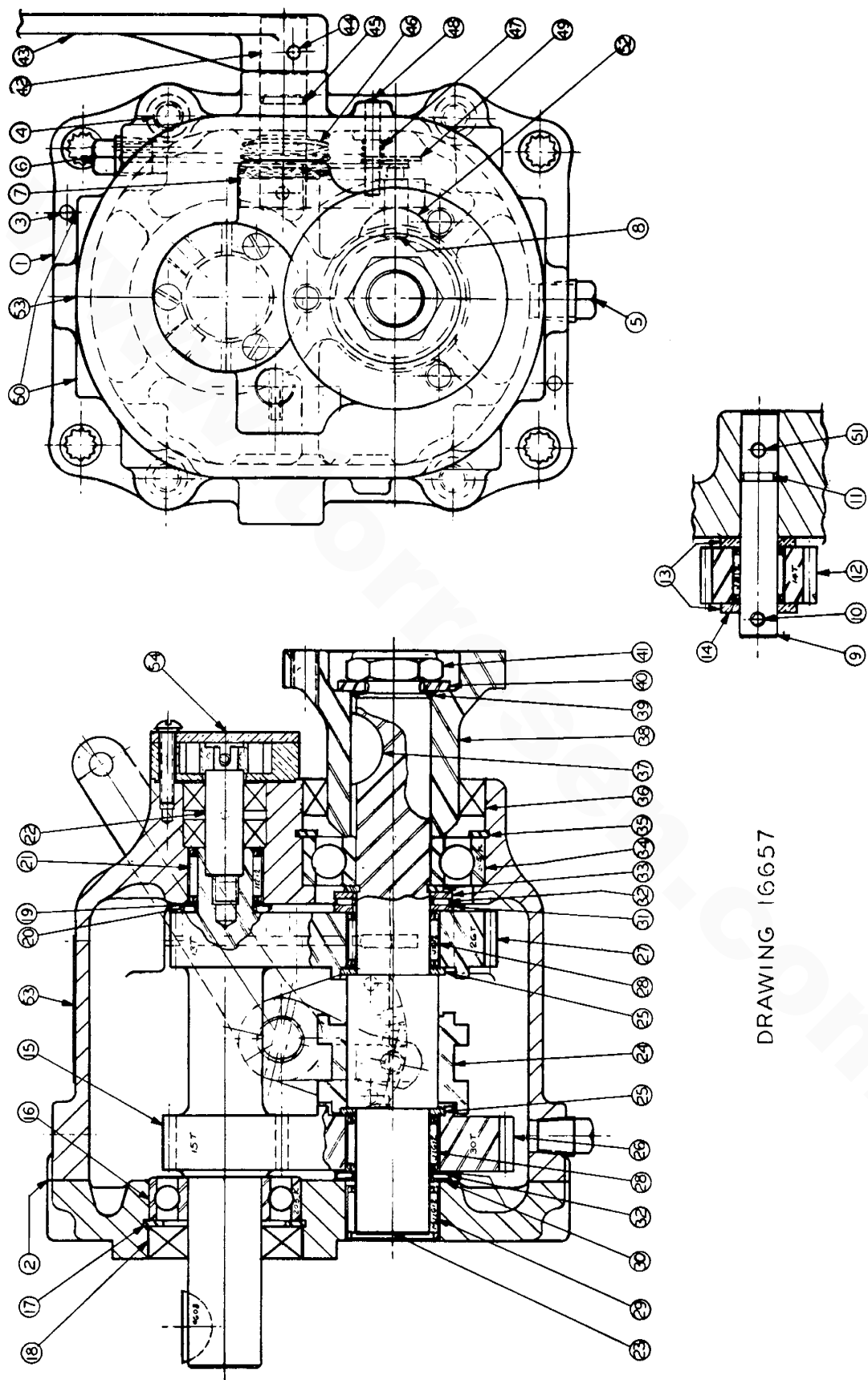


Engine parts from Torrsen Marine - www.torresen.com - 231-759-8596

TYPE SSR (DS ENGINE) & SSL (4-60 ENGINE) TRANSMISSION

REF	PN	NAME	REMARKS
1-1	14998	HOUSING	HOUSING & PLATE ASSY - DS ENGINE
1-2	16310	HOUSING	HOUSING & PLATE ASSY - FOUR 60 ENGINE
2	14993	GASKET	
3	14990	PIN	ALIGNMENT
4	14999	CAPSCREW	12 POINT
5	13341	PLUG	PIPE
6	14992	DIPSTICK	DIPSTICK AND VENT ASSEMBLY
7	14981	ARM	LEVER
8	14975	PIN	CLUTCH ACTUATING
9	14974	SHAFT	IDLER
10	14955	PIN	IDLER SHAFT
11	14950	O-RING	IDLER SHAFT
12	14983	IDLER	
13	14973	WASHER	THRUST - IDLER
14	14954	BEARING	NEEDLE ROLLER - IDLER
15-1	14986	GEAR	DRIVER - DS ENGINE & FOUR 60 ENGINE 2:1
15-2	16311	GEAR	DRIVER - FOUR 60 ENGINE 1,3:1
16	14969	BEARING	BALL - ASSEMBLY
17	14952	RING	RETAINING
18	14971	SEAL	INPUT SHAFT
19	14962	RACE	THRUST - INPUT SHAFT
20	14964	BEARING	NEEDLE THRUST - INPUT SHAFT
21	14965	BEARING	NEEDLE ROLLER - INPUT SHAFT
22	14976	SHAFT	IMPELLER
23	14982	SHAFT	OUTPUT
24-1	14985	CLUTCH	DS ENGINE
24-2	16314	CLUTCH	FOUR 60 ENGINE
25	14978	WASHER	CLUTCH FACE
26-1	14988	GEAR 30T	DRIVEN - DS ENGINE
26-2	16312	GEAR 30T	DRIVEN - FOUR 60 ENGINE 1,3:1
