marine engines

section 7

8281 series

workshop manual

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

This publication supplies features and data together with the suitable methods for repair operations to be carried out on each single component of the engine.
Following the supplied instructions and using the inherent specific fixtures, a correct repair procedure will be obtained in due time, protecting the operators from all possible accidents
Before starting any repair, be 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 8281M32
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
Net power at flywheel (*) .
- Light-duty commercial..... 236 kW (320 CV)
At.....2200 rpm
- Continuous duty..... 206 kW (280 CV)
At.....2100 rpm
Engine rotation :
(see from flywheel) ..... CCW
(*) Net rating at flywheel according to ISO 3046-1
- Ambient reference conditions . 750 mmHg ; 25° C ;
30 % relative humidity.

TIMING

Valve Timing :
- Intake
opens · before T.D C..... 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 valve 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

Rotary injection pump type PE 8P.
Fixed injection pump delivery start advance . ..... 18 °
Fuel injectors setting..... 200 + 5 bar
Firing order..... 1 - 3 - 7- 2 - 6 - 5 - 4 - 8

LUBRICATION

Minimum oil pressure .
- at full throttle ..... .5 kg/cm^2
- when idling ..... 1.5 kg/cm^2

COOLING SYSTEM

Cooling by dual water circuit :
- Primary circuit (closed) by fresh water;
- Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.
Complete sea water circuit is protected from corrosion by replaceable sacrifical anodes.

STARTING

By starter motor.

ELECTRIC SYSTEM

- Voltage..... 24 V
- Self-regulated alternator..... 24 V, 30 A
- Starting motor power..... 6.6 kW
- Battery (optional)..... 2 ,each 176 Ah

MARINE GEAR

Available in different models for their overhauling see the specific manual of the manufacturer.

ENGINE SPECIFICATIONS

Engine type 8281SRM44
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 .5 : 1
Net power at flywheel (*) :
-- Continuous duty ..... 324 kW (440 CV)
At ..... 2000 rpm
Engine rotation :
(see from flywheel) ..... CCW
(*) Net rating at flywheel according to ISO 3046-1
- Ambient reference conditions : 750 mmHg ; 25° C ;
30 % relative humidity.

TIMING

Valve Timing :
- Intake
opens : before T.D.C ..... 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 valve 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

Rotary injection pump type PE 8P.
Fixed injection pump delivery start advance ..... .24 °
Fuel injectors setting ..... 210 + 8 bar
Firing order ..... 1 - 3 - 7 - 2 - 6 - 5 - 4 - 8

TURBOCHARGING

The engine is turbocharged by 2 turbochargers driven by the exhaust gases
The turbochargers are lubricated with the engine oil under pressure.

LUBRICATION

Minimum oil pressure :
- at full throttle ..... 5 kg/cm^2
- when idling ..... 1 5 kg/cm^2

COOLING SYSTEM

Cooling by dual water circuit :
- Primary circuit (closed) by fresh water;
- Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.
Complete sea water circuit is protected from corrosion by replaceable sacrifical anodes.

STARTING

By starter motor

ELECTRIC SYSTEM

- Voltage ..... 24 V
- Self-regulated alternator ..... .24 V, 55 A
- Starting motor power ..... 6.6 kW
- Battery (optional) ..... 2 ,each 176 Ah

MARINE GEAR

Available in different models for their overhauling see the specific manual of the manufacturer

ENGINE SPECIFICATIONS

Engine type 8281SRM70
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 .5 : 1
Net power at flywheel (*) :
- Pleasure craft .... 515 kW (700 CV)
At..... ... .2200 rpm
-- Continuous duty. .. . . .397 kW (540 CV)
At..... . .. . 2200 rpm
Engine rotation .
(see from flywheel) .... CCW
(*) Net rating at flywheel according to ISO 3046-1
- Ambient reference conditions : 750 mmHg ; 25° C ;
30 % relative humidity.

TIMING

Valve Timing :
- Intake
opens : before T.D.C..... ....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 valve 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

Rotary injection pump type PE 8P.
Fixed injection pump delivery start advance .....21 °
Fuel injectors setting..... .. .. 230 + 8 bar
Firing order..... ....1 - 3 - 7- 2 - 6 - 5 - 4 - 8

TURBOCHARGING

The engine is turbocharged by 2 turbochargers driven by the exhaust gases.
The turbochargers are lubricated with the engine oil under pressure.

LUBRICATION

Minimum oil pressure :
- at full throttle . ... 5 kg/cm^2
- when idling ... .1 5 kg/cm^2

COOLING SYSTEM

Cooling by dual water circuit :
- Primary circuit (closed) by fresh water;
- Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.
Complete sea water circuit is protected from corrosion by replaceable sacrifical anodes

STARTING

By starter motor.

ELECTRIC SYSTEM

- Voltage..... .... 24 V
- Self-regulated alternator..... .... 24 V, 55 A
- Starting motor power..... .. .. 6.6 kW
- Battery (optional).....2 ,each 176 Ah

MARINE GEAR

Available in different models for their overhauling see the specific manual of the manufacturer.

SEA WATER PUMP

GENERALITIES

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

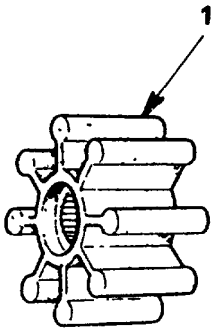
INSTRUCTION FOR USE

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

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

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

If not replace it.



FRESH WATER-SEA WATER HEAT EXCHANGER

GENERALITIES

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

65 °C - 8281M32

68 °C - 8281SRM70

74 °C - 8281SRM44

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

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

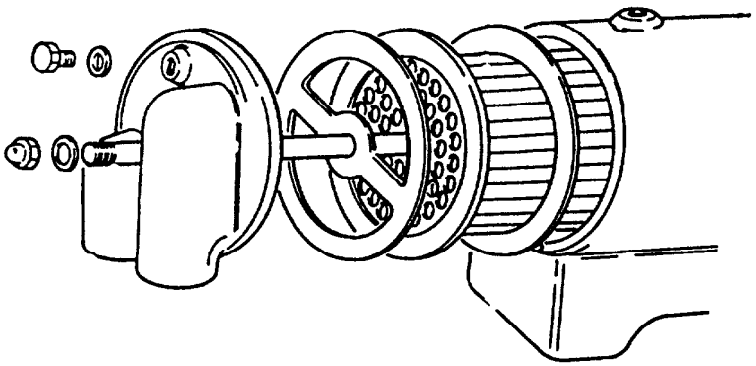
MAINTENANCE

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

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

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

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



FITTING DATA

ENGINE BLOCK - CONNECTING RODS

DESCRIPTION	mm
Cylinder sleeve bore dia.	145.000 to 145.030
Cylinder bore dia. in engine block: — Upper	164.000 to 164.040
— Lower	158.500 to 158.540
Sleeve pilot dia.: — Upper	164.003 to 164.028
— Lower	158.461 to 158.486
Sleeve interference fit in block: — Upper	−0.028 to + 0.037
— Lower	0 014 to 0 079
Sleeve length	261.500 to 262 500
Camshaft bush housing bore dia.: — 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
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	3.705 to 3.735
— 2nd groove	3.040 to 3.060
— Bottom groove	6 030 to 6 050
Ring thickness:	
— Top compression ring, double taper chromium plated	3 575 to 3 595
— 2nd compression ring, straight	2 978 to 2 990
— Oil scraper ring, slotted, spring loaded	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	0.110 to 0 160
— Second compression ring, straight	0.050 to 0.082
— Oil scraper ring	0.040 to 0 072
Ring gap in sleeve:	
— Top compression ring, double taper chromium plated	0 40 to 0.60
— Second compression ring, straight	0 55 to 0 75
— Oil scraper ring	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 ± 2,5 kg	57 5
Spring height under 80 ± 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^2

FITTING DATA

DESCRIPTION		mm
ENGINE BLOCK-CONNECTING RODS		
Cylinder sleeve bore dia		145 000 to 145 030
Cylinder bore dia in engine block	upper	164 000 to 164 040
	lower	158 500 to 158 540
Sleeve pilot dia.	upper	164 003 to 164 028
	lower	158 461 to 158 486
Sleeve interference fit in block	upper	−0 028 to +0 037
	lower	0 014 to 0 079
Sleeve length		261 500 to 262 500
Camshaft bush housing bore dia	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
PISTONS - PINS - RINGS		
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	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	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 50 to 0 82
	Oil scraper	0 40 to 0 72
Ring gap in sleeve	Top compression ring, double taper, chromium plated	0 40 to 0 60
	2nd compression ring, straight	0 70 to 0 102
	Oil scraper	0 40 to 0 60
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
	Fxhaust	47 136 to 47 161

DESCRIPTION		mm
Max valve stem distorsion 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 deep in cylinder head	Inlet Exhaust	0 1 to 0.45 0 3 to 0 75
VALVE SPRINGS		
Released spring height		~74
Spring height under 45 ± 2 5 kg		57 5
Spring height under 80 ± 4 kg		46 5
VALVE GEAR		
Camshaft bush housing fitted in engine block □ 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
Bush interference fit in engine block		There should be always interference
Bush fitted I D after reaming □ front □ front intermediate □ center □ rear intermediate □ rear		 70 570 to 70 620 71 070 to 71.120 71 570 to 71 620 72 070 to 72 120 72 570 to 72 620
Camshaft journal dia □ front □ front intermediate □ center □ rear intermediate □ rear		 70 470 to 70 500 70 970 to 71 000 71 470 to 71 500 71 970 to 72 000 72 470 to 72.500
Camshaft journal clearance in bushes □ Clearance		 0 070 to 0 150
Cam lift - Intake and exhaust		8.210
Tappet housing bore dia		26 000 to 26 025
"Crowned" tappet O D (measured at middle)		25 927 to 25 960
Tappet interference fit in housing		0 040 to 0 098
Camshaft thrust plate thickness		5 970 to 6.000
Thrust plate housing thickness		6 070 to 6 145
Camshaft thrust clearance		0.070 to 0 175
Injection pump drive shaft support bushing dia		70 879 to 70 909
Injection pump drive shaft support bushing O D		70 970 to 71 000
Bushing interference fit in housing		0 061 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
OIL PUMP	
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
OIL PRESSURE BOOST VALVE	
Oil pressure relief valve - seat clearance	0 016 to 0 061
Relief valve opening pressure	4 5 kg/cm^2
HEAT EXCHANGER RELIEF VALVE	
Relief valve - valve seat clearance	0 016 to 0 061
Heat exchanger relief valve opening pressure	1 6 kg/cm^2
Relief valve opening on three filter cartridges	1 6 kg/cm^2

FAULT FINDING DIAGNOSIS

TROUBLE	POSSIBLE CAUSE	REMEDY
The engine does not start		
	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 Disasse 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
The engine stalls	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. Disasse 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
The engine owerheats	Defective water pump	Check clearance between impeller blades and pump casing Overhaul the assembly and replace gasket
	Thermostat failure.	Valve stem jamming in its guide

TROUBLE	POSSIBLE CAUSE	REMEDY
The engine warms up excessively	Scale in water passages in engine block and cylinder head	Wash thorougly, 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
The engine is under power and its operation is uneven	Incorrect timing of injection pump	Check pump timing and correct it
	Excessive wear in plungers and barrels of injection pump	Ovehaul 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	Thorougly 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^2, overhaul the engine
	Defective turbocharger	Overhaul the assembly or replace it
	Air cleaner clogged	Clean air cleaner and inherent system
	Incorrect adjustment of injection pump peak capscrew or of control rod stop	Adjust stops correctly
The engine knocks abnormally	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
The engine knocks abnormally	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 cranckshaft journals and mount undersize bearings Replace thrust washer halves with oversized ones.
	Cranckshaft 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 an rockers and check if there are broken springs or excessive clearance between stems and guides, or tappets and seats
The engine smokes abnormally **1) Black or dark grey smoke:**	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 uncorrectly	Overhaul engine or repair concerned parts

TROUBLE	POSSIBLE CAUSE	REMEDY
1) Dark grey or black smoke:	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 blockage	Check conditions of ends and connectors Replace where necessary
2) Blue, grey/blue, or clear grey smoke	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
The engine does not stop	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
	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
Stepless change of max. speed (engine not loaded)	Governor springs too weak, causing an excessive sensitivity from governor	Replace governor springs
	Pushrod stroke too small	Fit plungers with flatter helical edge
	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)
The pump does not deliver fuel	Foreign matter in pipes	Clean thorougly
	Dirty fuel filters	Clean thorougly
	Squashed pipes	Replace pipes or, if possible repair them (the low pressure ones)
	Air in injection pump	Deaerate pump

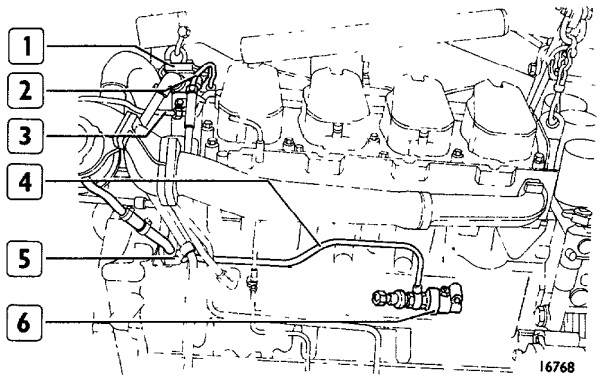
TROUBLE	POSSIBLE CAUSE	REMEDY
The pump does deliver fuel	Plunger tappets may be seized.	Remove part and repair it (if failure is minor); if necessary, replace it
	Plunger seized	Change defective pumping element, as barrels and piston are not interchangeable.
	Delivery valves seized	If failure is only due to foreign matter, clean valve and sligtly regrind taper faces with an emery cloth, if reasons are different, replace pair valve holder - valve with are not interchageable from each other
The pump does not deliver enough fuel	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
The pump feeds abnormally	Air bubbles in fuel feed pump	Deaerate fuel feed pump
	Plunger return spring broken.	Replace spring
	The plunger is about to seize	Thorougly clean plunger and its cylinder.
	Tappet pin worn-out	Replace tappet.
Injection start faulty timed	Uneven delivery start	Adjust delivery start replacing adjusting shims
	Cam lobe damaged.	Replace camshaft, using the stroboscopic check method
The control rod shakes	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
INJECTORS **The injector drips**	Nozzle and needle valve (pin) are not sealed	Thorougly clean nozzle, if the trouble is due to foreing matter preventing normal operation; otherwise replace the nozzle valve pair.
Too high injection pressure	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
Fuel seeps from injector unions	The upper air bleeder plug is not tightened	Tighten it.
	Nozzle check nut not tightened	Tighten it
Abnormal jet	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
INJECTION PUMP		
Injection pump Difficult starting	Electromagnet for excess fuel device	Check electric contacts on control button and on that same electromagnet
	Air in fuel feed system	Deaerate system until only diesel oil comes out from filter drain screw
	Fuel filters clogged	Replace filters, clean the filter corresponding to hand primer
	Injectors with nozzles seized or clogged	Check injectors, overhaul or replace 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
Uncorrect idling	Accelerator lever stop screw	With the vehicle at idling running, carry out accurate adjustment
Abnormal idling	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
Low efficiency	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 diaphram 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

TROUBLE	POSSIBLE CAUSE	REMEDY
Excessive exhaust smoke with cold engine	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
Excessive exhaust smokes (black) with engine under load	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.
Excessive fuel consumption	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

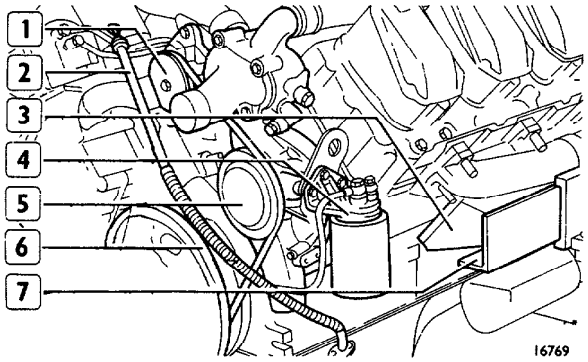
ENGINE DISASSEMBLY

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).

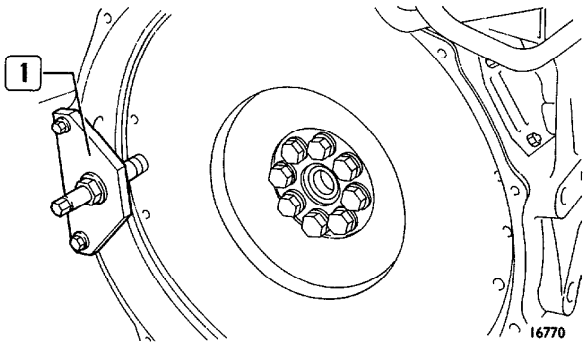
FIGURE 17



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:

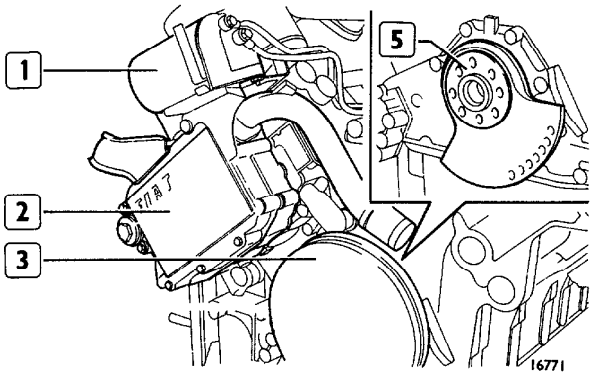
- ☐ Drive belt pulley (6).
- ☐ Alternator (1) and relevant drive belt
- ☐ Oil dipstick hose (2)
- ☐ Support (4) with corrosion proofing filter
- ☐ Water pump (5) with its thermostats

FIGURE 18



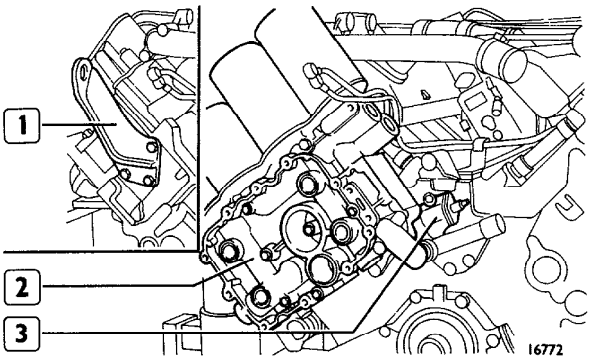
Lock crankshaft rotation using tool 360351 (1) positioned as indicated.

