

# Repair Manual

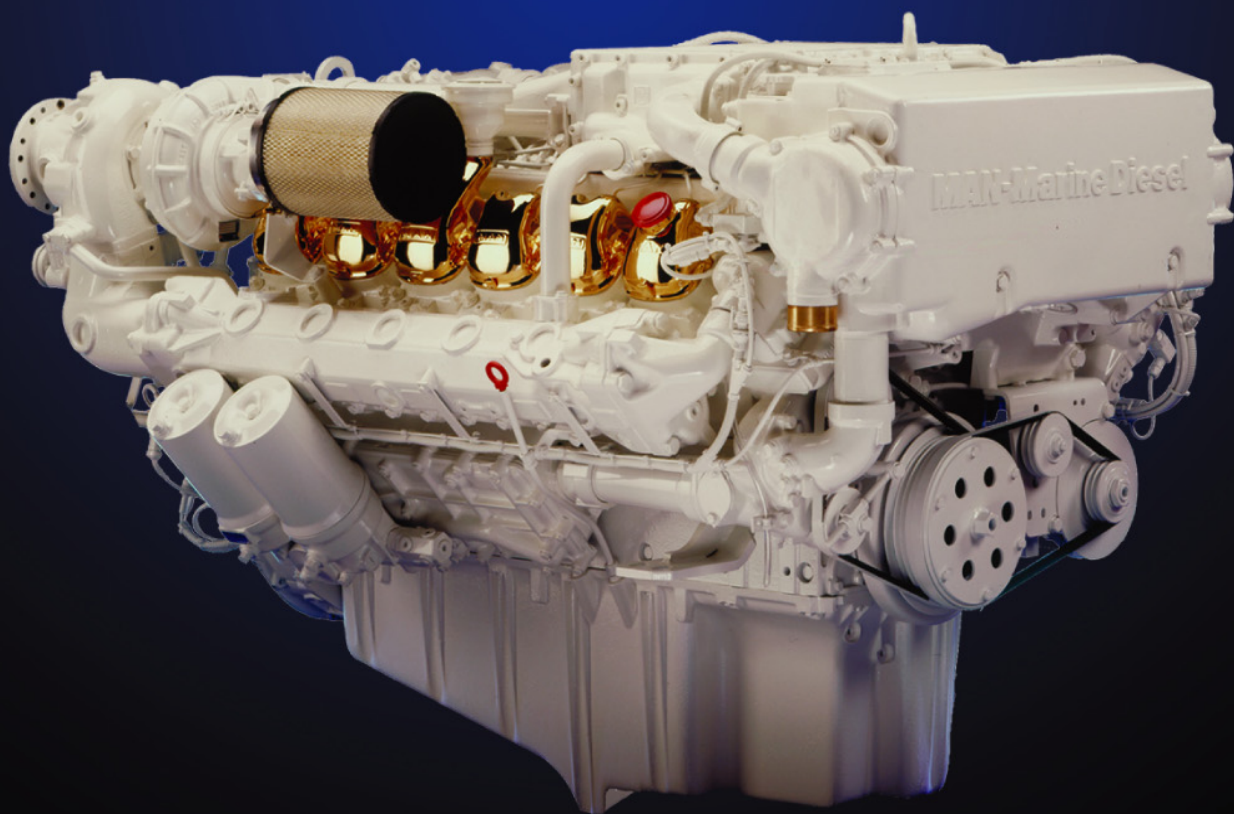


## MAN-Marine Diesel Engines

D 2848 LXE / LE 401 / 403 / 405

D 2840 LXE / LE 401 / 402 / 407

D 2842 LYE / LZE / LE 401 / 402 / 403 / 406 / 408 / 411 / 412 / 413





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.

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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.

### Assembly of pipes

**Danger:**

No pipes may be bent.  
Risk of breakage!

### 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

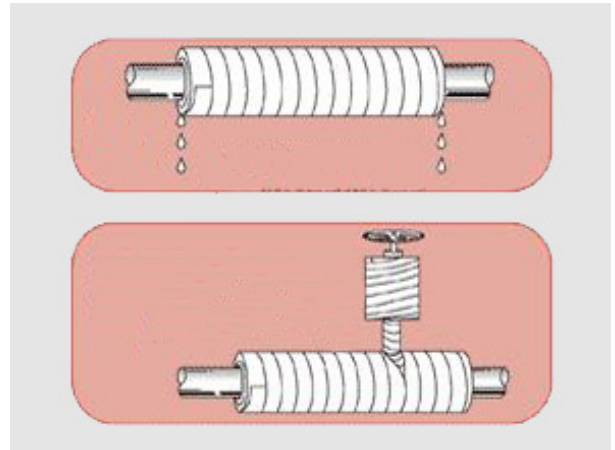
- Use only genuine MAN round sealing rings.
- The sealing faces must be undamaged and clean.
- Always wet round sealing rings with engine oil before fitting them.

**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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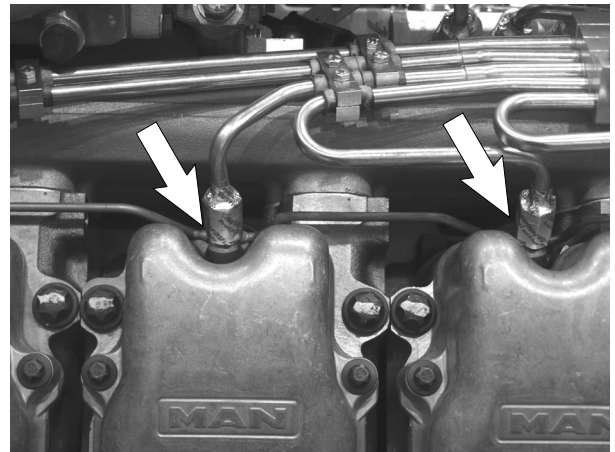
Fig. 1

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

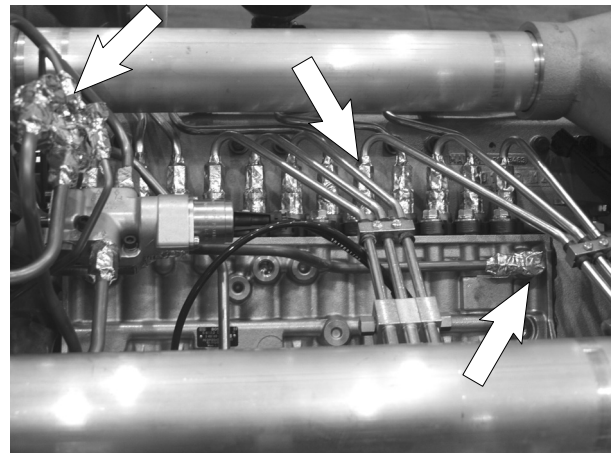
Figs. 2-4

The unions to be masked must be clean and free of oil and grease.

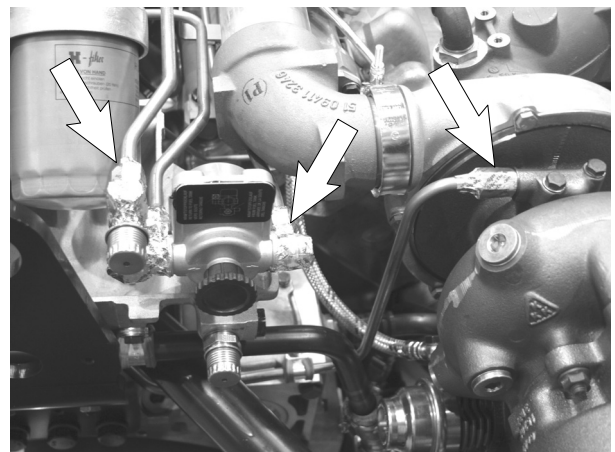
Do not apply the protective tape unless this is the case



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### General notes

This quick overview summarises important regulations and arranges them according to important aspects to provide the knowledge required to avoid accidents involving personal injury, damage to property and environmental damage. Additional information can be found in the operating instructions of the engine.

#### Important:

Should an accident occur despite all precautionary measures, particularly one involving contact with corrosive acid, penetration of fuel under the skin, scalding by hot oil, antifreeze splashing into the eyes etc. **you must seek medical assistance immediately.**

#### 1. Regulations designed to prevent accidents with injury to persons

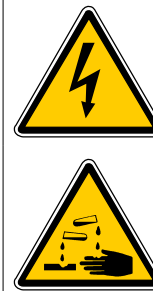
**Checks, setting jobs and repair work must be carried out by authorised skilled personnel only.**

- When carrying out maintenance and repair work, ensure that the engine cannot be accidentally started from the bridge by unauthorised persons.
- The engine may only be started and operated by authorised personnel.
- When the engine is running, do not get too close to rotating parts. Wear tight-fitting working clothes.
- Do not touch the warm engine with your bare hands: danger of burns.
- Keep the area round the engine, ladders and steps free of oil and grease. Accidents caused by slipping can have serious consequences.
- Only work with tools that are in perfect working order. Worn spanners / wrenches slip: danger of injury.
- Persons must not place themselves beneath an engine hanging on a crane hook. Keep lifting gear in order.
- Only open the coolant circuit when 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 pull nor open pipes and hoses that are under pressure (lubricant circuit, coolant circuit and possible downstream hydraulic oil circuit): danger of injury from outflowing 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, first disconnect the earth cable of the battery and reconnect this last to prevent short circuits.
- Observe the manufacturer's instructions for handling batteries.  
**Caution:**  
Battery acid is toxic and caustic. Battery gases are explosive.
- When performing welding work, observe the "Notes for welders".



### 2. Regulations designed to prevent damage to 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.**
- If engine operation is disrupted, immediately determine the cause and have it remedied to prevent additional 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 allow the engine to run dry, i.e. without lubricant or coolant.  
**Appropriate notices must be attached to engines that are 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 engine oil beyond the max. notch on the dipstick. Do not exceed the maximum permitted operating inclination of the engine.**  
Non-observance can lead to severe engine damage.
- Control and monitoring devices (charge control, oil pressure, coolant temperature) must be in perfect working order.
- Observe the instructions for operating the alternator; see chapter "Maintenance and care" in the Operator's Manual.



### 3. Regulations designed to prevent pollution

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

- Old oil must be passed on for recycling.
- 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 used filter inserts and cartridges as hazardous waste.

#### Coolant

- Treat undiluted corrosion protection agents and / or antifreeze as hazardous waste.
- When disposing of used coolant, the regulations issued by the relevant local authorities must be observed.

### 4. Notes on safety in handling used engine oil \*

Prolonged or repeated skin contact with any type of engine oil draws grease from your skin. This can lead to dryness, irritation or skin inflammation. Used engine oil also contains hazardous substances that have caused skin cancer in tests on animals. Handling old engine oil does not pose any health hazard if the basic safety and hygiene related regulations are observed.

#### **Precautionary measures to protect your health:**

- Avoid prolonged, repeated skin contact with used engine oil.
- Protect your skin with suitable skin protection cream or protective gloves.
- Clean any skin that comes into contact with engine oil.
  - Wash yourself thoroughly with soap and water. A nail brush provides effective assistance here.
  - Special hand cleaning agents facilitate cleaning soiled hands.
  - Do not use petrol, Diesel fuel, gas oil, fluxes or solvents as cleaning agents.
- After cleaning, apply skin cream containing fat.
- Change clothing and shoes that are soaked in oil.
- Do not put oily cloths in your pockets.

**Ensure that used engine oil is disposed of in the appropriate manner.**  
– Engine oil is a substance that endangers the water supply –

For this reason, do not pour engine oil on the ground, in lakes or rivers, down plugholes or in the waste water system. Violations of this regulation are punishable offences.

Carefully collect and dispose of used engine oil. Information on collection points can be obtained from sales personnel, the supplier or the local authorities.

\* Based on "Information sheet for handling used engine oil".



### 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	<ul style="list-style-type: none"> <li>● Battery main switch in "off" position</li> <li>● Batteries flat</li> <li>● Crankgear blocks</li> <li>● Battery cable connections loose or corroded</li> <li>● Starter electromagnetic switch sticking (clicks)</li> <li>● Cable connection from ignition lock to starter electromagnetic switch is loose or interrupted</li> <li>● Starter electromagnetic switch faulty</li> <li>● Starter defective (carbon brushes loose, winding faulty, short-circuit to earth)</li> <li>● Engine oil viscosity not suitable</li> <li>● Starter interlock relay defective</li> </ul>	<ul style="list-style-type: none"> <li>● Knock on the magnet</li> <li>● Check with check lamp</li>   <li>● See "Fuels, Lubricants ..."</li> <li>● Checking: Connect terminals 50e and 50f</li> </ul>
Engine does not start	<ul style="list-style-type: none"> <li>● Fuel tank empty</li> <li>● Fuel valve shut</li> <li>● Air in fuel system</li> <li>● Fuel lines leaky, ruptured, clogged</li> <li>● Fuel filter / prefilter clogged</li> <li>● Suction height of fuel delivery pump (max. 1m) exceeded</li> <li>● Fuel delivery pump faulty</li> <li>● Air supply/exhaust gas pipes clogged</li> <li>● Unsuitable fuel</li> <li>● Delivery start incorrect</li> <li>● Valve clearance incorrect</li> <li>● Injection nozzles worn</li> <li>● Compression insufficient</li> </ul>	
Engine does not start while cold	<ul style="list-style-type: none"> <li>● Fuel filter clogged with paraffin</li> <li>● Engine oil viscosity unsuitable see: "Engine does not start"</li> </ul>	<ul style="list-style-type: none"> <li>● See "Fuels, Lubricants ..."</li> </ul>
Engine does not run smoothly, and stops	<ul style="list-style-type: none"> <li>● Lower idle speed set too low</li> <li>● Air in fuel system</li> <li>● Fuel lines leaky, ruptured, clogged</li> <li>● Fuel filter clogged</li> <li>● Inlet chamber pressure of injection pump too low</li> <li>● Fuel high-pressure part leaky</li> <li>● Injector needle sticking</li> <li>● Delivery start set incorrectly</li> <li>● Injection pump set incorrectly or defective</li> <li>● Valve clearance incorrect</li> <li>● Compression insufficient</li> </ul>	<ul style="list-style-type: none"> <li>● Remedy by Bosch Service</li> </ul>



## Trouble shooting table

<p>Engine speed variations during operation</p>	<ul style="list-style-type: none"> <li>● Too little fuel in fuel tank</li> <li>● Air in fuel system</li> <li>● Fuel lines leaky</li> <li>● Fuel high-pressure part leaky</li> <li>● Injection nozzles defective, worn</li> <li>● Speed governor defective</li> </ul>	<ul style="list-style-type: none"> <li>● Remedy by Bosch Service</li> </ul>
<p>Engine cannot be stopped</p>	<ul style="list-style-type: none"> <li>● Cut-off linkage bent or jammed</li> <li>● Cut-off solenoid without voltage</li> <li>● Injection pump set incorrectly or defective</li> </ul>	<ul style="list-style-type: none"> <li>● Remedy by Bosch Service</li> </ul>
<p>Performance unsatisfactory, max. boat speed is not reached</p>	<ul style="list-style-type: none"> <li>● Engine speed adjusting lever not in full-load position</li> <li>● Incrustation of hull, shaft system and propeller with foreign matter</li> <li>● Propeller consumes too much power, nominal speed is not reached</li> <li>● Propeller consumes too much power, engine runs in the breakaway range</li> <li>● Flow of water on to the propeller insufficient</li> <li>● Fuel temperature too high</li>   <li>● Unsuitable, contaminated fuel</li> <li>● Fuel filter clogged</li> <li>● Air in fuel system</li> <li>● Lack of fuel</li>   <li>● Temperature in engine room too high, combustion air and fuel too hot</li> <li>● Supply of combustion air insufficient, intake vacuum too high</li> <li>● Charge-air pipes leaky</li> <li>● Intercooler contaminated</li> <li>● Turbocharger contaminated or defective</li> <li>● Compression insufficient</li> <li>● Injection pump and / or governor defective</li> </ul>	<ul style="list-style-type: none"> <li>● Fuel lines routed near hot engine components</li> <li>● See "Fuels, Lubricants ..."</li>   <li>● Check fuel lines and delivery pump</li> <li>● Check inward and outward ventilation</li> <li>● Check intake air supply to air filters</li>   <li>● Remedy by Bosch Service</li> </ul>
<p>Coolant temperature too high, coolant loss</p>	<ul style="list-style-type: none"> <li>● Coolant level too low</li> <li>● Air in coolant circuit</li> <li>● Proportion of anti-freeze / anticorrosion agent too high</li> <li>● Raw water supply clogged</li> <li>● Raw water supply insufficient</li>   <li>● Cap with working valves on expansion tank defective, leaky</li> <li>● Thermostat in closed position blocked</li> <li>● Heat exchanger heavily contaminated, pipe group coated with foreign matter</li> <li>● V-belt for water pump drive not correctly tensioned (slipping)</li> <li>● Water pump leaky, defective (bearing damage)</li> <li>● Coolant circuit clogged by foreign matter</li> <li>● Thermostat jammed in "shut" position</li> </ul>	<ul style="list-style-type: none"> <li>● See "Fuels, Lubricants ..."</li>   <li>● Check inlet orifice</li> <li>● Impeller worn. Measure delivery of raw water pump and vacuum at inlet</li> </ul>

## Trouble shooting table



<p>Lube oil pressure varies / too low</p>	<ul style="list-style-type: none"> <li>● Oil level in oil pan too low</li> <li>● Oil level in oil pan too high</li> <li>● Max. inclination exceeded</li> <li>● Engine temperature too high</li> <li>● Oil viscosity unsuitable (viscosity too low)</li> <li>● Oil in oil pan too thin (mixed with condensation or fuel)</li> <li>● Heavy bearing wear</li> <li>● Oil pump gears heavily worn</li> <li>● Safety valve in oil circuit defective (does not shut, spring fatigued or broken)</li> <li>● Oil pressure gauge defective</li> </ul>	<ul style="list-style-type: none"> <li>● Dipstick marked correctly? See Operator's Manual</li> <li>● See "Fuels, Lubricants ..."</li> </ul>
<p>Lub oil pressure too high</p>	<ul style="list-style-type: none"> <li>● Engine cold</li> <li>● Oil viscosity unsuitable (viscosity too high)</li> <li>● Safety valve in oil circuit defective (does not open)</li> <li>● Oil pipes/oil galleries clogged</li> <li>● Oil pressure gauge defective</li> </ul>	<ul style="list-style-type: none"> <li>● See "Fuels, Lubricants ..."</li> </ul>
<p>Lube oil consumption too high</p>	<ul style="list-style-type: none"> <li>● Leaks in the lube oil circuit, particularly at the turbocharger and oil cooler</li> <li>● Oil level in oil pan too high</li> <li>● Lube oil quality does not satisfy regulations</li> <li>● Turbocharger wear</li> <li>● Piston rings heavily worn</li> <li>● Valve guides heavily worn</li> </ul>	<ul style="list-style-type: none"> <li>● See "Fuels, Lubricants ..."</li> <li>● Measure play of rotor</li> </ul>



## Trouble shooting table

<p>Fuel consumption too high</p>	<ul style="list-style-type: none"> <li>● Constant full-load operation</li> <li>● Speed resistance owing to incrustation of hull, shaft system and propeller with foreign matter</li> <li>● Poor efficiency of the drive system</li> <li>● Fuel quality does not satisfy regulations</li> <li>● Fuel leaks in the system</li> <li>● High power requirements by additional units (hydraulic pumps, compressors etc)</li> <li>● Delivery start set incorrectly</li> <li>● Injection pump set incorrectly or defective</li> <li>● Valve clearance incorrect</li> <li>● Intake vacuum / exhaust backpressure too high</li> <li>● Injection nozzles worn</li> </ul>	<ul style="list-style-type: none"> <li>● Adjust propeller</li> <li>● See "Fuels, Lubricants ..."</li>   <li>● Remedy by Bosch Service</li> </ul>
<p>Black smoke</p>	<ul style="list-style-type: none"> <li>● Lack of combustion air, intake vacuum too high</li> <li>● Engine speed reduction owing to the propeller's taking up too much power</li> <li>● Sudden full load after long low load or idling periods</li> <li>● Air filter contaminated</li> <li>● Leaks in air pipes downstream of compressor</li> <li>● Diaphragm in wastegate leaky</li> <li>● Intercooler leaky, defective</li> <li>● Unsuitable fuel</li> <li>● Turbocharger defective</li> <li>● Delivery start set incorrectly</li> <li>● Injection nozzles defective, coked</li> <li>● Injection pump set incorrectly or defective</li> <li>● Exhaust backpressure too high</li> </ul>	<ul style="list-style-type: none"> <li>● Check intake air supply to air filters (engine room ventilation)</li>   <li>● See "Fuels, Lubricants ..."</li>   <li>● Remedy by Bosch Service</li> </ul>
<p>Blue smoke</p>	<ul style="list-style-type: none"> <li>● Engine coolant/intake air still too cold</li> <li>● Mainly low-load operation</li> <li>● Piston rings worn or broken</li> <li>● Valve guides worn</li> <li>● Crankcase breather clogged (overpressure in crankcase)</li> </ul>	



## Trouble shooting table



White smoke	<ul style="list-style-type: none"> <li>● Engine coolant/intake air still too cold</li> <li>● Intake air preheater not in operation during warm-up phase</li> <li>● Water evaporates in exhaust gas pipe during raw water injection</li> <li>● Delivery start set incorrectly</li> <li>● Cylinder head gasket leaky/burned through</li> <li>● Fuel quality does not satisfy regulations</li> <li>● Injection nozzles defective</li> <li>● Injection pump set incorrectly or defective</li> </ul>	<ul style="list-style-type: none"> <li>● See "Fuels, Lubricants ..."</li> <li>● Remedy by Bosch Service</li> </ul>
Vibrations, droning noise, structure-borne sound	<ul style="list-style-type: none"> <li>● Drive system not or inaccurately aligned</li> <li>● Unsuitable clutch</li> <li>● Unsuitable engine/gearbox mounts</li> <li>● Elastic mounts unequally loaded (height adjustment)</li> <li>● Propeller shaft unbalanced</li> </ul>	
Engine knocks	<ul style="list-style-type: none"> <li>● Engine in cold running phase</li> <li>● Delivery start set incorrectly</li> <li>● Injector needle sticking</li> <li>● High load at low speed</li> <li>● Fuel is slow to ignite</li> <li>● Compression too low</li> </ul>	
Engine is too loud	<ul style="list-style-type: none"> <li>● Intake or exhaust gas pipe leaky</li> <li>● Valve clearance too large</li> <li>● V-belt slipping</li> <li>● Timing gears worn, backlash of teeth too large</li> </ul>	

<p><b>Starter</b></p> <ul style="list-style-type: none"> <li>● Pinion does not turn or turns too slowly</li>   <li>● Pinion does not engage</li> <li>● Pinion engages but stops</li> <li>● Pinion continues to run after starter switch has been released</li> <li>● Pinion does not disengage after successful start</li> </ul>	<ul style="list-style-type: none"> <li>● Battery insufficiently charged</li> <li>● Terminals loose or oxidised, poor earth connection</li> <li>● Terminals or carbon brushes have short-circuit to earth</li> <li>● Carbon brushes are stuck or have poor contact</li>   <li>● Pinion or starter gear ring heavily contaminated or damaged</li> <li>● Electromagnetic switch defective</li> <li>● One-way clutch slips</li>   <li>● Starter switch defective</li> <li>● Electromagnetic switch defective</li>   <li>● Starter defective</li> </ul>	<ul style="list-style-type: none"> <li>● Switch off engine immediately</li> </ul>
<p><b>Alternator</b></p> <ul style="list-style-type: none"> <li>● Alternator check lamp does not come on when engine is stationary and starter switch is switched on</li>   <li>● Alternator check lamp brightly illuminated when engine is running</li> <li>● Alternator check lamp brightly illuminated when engine is stationary, dimmer or glowing when engine is running</li> <li>● Battery does not charge up</li> </ul>	<ul style="list-style-type: none"> <li>● Check lamp burnt out</li> <li>● Battery discharged</li> <li>● Terminal clamps loose or oxidised</li> <li>● Regulator defective</li> <li>● Short-circuit in alternator</li> <li>● Carbon brushes worn</li>   <li>● Cable D+ has short-circuit to earth</li> <li>● Regulator defective</li> <li>● Rectifier damaged, slip rings dirty</li> <li>● V-belt slipping or cracked</li>   <li>● Resistance in cable between alternator and battery is too high, terminal clamps oxidised</li> <li>● Regulator defective</li> <li>● Alternator defective</li>   <li>● Cable between alternator and battery interrupted</li> <li>● Battery defective</li> <li>● Alternator defective</li> <li>● V-belt slipping</li> </ul>	<ul style="list-style-type: none"> <li>● Change regulator</li> <li>● Repair in specialist workshop</li>   <li>● Change regulator</li> <li>● Repair in specialist workshop</li>   <li>● Change regulator</li> <li>● Repair in specialist workshop</li>   <li>● Repair in specialist workshop</li> </ul>

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.

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:

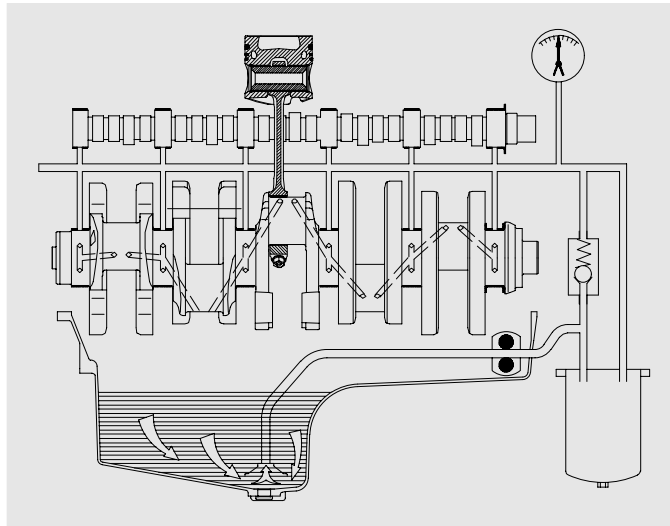
- Correct output setting according to the type of operation
- Expert installation in accordance with the installation instructions
- Inspection of the installation by authorized personnel
- Regular maintenance as per maintenance plan in the Operator's manual
- Selection and quality of lube oil, fuel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

### Pressurisation

It is of advantage 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.

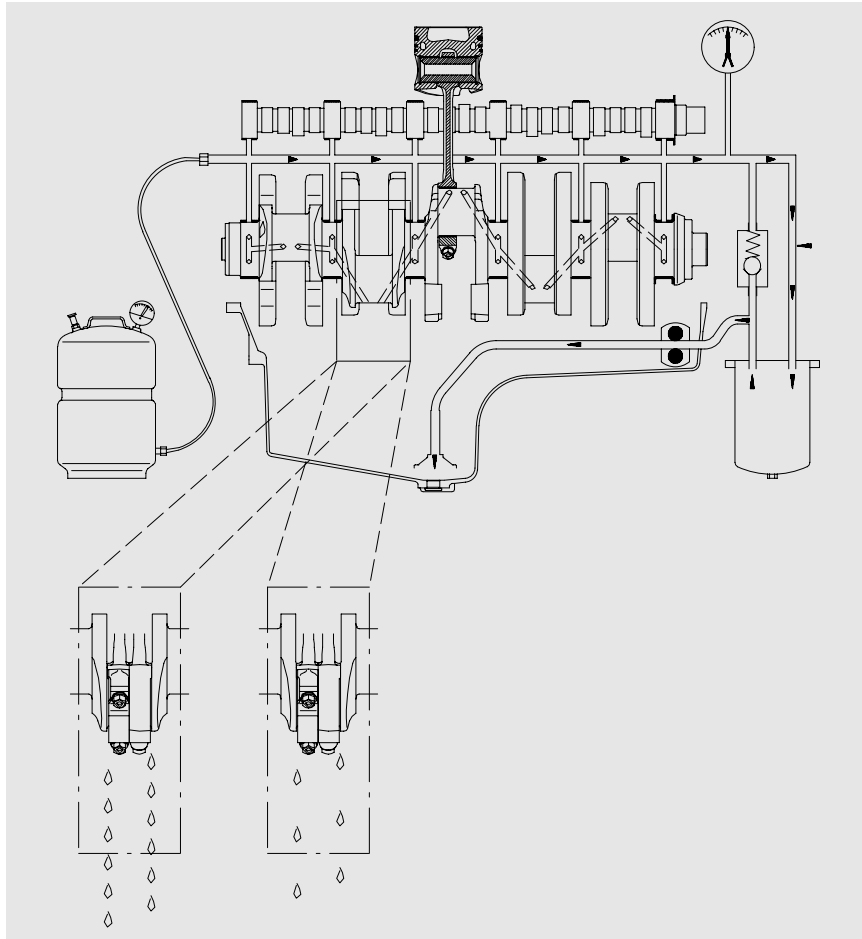
Such incipient damage need not necessarily lead to bearing failure, but may affect the functioning of bearings and shorten their service lives.



Schematic diagram of the flow of oil in non-pressurised engines.

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.

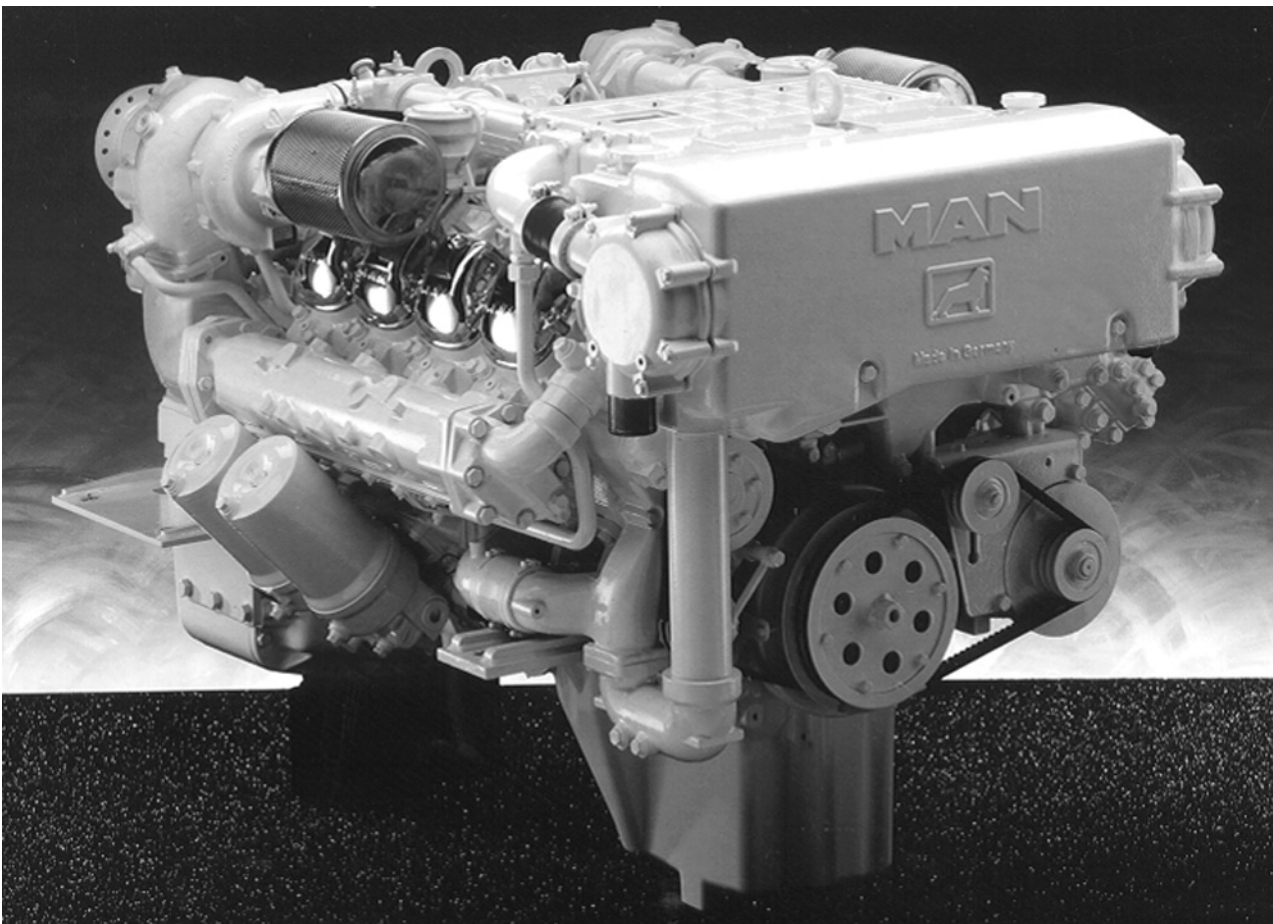
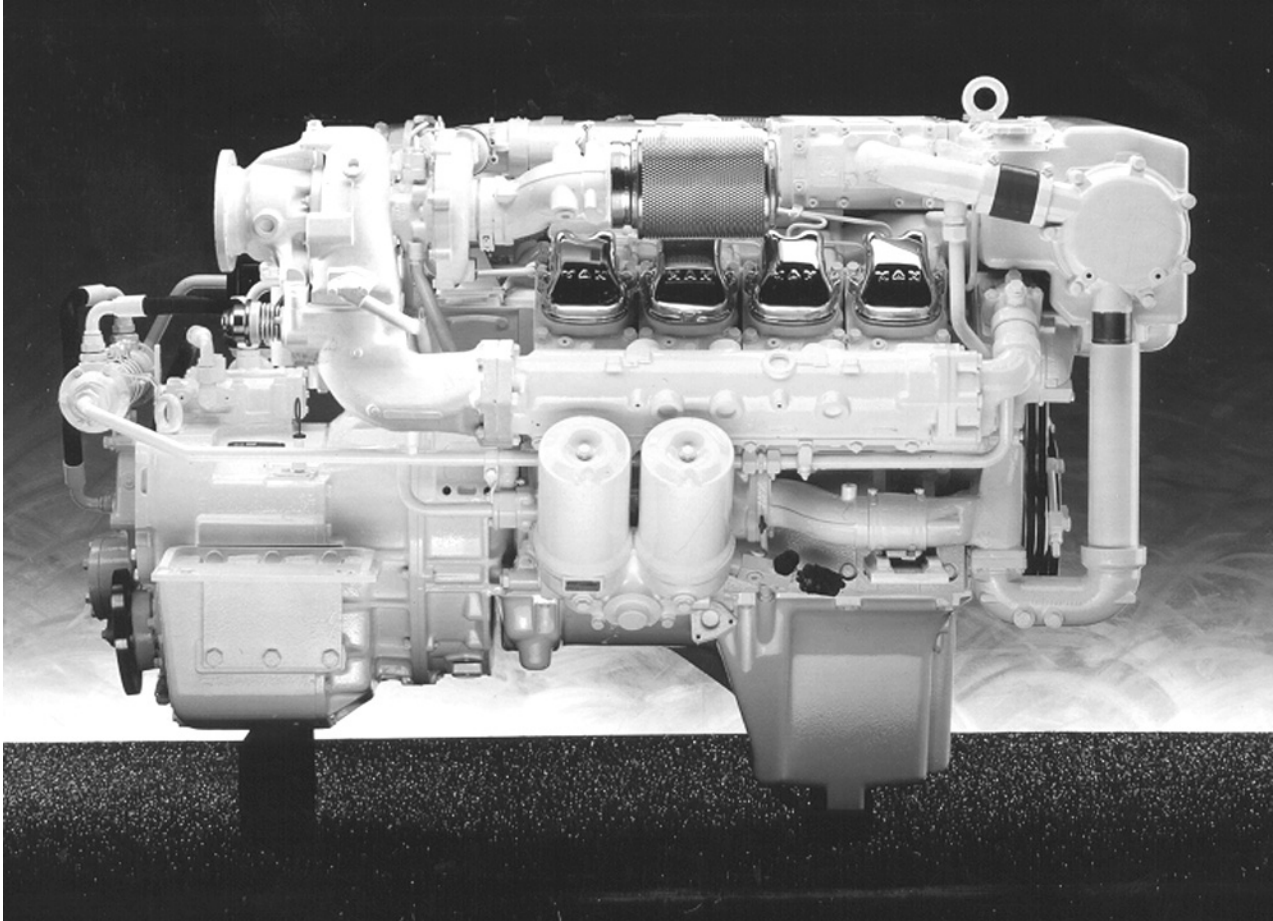


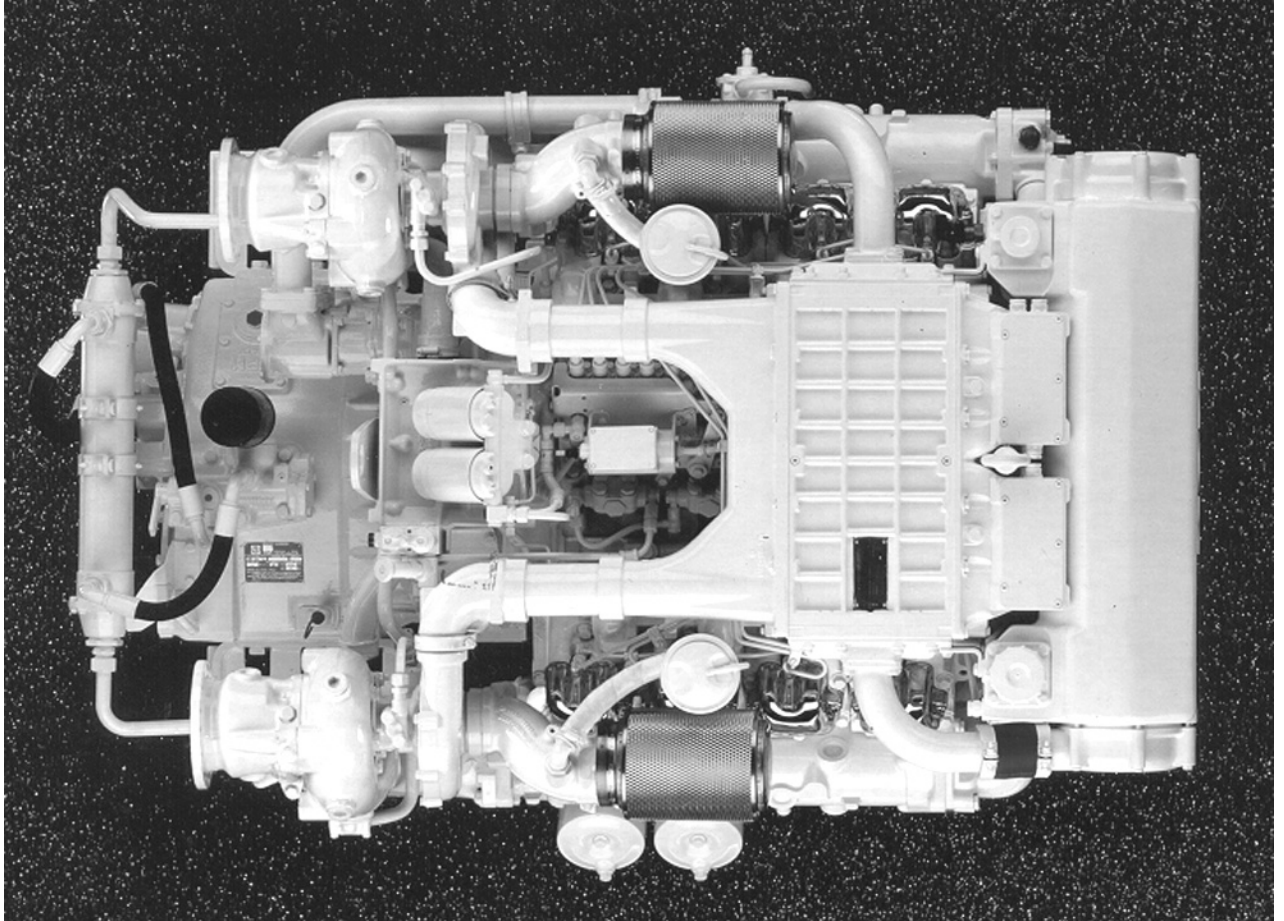
Execution of pressurisation:

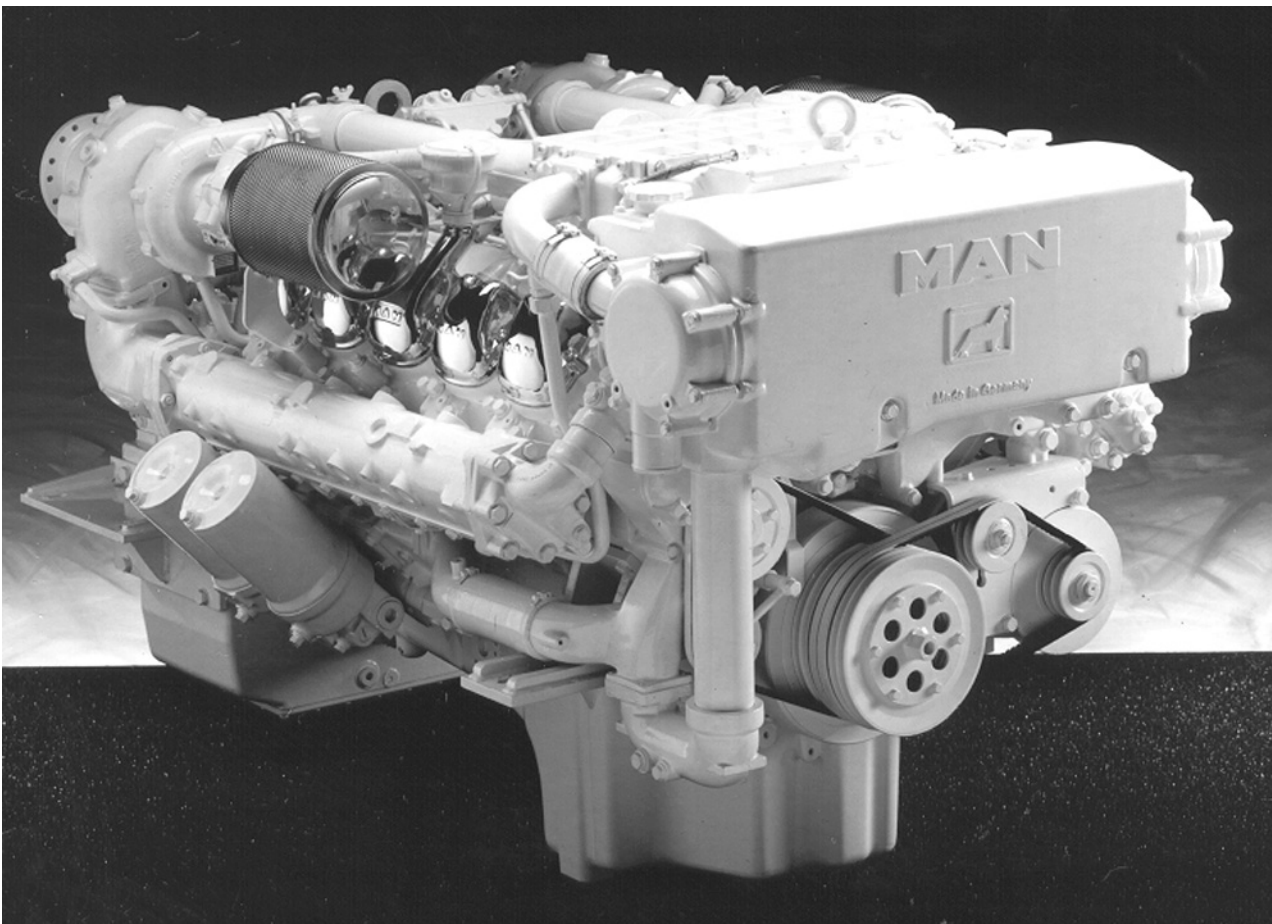
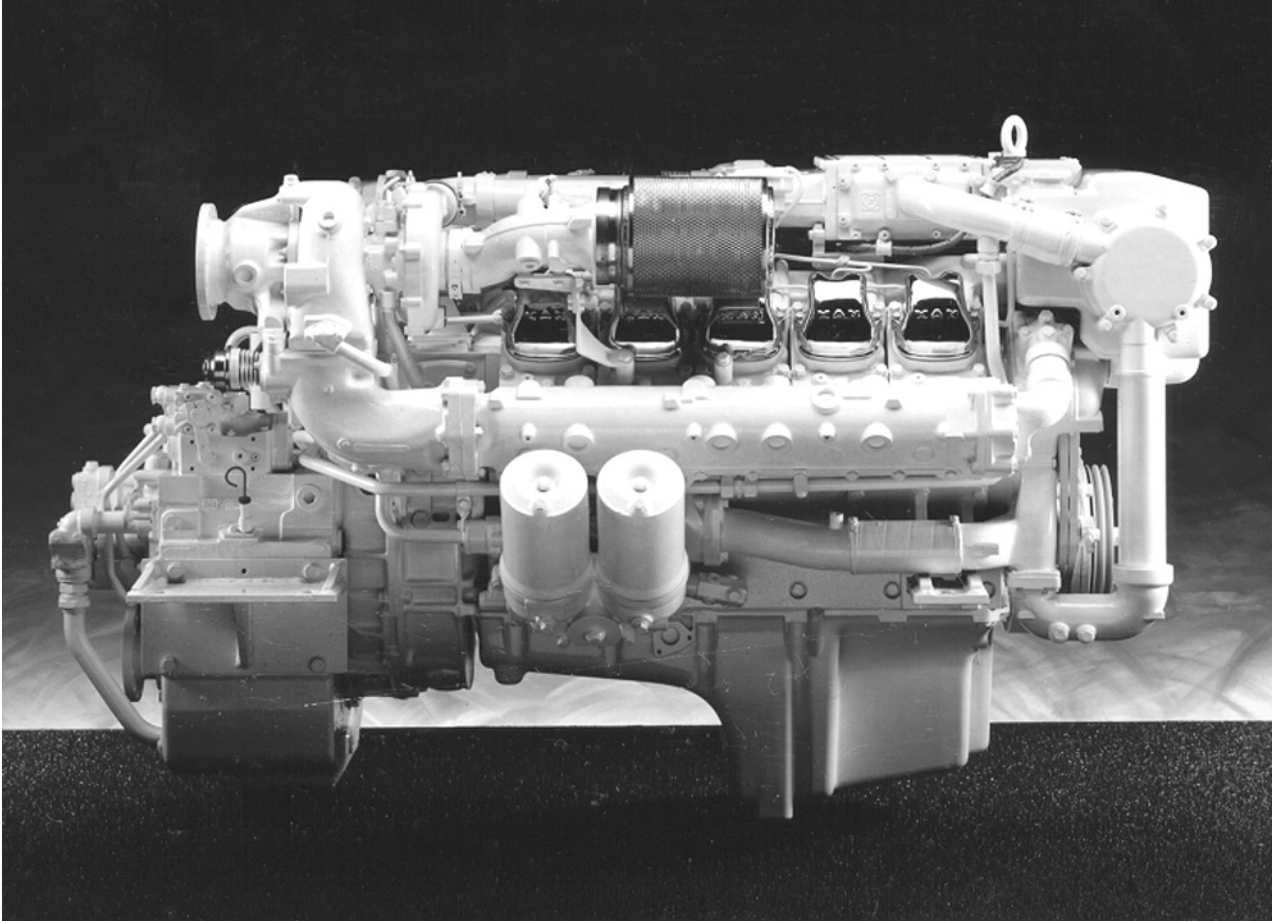
At least 30 % of the overall oil quantity is pressed from the pressurisation container into the engine oil circuit. The operating pressure serves as a yardstick for the pressure to be injected. This must not be exceeded.

The pressurisation container is connected up to the engine's oil circuit at the oil filter head (screw plug).

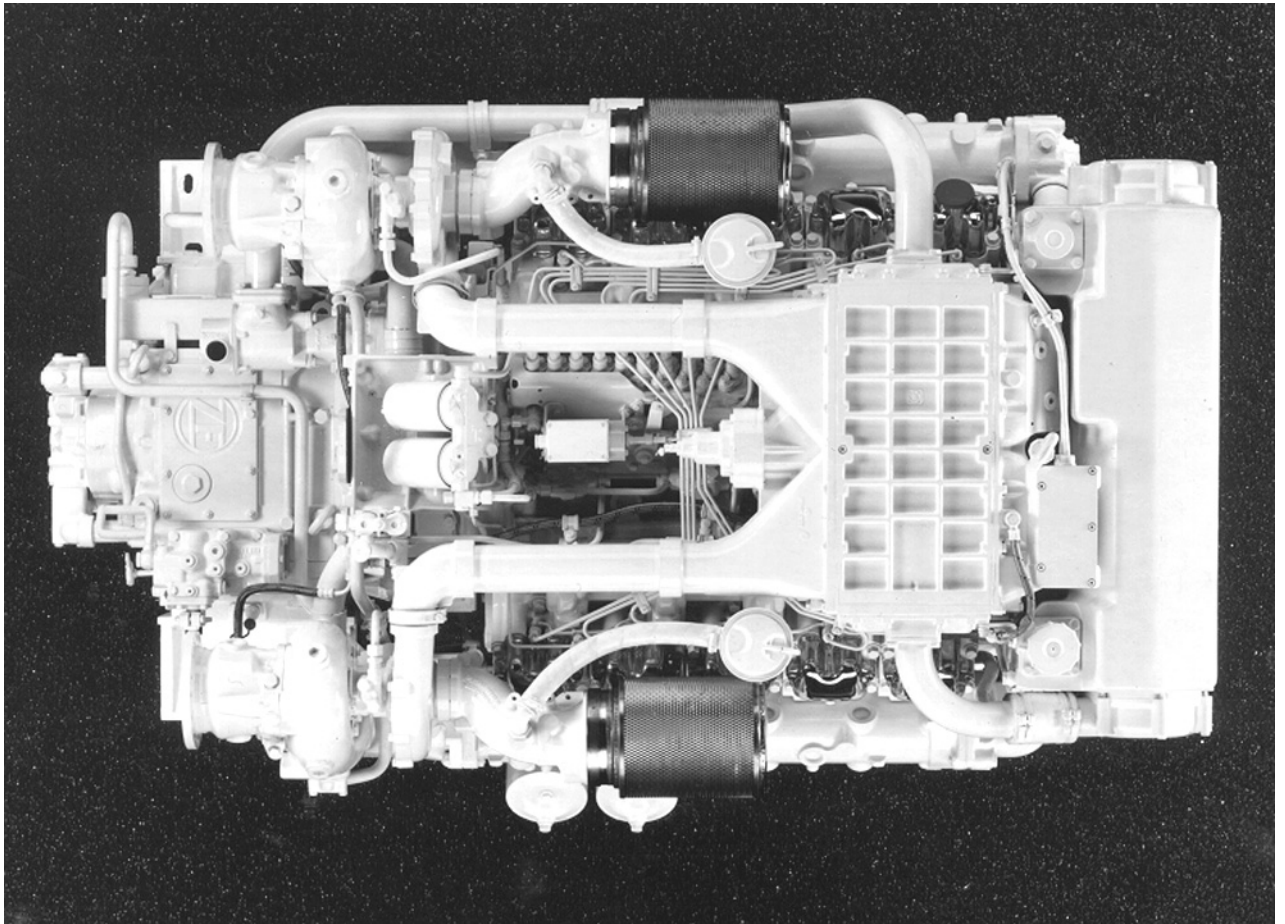


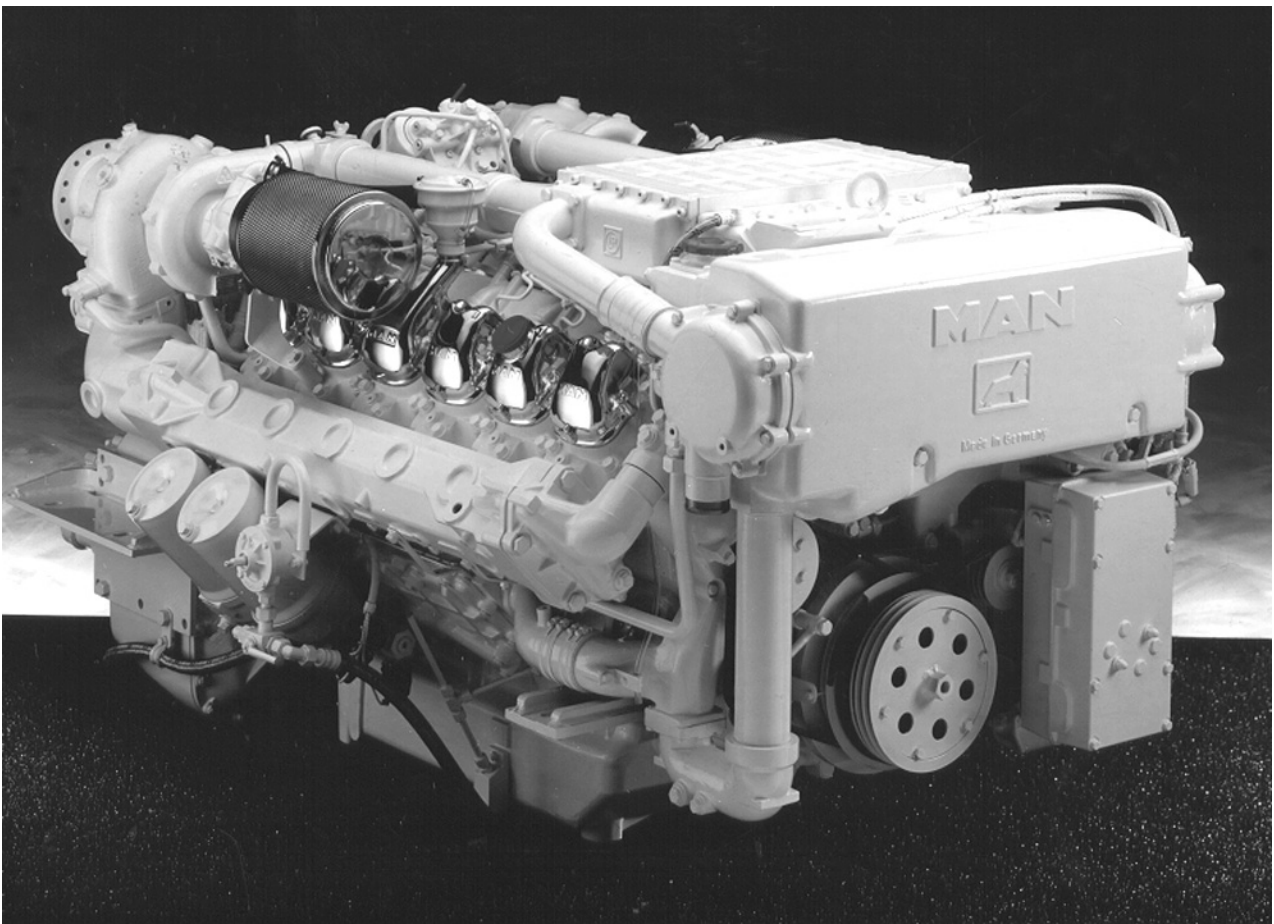
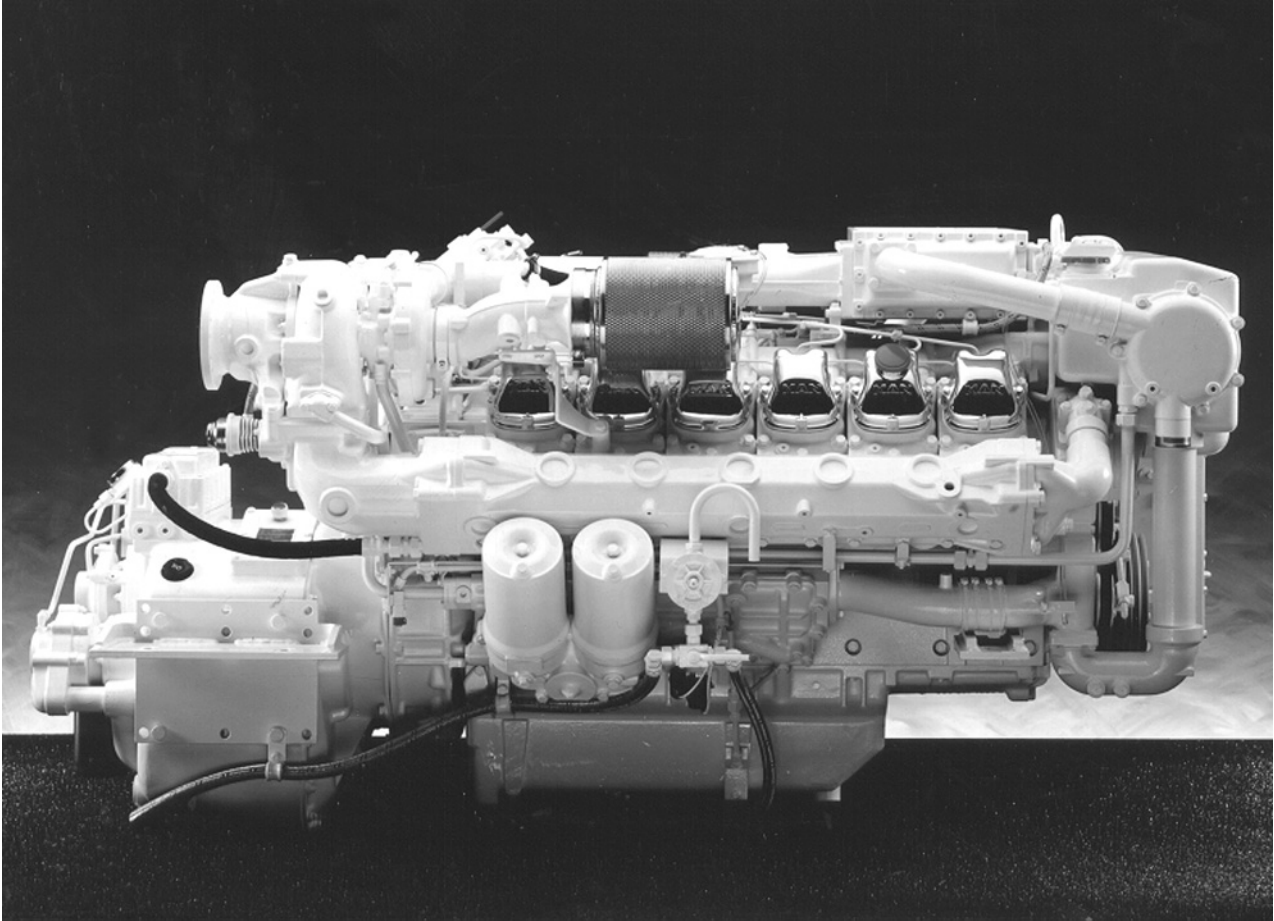


