Publ. nr. 2120
Dec. 66.

VOLVO PENTA

D 1 · MD 1
D 2 · MD 2

WORKSHOP MANUAL

DIESEL ENGINES

AB VOLVO PENTA

WORKSHOP MANUAL

D1, MD1, D2, MD2.

FOREWORD

This Service Manual concerns Volvo Penta engines of the D1, MD1, D2 and MD2 types.

The instructions assume the use of certain special tools and since it is in your own interest as well as ours that repairs are properly carried out, we request you to study and carefully follow the instructions in this book.

We retain the right to carry out design modifications and for this reason the contents of this book are not to be considered binding.

AB VOLVO PENTA
Technical Information Department

CONTENTS

GENERAL

DESCRIPTION

Engines with type designations D1 and MD1 are one-cylinder, four-stroke Diesel engines with overhead valves. The total capacity is 445 c.c.

Engines with type designation D2 and MD2 are two-cylinder, four-stroke Diesel engines with overhead valves. The total capacity is 890 c.c.

MD1 and MD2 are marine Diesel engines. D1 and D2 are industrial Diesel engines. The combustion chambers in the engines are designed for direct fuel injection, this resulting in low fuel consumption, smooth running and immediate starting.

The engines are fitted with a manual or electric starter. A decompression device on the rocker arm cover facilitates starting.

The marine engines are sea-water cooled and the industrial engines are fitted with a cellular type radiator. A thermostat maintains the operating temperature of the engine automatically within the correct values.

The fuel system includes a filter with a replaceable element and is thus well protected from running interruptions. D2 and MD2 units are fitted with a feed pump.

Engine lubrication is through a pressure system where an oil pump supplies lubricating oil to all the points in the correct quantities at different speeds. The D2 and MD2 are fitted with a full flow oil filter. The big-end bearing shells are replaceable and are accessible through the oil sump crankcase covers. Major repair work can also be carried out through these covers.

The engines have closed circuit crankcase breathing and this prevents crankcase gases from getting out into the engine compartment. This device consists of a filter with connections and an oil trap located in the space above the valve tappets. Crankcase gases are then sucked directly into the engine induction manifold and into the cylinders.

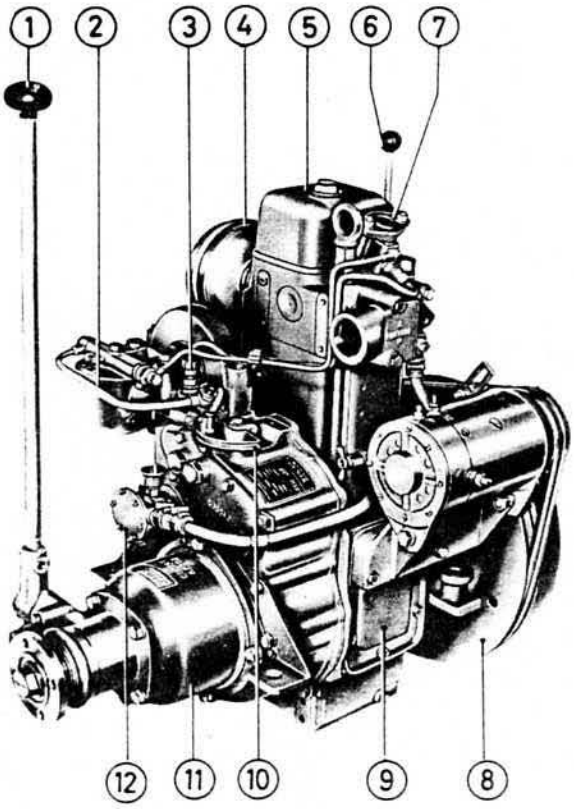


Fig 1. MD1 engine

1 Control lever
2 Fuel filter
3 Fuel injection pump
4 Air cleaner
5 Rocker arm cover
6 Decompression device
7 Injector
8 Flywheel
9 Crankcase cover
10 Control arm
11 Reduction - reverse gear
12 Sea-water pump

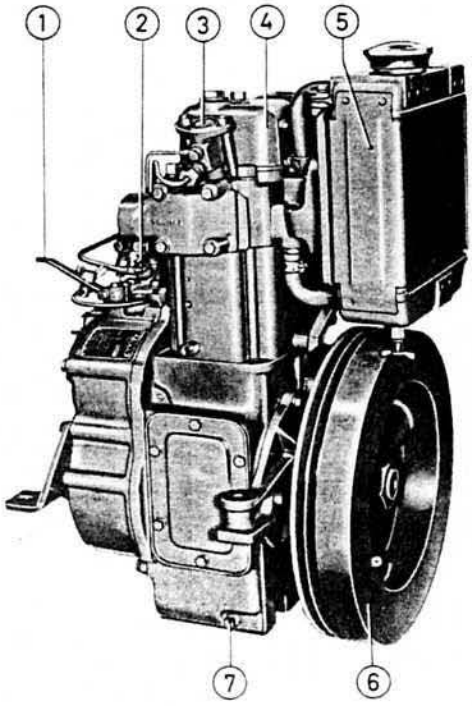


Fig 2. D1 engine

1 Control arm
2 Fuel injection pump
3 Injector
4 Rocker arm cover
5 Radiator
6 Flywheel
7 Oil plug

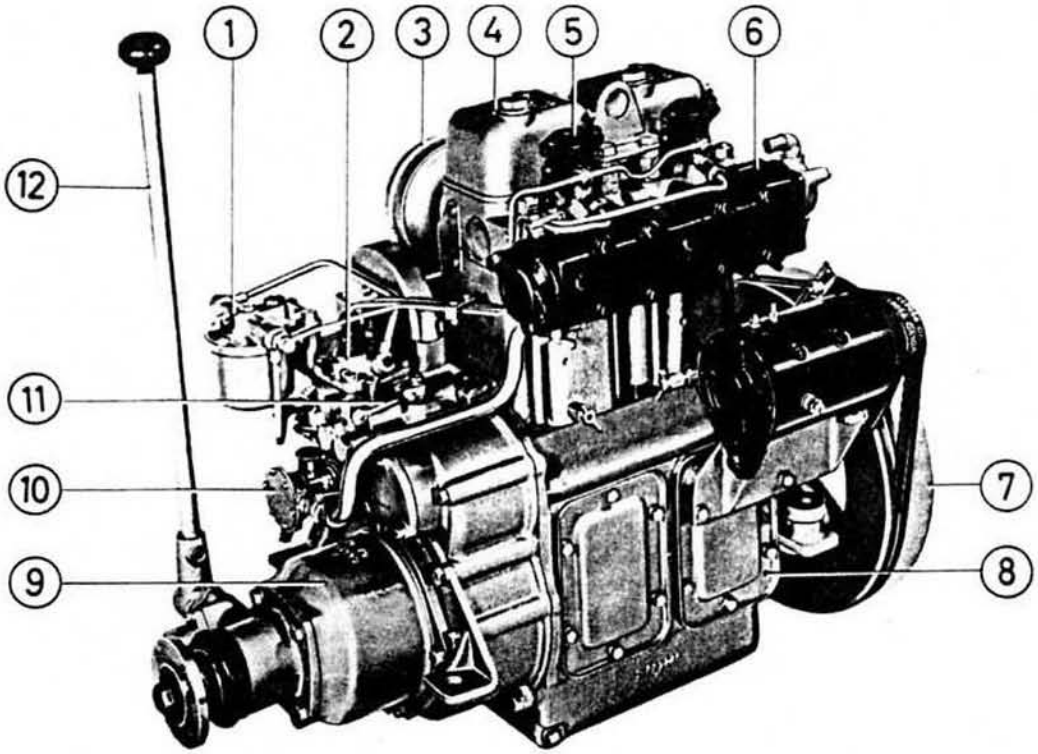


Fig 3. MD2 engine

1 Fuel filter
2 Fuel injection pump
3 Air cleaner
4 Rocker arm cover
5 Injector
6 Water-cooled exhaust manifold
7 Flywheel
8 Crankcase cover
9 Reduction - reverse gear
10 Sea-water pump
11 Control arm
12 Control lever

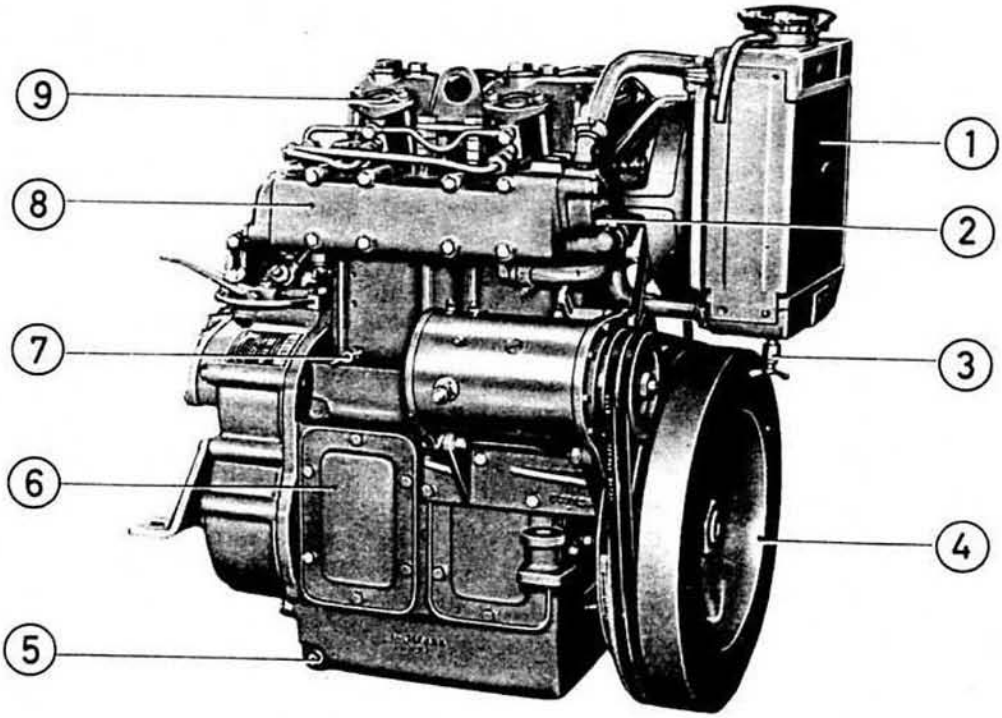


Fig 4. D2 engine

1 Radiator
2 Thermostat housing
3 Drain cock
4 Flywheel
5 Oil plug
6 Crankcase cover
7 Drain cock
8 Water-cooled exhaust manifold
9 Injector

GENERAL SERVICE WORK

All the repair instructions concern both one and two cylinder industrial and marine engines and these instructions should be applied according to the engine concerned.

COMPRESSION TEST

A compression test is used to determine the condition of the engine in a simple and reliable way. The compression gauge is usually graduated in kg/cm^2 or lb./sq.in.

The test is carried out by first running the engine warm and then removing the injectors and checking the compression on each cylinder in turn.

Move the speed control to the zero position or turn the fuel injection pump lever in a clockwise direction.

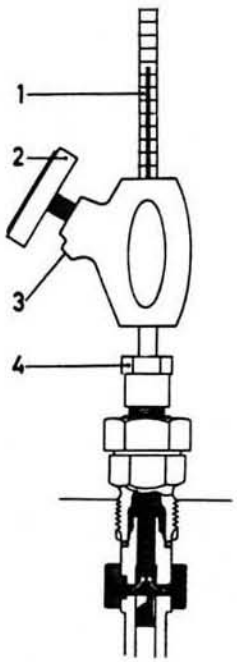
Engine with manual starter

Move the decompression handle so that it points upwards. Turn the engine over as fast as possible by using the starter crank and push down the decompression handle completely while continuing to turn the engine over.

Engine with electric starter

Turn on the key switch. Then press the starter button. Make sure that the battery is in good enough condition to turn the engine over at 200-240 r.p.m. It is also important to ensure that the compression gauge connection is in good condition and that tightening is properly carried oût if the test is to be reliable.

Compression pressure should normally be 21-24 kg/cm^2 (300-340 lb./sq.in)



1 Level tube (fuel level)
2 Level valve control
3 Housing
4 Connection nipple

Fig 5 Level control (Wilbär tube)

NOTE! It is absolutely useless to carry out this test without running the engine warm since engine temperature has two affects. To start with a warm engine rotates easier than a cold engine with its stiff oil. Secondly the compression value is higher when the engine runs easily and therefore rotates faster. The air expands due to this heat and produces higher pressure. With a higher initial temperature, the final temperature and therefore the pressure are also higher. Low compression pressure on cylinders indicates worn cylinders and piston rings.
If the compression pressure in one of the cylinders is lower, this can depend either on leaking valves, broken piston rings or a blown cylinder head gasket.

CHECKING FEED PRESSURE (D2, MD2)

It is important that the fuel always has sufficiently high pressure when it is fed to the fuel injection pump and feed pressure should therefore be checked if engine output decreases or there is reason to suspect a blocked fuel filter.

Feed pressure is checked by using a pressure gauge which is attached to the air-venting screw on the fuel filter. While testing the engine should run at a speed slightly above idling. After the pump has been operating for some time, read off the pressure gauge. The pressure should be about 0.5 kg/cm^2 (7 lb./sq.in.). The pressure should not be less than 0.1 kg/cm^2 (1.4 lb./sq.in.) if the pump is to feed the injection pump under all conditions and also circulate the fuel in the system to eliminate air. If the feed pressure is too low, check the following possible causes in the given order.

1. Fuel tank empty.
2. Blocked filter
3. Faulty relief valve
4. Worn-out diaphragm
5. Leaking suction or pressure valve.
6. Air leakage on suction side of feed pump.
7. Fuel leakage on pressure side of feed pump.

CHECKING THE INJECTION ANGLE

The injection angle is checked by using a Wilbär tube and tool no. 884057. On D2 and MD2 engines, the test is carried out on the cylinder nearest the timing gear casing.

1. Fit the Wilbär tube on the delivery pipe nipple. Set the pump for maximum feed. Turn the engine over in its correct direction of rotation until the level tube is full of air-free fuel. See Fig 5.
2. Open the level valve on the measuring apparatus so that the level is 25-30 mm (0.98 - 1.2") counting from the bottom.
3. Fit tool 884057. The tool is fitted on the manual starter shaft and rests with the marked part on the flywheel.
4. Turn the engine over until the compression stroke starts.
5. Continue to turn the engine over carefully until the fuel just starts to rise in the tube. Stop turning at this point.
6. Then check the position of the flywheel marking (Fig 19) in relation to the tool marking. The injection angle should be 25-28°. Remember that there is a delay of one or two degrees due to the off-loading valve

DESCRIPTION

CYLINDER HEAD AND VALVE SYSTEM

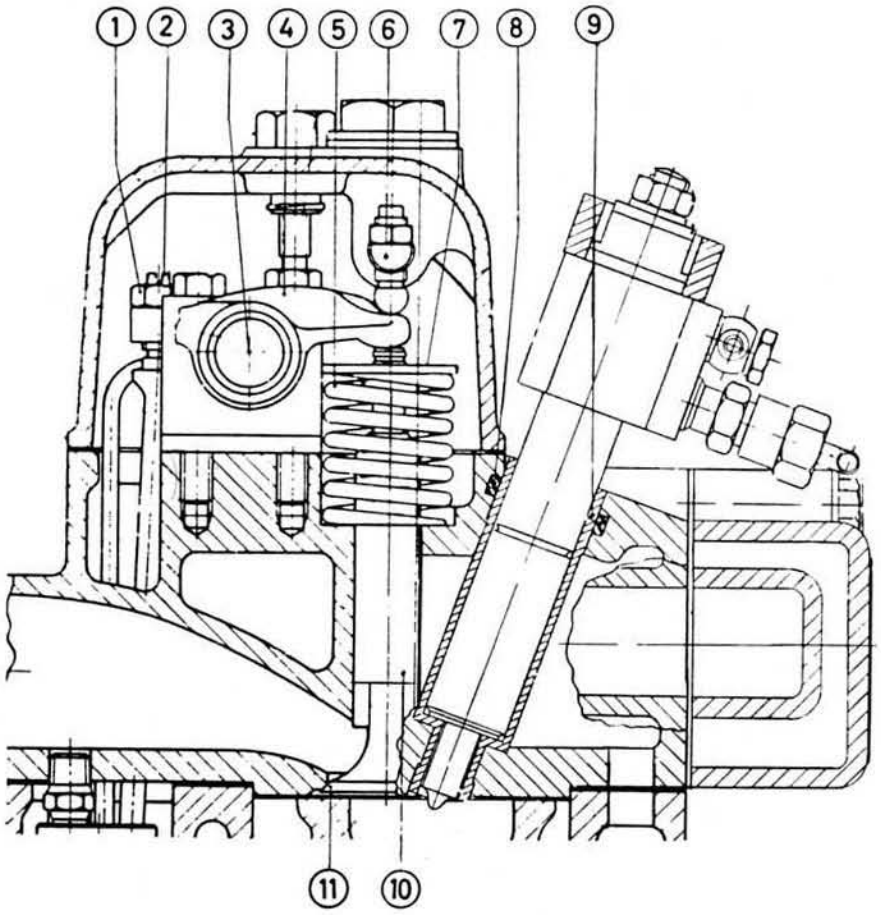


Fig 6. Cylinder head and valves

1. Lock nut
2. Adjusting screw
3. Rocker arm shaft
4. Rocker arm
5. Valve spring
6. Decompression device
7. Spring disc
8. O-ring
9. Copper sleeve
10. Valve guide
11. Valve

The cylinder heads, one for each cylinder, are made of special-alloy cast-iron with high heat resistance.

The injectors are fitted in thin copper sleeves directly flushed by the coolant. This design ensures effective cooling of the injectors.

The valves, rocker arms and rocker arm shaft are located in the cylinder head. Each cylinder head is fitted with a rocker arm shaft carried in a bearing bracket.

The overhead valves are fitted in the cylinder head and are actuated by the camshaft through tappets, push rods and rocker arms

The valves operate in replaceable valve guides. The clearance between the valve and the rocker arm is set by means of adjusting screws in the rocker arms.

A decompression device is incorporated in the rocker arm covers to make possible manual starting.

The rocker arms are lubricated by an oil pipe which is connected to the lubricating oil pump.

Removing the cylinder head

1. Empty the cooling system, remove the radiator and cooling water pump. See the instructions concerning removal of the coolant pump.
2. Remove the rocker arm covers.
3. Remove the air cleaners.
4. Remove the delivery pipe and leak-off oil line. Fit protective caps.
5. Loosen the hoses at the thermostat housing and remove the exhaust manifold.
6. Disconnect the oil pipe line from the rocker arm shaft and then remove the attaching screws on the rocker arm bearing brackets. Remove the rocker arm mechanism and push rods. NOTE. Mark the rocker arm bearing brackets so that they are re-fitted correctly.
7. Loosen and remove the cylinder head nuts. Carefully straighten out the oil pipes to the rocker arm shaft. Then lift the cylinder head straight up.
8. Remove the cylinder head gasket.

Be careful to avoid damaging the injector tip.

Disassembling the cylinder head

1. Remove the crankcase breather filter.
2. Remove the nuts retaining the injectors. Pull out the injectors.
3. Remove the valves and valve springs. Use a valve spring compressor tool when removing the valve key. Place the valves in the correct order in a valve stand.
4. Clean all parts. Be particularly thorough with cooling water channels. Examine seal plugs for leakage and corrosion.

Replacing the copper sleeve and injector seal ring

Removing

1. Insert puller no. 884081 in the injector sleeve until it bottoms with the yoke tubes over the stud bolts.

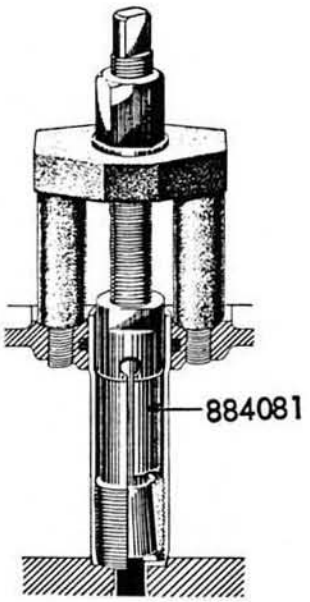


Fig 7. Removing the injector sleeve.

2. Turn the expanding tool spindle anti-clockwise to tension the spindle in the sleeve. Do not pull too hard but just enough to give the spindle a firm grip, Fig 7.
3. Tighten down the nut whereby the spindle and the sleeve are pulled up, remove the sleeve and then take off the tool from the sleeve.
4. Remove the seal ring in the upper part of the cylinder head and clean the hole thoroughly, particularly the lower thinner part. Make sure that the hole is smooth and free from rusting which could cause leakage on the new injector sleeve.