26-3	16313	GEAR 30T	DRIVEN - FOUR 60 ENGINE 2:1
27-1	14987	GEAR 26T	DRIVEN - DS ENGINE
27-2	16315	GEAR 26T	DRIVEN - FOUR 60 ENGINE 1,3:1
27-3	16316	GEAR 26T	DRIVEN - FOUR 60 ENGINE 2:1
28	14966	BEARING	NEEDLE ROLLER - GEAR
29	14967	BEARING	NEEDLE ROLLER - BASE
30	14960	RACE	THRUST - OUTPUT SHAFT
31	14961	RACE	THRUST - OUTPUT SHAFT
32	14963	BEARING	NEEDLE THRUST - OUTPUT SHAFT
33	14953	RING	RETAINING
34	14968	BEARING	
35	14951	RING	RETAINING
36	14972	SEAL	OUTPUT SHAFT
37	14957	KEY	OUTPUT SHAFT
38	14984	COUPLING	
39	14958	O-RING	COUPLING
40	14980	WASHER	COUPLING
41	14970	LOCKNUT	COUPLING
42	14996	SHAFT	LEVER ARM
43	14997	ARM	LEVER
44	14956	PIN	LEVER ARM SHAFT
45	14959	O-RING	LEVER ARM SHAFT
46	14989	WASHER	BELLEVILLE

TYPE SSR AND SSL MANUAL TRANSMISSION



DRAWING 16657

TYPE SSR (DS ENGINE) & SSL (4-60 ENGINE) TRANSMISSION

REF	PN	NAME	REMARKS
47	14979	SPRING	INDEXING SEGMENT
48	14990	PIN	GUIDE - INDEXING - SEGMENT
49	14977	SEGMENT	INDEXING
50	16119	NAMEPLATE	DRIVE SCREW
51	14994	PIN	IDLER SHAFT
52	14995	SHOE	CLUTCH
53	16428	NAMEPLATE	
54-1	16662	KIT	IMPELLER REPLACEMENT PUMP REBUILD
54-2	16663	SEAL	
54-3	16445	KIT	