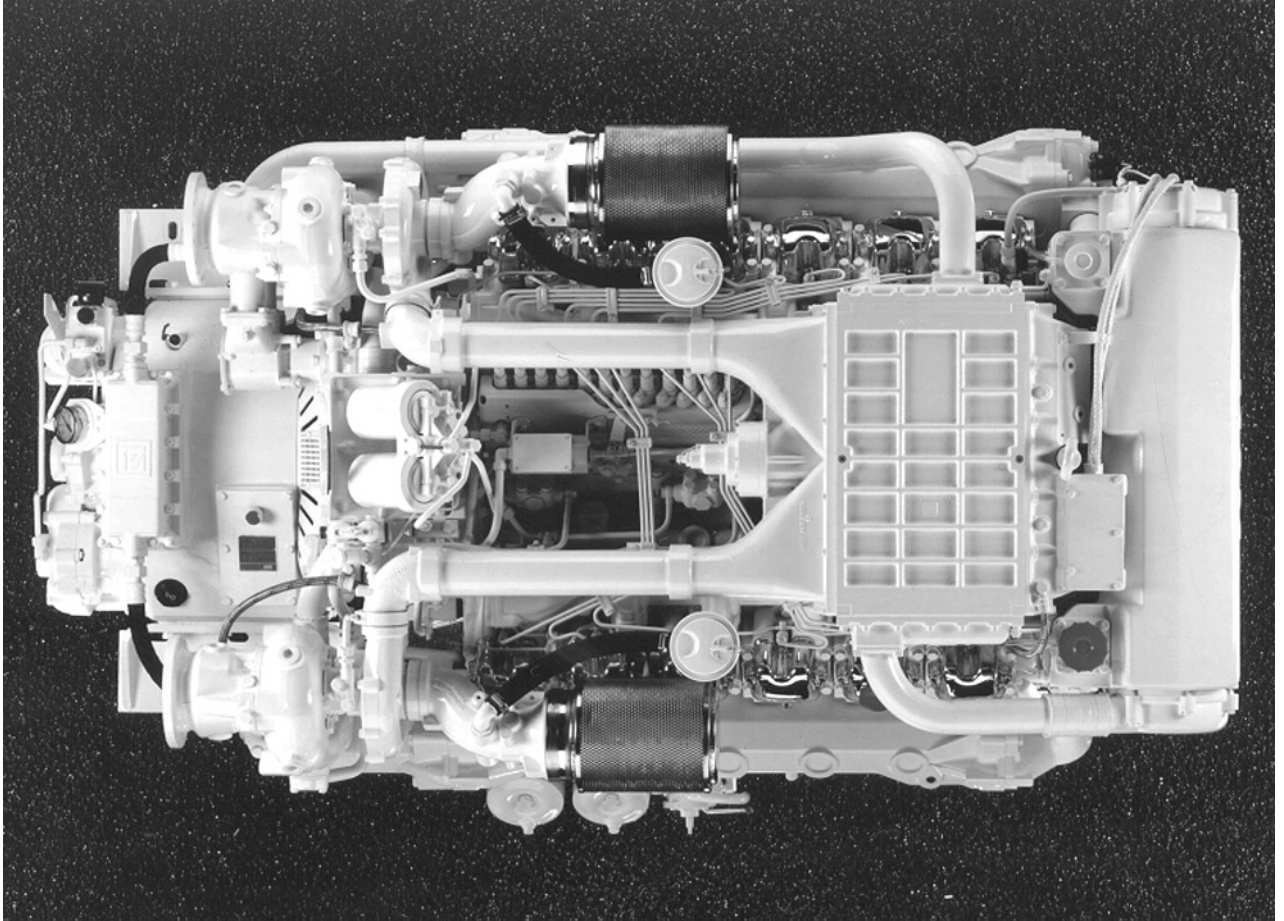


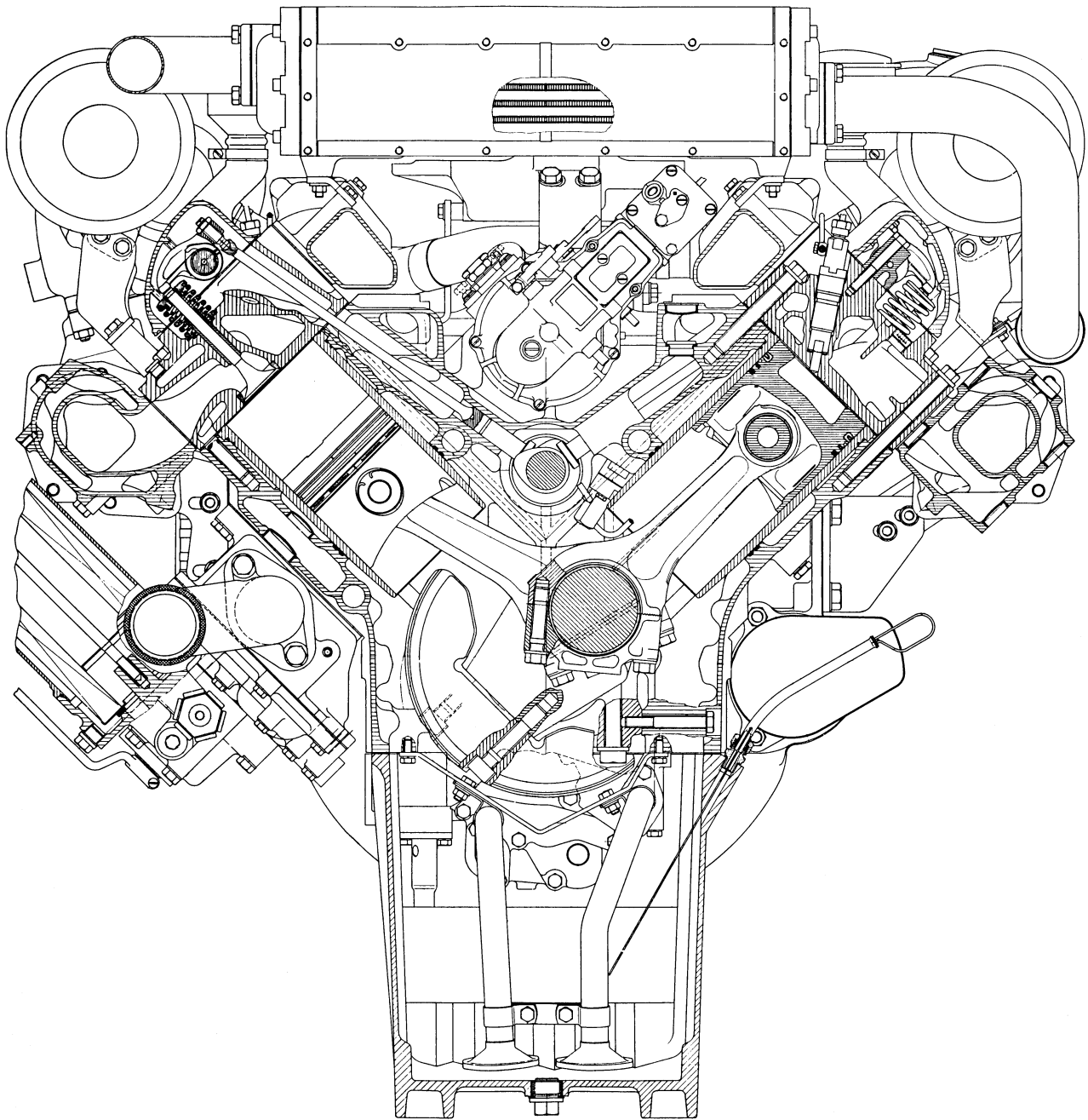


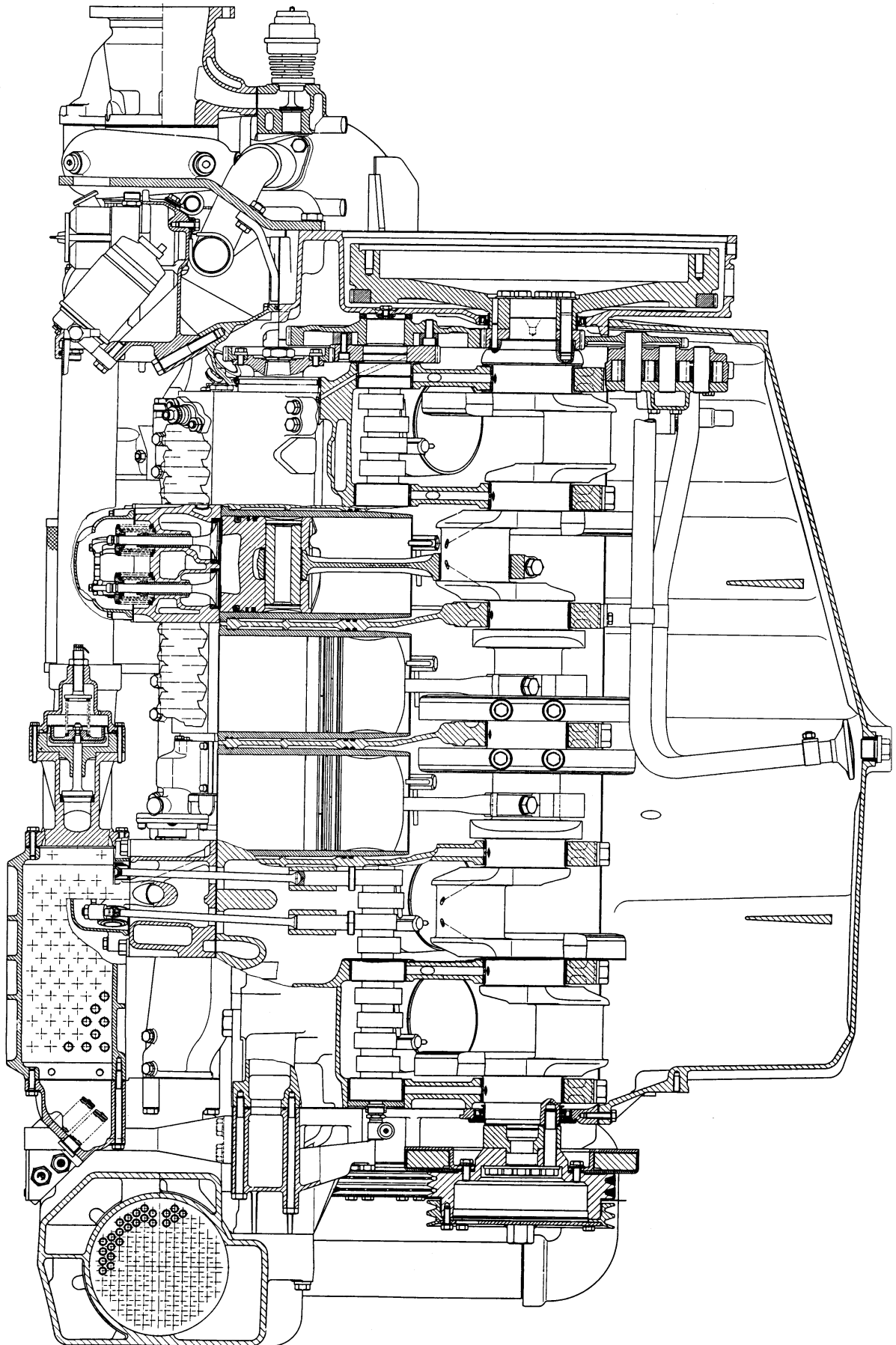


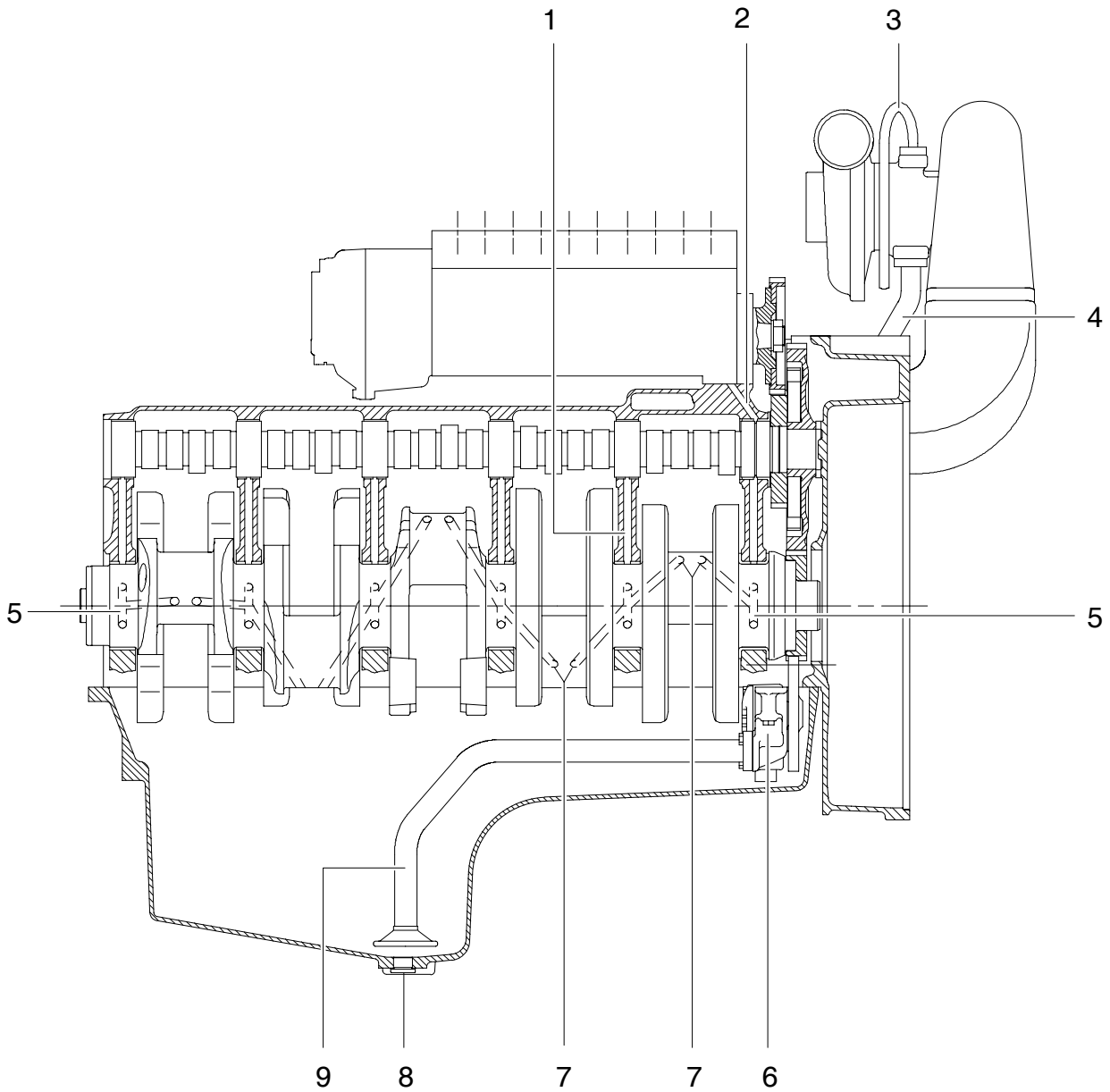




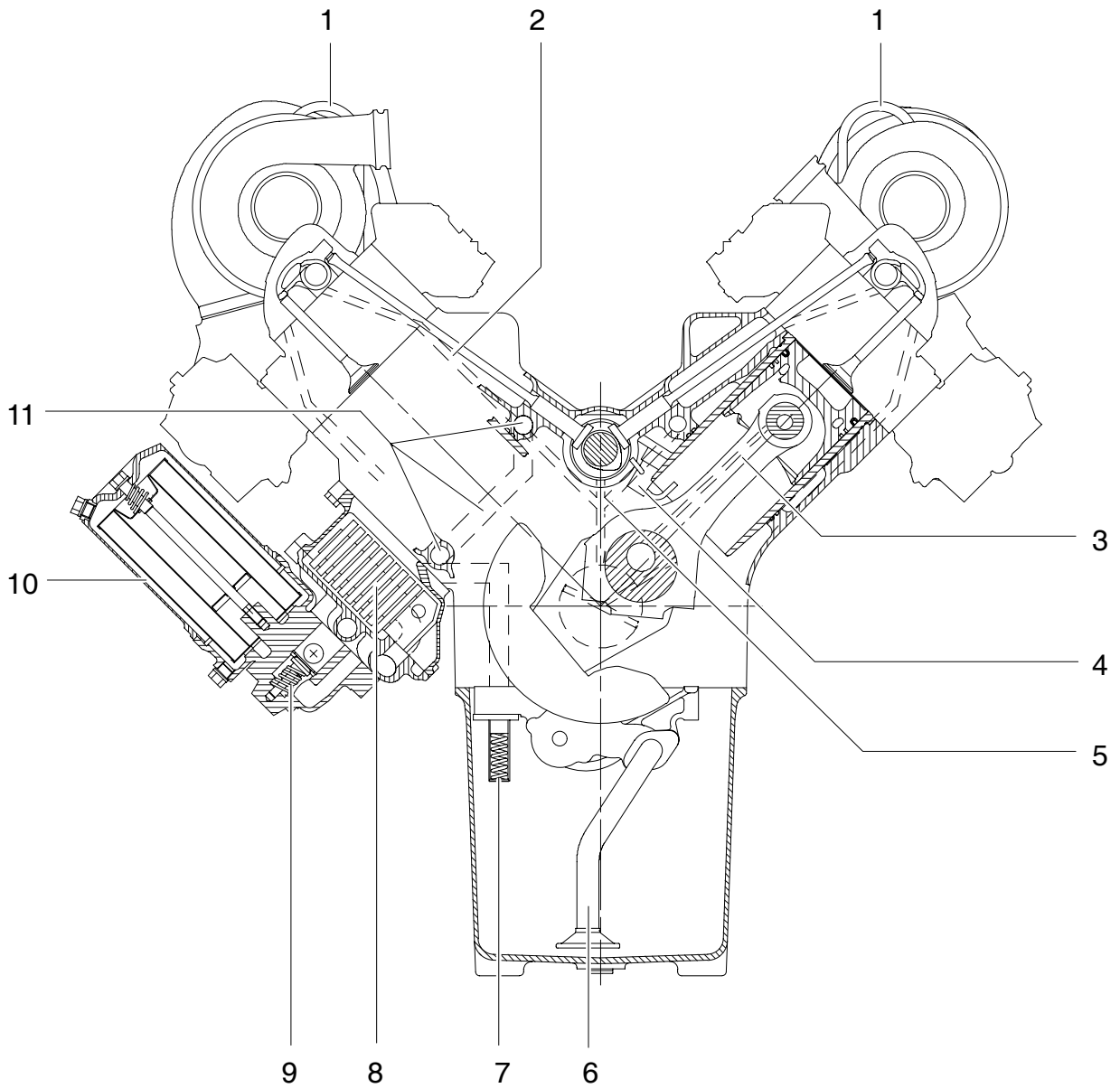








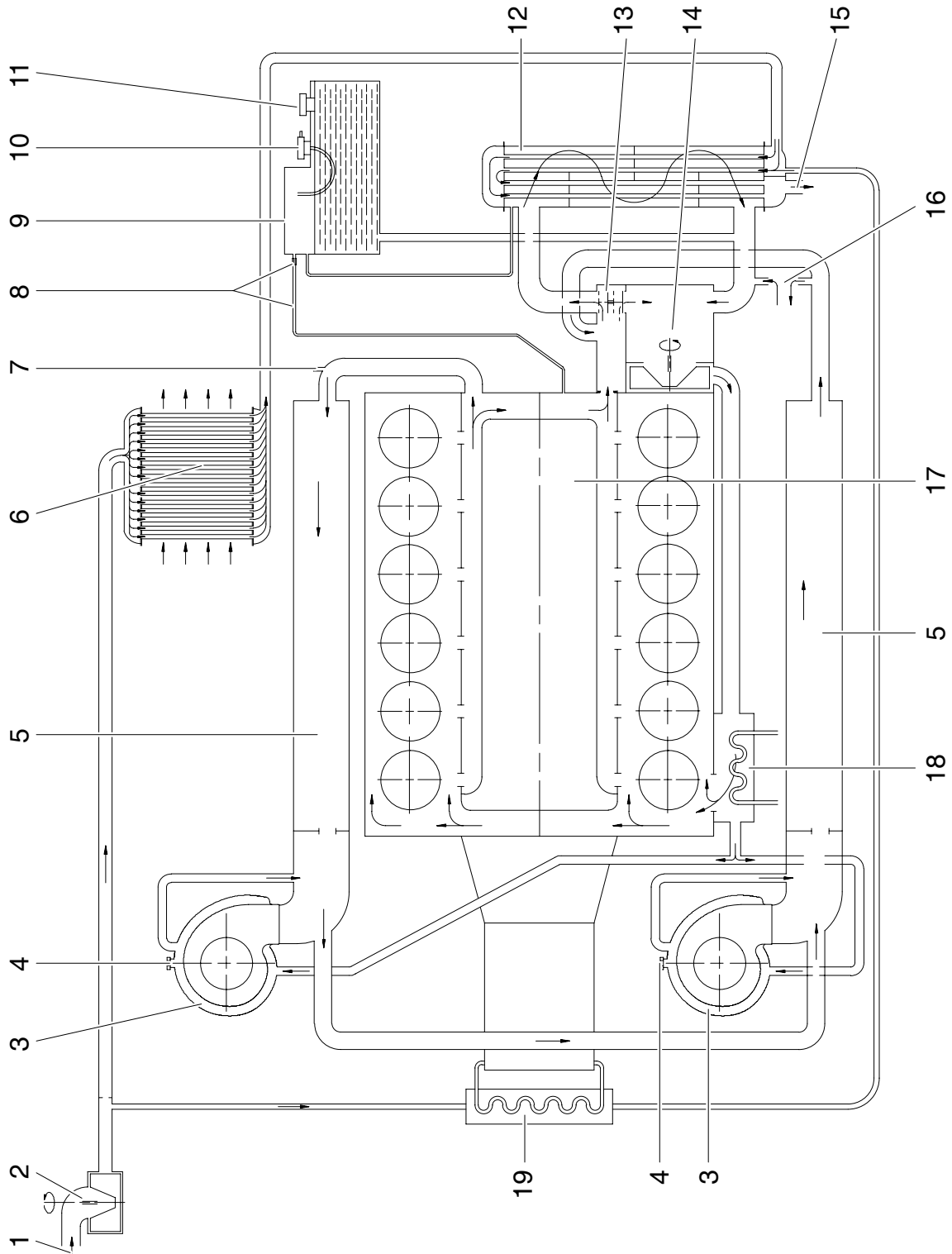
- |                                      |  |
|--------------------------------------|--|
| 1 Oil line to crankshaft             | 5 Bores for main bearing lubrication           |
| 2 Injection pump lubrication         | 6 Oil pump with oil pressure relief valves     |
| 3 Lube oil lines to turbochargers    | 7 Bores for connecting rod bearing lubrication |
| 4 Oil return line from turbochargers | 8 Oil drain plug                               |
|                                      | 9 Oil suction pipe                             |



- 1 Lube oil lines to turbochargers
- 2 Rocker arm lubrication
- 3 Gudgeon pin lubrication
- 4 Spray nozzles for piston cooling and cam lubrication
- 5 Camshaft bearing lubrication

- 6 Oil suction pipe
- 7 Oil pressure relief valve
- 8 Oil cooler
- 9 Bypass valve
- 10 Oil filter
- 11 Oil galleries

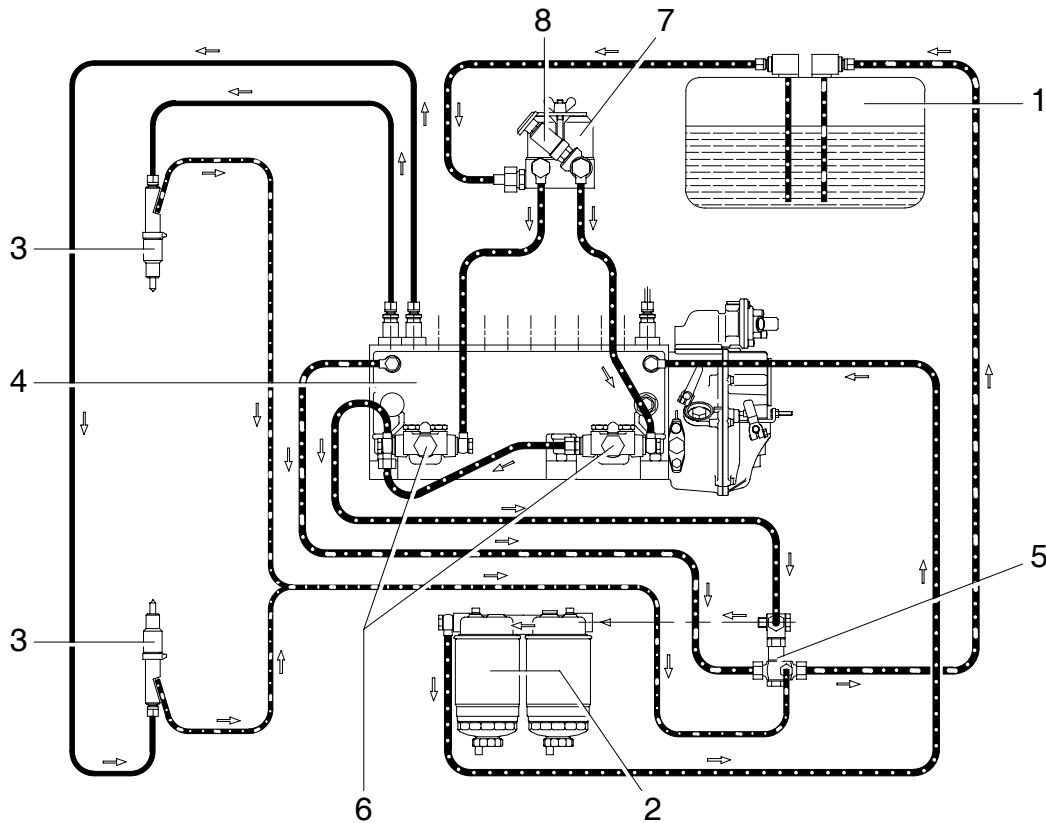
for the D 2842 L.. engine





- 
- 1 Raw water inlet
  - 2 Raw water pump
  - 3 Turbocharger, liquid-cooled
  - 4 Bleeder screw on turbocharger (only for initial filling of coolant or refilling)
  - 5 Exhaust manifold, liquid-cooled
  - 6 Intercooler
  - 7 Coolant temperature measuring point
  - 8 Engine expansion tank bleeder pipe with construction
  - 9 Expansion tank
  - 10 Positive pressure / negative pressure valve
  - 11 Coolant filler neck
  - 12 Heat exchanger, engine coolant / raw-water
  - 13 Thermostat (open)
  - 14 Water pump housing with integrated thermostat housing
  - 15 Raw water outlet
  - 16 Heater feed and return system
  - 17 Crankcase
  - 18 Engine oil cooler
  - 19 Gearbox oil cooler

D 2848 L, D 2840L, D 2842 L

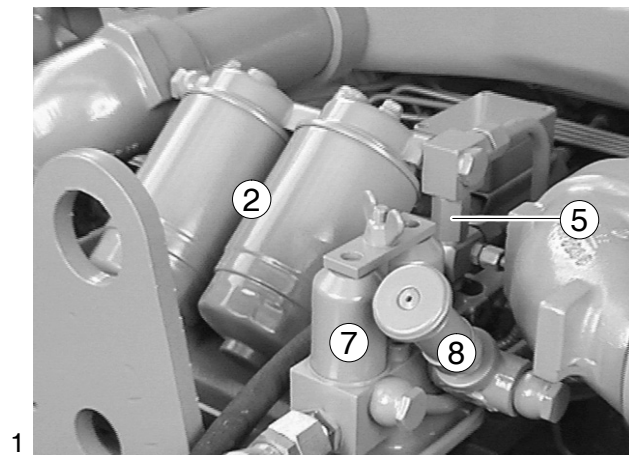


- |                       |  |
|-----------------------|--|
| 1 Fuel tank           | 5 Overflow valve (attached to fuel filter) |
| 2 Fuel filter         | 6 Fuel delivery pumps                      |
| 3 Fuel injector       | 7 Fuel prefilter                           |
| 4 Fuel injection pump | 8 Hand priming pump                        |



**Note:**

For greater clarity, the fuel system diagram shows the fuel filter ②, overflow valve ⑤, fuel prefilter ⑦ and hand priming pump ⑧ as separate components. Fig. no. 1 shows the real arrangement of these components on the engine.

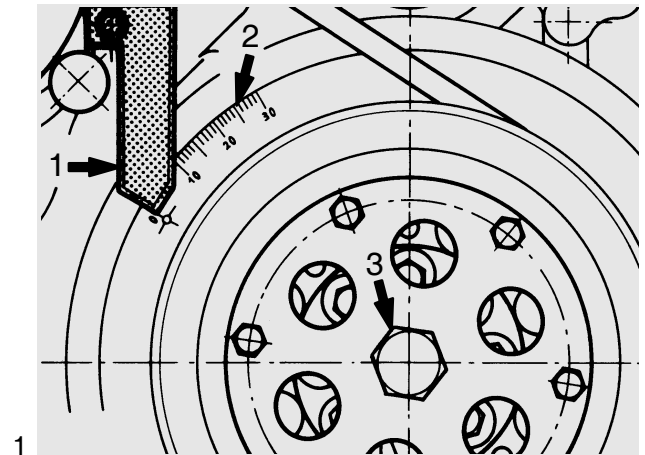


## Checking start of delivery

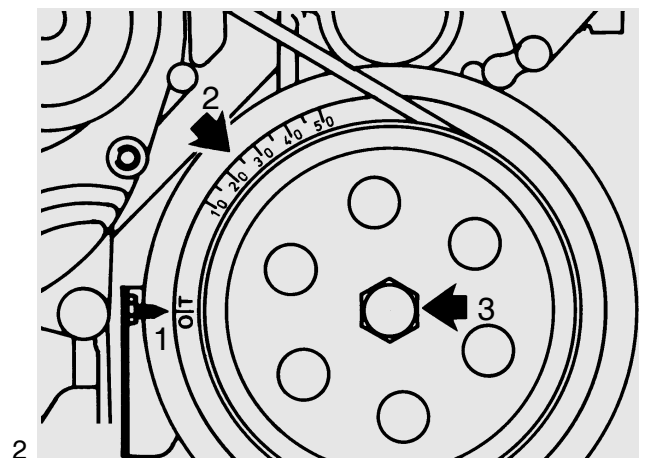
Figs. 1 and 2

For the purpose of checking the start-of-delivery setting, an "OT" (= TDC) mark and a scale from 10 ... 40° or 50° before TDC are engraved on a disc fitted in front of the torsional vibration damper. The scale marks are read against a pointer fitted to the crankcase.

- ① Pointer
- ② "OT" (= TDC) mark and scale
- ③ Hexagon driver to rotate engine by hand  
(Width across flats 32)



1 D 2840 LE 401



2 D 2848 LE 401, D 2842 LE 4..

Figs. 3 and 4

There is another scale engraved on the flywheel which can be read through an inspection hole in the flywheel housing but access may be difficult. The scale should be used for readjusting the pointer after the vibration damper has been removed or replaced.

In other words, before the vibration damper with the scale disc is installed, the engine should be positioned at "OT" (= TDC) by means of the scale on the flywheel.

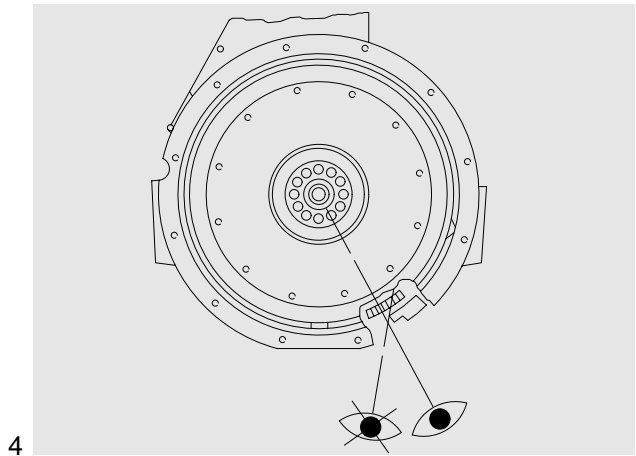
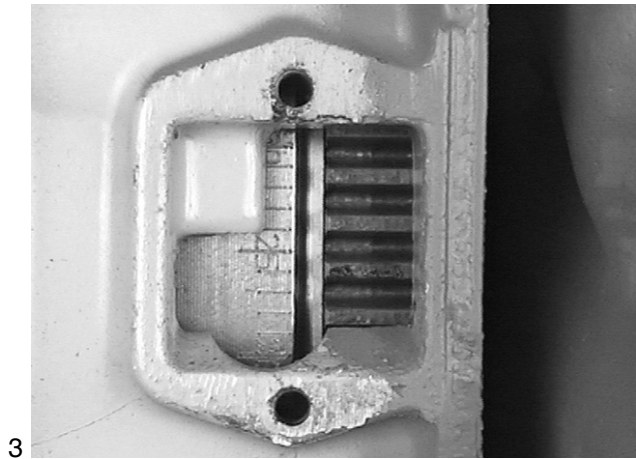


Fig. 5

The pointer should then be aligned such that its measuring edge exactly coincides with the "OT" mark on the scale disc.

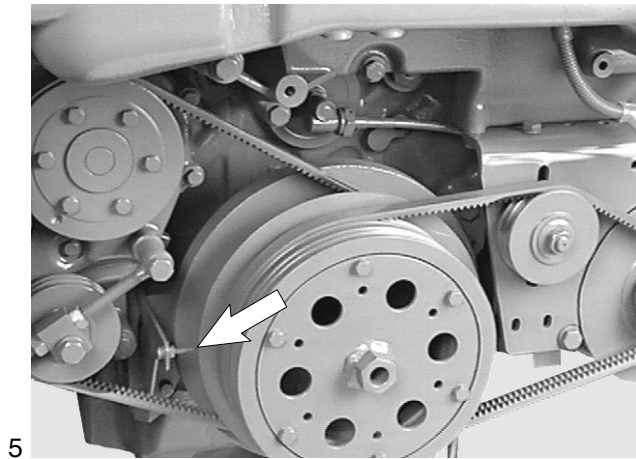


Fig. 6

Remove screw plug ① on governor housing.



**Caution:**

If the injection pump is blocked the camshaft must on no account be loaded or turned because parts of the blocking pin may break off and fall into the governor.

**Non-compliance with this may result in severe damage to the injection pump.**

If fitted, take out blocking pin ②.

If the pointer is exactly in the centre of the inspection hole, the pump plunger for cylinder no. 1 is at start of delivery. However, it is possible to determine exactly whether or not the pump is at start of delivery only by means of the following special tools:

**a. Light signal transmitter**

Fig. 7

Push light signal transmitter into socket in governor housing. Ensure that the lug ③ fits in the groove ④. Tighten the knurled nut ⑤ by hand.

Fig. 8

Turn engine by hand so that piston in cylinder no. 1 in the compression stroke comes close to the start of delivery.

Lamp (A) comes on shortly before start of delivery is reached.

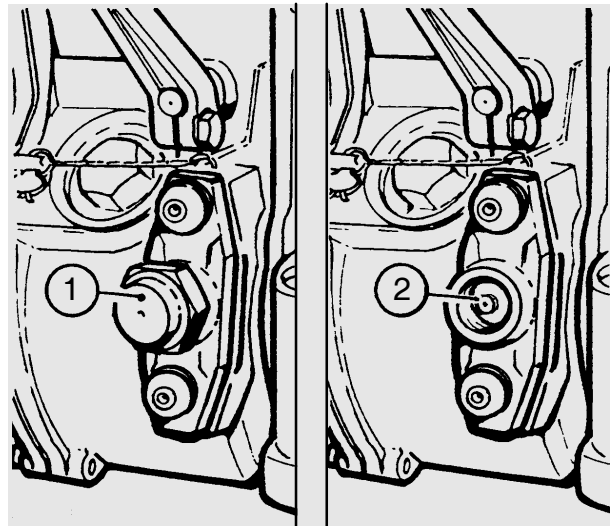
Slowly turn the engine further until lamp (B) comes on too. The injection pump is now at start of delivery.



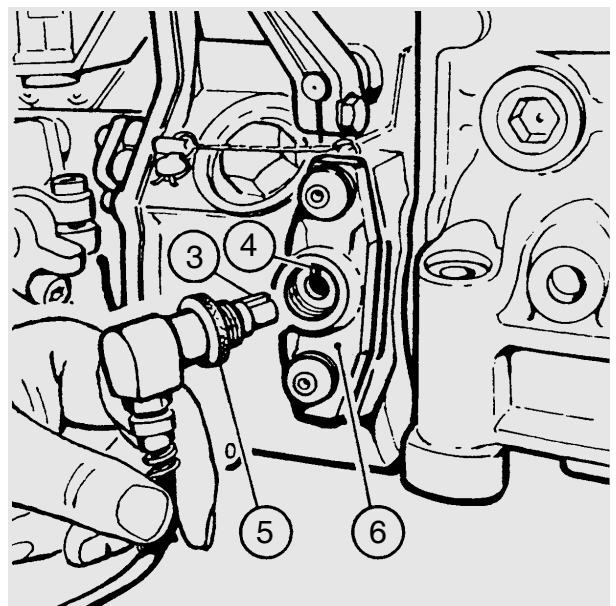
**Note:**

If only lamp (B) comes on during this test, the engine has been turned past the start of delivery. In this case turn the engine back and repeat the procedure.

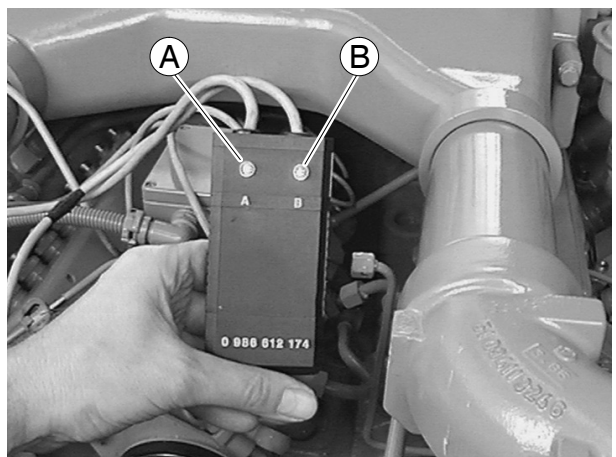
The picture shows the light signal transmitter KDEP 1601, which is energised by its own power supply.



6



7



8

### b. Sleeve

Fig. 9

If a light signal transmitter is not available, good measurement results can also be achieved with a plug-in sleeve.

The sleeve is to be made of aluminium or steel

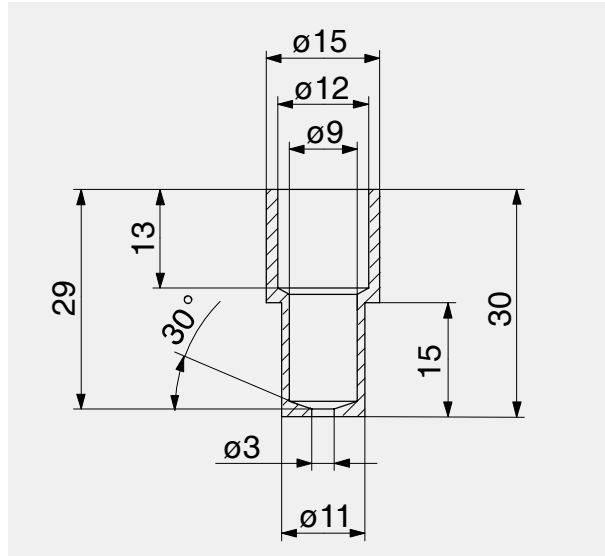
Set engine to start of delivery as described above.  
Insert the sleeve into the governor housing up to the stop.

The start of delivery is set exactly when the pointer for start of delivery is in the centre of the 3 mm bore in the sleeve.



**Note:**

The plug-in sleeve can be inserted only after the intercooler has been removed because only then will the governor housing be accessible for the visual inspection described above.

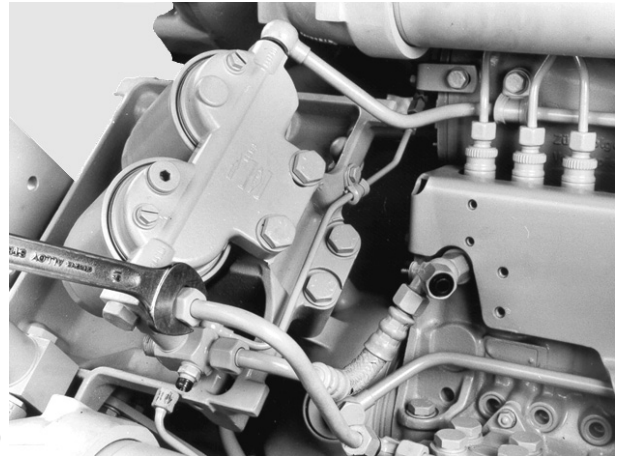


## Adjusting start of delivery

If the check according to method a) or b) should prove that the delivery start is not correct, proceed as follows:

Fig. 10

To adjust the start of delivery, the injection pump drive must be made accessible. For this purpose the fuel filter is to be removed (only in engine models with box filters). Drain fuel from the filter cartridges, loosen all fuel lines and completely remove filter with collector pan.



10

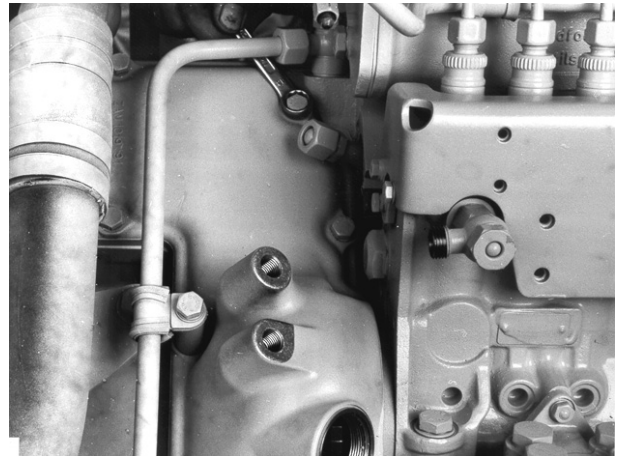
Fig. 11

Remove timing case cover.



**Note:**

Pipelines are attached to the timing case cover. To facilitate reassembly, memorise or make a drawing or photograph of the positions of holders, pipe clamps, spacer sleeves etc.



11

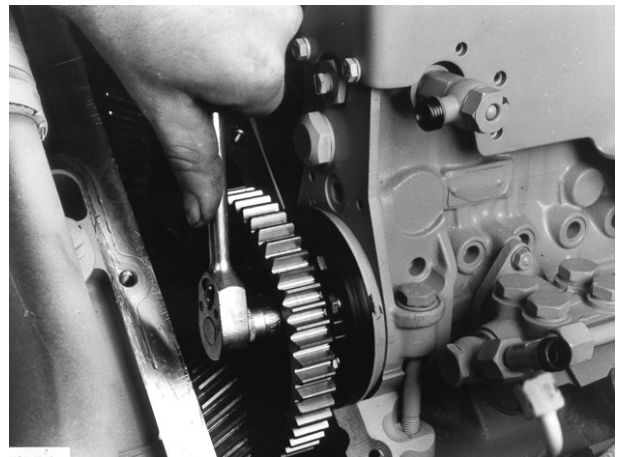
Loosen all bolts fastening the drive gear to the injection pump hub. For this, two complete turns of the engine are necessary.

Fig. 12

Turn engine to specified angle for delivery start. Remove screw plug from governor housing. The delivery start pointer must be visible in the centre of the inspection hole.

Turn the injection pump camshaft on the drive flange to the left or right until the conditions mentioned under a) or b) apply.

Tighten bolts for fastening drive gear to drive flange consecutively to 5 Nm and then to 38 Nm.



12



**Note:**

Use only M8x22 mounting bolts (property class 12.9).

Check delivery start once again.  
Close governor housing.

### Fuel injection pump in general

Fig. 1

Bosch in-line injection pump for a 10-cylinder engine with attached cut-off solenoid ① and speed adjustment device ②. The speed adjustment device is connected with the variable-speed lever on the governor and facilitates the connection of a Bowden cable.

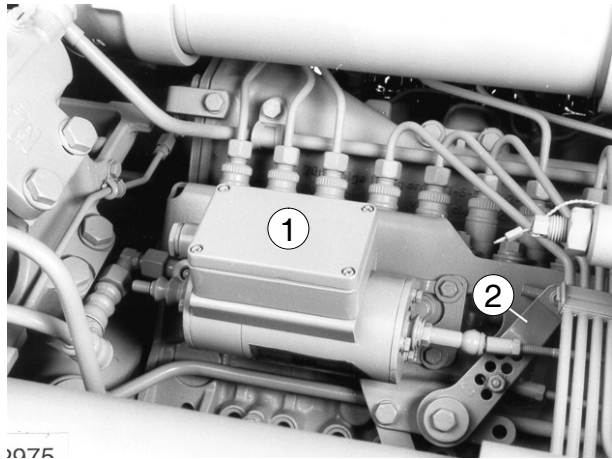
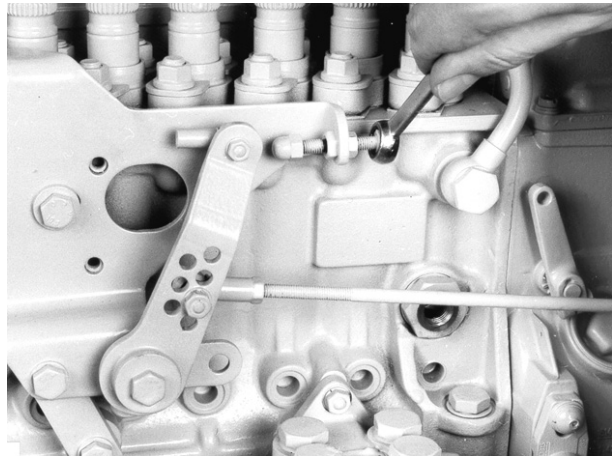


Fig. 2

The speed adjustment device is used to set the engine's lower idle speed. For this purpose loosen lock nut on the adjusting screw and turn adjusting screw (10 mm).

- To increase idle speed:  
Turn screw clockwise
- To decrease idle speed:  
Turn screw anticlockwise





## Removing injection pump

- Shut shut-off valve from tank to engine.

Fig. 1

The subsequent reinstallation of the injection pump is rendered considerably easier if before its removal the engine has been turned to start of delivery.

Start of delivery of individual engines is indicated in the publication "Engineering • Data • Setting values".

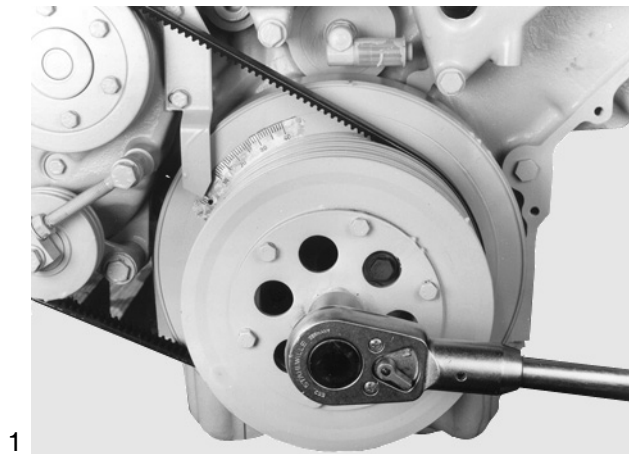


Fig. 2

To remove the injection pump, the fuel filter is to be detached (only in engine models with box filters). Drain fuel from fuel cartridges, remove all fuel lines and remove filters complete with collector pan.

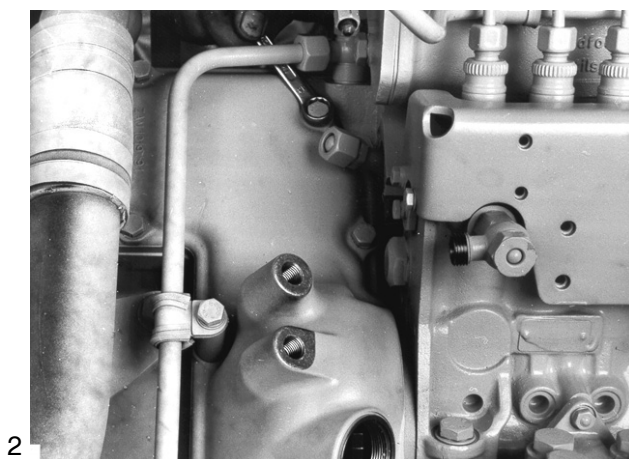


Fig. 3

Remove timing case cover.  
The injection pump drive can now be seen.

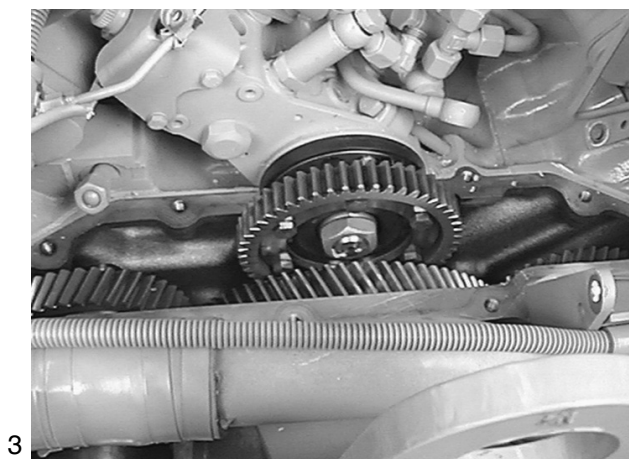


Fig. 4

Measure and note down distance between injection pump and crankcase.  
Maintaining this distance in the assembly later on ensures that the oil supply bore of the injection pump will remain clear.

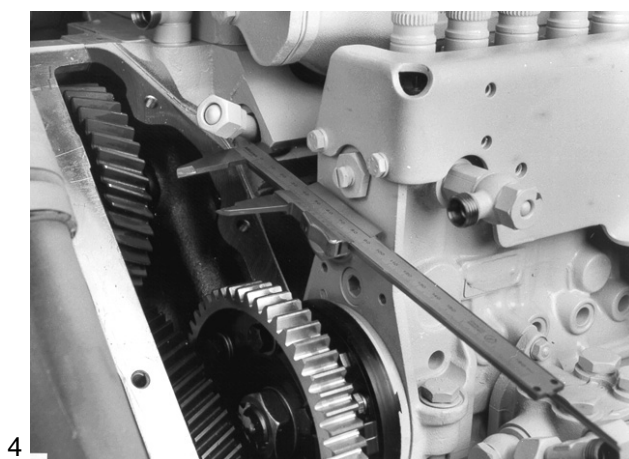


Fig. 5

Remove charge-air pipe of the left-hand cylinder bank.  
Remove injection lines. Disconnect all fuel, oil and air (aneroid device) pipes from injection pump.

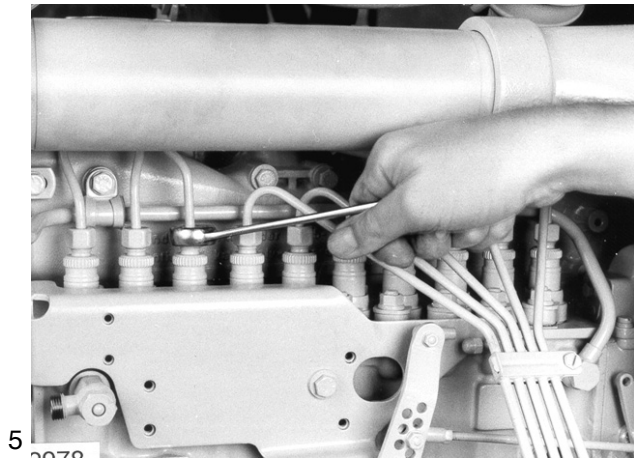


Fig. 6

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.



**Caution:**

Dirt in the injection system causes:

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

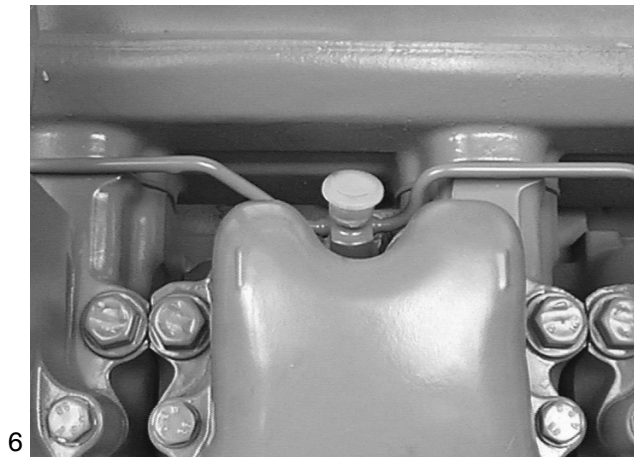


Fig. 7

**D 2848 L.. only:**

In 8-cylinder engines the injection pump can be removed only if the intercooler is taken off first.

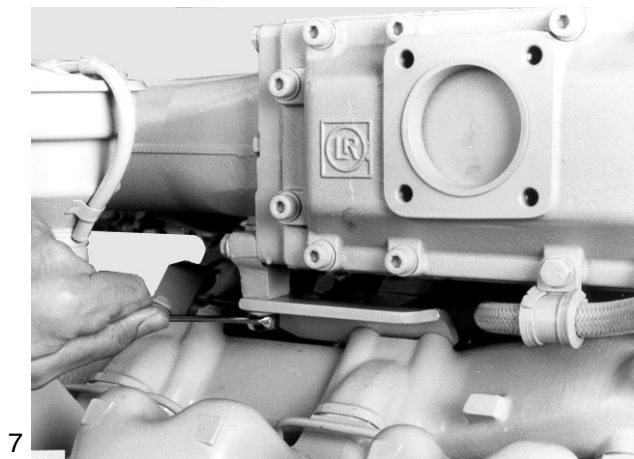


Fig. 8

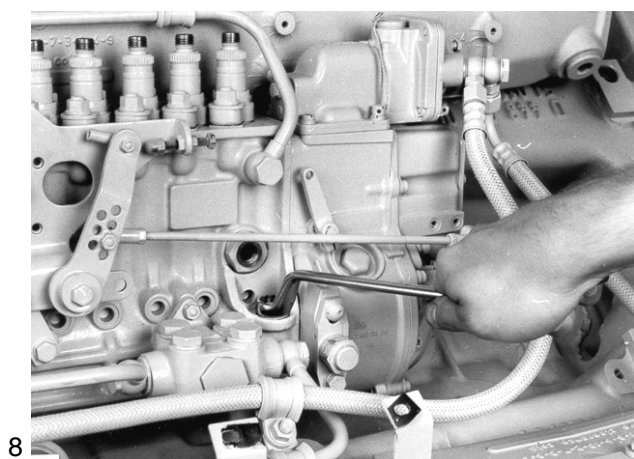
Remove mounting bolts from injection pump (17 mm).



**Note:**

For reasons of space the mounting bolts between the injection pump and the left-hand cylinder bank can be reached only with a 3/8" socket spanner with extension.

Take off injection pump.



## Installing injection pump

Fig. 9

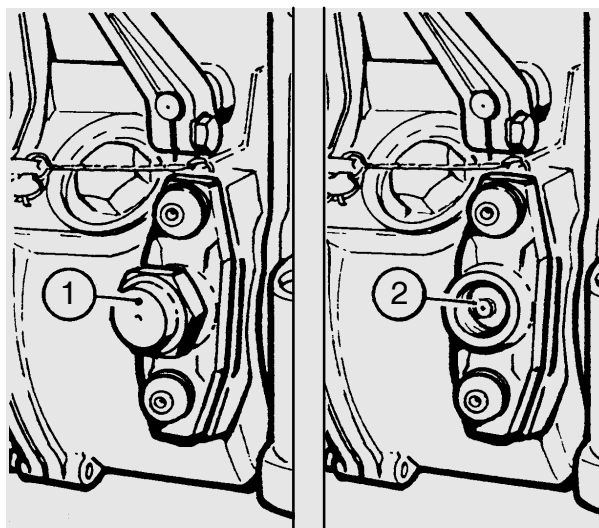


**Caution:**

If the injection pump is blocked the camshaft must on no account be loaded or turned because parts of the blocking pin may break off and fall into the governor.

**Non-compliance with this may result in severe damage to the injection pump.**

Remove screw plug ① from governor housing. Take out blocking pin ② if fitted.

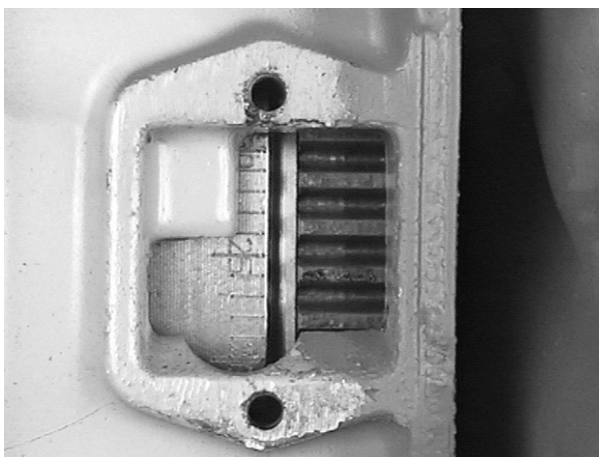


9

Fig. 10

Check whether the engine is set to start of delivery.

Start of delivery of individual engines is indicated in the publication "Engineering • Data • Setting values".



10

Fig. 11

Check whether the injection pump is in delivery start position. To do this, remove the screw plug from the governor housing (see Fig. 7). The delivery start pointer must be visible in the centre of the inspection hole.

Remove the mounting bolts from the injection pump drive gear (13 mm) so that it can be turned in the slots.

Hold injection pump camshaft in place while turning the gear (41 mm).

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



11

Fig. 12

Fit injection pump in such a way that the mounting bolts can be screwed in by hand. Check distance between injection pump and crankcase.