Fitting

1. Smear the new seal ring with soap and fit the ring in the slot in the cylinder head. Make sure the ring is correctly located and undamaged.
2. Fit the injector sleeve on tool no. 884077 and oil in the sleeve externally. Push down the tool with the sleeve in the cylinder head hole while the tool and sleeve are turned clockwise or anti-clockwise.
   As soon as the thin part of the sleeve is correctly located, drive it into position with a hammer and a drift, Fig 8.

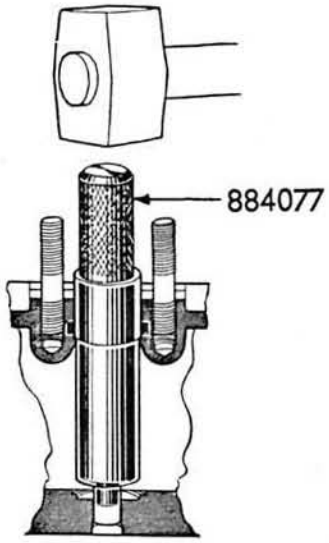


Fig 8. Pressing in the injector sleeve

3. Oil in the spreader tool no. 884085 and push the tool down into the sleeve. Screw down both the attaching nuts without tightening them.
4. Screw down the tool until it is located in the thinner part of the injector sleeve and tighten the attaching nuts equally hard. See Fig 9.
5. Screw down the tool as far as the shoulder in the injector sleeve permits and this will spread the injector sleeve. Remove the tool.
6. Then adjust the length of the sleeve as shown in Fig 10.

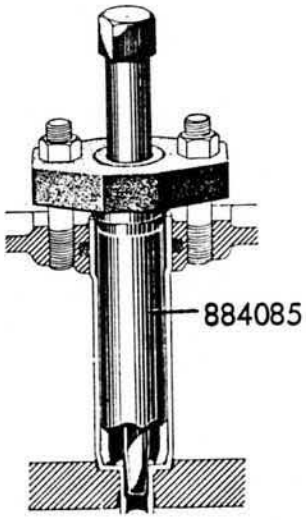


Fig. 9 Spreading the sleeve

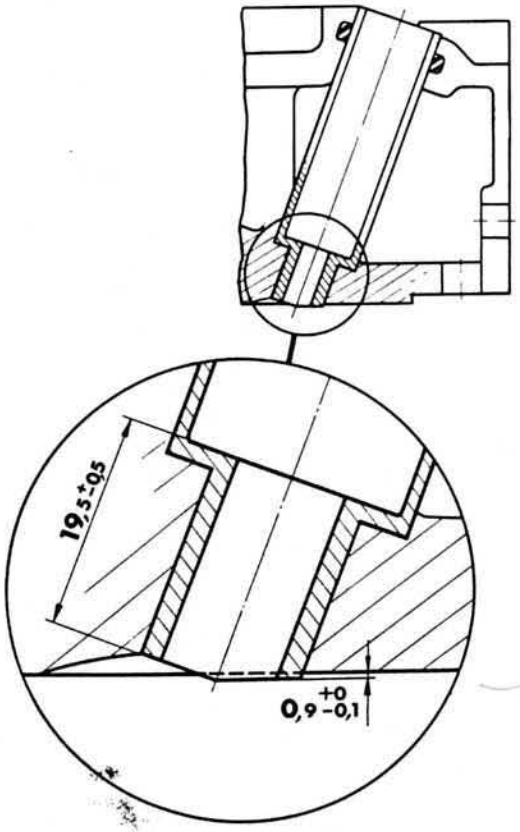


Fig. 10 Adjusting the sleeve

Valve guides

To measure valve guide wear, fit a new valve in the guide and then measure the clearance with an indicator as shown in Fig. 11. See the specifications for wear tolerances. If these tolerances are exceeded, replace the valve guides.

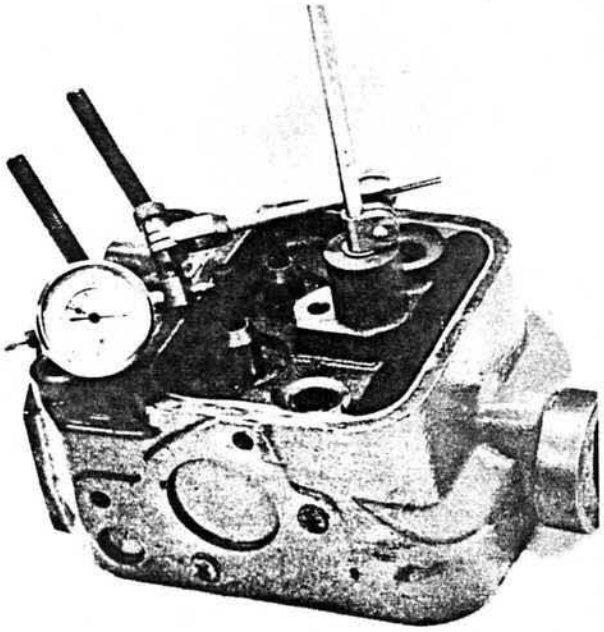


Fig. 11. Checking valve guide wear.

Replacing valve guides

1. Press out the valve guides using tool number 9991459, Fig. 12.
2. Oil in the guides externally and press them in with tool number 9994158 which gives the guide the correct height above the cylinder head spring plane. After they are pressed in, the distance "A" should be 21 mm (0.83"), see Fig. 12.
3. If necessary ream the guides. See the specifications for the valve - valve guide clearance. Reaming is carried out by using tool number 9994128.

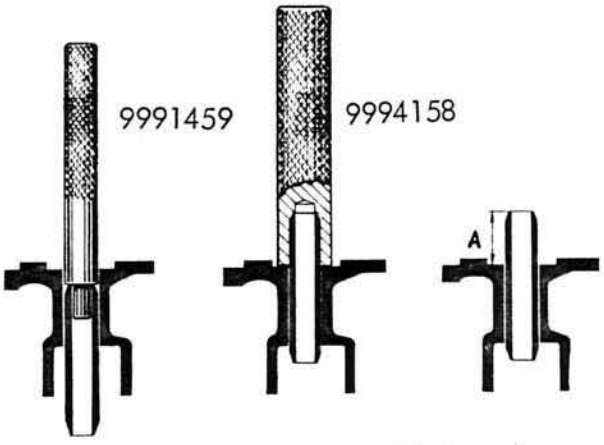


Fig. 12. Removing and fitting valve guides.

Grinding the valve seats

Before starting grinding work, replace and ream the valve guides if the wear tolerances have been exceeded.

Reaming should be carried out manually but a Vibrocentric machine and grinding stones can also be used. The grinding stones are located by a self-centring pilot spindle which is fitted in the valve guides. Through the self-centring property of this pilot spindle, the work is always carried out correctly in relation to the centre-line of the valve guide. To obtain the best possible result, make sure that the grinding stones are always dressed to ensure the correct angle.
Another point which is not to be neglected is the tightening of the pilot spindle. It must be firmly in position since the grinding stone must work in a position which is absolutely at right-angles to the longitudinal axis of the valve.

Make sure that not too much material is ground off and also make sure that the correct form and a good mating surface are obtained by removing the smallest possible amount of material.

The grinding stone used should be an aluminium - oxide grindstone with ceramic binding agent. The stone is dressed and the angle checked in a dressing unit, Fig. 13, in which a diamond gives the stone the right angle and surface. The stone must have the same angle as the mating surface of the valve seat.

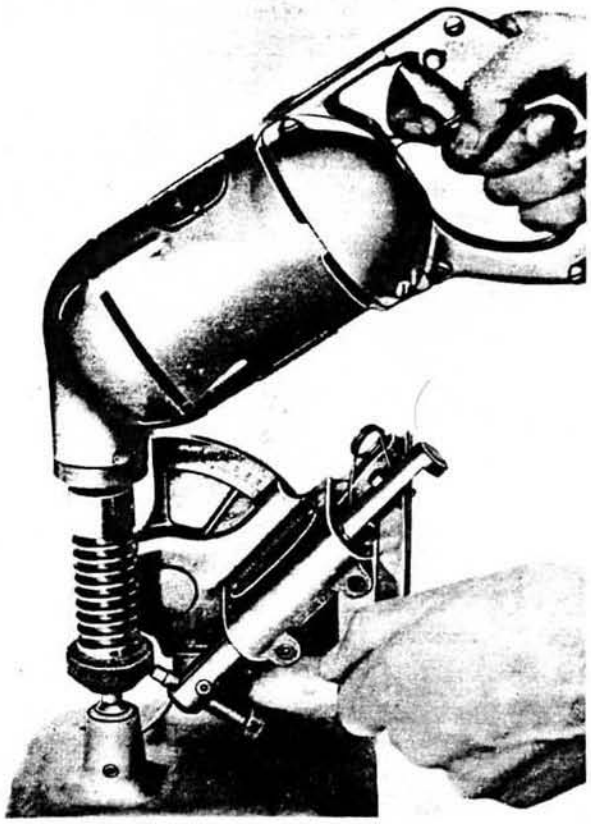


Fig. 13. Dressing the grinding stone.

Grinding the valves

If the valve disc sealing surfaces are burned or damaged in any other way, the valves must be machine-ground, see Fig. 14.

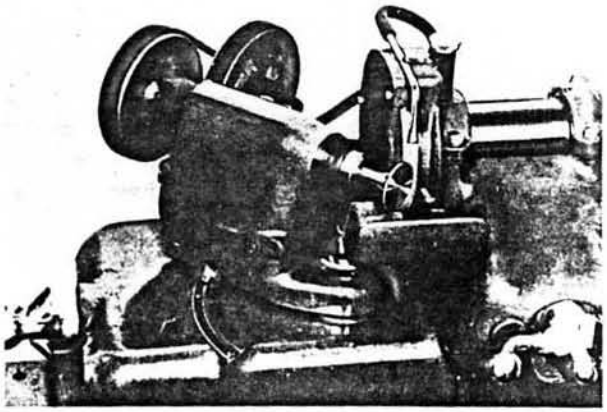


Fig. 14. Grinding a valve

The grinding disc should be an aluminium oxide disc with ceramic binding agent. The grinding machine is set at an angle of 45.5° for the exhaust and inlet valves. The mating surface must be ground as little as possible and only until it is "clean". If there is less than 1.0 mm (0.04") edge left on the valve disc, scrap the valve. Also scrap valves with distorted spindles.

After machine-grinding, the valve disc should be ground in against the valve seat with grinding compound such as "Carborundum". The valve is then checked for leakage in the following way:

Fit the valve without its spring in the cylinder head and pour a little fluid onto the top of the valve disc. Press the valve against the seat and blow carefully from below with compressed air. Do not blow so hard that the valve lifts from its seat. If the valve is not sealing properly, air bubbles will form round the valve disc, see Fig. 15.

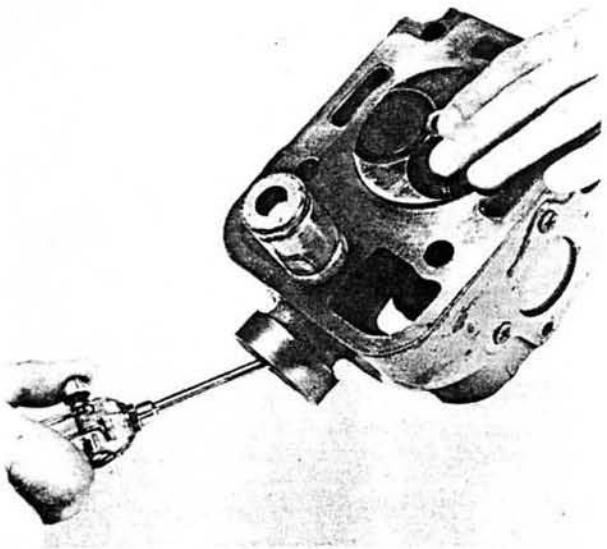


Fig. 15. Checking a valve for leakage.

Checking the valve springs

The valve springs are checked for straightness, length and tension. This is carried out in a spring tester, see Fig. 16. The valve springs must have the values shown in the specifications.

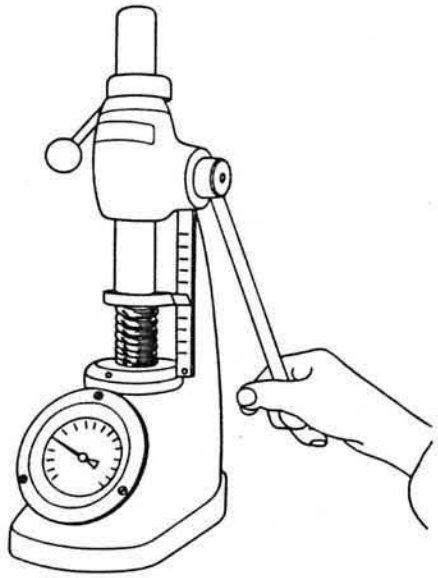


Fig. 16 Checking a valve spring.

Push rods

The push rods should be straight throughout their entire length. This can be checked by using a faceplate. If the deviations are not too large, the push rods can be rectified by using a rubber faced mallet. Check the ball ends and ball sockets for damage.

Tappets

The tappets are located in holes in the crankcase above the camshaft, and they actuate the valves through the push rods and rocker arms. The contact surface of the tappets against the camshaft must not be worn or cracked. Severe pitting cannot be approved, excessively loose tappets or tappets with damaged contact surfaces must be replaced.

Rocker arm mechanism

1. Remove the lock rings from the rocker arm shaft and remove the rocker arms from the rocker arm shaft.

NOTE. The rocker arms are not identical. Mark them so that they are correctly re-fitted.

2. Clean the parts, being particularly careful with the rocker arm shaft oil drillings and also the rocker arm oil holes.

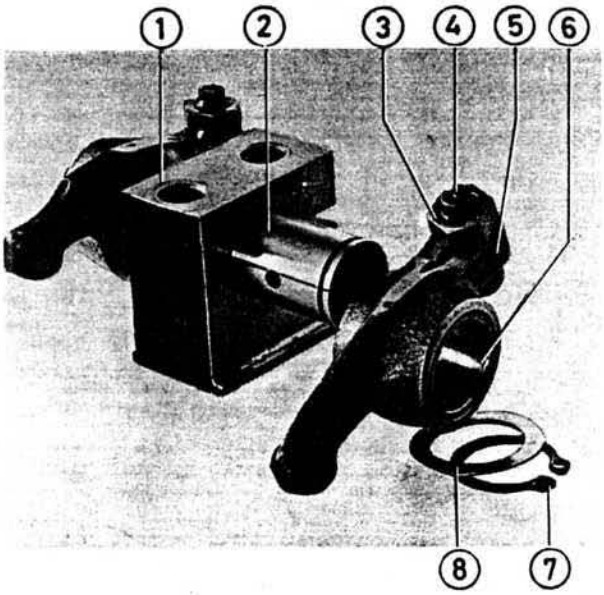


Fig. 17. Rocker arm mechanism

1. Bearing bracket
2. Rocker arm shaft
3. Locknut
4. Adjusting screw
5. Rocker arm
6. Bushing
7. Lockring
8. Washer

3. Check for rocker arm shaft wear. Also check that the ball stud spherical section is not deformed or worn. The threads must be undamaged on the pin and locknut. The nut hex must also be in good condition. The spherical surface of the rocker arm contact surfaces against the valve spindle must not be worn or pitted. Adjustment can be carried, out in the grinding machine in the case of slight wear.

4. Oval-worn rocker arm bushings must be replaced. Use a drift to press them out and in. When the bushing is pressed in, the oil hole must be located as shown in Fig. 18. After pressing in, ream the bushing to a close running fit on the shaft. Remove all metallic particles.

5. Lubricate the rocker arm shaft, fit the rocker arms and then secure them with their lock rings.

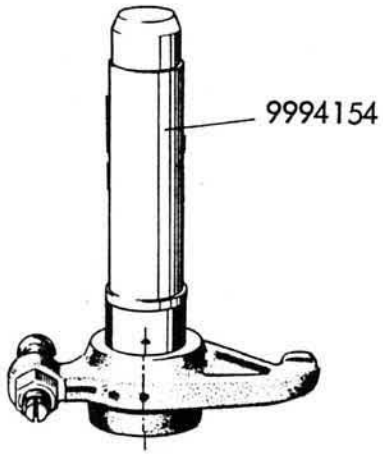


Fig. 18. Replacing a rocker arm bushing.

Assembling the cylinder head

1. Oil in the valve spindles and fit the valves in their respective guides.
2. Fit the valve springs and washers. The valve springs are fitted with the tightly wound end against the cylinder head.
3. Compress the valve springs with the special tool and fit the valve keys.
4. Fit the filter for the engine crankcase breather.
5. Fit the injectors but do not tighten them.

Fitting the cylinder head

If the pistons, cylinder head or cylinder block have been replaced, assembly must be carried out according to special instructions. (See "Adjusting the compression ratio").

1. Dry off the contact surface and smear the new gasket round the holes for the push rods with non-hardening sealing compound (Permatex). Then fit the gasket with the copper-faced side upwards.
2. Fit the cylinder head without tightening it.
3. Fit the exhaust manifold and tighten it slightly just so that it lines up the cylinder head.
4. Tighten the cylinder head bolts diagonally and alternately using a torque wrench. The tightening torque is 11 kgm (80 lb.ft.).
5. Tighten the exhaust manifold.
6. Fit the push rods and rocker arm mechanism.
7. Connect the lubricating oil pipes to the rocker arm mechanism.
8. Adjust the valves then fit the rocker arm covers and adjust the decompression device (see below).
9. Connect up the fuel lines, tighten the injectors. Fit the radiator and coolant pump.
10. Air-vent the fuel system (see instructions on page 25).
11. Start the engine, run it warm and then re-tighten the cylinder head nuts.
12. Remove the rocker arm covers and finely adjust the valves. When the engine is warm, the clearance for the inlet valve is 0.30 mm (0.012") and for the exhaust valve 0.35 mm (0.014").
13. Fit the rocker arm covers and air cleaners, then finally adjust the decompression device.

Adjusting the valves

After the cylinder head and cylinder block have been assembled, the valves are adjusted before the engine is started.

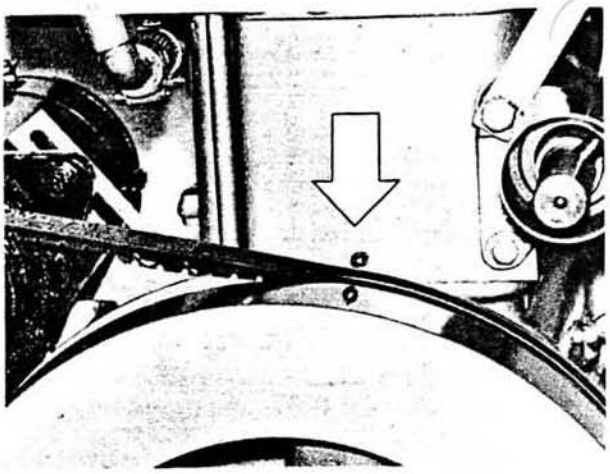


Fig. 19.

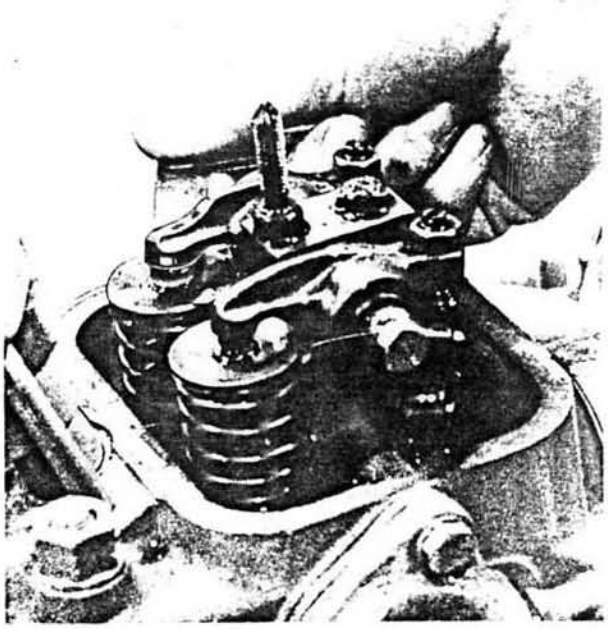


Fig. 20. Adjusting the valves.

Watch the valves while turning the crankshaft with the manual starter. When the inlet valve starts to open and the outlet valve closes, the O-mark on the flywheel is at the top as shown in Fig. 19. Then turn the crankshaft one more turn forward and adjust the valve clearance on this cylinder. Repeat the same procedure for the other cylinder.

