

Repair Manual



MAN-Marine Diesel Engines

D 2866 LE 401 / 402 / 403 / 405

D 2876 LE 301

D 2876 LE 403



This Repair Manual is designed to facilitate repair of the engines listed in line with accepted technical principles.

In addition to this Repair Manual the following publications are available:

- Operating Instructions
- Fuels, Lubricants and Coolants for MAN Diesel Engines
- Spare-parts catalogue
- Service record book with maintenance plan

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 describe 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's 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 in the internet under:

<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

We reserve the right to make technical modifications in the course of further development.

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Important instructions which concern technical safety and protection of persons are emphasised as shown below.

**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

Flat seals / gaskets are often inserted with sealing agents or adhesives to make fitting them easier or to achieve better sealing. Flat seals may slip in operation due to the “sewing-machine” effect, in particular if they are used between parts with different rates of linear expansion under heat (e.g. aluminium and cast iron), and leaks may then 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.

Flat seals / gaskets can be fitted properly only if the following points are observed:

- 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

Fitting 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)

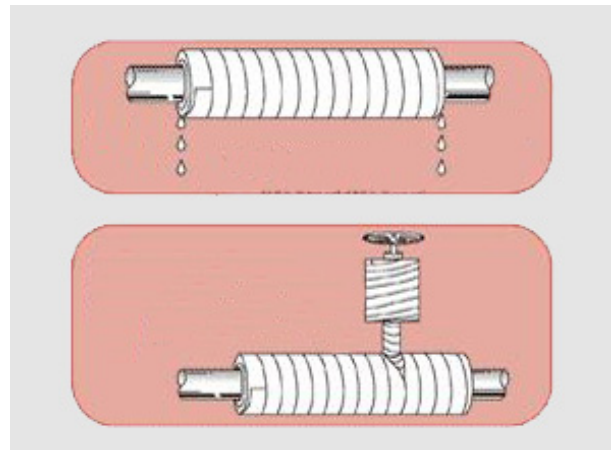
The unions of pressurised oil and fuel pipes are masked with a protective tape. If this tape is removed during a repair, the unions must be masked with protective tape again afterwards.

The following pipes are affected:

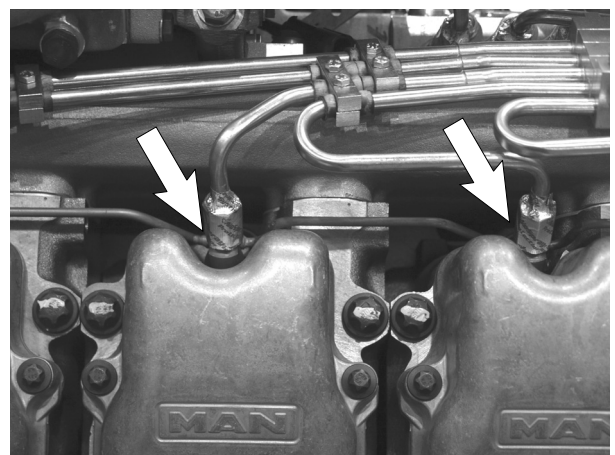
- Oil supply pipe to turbochargers
- Fuel pipes between supply pump, filter and injection pump
- Injection pipes protected against leaks

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

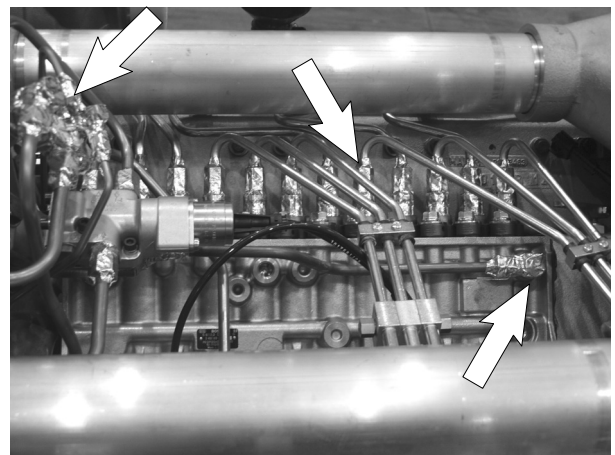
Figs. 2-4
The unions to be masked must be clean and free of oil and grease. Do not apply the protective tape unless this is the case



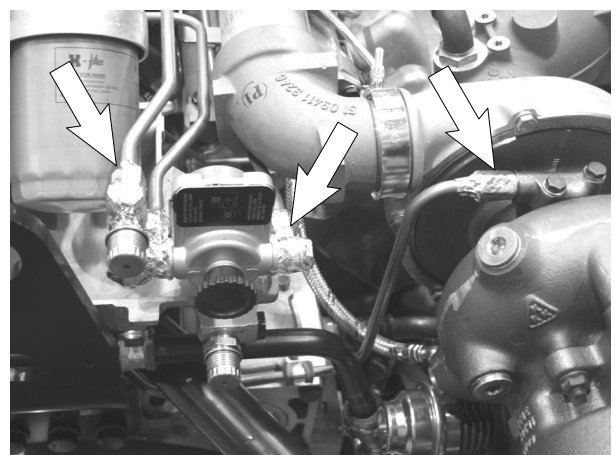
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General information

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

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

1. Instructions for preventing accidents with injury to persons

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

- When carrying out maintenance and repair work, ensure that the engine cannot be accidentally started from the bridge by unauthorised persons.
- The engine must be started and operated by authorised personnel only.
- When the engine is running, do not get too close to revolving components. Wear tight-fitting working clothes.
- Do not touch hot engine with bare hands: risk of burning yourself.
- Keep engine vicinity, ladder and steps free of oil and grease. Accidents resulting from slipping may have serious consequences.
- Work only with tools that are in good condition. Worn spanners slip: risk of injuries.
- Persons must not stand under an engine suspended from a crane hook. Keep lifting gear in good order.
- Open coolant circuit only after the engine has cooled down. If opening the coolant circuit while the engine is hot is unavoidable, observe the instructions in the chapter "Maintenance and care" in the Operator's Manual.
- Neither retighten nor open pressurised pipelines and hoses (lube oil circuit, coolant circuit and downstream hydraulic oil circuit if fitted): risk of injuries resulting from emerging fluids.
- When checking the injection nozzles, do not hold your hands in the fuel jet. Do not inhale fuel mist.



- When working on the electrical system, unplug earth cable from battery first and reconnect it last to avoid short-circuits.
- Observe the manufacturer's instructions for handling batteries.
Caution:
Battery acid is toxic and caustic. Battery gases are explosive.
- When carrying out welding work, observe the "Information sheets for welders".





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

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

3. Instructions for preventing environmental damage

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

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

Coolant

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

4. Instructions for handling used engine oil *

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

Health and safety regulations:

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

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

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

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

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



General information on the overhaul of engines

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

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

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

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

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

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

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 Operating Instructions as well as the publication “Fuels, Lubricants, Coolants for MAN Diesel Engines”.

Fault	Probable cause	Remedy <small>(This column is filled in only if the "probable cause" gives no clue as to what must be done).</small>
Starter does not crank the engine or only too slowly	<ul style="list-style-type: none"> ● Battery main switch in "off" position ● Batteries flat ● Crankgear blocks ● Battery cable connections loose or corroded ● Starter electromagnetic switch sticking (clicks) ● Cable connection from ignition lock to starter electromagnetic switch is loose or interrupted ● Starter electromagnetic switch faulty ● Starter defective (carbon brushes loose, winding faulty, short-circuit to earth) ● Engine oil viscosity not suitable ● Starter interlock relay defective 	<ul style="list-style-type: none"> ● Knock on the magnet ● Check with check lamp ● See "Fuels, Lubricants ..." ● Checking: Connect terminals 50e and 50f
Engine does not start	<ul style="list-style-type: none"> ● Fuel tank empty ● Fuel valve shut ● Cut-off solenoid in "STOP" position ● Air in fuel system ● Fuel lines leaky, ruptured, clogged ● Fuel filter / prefilter clogged ● Suction height of fuel delivery pump (max. 1m) exceeded ● Fuel delivery pump faulty ● Air supply/exhaust gas pipes clogged ● Unsuitable fuel ● Delivery start incorrect ● Valve clearance incorrect ● Injection nozzles worn ● Compression insufficient 	
Engine does not start while cold	<ul style="list-style-type: none"> ● Fuel filter clogged with paraffin ● Engine oil viscosity unsuitable see: "Engine does not start" 	<ul style="list-style-type: none"> ● See "Fuels, Lubricants ..."
Engine does not run smoothly, and stops	<ul style="list-style-type: none"> ● Lower idle speed set too low ● Air in fuel system ● Fuel lines leaky, ruptured, clogged ● Fuel filter clogged ● Inlet chamber pressure of injection pump too low ● Fuel high-pressure part leaky ● Injector needle sticking ● Delivery start set incorrectly ● Injection pump set incorrectly or defective ● Valve clearance incorrect ● Compression insufficient 	<ul style="list-style-type: none"> ● Remedy by Bosch Service

Trouble shooting table



<p>Engine speed variations during operation</p>	<ul style="list-style-type: none"> ● Too little fuel in fuel tank ● Air in fuel system ● Fuel lines leaky ● Fuel high-pressure part leaky ● Injection nozzles defective, worn ● Speed governor defective 	<ul style="list-style-type: none"> ● Remedy by Bosch Service
<p>Engine cannot be stopped</p>	<ul style="list-style-type: none"> ● Cut-off linkage bent or jammed ● Cut-off solenoid without voltage ● Injection pump set incorrectly or defective 	<ul style="list-style-type: none"> ● Remedy by Bosch Service
<p>Performance unsatisfactory, max. boat speed is not reached</p>	<ul style="list-style-type: none"> ● Engine speed adjusting lever not in full-load position ● Incrustation of hull, shaft system and propeller with foreign matter ● Propeller consumes too much power, nominal speed is not reached ● Propeller consumes too much power, engine runs in the breakaway range ● Flow of water on to the propeller insufficient ● Fuel temperature too high ● Unsuitable, contaminated fuel ● Fuel filter clogged ● Air in fuel system ● Lack of fuel ● Temperature in engine room too high, combustion air and fuel too hot ● Supply of combustion air insufficient, intake vacuum too high ● Charge-air pipes leaky ● Intercooler contaminated ● Turbocharger contaminated or defective ● Compression insufficient ● Injection pump and / or governor defective 	<ul style="list-style-type: none"> ● Route the ship-mounted fuel lines well apart from the hot engine parts. ● See "Fuels, Lubricants ..." ● Check fuel lines and delivery pump ● Check inward and outward ventilation ● Check intake air supply to air filters ● Remedy by Bosch Service



Trouble shooting table

<p>Coolant temperature too high, coolant loss</p>	<ul style="list-style-type: none"> ● Coolant level too low ● Air in coolant circuit ● Proportion of anti-freeze / anticorrosion agent too high ● Raw water supply clogged ● Raw water supply insufficient ● Cap with working valves on expansion tank defective, leaky ● Thermostat in closed position blocked ● Heat exchanger heavily contaminated, pipe group coated with foreign matter ● V-belt for water pump drive not correctly tensioned (slipping) ● Water pump leaky, defective (bearing damage) ● Coolant circuit clogged by foreign matter ● Thermostat jammed in "shut" position 	<ul style="list-style-type: none"> ● See "Fuels, Lubricants ..." ● Check inlet orifice ● Impeller worn. Measure delivery of raw water pump and vacuum at inlet
<p>Lube oil pressure varies/too low</p>	<ul style="list-style-type: none"> ● Oil level in oil pan too low ● Oil level in oil pan too high ● Max. inclination exceeded ● Engine temperature too high ● Oil viscosity unsuitable (viscosity too low) ● Oil in oil pan too thin (mixed with condensation or fuel) ● Heavy bearing wear ● Oil pump gears heavily worn ● Safety valve in oil circuit defective (does not shut, spring fatigued or broken) ● Oil pressure gauge defective 	<ul style="list-style-type: none"> ● Dipstick marked correctly? See Operator's Manual ● See "Fuels, Lubricants ..."
<p>Lub oil pressure too high</p>	<ul style="list-style-type: none"> ● Engine cold ● Oil viscosity unsuitable (viscosity too high) ● Safety valve in oil circuit defective (does not open) ● Oil pipes/oil galleries clogged ● Oil pressure gauge defective 	<ul style="list-style-type: none"> ● See "Fuels, Lubricants ..."
<p>Lube oil consumption too high</p>	<ul style="list-style-type: none"> ● Leaks in the lube oil circuit, particularly at the turbocharger and oil cooler ● Oil level in oil pan too high ● Lube oil quality does not satisfy regulations ● Turbocharger wear ● Piston rings heavily worn ● Valve guides heavily worn 	<ul style="list-style-type: none"> ● See "Fuels, Lubricants ..." ● Measure play of rotor

Trouble shooting table



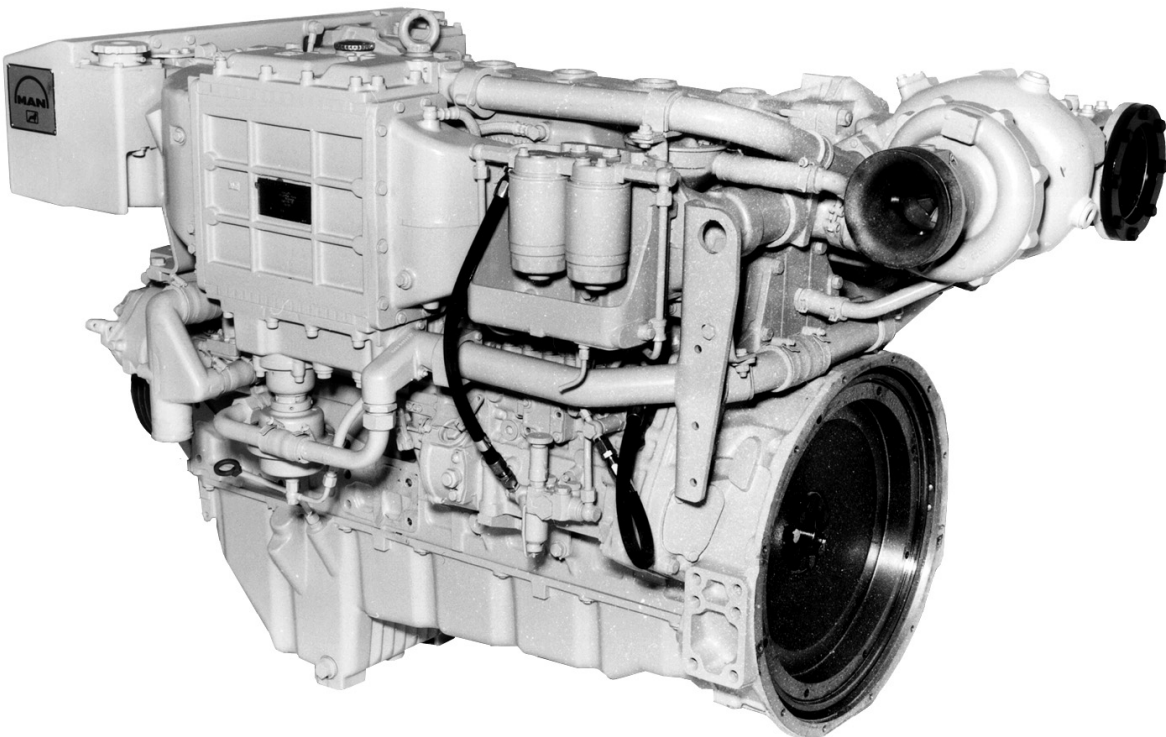
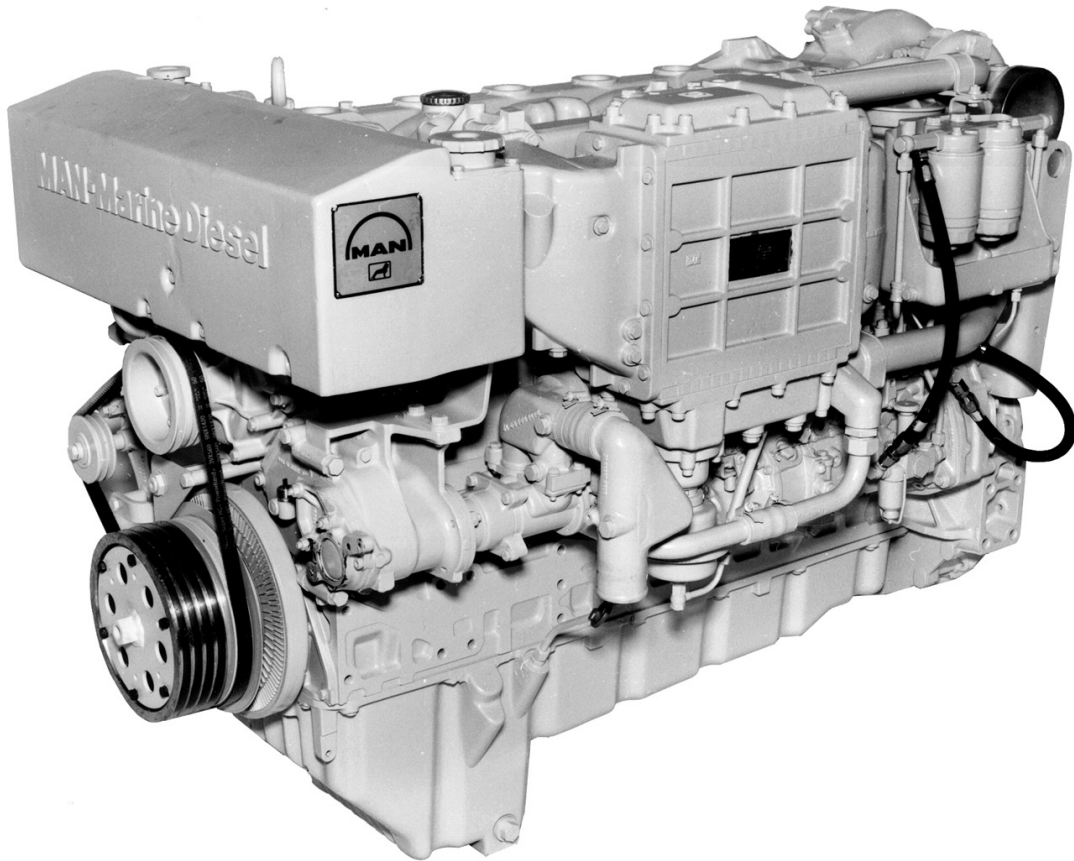
<p>Fuel consumption too high</p>	<ul style="list-style-type: none"> ● Constant full-load operation ● Speed resistance owing to incrustation of hull, shaft system and propeller with foreign matter ● Poor efficiency of the drive system ● Fuel quality does not satisfy regulations ● Fuel leaks in the system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

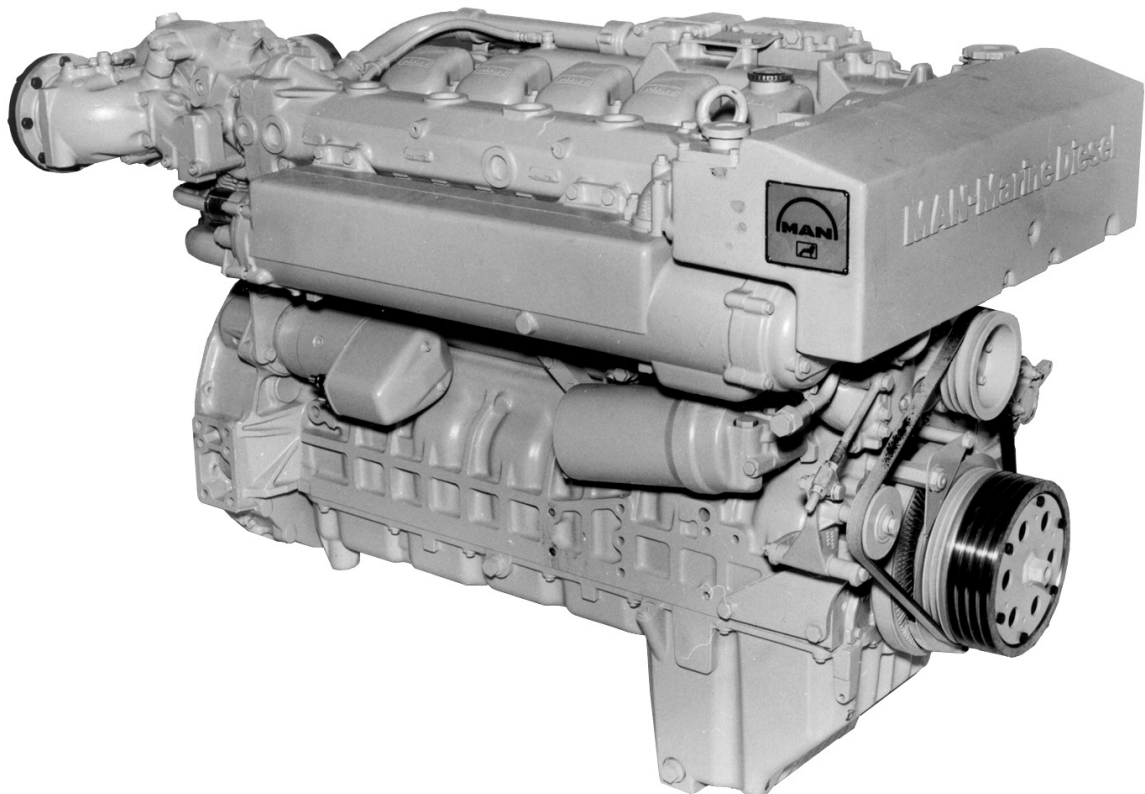
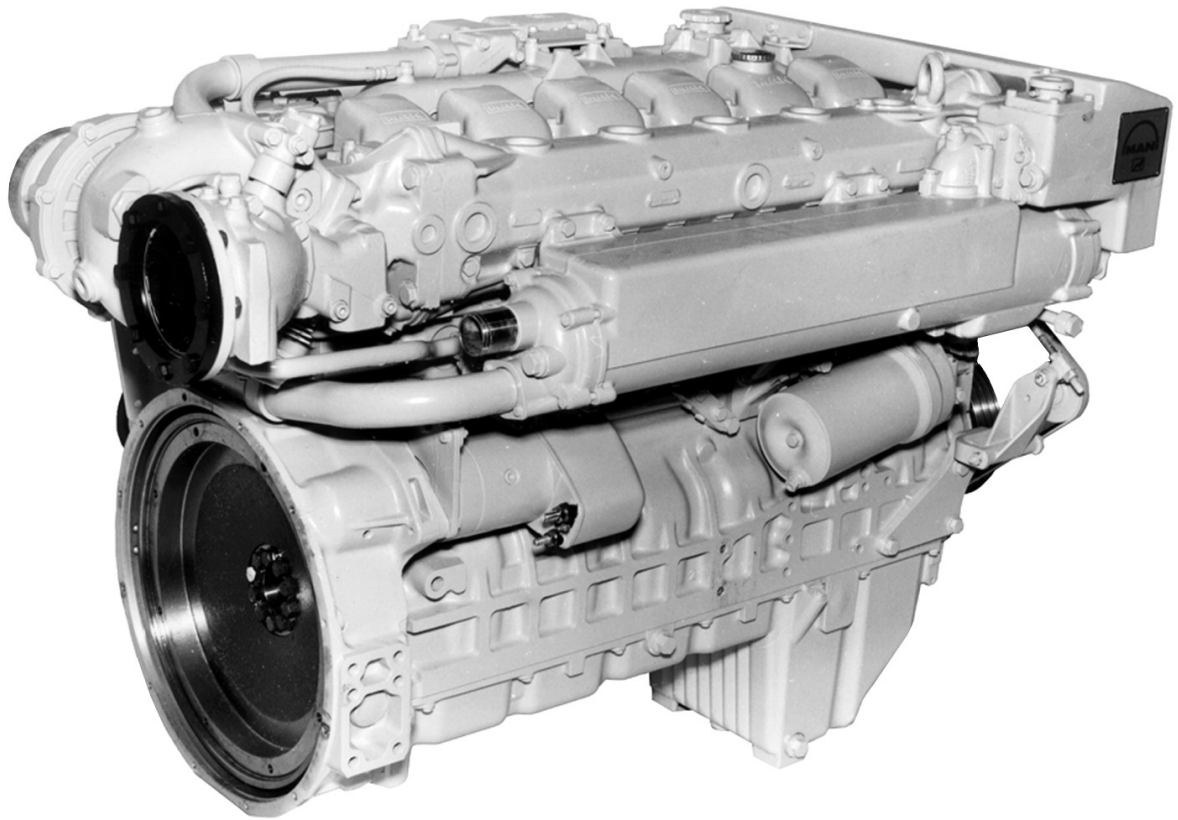


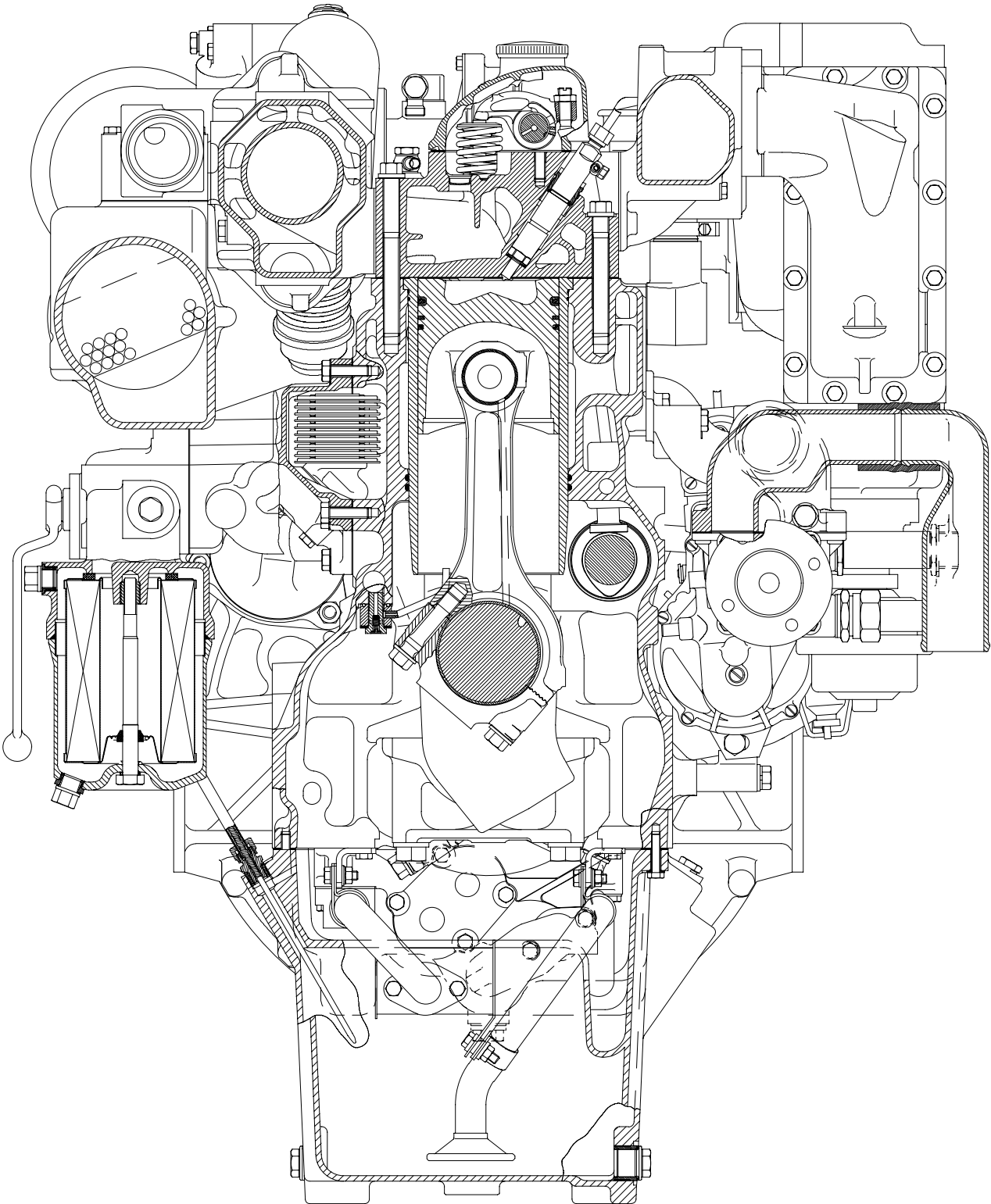
Trouble shooting table

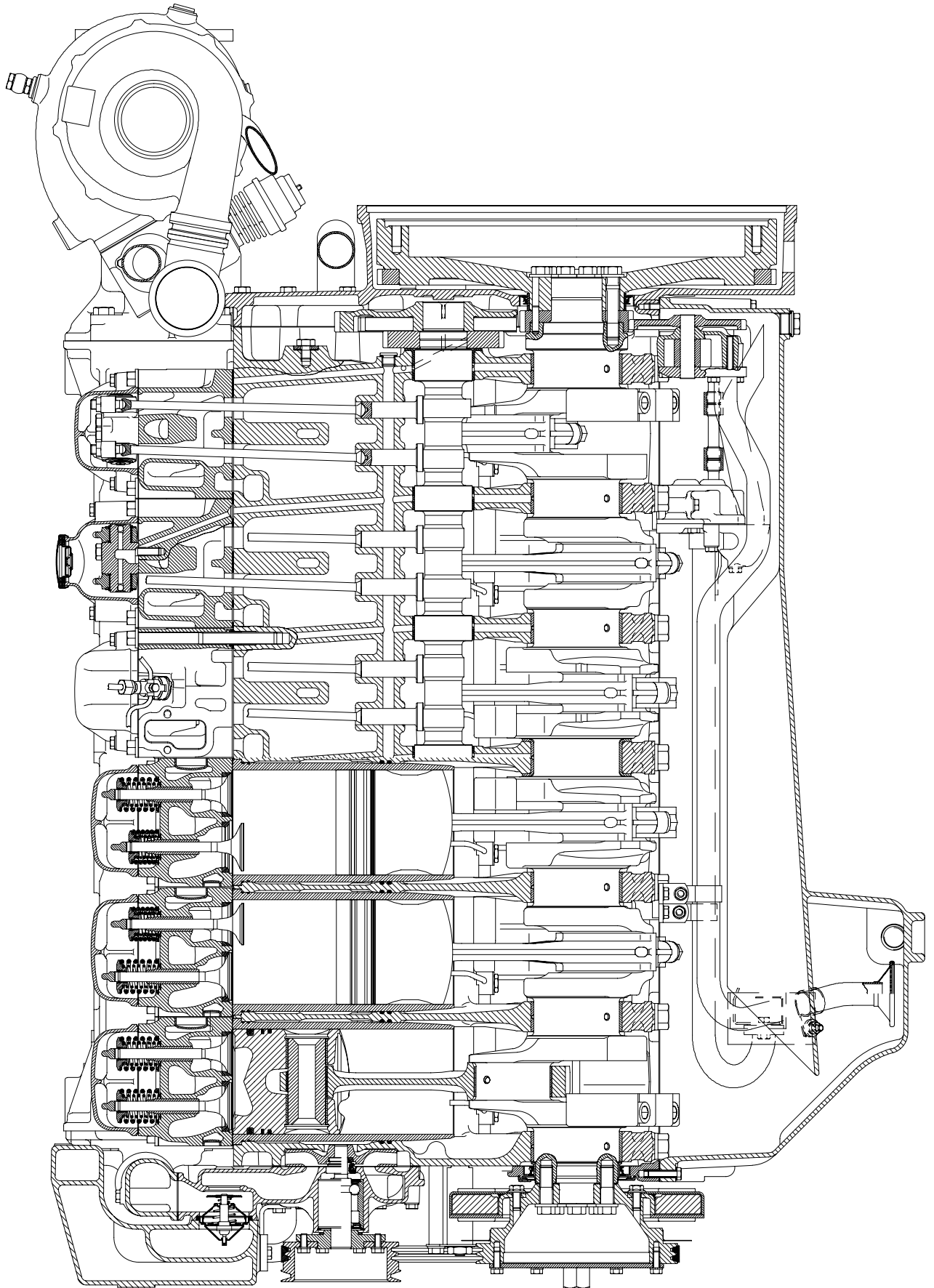
Vibrations, droning noise, structure-borne sound	<ul style="list-style-type: none">● Drive system not or inaccurately aligned● Unsuitable clutch● Unsuitable engine/gearbox mounts● Elastic mounts unequally loaded (height adjustment)● Propeller shaft unbalanced	
Engine knocks	<ul style="list-style-type: none">● Engine in cold running phase● Delivery start set incorrectly● Injector needle sticking● High load at low speed● Fuel is slow to ignite● Compression too low	
Engine is too loud	<ul style="list-style-type: none">● Intake or exhaust gas pipe leaky● Valve clearance too large● V-belt slipping● Timing gears worn, backlash of teeth too large	

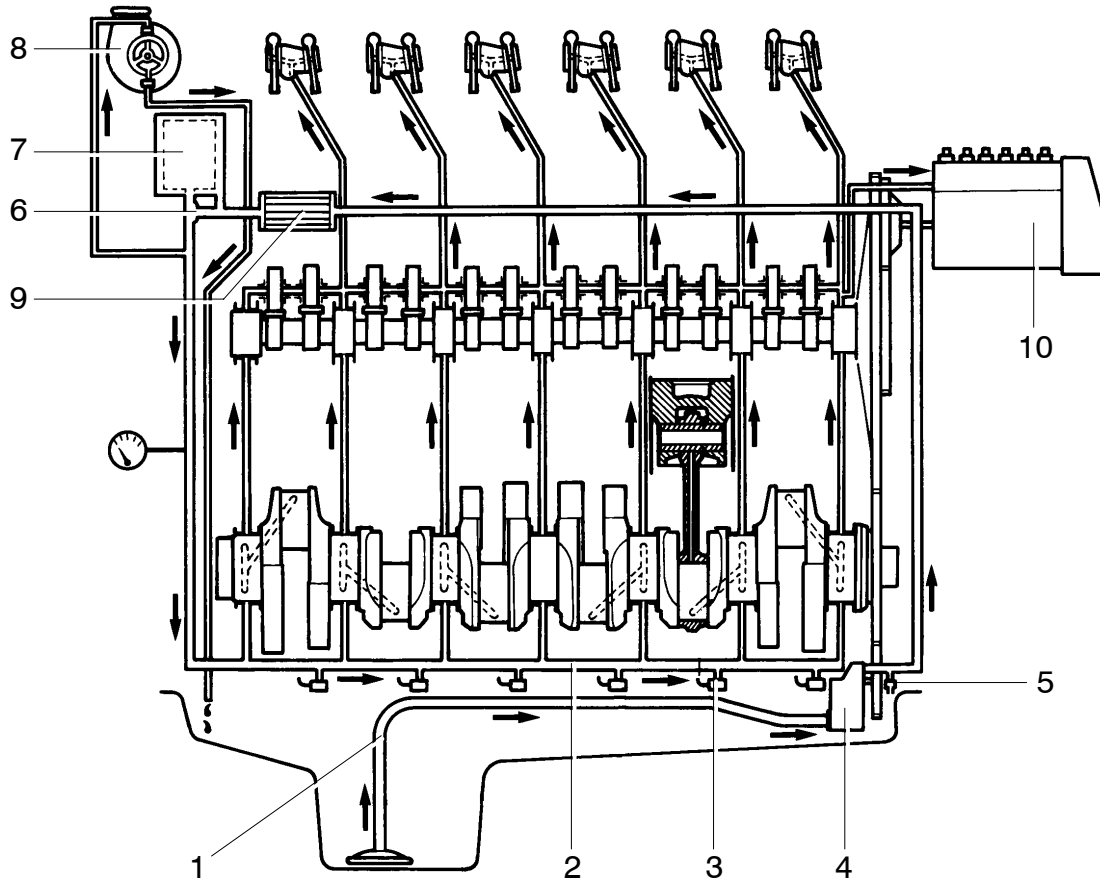
<p>Starter</p> <ul style="list-style-type: none"> ● Pinion does not turn or turns too slowly ● Pinion does not engage ● Pinion engages but stops ● Pinion continues to run after starter switch has been released ● Pinion does not disengage after successful start 	<ul style="list-style-type: none"> ● Battery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







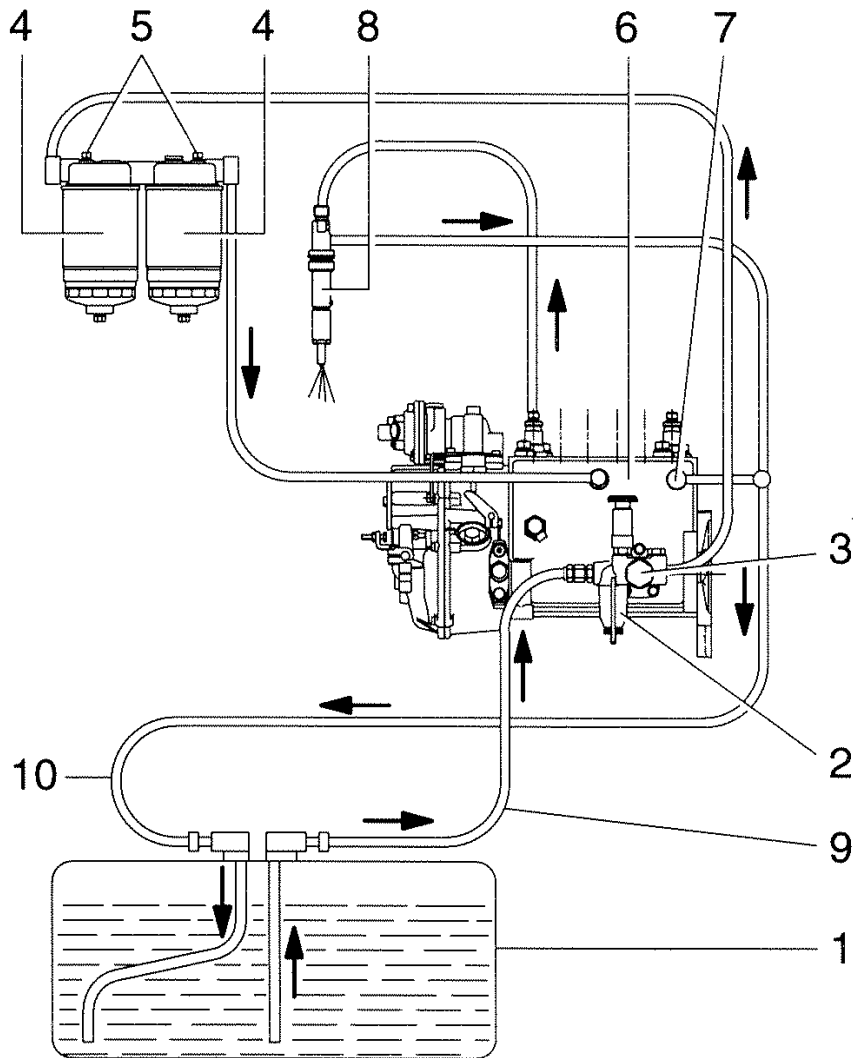




- 1 Oil suction pipe
- 2 Distributor pipe
- 3 Oil spray nozzle
- 4 Oil pump
- 5 Oil pressure relief valve

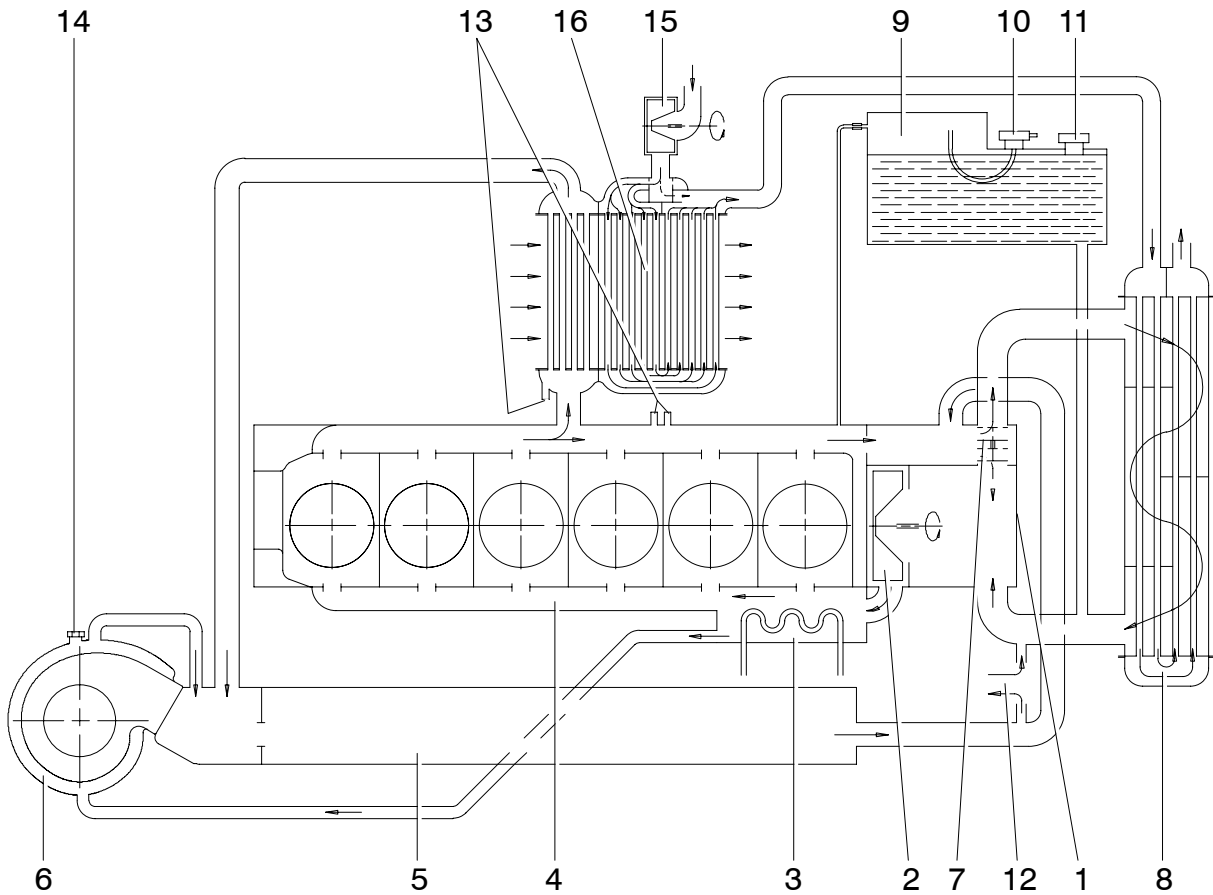
- 6 Bypass valve
- 7 Oil filter
- 8 Turbocharger
- 9 Oil cooler
- 10 Injection pump

Schematic diagram of fuel system



- 1 Fuel tank
- 2 Fuel prefilter
- 3 Fuel delivery pump
- 4 Fuel filter
- 5 Bleed screw

- 6 Fuel injection pump
- 7 Overflow valve
- 8 Fuel injector
- 9 Suction pipe
- 10 Return pipe



- | | | | |
|---|---|----|---|
| 1 | Water pump housing with integrated thermostat housing | 9 | Expansion tank |
| 2 | Water pump impeller | 10 | Over/underpressure valve |
| 3 | Engine oil cooler | 11 | Coolant filler neck |
| 4 | Crankcase | 12 | Heating lead and return line |
| 5 | Exhaust manifold, liquid-cooled | 13 | Measuring point for cooling water temperature |
| 6 | Turbocharger, liquid-cooled | 14 | Bleed screw on turbocharger |
| 7 | Thermostat | 15 | Raw water pump |
| 8 | Engine coolant/raw water heat exchanger | 16 | Intercooler |

Checking start of delivery

Fig. 1

For the purpose of checking the start-of-delivery setting, an “OT” (= TDC) mark and a scale (2) from 10 ... 50° before TDC are engraved on a disc fitted in front of the torsional vibration damper. The scale marks are read against a pointer (1) fitted to the crankcase.

