



marine engines

section 5

8460 series

workshop manual

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IVECO *aifo*

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

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

8460 SRM 45

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ENGINE SPECIFICATIONS

Engine type8460SRM45.11
 4 - stroke Diesel with direct injection
 Cylinders, number and arrangement.....6, in line
 Bore x stroke 120 x 140 mm
 Displacement..... 9.5 l
 Compression ratio 15.8 : 1
 Net power at flywheel (*) :

- Pleasure craft..... 331 kW (450 CV)
- At2200 rpm
- Light-duty commercial..... 258 kW (358 CV)
- At2200 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..... 27°6'
- closes : after B.D.C. 35°39'
- Exhaust
- opens : before B.D.C. 41°39'
- closes : after T.D.C. 4°54'

Clearance between valve and rockers for
 timing checks mm
 Operating clearance between valves and rockers, cold
 engine :

- intake 0.25 mm
- exhaust..... 0.50 mm

FUEL SYSTEM

In line injection pump type Bosch PES 6P.
 Fixed injection pump delivery start advance . 25° 30' ± 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 3.5 kg/cm²
- when idling 1 kg/cm²

COOLING SYSTEM

Cooling by dual water circuit :

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

Water filtering with multiple recycle filter.

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

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

STARTING

By starter motor.

ELECTRIC SYSTEM

- Voltage 24 V
- Self-regulated alternator 28 V, 55 A
- Starting motor power 5.4 kW
- Battery (optional)..... 2, each 110 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

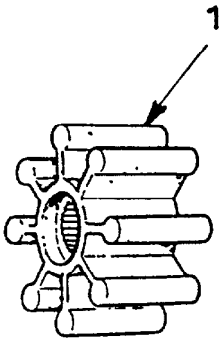
INSTRUCTION FOR USE

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 79°C , it is conveyed under thermostatic control to the fresh water-sea water heat exchanger, where it is cooled and returned to circulation.

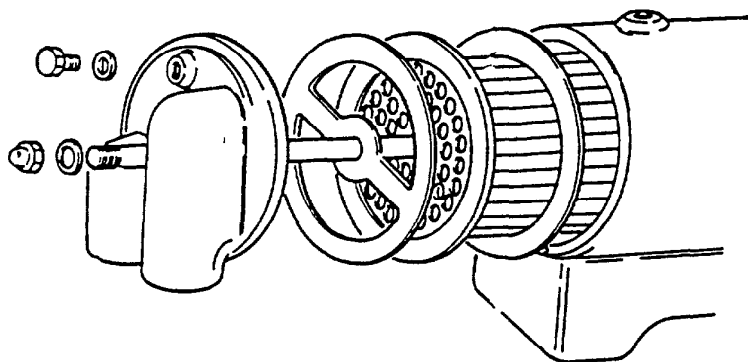
This heat exchanger consists essentially of a cast-iron body with the fresh water circulating therein and a copper tube bundle containing the circulating sea water for cooling the fresh water.

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 (1) which does not attack copper, brass, aluminium and tin.
- After the end of the reaction (indicated by effervescence) after about 15 to 10 minutes, rinse the tube bundle abundantly with running water for completely eliminating any residue of the solution and re-assemble the bundle onto the exchanger body.

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



FITTING TOLERANCES

DESCRIPTION	mm				
ENGINE BLOCK - CONNECTING RODS					
Cylinder sleeve bore dia	119.990 to 120.015				
Standard cylinder sleeve O D	<table border="0"> <tr> <td>{ top one</td> <td>137.010 to 137.035</td> </tr> <tr> <td>{ bottom one</td> <td>134.000 to 134.025</td> </tr> </table>	{ top one	137.010 to 137.035	{ bottom one	134.000 to 134.025
{ top one	137.010 to 137.035				
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Cylinder sleeve housing bore dia.	<table border="0"> <tr> <td>{ top one</td> <td>136.975 to 137.000</td> </tr> <tr> <td>{ bottom one</td> <td>133.972 to 133.990</td> </tr> </table>	{ top one	136.975 to 137.000	{ bottom one	133.972 to 133.990
{ top one	136.975 to 137.000				
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Sleeve and housing fit in bloc	<table border="0"> <tr> <td>{ top one</td> <td>0.010 to 0.060</td> </tr> <tr> <td>{ bottom one</td> <td>0.010 to 0.053</td> </tr> </table>	{ top one	0.010 to 0.060	{ bottom one	0.010 to 0.053
{ top one	0.010 to 0.060				
{ bottom one	0.010 to 0.053				
Sleeve protrusion from engine block face	0.040 to 0.070				
Sleeve protrusion ring thickness (± 0.05)	0.08 - 0.10 - 0.12 - 0.14				
Camshaft bush housing bore dia.	65.000 to 65.030				
Main bearing housing bore dia	96.000 to 96.022				
Standard tappet housing bore dia	18.000 to 18.027				
Big end bore dia	86.213 to 86.235				
Small end bush housing bore dia	52.000 to 52.025				
Big end bearing thickness	2.079 to 2.089				
Spare big end bearing undersize range	0.254 - 0.508 - 0.762 - 1.016				
Small end bushing fitted I D (fitted)	48.023 to 48.033				
Piston pin clearance in small end bushing	0.030 to 0.048				
Bushing clearance in small end	Interference always necessary				
Crankpin clearance in big end bearing	0.035 to 0.097				
Max connecting rod misalignment (measured at 125 mm from axes)	0.07				
PISTON - PINS - RINGS					
Piston dia. at right angle to pin bore and at 24 mm from base of skirt	119.851 to 119.869				
Piston pin bore dia in piston	47.994 to 48.000				
Piston pin dia	47.985 to 47.993				

DESCRIPTION	mm	
Ring groove width in piston	top groove, double taper (measured on 117 mm dia) 2nd groove 3rd groove	3.200 to 3.230 3.060 to 3.080 5.030 to 5.050
Ring thickness:		
<input type="checkbox"/> Top compression ring, double taper, chromium plated (measured on 117 mm dia)		3.075 to 3.095
<input type="checkbox"/> 2nd compression ring, straight		2.975 to 2.990
<input type="checkbox"/> Oil scraper ring, slotted, spring loaded		4.975 to 4.990
Piston fit in sleeve (37.5 mm from piston base):		
<input type="checkbox"/> clearance		0.121 to 0.164
Piston pin clearance in piston		0.001 to 0.015
Ring clearance in piston (vertical)		
<input type="checkbox"/> Top compression, double taper		0.105 to 0.155
<input type="checkbox"/> 2nd compression ring, straight		0.070 to 0.105
<input type="checkbox"/> Oil scraper ring, slotted, clearance		0.040 to 0.075
Ring gap in sleeve:		
<input type="checkbox"/> Top compression ring, double taper		0.40 to 0.65
<input type="checkbox"/> 2nd compression ring, straight		0.25 to 0.50
<input type="checkbox"/> Oil scraper ring, slotted, assembly clearance		0.30 to 0.45
Piston protrusion from engine block		0.37 to 0.75
CRANKSHAFT - BEARINGS		
Standard main journal dia		89.958 to 89.980
Main bearing housing bore dia		96.000 to 96.022
Standard main journal thickness		2.981 to 2.991
Spare main bearing undersize range		0.254 - 0.508 - 0.762 - 1.016
Standard crankpin dia.		81.978 to 82.000
Main journal - bearing fit:		
<input type="checkbox"/> clearance.		0.038 to 0.102
Center main journal width (among thrust washers)		55.940 to 56.000
Center main bearing housing width among thrust washer faces		48.000 to 48.050
Center main bearing housing width over thrust washers		55.740 to 55.890
Standard thrust washer thickness		3.870 to 3.920
Oversized thrust washer thickness		0.127 - 0.254 - 0.508
Crankshaft washer thrust and center bearing		
<input type="checkbox"/> clearance		0.050 to 0.260
Max main journal misalignment (total gauge reading)		0.05
Max crankpin misalignment vs main journals		± 0.25
Max main journal and crankpin ovalization after grinding		0.010
Max main journal and crankpin taper after grinding		0.010

DESCRIPTION	mm
CYLINDER HEAD	
Valve guide housing in head	16 000 to 16 018
Valve guide O D	16 028 to 16 039
Valve guide fitted I D	9 025 to 9 045
Valve guide interference fit in head	0.010 to 0 039
Valve stem dia	8 980 to 8 995
Valve stem in guide. □ clearance	0 035 to 0 065
Valve seat angle { Inlet Exhaust	60° 45°
Valve face angle { Inlet Exhaust	60° 15' + 15' 45° 15' + 15'
Max valve stem distortion over one complete revolution with dial gauge stylus in midstem position	0 04
Valve seat width	~4
Valve seat O D { Inlet Exhaust	51.070 to 51.085 44.060 to 44 075
Valve seat I.D { Inlet Exhaust	50.995 to 51 020 43 985 to 44.075
Valve seat interference fit in head { Inlet Exhaust	0.050 to 0 090 0.045 to 0 090
Valve fitted depth in cylinder head	0.35 to 0 60
Max allowed valve fitted depth after overhaul	0 80 to 1.05
Spray nozzle protrusion in cylinder head	3 1 to 3.9
VALVE SPRINGS	
Free spring height	83 3
Spring height under 52 ± 2 kg	53
Spring height under 78.75 ± 3 kg	40
VALVE GEAR	
Camshaft bushing dia	63 000 to 63.030
Bushing fit in housing	Interference always necessary
Bushing fitted I D after reaming	62 000 to 62 030
Camshaft journal dia.. □ front □ intermediate and rear	59.910 to 59.940 61.870 to 61 900
Camshaft journal fit in bushing: □ clearance { front intermediate and rear	0.060 to 0.120 0 100 to 0 160

DESCRIPTION	mm
Cam lift - intake and exhaust	8
Standard tappet housing dia.	18.000 to 18 027
Standard tappet O.D. $\left\{ \begin{array}{l} \text{measured at top and bottom} \\ \text{measured at the middle} \end{array} \right.$	$\left. \begin{array}{l} 17 860 \text{ to } 17 892 \\ 17 938 \text{ to } 17 970 \end{array} \right\}$
Spare tappet oversize range	0.5 - 1
Tappet fit in housing (at tappet max dia): □ clearance	0.030 to 0.089
Rocker shaft dia.	24.015 to 24.036
Rocker shaft housing dia.	24.060 to 24.080
Rocker housing fit in rocker shaft □ clearance	0.024 to 0.065
Camshaft retaining plate thickness	7.760 to 7.820
Camshaft retaining plate housing width (after fit)	7.950 to 8.100
Camshaft end float	0.130 to 0.340
INJECTION PUMP CONTROL SUPPORT	
Bush housing dia. in gear shaft support controlling injection pump	70.850 to 70.990
Bush housing I D in gear shaft support controlling injection pump	65.060 to 65.090
Injection pump gear shaft dia.	65.000 to 65.030
Bush fit in support housing	Interference always necessary
Injection pump gear shaft bushing fit in shaft □ clearance	0.030 to 0.090
OIL PUMP	
Driving shaft bushing seat dia. in pump housing and cover	30.000 to 30.033
Bushing I D after fitting	27.000 to 27.033
Gear shaft O.D.	26.959 to 26.972
Driving gear I D	26.923 to 26.944
Bush and seat fit in pump cover and housing	Interference always necessary
Shaft fit in bushing: □ clearance	0.028 to 0.047
Driving shaft interference fit in gear	0.015 to 0.049
RELIEF VALVE	
Opening start pressure	5 bar
OVERPRESSURE VALVE	
Opening start pressure	8 bar
SPRING FOR RELIEF AND OVER PRESSURE VALVES	
Height of released spring	79.2
Height of spring under load of hg $\left\{ \begin{array}{l} 141 \pm 0.7 \\ 88 \pm 0.4 \end{array} \right.$	$\left. \begin{array}{l} 58 \\ 66 \end{array} \right\}$

FAULT FINDING DIAGNOSIS

INCONVENIENCE	POSSIBLE CAUSES	ACTION
The engine doesn't start	Injection pump timed erroneously	Check and time injection pump
	Deposits or water in fuel lines	Disconnect lines and clean with air blows. Remove and clean injection pump. Dry fuel tank and refuel
	Fuel reserve insufficient	Refuel
	Fuel feed pump defective	Overhaul or replace pump.
	Air bubbles in fuel lines or injection pump.	Inspect lines and feed pump for possible air; purge air from injection pump unscrewing the suitable plug and manually operating feed pump.
	Defective starter.	Repair or replace starter.
The engine stops	Idle speed too low	Control through adjusting screw.
	Uneven injection pump deliveries.	Set deliveries. Replace plunger spring, if broken. Replace tappet, plunger and barrel if seized or no sealing.
	Foreign matter or water in fuel lines	Disconnect lines, clean with compressed air. Remove and clean injection pump. Clean fuel tank and refuel
	Fuel filters clogged.	Disconnect filters; replace, if necessary
	Abnormal valve-rocker clearance.	Adjust valve-rocker clearance
	Valves burnt, worn-out or cracked.	Replace valves.
	Air present in feed and injection systems	Check lines for cracks or loose joints. Replace worn-out parts, then bleed air from lines and remove air from injection pump and fuel filter by unscrewing the suitable plugs and manually acting on feed pump
	Fuel filter and feed pump valves clogged	Replace fuel filter and overhaul feed pump valves.
Injection pump controls broken	Replace defective parts and check pump timing	

INCONVENIENCE	POSSIBLE CAUSES	ACTION
The engine warms up excessively	Water pump defective	Replace assembly
	Thermostats damaged	Valve stem jammed in its guide Replace
	Scales in water inlet in head and engine block	Thoroughly wash following scale remover directions carefully
	Cooling fluid level too low	Top up radiator
	Uncorrect engine timing.	Check timing and correct it
	Pump over or under-calibrated.	On test bench correct pump delivery so that injection can take place at prescribed delivery
	Air cleaner clogged	Clean air cleaner and inherent system
The engine loses power and runs unevenly	Uncorrect injection pump timing	Check timing and position pump correctly
	Excessive wear in injection pump plungers and barrels	Overhaul injection pump and replace worn-out parts
	Uncorrect calibration of speed governor	Check and exactly calibrate speed governor
	Nozzles partially clogged or injector operations defective	Clean nozzle holes with suitable tools and totally overhaul injectors.
	Foreign matter or water in injection and feed system.	Thoroughly clean and refuel
	Feed pump defective	Disassemble fuel feed pump and replace as necessary.
	Uncorrect valve - rocker clearances	Check clearance and adjust
	Compression loss	With tool 99395682 check cylinder pressure equality at TDC and pressure value
Turbocharger defective	Overhaul or replace the unit	

INCONVENIENCE	POSSIBLE CAUSES	ACTION
The engine loses power and runs unevenly	Air cleaner clogged	Clean air cleaner and inherent system
	Uncorrect adjustment of injection pump set screw or of push rod lever stop	Correctly adjust stop devices.
The engine has abnormal knocks	Defective injector operations	Check that the pin in nozzle spray is not causing resistance and that calibration value is as prescribed.
	Fuel lines clogged.	Remove lines and clean Replace those too much dented
	Uncorrect injection pump position	Correct pump position so that injection can take place at required advanced angles.
	Crankshaft knocks due to excessive main bearing or big end bearing end float or too high thrust clearance.	Grind crankshaft journals and fit undersized bearings Replace bearing valves with oversized ones
	Crankshaft unbalanced	Check for crankshaft misalignment, correct, if necessary, and check balance
	Flywheel capscrews loose	Replace loose screws and tighten to required torque.
	Connecting rod misalignments.	Straighten connecting rods using a hydraulic press and check axle parallelism.
	Piston slaps	Replace sleeves and pistons
	Piston pins noisy because of excessive clearance in piston hubs & connecting rod bushes. Loose bushings in connecting rod seat	Replace piston pin and connecting rod bushings and also piston if necessary. Replace bushings with new ones.
Tapping due to noisy valve system.	Adjust clearance between valves and rockers, check that there are no broken springs and there is not excessive clearance between stems and guides or tappets and seats	
The engine smokes abnormally 1) Black or dark gray smokes	Excessive max. pump delivery	Disconnect pump and adjust delivery as per data in calibration table
	Injection pump excessively retarded	Correct position.
	Injection pump excessively advanced.	Correct position

INCONVENIENCE	POSSIBLE CAUSES	ACTION
1) Black or dark gray smokes	Nozzle holes (or some of them) partially or totally clogged	Replace nozzles with a series of new injectors, or clean and recondition the original ones using suitable tools
	Air cleaner clogged or damaged	Clean or replace filter cartridge
	Nozzle needle desultorily jammed in open position	Inspect injectors, check for jammed needles, or broken springs be sure that calibration is not too low.
	Governor adjustment higher than maximum allowed	Bench adjust governor, according to table data
	Nozzle sprays are directed to the head because the injector has been fitted erroneously	Verify nozzle protrusion as to head face
	Excessive injector needle lift due to abnormal wear	Replace anomalous nozzle
	Loss of engine compression due to: <ul style="list-style-type: none"> □ piston rings stuck, □ sleeves worn-out, □ valves damaged or valve timed incorrectly 	Overhaul engine or limit repair action to the concerned parts
	Improper injector type, or injectors of different types, or uncalibrated	Replace injectors
Injection lines of improper I D , or pipe ends squashed due to repeated jams	Verify conditions of ends and connections, in case replace pipes	
2) Blue or blue/gray smoke, or gray smoke verging on white:	Excessive injection lag	Correct injection pump position
	Injector needles jammed or defective injectors	Be sure that the needle is not jammed or the spring is not broken
	Oil seeps through piston rings because the rings are jammed or sleeve walls are worn-out	Overhaul engine
	Engine oil goes through intake valve-guides due to valve stem or valve guide wears	Re-grind cylinder heads
	Engine too cold (thermostat blocked or not present)	Replace thermostat

