



industrial engines

**section 5**

**8281 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.

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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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## ENGINE SPECIFICATIONS

Engine type. . . . . 8281I03  
 4 - stroke Diesel with direct injection  
 Cylinders, number and arrangement. . . . . 8 at 90° Vee  
 Bore x stroke. . . . . 145 x 130 mm  
 Displacement. . . . . 17,2 L  
 Compression ratio. . . . . 16,5:1  
 Automotive rating \* . . . . . 265 kW (360 CV)  
 At. . . . . 2400 rpm  
 Intermittent rating. . . . . 238 kW (323 CV)  
 At. . . . . 2200 rpm  
 Continuous rating (10% overload allowed) . . . . . 214 kW (291 CV)  
 At. . . . . 2200 rpm  
 Engine rotation  
 (see from flywheel) . . . . . CCW

\* Duty according to DIN 70020

- Ambient reference conditions:  
760 mmHg; 20°C; 60% relative humidity

## TIMING

Valve Timing:

- Intake:  
opens: before T.D.C . . . . . 8° 42'  
closes: after B.D.C . . . . . 43° 6'
- Exhaust:  
opens: before B D C . . . . . 45° 42'  
closes: after T.D.C . . . . . 6° 6'

Clearance between valves and  
rockers for timing checks. . . . . 0,254 mm

Operating clearance between valves and rockers, cold engine:

- intake . . . . . 0,20 to 0,25 mm
- exhaust. . . . . 0,40 to 0,45 mm

## FUEL SYSTEM

In line injection pump type PE

Fixed injection pump delivery start advance. . . . . 18° ± 1°  
 Fuel injectors setting. . . . . 210 + 8 bar  
 Firing order. . . . . 1-3-7-2-6-5-4-8

## LUBRICATION

Minimum oil pressure:

- at full throttle. . . . . 4 to 6 Kg/cm<sup>2</sup>
- when idling. . . . . 2 kg/cm<sup>2</sup>

## COOLING SYSTEM

Forced water circulation controlled by centrifugal pump.  
 Water temperature controlled by thermostat.  
 Radiator cooling fan drive by V-belt.  
 Water filtering with multiple type PERRY recycle filter.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage . . . . . 24 V
- Self-regulated alternator. . . . . 28 V, 30 A
- Starting motor power. . . . . 6,6 kW
- Battery (optional). . . . . 2, each 150 Ah

## ENGINE SPECIFICATIONS

Engine type.....	8281SI10
4 - stroke Diesel with direct injection	
Cylinders, number and arrangement.....	8 at 90° Vee
Bore x stroke.....	145 X 130 mm
Displacement.....	17,2 l
Compression ratio.....	15:1
Automotive rating * .....	309 kW(420 CV)
At.....	1800 rpm
Intermittent rating.....	249 kW(400 CV)
At.....	1800 rpm
Continuous rating(10% overload allowed).....	264 kW(359 CV)
At.....	1800 rpm
Engine rotation:	
(see from flywheel) .....	CCW

\* Duty according to DIN 70020

- Ambient reference conditions:

760 mmHg; 20°C; 60% relative humidity

## TIMING

Valve Timing:

- Intake:

opens: before T.D.C ..... 8° 42'

closes: after B.D.C ..... 43° 6'

- Exhaust:

opens: before B.D.C ..... 45° 42'

closes: after T.D.C ..... 6° 6'

Clearance between valves and

rockers for timing checks..... 0,254 mm

Operating clearance between valves and rockers, cold engine,

- intake..... 0,20 to 0,30 mm

- exhaust..... 0,40 to 0,45 mm

## FUEL SYSTEM

In line injection pump type PE

Fixed injection pump delivery start advance..... 24° ± 1°

Fuel injectors setting ..... 210 + 8 bar

Firing order..... 1-3-7-2-6-5-4-8

## TURBOCHARGING

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

The turbocharger is lubricated with the engine oil under pressure.

## LUBRICATION

Minimum oil pressure:

- at full throttle ..... 3 bar

- when idling..... 0,7 bar

## COOLING SYSTEM

Forced water circulation controlled by centrifugal pump.

Water temperature controlled by thermostat.

Radiator cooling fan driven by V-belt.

Water filtering with multiple type PERRY recycle filter.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage..... 24 V

- Self-regulated alternator..... 28 V, 30 A

- Starting motor power..... 6,6 kW

- Battery (optional)..... 2, each 150 Ah

## ENGINE SPECIFICATIONS

Engine type.....	82810SRI10
4 - stroke Diesel with direct injection	
Cylinders,number and arrangement.....	8 at 90° Vee
Bore x stroke.....	145 X 130 mm
Displacement.....	17,2 l
Compression ratio.....	15:1
Automotive rating * .....	383 kW(520 CV)
At.....	2000 rpm
Intermittent rating.....	353 kW(480 CV)
At.....	1800 rpm
Continuous rating(10% overload allowed) .....	324 kW(440 CV)
At.....	1800 rpm
Engine rotation:	
(see from flywheel) .....	CCW

- \* Duty according to DIN 70020  
 - Ambient reference conditions:  
 760 mmHg;20°C;60% relative humidity

## TIMING

## Valve Timing:

- Intake:
  - opens: before T.D.C .....8° 42'
  - closes: after B.D.C .....43° 6'
- Exhaust:
  - opens: before B.D.C .....45° 42'
  - closes: after T.D.C .....6° 6'

Clearance between valves and  
 rockers for timing checks.....0,254 mm

Operating clearance between valves and rockers,cold engine;  
 - intake.....0,20 to 0,25 mm  
 - exhaust.....0,40 to 0,45 mm

## FUEL SYSTEM

In line injection pump type PE

Fixed injection pump delivery start advance.....24° ± 1°  
 Fuel injector setting.....230 + 8 bar  
 Firing order.....1-3-7-2-6-5-4-8

## TURBOCHARGING

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

The turbocharger is lubricated with the engine oil under pressure.

## LUBRICATION

Minimum oil pressure:

- at full throttle.....5 to 6 bar
- when idling.....1,5 to 2 bar

## COOLING SYSTEM

Forced water circulation controlled by centrifugal pump.

Water temperature controlled by thermostat.

Radiator cooling fan driven by V-belt.

Water filtering with multiple type PERRY recycle filter.

## STARTING

By starter motor.

## ELECTRIC SYSTEM

- Voltage .....24 V
- Self-regulated alternator.....28 V,30 A
- Starting motor power.....6,6 KW
- Battery(optional).....2,each 150 Ah



**FITTING DATA  
ENGINE BLOCK - CONNECTING RODS**

DESCRIPTION	mm
Cylinder sleeve bore dia.	145.000 to 145.030
Cylinder bore dia. in engine block: — Upper — Lower	164.000 to 164.040 158.500 to 158.540
Sleeve pilot dia.: — Upper — Lower	164.003 to 164.028 158.461 to 158.486
Sleeve interference fit in block: — Upper — Lower	-0.028 to +0.037 0.014 to 0.079
Sleeve length	261.500 to 262.500
Camshaft bush housing bore dia.: — Front — Front intermediate — Center — Rear intermediate — Rear	76.480 to 76.520 76.980 to 77.020 77.480 to 77.520 77.980 to 78.020 78.480 to 78.520
Crankshaft bearing housing bore dia.	118.000 to 118.020
Tappet housing bore dia.	26.000 to 26.025
Big end bore dia.	97.950 to 97.972
Small end bore dia.	59.963 to 59.994
Big end bearing thickness	1.810 to 1.819
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
Piston pin clearance in small end bushing	0.025 to 0.048
Crankpin clearance in big end bearings	0.060 to 0.120
Max. connecting rod axis misalignment 125 mm away	0.025

**PISTONS - PINS - RINGS**

DESCRIPTION	mm
Piston dia. at right angles to pin bore and at 18 mm from base of skirt	144.808 to 144.832
Piston pin bore dia. in piston	55.002 to 55.008
Piston pin dia.	54.982 to 54.990
Ring groove width in piston: — Top groove — 2nd groove — Bottom groove	3.705 to 3.735 3.040 to 3.060 6.030 to 6.050
Ring thickness: — Top compression ring, double taper chromium plated — 2nd compression ring, straight — Oil scraper ring, slotted, spring loaded	3.575 to 3.595 2.978 to 2.990 5.978 to 5.990
Piston fit in sleeve: — Clearance	0.168 to 0.222
Piston pin clearance in piston	0.012 to 0.026
Ring clearance in piston: — Top compression ring, double taper chromium plated — Second compression ring, straight — Oil scraper ring	0.110 to 0.160 0.050 to 0.082 0.040 to 0.072
Ring gap in sleeve: — Top compression ring, double taper chromium plated — Second compression ring, straight — Oil scraper ring	0.40 to 0.60 0.55 to 0.75 0.40 to 0.60
Piston weight	3570 ± 15 g

**CRANKSHAFT - BEARINGS**

DESCRIPTION	mm
Main journal dia.	112,975 to 112,995
Main bearing housing bore dia.	118,000 to 118,022
Main bearing thickness	2,460 to 2,469
Main bearing undersize range	0 127-0 254-0 508-0 762-1 016
Crankpin dia.	94 232 to 94 252
Main journal clearance in bearing	0 067 to 0 127
Center main journal width	50,300 to 50 350
Center main bearing housing width over thrust washer faces	43 324 to 43,372
Center main bearing housing width over thrust washers	50,080 to 50 230
Standard thrust washer thickness	3 378 to 3 429
0.127 mm oversize thrust washer thickness	3 505 to 3 556
Crankshaft end float at center main bearing	0 070 to 0 270

**CYLINDER HEAD**

DESCRIPTION	mm
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
Valve seat angle. — Inlet — Exhaust	60° 45°
Valve face angle: — Inlet — Exhaust	60° + 15' 45° + 15'
Valve seat O.D.: — Inlet — Exhaust	53 172 to 53 202 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 — Exhaust	0 142 to 0 202 0,111 to 0,161
Valve seat I.D.: — Inlet — Exhaust	53 000 to 53,030 47 000 to 47 025
Valve fitted depth in cylinder head	0.3 to 0 7

**VALVE SPRINGS**

DESCRIPTION	mm
Spring height under $45 \pm 2,5$ kg	57 5
Spring height under $80 \pm 4$ kg	46 5

## VALVE GEAR

DESCRIPTION	mm
Bushing fitted I.D. after reaming:	
— Front	70 570 to 70 620
— Front intermediate	71 070 to 71 120
— Center	71 570 to 71 620
— Rear intermediate	72.070 to 72.120
— Rear	72.570 to 72 620
Camshaft journal dia.:	
— Front	70 470 to 70 500
— Front intermediate	70 970 to 71 000
— Center	71 470 to 71 500
— Rear intermediate	71 970 to 72.000
— Rear	72.470 to 72,500
Camshaft journal clearance in bushes	0.070 to 0.150
Cam lift - Intake and exhaust	8 210
Tappet housing bore dia.	26 000 to 26.025
Tappet O.D.	25.927 to 25 960
Tappet clearance in housing	0 040 to 0 098
Rocker shaft dia.	23 979 to 24 000
Injection pump drive shaft support bushing housing dia.	70.879 to 70 909
Injection pump drive shaft support bushing housing O.D.	70.970 to 71 000
Bushing interference fit in housing	0 061 to 0 121
Bushing fitted I.D. after reaming	65 030 to 65.060
Injection pump drive shaft dia.	64 970 to 65.000
Bushing-to-drive shaft clearance	0.030 to 0 090

## OIL PUMP

DESCRIPTION	mm
Drive shaft housing fit in pump dia	26 065 to 26.097
Pin seat dia for driven gear in pump	25.965 to 25 968
Drive shaft dia on cover	26 065 to 26 097
Pin seat dia for driven gear in cover	25.865 to 25.885
Driving gear I D	25.965 to 25.986
Drive and driven gears I D	25.972 to 25.993
Drive shaft O D	26 022 to 26 035
Driven gear pin O D	25 918 to 25 942
Drive shaft housed in pump casing - cover clearance	0 030 to 0 075
Drive shaft interference fit in drive gear	0 036 to 0 070
Drive shaft interference fit in driving gear	0 029 to 0 063
Driven gear pin - pump housing clearance	0 023 to 0.066
Driven gear pin interference fit in cover housing	0.033 to 0.077
Driven gear pin - driven gear clearance	0.030 to 0.075
Clearance among driving gear, driven gear, pump casing	0 060 to 0 136
Clearance among driving gear driven gear cover	0.020 to 0.105
Driving side - driven side tooth clearance	0 10

## OIL PRESSURE BOOST VALVE

DESCRIPTION	mm
Oil pressure relief valve - seat clearance	0 016 to 0 061
Relief valve opening pressure	4 5 Kg/cm <sup>2</sup>

**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	<table border="0"> <tr> <td>{ upper</td> <td>164 000 to 164 040</td> </tr> <tr> <td>{ lower</td> <td>158 500 to 158 540</td> </tr> </table>	{ upper	164 000 to 164 040	{ lower	158 500 to 158 540						
{ upper	164 000 to 164 040										
{ lower	158 500 to 158 540										
Sleeve pilot dia.	<table border="0"> <tr> <td>{ upper</td> <td>164 003 to 164 028</td> </tr> <tr> <td>{ lower</td> <td>158 461 to 158 486</td> </tr> </table>	{ upper	164 003 to 164 028	{ lower	158 461 to 158 486						
{ upper	164 003 to 164 028										
{ lower	158 461 to 158 486										
Sleeve interference fit in block	<table border="0"> <tr> <td>{ upper</td> <td>- 0.028 to + 0.037</td> </tr> <tr> <td>{ lower</td> <td>0.014 to 0.079</td> </tr> </table>	{ upper	- 0.028 to + 0.037	{ lower	0.014 to 0.079						
{ upper	- 0.028 to + 0.037										
{ lower	0.014 to 0.079										
Sleeve length	261 500 to 262 500										
Camshaft bush housing bore dia	<table border="0"> <tr> <td>{ front</td> <td>76 480 to 76 520</td> </tr> <tr> <td>{ front intermediate</td> <td>76 980 to 77 020</td> </tr> <tr> <td>{ center</td> <td>77 480 to 77 520</td> </tr> <tr> <td>{ rear intermediate</td> <td>77 980 to 78 020</td> </tr> <tr> <td>{ rear</td> <td>78.480 to 78 520</td> </tr> </table>	{ front	76 480 to 76 520	{ front intermediate	76 980 to 77 020	{ center	77 480 to 77 520	{ rear intermediate	77 980 to 78 020	{ rear	78.480 to 78 520
{ front	76 480 to 76 520										
{ front intermediate	76 980 to 77 020										
{ center	77 480 to 77 520										
{ rear intermediate	77 980 to 78 020										
{ rear	78.480 to 78 520										
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- 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										
Piston pin clearance in small en bushing	0 025 to 0 048										
Crankpin clearance in big end half bearing	0 060 to 0 120										
Max. connecting rod misalignment, 125 mm from axis	0 025										
<b>PISTONS - PINS - RINGS</b>											
Standard piston dia. at right angle to pin bore, 21 mm from skirt base	144.813 to 144.827										
Gudgeon pin dia. in piston	55 020 to 55 037										
Gudgeon pin dia	54 982 to 54 990										
Ring groove width in piston	<table border="0"> <tr> <td>{ Top groove, double taper measured on 142 mm bore dia</td> <td>3 705 to 3 735</td> </tr> <tr> <td>{ 2nd groove</td> <td>3 060 to 3 080</td> </tr> <tr> <td>{ Bottom groove</td> <td>6 030 to 6.050</td> </tr> </table>	{ Top groove, double taper measured on 142 mm bore dia	3 705 to 3 735	{ 2nd groove	3 060 to 3 080	{ Bottom groove	6 030 to 6.050				
{ Top groove, double taper measured on 142 mm bore dia	3 705 to 3 735										
{ 2nd groove	3 060 to 3 080										
{ Bottom groove	6 030 to 6.050										
Ring thickness	<table border="0"> <tr> <td>{ Top compression ring, double taper, chromium plated, measured on 142 mm bore dia</td> <td>3 575 to 3 595</td> </tr> <tr> <td>{ 2nd compression ring, straight</td> <td>2 978 to 2 990</td> </tr> <tr> <td>{ Oil scraper ring</td> <td>5 978 to 5 990</td> </tr> </table>	{ Top compression ring, double taper, chromium plated, measured on 142 mm bore dia	3 575 to 3 595	{ 2nd compression ring, straight	2 978 to 2 990	{ Oil scraper ring	5 978 to 5 990				
{ Top compression ring, double taper, chromium plated, measured on 142 mm bore dia	3 575 to 3 595										
{ 2nd compression ring, straight	2 978 to 2 990										
{ Oil scraper ring	5 978 to 5 990										

DESCRIPTION	mm	
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	0.050 to 0.082
	{ Oil scraper	0.040 to 0.072
Ring gap in sleeve	{ Top compression ring, double taper, chromium plated	0.040 to 0.060
	{ 2nd compression ring, straight	0.070 to 0.102
	{ Oil scraper	0.040 to 0.060
Piston weight	3390 ± 17.5 g	

**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)	0.127-0.254-0.508-0.762-1.016
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	
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

DESCRIPTION	mm				
Max valve stem distortion over one complete revolution with dial gauge stylus in midstem position	0.03				
Valve seat interference fit in head	<table border="0"> <tr> <td style="border-right: 1px solid black;">Inlet</td> <td>0.142 to 0.202</td> </tr> <tr> <td style="border-right: 1px solid black;">Exhaust</td> <td>0.111 to 0.161</td> </tr> </table>	Inlet	0.142 to 0.202	Exhaust	0.111 to 0.161
Inlet	0.142 to 0.202				
Exhaust	0.111 to 0.161				
Valve seat ID	<table border="0"> <tr> <td style="border-right: 1px solid black;">Inlet</td> <td>53.000 to 53.030</td> </tr> <tr> <td style="border-right: 1px solid black;">Exhaust</td> <td>47.000 to 47.025</td> </tr> </table>	Inlet	53.000 to 53.030	Exhaust	47.000 to 47.025
Inlet	53.000 to 53.030				
Exhaust	47.000 to 47.025				
Valve fitted deep in cylinder head	<table border="0"> <tr> <td style="border-right: 1px solid black;">Inlet</td> <td>0.1 to 0.45</td> </tr> <tr> <td style="border-right: 1px solid black;">Exhaust</td> <td>0.3 to 0.75</td> </tr> </table>	Inlet	0.1 to 0.45	Exhaust	0.3 to 0.75
Inlet	0.1 to 0.45				
Exhaust	0.3 to 0.75				
<b>VALVE SPRINGS</b>					
Released spring height	~74				
Spring height under $45 \pm 2.5$ kg	57.5				
Spring height under $80 \pm 4$ kg	46.5				
<b>VALVE GEAR</b>					
Camshaft bush housing fitted in engine block					
<input type="checkbox"/> front	76.480 to 76.520				
<input type="checkbox"/> front intermediate	76.980 to 77.020				
<input type="checkbox"/> center	77.480 to 77.520				
<input type="checkbox"/> rear intermediate	77.980 to 78.020				
<input type="checkbox"/> rear	78.480 to 78.520				
Bush interference fit in engine block	There should be always interference				
Bush fitted ID 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	72.570 to 72.620				
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	72.470 to 72.500				
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 OD (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				
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 OD	70.970 to 71.000				
Bushing interference fit in housing	0.061 to 0.121				

DESCRIPTION	mm
Bush fitted I D after reaming	65 030 to 65 060
Injection pump drive shaft dia	64 970 to 65 000
Bush - drive shaft clearance	0 03 to 0 09
<b>OIL PUMP</b>	
Drive shaft housing fit in pump dia	26 065 to 26 097
Pin seat dia for driven gear in pump	25 965 to 25 986
Drive shaft dia on cover	26 065 to 26 097
Pin seat dia for driven gear in cover	25 865 to 25 885
Driving gear I D	25 965 to 25 986
Drive and driven gears I D	25 972 to 25 993
Drive shaft O D.	26.022 to 26 035
Driven gear pin O D	25 918 to 25 942
Drive shaft housed in pump casing - cover clearance	0 030 to 0 075
Drive shaft interference fit in drive gear	0 036 to 0 070
Drive shaft interference fit in driving gear	0 029 to 0 063
Driven gear pin - pump housing clearance	0 023 to 0 066
Driven gear pin interference fit in cover housing	0 033 to 0 077
Driven gear pin - driven gear clearance	0 030 to 0 075
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
<b>OIL PRESSURE BOOST VALVE</b>	
Oil pressure relief valve - seat clearance	0 016 to 0 061
Relief valve opening pressure	4 5 kg/cm <sup>2</sup>
<b>HEAT EXCHANGER RELIEF VALVE</b>	
Relief valve - valve seat clearance	0 016 to 0 061
Heat exchanger relief valve opening pressure	1 6 kg/cm <sup>2</sup>
Relief valve opening on three filter cartridges	1 6 kg/cm <sup>2</sup>

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**FAULT FINDING DIAGNOSIS**


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TROUBLE	POSSIBLE CAUSE	REMEDY
<b>The engine does not start</b>	Battery charged partially	Check batteries and charge them 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 sealing
	Foreign matter or water in fuel pipings	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.
	Partially ineffective radiator	Wash out possible scaling in compliance with the instructions given for the type of scale remover used Detect and repair possible leaks from radiator hoses

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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	Top-up radiator with water
	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
<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
	Too short control tie rods between accelerator pedal and governor lever	Adjust tie rods so that the control lever can reach its max range position
Incorrect adjustment of injection pump peak capscrew or of control rod stop	Adjust stops correctly	
<b>The engine knocks abnormally</b>	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 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 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	
<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 – Piston rings stuck – Cylinder sleeve worn-out – 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>3) Blue, grey/blue, or grey/white smoke</b>	Thermostarter electrovalve and resistor blocked in open position (simultaneously)	Replace electrovalve and thermostat
	Thermostarter resistor blocked in open position	Replace resistor
<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