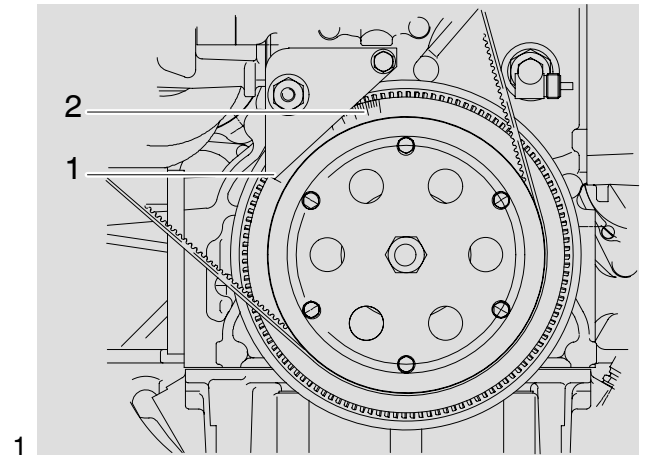


Fig. 2

To turn the engine over manually during the setting work, a plate with a central hexagon bolt is located on the front side of the crankshaft pulley.



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.

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

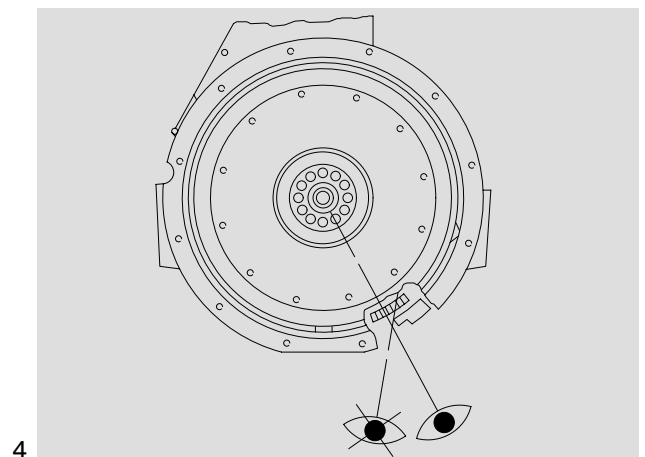
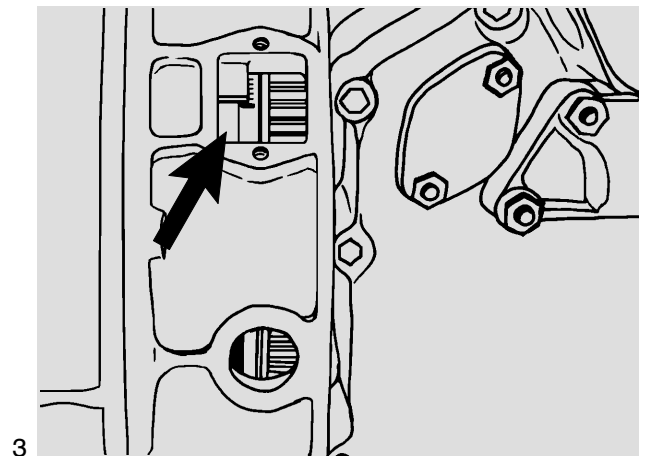
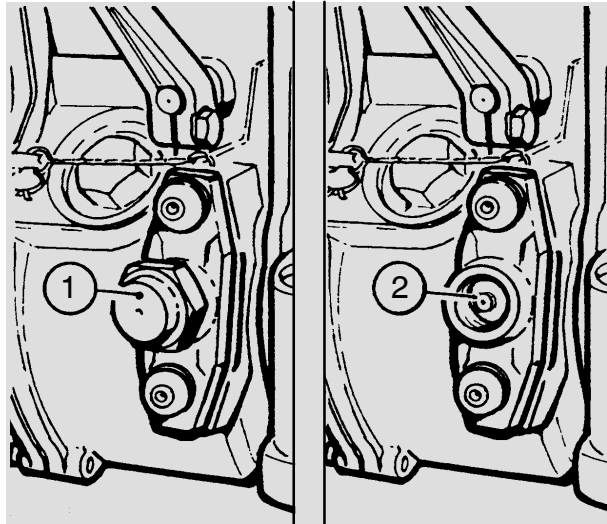


Fig. 5

Remove screw plug ① on governor housing.
 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:



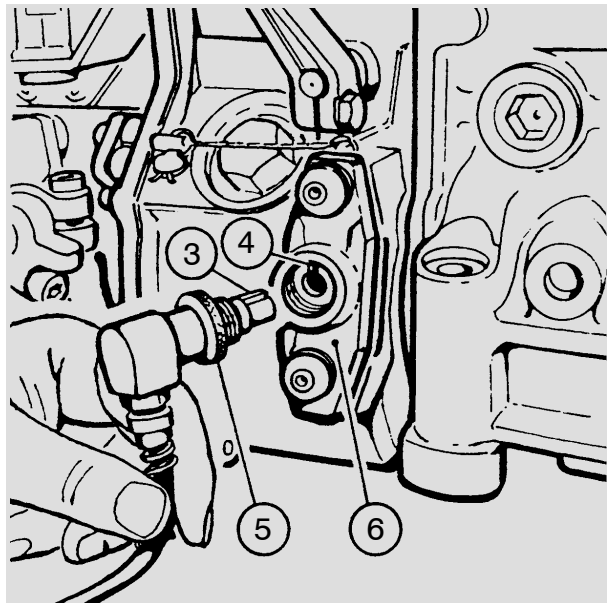
5

a. Light signal transmitter

Fig. 6

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.

Connect up power supply of light signal transmitter (red terminal = +). 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.



6

Fig. 7

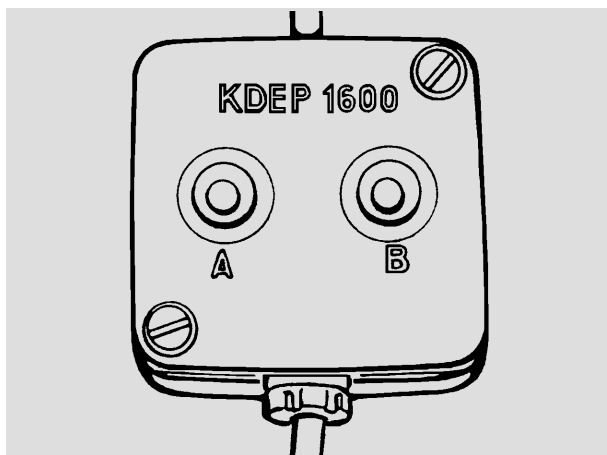
Slowly turn the engine further until lamp (B) comes on too. The injection pump is now at start of delivery.

The light signal transmitter KDEP 1600 (Fig.) is connected to the starter battery for the power supply.



Note:

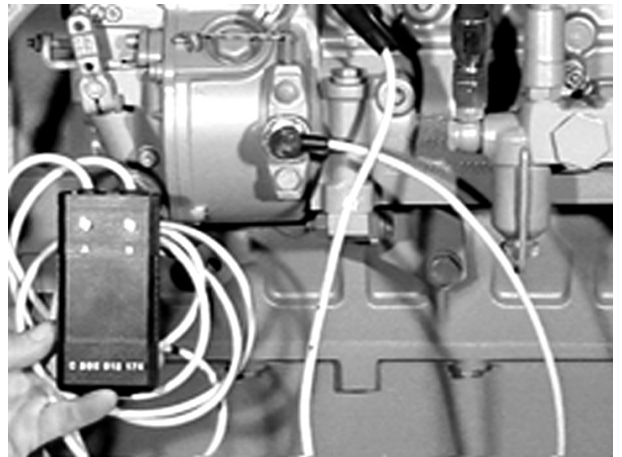
If only lamp (B) comes on during this test, the engine has been turned past the start of delivery. In this case turn the engine back and repeat the procedure.



7

Fig. 8

The light signal transmitter KDEP 1601 (Fig.) is energized by its own power supply.



8

b. Sleeve

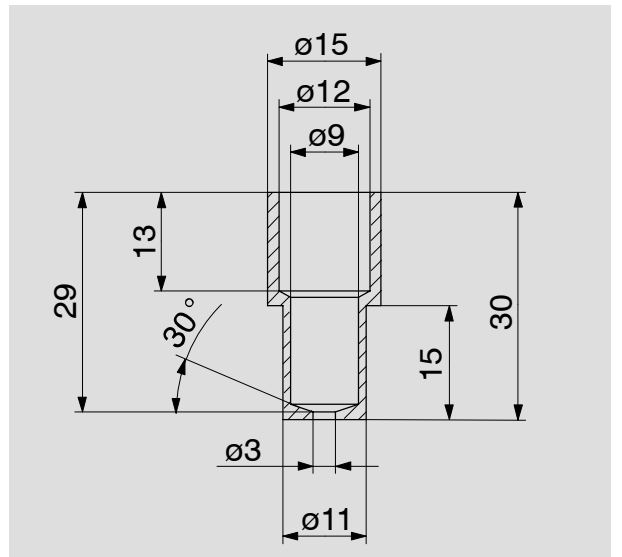
Fig. 9

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.



9

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

Remove timing case cover (13mm).

10



Fig. 11

Loosen all bolts fastening the drive gear to the injection pump hub (13mm). For this, two complete turns of the engine are necessary.

11

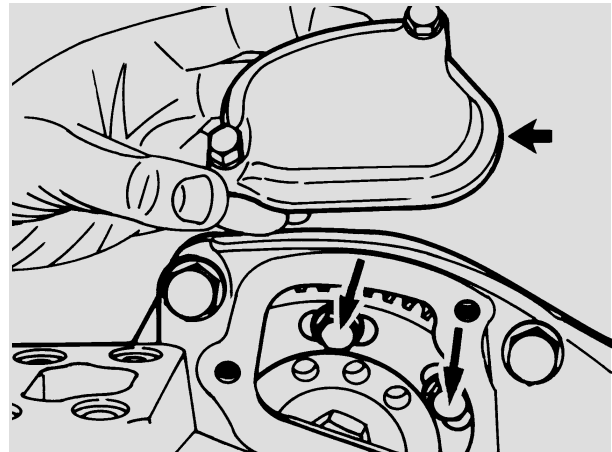


Fig. 12

Turn engine to specified angle for delivery start. Remove cylinder head cover from cylinder no. 6 (flywheel end). When the values of this cylinder are in crossover, the piston in cylinder no. 1 is at ignition TDC.

Remove screw plug from governor housing (see Fig. 5). 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 30 Nm.

Check delivery start once again.

Close governor housing.

12



Removing injection pump

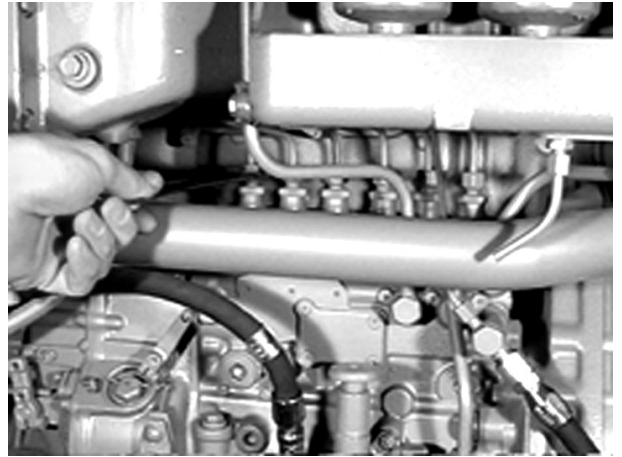
Fig. 1

Close cut-off valve from fuel tank to engine.
Remove all fuel and air (LDA) connections from the injection pump and detach the injection lines.



Caution:

The lines contain fuel.
Catch emerging fuel in a container.



1

Fig. 2

Remove bracket from the injection pump (19 mm).



2

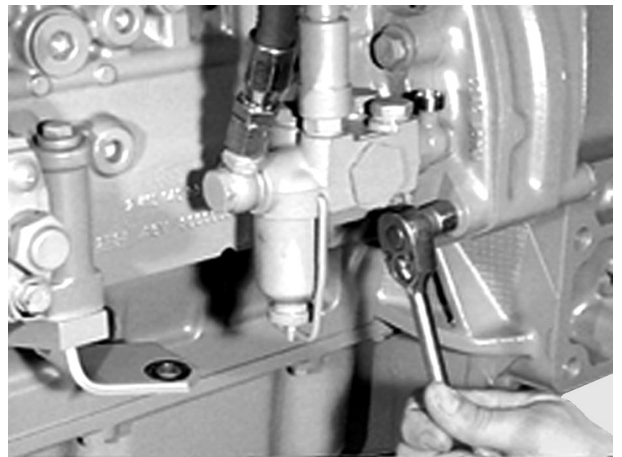
Fig. 3

Remove the mounting bolts from the injection pump flange (17 mm).



Note:

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



3

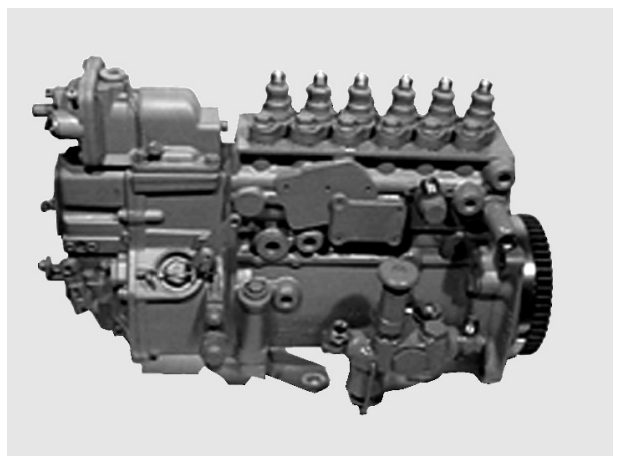
Fig. 4

Take off injection pump.



Note:

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



4

Installing injection pump

Fig. 5

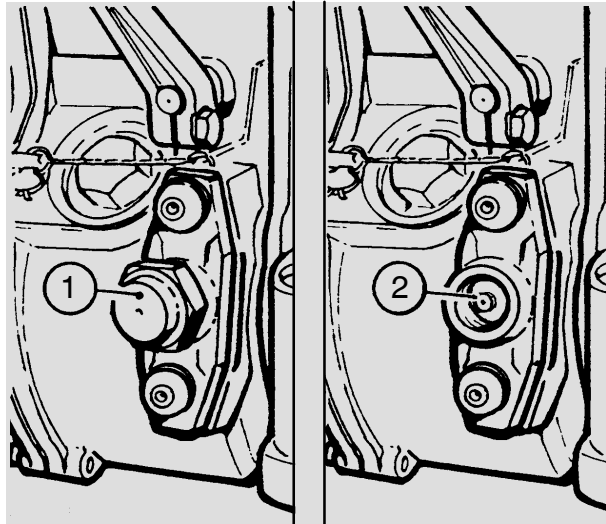


Caution:

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.



5

Fig. 6

Turn engine to angle for delivery start.
Take cylinder head cover off cylinder no. 6 (fly-wheel end). When the cylinders are in crossover, the piston of cylinder no. 1 is at TDC at the end of the compression stroke.



6

Fig. 7

Check whether the injection pump is in delivery start position. To do this, remove the screw plug from the governor housing (see Fig. 5). 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.



7

Fig. 8

Insert the injection pump and tighten the mounting bolts.

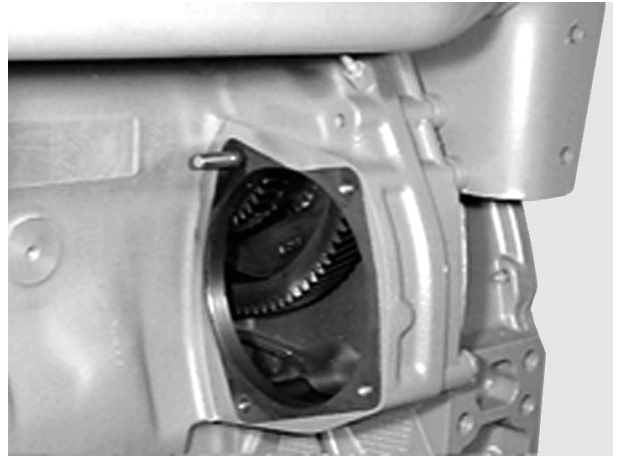
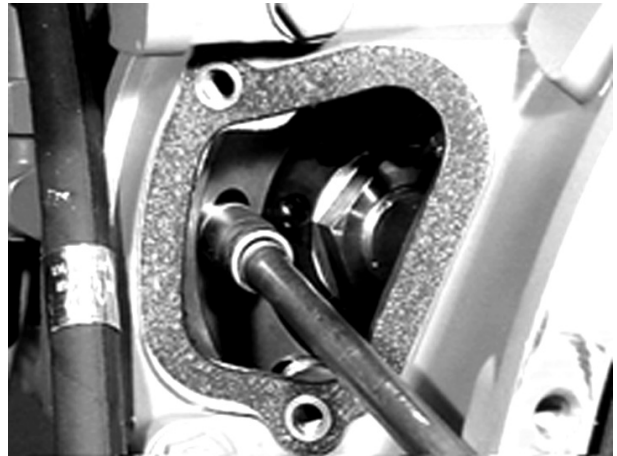


Fig. 9

Apply an initial torque of 5 Nm to all mounting bolts on the gear through the inspection hole. Two complete engine turns are necessary for this operation. Now tighten all mounting bolts to 30 Nm. Check delivery start, if necessary readjusting it (see page 25). Screw in screw plug on the governor housing and fit cover to timing case.



Caution:

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

Removing fuel injectors

Fig. 1

Remove leakage fuel return lines.

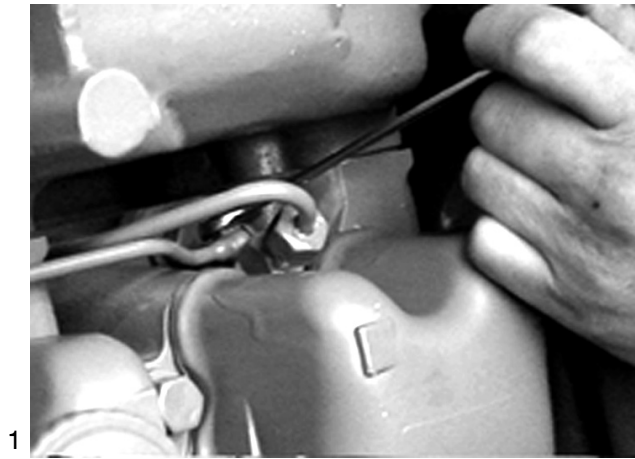


Fig. 2

Remove injection lines.

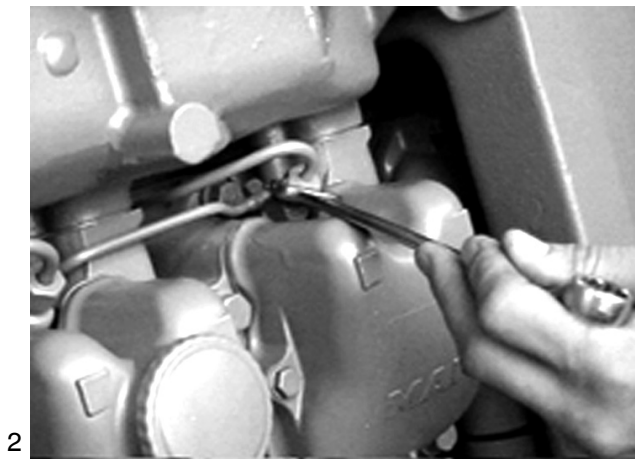


Fig. 3

Remove pressure screw from fuel injector using a pin spanner.

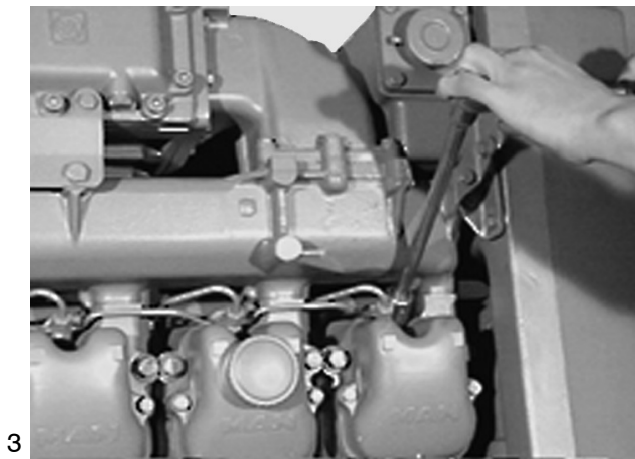


Fig. 4

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

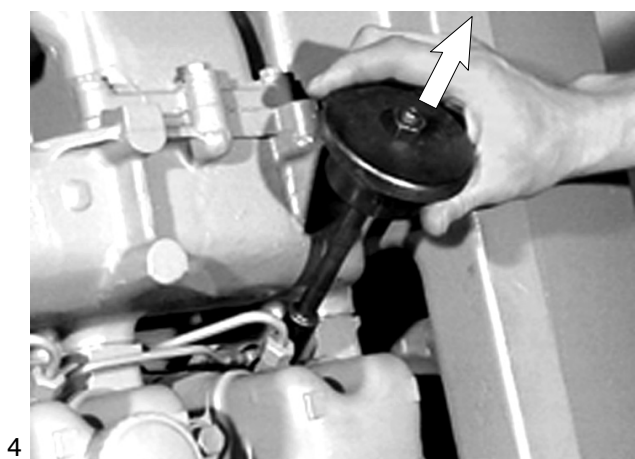
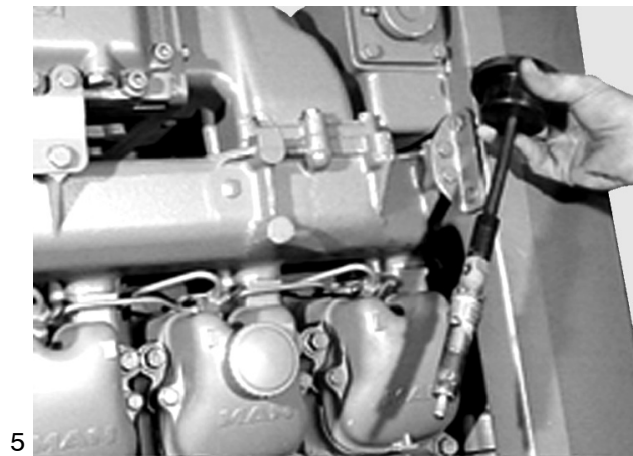


Fig. 5

Take out injector and injector seal.
Check and repair injector.



Installing fuel injectors

Fig. 6

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

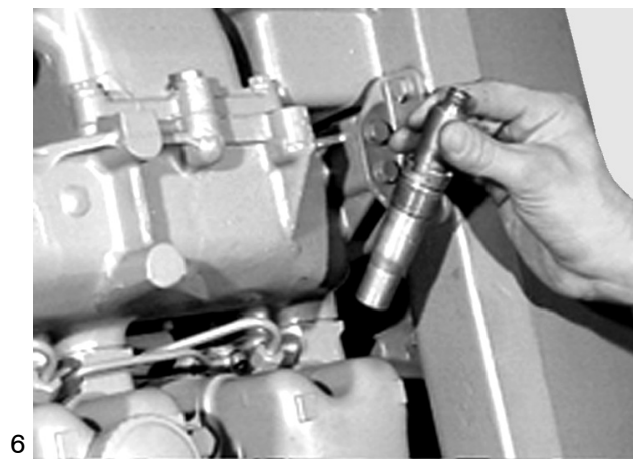
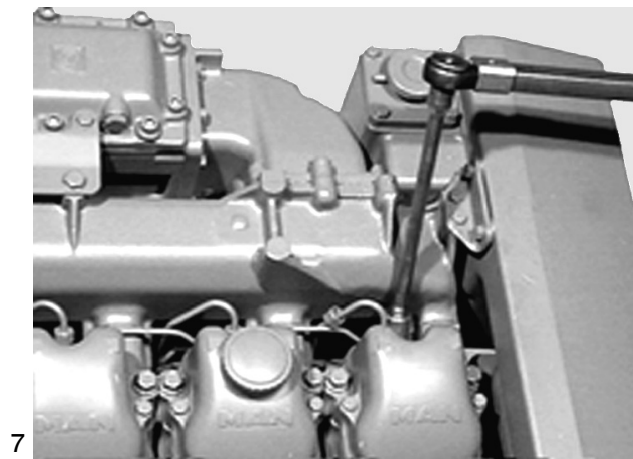


Fig. 7

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.

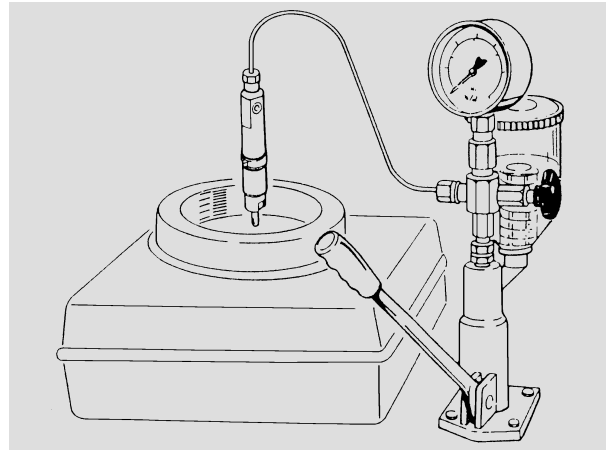


Fig. 2

Check injector assembly.

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

1



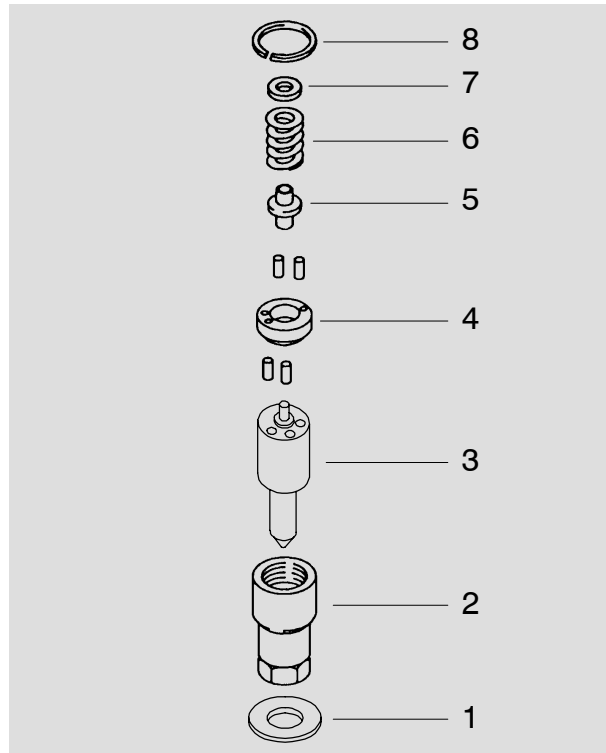
Danger:

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

1. Checking opening pressure:

Switch on the pressure gauge and slowly press lever downwards until the nozzle emits a jet with a light grating noise.

Read **opening pressure** from the pressure gauge. In the event of a pressure deviation insert a different shim. If the pressure is too low, insert thicker shims, if it is too high, insert thinner shims (7). The initial tension of the compression spring (6) decreases if a high number of operating hours has been clocked up. Consequently, the injection pressure drops slightly. When repairing injection nozzles, always set the opening pressure to the upper limit (+ 8 bar).



2



Note:

Shims are available in 0.02 mm steps from 1.0 mm to 1.98 mm.

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

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:

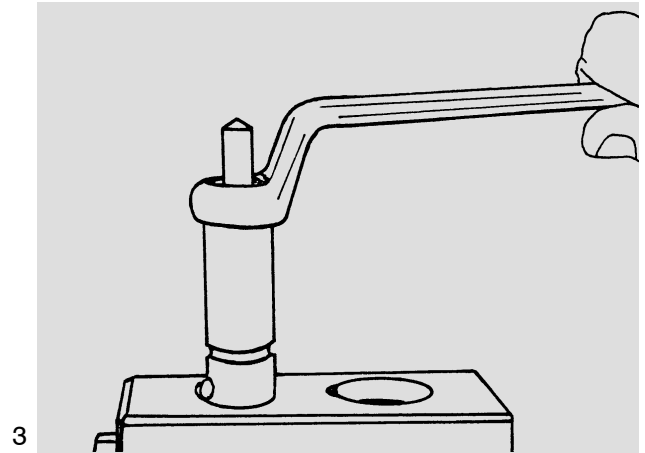
Switch off pressure gauge and carry out some swift strokes. The nozzle must emit an audible grating noise and/or a well-atomised jet.

Nozzles that satisfy these three requirements can be reused.

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

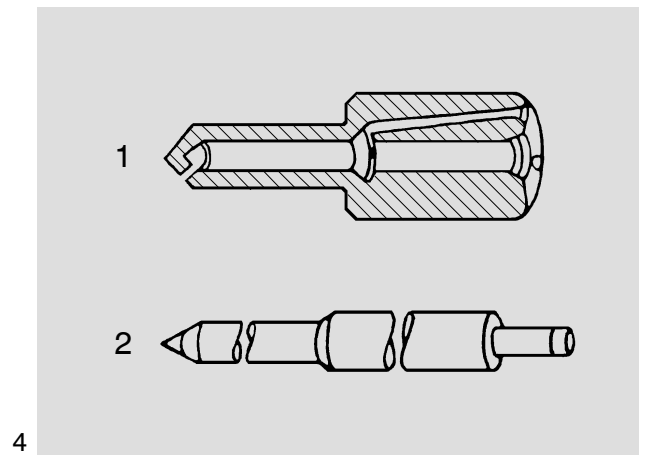
Fig. 4

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.

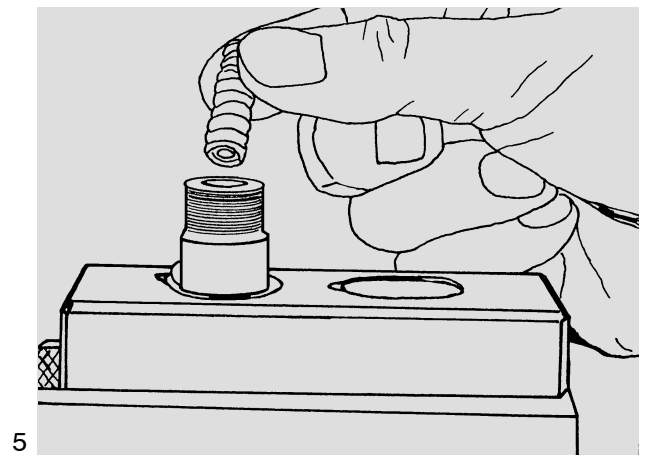


Fig. 6

Insert pressure pin and intermediate washer.

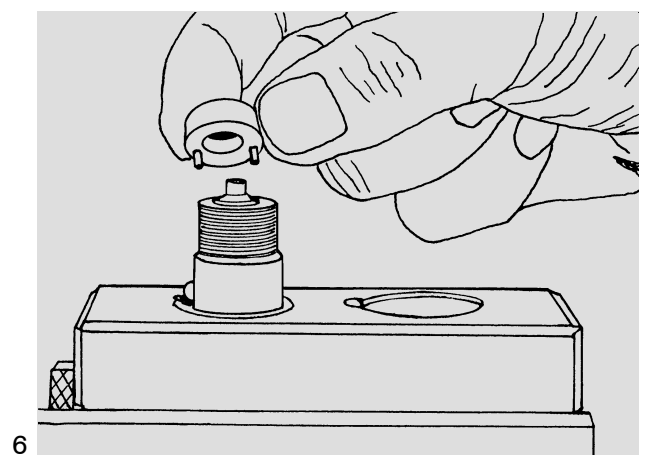


Fig. 7

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

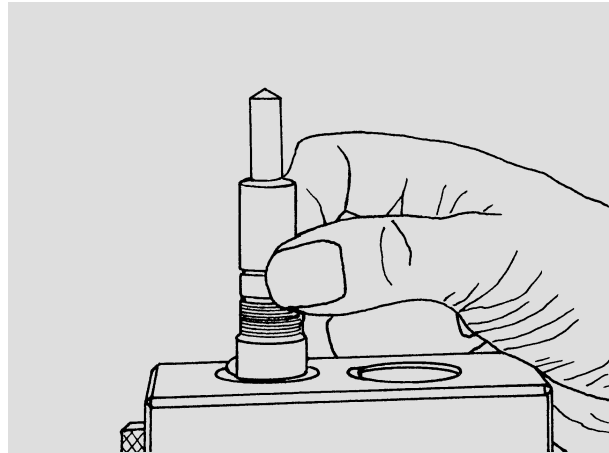


Fig. 8

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

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

8

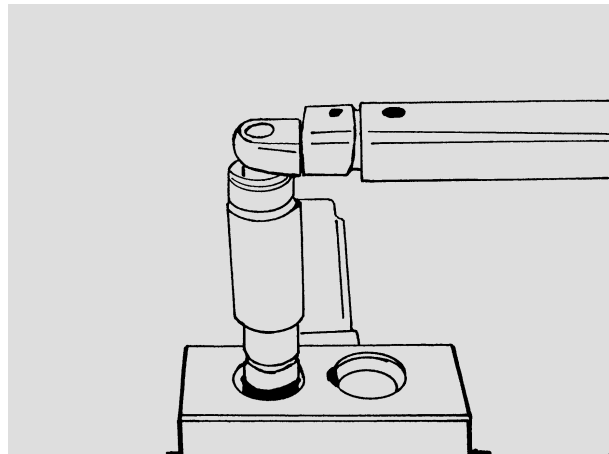


Fig. 9

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

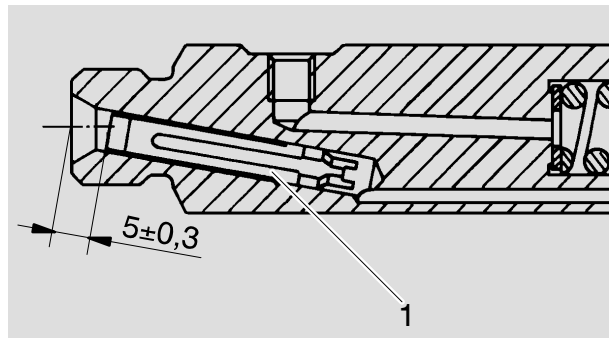
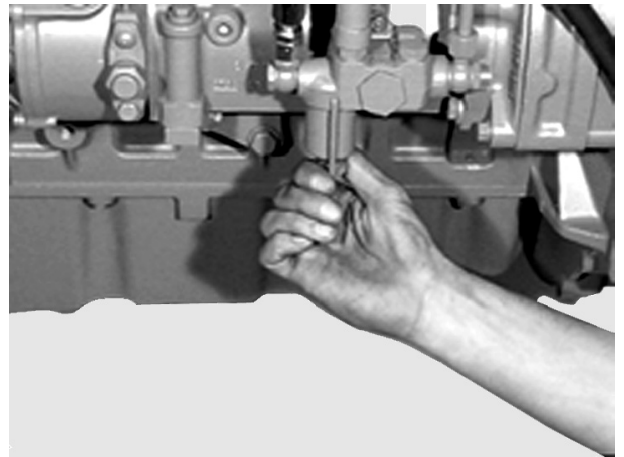


Fig. 1

Shut cut-off valve from fuel tank to engine.
Remove round nut and take off filter housing with sieve.
Use a bowl to catch fuel that may emerge.



1

Fig. 2

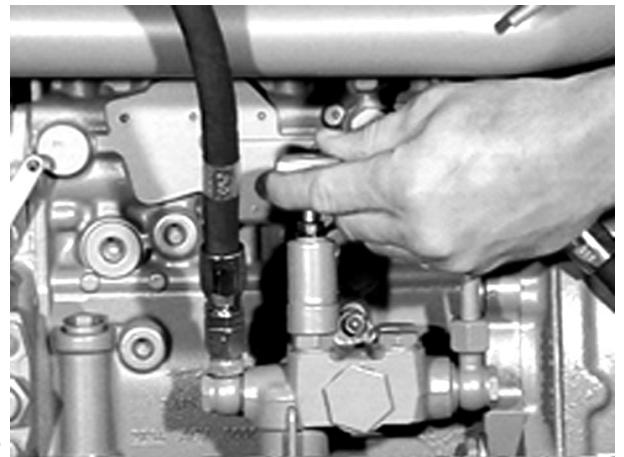
Wash out filter housing and gauze filter in clean Diesel fuel and blow them out with compressed air.
Reassemble fuel prefilter using new seal.



2

Fig. 3

Actuate plunger of hand priming pump until the overflow valve of the injection pump opens audibly.
Check fuel pre-filter for leaks while engine is running.



3

Fig. 1

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

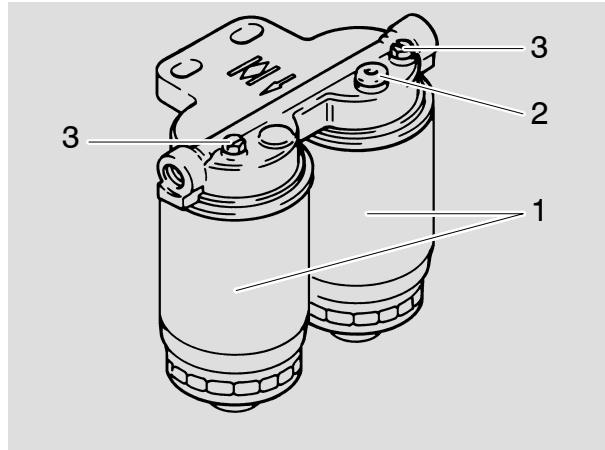
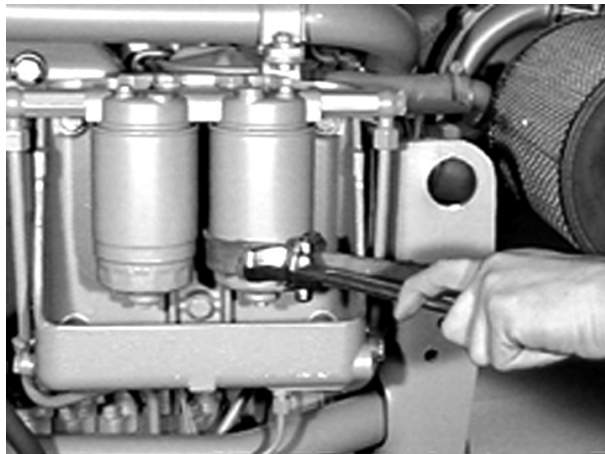


Fig. 2

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 at fuel filter.

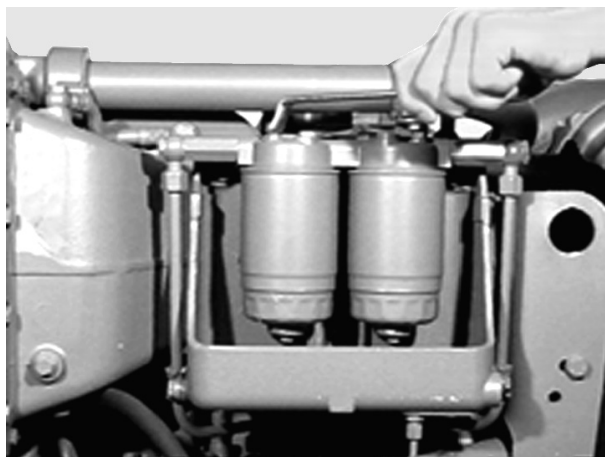
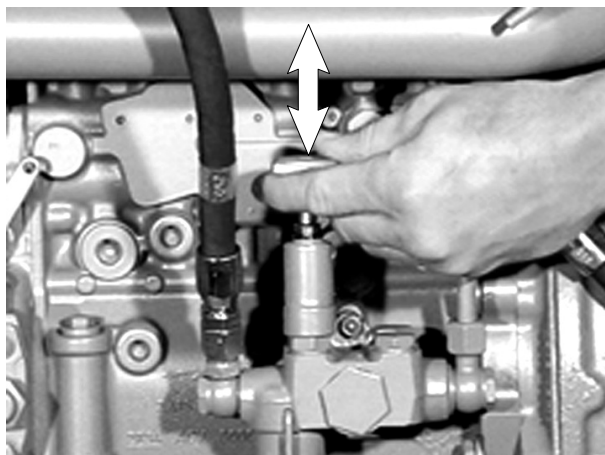


Fig. 4

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:

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

Fig. 1

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

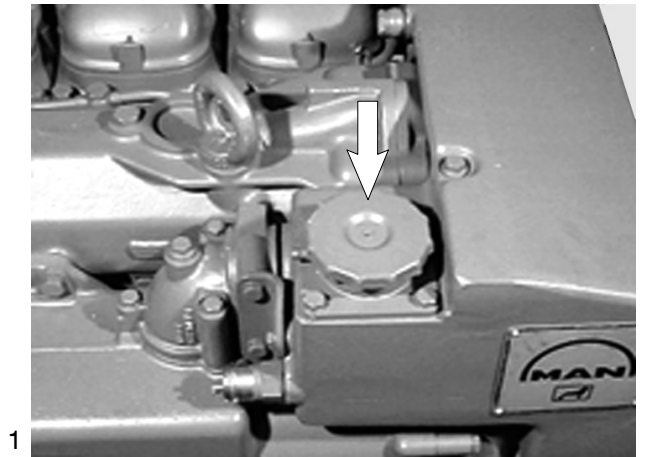


Fig. 2

Open drain plug in the oil cooler housing. Use a container to catch coolant that may emerge.

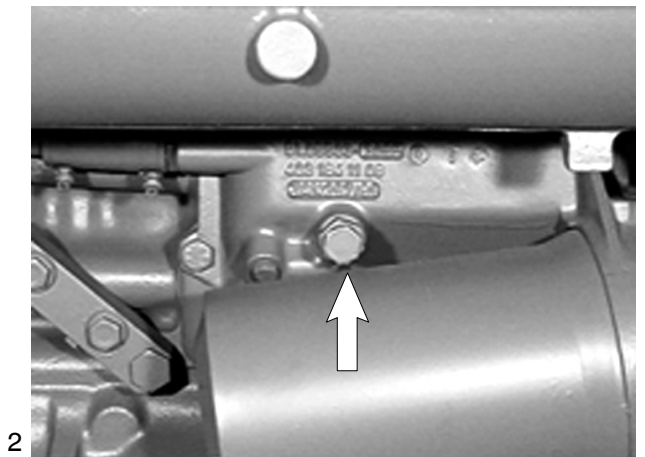
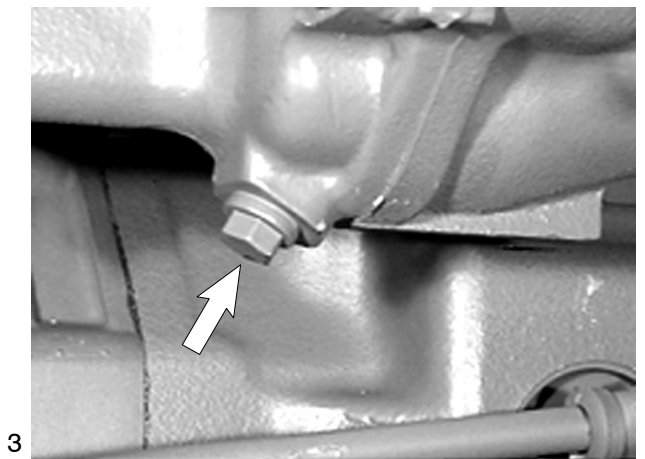


Fig. 3

Further drain plugs for draining the coolant are located on the exhaust-gas collector pipe (picture) and on the intercooler.