With a warm engine, the clearance should be 0.30 mm (0.12") for the inlet valve and 0.35 mm (0.014") for the exhaust valve.

Since the pistons are designed with the combustion chamber in the piston crown, the pistons go so high against the valves that valve adjustment must never be carried out while the engine is running, since there is risk of the valves coming into contact with the piston and serious damage resulting.
Adjustment is carried out by means of a slotted screw which is secured by a locknut.

Adjusting the decompression device

The degree to which the decompression device presses down the outlet valve must always be checked when valve clearance is checked. If the downward movement exceeds 0.5 mm (0.02') there is risk for piston damage.

Adjustment is carried out with the exhaust valve off-loaded. Remove the oil filler plug. Loosen the locknut and unscrew the adjusting screw. Then re-tighten the adjusting screw until it just reaches the rocker arm. Tighten the adjusting screw one further half turn corresponding to a downward movement of 0.5 mm (0.02"). Then tighten the locknut.

DESCRIPTION

CYLINDER BLOCK AND CRANKCASE

The engine cylinder block is fitted in the upper part of the crankcase. It is held in position by the cylinder head which is bolted to the crankcase by long stud bolts.
The cylinder block is made of cast-iron, on two-cylinder engines the blocks are identical and interchangeable. The cylinders are surrounded by a cooling jacket. The crankcase is made of cast-iron and fitted with an inspection cover.

PISTONS, PISTON RINGS, CONNECTING RODS

The connecting rods are made of drop-forged steel and are fitted at the top with a precision-machined bushing which acts as a bearing for the gudgeon pin. The big-end bearing shells are precision-manufactured and replaceable. The bearing metal on them consists of indium-plated lead-bronze. The pistons are made of light-alloy and each has three compression rings and two oil control rings. The upper compression ring on each piston is chromed to reduce cylinder wear. The crown of each cylinder has a cardioid recess which is the combustion chamber.

GUDGEON PINS

The gudgeon pins make up the bearing unit for the pistons on the connecting rods. Due to the comparatively high pressure under which Diesel engines operate, the gudgeon pins must transfer considerable forces and this means that they must be constructed with particular care and made of the best material. The gudgeon pins are made of case-hardened steel. Case-hardening gives the pins a very hard and durable surface layer at the same time as thecore retains its toughness, this ensuring resistance to fracture.

CRANKSHAFT AND MAIN BEARINGS

The crankshaft is made of forged steel, on D2 and MD2 engines it is carried in three main bearings fitted with replaceable bearing shells for the centre bearing and bushings for the end bearings. On D1 and MD1 engines the crank-shaft is carried in two main bearings. The bearing consists of white metal.
The rear main bearing is fitted with an axial washer to locate the crankshaft axially. At the flywheel there is a seal ring of rubber and inside this a labyrinth type seal.

REPAIR INSTRUCTIONS

Removing the cylinder block

1. Remove the cylinder block in accordance with the previous instructions.
2. Loosen and remove the manual starter.
3. Loosen the cooling water line attachment.
4. Lift the cylinder block straight upwards.

Inspection of cylinder block

After the block has been thoroughly cleaned and all deposits removed, make sure that all channels are free from dirt and deposits, and also that there are no cracks in the block.

Measuring the cylinder bore

The cylinder bore is subject to most wear at the upper part and it therefore becomes tapered. The cylinders also become out-of-round. To obtain a complete picture of the condition of the cylinders, measurement must therefore be carried out at several different points both laterally and longitudinally. Measurement is carried out by using a special cylinder bore indicator, Fig. 21.

The degree of wear decides the measures to be taken. If there are scratches or scoring in the cylinder walls or the wear exceeds the values stated in the specifications, re-boring should be carried out.

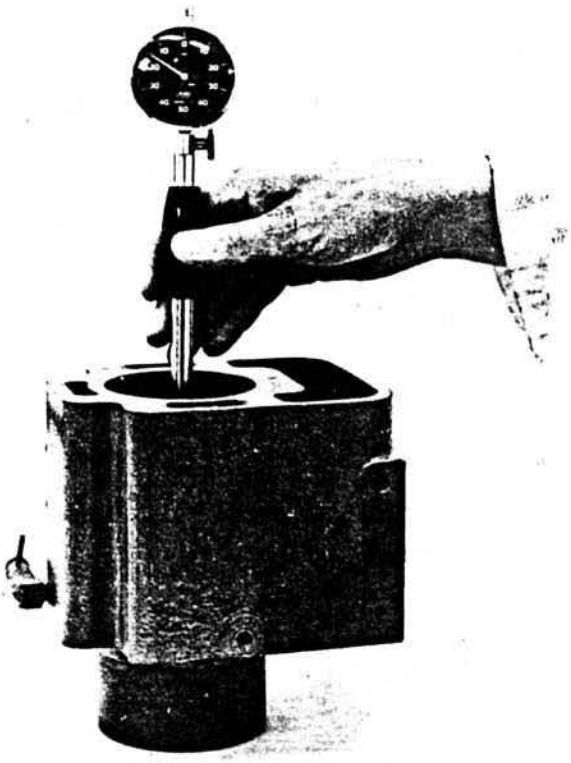


Fig. 21. Measuring cylinder bore wear.

Re-boring

Re-boring must be carried out with special machines. Since exceptionally severe demands are made on the result of this work, experience and skill are needed on the part of the mechanic carrying out the operation. It is essential for the bore to be round, cylindrical and at right-angles to the crankshaft within very close tolerances. The surfaces of the cylinder bore must also be finely machined to the greatest possible smoothness to ensure a short running-in time. We therefore recommend that this work is carried out by a specialized company.

Removing the pistons

1. Remove the cylinder head and cylinder block. See the instructions under the heading concerned.
2. Loosen and remove the inspection covers on the crankcase.
3. Mark the connecting rods and bearing caps. Remove the pistons.

Inspecting the pistons

After removing the piston rings and washing the pistons, examine the pistons to decide as to whether they are in such good condition so that they can be re-fitted.

Measuring the pistons

Measurement is carried out by using a micrometer at right-angles to the gudgeon pin hole at the lower edge of the piston. See Fig. 22.

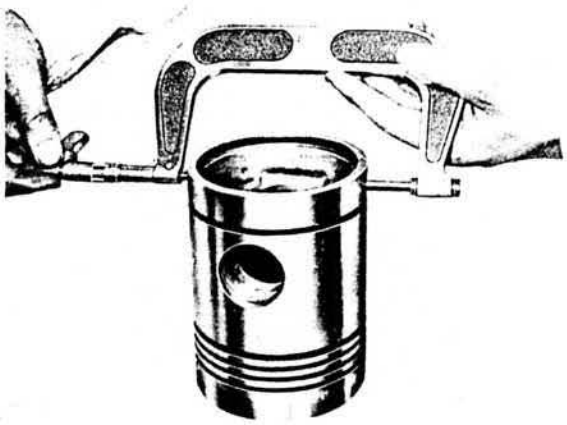


Fig. 22. Measuring a piston.

Inspecting the piston rings

In a Diesel engine it is very important for the piston rings to be in good condition since they must seal against high pressure and withstand high temperatures.

The point at which piston ring replacement is carried out depends on oil consumption and the condition of the engine in general.

If the piston rings must be removed for one reason or another, they should always be replaced as a rule by new rings.

Fitting the piston rings

The fit of the piston rings must always be checked concerning ring gap and axial clearance in the piston ring groves. If the seal is to be "gas-tight", in addition to good contact against the cylinder bore, the rings must also provide a gas-tight seal against the ring groove in the piston as the piston moves up and down. This means that the rings must move freely in the grooves at all temperatures since they must follow the cylinder bore even when this has become worn.

Concerning piston ring gap and axial clearance, see the specifications on page 33.

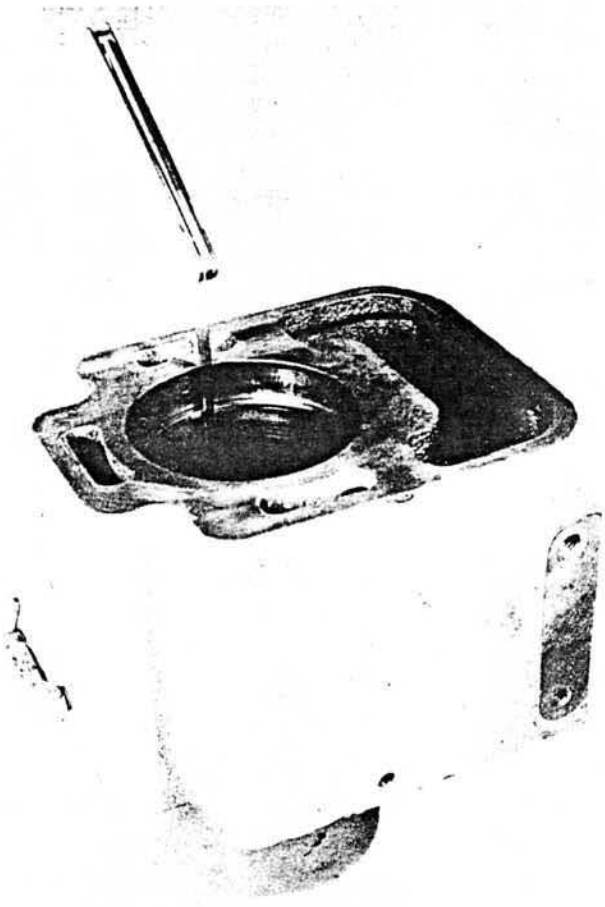


Fig. 23. Checking piston ring gap.

Fitting the piston rings

1. Remove soot deposits from the piston ring grooves.
2. Fit the new piston rings in the cylinder bore. Push the rings down with the piston. Measure the end clearance with a feeler gauge. See Fig. 23.
3. Check the axial play of the rings in the grooves (Fig. 24).
4. Fit the piston rings on the piston with the help of a ring assembly tool, see Fig. 25. Fit the oil rings first, either way up. The compression rings are fitted as shown in Fig. 26.
5. Turn the rings so that the gaps are not opposite each other. The oil control ring gaps should be at 180° to each other.

Fitting the piston

If the pistons, cylinder block or cylinder head have been replaced, assembly is carried out a special way. (See "Adjusting the compression ratio").

1. Clean the bearing surfaces and crank journals.
2. Smear the bearing surfaces with engine oil.
3. Fit the piston and connecting rod in each cylinder.
   NOTE. Make sure the piston is correctly located when fitting. The recess should be fitted so that it is directly under the injector.
4. Install and tighten the bearing caps. The tightening torque is 6.5 kgm (47 lb. ft.). Always use new nuts and bolts when fitting.
5. Fit the inspection covers. Use new gaskets and smear with Permatex or corresponding compound.

Replacing a gudgeon pin and bushing

1. Mark the piston and connecting rod.
2. Remove the lockrings.
3. Press out the gudgeon pin with a drift.
4. Press out the old bushing.

Fig. 24. Piston ring clearance in groove

Fig. 25. Fitting the piston rings

5. Press in a new bushing. Make sure that the lubricating hole in the bushing indexes with the hole in the connecting rod.
6. Ream or diamond-drill the bushing to an accurate running fit. When clearance is correct the gudgeon pin should slide through the bushing under its own weight without noticeable looseness. See Fig. 27.
7. Oil in the gudgeon pin and connecting rod bushing.
8. Fit one of the circlips.
9. Warm up the piston to about 70°C (160°F). Fit together the piston and connecting rod.
   NOTE. It should be possible to press in the gudgeon pin, never hammer it in.
10. Fit the other circlip.
11. Check that the connecting rod runs easily in the connecting rod bearing.

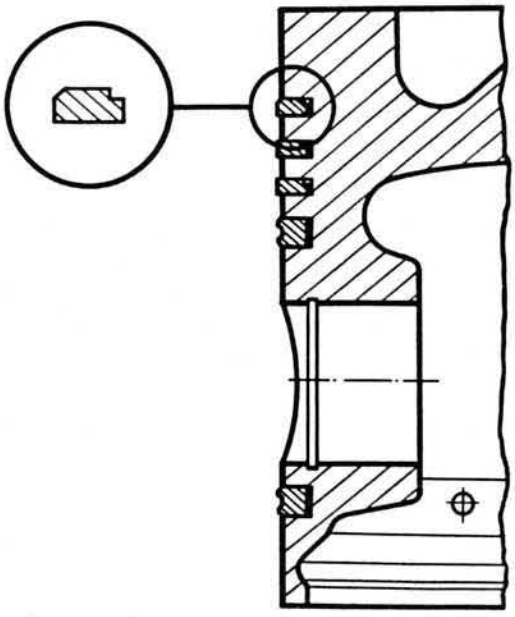


Fig. 26. Piston ring location

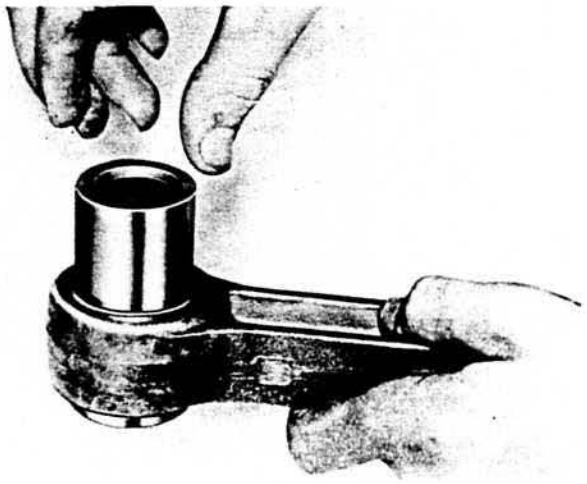


Fig. 27. Gudgeon pin fit

Connecting rods

Carry out a careful control after the connecting rods have been thoroughly cleaned.
Fit new connecting rod bolts when reconditioning since they are subjected to great stresses.
Check the connecting rod bushings, preferably using a gudgeon pin as gauge. There must be no noticeable looseness.

Checking connecting rods

Before fitting check the connecting rods for straightness and distortion. Rectify if necessary. Checking and rectification is carried out in a special apparatus as follows:

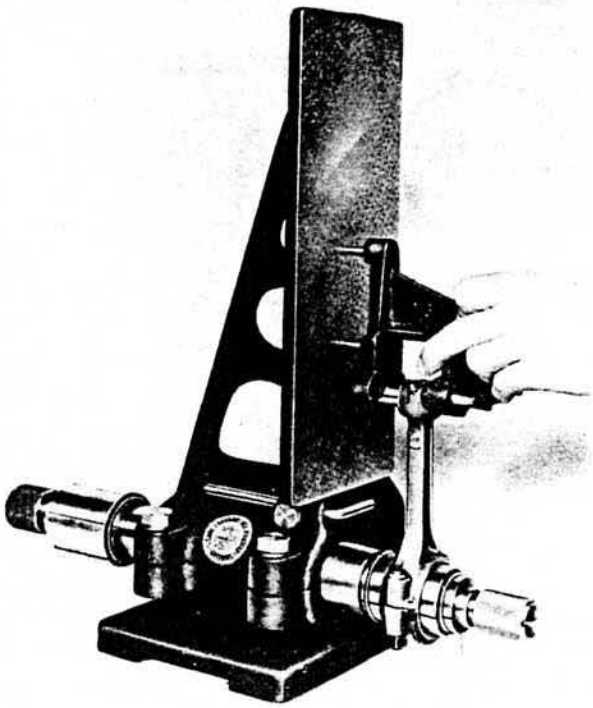


Fig 28. Checking straightness

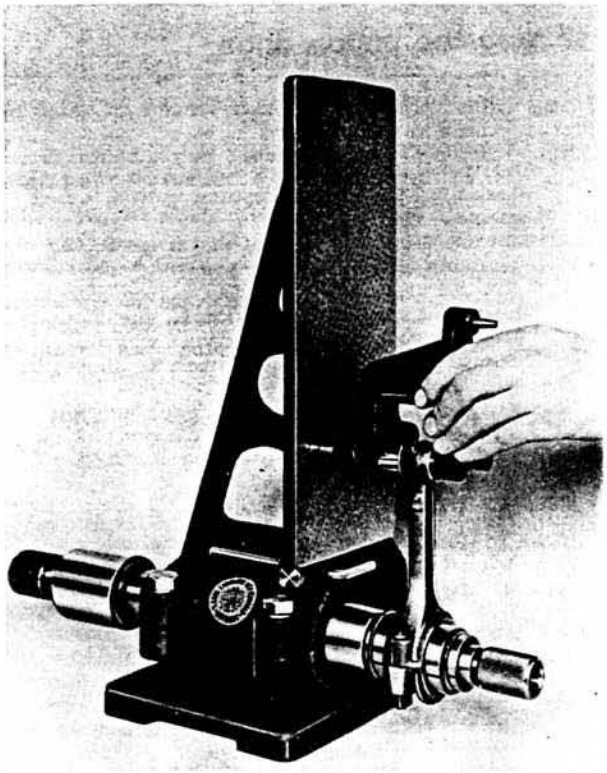


Fig. 29. Checking for distortion

1. Fit the cap and attach the connecting rod in the tool with the expander. Fit the gudgeon pin which belongs to the connecting rod. Check straightness when the indicator is placed on the gudgeon pin as shown in Fig. 28.
2. When checking for distortion, locate the indicator as shown in Fig. 29.
3. Check for S-distortion of the connecting rod. Use the apparatus support against the side of the connecting rod. The distance between the indicating surface and the connecting rod at the gudgeon pin hole must be equal on both sides of the connecting rod. Scrap and replace distorted or twisted connecting rods.

Fitting the cylinder block

If the pistons, cylinder block or cylinder head have been replaced, assembly is carried out a special way. (See "Adjusting the compression ratio").

1. Clean all contact surfaces thoroughly.
2. Fit the shims.
3. Clean the cylinder bore.
4. Push down the cylinder block over the piston in question using a piston ring compressor.

Adjusting the compression ratio

When replacing pistons, cylinder head and cylinder block, the clearance between the piston and the cylinder head must be measured. If this is not done, there is risk for the engine labouring or not providing the right output.

1. Decarbonize and carefully dry off all contact surfaces.
2. Fit the piston. (See "Fitting the piston").

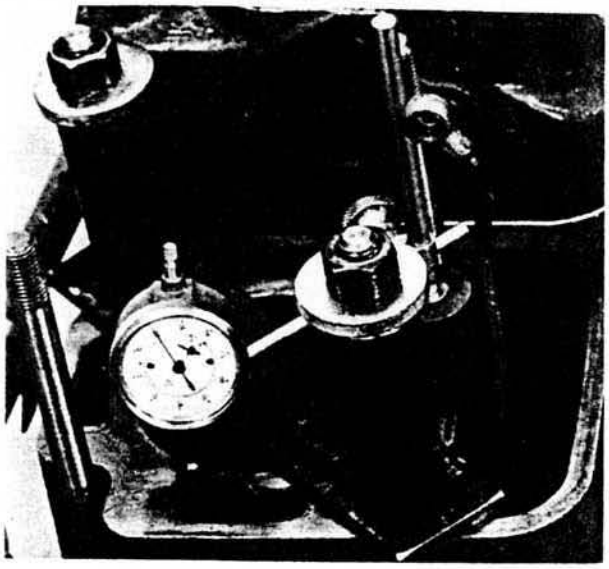


Fig 30

3. Fit the cylinder block. Make sure that there is always an 0.2 mm (0.008") shim between the cylinder block and the crankcase.
4. Tension the cylinder block so that it is pressed down against the crankcase (See Fig. 30).
5. Move the piston to its top position. This can be done with the help of an indicator dial.
6. Measure the distance from the upper part of the cylinder block to the piston using an indicator gauge or a depth micrometer.
   To this measurement "A", see Fig. 32, add 1.3 mm (0.051") which is the thickness of a compressed cylinder head gasket.
7. Then measure the height difference between the downward projecting part of the cylinder head and the mating surface, see Fig. 31. This corresponds to "B" in Fig. 32.
   From the value "A" + 1.3, subtract "B". The resulting value should be 0.4 - 0.5 mm (0.016 - 0.020").
   Try to be as near 0.4 mm as possible.
   Example: "A" = 2.5 mm and "B" = 3.5 mm
   2.5 + 1.3 = 3.8
   3.8 - 3.5 = 0.3 (tol. 0.4 - 0.5)
   0.5 - 0.3 = 0.2
   This means that a further 0.2 mm (0.008") shim must be fitted.

