marine engines

section 6

8210 series

workshop manual

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IVECO aifo

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

This publication supplies features and data together with the suitable methods for repair operations to be carried out on each single component of the engine.
Following the supplied instructions and using the inherent specific fixtures, a correct repair procedure will be obtained in due time, protecting the operators from all possible accidents.
Before starting any repair, be 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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8210 SRM 36

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ENGINE SPECIFICATIONS

Engine type 8210M22
4 - stroke Diesel with direct injection
Cylinders, number and arrangement .... 6, in line
Bore x stroke .... 137 x 156 mm
Displacement ..... 13 8 l
Compression ratio .... 16 : 1
Net power at flywheel (*) :
- Continuous duty .... 162 kW (220 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. .... 16 °
closes : after B D.C. .... 52 °
- Exhaust
opens : before B.D.C. ....58 °
closes : after T.D.C. ..... 18 °
Clearance between valve and rockers for
timing checks .... mm
Operating clearance between valves and rockers, cold engine :
- intake ....0.30 mm
- exhaust..... .....0.40 mm

FUEL SYSTEM

Rotary injection pump type PES 6P.
Fixed injection pump delivery start advance ..... 22 ° ± 1°
Fuel injectors setting..... 200 + 8 bar
Firing order..... 1 - 5 - 3 - 6 - 2 - 4

LUBRICATION

Minimum oil pressure :
- at full throttle ..... 4 - 5.5 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 190 Ah

MARINE GEAR

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

ENGINE SPECIFICATIONS

Engine type 8210SRM36
4 - stroke Diesel with direct injection
Cylinders, number and arrangement ..... 6, in line
Bore x stroke ..... 137 x 156 mm
Displacement ..... 13 8 l
Compression ratio ..... 16 · 1
Net power at flywheel (*) .
- Light-duty commercial ..... 265 kW (360 CV)
At ..... 1800 rpm
Engine rotation :
(see from flywheel) ..... CCW

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

TIMING

Valve Timing :
- Intake
opens : before T D C ..... 16 °
closes · after B.D.C. ..... 40 °
- Exhaust
opens : before B D C. ..... 58 °
closes : after T.D.C. ..... 18 °
Clearance between valve and rockers for
timing checks ..... mm
Operating clearance between valves and rockers, cold engine .
- intake ..... 0 30 mm
- exhaust ..... 0 40 mm

FUEL SYSTEM

In line injection pump type PES 6P.
Fixed injection pump delivery start advance ..... 22 ° ± 1°
Fuel injectors setting ..... 250 + 8 bar
Firing order ..... 1 - 5 - 3 - 6 - 2 - 4

TURBOCHARGING

The engine is turbocharged by turbocharger driven by the exhaust gases
The turbocharger is lubricated with the engine oil under pressure.

LUBRICATION

Minimum oil pressure ·
- at full throttle ..... 4 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 ..... 28 V, 40 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 gear oil is ensured by a self-priming pump type neoprene impeller

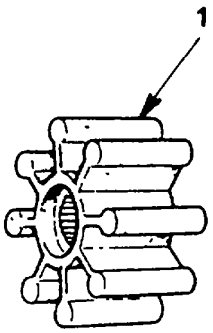
INSTRUCTION FOR USE

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

- 68 °C (8210 M22)
- 74 °C (8210 SRM36)

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

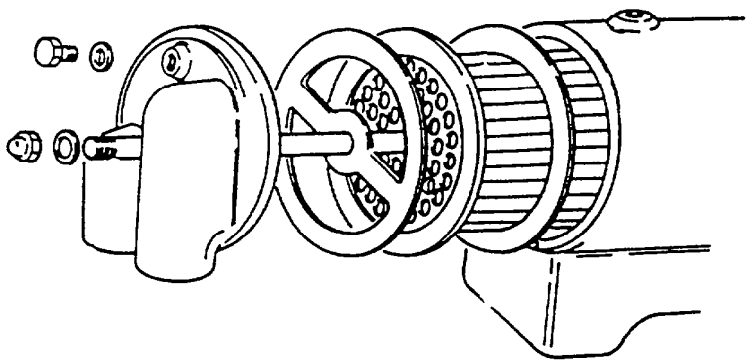
This heat exchanger consists essentially of a cast iron body with the fresh water circulation therein and a copper tube bundle containing the circulating sea water for cooling the fresh water

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

DESCRIPTION		mm
ENGINE BLOCK - CONNECTING RODS		
Cylinder sleeve bore dia (fitted and machined)	Class A	136.955 to 136 990
	Class B	136 990 to 137 025
Outside standard cylinder sleeve bore dia		143 020 to 143 040
Oversize on outside replacement cylinder bore dia		0 25
Cylinder bore dia in engine block		142 975 to 143 000
Sleeve interference fit in block		0 020 to 0 065
Sleeve length		281 5 to 282
Sleeve protrusion in block		−0 02 to +0 055
Camshaft bush housing bore dia		
□ Front		68 515 to 68 550
□ Front intermediate		68 015 to 68 050
□ Rear intermediate		67 515 to 67 550
□ Rear		67 015 to 67 050
Crankshaft bearing housing bore dia		107 976 to 108 001
Standard tappet housing bore dia		34 010 to 34 045
Big end bore dia.		88 482 to 88 504
Small end bore dia		52 849 to 52 894
Big end standard bearing thickness		1 826 to 1 835
Undersize bearing for replacement big end bore dia.		0 254-0 508-0 762-1 016
Small end bushing O D		53 010 to 53 061
Small end bushing fitted I D		48 019 to 48 035
Piston pin clearance in small end bushing		0 019 to 0 040
Small end bushing interference fit		0 116 to 0 212
Crankpin clearance in big end half bearings		0 077 to 0 139
Max connecting rod parallelism tolerance·		
□ At 125 mm from connecting rod stem		0 07
PISTONS - PINS - RINGS		
Piston dia at right angles to pin bore		
□ At 35 mm from base of skirt	Class A	136 758 to 136 782
	Class B	136 793 to 136 817
Piston pin bore dia in piston		48 000 to 48 006
Piston pin dia		47 995 to 48 000
Ring groove width in piston	1st Top grouve (measured on bore dia of 134 mm)	3 720 to 3 750
	2nd groove	3 050 to 3 070
	3rd groove	3 050 to 3 070
	4th groove	5 530 to 5 550

DESCRIPTION	mm
Ring thickness	
□ Top compression ring, double taper, chromium plated (measured at 1 5 mm from dia 134 mm)	3 575 to 3 595
□ 2nd compression ring, straight	2 978 to 2 990
□ 3rd compression ring, straight	2,978 to 2,990
□ 4th oil scraper ring, slotted, spring-loaded	5 478 to 5 490
Piston fit in sleeve (measured on standard axis to pin 35 mm from piston base)	
□ Clearance	0 173 to 0 232
Piston pin clearance in piston	0 to 0011
Ring clearance in piston (vertical)	
□ Top compression ring, double taper	0 125 to 0 175
□ 2nd compression ring, straight	0 060 to 0 092
□ 3rd compression ring, straight	0 060 to 0 092
□ 4th oil scraper ring	0 040 to 0 072
Ring gap in sleeve	
□ Top compression ring, double taper	0 60 to 0 80
□ 2nd compression ring, straight	0 50 to 0 70
□ 3rd compression ring, straight	0 50 to 0 70
□ 4th oil scraper ring	0 40 to 0 60
Piston weight	3325 to 3370 g
CRANKSHAFT - BEARINGS	
Main journal dia	102 874 to 102 901
Main bearing housing bore dia	107 976 to 108 001
Standard main bearing thickness	2 487 to 2 496
Main bearing undersize range	0 254-0 508-0 762-1 016
Crankpin dia	84 708 to 84 735
Main journal in bearing	
□ Clearance	0 085 to 0 148
Centre main journal length between thrust washers	65 00 to 65 10
Centre main bearing housing width over thrust washer faces	60 150 to 60 200
Centre main bearing housing plus thrust washer width	64 780 to 64 930
Standard thrust washer thickness	2 311 to 2 362
Thrust washer oversize range (0 127 mm)	2 438 to 2 489
Between shaft and centre main bearing with thrust washers	
□ Clearance	0 070 to 0 320
Max permissible misalignment on main journals (total gauge reading)	0 05
Max permissible misalignment between crankpins and main journals	±0 25
Max main journal ovalization after grinding	0 008
Max main journal and crankpin taper after grinding	0 012

DESCRIPTION	mm
CYLINDER HEAD	
Valve guide housing bore in head	17 977 to 17 995
Valve guide O D	18 005 to 18 030
Valve guide oversize	0 04-0.20-0 24
Valve guide fitted I D	11 025 to 11 045
Valve guide interference fit in head	0 010 to 0 053
Valve stem dia	10 982 to 11 000
Valve stem and guide interference □ Clearance	0 025 to 0 063
Valve seat angle { inlet exhaust	45° ± 5' 45° ± 5'
Valve face angle { inlet exhaust	45° ± 5' 45° ± 5'
Max valve stem distorsion over one complete revolution with dial gauge stylus in midstem position	0 04
Valve seat width	~ 4 3
Valve seat O D { inlet exhaust	61 080 to 61 105 51 080 to 51 105
Valve seat I D { inlet exhaust	60 900 to 60 930 50 900 to 50 930
Valve seat interference fit in head { inlet exhaust	0 150 to 0 205
Valve fitted depth in cylinder head { inlet exhaust	1 4 to 1 8 1,3 to 1,9
Nozzle protrusion over cylinder head	1 5 to 2
VALVE SPRINGS	
Outside free spring height	~ 84 7
Inside free spring height	~ 75 2
Outside spring height under 41 ± 2 kg	58 1 ± 0 5
Inside spring height under 15 ± 0 65 kg	52 6
VALVE GEAR	
Camshaft bushing housing fitted in engine block	
□ Front	68 515 to 68 550
□ Front intermediate	68 015 to 68 050
□ Rear intermediate	67 515 to 67 550
□ Rear	67 015 to 67 050
Bushing interference fit in engine block	There should be always interference
Bushing fitted I D after reaming·	
□ Front	62 599 to 62 660
□ Front intermediate	62 099 to 62.160
□ Rear intermediate	61.600 to 61 661
□ Rear	61 100 to 61 160

DESCRIPTION	mm
Camshaft journal dia	
□ Front	62 500 to 62 530
□ Front intermediate	62 000 to 62 030
□ Rear intermediate	61 500 to 61 530
□ Rear	61 000 to 61 030
Camshaft journal and bushing fit	
□ Clearance — Front	0 069 to 0 160
□ Clearance — Front intermediate	0 069 to 0 160
□ Clearance — Rear intermediate	0 070 to 0 161
□ Clearance — Rear	0 070 to 0 160
Cam lift - intake and exhaust	8
Tappet housing bore dia	34 010 to 34 045
«Crowned» tappet O D — Measured at top and base	33 840 to 33 860
«Crowned» tappet O D — Measured at middle	33 920 to 33 940
Oversize spare tappet	0 10-0 20-0 30
Tappet interference fit in housing (with reference to max tappet dia)	
□ Clearance	0 070 to 0 125
Rocker axle bore dia	25 000 to 25 033
Rocker shaft dia	24 979 to 25 000
Rocker shaft interference fit	
□ Clearance	⩽ 0 054
Rocker bushing seat dia	28 939 to 28 972
Rocker bushing O D	29 032 to 29 070
Rocket bushing I.D (with fitted bushing)	25 020 to 25 041
Rocker bushing interference fit in shaft	
□ Clearance	0 020 to 0 062
MAIN AND SCAVENGE OIL PUMPS	
By-pass valve opening calibration pressure	1 ± 0 1 kg/cm²
Oil pressure relief valve opening start	5 ± 0 25 kg/cm²
INJECTION PUMP	
Distance between flange and pump body	13 5
Camshaft end float	0 02 to 0 06
Spider pin end float	~ 1
Distance between knuckle pin and speed governor case	35
Idle spring operation range	2 0 ± 0 2
Counterweights end float (for checking silentblock preloading)	0 05 to 0 1

FITTING DATA

DESCRIPTION		mm
ENGINE BLOCK - CONNECTING RODS		
Cylinder sleeve bore dia. (fitted and machined)	Class A	136 955 to 136 990
	Class B	136 990 to 137 025
Outside normal cylinder sleeve bore dia		143 020 to 143 040
Oversize on outside replacement cylinder bore dia		0 05-0 25
Cylinder bore dia in engine block		142 975 to 143 000
Sleeve interference fit in block		0 020 to 0 065
Sleeve length		281 5 to 282
Sleeve protrusion in block		—0 02 to +0 045
Camshaft bush housing bore dia		
□ Front		68 515 to 68 550
□ Front intermediate		68 015 to 68 050
□ Rear intermediate		67 515 to 67 550
□ Rear		67 015 to 67 050
Crankshaft bearing housing bore dia		107 976 to 108 001
Normal tappet housing bore dia		34 009 to 34 034
Big end bore dia		88 482 to 88 504
Small end bore dia		54 852 to 54 899
Big end bearing thickness		1 826 to 1 835
Undersize bearing for replacement big end bore dia		0 254-0 508-0 762-1 016
Small end bushing O D		55 015 to 55 065
Small end bushing fitted I D		50 019 to 50 035
Piston pin clearance in small end bushing		0 019 to 0 040
Small end bushing interference fit		0 117 to 0 215
Crankpin clearance in big end half bearings		0 077 to 0 139
Max connecting rod parallelism tolerance		
□ At 125 mm from connecting rod stem		0 07
PISTONS - PINS - RINGS		
Piston dia at right angles to pin bore.		
□ At 33 mm from base of skirt	Class A	136 813 to 136 827
	Class B	136 848 to 136 862
Piston pin bore dia in piston		50 000 to 50 006
Piston pin dia		49 995 to 50 000
Ring groove width in piston	1st Top groove (measured on bore dia of 134 mm)	3 720 to 3 750
	2nd groove	3 070 to 3 090
	3rd groove	5 530 to 5 550

DESCRIPTION	mm
Ring thickness	
□ Top compression ring, double taper, chromium plated (measured at 1 5 mm from dia 137 mm)	3 575 to 3 595
□ 2nd compression ring, straight	2 978 to 2 990
□ 3rd oil scraper ring, slotted, spring-loaded	5 478 to 5 490
Piston fit in sleeve (measured on normal axis to pin, 33 mm from piston base)	
□ Clearance	0 128 to 0 177
Piston pin clearance in piston	0 to 0 011
Ring clearance in piston (vertical)	
□ Top compression ring, double taper	0 122 to 0 163
□ 2nd compression ring, straight	0 080 to 0 112
□ 3rd oil scraper ring	0 040 to 0 072
Ring gap in sleeve	
□ Top compression ring, double taper	0 50 to 0 75
□ 2nd compression ring, straight	0 50 to 0 75
□ 3rd oil scraper ring	0 40 to 0 60
CRANKSHAFT - BEARINGS	
Main journal dia	102 879 to 102 901
Main bearing housing bore dia	107 976 to 108 001
Main bearing thickness	2 487 to 2 496
Main bearing undersize range	0 254-0 508-0 762-1 016
Crankpin dia	84 713 to 84 735
Main journal in bearing	
□ Clearance	
Centre main journal length between thrust washers	65 00 to 65 10
Centre main bearing housing width over thrust washer faces	60 150 to 60 200
Centre main bearing housing plus thrust washer width	64 772 to 64 924
Standard thrust washer thickness	2 311 to 2 362
Thrust washer oversize range	0 127
Between shaft and centre main bearing with thrust washers	
□ Clearance	0 076 to 0 328
Max permissible misalignment on main journals (total gauge reading)	0 05
Max permissible misalignment between crankpins and main journals	±0 25
Max main journal ovalization after grinding	0 008
Max main journal and crankpin taper after grinding	0 012

DESCRIPTION	mm
CYLINDER HEAD	
Valve guide housing bore in head	17 977 to 17 995
Valve guide O D	18 005 to 18 030
Valve guide oversize	0 04-0 20-0 24
Valve guide fitted I D	11 025 to 11 045
Valve guide interference fit in head	0 010 to 0 053
Valve stem dia	10 982 to 11 000
Valve stem and guide interference □ Clearance	0 025 to 0 063
Valve seat angle { inlet exhaust	60° ±5' 45° ±5'
Valve face angle { inlet exhaust	60°30' +5' 45°30' +5'
Max valve stem distorsion over one complete revolution with dial gauge stylus in midstem position	0 04
Valve seat width	4 3 approx
Valve seat O D { inlet exhaust	59 080 to 59 105 51 075 to 51 090
Valve seat I D { inlet exhaust	58 900 to 58 930 50 900 to 50 930
Valve seat interference fit in head { inlet exhaust	0 150 to 0 205 0 145 to 0 190
Valve fitted depth in cylinder head { inlet exhaust	1 4 to 1 8 1 3 to 1 9
Nozzle protrusion over cylinder head	1 5 to 2
VALVE SPRINGS	
Outside free spring height	~90 5
Inside free spring height	~83 1
Outside spring height under 50±2 kg	58 1 ±0 5
Inside spring height under 21 2±0 65 kg	52 6
VALVE GEAR	
Camshaft bushing housing fitted in engine block □ Front □ Front intermediate □ Rear intermediate □ Rear	 68 515 to 68.550 68 015 to 68 050 67 515 to 67 550 67 015 to 67 050
Bushing interference fit in engine block	There should be always interference
Bushing fitted I D after reaming □ Front □ Front intermediate □ Rear intermediate □ Rear	 62 559 to 62 660 62 099 to 62 120 61.600 to 61 661 61 100 to 61 160

DESCRIPTION	mm
Camshaft journal dia	
□ Front	62 500 to 62 530
□ Front intermediate	62 000 to 62 030
□ Rear intermediate	61 500 to 61 530
□ Rear	61 000 to 61 030
Camshaft journal and bushing fit	
□ Clearance — Front	0 069 to 0 160
□ Clearance — Front intermediate	0 069 to 0 160
□ Clearance — Rear intermediate	0 070 to 0 161
□ Clearance — Rear	0 070 to 0 160
Cam lift - intake	7 921
Cam lift - exhaust	8
Tappet housing bore dia	34 009 to 34 034
"Crowned" tappet O D — Measured at top and base	33 888 to 33 863
"Crowned" tappet O D — Measured at middle	33 920 to 33 940
Oversize spare tappet	0 10-0 20-0 30
Tappet interference fit in housing (with reference to max tappet dia)	
□ Clearance	0 069 to 0 114
Rocker axle bore dia	25 000 to 25 033
Rocker shaft dia	24 979 to 25 000
Rocker shaft interference fit	
□ Clearance	≤0 054
Rocker bushing seat dia	28 939 to 28 972
Rocker bushing O D	29 030 to 29 060
Rocker bushing I D (with fitted bushing)	25 020 to 25 041
Rocker bushing interference fit in shaft	
□ Clearance	0 020 to 0 062
OIL PUMP	
Drive shaft dia on rear cover	25 910 to 25 940
Bushing I D (after fitting)	20 040 to 20 061
Gear shaft O D	19 987 to 20 000
Driven gear bushing seat dia	22 910 to 22 940
Driven gear bushing O D	22 979 to 23 000
Bushing I D (after fitting)	20 020 to 20 053
Clearance between driving gear shaft and bushing	0 040 to 0 074
Clearance between driven gear shaft and bushing	0 020 to 0 060
Oil pressure relief valve seat dia	17 016 to 17 043
Oil pressure relief valve dia	16 982 to 17 000
Relief valve interference fit in seat	0 016 to 0 061
Calibration pressure for by pass valve (kg/cm²)	1 ±0 1
Oil pressure relief valve opening start (kg/cm²)	5 5 to 6

FAULT-FINDING DIAGNOSIS

TROUBLE	POSSIBLE CAUSE	REMEDY
The engine does not start	Battery charged partially	Check batteries and charge them If necessary, replace them
	Battery terminal connections corroded or loose	Clean, check and tighten nuts on battery terminals Replace cable terminals and nuts, if badly corroded
	Incorrect timing of injection pump	Check and carry out injection pump timing
	Deposits or water in fuel lines	Detach pipes and clean them with air 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 syops	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 warms up excessively	Defective water pump	Check clearance between impeller blades and pump casing Overhaul the assembly and replace gasket.
	Thermostat failure	Valve stem jamming in guide.

TROUBLE	POSSIBLE CAUSE	REMEDY
The engine warms up excessively	Scale in water passages in engine block and cylinder head	Wash thoroughly in compliance with directions given for the type of scale remover used
	Insufficient tension of water pump belt	Check and adjust belt tensions
	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	Overhaul injection pump and replace worn-out parts
	Incorrect calibration of speed governor	Check governor calibration and again calibrate it, if necessary
	Injector nozzles clogged or incorrect injector operations	Clean nozzle holes with suitable tool and totally overhaul injectors
	Foreign matter or water in injection feed system	Thoroughly clean and refill with new fuel
	Defective fuel feed pump	Disassemble pump, and, if necessary, replace pump components
	Incorrect clearance between valves and rockers	Check clearance and proceed to a correct adjustment
	Low compression	With tool 99395682 check compression pressure at T D C 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	Incorrect 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	Incorrect 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
	Crankshaft unbalanced	Check shaft alignment, if necessary correct as required and check balance
	Flywheel capscrew loose	Replace loose screws and tighten to the prescribed torque value
	Connecting rods out-of-alignment	Straighten connecting rods under a hydraulic press, and check parallelism
	Piston knocks due to slap	Replace cylinder sleeves and pistons
	Noisy piston pins due to excessive clearance in piston and in connecting rod bushing Loose bushings in connecting rod seat	Replace piston pin with an oversize one and adjust piston hubs and connecting rod bushings Replace bushings with new ones
	Tapping due to noisy valve system	Adjust clearance between valves an rockers and check if there are broken springs or excessive clearance between stems and guides, or tappets and seats
The engine smokes abnormally **I) Black or dark grey smoke:**	Excessive pump delivery	Detach pump and adjust delivery according to the data of calibration table
	Injection pump retarded excessively	Correct timing
	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 refitting	Check conditions of ends and connectors Replace where necessary
2) Blue, grey/blue, or clear grey smoke	Excessive injection delay	Correct pump timing
	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
	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 thoroughly
	Dirty fuel filters	Clean thoroughly.
	Squashed pipes	Replace pipes or, if possible repair them (the low pressure ones)
	Air in injection pump	Deaerate pump

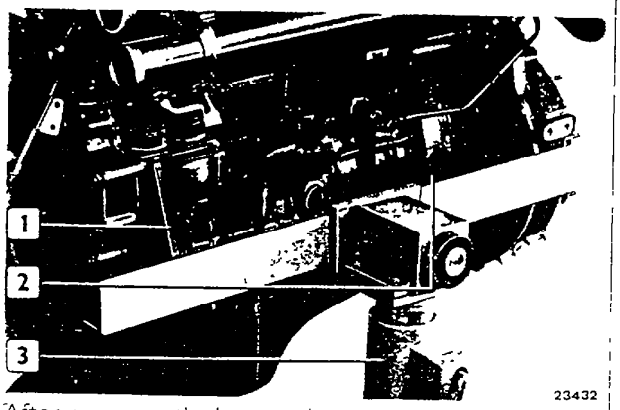
TROUBLE	POSSIBLE CAUSE	REMEDY
The pump does deliver fuel	Plunger tappets may be seized	Remove part and repair it (if failure is minor), if necessary, replace it
	Plunger seized	Change defective pumping element, as barrels and piston are not interchangeable
	Delivery valve seized	If failure is only due to foreign matter, clean valve and sligtly regrind taper faces with an emery cloth if reasons are different, replace pair valve nolder - valve which are not inter changeable 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 ther 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	Thoroughly clean plunger and its cylinder
	Tappet pin worn-out	Replace tappet
Injection start faulty timed	Uneven delivery start	Adjust delivery start replacing adjusting shims
	Eccentric 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	Thoroughly clean nozzle, if the trouble is due to foreign 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 diamter 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 keying on engine	Check if the static keying 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
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
	Worng pump keying on engine	Check if the static keying 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 keying on engine	Check the static keying 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 keying on engine	Check static pump keying on engine

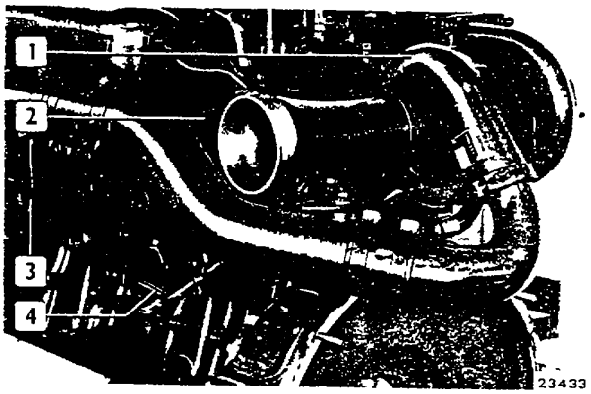
DISMANTLING THE ENGINE

FIGURE 14



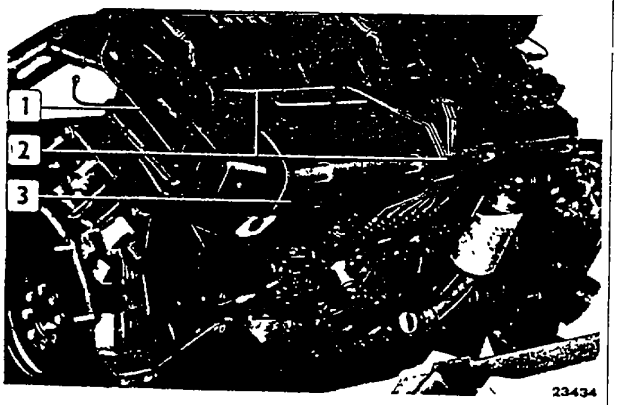
After removing the heat exchanger on one side and the turbocharger oil return pipe on the opposite side, fit brackets 99361015 (2) and 99361014 (1) Then place the engine on revolving stand 99322230 (3)