Filling up with coolant

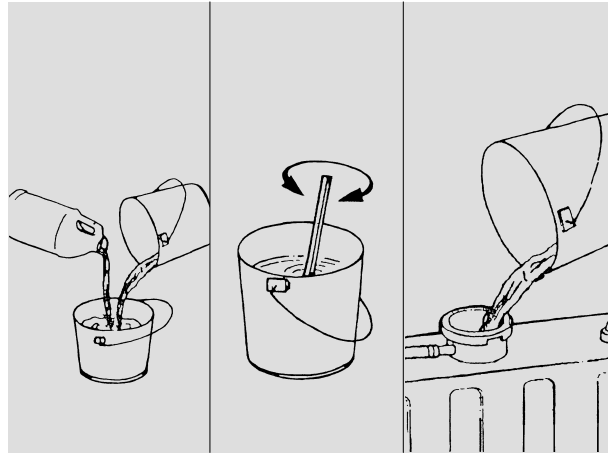
Fig. 4

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

Coolant must be added at the filler neck only.

Do not put cold coolant into an engine which is warm from operation.

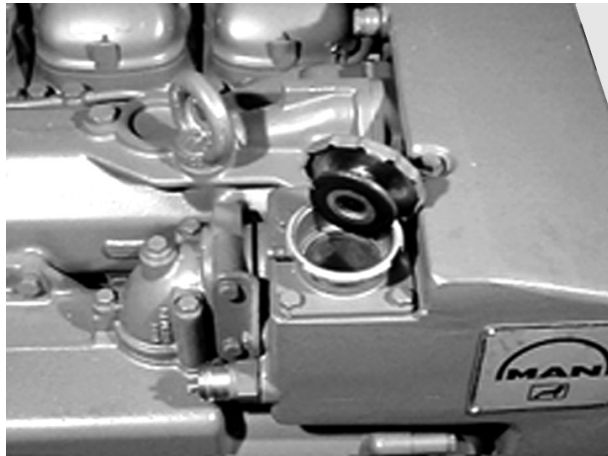
Ensure that the ratio of water to anti-freeze is correct.



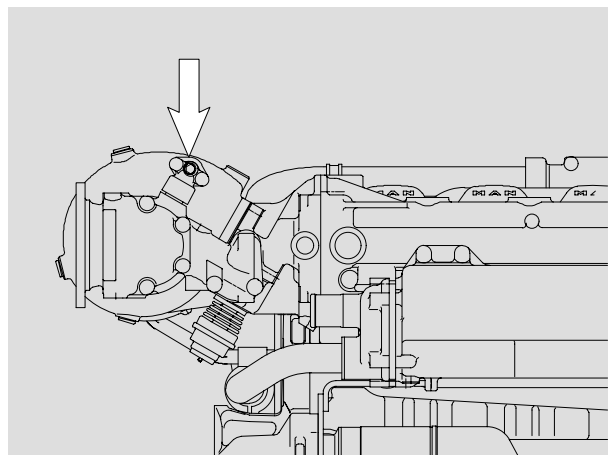
4

Figs. 5 and 6

- Remove cap (large cap)
- Set heating (if fitted) to full output, open all shut-off valves, open bleeders (if fitted)
- Unscrew bleeder screw on liquid-cooled turbo-charger
- Slowly fill up with coolant via filler neck on expansion tank until fluid level has reached the lower edge of the filler neck
- Screw in bleeder screws again and refit cap
- Let engine run at a speed of 2,000 rpm for approx. 5 minutes
- Switch off engine, carefully turn cap (large cap) with safety valve to first detent –let off pressure– then carefully take off cap



5



6

Fig. 1

- Drain coolant, see page 39
- Remove expansion tank, see page 47

Once the expansion tank has been removed the thermostats in the water pump housing are visible.

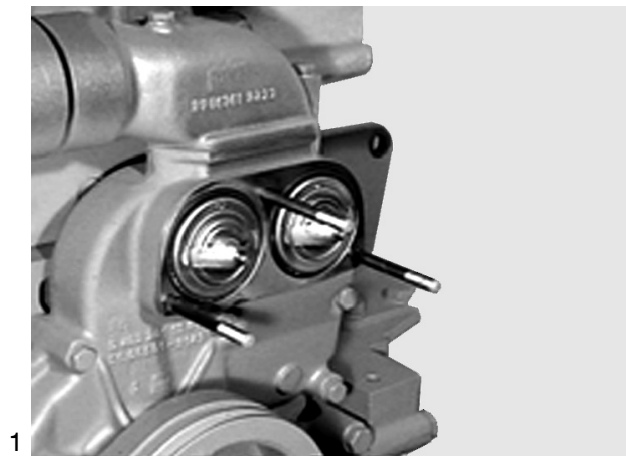


Fig. 2

Take out thermostat.

Check the function of the thermostat 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.

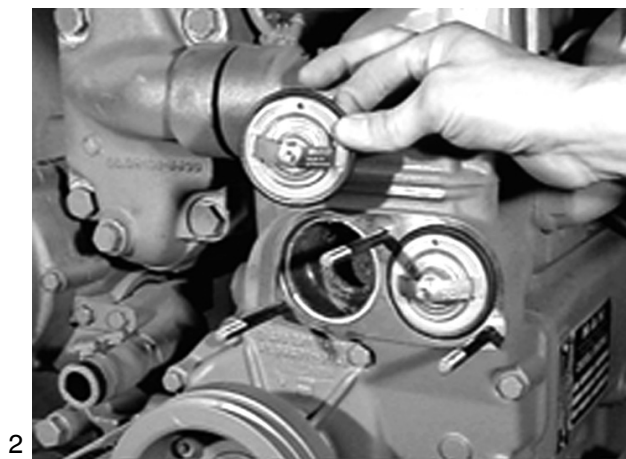
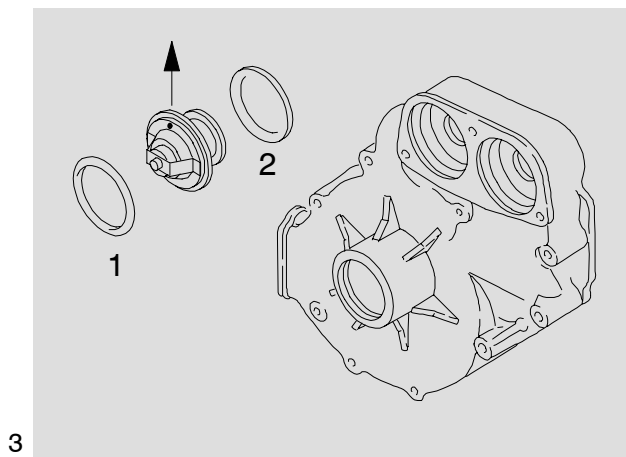


Fig. 3

Insert thermostat inserts (ball valve facing upwards (“TOP”) with new O-ring seal (1) and new seal (2).



- Take off V-belt, see page 129
- Drain coolant, see page 39
- Detach expansion tank, see page 47
- Take out thermostats, see page 41

**Note:**

If the water pump is to be disassembled at a later date, remove V-belt pulley before the disassembly and pull off water pump hub with a stable three-arm puller.

Fig. 1

Remove the mounting bolts from the cooling-water elbow (13 mm).



Fig. 2

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

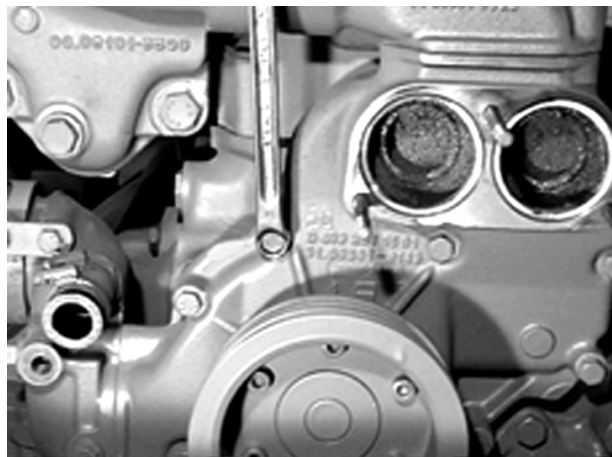
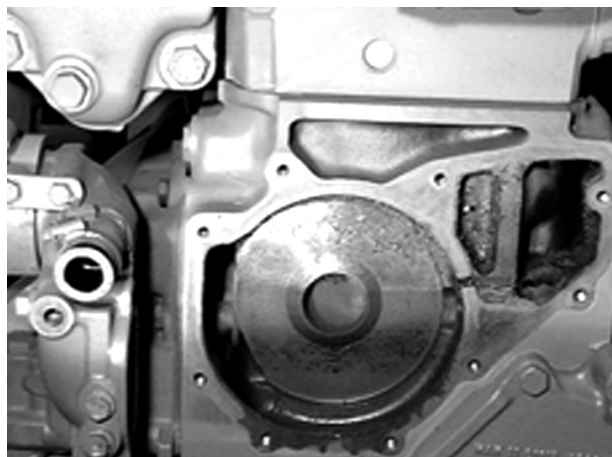


Fig. 3

Clean the sealing faces on water pump and engine housing using a scraper and fine abrasive paper. Stick the new seal for the water-pump housing to the crankcase using grease. Fit water pump. Use new seals for the cooling-water elbow.



Disassembling water pump

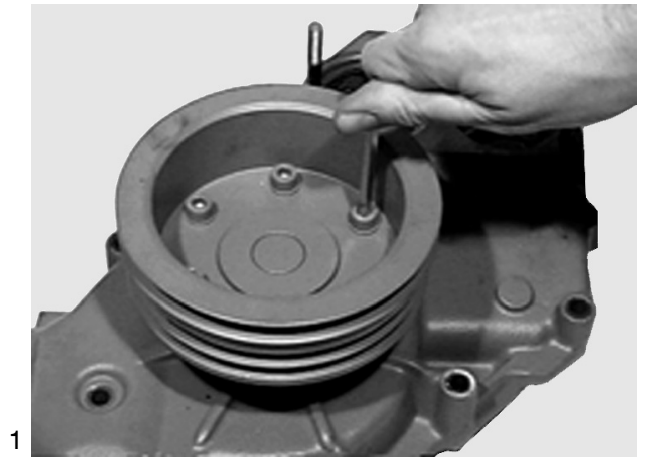
The following special tools are required for disassembling and assembling the water pump:

- Press
- Improvised tools, see page 146.

Fig. 1

Remove V-belt pulley.

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



1

Fig. 2

Unclip the circlip from the water-pump housing.



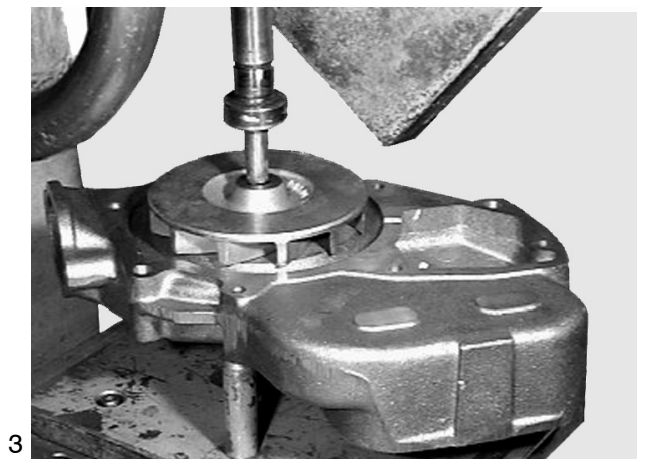
2

Fig. 3

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

The picture shows an assembly device for this. If such a device is not available, use a support ring (special tool, see page 146).

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

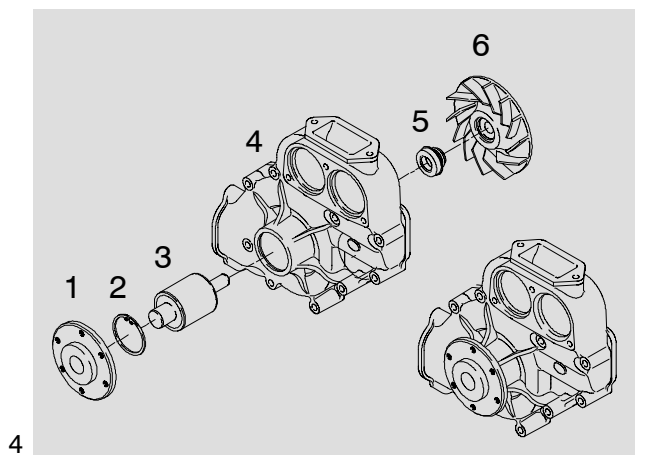


3

Fig. 4

Water pump disassembled

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



4

Assembling water pump

Fig. 5

Press in water pump bearing.

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

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

5



Fig. 6

Refit circlip.

6



Fig. 7

Press in new mechanical seal with press-fitting sleeve (special tool see page 137, item 11) until it stops.

Observe installation note for seal on page 46.



Note:

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

7



Fig. 8

Press impeller on to bearing shaft.

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

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

Check the gap dimension with the feeler gauge.

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

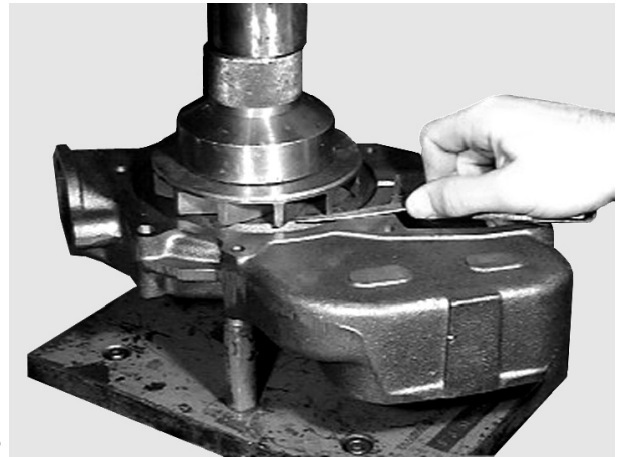
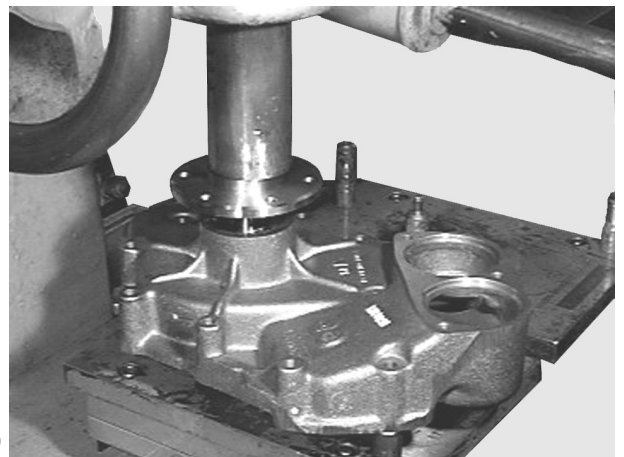


Fig. 9

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

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



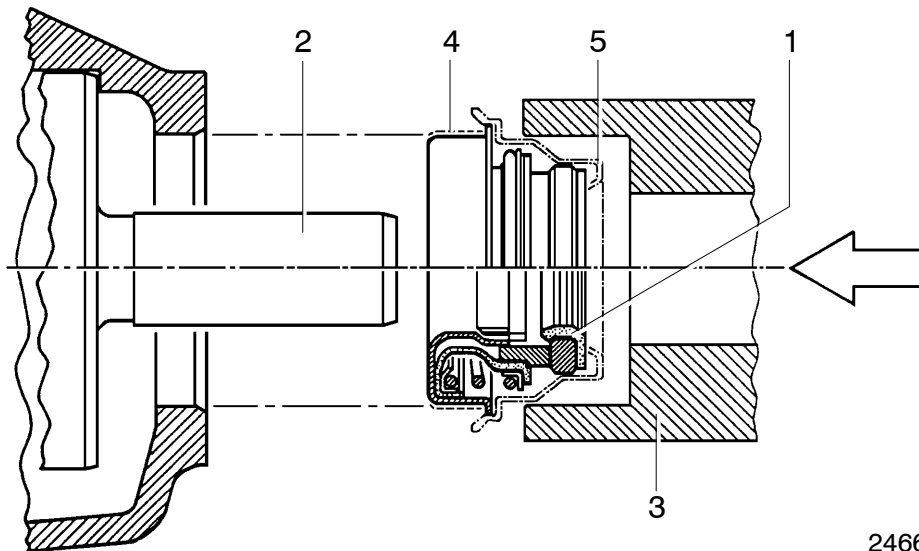
Installation note for mechanical seal:

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.



2466



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 MAN Diesel Engines") guarantee faultless operation.

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

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

For this reason before exchanging or repairing a water pump ascertain

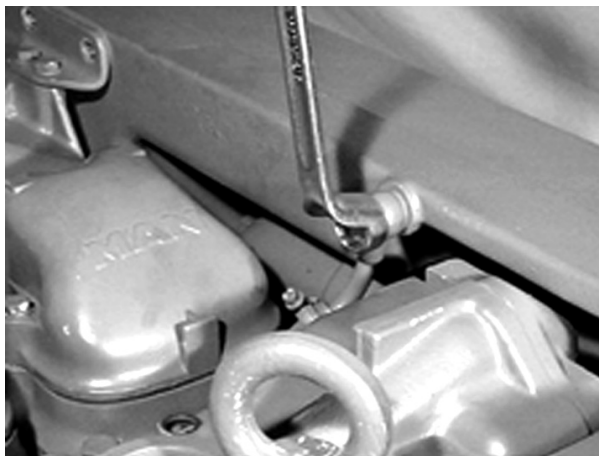
- whether the coolant circuit shows visible and recurrent loss of water; if so
- whether the loss of water is caused by coolant emerging from the expansion tank (e.g. overfilled) or by other leaks on hoses, etc.

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

- Drain coolant, see page 39

Fig. 1

Remove hollow bolt from bleeder line.
Remove coolant level sensor.



Figs. 2 and 3

Remove the mounting bolts from the brackets of the expansion tank (13 mm and 19 mm).

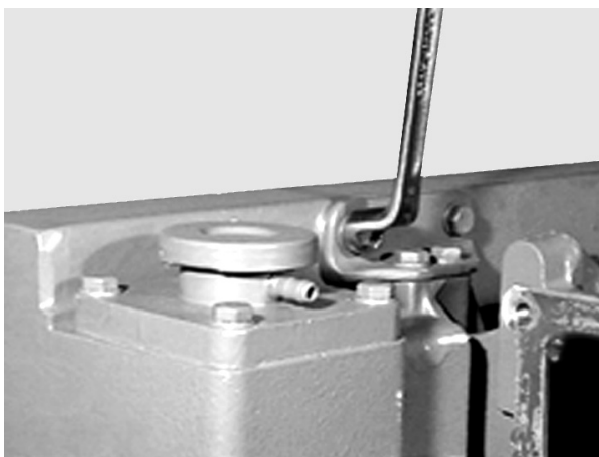
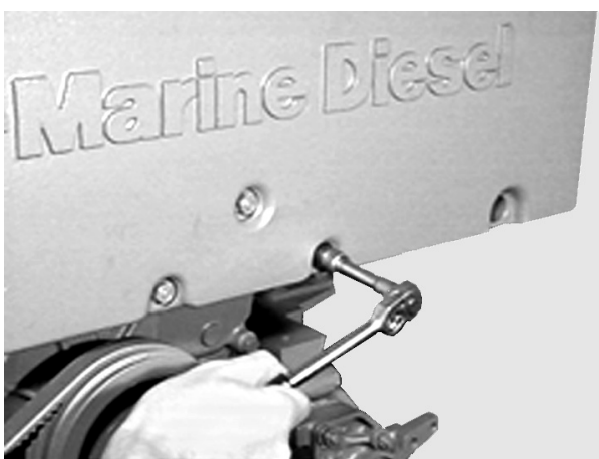


Fig. 4

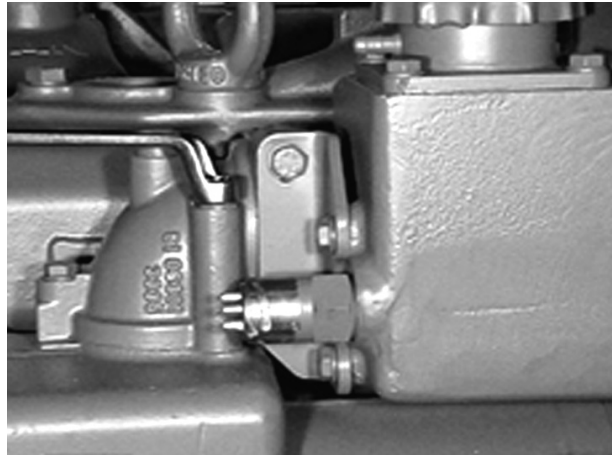
Remove nut (13 mm) from the front side of the expansion tank.
Take off the expansion tank.
The expansion tank is attached in reverse sequence.



- Drain coolant, see page 39

Fig. 1

Remove mounting bolts from the coolant elbow between expansion tank and raw-water heat exchanger (13 mm, 17 mm).



Figs. 2 and 3

The raw-water connecting pipe from the intercooler is fastened to the heat exchanger by means of a plug connection. To detach it, remove pressure flange (10 mm).

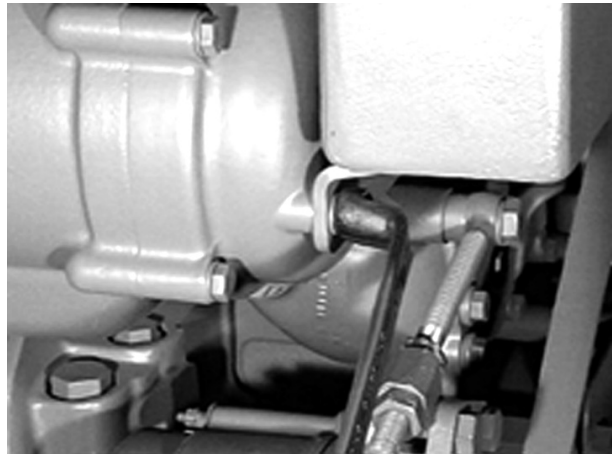
Remove pipe clamps from the raw-water pipe and pull out pipe plug connection.

Remove mounting bolts from the heat exchanger brackets (13 mm).

Take off heat exchanger.

The heat exchanger is attached in reverse sequence.

When assembling, fit new O-rings at the plug connection.



- Remove raw-water heat exchanger, see page 48

Fig. 1

Match-mark the position of the covers relative to the heat-exchanger housing (arrow) and remove both covers (13 mm).

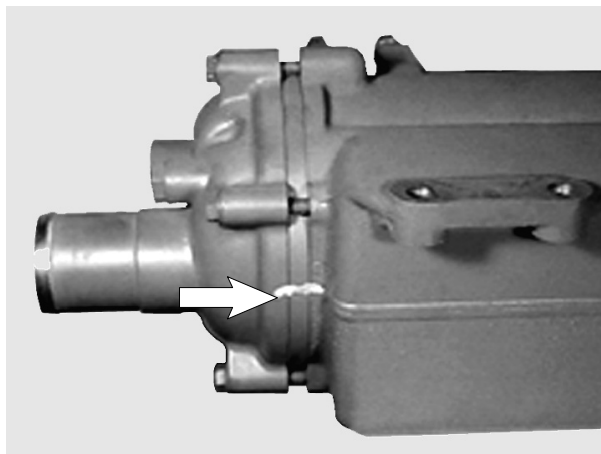


Fig. 2

Take off cover.

At the flywheel end of the heat exchanger the collar of the pipe cluster (arrow) is visible.

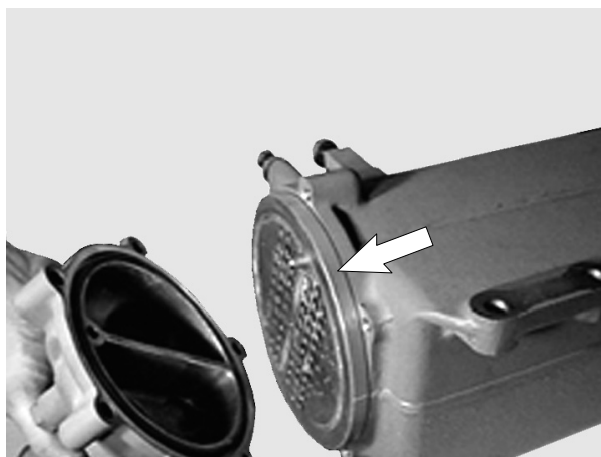


Fig. 3

Carefully knock out pipe cluster from the opposite end using a block of wood.

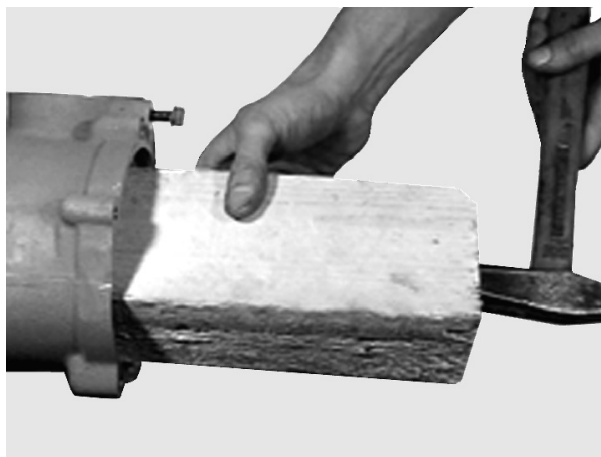
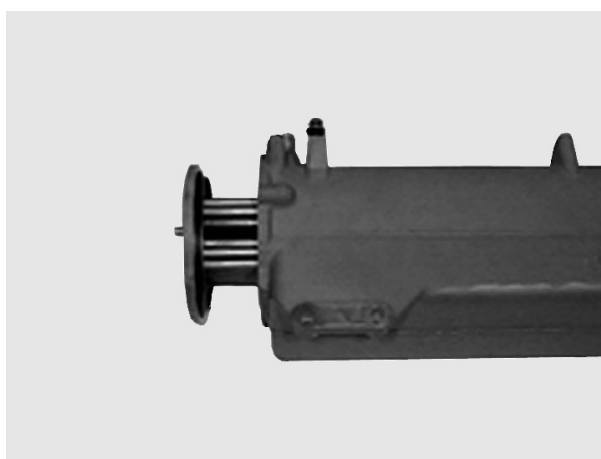


Fig. 4

Pull out pipe cluster.

The pipe cluster is installed in reverse sequence. When installing the pipe cluster, use new O-rings and check the heat exchanger for leaks.





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.

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

Removing and installing raw-water pump



Note:

The raw-water pump shown in these pictures was used up to engine no. ... 8120 999 From engine no. ... 8121 001 ... onwards double pumps have been in use for improved cooling. However, the assembly steps are the same in principle.

Fig. 1

Remove the mounting bolts from the suction and compression necks (13 mm).

1

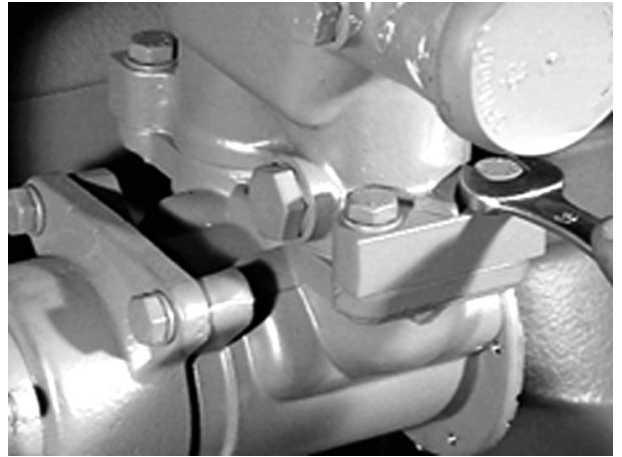


Fig. 2

Remove the nuts from the raw-water pump flange (17 mm).

2

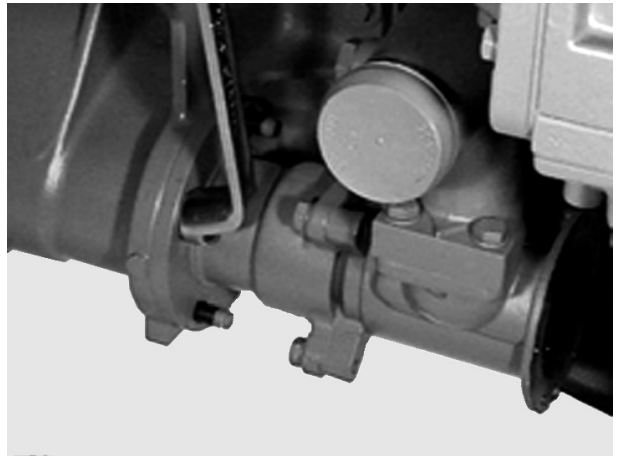
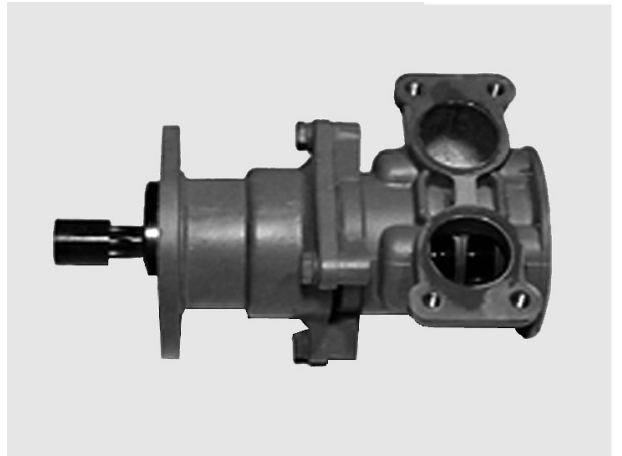


Fig. 3

Take off raw-water pump. The raw-water pump is installed in reverse sequence. Exchange the seal between the raw-water pump and the necks.

3



Changing impeller

Fig. 1

Remove cover (8 mm).



Fig. 2

The impeller can be removed only together with the cam.



Note:

The impeller will be destroyed if it is forcibly pulled out without the cam.

To do this, remove the cap screw in the pump housing between the suction and the compression neck using a screwdriver.



Fig. 3

Pull out impeller together with the cam using a pair of pliers.

Exchange worn or damaged impeller together with the wearing parts (repair kit) (observe the direction of rotation).

Coat new impeller slightly with Vaseline before assembling it.

When assembling, secure cap screw with Loctite 648.

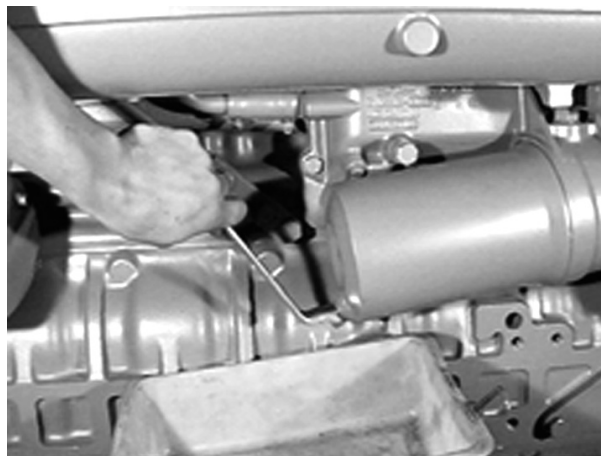
Fit cover with new seal.

Operating the impeller while it is dry entails irreparable damage. Fill pump with water before commissioning it and check it for leaks.



Fig. 1

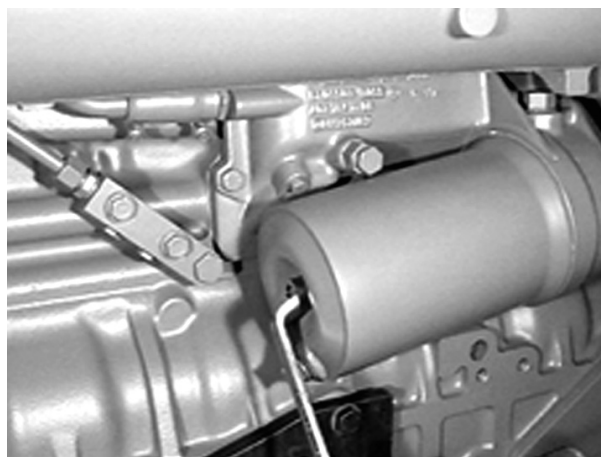
Open oil drain plug on oil filter can (19 mm) and use container to catch oil that may emerge. Refit oil drain plug with new seal.



1

Fig. 2

Remove mounting bolt of filter bowl (17 mm).

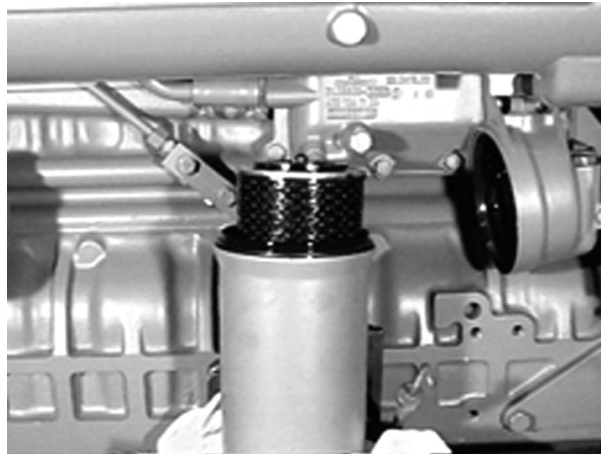


2

Fig. 3

Take off filter bowl and clean it internally. Insert new filter element and fit filter bowl with new seals.

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



3



Note:

The pictures show the standard oil filter. Classifiable engines have a filter with a changeover feature. However, the oil filter cartridges are changed analogously.

- Drain engine oil
- Drain coolant, see page 39.
- Remove oil filter, see page 53.

Fig. 1

Remove hose clamp on the coolant outlet pipe leading from the oil cooler housing.

Remove the mounting bolts from the oil cooler housing (17 mm).



Note:

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

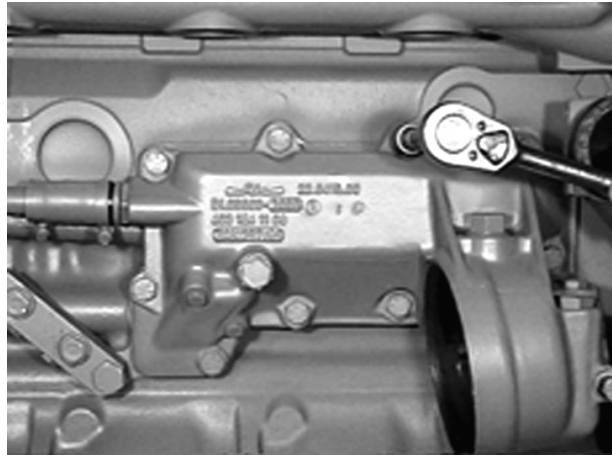


Fig. 2

Take off oil cooler housing together with oil cooler.
Remove oil cooler from housing (13 mm).



Fig. 3

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 oil pump

- Drain engine oil.

Fig. 1


Remove oil pan (13 mm).

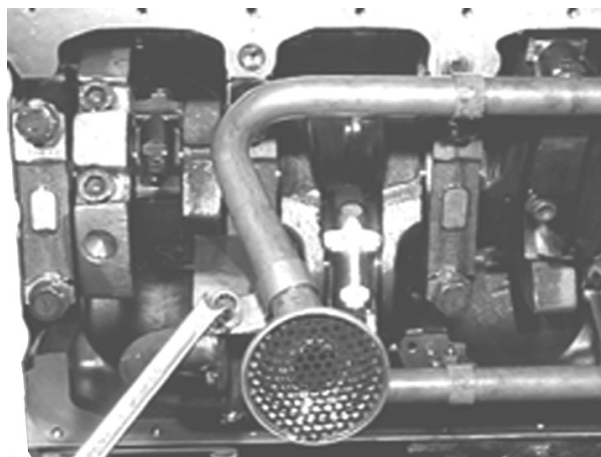
 **Note:** Various oil pan variants are possible. The picture shows a deep oil pan for inclinations of up to 30°.



Figs. 2 and 3

Remove oil suction pipe (13 mm).

 **Note:** Depending on the oil pan variants, various versions are possible. The pictures show a tandem oil pump with pipes. The work is fundamentally the same for all versions.



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

Replace worn gears.

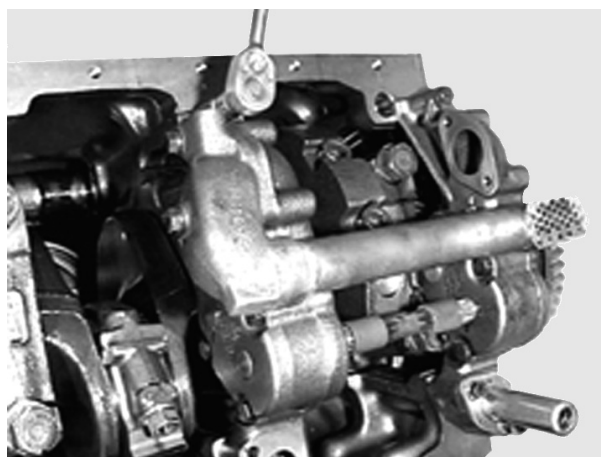


Fig. 4

Remove pressure relief valves (13 mm). The pressure relief valves are encapsulated. Opening pressures see "Engineering • Data • Setting values".



Fig. 5

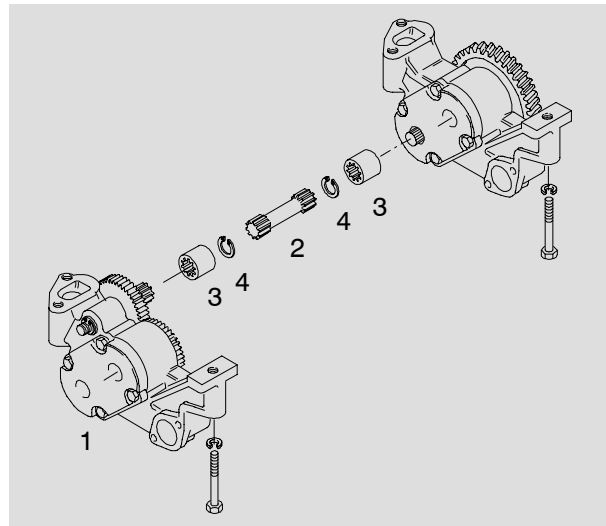
Remove oil pump.



Note:

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

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. 6

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

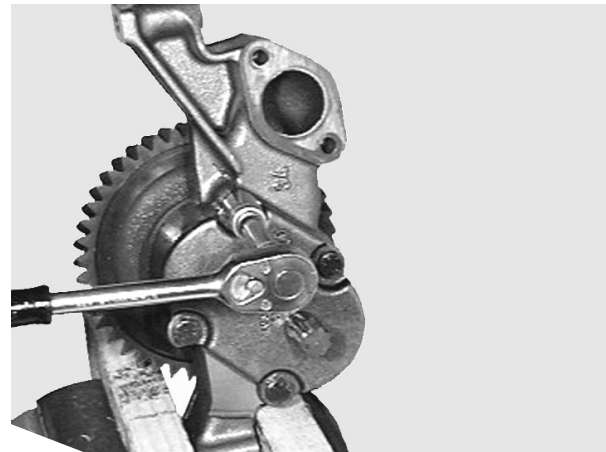


Fig. 7

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



Fig. 8

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".

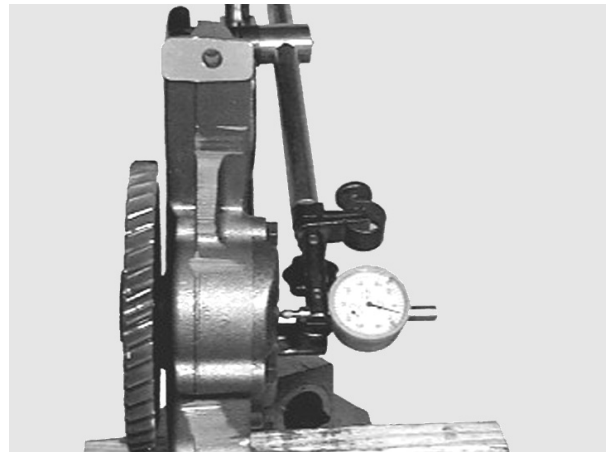


8

Checking axial play of the pump gears

Fig. 9

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.



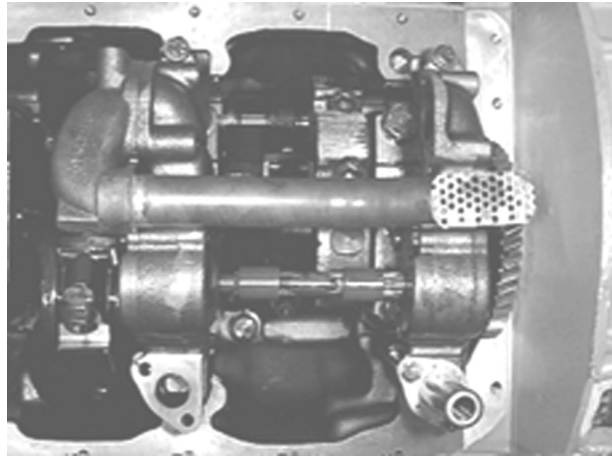
9

Installing oil pump

Fig. 10

Before installing, check whether the oil pump(s) run(s) smoothly and then fit it/them free of tension (13 mm).

10



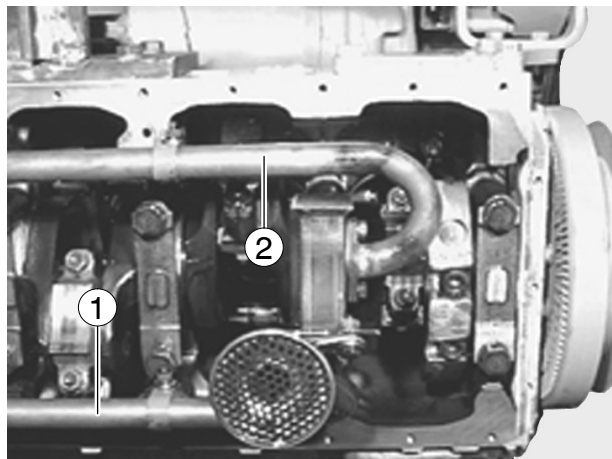
Figs. 11 and 12

Fit the oil intake lines ① with seals and the oil return lines ② without seals so that they are free of tension (13 mm). Screw on pressure-relief valve without seal (13 mm).

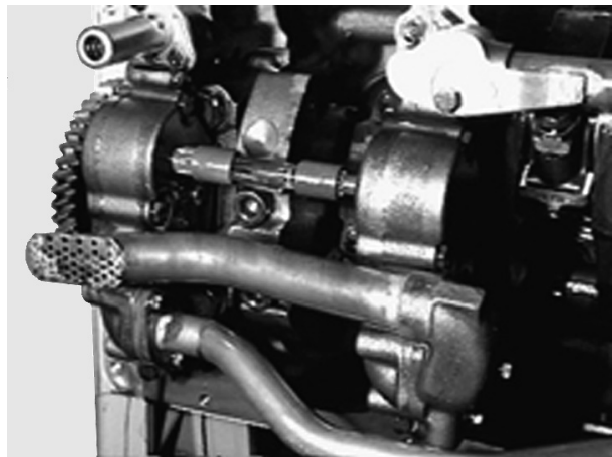
Before mounting the oil pan, turn over the engine to check whether the crankgear and the oil pumps run unimpeded and smoothly.

