



marine engines

**sezione 8**

**8291 series**

**workshop manual**

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**IVECO *aifo***

— The data contained in this publication may not have been updated following modifications carried out by the manufacturer, at any time, for technical or commercial reasons and also to conform to the requirements of the law in the various countries.

— This publication supplies features and data together with the suitable methods for repair operations to be carried out on each single component of the engine. Following the supplied instructions and using the inherent specific fixtures, a correct repair procedure will be obtained in due time, protecting the operators from all possible accidents. Before starting any repair, be sure that all accident prevention devices are available and efficient. Therefore check and wear what indicated by the safety provision: protective glasses, helmet, gloves, safety shoes. Before use, check all work, lifting and transport equipment.

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# SECTION 8

8291SM49.11

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8291SRM11.10

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8291SRM12.11

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## ENGINE SPECIFICATIONS

Engine type. ....8291SM49.11  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement.....12 at 90° Vee  
 Bore x stroke.....145 x 130 mm  
 Displacement.....25,8 l  
 Compression ratio.....15,9:1  
 Net power at flywheel (\*):  
 Max power.....375 kW(490 CV)  
 At.....1800 rpm  
 Engine rotation:  
 (see from flywheel) .....CCW

\* Net rating at flywheel according to ISO 3046-1  
 - Ambient reference conditions:  
 750 mmHg; 25°C; 30% relative humidity

## TIMING

## Valve Timing:

## - Intake:

opens: before T.D.C .....12° 18'  
 closes: after B.D.C .....30° 18'

## - Exhaust:

opens: before B.D.C .....55° 30'  
 closes: after T.D.C .....16° 18'

Clearance between rockers  
 and actuators for timing checks.....0,25 mm

Operating clearance between rockers  
 and actuators, cold engine;

- intake.....0,15 to 0,20 mm  
 - exhaust.....0,35 to 0,40 mm

## FUEL SYSTEM

In line injection pump type BOSCH PE12P130A

Boost control(LDA) on injection pump

Fixed injection pump delivery start advance.....21°  
 Fuel injectors setting.....250 + 8 bar  
 Firing order.....1-12-5-8-3-10-6-7-2-11-4-9

## TURBOCHARGER

The engine is supercharged by two turbocharger driven by the exhaust gases.

The turbocharger is lubricated with the engine oil under pressure.

## LUBRICATION

Minimum oil pressure:

- at full throttle.....5 kg/cm²  
 - when idling.....2 kg/cm²

## COOLING SYSTEM

Cooling by dual water circuit:

- Primary circuit (closed) by fresh water.  
 - Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.

Complete sea water circuit is protected from corrosion by replaceable sacrificial anodes.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage.....24 V  
 - Self-regulated alternator.....28 V, 100 A  
 - Starting motor power.....9 kW  
 - Battery (optional).....2, each 176 Ah

## MARINE GEAR (on request)

Hydraulic drive with integral thrust and oil cooler

## ENGINE SPECIFICATIONS

Engine type. ....8291SRM11.10  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement.....12 at 90° Vee  
 Bore x stroke.....145 X 130 mm  
 Displacement.....25,8 l  
 Compression ratio.....15,9:1  
 Net power at flywheel (\*):  
 Max power.....810 kW(1100 cv)  
 At.....2100 rpm  
 Engine rotation:  
 (see from flywheel) .....CCW

- \* Net rating at flywheel according to ISO 3046-1  
 - Ambient reference conditions:  
 750 mmHg; 25°C; 30% relative humidity

## TIMING

## Valve Timing:

- Intake:  
 opens: before T.D.C .....12° 18'  
 closes: after B.D.C .....39° 30'  
 - Exhaust:  
 opens: before B.D.C .....65° 30'  
 closes: after T.D.C .....16° 18'

Clearance between rockers  
 and actuators for timing checks.....0,20 mm

Operating clearance between rockers  
 and actuators, cold engine;

- intake.....0,15 to 0,20 mm  
 - exhaust.....0,35 to 0,40 mm

## FUEL SYSTEM

In line injection pump type BOSCH PE12P130A

Boost control(LDA) on injection pump

Fixed injection pump delivery start advance.....21°  
 Fuel injectors setting.....250 + 8 bar  
 Firing order.....1-12-5-8-3-10-6-7-2-11-4-9

## TURBOCHARGER

The engine is supercharged by two turbocharger driven by the exhaust gases.

The turbocharger is lubricated with the engine oil under pressure.

Turbine housing cooled with fresh water.

Cooling intake air with-water heat exchanger.

## LUBRICATION

Minimum oil pressure:

- at full throttle.....5 kg/cm²  
 - when idling.....2 kg/cm²

## COOLING SYSTEM

Cooling by dual water circuit:

- Primary circuit (closed) by fresh water.  
 - Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.

Complete sea water circuit is protected from corrosion by replaceable sacrificial anodes.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage.....24 V  
 - Self-regulated alternator.....28 V, 100 A  
 - Starting motor power.....9 kW  
 - Battery (optional).....2, each 176 Ah

## MARINE GEAR (on request)

Hydraulic drive with integral thrust and oil cooler

## ENGINE SPECIFICATIONS

Engine type.....8291SRM12.11  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement.....12 at 90° Vee  
 Bore x stroke.....145 x 130 mm  
 Displacement.....25,8 l  
 Compression ratio.....15,9:1  
 Net power at flywheel (\*):  
 Max power.....882 kW(1200 CV)  
 At.....2100 rpm  
 Engine rotation:  
 (see from flywheel) .....CCW

\* Net rating at flywheel according to ISO 3046-1  
 - Ambient reference conditions:  
 750 mmHg; 25°C; 30% relative humidity

## TIMING

## Valve Timing:

## - Intake:

opens: before T.D.C .....12° 18'  
 closes: after B.D.C .....39° 30'

## - Exhaust:

opens: before B.D.C .....65° 30'  
 closes: after T.D.C .....16° 18'

Clearance between rockers  
 and actuators for timing checks.....0,20 mm

Operating clearance between rockers  
 and actuators, cold engine;

- intake.....0,15 to 0,20 mm  
 - exhaust.....0,35 to 0,40 mm

## FUEL SYSTEM

In line injection pump type BOSCH PE12P130A

Boost control(LDA) on injection pump

Fixed injection pump delivery start advance.....21°  
 Fuel injectors setting.....250 + 8 bar  
 Firing order.....1-12-5-8-3-10-6-7-2-11-4-9

## TURBOCHARGER

The engine is supercharged by two turbocharger driven by the exhaust gases.

The turbocharger is lubricated with the engine oil under pressure.

Turbine housing cooled with fresh water.

Cooling intake air with-water heat exchanger.

## LUBRICATION

Minimum oil pressure:

- at full throttle.....5 kg/cm<sup>2</sup>  
 - when idling.....2 kg/cm<sup>2</sup>

## COOLING SYSTEM

Cooling by dual water circuit:

- Primary circuit (closed) by fresh water.  
 - Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.

Complete sea water circuit is protected from corrosion by replaceable sacrificial anodes.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage.....24 V  
 - Self-regulated alternator.....28 V, 100 A  
 - Starting motor power.....9 kW  
 - Battery (optional).....2, each 176 Ah

## MARINE GEAR (on request)

Hydraulic drive with integral thrust and oil cooler

## ENGINE SPECIFICATIONS

Engine type. ....8291SRM75.10  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement. ....12 at 90° Vee  
 Bore x stroke. ....145 X 130 mm  
 Displacement. ....25,8 l  
 Compression ratio. ....15,9:1  
 Net power at flywheel (\*):  
 Max power. ....552 kW (750 CV)  
 At. ....1800 rpm  
 Engine rotation:  
 (see from flywheel) .....CCW

\* Net rating at flywheel according to ISO 3046-1  
 - Ambient reference conditions:  
 750 mmHg; 25°C; 30% relative humidity

## TIMING

## Valve Timing:

- Intake:  
 opens: before T.D.C .....12° 18'  
 closes: after B.D.C .....39° 30'  
 - Exhaust:  
 opens: before B.D.C .....65° 30'  
 closes: after T.D.C .....16° 18'

Clearance between rockers  
 and actuators for timing checks. ....0,20 mm

Operating clearance between rockers  
 and actuators, cold engine;

- intake. ....0,15 to 0,20 mm  
 - exhaust. ....0,35 to 0,40 mm

## FUEL SYSTEM

In line injection pump type BOSCH PE12P130A

Boost control (LDA) on injection pump

Fixed injection pump delivery start advance. ....21°  
 Fuel injectors setting. ....250 + 8 bar  
 Firing order. ....1-12-5-8-3-10-6-7-2-11-4-9

## TURBOCHARGER

The engine is supercharged by two turbocharger driven by the exhaust gases.

The turbocharger is lubricated with the engine oil under pressure.

Turbine housing cooled with fresh water.

Cooling intake air with-water heat exchanger.

## LUBRICATION

Minimum oil pressure:

- at full throttle. ....5 kg/cm<sup>2</sup>  
 - when idling. ....2 kg/cm<sup>2</sup>

## COOLING SYSTEM

Cooling by dual water circuit:

- Primary circuit (closed) by fresh water.  
 - Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.

Complete sea water circuit is protected from corrosion by replaceable sacrificial anodes.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage. ....24 V  
 - Self-regulated alternator. ....28 V, 100 A  
 - Starting motor power. ....9 kW  
 - Battery (optional). ....2, each 176 Ah

## MARINE GEAR (on request)

Hydraulic drive with integral thrust and oil cooler

## ENGINE SPECIFICATIONS

Engine type. ....8291SRH75.11  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement.....12 at 90° Vee  
 Bore x stroke.....145 X 130 mm  
 Displacement.....25,8 l  
 Compression ratio.....15,9:1  
 Net power at flywheel (\*):  
 Max power.....552 kW(750 CV)  
 At.....1800 rpm  
 Engine rotation:  
 (see from flywheel) .....CCW

\* Net rating at flywheel according to ISO 3046-1  
 - Ambient reference conditions:  
 750 mmHg; 25°C; 30% relative humidity

## TIMING

## Valve Timing:

- Intake:  
 opens: before T.D.C .....12° 18'  
 closes: after B.D.C .....30° 18'  
 - Exhaust:  
 opens: before B.D.C .....55° 30'  
 closes: after T.D.C .....16° 18'

Clearance between rockers  
 and actuators for timing checks.....0,25 mm

Operating clearance between rockers  
 and actuators, cold engine;  
 - intake.....0,15 to 0,20 mm  
 - exhaust.....0,35 to 0,40 mm

## FUEL SYSTEM

In line injection pump type BOSCH PE12P130A

Boost control(LDA) on injection pump

Fixed injection pump delivery start advance.....21°  
 Fuel injectors setting.....250 + 8 bar  
 Firing order.....1-12-5-8-3-10-6-7-2-11-4-9

## TURBOCHARGER

The engine is supercharged by two turbocharger driven by the exhaust gases.

The turbocharger is lubricated with the engine oil under pressure.

Turbine housing cooled with fresh water.

Cooling intake air with-water heat exchanger.

## LUBRICATION

Minimum oil pressure:

- at full throttle.....5 kg/cm²  
 - when idling.....2 kg/cm²

## COOLING SYSTEM

Cooling by dual water circuit:

- Primary circuit (closed) by fresh water.  
 - Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.

Complete sea water circuit is protected from corrosion by replaceable sacrificial anodes.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage.....24 V  
 - Self-regulated alternator.....28 V, 100 A  
 - Starting motor power.....9 kW  
 - Battery (optional).....2, each 176 Ah

## MARINE GEAR (on request)

Hydraulic drive with integral thrust and oil cooler

## ENGINE SPECIFICATIONS

Engine type.....8291SRM75.31  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement.....12 at 90° Vee  
 Bore x stroke.....145 X 130 mm  
 Displacement.....25,8 l  
 Compression ratio.....15,9:1  
 Net power at flywheel (\*):  
 Max power.....552 kW(750 CV)  
 At.....2100 rpm  
 Engine rotation:  
 (see from flywheel) .....CCW

\* Net rating at flywheel according to ISO 3046-1  
 - Ambient reference conditions:  
 750 mmHg; 25°C; 30% relative humidity

## TIMING

## Valve Timing:

## - Intake:

opens: before T.D.C .....12° 18'  
 closes: after B.D.C .....30° 18'

## - Exhaust:

opens: before B.D.C .....55° 30'  
 closes: after T.D.C .....16° 18'

Clearance between rockers  
 and actuators for timing checks.....0,25 mm

Operating clearance between rockers  
 and actuators, cold engine;

- intake.....0,15 to 0,20 mm  
 - exhaust.....0,35 to 0,40 mm

## FUEL SYSTEM

In line injection pump type BOSCH PE12P130A

Boost control (LDA) on injection pump

Fixed injection pump delivery start advance.....21°  
 Fuel injectors setting.....250 + 8 bar  
 Firing order.....1-12-5-8-3-10-6-7-2-11-4-9

## TURBOCHARGER

The engine is supercharged by two turbocharger driven by the exhaust gases.

The turbocharger is lubricated with the engine oil under pressure.

Turbine housing cooled with fresh water.

Cooling intake air with water heat exchanger.

## LUBRICATION

Minimum oil pressure:

- at full throttle.....5 kg/cm²  
 - when idling.....2 kg/cm²

## COOLING SYSTEM

By fresh water and prearranged for keel-cooling.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage.....24 V  
 - Self-regulated alternator.....28 V, 100 A  
 - Starting motor power.....9 kW  
 - Battery (optional).....2, each 176 Ah

## MARINE GEAR (on request)

Hydraulic drive with integral thrust and oil cooler

## SEA WATER PUMP

### GENERALITIES

The sea water circulation for cooling the fresh water and the marine ger oil is ensured by a self-priming pump type neoprene impeller

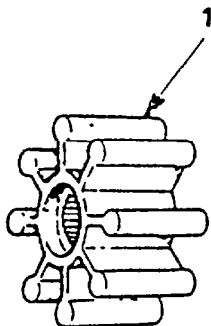
### INSTRUCTION FOR USE

Each time the engine is started, check that the sea water intake valve is open. Dry running of the pump would damage the impeller (1) in a very short time.

Under normal operating conditions of the engine check every 800 hours the state of the neoprene impeller, after removing first the cover

Make sure that it is free from cracks or excessive wear of the lobe.

If not replace it



## FRESH WATER-SEA WATER HEAT EXCHANGER

### OIL-WATER HEAT EXCHANGER

#### GENERALITIES

When the fresh water circulating in the engine reaches temperature values in excess of

65°C

is conveyed under thermostatic control to the fresh water-sea water heat exchanger, where it is cooled and returned to circulation

This heat exchanger consists essentially of a cast iron body with the fresh water circulation therein and a copper tube bundle containing the circulating sea water for cooling the fresh water

On the engine is also fitted an oil water heat exchanger composed by a cast iron body, in which the fresh water passes and a copper tube stack in which the sea water passes cooling the fresh water.

#### MAINTENANCE

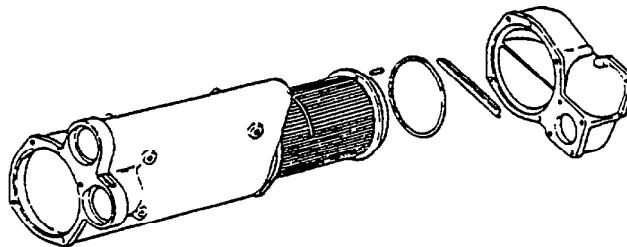
To ensure a right efficiency of the heat exchanger it is necessary to clean regularly the tube stack.

For ensuring the perfect efficiency of the fresh water-sea water heat exchanger it is necessary to clean periodically the tube bundle:

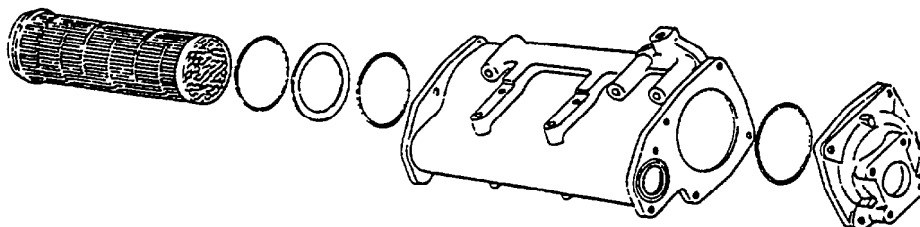
- Remove the tube bundle from the exchanger body and immerse it into a solution of water and anti-incrustator type 'P3' or the like (\*) which does not attack copper, brass, aluminium and tin

- After the end of the reaction (indicated by effervescence) after about 15 to 20 minutes, rinse the tube bundle abundantly with running water for completely eliminating any residue of the solution and re-assemble the bundle into the exchanger body.

(\*) When using solvents observe the prescriptions of the makers.



FRESH WATER-SEA WATER HEAT EXCHANGER



OIL-WATER HEAT EXCHANGER



**FITTING DATA**

| DESCRIPTION   |   | mm   |
|---|---|--|
| <b>ENGINE BLOCK-CONNECTING RODS</b>                                       |   |  |
| Cylinder sleeve bore dia  |   | 145 000 to 145 030   |
| Cylinder bore dia. in engine block  | { upper<br>lower  | 164 000 to 164 040<br>158.500 to 158.540   |
| Sleeve pilot dia.   | { upper<br>lower  | 164.003 to 164 028<br>158.461 to 158 486   |
| Sleeve interference fit in block  | { upper<br>lower  | -0.028 to +0 037<br>0.014 to 0 079   |
| Sleeve length   |   | 261.500 to 262 500   |
| Camshaft bush housing bore dia.   | { front<br>front intermediate<br>center<br>rear intermediate<br>rear center<br>rear intermediate center<br>rear | 76.480 to 76 520<br>76 980 to 77.020<br>77.480 to 77 520<br>77.980 to 78 020<br>78.480 to 78.520<br>78,980 to 79,020<br>78,480 to 79,520 |
| Main bearing housing dia.   |   | 118 000 to 118.022   |
| Engine block tappet dia.  |   | 26.000 to 26 025   |
| Big end bore dia.   |   | 97.950 to 97 972   |
| Small end bore dia.   |   | 59.963 to 59 994   |
| Standard big end bearing thickness  |   | 1 810 to 1.819   |
| Undersize scale for spare big end bearing                                 |   | 0.127-0 254-0 508-<br>0 762-1 016  |
| Small end bushing O.D.  |   | 60.109 to 60 160   |
| Small end bushing fitted I D  |   | 55.015 to 55 030   |
| Small end - bushing interference fit                                      |   | 0 115 to 0.197   |
| Crankpin clearance in big end bearing                                     |   | 0.025 to 0 048   |
| Max. connecting rod misalignment, 125 mm from axis                        |   | 0.060 to 0 120   |
| <b>PISTONS - PINS - RINGS</b>   |   |  |
| Standard piston dia. at right angle to pin bore,<br>21 mm from skirt base |   | 144.813 to 144 827   |
| Gudgeon pin dia. in piston  |   | 55.002 to 55.008   |
| Gudgeon pin dia.  |   | 54.982 to 54.990   |
| Ring groove width in piston   | { Top groove, double taper measured<br>on 142 mm bore dia<br>2nd groove<br>Bottom groove                        | 3.705 to 3.735<br>3 040 to 3.060<br>6 030 to 6.050   |

## DESCRIPTION

mm

|                                     |   |                                  |
|-------------------------------------|---|----------------------------------|
| Ring thickness                      | Top compression ring, double taper, chromium plated, measured on 142 mm bore dia. | 3 575 to 3 595<br>2 978 to 2 990 |
|                                     | 2nd compression ring, straight  |                                  |
|                                     | Oil scraper ring  | 2,975 to 5,990                   |
|                                     |   |                                  |
| Piston fit in sleeve (clearance)    |   | 0 173 to 0 217                   |
| Gudgeon pin clearance in piston     |   | 0.012 to 0 026                   |
| Ring clearance in piston (vertical) | Top compression ring, double taper, chromium plated                               | 0.110 to 0 160                   |
|                                     | 2nd compression ring, straight  | 070 to 0,105                     |
|                                     | Oil scraper   | 0 40 to 0,075                    |
|                                     |   |                                  |
| Ring gap in sleeve                  | Top compression ring, double taper, chromium plated                               | 0,6 to 0,75                      |
|                                     | 2nd compression ring, straight  | 0 50 to 0 75                     |
|                                     | Oil scraper   | 0.40 to 0,70                     |
|                                     |   |                                  |

## CRANKSHAFT - BEARINGS

|  |                                   |
|--|-----------------------------------|
| Standard main journal dia.                                 | 112.975 to 112.995                |
| Main bearing housing bore dia.                             | 118 000 to 118 022                |
| Standard main bearing thickness                            | 2.460 to 2.469                    |
| Main bearing undersize range (spare)                       | 0.127-0 254-0 508-<br>0.762-1 016 |
| Standard crankpin dia.                                     | 94.232 to 94 252                  |
| Main journal clearance in bearing                          | 0 067 to 0 127                    |
| Center main journal length                                 | 50.300 to 50.350                  |
| Center main bearing housing width over thrust washer faces | 43.324 to 43 372                  |
| Thrust washer thickness                                    | 3.378 to 3 429                    |
| Center main bearing housing plus thrust washer width       | 50 080 to 50 230                  |
| Crankshaft thrust clearance                                | 0 070 to 0 270                    |

## CYLINDER HEAD

|                                      |                  |
|--------------------------------------|------------------|
| Valve guide housing bore in head     | 17.000 to 17 018 |
| Valve guide O.D.                     | 17.028 to 17 039 |
| Valve guide oversize                 | 0.04 - 0 24      |
| Valve guide fitted I.D.              | 10.025 to 10.040 |
| Valve guide interference fit in head | 0.010 to 0 039   |
| Valve stem dia.                      | 9 985 to 10 000  |
| Valve stem clearance in guide        | 0.025 to 0 055   |

| DESCRIPTION   |         | mm               |
|---|---------|------------------|
| Valve seat angle  | Inlet   | 60°              |
|   | Exhaust | 45°              |
| Valve face angle  | Inlet   | 60° + 15'        |
|   | Exhaust | 45° + 15'        |
| Valve seat O D  | Inlet   | 53.172 to 53.202 |
|   | Exhaust | 47.136 to 47.161 |
| Max valve stem distortion over one complete revolution with dial gauge stylus in midstem position |         | 0.03             |
| Valve seat interference fit in head   | Inlet   | 0.142 to 0.202   |
|   | Exhaust | 0.111 to 0.161   |
| Valve seat I D  | Inlet   | 53.000 to 53.030 |
|   | Exhaust | 47.000 to 47.025 |
| Valve fitted deep in cylinder head  | Inlet   | 0.22 to 0.02     |
|   | Exhaust | 0.95 to 1.20     |
| VALVE SPRINGS   |         |                  |
| Released spring height  |         | ~74              |
| Spring height under 45 ± 2.5 kg   |         | 57.5             |
| Spring height under 80 ± 4 kg   |         | 46.5             |
| VALVE GEAR  |         |                  |
| Bush fitted I.D. after reaming:   |         |                  |
| <input type="checkbox"/> front  |         | 70.570 to 70.620 |
| <input type="checkbox"/> front intermediate   |         | 71.070 to 71.120 |
| <input type="checkbox"/> center   |         | 71.570 to 71.620 |
| <input type="checkbox"/> rear intermediate  |         | 72.070 to 72.120 |
| <input type="checkbox"/> rear center  |         | 72.570 to 72.620 |
| <input type="checkbox"/> rear intermediate center   |         | 73.070 to 73.120 |
| <input type="checkbox"/> rear   |         | 73.570 to 73.620 |
| Camshaft journal dia  |         |                  |
| <input type="checkbox"/> front  |         | 70.470 to 70.500 |
| <input type="checkbox"/> front intermediate   |         | 70.970 to 71.000 |
| <input type="checkbox"/> center   |         | 71.470 to 71.500 |
| <input type="checkbox"/> rear intermediate  |         | 71.970 to 72.000 |
| <input type="checkbox"/> rear center  |         | 72.470 to 72.500 |
| <input type="checkbox"/> rear intermediate center   |         | 72.970 to 73.000 |
| <input type="checkbox"/> rear   |         | 73.470 to 73.500 |
| Camshaft journal clearance in bushes:   |         |                  |
| <input type="checkbox"/> Clearance  |         | 0.070 to 0.150   |
| Cam lift - Intake and exhaust   |         | 8.210            |
| Tappet housing bore dia.  |         | 26.000 to 26.025 |
| "Crowned" tappet O.D. (measured at middle)  |         | 25.927 to 25.960 |
| Tappet interference fit in housing  |         | 0.040 to 0.098   |
| Camshaft thrust plate thickness   |         | 5.970 to 6.000   |
| Thrust plate housing thickness  |         | 6.070 to 6.145   |

| DESCRIPTION  | mm                     |
|--|------------------------|
| Camshaft thrust clearance                              | 0 070 to 0 175         |
| Injection pump drive shaft support bushing dia         | 70 879 to 70 909       |
| Injection pump drive shaft support bushing O D         | 70 970 to 71 000       |
| Bushing interference fit in housing                    | 0,084 to 0,165         |
| Bush fitted I D after reaming                          | 65,025 to 65,050       |
| Injection pump drive shaft dia                         | 64 970 to 65 000       |
| Bush - drive shaft clearance                           | 0 025 to 0,080         |
| OIL PUMP   |                        |
| Clearance among driving gear, driven gear, pump casing | 0 060 to 0 136         |
| Clearance among driving gear driven gear cover         | 0 02 to 0 105          |
| Driving side - driven side tooth clearance             | 0 1                    |
| OIL PRESSURE BOOST VALVE                               |                        |
| Relief valve opening pressure                          | 4 5 kg/cm <sup>2</sup> |