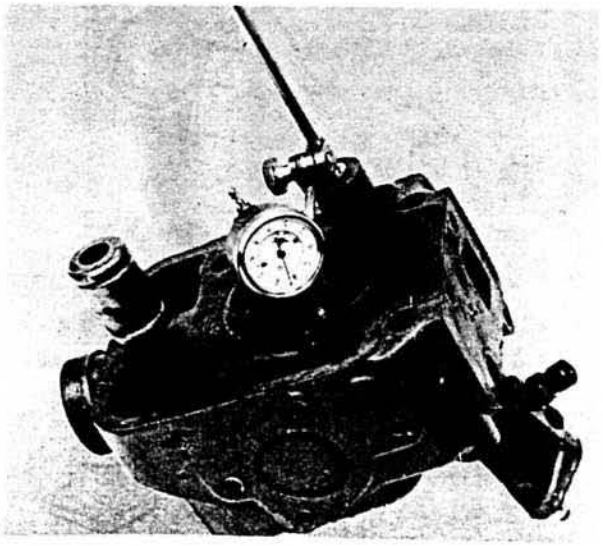


Fig. 31.

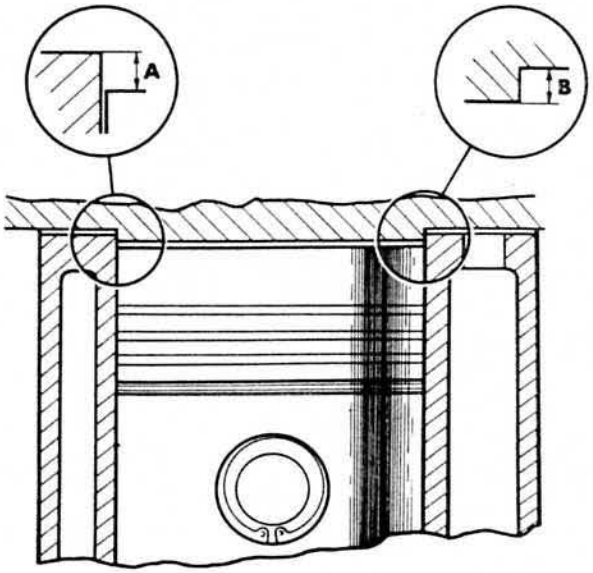


Fig. 32.

If it found that measurement "A" is so large that the clearance 0.4 - 0.5 mm cannot be obtained with an 0.2 mm shim, the upper surface of the cylinder block must be ground. This work requires great precision and should be carried out by a specialized workshop.

8. After the shim thickness has been determined, remove the cylinder block and fit the required number of shims.
9. Before placing the cylinder block in position, inspect it. If cylinder wear is slight, the wear edge at the top of the bore does not need removing.
10. Then slide the cylinder block over the piston. Use a low band type ring compressor. First compress the four upper rings and slide the cylinder block carefully down over them. Then move the compressor tool to the oil control ring and move down the cylinder over this ring.
11. Smear the new cylinder head gasket round the holes for the push rods with sealing compound of the non-hardening type (Permatex) then fit the gasket, copper side upwards. Then fit the cylinder head (See "Fitting the cylinder head").

CAMSHAFT

Removing

1. Remove the cylinder head (see page 6).
2. Remove the timing gear casing (see page 17).
3. Lift up the tappets and place them in order in a stand.
4. Remove the flange bolt (1), Fig. 34. NOTE. Left-hand thread.
5. Pull off the cam disc (2) and the gear (3) from the shaft. Use a three-arm universal puller.
6. Loosen and remove the thrust flange which is located behind the gear.
7. Then pull the camshaft straight out to avoid damaging the bearings.

Inspection

Check the camshaft for wear on the bearing journals and cams. To ensure a smooth running engine after reconditioning, it is important to

pay special attention to the camshaft cams so that there is no uneven wear. In case of wear, replace the camshaft.

Replacing the bearings

The bearings are pressed into their recesses and are line-bored after pressing in, so that camshaft bearing replacement can only be carried out when the engine is fully reconditioned.
When pressing in the bearings make sure that they are pressed in so that the oil holes index with the corresponding oil drillings in the block.

Fitting

1. Oil in the bearing surfaces and slide in the camshaft. Take care to avoid damaging the bearings. NOTE. If the oil pump is fitted, the camshaft must be turned so that it engages in the oil pump dog clutch.
2. Fit the thrust flange and secure the bolts.
3. Check that the Woodruff keys are not damaged and fit them on the shaft.
4. Fit the camshaft gear and cam disc. NOTE. The punch marks on the camshaft gear must register with the punch mark on the crankshaft gear, see Fig. 33.
5. Tighten the flange bolt to a torque of 8 kgm (58 lb.ft.).
6. Fit the timing gear casing. Use a new gasket and smear it with Permatex or similar compound.
7. Fit the feed pump, manual starter, tappets, push rods, cylinder head, etc. For special instructions see under these headings.

CRANKSHAFT

Removing

Concerning the cylinder head, cylinder block and pistons, see under these headings.

1. Loosen and remove the clutch or reverse gear.
2. Remove the flywheel, Woodruff key and front bearing housing.

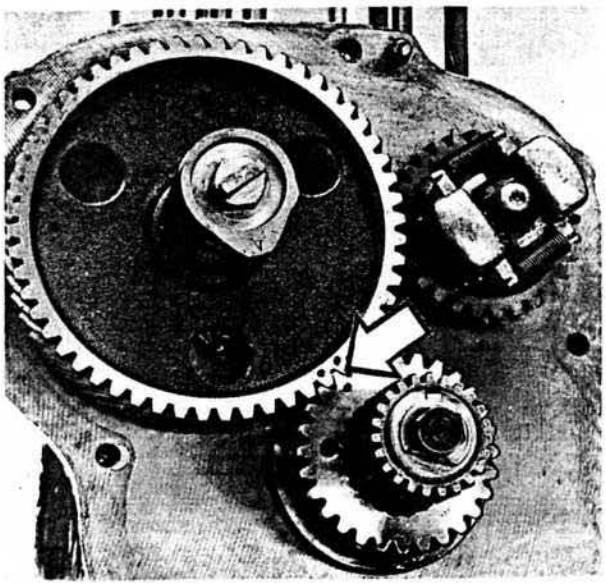


Fig. 33. Timing gear markings.

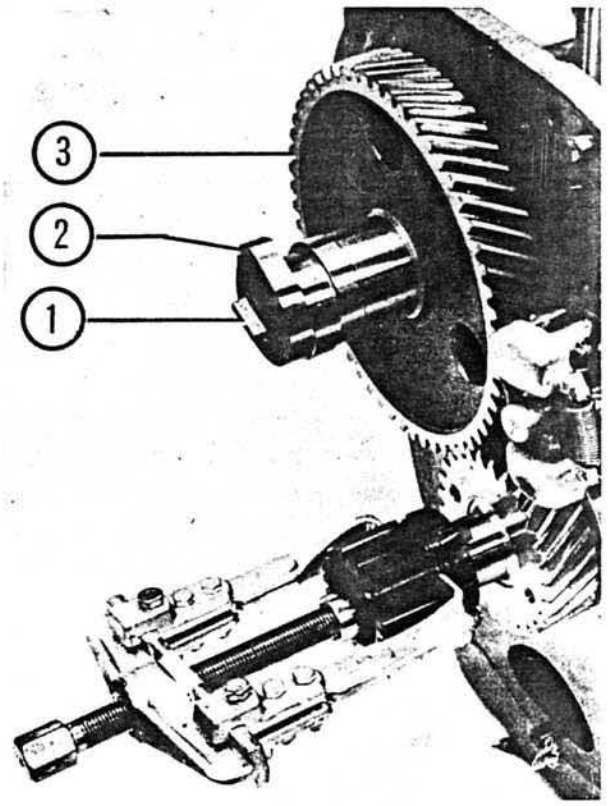


Fig. 34. Removing the gear.

3. Loosen the lock washer retaining the output gear.
4. Then pull off the gear, see Fig. 34.
5. Pull off the crankshaft gear. Fit tool 884078.
6. Then loosen the stop screw located opposite the centre bearing in the engine block.
7. Pull out the crankshaft.

Inspektion

Before inspecting, remove the centre bearing from the crankshaft. Then clean all the crankshaft drillings thoroughly. After this examine and measure the crankshaft. See the specifications on page 32.

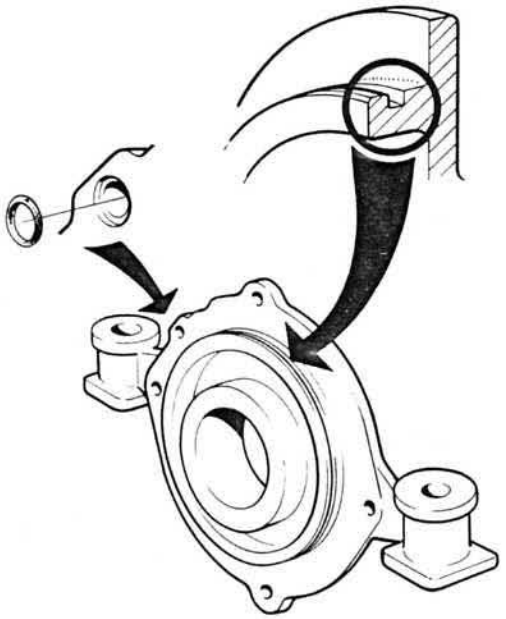


Fig. 35. Crankcase and bearing cover sealing.

Grinding

It is possible to grind the crankshaft to an undersize (see specifications). Use standard size main bearing bushings which are dimensioned to permit this.

The crankshaft is ground in a special machine and requires great precision. Have this work done by a special firm.

Fitting

1. Check the cleaning of the crankshaft drillings and the contact surfaces for the bearing shells.
2. Fit together the centre bearing with its cap. Tightening torque 8 kgm (58 lb. ft.).
3. Fit the crankshaft in the crankcase. Make sure that the lock screw hole in the centre bearing registers with the hole in the crankcase.
   NOTE. If the camshaft gear is not removed, the axial washer and thrust washer are fitted on the crankshaft before it is pushed into position.
4. Make sure that the thrust washer lugs engage in the corresponding slots in the crankcase. The thrust washers are fitted with the slots facing away from the crankcase.
5. Tighten the lock screw on the centre bearing. Make sure that the lock screw seal ring is in good condition.
6. Fit the gear on the crankshaft. NOTE. Locate it with the markings, Fig. 33.
7. Tighten the gear and secure it. Tightening torque 8 kgm (58 lb. ft.).
8. Clean the bearing housing and fit new seal rings in the bearing housing slots, see Fig. 35.
   Oil in the large O-ring and push carefully into the bearing housing so as not to damage the seal rings.
9. Fit the flywheel, cylinder block and cylinder head.

Replacing the crankshaft seal

1. Loosen the dynamo tensioner and remove the vee-belts.
2. Loosen and remove the nut from the flywheel.
3. Pull off the flywheel using puller no. 884078, see Fig. 37.
4. Remove the Woodruff key.
5. Loosen and remove the sealing cover.
6. Remove the old seal ring with a new ring.
7. Re-fit the parts in the reverse order. Tighten the flywheel nut to 70 kgm (500 lb. ft.).

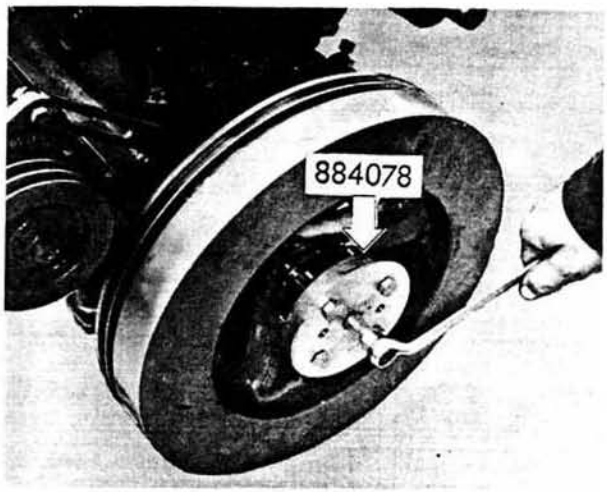


Fig. 37. Removing the flywheel.

Removing the timing gear casing

1. Loosen and remove the manual starter.
2. Remove the feed pump (D2 and MD2) and fuel injection pump.
3. Loosen all pipes and hoses connected to the timing gear casing.
4. Loosen and remove the clutch or reverse gear.
5. Remove the timing gear casing. Re-fit in the reverse order. Use a new gasket and smear it with Permatex or corresponding compound.

Manual starter
Removing

If only the seal ring (5) and O-ring (6) are to be replaced, follow points 4, 5, 6 and 8. Removal of the ball bearing (7) is not necessary. Re-fit in the reverse order.

1. Loosen and remove the manual starter.
2. Remove the cover (8, see Fig. 36.).
3. Loosen the screws (9) and remove the gear.
4. Knock loose the sleeve (1) pressed on the housing.
5. Drive out the pin (2), use a support under the shaft.
6. Drive out the spring pin (3) and pull off the sleeve (4).
7. Press the shaft out of the housing. Press as shown by the arrow in Fig. 36.
8. Remove the seal ring (5), the O-ring (6) and the ball bearing (7).

Before fitting clean all parts. Re-fit in reverse order. Before pressing the shaft into the housing, fill the space between the seal ring and ball bearing and the large space behind the ball bearing with heat-resistant grease.

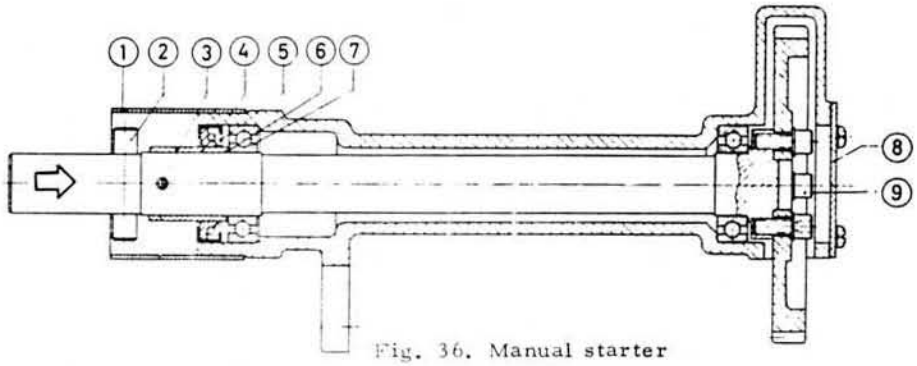


Fig. 36. Manual starter

LUBRICATING SYSTEM

DESCRIPTION

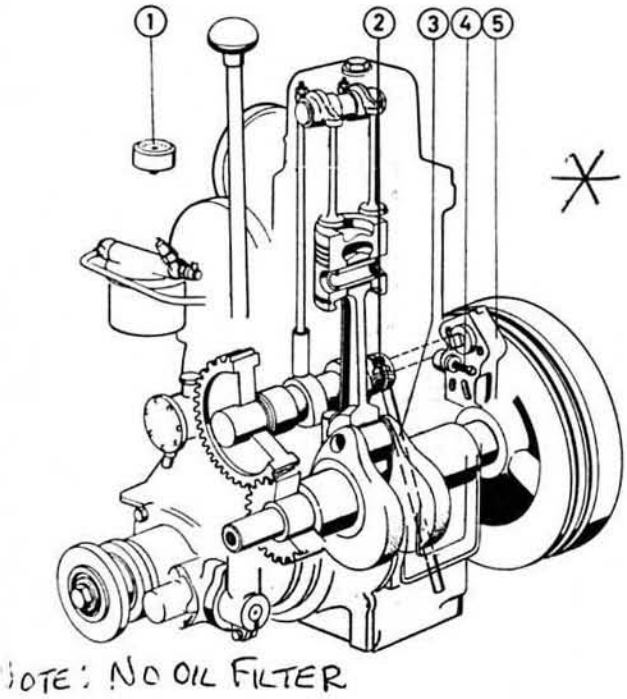


Fig. 38. Lubricating system, D1 and MD1

1. Pressure gauge (with manual starter)
2. Oil dipstick
3. Oil strainer
4. Relief valve
5. Oil pump

The engines are fitted with complete pressure lubrication systems shown in Fig. 38 and 39. Pressure is produced by a wing type pump forcing oil through the drillings to the lubricating points. The pump is driven through a dog clutch from the camshaft.
Oil is sucked from the sump through the strainer and then forced past a relief valve in the pump which prevents excessively high oil pressure. The oil is then forced out to an oil gallery which feeds all the main, big-end and camshaft bearings as well as the valve mechanism. An oil pressure contact with a warning lamp or a pressure gauge is also included in the system so that oil pressure can be checked.

Lubricating oil pump

The pump is of the wing pump type, see Fig. 40. It is driven by a dog clutch from the camshaft. It sucks oil through a strainer and suction pipe and the oil is then fed by wings in contact with the pump housing. From the pressure side oil is fed through the filter to the various lubricating drillings. Oil pressure is limited by a relief valve in the pump. Oil pressure should be 1.5 - 2.5 kg/cm^2 (20 - 35 lb./sq.in.).

Crankcase ventilation

The engine has a closed circuit crankcase breather and this prevents crankcase gases from coming out into the engine compartment. This breather consists of a filter with connections and oil trap in the space above the tappets, see Fig. 41. Crankcase gases are sucked directly into the engine induction manifold and into the cylinders.

Lubricating oil filter

On D2 and MD2 engines there is an oil cleaner, see Fig. 42. A cleaner together with the insert and relief valve makes up one unit bolted to the crankcase. Replace after every 50 hours of operation and when changing the oil.
With a new or reconditioned engine also change the cleaner for the first time after 20 hours of operation.

Lubricating oil strainer

The strainer, of wire mesh, traps any large particles in the oil before the oil passes to the pump.

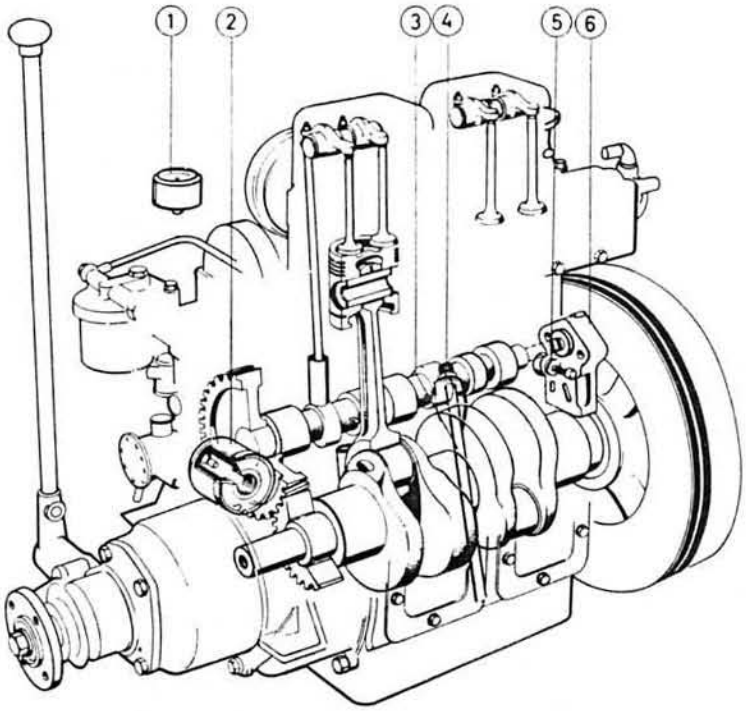


Fig. 39. Lubricating system, D2 and MD2

1. Pressure gauge (with manual starter)
2. Oil cleaner
3. Oil strainer
4. Oil dipstick
5. Relief valve
6. Oil pump

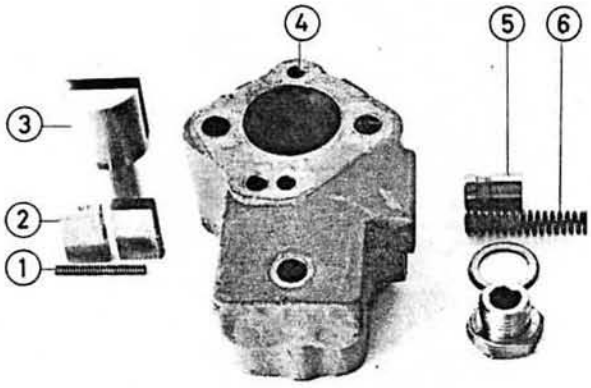


Fig. 40. Lubricating oil pump

1. Spring between wings
2. Wings
3. Spindle
4. Housing
5. Plunger for relief valve
6. Spring for relief valve

Lubricating oil strainer

The strainer should be removed and cleaned after every 100 hours of operation.

1. Loosen the square nut on the strainer. Lift up the strainer, Fig. 43.
2. Clean the strainer in fuel oil or white spirit and re-fit. TIGHTEN THE NUT THOROUGHLY OTHERWISE NO OIL PRESSURE IS OBTAINED AND THE ENGINE WILL SEIZE.

