

# Workshop Manual

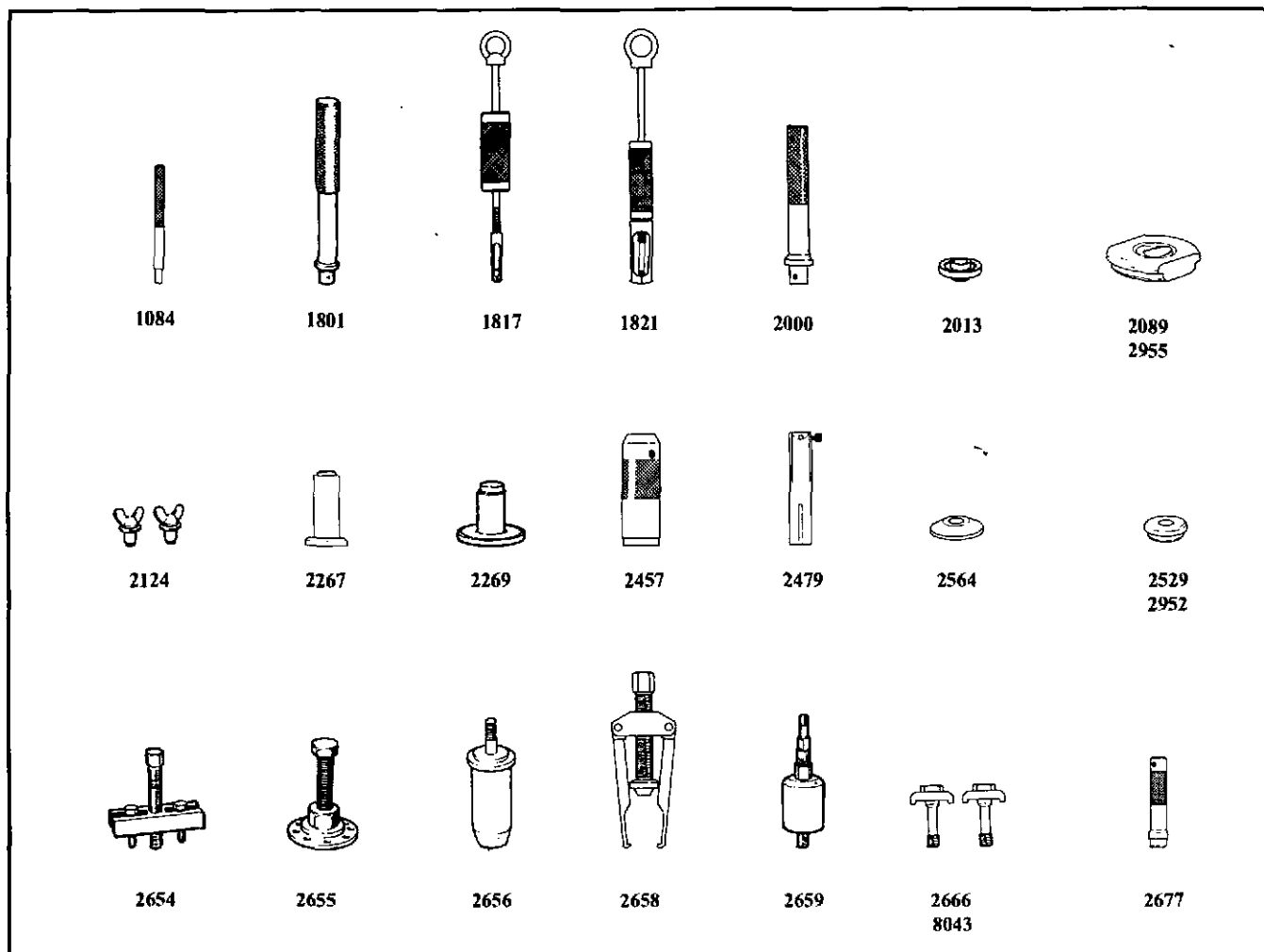
TAD1030G/P, TWD1030ME  
TWD1210G/P, TWD1211G/P, TAD1230G/P, TWD1230ME

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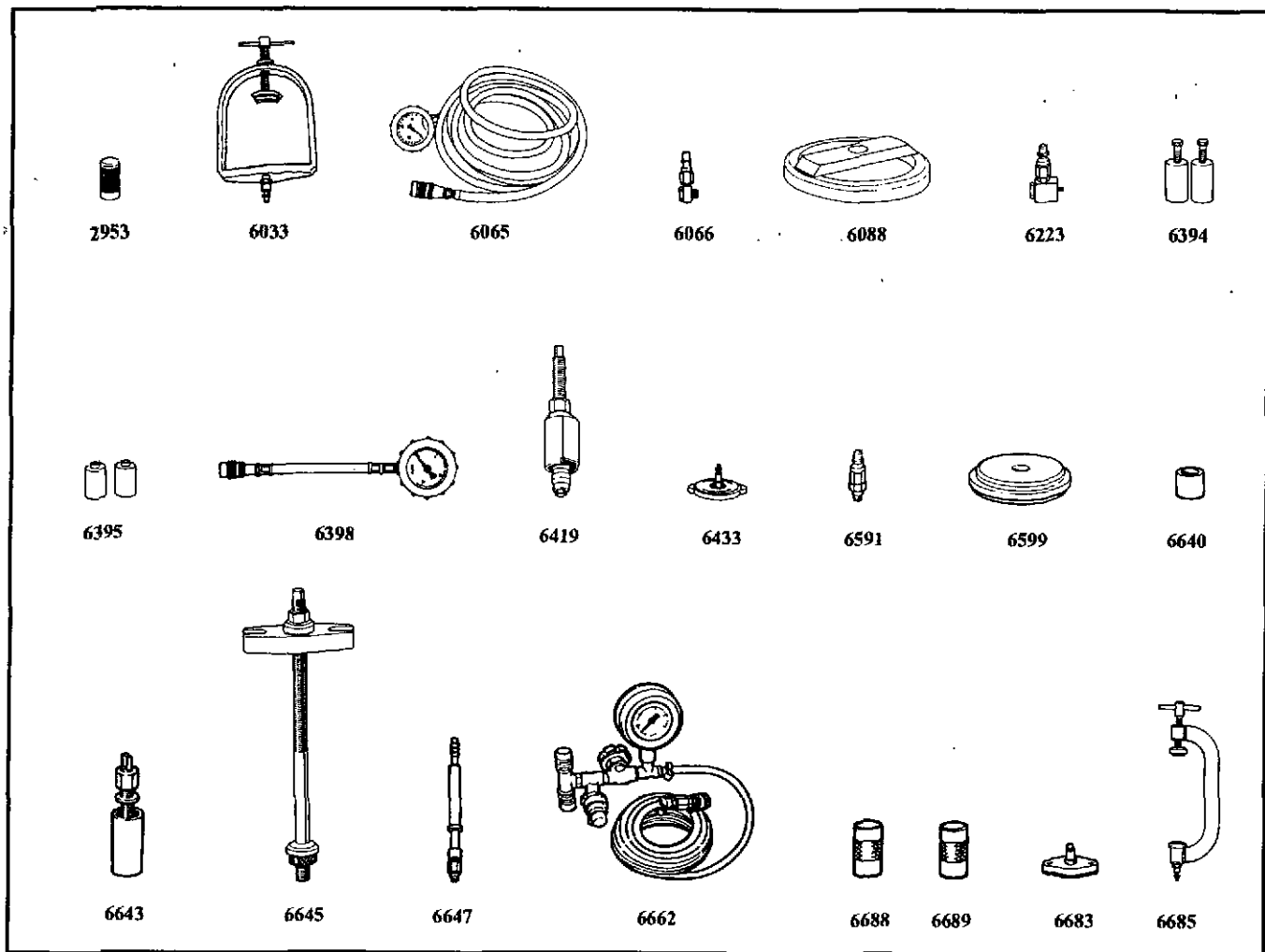
# Tools

## Special tools

When ordering tools the digits 999 shall be placed in front of the 4-digit tool numbers (e.g. 999 1084).

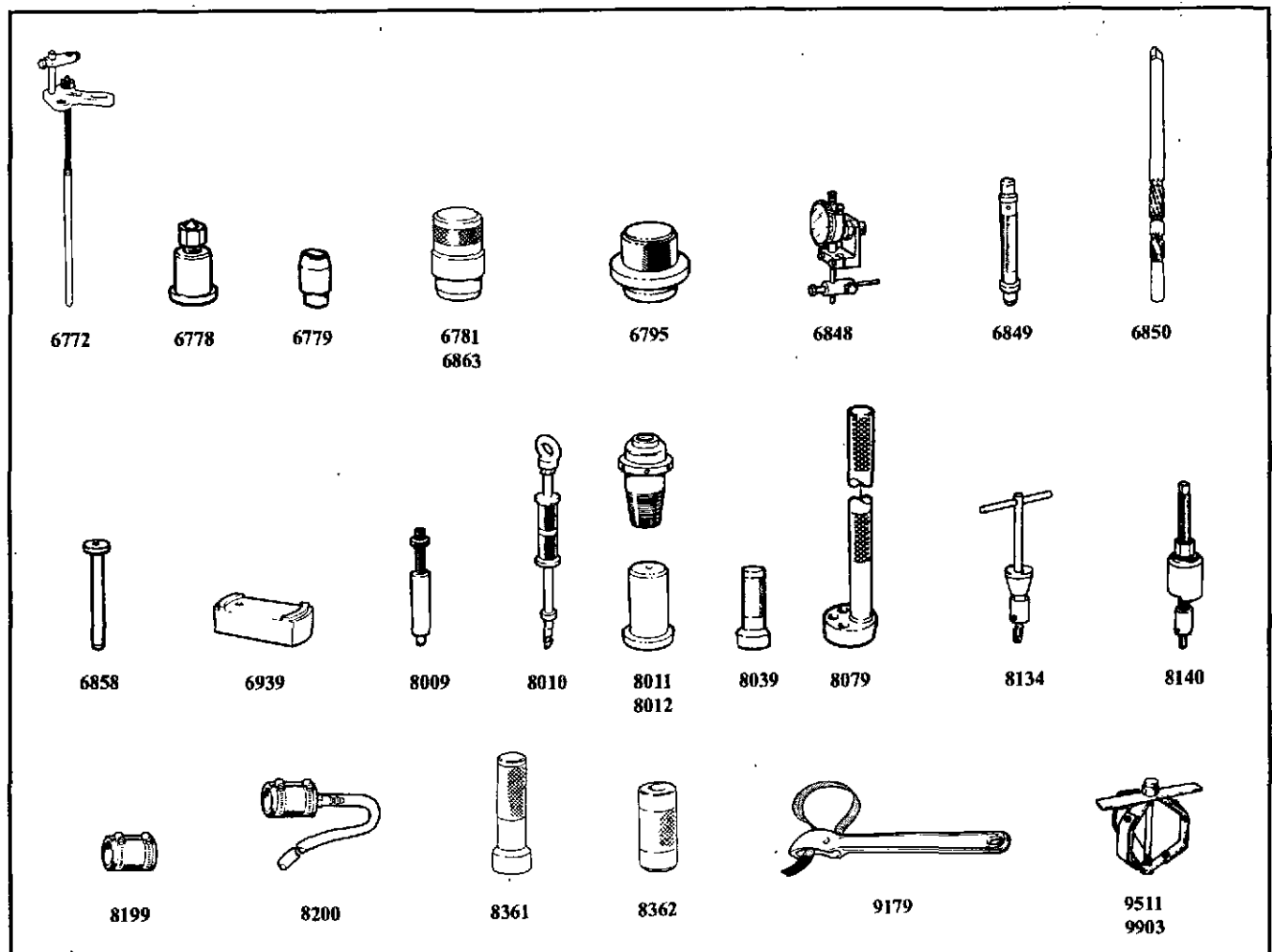


- |               |   |               |  |
|---------------|---|---------------|--|
| <b>1084-6</b> | Drift for removing valve guides   | <b>2457-3</b> | Drift for overhauling coolant pump   |
| <b>1801-3</b> | Standard handle 18 x 200 mm   | <b>2479-7</b> | Holder for dial test indicator when checking height of liner collar above the block plane                                    |
| <b>1817-9</b> | Extractor for overhauling coolant pump  | <b>2564-6</b> | Drift for flywheel bearing   |
| <b>1821-1</b> | Extractor for flywheel bearing  | <b>2529-9</b> | Drift for removing and fitting of connecting rod bushing, 10 resp. 12 ltr engines  |
| <b>2000-1</b> | Standard handle 25 x 200 mm   | <b>2952-3</b> | Extractor for oil pump drive gear  |
| <b>2013-4</b> | Drift for removing and fitting piston journal, used with 1801   | <b>2654-5</b> | Extractor for polygon hub on crankshaft  |
| <b>2089-4</b> | Extractor plate for cylinder liner, 10 ltr resp. 12 ltr engines, used with 6645                             | <b>2655-2</b> | Extractor for polygon hub on crankshaft  |
| <b>2955-6</b> | Extractor plate for cylinder liner, 10 ltr resp. 12 ltr engines, used with 6645                             | <b>2656-0</b> | Fitting tool for polygon hub on crankshaft   |
| <b>2124-9</b> | Expander plug (2 pcs) for pressure testing of cylinder head   | <b>2658-6</b> | Puller for crankshaft gear   |
| <b>2267-6</b> | Drift for fitting bearings, injection pump drive device. Counterforce when pressing out rocker arm bushing. | <b>2659-4</b> | Press tool for fitting crankshaft gear   |
| <b>2269-2</b> | Drift for fitting flywheel bearing (stationary engines)   | <b>2666-9</b> | Press tool (min. 2 pcs) for cylinder liner when measuring height of liner collar above block plane, 10 resp. 12 ltr engines. |
|               |   | <b>8043-5</b> | Press tool (min. 2 pcs) for cylinder liner when measuring height of liner collar above block plane, 10 resp. 12 ltr engines. |
|               |   | <b>2677-6</b> | Drift for removing and fitting of rocker arm bushing   |



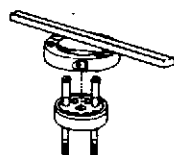
- 2953-1** Drift for fitting of valve guides, 12 ltr engines  
**6033-8** Pressure testing device, oil cooler  
**6065-0** Manometer with hose for checking of fuel's feed pressure alt. boost pressure of turbo. When checking feed pressure also use banjo nipple 6066  
**(Note! The same tool should not be used for checking both the feed pressure and boost pressure.)**  
**6066-8** Banjo nipple with quick coupling for connection to 6065  
**6088-2** Fitting tool for rear crankshaft seal  
**6223-5** Nipple for checking boost pressure (TAD)  
**6394-4** Supports (2 pcs) for liner extractor 6645  
**6395-1** Supports (2 pcs) for liner extractor 6645  
**6398-5** Manometer for checking of lubrication pressure. Used with 6591  
**6419-9** Extractor for ring, copper sleeve  
**6433-0** Adapter used with 6662

- 6591-5** Connection nipple for checking of oil pressure alt. boost pressure (TWD).  
**(Note! The same tool should not be used for checking both the feed pressure and boost pressure.)**  
**6599-8** Plate for pressing in liners  
**6640-0** Drift, used together with puller 8011  
**6643-4** Extractor for injectors  
**6645-9** Extractor for liners, used with 6394 and 6695  
**6647-5** Flare tool for copper sleeve  
**6662-4** Pressure testing device for cooling system  
**6668-1** Drift for fitting of valve guides (inlet), 10 ltr engines  
**6669-9** Drift for fitting of valve guides (outlet), 10 ltr engines  
**6683-0** Connection washer for pressure testing of cylinder head, 12 ltr engines  
**6685-5** Clamp for pressure testing of cylinder head, 10 ltr engines

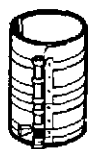


- 6772-1** Tools for checking of camshaft lifting height  
**6778-8** Tool for pressing in seal ring, injection pump drive  
**6779-6** Tool for extraction of seal ring for injection pump drive  
**6781-2** Drift for changing seal, sleeve thermostat, 10 ltr engines  
**6795-2** Drift for fitting of front crankshaft seal  
**6848-9** Fixture for checking of injection angle, used with 9989876  
**6849-7** Drift for removal and fitting of bushings in oil pump  
**6850-5** Reamer for bushings in oil pump  
**6858-8** Drift for overhauling coolant pump  
**6863-8** Drift for changing sleeve thermostat seal, 12 ltr engines  
**6939-6** Spacer for overhauling coolant pump

- 8009-6** Adapter for measurement of compression pressure  
**8010-4** Extractor for rear crankshaft seal  
**8011-2** Puller for seal ring, injection pump drive, used together with 6640  
**8012-0** Pressing tool for fitting seal ring, pump drive  
**8039-3** Drift for fitting of seal, coolant pump  
**8079-9** Tool for lifting camshaft in and out  
**8134-2** Thread cutting tool for extraction of copper sleeve. Used with 8140  
**8140-9** Extractor for copper sleeve  
**8199-5** Seal for leakage test, oil cooler  
**8200-1** Connection for leakage test, oil cooler  
**8361-1** Drift for overhauling coolant pump  
**8362-9** Drift for overhauling coolant pump  
**9179-6** Tool for removing fuel- and oil filters  
**9511-0** Expander for turning of cylinder liner, 10 resp. 12 ltr engines  
**9903-9**



9531

9551  
9902884969  
884971

885126



9812546



885231



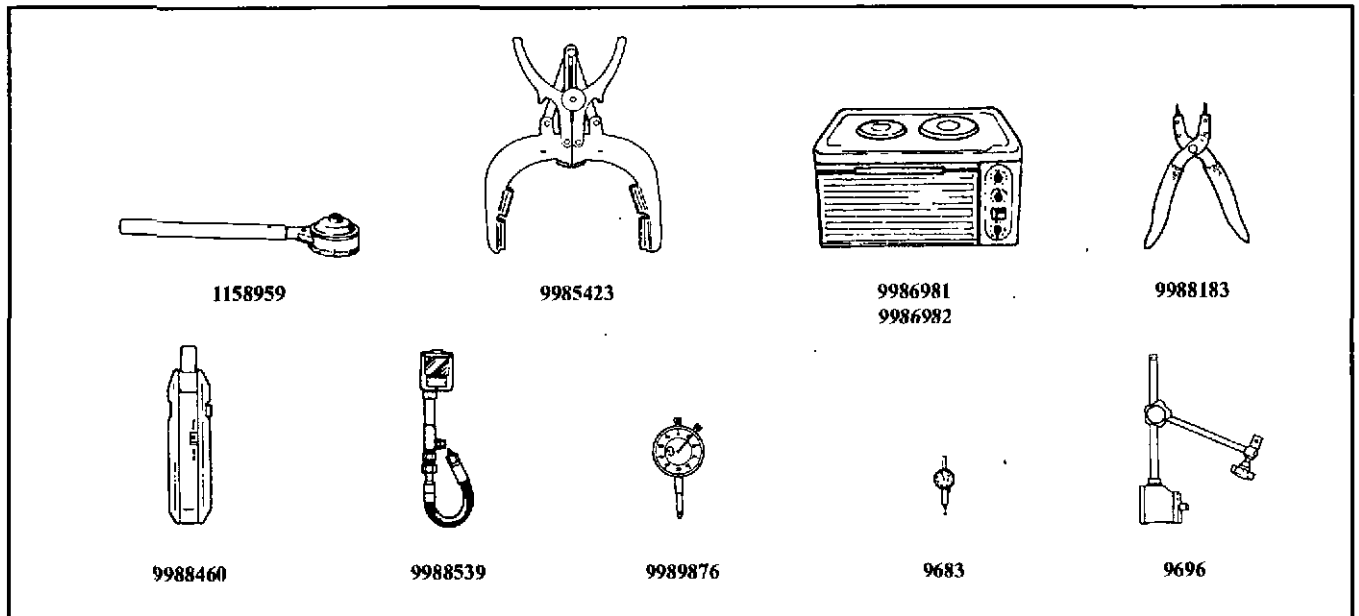
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- 9531-8** Milling tool for sealing groove in cylinder head, 12 ltr engines  
**9551-6** Milling tool for renovating liner recess, 10 resp. 12 ltr engines  
**9902-1** Milling tool for renovating liner recess, 10 resp. 12 ltr engines  
**884 971-3** Flange kit for measuring counter pressure in exhaust system, 10 lit resp. 12 ltr engines  
**884 969-7** Flange kit for measuring counter pressure in exhaust system, 10 lit resp. 12 ltr engines

- 885 126-3** Piston ring compressor  
**885 231-1** Connection washer for leakage check, charge air cooler (TAD-engines)  
**885 232-9** Sealing washer for leakage check, charge air cooler (TAD-engines)  
**981 2546-1** Brush for cleaning of copper sleeve bottom and for sealing surface between copper sleeve and cylinder head

## Other special equipment

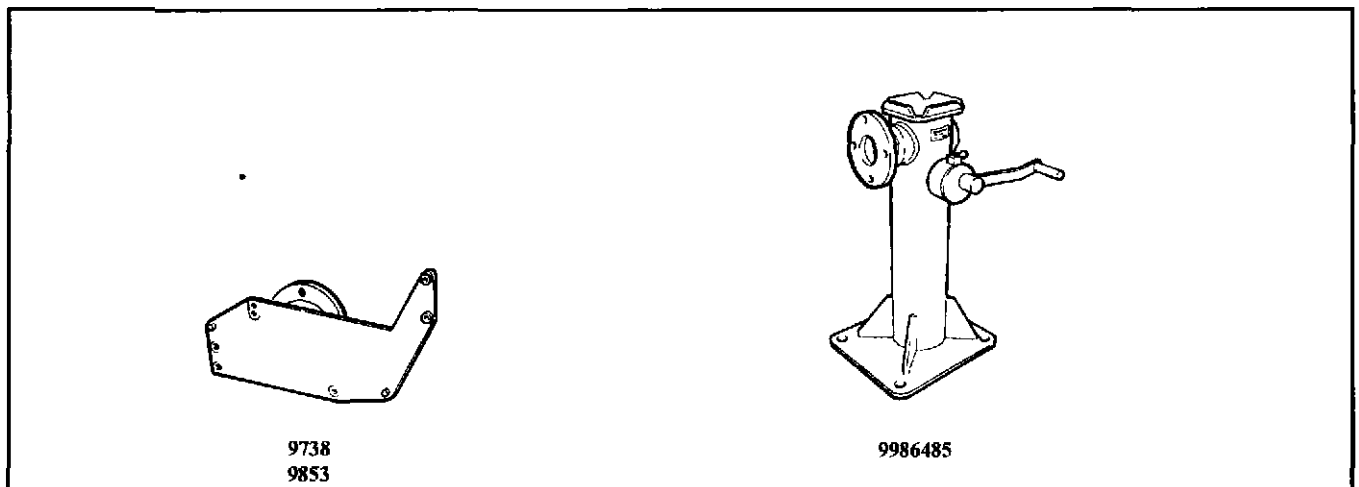
Like the preceding special tools the following are available to order from AB Volvo Penta specifying the appropriate Part number.



- 115 8959-5** Torque multiplier, ratio 1:4
- 998 5423-4** Piston ring tool
- 998 6981-0** Oven 220 V
- 998 6982-8** Oven 380 V
- 998 8183-1** Circlip pliers
- 998 8460-3** Tachometer
- 998 8539-4** Compression tester
- 998 9876-9** Dial indicator
- 999 9683-7** Dial indicator
- 999 9696-9** Magnetic stand for dial indicator

### Spare parts and accessories for special tools

- 9501-1** Milling tool for tool 9531
- 9532-6** Cutting tool with holder for tool 9531
- 9693-6** Card for compression tester 9988539
- 9904-7** Milling tool for tool 9902



- 9738-9** Fixture for engine block, 10 resp.
- 9853-6** 12 ltr engines

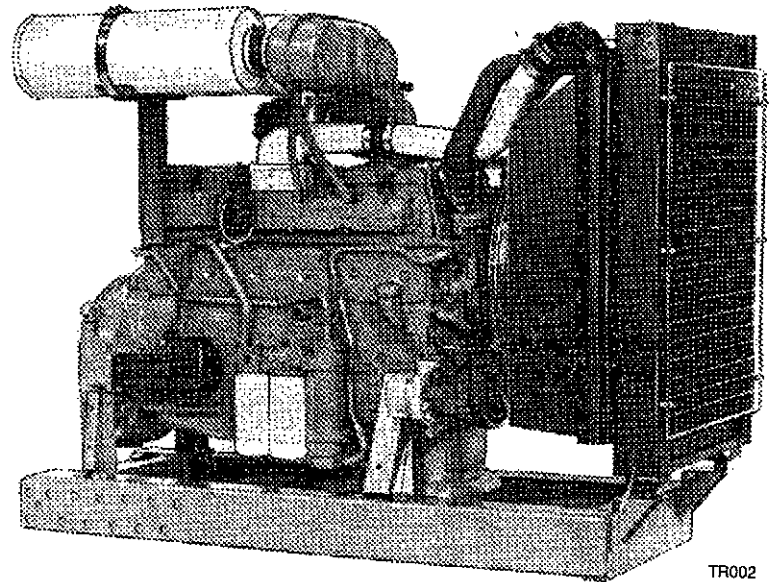
- 998 6485-2** Overhaul stand

## Engine body Design and function

The engines are in-line, 6-cylinder, 4-stroke, diesel engines with direct injection. The engines are designed with oil cooled pistons and wet, replaceable cylinder liners, separate cylinder heads, one for each cylinder and exhaust driven turbo chargers.

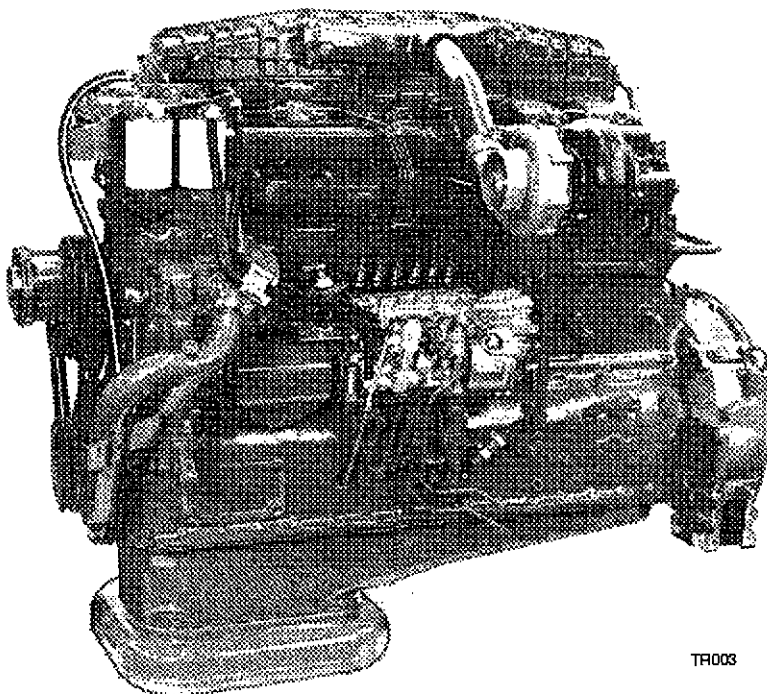
TAD-engines are equipped with an intercooler, located behind the radiator and cooled by air via a thrust type of fan. TWD-engines are equipped with an intercooler, cooled by water.

TAD1030G



TR002

TWD1230ME



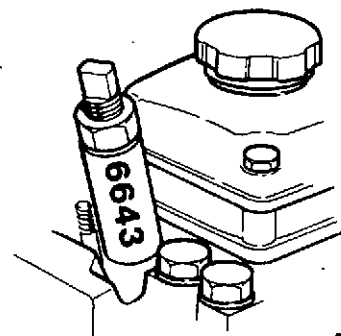
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## Service Procedures

### Cylinder head, removing

*Special tools: 6643, 10 ltr: 2666 (at least 2 pcs) 12 ltr: 8043 (at least 2 pcs)*

- 1**  
Drain off engine's coolant.
- 2**  
Close fuel cocks.
- 3**  
Disconnect the battery cables.
- 4**  
Remove the exhaust pipe and silencer (if fitted).
- 5**  
Remove the air filters and required tubes, hoses and cables.
- 6**  
Disconnect the inlet manifold. Note! TWD-engines: Let the charge air cooler remain on the inlet manifold.
- 7**  
Disconnect requisite pressure pipes, and fit protective caps. Observe cleanliness when working with fuel system.  
**NOTE! Do not bend the pipes.**
- 8**  
Remove the exhaust manifold together with the turbo-charger. If only one or a few cylinder heads are to be removed the exhaust manifold can be left in place. In which case remove screws for intended cylinder head and loosen screws somewhat for other cylinder heads.
- 9**  
Remove the oil leak pipe for the injectors.
- 10**  
Remove the injectors for the cylinder head to be dismantled. Turn the injector with a wrench (U-15) and pull upwards at the same time. Use extractor 6643 where necessary.



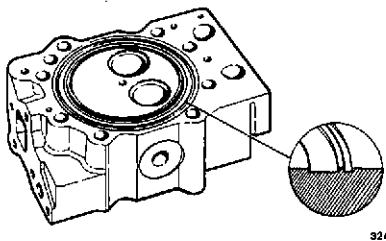
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- 11**  
Remove the valve covers, rocker gear mechanism and push rods.  
**NOTE!** To simplify removal of the rocker gear mechanism the engine should be turned so that the valves are closed.
- 12**  
Remove the screws which hold the cylinder head.  
**1030:** Remove the insert seals between the cylinder head. Lift off the cylinder head.
- 13**  
Remove the cylinder head gaskets, rubber seals and their guides from the block.  
**Comment:** If the crankshaft has to be turned: fit tool 2666 for the 10 ltr resp. 8043 for the 12 ltr to hold the cylinder liners secure.

## Cylinder head, dismantling

*Special tool: valve spring compressor*

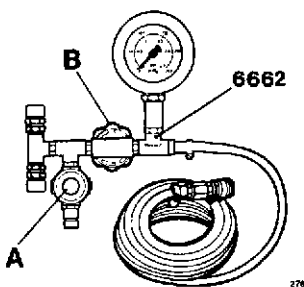
- 1**  
Remove valves and valve springs. Use a valve spring compressor to remove the valve collets.
- 2**  
Place the valves on a valve rack in the order they were in the engine.
- 3**  
Clean all parts. Observe special care with channels for oil and coolant. Examine tightness via the leakage test.
- 4**  
Remove residual soot and impurities from the sealing surfaces on the cylinder head. **12 ltr:** clean the sealing groove. Observe care so that the thin edge is not damaged.



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## Cylinder head, leakage test

*Special tools: 2124 (2 pcs), 6662,  
10 ltr: 6685  
12 ltr: 6683*

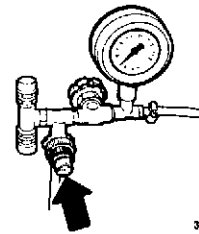


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- A. Reducing valve  
B. Cock

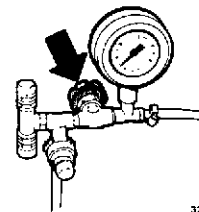
Before using the testing device it should be checked as follows:

- 1**  
Connect testing device 6662 to the pressure supply and set the manometer to 100 kPa with the reducing valve (A).
- NOTE!** The knob on the reducing valve can be locked with a circlip which is moved in an axial direction.



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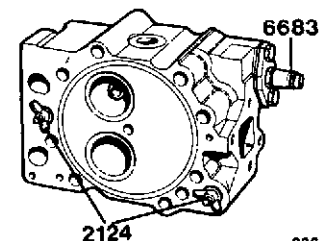
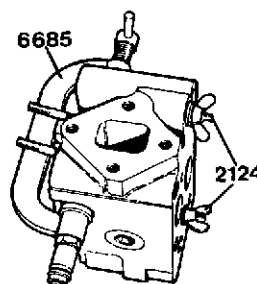
- 2**  
Now close the cock (B). The manometer should not drop for two minutes if the pressure testing device is to be considered reliable.



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## Leakage test

- 1**  
**10 ltr:** Fit the clamp 6685 and the expander screws 2124 (2 pcs), see fig.  
**12 ltr:** Fit connecting washer 6683 and the expander screws 2124 (2 pcs), see fig.  
Do not tighten the wing nuts too hard to avoid damaging the rubber seal.



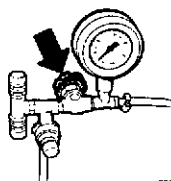
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- 2**  
Check that the knob on the reducing valve is unscrewed and connect the hose from the pressure testing device to the cylinder head.

**3**  
Submerge the cylinder head in water, temp. approx. **70°C (158°F)**.

**4**  
Connect the test device to the compressed air supply and open the cock.

**NOTE! Follow the relevant safety instructions. Do not stand over the expander screws.**



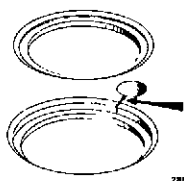
**5**  
Pull out the circlip for the knob on the reducing valve. Increase the pressure by screwing in the knob until the the manometer shows **50 kPa (7.25 psi)**. Hold this pressure for one minute, then increase to **150 kPa (21.75 psi)**. Lock the knob by pressing in the circlip and closing the cock. Check after 1-2 minutes if the pressure drops or if air bubbles escape from the water.

**6**  
Release the compressed air hose. Open the cock and reducing valve. Remove the testing equipment.

## Cracks in cylinder head

During the renovation of engines which have gone many hours an inspection of the cylinder head may reveal heat cracks between the valve recess and hole for the injector; see Fig. below.

The cylinder head does not need to be replaced or scrapped because of heat cracks. Heat cracks stop after a time and they have proved not to have any effect on engine performance. The cracks begin at the copper sleeve of the injector and run towards the recess for the valve seat.



Cracks can be caused by over-tightening the fixture for the injector. This type of crack has when tested not resulted in gas or coolant leakage, since the crack has not continued through the base of the cylinder head.

Where leakage has been confirmed this has proved to be the result of impurities or damage to the seat of the copper sleeve, which must therefore be corrected.

Cylinder heads in Volvo Penta's replacement system may also display heat cracks. These cracks are checked during reconditioning and are not considered to be of importance, that is, the cylinder heads are guaranteed to be fully usable.

## Cylinder head, inspection

The cylinder head warp shall be max. **0.02 mm (0.0008")**. If the warp is greater than 0.02 mm, or if there are blasting marks, the cylinder head shall be machined flat or replaced.

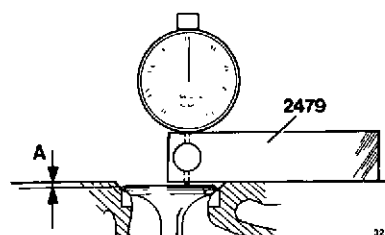
**12 ltr engines:** after grinding new sealing grooves must be milled.

The flame edge groove does not require machining as long as the grinding stays within the tolerance for min. cylinder head height; see "Cylinder head, surface grinding" below.

## Cylinder head, surface grinding

*Special tool: 2479, dial test indicator*

**1**  
Surface roughness shall after surface grinding be max. **1.6 RA**. The distance (A) from the machined surface of the cylinder head to the valve disc must not be less than minimum value specified in "Workshop Manual, Technical Data". If additional grinding of the cylinder head is necessary the valve seats must be milled to size.



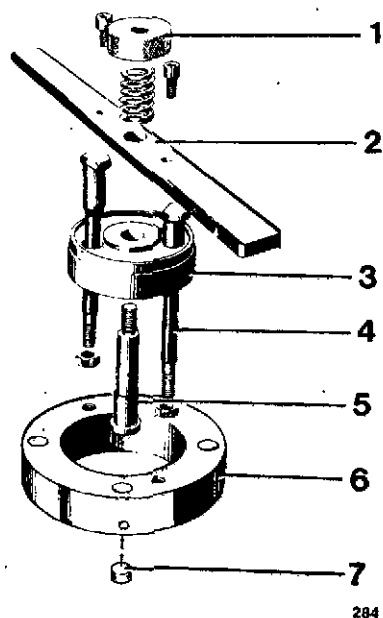
**2**  
The height of the cylinder head after surface grinding must not be less than minimum value specified in "Workshop Manual, Technical Data".  
The flame edge groove does not require machining.

**3**  
**12 ltr engines:** new sealing grooves has to be milled in the head as per instructions below.

## Cylinder head, milling of sealing grooves, 12 ltr engines

Special tool: 9531

Before milling new grooves the cylinder head must be surface grinded so that the previous sealing grooves are completely removed.



- |                   |                 |
|-------------------|-----------------|
| 1. Nut            | 5. Spindle      |
| 2. Turning handle | 6. Milling head |
| 3. Guide plate    | 7. Steel holder |
| 4. Guide pins     |                 |

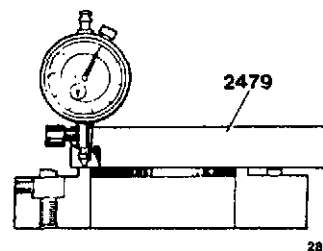
The height of the cylinder head, and distance between the valve disk plane and the cylinder head plane, must not be less than the dimensions given in the specifications.

Check also that the valve guides are not worn, since the guiding of the grooving tool is fixed with guide pins through the valve guides.

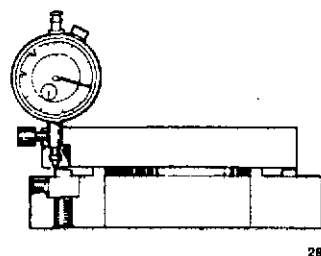
### Setting of cutting depth of the tool

- 1 Set up the tool in a vice with the tool facing upwards.
- 2 Fix a dial test indicator in the holder 9992479 and place this over the shoulder of the ring-shaped grooving tool.

- 3 Set the dial test indicator to zero to the shoulder.

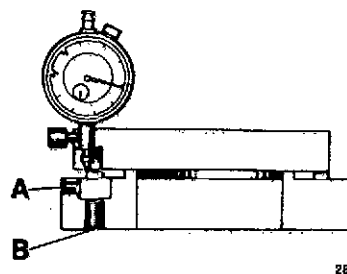


- 4 Push the holder with the indicator sideways so that the indicator tip rests on the highest point on one of the cutting tools. Correct cutting depth (tool height): 0.20 mm (0.0079").



### Adjusting

- 5 Release the lock screw A (hexagon wrench 4 mm) and the adjusting screw B (hexagon wrench 5 mm), a few turns.



- 6 Press down the tool holder and tighten the lock screw slightly so that it presses to the holder.
  - 7 Place the indicator tip to the highest point of the tool and screw the adjusting screw upwards until the correct value of the tool height is obtained.
  - 8 Tighten the lock screw.
- NOTE!** Check that the upper edge of the tool holder is level with the cutting head. If this is not so the dial test indicator has moved an extra turn.

## Milling of sealing grooves

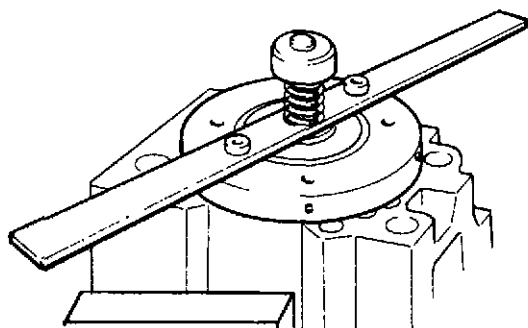
**1**  
Set up the cylinder head in a vice.

**2**  
Screw tight the guide plate on the cylinder head. The plate shall be placed so that it centres between the holes for the cylinder head's fixing screws.

**NOTE!** Do not over-tighten the nuts for the guide pins to avoid pressing the valve guides into the cylinder head.

**3**  
Brush a little oil on the internal diameter of the milling head. Make sure that the cylinder head surface is completely clean and then carefully apply the milling head on the guide plate with a turning movement so that it does not chatter.

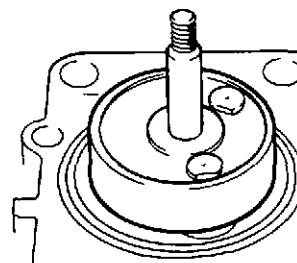
**4**  
Place the spring and nut in position and tighten the nut slightly.



**5**  
Turn the milling tool clockwise and with a uniform movement. The cutting feed takes place automatically in that the nut follows the movement and presses the spring together.

**6**  
Turn the tool until the steel ceases to cut, and then remove the nut and lift up the milling head.

**7**  
Clean the cylinder head carefully. Check the depth of the grooves by replacing the milling head without spring and nut, and by turning it round a few turns with hand pressure. If the tool does not cut, the grooves have the correct depth. This check shall always be made because shavings can come in under the shoulder of the milling head. The burrs which arise on the edges of the grooves shall be left, since removing these may imply damage to the edges and inferior sealing.



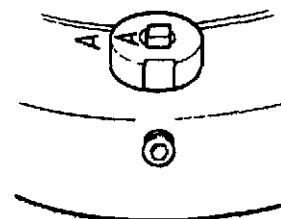
## Replacement of cutter sets

**1**  
Unscrew the lock screw a few turns and screw the adjusting screw upwards so that the cutter holder can be removed from the cutting head.

**2**  
The cutter holders are marked with the letter A, B, C or D and the corresponding letter is stamped in the cutting head where the cutter holder shall be placed.

**NOTE!** The two socket head screws in the cutter holder shall not be touched.

**3**  
Put the cutter holders in the milling head as per the letter markings and with the groove turned to the lock screws. Adjust the cutter height as per previous instructions.