**DIAGNOSTIC**

| TROUBLE                                | POSSIBLE CAUSE                                       | REMEDY   |
|--|--|--|
| <b>The engine does not start</b>       | Battery charged partially                            | Check batteries and charge them<br>If necessary, replace them  |
|  | Battery terminal connections corroded or loose.      | Clean, check and tighten nuts on battery terminals. Replace cable terminals and nuts, if badly corroded  |
|  | Incorrect timing of injection pump                   | Check and carry out injection pump timing  |
|  | Deposits or water in fuel lines.                     | Detach pipes and clean them with air. Disassemble and clean injection pump. Dry fuel tank and refuel   |
|  | Insufficient fuel reserve.                           | Refuel.  |
|  | Defective fuel pump.                                 | Overhaul pump or change it   |
|  | Air bubbles in fuel lines or in injection pump.      | Check pipes and fuel feed pump to detect the reasons of air presence, bleed air from injection pump unscrewing the relevant plug and manually operating fuel feed pump.  |
|  | Defective starter                                    | Repair or replace starter  |
|  | Inefficient thermo-starter                           | At low temperature switch on thermo-starter. If inefficient, replace it.   |
| <b>The engine stops</b>                | Too low idling                                       | Adjust idle speed by adjusting screw   |
|  | Uneven delivery of injection pump.                   | Adjust delivery. If broken, replace pumping element spring. Replace tappets plunger and barrel, if seized or not seating   |
|  | Foreign matter or water in fuel pipes.               | Detach pipes and clean with air. Disassemble and clean injection pump. Clean fuel tank and refuel.   |
|  | Fuel filters clogged.                                | Remove filter elements and replace them, if necessary  |
|  | Abnormal clearance between valves and valve rockers. | Adjust clearance.  |
|  | Valves burnt, corroded or cracked.                   | Replace valves.  |
|  | Air in fuel feed or injection systems                | Check pipes for possible cracks, check for loose connectors. Replace worn parts, then bleed air from pipes and proceed to deaerate injection pump and fuel filter unscrewing the relevant plugs and operating the fuel feed pump manually. |
|  | Fuel filter and fuel feed pump valves clogged.       | Replace fuel filter and overhaul fuel feed pump valves.  |
|  | Injection pump controls broken                       | Replace defective parts and check pump timing  |
| <b>The engine warms up excessively</b> | Defective water pump.                                | Check clearance between impeller blades and pump casing. Overhaul the assembly and replace gasket.   |
|  | Thermostat failure.                                  | Valve stem jamming in guide  |

| TROUBLE  | POSSIBLE CAUSE  | REMEDY  |
|--|---|---|
| <b>The engine warms up excessively</b>                       | Scale in water passages in engine block and cylinder head.                            | Wash thoroughly, in compliance with directions given for the type of scale remover used.  |
|  | Insufficient tension of water pump belt.  | Check and adjust belt tensions.   |
|  | Cooling water level too low   | Fill the expansion tank with water, restoring the level.  |
|  | Incorrect engine timing   | Check timing and proceed to correct timing  |
|  | Incorrect injection pump calibration (upwards or downwards).                          | On test bed correct pump delivery so that injection has the prescribed delivery   |
|  | Air cleaner clogged.  | Clean air cleaner and inherent system.  |
|  | Engine brake engaged partially because of the seizure of engine brake throttle valve. | Overhaul throttle valve assembly, replace worn-out parts if necessary   |
| <b>The engine is under power and its operation is uneven</b> | Incorrect timing of injection pump  | Check pump timing and correct it.   |
|  | Automatic advance of injection pump defective.  | On test bed check injection pump operation; if the observed values do not comply with the prescribed ones, replace inner springs of advance unit. |
|  | Excessive wear in plungers and barrels of injection pump                              | Overhaul injection pump and replace worn-out parts  |
|  | Incorrect calibration of speed governor.  | Check governor calibration and again calibrate it, if necessary   |
|  | Injector nozzles clogged or incorrect injector operations.                            | Clean nozzle holes with suitable tool and totally overhaul injectors.   |
|  | Foreign matter or water in injection feed system.                                     | Thoroughly clean and refill with new fuel.  |
|  | Defective fuel feed pump.   | Disassemble pump, and, if necessary, replace pump components.   |
|  | Incorrect clearance between valves and rockers.                                       | Check clearance and proceed to a correct adjustment   |
|  | Low compression.  | With tool 395682 check compression pressure, if this is less than 20 kg/cm <sup>2</sup> , overhaul the engine.                                    |
|  | Defective turbocharger  | Overhaul the assembly or replace it.  |
|  | Air cleaner clogged.  | Clean air cleaner and inherent system.  |
|  | Engine brake engaged partially, because of throttle valve seizure.                    | Overhaul throttle valve assembly; replace worn-out parts if necessary.  |
| <b>The engine knocks abnormally</b>                          | Incorrect adjustment of injection pump peak capscrew or of control rod stop.          | Adjust stops correctly.   |
|  | Uncorrect injector operations.  | Check that nozzle pin does not cause resistance and calibration is of prescribed value.   |
|  | Fuel lines clogged.   | Remove pipes; clean them and replace those which are damaged or clogged.  |

| TROUBLE                             | POSSIBLE CAUSE  | REMEDY   |
|-------------------------------------|---|--|
| <b>The engine knocks abnormally</b> | Uncorrect injection pump timing   | Correct pump timing so that injection takes place according to the prescribed advance angles.  |
|                                     | Crankshaft knocks because of excessive clearance of one or more main bearings or of high thrust clearance.                            | Recondition crankshaft journals and mount undersize bearings.<br>Replace thrust washer halves with oversized ones.                                       |
|                                     | Crankshaft unbalanced.  | Check shaft alignment; if necessary correct as required and check balance.   |
|                                     | Flywheel capscrew loose.  | Replace loose screws and tighten to the prescribed torque value.   |
|                                     | Connecting rods out-of-alignment.   | Straighten connecting rods under a hydraulic press, and check parallelism  |
|                                     | Piston knocks due to slap.  | Replace cylinder sleeves and pistons   |
|                                     | Noisy piston pins due to excessive clearance in piston and in connecting rod bushing<br>Loose bushings in connecting rod seat.        | Replace piston pin with an oversize one and adjust piston hubs and connecting rod bushings. Replace bushings with new ones                               |
|                                     | Tapping due to noisy valve system.  | Adjust clearance between valves and rockers and check if there are broken springs or excessive clearance between stems and guides, or tappets and seats. |
| <hr/>                               |   |  |
| <b>The engine smokes abnormally</b> |   |  |
| <b>1) Black or dark grey smoke:</b> | Excessive pump delivery.  | Detach pump and adjust delivery according to the data of calibration table.  |
|                                     | After starting the automatic fuel excess device does release.   | Check and, in case, replace this device.   |
|                                     | Injection pump retarded excessively (or advance governor defective).  | Correct timing, verify governor  |
|                                     | Injection pump excessively advanced.  | Correct timing   |
|                                     | Nozzle holes (or some of them) partially or totally clogged.  | Replace injectors with a set of new injectors, or clean and recondition the original ones with suitable fixtures   |
|                                     | Air cleaner clogged or worn-out.  | Clean or replace filter element.   |
|                                     | Nozzle pin intermittently locked in open position.  | Check injectors, check for possible locked pins, broken springs, too low calibration.  |
|                                     | Governor adjustment over max. stated.   | Bench adjust governor, according to table data.  |
|                                     | Nozzle sprays are sent to the head because of incorrect injector assembly.  | Check nozzle protrusion as to head face.   |
|                                     | Excessive lift of injector pin due to abnormal wear.  | Replace affected nozzle.   |
|                                     | Engine compression loss due to:<br>- Piston rings stuck.<br>- Cylinder sleeve worn-out.<br>- Valves worn-out or adjusted incorrectly. | Overhaul engine or repair concerned parts  |

| TROUBLE  | POSSIBLE CAUSE   | REMEDY   |
|--|--|--|
| <b>1) Dark grey or black smoke:</b>                      | Incorrect type of injector or injectors of different types or uncalibrated                 | Replace injectors or calibrate them  |
|  | Injection pipes of inadequate inside bore pipe ends squashed because of repeated refitting | Check conditions of ends and connectors. Replace where necessary   |
| <b>2) Blue, grey/blue, or clear grey smoke</b>           | Excessive injection delay or automatic advance device worn-out                             | Correct pump timing and check governor   |
|  | Injector needles blocked or defective injectors  | Check for blocked needles or broken springs  |
|  | Oil seeping through piston rings due to stuck rings or to wear of sleeve walls             | Overhaul engine.   |
|  | Engine oil seeping through intake valve guides, due to wear of valve stems or guides       | Recondition cylinder head.   |
|  | Engine too cold (thermostat missing or not present)  | Replace thermostat   |
| <b>The engine does not stop</b>                          | Governor broken  | Unscrew the joint connecting fuel supply, then repair as necessary   |
|  | Seizure of flow pushrod  | Unscrew the joint connecting fuel supply and repair as required.   |
|  | Seizure of injection pump pumping element.   | Unscrew the joint connecting supply and repair as required.  |
|  | Hard pushrod motion  | Clean pushrod seat, and check that malfunction is not due to careless mounting of rod                                      |
|  | Governor parts cause resistance.   | Free of governor sleeve and from control level   |
|  | Excessive clearance between the various governor parts                                     | Remove all clearances, only leaving minimum tolerances; in case replace worn-out parts                                     |
| <b>Stepless change of max. speed (engine not loaded)</b> | Governor springs too weak, causing an excessive sensitivity from governor.                 | Replace governor springs.  |
|  | Excessive clearance between the various parts transmitting control to pump.                | Adjust all clearances among the various parts transmitting control (be sure that pushrod stroke is exactly as prescribed). |
| <b>The pump does not deliver fuel</b>                    | Foreign matter in pipes.   | Clean thoroughly   |
|  | Dirty fuel filters.  | Clean thoroughly   |
|  | Squashed pipes.  | Replace pipes or, if possible repair them (the low pressure ones).   |
|  | Air in injection pump.   | Deaerate pump.   |

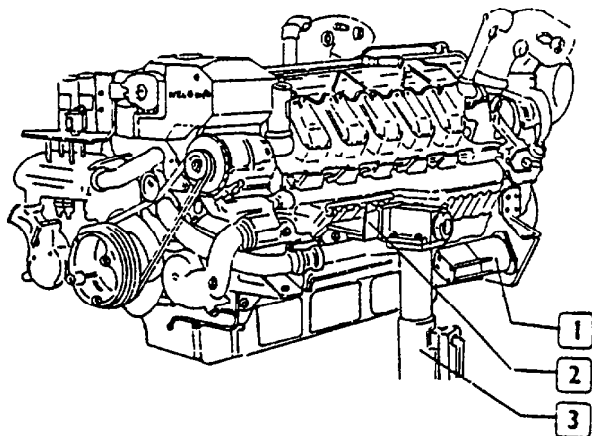


| TROUBLE                                      | POSSIBLE CAUSE                                      | REMEDY   |
|--|---|--|
| <b>The pump does deliver fuel</b>            | Plunger tappets may be seized                       | Remove part and repair it (if failure is minor); if necessary, replace it.   |
|  | Plunger seized                                      | Change defective pumping element, as barrels and piston are not interchangeable  |
|  | Delivery valves seized.                             | If failure is only due to foreign matter, clean valve and slightly regrind taper faces with an emery cloth; if reasons are different, replace pair valve holder - valve with are not interchangeable from each other |
| <b>The pump does not deliver enough fuel</b> | Imperfect seal unions                               | Be sure that fuel feeding pipe nut washers are not broken or deformed; then tighten joints very carefully  |
|  | Imperfect seal in delivery valves of some elements. | Replace the pair valve - tube holder.  |
|  | Pumping elements worn-out.                          | Replace pumping elements   |
| <b>The pump feeds abnormally</b>             | Air bubbles in fuel feed pump.                      | Deaerate fuel feed pump.   |
|  | Plunger return spring broken.                       | Replace spring   |
|  | The plunger is about to seize.                      | Thoroughly clean plunger and its cylinder  |
|  | Tappet pin worn-out.                                | Replace tappet.  |
| <b>Injection start faulty timed</b>          | Uneven delivery start.                              | Adjust delivery start replacing adjusting shims.   |
|  | Eccentric damaged.                                  | Replace camshaft, using the stroboscopic check method.   |
| <b>The control rod shakes</b>                | Vibration due to high pump stress.                  | Check the efficiency of spring small blocks of adjusting device.   |
|  | Critical engine rpm.                                | Check the efficiency of spring small blocks of adjusting device.   |
| <b>INJECTORS</b>                             |   |  |
| <b>The injector drips</b>                    | Nozzle and needle valve (pin) are not sealed.       | Thoroughly clean nozzle, if the trouble is due to foreign matter preventing normal operation; otherwise replace the nozzle valve pair.   |
| <b>Too high injection pressure</b>           | Incorrect injector calibration.                     | Calibrate injector with the greatest care.   |
|  | Valve seized inside spray nozzle.                   | Replace nozzle valve pair.   |
|  | Adjusting spring too strong                         | Replace spring with a more suitable one.   |
| <b>Fuel seeps from injector unions</b>       | The upper air bleeder plug is not tightened.        | Tighten it.  |
|  | Nozzle check nut not tightened.                     | Tighten it.  |
| <b>Abnormal jet</b>                          | Nozzle holes clogged by carbon deposits.            | Clean nozzle holes with the suitable tool and steel wire of smaller diameter than holes. Then clean the whole nozzle.  |
|  | Holes deformed due to wear.                         | Replace nozzle-valve pair.   |

| TROUBLE  | POSSIBLE CAUSE   | REMEDY   |
|--|--|--|
| <b>INJECTION PUMP</b>                              |  |  |
| <b>Injection pump</b><br><b>Difficult starting</b> | Electromagnet for excess fuel device                   | Check electric contacts on control button and on that same electromagnet   |
|  | Air in fuel feed system                                | Deaerate system until only diesel oil comes out from filter drain screw  |
|  | Fuel filters clogged                                   | Replace filters, clean the filter corresponding to hand primer   |
|  | Injectors with nozzles seized or clogged.              | Check injectors, overhaul or replace nozzles, proceed to calibrate   |
|  | Incorrect pump timing on engine                        | Check if the static timing of injection pump on engine is correct.   |
|  | Starting delivery not complying with calibration table | Place injection pump on test bed and verify excess fuel delivery   |
| <b>Uncorrect idling</b>                            | Accelerator lever stop screw                           | With the vehicle at idling running, carry out accurate adjustment.   |
|  | Linkage  | Check linkage starting from accelerator pedal to the connection on speed governor lever. Remove possible resistances.  |
| <b>Abnormal idling</b>                             | Injector uncalibrated or nozzles seized or clogged.    | Check injectors, overhaul or replace nozzles, proceed to calibrate   |
|  | Speed governor   | On test bed check the correct setting up and operation of speed governor   |
|  | Unbalanced delivery                                    | Check and adjust at test bench   |
| <b>Low efficiency</b>                              | Fuel filters clogged.                                  | Replace filters, clean filter on hand primer and on suction pump reservoir   |
|  | Air cleaner dirty                                      | Through the pilot lamp in the cab, check if the cartridge is clogged; if necessary, clean it or replace it   |
|  | Injector uncalibrated or nozzles seized or clogged     | Check injectors, overhaul or replace nozzles, proceed to calibrate   |
|  | Wrong pump timing on engine                            | Check if the static timing of injection pump on engine meets the calibration table.  |
|  | Injection pump has insufficient fuel inlet.            | Detach injection pump from engine and verify calibration at test bed.  |
|  | LDA device.  | <ul style="list-style-type: none"> <li>- Be sure that the diaphragm has no holes, that the control spring is adequate and with a correct load (test bench checking). Verify that the turbocharger compressor wheel can rotate freely and the tabs have no failure marks. Check for adequate pressure inside intake manifold according to engine rpm at full load.</li> </ul> |

| TROUBLE  | POSSIBLE CAUSE                                       | REMEDY   |
|--|--|--|
| <b>Excessive exhaust smoke with cold engine</b>                | Wrong injection pump timing on engine.               | Check the static timing of injection pump on engine  |
|  | Injector uncalibrated or nozzles seized or clogged   | Check injectors, overhaul or replace nozzles, proceed to calibrate   |
|  | Insufficient compression pressure                    | Check with motometer   |
| <b>Excessive exhaust smokes (black) with engine under load</b> | Excessive fuel delivery to engine.                   | Check max. pump delivery at test bench   |
|  | Low air induction.                                   | Check air cleaner through its suitable inspection hole   |
|  | Wrong injection pump timing on engine.               | Check the static timing of injection pump on engine  |
|  | Injectors uncalibrated, or nozzles seized or clogged | Check injectors, overhaul or replace nozzles, proceed to calibrate.  |
|  | Defective advance variator                           | Overhaul or replace variator   |
| <b>Excessive fuel consumption</b>                              | Fuel leakages  | Check pipes and joints   |
|  | Dirty air cleaner.                                   | Through the pilot lamp in the cap check if the cartridge is clogged; if necessary, clean it or replace it. |
|  | Injectors uncalibrated, or nozzle seized or clogged. | Check injectors, overhaul or replace nozzles, proceed to calibrate.  |
|  | Injection pump excessively uncalibrated.             | Check and adjust injection pump at test bench  |
|  | Abnormal operation of L.D.A. device.                 | Check and adjust at test bench   |
|  | Incorrect pump timing on engine.                     | Check static pump timing on engine   |
|  | Defective advance variator                           | Overhaul or replace variator   |

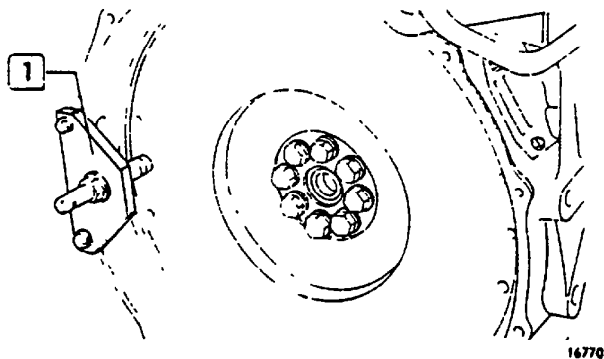
## ENGINE DISASSEMBLY



Secure engine to stand 99322230 (3) using brackets 99361011 (2).

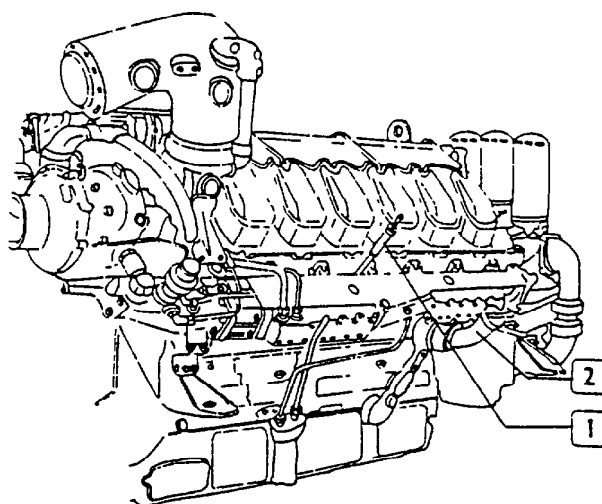
Drain oil from engine oil sump, and cooling fluid from engine block.

From front side of engine detach (1)



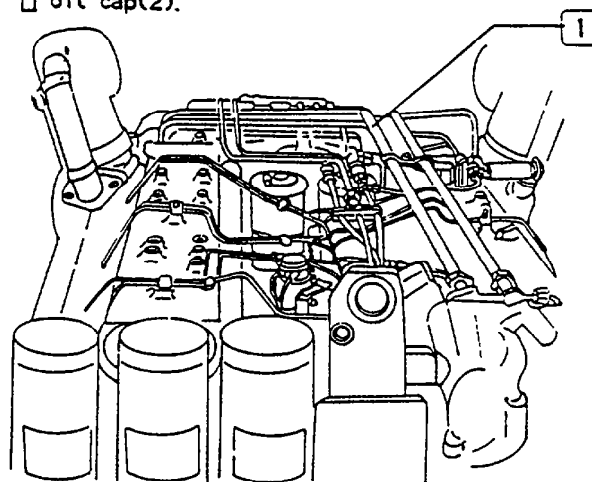
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Lock crankshaft rotation using tool 99360351 (1) positioned as indicated.

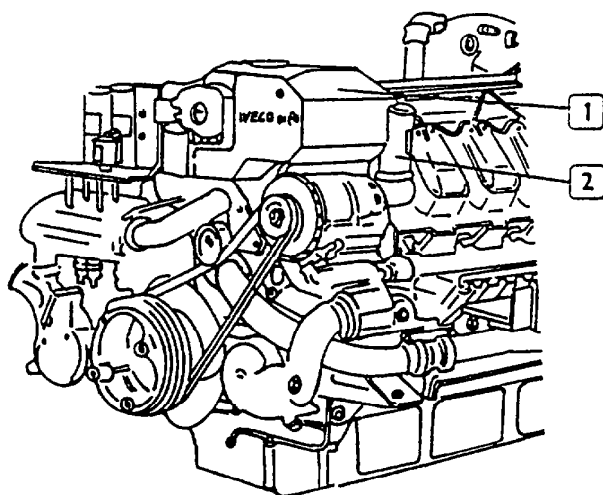


Remove:

- ☐ oil dipstick(1),
- ☐ oil cap(2).

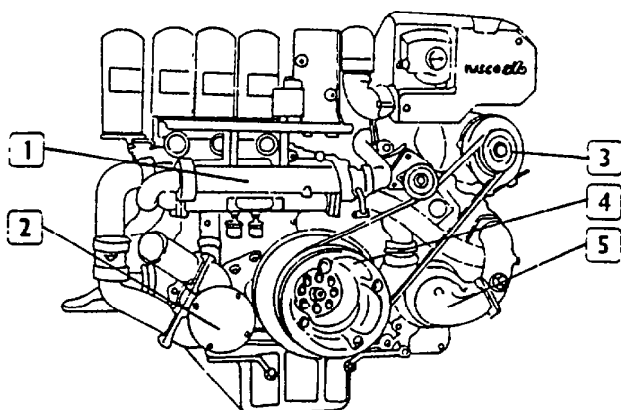


Remove the pipes of turbocharging, water and fuel



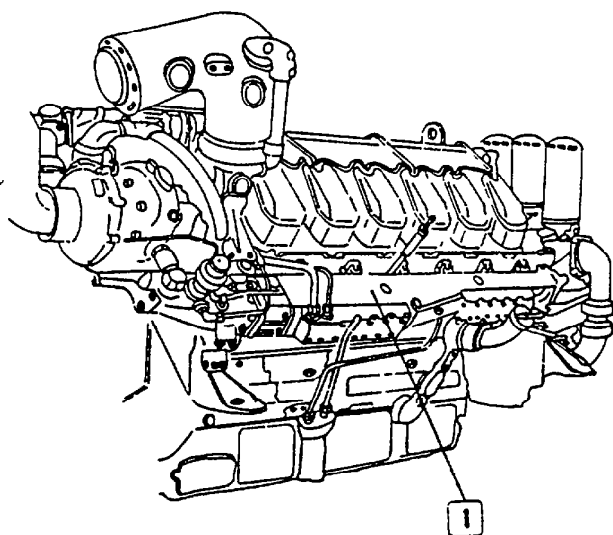
Remove:

- ☐ expansion tank (1) complete with thermostat and water filter(2).



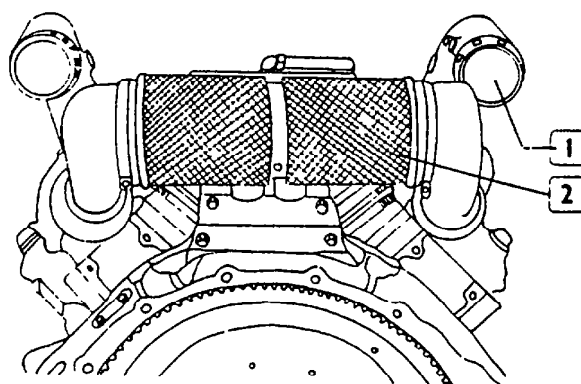
## Take off:

- ☐ oil water heat exchanger(1).
- ☐ sea water pump(2).
- ☐ alternator(3) with stretcher and belt.
- ☐ pulley (4) with damper.
- ☐ sweet water pump(5) with relevant pipes.



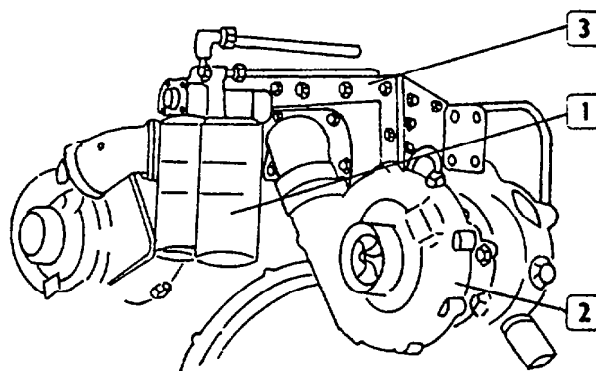
## Remove:

- ☐ the exhaust manifolds(1).



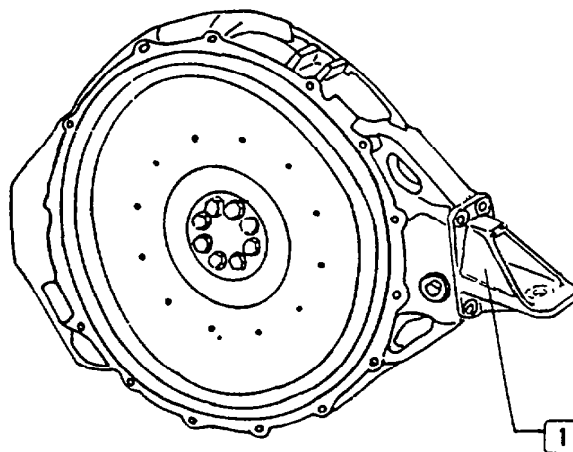
## Take off:

- ☐ gas water mixers(1).
- ☐ air filters(2).



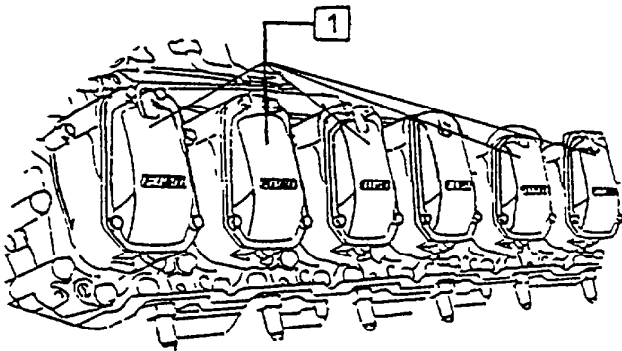
## Remove:

- ☐ fuel filters(1)
- ☐ turbochargers(2)
- ☐ air-water heat exchanger(3)

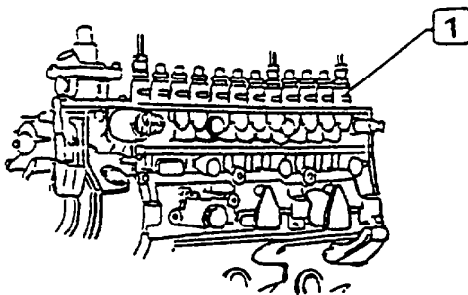


## Take off:

- ☐ engine mounting(1).



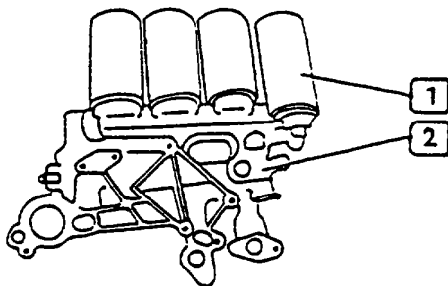
Remove inspection covers(1)



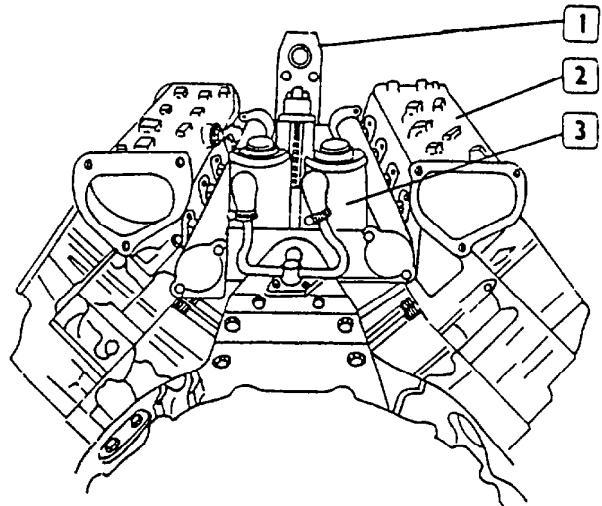
Remove:

- from the injection pump(1), the fuel delivery pipes, the return fuel pipe; from the filter, the inlet pipe.
- from the injectors and from the injection pump, the fuel delivery pipes, with the tool 99352160
- take off the clamps and fuel delivery pipes; the return fuel pipes from the injectors.

**NOTE** When you intend to change (or during a simple disassembling) one or plus injection pipes, from the injection pump to the injectors, you must replace all the relevant clamps complete with pad and screw.



Remove oil filters(1) from the support(2)



Take off:

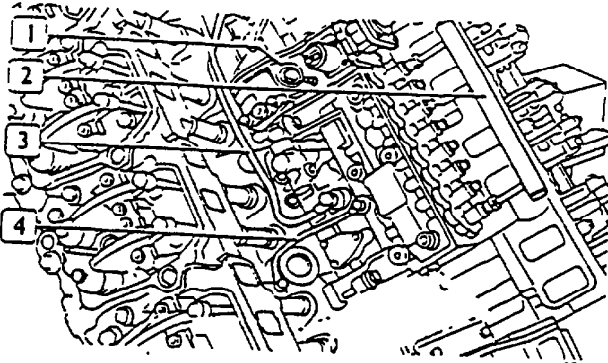
- engine lifting eye(1).
- intake manifolds(2).
- oil breather(3) complete with pipes



16778

Disconnect:

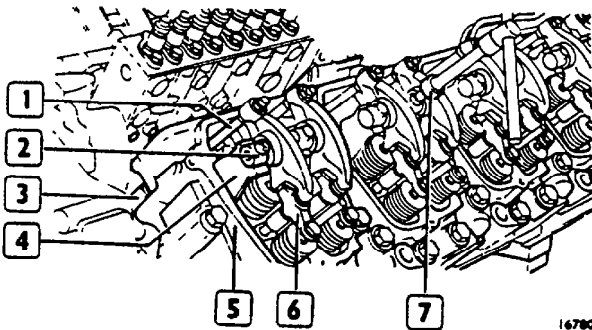
- Fuel leak-back lines (1) from injectors (3).
- Fuel delivery lines (2) from injectors (3) and injection pump, using wrench 99352120 (4).
- Injectors (3) from cylinder heads, using puller 99340205 (6) and puller 99342135 (5)



Disconnect inlet (4) and outlet (3) oil pipes from injection pump (1).

Then remove the output oil pipes from the injection pump governor to the crankcase.

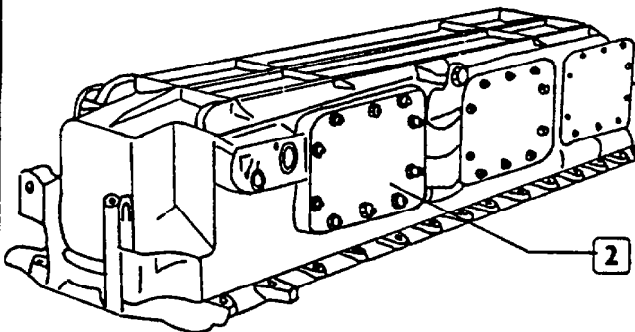
Install fixture (2) on injection pump (1) unions; disconnect pump from engine removing the screws which secure it to their supports



Disconnect:

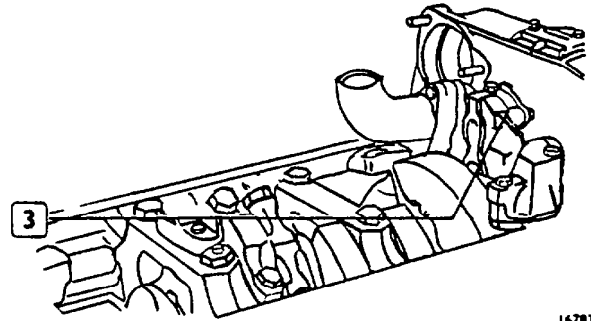
- Rocker shafts (2) from housings (4), removing cap-screws by wrench 99389856 (7).
- Housings (4), bridges (6) and rods (1) from cylinder heads (5).

Disconnect cylinder head (5) and withdraw pushrod (1) sleeves (3).

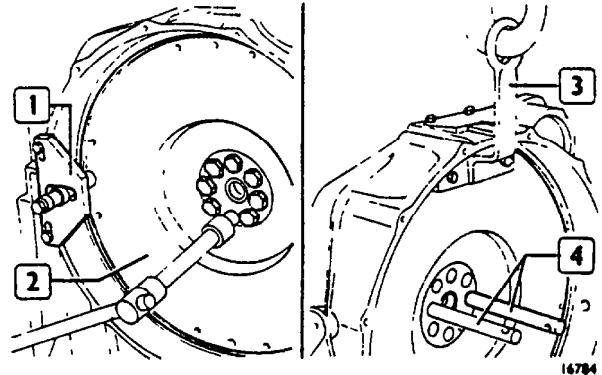


From engine disconnect:

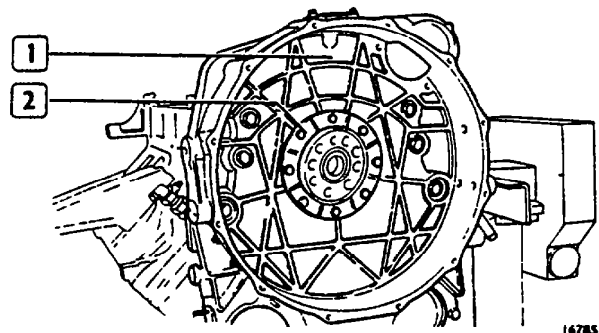
- Oil sump (2).



