Repair manual

MAN-Industrial Diesel Engines

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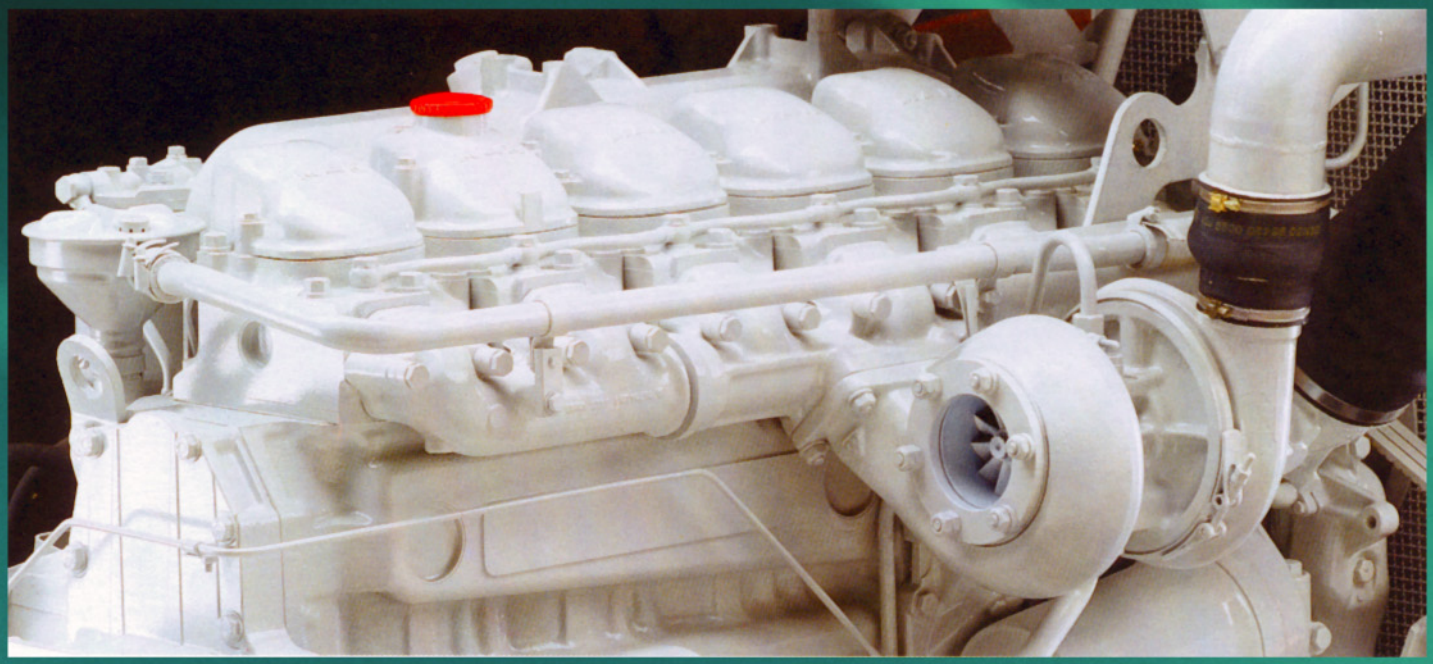

This Repair Manual is designed to facilitate proper repair of the engines listed here.

The pictures and associated descriptions show typical work that may not always be applicable to the engine in hand, which nevertheless does not mean that they are not correct.
In such cases, the repair work is to be planned and carried out in a similar way.

It is compulsory that the engine be removed before performing any of the work described in this Repair Manual.

The expert knowledge necessary for handling diesel engines was taken for granted when this publication was compiled.

Note:
Only use fuel, coolants and lubricants in accordance with MAN regulations, otherwise the manufacturer's warranty will not apply!
For basic information on the fuels see the publication "Fuels, Lubricants and Coolants for MAN Diesel Engines".
You can find the approved products on the Internet at:
–http://www.man-mn.com/ → Products & Solutions → E-Business–

Any repair of components such as injection pump, alternator etc. ought to be left to our or the manufacturer's service department.

Best regards
MAN Nutzfahrzeuge Aktiengesellschaft
Nuremberg Plant

Since our products are in continuous development, we reserve the right to make technical modifications.

MTDB Technical status: 03.2006 51.99598–8009

Important instructions concerning technical safety and personal protection are, as shown below, especially highlighted.

Danger:
This refers to working and operating procedures which must be complied with in order to rule out the risk to persons.

Caution:
This refers to working and operating procedures which must be complied with in order to prevent damage to or destruction of material.

Note:
Explanatory descriptions which help in understanding the relevant work or operating procedure to be carried out.

Fitting flat seals / gaskets

Gaskets are frequently used with sealants or adhesives as an aid to assembly or to achieve a better seal. Above all when parts with different levels of thermal expansion (e.g. aluminium and cast iron) are bonded, this can mean that the gasket is shifted during operation by the so-called stitching or sewing machine effect and leaks occur.

Example: The cap of the front crankshaft seal. If a sealing agent or an adhesive is used here the flat seal will move inwards in the course of time as a result of the different expansion rates of the materials. Oil will be lost, for which the shaft seal may be thought to be responsible.

Perfect assembly of gaskets can only be achieved if the following instructions are adhered to:

- Use only genuine MAN seals / gaskets.
- The sealing faces must be undamaged and clean.
- Do not use any sealing agent or adhesive – as an aid to fitting the seals a little grease can be used if necessary so that the seal will stick to the part to be fitted.
- Tighten bolts evenly to the specified torque.

Assembly of round sealing rings

- Use only genuine MAN round sealing rings.
- The sealing faces must be undamaged and clean.
- Always wet round sealing rings with engine oil before fitting them.

Masking of fuel and lube oil pipe connections (for classified engines only)

The unions of pressurised oil and fuel pipes are masked with a protective tape.
If this tape is removed during a repair, the unions must be masked with protective tape again afterwards.

The following pipes are affected:

- Oil supply pipe to turbochargers
- Fuel pipes between supply pump, filter and injection pump
- Injection pipes protected against leaks

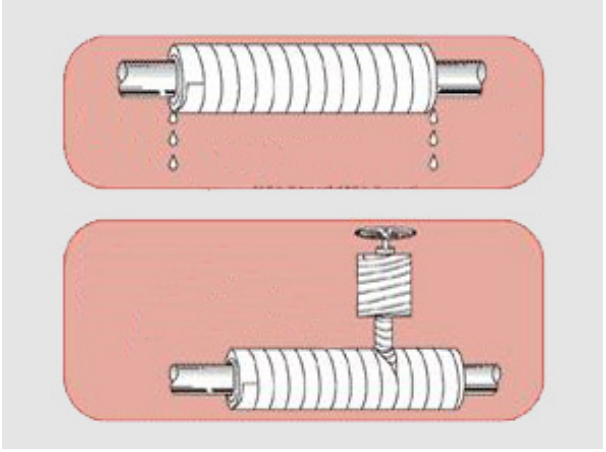

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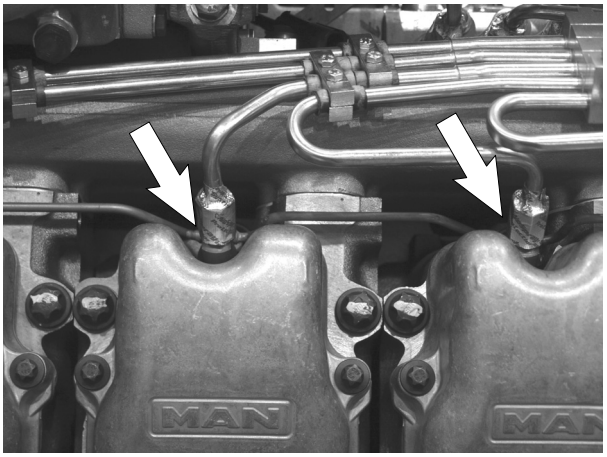
Fig. 1
A protective tape is wound around the unions. Ensure that there is 50 % overlap on every pass.



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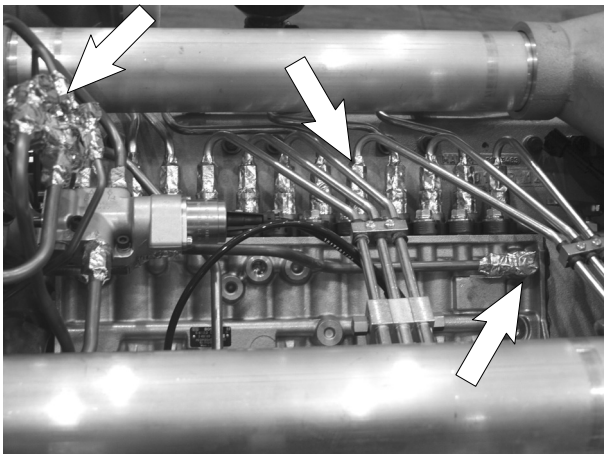
Figs. 2–4
The unions to be masked must be clean and free of oil and grease.
Do not apply the protective tape unless this is the case



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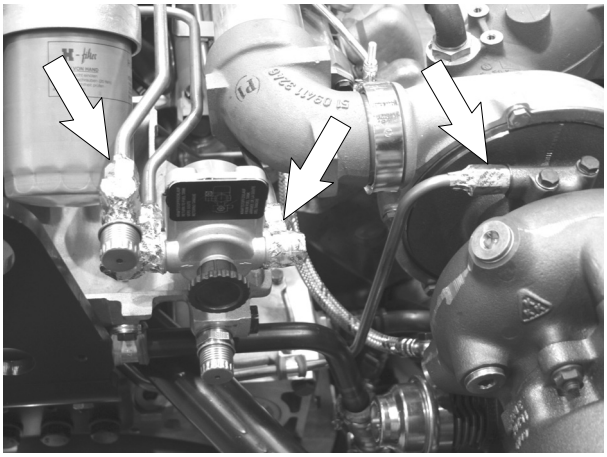


4

Contents

Page

General information

This brief overview summarises important instructions and is structured into areas of main concern in order to impart the knowledge necessary to prevent accidents involving injury to persons, damage to the engine or other property and harm to the environment. Additional notes are included in the operator's manual for the engine.

Important: If despite all safety precautions an accident occurs as a result of contact with caustic acids, penetration of fuel into the skin, scalding with hot oil, anti-freeze splashes into the eyes etc, ***consult a doctor immediately!***

1. Instructions for preventing accidents with injury to persons

Checks, setting jobs and repair work must be carried out by authorised skilled personnel only.

- When carrying out maintenance and repair work, ensure that the engine cannot be accidentally started from the bridge by unauthorised persons.
- The engine must be started and operated by authorised personnel only.
- When the engine is running, do not get too close to revolving components. Wear tight-fitting working clothes.

- Do not touch hot engine with bare hands: risk of burning yourself.

- Keep engine vicinity, ladder and steps free of oil and grease. Accidents resulting from slipping may have serious consequences.
- Work only with tools that are in good condition. Worn spanners slip: risk of injuries.
- Persons must not stand under an engine suspended from a crane hook. Keep lifting gear in good order.

- Open coolant circuit only after the engine has cooled down. If opening the coolant circuit while the engine is hot is unavoidable, observe the instructions in the chapter "Maintenance and care" in the Operator's Manual.
- Neither retighten nor open pressurised pipelines and hoses (lube oil circuit, coolant circuit and downstream hydraulic oil circuit if fitted): risk of injuries resulting from emerging fluids.

- When checking the injection nozzles, do not hold your hands in the fuel jet. Do not inhale fuel mist.

- When working on the electrical system, unplug earth cable from battery first and reconnect it last to avoid short-circuits.

- Observe the manufacturer's instructions for handling batteries.
  Caution:
  Battery acid is toxic and caustic. Battery gases are explosive.

- When carrying out welding work, observe the "Information sheets for welders".

2. Instructions for preventing damage to the engine and premature wear

- ***Prior to repairing the engine, clean it thoroughly. Ensure that dirt, sand or foreign matter will not get into the engine during repair work.***
- In the event of operational faults immediately identy the cause and rectify to prevent more serious damage.
- Always use genuine MAN parts only. Installation of "equally" good parts from other suppliers may cause severe damage for which the workshop carrying out the work is responsible.
- Never operate the engine while it is dry, i.e. without lubricant or coolant.
  Use a suitable label to mark engines not ready for operation.
- Only use operating materials (fuel, engine oil, antifreeze and anticorrosion agents) approved by MAN. Ensure that everything is kept clean. Diesel fuel must be free of water.
- ***Do not fill up with engine oil above the max. notch on the dipstick. Do not exceed the engine's maximum permissible operating inclination.***
  Non–compliance with these instructions may cause severe engine damage.
- Control and monitoring devices (charge check, oil pressure, coolant temperature) must work faultlessly.
- Observe the instructions for operating the alternator; see chapter "Commissioning and operation" in the Operator's Manual.

3. Instructions for preventing environmental damage

Engine oil and filter cartridges and elements, fuel/fuel filters

- Take old oil to an old oil disposal point only.
- Ensure without fail that oil and Diesel fuel will not get into the sewerage system or the ground.
  Caution:
  Danger of contaminating potable water!
- Treat filter elements and cartridges as special waste.

Coolant

- Treat undiluted anticorrosion and/or antifreeze agents as special waste.
- The regulations of the relevant local authorities are to be observed for the disposal of spent coolants.

4. Instructions for handling used engine oil *

Prolonged or repeated contact of any kind of engine oil with the skin causes the skin to degrease, which may result in dryness, irritation or inflammation. Old engine oil also contains hazardous substances which in animal experiments have caused skin cancer. Handling old engine oil does not pose any health hazard if the basic safety and hygiene related regulations are observed.

Health and safety regulations:

- Avoid prolonged, excessive or repeated contact of old engine oil with the skin.
- Use a suitable skin protection agent or wear protective gloves.
- Clean the skin that has been in contact with engine oil.
  - Wash yourself thoroughly with soap and water. A nailbrush is an effective aid.
  - Special hand cleaning agents facilitate cleaning soiled hands.
  - Do not use petrol, Diesel fuel, gas oil, fluxes or solvents as cleaning agents.
- After washing apply moisturising handcream to your skin.
- Change oil-soaked clothes and shoes.
- Do not put any oil-soaked cloths into pockets.

Pay meticulous attention to the proper disposal of old engine oil.
– Old oil is a water hazard –

Therefore, do not pour any old oil into the ground, the drains or the sewerage system. Any violation of this rule is punishable.

Collect and dispose of old engine oil properly. For information concerning collection points, contact seller, supplier or the local authorities.

* Based on the ”Merkblatt für den Umgang mit gebrauchtem Motorenöl” (Notes on how to handle old engine oil).

Very different factors have an influence on the life expectancy of an engine. For this reason it is not possible to give certain predetermined numbers of operating hours for basic overhauls.

Regular interim inspections and overhauls frequently carried out on large engines (e.g. on those from MAN Augsburg) are generally not necessary on MAN Diesel engines from the MAN Nuremberg works.

In our opinion, opening an engine or carrying out a basic overhaul is not appropriate as long as the engine achieves good compression values and the following operating values measured and recorded and have not changed significantly since commissioning:

- Charge-air pressure
- Exhaust-gas temperature
- Coolant and lube-oil temperature
- Oil pressure and oil consumption
- Formation of smoke

The following criteria have a major influence on the life expectancy of an engine:

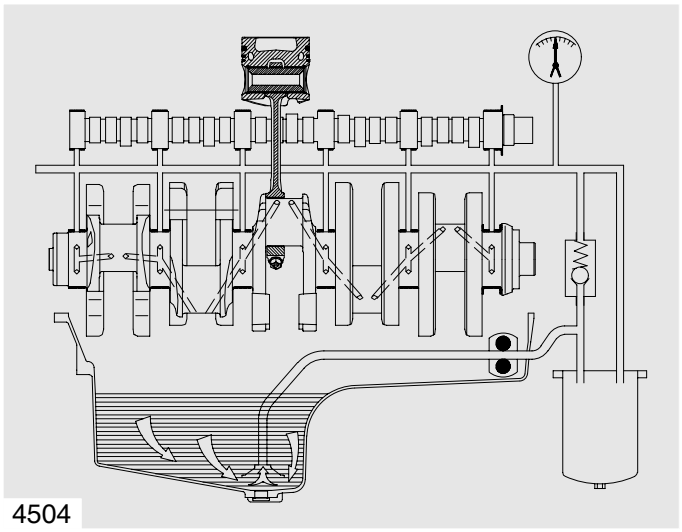
- Correct output setting according to the type of operation.
- Expert installation in accordance with the installation instructions.
- Inspection of the installation by authorized personnel.
- Regular maintenance as per maintenance plan in the Operator’s manual or in the Service Checklist.
- Selection and quality of lube oil, fuel and coolant as specified in the publication ”Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines”.

Pressurisation

It is of utmost importance that after completion of repair work, ie in the dry condition, internal combustion engines be pressurised with lube oil before being recommissioned. This procedure may also be used for ascertaining damage and the cause of it.

If engines are not pressurised, the risk of premature damage to bearing surfaces is very high, because it takes a relatively long period of time until the lube oil sucked in from the oil pan via the oil pump has reached the individual bearing points.

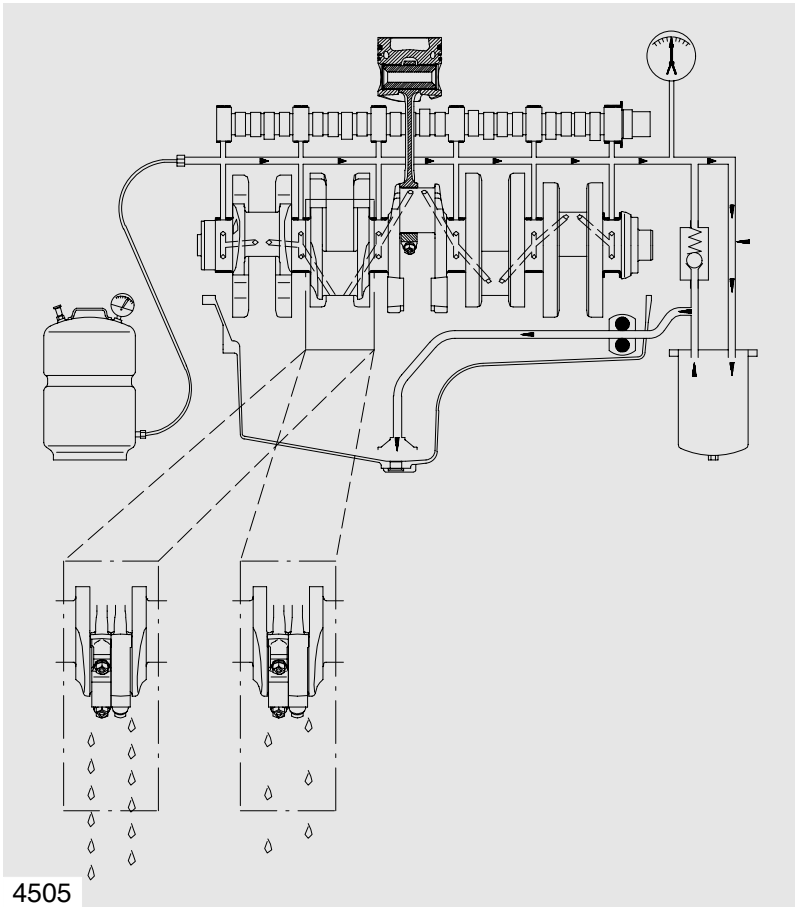
Such incipient damage need not necessarily lead to bearing failure, but may affect the functioning of bearings and shorten their service lives.



Schematic diagram of the flow of oil in non-pressurised engines (diagram shows a V-engine).

Pressurising an engine affords the following advantages:

- All engine parts are lubricated before engine start; inside the bearings a lubricating film can build up as early as after the first few turns of the crankshaft, which prevents damage to the bearing races.
- Loss of oil, be it the result of excessively large bearing play or leaks from the crankcase or from crankcase bores which may not be plugged, can be recognised immediately. For this purpose mount the engine on a dolly, take off the oil pan and install a suitable oil collector under the crankcase in such a way that the bearings are visible.



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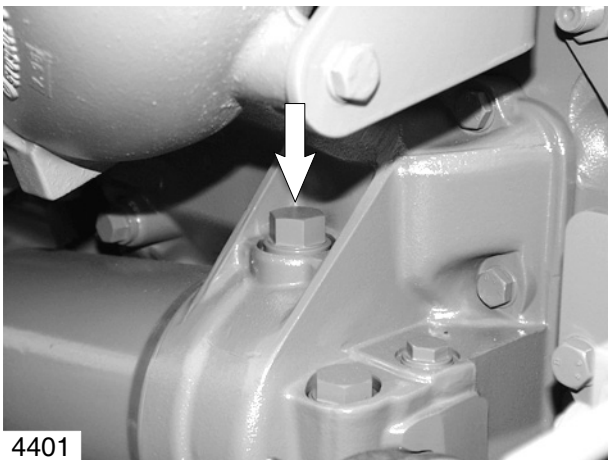
Execution of pressurisation:

At least 30 % of the overall oil quantity is pressed from the pressurisation container into the engine oil circuit. The operating pressure serves as a yardstick for the pressure to be injected. This must not be exceeded. The pressurisation container is connected up to the engine's oil circuit at the oil filter head (screw plug, arrow).



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Faults and possible causes

We recommend

Repair work is to be considered complete only after the damage which has occurred and the possible causes have been eliminated. Ascertaining the causes of damage is frequently more difficult than eliminating the damage caused. For this reason we recommend you have the operational fault exactly described to you before removal or disassembly work is commenced. Then, track down the probable causes by asking specific questions, examining and eliminating these causes one by one with the aid of the table ***and your own experience.*** This helps to reduce repairs to those necessary and counter complaints about ”premature” exchange of parts and expensive working and downtimes.

Remark:

The subsequent list is meant to be a memory aid so that no causes of damage will be overlooked in the elimination of faults. The precondition for this, however, is that you are familiar with the Repair Manual for the engine and the relevant Operator’s Manual as well as the publication ”Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines”.

Fault	Probable cause	Remedy (This column is filled in only if the ”probable cause” gives no clue as to what must be done).
Starter does not crank the engine or only too slowly	• Battery main switch in ”off” position • Batteries flat • Crankgear blocks • Battery cable connections loose or corroded • Starter electromagnetic switch sticking (clicks) • Cable connection from ignition lock to starter electromagnetic switch is loose or interrupted • Starter electromagnetic switch faulty • Starter defective (carbon brushes loose, winding faulty, short-circuit to earth) • Engine oil viscosity not suitable • Starter interlock relay defective	• Knock on the magnet • Check with check lamp • Check with check lamp • See ”Fuels, Lubricants ...” • Checking: Connect terminals 50e and 50f
Engine does not start	• Fuel tank empty • Fuel valve shut • Air in fuel system • Electro-hydraulic shut-off valve (EHAB) without current • Battery voltage at control unit is too low • Final controlling element does not move control rod • Speed pickup signal is inadequate • Fuel lines leaky, ruptured, clogged • Fuel filter / prefilter clogged • Suction height of fuel delivery pump (max. 1m) exceeded • Fuel delivery pump faulty • Air supply/exhaust gas pipes clogged • Unsuitable fuel • Delivery start incorrect • Valve clearance incorrect • Injection nozzles worn • Compression insufficient	For checking procedure see page 117 For checking procedure see page 117 For checking procedure see page 117
Engine does not start while cold	• Fuel filter clogged with paraffin • Engine oil viscosity unsuitable see: ”Engine does not start”	• See ”Fuels, Lubricants ...”

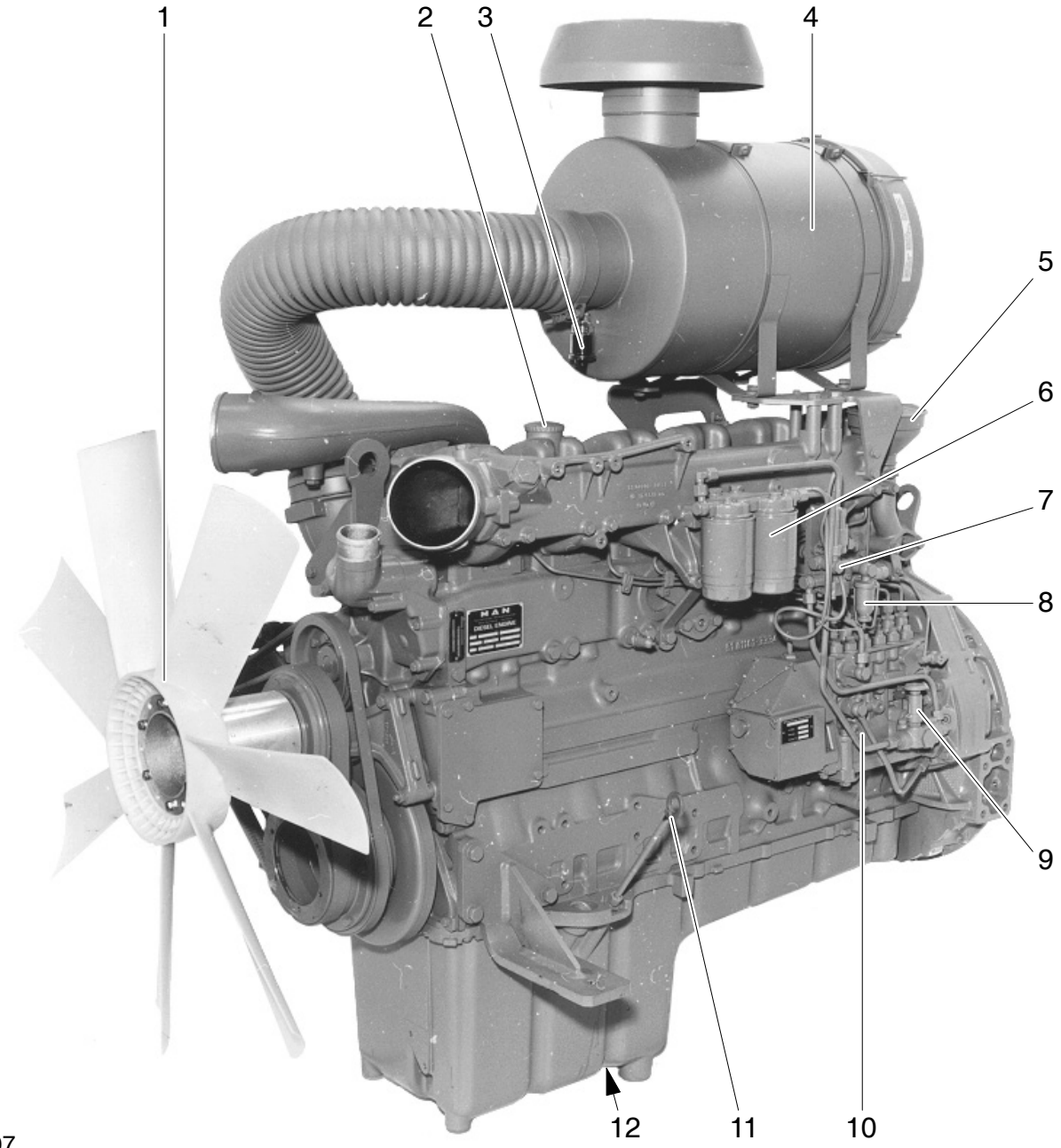
Engine does not run smoothly, and stops	• Lower idle speed set too low • Air in fuel system • Fuel lines leaky, ruptured, clogged • Fuel filter clogged • Inlet chamber pressure of injection pump too low • Fuel high-pressure part leaky • Injector needle sticking • Delivery start set incorrectly • Injection pump set incorrectly or defective • Valve clearance incorrect • Compression insufficient	
Speed fluctuations during operation Slow, periodic oscillating of speed (approx. 0.5 – 1 Hz) Quick periodic oscillating of speed (approx. 8 – 12 Hz)	• Air in fuel system • Fuel lines leaky • Fuel high-pressure part leaky • Injection nozzles defective, worn • Excessive friction in power transmission ”final controlling element – linkage – control rod” • Battery voltage too low • Force of final controlling element too low • Setting of the D proportion too small • Setting of the D proportion too large • Resonance vibrations in the drive / clutch	• Exchange final controlling element • See description of control unit • See description of control unit • Reduce sensitivity; see description of control unit
Engine cannot be switched off	• ”Final controlling element – control rod” transmission stiff / blocked	
Performance unsatisfactory	• Engine speed adjusting lever not in full-load position • Fuel temperature too high • Unsuitable, contaminated fuel • Fuel filter clogged • Air in fuel system • Lack of fuel • Temperature in engine room too high, combustion air and fuel too hot • Supply of combustion air insufficient, intake vacuum too high • Charge-air pipes leaky • Intercooler contaminated • Turbocharger contaminated or defective • Compression insufficient • Injection pump defective	• Route the fuel lines well apart from the hot engine parts • See ”Fuels, Lubricants ...” • Check fuel lines and delivery pump • Check inward and outward ventilation • Check intake air supply to air filters

Coolant temperature too high, coolant loss	• Coolant level too low • Air in coolant circuit • Proportion of anti-freeze / anticorrosion agent too high • Cap with working valves on expansion tank defective, leaky • Thermostat in closed position blocked • Radiator heavily contaminated • V-belt for water pump drive not correctly tensioned (slipping) • Water pump leaky, defective (bearing damage) • Coolant circuit clogged by foreign matter • Temperature indicator defective	• See ”Fuels, Lubricants ...”
Lube oil pressure varies/too low	• Oil level in oil pan too low • Oil level in oil pan too high • Max. inclination exceeded • Engine temperature too high • Oil viscosity unsuitable (viscosity too low) • Oil in oil pan too thin (mixed with condensation or fuel) • Heavy bearing wear • Oil pump gears heavily worn • Safety valve in oil circuit defective (does not shut, spring fatigued or broken) • Oil pressure gauge defective	• Dipstick marked correctly? See Operator’s Manual • See ”Fuels, Lubricants ...”
Lub oil pressure too high	• Engine cold • Oil viscosity unsuitable (viscosity too high) • Safety valve in oil circuit defective (does not open) • Oil pipes/oil galleries clogged • Oil pressure gauge defective	• See ”Fuels, Lubricants ...”
Lube oil consumption too high	• Leaks in the lube oil circuit, particularly at the turbocharger and oil cooler • Oil level in oil pan too high • Lube oil quality does not satisfy regulations • Turbocharger wear • Piston rings heavily worn • Valve guides heavily worn	• See ”Fuels, Lubricants ...” • Measure clearance of rotor
Fuel consumption too high	• Fuel quality does not satisfy regulations • Fuel leaks in the system • High power requirements by additional units (hydraulic pumps, compressors etc) • Delivery start set incorrectly • Injection pump set incorrectly or defective • Valve clearance incorrect • Intake vacuum / exhaust backpressure too high • Injection nozzles worn	• See ”Fuels, Lubricants ...”

Black smoke	• Lack of combustion air • Sudden full load after long low load or idling periods • Air filter contaminated • Leaks in air pipes downstream of compressor • Intercooler leaky, defective • Unsuitable fuel • Turbocharger defective • Delivery start set incorrectly • Injection nozzles defective, coked • Injection pump set incorrectly or defective • Exhaust backpressure too high	• See ”Fuels, Lubricants ...”
Blue smoke	• Engine coolant/intake air still too cold • Mainly low-load operation • Piston rings worn or broken • Valve guides worn • Crankcase breather clogged (overpressure in crankcase)	
White smoke	• Engine coolant / intake air still too cold (engine is idling during long periods) • Delivery start set incorrectly • Cylinder head gasket leaky/burned through • Fuel quality does not satisfy regulations • Injection nozzles defective • Injection pump set incorrectly or defective	• See ”Fuels, Lubricants ...”

Vibrations, droning noise, structure–borne sound	• Unsuitable engine mounts • Unsuitable clutch	
Engine knocks	• Engine in cold running phase • Delivery start set incorrectly • Injector needle sticking • High load at low speed • Fuel is slow to ignite • Compression too low	
Engine is too loud	• Intake or exhaust gas pipe leaky • Valve clearance too large • V-belt slipping • Timing gears worn, backlash of teeth too large	

Starter		
• Pinion does not turn or turns too slowly	• Battery insufficiently charged • Terminals loose or oxidised, poor earth connection • Terminals or carbon brushes have short-circuit to earth • Carbon brushes are stuck or have poor contact	
• Pinion does not engage	• Pinion or starter gear ring heavily contaminated or damaged	
• Pinion engages but stops	• Electromagnetic switch defective • One-way clutch slips	
• Pinion continues to run after starter switch has been released	• Starter switch defective • Electromagnetic switch defective	
• Pinion does not disengage after successful start	• Starter defective	• Switch off engine immediately
Alternator		
• Alternator check lamp does not come on when engine is stationary and starter switch is switched on	• Check lamp burnt out • Battery discharged • Terminal clamps loose or oxidised • Regulator defective • Short-circuit in alternator • Carbon brushes worn	• Change regulator • Repair in specialist workshop
• Alternator check lamp brightly ilumi-nated when engine is running	• Cable D+ has short-circuit to earth • Regulator defective • Rectifier damaged, slip rings dirty • V-belt slipping or cracked	• Change regulator • Repair in specialist workshop
• Alternator check lamp brightly ilumi-nated when engine is stationary, dimmer or glowing when engine is running	• Resistance in cable between alternator and battery is too high, terminal clamps oxidised • Regulator defective • Alternator defective	• Change regulator • Repair in specialist workshop
• Battery does not charge up	• Cable between alternator and battery interrupted • Battery defective • Alternator defective • V-belt slipping	• Repair in specialist workshop



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1 Fan

2 Oil filler neck

3 Air filter contamination gauge

4 Air cleaner

5 Crankcase breather

6 Fuel filter

7 Electro-hydraulic shut-off (EHAB)

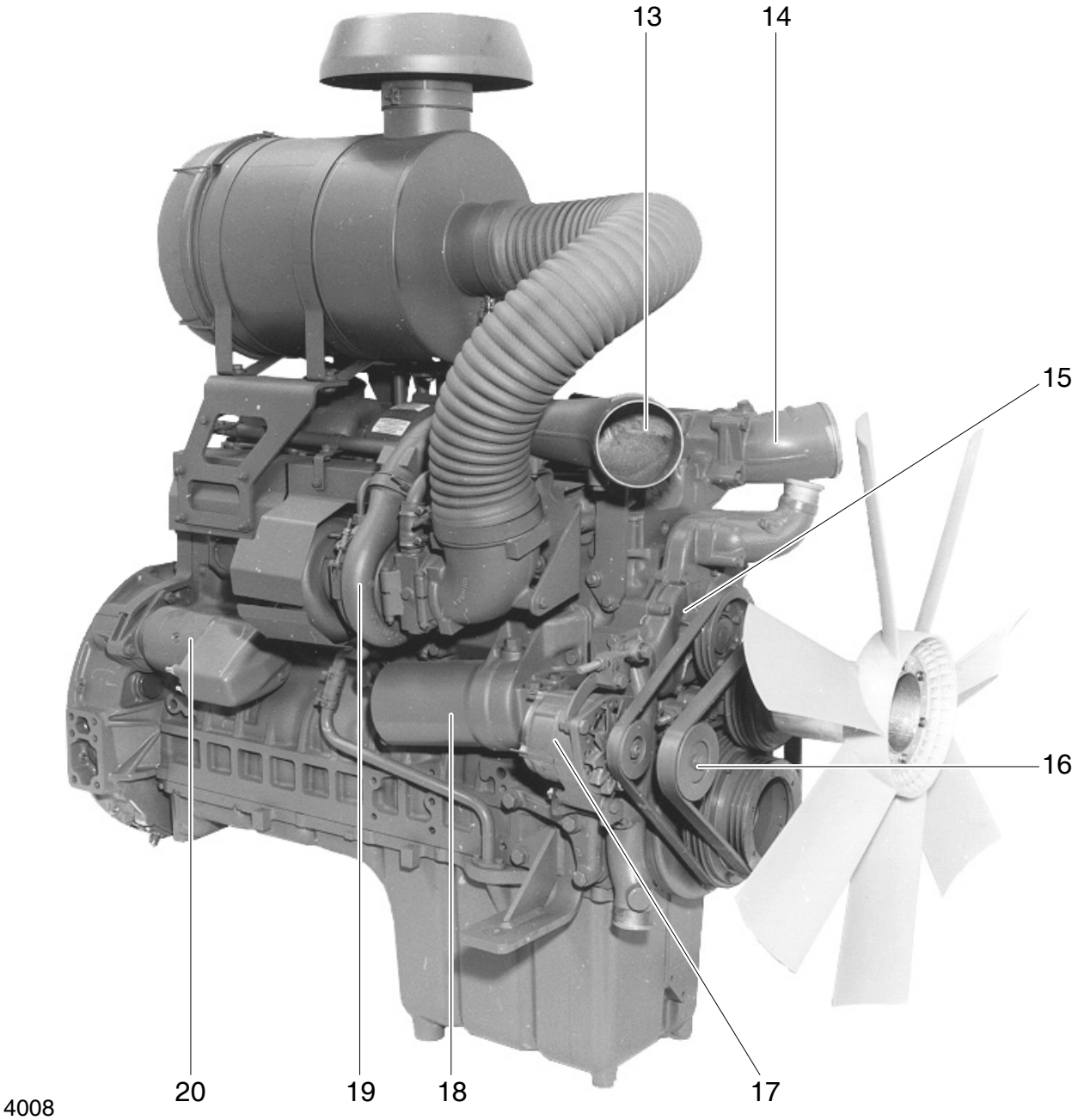
8 Fuel strainer

9 Fuel lift pump

10 Injection pump

11 Oil dipstick

12 Oil drain plug



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13 Combustion air pipe to intercooler

14 Combustion air pipe from intercooler

15 Water pump

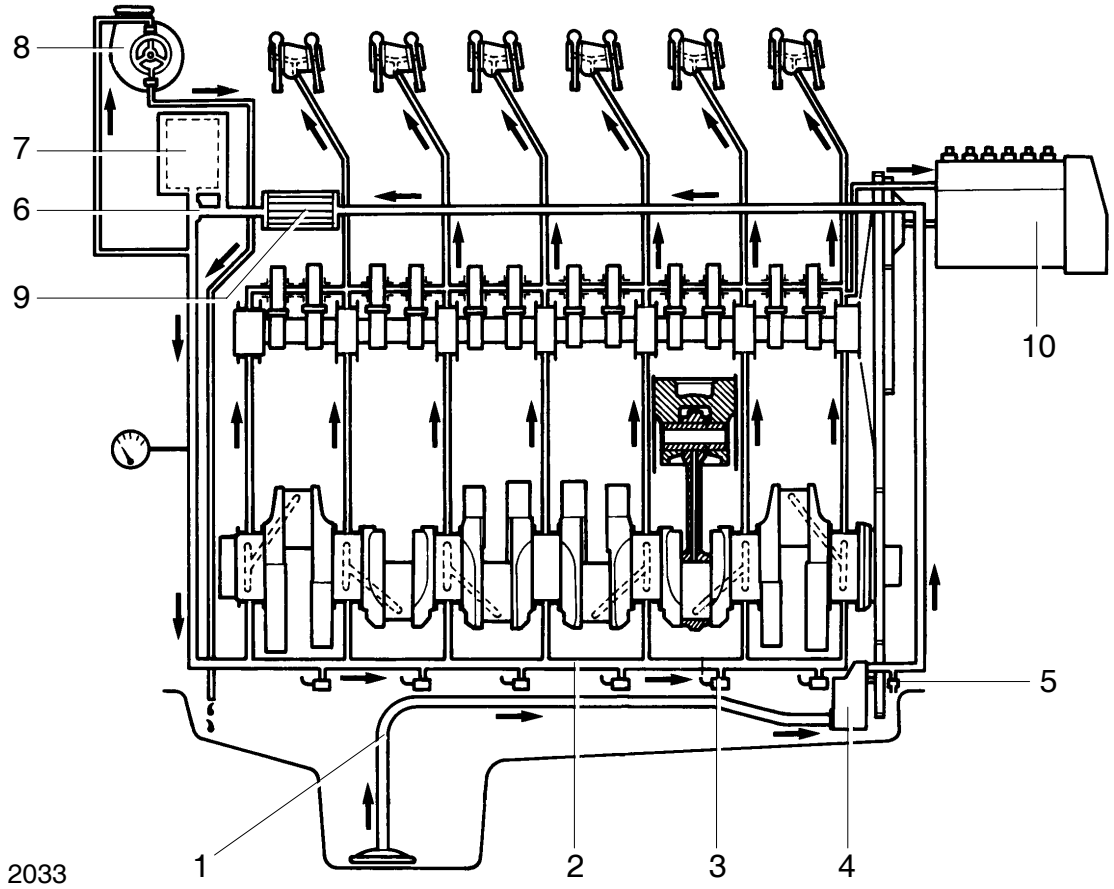
16 Tensioning pulley

17 Alternator

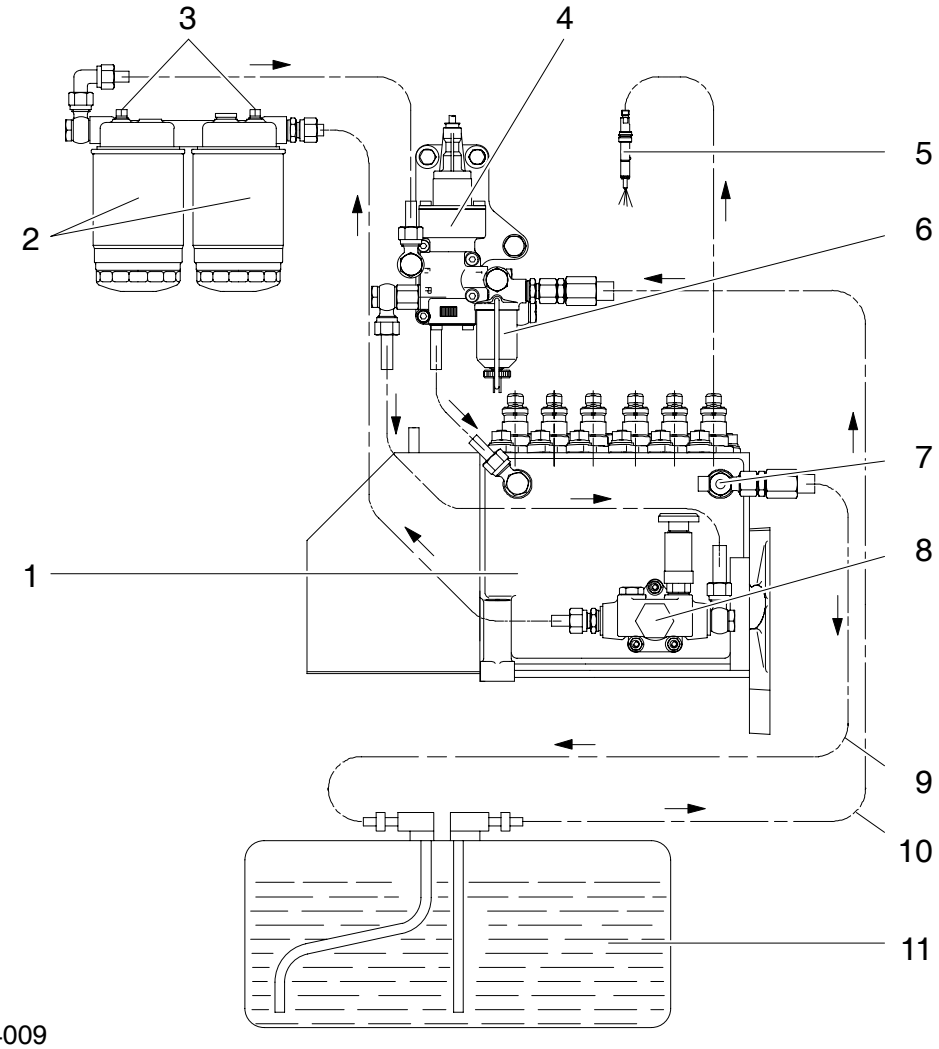
18 Oil filter

19 Turbocharger

20 Starter motor



1 Oil suction pipe
2 Distributor pipe
3 Oil spray nozzle
4 Oil pump
5 Oil pressure relief valve
6 Bypass valve
7 Oil filter
8 Turbocharger
9 Oil cooler
10 Injection pump



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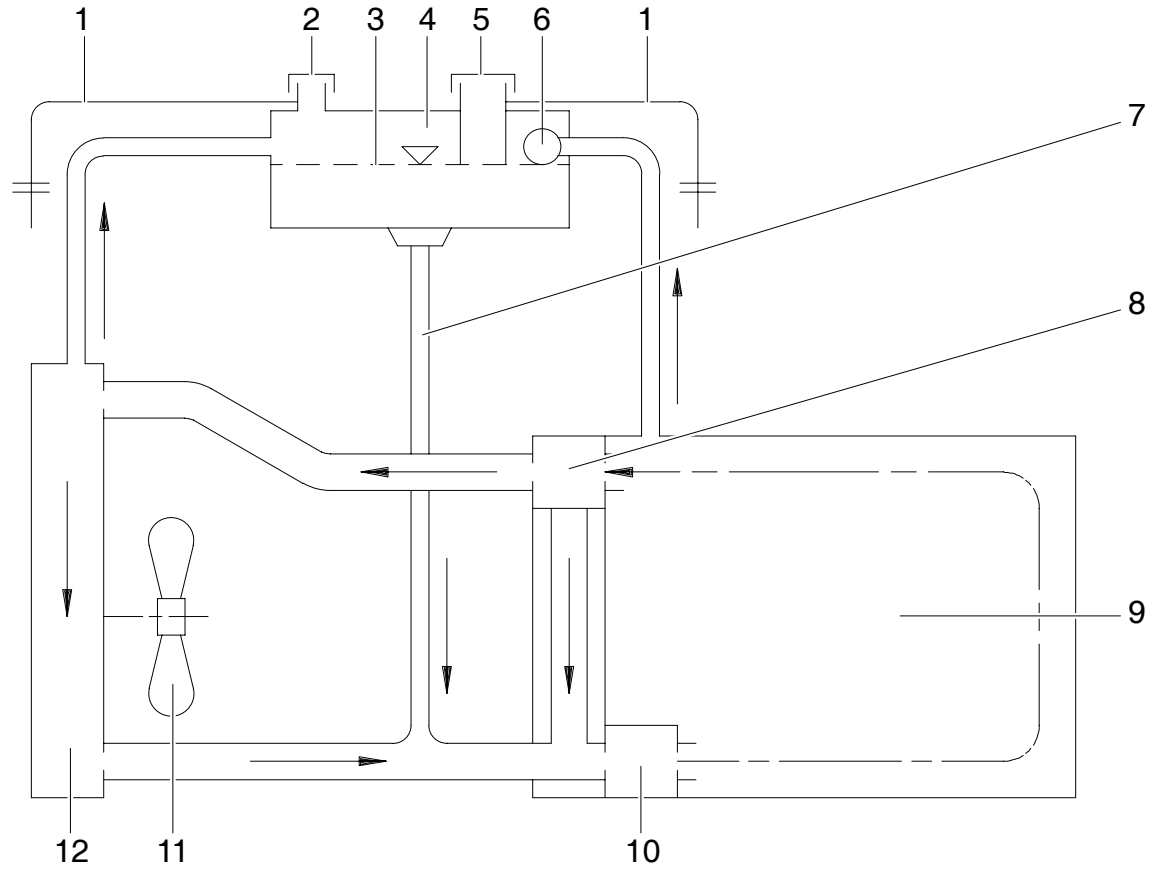
1 Injection pump
2 Fuel filter
3 Bleed screws
4 Electro-hydraulic shut-off (EHAB)
5 Injector
6 Fuel strainer
7 Overflow valve
8 Fuel lift pump
9 Return line
10 Suction line
11 Fuel tank



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1 Overflow and vent pipe
2 Positive pressure / negative pressure valve
3 Coolant level in surge tank
4 Surge tank
5 Coolant filler neck
6 Degassing system
7 Filler pipe
8 Thermostat
9 Engine / crankcase
10 Water pump
11 Fan
12 Radiator / intercooler

Checking start of delivery

Fig. 1

The speed pickup is fitted to the bottom right-hand side of the flywheel housing. Remove the mounting bolts from the retaining plate and take it off together with the speed pickup.