## Valve guides, inspection

Special tools: 9989876, 9696

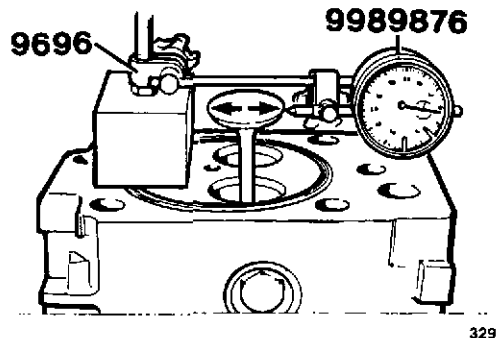
To determine the wear on the valve guides a new valve is put in the guide, after which the clearance is measured with a dial test indicator.

**1**  
Remove the screw pin for the injector yoke and place the cylinder head on a flat surface so that it rests on the valve guides.

Block up the one edge of the cylinder head so that it rests secure on the underlying surface.

**2**  
Put a new valve in the valve guide so that the valve spindle stands on the underlying surface.

**3**  
Place a dial test indicator with magnetic stand so that the tip of the indicator makes contact with the edge of the valve.



**4**  
Move the valve sideways in the direction of the outlet or inlet channels. Read off the value on the dial test indicator.

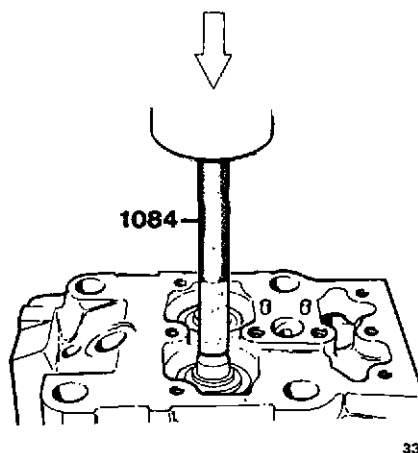
**Wear tolerances:** See "Workshop Manual, Technical Data".

If these values are exceeded the valve guides shall be changed.

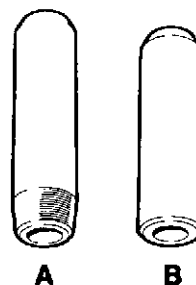
## Valve guides, replacement

Special tools: 10 ltr engines: 1084, 6668, 6669,  
12 ltr engines: 1084, 2953

**1**  
Press out the valve guides with drift 1084.



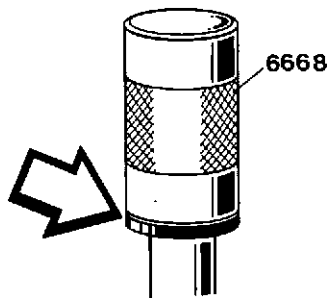
**2**  
Oil in the new valve guides.  
**NOTE!** The guides are of different types, see figure.



A = Guide for inlet valve  
B = Guide for outlet valve

**3**  
Press in the guides with drift 6668 (inlet) and 6669 (outlet) for the 10 ltr, resp. 2953 for the 12 ltr engines. The tools give the correct height over the cylinder head's spring plane.

**NOTE!** A 2 mm washer must be added to the drift 6668 (see fig.) to give the guide the proper height (19 mm) above the cylinder head spring face.

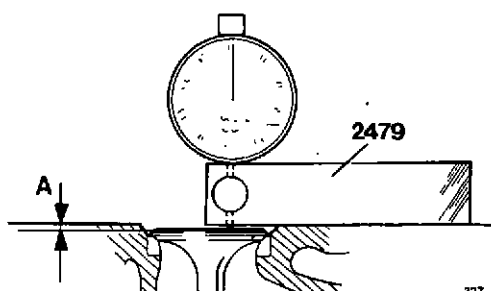


**4**  
Ream the valve guides if so required. Clearance valve - valve guide: see "Workshop Manual, Technical Data".

## Valve seats, replacement

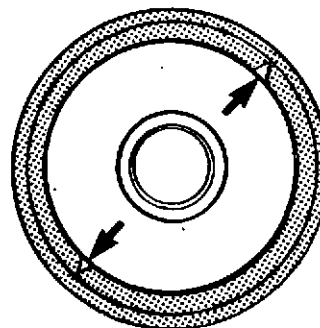
The valve seat should be replaced when the distance A, measured with new valve, is greater than the value specified in "Workshop Manual, Technical Data".

This measurement refers to both inlet and outlet valves.



**1**  
Remove the old valve seat by grinding two diametrical notches, and then cracking it with a chisel; see figure.

**NOTE!** Observe care to avoid damaging the cylinder head.



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**2**  
Clean the seat recess carefully and check the cylinder head for cracks.

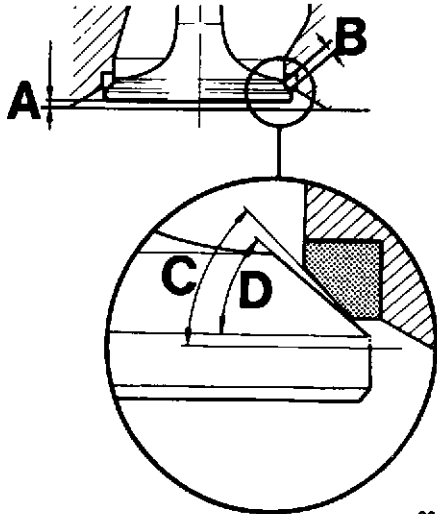
**3**  
Measure the diameter of the valve seat recess. Examine if a seat of standard size or oversize shall be used. Perform any necessary preparation of the valve seat recess.

**4**  
Cool the seat in dry ice to a temperature of minus 60-70°C (minus 76-94°F) and warm the cylinderhead by flushing with hot water or the like. Press in the seat with a drift.

**5**  
Machine the seat the correct angle and width.

## Valve seats and valves, grinding

Before grinding the valve guides shall be checked and replaced if the wear tolerances are exceeded. See "Workshop Manual, Technical Data".

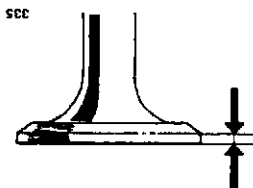


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**1**  
Ream or grind the valve seats (sufficiently to ensure correct shape and good contact) The seat angle shall be 45° resp. 30°.

**NOTE!** If the distance from valve disc (new valve) to cylinder head face exceeds the value specified in "Workshop Manual, Technical Data" the seat must be replaced.

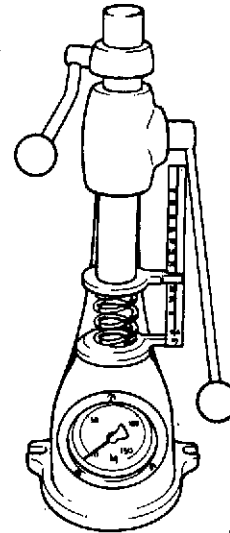
**2**  
Clean the valves and machine grind. Set the grinding machine to 44.5° resp. 29.5°. Grind just enough to ensure a "clean" surface. If the disc edge thickness (see fig) is less than specified value, see "Workshop Manual, Technical Data", after grinding the valve shall be scrapped. Similarly, a valve with bent spindle is also scrapped.



**3**  
Check the fit with marking dye. In the event of poor tightness an additional grinding is made, followed by a new check.

## Valve springs, checking

Check the length of the valve springs, unloaded and loaded, by using a spring gauge. The springs shall maintain the values given in the "Workshop Manual, Technical Data".



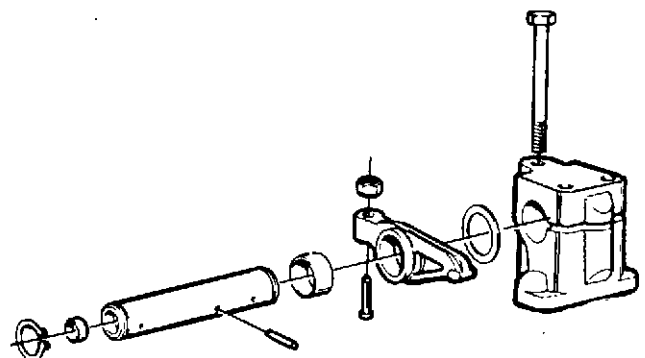
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## Rocker mechanism, overhauling

*Special tools: 2267, 2677*

**1**  
Remove the circlips, rocker arms and shaft.

**2**  
Clean the parts, observing special care with the oil channel in the bearing housing, and the oil holes in the rocker arm shaft and rocker arm.



3

Check the wear on rocker arm shaft and ball pin. The threads shall be undamaged on the ball pin and lock nut. The contact surface on the rocker arm to the valve cap must not be worn or pitted. Adjustment in a grinding machine can be made in the event of less serious wear. Check the tightness of the cap plugs at the shaft ends.

4

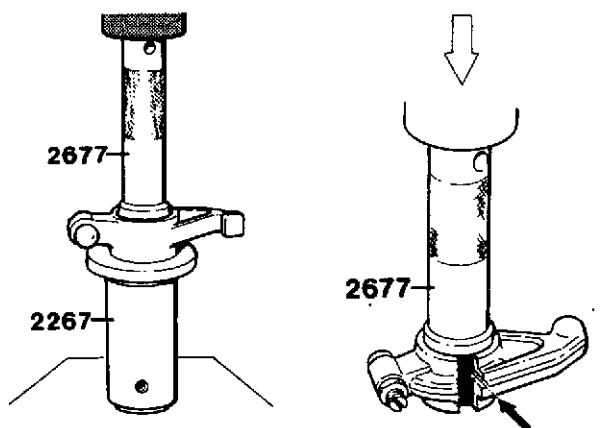
Ovally worn rocker bushings are replaced. Press out the bushing with drift 2677; use drift 2267 as counterforce.

Press in the new bushing with drift 2677. Make sure that the oil hole comes in the middle of the oil channel in the rocker arm.

The new bushing must be reamed after being pressed in.

5

Oil in the shaft and assemble the parts.



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## Cylinder head, assembly

If the injector's copper sleeve requires replacing, see "Fuel system."

1

12 ltr engine: place the lower valve spring washers on the cylinder head. There are no such washers in the 10 ltr engines.

2

Oil in the valve spindles and fit the valves in their guides. Fit the springs and upper washers.

3

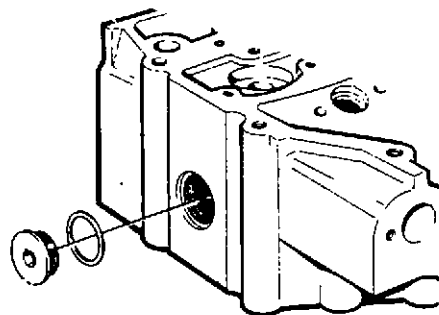
Press the springs together with a valve spring tensioner and fit the valve lock. Put on the valve caps.

4

If the cylinder head's cleaning plugs have been removed make sure that the sealing surfaces are well cleaned.

Put on new gaskets: tighten the plugs with a torque of 60 Nm (44lbf.ft).

**NOTE!** The plugs must not be machine tightened.



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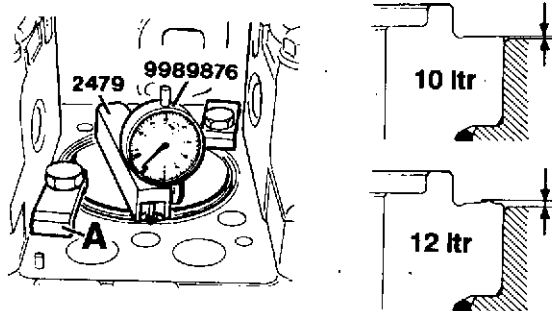
## Cylinder head, fitting

**Special tools:** 2479, 998 9876  
 10 ltr engines: 2666 (2 pcs)  
 12 ltr engines: 8043 (2 pcs)

**1**  
 Clean the cylinder block surface with a brass brush. Make sure that the surfaces are not scratched.

**2**  
 Check the height of the cylinder liner over the block plane, see "Cylinder liner and piston, fitting."

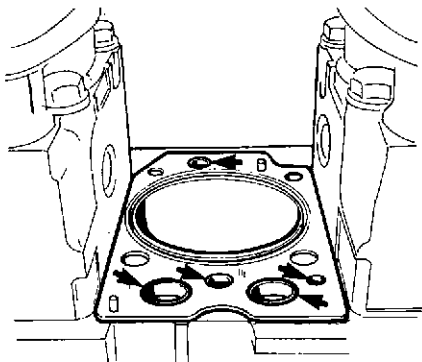
Correct height above cylinder block surface: see "Workshop Manual, Technical Data".



**A:** 10 ltr engines: 2666  
 12 ltr engines: 8043

**3**  
 Place new sealing rings on new cylinder head gasket on the cylinder block.

**10 ltr engine:** clean the mating surfaces for the insert seals between the heads, use fine emery cloth.

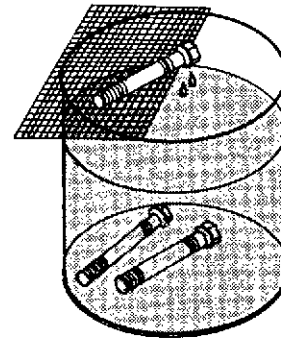


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**4**  
 Place the cylinder head on the block.

**5**  
 Check the cylinder head screws.

**NOTE!** The screws are phosphated and must not be cleaned with wire brush. If there are cut marks under the screw heads or in the threads they shall be replaced with new.



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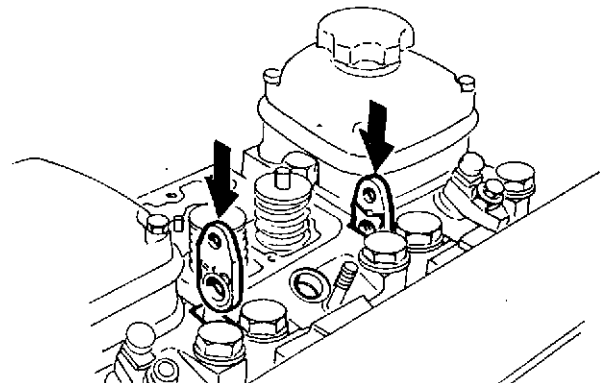
Dip the cylinder head screws fully (heads also) in rust-proof agent, part No. 1161346-0 (or a mixture of 75 % Tectyl 511 and 25 % varnolen). The screws shall be drip-free before fitting (oil may otherwise be forced up and seen as leakage).

See "Workshop Manual, Technical Data", for correct tightening order and torque.

**6**  
**10 ltr engine:** fit the insert seals between the cylinder heads. **NOTE!** Grease or oil must not be used on the seals. Use soap water.

Fit the lower parts to the valve covers. Tighten the screws with a torque of **10 Nm (7 lbf.ft)**.

**NOTE!** Higher torque will risk damaging the seal.



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**7**  
 Fit the push rods and rocker mechanism. Adjust the valves (see below). Put on the valve covers.

**8**  
 Fit the injectors. Tightening torque **50 Nm (36.9 lbf.ft)**.  
 Fit the remaining equipment.

**NOTE!** The gasket between cylinder head and exhaust pipe is turned so that the plate covered side faces the exhaust pipe.

## Valves, adjustment

*Special tools: 3590*

**1**  
Valve adjustment must only be done when the engine is stopped: cold or at operating temperature. Make sure that the stop control is pulled out and that the starting key is at "OFF".

**NOTE!** Valve clearance must not be adjusted with the engine running since the pistons could hit the valves. The valves can be adjusted according to the two-position method.

**2**  
Remove the valve covers.

**3**  
Crank the engine round in its direction of rotation until **1st piston is at T.D.C.** after compression. (The valves of the 6th cylinder are rocking, 0° on the flywheel).

**4**  
Adjust the valves according to "Workshop Manual, Technical Data".

**5**  
Crank the engine again in the direction of rotation (one complete turn) until **6th piston is at T.D.C.** after compression. (The valves of the 1st cylinder are rocking, 0° on the flywheel).

**6**  
Adjust the valves according to "Workshop Manual, Technical Data".

**7**  
Change the valve cover gaskets if required and fit the valve covers.

## Cylinder liners and pistons, removing

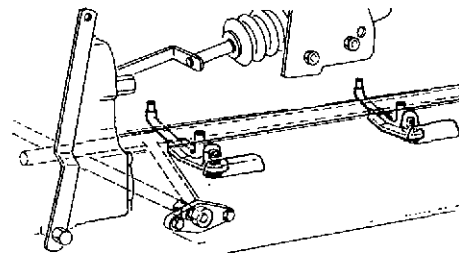
*Special tools: 1801, 2013, 6394 (2 pcs),  
6395 (2 pcs), 6645  
10 ltr engines: 2089, 2666 (2 pcs)  
12 ltr engines: 2955, 8043 (2 pcs)*

**Note!** Piston and liner are a matched pair.

**1**  
Remove the cylinder head and oil sump.

If the cylinder liner is to remain on the engine when the pistons are removed, the holders 2666 (10 ltr) resp. 8043 (12 ltr) must be fitted so that the liner is not moved out of position. If the liner should glide up during removal of the piston then the liner should also be removed, since there is considerable risk that impurities will fall down between liner and block and cause leakage.

**2**  
Turn the crankshaft so that the piston for the actual cylinder is in the top firing position. Remove the piston cooling nozzle.



Piston cooling nozzle, 10 ltr. engine

**3**  
Turn the crankshaft until the connecting rod comes in position to remove the big end cap screws.

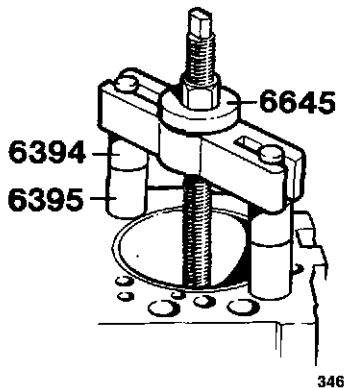
**4**  
Remove the big end cap. Tap up the connecting rod, with for example the handle of a hammer, so that the piston rings are released from the cylinder liner. Lift off the piston and connecting rod.

**Note!** Scrape off the soot edge on the upper part of the cylinder liner to simplify removal of the piston and connecting rod.

5

Mark the piston and liner before removing, to make sure that the same piston and liner are refitted in the same place as before.

Remove the cylinder liner with extractor 6645, support 6394 and 6395, and extractor plate 2089 for the 10 ltr, resp. 2955 for the 12 ltr engines.

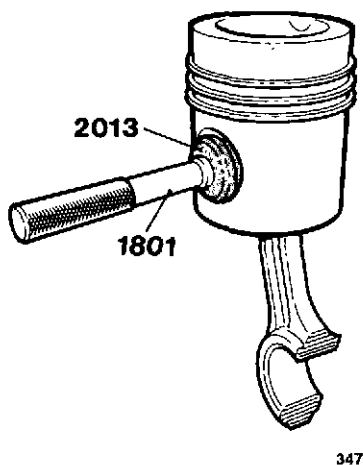


6

Remove the circlips for the gudgeon pin.

7

Tap out the gudgeon pin carefully with drift 2013 and handle 1801.



8

Remove the piston rings with a piston ring rod.

For fitting of pistons and liners see page 25.

## Cylinder liner, inspection

The cylinder liners must be carefully cleaned before carrying out inspection and measurement. To be able to carry out a careful check for cracks, the cylinder liner must be removed from the cylinder block.

The position of the cylinder liner must be marked with a marking pen before it is removed.

1

Check for cracks, extra care must be taken when checking the liner collar. Checking can be carried out using a magnetic powder test.

2

### Wear measuring using a cylinder indicator

In order to measure the wear as accurately as possible, the cylinder indicator should first be set using a gauge ring or micrometer.

Use the original bore size of the cylinder liner as a reference measurement.

Measure the cylinder liner in the upper and lower dead centres and also at different heights. At each measurement point, measuring should be carried out both crosswise and lengthwise in relation to the engine.

3

### Wear measuring using a piston ring (alt.)

Liner wear is easily determined by placing a new piston ring at the upper turning position and measuring the piston ring gap. This is then compared with the piston ring gap below the lower turning point. The wear is determined by dividing the difference by 3.14.

#### Example:

Piston ring gap in unworn section 0.60mm(0.0236")  
Piston ring gap at upper turning point 1.70mm(0.0669")

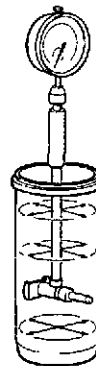
Difference:

$1.70\text{mm} - 0.60\text{mm} (0.0669 - 0.0433) = 1.10\text{mm} (0.0433")$

Diameter wear:

$1.10\text{mm} (0.0433")$

$\frac{1.10\text{mm} (0.0433")}{3.14} = 0.35\text{mm} (0.0138")$



**4**  
If wear is greater than **0.40–0.45 mm (0.0157–0.0177")**, the cylinder liner with piston and piston rings should be changed.

Oil consumption should also be taken into account when a cylinder liner is to be changed.

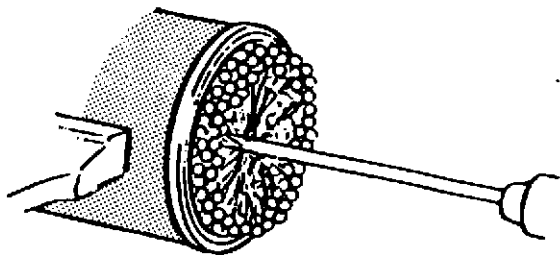
**NOTE!** Cylinder liners and pistons are a matched pair. This means that the piston must be kept with its matched liner.

Pistons and cylinder liners are only available from stock as one unit.

### Cylinder liners, honing

For good lubrication and sealing it is important that the liner walls retain the original honing pattern, see fig. Honing, to restore the pattern, is therefore to be carried out when:

- the cylinder liner has scratches (ring seizure, dirt)
- the cylinder liner has bright spots (polishing)



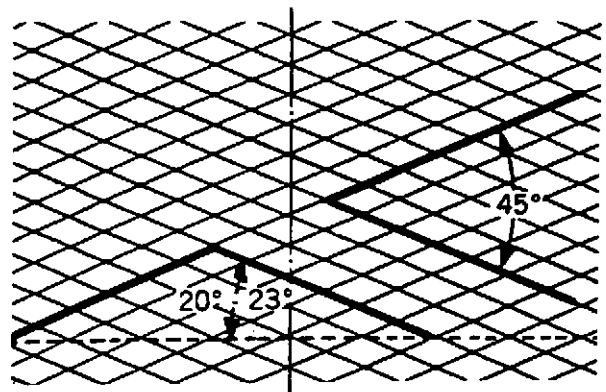
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**1**  
Place the cylinder liner in a vice, see fig. Honing of the cylinder liner when installed in the block is not recommended due to the risk of oil channels becoming clogged and the difficulties to feed correctly.

**2**  
Remove the carbon edge at the top of the liner. Also clean under the liner collar and the recess in the block.

**3**  
Use a low speed electric drill with a speed of 200–400 rpm and "Flex-Hone" tool type GBD 127 mm (5") for 10 liter engines, and GBD 140 mm (5 1/2") for 12 liter engines. Grade size 80.

Lubricate the cylinder liner with light engine oil before and during honing. Move the honing tool in and out of the cylinder liner at 60 strokes/min. (One inward and outward stroke per second).



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**4**  
The cylinder liners have a honing pattern where the angles are carefully calculated to give optimal life span, see fig.

When honing after a piston ring change the original honing pattern must be followed to keep the lubrication properties.

The honing marks must be formed uniformly and cut evenly in both directions over all the cylinder surface.

**NOTE!** The correct speed must be maintained to obtain the correct pattern.

**5**  
**Clean the liner thoroughly after honing.** Use warm water, a brush and detergent (never use thinners, paraffin or diesel oil). Dry the liner using paper or a cloth which does not leave any fluff. After drying, lubricate the liner with light engine oil.

## Cylinder liner seats, overhauling

**Special tools:** 2479, 998 9876.

10 ltr engines: 2666, 9511, 9551

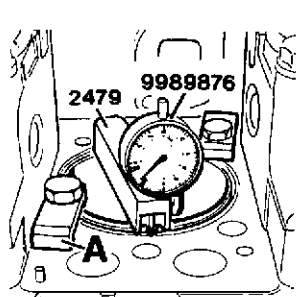
12 ltr engines 9902, 9903, 8043

Remove the lower liner seals from the cylinder block.

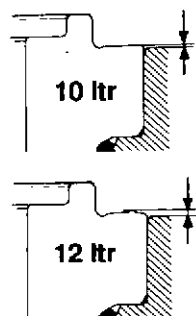
Examine the contact plane of the upper liner seat with marking dye if there is any doubt as to the extent of the damage. See "Fitting of cylinder liners and pistons".

In the event of negligible damage adjustment can be carried out with grinding paste, see item 6. For more extensive damage adjustment is made with milling tool 9551 (10 ltr engines) and 9902 (12 ltr engines).

**1**  
Clamp the liner in the block (without sealing rings) and measure the liner height as per the figure (set the dial test indicator to zero to the cylinder block).



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**A:** 10 ltr engines: 2666  
12 ltr engines: 8043

Correct height over the block plane see "Workshop Manual, Technical Data".

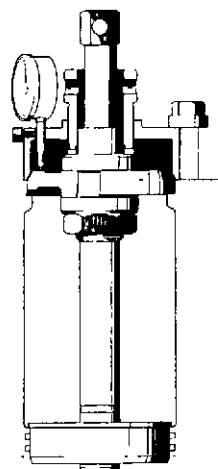
Removed material is compensated with shims, which are available in thicknesses 0.20, 0.30 and 0.50 mm. A minimum number of shims should be used. Calculate the thickness of the shim with respect to the extent of the damage and the height of the liner above the block plane.

**Note!** If shims are to be used a certain machining of the liner seat must be carried out even if the seats in the cylinder block are undamaged, since the radius at the bottom of the liner seat must be removed to ensure that the shim receives a correct contact.

**2**  
Before milling of the liner seat the surface should be roughened up with emery cloth to preserve the sharpness of the tool, especially if the surface has previously been ground with grinding paste.

To improve the guiding of the milling tool the lower liner seals should be fitted in the block.

**3**  
Set up milling tool 9551 for the 10 ltr engines and 9902 for the 12 ltr engines. Make sure that the tool collar does not catch on the middle wall in the block.



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**4**  
Position the milling tool and yoke. The tool is secured to the cylinder block with screws. Suitable flat washers should be placed under the screw heads. Make sure that the feed screw does not press on the milling tool.

**5**  
Apply a dial test indicator as per fig. and screw down the feed sleeve so that it presses lightly to the milling tool. Set the dial test indicator to zero.

A T-bar with 3/4" connection and 25 mm socket is used to turn the milling tool.

The milling tool should be turned with a uniform movement as the same time as the feed sleeve is turned.

Discontinue feeding and turn the milling tool a few turns.

Check the mating surface of the liner seat and the height of the stepped edge at regular intervals.

When 0.02 mm remains to the correct height, discontinue the milling.

6

Coat the underside of the liner collar with grinding paste.

Fit the liner and turn it back and forwards until the grinding paste is used up (use tool 9511 for 10 ltr engines and 9903 for 12 ltr engines). Remove the liner and wipe off the paste. Repeat the grinding until a satisfactory mating surface is obtained.

7

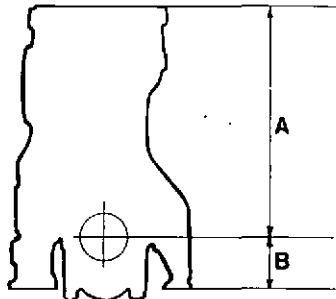
Check the mating surface with marking dye on the liner lip. Turn the liner back and forwards. Mark the liner so that when it is re-positioned it comes to the same position as when the mating surface was checked.

8

Clean all parts carefully.

## Cylinder block, surface grinding

When surface grinding the cylinder block do not go below the minimum dimensions.



4

A = Height, upper block plane - crankshaft centre

10 ltr engines: min. 438.8 mm.

12 ltr engines: min. 463.8 mm

B = Height, lower block plane - crankshaft centre

10 ltr engines, 12 ltr engines: min. 120 mm

**Note!** After grinding of the upper block plane the piston height must be measured as per the instructions. See "Cylinder liners and pistons, assembly", item 15.

## Pistons, checking

Check the pistons for cracks and other damage. If the piston has deep lines around the sleeve surface it (liner unit) must be scrapped. Similarly, if the piston has one or several cracks in the gudgeon pin hole or in the bottom of the combustion chamber it shall also be scrapped. Cracks in the edge of the piston top around the combustion chamber are not serious as a rule. The crack test is carried out as per the powdered lime method.

**NOTE!** If cracks are found in the pistons the fuel injection volume should also be checked.

Cylinder liners and pistons are a matched pair. This means that the piston must be kept with its matched liner.

Pistons and cylinder liners are only available from stock as one unit.

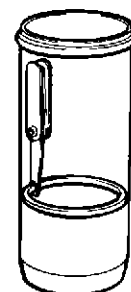
## Piston rings, checking

Check the wear surfaces and sides. Black patches on the surfaces indicate poor contact, and the piston rings should be replaced. Oil consumption is of critical importance for indicating when piston rings should be replaced.

Also, the piston rings should be replaced if there is noticeable wear or ovality in the cylinders, since the rings are seldom re-positioned in the same position they had before removing.

Check the piston ring gap. The ring is pushed down **below the L.D.C.** with the help of a piston for this measurement. Replace piston rings if the gap amounts to **1.5 mm (0.0591")** or more.

Check the piston ring gap on new rings also. For dimensional data see "Workshop Manual, Technical Data".



## Connecting rods, checking

Check for cracks.  
Check straightness and warping.

**Straightness**, max. deviation: **0.05 mm** for 100 mm measuring length.

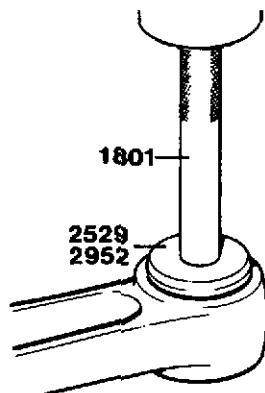
**Warping**, max. deviation: **0.1 mm** for 100 mm measuring length.

Measuring is carried out in a control fixture for connecting rods. Bent or warped connecting rods are scrapped. Check the connecting rod bushings, which is appropriately carried out by using the gudgeon pin as a gauge. There should be no noticeable clearance.

## Connecting rod bushings, replacement

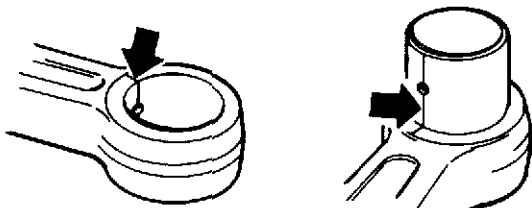
*Special tools:* 1801,  
10 ltr engines: 2529  
12 ltr engines: 2952

**1**  
Press out the old bushing with drift 2529 (10 ltr engines) or 2952 (12 ltr engines).



**2**  
Draw a line over the hole on the new bushing and connecting rod. Use a felt-tip pen.

**3**  
Heat up the connecting rod to approx. **100°C (212°F)**.



**4**  
Carefully press the new bushing into the connecting rod. Use the same drift as for pressing out.

**NOTE!** Check that the bushing hole corresponds with the oil channel in the connecting rod.

**5**  
Ream the bushing. If the fit is correct an oiled gudgeon pin should slowly glide through the bushing by virtue of its own weight.

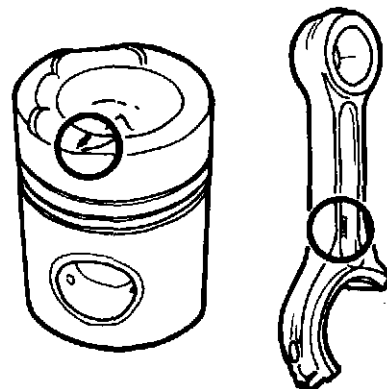
## Pistons, rings and connecting rods, assembly

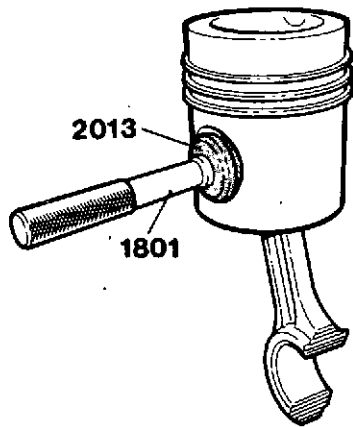
*Special tools:* 1801, 2013

**1**  
Fit one circlip.

**2**  
Oil in the gudgeon pin and the connecting rod bushing.

**3**  
Heat up the piston to approx. **100° C (212°F)**. Place the piston and connecting rod so that the "Front" markings of the piston and connecting rod face in the same direction.





Press in the gudgeon pin with drift 2013 and the standard handle 1801.

**NOTE!** It should be easy to press in the gudgeon rod, it shall not be tapped in.

**4**  
Fit the second circlip.

**5**  
Check that the connecting rod does not turn stiffly in the gudgeon pin bushing.

**6**  
Check the piston ring gap in the cylinder bore (see piston rings, checking), and that the rings do not bend in the piston ring groove.

**7**  
Fit the piston rings on the piston with piston ring pliers so that the markings face upwards. The opening in the expander spring should be placed opposite the oil ring gap.

## Cylinder liners and pistons, fitting

*Special tools: 885126, 9989876; 2000, 2479, 6599  
10 ltr engines: 2666, 9511  
12 ltr engines: 8043, 9903*

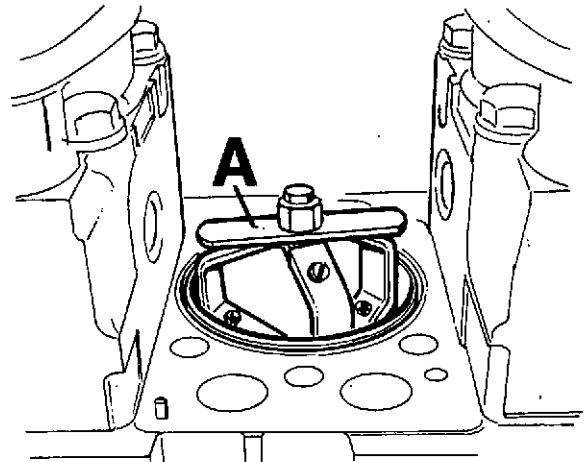
**1**  
Carefully clean the liner recess in the cylinder block. The sealing surfaces must be completely free from rust and deposits. Use cleaning agent and brass brush and blow dry with compressed air.

**NOTE!** scraping tools must not be used.

Clean also the grooves for the lower liner seals.

**2**  
Apply on the underside of the liner flange a thin coat of marking dye.

Push down the liner in its position without the sealing rings, and turn slightly. Use expander 9511 for the 10 ltr engines and 9903 for the 12 ltr engines.



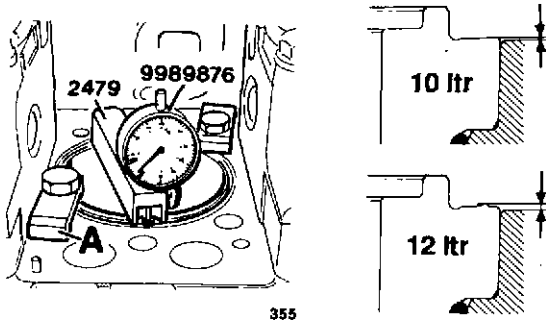
**A:** 10 ltr engines: 9511  
12 ltr engines: 9903

**3**  
Pull up the liner and examine if the dye has covered the entire surface. If the dye indicates poor contact it may be possible to adjust with grinding paste if the damage is slight. In the event of more serious damage the liner recess must be milled with a special milling tool and the material removed compensated with steel shims. See "Cylinder liner seats, overhauling".

4

Clamp the liner in the block (without sealing rings) and measure the liner height as per the figure (set the dial test indicator to zero to the cylinder block).

Correct height over the block plane: see "Workshop Manual, Technical Data".



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A: 10 ltr engines: 2666  
12 ltr engines: 8043

5

Mark up the position of the cylinder liner to the cylinder block with a colour pen. Remove the press tool and lift up the cylinder liner.

6

Fit the new lower sealing rings in the cylinder block.

**NOTE!** lubricate the rings with the lubricant included in the gasket for the rings.

For positioning of the rings see the fitting instructions in the gasket.

7

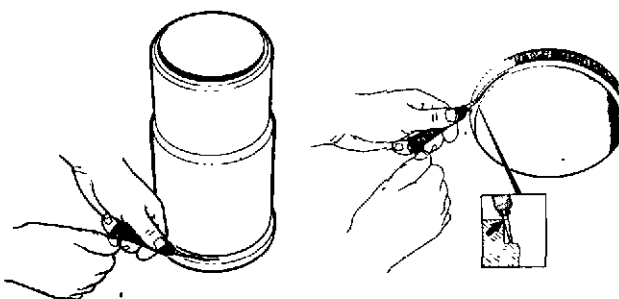
Clean the cylinder liner collar carefully. The collar shall be dry and free from grease. Use de-greasing agent of the white spirit type.

8

Place a uniform, max. **0.8 mm (0.0315")** wide, bead of sealant (1161277-7) on the cylinder liner.

Note: in the event of shims for the liner, the bead of sealant is placed on the liner recess in the cylinder block.

**NOTE!** No sealant between shim and liner collar.



9

Place a new sealing ring under the liner collar.

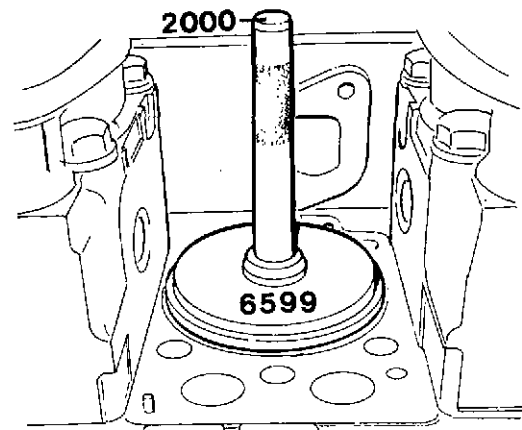
**NOTE!** The ring shall be dry (not lubricated).

After application of the sealant the liner must be put in position within **20 minutes**. The liner must be clamped and not released until the cylinder head is to be put in position.

When positioning the pistons, or if the engine is to be turned over, all the cylinder liners must be clamped to prevent movement between cylinder liner and cylinder block.

10

Fit the cylinder liner in the cylinder block as per the markings made. Tap down the liner with the aid of the plate 6599 and the handle 2000.



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11

Fit the clamp tool on the liner.

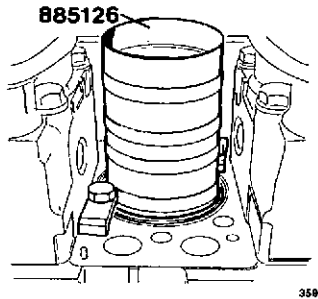
12

Place the bearing shells in their positions in the connecting rod and cap. Check that the hole in the bearing shell comes opposite the hole in the connecting rod.

Lubricate the piston and big end with engine oil, and turn the rings so that the piston ring gap is uniform round the piston.

**13**

Check that the arrow on the piston top and "FRONT" marking on the connecting rod are facing the same direction. Fit the piston and connecting rod in the respective cylinder so that the arrow on the piston top points forward. Use piston ring compressor 885126.

**14**

Screw tight the big end cap as per the marking. Tightening torque: see "Workshop Manual, Technical Data"

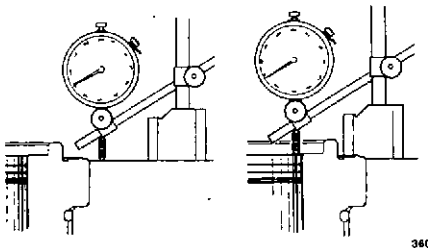
**15**

Turn the flywheel until the piston comes to the top position. Check the piston height over the cylinder block plane.

Place a dial test indicator in a magnetic frame and set the indicator to zero to cleaned cylinder block plane.

Release the magnetic frame and place the indicator tip to the piston.

**Max. piston height over the block plane: "Workshop Manual, Technical Data".**

**16**

Fit the piston cooling nozzle if this has been removed.

**NOTE!** Use new screws.

## Front crankshaft seal, replacement

*Special tools: 2655, 6795, 2656*

**1**

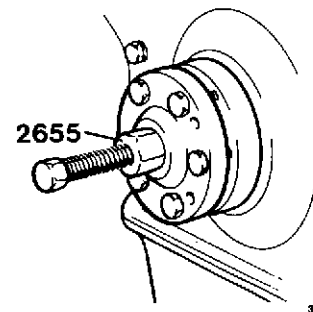
Remove the fan and drive belts.

**2**

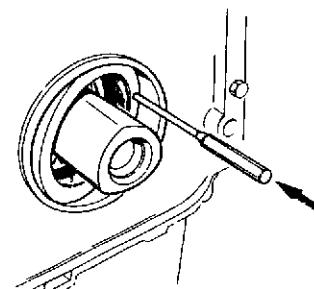
Remove the pulley and the vibration damper.

**3**

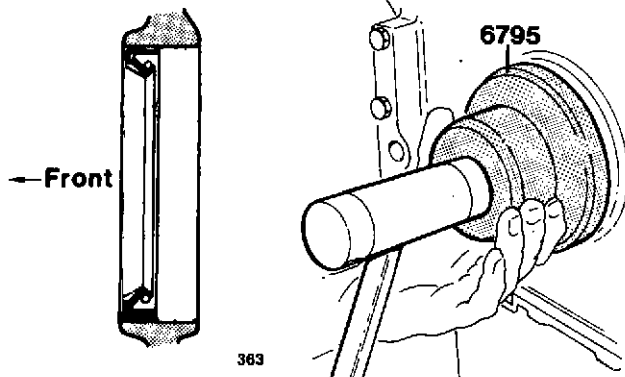
Remove the polygon hub's centre screw, remove the washer, and pull off the hub with extractor 2655.