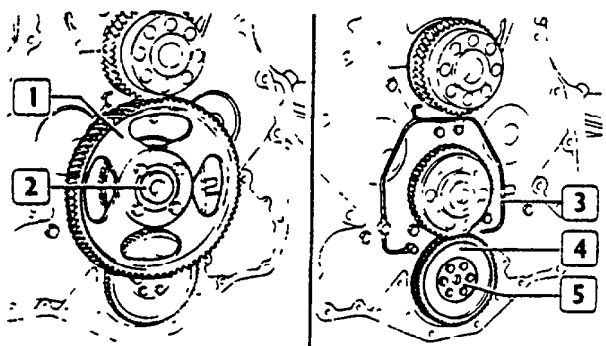
Disconnect oil pump (3) with attached oil suction



Stop crankshaft rotation using tool 99360351 (1) and remove the screws securing flywheel (2) to crankshaft. On crankshaft, screw down guide pins (4), apply bracket (3) on flywheel (2) and take off this using a hoist.



From flywheel housing (1) disconnect rear cover (2) and remove the flywheel housing (1) from engine block.

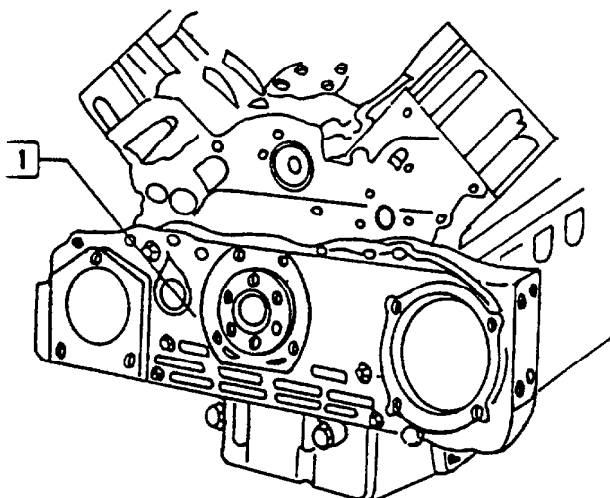


17213

Disassemble gear (1) from camshaft (2).

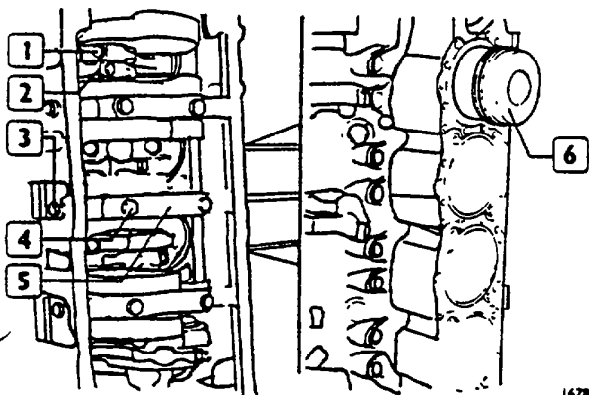
Remove lubrication line (3).

Disconnect gear (4) from injection pump shaft (5) and draw this out from its support.



16788

Detach cover (1) with seal from the rear side of the engine.



16787

Position engine block vertically

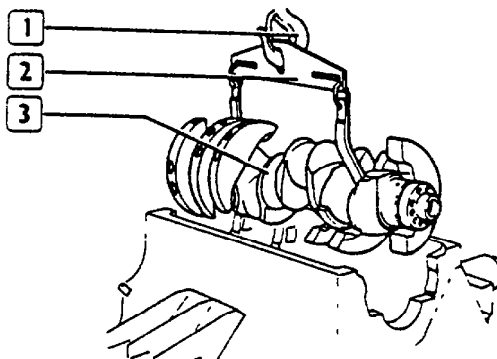
Withdraw pistons as follows:

- Loosen connecting rod cap nuts (1)
- Rotate crankshaft until the piston is exactly on T.D.C. In different positions the piston could not be withdrawn as the connecting rod interferes with cylinder sleeve.
- Remove connecting rod cap (2) and withdraw piston (6) from cylinder sleeve

Position engine block horizontally

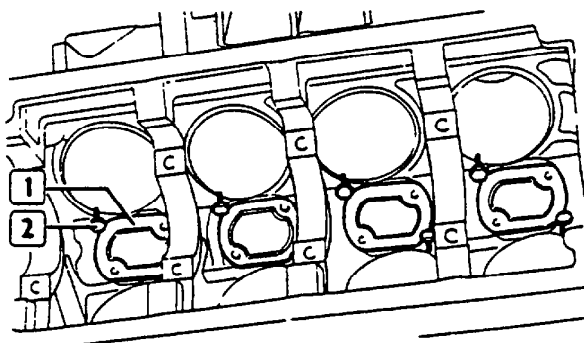
Remove upper (4) and side (3) screws securing main bearing caps to engine block, and withdraw them

NOTE - Center bearing housing (5) and cap carry thrust washers for crankshaft end float.



16789

Using hoist (1) and fixture 99360500 (2) installed on crankpins, withdraw crankshaft (3) from engine block.

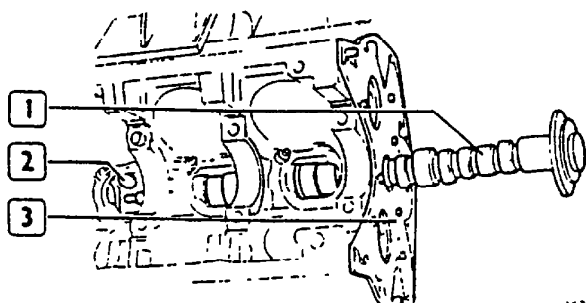


16789

Remove oil catchers (1) and oil spray nozzles (2).

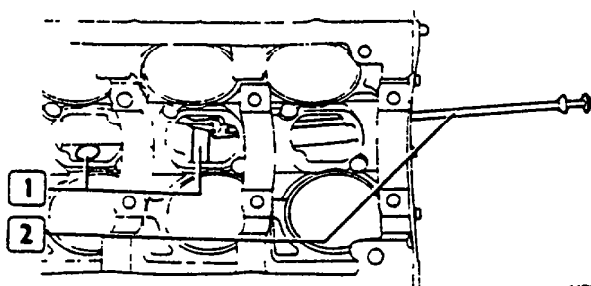


# REPAIR ACTIONS ENGINE BLOCK



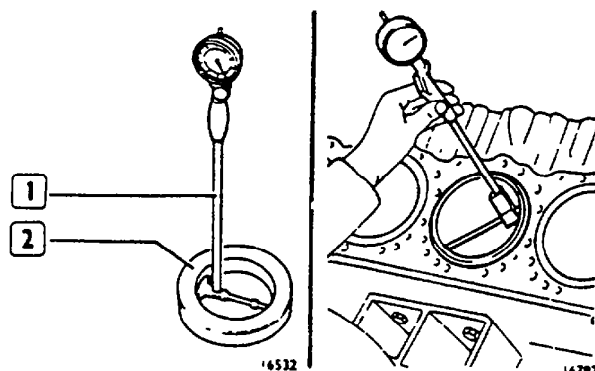
16790

From engine block remove camshaft (1) taking care not to damage bushings  
Withdraw tappets (2) and take off rear plate (3)



16791

This figure shows how withdraw tappets (1) from engine block using workshop tool 345075 (2). This operation is carried out when only tappet checks or removals are necessary. In this case, remove only the components which make it possible to withdraw camshaft from engine block.



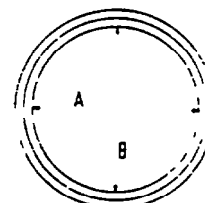
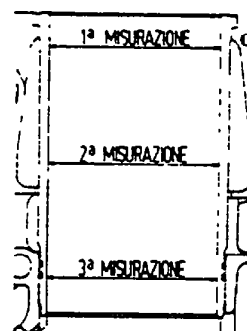
16532

16792

## CHECKS AND MEASUREMENTS

After engine disassembly, clean engine block thoroughly and inspect cylinder sleeves, which should not show pick-ups, score marks, out-of-roundness, taper or wear.

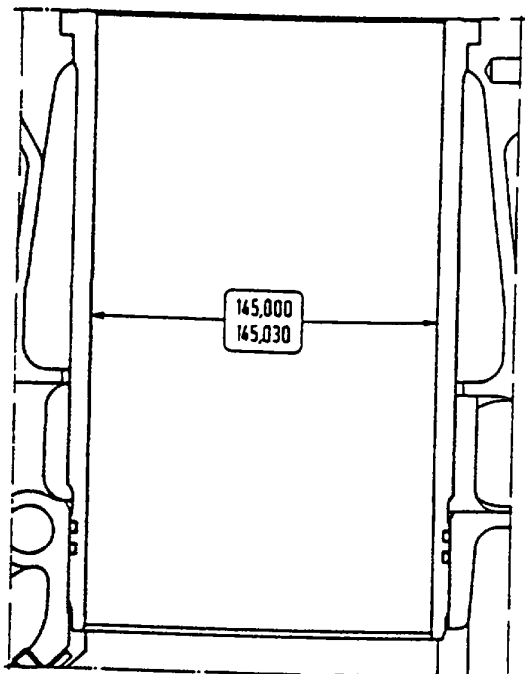
To check cylinder sleeve bore for ovality, taper or wear, use gauge 99395687 (1) with attached dial gauge previously set to zero against ring gauge (2) (145 mm dia.).



1ª MISURAZIONE = 1st MEASUREMENT  
2ª MISURAZIONE = 2nd MEASUREMENT  
3ª MISURAZIONE = 3rd MEASUREMENT

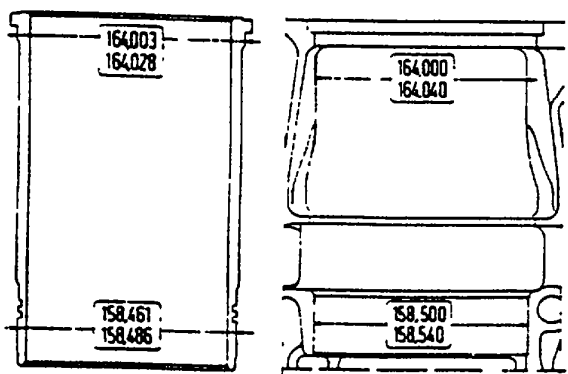
2284

Each sleeve cylinder bore must be measured at three different points on two planes at right angles, as indicated in the diagram. Max. wear is usually observed on first measurement level (B axis).



2286

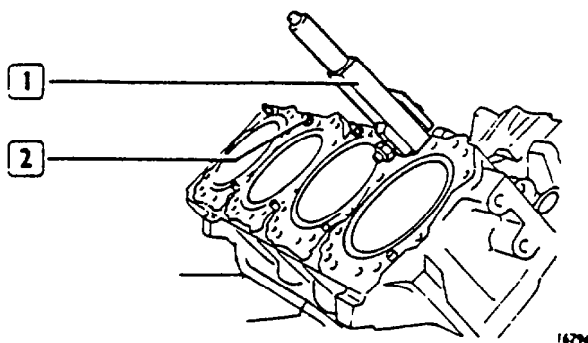
If higher values than those indicated in the figure are detected, replace cylinder sleeves, as the sleeve bore is liquid nitrided and must not be ground, honed or dressed.



2290

The above scheme indicates cylinder sleeve bore and O.D.

If necessary, cylinder sleeves can be removed and inserted in different seats several times.

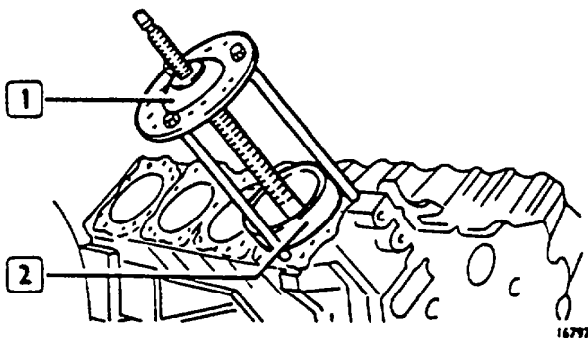


16796

Check engine block face for distortion, using a straight-edge and a feeler.

If necessary, remove dowels (2) and, using fixture (1), withdraw sleeves from engine block and grind surfaces.

NOTE - Remove as little material as possible, considering that the same thickness must be removed from sleeve shoulder seats using a suitable fixture.

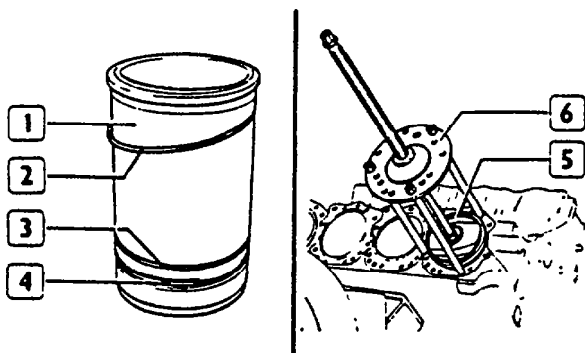


16797

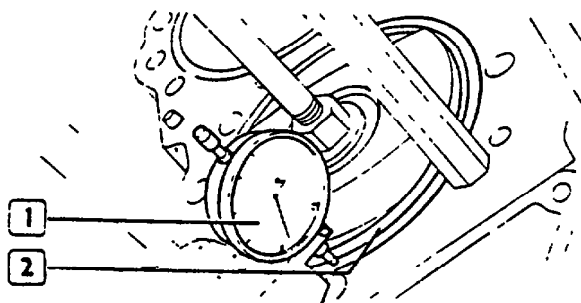
Take off cylinder sleeves (2) from engine block using plate 99360785 and tool 99360799 (1) positioned as indicated in the figure.

Thoroughly check cylinder sleeve housings and engine block side surfaces. Inspect conditions of gap on cylinder block bores.

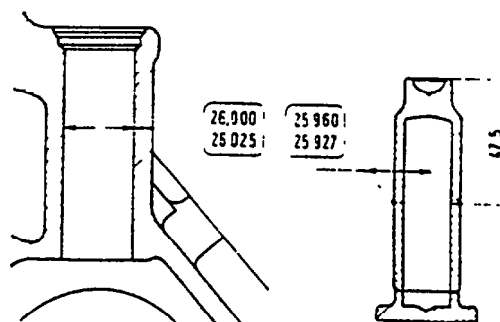
If rusted or mis-sealed, replace them.



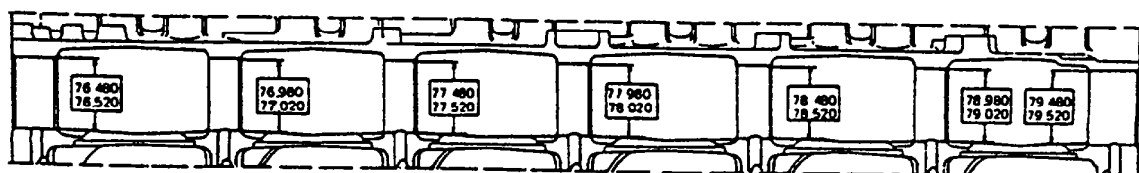
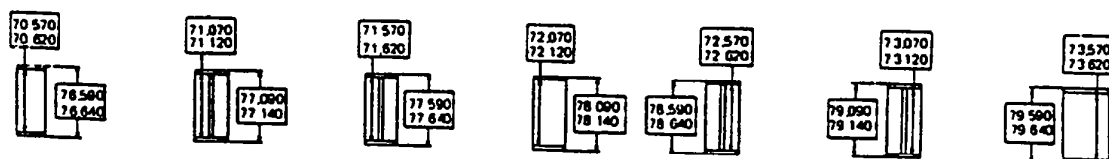
Always replace water seals (3 and 4).  
Slide the upper brass sealing ring (2) into cylinder sleeve (1), and lubricate lower sleeve end before inserting it in cylinder through plate 99360785 (5) and tool 99360799 (6).



Through gauge (1) measure cylinder sleeve protrusion (2) as to engine block face. It should be 0.03 to 0.09 mm.

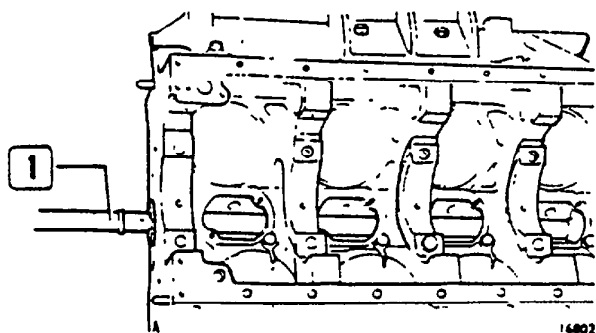


Normal tappet clearance is 0.040 to 0.098  
Spare oversize tappet ranges are: 0.1 - 0.2 - 0.3 mm  
Tappet surface in contact with camshaft lobe should be smooth and free from dents. Slight dents may be repaired with a zero grade emery paste.



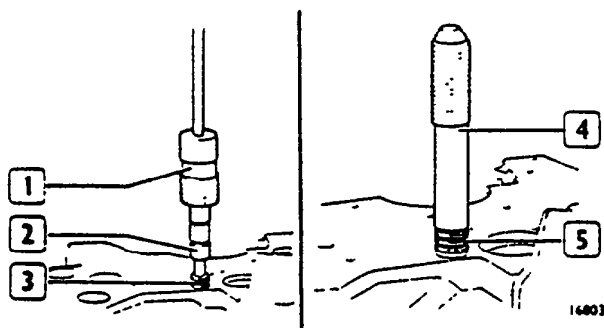
CAMSHAFT BUSHING AND SEAT DETAILS

Bushings must be press fitted in their seats. Inside surfaces must be smooth and free from seizure, and should not be worn-out.



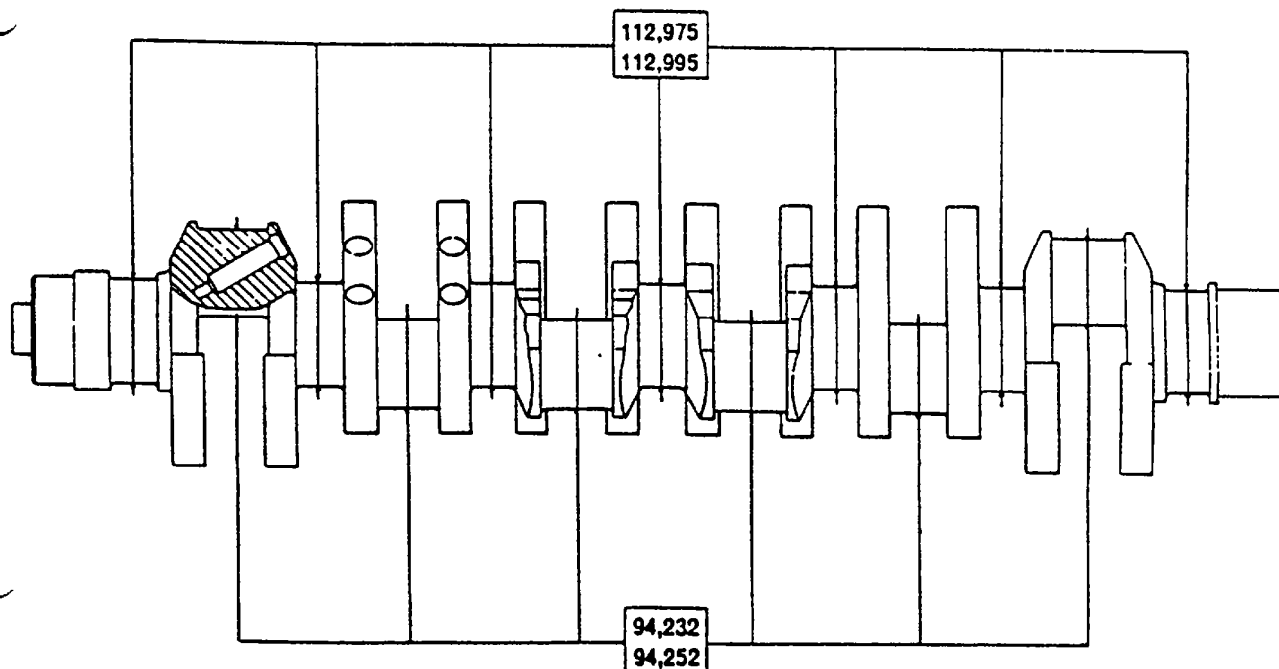
To replace bushing use remover/installer tool 99360385 (1).

Camshaft clearance should be 0.07 to 0.15 mm

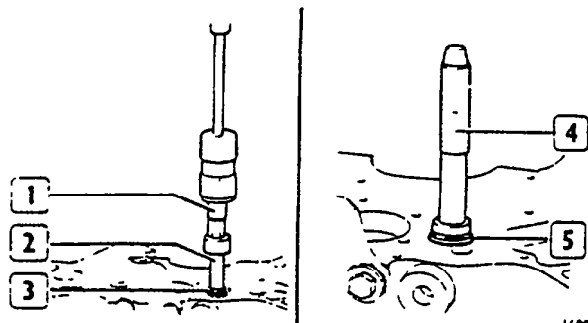


Replace bushing (3) sealing ring (5) of main left oil gallery removing the bushing from engine block by means of remover/installer 99340205 (1) together with (2). To insert bushing, use suitable remover/installer tool (4).

### CRANKSHAFT

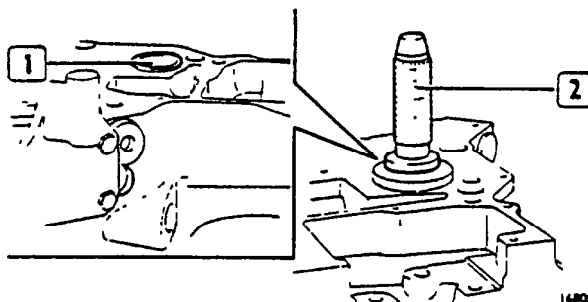


CRANKSHAFT JOURNAL DETAILS



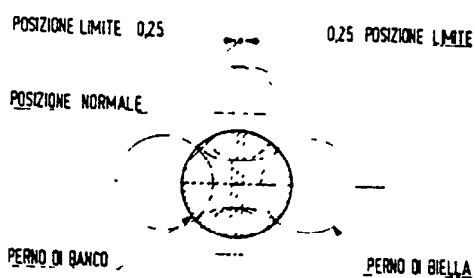
Replace bushing (3) sealing rings (5) of main right oil gallery removing the bushing from engine block by means of remover/installer 99340205 (1) together with part 99340215 (2).

To again insert bushing, use suitable installer/remover (4).



To replace cooling fluid bushing (1), use suitable means for removal. For insertion, use suitable installer (2).

Check crankshaft journal and crankpin conditions. They should not show scores, ovalities or excessive wear. Data in diagram refers to normal journal diameters.  
Before regrounding crankshaft, remove counterweights.



POSIZIONE LIMITE = LIMIT POSITION  
POSIZIONE NORMALE = BASIC POSITION  
PERNO DI BANCO = CRANKPIN  
PERNO DI BIELLA = JOURNAL

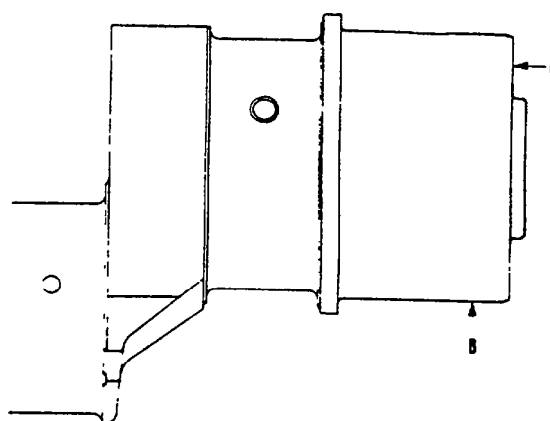
8296

### MAX. ALLOWABLE CLEARANCE ON CRANKPIN ALIGNMENT VS. MAIN JOURNAL

During crankshaft journal regrounding, the allowed tolerances are:

- Ovalization 0.008 mm
  - Taper 0.012 mm
  - Main journal misalignment: 0.10 mm
  - Crankpin misalignment:  $\pm 0.25$  mm.
- Undersize range: 0.127 - 0.254 - 0.508 0.762 - 1.016 mm

NOTE - Journals must be reground to a same undersize class.



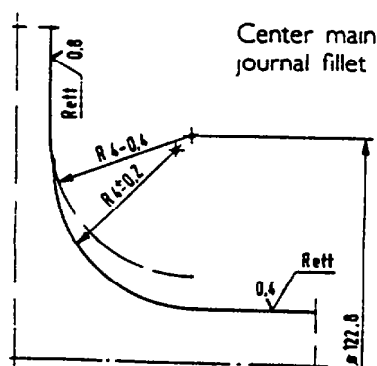
8297

Checking squareness and concentricity of flywheel face as to rotation axis and main journals.

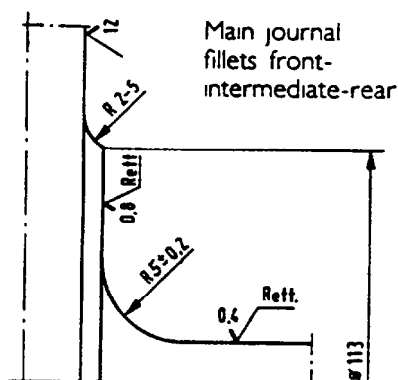
Rotate shaft.

with the gauge positioned on B, changes over 0.4 mm should not be detected;

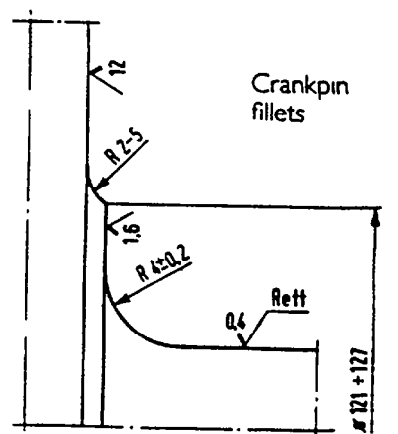
with the gauge positioned on A, changes over 0.02 mm should not be detected



Center main journal fillet



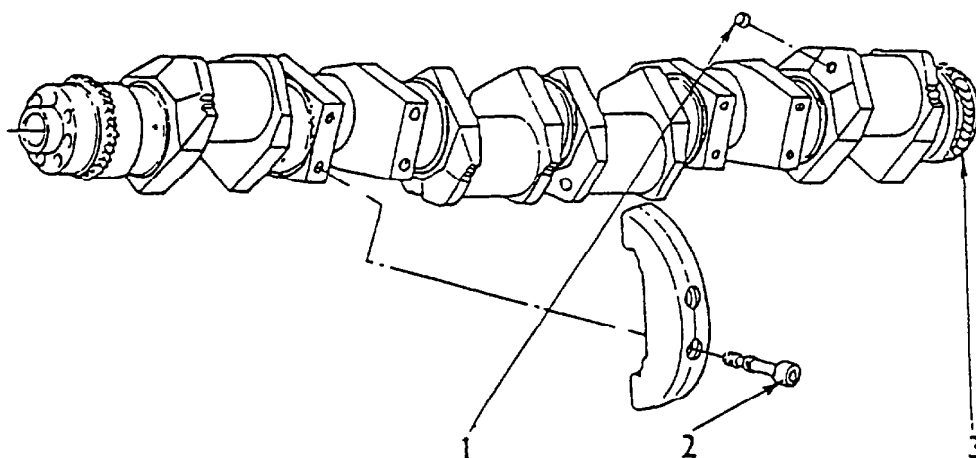
Main journal fillets front-intermediate-rear



Crankpin fillets

8298

When grinding crankshaft journals, machine them as indicated in the picture.

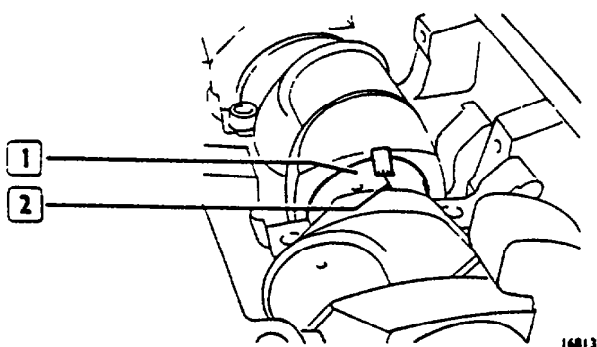


After grinding crankshaft journals, remove oil lines caps (1), dress seats using cutter and spindle wash oil ducts thoroughly, insert new caps (1) using remover/installer 99386012 and caulk them on their seats. Check for cap leaks to a 15 bar pressure (15 kg/cm<sup>2</sup>).

Counterweight installations (2) must be carried out with crankshaft fitted in engine block; the numbers marked in the counterweights should be correspondent to those on crankshaft cranks.

Crankshaft counterweight capscrews should be lubricated with UDM oil and tightened to the prescribed torque, when the counterweights are parallel to main journals.

Check conditions of valve system gear teeth (3); in case of breakages or excessive wear, remove gear from shaft with a cut in key slot and avoiding damage the shaft. Gear (3) installation on crankshaft must be carried out when a difference of 230°C is observed between the two parts.

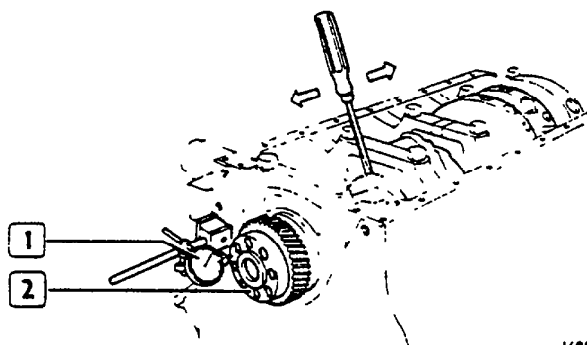


16813

Check journal running clearance as follows.