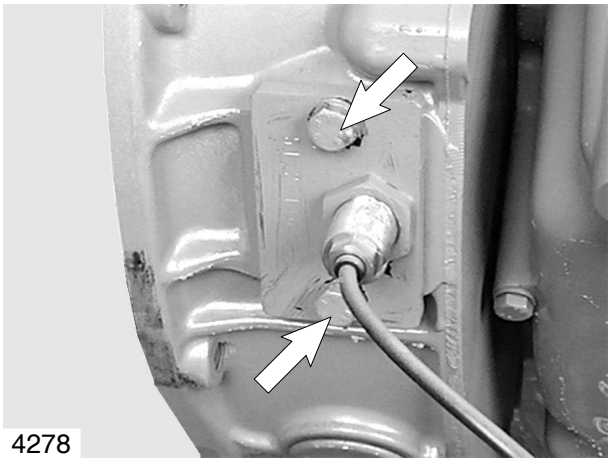

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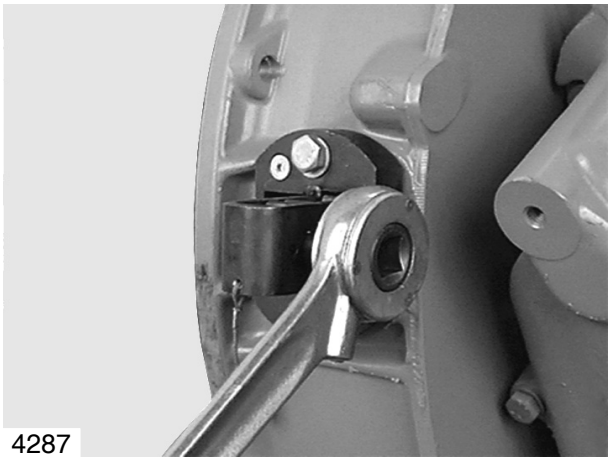
Fig. 2

Fit cranking device (standard ratchet, special tool).

Turn engine to ignition TDC.

In 6-cylinder engines cylinder 1 is at ignition TDC if the valves of cylinder 6 are in crossover. To check this, take valve cover off this cylinder.



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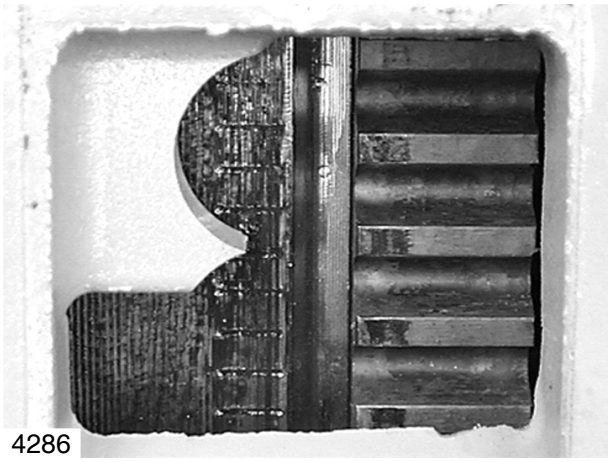
Figs. 3 and 4

The picture shows the graduated scale on the flywheel and the counter-marking visible when the cranking device is removed.

When the cranking device is fitted, the graduated scale is visible through the inspection hole in the base plate of the cranking device.

Turn engine to specified start of delivery (see ”Engineering • Data • Setting values”).

Note:
Turn engine only in sense of rotation (ie anti−clockwise − as viewed in relation to flywheel) until specified start of delivery is reached.
If engine is turned beyond start of delivery, turn it back by some degrees and repeat procedure.



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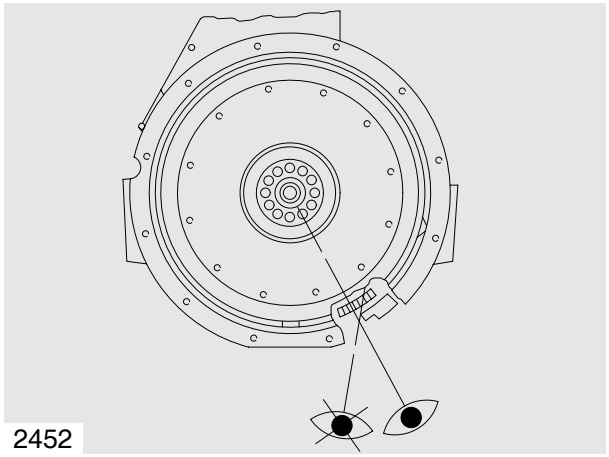

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Fig. 5

Remove screw plug for inspection hole in mounting flange of injection pump.

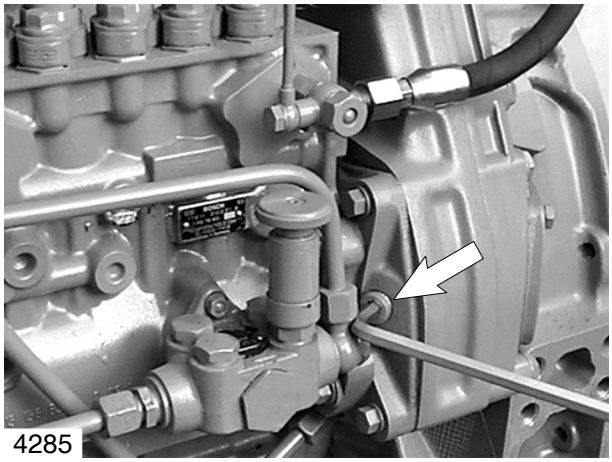

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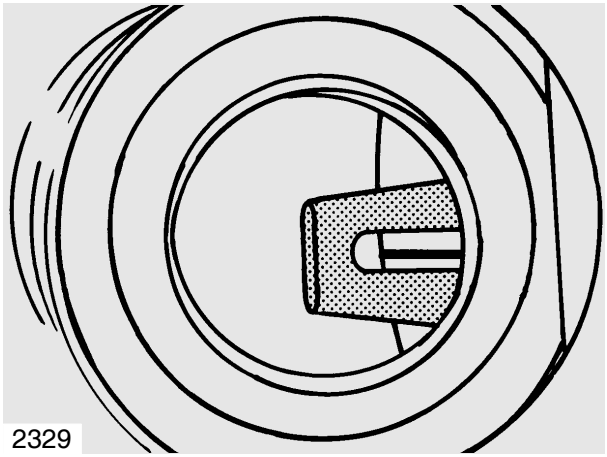
Fig. 6

The start of delivery is set correctly if the marking in the long hole of the pointer is visible.

If the inspection should reveal that start of delivery is set incorrectly, proceed as follows:

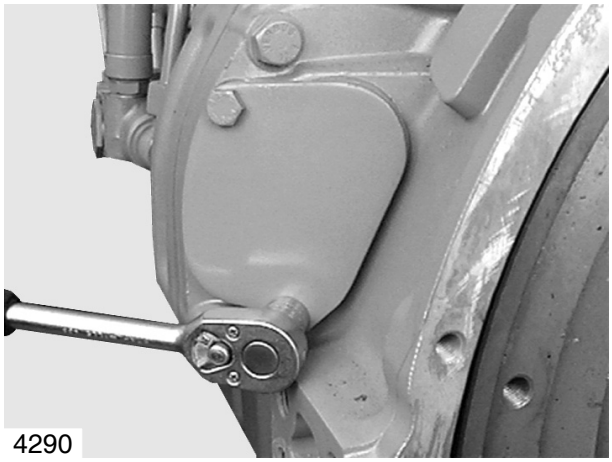


6 2329

Adjusting start of delivery

Fig. 7

Remove timing case cover.

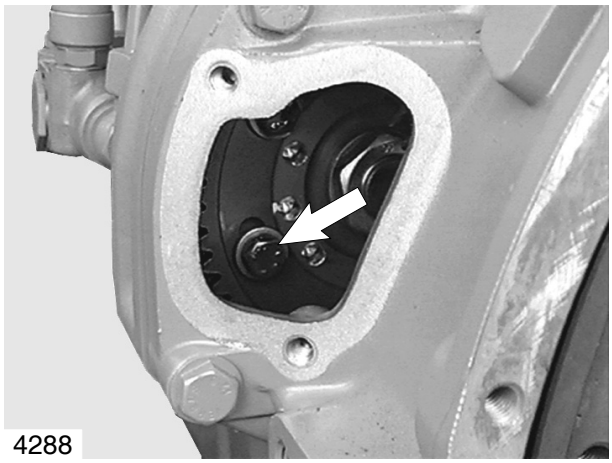


7 4290

Fig. 8

Loosen all bolts fastening the drive gear to the injection pump hub. For this, two complete turns of the engine are necessary.

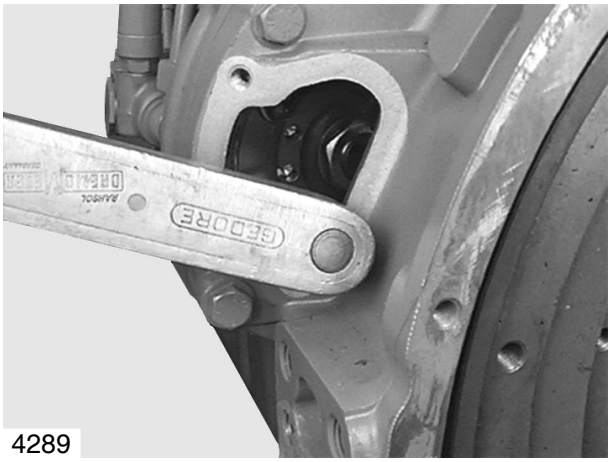
Turn the injection pump camshaft at the drive flange either to the left or right until the marking reaches the position shown in Fig. 6.



8 4288

Fig. 9

Tighten bolts for fastening drive gear to drive flange consecutively to 5 Nm and then to 30 Nm.
Check delivery start once again.
Close timing case.



9 4289

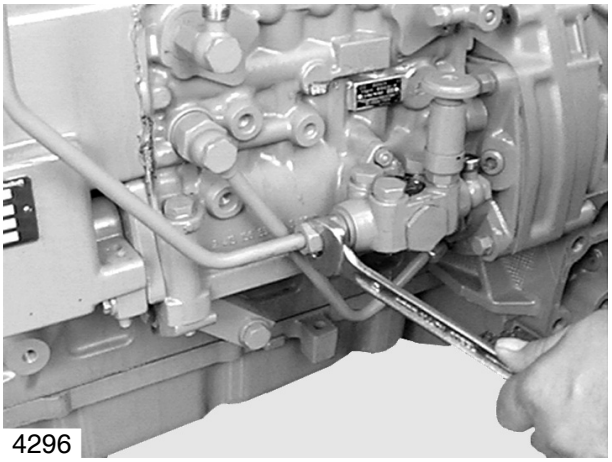
Removing injection pump

- Close cut-off valve from fuel tank to engine.

Note:
The subsequent reinstallation of the injection pump is rendered considerably easier if before its removal the engine has been turned to start of delivery. See chapter “Adjusting start of delivery” on page 25.

Fig. 1

Remove all fuel lines from injection pump.



1 4296

Caution:
The lines contain fuel.
Catch emerging fuel in a suitable container.

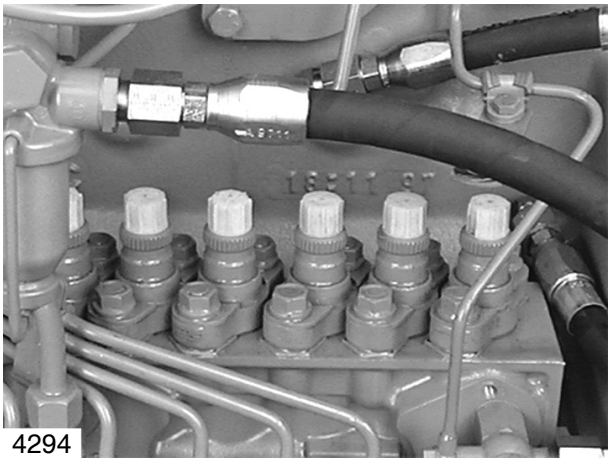
Fig. 2

Remove injection-lines.

2 4295

Fig. 3

After removal of the injection lines we recommend fitting caps to the connections on the injection nozzles and injection pump.
This prevents dirt from getting into the injection system.



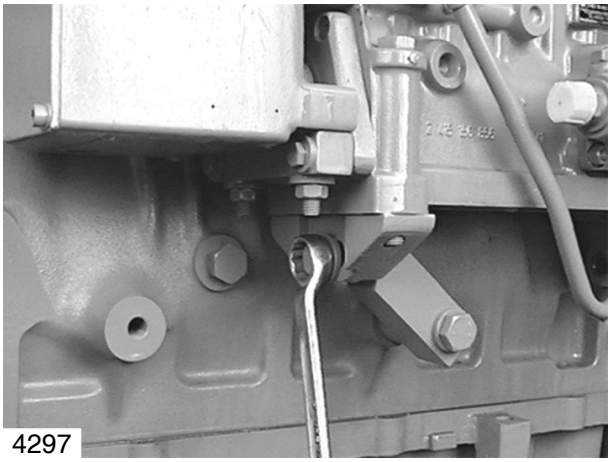
3 4294

Caution:
Dirt in the injection system causes:

- nozzles to jam
- the injection-pump drive gear to break

Fig. 4

Remove holders from injection pump.



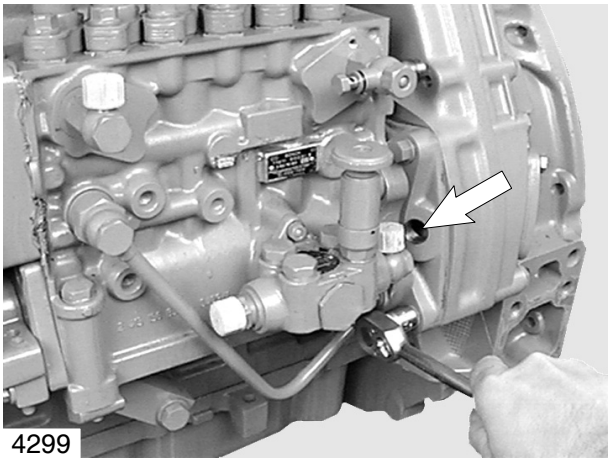
4 4297

Fig. 5

Remove the mounting bolts from the injection pump flange.

The screw plug for the inspection hole in the mounting flange of the injection pump (arrow) is removed.

Note:
For reasons of space the mounting bolt between the injection pump and the crankcase (hexagon M10 bolt with reduced head 13 mm) can be reached only with a 3/8” socket and an extension.



5 4299

Take off injection pump.

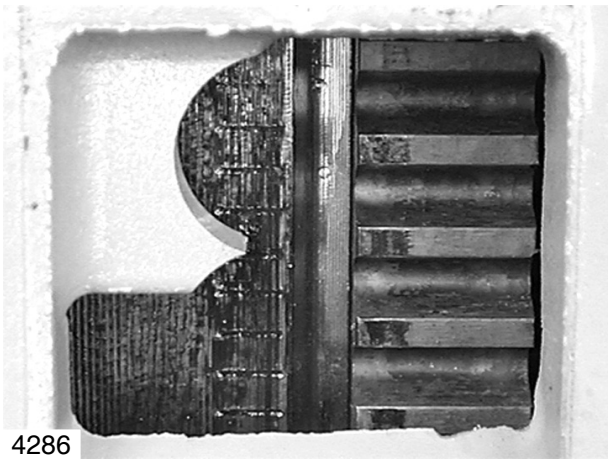
Note:
Ensure meticulous cleanliness when working on the injection pump.
Prevent dirt and foreign matter from penetrating into opened line connections.

Installing injection pump

Fig. 6

Check whether engine is at start of delivery.

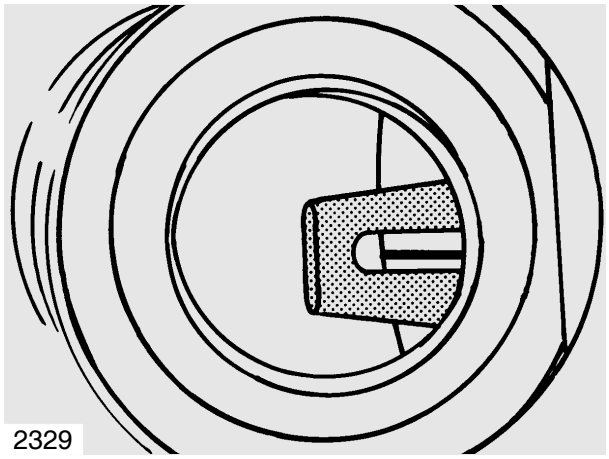
The start of delivery of individual engines is indicated in the publication ”Engineering • Data • Setting values”.



6 4286

Fig. 7

Check whether the injection pump is in delivery start position. To do this, remove the screw plug from injection pump flange (see Fig. 5). The delivery start pointer must be visible in the centre of the inspection hole.



6 2329

Fig. 8

Remove the mounting bolts from the injection pump drive gear so that it can be turned in the slots.

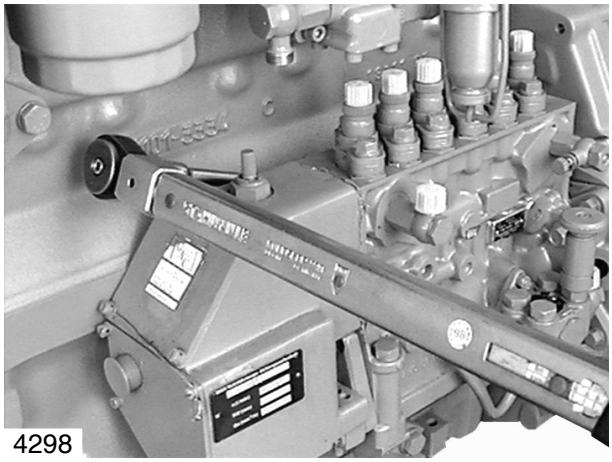
Hold injection pump camshaft in place while turning the gear.

Fit new O-ring (slightly coated with oil) to injection pump flange.

8 3400

Fig. 9

Insert the injection pump and tighten the mounting bolts.



9 4298

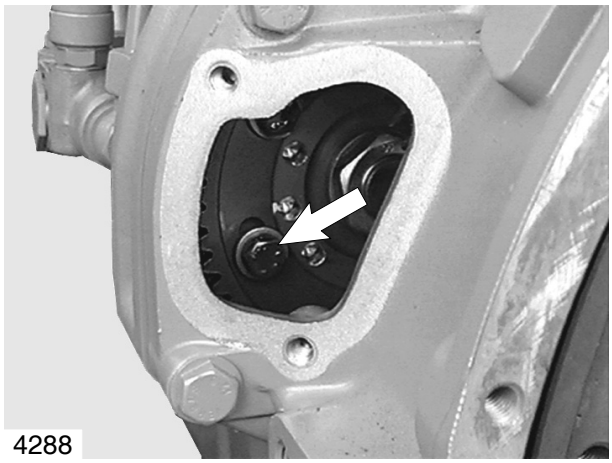
Fig. 10

Apply an initial torque of 5 Nm to all mounting bolts on the gear through the inspection hole. Two complete engine turns are necessary for this operation.

Now tighten all mounting bolts to 30 Nm.

Check delivery start, if necessary readjusting it (see page 25).

Screw screw plug into mounting flange of injection pump.



10 4288

Caution:
Comply with instructions for masking unions on pressurised oil and fuel pipes (see page 3).

Removing fuel injectors

Fig. 1

Remove injection lines and leakage fuel return lines.

1 4295

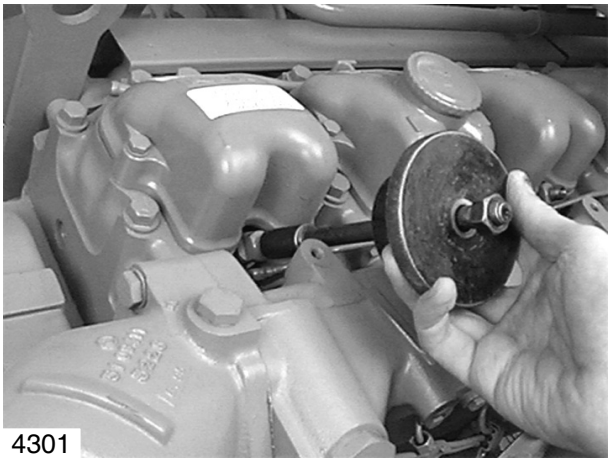
Fig. 2

Remove pressure screw from fuel injector using a pin spanner.

2 4300

Fig. 3

Bolt inertia puller on to fuel injector and knock out the injector.



3 4301

Fig. 4

Take out injector and injector seal.

Check and repair injector.

4 4302

Installing fuel injectors

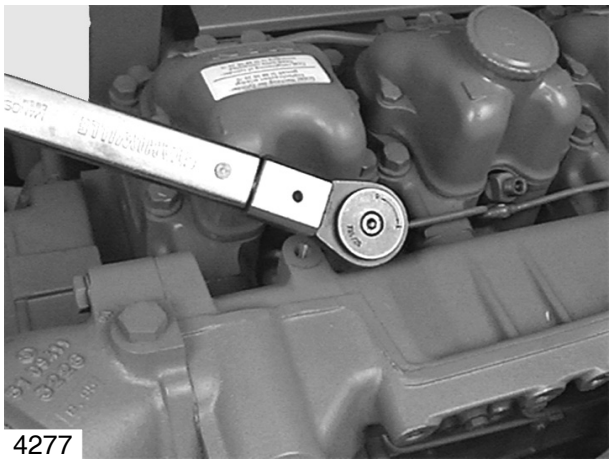
Fig. 5

Apply ”Never Seeze” to contact areas of injector.
Screw in injector with new seal.

5 4273

Fig. 6

Screw on union nut and tighten to specified torque.
Connect up injection lines and leakage fuel return lines.
Tighten pressure pipes to injector and injection pump with specified torque
(see “Engineering • Data • Setting values”.



6 4277

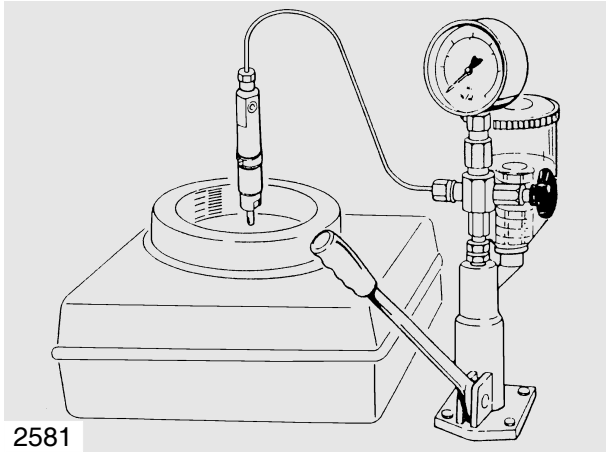
Caution:
Comply with instructions for masking unions on pressurised oil and fuel pipes (see page 3).

Checking fuel injectors

Fig. 1

The nozzle tester (manual test stand) is used to check the
- opening pressure
- tightness
- spray pattern of the injection nozzle.

Use pure testing oil or pure Diesel fuel for the test. Prior to testing, clean nozzle and check it for wear.



1 2581

Fig. 2

Check injector assembly.
Connect the nozzle's supply connection to the test unit's pressure line.

Danger:
The high opening pressure may lead to severe injuries. Do not place hands under the jet. Wear safety goggles.

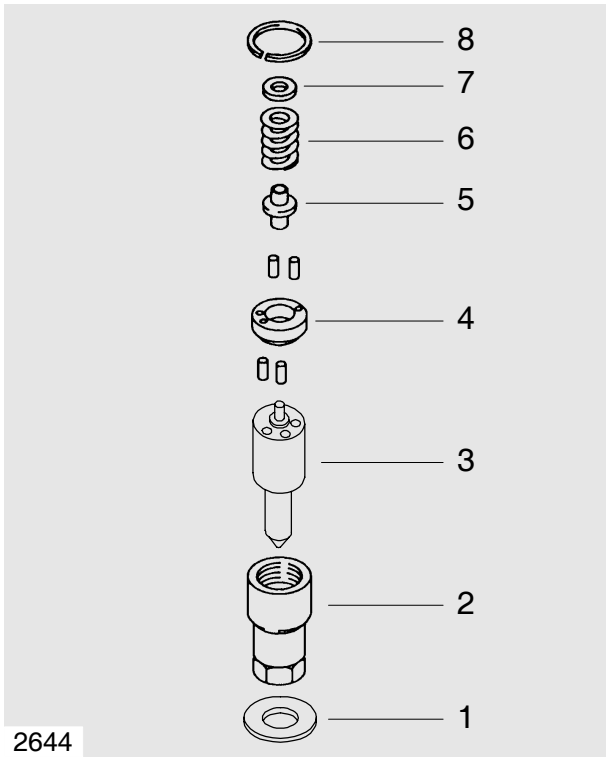
1. Checking opening pressure:
Switch on the pressure gauge and slowly press lever downwards until the nozzle emits a jet with a light grating noise.
Read **opening pressure** from the pressure gauge. In the event of a pressure deviation insert a different shim. If the pressure is too low, insert thicker shims, if it is too high, insert thinner shims (7). The initial tension of the compression spring (6) decreases if a high number of operating hours has been clocked up. Consequently, the injection pressure drops slightly. When repairing injection nozzles, always set the opening pressure to the upper limit (+ 8 bar).

Note:
Shims are available in 0.05 mm steps from 1.0 mm to 1.98 mm.

2. Checking tightness:
Actuate hand lever. At a pressure of 20 bar below the opening pressure set not a single drop must fall from the nozzle opening within 10 sec.

3. Checking jet:
Switch off pressure gauge and carry out some swift strokes. The nozzle must emit an audible grating noise and/or a well-atomised jet.

Nozzles that satisfy these three requirements can be reused.



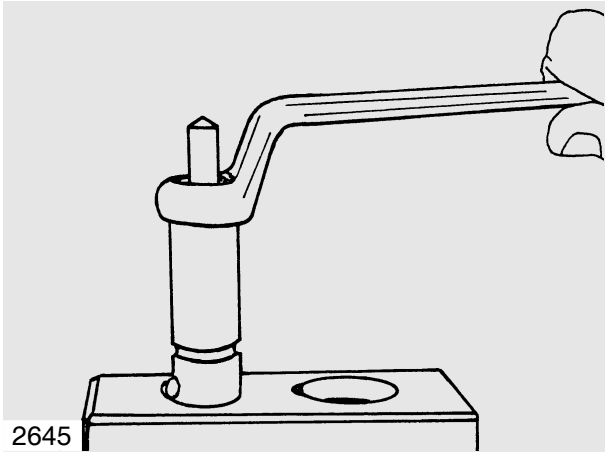
2 2644

1 Seal
2 Nozzle tension nut
3 Injection nozzle
4 Intermediate washer
5 Pressure pin
6 Compression spring
7 Shim
8 Circlip

Disassembling fuel injectors

Fig. 3

Insert injector assembly (the inlet orifice facing downwards) into the clamping device and hold in a vice. Remove union nut and take out nozzle body, intermediate washer, pressure pin, compression spring and shim. Take pressure pipe neck out of holder.



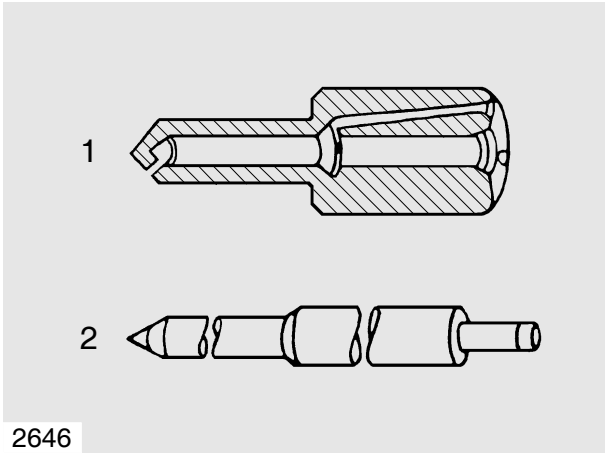
3 2645

Repairing fuel injectors

Fig. 4

Clean interior of injection body (1) with a small wooden stick and petrol or Diesel fuel.
Clean nozzle needle (2) with a clean cloth.

Note:
To prevent corrosion, do not touch lapped faces of nozzle needle with the fingers. The needle and injection nozzle are matched to each other and must not be interchanged.



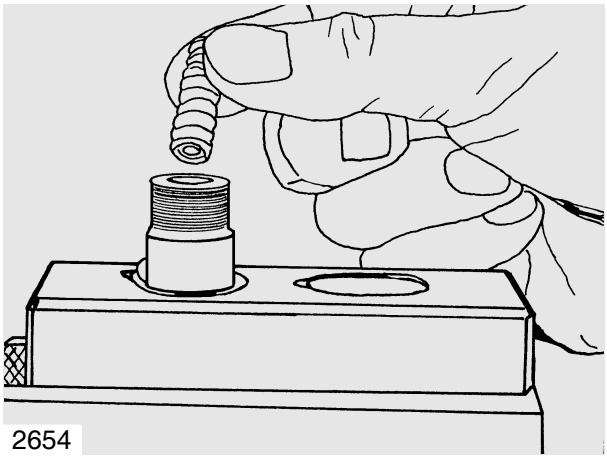
4 2646

Check cleaned parts for wear and damage, replacing them if necessary. De-grease new parts.

Assembling fuel injectors

Fig. 5

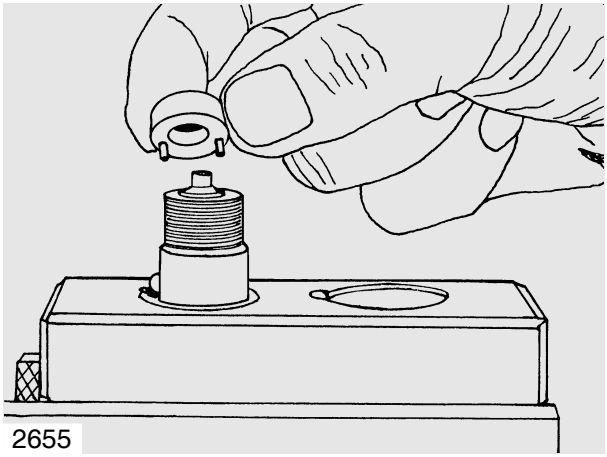
Insert pressure pipe neck into clamping device. Insert shim and compression spring.



5 2654

Fig. 6

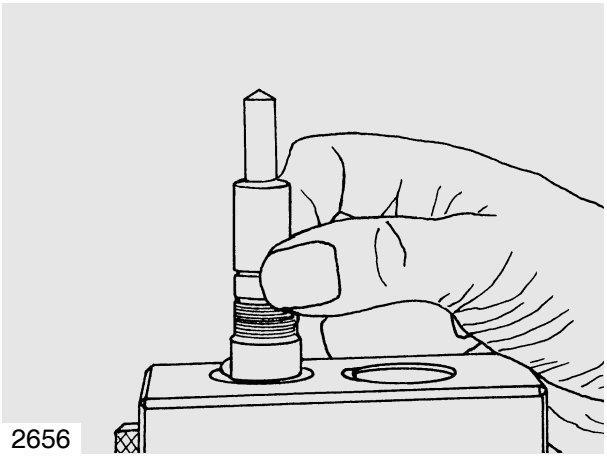
Insert pressure pin and intermediate washer.



6 2655

Fig. 7

Dip nozzle body and nozzle needle separately into filtered Diesel fuel and check their gliding quality. When pulled out of the nozzle body by up to a third of its length the nozzle needle must sink back to its seat under its own weight when released. Place injection nozzle on top, ensuring that the associated pins are correctly fitted.

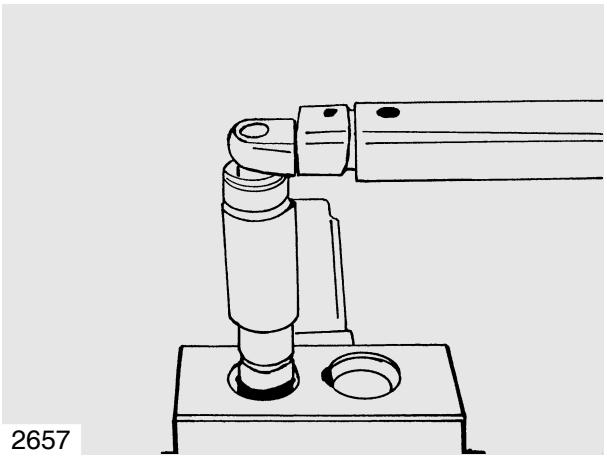


7 2656

Fig. 8

Screw on union nut, tightening it to the specified torque.
Check injector on the manual test stand.

Ensure that the edge-type filter is correctly seated in the injector body.



8 2657

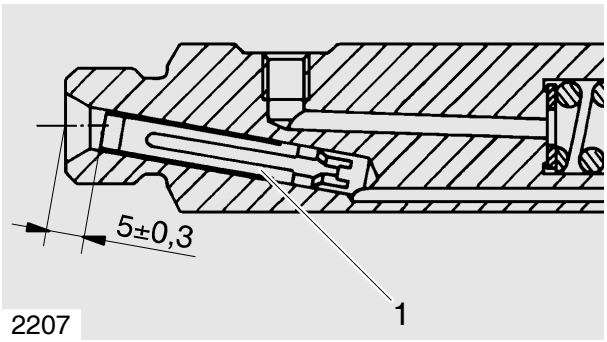
Fig. 9

A dislocated sieve bar filter throttles and prolongs the injection and consequently causes poor performance, high consumption and heavy smoke formation in conjunction with heavy engine vibrations.

For this reason measure the rim offset of the sieve bar filter in the nozzle inlet.

The sieve bar filter must not be pressed into the nozzle holder farther than approx 5 mm.

In the event of larger rim offsets, the nozzle holder is to be replaced.



9 2207

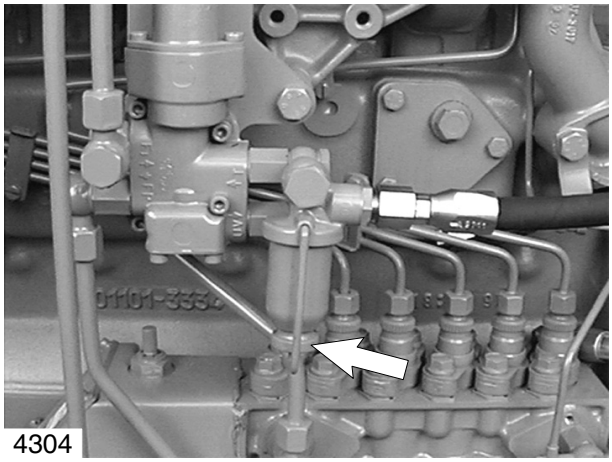
Cleaning fuel prefilter

- Shut cut-off valve from fuel tank to engine.

Fig. 1

Remove round nut and take off filter housing with sieve.

Use a bowl to catch fuel that may emerge.

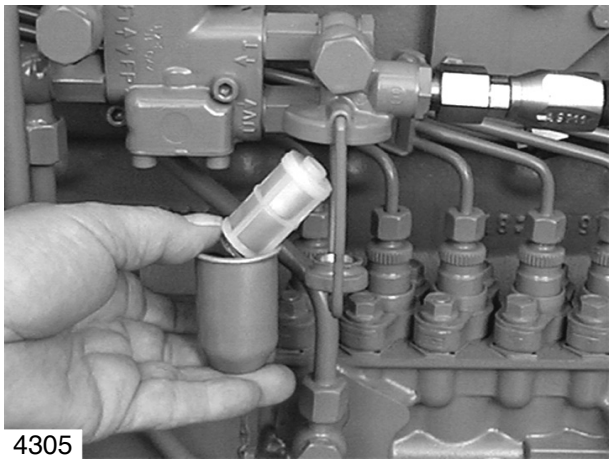


1 4304

Fig. 2

Wash out filter housing and gauze filter in clean Diesel fuel and blow them out with compressed air.

Reassemble fuel prefilter using new seal.



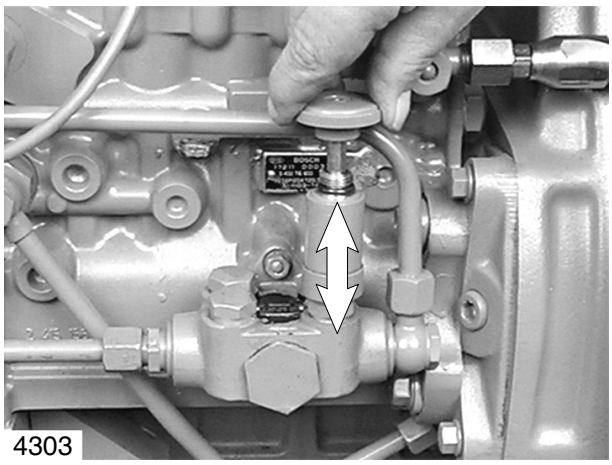
2 4305

Fig. 3

Actuate plunger of hand priming pump until the overflow valve of the injection pump opens audibly.

Check fuel pre-filter for leaks while engine is running.

Note:
When bleeding the fuel system switch on the electromagnetic shut-off valve (EHAB) without fail (ignition on), as otherwise fuel cannot reach the injection pump suction gallery / suction chamber.
Wiring diagram see page 120.

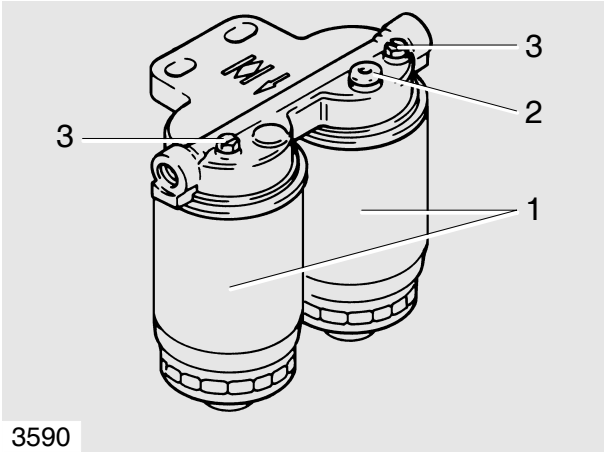


3 4303

Changing fuel filter cartridge

Fig. 1

1 Disposable filter
2 Screw plug
3 Bleed screw

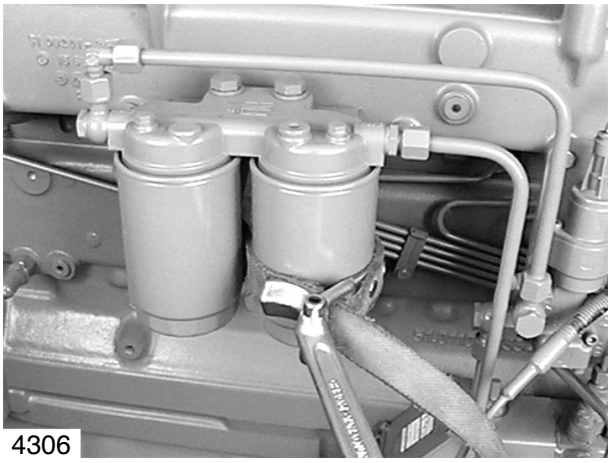


3 3590

Bild 2

Use tape wrench to loosen filter cartridge and remove cartridge by hand. Fit a new seal.

Lightly coat seal on the filter cartridge with fuel. Screw on filter cartridge and firmly tighten it by hand.

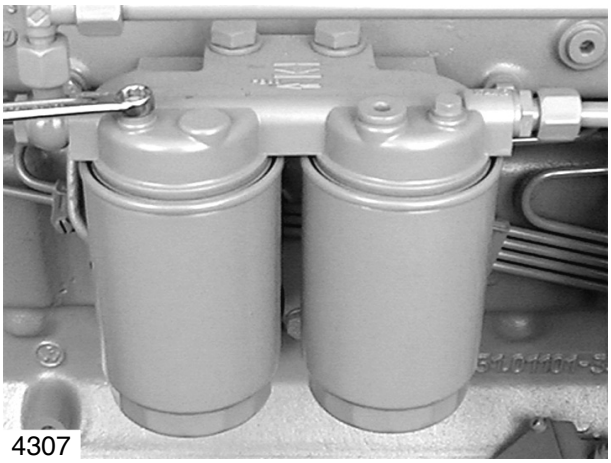


2 4306

Bleeding fuel system

Fig. 3

Open bleed screws at fuel filter.



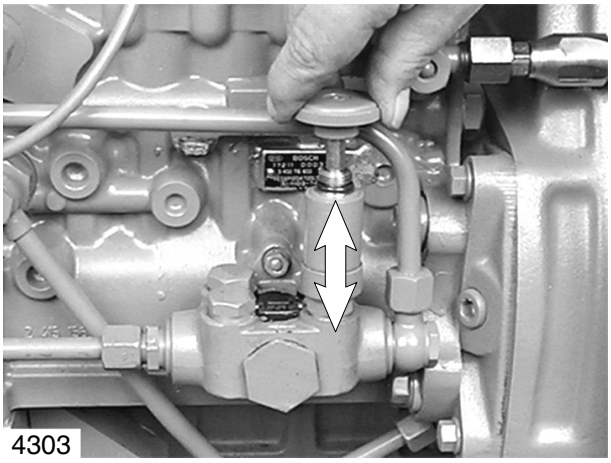
3 4307

Fig. 4

Actuate hand priming pump until bubble-free fuel emerges.
Close bleed screws.

Check system for leaks.

Note:
When bleeding the fuel system switch on the electromagnetic shut-off valve (EHAB) without fail (ignition on), as otherwise fuel cannot reach the injection pump suction gallery / suction chamber.
Wiring diagram see page 120.



4 4303

Draining coolant

Drain coolant as follows when the engine is cold:

Danger:
Risk of scalding if hot coolant is drained!
Drain coolant into a container and dispose of it in accordance with local regulations

Fig. 1

Open cap on filler neck of expansion tank at fan radiator to offset pressure.

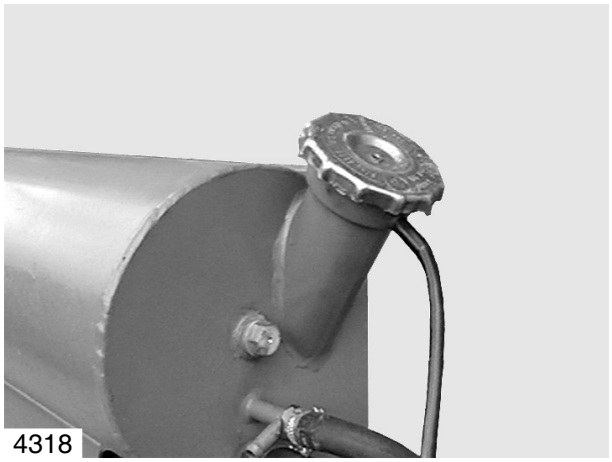

1 4318

Fig. 2

Open drain plug in the oil cooler housing.

Use a container to catch coolant that may emerge.

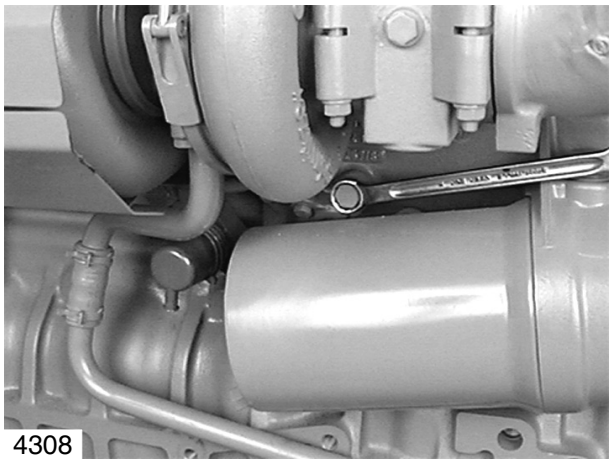
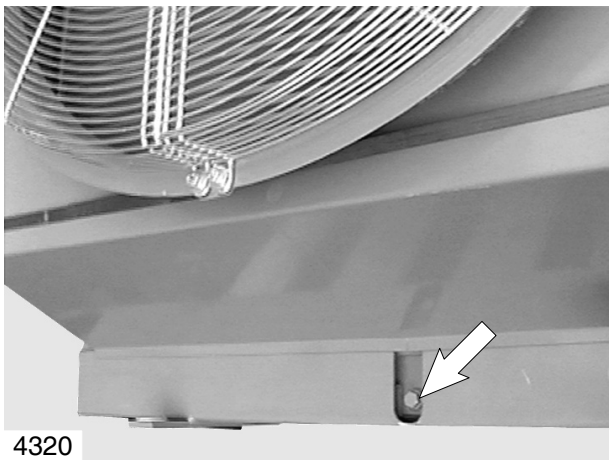

2 4308

Fig. 3

Further drain plugs for draining coolant are located on the fan radiator (example).