LUBRICATING OIL PUMP

Removing and disassembling

1. Loosen the three attaching bolts.

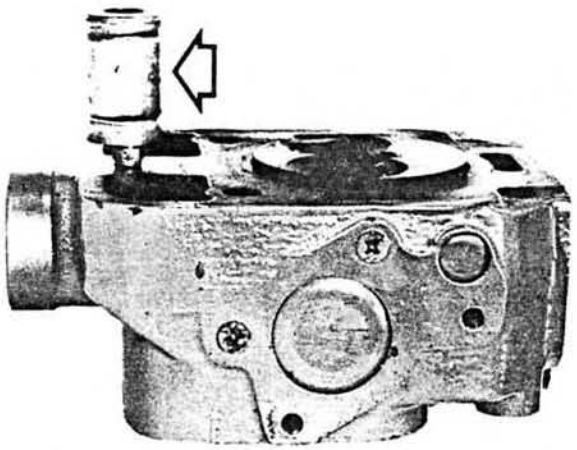


Fig. 41. Crankcase ventilation

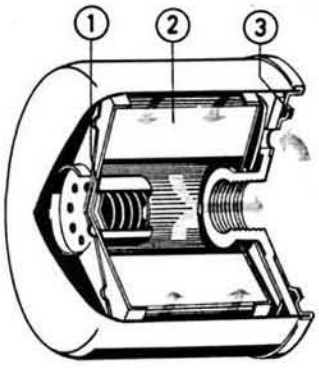


Fig. 42. Oil cleaner.

1. Relief valve
2. Insert
3. Gasket

2. Remove the oil pump.
3. Loosen and remove the pump cover.
4. Remove the spindle with wings.
5. Loosen the plug at the relief valve, remove the spring and plunger.

Clean all parts thoroughly and check the housing, spindle and wings for scoring and wear. Scoring is not permissible.
After checking all parts, test the oil pump springs, i.e. the spring between the wings and the relief valve spring. See specifications for test figures.

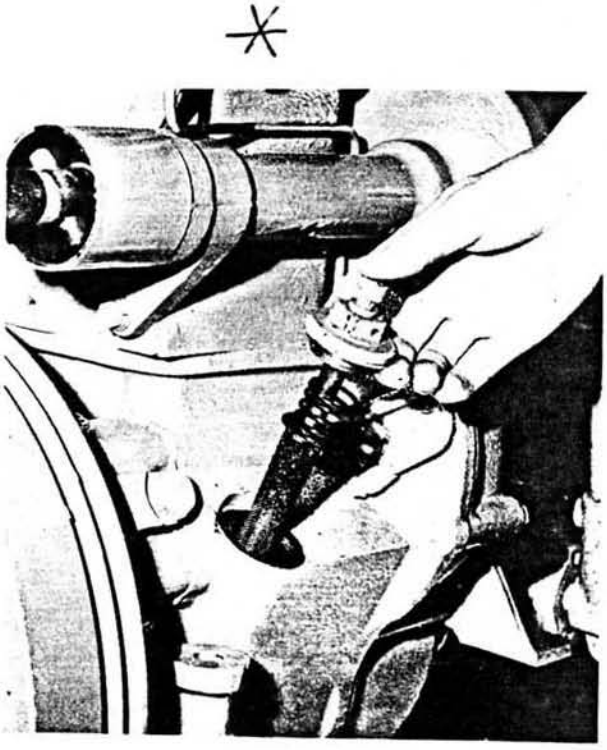


Fig. 43. Removing the oil strainer

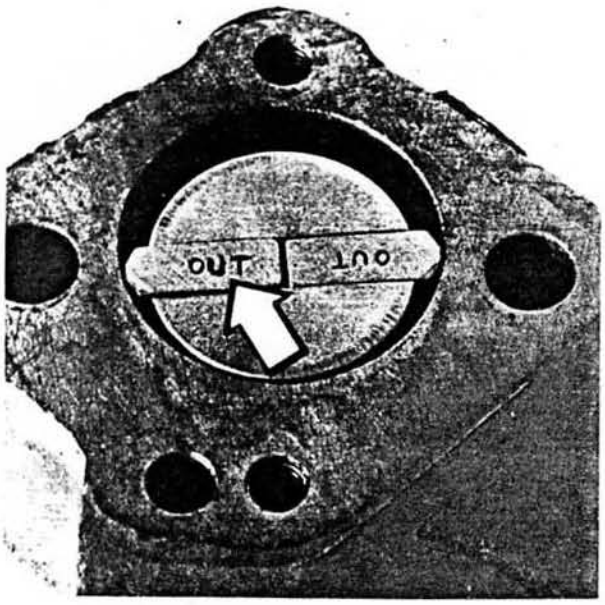


Fig. 44. Location of wings

Assembling and fitting

1. Assemble the spindle, spring and wings and fit in housing. NOTE. The "OUT" marking on the wings should be fitted facing away from the engine, see Fig. 44.
2. Oil in the pump components.
3. Fit the cover with a new gasket smeared with Permatex or corresponding compound.
4. Fit the relief valve.
5. Fit the pump on the engine, use a new gasket and smear the new gasket with Permatex or corresponding compound.

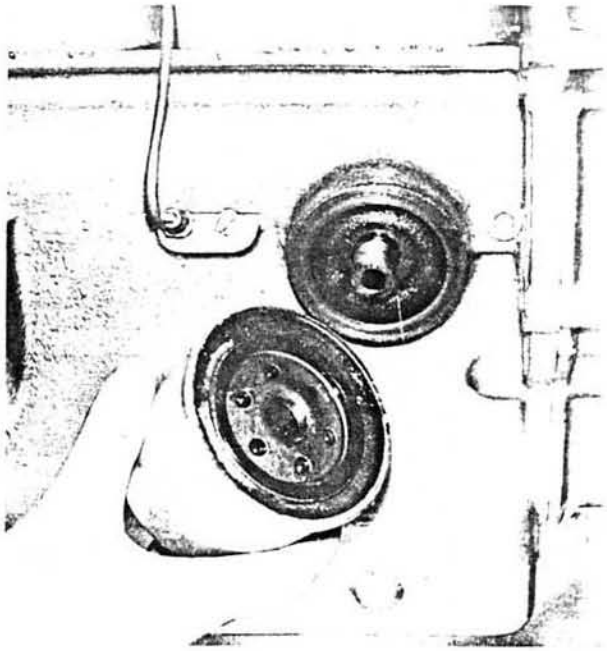


Fig. 45. Removing the oil filter

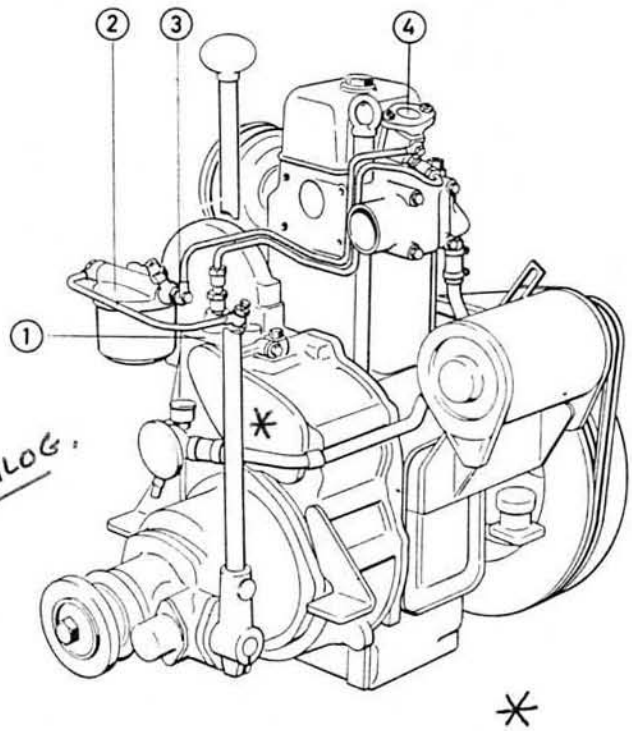
Replacing the oil filter

1. Screw off the old cleaner, Fig. 45.
2. Smear oil on the new cleaner rubber gasket, and make sure that the contact surface on the block is free from dirt. Screw on the oil cleaner by hand until it just touches the crankcase.
3. Tighten the oil cleaner a further half turn but no more. Start the engine and check for leakage. Check that the oil level in the engine is correct.

FUEL SYSTEM

DESCRIPTION

The fuel system consists of the fuel pump with pre-filter (only D2 and MD2), the fuel injection pump with governor, injectors as well as pipe lines and fuel tank. Fuel is sucked by the feed pump from the fuel tank through the pre-filter and forced through the fuel filter to the injection pump. On D1 and MD1 engines there is gravity feed from the fuel tank. This means that the fuel tank must be at least 150 mm (6") higher than the inlet on the engine fuel filter to obtain a gravity feed.



SEE PG 63 IN PARTS CATALOG.

Fig. 46. Fuel system D1 and MD1

1. Injection pump
2. Fuel filter
3. Leak-off line connection
4. Injector

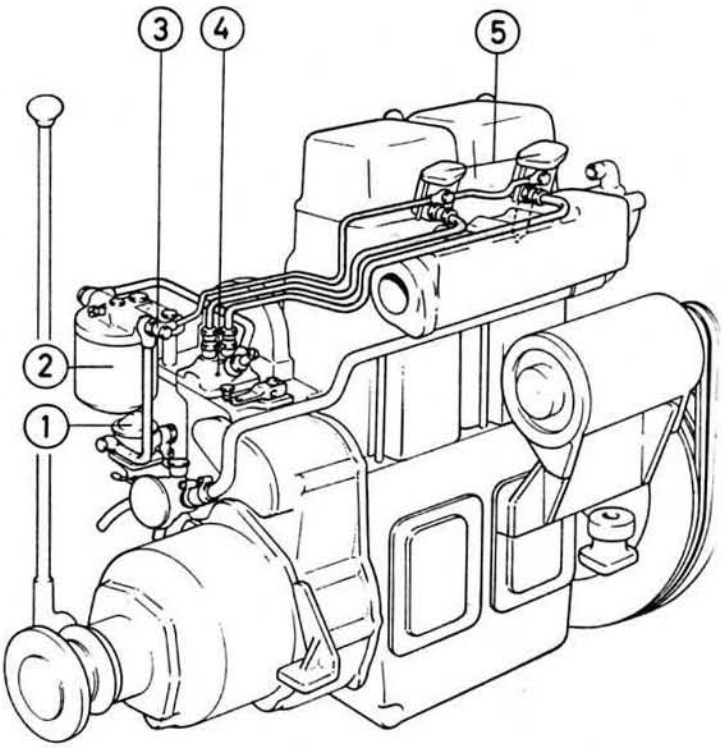


Fig. 47. Fuel system, D2 and MD2

1. Feed pump with pre-filter
2. Fuel filter
3. Leak-off connection
4. Injection pump
5. Injectors

REPAIR INSTRUCTIONS

THE GREATEST CLEANLINESS MUST BE OBSERVED IN ALL WORK ON THE FUEL SYSTEM AND ITS EQUIPMENT.

NOTE. Repair work including adjustment to the internal pump components and which can alter their settings may only be carried out by authorized Diesel workshops with the required tools and test devices.

FUEL INJECTION PUMP

*Removing

FIRST

1. Loosen all pipe connections and fit protective caps.
2. Loosen the control arm spring.
3. Loosen the four pump attaching bolts.
4. Lift the pump straight upwards. If the pump jams this can be due to the control rod contacting the timing gear casing. Push this in one direction or the other.

→ REMOVE INSPECTION COVER (* ABOVE) AND STUFF A "HAND TOWEL" SIZE RAG IN THE HOUSING UNDER NEITH THE PUMP —TO CATCH ANY PARTS THAT FALL DURING PUMP REMOVAL

Fitting

1. Clean round the pump attachment.
2. Measure the distance from the attaching surface on the timing gear casing to the pump cam basic circle, use a depth micrometer or a sliding calliper. The measurem should be 82.8 ± 0.2 mm (3.260 + 0.008"). This measurement includes the gasket

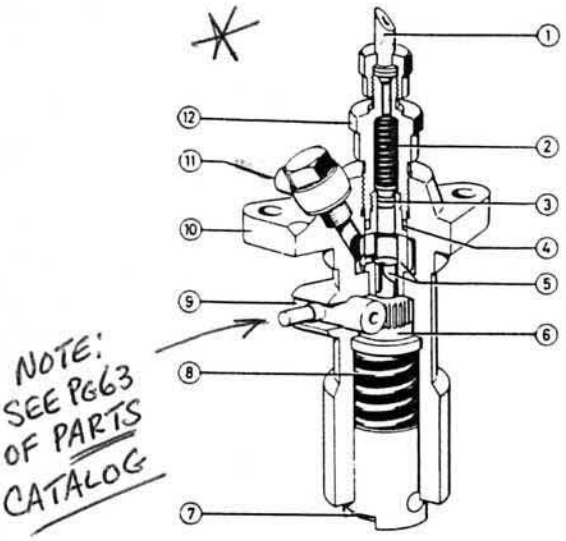


Fig. 48. Injection pump, D1 and MD1

between the pump flange and the timing gear casing. This measurement must agree if the injection angle is to be correct, Fig. 50.

3. Fit a new gasket and smear with Permatex or similar compound.
4. Fit the injection pump. NOTE. Make sure that the control arm cube is correctly located in the governor lever.
5. Tighten the pump. Use new copper washers.
6. Connect up the fuel lines.
7. Air-vent the system. (See "Air-venting the fuel system").
8. Fit the inspection cover. Use a new gasket and smear with Permatex or corresponding compound.

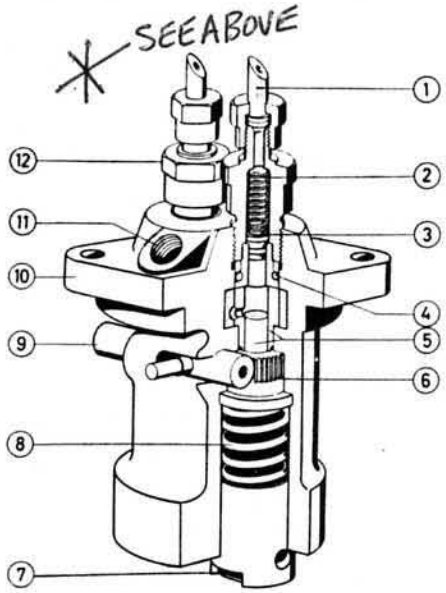


Fig. 49. Injection pump, D2 and MD2

Figs. 48 and 49. Injection pump

1. Delivery pipe
2. Spring
3. Off-loading valve
4. Seal
5. Pump element
6. Sleeve
7. Roller tappet
8. Spring
9. Control rod
10. Pump housing
11. Inlet
12. Screw union

Fig. 50. Measuring the timing gear casing

INJECTORS

Removing

1. Clean the injector, delivery pipe and cylinder head round the injector.
2. Unscrew the delivery pipe and leak-off line from the injectors. Fit protective caps.
3. Loosen both the nuts retaining the injector to the cylinder head and lift up the injector.

Testing

If there is reason to believe that an injector is faulty, it should be removed from the engine and tested in a special apparatus.

1. Wash the injector until clean and fit in the test apparatus, see Fig. 52.

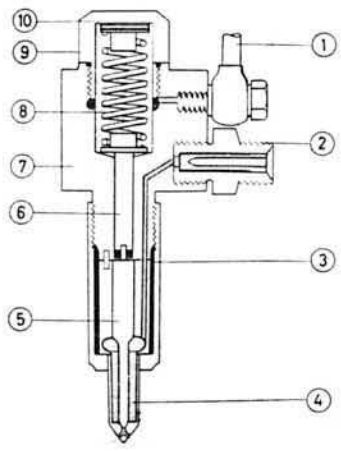


Fig. 51. Injector

1. Leak-off line
2. Delivery pipe connection
3. Nozzle nut
4. Nozzle
5. Nozzle needle
6. Push rod
7. Nozzle holder
8. Spring
9. Protective casing
10. Adjusting washer

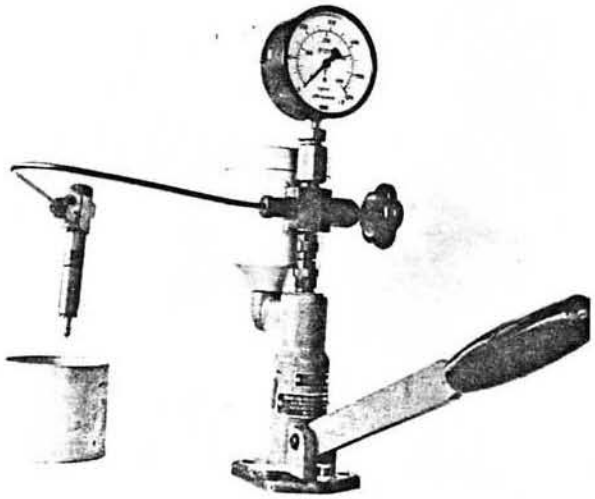


Fig. 52. Injector tester

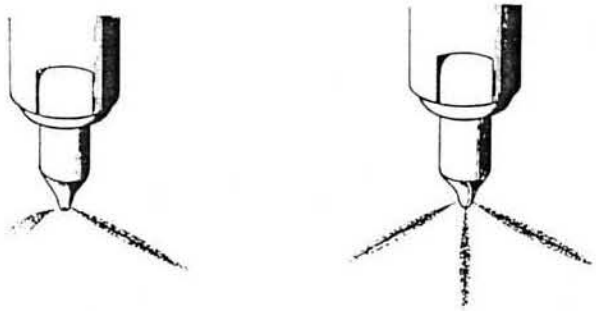
2. Pump up the pressure until the injector needle opens and then read off the opening pressure. This varies depending on the type of injector. See the specifications on page 32.

   The opening pressure can be adjusted by means of washers located between the upper spring retainer and the protective casing, see 10, Fig. 51. Remember that the spring retainer must be pulled right down to the bottom for each new test.

3. Pump up to a pressure of 120 kg/cm^2 (1700 lb./sq.in.) for injector DLLA 150S164 and DLLA 150S245 or 135 kg/cm^2 (1920 lb./sq. in.) for injector DLLA 150S120 135 and maintain this pressure for 10 seconds. During this period there must be no moisture on the dried injector point.

4. Check the spray pattern. The individual spray jets must be identical and be directed as shown in Fig. 53. Check that there is a clearly audible creaking sound when injection occurs.

If these tests are satisfactory, the injectors should not be disassembled but should instead be re-fitted on the engine. If unsatisfactory, disassemble, clean and adjust the injectors.



Wrong Right

Fig. 53.

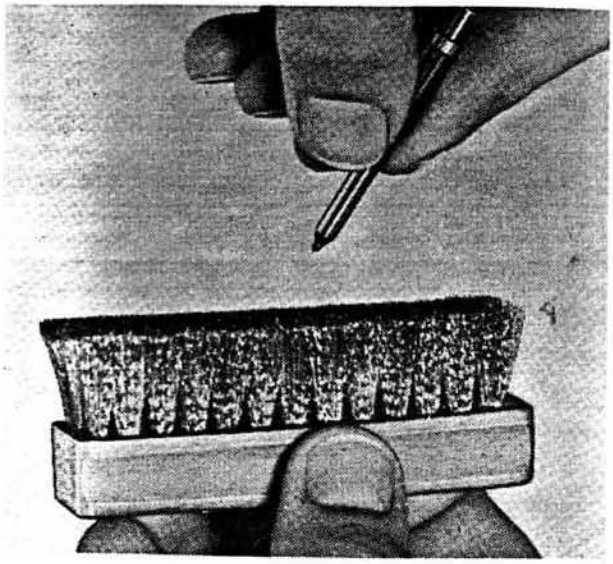


Fig. 54. Cleaning a nozzle needle

Disassembling

If the injector is to lie disassembled for some time, it should be kept in fuel oil. Finger prints can cause rusting which ruins the precision grinding work with which the parts are manufactured.
The nozzle and nozzle needle are matched together and should therefore not be mixed up with parts from other nozzles.

1. Remove the protective casing, 9 Fig. 51, release and remove the nozzle nut.
2. Remove the nozzle needle from the nozzle.

Cleaning and adjusting

1. Lay the needle and nozzle in alcohol for about 30 minutes before starting cleaning to dissolve resin deposits. Do not mix together nozzles and needles from different injectors.
2. Clean the needle with a brush and pure oil (white spirit). See Fig. 54.
3. Clean the channels to the nozzle pressure chamber using a drill or a silver wire.
4. Use a special scraper to clean the nozzle pressure chamber, Fig. 55.