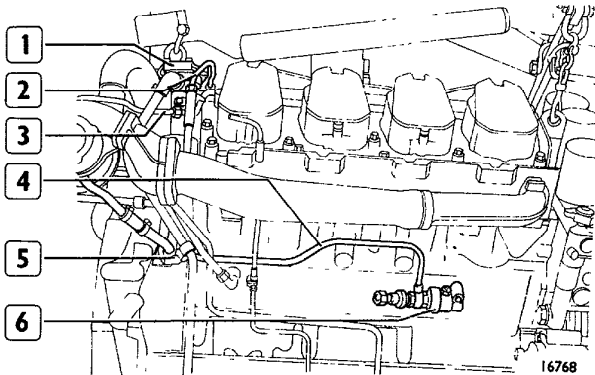
TROUBLE	POSSIBLE CAUSE	REMEDY
<b>The pump does deliver fuel</b>	Plunger tappets may be seized	Remove part and repair it (if failure is minor), if necessary, replace it
	Plunger seized	Change defective pumping element, as barrels and piston are not interchangeable
	Delivery valves seized	If failure is 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
	Cam lobe 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>	Electromagnet for excess fuel device	Check electric contacts on control button and on that same electromagnet
<b>Injection pump Difficult starting</b>	Thermo-starter	Remove thermo-starter from induction manifold and check its efficiency
	Solenoid valve for the inlet of atmospheric pressure in the thermo-starter reservoir	Check its correct operation
	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 nozzle, 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 oil 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	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
	Defective advance variator	Overhaul or replace variator

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.
<b>Excessive fuel consumption</b>	Fuel leakages.	Check pipes and joints.
	Dirty air cleaner.	Through the pilot lamp in the cab 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

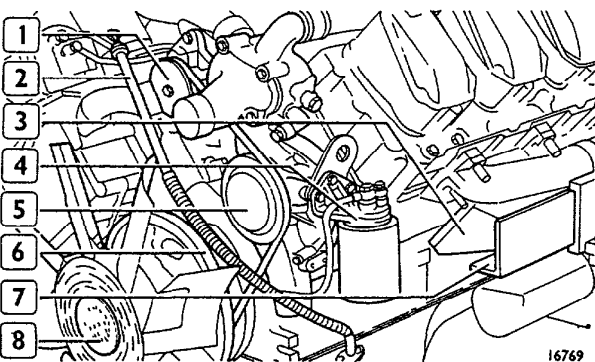
**ENGINE DISASSEMBLY**

**FIGURE 16**



Before securing engine to revolving stand 322230, disconnect turbocharger lubrication pipe (4) from lines (3 and 2), from oil filter housing (6), and draw it out from oil vapour condenser (1) and oil piping flange (5)

**FIGURE 17**



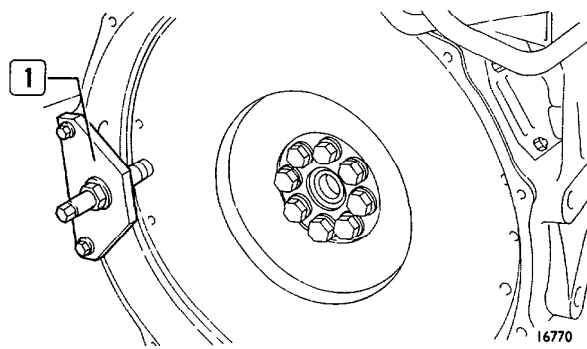
Secure engine to stand 322230 (7) using brackets 361002/9 (3).

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

From front side of engine detach:

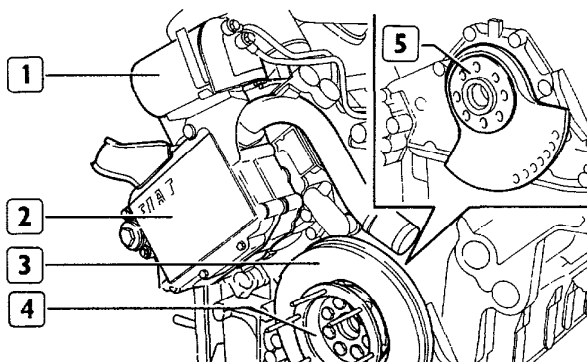
- Viscostatic fan (8) and position it vertically so as to avoid possible damage.
- Drive belt pulley (6).
- Alternator (1) and relevant drive belt.
- Oil dipstick hose (2)
- Support (4) with corrosion proofing filter
- Water pump (5) with its thermostats.

**FIGURE 18**



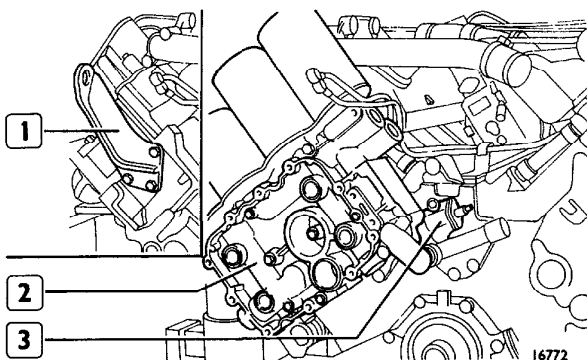
Lock crankshaft rotation using tool 360351 (1) positioned as indicated.

**FIGURE 19**



Remove viscostatic fan flange (4), damper flywheel (3), counterbalance (5); fuel filter (1), heat exchanger (2)

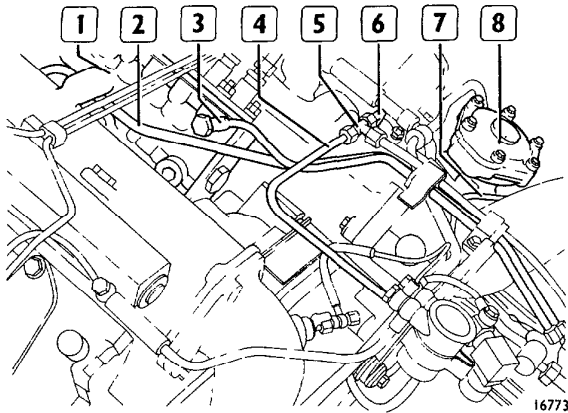
**FIGURE 20**



Remove

- Oil filter housing (2) with filters.
- Engine tachometer control (3).
- Bracket (1) for engine lift.

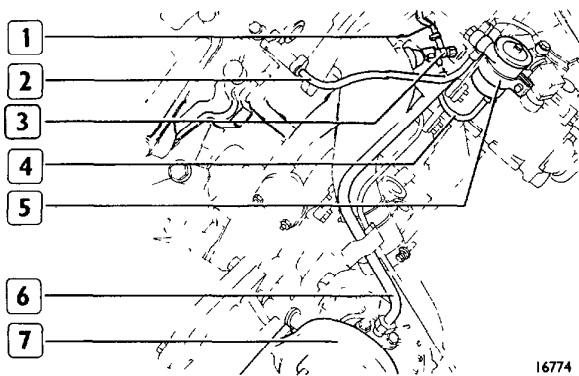
FIGURE 21



From rear engine side, disconnect.

- From injection pump (1) fuel delivery line (2) and fuel return line (3)
- From pipe union (5) fuel lines (4 and 6)
- From oil vapour condenser (8) oil piping (7)

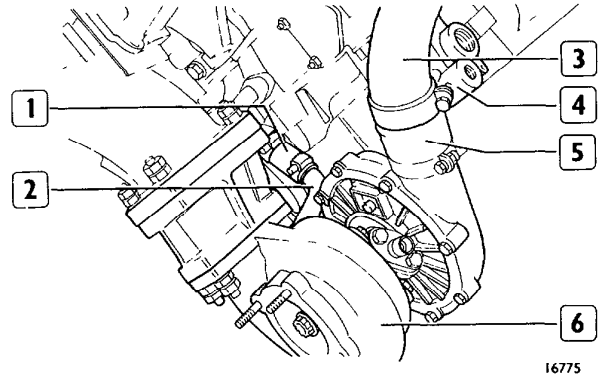
FIGURE 22



Disconnect

- Injector fuel leak-back line (2)
  - From thermostarter (3) fuel lines (1 and 4)
  - From turbocharger (7) oil inlet line (6).
- From flywheel cover disconnect tank bracket (5) of thermostarter reservoir with all its lines

FIGURE 23

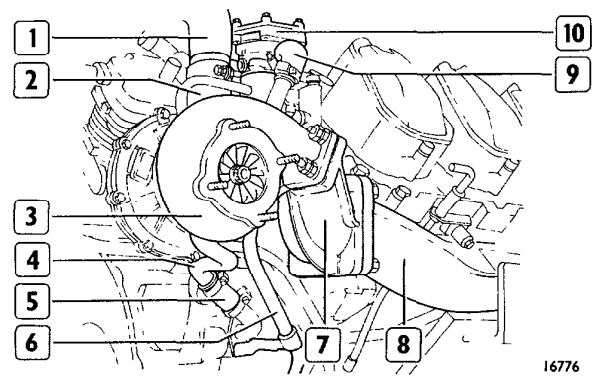


Loosen hose clamps (1) for oil outlet pipe (2) from turbocharger (6), and hose (5) connecting turbocharger to intake manifold (3)

Detach exhaust manifold, and housing complete with turbocharger (6)

From flywheel housing disconnect the power steering oil pump (4)

FIGURE 24

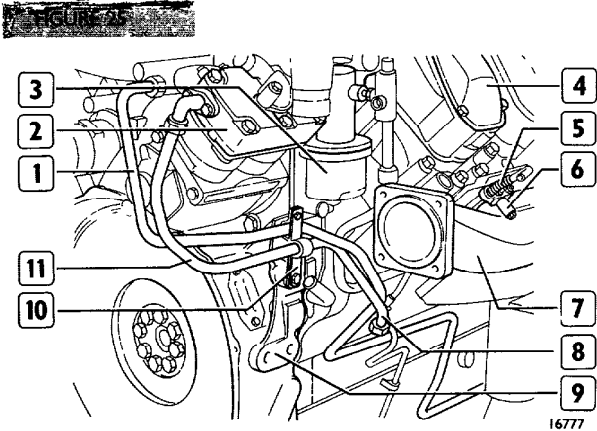


From the rear right side of engine, disconnect from engine block the bracket securing oil vapour breather pipe (6)

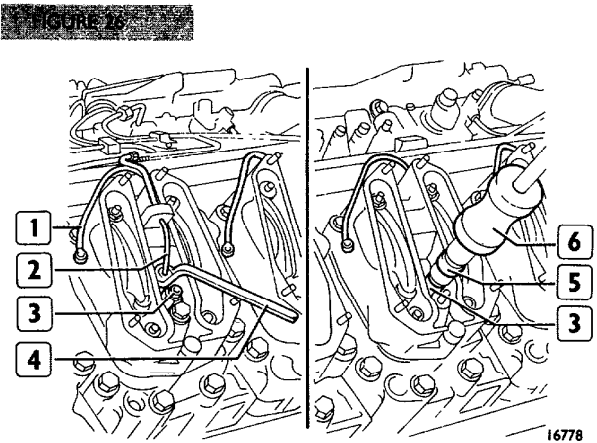
Loosen hose clamps securing the turbocharger (3) sleeve (2) to intake manifold (1), sleeve (9) connecting oil vapour breather pipe (6) to oil vapour condenser (10), and sleeve (5) connecting the turbocharger (3) oil outlet pipe (4) to the flywheel housing line

From exhaust manifold (8) disconnect housing (7) with turbocharger (3).

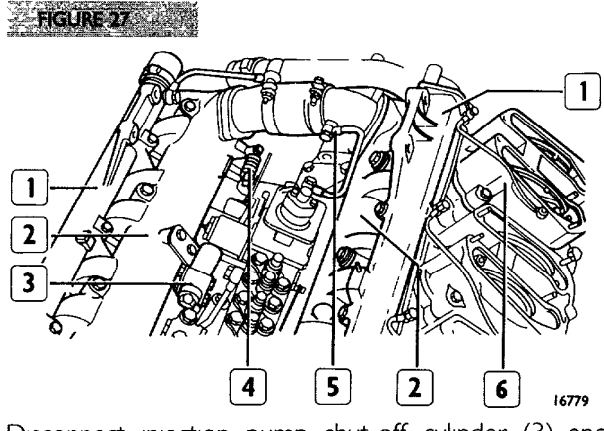




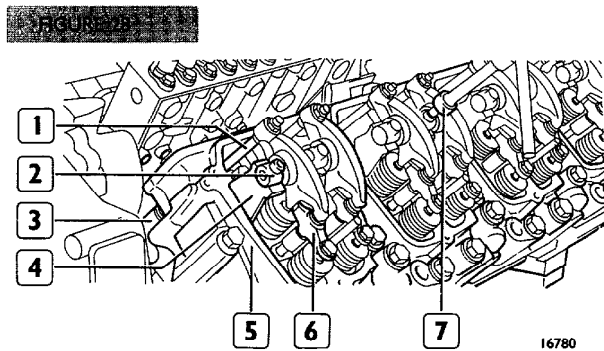
- Disconnect compressed air delivery pipe (1) from compressor (2)  
 Disconnect outlet cooling fluid pipe (11) from compressor (2) and union (8).  
 Detach pipes (1 and 11) from flywheel housing (9) after removing.
- Retainer brackets (10).
  - Compressor (2) from flywheel housing (9) after loosening the hose clamp securing the fluid pipe sleeve
  - Oil vapour condenser (3)
  - Exhaust manifold from retainer block (6) and rod (5) controlling cooling fluid drain cock
  - Exhaust manifolds (7) with gaskets.
  - Tappet housing covers (4).



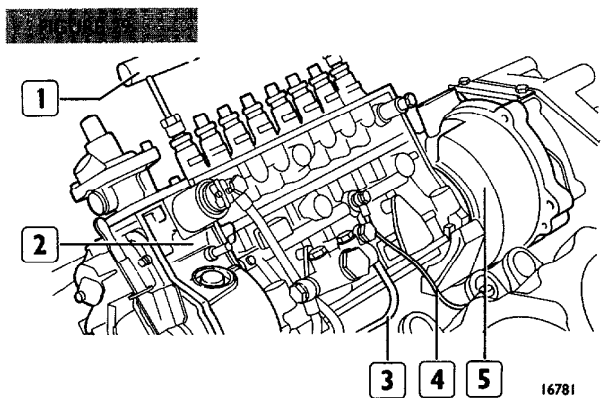
- Disconnect:
- Fuel leak-back lines (1) from injectors (3)
  - Fuel delivery lines (2) from injectors (3) and injection pump, using wrench 352120 (4).
  - Injectors (3) from cylinder heads, using puller 340206/801 (6) and puller 342135 (5).



- Disconnect injection pump shut-off cylinder (3) and return spring (4).  
 Disconnect air line (5) controlling LDA device  
 From cylinder heads detach: cooling fluid manifolds (1), intake manifold (2), rocker housing (6)

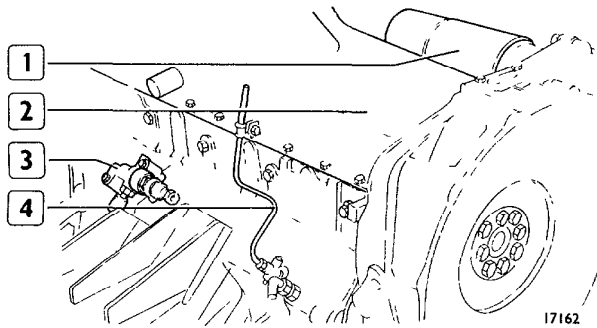


- Disconnect:
- Rocker shafts (2) from housings (4), removing cap-screws by wrench 389856 (7).
  - Housings (4), bridges (6) and rods (1) from cylinder heads (5).
- Disconnect cylinder head (5) and withdraw pushrod (1) sleeves (3).



- Disconnect inlet (4) and outlet (3) oil pipes from injection pump (2)  
 Install fixture (1) on injection pump (2) unions; disconnect pump from engine removing the screws which secure it to their supports and the screws which secure flange housing (5) to flywheel housing.

FIGURE 30

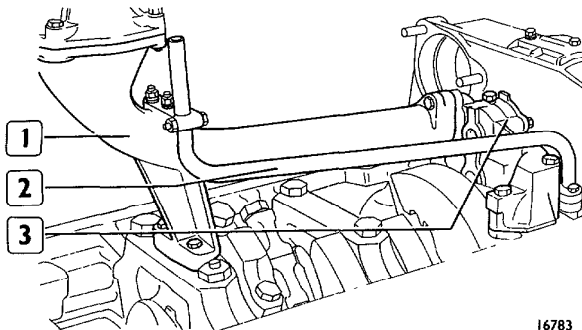


From engine disconnect:

- Oil sump (2)
- Support (3)
- Cooling fluid drain pipe (4)
- Starter (1)

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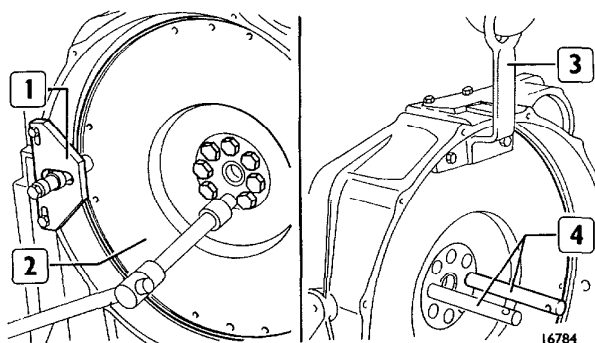
FIGURE 31



Disconnect oil pump (3) with attached oil suction (1) and drain pipe (2)

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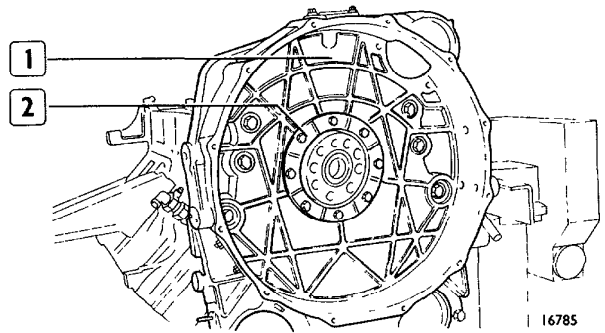
FIGURE 32



Stop crankshaft rotation using tool 360351 (1) and remove the screws securing flywheel (2) to crankshaft. On crankshaft, screw down guide pins 360349 (4), apply bracket 360350 (3) on flywheel (2) and take off this using a hoist.

16784

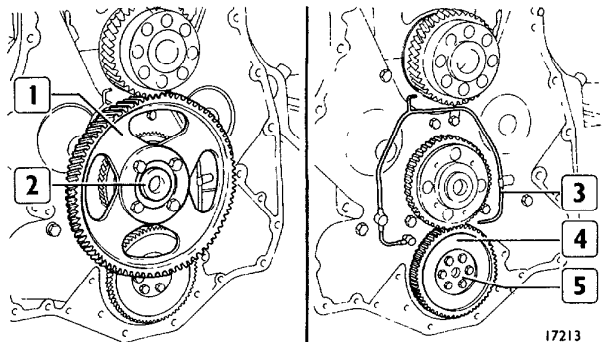
FIGURE 33



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

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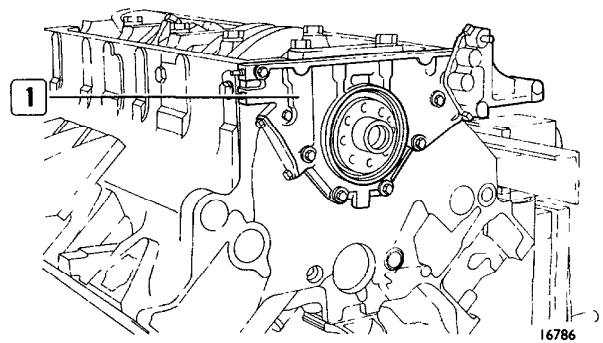
FIGURE 34



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.

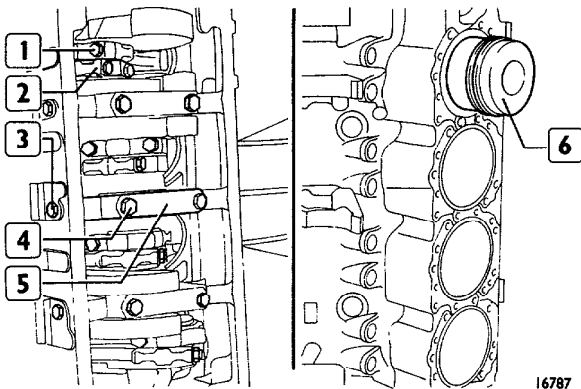
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FIGURE 35



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

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16787

Position engine block vertically.

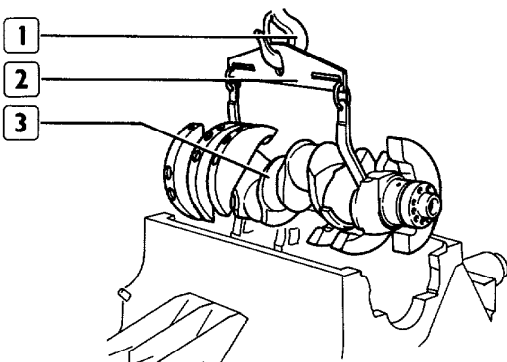
Withdraw pistons as follows:

- Loosen connecting rod cap nuts (1).
- Rotate crankshaft unit 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

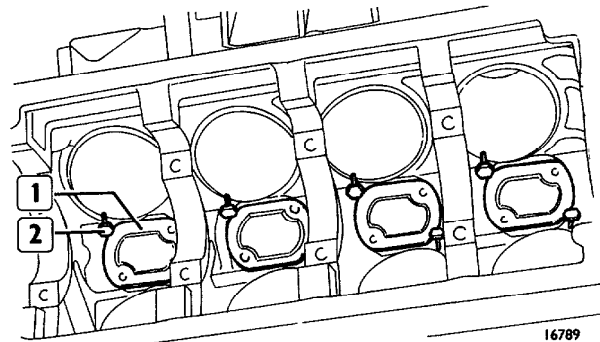
Remove upper (4) and side (3) screws securing main bearing caps to engine block, and withdraw them.