FIGURE 19



Remove: damper flywheel (3), counterbalance (5), fuel filter (1), heat exchanger (2).

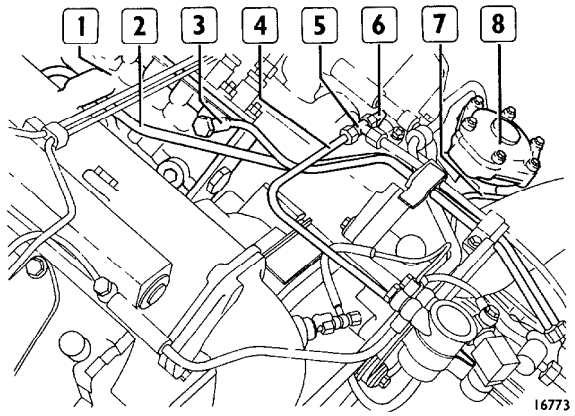
FIGURE 20



Remove:

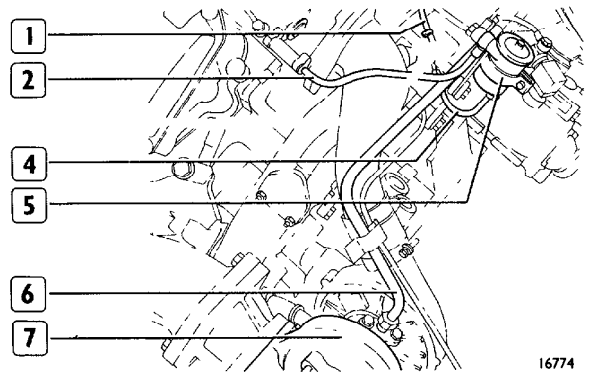
- ☐ Oil filter housing (2) with filters
- ☐ Engine tachometer control (3)
- ☐ Bracket (1) for engine lift

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)

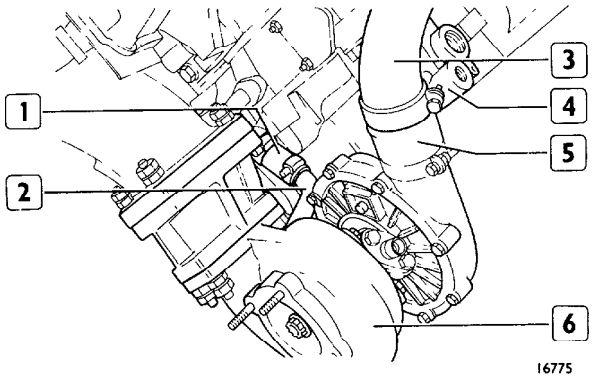
FIGURE 22



Disconnect:
- Injector fuel leak-back line (2).
- fuel lines (1 and 4)
- From turbocharger (7) oil inlet line (6)

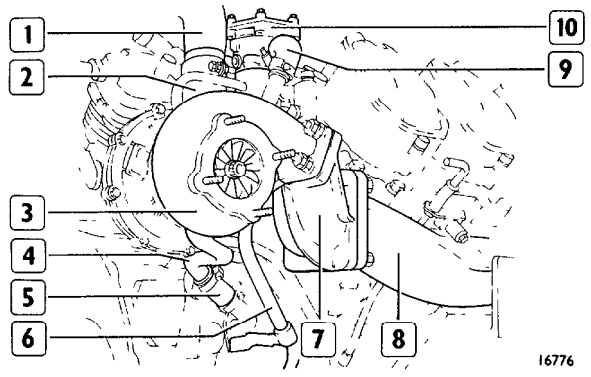
From flywheel cover disconnect tank bracket (5) of thermostarter reservoir with all its lines

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)

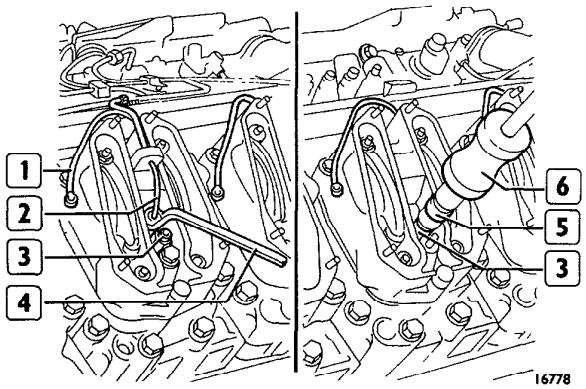
FIGURE 24



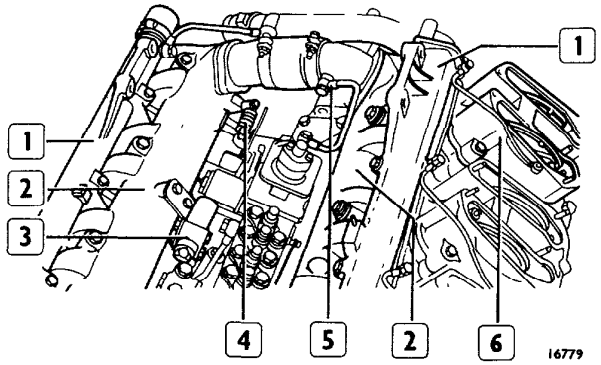
From the rear right side of engine, disconnect from engine block the bracket securing oil vapour breather pipe (6)
Loosen hose clamps securing the turbocharger (3) sleeve (2) to intake manifold (1), sleeve (9) connecting oil vapour breather pipe (6) to oil vapour condenser (10), and sleeve (5) connecting the turbocharger (3) oil outlet pipe (4) to the flywheel housing line

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

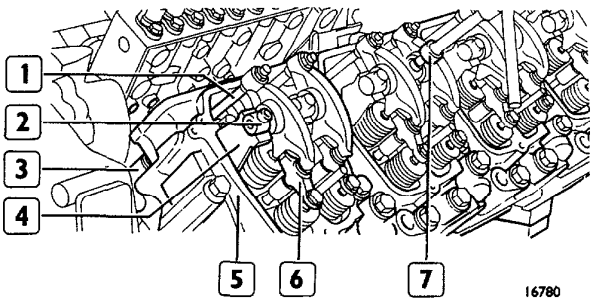
- Exhaust manifolds with gaskets.
- Tappet housing covers



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)

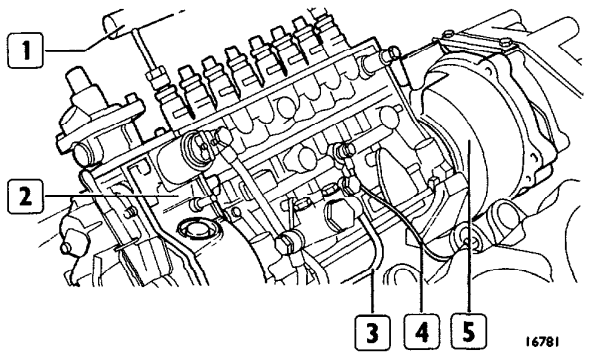


Disconnect injection pump shut-off cylinder (3) and return spring (4).
Disconnect air line (5) controlling LDA device
From cylinder heads detach cooling fluid manifolds (1), intake manifold (2), rocker housing (6).



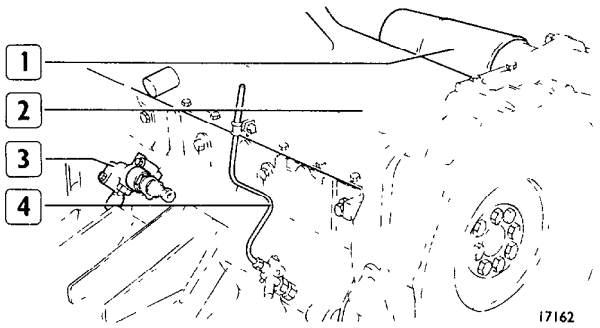
Disconnect:
- Rocker shafts (2) from housings (4), removing cap-screws by wrench 389856 (7).
- Housings (4), bridges (6) and rods (1) from cylinder heads (5).

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



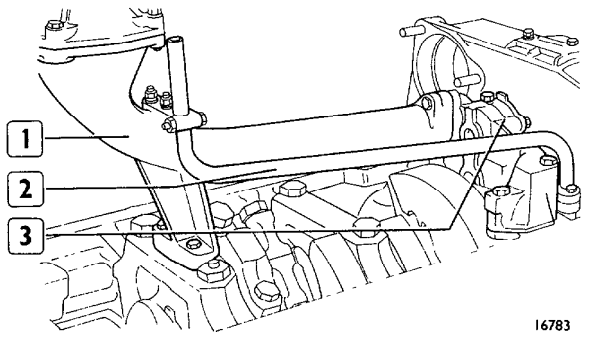
Disconnect inlet (4) and outlet (3) oil pipes from injection pump (2).
Install fixture (1) on injection pump (2) unions, disconnect pump from engine removing the screws which secure it to their supports and the screws which secure flange housing (5) to flywheel housing

FIGURE 30



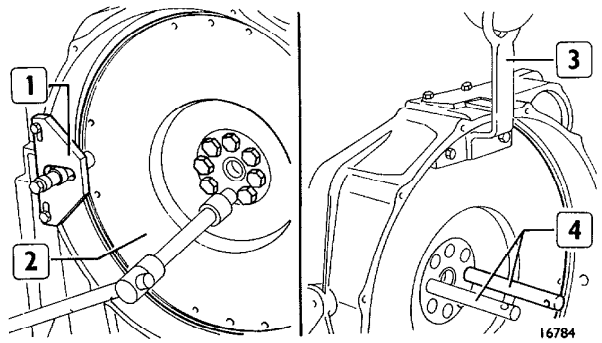
From engine disconnect
- □ Oil sump (2)
- □ Support (3)
- □ Cooling fluid drain pipe (4)
- □ Starter (1)

FIGURE 31



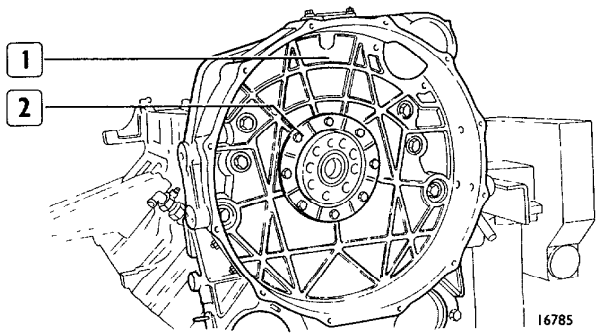
Disconnect oil pump (3) with attached oil suction (1) and drain pipe (2).

FIGURE 32



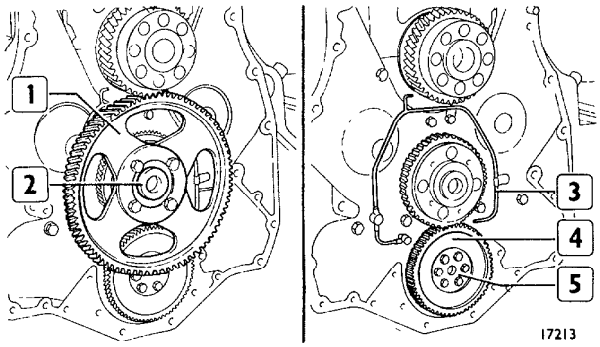
Stop crankshaft rotation using tool 360351 (1) and remove the screws securing flywheel (2) to crankshaft
On crankshaft, screw down guide pins 360349 (4), apply bracket 360350 (3) on flywheel (2) and take off this using a hoist

FIGURE 33



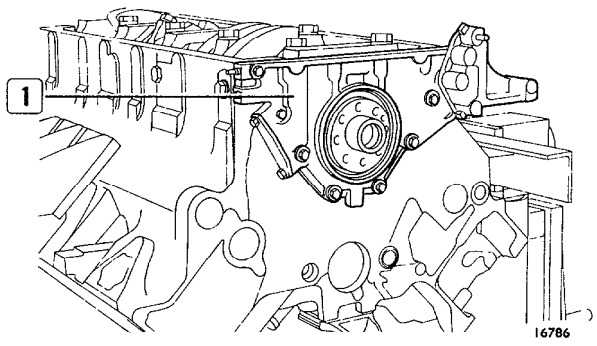
From flywheel housing (1) disconnect rear cover (2) and remove the flywheel housing (1) from engine block

FIGURE 34

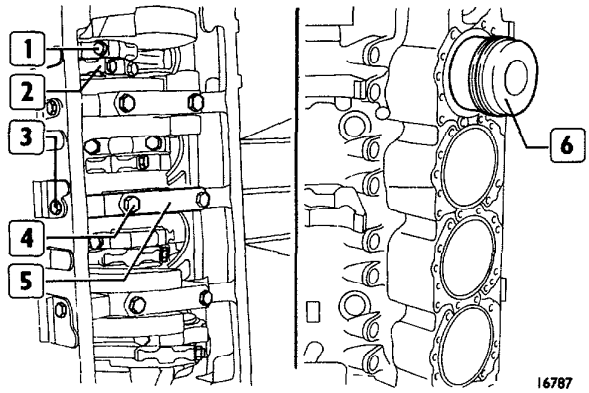


Disassemble gear (1) from camshaft (2)
Remove lubrication line (3)
Disconnect gear (4) from injection pump shaft (5) and draw this out from its support

FIGURE 35



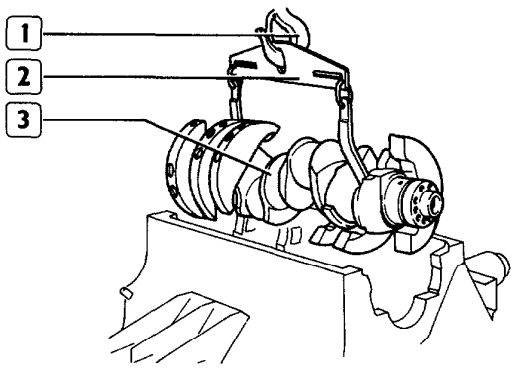
Detach cover (1) with seal from the front side of the engine



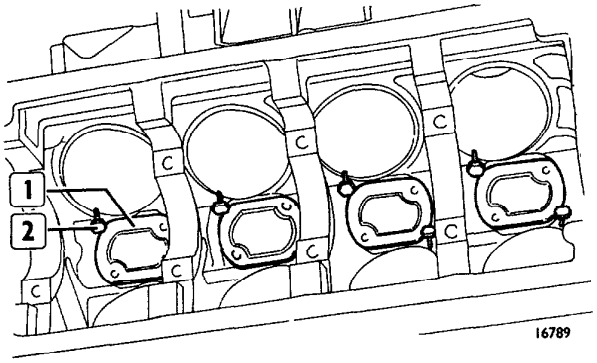
Position engine block vertically.
Withdraw pistons as follows:
- Loosen connecting rod cap nuts (1).
- Rotate crankshaft unit the piston is exactly on T.D.C. In different positions the piston could not be withdrawn as the connecting rod interferes with cylinder sleeve.
- Remove connecting rod cap (2) 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.