INCONVENIENCE	POSSIBLE CAUSES	ACTION
The engine does not stop	Governor broken	Unscrew the joint connecting fuel delivery line, then repairs as required
	Delivery push rod seized	Unscrew the joint connecting fuel delivery line and repair as required
	Resistance in push rod motion	Clean push rod housing, also verifying in the malfunction is due to a not well performed fitting
	Governor parts cause resistances	Remove any cause of resistance from governor sleeve and control lever
	Excessive clearance in governor parts	Take up clearances, only leaving min tolerances, in case replace too worn-out components
INJECTION PUMP Difficult starting	Electromagnet for extra power supply	Check electric connections on electromagnet control switch
	Air in fuel feed system	Use specific manual pump to bleed system until Diesel fuel only comes out from bleed screw
	Clogged fuel filters	Replace filters Clean filter located near manual bleed pump
	Pump erroneously keyed on engine	Check that static keying of injection pump on engine has been carried out correctly
	Starting deliveries do not correspond to calibration table	Install injection pump on test bench and check enrichment deliveries
Uncorrect idle speed	Accelerator control lever stop screw	Carry on exact adjustment with vehicle running at idle speed
	Linkages	Check linkages from accelerator pedal to attachment on governor control lever and eliminate possible hardened points
Uneven idle speed	Erroneously calibrated injectors or jammed / clogged nozzles	Check injectors, overhaul or replace nozzles and calibrate
	Speed governor	On test bench, check exact positioning and operation of speed governor
	Idle speed deliveries uneven	Check on test bench and adjust if necessary

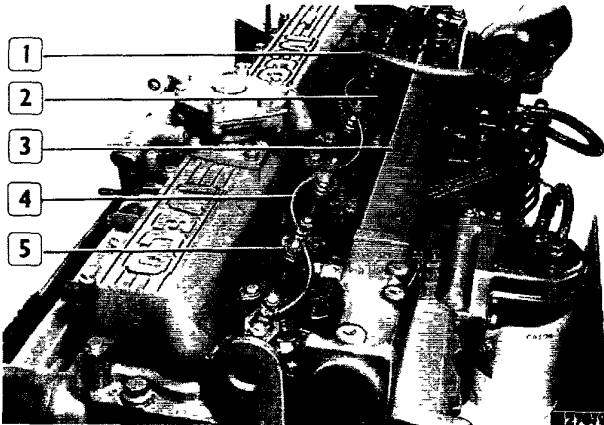
INCONVENIENCE	POSSIBLE CAUSES	ACTION
Low performance	Clogged fuel filters	Replace filters, clean filter on manual bleed pump and on tank float
	Air filter dirty	Look at telltale to check cartridge is not clogged, clean or replace if necessary
	Erroneously calibrated injectors or jammed / clogged nozzles	Check that injectors, overhaul or replace nozzles and calibrate
	Pump erroneously keyed on engine.	Check that static keying of injection pump on engine has been correctly carried out.
	Injection pump delivery insufficient	Remove injection pump from engine and check exact calibration on test bench
	LDA device	Check that diaphragm has no holes, thrust spring is adequate and correctly loaded (check on test bench) Check that turbocharger wheels rotate freely and blades are not broken. Check air pressure inside intake manifold is adequate according to fully loaded engine r.p.m
Excessive exhaust fumes when engine is cold	Pump erroneously keyed on engine	Check that static keying of injection pump on engine has been carried out correctly
	Erroneously calibrated injectors or jammed / clogged nozzles	Check injectors, overhaul or replace nozzles and calibrate
	Insufficient pressure at end of compression stroke.	Check using motometer
Excessive exhaust fumes (black) with fully - loaded engine	Excessive fuel delivery to engine	Check max output on test bench
	Low air intake	Check telltale to verify filter condition.
	Pump erroneously keyed on engine	Check that static keying of injection pump on engine has been carried out correctly
	Erroneously calibrated injectors or jammed / clogged nozzles	Check injectors; overhaul or replace nozzles and calibrate
Excessive fuel consumption	Fuel leaks	Check pipes and unions
	Air filter dirty	Look at telltale to check cartridge is not clogged, clean or replace if necessary
	Erroneously calibrated injectors or jammed / clogged nozzles	Check injectors, overhaul or replace nozzles and calibrate
	Erroneously calibrated injection pump	Check and time injection pump on test bench
	Abnormal operation of LDA device	Check and adjust on test bench
	Pump erroneously keyed on engine	Check that static keying of injection pump on engine has been carried out correctly

DISMANTLING ENGINE

Secure engine to revolving stand 99322230 (2) using brackets 99361032 (3) Drain lubrication oil from crankcase sump and disconnect oil dipstick (1)

NOTE - Before applying rear right bracket, disconnect oil fumes exhaust pipe

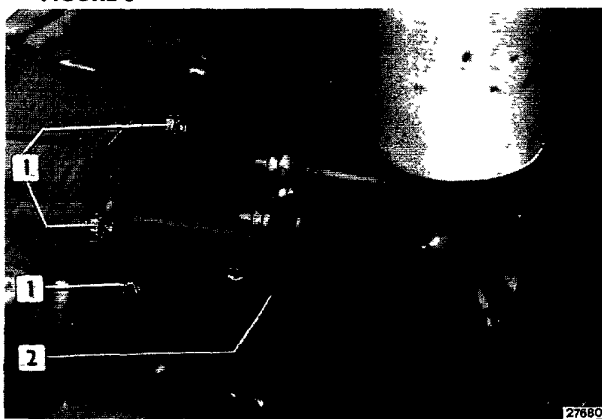
FIGURE 2



Disconnect fuel line (1) from thermostarter tank Remove line for fuel recovery (4) from injectors and delivery (2) to injectors

Remove injector retaining brackets (5) and cylinder head coolant manifold (3)

FIGURE 3



Undo nuts (1) and disconnect starter (2).

FIGURE 4



Remove fuel lines (3 and 4), disconnect fuel delivery lines (1) to injectors and air pipe (2) for L D A device

FIGURE 5



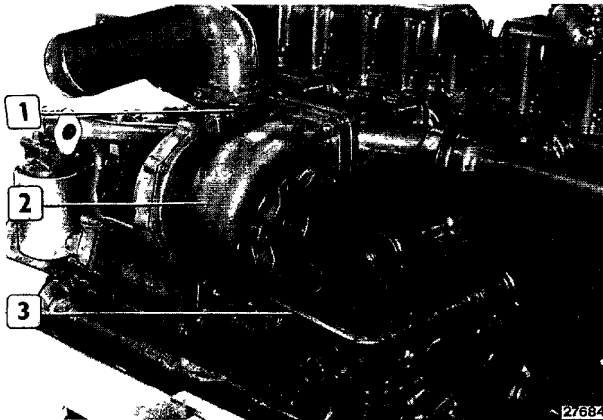
Use wrench 99360311 (2) to remove fuel filter (1)

FIGURE 6



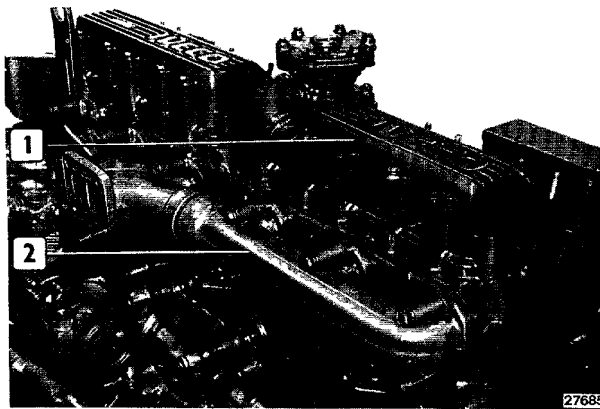
Disconnect intake manifold (2) from cylinder heads Extract injectors (1)

FIGURE 7



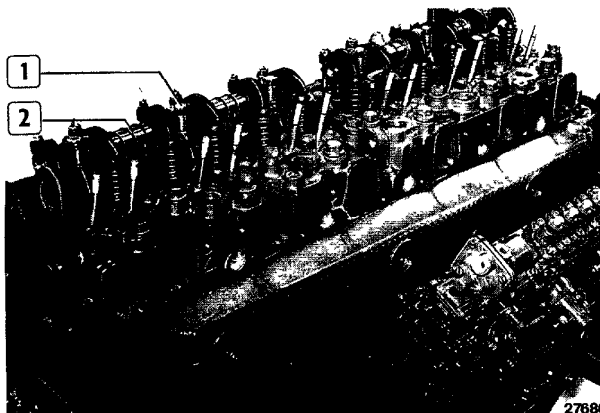
Disconnect turbocharger lubricant delivery and recovery lines (1 and 3), remove screws and disconnect turbocharger (2)

FIGURE 8



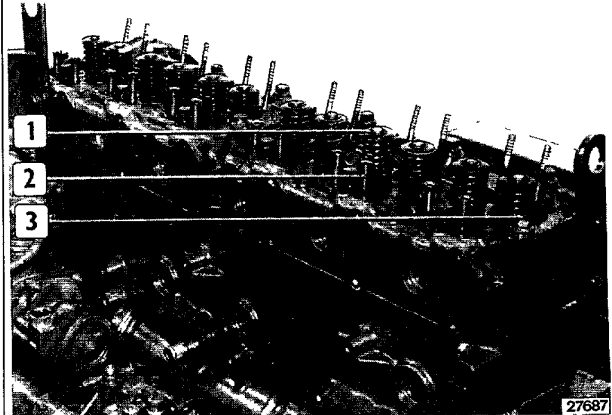
Remove exhaust manifold (2) and rocker caps (1) from cylinder heads.

FIGURE 9



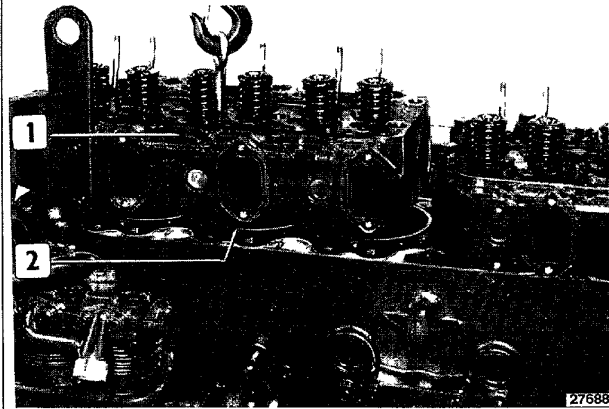
Remove bracket fastening screws (1) and pull out rocker shafts (2) assemblies

FIGURE 10



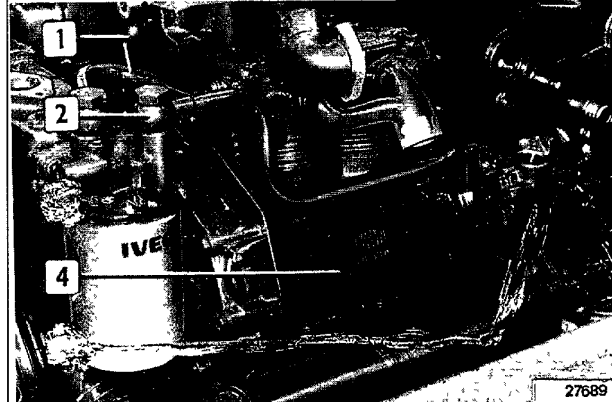
Pull out control rods (2), recover caps (1) from valve stems. Remove screws (3) fastening cylinder heads

FIGURE 11



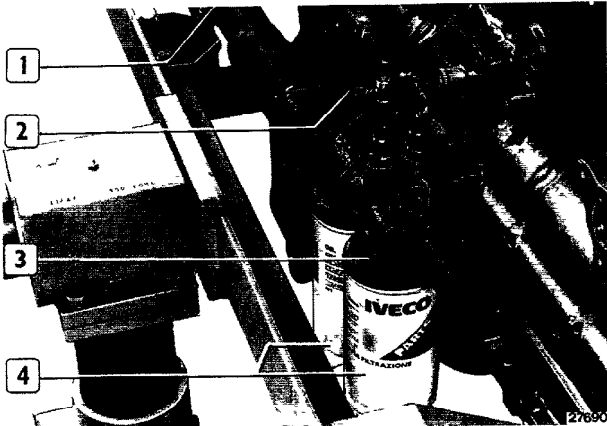
Remove cylinder heads (1), recover gaskets (2)

FIGURE 12



From compressor disconnect lines (1 and 2) (cooling fluid inlet and outlet) and take off the inhibiting filter with attached support

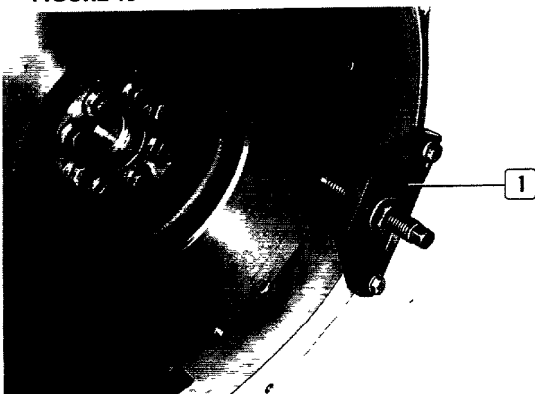
FIGURE 13



Disconnect line (1) from heat exchanger, use wrench 99360314 to remove oil filters (4) and an Allen wrench to remove screws (2) and filter support (3) complete with heat exchanger

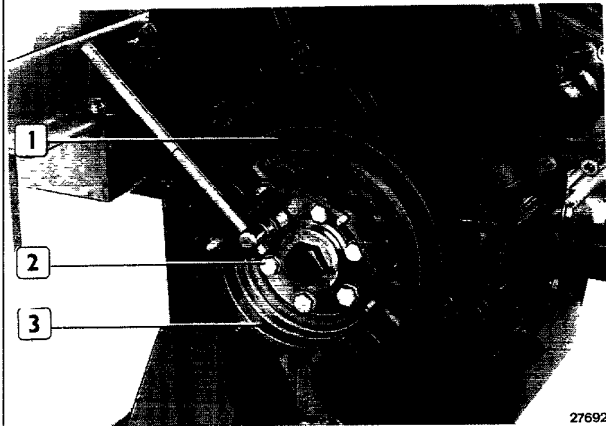
Remove alternator and control belt

FIGURE 15



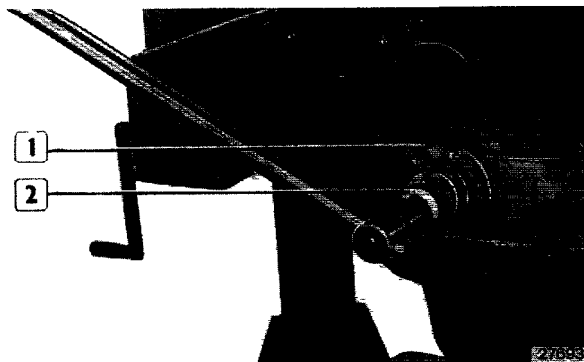
Stop crankshaft rotation by means of tool 99360351 (1) and position it as indicated in the figure

FIGURE 16



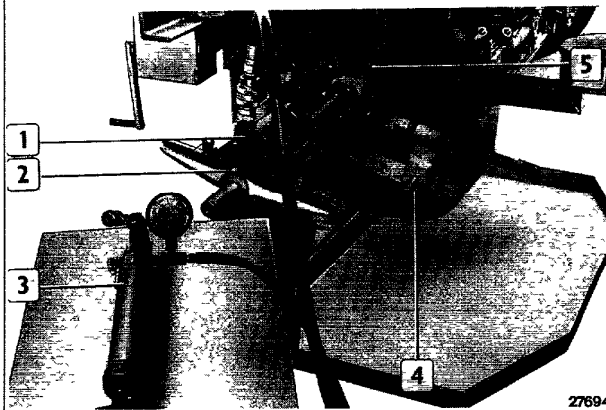
Remove screws (2), fan drive pulley (3) and alternator, extract damper flywheel (1)

FIGURE 17



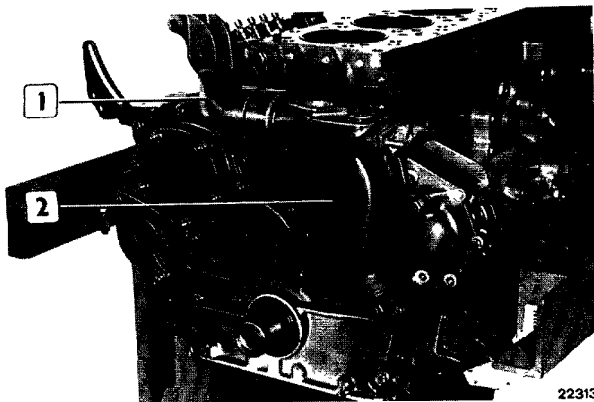
Use specific socket wrench to loosen hub retaining screw (1) so as to interpose a shim between washer (2) and crankshaft; fully retighten the screw. This will avoid sudden unlocking of hub during pull-out