12

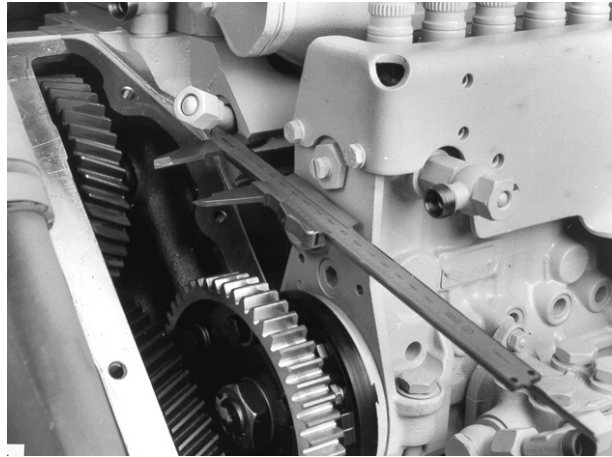


Fig. 13

Tighten mounting bolts to specified torque (see "Engineering • Data • Setting values")

13

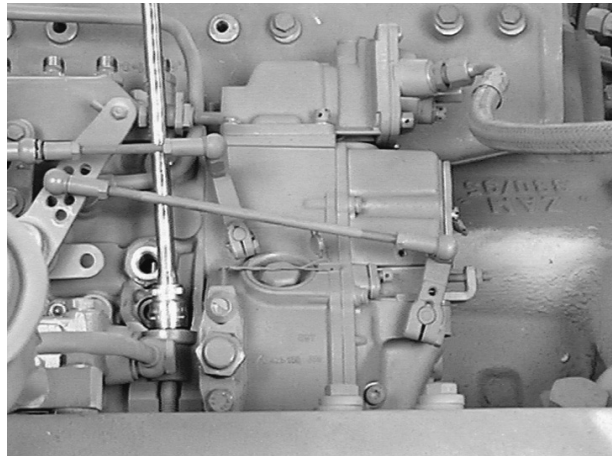


Fig. 14

Tighten bolts for fastening drive gear to drive flange consecutively to 5 Nm and then to 38 Nm.



**Note:**

Use only M8x22 mounting bolts (property class 12.9).

For this, two complete turns of the engine are necessary.

14

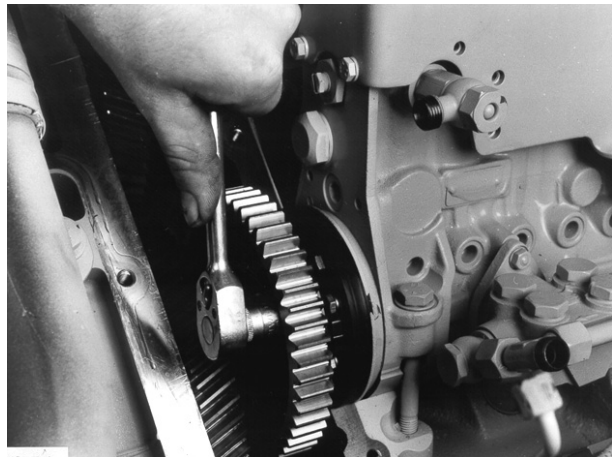


Fig. 15

Check and, if necessary, adjust delivery start, see page 33).

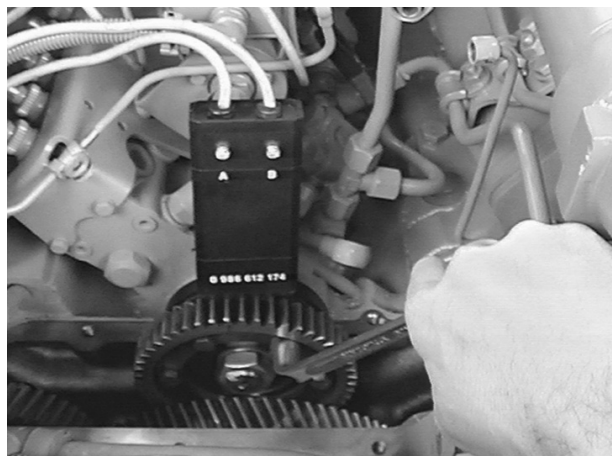
Close governor housing and fit timing case cover.



**Caution:**

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

15



## Removing fuel injectors

Fig. 1

Remove injection lines and leakage fuel return lines.

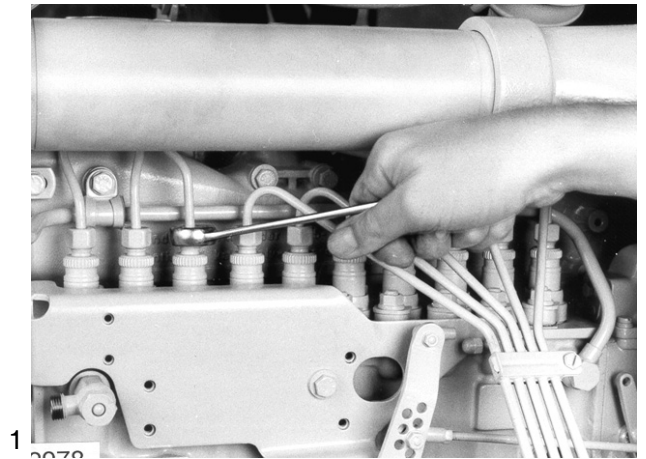


Fig. 2

Remove pressure screw from fuel injector using a pin spanner.



Fig. 3

Bolt inertia puller on to fuel injector and knock out the injector.  
Take out injector seal.  
Check and repair injector.

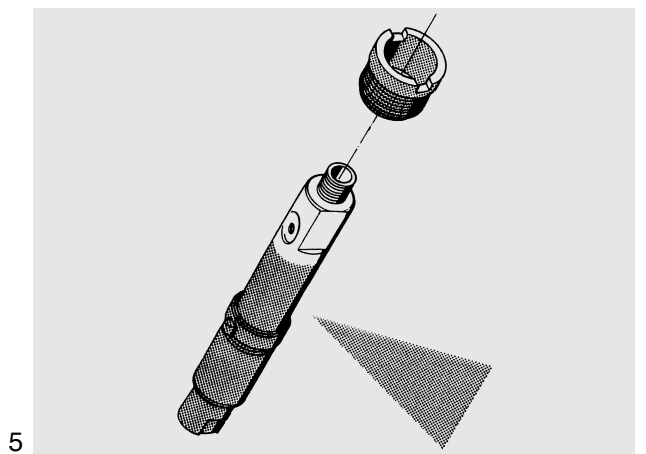


## Installing fuel injectors

Fig. 4

Apply "Never Seeze" to contact areas of injector.  
Screw in injector with new seal. Screw on union nut and tighten to specified torque.

Connect up injection lines and leakage fuel return lines.



## 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.

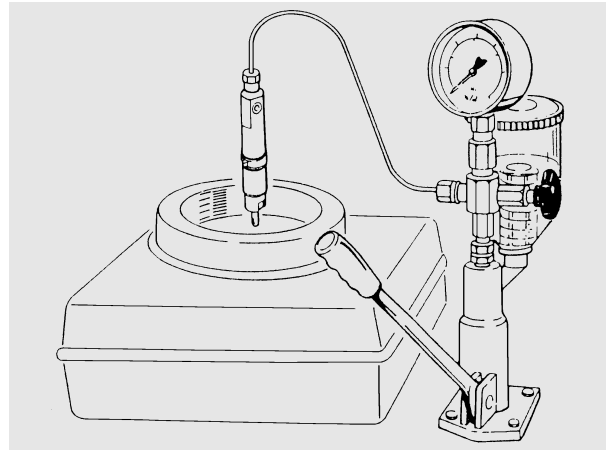


Fig. 2

Check injector assembly.

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



**Caution:**

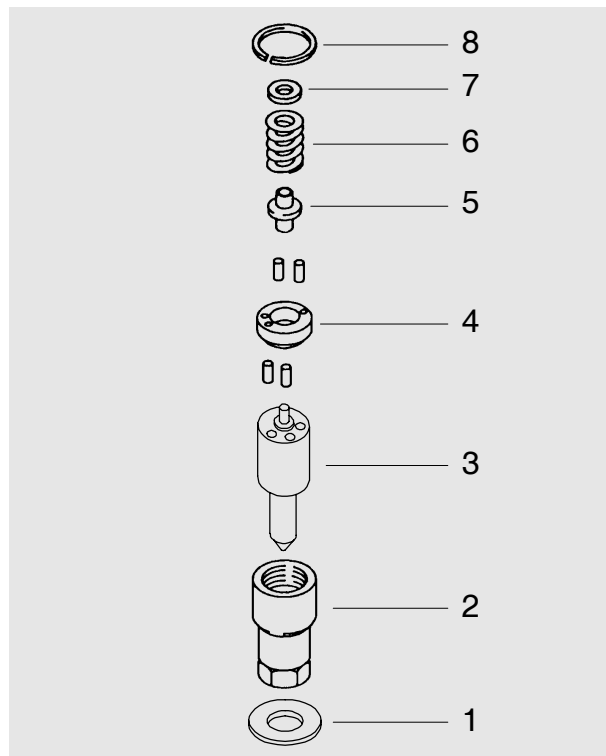
The high opening pressure may lead to severe injuries. Do not place hands under the jet. Wear safety goggles.

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).

1



2



**Note:**

Shims are available in 0.02 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.

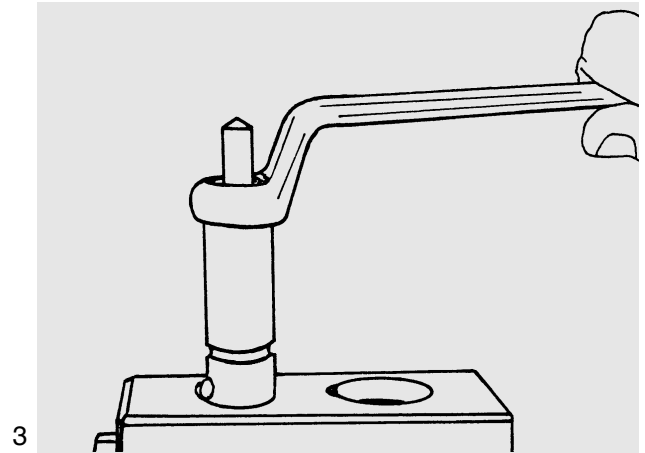
Nozzles that satisfy these three requirements can be reused.

- 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.



## Repairing fuel injectors

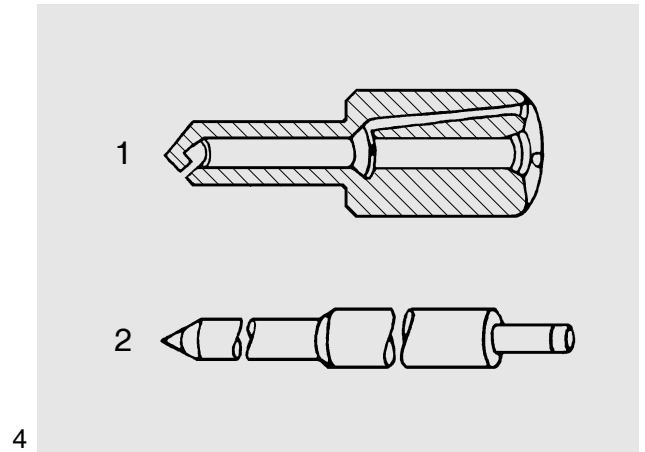
Fig. 4

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.



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.

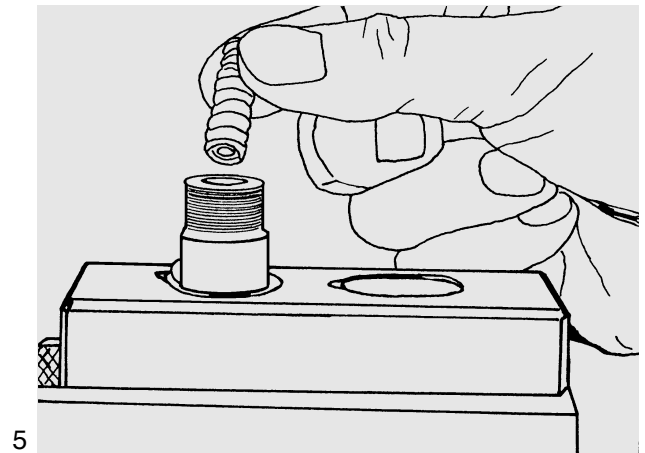


Fig. 6

Insert pressure pin and intermediate washer.

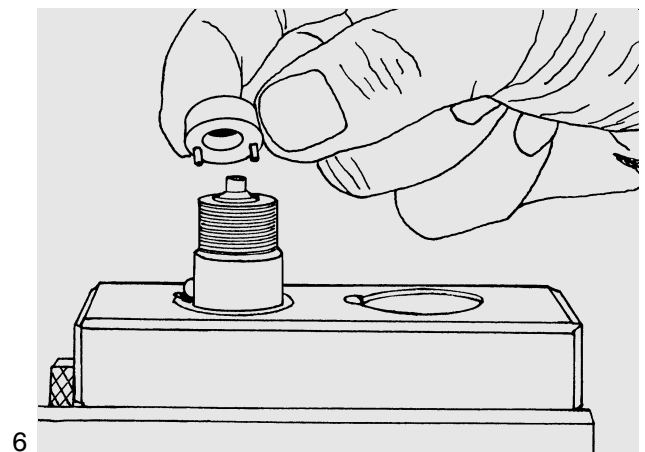


Fig. 7

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

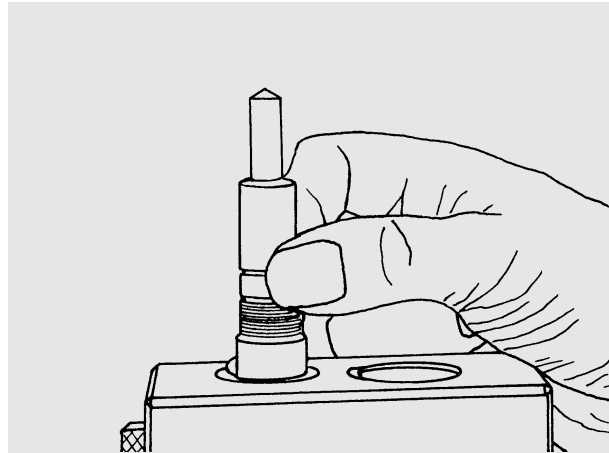
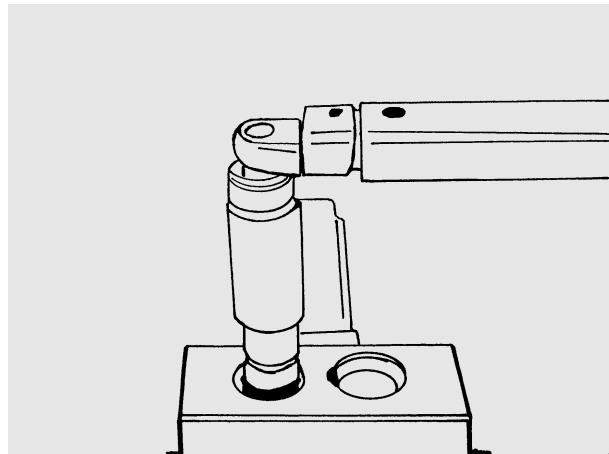


Fig. 8

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

8



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

Fig. 9

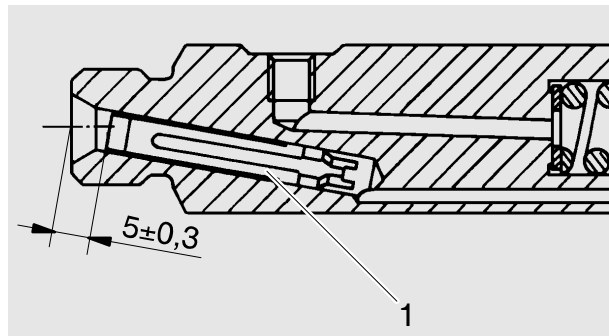
A dislocated sieve bar filter throttles and prolongs the injection and consequently causes poor performance, high consumption and heavy smoke formation in conjunction with heavy engine vibrations.

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





Figs. 1 and 2

Disassemble fuel prefilter.

- Loosen wing nut ① and take off bracket ②
- Wash out filter housing ③ and gauze filter ④ in clean Diesel fuel and blow them out with compressed air
- Reassemble using new seal

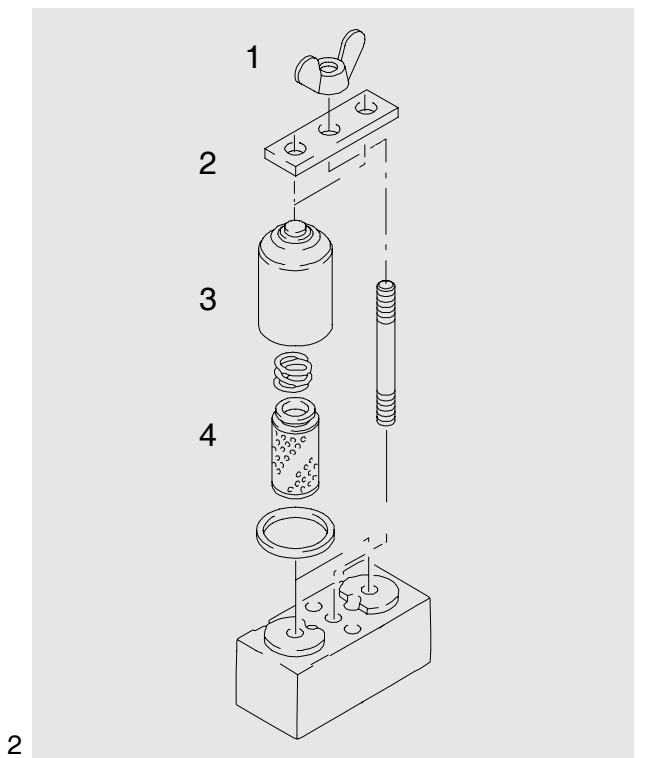
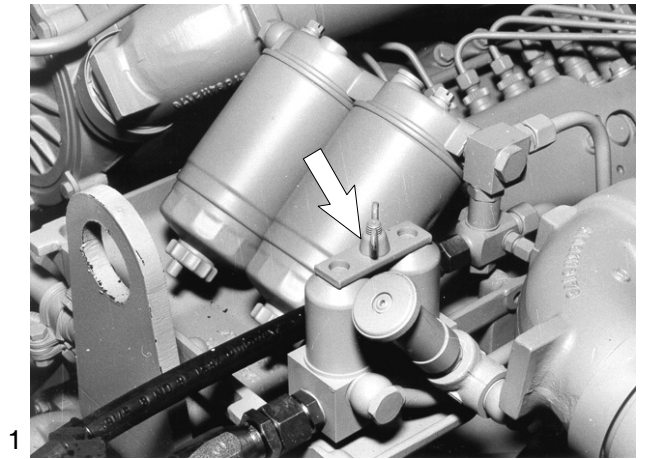


Fig. 3

- Actuate plunger of hand priming pump until the overflow valve of the injection pump opens audibly
- Start engine
- Check fuel prefilter for leaks

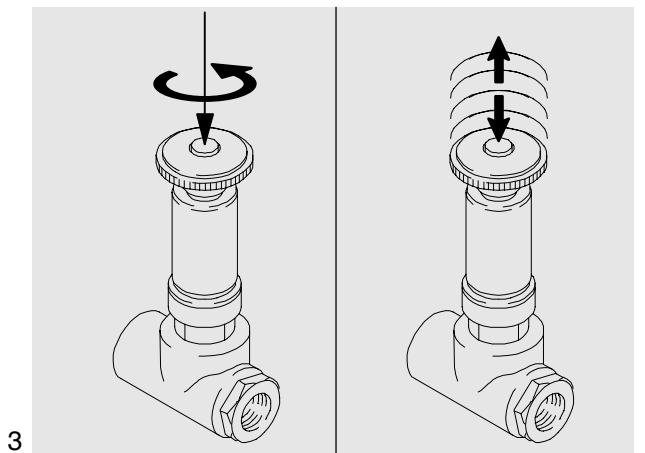


Fig. 1

Open drain screw by approx 1/2 a turn and let condensation drain out of the water separator.  
Remove drain screws completely.  
Let fuel drain into container.

- 1 Disposable filter
- 2 Screw plug
- 3 Bleed screw

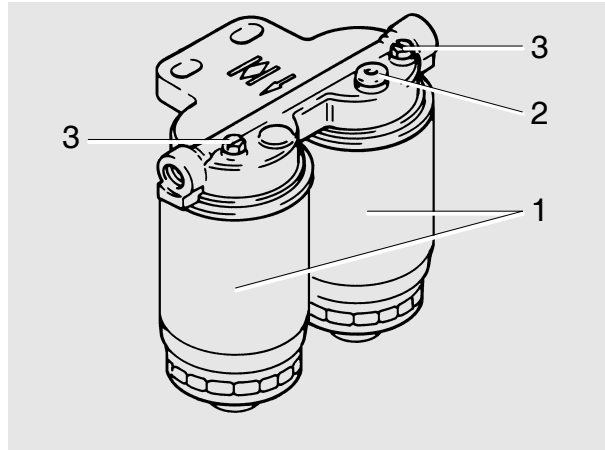
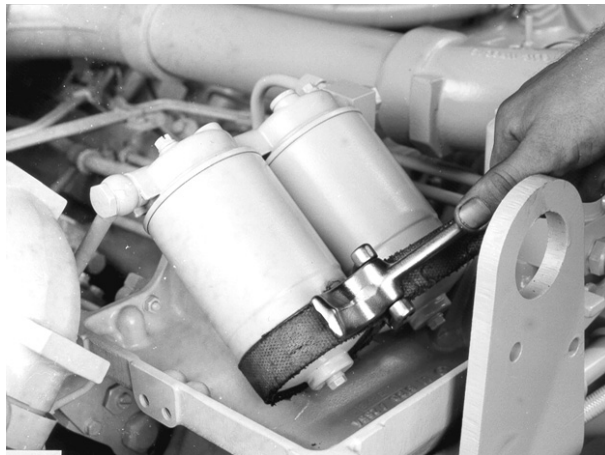


Fig. 2

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.

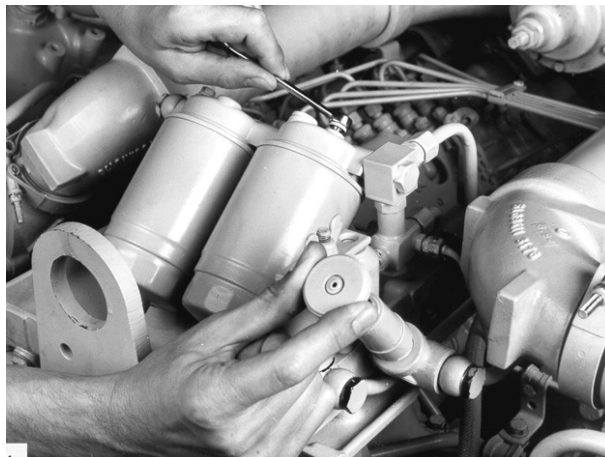


### Bleeding fuel system

Fig. 3

Open bleed screws and actuate hand priming pump until bubble-free fuel emerges.  
Close bleed screws.

Check system for leaks.



## Draining coolant

Drain coolant as follows when the engine is cold:

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

Fig. 1

Remove cap from filler neck on the coolant expansion tank. Open drain plugs.

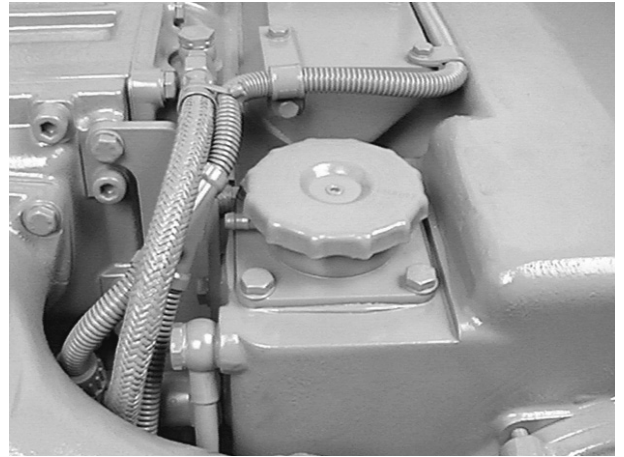


Fig. 2

Drain plug in exhaust manifold.

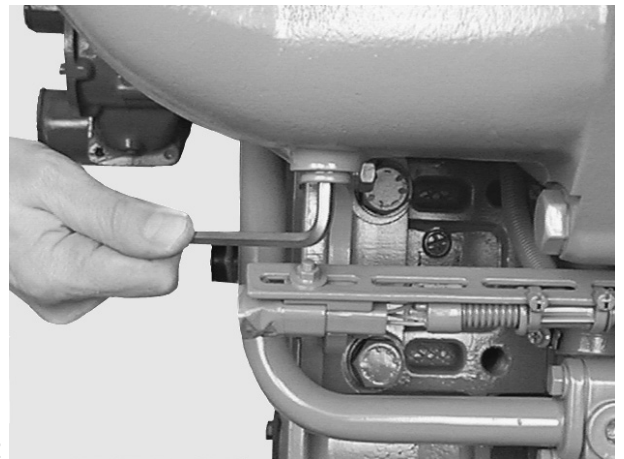


Fig. 3

Drain plug in oil cooler housing.

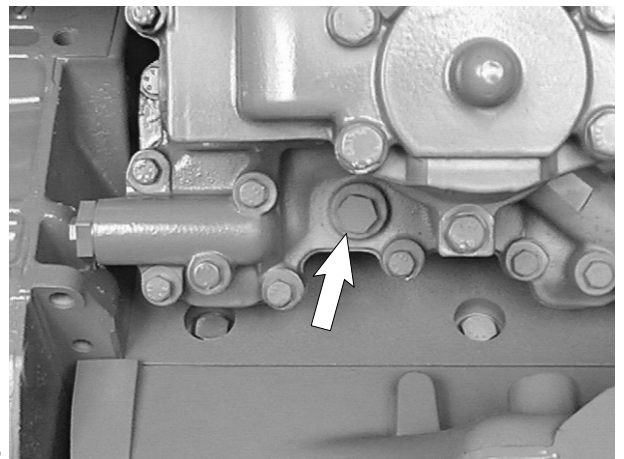
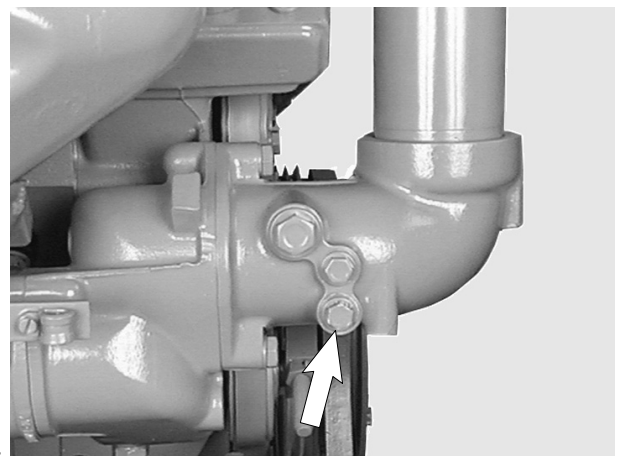


Fig. 4

Drain plug in coolant manifold (arrow).  
Drain coolant into containers of sufficient size.  
Screw in drain plugs again.



### Filling up with coolant

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".

Figs. 5 and 6

- Remove cap (large cap)
- Fill in the coolant slowly
- During refilling bleeding of liquid-cooled turbochargers is required. To do so, open bleeder screw ① in oval flange on back of turbine housing until coolant flows out bubble-free
- Run the engine briefly and then check coolant level once more

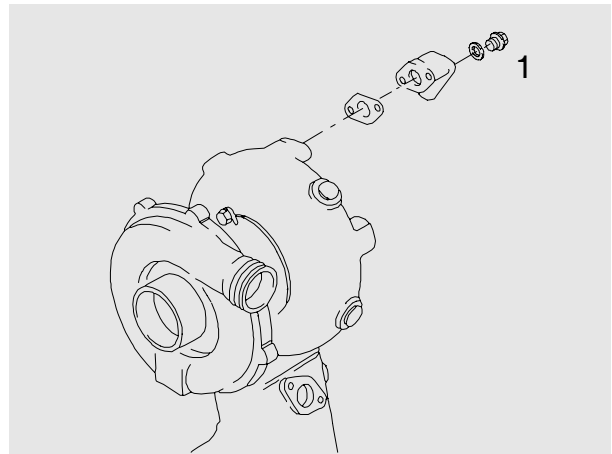


**Note:**

It is not necessary to bleed the turbochargers when the cooling system is being topped up.



5



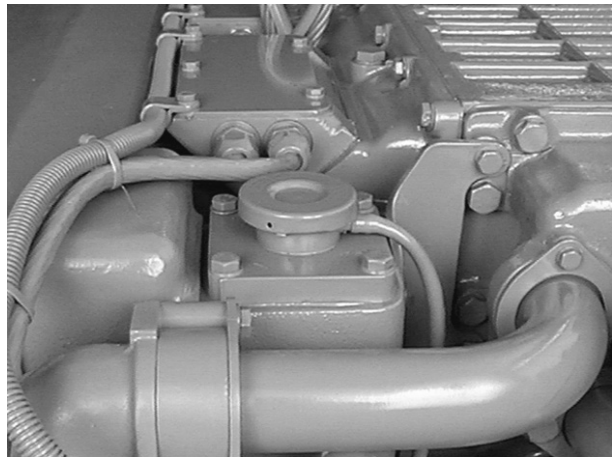
6

Fig. 7



**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.



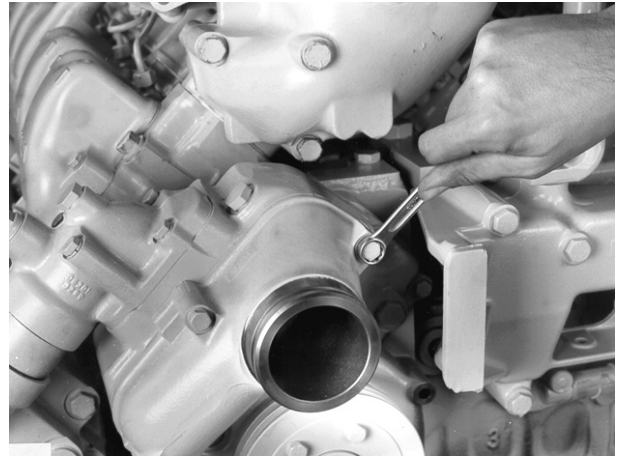
7

## Removing thermostats

- Drain coolant, see page 49
- Remove heat exchanger, see page 60

Fig. 1

Remove cooling water neck (13 mm).  
Take out thermostat.



## Checking thermostats

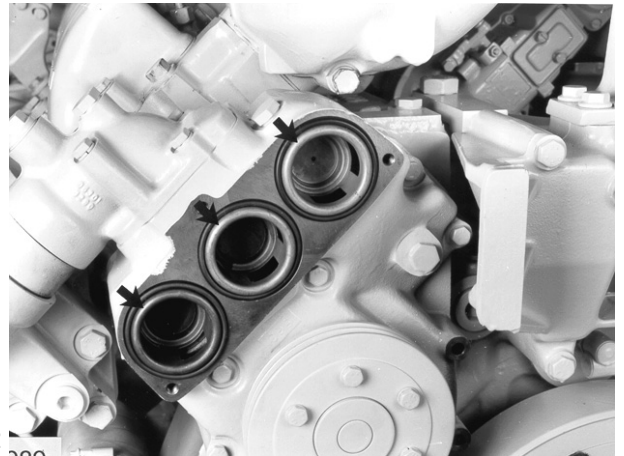
Check the function of the thermostats as follows.

- 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.

Fig. 2

Engines with remote thermostats have short-circuit elements (arrows) instead of thermostats in the water pump.



## Removing water pump

Fig. 3

- Take off V-belts, see page 151

Remove mounting bolts from water pump (13 mm) and take off water pump.



## Installing water pump

Fig. 4

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.

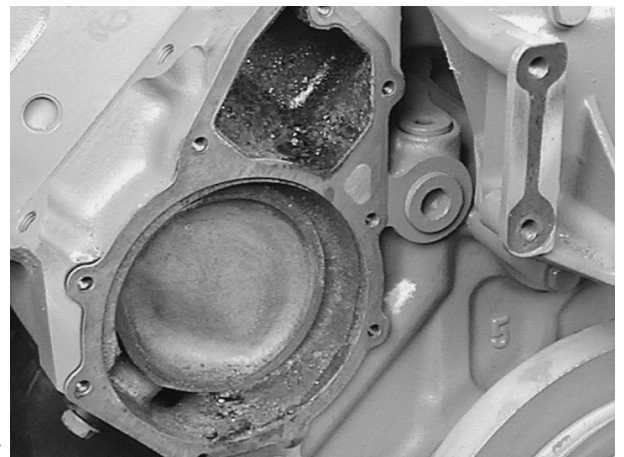
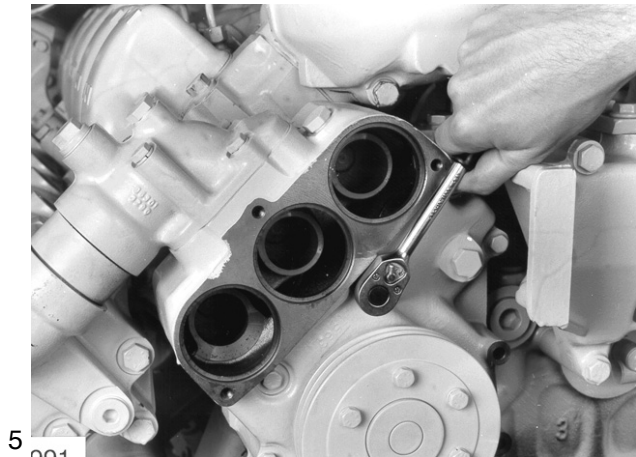


Fig. 5

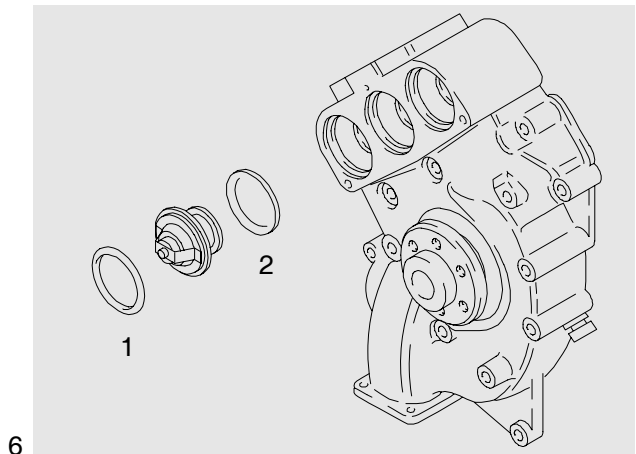
Fit water pump.



### Installing thermostats

Fig. 6

Insert thermostat inserts (ball valve facing upwards ("TOP") with new O-ring seal ① and new seal ②.  
Fit cooling water neck (13 mm).  
Fit exchanger, see page 60.  
Fill up with coolant, see page 50.  
Refit and tension V-belt.



**Caution:**

The ratio of mixture water to antifreeze must be reestablished. See publication "Fuels, Lubricants, Coolants for Industrial and Marine Diesel Engines".



**Note:**

**Exchange or repair 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 or repaired 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.

## Disassembling water pump

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

- Press
- Improvised tools (see page 176).

Fig. 1

- 1 Hub
- 2 Circlip
- 3 Impeller
- 4 Cap
- 5 Pump bearing
- 6 Mechanical seal

Remove water pump (see page 51).

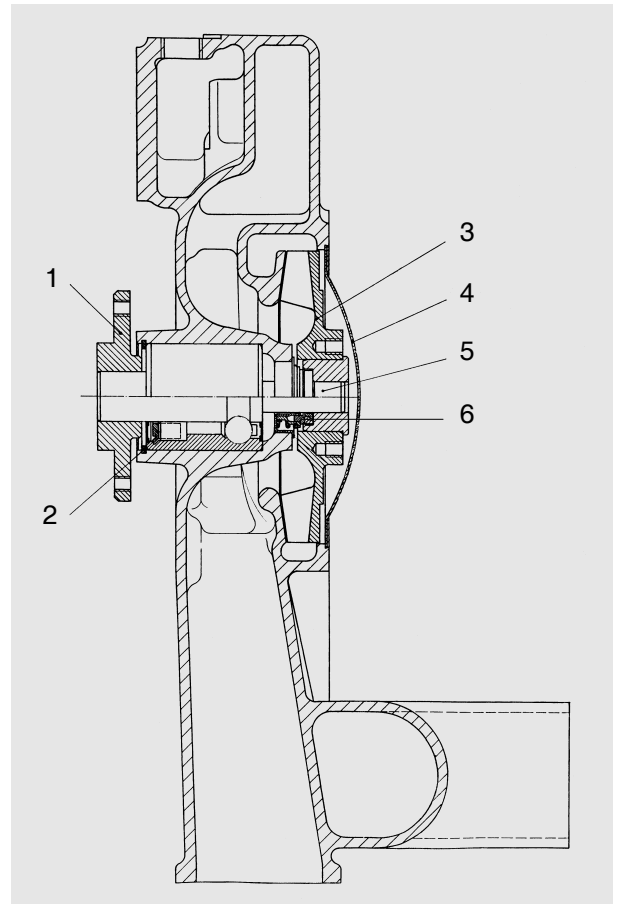


Fig. 2

Clamp water pump in vice (using soft jaws).  
Pull off hub with special puller or three-arm puller.

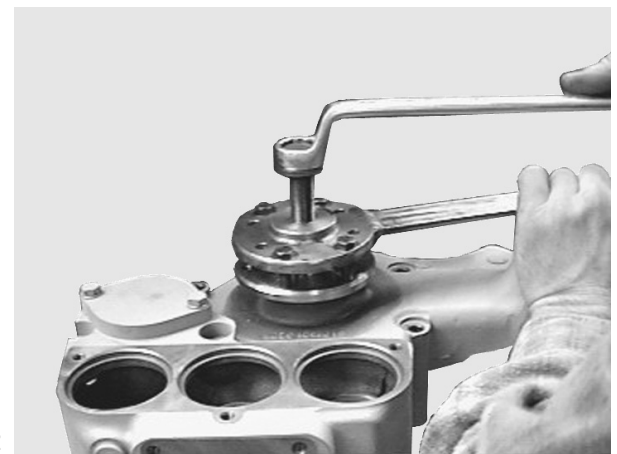


Fig. 3

Unclip the circlip from the water-pump housing.  
Knock out cap by driving a suitable mandrel under the cap (4) at the notch.  
Pull impeller (3) off the pump bearing. For this purpose two (from engine no. ... 5025 001 .... onwards four) M8 threaded bores are provided.  
Push out mechanical seal.



Fig. 4

Knock out cap by driving a suitable mandrel under the cap at the notch (arrow).

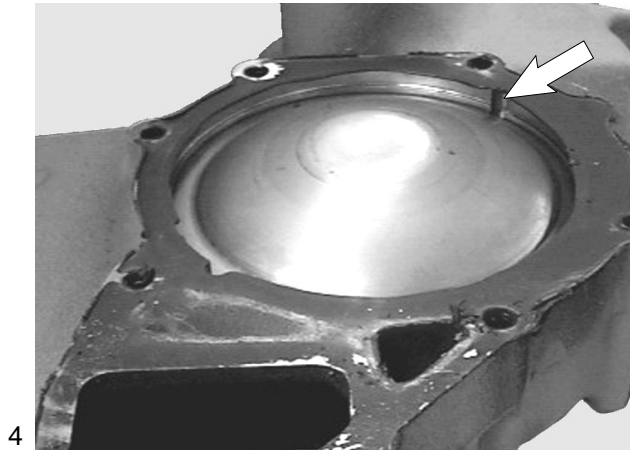


Fig. 5

Pull impeller off the pump bearing. For this purpose two (from engine no. ... 5025 001 ... onwards four) M8 threaded bores are provided.

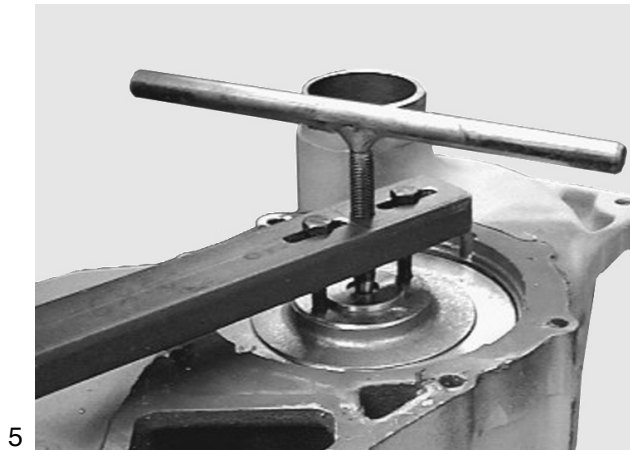
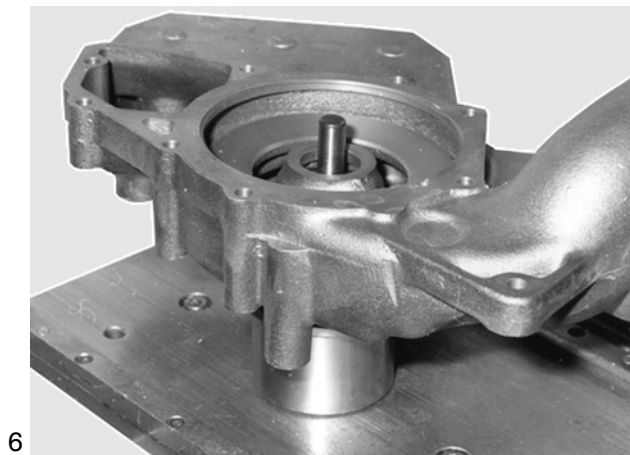


Fig. 6

Centre the pump housing on a suitable holder. Use suitable mandrel to press the water pump shaft with bearing out of the housing. The shaft and bearing are encapsulated and are exchanged together only. When pressing out, place support under water pump housing.



### Assembling water pump

Fig. 7

Press in water pump bearing. Use hollow mandrel to press on the outer bearing ring and not on the bearing shaft.

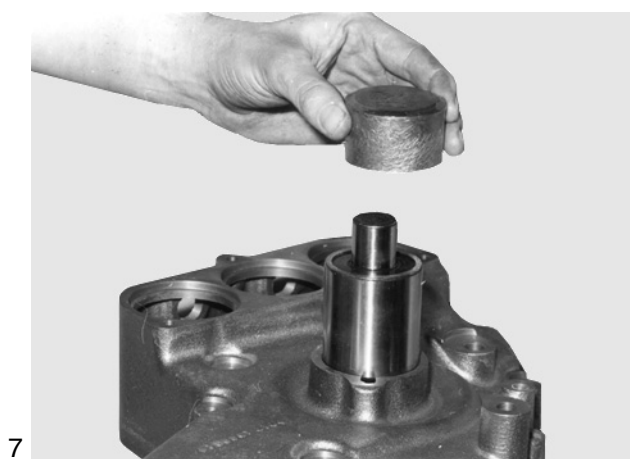




Fig. 8

Refit circlip. Press the pump hub on to the bearing shaft so that it fits flush. Use the other shaft end as support.



8

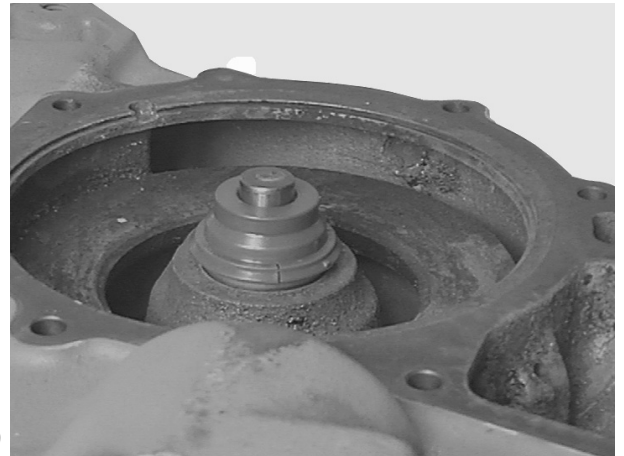
Figs. 9 and 10

Turn water pump housing over.  
 Press in new mechanical seal with press-fitting sleeve (special tool) until it stops.  
 Observe installation note for seal on page 57.

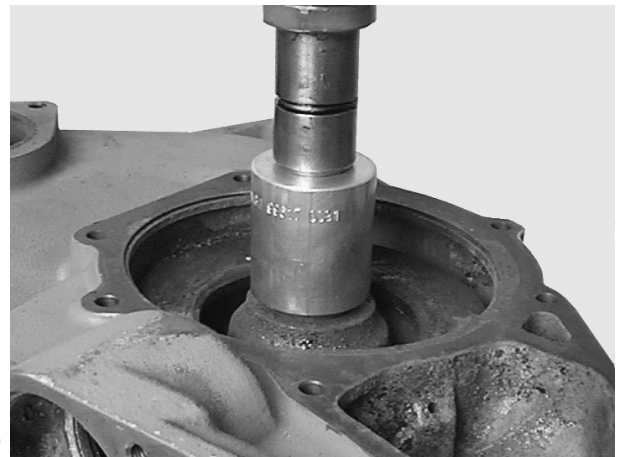


**Note:**

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



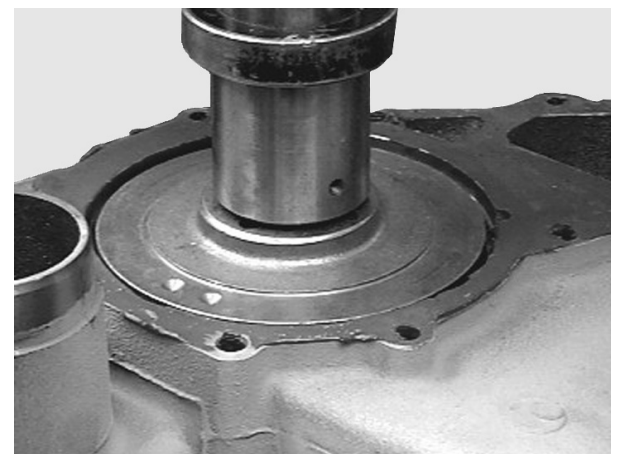
9



10

Fig. 11

Press impeller slowly on to bearing shaft to ensure correct gap.



11

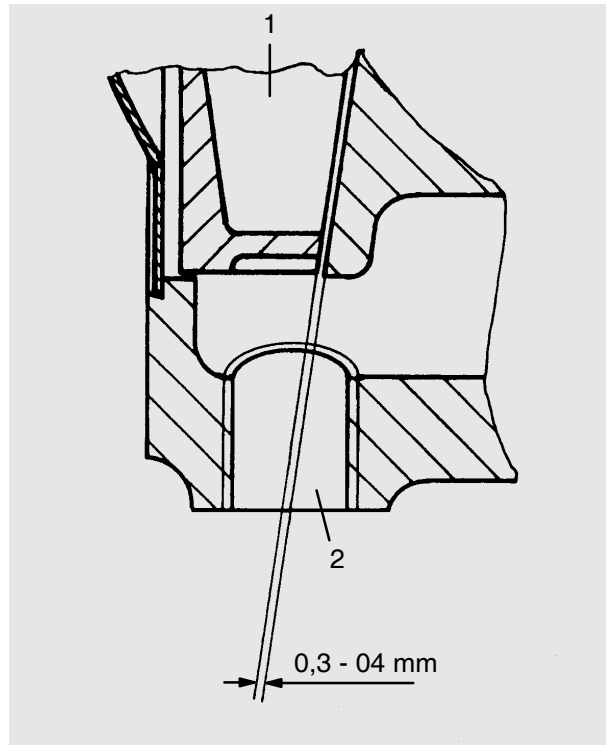
Fig. 12

For this purpose an inspection hole closed up with a screw plug (M16x1.5) is provided on the bottom of the water pump housing.



**Note:**

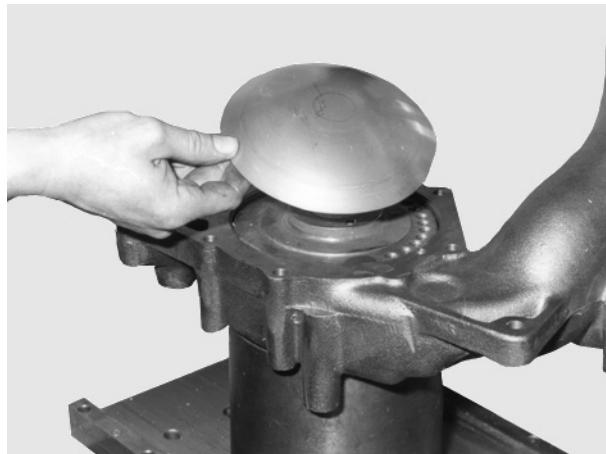
Only new versions of the pump housing have this inspection hole.



12

Fig. 13

Use suitable holder to centre pump housing. Fit new pump cover.

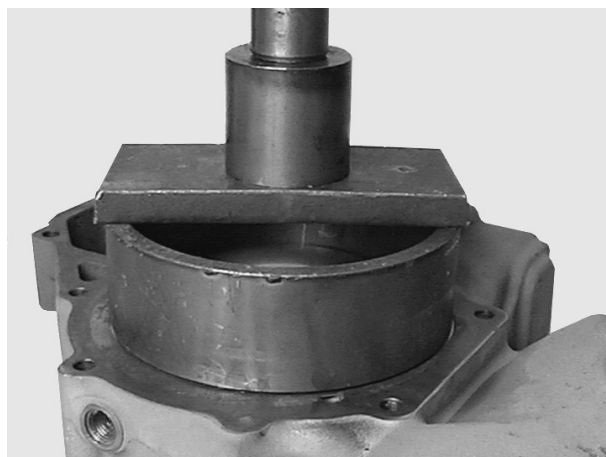


13

Fig. 14

Press pump cover into housing using a suitable mandrel.

Fit water pump with new gasket to crankcase.



14

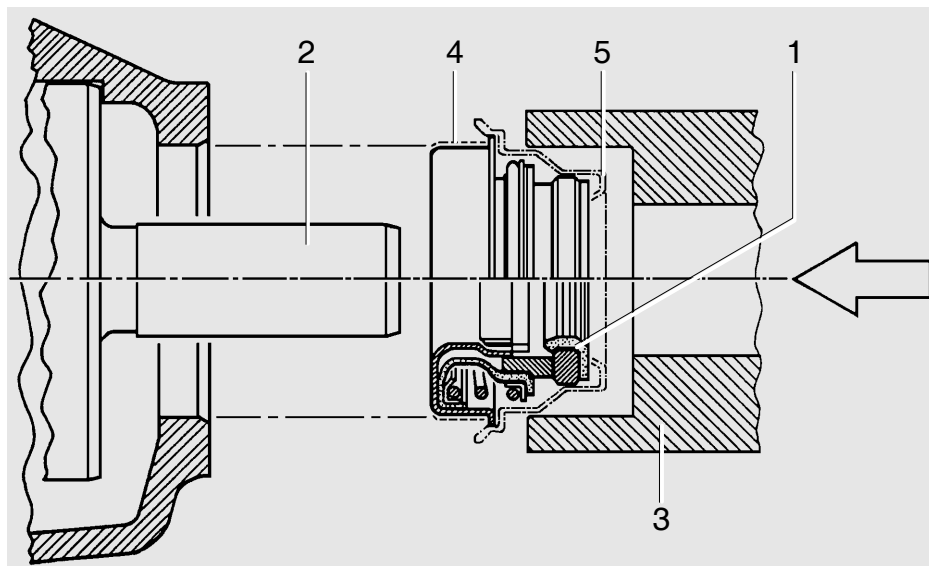
## Installation note for mechanical seal:

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 anticorrosion 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.

### 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 leaks 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 neutrassel 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 (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 ..."

### 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.

### Sources of supply for pickling fluids

Motor pickling fluid RB-06  
Reincolor-Chemie GmbH  
Werkstr. 21  
D-90518 Altdorf  
Tel.: (0 91 87) 97 03 0

- Drain coolant, see page 49

Fig. 1

Remove the mounting bolts from holder

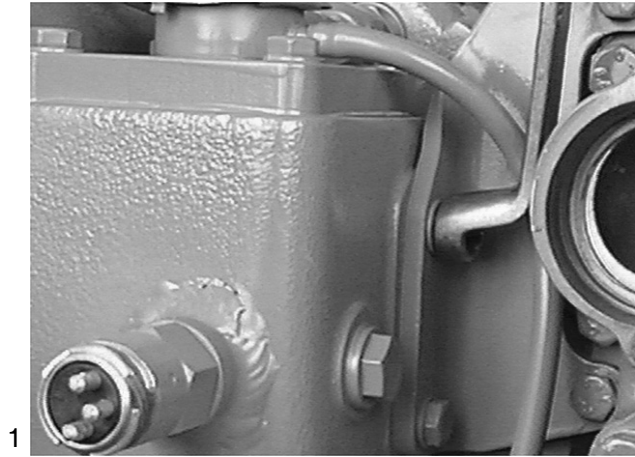


Fig. 2

Remove the bolts from the pipe connections.



Figs. 3 and 4

Remove the mounting bolts from the engine's front side.

Take off heat exchanger.



**Danger:**

The heat exchanger is heavy.  
Use lifting gear or work with helper.

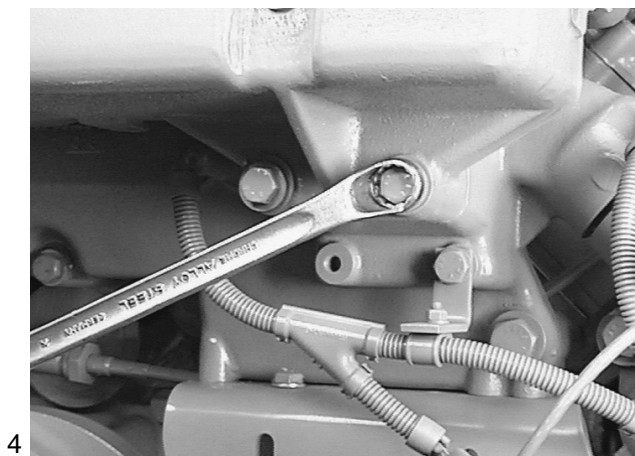


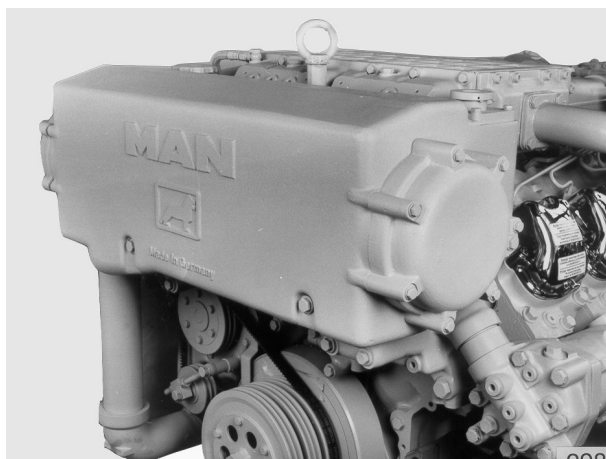
Fig. 5

Attachment is to be carried out in reverse sequence.

Use new O-rings for the pipe connections.

Check system for leaks.

5



### Removing pipe cluster for heat exchanger

- Remove heat exchanger, see page 60

Fig. 1

In the installed condition the collar of the pipe cluster can be seen between the cover and the heat exchanger housing (arrow).

Match-mark the position of the pipe cluster relative to the heat-exchanger housing.

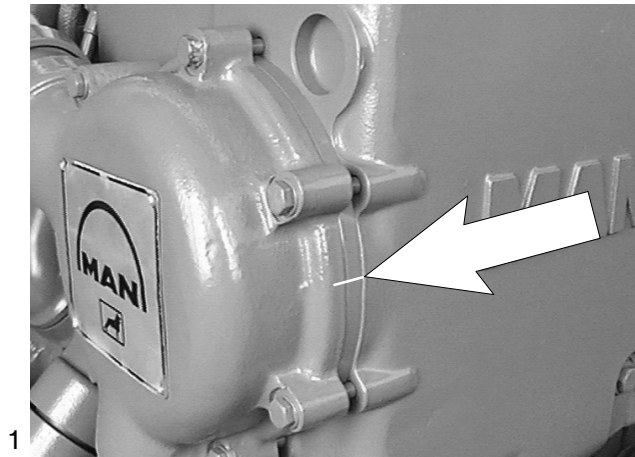


Fig. 2

Remove both covers.

Remove the O-rings.



Fig. 3

Remove the two screw plugs from the rear side of the heat exchanger. Once these screw plugs are removed, two stud bolts are visible.

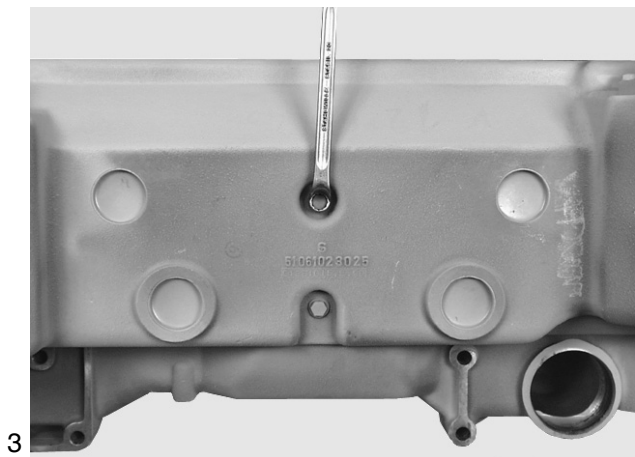


Fig. 4

Remove the two stud bolts. These hold the pipe cluster in a fixed position relative to the heat exchanger (or expansion tank).

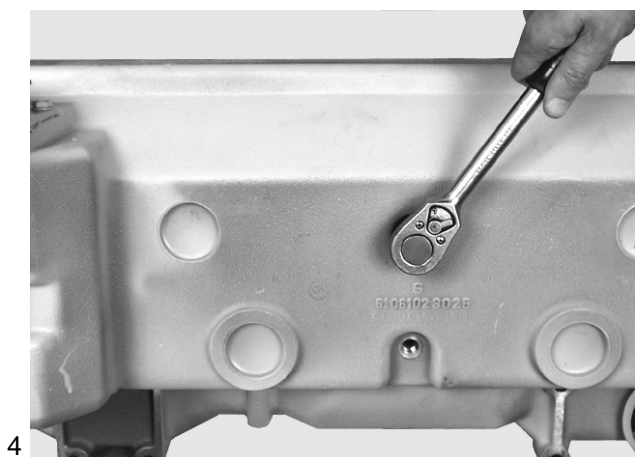




Fig. 5

Carefully knock pipe cluster out from the other end with a block of wood.