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



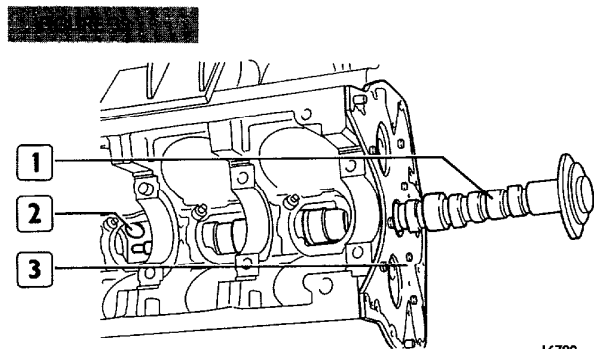
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Using hoist (1) and fixture 360500 (2) installed on crankpins, withdraw crankshaft (3) from engine block



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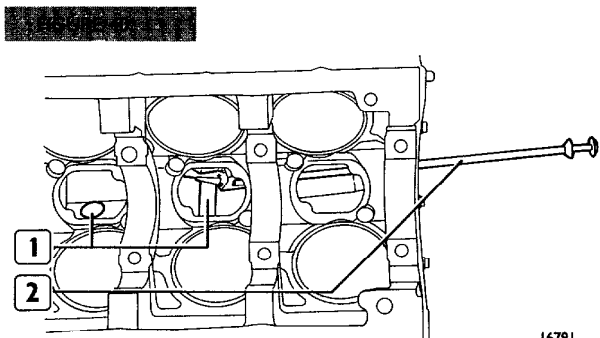
Remove oil catchers (1) and oil spray nozzles (2).



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From engine block remove camshaft (1) taking care not to damage bushings.

Withdraw tappets (2) and take off rear plate (3)

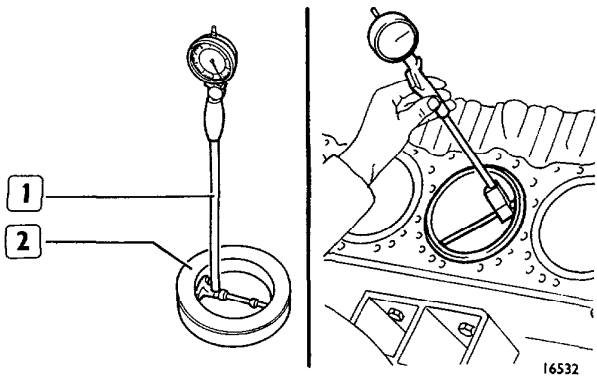


16791

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.

**REPAIR ACTIONS  
ENGINE BLOCK**

**FIGURE 41**

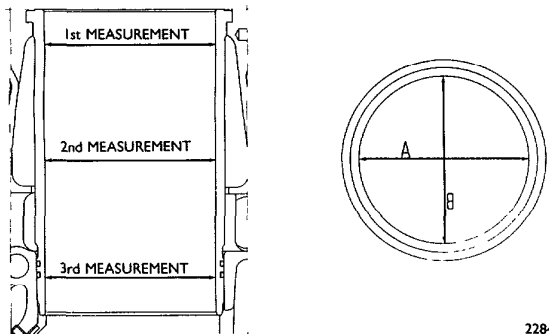


**CHECKS AND MEASUREMENTS**

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

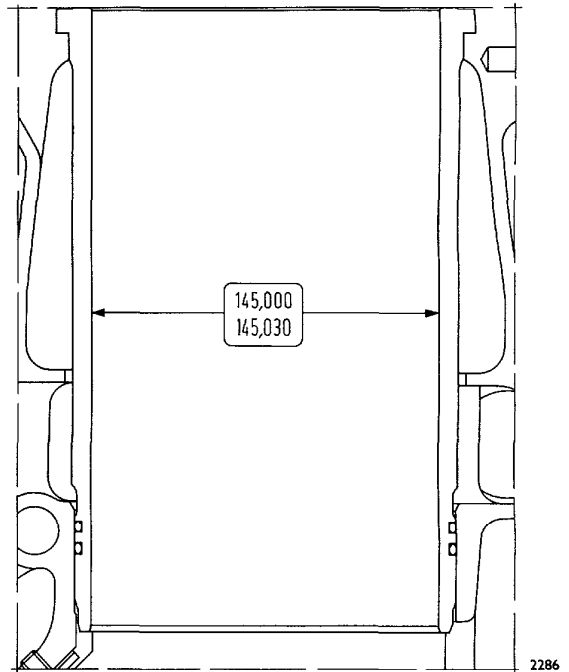
To check cylinder sleeve bore for ovality, taper or wear, use gauge 395687 (1) with attached dial gauge previously set to zero against ring gauge 396149 (2) (145 mm dia.).

**FIGURE 42**



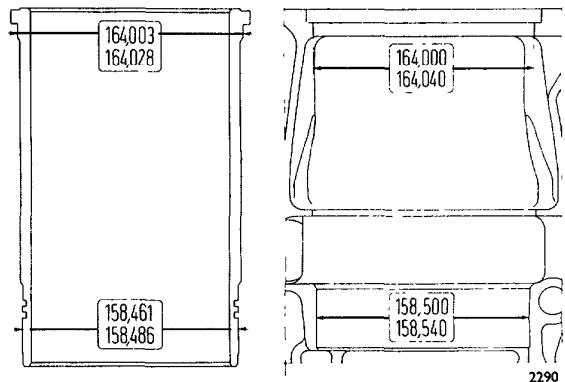
Each sleeve cylinder bore must be measured at three different points on two planes at right angles, as indicated in the diagram. Max wear is usually observed on first measurement level (B axis)

**FIGURE 43**



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

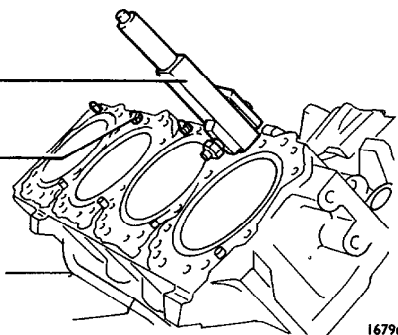
**FIGURE 44**



The above scheme indicates cylinder sleeve bore and O/D. If necessary, cylinder sleeves can be removed and inserted in different seats several times

1

2



16796

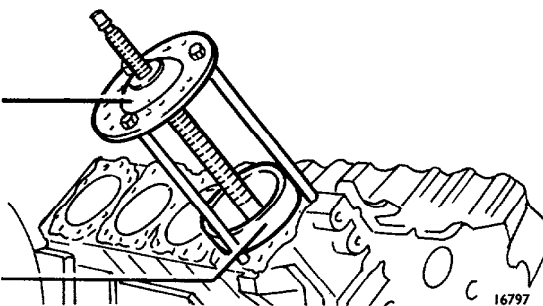
Check engine block face for distortion, using a straight-edge and a feeler

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.

1

2



16797

Take off cylinder sleeves (2) from engine block using plate 360711/14 and tool 360711/35 (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.

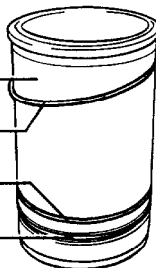
FIGURE 47

1

2

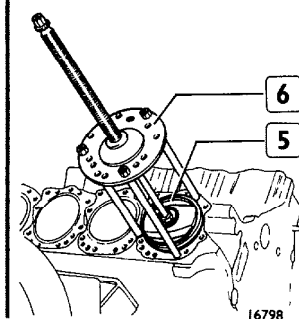
3

4



6

5



16798

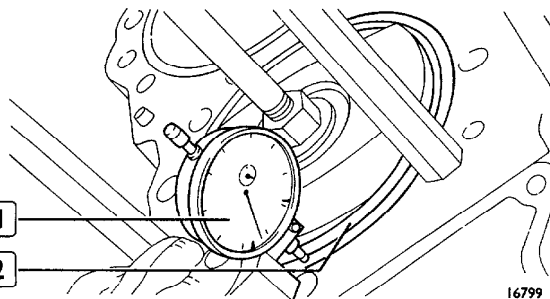
Always replace water seals (3 and 4).

Slide the upper brass sealing ring (2) into cylinder sleeve (1), and lubricate lower sleeve end before inserting it in cylinder through plate 360711/14 (5) and tool 360711/35 (6).

FIGURE 48

1

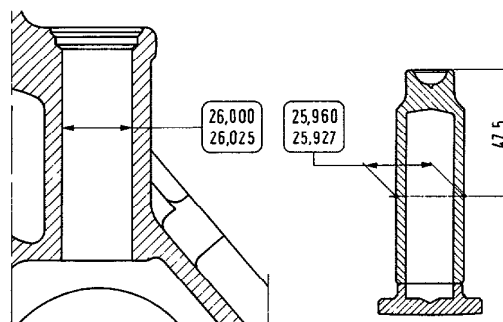
2



16799

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

FIGURE 49



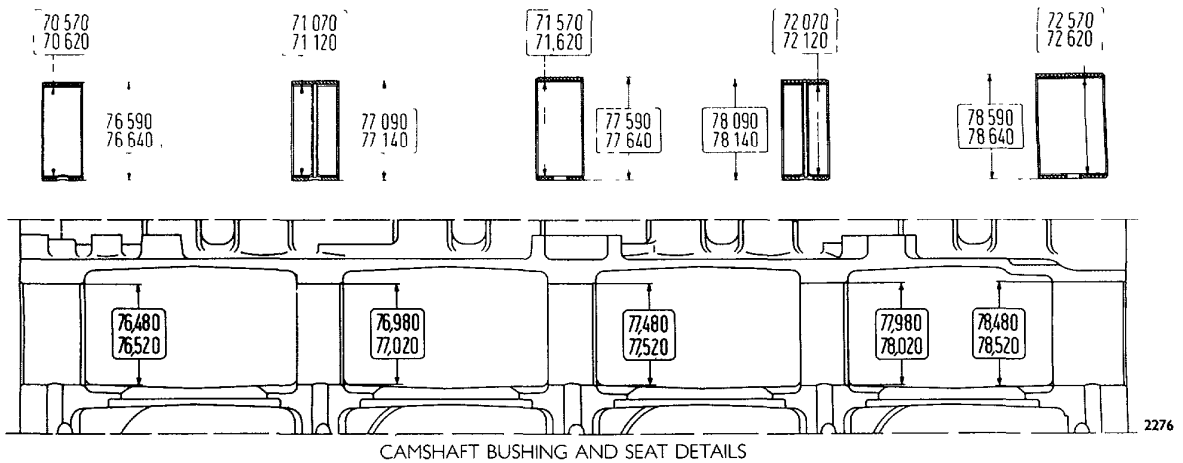
8611

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 zerograde emery paste

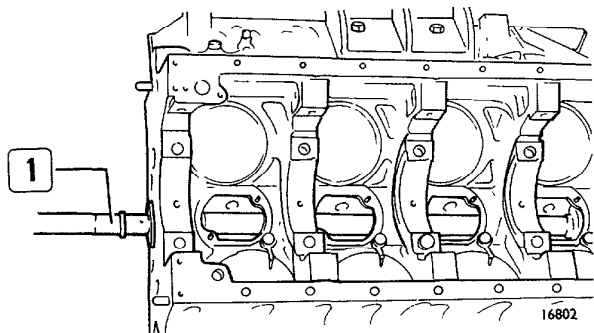
FIGURE 50



CAMSHAFT BUSHING AND SEAT DETAILS

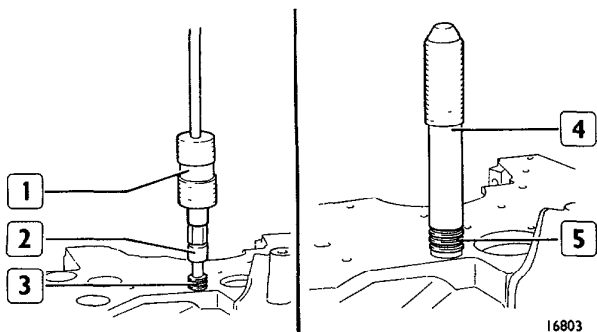
Bushings must be press fitted in their seats. Inside surfaces must be smooth and free from seizure, and should not be worn-out.

FIGURE 51



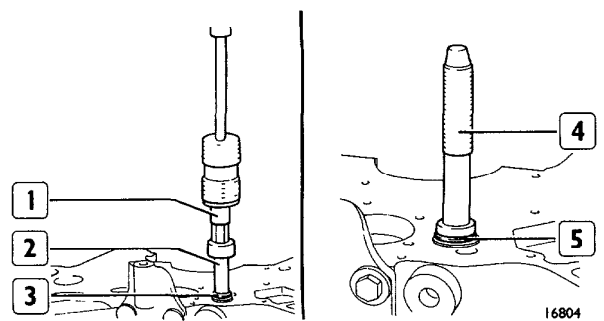
To replace bushing use remover/installer tool 360385 (1).  
Camshaft clearance should be 0.07 to 0.15 mm.

FIGURE 52



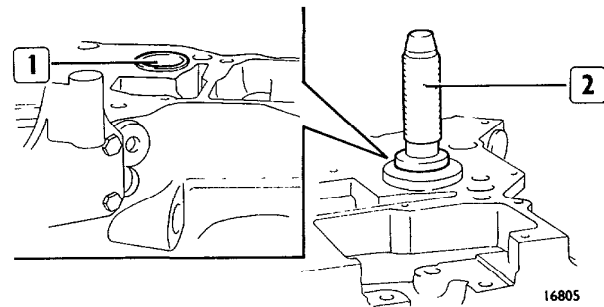
Replace bushing (3) sealing ring (5) of main left oil gallery removing the bushing from engine block by means of remover/installer 340206/801 (1) together with 340207/814 (2). To insert bushing, use suitable remover/installer tool (4).

FIGURE 53



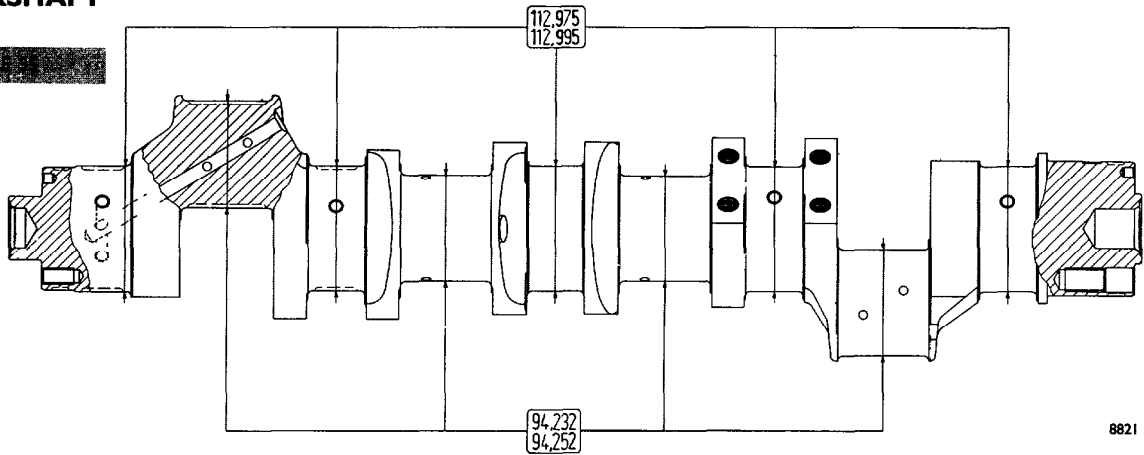
Replace bushing (3) sealing rings (5) of main right oil gallery removing the bushing from engine block by means of remover/installer 340206/801 (1) together with part 340207/815 (2). To again insert bushing, use suitable installer/remover (4).

FIGURE 54



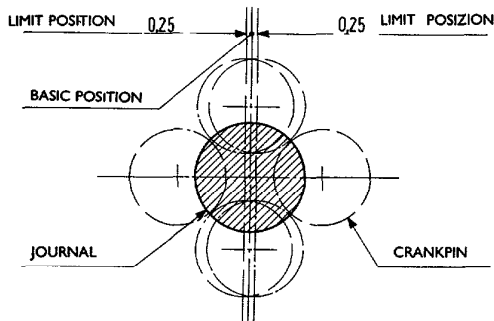
To replace cooling fluid bushing (1), use suitable means for removal. For insertion, use suitable installer (2).

**CRANKSHAFT**



CRANKSHAFT JOURNAL DETAILS

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

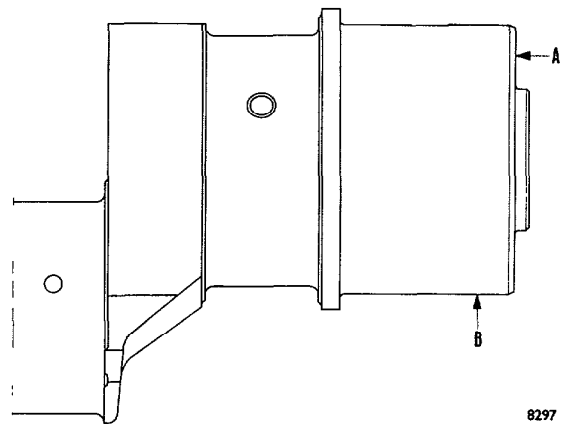


**MAX. ALLOWABLE CLEARANCE ON CRANKPIN ALIGNMENT VS. MAIN JOURNAL**

During crankshaft journal regrinding, 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: 0.254 - 0.508 - 0.762 - 1.016 mm

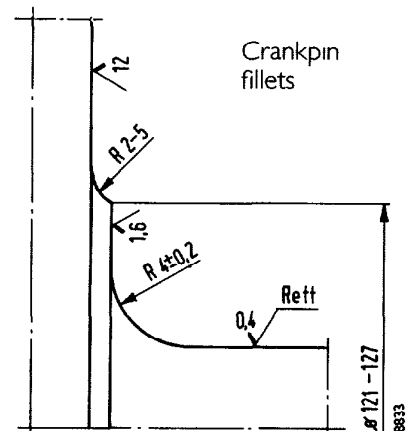
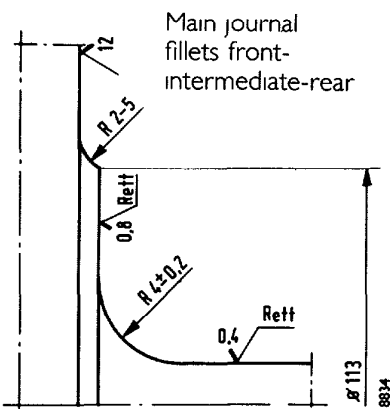
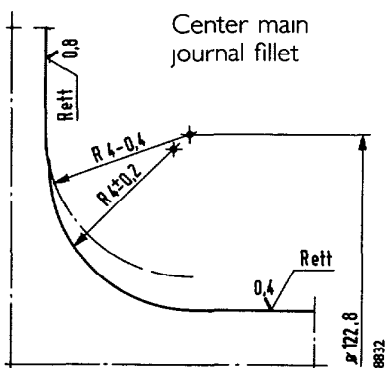
NOTE - Journals must be reground to a same undersize class.



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

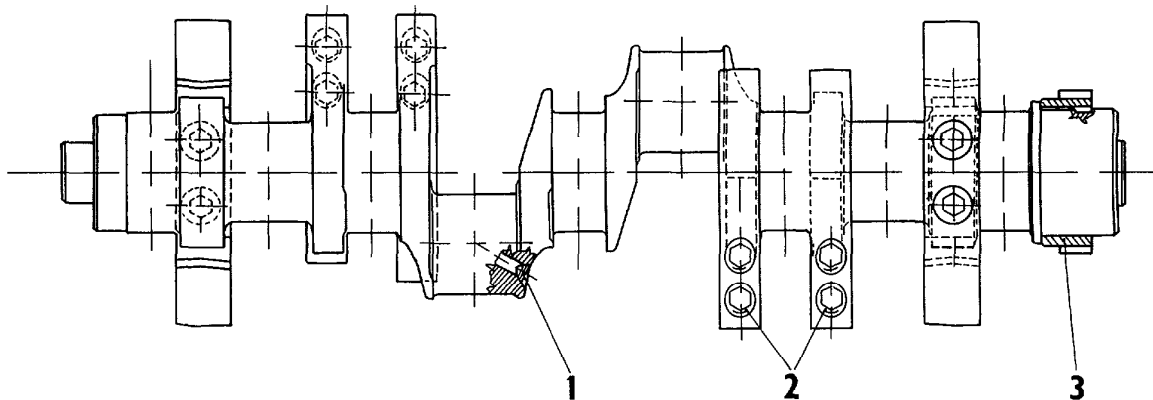
Rotate shaft:

- 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.