FIGURE 18



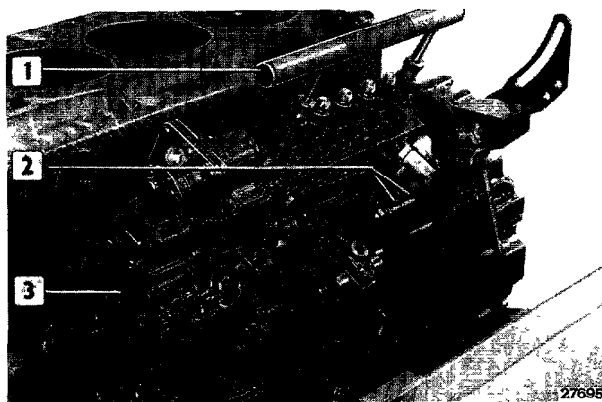
Apply puller 99340032 (2) complete with hydraulic unit 99341033 (1) and clamp 99341015 (4) to damper flywheel hub (5), use hydraulic pump 99341034 (3) to remove hub from flywheel

FIGURE 19



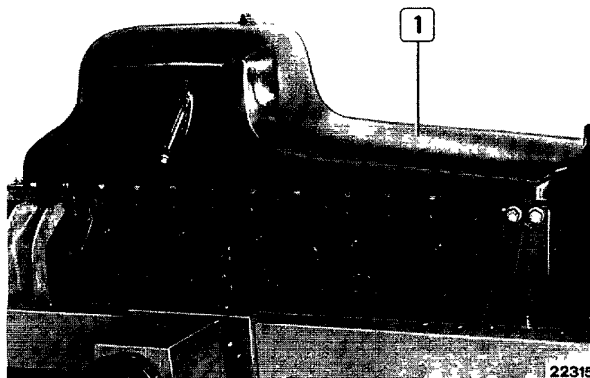
Loosen screws and remove water pump (2); also remove intake union (1)

FIGURE 20



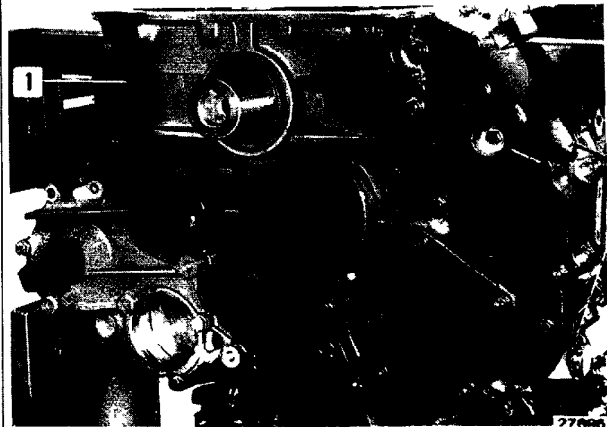
Using tool 99365136 (1) remove injection pump (3) after marking two dents (2) to indicate assembly position of injection pump

FIGURE 21



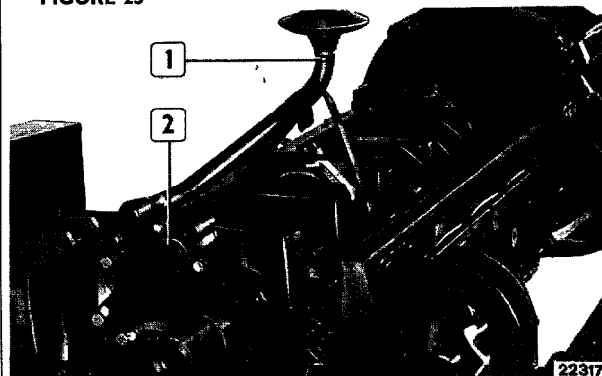
Rotate engine by 180°, remove oil sump (1) Recover gasket

FIGURE 22



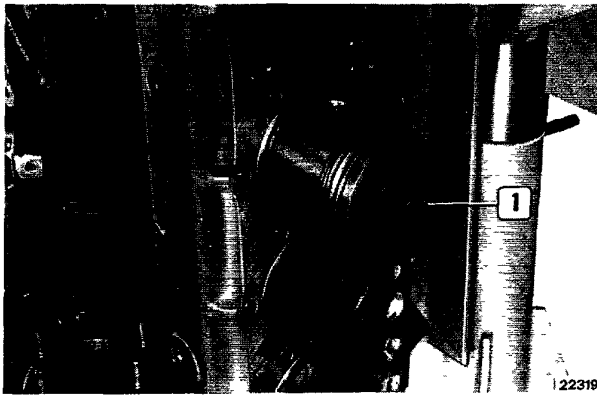
Remove timing cover (1)

FIGURE 23



Remove suction rose (1) with its support bracket
Disassemble oil pump (2)
Remove flywheel retainer 99360351 and fit specific handles
Position engine vertically

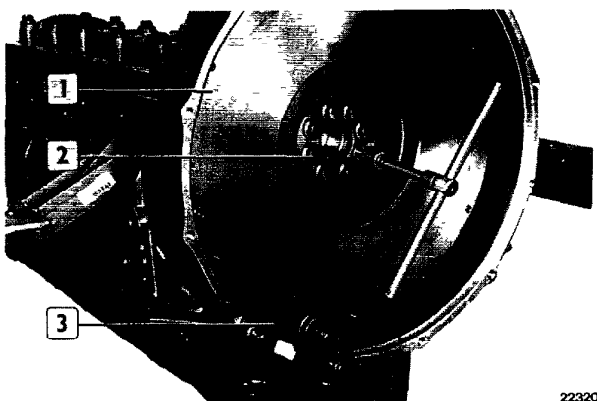
FIGURE 24



Disconnect connecting rod caps and relevant half-bearings; then withdraw connecting rod-piston assemblies (1) from cylinder sleeves.

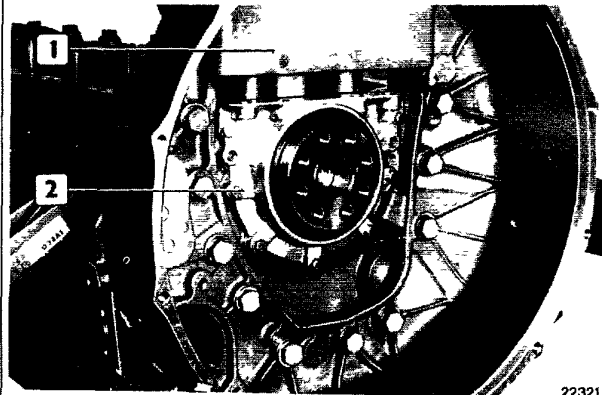
NOTE - If, when removing connecting rod-piston assemblies, one notices that the connecting rods and relevant caps have not been numbered, mark them in accordance with the numbers of inherent cylinders

FIGURE 25



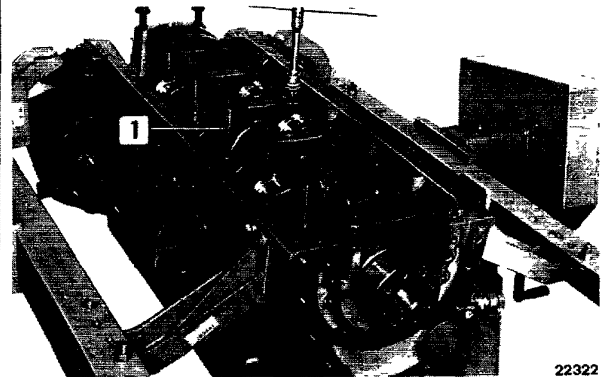
Stop engine flywheel (1) rotation using tool 99360351 (3) and remove screws (2)
Disconnect tool 99360351 (3) and remove engine flywheel (1).

FIGURE 26



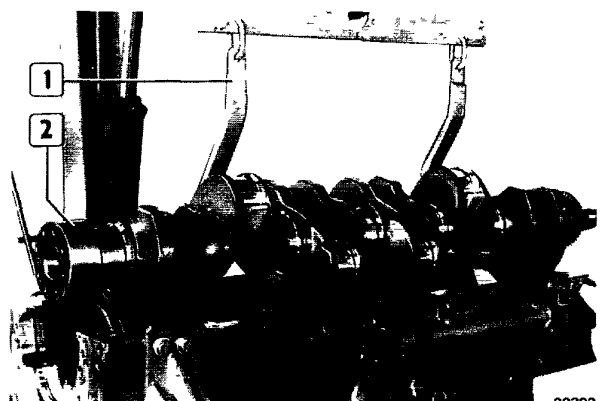
Loosen screws and remove rear support (1) and cover (2) with crankshaft seal ring

FIGURE 27



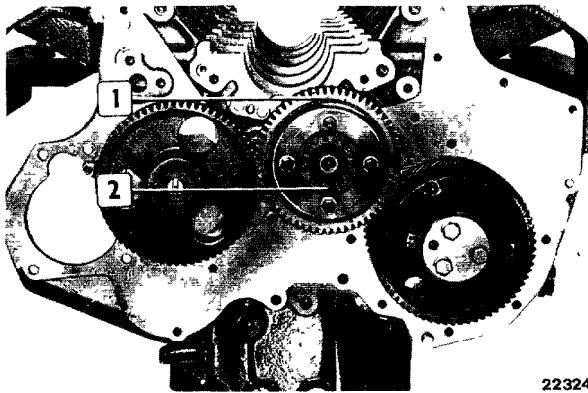
Remove main bearing caps (1) and relevant half-bearings and thrust washer halves by means of a suitable wrench

FIGURE 28



Using a hoist and tool 99360500 (1) lift up and remove crankshaft (2) Remove bearing halves and thrust washer halves

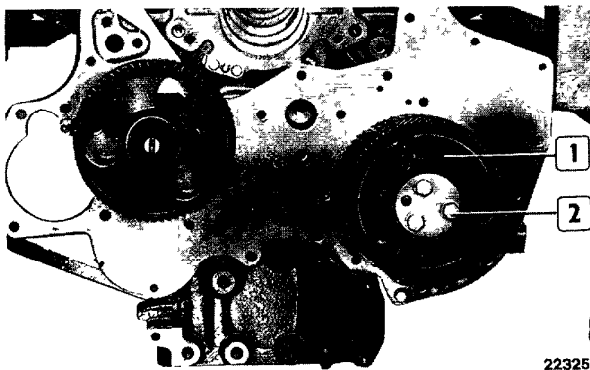
FIGURE 29



22324

Remove screws and withdraw intermediate gear (1) complete with support (2)

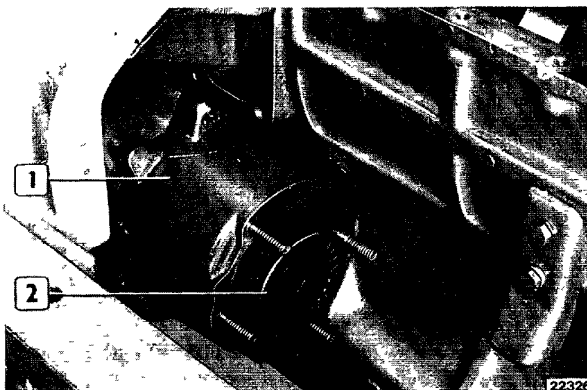
FIGURE 30



22325

Remove screws (2) fastening injection pump control gear (1) and remove it

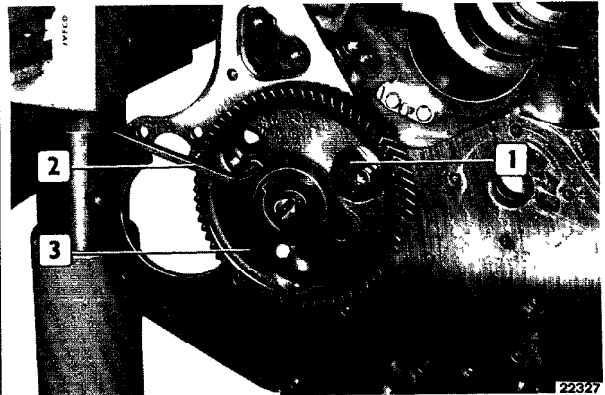
FIGURE 31



22326

Extract connection toothed gear (2) from support (1) Loosen screws and remove support (1) from plate

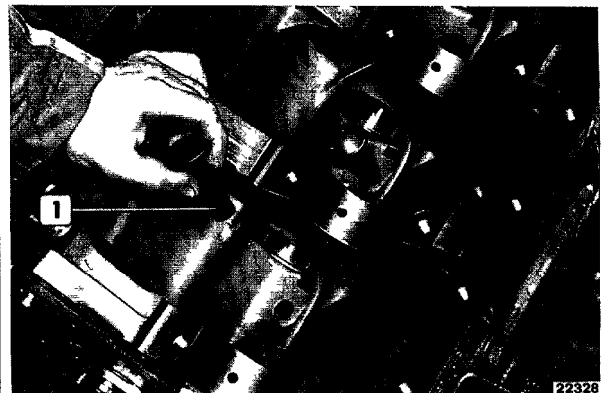
FIGURE 32



22327

Using a socket wrench (2) undo screws fastening camshaft thrust plate (1) and remove camshaft from cylinder block taking care not to damage support bushes

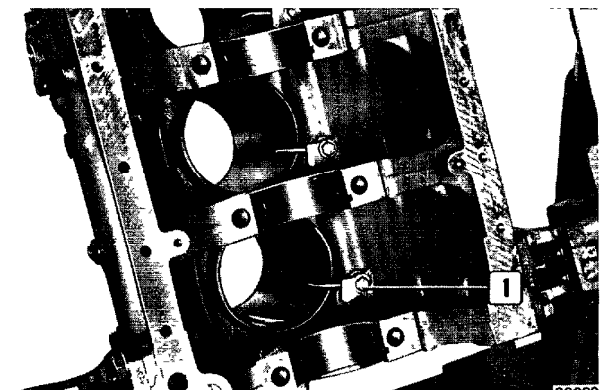
FIGURE 33



22328

Then withdraw tappets (1) from housings

FIGURE 34



22329

Disassemble oil nozzles (1); extract cylinder sleeves as described.

REPAIR ACTIONS

ENGINE BLOCK

After engine disassembly clean engine block thoroughly.

INSPECTIONS AND MEASUREMENTS

Inspect cylinder sleeve surfaces which should not show marks, ovality, taper or excessive wear

FIGURE 50

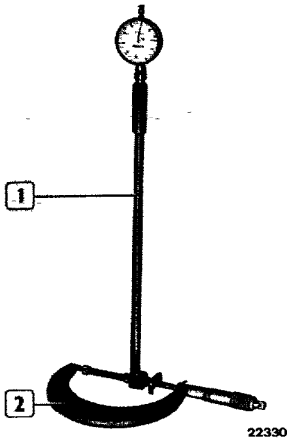
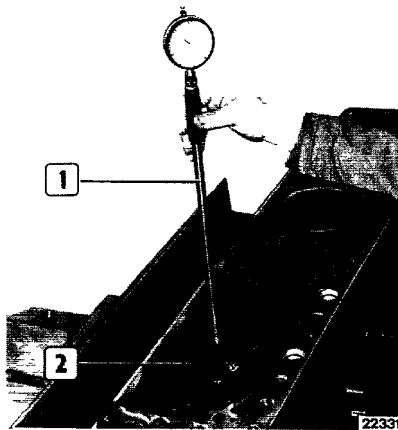
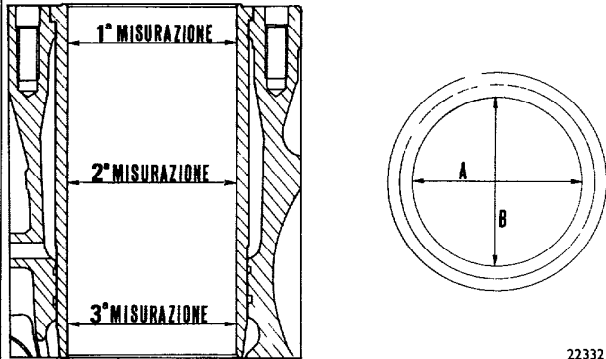