**Caution:**

The pipe cluster is bolted to the heat exchanger.  
See Figs. 3 and 4.



5

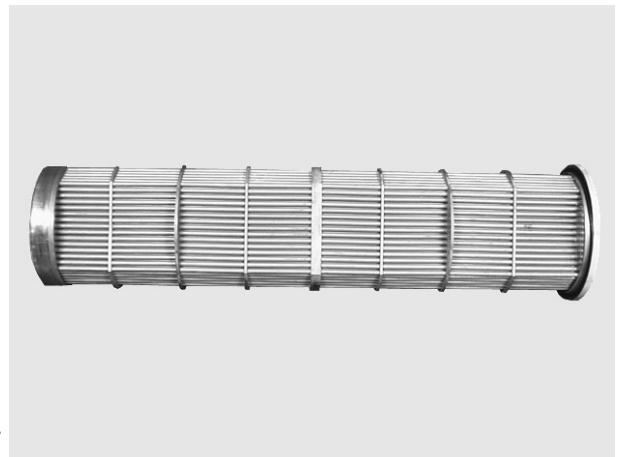
Figs. 6 and 7

Pull out pipe cluster.

Check pipe cluster and, if necessary, clean it; see page 67.



6



7

## Installing pipe cluster for heat exchanger

Figs. 8 and 9

The pipe cluster is installed in reverse order.

When installing the pipe cluster, use new O-rings (total of 4 rings).

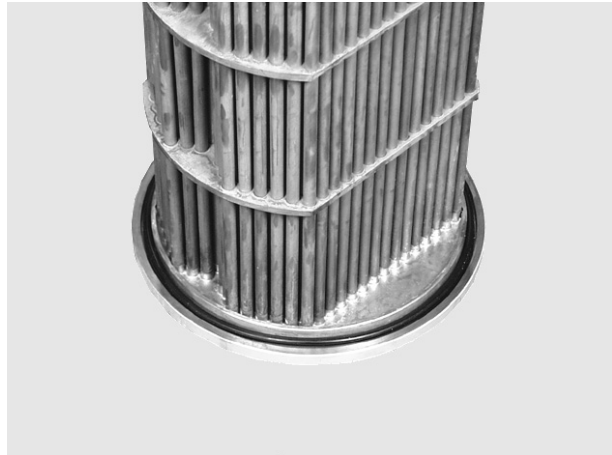


Fig. 10

Push pipe cluster into heat exchanger housing.

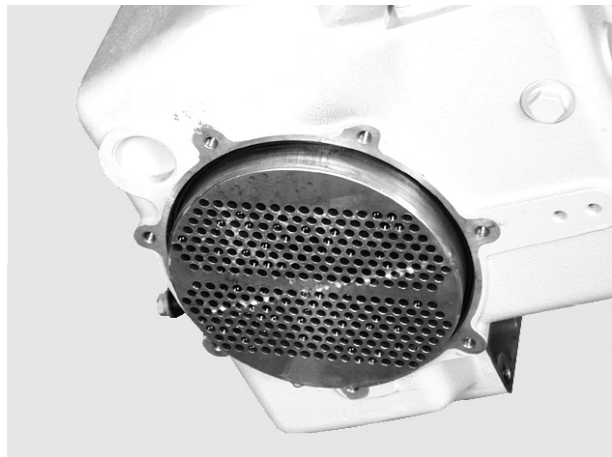
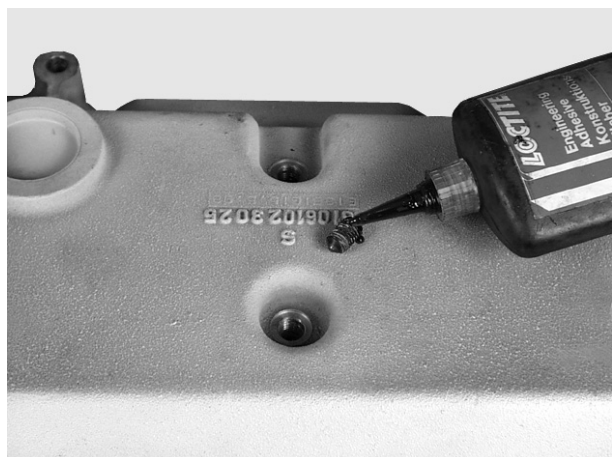


Fig. 11

Screw in stud bolts with “Loctite 242”.

Fit screw plugs with new sealing rings.

- Install heat exchanger, see page 60

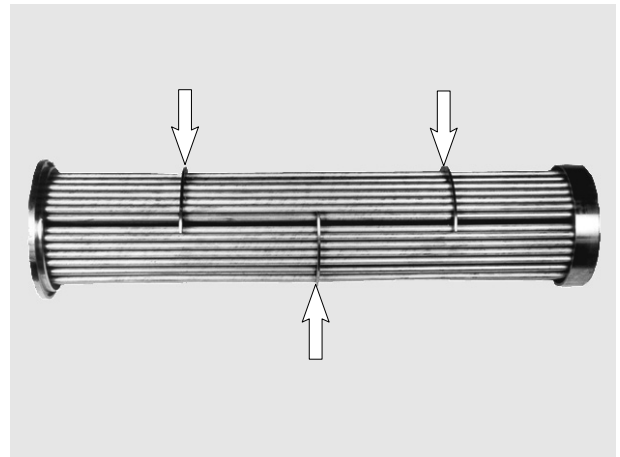


- Remove pipe cluster, see page 62

Fig. 1

When the pipe cluster is removed, we recommend always checking the position of the deflectors (arrows) (the picture shows the pipe cluster for a D 2848 LE 403 engine).

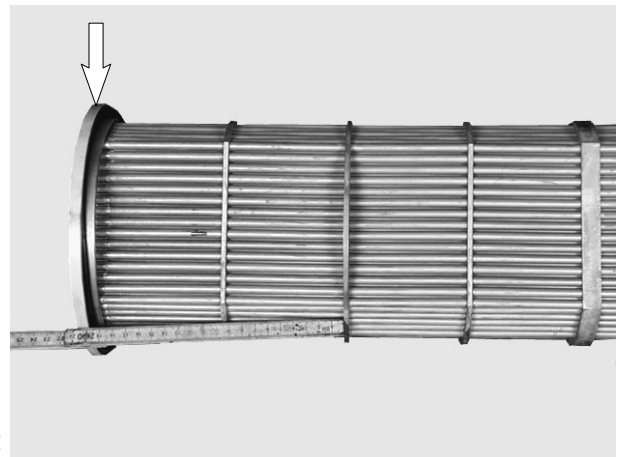
Displaced deflectors may reduce the flow of coolant, which in turn leads to an increase in coolant temperature.



1

Fig. 2

Measure the position of the deflectors. Use the pipe-cluster side with the collar (arrow) as reference edge (this side can be recognised as that end of the pipe cluster with the larger diameter).

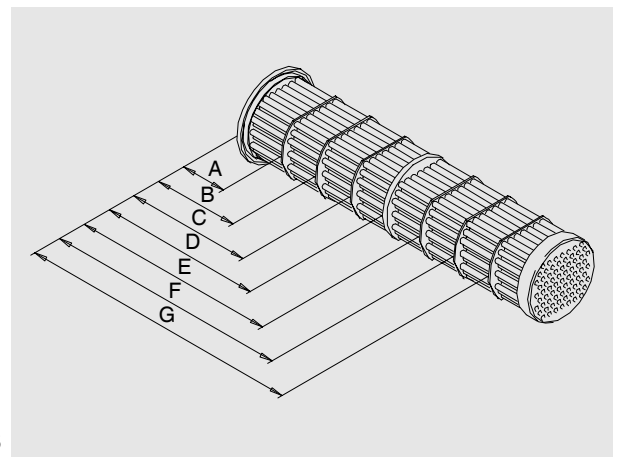


2

Fig. 3

Reference spacing of the deflectors.

- A 111
- B 207.5
- C 304
- D 394.5
- E 497
- F 593,5
- G 690

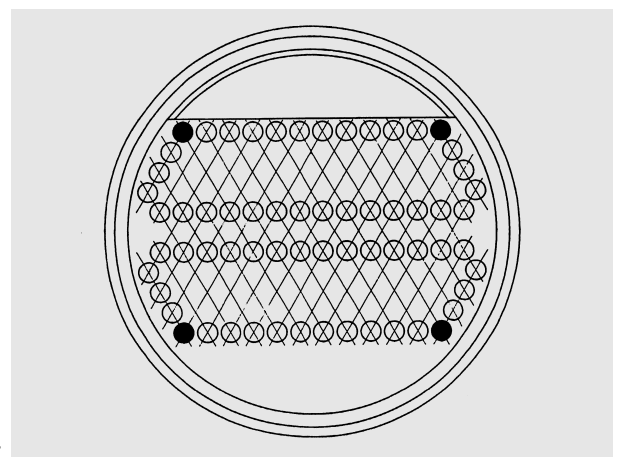


3

Fig. 4

If deflectors are found displaced, bring them into their original position.

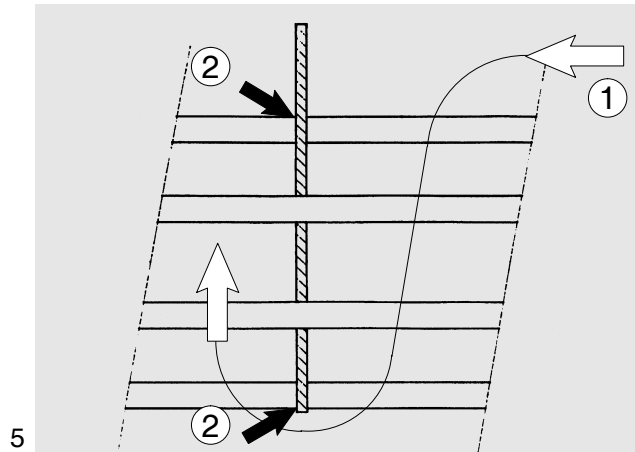
To prevent the deflectors from being displaced again, the 4 outer pipes on the edges (marked black in the picture) are to be soldered on to every deflector.



4

Fig. 5

The soldering ① is to be effected on the side facing away from the engine coolant inlet ②.



### Job instruction for soldering the deflectors on to the pipe cluster

Each of the 4 outer pipes on the edges is to be cleaned with the aid of a brass brush / emery cloth in the area where the soldering is to be effected. The area must also be free of grease.

To effect the soldering, use soldering tin DIN 1707 – L – SN 50 PB SB (MAN no. 09.43007–0092), melting range 183°C–215°C and soldering fluid such as DEGUSSA Soltaflux K or similar products from other manufacturers.

The soldering burner is to be set for a soft flame. At the soldering joint the parts are to be evenly heated but must not glow. The soldering fluid must remain “vitreous” and must not burn.

### Internal cleaning of the pipe set in raw water heat exchangers

Deposits may form on the sea-water side of the pipe cluster in the heat exchanger, impairing the heat transition to such an extent that the coolant heat can no longer be sufficiently conducted away. This is bound to cause an increase in the coolant temperature.

In the event of an increase in coolant temperature, check all other components of the cooling system first.

- Raw-water filter contaminated?
- Raw-water inlet clogged up?
- Flow rate of raw water sufficient? Impeller of raw-water pump worn?

If all components of the cooling system are in order, but the coolant temperature remains nevertheless high, cleaning the pipe cluster may eliminate the fault.

#### ***Proceed as follows:***

- Lay or stand removed pipe set in a suitable container made of synthetic material such as PE, PP, PVC, GRP etc.
- Fill container with undiluted genuine pickling liquid at room temperature (engine pickling fluid RB-06) until the pipe set is completely submerged.
- Allow pickling fluid to soak in for approx. 10 hours. If this period of time is not sufficient, allow another 5 hours
- The pickling period can be shortened by heating up the pickling fluid up to a maximum of 50°C (120°F) and by moving the set of pipes from time to time.
- After the pickling the pipe set is to be intensively rinsed with tap water and again installed in the heat exchanger.
- Use new seals (O-ring seals) for the caps.
- Install pipe set and check heat exchanger for leaks.

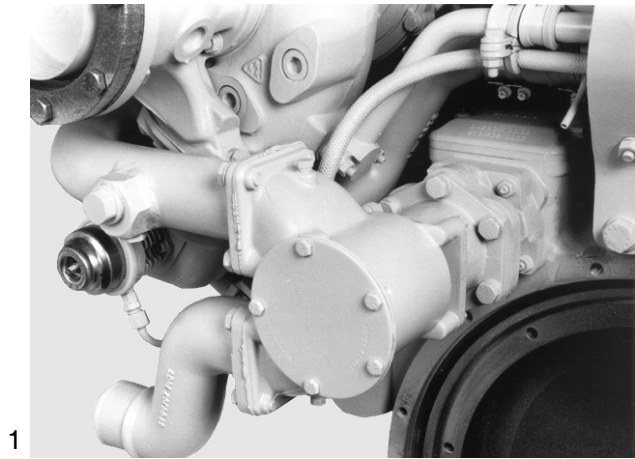
### Waste water conditioning

With the aid of soda lye the drained and used cleaning and pickling fluid is conditioned to a pH value of 7.5 to 8.5. After the sediments have settled the clear fluid above can be drained into the sewerage system. The sludge is to be taken to a dump for special waste.

### Changing impeller

Fig. 1

Replace worn or damaged impeller together with wearing plate and seal (repair kit).



Figs. 2 and 3

To do this, unscrew cover and remove rubber cap.

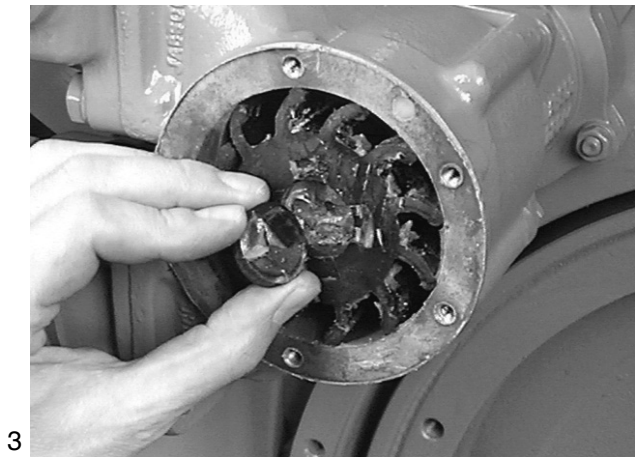
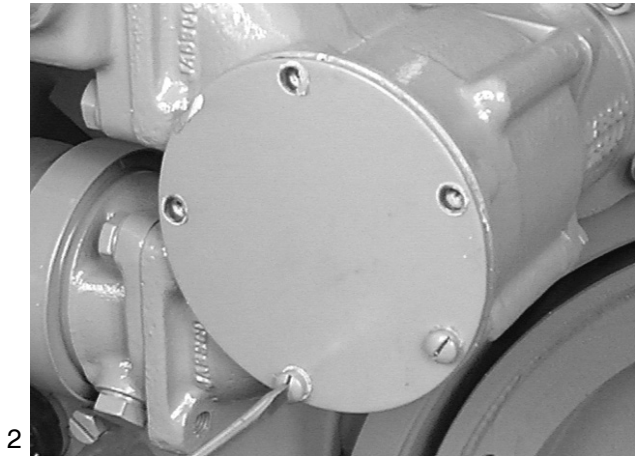


Fig. 4

Remove mounting bolt from the cam.

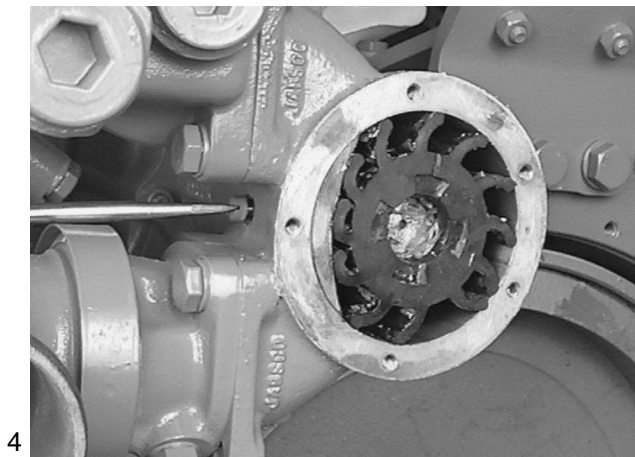
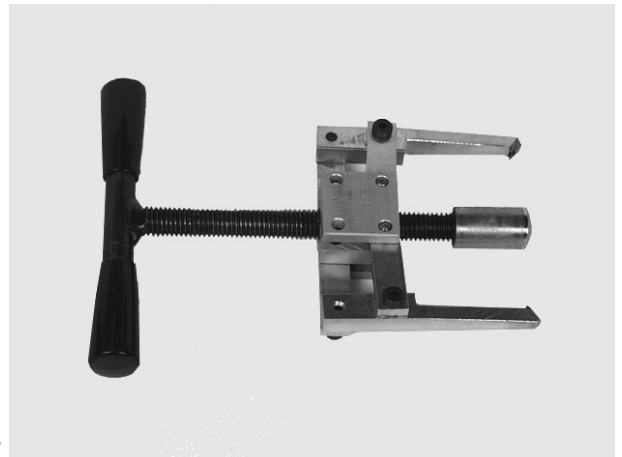


Fig. 5

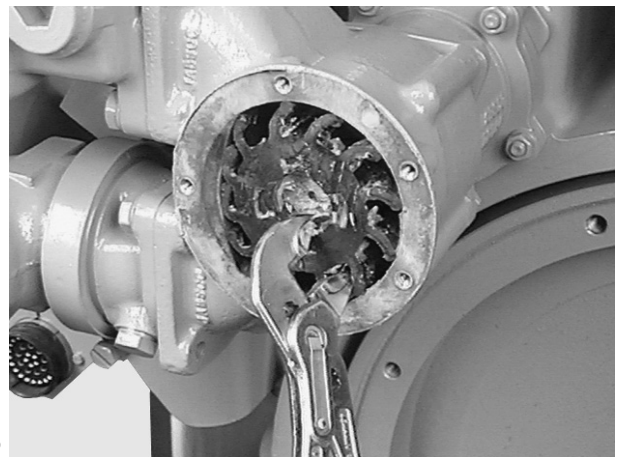
Pull out impeller, using a suitable extractor (available from the manufacturer of the raw-water pump).



4

Fig. 6

Pull out impeller together with the cam, using pliers.



5

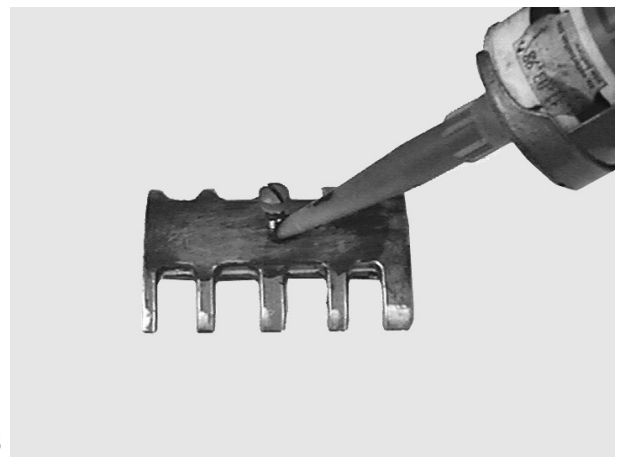
Fig. 7

Installation is to be carried out in reverse sequence.

Apply sealant to eccentric before installing it. Lightly coat new impeller with vaseline prior to its installation.

Dry running will destroy the impeller. Fill pump with water prior to operation.

Check for leaks.



6

Fig. 1

Remove the raw-water pipes from the raw-water pump.

Remove the mounting bolts of the raw-water pump from the flange.



Fig. 2

Take off raw-water pump and drive sleeve.



Fig. 3

The installation is carried out in reverse sequence.

Push drive sleeve with internal circlip on to the drive shaft. The "short side" of the sleeve must point towards the engine.







**Caution:**

Used oil and oil filters are classed as dangerous waste and must be disposed of accordingly.  
Note instructions for preventing environmental damage.

Fig. 1

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



**Danger:**

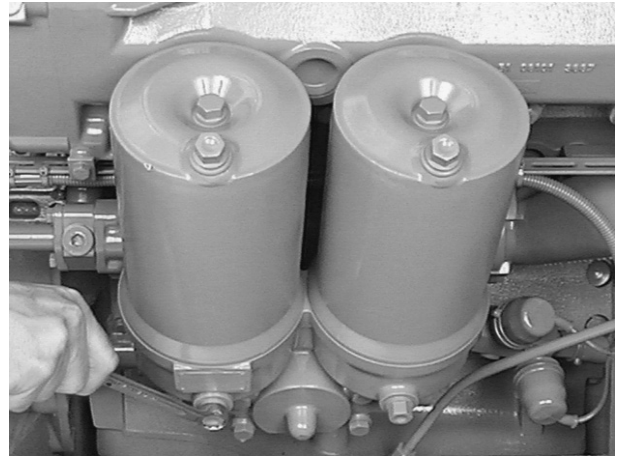
Oil filter can and oil filter are filled with hot oil.  
Risk of burns and scalds.

Fig. 2

Remove mounting bolt of the relevant filter bowl.  
Take off filter bowl and clean it internally.

Fig. 3

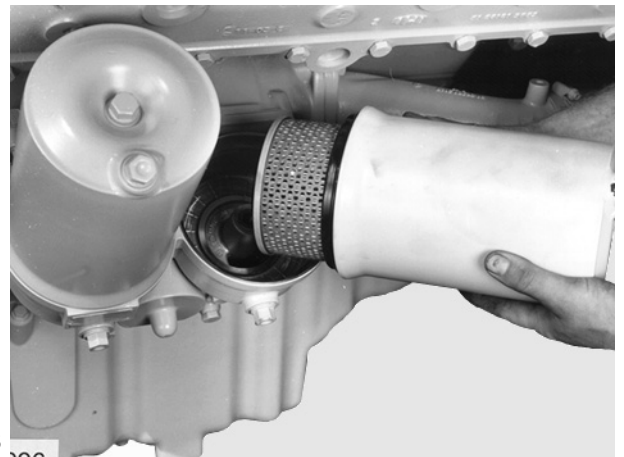
Insert new filter element and fit filter bowl with new seals.  
Observe tightening torque for mounting bolt.



1



2



3

- Drain coolant, see page 49
- Drain engine oil

Fig. 1

Remove oil filter (17 mm) and filter head gasket.

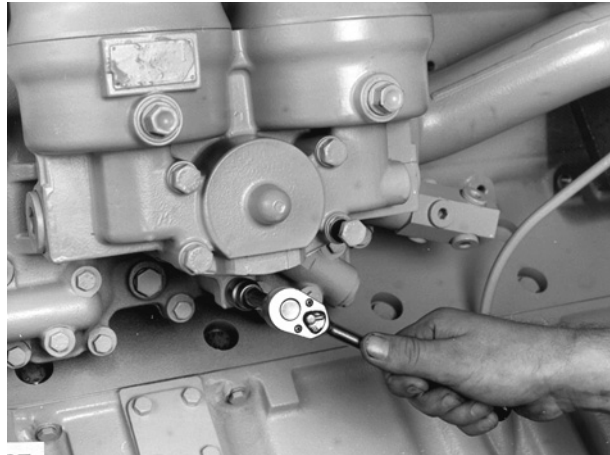


Fig. 2

Remove oil cooler housing cover with the oil cooler attached (13 mm).

The oil cooler is secured by the 5 bolts marked. Loosen these screws only after removal of the housing cover.

The picture shows the oil cooler housing cover of a 10-cylinder engine.

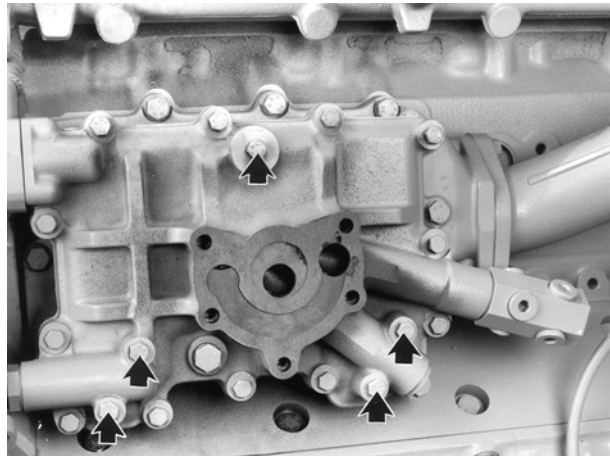


Fig. 3

12-cylinder engines are equipped with 2 oil coolers secured by a total of 10 bolts.

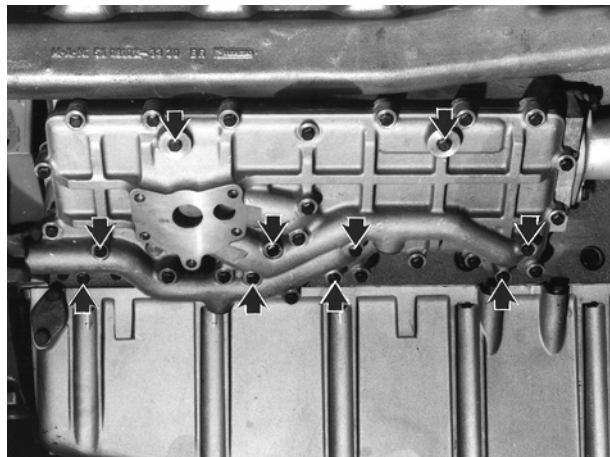


Fig. 4

Check oil cooler for damage, changing it if necessary. Fit oil cooler with new gaskets.

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



## Removing and installing oil pump

Figs. 1 and 2

Drain engine oil from the oil pan and from the oil filters.

Use a sufficiently large container to prevent oil from overflowing.



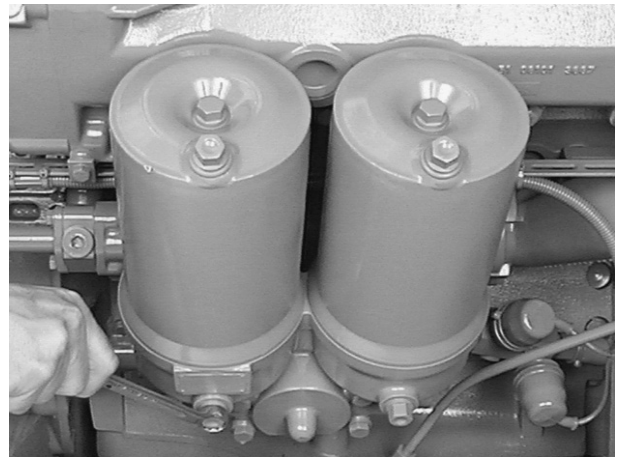
**Danger:**

The oil is hot- risk of scalding. Do not touch the oil drain plug with bare fingers. Oil is an environmental hazard. Handle it with care!

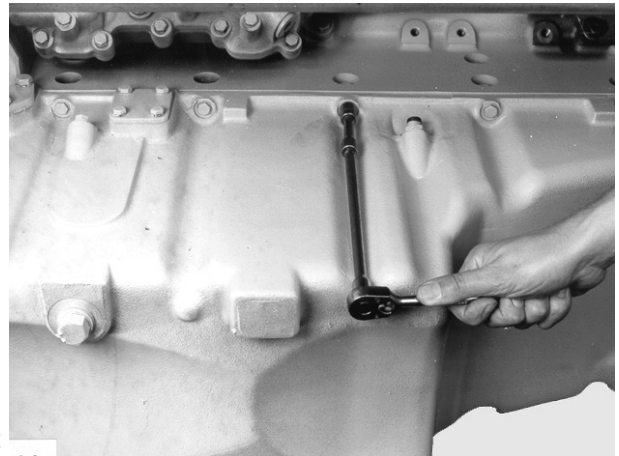


**Caution:**

Used oil and is classed as dangerous waste and must be disposed of accordingly. Note instructions for preventing environmental damage.



1



2

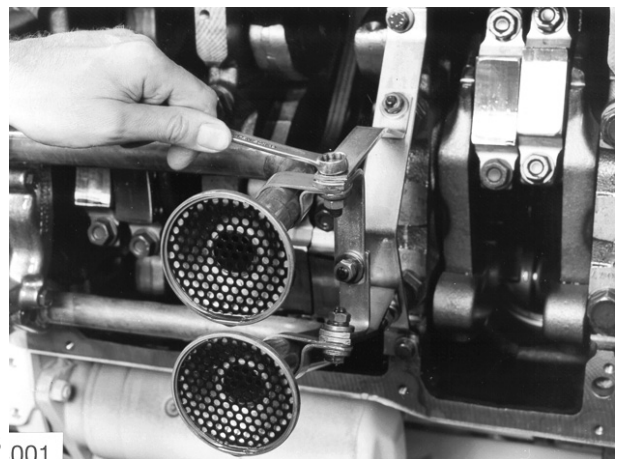
Fig. 2

Remove oil pan (13 mm).



**Note:**

Various oil pan variants are possible. The picture shows a deep oil pan.



3

Fig. 3

Remove oil suction pipe.



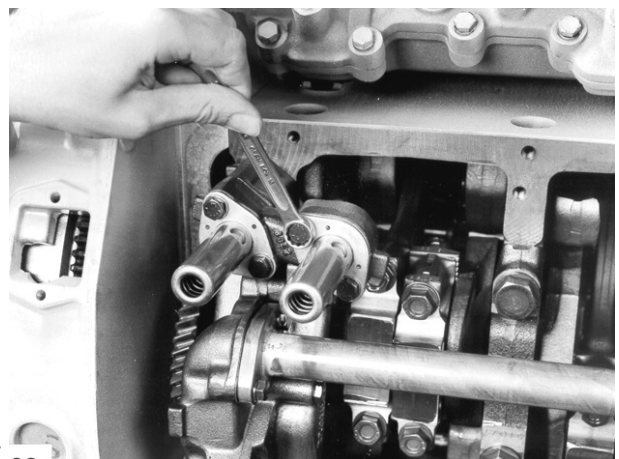
**Note:**

Various variants are possible. The picture shows the 10-cylinder engine.

Fig. 4

Remove mounting bolts of pressure relief valve (13 mm).

The pressure relief valve is encapsulated. Opening pressures see "Engineering • Data • Setting values".



4

Fig. 5

The 8-cylinder-engine is equipped with only one pressure relief valve.

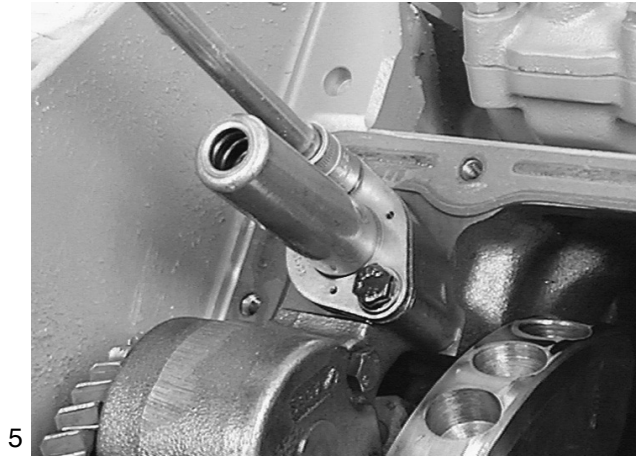


Fig. 6

Remove oil pump.



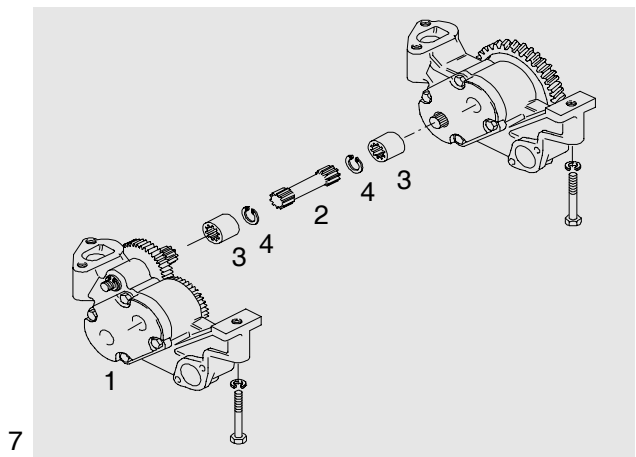
**Note:**

Depending on the engine model and oil pan variant, various oil pump versions are possible.



Fig. 7

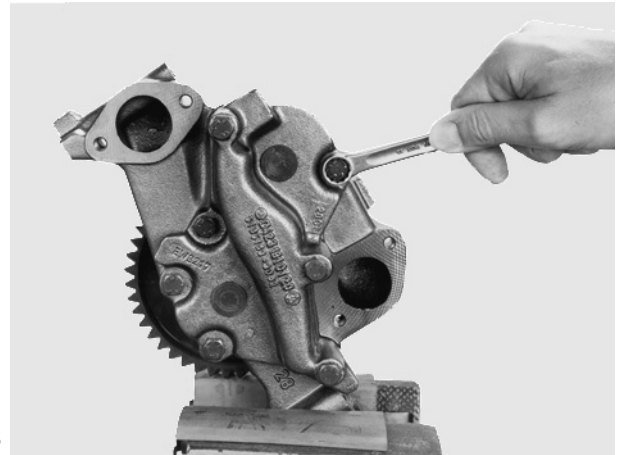
In engines with tandem pumps, first remove the 2nd pump ① with intermediate shaft ②, connection sleeves ③ and circlips ④.



## Disassembling and assembling oil pump

Fig. 8

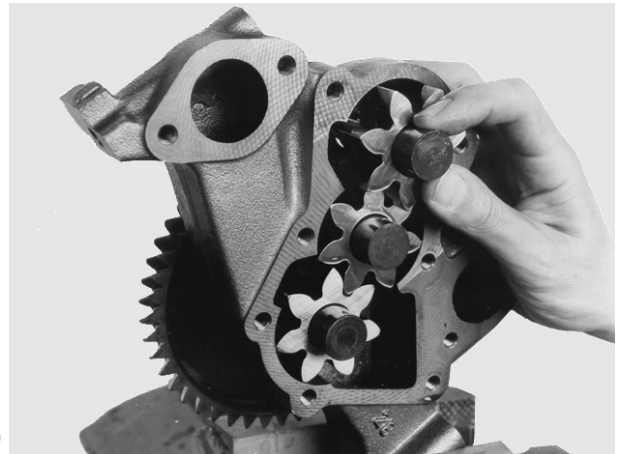
Clamp oil pump in a vice (fitted with soft jaws). Remove oil pump cover (13 mm).



8

Fig. 9

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



9

Fig. 10

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”.



10

Fig. 11

Fit cover.  
Tighten mounting bolts to specified torque.  
Grind or exchange covers if they are severely worn.

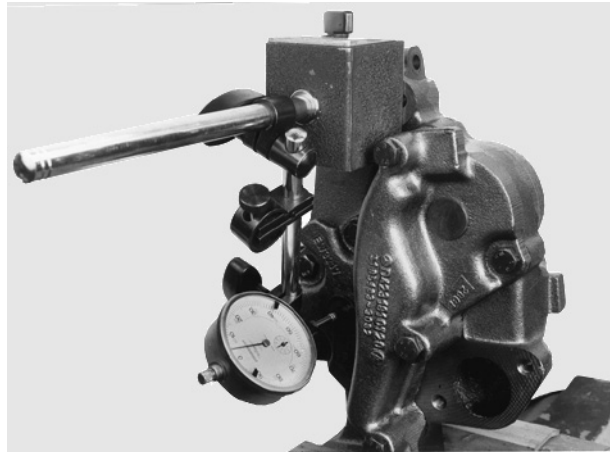


11

### Checking axial play of the pump gears

Fig. 12

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.



12

### Installing oil pump

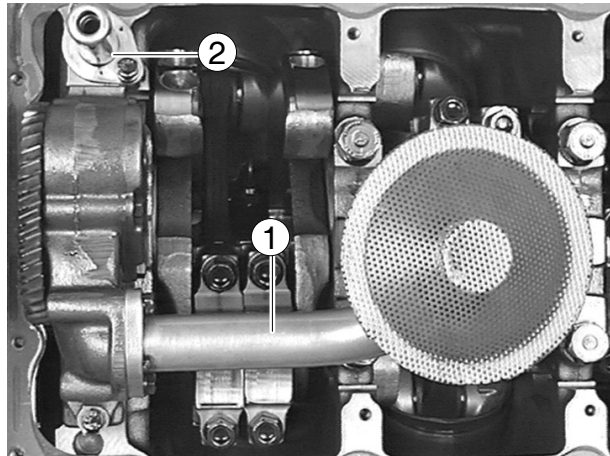
Fig. 13

Before installing, check whether the oil pump runs smoothly

Fit the oil intake lines ① with seals and pressure relief valve ② without seal. (13 mm).

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.



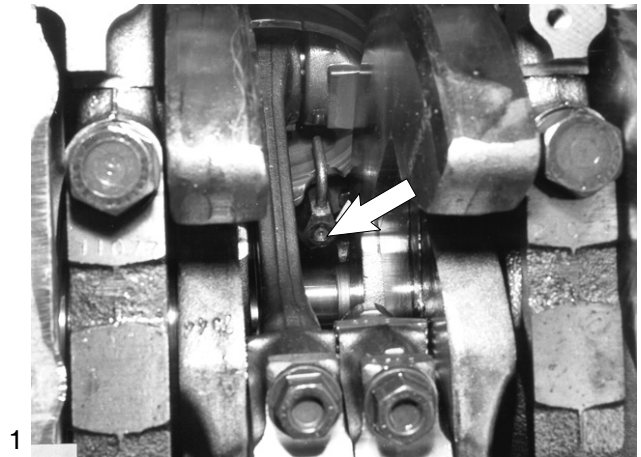
13

## Removing oil spray nozzle

- Drain engine oil
- Remove oil pan, see page 73

Fig. 1

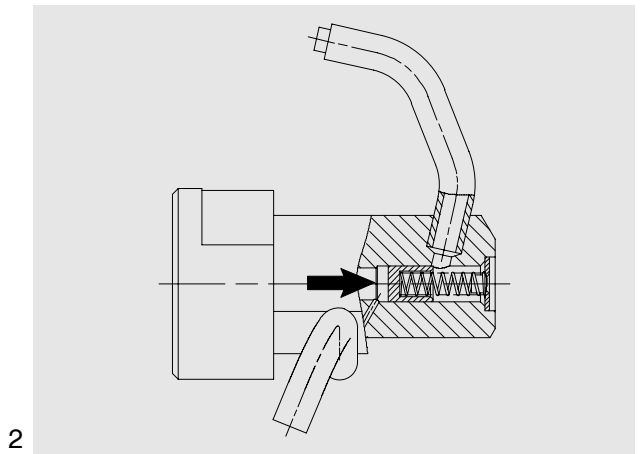
Remove mounting bolts from oil spray nozzle (arrow) (10 mm).  
Take off oil spray nozzle with valve.



## Checking oil spray nozzle valve

Fig. 2

Remove oil spray nozzle valve from oil spray nozzle body.  
It must be possible to move the valve plunger up and down easily. If the plunger sticks, change the oil spray nozzle.  
For opening pressures, see “Engineering • Data • Setting values”.



## Installing oil spray nozzle

Fig. 3

Place oil spray nozzle ① on oil spray nozzle flange ②



**Note:**

Older engines have a seal between the oil spray nozzle flange and the oil spray nozzle. According to more recent findings these are no longer necessary.

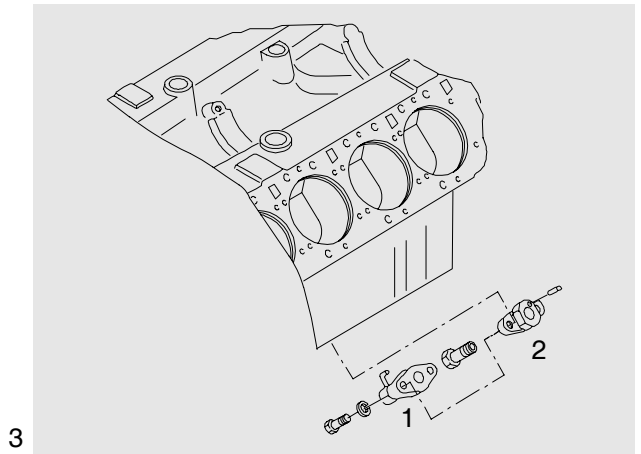


Fig. 4

Tighten mounting bolts to specified torque.



**Note:**

In older engines the oil spray nozzles are held in place by two M6 x 25 bolts. In the event of repairs these are to be replaced by M6 x 30 bolts.

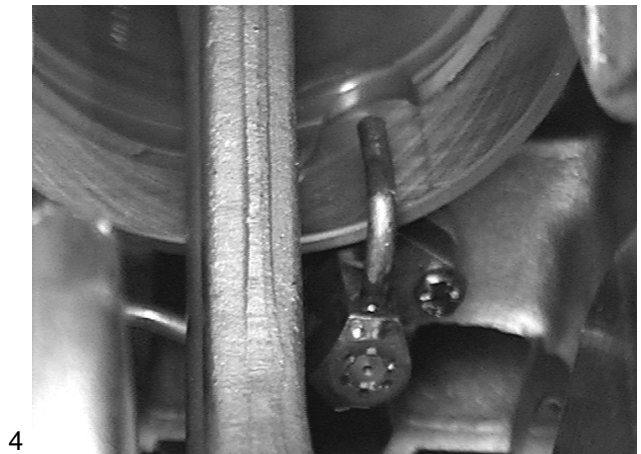
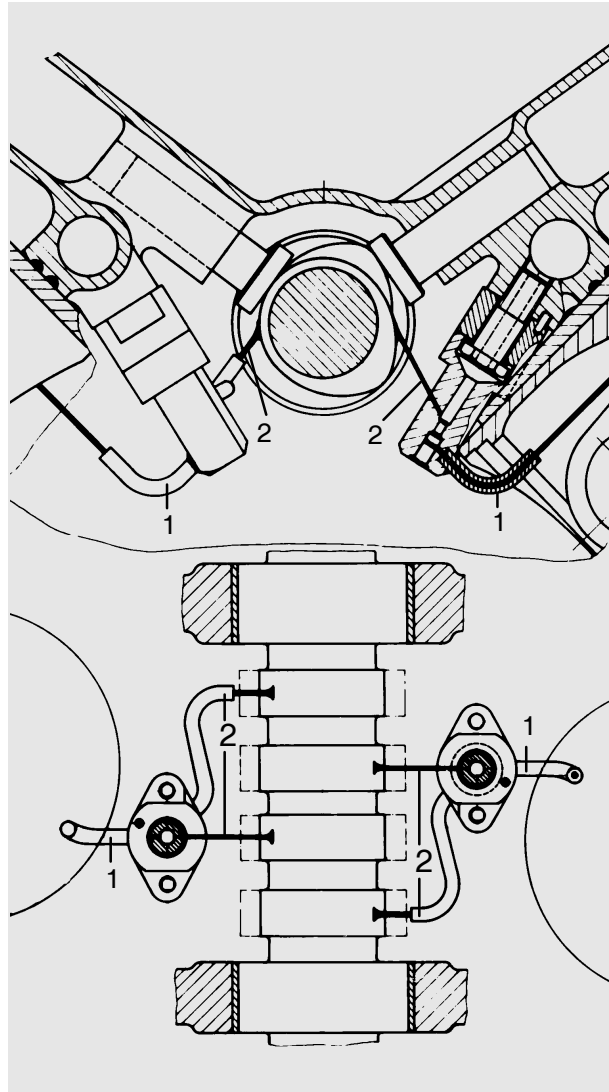


Fig. 5

Check direction of oil jet. The oil jet from each nozzle must reach unhampered the inlet port of the cooling duct in the piston crown ① and two cams ②.

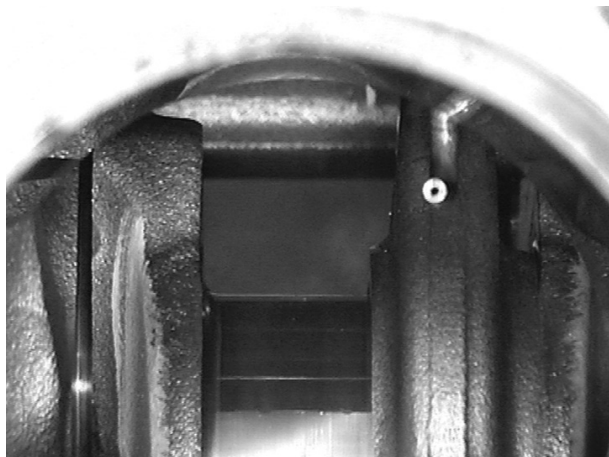
On no account must bent oil spray nozzles be readjusted.



5

Fig. 6

Turn the engine over. Neither the crankgear nor the pistons must collide with the oil spray nozzle.



6



## Removing vibration damper

- Turn engine to ignition TDC. Cylinder 1 is at ignition TDC if the valves of the following cylinders are in crossover:
  - Cylinder no. 6 in 8-cylinder engines
  - Cylinder no. 7 in 10-cylinder engines
  - Cylinder no. 6 in 12-cylinder enginesThis ensures that in subsequent assembly work the indicating dial will be in the correct position.
- Block the crankgear.
- Relax and remove V-belt; see page 151

Fig. 1

Remove V-belt pulleys.

Fig. 2

Remove delivery start indicator (picture shows arrangement of engine D 2840 LE 401)

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.

Fig. 4

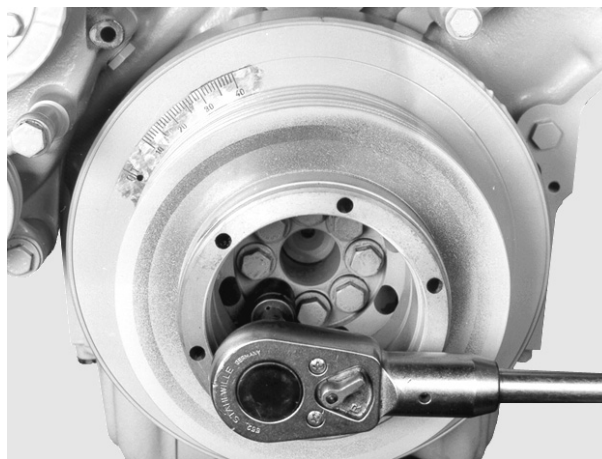
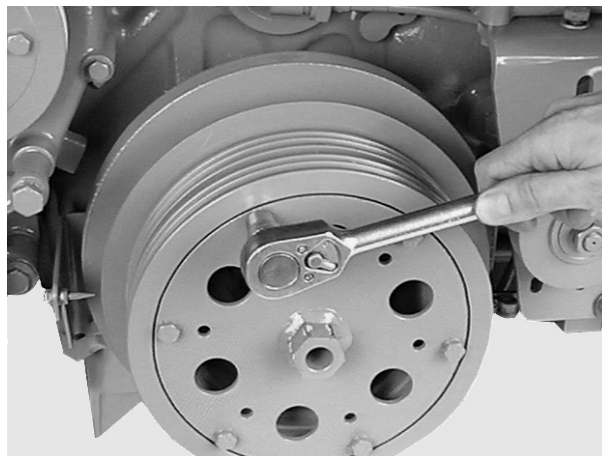
Remove two bolts facing each other and replace them by two guide pins (M16 x 1,5).  
Remove all bolts.  
Remove vibration damper.



**Caution:**

The vibration damper is susceptible to shocks.

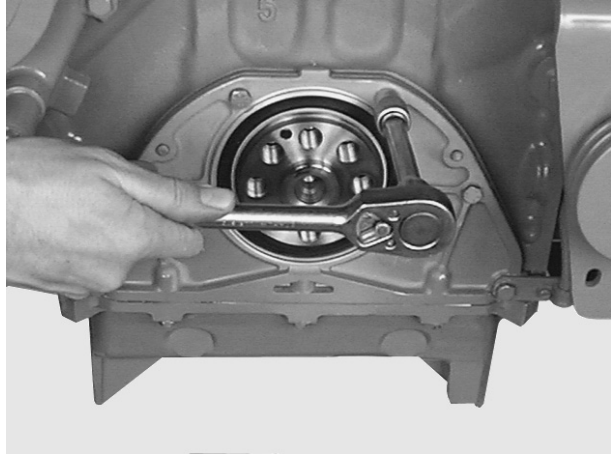
Take hub and oil splash ring off the crankshaft.



## Changing front crankshaft seal

Figs. 5 and 6

Remove cover bolts (13 mm).



5

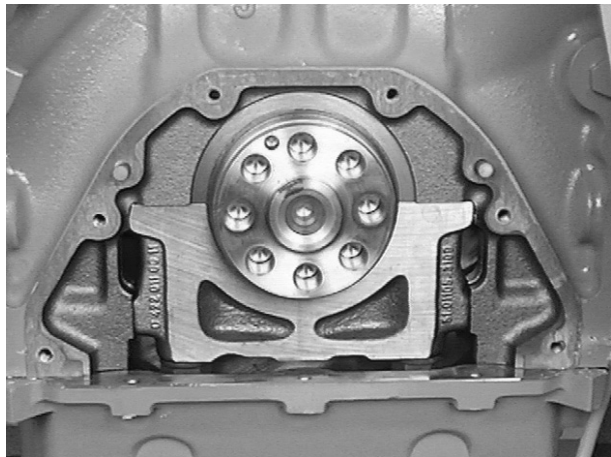


6

Fig. 7

Remove cover.

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

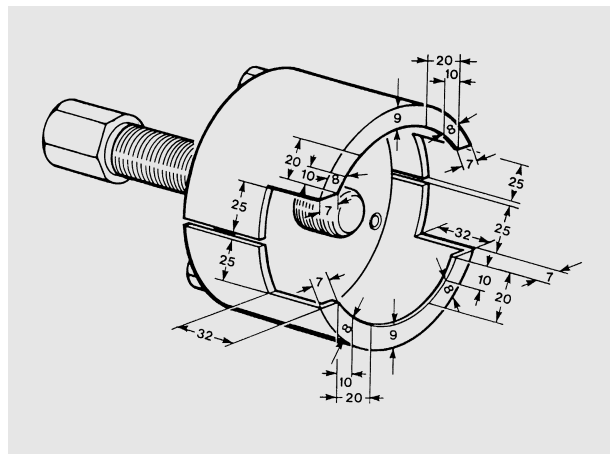


7

## Replace race

Fig. 8

To remove the race, a puller (special tool, see page 169, item 15) is necessary.



8

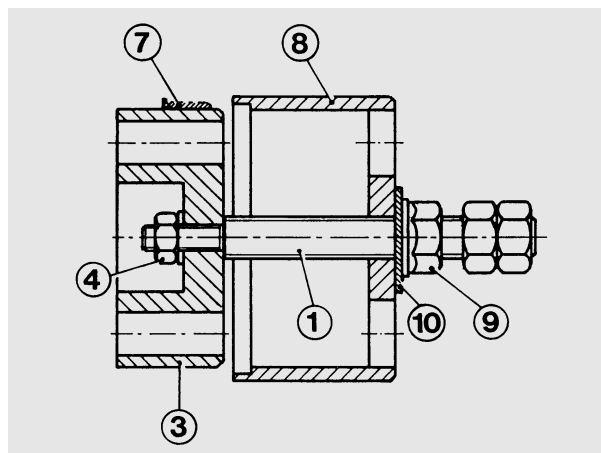
Fig. 9  
Pull off race.



9

Fig. 10  
Special tools are required for installing the race (see page 169, item 15).  
Clean inner side of race and crankshaft stub. Coat crankshaft stub with sealing agent "Antipor 46".

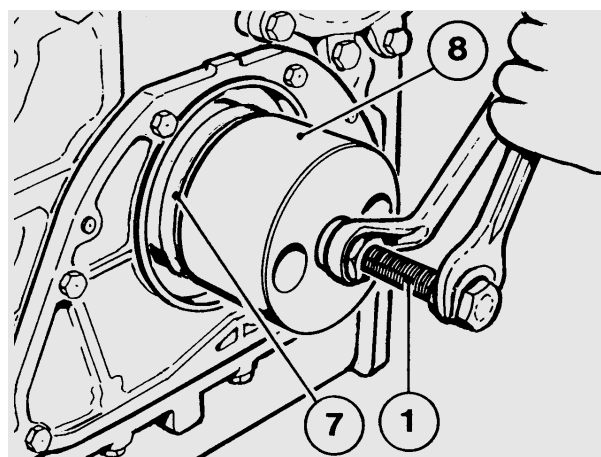
- Push race ⑦ and pressing sleeve ⑧ onto adapter ③.
- Tighten spindle ① in adapter ③ with nut ④.
- Bolt adapter ③ to crankshaft.



10

Fig. 11  
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. 10) until pressing sleeve ⑧ stops on the adapter.

**Note:**  
The bearing race can be installed even while the cover remains fitted.



11

## Exchanging radial shaft seal

Fig. 12  
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

Fig. 13

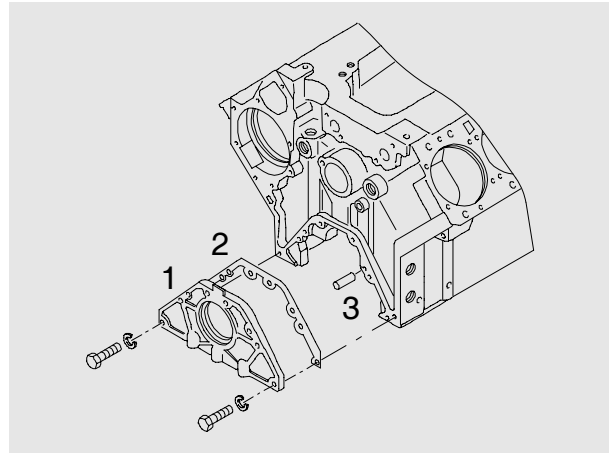
Fit cover ① with new seal ②.

The cylinder pins ③ provide better guidance for the cover.

These will ensure that the seal is not too easily damaged when the cover is put on.

Tighten screws (13 mm) to specified torque.

13



### Installing vibration damper

Fig. 14

Push hub and oil splash ring on to crankshaft.

14

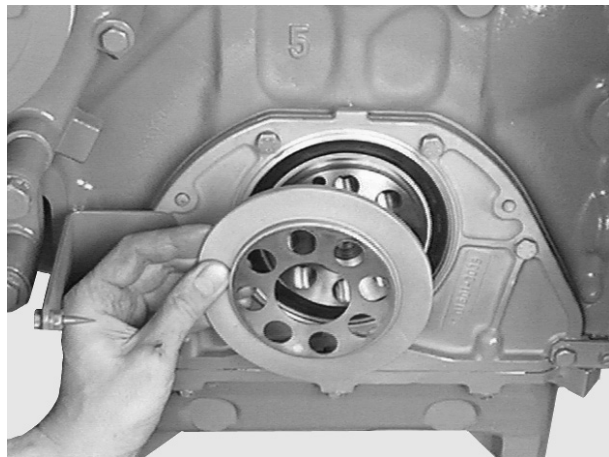


Fig. 15

Place vibration damper on two guide pins (M16 x 1.5). Ensure that the position of the graduated disc relative to the crankshaft is correct.

15



Fig. 16

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.

16

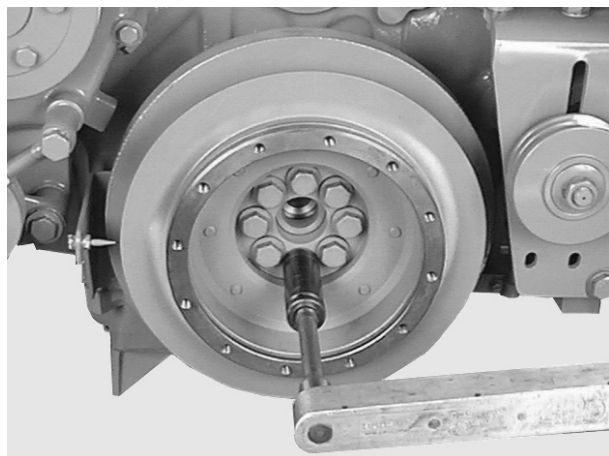
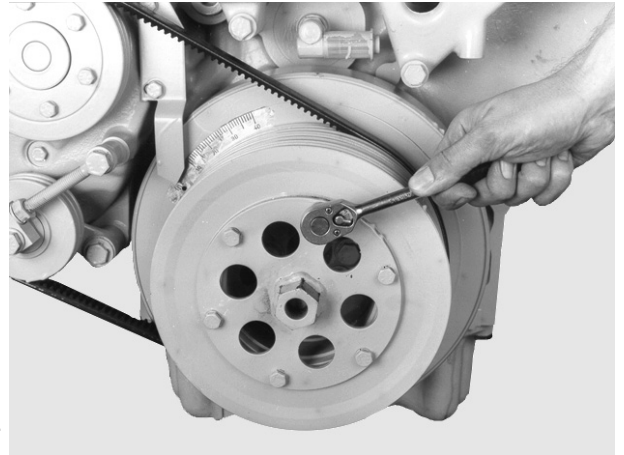


Fig. 17

Screw on delivery start indicator and  
V-belt pulleys.  
Fit and tension V-belts (see page 150).



17

Figs. 18 and 19

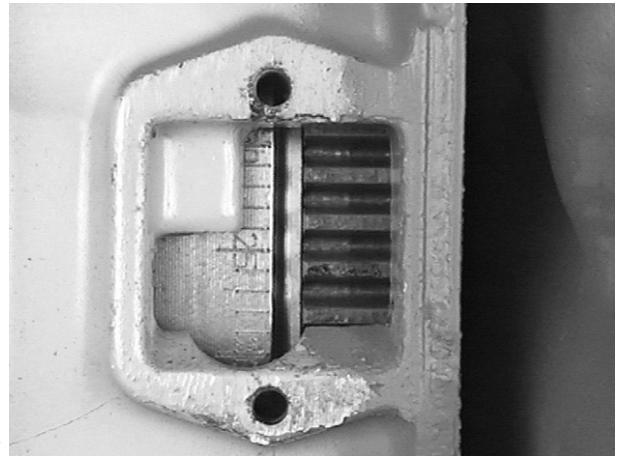
During assembly the delivery start indicator on the  
vibration damper may have moved out of correct  
adjustment.