- Thoroughly clean bearings and journals.
- Position bearings in their housings.
- Insert crankshaft.
- Place a calibrated wire (2) on journals (1); insert main bearing caps with attached bearings.
- Tighten cap capscrews, previously lubricated.
- Remove main bearing caps.

Clearance between bearings and main journals is defined by comparing the width of the calibrated wire at the point of maximum deformation to the scale printed on wire container. The figures given on the container indicate clearance in mm. This should be 0.067 to 0.0127 mm.

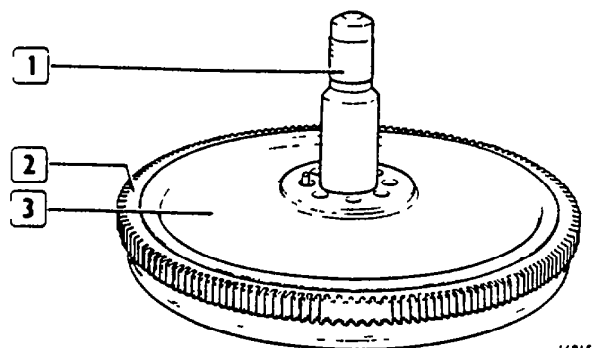


16814

Check of crankshaft (2) thrust clearance (1) is carried out using a magnetic base gauge and operating as indicated in the figure. Standard clearance should be 0.070 to 0.270 mm.

In case of wider clearance, replace thrust washers with new ones of standard width or, if necessary, undersized. Housing thrust washers are not interchangeable with cap washers.

Thrust washers must be inserted with the slots machined on the antifriction surface positioned towards crankshaft.

**ENGINE FLYWHEEL**

16815

Check clutch plate face; if scores are observed, machine it off.

Removal/insertion of spigot shaft bearing is carried out using standard tool (1).

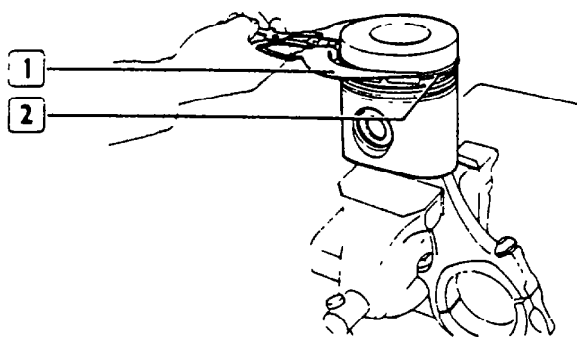
Check flywheel ring gear teeth (2); if breakages or excessive wear is noticed on teeth, remove ring gear from engine flywheel (3) using a standard removal/insertion tool, and insert a new ring gear previously heated to 150°C by 15 to 20 minutes. Keep the bevel of ring gear slot positioned towards engine flywheel.

**PISTON - CONNECTING ROD ASSEMBLY**

Check pistons for pick-up, score marks and cracks or excessive wear; in necessary, replace them.

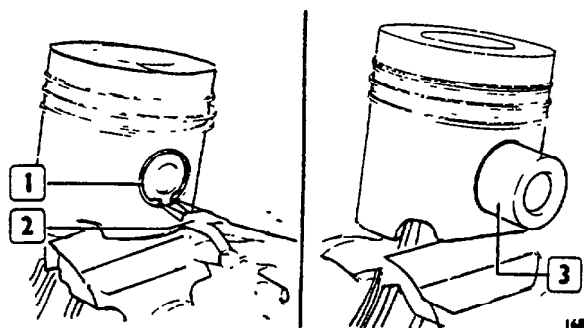
Check that gudgeon pin and its seat on piston are not worn out, clearance should be 0.012 to 0.026 mm.

Piston rings should not be damaged or loose.



16817

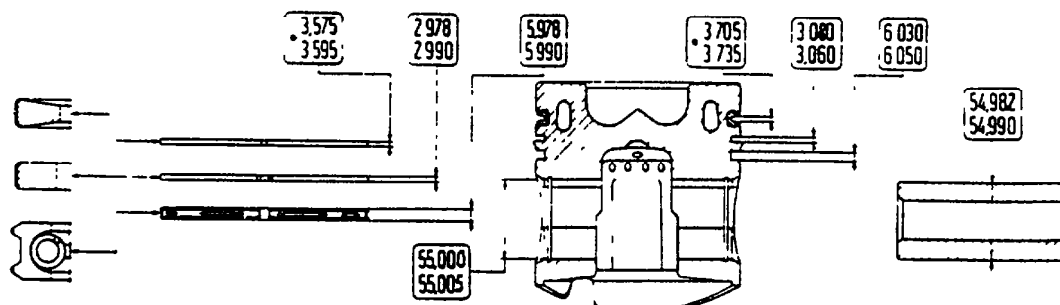
Piston ring (2) removal/insertion by means of pliers 99360184 (1).



16818

Removal/insertion: gudgeon pin circlip (1) through round nose pliers (2) and gudgeon pin (3).

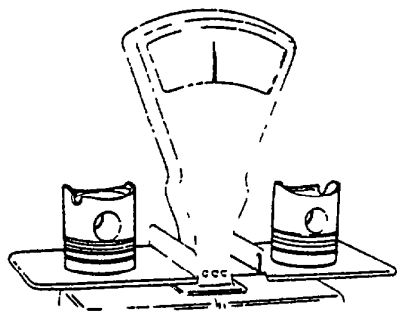
**NOTE** - Piston - connecting rod fit must be carried out considering that, when the assembly is inserted in engine block, words "LATO POSTERIORE" on piston crown must be positioned towards the rear side of engine, and connecting rod figures must be opposite the figures on engine block.



8653

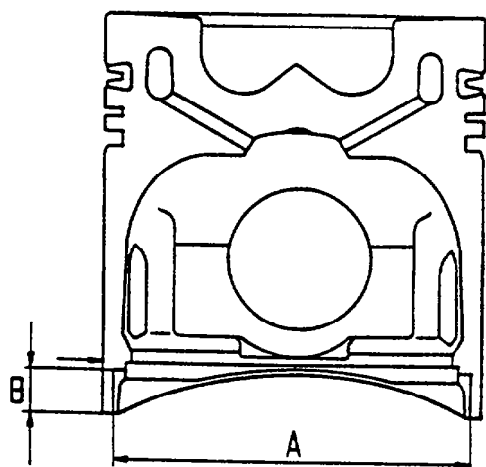
PISTON, PIN, RING DETAILS

\* Dimension detected on 142 mm dia.



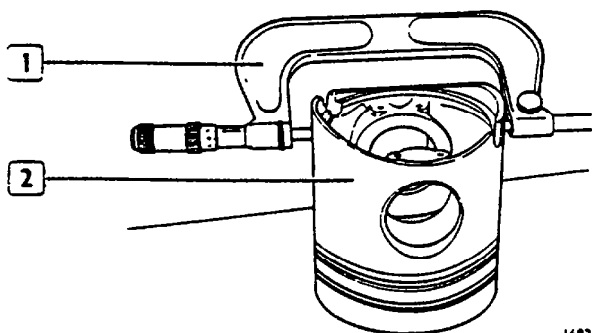
16547

Check for piston weight equalities. Allowance is  $\pm 15$  gr



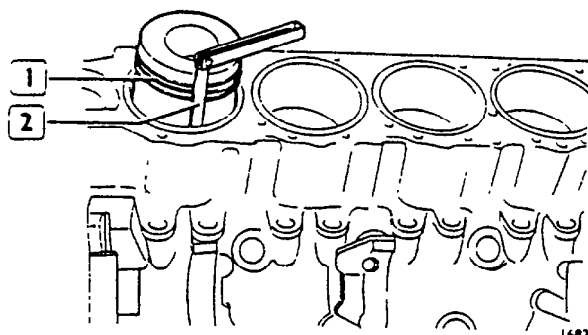
16283

In case of over weight, remove material on diameter A (without exceeding 137 mm) and on depth B (without exceeding 17 mm).



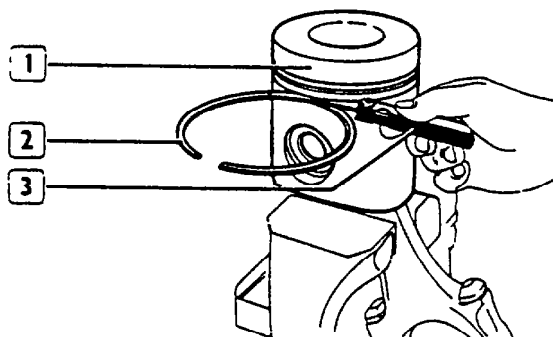
16821

With micrometer (1) define clearance of piston diameter. Diameter must be read 21 mm from piston skirt.



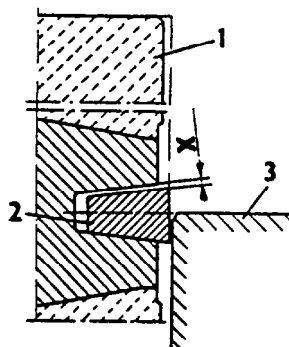
16822

With feeler (2) check clearance between piston (1) and cylinder sleeve. Clearance must be read 21 mm from piston skirt.



16823

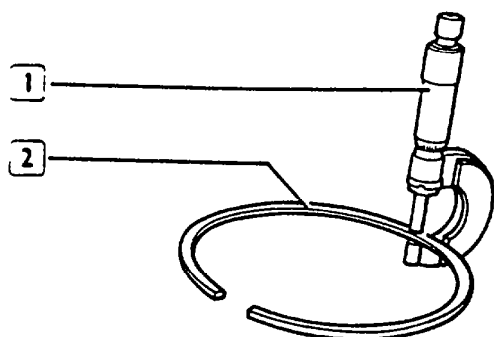
Check clearance between piston rings (2) and relevant seats on piston (1), using feeler (3).



3513

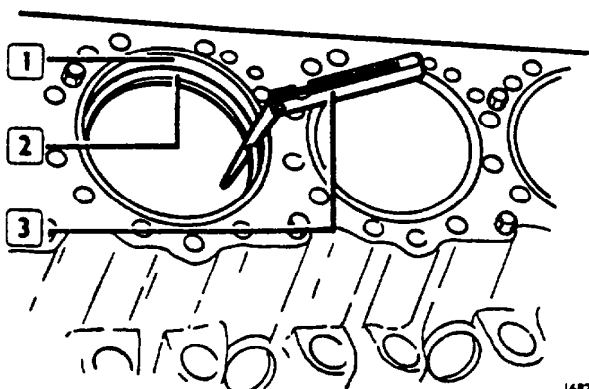
Top compression ring (2) is of double taper type: clearance is measured positioning piston (1) with relevant ring into cylinder sleeve (3) so that the compression ring protrudes half its length from cylinder sleeve.





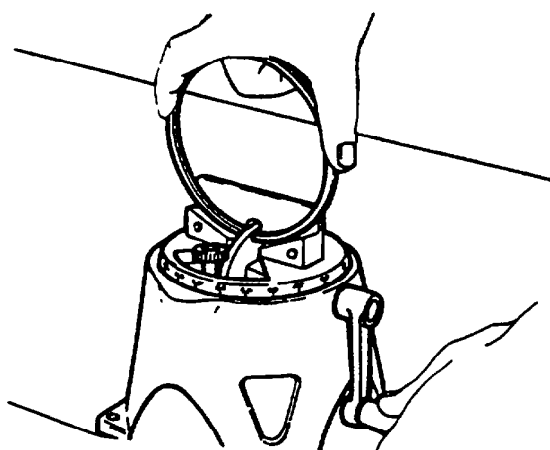
16552

Check ring (2) thickness using micrometer (1)



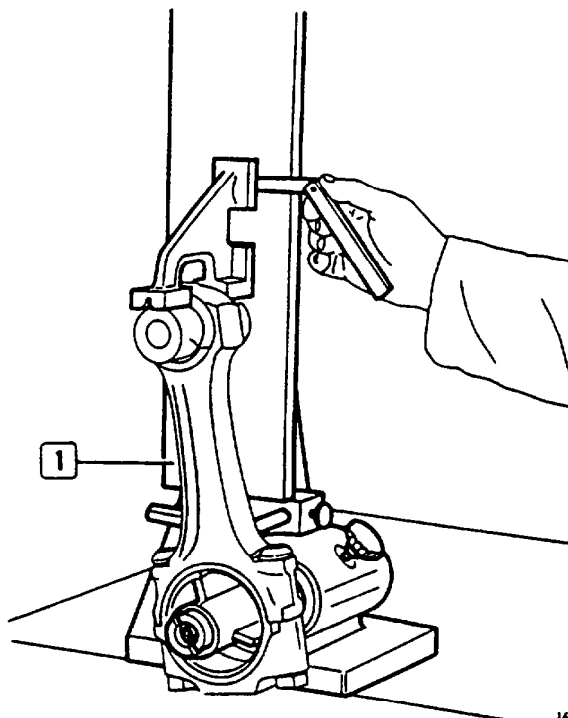
16826

With feeler gauge (3) check the gap at the end of sealing rings (2) inserted in cylinder sleeve (1)



16554

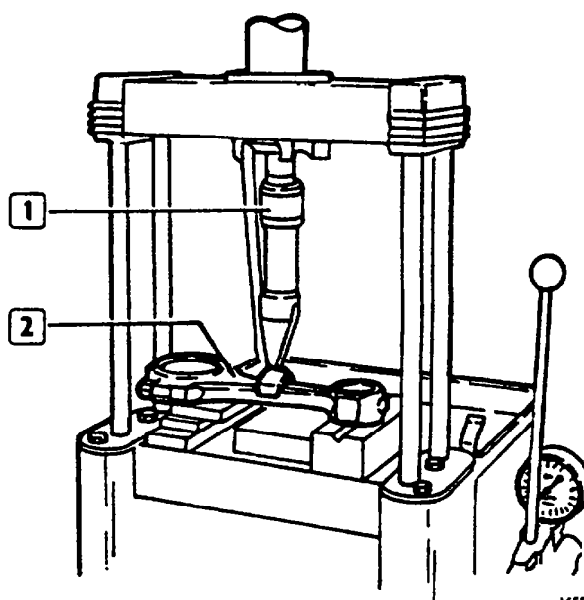
If a distance shorter than the prescribed value is detected, remove the excess material by means of tool 99360188, operating as indicated in the figure.



16557

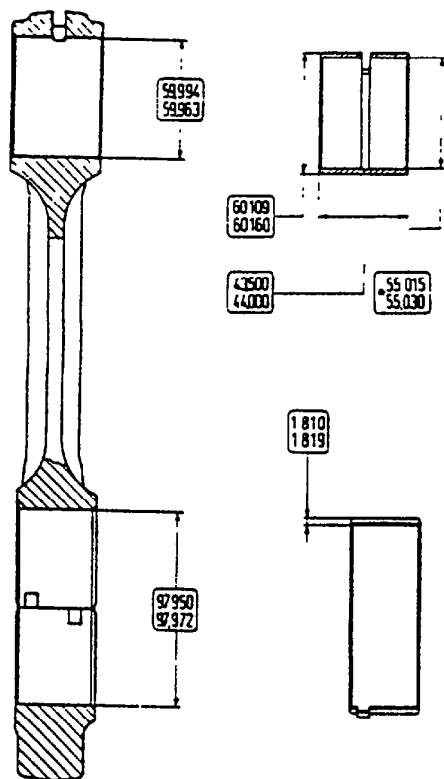
Check parallelism of connecting rod axes using tool 99395363 (1).

Maximum allowed tolerance is  $\pm 0.025$  mm at 125 mm from the longitudinal connecting rod axis.



16558

If a parallelism error greater than the allowed value is detected, straighten the connecting rod (2) by means of a hydraulic press, (1) as indicated in the diagram.

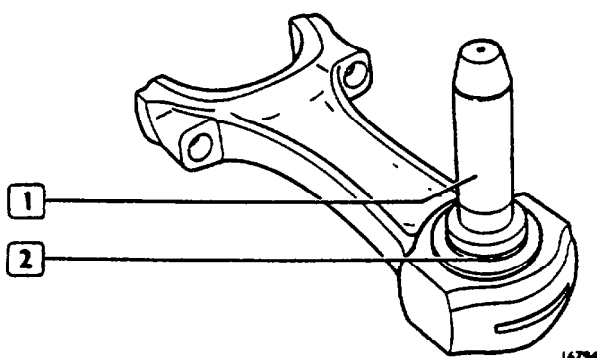


CONNECTING ROD BIG END BEARING AND BUSHING DETAILS

\* Fitted ID

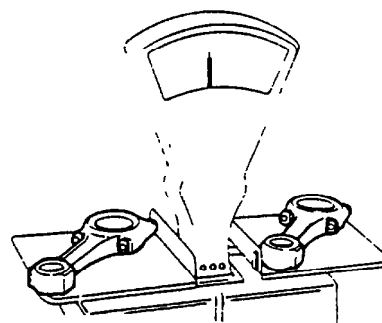
Check inner bushing surface for marks of seizure or scoring.

Check clearance between bushing and gudgeon pin: which should be 0.025 to 0.048 mm.



Bushing (2) removal/insertion is carried out using suitable tool (1).

After insertion, ream bushing until normal diameter is obtained.



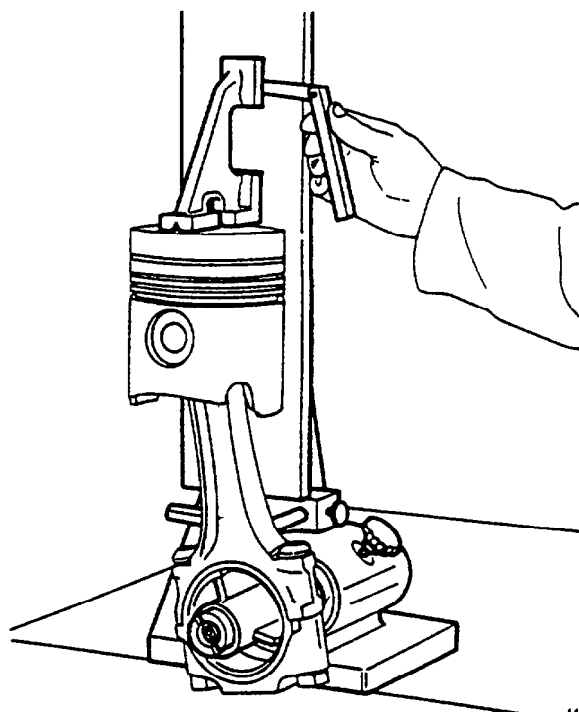
16541

Check connecting rod weight equality Allowance is  $\pm 20$  gr

This check must be carried out with connecting rod with attached caps, bushing, bolts and nuts.

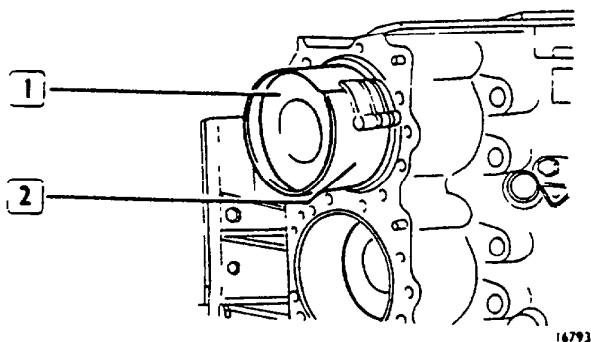
NOTE - Each connecting rod body and cap carry a reference number identical with that of the cylinder to which it belongs.

In case of replacement, apply the same reference number to the new connecting rod.



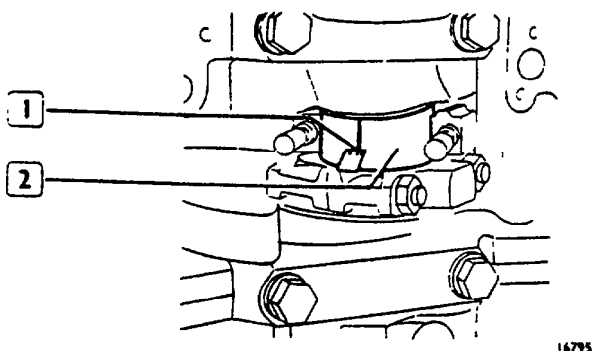
16562

Check alignment in connecting rod - piston assembly, using tool 99395363 and a feeler. Piston crown should be perfectly orthogonal to the face of tool 99395363.



When fitting connecting rod-piston assemblies (1) in cylinder sleeve using clamp 99360603 (2), proceed to

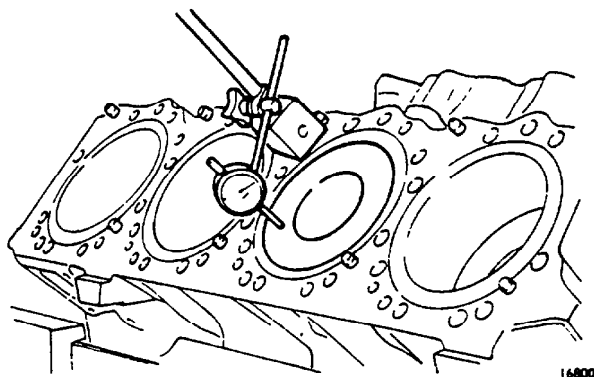
- Lubricate (with engine oil) pistons, compression rings, cylinder sleeves.
- Move to T.D.C. the piston crankpin concerned to fitting
- Remember that the connecting rod number should correspond with that on cylinder sleeve to which it pertains and must be opposite to that on cylinder block; also, words "LATO POSTERIORE" on piston crown should be positioned towards the rear side of engine.
- Remember that ring gaps must be offset 120° from one another



Check clearance between crankshaft crankpins and relevant bearings operating as follows:

- Thoroughly clean crankpins and bearings.
- Insert bearings in their seats.
- Position a calibrated wire (1) on crankshafts (2).
- Tighten capscrew nuts (previously lubricated) of connecting rod caps to the prescribed torque, and again remove caps.

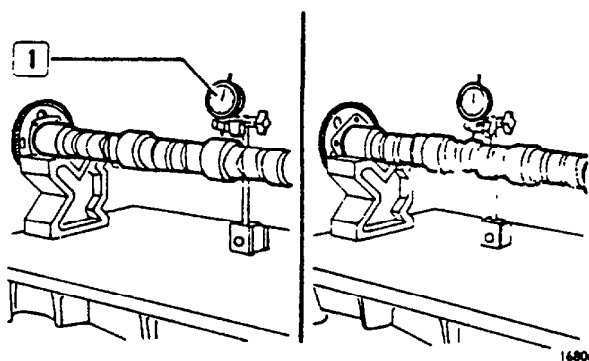
Define clearance between crankpins and relevant bearings, comparing the width of the calibrated wire at the point of max. deformation to the scale printed on wire container. The figures given on the container indicates the amount of clearance in mm (0.060 to 0.120 mm). On final fitting of connecting rods replace capbolts and torque nuts of caps.



Check piston positions at T.D.C. vs. cylinder sleeve faces using magnetic base gauge, as indicated in the figure. The required position is between -0.25 to 0.15 mm.

### CAMSHAFT

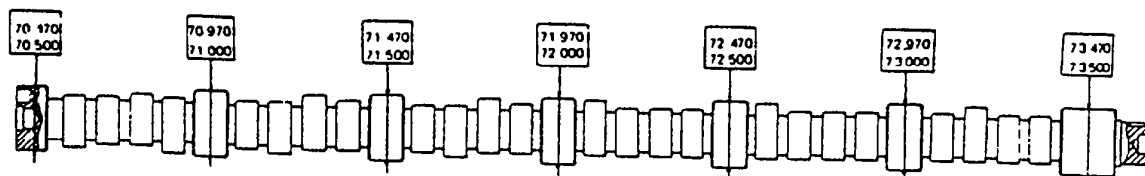
Check camshaft lobe and support pins. In case marks of seizing, scoring or excessive wear are detected, replace camshaft and relevant bushings fitted in engine block.



Check for journal alignments positioning camshaft as indicated in the figure. Using magnetic base gauge (1) detect misalignment which should never exceed 0.10 mm. In the negative, straighten camshaft using a press

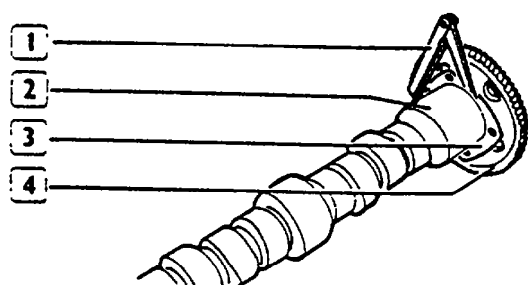
Check cam lobe lift, which should be 8.21<sup>\*</sup> for both intake and exhaust. In case of different values, replace camshaft.

<sup>\*</sup> In the previous engines it was 7.55 mm for cam lobe lift, intake.



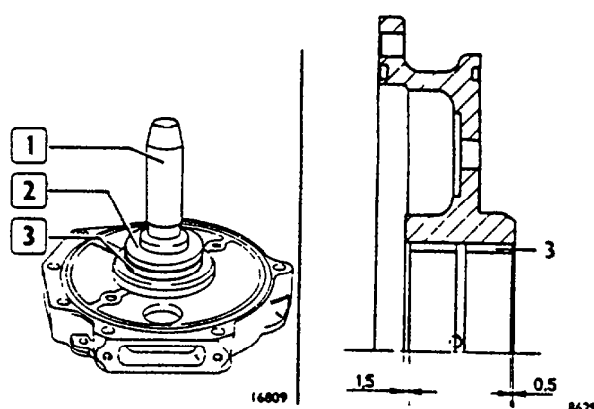
CAMSHAFT DETAILS

Check camshaft journal diameters using a micrometer; they must be within the values indicated on figure.



16408

With feeler (1) check clearance between plate (3) retaining camshaft (2) to engine block and drive gear (4), which should be 0.070 to 0.175 mm. Check that drive gear (4) teeth are not broken or worn-out. Removal of drive gear (4) from camshaft is carried out using a puller. Insertion must be carried out with a temperature difference of 155°C between drive gear and camshaft.

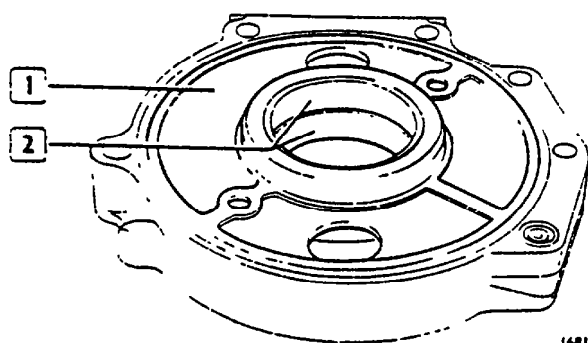


16809

8629

Remove or insert injection pump shaft bushing (3) with tool (2) and handgrip (1). After fitting, the bushing depth should result (as to housing face) by the values indicated in figure. Ream bushings to 65,025 to 65,050 mm dia.

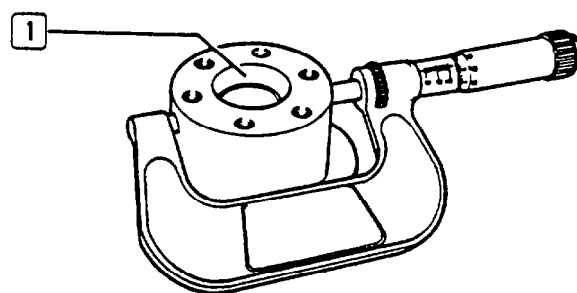
## INJECTION PUMP CONTROL



16810

Check that connection surfaces of injection pump shaft housing (1) are not damaged.

Bushings (2) should be press fitted in their seat and the inner surface should not show marks of seizure, scoring or wear.

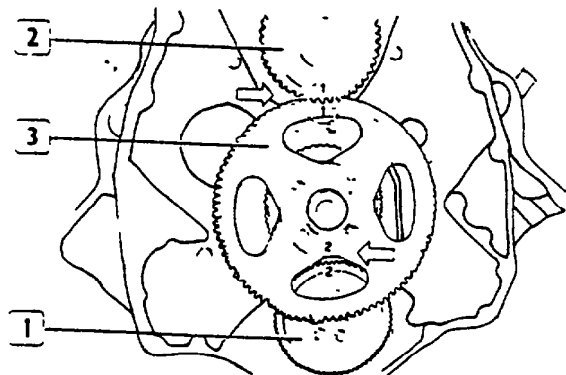


16811

Check that injection pump drive shaft (1) diameter is 64.970 to 65.000 mm. If different values, or wear, or score marks are observed, replace shaft. Shaft clearance vs. bushings should be 0,025 to 0,080 mm.

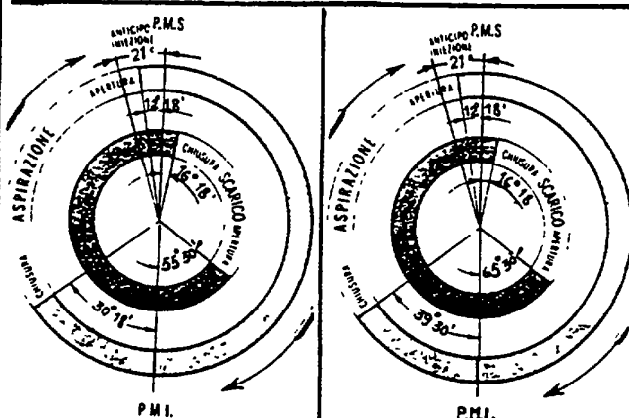
Check that the teeth of shaft gear (1) controlling the injection pump are not broken or worn-out.