FIGURE 51



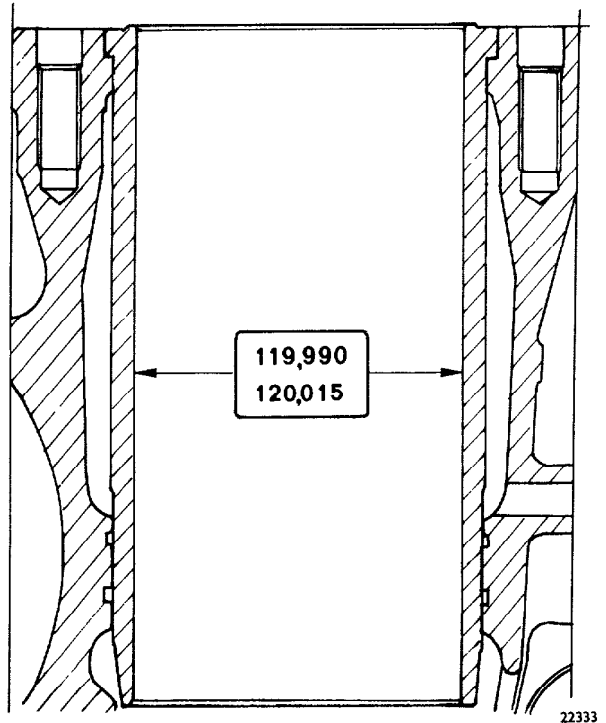
Each cylinder sleeve (2) bore diameter, must be checked using gauge 99395687 (1) with gauge previously zeroed on ring gauge (2, fig 50) (dia 120 mm)

FIGURE 52



Each cylinder sleeve bore must be measured at three different points on two planes at right angles. Max wear is detected at the top measuring, along the axle B

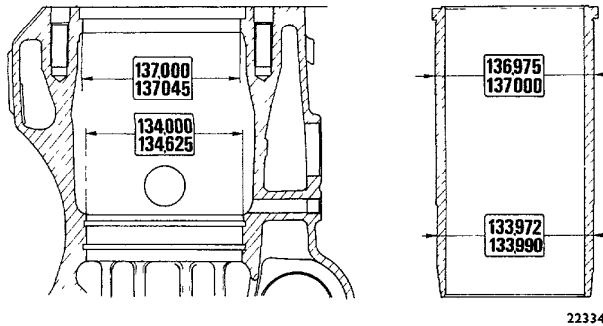
FIGURE 53



Should a max wear of 0.150 mm or a max. ovality of 0.100 mm as to the values indicated in the figure be detected, replace cylinder sleeve because, since its inside surface has been "sur sulf" treated, no grinding, lapping or dressing operation is allowed

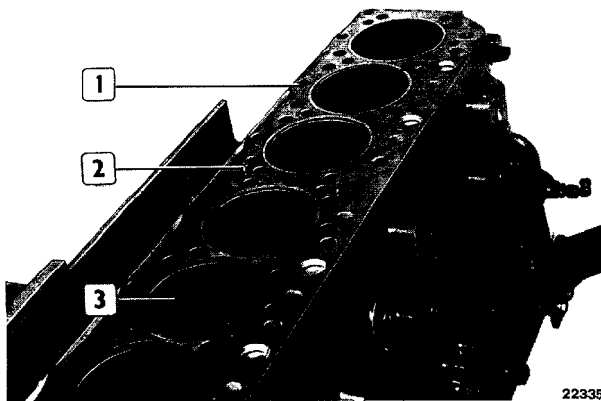
CYLINDER SLEEVE DISASSEMBLY - ASSEMBLY

FIGURE 54



The sketch in the figure indicates outside diameters of cylinder sleeves and inside diameters of relevant housings. If necessary, cylinder sleeves can be removed and reinstalled several times in different housings.

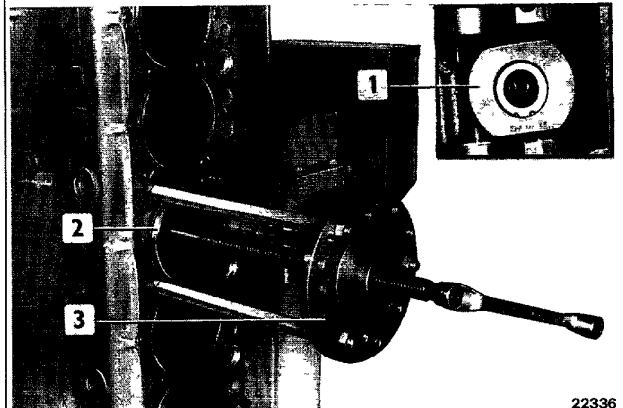
FIGURE 55



Remove cylinder sleeves as described in the relevant chapter and check cylinder head face (1) flatness through straightedge and feeler. If a distortion is detected, withdraw centering dowels (2) and grind head faces, removing as small material as possible.

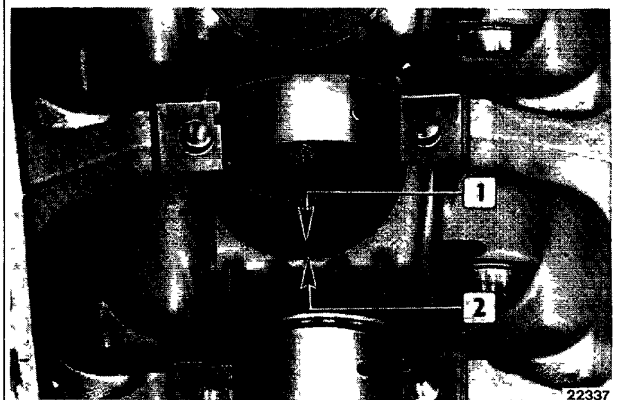
NOTE - After grinding head face, recondition cylinder sleeve edge housing depth, that must be 10.09 to 10.05 mm.

FIGURE 56



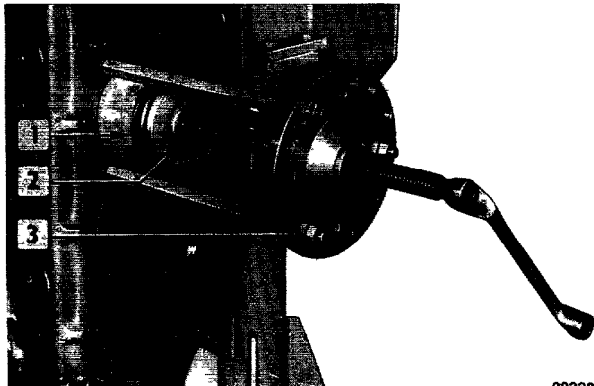
Withdraw cylinder sleeves (2) using plate 99360782 (1) and tool 99360711 (3) as shown in figure. Carefully inspect cylinder sleeve housings and lateral engine block faces. Check conditions of plugs on operation ports of engine block. Replace them, if rusty or not well sealed.

FIGURE 57



Before assembly, always replace water seals (1 and 2).

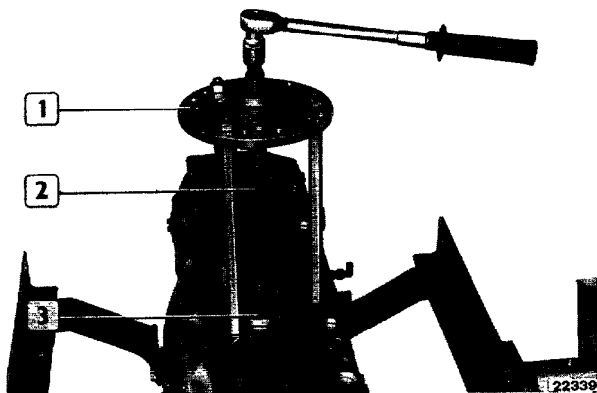
FIGURE 58



Fit adjust ring (1) on cylinder sleeve
Lubricate lower sleeve section Use plate 99360782 (2) and tool 99360711 (3) to assemble it. Repeat check of cylinder sleeve protusion as described in relevant chapter.

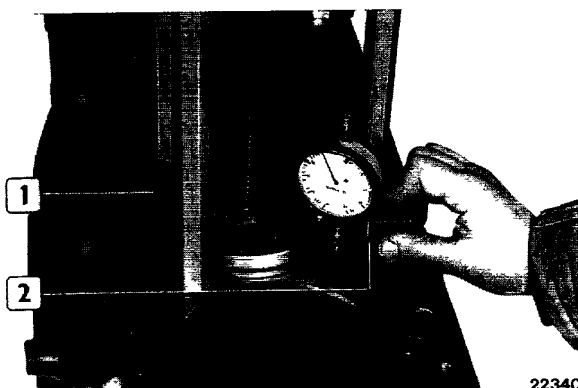
CYLINDER SLEEVE PROTUSION CHECK AND ADJUSTMENT

FIGURE 59



Use plate 99360782 (3) and tool 99360711 (1) tightening screw (2) at 140 Nm torque to check cylinder sleeve protusion

FIGURE 60



Use tool 99370415 (2) with gauge to check that cylinder sleeve (1) protusion is 0.045 to 0.065 mm. Should value be different, adjust protusion operating as follows

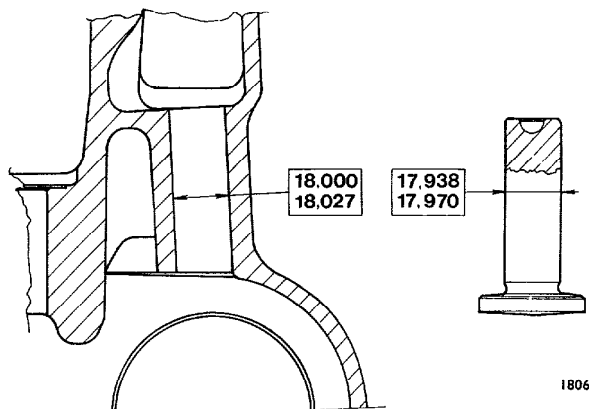
- withdraw cylinder sleeve, remove water seals (1 and 2, fig 57) Remove adjust ring (1, fig 58),
- refit the sleeve and install the tool (1 and 3, fig. 59),
- tighten screw at 140 Nm torque to ensure correct sleeve stand-in as to engine block,
- use tool 99370415 (2, fig 60) with gauge to measure protusion between two opposite points (at 180°); calculate the mean of the two measured values

According to measured protusion value, select correct adjust ring from the following table

Protrusion range mm	Adjust ring thickness mm
0.015 to 0.034	0.08
0.035 to 0.054	0.10
0.055 to 0.074	0.12
0.075 to 0.095	0.14

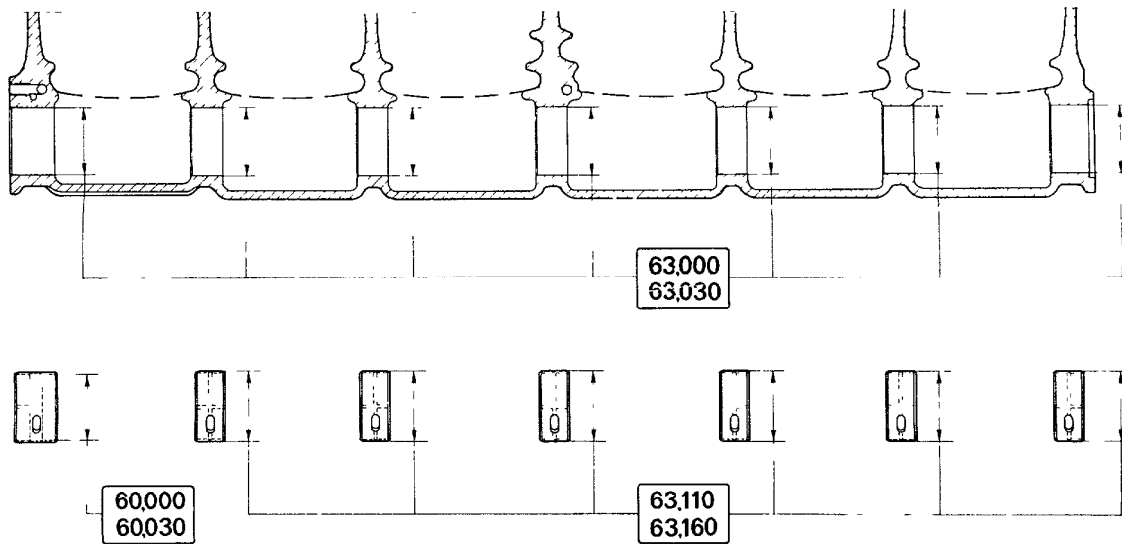
TAPPETS - TAPPET HOUSINGS CHECK

FIGURE 61



Check tappet housing inside surface, that must be smooth, free from dents and not too worn out, use adequate bore gauge to check inside section

FIGURE 62

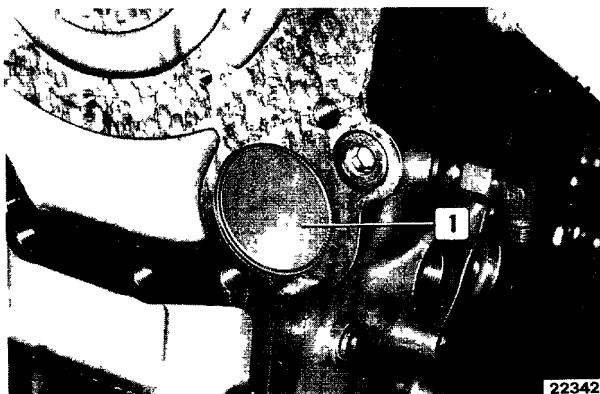


CHAMSHAFT BUSHINGS AND RELEVANT HOUSINGS IN ENGINE BLOCK - DETAILS

* Measurement after bushing fit

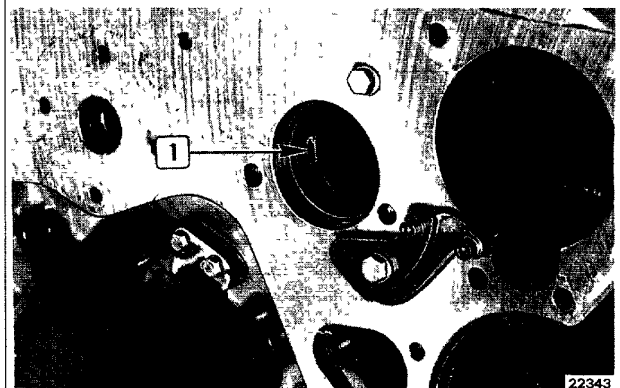
Camshaft bushings must be forced in their housings. Inside surfaces must be very smooth with no signs of seizure or wear. To remove or insert bushings use the appropriate drift.

FIGURE 63



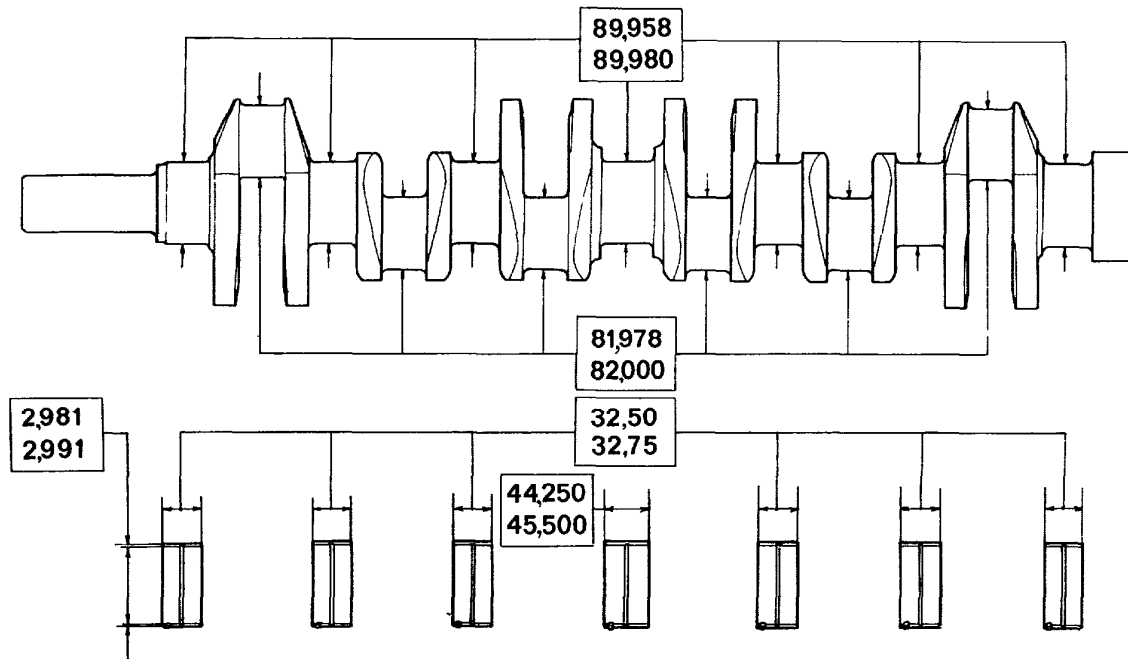
NOTE - To replace rear bushing, previously remove the seal plug (1) on engine block. When the plug is again inserted, coat its sealing surface with LOCTITE 275.

FIGURE 64



When inserted, the bushing must be positioned so that their lubrication holes (1) coincide with those on their housings.

FIGURE 65

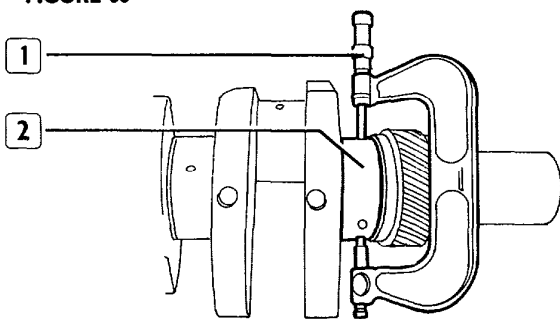


22344

CRANKSHAFT JOURNAL AND MAIN BEARING HALF DETAILS

Check conditions of main journals and crankpins in crankshaft. They should show no scores, ovality or excessive wear. Data in figure refer to normal pin diameters.