**4**

Tap in the sealing ring on one side so that it angles out. Carefully bend out the ring with a screwdriver.



- 5**  
Oil in the new sealing ring and fit it with drift 6795.

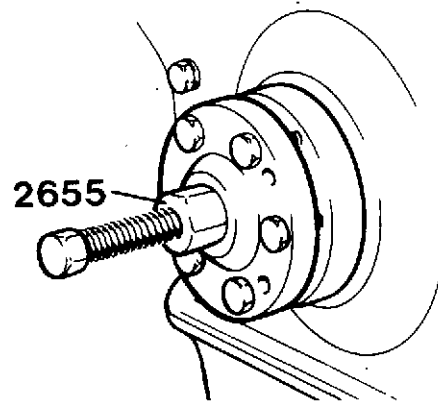


- 6**  
Fit the polygon hub and vibration damper, see "Fitting of timing gear cover".

## Timing gear cover, removing

*Special tool: 2655*

- 1**  
Remove the drive belts for the alternator. Remove the alternator and the bracket.
- 2**  
Remove the fan and the drive belts.
- 3**  
**12 litre engines:** Drain the coolant and remove the pipe between the coolant pump and the radiator hose.
- 4**  
Remove the vibration damper and pulley.  
**NOTE!** The vibration damper must not be exposed to knocks or blows, since its characteristics can be completely changed if the carefully balanced fluid chamber changes form and volume.
- 5**  
Remove the polygon hub's center screw, remove the washer, and pull off the hub with extractor 2655.



- 6**  
Remove the screws which hold the timing gear cover. Do not forget the screws for the oil pan. Carefully tap off the timing gear cover.

**1030ME:** The timing gear cover and the silencer shield should not be separated.

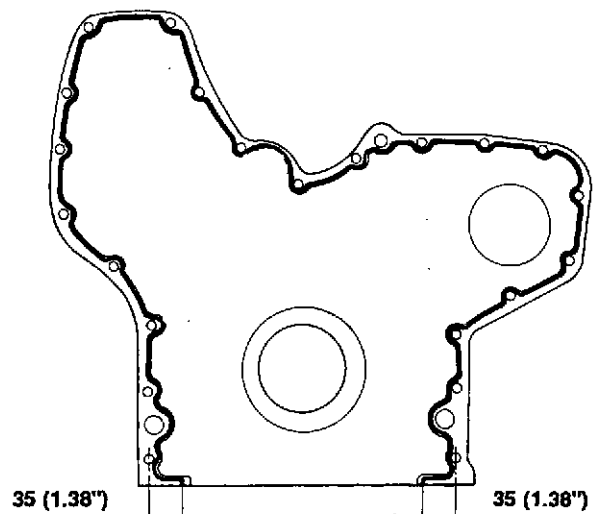
**NOTE!** Observe care so that the pan gasket is not damaged. Otherwise, the oil pan must be removed and the gasket replaced.

## Timing gear cover, fitting

*Special tools: 2656, 115 8959*

For replacement of the front crankshaft seals see page 26.

- 1**  
Clean the mating surfaces. Scrape off all remains of the sealant.
- 2**  
Apply a bead of sealant (1161231-4) on the timing gear cover, see figure. Apply Permatex on the pan gasket.

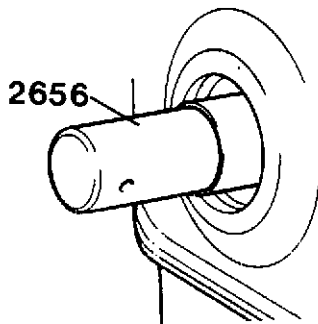


**3**  
Oil in the sealing rings for the crankshaft.

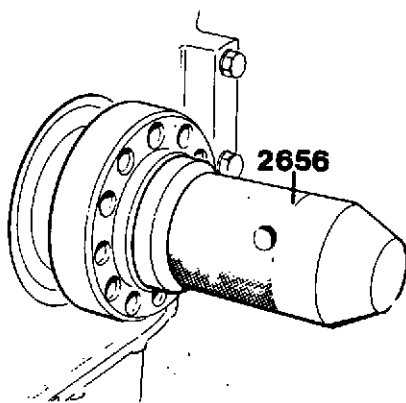
**4**  
Fit the cover within 20 minutes.

Tightening torque: see "Workshop Manual, Technical Data".

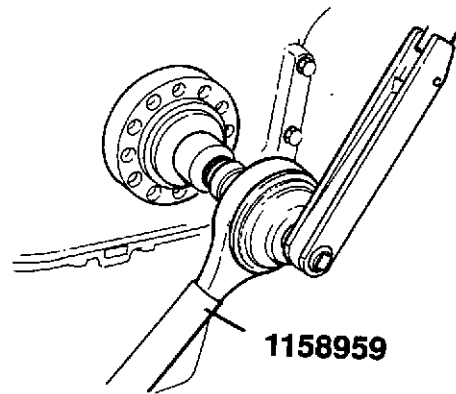
**5**  
Check the polygon hub and its mating surface on the crankshaft. Cutting marks are removed with fine emery paper. Grease in the crankshaft journal with molybdenum disulphide. Fit the centering part for the tool 2656 on the crankshaft journal.



**6**  
Heat the polygon hub to approx. 100°C (212°F). Tap the hub onto the shaft with the aid of the drift 2656.



**7**  
Fit the washer and center screw and tighten the hub while hot.  
Tightening torque: 400 Nm (295 lbf.ft). When the hub has cooled tighten the screw to 550 Nm (406 lbf.ft).



**8**  
Fit the vibration damper and pulley. Tightening torque: see "Workshop Manual, Technical Data".

Fit remaining equipment.

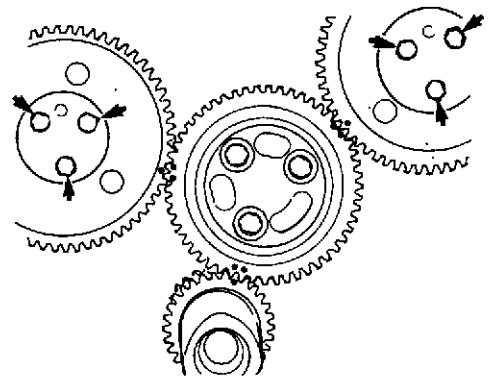
### Timing gears; removing (With the timing gear cover removed)

*Special tool: 2658*

**Warning!** If the crankshaft and camshaft are turned without being synchronized with each other the valves can be damaged.

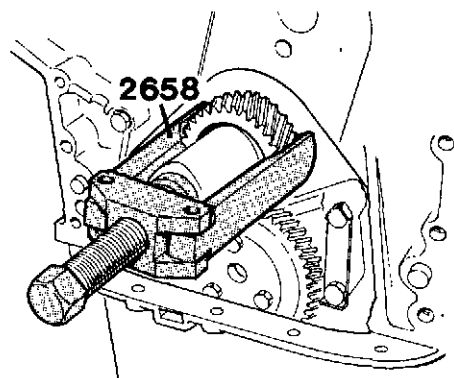
**1**  
Remove the rear valve cover. Turn the crankshaft until the valves for cylinder No. 6 "rock" and the flywheel is at 0°.

**2**  
Remove the screws which hold the camshaft gear and injection pump gear. Remove the gears.



**3**  
Remove the intermediate gear and its bearing journal when the three screws have been released.

- 4**  
Remove the crankshaft gear with the puller 2658.



If the oil pump gear is damaged the oil pump must be removed and the gear replaced.

## Timing gears, inspection

Clean the gears and other parts in the timing gears and inspect. Replace gears which are severely worn or damaged. See "Workshop Manual, Technical Data" for dimensions.

## Timing gears, fitting

*Special tool: 2659*

**Note!** Certain timing gears are nitro-carburated (marked "N" or "NITRO"). They can also be recognized by their flat grey to grey-yellow colour. These gears must not be installed together with earlier, induction hardened gears (marked HT).

Case hardened gears (marked CH) are permitted in all gear combinations.

See also "Service Bulletin" 21-5 no. 5.

**Warning!** If the crankshaft and camshaft are turned without being synchronized to each other the valves can be damaged.

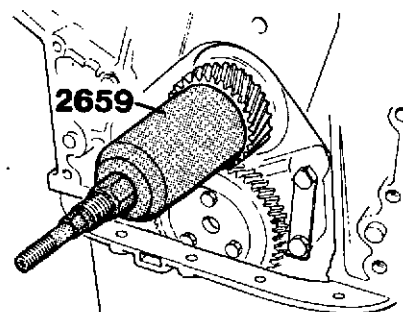
All gears in the timing gears which are of importance for the setting are marked with punch marks opposite the tooth and tooth gap.

See "Workshop Manual, Technical Data" for correct tightening torques!

- 1**  
Check that the crankshaft key is fitted. Fit the crankshaft gear with tool 2659.

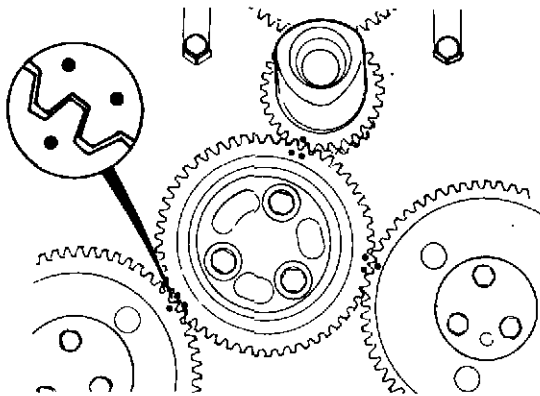
**NOTE!** The larger thread on the tool's spindle fits in the crankshaft. Hold the tool's spindle so that the crankshaft does not turn (with possible valve damage as the result).

**NOTE!** Make sure that the crankshaft gears meshes in the oil pump's middle gear if this is fitted.

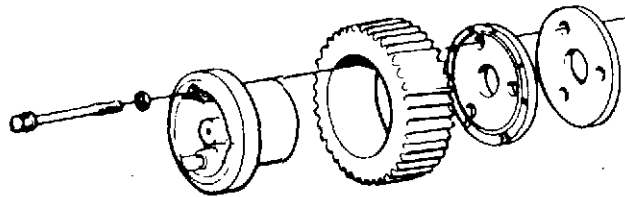


- 2**  
Check that the camshaft gear's guide pin is fitted. Fit the camshaft gear. Do not tighten the screws.

- 3**  
Fit the middle gear as per the markings. The bearing shell and pressure washer are positioned as per fig.

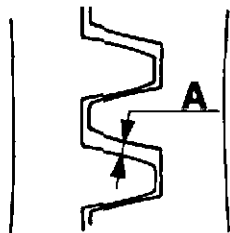


Timing gears, basic setting



Intermediate gear

- 4**  
Check that the guide pin is fitted in the shaft for the injection pump, and fit the pump gear. Make sure that the markings correspond. Tighten the camshaft gear and the pump gear.
- 5**  
Check the axial and the radial clearance of the camshaft. Correct clearance: see "Workshop Manual, Technical Data".
- 6**  
Check the axial and the radial clearance of the intermediate gear. Correct clearance: see "Workshop Manual, Technical Data".
- 7**  
Check the tooth flank clearance on all gears. Correct clearance: see "Workshop Manual, Technical Data".

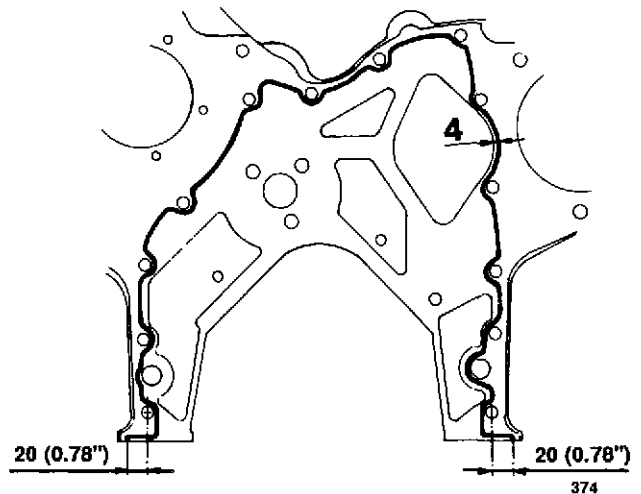


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A. Tooth flank clearance

## Timing gear casing, removing and fitting

- 1**  
Remove the screws and lift off the timing gear casing.
- 2**  
Carefully clean the mating surfaces of the engine block and timing gear casing.
- 3**  
Apply a uniform **2 mm (0.08")** bead of sealant (1161231-4) on the timing gear casing as per the figure.
- 4**  
Fit the timing gear casing **within 20 minutes**. Tighten the screws with **40 Nm (30 lbf.ft)**.



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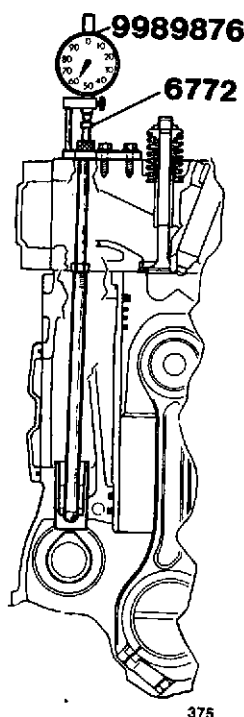
## Camshaft, checking of wear

(With the camshaft fitted)

*Special tool: 6772*

**1**  
Remove the valve covers. Remove the screws for the rocker arm bearing supports and remove the rocker mechanism. Lift out the push rods.

**2**  
Fit the tool 6772 at the front tappet. Adjust the length of the rod on the tool so that it pressures slightly on the tappet.



**3**  
Turn the engine until the rod (tappet) is in its lower position. Check that the rod is tensioned and set the dial test indicator to zero.

**4**  
Turn the engine round until the push rod (tappet) is in its upper position. Read off the dial test indicator and compare with the values in "Workshop Manual, Technical Data".

**5**  
Fit the push rods and rocker arm bridges after all cams have been checked. Adjust the valve clearance.

## Valve timing, checking

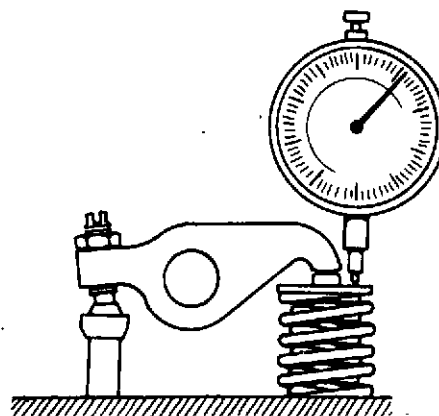
**1**  
Remove the front valve cover. Turn the crankshaft until the valves for cylinder No. 1 rock. Turn the crankshaft in the opposite direction of rotation until the inlet valve is fully closed. Temporarily adjust the valve clearance for the inlet valve to  $\pm 0 \text{ mm}$  ( $\pm 0''$ ).

**2**  
Place a dial test indicator with the measuring tip to the upper valve washer. Fit the clock with approx.  $5 \text{ mm}$  ( $0.20''$ ) pretensioning.

**3**  
Observe the indicator while another person continues to turn the engine round by hand in the direction of rotation. The indicator gives a reading when the inlet valve begins to open. Set the indicator's 1/100 scale to zero at exactly this opening point.

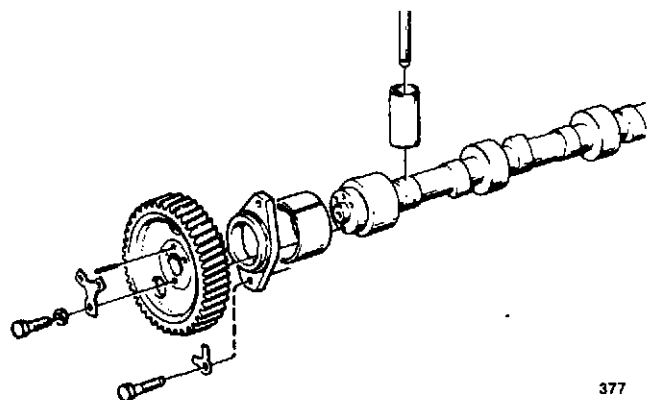
**4**  
Continue to turn the engine past the  $0^\circ$  marking on the flywheel until the marking for  $10^\circ$  after T.D.C. Make sure that the degree setting is opposite the flywheel cover's dial point.

**5**  
Check that the dial test indicator reading corresponds to the value given in "Workshop Manual, Technical Data".



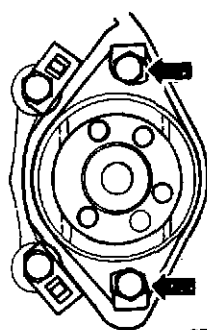
## Camshaft, removing

Special tools: 2655, 8079

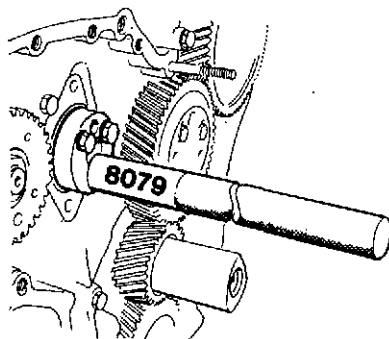


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- 1 Remove the airfilter with bracket and connection pipe. Remove the connection pipe between the turbocharger and the aftercooler (TWD only)
- 2 Remove the valve covers.
- 3 Release and remove the rocker arm mechanism.
- 4 Remove the push rods.
- 5 Release and remove the three inspection covers opposite the tappets. Remove the tappets and place them in order on a rack.
- 6 Carry out the work as per items 1 to 6 under the heading "Timing gear cover, removing".
- 7 Remove the camshaft gear.
- 8 Remove the intermediate gear.
- 9 Remove the flange and lift out the camshaft with the aid of 8079.



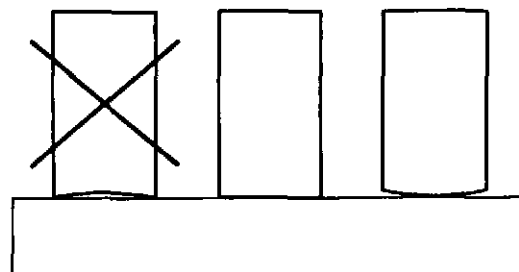
379



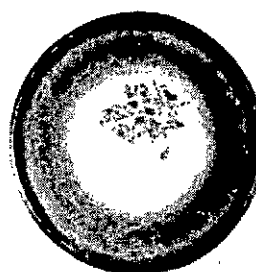
378

## Camshaft and tappets, inspection

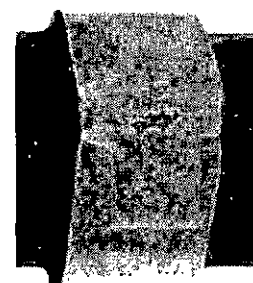
Check with a steel ruler that the contact surface of the tappets to the camshaft is spherical (convex). It may also be completely flat, but absolutely not concave. If there is a visible light aperture in the middle of the lift surface between ruler and tappet the tappet shall be replaced.



Checking the tappets



A



B

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Slight pitting damage on tappet (A) and camshaft (B).

**NOTE!** If the tappet is worn across the lifting surface the tappet shall be scrapped. The groove shows that the tappet has not rotated. A dark stripe around the outside of the lifter face indicates that the surface is worn down.

It is the condition of the tappets that determines if checking of camshaft wear is necessary.

Check the tappets with respect to pitting damage. Pitting damage can occur for many reasons. The damage consists of small metal particles which loosen from the hardened surface. Tappets and camshafts with slight pitting damage can be re-fitted. It has been proved that such damage seldom becomes worse.

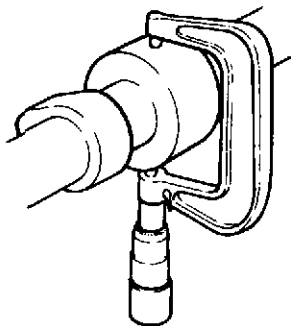
Check the bearing races and cam curves of the camshaft for wear. The cams may, for example, be angularly worn in an axial direction. This can in less serious cases be adjusted by grinding the cams. Replace the camshaft in the event of further damage or wear. When replacing the camshaft all the tappets must also be replaced.

## Camshaft, measurement

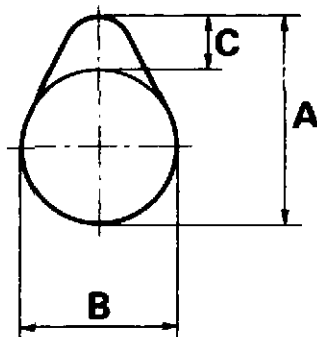
See "Workshop Manual, Technical Data", for wear tolerances!

Measure the camshaft's bearing races with a micrometer.

The straightness of the shaft is checked via indicating. Max. radial throw relative to the end bearings: **0.04 mm (0.0016")**. Lift height is measured with sliding calipers.



Measurement of bearing races



Measurement of camshaft lift C  
 $C = A - B$

Measurements for camshaft and camshaft bearings are to be found in "Workshop Manual, Technical Data".

An estimation of cam wear can be obtained without removing the camshaft. See "Checking of cam wear".

## Camshaft bearings, replacement

The bearings are pressed in their seats and must be line bored after being pressed in. The replacement of camshaft bearings can therefore only take place in connection with a complete reconditioning of the engine.

Check when pressing in the bearings that the oil holes align opposite the corresponding oil channels in the block.

## Camshaft, fitting

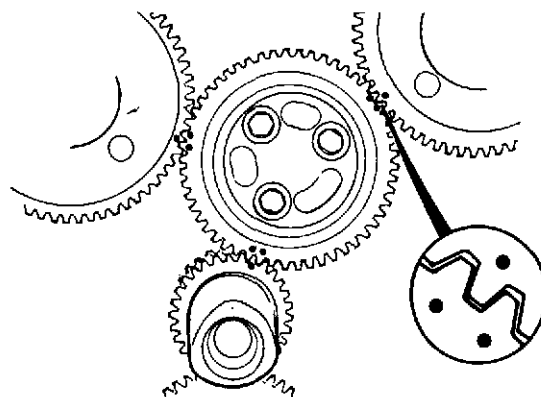
*Special tools: 8079, 2656*

**1**  
Oil in the camshaft's bearing races and carefully lift the camshaft into position so that the bearings are not damaged. Use tool 8079.

**2**  
Fit the flange for the camshaft. Tighten the screws with **40 Nm (30 lbf.ft)**.

**3**  
Turn the engine until the No 1 piston is in T.D.C. on the compression stroke ( $0^\circ$  on the flywheel).

**4**  
Check that the camshaft gear's guiding pin is fitted. Fit the camshaft gear and intermediate gear so that the markings correspond. Tightening torque, see "Workshop Manual, Technical Data".

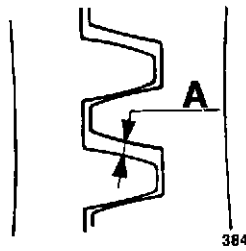


Timing gears, basic setting

**5**  
Check the axial and the radial clearance of the camshaft. Correct clearance: see "Workshop Manual, Technical Data".

**6**  
Check the axial and the radial clearance of the intermediate gear: Correct clearance: see "Workshop Manual, Technical Data".

- 7**  
Check the tooth flank clearance. See "Workshop Manual, Technical Data"



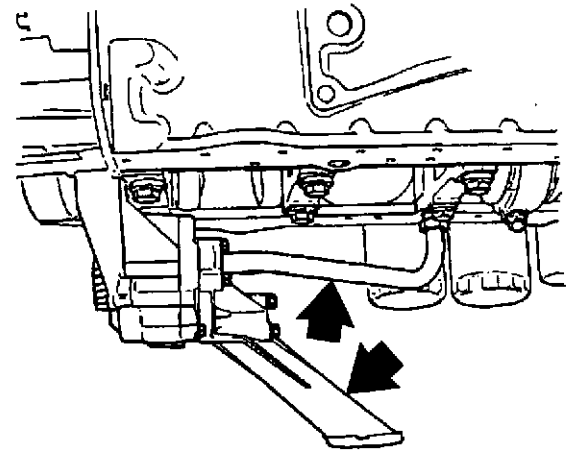
Tooth flank clearance (A)

- 8**  
Fit the timing gear cover. See "Timing gear cover, assembly".
- 9**  
Lubricate the contact surface of the tappets to the camshaft with molybdenum disulphide and oil in the tappets bore in the cylinder block. Install the tappets in the correct order.
- 10**  
Install the push rods and rocker mechanism.
- 11**  
Adjust the valves, and fit the valve covers.
- 12**  
Fit the remaining equipment. Where necessary top up with lubricant and coolant. Test run the engine.

## Crankshaft, removing (With engine removed)

*Special tool: 2655*

- 1**  
Drain the oil.
- 2**  
Remove the oil pan.  
Remove the oilstrainer and the pressure pipe for the oil pump.



Engine with forged oil strainer

- 3**  
Remove the crankshaft pulley, vibration damper, polygon hub and timing gear cover. See "Timing gear cover, removing".
- 4**  
Remove the flywheel and flywheel cover.
- 5**  
Remove the main bearing and big end caps. (The lubricating oil pump is removed together with the front main bearing cap). Lift out the crankshaft.

## Crankshaft

The crankshaft is nitro-carburized.

A nitro-carburized crankshaft has a greater resistance to fatigue and wear than an induction-hardened crankshaft.

### Inspection

The inspection of the crankshaft must be extremely thorough to avoid unnecessary overhauling. To determine overhauling requirements, the following applies:

**A. Measure the bearing journals and pins for out-of-roundness, wear and taper.** See "Workshop Manual, Technical Data".

**B. Assess the surface damage.**

For nitro-carburized shafts, the following applies:

What on an induction-hardened crankshaft may be regarded as scoring due to dirt can in the case of a nitro-carburized shaft be the normal surface finish as on a new crankshaft. The markings show up very clearly on a shaft that has been in use because of the shiny bearing surfaces. Very small particles can loosen from the thin surface layer after the shaft has been in use for some time.

This phenomenon is easily confused with scoring caused by dirt, but close inspection will show that the marks do not go entirely round the bearing journal and have uneven edges. These slight defects do not necessarily require the regrinding of the crankshaft.

Usually it is enough to polish the bearing journals lightly with emery cloth and fit new bearings.

**C. Measure crankshaft alignment (throw).**

The crankshaft should be placed on either a pair of V-blocks, under 1st and 7th main bearing journals, or fixed between stocks. Measurements should be made on the 4th main bearing.

The following applies with regard to the values measured:

**1**  
Less than **0.2 mm (0.0079")** — no alignment necessary if wear and surface damage do not necessitate regrinding.

**2**  
Between **0.2–0.7 mm (0.0079–0.0276")** — can be aligned, but care must be taken to avoid over-alignment.

**Note!** Do not align more than absolutely necessary.

**3**  
More than **0.7 mm (0.0276")** — the shaft must be scrapped due to risk of cracking during alignment.

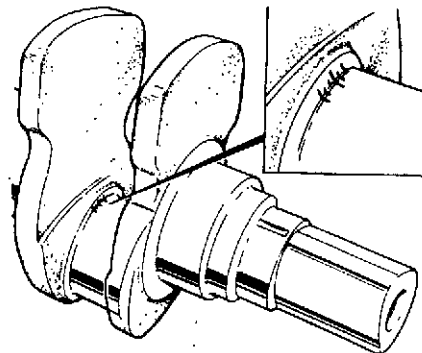
**D. Checking for cracks.**

Checking must be carried out after alignment and before and after grinding.

To check, use a magnetic powder test of type Magna-glo, i.e. fluorescent powder which can be seen under ultraviolet light.

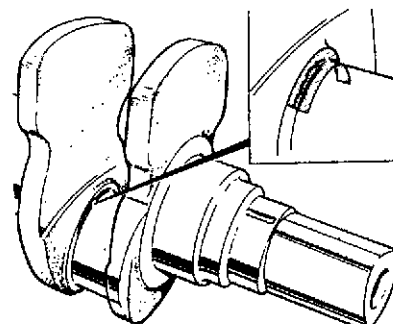
Refer to crack detection, manufacturer's instructions on the method to be adopted. When assessing the cracks, the following applies:

**1**  
The shaft must be scrapped if there are longitudinal cracks on the journals and in the fillets.



386

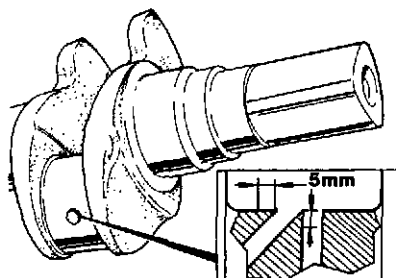
**2**  
The shaft must be scrapped if there are crosswise cracks within the marked zone. This applies to both crank pins and main bearing journals.



387

3

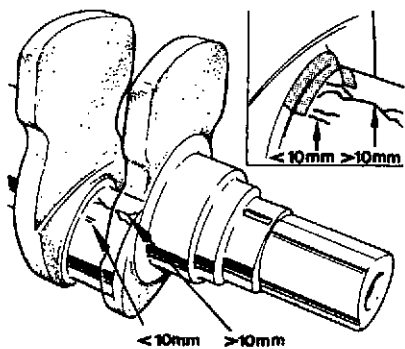
The shaft must be scrapped when cracks longer than **5 mm (0.2")** are adjacent to the area around the oil holes. Cracks shorter than **5 mm (0.2")** can be removed by grinding.



388

4

The shaft must be scrapped when cracks are longer than **10 mm (0.4")** outside the marked area. Isolated cracks less than **10 mm (0.4")** are acceptable.



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## Grinding

When overhauling, keep to the following routines:

1

Alignment (only as required).

2

Check for cracks.

3

Measure the bearing journals, see "Workshop Manual, Technical Data".

4

Grind to undersize as specified in "Workshop Manual, Technical Data".

5

Check for cracks.

6

Re-nitro-carburize after grinding to undersize more than **0.50 mm (0.02")**. Nitro-carburizing can be done using the gas or salt method according to the experience of the operator carrying out the treatment.

7

Check for throw after nitro-carburizing.

8

Align if necessary (throw between **0.2–0.7 mm (0.0079–0.0276")**).

9

Carry out a magnetic powder test.

10

The crankshaft must be carefully lapped and cleaned after nitro-carburizing. The crankshaft must always be thoroughly cleaned after overhauling.

In order that all oil drillings are cleaned efficiently, late production crankshafts are fitted with threaded plugs in each crank web. These plugs should be removed during the cleaning procedure.

## Crankshaft, fitting

*Special tool: 2656*

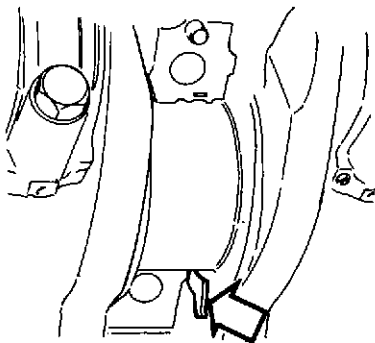
**1**  
Check the cleaning of the crankshaft's channels and bearing surfaces, cylinder block and cap.

Check the bearing shells. Replace worn bearing shells.

**2**  
Place the main bearing and big end journals in their places. Make sure that the lubricating holes in the upper bearing shells come opposite the oil channels and that the bearing shells and their mating surfaces have no burrs or upendings. Oil in the bearings.

**3**  
Lubricate the shaft journals with engine oil and lift the crankshaft carefully in place. Make sure that the timing gear marking corresponds if the gear is in place.

**4**  
Fit the thrust washers for the middle main bearing (axial bearing). The washers can only be fitted in one position in the fitting socket.



Guide for axial bearing

**5**  
Fit the main bearing cap. The middle cap is provided with a recess, which is turned so that it comes over the guide pin. This ensures that the bearing cap is always placed in the correct position in its axial plane. Note the number of the main bearing cap, which indicates positioning.

**6**  
Fit the main bearing screws when the threads have been oiled. Tightening torque: see "Workshop Manual, Technical Data".

**7**  
Check the axial clearance of the crankshaft (see "Workshop Manual, Technical Data").

**8**  
Check that the "Front" marking on the connecting rods faces forwards.

**9**  
Screw tight the big end journals as per the markings. Tightening torque: see "Workshop Manual, Technical Data"

**10**  
Fit the oil strainer, delivery pipe and oil pan, see "Lubrication system".

## Main bearings, replacement

(Crankshaft not removed)

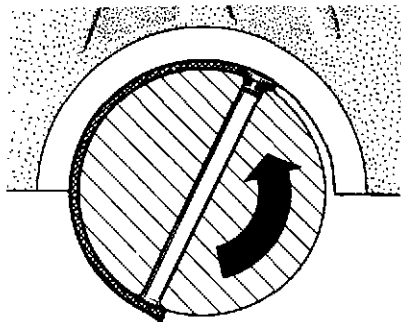
**1**  
Drain the engine oil. Remove the oil pan.

**2**  
Release the main bearing screws and remove the main bearing cap with bearing shell. The front main bearing cap can be removed together with the lubricating oil pump.

**3**  
Release the injectors so that the engine is easier to rotate.

- 4** Turn the crankshaft until its oil hole is exposed. Insert a stud in the oil hole. The stud must be of such a dimension that it brings the upper bearing shell around, when the crankshaft is rotated, see fig.

**NOTE!** The engine is rotated in its normal direction of rotation when rolling out the bearing shell.



Rear view

- 5** Wipe the shaft journal clean and examine for damage. If there is severe wear or excessive ovality the crankshaft must be ground.

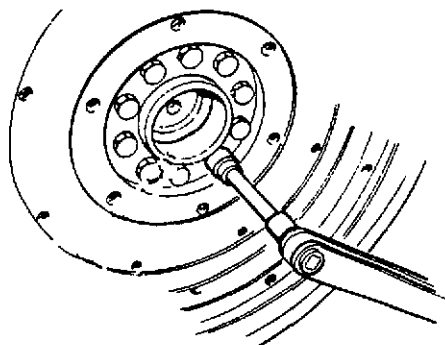
- 6** Fit the new bearing shells in the same way as they were removed. The shaft is rotated counter-wise to the direction of rotation. Check that the pressed out lugs of the shells engage correctly. Fit the lower bearing shell and cap. Tighten the screws. See "Workshop Manual, Technical Data", for correct tightening torque.

- 7** Fit the oil pipes and oil pan; see "Lubrication system".

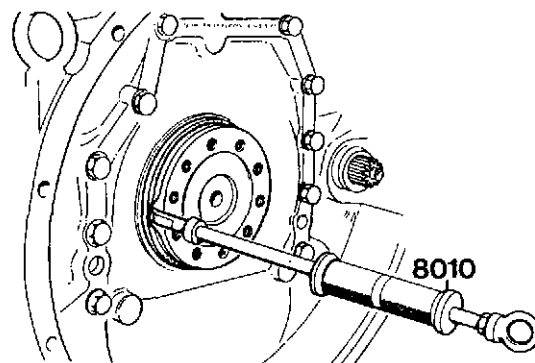
## Rear crankshaft seal, replacement

*Special tools: 8010, 6088, 2000*

- 1** Remove the flywheel.



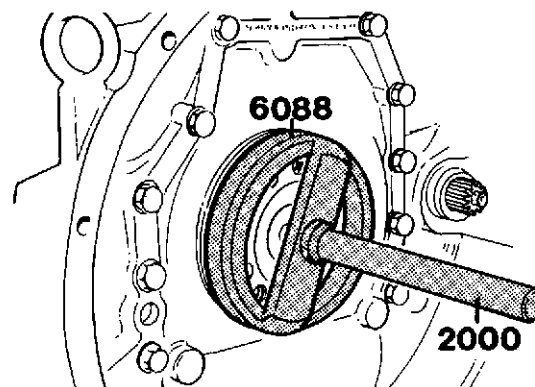
- 2** Remove the crankshaft seal with tool 8010.



- 3** Clean the mating surfaces between the crankshaft and flywheel carefully. Clean also the contact surface of the sealing ring in the cover.

- 4** Oil in the new sealing ring and fit it with the aid of drift 6088 and handle 2000.

**Note!** If the sealing surface on the crankshaft is worn, it is necessary to install the sealing ring somewhat deeper than original.



- 5** Install the flywheel. Tightening torque: see "Workshop Manual, Technical Data".

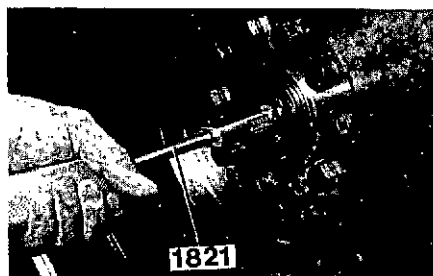
## Flywheel bearing, changing (Clutch removed)

Special tools, mobile engines: 1801, 1821, 2564  
stationary engines: 2269

### Mobile engines

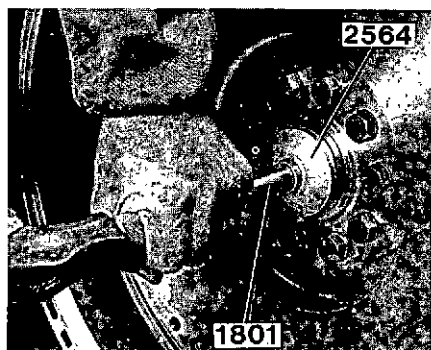
1

Remove the flywheel bearing using tool 1821.



2

Fit the new flywheel bearing using drift 2564 and handle 1801.



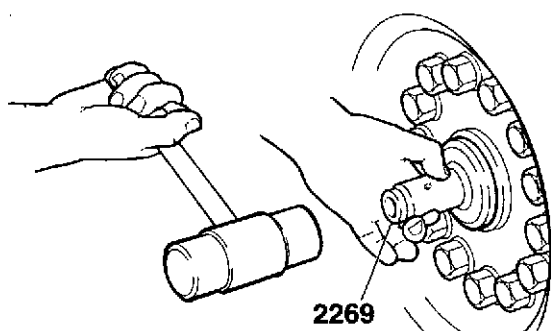
### Stationary engines

1

Due to hard fit, the flywheel must be removed to allow the flywheel bearing to be removed. Use a suitable drift to knock out the bearing.

2

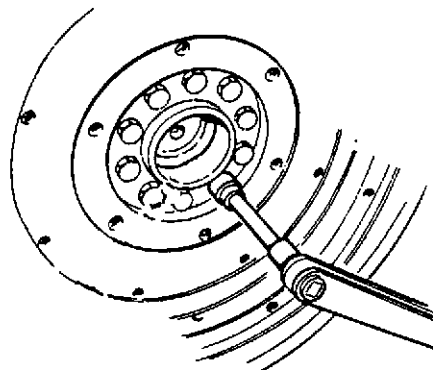
Fit a new flywheel bearing using 2269 and a plastic mallet.



## Flywheel ring gear, replacement

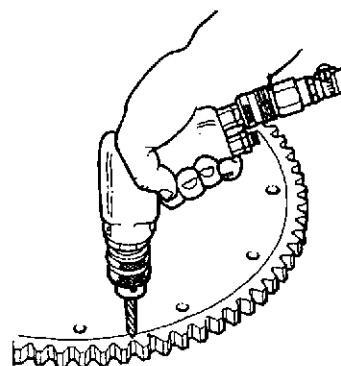
1

Remove the flywheel.



2

Drill 1-2 holes in a tooth gap on the gear flange. Crack the ring gear at the drilled hole with a chisel, after which the ring gear can be removed.



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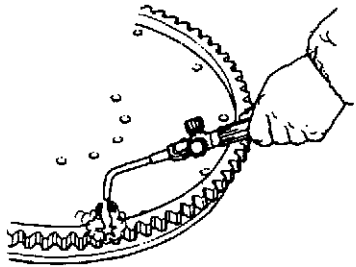
3

Brush the mating surface clean with a wire brush.

4

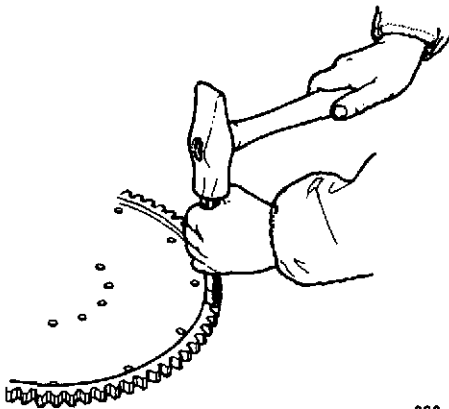
Heat up the new ring gear with a welding torch. Heat up the ring uniformly. Observe care so that the ring does not become too hot and thus loses its temper.

To check the heating, the ring can be polished bright at several places, whereby these surfaces become blue at the correct temperature **180-200°C (356-392°F)**, whereby the heating shall be discontinued.



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- 5**  
Place the hot ring gear on the flywheel. Tap on the ring with a soft drift and a hammer. Check that it is seated correctly.



398

- 6**  
Clean the mating surfaces between the crankshaft and the flywheel carefully.

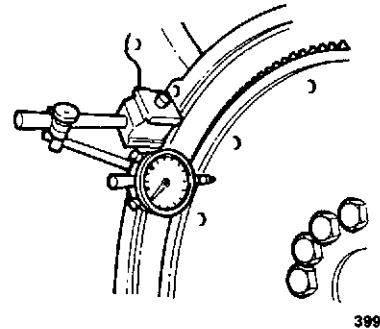
- 7**  
Check, where necessary, if the sealing ring for the crankshaft requires replacing.