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

FIGURE 59



16812

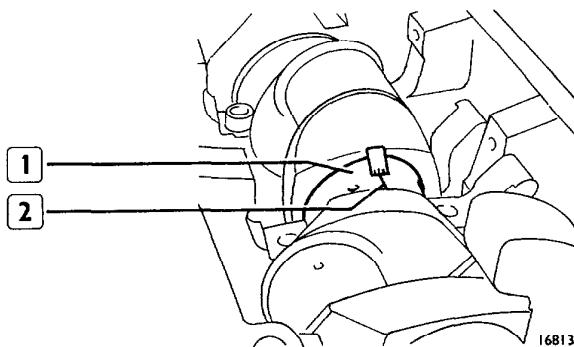
After grinding crankshaft journals, remove oil lines caps (1), dress seats using cutter 394016/12 and spindle 394016, wash oil ducts thoroughly, insert new caps (1) using remover/installer 386012 and caulk them on their seats. Check for cap leaks to a 15 bar pressure (15 kg/cm<sup>2</sup>).

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 UTDM 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.

FIGURE 60



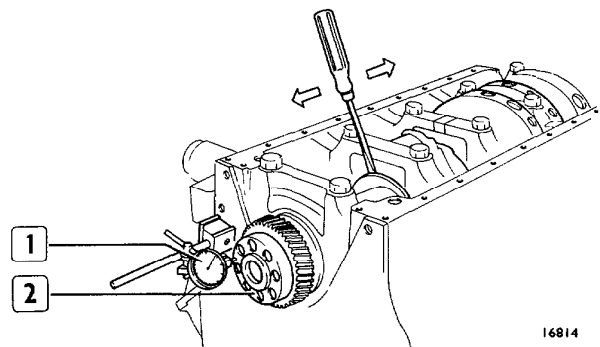
16813

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.

FIGURE 61



16814

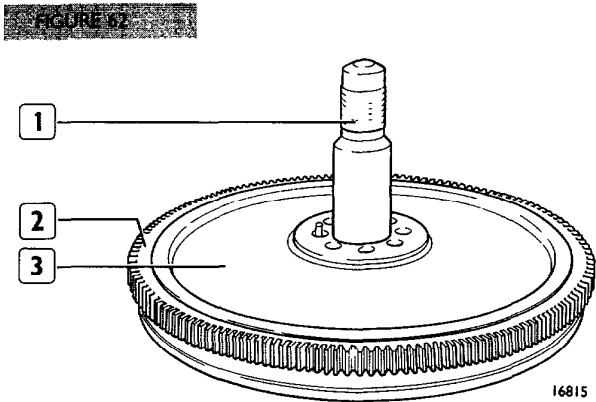
Check of crankshaft (2) thrust clearance (1) is carried out using a magnetic base gauge and operating as indicated in the figure. Standard clearance should be 0.070 to 0.270 mm.

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**

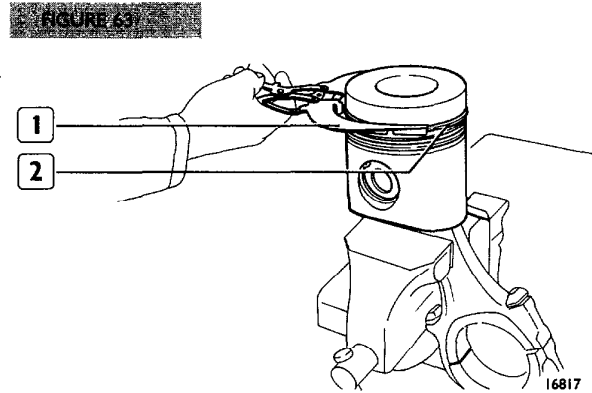


16815

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.

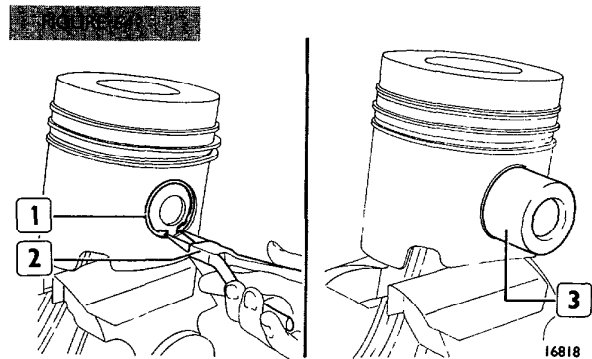
**PISTON - CONNECTING ROD ASSEMBLY**

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

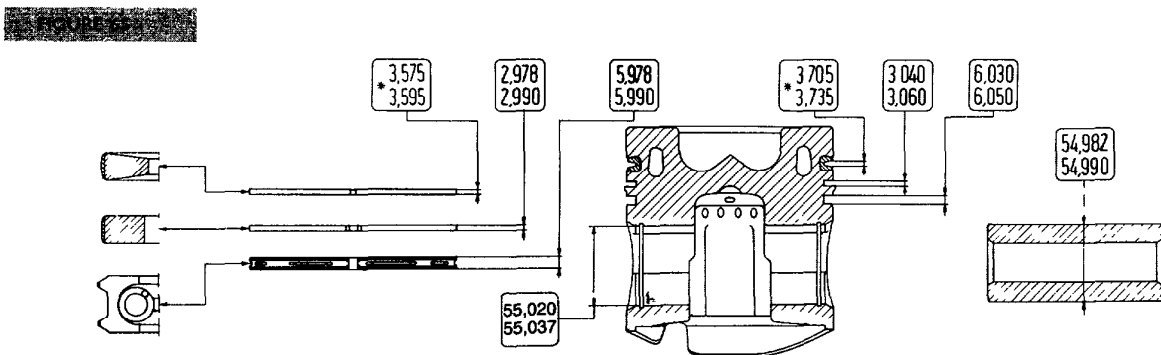
Piston ring (2) removal/insertion by means of pliers 360184 (1).



16818

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

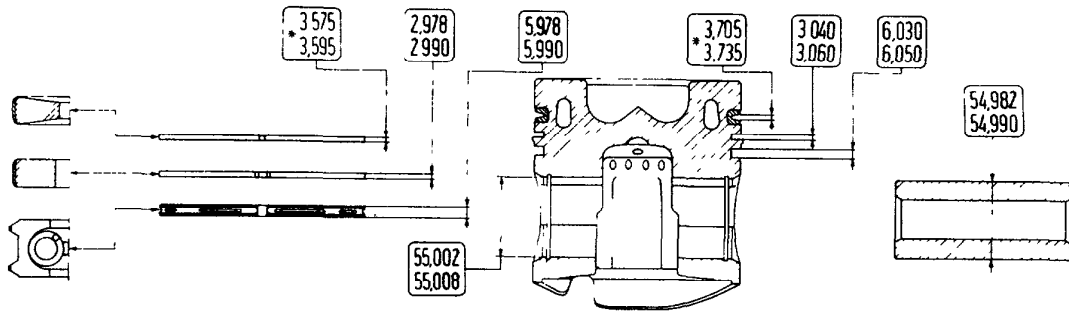
NOTE - Piston - connecting rod fit must be carried out considering that, when the assembly is inserted in engine block, words "LATO POSTERIORE" on piston crown must be positioned towards the rear side of engine, and connecting rod figures must be opposite the figures on engine block.



8653

PISTON, PIN, RING DETAILS

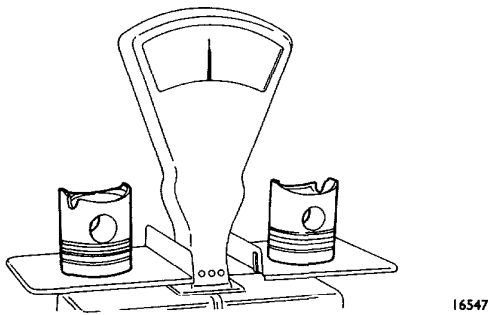
\* Dimension detected on 142 mm dia (8281SI10-SRI10)



PISTON PIN, RING DETAILS

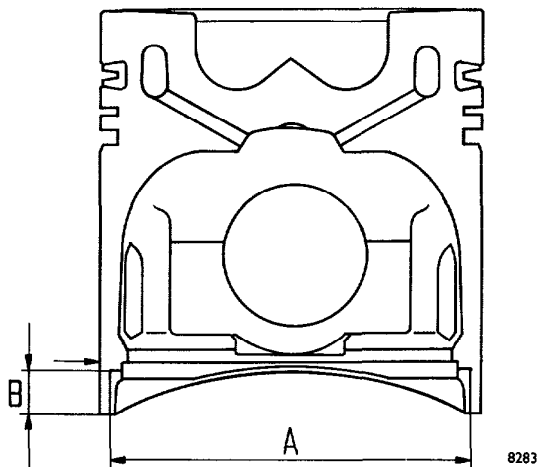
\* Dimension detected on 142 mm dia (8281103)

FIGURE 66



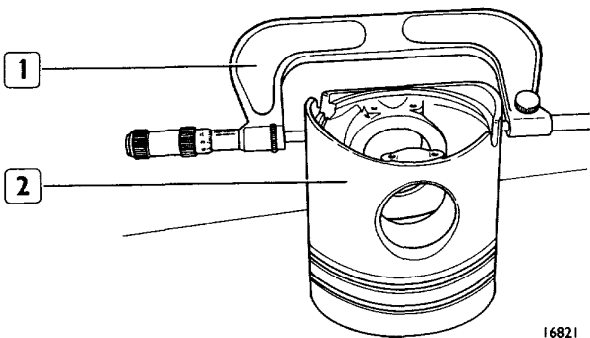
Check for piston weight equalities Allowance is  $\pm 15$  gr

FIGURE 67



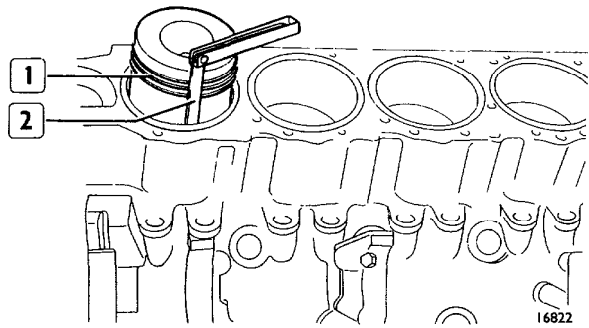
In case of over weight, remove material on diameter A (without exceeding 137 mm) and on depth B (without exceeding 17 mm)

FIGURE 68



With micrometer (1) define clearance of piston diameter (2) Diameter must be read 21 mm from piston skirt

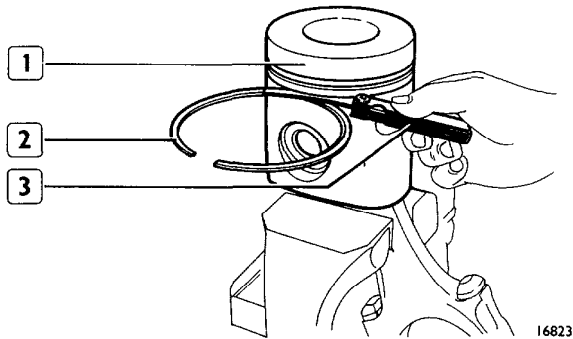
FIGURE 69



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

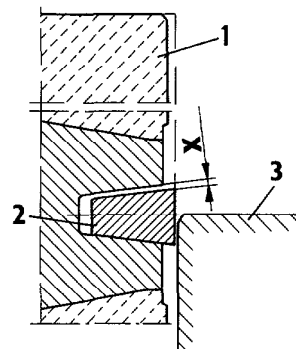
PISTON RINGS

FIGURE 70

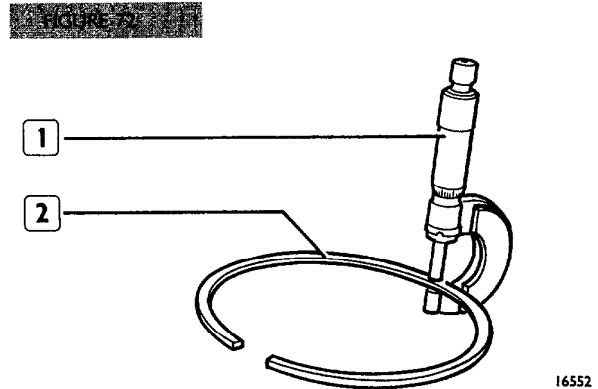


Check clearance between piston rings (2) and relevant seats on piston (1), using feeler (3)

FIGURE 71

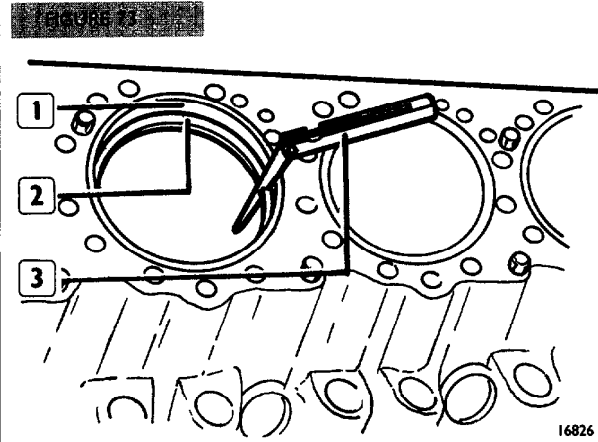


Top compression ring (2) is of double taper type, clearance is measured positioning piston (1) with relevant ring into cylinder sleeve (3) so that the compression ring protrudes half its length from cylinder sleeve



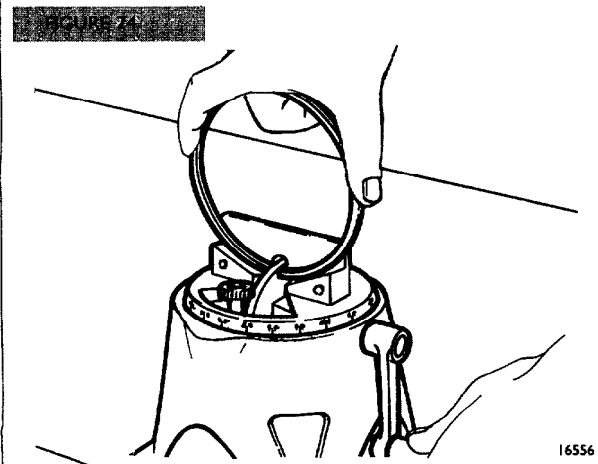
16552

Check ring (2) thickness using micrometer (1).



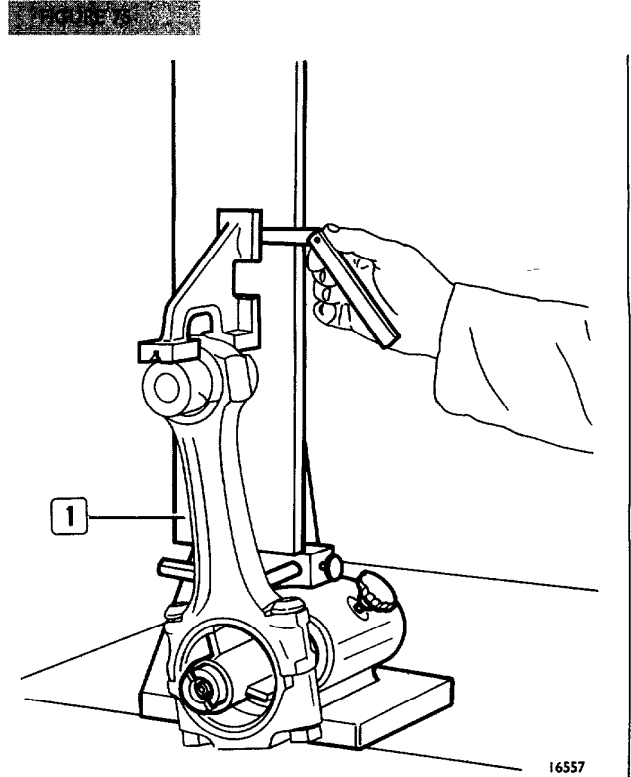
16826

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



16556

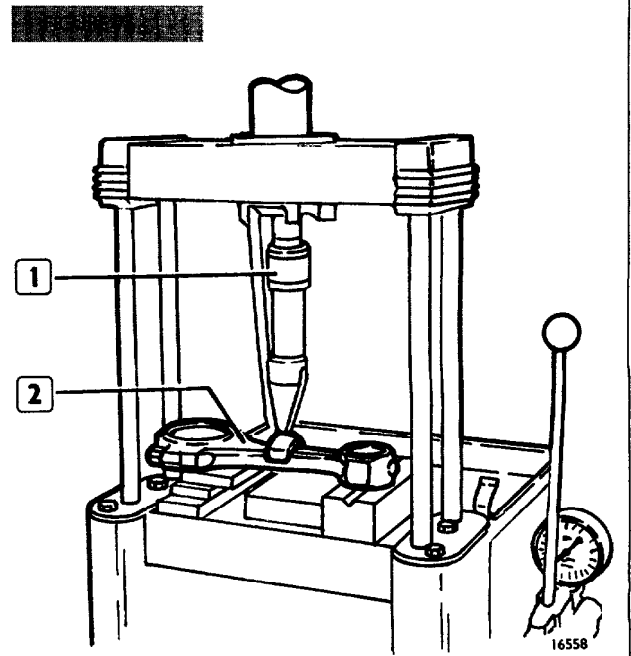
If a distance shorter than the prescribed value is detected, remove the excess material by means of tool 360188, operating as indicated in the figure



16557

Check parallelism of connecting rod axes using tool 395363 (1).

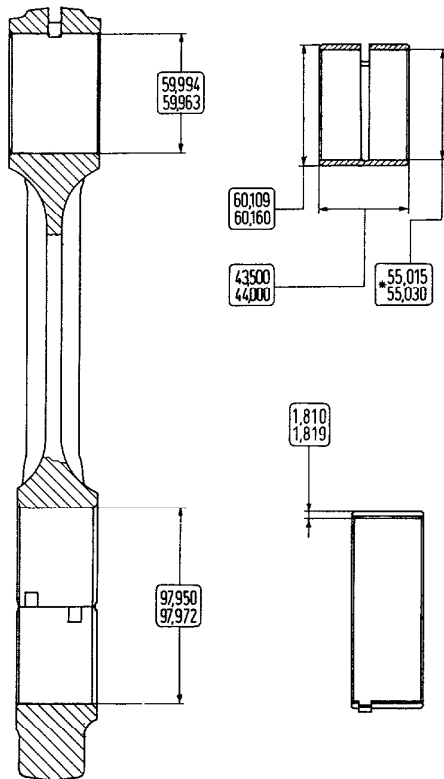
Maximum allowed tolerance is  $\pm 0.025$  mm at 125 mm from the longitudinal connecting rod axis.



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.

FIGURE 77



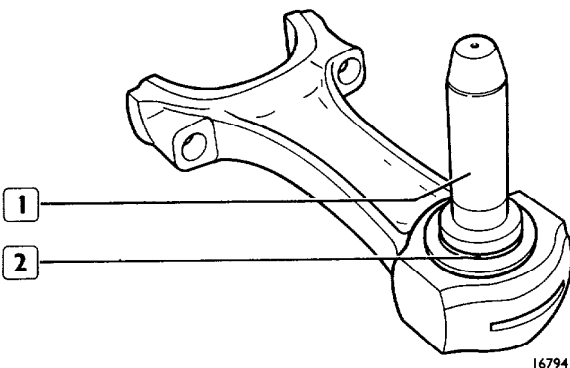
8220

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

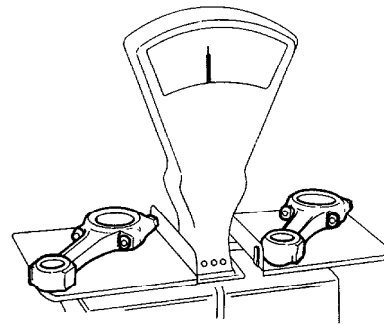
FIGURE 78



16794

Bushing (2) removal/insertion is carried out using tool 360474 (1)  
 After insertion, ream bushing until normal diameter is obtained.

FIGURE 79

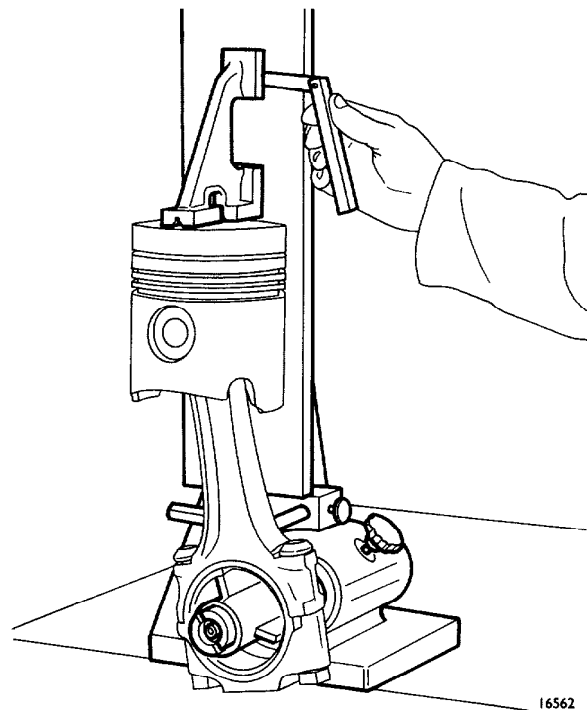


16561

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.