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

11



12



Removing oil spray nozzle

- Drain engine oil
- Remove oil pan, see page 55

Fig. 1

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

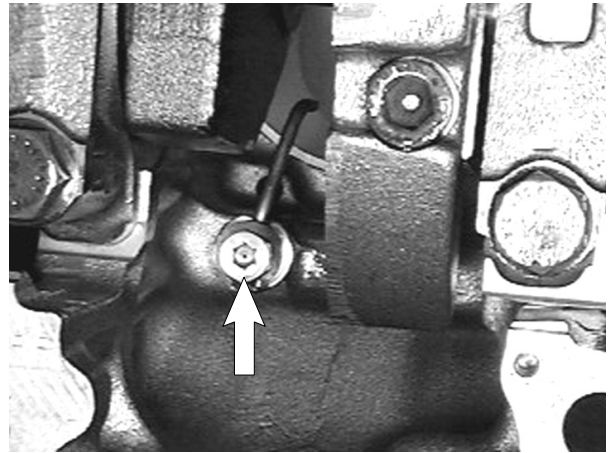
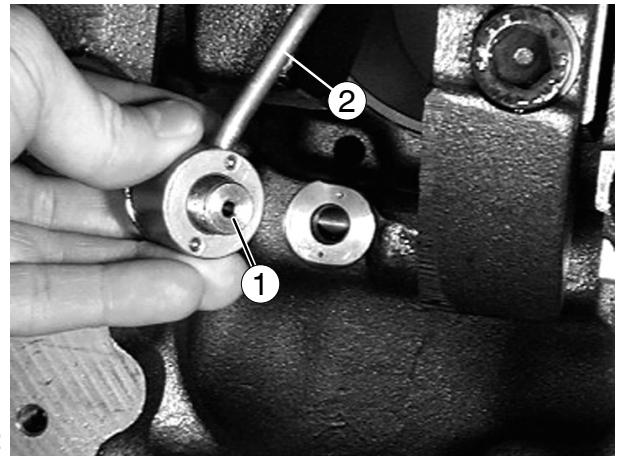


Fig. 2

- 1 Oil spray nozzle valve
- 2 Oil spray nozzle

1



2



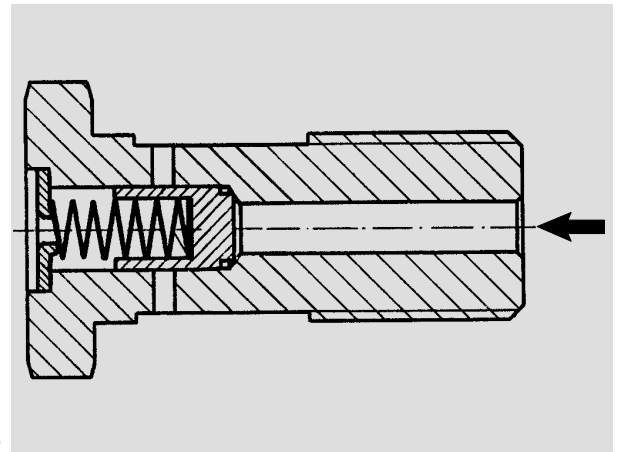
Note:

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

Checking oil spray nozzle valve

Fig. 3

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



3

Installing oil spray nozzle

Fig. 4

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



4

Removing vibration damper

- Turn engine to TDC to facilitate the installation of the scale disc during the assembly.
- Block the crankgear.
- Release the tension and take off the V-belt(s).

Figs. 1 and 2

Remove the barring device (13 mm) and the delivery start pointer (17 mm).

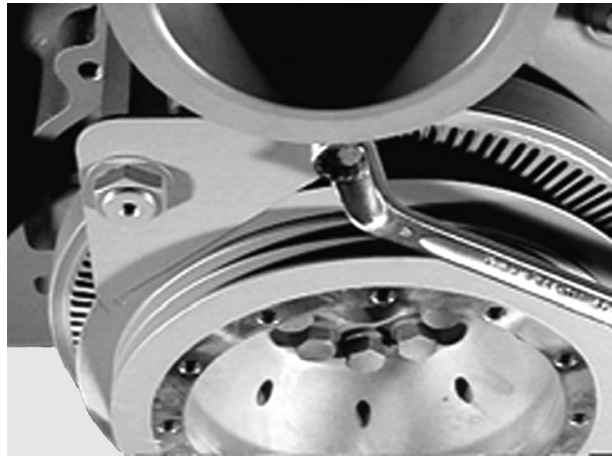


Fig. 3

Loosen mounting bolts on vibration damper (24 mm).



Note:

Owing to the high tightening torque a reinforced socket in conjunction with a 1/2" tool is required. Prior to removal mark the position of the vibration damper relative to the crankshaft. This will ensure that in the subsequent reassembly the graduated disc is in correct position.

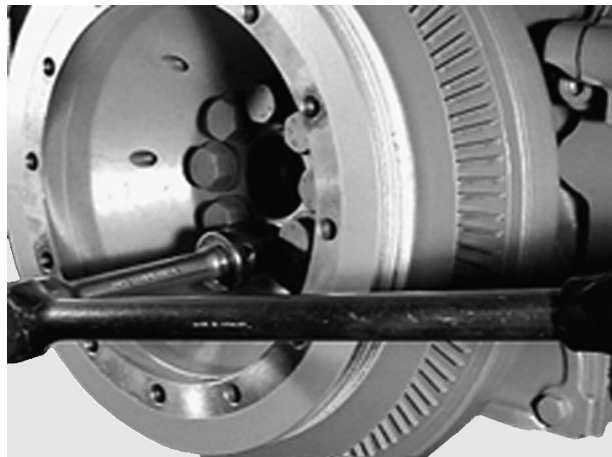


Fig. 4

Remove vibration damper carefully.



Caution:

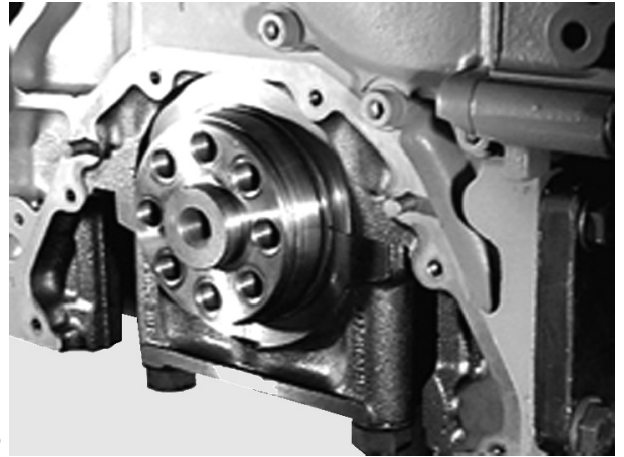
The vibration damper is susceptible to shocks.



Changing front crankshaft seal

Fig. 5

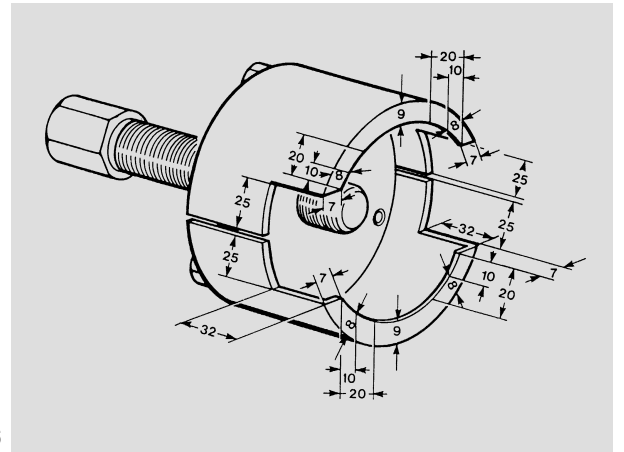
Remove cover (13 mm).
Replace front crankshaft seal only as a complete unit, i.e. race and radial shaft seal.



5

Fig. 6

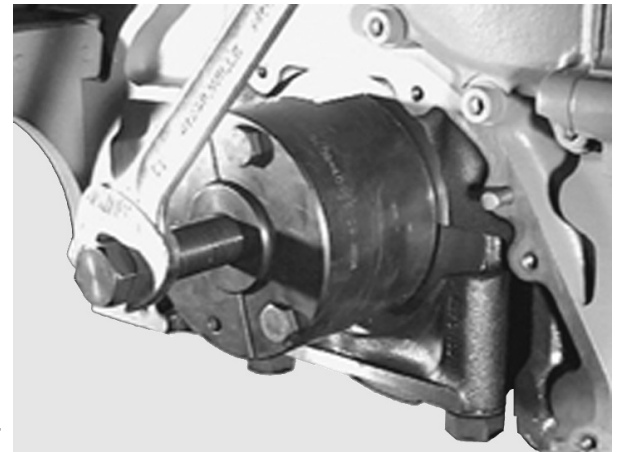
To remove the race, a puller (special tool, see page 139, item 13) is necessary.



6

Fig. 7

Pull off race.



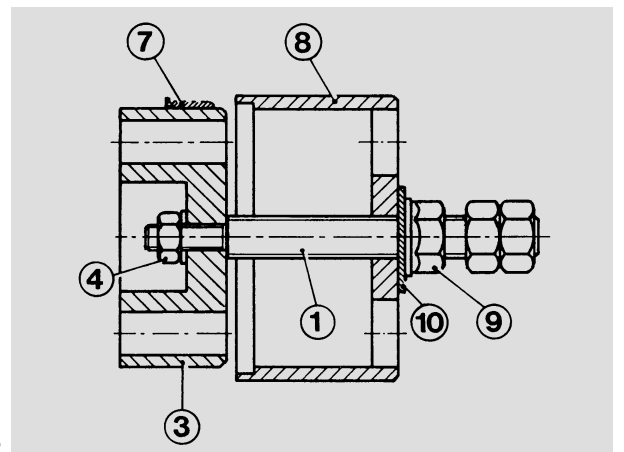
7

Fig. 8

Special tools are required for installing the race (see page 139, 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.

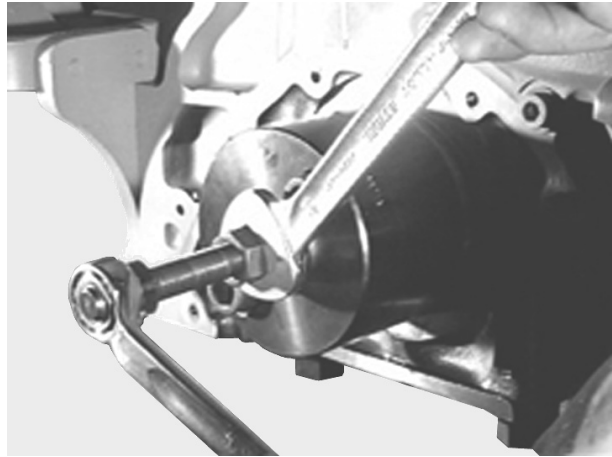


8

Fig. 9

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

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



9

Fig. 10

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

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



10

Fig. 11

Fit cover with new seal (13 mm).

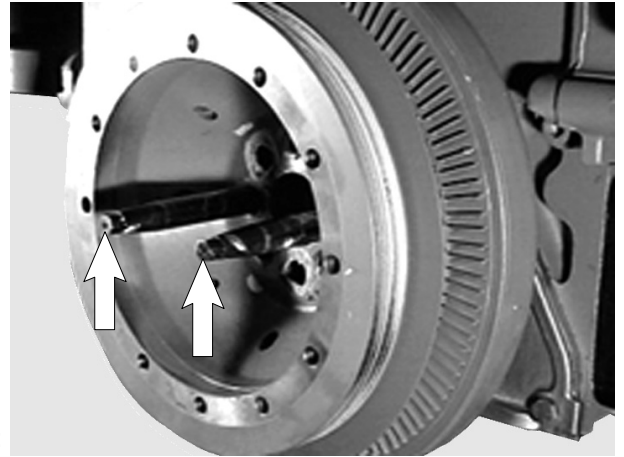


11

Installing vibration damper

Fig. 12

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.



12

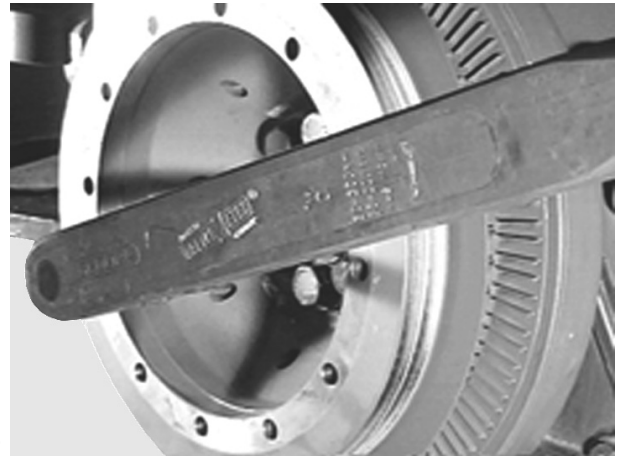
Fig. 13

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.

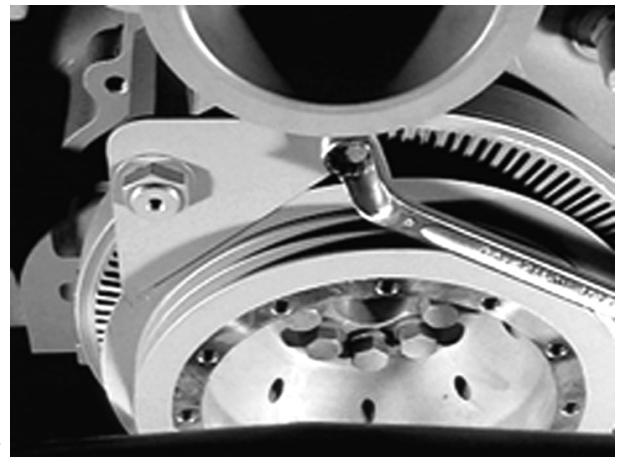


13

Fig. 14

Screw on delivery start indicator and V-belt pulleys.

Fit and tension V-belts (see page 129).

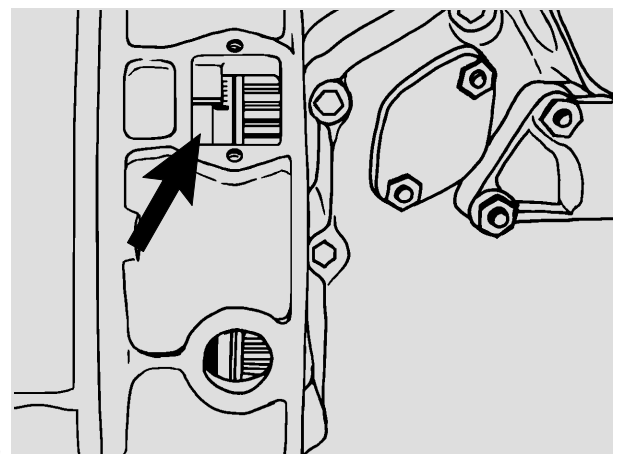


14

Fig. 15

After the installation, check whether the scale of degrees on the inspection hole cover of the fly-wheel housing and on the vibration damper indicate the same values.

If necessary readjust delivery start indicator.



15

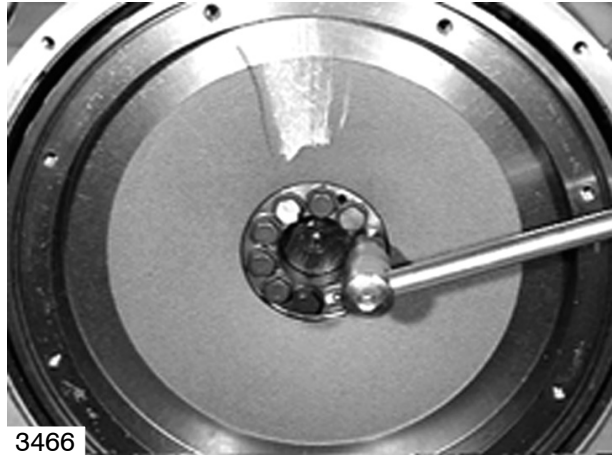
Removing flywheel

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.

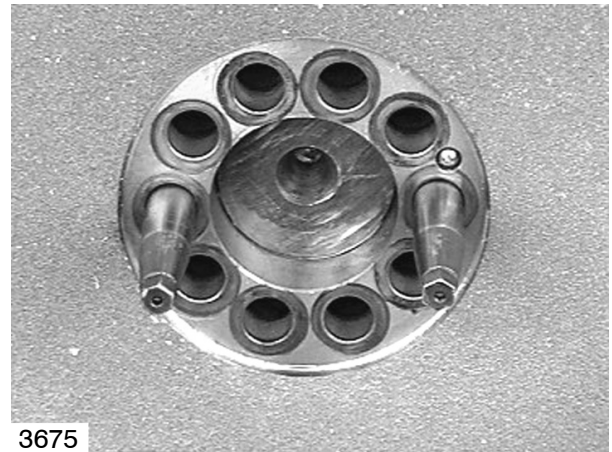


1 3466

Fig. 2

Remove two bolts facing each other and replace them by two guide pins (special tool, see page 139, item. 16).

Remove all bolts.



2 3675

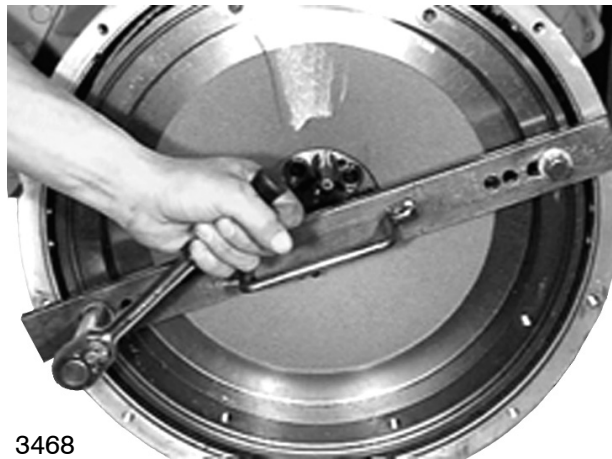
Fig. 3

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



Caution:

The flywheel is heavy.
Use lifting gear.



3 3468

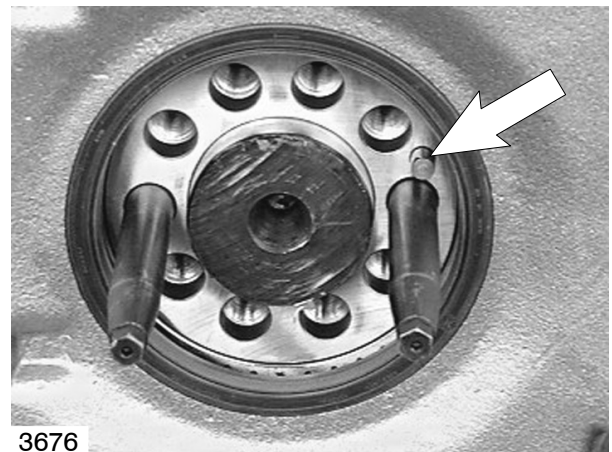
Installing flywheel

Fig. 4

Screw in guide mandrels (special tool, see page 139, 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.



4 3676

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 3470

Changing starter gear ring

Fig. 6

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

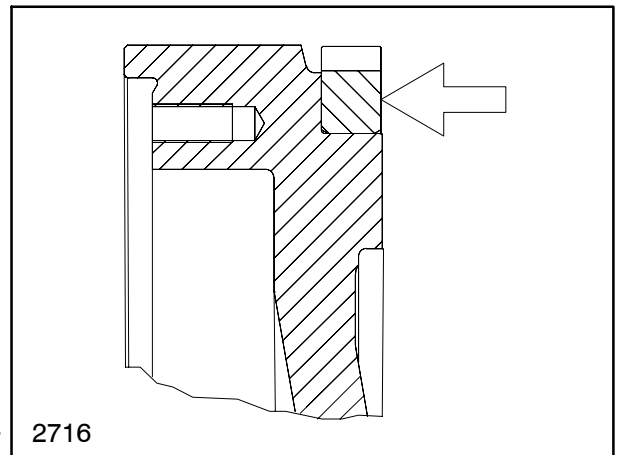
Caution:
Take care not to damage the flywheel.



6 3471

Fig. 7

Heat new starter gear ring up to approx. 200°C to 230°C and press on until it stops.
Check axial runout and compare with max. permissible value.



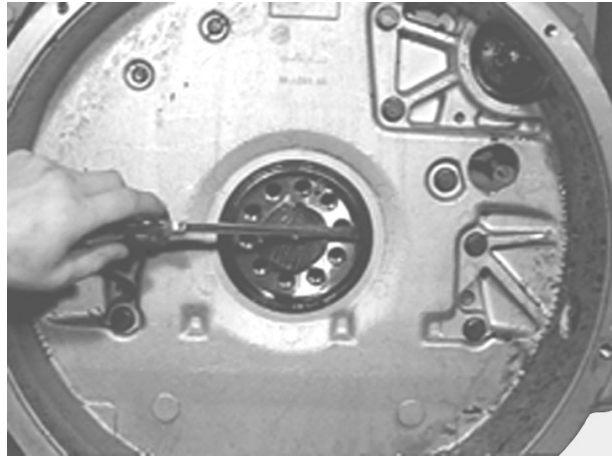
7 2716

- Remove flywheel, see page 64

Removing crankshaft seal

Fig. 1

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



Installing crankshaft seal

Fig. 2

Insert new shaft seal into the flywheel housing.

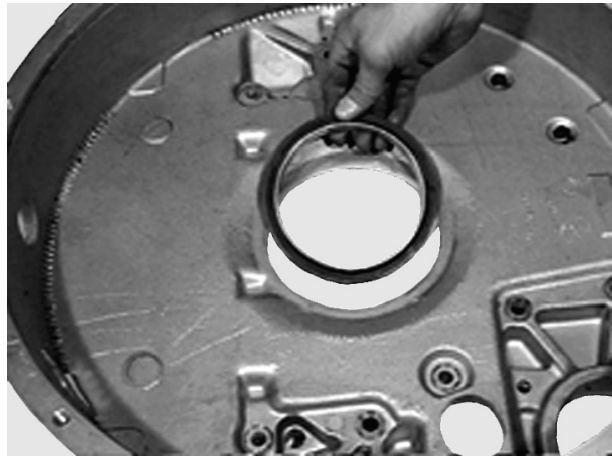
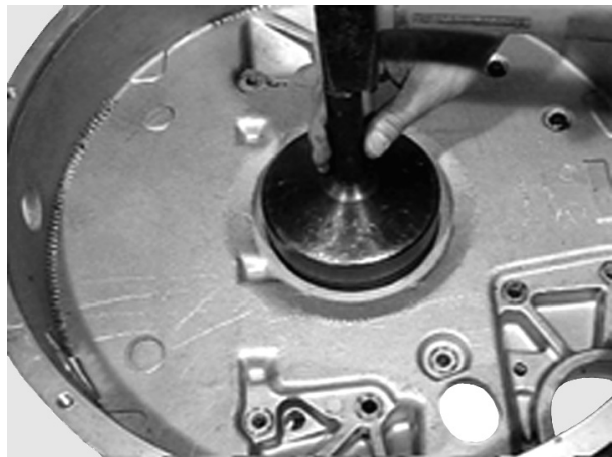


Fig. 3

Drive in seal with mandrel (special tool, see page 137, item 12) until flush.

The pressing mandrel consists of two parts.

Observe remarks and installation notes on page 68.



Note:

The pictures show the installation of the shaft seal with the flywheel housing removed. It is also possible to install the seal when the flywheel housing is attached.

To do this, place the guide ring of the press-in mandrel on the crankshaft before pressing in the shaft seal.

Exchanging bearing race

- Remove flywheel, see page 64

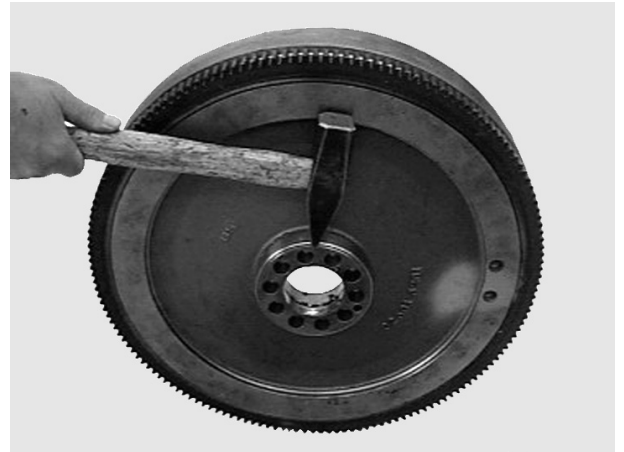
Fig. 1

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 139 , 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).



3

Fig. 3

Press in bearing race until it stops.



4

Fig. 4

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

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 39
- Remove intercooler, see page 79



Note:

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

Removing intake manifold

Fig. 1

Remove hose connection from LDA.

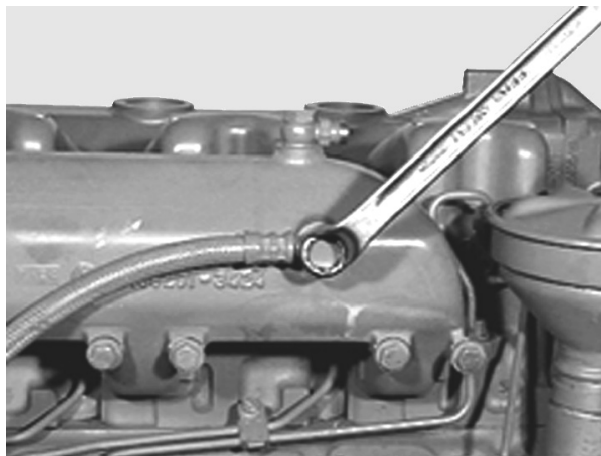


Fig. 2

Remove the mounting bolts from the intake pipe (13 mm).

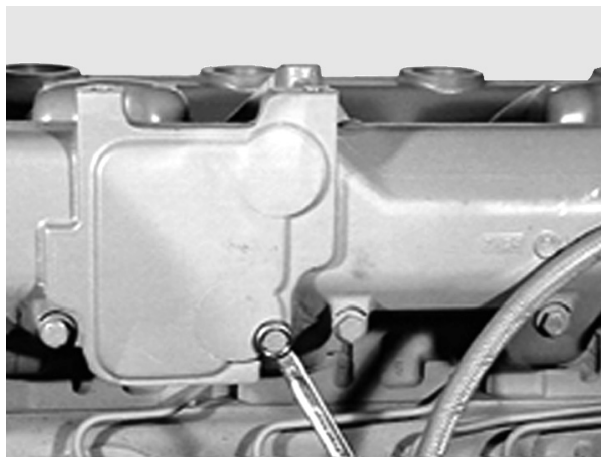
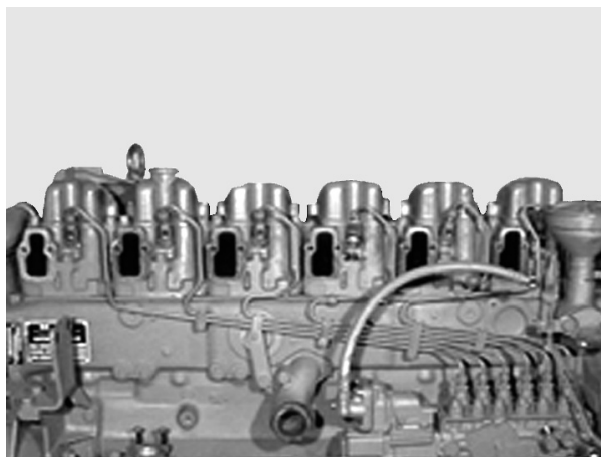


Fig. 3

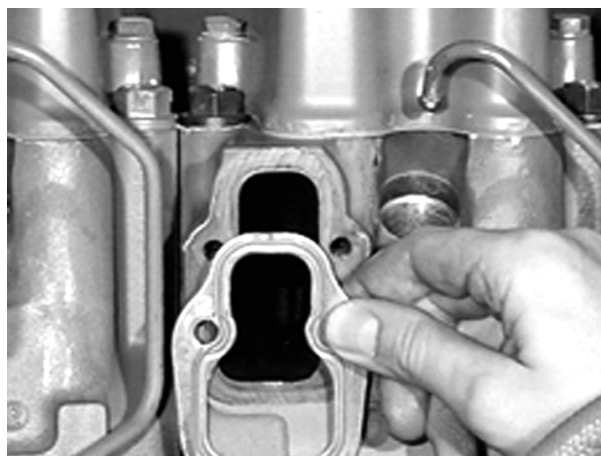
Take off intake pipe.



Installing intake manifold

Fig. 4

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



- Drain coolant, see page 39.
- Remove turbocharger, see page 75.
- Remove heat exchanger, see page 48.

Removing exhaust manifold

Fig. 1

Remove the mounting bolts from the exhaust pipe (17 mm).

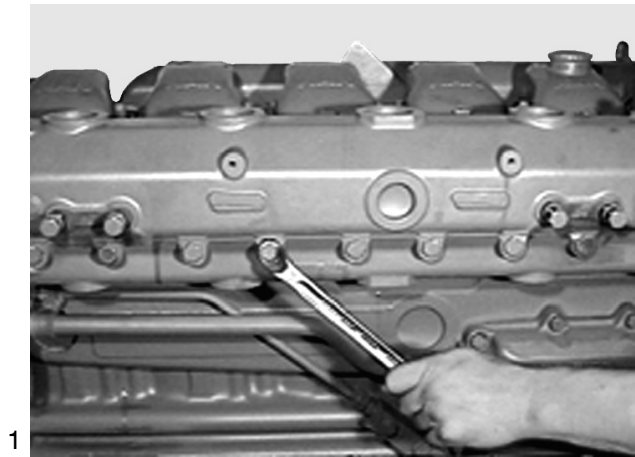


Fig. 2



Caution:
The exhaust pipe is heavy.

Before removing all mounting bolts, it is advisable to replace two bolts with self-made threaded guide pins (arrow) (10 mm).

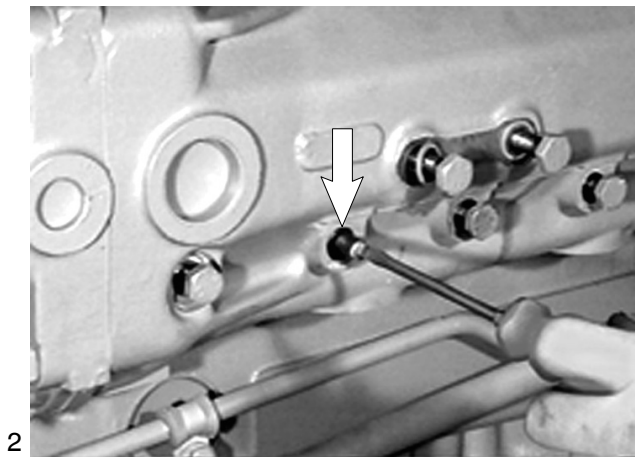
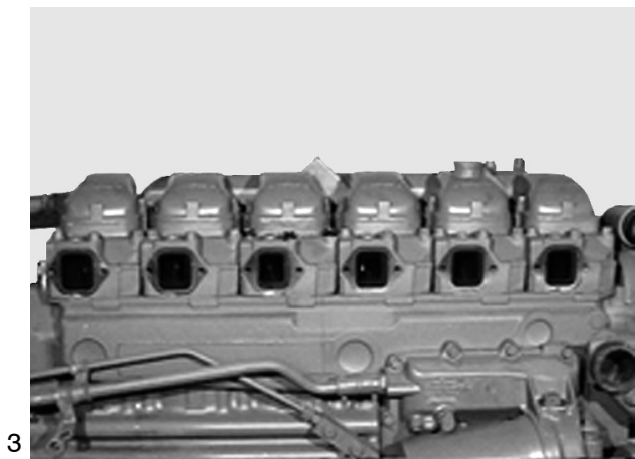


Fig. 3

Take off the exhaust pipe.



Installing exhaust manifold

Fig. 4

Before fitting the exhaust pipe, screw in two guide pins.

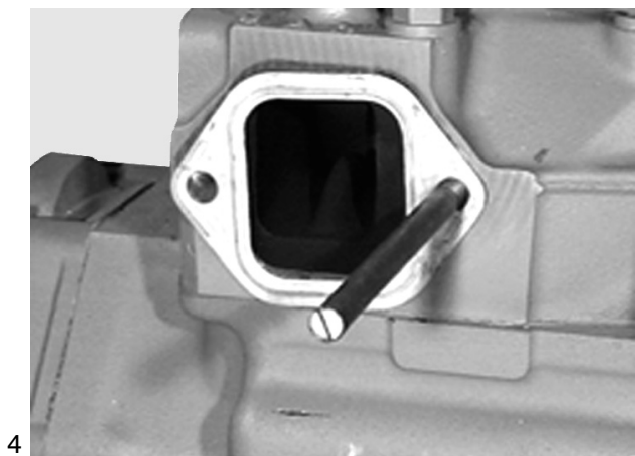
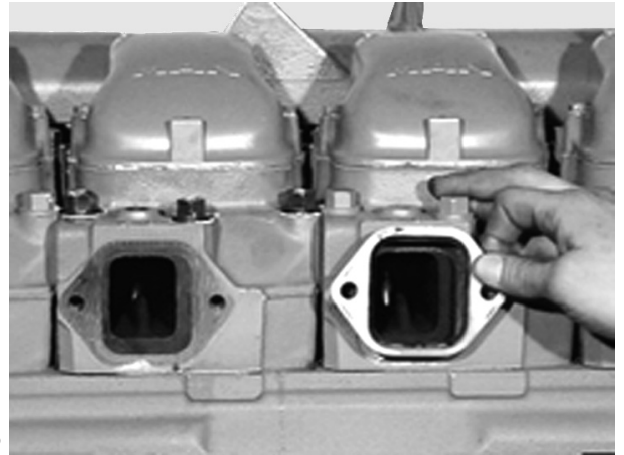


Fig. 5

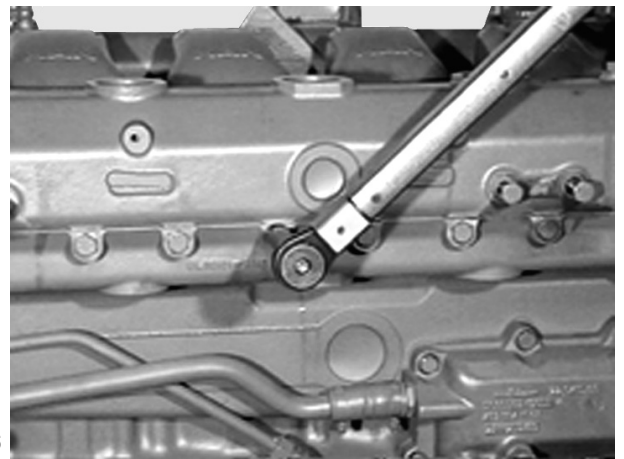
Fit exhaust pipe with new seals.



5

Fig. 6

Tighten the mounting bolts to specified torque (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 MAN Diesel Engines")

Why must the charge-air pressure be checked?

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

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

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

Preconditions for the measurement

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

Charge-air pressure

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

When carrying out the measurement, observe the following

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

Fig. 1

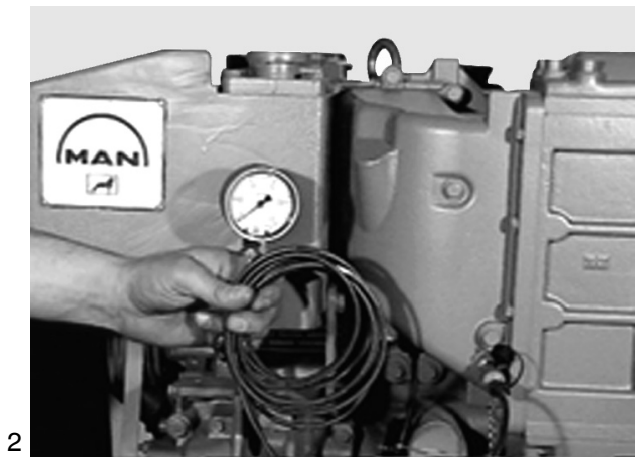
Two measuring connections for checking the charge-air pressure and the charge-air temperature are located in the charge-air elbow behind the intercooler.

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

- Drain coolant, see page 39

Fig. 1

Take off air filter. Remove the hose from the crank-case breather.

Take off air filter. Remove the hose from the crank-case breather.

Remove the air intake funnel and the connection from the compressor to the charge-air elbow.

Remove the hose from the wastegate.

1

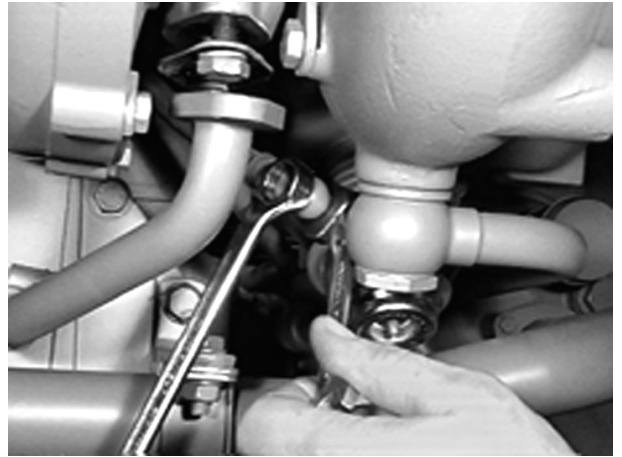


Fig. 2

Remove oil supply and return lines (17 mm).

2

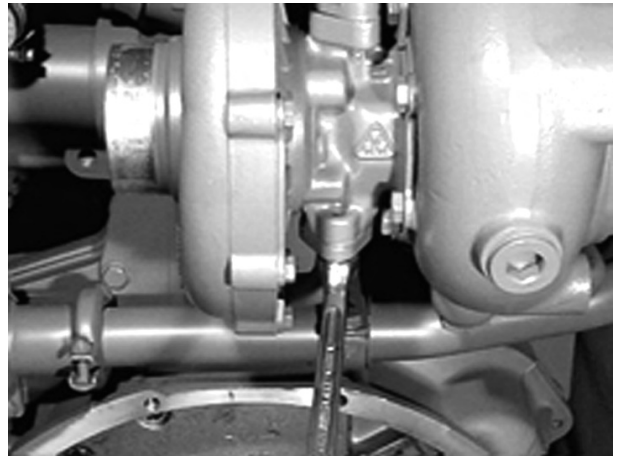


Fig. 3

Remove the coolant supply line from the turbocharger.

3

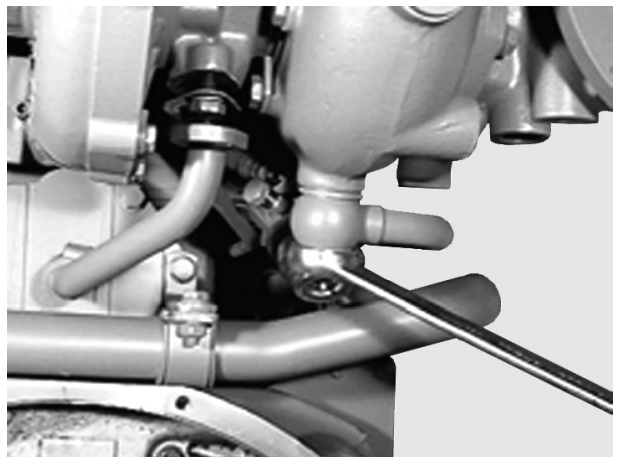


Fig. 4

Remove the mounting bolts from the exhaust manifold (17 mm).

Remove the coolant line between the turbine housing and the exhaust manifold.

4

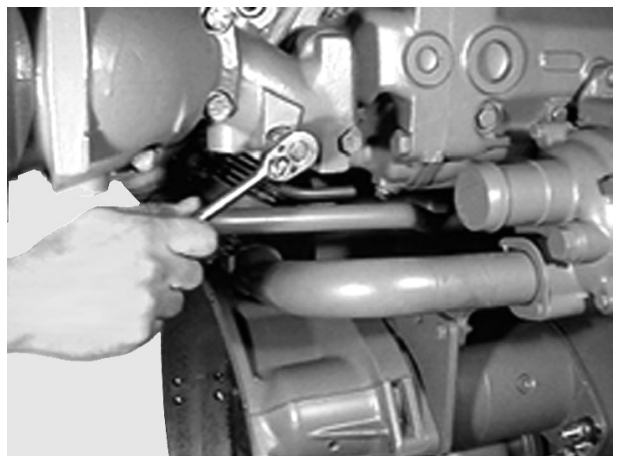


Fig. 5

Take off exhaust manifold.

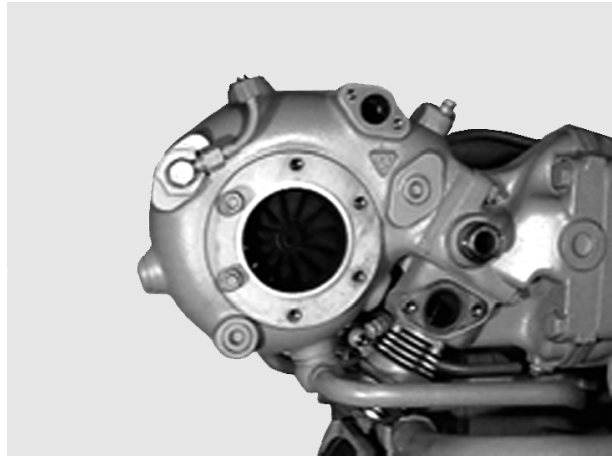


Fig. 6

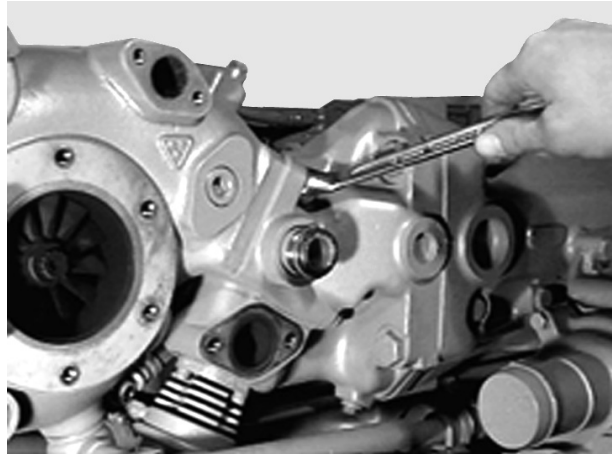
Remove the four (self-locking) nuts from the turbocharger flange (17 mm).

Take off turbocharger.



Note:

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



Installing turbocharger

Fig. 7

The turbocharger is assembled in reverse order. When assembling, use new seals and new self-locking nuts.

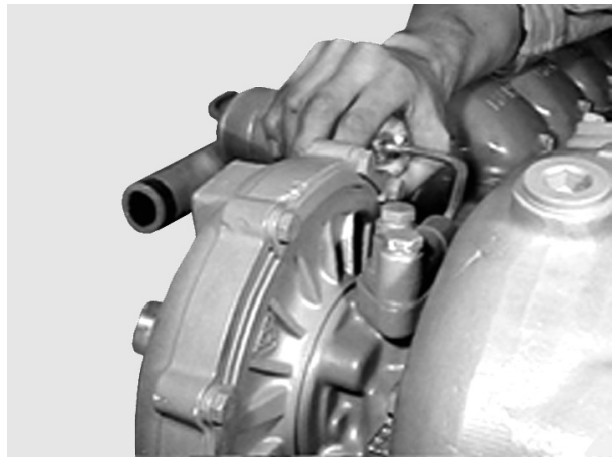
Before connecting up the oil supply line, fill bearing housing up with clean engine oil.