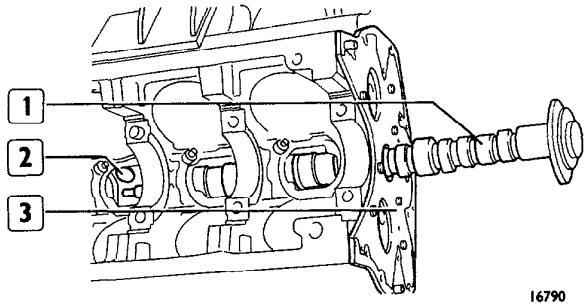
NOTE - Center bearing housing (5) and cap carry thrust washers for crankshaft end float



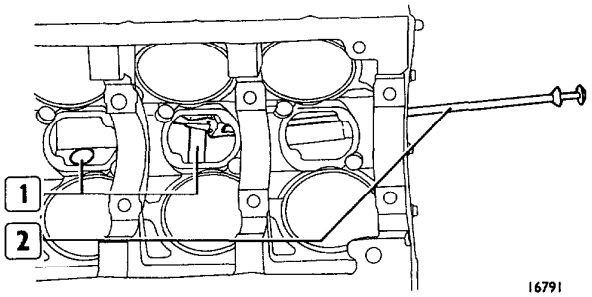
Using hoist (1) and fixture 360500 (2) installed on crankpins, withdraw crankshaft (3) from engine block



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



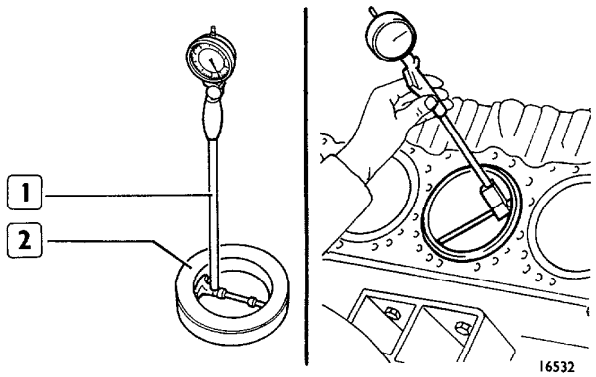
From engine block remove camshaft (1) taking care not to damage bushings
Withdraw tappets (2) and take off rear plate (3)



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

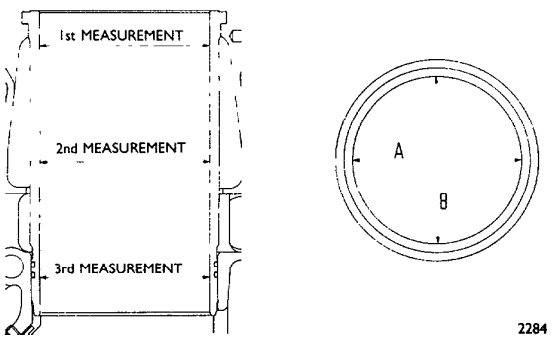


CHECKS AND MEASUREMENTS

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

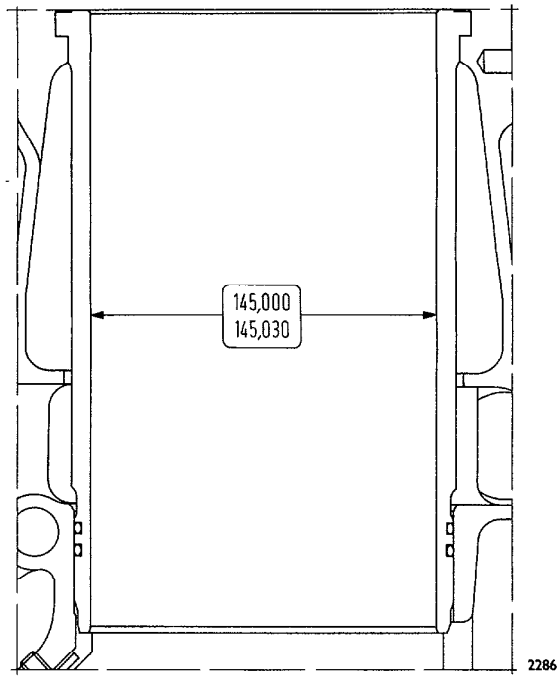
To check cylinder sleeve bore for ovality, taper or wear, use gauge 395687 (1) with attached dial gauge previously set to zero against ring gauge 396149 (2) (145 mm dia)

FIGURE 42



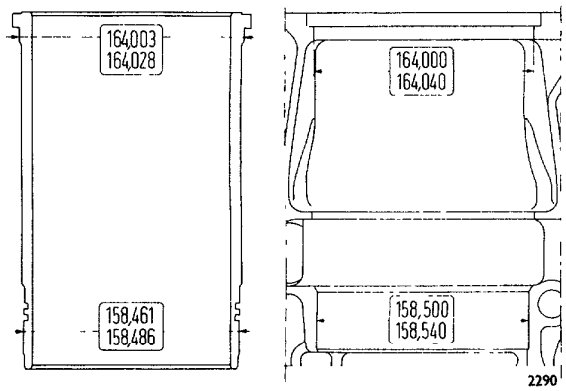
Each sleeve cylinder bore must be measured at three different points on two planes at right angles, as indicated in the diagram Max wear is usually observed on first measurement level (B axis)

FIGURE 43



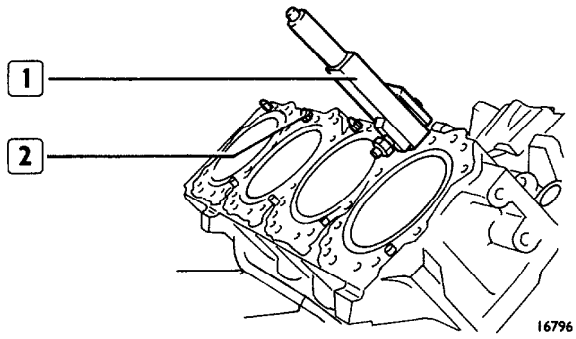
If higher values than those indicated in the figure are detected, replace cylinder sleeves, as the sleeve bore is liquid nitrided and must not be ground, honed or dressed

FIGURE 44



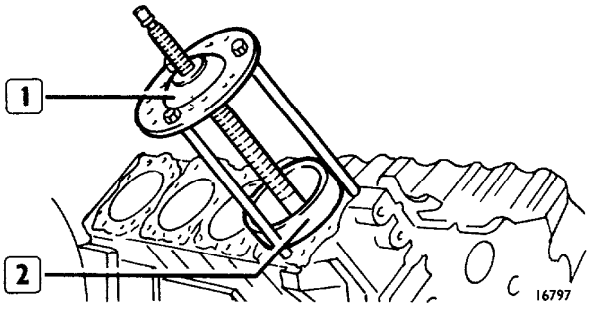
The above scheme indicates cylinder sleeve bore and O.D

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

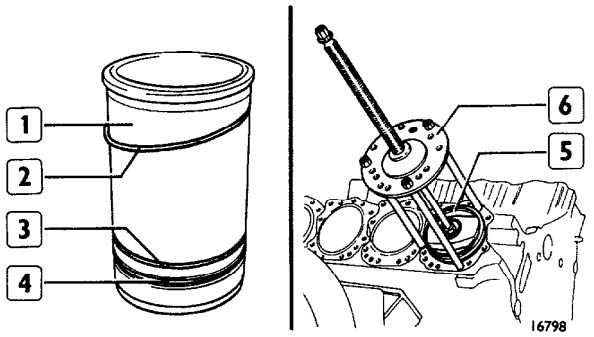


Check engine block face for distorsion, using a straight-edge and a feeler.
If necessary, remove dowels (2) and, using fixture (1) withdraw sleeves from engine block and grind surfaces

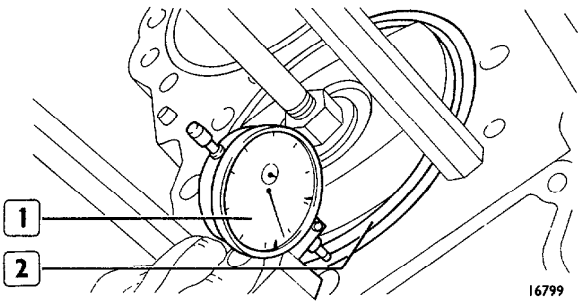
NOTE - Remove as little material as possible, considering that the same thickness must be removed from sleeve shoulder seats using a suitable fixture.



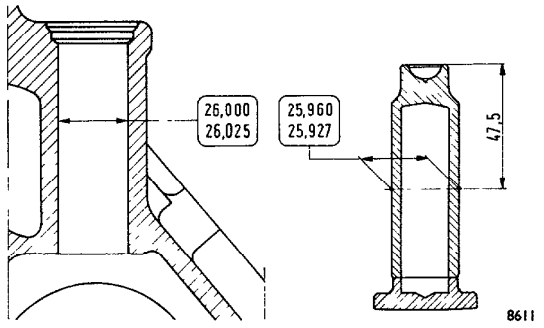
Take off cylinder sleeves (2) from engine block using plate 360711/14 and tool 360711/35 (1) positioned as indicated in the figure
Thorougly check cylinder sleeve housings and engine block side surfaces Inspect conditions of gap on cylinder block bores.
If rusted or mis-sealed, replace them.



Always replace water seals (3 and 4).
Slide the upper brass sealing ring (2) into cylinder sleeve (1), and lubricate lower sleeve end before inserting it in cylinder through plate 360711/14 (5) and tool 360711/35 (6).

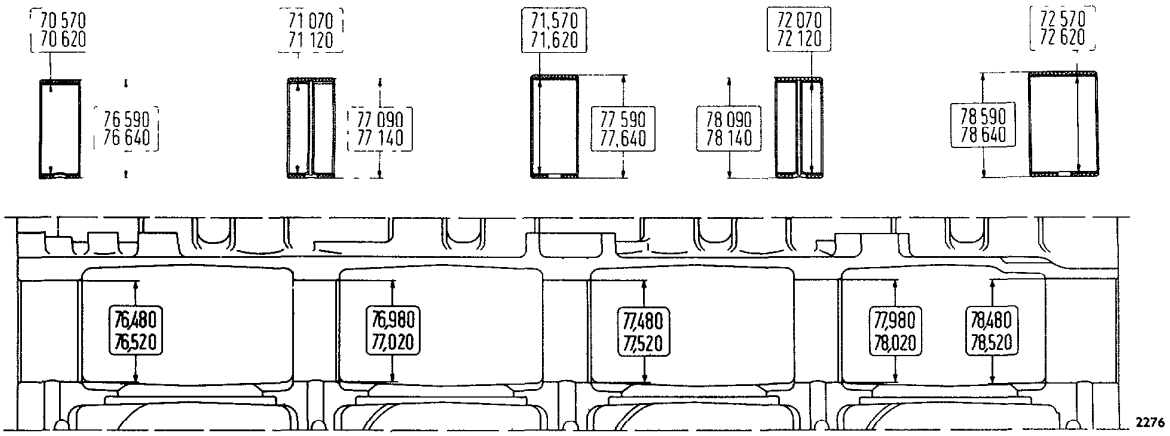


Through gauge (1) measure cylinder sleeve protrusion (2) as to engine block face It should be 0 03 to 0 09 mm.



Normal tappet clearance is 0 040 to 0 098
Spare oversize tappet ranges are 0 1 - 0 2 - 0.3 mm
Tappet surface in contact with camshaft lobe should be smooth and free from dents Slight dents may be repaired with a zerograde emery paste.

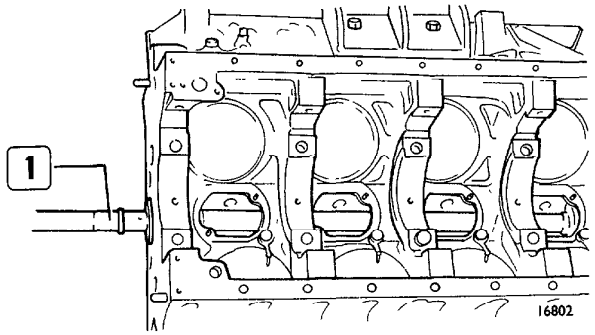
FIGURE 50



CAMSHAFT BUSHING AND SEAT DETAILS

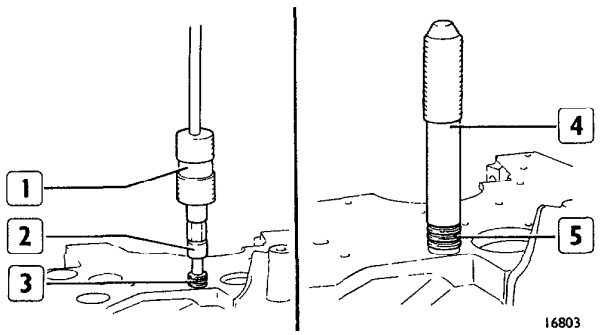
Bushings must be press fitted in their seats Inside surfaces must be smooth and free from seizure, and should not be worn-out

FIGURE 51



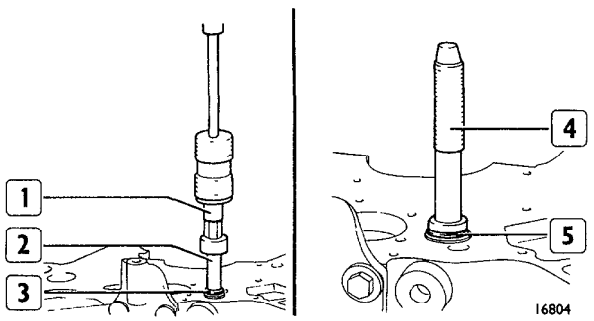
To replace bushing use remover/installer tool 360385 (1)
Camshaft clearance should be 0 07 to 0.15 mm

FIGURE 52



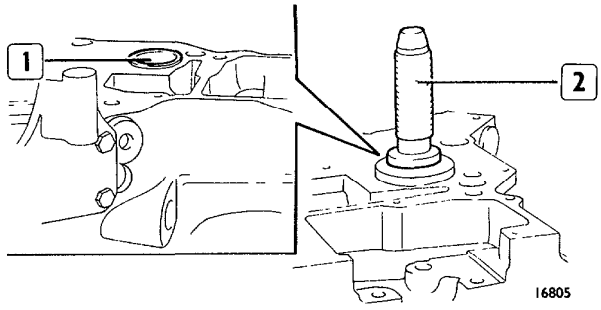
Replace bushing (3) sealing ring (5) of main left oil gallery removing the bushing from engine block by means of remover/installer 340206/801 (1) together with 340207/814 (2) To insert bushing, use suitable remover/installer tool (4)

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)

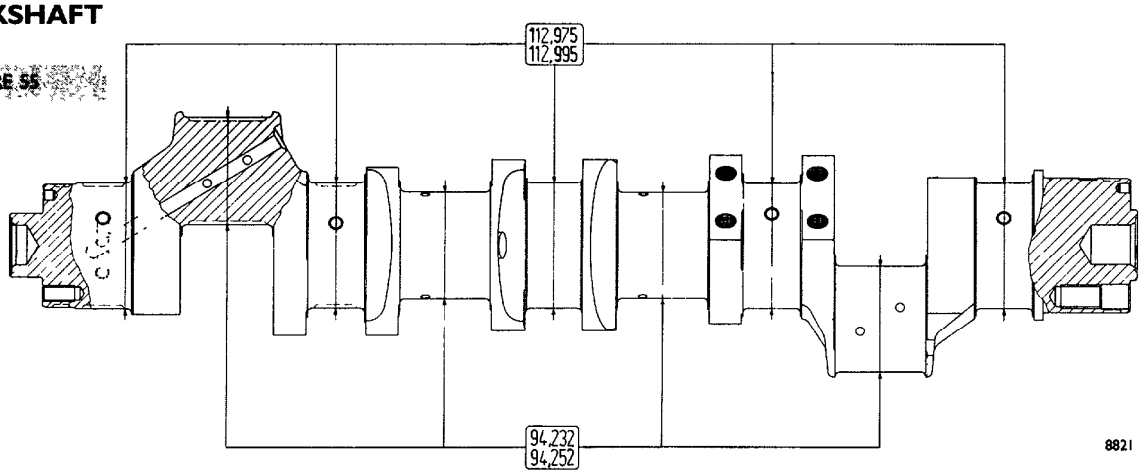
FIGURE 54



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

CRANKSHAFT

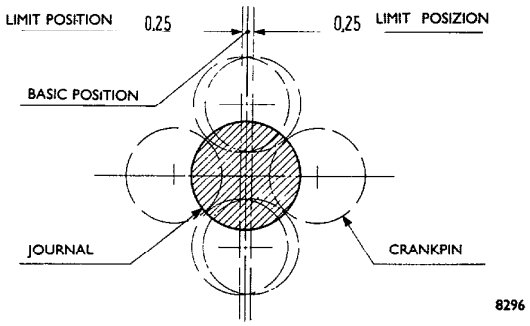
FIGURE 55



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

FIGURE 56



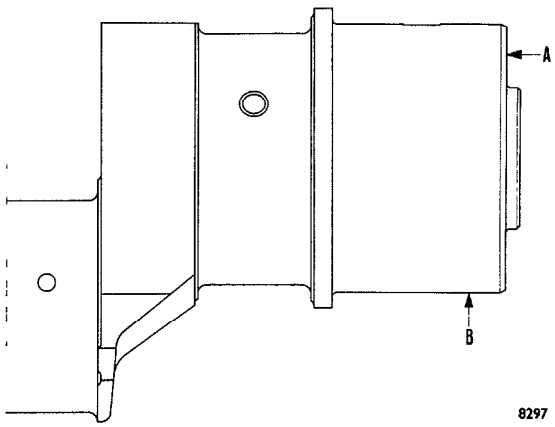
MAX. ALLOWABLE CLEARANCE ON CRANKPIN ALIGNMENT VS. MAIN JOURNAL

During crankshaft journal regrinding, the allowed tolerances are:
- Ovalization 0 008 mm
- Taper: 0.012 mm.
- Main journal misalignment· 0 10 mm
- Crankpin misalignment. ± 0.25 mm

Undersize range· 0 254 - 0 508 - 0 762 - 1 016 mm.