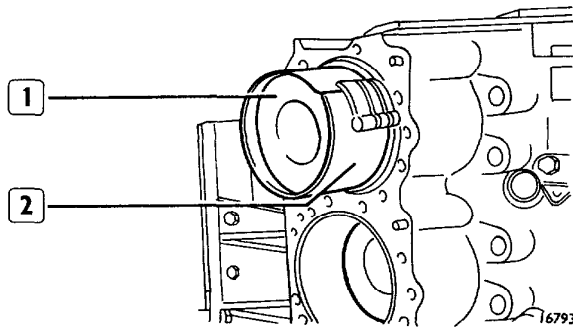
FIGURE 80



16562

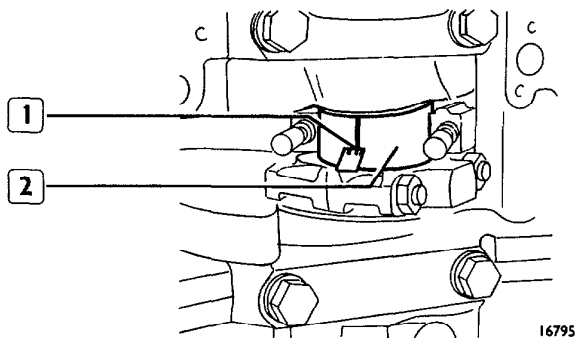
Check alignment in connecting rod - piston assembly, using tool 395363 and a feeler. Piston crown should be perfectly orthogonal to the face of tool 395363

FIGURE 81



When fitting connecting rod-piston assemblies (1) in cylinder sleeve using clamp 360603 (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

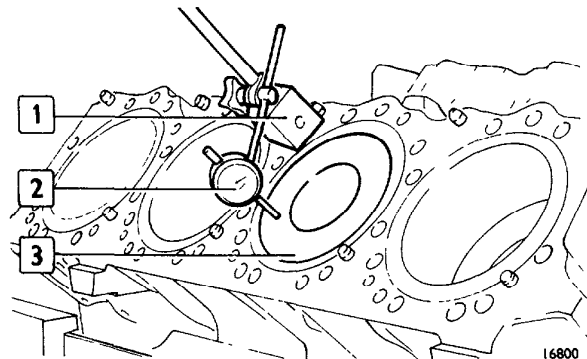


Check clearance between crankshaft crankpins and relevant bearings operating as follows:

- 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.

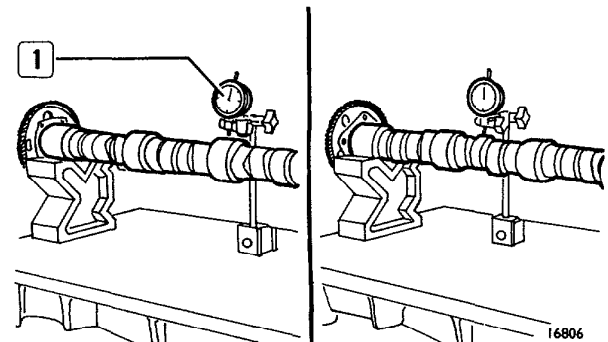
FIGURE 83



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

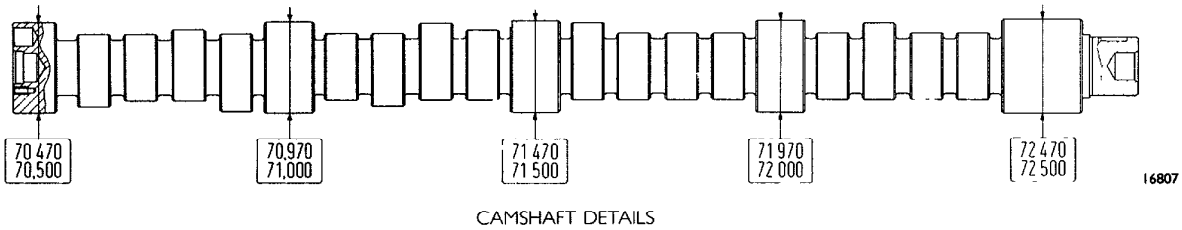
Check camshaft lobe and support pins. In case marks of seizing, scoring or excessive wear are detected, replace camshaft and relevant bushings fitted in engine block.



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 for both intake and exhaust. In case of different values, replace camshaft.

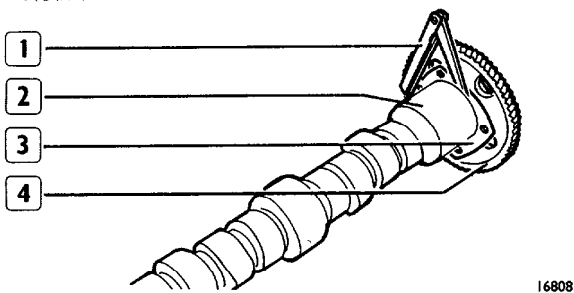
FIGURE 85



CAMSHAFT DETAILS

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

FIGURE 86

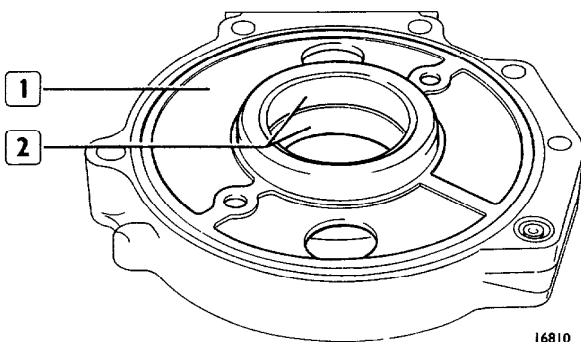


16808

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.

INJECTION PUMP CONTROL

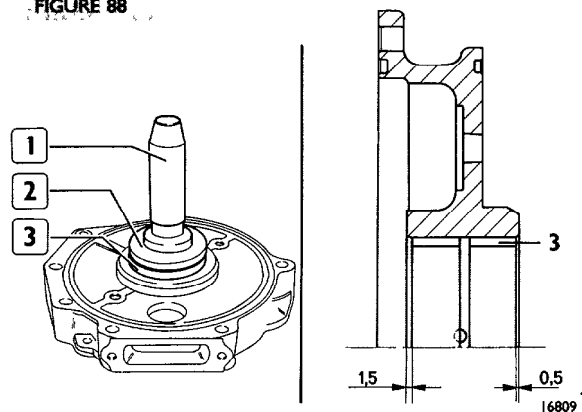
FIGURE 87



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.

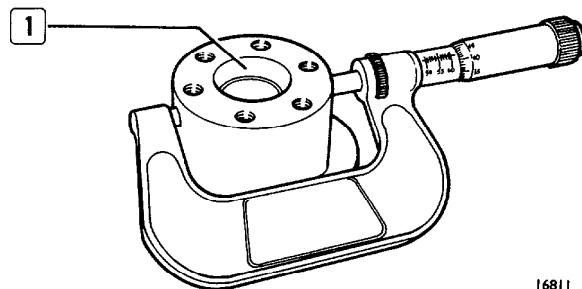
FIGURE 88



16809

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 65.03 to 65.06 mm dia.

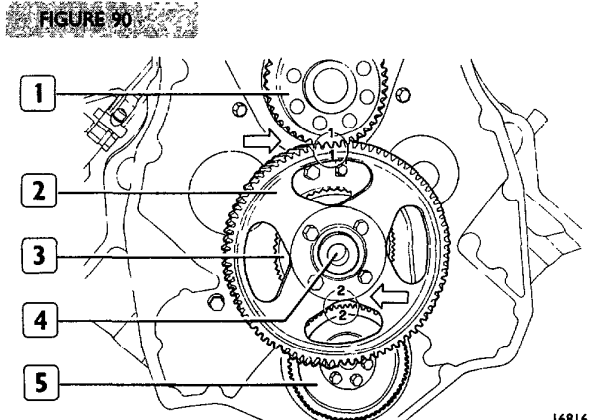
FIGURE 89



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 0.03 to 0.09 mm. Check that the teeth of shaft gear (1) controlling the injection pump are not broken or worn-out.

VALVE SYSTEM CONTROL

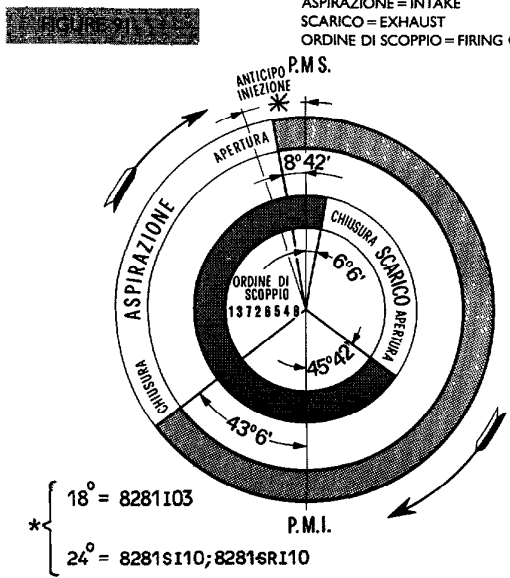


16816

Valve system timing is carried out as follows:

- Rotate crankshaft until mark "PMS Cil 8" on flywheel (indicating T.D.C. of piston No. 8) corresponds to the reference index on flywheel housing
- Rotate camshaft until the mark on drive gear (3) coincides with that machined on injection pump shaft gear (5)
- On camshaft (4) fit gear (2) until its mark coincides with that on crankshaft gear (1) In such a condition, all marks machined on gears and indicated by arrows, should coincide

PMS = TDC  
 PM1 = BDC  
 ANTICIPO INIEZIONE = INJECTION ADVANCE  
 APERTURA = OPENING  
 CHIUSURA = CLOSING  
 ASPIRAZIONE = INTAKE  
 SCARICO = EXHAUST  
 ORDINE DI SCOPPIO = FIRING ORDER



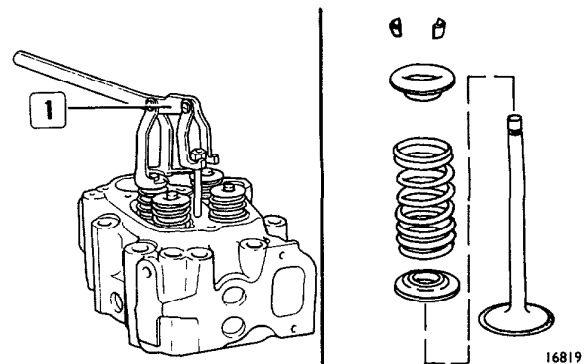
8646

Check of valve system diagram is carried out as follows

- Adjust clearance between rockers and bridges to 0.25 mm
- Rotate crankshaft and, with a notched quadrant, check that valves open and close according to the diagram angles indicated in the figure.

CYLINDER HEADS

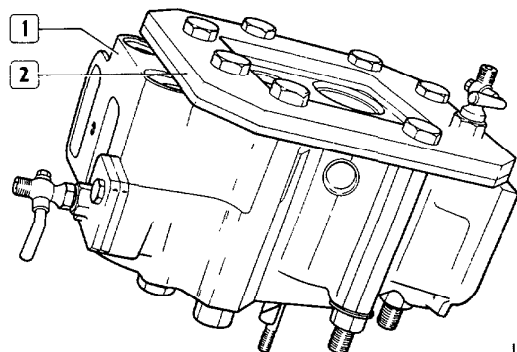
FIGURE 92



16819

Remove/install valves using tool 360274 (1) On installation, lubricate valve stems with engine oil

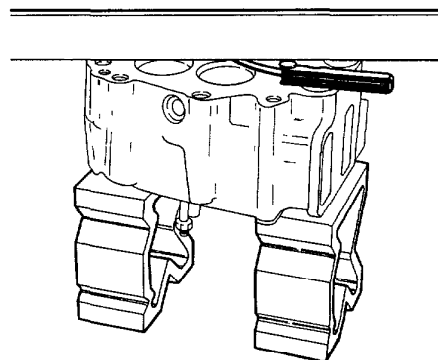
FIGURE 93



16820

Using tool 360443 (2) check cylinder head (1) seal. Through pump 305048 inlet water heated to ~ 90°C at a pressure of 4 to 5 kg/cm<sup>2</sup> No leakage should be observed; in the negative, replace cylinder head

FIGURE 94

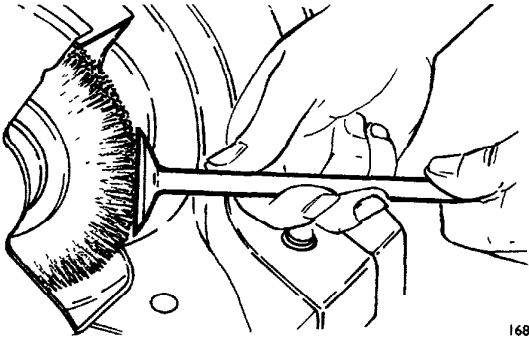


16824

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



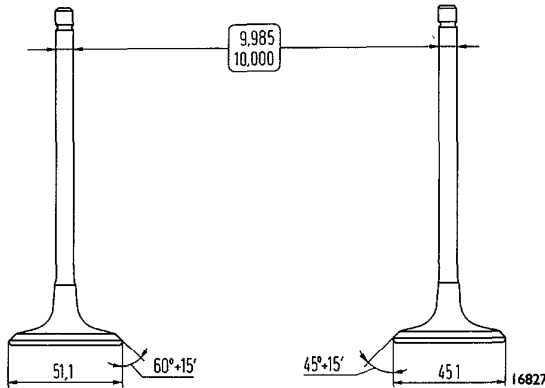
FIGURE 95



16825

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

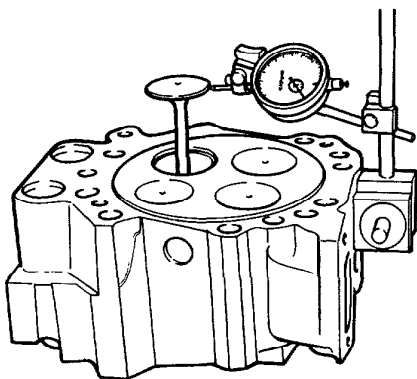
FIGURE 96



16827

With a micrometer check that stem diameters are those indicated in the figure. Using grinder 301014, dress valve seats removing as little material as possible

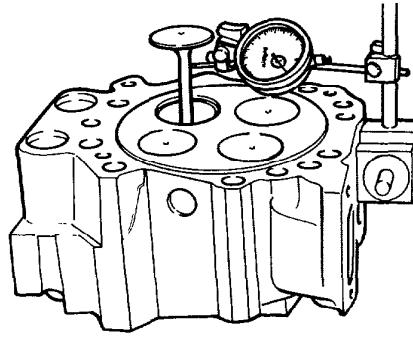
FIGURE 97



16828

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

FIGURE 98

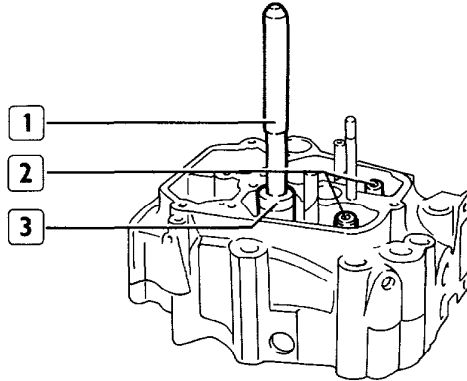


16829

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

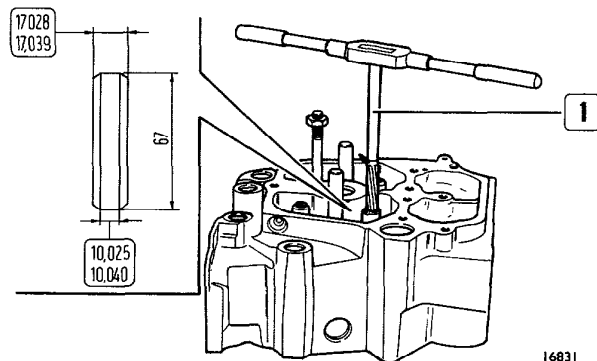
FIGURE 99



16830

Remove valve guide (2) using tool 360143 (1). For valve guide insertion, use remover/installer 360143 together with component 360280 (3)

FIGURE 100

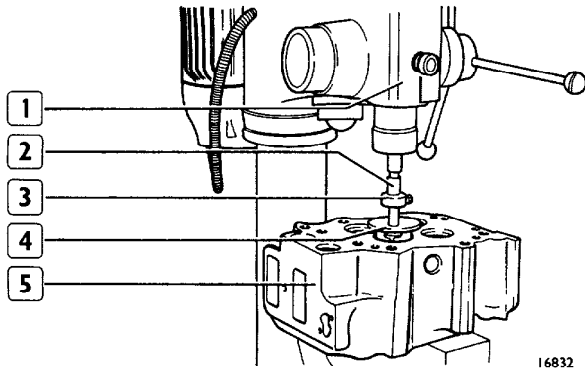


16831

With reamer 390330 (1) dress valve guide until the value indicated in the figure is obtained

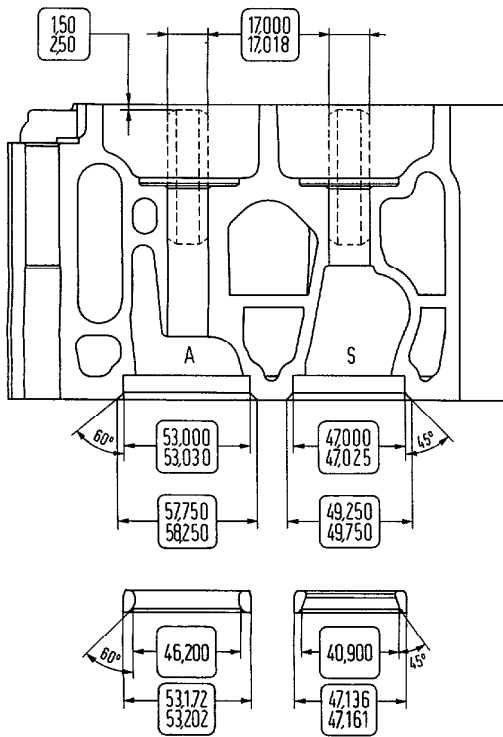
VALVE SEAT

FIGURE 101



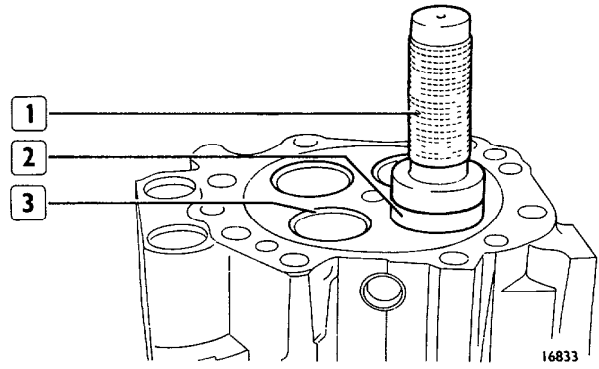
- Renew valve seats operating as follows
- Position cylinder head (5) on pillar drill (1)
  - Insert tool 360376 (4) on pillar drill and adjust stop device (3) on cutter 390358 (2)
  - Operate cutter and remove valve seat
  - Thoroughly clean cylinder head
  - Cool the new valve seat to  $-180^{\circ}\text{C}$  (for instance, in a tank containing liquid nitrogen).

FIGURE 102



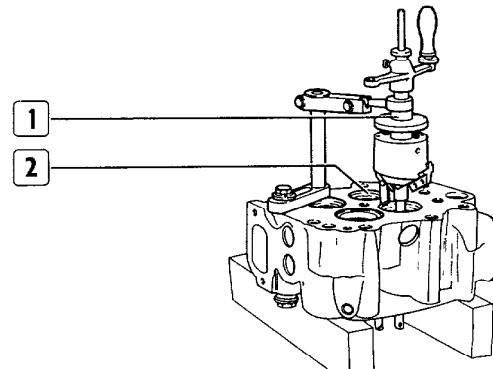
VALVE SEAT AND VALVE GUIDE SEAT IN CYLINDER HEAD - DETAILS

FIGURE 103



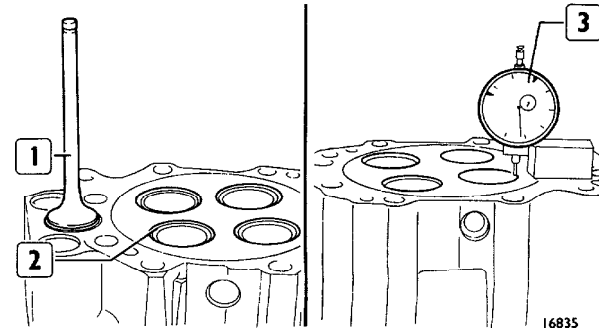
- Fit valve seats (3) in cylinder head using tool 360394 (1) together with component 360382 (2).
- Clearance:
- Intake: 0.142 to 0.202 mm.
  - Exhaust: 0.111 to 0.161 mm

FIGURE 104



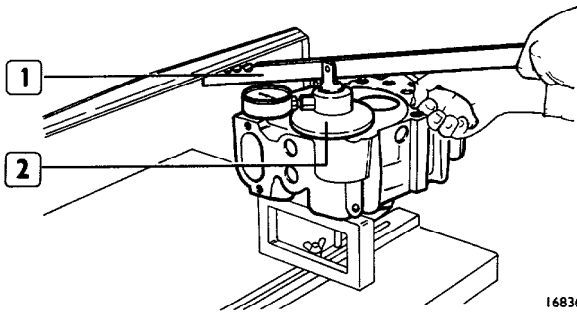
Dress valve seats (2) using HUNGER tool 360319 (1)

FIGURE 105



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 valve and 0.1 to 0.45 mm for intake valve, dress seats again.

FIGURE 106

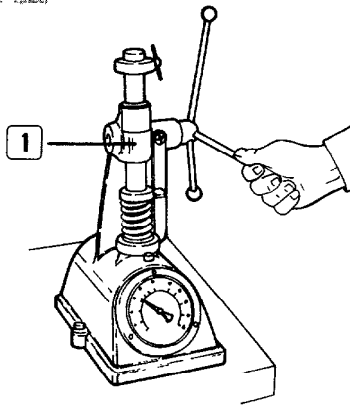


16836

Close injector seat and check valve seat seals using device 395868 (2) and lever 360042 (1) positioned as shown in the figure. With a dial gauge check that pressure drop takes place slowly.