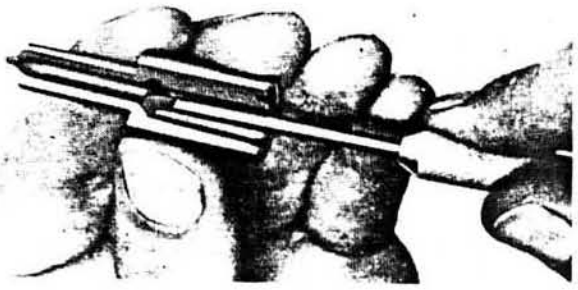


Fig. 55. Cleaning the pressure chamber

Fig. 56. Cleaning the nozzle chamber

5. Remove soot from the nozzle chamber, Fig. 56, by using a special reamer.
6. Clean the nozzle seat with a seat reamer, Fig. 57.
7. Clean the nozzle holes, Fig. 58, if they are fully or partly blocked by soot with a small cleaning needle fitted in a hand chuck. It is important when cleaning the holes to use a cleaning needle with a diameter 0.02 mm (0.0008") smaller than the holes in the nozzle. See the specifications for the nozzle hole diameter.
8. Remove loose particles from the nozzle and its holes by fitting the nozzle in a flushing apparatus connected to the injector tester and flush it through by energetic pumping. The pressure gauge valve on the test apparatus must be closed.
9. Clean the nozzle holder in solvent, taking care to protect the body sealing surface against the nozzle. Use a metal brush to remove soot, dirt and rust from the outside of the nozzle holder.

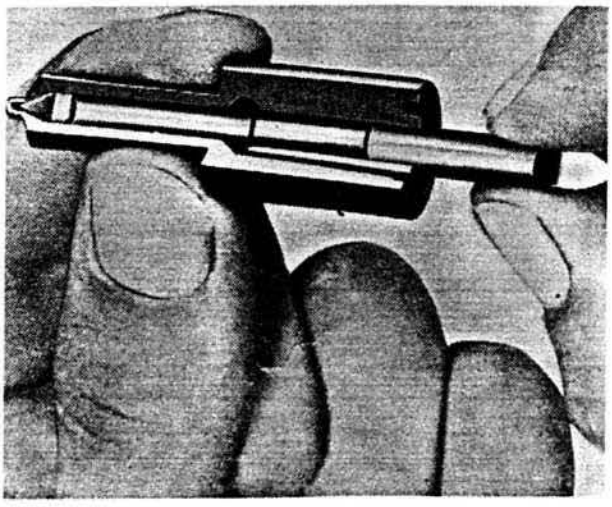


Fig. 57. Cleaning the nozzle seat

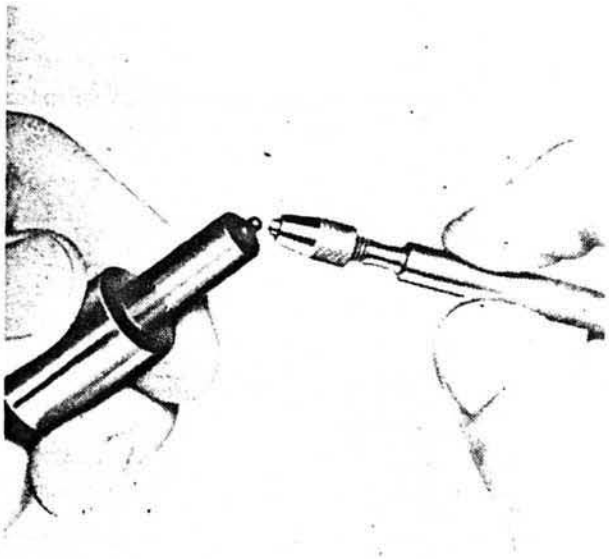


Fig. 58. Cleaning the nozzle holes

Inspecting

The following points should be checked when inspecting injectors and cover most faults that may occur.

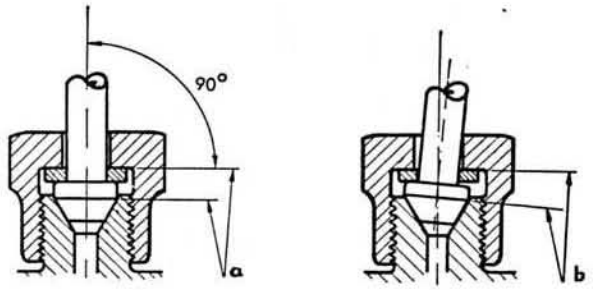
1. Check that the needle runs easily in the nozzle guide. If the clearance between the guide and the nozzle needle is correct, the needle should slide without chafing. Lift up the needle about 10 mm (1/2") and release it. If the clearance is correct the needle should slide slowly down into position under its own weight. If the needle chafes, careful hand lapping with tallow should be carried out. The nozzle and needle must be thoroughly clean after lapping.
2. Check the condition of the thrust spring.
3. Check that the wrench flats on the nozzle nut, cap nut, adjusting screw lock nut and the delivery pipe nut as well as their threads are in good condition.

Assembling and installing

1. Check that the flat, lapped surfaces on the nozzle and nozzle holder are clean and free from dirt, metallic particles and dust. Rinse the nozzle needle and nozzle in fuel oil. Fit the nozzle needle and nozzle, tighten the nozzle nut but not too hard.
   Make sure that the nozzle is correctly located.
2. Fit the upper spring retainer, shims and protective casing. Tighten the casing thoroughly.
3. Test the injector in an injector tester.

   With the pressure gauge operating, pump fuel up to and out through the injector. The opening pressure varies due to the type of injector. See the specifications on page 32.

The setting is adjusted by using shims, 10, Fig. 51. If pressure is too low, fit more shims. If pressure is too high, remove one or more shims. Check the spray pattern as already described.



Correctly fitted
Surfaces (a) parallel

Wrongly fitted
Surfaces (b) not parallel

Fig. 59. Fitting the pipelines.

See "Testing". Make sure that there is no leakage at any joint. When the opening pressure has been set, shut off the pressure gauge. Then press slowly down on the arm of the injector tester until the injector opens. At this point the test oil should spray out in spurts with a "creaking" noise. The shorter the spurts are, the better the condition of the injector.

Fitting

1. Turn the engine over a few revolutions to blow the copper sleeves clean before fitting the injectors. Check that the contact surface for the injector in the bottom of the copper sleeve is clean.
2. Slide down the injectors into position and then fit the washers and nuts without tightening them.
3. Connect up the leak-off line. Replace damaged washers.
4. Connect up the delivery pipes. Make sure the cones are correctly located. If the cone is tightened askew, the delivery pipe will fail after some time due to the stresses occurring from faulty tightening. See Fig. 59.
5. Then tighten the injectors. The nuts are tightened alternately to avoid stresses which can affect the function of the nozzle needle. The tightening torque is 2 kgm (15 lb.ft.).

FUEL FILTER

✳ Replacing the filter insert

1. Clean round the filter, particularly under the projecting edges of the cover.
2. Remove the container with filter insert.
3. Clean the container internally.
4. Remove the gasket in the cover and clean the gasket groove.
5. Fit a new gasket in the cover. Fit a new insert. NOTE. Never try to clean an old insert.
6. Fit the container in position again.
7. Air-vent the fuel system.

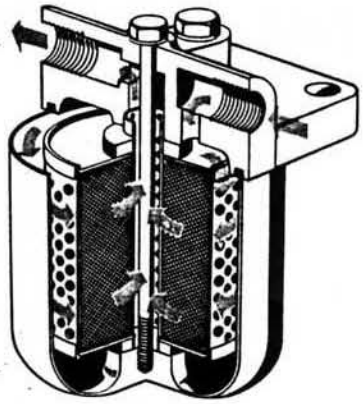


Fig. 60. Fuel filter.

✳ Air-venting the fuel system

1. Open the air-venting screw on the fuel filter. See the arrow. (FIG. 61)
✳ 2. On D1 and MD1 engines fuel will run out through gravity feed. On D2 and MD2 engines, the primer is used to pump up fuel primer.
Close the air-venting screw when there are no more air bubbles in the fuel oil.
✳ 3. Open the air-venting screw on the injection pump and repeat operation two above.
Close the air-venting screw when there are no more air bubbles.

✳ See Arrows below

FEED PUMP

● A feed pump is fitted only on D2 and MD2 engines, see 1, Fig 47, this being installed beside the injection pump and driven directly from the camshaft.

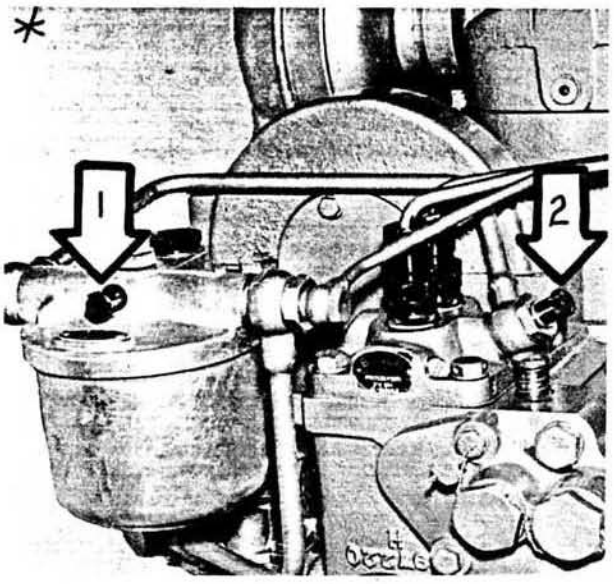


Fig. 61. Air-venting the fuel system

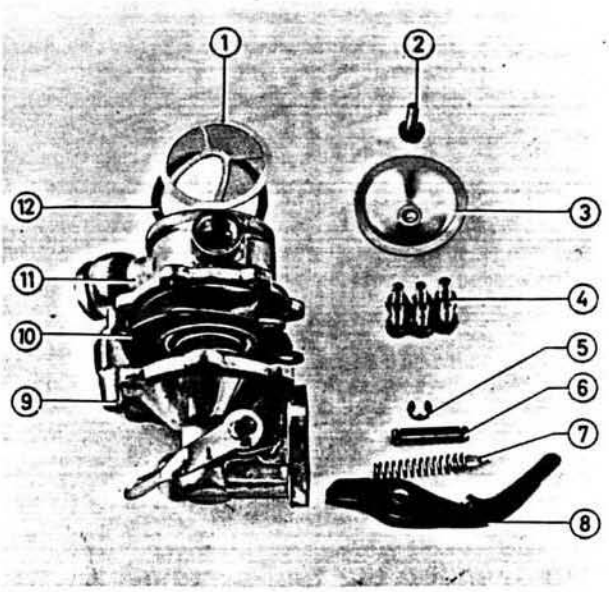


Fig. 62. Feed pump

1. Strainer
2. Screw
3. Cover
4. Screws
5. Lock ring
6. Lever spindle
7. Return spring
8. Lever
9. Lower pump housing
10. Diaphragm
11. Upper pump housing
12. Gasket

The feed pump is fitted with a hand primer. This is used, for example after adjusting work, to pump fuel to the filter and injection pump. A pre-filter is incorporated in the feed pump housing.

Removing

1. Clean the pump and round the pump.
2. Disconnect the pipe screw unions.
3. Loosen and remove the pump from the engine.

Disassembling

1. Mark the upper section and lower section. Unscrew the upper section from the lower section.
2. Remove the lock ring from the lever spindle. press out the spindle.
   Pull out the lever and spring.
3. Remove the diaphragm with spring, guide and rubber seal. The spring can be removed after the rubber seal is forced over the nylon washer.
4. Loosen the screw on the underside of the upper section, remove the stop arm and spring valve. The inlet valve cannot be removed.

Inspecting

Check the diaphragm and gasket for leakage and check the moving parts for wear.
Remove damaged and worn parts.

Assembling

1. Fit the leaf spring, Fig. 63, and the stop arm.
   Tighten the screw, but only so hard that the leaf spring is in good contact with the pump housing.

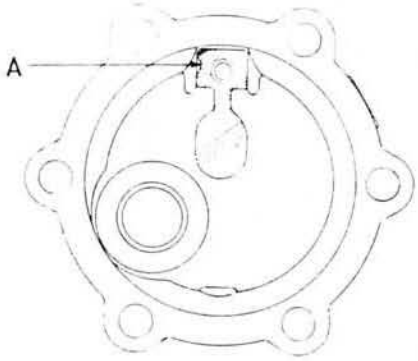


Fig. 63. Location of leaf spring.

2. Fit the spring and guide, pull on the rubber gasket with the flange towards the guide.
3. Fit the diaphragm unit in the pump lower section. Press downwards to correctly locate the rubber gasket.
4. Press down the diaphragm, insert the lever and make sure that it is correctly located relative to the diaphragm rod. Fit the spindle, lock rings, spring retainer and spring.
5. Fit the upper section by following the marking and tighten it.
6. Fit the strainer and cover.
   Make sure when fitting that the lever is correctly located above its cam.

Fitting

1. Fit a new gasket and smear it with Permatex or corresponding compound.
2. Fit and tighten the feed pump.
3. Connect up the fuel lines.
4. Air-vent the system (see instructions).

Cleaning the strainer

*NOT ON MY ENGINE

Loosen and remove the lid. Remove and blow clean the strainer. Check before fitting the lid that the gasket is in good condition and seals properly. Fit a new gasket if necessary. See Fig. 64.

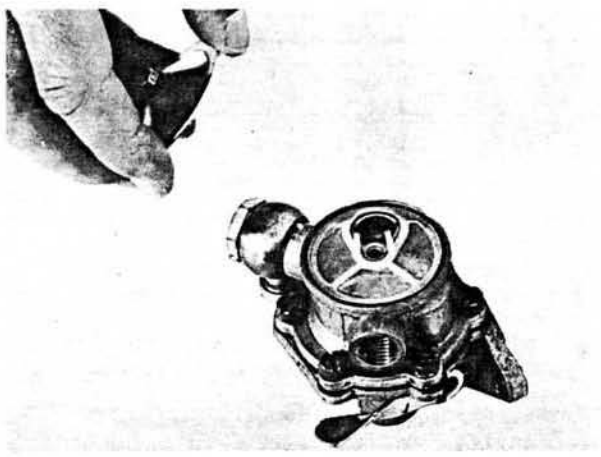
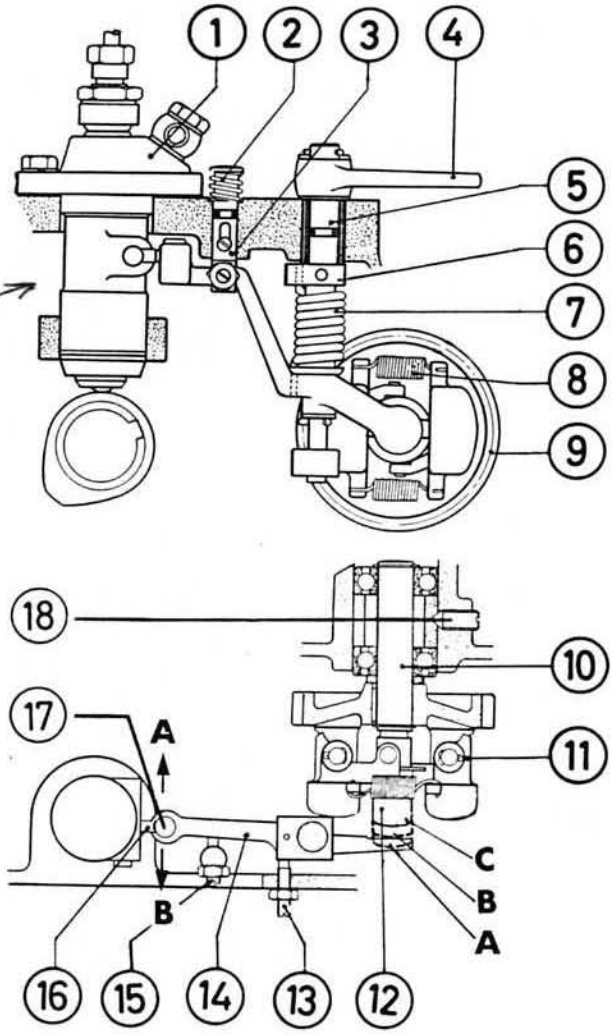


Fig. 64. Cleaning the strainer.



SEE NOTE ON PG 63 OF PARTS CATALOG

Fig. 65. Centrifugal governor

1. Injection pump
2. Spring
3. Cold starting button
4. Control lever
5. Spindle
6. Stop sleeve
7. Governor spring
8. Damping spring
9. Gear
10. Governor spindle
11. Governor weight
12. Friction sleeve
13. Adjusting screw for speed
14. Governor lever
15. Adjusting screw for fuel
16. Rack (injection pump)
17. Cube
18. Stop screw

A Minimum injection
B Maximum injection
C Engine stopped.

Centrifugal governor

The governor on these engines is of the centrifugal type and gear-driven from the camshaft. The governor weights (11) are journalled on the gear (9, Fig. 65). The weights are connected by damping springs (8). When the governor rotates, the weights are thrown outwards by centrifugal force and displace the friction sleeve (12) axially. The sleeve exerts the pressure on the governor lever (14). The lever can twist relative to its spindle but this twisting is counteracted by a spring.

The control lever has two functions, to regulate speed and to stop the engine.

Since the lever tensions a spring (7) when it turns anti-clockwise, the governor lever is twisted and the injection pump rack (16) displaced so that the engine obtains maximum fuel injection when starting. When the engine has started, the injected quantity is controlled by the position of the weights. When the lever is moved in the opposite direction, spring tension decreases and engine speed decreases too. If the lever is turned further, the injection pump rack is taken by the governor lever to the stop position and the engine stops. Maximum turning is determined by an adjusting screw (13) which contacts a stop sleeve. Maximum engine speed is set with this screw.

The control lever (4) position determines engine speed. If the engine tends to increase its speed when the loading decreases, the governor weights are swung out more, the friction sleeve presses against the governor lever. This is then turned relative to the spindle without the governor lever moving since the spring is tensioned. The other arm of the governor lever then displaces the injection pump rack so that injected fuel decreases and engine speed goes down.

When engine speed decreases, the governor weights move in again, the sleeve is pulled back and the governor lever is turned by the spring back to its original position.

The adjusting screw (15) determines the maximum fuel feed to the engine by stopping the governor lever movement. The adjusting screw is threaded into the rod on the cold starting button (2). When the rod is pressed down, the adjusting screw is displaced past the governor lever so that the arm instead rests against the cylindrical part of the rod whereby governor lever movement becomes greater. This also displaces the injection pump rack so that a larger fuel quantity than normal is supplied to the engine when starting.

When the engine starts, through the pressure exerted by the governor weights through the friction sleeve on the governor lever, this lever is moved back from the cold starting position and the cold starting rod is returned by a spring to its original position.

Removing

1. Loosen and remove the manual starter.
2. Loosen and remove the injection pump.
3. Remove the power take-off if fitted.
4. Loosen and remove the feed pump.
5. Loose the timing gear casing bolts, (notice they have different lengths) and lift the casing off the engine.
6. Remove the stop screw (18) on the right-hand side of the engine viewed from the governor.
7. Pull out the spindle with governor weights and gear.
8. Clean all parts.

Inspektion

1. Check that the weights do not chafe on their spindle or that there is excessive clearance between the spindle and governor weights.
2. Check that the governor lever is not chafing or has not excessive clearance.
3. Check the springs on the weights and governor lever. See the specifications.
4. Check that the friction sleeve runs easily on its spindle.
5. Check that both ball bearings are in good condition.

Fitting

Fitting is carried out in the reverse order. Make sure that moving parts run easily and grease them before fitting

COOLING SYSTEM

DESCRIPTION

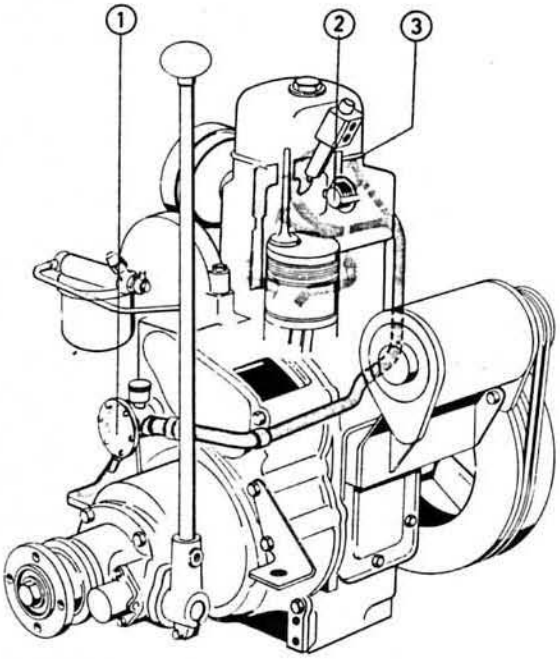


Fig. 66. Cooling system MD1

1. Sea-water pump
2. Thermostat
3. Distribution housing (thermostat housing)

To provide effective cooling water circulation, the engine is fitted with a sea-water pump. This pump is fitted on the timing gear casing and driven by the camshaft through a flange. Its function is shown in Fig. 66. The impeller in the sea-water pump is made of neoprene rubber and operates against a cam.