- 8**  
Fit the flywheel. Tightening torque: see "Workshop Manual, Technical Data".

## Flywheel, checking for warp

*Special tool: 998 9876, 9696*

- 1.**  
Mount the dial indicator in a magnetic stand and set the dial indicator to zero.



399

- 2**  
Crank the flywheel round, noting the max. and min. values.

- 3**  
The difference must not exceed **0.15 mm (0.006")** on a measuring radius of 150 mm (6").

In the case of excessive warp, remove the flywheel and check for dirt or unevenness between the flywheel and the crankshaft contact face.

## Flywheel casing, checking for warp

Special tool: 998 9876, 9696

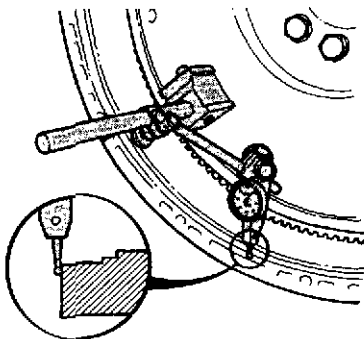
**1**  
Clean the flywheel and flywheel casing.

**2**  
Fit a dial indicator to a magnetic stand.  
Mount the magnetic stand on the flywheel with the probe of the dial indicator against the outer edge of the flywheel casing.

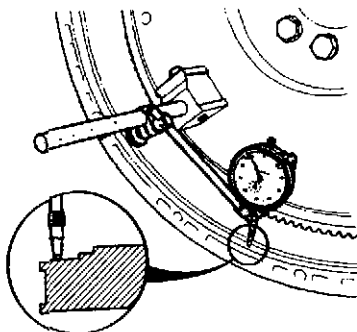
Crank the flywheel round and calculate the difference between the max. and min. values.

Transfer the magnetic stand and dial indicator to the opposite side of the flywheel and carry out the same measurement procedure.

The difference between these two results must not exceed **0.20 mm (0.008")**.



**3**  
Mount the magnetic stand on the flywheel with the probe of the dial indicator against the inner edge of the flywheel casing.



Crank the flywheel round noting the max. and min. values.

The inner edge of the casing must be concentric with the flywheel within **0.25 mm (0.010")**.

**4**  
Should any of the readings in points 3 and 4 be exceeded, check the contact of the flywheel casing against the cylinder block.

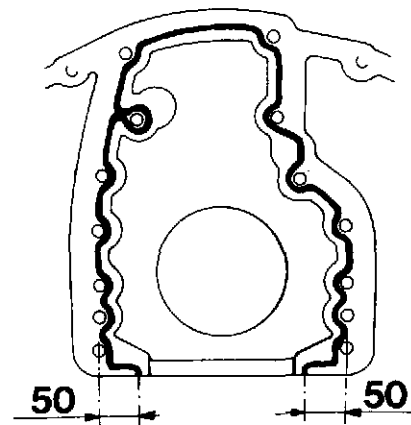
## Flywheel casing, removing/fitting

(With flywheel removed.)

**1**  
Remove the flywheel casing from the cylinder block.

**2**  
Clean the sealant off both the cylinder block and the flywheel casing.

**3**  
Apply a uniform **2 mm (0.08")** thick bead of sealant, Part No. 1161231-4, as per the diagram, on the flywheel cover.



Application of sealant (50 mm/2")

**4**  
Fit the flywheel casing on the cylinder block within 20 min. Tightening torque: see "Workshop Manual, Technical Data".

# Lubricating system

## Design and function

### General

The engine is pressure lubricated by a gear-driven pump.

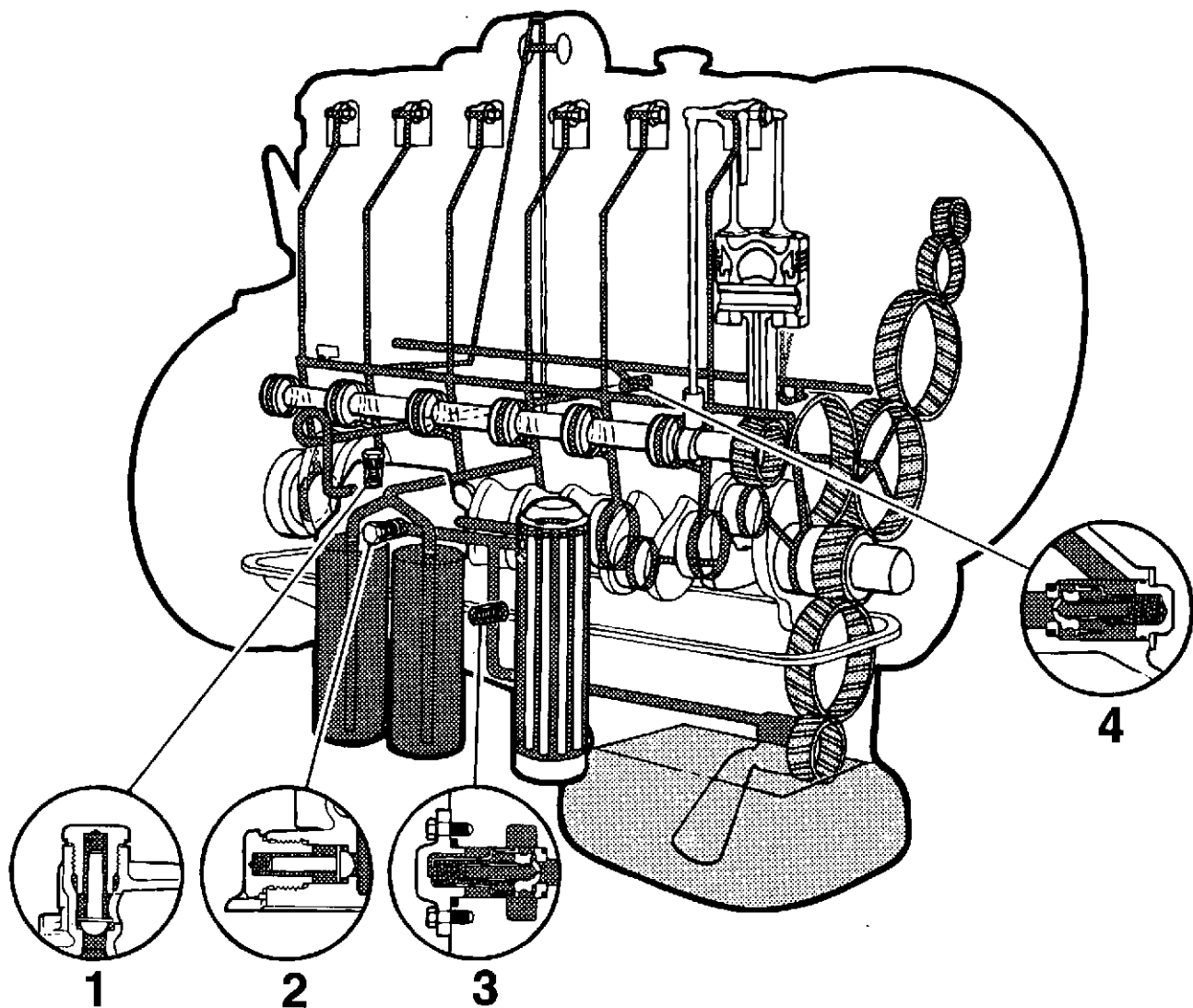
The lubricating oil is cleaned by two full-flow filters.

The cooling of the oil is carried out by a round-type oil cooler which is mounted on the oil filter bracket.

The system incorporates four valves:

1. Overflow valve for oil filter
2. By-pass valve for oil cooler (marked SIDE)
3. Reduction valve
4. Piston cooling valve

The illustration shows TAD 1030.



The lube oil pump forces the oil through the oil cooler and the two full-flow filters before directing it out to all the lubricating points of the engine via ducts.

The lubrication system incorporates four valves:

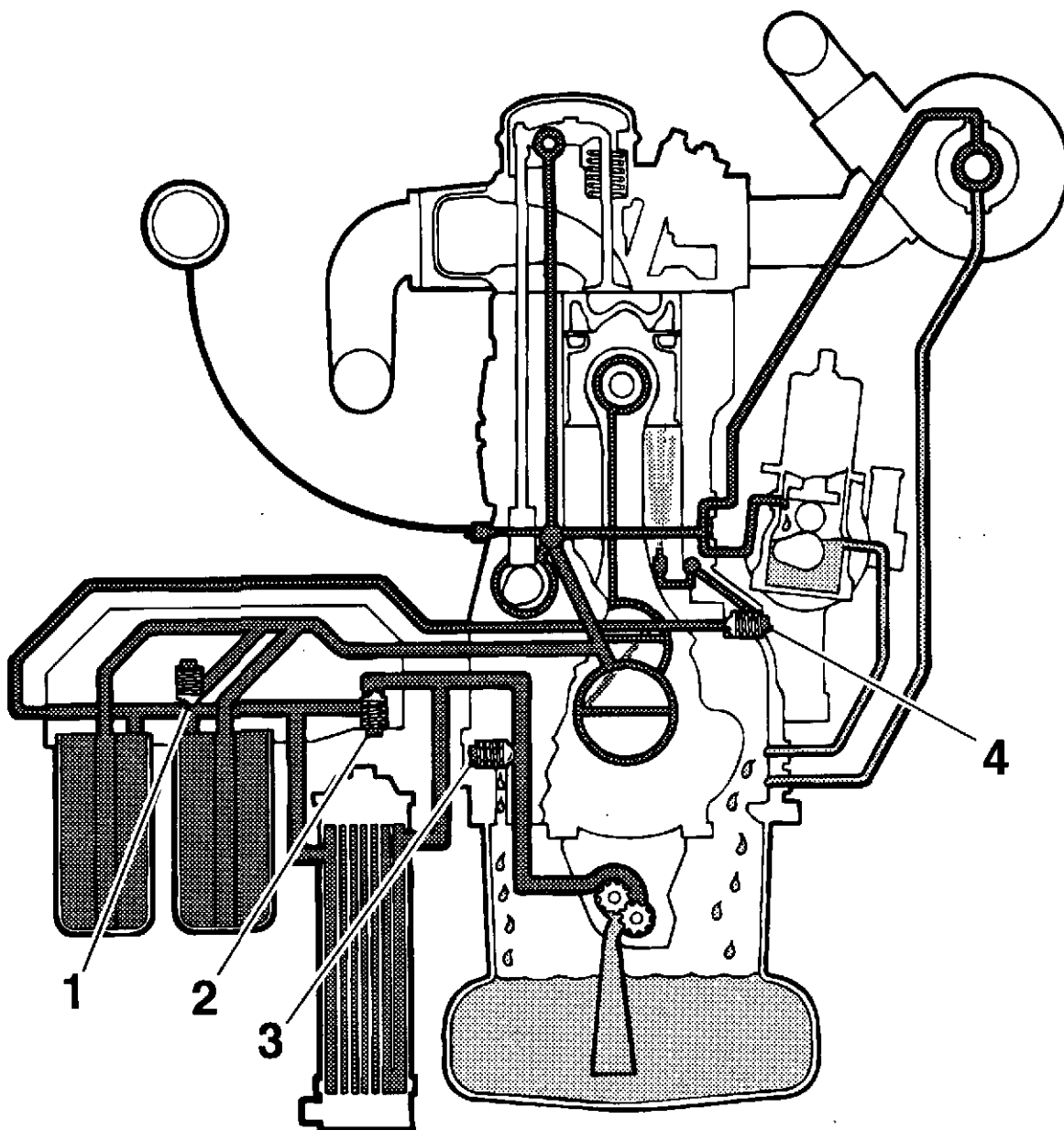
1. An overflow valve for the oil filters opens to guarantee lubrication if the filters are blocked.
2. The by-pass valve opens when pressure drop across the oil cooler becomes too high, for example in connection with cold starting. When the valve opens, oil is directed past the oil cooler to reach the engine lubrication points more quickly.

3. The reduction valve opens when the lubricating oil pressure becomes too high and directs any surplus oil back to the oil sump.

4. The piston cooling valve opens when engine revs have increased to slightly above idling speed and when oil pressure has increased. This causes oil to flow to the piston cooling nozzles via a drilling in the engine block.

Six nozzles are connected to the piston cooling ducts, one for each piston and from these, oil is sprayed against the underside of the pistons.

The illustration shows TAD 1030.



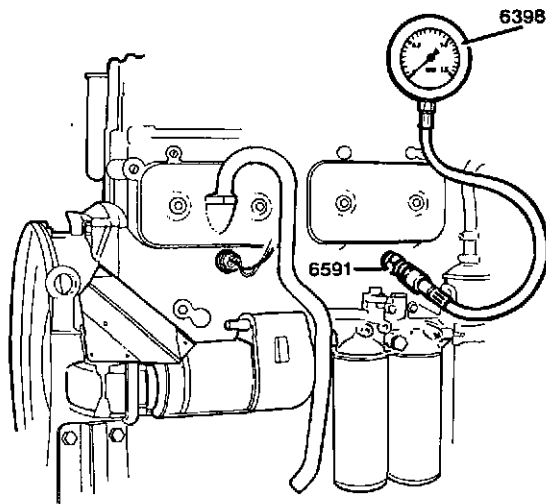
## Service procedures

### Oil pressure, checking

Special tools: 6398, 6591

1

Remove the oil pressure sensor and fit nipple 6591. Connect the manometer 6398, see figure. The oil pressure shall be **300-500 kPa (43.5-72.5 psi)** during operating revs and at operating temperature.



2

If the oil pressure goes below **150 kPa (21.75 psi)** when the engine is warm and idling, this will not imply a problem as long as the pressure does not fall below **300 kPa (43.5 psi)** at working speed.

If the oil pressure is too low the reducing valve should be replaced first, after which the oil pressure should be re-checked.

### Oil pump, removing

1

Drain the oil from the engine.

2

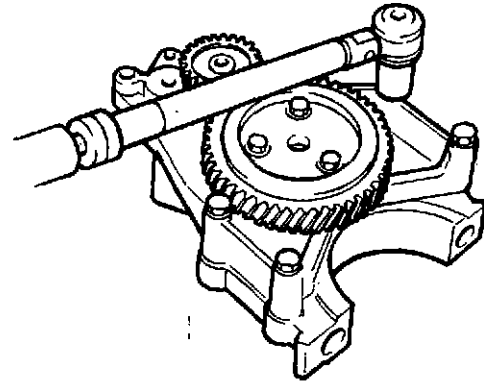
Remove the oil pan.

3

Remove the oil pipes.

4

Unscrew the front main bearing cap and lift off the cap together with the oil pump. Unscrew the oil pump from the cap.



### Oil pump, reconditioning

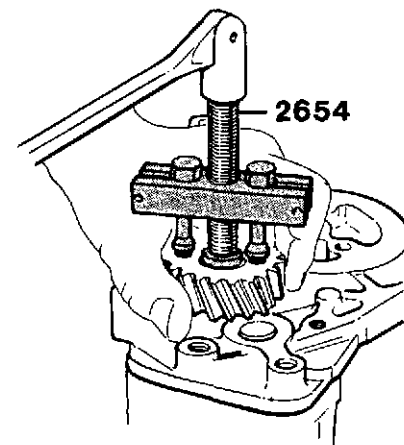
(With removed lubricating oil pump)

Special tools: 2654, 6849, 6850

Observe care during removing so as not to damage the polished surfaces.

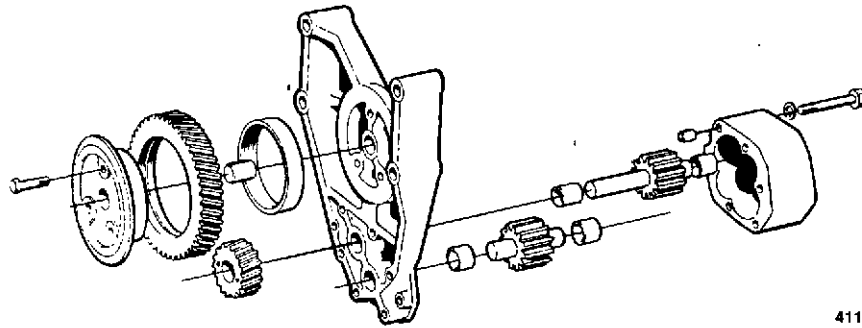
1

Pull off the drive gear with extractor 2654.



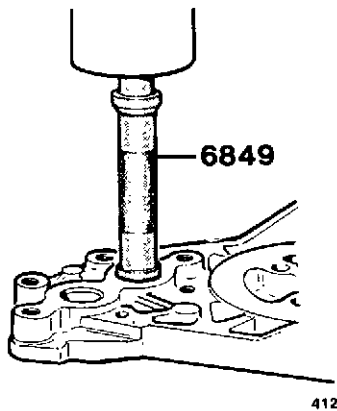
410

Removing the drive gear



411

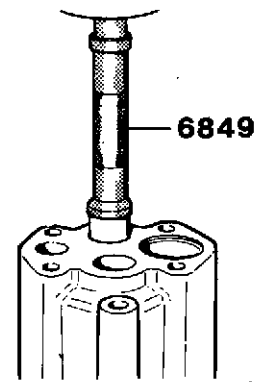
- 2**  
Remove the intermediate gear.
- 3**  
Remove the screws for the pump housing and remove the housing.
- 4**  
Remove the pump wheel from the pump bracket.
- 5**  
Check the pump housing for scratches and wear, and also tightness between bracket and pump housing. In the event of leakage the mating surfaces will be black.
- 6**  
Press out the bushings of the bracket and pump housing with tool 6849.



412

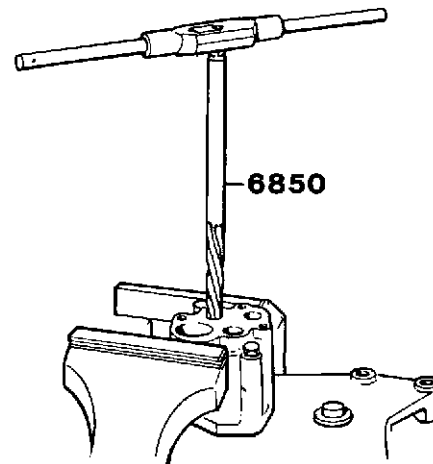
- 7**  
Press in new bushings in the pump housing and bracket with tool 6849.

- 8**  
Tighten the pump housing to the bracket again to enable guiding when reaming the bushings.



413

- 9**  
Ream the bushings in the pump housing and bracket with tool 6850.



414

- 10**  
Release the screws and remove the pump housing from the bracket.

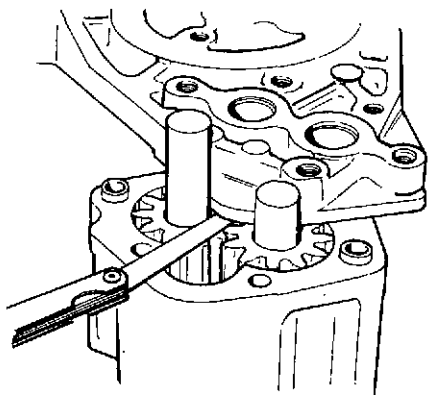
**11**

Clean the pump housing and bracket carefully from reaming shavings.

**12**

Fit the new pump gear in the pump housing and check the axial clearance of the gear with a feeler gauge.

The correct clearance shall be **0.07-0.15 mm (0.0028 - 0.0059")**.

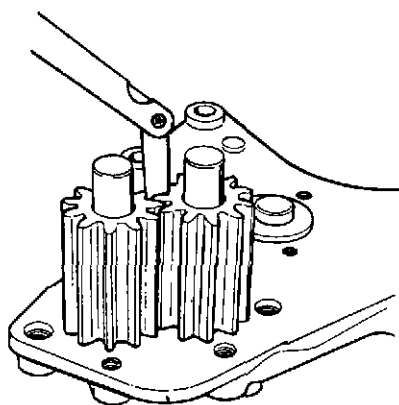


415

Checking of axial clearance

**13**

Check the gear flank clearance with a feeler gauge. The correct clearance shall be **0.15-0.30 mm (0.0059-0.0118")**.

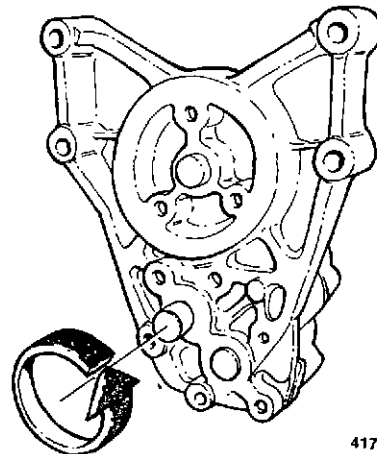


416

Checking of gear flank clearance

**14**

Move over the pump gear to the bracket. Place the pump housing on the bracket and tighten. Check that the pump gear runs easily and does not snatch by turning the pump shaft a full turn.



417

**15**

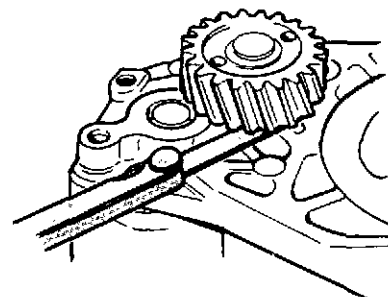
When reconditioning a pump of previous version where the pump shaft and drive gear have grooves for keys, the drive gear shall also be replaced.

**16**

Heat the oil pump's drive gear to **180±20°C (356±36°F)**, and then tap the gear on the shaft.

**NOTE!** The clearance between drive gear and pump bracket shall be **1.6±0.2 mm (0.063±0.008")**.

**NOTE!** On older pump versions there is an axial washer between drive gear and bracket. This washer is excluded during reconditioning.



418

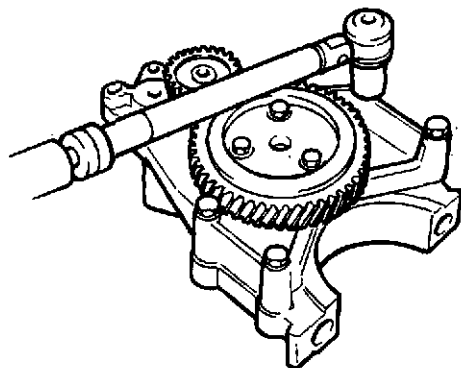
**17**

Fit the intermediate gear. Tightening torque: see "Workshop Manual, Technical Data".

## Oil pump, fitting

All 10 ltr. engines and 12 ltr. engines with forged oil strainer

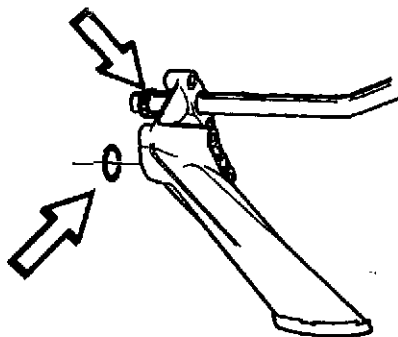
**1**  
Screw tight the main bearing cap on the oil pump's bracket. Tightening torque: see "Workshop Manual, Technical Data".



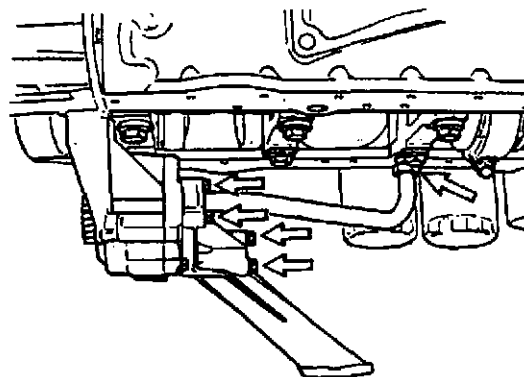
**2**  
Clean the bearing shell and shaft journal. Oil in the bearing shell and screw tight the cap. Tightening torque: see "Workshop Manual, Technical Data".

**3**  
Check the delivery pipe for cracks at the ends. Replace if necessary.

**4**  
Fit the oil strainer on the delivery pipe and fit new sealing rings



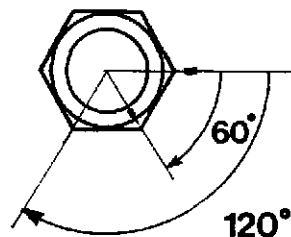
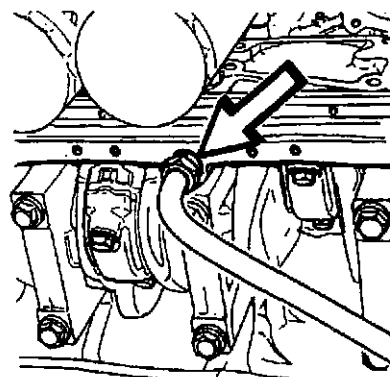
**5**  
Fit the oil strainer and the delivery pipe. Tighten the oil strainer to the oil pump.  
Tightening torque, see "Workshop Manual, Technical Data".



**6**  
Tighten the union in the cylinder block approx. 10 Nm  
For a new pipe, tighten the union a further 120°.

For a pipe that was previously fitted, the union should only be tightened a further 60°.

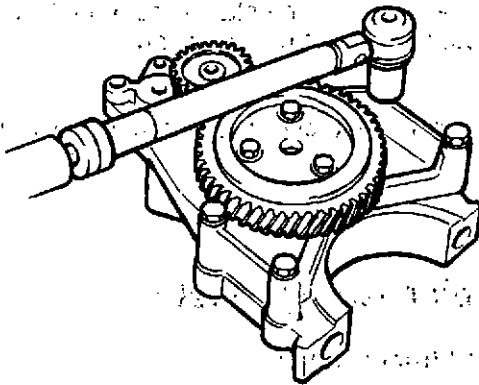
Check that the pipe is securely fitted.



# Oil pump, fitting

## 12 ltr. engines with steel oil strainer

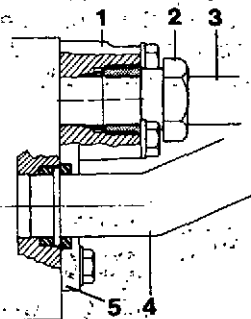
**1**  
Screw tight the main bearing cap on the oil pump's bracket. Tightening torque: see "Workshop Manual, Technical Data".



**2**  
Clean the bearing shell and shaft journal. Oil in the bearing shell and screw tight the cap. Tightening torque: see "Workshop Manual, Technical Data".

**3**  
Check the delivery pipe for cracks at the ends. Replace if necessary.

**4**  
Thread on the fitting ring together with the screw cap (2) and middle part (1) on the delivery pipe.



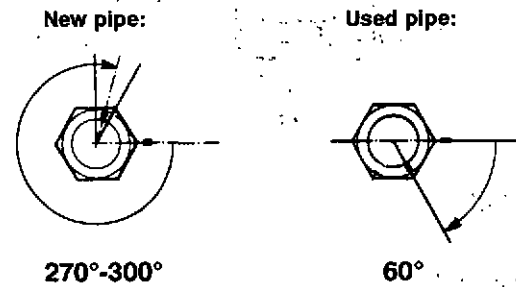
421

- Attachment of oil pipes in oil pump
- 1. Middle part
  - 2. Pipe coupling
  - 3. Pressure pipe
  - 4. Suction pipe
  - 5. Flange

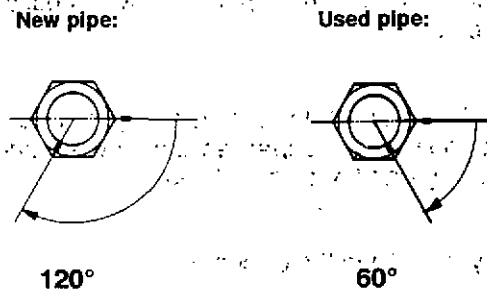
**5**  
Place the clamp and rear screw cap on the pipe. Oil in the screw caps and place the pipe in position.

**6**  
Press the pipe into the block until it reaches the bottom and screw in the union by hand until it stops.

**7**  
Screw tight the middle part to the pump. Screw in the coupling in the middle part by hand until it stops. Tighten the coupling:

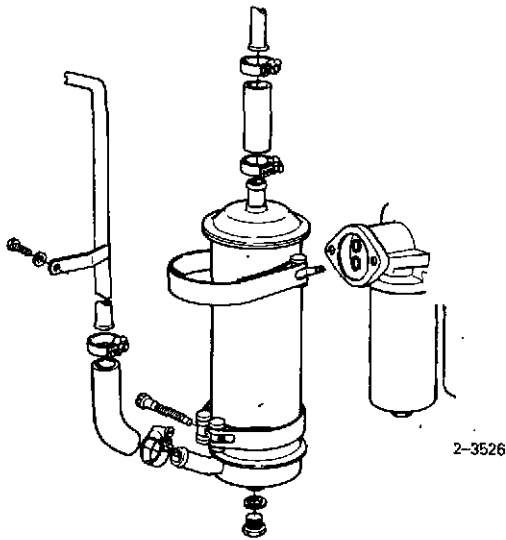


**8**  
Tighten the coupling in the block:  
New pipe: 120°  
Used pipe: 60°  
Tighten the clamp.



**9**  
Fit the suction pipe using new sealing rings.

## Oil cooler, changing



### Removing

- 1 Drain the coolant.
- 2 Place a container under the oil cooler.
- 3 Slacken the oil cooler bottom plug.
- 4 Disconnect the coolant upper and lower hoses from the oil cooler.
- 5 Remove the oil cooler lower tensioning band. Slacken the outer bolt for the upper tensioning band and fold the tensioning band over the oil cooler.
- 6 Carefully take down the oil cooler.

### Installing

- 7 Fit new O-rings to the oil cooler.
- 8 Lift the oil cooler up against the filter housing and check that the O-rings fit into the grooves.
- 9 Tighten the upper tensioning band.

10 Fit and tighten the lower tensioning band round the oil cooler and bracket.

11 Tighten the oil cooler bottom plug.

12 Fill with coolant and check oil level.

13 Crank the engine with the starter motor until oil pressure is recorded by the pressure gauge.

14 Start the engine and check for leakage round the oil cooler.

## Oil cooler, leakage test

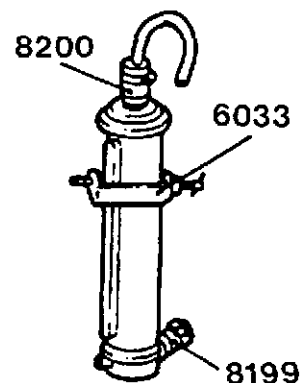
(Removed from engine)

*Special tools: 6662, 6033, 8199, 8200*

1 Flush the coolant side of the oil cooler with water-soluble degreasing fluid. Wash the oil side of the cooler with degreasing solvent.

2 In order to discover any small leakages, the oil cooler must be the same temperature as the room temperature. To achieve this, flush the oil cooler with water which has the same temperature as the room until the cooler reaches the required temperature. Drain off all water in the cooler.

3 Fit leak detection equipment 6033 and check that it seals correctly. Fit seal 8199 on one of the coolant connections and hose connection 8200 on the other. Make sure that they seals correctly.



4

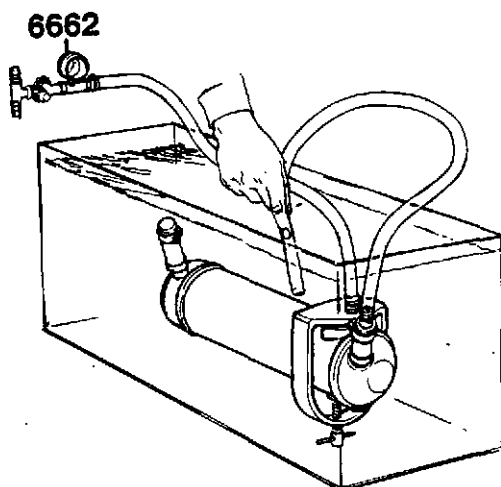
Connect leak detection equipment 6662 to 6033.

**Note!** Water must not enter the measurement hose.

5

Lower the oil cooler into the bath which contains water that has room temperature. The leakage test is to be carried out at **15, 100 and 250 kPa (2.175, 14,5 and 36.25 psi)**. Begin with 15 kPa and then continue with 100 and 250 kPa. Position the measurement hose approx. 2 cm (0,79") under the surface of the water. The test period for each test should last for at least one minute.

Air bubbles emerging from the measurement hose indicate *internal leakage* in the oil cooler. Air bubbles around the oil cooler indicate external leakage.



6

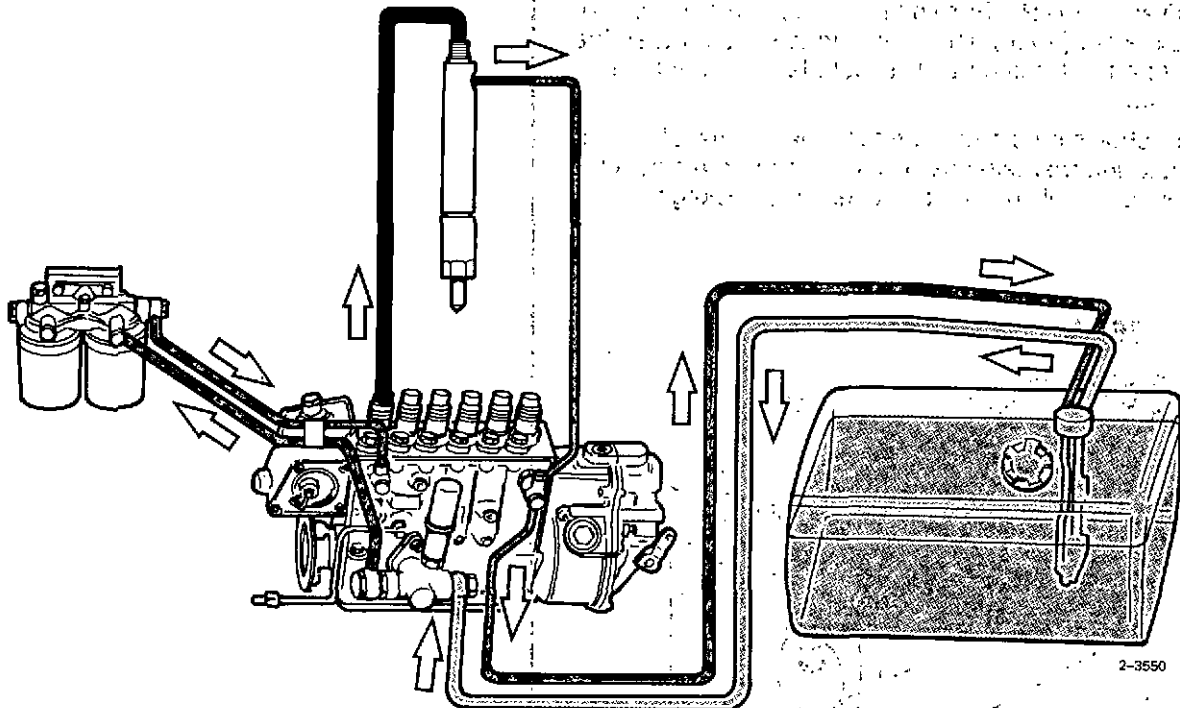
Lift up the oil cooler and remove the leak detection equipment.

# Fuel system

## Design and function

### General

The main components of the fuel system are: fuel tank with level sensor, feed pump, two fuel filters, injection pump, injection timing adjuster (only TWD 1030 ME), injectors and piping.



### Injection pump

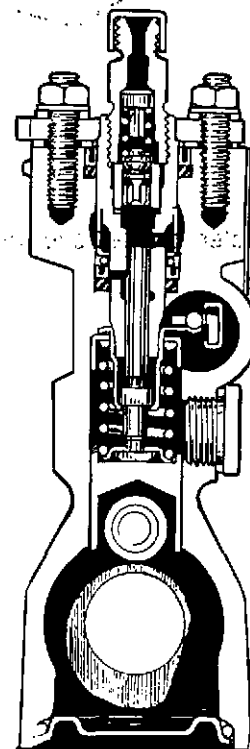
The injection pump is mounted on a bracket on the left-hand side of the engine. It is driven from the engine timing gears via a pump coupling consisting of two flanges and an intermediate section.

Lubrication is by means of a connection to the engine lubrication system.

The pressure levelling device and overflow valve are mounted opposite each other at the rear of the pump.

The injection angle is measured as a lift from the basic circle with the dial indicator on the tappet for no. 1 cylinder pump element.

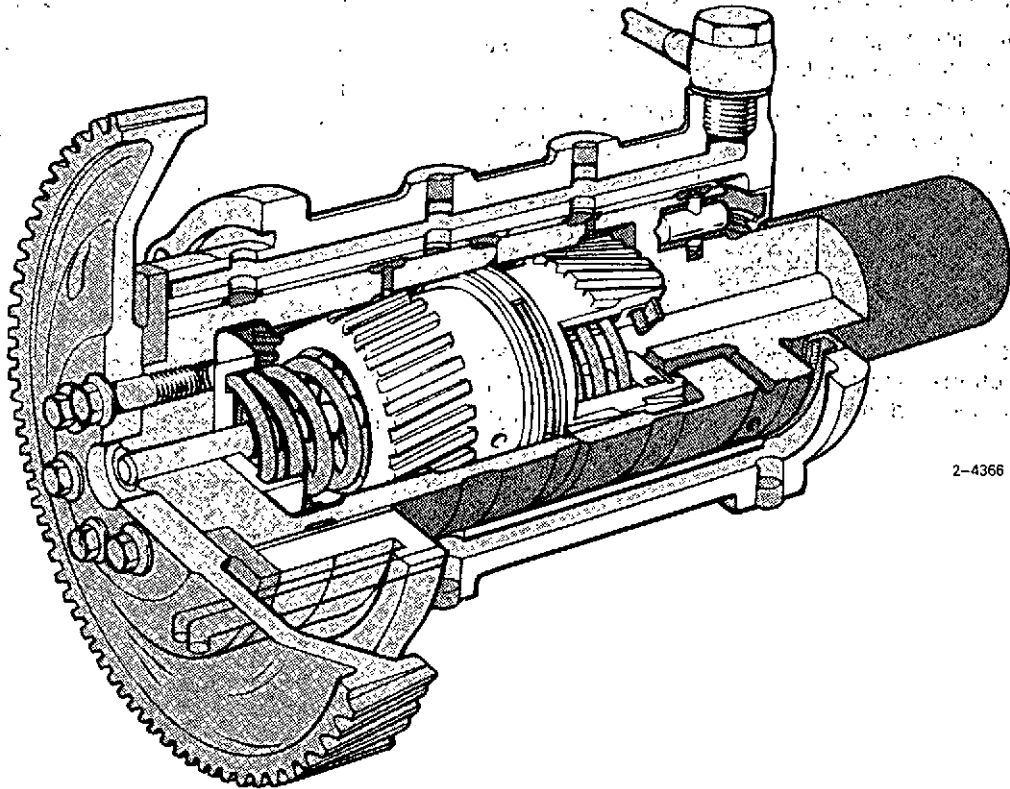
The injection pump on some of the engines also have a smoke limiter, which is placed at the front of the injection pump.



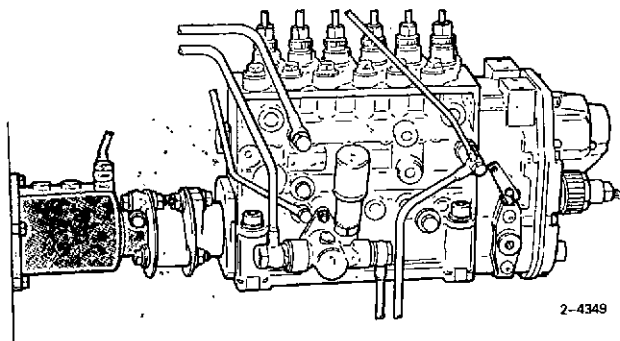
## Injection timing adjuster (TWD1030ME)

The injection timing adjuster is fitted to the timing gear casing and its purpose is to vary the injection angle, depending on engine speed.

The injection pump timing gear is fitted to the front flange of the adjuster and the rear flange is connected via a coupling to the injection pump drive shaft.



2-4366



2-4349

## Governors

### Mechanical governor

A mechanical governor works by means of speed sensitive flyweight. The speed is regulated throughout the entire speed range of the engine, from low idling to high idling (variable speed type).

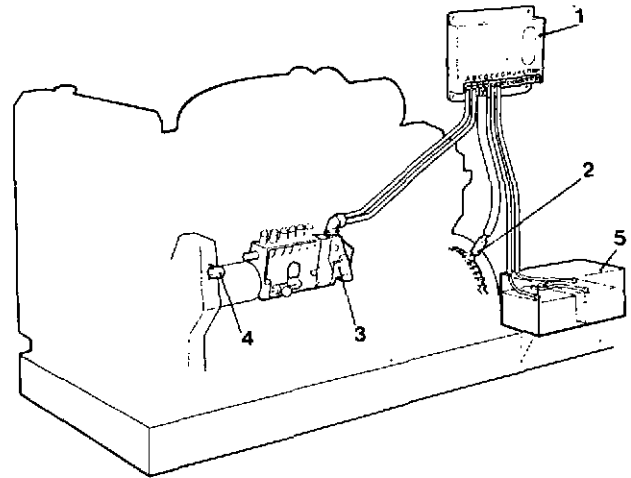
### Electronic governor

The electronic governor system is a control unit which controls the engine speed. Its task is to:

- maintain the idling speed at the set value
- maintain the engine's operating speed at the preset value despite varying loads.