## VALVE SYSTEM CONTROL



The valve timing is performed as follows:

- turning the camshaft, balance the valve-tappets of the piston n°7 (the piston n°12 is in the combustion phase, at T.D.C.). Then install the injection pump drive gear(1) and align the marks 2-2.
- turning the crankshaft, balance the piston n° 7 (the piston n°12 is in the combustion phase, at T.B.C.).
- Then install the valve timing gear (2) with relevant dowel pin on the crankshaft. install the valve timing gear(3) and align the marks. 1-1



(8291SM49.11)  
(8291SRM75.11)  
(8291SRM75.31)

(8291SRM11.10)  
(8291SRM12.11)  
(8291SRM75.10)

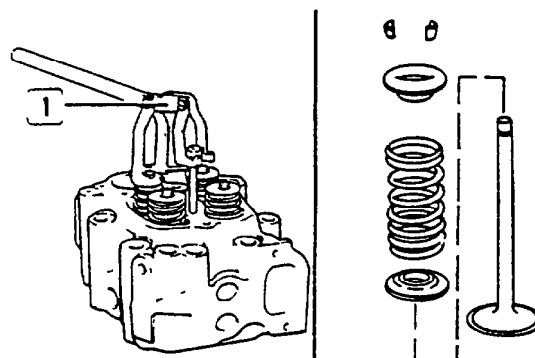
P.M.S. = T.D.C.  
P.M.I. = B.D.C.  
ANTICIPO INIEZIONE = INJECTION ADVANCE  
APERTURA = OPENING

CHIUSURA = CLOSING  
ASPIRAZIONE = INTAKE  
SCARICO = EXHAUST  
ORDINE DI SCOPPIO = FIRING ORDER

Check of valve system diagram is carried out as follows

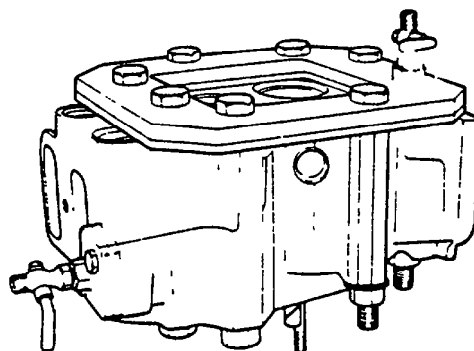
- Adjust clearance between rockers and bridges to 0.25 mm. (8291SM49.11-8291SRM75.11-8291SRM75.11)
- Adjust clearance between rockers and bridges to 0.25 mm. (8291SRM11.10-8291SRM12.11-8291SRM75.10)
- Rotate crankshaft and, with a notched quadrant, check that valves open and close according to the diagram angles indicated in the figure.

## CYLINDER HEADS



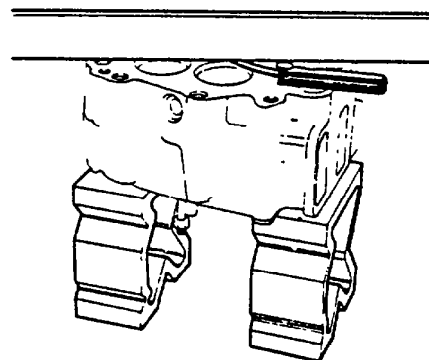
16819

Remove/install valves using tool 99360274 (1). On installation, lubricate valve stems with engine oil.



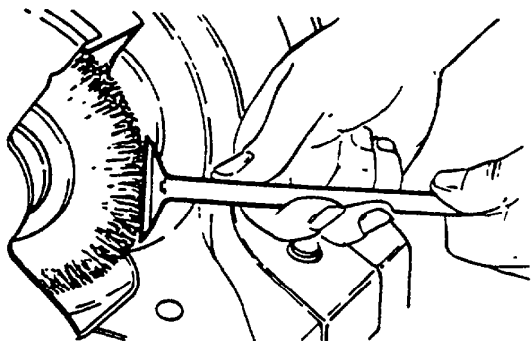
16820

Using suitable tool check cylinder head seal. Through pump inlet water heated to ~ 90°C at a pres. ure of 4 to 5 kg/cm<sup>2</sup>. No leakage should be observed; in the negative, replace cylinder head.



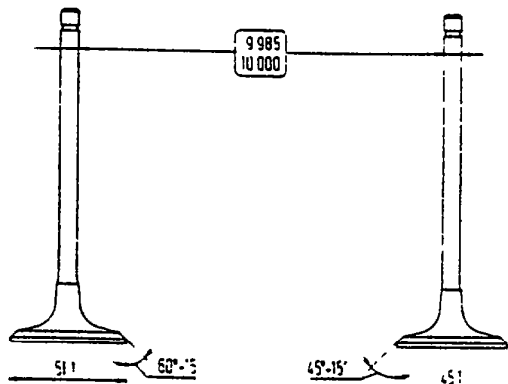
16824

Check flatness of cylinder head face using a straightedge and a feeler, as indicated in the figure. If flatness errors exceeding 0.05 mm are detected, proceed to skim head.



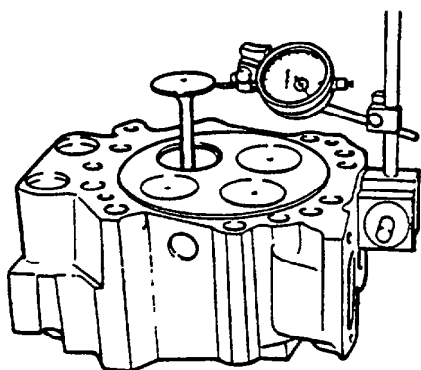
16825

Using a wire brush clean valves and check for possible marks of seizure, cracks or wear.



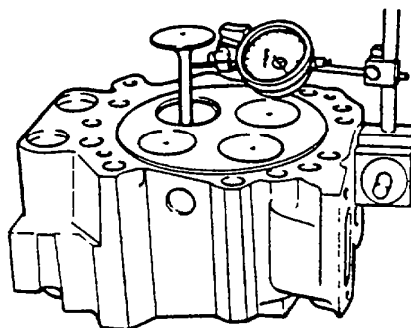
16827

With a micrometer check that stem diameters are those indicated in the figure. Using grinder 99301014, dress valve seats removing as little material as possible.



16828

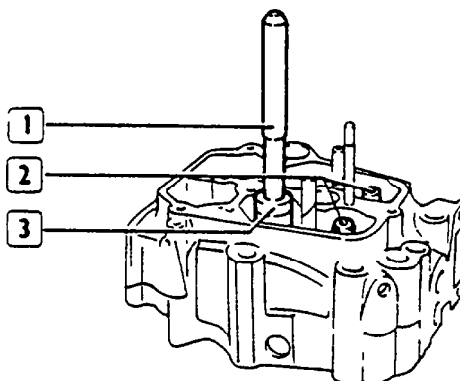
Check valve eccentricity using a magnetic base dial gauge, as indicated in the figure. If eccentricity exceeds 0.03 mm replace valve



16829

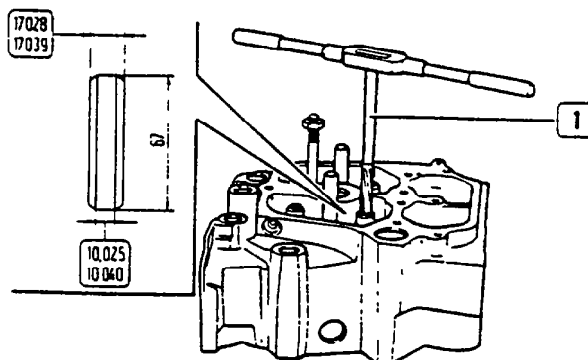
Check clearance between valve stem and valve guide using a magnetic base dial gauge as indicated in the figure. If clearance exceeds 0.025 to 0.055, replace valve and valve guide.

### VALVE GUIDE



16830

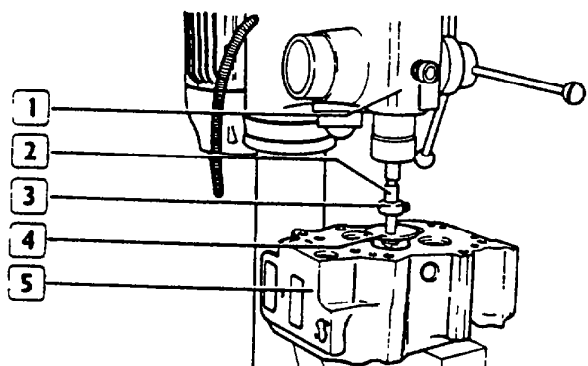
Remove valve guide (2) using tool 99360143 (1). For valve guide insertion, use remover/installer 99360143 together with component 99360280 (3)



16831

With reamer (1) dress valve guide until the value indicated in the figure is obtained.

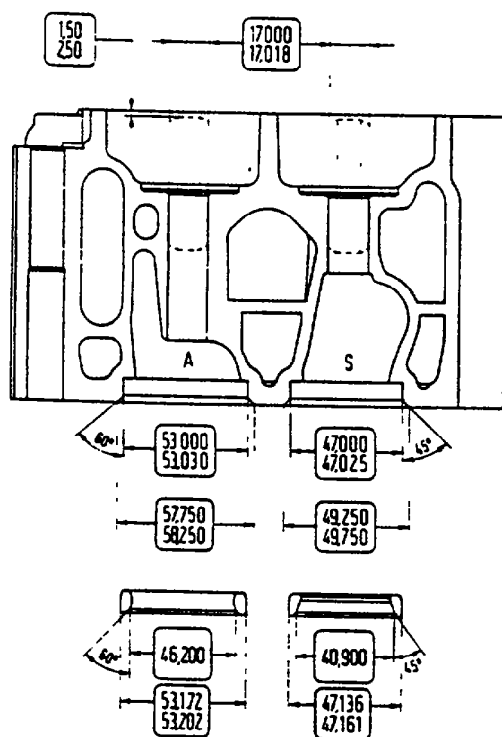
## VALVE SEAT



16832

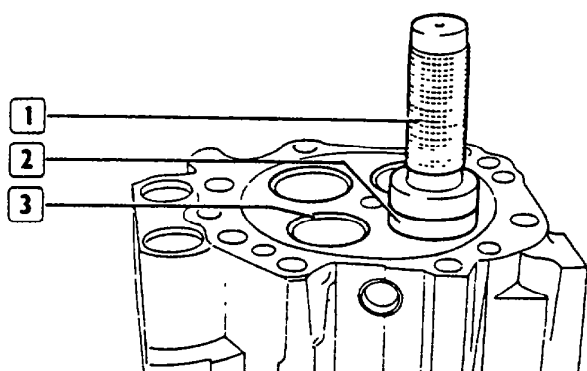
Renew valve seats operating as follows:

- Position cylinder head (5) on pillar drill (1)
- Insert tool 99360376 (4) on pillar drill and adjust stop device (3) on cutter 99390358 (2).
- Operate cutter and remove valve seat.
- Thoroughly clean cylinder head.
- Cool the new valve seat to  $-180^{\circ}\text{C}$  (for instance, in a tank containing liquid nitrogen)



2291

VALVE SEAT AND VALVE GUIDE SEAT IN CYLINDER HEAD - DETAILS

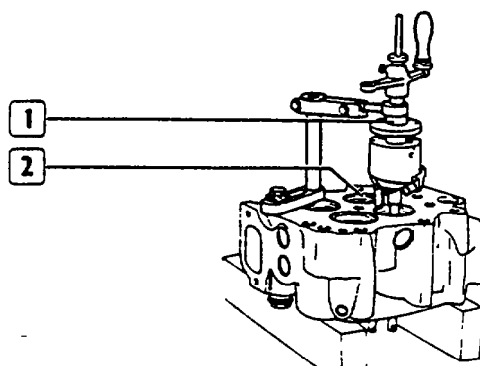


16833

- Fit valve seats (3) in cylinder head using tool (1) together with component (2).

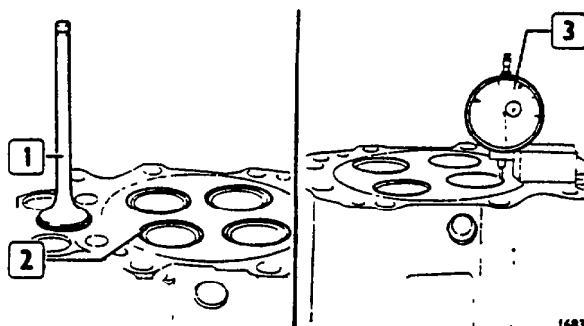
Clearance:

- Intake: 0.142 to 0.202 mm.
- Exhaust: 0.111 to 0.161 mm.



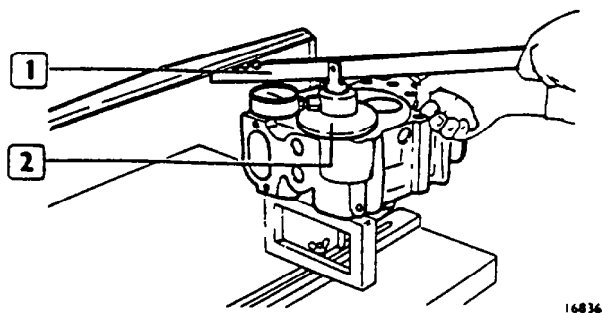
16834

Dress valve seats (2) using HUNGER tool 99360319 (1).



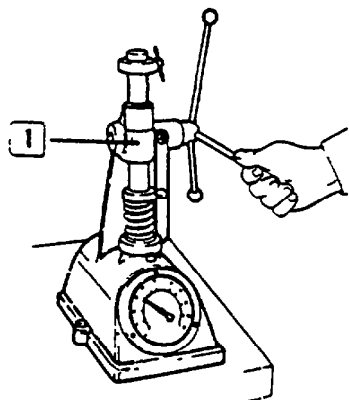
16835

Observe valve (1) seal line on its seat (2) and valve stand-in as to cylinder head face, using dial gauge (3). If seat valve eccentricity is observed, or valve stand-in is less than 0.3 to 0.75 mm for exhaust valves and 0.1 to 0.45 mm for intake valves, dress seats again.

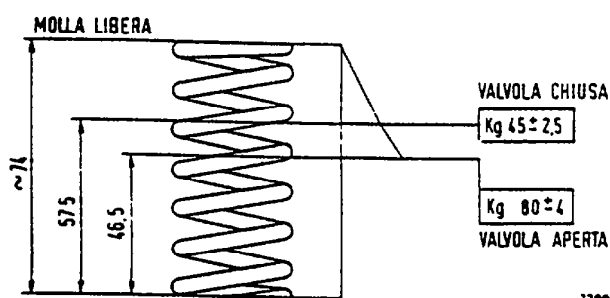


Close injector seat and check valve seat seals using device (2) and lever (1) positioned as shown in the figure. With a dial gauge check that pressure drop takes place slowly.

### VALVE SPRING



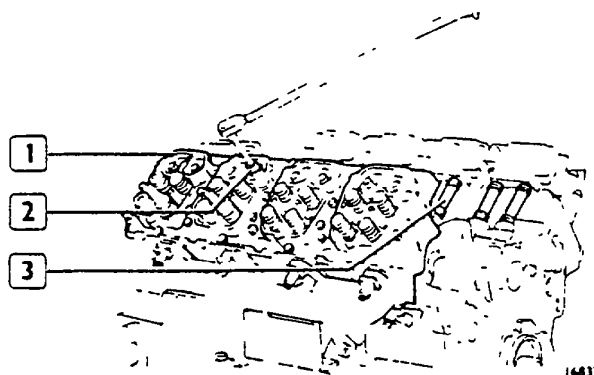
Using fixture 305049 (1) check that spring load is within the values indicated in figure 109



INTAKE AND EXHAUST VALVE SPRING DETAILS

MOLLA LIBERA = SPRING FREE  
VALVOLA CHIUSA = VALVE CLOSED  
VALVOLA APERTA = VALVE OPEN

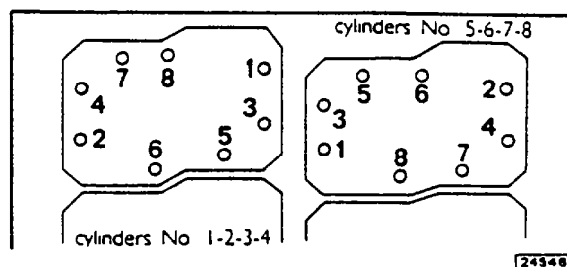
### CYLINDER HEAD ASSEMBLY



Insert cylinder heads on engine block as follows:

- On engine block position pushrod tubes (3) with attached the new retainer rings
  - Insert new cylinder head gaskets.
  - Insert cylinder heads (1).
  - Lubricate fastening screws with UTM oil.
  - Align cylinder heads with a suitable tool applied to exhaust manifold bores.
  - Tighten cylinder head screws following the order indicated in figure
- 1st phase-pre-torque 30 Nm  
2nd phase-pre-torque: 160 Nm  
3rd phase-angle torque: 120°

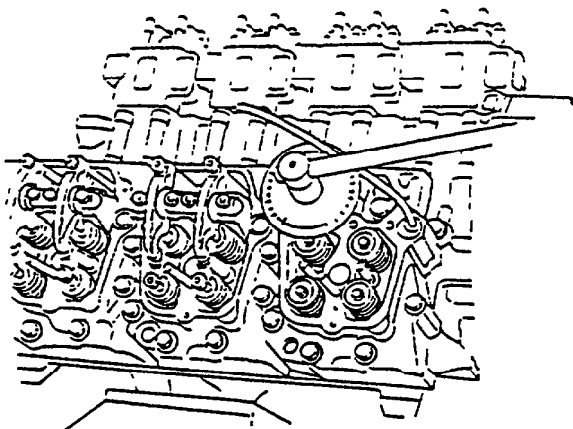
FIGURE 109



TIGHTENING SEQUENCE OF CYLINDER HEAD CAPSCREWS TO ENGINE BLOCK

CILINDRI = CYLINDERS



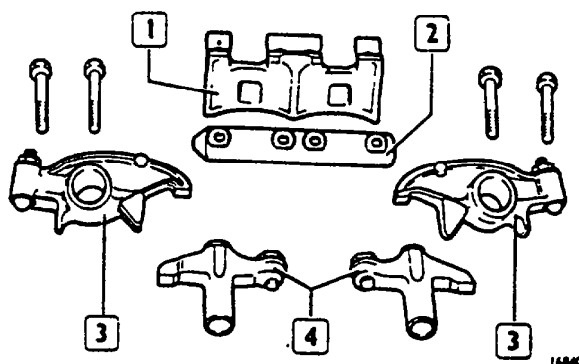


NOTE - The screw may be reused until thread outer dia. is not less than 155 mm measured at any point.

### ROCKER PUSHRODS - ROCKERS - ROCKER SHAFTS - BRIDGES

Pushrods should be free from distortion and the spherical seats in contact with the rocker adjusting screw and with the tappet should not show signs of pick-up or wear: in the negative, replace them.

Check rockers (3), bridges (4), rocker shafts (3) and bracket (1) for signs of wear, score marks and pick-up. In case, replace damaged components. Check for the perfect seal of the cap at the end of each rocker shaft.



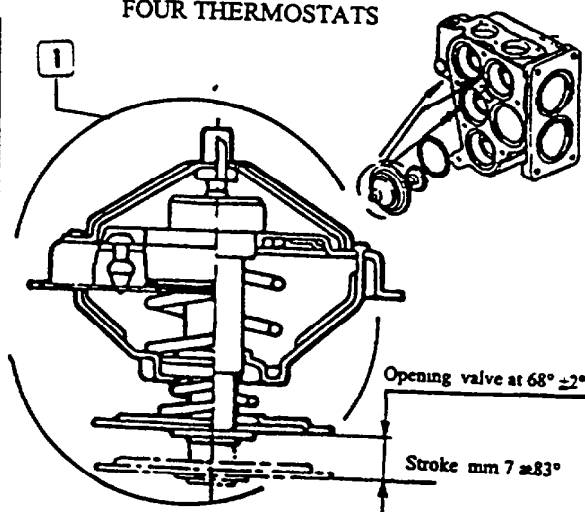
### COOLING SYSTEM

It has a double water circuit.

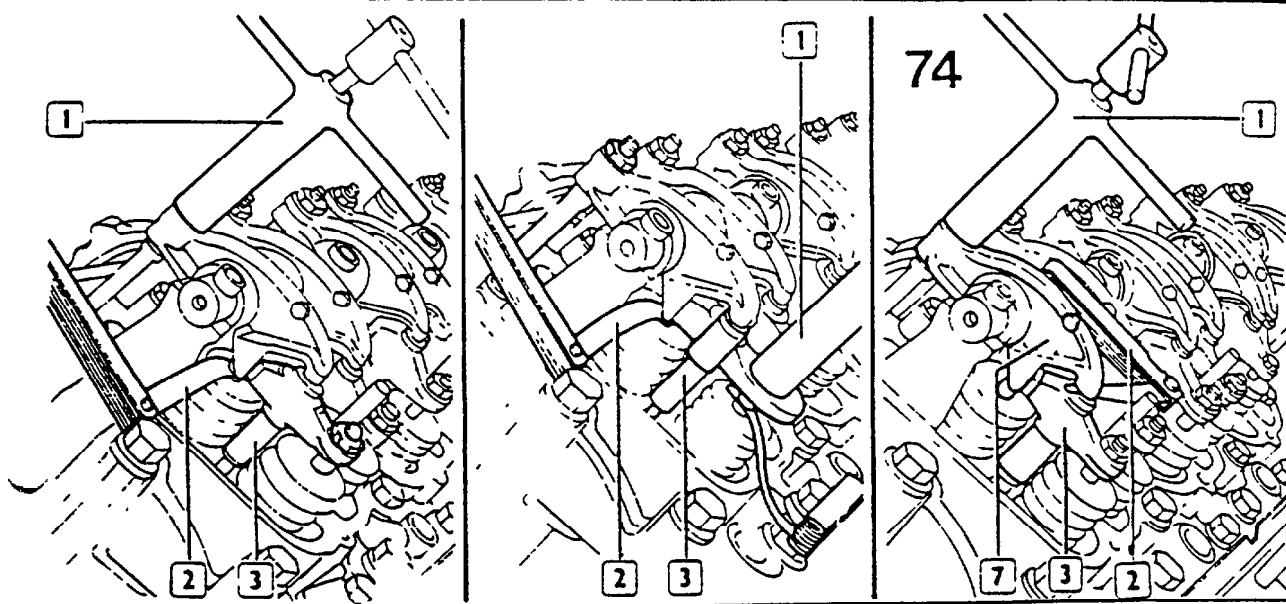
- the fresh water of the primary circuit (closed)
- the sea water of the secondary circuit (open)
- the engine cooling circuit is composed by: a centrifugal pump driven by a gear from the crankshaft.
- Four thermostats (1) with opening valve at 68°C which Control the temperature of the engine flow

Check thermostat operation and replace if in doubt as to efficiency.

### FOUR THERMOSTATS



## - Valve Clearance Adjustment



Valve clearance adjustment should be carried out with the utmost care to prevent adversely affecting the valve timing. In this connection it should be noted that excessive valve clearance results in noisy operation, delays opening and anticipates closing of the valves, whereas insufficient clearance has a reverse effect. If there is no clearance at all, the valves are kept constantly slightly open, the consequence of this being a much reduced valve and seat life.

To adjust the valve clearance proceed as follows:

- Slowly rotate the crankshaft until the cylinder of the valves to be adjusted is on firing stroke. The valves of this cylinder are closed when those of the symmetrical cylinder are in a condition of balance i.e. start of intake stroke, symmetrical cylinders are 1-6, 12-7, 5-2, 8-11, 3-4 and 10-9

E.g. when cylinder 5 is in firing stroke cylinder 2 is in a condition of balance and vice versa.

- Back off the bridge adjusting screw until the bottom face is higher than the fixed surface (Fig. 73).
- Screw in the rocker adjusting screw until contact between rocker toe and bridge button causes resistance to be felt when rocker-to-pushrod contact is established.
- Bring the bridge adjusting screw in contact with the valve stem and clamp using the nut provided, so as to achieve simultaneous bridge contact with the two valves.

Adjust the rocker to bridge clearance (Fig. 74).

Which must be 0.15 + 0.20 mm for the intake valve and 0.35 + 0.40 mm for the exhaust valve.

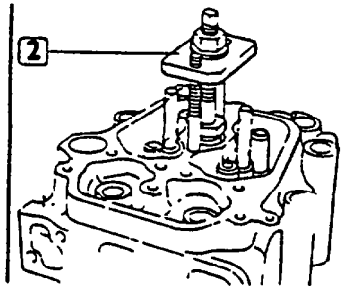
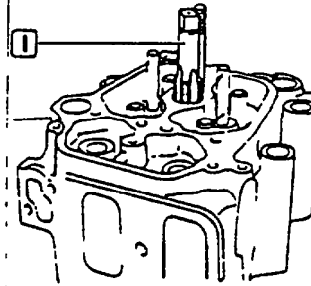
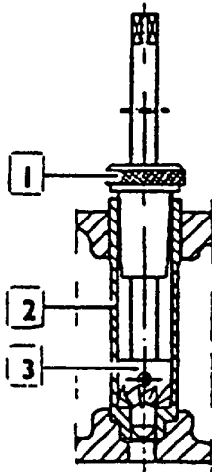
After adjusting the valves of one cylinder, repeat the operation on the remaining cylinders.

Fig. 103. Clearance adjustment between the bridge and valves. Tool 99352137(1). Feeler gauge(2). Bridge(3).

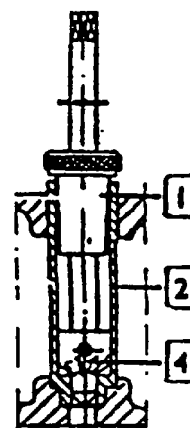
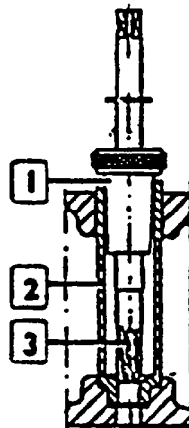
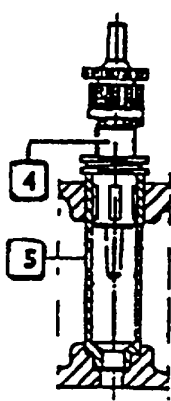
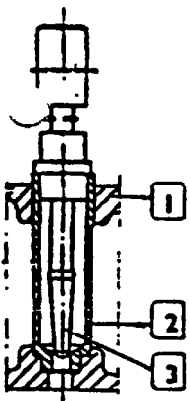
Fig. 103A. Clearance adjustment between the rocker(7) and bridge(3).

## REPLACING INJECTOR SLEEVES

Incorrect mating between injector and sleeve press-fitted into cylinder head or between sleeve and seat on cylinder head may cause a loss of compression or water leakage



To remedy the first of these two defects, dress the sleeve seat (2) using cutter 99394031 (3) and bushing 99394019 (1). In the second case, proceed as follows to replace sleeve (2) using set of taps 99390800(1):  
 Note that the injector must protrude  $2.97 \div 3.74$  mm from the cylinder head. ☐ use extractor 99342145 (2) to remove it from cylinder head.

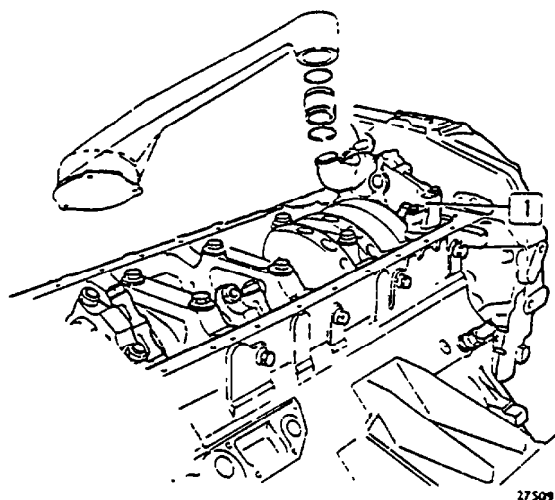


fit new sleeve (2) into seat on cylinder head (1) and spread lower part of sleeve seat in cylinder head using swaging tool 99365063 (3) and an electric drill. Roll upper inside part of sleeve using tool 99365011(4) and an electric drill.

Use reamer 99394017 (3) and bushing 99394019 (1) to restore sleeve bore (2).

Also restore injector protrusion in relation to cylinder head using cutter 99394018 (4) and bushing 99394019 (1). This should be  $3.6 \div 4$  mm.

## LUBRICATION SYSTEM



27509

Engine is lubricated by a gear pump (1) gear driven from crankshaft.

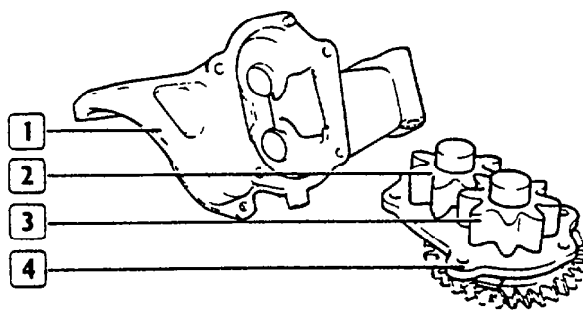
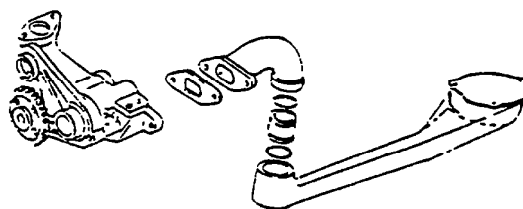
Relief and by-pass valves are fitted on oil filter support.

Lubrication pressure (oil at 110°C):

- Governed speed 5 to 6 kg/cm<sup>2</sup>.
- At idle 1.5 to 2 kg/cm<sup>2</sup>.

Oil vapours which develop inside engine during running, are conveyed to a condenser where part of them is condensed and again recirculated. Through a pipe, the other part is conveyed to air cleaner where the vapours are aspirated by engine and burned. When inside condenser the oil vapour pressure exceeds a given value, these vapours are blown off to atmosphere. The condenser does not require overhaul operation; it is sufficient to thoroughly clean its inside.

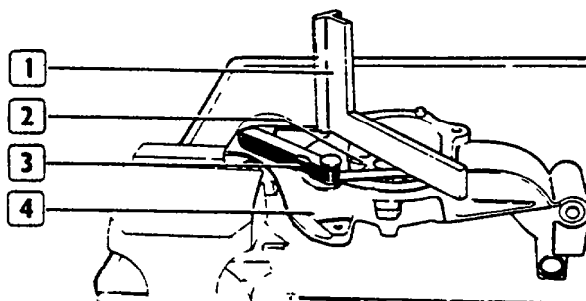
## OIL PUMP



14843

Check that pump casing (1) is not damaged and gear shaft seats are not worn-out.