FIGURE 66



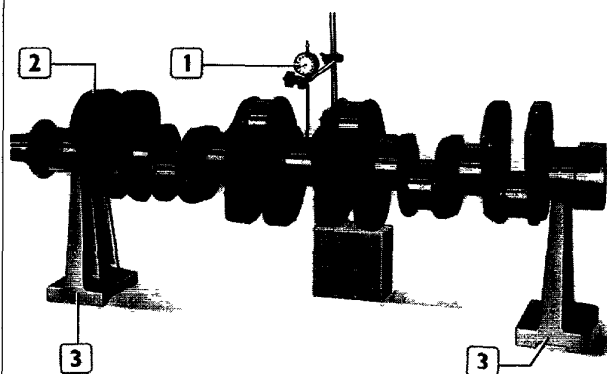
18073

Before grinding journals, measure them (2) with micrometer (1) so as to define the required diameter in accordance with the undersize range of bearings. During regrinding, ovality should 0.008 mm and taper 0.012 mm. Undersize range is 0.254 - 0.508 - 0.762 - 1.016 mm.

NOTE - Main journals and crankpins should always be ground at a same undersize range.

MAIN JOURNAL AND CRANKPIN ALIGNMENT CHECK

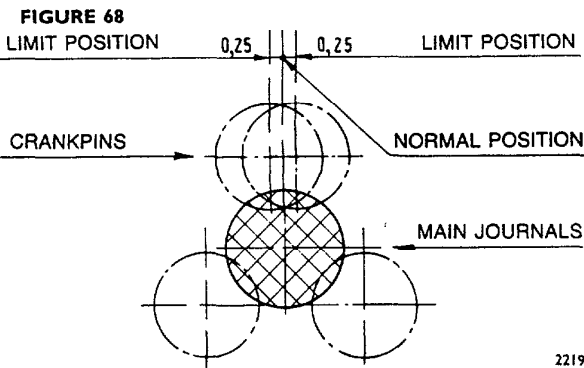
FIGURE 67



22345

After grinding, place the crankshaft (2) over a pair of V-blocks (3) and using a suitable dial gauge check the following:

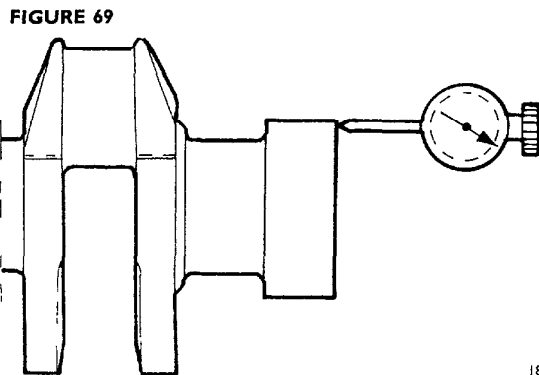
- Main journal misalignment: max. allowance 0.20 (total indicator reading) and 0.10 mm between the two next ones.



2219

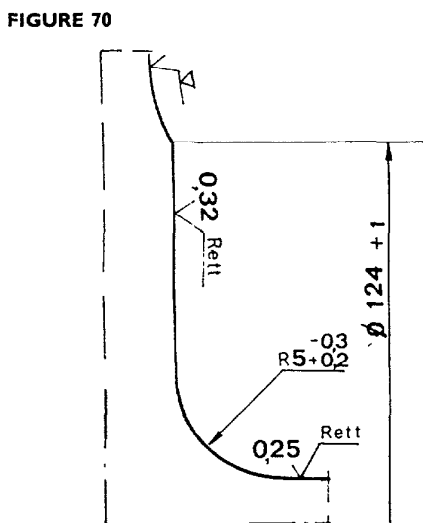
□ crankpin alignment as to main journals: each pair of crankpins should lie on the same plane as the main journal centerline, maximum tolerance is $\pm 0,25$ mm

For gap between crankshaft rotation axis and crankpin external face, the max, allowed tolerance is $\pm 0,10$ mm



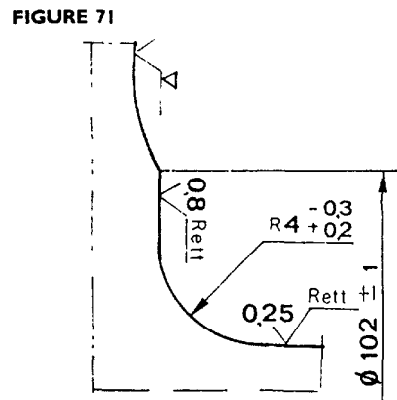
18074

Flywheel connection flange when the shaft is rotated having a gauge positioned as indicated in the figure, on a diameter of 2 to 4 mm less than max. face diameter, variations should not exceed 0 02 mm



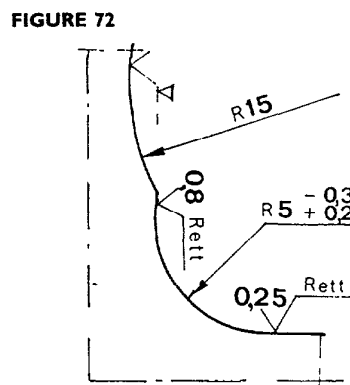
22346

Center main journal fillet details.



22347

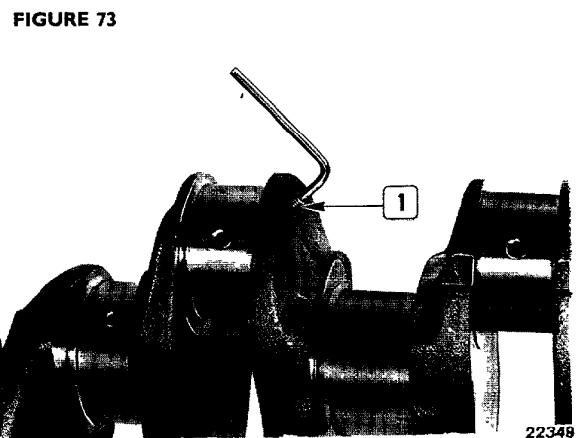
Crankpin fillets



2234E

Front - intermediate - rear main journal fillets.

When grinding crankshaft journals be extra careful as to the fillets values, since such values must be exactly the same as those indicated in the figures.

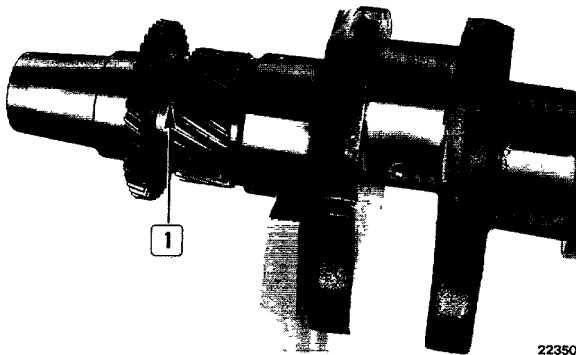


22348

After grinding crankshaft journals, remove from this shaft caps (1) of oil ducts, thoroughly wash oil lines, tighter caps again.

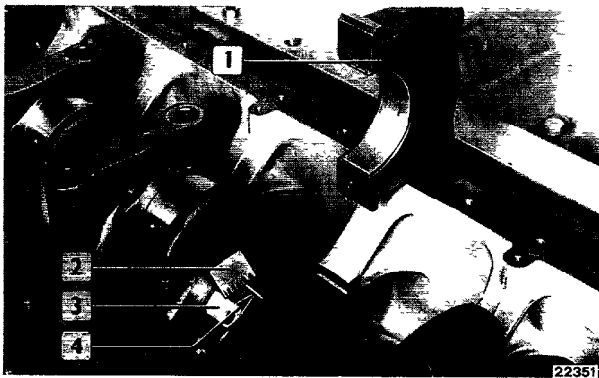
With a pressure of 15 bars (15 kg/cm²) check that there are no leaks from caps.

FIGURE 74



Inspect valve system drive gear teeth conditions; if breakages or excessive wears are detected, remove gear from crankshaft. After heating the new gear at a temperature of 200°C max, key it to the crankshaft so that hole (1) coincides with the relevant hole on crankshaft.

FIGURE 75

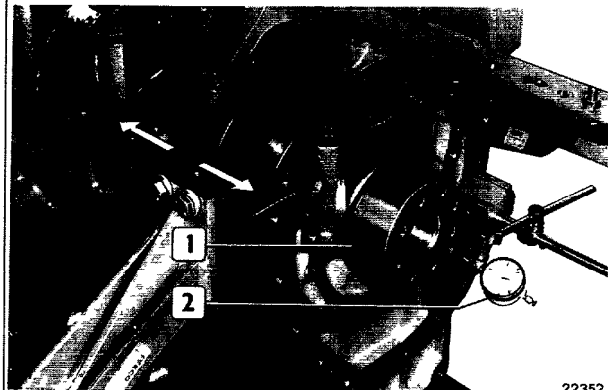


Check clearance between crankshaft main journals and relevant bearings, operating as follows.

- thoroughly clean main journals and bearings;
- place bearings in their housings;
- insert crankshaft;
- on main journals (3) insert a calibrated wire (4); mount main bearing caps (1) together with bearings;
- tighten to prescribed torque the screws securing bearing caps, after lubricating them;
- remove main bearing caps.

Clearance between main bearings and relevant journals is measured comparing wire (4) width of max. compression area with the values of the graduated scale in the calibrated wire container (2). The scale figures indicate (in mm) fit clearance which should be between 0.038 and 0.102.

FIGURE 76

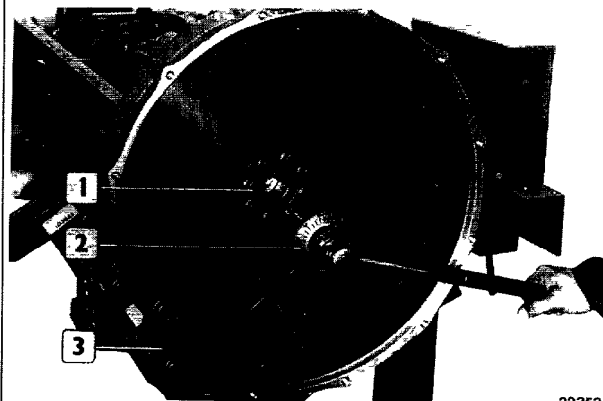


Crankshaft (2) end float is checked using a magnetic base gauge (1) and acting on it as indicated in the figure. Correct end float is 0.050 to 0.260 mm. If excessive play is detected, replace thrust washer halves with new ones of normal thickness or oversized, if necessary. Bearing thrust washer halves are not interchangeable with cap washers. Position thrust washer halves with grooved white metal line sides facing the crankshaft shoulder.

REPLACEMENT OF ENGINE FLYWHEEL TOOTHED GEAR

Check conditions of crown gear teeth, in case of teeth broken or worn out, remove crown gear and install a new one previously warmed to 80°C.

FIGURE 77



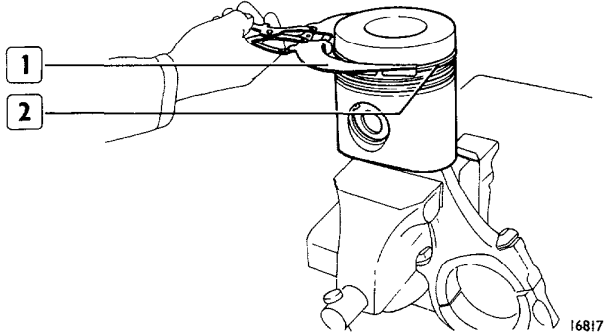
Assembly of engine flywheel. Apply tool 99360351 (3), tighten retaining screws (1) at 100 Nm torque. Use tool 99395202Z (2) to further tighten screws by $60^\circ \pm 5^\circ$.

NOTE - Screws can be used again until screw end thread section of 25 mm is less than 15.5 mm.

CONNECTING ROD-PISTON ASSEMBLY

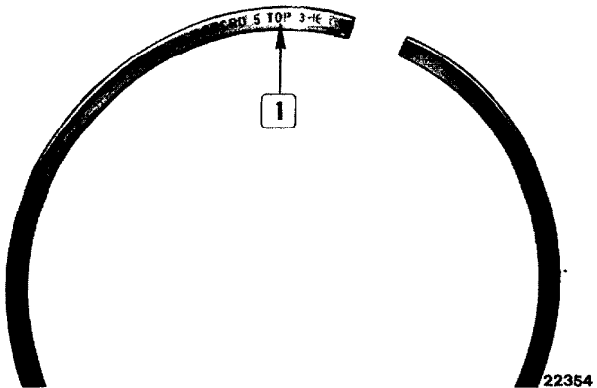
Check pistons for pick-up, score marks or cracks. Replace, as necessary.
 Check piston pin and its seat for wear: fit clearance is 0.001 to 0.015.
 Retaining rings should not be damaged or loose.

FIGURE 78



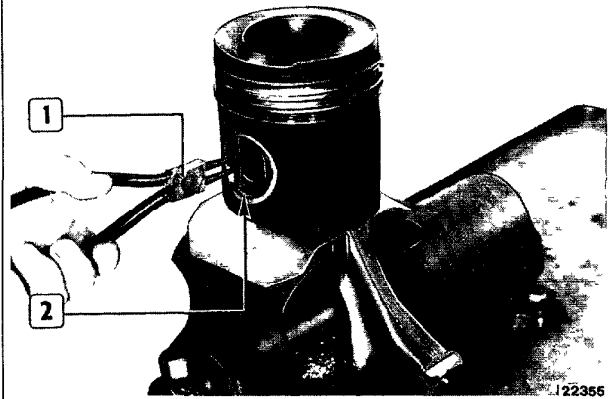
Piston rings (2) removed and installed by means of tool 99360184 (1)

FIGURE 79



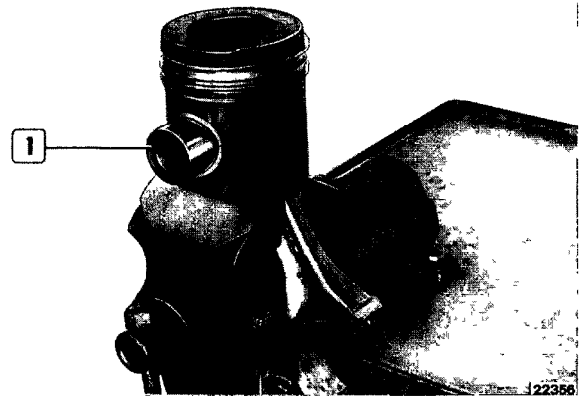
When assembling retaining rings, check that "TOP" mark (1) is upwards

FIGURE 81



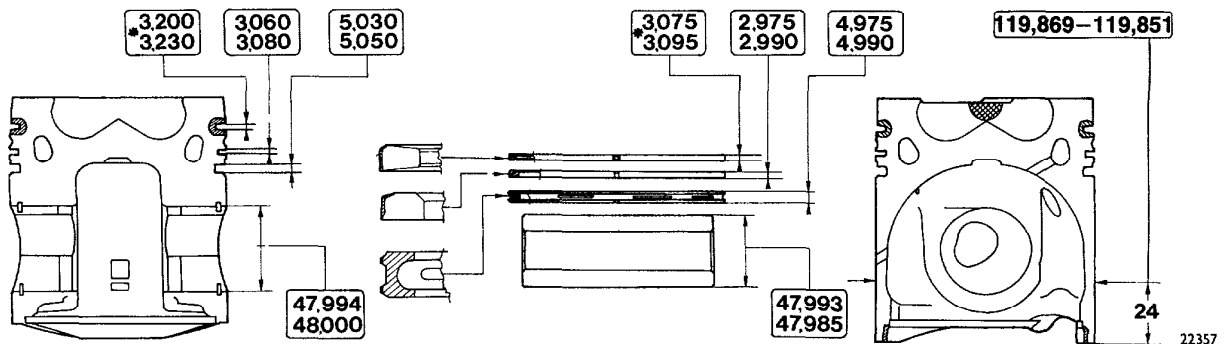
Piston ring (2) retained piston pin removed/installed through roundnose pliers (1)

FIGURE 82



Disassembly and assembly of piston pin (1) Should disassembly be difficult use adequate drift.