Therefore check whether the scale of degrees on  
the inspection hole cover of the flywheel housing  
(picture 18) and on the vibration damper (picture  
19) indicate the same values.

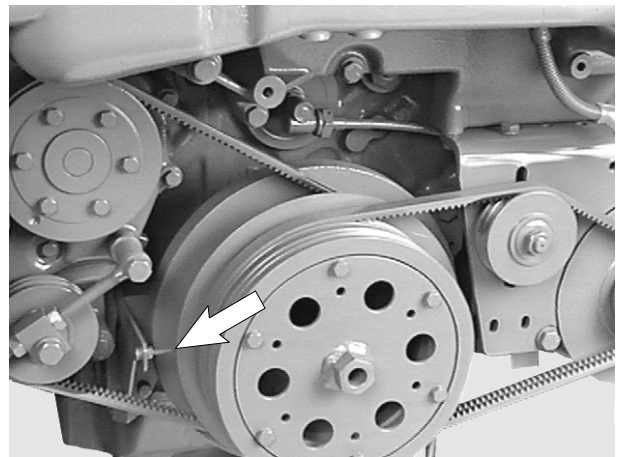
If necessary readjust delivery start indicator.



**Caution:**  
Unblock the crankshaft.



18



19

## Removing flywheel

Fig. 1

Loosen mounting bolts (24 mm), securing the engine against turning if necessary.



**Note:**

Owing to the high initial torque a reinforced socket (for machine screws) in connection with a 1/2" tool is required.

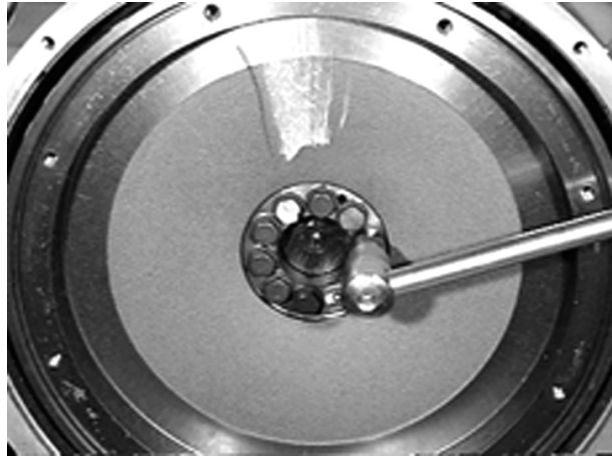


Fig. 2

Remove two bolts facing each other and replace them by two guide pins (special tool, see page 169, item. 16).

Remove all bolts.



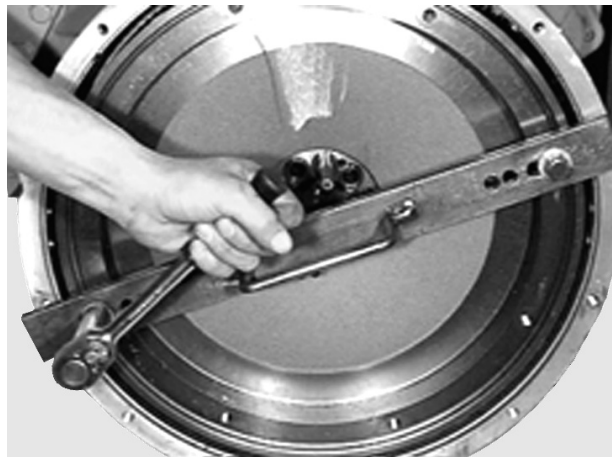
Fig. 3

Pull off flywheel using a flat metal bar and two bolts M12 x 1.5. Do not tilt it so that it jams.



**Danger:**

The flywheel is heavy.  
Use lifting gear.



## Installing flywheel

Fig. 4

Screw in guide mandrels (special tool, see page 169, 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.

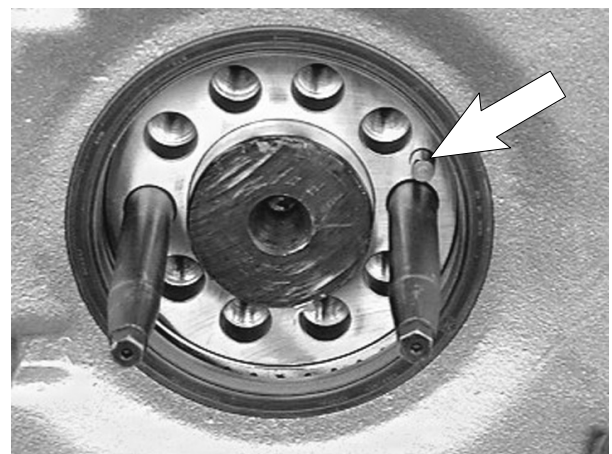


Fig. 5

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”).



5

## Changing starter gear ring

Fig. 6

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

**Caution:** Take care not to damage the flywheel.

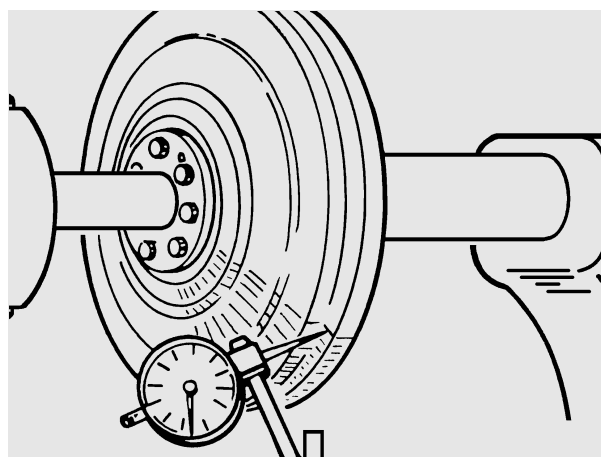


6

Fig. 7

**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.



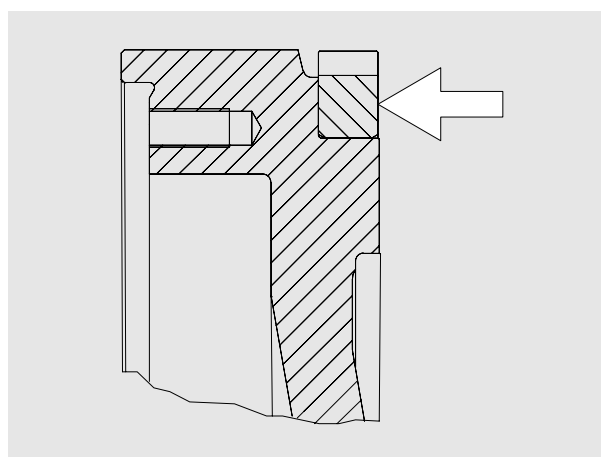
7

Fig. 8

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.



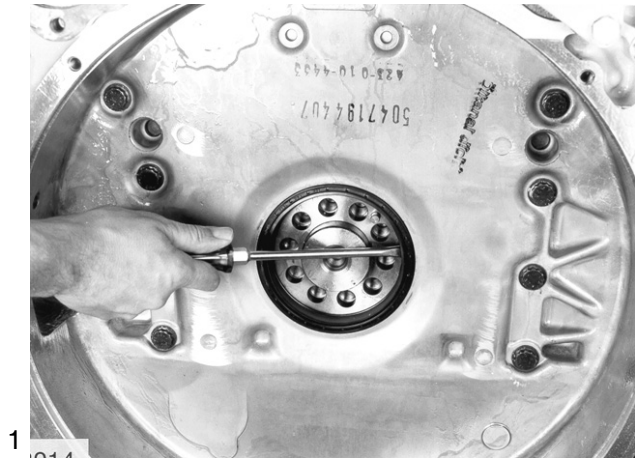
8

### Removing crankshaft seal

- Remove flywheel, see page 84

Fig. 1

Use a screwdriver to prise seal out of the timing case.



### Installing crankshaft seal

Fig. 2

The pressing mandrel consists of two parts. For pressing in, place guide ring of mandrel on crankshaft.



Fig. 3

Drive in seal with mandrel until flush. Observe remarks and installation notes on page 88.





## Exchanging bearing race

- Remove flywheel, see page 84

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.



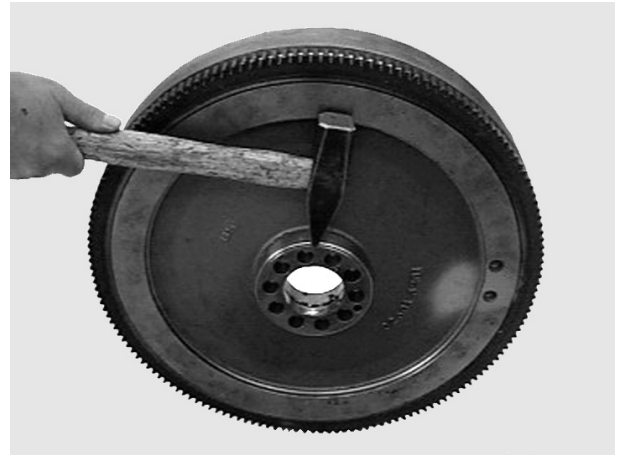
**Danger:**

Wear goggles and working gloves for protection against metal fragments.



**Caution:**

Do not damage flywheel.  
Do not use a chisel.



1



2

Fig. 2

Insert the new bearing race into the pressing mandrel (special tool, see page 169, 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).

Fig. 3

Press in bearing race until it stops.



3

Fig. 4

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



4

### 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 loses its initial stress and becomes useless.

- Drain coolant, see page 49



**Note:**

When carrying out work on the intake system ensure meticulous cleanliness to avoid damage to the engine.

## Removing intake manifolds

Fig. 1

The intake manifolds are located in the engine's V area. For this reason the intercooler, charge-air pipes and injection lines must be removed first.

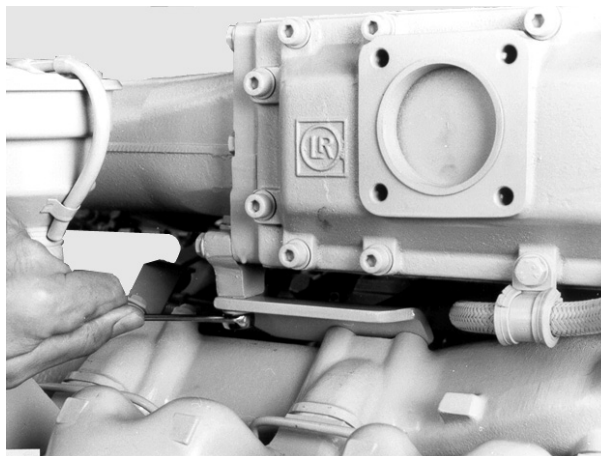


Fig. 2

Remove charge-air manifold. For this purpose the heat exchanger must be removed.

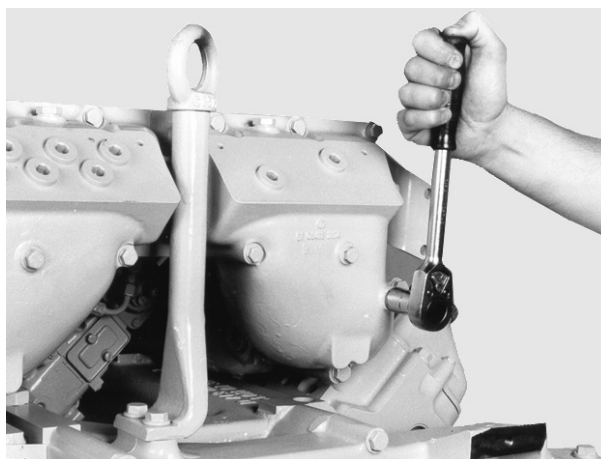


Fig. 3

Numerous brackets for fuel lines and air hoses for the charge-air pressure control valves (only on LE4.. models) are attached to the intake manifolds.

Before removing these lines, memorise or note down in a drawing the position of the individual brackets, hose clamps, discs etc to facilitate subsequent assembly.

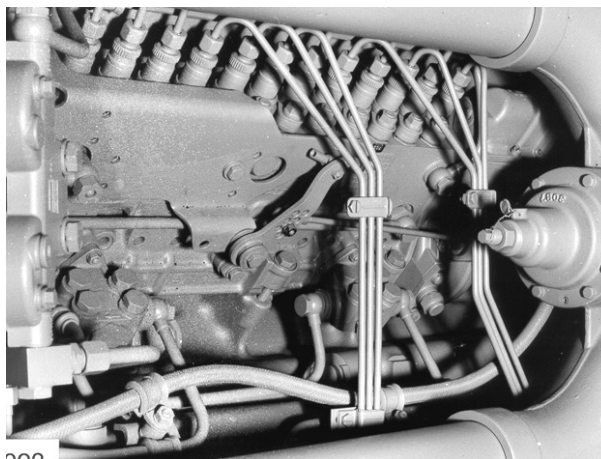


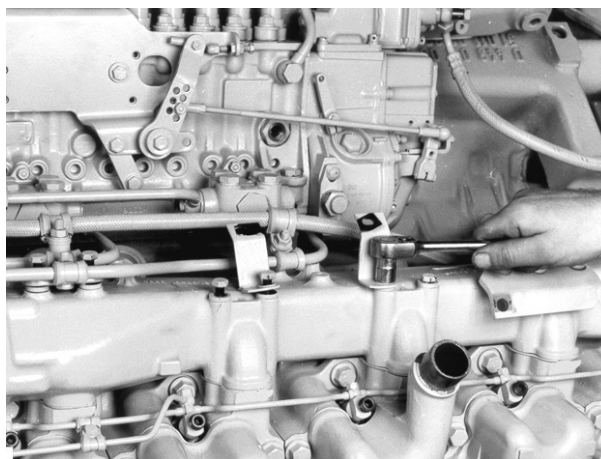
Fig. 4

Loosen mounting bolts and remove intake manifolds.



**Caution:**

Ensure that no impurities get into the intake ducts.



### Installing intake manifolds

Fig. 5

Place intake manifold with new seals in position. Screw in mounting bolts but do not tighten them yet.

Ensure that the arrangement of brackets and hose clamps for the fuel lines and air hoses is correct.

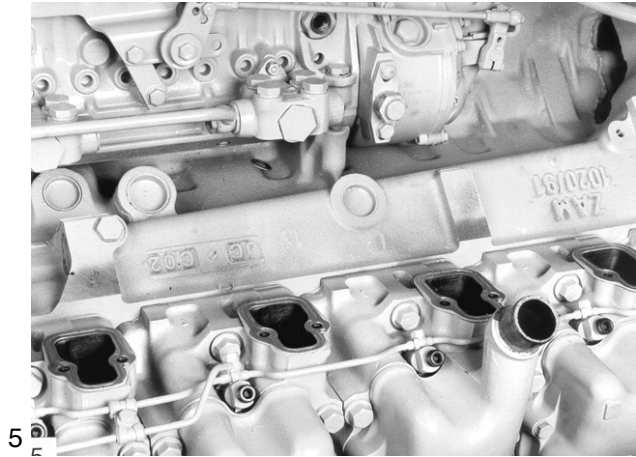


Fig. 6

Fit charge-air manifold.

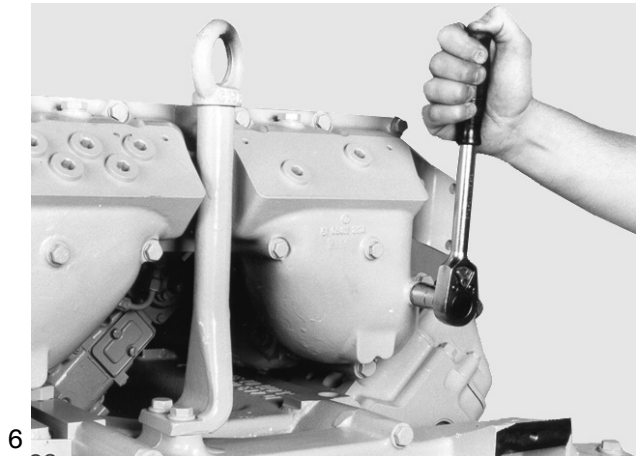


Fig. 7

Only now tighten mounting bolts on the intake pipes to the specified torque.

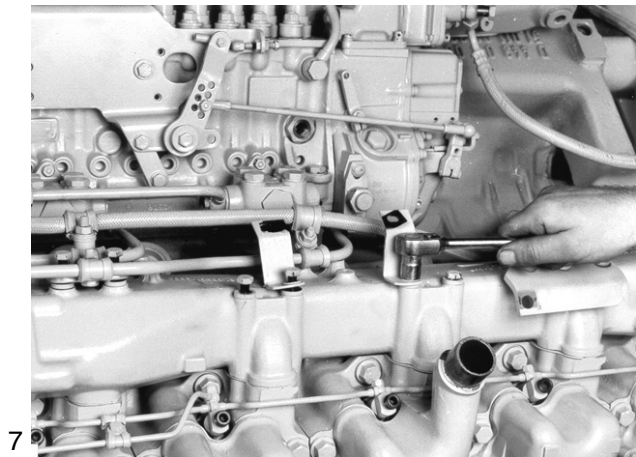


Fig. 8

Install injection lines, intercooler and charge-air pipes.

Bleed fuel system.

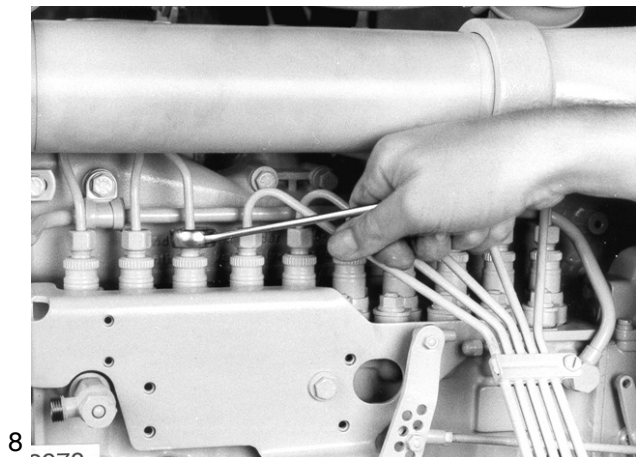


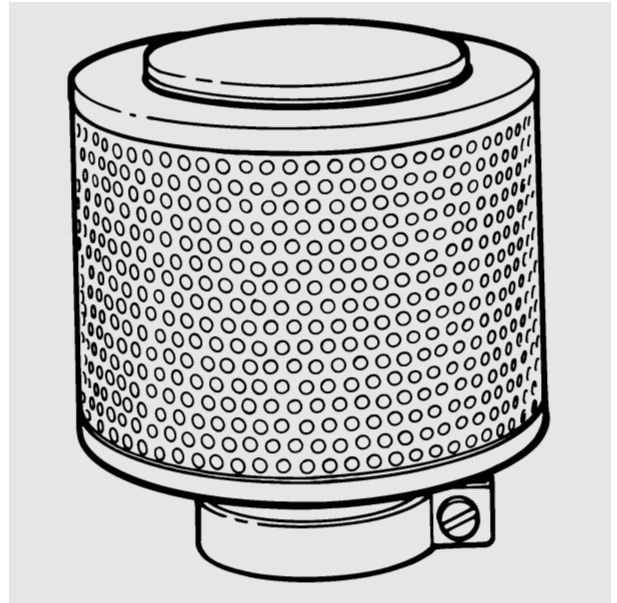
Fig. 1

**Only if wet-air filter is fitted:**

Once dust has visibly settled on the filter, remove filter and rinse it out in fuel or washing oil.

Dry the element by shaking it out vigorously.

Coat filter surface with engine oil lightly and evenly.

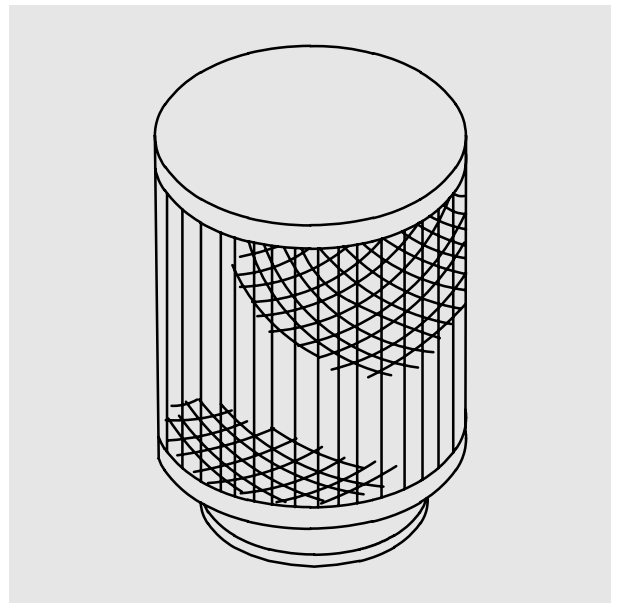


1

Fig. 2

**Only if DURALITE dry-air filter is installed:**

DURALITE air filters cannot be washed out but must be exchanged.



2

## Removing exhaust manifold

- Drain coolant, see page 49

Fig. 1

Remove turbocharger (in LE4.. models complete with diffuser) (see page 99).  
Remove exhaust manifold (19 mm).



**Note:**

The picture shows an exhaust manifold with charge-air pressure control valve.

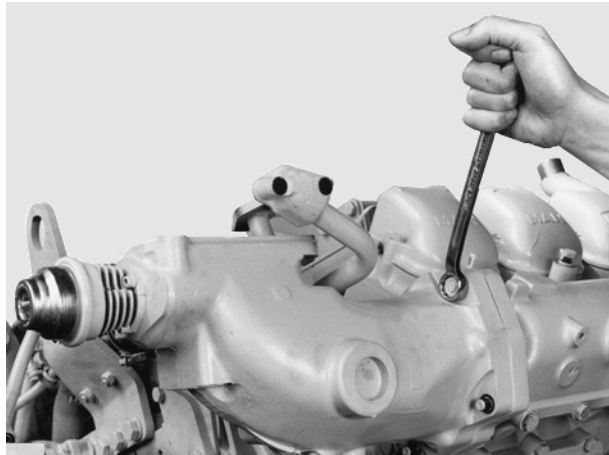


Fig. 2

Loosen mounting bolts (17 mm) and take off exhaust manifold.

To remove the right-hand exhaust pipe, the oil filter bowls must be removed (see page 71). Close up oil filter console to prevent dirt or foreign matter from getting into the lube oil circuit.



**Danger:**

The exhaust pipe is heavy.  
Replace two screws by stud bolts as a guide aid if necessary.



Remove exhaust manifold flanges.

## Installing exhaust manifold

Fig. 3

To install the exhaust manifold flanges (8-hole flange), a dropped ring spanner (special tool, 19 mm) is required. Use dropped ring spanner only with torque wrench up to 200 Nm.

Observe the order in which the bolts and nuts are to be tightened and the torque (see “Engineering, Data, Setting values”). Use new seals.

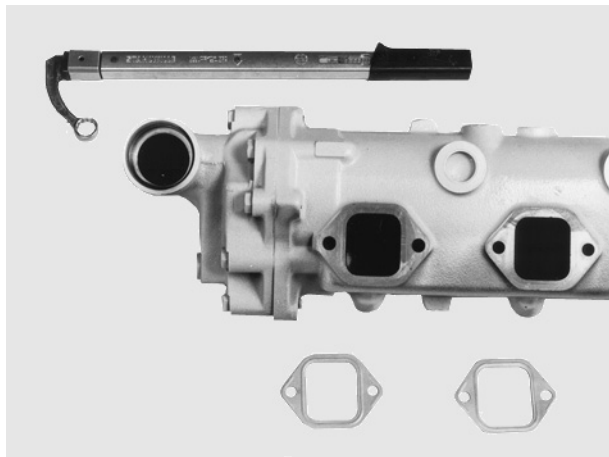


Fig. 4

The coolant inlet to the liquid-cooled exhaust pipes is located at the heat exchanger end.

Ensure that the correct O-rings are used for the assembly.

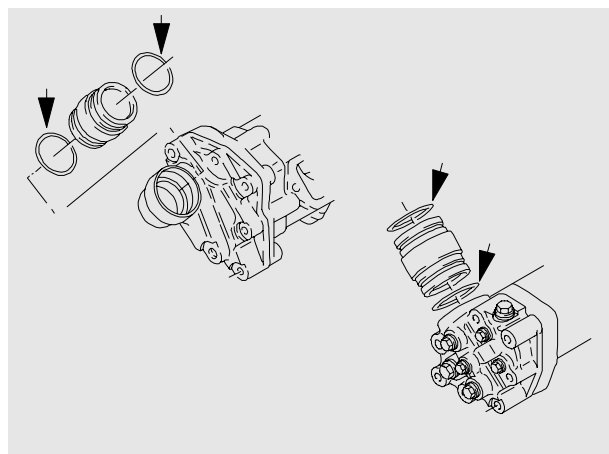
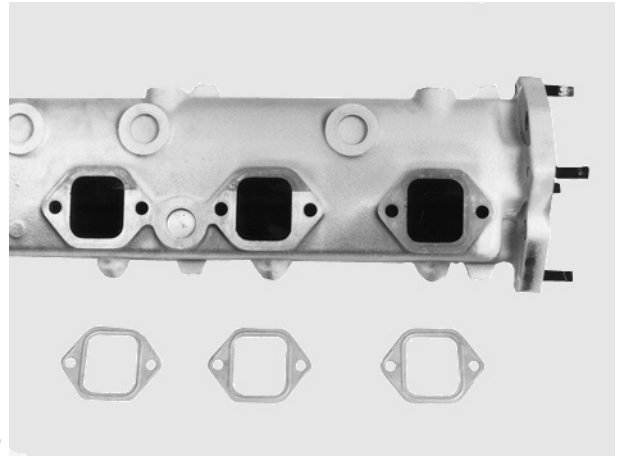


Fig. 5

Install exhaust manifold with new seals. Ensure that the bolts are tightened to the correct torque.



5

## Removing exhaust manifold

- Drain coolant, see page 49
- Remove turbocharger, see page 99

Fig. 1

Remove exhaust manifold.

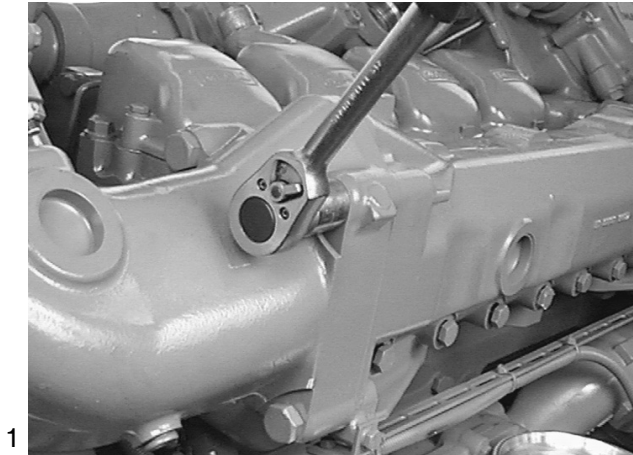


Fig. 2

Loosen mounting bolts (17 mm).

To remove the right-hand exhaust pipe, the oil filter bowls must be removed (see page 71). Close up oil filter console to prevent dirt or foreign matter from getting into the lube oil circuit.

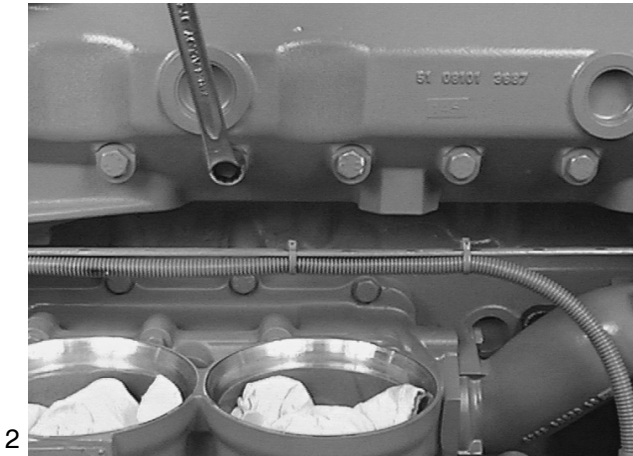


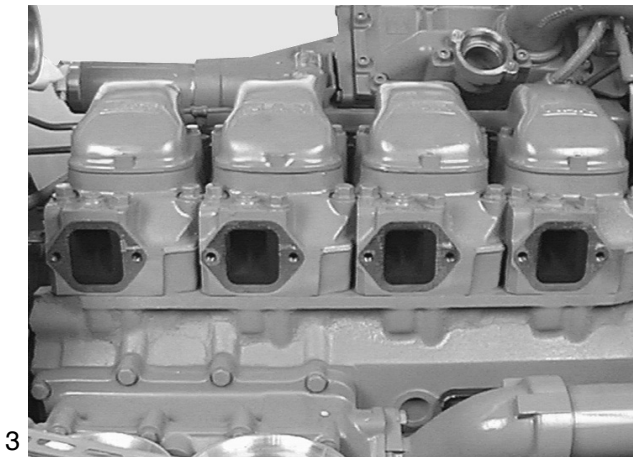
Fig. 3

Take off exhaust manifold.



**Danger:**

The exhaust pipe is heavy.  
Replace two screws by stud bolts as a  
guide aid if necessary.



## Installing exhaust manifold

Fig. 4

Install exhaust manifold with new seals.

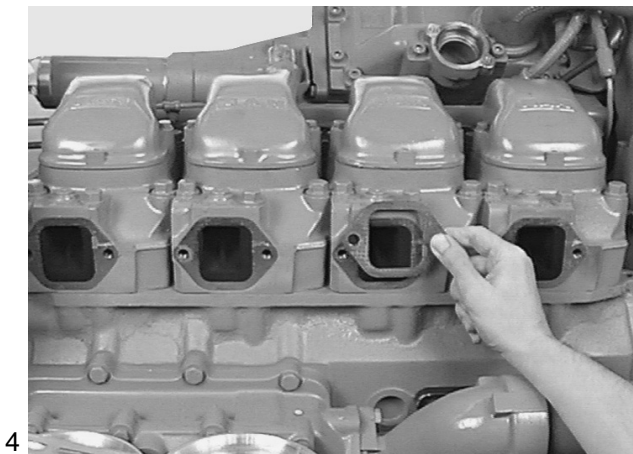
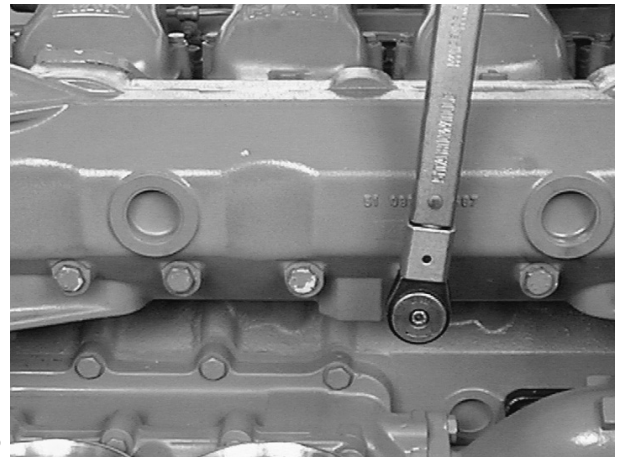




Fig. 5

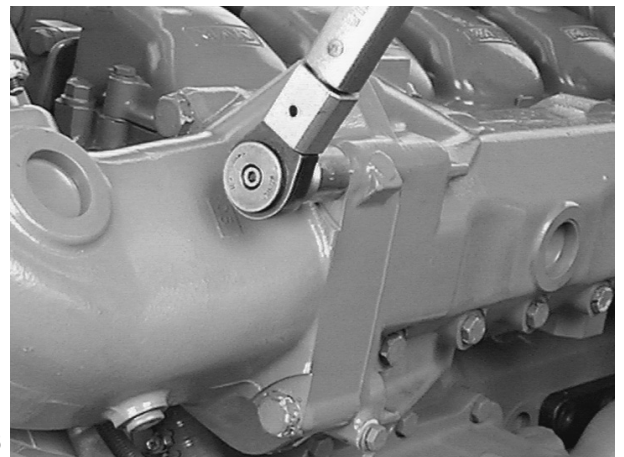
Tighten mounting bolts to specified torque (see “Engineering • Data • Setting values”).



5

Fig. 6

Tighten mounting bolts on exhaust manifold cross-wise to Works Standard M 3059 (see “Engineering • Data • Setting values”).



6

### 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,
- speed adjustment (to full load stop).

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 too 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 "Service Products 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.

### The right value for the 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 when the ship was commissioned and was noted in the commissioning report is to be used as the set-point value.

### Special features of the measurement

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

Fig. 1

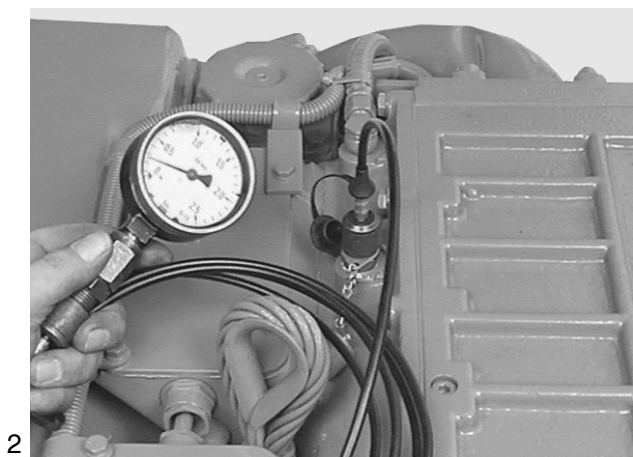
Two measuring connections for checking the charge-air pressure and the charge-air temperature (also see the measuring points table in "Engineering, Data and Setting values") are located in the charge-air elbow behind the intercooler.

Remove the screw plug and connect up the pressure gauge (M14x1.5).



Fig. 2

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



## Removing turbocharger

Fig. 1

Remove intake neck and charge-air pipes.

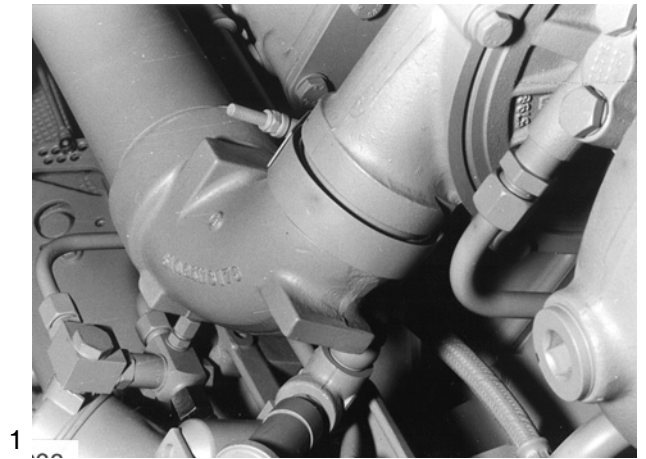


Fig. 2

Remove oil supply and return lines (17 mm).

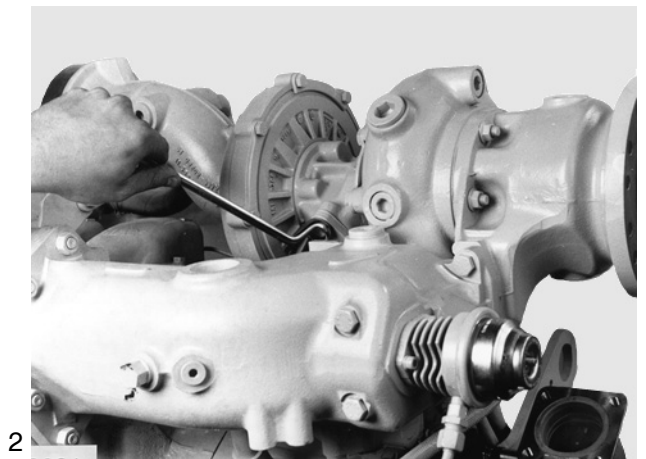


Fig. 3

Loosen mounting bolts (17 mm).  
Remove turbocharger.



## Installing turbocharger

Fig. 4

In LE4.. models install turbocharger only together with diffuser because of the joint seal. The turbocharger-diffuser sealing face must be completely level.



Fig. 5

Check intake lines and exhaust manifold for foreign matter. Check oil supply and return lines for damage, clogging and leaks.

Remove old seals completely and fit new ones.

Connect up air filter and charge-air pipes.



5

Fig. 6

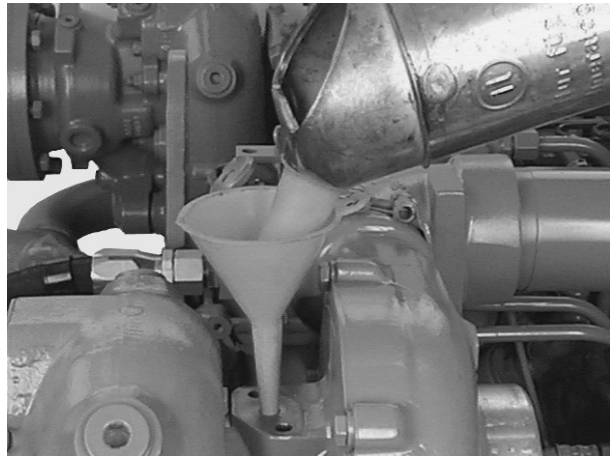
Tighten mounting bolts to specified torque.

Fill bearing housing up with clean engine oil.

Connect up oil supply line.

Prior to mounting the oil return line let engine turn over until a constant oil stream emerges from the turbocharger.

Mount oil return line.



6

Fig. 7

Connect up charge-air pipes.

Check all connections for leaks and tension.



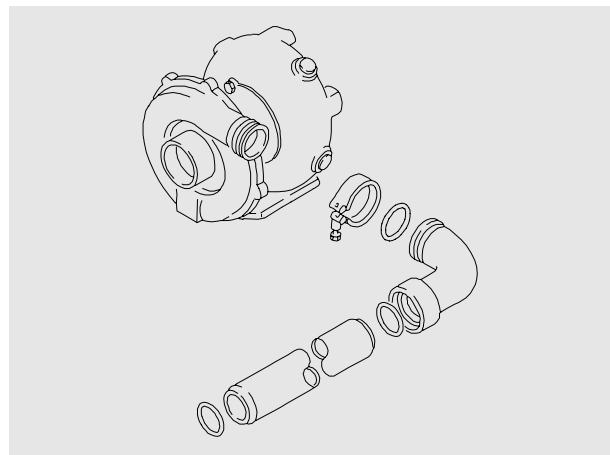
**Note:**

Leaky charge-air pipes cause charge-air pressure loss. This results in the formation of black smoke and poor performance.



**Caution:**

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



7

- Remove turbocharger, see page 99

Fig. 1

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

## Axial clearance

Fig. 2

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 clearance is exceeded.

## Radial clearance

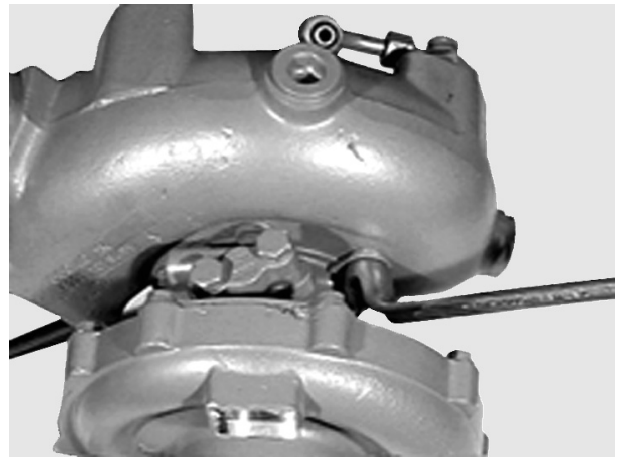
Fig. 3

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

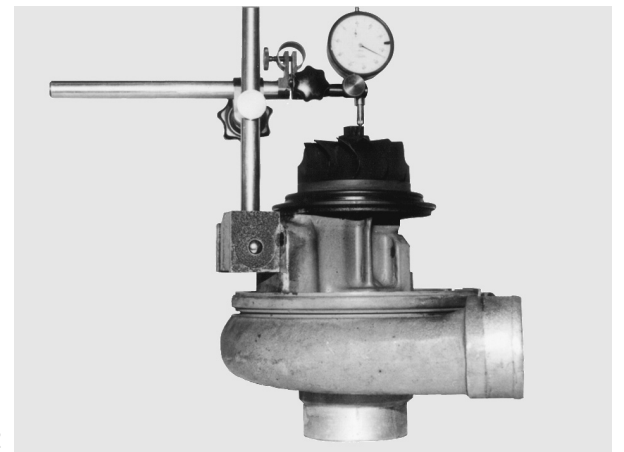
Apply dial gauge tip to side of hub. Push turbine wheel towards dial gauge. Read and note down value.

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

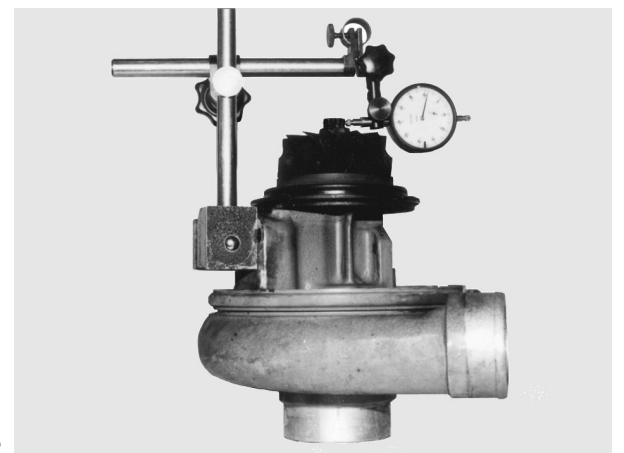
Place turbine housing in position, observe markings and screw on turbine housing.



1



2



3

Fig. 1

New D 284. LE4.. engines are equipped with waste gates (arrow). Their task is to limit the charge-air pressure to a precisely defined value.

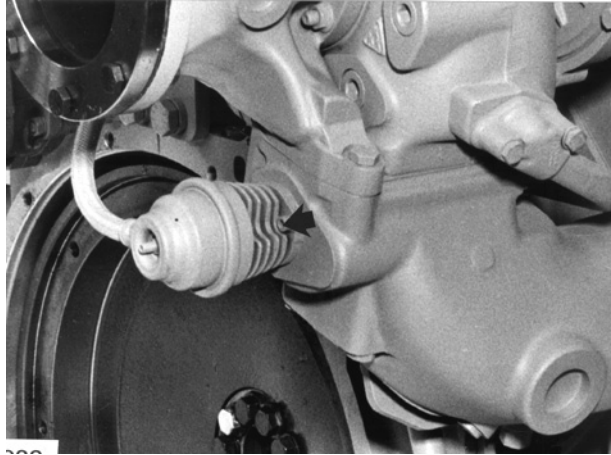


Fig. 2

The waste gates are maintenance-free. Manipulation or modification of the setting is not permitted.





Fig. 1

D 2840 L.. and D 2842 L.. engines are equipped with a charge-air pressure relief valve. Its task is to offset charge-air differences between the individual cylinder banks in engines with cylinder bank cutout and intercooler separated on the air side. The intercooler separation on the air side ensures that in low-load operation the bank fired is supplied with a sufficient quantity of combustion air.

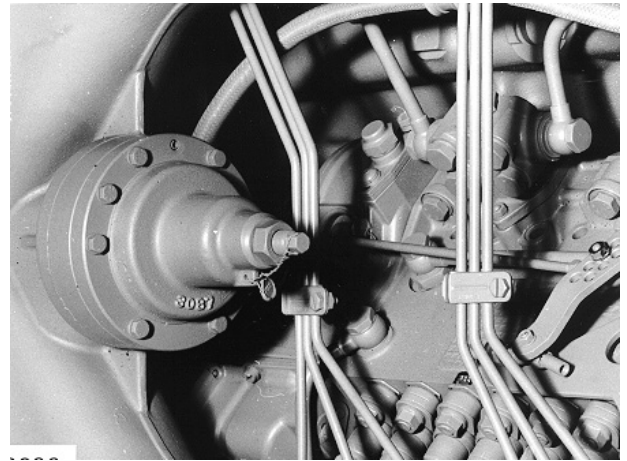


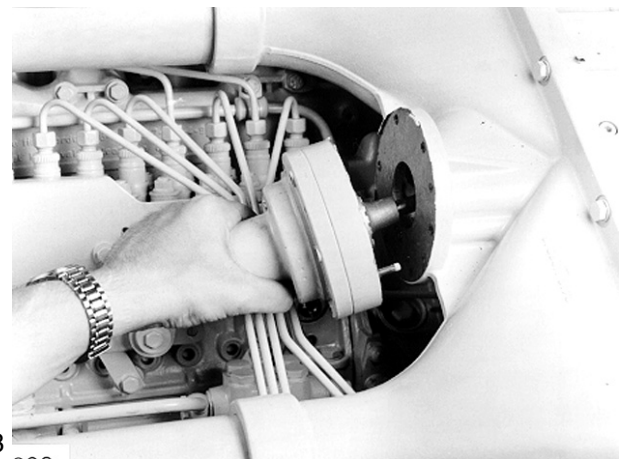
Fig. 2

If charge-air pressure relief valves are defective (diaphragm leaky) charge air emerges from the relief bore (arrow).



Fig. 3

Exchange defective charge-air pressure relief valve assembly complete. Remove mounting bolts (10 mm) and take off valve. The installation is carried out in reverse sequence. Clean sealing face beforehand, coating it with "CURIL" sealing agent.



## Removing cylinder head

- Drain coolant, see page 49
- Remove injectors, see page 43

**Note:**

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

Fig. 1

Take off the cylinder head covers (13 mm).

**Note:**

On engines recently manufactured the valve covers are fastened with Torx bolts for which an E12 – ½” wrench is required.

Fig. 2

Back off valve adjusting screws.  
Loosen mounting bolts of rocker arm bracket (17mm).

Fig. 3

Remove rocker arm bracket.

Fig. 4

Take out push rods.

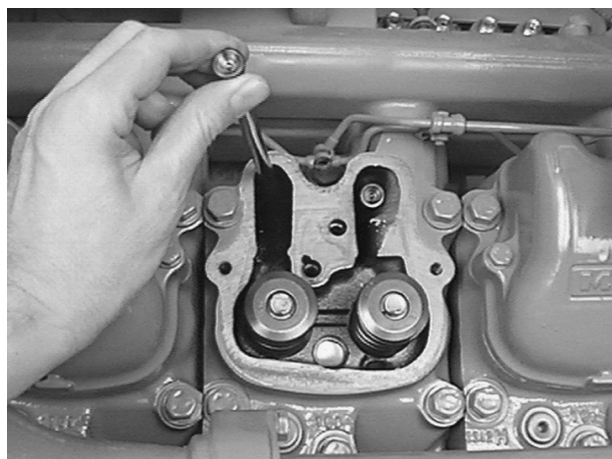
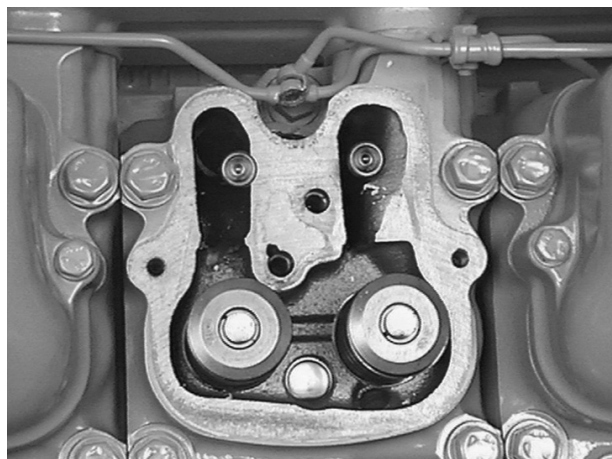
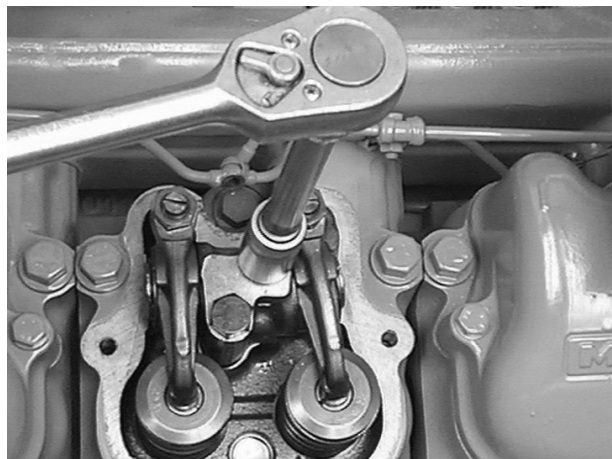
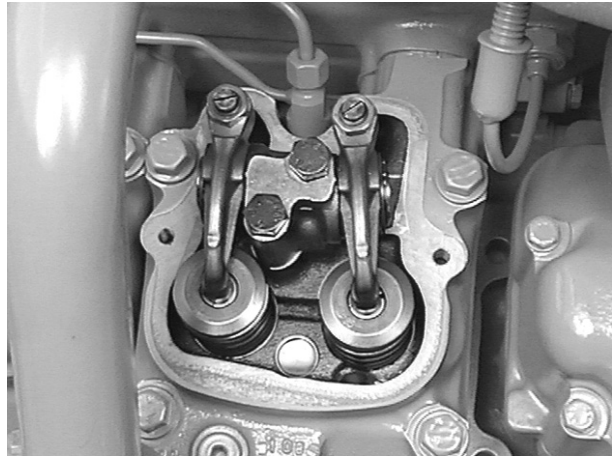


Fig. 5

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

Fig. 6

Remove the mounting bolts from the intake and exhaust pipes for the respective cylinder head. Also remove those intake and exhaust pipe bolts, which are adjacent to the respective cylinder head. This will reduce the tension on the cylinder head, and the head can be taken off more easily.



6

Fig. 7

Take off cylinder head and cylinder head gasket. Check whether cylinder head sealing face and cylinder block are plane using a straight edge. Non-plane cylinder heads can be remilled 1 mm. Notice specified projection of injection nozzles and valve recess (see "Engineering • Data • Setting values").



**Note:**

Check cylinder heads for cracks.



7

## 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.

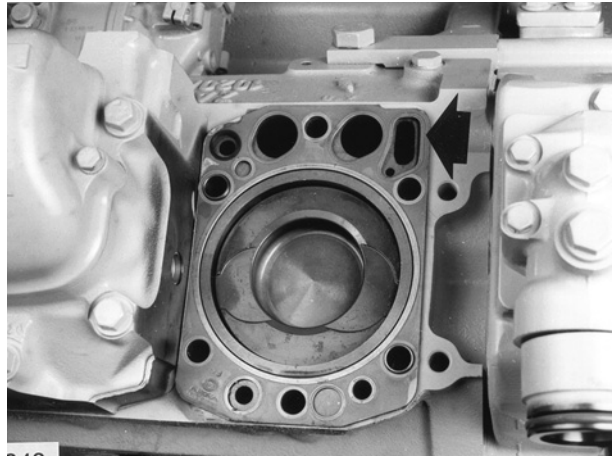


Fig. 9

Each cylinder head is located with two fitting sleeves.



Fig. 10

Check whether the cylinder head bolts have the max. permissible length (see: "Engineering, data and 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.

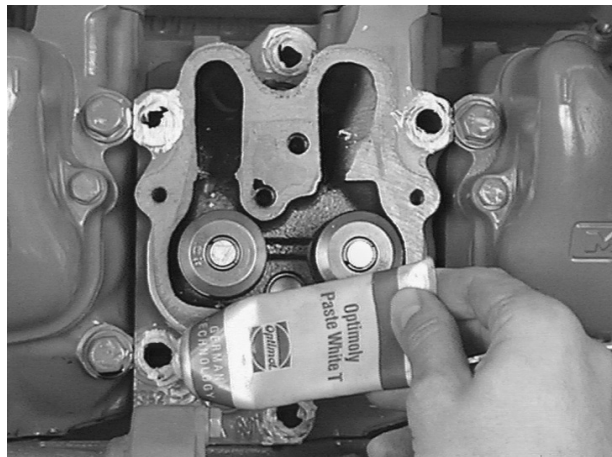
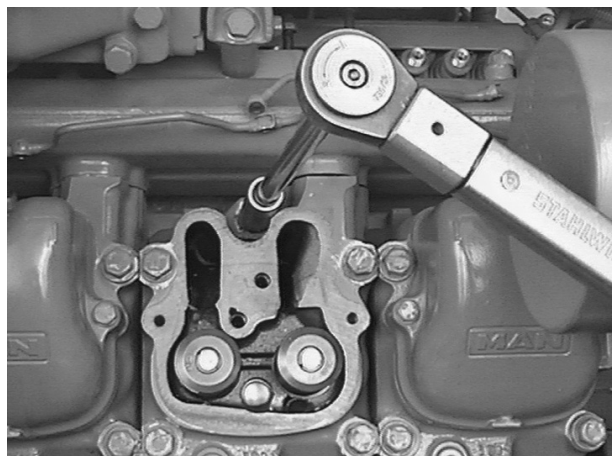


Fig. 11

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.

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

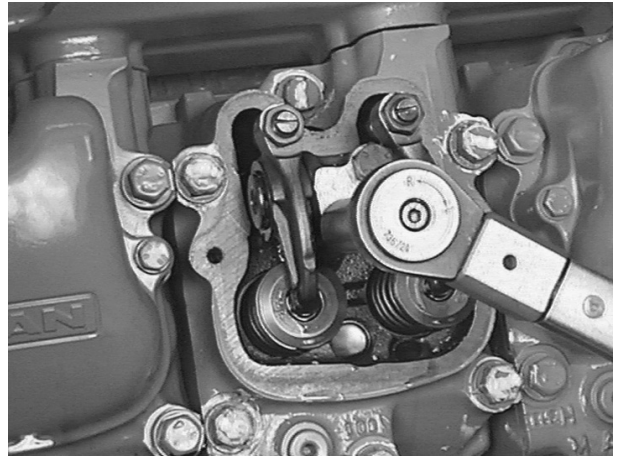


Fig. 13

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

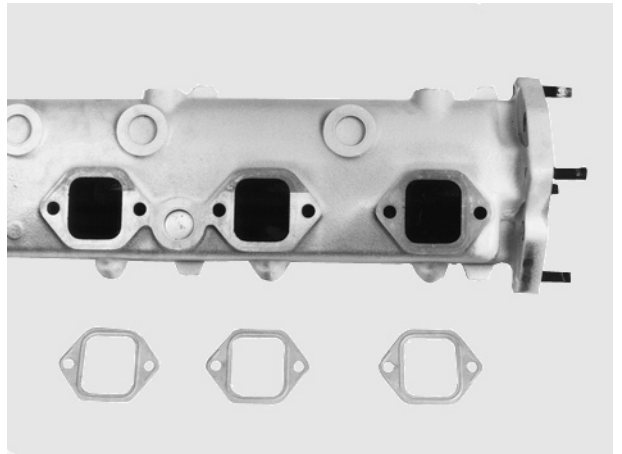
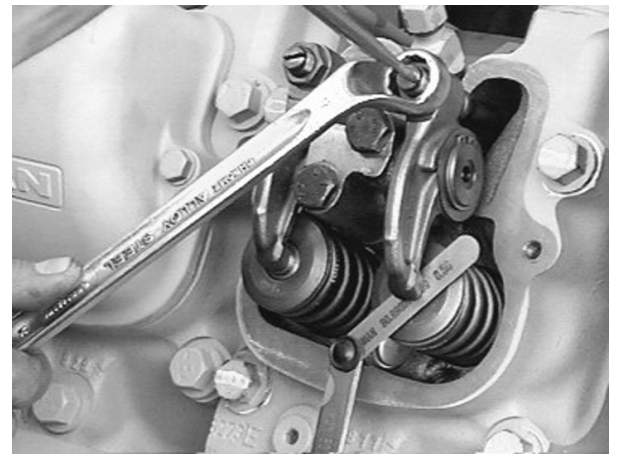


Fig. 14

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

14



### 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<sub>2</sub>.

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.

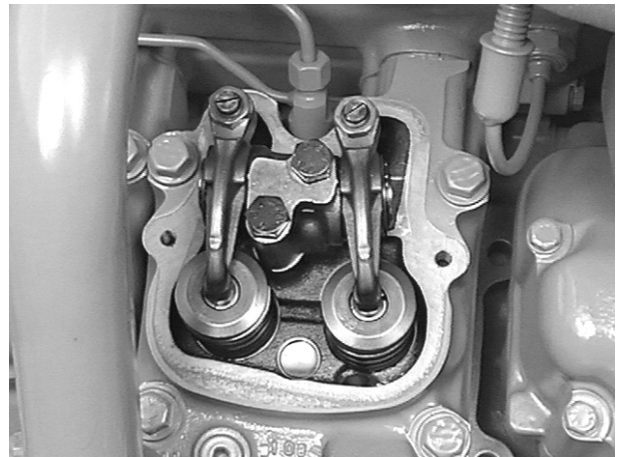
**Caution:**

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.

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

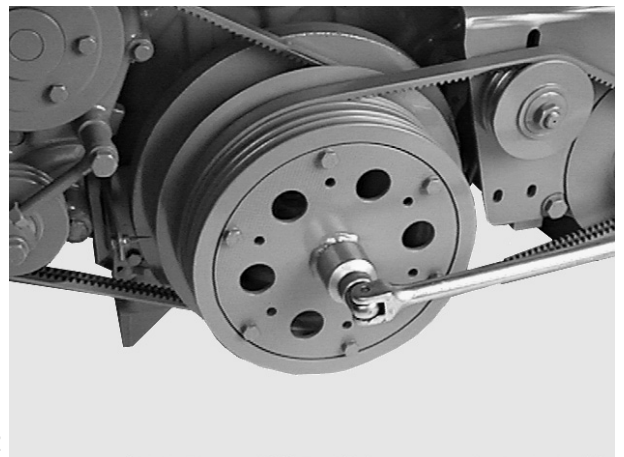


1

Fig. 2

Turn engine with engine cranking device until the piston in the cylinder to be set is at TDC (Top Dead Centre). At this point both inlet and exhaust valves will be open i. e. valves overlap.

**Note:**  
 As far as possible turn engine only in direction of rotation (anti-clockwise as seen when looking at the flywheel) in order to prevent the direction of rotation of the raw water pump impeller being reversed.