Check all connections for leaks and tension.



Caution:

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



- Remove turbocharger, see page 75

Fig. 1

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

Axial play

Fig. 2

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

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

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

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

Radial play

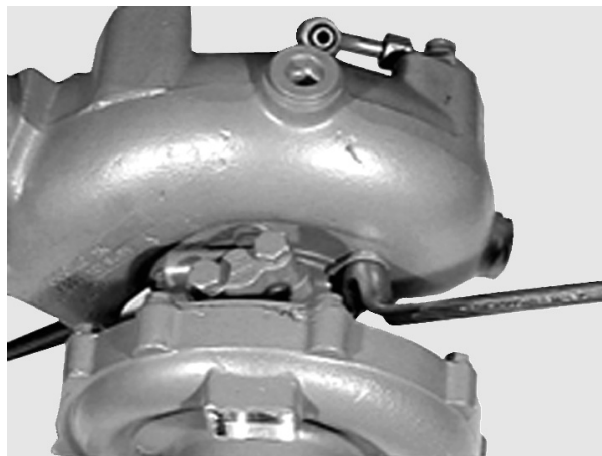
Fig. 3

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

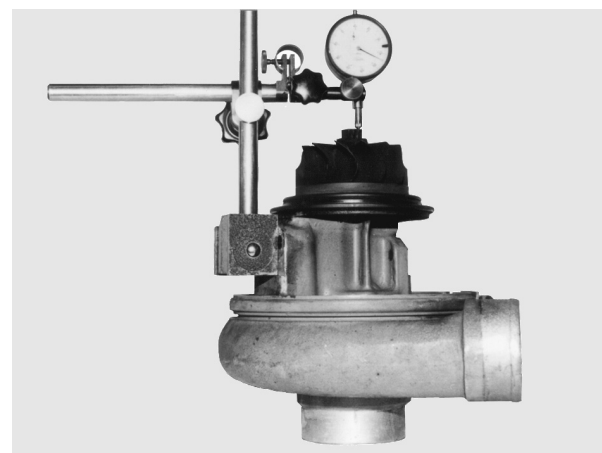
Apply dial gauge tip to side of hub. Push turbine wheel towards dial gauge. Read and note down value.

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

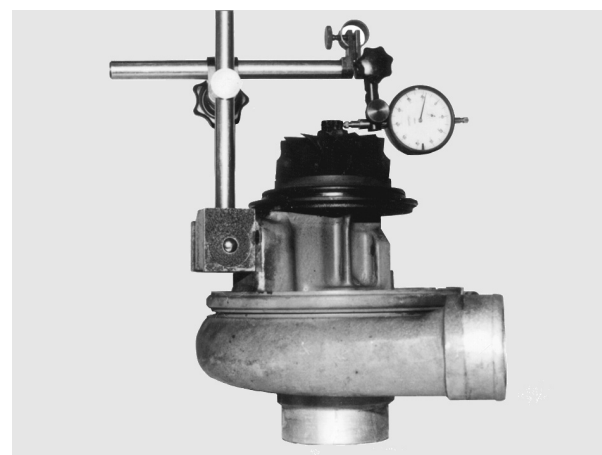
Place turbine housing in position, observe markings and screw on turbine housing.



1



2



3

Fig. 1

D 2866 LE4.. engines are equipped with waste gates (arrow). Their task is to limit the charge-air pressure to a precisely defined value.

Manipulation or modification of the setting is not permitted.

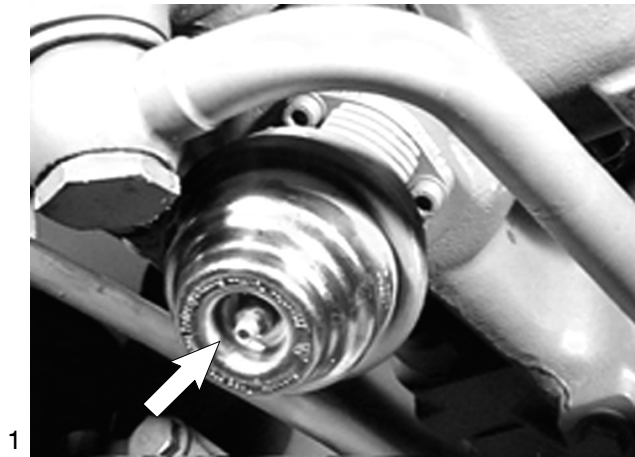
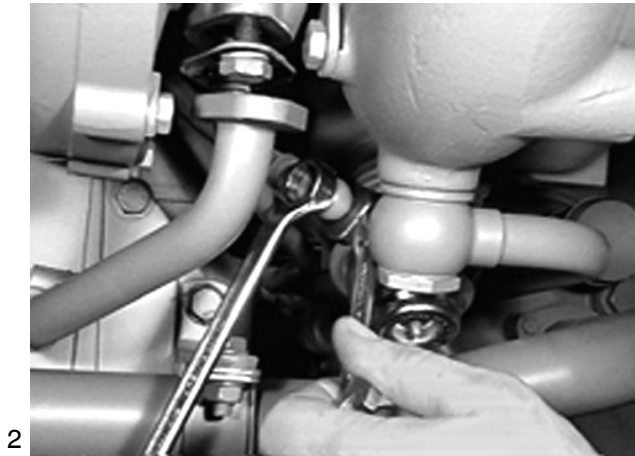


Fig. 2

The waste gates are maintenance-free.

Remove the air hose and the mounting bolts to exchange the wastegates. Use new seal.

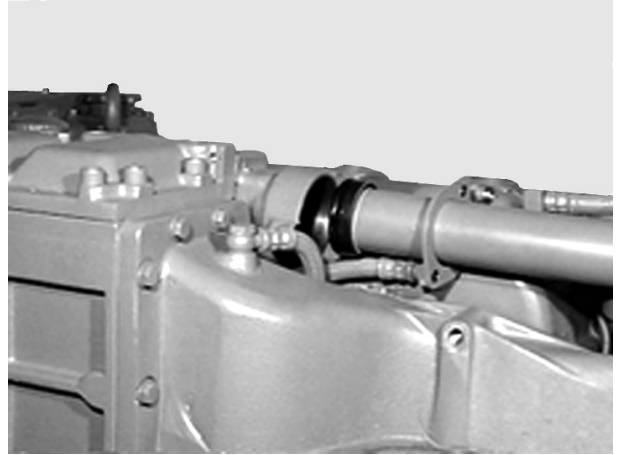


- Drain coolant from crankcase and intercooler, see page 39

Fig. 1

Remove the pipes from the fuel filter and detach the fuel filter.

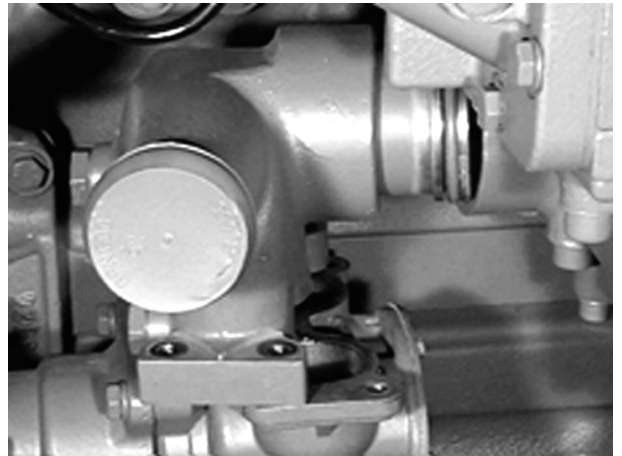
The coolant lines are fastened by means of plug connections. To remove them, unscrew pressure flange. (10 mm).



1

Fig. 2

Remove neck from the raw-water pump (13 mm).



2

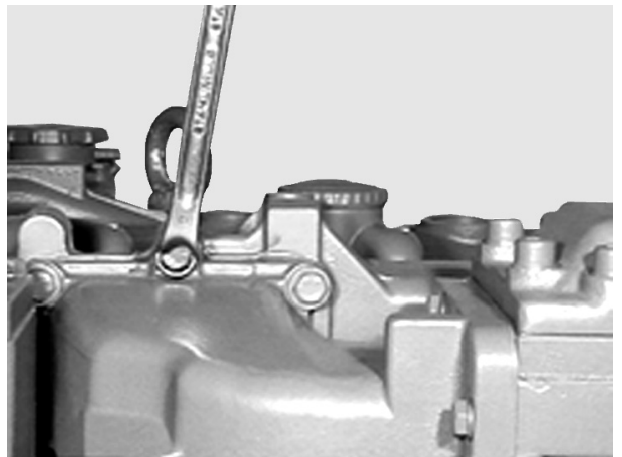
Fig. 3

Remove the five bolts from the intercooler connecting elbow leading to the intake pipe (13 mm).



Note:

For reasons of space, one bolt between the expansion tank and the elbow can be reached only with a 1/4" socket and an extension.



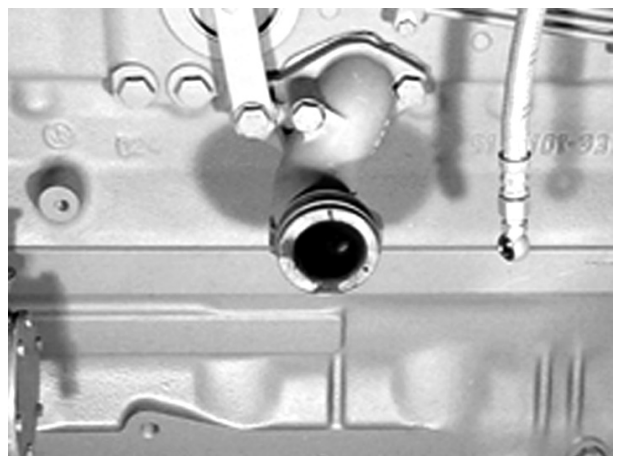
3

Take the brackets off the charge-air pipe leading from the compressor to the intercooler (13 mm).



Danger:

The intercooler is heavy. It is now supported only by the lower coolant intake neck.



4

Fig. 4

Take off intercooler. Shake the intercooler to open the lower plug connection from the coolant intake neck.

Take off intercooler with the assistance of a helper.

Disassembling and cleaning intercooler

Fig. 5

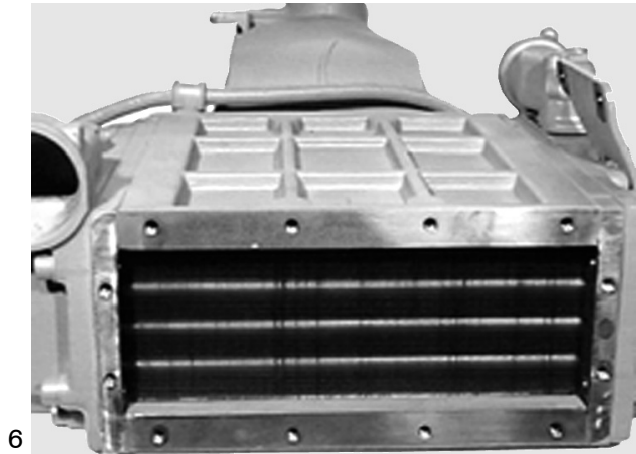
Remove charge-air elbow (13 mm).



Fig. 6

Clean the fins on the intercooler of oil and residues, using a steam jet cleaner.

Do not damage the fins.



Removing cylinder head

- Drain coolant, see page 39



Note:

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

Fig. 1

Remove the injection nozzles, see page 32.
Take off the cylinder head covers (13 mm).

1

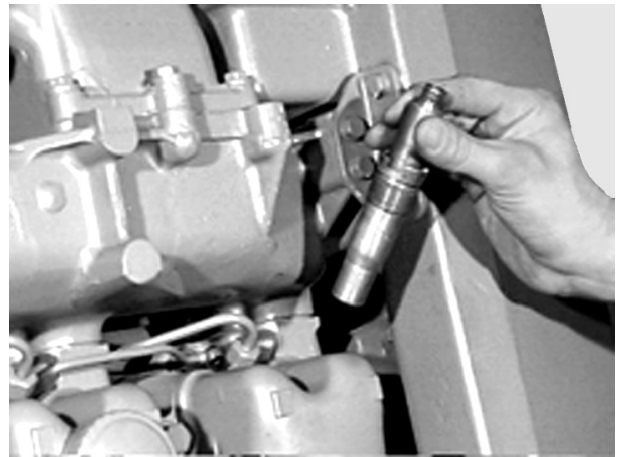


Fig. 2

Remove the coolant bleed pipe.

2

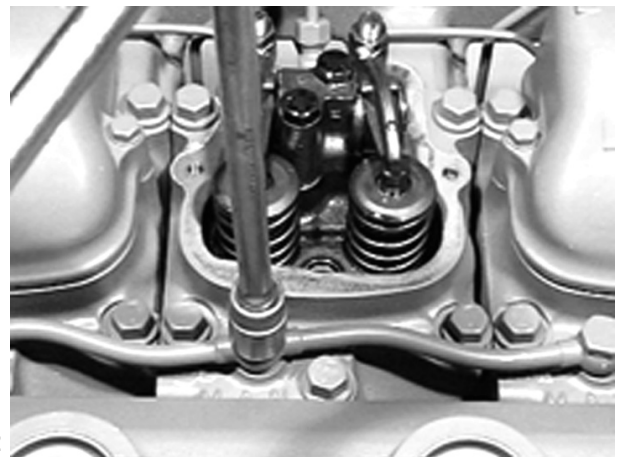


Fig. 3

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

3

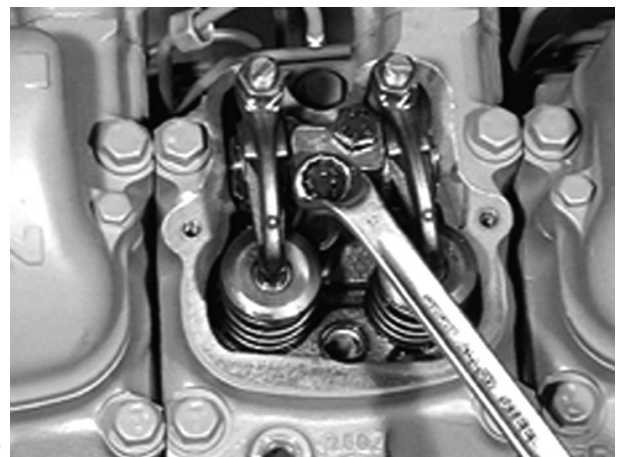


Fig. 4

Remove rocker arm bracket.

4

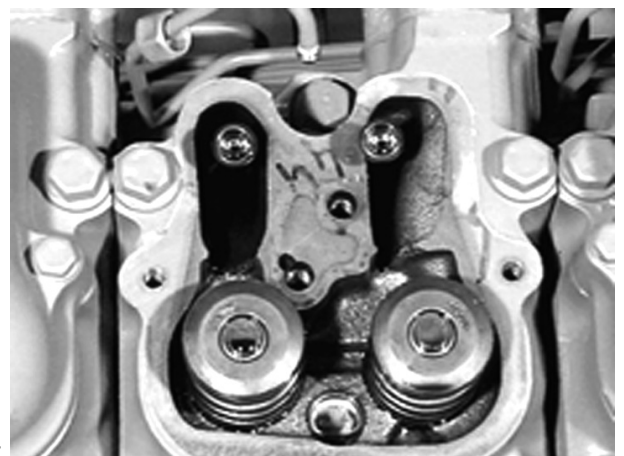


Fig. 5

Take out push rods.

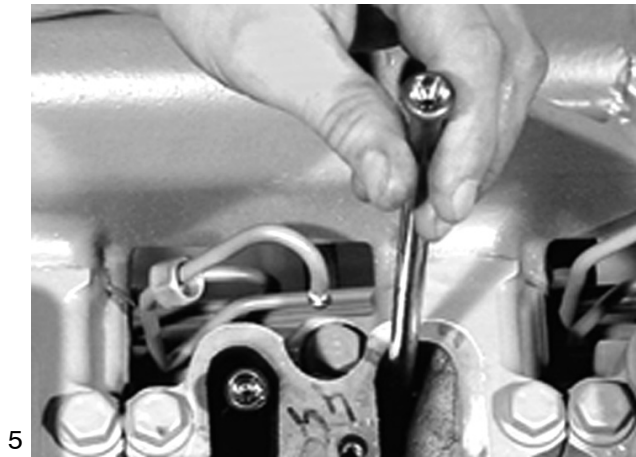


Fig. 6

Remove cylinder head bolts in reverse order of tightening.



Note:

Use reinforced socket (screw-driving machine) to loosen and tighten the cylinder head bolts.

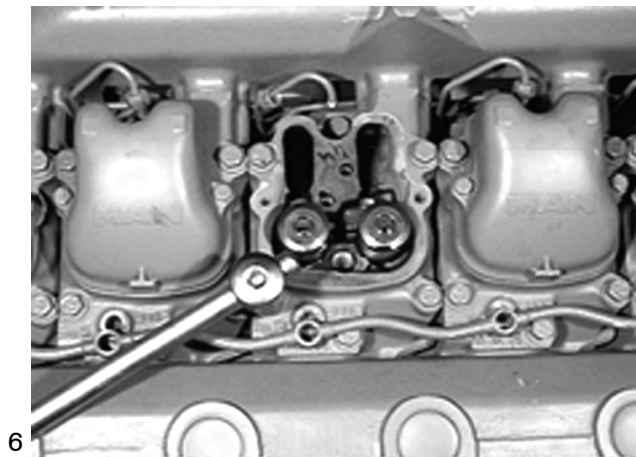


Fig. 7

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.



Fig. 8

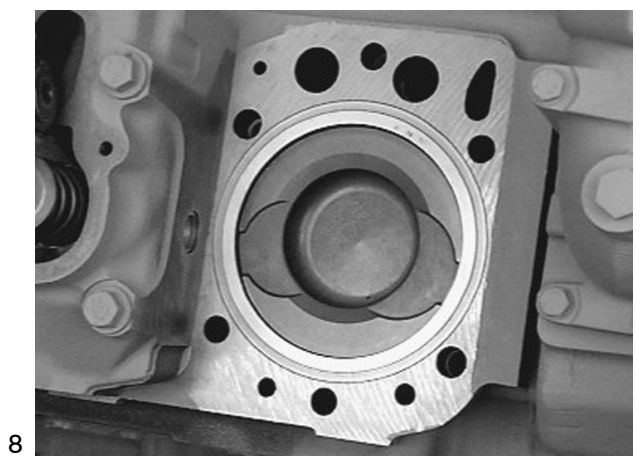
Take off cylinder head and cylinder head gasket.

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.

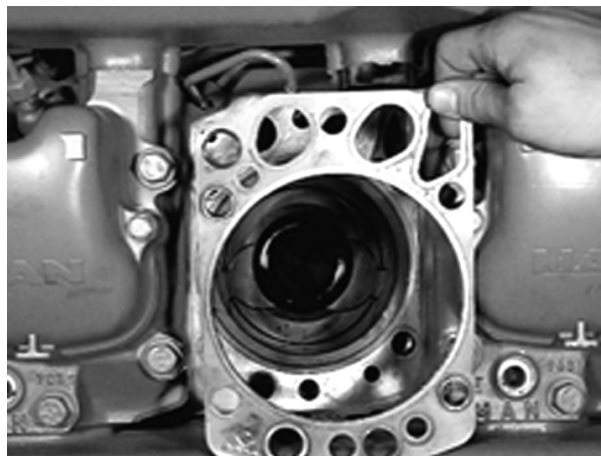


Installing cylinder head

Fig. 9

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.



9

Fig. 10

Each cylinder head is located with two fitting sleeves (arrow).

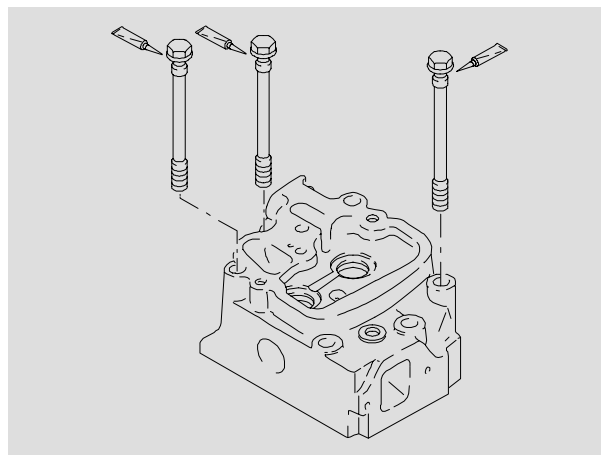


10

Fig. 11

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

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



11

Fig. 12

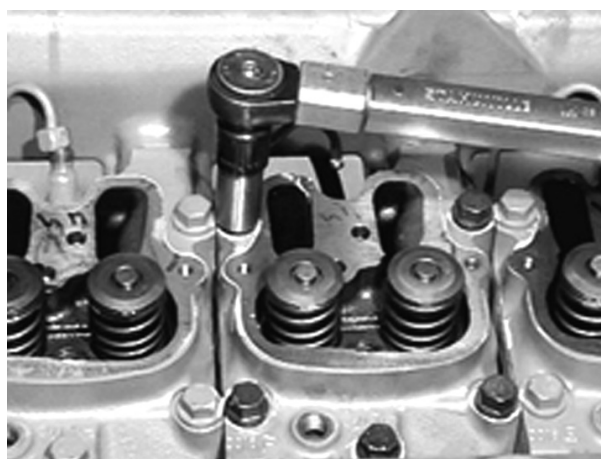
Tighten bolts by angle. Observe order of tightening and specified tightening method, and see instructions and notes on the cylinder head bolts in the publication "Engineering • Data • Setting values".



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.



12

Fig. 13

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).

13

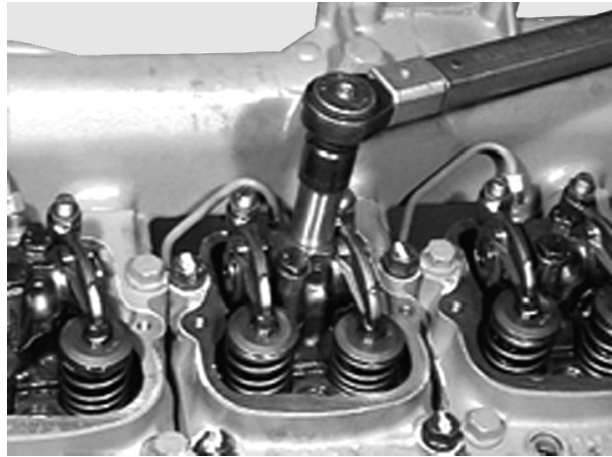


Fig. 14

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.

14

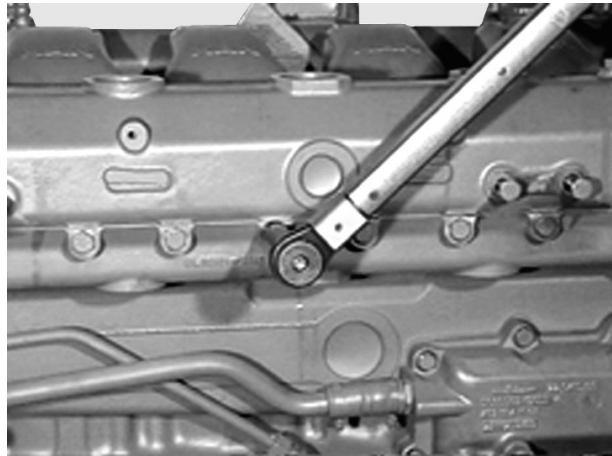
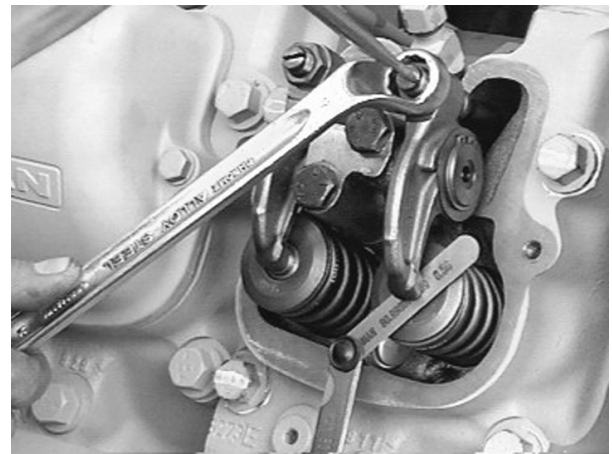


Fig. 15

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

15



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 MoS₂.

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 (13 mm).



Fig. 2

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



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.

1

Valves are in crossover in cylinder

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

Set valves in the cylinder

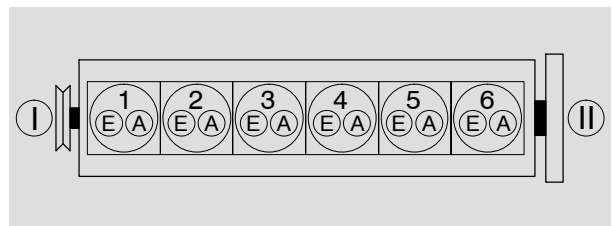


2

Fig. 3

Arrangement of cylinders and valves

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



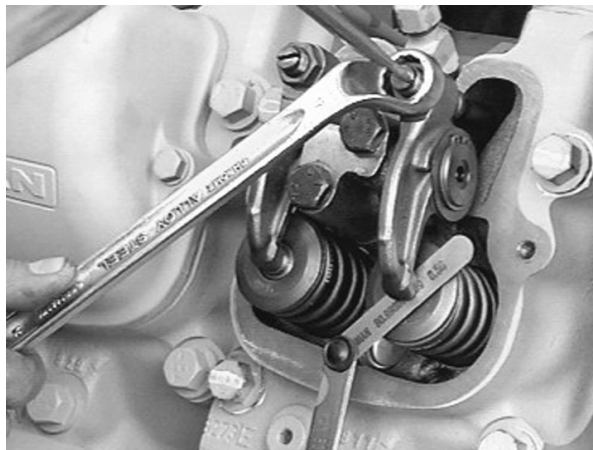
3

Fig. 4

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.

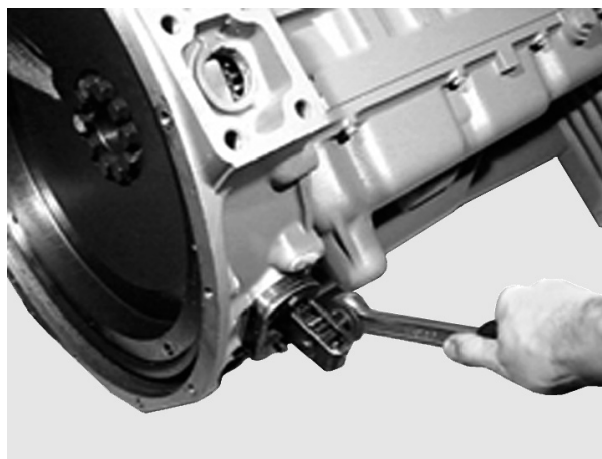
Refit cylinder head covers.



4

Fig. 5

If the inspection hole on the flywheel housing is accessible, a device with ratchet (special tool) may be attached there for turning the engine over.



5

Fig. 1

Remove rocker arms.



Fig. 2

Unclip circlip.



Fig. 3

Take rocker arms off the rocker arm shaft.



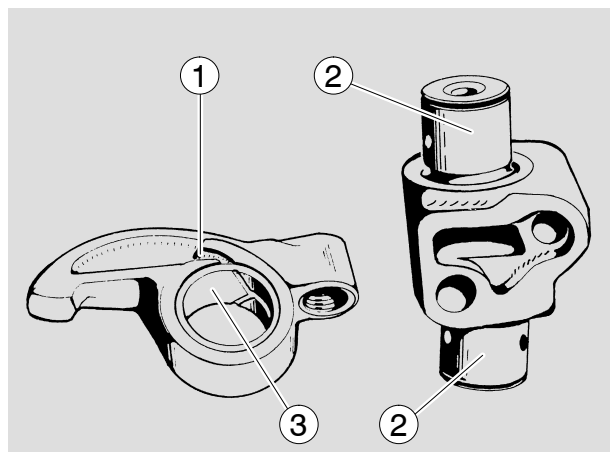
Note:

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



Fig. 4

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.



Removing valves

- Remove rocker arms. Take off cylinder head see page 81.

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.

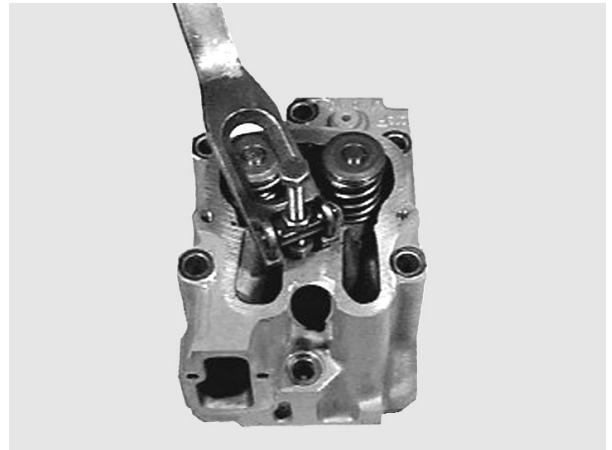
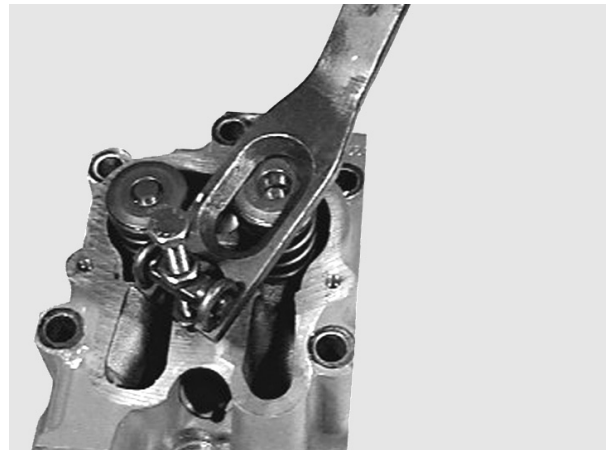


Fig. 2



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.

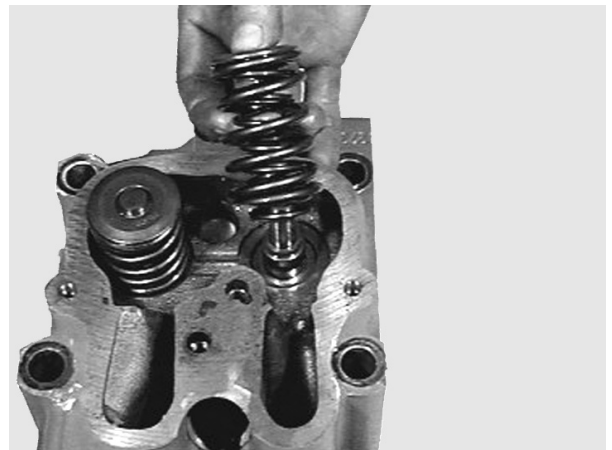
Figs. 3 and 4

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



Note:

The engines D 2866 LE4.. are equipped with valve stem seals (arrow).



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



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

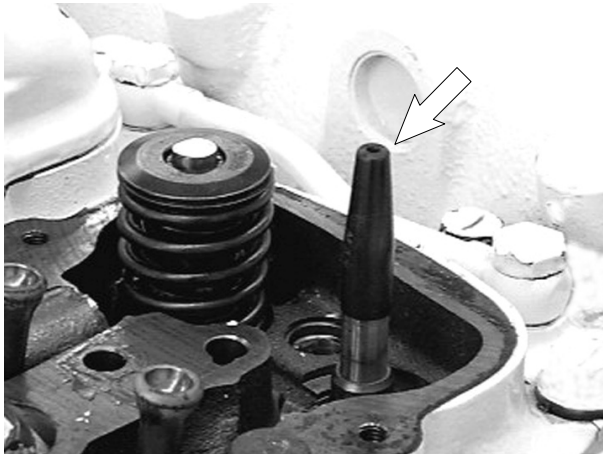
Place insert sleeve for valve shaft seals (special tool, see page LEERER MERKER, item 19) on the respective valve and push on seal.



Note:

Use new valve shaft seals only.

6



7



Fig. 8

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

8



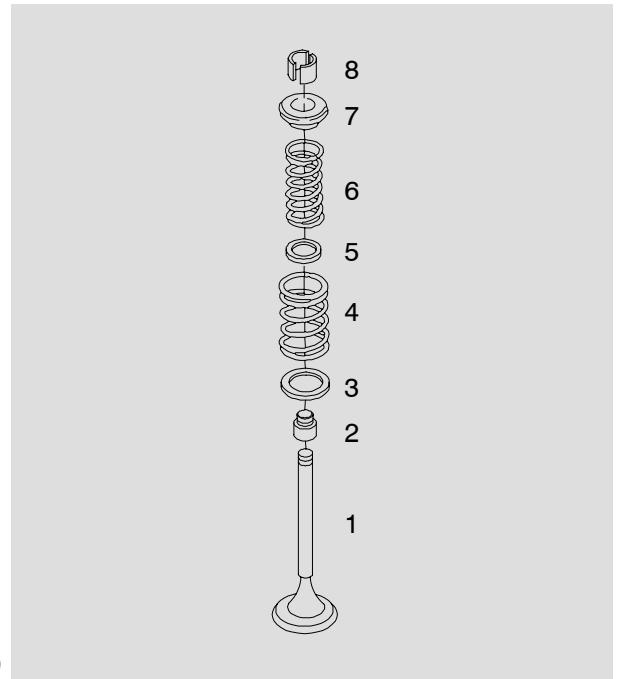
Fig. 9

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

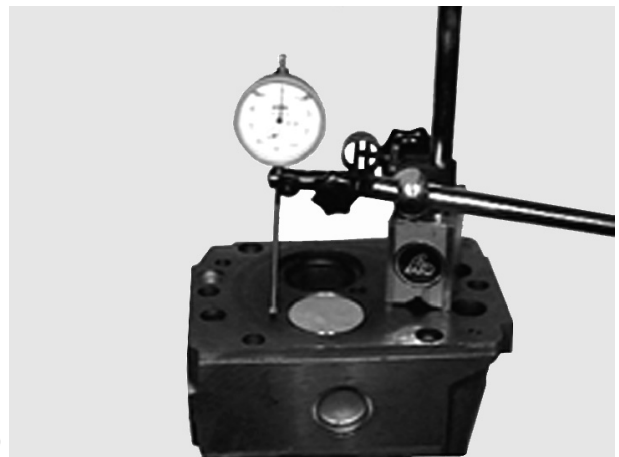


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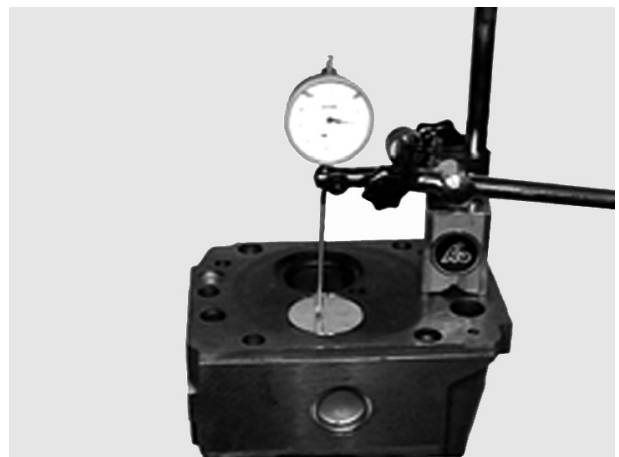
Measuring valve recess

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 retraction. If necessary, change valve and/or valve seat insert.



10



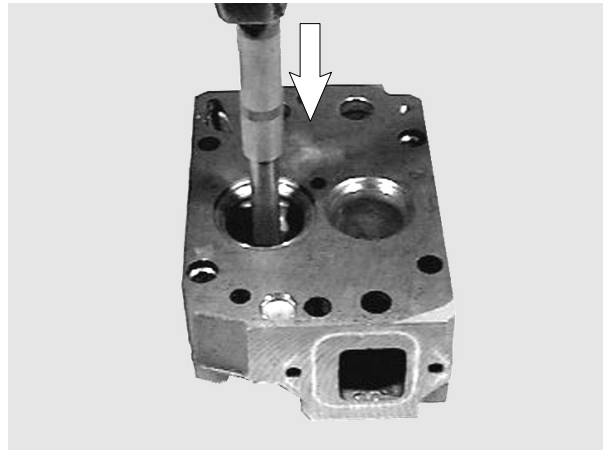
11

- For removing and installing cylinder head, see page 81
- For removing and installing valves, see page 89

Fig. 1

Press valve guide out of the combustion chamber side using pressing mandrel (special tool, see page 141, item 20).

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



1

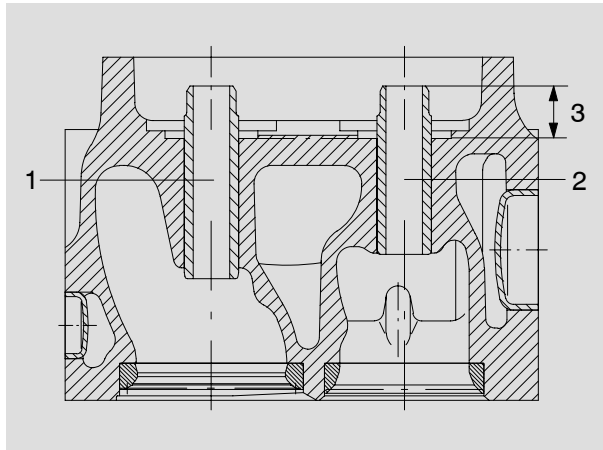
Fig. 2

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



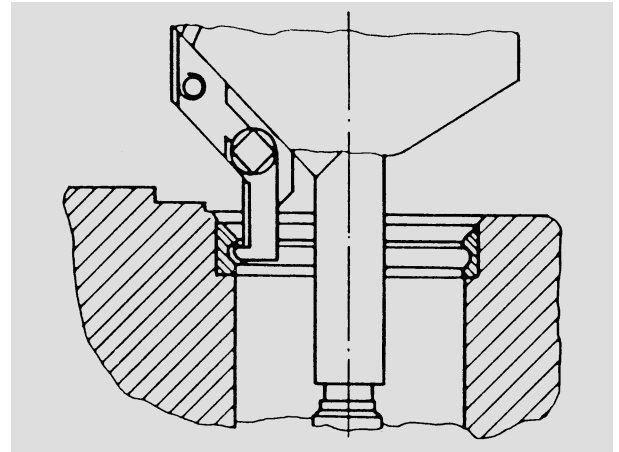
Note:

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

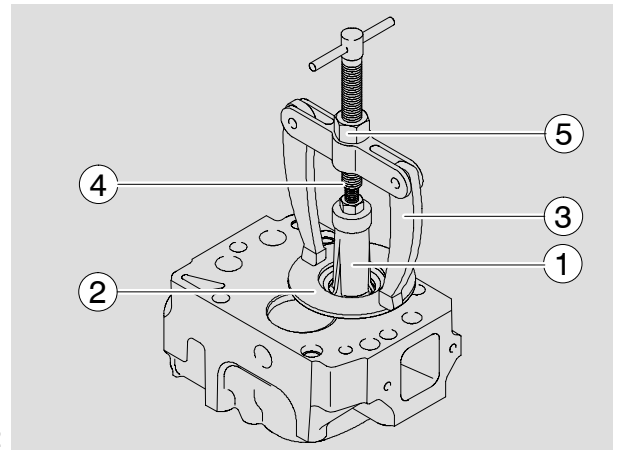


Note:

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.

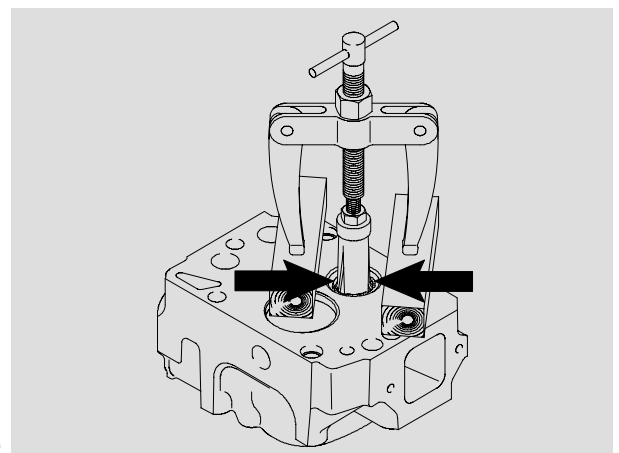


2

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) loose their tightness and must be exchanged.
- To do this, clean core holes, blow out channels and press in new core hole covers with "LOCTITE 648" and pressing mandrel (special tool, see page 145).

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

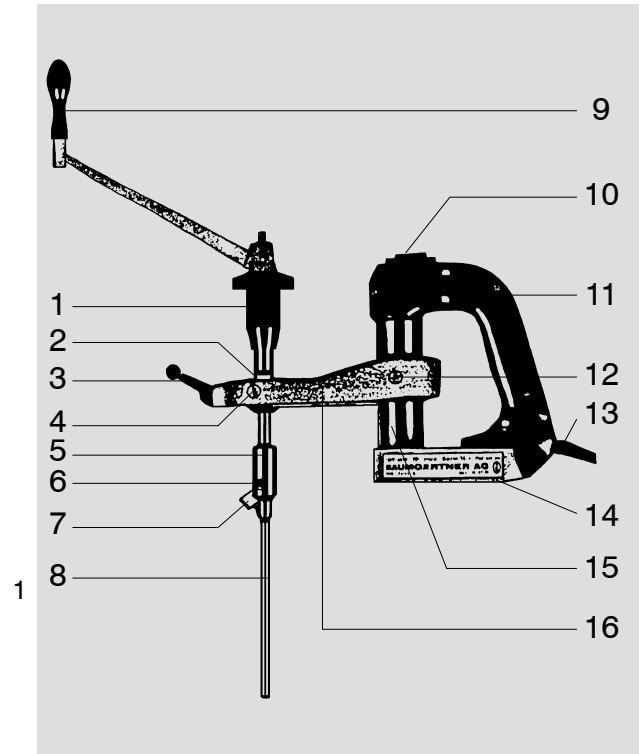



Fig. 2

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.



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.

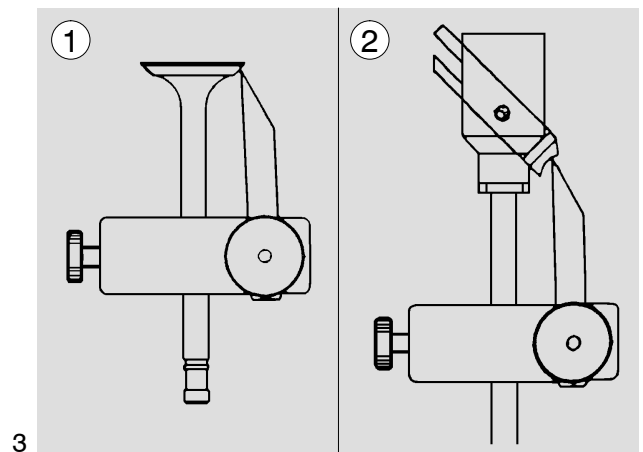


Fig. 4

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.