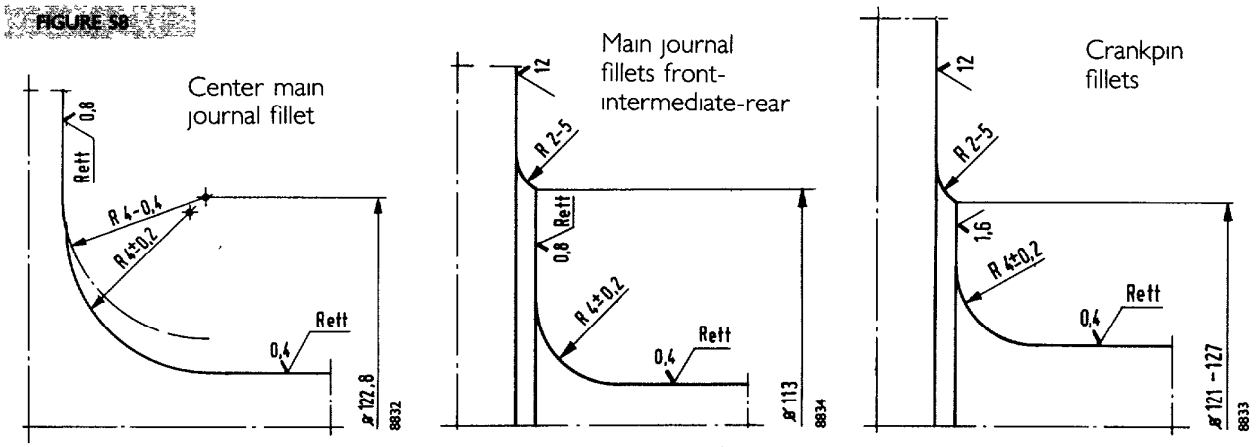
NOTE - Journals must be reground to a same undersize class.

FIGURE 57



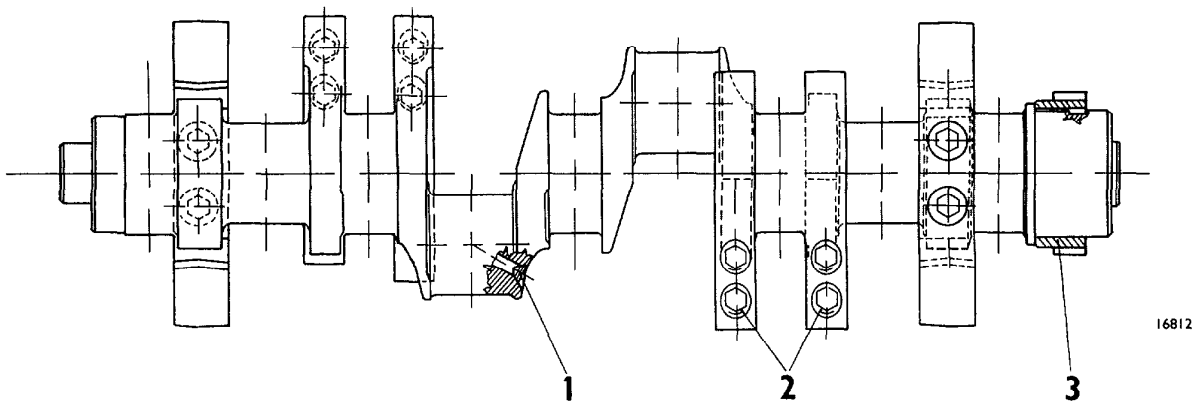
Checking squareness and concentricity of flywheel face as to rotation axis and main journals
Rotate shaft·
with the gauge positioned on B, changes over 0.4 mm should not be detected;
with the gauge positioned on A, changes over 0 02 mm should not be detected

FIGURE 58



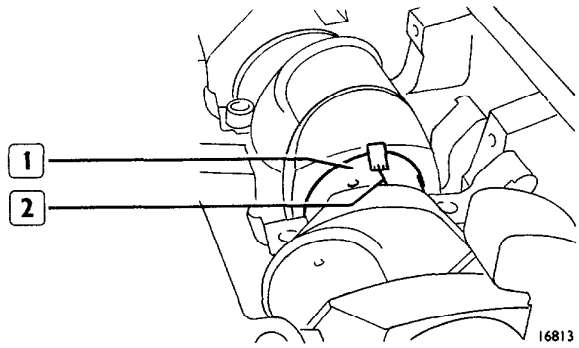
When grinding crankshaft journals, machine them as indicated in the picture

FIGURE 59



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^2)
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

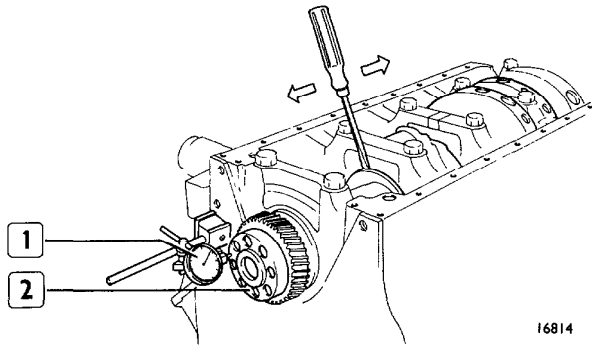
FIGURE 60



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

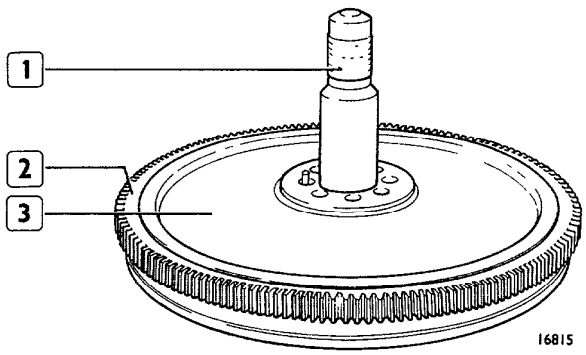
FIGURE 61



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

FIGURE 62

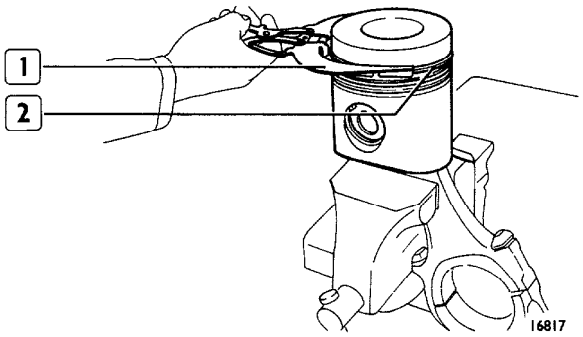


Check clutch plate face; if scores are observed, machine it off
Removal/insertion of spigot shaft bearing is carried out using standard tool (1)
Check flywheel ring gear teeth (2); if breakages or excessive wear is noticed on teeth, remove ring gear from engine flywheel (3) using a standard removal/ 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

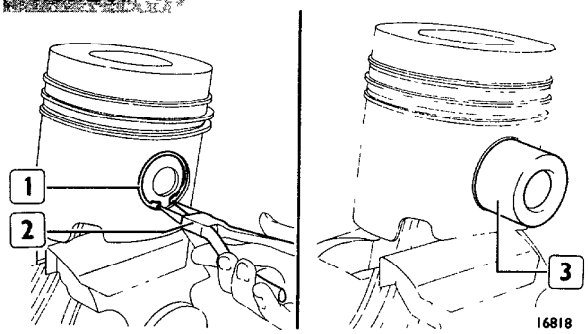
Check pistons for pick-up, score marks and cracks or excessive wear; in necessary, replace them.
Check that gudgeon pin and its seat on piston are not worn out; clearance should be 0 012 to 0 026 mm
Piston rings should not be damaged or loose

FIGURE 63



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

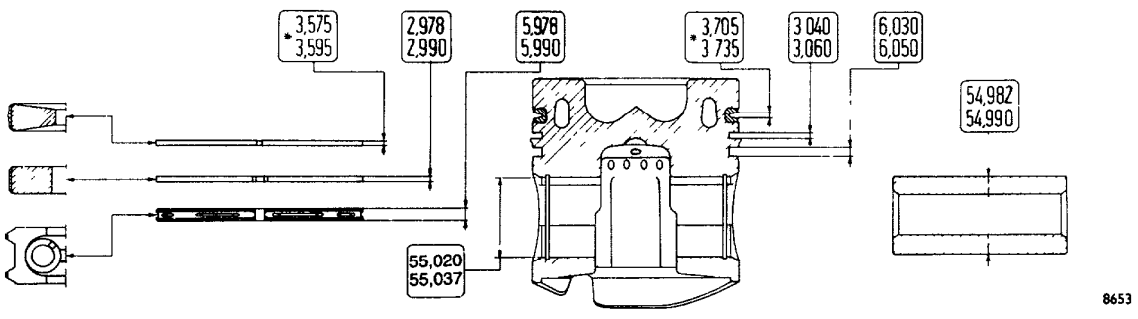
FIGURE 64



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

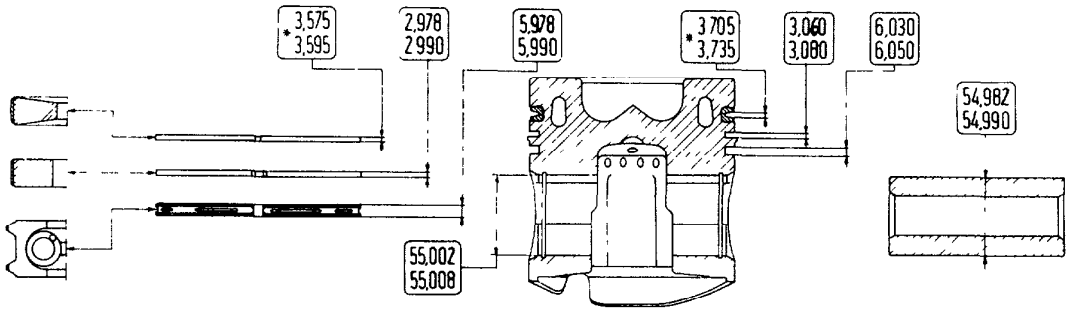
NOTE - Piston - connecting rod fit must be carried out considering that, when the assembly is inserted in engine block, words "LATO POSTERIORE" on piston crown must be positioned towards the rear side of engine, and connecting rod figures must be opposite the figures on engine block

FIGURE 65



PISTON, PIN, RING DETAILS

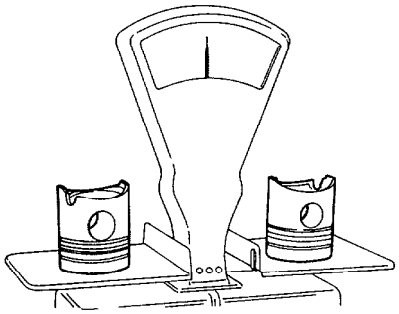
* Dimension detected on 142 mm dia (8281SRM44 8281SRM70)



PISTON, PIN RING DETAILS

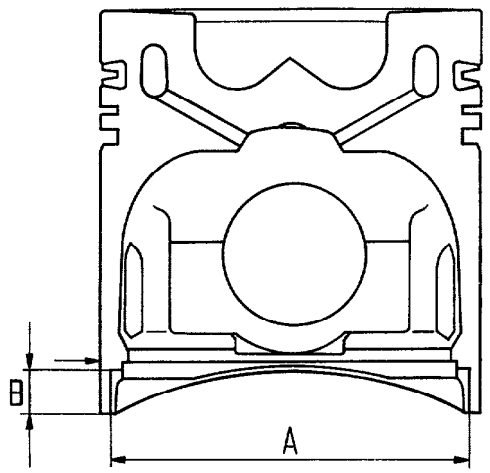
* Dimension detected on 142 mm dia (8281M32)

FIGURE 66



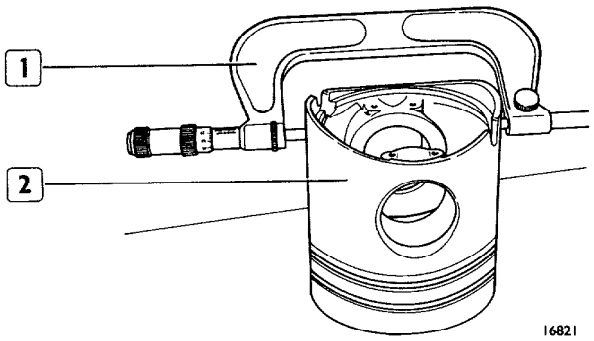
Check for piston weight equalities Allowance is ± 15 gr

FIGURE 67



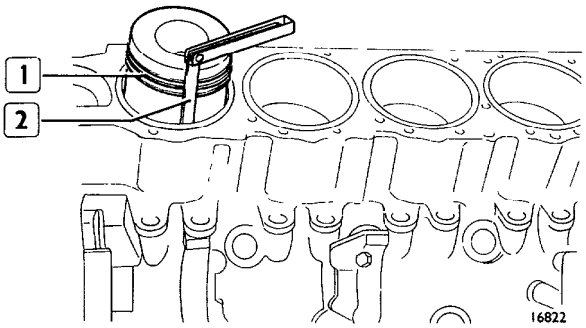
In case of over weight, remove material on diameter A (without exceeding 137 mm) and on depth B (without exceeding 17 mm).

FIGURE 68



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

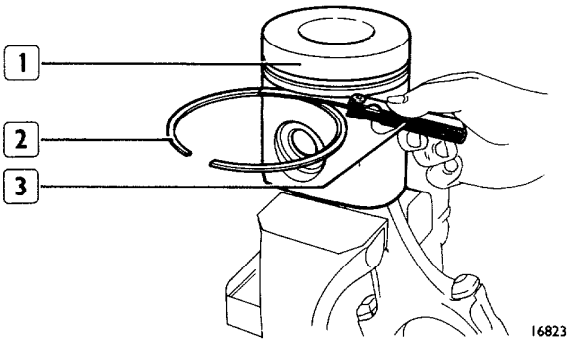
FIGURE 69



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

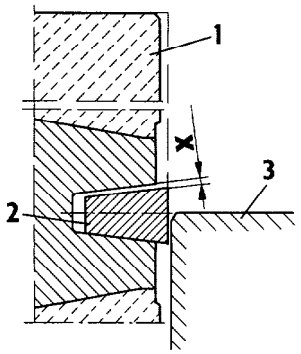
PISTON RINGS

FIGURE 70



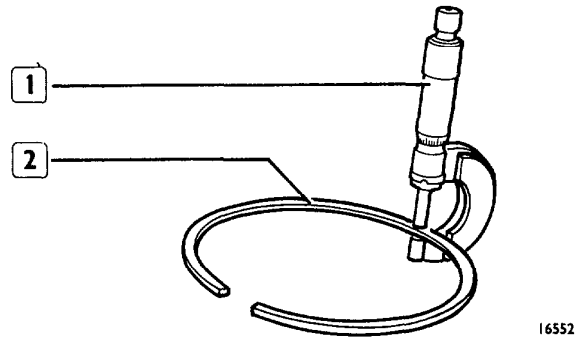
Check clearance between piston rings (2) and relevant seats on piston (1), using feeler (3)

FIGURE 71



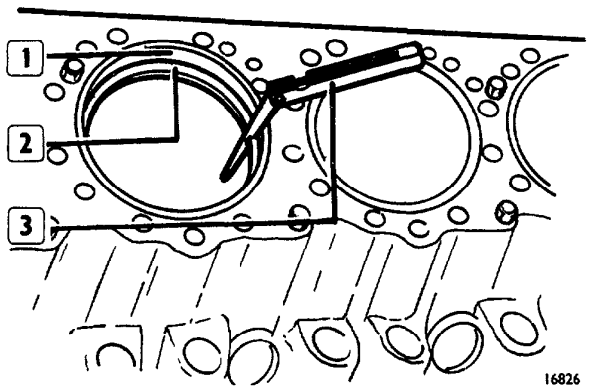
Top compression ring (2) is of double taper type, clearance is measured positioning piston (1) with relevant ring into cylinder sleeve (3) so that the compression ring protrudes half its length from cylinder sleeve

FIGURE 72



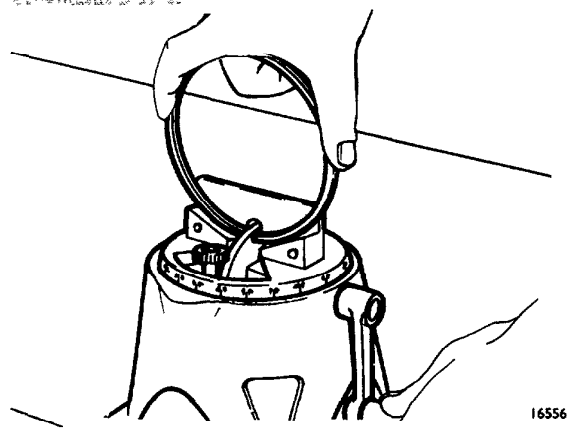
Check ring (2) thickness using micrometer (1)

FIGURE 73



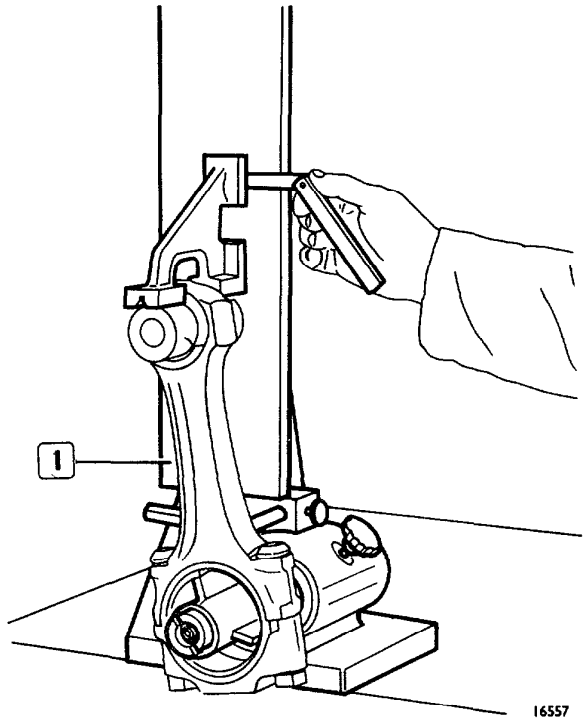
With feeler gauge (3) check the gap at the end of sealing rings (2) inserted in cylinder sleeve (1).