3 4320

Filling up with coolant

Fig. 4

The engine's cooling system is to be filled up with a mixture of potable tap water and antifreeze agent on ethylene glycol basis or anticorrosion agent. See publication "Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines".

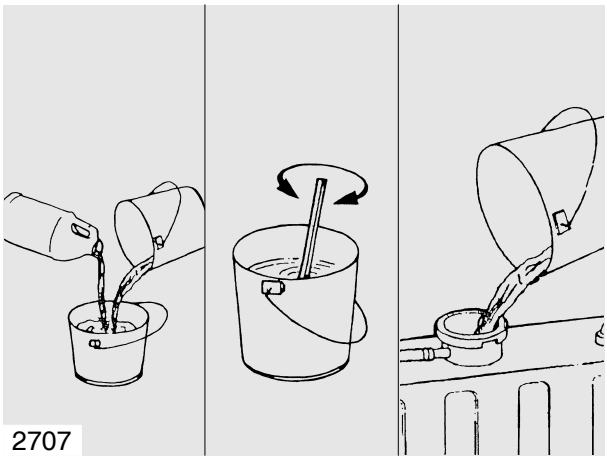
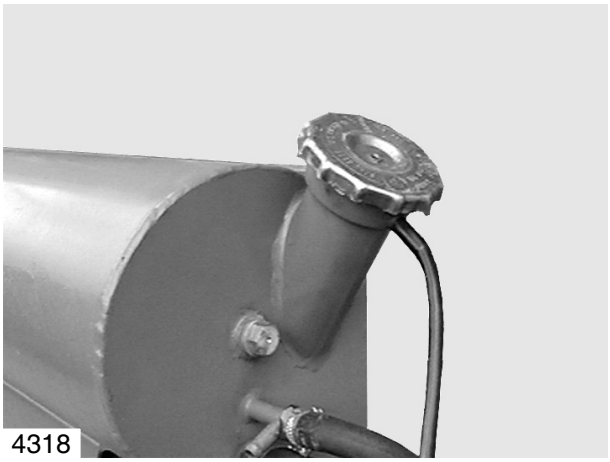

4 2707

Fig. 5

Coolant must be added **only via the filler neck.**
Do not add cold coolant while the engine is hot.

Danger:
If in an **exceptional case** the coolant level has to be checked while the engine is hot, first turn large cap with the safety valve (Fig. 1) carefully to first notch and let off steam. Then continue turning to second notch and remove cap.



5 4318

Fig. 6

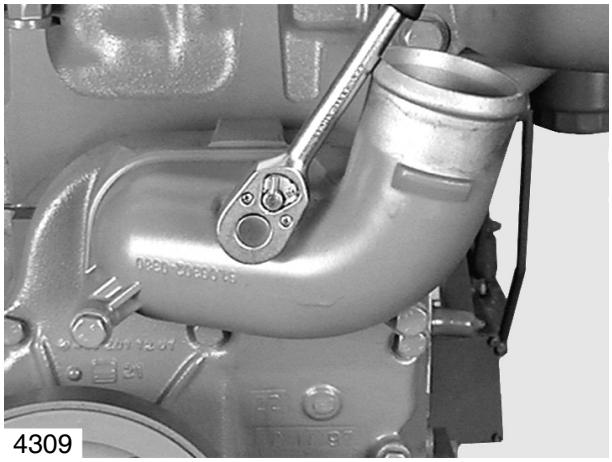
Caution:
If the cap with the working valves is opened, there is the risk that it will not close tightly again afterwards. The excess pressure required in the system will then no longer build up. Premature boiling occurs and coolant is lost. To prevent damage to the engine open this cap only in exceptional circumstances and fit a new one as soon as possible.

6 4319

Fig. 1

- Drain coolant, see page 38

Remove coolant neck from water pump.



1 4309

Fig. 2

Take out thermostat insert.

Check the function of the thermostat insert as follows.

- Hang thermostat in a pot filled with water
- Heat water
- Use suitable thermometer to ascertain the opening start and compare it with the set–point value given in ”Engineering • Data • Setting values”.
- Measure opening stroke if necessary.

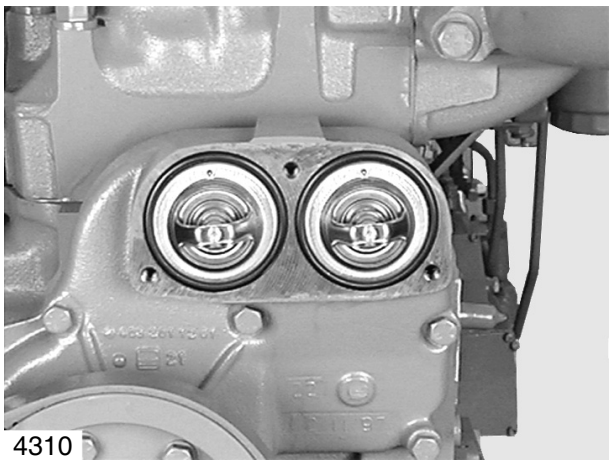
Exchange defective thermostats.

2 4311

Fig. 3

Insert thermostat inserts (ball valve facing upwards (”TOP”) with new O-ring seal and new seal.

Caution:
Never let engine run without thermostats.

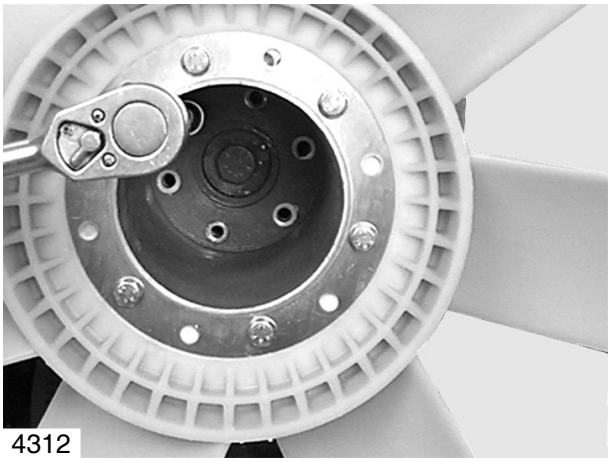


3 4310

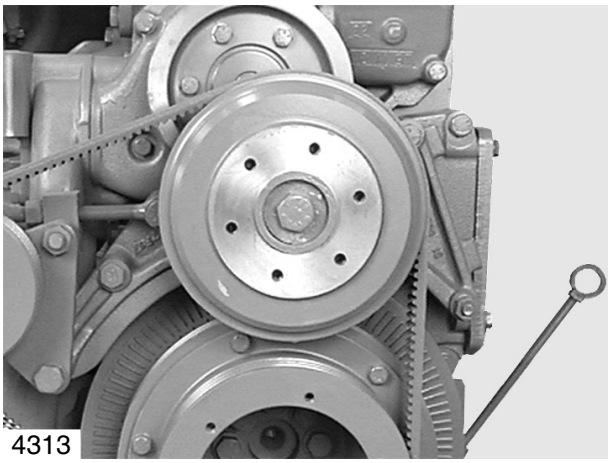
- Drain coolant, see page 38
- Take out thermostats, see page 40

Figs. 1 and 2

Remove fan and fan hub.



1 4312

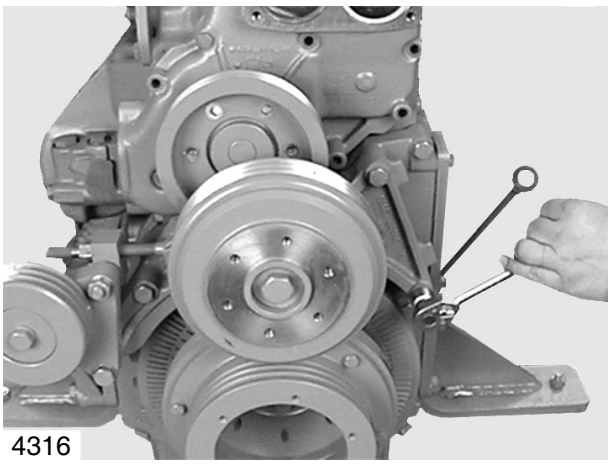


2 4313

Fig. 3

Take off V-belt, see page 113.

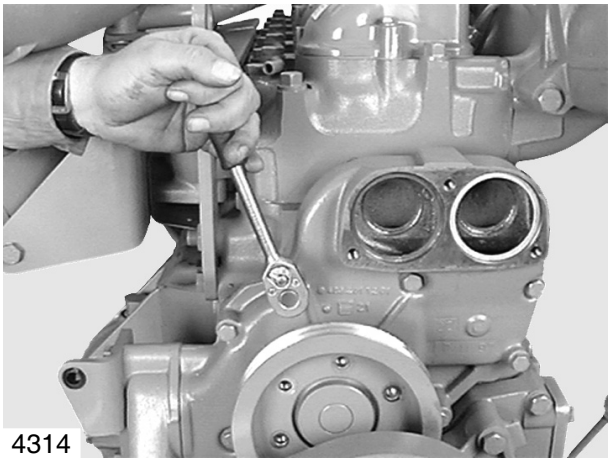
Remove the mounting bolts from fan bracket and take it off.



3 4316

Fig. 4

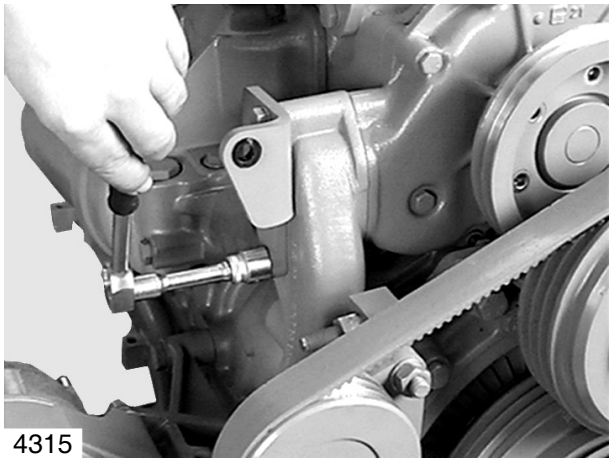
Remove the mounting bolts from water pump.



4 4314

Fig. 5

Remove the mounting bolts from cooling water elbow and take off water pump.



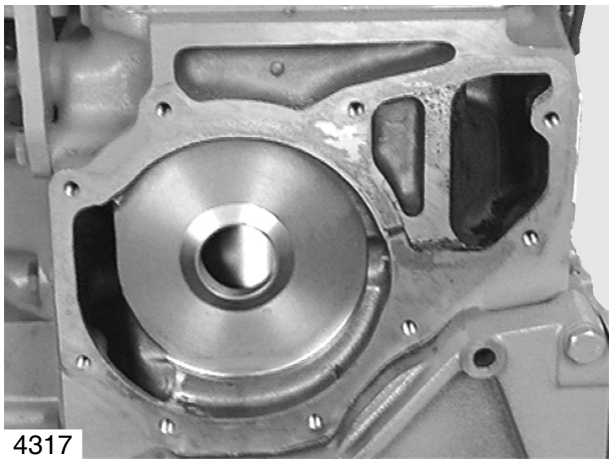
5 4315

Fig. 6

Clean the sealing faces on water pump and engine housing using a scraper and fine abrasive paper.

Stick the new seal for the water-pump housing to the crankcase using grease. Fit water pump.

Use new seals for the cooling-water elbow.



6 4317

Disassembling water pump

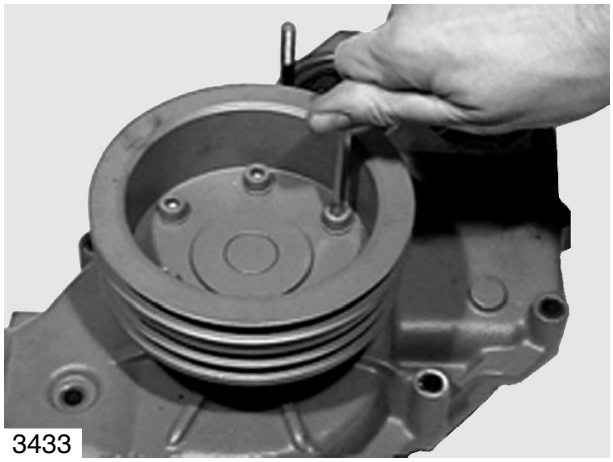
The following special tools are required for disassembling and assembling the water pump:

- Press
- Improvised tools, see page 133.

Fig. 1

Remove V-belt pulley.

Pull off water pump hub with a stable three-arm puller.



1 3433

Fig. 2

Unclip the circlip from the water-pump housing.

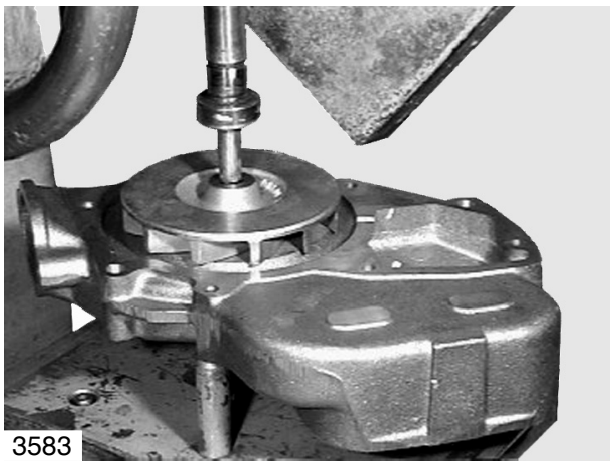
2 3434

Fig. 3

Press impeller off the shaft, using a suitable mandrel. For this purpose align water-pump housing horizontally on a stable support.

The picture shows an assembly device for this. If such a device is not available, use a support ring (special tool, see page 133).

Use a suitable mandrel to press the water-pump shaft together with bearing out of the housing. Shaft and bearing are encapsulated and exchanged together only.

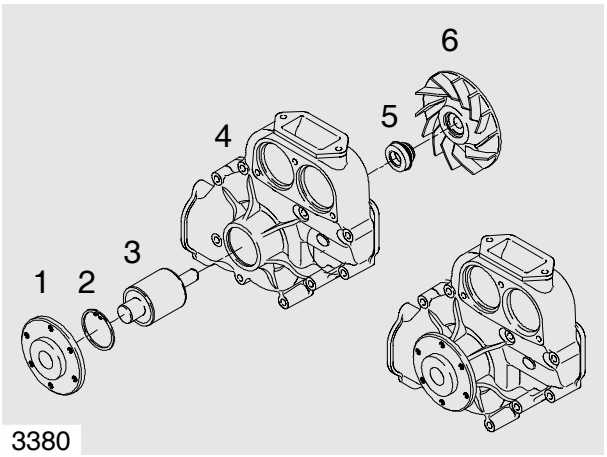


3 3583

Fig. 4

Water pump disassembled

1 Hub
2 Circlip
3 Pump bearing
4 Housing
5 Axial face seal
6 Impeller



4 3380

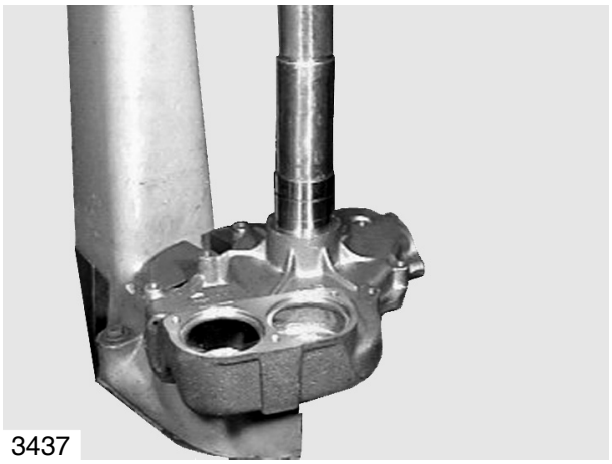
Assembling water pump

Fig. 5

Press in water pump bearing.

Use hollow mandrel to press on the outer bearing ring and not on the bearing shaft.

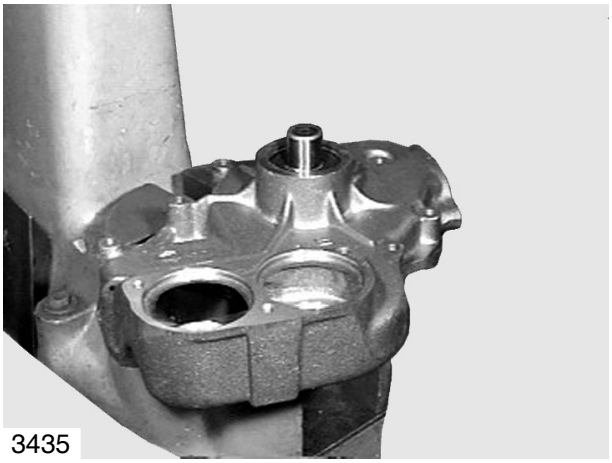
For this purpose align water-pump housing horizontally on a stable support.



5 3437

Fig. 6

Refit circlip.

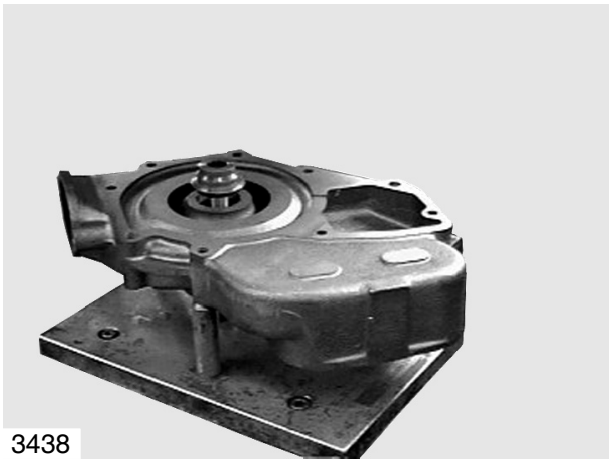


6 3435

Fig. 7

Press in new mechanical seal with press-fitting sleeve (special tool see page 126, item 11) until it stops.
Observe installation note for seal on page 46.

Note:
The seal can be exchanged even without removing the water pump shaft.



7 3438

Fig. 8

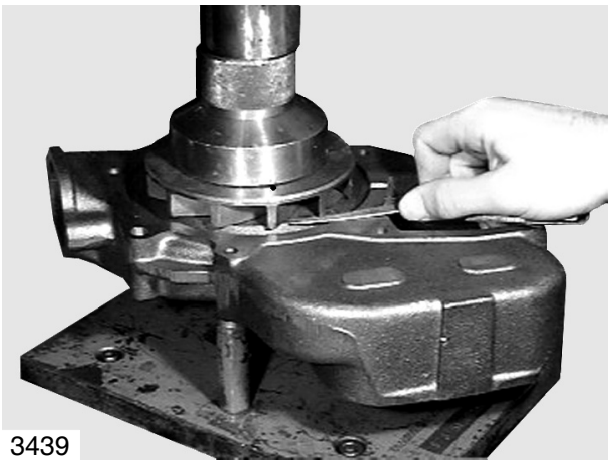
Press impeller on to bearing shaft.

For this purpose place water-pump bearing shaft on a stable support.

The correct gap dimension (see ”Engineering • Data • Setting values”) is achieved if the outer face of the impeller is flush with the front face of the bearing shaft.

Check the gap dimension with the feeler gauge.

The impeller must be easy to turn and must not contact the water-pump housing.

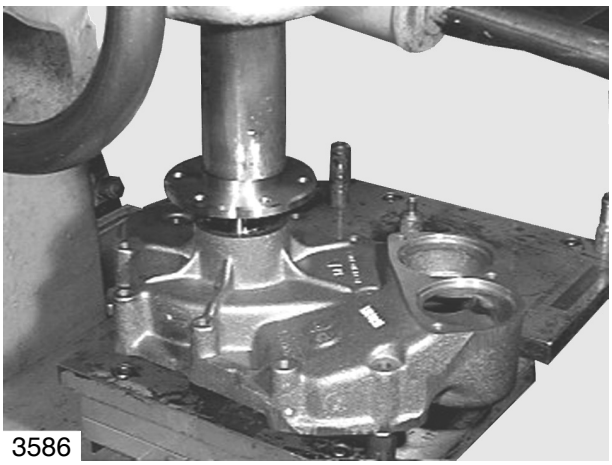


8 3439

Fig. 9

Turn pump housing over and align it horizontally on a suitable support. Press hub on to the bearing shaft until flush.

For this purpose place bearing shaft together with the flush-fitting impeller on a stable support.

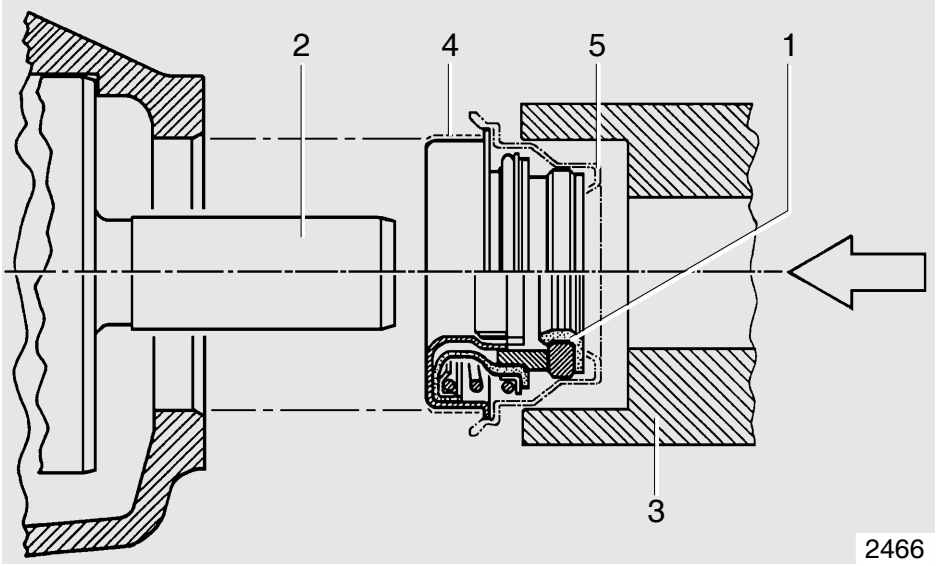


9 3586

Installation note for mechanical seal:

Install mechanical seal while ”wet”, i.e. to install it, coat holding sleeve (1) and water pump shaft (2) with a mixture of either 50 % water and 50 % cleaning spirit or 35 % to 50 % antifreeze agent as per MAN 324 and water.
Other lubricants must not be used.

Since the seal on collar (4) is coated with sealing paint, no sealing agent must be applied if the location bore in the water pump housing is in faultless condition. If the bore shows even the slightest scores or other minor damage, Dirko-Transparent, part no. 04.10394.9229 is to be applied to the collar.
Place seal with synthetic transport cap on shaft (2) and use installation tool to press it in until the tool contacts the housing. Remove synthetic cap.



Note: Examinations have shown that most cases of damage to the water pump can be attributed to unsuitable coolants. **Only** the antcorrosion and antifreeze agents expressly approved by MAN Nutzfahrzeuge AG as per MAN norm 324 (see brochure ”Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines”) guarantee faultless operation.

In the event of repairs exchange water pump only if it has been found to be leaky.

For design-related reasons small quantities of coolant may permeate through the mechanical seal on the water pump. This permeating coolant leaves a trace below the drain bore on the water pump. The water pump need not be exchanged because of this trace of permeating coolant.

For this reason before exchanging or repairing a water pump ascertain

- whether the coolant circuit shows visible and recurrent loss of water; if so
- whether the loss of water is caused by coolant emerging from the expansion tank (e.g. overfilled) or by other leaks on hoses, etc.

Water pumps must be exchanged only if water drips visibly while the engine is in operation or after the engine has been switched off.

Cleaning the outside of the radiator

Extreme dirt deposits can clog the honeycombs so that the remaining surface no longer ensures sufficient cooling. In such cases, the insects, dust etc. should be removed from the honeycomb system of the radiator block and the radiator itself then cleaned with the cleansing agent HENKEL P3-begesol. This cleansing agent is available from MAN in 10-kg cans under Part No. 09.21002-0164.

Procedure:

- Mix P3-begesol with water, ratio 1:1
- Using a spray gun, spray the mixture in as straight a jet as possible directly into the radiator fins
- Let the mixture work for 5 minutes
- Hose down the radiator with a straight jet of tap water directly from the front. In cases of stubborn dirt deposits remove the radiator and hose it down directly from behind. Do not use high-pressure cleaners (steam sprayers may be used)

Henkel P3-begesol contains no toxic or corrosive substances and, if handled properly, may be used without hesitation.

Cleaning the inside of the cooling system

Investigations have shown that in many cases the poor condition of the coolant and / or the cooling system accounts for damage to the water pump mechanical seal. The poor condition of the cooling system is normally due to use of unsuitable or no anti-freezing agents and corrosion inhibitor or defect, not early enough replaced covers for filler neck and working valves.

If twice in a short time the water pump of an engine develops leakes or the coolant is heavily contaminated (dull, brown, mechanically contaminated, grey or black signs of a leakage on the water pump casing, after the defect on the oil cooler) clean the cooling system **prior to** removing that water pump as follows:

a) Drain coolant
b) Open thermostats positively (use short-circuit inserts), so that the entire coolant circuit is flushed in the cleaning operation
c) Fill coolant circuit with a mixture of hot water (min. 50°C) and Henkel P 3 neutrasel 5265 detergent (1.5% by volume) (-5266, -5225, Kluthe Hakopur 316), refer to Publication ”Fuels, Lubricants ...”
d) Warm up engine under load. After a temperature of 60°C is reached, run engine for a further 15 minutes
e) Drain cleaning fluid
f) Repeat steps c) and d)
g) Flush cooling system. To this effect
h) Replace drain plug by drain plug with a bore of 8 mm dia
i) Fill cooling system with hot water
k) Run engine at idle for 30 minutes. At the same time continuously replenish the water leaking from the bore in drain plug by adding fresh water

Repair water pump only now. Thereafter, fill the cooling system with approved cooling fluid. See Publication ”Fuels, Lubricants ...”.

Note:
Only sediments and suspended particles can be removed by this cleaning method. If corrosion and lime deposits are found, proceed according to the following section:

Removal of lime deposits in the cooling system

Procedure:

- Drain the coolant
- Fill the system with undiluted original pickling fluid (Lithsolventsäure or engine pickling fluid RB-06), see sources of supply
- Let the engine run (also in normal operation) for approx. 8 hours with this filling in the cooling circuit
- Drain the pickling fluid and thoroughly flush the system with tap water
- If necessary, refill the circuit again with fresh pickling fluid and pickle the engine for another 8 hours
- Drain the pickling fluid, fill the system with tap water, and run the engine at idle for 5 minutes to flush out all fluid; then drain the water
- Fill the system with a 1% soda solution. Drain the soda solution after running the engine at idle for 5 minutes, and flush with tap water until the discharging water is clear
- Fill cooling circuit with a mixture of potable tap water and anti-freeze with at least 40% by volume, refer to Publication ”Fuels, Lubricants ...”

Note:
Older radiators may develop leaks when such deposits are removed. The surge tank should be filled only up to the bottom edge as otherwise foaming will cause the pickling fluid to spill over. Damaged tube bundles may develop leaks when dirt deposits are removed.

Filler caps and working valves of cooling system

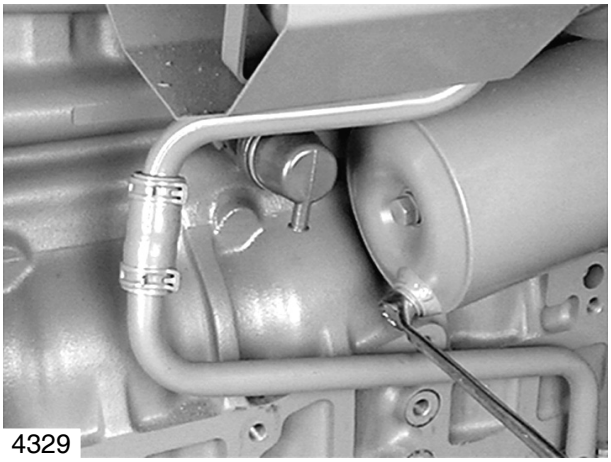
The rubber gaskets of the filler caps and working valves (negative pressure and positive pressure valves) of the cooling system are subject to natural aging.
To preclude leakages in the cooling system and tailing pressure drop and its consequences up to severe engine damage, renew the filler caps and working valves in line with the change of coolant (every two years at the latest) see also ”Filling-in of coolant” in this chapter.

Waste water treatment

Drained and spent cleaning and pickling fluid should be brought up to a pH value of 7.5 to 8.5 with the aid of caustic soda. Once the precipitation has settled to the bottom of the container the clear fluid above can be dumped into the sewer. The sludge at the bottom should be taken to a special waste dump. Anyway, it is recommended to consult the local authorities for more information about waste water rules or restrictions.

Fig. 1

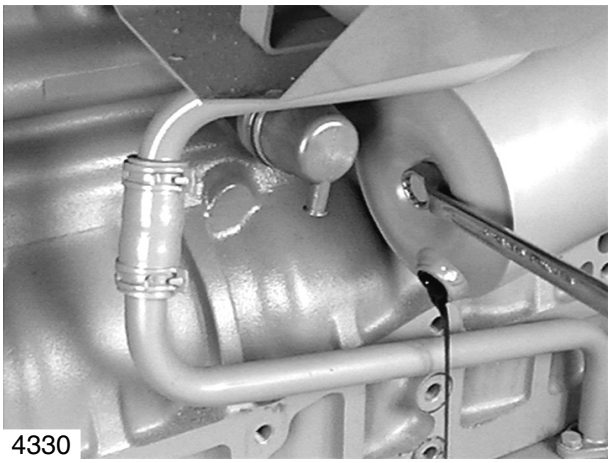
Open oil drain plug on oil filter can and use container to catch oil that may emerge.



1 4329

Fig. 2

Remove mounting bolt of filter bowl.



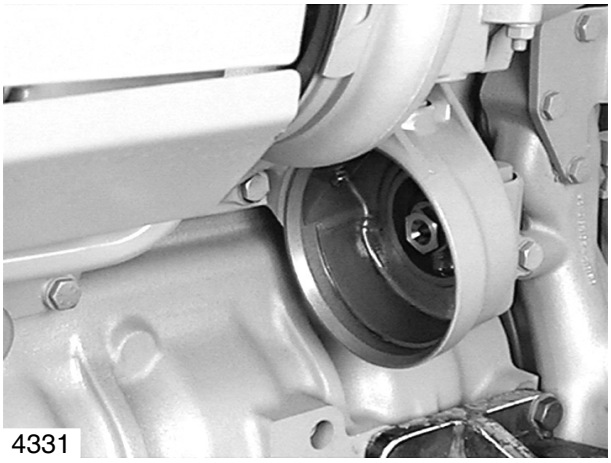
2 4330

Figs. 3 and 4

Take off filter bowl and clean it on the inside. Refit oil drain plug with new seal.

Insert new filter element and fit filter bowl with new seals.

Observe tightening torque for mounting bolt (see “Engineering • Data • Setting values”).



3 4331

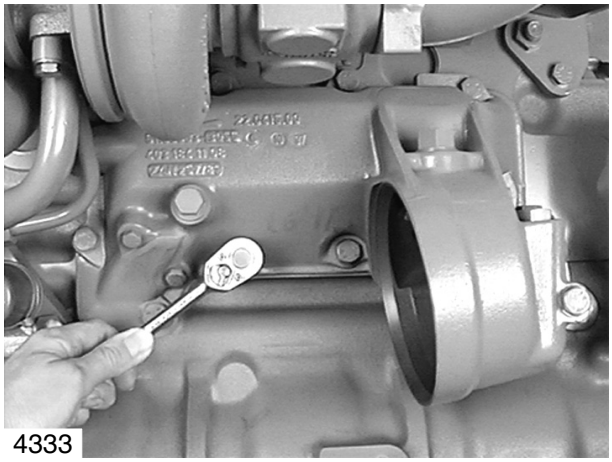
4 4332

- Drain engine oil
- Drain coolant, see page 38
- Remove oil filter, see page 49

Fig. 1

Remove the mounting bolts from the oil cooler housing.

Note:
Do not remove the four 13 mm mounting bolts. They keep the oil cooler in place.

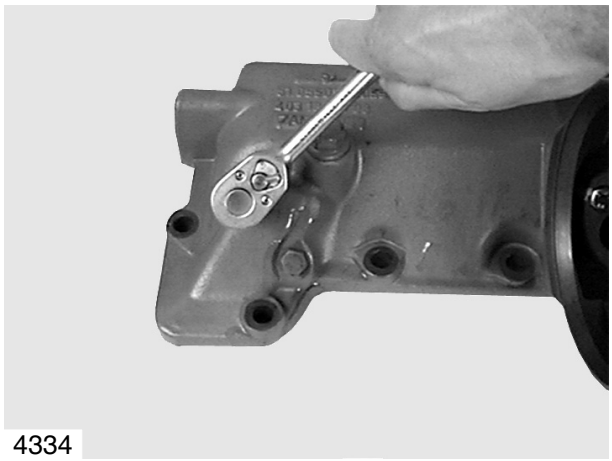


1 4333

Figs. 2 and 3

Take off oil cooler housing together with oil cooler.

Remove oil cooler from housing.



2 4334

3 4335

Fig. 4

Check oil cooler for damage, changing it if necessary.

Fit oil filter with new gasket. Fill up with engine oil and coolant.

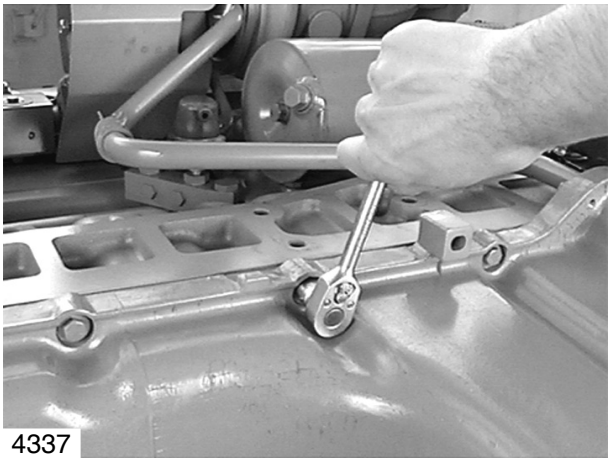
4 3452

Removing oil pump

- Drain engine oil

Fig. 1

Remove oil pan.



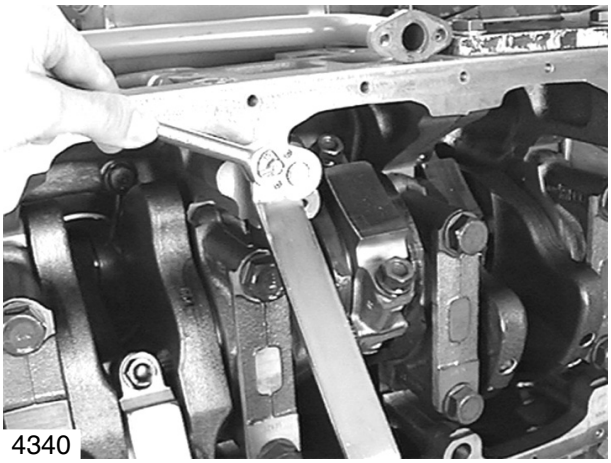
1 4337

Fig. 2

Remove oil suction pipe.

Measure backlash between oil pump drive gear and crankshaft gear and compare value with the nominal value.

Replace worn gears.

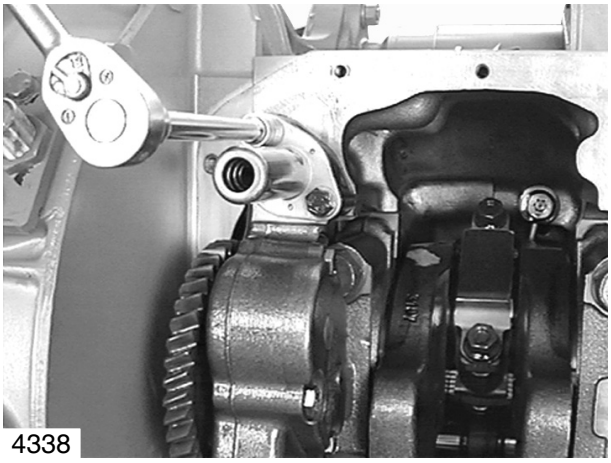


2 4340

Fig. 3

Remove mounting bolts of pressure relief valve and oil pump.
The pressure relief valve is encapsulated.
Opening pressures see ”Engineering • Data • Setting values”.

Take off oil pump.

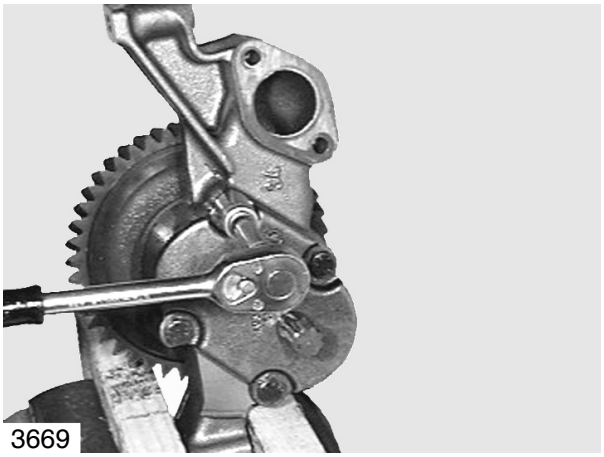


3 4338

Disassembling and assembling oil pump

Fig. 4

Clamp oil pump in a vice (fitted with soft jaws). Remove oil pump cover (13 mm).



4 3669

Fig. 5

Pull driven oil pump gears out of the housing. Check gears and pump housing for wear (see ”Engineering • Data • Setting values”).

5 3458

Fig. 6

Remove oil pump drive gear. To do this, lay pump on suitable support and press off drive gear using a mandrel.

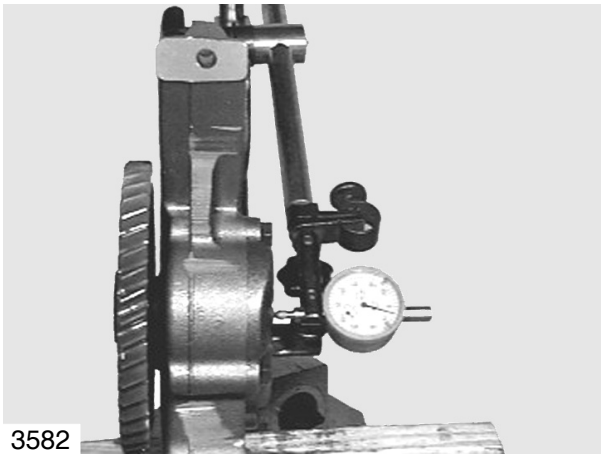
Place drive gear on the shaft and press it into place. Thereby support opposite shaft end. Pressing force see ”Engineering • Data • Setting values”.

6 3459

Checking axial play of the pump gears

Fig. 7

Position dial gauge and push shaft up to the stop in one direction and set dial gauge to “0”. Push shaft in opposite direction and read the movement from the dial gauge.



7 3582

Installing oil pump

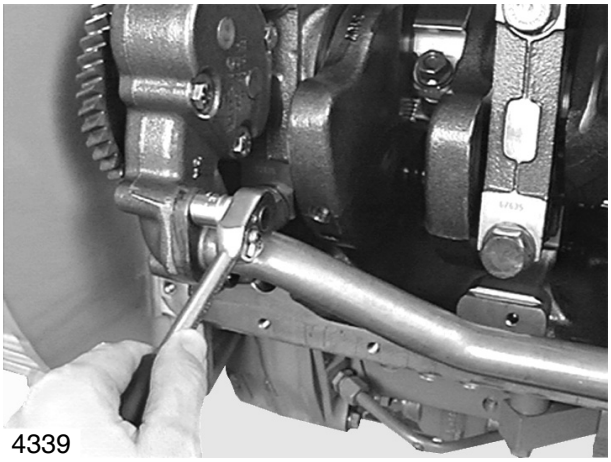
Fig. 8

Before installing, check whether the oil pump runs smoothly and then fit it free of tension.

Fit the oil intake line with seal. Screw on pressure-relief valve without seal.

Before mounting the oil pan, turn over the engine to check whether the crankgear and the oil pumps run unimpeded and smoothly.

Stick new oil-pan gasket on to oil pan using grease and then bolt oil pan into place.



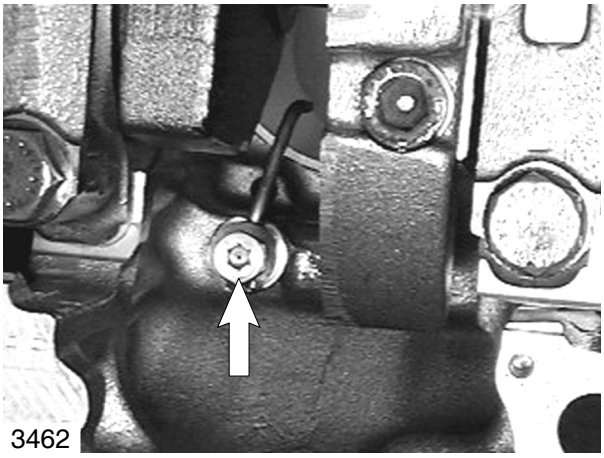
8 4339

Removing oil spray nozzle

- Drain engine oil
- Remove oil pan, see page 51

Fig. 1

Remove oil spray nozzle valve (arrow) and take out oil spray nozzle.

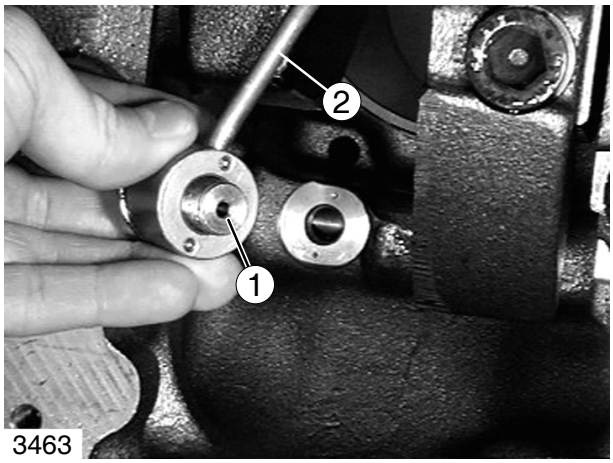


1 3462

Fig. 2

1 Oil spray nozzle valve
2 Oil spray nozzle

Note:
The oil spray nozzles are provided with two balls. When the oil spray nozzles are tightened at the factory the balls are pressed into the crankcase where they make impressions used as marker points for the installation of oil spray nozzles in the event of repair work.

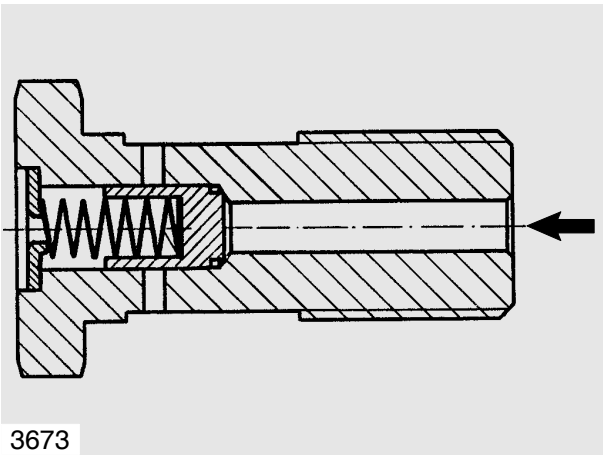


2 3463

Checking oil spray nozzle valve

Fig. 3

Use a piece of wire to check whether the valve piston is easy to move.
For opening pressures, see ”Engineering • Data • Setting values”.



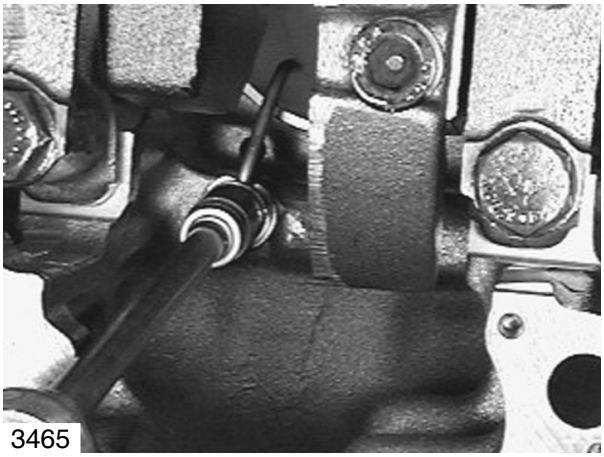
3 3673

Installing oil spray nozzle

Fig. 4

Screw in the oil spray nozzle together with the oil spray nozzle valve.
The balls of the oil spray nozzle must be located in the impressions provided for this purpose in the crankcase. This will ensure that the oil spray nozzle will be installed in the correct position.
Turn the engine over. Neither the crankgear nor the pistons must collide with the oil spray nozzle.

Tighten the mounting bolts to the specified torque.