The pump (1, Fig. 66) sucks cooling water from outside the boat through the externally located sea-cock strainer and forces the water to the distribution housing (thermostat housing).

The cooling water has the possibility of following two ways from the distribution housing. The thermostat (2) in the thermostat housing keeps the passage from the engine closed at the same time as it opens the passage from the distribution housing above the thermostat. The water in the engine is therefore warmed up rapidly while the water supplied by the sea-water pump passes the engine through the bypass without cooling it.

When the engine has obtained its normal operating temperature, the thermostat opens the outlet from the engine at the same time as it closes the bypass line from the distribution housing above the thermostat.

In this way the thermostat balances cooling water circulation through the engine so that engine temperature is always correct independent of loading.

D1 and D2 engines are fitted with cellular radiators of the pressure type. Coolant is sucked by the pump from the bottom of the radiator and forced into a distribution housing from which the coolant is taken through drillings to the cylinder block and cylinder head. The flow of coolant is directed so that it flushes the injector sleeves, the valve seats and the cylinders. When the engine has attained its normal operating temperature, the thermostat opens.

REPAIR INSTRUCTIONS

SEA-WATER PUMP

Checking

1. Remove the pump.
2. Loosen and remove the cover from the pump.
3. Remove the impeller.
4. Press out the shaft.
5. Replace the seal rings, shaft or impeller if necessary.
6. Re-assemble the pump in the reverse order. Make sure that it does not chafe then fit it on the engine.

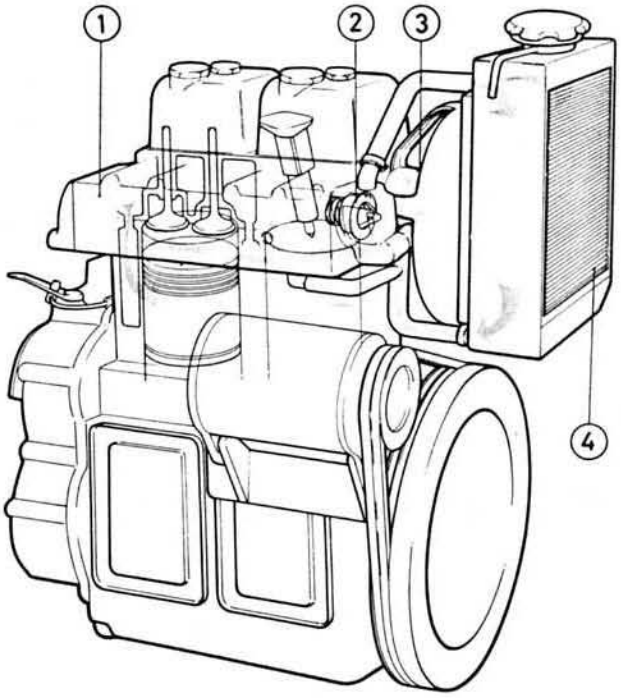


Fig. 67. Cooling system, D2

1. Water-cooled exhaust manifold
2. Thermostat
3. Cooling water pump
4. Cellular radiator

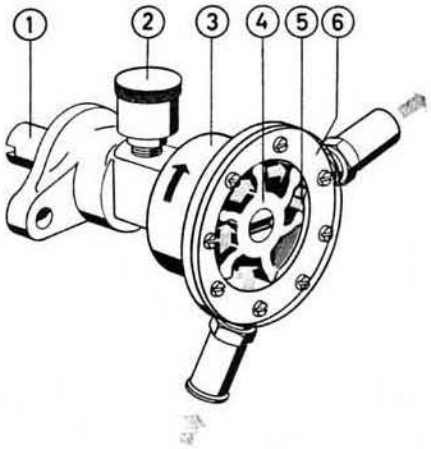


Fig. 68. Sea-water pump

1. Shaft
2. Lubricator
3. Housing
4. Impeller
5. Cam
6. Cover

COOLING WATER PUMP

Removing

1. Drain the cooling system.
2. Remove the radiator.
3. Loosen the fan belt.
4. Remove the fan (1, Fig. 69). On D1 engines the fan and pulley are integral.
5. Loosen and remove the pulley (2).
6. Remove the bolts (10).
7. Force off the washer (9).
8. Press out the shaft (5) in the direction of the arrow. The seal (7) and impeller (8) will follow with it.

If the bearings are also to be replaced, carry out the following.

9. Remove the lock ring (6).
10. Press out the bearings (3), and the spacer ring (4) will follow them.

Clean all component parts and always replace the seal ring (7) if the pump has been disassembled.

Fitting

1. Fit the seal ring (7) in its slot.
2. Fit the bearings and spacer ring on the shaft and insert the shaft in the direction of the arrow then secure it with the lock ring (6).
3. Hold the pump shaft (5) against a counterhold and press in the washer (9) against the stop. Make sure the impeller rotates freely.
4. Then fit the pump.
5. Connect up the pulley, fan and radiator.

THERMOSTAT

Removing

On the MD1 the thermostat is located in the cylinder head and on the MD2 it is located in the exhaust manifold.

1. Loosen the cooling water lines.
2. Loosen and remove the distribution housing.
3. Remove the thermostat.

On the D1 the thermostat is located in the cylinder head behind the cooling water pump. On the D2 it is located in the exhaust manifold.

1. Drain the cooling system.
2. Loosen and remove the thermostat housing (D2). On the D1 the cooling water pump must be removed, see the special instructions.
3. Remove the thermostat.

If the thermostat is fully open or has any other defect, fit a new thermostat. Fit in the reverse order.

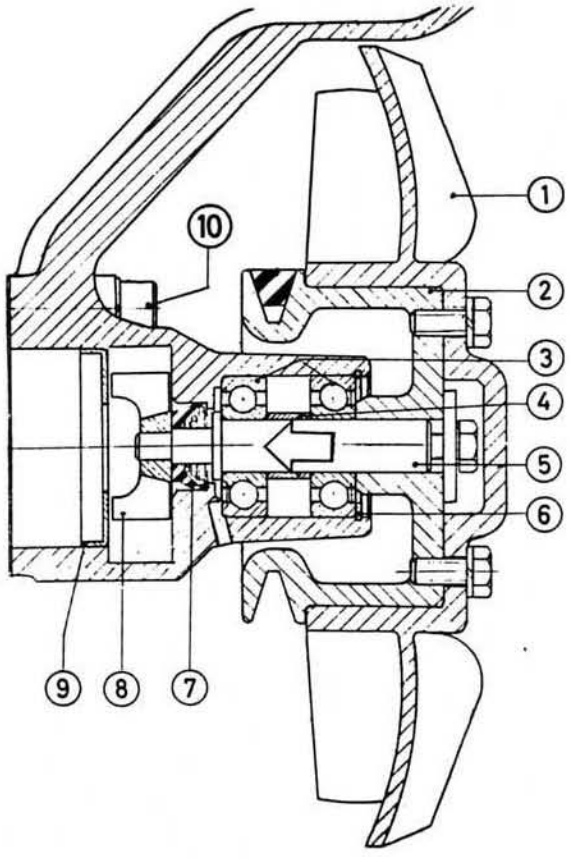


Fig. 69. Cooling water pump.

REVERSE GEAR

DESCRIPTION

The Volvo Penta type RB reduction - reverse gear has a built-in reduction gear with ratio 1.87:1. Engagement of "ahead" or "astern" is carried out by self-adjusting cones which are retained in the engaged position by the propeller pressure. The reverse gear and engine have the same lubricating system.

When "ahead" is engaged, the outgoing shaft with its cone is moved forward and engagement occurs against the front cone. Engine driving power is transmitted from the crankshaft gear to the internally toothed ring on the front cone.

When "astern" is engaged, the outgoing shaft is moved backwards and engagement occurs against the inner cone. This functions through an idler gear and this means that the direction of rotation of the outgoing shaft is therefore reversed.

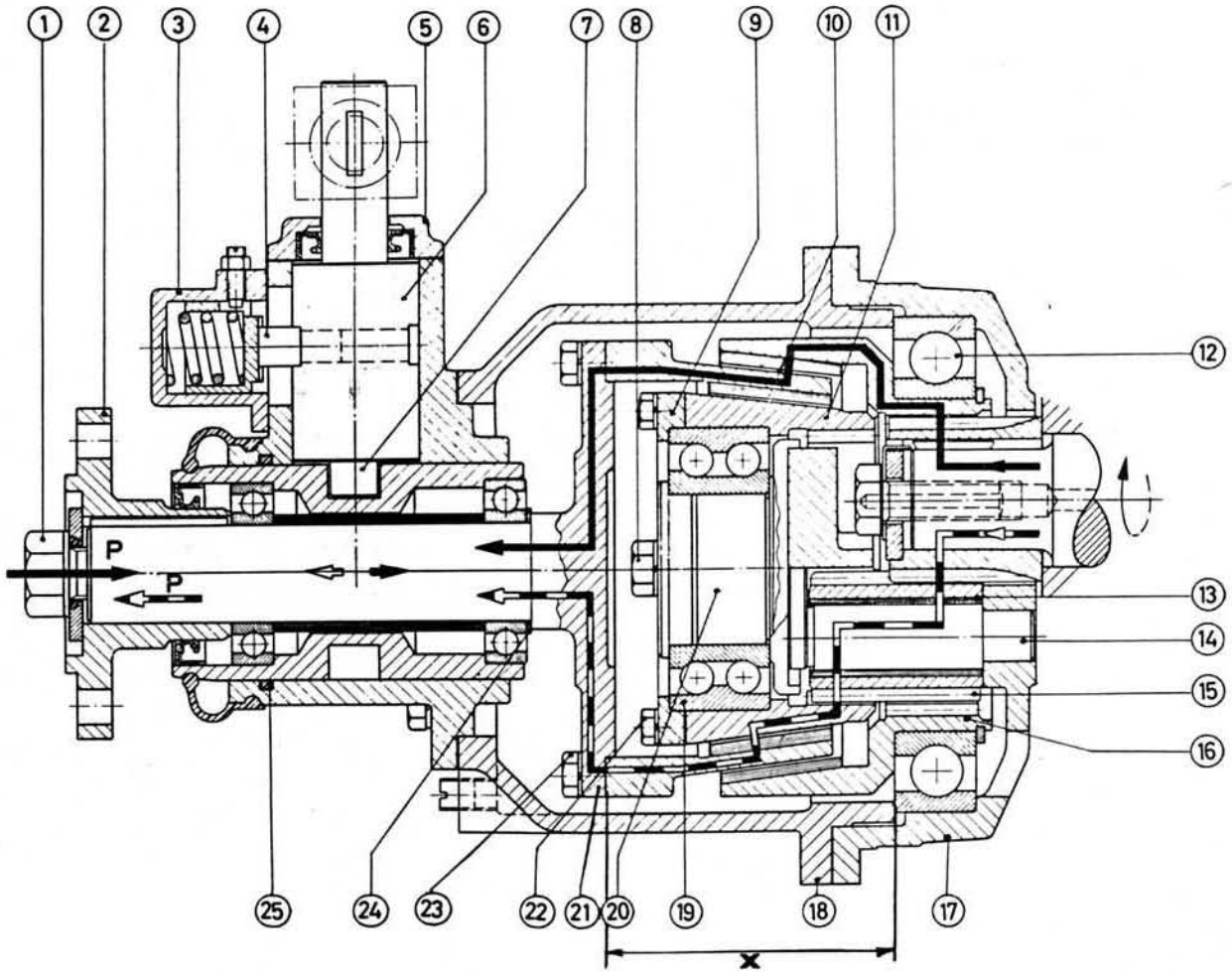


Fig. 70. Reduction - reverse gear

"Ahead" = Thick unbroken black line
"Astern" = Thick black broken line
P = Propeller pressure

REPAIR INSTRUCTIONS

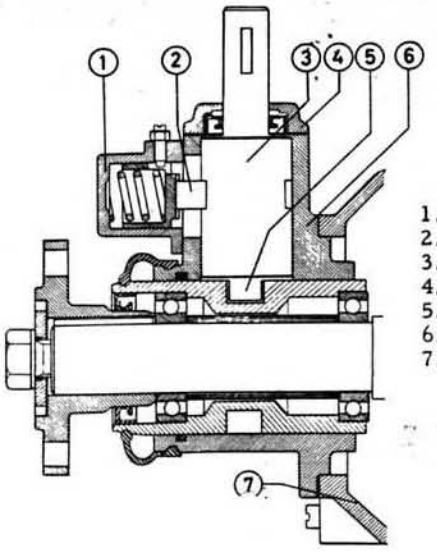
Disassembling

1. Loosen the bolt (1, Fig. 70) and pull off the coupling flange (2).
2. Loosen the interlock housing (3) and pull out the interlock pin (4).
3. Loosen the cover (5) and pull out the actuating shaft (6) and pin (7). Notice the position of the pin which has marked sides. See under the heading "Fitting".
4. Loosen the bolts retaining the reverse gear casing (18) to the housing (17). Separate the casing from the housing with light blows of a mallet.
5. Loosen the bolts (23) and remove the shaft.

6. Loosen the bolts (8). Fit one of the bolts in the centre hole on the bearing support (20) and pull the gear (11) loose by screwing in the bolt. If the ball bearing (19) is to be removed from the gear, loosen the bolts (22) and the ring (9) whereby the ball bearing is pressed out.
7. Lift out the cone (10).
8. Take out the gear (16) and the bearing (12) from the housing. Removal is facilitated by inserting a drift in the two holes on the housing, knocking on the bearing race and thus striking the bearing out of the housing.
9. Drive out the shaft (14) with the gear (15) and the bearing.

Inspecting

Before re-fitting the reverse gear, clean all parts carefully. Inspect all the parts and replace all worn units (washers, O-ring, spring washers). Check the seal rings carefully for damage. Wear on the friction facing on the gear (16), which is most subjected to wear, is compensated by increasing the thickness of the shims (24) as follows:
Place the cone (10) in the gear (16) and measure "X", see Fig. 69. The difference between "X" and 85 mm decides the thickness of shims. If the measurement, for example, is 83 mm, fit a washer with a thickness of 2 mm. If wear is so great that "X" is less than 81 mm, the worn parts must be replaced. The friction facing in the gear and the cone are not replaceable.



1. Spring housing
2. Interlock pin
3. Control shaft
4. Cover
5. Flange
6. Bearing housin
7. Reverse gear housing

Fig. 71. Rear section of reverse gear

If the flange is fitted so that the projecting side is turned forwards, this reduces the movement of the reverse gear lever from "ahead" to neutral. If the pin is given a half turn so that the projecting side faces rearwards, the movement of the lever from neutral to "astern" is reduced.

Then check that the reverse gear engages in both "ahead" and "astern".

Assembling

1. Place the bearing (13) and the gear (15) on the shaft and press the shaft into the housing.
2. Fit the gear (16) with the bearing (12) in the housing.
3. Lay the cone (10) in the gear (16).
4. Fit together the bearing (19), the cover (20) and the gear (11) to one unit and tighten the cover. Fit the ball bearing so that the recess on one side of the bearing faces away from the washer (20). The bearing support and washer are fitted so that the centre through-going hole faces upwards.
5. Fit the unit in the cone (10).
6. Fit the shaft at the sleeve to the cone.
7. Fit the reverse gear casing over the assembled parts and tighten it to the housing.
8. Fit the bellows and clutch flange. Check before fitting that the bolt (1) is well tightened and that the key is located in its groove.
9. Fit the flange, shaft, interlock pin, sleeve, spring and interlock housing. Oil in parts liberally when fitting. The flange (7) is fitted so that the unmarked sides are in the longitudinal axis of the engine. Fit the reverse gear lever and check the lever movements from neutral to "ahead" and "astern", these movements should be equal. If movement one way considerably exceeds the other, adjust by turning the flange (7). This is designed so that the centre for the rectangular section is offset relative to the centre of the cylindrical section.

POSITION OF CONTROL ARM

The clutch mechanism can be placed in different positions with the shaft straight up, to port or starboard. Modification is carried out as follows:

1. Move the reverse gear lever to the neutral position.
2. Loosen the bolts retaining the bearing housing (6, Fig. 71) attached to the reverse gear housing (7). Pull the bearing housing rearwards very slightly (facilitated by carefully engaging the lever), insert a knife between the sealing surfaces and carefully loosen the washer so that it only remains attached to one sealing surface. Remove the drain plug in the lower edge of the housing.
3. Turn the bearing housing to the desired position and tighten it there.

   If the keyway is in such a position after adjustment that the reverse gear lever cannot be fitted, turn the shaft and the flange as follows. There is a keyway on the shaft so both the gear retainer and shaft must be turned.

1. Loosen the spring housing (1) and lift out the interlock pin (2).
2. Loosen the cover (4) without pulling it off the shaft.
3. Lift the shaft (3) with cover (4) out of the housing and turn the shaft 180° (half a turn) Also turn the flange (5) half a turn and then re-fit the shaft.
4. Re-fit the parts

SPECIFICATIONS

The output of the D1 which has been increased on two occasions means that the specifications have been divided up into 5, 6 and 7 h.p. at certain places.

From 5 to 6 h.p.:

MD1, specification 9331 with effect from engine number 2554
MD1, specification 9382 with effect from engine number 2599
D1, Specification 9399 with effect from engine number 2629
D1, specification 9410 with effect from engine number 2639

From 6 to 7 h.p.:

D1 and MD1 with effect from engine number
10366-10385
10398-10400
10407-10408
10422-10423
10426-10428
10431 onwards.