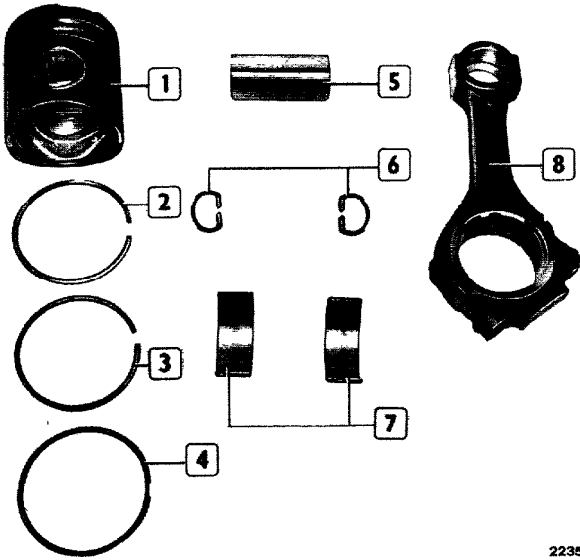
FIGURE 80



PISTON, PIN AND RING DETAILS

* on 117 mm dia

FIGURE 83

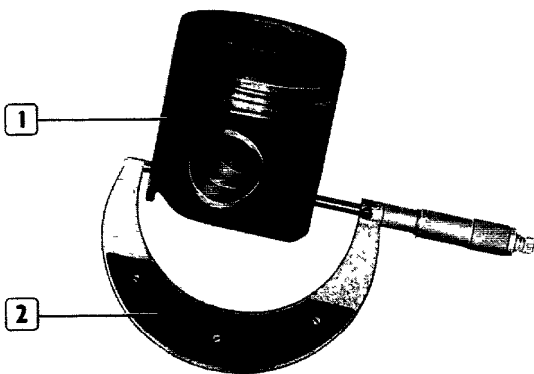


22358

PISTON - CONNECTING ROD ASSEMBLY

- 1 Piston - 2 Compression ring - 3 Retaining ring - 4 Oil scraper ring - 5 Pin - 6 Compression rings - 7 Half bearings - 8 Connecting rod

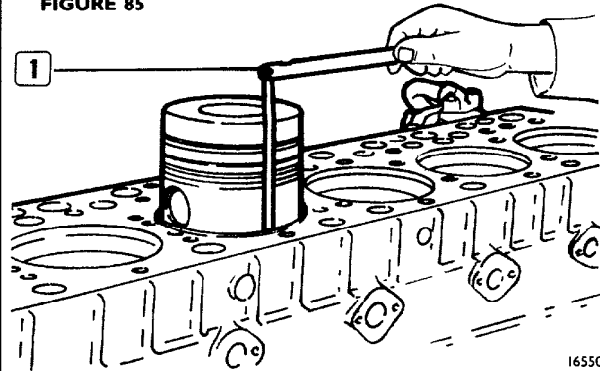
FIGURE 84



22359

With micrometer (1) measure piston (2) diameter to define clearance. The diameter must be measured 24 mm from skirt base.

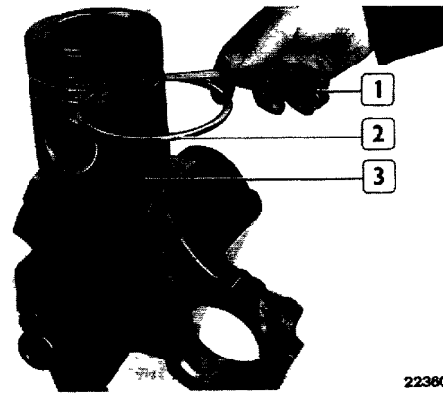
FIGURE 85



16550

Check piston - cylinder sleeve clearance using feeler gauge (1) as shown in figure or measure piston - cylinder sleeve dia

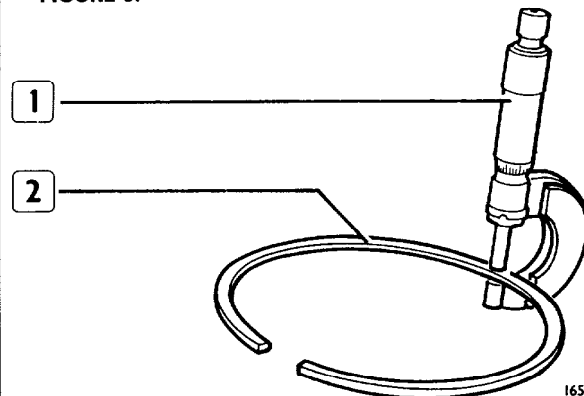
FIGURE 86



22360

Check piston rings (2) - piston grooves (3) clearances using feeler gauge (1)

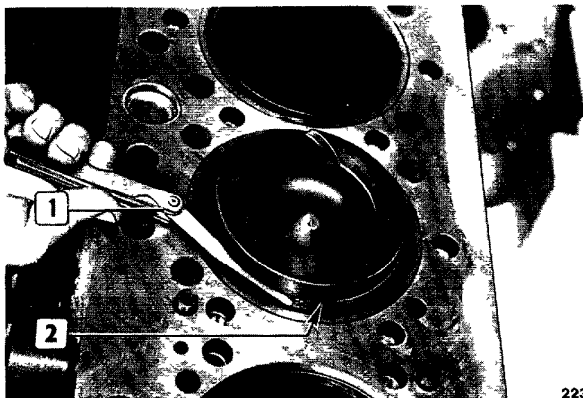
FIGURE 87



16552

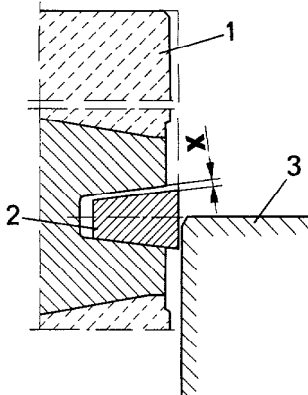
Check compression ring (2) thickness using micrometer (1).

FIGURE 88



Check clearance between compression ring (2) and relevant seat on piston using a feeler gauge (1)

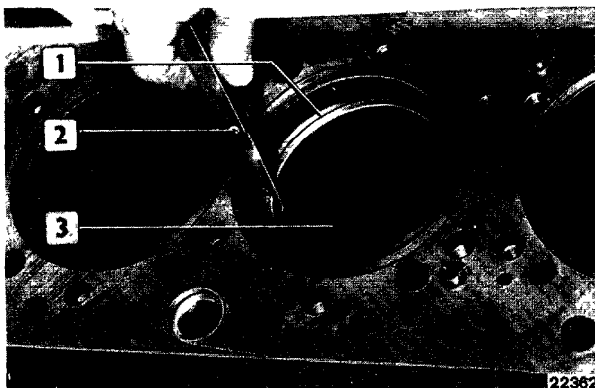
FIGURE 89



3513

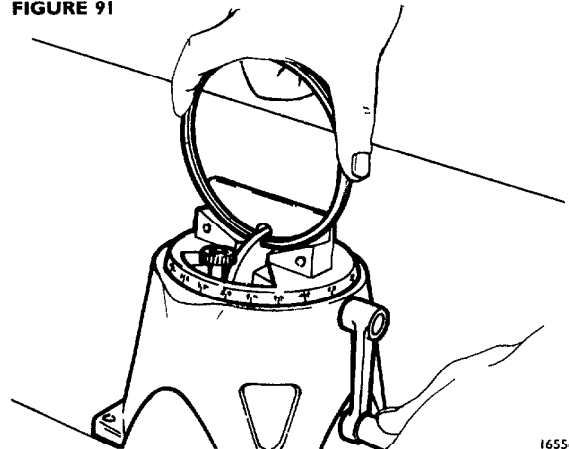
Compression ring (2) in top groove is of double taper shape. Ring clearance (X) is checked placing piston (1) with relevant ring in cylinder sleeve (3) so that the compression ring can protrude half its length from cylinder sleeve

FIGURE 90



Check the gap of compression rings (1) inserted in cylinder sleeve (3) using feeler gauge (2)

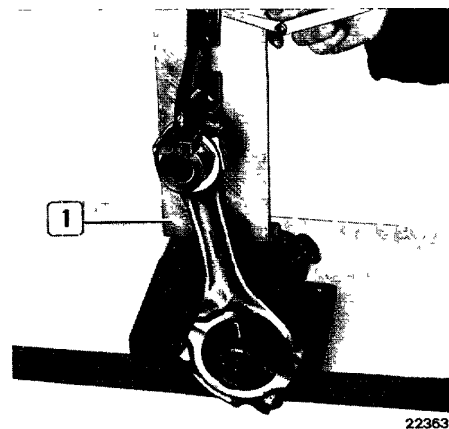
FIGURE 91



If gap between compression ring ends is less than the prescribed value, dress ring ends using tool 99360188 as indicated in the figure

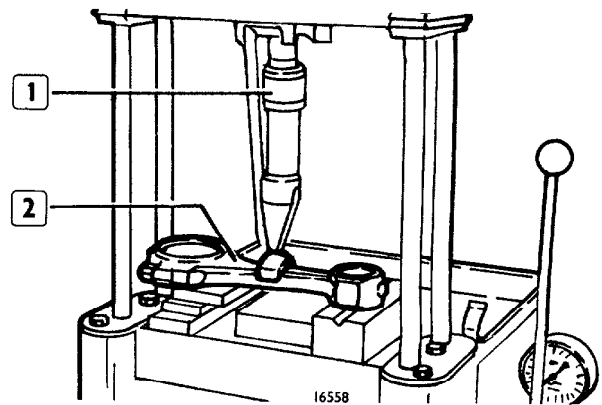
CONNECTING RODS

FIGURE 92

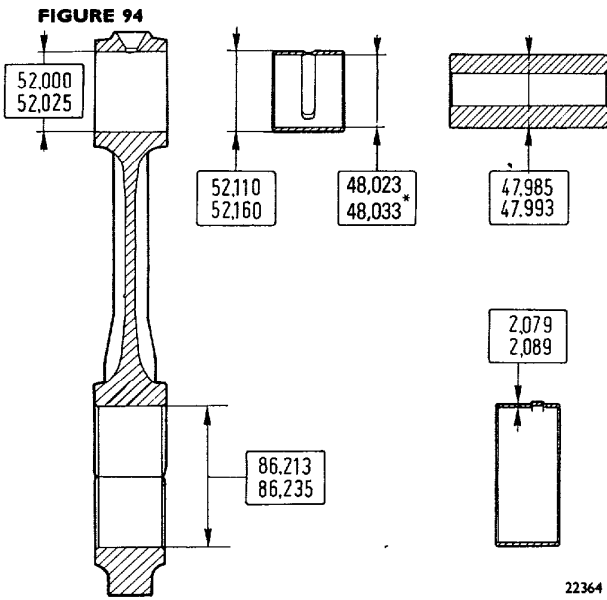


Check connecting rod axis misalignment using gauge 99395363 (1). Max permitted allowance 0.07 mm

FIGURE 93



If misalignment is detected on connecting rod axes straighten them using a suitable hydraulic press as indicated in the figure



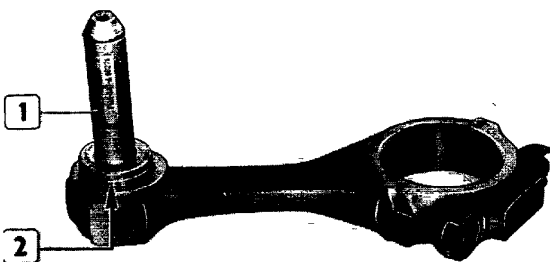
CONNECTING ROD, BEARING, BUSHING DETAILS

(*) The value indicated is to be obtained after the bushing has been fitted in its seat

Check bushing internal surface: it should show no traces of seizure or deep score.

Check clearance between bushing and piston pin; normal clearance is 0.030 to 0.048 mm.

FIGURE 95

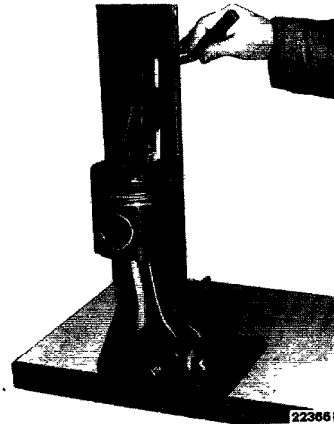


22365

Use specific side hammer (1) to disassemble and assemble bushing (2).

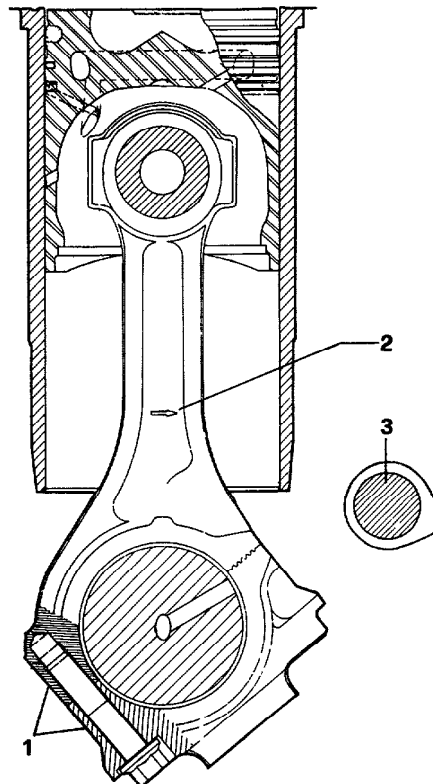
After fitting, bore the bushing so as to obtain the normal diameter.

FIGURE 96



NOTE - Before assembling connecting rod - piston assembly, check squareness. Squareness must be perfect, otherwise investigate the cause of the defect, replacing faulty parts

FIGURE 97



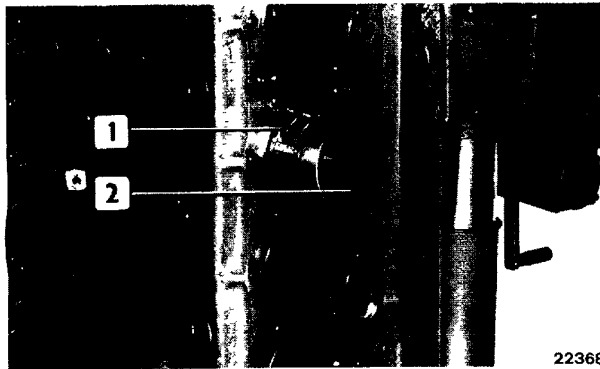
22367

DIAGRAM FOR CONNECTING ROD - PISTON ASSEMBLY INSTALLATION IN CYLINDER

1 Connecting rod - cylinder reference mark area - 2 Arrow protruding from connecting rod indicating engine direction of rotation - 3 Camshaft

NOTE - Connecting rod screws may be used again until thread \varnothing is less than 13.4 mm

FIGURE 98

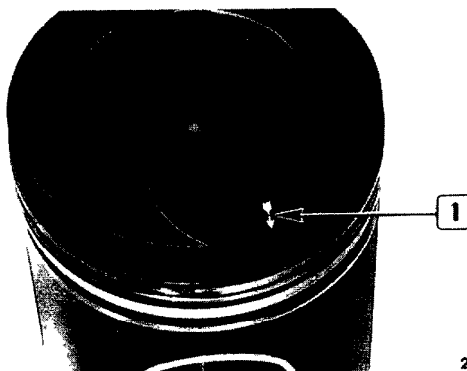


22368

Installation of connecting rod-piston assemblies (2) in cylinder sleeves, must be carried out with compression ring 99360603 (1) considering the following

- the number in connecting rod must be equal to the number in cylinder sleeve where it is to be inserted,

FIGURE 99



22369

- arrow (1) marked on piston crowns must be towards engine front;
- connecting rod numbers must face camshaft,
- gaps between ring ends must be offset 120° from one another.

Piston, rings and cylinder sleeves must be lubricated with engine oil.