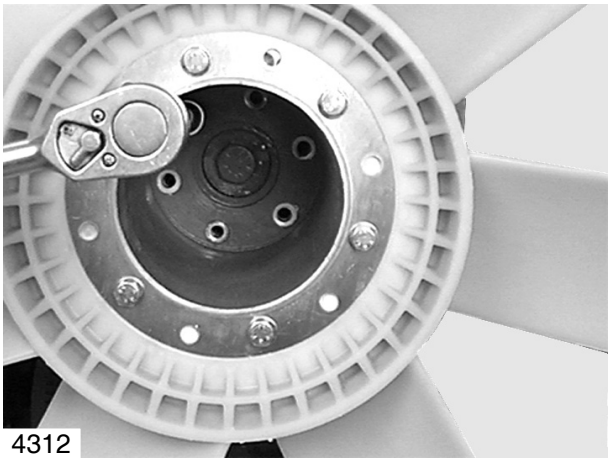
4 3465

Removing vibration damper

- Block the crankgear

Fig. 1

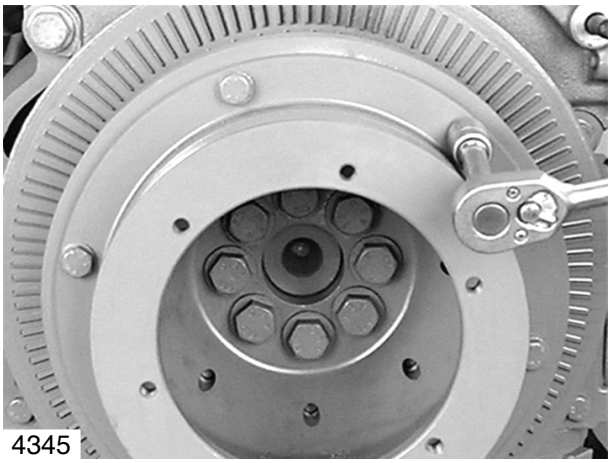
Remove fan and fan hub.
Release the tension and take off the V-belt, see page 113.



1 4312

Fig. 2

Remove the mounting bolts from the front V-belt pulley and take it off.

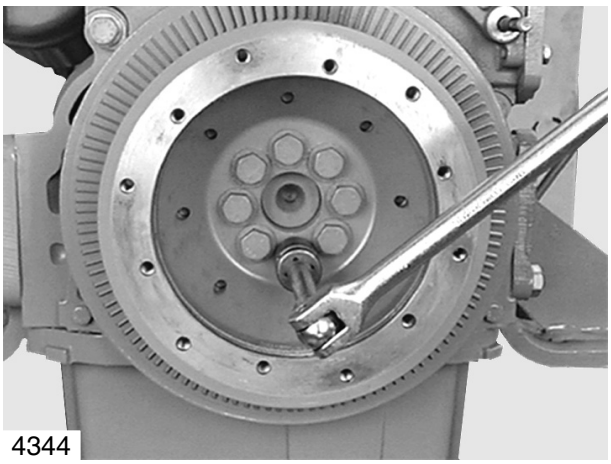


2 4345

Fig. 3

Loosen mounting bolts on vibration damper.

Note:
Owing to the high tightening torque a reinforced socket in conjunction with a 1/2" tool is required. Prior to removal mark the position of the vibration damper relative to the crankshaft.



3 4344

Fig. 4

Remove vibration damper carefully.

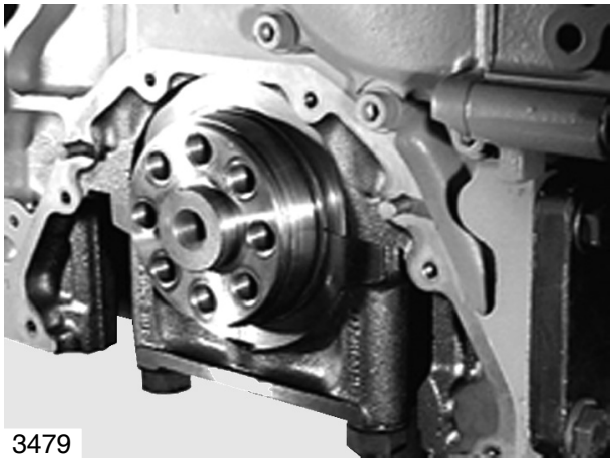
4 3478

Exchanging of crankshaft seal at front

Fig. 5

Remove cover.

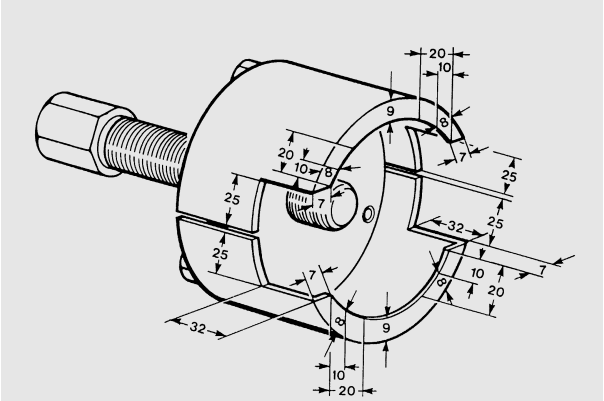
Replace front crankshaft seal only as a complete unit, i.e. race and radial shaft seal.



5 3479

Fig. 6

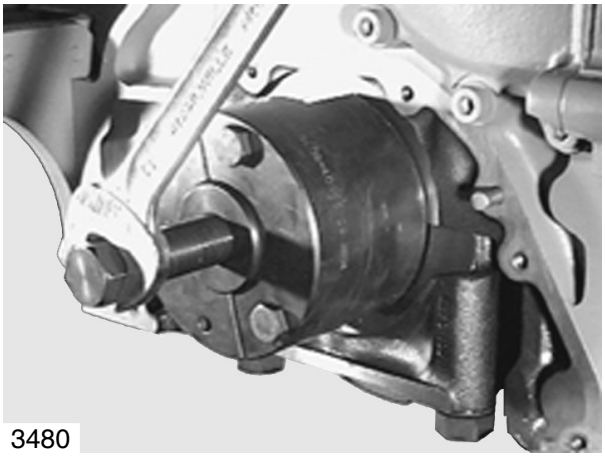
To remove the race, a puller (special tool, see page 126, Pos. 13) is necessary.



8 2718

Fig. 7

Pull off race.



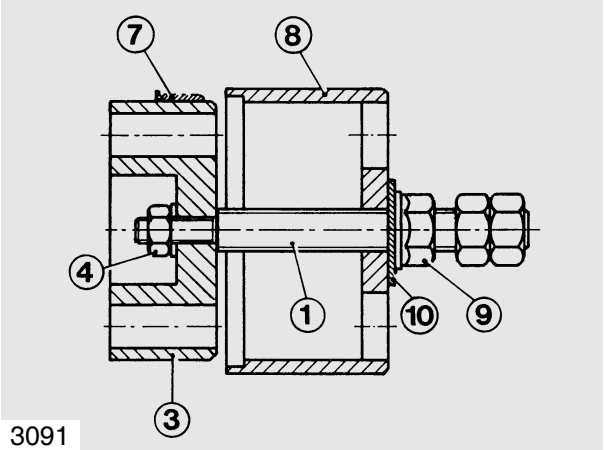
7 3480

Fig. 8

Special tools are required for installing the race (see page 126, item 15).

Clean inner side of race and crankshaft stub. Coat crankshaft stub with sealing agent ”Antipor 46”.

- Push race ⑦ and pressing sleeve ⑧ onto adapter ③.
- Tighten spindle ① in adapter ③ with nut ④.
- Bolt adapter ③ to crankshaft.

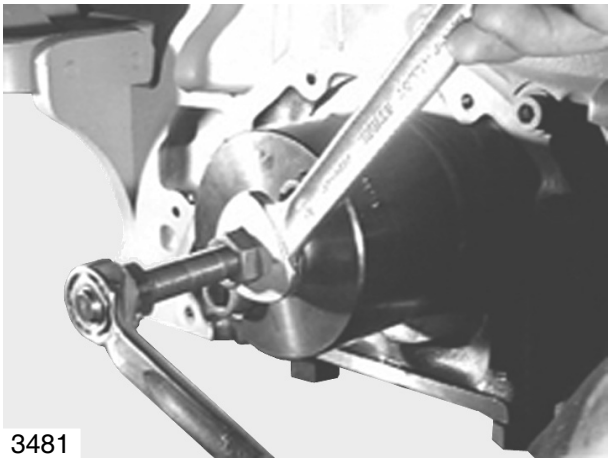


10 3091

Fig. 9

The adapter must contact the crankshaft free of play so that the correct pressing depth for the race is ensured.

Pull in race using collar nut and pressing plate (⑨ and ⑩ in Fig. 8) until pressing sleeve ⑧ stops on the adapter.

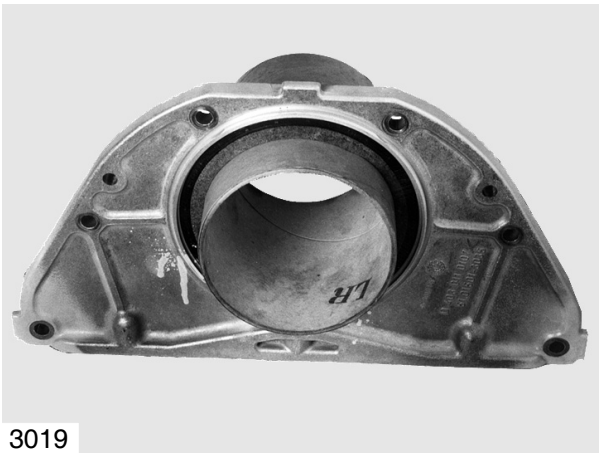


9 3481

Fig. 10

As spare parts the cover and shaft seal are delivered only as a complete assembly in order to ensure correct installation.

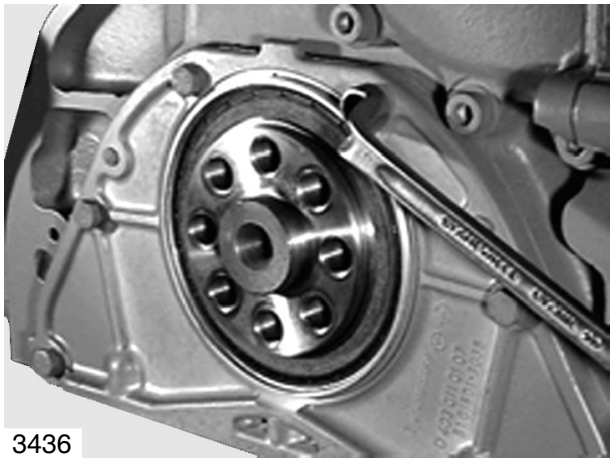
To ensure that the shaft seal remains suitable for installation, it must remain on the transport and assembly sleeve until installed.



12 3019

Fig. 11

Fit cover with new seal.



11 3436

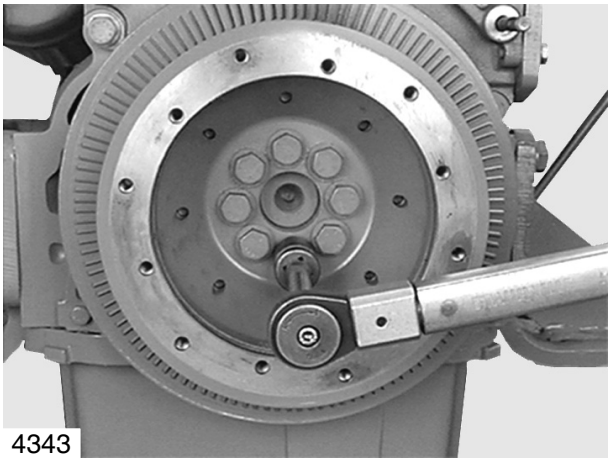
Installing vibration damper

Fig. 12

Place vibration damper on two guide pins (M16 x 1.5).

Tighten mounting bolts (24 mm) to specified torque.

Note:
Owing to the high tightening torque a reinforced socket in conjunction with a 1/2" tool is required.



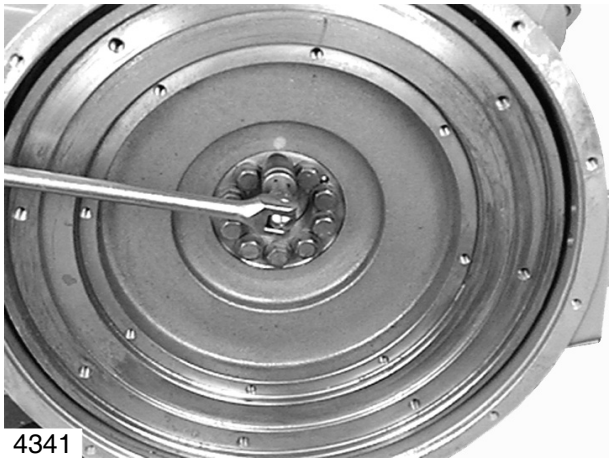
12 4343

Removing flywheel

- Remove speed pickup, see page 119

Fig. 1

Loosen mounting bolts, securing the engine against turning if necessary.



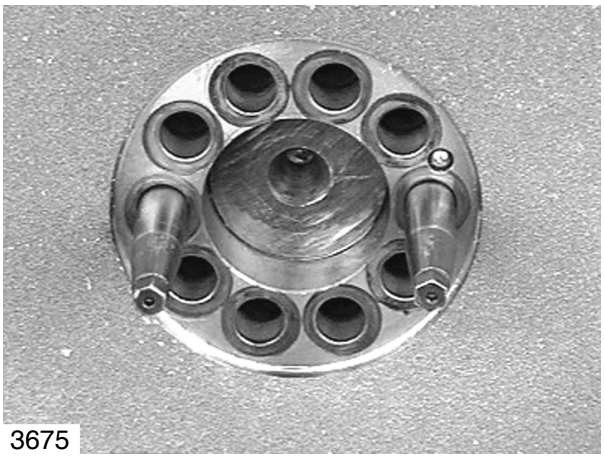
1 4341

Fig. 2

Remove two bolts facing each other and replace them by two guide pins (special tool, see page 126, item 16).

Remove all bolts.
Pull off flywheel, using a lifting gear.

Danger:
The flywheel is heavy.
Use lifting gear.

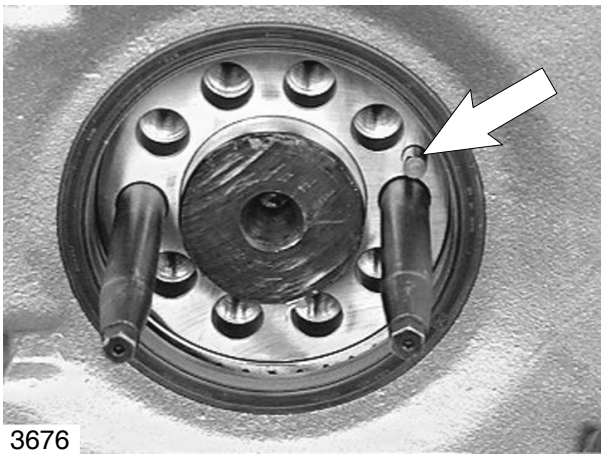


2 3675

Installing flywheel

Fig. 3

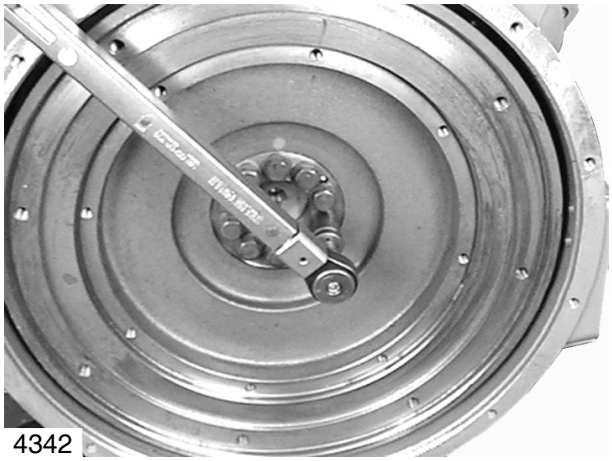
Screw in guide mandrels
(special tool, see page 126, item 16). Apply sealing agent ”Antipor 46” to the inside of the flywheel. Place guide mandrels on the flywheel, ensuring that the centering mandrel (arrow) fits correctly into the bore in the flywheel. Push on flywheel until it stops.



3 3676

Fig. 4

Lightly oil new mounting bolts (elasticated bolts) , screw them in and tighten alternately on opposite sides of the ring gear to specified torque
(see ”Engineering • Data • Setting values”).



4 4342

Changing starter gear ring

Fig. 5

Remove flywheel.
Drill a hole in starter gear ring and snap it using a chisel.

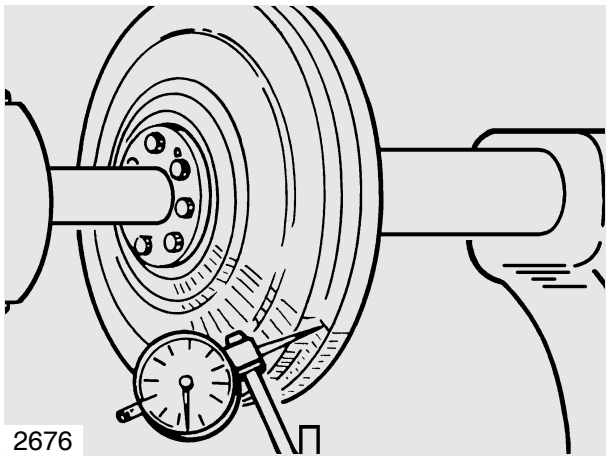
Danger:
Take care not to damage the flywheel.

5 3678

Fig. 6

Note:
Since the maximum axial runout (lateral runout) of the starter ring gear must not be exceeded, the axial runout of the flywheel is to be measured on the contact face of the starter ring gear before the starter ring gear is shrunk on.
Exchange flywheel if the value required is exceeded.

Take up flywheel at hub.
Apply dial gauge to contact face of ring gear.
Turn flywheel by hand by several revolutions and observe the deflection shown on the dial gauge.



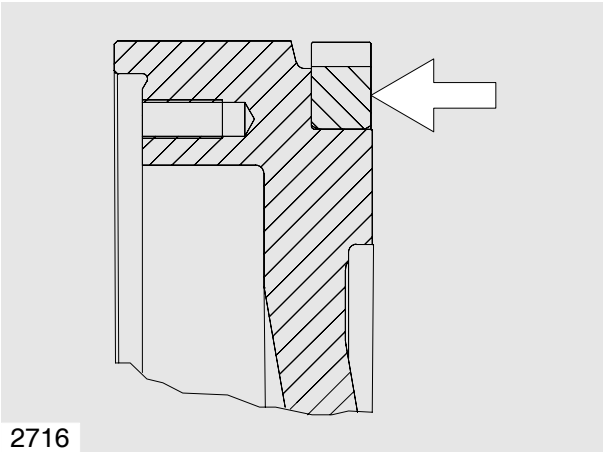
6 2676

Fig. 7

Heat new starter gear ring up to approx. 200°C to 230°C and press on until it stops.

Danger:
The parts are hot. Risk of burns. Wear protective gloves.

Check axial runout and compare with max. permissible value.



7 2716

Removing crankshaft seal

- Remove flywheel, see page 58

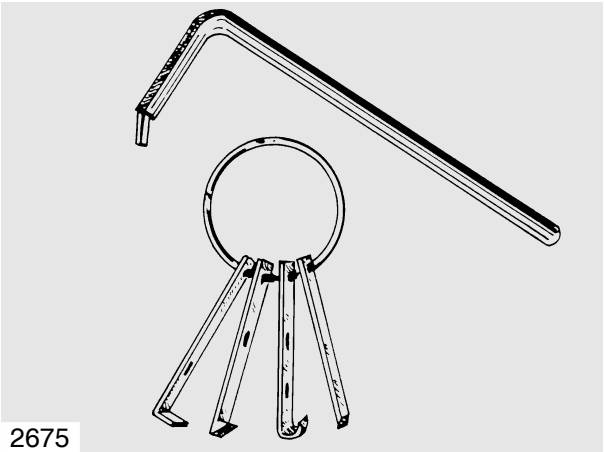
Fig. 1

Use a screwdriver or special tool (fig. 2) to prise seal out of the timing case.

1 3679

Fig. 2

Special tool for prizing out crankshaft seal.



2 2675

Installing crankshaft seal

Fig. 3

When exchanging the shaft seal, also exchange the bearing race of the flywheel.
Insert new shaft seal into the flywheel housing. Drive in seal with mandrel (special tool, see page 126, item 12) until flush.
Observe remarks and installation notes on page 62.

3 3680

- Remove flywheel, see page 58

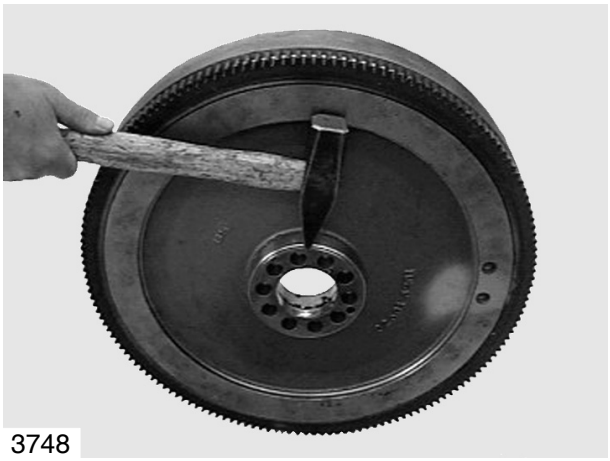
Fig. 1

If the shaft seal on the flywheel end is to be exchanged, it is advisable to exchange the bearing race too.

Snap the bearing race to be exchanged by applying a blow with a hammer.

Danger:
Wear goggles and working gloves for protection against metal fragments.

Caution:
Do not damage flywheel.
Do not use a chisel.



1 3748

Fig. 2

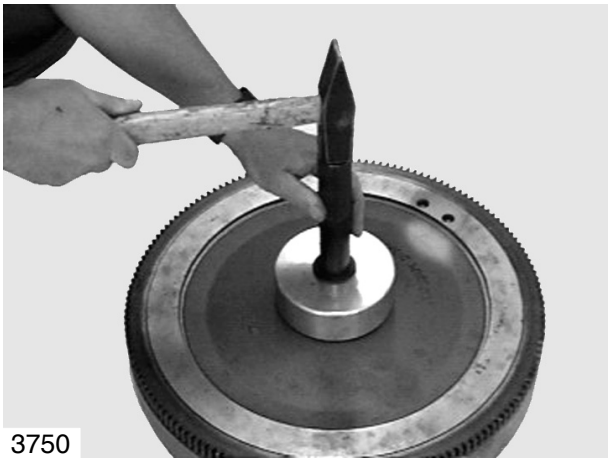
Insert the new bearing race into the pressing mandrel (special tool, see page 126 , item 14) so that for the subsequent assembly the internally chamfered side faces the flywheel.

Carefully heat the pressing mandrel with the bearing race. The installation temperature for the bearing race is about 150°C (300°F).

2 3749

Fig. 3

Press in bearing race until it stops.



3 3750

Fig. 4

Seal the gap between the flywheel and the bearing race with “Antipor 46”.

4 3751

General remarks on crankshaft seals

As a matter of fundamental principle only radial shaft seals made of polytetrafluor ethylene (PTFE), trade name Teflon, are used.

PTFE seals can be easily distinguished from the former elastomer seals by their considerably wider and flat sealing lip which is no longer pre-loaded by means of a tubular spring.

As a result of its relatively high initial stress the sealing lip curves inwards. For this reason PTFE seals are supplied on transport sleeves. They must not be taken off the sleeves before they are needed so as to ensure that they can still be installed. Great care should be taken when fitting lip seals. Even the slightest damage to the seal would result in leaks.

The sealing lip and the race of the flywheel must not be coated with oil or any other lubricants.

When installing a new seal always replace the race too.

Assembly instructions for crankshaft seals

- The PTFE seal must be absolutely free of oil and grease when installed. Even the slightest traces of oil on the race or the sealing ring cause leakage.
- Before installing the race remove oil, grease and anticorrosion agent from it. All cleaning agents normally used in workshops can be used for this purpose.
- A PTFE seal soiled with oil or grease is useless. Cleaning it is not permissible.
- The PTFE seal must never be stored without the transport sleeve delivered with it. Even after a storage period of only 30 minutes without the transport sleeve it looses its initial stress and becomes useless.

- Remove air filter

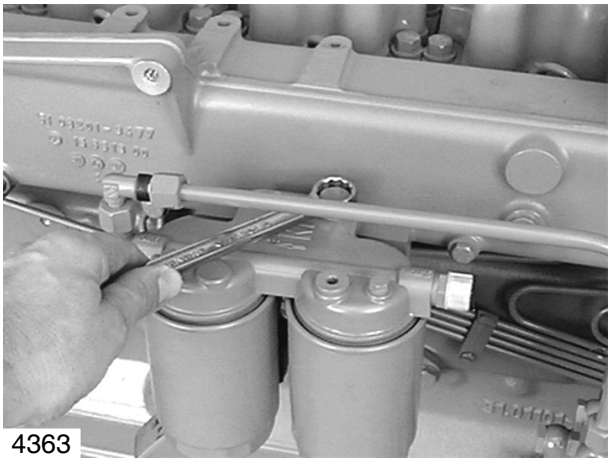
Note:
When carrying out work on the intake system, ensure meticulous cleanliness to prevent dirt and foreign matter from penetrating into the system.

Removing intake manifold

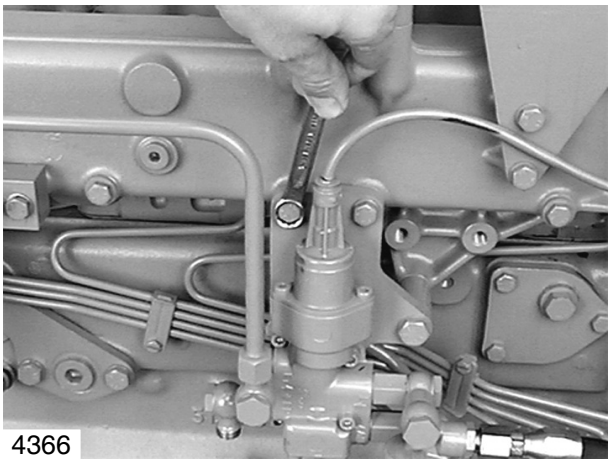
Figs. 1 and 2

Remove fuel filter and electro-hydraulic shut-off device (EHAB).

Caution:
The lines contain fuel.
Catch emerging fuel in a suitable container.



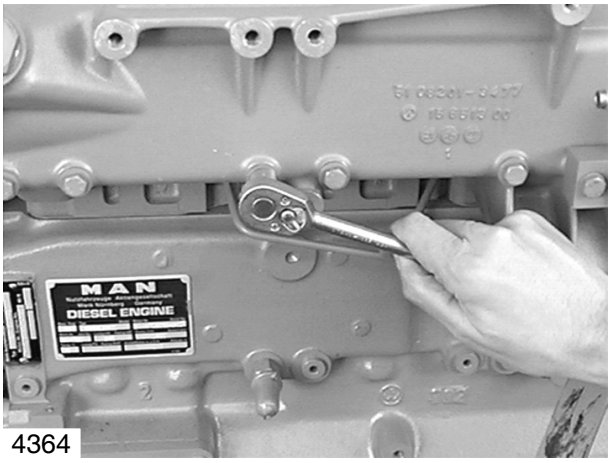
1 4363



2 4366

Fig. 3

Loosen mounting bolts and remove intake pipe.

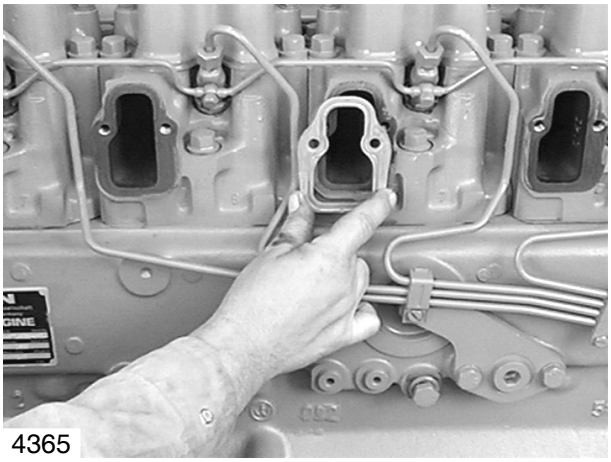


3 4364

Installing intake manifold

Fig. 4

Place intake manifold with new seals in position.
Tighten mounting bolts to the specified torque.
Ensure that the seals are correctly seated.



4 4365

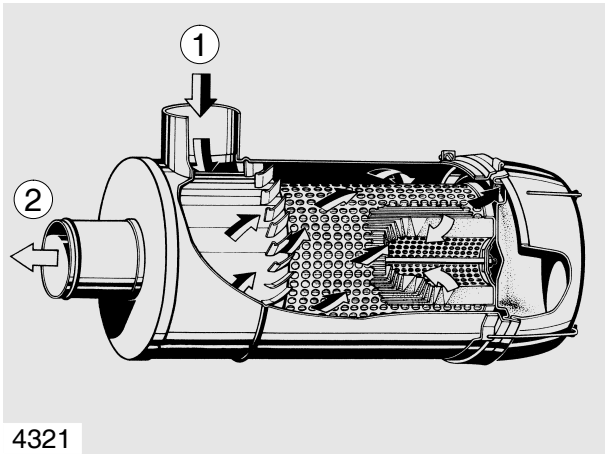
Exchanging of air filter cartridge

Fig. 1

D 2866 LE 2.. engines are equipped with Mann-Piclon combination air filters.

① Air intake

② Air outlet



1 4321

Fig. 2

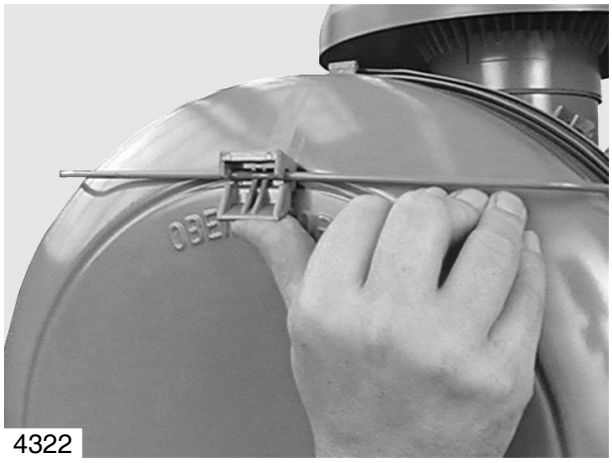
The air filters are equipped with maintenance indicators which are triggered once the air filters have reached a certain degree of contamination with the ensuing loss of pressure.

The picture shows an electric maintenance switch which is triggered at an intake vacuum of 50 mbar and can trigger a monitor.

2 4327

Fig. 3

To exchange filter cartridge, disengage and open clip.



3 4322

Fig. 4

Take off dust collector

① Dust collector

② Cover

Take cover off the dust collector and empty the collector.

4 4324

Fig. 5

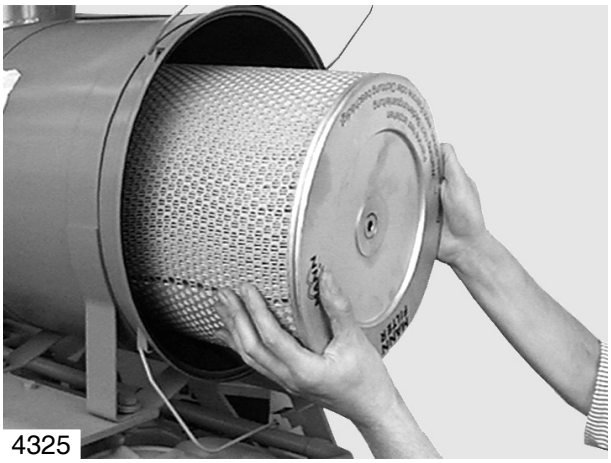
Remove the mounting bolts from filter cartridge.

5 4323

Fig. 6

Take out contaminated filter cartridge, exchange it for new one or clean it.

Clean sealing face of filter housing, using a moist cloth.



6 4325

Fig. 7

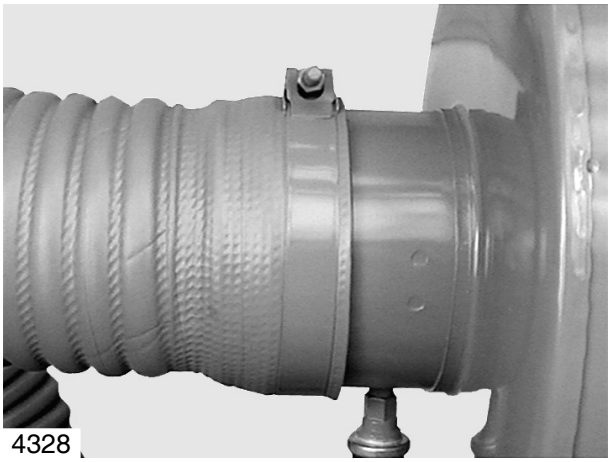
Exchange safety cartridge after the fifth maintenance service or every 2 years.

Caution:
Safety cartridges must not be cleaned.
The engine must not be operated with the safety cartridge alone.

7 4326

Fig. 8

Check hose connections for leaks.



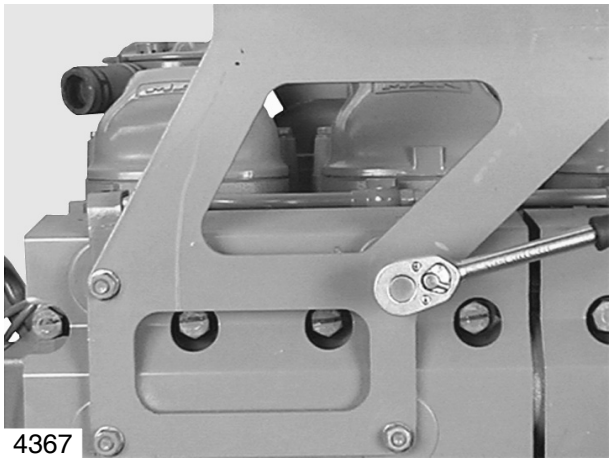
8 4328

- Remove air filter
- Remove turbocharger, see page 71

Removing exhaust manifold

Fig. 1

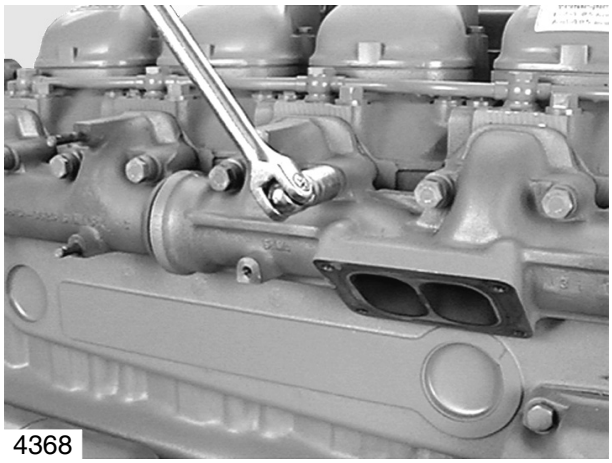
Remove anti-contact protection device and bracket for air filter.



1 4367

Fig. 2

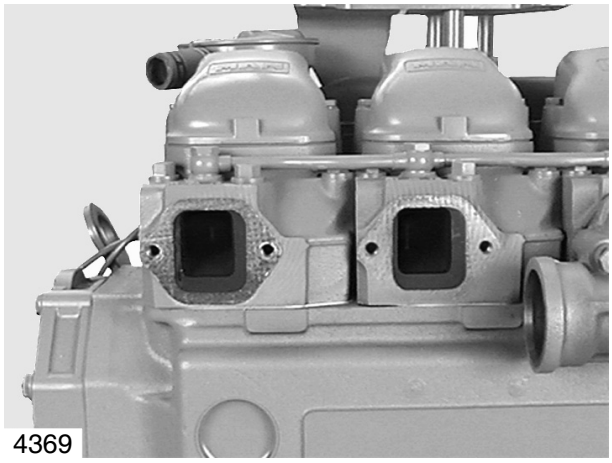
Remove the mounting bolts from the exhaust pipe.



2 4368

Fig. 3

Take off the exhaust pipe.

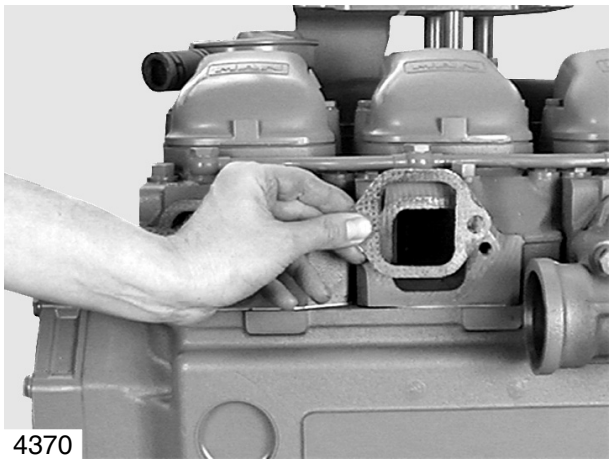


3 4369

Installing exhaust manifold

Fig. 4

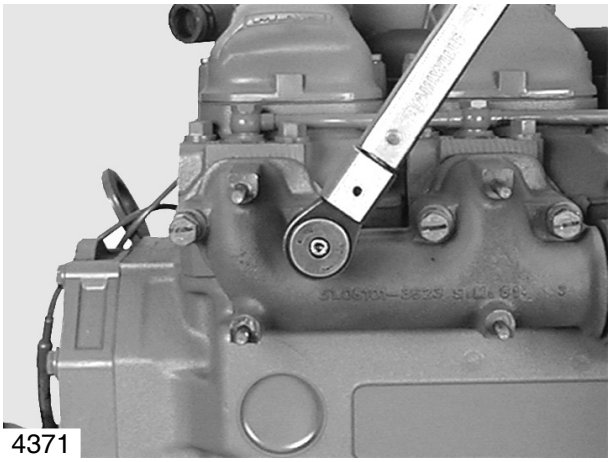
Fit exhaust pipe with new seals.



4 4370

Fig. 5

Tighten the mounting bolts to specified torque (see ”Engineering • Data • Setting values”).



5 4371

Before removing the turbocharger carry out the following checks

Turbochargers are frequently exchanged if the oil consumption is too high, the output too low or the intake and/or exhaust gas noises appear to be abnormal. Subsequent inspections by the manufacturer of the supposedly defective parts frequently prove the turbochargers to be in order.

To ensure that only defective turbochargers will be exchanged in future, the following checks are to be carried out beforehand:

If the oil consumption is too high

- Check air filter for contamination,
- ensure that the engine room ventilation is adequate,
- check intake pipe for cross section reduction (owing e.g. to damage, contamination).

These causes lead to higher oil consumption owing to the increased vacuum on the intake side of the compressor.

- Check outside of turbocharger for oil traces.

Oil consumption caused directly by turbocharger depends on the bearing wear and results in relatively early mechanical damage.

If engine performance is not satisfactory

Correct adjustment of the

- delivery start,
- valve clearance,
- function of final controlling element / control rod (rack not in full load position)

In addition, the following are to be checked:

- the compression,
- the air filters for contamination,
- the charge-air pressure,
- the pressure in the inlet chamber of the injection pump,
- the exhaust back pressure.

If you do not detect any possible cause in the above checks, check the turbocharger for:

- Carbonization in the turbine area, which impairs the movement of the wheel assembly (can be eliminated by axial movement).
- Dirt in the compressor area.
- Damage caused by foreign objects.
- Scraping of the turbine rotor on the housing.

If a considerable amount of dirt has accumulated, clean the compressor end and check the bearing clearance.

Caution:
Do not damage the aluminium compressor wheel.

When there is unusual intake or exhaust noise

- Check the intake and exhaust system in the area of the charger group.
  Defective gaskets can lead you to think the turbocharger is defective. Replace them.
- If there are still unusual noises, check the bearing clearance.
  Turbochargers in good working order do not make any excessive noise.

Oil accumulation in charge-air lines and the intercooler

A small amount of oil collects in the charge-air system. This is supposed to happen, is caused by oil mist, and is desirable. The oil mist is required to lubricate the intake valve seats.

If more oil accumulates than usual, that is, if oil pockets develop in the lower air box of the intercooler, for example, this can lead to oil disintegration or uncontrolled raising of the engine speed when the oil is separated. In such cases, you must eliminate the cause.

Possible causes:

- The engine is overfilled with oil.
- Check whether the correct dipstick and guide pipe combination is installed.
- The engine oil used is unsuitable (see publication ”Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines”).
- The engine is being run on impermissibly steep inclines.
- The crankcase pressure is to high. This may be caused by a defective oil separator valve or piston ring wear.

Compressor carbonization

This can occur when the charge-air temperature is permanently high, for example when the engine is constantly run at full load.

Carbonization lowers the charging pressure but does not negatively affect performance or acceleration. Carbonization can lead to increased exhaust clouding.

If exhaust emissions test values are no longer met:

- Remove the compressor housing, being careful not to let it get jammed. If it gets jammed, the compressor wheel blades may get damaged or bent, and the resultant imbalance can ruin the turbocharger.
- Remove carbonization in the compressor housing with a suitable cleaning agent.

Danger:

Never spray in cleaning agent while the engine is running.

- ineffective
- dangerous

- In problem cases, use oil types that are less likely to lead to compressor carbonisation (see publication ”Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines”)

Checking charge-air pressure

Sufficient charge-air pressure is indispensable for full power output and clean combustion.

Checking the charge-air pressure helps detect damage to the turbocharger, operating faults in the wastegate and leaks in the intercooler and in the charge-air pipes.

Extreme operating conditions (full-load operation and high air temperature) and the use of unsuitable engine oils (also see publication ”Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines”) may cause deposits on the compressor as well as in the intercooler, which results in a reduction in charge-air pressure.

Preconditions for the measurement

The delivery start and the valve clearance must be set as specified, and the engine must be at operating temperature.

Charge-air pressure:

A general set-point value for the charge-air pressure cannot be given. Values ascertained on the test bed ought not to be used for comparison, as the respective installation conditions are decisive. The value which was ascertained during commissioning and was noted in the commissioning report is to be used as the set-point value.

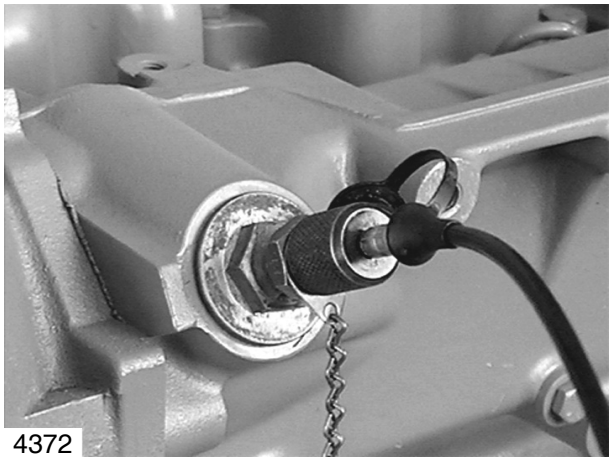
When carrying out the measurement, observe the following:

Owing to various atmospheric reference conditions during the measurements and to tolerances of the pressure gauges used, deviations of max. ± 100 hPa (± 100 mbar) are permissible.

Fig. 1

A measuring connection for checking the charge-air pressure and the charge-air temperature is located in the intake manifold behind the intercooler.

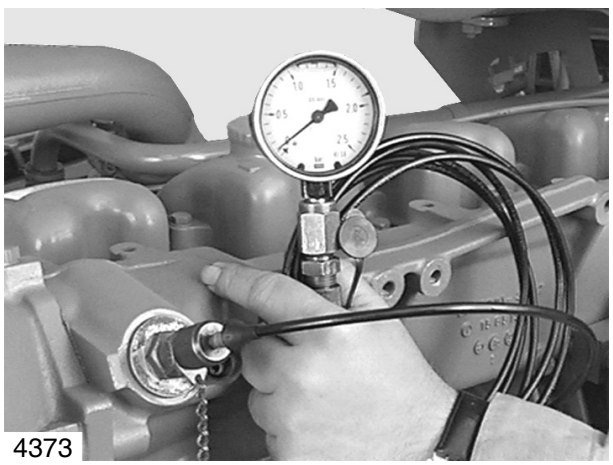
Remove screw plug (M32x1.5).
Connect up pressure gauge (if necessary using a suitable threaded pipe as adapter).



1 4372

Fig. 2

Measure the charge-air pressure downstream of the intercooler at nominal engine speed and full load.

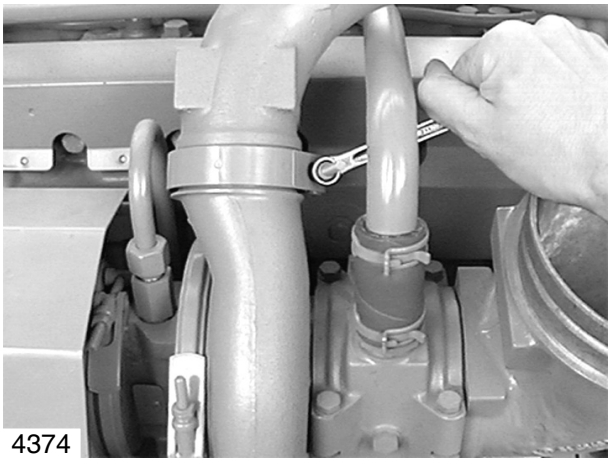


2 4373

Removing turbocharger

Fig. 1

Remove corrugated hose from between air filter and compressor and charge-air pipe from between compressor and intercooler.

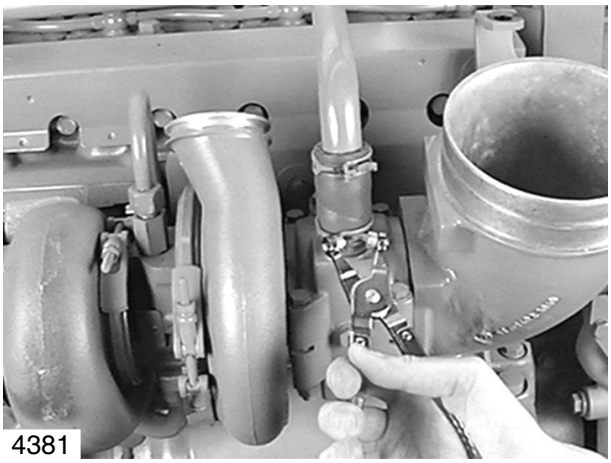


1 4374

Fig. 2

Remove anti-contact protection device from turbine housing.