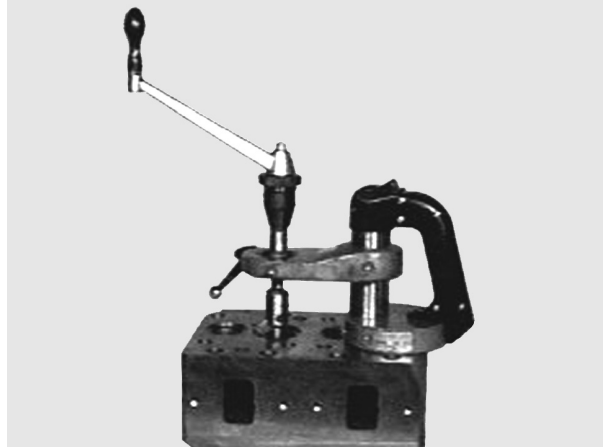


Fig. 5

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.

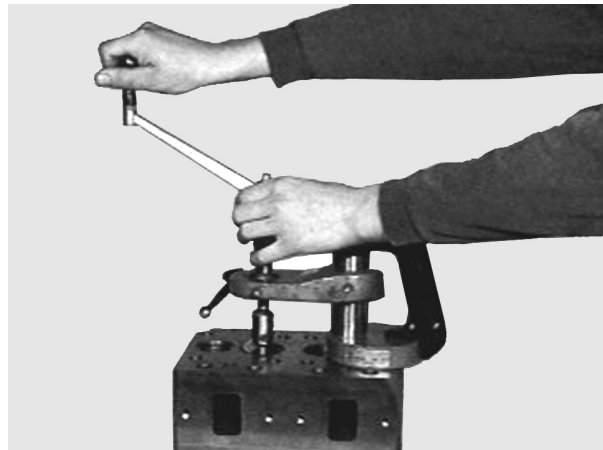


Fig. 6

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).

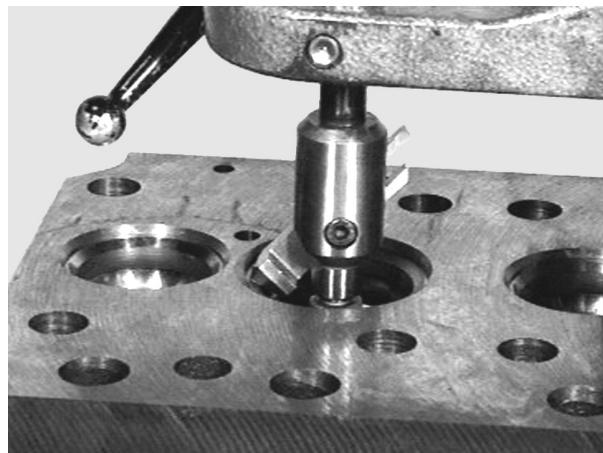


Fig. 7

Observe specified seat angle.

1 Exhaust, total angle: 90° , tool setting: 45°

2 Inlet, total angle: 120° , tool setting: 30°

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

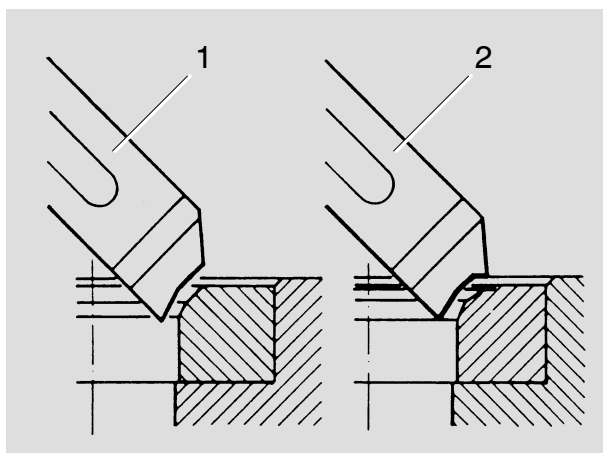


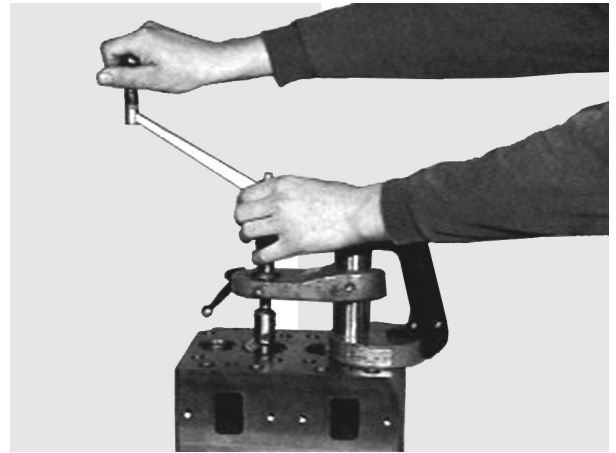
Fig. 8



Note:

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

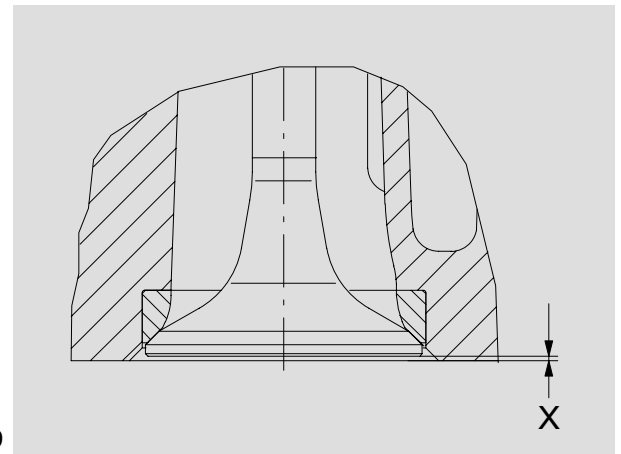
If the cylinder head interface is to be machined (max. 1 mm), the seat inserts must be reworked to achieve the valve retraction.
If new valves and seat inserts are used, increase the depth of the seat bore in the cylinder head according to the amount of material removed from the cylinder head interface.



8

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 91.



9

Fig. 1

Apply abrasive paste to tapered area on the valve seat.

Oil valve guide and insert valve.

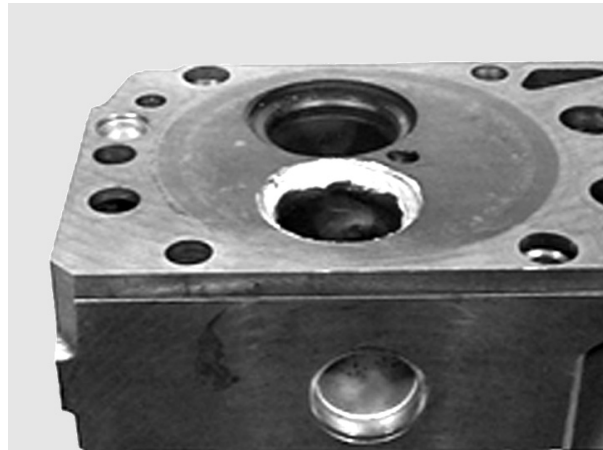


Fig. 2

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.

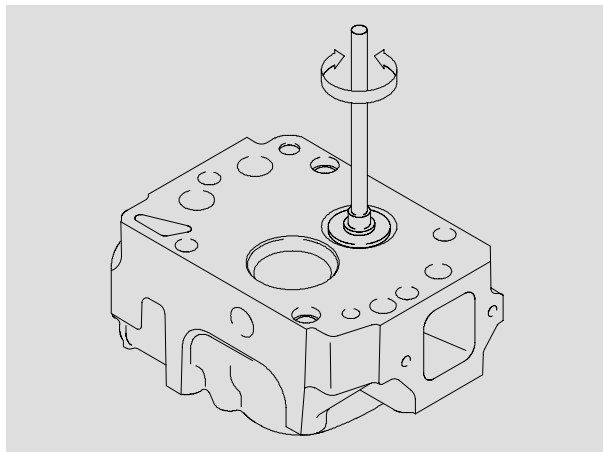


Fig. 3

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

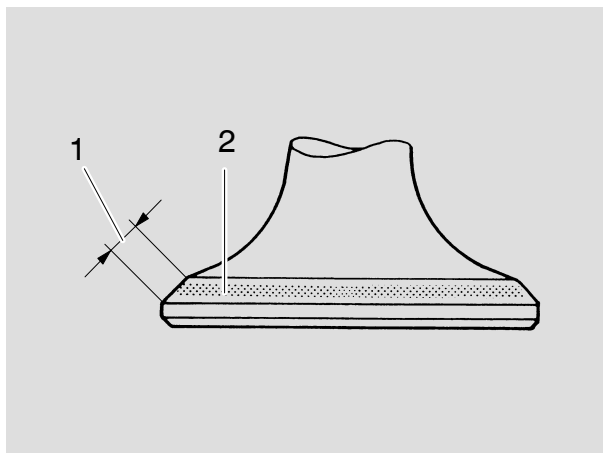


Fig. 4

- 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 –

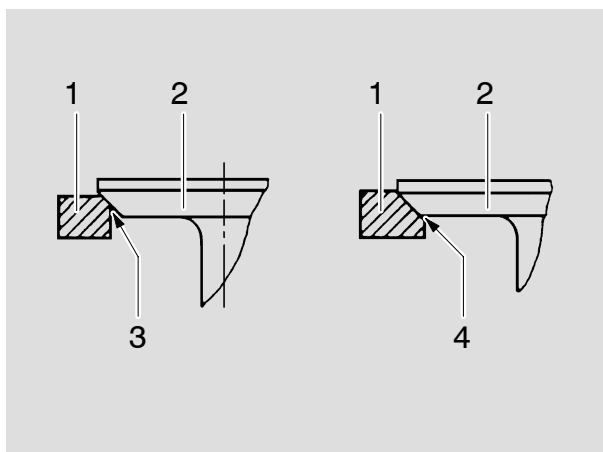
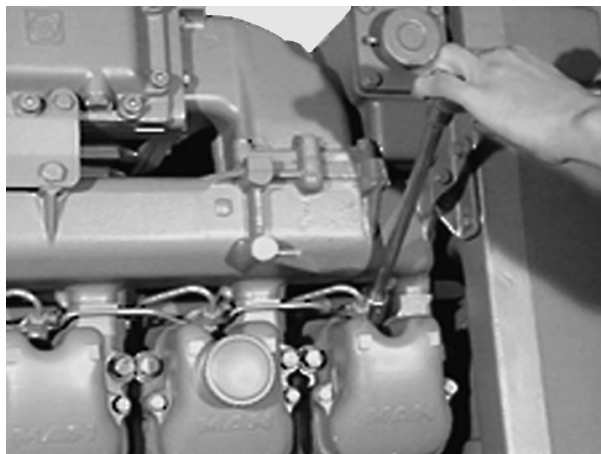


Fig. 1

- Check valve clearance and adjust, if necessary, see page 86
- Let engine warm up
- Remove all fuel injectors, see page 32
- For compression guideline values, see publication “Engineering • Data • Setting values”

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



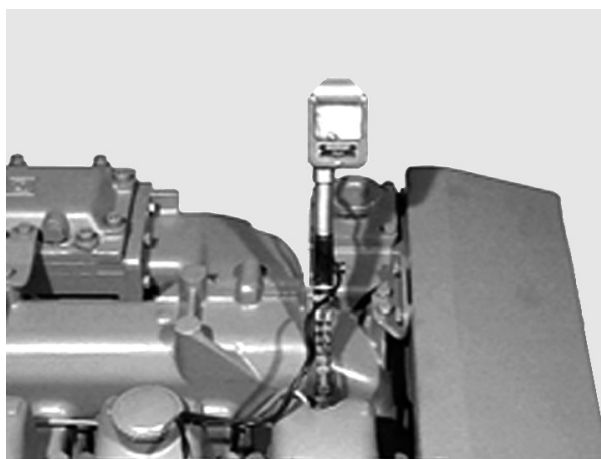
1

Fig. 2

Insert test sheet into compression recorder. Screw compression recorder for diesel engines 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.

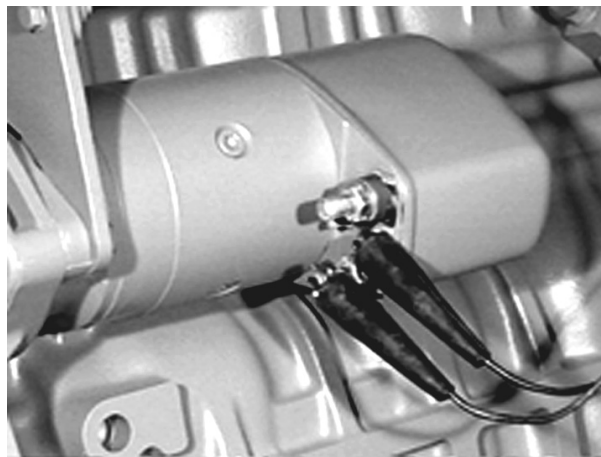
Connect up compression recorder with test connection to the next cylinder, and check all cylinders as described above.



2

Fig. 3

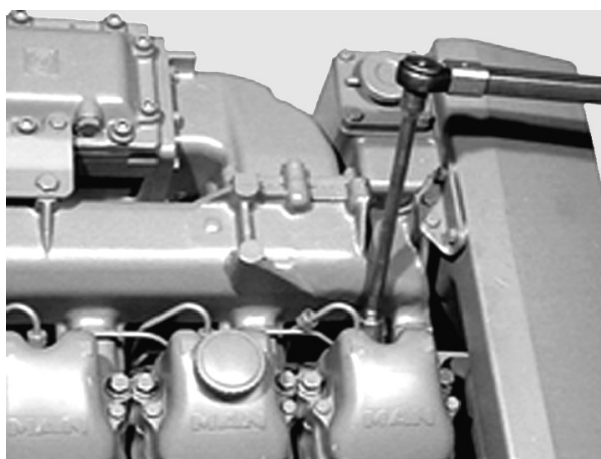
Depending on the compression recorder design, the engine can also be started directly by the compression recorder. For this purpose the electrical connections on the starter electromagnetic switch (terminals 50 and 30) are to be accordingly connected up.



3

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.

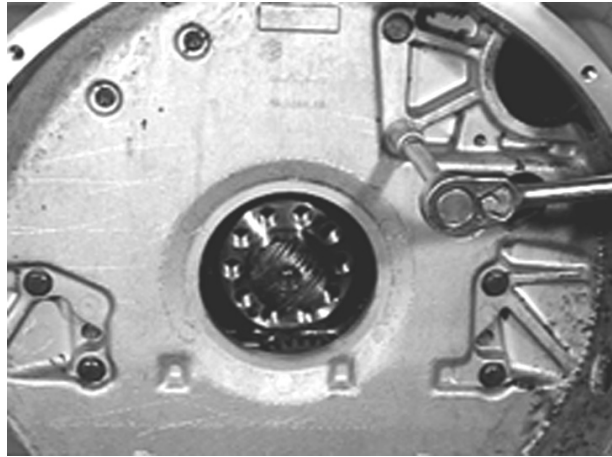


4

- Remove starter, see page 127
- Remove flywheel, see page 64

Fig. 1

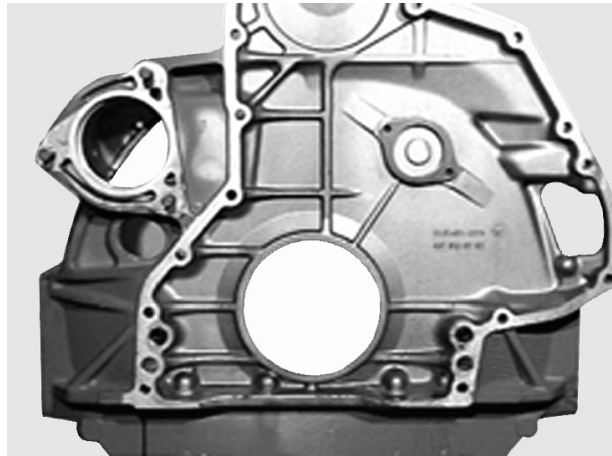
Remove the mounting bolts (17 mm).
The bottom of the timing case is bolted to the oil pan.



1

Fig. 2

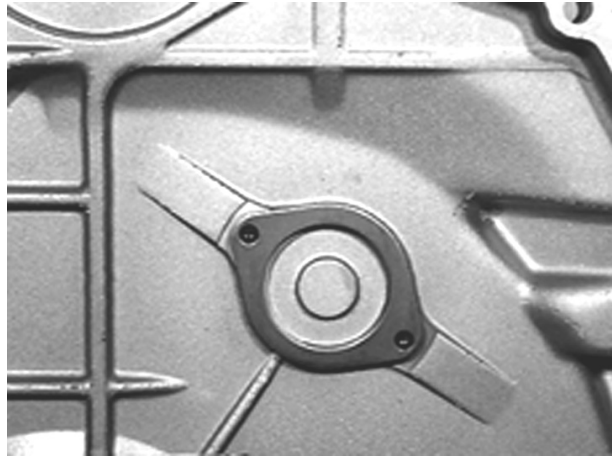
Take off the timing case. Take the gasket off the timing case and fit a new one.



2

Fig. 3

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



3

Fig. 4

Stick new gasket to timing case using grease.
Fit flywheel housing. Check whether the oil-pan gasket is in order, if necessary fitting a new one.
Slightly oil the threads and the contact faces of the mounting bolts and tighten the bolts to the specified torque (see “Engineering, Data and Setting values”).



4

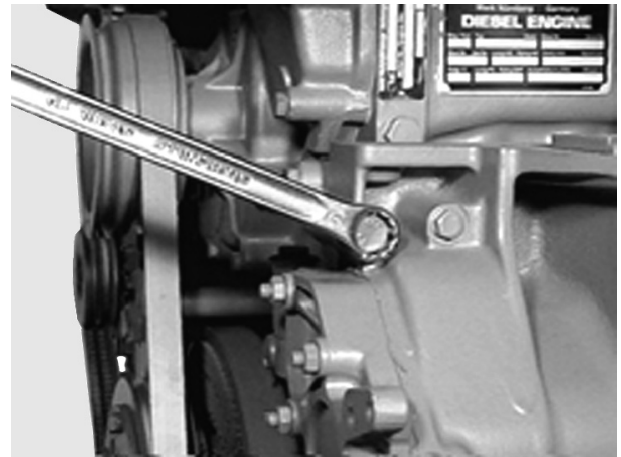
Removing the camshaft

- Draining off coolant, see page 39
- Removing the oil pan, see page 55
- Removing the starter motor, see page 127
- Removing the flywheel and timing case, see page 100
- Removing the rocker arms and take out the push, see page 81



Note:

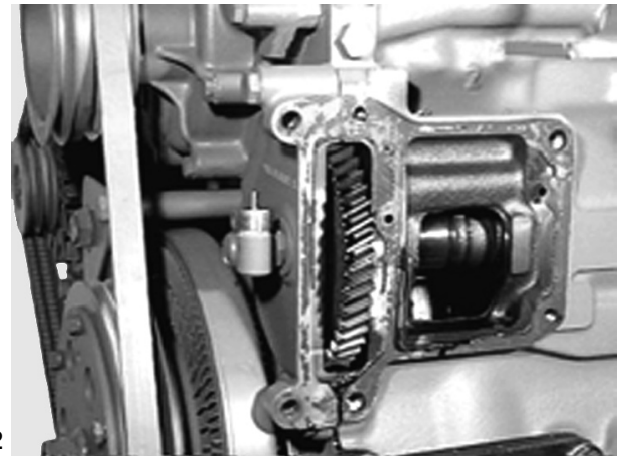
The engine must be turned through 180° in order to remove the camshaft. To do so, the engine must be placed on assembly truck.



1

Fig. 1

Remove seawater pump with drive system.



2

Fig. 2

Remove angle drive, cover and seawater-pump drive gear from the camshaft.

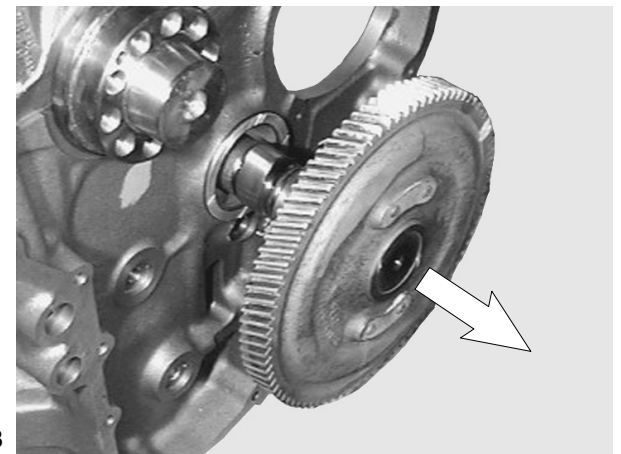
Fig. 3

Turn the engine upside down so that the valve tappets do not obstruct removal of the camshaft.

Fit insert mandrel (special tool) to camshaft.

Withdraw the camshaft. Take care not to damage the camshaft bearings. Check the camshaft for wear and damage.

In the case of damage to the camshaft or drive toothed gear, the entire unit (camshaft - toothed gear) must be replaced.

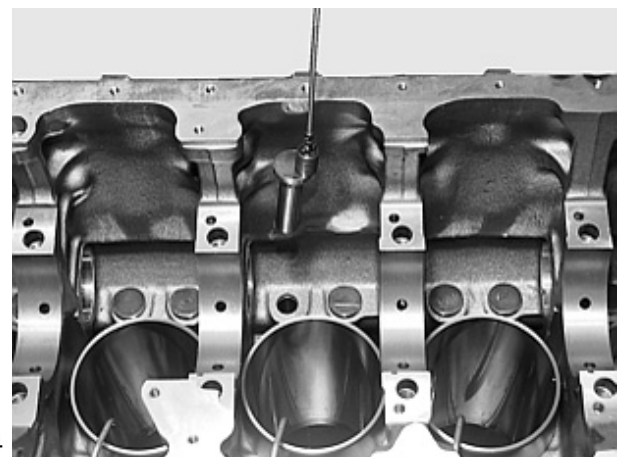


3

Fig. 4

Pull out the valve tappets with a magnet, check for wear and replace if necessary.

Valve tappets can only be removed when the camshaft has been removed.



4

Fitting the camshaft

Fig. 5

Fit insert mandrel (special tool) to camshaft.
Oil the camshaft and insert carefully.

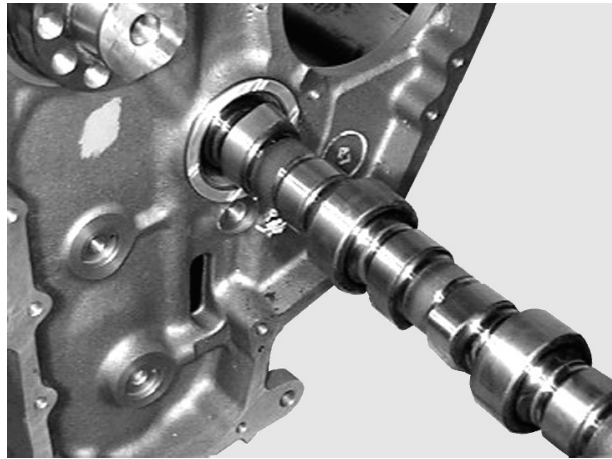


Fig. 6

In doing so, note the marking of the crankshaft and camshaft toothed gear.



Removing the camshaft bearing bushes



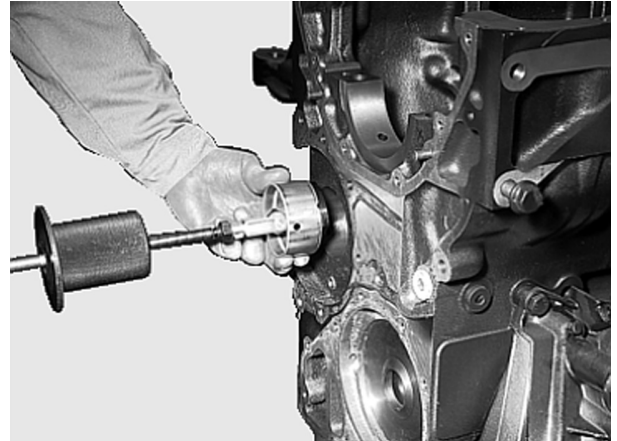
Note:

The engine is equipped with 7 camshaft bearings. Bearing no. 1 is located on the counter-flywheel side.

Press out the camshaft bearing bush, bearing 1

Fig. 1

Use the impact extractor (special tool) to pull out the bearing bush of bearing 1 from the counter-flywheel side.

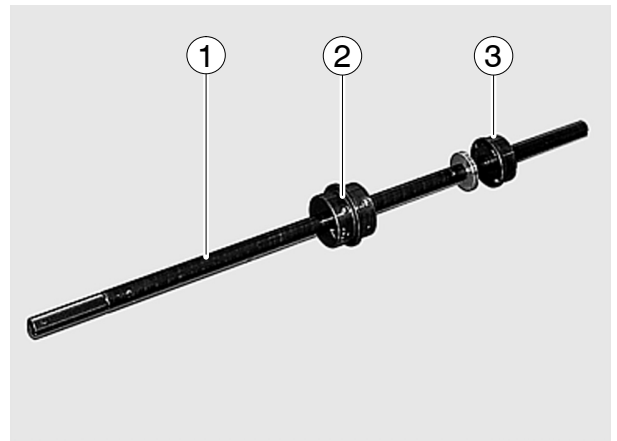


1

Fig. 2

Special tool for pressing out bearing bushes 2 to 6 from the mounting too.

- ① Shaft with groove and fixed stop
- ② Double-sided guide bush
- ③ Press-out plate



2

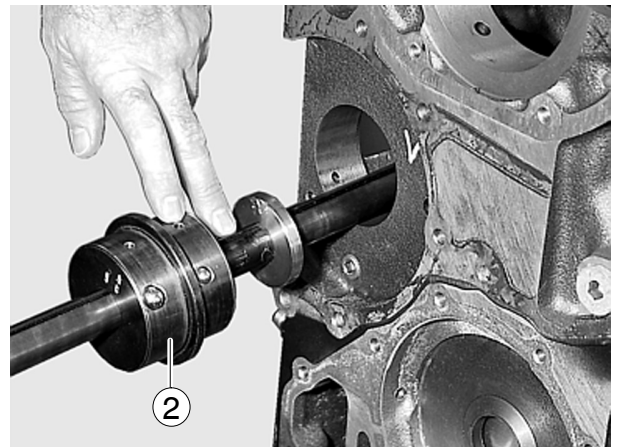
Press out camshaft bearing bush of bearings 2, 3 and 4

Fig. 3

Use the special tool, see Fig. 2, to pull out bearings 2, 3 and 4 from the counter-flywheel side.

Place the guide bush ② on the shaft with groove, ensuring that you have the correct bush side (the sides have different diameters!).

The spring-loaded balls lock into the oil holes.



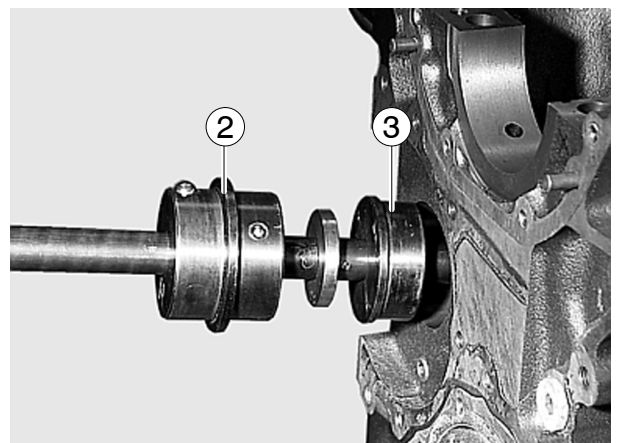
3

Fig. 4

Place the press-out plate ③ from the other side of the stop onto the shaft and insert in bearing bush 2.

Here, insert the guide bush ② with the small diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.

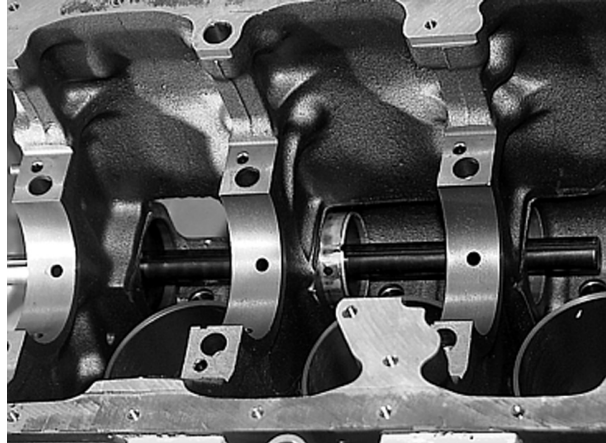
The groove of the shaft must face upwards.



4

Fig. 5

Use a soft hammer (plastic or copper) to knock out camshaft bearing bushes 2, 3 and 4 in succession.

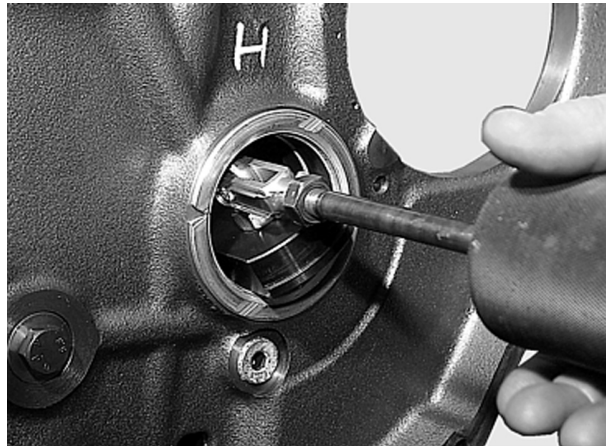


5

Press out the camshaft bearing bush, bearing 7

Fig. 6

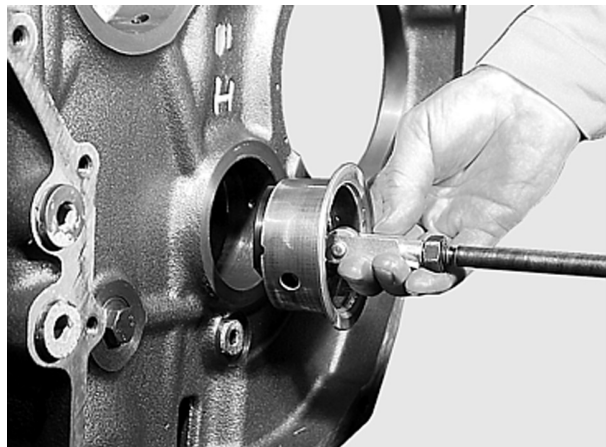
Use the impact extractor (special tool) to pull out the cam bearing bush of bearing 7 from the fly-wheel side.



6

Fig. 7

Pull out the bearing bush.



7

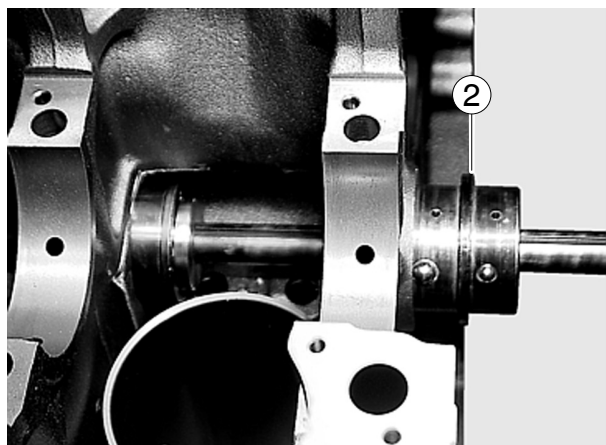
Press out camshaft bearing bushes of bearings 5 and 6

Fig. 8

Press out the bearing bushes of bearings 5 and 6 from the flywheel side.

Place the guide bush ② on the shaft with groove, ensuring that you have the correct bush side (the sides have different diameters!).

The spring-loaded balls lock into the oil holes.



8

Fig. 9

Place the press-out plate ③ from the other side of the stop onto the shaft and insert in bearing bush 6.

Here, insert the guide bush ② with the larger diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.

The groove of the shaft must then face upwards.

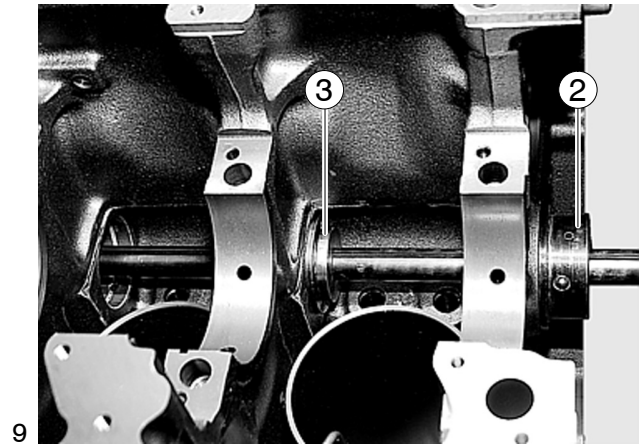
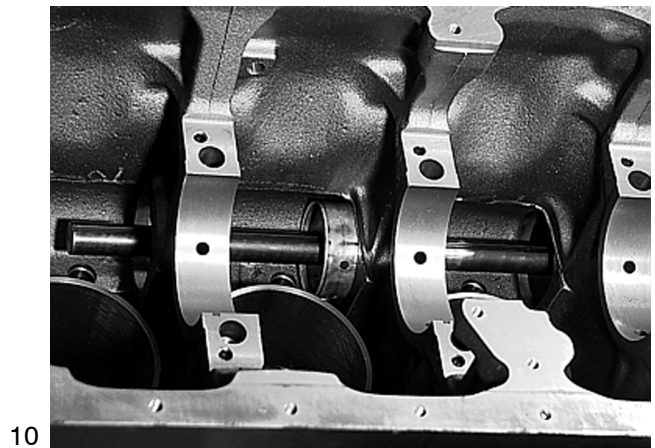


Fig. 10

Use a soft hammer (plastic or copper) to knock out bearing bushes 6 and 5 in succession.



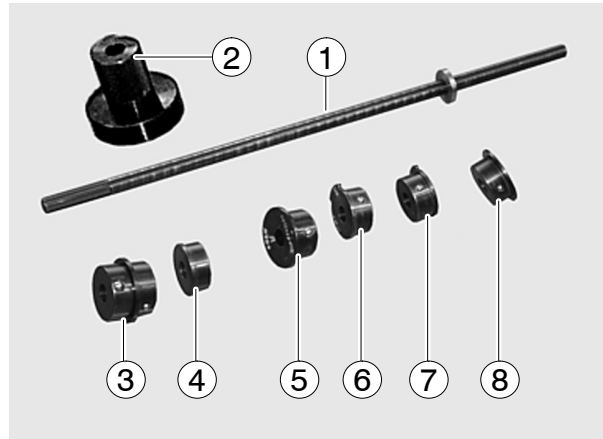
Fitting the camshaft bearing bushes

Fig. 11

Depending on the number of the camshaft bearing, there are various press-in plates (special too) for pressing in the bearing bushes

- ① Shaft with groove and fixed stop
- ② Striking weight for ①
- ③ Double-sided guide bush
- ④ Press-out plate for bearing bushes 2 to 6
- ⑤ Press-in plate for bearing bush 1
- ⑥ Press-in plate for bearing bushes 2 to 4
- ⑦ Press-in plate for bearing bushes 5 and 6
- ⑧ Press-in plate for bearing bush 7

11



Press in the camshaft bearing bush, bearing 2

Figs. 12 and 13

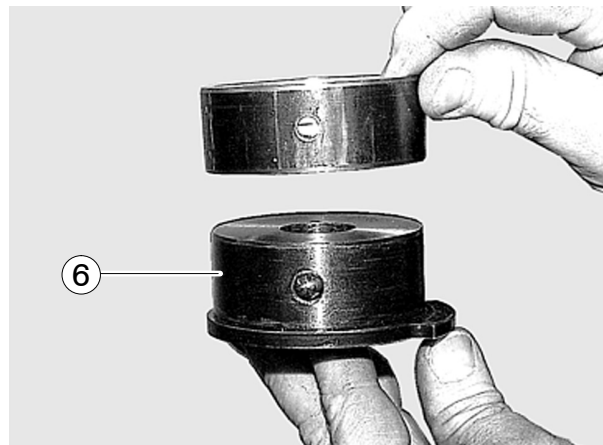
Place the bearing bush on the press-in plate ⑥.



Caution:

- One oil hole of the bearing bush must be fixed in place by the spring-loaded ball
- The other oil hole must be flush with the recess of the press-in plate
- The bearing bush must be seated up to the stop on the press-in plate

12



13

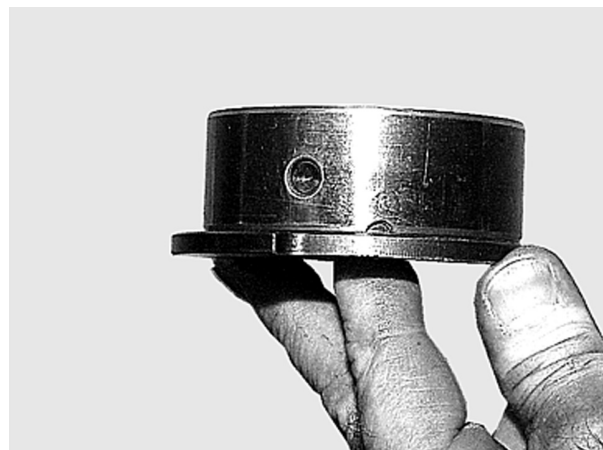


Fig. 14

Place the guide bush ③ on the shaft with groove, ensuring that you have the correct bush side (the sides have different diameters!).

When the shaft is put in place, the groove must face upwards so that the guide bush is fixed in place by the correct oil holes.

14

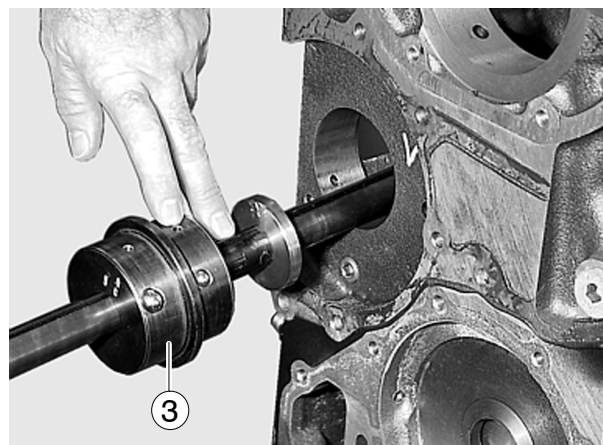


Fig. 15

Place the press-in plate ⑥ with fitted bearing bush on the shaft.

The press-in plate is fixed in place by the groove so that the oil holes line up after pressing in.

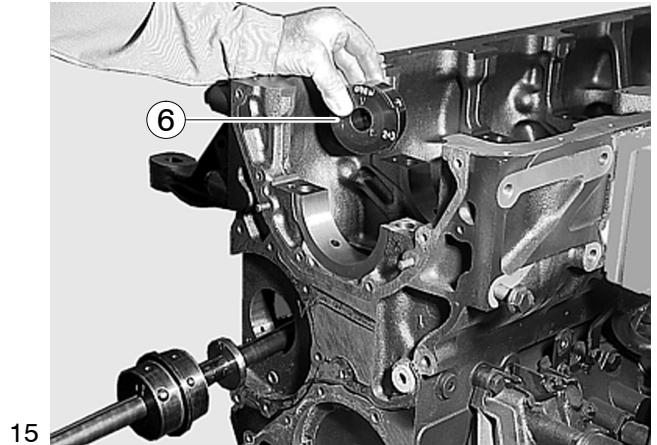


Fig. 16

Here, insert the guide bush ③ with the small diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.

The groove of the shaft must then face upwards. Apply the press-in plate ⑥ with fitted bearing bush.

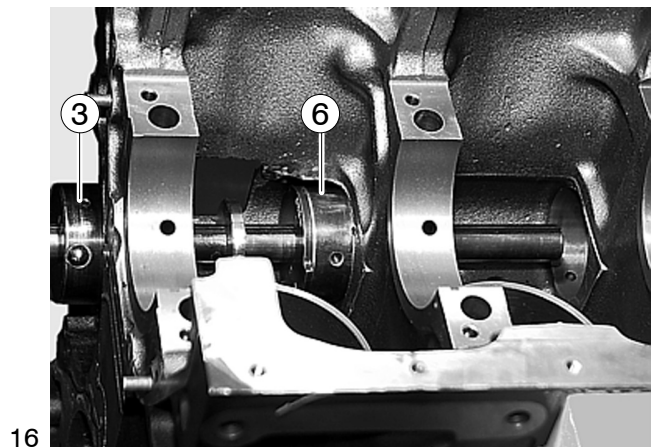


Fig. 17

Use a soft hammer (plastic or copper) to drive camshaft bearing bush 2 in as far as it will go.



Press in camshaft bearing bushes, bearings 3 and 4

Fig. 18

Arrangement of special tools:

- ① Shaft with groove and fixed stop
- ③ Double-sided guide bush
- ④ Press-out plate as additional guide
- ⑥ Press-in plate

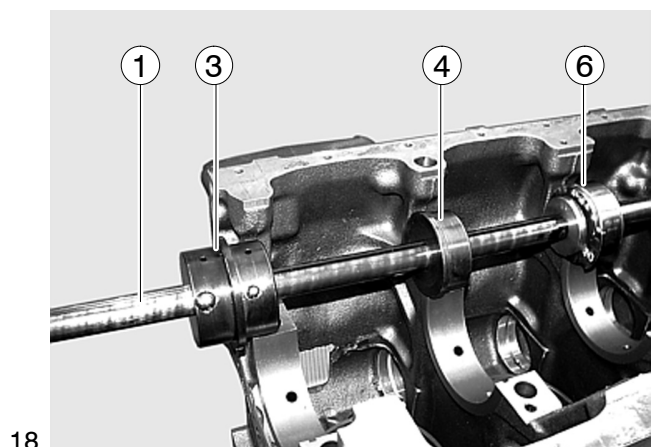


Fig. 19

From the counter-flywheel side, insert the press-out plate ④ in bearing 2.
Insert the shaft with guide bush ③ through bearing 1, then through the press-out plate ④ (bearing 2).

Here, insert the guide bush ③ with the small diameter in the bearing hole and let the spring-loaded balls lock into the oil holes.
The groove of the shaft must then face upwards.

Place the press-in plate ⑥ with fitted bearing bush on the shaft.

The press-in plate is fixed in place by the groove so that the oil holes line up after pressing in.

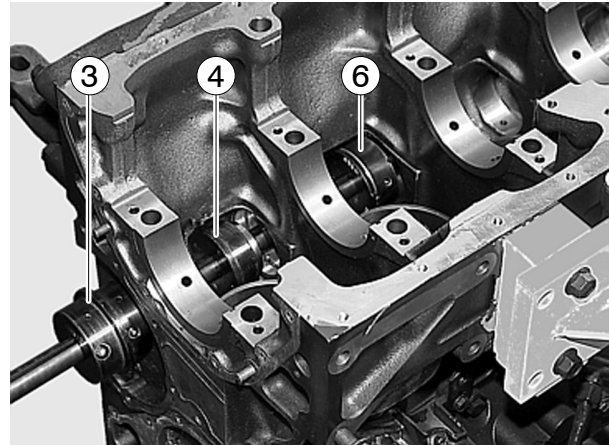
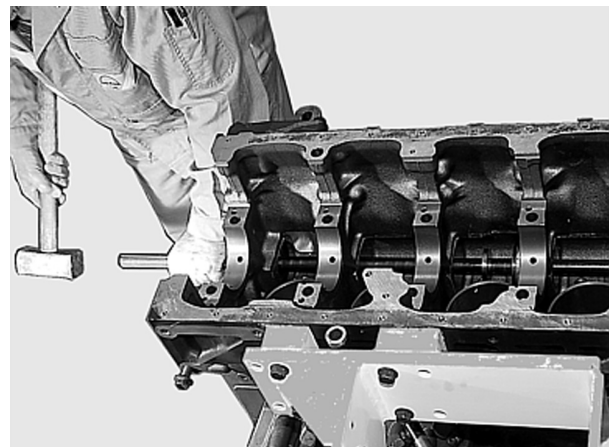


Fig. 20

Use a soft hammer (plastic or copper) to drive the bearing bush into bearing 3 as far as it will go.