2

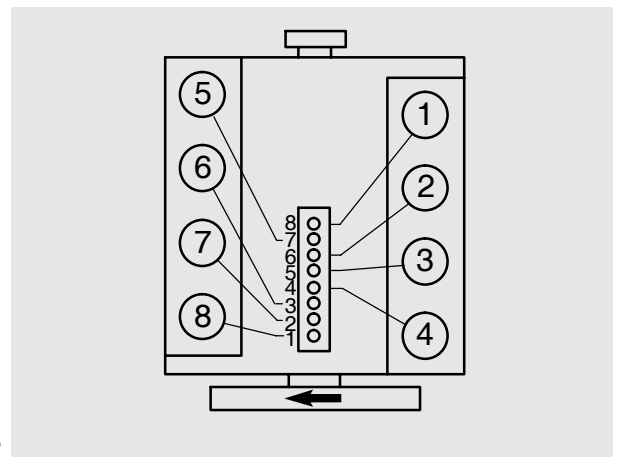
Fig. 3

D 2848 L..

Valves are in crossover in cylinder

1	5	7	2	6	3	4	8
6	3	4	8	1	5	7	2

Set valves in the cylinder



3

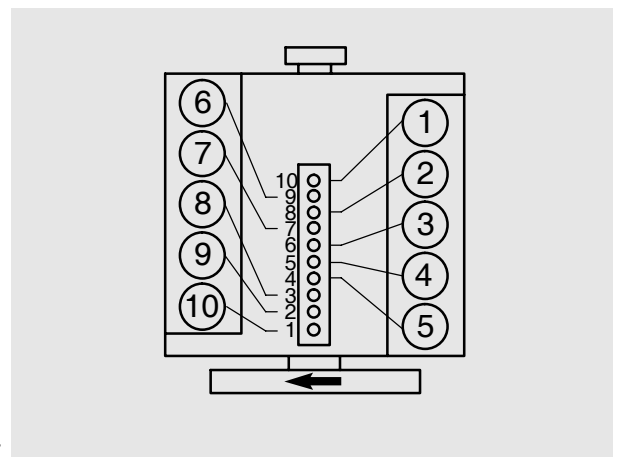
Fig. 4

D 2840 L..

Valves are in crossover in cylinder

1	6	5	10	2	7	3	8	4	9
7	3	8	4	9	1	6	5	10	2

Set valves in the cylinder



4

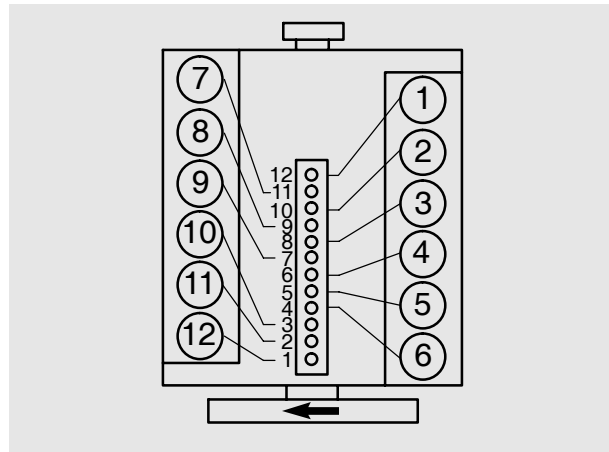
Fig. 5

D 2842 L..

Valves are in crossover in cylinder

1	12	5	8	3	10	6	7	2	11	4	9
6	7	2	11	4	9	1	12	5	8	3	10

Set valves in the cylinder

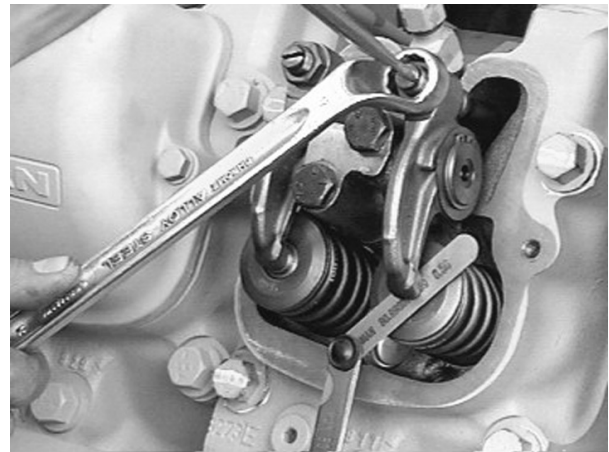


5

Fig. 6

Push feeler gauge between valve stem and rocker arm. Loosen lock nut (17 mm) 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.



6

Fig. 7

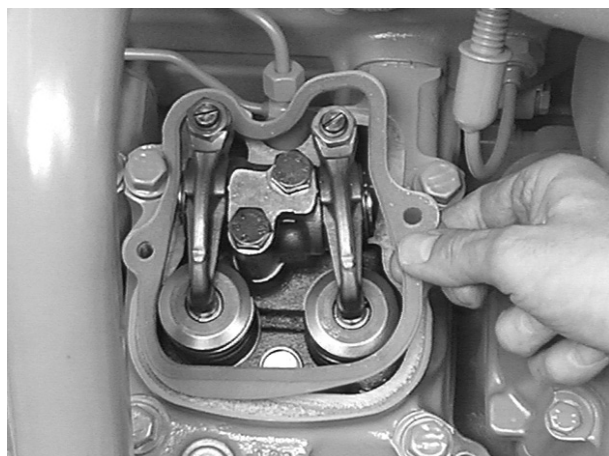
Setting the valves can be considerably facilitated by using the valve setting tool.



7

Fig. 8

Refit cylinder head covers with new gaskets.



8



- ,Remove rocker arms. see page 104

Fig. 1

Unclip circlip.



1

Fig. 2

Take rocker arms off the rocker arm shaft.



**Note:**

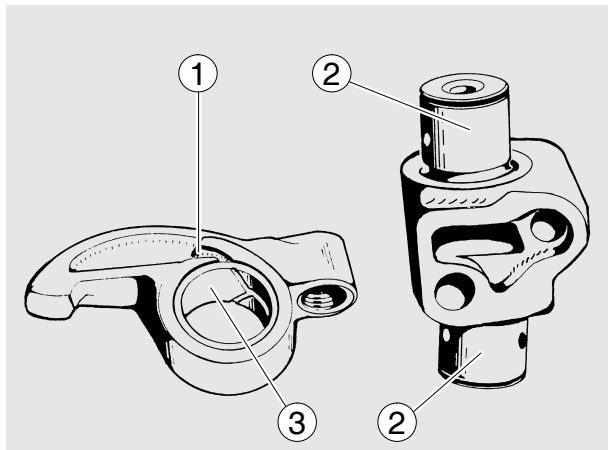
If the rocker arm bearing bushes have to be exchanged, ready-to-install new or re-conditioned rocker arms are to be used.



2

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.



3

### Removing valves

- Remove rocker arms. Take off cylinder head, see page 104.

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

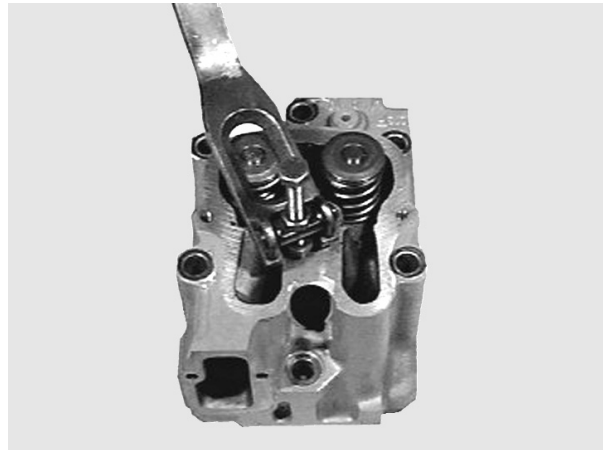


Fig. 2

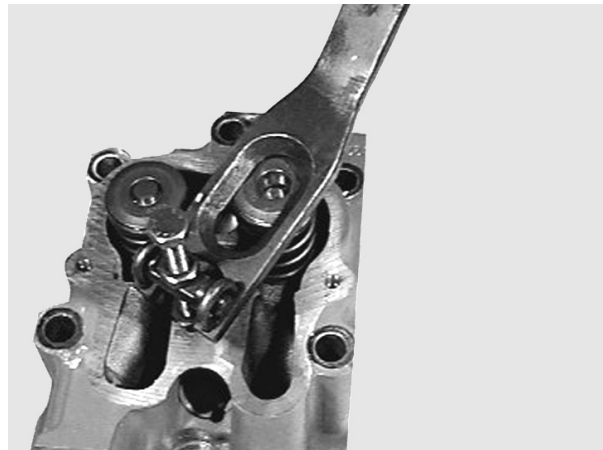


**Note:**

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



Figs. 3 and 4

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

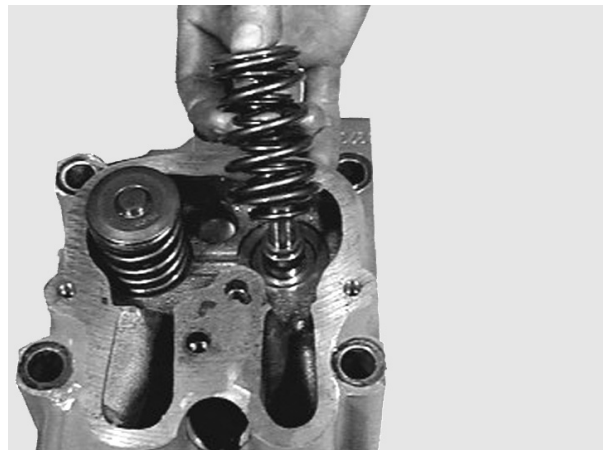


**Note:**

The engines are equipped with valve stem seals (arrow).

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

3



4



## Installing valves

Fig. 5

Apply oil to valve stem 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



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 171, item 19) on the respective valve and push on seal.



**Note:**

Use new valve shaft seals only.

6



7



Fig. 8

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

8



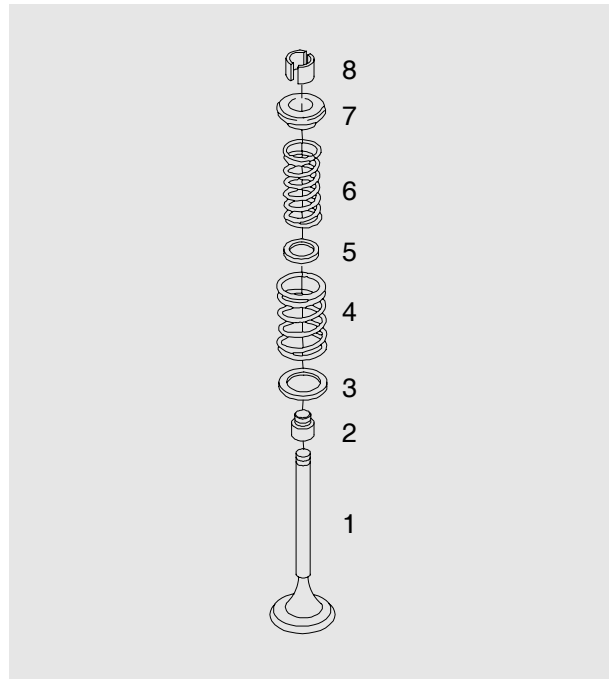
Fig. 9

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

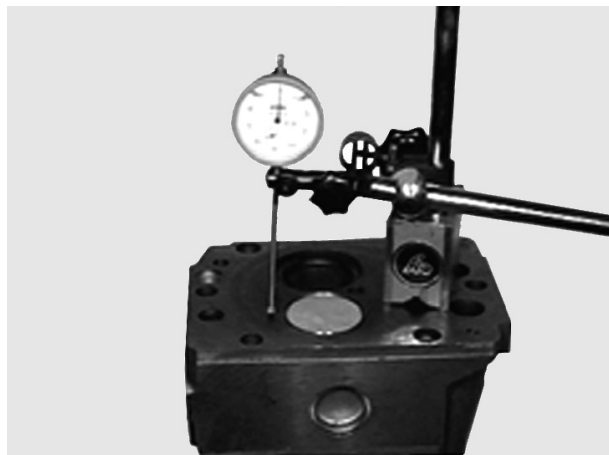


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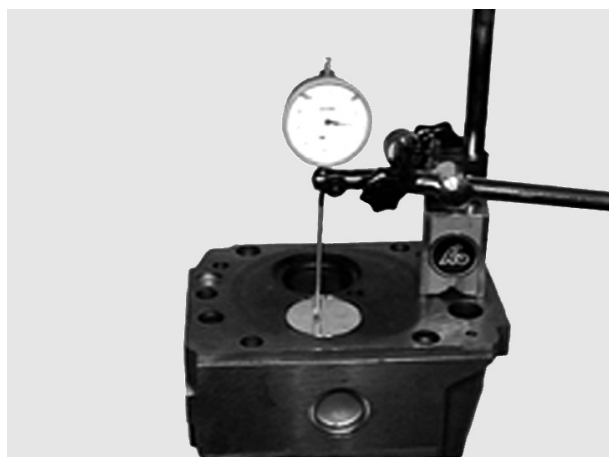
### Measuring valve recess

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



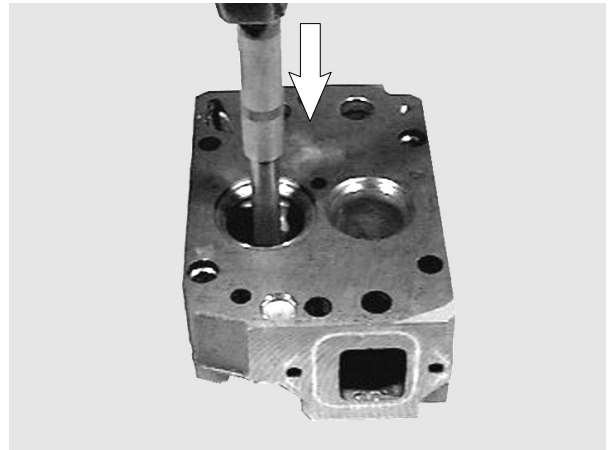
11

- For removing and installing cylinder head, see page 104
- For removing and installing valves, see page 112

Fig. 1

Press valve guide out of the combustion chamber side using pressing mandrel (special tool, see page 171, item 20).

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



1

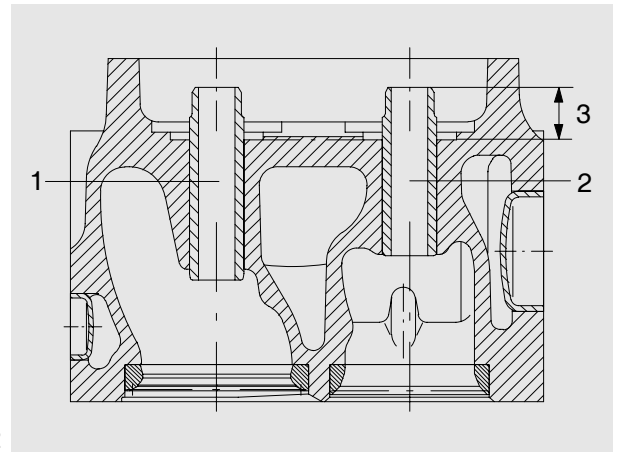
Fig. 2

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



**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



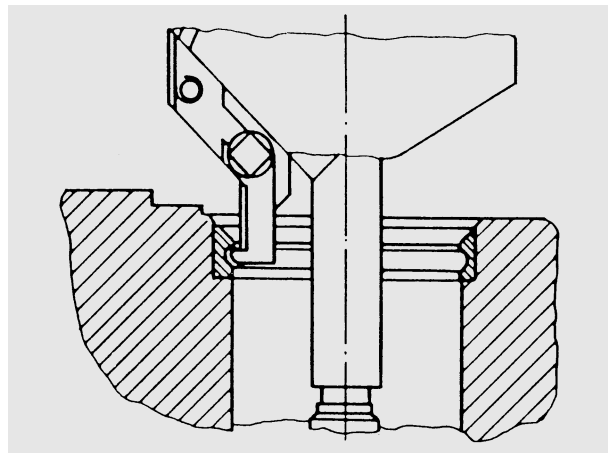
**Note:**

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

Fig. 2

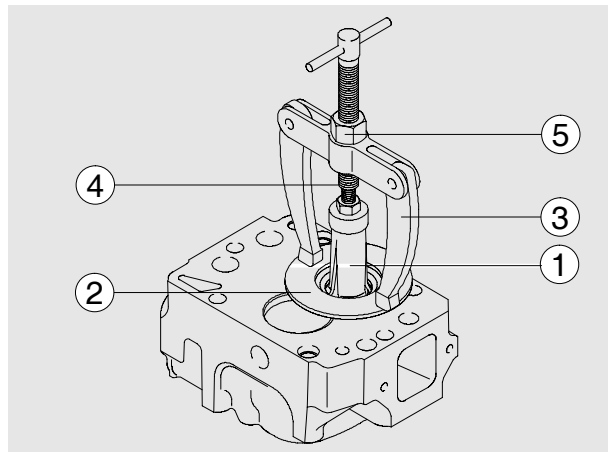


**Note:**

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.

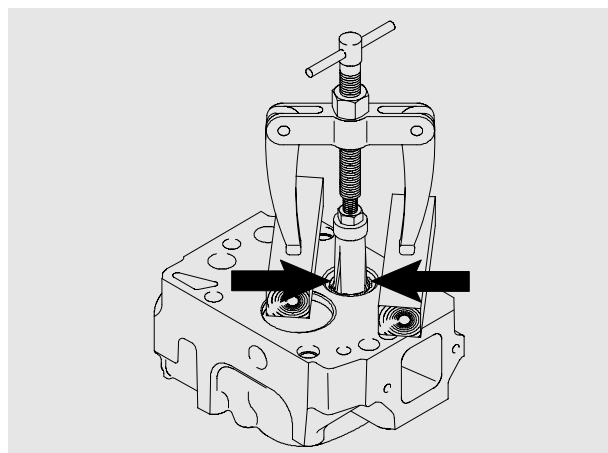


2

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

## 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



**Note:**

When the valve seat inserts have been changed, the valve seats must be re-worked.



**Note:**

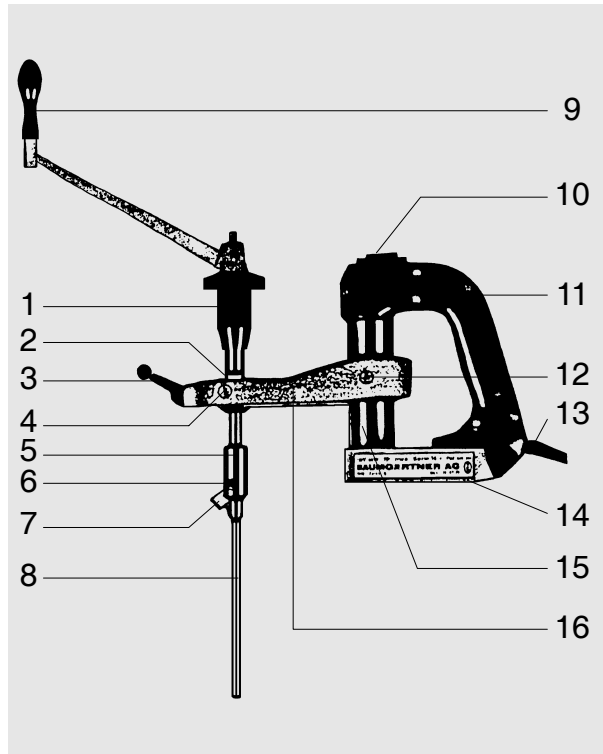
- After temperature equalization, machine valve seats.
- After machining, clean cylinder head and check for leaks using leak testing device.
- If the cylinder head is excessively heated (above +200°C, +390°F) the core hole covers (end covers) lose their tightness and must be exchanged.
- To do this, clean core holes, blow out channels and press in new core hole covers with "LOCTITE 648" and pressing mandrel (special tool, see page 175).

## 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

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.

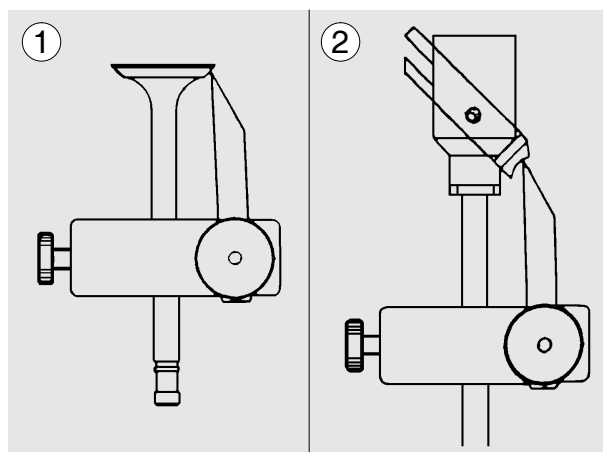


2

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



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.

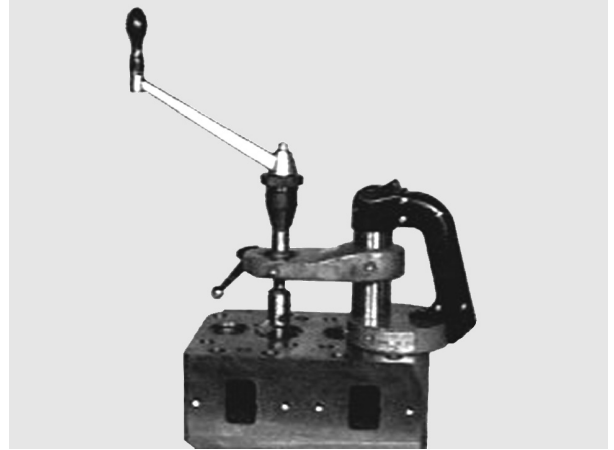



Fig. 5

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.

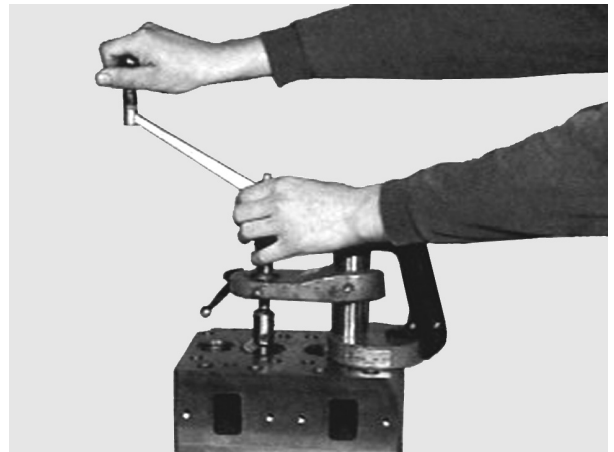


Fig. 6

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).

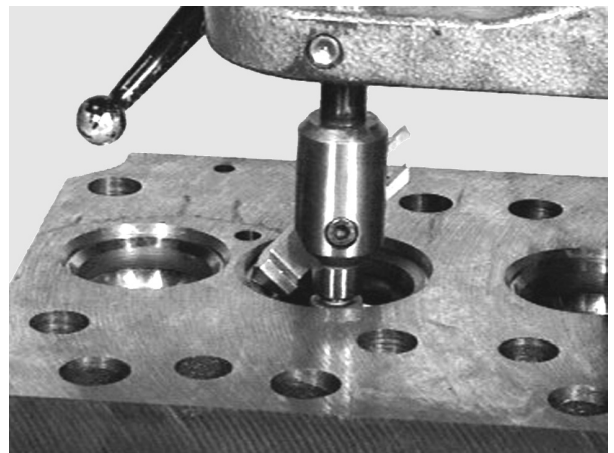


Fig. 7

Observe specified seat angle.

1 Exhaust, total angle:  $90^\circ$ , tool setting:  $45^\circ$

2 Inlet, total angle:  $120^\circ$ , tool setting:  $30^\circ$

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

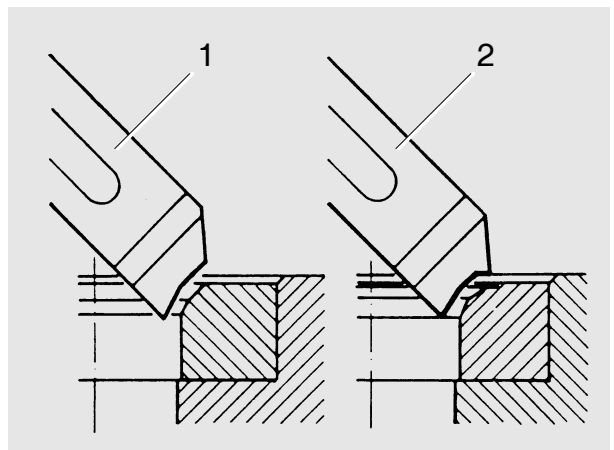


Fig. 8



**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.

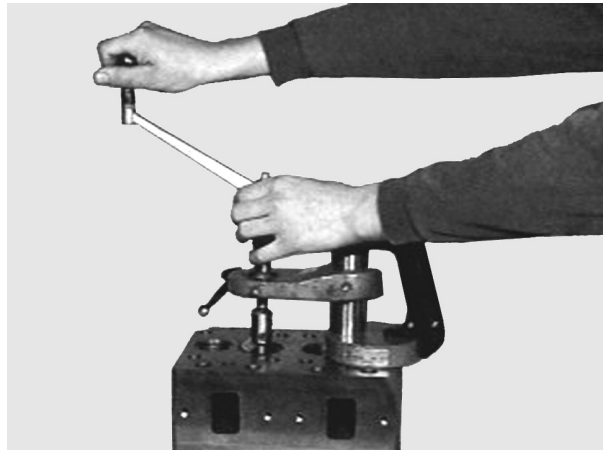
If the cylinder head interface is to be machined (max. 1 mm), the seat inserts must be reworked to achieve the valve retrusion.

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.

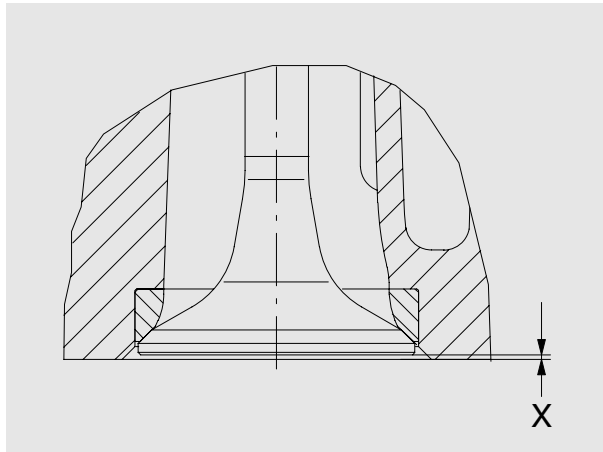
Fig. 9

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 114.



8



9

Fig. 1

Apply abrasive paste to tapered area on the valve seat.

Oil valve guide and insert valve.

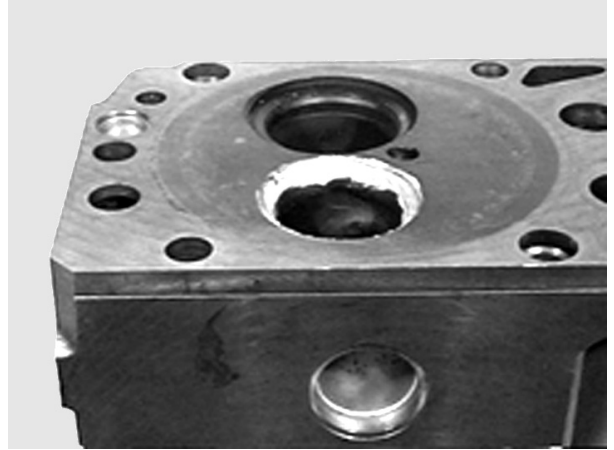



Fig. 2

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



**Caution:** Keep valve stem and valve guide free of abrasive paste.

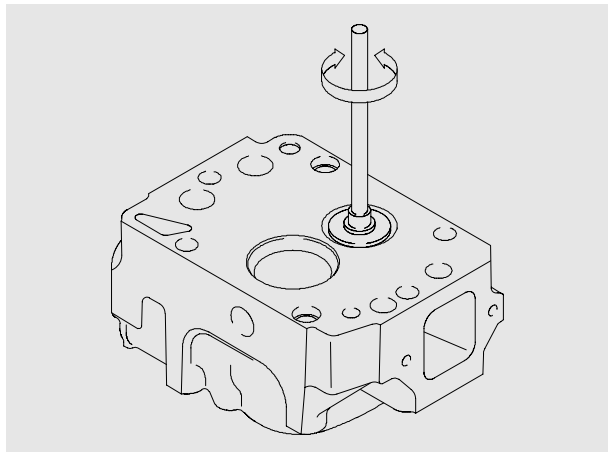


Fig. 3

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

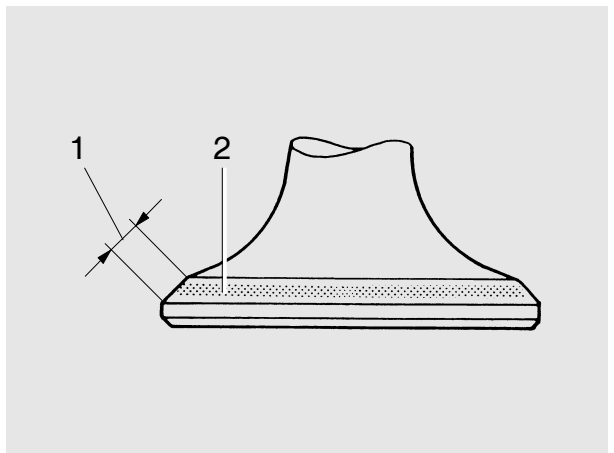



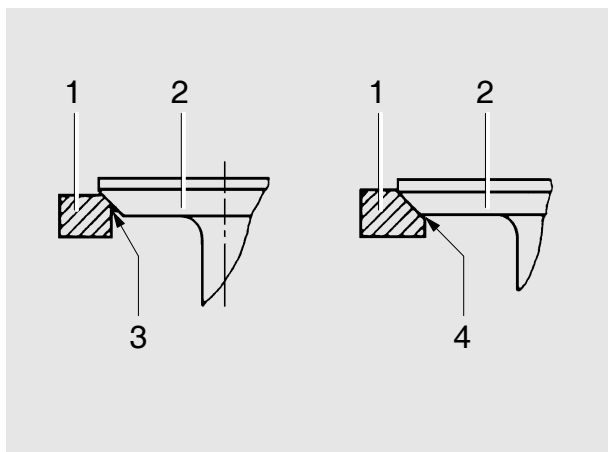
Fig. 4

- 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 –



- Check valve clearance and adjust, if necessary, see page 109
- Let engine warm up
- Remove all fuel injectors, see page 43
- For compression guideline values, see publication "Engineering • Data • Setting values"

Fig. 1

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



Fig. 2

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

Turn engine over with starter until needle deflection of compression recorder stops, at the same time holding adjusting lever of injection pump in stop position.

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



Fig. 3

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.

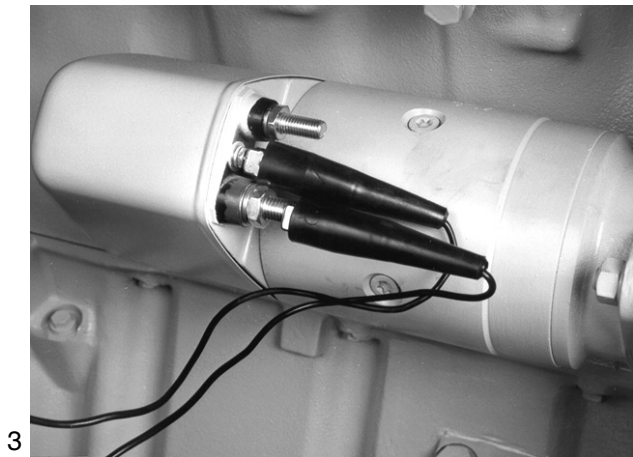
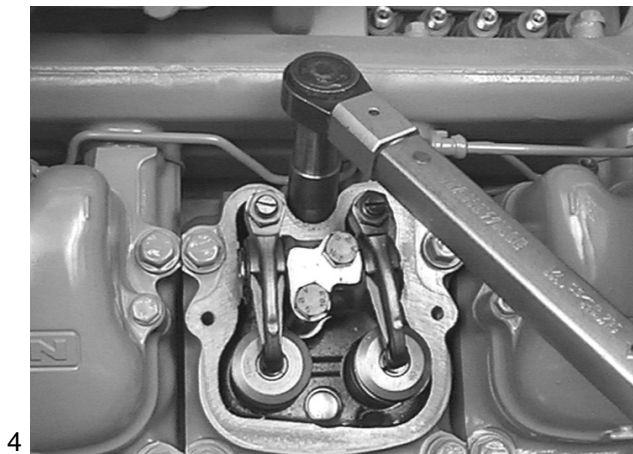


Fig. 4

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

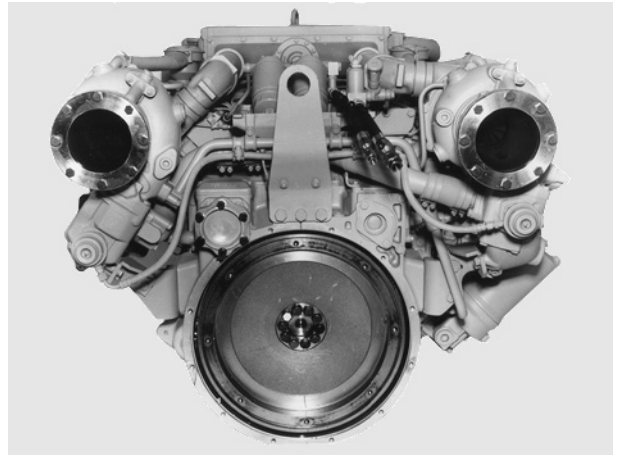


## Removing timing case

Fig. 1

The following engine components / auxiliary units are attached to the timing case and have to be removed:

- Starter
- Raw-water pump
- Hydraulic pump if fitted
- Fuel filter
- Oil and coolant lines
- Bracket for exhaust manifold
- Engine mounts if fitted



1

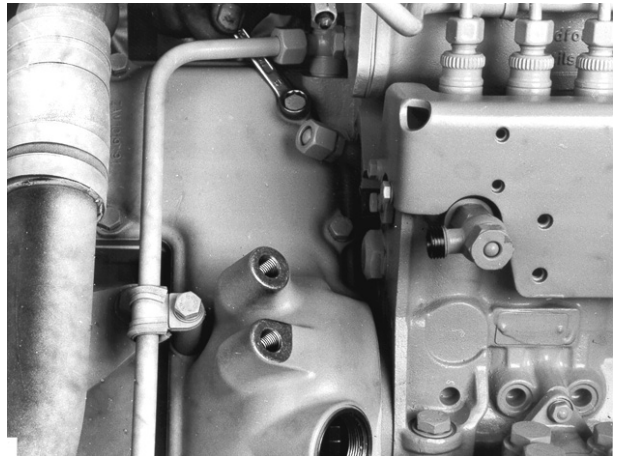
Fig. 2

Remove timing case cover (13 mm).



**Note:**

Pipelines are attached to the timing case cover. To facilitate reassembly, memorise, note down in a drawing or take a photo of the position of the brackets, pipe clamps, spacer sleeves etc.

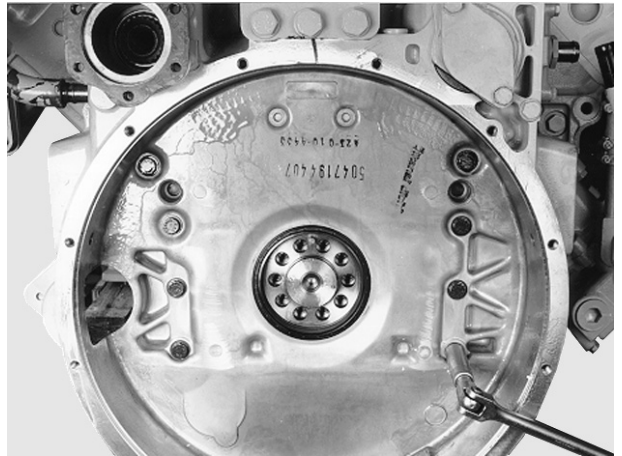


2

Fig. 3

Remove flywheel (see page 84).

Remove mounting bolts from timing case (17 mm). The timing case is bolted to the oil pan at the bottom.



3

Fig. 4

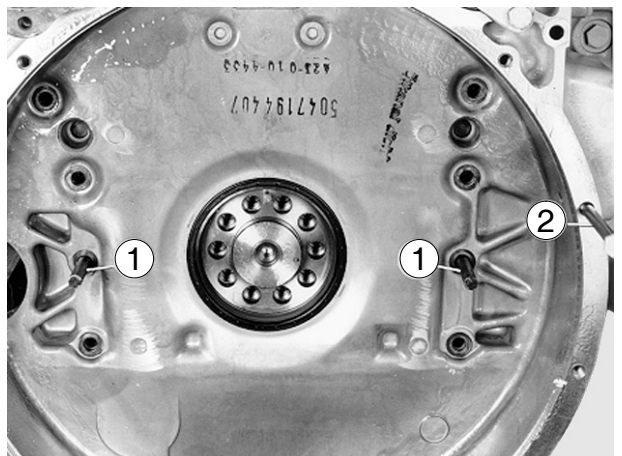


**Danger:**

The timing case is heavy.

Replace two opposite bolts with guide pins M12 x 1.5 ① if necessary.

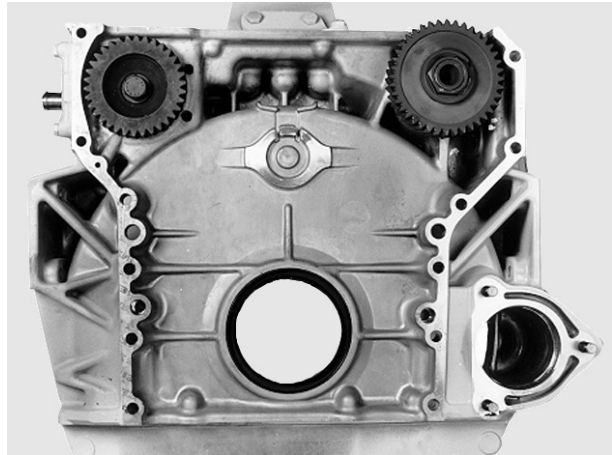
Two long M10 bolts ② screwed into the dead-end holes in the flange-on face facilitate handling the timing case.



4

Fig. 5

Remove timing case.



### Installing timing case

Fig. 6

Clean contact face on crankcase of sealing residues. Fit a new seal, sticking it on with a small amount of grease if necessary.

Guide timing case on to the alignment pins and bolt it into place.

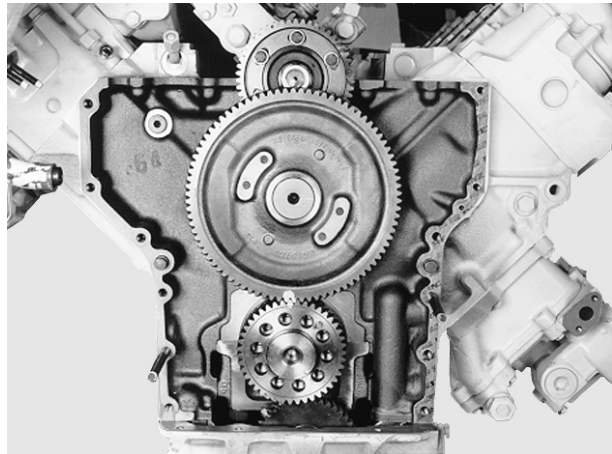


Fig. 7

Tighten bolts to specified torque.



**Note:**

Observe the different thread sizes when tightening the screws:  
10 bihexagonal bolts (M12, 17 mm) and  
2 hexagonal bolts (M10, 17 mm).

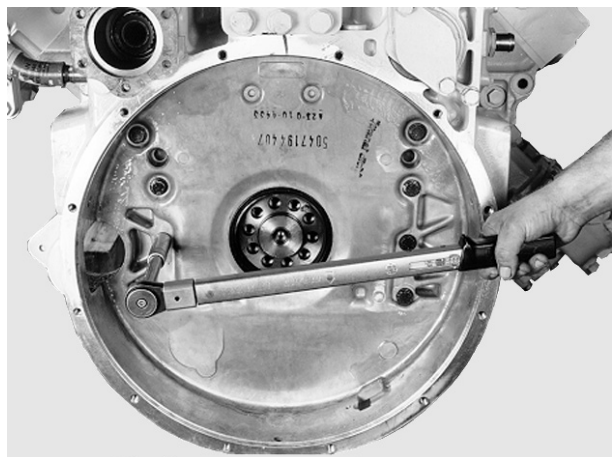


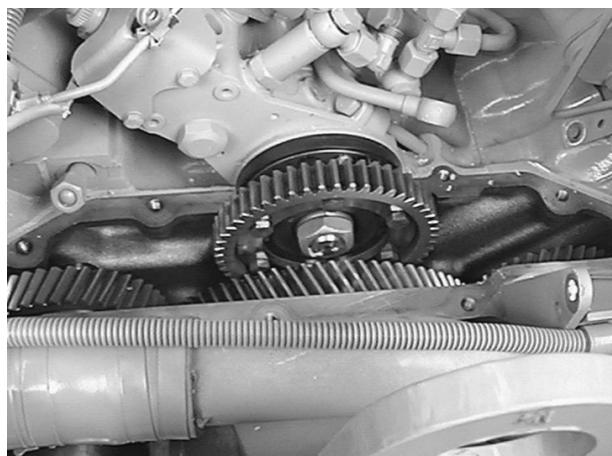
Fig. 8

Remove seal residues from sealing face of timing case cover.

Screw on timing case cover with new seal.

Fit the oil and coolant lines.

Refit all components previously removed.



## Removing camshaft

- Drain coolant, see page 49
- Remove oilpan, see page 73
- Remove starter, see page 148
- Remove flywheel and timing case, see page 123
- Remove the rocker arms and take out the push rods, see page 104



**Note:**

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

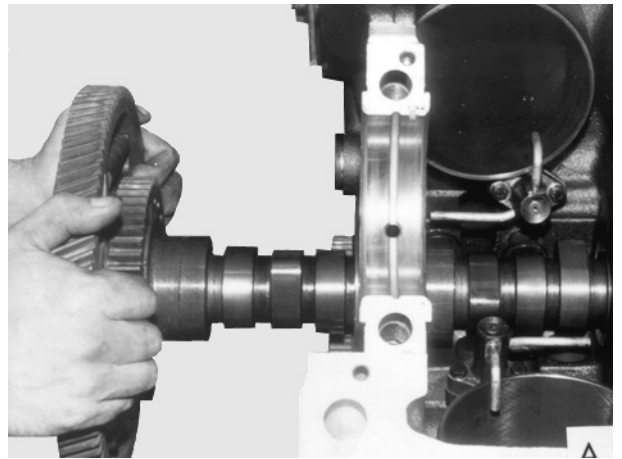


Fig. 1

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.

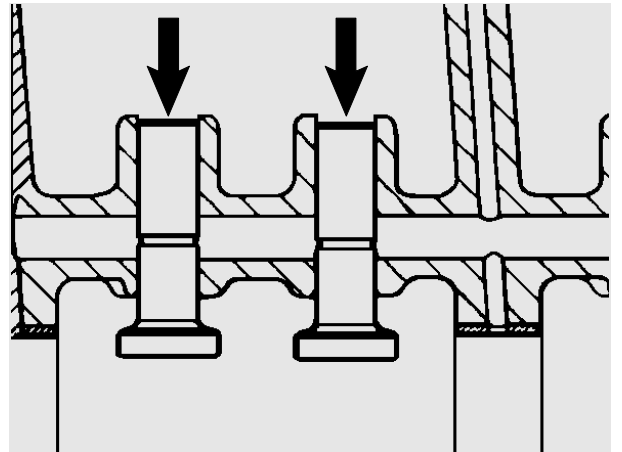


Fig. 2

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

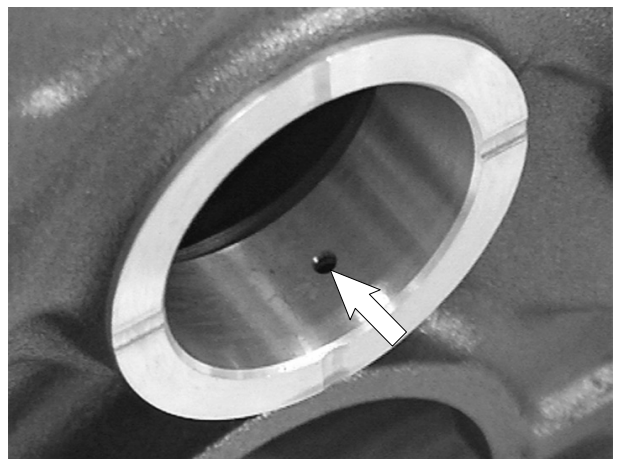
Fig. 3

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



**Note:**

The axial camshaft stop is located behind the last camshaft bearing bush on the timing case side. Owing to the helical gearing of the drive gear, the camshaft is always pulled against this stop.



## Installing camshaft

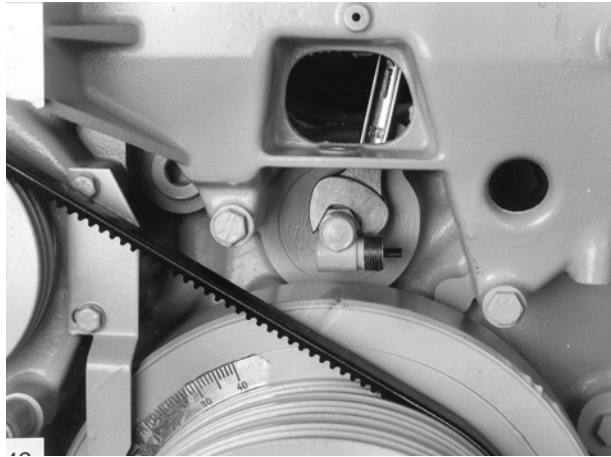
Fig. 4

The angle drive on the front side of the engine is driven by the camshaft.  
Before reinstalling the camshaft remove the angle drive.



**Note:**

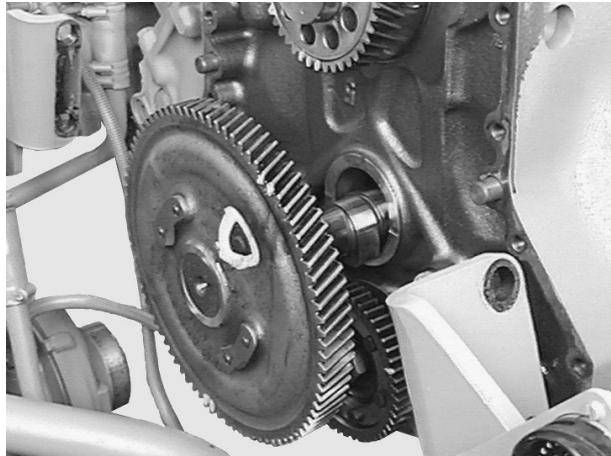
If the angle drive is installed the driving dog pressed into the camshaft cannot engage in the angle drive.



4

Fig. 5

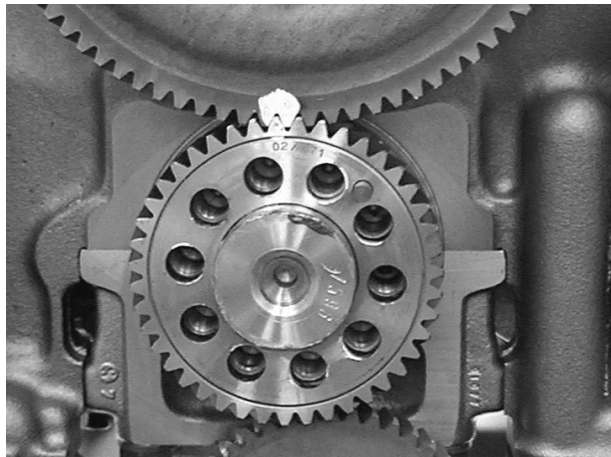
Apply oil to camshaft and insert it carefully.



6

Fig. 6

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

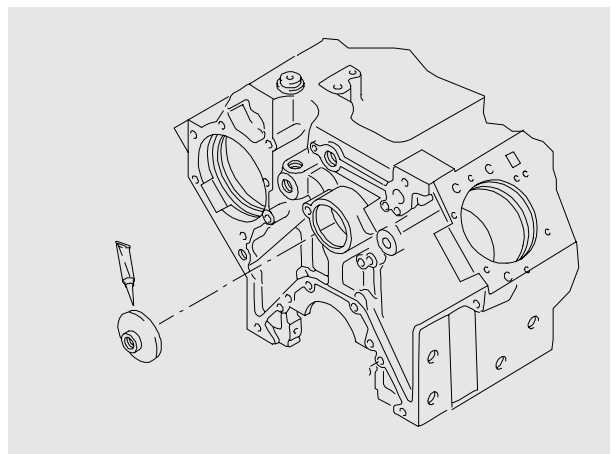


7

Fig. 7

If the camshaft cover has been removed from the crankcase, it is to be inserted as follows:

- Remove grease from bore and cover.
- Apply "Hylomar" sealing agent to bore and cover including chamfer.
- Carefully press in cover, taking care not to tilt it so that it jams.
- Ensure that there is no oil leakage.



8



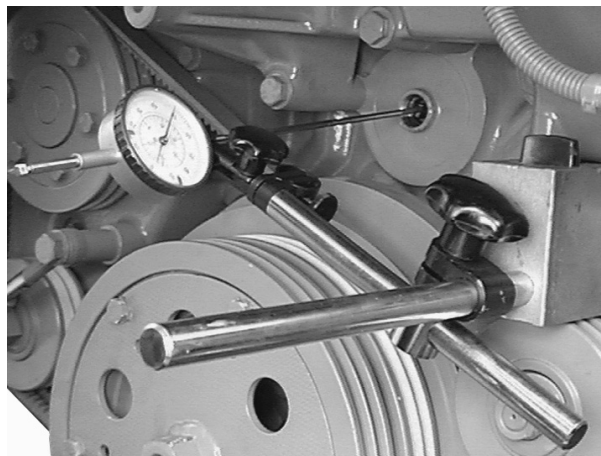
### Measuring camshaft axial clearance

Fig. 8

Remove screw plug or angle drive for tachometer from camshaft cover.

Apply feeler of dial gauge to end of camshaft or to driving dog for tachometer.

Set dial gauge to zero.



8

Fig. 9

Use suitable lever to press camshaft up to stop on timing case.

Push camshaft forwards against the dial gauge feeler until stop is reached. The dial gauge reading equals the camshaft axial play.

Refit all removed parts.

Fill up with engine oil and coolant as specified.

Check delivery start and valve clearance.



9



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

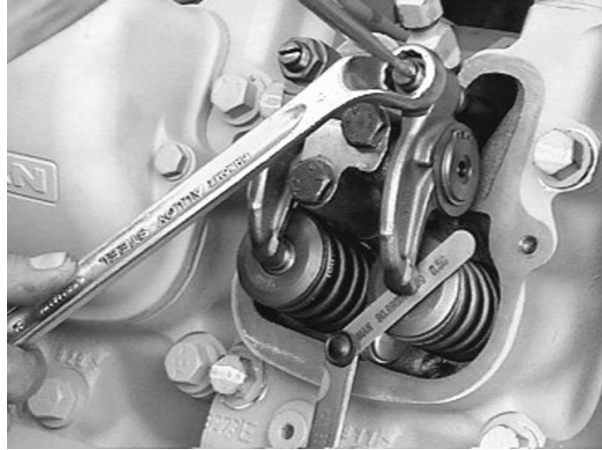


Fig. 2

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

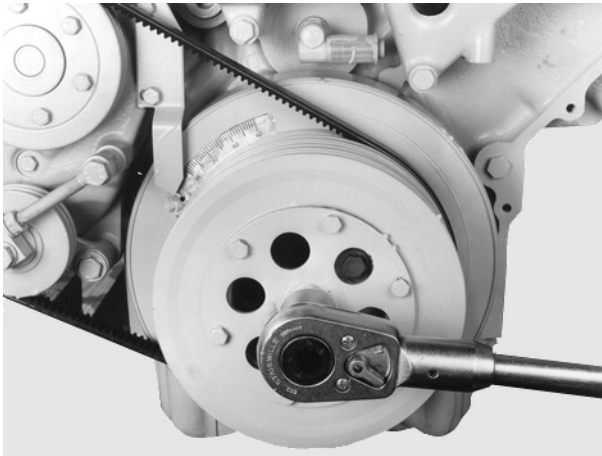


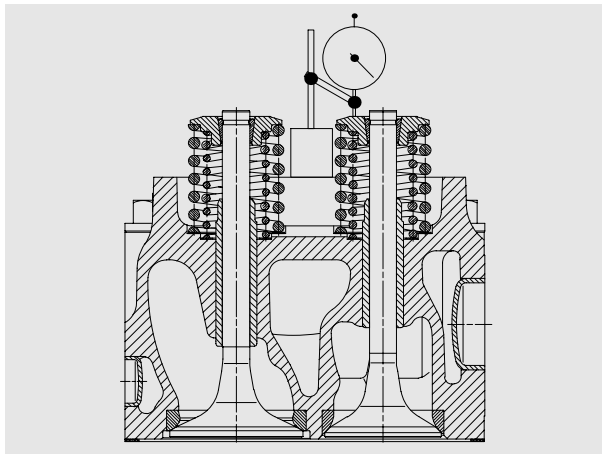
Fig. 3

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 4.5 and 5.4 mm.



## Removing broken driving dog

Fig. 1

The tachometer drive (angle drive) is located on the engine front side and connected with the camshaft.

Remove angle drive.

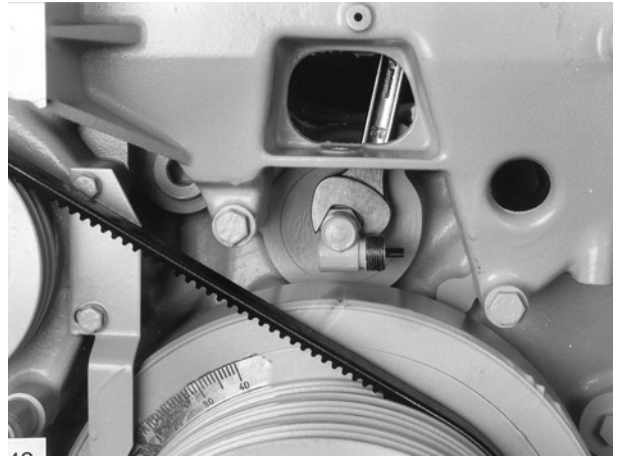


Fig. 2

Before drilling out the broken driving dog seal the space between camshaft (1) and cover (2) with grease to prevent metal chips getting into the engine.

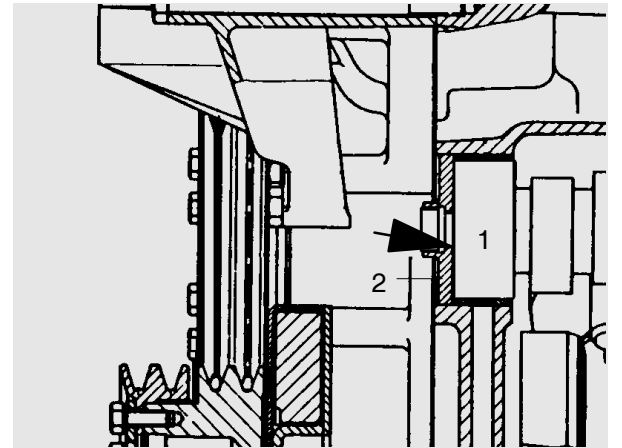


Bild 3

Drill out broken driving dog, ensuring exact centring (driving dog material is very hard).

Initial drilling with 4 – 4.5 mm drill, final drilling with 6.5 mm drill.

After a 1 – 2 mm hole has been drilled, grease drill completely without fail so that drilling chips will be collected. Proceed by the millimetre only. Pull drill out of the hole again and again, wipe off chips and regrease drill.



**Note:**

The driving dog is not fully inserted in the dead-end hole in the camshaft. Take care when pushing the drill through (risk of drill breaking).

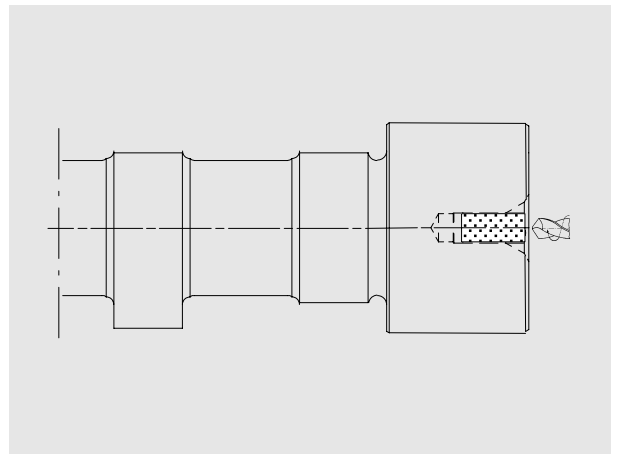
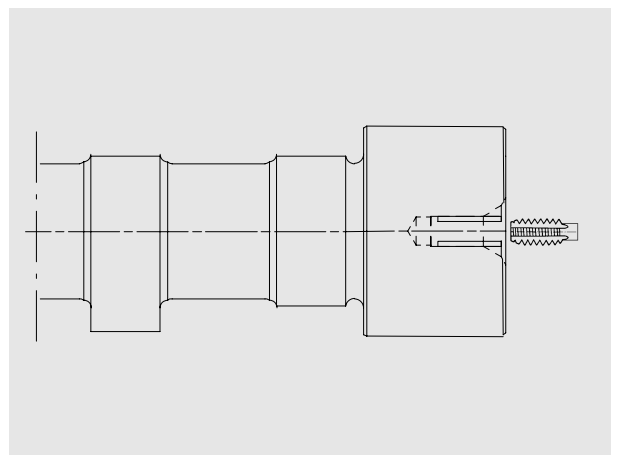


Fig. 4

Cut M8 thread into driving dog.