Unlike the mechanical governor, the electronic governor does not have governor weights. The speed is instead controlled by the control unit, "sensing" the difference between the set speed and the actual speed. The difference value is converted into a signal to an electromagnet (actuator) which adjusts the injection pump's control rod to increase or decrease the injection quantity.

An electronic overspeed protection must always be fitted besides the electronic governor to prevent bodily injury or material damage if the engine should go out of control.



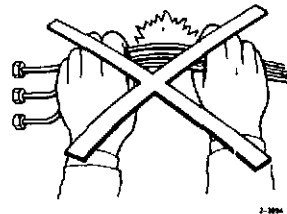
Electronic speed governor

- 1 Control Unit
- 2 Engine speed pickup
- 3 Actuator GAC/ACB 275D
- 4 Engine speed pickup for overspeed protection
- 5 Batteries

## Fuel delivery pipes

All engines except TWD1210, TWD1211 are fitted with pre-tensioned fuel delivery pipes. Under no condition should these pipes be bent or reshaped. Should a pre-tensioned pipe be bent or deformed, there is a considerable risk of it snapping. A damaged pipe should always be replaced with a new one.

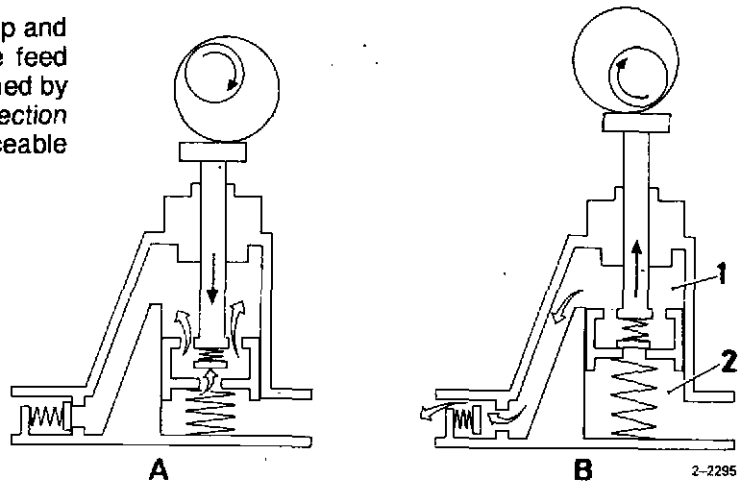
When removing injectors or the injection pump, the entire pipe assembly must be removed as one. Do not remove the pipe clamps. Remove the pipes in threes. If the entire pipe assembly is clamped together, then remove all pipes as one.



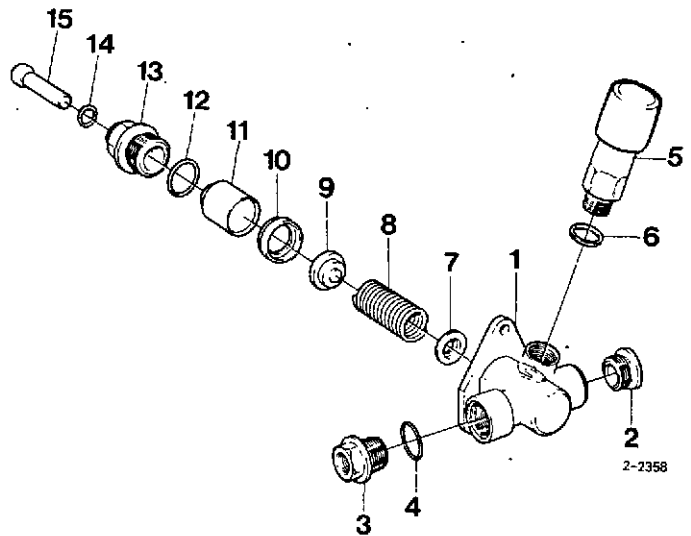
## Feed pump

The feed pump is mounted on the injection pump and is driven by the injection pump camshaft. The feed pump pressure in the injection pump is determined by the *bypass valve* which is mounted on the injection pump. The feed pump has completely replaceable valves.

- 1 Work chamber
- 2 Suction chamber
- A Cam lift
- B Spring lift

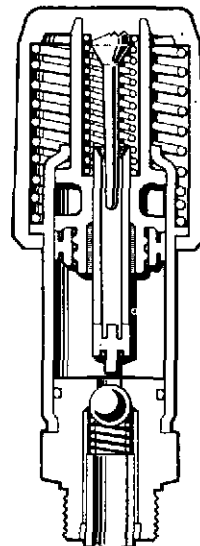


- 1 Housing
- 2 Screw cap
- 3 "
- 4 O-ring
- 5 Manual pump
- 6 Gasket
- 7 Spring disc
- 8 Spring
- 9 Valve
- 10 Spacer ring
- 11 Pump piston
- 12 O-ring
- 13 Screw cap
- 14 O-ring
- 15 Push rod



## Hand primer pump

The hand primer pump is mounted on top of the feed pump.



## Injectors

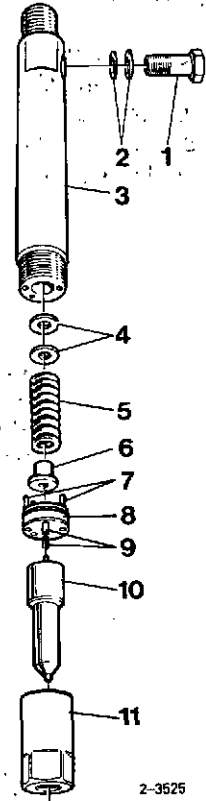
The injectors are of type KBEL.

The function of the injectors is:

- To atomise the fuel in order to provide reliable ignition and combustion.
- Together with the turbulence of the air, to distribute the jets of fuel in the combustion chambers so as to give a mixture of fuel and air.

The injector opening pressure is determined by the tension of the delivery spring.

- 1 Banjo bolt
- 2 Gaskets
- 3 Injector holder
- 4 Adjusting washers
- 5 Spring
- 6 Pressure pin
- 7 Guide pins
- 8 Guide
- 9 Guide pins
- 10 Injector, nozzle assembly
- 11 Injector nut



## Smoke limiter

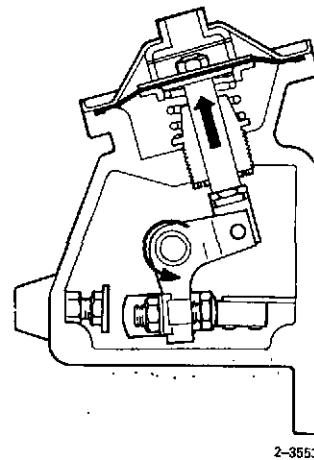
The purpose of the smoke limiter is to limit the amount of fuel in the case of low boost pressure from the turbo compressor.

Via a pipe, the diaphragm in the smoke limiter monitors the pressure in the inlet manifold. Via a linkage system, movement of the diaphragm acts on a lever.

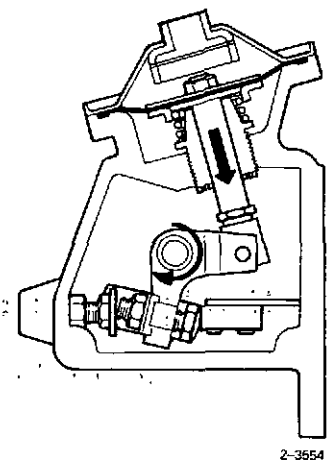
The lower section of the lever acts on the control rod of the injection pump.

In the case of low boost pressure, the lever acts on the control rod to lower the maximum amount of fuel available.

In the case of a high boost pressure, the lever permits the control rod to allow a higher maximum quantity of fuel.



A. Low boost pressure



B. High boost pressure

## Service procedures

Observe greatest possible cleanliness when working with the fuel system.

**NOTE!** Repair work which requires work on the injection pump and which can alter its setting shall only be carried out by specially trained mechanics, who have the proper tools and test devices at their disposal.

All engine warranties expire if the seals are broken by unauthorized personnel.

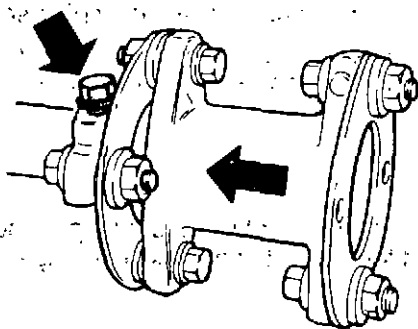
### Injection pump, removing

**1** Carefully wash clean the injection pump, pipes and the engine near the pump. Remove the protection plate for the pump coupling.

**2** Close the fuel cocks. Undo the pressure pipes, fuel and lubrication pipes at the pump and the control connections. Fit protective caps. Un-screw the pipe from the smoke control device if in use.

**3** Remove the protection plate over the pump coupling. Undo the clamping screws on the pump coupling. Remove the screws between the pump coupling and the carrier on pump. Press the pump coupling forwards on the drive shaft.

**4** Unscrew the pump's fixing screws and lift off the pump. Observe care so as not to damage the steel laminates.



### Injection pump, fitting and adjusting

*Special tools: 6848, 998 9876*

**NOTE!** Check that there is about 1 litre of engine oil in the injection pump and governor (only mechanical governors).

**NOTE!** Do not remove the protective plugs from the injection pump until immediately before connecting the pipes. Check that the pump and governor are correctly filled with oil.

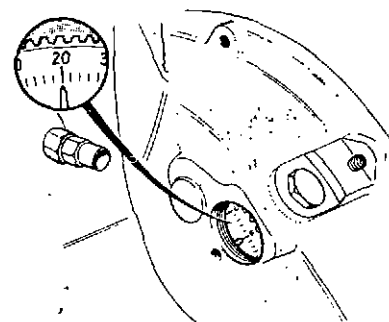
Use new copper washers.

**1** Remove the valve cover on 1st cylinder.

**2** Remove the inspection plug on the flywheel casing.

**3** Crank the engine in its direction of rotation until 1st cylinder is on compression ( $0^\circ$  on the flywheel and both valves of 1st cylinder closed).

**4** Crank the flywheel back against the engine's direction of rotation, approx.  $90^\circ$  and then forwards in its direction of rotation until the correct degrees according to the "Workshop Manual, Technical Data" are immediately behind the pointer on the flywheel casing.

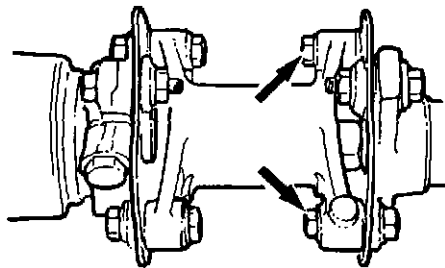


**5** Fit the injection pump and bracket in position and fit the attachment screws.

**6**  
Make sure that the pump coupling is clean and free from oil and impurities.

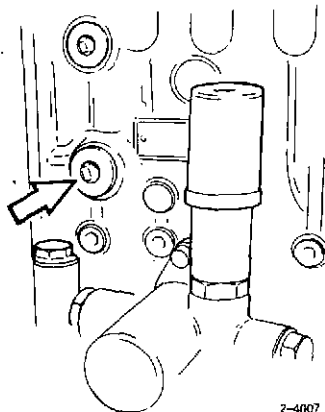
Connect the pump coupling to the pump flange and torque-tighten.

**NOTE!** Do not tighten the clamping screw.



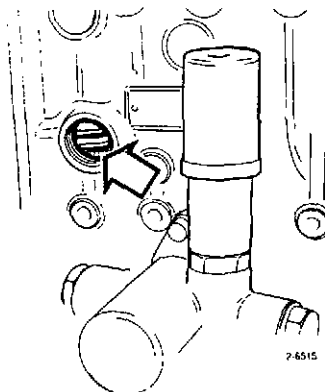
2-6482

**7**  
Remove the hex socket plug together with washer to reveal the 1st tappet on the injection pump.



2-4007

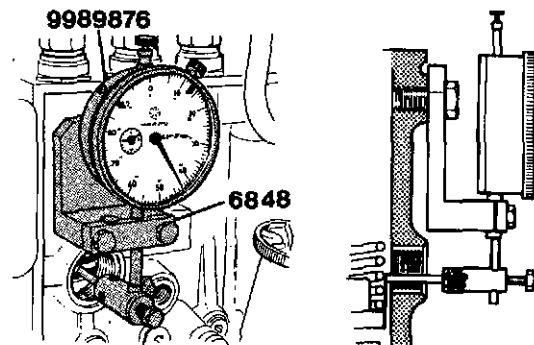
**8**  
Turn the pump coupling in the engine's direction of rotation until the tappet is in its bottom position.



2-6515

**9**  
Fit tool 6848 to the injection pump.

Fit a dial indicator to 6848. Adjust the probe so that it is in contact with the tappet.



**10**  
Zero-set the dial indicator.

**11**  
Tighten the clamping screw so hard that the pump coupling can be turned with great resistance against the engine's direction of operation. This must be done in order to eliminate as much as possible of the tooth flank clearance in the transmission gears and in the injection timing adjuster (if fitted).

**12**  
Turn the pump coupling against the engine's direction of rotation. Check that the zero-setting of the dial indicator is still correct when turning is commenced.

**13**  
Continue to turn the pump coupling against the engine's direction of rotation until the value of the lift from basic circle, see "Workshop Manual, Technical Data", is shown on the dial indicator.

**Note!** If you turn too far, out cannot turn back the pump coupling. You have to start from the beginning (tappet in bottom position).

**14**  
Torque-tighten the pump coupling clamping screw. After adjustment, repeat step 4 above. Check the reading with the dial indicator and if necessary adjust the pump.

**15**  
After any adjustment, tighten the clamping screw to the specified torque and check the value again.

Remove tool 6848 and dial indicator from the pump.

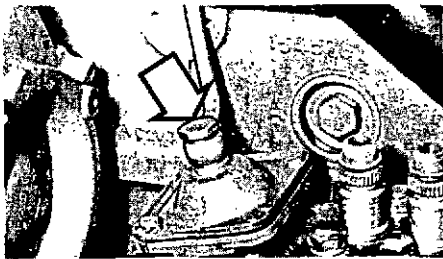
**17**  
Fit the hex socket plug using a new copper washer.

**18**  
Fit the inspection plug on the flywheel casing.

**19**  
Fit the oil pipes between the injection pump and engine block.

**20**  
Connect the fuel pipes.

**21**  
Fit the pipe to the smoke limiter, if any.



**22**  
Connect up the fuel delivery pipes and fit the fuel return pipe.

**NOTE!** Fuel delivery pipes must never be bent or altered. A damaged fuel delivery pipe should always be replaced with a new one.

**23**  
Fit the valve covers on 1st cylinder.

**24**  
Fit the fuel pipes between the filters and pump.

**25**  
Bleed the fuel system.

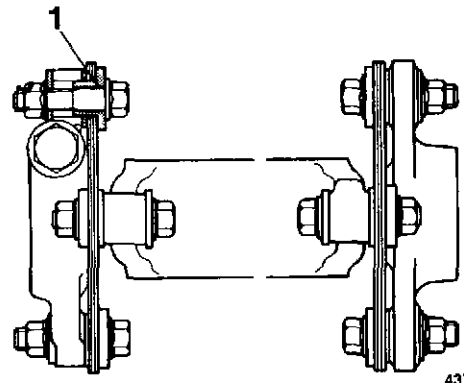
## Pump coupling, checking and replacement of laminates

Check that the laminates in the pump coupling are not cracked or warped.

Start the engine and idle at low revs (approx. 525 rpm). Check visually that the laminates are not warped.

If the laminates are broken or warped, both laminate units shall be replaced.

**NOTE!** The laminates shall only be fitted when dry. All screws shall be torque tightened. See "Workshop Manual, Technical Data".



437

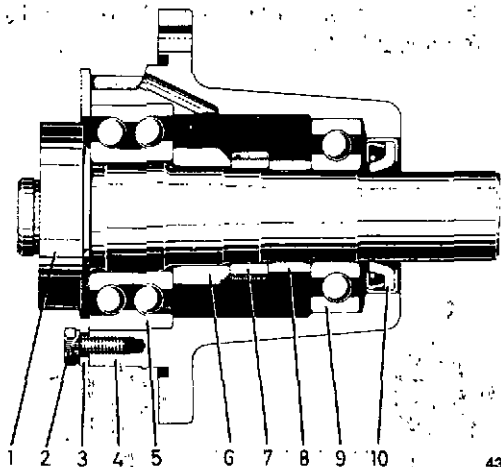
Pump coupling  
1. Sleeve

## Injection pump's drive

### Removing

**1**  
Remove the timing gear cover, pump coupling and the gear for the injection pump.

**2**  
Remove the fitting screws and lift off the drive.



Drive for injection pump

- |                  |  |
|------------------|--|
| 1. Shaft         | 6. Spacer sleeve                       |
| 2. Fitting screw | 7. Gear for tachometer or hour counter |
| 3. Lock washer   | 8. Spacer sleeve                       |
| 4. Housing       | 9. Rear bearing                        |
| 5. Front bearing | 10. Seal                               |

**3**  
Remove the fixing screws (2) and washer (3).

**4**  
Press out the shaft with bearings, spacer sleeves and rev counter gear, from the housing. If the bearing (9) does not follow, dismantling is made in two stages. Remove the bearings and rev counter gear from the shaft.

**5**  
Remove the shaft seal (10) from the housing.

### Assembly

Special tools: 2267, 6778

**1**  
Fit the rear bearing (9) in the housing with drift 2267.

**2**  
Press the front bearing (5) on the shaft. Fit the spacer sleeve (6) and press on the rev counter gear (7). Fit the spacer sleeve (8) on the shaft.

**3**  
Press the complete unit in the housing when the counterforce is applied to the rear bearing's (9) inner ring. Press until the different parts in the drive connect with each other.

**4**  
Fit the washer (3) and tighten the fixing screws (2). Lock with the thrust washers.

**5**  
Press the sealing ring (10) in the housing with tool 6778.

**NOTE!** Clean the mating surfaces on the shaft journal and carrier with acetone prior to fitting.

**6**  
Check the setting of the injection pump. See "Injection pump, fitting and adjusting" on page 57.

## Injection pump's drive , replacement of sealing ring (Engines without injection timing adjuster)

Special tools: 6778, 6779

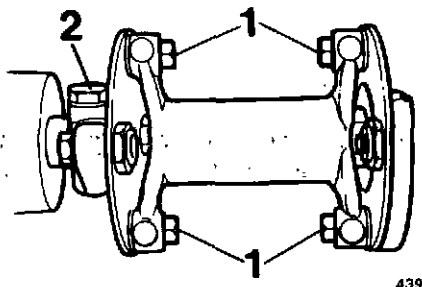
1

Remove the protection plate at the pump coupling. Remove the screws (1) and lift off the spacing piece.

**NOTE!** Do not rotate the injection pump or engine.

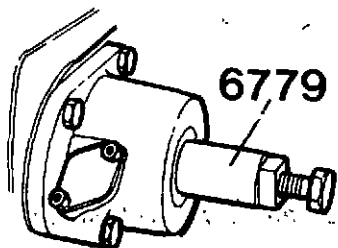
2

Release the clamping screw (2) and remove the carrier from the drive shaft.



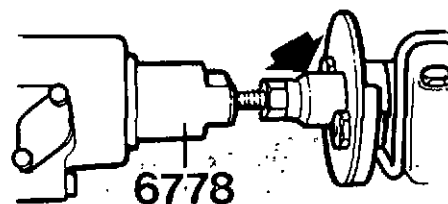
3

Screw in the extractor 6779 fully in the seal. At the same press on the extractor so that the threads cut into the seal's steel ring. Pull out the seal by screwing in the screw.



4

Oil in the new sealing ring and drive shaft. Place the sealing ring on the drive shaft. Press in the sealing ring with the aid of 6778 until it is plane with the housing. On the 10 ltr engines a 1 1/6" sleeve is placed on the injection pump's carrier as a counterforce. On the 122 series a 1 1/6" sleeve is used with a short extension as a counterforce.



5

Fit the carrier.

**NOTE!** Clean the mating surfaces on the shaft journal and carrier with acetone prior to fitting.

Do not tighten the clamping screw.

6

Fit the spacer. Tightening torque: See "Workshop Manual, Technical Data".

7

Tighten the clamping screw. Tightening torque: See "Workshop Manual, Technical Data".

8

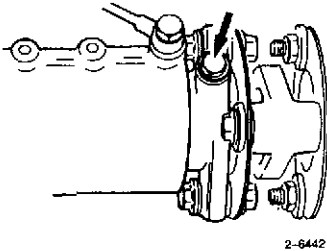
Check the setting of the injection pump. See "Injection pump, fitting and adjusting" on page 57.

## Injection pump's drive , replacement of sealing ring (Engines with injection timing adjuster)

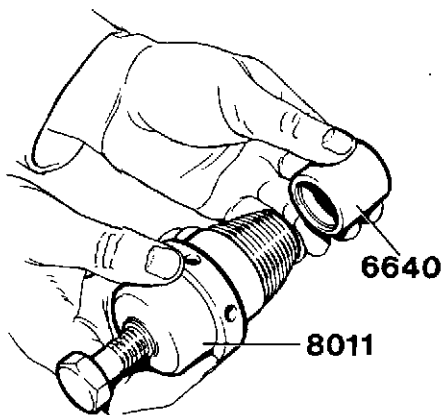
(Injection pump removed)

Special tools: 6640, 8011, 8012

**1**  
Slacken the clamping bolt which holds the flange to the shaft and remove the flange.

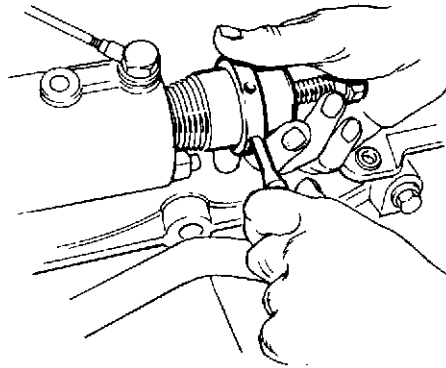


**2**  
Fit drift 6640 into puller 8011. Turn the drift so that the shallow hole faces the puller bolt.

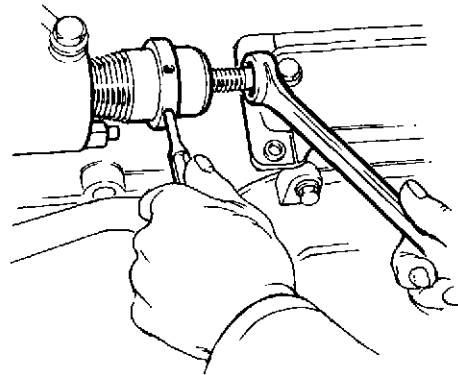


**3**  
Screw the puller into the old seal with the help of a drift.

At the same time, apply pressure to the puller so that the puller threads cut into the steel ring of the seal.



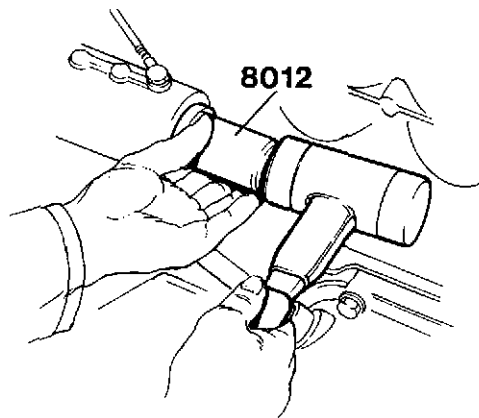
**4**  
Pull out the old seal by screwing in the puller bolt and counterholding the puller at the same time with the drift.



**5**  
Smear the new seal and drive shaft with oil.

6

Fit the seal on the shaft and tap it in with drift 8012 until it is flush with the shaft housing.



7

Fit the flange, the pump coupling and the injection pump. (See "Fuel System").

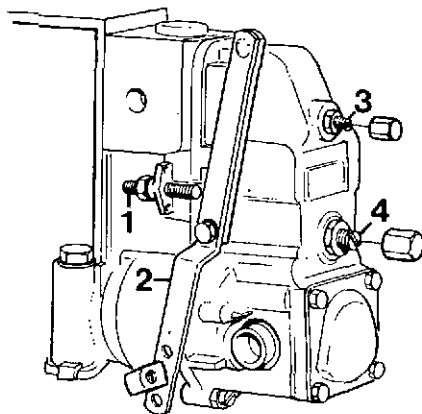
8

Check the setting of the injection pump. See "Injection pump, fitting and adjusting" on page 57.

### RSV-governor

(The engine should be at normal operating temperature!)

Check that the throttle functions normally, i.e. that the injection pump's throttle lever goes against the low idling stop when the throttle is moved to the idling position, and is pressed against the max. stop when the lever is moved to max. position. Adjust the control if necessary. Make sure that the air filter is not blocked.



Adjustment of revs, RSV regulator

1. Stop screw for max. revs (sealed)
2. Throttle lever
3. Adjusting screw for low idling
4. Adjusting screw, idling stabilization

### Low idling

1

Run the engine at low idle and check the revs. See Service Bulletin "Setting data" for revs.

2

Adjust revs if necessary by removing the domed nut and screwing the adjusting screw (3) in or out.

**If there is hunting in the revs the idling damping shall be adjusted as follows:**

1

Remove the domed nut (4) and release the lock nut, and turn the damping screw carefully clockwise until the hunting ceases.

2

Check that the high idling revs have not changed. If so, the damping screw has been screwed in too far.

3

Lock the adjusting screw and fit the domed nut when the adjustment is ready.

### High idling

The stop for max. revs is sealed. This seal shall only be broken by specially trained personnel.

1

Run the engine unloaded with max. revs.

2

Check the revs with a rev counter. Adjust if necessary the stop screw (1), so that the correct revs are obtained. See Service Bulletin "Setting data" for revs.

3

Seal the screw.

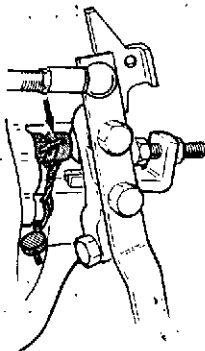
## Revs, adjustment RQV, RQ-governor

1

The engine should be at normal operating temperature. Make sure that the throttle lever pulls back fully the arm on the injection pump to the stop position for low idle.

2

Move the throttle lever to max. position and check that the lever reaches the stopping screw for high idle. Make necessary adjustments.



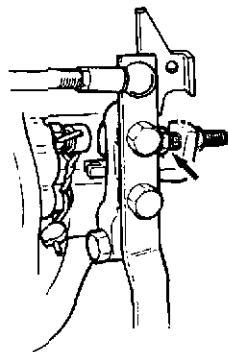
### Low idle

3

Run the engine at low idle and check the revs. See Service Bulletin "Setting data" for revs.

4

If required, adjust speed with the low idle screw.



### High idle

5

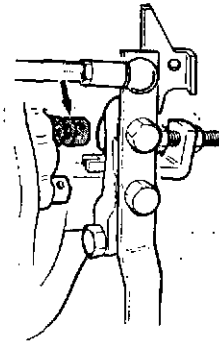
The stopping screw for high idle is sealed. This seal may only be broken by specially trained personnel. The engine should be at normal operating temperature during this check.

6

Run the engine at maximum revs for a few seconds without load. Check that the lever stops up against the screw for max. revs.

7

Check the high idle revs. See Service Bulletin "Setting data" for revs. Should high idle need to be adjusted, the setting screw must be sealed afterwards.



## Feed pressure, checking

*Special tools: 6065, 6066*

The Banjo nipple 6066 and the manometer 6065 are connected to the existing connection on the filter's outlet side.

The pressure is measured after the fuel has passed the filter cartridge. When checking the engine revs are first increased, after which the revs are reduced so that the pressure can be read off at low idling speed.

The feed pressure must not be less than **100 kPa (14.5 psi)**.

Low feed pressure may be the result of a blocked filter, defective overflow valve or defective feed pump.

The overflow valve must not be adjusted. Replace the valve if necessary.

## Feed pump, replacement

**1**  
Close the fuel cocks. Clean around the feed pump.

**2**  
Release both fuel pipes from the pump.

**3**  
Remove the feed pump from the injection pump.

**4**  
Clean, and place a new gasket on the injection pump. Fit the feed pump.

**NOTE!** If lubricating oil has run out from the injection pump the corresponding volume should be topped up through the hole for the regulator's oil level plug at the back of the regulator.

**5**  
Screw tight the fuel pipe. Open the fuel cocks.

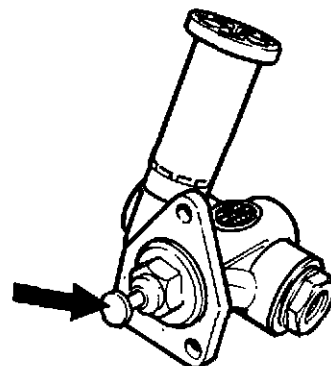
**6**  
Vent the fuel system.

**7**  
Start the engine and check that no leakage occurs.

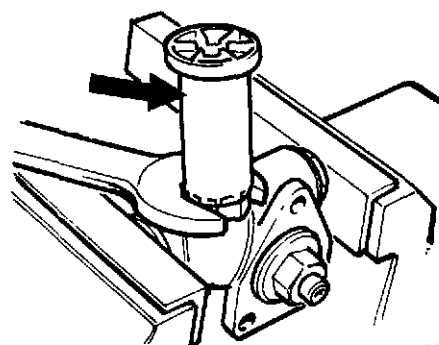
## Feed pump, reconditioning

### Dismantling

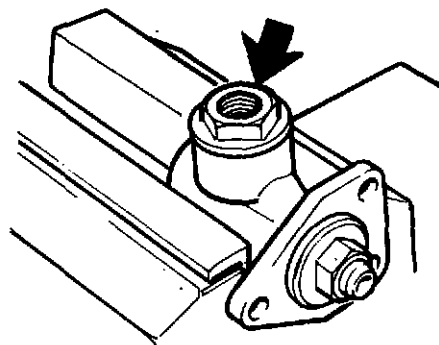
**1**  
Remove the push rod.



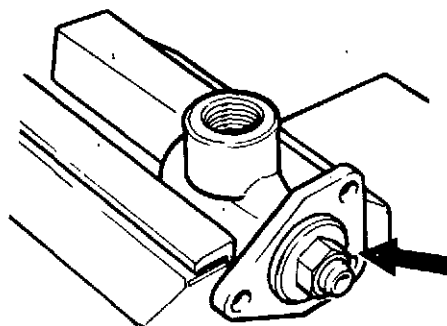
**2**  
Screw off the manual pump.



**3**  
Remove the screw cap (3)



**4**  
Remove the screw cap (13) for the valve and piston.

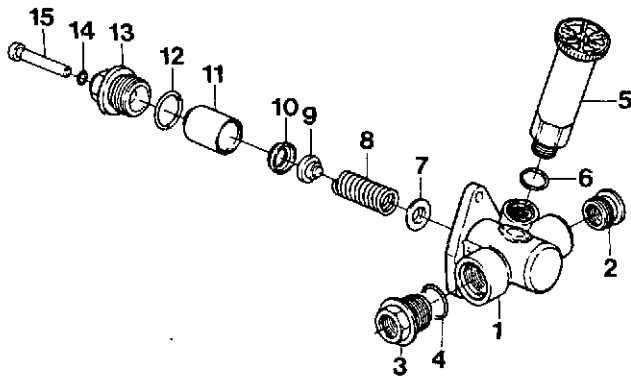


**5**  
Remove the valve, spring and discs (2 pcs).

**6**  
Examine the parts and replace those that are damaged or worn.

### Assembly

Observe the greatest possible cleanliness. Rinse the parts in diesel oil prior to assembly.



Feed pump

- |                |                 |
|----------------|-----------------|
| 1. Housing     | 9. Valve        |
| 2. Screw cap   | 10. Spacer ring |
| 3. Screw cap   | 11. Pump piston |
| 4. O-ring      | 12. O-ring      |
| 5. Manual pump | 13. Screw cap   |
| 6. Gasket      | 14. O-ring      |
| 7. Spring disc | 15. Push rod    |
| 8. Spring      |                 |

**7**  
Place the spacer ring (10) in the pump piston (11).

**8**  
Put the valve (9), spring disc (7) and spring (8) in the pump piston (11). Place the pump piston in the pump housing.

**9**  
Place the O-ring (12) on the screw cap (13) for the valve. Fit the screw cap on the housing.

**10**  
Fit the screw cap (3) and O-ring (4) on the pump housing.

**11**  
Fit the manual pump (5) and gasket (6).

**12**  
Put the push rod (15) and O-ring (14) in position.

**NOTE!** Fit the protection plugs for the fuel connections if the pump is not to be replaced immediately.

## Smoke limiter, replacement of diaphragm

(Can be carried out with the pump fitted to the engine)

**NOTE!** The seal shall only be broken by authorized personnel.

**1**  
Remove the pipe between the smoke control device and the inlet pipe.

**2**  
Remove the seals on the smoke control device and remove the upper cover and outer end cover.

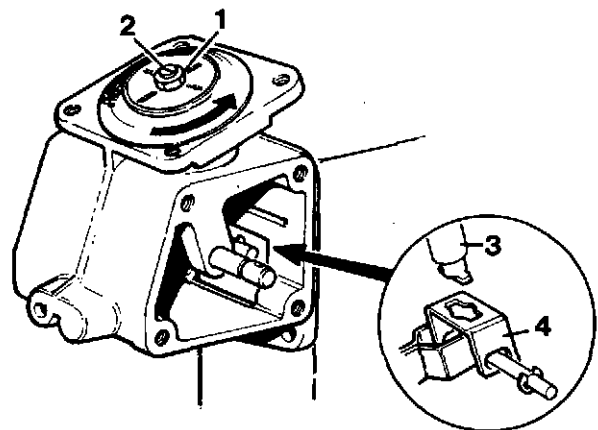
**3**  
Rotate the diaphragm 90° and lift off.

**4**  
Unscrew the nut (1), remove the diaphragm and screw on a new one.

**5**  
Fit the diaphragm in the smoke control device.

**NOTE!** The groove (2) in the shaft shall be across the pump's lengthwise direction before rotation. Check after fitting that the diaphragm's shaft (3) is correctly secured in the yoke (4).

**6**  
Fit the cover and pipe. Seal the screws.



Fitting of diaphragm in the smoke control device

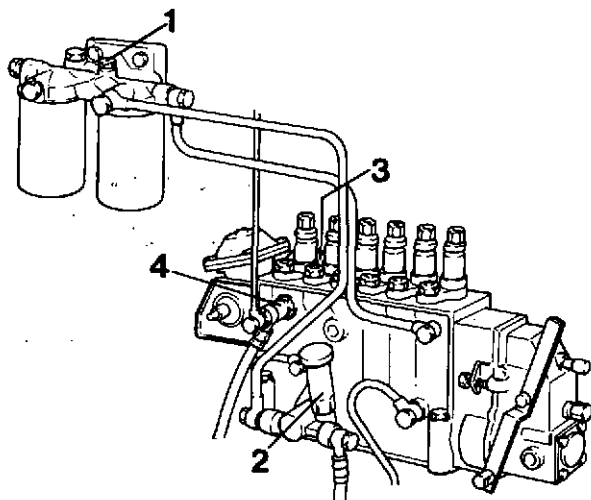
## Fuel filter, replacement

*Special tool: 9179*

- 1 Wash the filter cover well, unscrew the old filters and scrap. Use tool 9179.
- 2 Make sure that the new filters are absolutely clean and that the gaskets are not damaged.
- 3 Install the new filters by hand until the gasket mates with the cover. Tighten the filter an additional 1/2 turn.
- 4 Bleed the fuel system, pump up the feed pressure and check tightness.

## Bleeding

- 1 Open the bleeding screw (1) on the cover for the fuel filters. Pump up fuel with the manual pump (2) until it is free from air bubbles. Tighten the screw while the fuel flows out.
- 2 Continue to pump in order to maintain a substantial feed pressure. Further bleeding is not normally required.



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Bleeding of the fuel system

- |                   |                       |
|-------------------|-----------------------|
| 1. Bleeding screw | 3. Pressure equalizer |
| 2. Manual pump    | 4. Overflow valve     |

If the injection pump needs bleeding, release the connection for the overflow valve (4) at the pump and continue pumping by hand until air-free fuel flows out. Tighten the connection while fuel flows out. Continue to pump so that an adequate feed pressure is obtained. Check that the connection seals well.

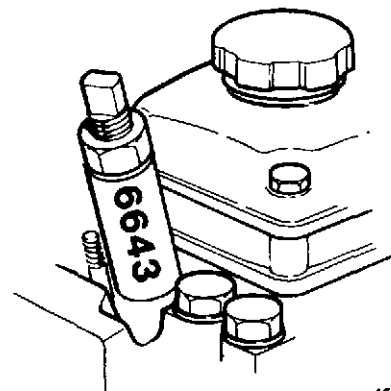
**NOTE!** Do not bleed at the pressure equalizer! Because of the positioning of the pressure equalizer on most engines the sealing washer at the connection to the injection pump can become incorrectly positioned after removal, resulting in leakage.

- 3 Start the engine. If the engine does not start after a short moment, release the pressure pipe at the injectors one or two turns. Set the injection pump's throttle lever in max. position and turn over the engine with the starter motor until fuel is forced forwards. Tighten the pressure pipe nuts.

## Injectors, replacement

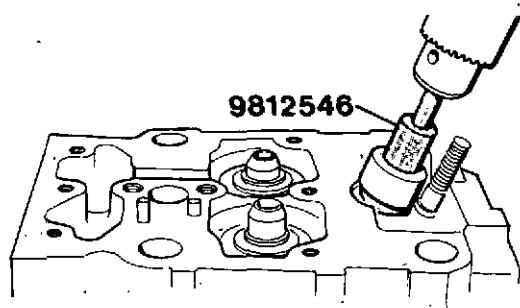
*Special tool: 6643, 981 2546*

- 1 Drain the coolant.
- 2 Clean around the injectors, and at the pressure pipe and fuel return pipe connections.
- 3 Remove all pressure pipes. Remove the fuel return pipe at the injectors. Fit protection caps.
- 4 Unscrew the injectors' yoke.
- 5 Turn the injector with a wrench and pull upwards at the same time. If the injector is stuck, use extractor 6643.



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- 5 Clean the bottom of the copper sleeve with tool 9812546 and a drilling-machine.



- 6 Fit the new injector together with the protection ring. Tightening torque **50 Nm (37 psi)**.

- 7 Fit the pressure pipes and fuel return pipe.

- 8 Fill engine with coolant. Start the engine and check tightness at all connections.

- 9 Recheck water level.

## Recommendations for adjusting opening pressure, setting pressure and changing injectors

The injection process is carried out under very high pressure so that the dispersal of fuel is as effective as possible. As the injectors become older, opening pressure drops below the given pressure of new injectors.

This pressure drop is completely normal and does not affect the function of the injectors or the engine performance to any great degree. Adjusting the injectors can mean that the service life of the nozzle assembly is shortened.

In the following we give some general recommendations on how to check the injectors and so avoid unnecessary replacing and adjusting of same.

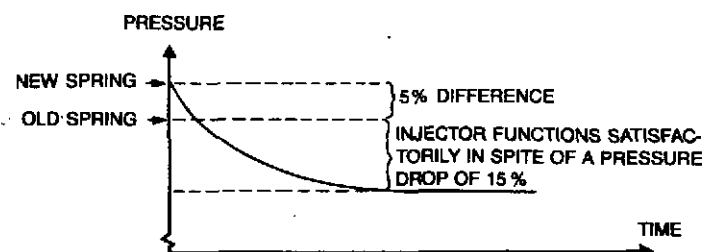
The injectors should not be checked unless there are clear indications that they are not operating normally, for example, a considerable increase in exhaust smoke has been noted.

Most important in this test are the opening/adjusting pressures and leakage.

Spray pattern and chatter are more difficult to assess and do not give any clear indication of the condition of the nozzle.

In addition to the opening pressure, Volvo service manuals also state the setting pressure. These values refer to new injectors or injectors with new thrust springs.

Since the setting pressure for a new spring is somewhat higher than the opening pressure, this gives one a certain margin to allow for fatigue of the thrust spring. When a thrust spring has become fatigued, the opening pressure drops about **5 per cent**.



Opening pressure will in time drop even more, but the injector will still function satisfactorily.

Investigations have shown that for a used spring the pressure drop evens out at about **15 per cent** below opening pressure. However this pressure drop is no reason to adjust or replace the injector. The pressure drop lies within the specified working area.

### Leakage test

The test is to check if there is any leakage from the nozzle. If leakage is present it occurs between the tip of the nozzle needle and the tapered sealing area of the nozzle sleeve.

Wipe the nozzle tip dry. Connect a pressure gauge and pump up pressure to **2 MPa (290lb/in<sup>2</sup>)** below the opening pressure of the injector. Keep the pressure constant for **10 seconds**. No fuel should drip from the nozzle tip, but a moist nozzle is acceptable.

### Spray pattern and chatter

The condition of the nozzle is difficult to assess concerning spray pattern and chatter.

Many times the nozzle can function satisfactorily in the engine, even though some doubts may exist concerning spray pattern and chatter.

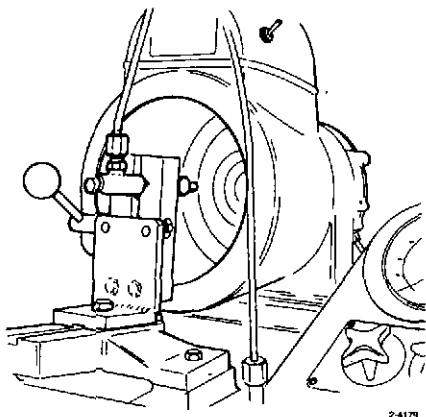
**Note!** Late design nozzles have a chatter-free pressure area.