FIGURE 74



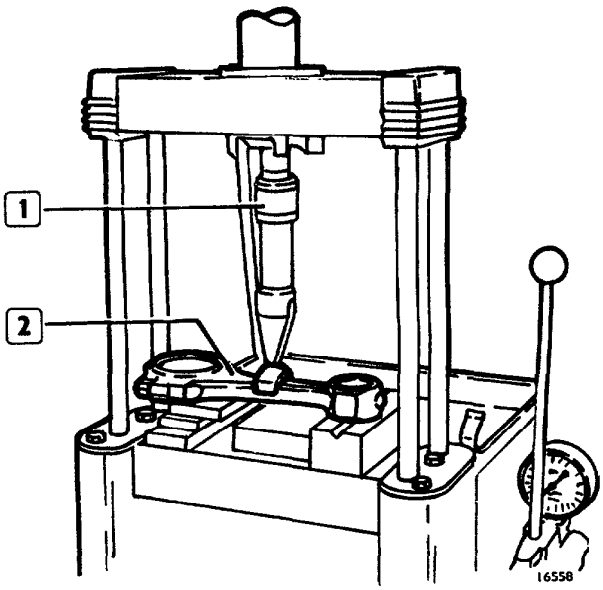
If a distance shorter than the prescribed value is detected, remove the excess material by means of tool 360188, operating as indicated in the figure

FIGURE 75



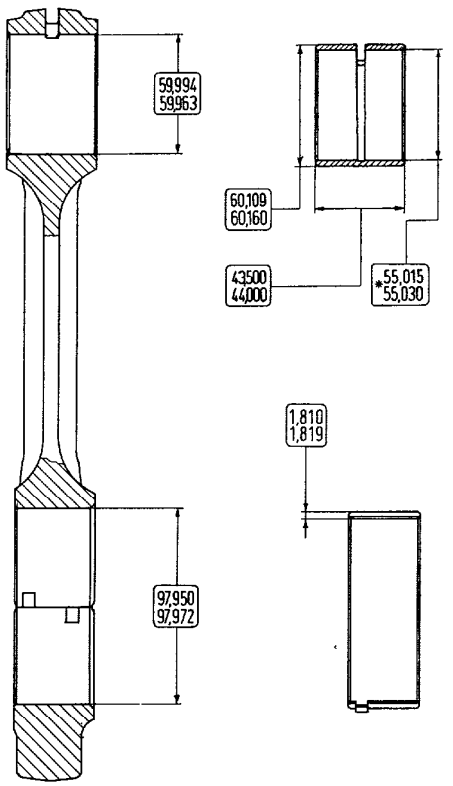
Check parallelism of connecting rod axes using tool 395363 (1).
Maximum allowed tolerance is ± 0 025 mm at 125 mm from the longitudinal connecting rod axis.

FIGURE 76



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

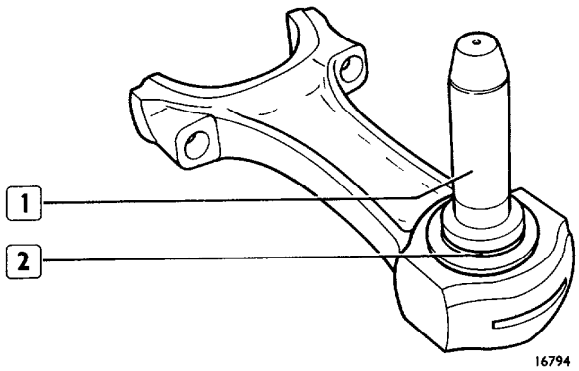


CONNECTING ROD, BIG END BEARING AND BUSHING DETAILS

* Fitted I D

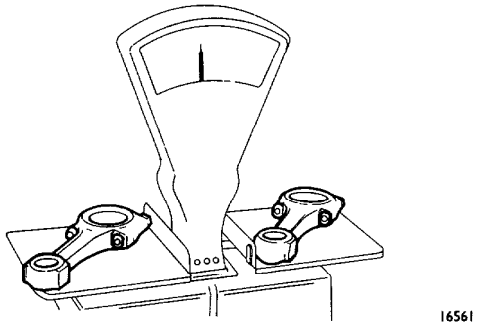
Check inner bushing surface for marks of seizure or scoring
Check clearance between bushing and gudgeon pin; which should be 0 025 to 0.048 mm

FIGURE 78



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

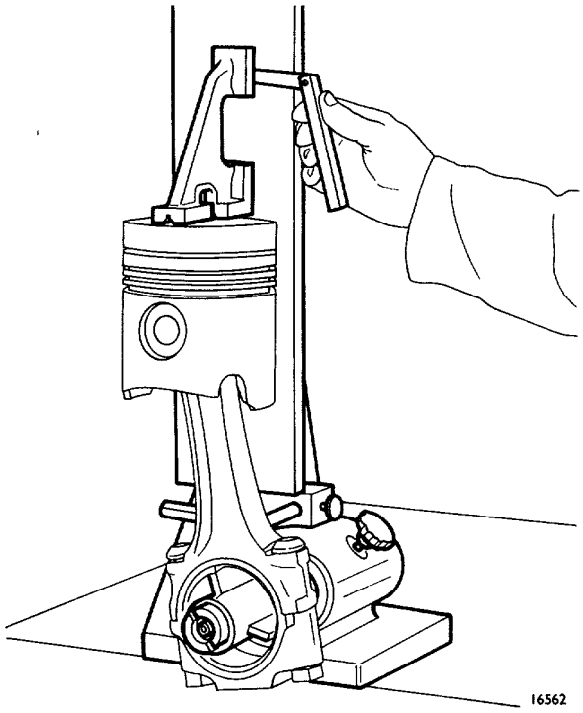
FIGURE 79



Check connecting rod weight equality Allowance is ± 20 gr
This check must be carried out with connecting rod with attached caps, bushing, bolts and nuts

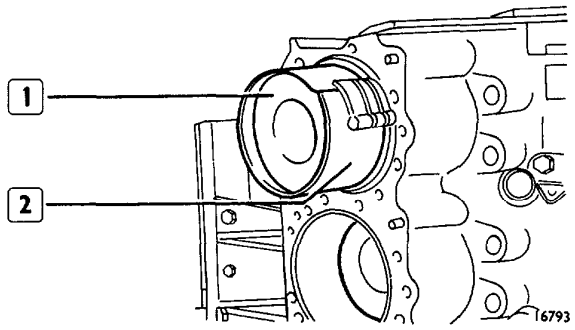
NOTE - Each connecting rod body and cap carry a reference number identical with that of the cylinder to which it belongs
In case of replacement, apply the same reference number to the new connecting rod.

FIGURE 80



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

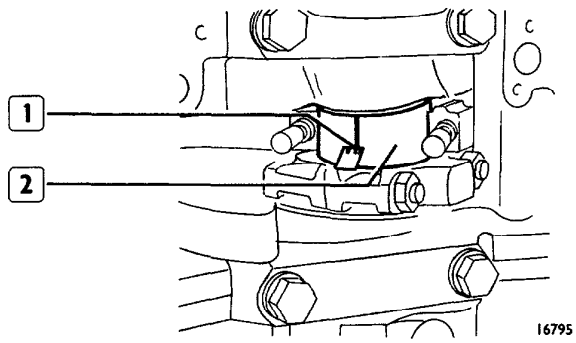
FIGURE 81



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.

FIGURE 82

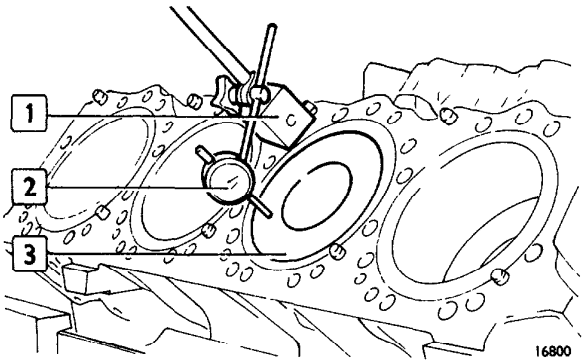


Check clearance between crankshaft crankpins and relevant bearings operating as follows:

- Thorougly 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

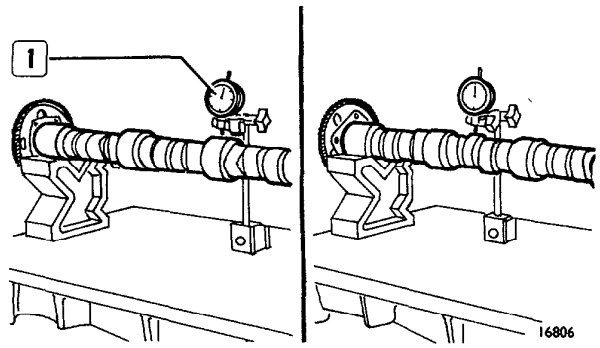


Check piston positions at T.D.C. vs cylinder sleeve faces using magnetic base, gauge, as indicated in the figure. The required position is between −0.25 to + 0.15 mm.

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.

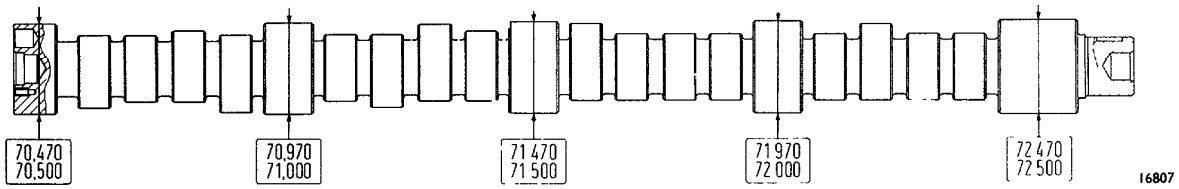
FIGURE 84



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

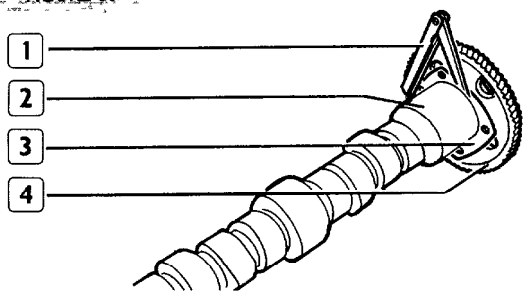
FIGURE 85



CAMSHAFT DETAILS

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

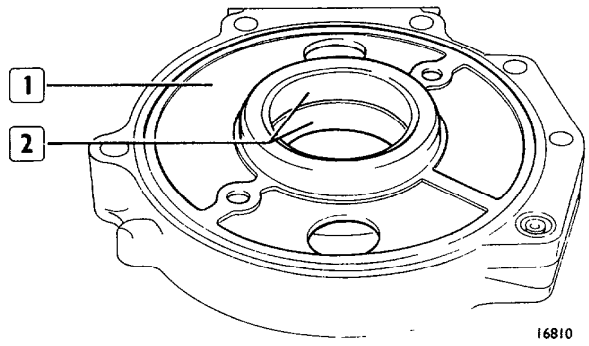
FIGURE 86



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

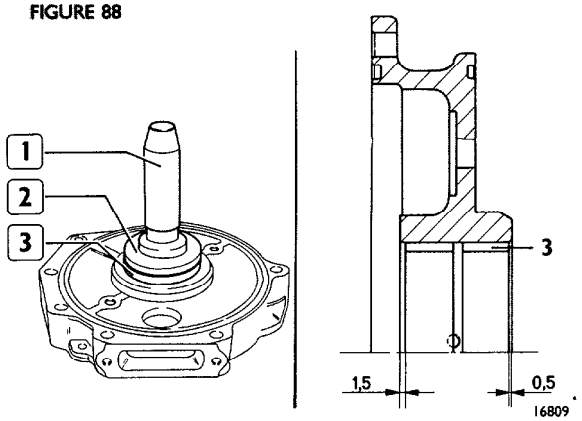
INJECTION PUMP CONTROL

FIGURE 87



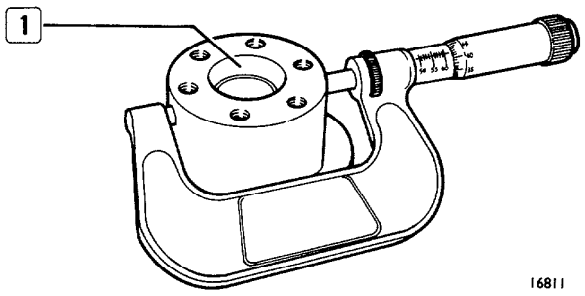
Check that connection surfaces of injection pump shaft housing (1) are not damaged
Bushings (2) should be press fitted in their seat, and the inner surface should not show marks of seizure, scoring or wear

FIGURE 88



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

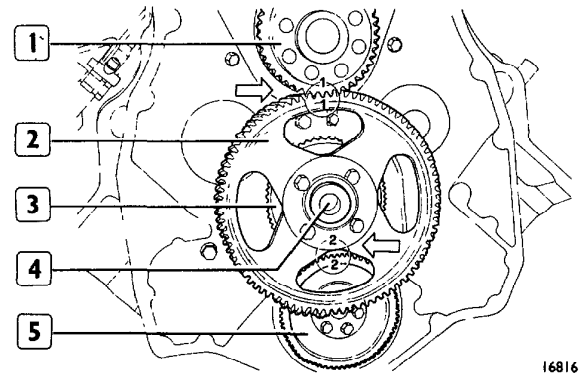
FIGURE 89



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

FIGURE 90

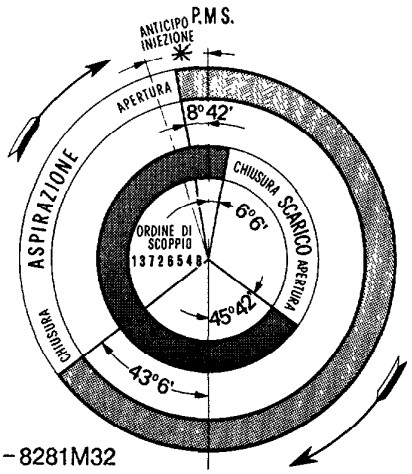


Valve system timing is carried out as follows:

- 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
PMI = BDC
ANTICIPO INIEZIONE = INJECTION ADVANCE
APERTURA = OPENING
CHIUSURA = CLOSING
ASPIRAZIONE = INTAKE
SCARICO = EXHAUST
ORDINE DI SCOPPIO = FIRING ORDER

FIGURE 91



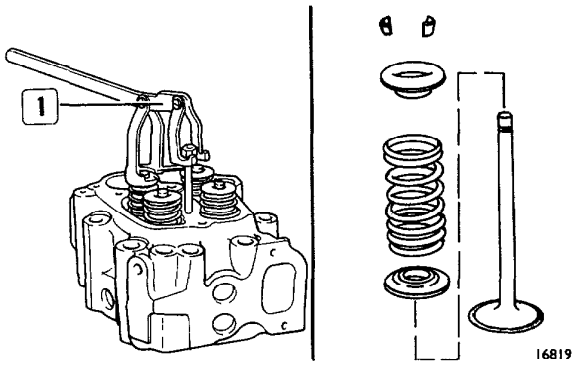
* 18° - 8281M32
24° - 8281SRM44
21° - 8281SRM70

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.

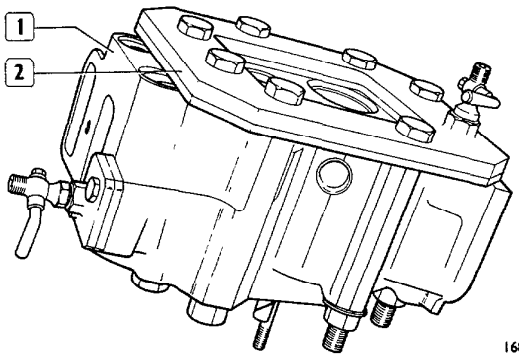
CYLINDER HEADS

FIGURE 92



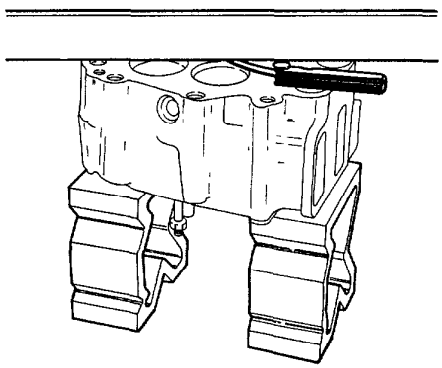
Remove/install valves using tool 360274 (1) On installation, lubricate valve stems with engine oil

FIGURE 93



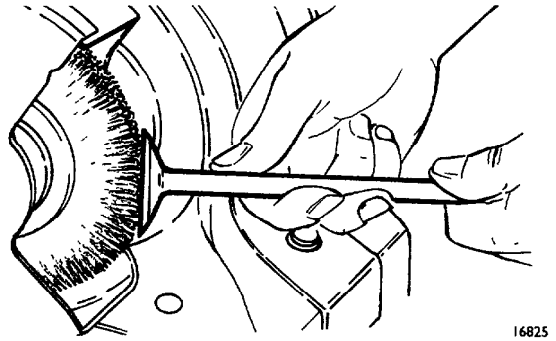
Using tool 360443 (2) check cylinder head (1) seal Through pump 305048 inlet water heated to ~ 90°C at a pressure of 4 to 5 kg/cm^2. No leakage should be observed, in the negative, replace cylinder head

FIGURE 94



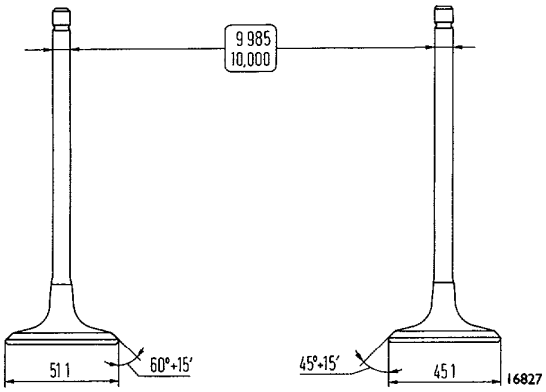
Check flatness of cylinder head face using a straightedge and a feeler, as indicated in the figure
If flatness errors exceeding 0.05 mm are detected, proceed to skim head.