Grease an M8 x 70 or M8 x 80 cylinder bolt and screw it into the dead-end hole until stop is reached. Push rest of driving dog out of the bore by carefully continuing to turn.



### Installing new driving dog

Fig. 5

Cool driving dog in refrigerator for approx. 1 hour.  
Before installing the new driving dog, turn it two or three times to the left and right to ensure that it is really centred.

Then, using pressing mandrel (special tool) and hammer, carefully drive in driving dog until assembly tool reaches stop.

After assembly check whether the driving dog runs in centred position.

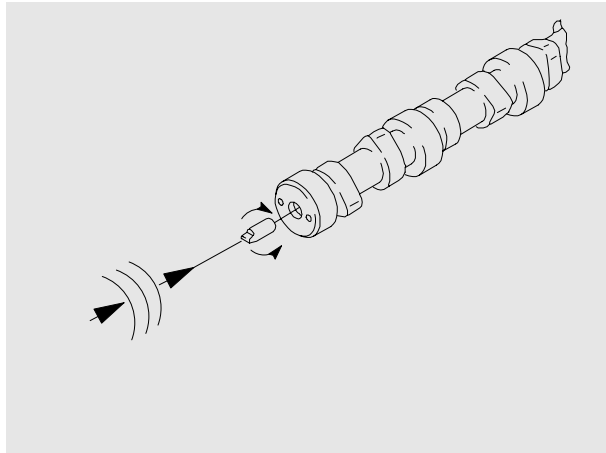
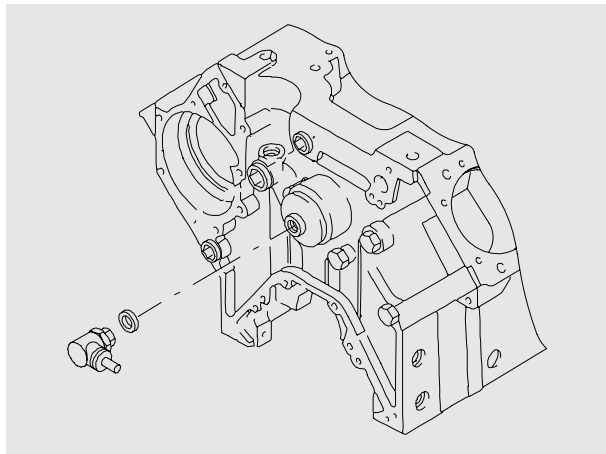


Fig. 6

Remove grease from annular space between camshaft and cover.

Screw on angle drive.



## Removing crankshaft

- Remove oil pan, see page 73
- Remove oil pump, see page 73
- Remove timing case, see page 123
- Remove front cover of crankshaft seal, see page 79
- Remove all pistons with connecting rods, see page 135


Fig. 1

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



Fig. 2

Remove horizontal bolts from crankshaft bearing caps.

 **Note:** Crankshaft bearing no. 1 is located on the non-flywheel end.

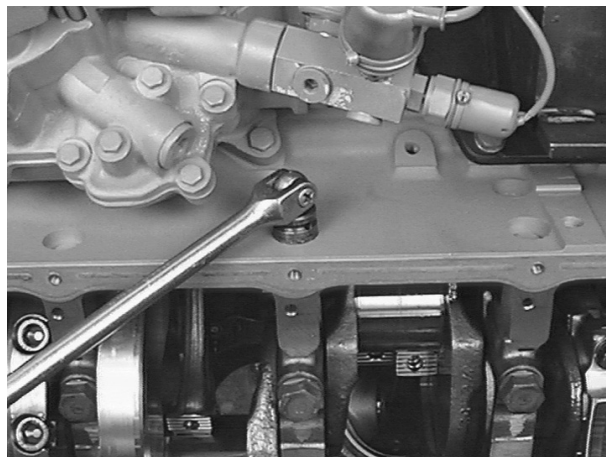


Fig. 3

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 shells out of the crankcase and put them aside, arranging them in the sequence of installation.

Clean the parts and check them for wear, if necessary exchanging them.

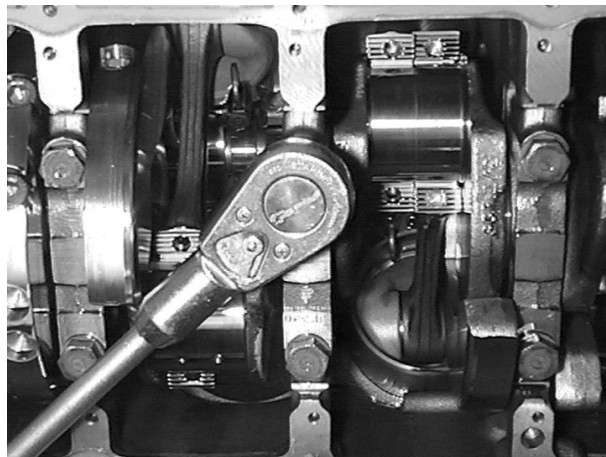



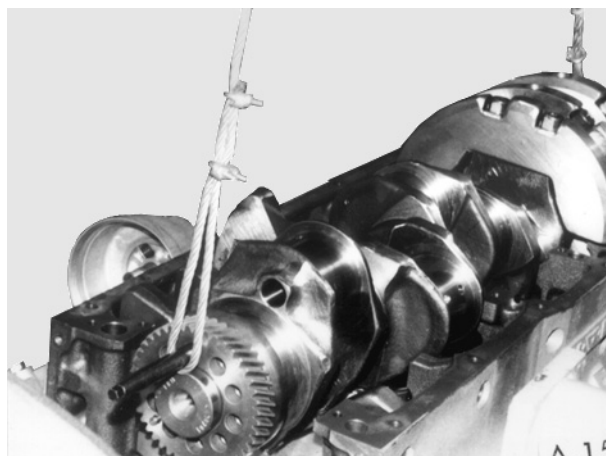
Fig. 4

Lift out crankshaft.

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

Take bearing shells out of the crankcase and use electric marker to matchmark them with the same numbers as the bearing caps, unless they are already marked.

Clean parts and check for wear, replacing them if necessary.

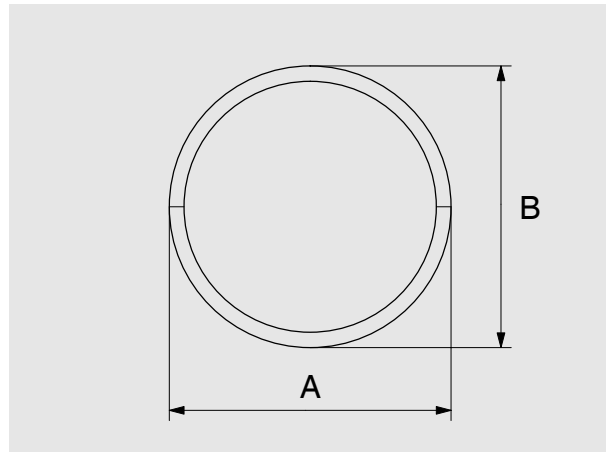


## Checking spread of bearing shells

Fig. 5

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

Spread dimension = A - B



5

## Installing crankshaft

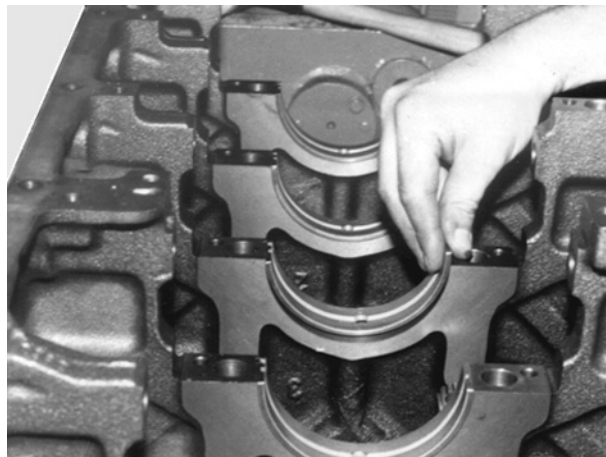
Fig. 6

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.



**Caution:**

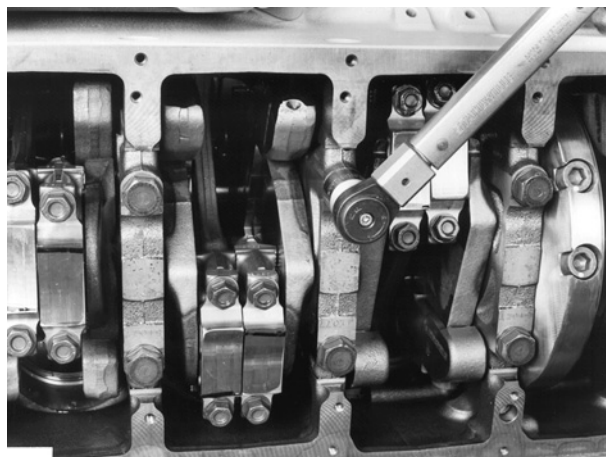
Observe relevant repair stage when using new bearing shells.



6

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

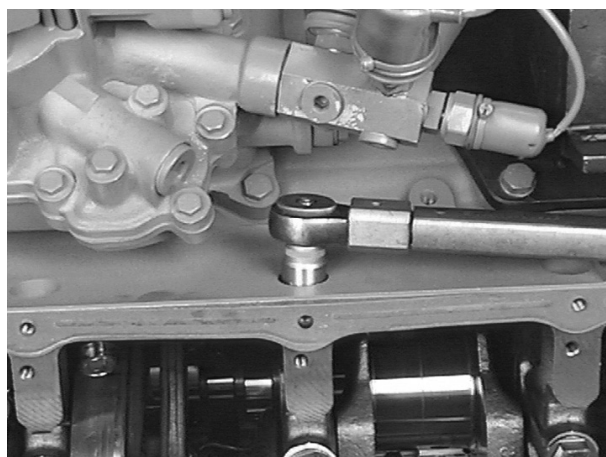
Fig. 8

Reassemble bearing caps with associated bearing shells. Insert vertical bearing cap screws and tighten to specified torque in stages from the inside out (see "Engineering • Data • Setting values"). Tighten finally by angle. Insert horizontal crankshaft bearing cap screws and tighten to specified torque.



**Caution:**

As replacement for the lateral crankshaft bearing cap bolts now use only collar bolts 51.90020-0382 (M12x1.5x85, 12.9). Previously used bolts of other types must be replaced by these bolts.



8

Check to see that crankshaft runs smoothly.



**Caution:**

Faulty bearing caps cannot be replaced singly.

## Checking axial clearance

Figs. 9 and 10



**Note:**

The axial clearance of the crankshaft depends on the crankshaft bearing at the fly-wheel end (thrust bearing).

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

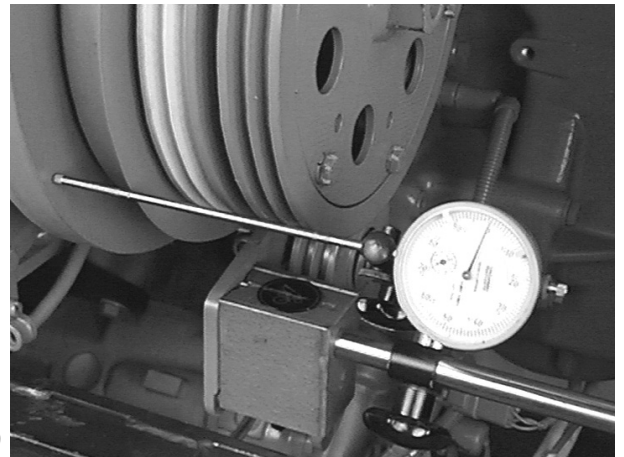


Fig. 11

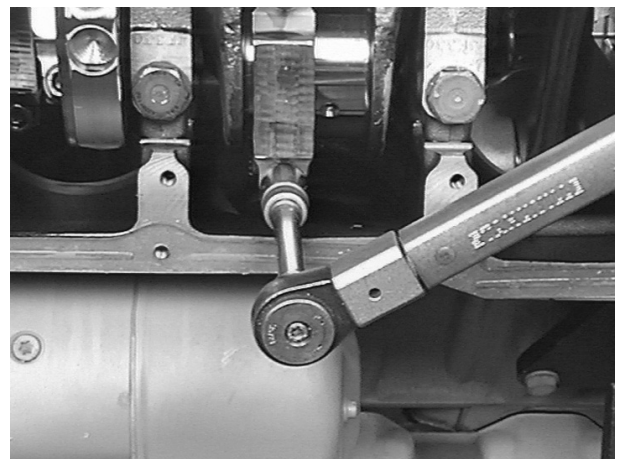
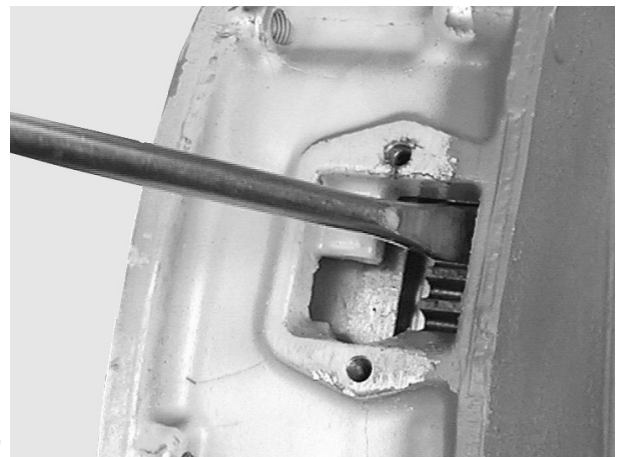
Measure connecting rod bearing, insert pistons with connecting rod. Coat connecting rod bearing shells with oil and pull connecting rods to bearing pin.

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".)



### Important notes on the installation of offset pistons

In the past, some engines were equipped with pistons with offset gudgeon pin bearings.

In the spare-parts catalogue a distinction is made between pistons for the right - and left - hand cylinder banks.

In the event of repairs only pistons of this type must be installed in these engines. Mixed use of offset and non-offset pistons is not permissible.

Since the gudgeon pin offset points towards the cylinder's back-pressure side, correct piston arrangement must be ensured in the installation in V-type engines owing to the different pressure sides in the right- and left-hand cylinder banks (see page 138).

The left- and right-hand cylinder banks are defined relative to the flywheel end of the engine. Consequently, the pistons are marked on the piston bottom with an

R for the right-hand cylinder bank

L for the left-hand cylinder bank



**Caution:**

If damage to a piston occurred in an engine, the delivery start must be checked without fail. If it does not comply with the specification, it is to be adjusted accordingly.

In addition, it must be verified that the injection and oil spray nozzles work faultlessly.



## Removing piston with connecting rod

Fig. 1

Remove oil pan, oil suction pipe and cylinder heads. Remove bolts from connecting rod bearing cap.

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.



Figs. 2 and 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.



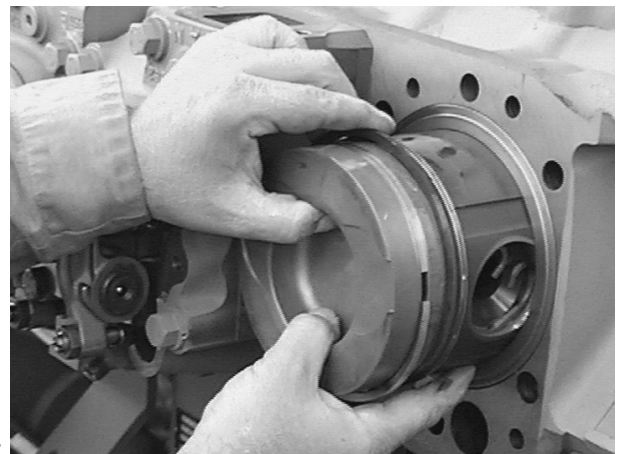
**Caution:**

Do not damage oil spray nozzles.



Fig. 4

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



## Installing piston with connecting rod

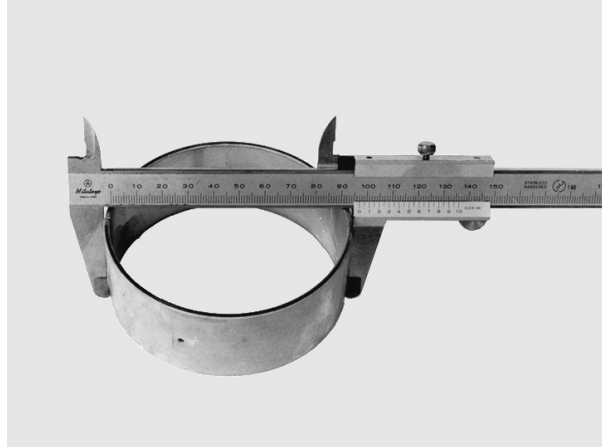


**Note:**

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”).

Fig. 5

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



5

Fig. 6

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



**Caution:**

The rod shell has a red mark on the side and a brown reverse side.

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



6

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

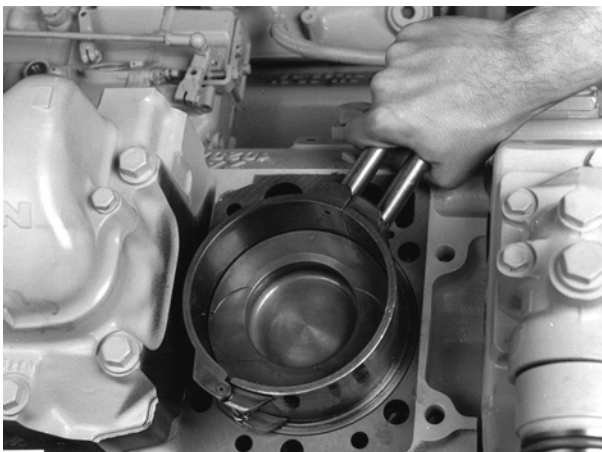
Fig. 8

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

Fig. 9


The arrow on the top of the piston must always point towards the engine centre, i. e. towards the injection pump.



9

Fig. 10

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.



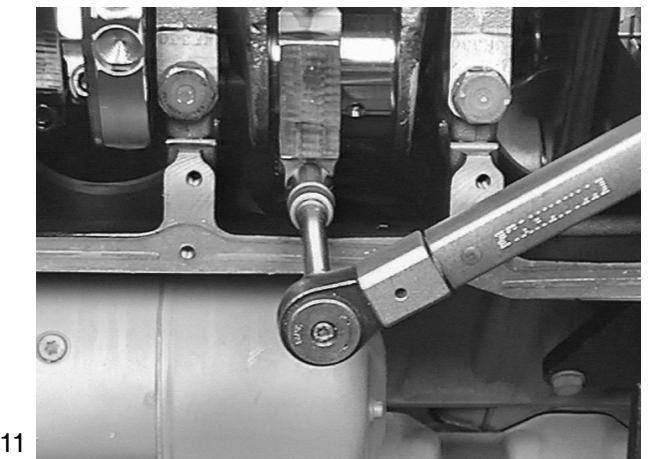
10

Fig. 11

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".)




11

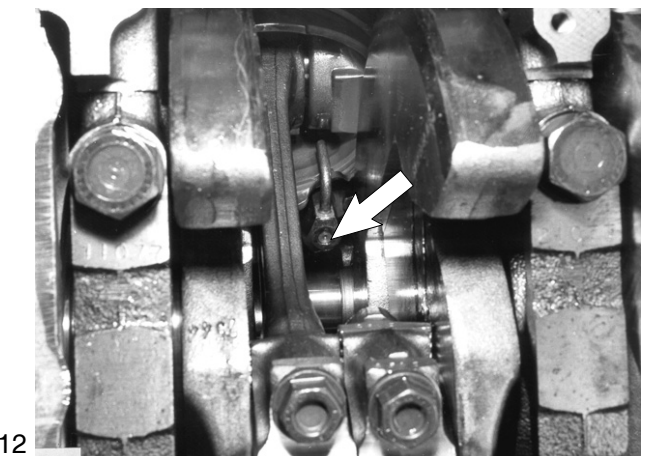
Fig. 12

Slowly turn engine over.

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



**Note:** As far as possible turn engine only in direction of rotation (anti-clockwise as seen when looking at the flywheel) in order to prevent the direction of rotation of the raw water pump impeller being reversed.



12

### Additional notes for installing offset pistons

Fig. 1

In engines with offset pistons, the pistons for the right-hand cylinder bank (as viewed from the flywheel) are marked with an “R” on the top of the piston.

(For important notes, see page 134)

1



Fig. 2

The pistons for the left-hand cylinder bank (as viewed from the flywheel) are marked with an “L” on the top of the piston.

2



Fig. 3

The arrow on the top of the piston must always point towards the engine centre, i. e. towards the injection pump.

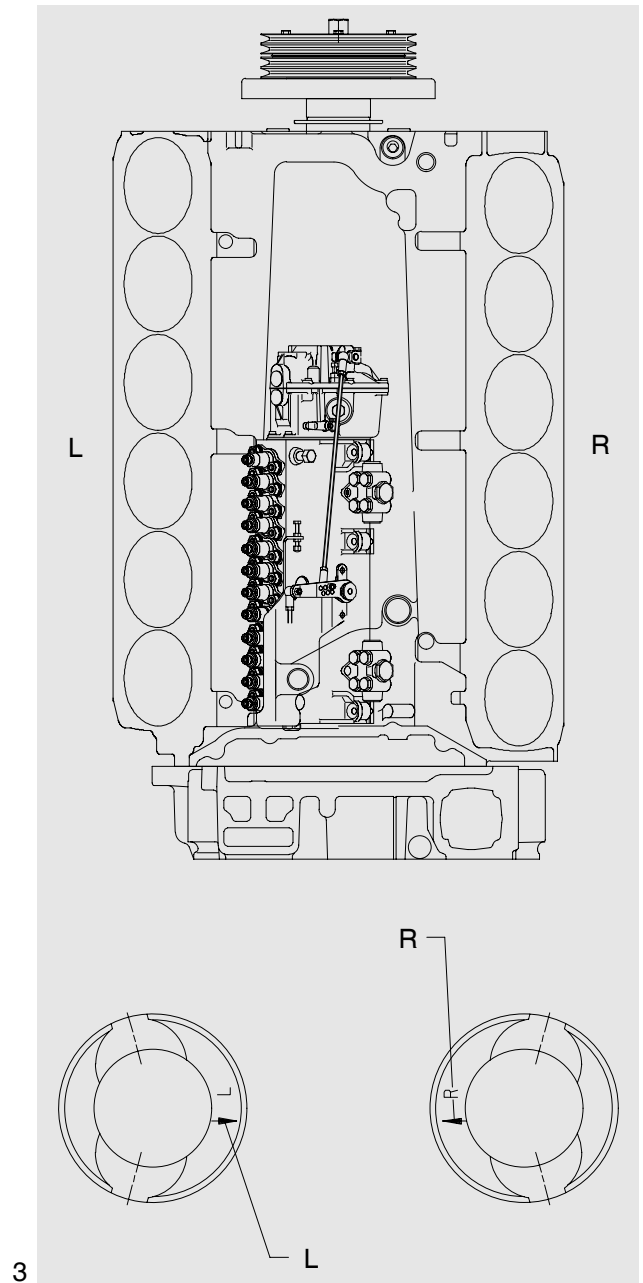
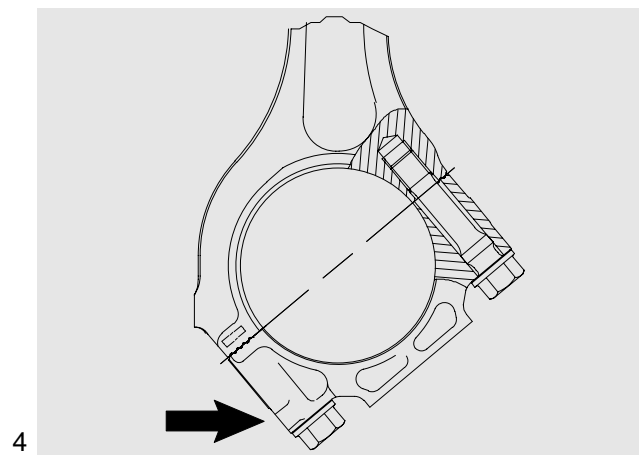


Fig. 4

In addition, the arrow on the piston crown must point towards the long side of the big end.



## 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.



Fig. 2

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



## 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.

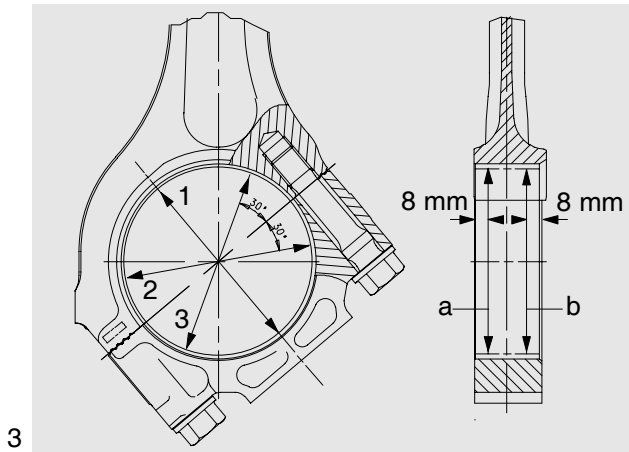


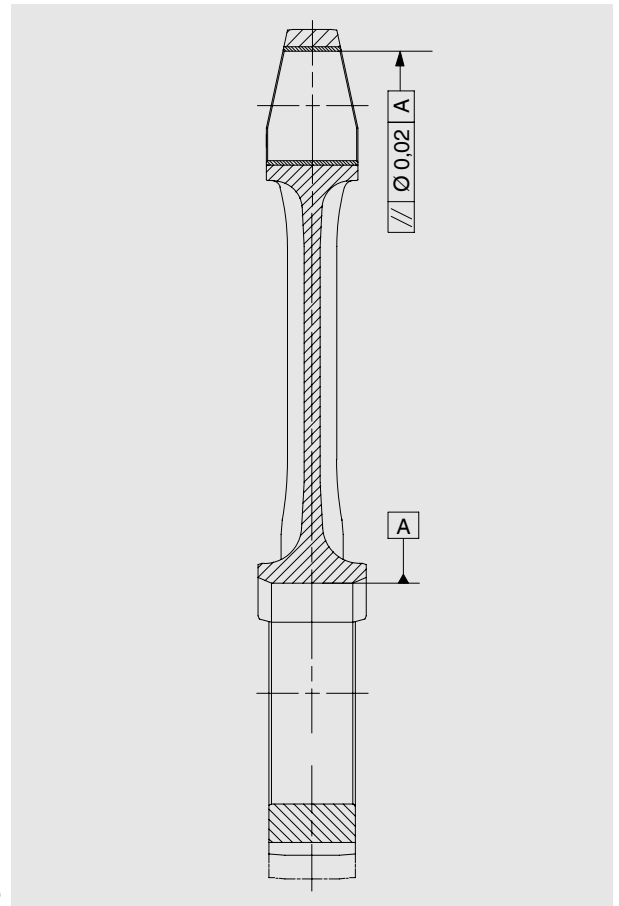
Fig. 4

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




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.

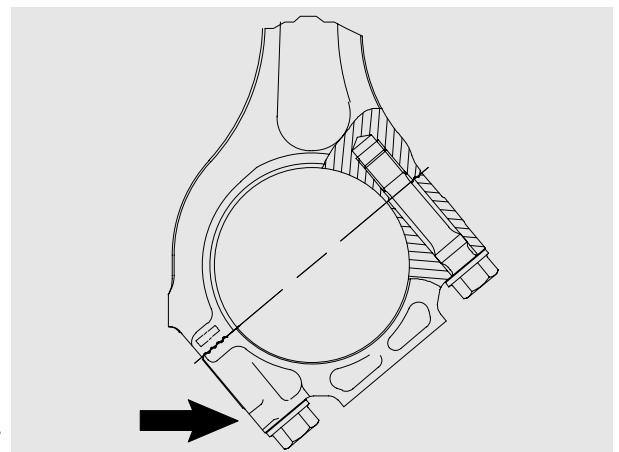


Figs. 6 and 7

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 long end.

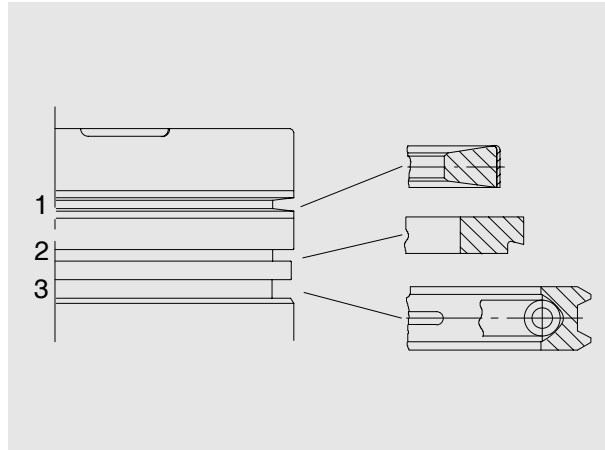
Insert gudgeon pin. Fit circlips.  
Install piston, see page 136.



## 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)



## 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.

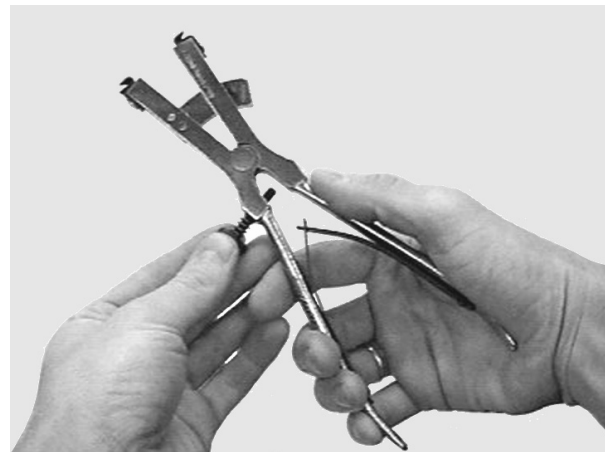


Fig. 3

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.

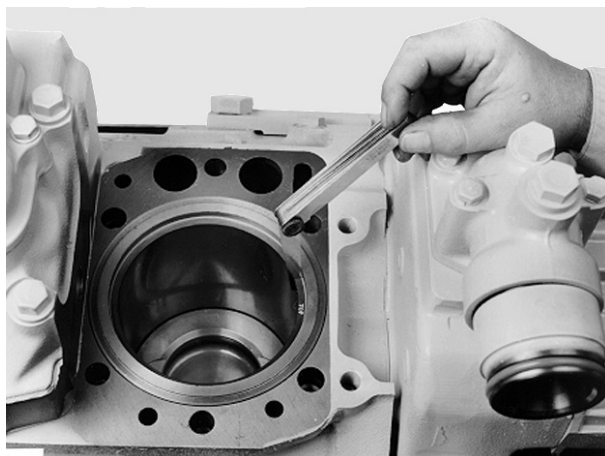
Carefully clean the piston ring grooves using a piece of wood.  
Do not damage the piston ring grooves.



## 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".

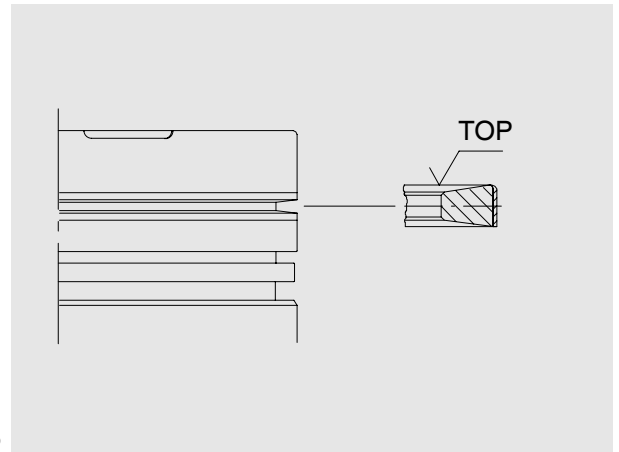




### Installing piston rings

Figs. 5 and 6

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



5



6

### 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

## Removing cylinder liners



**Note:**

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

- Remove cylinder head, see page 104
- Remove pistons, see page 135

Figs. 1 and 2

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

Insert cylinder liner extractor device (special tool, see page 171, item 25) into cylinder liner, taking care not to damage the oil spray nozzle.

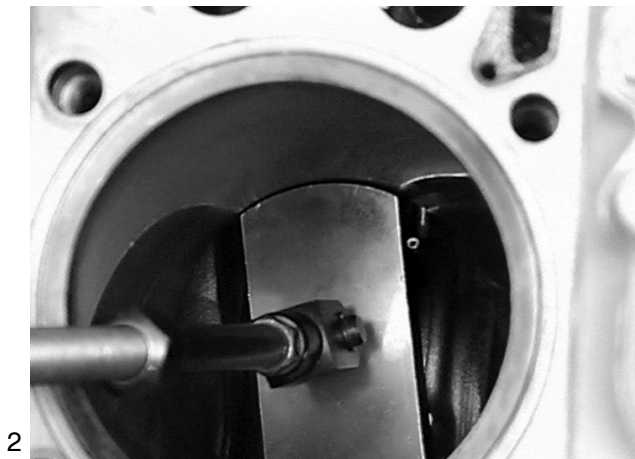
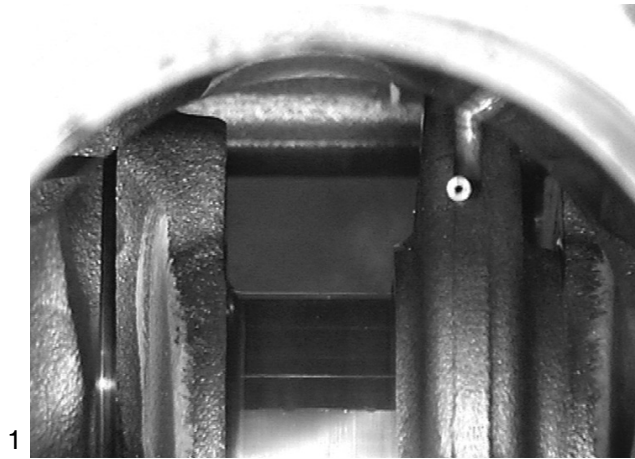


Fig. 3

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

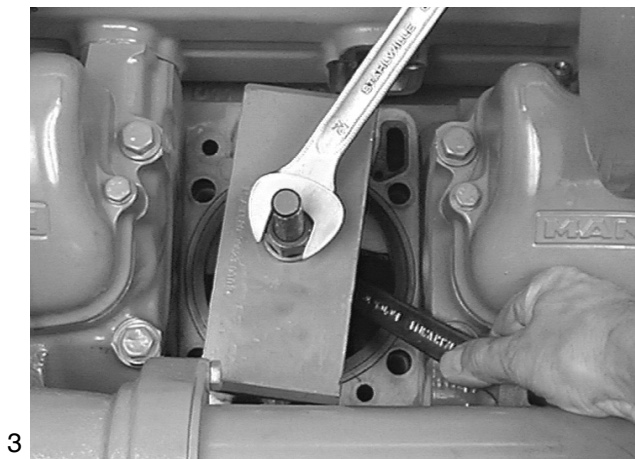


Fig. 4

Take off extractor device and take out cylinder liner.




Fig. 5

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

### Checking cylinder liner protrusion

Fig. 6

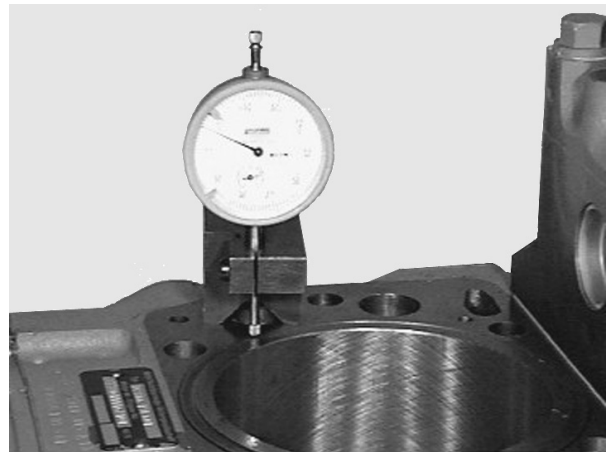
Clean basic bore and cylinder liner. Insert cylinder liner without O-rings into crankcase, observing the marking (ensure that it is identical with the position prior to removal). Measure cylinder liner protrusion at at least four different points, using gauge holder and gauge.

 **Note:** If available, use measuring plate for the measurement (special tool, see page 174). Proceed as follows:

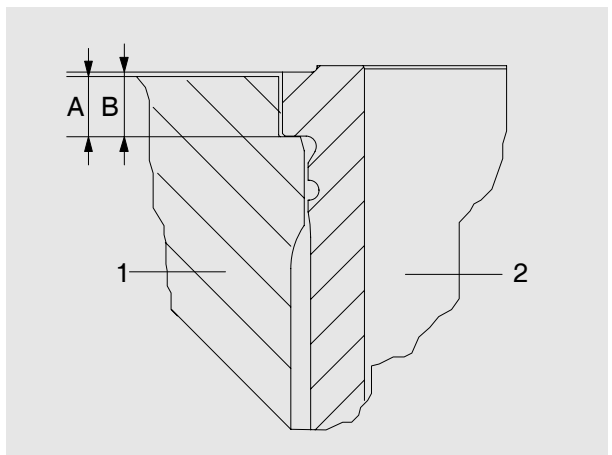
- Position press-on measuring plate with turned collar facing the liner using 2 fitting sleeves to centre plate.
- Tighten 4 bolts (improved: collar bolt 51.90020-0270, length shortened to 90 mm) on the press-on measuring plate in stages and crosswise to 40 Nm.
- Set dial gauge combination above press-on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



5



6



7

Fig. 7

The cylinder liner protrusion is the difference between the collar height and the collar recess in the crankcase.

1 Crankcase

2 Cylinder liner

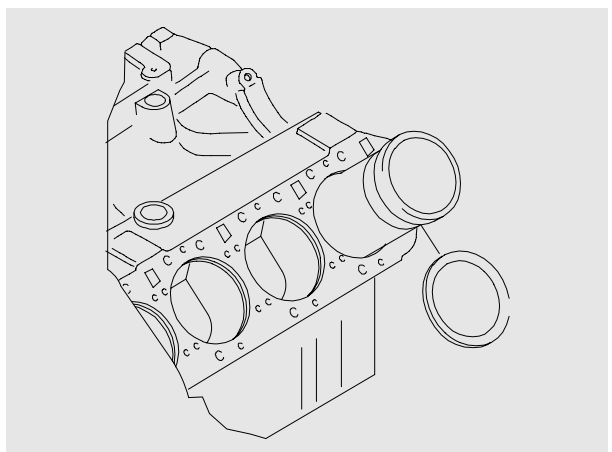
$B - A =$  cylinder liner protrusion

Fig. 8

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.



8

### Installing cylinder liners

Fig. 9

Oil new O-rings for the lower seal (144x4) and insert them in crankcase.

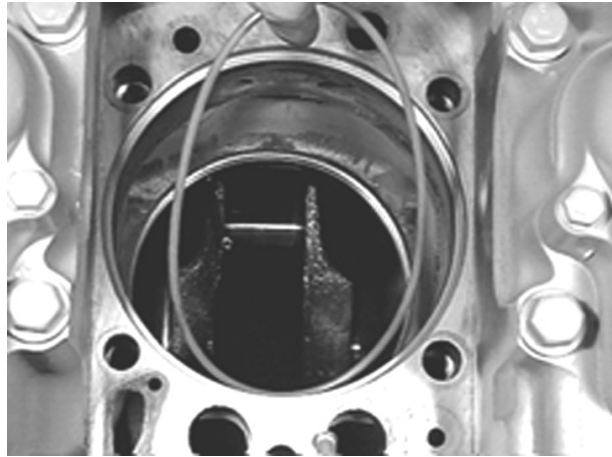
Oil new O-rings for the upper seal (138x2) and roll them from below on to the cylinder liner and into the grooves.

Do not overstretch the O-rings.



**Note:**

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



9

Fig. 10

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

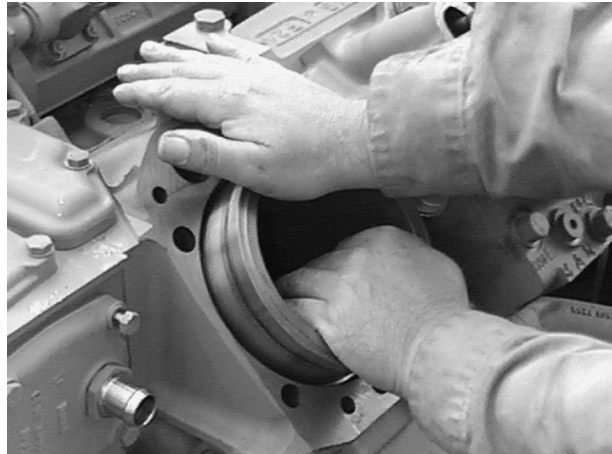
Apply thin coat of engine oil to lower O-rings in the crankcase.

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.



10



**Note:**

After fitting the cylinderliners ensure that the O-rings are in the correct position by checking the liner protrusion.

Use special tool (see page 174) and proceed as follows:

- Position press-on measuring plate with turned collar facing the liner using 2 fitting sleeves to centre plate.
- Tighten 4 bolts (improved: 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.

### Measuring piston protrusion

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".

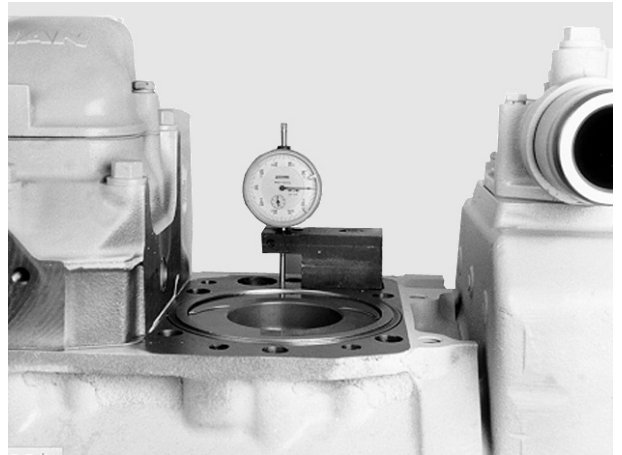
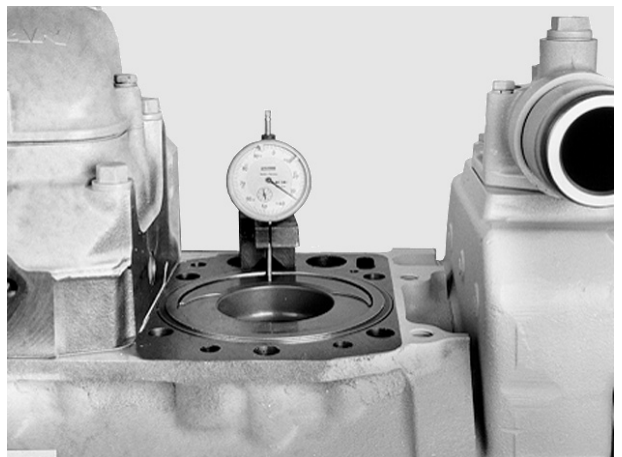


Fig. 2

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.



### Removing starter

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.

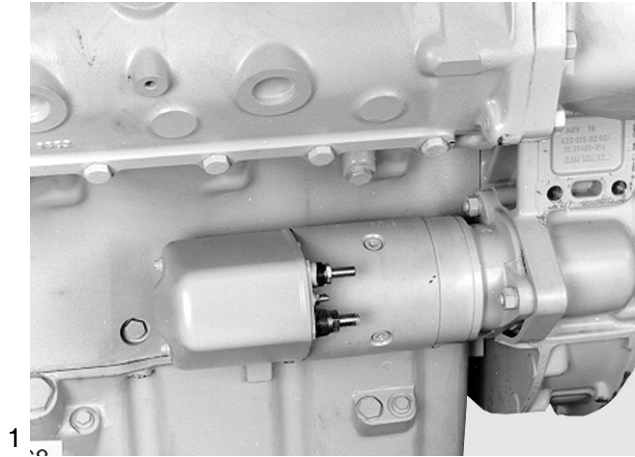


Fig. 2

Remove mounting nuts (19 mm).



**Note:**

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

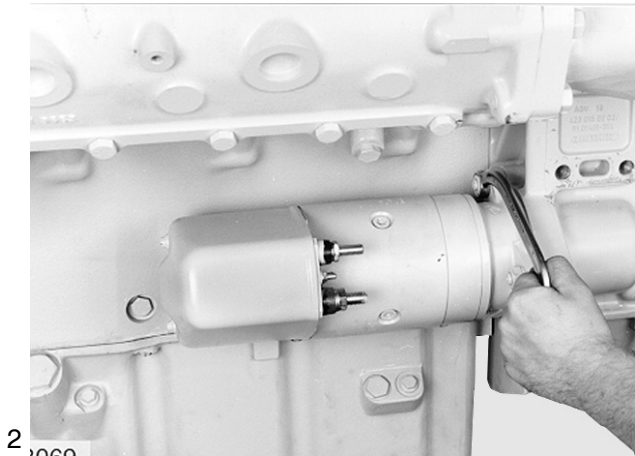


Fig. 3

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.



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 85.

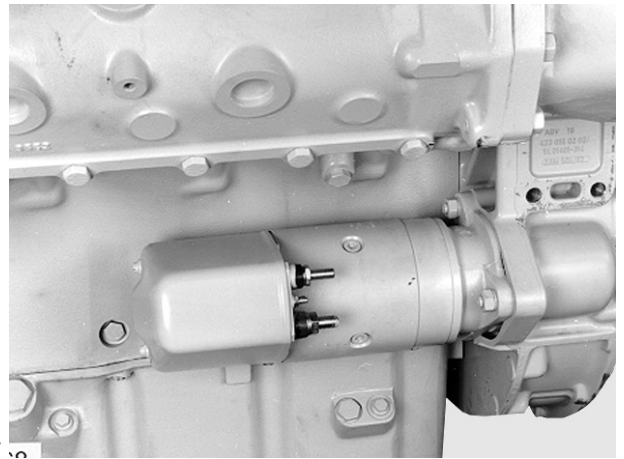
### Installing starter

Fig. 4

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.

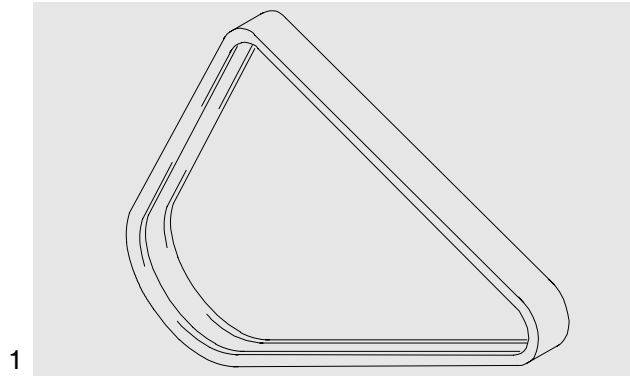
After installation check starter to see that it works properly.



## Checking condition

Fig. 1

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



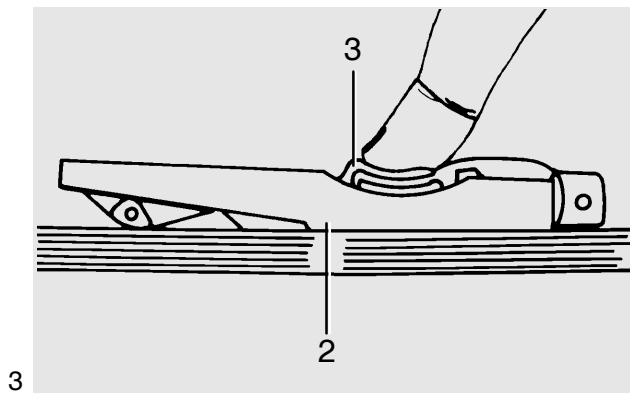
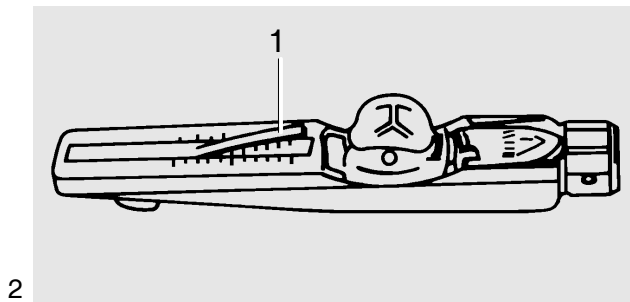
## Checking tension

Fig. 2

Use belt tension indicator to check V-belt tension.

- Lower the gauge arm ① in the scale.
- Position the tension indicator in the centre of the belt between the two pulleys so that the edge of the stop face ② 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.



## Taking tension reading

Figs. 3 and 4

- The tension is shown where the top of the gauge arm ① 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.

3

Riemenbreite	Spannkräfte nach kg-Skala auf dem Gerät		
	bei Neumontage		bei Wartung nach längerer Laufzeit
	bei Montage	nach 10 min. Laufzeit	
10	50	45	40
13	55	50	45
20,0	75	70	60
22,0	75	70	60
2/3VX	90-100	80-90	60
3/3VX	135-150	120-135	90

4



## Tensioning and changing V-belts

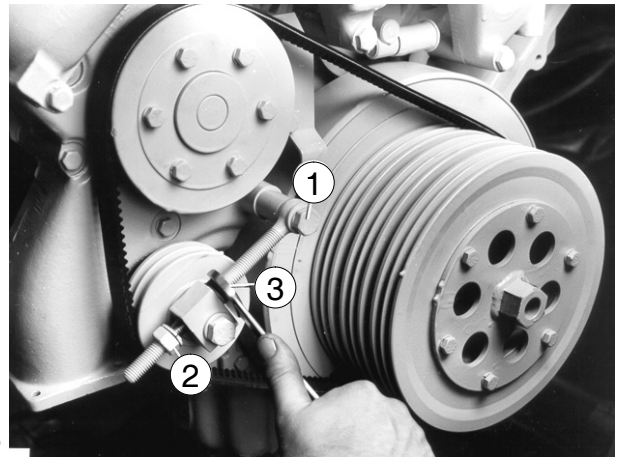
Fig. 5

The picture shows the V-belt for the water pump drive.

- Loosen mounting bolts ①
- Loosen lock nut ②
- Turn adjusting nut ③ until the V-belts are correctly tensioned.
- Retighten lock nut and mounting bolts.

To change the V-belts, turn adjusting nut back and swing tension pulley inwards.

5



## Removing power take-off for raw-water pump

- Remove raw-water pump, see page 70
- Remove timing case, see page 123

Fig. 1

To remove the drive wheel from the raw-water pump (arrow), the drive shaft must be held stationary.

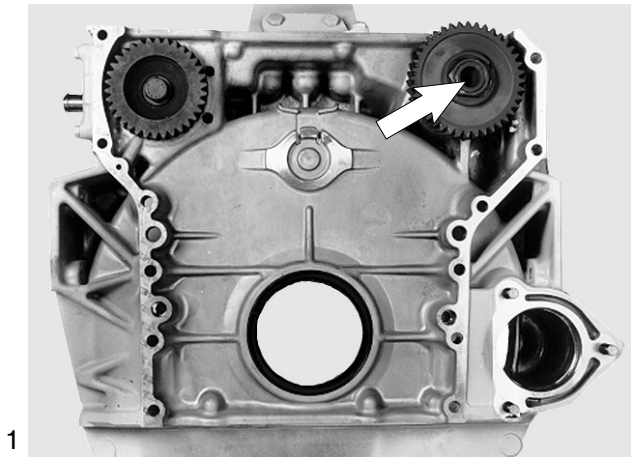


Fig. 2

To hold drive shaft stationary, we recommend welding a spare coupling sleeve on to a suitable square-section bar so that the coupling sleeve can be held in a vice.

To protect the stud bolts projecting from the timing case, ensure that the coupling sleeve is at least 30 mm above the vice.



Fig. 3

Plug the splined section end of the drive shaft into the coupling sleeve.

Bend open caulked collar of nut.



Fig. 4

Remove nut from shaft.

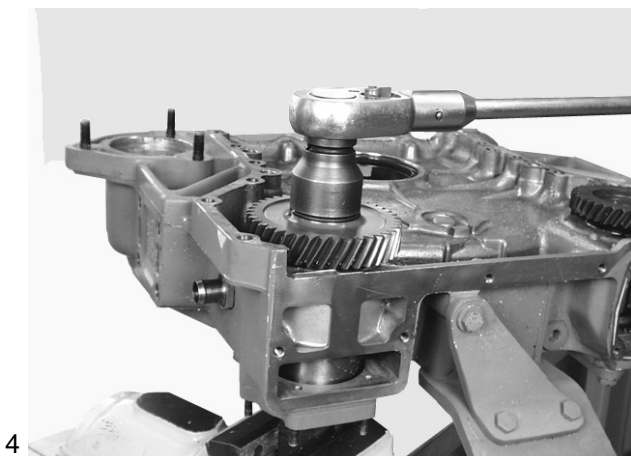


Fig. 5  
Take off gear.

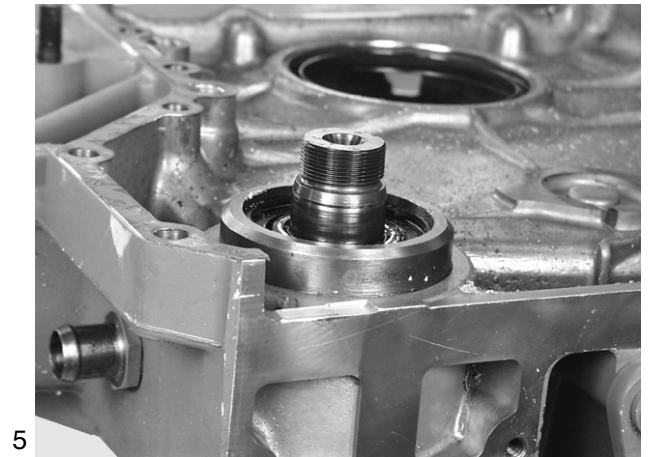


Fig. 6  
Unclip circlip.  
Press power take-off for raw-water pump out of timing case.



## Installing power take-off for raw-water pump

Fig. 7

Place timing case under a press on a suitable support in a horizontal, tilt-resistant position. Align new bearing to correct seat in timing case.



Fig. 8

Press in bearing.  
 For this purpose use suitable pressing die to ensure that pressure is applied to the bearing outer ring and not to the bearing shaft.  
 A tube with the following dimensions may be used as a pressing die:  
 External diam. = 73 mm  
 Internal diam. = 60 mm  
 Length = 50 – 60 mm



Fig. 9

Hold drive shaft in vice stationary (see device in Fig. 2).  
 Fit drive gear.  
 Tighten collar nut to the specified torque of 390 Nm.



Fig. 10

Caulk collar of nut into the groove of the drive gear.

Attach flywheel housing.



## Lubricating power take-off for raw-water pump

Fig. 1

Once the timing case is removed, a screw plug (arrow) which closes up an oil duct is visible on the engine rear side.

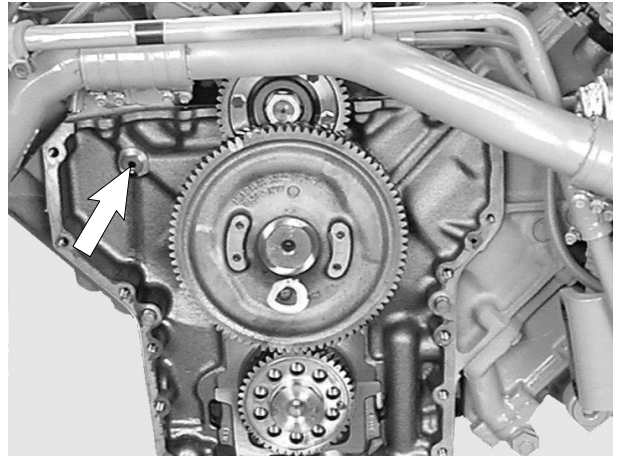


Fig. 2

The screw plug is provided with a bore from which oil jets emerge to lubricate the power take-off.



**Caution:**

The screw plug must on no account be replaced by a similar plug from the usual range of spare plugs available in workshops, as this would no longer guarantee the proper lubrication of the power take-off.



### Removing power take-off for hydraulic pump

- Remove hydraulic pump or blind flange

Figs. 1 and 2

For work on the power take-off the engine timing gear (gear for camshaft, injection pump and power take-off) must be made accessible.

For this purpose detach the fuel filter.

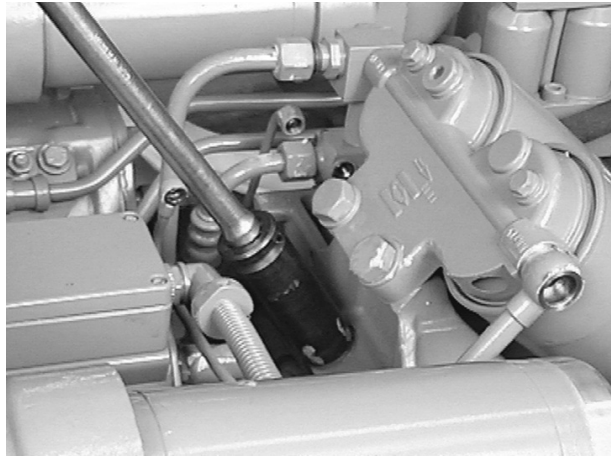
Shut shut-off valve from tank to engine. Remove all fuel lines and the filter complete with catch pan.



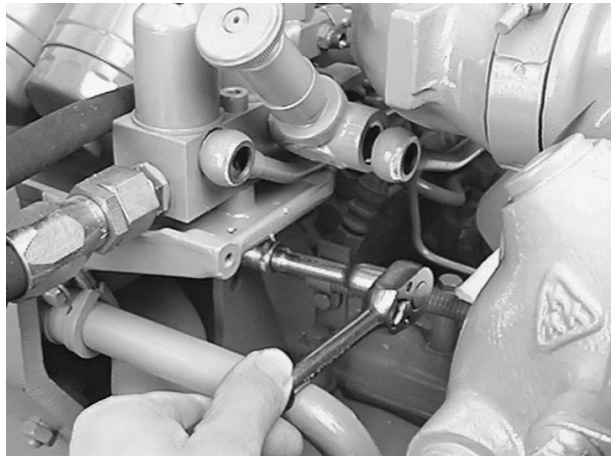
**Caution:**

The filter cartridges contain fuel. When putting aside the filter, catch emerging fuel in a suitable container.