## Injectors, reconditioning

- 1**  
Clean the outside of the injectors with chemically pure gasoline.
- 2**  
Dismantle the injectors. Pull out the nozzle needle from the nozzle sleeve, and place all parts in chemically pure gasoline.  
**NOTE!** If several injectors are cleaned at the same time make sure that the springs and adjusting washers as well as the needles and sleeves which belong together are not mixed.
- 3**  
Wash the parts in an Ultrasonic washer. Blow them dry.
- 4**  
Check the nozzle needle and the nozzle sleeve thoroughly.  
Inspection is carried out in an illuminated magnifying glass or a diffuser microscope. If the seat is dented the nozzle needle must be replaced together with the nozzle sleeve.
- 5**  
Check all other parts. Dip them in testing oil.
- 6**  
Reassemble the injector with the same thickness of adjusting washer as origin.  
Check opening pressure and spray pattern, see "Opening pressure, adjusting" page 70.

## Opening pressure, adjusting

- 1 Connect the injector to an injection tester.

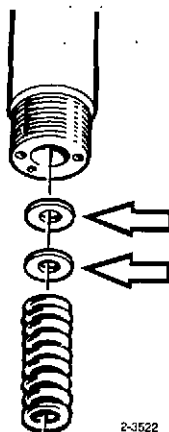


- 2 Slowly press down the tester lever until the injector opens and releases fuel.

- 3 Read off the opening pressure on the tester pressure gauge.

- 4 If the reading does not agree with the pressure stipulated by the "Specifications", the setting must be altered. This is done by fitting adjusting washers.

**Note!** No more than two washers may be used. If sufficient pressure cannot be obtained using the two thickest washers, the spring must be replaced.



## Opening pressure/setting pressure

See engine "Specifications" concerning opening pressure and setting pressure (new spring).

## Spray pattern

At a pump speed of 4–6 strokes per second, the spray pattern should be uniform and the fuel finely atomised. On completion of testing, plug the pipe connections and protect the injector tips with caps.

## Copper sleeve for injectors, replacement

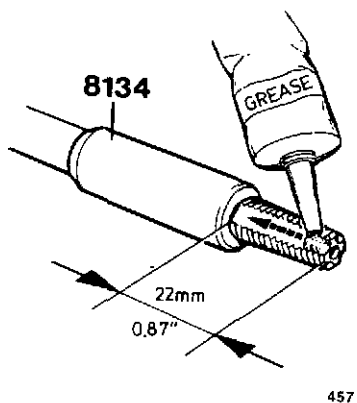
(Cylinder head fitted)

*Special tools: 6419, 6643, 6647, 8134, 8140, 9812546*

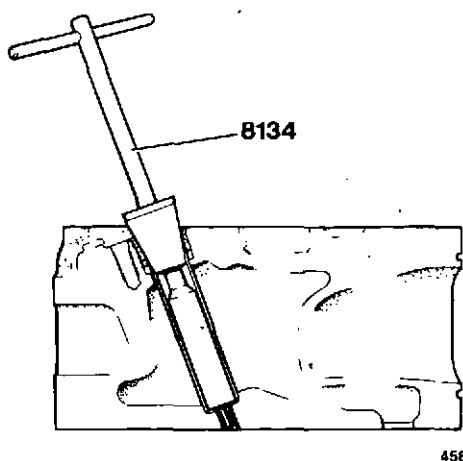
- 1 Drain the cooling system.
- 2 Remove the injectors, see "Injectors, replacement".
- 3 Rotate the engine until the piston in the cylinder where the replacement of the copper sleeve is to be carried out is in its lower position.

**4**  
Grease the threaded tap on tool 8134.

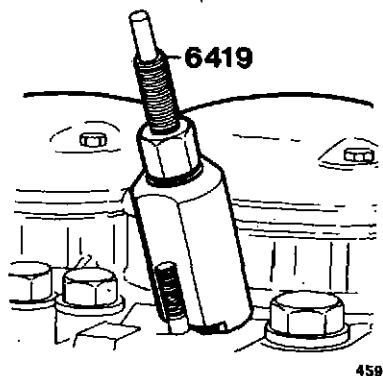
**NOTE!** The grease ensures that swarf will not fall into the cylinder and cause damage. Set the tap so that it extrudes approx. **22 mm (0.87")**.



**5**  
Make threads in the copper sleeve's tap with 8134.

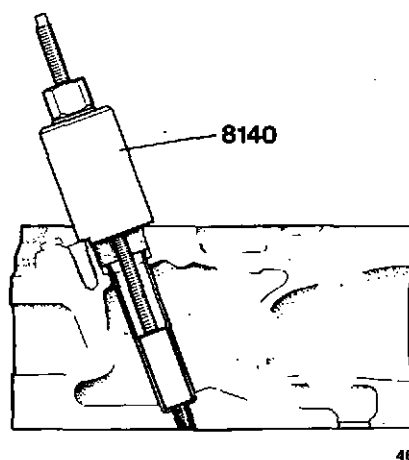


**6**  
Remove the steel ring with tool 6419.



**7**  
Remove the pin screw for the injector's yoke. Check that the screw on tool 8140 extrudes approx. **16 mm (0.63")** from the tool.

**8**  
Screw tight the tool in the copper sleeve. Remove the copper sleeve from the cylinder head. Remove the sealing ring.

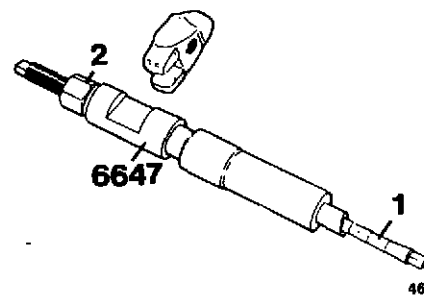


*Fit the pin screw for the injector's yoke.*

**9**  
Clean the sealing surface between the cylinder head and the base of the copper sleeve. Tool 9812546 can be used for this purpose.

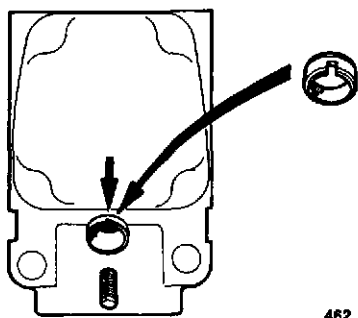
**10**  
Unscrew the flare tap (1) from tool 6647. Unscrew the nut (2) for the tool's spindle. Place the new copper sleeve on the tool and screw in the flare tap.

**Note!** Grease the flare tap.



**11**  
Oil in a new O-ring and place it in the cylinder head.

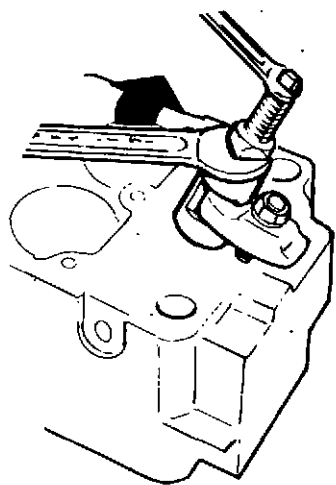
**12**  
Push down the sleeve and tool in the cylinder head. Check that the sleeve's indicating mark (recess) points straight up.



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**13**  
Tighten the flare tool with the injector's yoke and nut until the copper sleeve reaches the base of the cylinder head.

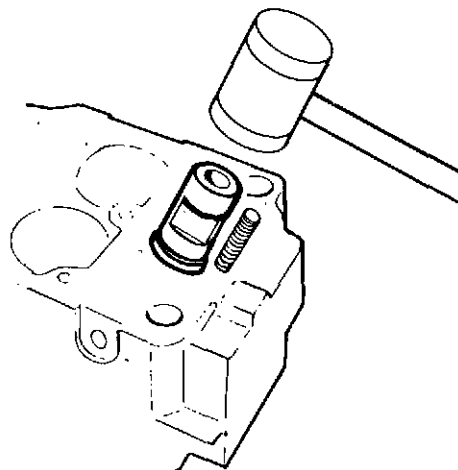
**14**  
Secure the tool's spindle and screw down the large nut. The flare tap is then pressed through the lower section of the copper sleeve.



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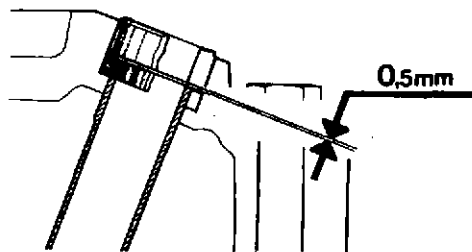
**15**  
Screw down the nut until the tool's spindle releases from the sleeve. Pull up the spindle and remove the rest of the tool from the cylinder head.

**16**  
Put the steel ring on tool 6647 (without spindle and flare tap). Carefully drive the steel ring down with a plastic mallet.



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**NOTE!** The distance between steel ring and copper sleeve shall be **0.5 mm (0.02")**. Check the distance with an angular feeler gauge.



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**17**  
Fit the injector (tightening torque: see "Workshop Manual, Technical Data"). Connect the fuel pipe.

**18**  
Fill with coolant.

# Intake and exhaust systems

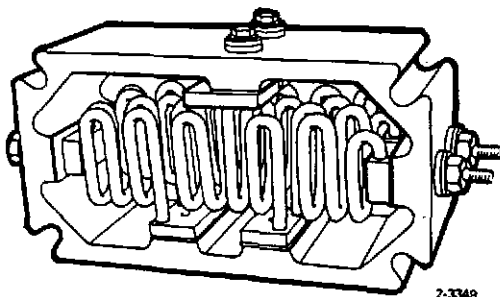
## Design and function

### Starting heater

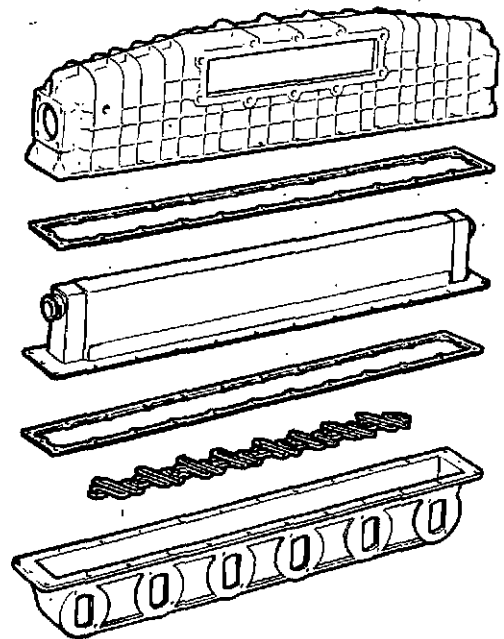
The pre-heating and post-heating times are a factor of engine temperature.

The purpose of the starting heater is to warm up the air in the intake manifold when the engine is started. The heated air makes for easier starting and also reduces the generation of exhaust smoke during cold starts.

### TAD-engines



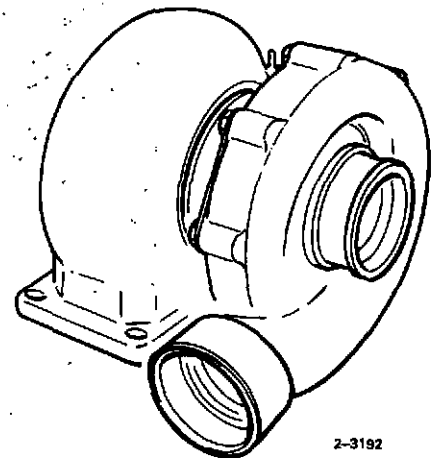
### TWD-engines



### Turbocharger

The turbocharger is powered by the exhaust gases which pass through the turbine housing to reach the exhaust system. The passage of the exhaust gases causes the turbine wheel to spin. On the same shaft as the turbine wheel is a compressor wheel. The compressor wheel spins in a compressor housing which is connected between the air cleaner and the engine's inlet manifold.

As the compressor wheel rotates, air is sucked in from the air cleaner. The air is compressed by the compressor wheel and is forced into the cylinders of the engine.



## Charge air cooler (Intercooler)

The TAD-engines is equipped with an air to air charge air cooler, the purpose of which is to lower the temperature of the intake air before it is blown into the engine cylinders.

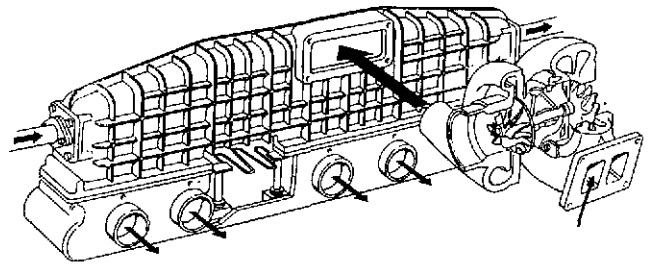
The TWD-engines is equipped with a charge air cooler of the water to air type.

The charge air cooler lowers the air temperature by about 100°C (TWD) and 150°C (TAD) resp. and increases engine output. Engine torque is also higher and fuel consumption is lower.

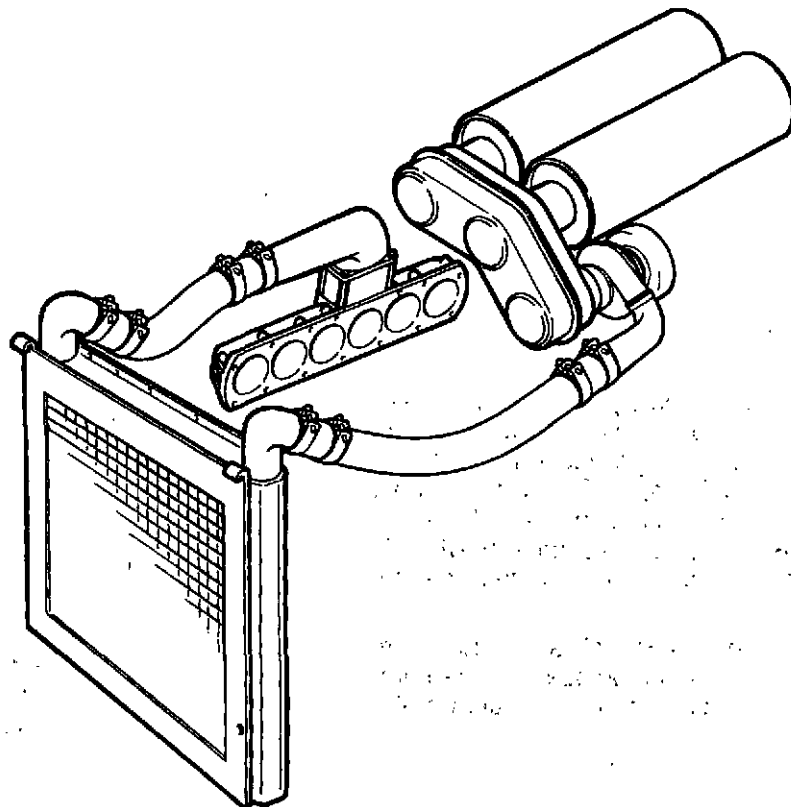
On the TAD-engines the charge air is cooled when it is passing the charge air cooler which is placed behind the engine's cooler. The air is pressed from the turbo-charger through the charge air cooler and into the inlet manifold (air to air cooling).

On the TWD-engines the charge air is cooled by the water cooled charge air cooler placed on top of the inlet manifold (water to air cooling).

## TWD-engines



## TAD-engines



## Service Procedures

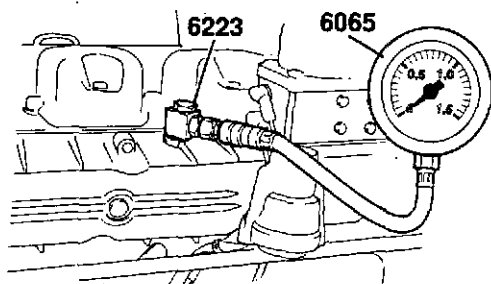
### Boost pressure, checking

Special tools: 6065, 6223(TAD), 6591 (TWD)

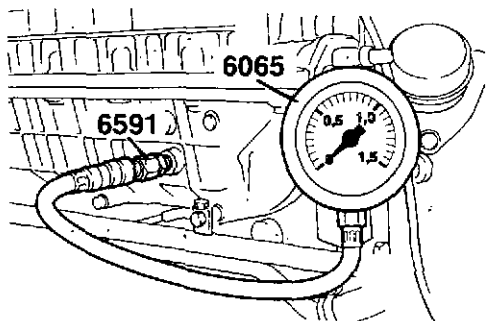
1

Fit the nipple 6223 (6591) in the existing socket in the inlet pipe. Connect manometer 6065.

#### TAD-engines



#### TWD-engines



2

Measurement shall take place continuously with full load with full throttle, while the engine revs slowly passes a given number of revs for the engine; see "Workshop Manual, Technical Data". The pressure must not be less than the given values.

**NOTE!** Full load must be maintained long enough so that the pressure can stabilize.

The pressure varies, depending on the temperature of the inlet air. The boost pressure is given at **+25°C (77°F)**, which implies that the measured pressure must be corrected as per the diagram below, if the inlet air does not have this temperature during the measurement.

**Example:** A pressure measurement of 100 kPa (14.5 ft/lb) at 0°C (32°F) corresponds to a pressure of 90 kPa (13.05 ft/lb) at +25°C (77°F).

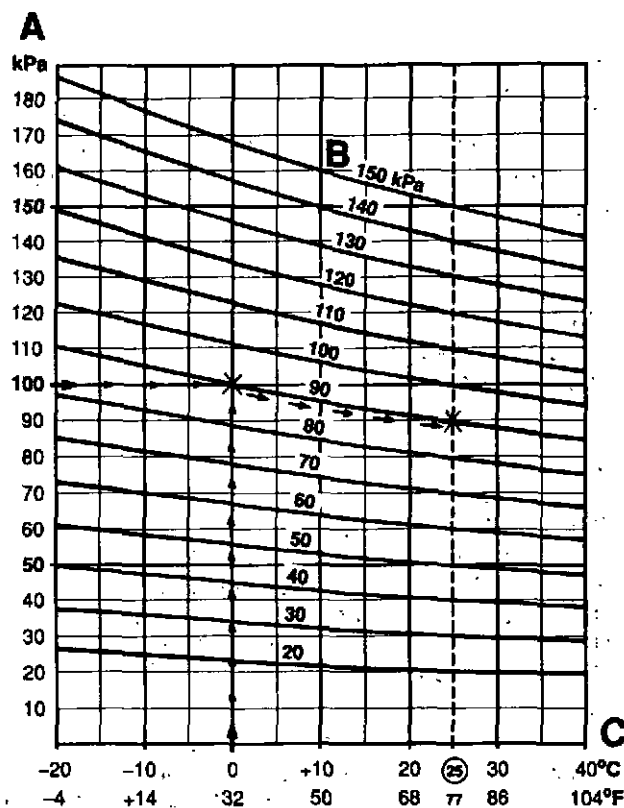


Table. Boost pressure at different temperatures

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- A. Measured boost pressure
- B. Correction curves
- C. Temp. of inlet air

## Rectifying low boost pressure

1

### Air intake

Check that the air intake to the engine compartment is sufficient. See installation instructions.

2

### Air filters

Check that the air filters are not blocked, and that correct filters are used. Replace filter when necessary.

3

### Tightness

The inlet pipe, exhaust pipe and other connections must not leak. Check also that the joints between the compressor bearing housing and turbine housing resp. compressor housing are tight.

4

### Throttle control

Check that the control can direct the injection pump's throttle lever to max. position.

5

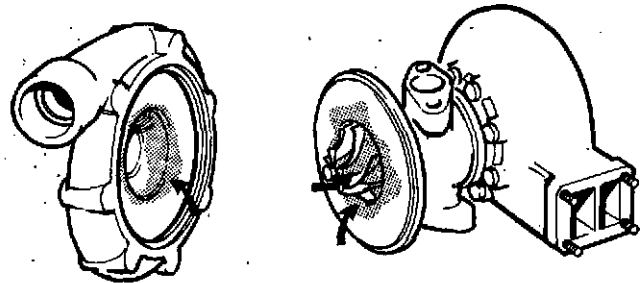
### Turbocharger

Check if the rotor shaft is sluggish or if the turbine wheel and compressor wheel chafe against their housings. Turn the wheel at first with a slight pressure, and then with a slight axial pull. If the wheel is sluggish the turbocharger must be immediately replaced or reconditioned. Check the wheel for damage.

In the event of daily operation in dusty or oily air, regular cleaning of the compressor housing and compressor wheel is recommended. Fouled compressor parts can result in low boost pressure.

The compressor parts can be cleaned with the unit fitted as follows:

Remove the compressor housing. Clean the compressor housing, compressor wheel and the end-head in paraffin or the like. Fit the compressor housing and measure the boost pressure again.



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Cleaning of compressor parts

6

### Back pressure

Check that the back pressure in the exhaust system is not excessive when installed. See: Exhaust back pressure, checking.

7

### Injection pump

Check the pre-injection angle and high idling speed. Check the whole pump in necessary in a pump testing bench.

8

### Feed pressure

Replace fuel filter if necessary. There must be no fuel leaks.

9

### Injector/pressure pipes

Check that the correct injector is used. Check also the opening pressure and spray pattern. Check that the pressure pipes are not damaged.

10

### Engine condition

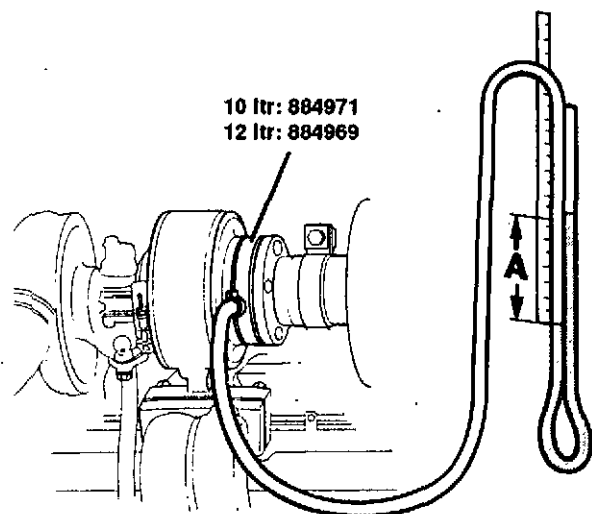
Check valve clearance and compression pressure.

**If the boost pressure remains unsatisfactory after checking the above items, the turbocharger should be reconditioned or replaced.**

## Exhaust back pressure, checking

*Special tools: Measuring flange kit 884969 (12 ltr), 884971 (10 ltr)*

- 1 Remove the exhaust pipe from the turbocharger's exhaust outlet. Remove the studs.
- 2 Clean the sealing surfaces. Fit the longer studs included in the flange kit.
- 3 Fit the measuring flange on the turbine housing with gaskets on both sides.  
Fit the exhaust pipe.



- 4 Connect a transparent plastic hose to the measuring flange as per fig. or alt. a low-pressure manometer.  
The difference between the water columns (A) gives the back pressure of the exhaust pipe in mm water column.

- 5 Run the engine with full load and full throttle for a few minutes and check the back pressure. See "Workshop Manual, Technical Data" for max. permissible back pressure.

An exhaust system with an excessive back pressure reduces the boost pressure, gives reduced engine output and increases exhaust smoke and exhaust temperature, which in turn can result in burned valves and turbo breakdown.

## Bearing clearance, checking

Checking of axial and radial clearance is usually only carried out in connection with reconditioning, when it is necessary to determine the extent of wear in the unit.

### Axial clearance

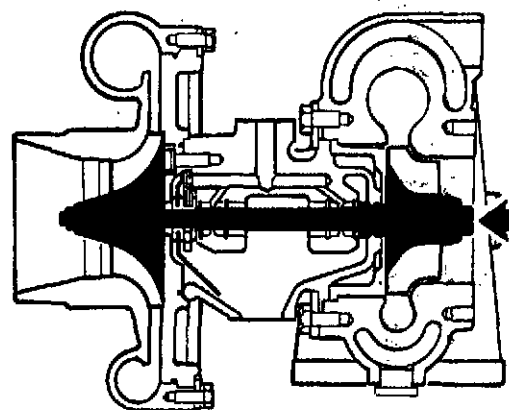
Set the tip of the dial test indicator to zero on the end of the turbine shaft, at the arrow in the fig.

Press the compressor wheel in the direction of the dial test indicator and read off the measurement value.

Press the turbine shaft in the direction of the compressor housing and read off the measurement value.

### Axial clearance:

Holset	max. 0.102 mm (max 0.004")
KKK	max. 0.160 mm (max 0.006")
Switzer	max 0.170 mm (max 0.007")



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Measurement of axial clearance

**Radial clearance**

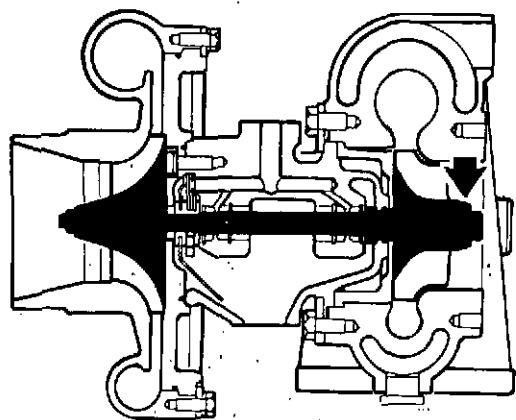
The radial clearance only needs to be checked on the turbine side.

Place the tip of dial test indicator as per the arrow in the figure. Press the turbine wheel downwards and read off the measurement value.

Press in the turbine wheel in the opposite direction and read off the measurement value.

**Radial clearance:**

Holset	max. 0.58 mm (max. 0.0228")
KKK	max. 0.46 mm (max. 0.0181")
Switzer	max 0.70 mm (max 0.028")



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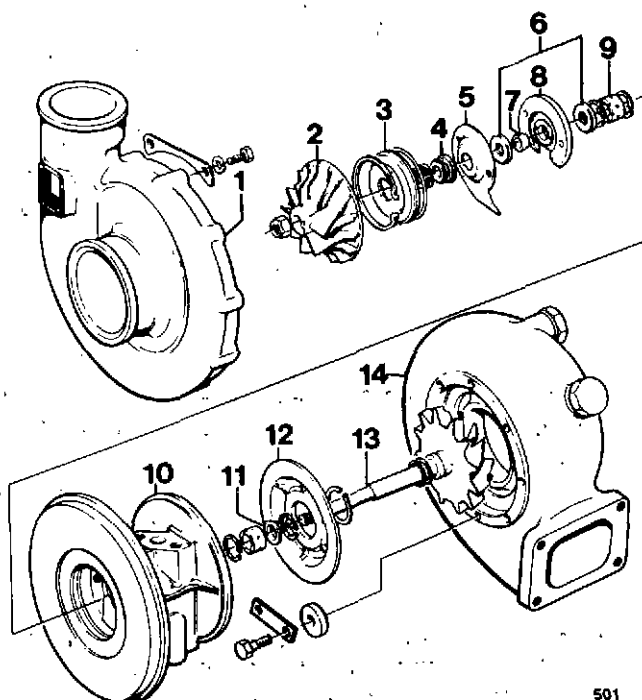
Measurement of radial clearance

**Turbocharger, removing**

- 1 Wash clean around the turbocharger.
- 2 Release the connection on the compressor side. Release the oil pipes.
- 3 Release the exhaust pipe's connection at the turbo. Release the turbocharger's fixing nuts and lift off.

**Holset turbocharger****Dismantling**

- 1 Scribe in line-up markings between the turbine housing (14), bearing housing (10) and the compressor housing (1).



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**Turbocharger, Holset**

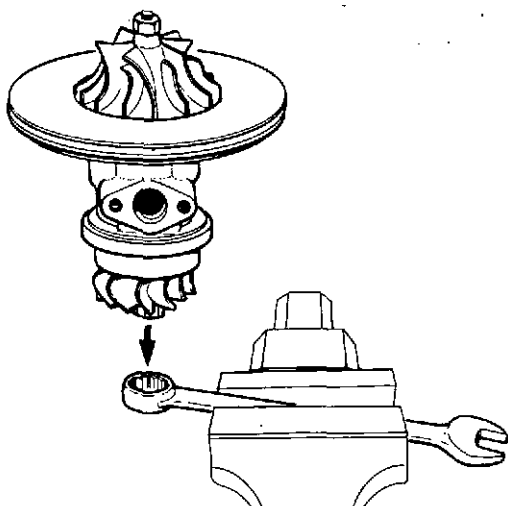
- |                       |                              |
|-----------------------|------------------------------|
| 1. Compressor housing | 8. Thrust bearing            |
| 2. Compressor wheel   | 9. Bearing bushing           |
| 3. Cover              | 10. Bearing housing          |
| 4. Piston ring holder | 11. Sealing washer           |
| 5. Oil guide plate    | 12. Heat shield              |
| 6. Thrust washers     | 13. Shaft with turbine wheel |
| 7. Spacer sleeve      | 14. Turbine housing          |

**2**  
Remove the compressor housing. Tap if necessary with a soft mallet so that the parts separate.

**NOTE!** Observe care when removing the housing so that the compressor and turbine wheel are not damaged. These parts cannot be repaired and must be replaced in the event of damage.

**3**  
Remove the turbine housing.

**4**  
Place the turbine wheel hub on a suitable cap wrench as per the figure.



**5**  
Unscrew the compressor wheel's shaft nut. Use a T-bar together with a universal joint and sleeve so that the turbine wheel shaft is not unevenly loaded. Mark up the position of the compressor wheel in relation to the shaft. Lift off the compressor wheel.

**6**  
Carefully brace the turbine wheel hub in a vice provided with protection pads. Observe care with turbine wheel blades.

**7**  
Remove the circlip and lift up the cover (3) with the aid of two screwdrivers. Remove the piston ring holder (4) and the O-ring from the cover.

**8**  
Lift off the oil guide plate, thrust washer, thrust bearing, spacer ring and inner thrust washer.

**9**  
Lift off the bearing housing from the shaft. Remove the circlip and lift off the heat shield (12).

**10**  
Remove the circlips, bearing bushings and sealing washer (11) from the bearing housing.

**11**  
Remove the piston rings from the piston ring holder and turbine shaft.

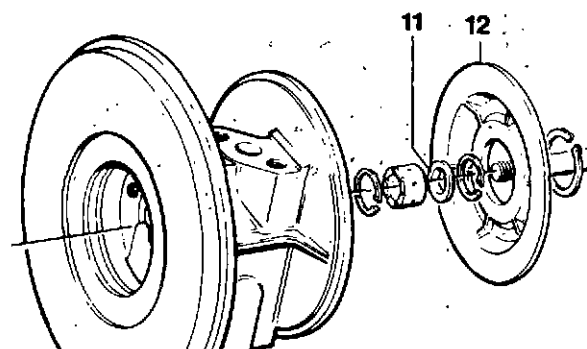
**Cleaning and inspection, see page 87.**

### Assembly

Check before assembly that all parts are thoroughly cleaned. It is very important that no foreign particles come into the turbine during assembly. **Lubricate all moving parts with clean engine oil in connection with assembly.**

**1**  
Fit the bearing bushings and circlips in the bearing housing. Do not forget the sealing washer (11) on the turbine side. Check that all bushings can rotate.

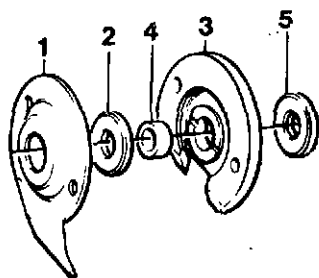
**2**  
Fit the heat shield (12) on the turbine side of the bearing housing together with the circlip.



**3**  
Place the piston rings on the turbine wheel shaft. Observe care so that they do not break apart or damage the bearing surfaces.

**4**  
Center the piston rings. Shift the piston ring gap and put in the turbine wheel with shaft in the bearing housing. The shaft must **absolutely not be forced** down in the bearing housing.

**5**  
Brace the turbine wheel hub in a vice provided with protection pads. Fit the thrust washer (5) spacer ring (4), thrust bearing (3), outer thrust washer (2), and oil guide plate (1).



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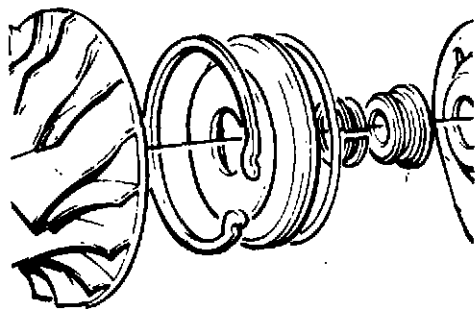
#### Axial bearing

- |                    |                  |
|--------------------|------------------|
| 1. Oil guide plate | 4. Spacer ring   |
| 2. Thrust washer   | 5. Thrust washer |
| 3. Thrust bearing  |                  |

**6**  
Fit the piston rings on the ring holder. The piston ring gaps are turned 90° in each direction in relation to the bearing housing's oil inlet.

Place the ring holder in the cover and put on the cover together with the O-ring.

Fit the circlip with the bevel turned **upwards**.



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**7**  
Place the turbine wheel hub in a suitable cap wrench as per dismantling. Fit the compressor wheel (note the marking to the shaft).  
Tightening torque: 40,7 Nm (360 lbf.in).

**NOTE!** A T-bar together with a universal joint and sleeve should be used to avoid bending stress on the rotor shaft.

Check the radial and axial clearance of the shaft, see page 77.

**8**  
Place the turbine housing in a vice. Fit the bearing housing on the turbine housing as per previous marking.

Apply heat resistant grease to the screws before fitting.

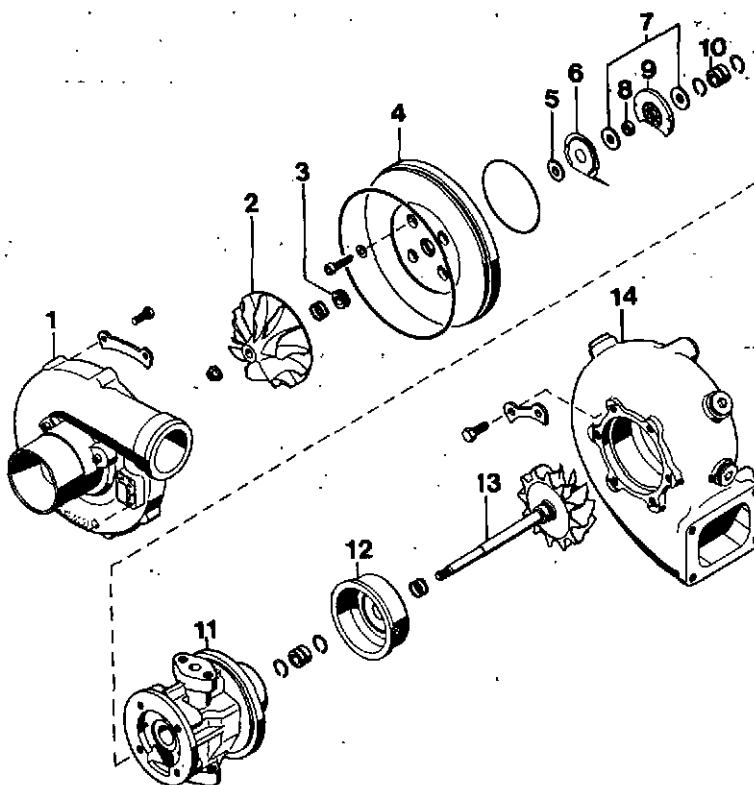
**9**  
Fit the compressor housing as per the marking.

**10**  
Check that the rotor can move freely by turning the shaft, at the same time as the turbine wheel is pressed inwards. Press in the compressor wheel and carry out same check.

**11**  
Inject clean engine oil into the bearing housing. Plug all the openings if the unit is not to be fitted immediately.

## KKK Turbocharger

1. Compressor housing
2. Compressor wheel
3. Piston ring holder
4. Cover
5. Oil ejector
6. Oil guide plate
7. Thrust washers
8. Spacer sleeve
9. Thrust bearing
10. Bearing bushing
11. Bearing housing
12. Heat shield
13. Shaft with turbine wheel
14. Turbine housing



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### Dismantling

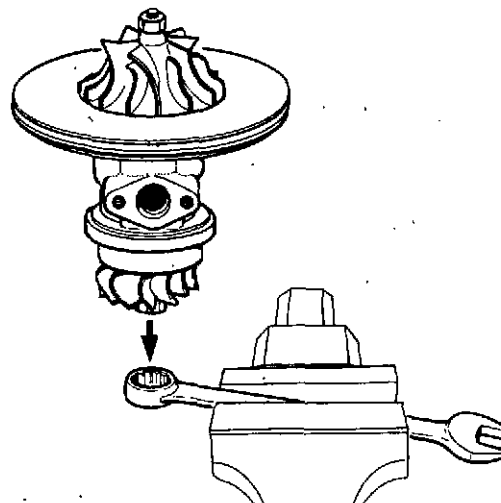
**1**  
Scribe in markings between the compressor housing (1), the cover (4), bearing housing (11), and turbine housing (14).

**2**  
Remove the compressor housing: Tap if necessary with soft mallet so that the parts separate.

**NOTE!** Observe care when removing the housing so that the compressor and turbine wheels are not damaged. These parts cannot be repaired and must be replaced if damaged.

**3**  
Remove the turbine housing. Heat up the housing somewhat with a hot-air gun if it is tight.

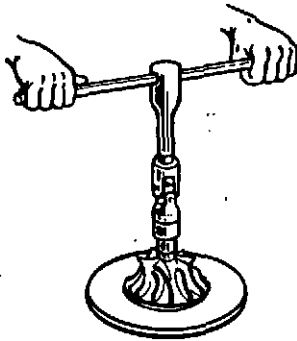
**4**  
Place the turbine wheel hub on suitable cap wrench as per fig.



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**5**  
Unscrew the compressor wheel's shaft nut. Use a T-bar together with a universal joint and sleeve so that the turbine wheel shaft is not unevenly loaded.

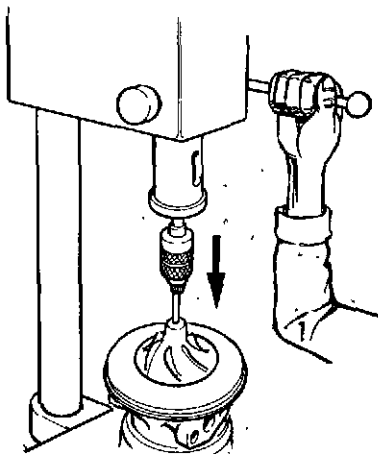
**NOTE!** The nut is secured with Loctite. If it is tight heat with hot-air gun to max. **130° (266°F)**.



**6**  
Mark up the position of the compressor wheel in relation to the shaft.

Heat the compressor wheel in the same way to max. **130° (266°F)**. Carefully press out the shaft with a press tool or pillar drill.

**NOTE!** The heat shield (12) must be held centred to the bearing housing when the shaft is pressed out.



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**7**  
Remove the shaft carefully from the bearing housing. Remove the piston rings from the shaft. Remove the heat shield (12).

**8**  
Place the bearing housing in a vice with the jaws against the oil connection flanges.

**NOTE!** Use protective pads. Remove the cover (4).  
**NOTE!** The screws are secured with Loctite.

**9**  
Remove the piston ring holder (3) and O-rings from the cover. Remove the piston rings from the piston ring holder.

**10**  
Remove the oil ejector (5), oil guide plate (6), thrust bearing (9), thrust washers (7) and spacer sleeve (8).

**11**  
Remove the circlips and bearing bushings from the bearing housing.

**Cleaning and inspection, see page 87.**

### Assembly

Check before assembly that all parts are thoroughly cleaned. It is very important that no foreign particles come into the turbo during assembly. **Lubricate all moving parts with clean engine oil in connection with assembly.**

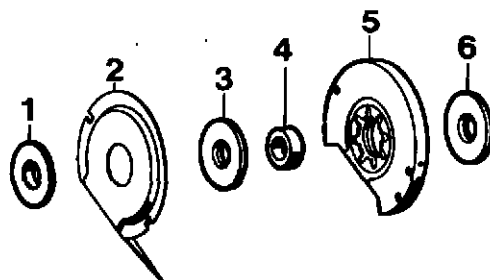
**1**  
Fit the bearing bushings and circlips in the bearing housing. **Check that the bushings can rotate.**

**2**  
Brace the turbine wheel hub in a vice provided with protection pads.

**3**  
Fit the piston rings on the shaft, shift the openings **180°**. Place the heat shield (12) on the shaft.

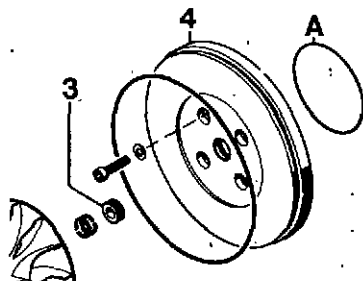
**4**  
Guide the bearing housing carefully on the shaft. Check that the heat shield and bearing housing can be freely rotated.

**5**  
Fit the thrust washer (6), spacer sleeve (4), thrust bearing (5), outer thrust washer (3), oil guide plate (2), and oil ejector (1). Turning the collar upwards.



**6**  
Fit the piston rings on the piston ring holder. Shift the openings 180°.

**7**  
Fit the piston ring holder (3) in the cover (4). Press the piston rings together with two screwdrivers if necessary.



**8**  
Apply sealing agent, part no. 840879-1, on the mating surface of the cover to the bearing housing.

Fit the cover as per the markings together with new O-ring (if groove exists in sealing surface of bearing housing).