FIGURE 95



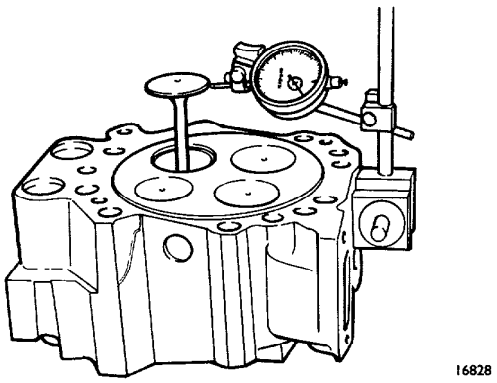
Using a wire brush clean valves and check for possible marks of seizure, cracks or wear

FIGURE 96



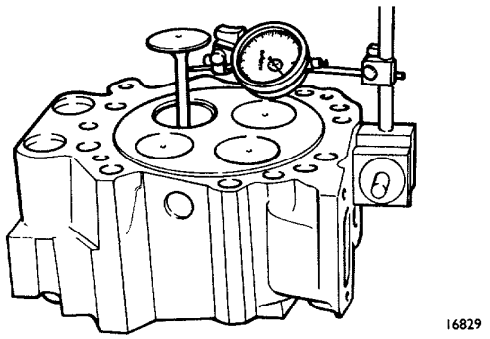
With a micrometer check that stem diameters are those indicated in the figure Using grinder 301014, dress valve seats removing as little material as possible

FIGURE 97



Check valve eccentricity using a magnetic base dial gauge, as indicated in the figure
If eccentricity exceeds 0 03 mm replace valve

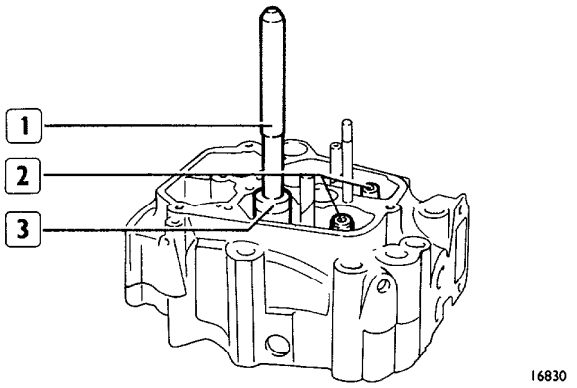
FIGURE 98



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

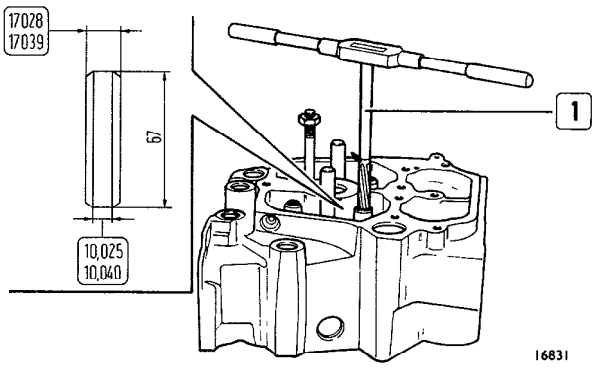
VALVE GUIDE

FIGURE 99



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

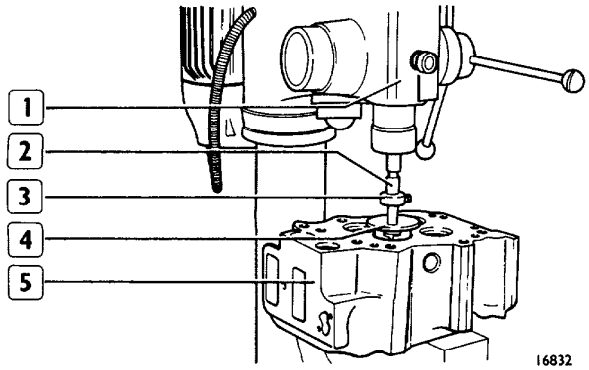
FIGURE 100



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

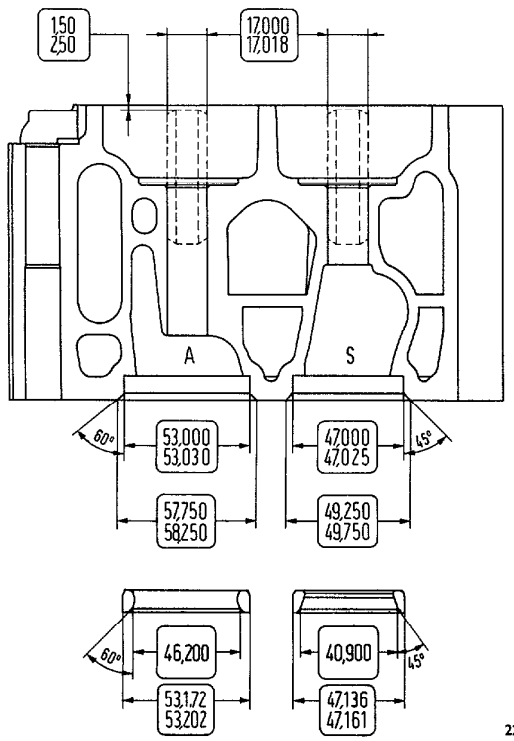
VALVE SEAT

FIGURE 101



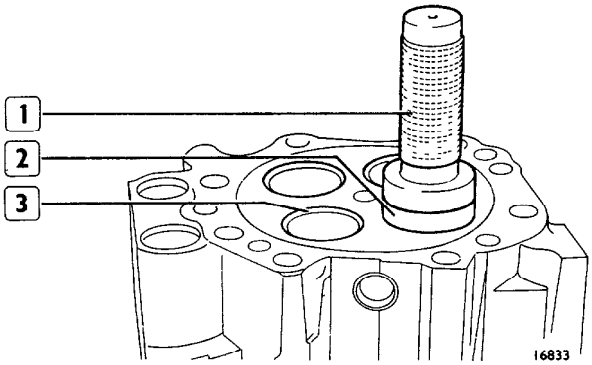
Renew valve seats operating as follows:
- Position cylinder head (5) on pillar drill (1).
- Insert tool 360376 (4) on pillar drill and adjust stop device (3) on cutter 390358 (2)
- Operate cutter and remove valve seat
- Thorougly clean cylinder head
- Cool the new valve seat to −180°C (for instance,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

FIGURE 102



VALVE SEAT AND VALVE GUIDE SEAT IN CYLINDER HEAD - DETAILS

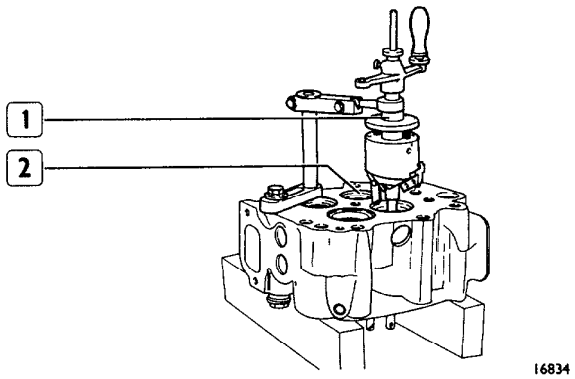
FIGURE 103



- Fit valve seats (3) in cylinder head using tool 360394 (1) together with component 360382 (2)

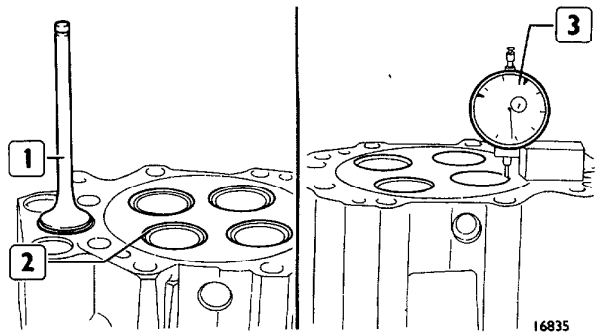
Clearance:
- Intake: 0.142 to 0.202 mm
- Exhaust: 0.111 to 0.161 mm

FIGURE 104



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

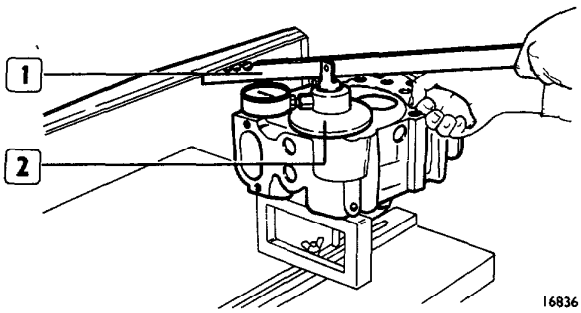
FIGURE 105



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

CYLINDER HEAD ASSEMBLY

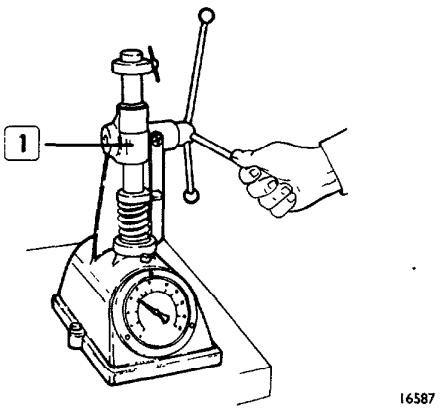
FIGURE 106



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

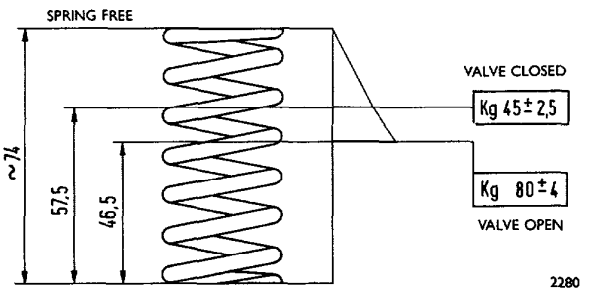
VALVE SPRING

FIGURE 107



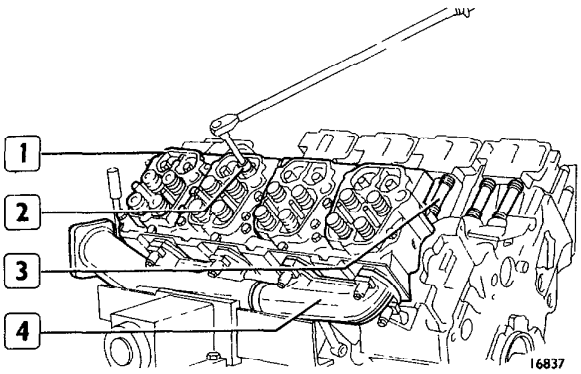
Using fixture 305049 (1) check that spring load is within the values indicated in figure 108

FIGURE 108



INTAKE AND EXHAUST VALVE SPRING DETAILS

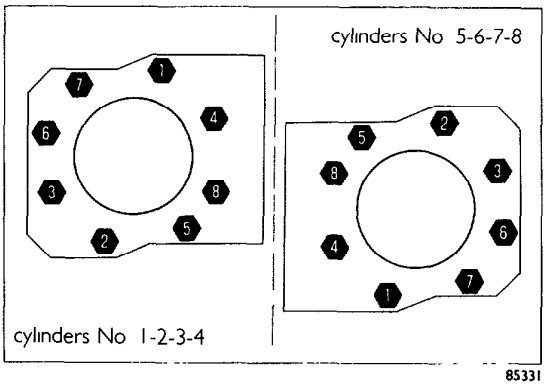
FIGURE 109



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°

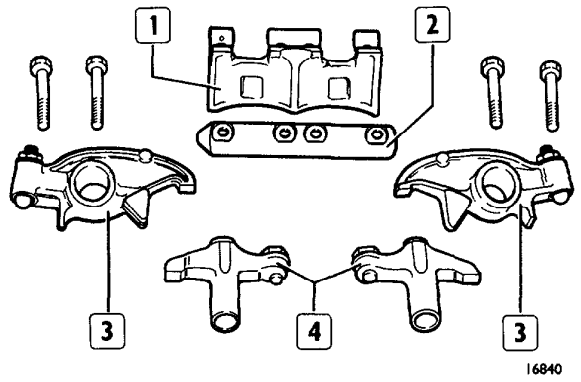
FIGURE 110



TIGHTENING SEQUENCE OF CYLINDER HEAD CAPSCREWS TO ENGINE BLOCK

ROCKER PUSHRODS - ROCKERS - ROCKER SHAFTS - BRIDGES

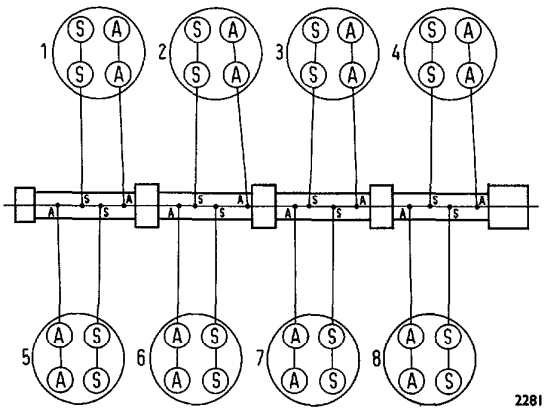
FIGURE 111



Pushrods should be free from distorsion 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

VALVE - ROCKER CLEARANCE ADJUSTMENT



This scheme represents valve positions on cylinder heads.

Rotate crankshaft and:

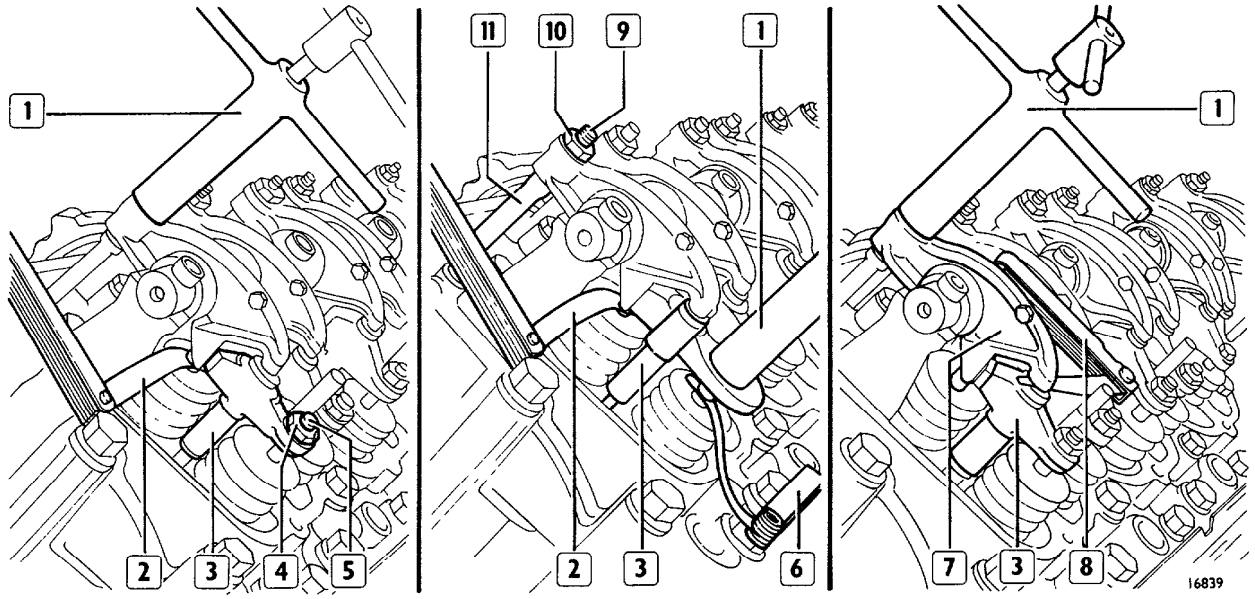
- ☐ Balance cylinder No 1 valves; following the sequence indicated in the scheme, adjust the valves marked with an asterisk

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)

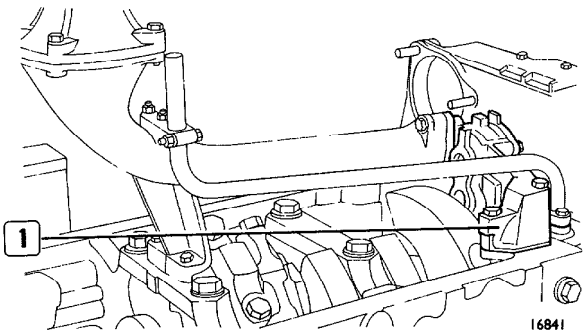
To check and adjust valve - rocker clearance on a engine on-vehicle according to the above scheme, operate as follows:

- 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



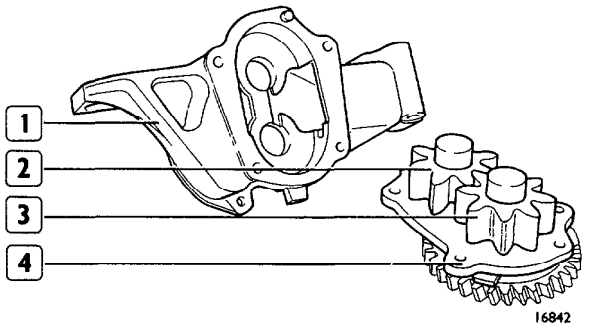
Engine is lubricated by a gear pump (1) gear driven from crankshaft.