Not applicable
on
Model Four-60

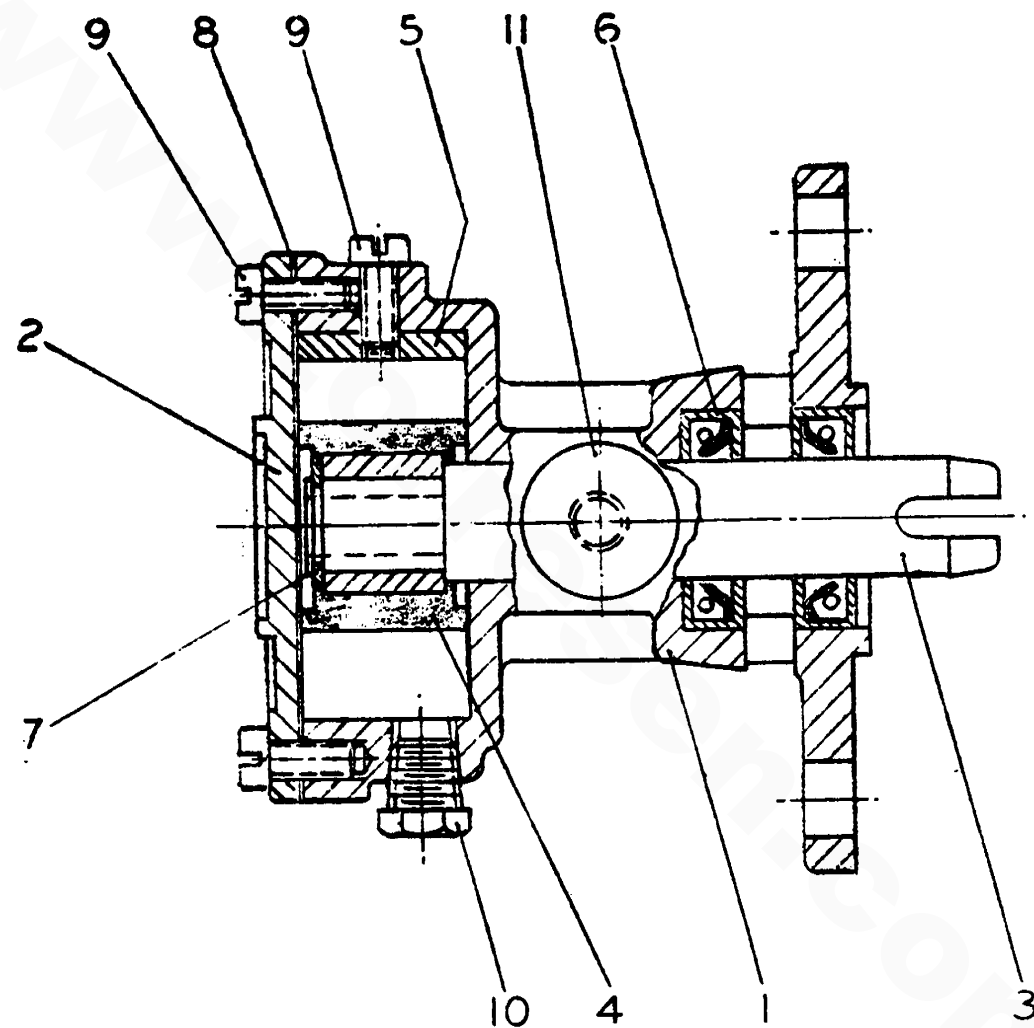
11192 Trans

SSL-13

11853 Trans

SSL-20

FOUR 60: RAW WATER PUMP



DWG NO. 11197

FOUR 60: RAW WATER PUMP

REF	PN	NAME	REMARKS
1-1	17557	BODY	
1-2	17561	KIT	PUMP REBUILD
2	17558	COVER	
3	17559	SHAFT	
4	17556	IMPELLER	
5	17555	CAM	
6	17552	SEAL	TWO REQUIRED
7	17550	RING	RETAINING
8	17560	GASKET	COVER
9	17551	SCREW	COVER - FIVE REQUIRED
10	17554	PLUG	
11	17553	GREASE CUP	

FOUR 60: MISCELLANEOUS

REF	PN	NAME	REMARKS
1	13859	BELT	ALTERNATOR DRIVING
2	15457	GASKET SET	UPPER
3	15456	GASKET SET	LOWER
4	16650	KIT	SPARE PARTS 'A'
5	16651	KIT	SPARE PARTS 'B'
6	13758	PAINT	RED - AEROSOL CAN
7	11592	PUMP	LUBE OIL SUMP
8	13826	TURING	SUMP PUMP TO DIPSTICK TUBE

www.torresen.com