VALVE SPRING

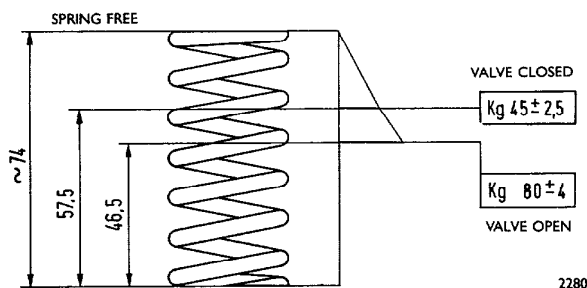
FIGURE 107



16587

Using fixture 305049 (1) check that spring load is within the values indicated in figure 108

FIGURE 108

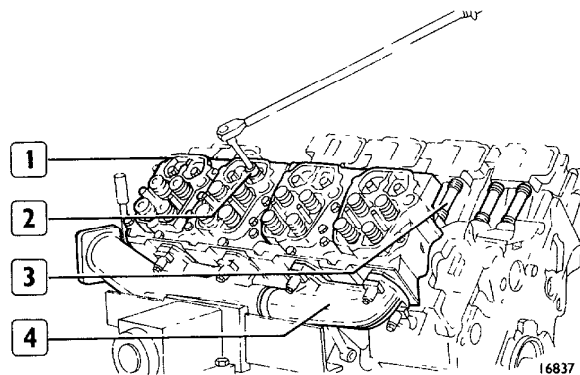


2280

INTAKE AND EXHAUST VALVE SPRING DETAILS

CYLINDER HEAD ASSEMBLY

FIGURE 109

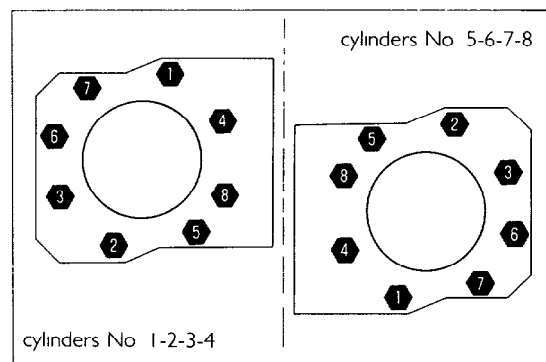


16837

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 capscrews with UTDM oil
- Tighten capscrews in the order given in fig. 110, using wrench 350071 (2) to a torque of 27.5 Nm (2.8 kgm)
- Insert exhaust manifolds (4) and tighten capscrews, previously lubricated with graphite oil, to a 32 Nm torque (3.2 kgm) so that cylinder heads are aligned
- Tighten cylinder head capscrews in the order given in the figure in two consecutive phases
- 1st phase 160 Nm (16.3 kgm)
- 2nd phase +60° +60°

FIGURE 110

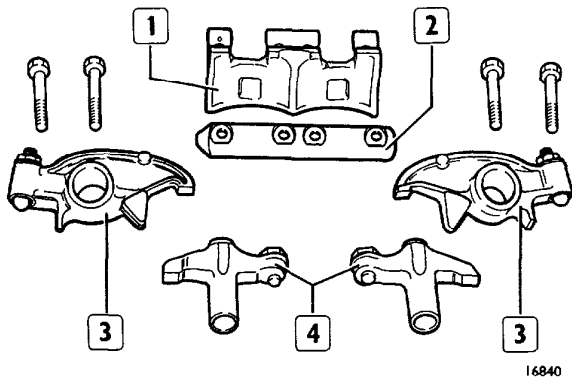


85331

TIGHTENING SEQUENCE OF CYLINDER HEAD CAPSCREWS TO ENGINE BLOCK

ROCKER PUSHRODS - ROCKERS - ROCKER SHAFTS - BRIDGES

FIGURE 111



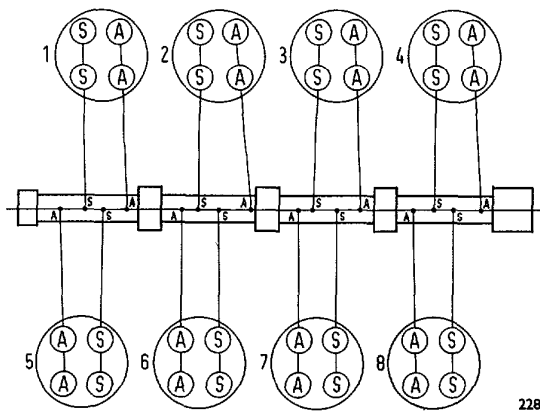
Pushrods should be free from distortion and the spherical seats in contact with the rocker adjusting screw and with the tappet should not show signs of pick-up or wear; in the negative, replace them. Intake valve pushrods are identical and therefore interchangeable

Check rockers (3), bridges (4), rocker shafts (2) 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.

16840

VALVE - ROCKER CLEARANCE ADJUSTMENT

FIGURE 112



This scheme represents valve positions on cylinder heads

Rotate crankshaft and.

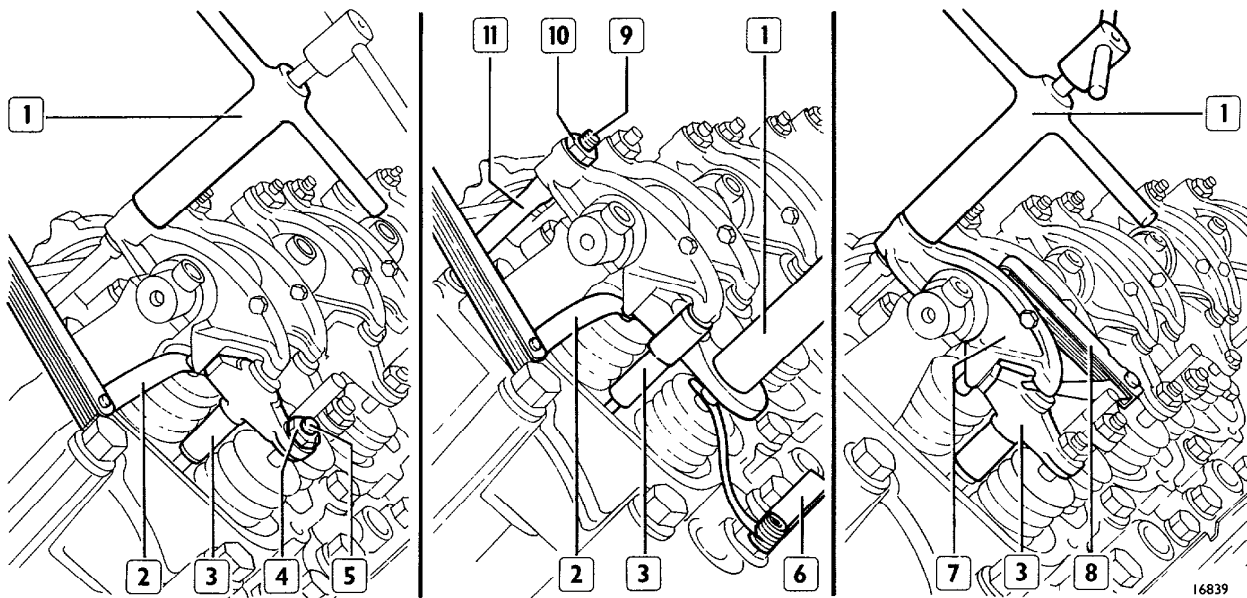
□ Balance cylinder No. 1 valves; following the sequence indicated in the scheme, adjust the valves marked with an asterisk.

Cylinder No.	1	2	3	4	5	6	7	8
Intake valve	-	*	*	-	*	*	*	-
Exhaust valve	-	*	-	*	*	*	-	*

□ Balance cylinder No. 6 valves; following the sequence indicated in the scheme, adjust the valves marked with an asterisk.

Cylinder No	1	2	3	4	5	6	7	8
Intake valve	*	-	-	*	-	-	-	*
Exhaust valve	*	-	*	-	-	-	*	-

FIGURE 113



In the above balancing conditions, adjust clearance between rockers and valves as follows

- With wrench 342137 (1) loosen nut (4) and unscrew screw (5) so that the distance from screw to valve is greater than the distance between bridge end (3) and relevant valve
- Loosen nut (10) and unscrew or screw down screw (9) so that to obtain a clearance of 0.05 mm, measured by feeler (2), between bridge (3) end and relevant valve
- Using another feeler (6), adjust a 0.05 clearance between screw (5) and relevant valve, simultaneously checking (with feeler 2) that previous clearance does not change. Then tighten check nut (4) of screw (5)
- Acting on screw (9) and using feeler (8) adjust clearance between rocker (7) and bridge (3), it should be 0.20 mm for intake valves, and 0.40 mm for exhaust valves. Tighten nut (10)

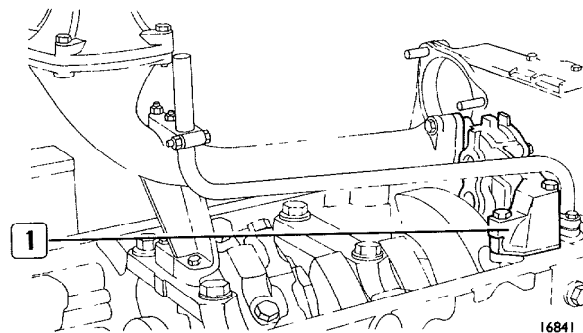
To check and adjust valve - rocker clearance on an engine on-vehicle according to the above scheme, operate as follows

- Remove covers from tappet housings
- Unscrew adjusting screw (5) of bridge (3) until the bottom face is higher than the fixed surface
- Screw down rocker (9) adjusting screw until contact between rocker toe and bridge button causes resistance to be felt when rocker-to-pushrod (11) contact is established
- Bring the bridge (3) adjusting screw (5) in contact with valve stem and clamp using check nut (4), so as to achieve simultaneously bridge contact with the two valves

Then adjust rocker (7) - bridge (3) clearance to the indicated values

## LUBRICATION SYSTEM

FIGURE 114



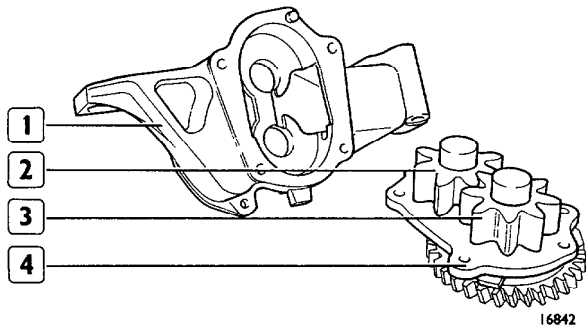
Engine is lubricated by a gear pump (1) gear driven from crankshaft

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.

FIGURE 115

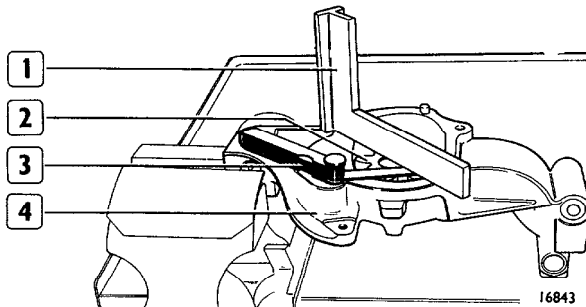


**OIL PUMP**

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

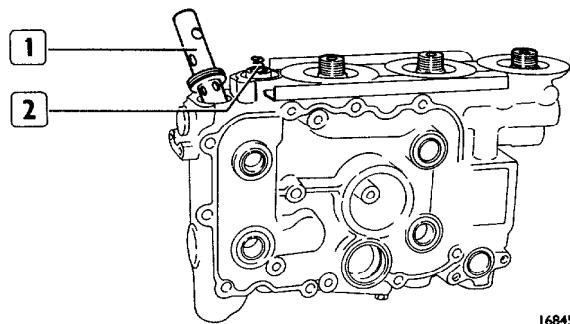
FIGURE 117



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.

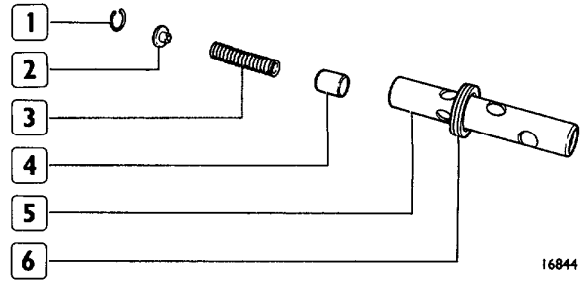
**OIL FILTER SUPPORTS**

FIGURE 116



Removal/installation: oil relief valve (1) and by-pass valve (2). Check that oil filter support faces are not damaged.

FIGURE 119

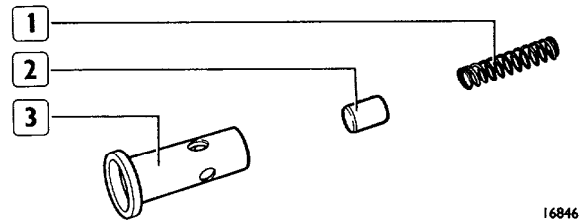


OIL PRESSURE RELIEF VALVE COMPONENTS

1 Retaining ring - 2 Cap - 3 Spring - 4 Valve - 5 Valve body - 6 O-ring

The separation of oil pressure relief valve (see figure) is carried out removing retaining ring (1) from valve body (5)

FIGURE 120



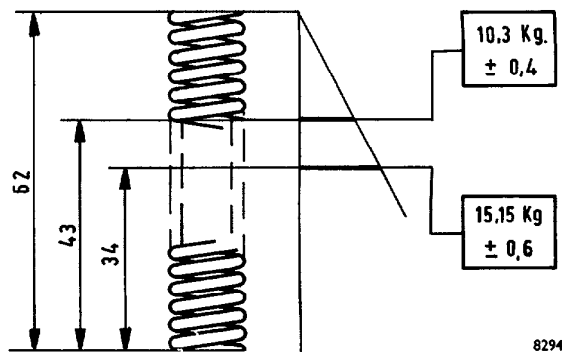
BY-PASS VALVE COMPONENTS

1 Spring - 2 Valve - 3 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

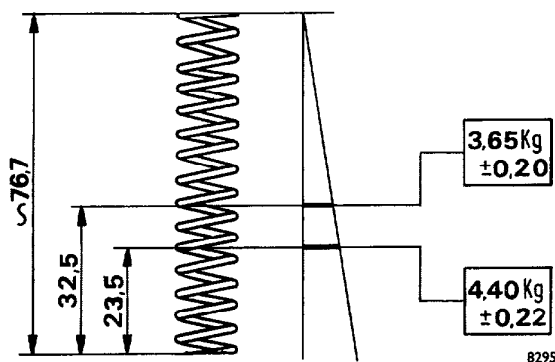
FIGURE 121



OIL PRESSURE RELIEF VALVE SPRING-DETAILS

With fixture 305049 check that valve spring loads are within the indicated values

FIGURE 172



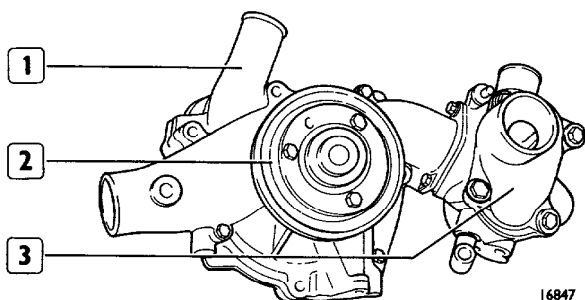
BY-PASS VALVE SPRING DETAILS

## COOLING SYSTEM

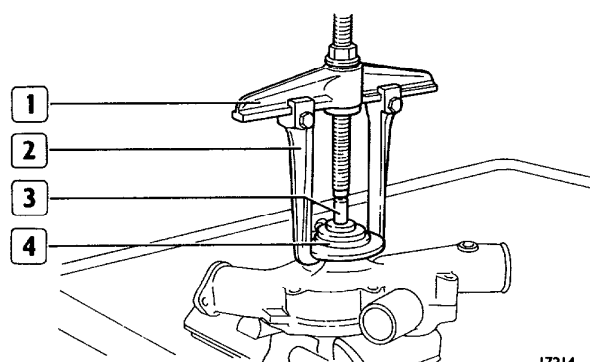
Engine cooling system consists of a centrifugal pump driven by crankshaft via a "V" belt.

Two parallel-connected thermostats control engine temperature. A multipurpose filter is supplied rust and corrosion preventer and for foreign matters

## WATER PUMP DISASSEMBLY

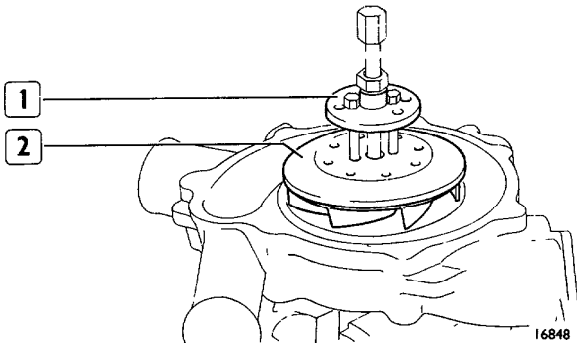


From water pump (1) disconnect thermostat housing (3), pulley (2) and pump cover.



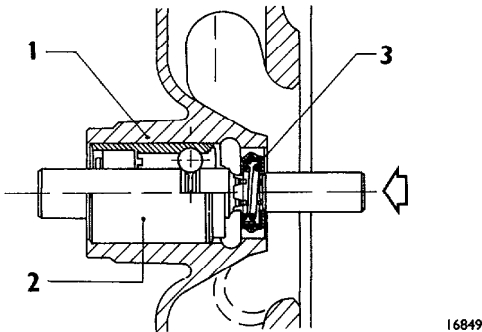
From impeller housing bearing withdraw pulley hub (4) using puller 340002/2 (1), grips 340002/11 (2) and distance piece 345070 (3).

FIGURE 126



Remove impeller (2) from relevant bearing using puller 340035 (1).

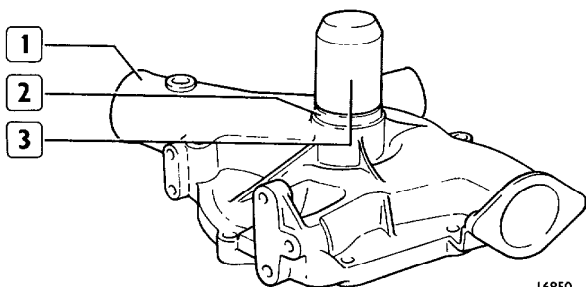
FIGURE 127



From pump casing (1) withdraw impeller bearing (2) operating under a press in the direction indicated by arrow. Also remove seal (3)

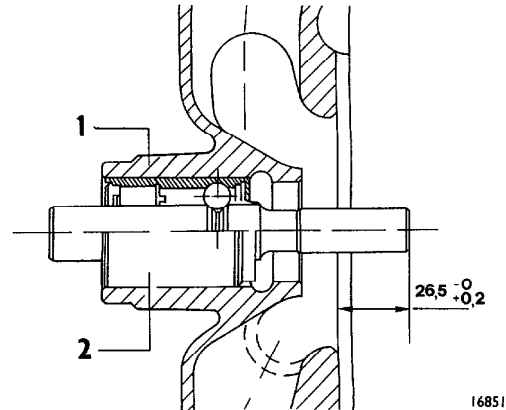
ASSEMBLY

FIGURE 128



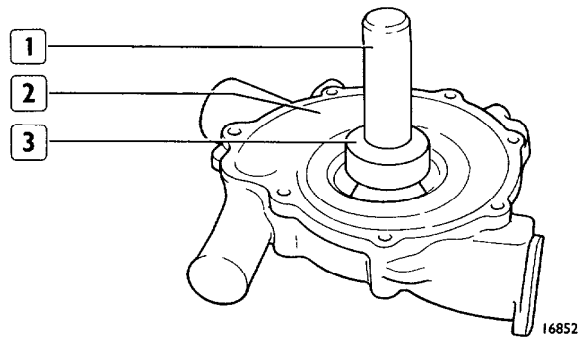
Heat pump casing (1) to 80° to 90°C and fit impeller bearing (2) using installer/remover 360456 (3)

FIGURE 129



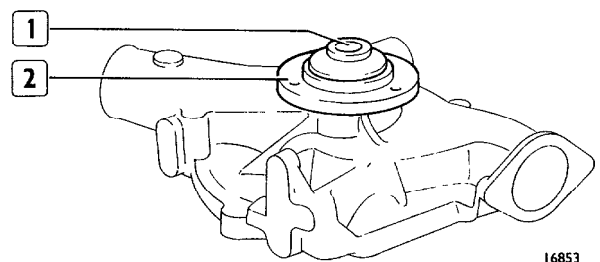
Check that the bearing shaft end (2) is positioned as to the inner pump casing face by the value indicated in the figure

FIGURE 130



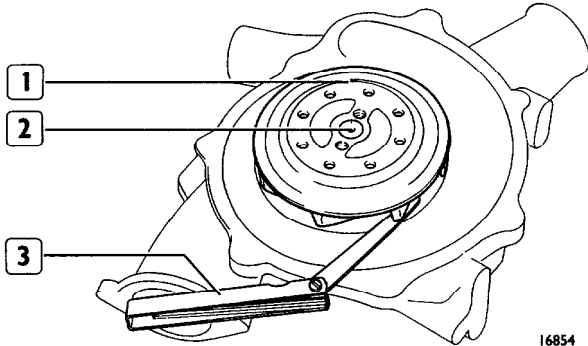
With tool 360457 (1) fit seal (3) in pump casing (2)

FIGURE 131



Heat pulley hub (2) so that a difference of 90 to 110°C exists between it and bearing shaft (1) Fit hub to bearing shaft so that hub face is flush with shaft face





16854

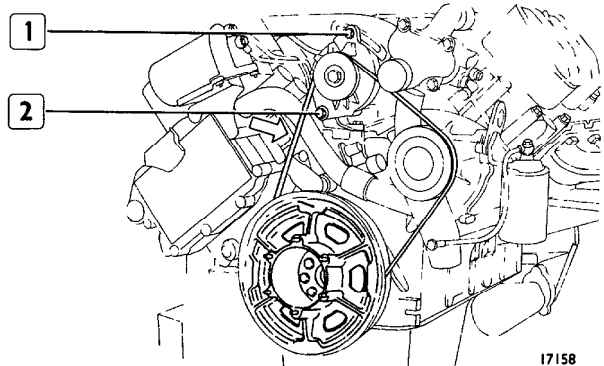
Heat impeller (1) so as between it and bearing shaft (2) there is a difference of 90 to 110°C. Fit impeller to shaft so that its outer face is flush with the shaft.