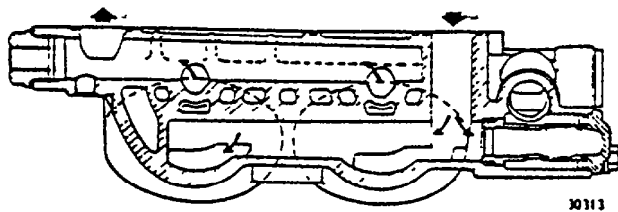
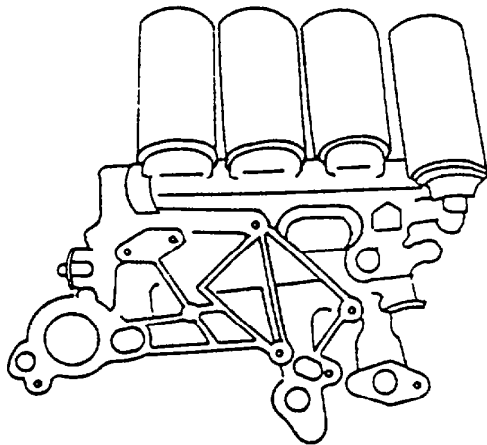
Check that teeth in gears (2 and 3) are not broken or partially worn-out; in the negative replace pump cover (4) with attached gears.



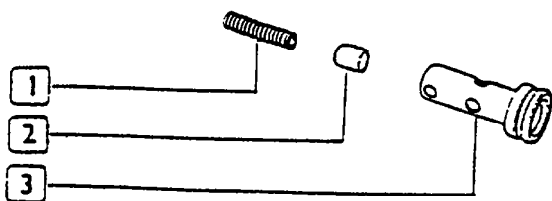
14843

With feeler (3) and tri-square (1) check that the clearance between pump casing (4) cover face and gear (2) is 0.020 to 0.105 mm.

## OIL FILTER SUPPORTS

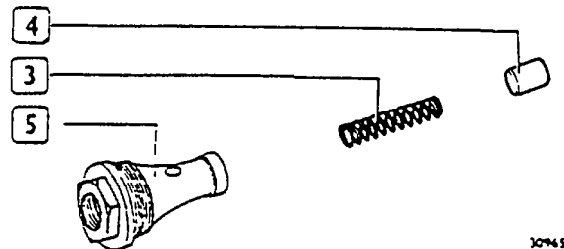


oil filter support



BY-PASS VALVE COMPONENTS

1. Spring - 2. Valve - 3. Valve body.

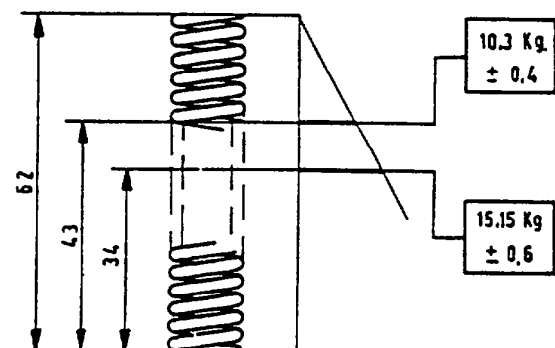


OIL PRESSURE RELIEF VALVE COMPONENTS

- 3 Spring - 4 Valve - 5 Valve body -

Check that oil pressure relief valve and by-pass valve run freely in their seats. Clearance should be 0.016 to 0.061 mm.

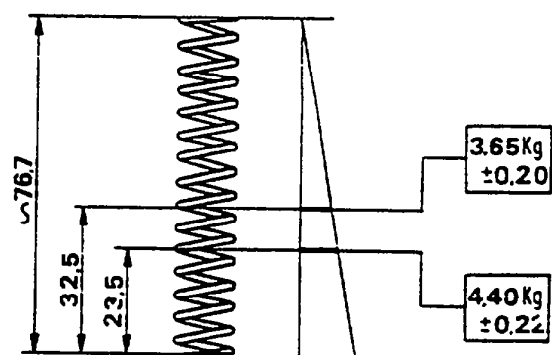
By-pass valve assembly is used to short-circuit oil lines when heat exchanger is clogged.



8294

OIL PRESSURE RELIEF VALVE SPRING-DETAILS

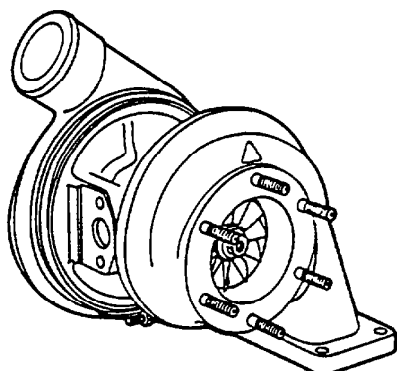
With fixture 99305049 check that valve spring loads are within the indicated values



8295

BY-PASS VALVE SPRING DETAILS

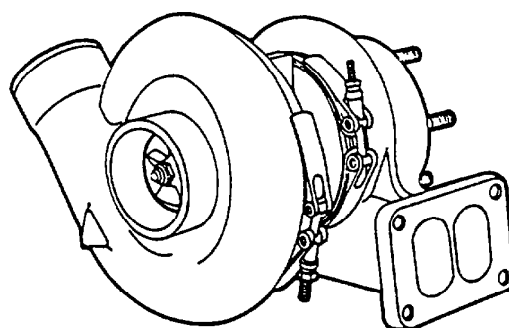
## TURBOCHARGER



16695

## DESCRIPTION

The turbocharger consists of the following main parts: a turbine, a central housing and a compressor. The turbine is located to one side of central housing and the compressor on the other. A bearing mounted shaft connects turbine to compressor which, together, make up the bladed wheel assembly. The turbocharger uses the energy contained in engine exhaust gases. During engine running, exhaust gases are directed through turbine housing, causing the turbine to rotate. Connected to the turbine through the shaft, also compressor wheel is set into motion. The compressor draws atmospheric air and produces compressed air to be supplied to the engine intake manifold. Turbocharger and bearings cooling and lubrication is through engine oil.



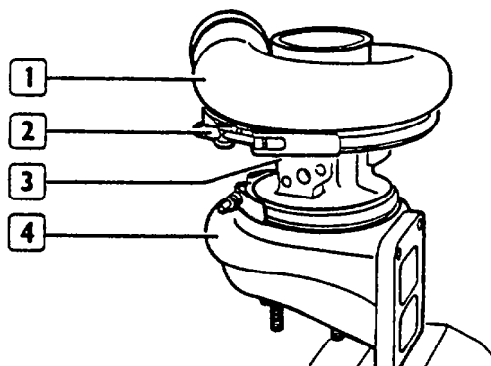
16696

## INSPECTION BEFORE DISASSEMBLY

Before turbocharger disassembly or repair, carry out the following checks.  
Inspect oil drain line: it should never be clogged.  
Check that oil circulation is not restricted.  
Be sure that engine vent on cylinder block is not obstructed.  
Check all seals and connecting hoses for leakage.  
Be sure that air suction line is not obstructed because of air cleaner or pipe clogging

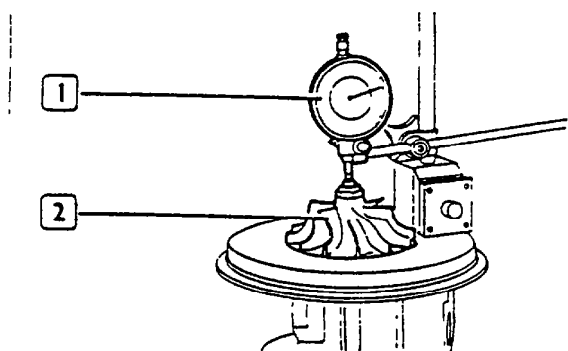
## DISASSEMBLY

Thoroughly clean the outside of turbocharger using non corrosive anti-rust liquids.  
Position turbocharger in a vice.



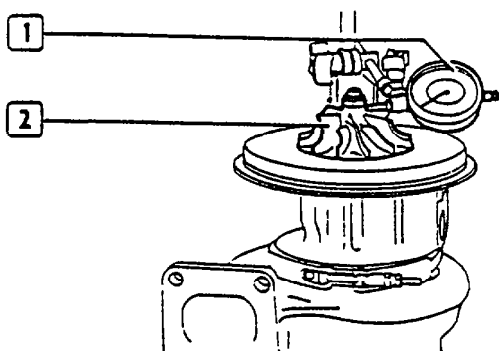
16697

Mark the position of compressor (1) and turbine (4) as to centre housing (3).  
Remove lock plate (2) and remove compressor casing (1).



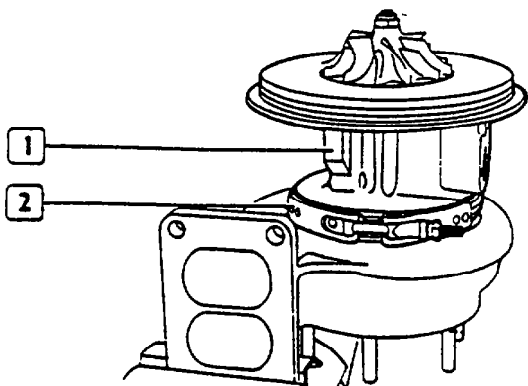
16698

Using magnetic base dial gauge (1) check bladed wheel assembly (2) end float which should be 0.08 to 0.15 mm when the components are new, and 0.20 mm (max.) during use.



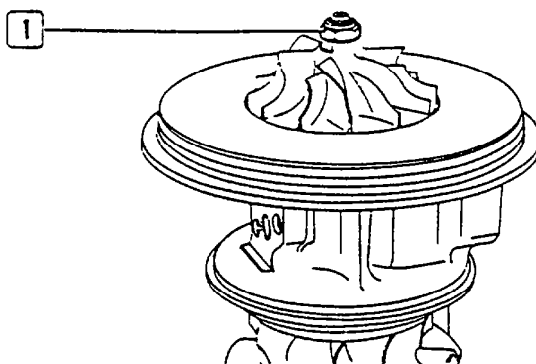
16699

With the dial gauge (1) positioned as illustrated, check bladed wheel assembly (2) clearance, which should be 0.37 to 0.53 mm when the components are new, and 0.61 mm (max.) during use.



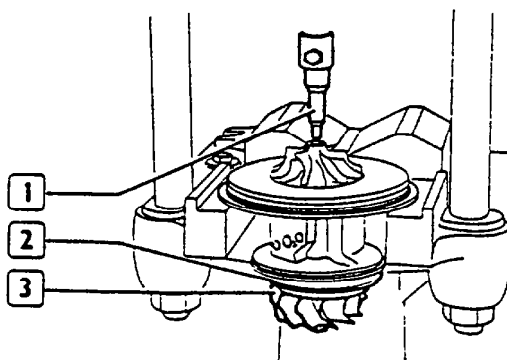
16700

Remove clamp (2).  
Remove the whole centre housing (1).



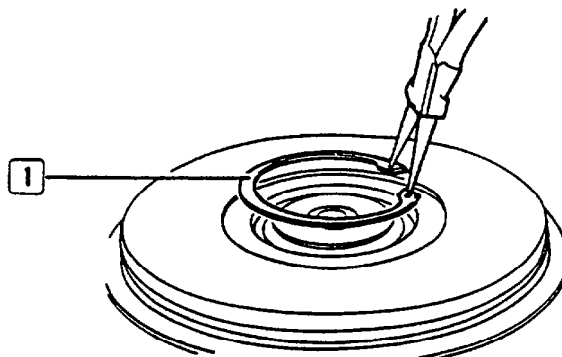
16701

Grip in a vise the centre housing and unscrew self-locking nut (1).



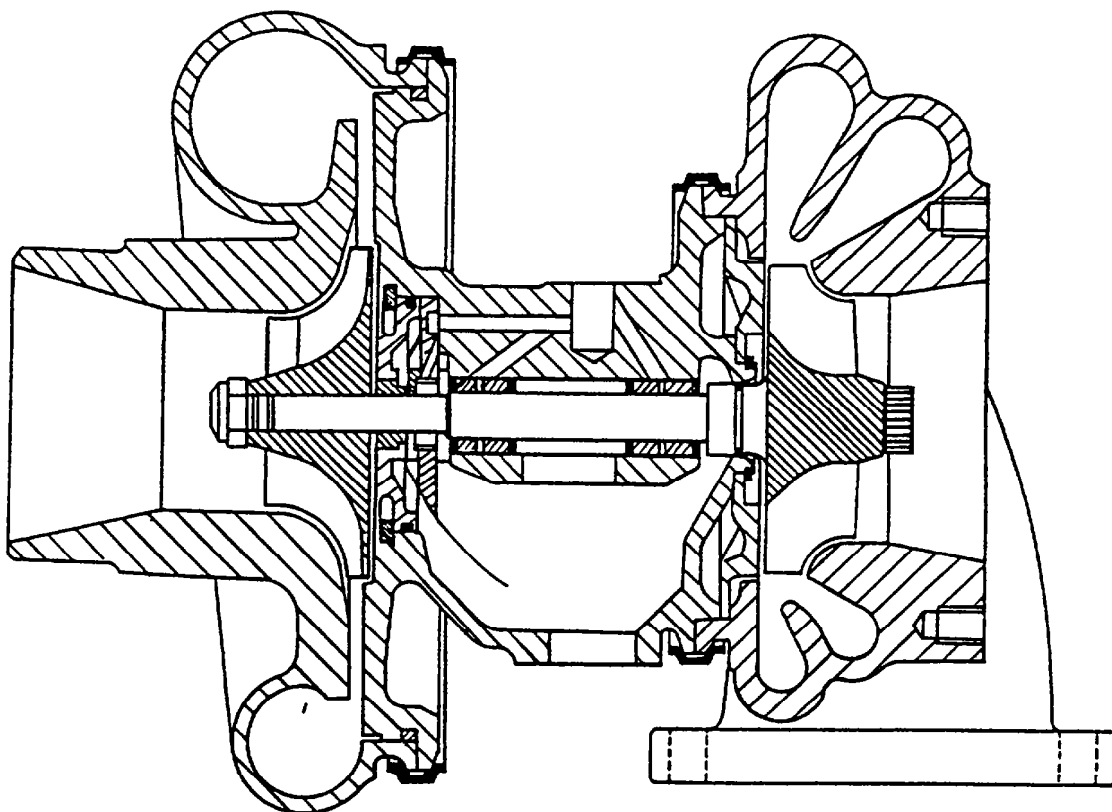
16702

Using press 305074 (1) withdraw turbine shaft assembly (3) together with heat protection disk (2).



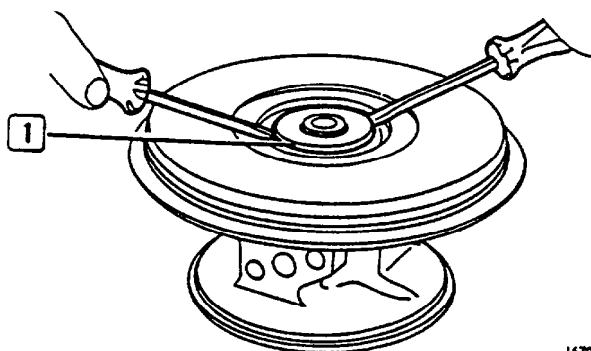
16704

With round nose pliers remove retaining ring (1).



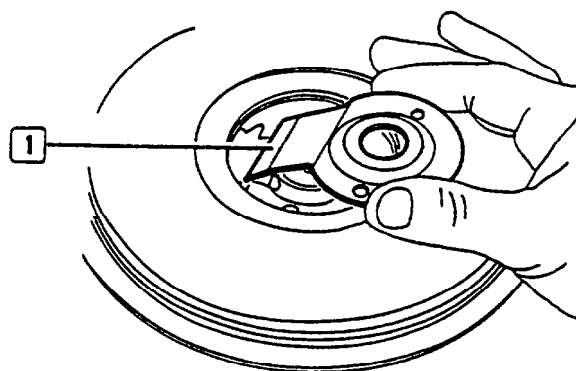
16703

LONGITUDINAL SECTION THROUGH TURBOCHARGER



16705

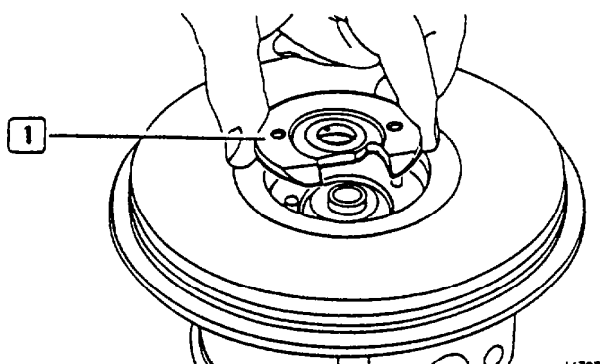
By means of two screwdrivers, remove the intermediate plate (1) with attached seal.



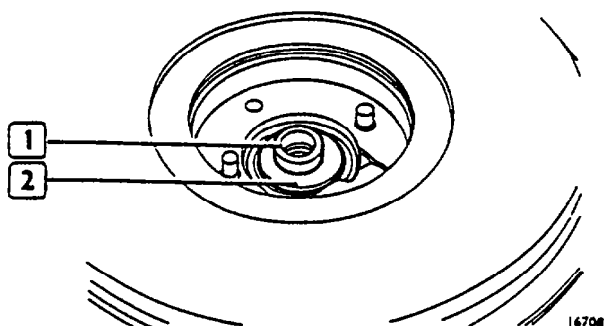
16706

Withdraw oil baffle (1).

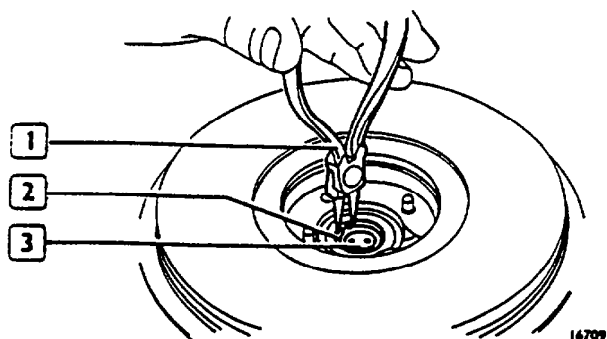




Remove thrust bearing (1).



Remove spacer (1) and thrust ring (2).



With pliers 381103 (1) remove retaining ring (2) and withdraw bushing (3). Repeat this operation for the bushing on turbine side, removing also the thrust washer.

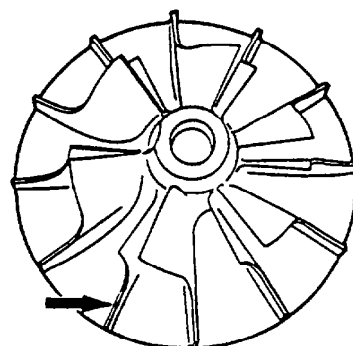
## CHECKS

Thoroughly clean (with kerosene and a hard bristle brush) all the parts composing the turbocharger and dry with compressed air.

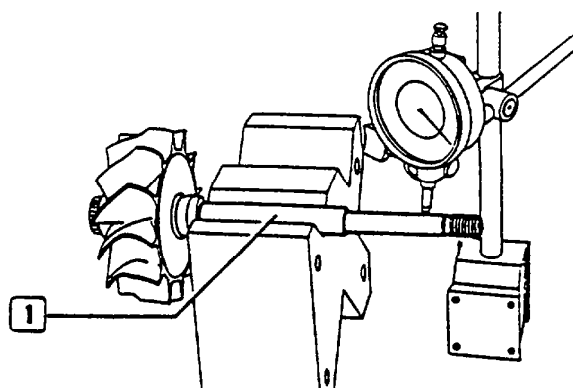
To clean turbine volute whose carbon deposits are hard remove, use suitable means, such as a sandblasting machine.

Check that all parts do not show wear, seizure or deterioration.

NOTE - We suggest replacement of all the parts showing wear, seizure or damage and which are supplied as a kit.

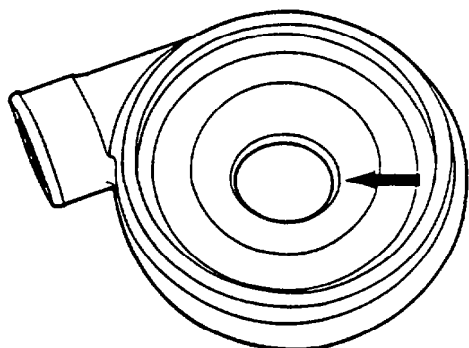


Checking compressor wheel blades (see arrow).



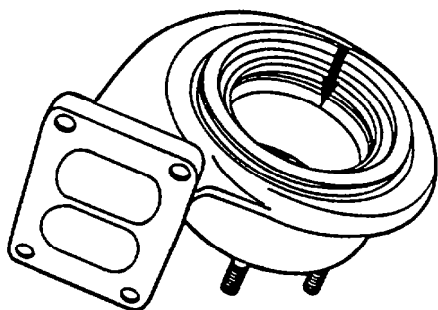
Turbine wheel-shaft (1) eccentricity should be 0.007 mm, measured approximately 10 mm from threads.

## ASSEMBLY



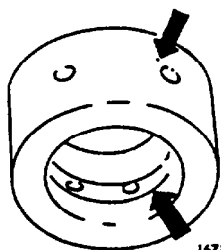
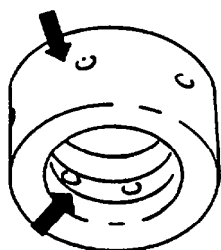
16712

Check compressor housing. The arrow shows the internal seat to be checked.



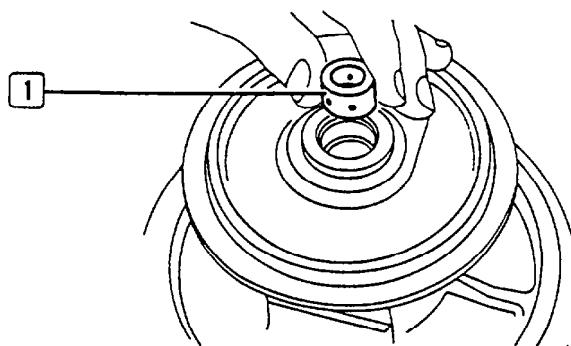
16713

Check turbine housing. The arrow shows the internal seat to be checked.



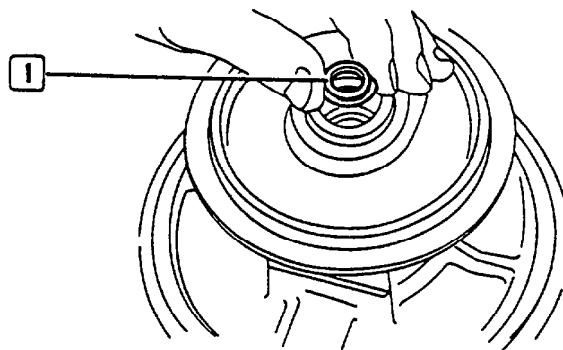
16714

Check wheel assembly bushings. The arrows indicate the bushing surfaces to be checked.



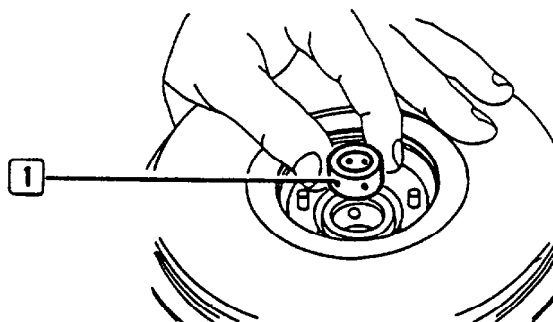
16715

With pliers 381103 fit the inner retaining ring and insert bushing (1).



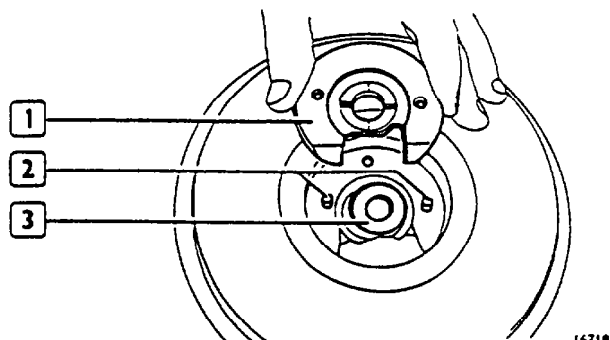
16716

Insert thrust washer (1) and retaining ring

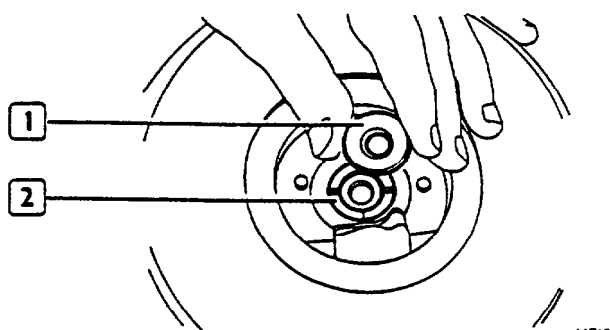


16717

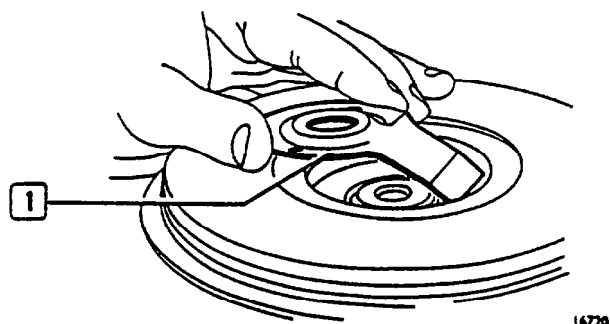
Rotate central housing. On compressor side insert the inner retaining ring, bushing (1), and the outer retaining ring



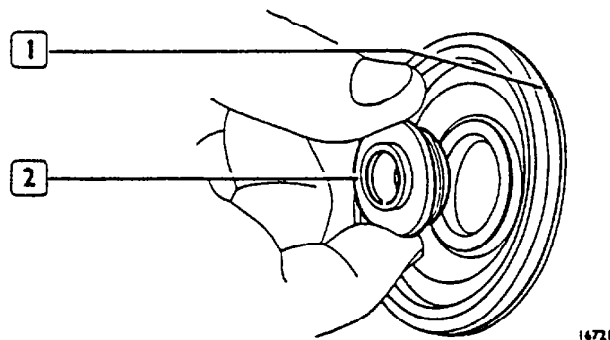
Insert thrust ring (3), and place thrust bearing (1) on the two positioning dowels (2).



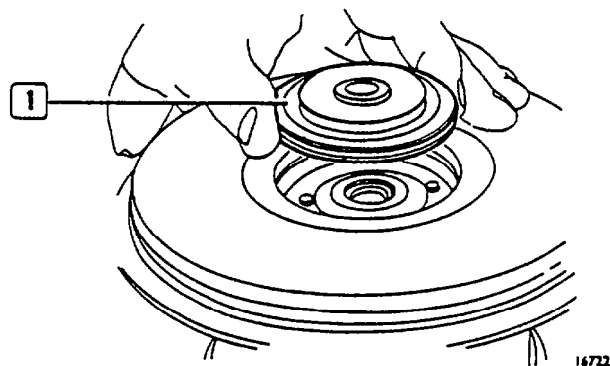
Insert spacer (2) and thrust ring (1).



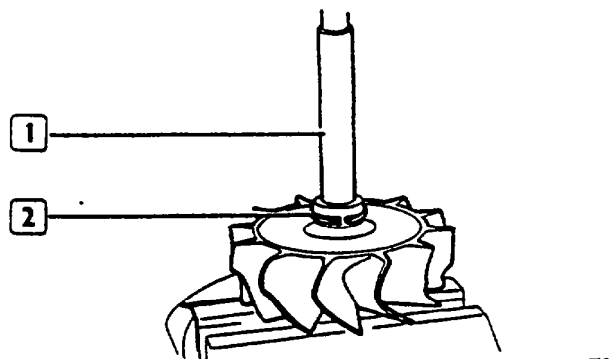
Insert oil baffle (1).



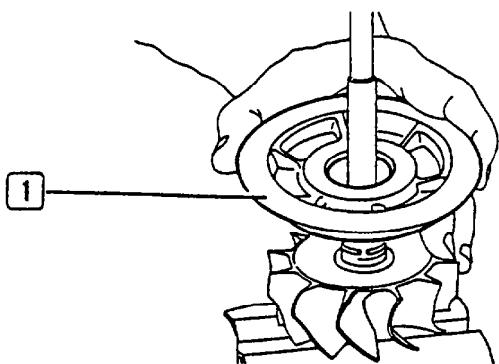
On the intermediate plate complete with seal ring (1) insert retaining ring sleeve (2).



Insert the complete intermediate plate (1) on centre housing and position retaining ring

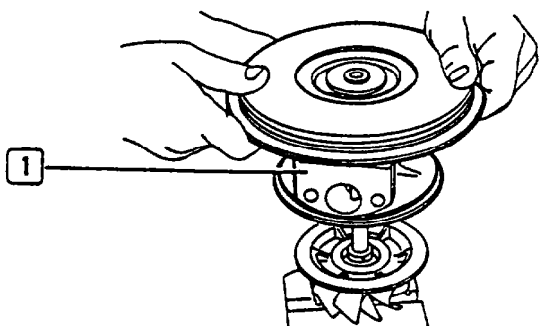


Grip in a vise turbine wheel-shaft assembly (1) and insert retaining ring (2).



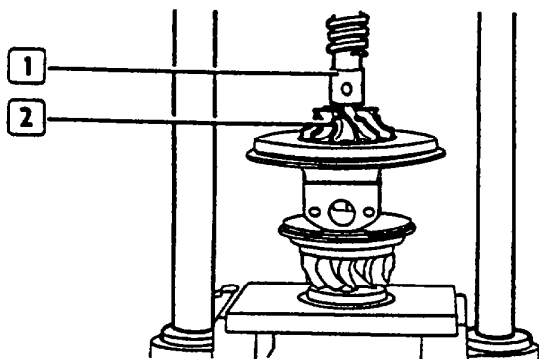
16724

Position heat protection plate (1) on turbine shaft.