Apply locking fluid, part no. 1161053-6, on the screw threads and tighten the cover.

**9**  
Heat the compressor wheel to max. 130°C (266°F). Oil in the thrust collar on the rotor shaft. Fit the compressor wheel (note the marking to the rotor shaft).

Place the turbine wheel hub on a suitable cap wrench as per dismantling.

Tighten the nut. Use a T-bar together with a universal joint and sleeve. Tightening torque, **M6: 7 Nm (5.2 ft/lb)**, **M8: 15 Nm (11 ft/lb)**.

When the compressor wheel has cooled apply Loctite 640 on the free threads of the shaft. Release the nut approx. 2 turns and screw on again. Tightening torque, **M6: 5 Nm (3.7 ft/lb)** and angle tightening **60°**. **M8: 10 Nm (7.4 ft/lb)** and angle tightening **100°**.

**10**  
Check the radial and axial clearance of the shaft, see page 77.

**11**  
Apply grease on the O-ring and place it in the cover groove. Fit the compressor wheel as per the marking.



**Warning!**

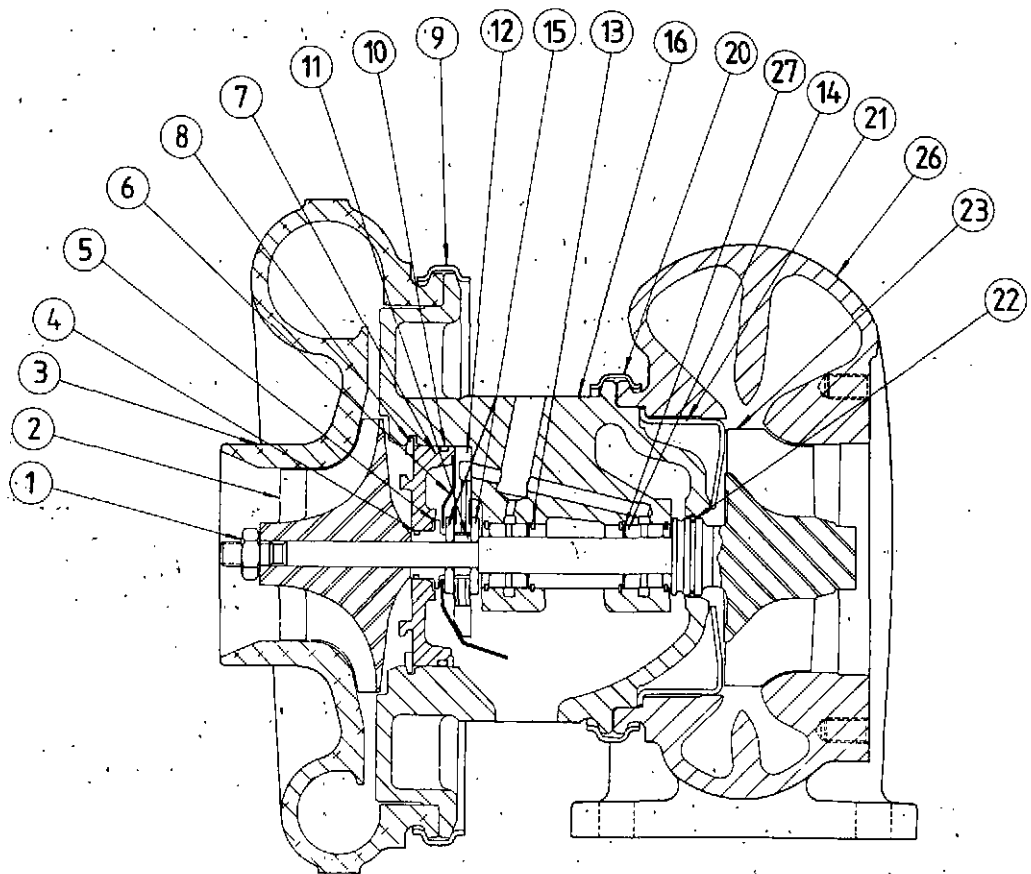
If the compressor housing comes at an angle when fitting, the blade may be damaged.

**12**  
Apply heat resistant grease on the screws for the turbine housing. Fit the housing as per the markings.

**13**  
Check that the rotor shaft rotates freely by turning the shaft, at the same time as the turbine wheel is pressed inwards. Press in the compressor wheel and carry out the same check.

**14**  
Inject clean engine oil into the bearing housing. Plug all openings if the unit is not to be fitted immediately.

## Switzer turbocharger



- 1 Locknut
- 2 Compressor wheel
- 3 Compressor cover
- 4 Piston ring
- 5 Piston ring holder
- 6 Oil deflector
- 7 Cover
- 8 Snap ring
- 9 Vee clamp
- 10 O-ring
- 11 Spacer sleeve
- 12 Thrust bearing
- 13 Snap rings (4 pcs)
- 14 Journal bearings (2 pcs)
- 15 Thrust rings (2 pcs)
- 16 Bearing housing assembly
- 20 Vee clamp
- 21 Backplate
- 22 Piston ring
- 23 Shaft & wheel assembly
- 26 Turbine housing
- 27 Speed control washers (2 pcs)
- Locknuts (vee clamp) (2 pcs)

## Dismantling

**1**  
Mark the relative positions of the compressor cover (3) and the turbine housing (26) to the bearing housing (16).

**2**  
Fix the turbine housing (26) in the vice using soft jaws with the turbocharger shaft vertical.

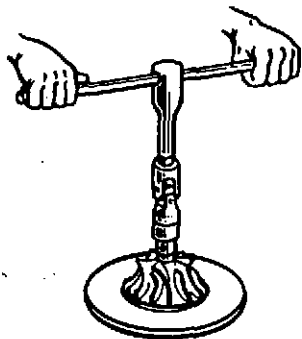
**3**  
Release the compressor cover vee clamp (9). Lift off the compressor cover (3) and vee clamp.

**4**  
Release the turbine and vee clamp (20).

**5**  
Lift the central core assembly out of the turbine housing (26).

6

Place the turbine wheel hub on a suitable cap wrench as per fig. Release the compressor wheel locknut (1).



**NOTE!** Use **T-handle wrench** together with a universal joint to avoid side-loading the turbine wheel shaft.

7

Remove the compressor nut (1) and slide the compressor wheel (2) from the turbine shaft.

8

Gently remove the turbine shaft and wheel (23) by tapping with a small soft faced mallet on the compressor end of the shaft. Be careful not to bend or damage the shaft.

9

Put the bearing housing on the turbine backplate (21) on the bench and remove the insert retaining snap ring (8).

10

Lever out the insert assembly from the bearing housing by prying evenly with screwdrivers under the lip.

**NOTE!** Thread a piece of plastic tubing over the screwdrivers to avoid damaging the bearing housing.

11

Dismantle the insert assembly by pushing the piston ring holder (5) out of the insert.

12

Lift out the thrust rings (15) and thrust bearing (12) from the bearing housing.

13

Using suitable circlip pliers, remove the outer circlips from both ends of the bearing housing, remove the journal bearings (14) and inner circlips.

**Cleaning and inspection, see page 87.**

## Assembling

Before reassembly, check that all parts have been thoroughly cleaned. It is very important that no foreign particles enter the turbo during assembly. All parts must be washed in clean solvent and dried in compressed air.

Use only parts complying with the dimensions outlined in the inspection instruction, plus an "Overhaul Kit".

1

Fit the inboard snap rings to the bearing housing bore. Add a few drops of oil to the bore and fit the journal bearings (14), speed control washers (27) and outboard circlips.

2

Fit a new piston ring seal to the groove in the shaft and wheel assembly (23).

3

Fit turbine backplate (21) over the shaft section and rest on the back of the turbine wheel.

4

Fit the shaft and wheel etc. into the bearing housing assembly after lubrication both shaft and piston ring (22). Take care not to damage the piston ring when entering the sealing bore.

5

Place this assembly into the turbine housing with the shaft vertical. Fit the thrust ring (15) onto the shaft. Fit the thrust bearing (12) into the bearing housing and lubricate the bearing surfaces.

6

Fit the second thrust ring (15) and oil deflector (6). Fit a new O-ring (10) to the groove in the insert. Fit a new piston ring (4) into the piston ring holder (5).

7

Assemble the piston ring holder (5) into the insert taking care not to damage the piston ring.

8

Lubricate the O-ring (10) and assemble the insert assembly into the bearing housing and shaft assembly and retain with the snap ring (8), taking care to ensure the bevelled edge is uppermost.

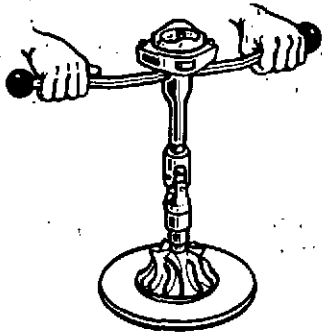
9

Fit the compressor wheel (2) and lock nut (1).

10

Place the turbine wheel hub in a suitable cap wrench.

Tighten the compressor locknut to **5.5 Nm (4.0 ft.lb) + angle tightening 61°-66°**. Apply two drops of locking fluid, part no. 1161053-6, to the threads.



**NOTE!** Use a T-handle torque-wrench together with a universal joint to avoid side-loading the turbine wheel shaft.

11

Check the wheel assembly's radial and axial clearances. See page 77.

12

Fit the core assembly into the compressor cover, orientate to the marks, fit the vee clamp (9) and tighten the nut to **11 Nm (8 ft.lb)**.

13

Fit the core assembly into the turbine housing, orientate to the marks, fit the vee clamp (20) and tighten the nut to **11 Nm (8 ft.lb)**.

## Turbocharger, cleaning

Examine all parts **before** cleaning. Certain friction marks, heat damage and the like, disappear after cleaning.

Submerge the parts in carbon solvent. Cleaning solutions shall not be caustic.

Remove impurities with a stiff bristle brush.

**NOTE!** Wire brushes must not be used since they can cause scratching.

## Turbocharger, inspection

The cleaned parts are inspected for wear, cracks and scratches. Slight damage can be removed with an emery cloth applied with silicon carbide for aluminium parts, and high gloss grinding agent for steel parts.

Always replace bushings, circlips, piston rings, sealing rings, compressor wheel nuts and screws and lock-plates. Rotating parts with cracks must always be replaced.

### Bearing housing

Check worn parts resulting from contact with moving parts.

Check sealing surfaces, the position of bushings, and bearing races. Lubricating channels shall always be clean and free from constrictions.

### Compressor wheel and turbine wheel with shaft

Check friction damage and cracks on the compressor wheel, turbine wheel and shaft.

The blades must not be worn, twisted or cracked. There must be no sharp edges.

The shaft may only have negligible marks, scratches or seizure damage at the bearing recesses.

Damage to the turbine wheel blades may be the result of abnormal bearing wear, or from loose particles from exhaust channels and outlet pipes. In such cases these shall also be examined.

If there are grooves in the bearing recesses this has probably been caused by insufficient lubrication as a result of badly managed service of the engine's lubrication system.

For balancing during the replacement of rotating parts see: "Balancing of rotor shaft".

### Thrust bearings and thrust washers

Wear damage to these components can be discovered by measuring the axial clearance of the turbocharger before removing; see "Bearing clearance, checking".

These parts are replaced during each reconditioning.

### Cover

Check damage caused by contact with rotating parts. The mating surface for the piston seal on the compression side must not be grooved or worn.

### Turbine housing/ compressor housing

Check the housings for damage. Cracks or indications of contact with rotating parts imply the replacement of the housing.

### Balancing of the rotor shaft

All rotating parts are separately balanced. This means that balancing is not necessary irrespective of which part is replaced. This assumes, however, that the rotating part is replaced at the first sign of damage. If there is access to a balancing machine it can prolong service-life if an all-round balancing is carried out.

More detailed information on balancing machines and procedures, max. permissible imbalance, and where material can be removed, is available from the turbocharger manufacturer. As a rule balancing machines are only profitable for special workshops.

## Turbocharger, fitting

If the turbocharger has been replaced or reconditioned, **always determine the reason for the breakdown.** Correct any faults before refitting the turbo unit.

Bearing breakdown is often caused by sludge deposits in the engine's lubricating system. This can be checked by opening a valve cover. If there are sludge deposits there, the whole lubricating system must be cleaned.

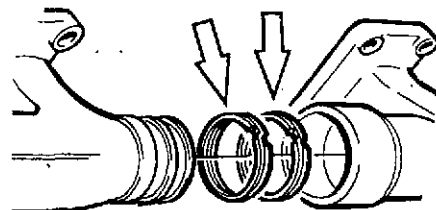
The correct oil quality and regular oil changes and filter changes in accordance with the servicing schedule are necessary to keep the engine clean and avoid breakdowns.

- 1 Change the engine oil and lubricating oil filter.
- 2 Clean the inlet pipe between the compressor and engine. After a turbo breakdown foreign objects, such as a broken compressor wheel, may remain and come into the engine or break up the new compressor or turbine wheel. If the engine is equipped with aftercooler this shall also be checked.
- 3 Clean exhaust manifold from loose carbon, coke or metal flakes.
- 4 Fit the turbocharger on the engine. Connect the return oil pipe.
- 5 Connect the air pipe. Fit connection pipe/hose for air filter. Replace air filter.
- 6 Connect the exhaust pipe.
- 7 Inject clean engine oil via the lubricating oil inlet in the bearing housing. Connect the pressure oil pipe.
- 8 Release the return oil pipe's connection at the engine block. Place a collection vessel under the pipe.
- 9 Run the engine round with the starter motor (stop button pressed in), until oil pressure is obtained. Start engine and check that oil flows out from the return pipe.
- 10 Stop the engine and screw tight the oil return pipe. Check the oil level in engine. Start the engine and check that there is no leakage.

## Exhaust manifold, changing gaskets

### Removing

- 1 Remove the return oil pipe from the turbo.
- 2 Remove the turbo delivery oil pipe.
- 3 Remove the charge air pipe.
- 4 Remove the nuts and lift off the turbo from the exhaust manifold.
- 5 Remove the four front fuel delivery pipes and fit protective plugs on the injectors and injection pump connections. (Not required on some engines).  
**NOTE!** Fuel delivery pipes must never be bent or altered. A damaged fuel delivery pipe should always be replaced with a new one.
- 6 Straighten the locking tabs securing the exhaust manifold bolts.
- 7 Remove the attaching bolts, locking tabs, washers and sleeves from the exhaust manifold.  
Remove the exhaust manifold.
- 8 Remove the gaskets and clean all contact surfaces of the manifold and the cylinder heads.  
Remove the gaskets and clean the oil pipe connections on the turbo.  
Disassemble the exhaust manifold.  
Remove the sealing rings from the exhaust manifold.



**Fitting****9**

Blow out any flakes of soot with compressed air. Fit new sealing rings to the exhaust manifold.

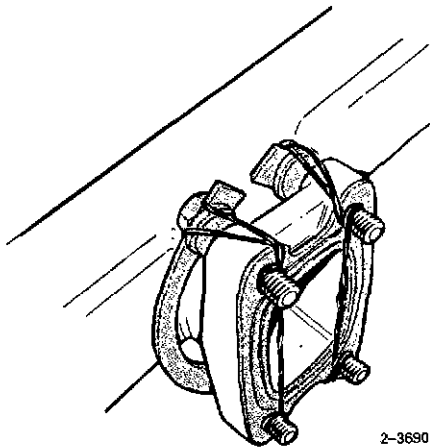
Assemble the exhaust manifold.

**10**

Fit the sleeves, washers, locking tabs and bolts to the exhaust manifold.

Fit the new gaskets over the bolts.

Stretch rubber bands between the bolts to hold the gaskets, bolts, sleeves, washers and locking tabs in position.

**11**

Lift the exhaust manifold into position and screw in the bolts 2-3 turns. Cut off and remove the rubber bands.

**12**

Tighten the exhaust manifold down and secure the bolts with the locking tabs.

**13**

Fit the fuel delivery pipes. (if loosened)

**14**

Fit a new gasket to the exhaust manifold.

**15**

Lift up the turbo and screw it onto the exhaust manifold.

**16**

Fit the turbo delivery oil pipe with new gasket and new washers.

**17**

Connect the exhaust pipe.

**18**

Fit the charge air pipe.

**19**

Place a container under the return oil opening of the turbo. Crank the engine round with the starter motor and with the injection pump in the stopped position, until a steady flow of oil runs out of the return oil opening.

**20**

Fit the return oil pipe using a new gasket.

**21**

Check engine oil level, top up if necessary.

**22**

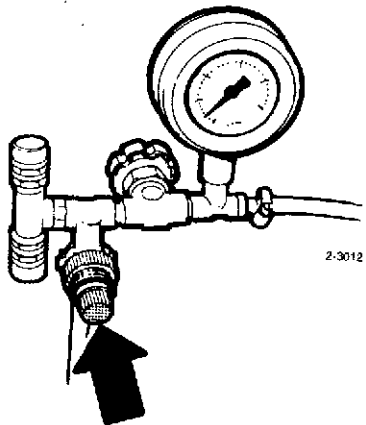
Start the engine and check that there is no leakage.

## Charge air cooler, checking for leakage (TAD)

Special tools: 6662, 885231, 885232

Before using pressure tester, it should be checked.

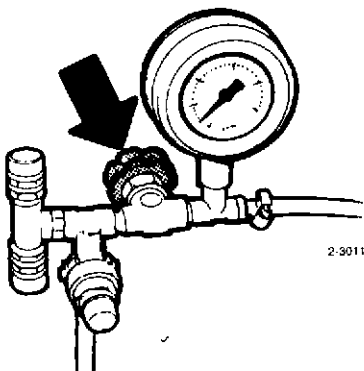
1



Connect the pressure tester to the workshop air supply and set the pressure gauge to 100 kPa (14.5 psi) with the reduction valve.

**Note!** To lock the reduction valve knob, move the lock ring axially.

2

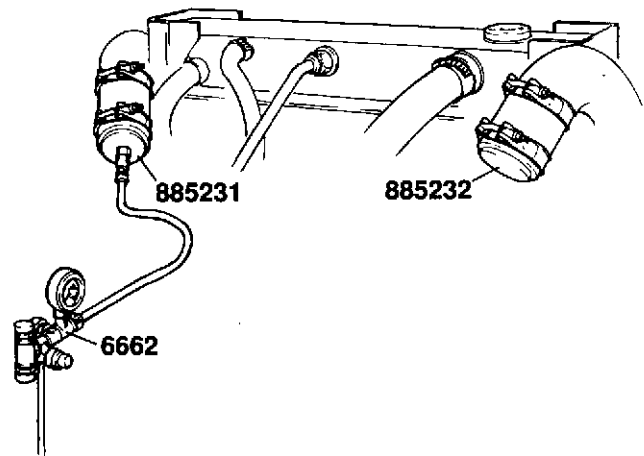


Shut off the valve. The pressure gauge dial pointer must not drop during 2 minutes otherwise the gauge cannot be relied upon.

3

Disconnect the charge air hoses from the charge air cooler.

4



Fit connection washer 885231 and sealing washer 885232 with new sealing rings on the charge air cooler.

Unscrew the pressure tester reduction valve.

Connect the pressure tester to the charge air cooler.

5

Open the shut-off valve knob and set the gauge to a pressure of 70 kPa (10.2 psi) with the reduction valve.

6

Close the shut-off valve. During one minute pressure may not drop more than 20 kPa (2.9 psi) otherwise the charge air cooler cannot be approved.

7

In the event of leakage, repeat the check several times. Also check the pressure tester hoses and connections.

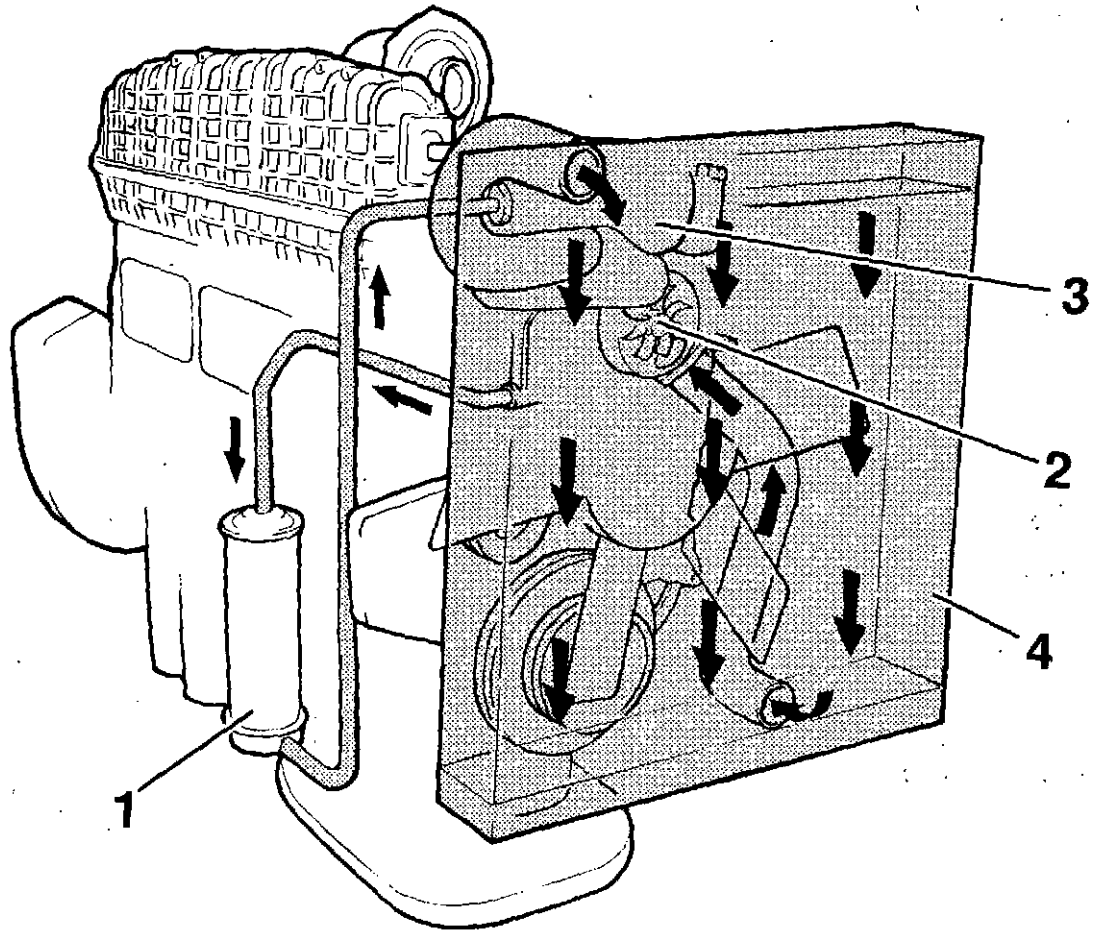
8

Remove the pressure tester, connection washer and sealing washer.

9

Connect the charge air hoses using new sealing rings.

# Cooling system Design and function



- 1 Oil cooler
- 2 Coolant pump
- 3 Thermostat housing
- 4 Radiator

## Cooling system

The coolant is pumped round the system by a gear driven pump and is led via a distribution gallery into the cylinder block.

After cooling the cylinder heads and cylinder liners, the coolant reaches the thermostat housing.

Depending on coolant temperature (thermostat opening) it is led either back to the engine block or to the radiator through the top radiator hose.

From the thermostat housing, the coolant is also distributed to the oil cooler and the charge air cooler (TWD).

The radiator is of a new type with embossed tubes to give better heat transition and higher cooling capacity.

A pressure valve in the expansion tank cap regulates pressure in the cooling system.

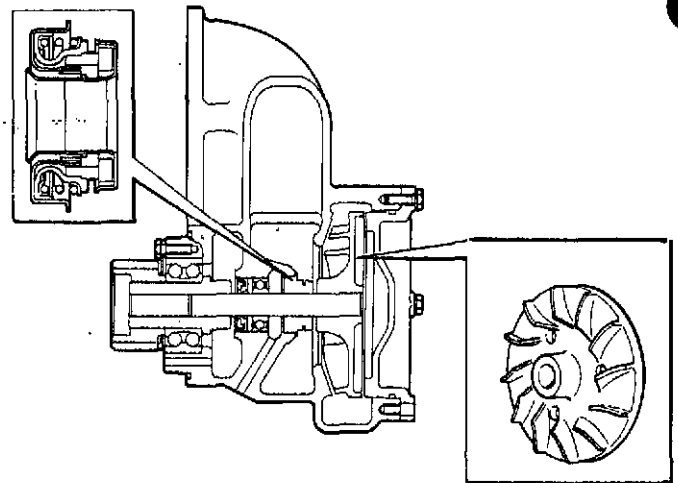
The pressure valve opens at approx. 70 kPa.

## Coolant pump

The TAD/TWD is equipped with a gear driven high flow coolant pump.

The high flow pump is mounted on engines where particularly high demands are made on cooling capacity.

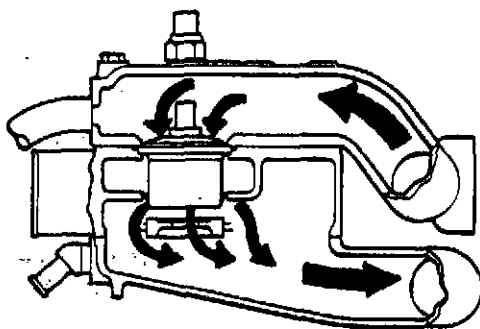
The coolant seal is made in one piece using carbon/ceramics as the sealing element.



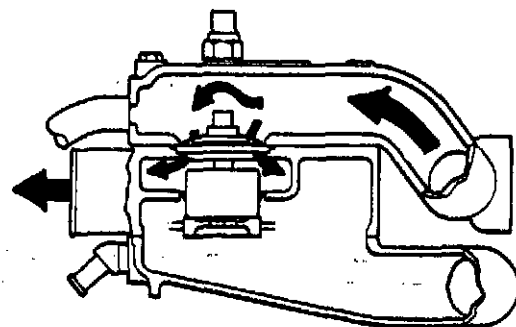
2-3688

## Thermostat, thermostat housing

Thermostat opening temperature:  
See "Workshop Manual, Technical Data".



Thermostat in closed position

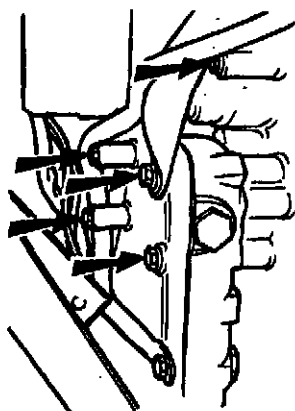


Thermostat in open position

## Service Procedures

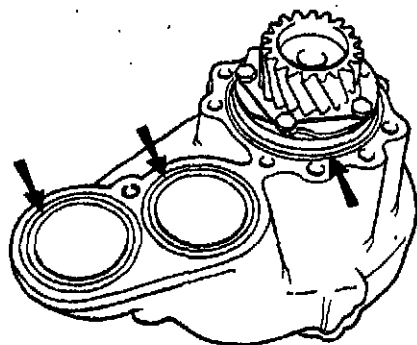
### Coolant pump, changing

- 1 Drain off the coolant.
- 2 Disconnect the pipe from the coolant pump.
- 3 Remove the bolts holding the coolant pump (five). Carefully tap loose the pump and remove it.

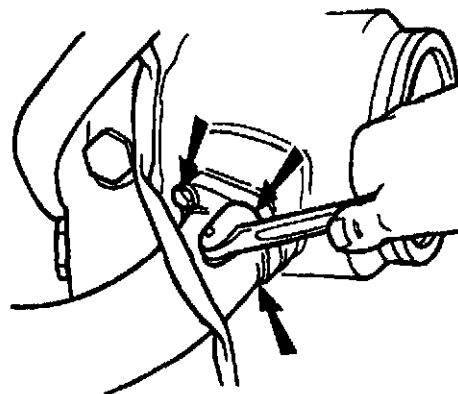


- 4 Clean the sealing surfaces on the coolant pump and engine and on the pipe from the lower radiator hose.

- 5 Fit new O-rings to the coolant pump.



- 6 Fit the coolant pump.
- 7 Fit a new O-ring to the pipe leading to the coolant pump.
- 8 Attach the pipe to the coolant pump.



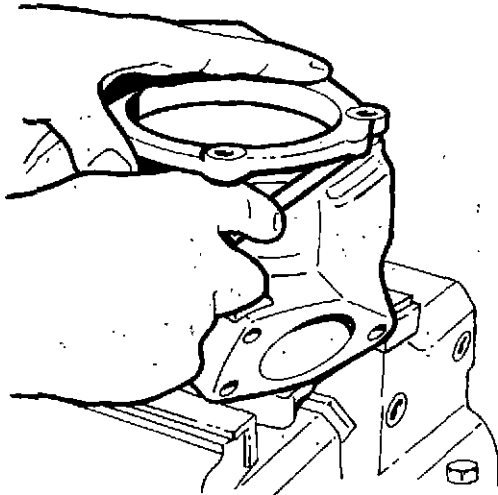
- 9 Fill up with coolant and carry out a leakage test.

## Coolant pump, overhauling

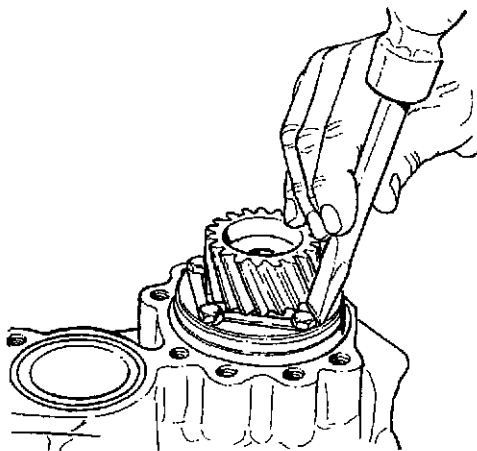
Special tools: 1801, 1817, 2457, 6858, 6939, 8361, 8362

### Disassembling

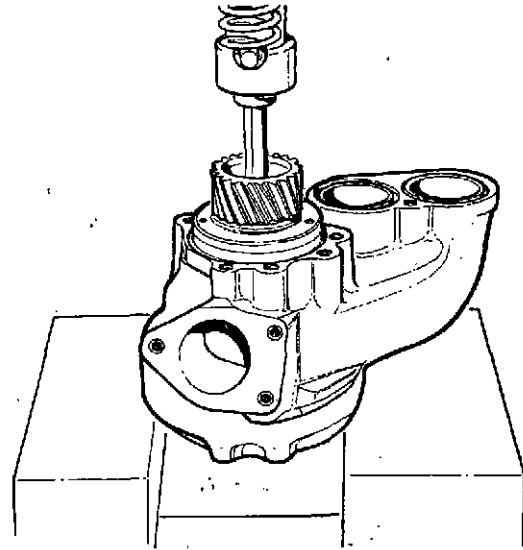
- 1  
Attach the coolant pump in a vice with the end cover facing upwards.  
Remove the screws and prise off the cover using a screwdriver.



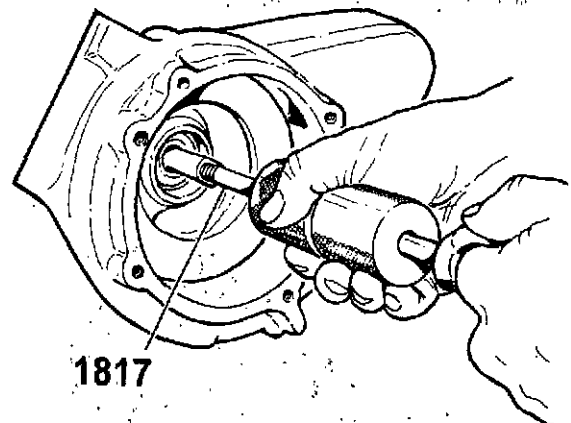
- 2  
Turn the pump over in the vice and flatten the locking tabs for the bearing screws.  
Remove the screws, the locking tabs and the bearing holder.



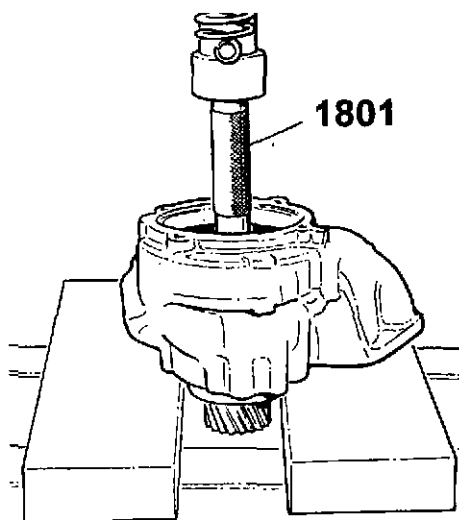
- 3  
Place the pump in a press. Place a counterhold under the pump housing so that the impeller can go free.  
Press out the pump shaft, impeller and seal using a 14x100 mm (0.55x3.94") drift.



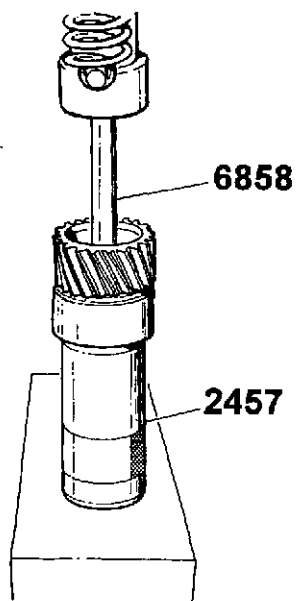
- 4  
If the complete seal does not come out, remove the remainder of the seal with extractor 1817.



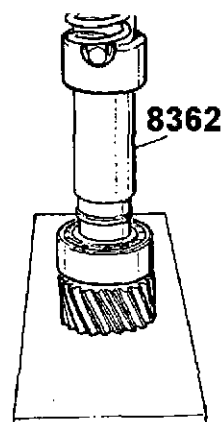
- 5 Using drift 1801, press the drive gear, bearing and oil seal out of the pump housing.



- 6 Press the drive gear and bearing off the shaft using tool 6858. Use 2457 as a counterhold.

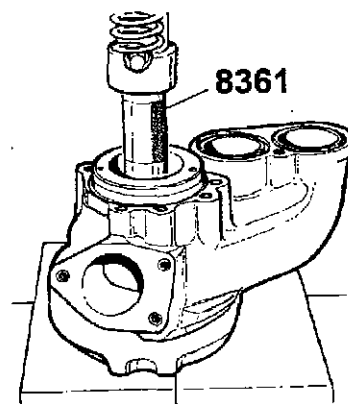
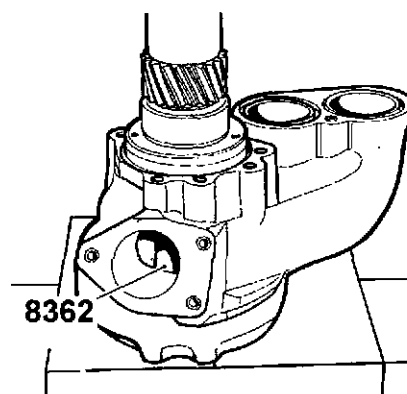


- 7 Lubricate the shaft with engine oil. Press on the new bearing and drive gear.



- 8 Place 8362 in the pump housing's impeller side as a counterhold for the inner bearing. Press on the bearing using 8361 until it bottoms against 8362.

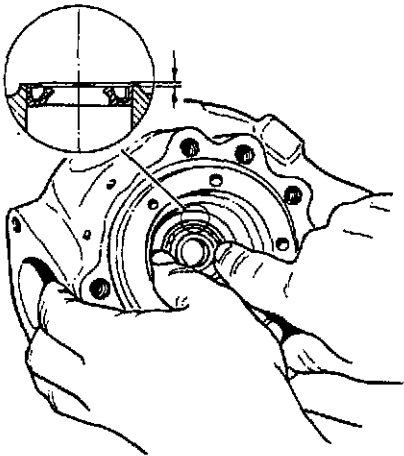
**Note:** Press on the bearing outer race.



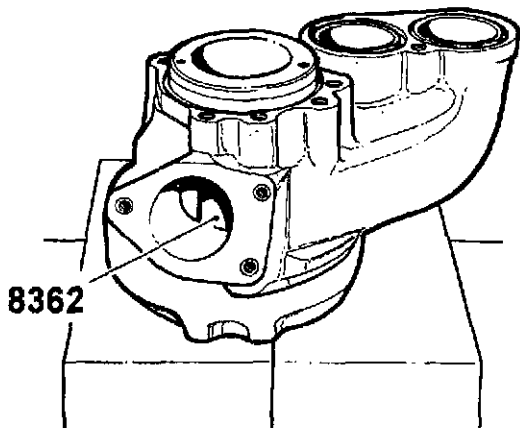
**Assembly****9**

Oil the seal. Press the seal into the pump housing until the seal's upper edge is below the bevelled edge of the pump housing.

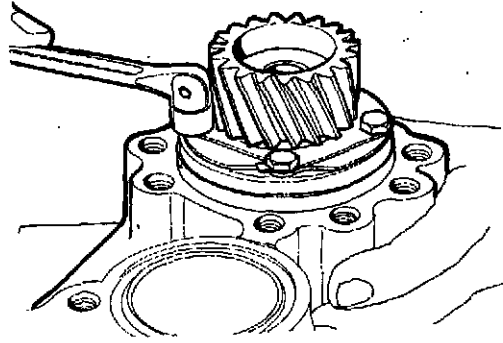
**Note:** The sealing lip should face the gear wheel side. Oil the sealing lip.

**10**

Press the drive gear, bearing and shaft into the pump housing. Use 8362 as a counterhold for the inner bearing. Continue pressing until the shaft's outer bearing race bottoms against the pump housing. Check that the shaft rotates easily.

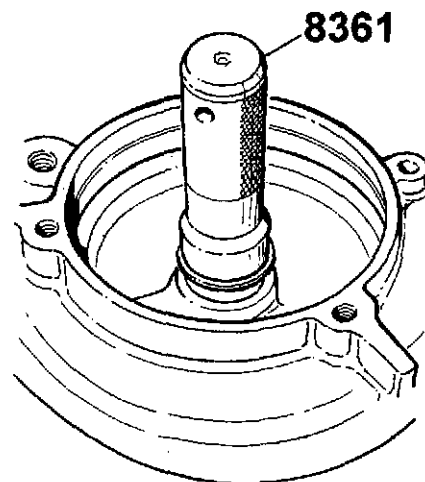
**11**

Fit the bearing holder, the locking tabs and the screws. Tighten the screws and lock with the tabs.

**12**

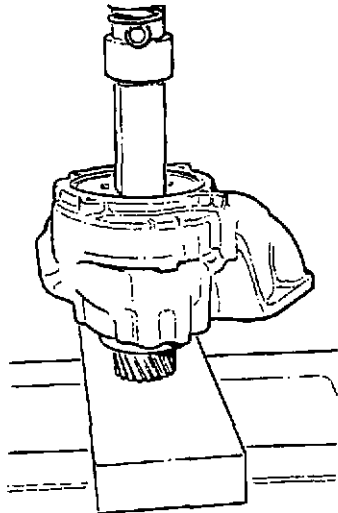
Press on the coolant seal using tool 8361.

**Note:** Use locking fluid between the seal and pump housing.



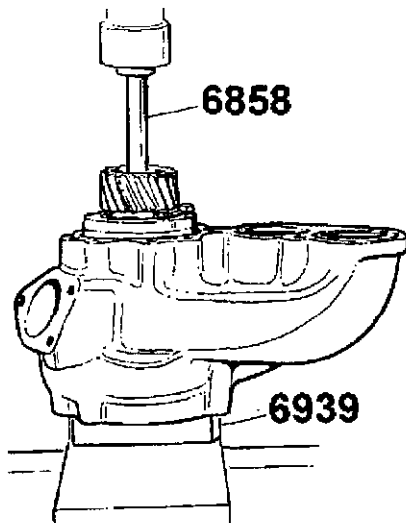
13

Press the impeller a short distance onto the shaft until it feel secure, do not press it to the bottom.



14

Place tool 6939 with the flat side facing downwards. Position the pump with the impeller resting on drift 6858. Press on the shaft using 6858 until the pump housing bottoms against the pressing table.



15

Fit the end cover together with a new o-ring.

## Thermostat

### Changing thermostat 10 ltr engines

*Special tools: 6781*

1

Drain off the coolant.

2

Remove the upper radiator hose.

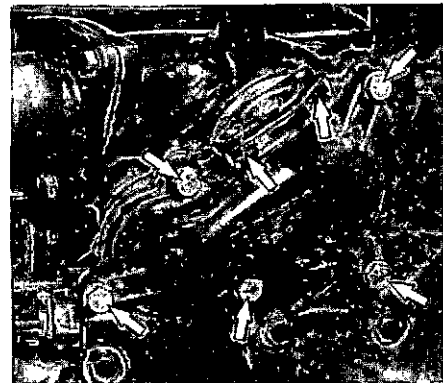
3

Remove the coolant pipe from the thermostat housing cover.

4

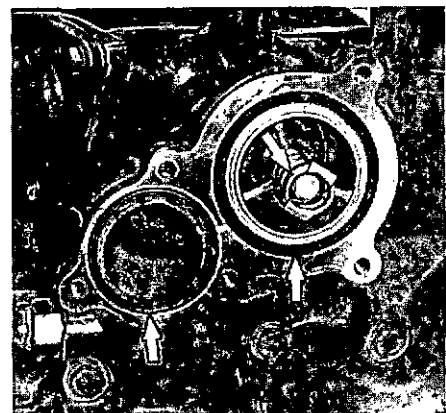
Remove the thermostat housing cover.