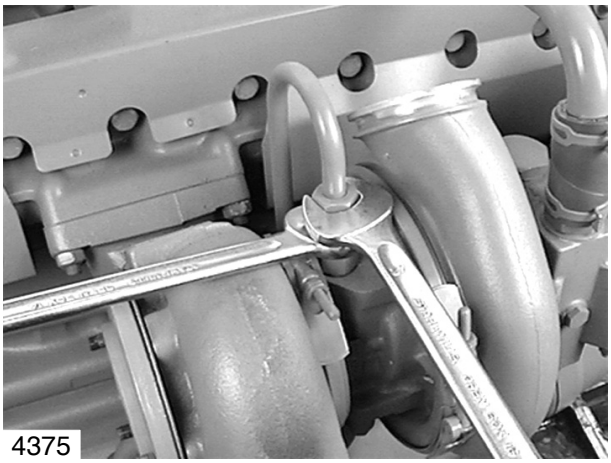
Remove hose from crankcase breather.



2 4381

Fig. 3

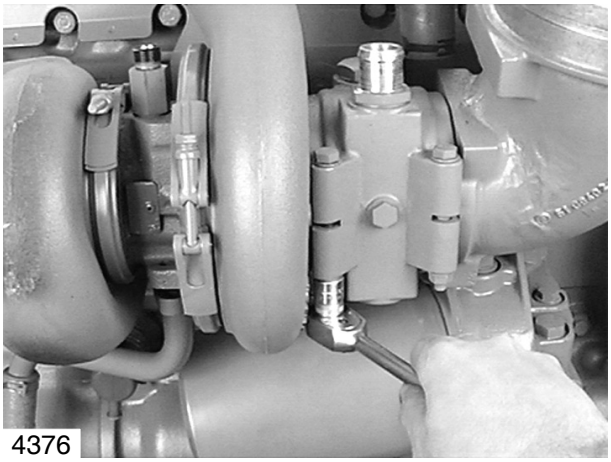
Remove oil supply and return lines.



3 4375

Fig. 4

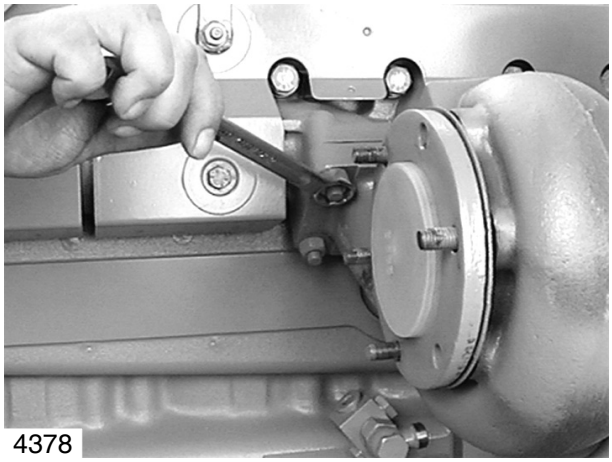
Remove air intake manifold from compressor.



4 4376

Fig. 5

Remove the four (self-locking) nuts from the turbocharger flange.

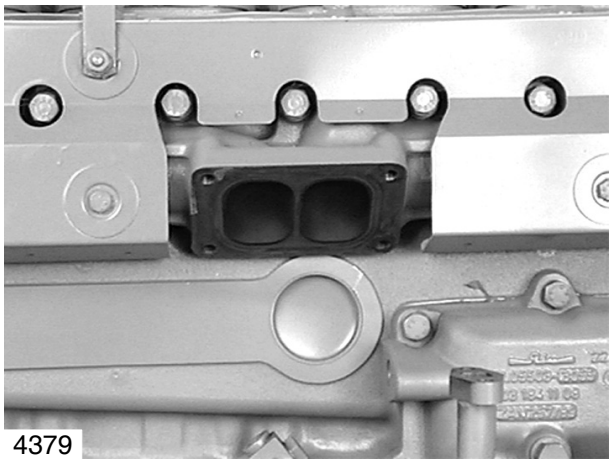


5 4378

Fig. 6

Take off turbocharger.

Note:
Ensure meticulous cleanliness when putting the turbocharger aside to prevent dirt and foreign matter from penetrating into the interior of the turbocharger.



6 4379

Installing turbocharger

Figs. 7 and 8

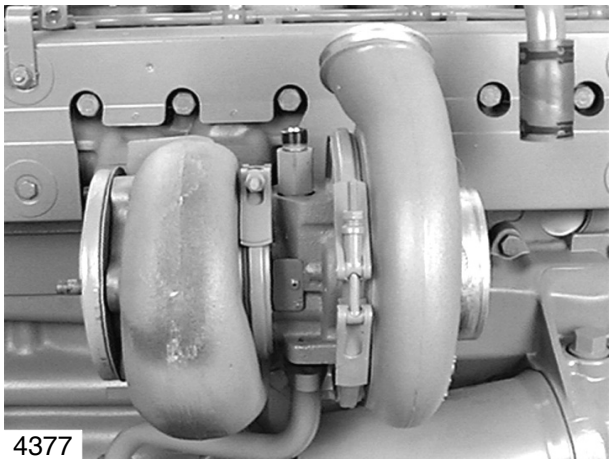
The turbocharger is assembled in reverse order.

When assembling, use new seals and new self–locking nuts.

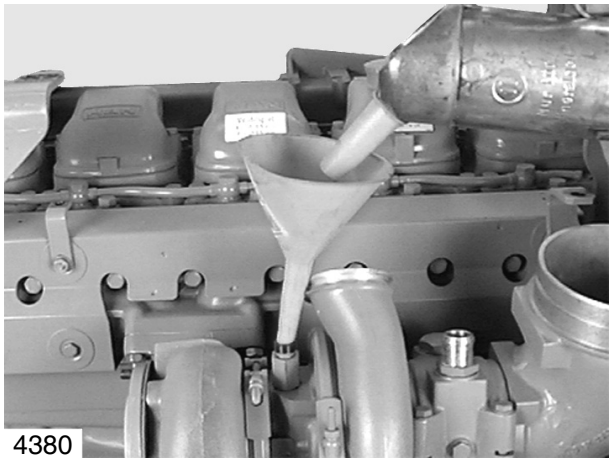
Before connecting up the oil supply line, fill bearing housing up with clean engine oil.

Check all connections for leaks and tension.

Caution:
Comply with instructions for masking unions on pressurised oil and fuel pipes (see page 3).



7 4377



7 4380

- Remove turbocharger, see page 71
- Mark turbine housing relative to the bearing housing and remove turbine housing.

Axial play

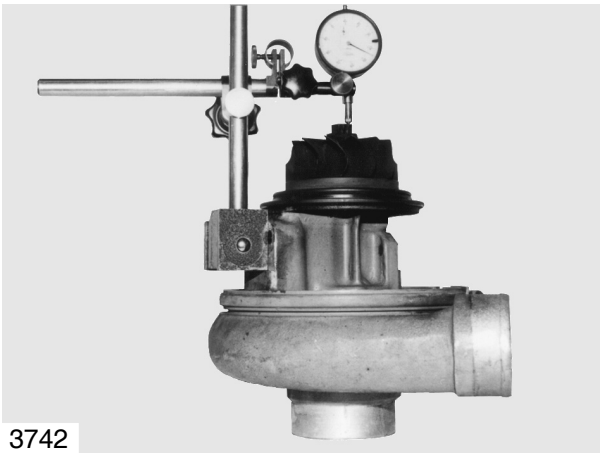
Fig. 1

Remove turbocharger. Mark turbine housing relative to the bearing housing and remove turbine housing.

Apply dial gauge holder and dial gauge under preload to shaft end face of the turbine wheel as shown.

Press rotor shaft against dial gauge. Read and note down value. Push rotor in opposite direction. Read and note down value.

The difference between the two is the axial play. Change turbocharger if axial play is exceeded.



1 3742

Radial play

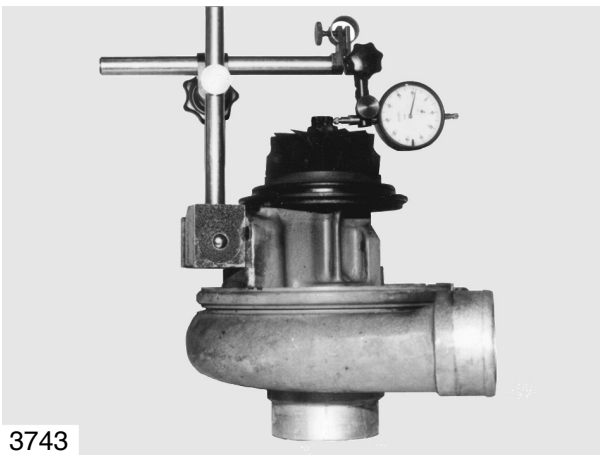
Fig. 2

Radial play is measured only on turbine end with dial gauge or feeler gauge.

Apply dial gauge tip to side of hub. Push turbine wheel towards dial gauge. Read and note down value.

Push turbine wheel in opposite direction. Read and note down value. The difference between the values is the radial play.

Place turbine housing in position, observe markings and screw on turbine housing.



2 3743

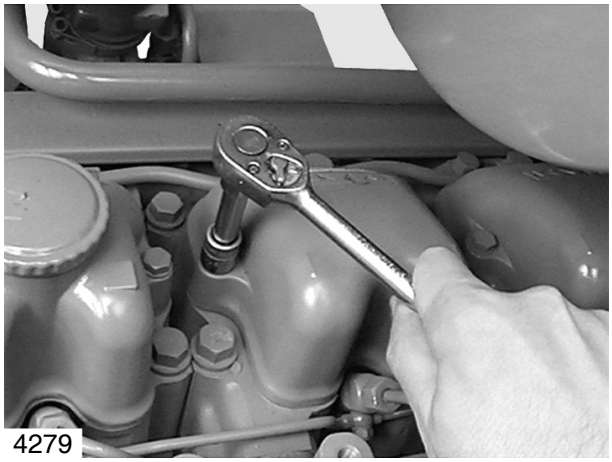
Removing cylinder head

- Drain coolant, see page 38
- Remove the injectors, see page 31

Note:
The intake and exhaust pipes need not be detached for removing the cylinder head.

Fig. 1

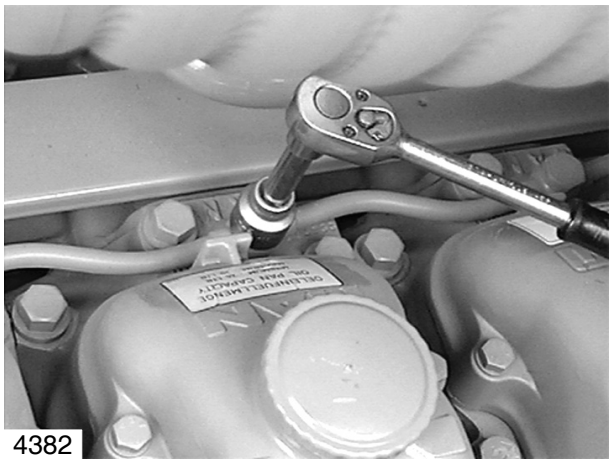
Take off the cylinder head covers.



1 4279

Fig. 2

Remove the coolant bleed pipe.

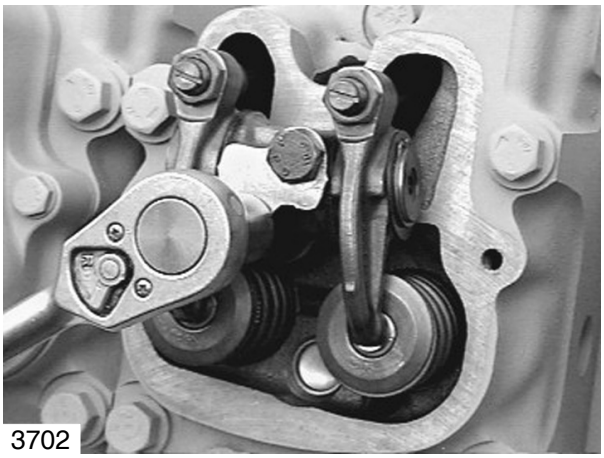


2 4382

Fig. 3

Back off valve adjusting screws.

Loosen mounting bolts of rocker arm bracket.

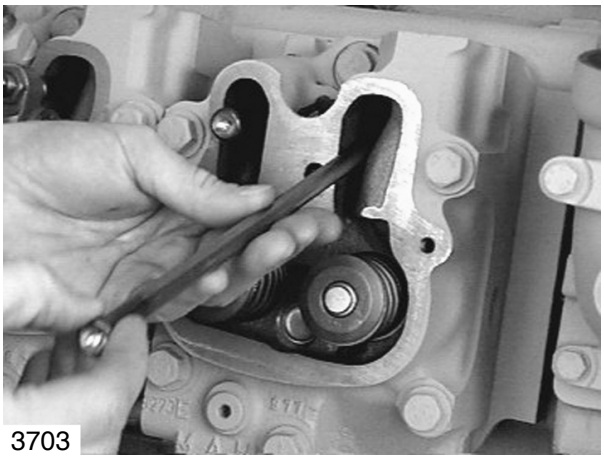


3 3702

Fig. 4

Remove rocker arm bracket.

Take out push rods.

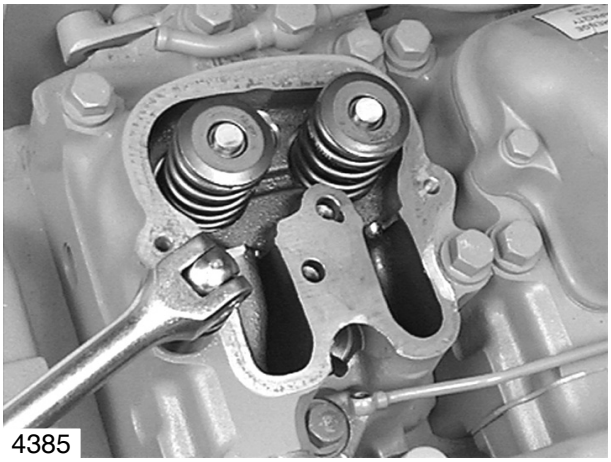


4 3703

Fig. 5

Remove cylinder head bolts in reverse order of tightening.

Note:
Use reinforced socket (screw-driving machine) to loosen and tighten the cylinder head bolts.
On engines recently manufactured Torx bolts are fitted for which an E20 – 1/2” wrench is required.

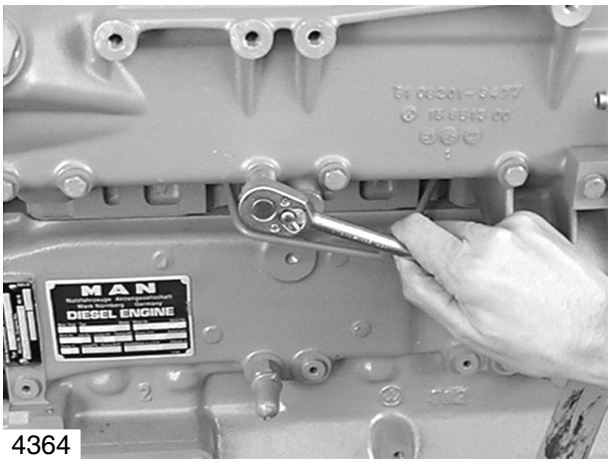


5 4385

Fig. 6

Loosen all mounting bolts from the intake and exhaust manifolds.

This will reduce the tension on the cylinder head, and the head can be taken off more easily.

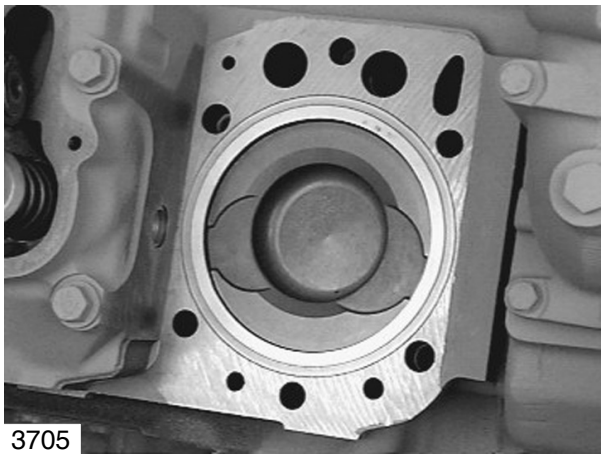


6 4364

Fig. 7

Take off cylinder head and cylinder head gasket.

Note:
If within the context of an engine overhaul all cylinder heads of a bank are removed, check the sealing faces of the cylinder heads and of the cylinder block with a straight edge to see whether they are plane.
Cylinder heads which are not plane may be remilled by 1 mm. Observe specified nozzle protrusion and valve retrusion (see ”Engineering • Data • Setting values”).
Check the cylinder heads for cracks.



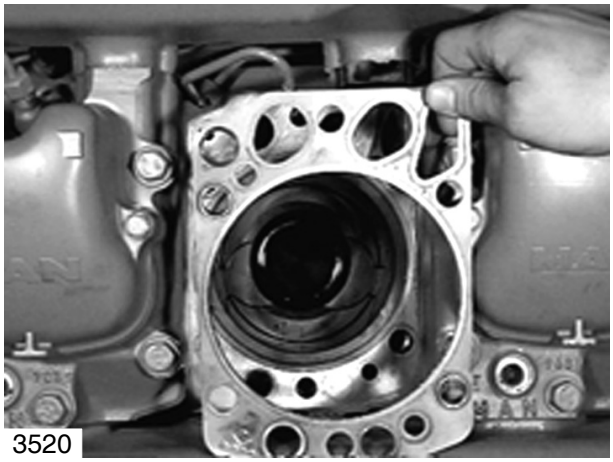
7 3705

Installing cylinder head

Fig. 8

Before installation clean and blow out threaded bores in crankcase. Clean sealing faces on cylinder head and crankcase.

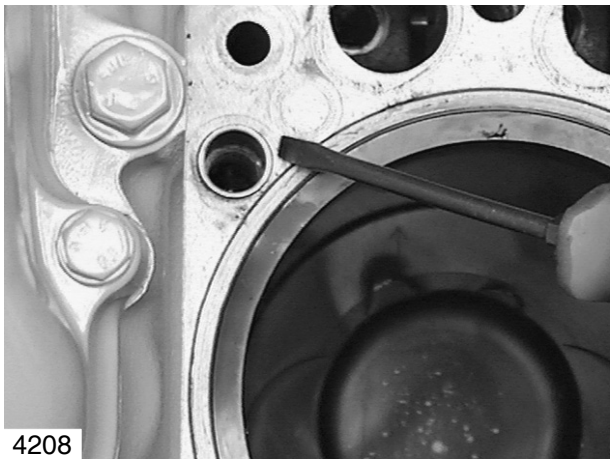
Lay new cylinder head gaskets in place in dry condition, ensuring that the holes match those in the crankcase, and place cylinder head on top.



8 3520

Fig. 9

Each cylinder head is located with two fitting sleeves.

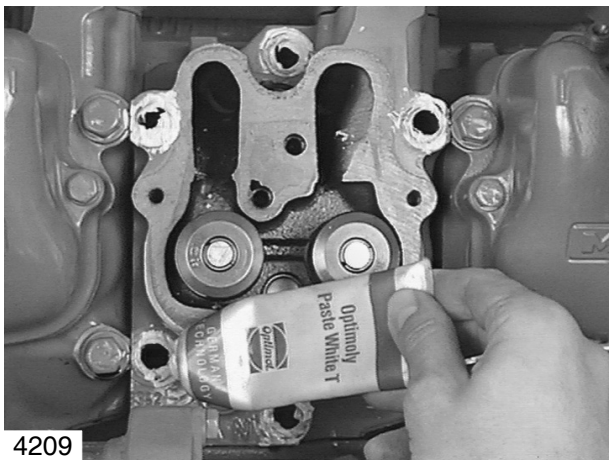


9 4208

Fig. 10

Check whether the cylinder head bolts have the max. permissible length (see: ”Engineering • Data • Setting values”). Bolts that have been removed may be used again if the max. permissible length is not exceeded.

Coat cylinder head bolts with engine oil before inserting them and apply ”Optimoly WhiteT” assembly paste to the contact face of the bolt head.



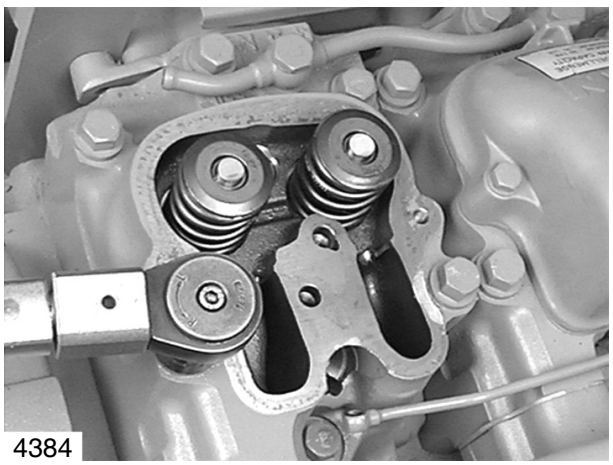
10 4209

Fig. 11

Tighten bolts by angle. Observe order of tightening and specified tightening method, and see instructions and notes on the cylinder head bolts in the publication ”Engineering • Data • Setting values”.

Note:
To avoid any distortion between cylinder heads and exhaust manifolds, we recommend proceeding as follows:

- Place cylinder head gaskets and cylinder heads in position.
- Screw in head bolts by a few turns.
- Secure steel ruler (special tool) with ground face on the exhaust side; tightening torque for mounting bolts: 20 Nm.
  If a steel ruler is not available, mount exhaust manifold and tighten to 20 Nm.
- Tighten cylinder head bolts as specified.
- Remove steel ruler.
- Tighten exhaust manifold and intake manifold to specified torque.



11 4384

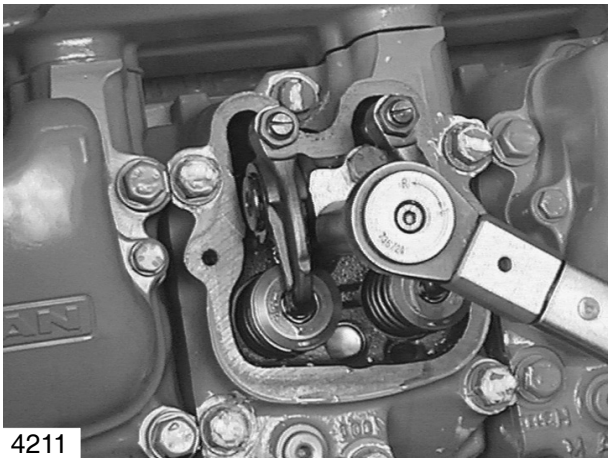
Fig. 12

Check push rods for distortion. When inserting the push rods ensure that they fit into the seat of the valve tappet.

Put rocker arms and push rods in place. Screw in the mounting bolts without washers and tighten them slightly.

Align rocker arms to valves. Tighten the mounting bolts to the specified torque.

Note:
Use only M10x70 mounting bolts (property class 10.9).

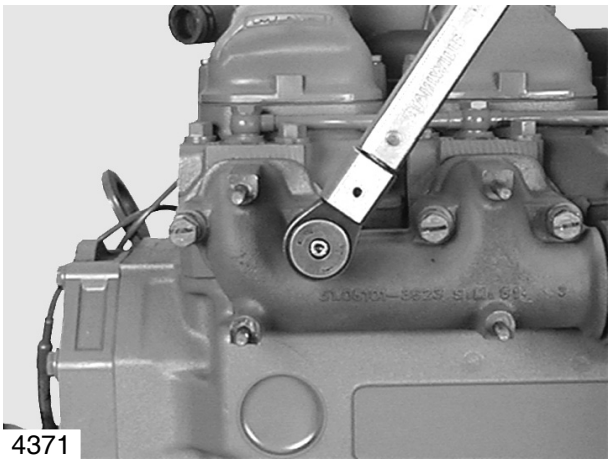


12 4211

Fig. 13

Fit new seals between the cylinder head and the intake and exhaust pipes.

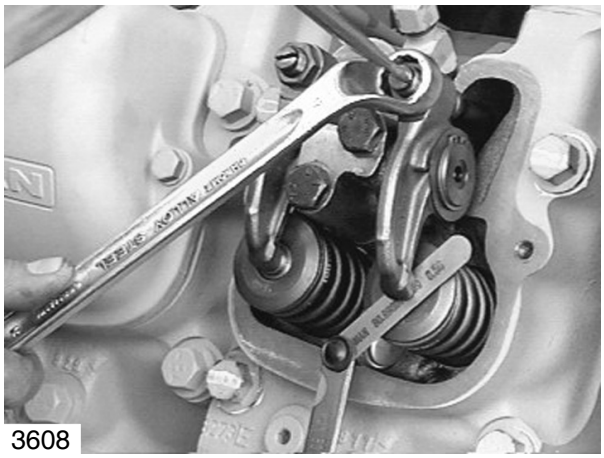
Tighten the mounting bolts on the intake and exhaust pipes to the specified torque.



13 4371

Fig. 14

Set valve clearance. Fit injection nozzle.
Mount cylinder head cover with new seal.
Fit coolant bleed line with new seals.
Fill up with coolant.



14 3608

General notes:

The sealing effect of the cylinder head gasket largely depends on whether the required initial tension for the cylinder head bolts is reached and maintained.

Use calibrated torque wrenches to tighten the cylinder head bolts. When the specified final torque is applied it must be maintained for at least 5 seconds. When using snap-type torque wrenches tighten bolts gradually since otherwise the torque selected will not be fully transferred to the bolts.

Observe notes on usability of cylinder head bolts, order of tightening and specified tightening method in publication ”Engineering, Data, Setting values”.

Tightening

”Tightening” is defined as the first–time tightening of newly fitted bolts that have not been tightened after a repair, e.g. changing the cylinder head gasket. Tighten cylinder head bolts while the engine is cold, i.e. the crankcase is warm to the touch or colder.

Before inserting the cylinder head bolts, apply engine oil to the thread (not to the threaded hole) and ”Optimoly White T” assembly paste to the contact faces of the bolt heads.
Do not use oil or oil additives containing MoS_2.
If the bolts are not oiled, a significant amount of the tightening torque is converted into friction and thus lost for the bolt pretensioning.

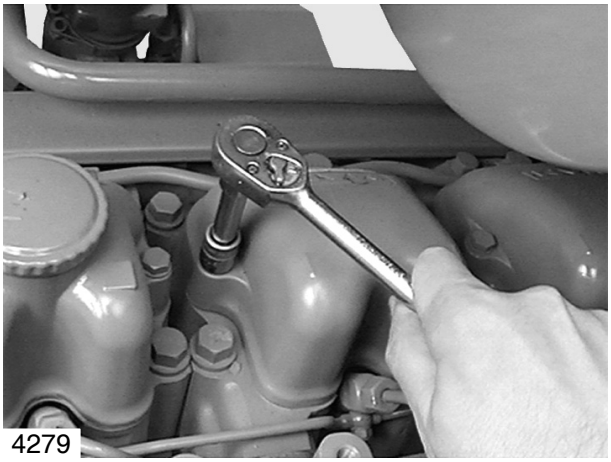
- To position cylinder heads, tighten cylinder head bolts only lightly.
- Align cylinder heads by screwing on the steel ruler (special tool). If a steel ruler is not available, use exhaust or intake manifold.
- Tighten bolts in specified order and to specified torque / tightening angle in steps.

Danger:
If during initial tightening some bolts are excessively tightened, the cylinder head will be distorted. This distortion cannot be cancelled out by continuing to tighten according to the instructions.

Fig. 1

Remove cylinder head cover (13mm).

Note:
On engines recently manufactured the valve covers are fastened with Torx bolts for which an E12 – 1/2” wrench is required.

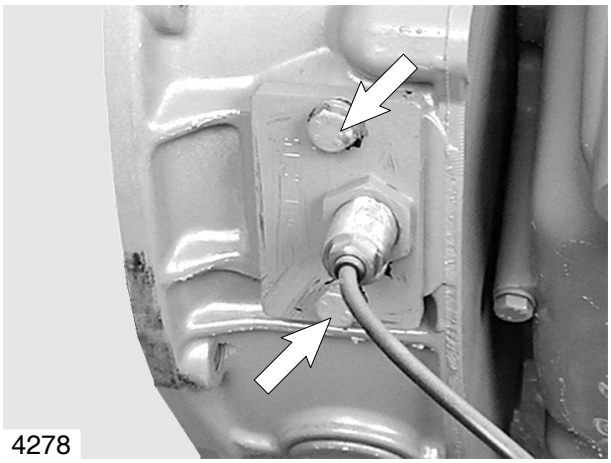


1 4279

Fig. 2

The speed pickup is fitted to the bottom right–hand side of the flywheel housing. Remove the mounting bolts from the retaining plate and take it off together with the speed pickup.

Fit cranking device (standard ratchet, special tool).



2 4278

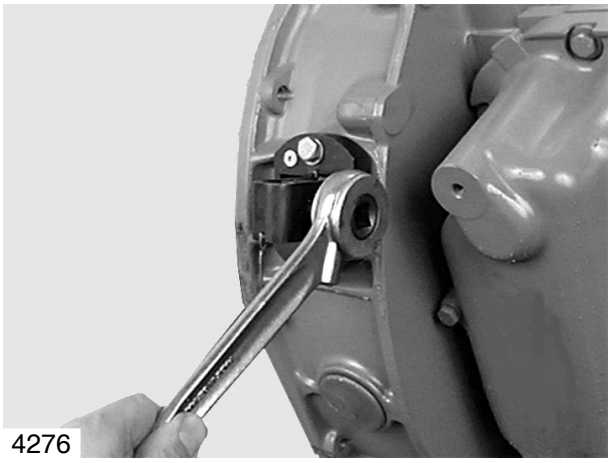
Figs. 3

Use barring device to turn engine so that the piston in the cylinder to be set is at TDC and the two valves are closed. At this point both inlet and exhaust valves will be open i. e. valves overlap.

Valves are in crossover in cylinder

1	5	3	6	2	4
6	2	4	1	5	3

Set valves in cylinder

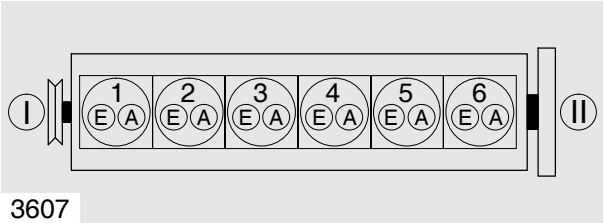


3 4276

Fig. 4

Arrangement of cylinders and valves

I Engine front end
II Flywheel side
A Exhaust valve
E Inlet valve



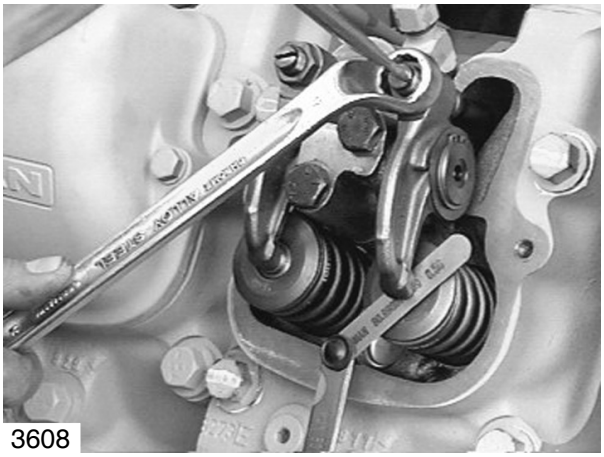
4 3607

Fig. 5

Push feeler gauge between valve stem and rocker arm. Loosen lock nut and turn adjusting screw with screwdriver until feeler gauge can be moved with slight resistance.

Tighten lock nut to the specified torque (see ”Engineering • Data • Setting values”) using screwdriver to prevent adjusting screw from turning. Check clearance again.

Refit cylinder head covers.

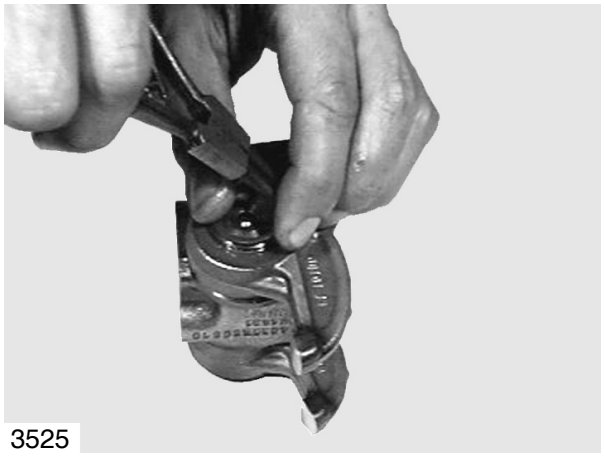


5 3608

- Remove rocker arms, see page 74

Fig. 1

Unclip circlip.



1 3525

Fig. 2

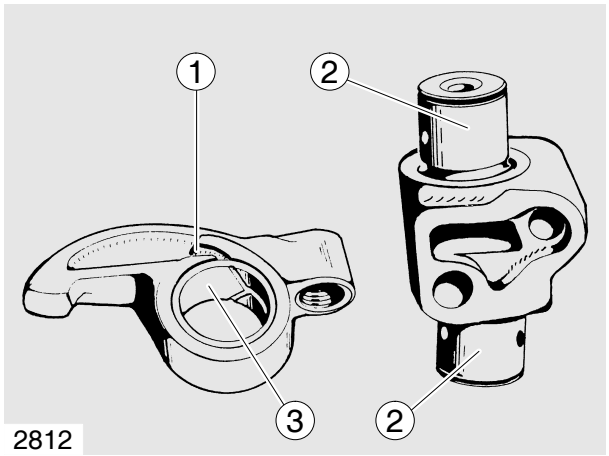
Take rocker arms off the rocker arm shaft.

Note:
If the rocker arm bearing bushes have to be exchanged, ready-to-install new or re-conditioned rocker arms are to be used.

2 3526

Fig. 3

Before fitting the rocker arms ① to the rocker arm shafts and brackets, coat sliding faces ② and ③ with Optimoly Paste White T. This applies to both new and already used parts.
This applies to both new and already used parts.



3 2812

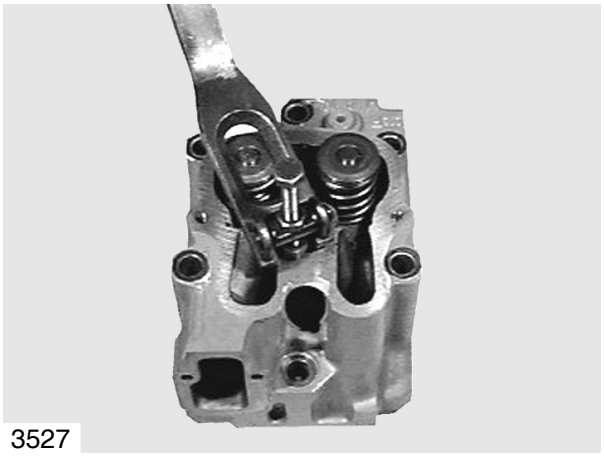
Removing valves

- Remove rocker arms. Take off cylinder head see page 74

Fig. 1

Screw valve assembly lever on to cylinder head.

Note:
Valve spring and valve spring retainer can also be replaced with the cylinder head installed. For this purpose the relevant piston must be at TDC, and the valve assembly lever is required.

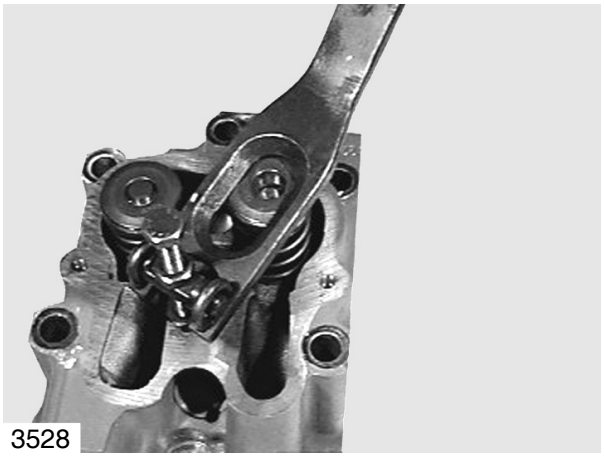


1 3527

Fig. 2

Note:
If a valve fixture is available in the workshop, the procedure described may also be carried out on the said fixture.

Use valve assembly lever to press valve spring retainer and spring downwards and take out tapered elements using a magnet. Lift assembly lever (caution: the spring is loaded) and slew it to one side.

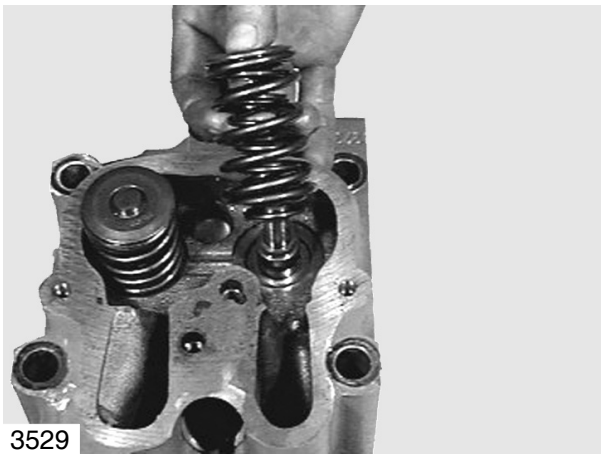


2 3528

Figs. 3 and 4

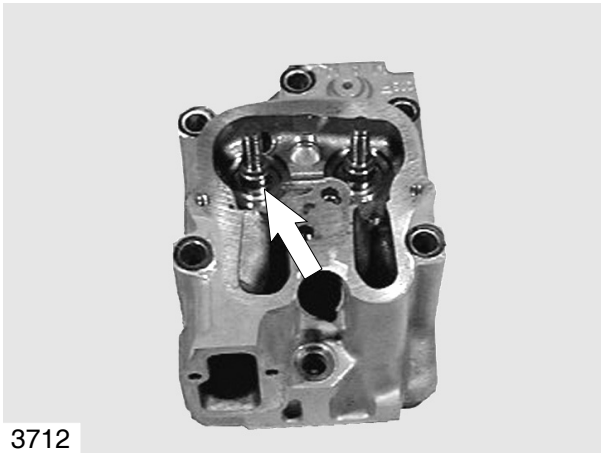
Take out valve discs, springs, discs and valves. Remove valve assembly lever.

Note:
The engines D 2866 LE 2.. are equipped with valve stem seals (arrow).



3 3529

Take off valve stern seals. Turn cylinder head over and take out valves.



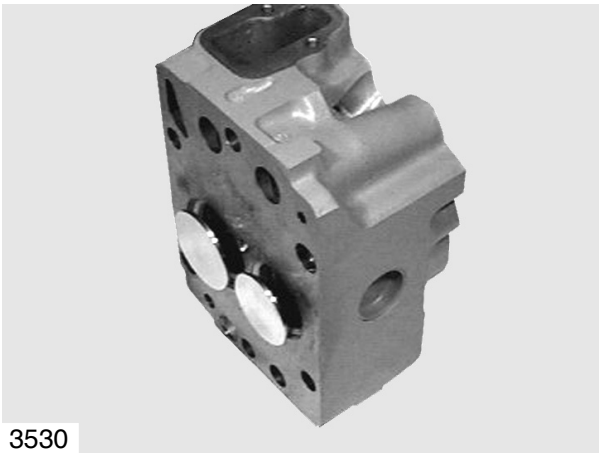
4 3712

Installing valves

Fig. 5

Apply oil to valve stern and insert valves into valve guides.

Note:
Minor damage to the valve seat can be eliminated by lapping using valve lapping paste. New valves must always be lapped until an even valve seat has been achieved. Machine valve seat insert if necessary.



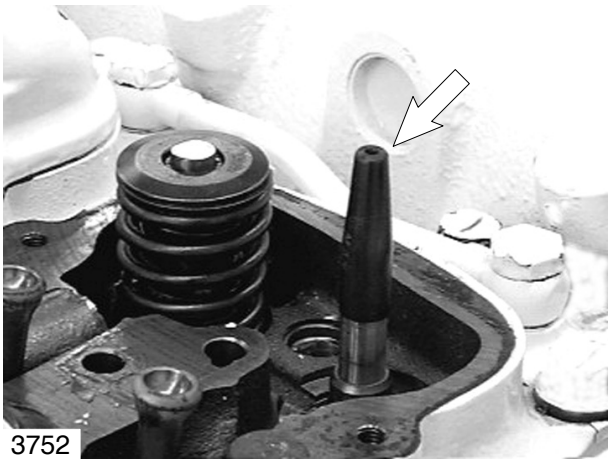
5 3530

Turn cylinder head over and insert valve spring washers. Screw off valve assembly lever.

Figs. 6 and 7

Place insert sleeve for valve shaft seals (special tool, see page 128, item 19) on the respective valve and push on seal.

Note:
Use new valve shaft seals only.

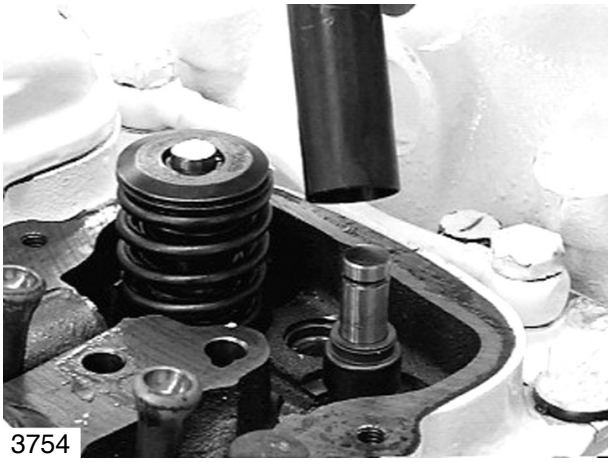


6 3752

7 3753

Fig. 8

Take off insert sleeve. Fit press-in sleeve and press in seal.



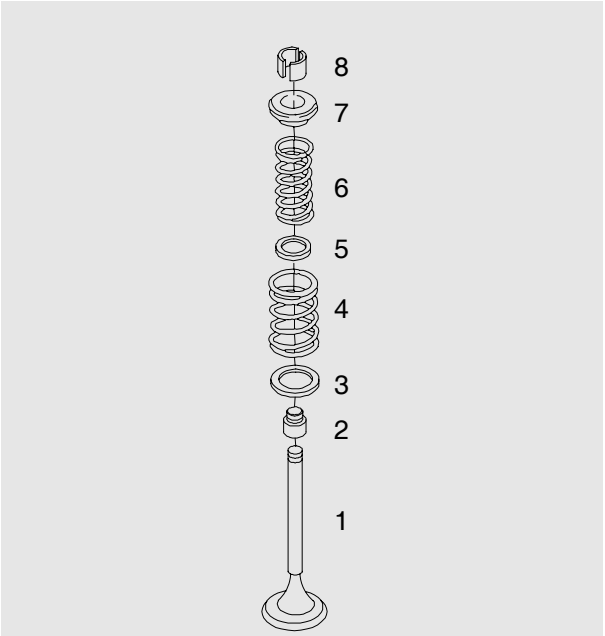
8 3754

Fig. 9

Insert discs and valve springs.
The word ”TOP” facing upwards, the tight coils facing downwards. Replace damaged or weak springs.

Fit valve discs and tapered elements.

1 Valve
2 Valve stem seal (on the inlet valve only)
3 Washer
4 Outer valve spring
5 Washer
6 Inner valve spring
7 Spring retainer
8 Tapered element

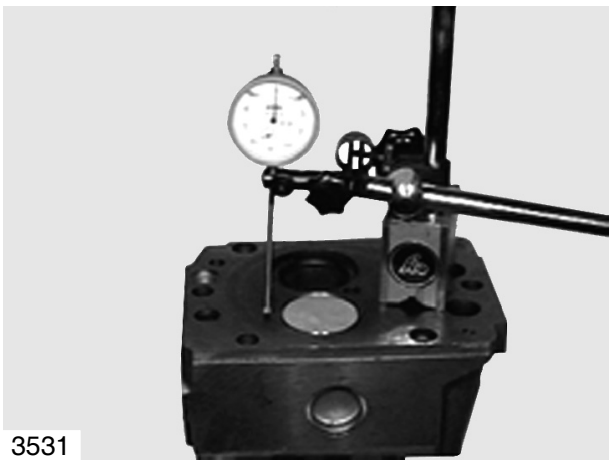


9 2817

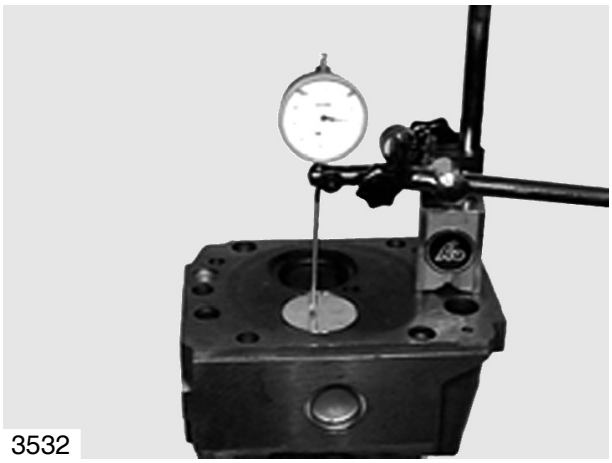
Measuring valve recess

Figs. 10 and 11

Place dial gauge holder and dial gauge on cylinder head so that the dial gauge tip contacts the cylinder head and set dial gauge to “0”. Slew dial gauge towards the valve disc and read off retrusion. If necessary, change valve and/or valve seat insert.