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

Lubrication pressure (oil at 110°C):

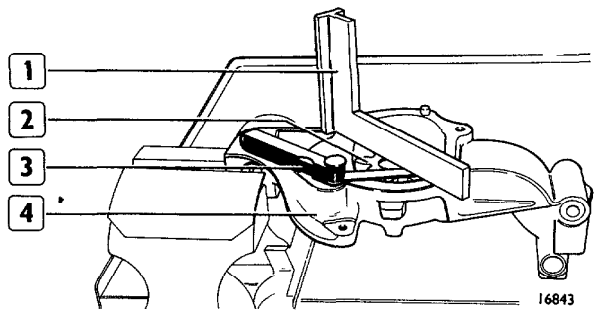
- Governed speed: 5 to 6 kg/cm^2
- At idle: 1.5 to 2 kg/cm^2

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 thorougly clean its inside.



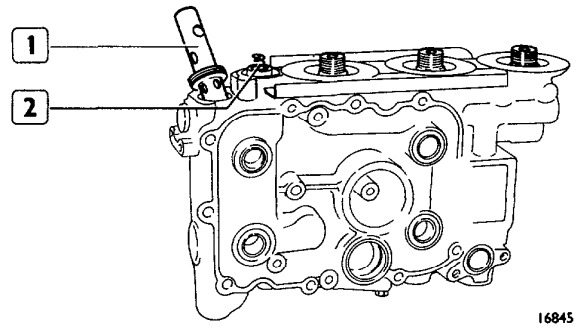
OIL PUMP

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.

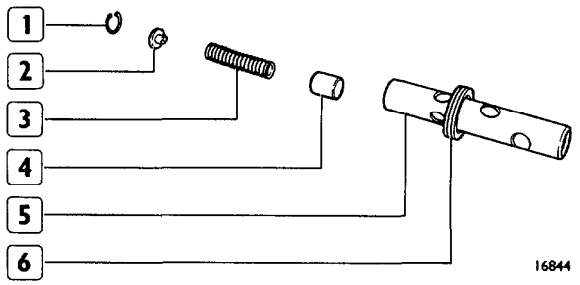


With feeler (3) and tri-square (1) check that the clearance between pump casing (4) cover face and gear (2) is 0.020 to 0.105 mm.

OIL FILTER SUPPORTS



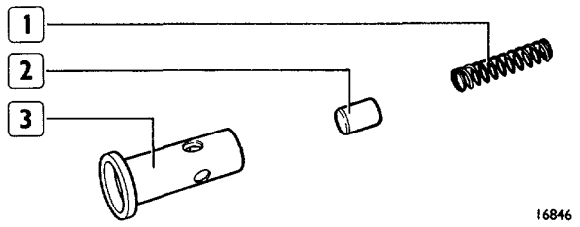
Removal/installation: oil relief valve (1) and by-pass valve (2) Check that oil filter support faces are not damaged



OIL PRESSURE RELIEF VALVE COMPONENTS

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

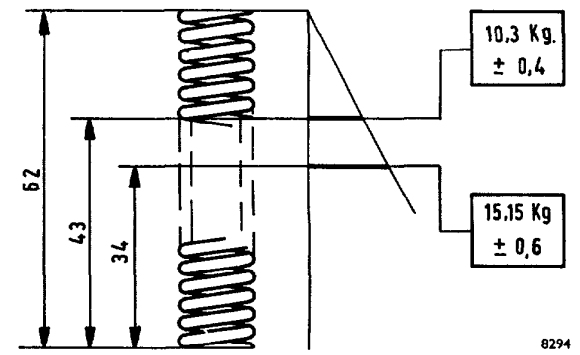
The separation of oil pressure relief valve (see figure) is carried out removing retaining ring (1) from valve body (5).



BY-PASS VALVE COMPONENTS

1 Spring - 2 Valve - 3 Valve body

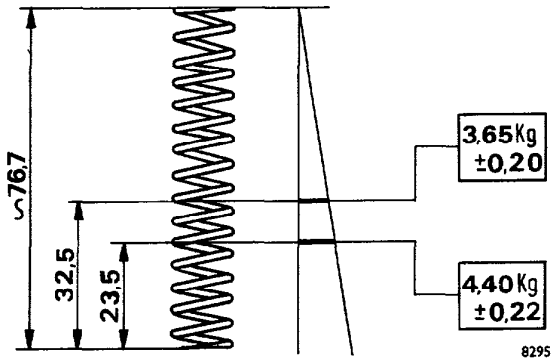
Check that oil pressure relief valve and by-pass valve run freely in their seats. Clearance should be 0 016 to 0 061 mm.
By-pass valve assembly is used to short-circuit oil lines when heat exhanger is clogged



OIL PRESSURE RELIEF VALVE SPRING-DETAILS

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

FIGURE 122



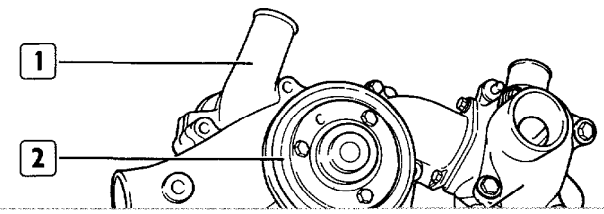
BY-PASS VALVE SPRING DETAILS

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



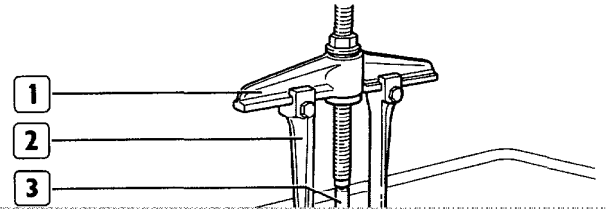
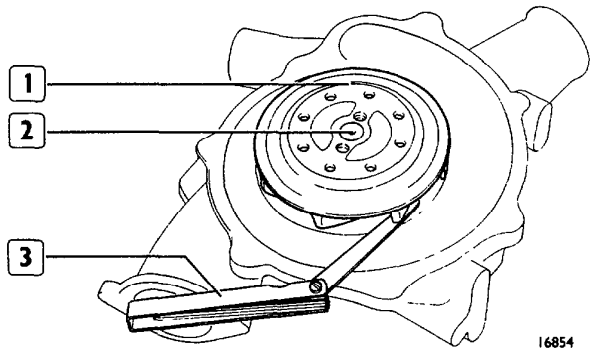


FIGURE 132

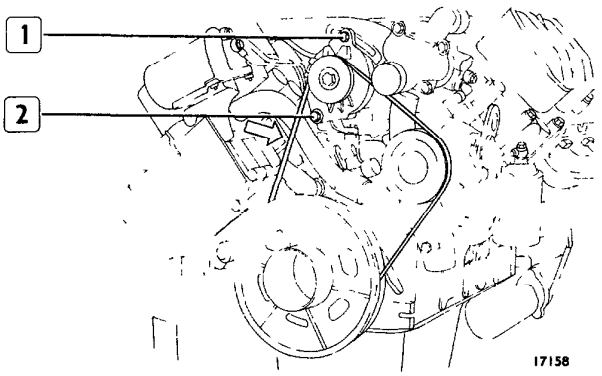


Heat impeller (1) so as between it and bearing shaft (2) there is a difference of 90 to 110°C. Fit impeller to shaft so that its outer face is flush with the shaft.
With feeler (3) check that the distance between impeller blade end and inner pump casing face is 1 to 1 3 mm

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 134

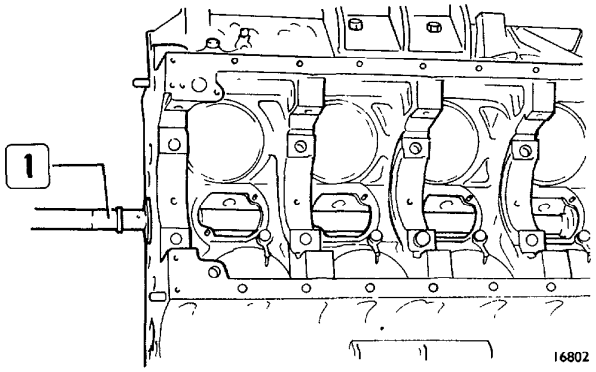


Belt tension should not be excessive otherwise alternator and water pump bearing stress will result. Insufficient belt tension prevents both water pump and alternator from producing their rated output, and is also the cause of premature belt wear
Check belt tension at the point indicated by an arrow. standard belt give is 1 cm under a load of 52 ± 8 Nm (5.2 ± 0.8 kg) when the belt is new, or 40.± 6 N (4 ± 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 DISASSEMBLY

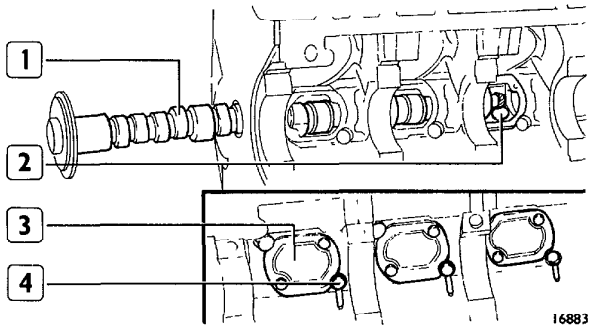
FIGURE 244



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

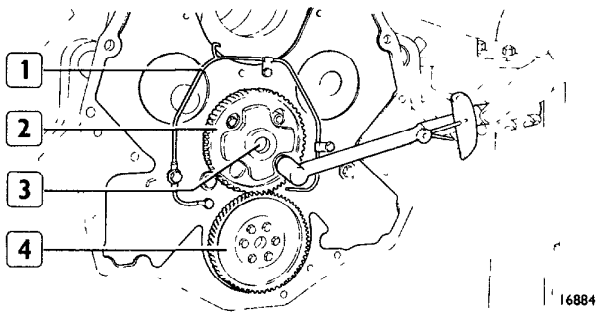
Fit camshaft bushings using tool 360385 (1)

FIGURE 245



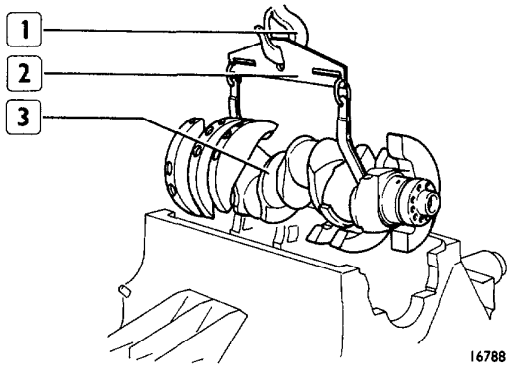
Lubricate tappets (2) and insert them in their seats
Lubricate camshafts bushings and insert camshaft (1) taking care not to damage bushings. Insert covers (3).
Insert spray nozzles (4) checking that dowels are correctly positioned on engine block

FIGURE 246



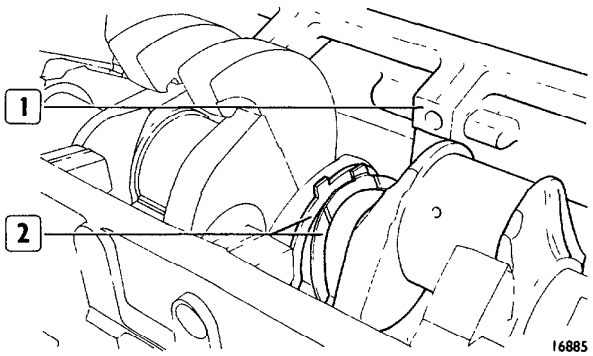
Tighten to suitable torque camshaft (3) thrust plate capscrews (2)
Insert support with attached injection pump shaft, and fit on this gear (4).
Insert gear lubrication line (1)

FIGURE 247



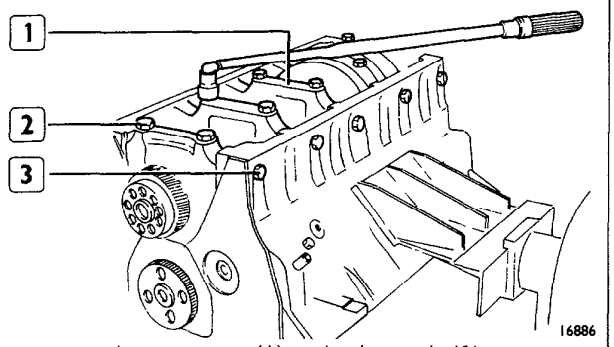
Insert in their seats the half journals lubricated through their lubrication hole and install crankshaft (3) using tool 360500 (2) and swinging hoist (1).

FIGURE 248



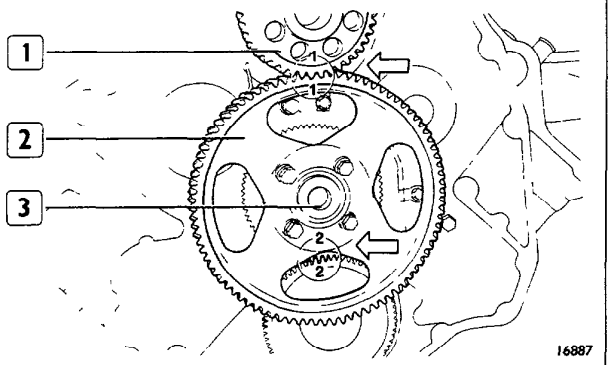
On main journal (1) insert thrust rings (2) with gaps towards crankshaft (3)

FIGURE 249



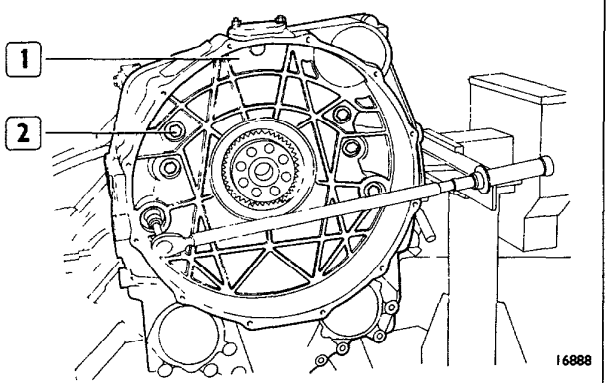
Insert main bearing caps (1) and relevant half bearings so as the printed figure is opposite to that on engine block Lubricate bearing cap screws (2 and 3) with UTDM oil and tighten to suitable torque

FIGURE 250



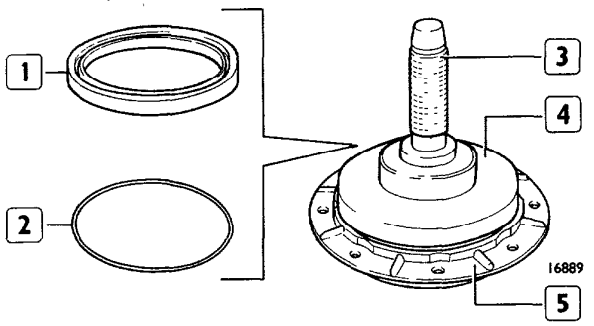
Rotate crankshaft (1) and camshaft (3) so as on inserting gear (2) the marks on each single gear (indicated by an arrow) is coincident with the other

FIGURE 251



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

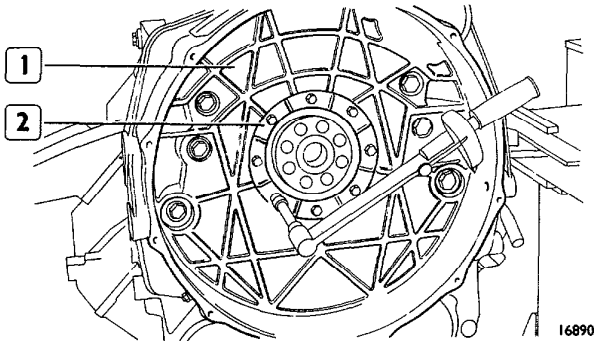
FIGURE 252



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

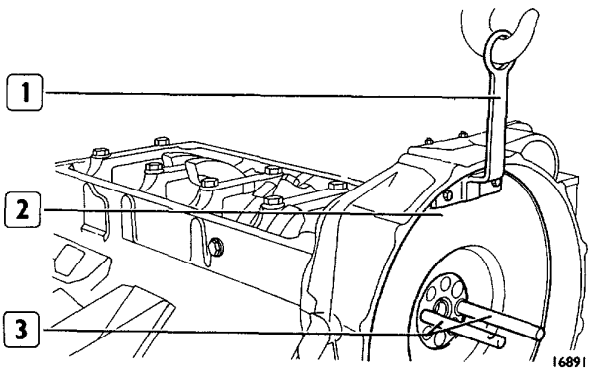
NOTE - If crankshaft is worn-out near retaining ring (1) circle, insert this without interposing spacer (2)

FIGURE 253



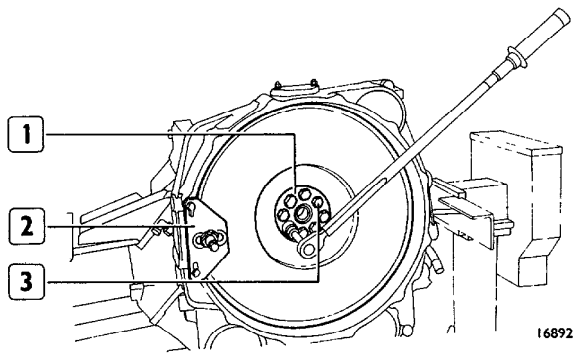
On flywheel cover (1) insert rear support (2) and tighten bolt to required torque.