FIGURE 15



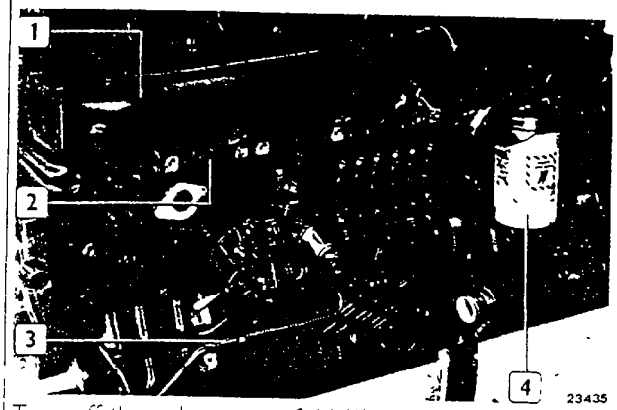
Remove starter and also clutch, if not yet detached Remove turbocharger (1) and pipings (2-3-4)

FIGURE 16



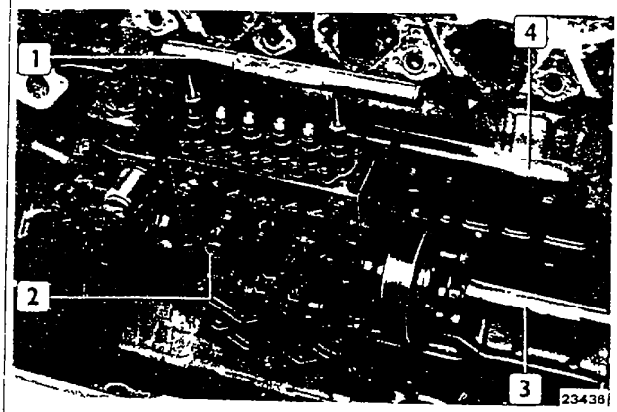
Remove LDA device air line (1), fuel delivery and return lines (2) from injectors
Remove fuel delivery lines and draw out heat shield (3)

FIGURE 17



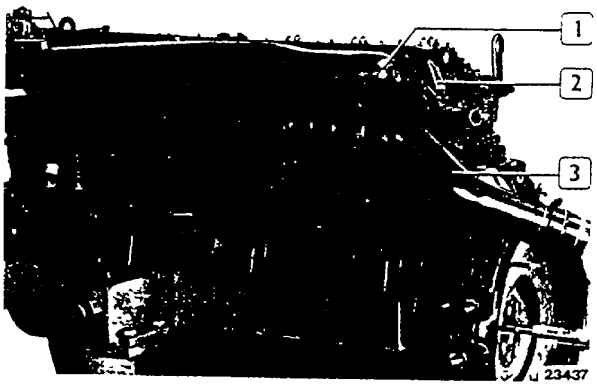
Take off the exhaust manifold (1) and the fuel filter (4)
Detach line (2) conveying water to cylinder heads
Disconnect oil return line (3)

FIGURE 18



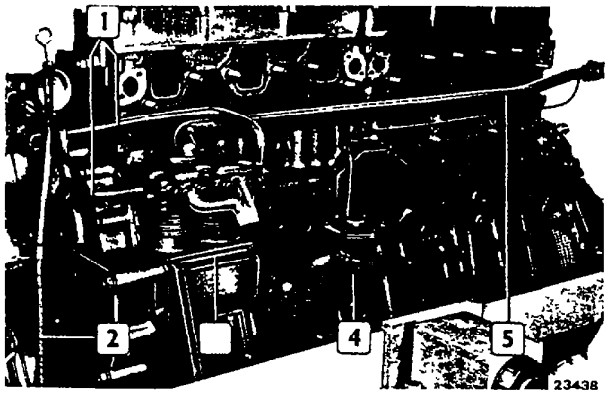
Using tool 99365136 (1) remove injection pump (2) by disconnecting it from the control shaft (3)
Remove line (4) conveying water to block

FIGURE 19



Remove air conveyor (3) and intake manifold (1)
Disconnect water outlet line (2) from cylinder head

FIGURE 20

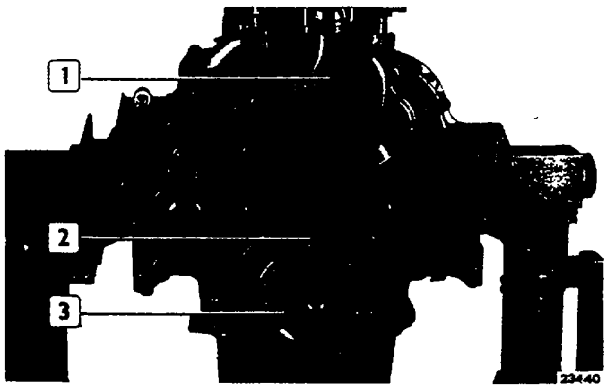


Remove the oil breather (4) together with its line Take off compressor head cooling water line (1) Disconnect pipe (5)
Remove oil dipstick (2)

FIGURE 21

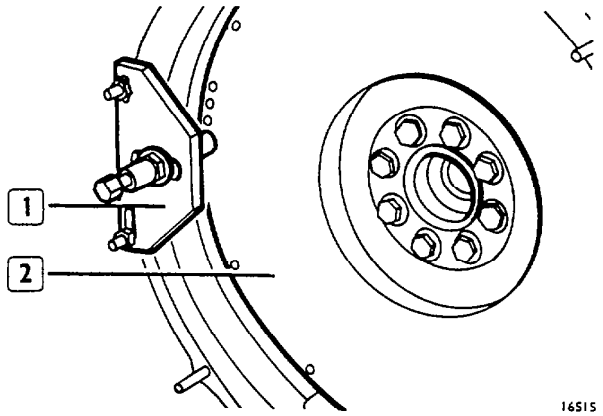
Take off the viscostatic fan assembly and position it vertically Loosen tensioner and remove water pump belts. Withdraw the alternator.

FIGURE 22



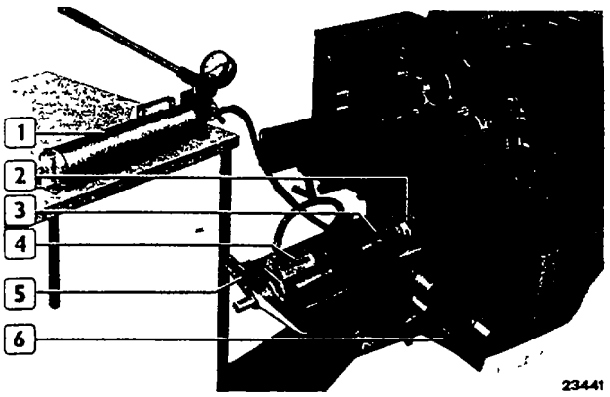
Loosen screws (3) and remove pulley (2)
Withdraw damper and then water pump (1)

FIGURE 23



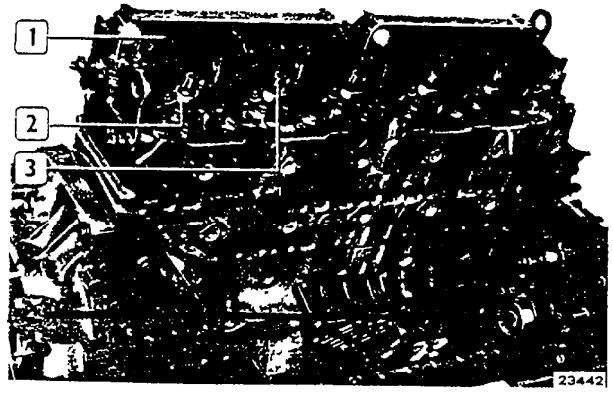
Fil tool 99360351 (1) to flywheel (2), then almost totally slacken flywheel hub check nut (3 figure 24)
This protects the operator from possible sudden hub release during withdrawing

FIGURE 24



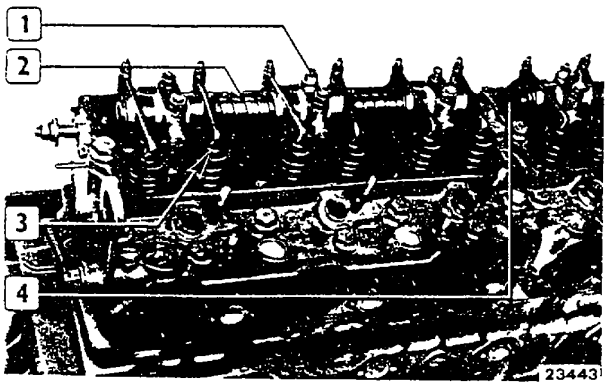
Fit puller 99340032 with relevant brackets to crankshaft damper hub (2), position clamp (6) and with hydraulic unit 99341033 (4) and hydraulic pump 99341034 (1) extract damper hub (2)

FIGURE 25



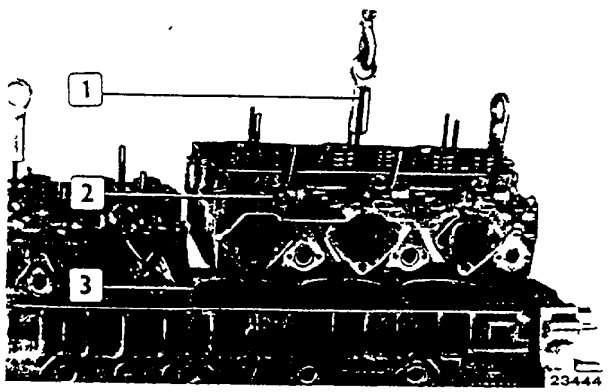
Remove rocker covers (1)
Take off clamp brackets (2) and draw out injectors (3)

FIGURE 26



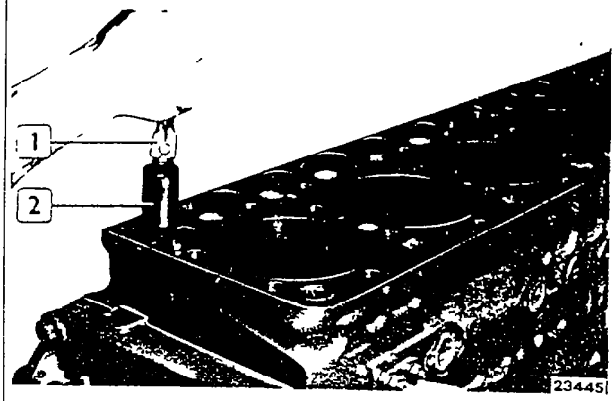
Loosen support nuts (1) and withdraw the complete rocker shafts (2)
Remove valve stem caps (3) and withdraw rocker pushrods (4)

FIGURE 27



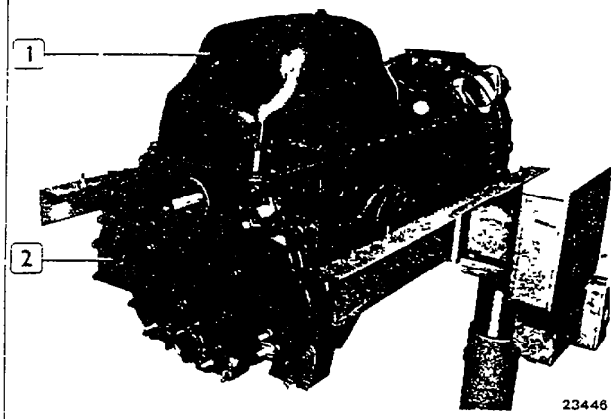
Loosen bolts and using a hoist and tool 99360502 (1) remove cylinder heads (2) and gaskets (3)

FIGURE 28



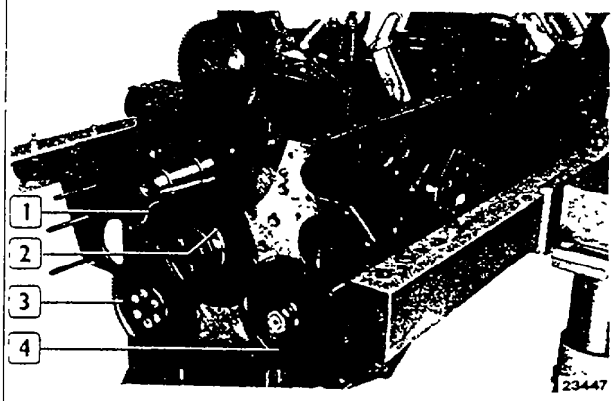
With suitable pliers (1) take off tappets (2)

FIGURE 29



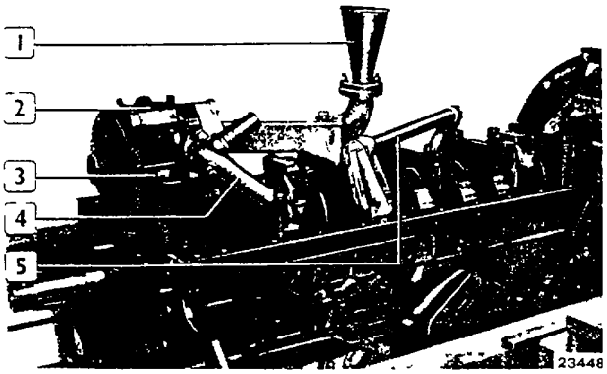
Rotate the engine by 180°, unscrew oil sump bolts (1) and remove it
Remove front timing cover (2)

FIGURE 30



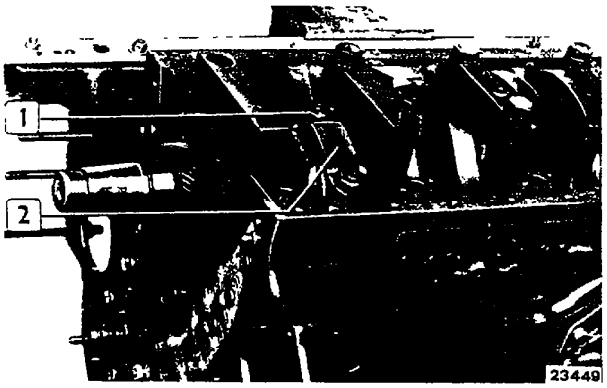
Remove injection pump driving gear (4) and its support
Take off camshaft driving gear (3), withdraw driving gear (2) with relevant support
Remove gear system lubrication line (1)

FIGURE 31



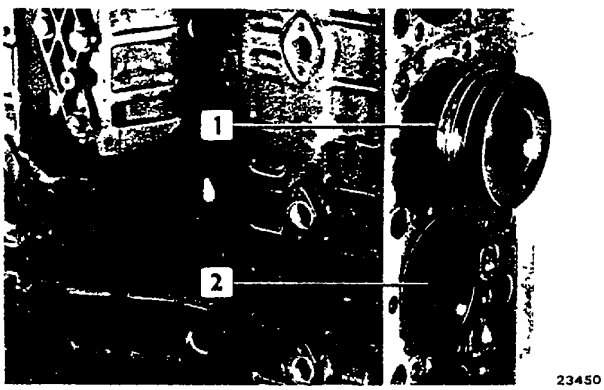
Remove oil delivery lines (4-5)
Take off suction strainer (1) Loosen screws (3) and withdraw oil pump (2)

FIGURE 32



Loosen nuts (1) securing connecting rod caps (2) Remove caps and half-bearings

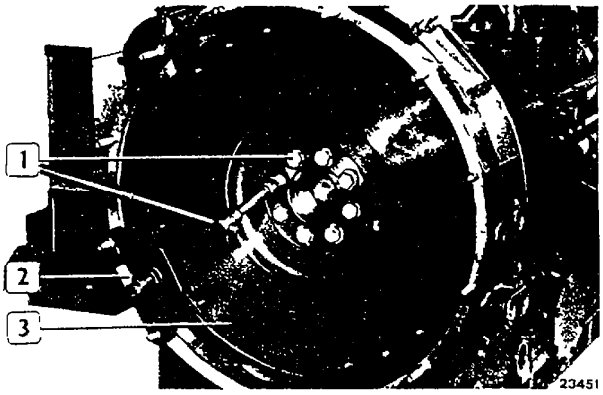
FIGURE 33



Rotate engine and position it vertically
Withdraw cylinder sleeves (2) and piston-connecting rod assemblies (1)

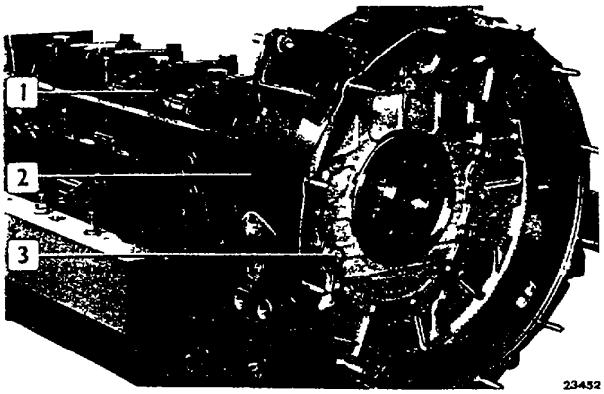
NOTE - If connecting rods and connecting rod caps are not numbered, stamp the number of the relevant cylinder

FIGURE 34



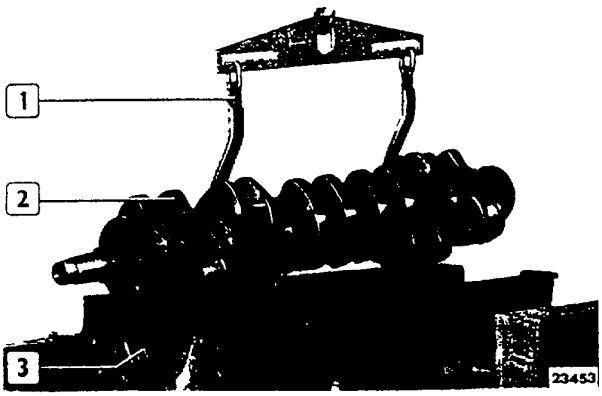
Again position engine horizontally
Remove capscrews (1) Take off tool 99360351 (2) and withdraw engine flywheel (3)

FIGURE 35



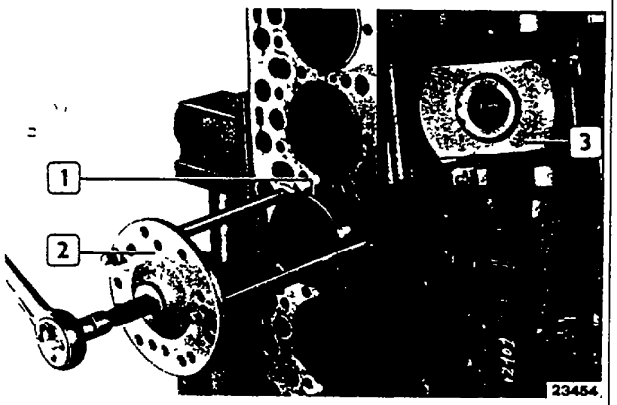
Unscrew capscrew (3) and remove rear support (2) Unscrew capscrew and remove main bearing caps (1)

FIGURE 36



Using a hoist and tool 99360500 (1) lift and remove crankshaft (2)
Take off main half-bearings (3)

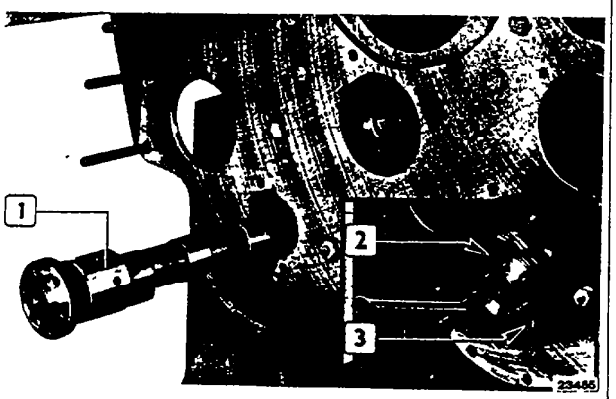
FIGURE 37



Rotate engine and position it vertically
Position tool 99360711 (2) and withdraw cylinder sleeves (1) To position plate (3) remove oil nozzles

NOTE - If cylinder sleeves cannot be withdrawn with tool (2) owing to excessive interference, use hydraulic device 99305007.

FIGURE 38



Again position engine horizontally Unscrew bolts (3) securing thrust plate (2) and take off camshaft (1)
Withdraw camshaft support bushings using a suitable driver
Place a pair of rings and lift engine block with a hoist; then remove front end plate
This plate is to be removed only to prevent deterioration during engine block handling and washing

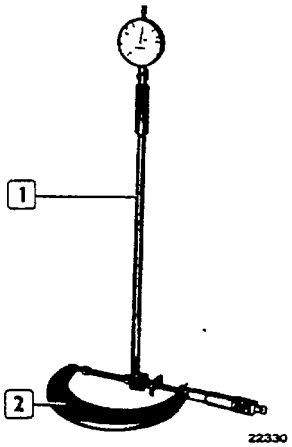
ENGINE BLOCK

After engine disassembly, clean engine block thoroughly

CHECKS AND MEASUREMENTS

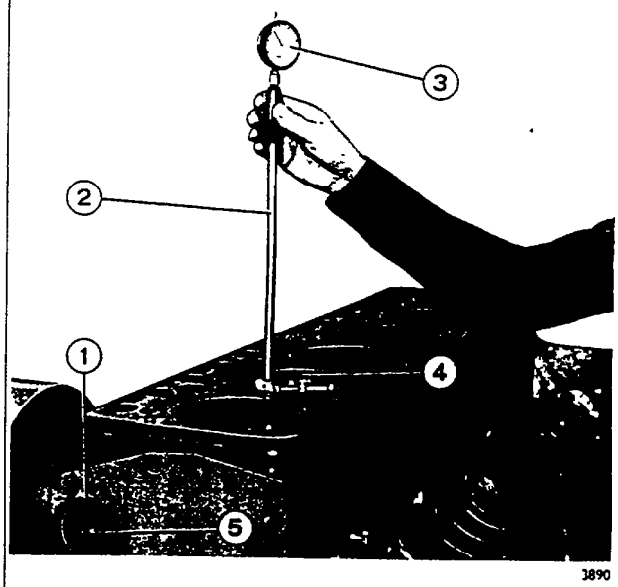
Check cylinder sleeve surface for traces of seizure, scoring, excessive ovalization, taper and wear

FIGURE 39



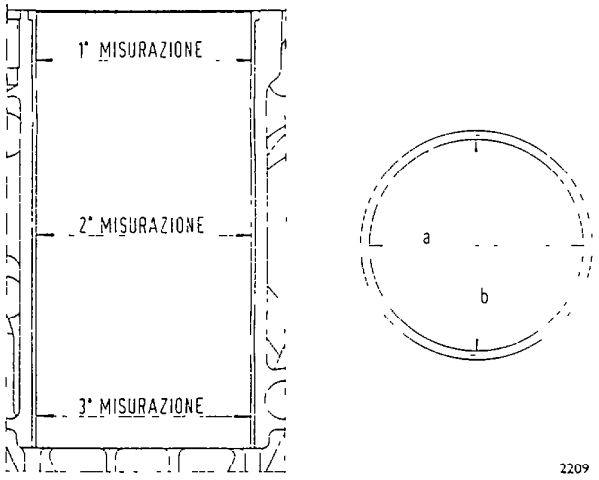
NOTE - To define the class it pertains to (A or B), never measure cylinder sleeve internally (with the component free) because it is easily distortable

FIGURE 40



To check cylinder sleeve bore (4) for ovalization, taper and wear, use gauge 99395687 (2) equipped with a dial gauge reset with micrometer (2, fig. 39) having a diameter of 137 mm

FIGURE 41



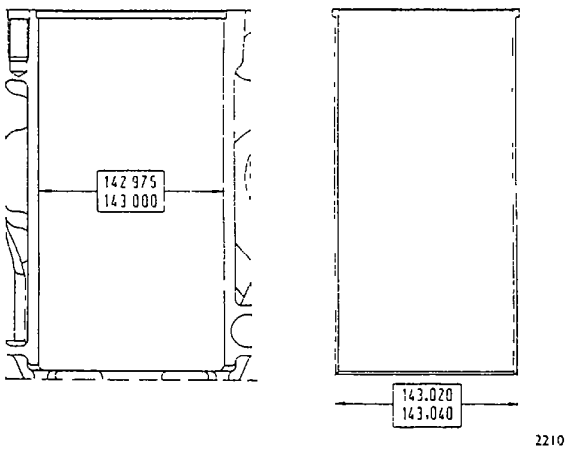
1 MISURAZIONE = 1st MEASUREMENT
2 MISURAZIONE = 2nd MEASUREMENT
3 MISURAZIONE = 3rd MEASUREMENT