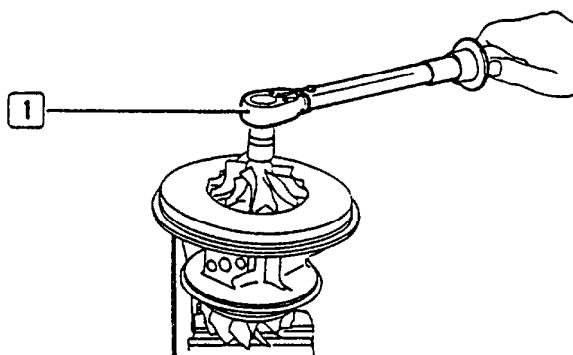
16725

Insert complete centre housing (1).



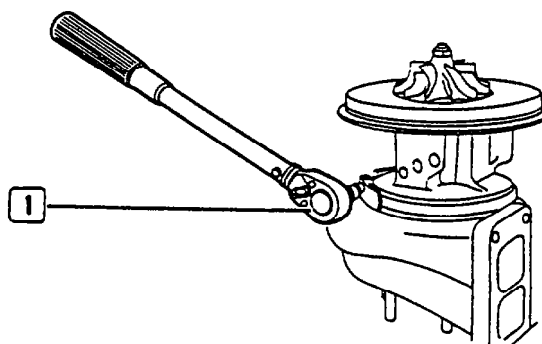
16726

Using press 305074 (1) fit compressor wheel (2).



16727

Screw down self-locking nut and tighten it with torque wrench (1) to 25 Nm (2.7 kgm).

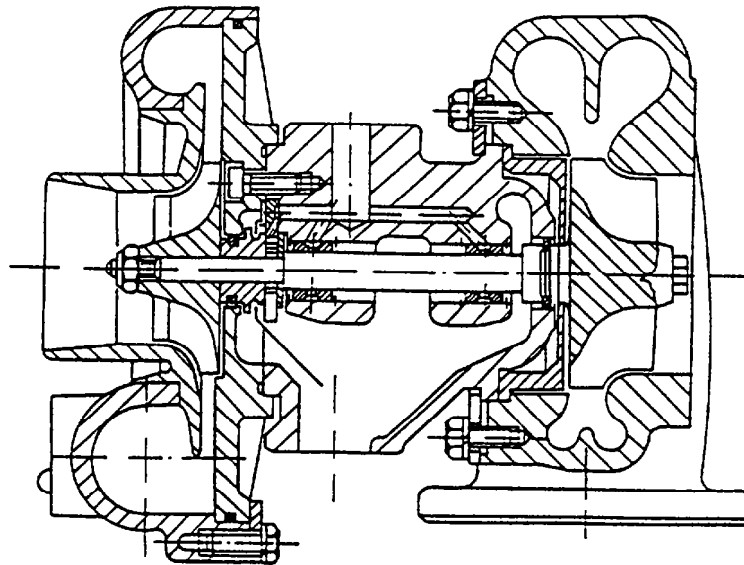


16728

Assemble compressor and turbine housings lining up the reference marks made during disassembly. Tighten lock plates using torque wrench (1) to a torque of 13 Nm (1.4 kgm).

On completion of assembly, lubricate internal parts of turbocharger using engine oil.

## TURBOCHARGER



16864

## DESCRIPTION

KKK turbocharger type mainly consists of a turbine, a center housing and a compressor.

The turbine is located on one side of centre housing and the compressor on the other; a bearing mounted shaft connects turbine and compressor which, together, make up the bladed wheel assembly. The turbocharger uses the energy contained in engine exhaust gases.

During engine running, exhaust gases are directed through the turbine housing, causing the turbine impeller to rotate.

Connected to the turbine through the shaft, the compressor wheel is also set into motion. Compressor draws atmospheric air and produces compressed air to be supplied to the engine intake manifold.

Turbocharger and bushing cooling and lubrication is through engine oil.

## INSPECTION BEFORE DISASSEMBLY

Before turbocharger disassembly or repair, carry out the following checks.

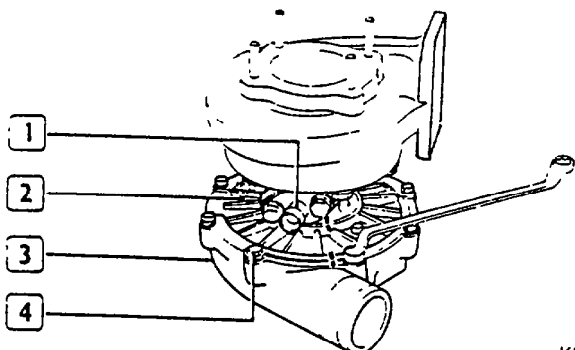
Inspect oil drain pipe; it should never be clogged.

Check that oil circulation is not restricted.

Be sure that engine vent on cylinder block is not obstructed. Check all seals and connecting hoses for leakage.

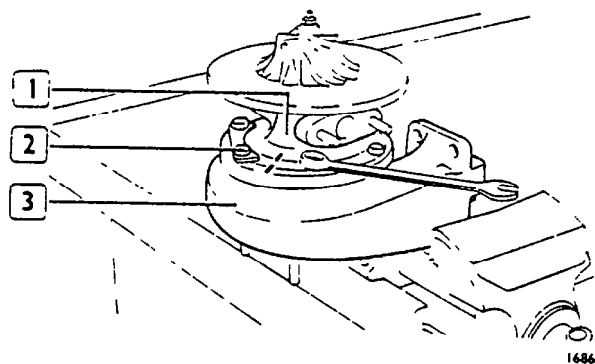
Be sure that air intake line is not obstructed by air cleaner clogged or pipe blockage.

## DISASSEMBLY



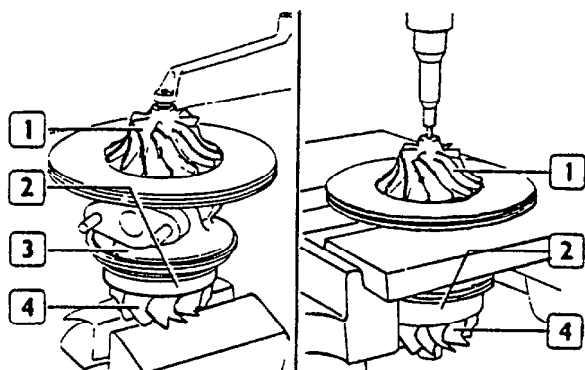
16865

Thoroughly clean outside of turbocharger using non corrosive and anti-rust liquids. Mark assembly position of compressor housing (3) on intermediate plate (2), and the position of intermediate plate on center housing. Disconnect compressor housing (3) from intermediate plate (2) removing cap screws (4).



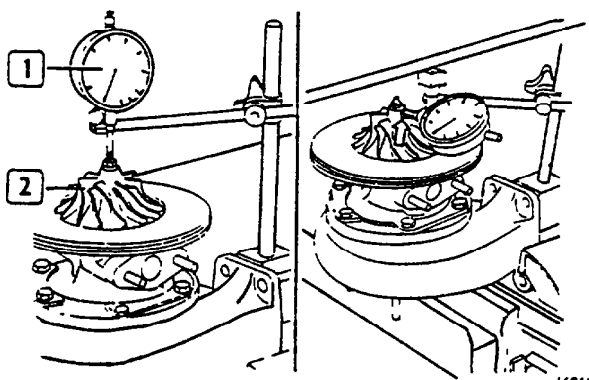
16866

Mark assembly position of turbine housing (3) on centre housing (1). Disconnect centre housing (1) from turbine housing (3) removing bolts (2).



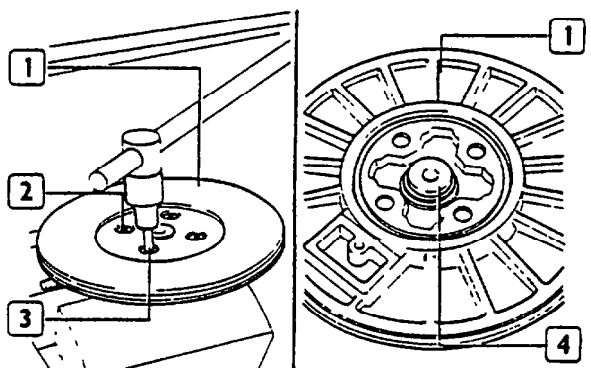
16869

Remove compressor wheel (1) checknut; using a press withdraw turbine shaft (4) with attached heat screen (2) from compressor wheel (1) and centre housing (3).



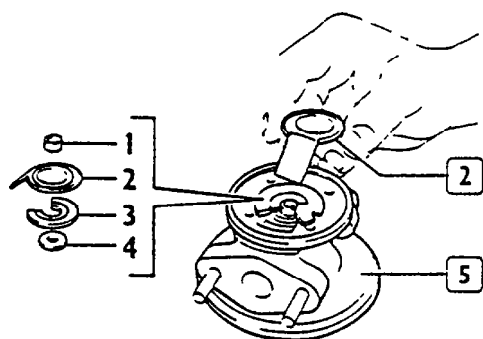
16866

Check end float and clearance of rotating assembly (2) using gauge (1). Clearance should be detected on mark machined on turbine (see arrow). End float should be 0.16 mm. Max. clearance should be 0.46 mm.



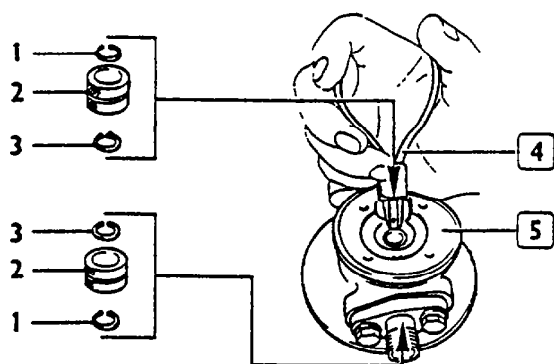
16870

Disconnect intermediate plate (1) from centre housing removing bolts (2) by means of socket wrench 99389866 (3). From intermediate plate (1) remove seal bushing (4) with attached spring rings.



16870

From centre housing (5) remove oil baffle (2), axial bearing (3), spacer (1) and thrust ring (4).



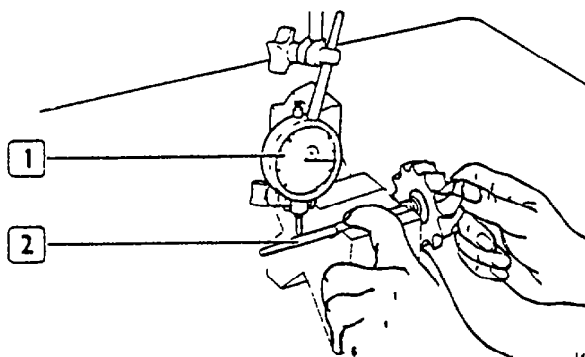
16871

With pliers (4) remove spring rings (1) and withdraw bushings (2) from centre housing (5). If replacement is necessary, remove retaining rings (3).

### INSPECTIONS

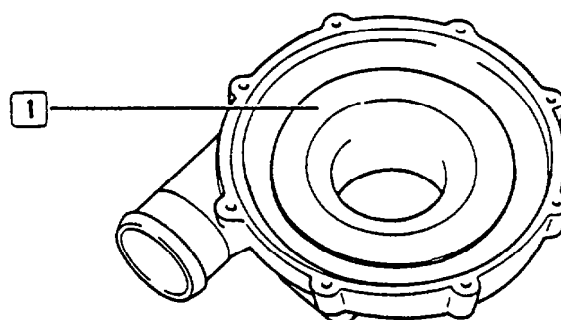
Thoroughly clean all turbocharger components using kerosene and a hard bristle brush; dry with compressed air. To clean turbine volute, where removal of carbon deposits is difficult, use suitable means (for instance a sandblasting machine). If excessive end float or clearance has been noticed in the assembly, locate the component responsible of the wear. We suggest to replace all the components supplied as spares.

Check that compressor and turbine blades do not show damage or distortion. Any anomaly requires replacement.



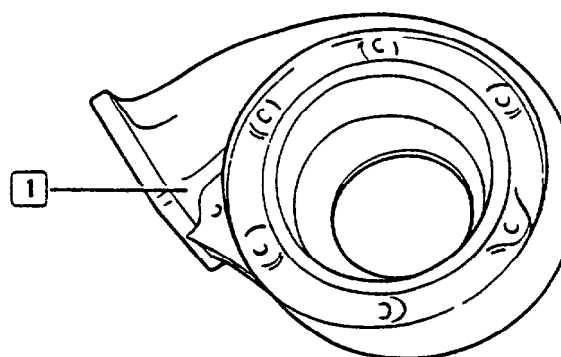
16872

With dial gauge (1) check turbine shaft (2) eccentricity 20 mm from shaft end. It should not exceed 0.007 mm.



16873

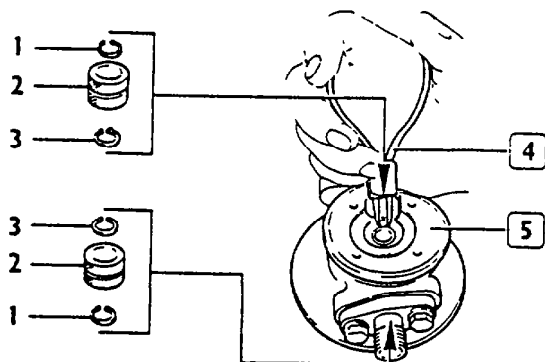
Check that internal surfaces of compressor housing (1) and turbine housing (2) are sound; in the negative they should impair the turbocharger efficiency.



16874

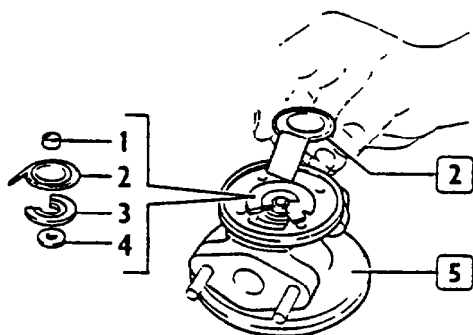
In case of anomalies replace the whole turbocharger, as the two housings are not supplied as spare parts.

## ASSEMBLY



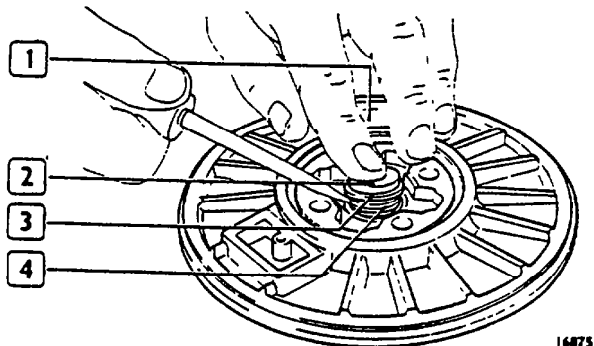
16871

Install inner retaining rings (3) on center housing (5) using pliers (4); insert bushings (2) lubricated with engine oil and fit them using inner retaining rings (1).



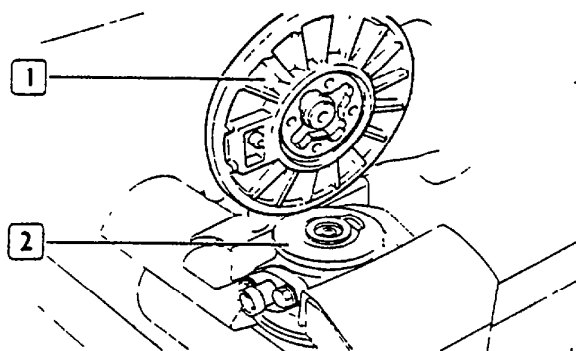
16870

In center housing (5) insert: thrust ring (4), axial bearing (3), spacer (1) and oil baffle (2).



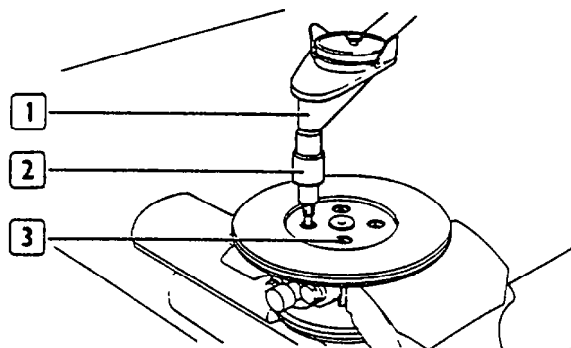
16875

On the intermediate plate (1) insert bushing (2) with attached retaining rings (3 and 4) being sure that ring ends are offset from one another and from the lubrication oil inlet.



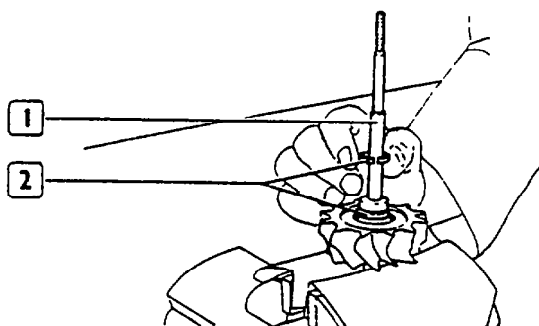
16876

Coat the intermediate plate surface (1) with Loctite 573 dope and insert it on center housing (2) so that the marks placed during disassembly coincide.



16877

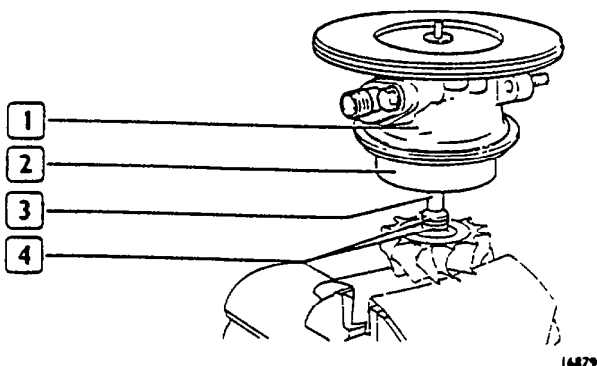
Using torque wrench 99389831 (1) and bushing 99389866 (2) tighten screws (3) previously covered (on threads) with Loctite 640 dope, to 8 Nm (0.8 kgm)



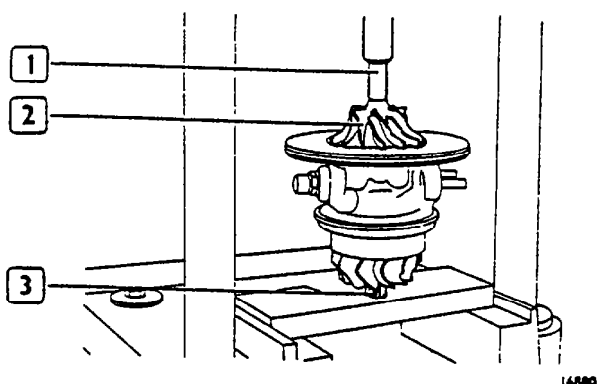
16878

Insert the two retaining rings (2) in their seats on turbine shaft (1).

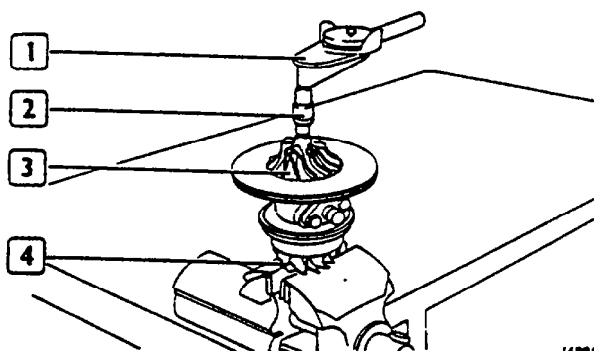




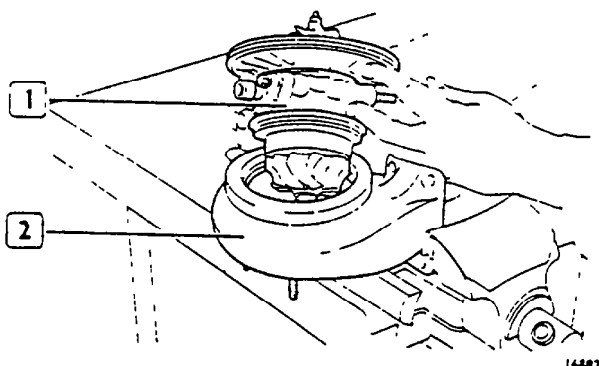
On turbine shaft (3) key center housing (1) with heat screen (2) taking care that retaining ring ends (4) are offset from one another and from lubrication hole.



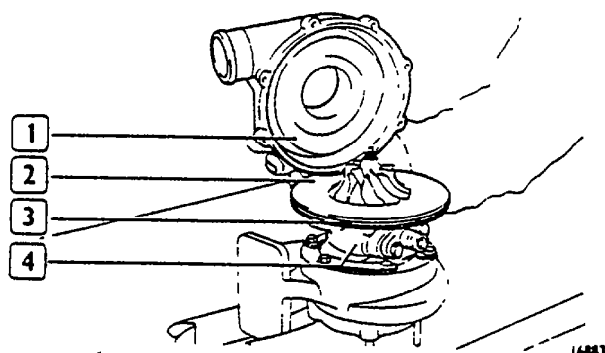
With press (1) key compressor wheel (2) on turbine shaft (3).



Coat turbine (4) shaft thread with Loctite 640 dope and tighten compressor wheel (3) to 12 Nm (1.2 kgm) using torque wrench 99389831 (1) and bushing (2).



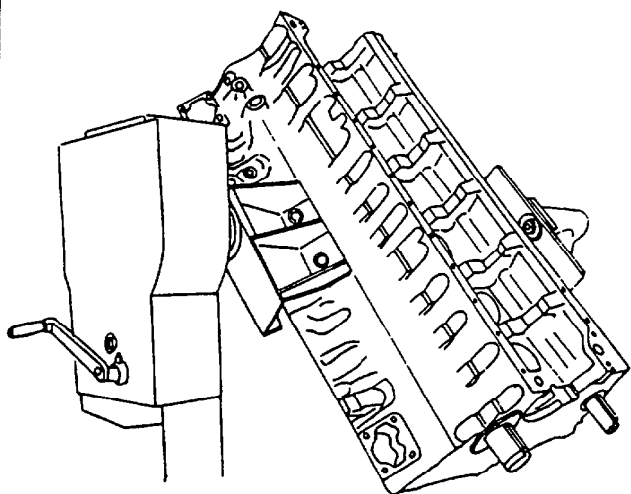
Insert the complete center housing (1) in turbine housing (2) being sure that the marks made during disassembling coincide. Tighten the screw securing centre housing to turbine housing to 20 Nm (2 kgm).



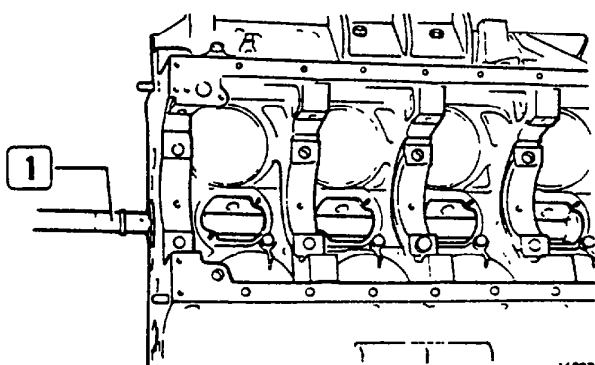
Place a new retaining ring (3) on intermediate plate (2) seat and insert compressor housing (1) on centre housing (4), taking care that marks made during disassembly coincide. Tighten to 7 Nm (0.7 kgm) the screw securing compressor housing to centre housing.

**NOTE** - Before installing turbocharger on engine, fill center housing with engine lubrication oil.

## ENGINE DISASSEMBLY

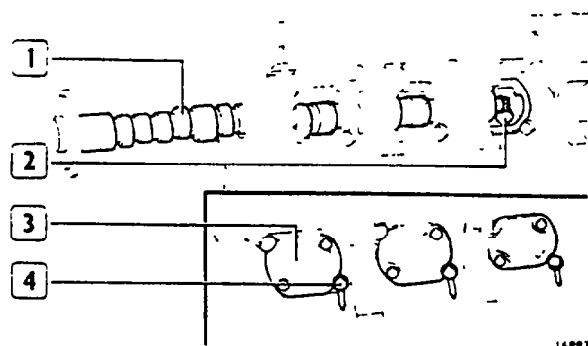


Position engine block on swinging stand 99322230 using brackets 99361011. To lift and support engine block during this operation, use rocking sling hook 99360585 with a set of eyes 99360503. Insert cylinder sleeves as indicated at paragraph page 27



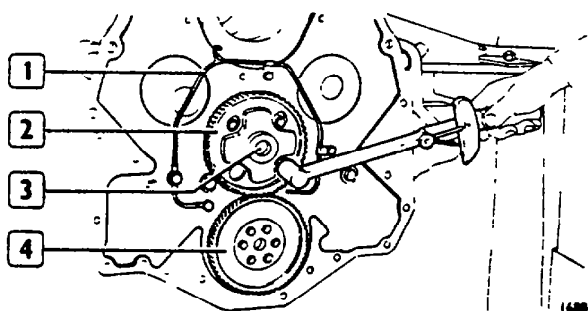
16802

Fit camshaft bushings using tool 99360385 (1).



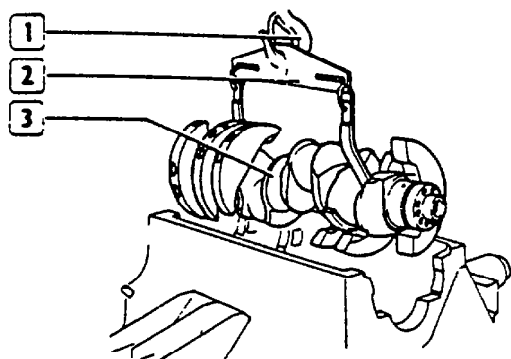
16803

Lubricate tappets (2) and insert them in their seats. Lubricate camshafts bushings and insert camshaft (1) taking care not to damage bushings. Insert covers (3). Insert spray nozzles (4) checking that dowels are correctly positioned on engine block.



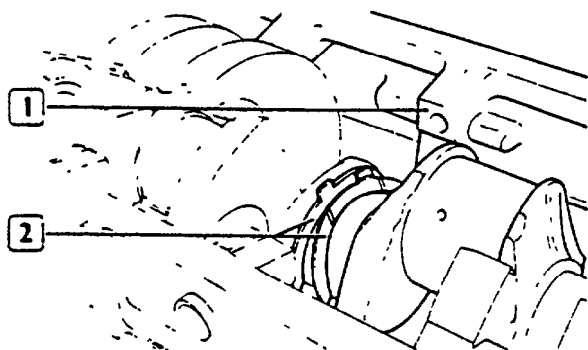
16804

Tighten to suitable torque camshaft (3) thrust plate cap screws (2). Insert support with attached injection pump shaft, and fit on this gear (4). Insert gear lubrication line (1).



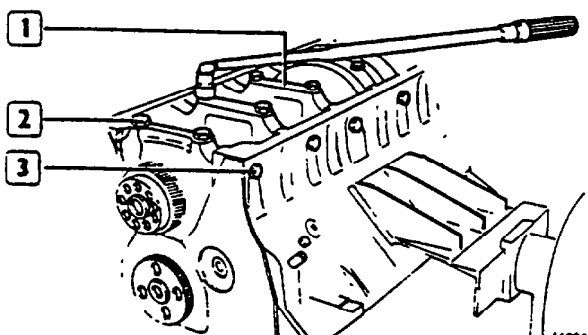
16700

Insert in their seats the half journals lubricated through their lubrication hole and install crankshaft (3) using tool 99360500 (2) and swinging hoist (1).



16885

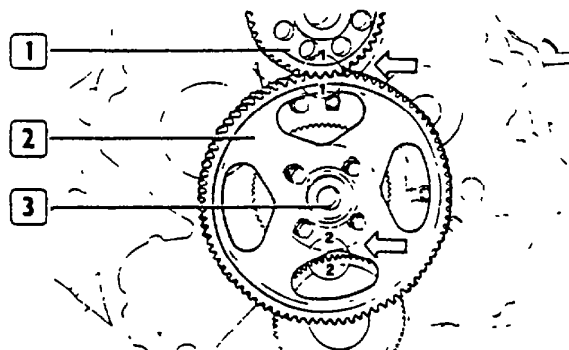
On main journal (1) insert thrust rings (2) with gaps towards crankshaft.



16886

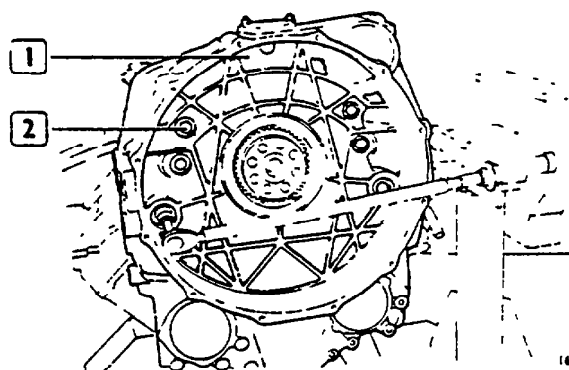
Insert main bearing caps (1) and relevant half bearings so as the printed figure is opposite to that on engine block.

Lubricate bearing cap screws (2 and 3) with UTDM oil and tighten to suitable torque.