FIGURE 254



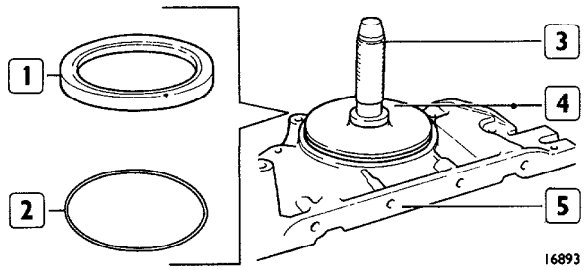
Screw down pins 360349 (3) on crankshaft and install flywheel (2) using bracket 360350 (1) and a hoist.

FIGURE 255



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

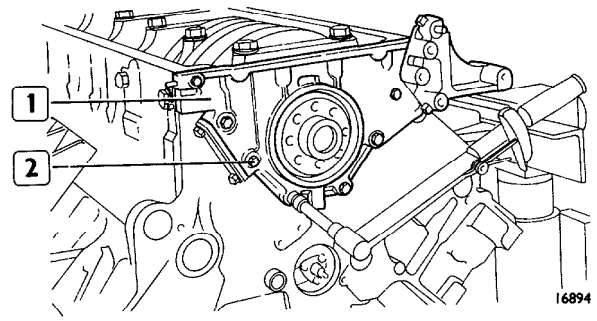
FIGURE 256



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

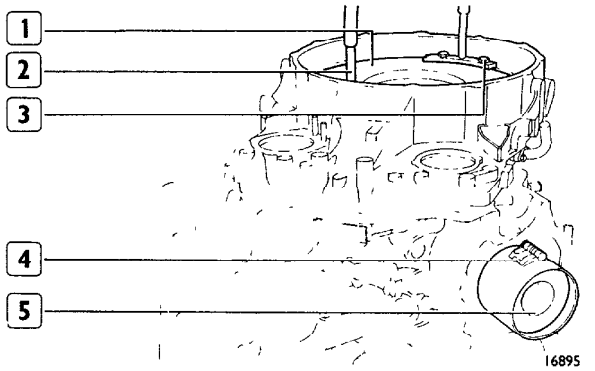
NOTE - If the crankshaft is worn-out near retaining ring (1) circle, insert this without interposing spacer (2).

FIGURE 257



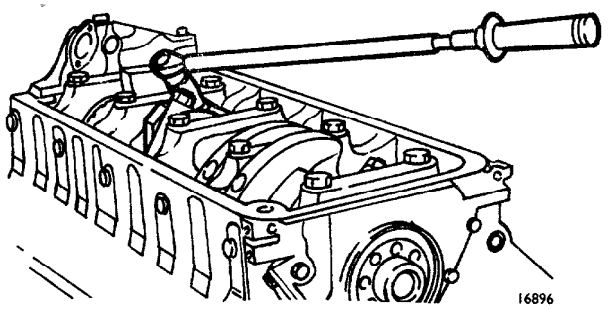
Install front cover (1) tightening to specified torque screws (2).

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.

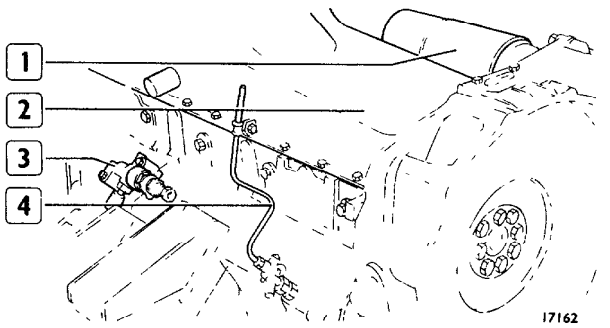
FIGURE 259



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.

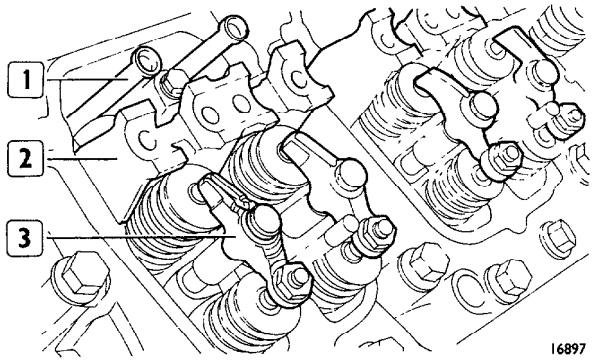
NOTE - On final assembly, all bolts and nuts securing connecting rod caps must be replaced

FIGURE 260



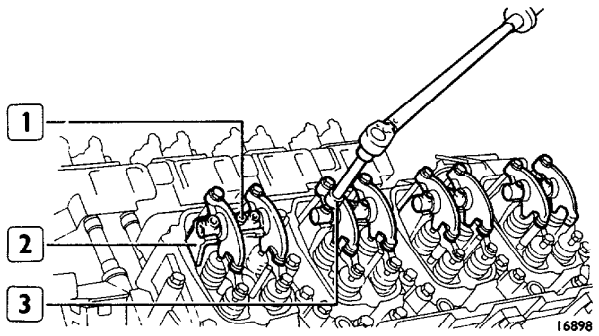
Install oil pump with attached suction scoop, oil sump (2), starter motor (1), support (3), and cooling fluid drain line (4).

FIGURE 261



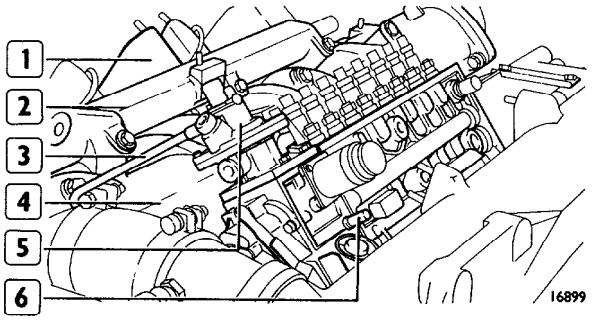
Install cylinder heads as indicated.
Insert rocker pushrods (1), rocker shaft supports (2) and bridges (3)

FIGURE 262



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.

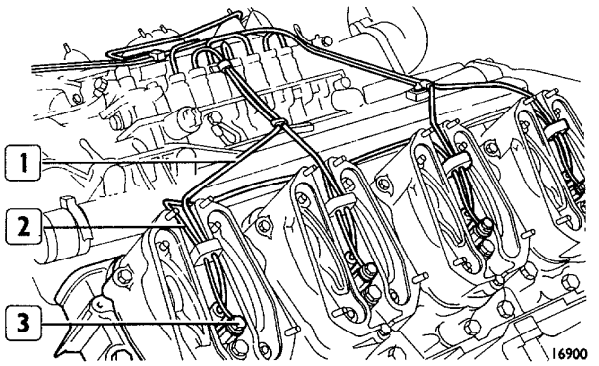
FIGURE 263



Install and time injection pump (6)

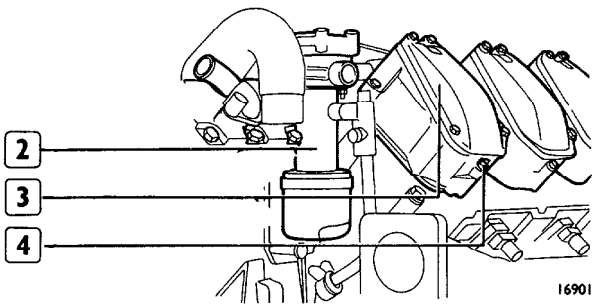
Insert cooling fluid manifolds (2), intake manifolds (4) rocker housings (1) Connect line (3) to intake manifold (4) and L D A device (5).

FIGURE 264



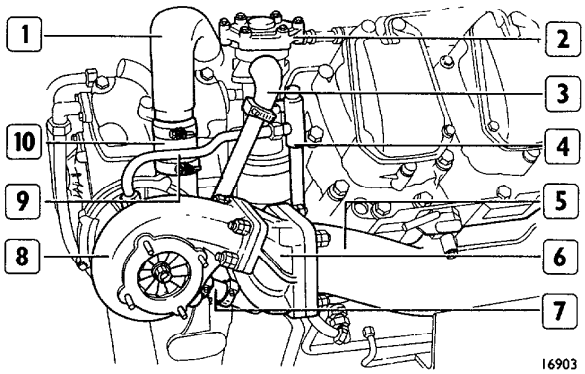
Install injectors (3), connect fuel lines (1) to injection pump and injectors, tightening unions with wrench 352120
Connect injectors to fuel leak-back lines (2).

FIGURE 265



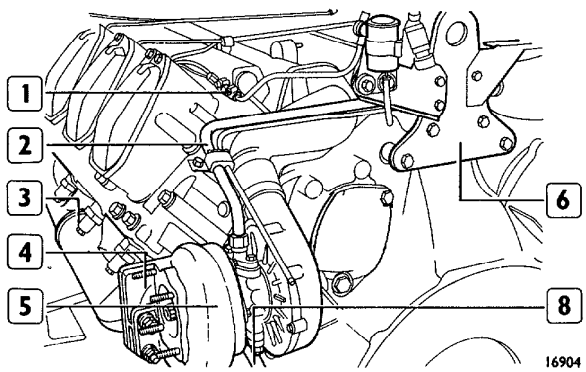
Insert retaining caps (4), install tappet housing caps (3) with attached gaskets Install oil vapour condenser (2)

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

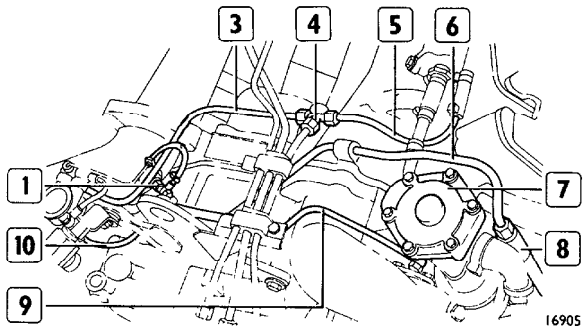
FIGURE 268



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)

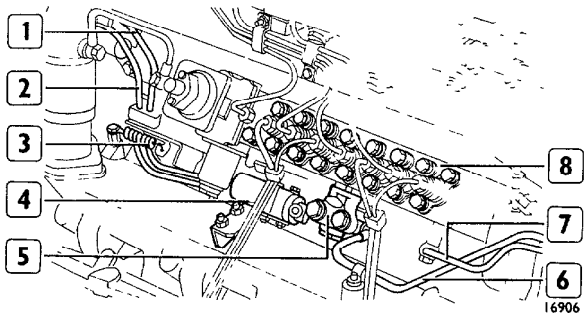
Connect hose (1) to fuel back-line from injectors

FIGURE 269



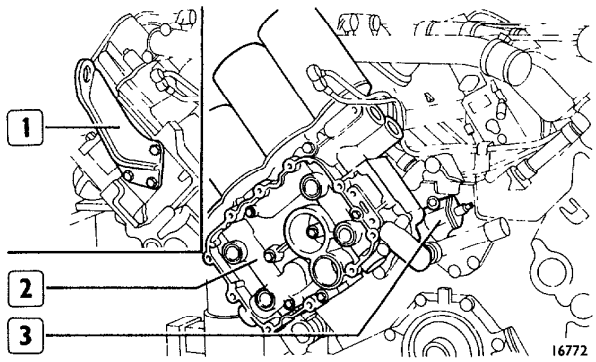
Connect fuel lines (2 and 10)
injector fuel leak-back lines (3 and 5) to three-way union (4); line (8) to lubrication line (6) of left turbocharger, line (9) delivering oil vapour to air cleaner to oil vapour condenser (7)

FIGURE 270



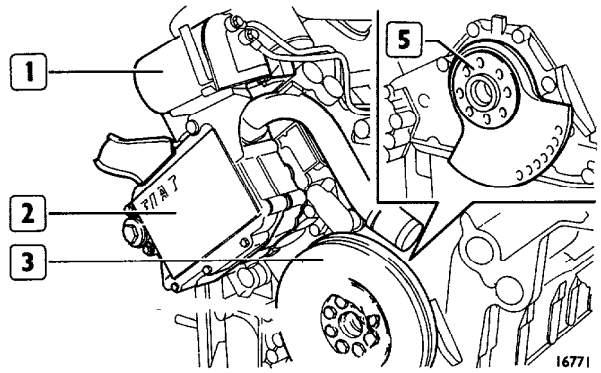
Connect the following lines to injection pump (8) fuel return line (7) to fuel tank, fuel inlet line (2) from fuel filter, lubricating oil inlet and outlet lines, connect the following pipes to the fuel pump (5) inlet (6) from fuel tank and outlet (1) to fuel filter Install barrel (4) controlling injection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

FIGURE 271

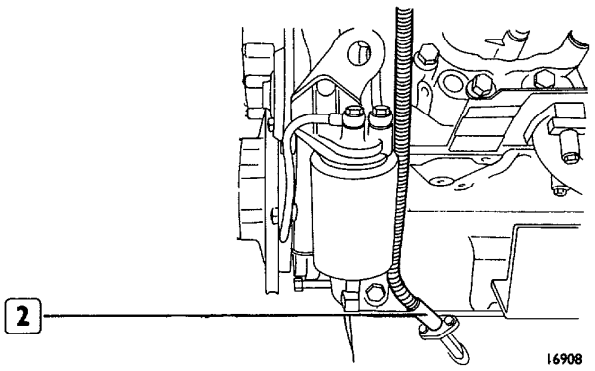


Insert bracket (1) to lift engine, oil filter supports (2) and engine tachometer control (3).

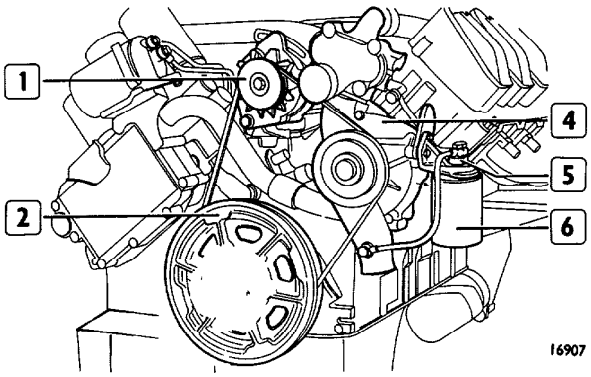
NOTE - Oil filters must be fitted to engine by tightening them manually



Fit on crankshaft: counterweight (5), damper flywheel (3), 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.



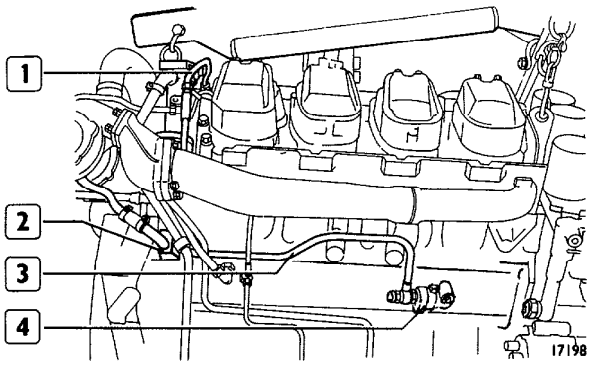
The arrows indicate check nuts
Insert hose (2) for oil dipstick



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±8 N (5.2±0.8 kg) (new belt), or 40±6 N (4±0 6 kg) (used belt)



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 (M14x1 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 (M12x1 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
● Lubricate with graphite oil

* For lateral screw.

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	II		127 5 (13)
Cap, oil filter body 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 ± 5%
- Class II ± 10%
- Class III ± 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	99360310	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 370006	99370005 99370006	Handle, driver, interchangeable.
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.