Diagram for checking cylinder sleeve diameters

Measurements muts be performed for each cylinder at three different sleeve levels on two planes at right angles, that is, one parallel to longitudinal centre line (a), and one perpendicular to that same centre line (b)
If excessive ovaility or taper is found, replace cylinder sleeves using tool 99360711 (figure 43)

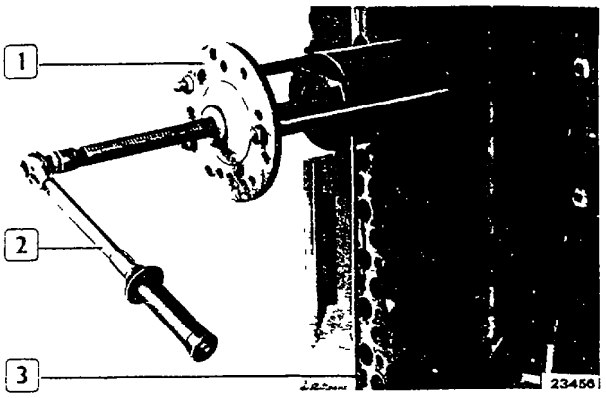
NOTE - Since the inside sleeve surface is treated with liquid nitriding, no grinding, lapping or dressing is allowed If necessary, the sleeves can be removed and installed several times in different position without impairing their conditions

FIGURE 42



O D value of a standard cylinder sleeve, and I D of sleeve lining

FIGURE 43



Before fitting the new cylinder sleeves, check housing diameters on engine block they should be of 142 975 to 143 000 mm
In case of an ovality over 0 10 mm on engine block, bore housing 143 225 to 143 250 mm and use sleeves oversized by 0 25 mm Cylinder sleeves fit in their housings is 0 020 to 0 065 mm
This type of fit requires a fitting load (after the sleeve has been inserted 100 mm in its housing) of 400 kg or more, namely 1 5 kgm To do so, use tool 99360711 (1) and torque wrench (2) The required load for sleeve fitting should never exceed 4500 kg (15 kgm) Use tool 99360711 (1) and torque wrench (2)
During cylinder sleeve fitting, lubricate only the engine block housing, taking care not to grease sleeve housing rim, thus avoiding that too much oil may cause an incorrect sleeve fitting and possible breaks in the rim

FIGURE 44

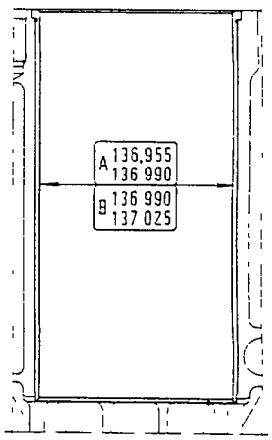
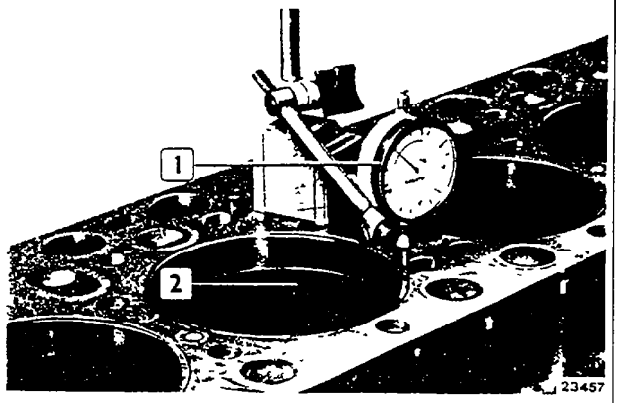


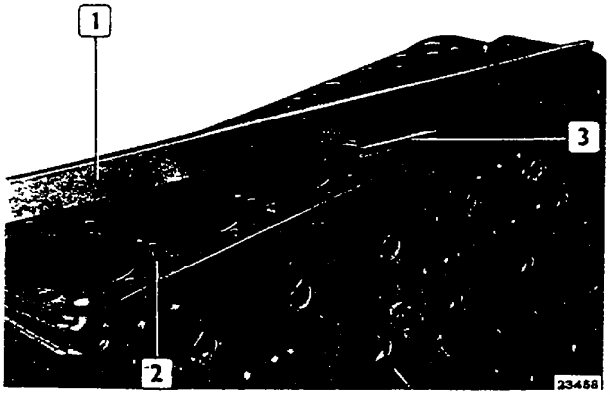
Diagram for checking sleeve I D , so as to define selection class values and to stamp the relevant letter on engine block

FIGURE 45



When fitting has been completed, check sleeve standout above cylinder block (2) using dial gauge (1) It should be from —0 020 to —0 045 mm

FIGURE 46

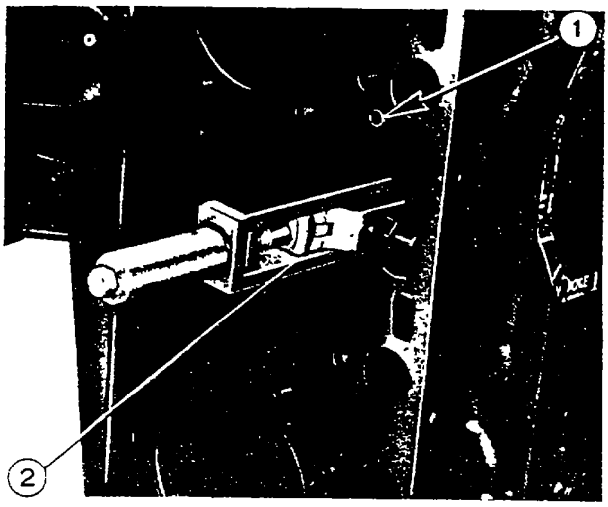


Check flatness of block face (2) using straightedge (1) and a feeler gauge (3)
After inspecting distorsion areas, grind the surface as required, taking care to remove as little material as possible

NOTE - Block face skimming must be carried out only with cylinder sleeves removed

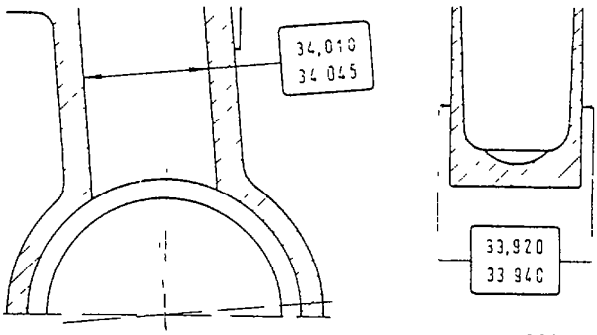
NOTE - If block skimming is carried out, restore the sleeve rim depth, which should be of 5 97 to 6 02 mm

FIGURE 47

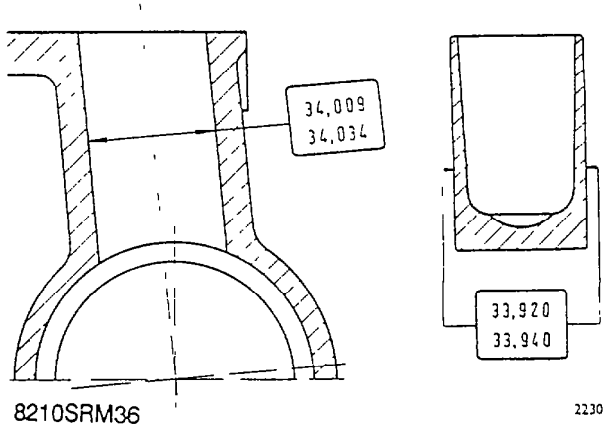


Remove dowel (1) using suitable tool (2)

NOTE - Remove dowels only if block skimming is to be carried out



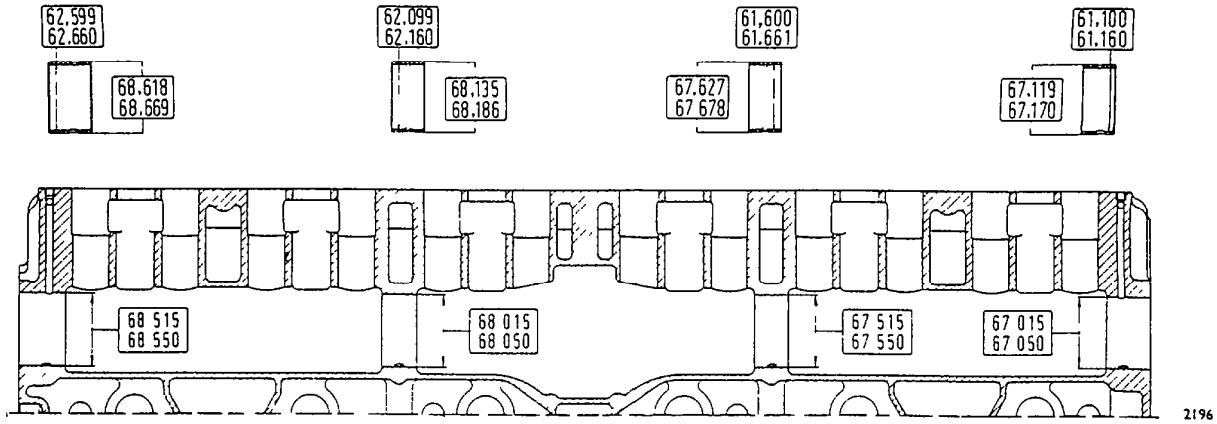
Details on tappets and their housings on the block



Details on tappets and their housings on the block

Tappet replacement, because of excessive housing clearances, requires oversized tappets and housing boring Tappets are supplied with standard spares and oversized of 0 10, 0 20, 0 30 mm

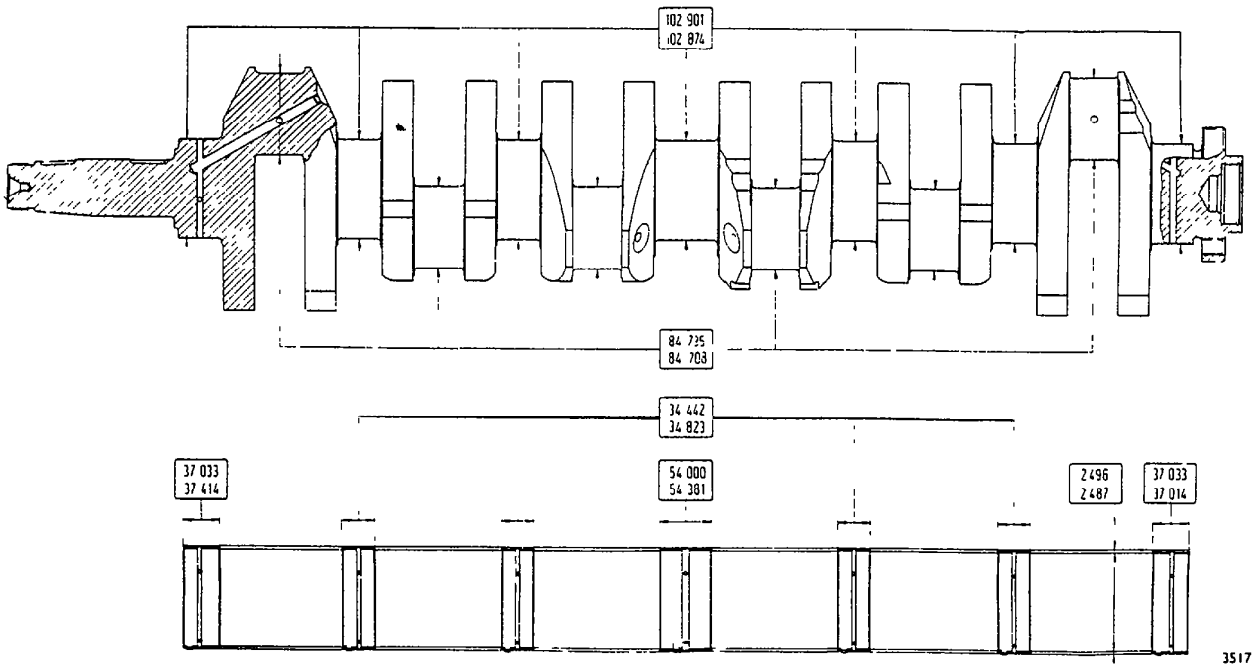
FIGURE 49



Details on camshaft bushings and their housing on engine block

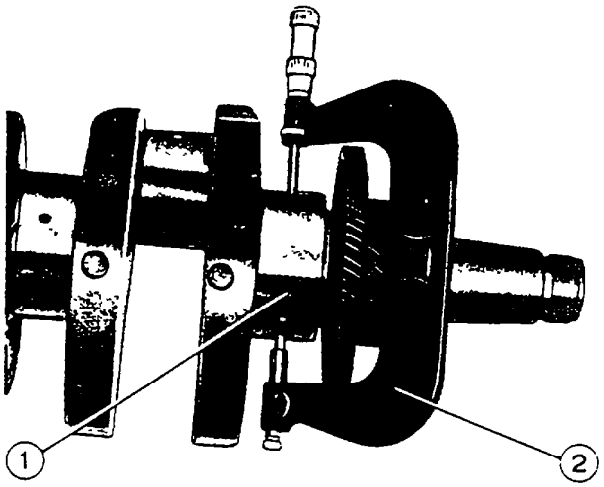
To remove and insert bushing use a suitable tool
During insertion, take care to position bushings so that their holes are aligned with those of capscrew seats and those for lubrication oil

CRANKSHAFT



Crankshaft journal and main half-bearing details

FIGURE 51



13762

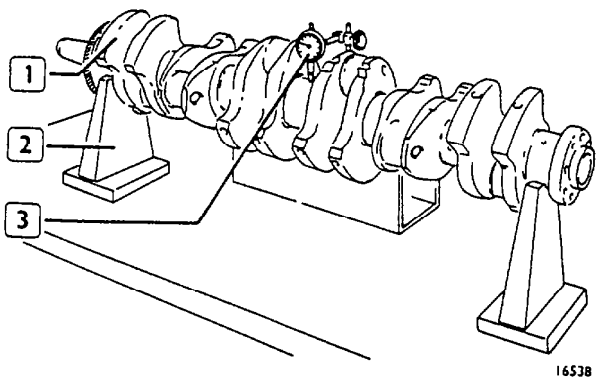
Main journal measurements.

Before regrinding, with micrometer (1) measure crankshaft journals (2) and define the undersize diameter required
Remember that ovality must be limited to 0 008 mm and taper to 0 012 mm
Undersize range is 0 254 - 0 508 - 0 762 - 1 016 mm

NOTE - Crankshaft journals and crankpins must always be ground to the same undersize class

CHECK OF CRANK SHAFT JOURNAL AND CRANKPIN ALIGNMENTS

FIGURE 52

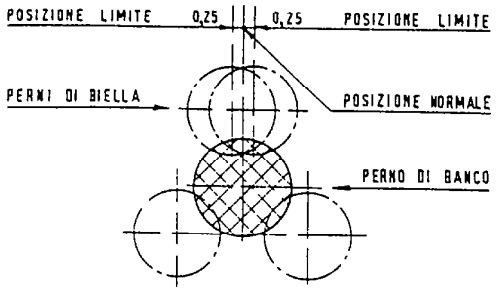


16538

This check must be carried out after grinding, placing crankshaft (1) on two V-blocks (2) and using dial gauge (3)

- Main journal alignment max tolerance 0 20 mm (total dial gauge reading), and 0 10 mm between two adjoining journals

FIGURE 53

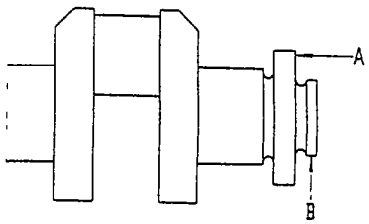


2219

- Crankpin alignment as to main journals Each pair of crankpins and each pair of main journals should lie on the same plane Max tolerance is ± 0 25 mm

Max allowed tolerance between shaft rotation axis and crankpin surfaces, is ± 0 10 mm

FIGURE 54

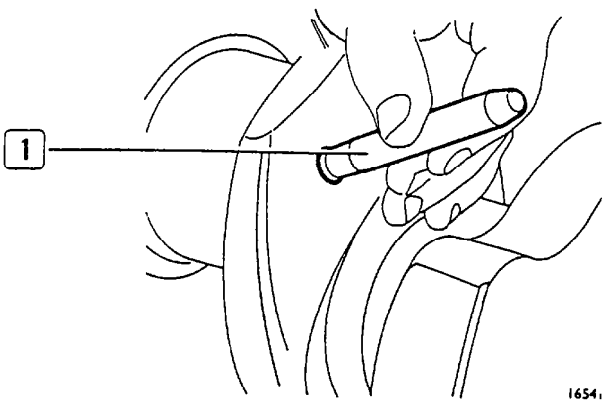


2218

Flywheel face check

Flywheel mounting flange when the shaft is rotated, crankshaft flange eccentricity relative to main journals (B) should not exceed 0 04 mm, crankshaft flange runout on periphery (A) (on a dia 2 to 4 mm less than the max resting surface dia) should not exceed 0 02 mm

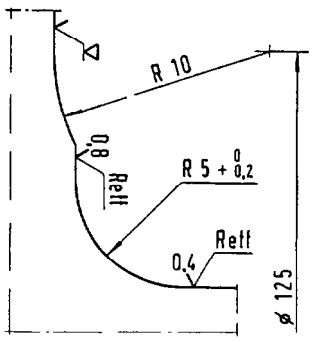
FIGURE 55



16541

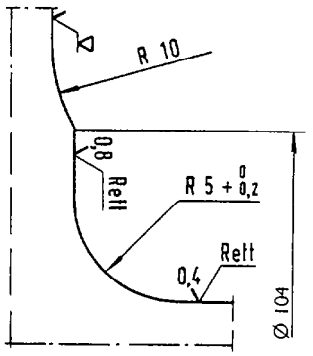
Check that lubrication circuit caps have no leakages at an internal pressure of 15 bar If so, replace them using tool 99386010 (1) for fitting

FIGURE 56



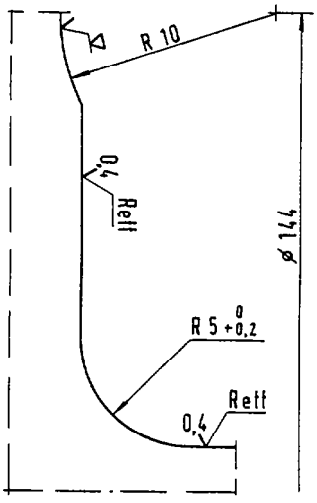
Details of front, intermediate and rear main journal fillets

FIGURE 57



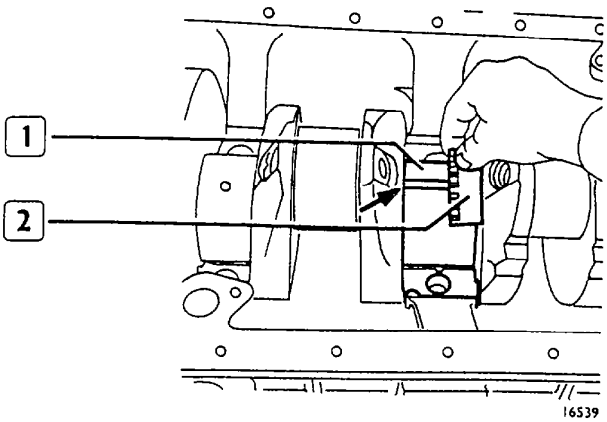
Details of crankpin fillets

FIGURE 58



Details of central main journal fillets
When grinding main journals, carefully observe fillet values, as these should not change as to those indicated

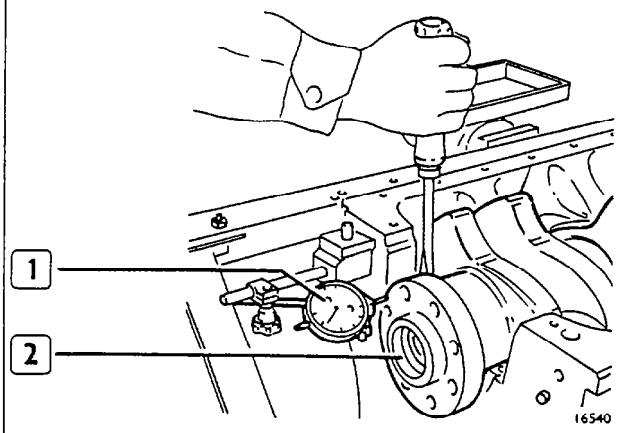
FIGURE 59



Insertion of a calibrated wire for clearance measurement

- Thoroughly clean all parts and wipe-out oil
- Place a calibrated wire on crankshaft journals (1) parallel to the longitudinal axis (see the arrow)
- Insert caps and tighten the screws (already lubricated) at the prescribed torque
- Remove caps and measure clearance, comparing the calibrated wire width (arrow) with scale graduation on the container (2)

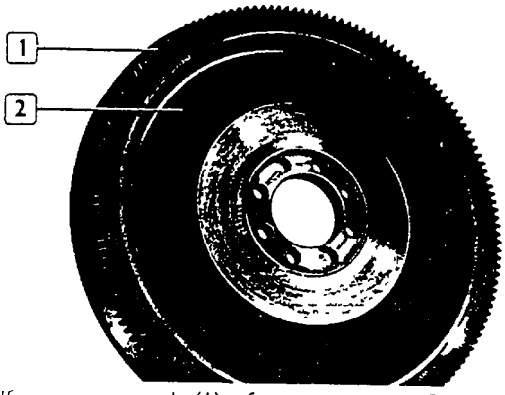
FIGURE 60



Check the measurement of crankshaft (2) end float by gauge (1)
Standard clearance is 0 076 to 0 328 mm
If excessive end float is noticed, replace thrust washers with new ones of standard thickness or oversized by 0 127 mm if necessary

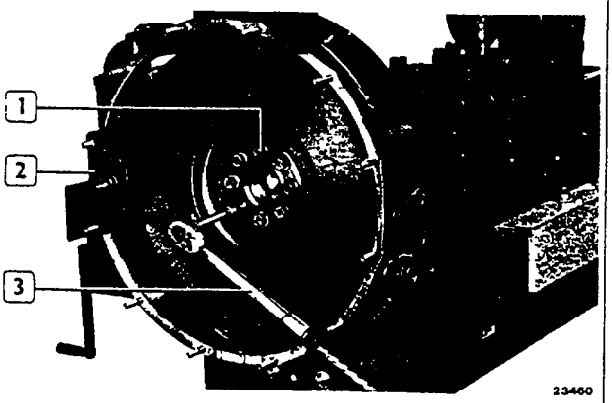
ENGINE FLYWHEEL RING GEAR REPLACEMENT

FIGURE 61



If ring gear teeth (1) of engine starter flywheel (2) are seriously damaged, replace the whole ring gear
To remove/install ring gear on flywheel use a suitable drift, before installation, heat ring gear to 80°C

FIGURE 62



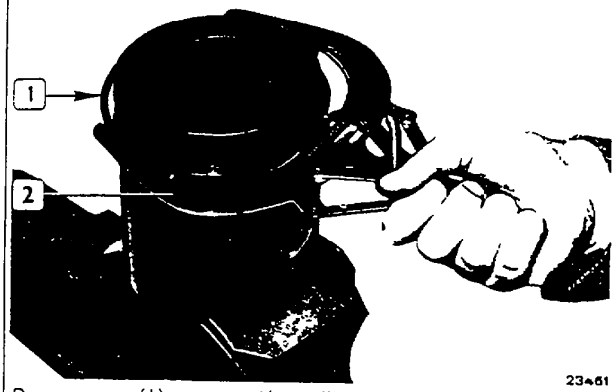
Engine flywheel assembly

Using tool 99360351 (2) and torque wrench (3) tighten capscrews (1) to a torque of 102 Nm (10 5 kgm), then furtherly tighten by 60°.