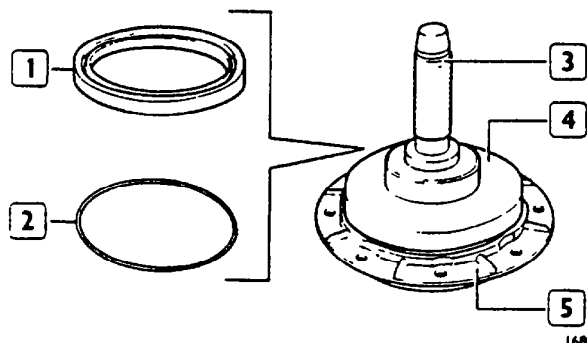
16887

Rotate crankshaft (1) and camshaft (3) so as on inserting gear (2) the marks on each single gear (indicated by an arrow) is coincident with the other.



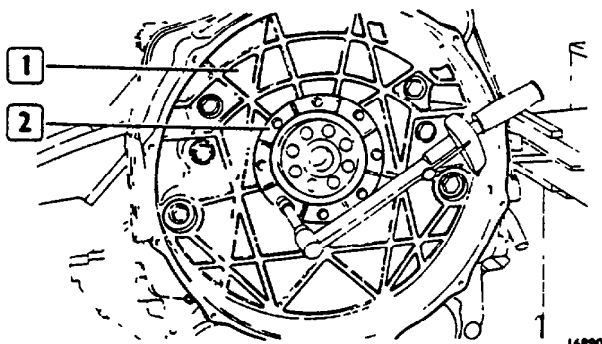
16888

Install flywheel housing (1) and tighten capscrews (2) to required torque.

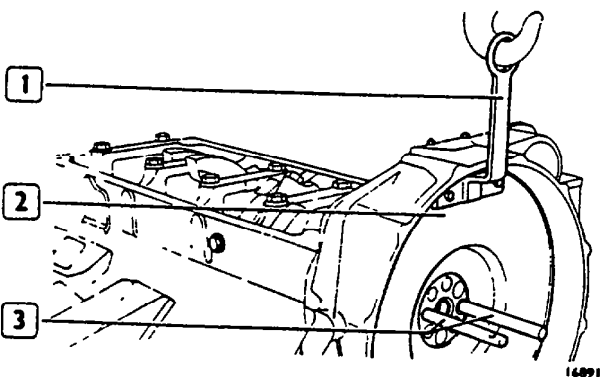


On rear cover (5) position spacer (2) and insert retaining ring (1) using tool 99360368 (4) with handgrip 99370006 (3).

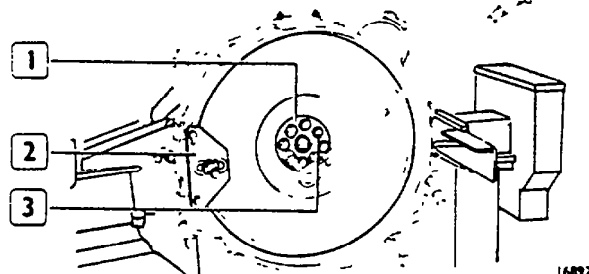
NOTE - If crankshaft is worn-out near retaining ring (1) circle, insert this without interposing spacer (2).



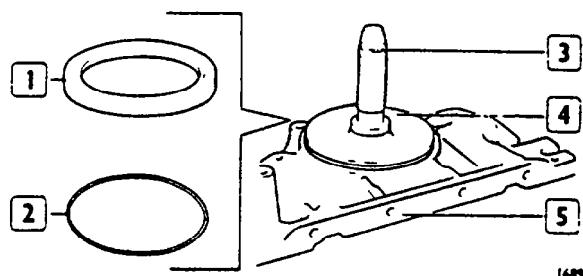
On flywheel cover (1) insert rear support (2) and tighten bolt to required torque.



Screw down pins 99360349 (3) on crankshaft and install flywheel (2) using bracket 99360350 (1) and a hoist.

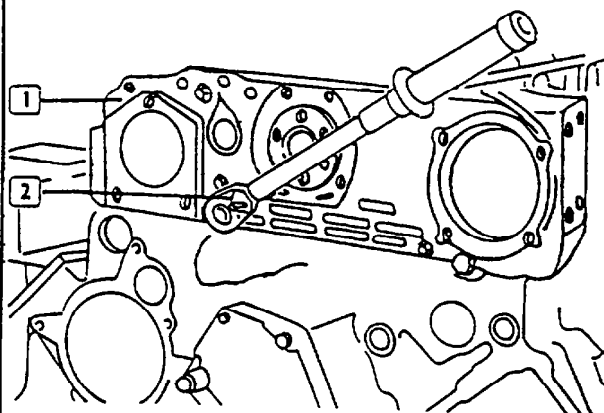


Clamp crankshaft (1) rotation using tool 99360351 (2) and tighten screws (3) previously lubricated with UDM oil.



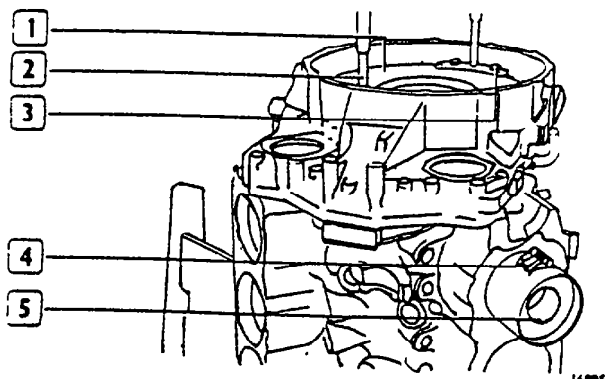
On rear cover (5) position spacer (2) and insert retaining ring (1) using tool 99360354 (1) with handgrip 99370006 (3).

NOTE - If the crankshaft is worn-out near retaining ring (1) circle, insert this without interposing spacer (2).

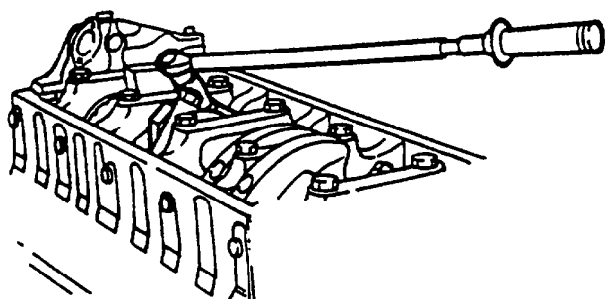


Install front cover (1) tightening to specified torque screws (2).

## INJECTION PUMP ASSEMBLY AND TIMING ON ENGINE



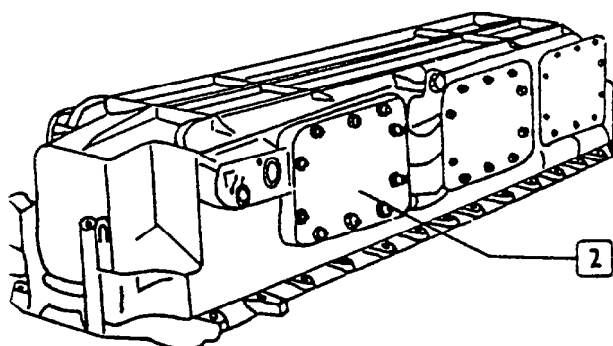
Fit brackets 99360304 (3) to engine flywheel (1) using handgrips 99360307 (2) to rotate crankshaft; install pistons (5) using compressor 99360603 (4) as indicated at page 35



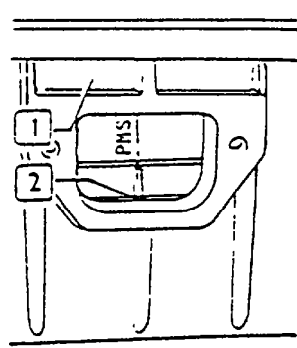
With engine oil lubricate big end bearings and insert them.

Tighten nuts of the screws securing connecting rod caps (previously lubricated with UTDM oil) to required torque.

NOTE - On final assembly, all bolts and nuts securing connecting rod caps must be replaced.



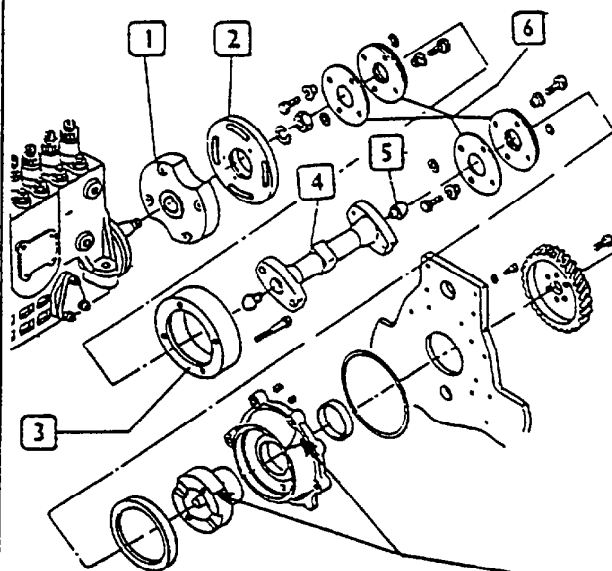
Install oil pump with attached suction scoop, oil sump (2).



Remove the plug of the opening of the flywheel housing (1) and indicator (2).

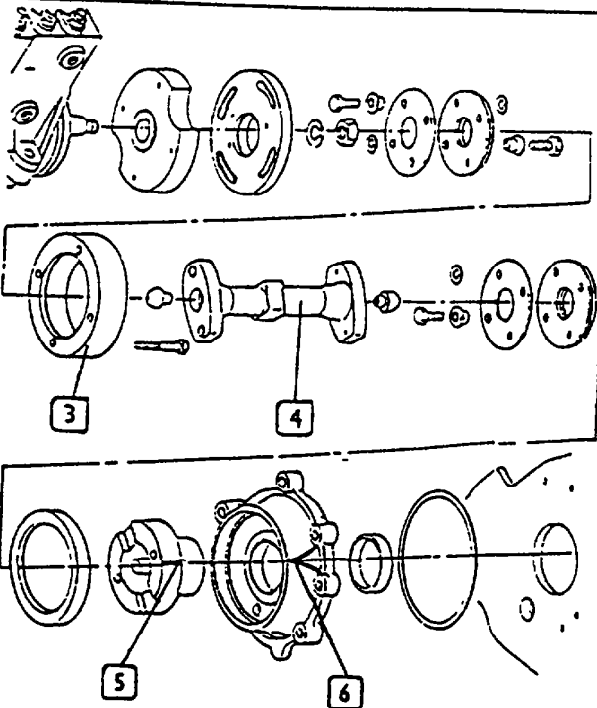
Fit to the engine flywheel the right grips, and turn it till the reference P.M.S. (= T.D.C.), punched on the flywheel corresponds to the indicator of the opening of the flywheel housing.

In this condition the cylinder n°1 is in combustion phase and the valves of the cylinder n°7 are in balance phase.

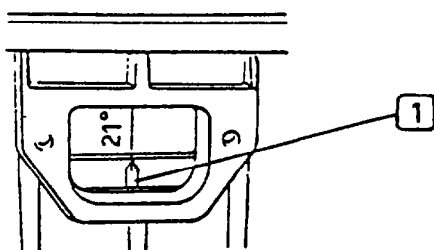


#### REFERENCE MARKS OF THE P.M.S. (= T.D.C.) CYLINDER N°1

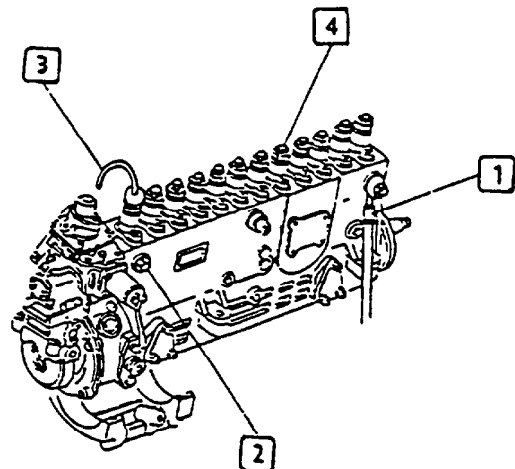
Fit on the injection pump: the hut (1), the driving ring (2), the flywheel to fix the hut (3), the driving shaft of the injection pump (4) complete with n°2 pads (5), n°10 elastic driving rings (6), (n°5 for each side).



Install the injection pump completely paying attention to put the shaft(4) in vertical position. Ensure the alignment of the marks of the shaft(5) and the support(6), without blocking the 4 screws fixing the flywheel (3) and injection pump.

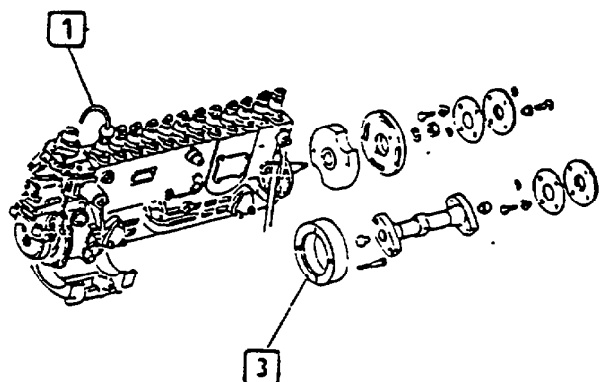


To perform the timing of the injection pump ensure the alignment of the indicator on the flywheel housing and the fixed advance (fuel delivery start) (8291 srm75 / srm85=18°/8291 srm12...=21°)



Connect the drop system hydraulic pump to the fuel intake of the injection pump(1). Close with a plug the fuel return of the injection pump (2).

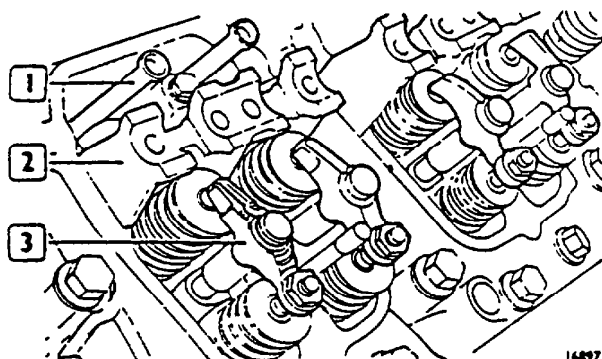
On the union of the 1° plunger, install a drop pipe (3) and close the other unions with plugs(4). Put the fuel rack at the max position. Send the Liquid operating with the hydraulic pump



Turn in clockwise direction the flywheel(3) of the injection pump till the opening of the first plunger(1), (drop system - the fuel comes out), then turn the flywheel in counter clock wise direction till the closing of the first plunger (the fuel stops to flow).

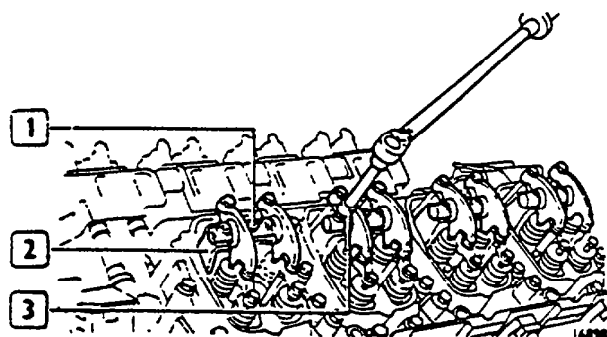
Block the 4 screws fixing the flywheel (3) to the driving shaft of the injection pump and verify that the mark is aligned with 21°

If the value is different, repeat the drop system test.



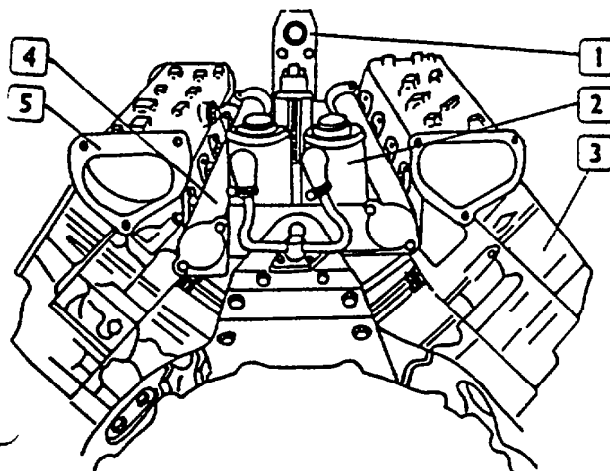
16897

Install cylinder heads as indicated at page 40  
Insert rocker pushrods (1), rocker shaft supports (2) and  
edges (3).



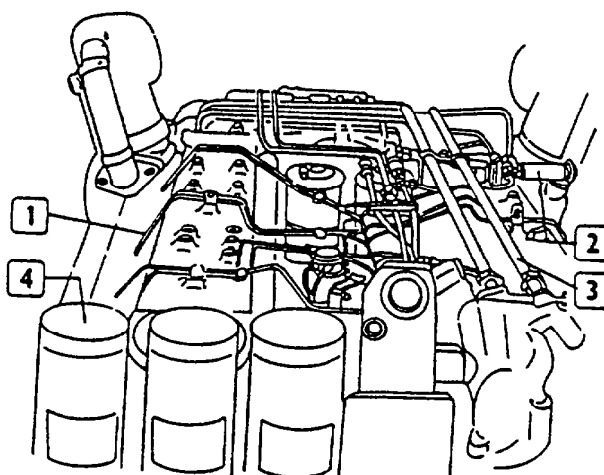
16898

Insert rocker shafts (1) with relevant rockers on sup-  
ports (2) and tighten capscrew to required torque using  
wrench 389856 (3). Adjust rocker - valve clearance as  
indicated at page 41



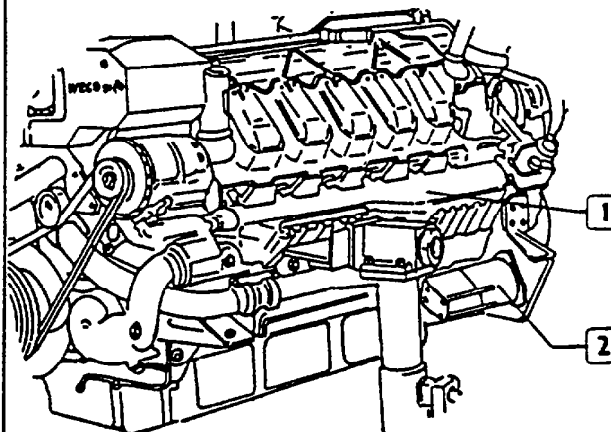
## Fit:

- ☐ engine mounting(1)
- ☐ oil breather (3) complete with pipes(2)
- ☐ rocker boxes(3)
- ☐ water pipes(4)
- ☐ oil inlet and outlet pipes to the injection pump
- ☐ inlet manifold(5)



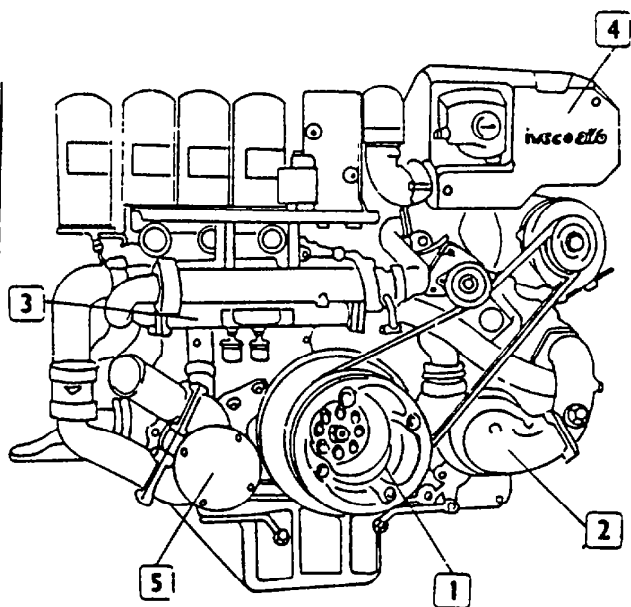
## Fit:

- ☐ injectors, with relevant pipes(1)
- ☐ rocker boxes cover, complete with gaskets
- ☐ fuel drain pump(2) with relevant pipes
- ☐ fix water pipes (3)
- ☐ oil filters and support(4)



## Fit:

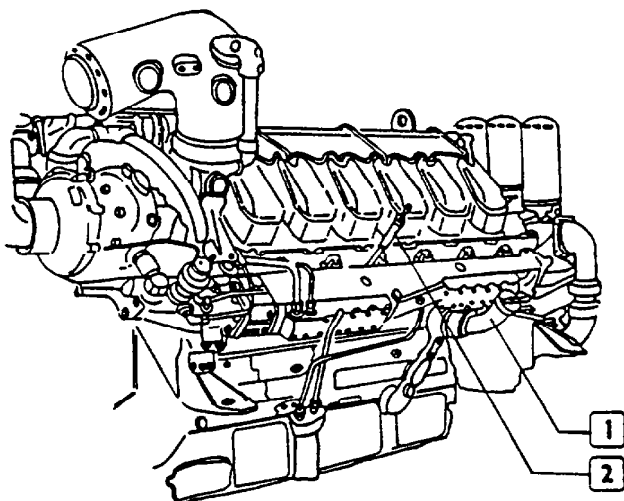
- ☐ starting motor(2).
- ☐ exhaust manifolds(1).



The damper at the required torque, after having blocked the crankshaft with the tool 99360531.

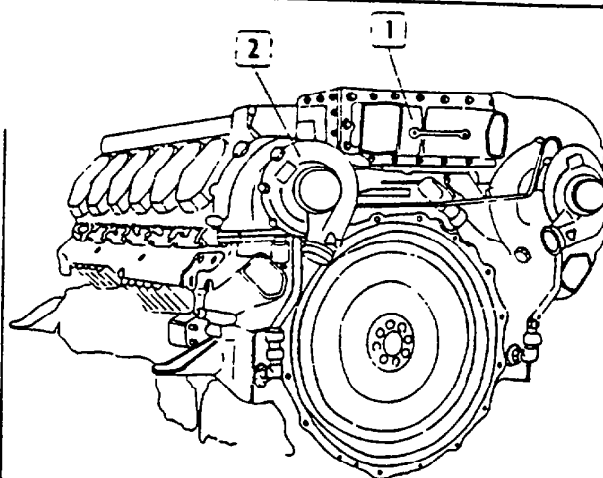
- ☐ pulley(1); belts and stretcher.
- ☐ water pump (2).
- ☐ water-water heat exchanger(3) with relevant pipes.
- ☐ expansion tank(4) complete with pipes water filter
- ☐ sea water pump(5) with relevant pipes.

**NOTE: REPLACE THE SACRIFICIAL ANODES**



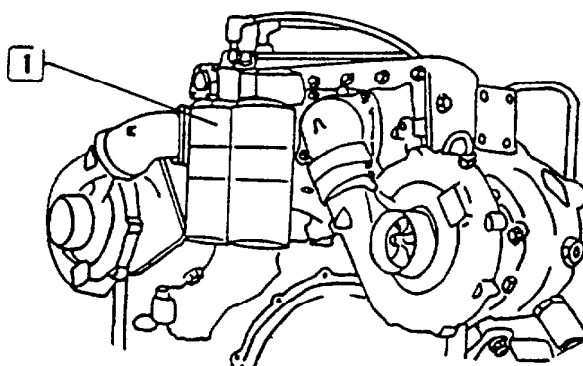
Fit:

- ☐ oil filter(1)
- ☐ oil dipstick



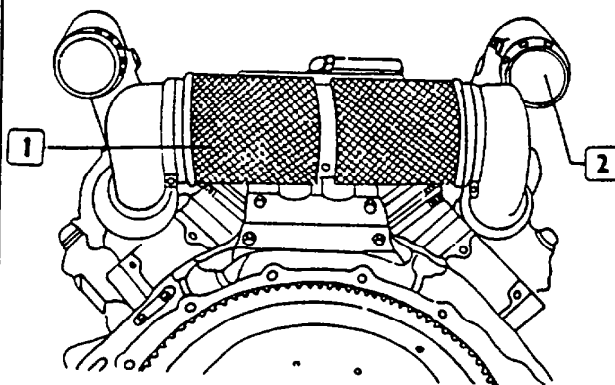
Fit:

- ☐ air-water heat exchanger(1).
- ☐ turbochargers(2) complete with oil intake and output pipes.



Fit:

- ☐ fuel filters(1)



Fit:

- ☐ air filters(1)
- ☐ gas-water mixers(2)



## TIGHTENING TORQUE DATA

| DESCRIPTION  | TORQUE Nm (kgm)     |
|--|---------------------|
| Capscrew, main bearing caps { pre-torque<br>angle  | ▲ 80<br>120°        |
| Capscrew, main bearing caps side { pre-torque<br>angle   | 70<br>90°           |
| Capscrew, sump to front cover  | 10 (1)              |
| Capscrew, sump to engine block   | 10 (1)              |
| Capscrew, sump to timing gear housing and flywheel   | 10 (1)              |
| Capscrew, gear housing to rear plate   | 78 (8)              |
| Capscrew, timing gear housing to rear plate  | 78 (8)              |
| Capscrew, injection pump drive shaft support and rear plate to gear housing  | 49.5 (5)            |
| Capscrew, injection pump drive shaft support, rear plate, power steering pump and engine lift hook to gear housing | 49.5 (5)            |
| Capscrew, rear plate to engine block   | 78 (8)              |
| Capscrew, front cover to engine block  | 24.5 (2.5)          |
| Nut, stud bolt, oil catcher to valve system axle   | 24.5 (2.5)          |
| Capscrew (M12x1.25), valve gear housing to rear plate  | 99 (10)             |
| Capscrew, engine breather support to gear housing  | 24.5 (2.5)          |
| Nut, engine breather support to gear housing   | 24.5 (2.5)          |
| Capscrew, cylinder head { pre-torque<br>pre-torque<br>angle  | ▲ 30<br>160<br>120° |
| Capscrew, central, cover to cylinder head  | 24.5 (2.5)          |
| Capscrew, cover to cylinder head   | 24.5 (2.5)          |
| Nut, rocker inspection cover   | 14.5 (1.47)         |
| Capscrew, left and right intake manifold to cylinder head  | 49.5 (5)            |
| Capscrew, exhaust manifold   | ● 32 (3.2)          |
| Nut, turbocharger connection stub pipe to exhaust manifold   | 78 (8)              |
| Capscrew, crankshaft counterweights  | ▲ - 276.5 (28)      |
| Nut, connecting rod cap  | ▲ 280 (28,5)        |
| Nut, engine flywheel { pre-torque<br>angle   | ▲ 400<br>90°        |

▲ Lubricate with UTDM oil.

● - Lubricate with graphite oil

| DESCRIPTION  | TORQUE Nm (kgm) |
|--|-----------------|
| Capscrew, thrust plate to engine block   | ▲ 24.5 (2.5)    |
| Capscrew, camshaft drive gear to driven gear   | ▲ 49.5 (5)      |
| Capscrew, rocker shaft bracket to head   | 78 (8)          |
| Capscrew, rocker bracket to head   | 24.5 (2.5)      |
| Capscrew, injection pump support   | ▲ 78 (8)        |
| Capscrew, injection pump to support  | 78 (8)          |
| Nut, injection plate spacer to injection pump  | 200 (20,4)      |
| Capscrew, injection pump spacer plate  | 24.5 (2.5)      |
| Capscrew, injection pump shaft support to rear engine block plate                                    | 24.5 (2.5)      |
| Capscrew, injection pump driven gear to shaft  | ▲ 24.5 (2.5)    |
| Nut, injector bracket to cylinder head   | 56 (5.7)        |
| Capscrew, fuel filter body to bracket  | 24.5 (2.5)      |
| Capscrew, fuel filter bracket to oil filter body   | 49.5 (5)        |
| Capscrew, oil filter body to engine block  | 24.5 (2.5)      |
| Capscrew, oil filter body and oil filter body connection elbow to tachometer housing in engine block | 24.5 (2.5)      |
| Capscrew, oil filter body to engine block  | 49.5 (5)        |
| Capscrew, alternator support to engine block   | 49.5 (5)        |
| Nut, alternator strut on thermostat housing  | 49.5 (5)        |
| Nut, alternator drive pulley   | 40 (4)          |

▲ Lubricate with UTDM oil.

**SPECIAL TOOLS**

| TOOL No. | DESCRIPTION  |
|----------|--|
| 99340035 | Puller, pulley hub and water pump impeller.                                |
| 99340205 | Puller, slide hammer.  |
| 99342135 | Puller, union, injectors (use with 99340205).                              |
| 99342145 | Remover, injector sleeve.  |
| 99345075 | Remover, tappet.   |
| 99352137 | Wrench, taper adjustment.  |
| 99360143 | Remover/installer, valve guide.  |
| 99360184 | Pliers, engine piston ring.  |
| 99360280 | Remover/installer, valve guide (use with 99360143).                        |
| 99360351 | Retainer, engine flywheel.   |
| 99360503 | Set of eyes, lift, engine block.   |
| 99360603 | Compressor, standard and oversize piston installation in cylinders.        |
| 99360785 | Compression ring, cylinder sleeve removal/installation (use with 99360799) |
| 99360776 | Set of studs.  |
| 99360799 | Cylinder sleeve removal/installation tool                                  |
| 99365063 | Spreader, injector sleeve.   |
| 99365160 | Wrench, injector pipe removal.   |
| 99370005 | Handle, driver, interchangeable.   |
| 99370006 |  |
| 99374193 | Remover/installer, compressor support bushing                              |
| 99386012 | Remover/installer, crankshaft core plugs.                                  |
| 99390330 | Reamer, valve guide hole.  |
| 99390789 | Set of taps, to thread injector sleeve to be extracted.                    |
| 99394017 | Dresser, lower injector sleeve portion.                                    |
| 99394019 | Bushing, pilot.  |
| 99346204 | Puller, for injector (use with 99340205/99342135).                         |
| 99360421 | Installer, crankshaft rear seal (use with 99370005).                       |
| 99360551 | Bracket for removing and refitting flywheel (use with 99360545).           |
| 99374195 | Installer, crankshaft rear seal (use with 99370005).                       |
| 99360083 | Connection, engine cylinder compression test (use with 99395682).          |