With feeler (3) check that the distance between impeller blade end and inner pump casing face is 1 to 1.3 mm

NOTE - Check hub and impeller assembly on bearing shaft; with a 147 Nm torque (1.5 kgm) on hub and impeller, they should not rotate.

## ALTERNATOR AND WATER PUMP DRIVE BELT TENSION ADJUSTMENT

FIGURE 17158



17158

Belt tension should not be excessive otherwise alternator and water pump bearing stress will result. Insufficient belt tension prevents both water pump and alternator from producing their rated output, and is also the cause of premature belt wear.

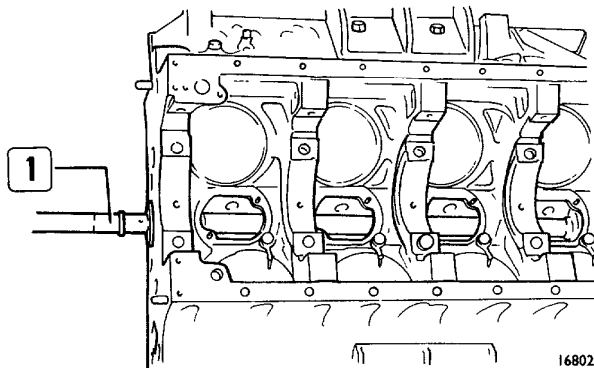
Check belt tension at the point indicated by an arrow. Standard belt give is 1 cm under a load of  $52 \pm 8$  Nm ( $5.2 \pm 0.8$  kg) when the belt is new, or  $40 \pm 6$  N ( $4 \pm 0.6$  kg) with the belt already in use.

To increase belt tension:

- Loosen retaining nuts of screws 1 and 2
- Move alternator outwards and tighten nuts to the prescribed torque.

ENGINE ASSEMBLY

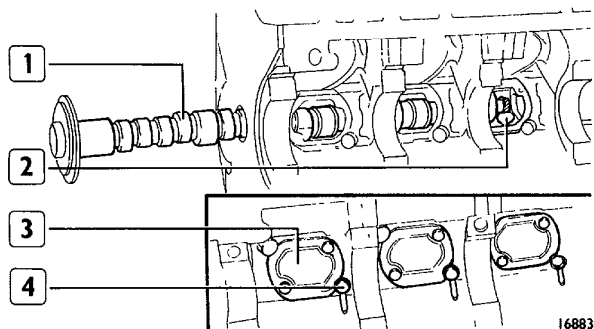
FIGURE 244



Position engine block on swinging stand 322230 using brackets 361002/9. To lift and support engine block during this operation, use rocking sling hook 360585 with a set of eyes 360503. Insert cylinder sleeves as indicated at paragraph

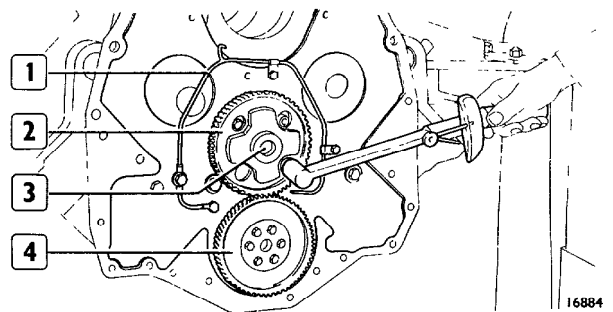
Fit camshaft bushings using tool 360385 (1).

FIGURE 245



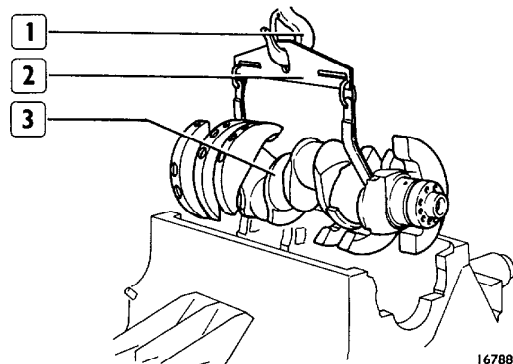
Lubricate tappets (2) and insert them in their seats. Lubricate camshaft bushings and insert camshaft (1) taking care not to damage bushings. Insert covers (3). Insert spray nozzles (4) checking that dowels are correctly positioned on engine block.

FIGURE 246



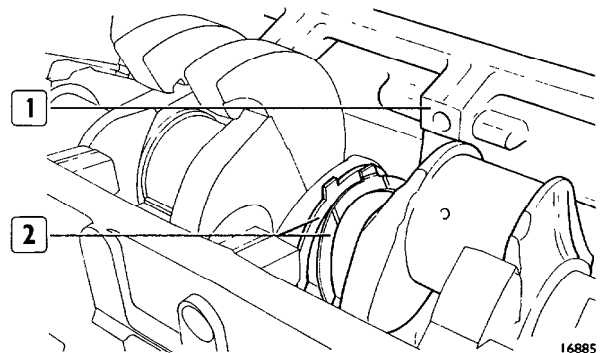
Tighten to suitable torque camshaft (3) thrust plate capscrews (2). Insert support with attached injection pump shaft, and fit on this gear (4). Insert gear lubrication line (1).

FIGURE 247



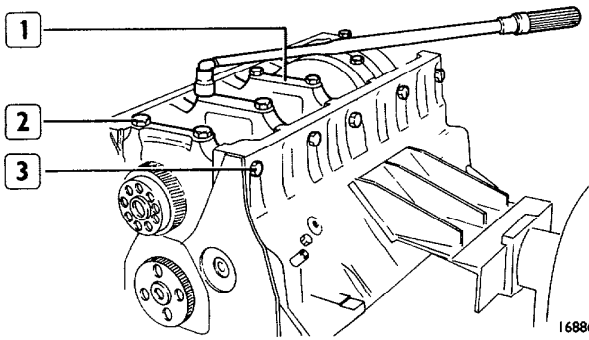
Insert in their seats the half journals lubricated through their lubrication hole and install crankshaft (3) using tool 360500 (2) and swinging hoist (1).

FIGURE 248



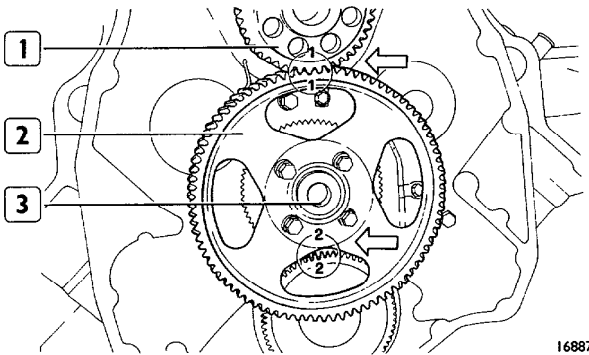
On main journal (1) insert thrust rings (2) with gaps towards crankshaft (3).

FIGURE 249



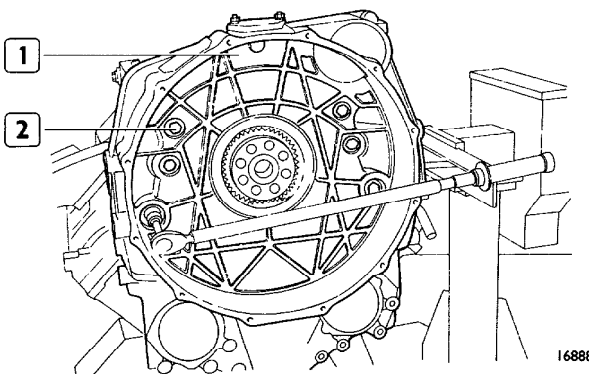
Insert main bearing caps (1) and relevant half bearings so as the printed figure is opposite to that on engine block. Lubricate bearing cap screws (2 and 3) with UTDM oil and tighten to suitable torque

FIGURE 250



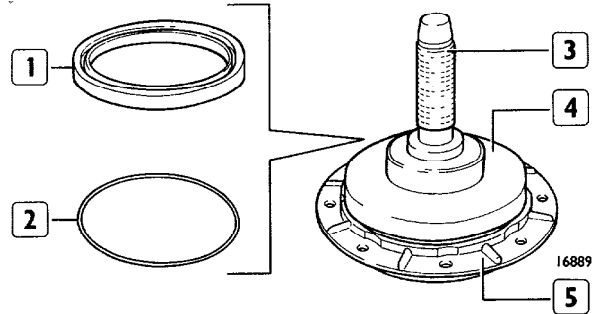
Rotate crankshaft (1) and camshaft (3) so as on inserting gear (2) the marks on each single gear (indicated by an arrow) is coincident with the other.

FIGURE 251



Install flywheel housing (1) and tighten cap screws (2) to required torque

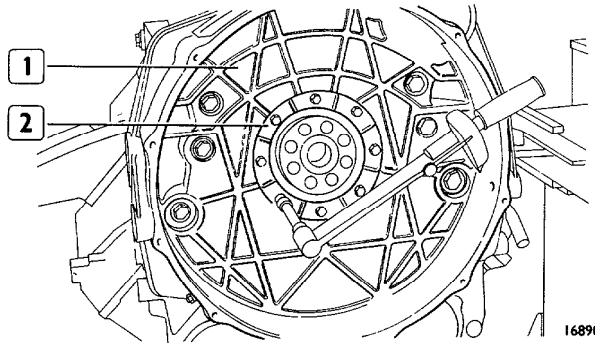
FIGURE 252



On rear cover (5) position spacer (2) and insert retaining ring (1) using tool 360454 (4) with handgrip 370006 (3)

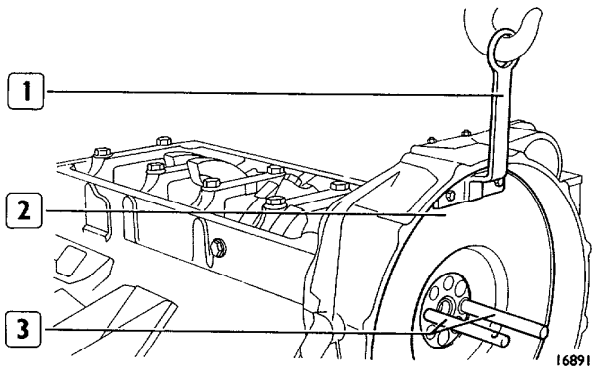
NOTE - If crankshaft is worn-out near retaining ring (1) circle, insert this without interposing spacer (2)

FIGURE 253



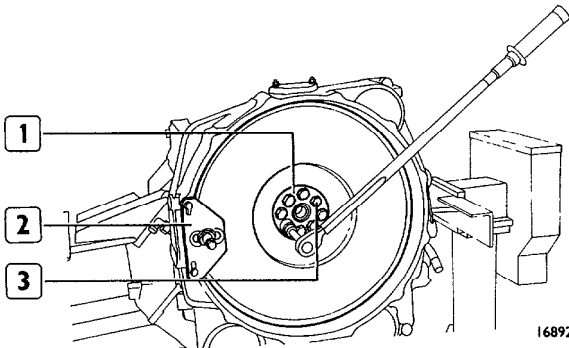
On flywheel cover (1) insert rear support (2) and tighten bolt to required torque

FIGURE 254



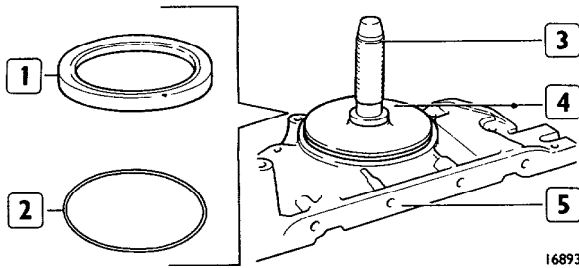
Screw down pins 360349 (3) on crankshaft and install flywheel (2) using bracket 360350 (1) and a hoist

FIGURE 255



Clamp crankshaft (1) rotation using tool 360351 (2) and tighten screws (3) previously lubricated with UTDM oil.

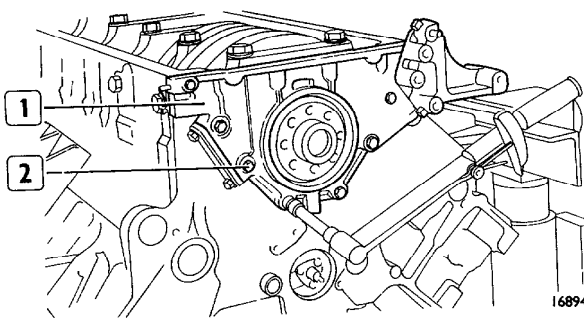
FIGURE 256



On front cover (5) position spacer (2) and insert retaining ring (1) using tool 360354 (4) with handgrip 370006 (3)

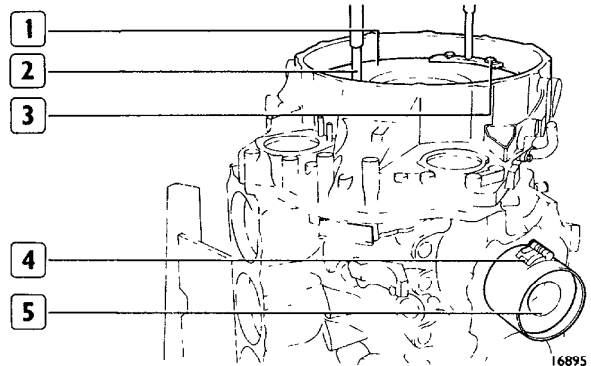
NOTE - If the crankshaft is worn-out near retaining ring (1) circle, insert this without interposing spacer (2)

FIGURE 257



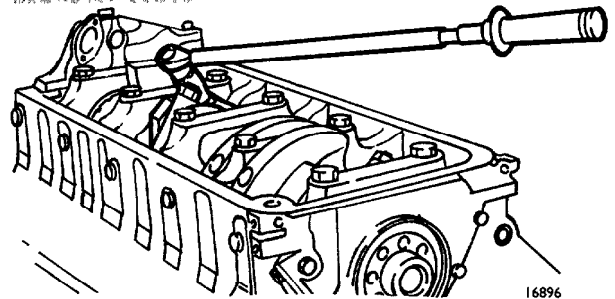
Install front cover (1) tightening to specified torque screws (2)

FIGURE 258



Fit brackets 360304 (3) to engine flywheel (1) using handgrips 360307 (2) to rotate crankshaft; install pistons (5) using compressor 360603 (4) as indicated.

FIGURE 259

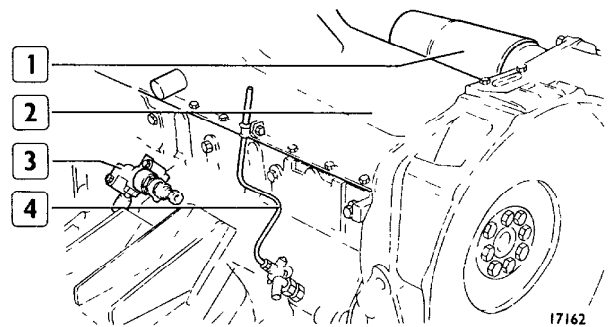


With engine oil lubricate big end bearings and insert them.

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

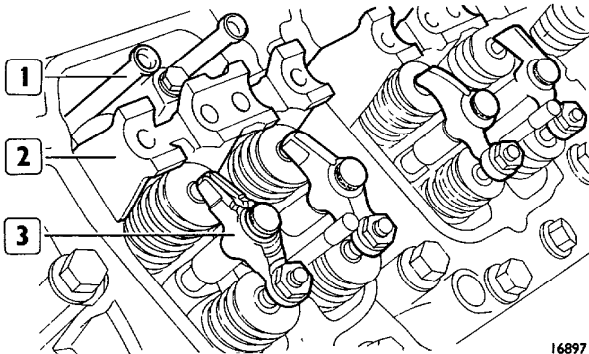
NOTE - On final assembly, all bolts and nuts securing connecting rod caps must be replaced.

FIGURE 260



Install oil pump with attached suction scoop, oil sump (2), starter motor (1), support (3), and cooling fluid drain line (4)

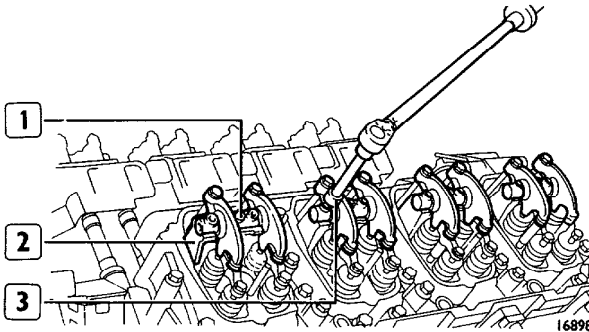
FIGURE 261



16897

Install cylinder heads as indicated. Insert rocker pushrods (1), rocker shaft supports (2) and bridges (3)

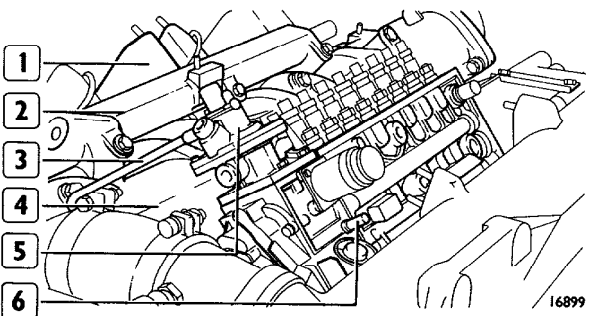
FIGURE 262



16898

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

FIGURE 263

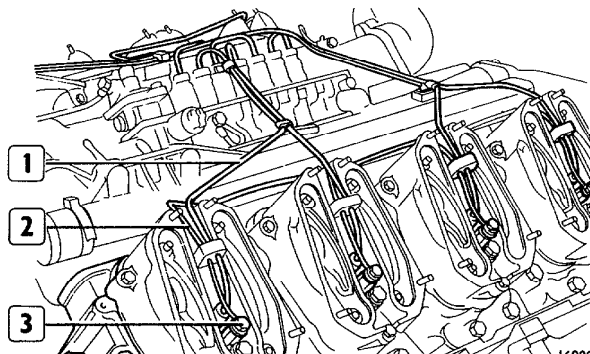


16899

Install and time injection pump (6)

Insert cooling fluid manifolds (2), intake manifolds (4) rocker housings (1) Connect line (3) to intake manifold (4) and LDA device (5)

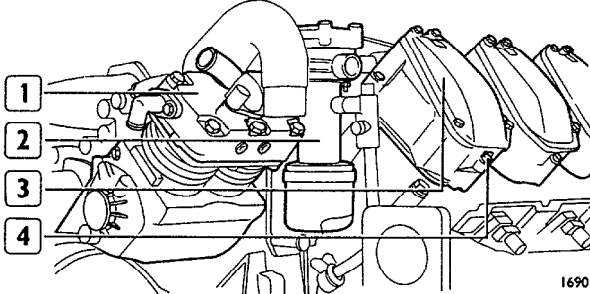
FIGURE 264



16900

Install injectors (3), connect fuel lines (1) to injection pump and injectors, tightening unions with wrench 352120. Connect injectors to fuel leak-back lines (2).

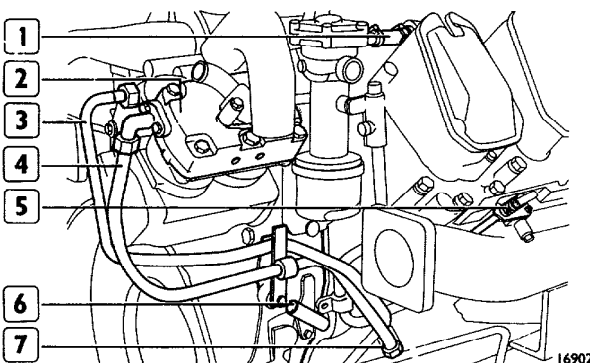
FIGURE 265



16901

Insert retaining caps (4), install tappet housing caps (3) with attached gaskets Install oil vapour condenser (2) and air compressor (1).

FIGURE 266

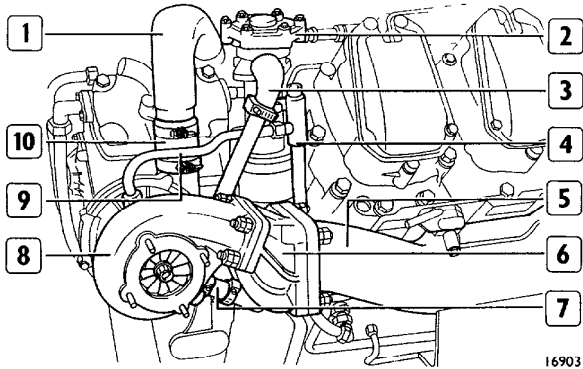


16902

Connect: those (1) to cooling fluid intake line of air compressor (2); air delivery line (3) to compressor (2), cooling fluid outlet line (4) to air compressor (2) and to union (7)

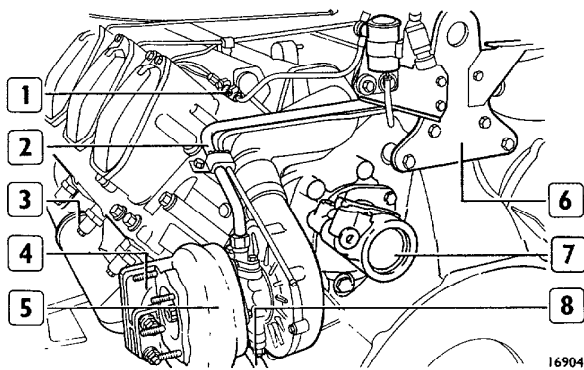
Insert the rod (5) controlling cooling fluid drain plug and pipe (6).