NOTE - Screws can be reused as long as thread dia. (measured at 25 mm from tip) is not lower than 15 5 mm

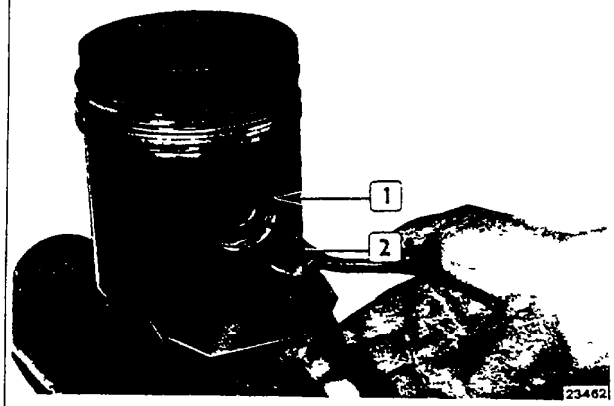
PISTON-CONNECTING ROD ASSEMBLY

FIGURE 63



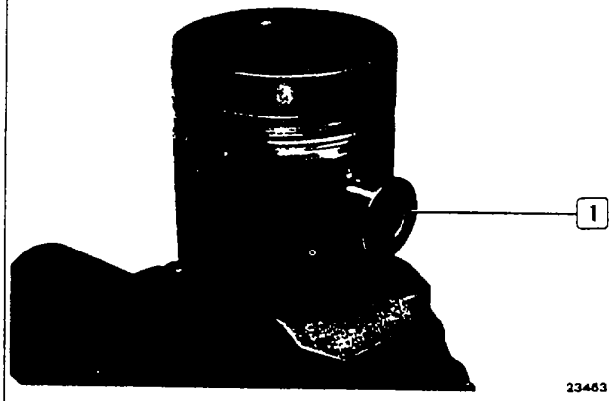
Piston ring (1) removal/installation by means of remover/installer 99360184 (2)

FIGURE 64



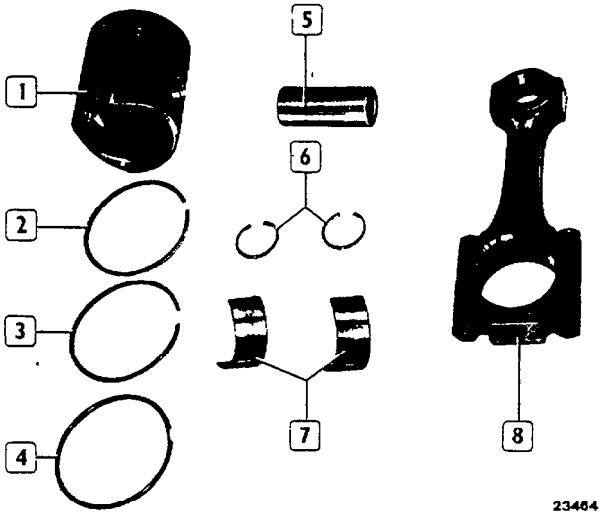
Piston ring (1) assembly/disassembly by means of roud-nose pliers (2)

FIGURE 65



Piston pin removal (1) If it is difficult to remove the pin, use a suitable driver.

FIGURE 66

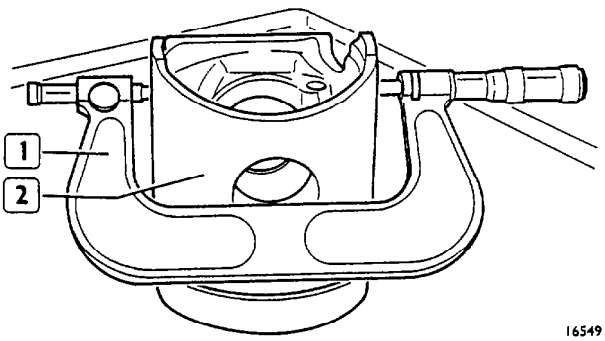


23464

PISTON CONNECTING ROD ASSEMBLY COMPONENTS

1 Piston - 2 Double taper ring 3 Ring 4 Oil scraper ring - 5 Pin - 6 Piston rings 7 Half-bearings 8 Connecting rod

FIGURE 67

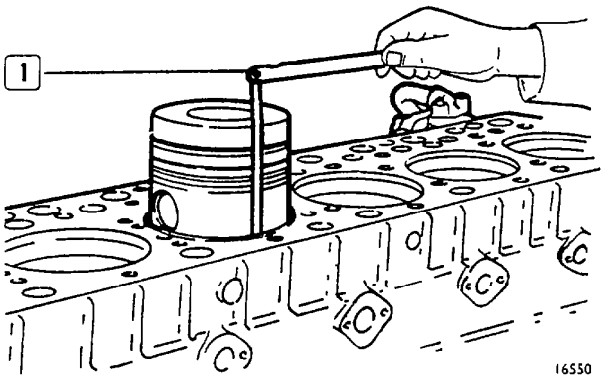


16549

Measure piston diameter (2) by micrometer gauge (1) to define clearance

NOTE - Diameter must be measured 33 mm from skirt base.

FIGURE 68

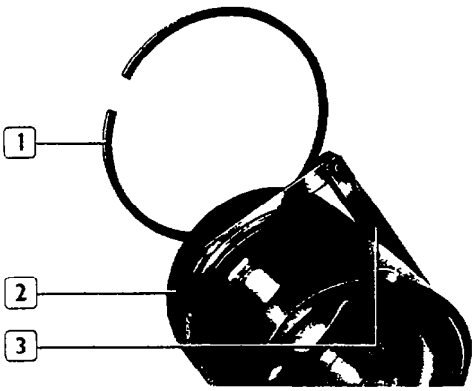


16550

Piston-cylinder liner clearance can be checked not only by measuring piston and liner diameters, but also with a feeler gauge (1), as indicated in the figure

PISTON RINGS

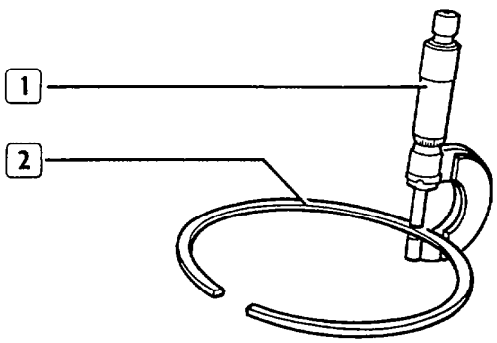
FIGURE 69



23465

Checking clearance between piston rings (1) and relevant grooves on piston (2) by feeler gauge (3)

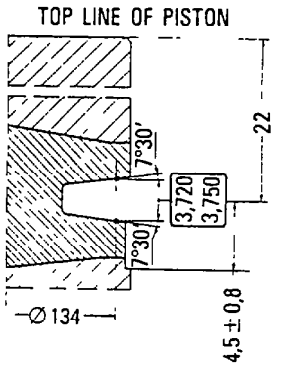
FIGURE 70



16552

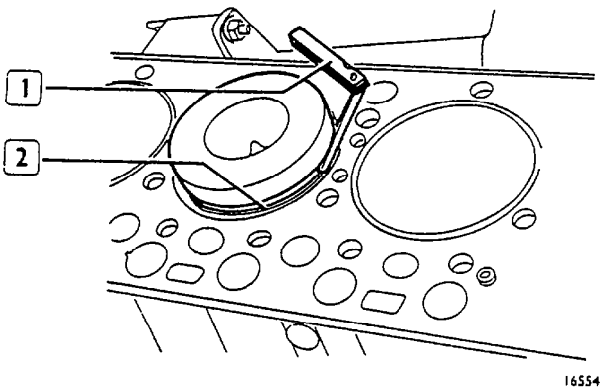
Check piston ring thickness (2) with micrometer gauge (1)

FIGURE 72



Detail of the first groove for double taper compression ring
Groove height is measured on 134 mm dia

FIGURE 73



Checking clearance between double taper ring (2) and its groove on piston, with a feeler gauge (1)

FIGURE 74

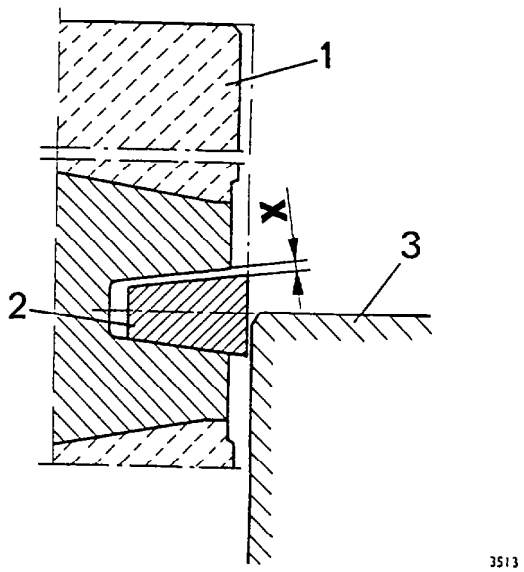
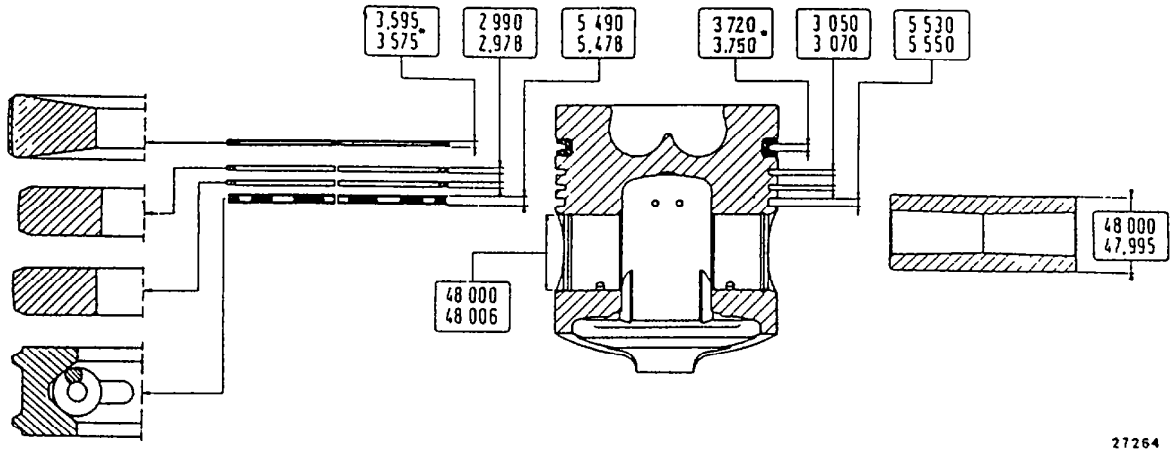


Diagram for measuring X clearance between the first piston groove and the double taper ring

Due to the special shape of the first compression ring (double taper section), the gap between groove and ring is measured as follows position piston (1) so that it protrudes from engine block with ring (2) half out of cylinder sleeve (3)
On this position, insert feeler gauge and check gap (X) between ring and groove Gap should be 0 122 to 0 163 mm

8210 M 22

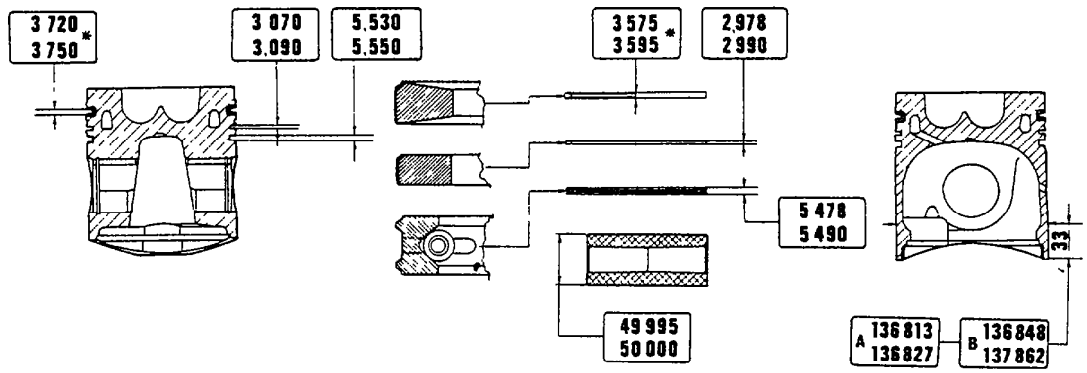
FIGURE 69



Details of pistons, piston pins and rings.
*Dimension obtained on 134 mm dia

8210 SRM 36

FIGURE 71

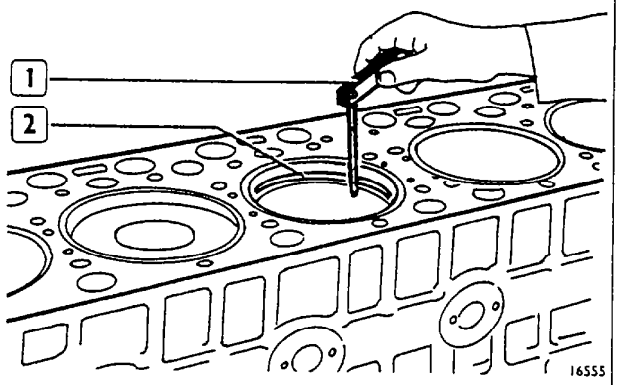


Details of pistons, piston pins and rings

* Dimension obtained on 134 mm dia

CONNECTING RODS

FIGURE 75



Piston ring end (2) gap inspection by feeler gauge (1)

8210SRM36

Gap between ring ends in cylinder sleeve should be

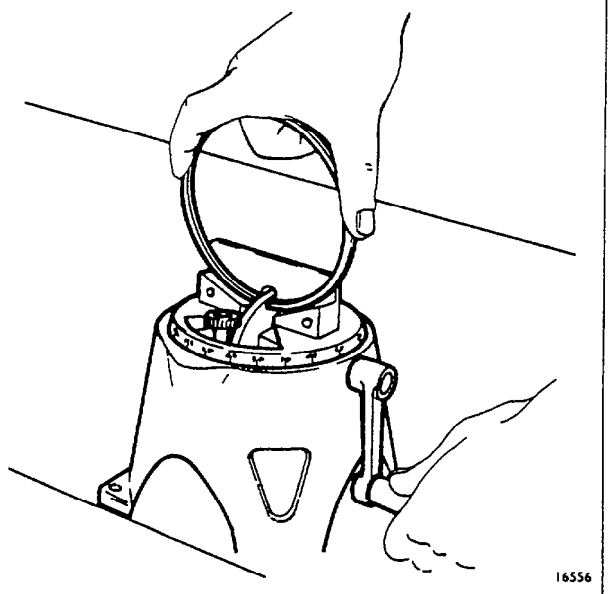
- Top compression ring, double taper mm 0 50 to 0 75
- 2nd compression ring, straight mm 0 50 to 0 75
- 3rd ring, oil scraper mm 0 40 to 0 60

8210M22

Ring gap in sleeve

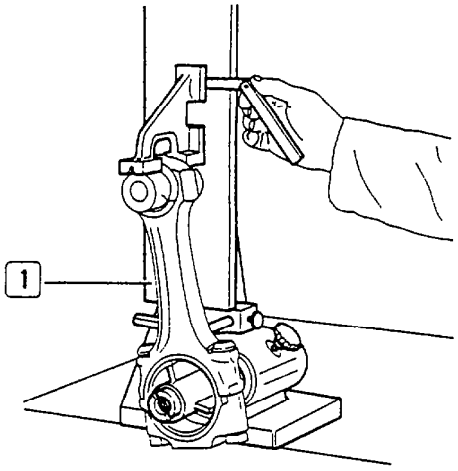
- Top compression ring, double taper mm 0 60 to 0 80
- 2nd compression ring, straight mm 0 50 to 0 70
- 3rd compression ring, straight mm 0 50 to 0 70
- 4th oil scraper ring mm 0 40 to 0 60

FIGURE 76



If the gap is less than the minimum allowed, rectify piston ring ends with tool 99360188, if gap is greater than the maximum allowed, replace rings

FIGURE 77

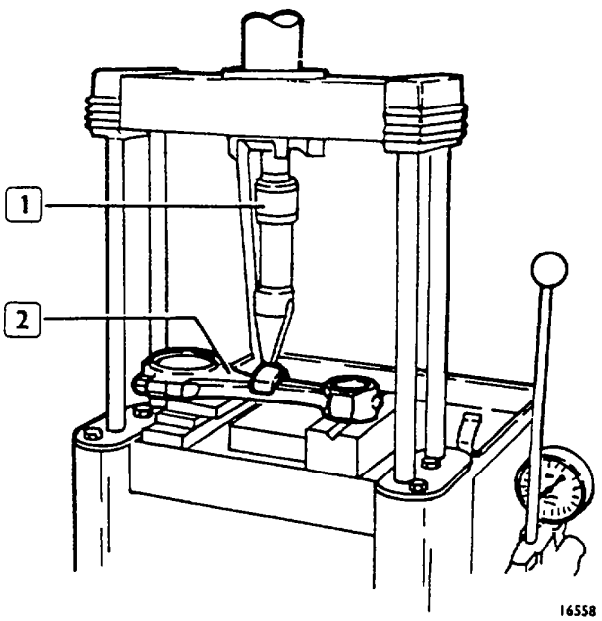


Check for connecting rod axis misalignment, using gauge 99395363 (1)

Max allowable tolerance is 0 07 mm measured 125 mm from the longitudinal rod centreline

For misalignment over the allowed tolerance, straighten connecting rod using a hydraulic press

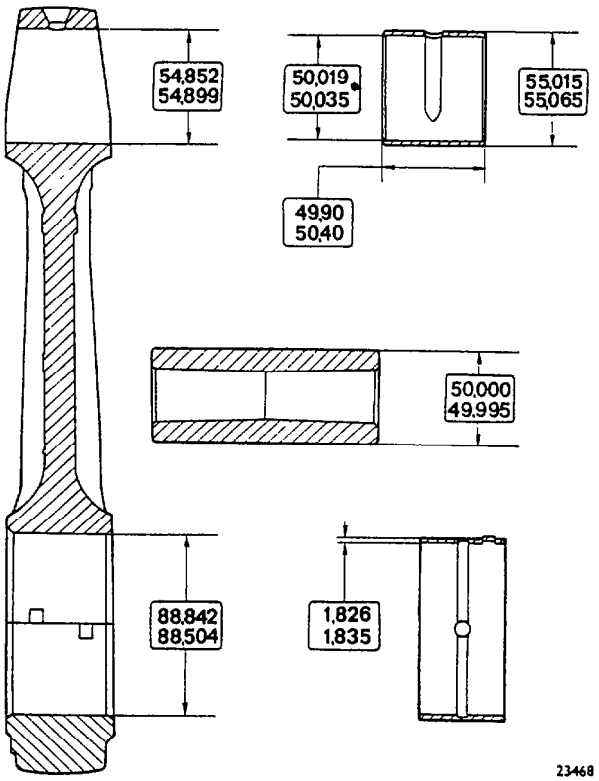
FIGURE 78



Straightening connecting rod stem (2) by press (1),.

8210 SRM 36

FIGURE 79

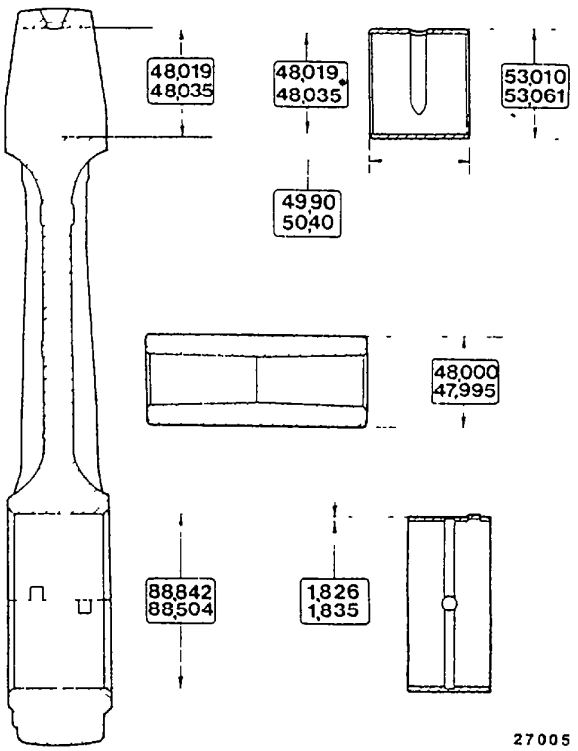


Details of connecting rods, bearings, bushing, piston pin

* Dimension to be obtained after fitting the bushing

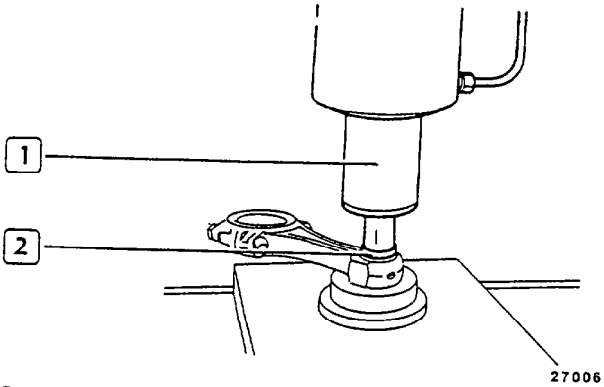
8210 M 22

FIGURE 77



Details of connecting rods, bearings, bushing and piston pin

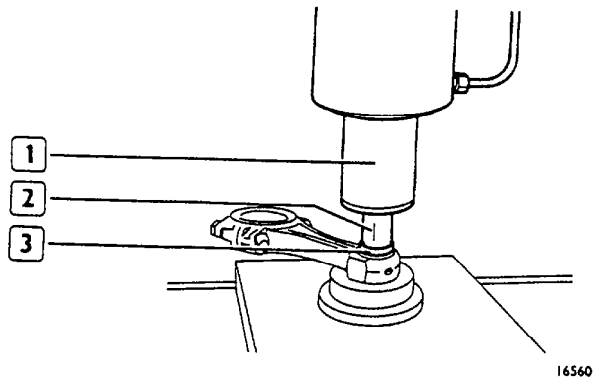
*Dimension to be obtained after fitting the bushing



Bushing (2) removal/refitting is carried out by hydraulic press (1) with the aid of a suitable tool
After fitting, remove the portion of bushing protruding laterally from connecting rod small end, then re-grind bushing to obtain diameter 48.019 to 48 035 mm

8210M22

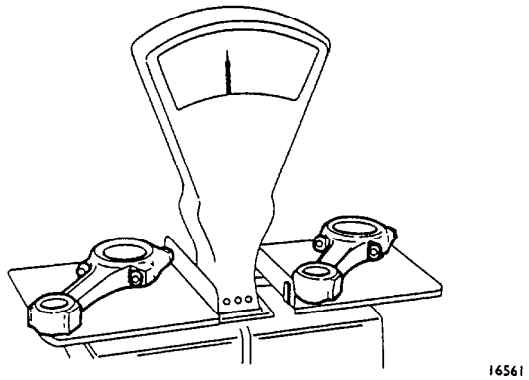
FIGURE 80



Bushing (3) removal/fitting is carried out by hydraulic press (1) with the aid of installer/remover tool 99360270 (2)
After fitting, remove the portion of bushing protruding laterally from connecting rod small end, then re-grind bushing to obtain diameter 50 019 to 50 035 mm

.8210SRM36

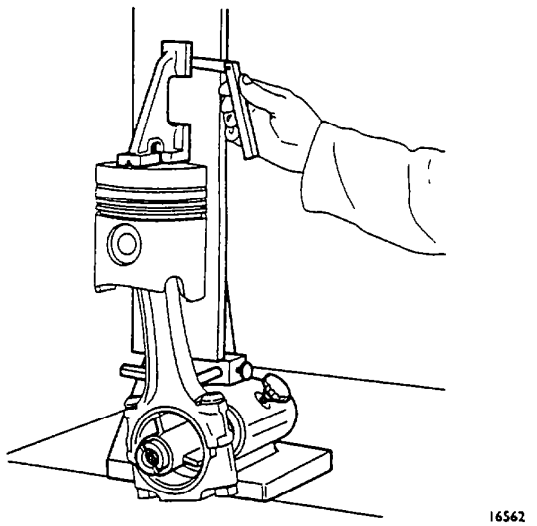
FIGURE 81



Checking connecting rod weight tolerance

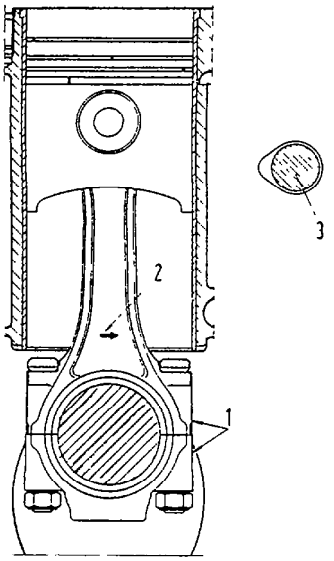
On connecting rod weight, the tolerance is ±20 gr
It must be checked with the connecting rod complete with small end bushing, cap, screw and nuts

FIGURE 82



NOTE - Before installing the connecting rod-piston assembly, check its squareness It should be perfect If not replace the affected parts

FIGURE 83



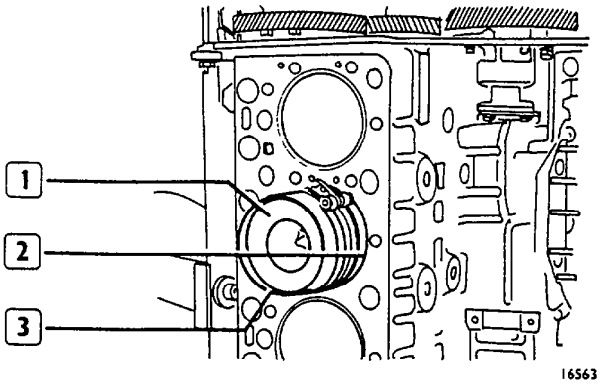
23469

DIAGRAM FOR INSERTING THE CONNECTING ROD - PISTON ASSEMBLY IN CYLINDER

1 Stamp mark area with the number of the cylinder which the connecting rod pertains to - 2 Raised arrow indicating engine direction of rotation 3 Camshaft

NOTE - In case of connecting rod removal and installation, replace old screws and nuts with new ones

FIGURE 84



16563

Connecting rod-piston (1) installation in cylinder sleeves (2) with piston ring clamp 99360603 (3)

Installation of connecting rod-piston assemblies in cylinder sleeves must be carried out checking that.