10 3531



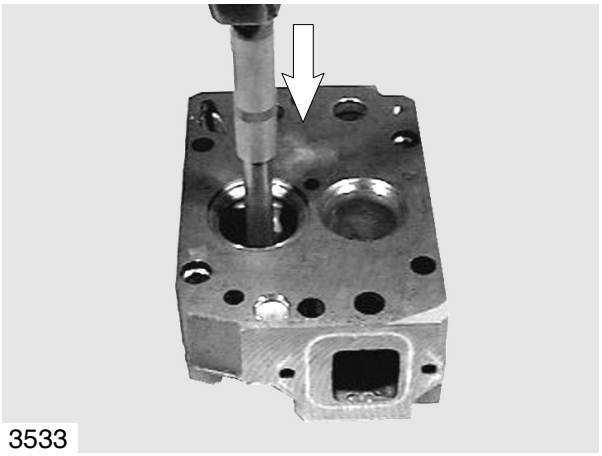
11 3532

- For removing and installing cylinder head, see page 74
- For removing and installing valves, see page 82

Fig. 1

Press valve guide out of the combustion chamber side using pressing mandrel (special tool, see page 128, item 20).

Oil new valve guide and drive/press it into the cylinder head using pressing mandrel and spacer sleeve (special tool).



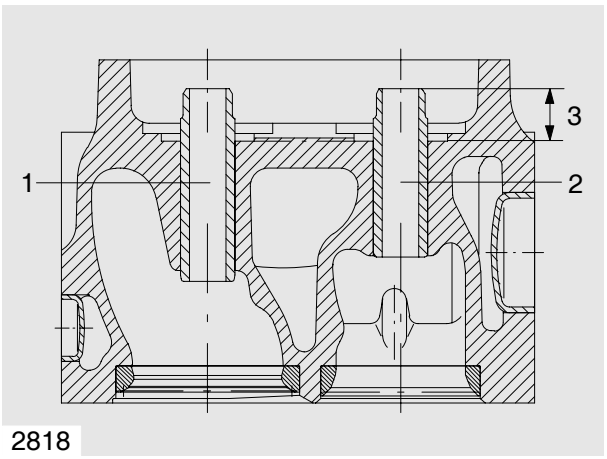
1 3533

Fig. 2

The valve guides vary only in length.

1 Inlet = long guide
2 Exhaust = short guide
3 Press-in depth (see publication ”Engineering • Data • Setting values”).

The correct press-in depth is obtained by using the spacer sleeve.
Afterwards ream valve guide to specified dimension.



2 2818

Note:
When the valve guides have been changed, the valve seats too must be reworked (see technical data and manufacturers’ instructions for valve seat lathes found in individual workshops).

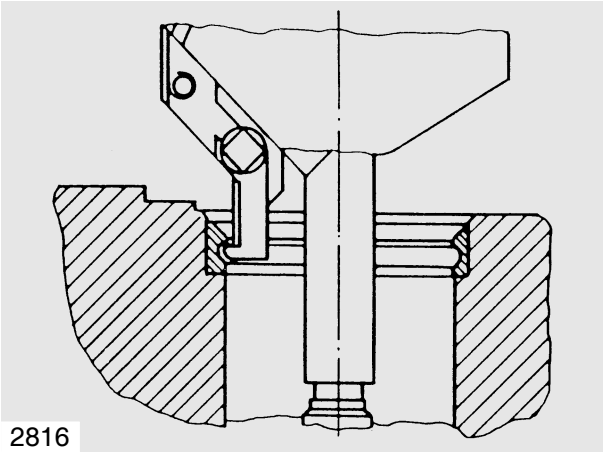
Removing valve seat insert

Note:
If the valve seat inserts have to be changed it is necessary to change the valve guides too, as otherwise exact refacing of the valve seat inserts after the replacement cannot be guaranteed. For these reasons previously mentioned the tool for removing and installing valve guides and valve seat inserts was also designed in such a way that if this tool is used valve seat inserts can be replaced only together with the valve guides, i.e. valve guides, however, can also be changed alone.

Fig. 1

Use a valve seat machining tool (valve seat lathe) to cut an approx. 3-4 mm wide groove in the valve seat insert.

Insert internal puller into the groove and tighten it.



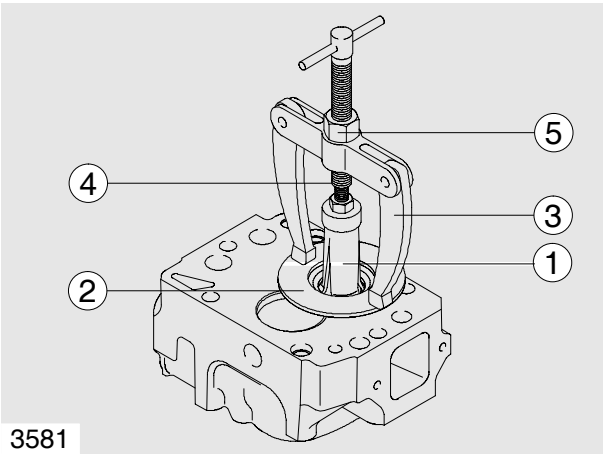
1 2816

Fig. 2

Note:
To avoid damage to the cylinder head sealing face, lay disc ② or similar item under the arms ③ of the support.

Turn threaded spindle ④ into the internal puller ①, align the arms ③ of the support and pull out valve seat insert by turning the nut ⑤.

Clean contact face of the seat insert in the cylinder head.

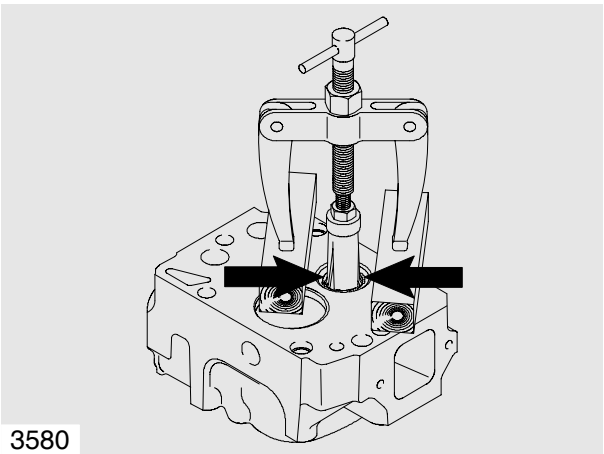


2 3581

Fig. 3

If no valve seat machining tool is available, the following procedure may be followed:

- Apply circular weld bead on the valve seat using an arc welding set (arrows),
- then pull out valve seat insert.
- Clean contact face of the seat insert in the cylinder head.

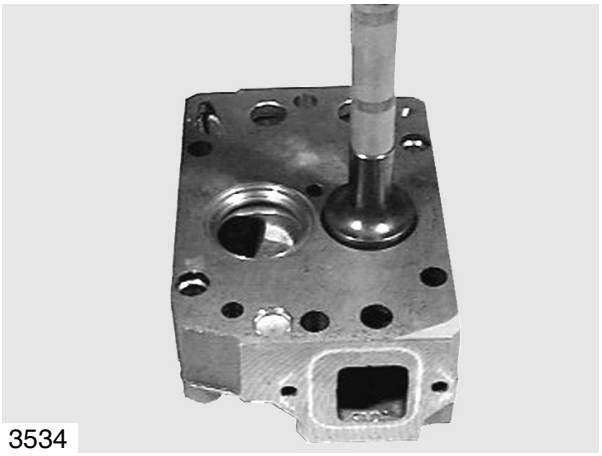


3 3580

Installing valve seat insert

Fig. 4

Heat cylinder head to approx. 80°C (175°F) in water bath.
Cool new valve seat insert to approx. –200°C (–330°F) and insert it in the cylinder head.
Carry out check by driving it in until the stop is reached using pressing tool.
Install valve guides.



4 3534

Note:
When the valve seat inserts have been changed, the valve seats must be reworked.

Note:

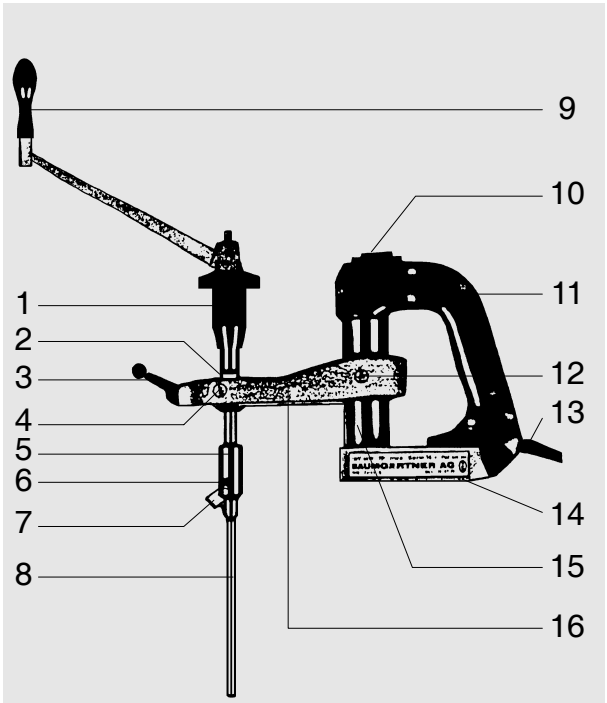
- After temperature equalization, machine valve seats.
- After machining, clean cylinder head and check for leaks using leak testing device.
- If the cylinder head is excessively heated (above +200°C, +390°F) the core hole covers (end covers) loose their tightness and must be exchanged.
- To do this, clean core holes, blow out channels and press in new core hole covers with ”LOCTITE 648” and pressing mandrel (special tool, see page 132).

Reworking valve seat

(with Mira precision valve seat machining device)

Fig. 1

1 Feed nut with mm scale
2 Guide ball
3 Jaccard lever
4 Lubricating nipple
5 Rotary head
6 Hex socket screw
7 Tool
8 Guide mandrel
9 Driving crank
10 Toggle switch
11 Handle
12 Lubricating nipple
13 Mains connection
14 Magnetic flange with coil
15 Guide pipe
16 Slewing arm



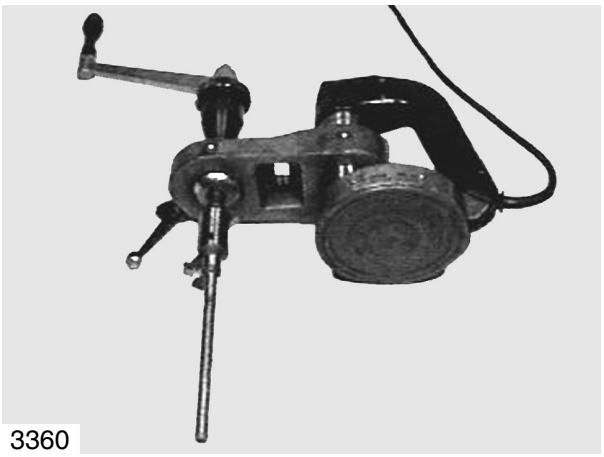
1 3358

Fig. 2

Select suitable guide mandrel, screw it in with a spanner (12 mm) and tighten it.

Note:
For extreme precision work the guide mandrel must fit snugly.

Select and insert the tool with the corresponding seat width and the corresponding seat angle.

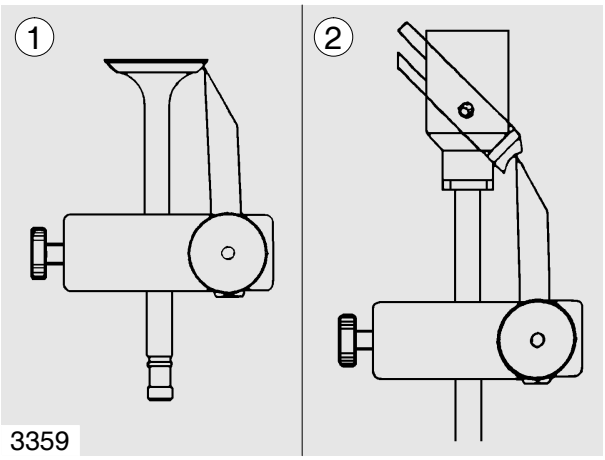


2 3360

Fig. 3

Set the tool with a setting gauge and tighten it with the hex socket screw.

Insert unit with guide mandrel into the valve guide.



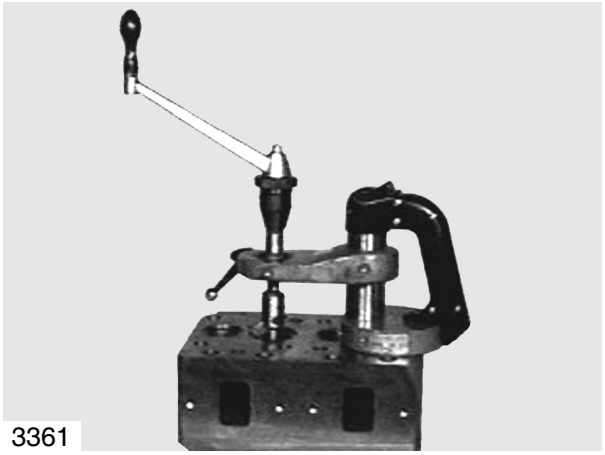
3 3359

Fig. 4

Release Jaccard lever, place magnetic flange flush on the clamping plate and set the height so that the tool does not contact the valve seat.

Set toggle switch to position 1.

Tighten the Jaccard lever.

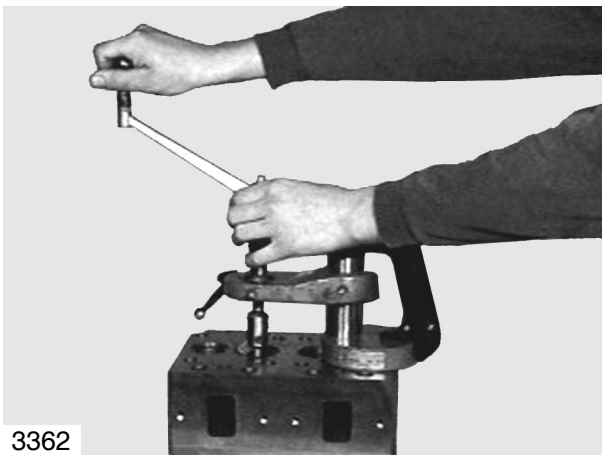


4 3361

Fig. 5

Machine the valve seat by turning the driving crank evenly in clockwise direction and simultaneously operating the feed nut.

Caution:
During the machining process turn the driving crank vigorously and evenly but under no circumstances against the direction of turning, as otherwise the carbide cutting edge may break.



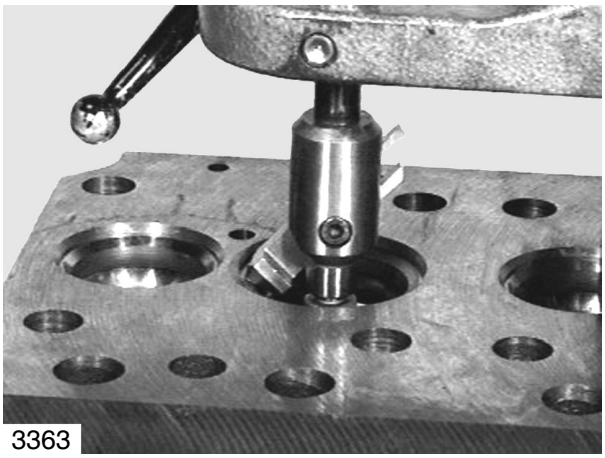
5 3362

Fig. 6

Once the valve seat has been expertly machined, reduce the working pressure of the tool by 2-3 revolutions without feed motion.
During these revolutions turn the feed nut 2-3 revolutions back.

Press toggle switch briefly to position 2 to lift the magnetic field.

Now move the whole Mira unit out upwards and insert it into the next valve guide, repeating the centering operation.
Use the same tool settings for all intake and all exhaust valve seats (see below).



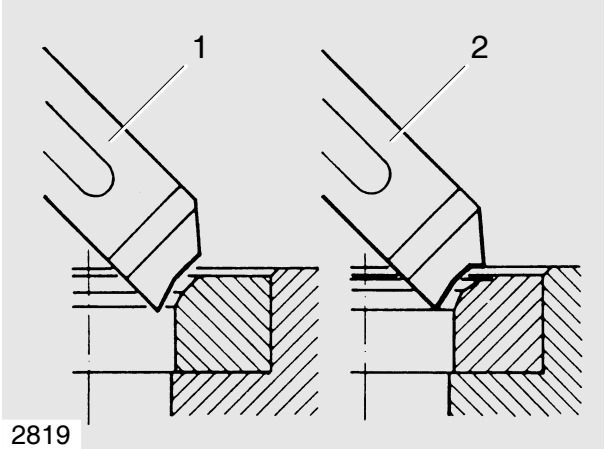
6 3363

Fig. 7

Observe specified seat angle.

1 Exhaust, total angle: 90°, tool setting: 45°
2 Inlet, total angle: 120°, tool setting: 30°

Repeat the chip-removing machining process until the valve seat is clean and free of pores.

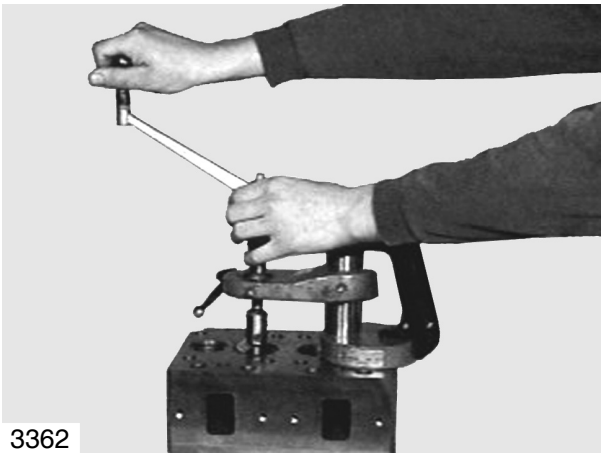


7 2819

Fig. 8

Note:
When dressing the valve seat inserts, remove as little material as possible from the seat face.
The valve retrusion is to be used as reference value.

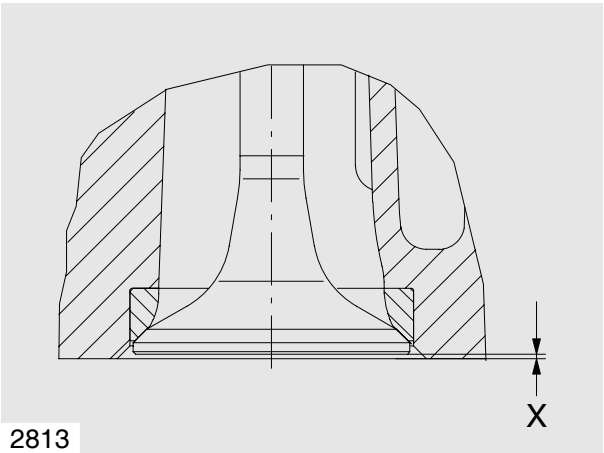
If the cylinder head interface is to be machined (max. 1 mm), the seat inserts must be reworked to achieve the valve retrusion.
If new valves and seat inserts are used, increase the depth of the seat bore in the cylinder head according to the amount of material removed from the cylinder head interface.



8 3362

Fig. 9

The valve seat insert must be changed if as a result of the cylinder head interface and the valve seat insert having been machined the theoretical valve seat is too deep in the cylinder head or the seat face has become too wide.
Ensure that the valve recess (X) is correct, see page 84.

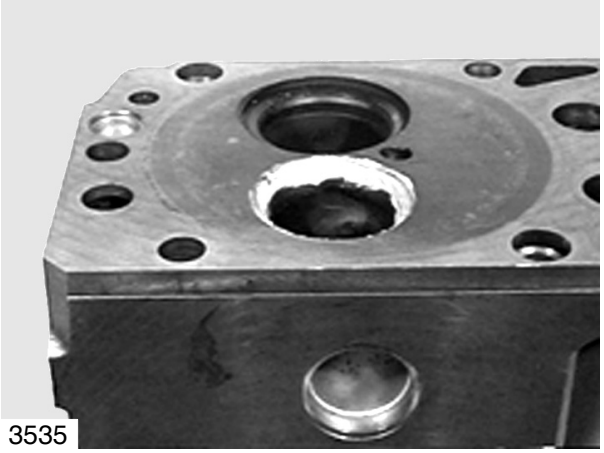


9 2813

Fig. 1

Apply abrasive paste to tapered area on the valve seat.

Oil valve guide and insert valve.

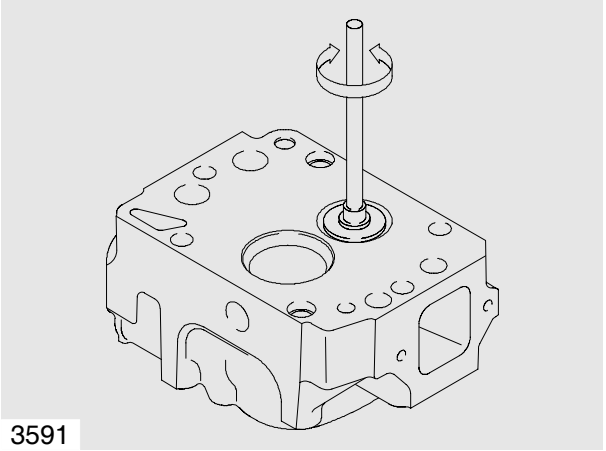


1 3535

Fig. 2

Use valve refacer to reface valve seat by applying moderate axial pressure and describing a turning motion.

Note:
Keep valve stem and valve guide free of abrasive paste.

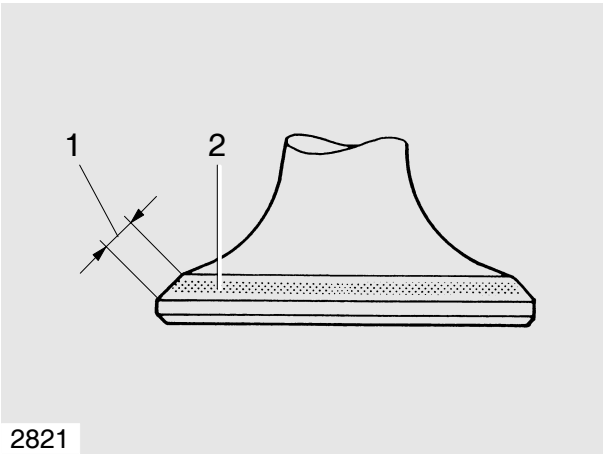


2 3591

Fig. 3

The valve seat must have a faultless, closed grinding pattern (2).
The grinding pattern width is correct if the valve seat insert is in order.

1 Valve tapered area
2 Valve seat



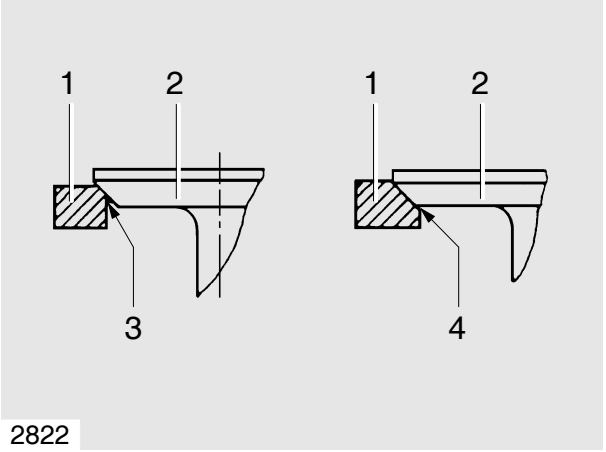
3 2821

Fig. 4

1 Valve seat insert
2 Valve
3 Valve seat good
4 Valve seat too wide

Note:
Valve seats which are too wide tend to accumulate coking residues,
– valves become leaky –

Valve seats that are too small prevent rapid discharge of heat from the valve disc to the cylinder head,
– valves burn –



4 2822

- Check valve clearance and adjust, if necessary, see page 79
- Let engine warm up
- Remove all fuel injectors, see page 31
- For compression guideline values, see publication ”Engineering • Data • Setting values”

Fig. 1

Start with 1st cylinder (water pump end). Insert new seal, screw on test connection of compression recorder with union nut and tighten with pin spanner.

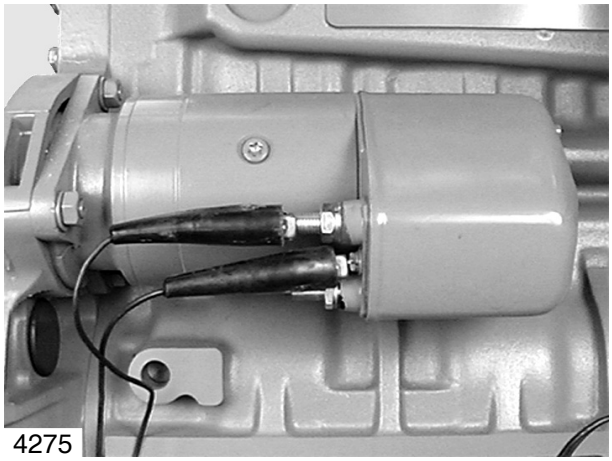
Insert test sheet into compression recorder. Screw compression recorder for diesel engines on to test connection.

Interrupt power supply to electro-hydraulic shut-off valve (EHAB) by removing the fuse; see circuit diagram on page 120).

Turn engine over with starter until needle deflection of compression recorder stops.

Connect up compression recorder with test connection to the next cylinder, and check all cylinders as described above.

1 4274



2 4275

Fig. 2

Depending on the compression recorder design, the engine can also be started directly by the compression recorder. For this purpose the electrical connections on the starter electromagnetic switch (terminals 50 and 30) are to be accordingly connected up.

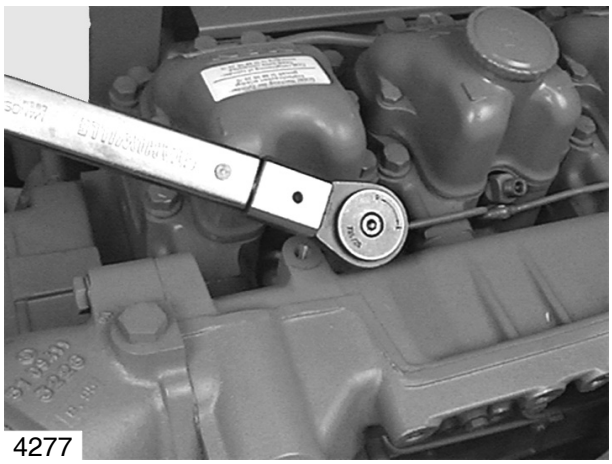
3 4273

Fig. 3

Compare the values measured and remove compression recorder and test connection. Apply ”Never Seeze” to contact faces on fuel injectors.

Fig. 4

Screw in fuel injectors with nozzle and new seal. Screw on union nut and tighten to specified torque (see ”Engineering • Data • Setting values”). Connect up injection and overflow oil lines and reinsert fuse of EHAB.



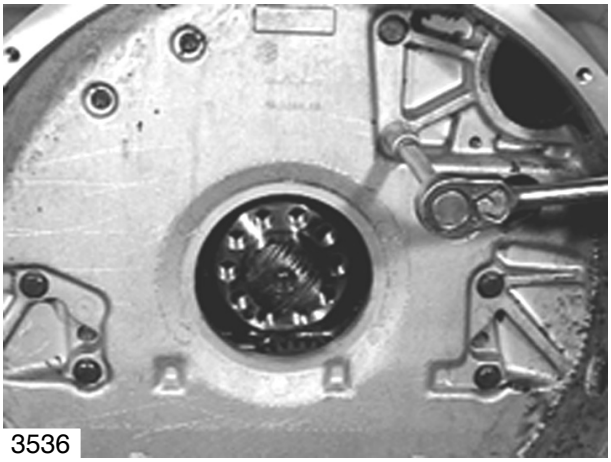
4 4277

- Remove starter, see page 111
- Remove speed pickup, see page 119
- Remove flywheel, see page 58

Fig. 1

Remove the mounting bolts.

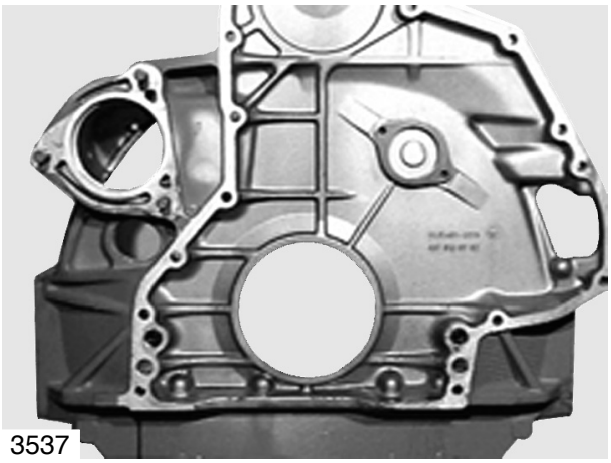
The bottom of the timing case is bolted to the oil pan.



1 3536

Fig. 2

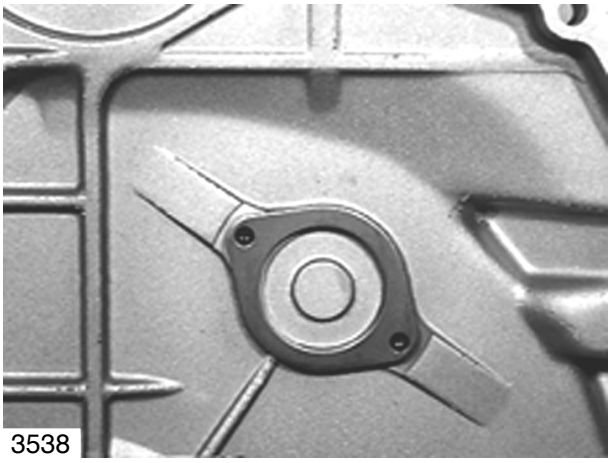
Take off the timing case. Take the gasket off the timing case and fit a new one.



2 3537

Fig. 3

Check the contact washer on the camshaft for wear, if necessary fitting a new one.



3 3538

Fig. 4

Stick new gasket to timing case using grease.

Fit flywheel housing. Check whether the oil-pan gasket is in order, if necessary fitting a new one.

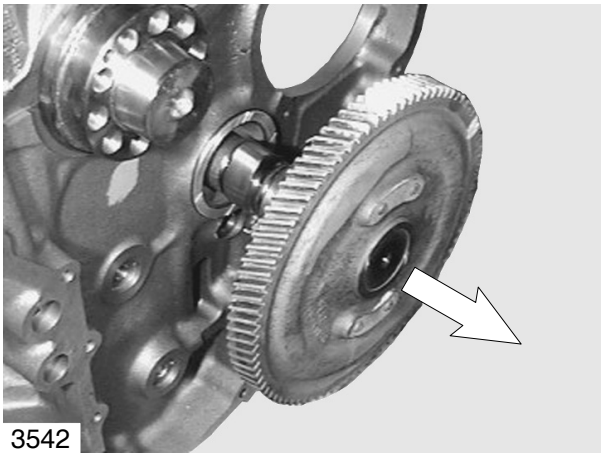
Slightly oil the threads and the contact faces of the mounting bolts and tighten the bolts to the specified torque (see ”Engineering • Data • Setting values”).

4 3539

Removing camshaft

- Drain coolant, see page 38
- Remove oilpan, see page 51
- Remove starter, see page 111
- Remove flywheel and timing case, see page 93
- Remove the rocker arms and take out the push rods, see page 74

Note:
For removing the camshaft the engine must be turned by 180°. For this reason the engine must be placed on a dolly.

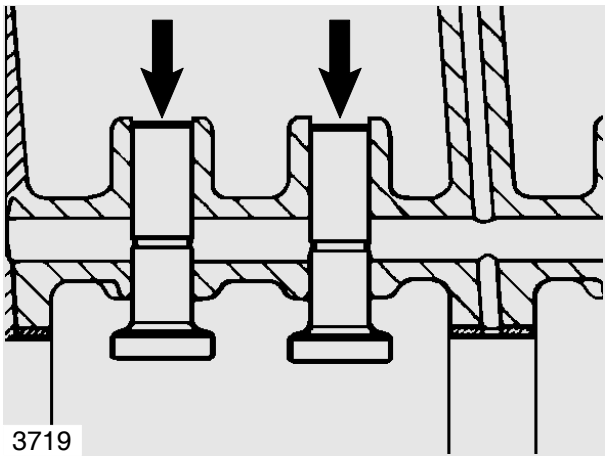


1 3542

Fig. 1

Turn engine upside down so that the valve tappets do not obstruct removal of camshaft.
Pull out camshaft, taking care not to damage the camshaft bearings. Check camshaft for wear and damage.
If the camshaft or the drive gear is damaged, a new entire camshaft/gear unit must be fitted.

Check the tappets, if necessary fitting new ones.



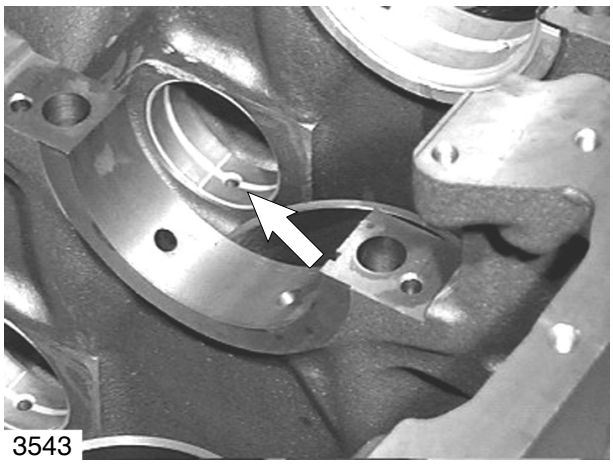
2 3719

Fig. 2

Remove valve tappets and check them for wear, changing them if necessary. The valve tappets can be removed only after removal of the camshaft.

Exchanging the camshaft bearings

Remove the cylinder heads, the pistons with the connecting rods and the crankshaft, before removing camshaft bearings.



3 3543

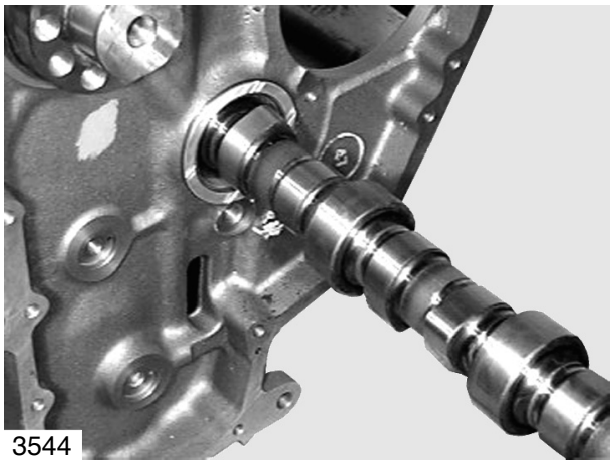
Fig. 3

Remove camshaft bearing bushes with suitable mandrel and drive in new bushes. Ensure that the oil supply bores are in correct position.

Installing the camshaft

Fig. 4

Apply oil to camshaft and insert it carefully.



4 3544

Fig. 5

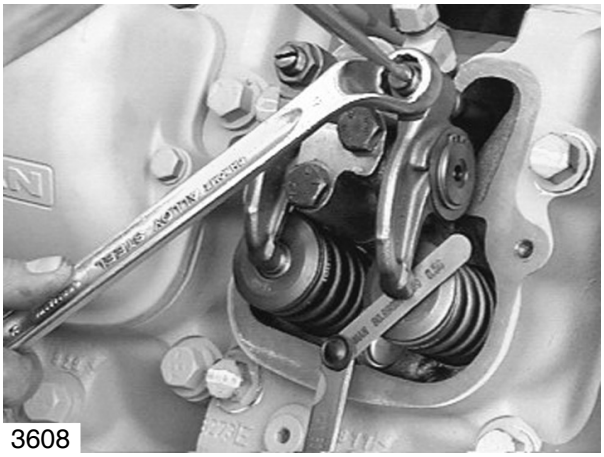
Ensure that the marks on the crankshaft and the camshaft gear match.

5 3545

Note:
If the valve timing is incorrect, serious damage to the engine may result. For this reason, if faults occur in the engine which could lead to the shrunk-fitted camshaft gear turning, check that the gear is correctly seated by checking the valve timing. Carrying out a check after installation of the camshaft is also recommended.

Fig. 1

Remove cylinder head cover from 1st cylinder. Carefully set exhaust valve for 1st cylinder.

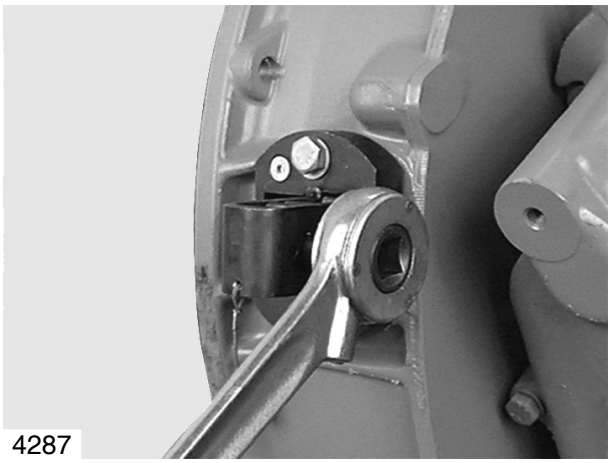


1 3608

Fig. 2

Turn engine until the valves of the 1st cylinder are in crossover.

Turn engine back to approx. 50° before TDC, then forwards to 30° before TDC (observe graduation on flywheel).



2 4287

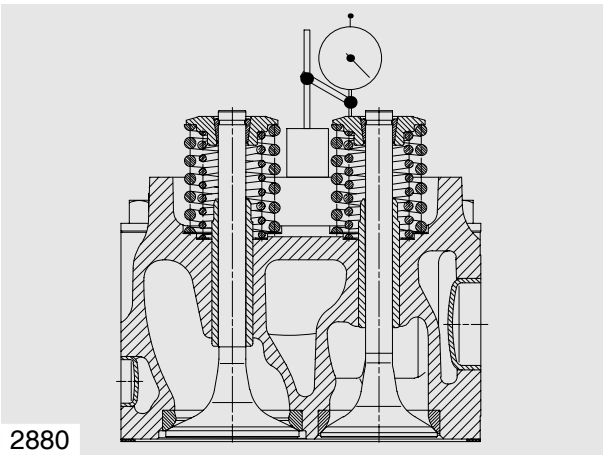
Fig. 3

Apply dial gauge with approx 2 mm preload to valve spring retainer of exhaust valve in 1st cylinder and set to “0”.

Turn engine in running direction through 180° (exhaust valve fully closed).

Read valve stroke from dial gauge.

The valve stroke must be between 5,5 and 6,5 mm.



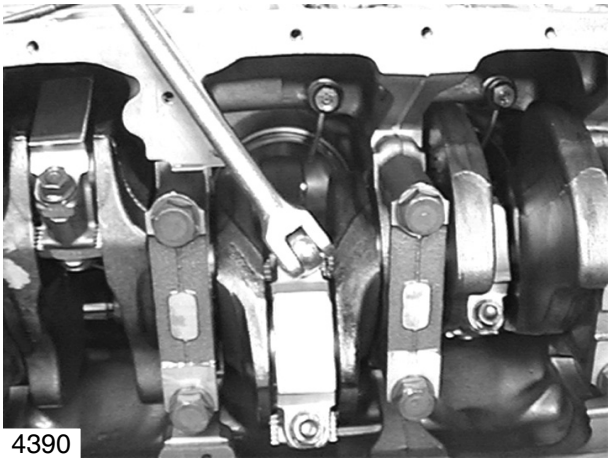
3 2880

Removing crankshaft

- ‚Remove oil pan and oil pump
  see page 51
- Remove timing case, see page 93
- Remove the front cover for sealing the crankshaft and the cylinder heads, see page 74

Fig. 1

Remove bolts from connecting rod bearing caps, take out connecting rods with pistons and arrange them in order of installation.

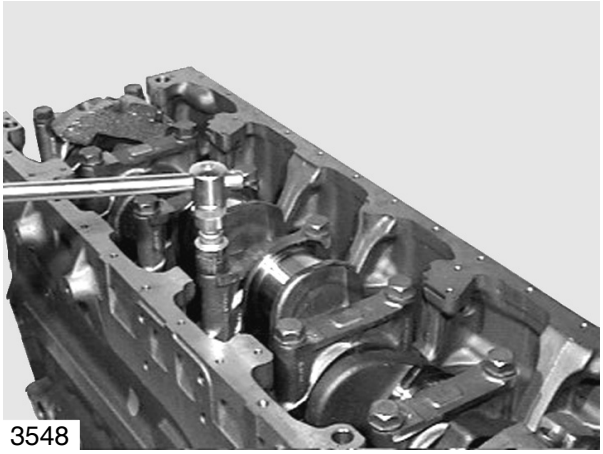


1 4390

Fig. 2

Loosen and remove mounting bolts from crankshaft bearing caps in stages from the inside out. Take off bearing caps and arrange them in order of installation.

Take the bearing shell halves out of the bearing caps and lay them aside together with their respective bearing caps.

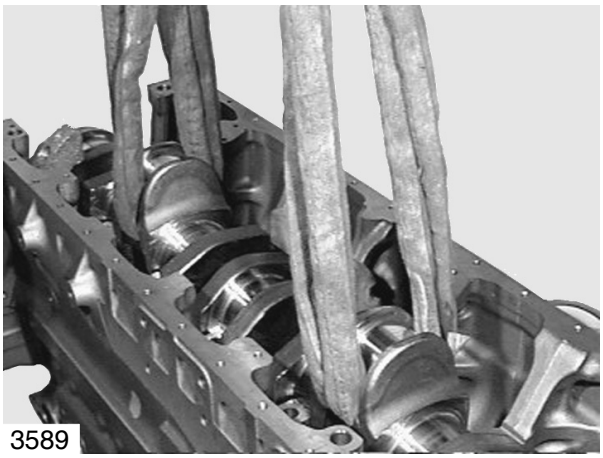


2 3548

Fig. 3

Lift out crankshaft.

> **Caution:**
> Do not damage the rolling surfaces of the crankshaft bearing pins.



3 3589

Fig. 4

Take the bearing shells out of the crankcase and lay them aside in the sequence of installation. Clean parts and check for wear, replacing them if necessary.

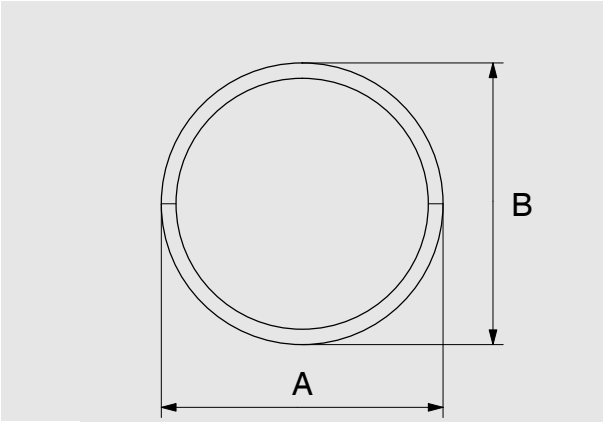
4 3550

Checking spread of bearing shells

Fig. 5

Position bearing shells together on flat surface. Measure and note down spread dimensions ”A” and ”B”.

Spread dimension = A – B



5 2376

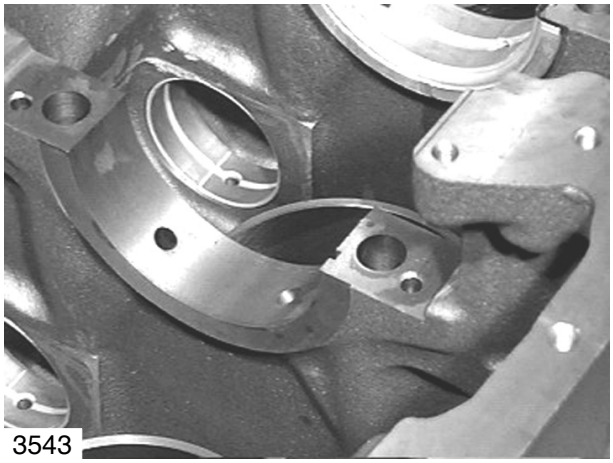
Installing crankshaft

Fig. 6

Clean oil ducts in crankcase and in crankshaft with dry compressed air.

Thoroughly clean bearing shells and bearing journals.

Install bearing shells in crankcase, observing the numbering.



6 3543

Fig. 7

Apply oil to the running surfaces on the bearing shells and install crankcase, ensuring that the markings on the crankshaft and camshaft gears coincide.

7 3545

Fig. 8

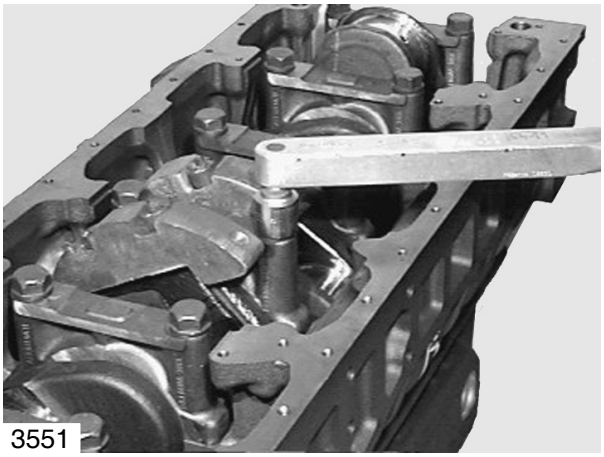
Check whether the bearing cap bolts have exceeded the max. permissible length (see ”Engineering • Data • Setting values”). Bolts that have been removed may be reused if the max. permissible length is not exceeded.

Insert bearing cap screws and tighten to specified torque in stages from the inside out (see ”Engineering, Data, Setting values”).

Tighten finally by angle.

Check to see that crankshaft runs smoothly.

Caution:
Faulty bearing caps cannot be replaced singly.