FIGURE 267



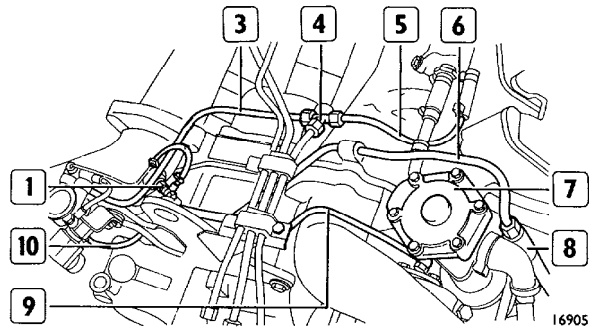
Connect sleeve (3) with attached breather pipe to oil vapour (2) condenser  
 Connect support (6) complete with turbocharger (8) to exhaust pipe (5)  
 Connect hose (10) to turbocharger (8) and intake manifold (1) Connect turbocharger lubrication line (9) to line (4)  
 Connect sleeve (7) to the turbocharger outlet oil piping and to the piping on flywheel housing

FIGURE 268



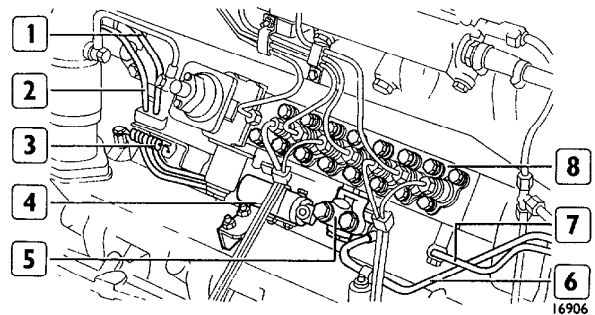
Install power steering pump (7)  
 Connect support (4) with turbocharger (5) to exhaust manifold (3)  
 Connect lubrication oil inlet piping (2) to turbocharger (5)  
 Connect sleeve to turbocharger oil outlet piping (8) and to the line on flywheel housing  
 To flywheel housing connect bracket (6) supporting thermostarter fuel reservoir  
 Connect hose (1) to fuel back-line from injectors

FIGURE 269



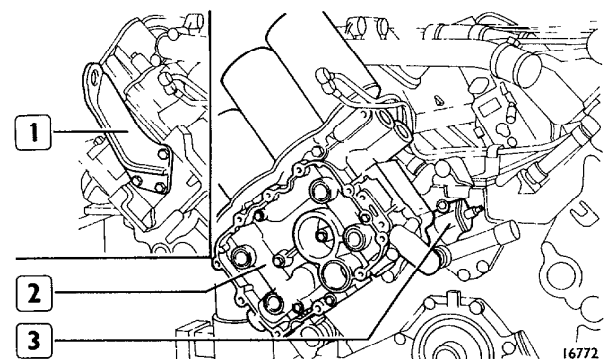
Connect: fuel lines (2 and 10) injector fuel leak-back lines (3 and 5) to three-way union (4), line (8) to lubrication line (6) of left turbocharger; line (9) delivering oil vapour to air cleaner to oil vapour condenser (7)

FIGURE 270



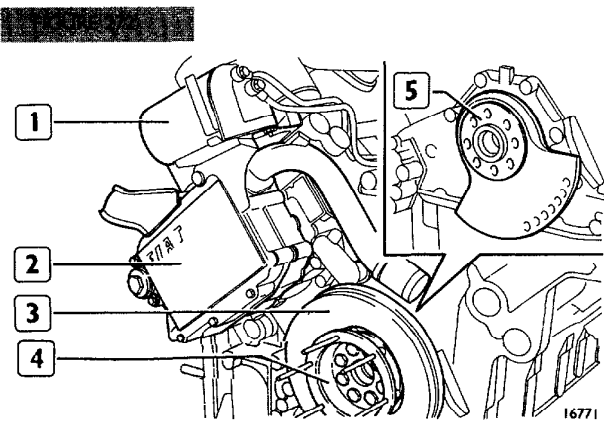
Connect the following lines to injection pump (8) fuel return line (7) to fuel tank, fuel inlet line (2) from fuel filter, lubricating oil inlet and outlet lines; connect the following pipes to the fuel pump (5): inlet (6) from fuel tank and outlet (1) to fuel filter Install barrel (4) controlling injection shut-off and connect spring (3)

FIGURE 271



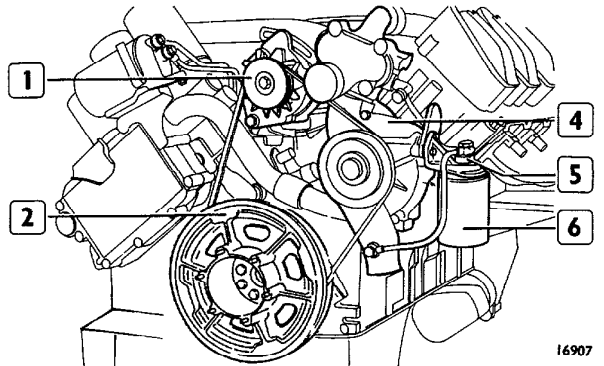
Insert bracket (1) to lift engine, oil filter supports (2) and engine tachometer control (3)

NOTE - Oil filters must be fitted to engine by tightening them manually



Fit on crankshaft: counterweight (5), damper flywheel (3), viscstatic fan connection flange (4). Tighten cap-screw with a torque wrench after clamping crankshaft rotation using tool 360351.

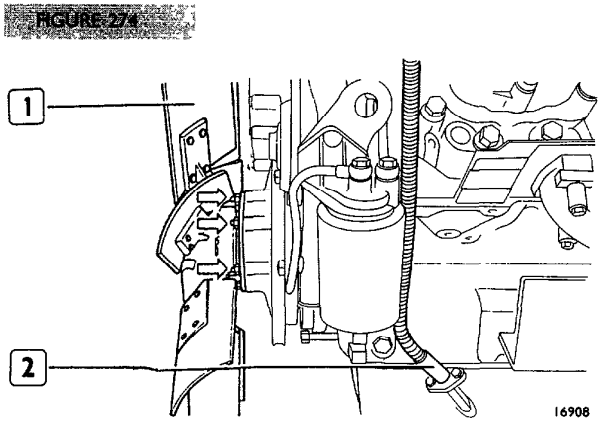
Install heat exchanger (2), fuel filter (1), and connect this filter to inlet and outlet fuel lines



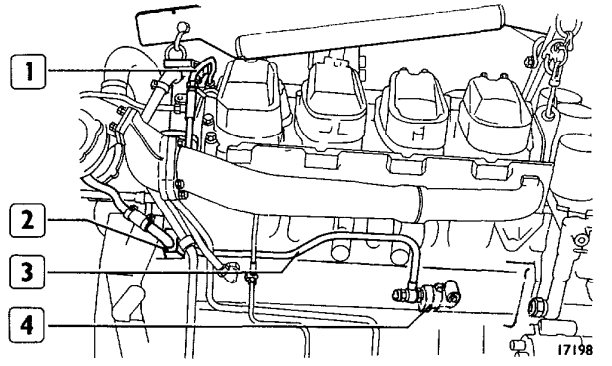
Install, pulley (2), alternator (1), water pump (4) with attached the thermostat units and the connected water suction and exhaust sleeves, and support (5) with corrosion-prevention filter (6).

NOTE - Corrosion-prevent filter must be fit to the support and tightened manually.

Fit the water pump and alternator drive belt  
Tighten nuts of alternator capscrews when belt has a give of 1 cm under a load of  $52 \pm 8$  N ( $5.2 \pm 0.8$  kg) (new belt), or  $40 \pm 6$  N ( $4 \pm 0.6$  kg) (used belt).



Install viscstatic fan (1). The arrows indicate check nuts  
Insert hose (2) for oil dipstick.



Remove engine from stand 322230 lifting it by means of a rocking sling hook 360585 and a hoist.  
Remove brackets 361002/9 and insert spring engine supports  
Connect oil piping (3) to oil filter housing (4) and connect the brackets securing this pipe to oil vapour condensator (1) and to oil line flange (3)

**TIGHTENING TORQUE DATA**

DESCRIPTION	COUPLES Nm (kgm)
Capscrew, main bearing caps	80 (8.2) + 120°/ 70 (7.1) + 90° *
Capscrew, main bearing caps side retention	◆ 245 (25)
Capscrew, sump to front cover, engine block, timing gear housing and bell housing	14 (1.4)
Capscrew, timing gear housing and rear plate to engine block	◆ 196 (20)
Capscrew, timing gear housing to rear plate	78 (8)
Capscrew, injection pump drive shaft support and rear plate to timing gear housing	49 (5)
Capscrew, injection pump drive shaft support, to timing gear housing	49 (5)
Capscrew, rear plate to engine block	◆ 78 (8)
Capscrew, timing gear housing and rear plate to engine block	98 (10)
Capscrew, cylinder head	◆ 160 (16.3) + 60° + 60°
Capscrew, RH and LH intake manifolds to cylinder head	49 (5)
Capscrew, RH intake manifold to cylinder head	49 (5)
Capscrew, exhaust manifold	◇ 34 (3.5)
Capscrew, intermediate crankshaft counterweights	◆ 275 (28)
Capscrew, end crankshaft counter weight	◆ 490 (50)
Nut, connecting rod cap	◆ 280 (28.5)
Capscrew, flywheel	◆ 140 (14.3) + 60°
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)
Capscrew, injection pump driven gear	◆ 24.5 (2.5)
Nut, injector bracket to cylinder head	55 (5.6)
Capscrew, oil pump to engine block	24.5 (2.5)

- ◆ Wet (UTDH oil).
- ◇ Wet (graphite oil).
- \* For lateral screw.



**TIGHTENING TORQUE DATA**

DESCRIPTION	CLASS	TORQUE Nm (kgm)
Capscrew, main bearing caps	I ▲	80 (8.2) + 120°/ 70 (7.1) + 90° *
Capscrew, main bearing caps side retention	I ▲	242.5 (24.7)
Capscrew, sump to front cover	III	10 (1)
Capscrew, sump to engine block	III	10 (1)
Capscrew, sump to timing gear housing and flywheel	III	10 (1)
Capscrew (M14×1.5), sump to timing gear housing and rear plate to engine block	II	201 (20.5)
Capscrew, gear housing to rear plate	II	78 (8)
Capscrew, timing gear housing to rear plate	II	78 (8)
Capscrew, injection pump drive shaft support and rear plate to gear housing	II	49.5 (5)
Capscrew, injection pump drive shaft support, rear plate, power steering pump and engine lift hook to gear housing	II	49.5 (5)
Capscrew, rear plate to engine block	II	78 (8)
Capscrew, front cover to engine block	II	24.5 (2.5)
Nut, stud bolt, oil catcher to valve system axle	II	24.5 (2.5)
Capscrew (M12×1.25), valve gear housing to rear plate	II	99 (10)
Capscrew, engine breather support to gear housing	II	24.5 (2.5)
Nut, engine breather support to gear housing	II	24.5 (2.5)
Capscrew, front right hook	II	49.5 (5)
Capscrew, engine lift rear hook to gear housing	II	49.5 (5)
Capscrew, cylinder head	I ▲	160 (16.3) + 60° + 60°
Capscrew, central, cover to cylinder head	II	24.5 (2.5)
Capscrew, cover to cylinder head	II	24.5 (2.5)
Nut, rocker inspection cover	II	14.5 (1.47)
Capscrew, left and right intake manifold to cylinder head	II	49.5 (5)
Capscrew, exhaust manifold	II ●	32 (3.2)
Nut, turbocharger connection stub pipe to exhaust manifold	II	78 (8)
Capscrew, intermediate crankshaft counterweights	I ▲	276.5 (28)
Capscrew, end crankshaft counterweights	I ▲	491 (50)
Nut, connecting rod cap	I ▲	276.5 (28)
Nut, engine flywheel	I ▲	140 (14.3) + 60°

▲ Lubricate with UTDM oil \* For lateral screw.

● Lubricate with graphite oil

DESCRIPTION	CLASS	TORQUE Nm (kgm)
Capscrew, thrust plate to engine block	II ▲	24 5 (2 5)
Capscrew, camshaft drive gear to driven gear	II ▲	49 5 (5)
Capscrew, rocker shaft bracket to head	II	78 (8)
Capscrew, rocker bracket to head	II	24 5 (2 5)
Capscrew, injection pump support	II ▲	78 (8)
Capscrew, injection pump to support	II	78 (8)
Nut, injection plate spacer to injection plate	II	127 5 (13)
Capscrew, injection pump spacer plate	II	24 5 (2 5)
Capscrew, injection pump shaft support to rear engine block plate	II	24 5 (2 5)
Capscrew, injection pump driven gear to shaft	II ▲	24 5 (2 5)
Nut, injector bracket to cylinder head	II	56 (5 7)
Capscrew, fuel filter body to bracket	II	24 5 (2 5)
Capscrew, fuel filter bracket to oil filter body	II	49 5 (5)
Nut, turbocharger to connection stub pipe	II	78 (8)
Capscrew, turbocharger air delivery elbow to manifolds	II	24 5 (2 5)
Capscrew, oil pump cover	II	24 5 (2 5)
Capscrew, oil pump to engine block	II	24 5 (2 5)
Pipe union, oil delivery to turbocharger and plug for electric pressure sender	II	40 (4)
Capscrew, flange union for oil delivery pipe to turbocharger	II	24 5 (2 5)
Nut, upper oil drain pipe to turbocharger	II	24 5 (2 5)
Nut, lower oil drain pipe from turbocharger to timing gear housing	II	24 5 (2 5)
Capscrew, oil filter body (cartridge) to engine block	II	24 5 (2 5)
Capscrew, suction scoop to oil pump	II	24 5 (2 5)
Capscrew, suction scoop to central support cap	II	24 5 (2 5)
Capscrew, oil filter body to engine block	II	24 5 (2 5)
Capscrew, oil filter body to engine block	II	24 5 (2 5)
Capscrew, oil filter body and oil filter body connection elbow to tachometer housing in engine block	II	24 5 (2 5)
Capscrew, oil filter body to engine block	II	49 5 (5)
Cap, oil filter body		
M 35 × 1 5		127 5 (13)
M 28 × 1 5	II	73 (7,4)
Cap, temperature and oil pressure indicator	II	43 (4,3)

▲ Lubricate with UTDM oil

DESCRIPTION	CLASS	TORQUE Nm (kgm)
Union pipe, piston cooling nozzle	II ▲	58 5 (5 9)
Cap, low oil pressure indicator	II	9 (0 9)
Capscrew, oil pressure adjusting valve cover and oil circulation by-pass valve	II	24 5 (2 5)
Capscrew, oil pressure and temperature hole flange to engine block	II	24 5 (2 5)
Cap, heat exchanger housing	II	155 (15 8)
Nut, spacer to heat exchanger housing	II	155 (15 8)
Capscrew, water pump driven pulley to hub	II	24 5 (2 5)
Capscrew, water pump cover and housing to engine block	II	49 5 (5)
Capscrew, water pump housing to cover	II	24 5 (2 5)
Capscrew, alternate water pump driving pulley	II	200 (20 4)
Capscrew, heat exchanger housing and water pump connection pipe	II	24 5 (2 5)
Capscrew, connection pipe to R head water outlet manifold	II	24 5 (2 5)
Nut, governor housing to water pump	II	24 5 (2 5)
Capscrew, elbow to governor housing	II	49 5 (5)
Nut, fan to water pump driving pulley of conditioning compressor alternator and to fan spacer	II	24 5 (2 5)
Capscrew, filter housing and L front hook to water pump housing	II	29 (2 9)
Nut, cylinder support for injection pump stop control	II	24 5 (2 5)
Capscrew, R and L manifold for water outlet from cylinder head	II	28 5 (2 9)
Capscrew, alternator support to engine block	II	49 5 (5)
Nut, alternator strut on thermostat housing	II	49 5 (5)
Nut, alternator drive pulley	II	40 (4)
Capscrew, driving gear shaft of tachometer driving control to camshaft	II	11 (1 1)
Capscrew, tachometer housing to engine block	II	24 5 (2 5)
Capscrew, power steering pump	II	49 5 (5)
Capscrew, front spring block support to engine	II	70 (7 1)
Nut (to be crimped), front spring block support	II	83 5 (8 5)
Capscrew, upper, rear spring block to engine	II	200 (20 4)
Capscrew, lower, rear spring block to engine	II	289 5 (29 5)
Nut, spring blocks to chassis	II	200 (20 4)

DESCRIPTION	CLASS	TORQUE Nm (kgm)
Capscrew, bracket to chassis	II	83.5 (8.5)

NOTE - Accuracy class allowances of tightening torque are:

- Class I  $\pm$  5%
- Class II  $\pm$  10%
- Class III  $\pm$  20%

CODE FOR MANUAL	CORRESPONDENT CODE FOR ORDER	DESCRIPTION
315068	99315068	Base, engine
340035	99340035	Puller, pulley hub and water pump impeller.
340206/801	99340205	Puller, slide hammer.
340207/814	99340214	Adapter, engine block oil port bushing (use with 99340205).
340207/815	99340215	Adapter, crankshaft pilot bearing (clutch shaft) (use with 99340205)
342135	99342135	Puller, union, injectors (use with 99340205).
342145	99342145	Remover, injector sleeve.
345075	99345075	Remover, tappet.
350071	99350071	Wrench, hexagonal socket (19 mm), 3/4" drive cylinder head.
352137	99352137	Wrench, tappet adjustment.
360042	99360042	Retainer, valve seal check 99395868.
360143	99360143	Remover/installer, valve guide.
360184	99360184	Pliers, engine piston ring.
360274	99360274	Remover/installer, engine valve.
360280	99360280	Remover/installer, valve guide (use with 99360143).
360304	99360304	Brackets, engine flywheel rotation (use with 99360307).
360307	99360307	Crank, engine flywheel rotation (use with 99360304).
360310	99360322	Rotator, engine flywheel.
360314	99360314	Remover/installer cartridge filter
360349	99360349	Guide studs, engine flywheel assembly/disassembly.
360350	99360350	Bracket, engine flywheel assembly/disassembly
360351	99360351	Retainer, engine flywheel.
360368	99360368	Installer, crankshaft rear seal (use with 99370005)
360376	99360376	Remover/installer valve seat (use with 99390358)
360382	99360382	Remover/installer cylinder head valve seat (use with 99360394).
360385	99360385	Remover/installer, camshaft bushing assembly/disassembly.
360394	99360394	Remover/installer, valve seat fitting in cylinder head.
360419	99360419	Dresser, HUNGER, universal, valve seat.
360442	99360442	Connection, engine cylinder compression test (use with 99395682)
360443	99360443	Tester, cylinder head hydraulic seal (use with 99305048).
360454	99360454	Installer, crankshaft seal (use with 99370006).
360456	99360456	Remover/installer, bearing on water pump casing.
360457	99360457	Remover/installer, bushing on water pump casing.
360474	99360474	Remover/installer, bushing on connecting rod small end (use with 99370006).
360500	99360500	Lifter, crankshaft.
360503	99360503	Set of eyes, lift, engine block.
360585	99360585	Rocking sling, engine removal/installation.
360603	99360603	Compressor, standard ad oversize piston installation in cylinder.
360605	99360605	Compressor, standard and oversize piston installation in compressor cylinder.
360711/1	99360772	Plate, threaded.
360711/14	99360785	Compression ring, cylinder sleeve removal/installation (use with 99360772/99360776/99360778/99360790)

CODE FOR MANUAL	CORRESPONDENT CODE FOR ORDER	DESCRIPTION
360711/36	99360790	Set of adapters.
360711/5	99360776	Set of studs.
360711/7	99360778	Screw, forcing.
361002/9	99361011	Brackets, engine to swinging stand.
365010	99365010	Burnisher, injector sleeve.
365063	99365063	Spreader, injector sleeve.
365160	99365160	Wrench, injector pipe removal.
370005 }	99370005 }	Handle, driver, interchangeable
370006 }	99370006 }	
374267	99374267	Remover/installer, compressor support bushing.
386012	99386012	Remover/installer, crankshaft core plugs.
389856	99389856	Wrench, socket head, rocker shaft.
389857	99389857	Wrench, socket head, crankshaft counterweight.
389858	99389858	Wrench, socket head, crankshaft counterweight.
390330	99390330	Reamer, valve guide hole
390358	99390358	Cutter, valve seat extraction (use with 99360376).
390424/1	99390789	Set of taps, to thread injector sleeve to be extracted.
394016	99394016	Spindle, core plug cutter.
394016/12	99394150	Cutter, crankshaft core plug.
394017	99394017	Dresser, lower injector sleeve portion.
394019	00394019	Bushing, pilot.
394031	99394031	Cutter, injector housing (use with 99394019).
395682	99395682	Tester, engine cylinder compression (use with 99360442).
395687	99395687	Gauge, cylinder sleeve dia.
396149	99396149	Gauge, ring, 99395687 reset, cylinder sleeve dia.