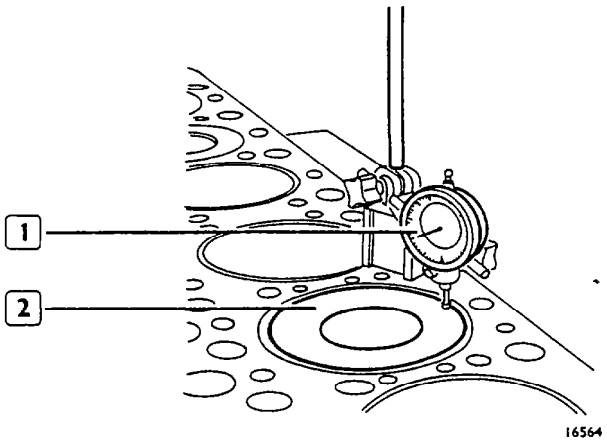
- Each piston - connecting rod assembly is of a same class (A or B)
- The connecting rod number corresponds to cylinder number
- Writing "LATO PUNTERIE" (TAPPETS END) stamped on piston crown is positioned towards camshaft
- Connecting rod numbers are positioned at camshaft end
- Piston ring openings are shifted 120° one another

Thoroughly lubricate pistons, rings, and cylinder sleeve insides included **8210SRM36**

- piston ring openings are shifted 90° one another,

Thoroughly lubricate pistons, rings, and inside of cylinder sleeves **8210M22**

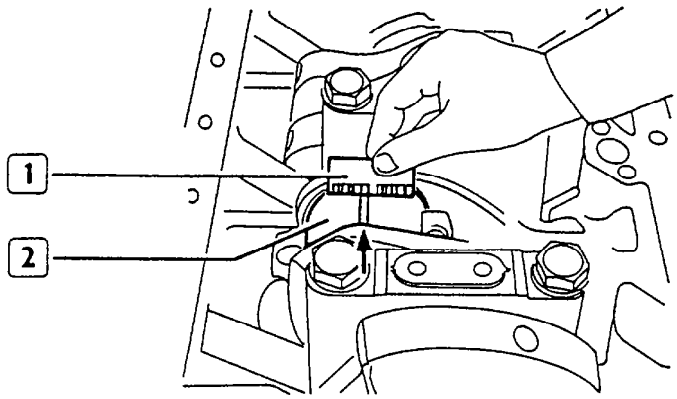
FIGURE 85



16564

After installation, with dial gauge (1) check that the piston protrusion (2) is —0 275 to +0 225 in relation to the block face

FIGURE 86



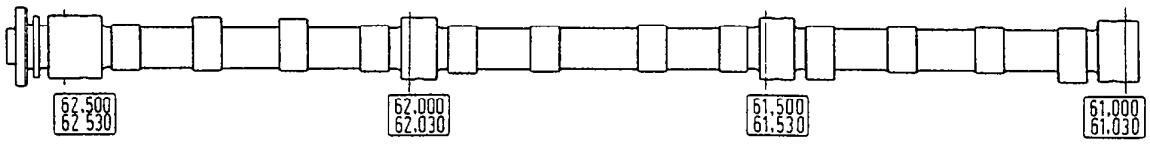
16565

Application of calibrated wire (arrow) to detect crankpin clearance.

To detect clearance, operate as follows
- Thoroughly clean all components and wipe out oil
- Insert on crankshaft journals (1) a calibrated wire (see arrow)
- Place a cap and tighten nuts at prescribed torque Screws and nuts must be lubricated
- Remove cap and detect clearance comparing calibrated wire width (see arrows) with scale graduation on container (1)

CAMSHAFT

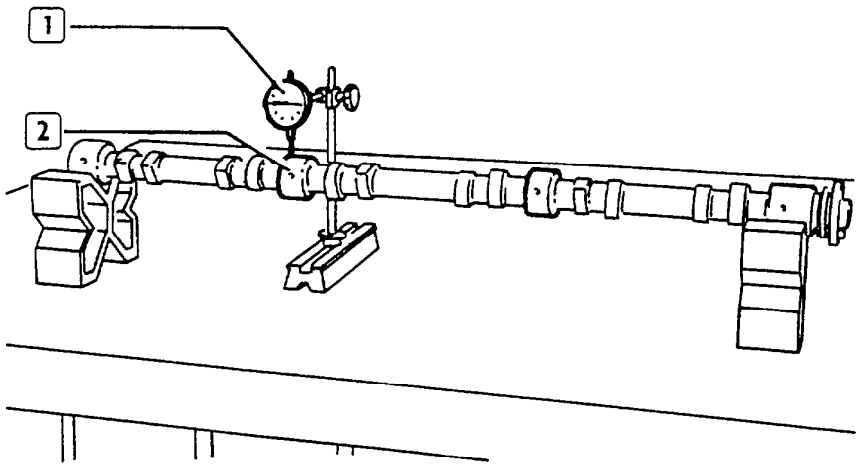
FIGURE 87



2201

Camshaft details

FIGURE 88

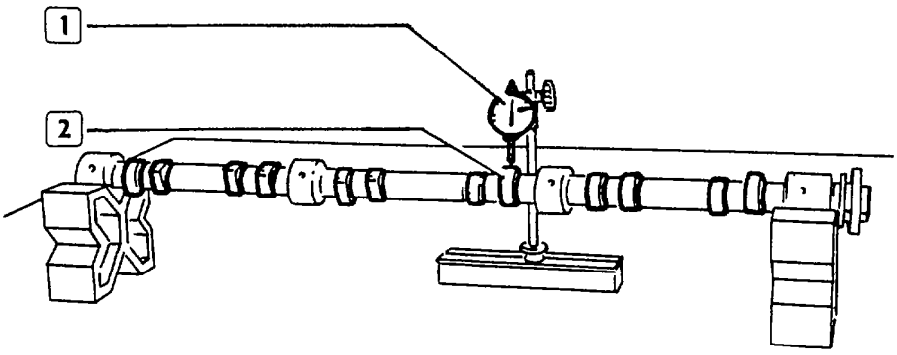


16566

Camshaft journal and lobe surfaces should be smooth If pick-up or scoring are detected, remove the whole shaft and its bushings.

With dial gauge (1) check journal (2) alignment; misalignment should not exceed 0 10 mm, if higher, straighten shaft with a press.

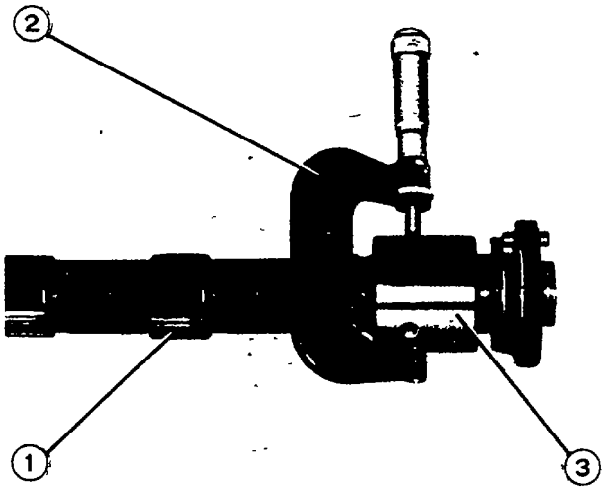
FIGURE 89



16567

With camshaft on V-blocks, with dial gauge (1) check cam lobe lift, which should be 7 921 mm for intake and 8 mm for exhaust

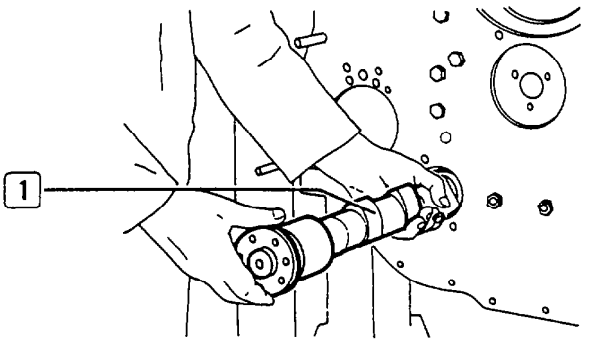
FIGURE 90



13768

To check camshaft running clearance, measure bushing bore I.D and camshaft pin (3) the difference is the real clearance
If clearance over 0.161 mm is detected, replace bushings and, if necessary, also camshaft

FIGURE 91



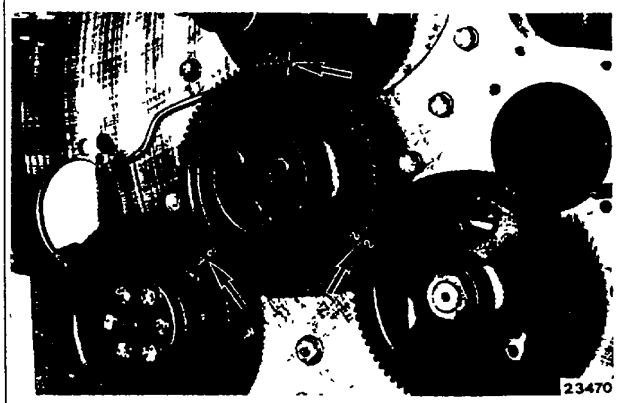
16569

Camshaft (1) installation

Before installing camshaft, lubricate journals with engine oil

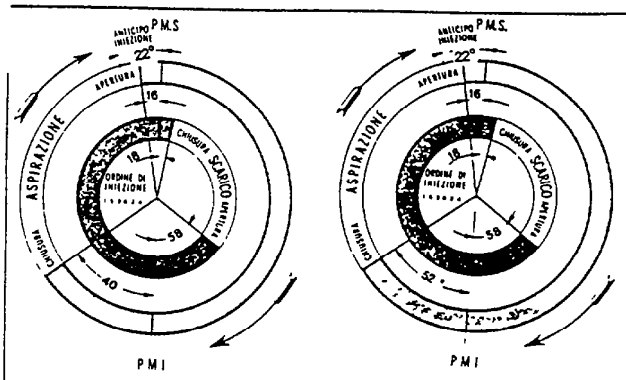
VALVE SYSTEM CONTROL

FIGURE 92



23470

When intalling valve system gears the numbers 1-2-3 (see arrows) on the gears should be in line with the same numbers on adjacent gears



8210SRM36 8210M22

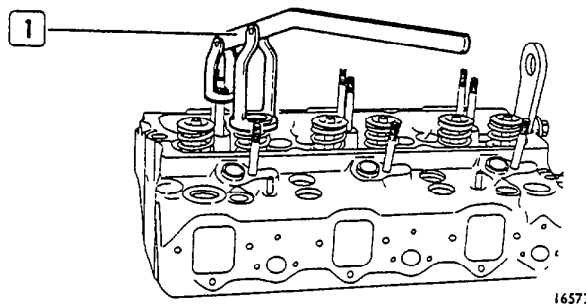
16572

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

Valve system diagram
Data refers to theoretical check gap of 0 55 mm between valves and rockers

CYLINDER HEADS

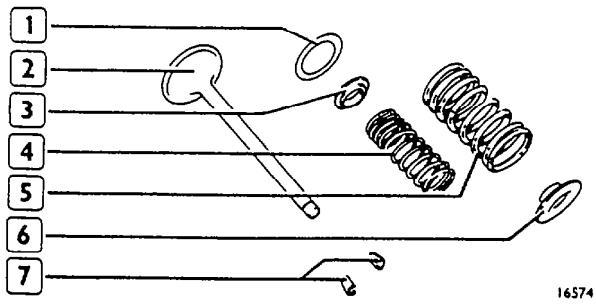
FIGURE 94



16573

Removal/installation of valves is carried out with tool 99360138 (1)

FIGURE 95

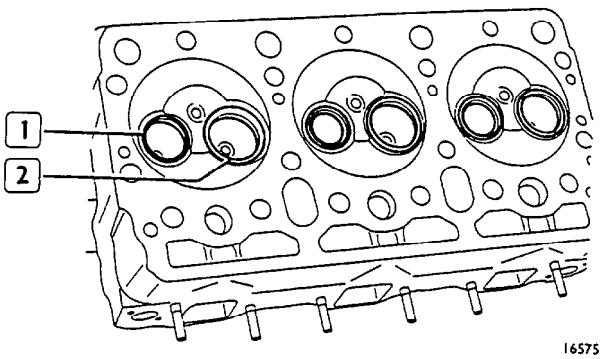


16574

PARTS COMPOSING VALVE ASSEMBLY

1 External spring washer - 2 Valve - 3 Bottom internal spring cap - 4 Internal spring - 5 External spring - 6 Top cap - 7 Retainer cotters

FIGURE 96

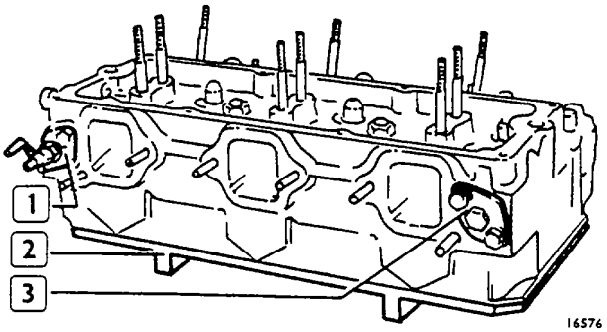


16575

Cylinder head bottom view

1 Exhaust valve housing
2 Intake valve housing

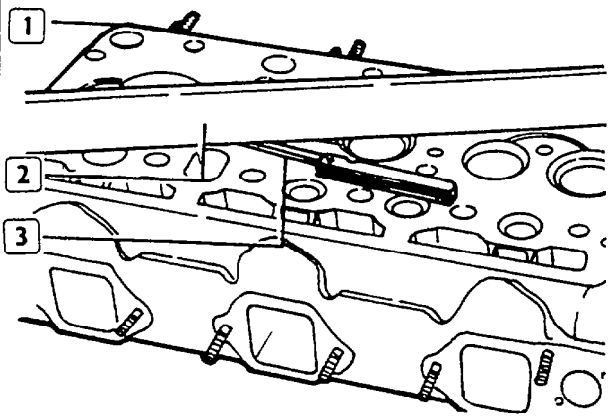
FIGURE 97



16576

Check for leakages using the proper tool (1, 2, 3) With a pump let in water heated to about 90°C and to a 4 to 5 kg/cm² pressure No leakage should be detected, if so, replace cylinder block

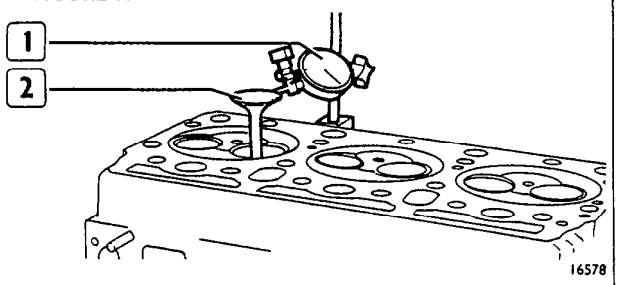
FIGURE 98



16577

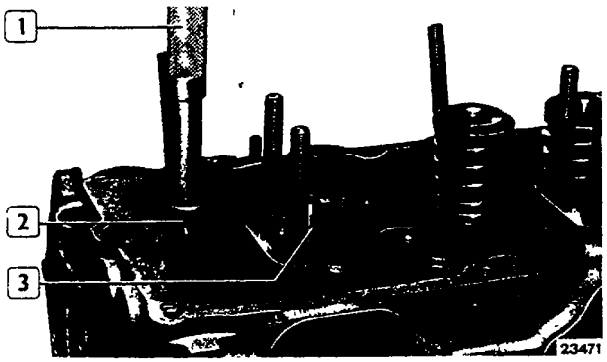
Cylinder head face (1) check is carried out with a straightedge (2) and a feeler gauge (3) If distortions greater than 0 15 mm are observed, dress head using suitable grinder.

FIGURE 99



With magnetic base dial gauge (2) check for maladjustment and clearance between valve stem (1) and its seat If clearance is excessive, replace valve and, in case, valve guide

FIGURE 100



Valve guide insertion/removal.

With reamer 99395723 measure valve guide diameters, which should be 11 025 to 11 045 mm If not, replace valve guides
Guides are supplied as spares with oversized diameters (0 04 - 0 20 - 0 24 mm)
Valve guide (3) assembly is carried out with remover/instiller tool 99360143 (1) complete with component 99360299 (2)

FIGURE 101

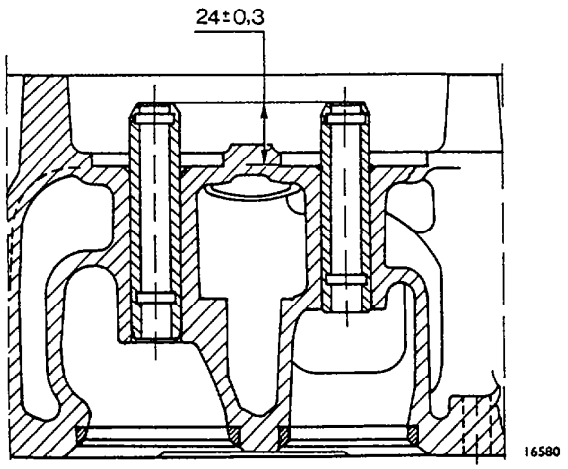
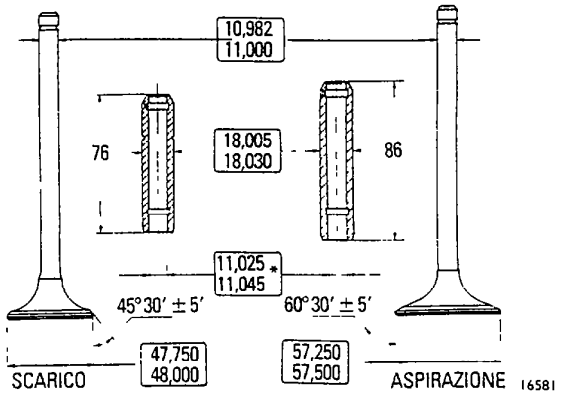


Diagram for correct fitting of exhaust and intake valve guides.

FIGURE 102

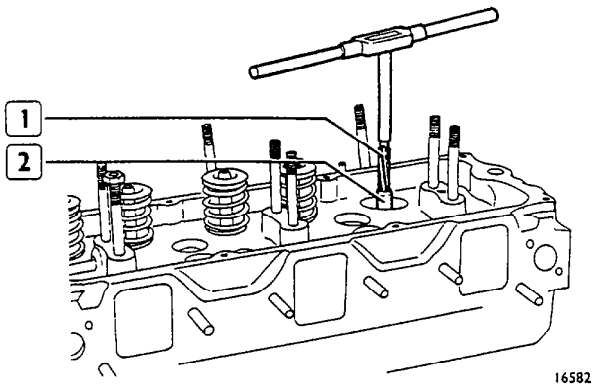


SCARICO = EXHAUST
ASPIRAZIONE = INTAKE

Valve and valve guide details

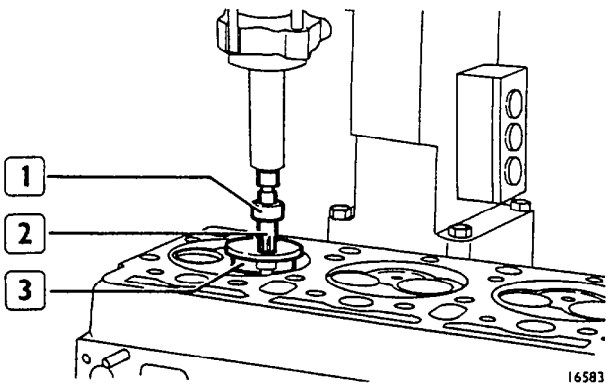
* Dimension to be obtained after valve guide fitting

FIGURE 103



After valve guide fitting, rebore valve guide (2) hole using reamer 99390331 (1)

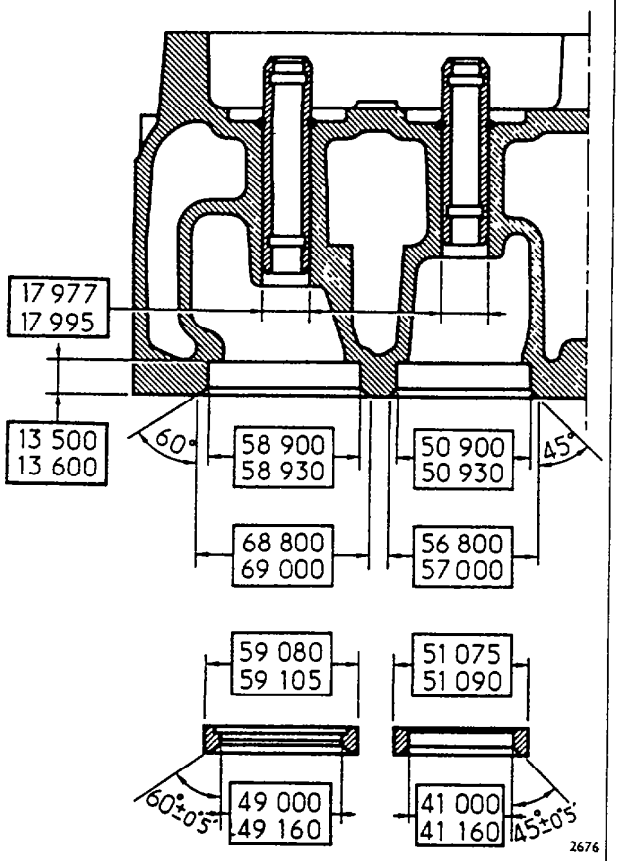
FIGURE 104



If valve seats have to be replaced, proceed as follows

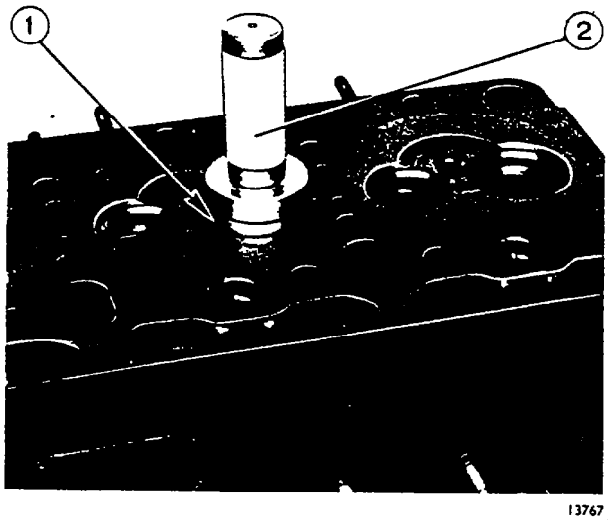
- Use tool (1)
- On cutter (3) adjust stop (2)
- Use cutter to remove valve seat
- Clean seat with compressed air

FIGURE 105



Cylinder head and valve seat details

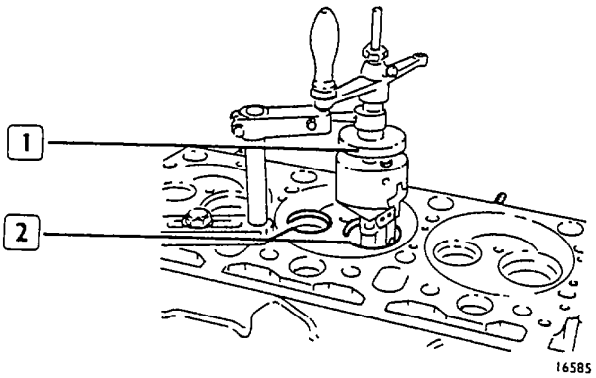
FIGURE 106



Valve seat (1) fitting is carried out with a suitable installer/remover tool (2), heating to about 50°C the cylinder head and cooling to —180° valve seats (for instance, in a liquid nitrogen tank).