FIGURE 100



22370

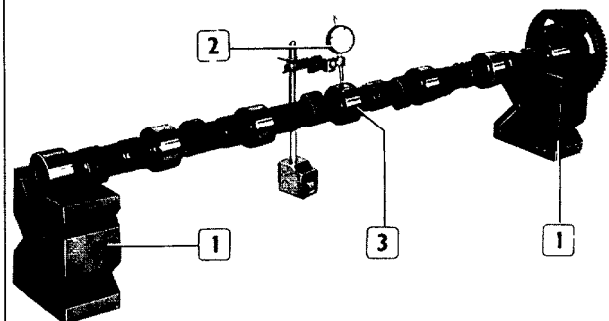
Check clearance between crankpins and relevant bearings, acting as follows:

- thoroughly clean crankpins and bearings;
 - insert bearings in their housings and caps,
 - insert a calibrated wire (3) on crankpins (2);
 - tighten nut of connecting rod capscrews (previously lubricated) to the prescribed torque,
 - remove connecting rod caps
- Clearance between crankpins and their bearings is detected by comparing the wire (3) with the graduated scale (1) in wire container

CAMSHAFT - TAPPETS

Check camshaft journals and lobes. In case pick-ups, scores or excessive wear are detected, replace camshaft and relevant bushings fitted in engine block

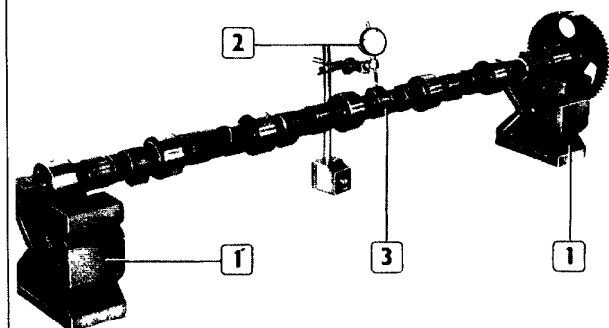
FIGURE 101



22371

Check journal alignment positioning the camshaft on parallels (1) as indicated in the figure. With a magnetic base gauge (2) measure misalignment (3), which should never exceed 0.10. In the negative, straighten camshaft using a press

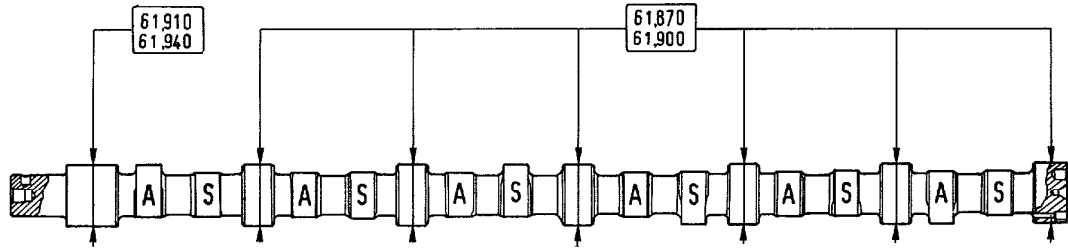
FIGURE 102



22372

With camshaft still positioned on parallels (1), use magnetic base gauge to check lobe lifts, which should be 8 mm for both intake and exhaust

FIGURE 103

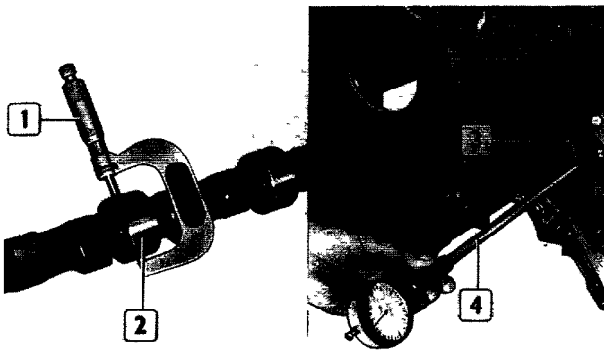


CAMSHAFT DETAILS

(Figure data refer to normal journal diameters)

18083

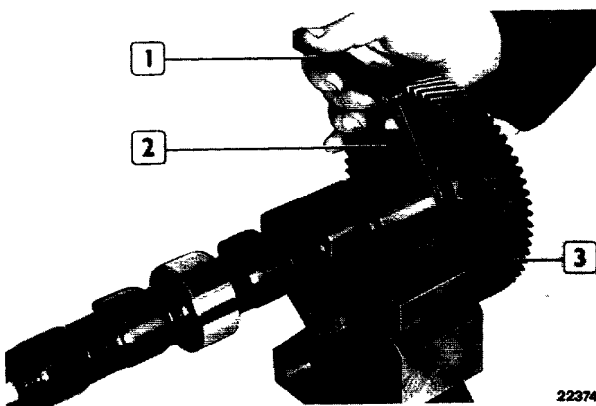
FIGURE 104



22373

To verify assembly clearance, use micrometer gauge (1) to measure camshaft pin (2) section and bore gauge (4) to measure bushings (3) internal section. The difference between measured values indicate actual assembly clearance, that must be 0.060 to 0.230 mm at front support and 0.100 to 0.160 mm at intermediate and rear supports. Should clearance be larger, replace bushings and even camshaft if necessary.

FIGURE 105



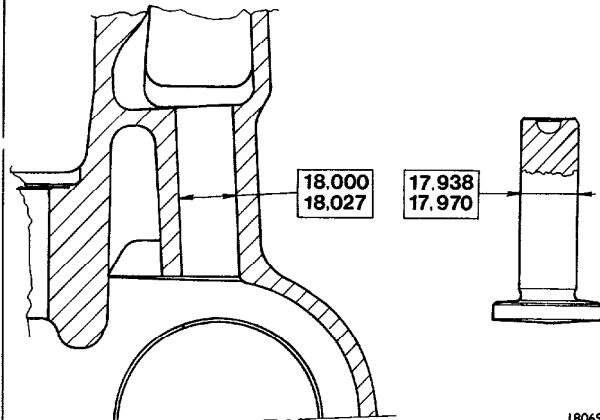
22374

Use feeler gauge (1) to check clearance between plate (2) retaining camshaft on cylinder block and control gear (3) which must be 0.130 to 0.340 mm.

Also check that gear teeth are not broken or worn-out. If the gear (3) has to be replaced, before installation warm it up to 200°C and install it so that the distance between camshaft shoulder and gear shoulder is $8^{+0.1}_{-0.05}$ mm.

TAPPETS

FIGURE 106



18069

TAPPETS AND TAPPET HOUSINGS ON CYLINDER BLOCK - DETAILS

FIGURE 194



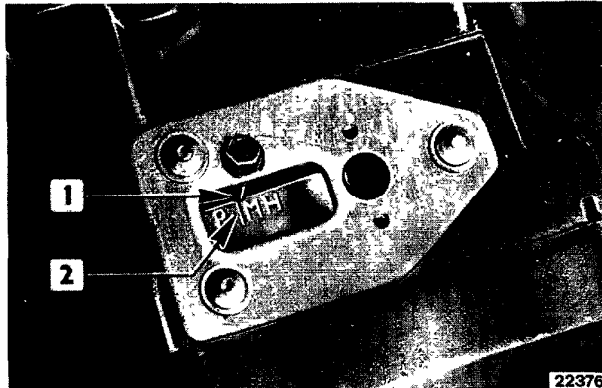
Should tappet clearance in their housings be excessive, install oversized tappets and bore housings (2) by means of specific reamer (1). Spare tappets are supplied standard and oversized by 0.5 - 1 mm.

VALVE TIMING CONTROL

Check gears for damages or dents. Worn-out or damaged gears must be replaced.

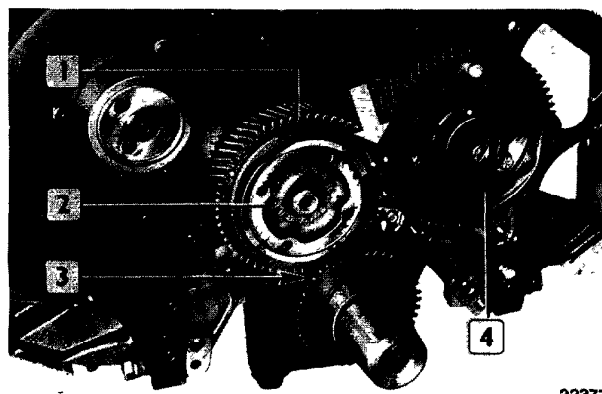
Time valve timing control as follows:

FIGURE 108



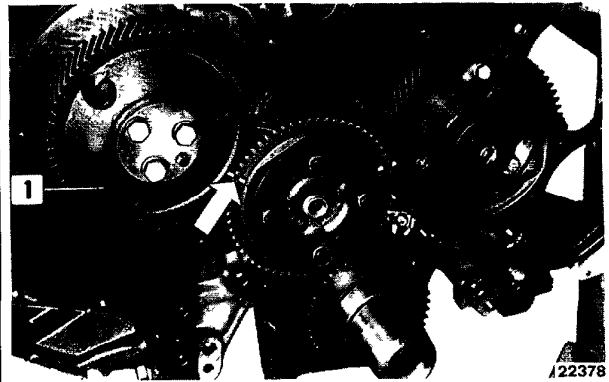
- rotate crankshaft until mark BDC (PMH) (2) in flywheel is coinciding with reference mark (1) in the slot of rear support;

FIGURE 109



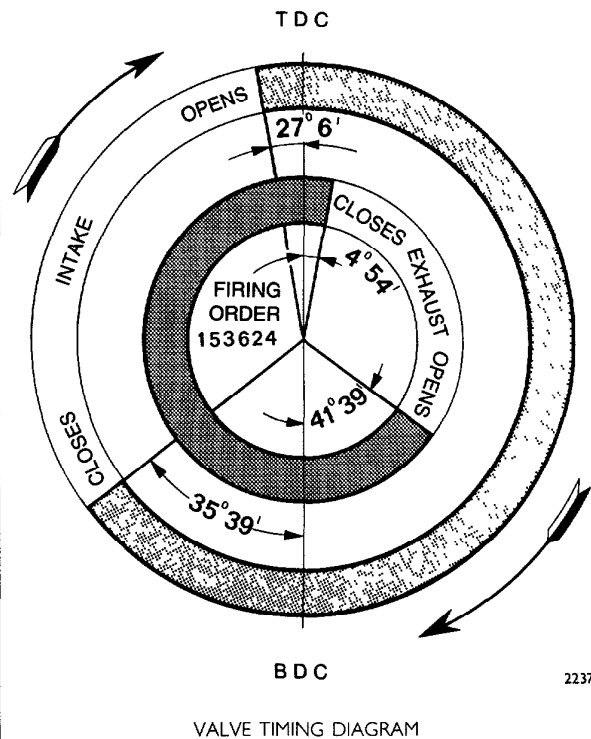
- install idle gear (1) complete with support (2) so that its reference marks coincide with those on the gears of camshaft (4), and crankshaft (3)

FIGURE 110



- key, always keeping reference marks (arrow) of injection pump gear control (1) coincident

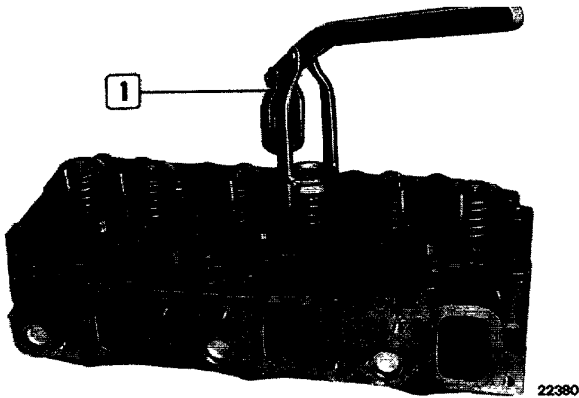
FIGURE 111



CYLINDER HEADS

With suitable equipment close all cooling fluid inlets. Introduce water heated to 90°C and at a pressure of 4 to 5 kg/cm². No leak should be noticed. In the negative, replace cylinder head

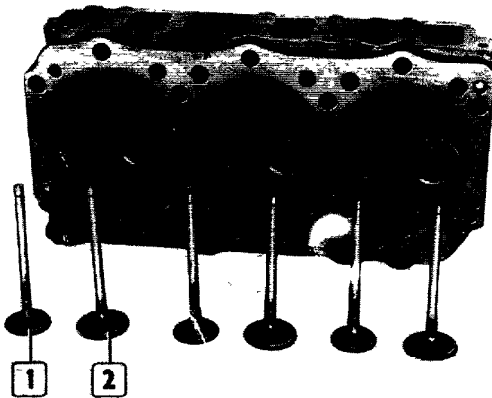
FIGURE 112



22380

Valve removal/insertion from cylinder heads by means of tool 99360138 (1). When installing, lubricate valve stem with engine oil.

FIGURE 113

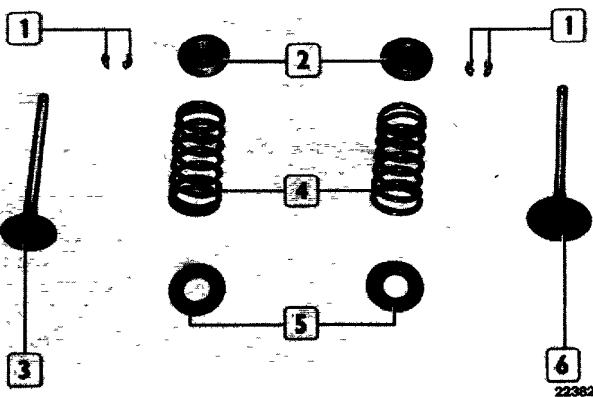


22381

CYLINDER HEADS VIEWED FROM BELOW

1 Exhaust valve - 2 Intake valve

FIGURE 114

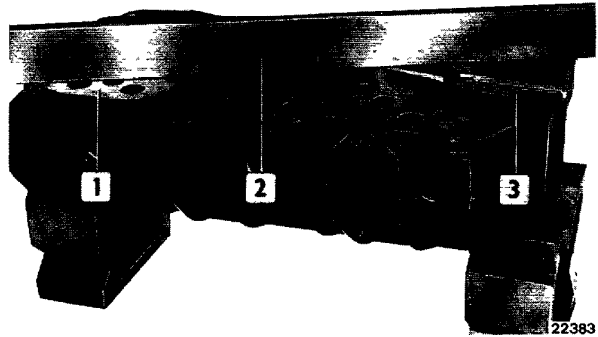


22382

VALVE ASSEMBLY - DETAILS

1 Retaining half washers - 2 Upper caps - 3 Exhaust valve - 4 Valve springs - 5 Lower washer - 6 Intake valve

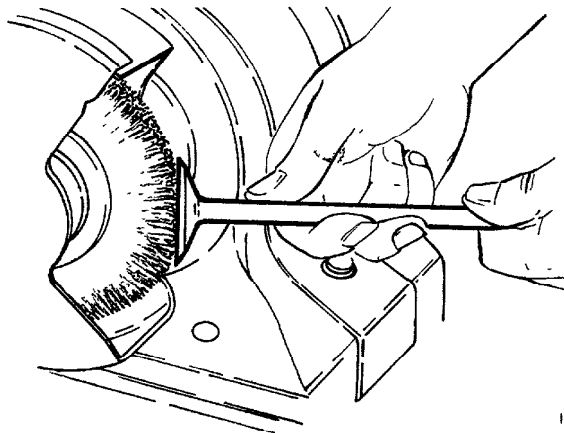
FIGURE 115



22383

Check cylinder head face flatness (1) using a straightedge (2) and a feeler gauge (3) as indicated in the figure. If flatness errors exceeding 0.15 mm are detected, proceed to dress the head by means of a surface grinder.

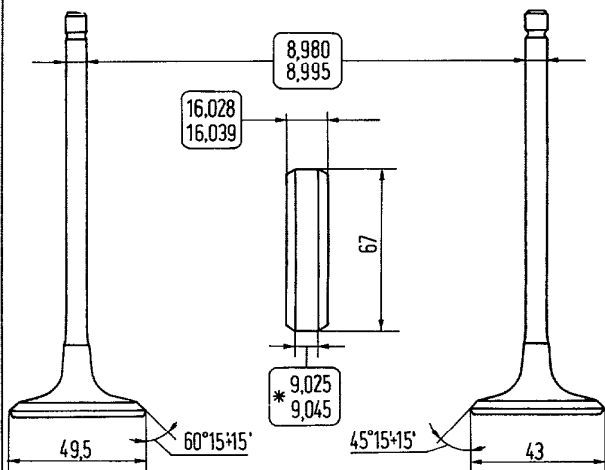
FIGURE 116



16825

Use wire brush to clean valves and check them for seizing, cracks and wear.

FIGURE 117

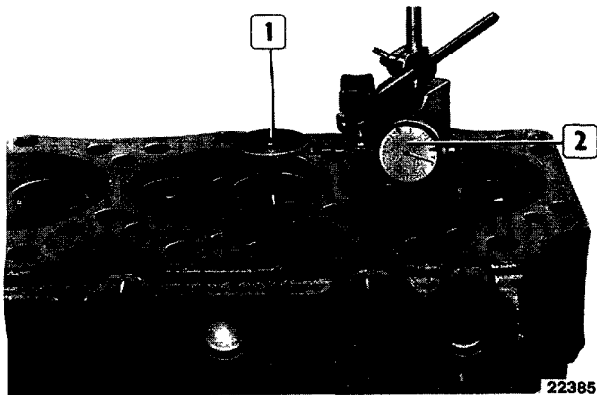


22384

VALVES AND VALVE GUIDE - DETAILS

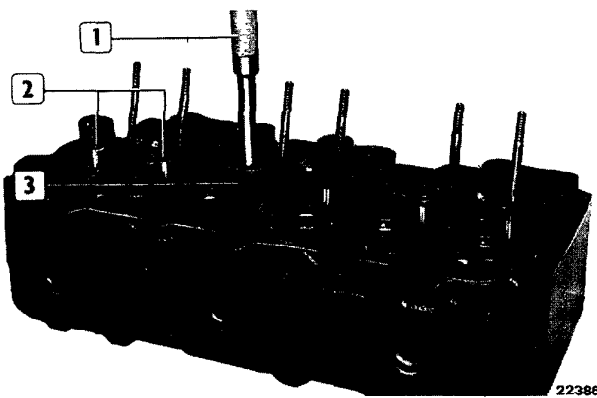
* Measurement after guide valve fit

FIGURE 118



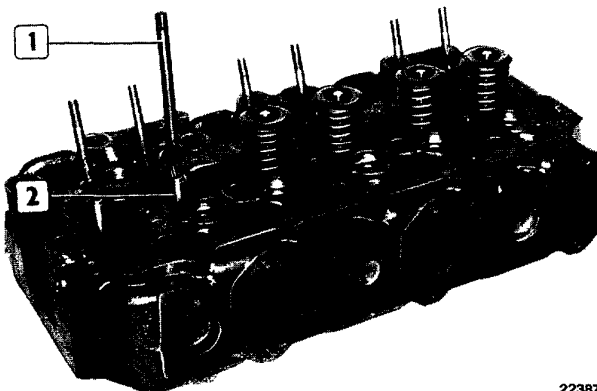
With a magnetic base dial gauge (2) check eccentricity and clearance between valve stem (1) and valve seat. In case of excessive clearance replace valve and valve guide if necessary.