To fit bearing 4, proceed in the same manner.



Press in the camshaft bearing bush, bearing 1

Figs. 21 and 22

Place the bearing bush on the press-in plate.



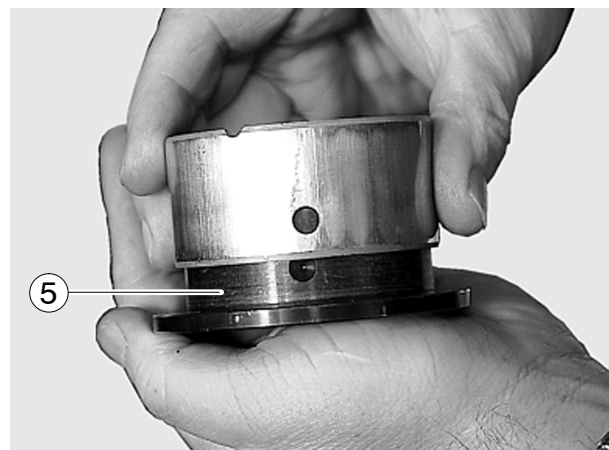
Note:

The bearing bush and press-in plate ⑤ for bearing 1 are wider than for bearings 2 to 6.



Caution:

- One oil hole of the bearing bush must be fixed in place by the spring-loaded ball
- The other oil hole must be flush with the recess of the press-in plate
- The bearing bush must be seated up to the stop on the press-in plate



Figs. 23 and 24


Arrangement of special tools:

- ① Shaft with groove and fixed stop
- ④ Press-out plate for bearing bushes 2 to 6 as additional guide
- ⑤ Press-in plate for bearing bush 1
- ⑥ Press-in plate for bearing bushes 2 to 4 as additional guide

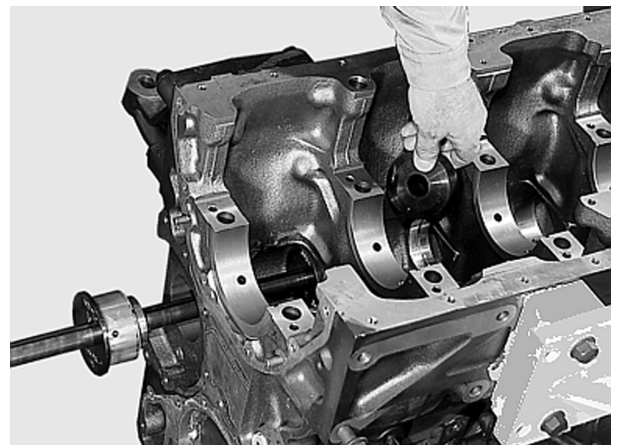
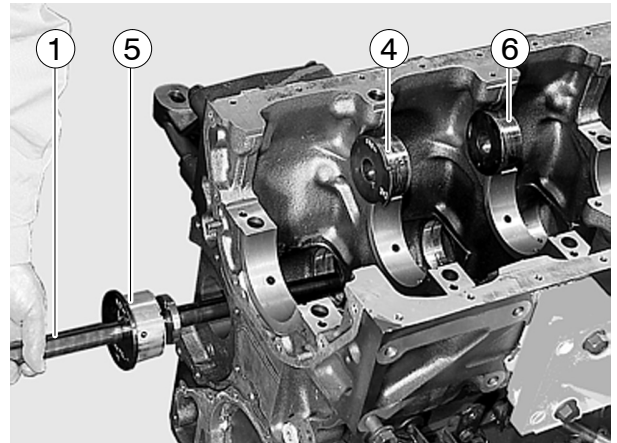
From the counter-flywheel side, insert the press-out plate as guide in camshaft bearing 2.

Insert the press-in plate ⑥ in bearing 3, letting the spring-loaded ball for fixing the position of the shaft ① lock into the oil hole. 23

Insert the shaft up to the stop into the press-in plate (bearing 2) and press-out plate (bearing 3).



Caution:
Do not twist the fixing from the groove.
The groove must face upwards.

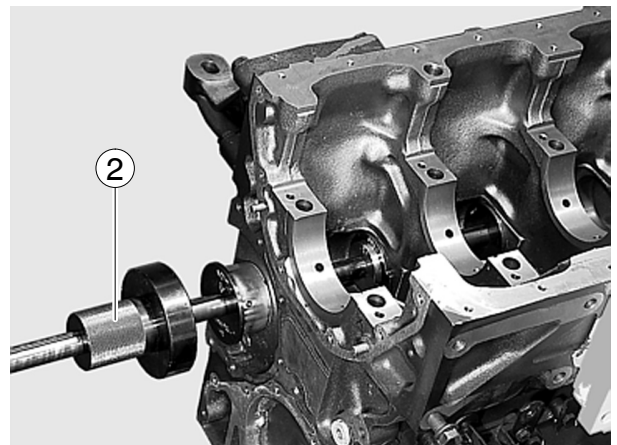


24

Fig. 25

Place the press-in plate with fitted bearing bush on the shaft.


The oil holes are covered in that the press-in plate is fixed in position by the groove of the shaft. Drive in the bearing bush with striking weight ②.



25

Fig. 26

Check all the pressed-in bearing bushes for seating and free access to the oil holes.



Caution:
Check that the bearing hole matches up to the oil hole in the housing.
Minimum cross section with mandrel
 $\varnothing = 2.5 \text{ mm}$.



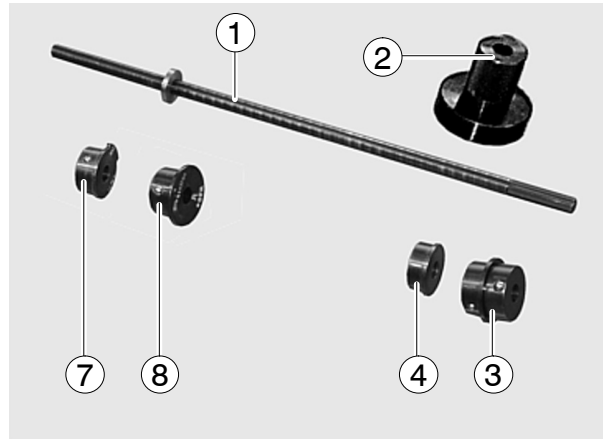
26

Fitting camshaft bearing bushes, bearings 3 and 4

Fig. 27

Special tool for pressing out bearing bushes 5, 6 and 7 from the mounting tool:

- ① Shaft with groove and fixed stop
- ② Striking weight for ①
- ③ Double-sided guide bush
- ④ Press-out plate as additional guide
- ⑦ Press-in plate for bearing bushes 5 and 6
- ⑧ Press-in plate for bearing bush 7



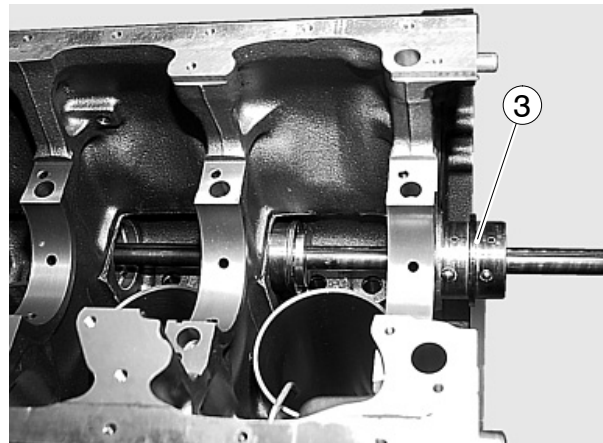
27

Fig. 28

From the counter-flywheel side, press in bearing bushes 5 and 6 as described for bearing bushes 2, 3, and 4.

Insert the guide bush ③ with large diameter in bearing 7.

The groove of the shaft must then face upwards.

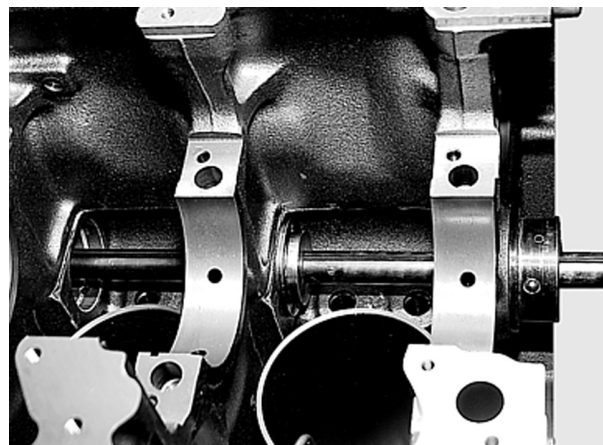


28

Fig. 29

Use a soft hammer (plastic or copper) to drive bearing bush 6 in as far as it will go.

To fit bearing 5, proceed in the same manner.



29

Press in the camshaft bearing bush, bearing 7

Fig. 30

From the flywheel side, insert the press-out plate as guide in bearing 5.

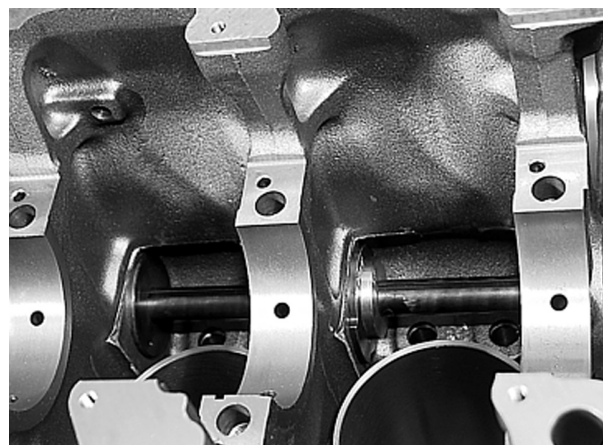
Insert the press-in plate as guide in bearing 6, letting the spring-loaded ball for fixing the position of the shaft lock into the oil hole.

Insert the shaft up to the stop into the press-in plate (bearing 6) and press-out plate (bearing 5).



Caution:

Do not twist the fixing from the groove.
The groove must face upwards.



30

Fig.31

Place the bearing bush with edge on the press-in plate.



Caution:

- One oil hole of the bearing bush must be fixed in place by the spring-loaded ball
- The other oil hole must be flush with the recess of the press-in plate
- The bearing bush must be seated up to the stop on the press-in plate

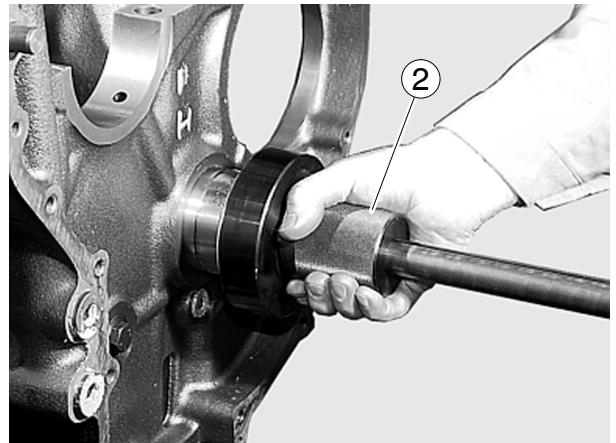


31

Fig. 32

The oil holes are covered in that the press-in plate is fixed in position by the groove of the shaft.

Drive in the bearing bush with striking weight ②.



32

Fig. 33

Check all the pressed-in bearing bushes for seating and free access to the oil holes.



Caution:

- Check that the bearing hole matches up to the oil hole in the housing.
- Minimum cross section with mandrel $\varnothing = 2.5 \text{ mm}$.



33



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

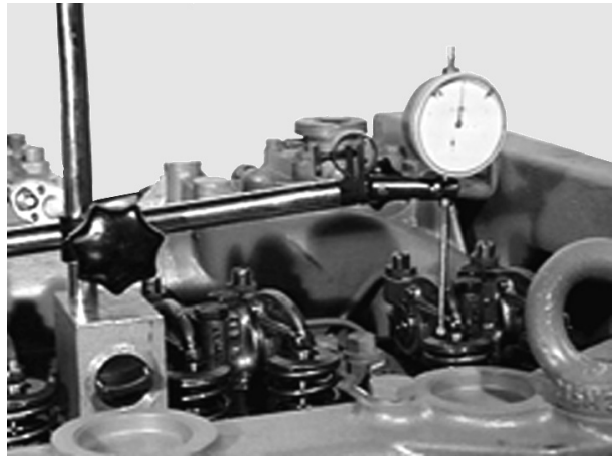
Remove cylinder head cover from 1st cylinder.
Carefully set exhaust valve for 1st cylinder.
Turn engine until the valves of the 1st cylinder are in crossover.
Turn engine back to approx. 50° before TDC, then forwards to 30° before TDC (observe graduation on flywheel).

Fig. 2

Apply dial gauge with approx 2 mm preload to valve spring retainer of exhaust valve in 1st cylinder and set to - 0 - .
Turn engine in running direction through 180° (exhaust valve fully closed).
Read valve stroke from dial gauge.
The valve stroke must be between 5,5 and 6,5 mm.



1



2

Removing crankshaft

- ,Remove oil pan and oil pump see page 55
- Remove timing case, see page 100
- Remove the front cover for sealing the crankshaft and the cylinder heads, see page 81

Fig. 1

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

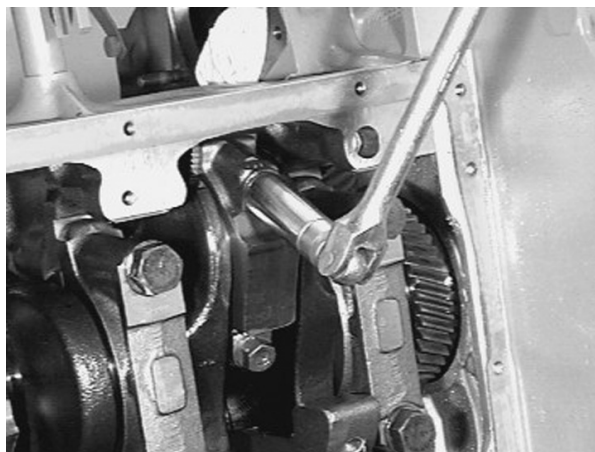


Fig. 2

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

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

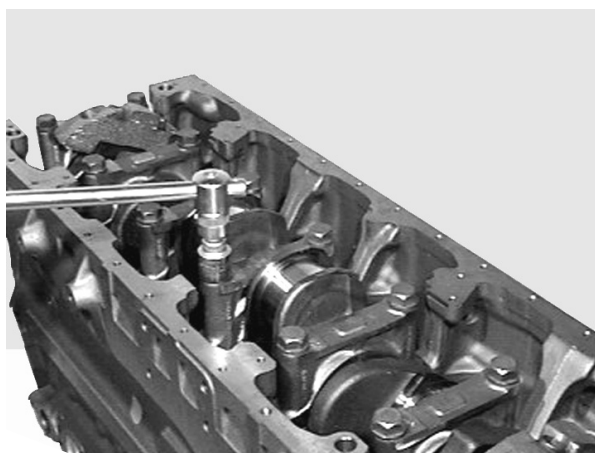



Fig. 3

Lift out crankshaft.

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

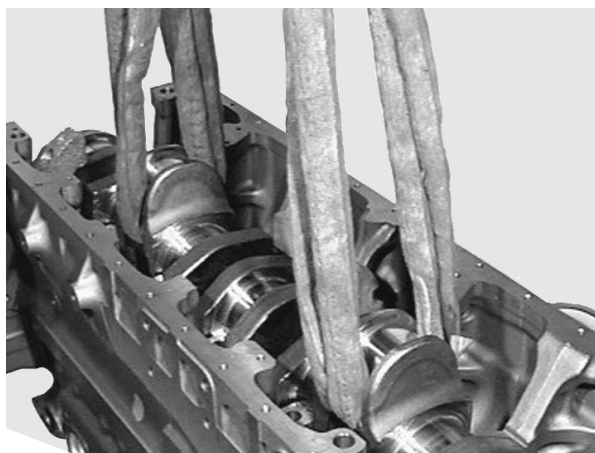


Fig. 4

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

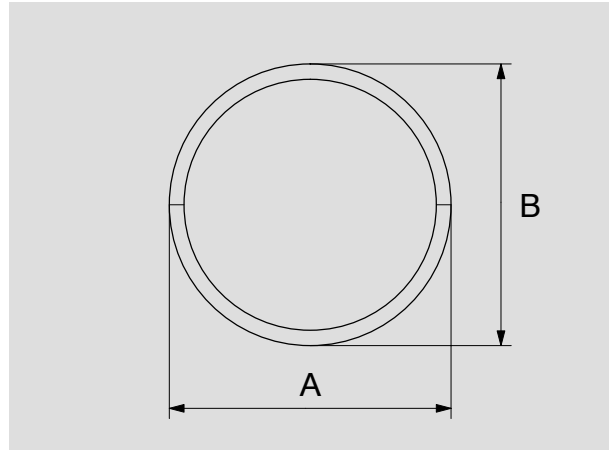


Checking spread of bearing shells

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.



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

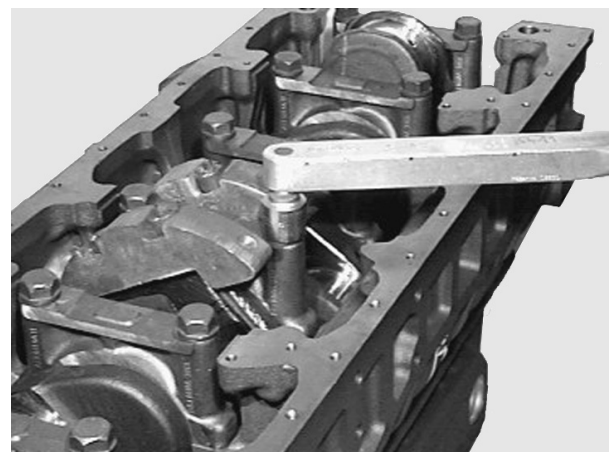
Fig. 8

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

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

Tighten finally by angle.

Check to see that crankshaft runs smoothly.



8



Caution:

Faulty bearing caps cannot be replaced singly.

Checking axial play

Fig. 9

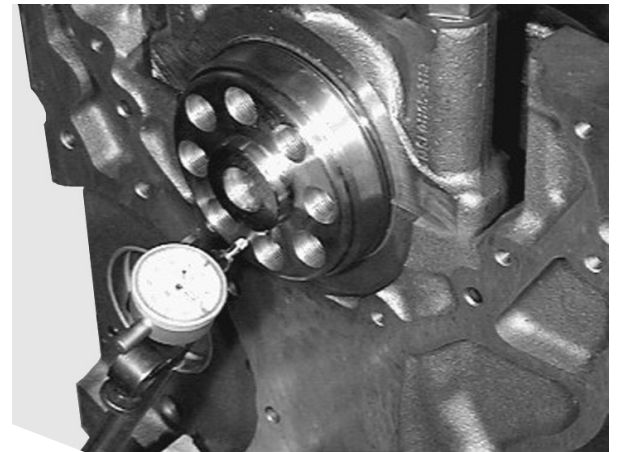
The axial play of the crankshaft is determined by the centre crankshaft bearing (thrust bearing).



9

Fig. 10

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



10

Fig. 11

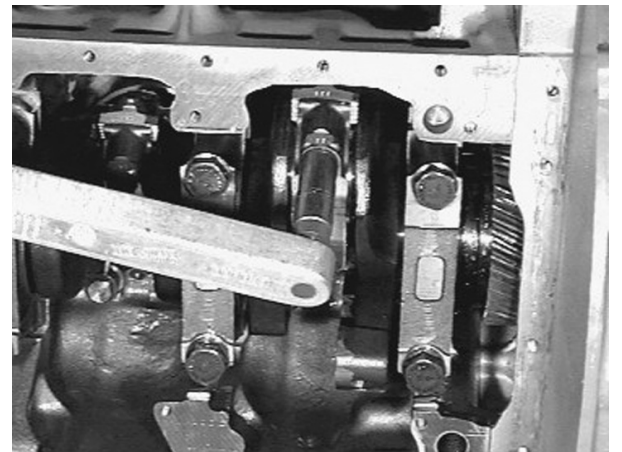
Measure connecting rod bearing, insert pistons with connecting rod. Coat connecting rod bearing shells with oil and pull connecting rods to bearing pin.

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".)



111

Removing piston with connecting rod

- Remove oil pan, oil suction pipe, see page 55
- Remove cylinder heads, see page 81

Fig. 1

Remove bolts from connecting rod bearing cap.

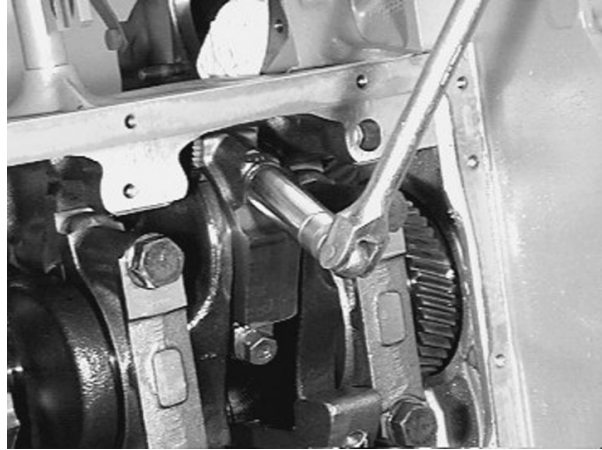


Fig. 2

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



Note:

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

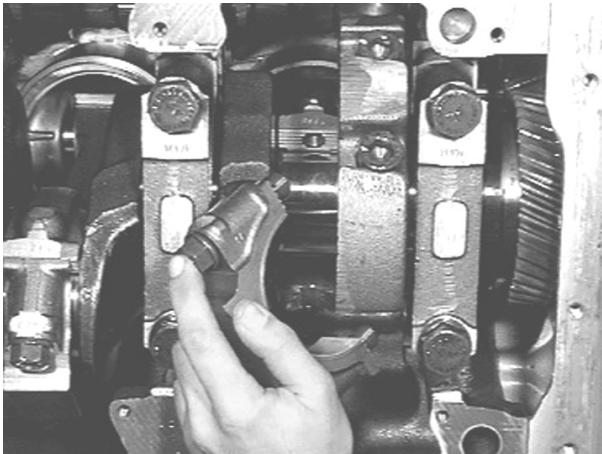


Fig. 3

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



Caution:

Do not damage cylinder liners.

Push out connecting rod with piston in upward direction.



Caution:

Do not damage oil spray nozzles.

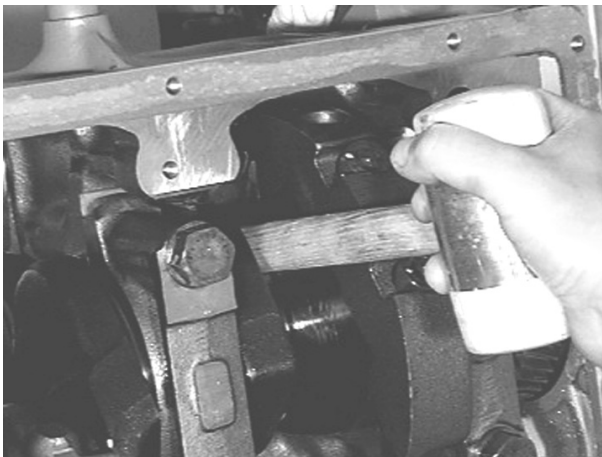


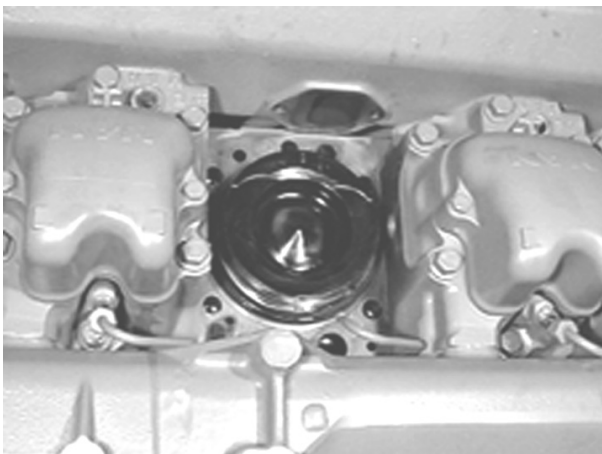
Fig. 4

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



Note:

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



Installing piston with connecting rod



Note:

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

Fig. 5

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

Fig. 6

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



Caution:

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

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

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.

Fig. 8

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



Caution:

Do not damage oil spray nozzles.



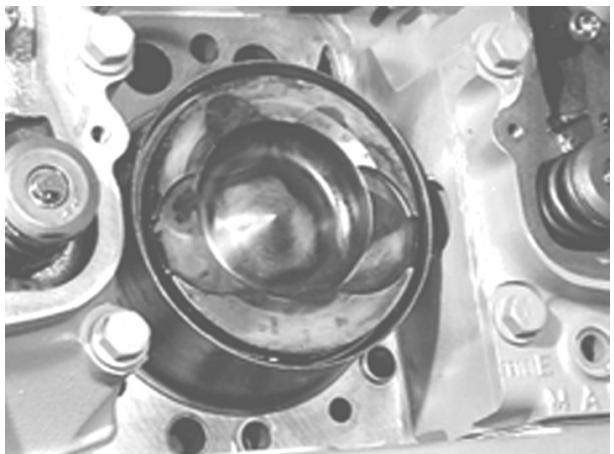
5



6



7



8

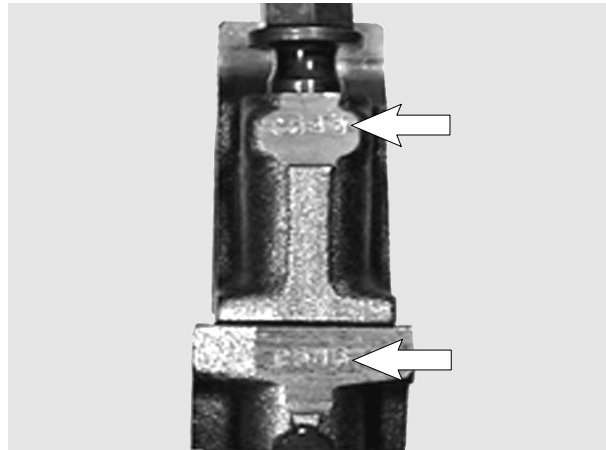
Fig. 9

Put connecting rod bearing caps in place.



Caution:

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



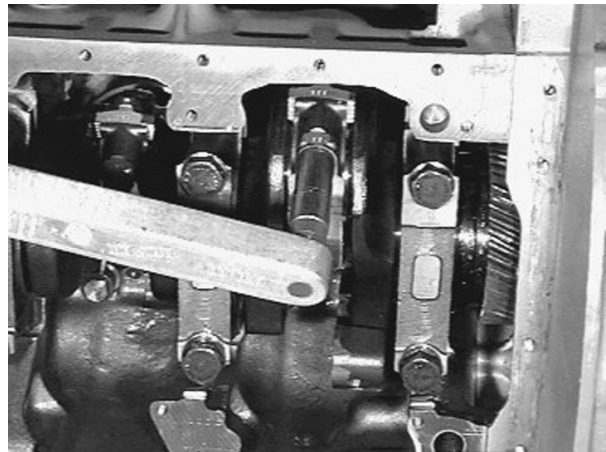
9

Fig. 10

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

Tighten finally by angle.

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



10

Fig. 11

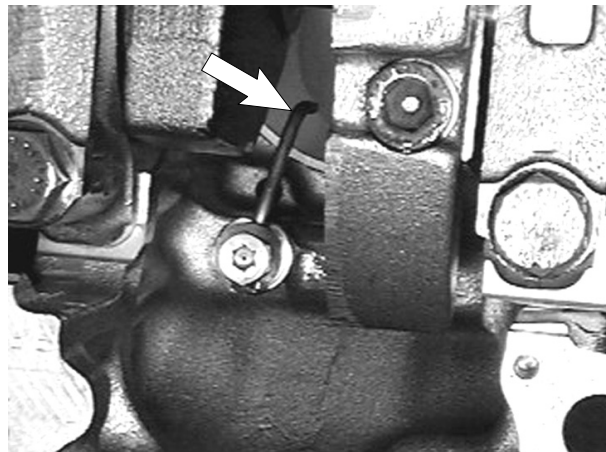
Slowly turn engine over.

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.



11

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.

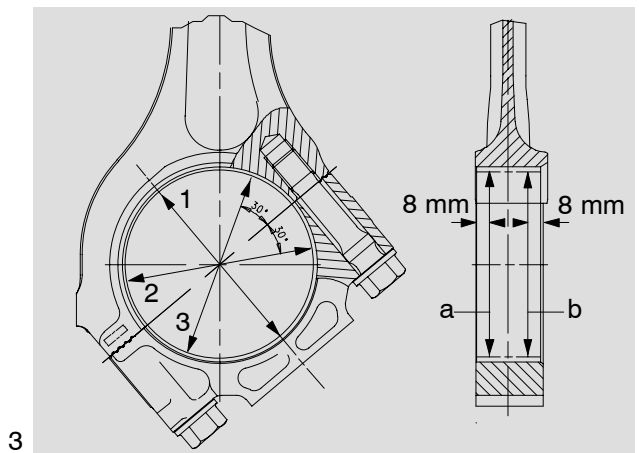


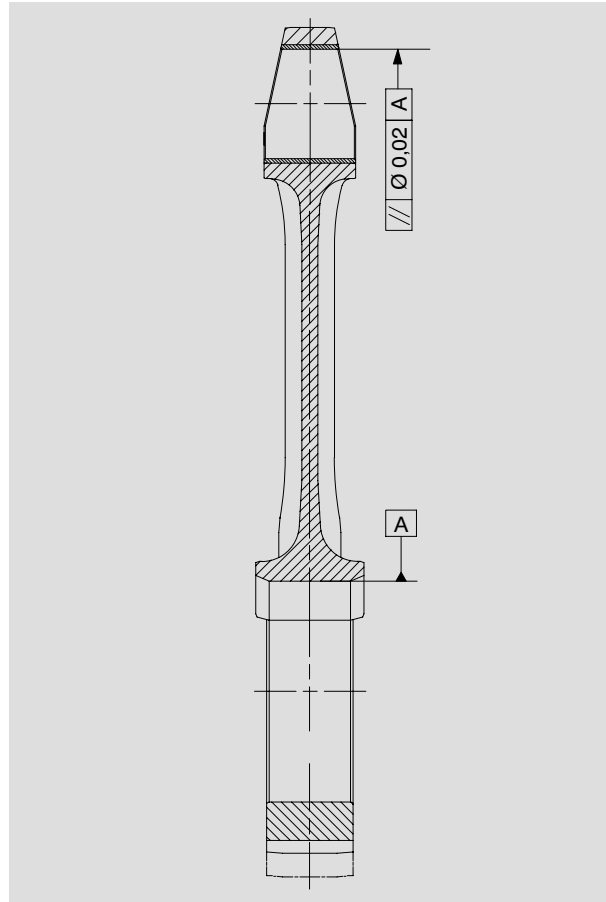
Fig. 4

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.



5

Fig. 6

Fit piston to connecting rod.



Caution:

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

Insert gudgeon pin. Fit circlips.
Install piston, see page 117.

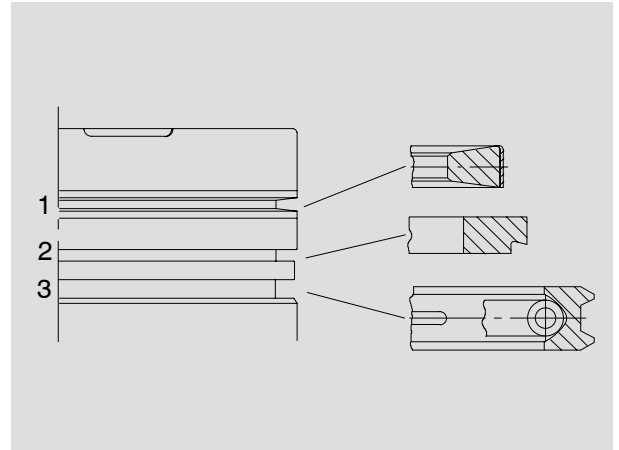


6

Piston ring arrangement

Fig. 1

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

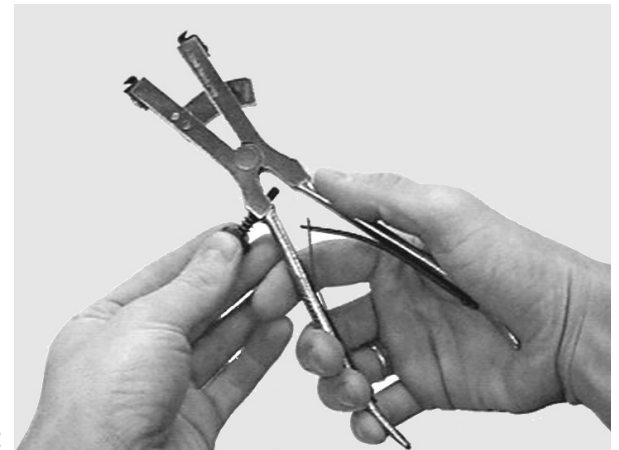


1

Removing piston rings

Fig. 2

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



2

Fig. 3

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



Note:

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

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



3

Checking ring gap

Fig. 4

Insert piston rings singly into the cylinder and ascertain the ring gap using a feeler gauge.
Replace piston rings if the ring gap is too large.
For ring gap see "Engineering • Data • Setting values".

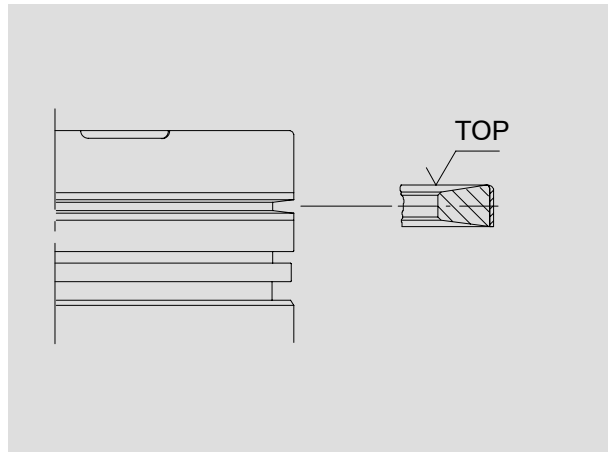


4

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
- Remove piston

Fig. 1

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

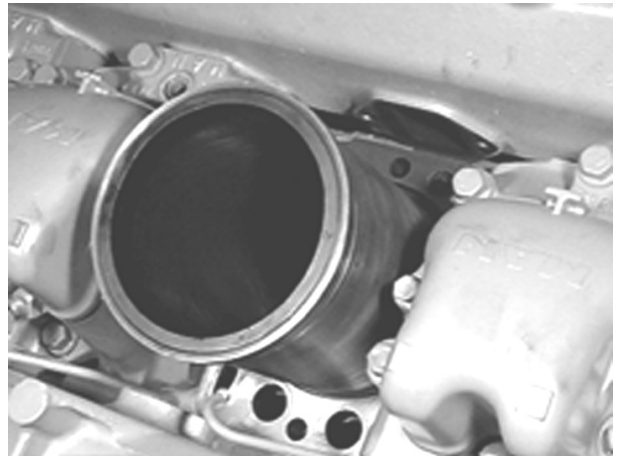
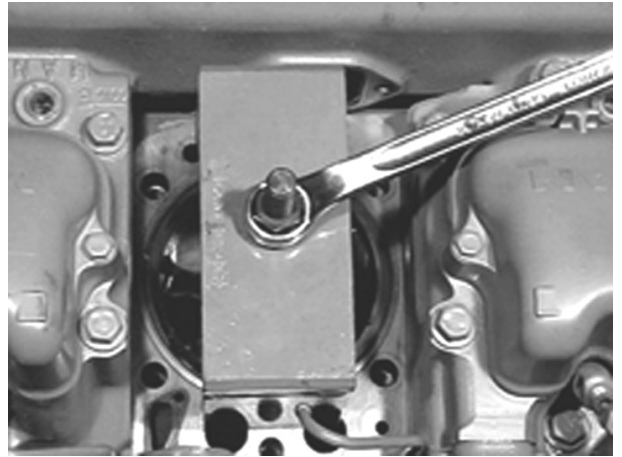
Put support on extractor spindle and tighten nut. Hold extractor spindle in place and extract cylinder liner by turning nut.

Fig. 2

Take off extractor device and take out cylinder liner.

Fig. 3

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

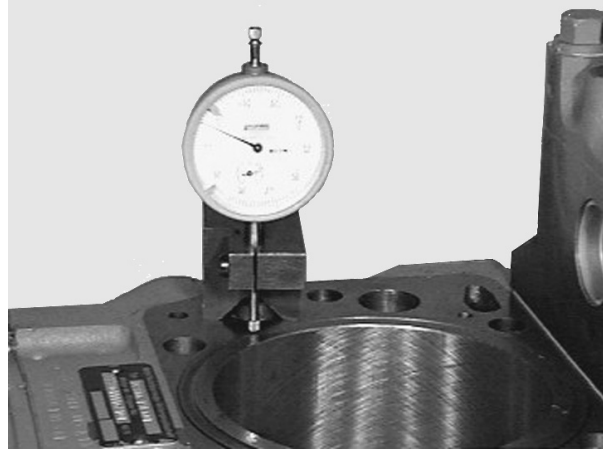


Installing cylinder liners

Checking cylinder liner protrusion

Fig. 4

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



4

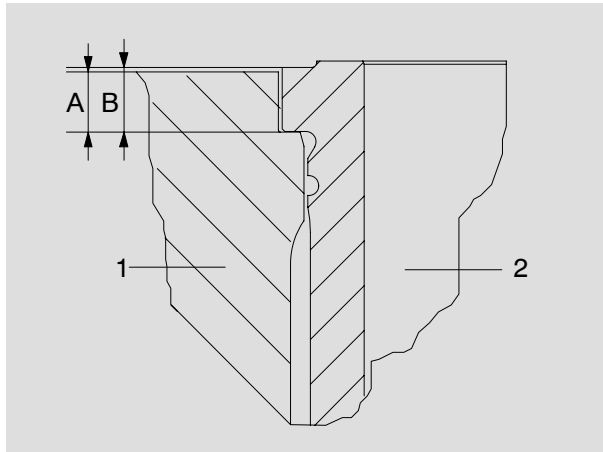


Note:

If available, use measuring plate for the measurement (special tool, see page 144).

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

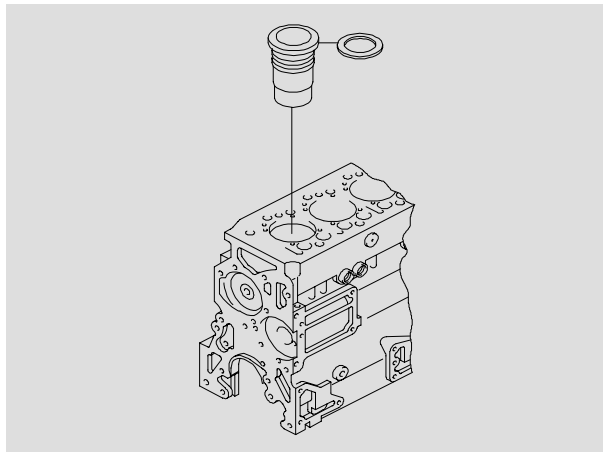
Fig. 5

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



6

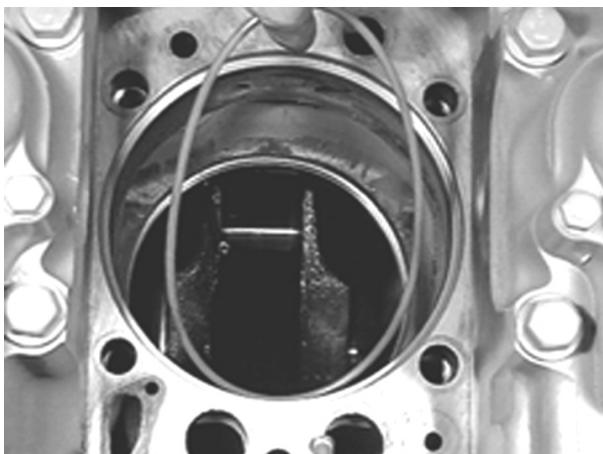
Fig. 6

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.

Fig. 7

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



7

Fig. 8

Insert new O-rings for the upper seal (138x2) into the grooves on the cylinder liner.
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.



8

Fig. 9

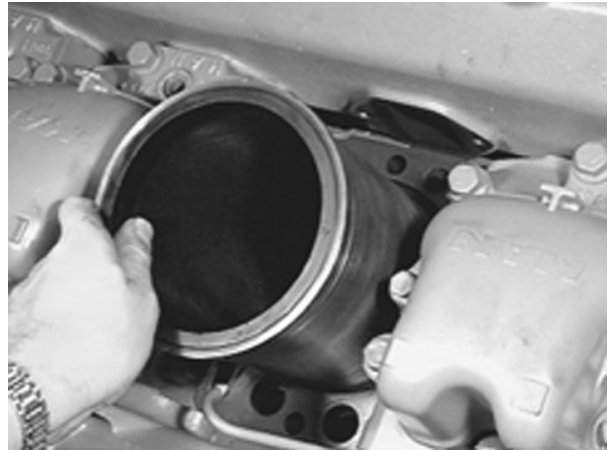
Apply thin coat of engine oil to cylinder liner in the area of the upper and lower O-ring.
Apply thin coat of engine oil to lower O-rings in the crankcase.

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.



9



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 144) 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.

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.



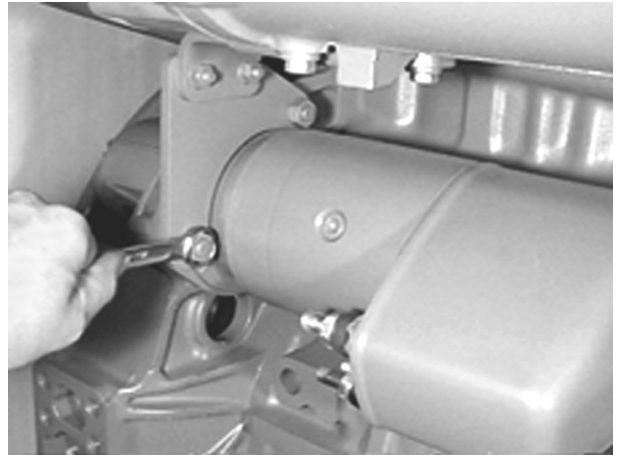
Fig. 1

Disconnect minus cable from battery or switch off battery main switch if fitted.
 Disconnect cable from terminal 31 (minus terminal, thick cable), terminal 30 (plus terminal, thick cable) and terminal 50 from starter.
 Remove mounting nuts (19 mm).