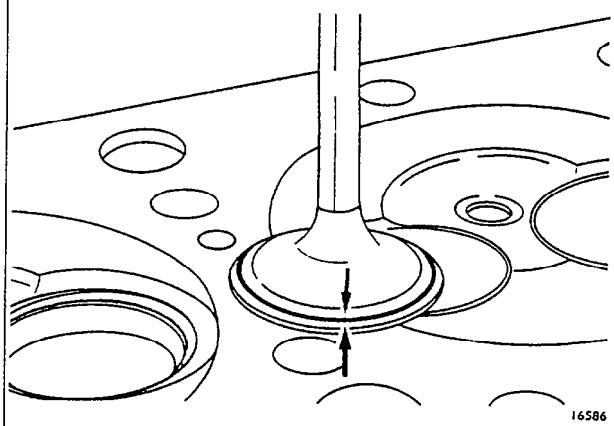
Fitting interference { intake 0.150 to 0.205 mm; exhaust 0.145 to 0.190 mm

FIGURE 107



If valve seats (2) are replaced or they are damaged, dress seats using HUNGER tool 99360419 (1)

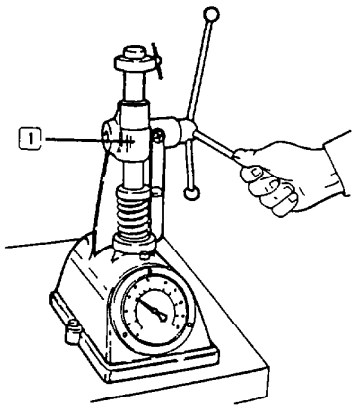
FIGURE 108



Detection of valve contact line in its seat

If contact (see arrows) is offset as to valve head seat, dress seat

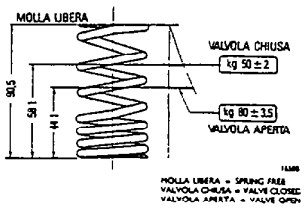
To dress valve faces, insert valve stem in the self centering chuck of grinder 99301014 and adjust the support to operate at 45°30' ± 5' for exhaust valves, and at 60°30' ± 5' for intake valves After dressing, check that stand-in is 1 4 to 1 8 mm for intake valves, and 1 3 to 1 9 mm for exhaust valves



16587

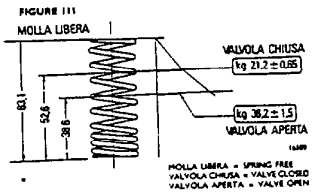
Valve spring rate (external and internal) must be checked using tester 99305049, comparing load and elastic strain with data of figs 110 and 111 relating to new springs

FIGURE 110



Details for the test of external intake and exhaust valve springs

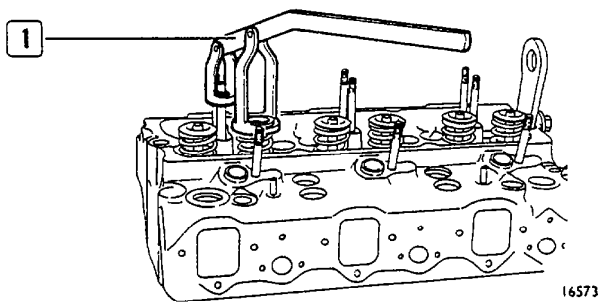
FIGURE 111



Details for the test of internal intake and exhaust valve springs

CYLINDER HEADS

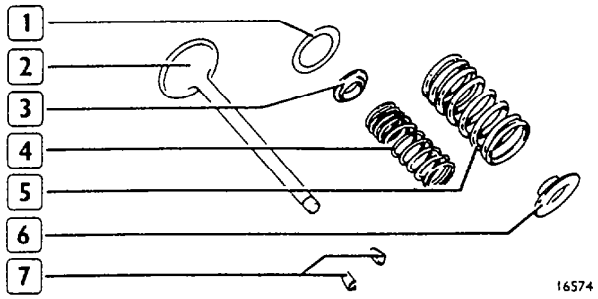
FIGURE 93



16573

Removal/installation of valves is carried out with tool 99360138 (1).

FIGURE 94

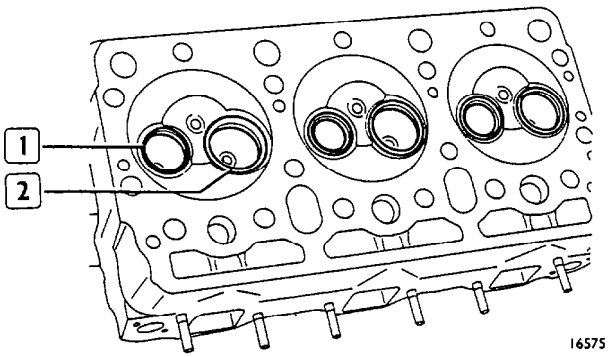


16574

VALVE ASSEMBLY COMPONENTS

1 External spring washer - 2 Valve - 3 Bottom internal spring cap - 4 Internal spring - 5 External spring - 6 Top cap - 7 Retainer cotters

FIGURE 95

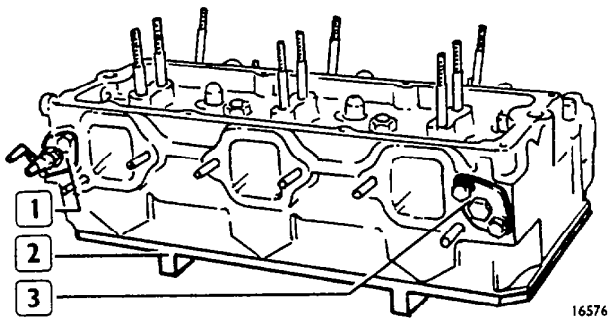


16575

CYLINDER HEAD BOTTOM VIEW

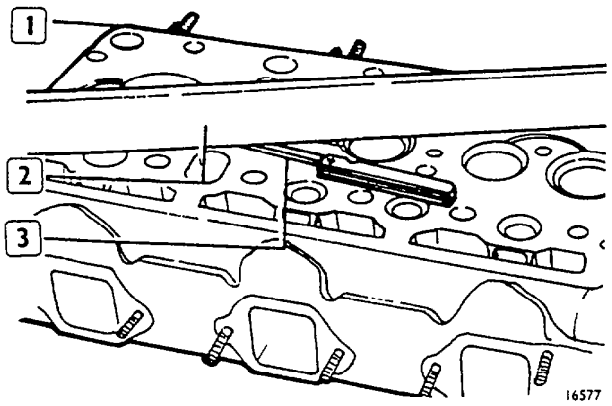
1 Exhaust valve housing
2 Intake valve housing

FIGURE 96



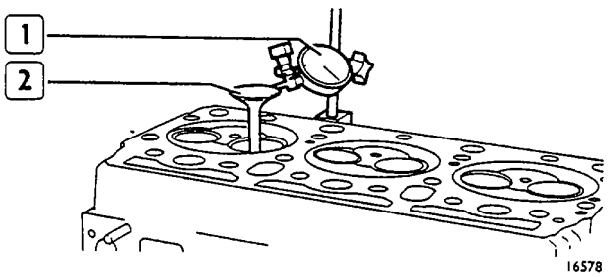
16576

Check for leakages using the proper tool (1, 2, 3)
With a pump let in water heated to about 90° C and to a 4 to 5 bar pressure
No leakage should be detected, if so, replace cylinder block



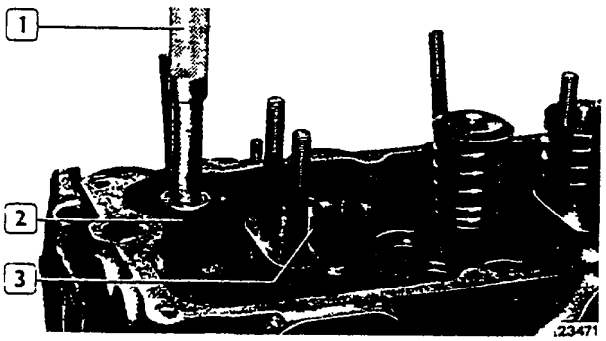
Cylinder head face check is carried out with a straight-edge (2) and a feeler gauge (3) If distortions greater than 0 15 mm are observed, dress head using a suitable grinder

FIGURE 98



With magnetic base dial gauge (1) check for maladjustment and clearance between valve stem (2) and its seat. If clearance is excessive, replace valve and, in case, valve guide.

FIGURE 99



Valve guide insertion/removal.
Using a reamer, measure valve guide diameters which should be 11 025 to 11 045 mm
If not, replace valve guides.
Guides are supplied as spares with oversized diameters (0.04-0.20-0.24 mm). Valve guide (3) assembly is carried out with drift 99360143 (1) complete with component 99360299 (2).

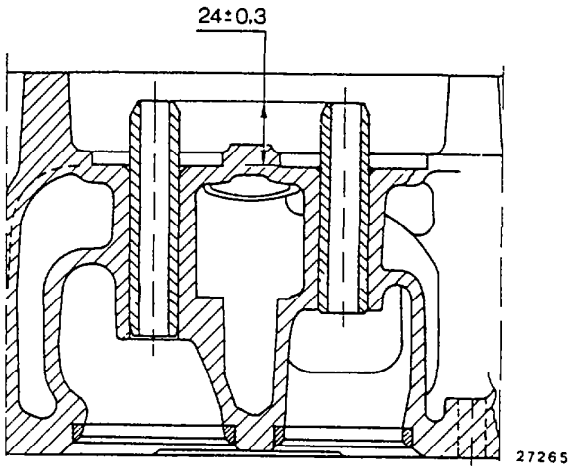
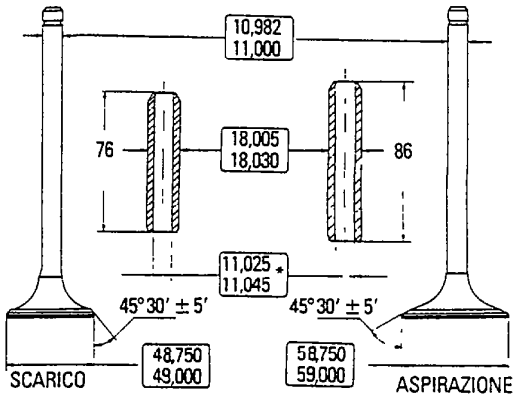


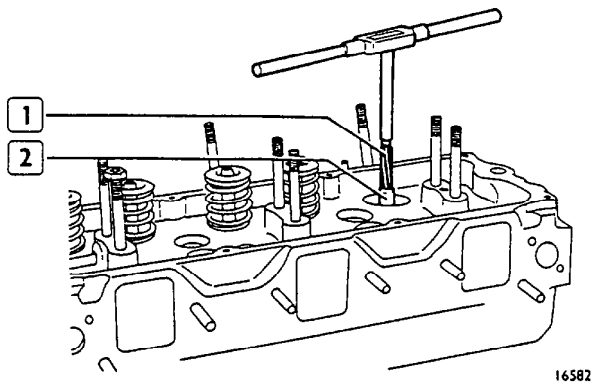
DIAGRAM FOR CORRECT FITTING OF EXHAUST AND INTAKE VALVE GUIDES

FIGURE 101

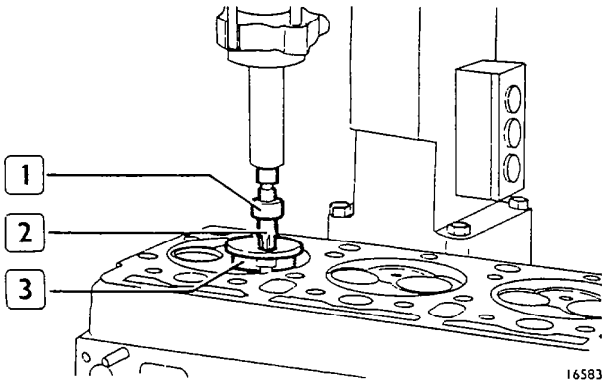


VALVE AND VALVE GUIDE DETAILS

FIGURE 102

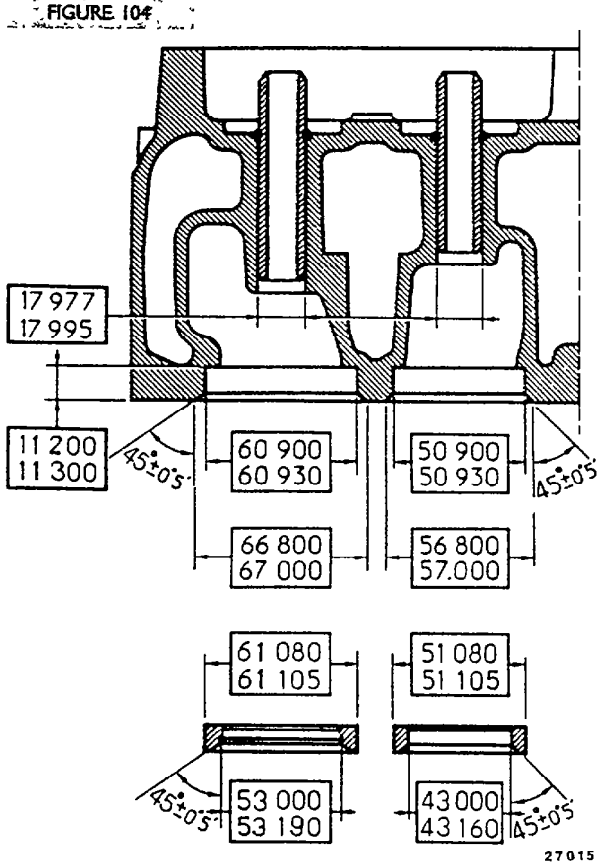


After valve guide fitting, rebore valve guide hole (2) using reamer 99390331 (1)

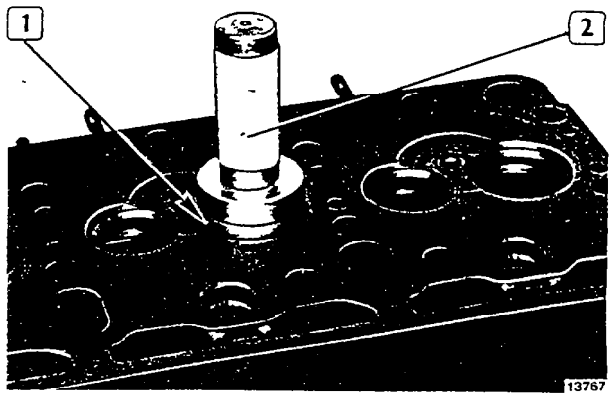


If valve seats have to be replaced, proceed as follows
- use tool (3)
- on cutter (2) adjust stop (1),
- use cutter to remove valve seat,
- clean seat with compressed air

FIGURE 104



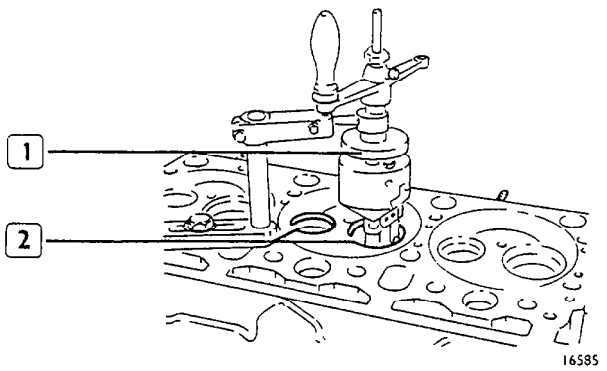
CYLINDER HEAD AND VALVE SEAT DETAILS



Valve seat (1) fitting is carried out with a suitable installer/remover tool (2), heating to about 50°C the cylinder head and cooling to − 180°C valve seats (for instance, in a liquid nitrogen tank)

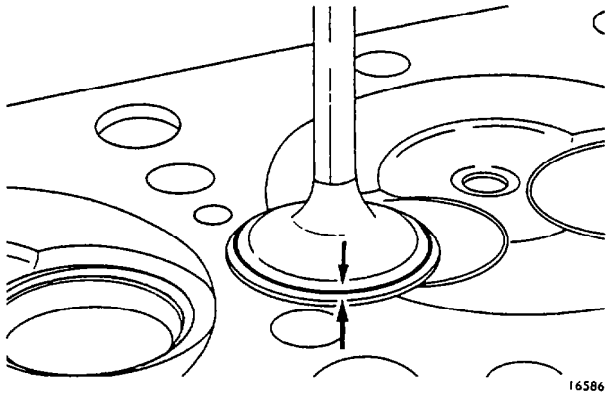
Fitting interference 0 150 to 0 205 mm

FIGURE 106



If valve seats (2) are replaced, or they are damaged dress them using HUNGER tool 99360419 (1)

FIGURE 107

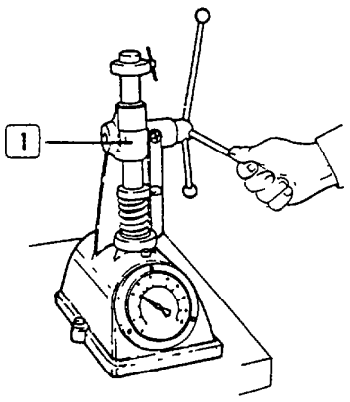


Detection of valve beat line on its seat

If contact (see arrows) is offset as to valve seat, dress seat

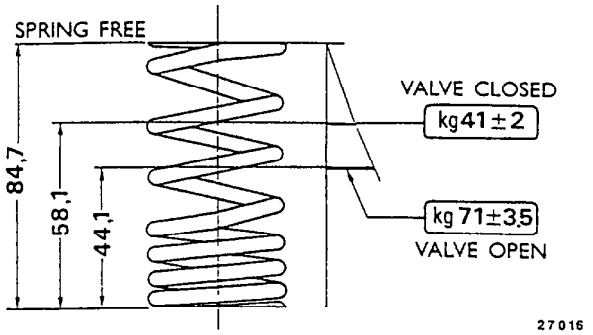
To dress valve faces, insert valve stem in the self-centering chuck of grinder 99301014 and adjust the support to operate at 45°30' ± 5' for both intake and exhaust valves After dressing, check that stand-in is 1 4 to 1 8 mm for intake valves and 1 3 to 1 9 for exhaust valves

FIGURE 108



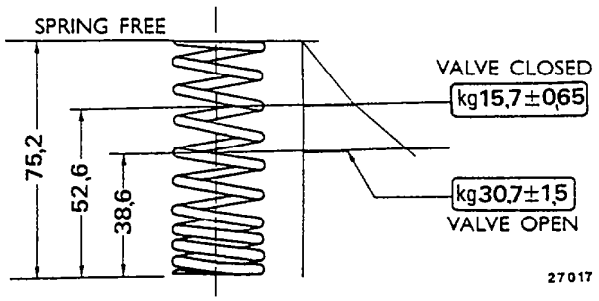
Valve spring rate (external and internal) must be checked using tester 99305049 (1), comparing load and elastic strain with data of figures 109 and 110.

FIGURE 109



DETAILS FOR TESTING EXTERNAL INTAKE AND EXHAUST VALVE SPRINGS

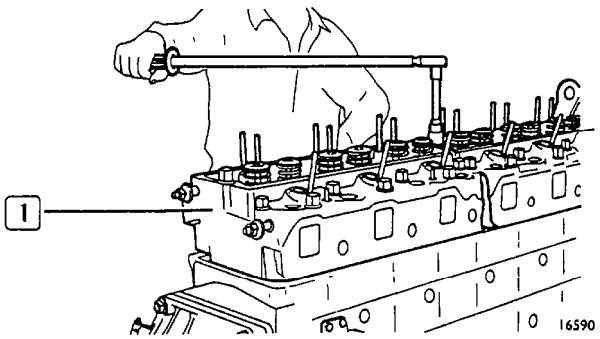
FIGURE 110



DETAILS FOR TESTING INTERNAL INTAKE AND EXHAUST VALVE SPRINGS

CYLINDER HEAD ASSEMBLY

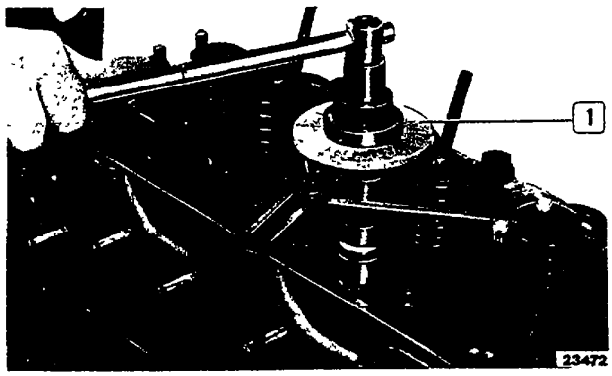
FIGURE 112



To assemble and tighten cylinder heads (1) proceed as follows

- On engine block position gasket with word "ALTO" (TOP) towards the operator
- Assemble cylinder head and check their alignment using a straightline
- After lubricating screws with UTDM, tighten them following the diagram in fig 114, to a torque of 200 Nm (20 5 kgm) **8210SRM36**.
- Repeat tightening to that same torque

FIGURE 113



Using tool 99395202 (1) tighten screws by 120°

For the engine 8210M22 the tightening torque is 294 Nm (30 kgm).

NOTE - The screws can be reused as long as thread external dia is not lower than 17 5 mm

FIGURE 114

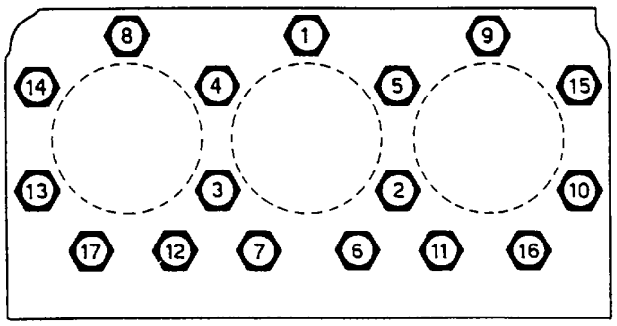
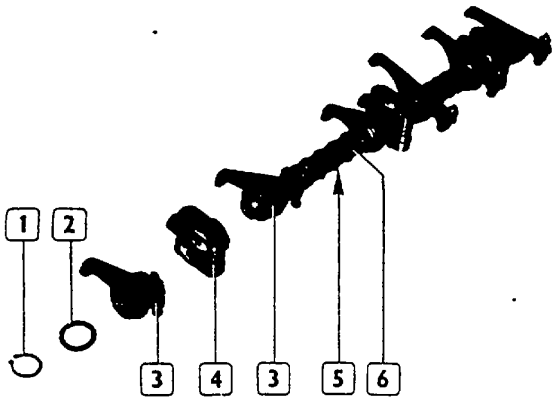


Diagram of tightening sequence for cylinder head capscrews

ROCKER SHAFTS - PUSHRODS

FIGURE 115



ROCKER SHAFT ASSEMBLY

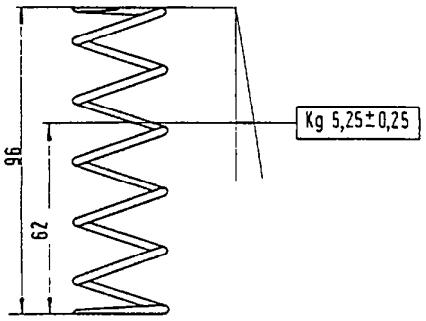
1 Retainer split ring - 2 Thrust washer - 3 Rocker - 4 Bracket 5 Rocker spacer spring - 6 Shaft

Check for scores or seizure in contact surfaces If detected, replace worn out components

Check clearance between valve rocker and rocker shaft, and between bracket and rocker shaft It should be 0 020 to 0 062 mm and 0 to 0 054 mm respectively
Parts causing oversize to prescribed clearance must be replaced

Verify seal of caps at the end of each shaft

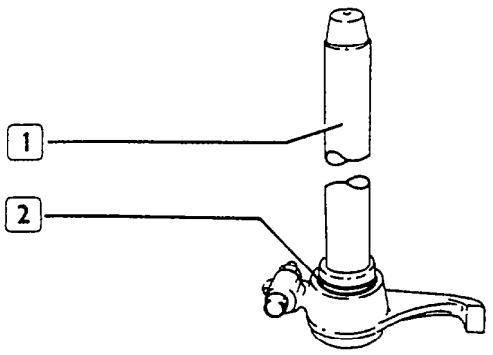
FIGURE 117



Details for checking rocker spacer springs

8210SRM36

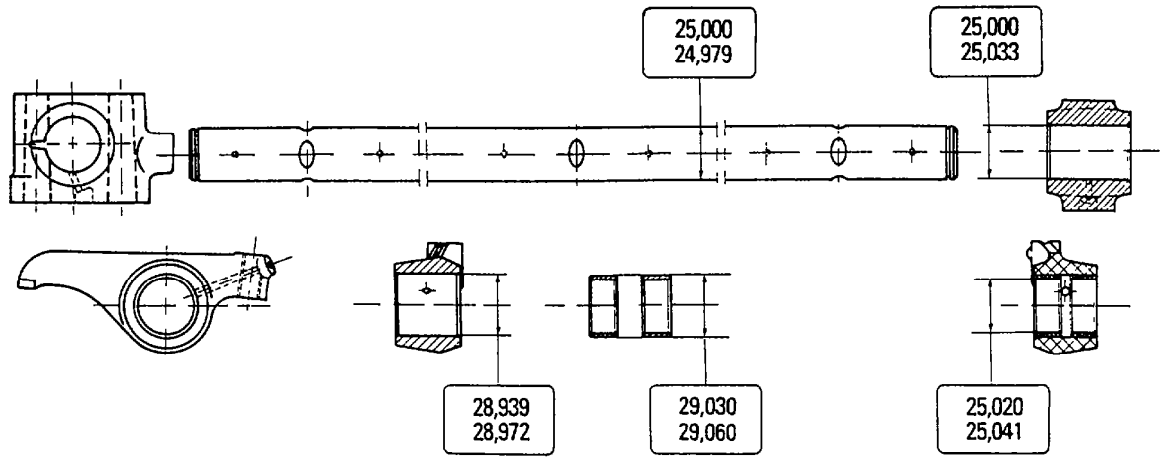
FIGURE 118



Rocker bushing (2) assembly, using suitable remover/installer tool (1)
When inserting new bushings take care they do not protrude from rocker sides