1



2



Figs. 3 and 4

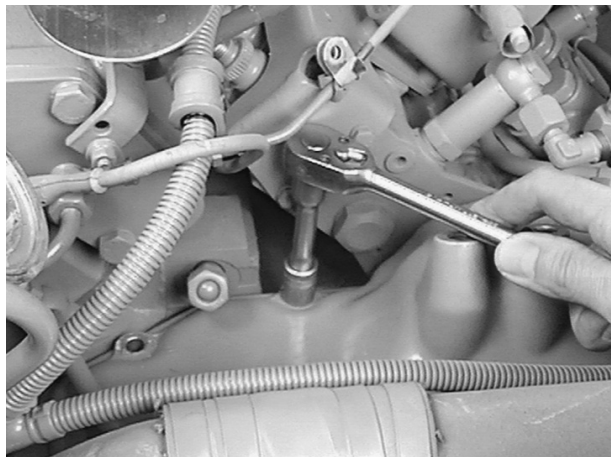
Remove timing case cover.



**Note:**

Pipes are attached to the timing case cover. To facilitate reassembly, memorise or mark down in a drawing or photo the positions of the brackets, pipe clamps and spacer sleeves etc.

3



4

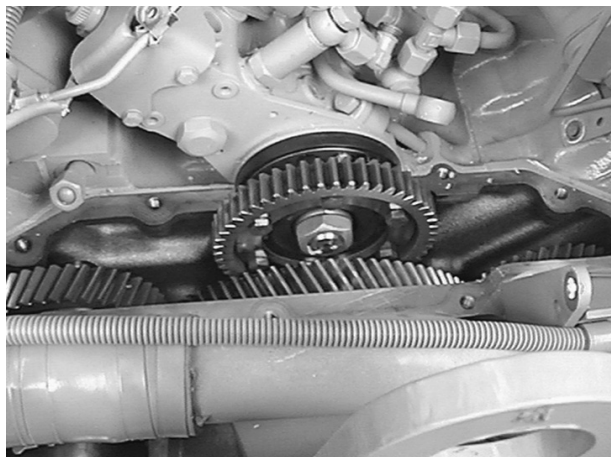
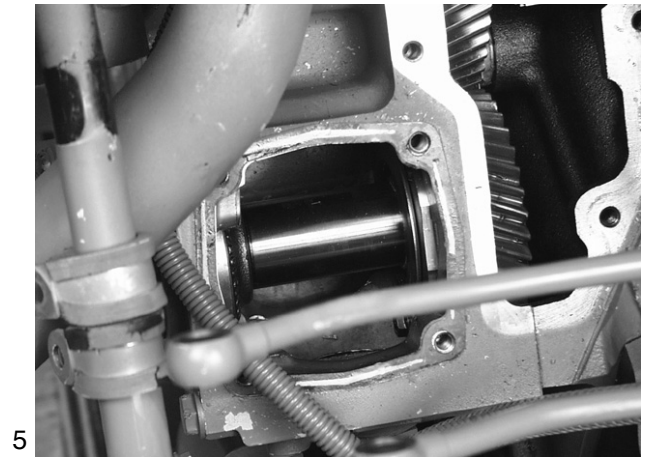


Fig. 5

Remove rectangular cover on right-hand side of timing case cover.  
The PTO shaft is now visible. For better accessibility we recommend removing the charge-air pipe on the right-hand side.



5

Fig. 6


Hold crankgear stationary.  
The picture shows a special tool to be attached to the inspection hole of the flywheel housing.

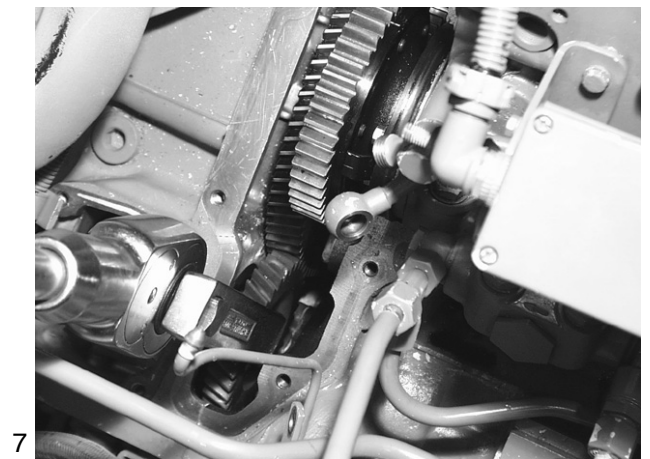


6

Fig. 7

Use ring spanner (special tool, see item 28 on page 171) to remove mounting bolt from drive gear.

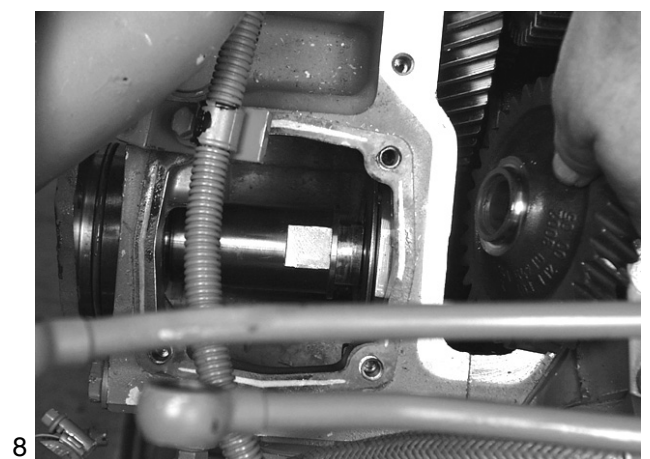
 **Caution:**  
The bolt must not fall into the engine.



7

Fig. 8

Take off drive wheel and pull out bearing flange with drive shaft.



8

## Installing power take-off for hydraulic pump

Fig. 9

Insert bearing flange with drive shaft into flywheel housing (oil O-ring lightly).



Fig. 10

Tighten drive wheel to specified torque, preventing drive shaft from turning.

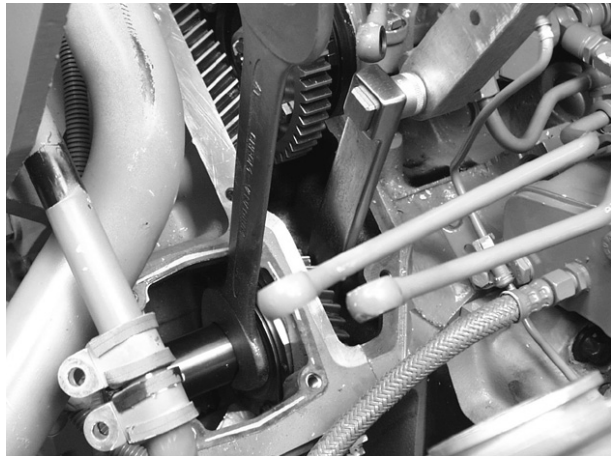


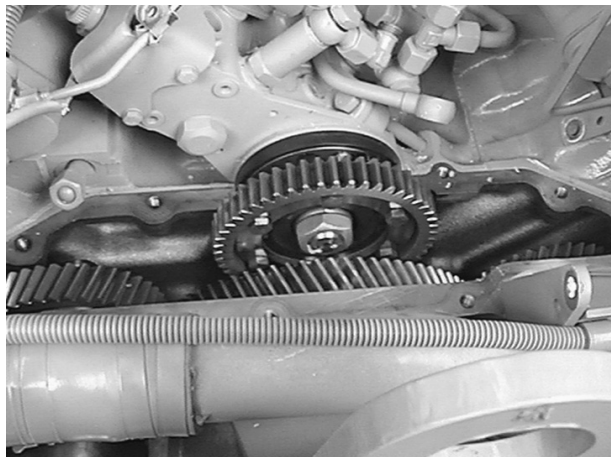
Fig. 11

Remove seal residues from sealing face of timing case cover.  
Screw on both covers with new seals.  
Refit all parts previously removed.



**Caution:**

Removing blocking tool from crankgear.





## 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 capacitive 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.

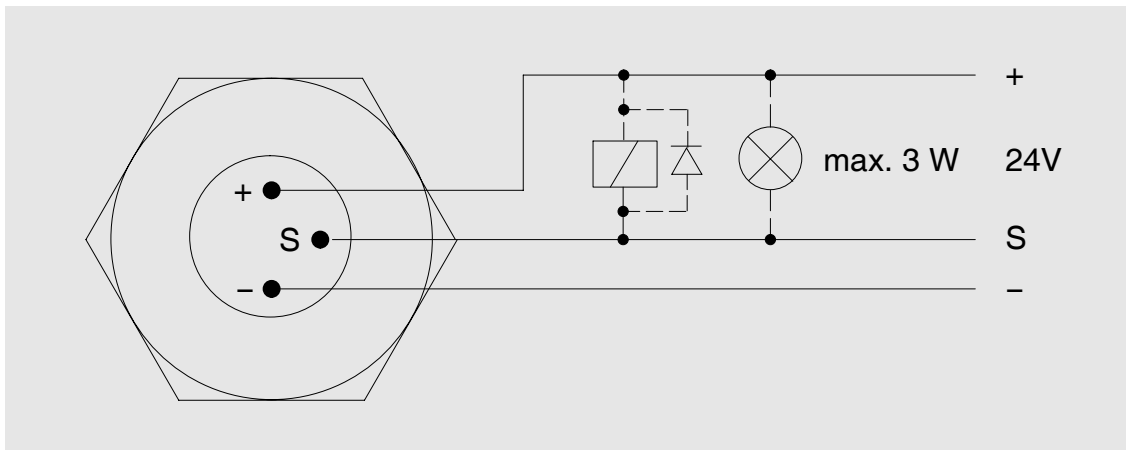
It is not possible to carry out a functional check by measuring the resistance (ohmmeter) because of the internal transistors.

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

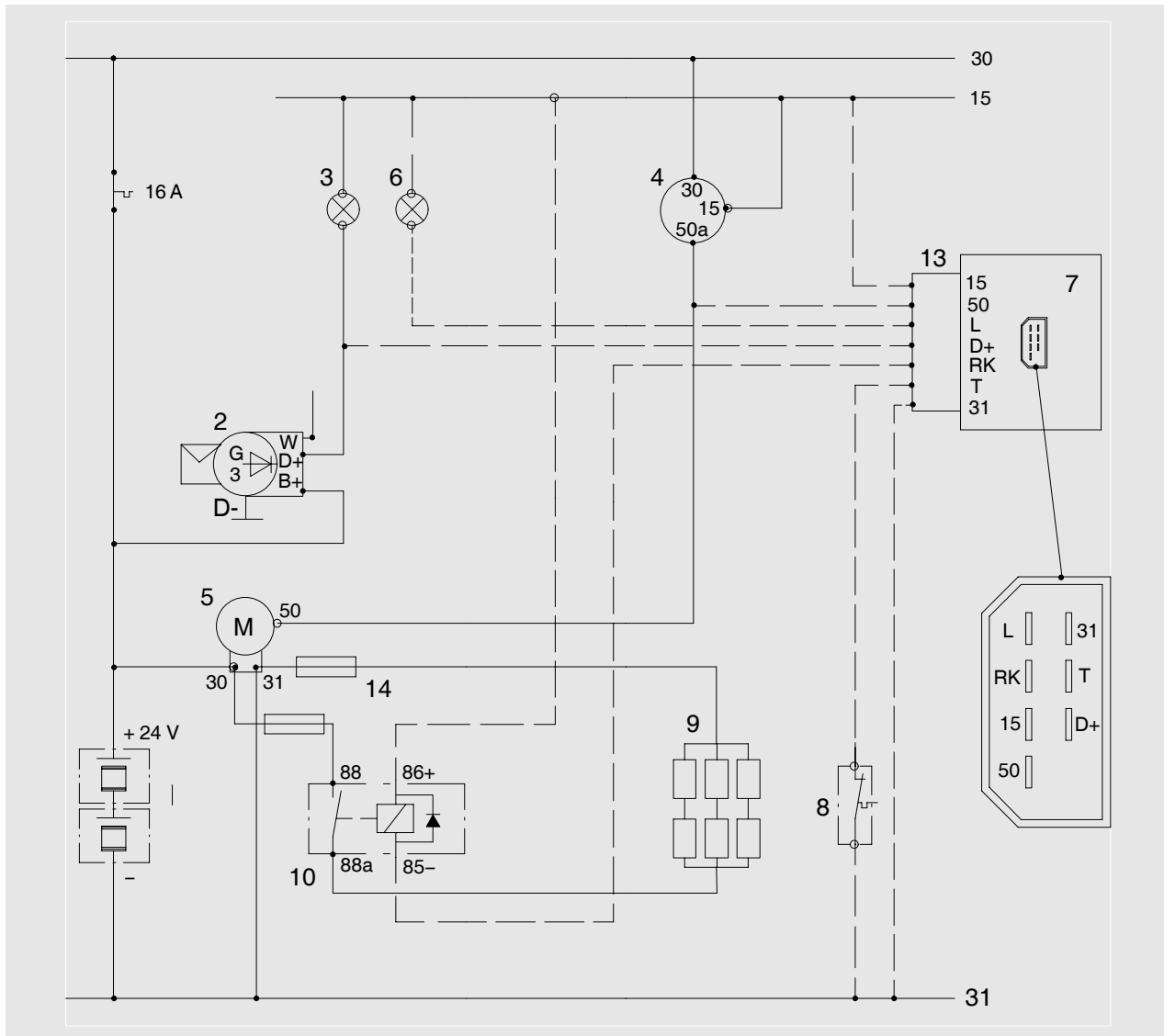
Dip the probe into the water and apply a supply voltage of 24 V to the plus and minus leads. The output "S" is to be connected to the plus lead via the test lamp. The test lamp does not come on.

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.



The intake air pre-heater is designed to prevent the formation of white smoke immediately after a cold start and during the cold running phase. For this the air taken in for combustion is heated with electrically heated glow plugs.



**Circuit diagram of intake air pre-heater**

- 1 Battery
- 2 Alternator
- 3 Charge check lamp
- 4 Starter switch
- 5 Starter motor
- 6 Lamp showing availability
- 7 Control unit for glow plugs
- 8 Temperature switch
- 9 Glow plugs: 4 x for D 2848, 6 x for D 2840 / 42
- 10 Power relay: 1 x for D 2848, 2 x for D 2840 / 42
- 13 Plug housing + receptacle
- 14 160 A NH fuse insert: 2x for D 2848  
200 A NH fuse insert: 2x for D 2840 / 42

The temperature switch (8) in the circuit diagram is attached to the front of the engine. It is closed when cold, and in this status the glow plugs can be put into operation. When the coolant temperature reaches 40 - 50°C (105 - 120°F) the temperature switch (8) opens and pre-heating stops.

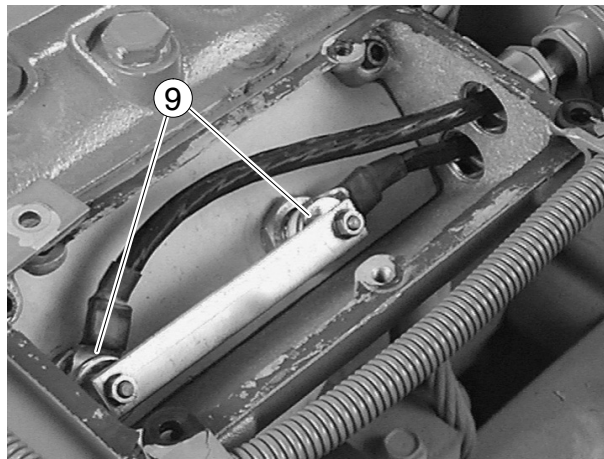
If the temperature switch (8) is defective, e.g. always open, pre-glowing is not possible.

If the temperature switch does not open, the glow plugs remain switched on for a maximum of 14 to 15 minutes. The pre-heating procedure is then stopped by the electronic control unit (7).

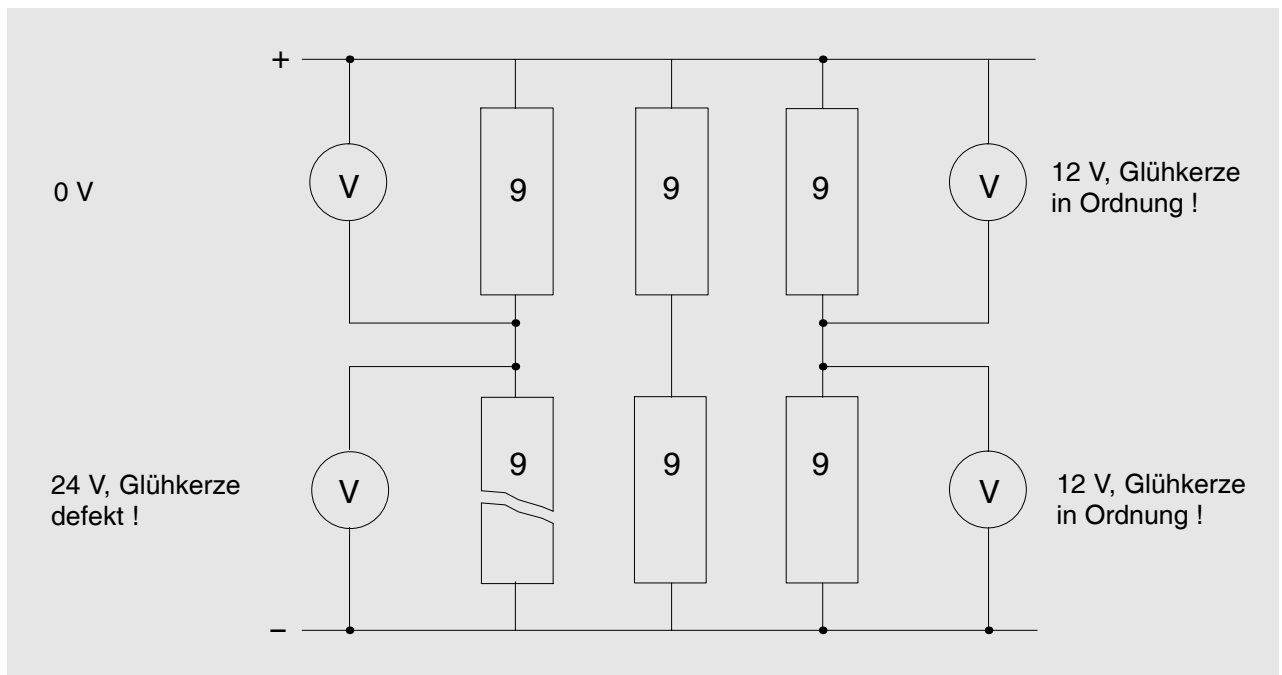
## Checking the glow plugs

If the glow plugs (9 in circuit diagram) are to be checked, the temperature switch (8) must be bridged. This leaves approx. 14 minutes in which to check the glow plugs.

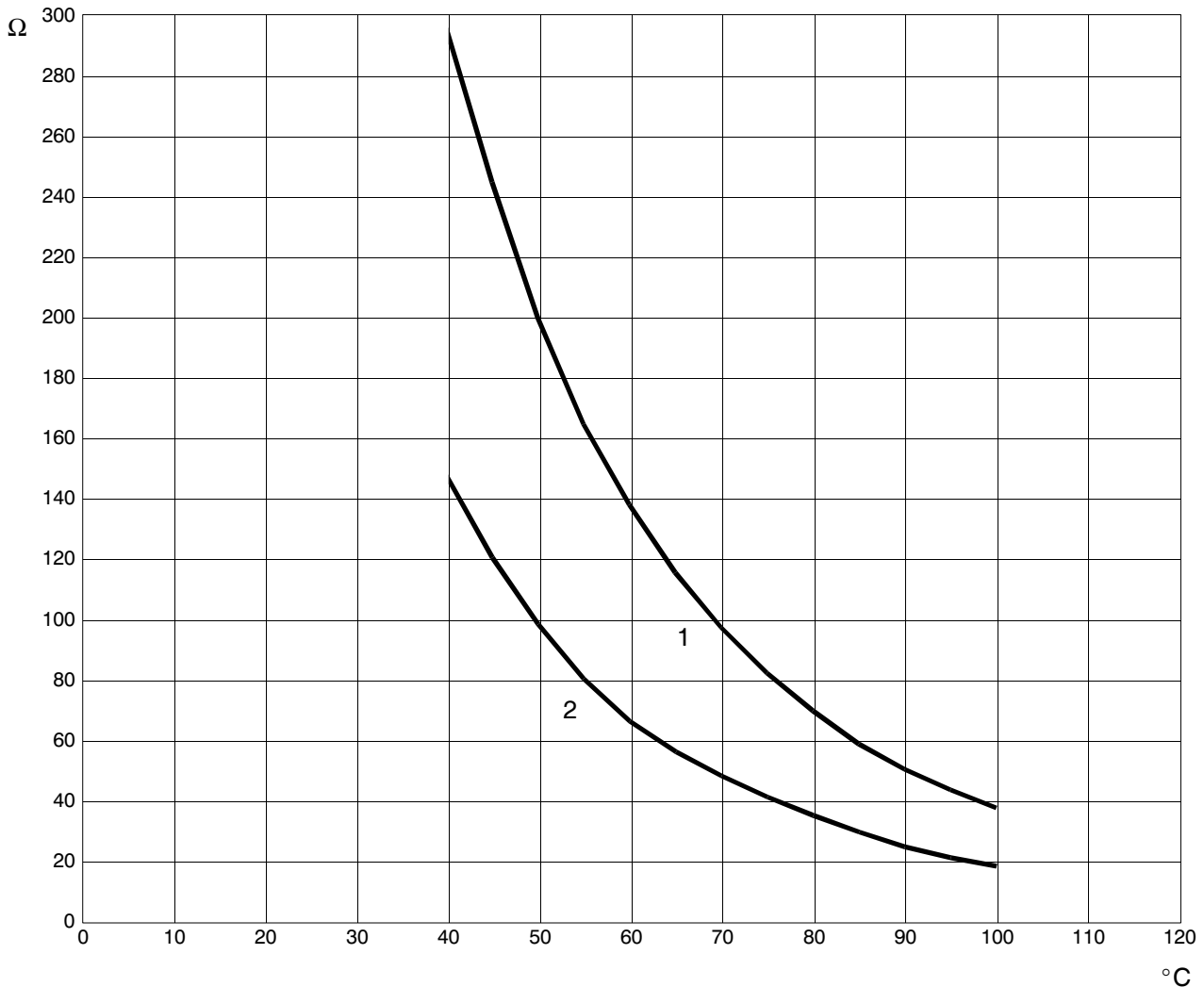
The glow plugs are checked with a voltmeter.



If a voltage of 12 V is present at a glow plug, this glow plug is in order. If the voltage present is 24 V, the glow plug is defective and must be changed.



## Checking the coolant temperature transmitter by measuring the resistance



Dip temperature sensor up to the lower edge of the hex section into a mixture of water and 30 % anti-freeze/anti-corrosion agent. The liquid must be circulated during this measurement. Check the temperature with a thermometer as the liquid is heated. Measure the resistance and compare it with the calibrated curves ( $^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$ ).

Curve 1: Temperature transmitter for 1 electrical instrument

Curve 2: Temperature transmitter for 2 electrical instruments

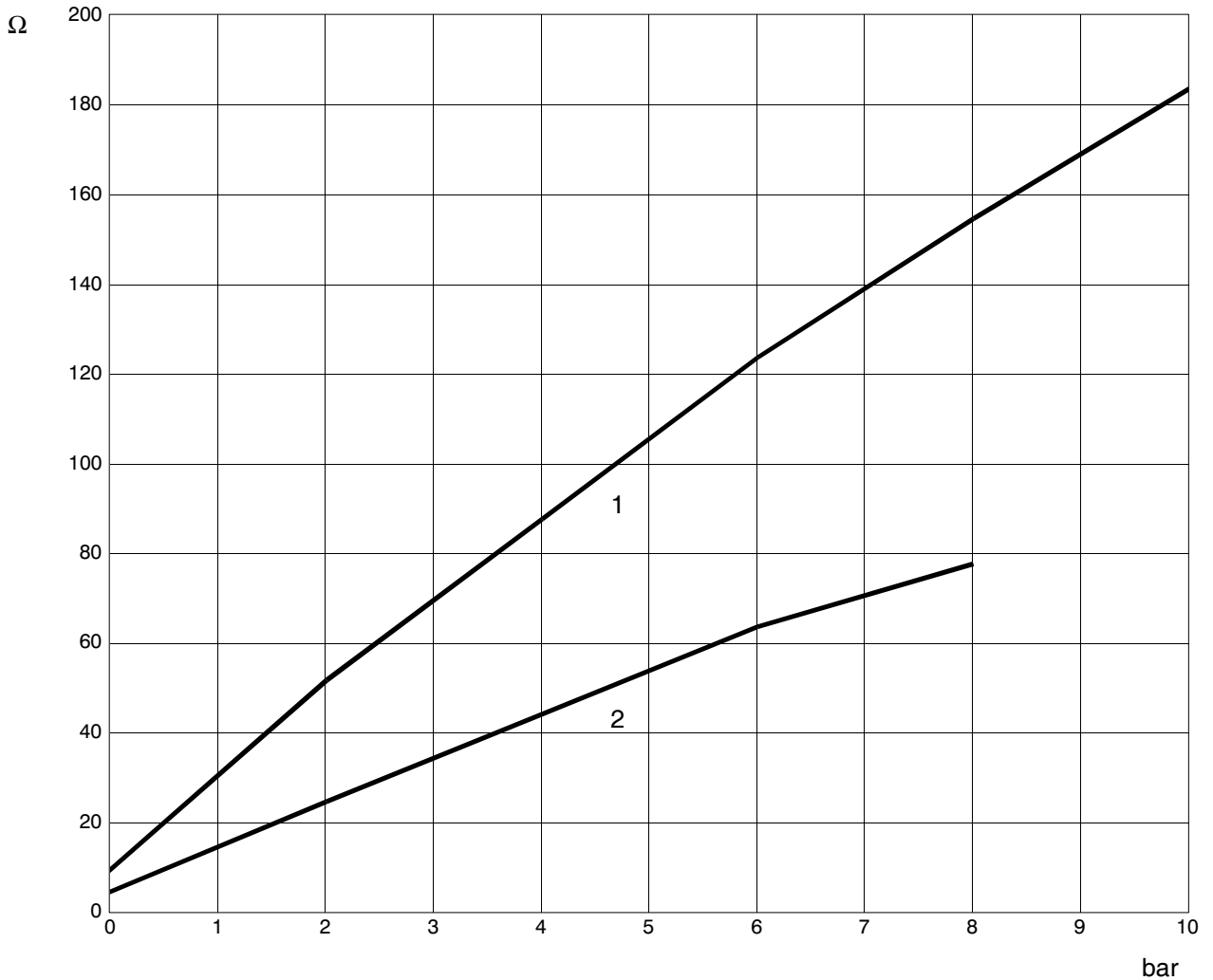
Temperature transmitter for 1 electrical instrument: checking values and tolerance of transmitter resistance

Temperature °C	40	60	90	100
Resistance Ω	296.0	134.0	51.2	38.5
Tolerance	-	$\pm 13.5 \Omega = \pm 4^{\circ}\text{C}$	$\pm 4.3 \Omega = \pm 3^{\circ}\text{C}$	$\pm 3.0 \Omega = \pm 3^{\circ}\text{C}$

Temperature transmitter for 2 electrical instruments: checking values and tolerance of transmitter resistance

Temperature °C	60	90	100
Resistance Ω	67	25.60	19.25
Tolerance	$\pm 6.5 \Omega = \pm 4^{\circ}\text{C}$	$\pm 2.1 \Omega = \pm 3^{\circ}\text{C}$	$\pm 1.5 \Omega = \pm 3^{\circ}\text{C}$

Checking the oil pressure transmitter by measuring the resistance



If the oil pressure transmitter is to be checked, the oil pressure must be measured with a second, independent instrument. Disconnect the gauge from the transmitter. Measure the resistance and compare it with the calibrated curves.

Curve 1: Pressure transmitter for 1 electrical instrument

Curve 2: Pressure transmitter for 2 electrical instruments

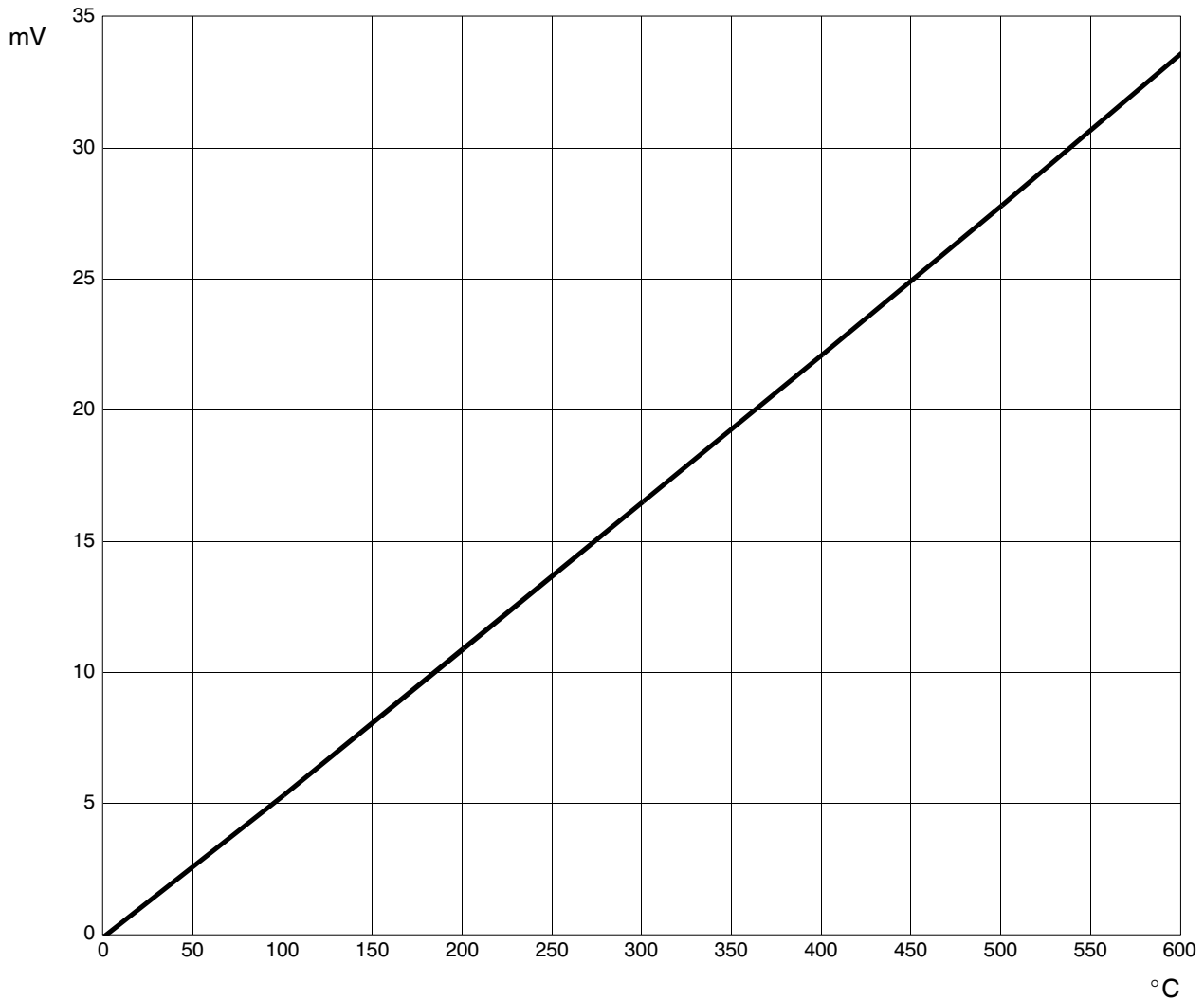
Pressure transmitter for 1 electrical instrument: checking values and tolerance of transmitter resistance

Pressure (bar)	0	2	4	6	8	10
Comparative resistance Ω	10 ± 6	52 ± 6	88 ± 6	124 ± 7	155 ± 7	184 ± 10

Pressure transmitter for 2 electrical instruments: checking values and tolerance of transmitter resistance

Pressure (bar)	0	2	6	8
Comparative resistance Ω	5 +1.8/ -3	25 ± 2.4	64 ± 3	78 ± 3

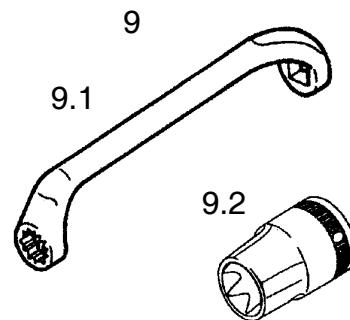
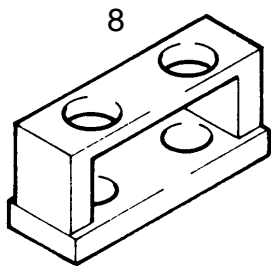
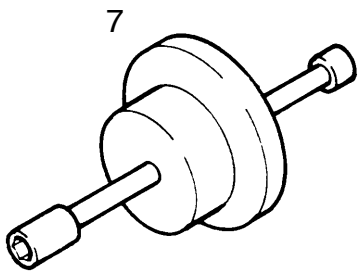
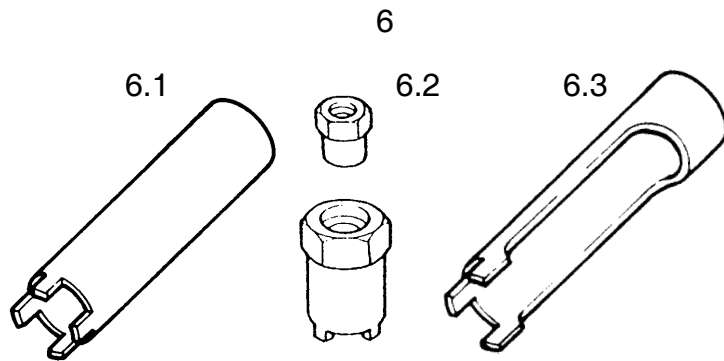
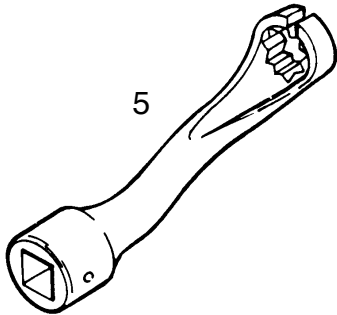
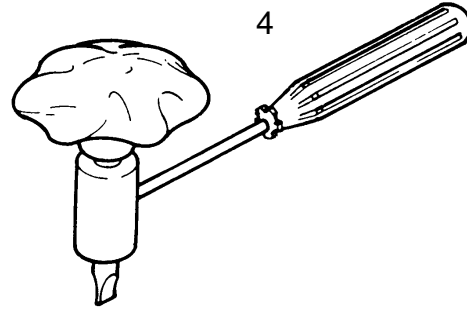
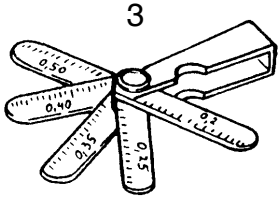
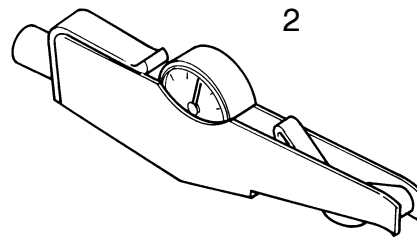
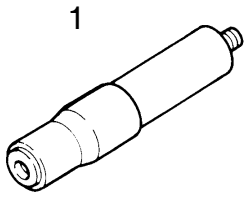
## Checking the exhaust gas temperature transmitter by measuring the voltage



If the exhaust gas temperature transmitter is to be checked, the exhaust gas temperature must be measured with a second, independent instrument. Disconnect the gauge from the transmitter. Measure the voltage and compare it with the calibrated curve ( $^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$ ).

Temperature °C	0	100	200	300	400	500	600
Voltage mV	0	5.37	10.95	16.56	22.16	27.75	33.67

## **Special tools**





---

<b>Fig. no.</b>	<b>Designation</b>	<b>Item number</b>
1	Test connection for compression recorder	80.99607-0002
2	V-belt tension indicator	81.66814-6001
3	Valve gauge	80.99607-6019
4	Valve setting spanner	80.99603-6007
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 injector	80.99602-0011
8	Clamping device for fuel injectors	80.99606-0312
9	Special wrench for cylinder head bolts	
9.1	Special wrench for cylinder head bolts	80.99603-0255
9.2	Socket for Torx bolts	08.06143-0215

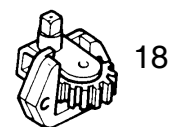
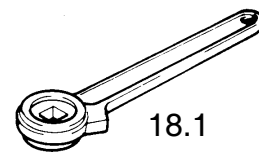
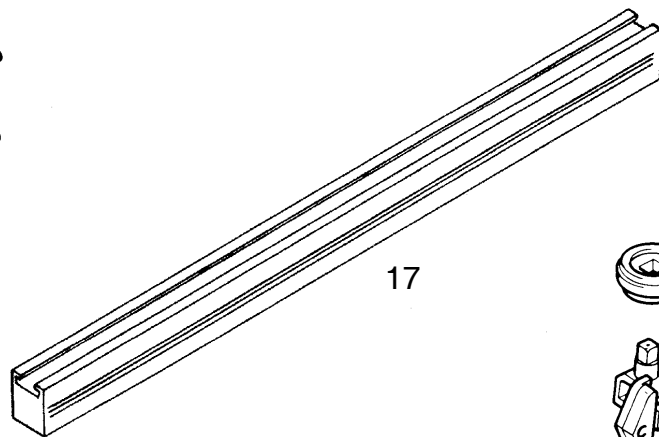
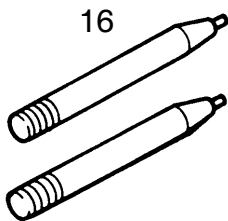
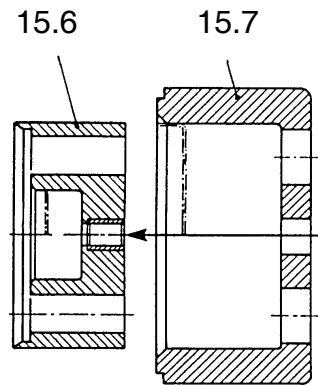
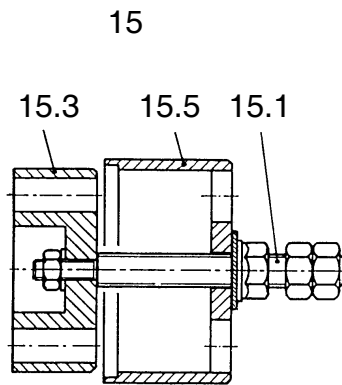
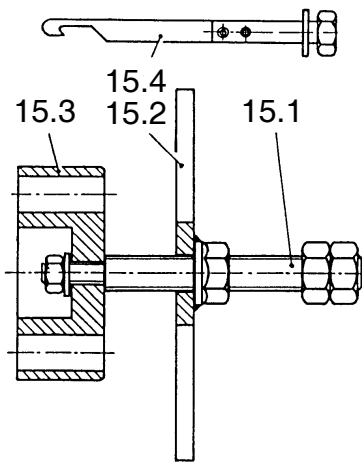
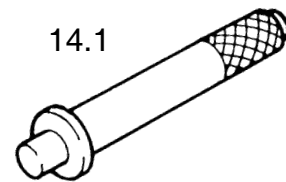
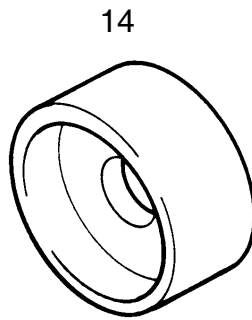
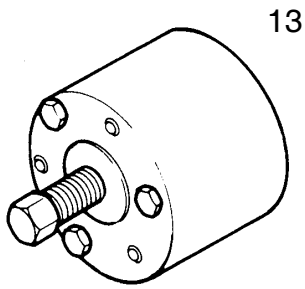
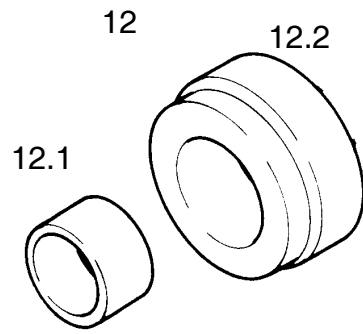
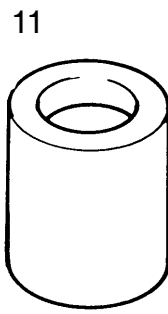
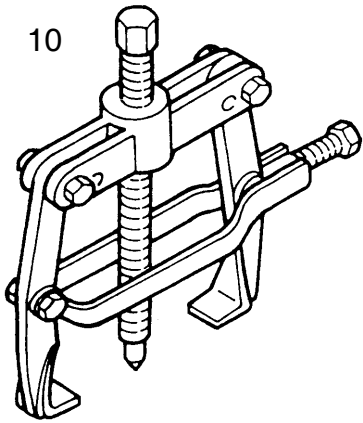
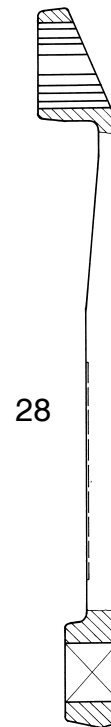
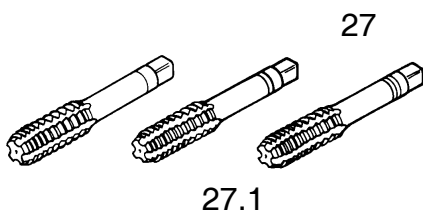
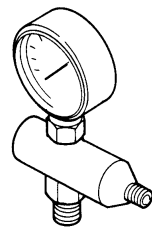
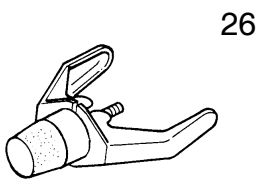
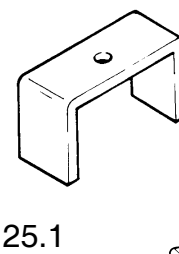
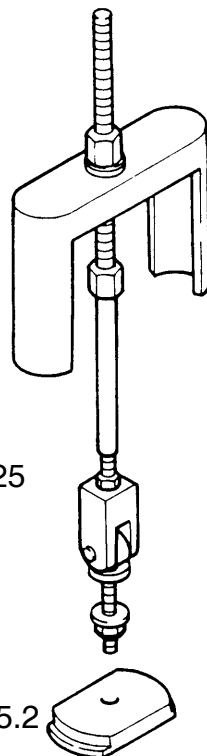
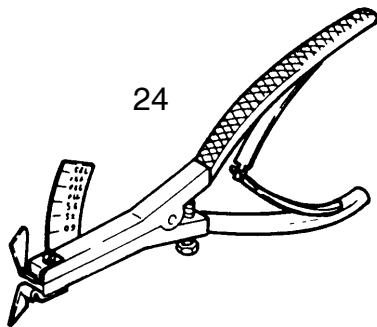
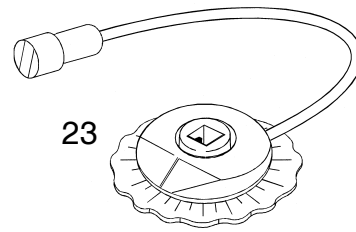
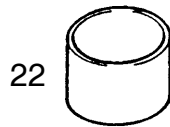
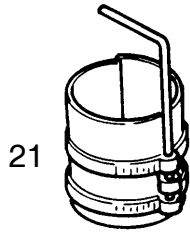
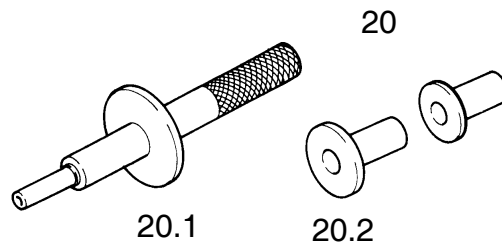
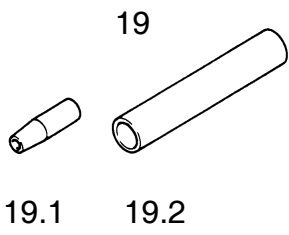
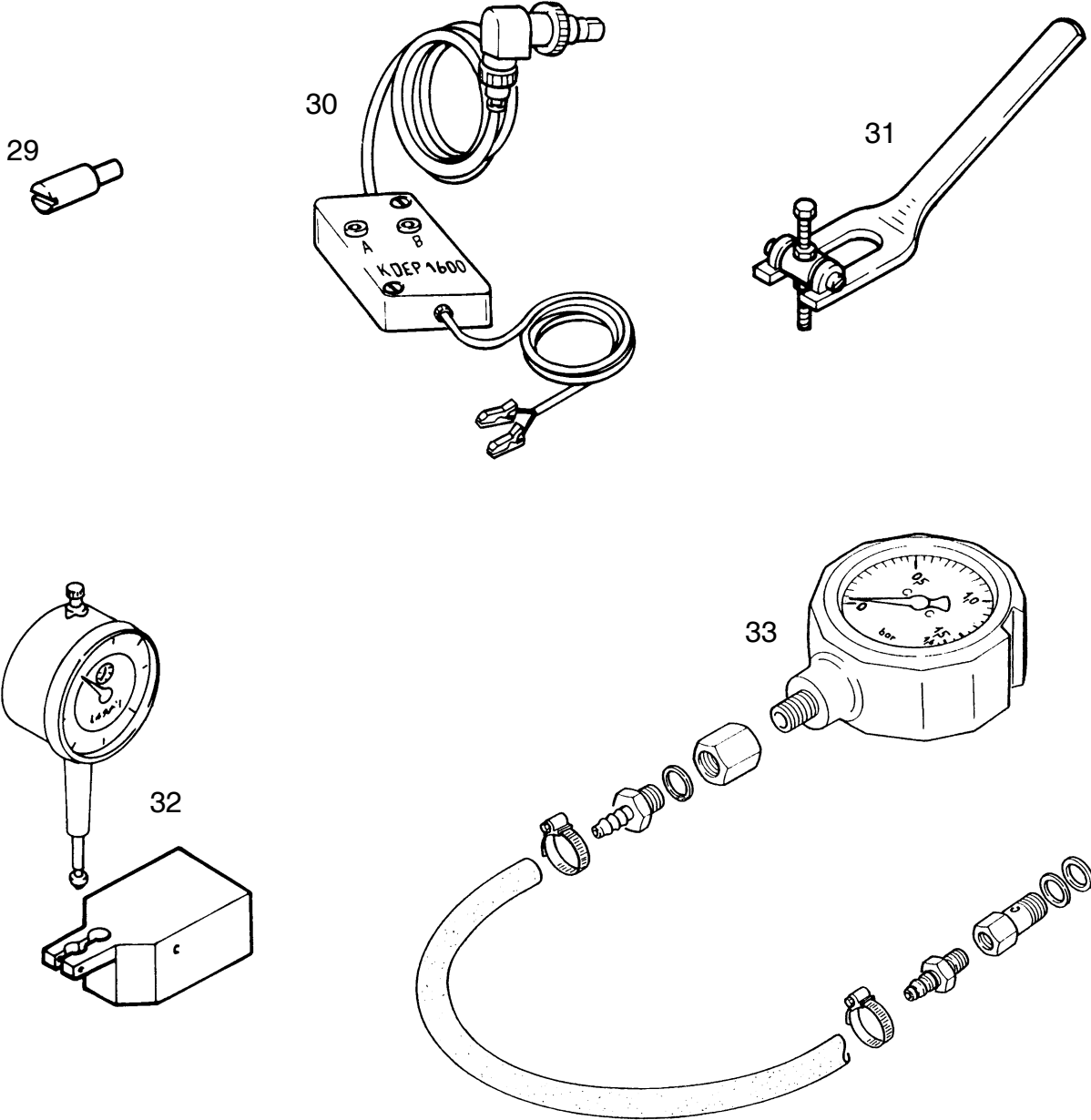


Fig. no.	Designation	Item number
10	Puller for water pump pulley	80.99601-0037
11	Pressing mandrel for cassette seal in conjunction with handle 14.1	80.99617-0091
12	Driving mandrel for seal in timing case consisting of:	80.99604-6002
12.1	Guide sleeve	80.99604-0068
12.2	Pressing plate in conjunction 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 Components:	80.99606-6011
15.1	Spindle	80.99606-0229
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	80.99605-0175
18	Engine turning device	80.99626-0004
18.1	Standard ratchet for 18	80.99627-0001



---

<b>Fig. no.</b>		<b>Item number</b>
19	Sleeves for valve stem seal	
19.1	Insert sleeve for valve stem seal	80.99606-0355
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	80.99607-0134
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	80.99607-6007
27	Thread-cutting tool	
27.1	Thread drill set, M15 x 2, for cylinder head bolt threads	80.40001-0001
28	Ring spanner for PTO drive gear	80.99603-0210



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<b>Bild-Nr.</b>	<b>Designation</b>	<b>Item number</b>
29	Blocking pin	80.99605-0217
30	Light signal transmitter	80.99605-6002
31	Valve assembly lever	80.99606-0031
32	Dial gauge holder for measuring valve retrusion and piston protrusion	90.99605-0172
33	Pressure gauge + accessories for charge-air pressure measurement	80.99605-0206

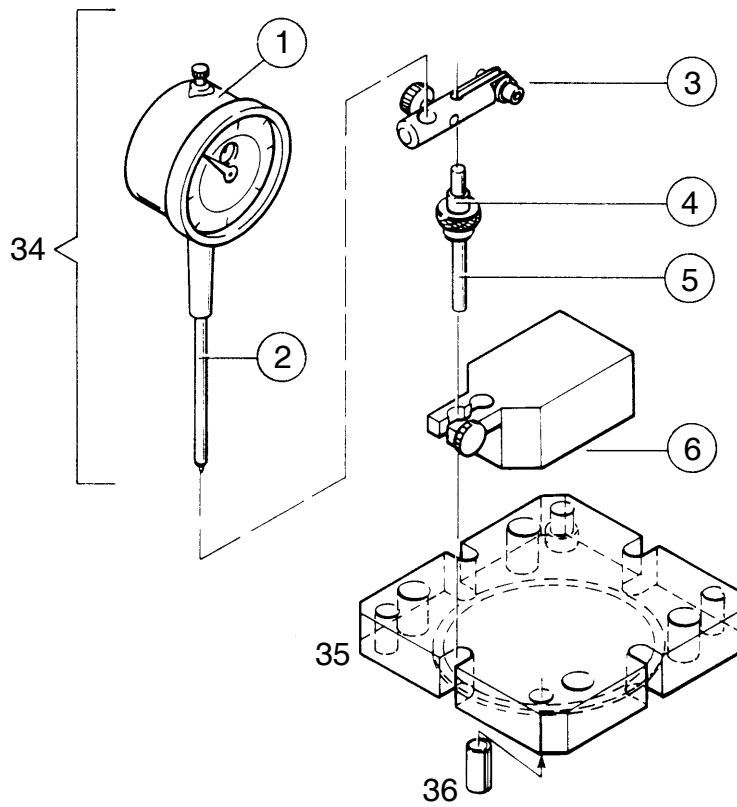
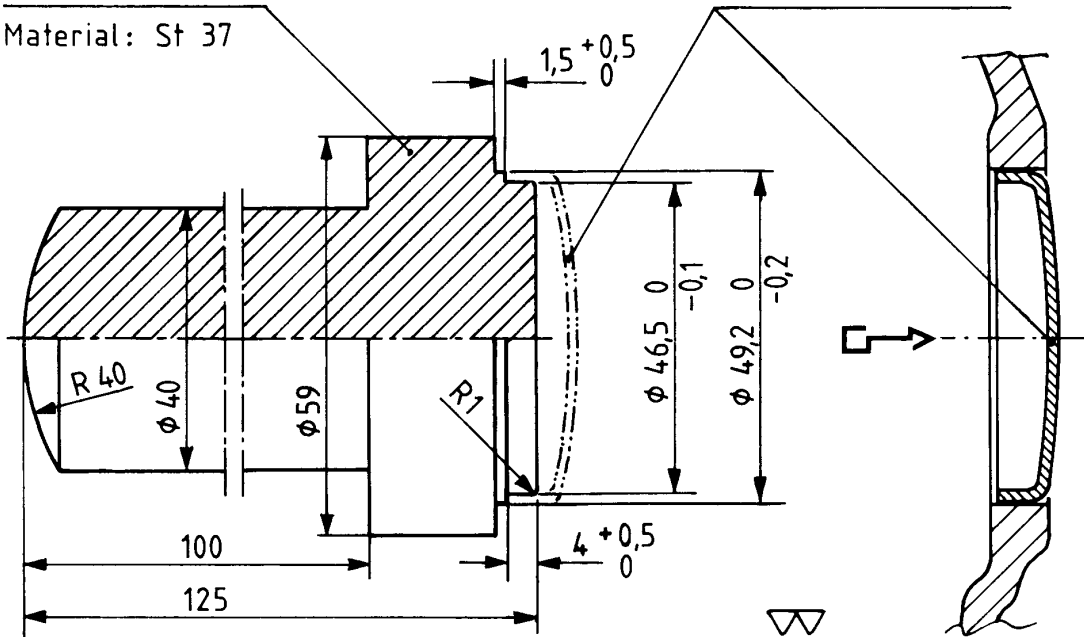


Fig. no.	Designation	Item number
34	Measuring combination, consisting of:	
	(1) Dial gauge	08.71000-1205
	(2) Tracer pin for dial gauge	80.99605-0197
	(3) Dial gauge holder	80.99605-0179
	(4) Contact pin	80.99605-0180
	(5) Dial gauge holder	80.99605-6006
	(6) Dial gauge holder	80.99605-0172
35	Press-on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



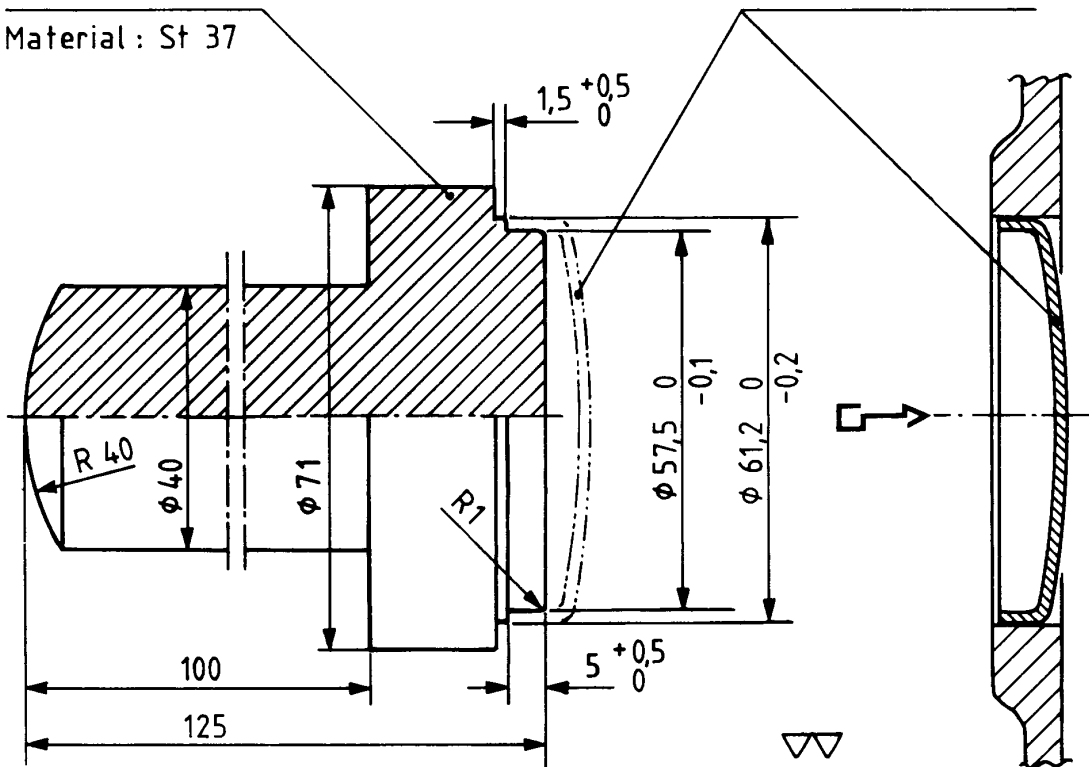
Pressing mandrel for cap, dia. 50.1 mm

Material: St 37



Pressing mandrel for cap, dia. 62.1 mm

Material: St 37

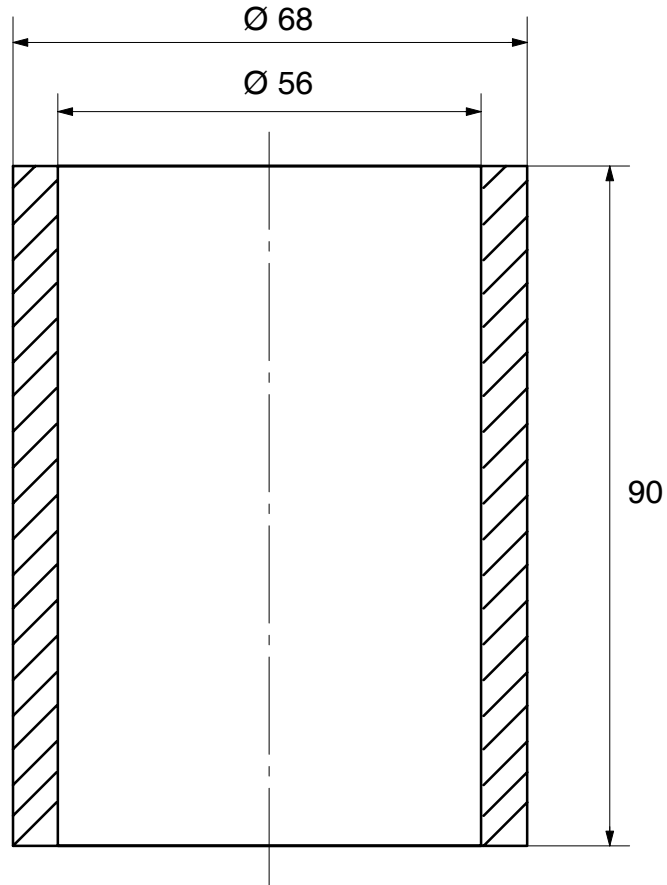


2843

**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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