ENGINE

GENERAL

	D1, MD1	D2, MD2
Type designation	5/2000 6/2000 7/2300	15.5/2300
Output, h.p. at r.p.m.	1	2
Number of cylinders	79.37 mm (3.125")	79.37 mm (3.125")
Bore	90 mm (3.54")	90 mm (3.54")
Stroke	445 c.c.	890 c.c.
Capacity	17.5:1	17.5:1
Compression ratio		
Compression pressure, kg/cm² (lb./sq.in.) at r.p.m.	21 - 24 (300 - 340)/200 - 240	21 - 24 (300 - 340)/200 - 240
Direction of rotation	Clockwise	Clockwise
Maximum engine speed, r.p.m.	2300 2300 2300	2300
Idling speed, r.p.m.	500-600, 400-500, 400-500	400-500

CYLINDERS

Material	Cast-iron
Cylinder bore	
standard	79.37 mm (3.125")
0.02" oversize	79.88 mm (3.145")
0.04" oversize	80.39 mm (3.165")

PISTONS

Material	Light-alloy
Height, total	103 mm (4.06")
Height from gudgeon pin centre to piston top	65 mm (2.56")
Piston clearance in cylinder	0.07 - 0.09 mm (0.0028" - 0.0035")
Pistons available as:	
Standard	79.28 mm (3.121")
0.02" oversize	79.79 mm (3.141")
0.04" oversize	80.30 mm (3.161")

PISTON RINGS

Compression rings	3
Oil control rings	2

The upper compression ring on each cylinder is chromed.
Piston rings available as:
Standard
0.02" oversize
0.04" oversize

AMMENDED: CORRECTION: SHOULD READ = 0.07 - 0.11 MM (0.0028 - 0.0043") 0.0035")

* Correction sheet

Page 32, Pistons

Enclosure to publ No 2120

Reads:	Piston clearance in cylinder	0,07 - 0,09 mm (0.0028-0,0035")
Should read:	Piston clearance in cylinder	0,07 - 0,11 mm (0.0028-0.0043")

Page 33, Big end bearing journals

Reads:	Big end bearing radial clearance	0.079 - 0.114 (0.0031-0.0045")
Should read:	Big end bearing radial clearance	0.066 - 0.098 (0.0026-0.0039")

	D1, MD1	D2, MD2
Piston ring clearance in groove, axially:		
1st compression ring		0.069-0.097 mm (0.0027"-0.0038")
2nd "		0.069-0.097 mm (0.0027"-0.0038")
3rd "		0.054-0.082 mm (0.0021"-0.0032")
1st oil control ring		0.033-0.063 mm (0.0013"-0.0025")
2nd "		0.033-0.063 mm (0.0013"-0.0025")
Piston ring gap in cylinder		0.25 - 0.50 mm (0.01 - 0.02")
CYLINDER HEAD		
Material		Special-alloy cast-iron
Tightening torque		See heading "Tightening torque"
CRANKSHAFT AND BEARINGS		
Crankshaft axial clearance		0.08 - 0.18 mm (0.003 - 0.007")
Main bearing radial clearance		0.038 -0.109 mm (0.0015 0.0043")
Tightening torque		See heading "Tightening torque"
BIG-END BEARING JOURNALS		
o Big-end bearing radial clearance CORRECTION=	SHOULD READ = 0.066-0.098 mm (0.0026-0.0039")	AMMENDED 0.079-0.114 mm (0.0031-0.0045")
Bearing surface width		27.076-27.330 mm (1.0660-1.0760")
Diameter, standard		53.950-53.960 mm (2.1240-2.1244")
0.010" undersize		53.696-53.706 mm (2.1140-2.1144")
0.020" undersize		53.442-53.452 mm (2.1040-2.1044")
0.030" undersize		53.188-53.198 mm (2.0940-2.0944")
BIG END BEARING SHELLS		
Thickness, standard		1.384-1.391 mm (0.0545-0.0548")
0.010" undersize		1.511-1.518 mm (0.0595-0.0598")
0.020" undersize		1.638-1.645 mm (0.0645-0.0648")
0.030" undersize		1.765-1.772 mm (0.0695-0.0698")
MAIN BEARING JOURNALS		
Diameter, standard		66.645-66.665 mm (2.6238-2.6246")
Diameter, undersize		66.445-66.465 mm (2.6159-2.6167")
GUDGEON PINS		
Diameter		28.00-28.004 mm (1.1024-1.1025")
Gudgeon pin bushing, diameter		28.014-28.025 mm (1.1029-1.1033")
Clearance, gudgeon pin - bushing		Close running fit
CONNECTING RODS		
The connecting rods are fitted with replaceable bearing shells.		
Axial clearance at crankshaft		0.05 0.25 mm (0.002" - 0.010")
Tightening torque		See heading "Tightening torque.
CAMSHAFT		
Drive		Gear
Axial clearance		0.05 - 0.15 mm (0.002" - 0.006")
Radial clearance		0.025 - 0.076 mm (0.001"- 0.003")
VALVE SYSTEM		
Inlet		
Disc diameter		32 mm (1.26")
Spindle diameter		7.857 - 7.877 mm (0.3093"- 0.3101")
Valve seat angle		45.5°
Seat angle in cylinder head		45°
Clearance, warm engine		0.30 mm (0.012")
EXHAUST		
Disc diameter		32 mm (1.26")
Spindle diameter		7.830 - 7.845 mm (0.3083" - 0.3088")
Valve seat angle		45.5°
Seat angle in cylinder head		45°
Clearance, warm engine		0.35 mm (0.014")
DECOMPRESSION DEVICE		
Maximum depression of exhaust valve		0.5 mm (0.020")

VALVE GUIDES

Length, inlet valve guide	62 mm (2.44")
Length, exhaust valve guide	62 mm (2.44")
Inner diameter, inlet	7.905 - 7.927 mm (0.311" - 0.312")
Inner diameter, exhaust	7.905 - 7.927 mm (0.311" - 0.312")
Height above cylinder head spring surface	21 mm (0.83")
Clearance, valve spindle - guide	
inlet valve	0.028 - 0.070 mm (0.0011" - 0.0027")
exhaust valve	0.060 - 0.097 mm (0.0024" - 0.0038")

VALVE SPRINGS

Length, unloaded	approx. 50 mm (2")
with 30 ± 0.2 kg (66 ± 0.4 lb.) loading	39 mm (1.53")
with 56 ± 0.2 kg (123 ± 0.4 lb.) loading	32 mm (1.26")

LUBRICATING SYSTEM

Oil capacity, excluding cleaner	1.5 litres (D1 and MD1) (1.3 Imp quarts = 1.6 US quarts)	3.0 litres (D2 and MD2) (2.6 Imp quarts = 3.2 US quarts)
Oil capacity, including cleaner		3.25 litres (D2 and MD2 (2.9 Imp quarts = 3.4 US quarts)
Oil grade	Service DS	
Viscosity between - 10°C (+ 15°F)and + 20°C (+ 70°F)	SAE 10 W	
Viscosity above + 20°C (+ 70°F)	• SAE 20	
Oil pressure, warm engine, idling speed, kg/cm² (lb./sq.in.)	1.5 - 2.5 (21-35)	

LUBRICATING OIL PUMP

Type	Wing pump
Spring for relief valve:	
Length, unloaded	40 mm (1.57")
Loaded with 2.5 ± 0.2 kg (5.5 ± 0.4 lb.)	34 mm (1.34")
Loaded with 3.5 ± 0.2 kg (7.7 ± 0.4 lb.)	31.5 mm (1.24")
Spring for oil pump wings:	
Length, unloaded	31 mm (1.22")
Loaded with 2 ± 0.2 kg (4.4 ± 0.4 lb.)	24.5 mm (0.96")

FUEL SYSTEM

Fuel injection pump, Bosch	PFR 1K65/264/11	PFR2K65/291/11
Injector (nozzle holder), Bosch	KBL52S58/4	KBL87S78/4
Injector (nozzle), Bosch	DLLA150S164	DLLA 150S245
Hole diameter	Three, 0.23 mm (0.009")	Three, 0.23 mm (0.009")
Injector opening pressure, kg/cm² (lb./sq.in.)	135-140 (1920-1990)	135-140 (1920-1990)
Pre-injection angle	25 - 28°	25 - 28°
Fuel injection pump, Bosch	PFR1K60/127/11	
Injector (nozzle holder), Bosch	KBL52S42/4	
Injector (nozzle), Bosch	DLLA150S120	
Hole diameter	Three, 0.25 mm (0.0098")	
Injector opening pressure, kg/cm² (lb./sq.in.)	175 (2485)	
Pre-injection angle	26°	
Fuel injection pump, Bosch	PFR1K65/264/11	
Injector (nozzle holder), Bosch	KBL87S78/4	
Injector (nozzle), Bosch	DLLA150S245	
Hole diameter	Three, 0.25 mm (0.0098")	
Injector opening pressure, kg/cm² (lb./sq.in.)	135-140 (1920-1990)	
Pre-injection angle	25 - 28°	

FUEL FILTER

Type	Bosch FJ/DW 2/3
Filter insert	• Bosch FJSJ 32 U7

FEED PUMP

Type	Pierburg PE15246
Feed pressure	Approx. 0.5 kg/cm² (7 lb./sq.in.)

	D1, MD1	D2, MD2
GOVERNOR		
Type	Centrifugal governor	
Length of damping spring, unloaded	35 - 0.5 mm (1.38 - 0.02")	
Loaded with 250 grams (0.55 lb.)	39 + 0.3 - 0.5 mm (1.54 + 0.012" - 0.020")	
Loaded with 500 grams (1.1 lb.)	43 ± 0.5 mm (1.69 ± 0.020")	
ELECTRICAL SYSTEM		
Battery voltage	12 V	
Battery capacity, max	60 amp. hrs.	
Starter - generator Bosch	LA/EJ90/12/2900/1.0 R2	
Generator output, max	135 W	
Generator output, continuous	90 W	
Starter motor output	1 h.p.	
Specific gravity of battery electrolyte:		
Fully charged battery	1.275 - 1.285	
When battery needs re-charging	1.230	
COOLING SYSTEM		
Engine	D1	D2
Type	Pressure	Pressure
Pressure valve opens at	1.2 - 1.3 kg/cm^2 (17 - 18 lb./sq. in.)	1.2 - 1.3 kg/cm^2 (17 - 18 lb./sq. in.)
Capacity	2.1 litres (1.8 Imp quarts = 2.2 US quarts)	3.5 litres (3.0 Imp quarts = 3.7 US quarts)
Thermostat:		
Type	Bellows thermostat	Wax thermostat
Starts to open at	75 - 78°C (167 - 171°F)	71°C (160°F)
Fully open at	90°C (195°F)	89°C (193°F)
Engine	MD1	MD2
Type	Sea-water cooled	Sea-water cooled
Thermostat:		
Type	Bellows thermostat	Bellows thermostat
Starts to open at	75 - 78°C (167 - 173 °F)	62 - 67°C (144 - 153°F)
Fully open at	90°C (195°F)	78°C (173°F)
REVERSE GEAR		
Type	Volvo Penta RB 1.87:1	
Reverse gear ratio, "ahead"	1.87:1	
Reverse gear ratio, "astern"	1.7:1	
Lubricating system	Same as engine	
Propeller type	Left hand thread	
WEAR TOLERANCES		
CYLINDERS		
To be re-bored when wear attains (or if engine has abnormally high oil consumption)	0.20 mm (0.008")	

CRANKSHAFT

Main bearing journals: Permissible out - of - round	0.06 mm (0.0024")
Main bearing journals: Permissible taper	0.05 mm (0.0020")
Big-end bearing journals: Permissible out- of - round	0.06 mm (0.0024")
Big-end bearing journals: Permissible taper	0.05 mm (0.0020")
Maximum axial clearance on crankshaft	0.35 mm (0.0140")

VALVES

Valve spindles, permissible wear	0.02 mm (0.0008")
Permissible clearance between valve spindle and valve guide:	
Inlet valves	0.15 mm (0.0060")
Exhaust valves	0.17 mm (0.0067")
The valve disc edge must be at least	1. 0 mm (0. 040")

CAMSHAFT

Bearing journals, permissible out - of - round with new bushings	0.03 mm (0.0012")
Bushings, permissible wear	0.05 mm (0.0020")

TIGHTENING TORQUE

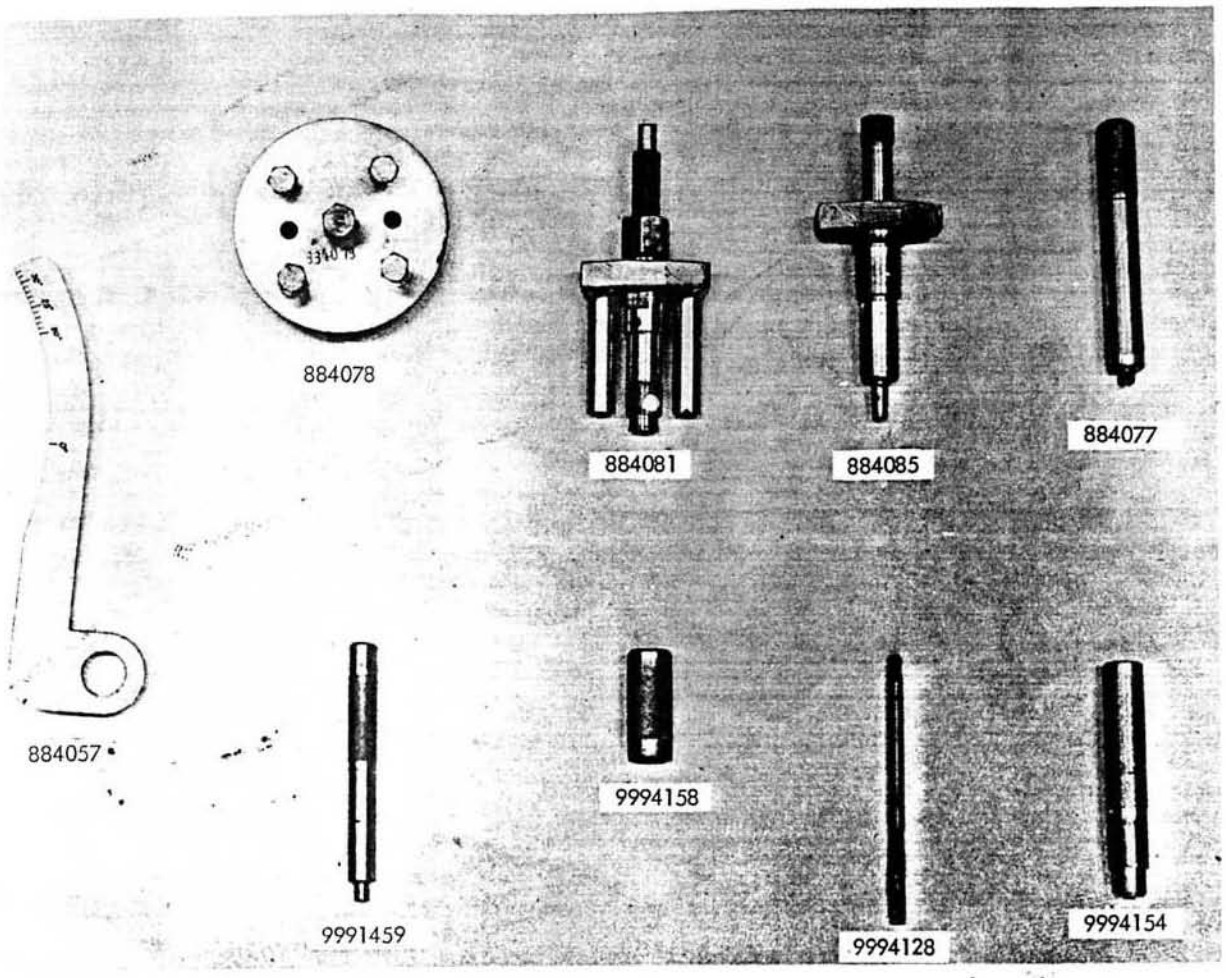
ENGINE

Cylinder head nuts	11 kgm (80 lb.ft.)
Centre bearing	8 kgm (60 lb.ft.)
Crankshaft gear bolts	8 kgm (60 lb.ft.)
Flywheel	70 kgm (500 lb.ft.)
Connecting rod bolts	6.5 kgm (47 lb.ft.)
Injectors	2 kgm (14 lb.ft.)
Oil filter nipple	4 kgm (30 lb.ft.)
Water pump flange	8 kgm (60 lb.ft.)
Main bearing cover	4.5 kgm (33 lb.ft.)

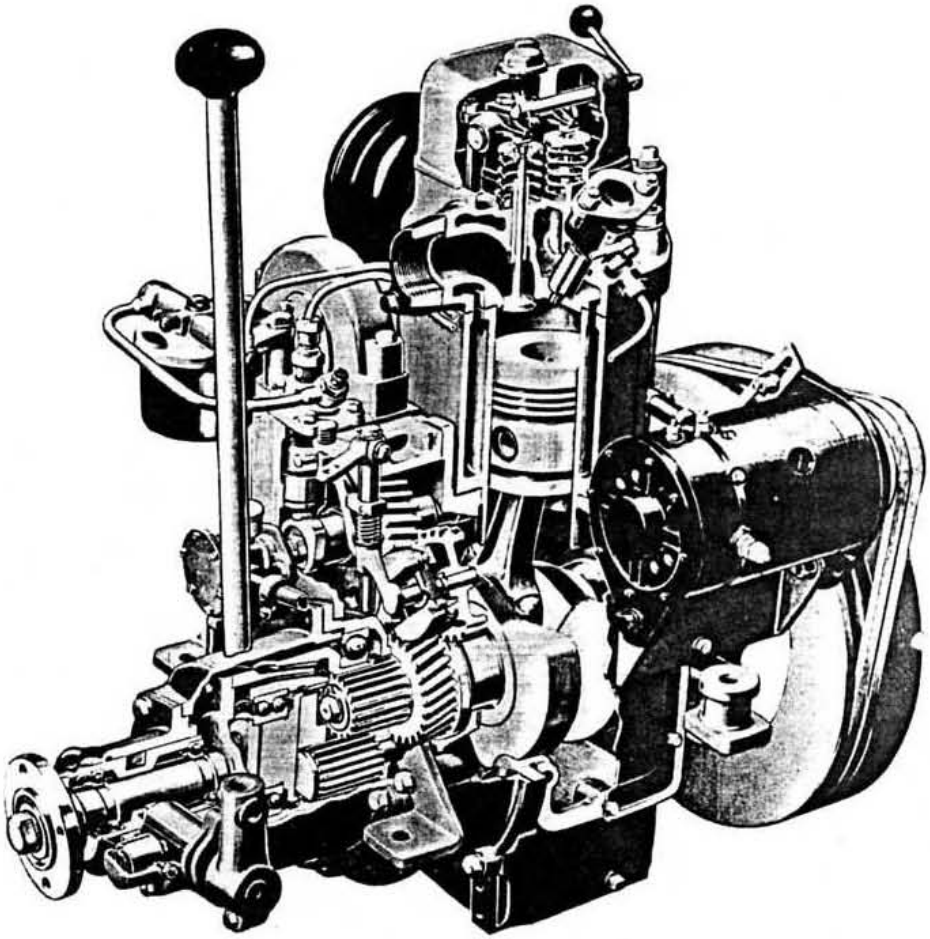
REVERSE GEAR

Bolt for clutch half	14 kgm (100 lb.ft.)

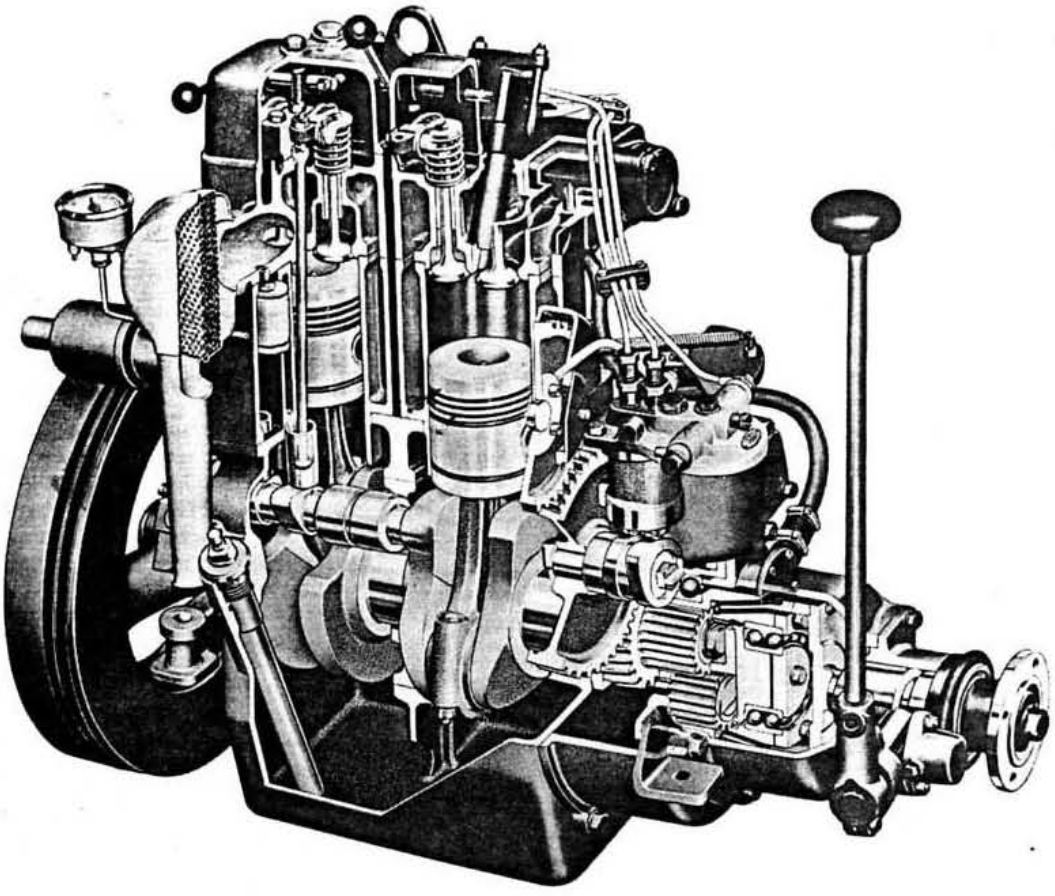
TOOLS



Part no.	Description
884047	Cleaning tool for injectors
884057	Control tool for injection angle
884077	Drift for fitting copper sleeve
884078	Puller for flywheel and crankshaft gear
884081	Puller for copper sleeve
884085	Spreader tool for copper sleeve
884200	Holder for cleaning needle
884201	Cleaning needle for injector
9991459	Drift for removing valve guide
9994128	Reamer for valve guide
9994154	Drift for removing and fitting rocker arm bushing
9994158	Drift for fitting valve guide



MD 1 Engine



MD 2 Engine

Notes

VOLVO PENTA
ENGINE: MDI-445CC

PG 34 - FUEL FILTER - BOSCH # FJSJ 32 U7
*PG 25 - AIR VENTING THE FUEL FILTER AND SYSTEM

PG 29 - WATER PUMP IMPELLER - #875807

PG 34 - OIL TYPE AND AMOUNT - SERVICE DS / SAE 20 / 1.5 LITRES

PG 35 - THERMOSTAT - BELLOWS 75° to 78°C (167-173°F)

CLEAN OIL SCREEN -

LUBRICATOR CUP (BEHIND WATER PUMP IMPELLER)

AB VOLVO PENTA
GOTEBORG SWEDEN

Printed in Sweden, Gotab, Surte 69.4725