8210 SRM 36

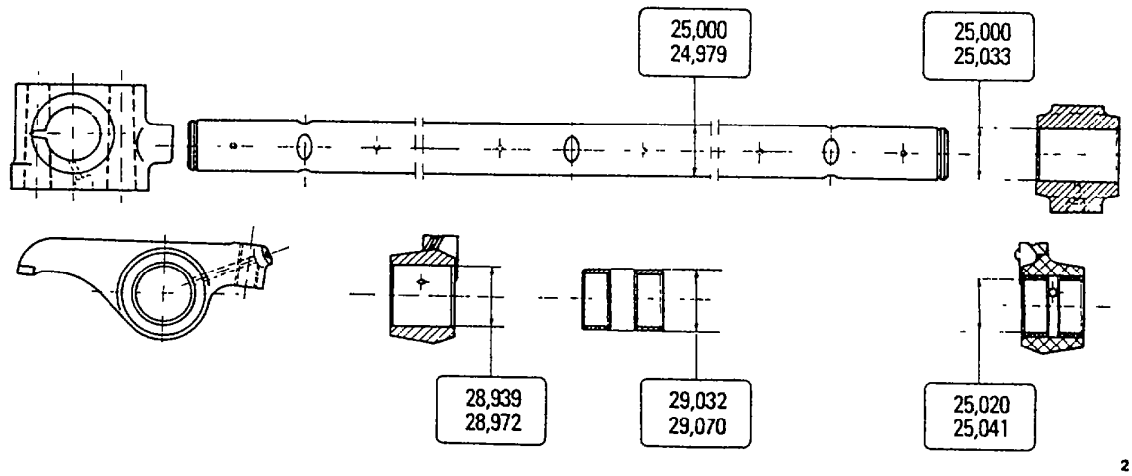
FIGURE 116



Bracket, rocker shaft, rocker and inherent bushing details

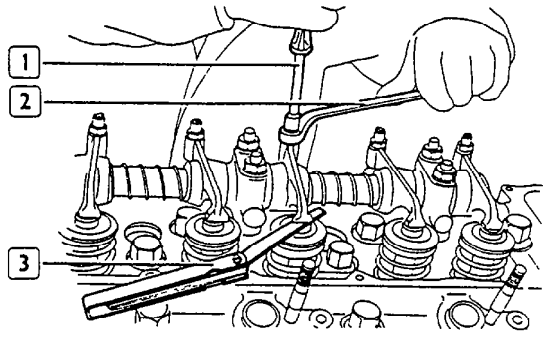
8210 M 22

FIGURE 116



BRACKET, ROCKER SHAFT, ROCKER AND INHERENT BUSHING DETAILS

FIGURE 119



Rocker and valve clearance adjustment using wrench 99350108 (1), box wrench (2) and feeler gauge (3) Running clearance is 0 30 mm for intake, and 0 40 mm for exhaust Position to firing stroke the cylinder on which clearance must be adjusted, the valves of this cylinder are closed when those of the symmetrical cylinder are in balance condition

Symmetric cylinders are 1-6, 2-5, 3-4

NOTE - To adjust valve-rocker clearance more quickly during engine re-assembly, proceed as follows

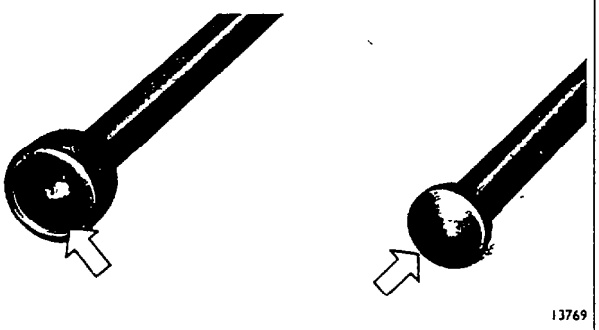
- Rotate crankshaft, have cylinder 1 valves in balance condition and adjust the valves marked with an asterisk, as indicated in the following scheme

Cylinder No	1	2	3	4	5	6
Intake	—	—	*	—	*	*
Exhaust	—	*	—	*	—	*

- Rotate crankshaft, have cylinder 6 valves in balance condition and adjust the valves marked with an asterisk, as indicated in the following scheme

Cylinder No	1	2	3	4	5	6
Intake	*	*	—	*	—	—
Exhaust	*	—	*	—	*	—

FIGURE 120

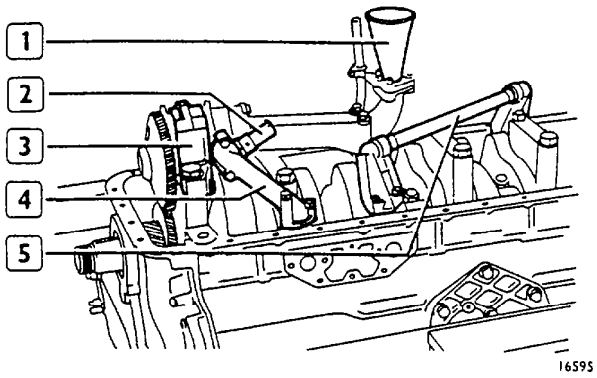


Pushrods should be free from distorsion, the spherical seats in contact with rocker adjusting screw and with tappet (see the arrows) should not show signs of pick-up or wear. If so, replace them

Intake and exhaust pushrods are identical, and, therefore, interchangeable

LUBRICATION

FIGURE 121

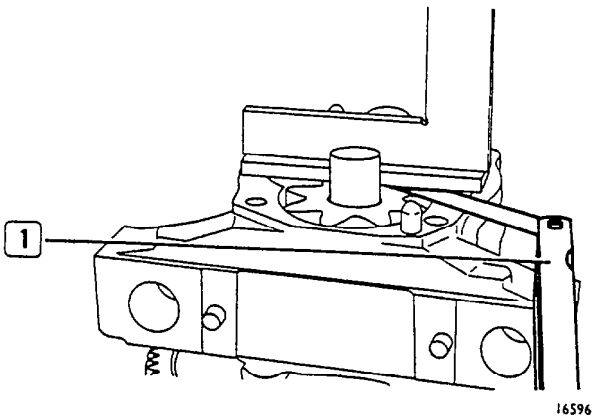


ENGINE WITHOUT OIL SUMP BOTTOM VIEW

1 Oil suction scoop 2 Relief valve 3 Oil pump 4 Oil delivery line to heat exchanger 5 Delivery line

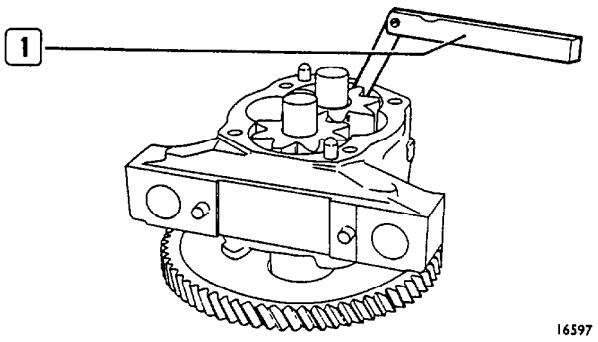
NOTE - Replacement of an oil pump gear requires the replacement of mating gear This will restore the pump to its initial efficiency

FIGURE 122



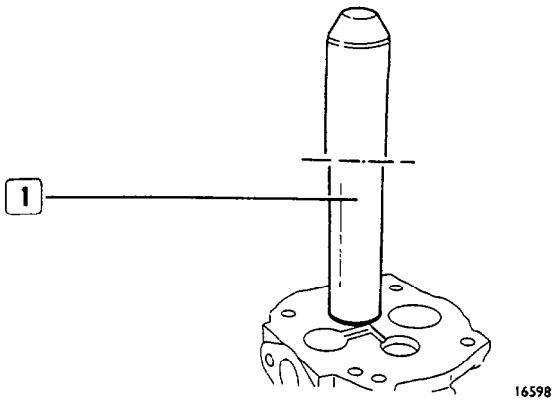
With feeler gauge (1) check clearance between gears and cover face Clearance should be 0 015 to 0 067 mm

FIGURE 124



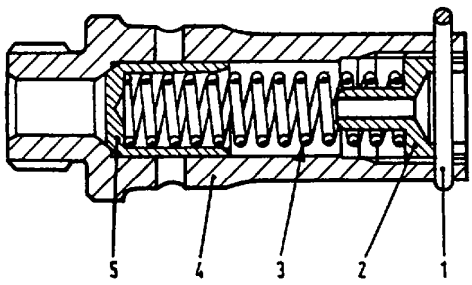
With feeler gauge (1) check gap between gear O D and pump casing It should be 0 130 to 0 210 mm

FIGURE 125



With installer/remover tool (1) insert bushing on oil pump cover

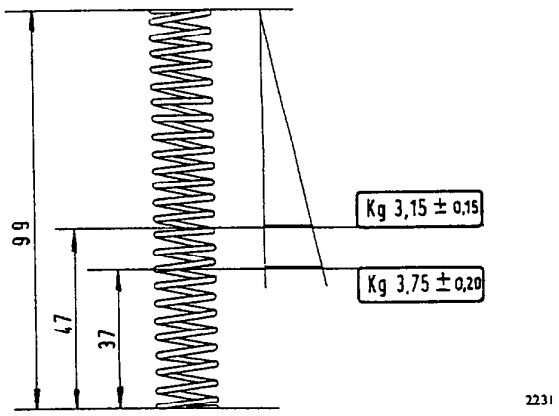
FIGURE 126



LONGITUDINAL SECTION THROUGH OIL PRESSURE RELIEF VALVE

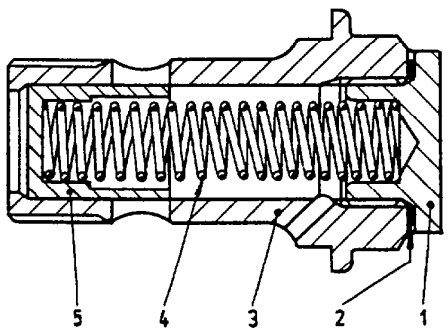
1 Split pin - 2 Threaded cap - 3 Spring 4 Valve body - 5 Valve

FIGURE 129



Details for testing filter by-pass spring valve

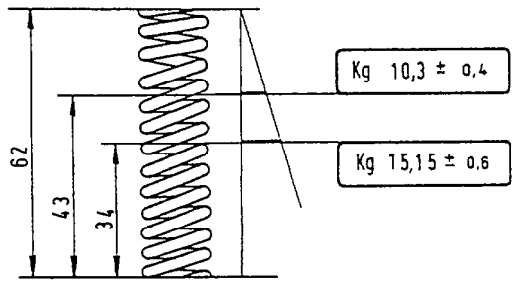
FIGURE 127



LONGITUDINAL SECTION THROUGH BY PASS VALVE

1 Cap - 2 Gasket - 3 Valve body - 4 Spring 5 Valve

FIGURE 128



Details for oil pressure check valve spring.

FIGURE 131

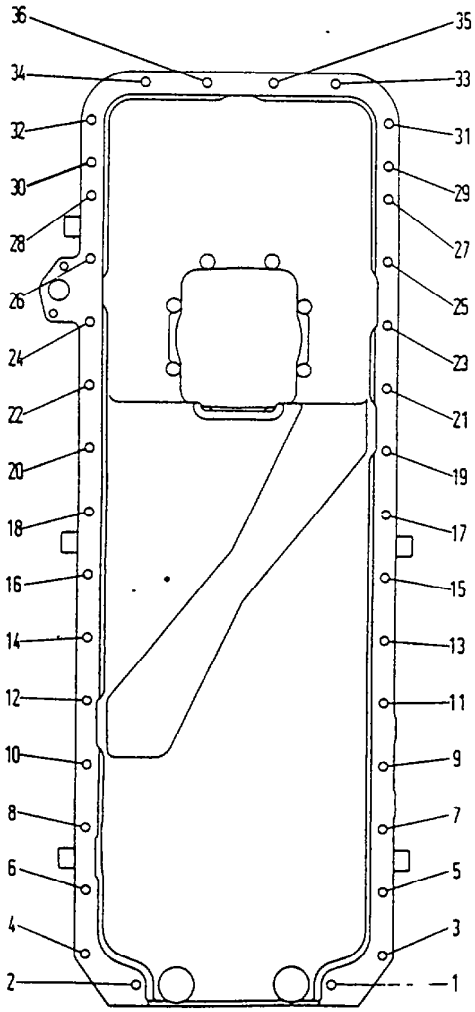
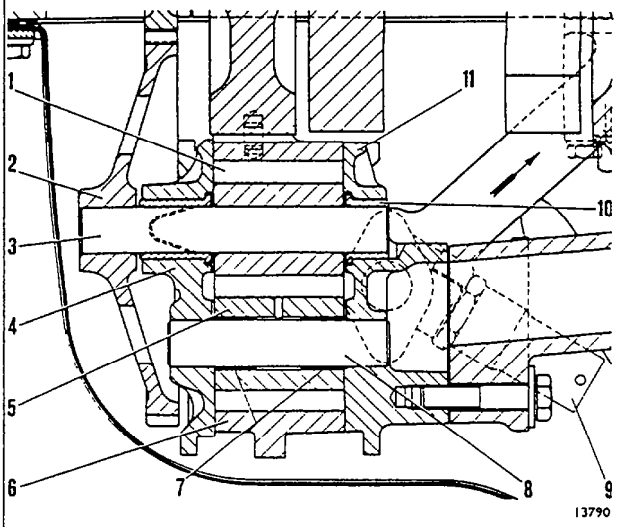


FIGURE 130



LONGITUDINAL SECTION THROUGH OIL PUMP

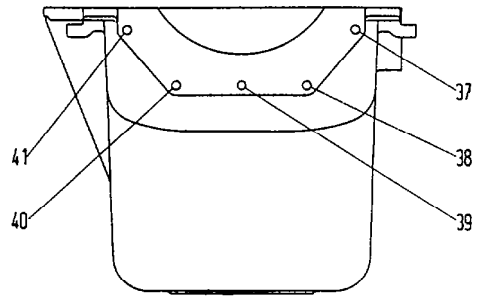
1 Driving gear - 2 Driven gear - 3 Top control shaft - 4 Front cover 5 Gear - 6 Body - 7 Bushings 8 Driven gear bottom shaft - 9 Valve 10 Rear bushing - 11 Rear cap

INSTRUCTION FOR INSTALLING OIL SUMP ON ENGINE BLOCK

To re-assembly oil sump (if previously disassembled) carefully follow this procedure and the diagram in the figure, so as to avoid oil seeping from oil sump

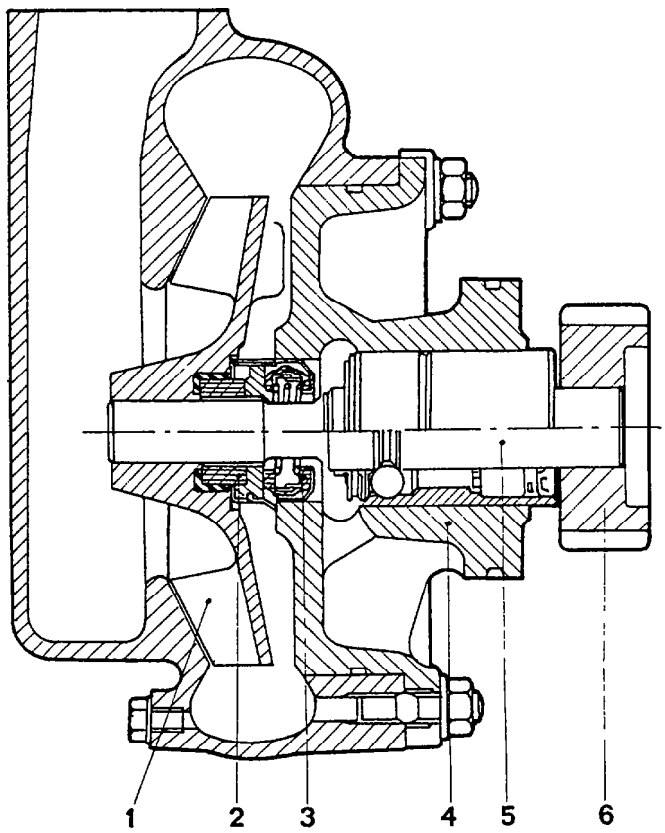
- Use jointing compound on the sections of the sealing gasket, taking care that the holes in the sump exactly correspond to those in the gasket Also, the gasket should protrude at least 1 mm as to the rear flange face
- With sealing compound, coat connection areas of gasket elements
- When compound is dried, check that the protruding portion of the gasket is between 0 5 and 1 5 mm It these values are exceeded the surplus portion must be trimmed
- Sump assembly must be carried out with the engine block complete with its valve system cover and rear support
- Install sump on engine block bottom, and slide it until it contacts the rear support
- Screw down screws from No 3 to No 36
- Tighten screws 1 and 2 (to have vertical clamp)
- Screw down (about 3/4 of total tightening) screws from No 37 to No 41
- Loosen screws 1 and 2
- Tighten screws 37 to 41
- Alternately tighten screws 3 to 36
- Again check screws 37 to 41, (in case they are loose), and tighten screws 1 and 2

FIGURE 132



COOLING SYSTEM
WATER PUMP DISASSEMBLY

FIGURE 135

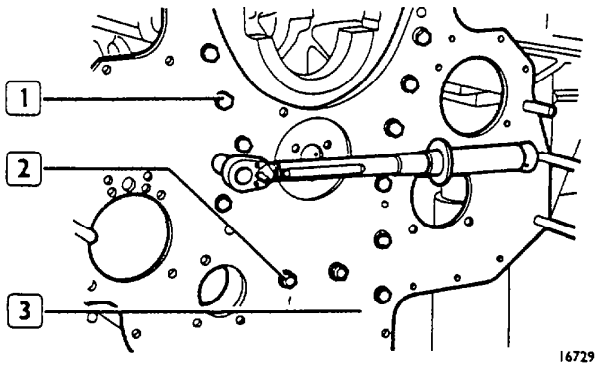


LONGITUDINAL SECTION THROUGH WATER PUMP

1 Impeller - 2 Retainer ring - 3 Seal gasket - 4 Water pump body 5 Control shaft with bearing - 6 Driving gear

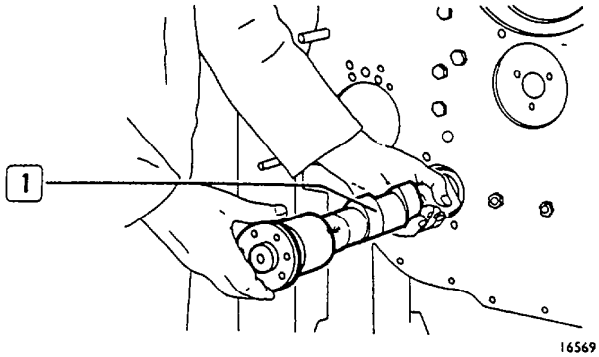
ENGINE ASSEMBLY

FIGURE 255



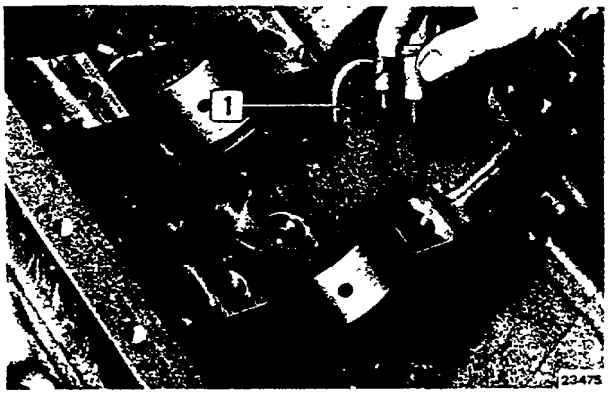
Using brackets 99361015 and 99361014 install engine block on revolving stand 99322230 Tighten screws (1) and nuts (2) of front plate (3) to a torque of 78 Nm (8 kgm).
Fit cylinder liners as indicated

FIGURE 256



Insert camshaft bushings using an appropriate tool Lubricate bushings and fit camshaft (1) fixing it to the front plate of the engine block with a suitable plate Lock screws to a torque of 78 Nm (8 kgm).

FIGURE 257

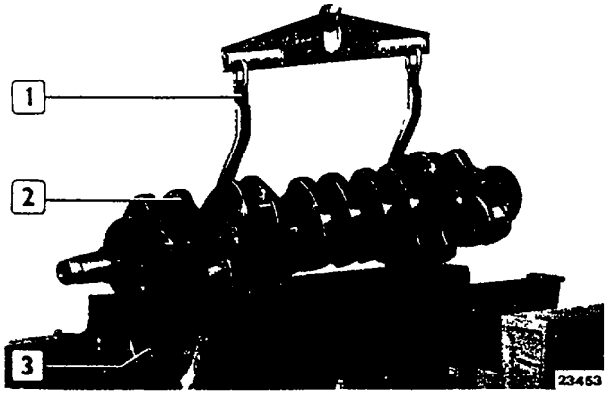


Insert oil spray nozzles (1)

FIGURE 258

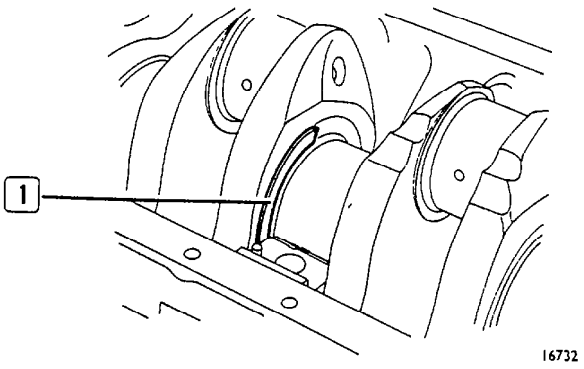
Place half-bearings (1) on main bearings

FIGURE 259



Lubricate half-bearings (3), then insert crankshaft (2) using a hoist with hook 99360500 (1)

FIGURE 260



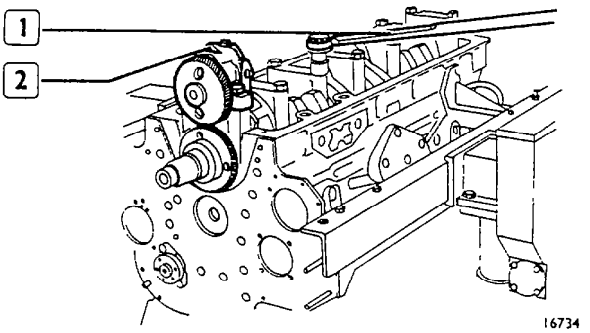
Insert thrust washers (1) in central main bearing

NOTE - Thrust washers must be installed with the anti-friction alloy towards the crankshaft block Top thrust washers are not interchangeable with the bottom ones

FIGURE 261

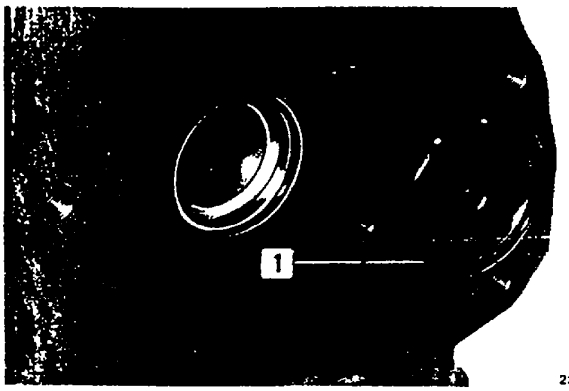
Position main bearing caps and relevant lubricated half-bearings on central cap (1) of thrust washers (2)
All caps are marked with a number corresponding to the relevant bearing on engine block

FIGURE 262



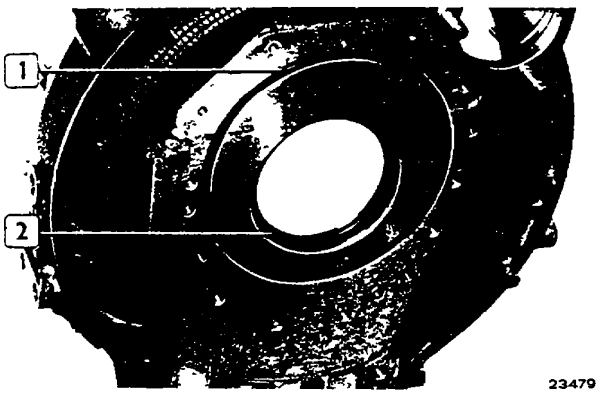
On main bearing cap No 1 install oil pump (2) Using torque wrench (1) tighten cap set screws to a torque of 412 Nm (42 kgm)