**NOTE!** Make sure that the nuts for the coolant pipe bolts do not fall out when the cover is removed.

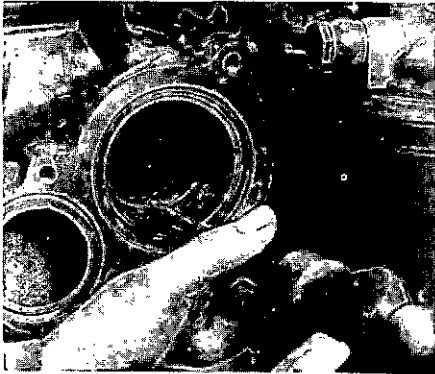


5

Remove the thermostat and sealing rings.



- 6**  
Remove the sealing ring from the thermostat housing by tapping it with a drift until it leans over and can be pulled out.

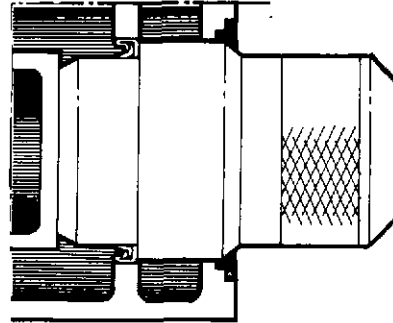
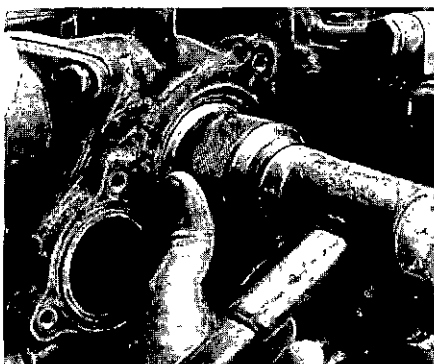


- 7**  
Clean the thermostat housing, the grooves for the sealing rings and the thermostat housing cover.

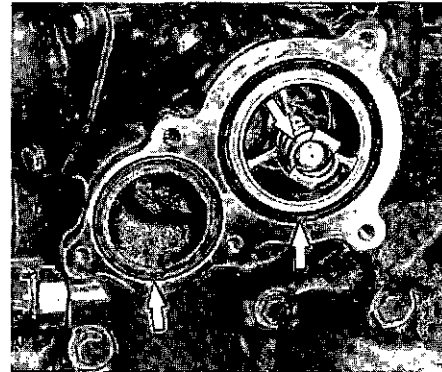
- 8**  
Fit a new sealing ring to drift 6781. The sealing ring must be turned so that the sealing lips are inwards toward the engine.



- 9**  
Carefully tap in the sealing ring until the drift bottoms in the thermostat housing.



- 10**  
Fit the new thermostat and new sealing rings to the thermostat housing.



- 11**  
Fit the thermostat cover and tighten down the screws.  
**NOTE!** Make sure that the nuts for the coolant pipe bolts are still in position in the cover.



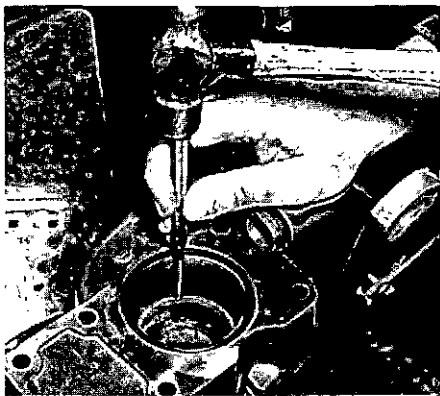
- 12**  
Fit a new sealing ring to the thermostat housing cover. Fit the coolant pipe. Attach the hose to the coolant pipe.

- 13**  
Fit the upper radiator hose.  
Fill with coolant and carry out a leakage check.

## Changing thermostat 12 ltr engines

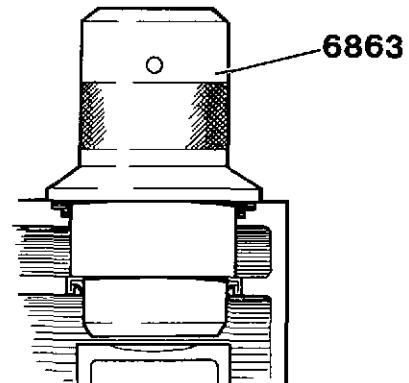
*Special tools: 6863*

- 1**  
Drain off the coolant.
- 2**  
Remove the bolts to the fuel filter housing.
- 3**  
Remove the radiator stay together with the thermostat housing bracket.
- 4**  
Remove the remaining bolts on the thermostat housing cover and remove the cover.
- 5**  
Lift up the sleeve thermostat.
- 6**  
Remove the lower sealing ring from the thermostat housing by tapping it with a drift until it leans over and can be pulled out.

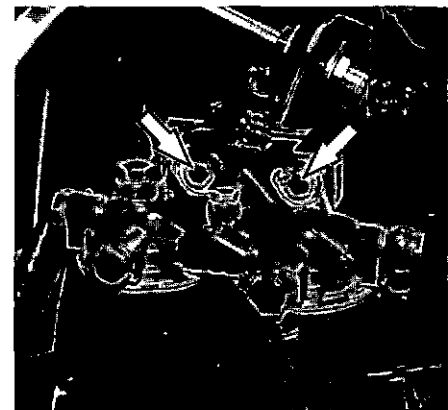


- 7**  
Remove the upper sealing ring and clean the groove. Clean the thermostat housing and cover.

- 8**  
Fit a new lower sealing ring on drift 6863 and **carefully** tap in the sealing ring until the drift bottoms.  
**NOTE!** The sealing ring lip should face downwards.



- 9**  
Fit a new upper sealing ring and a new sleeve thermostat.
- 10**  
Fit the thermostat housing cover and fit the radiator stay with bracket. Tighten all bolts.
- 11**  
Attach the fuel filter housing bolts.



- 12**  
Assemble the other components.  
Fill with coolant.
- 13**  
Start the engine and check for leakage.

## Thermostat, function check

A function check of the old thermostat must be carried out before fitting a new one.

**1**  
Check that the thermostat has closed fully. This can be done by holding it up against the light, there must be no visible gap at the opening point.

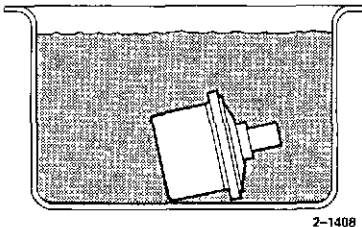
If the thermostat does not close properly, change it.

**2**  
Warm up water in a receptacle to:

**75°C (167°F)** for thermostat with opening temperatur  
**82°C (180°F)**.

**70°C (158°F)** for thermostat with opening temperatur  
**76°C (167°F)**.

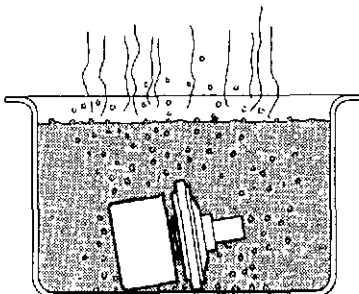
Immerse the thermostat in the water as illustrated.



2-1408

**3**  
Check after at least 30 seconds that the thermostat is still closed.

**4**  
Now warm the water to boiling point (100°C/212°F). Check after at least 30 seconds at boiling point that the thermostat has opened at least 7 mm.



2-1409

## Coolant distributor pipe, changing

Only 12 ltr engines

### Removing

**1**  
Drain off the coolant.

**2**  
Remove the four front fuel delivery pipes and fit protective plugs on the injectors and the injection pump connections.

**NOTE!** Fuel delivery pipes must never be bent or altered. A damaged fuel delivery pipe should always be replaced with a new one.

**3**  
Disconnect the fuel delivery pipe bracket from the coolant distributor pipe.

**4**  
Disconnect the pipes and remove the fuel filter housing.

**5**  
Remove the clamp between the coolant distributor pipe and thermostat housing.

**6**  
Remove the coolant distributor pipe bolts and lift out the pipe.

**7**  
Remove the gaskets and clean the contact surfaces of the cylinder heads and coolant distributor pipe.

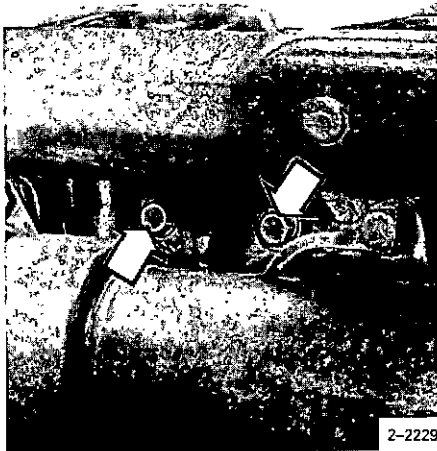
**Fitting**

**8**

Fit new gaskets on the cylinder heads.

**9**

Fit the coolant distributor pipe and fit and tighten the bolts.



**10**

Tighten the clamp between the coolant distributor pipe and thermostat housing.

**11**

Fit the fuel filter housing and connect the pipes. Use new copper washers.

**12**

Fit the fuel delivery pipes and screw the bracket to the coolant distributor pipe.

**NOTE!** Fuel delivery pipes must never be bent or altered. A damaged fuel delivery pipe should always be replaced with a new one.

**13**

Fill with coolant.

*Bleed the fuel system.*

**14**

Start the engine and check for leakage.

## Thermostatically controlled cooling fan, function check

*Special tool: 9988460*

Fan malfunction can be due to, among other things, an incorrect amount of silicone fluid or worn parts in the control device.

Before carrying out a function check, make sure that the radiator is not clogged and that the coolant temperature sensor is working.

If the thermostat in the cooling system is not functioning, this may disturb the function of the fan.

**Note** that fitting of so-called radiator blinds can mean that the thermostatically controlled fan will operate continuously.

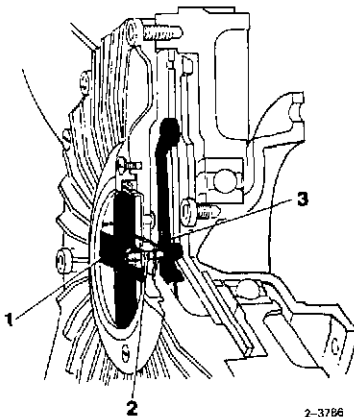
The fan can be presumed to not be working properly should any of the following be observed:

1. The fan does not engage, i.e. low fan speed is maintained despite high engine load. This will imply a high coolant temperature.
2. The fan does not disengage, despite low engine load.

### Control device

#### A. The fan rotates at reduced speed:

The bimetallic spring (1) presses against the control pin (2) moving it towards the valve lever (3).

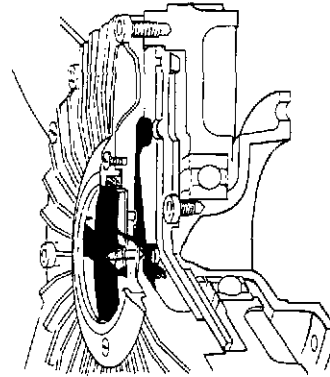


#### Control device

- |   |                   |
|---|-------------------|
| 1 | Bimetallic spring |
| 2 | Control pin       |
| 3 | Valve lever       |

#### B. The fan is fully engaged:

The bimetallic spring flexes outwards due to the temperature increase in the ambient air.



### Speed check, fan disengaged

#### 1

Run the engine at idling speed for **5 minutes**. Air temperature in front of the fan must not exceed **+ 30°C (+86°F)**.

The silicone fluid which, when the engine is switched off, ran into the drive chamber, is now pumped back to the storage chamber.

#### 2

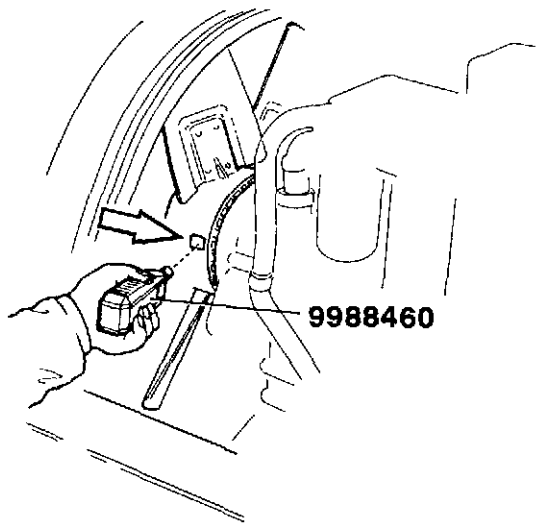
Increase engine speed to max rpm. Fan speed should now be 6.1-13.7 r/s (370-820 r/min).

If the fan speed is not as specified above, the fan should be changed.

**Note!** The fan must not be topped up with silicone fluid if the speed is too low.

## Checking revs of engaged cooling fan

- 1**  
The engine operating temperature should be high enough for the fan to be fully engaged.
- 2**  
Increase engine speed to max rpm. Fan speed should exceed 29 r/s (1740 r/min). If fan speed is lower, the fan should be changed.



Checking revs of thermostatically controlled cooling fan

**Warning!**  
Keep your hand and the measuring instrument at a safe distance from the blades of the fan when checking revs.

## Faulty cut-in temperature

If, despite the fact that the fan cut-in speed is correct, high coolant temperatures are suspected when driving, and also the fact that the fan cannot be heard engaging as coolant temperature rises, the fan cut-in temperature is probably incorrect.

Fan cut-in temperature cannot be adjusted or checked in the vehicle since special instruments are required.

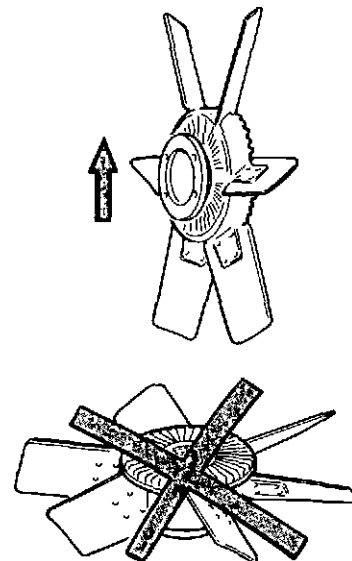
If the cut-in/cut-out temperatures are suspected as being incorrect, the fan must be changed.

## Thermostatically controlled cooling fan, changing

A thermostatically controlled fan contains an accurately adapted amount of silicone fluid in order to function reliably.

For this reason, such a fan must always be stood vertically when out of the vehicle.

If positioned horizontally, the silicone fluid may leak out, resulting in the fan losing its properties.



2-4189

When changing a fan, always check the new fan for leakage. If leakage is suspected, special instruments are required for checking cut-in temperature, speed, etc.

## Coolant

The coolant should be a mixture of anti-corrosion additive and water or, where there is a risk of freezing, antifreeze and water, see below.

The coolant should be changed and the system flushed clean once a year. At the same time check all hoses and connections and cure any leakage. Replace all loose, swollen or otherwise damaged hoses.

## Antifreeze

The antifreeze prevents corrosion in the cooling system and also freezing during the winter. We recommend the use of Volvo Penta antifreeze\* (ethylene glycol, bluegreen), which contains correctly balanced corrosion inhibitors. To get full protection against corrosion, always use at least 40% antifreeze. This means that topping-up, whenever necessary, should be done with the corresponding antifreeze mixture. This coolant mixture gives a protection against freezing down to approx.  $-25^{\circ}\text{C}$  ( $-13^{\circ}\text{F}$ ). For lower temperatures a greater quantity of antifreeze is required according to the table below:

**NOTE!** Volvo Penta antifreeze must not be mixed with any other kind of antifreeze.

\*)  
Part No. 1141591-6, 1 litre (0.88 Imp.qts/1.05 US qts).  
Part No. 1141590-8, 4 litre (3.5 Imp.qts/4.2 US qts).  
Part No. 1141589-0, 200 litre (44 Imp.qts/52.8 US gals).

### Mixing table, antifreeze/water

Resquisite volume of antifreeze in % of total coolant volume for freeze protection down to approx.		
$-28^{\circ}\text{C}$ ( $-18^{\circ}\text{F}$ )	$-40^{\circ}\text{C}$ ( $-40^{\circ}\text{F}$ )	$-56^{\circ}\text{C}$ ( $-69^{\circ}\text{F}$ )
40%	48%	60%

At the most, the freezing point can be lowered to  $-56^{\circ}\text{C}$  ( $-69^{\circ}\text{F}$ ) (60% antifreeze). **Increasing the mixture of antifreeze past this point reduces the protection from freezing.**

Mix the antifreeze with water in a separate vessel prior to filling the cooling system.

**NOTE!** Antifreeze is hazardous (poisonous if consumed).

## Anti-corrosion additives

To prevent corrosion it is simplest to use a suitable mixture of genuine Volvo Penta antifreeze (glycol) all year round (at least 40%). It should be changed every autumn.

In cases where antifreeze is not used, an anti-corrosion additive should be added to the coolant. Use **Volvo Penta anti-corrosion additive** (part No. 114526-2) which is available in quantities of 1/2 litre, 3 cans (1,5 litres) are required.

Clean the cooling system thoroughly before filling. Run the engine warm soonest after filling to get the best possible effect from the additive.

To maintain the protection against corrosion, the coolant should thereafter be **supplemented** with further 1/2 litre anti-corrosion additive every **400th hour of operation**.

**NOTE!** Other types of anti-corrosion additive, glycol or antifreeze must absolutely not be mixed with this anti-corrosion additive. The anti-corrosion additive does not prevent the formation of ice and should only be used where the temperature is always above  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ).

## Checking the coolant level

The level should be approx. 4–5 cm (2") below the filler caps sealing edge. There must be an air space to allow for expansion of the coolant.



**WARNING!** Open the filler cap very carefully when the engine is warm. Hot steam or fluid can spray out.

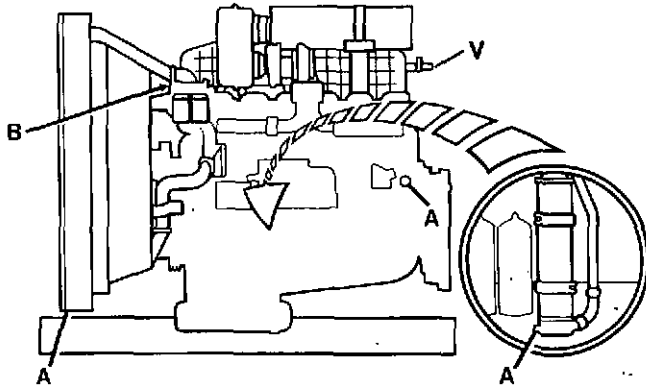
An insufficient quantity of coolant can lead to poor circulation, which increases the risk of overheating, resulting in damage to the engine.

## Draining the coolant

Before draining the coolant, stop the engine, unscrew the filler cap.

See figure for the location of drain cocks and plugs. If a compressed air compressor is fitted there is also a drain cock on this. Unscrew the coolant filter, if fitted.

Check carefully to make sure that all water runs out.



- A = Drain cock/plug for coolant  
 B = Drain cock for coolant (TWD)  
 V = Venting cock (TWD)

## Filling the coolant

**WARNING!** Open the filler cap (venting cock) very carefully when the engine is hot. Steam or hot coolant can spray out.

**NOTE!** Check that the drain cock is closed and that the drain plugs are fitted and tightened before replenishing the cooling system.

Replenishing shall be carried out when the engine is stopped.

Open the venting cock, see fig above. Do not replenish too quickly to avoid air-locks in the system. The air shall be able to flow out through the venting cock (TWD-engines) or filler opening.

If a heater is connected to the engine's cooling system the heat control valve shall be opened and the system vented during replenishing.

Fill with coolant to approx. 5 cm under the sealing surface of the filler cap. For coolants, see previous page.

**The engine must not be started before the system is vented and completely replenished.**

Start and run the engine warm. Open the venting cock for a moment after starting for the venting of any remaining air.

Check the coolant level and replenish if necessary.

Replenish with the same mixture already used in the cooling system.

## Coolant temperature too high

Too high coolant temperature can be caused by:

- Low coolant level, air in the system.
- Reduced air flow through the radiator, dirty radiator.
- *Poor drive belt tension.*
- Blocked cooling system.
- Faulty thermostat.
- Faulty temperature gauge.
- Faulty setting of injection pump with regard to the preinjection angle.
- Faulty thermostically controlled fan (if fitted).

## Coolant temperature too low

Too low coolant temperature can be caused by:

- Faulty thermostat
- Faulty temperature gauge.

## Checking the temperature gauge

Remove the temperature sender. Connect the cables to the temperature gauge and immerse the sender in hot water. Compare the temperature gauge reading with that of a thermometer.

## Coolant loss

Loss of coolant can occur in two ways:

- Loss of coolant during running
- Loss of coolant after stopping a hot engine.

Coolant loss during running can be due to leaks in the cooling system or air or combustion gases being pressed into the cooling system causing the coolant to be forced through the pressure valve. The fault can be in the compressed air compressor, if fitted, or leakage at the cylinder head gaskets.

Loss of coolant after stopping a hot engine is generally due to a faulty pressure valve (filler cap).

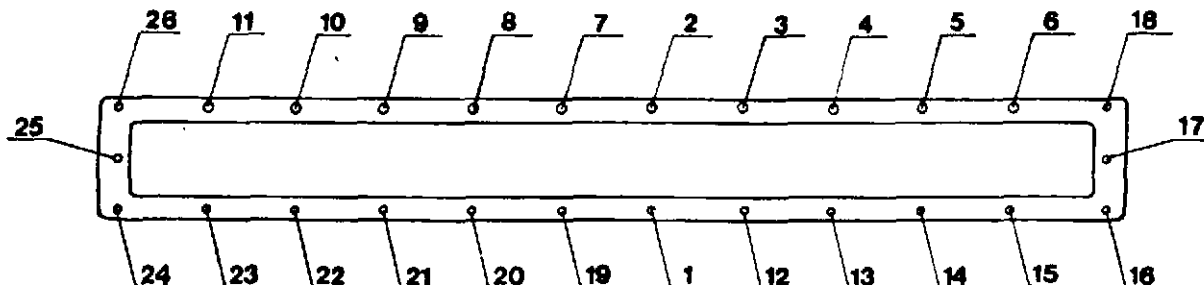
## Charge air cooler insert, changing (TWD)

### Removing

- 1 Drain the coolant.
- 2 Remove the front and rear flanges.
- 3 Loosen the bolts to flange, holding the drain cook and remove the drain cook.
- 4 Remove the tube between the compressor housing and the charge air cooler.
- 5 Loosen the plastic pipe to the smoke limiter (if any).
- 6 Remove the bolts to the charge air cooler housing and carefully separate the housing from the intake manifold. Lift out the insert.
- 7 Remove the gaskets and clean the contact surfaces on the housing and the insert.

### Fitting

- 8 Fit new gaskets. Assemble the insert and the charge air cooler housing.
- 9 Fit and tighten the bolts. See "Workshop Manual, Technical Data" for correct tightening torque.
- 10 Fit the rear and front flanges together with new O-rings.
- 11 Connect the plastic pipe to the smoke limiter (if any).
- 12 Fit the tube to the compressor housing (use new gasket and O-rings).
- 13 Fit the drain cook.
- 14 Fill with coolant.
- 15 Start the engine and check for leakage.



### Tightening schedule

Tightening should be carried out in two steps in order according to the schedule.

**Step 1.** Tighten the bolts until the boltheads are in contact with the surface.

**Step 2.** Tighten the bolts to  $20 \pm 2$  Nm.

## Checking the radiator (TAD/TWD)

### Checking the charge air cooler (TAD)

Should higher than normal coolant temperatures be observed, the passage of air through the charge air cooler and radiator must always be checked.

Check that the external cooling sections of the radiator and the charge air cooler (TAD) are not blocked by insects or other impurities that can restrict the air flow. If obstructions are found use a mild grease-dissolving detergent and water. Never use water at high pressure or compressed air.

Straighten out any bent cells in the cell system. Flush both radiators individually from front. In cases of more serious blockage the radiator/charge air cooler must be removed entirely and then cleaned with a mild detergent.

Also check that the fan cover and, if fitted, the sealing strip fitted between the fan cover and the charge air cooler has not come loose or is leaking in any other way.

## Adjusting the drive belts

Replace belts which have become oily, worn or damaged in any way. **NOTE!** Belts that work in pairs should always be replaced at the same time.

Tension the alternator belts after loosening the alternator. Correct tension is obtained when the belts can be depressed approx. 10 mm (0.4") midway between the pulleys.

The engines are equipped with an automatic belt tensioner for the fan belts.

## Cleaning the cooling system

The cooling system should be cleaned when changing the coolant.

It is generally sufficient to flush through with clean water, but if the cooling system has large rust and mud deposits we recommend the following cleaning method:

**1**  
Empty and flush the system clean. Dissolve 1 kg (2.2 lbs) of oxalic acid\* in 5 litres of hot water and pour into the cooling system. Top up with clean water.

**WARNING! Protect hands and face. Oxalic acid is poisonous and hazardous to the skin.**

**2**  
*Run the engine until it reaches normal operating temperature and then for another 2 hours approx.*

**NOTE!** Any heater controls must be on "hot".

**3**  
Drain the system and **flush out immediately and thoroughly with clean water**. For this purpose the thermostat housing (thermostat), upper and lower radiator hoses, drain cocks and plugs should be removed to give the best possible draining speed. Do not forget the engine heater or heater element, if fitted. Continue flushing until the water running out is clean. It is essential to remove all oxalic acid, otherwise the remains can increase the risk of further corrosion.

**4**  
Dissolve 200 grams (7 oz..) of bicarbonate\* (sodium hydrogen carbonate) in 5 litres of water and pour into the cooling system. Top up with clean water.

**NOTE!** Never use soda (sodium carbonate  $\text{Na}_2\text{CO}_3$ ) as incorrect handling can result in severe corrosion damage.

\*Not marketed by Volvo Penta, can be purchased from chemical stores.

Chemical formula for oxalic acid:  $\text{C}_2\text{H}_2\text{O}_2$ .

Chemical formula for sodium hydrogen carbonate:  $\text{Na HCO}_3$ .

**5**  
Run the engine at normal operating temperature for approx. 10–15 mins. This point must be done thoroughly in order to neutralize the oxalic acid.

**6**  
Flush the system thoroughly clean according to point 3. Increased flushing effect can be obtained by mixing air with water, in which case flushing must, without question, be carried out from bottom to top (radiator), or from the drain cock in question on the cylinder block.

**NOTE!** Remove the filler cap from the expansion tank/radiator. In the case of separate expansion tank, this should also be flushed from the bottom and up with the filler cap removed for efficient cleaning. Flush the heater, if fitted, with the hoses removed to be sure that remaining deposits are removed.

**7**  
If there are still deposits in the cooling system, repeat the steps under points 1–6.

When cleaning, check that all hoses are free from defects. Replace if necessary.

**8**  
Fill the system with a coolant recommended by Volvo Penta. See section "Coolant".

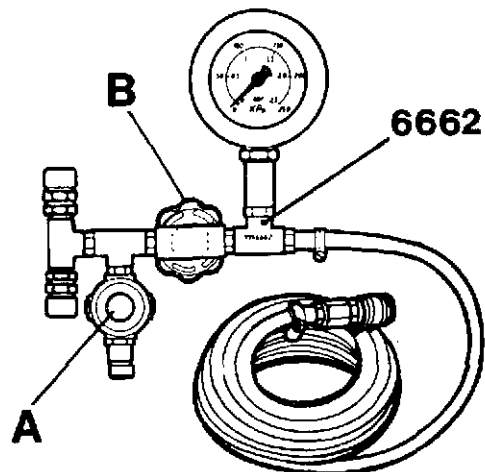
## Pressure-testing the cooling system

*Special tools: 6662, 998 9860 together with compressed air and 6433*

### Checking the pressure-testing device 6662

Before using the pressure-testing device it must be checked as follows:

**A**  
Check that the knob on the relief valve (A) is screwed out and connect the test device to the compressed air system. Open cock (B) and adjust the relief valve until a pressure of 100 kPa (14.5 psi) is indicated on the gauge.



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**NOTE!** The knob on the relief valve can be locked with a locking ring which is moved axially.

**NOTE!** Always follow valid safety regulations.

**B**  
Close cock (B). The pressure must not drop during two minutes if the test device is to be considered reliable.

## Pressure testing

**1**  
Remove the coolant filler cap and fit instead cap 6433 on the radiator. Plug the connection to an extra plastic expansion tank, if fitted, during the pressure-testing.

**2**  
Ensure that the knob on the relief valve (A) is screwed out and connect the hose from the pressure-testing device to the cap 6433 or 6441.

**3**  
Seal the drain line from the filler pipe.

**4**  
Connect the pressure-testing device 6662 to the compressed air system and open the cock (B).

**5**  
Pull out the lock ring for the knob on the relief valve. Increase the pressure by screwing in the knob until the pressure gauge reads **70 kPa (10 psi)**. Lock the knob by pressing in the lock ring and close the cock (B).

**6**  
Check during one minute that the pressure does not drop. If there is difficulty in locating the leak, drain the coolant, re-pressurize the system and apply soapy water to hose connections, drain cocks etc., until the leak is found.

**NOTE!** make sure that the pressure never exceeds 70 kPa (0.7 kp/cm<sup>2</sup>=10 psi). Increased pressure can among other things, damage the coolants pump seal.

**NOTE!** Always follow valid safety regulations.

**7**  
Remove the testing device.

## Checking the pressure valve

The pressure valve is located in the filler cap. For this test the same pressure-testing device is used as for testing for leakage in the cooling system. See previous section.

**1**  
Drain part of the coolant and connect the pressure-testing device with a nipple to any plugged hole in the cooling system.

**2**  
Extend the draining hose from the filler pipe with a hose which opens out into a vessel containing water.

**3**  
Apply the pressure, see "Pressure testing the cooling system", previous section, and read off the pressure gauge when the valve opens (water will bubble in the vessel with the drain line/filler cap).

See "Workshop Manual, Technical Data" for valve opening pressure.

**4**  
Remove the testing equipment. Fit the plug and fill the engine with coolant.

# Electrical system

The engines are equipped with a 2-pole electrical system with alternator. System voltage is 24 volts in most versions.

## Important

For engines with alternators the following are applicable:

**1**  
**Never break the circuit between alternator and battery when the engine is running. The main switch must therefore not be switched off until the engine has stopped.** Cables shall not be disconnected while the engine is running since this can also damage the voltage regulator.

**2**  
 Batteries, battery cables and cable terminals shall be checked regularly. The battery poles shall be well-cleaned and the terminal clamps always tightened and well greased so that no interruption occurs. All cables shall be well tightened, and there shall be no loose connections.

**NOTE!** Do not interchange the battery's plus and minus poles when fitting the batteries. Compare with wiring diagram. Check drive belt tension regularly.

**3**  
 When starting with auxiliary batteries, see "Starting with auxiliary battery".

**4**  
 In the event of repairs to alternator equipment both battery cables shall be removed first. The same applies for quick-charging of batteries.

**NOTE!** Follow the relevant safety instructions when charging batteries.

**5**  
 Never test with screwdriver or the like to any connection to see if it sparks.

## Arc welding

When arc welding on engines or installation parts the following measures shall be taken.

Disconnect both battery cables and all cables to the alternator. Always connect the welding clip to the component to be welded and as close to the weld as possible. The clip must never be connected to the engine or so that the current can pass over a bearing.

When welding is finished: always mount cables to the alternator **before** the battery cables are replaced.

## Starting with auxiliary battery



**WARNING!** The batteries (especially auxiliary batteries) contain an oxy-hydrogen gas mixture which is very explosive. A spark generated by connecting the jumper leads incorrectly is sufficient to explode a battery and cause personal injury and material damage.

If the batteries are frozen they must be thawed out first before attempting to start them with an auxiliary battery.

**1**  
 Check that the auxiliary batteries are connected (in series or parallel) so that the rated voltage corresponds with the engine's system voltage.

**2**  
 Connect the one end of the red jumper cable to the auxiliary battery's plus terminal (marked P or + with red paint). Always check that the clamps are well secured to avoid sparks.

**3**  
 Connect the other end of the red cable to the plus terminal on the flat battery where the plus cable to the engine is connected.

**4**  
 Connect the end of the black cable to the minus terminal on the auxiliary battery (marked with blue paint N or -).

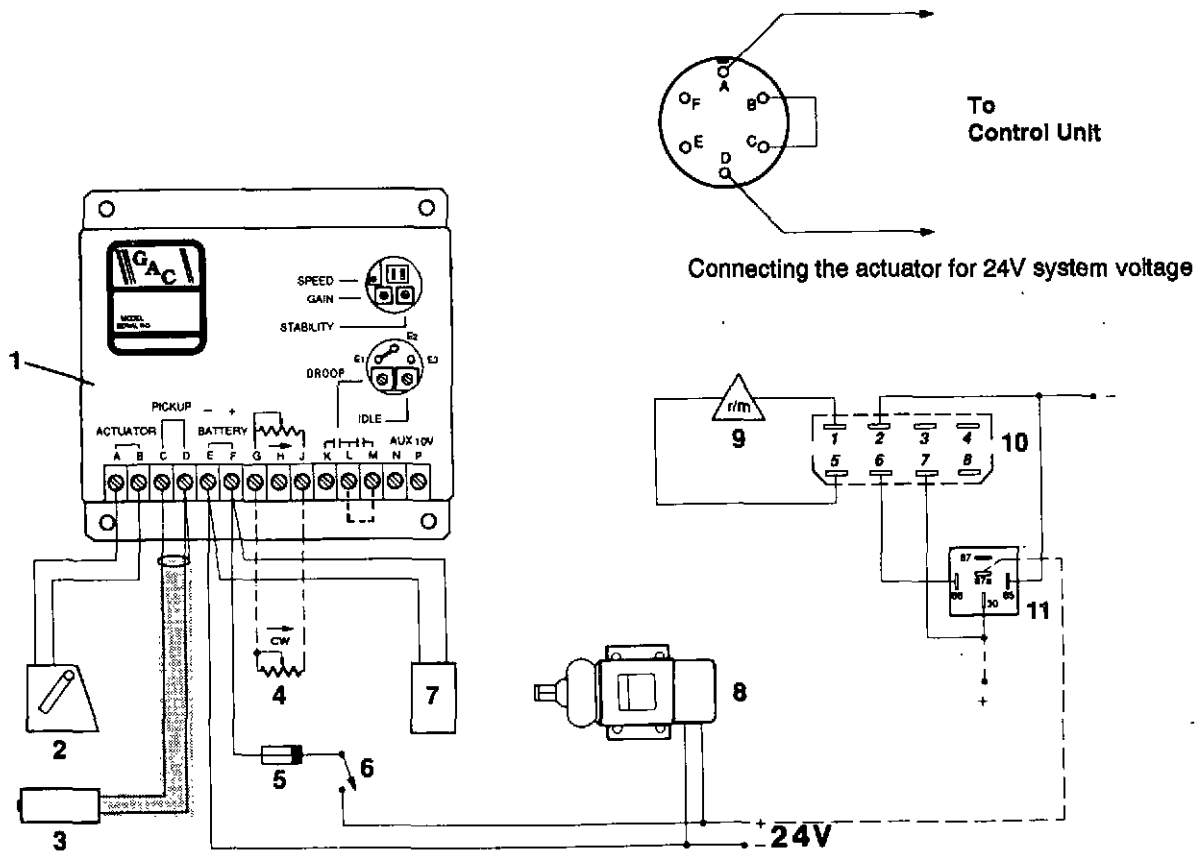
**5**  
 Connect the other end of the black cable **to a point some way off from the flat batteries**, e.g. at main switch, on minus cable or connection of minus cable to the engine.

**6**  
 Start the engine. **NOTE! Do not interfere with connections when attempting to start (spark risk) and do not lean over batteries.**

**7**  
 Remove cables in exactly the reverse order to which they were connected. **NOTE! The usual cables to the standard batteries must on no account be disconnected.**

# Electronic speed governor

## Wiring



The stop solenoid (8) connected live during operation (optional). Engine stops with switch (6).

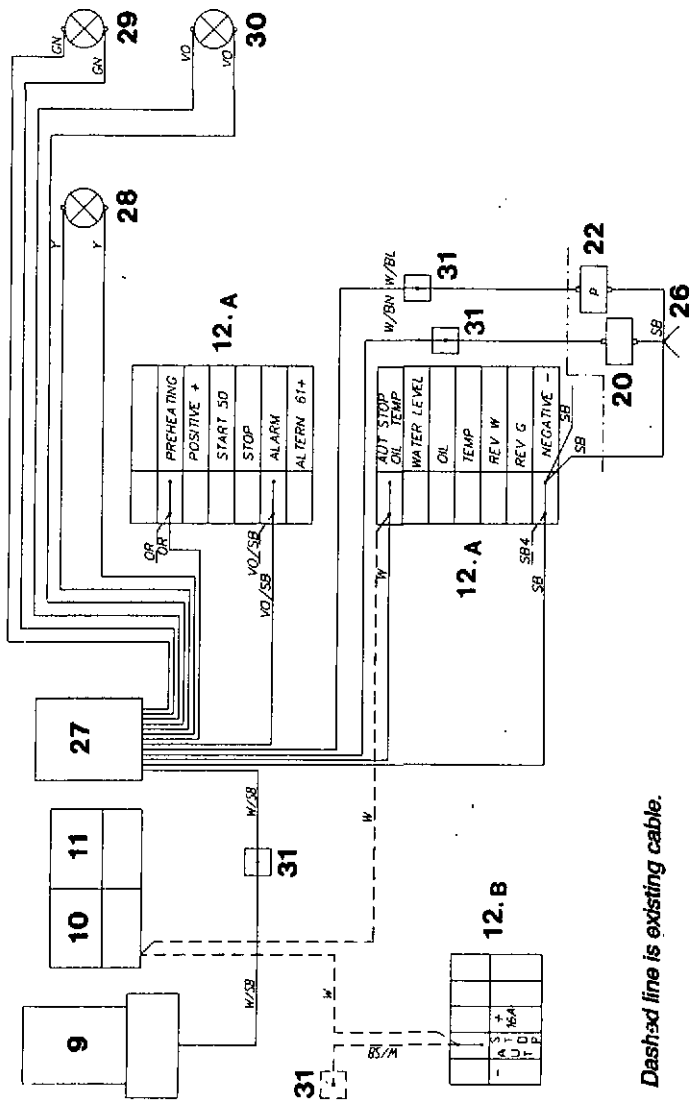
Note. Later version stop solenoid has a built-in transient protection. Therefore, only a separate transient protection (7) for the Control Unit is required

- |                              |                                    |   |
|------------------------------|------------------------------------|---|
| 1. Control Unit              | 5. Fuse (fast) 8A                  | 9. Engine speed pickup for overspeed protection |
| 2. Actuator                  | 6. Main switch                     | 10. Engine speed switch (overspeed protection)  |
| 3. Pickup                    | 7. Transient protection (849394-2) | 11. Relay                                       |
| 4. Multi-turn potentiometer* | 8. Stop solenoid                   |   |

\*Not from Volvo Penta

## Instrument panel and engine

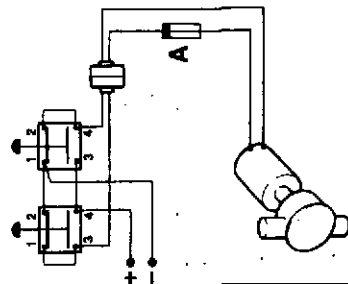
1. Oil pressure gauge
2. Coolant temperature gauge
3. Rev counter with built-in hour counter.
4. Warning lamp, charging
5. Semi-automatic fuses (manual resetting)
6. Stop button
7. Interlock button
8. Start button
9. Relay for coolant level switch (accessory)
10. Relay for coolant temp. switch, oil pressure switch
11. Holding current relay (operating current and instruments)
- 12.A Terminal for engine cables
- 12.B Terminal (extra power outlet, fused for 16 A. Outlet for automatic stop, closing in the event of fault).
13. Relay for starter element
14. Starter element
15. Starter motor
16. Batteries
17. Alternator
18. Rev counter sender
19. Coolant temperature sender
20. Coolant temperature switch (normally open)
21. Oil pressure sender
22. Oil pressure switch (normally open)
23. Level switch, coolant (accessory)
24. Stop solenoid (charged during operation)
25. Horn
26. Union
27. Alarm separator (accessory)
28. Warning lamp, high coolant temp. (accessory)
29. Warning lamp, low coolant level (accessory)
30. Warning lamp, low lubricating oil pressure (accessory)
31. Union



Dashed line is existing cable.

## Wiring diagram (parts).

Connection of alarm separator (accessory) to instrument panel



Recommended connection of oil scavenging pump (scavenging and filling).

A. Fuse (8A/24V or 15A/12V).

Cable areas in mm<sup>2</sup> (given after colour code in wiring diagram).  
1.5 mm<sup>2</sup> when no other area is given.

## Cable colours

- BL = Blue
- LBN = Light blue
- BN = Brown
- LBN = Light brown
- GN = Green
- GR = Grey
- OR = Orange
- VO = Violet
- R = Red
- SB = Black
- W = White
- Y = Yellow

Battery cable areas are related to battery positioning.

Distance, starter motor - batteries:

- max. 2 m, area = 70 mm<sup>2</sup>
- max. 4 m, area = 120 mm<sup>2</sup>

## Relation mm<sup>2</sup>/AWG\*

\*American Wiring Gauge

mm <sup>2</sup>	1.0	1.5	2.5	10	16
AWG	16 (17)	15 (16)	13	7	5

Battery cable areas are related to battery positioning.

AWG	16 (17)	15 (16)	13	7	5
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Yellow

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