8 3551

Checking axial play

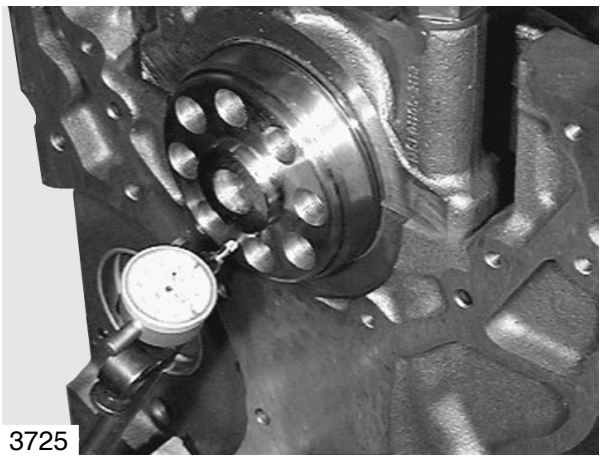
Fig. 9

The axial play of the crankshaft is determined by the centre crankshaft bearing (thrust bearing).

9 3550

Fig. 10

- Fit dial gauge holder with dial gauge to crankcase.
- Move crankshaft in axial direction to and fro and read off play on dial gauge.
- If permissible axial play is exceeded, replace main bearing shells complete.



10 3725

Fig. 11

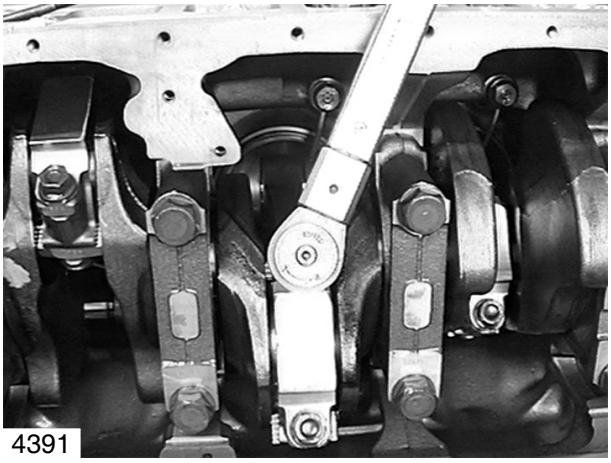
Measure connecting rod bearing, insert pistons with connecting rod. Coat connecting rod bearing shells with oil and pull connecting rods to bearing pin.

Mount connecting rod bearing caps with bearing shells (observe marking - numbers must be on the same side).

Screw in mounting bolts and tighten in stages to specified torque.

Tighten finally by angle.

(For tightening torques and reusability of bolts, see ”Engineering • Data • Setting values”.)



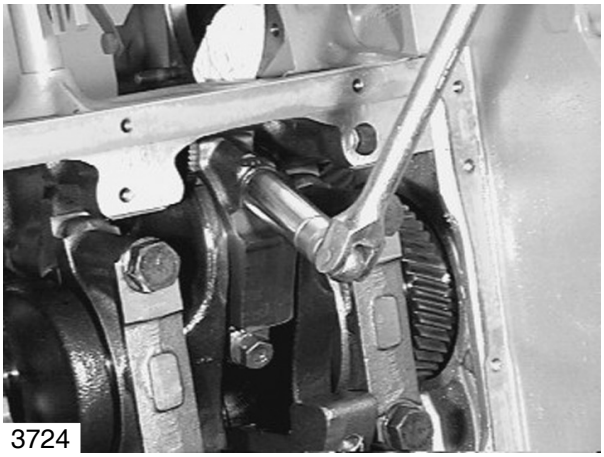
11 4391

Removing piston with connecting rod

- Remove oil pan, oil suction pipe, see page 51
- Remove cylinder heads, see page 74

Fig. 1

Remove bolts from connecting rod bearing cap.

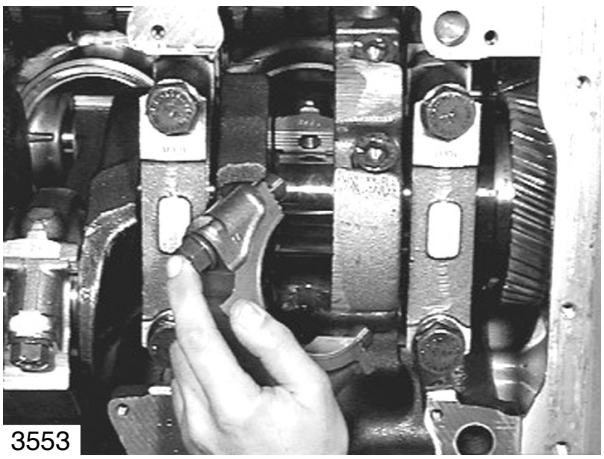


1 3724

Fig. 2

Take off connecting rod bearing caps with bearing shells, expediting the procedure by means of light strokes with a synthetic hammer if necessary.

Note:
Connecting rod bearing caps are match-marked with the connecting rod big ends; arrange them in corresponding order.



2 3553

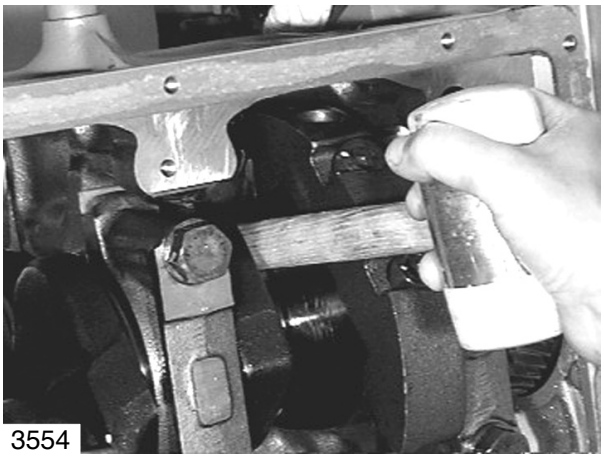
Fig. 3

Remove combustion residues (oil carbon) from top cylinder edge using a piece of hard wood.

Caution:
Do not damage cylinder liners.

Push out connecting rod with piston in upward direction.

Caution:
Do not damage oil spray nozzles.

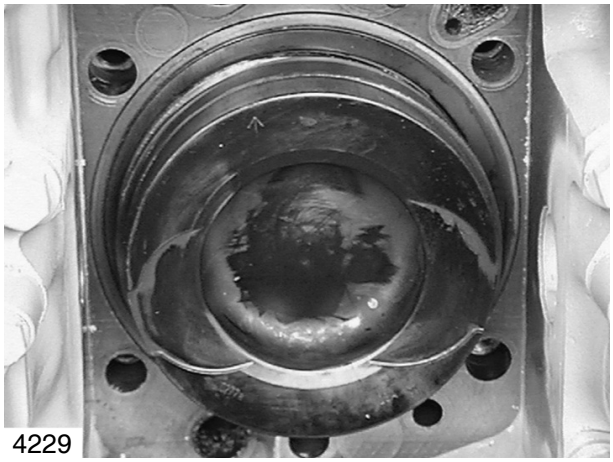


3 3554

Fig. 4

Lay pistons with connecting rods and associated caps aside; use deposit rack if available.
Inspect pistons and piston rings visually.

Note:
For reworked crankcase sealing faces repair pistons with undersizes of 0.2, 0.4 and 0.6 mm in the compression height are available (see ”Engineering • Data • Setting values”).



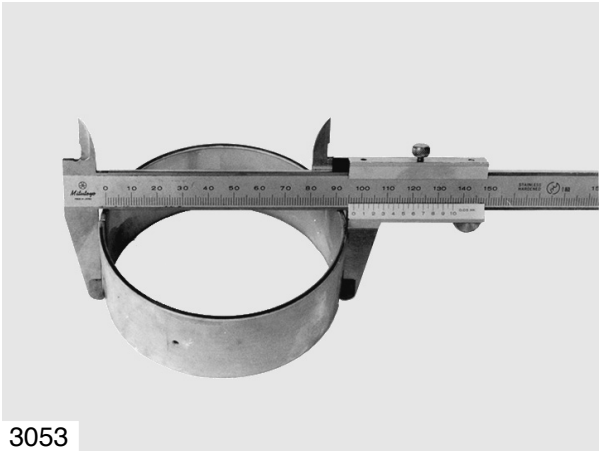
4 4229

Installing piston with connecting rod

Note:
If the pistons must be changed, ascertain by measuring the pistons or reading the measurement on the top of the piston whether undersized pistons were installed. If this is the case, undersized pistons must be used.

Fig. 5

Check bearing shells for wear and damage.
Measure the spread as for main bearing shells.
Install new bearing shells if necessary.
When repairing connecting rod bearing journals, use bearing shells of the corresponding repair stage.



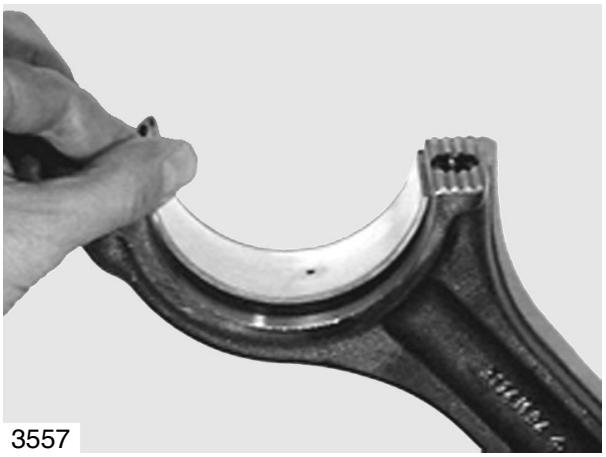
5 3053

Fig. 6

Insert bearing shells into the connecting rods or connecting rod bearing caps.

Caution:
The rod shell has a red or yellow mark on the side.

The top coat must not be damaged.
Apply a thin coat of oil to the connecting rod bearing shells.



6 3557

Fig. 7

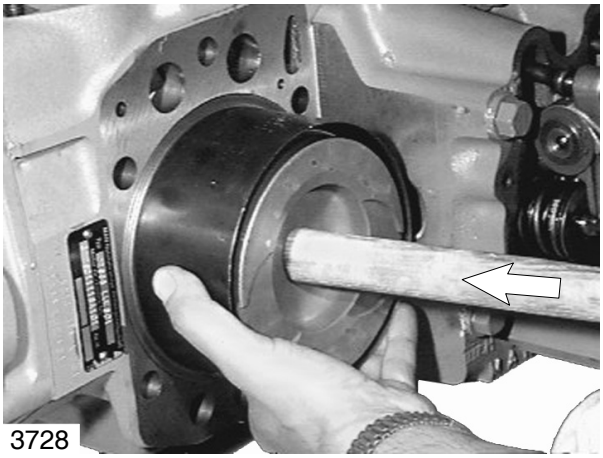
Apply a thin coat of oil to the cylinder liners and pistons.
Arrange piston ring gaps with an offset of approx. 120°.
Apply piston ring tightener and tighten piston rings.

7 3558

Fig. 8

Insert the pistons so that the recess on the piston skirt points towards the oil spray nozzle.
Guide connecting rod and insert piston until connecting rod big end contacts the connecting rod bearing journal.

Caution:
Do not damage oil spray nozzles.



8 3728

Fig. 9

Put connecting rod bearing caps in place.

Caution:
The numbers on the connecting rod bearing cap and connecting rod big end must be on one side.

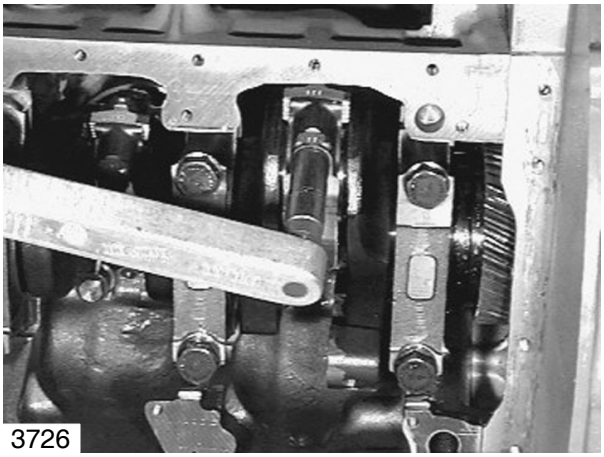
10 3560

Fig. 10

Screw in connecting rod bearing bolts and tighten them in stages to specified value.

Tighten finally by angle.

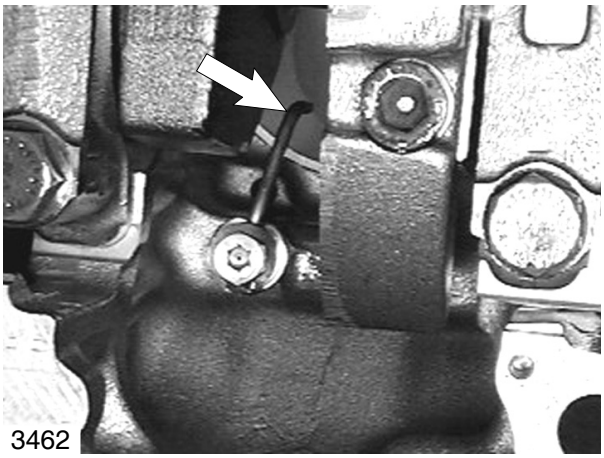
(For tightening torques and reusability of bolts, see ”Engineering • Data • Setting values”.)



10 3726

Fig. 11

Slowly turn engine over.
Connecting rods and oil spray nozzles (arrow) must not collide or grind against each other.



11 3462

Detaching piston from and attaching to connecting rod

Fig. 1

Remove piston with connecting rod.
Clamp connecting rod in a vice using soft jaws.
Remove gudgeon pin circlip.

1 3562

Fig. 2

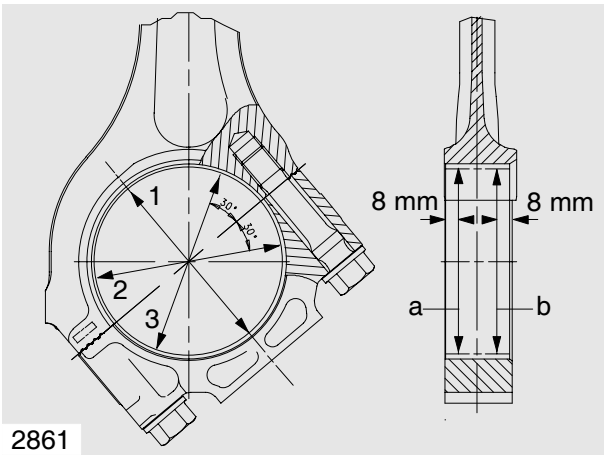
Push out gudgeon pin, holding piston in place.
Take off and lay it aside.

2 3563

Measure connecting rod big end bore (basic bore)

Fig. 3

Insert new connecting rod bearing and fit cap.
Tighten bolts to specified torque.
Measure bearing bores with inside micrometer in measuring directions 1, 2 and 3 as well as in planes a and b.
For max. perm. values, see ”Engineering • Data • Setting values”. Change connecting rods if deviations exceed the tolerance range.



3 2861

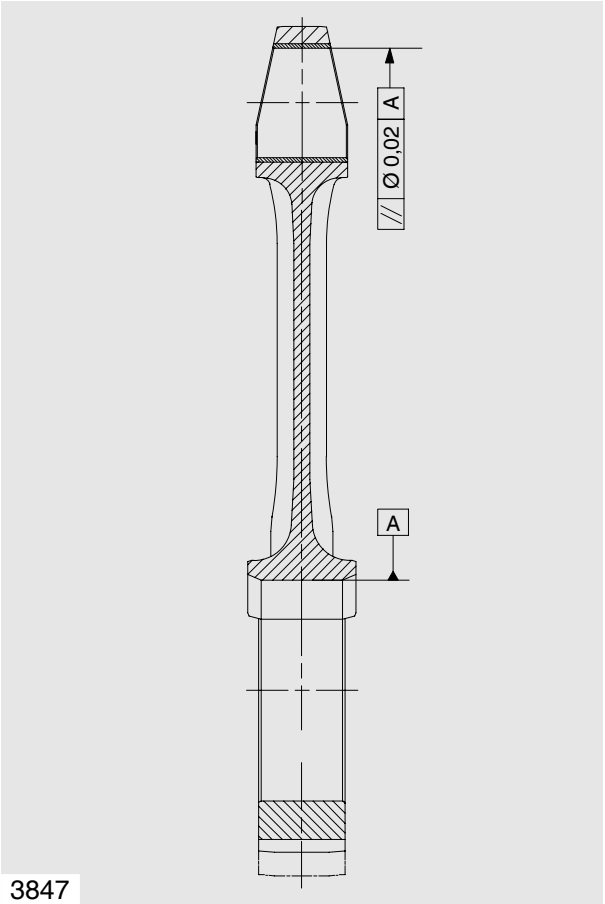
Fig. 4

Small end bushes are not available. If the bushes are worn, install reconditioned connecting rod.

4 3564

Fig. 5

Clean connecting rod and inspect for external damage; scrap any defective rods.
Check connecting rod to see whether the piston pin bore is parallel or twisted relative to the bearing shell bore. Change connecting rod if deviations exceed the tolerance range.



5 3847

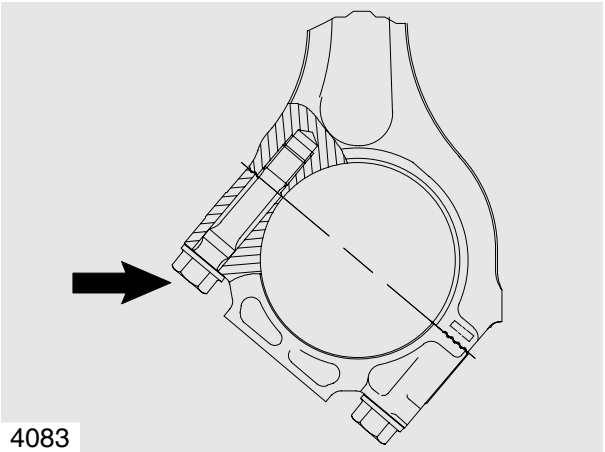
Figs. 6 and 7

Fit piston to connecting rod.

Caution:
The recess for the oil spray nozzle in the piston shaft (arrow) must be at the side of the small end.

Insert gudgeon pin. Fit circlips.
Install piston, see page 101.

6 3565

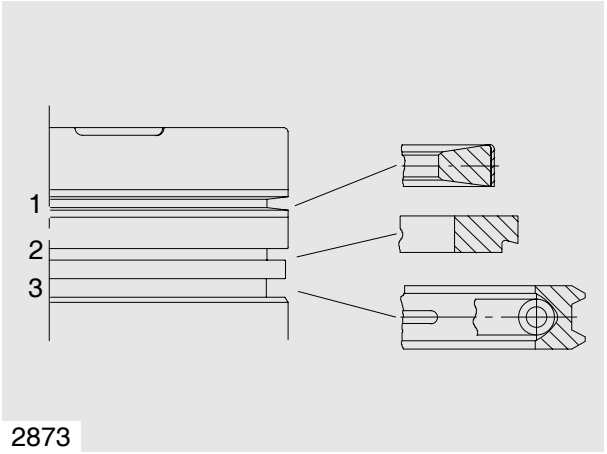


7 4083

Piston ring arrangement

Fig. 1

1 Compression ring (double-sided keystone ring)
2 Compression ring (tapered compression ring)
3 Oil scraper ring (bevelled-edge ring)

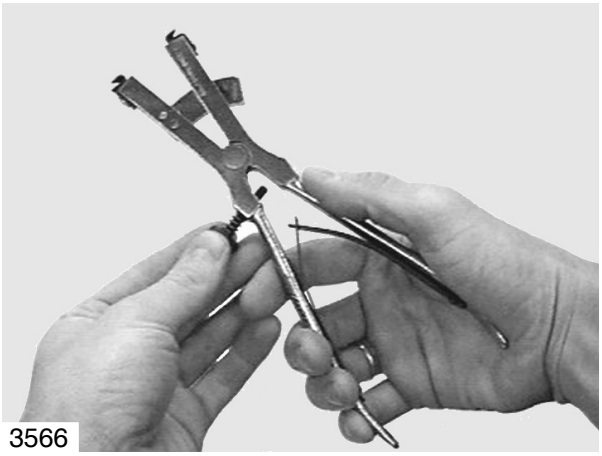


1 2873

Removing piston rings

Fig. 2

Remove piston with connecting rod.
Clamp connecting rod in a vice using soft jaws.
Adjust piston ring pliers to piston diameter.



2 3566

Fig. 3

Apply piston ring pliers at piston ring gap and unclip piston rings from piston ring grooves.

Note:
Owing to the hose-type spring the oil scraper ring has a higher tangential tension.

Carefully clean the piston ring grooves using a piece of wood.
Do not damage the piston ring grooves.

3 3567

Checking ring gap

Fig. 4

Insert piston rings singly into the cylinder and ascertain the ring gap using a feeler gauge.

Replace piston rings if the ring gap is too large.

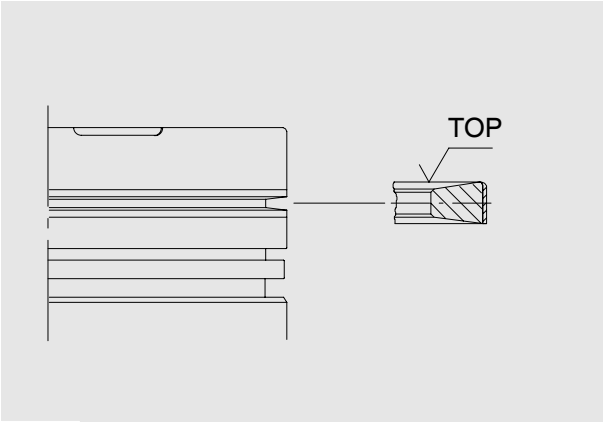
For ring gap see “Engineering • Data • Setting values”.

4 3568

Installing piston rings

Figs. 5 and 6

Use piston ring pliers to place piston rings in the correct piston ring grooves (”TOP” mark facing upwards).



5 2879

6 3729

Checking piston ring axial clearance

Fig. 7

Use feeler gauge to ascertain the piston ring clearance at several points in each groove.

For this purpose the piston ring is to be fully pressed into the piston ring groove at the point to be measured.

The pistons must be replaced if the clearance ascertained is too large.

For axial clearance see “Engineering, Data, Setting values”

7 4528

Removing cylinder liners

Note:
Observe oversizes for cylinder liner outer diameters and collar heights (see ”Engineering • Data • Setting values”).

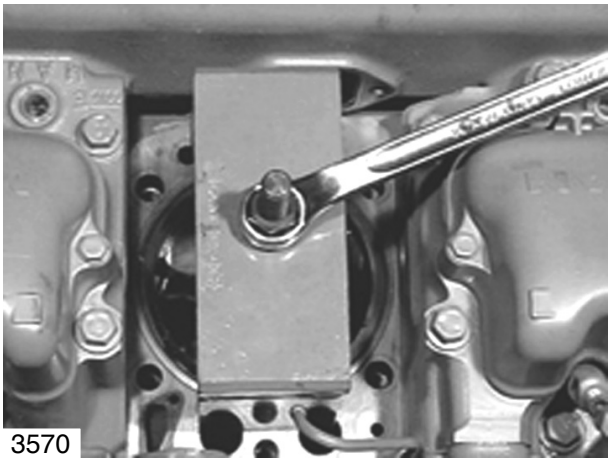
- Remove cylinder head, see page 74
- Remove piston, see page 100

Fig. 1

Mark cylinder liner position relative to engine so that it can be reinstalled in the same position if reused.

Insert cylinder liner extractor device into cylinder liner, taking care not to damage the oil spray nozzle.

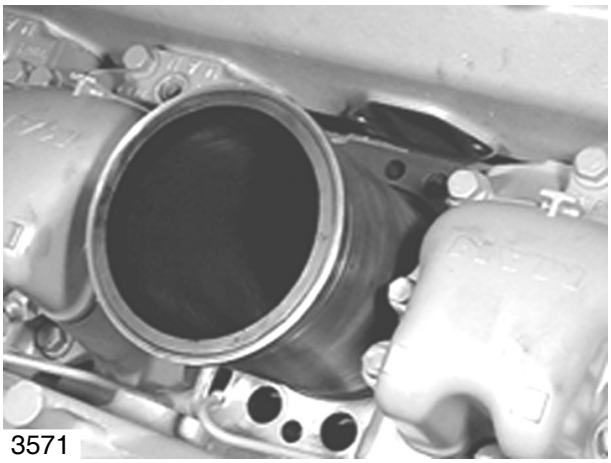
Put support on extractor spindle and tighten nut. Hold extractor spindle in place and extract cylinder liner by turning nut.



1 3570

Fig. 2

Take off extractor device and take out cylinder liner.



2 3571

Fig. 3

Deposit cylinder liner upright. Take off O-rings. Number cylinder liners in order of installation.

5 3065

Checking cylinder liner protrusion

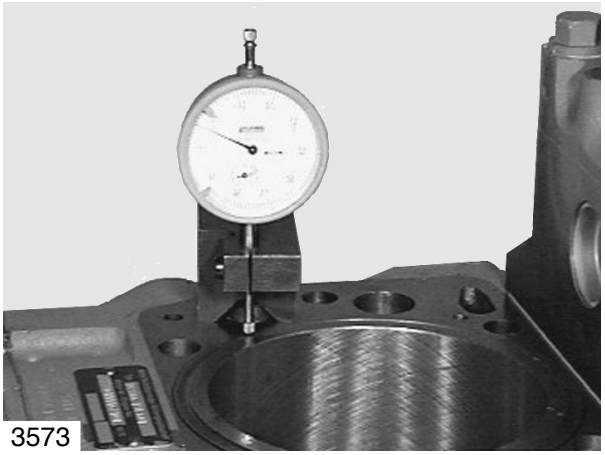
Fig. 4

Clean basic bore and cylinder liner.
Insert cylinder liner without O-rings into crankcase, observing the marking (ensure that it is identical with the position prior to removal).
Measure cylinder liner protrusion at at least four different points, using gauge holder and gauge.

Note:
If available, use measuring plate for the measurement (special tool, see page 131)

Proceed as follows:

Position press-on measuring plate with turned collar facing the liner using 2 fitting sleeves to centre plate.
Tighten 4 bolts (improvised: collar bolt 51.90020-0270, length shortened to 90 mm) on the press-on measuring plate in stages and crosswise to 40 Nm.
Set dial gauge combination above press-on plate to “0” under preload relative to the crankcase.
Measure cylinder liner protrusion at least at four points.



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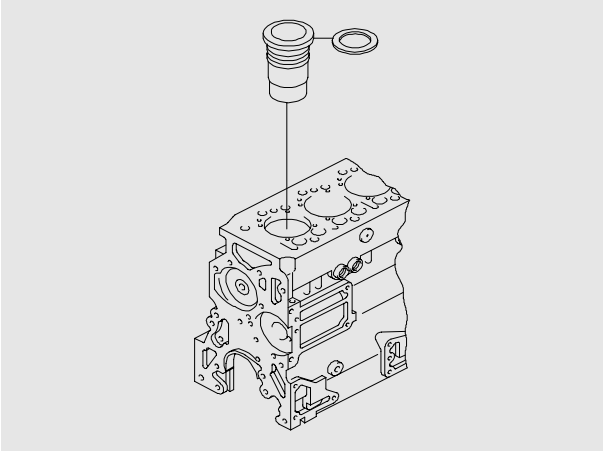

5

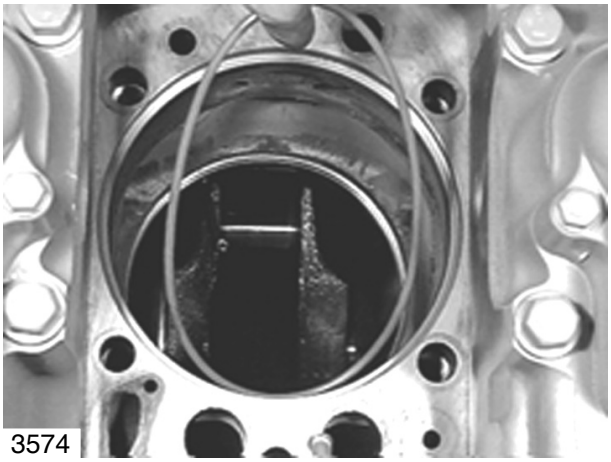
Fig. 5

Install shim if the protrusion is below the minimum protrusion even at only one point.
The shim is placed under the cylinder liner collar. However, it may be used only if after installation the upper tolerance limit is not exceeded.

Installing cylinder liners

Fig. 6

Insert dry new O-rings for the lower seal (144x4) into the crankcase.



6 3574

Fig. 7

Insert new O-rings for the upper seal (138x2) into the grooves on the cylinder liner.
Do not overstretch the O-rings.

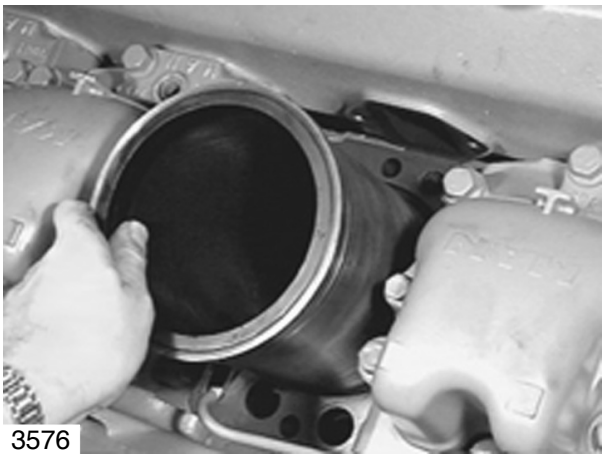
7 3575

Fig. 8

Apply thin coat of engine oil to cylinder liner in the area of the upper and lower O-ring.
Apply thin coat of engine oil to lower O-rings in the crankcase.

Insert cylinder liners into crankcase and push them down by hand.
Place clean metal plate on liner and exert uniform downward pressure until the liner is seated in the crankcase recess.

If a perceptible resistance can be felt in this operation, the O-rings are no longer in their proper place.
Reposition O-rings and insert cylinder liner again.



8 3576

Note:
No grease or sealing agents of any kind must be used for installing cylinder liners and O-rings.

Note:
After fitting the cylinderliners ensure that the O-rings are in the correct position by checking the liner protrusion with special tool. Use
special tool, see page 130 as follows:
Position press-on measuring plate with turned collar facing the liner using 2 fitting sleeves to centre plate.
Tighten 4 bolts (improvised: collar bolt 51.90020-0270, length shortened to 90 mm) on the press-on measuring plate in stages and crosswise to 40 Nm.
Set dial gauge combination above press-on plate to “0” under preload relative to the crankcase.
Measure cylinder liner protrusion at least at four points.

Fig. 1

Remove cylinder heads.
Move piston to be measured to TDC.

Apply dial gauge in holder to crankcase sealing face.
Set dial gauge to “0”.

1 3577

Fig. 2

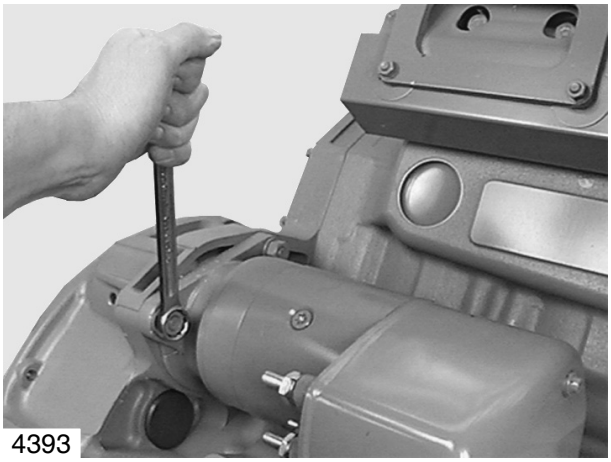
Carefully slew dial gauge holder round, lifting the dial gauge tip as you do so.

Lower dial gauge tip on to piston crown and read off piston protrusion.

2 3578

Fig. 1

Disconnect minus cable from battery or switch off battery main switch if fitted.
Disconnect cable from terminal 31 (minus terminal, thick cable), terminal 30 (plus terminal, thick cable) and terminal 50 from starter.
Remove mounting nuts.



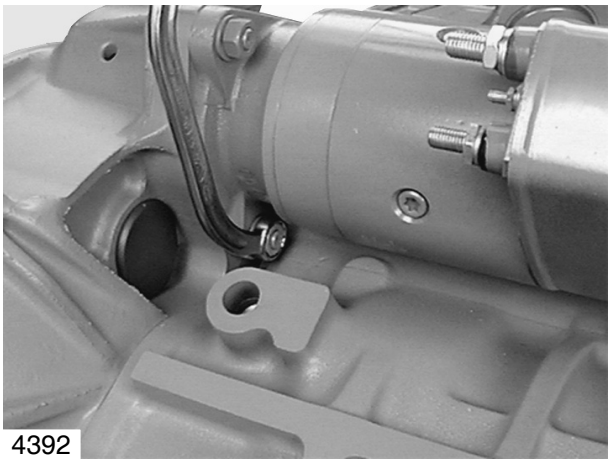
1 4393

Fig. 2

A curved wrench is advantageous for the inner bolts (see Fig.).

Take off starter.

Check starter pinion for wear and that it can move freely. If necessary, clean piston using a brush dipped in fuel and regrease it.



2 4392

Check flywheel gear ring for wear and damage.
Turn over engine by hand once, paying particular attention to the positions at which the engine finally stops; i. e. when the engine is switched off it always stops in certain positions.
The starter pinion engages in these positions when the engine is started.

For changing starter gear ring, see page 59.

The starter is installed in reverse sequence to the removal procedure. Ensure that the cables are correctly connected up and the bolts tightened to specified torque.

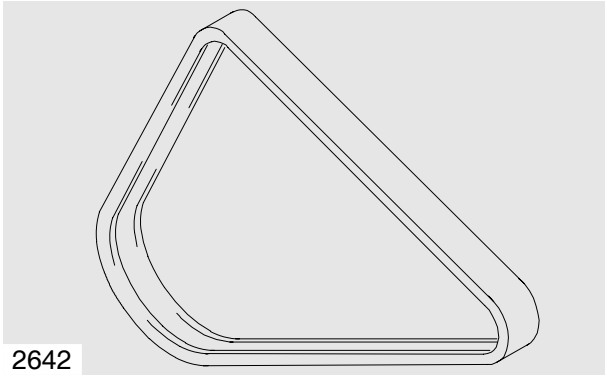
Connect up battery or switch on battery main switch.

After installation check starter to see that it works properly.

Checking condition

Fig. 1

- Check V-belts for cracks, oiling, overheating and wear.
- Change damaged V-belts.



1 2642

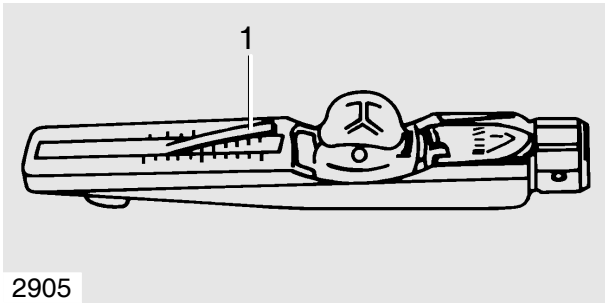
Checking tension

Figs. 2 and 3

Use belt tension indicator to check V-belt tension.

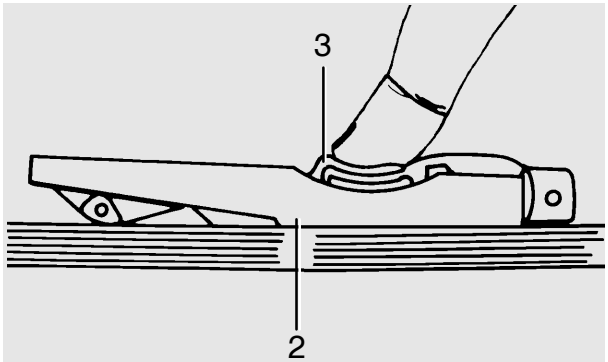
- Lower the gauge arm ① in the scale.
- Position the tension indicator ② in the centre of the belt between the two pulleys so that the edge of the stop face locates against the side of the belt.
- Slowly depress the pressure pad ③ vertically downwards until the spring disengages with an audible click; the gauge arm moves upwards.

A false reading will be obtained if you continue to apply pressure after the spring has disengaged.



2 2905

Note:
Measure tension only when V–belt is cold. In V–belts which have reached operating temperature tension increases up to 10 kp (10 kg on the measuring scale of the device), which may result in a wrong reading.



3 2906

Fig. 4

Taking tension reading

- The tension is shown where the top of the gauge arm (1 in picture 2) intersects the kg scale.
- Ensure that the gauge arm does not move before you take the reading.

If the reading does not correspond with the specified value, the V-belt tension must be corrected.

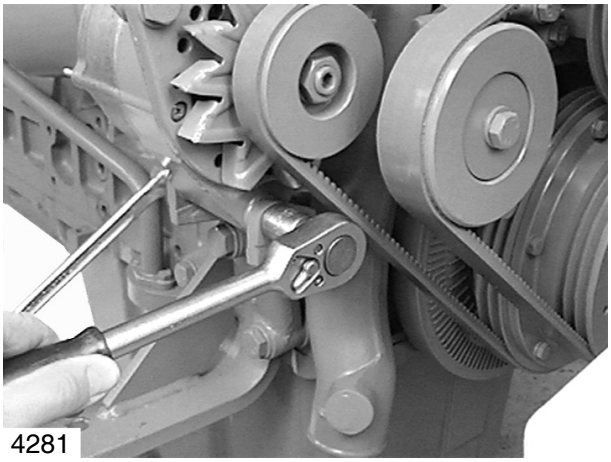
V-belt width	Tensioning forces as per kg scale on the indicator		
	for newly fitted assembly		for maintenance after prolonged periods of operation
	after assembly	after a running time of 10 min	
2/3VX	90–100	70–80	60
3/3VX	135–150	120–135	90

4

Tightening and exchanging of V-belts for driving alternators

Fig. 5

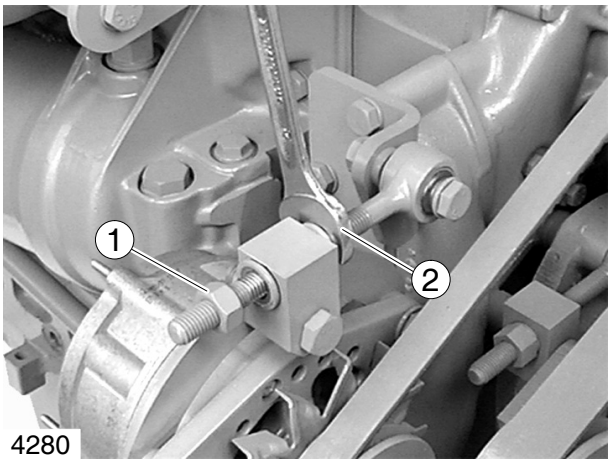
Remove the mounting bolts from alternator and tensioning device.



5 4281

Fig. 6

- Loosen lock nut ①
- Tighten V-belt via adjusting nut ②
- Retighten lock nut and mounting bolts



6 4280

Tightening and exchanging of V-belts for driving the fan

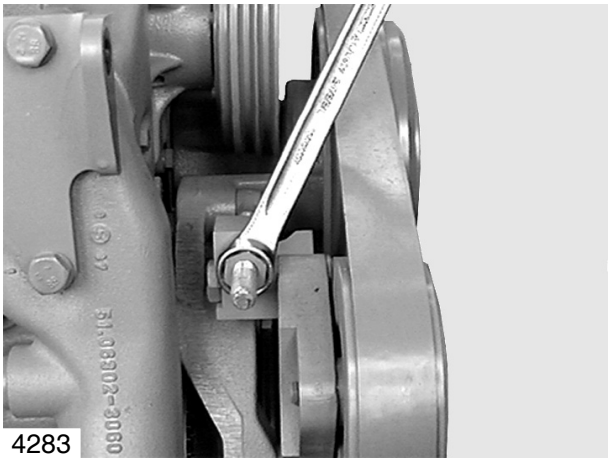
Fig. 7

Loosen the mounting bolts on the tensioning pulley.

7 4282

Fig. 8

Tighten V-belt via adjusting nut.



8 4283

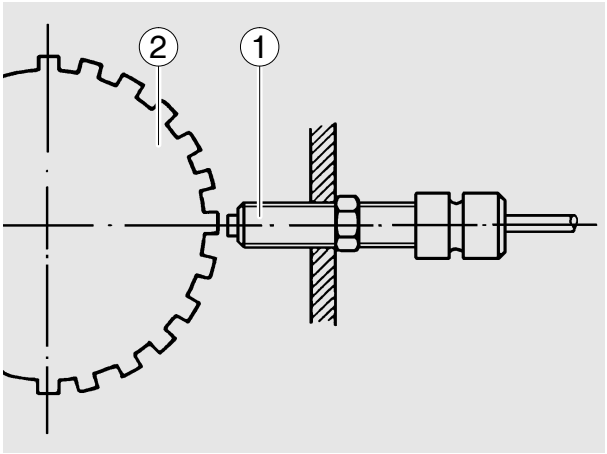
Basic design

An electronic control system consists of three components:

1. Speed pickup

   In MAN engines the speed pickup ①, which works according to the induction principle, is located on the flywheel housing. It consists of a permanent magnet surrounded by a coil.

   Depending on whether a tooth of the starter gear ring ② is before the magnet or not, the magnetic field changes and induces in the coil an alternating voltage which is proportional to the engine speed and serves as input signal for the control unit.



2. Electronic control unit

   The electronic control unit receives the signal (actual value) generated by the pickup and compares it with a preset value (nominal value).

   If the actual and the nominal values are identical, the electronic control unit will generate an output signal with which the final control element will be triggered.

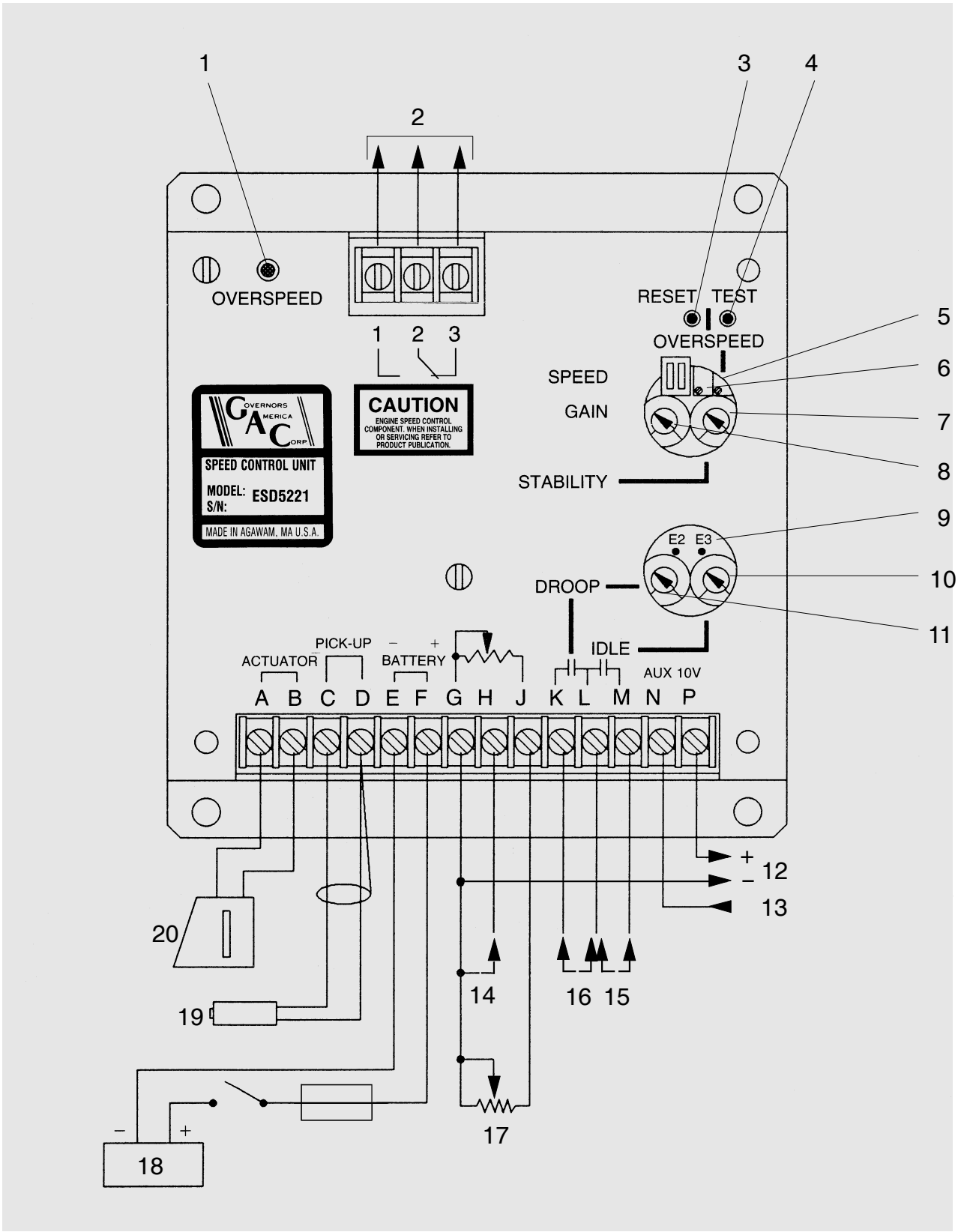
3. Final control element

   In GAC governors, for example, the final control element is a spring-loaded linear solenoid.

   This solenoid is connected to the control rod of the injection pump and changes its position according to the signal from the control unit. As a result, the injection quantity and, consequently, engine speed are controlled.

Electric control unit

The GAC ESD 5221 electronic speed governor is used as an example here to give a general overview of the possibilities provided by this control system and to show what characteristic data can be set or altered. When installing and commissioning, please **heed without fail the Operator's Manual for the respective control unit model**.



1 LED display for electronic overspeed control

2 Output contacts ”Overspeed” LED display for overspeed

3 Overspeed reset button: initial position of the relay contacts after overspeed signal has been sent. Re-setting can also be effected by briefly interrupting the battery power supply.