FIGURE 263



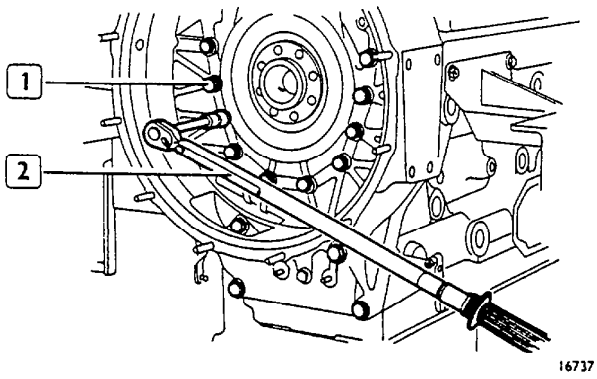
Position seal ring (1) on camshaft

FIGURE 264



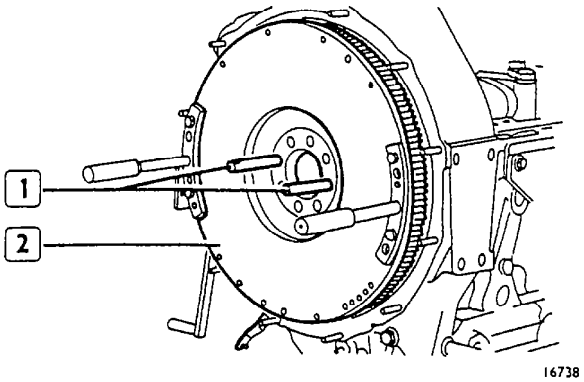
On housing fit seal ring (1) and seal (2)

FIGURE 265



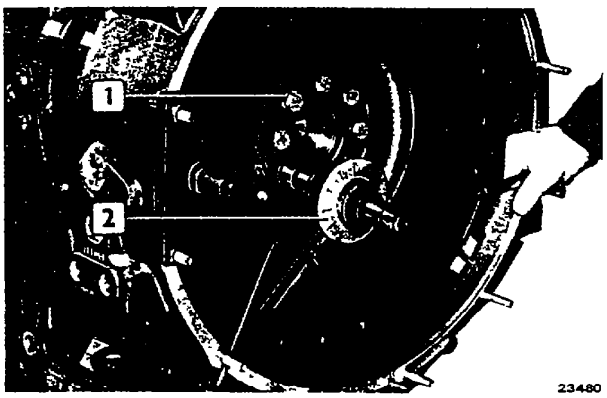
Insert the complete flywheel housing on engine block and tighten screws (1) with a torque wrench (2) to the prescribed value

FIGURE 266



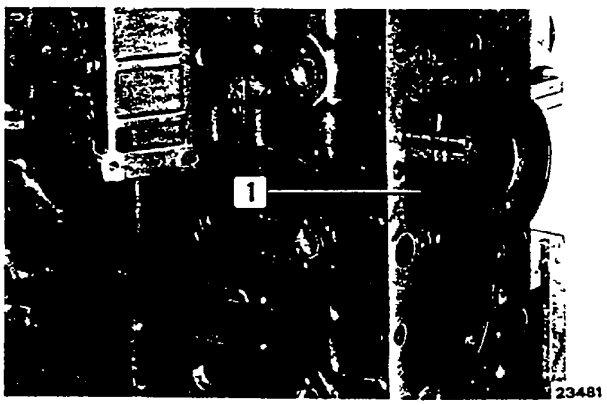
Insert guide pins (1) and engine flywheels (2), lock rotation with tool 99360351 and tighten screws to 95 Nm torque

FIGURE 267



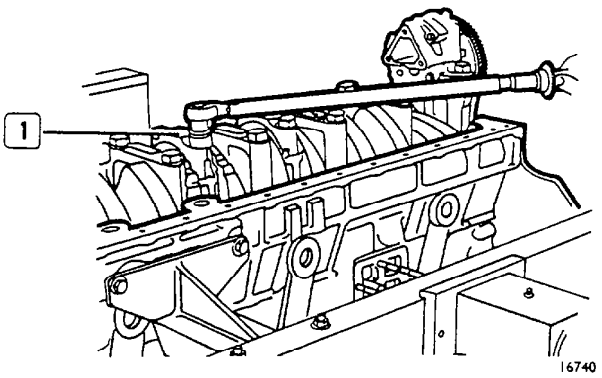
Using tool 99395202 (2) lock screws (1) to a 60° angle

FIGURE 268



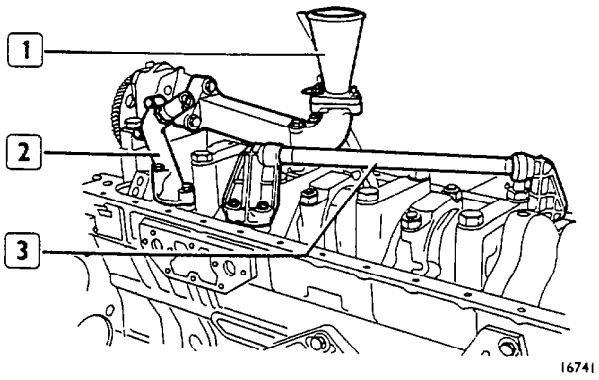
Rotate engine block positioning it vertically. Place connecting rod half-bearings in their seats, then insert connecting rod-piston-ring assemblies in the cylinder sleeves using piston ring clamp 99360603 (1) as described

FIGURE 269



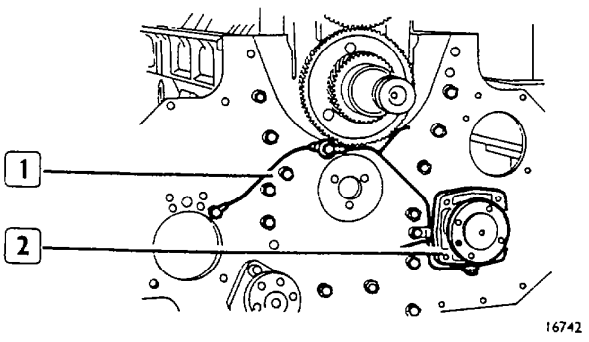
Connect connecting rods to crankpins, insert caps (1) complete with their half-bearings, tighten lock nuts to 275 Nm (28 kgm)

FIGURE 270



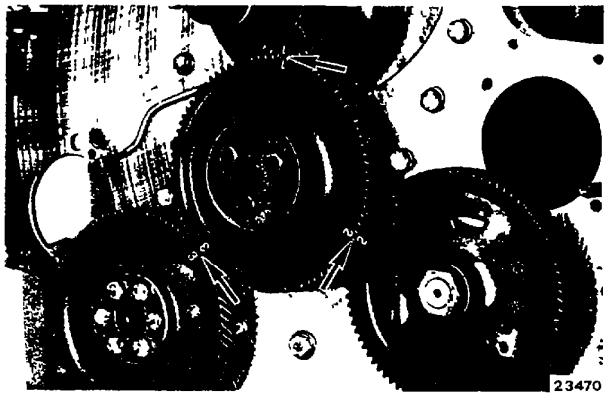
Fit oil delivery pipings (3 and 2) (interposing relevant gaskets) and oil suction scoop (1)

FIGURE 271



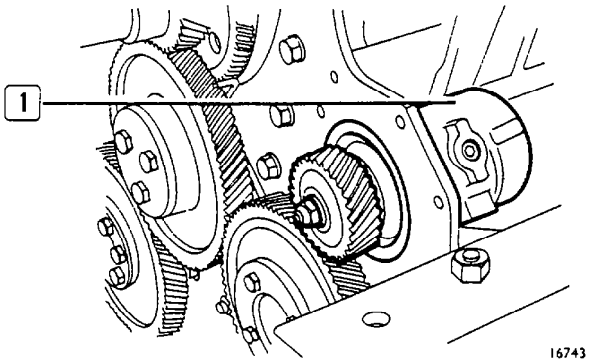
Install housing with injection pump drive shaft (2) and position oil line (1) for gear system lubrication

FIGURE 272



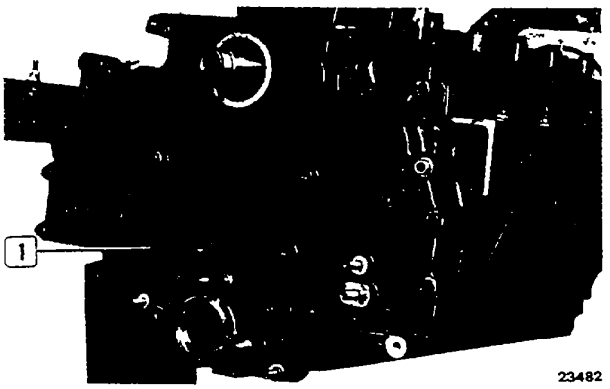
Have pistons 1 and 6 to T D C and key valve system gears, taking care that numbers 1-2-3 marked on intermediate gear coincide with the same numbers on drive gears of crankshaft, camshaft and injection pump

FIGURE 273



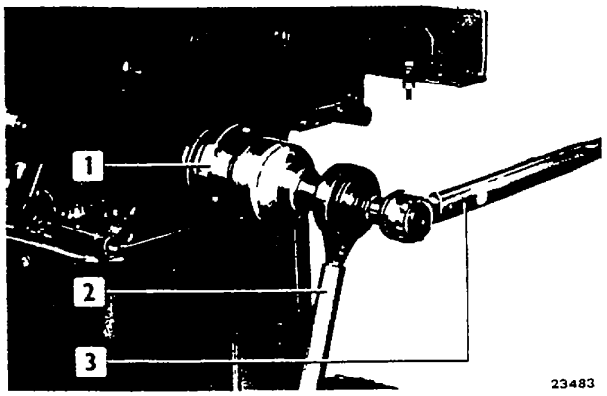
Install power steering pump (1)

FIGURE 274



Install valve system cover (1) with seal Insert seal and install oil pump as indicated
Install starter and rotate engine by 180°

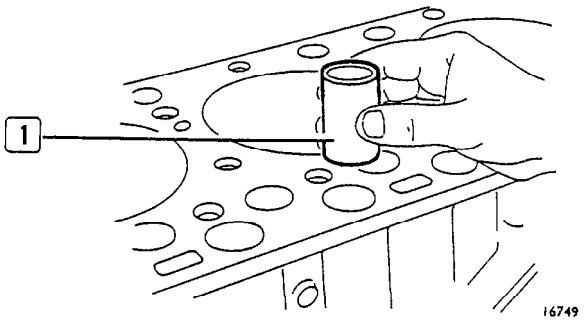
FIGURE 275



Install damper wheel hub (1) and using torque wrench (3) and torque multiplier (2) tighten nut 931 Nm (95 kgm)

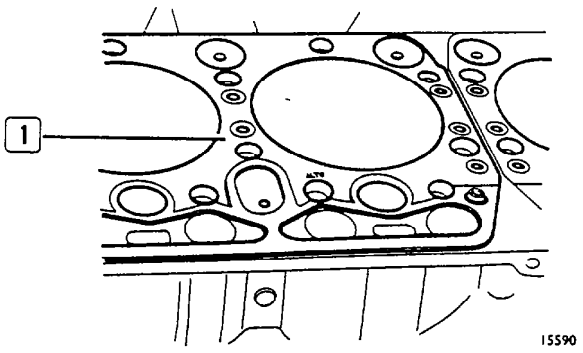
NOTE - Lubricate nut with minium dispersion in engine oil

FIGURE 276



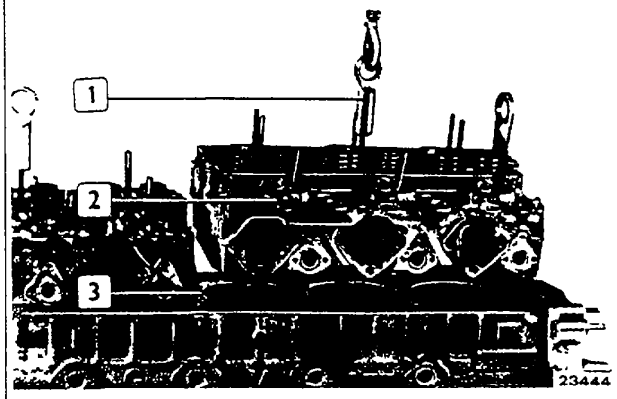
Lubricate tappets (1) with engine oil and insert them in their seats

FIGURE 277



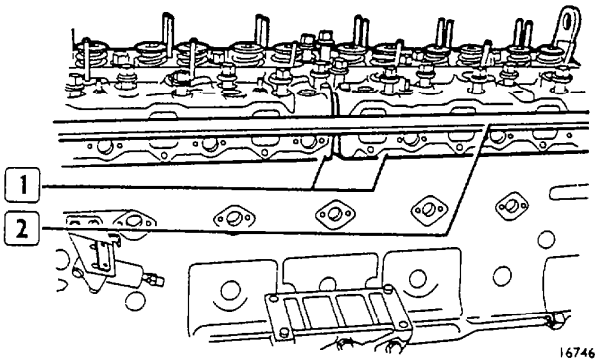
On engine block position cylinder head gaskets (1) with the world "ALTO", (TOP) towards cylinder heads

FIGURE 278



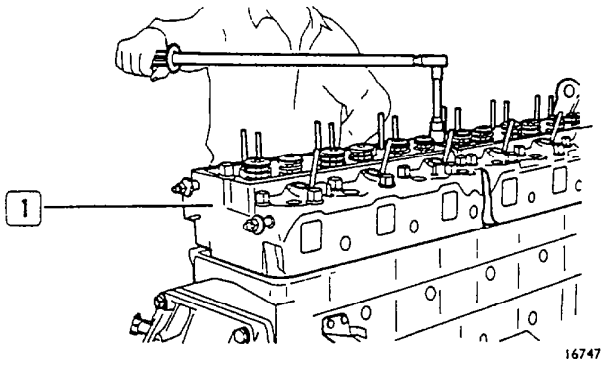
With a hoist lift up cylinder heads (1) one at a time and fit them on engine block

FIGURE 279



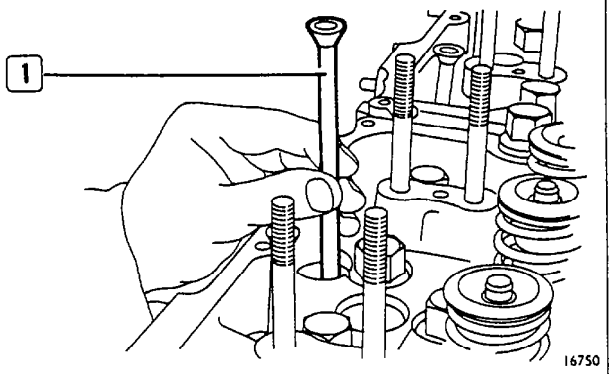
With straightedge (2) check alignment of cylinder heads (1) from exhaust manifold end

FIGURE 280



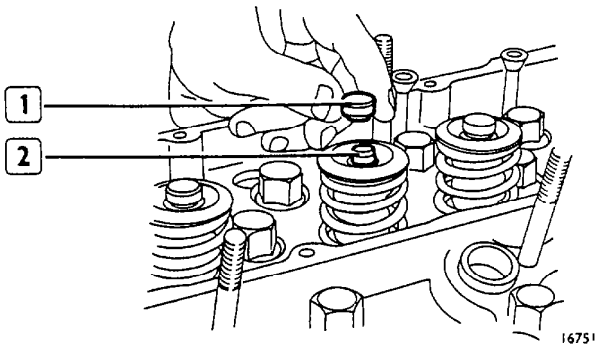
Screw down cylinder head securing screws (1) previously lubricated) and tighten them as described

FIGURE 281



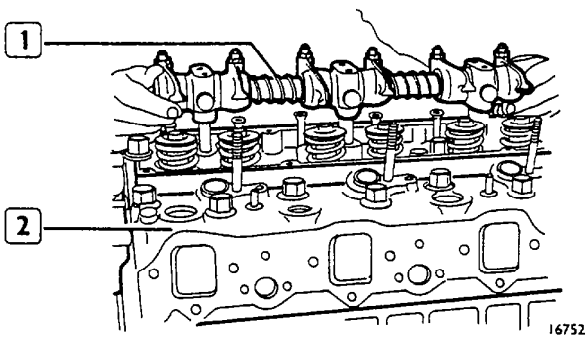
Insert rocker pushrods (1) in their housings

FIGURE 282



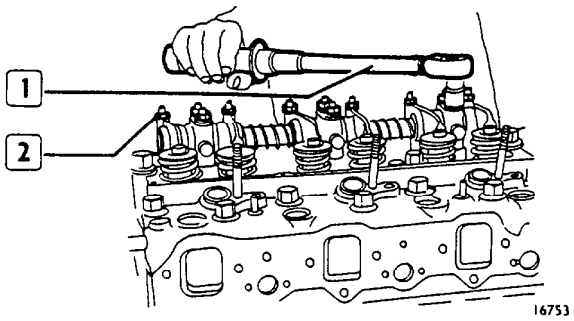
Insert caps (1) on valves (2)

FIGURE 283



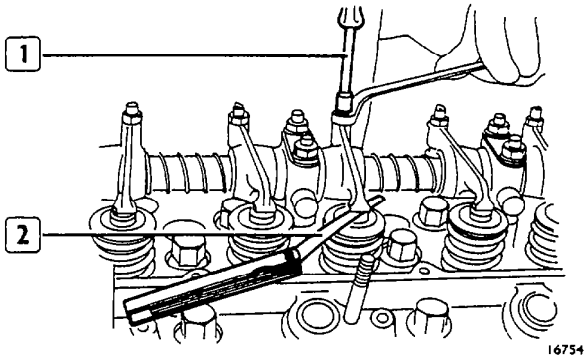
Insert rocker shaft assemblies (1) on heads (2)

FIGURE 284



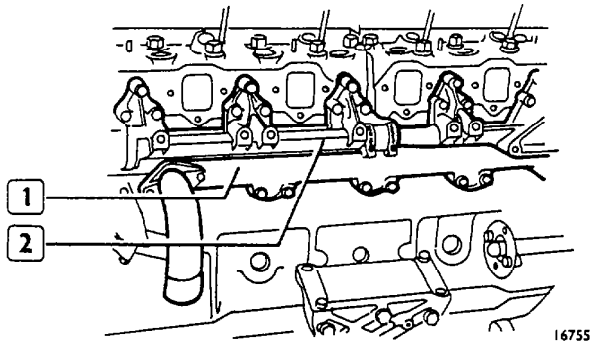
With a torque wrench (1) lock nuts to a 59 Nm (6 kgm) torque

FIGURE 285



As indicated at page 136, adjust clearance between rockers and valves using wrench 99350108 (1) and feeler gauge (2)

FIGURE 286



Insert waters lines (1 and 2) on engine block and cylinder heads Fit the complete fuel housing

TIGHTENING TORQUES (TEMPORARY DATA)

DESCRIPTION	TORQUE Nm (kgm)
Self-capscrew, main bearing caps (crankshaft and oil pump)	▲ 412 (42)
Capscrew, sump to engine block	14 (1 4)
Capscrew, sump to front cover	14 (1 4)
Capscrew, sump to rear cover	14 (1 4)
Nut, front cover to plate and front engine mounting	59 (6)
Stud, front plate to engine block	59 (6)
Capscrew, front cover to engine block plate	49 (5)
Capscrew, front plate to engine block	▲ 78 (8)
Capscrew, rear engine mounting to engine block	▲ 98 (10)
Capscrew, rear engine mounting to engine block	▲ 78 (8)
Capscrew, rear engine mounting to engine block	▲ 137 (14)
Capscrew, front cover to plate	▲ 29 (3)
Capscrew, head to engine block with cylinders	▲ 200 (20 5) + 120° 8210SRM36 294 (30) 8210M22
Stud, intake manifold to cylinder heads	39 (4)
Capscrew, exhaust manifold to cylinder heads	• 32 5 (3 3)
Capscrew nut, connecting rod cap	▲ 275 (28)
Self-locking capscrew, engine flywheel	▲ 95 +60°
Nut, damper hub	* 931 (95)
Self-locking capscrew, pin, driven gear to engine block	▲ 78 (8)
Capscrew, thrust plate to camshaft	▲ 78 (8)
Self-locking capscrew, camshaft driven gear	▲ 59 (6)
Cap, oil filter valve	68 (6 9)
Capscrew, heat exchanger to casing	24 (2 5)
Nut, cover to heat exchanger	24 (2 5)
Nut, heat exchanger to bracket	49 (5)
Nut, heat exchanger to filters	49 (5)
Capscrew, heat exchanger to engine block	59 (6)

▲ Wet lubrication UTDM oil.
• Lubricate with graphite oil W.
* Lubricate with minium dispersion in engine oil.

DESCRIPTION	TORQUE Nm (kgm)
Capscrew, engine block water inlet elbow	24 (2 5)
Nut, heat exchanger water outlet	24 (2 5)
Capscrew, water inlet pipe to engine block	24 (2 5)
Capscrew, water outlet pipe to engine block	49 (5)
Stud, elbow to front engine block water outlet	49 (5)
Stud, upper water delivery to front engine block water outlet	24 (2 5)
Capscrew, bottom delivery water pipe to pump	24 (2 5)
Nut, rocker holder shaft	59 (6)
Self-locking capscrew, injection pump housing to engine block	98 (10)
Self-locking capscrew, laminations to injection pump union	59 (6)
Nut, manifold capscrew for injection pump connection shaft	47 (4 8)
Stud, injector bracket to cylinder head	49 (5)
Self-locking capscrew, front and rear cover to oil pump casing	▲ 29 (3)
Nut, turbocharger capscrew to rear exhaust manifold	62 (6 3)
Collar, air inlet sleeve to turbocharger	11 (1 1)
Capscrew, oil delivery pipe to turbocharger	45 (4 6)
Capscrew, drain oil pipe to turbocharger	45 (4 6)
Nipple, oil delivery pipe to turbocharger	136 (13 9)
Pipe union, filter to injection pump	33 (3 4)
Pipe union, piston cooling oil nozzle	49 (5)
Capscrew, oil pump suction pipe to cover	49 (5)

▲ Wet lubrication, UTDM oil

DESCRIPTION	TORQUE Nm (kgm)
Capscrew, oil pump intake pipe to front interior intermediate cap	49 (5)
Capscrew, oil filter body to engine block	49 (5)
Pipe union, oil delivery pipe to turbocharger	77 (7 8)
Valve, oil pressure check	78 (7 9)
Valve, oil filter safety	136 (13 8)
Capscrew, front cover and housing to plate	29 (3)
Capscrew, housing to front cover	29 (3)
Stud alternator housing to front engine block cover	29 (3)
Nut, alternator capscrew to housing	88 (8 9)
Nut, pulley to alternator fan	52 (5 3)

SPECIAL TOOLS

TOOL NO	DESCRIPTION
ENGINE	
99315067	Base, engine
99340035	Puller, pulley hub/water pump impeller
99340205	Puller, slide hammer
99340215	Tool part for removing clutch shaft guide bush, or bearing, in crankshaft (use with 99340205)
99342145	Remover, injector sleeve
99350108	Wrench, tappet adjustment
99355039	Retainer, nut, damper flywheel
99360138	Remover/installer engine valves
99360143	Remover/installer valve guide
99360183	Pliers, compressor piston rings
99360184	Pliers, engine piston rings
99360299	Remover/installer, valve guide (use with 99360143)
99360314	Remover/installer cartridge filters
99360320	Rotator, crankshaft, tappet adjustment and valve gear timing
99360351	Retainer, engine flywheel
99360423	Installer, crankshaft rear seal (use with 99370006)
99360460	Connection, engine cylinder compression test (use with 993956682)
99360500	Lifter, crankshaft
99360502	Set of eyes, lift, cylinder heads
99360503	Set of eyes, lift, engine block
99360545	Bracket, engine flywheel assembly/disassembly (use with 99360551)
99360551	Bracket, engine flywheel assembly/disassembly
99360585	Rocking sling, engine removal/installation
99360603	Compressor, standard and oversize piston installation in cylinders
99360605	Compressor, standard and oversize piston installation in cylinder
99360772	Plate, threaded
99360773	Ring
99360774	Ring
99360778	Screw, forcing
99360788	Set of studs
99360790	Set of adapters
99361014	Brackets, engine to swinging stand 99322220
99361015	Brackets, engine to swinging stand 99322220
99365010	Burnisher, injector sleeve
99365063	Spreader, injector sleeve
99370005	Handle, driver, interchangeable
99370006	Handle, driver, interchangeable
99374218	Remover/installer, crankshaft rear seal (use with 99370005)
99386010	Remover/installer crankshaft core plugs
99390331	Reamer, valve guide
99390789	Set of taps, to thread injectors sleeves to be extracted
99394017	Dresser, lower injector sleeve portion (use with 99394019).
99394019	Bushing, pilot
99394031	Cutter, injector housing (use with 99394019)