Note:

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

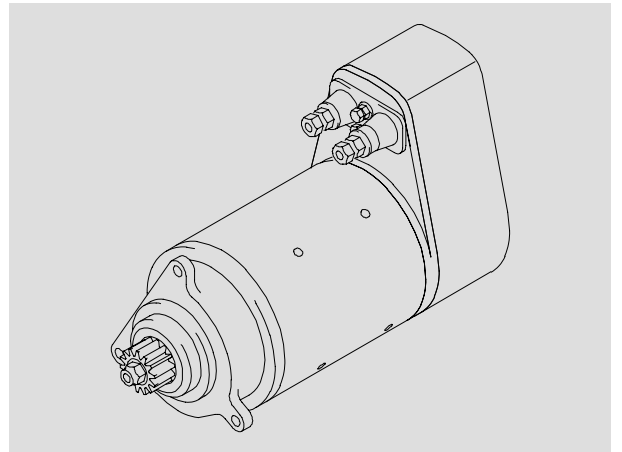


1

Fig. 2

Take off starter.

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



2

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 65.

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

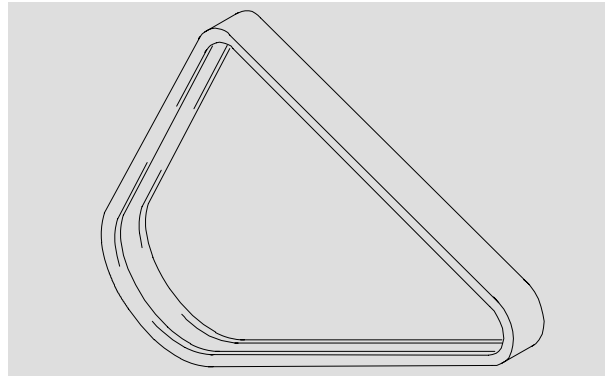
Connect up battery or switch on battery main switch.

After installation check starter to see that it works properly.

Checking condition

Fig. 1

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



1

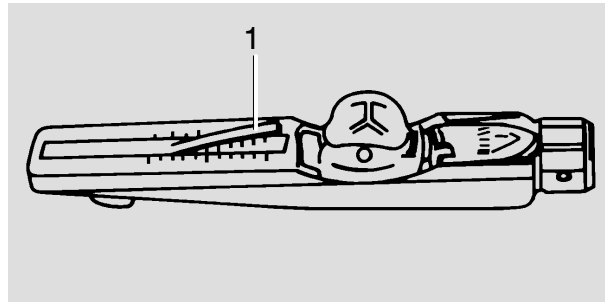
Checking tension

Figs. 2 and 3

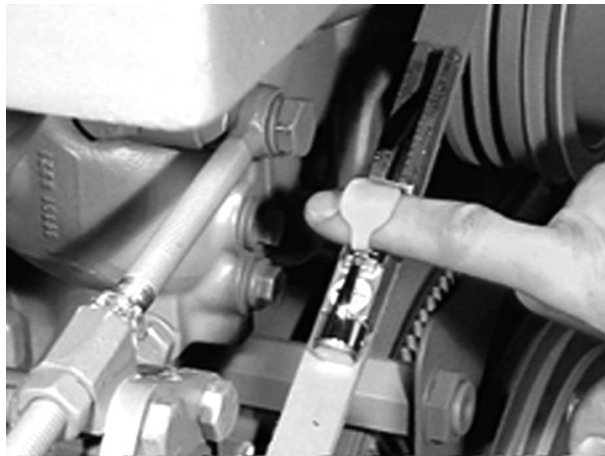
Use belt tension indicator to check V-belt tension.

- Lower the gauge arm ① in the scale.
- Position the tension indicator 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.



2



3

Fig. 4

Taking tension reading

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

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

V-belt width	Tensioning forces as per kg scale on the indicator		
	for newly fitted assembly		for maintenance after prolonged periods of operation
	after assembly	after a running time of 10 min.	
B 12,5	50-55	45-50	35
C 13	50-55	40-45	35
2/3VX	90-100	70-80	60

4

Tensioning V-belts

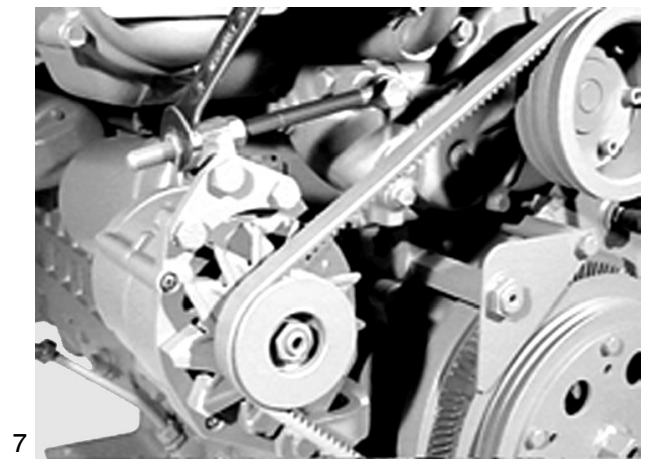
Figs. 5 and 6

Remove the mounting bolts from both the alternator and the tensioning device.



Fig. 7

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



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.

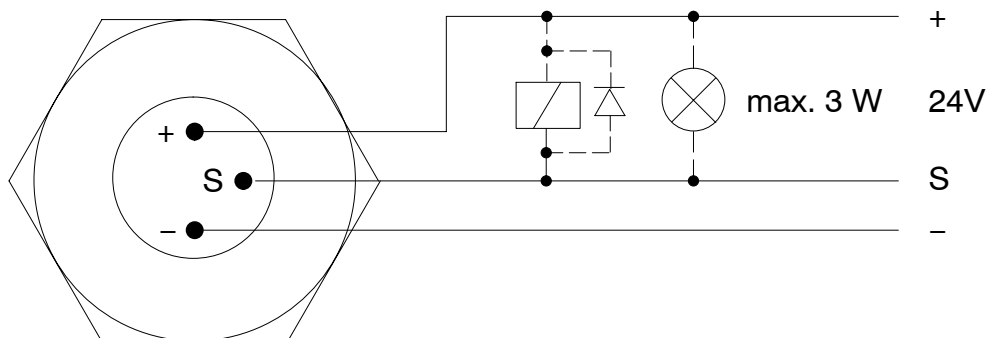
It is not possible to carry out a functional check by measuring the resistance (ohmmeter) because of the internal transistors.

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

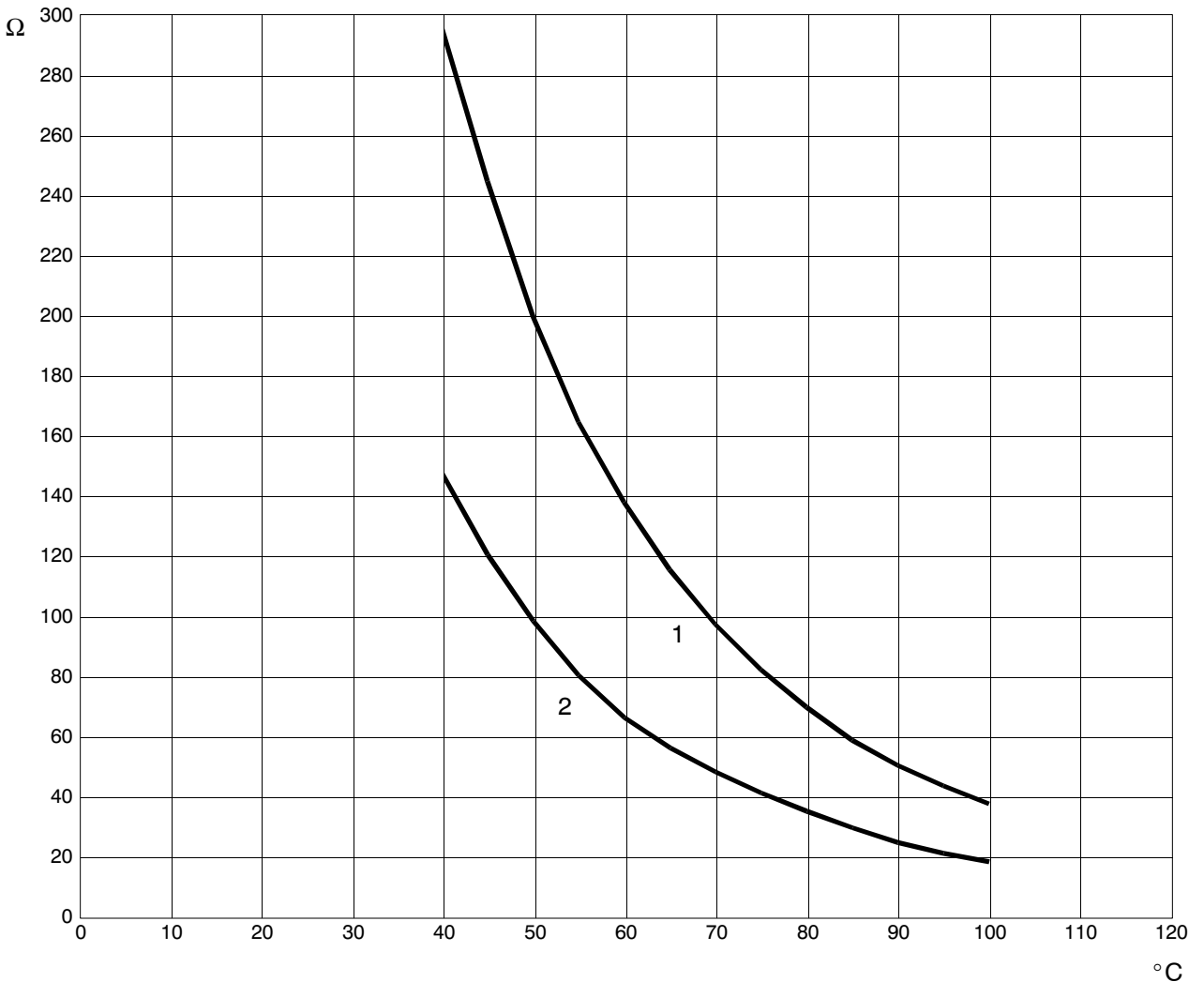
Dip the probe into the water and apply a supply voltage of 24 V to the plus and minus leads. The output "S" is to be connected to the plus lead via the test lamp. The test lamp does not come on.

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.



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

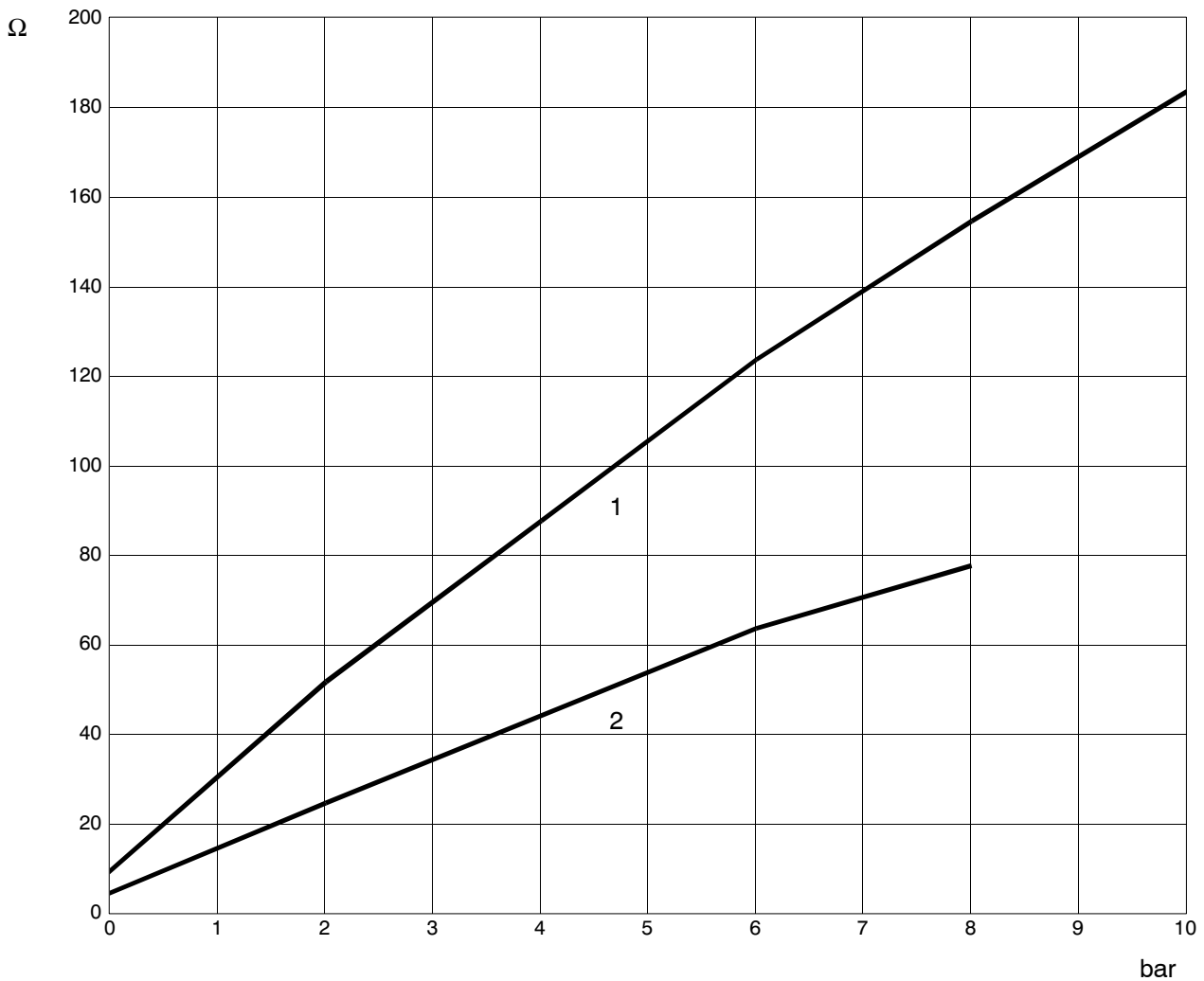
Temperature transmitter for 1 electrical instrument: checking values and tolerance of transmitter resistance

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

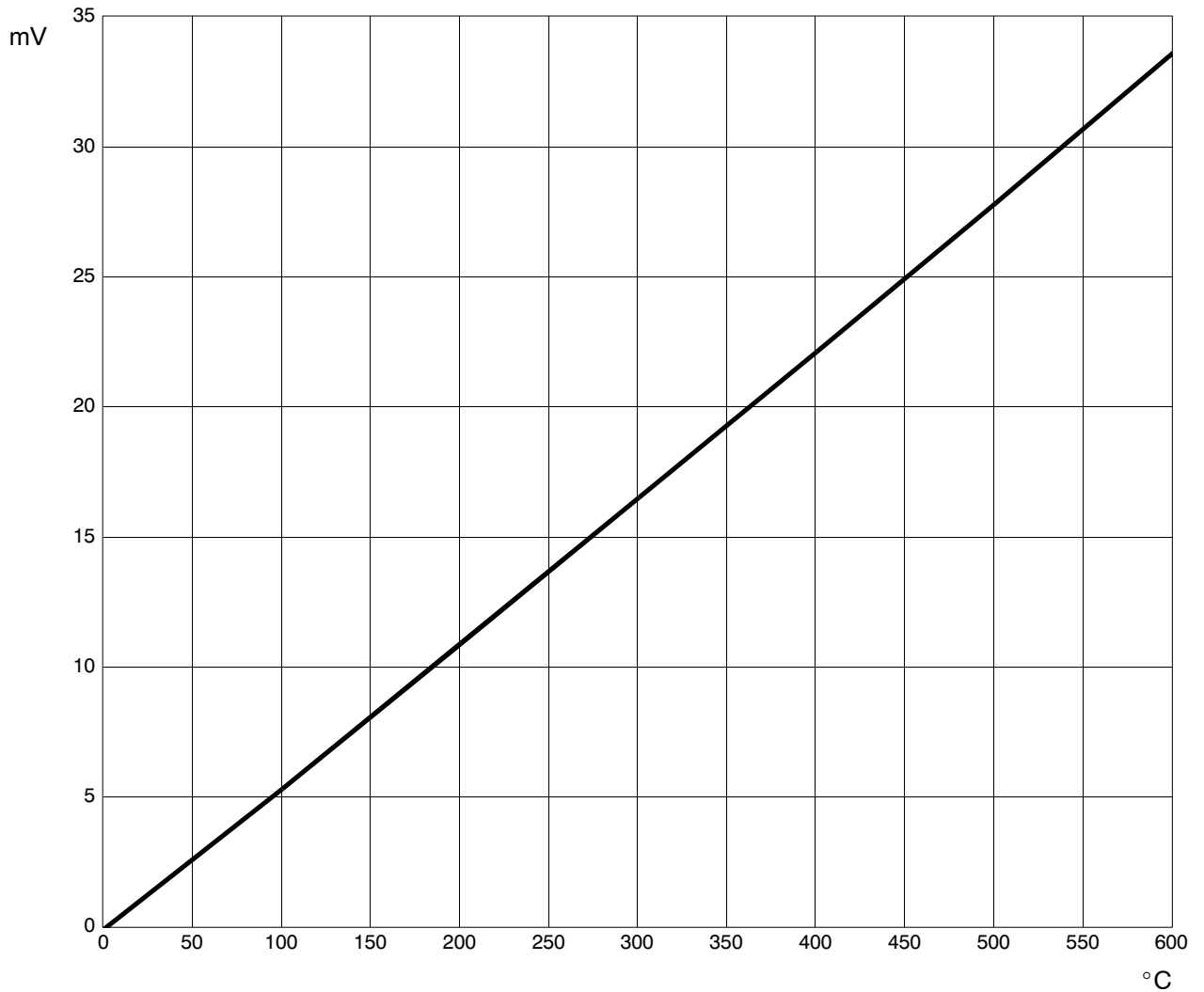
Pressure transmitter for 1 electrical instrument: checking values and tolerance of transmitter resistance

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

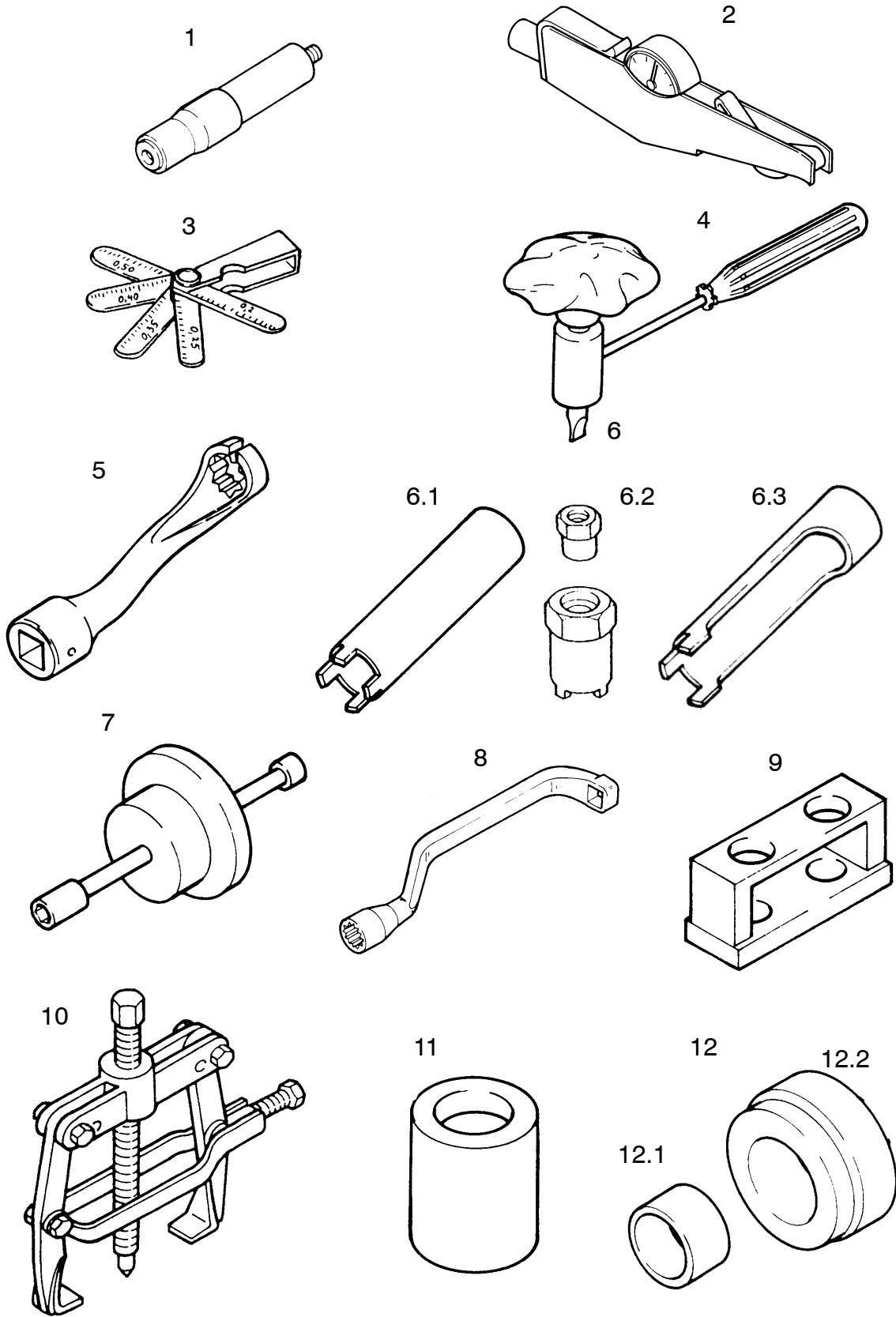


Fig. no.	Designation	Item number
1	Test connection for compression recorder	80.99607-0002
2	V-belt tension indicator	81.66814-6001
3	Valve gauge	80.99607-0076
4	Valve setting spanner	83.09195-0002
5	Spanner for nuts on injection lines (17 mm)	80.99603-0025
6	Socket spanner set for fuel injector	
6.2	4-groove	80.99603-0049
6.3	4-groove with fixing screw	80.99603-0121
6.4	open, 3-groove	80.99603-0038
7	Inertia puller for fuel injector	80.99602-0011
8	Special wrench for cylinder head bolt under fuel injector	80.99603-0095
9	Clamping device for fuel injectors	80.99606-0008
10	Puller for water pump pulley	80.99601-0037
11	Pressing mandrel for cassette seal in conjunction with handle 14.1	80.99617-0091
12	Driving mandrel for seal in timing case consisting of:	
12.1	Guide sleeve	80.99604-0068
12.2	Pressing plate in conjunction with handle 14.1	80.99604-0069

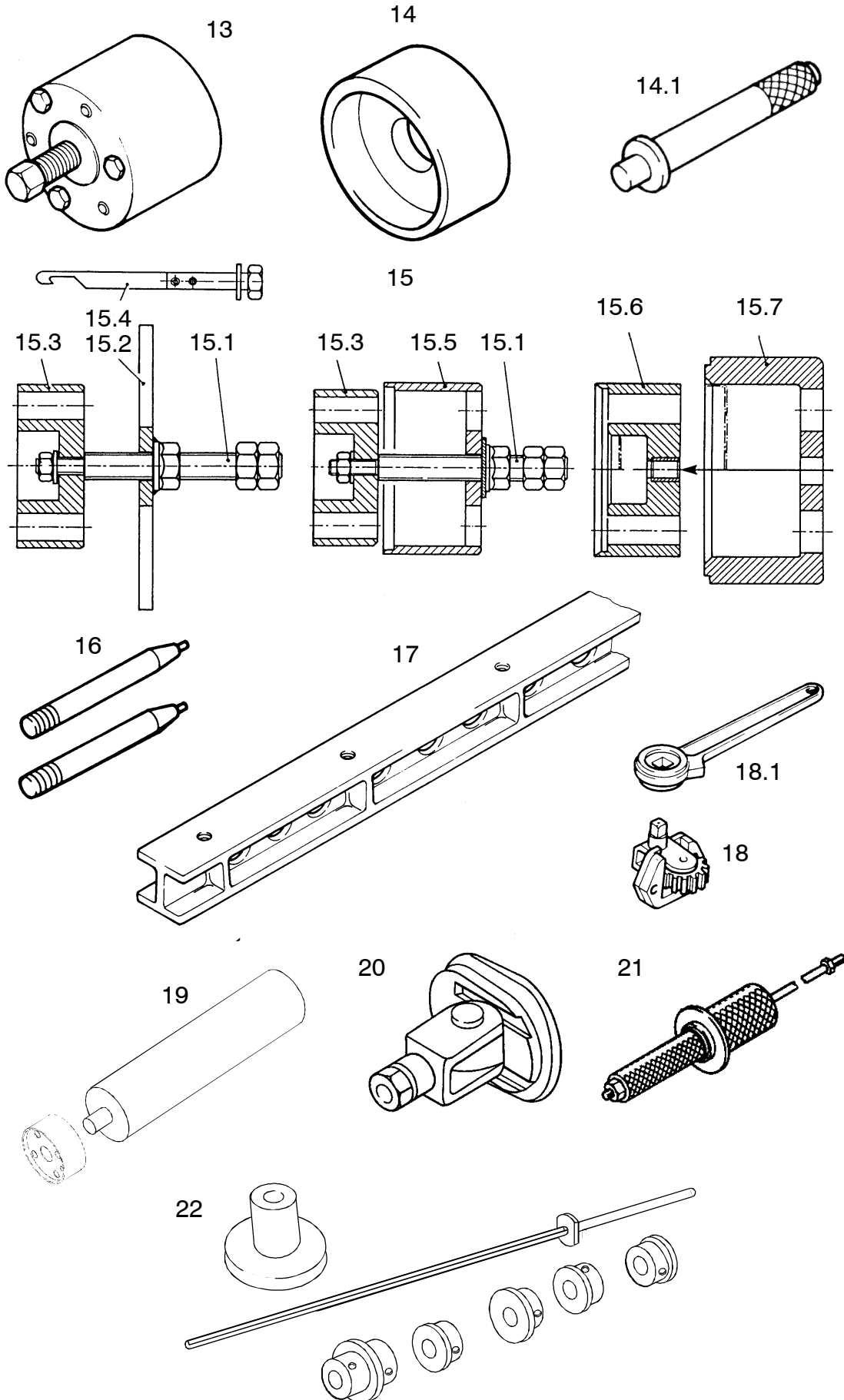


Fig. no.	Designation	Item number
13	Puller for front crankshaft bearing race	80.99601-0076
14	Pressing tool for bearing race on flywheel in conjunction with handle 14.1	80.99617-0017
14.1	Handle	80.99617-0129
15	Special tools for front crankshaft seal	80.99606-6011
	Components:	
15.1	Spindle	80.99606-0229
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	80.99607-0044
18	Engine turning device	80.99626-0004
18.1	Standard ratchet for 18	80.99627-0001
19	Guide mandrel for camshaft	80.99617-6007
20	Pulling tool for front and rear camshaft bearing bushes in conjunction with:	80.99606-6103
21	Impact puller	80.99602-0016
22	Fitting tool for camshaft bearing bushes	80.99606-6099

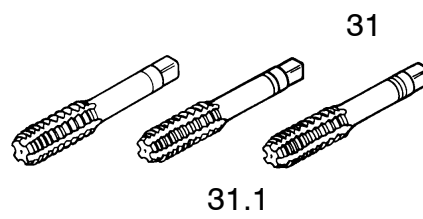
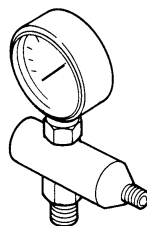
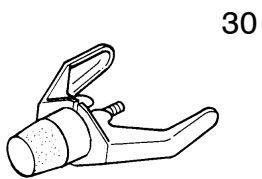
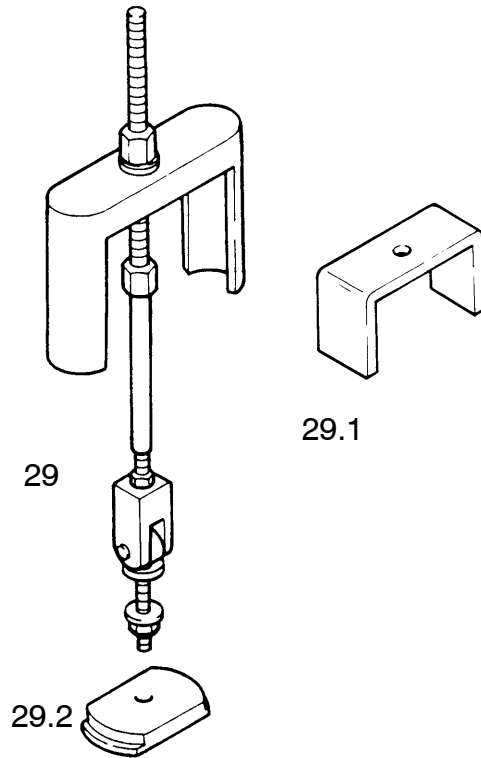
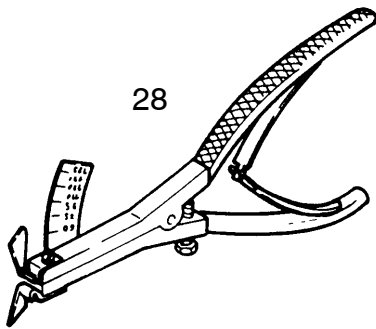
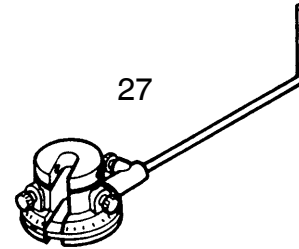
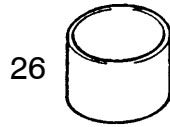
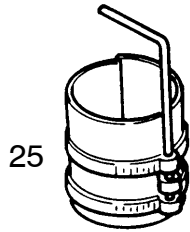
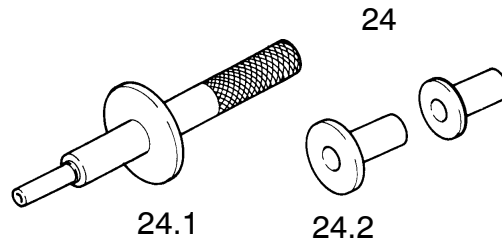
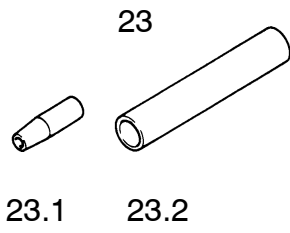


Fig. no.	Designation	Item number
23	Sleeves for valve stem seal	
23.1	Insert sleeve for valve stem seal	80.99616-0004
23.2	Pressing sleeve for valve stem seal	80.99604-0005
204	Pressing tool for valve guide	
24.1	Pressing mandrel for valve guide	80.99617-0013
24.2	Pressing rings in conjunction with 20.1	80.99616-0003
25	Piston ring tightener	80.99613-0035
26	Piston ring tightening sleeve	83.09144-0187
27	Tightening angle gauge	80.99605-0010
28	Piston ring pliers	83.09144-6090
29	Cylinder liner extractor device	80.99602-0019
29.1	Support for 25	80.99623-0003
29.2	Extractor plate	83.09143-0195
30	Cooling system test unit	80.99607-0061
31	Thread-cutting tool	
31.1	Thread drill set, M15 x 2, for cylinder head bolt threads	80.40001-0001
31.2	Associated die ring	80.43001-0001

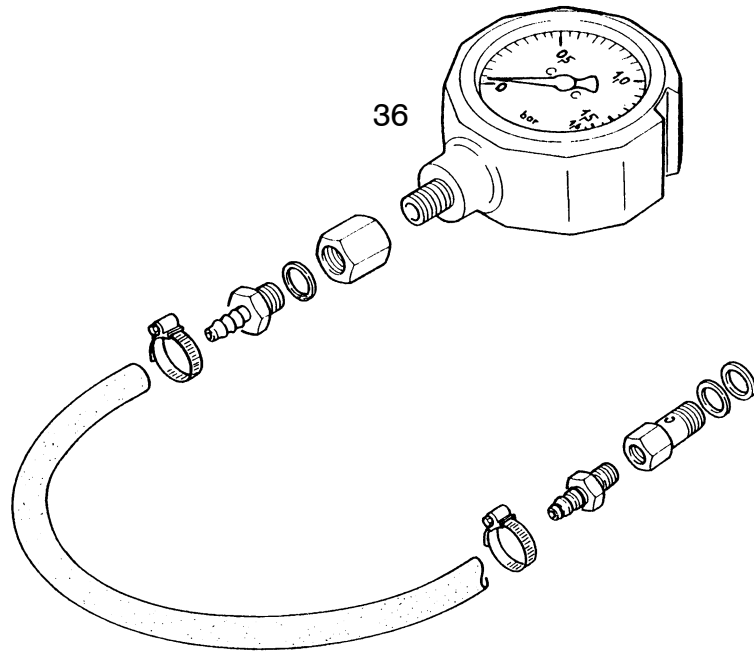
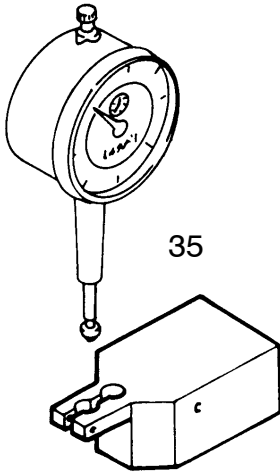
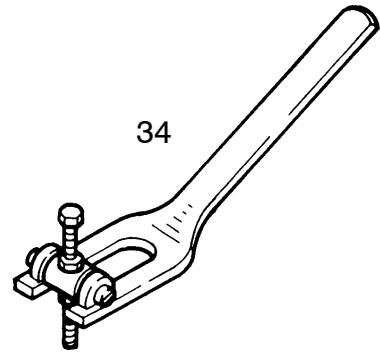
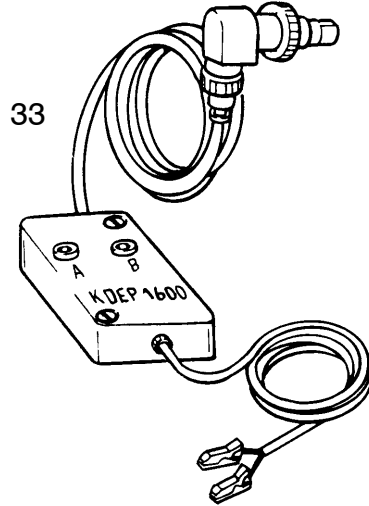
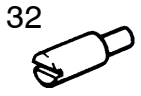


Fig. no.	Designation	Item number
32	Blocking pin	80.99605-0217
33	Light signal transmitter	80.99605-6002
34	Valve assembly lever	80.99606-0031
35	Dial gauge holder for measuring valve retrusion and piston protrusion	90.99605-0172
36	Pressure gauge + accessories for charge-air pressure measurement	80.99605-0160

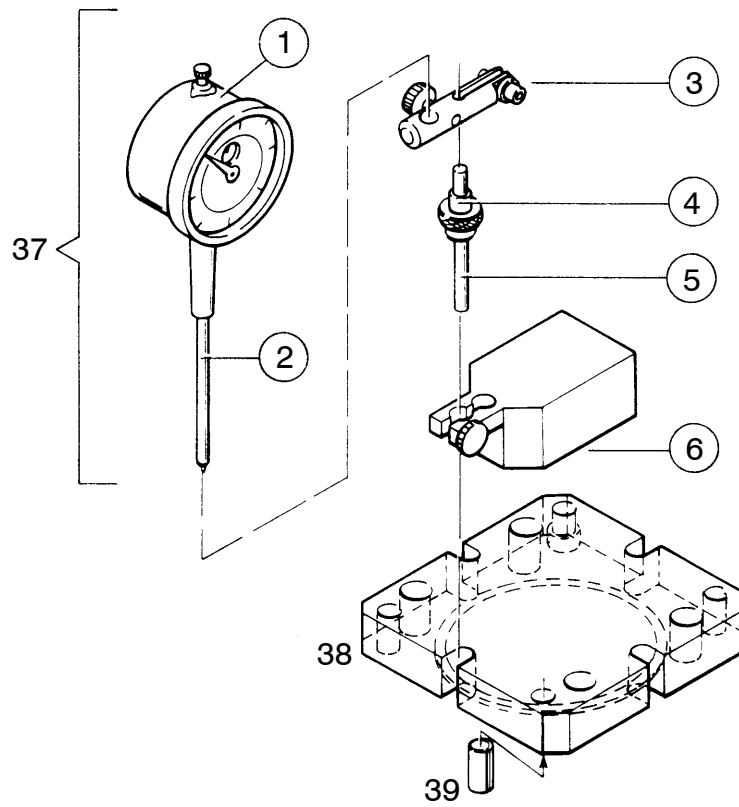
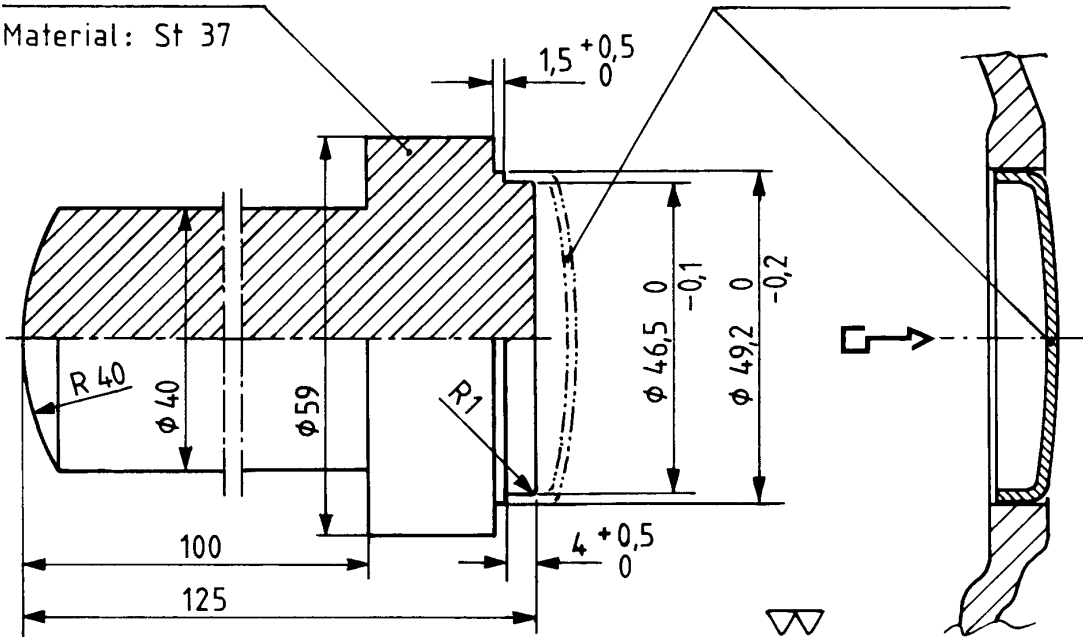


Fig. no.	Designation	Item number
37	Measuring combination, consisting of:	
(1)	Dial gauge	08.71000-1205
(2)	Tracer pin for dial gauge	80.99605-0197
(3)	Dial gauge holder	80.99605-0179
(4)	Contact pin	80.99605-0180
(5)	Dial gauge holder	80.99605-6006
(6)	Dial gauge holder	80.99605-0172
38	Press-on measuring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

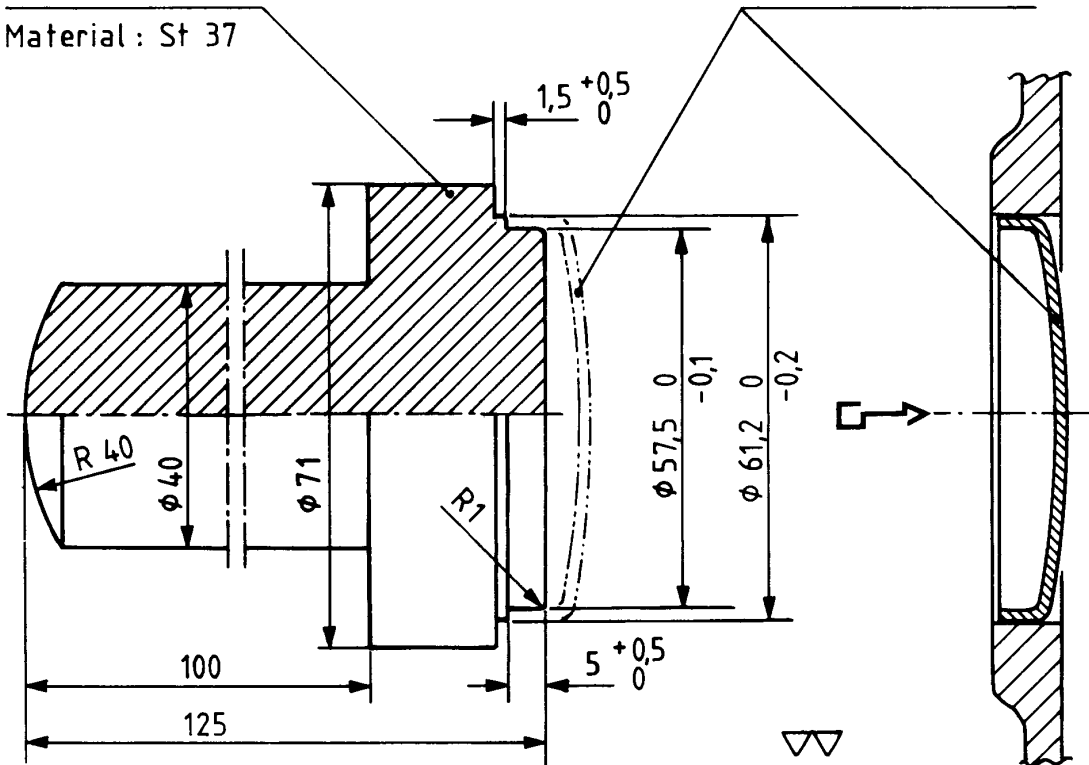
Pressing mandrel for cap, dia. 50.1 mm

Material: St 37



Pressing mandrel for cap, dia. 62.1 mm

Material: St 37

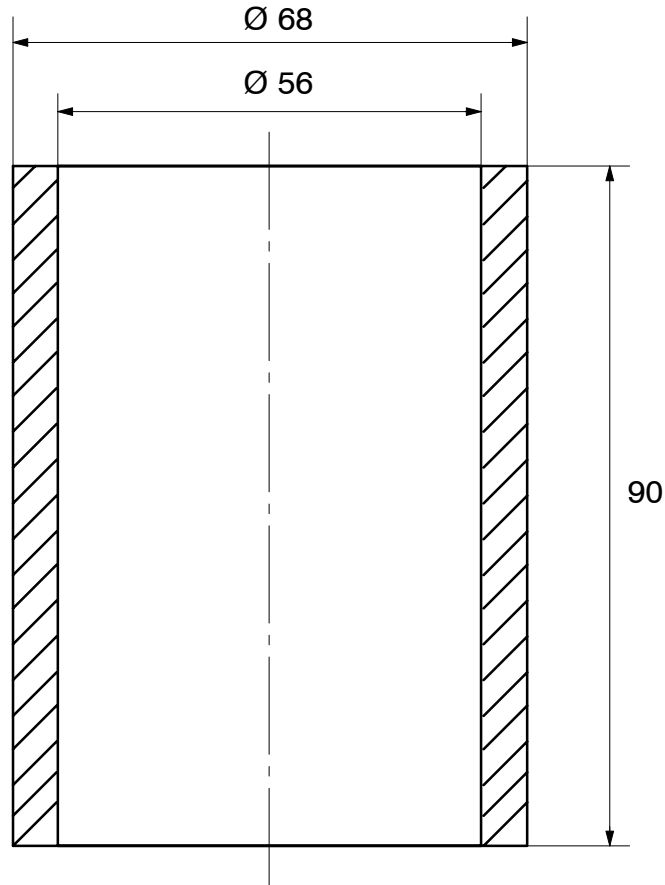


2843

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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