4 Overspeed test button, lowers the switching point by approx. 12 %

5 25-step potentiometer: setting of overspeed. Let engine idle, press test button and simultaneously turn it left until engine stops and the display comes on

6 25-step potentiometer: setting of rated speed

7 Setting of stability

8 Setting of sensitivity

9 Additional assistance for stability improvement. In the event of very slow pendulum motion, set 10 - 20 mF condensator from E3 to E2

10 This makes it possible to set the lower idling speed limit if ”L” and ”M” are connected

11 Setting the P degree if ”L” and ”K” are connected

12 Stabilised voltage 10 V for triggering additional modules

13 Input for signals from synchroniser, load divider, smoke limiter etc.

14 Connect ”G” and ”H” only if a high P degree (10 %) is required

15 Operation at low idling speed if L and M are connected

16 P degree if ”K” and ”L” are connected

17 Speed precision setting (only required for remote control)

18 Battery

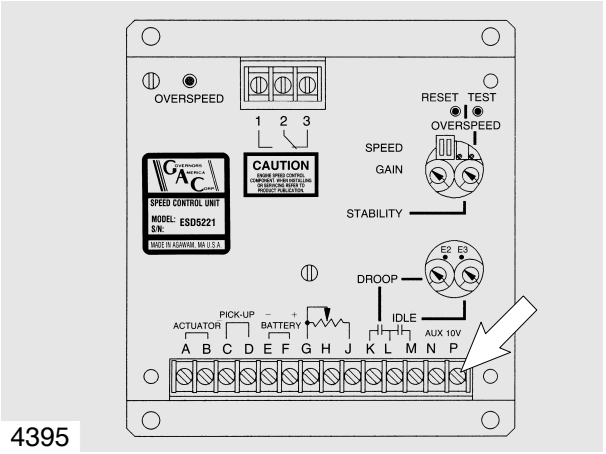
19 Pulse generator

20 Final control element

Caution:
Except in emergency cases, the engine must **never** be switched off by interrupting the cables for the final controlling elements, but only by interrupting the battery supply.

Fig. 1

The control unit is equipped with a terminal strip for the connections of the output and input signals.



1 4395

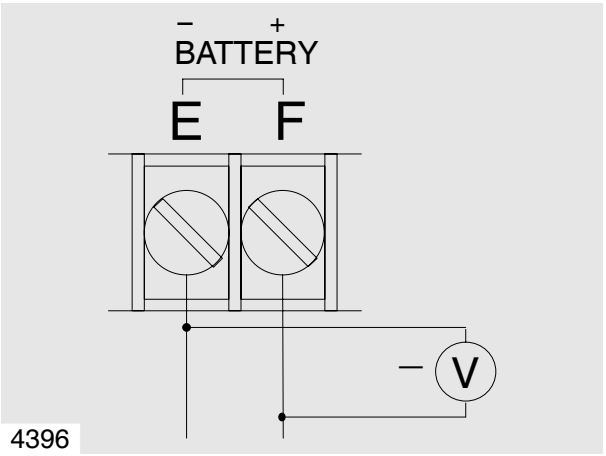
Checking procedure: Engine does not start.

Fig. 2

Check battery voltage on control unit during starting procedure.

Min. value: 17 V direct voltage

Otherwise exchange battery or reduce voltage drop in the supply line.



2 4396

Figs. 3 and 4

Check speed pickup signal on control unit during starting procedure.

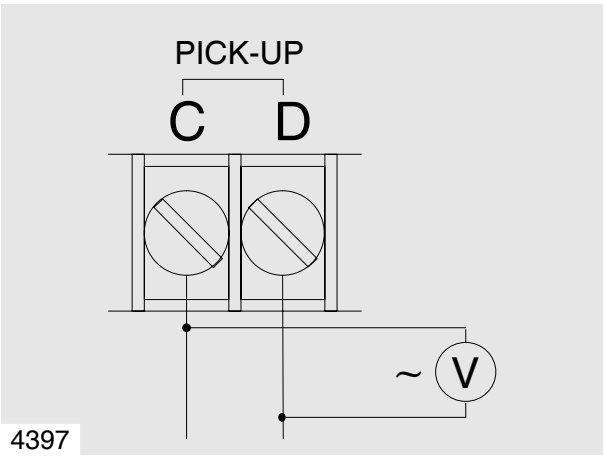
Min. value: 0.8 V alternating current

Otherwise check distance ”d” of speed pickup, if necessary correcting it, see page 119.

If distance ”d” is correct, but the voltage still too low, disconnect cable from terminals ”C” and ”D” on the control unit and measure the resistance between both cables.

Correct value: 150 - 200 Ω

If value deviates, exchange speed pickup.



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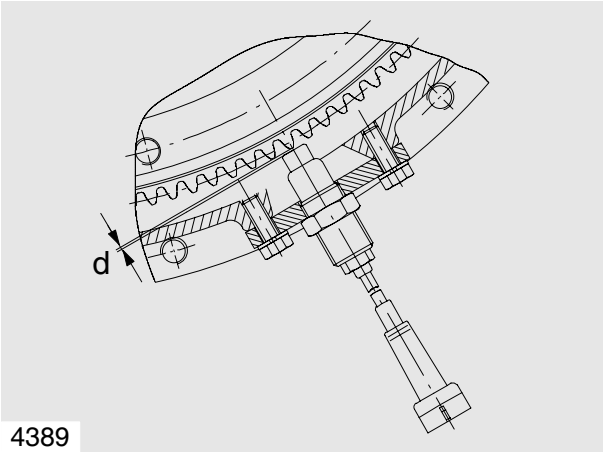


4 4389

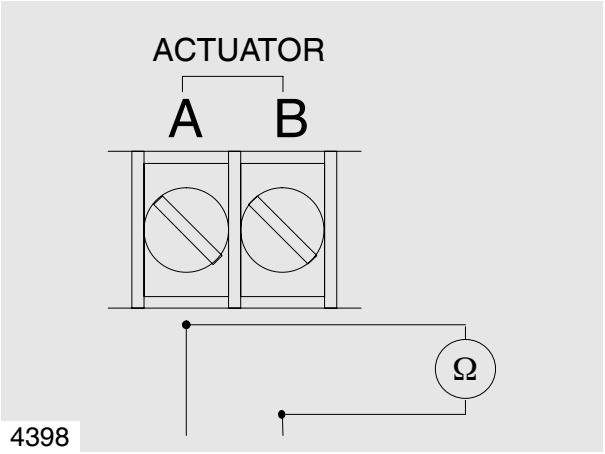
Fig. 5

Check final controlling element.

Remove both final controlling element cables from control unit and measure resistance.

Correct value: 4,6 - 5 Ω

If value deviates, check cabling and plug. If cabling and plug are in order, exchange final controlling element.

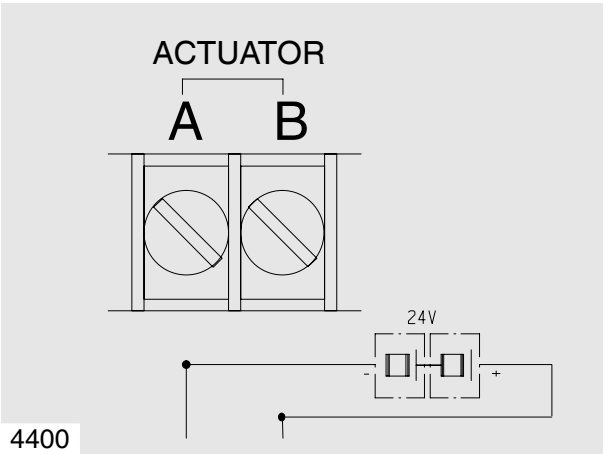


5 4398

Fig. 6

If resistance as per Fig. 5 is in order, connect both cables to battery voltage. The final controlling element must then switch to max. position.

If it does not, the transmission linkage to the injection pump control rod or the control rod itself is blocked.
If linkage is in order, exchange final controlling element.



6 4400

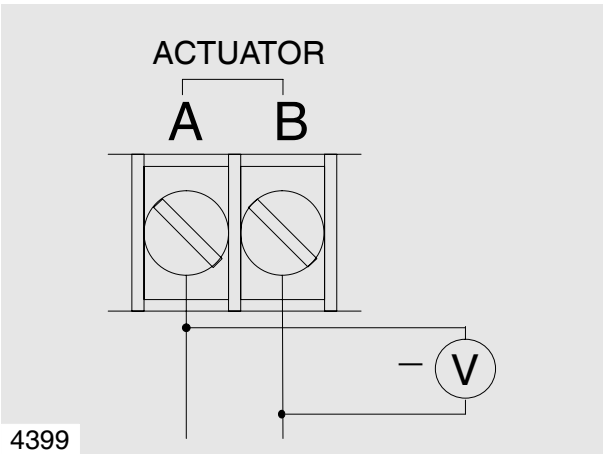
Fig. 7

If final controlling element is in order, but still fails to move during the starting procedure, the output voltage at the final controlling element terminals of the control unit are to be checked during the starting procedure.

Min. value: 17 V direct voltage

If no voltage is present, the control unit is defective.

Important:
Before installing a new control unit, always check the cabling and the final controlling element circuit for short circuits.

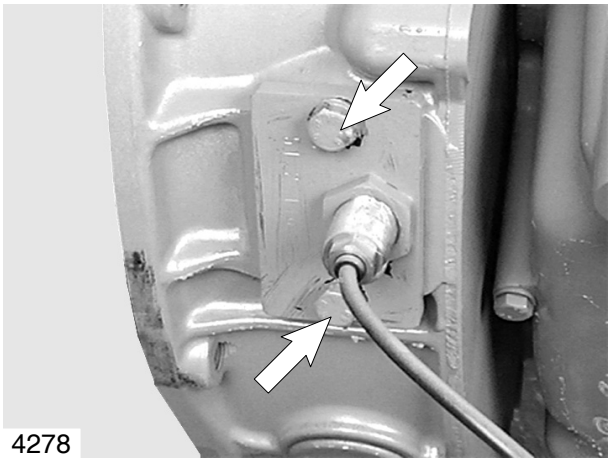


7 4399

Fig. 1

The speed pickup is fitted to the bottom right-hand side of the flywheel housing.

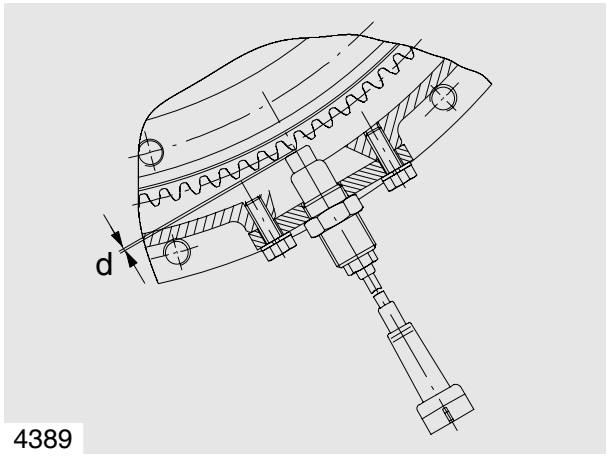
To remove it, disconnect cable from terminal, remove the mounting bolts from the retaining plate and take it off together with the speed pickup.



1 4278

Fig. 2

After the installation, distance ”d” between the speed pickup and the gear ring of the flywheel must be checked and, if necessary, readjusted.

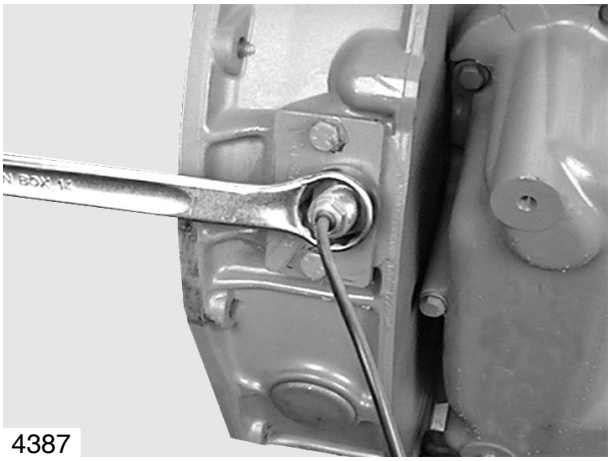


2 4389

Fig. 3

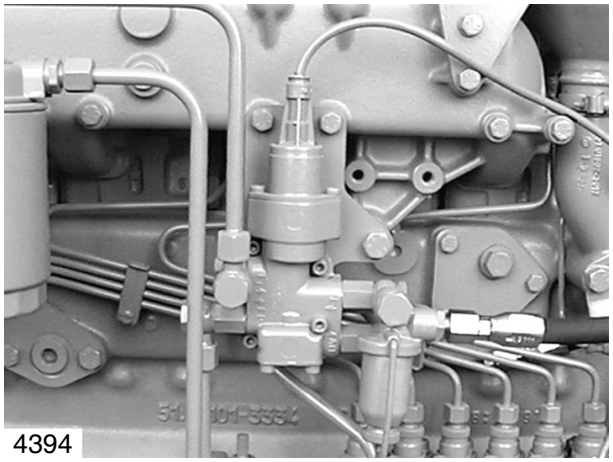
To do so, proceed as follows:

- Loosen counter nut and unscrews speed pickup.
- Turn gear ring so that one tooth is in centre position relative to the thread bore.
- Screw in speed pickup until it stops.
- Turn it back by one revolution and fit counter nut.

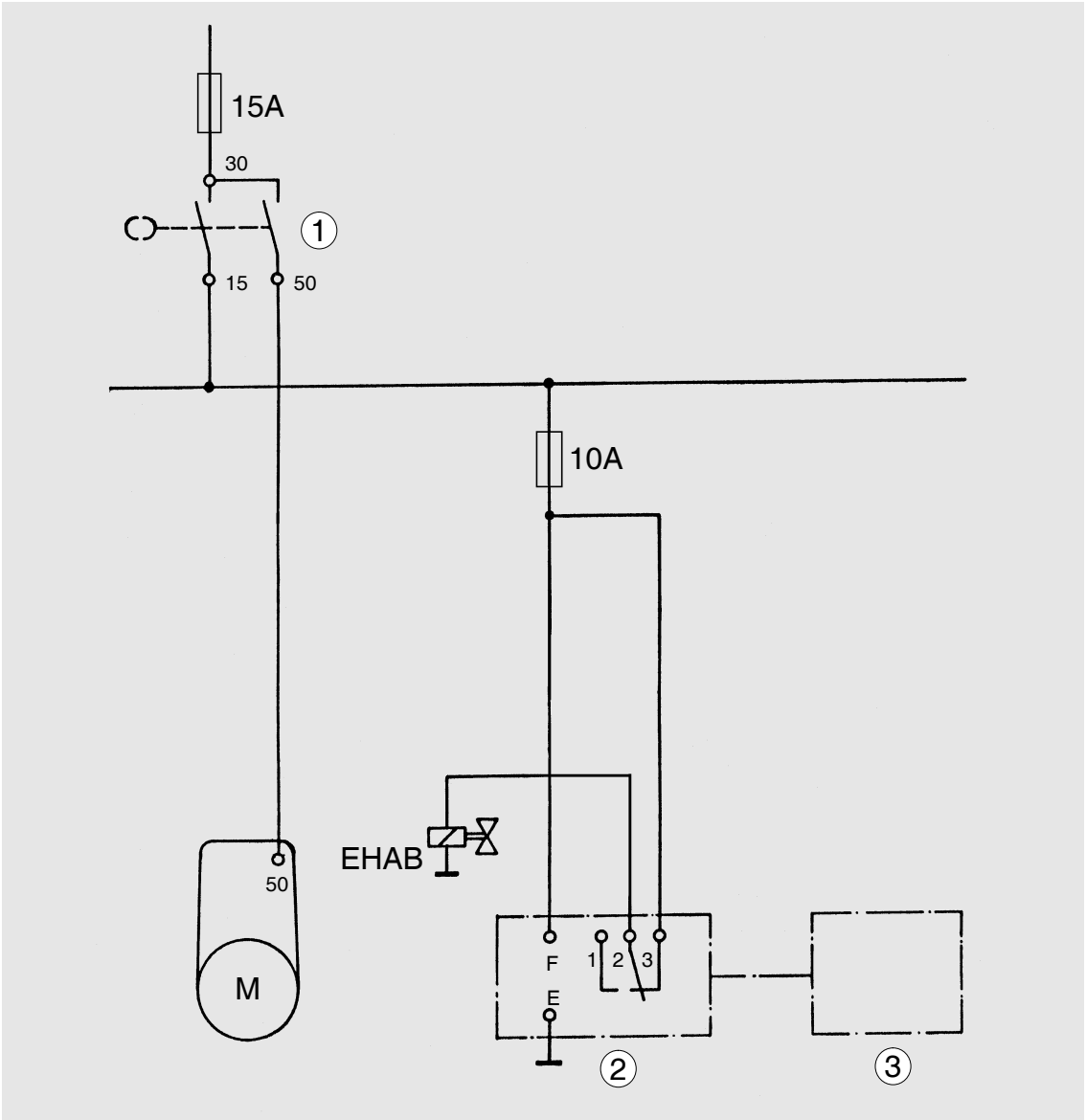


3 4387

If an electronic speed governor is used, an overspeed protection independent of the governor must be provided.
For this purpose an electromagnetic shut-off valve (EHAB) is installed in the fuel supply line to the injection pump. If the governor fails, this valve will shut off the fuel supply, thus preventing the engine from revving up in an uncontrolled manner.


4394

Proposal for the circuitry of an electromagnetic shut-off valve



1 Starter lock
2 GAC control unit
3 GAC actuator

Monitoring the coolant level

All engines are equipped with either one or two coolant level probes for monitoring the coolant level in the coolant expansion tank. This probe is of the capacitative type. The sensor and the evaluating electronics form a unit.

If the coolant falls below the level monitored a minus potential is sent to the signal output ”S”. With this a check lamp or a relay can be triggered.

Checking the coolant level probe

The probe features an integrated checking function. As soon as voltage is applied to the probe the signal appears for approx. 2 seconds to signalise that the probe is ready for operation.

If this signal does not appear, the probe must be checked.

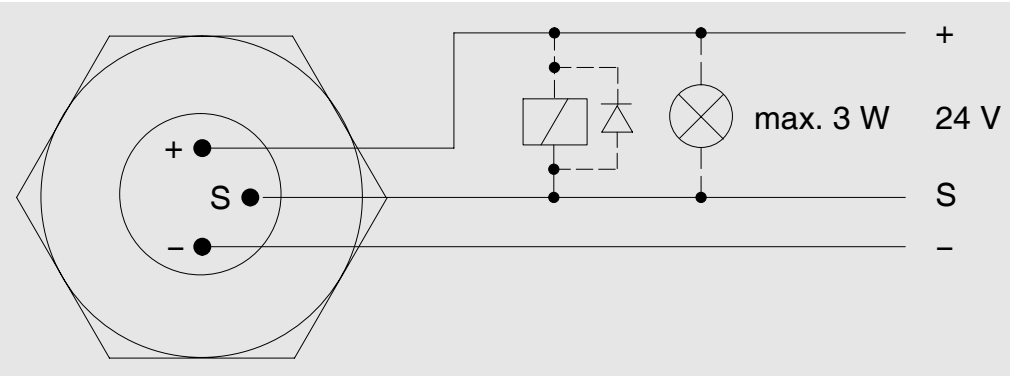
It is not possible to carry out a functional check by measuring the resistance (ohmmeter) because of the internal transistors.

The check can be carried out with a water tank and a small test bulb (< 3 watt).

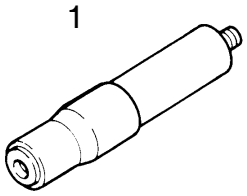
Dip the probe into the water and apply a supply voltage of 24 V to the plus and minus leads. The output ”S” is to be connected to the plus lead via the test lamp. The test lamp does not come on.

If the probe is taken out of the water, the test lamp must come on after approx. 7 seconds.

If the lamp does not come on the probe is defective and must be changed.



Special tools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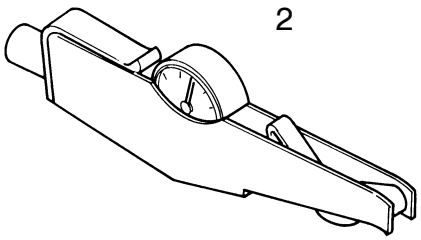
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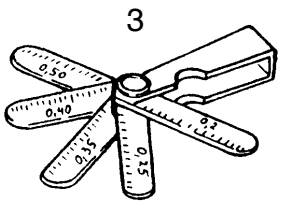
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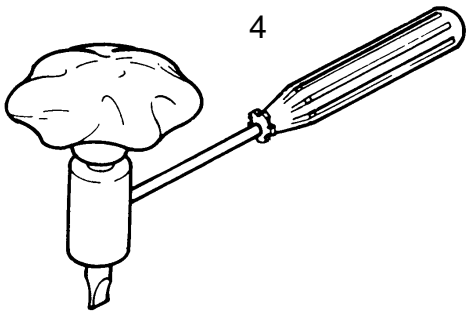
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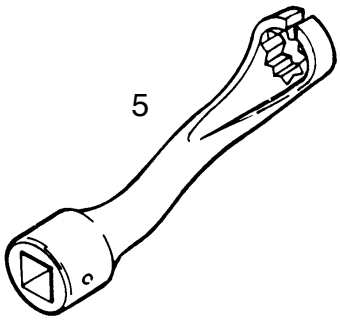
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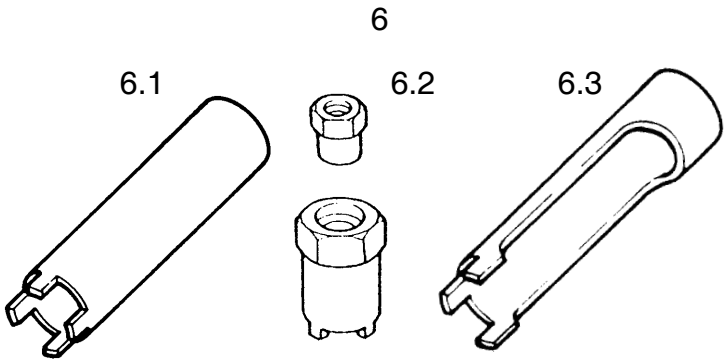
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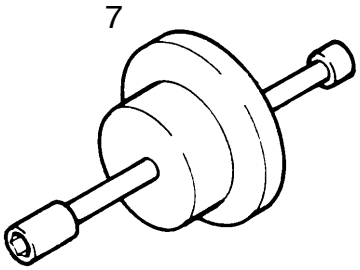
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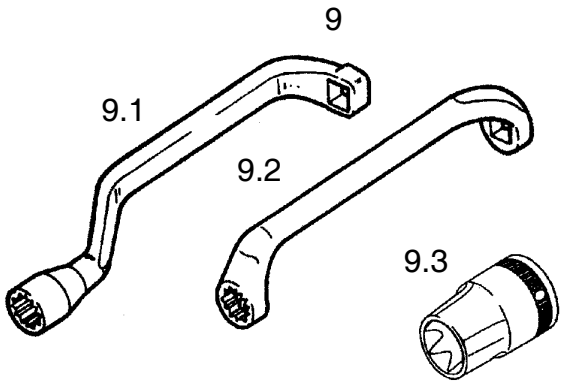
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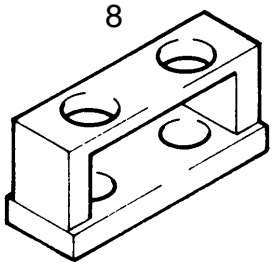
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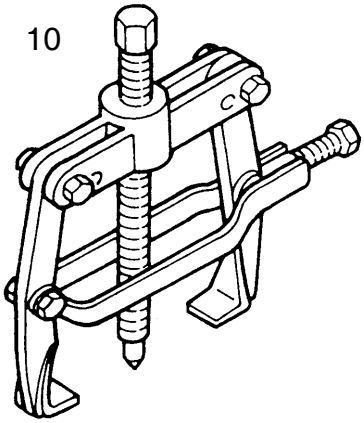
Fig. no.	Designation	Item number
1	Test connection for compression recorder	80.99607–0002
2	V-belt tension indicator	81.66814–6001
3	Valve gauge	80.99607–0076
4	Valve setting spanner	83.09195–0002
5	Spanner for nuts on injection lines (17 mm)	80.99603–0025
6	Socket spanner set for fuel injector	
6.2	4-groove	80.99603–0049
6.3	4-groove with fixing screw	80.99603–0121
6.4	open, 3-groove	80.99603–0038
7	Inertia puller for fuel injectior	80.99602–0011
8	Clamping device for fuel injectors	80.99606–0008
9	Special wrench for cylinder head bolts	
9.1	Special wrench for cylinder head bolts	80.99603–0069
9.2	Special wrench for cylinder head bolts	80.99603–0095
9.2	Special wrench for cylinder head bolts (Torx)	80.99603–0255
9.3	Socket for Torx bolts	08.06143–0215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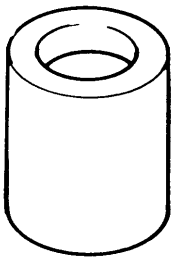
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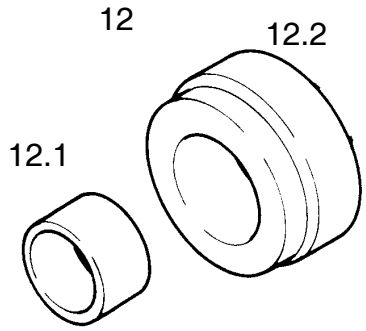
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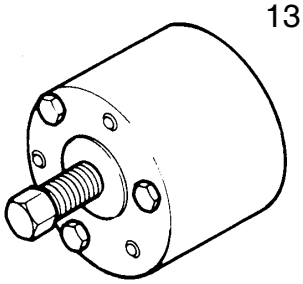
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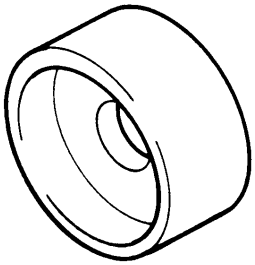
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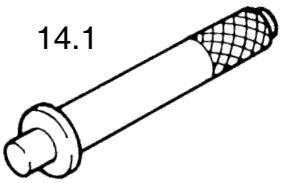
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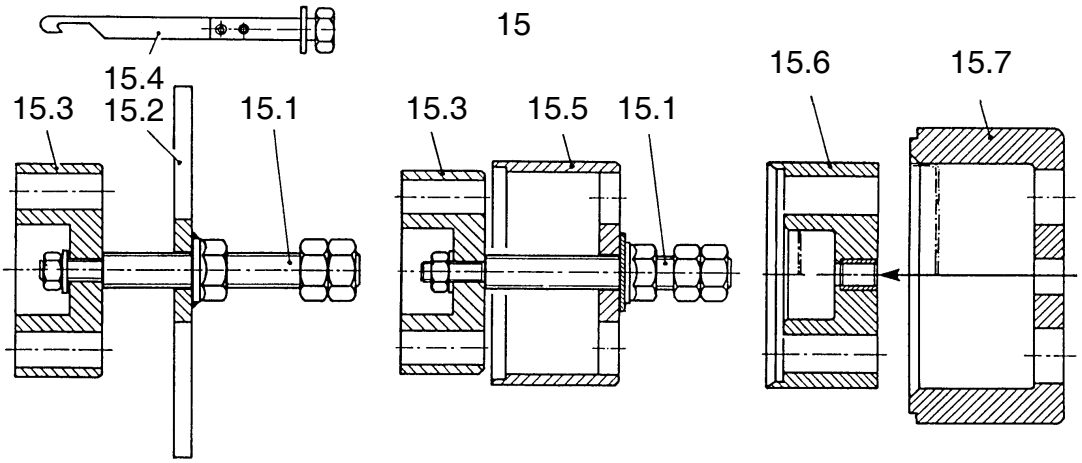
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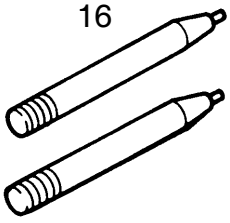
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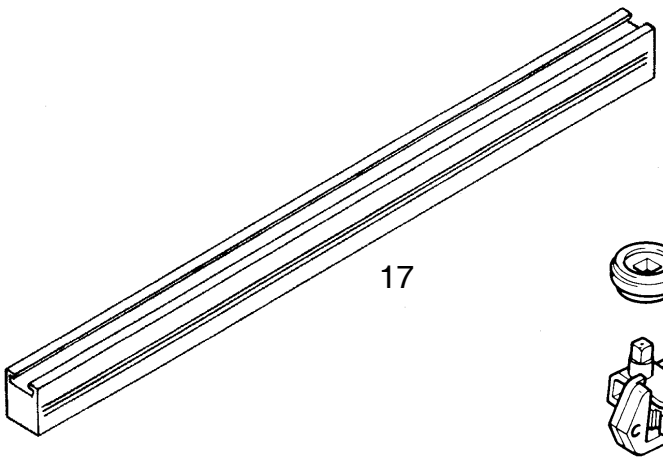
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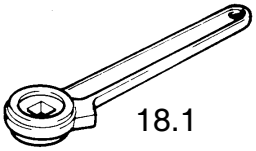
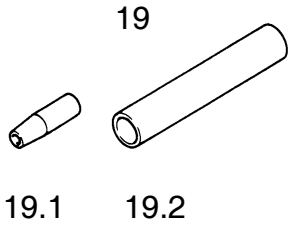

18.1


18

Fig. no.	Designation	Item number
10	Puller for water pump pulley	80.99601–0037
11	Pressing mandrel for cassette seal in conjunction with handle 14.1	80.99617–0091
12	Driving mandrel for seal in timing case	
	consisting of:	
12.1	Guide sleeve	80.99604–0068
12.2	Pressing plate in conjunction with handle 14.1	80.99604–0069
13	Puller for front crankshaft bearing race	80.99601–0076
14	Pressing tool for bearing race on flywheel in conjunction with handle 14.1	80.99617–0017
14.1	Handle	80.99617–0129
15	Special tools for front crankshaft seal	80.99606–6011
	Components:	
15.1	Spindle	80.99606–0299
15.2	Extractor device	80.99606–0298
15.3	Adapter	80.99606–0264
15.4	Extractor hook	80.99606–6013
15.5	Pressing sleeve	80.99606–0300
15.6	Adapter	80.99606–0302
15.7	Fitting sleeve	80.99606–0301
16	Guide mandrels for flywheel	80.99617–0020
17	Steel ruler	80.99607–0044
18	Engine turning device	80.99626–0004
18.1	Standard ratchet for 18	80.99627–0001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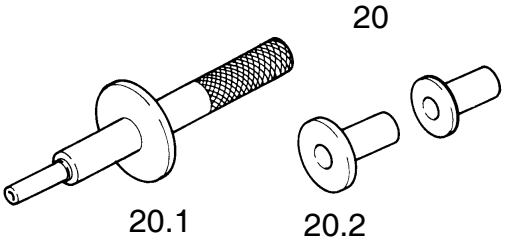
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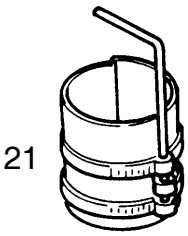
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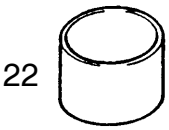
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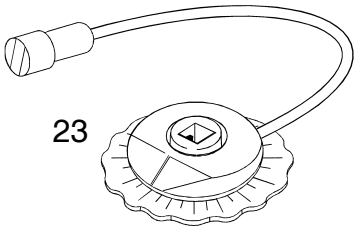
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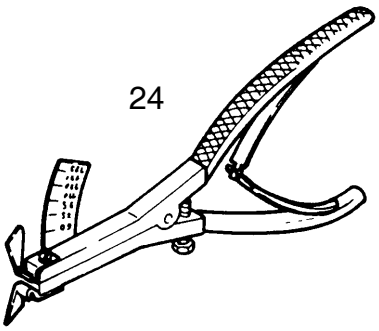
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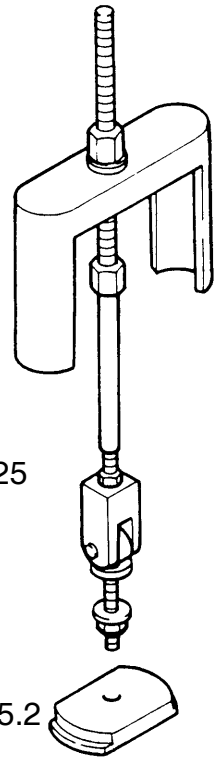
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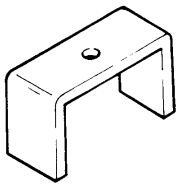
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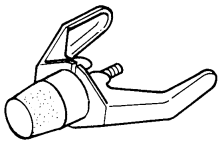
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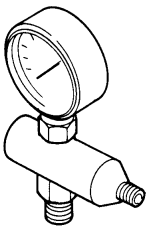

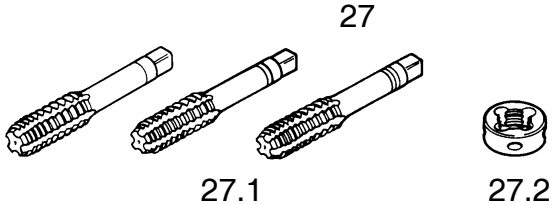
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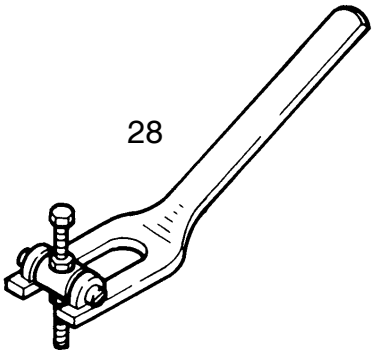
27.1
27.2

Fig. no.	Designation	Item number
19	Sleeves for valve stem seal	
19.1	Insert sleeve for valve stem seal	80.99616–0004
19.2	Pressing sleeve for valve stem seal	80.99604–0005
20	Pressing tool for valve guide	
20.1	Pressing mandrel for valve guide	80.99617–0013
20.2	Pressing rings in conjunction with 20.1	80.99616–0003
21	Piston ring tightener	80.99613–0035
22	Piston ring tightening sleeve	83.09144–0187
23	Tightening angle gauge	80.99605–0010
24	Piston ring pliers	83.09144–6090
25	Cylinder liner extractor device	80.99602–0019
25.1	Support for 25	80.99623–0003
25.2	Extractor plate	83.09143–0195
26	Cooling system test unit	80.99607–0061
27	Thread-cutting tool	
27.1	Thread drill set, M15 x 2, for cylinder head bolt threads	80.40001–0001
27.2	Associated die ring	80.43001–0001

28



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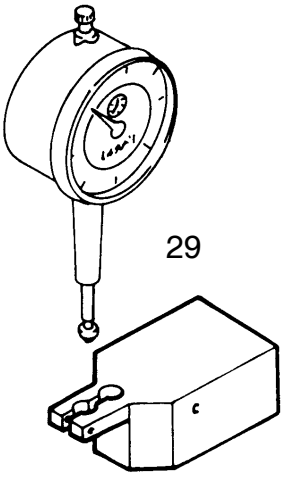

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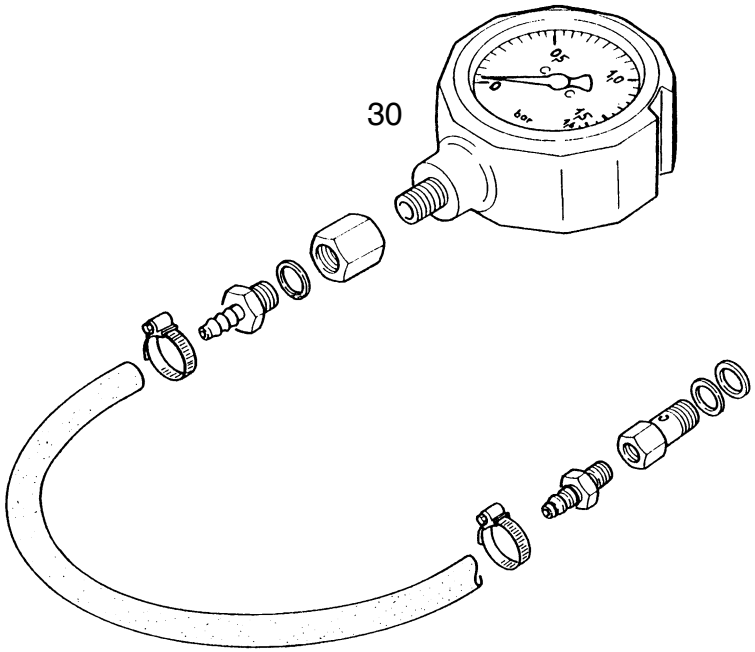


Fig. no.	Designation	Item number
28	Valve assembly lever	80.99606–0031
29	Dial gauge holder for measuring valve retrusion and piston protrusion	90.99605–0172
30	Pressure gauge + accessories for charge-air pressure measurement	80.99605–0160

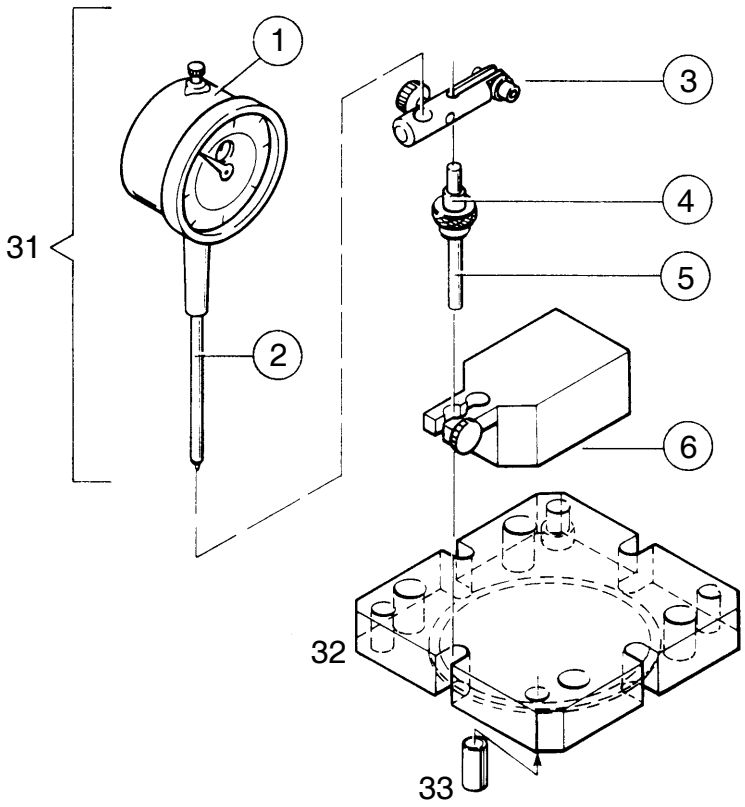
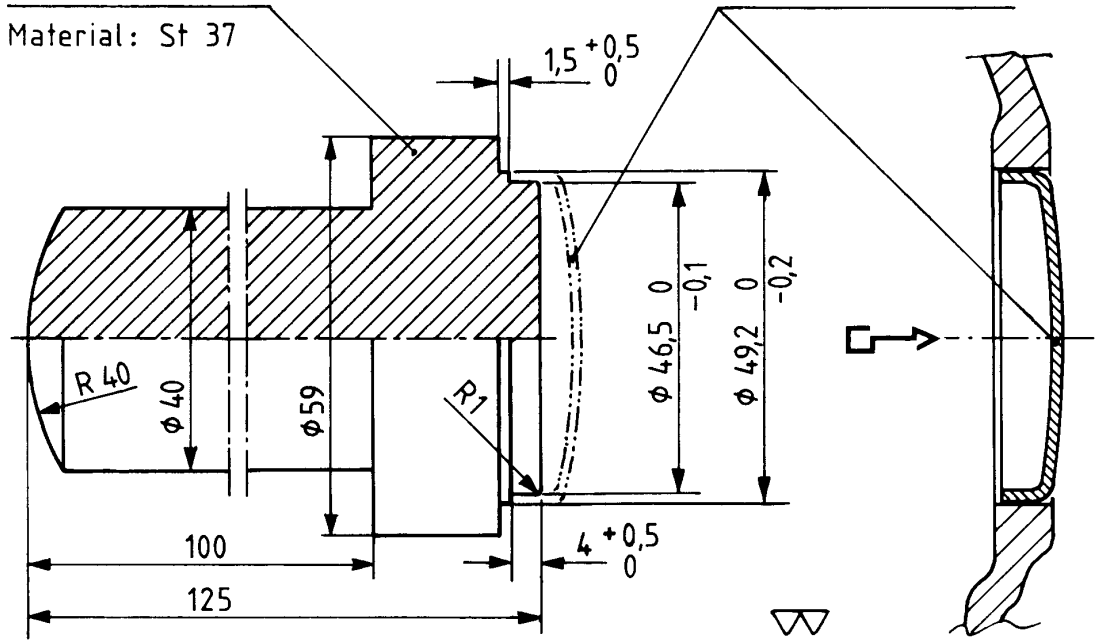
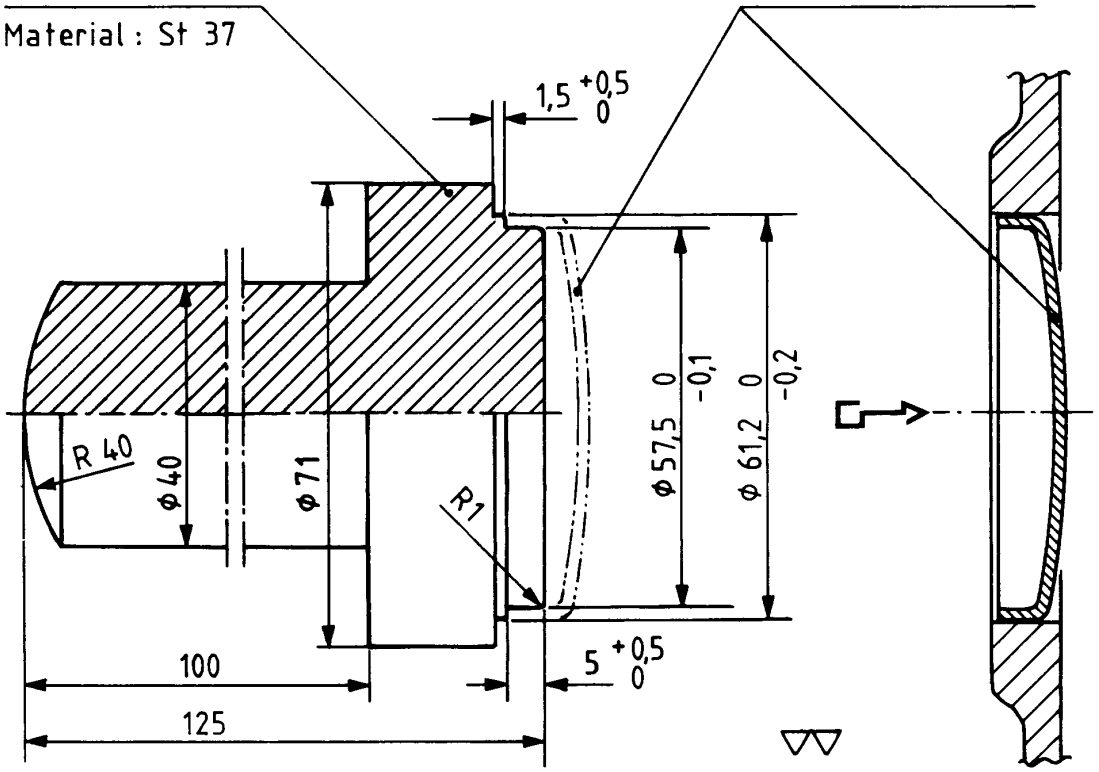


Fig. no.	Designation	Item number
31	Measuring combination, consisting of:	
	(1) Dial gauge	08.71000–1205
	(2) Tracer pin for dial gauge	80.99605–0197
	(3) Dial gauge holder	80.99605–0179
	(4) Contact pin	80.99605–0180
	(5) Dial gauge holder	80.99605–6006
	(6) Dial gauge holder	80.99605–0172
32	Press–on measuring plate	80.99605–0195
33	Fitting sleeves	51.91701–0247

Pressing mandrel for cap, dia. 50.1 mm



Pressing mandrel for cap, dia. 62.1 mm

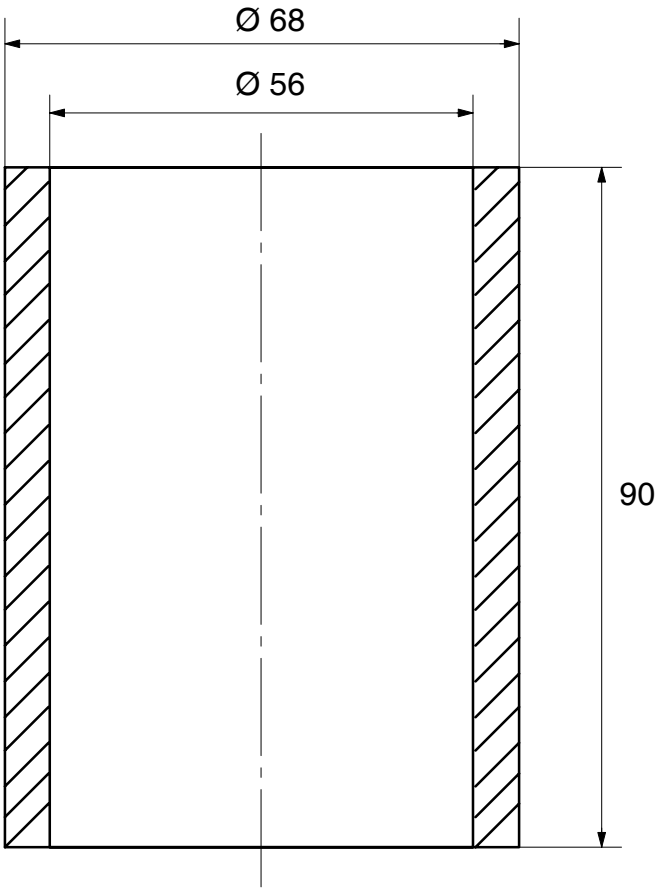


2843

Special tools for water pump repair for local manufacture

(Material: steel as available)

Support ring for pressing out the water pump bearing



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