FIGURE 119



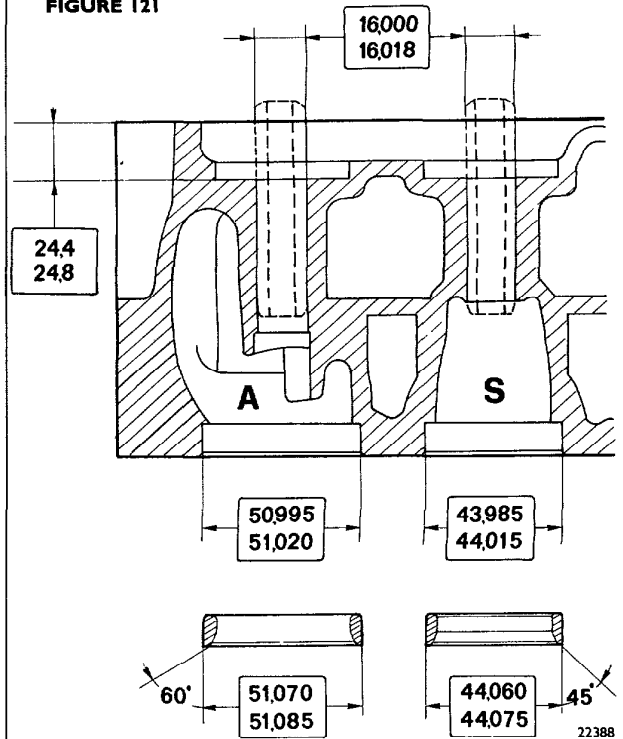
Remove valve guide (3) using tool 99360481 (1). To insert valve guide, use tool 99360481 (1) together with part 99360494 (3)

FIGURE 120



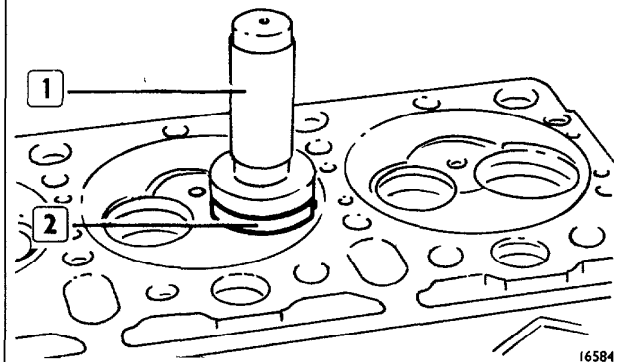
After fitting valve guides, using reamer 99390311 (1) ream valve guide hole (2)

FIGURE 121



CYLINDER HEAD AND VALVE SEAT DETAILS

FIGURE 122

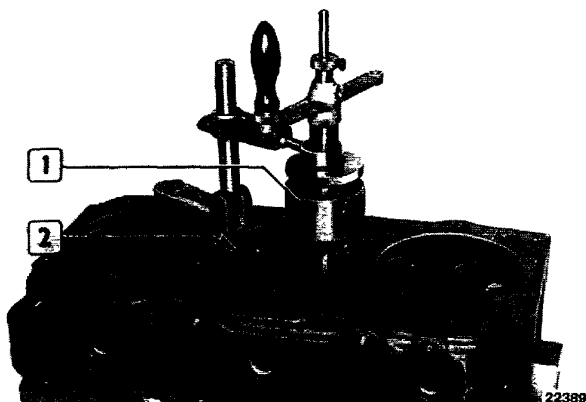


Replace valve seats using the appropriate tools to disassemble.

Cool valve seats (2) in liquid nitrogen tank (-180°C) then insert them in cylinder head using drift (1)

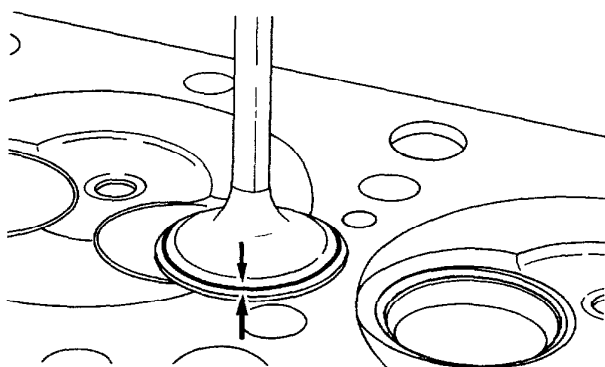
- intake 0.050 to 0.090
- exhaust. 0.045 to 0.090

FIGURE 123



Should valve seats (2) be replaced or be faulty dress valve seats using tool HUNGER 99360419 (1)

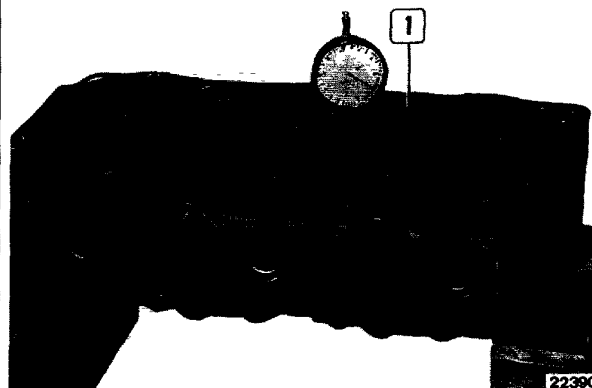
FIGURE 124



Observe the contact line of a valve in its seat, if an off-set contact is detected (arrows) dress seats

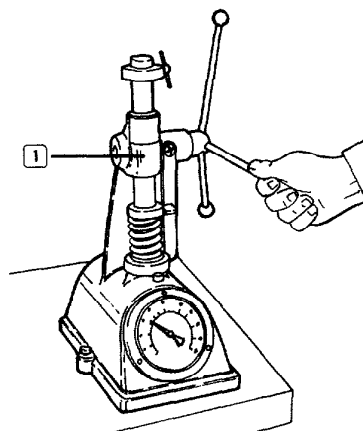
To dress, introduce valve stem into self - centering chuck of grinder 99301014 and direct support so as to grind at an angle of $45^{\circ} 15' + 15'$ for exhaust valves and of $60^{\circ} 15' + 15'$ for intake valves

FIGURE 125



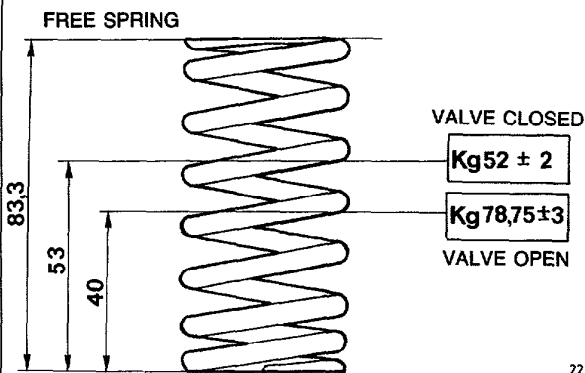
After dressing, check valve installation by means of tool 99370415 (1) From cylinder head face, intake valves must protend by 0.35 to 0.60 mm and exhaust valves must be sunk by 0.80 to 1.05 mm

FIGURE 126



With device 99305049 (1) check that spring load does not exceed the values indicated in the figure 127

FIGURE 127

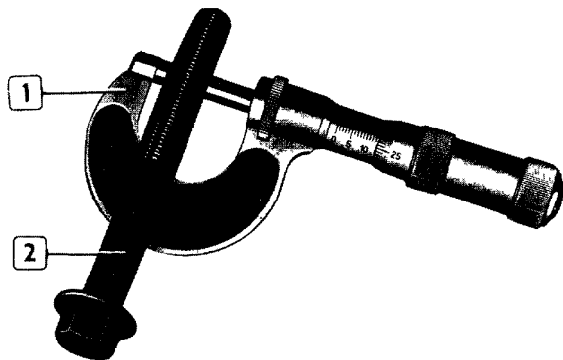


INTAKE AND EXHAUST VALVE SPRING DETAILS

22391

CYLINDER HEAD INSTALLATION

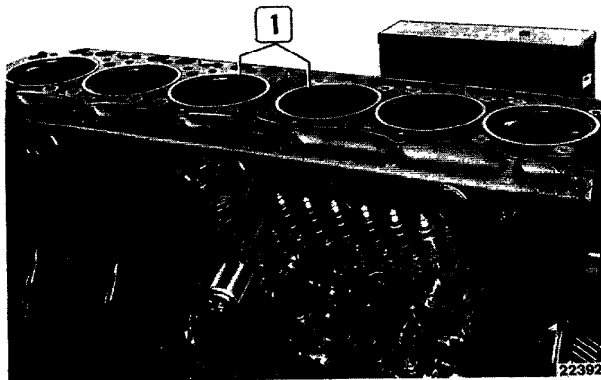
FIGURE 128



21196

Before re-using fastening screws (2) for cylinder heads, use micrometer (1) to check that threaded section is no less than 15.4 mm as measured between values 45 and 70 mm from start of thread. Should measure be different, replace them.

FIGURE 129

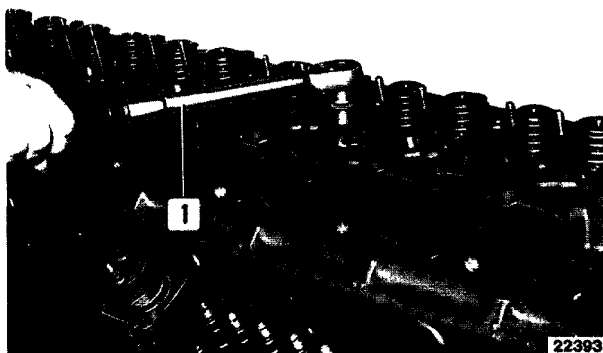


22382

Assemble and fasten cylinder heads as follows:

- position gaskets (1) on cylinder block, install cylinder heads,
- insert screws after lubricating with UTDM oil and tighten according to sequence described in fig 132.

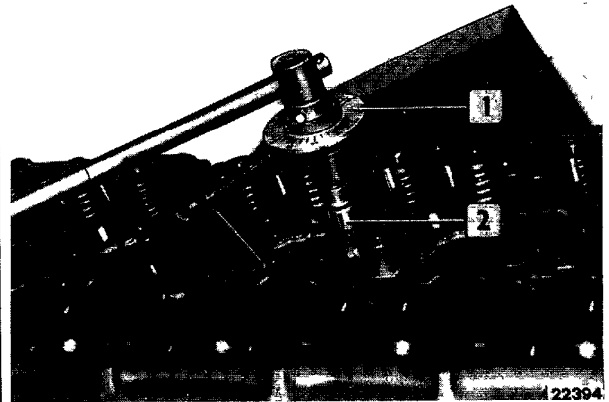
FIGURE 130



22393

- 1st step: use torque wrench (1) to pre - tighten at 100 Nm torque,
- 2nd step: dress at 100 Nm torque,

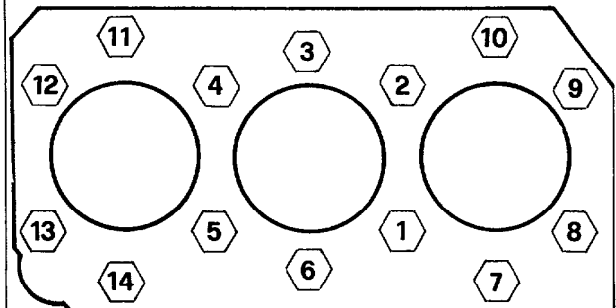
FIGURE 131



22304

- 3rd step. use socket wrench (2) with tool 99395202 (1) and tighten at $180^\circ \pm 5^\circ$ torque angle

FIGURE 132

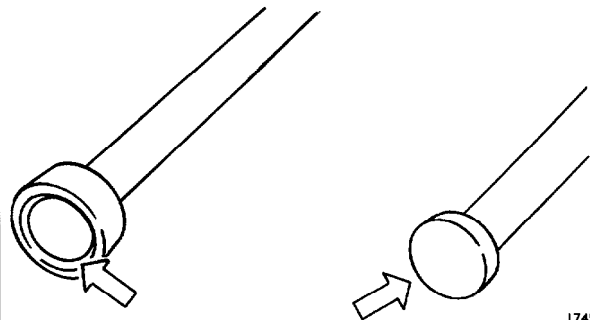


18095

TIGHTENING SEQUENCE OF CYLINDER HEAD FASTENING SCREWS

PUSHRODS - ROCKERS - ROCKER SHAFTS

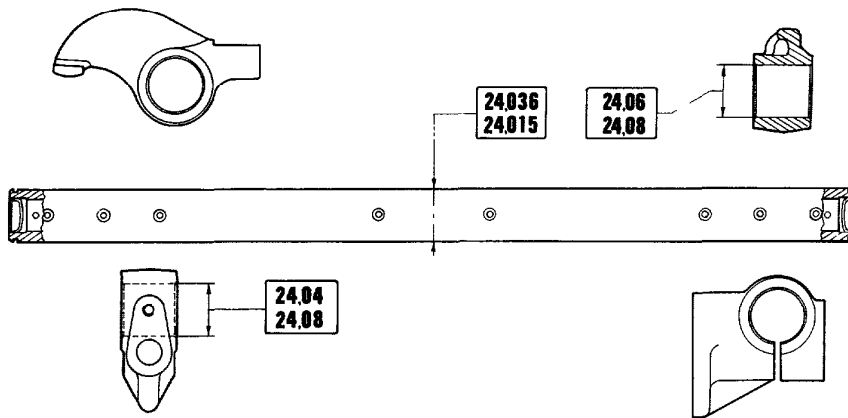
FIGURE 133



17453

Pushrods should be free from distortion, the spherical seats in contact with the rocker adjusting screw and with the tappet (arrows) should not show marks of pick-up or wear. Replace any defective rod, if necessary. Intake and exhaust pushrods are identical and interchangeable.

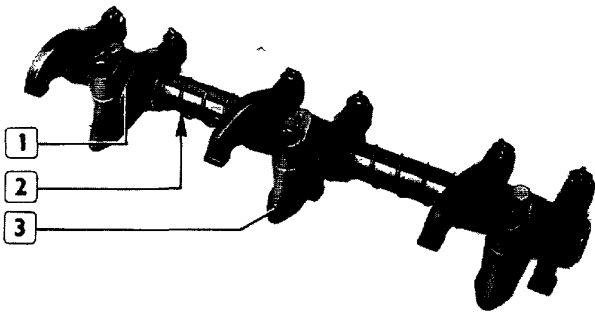
FIGURE 134



22395

BRACKET, ROCKER SHAFT, ROCKER DETAILS

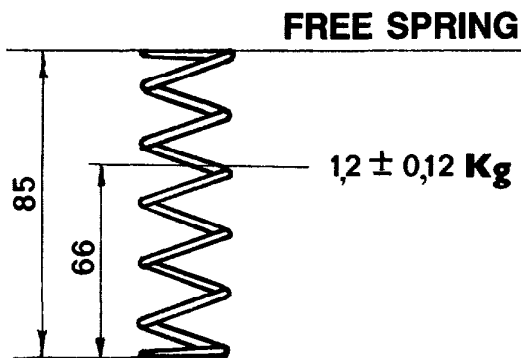
FIGURE 135



22396

Check rockers (1) rocker shafts (2) and brackets (3) for wear, scores or pick-up
Check the cap at the end of each rocker shaft for leakage.

FIGURE 136



18097

SPRING FOR ROCKER SPACER SPRING - CHECKING DETAILS

FIGURE 137



Adjust clearance between rockers and valves using wrench (1), box wrench (2) and feeler gauge (3).
Running clearance is intake 0.25 mm and exhaust 0.50 mm. Bring cylinder to be adjusted at expansion stroke: cylinder valves will be closed while balancing symmetrical cylinder ones.
Symmetrical cylinder are 1-6, 2-5, 3-4.

NOTE - When re-assembling engine, to adjust clearance between rockers and valves faster, proceed as follows. Rotate crankshaft; then:

- balance cylinder No 1 valves, and adjust the valves marked with an asterisk, following the sequence indicated in the scheme:

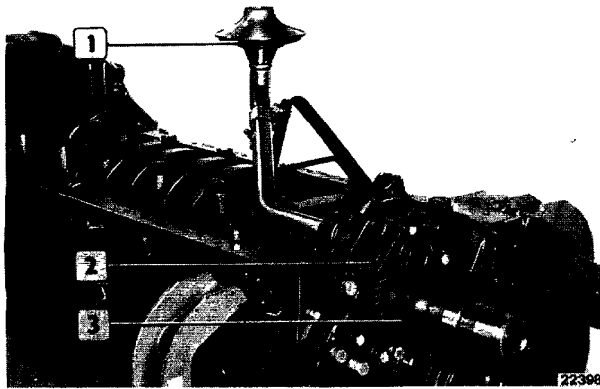
Cylinder No	1	2	3	4	5	6
Intake	—	—	*	—	*	*
Exhaust	—	*	—	*	—	*

- balance valves of cylinder No. 6 and adjust the valves marked with an asterisk, following the sequence indicated in the scheme:

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

LUBRICATION SYSTEM

FIGURE 138



ENGINE WITHOUT OIL SUMP VIEWED FROM BELOW

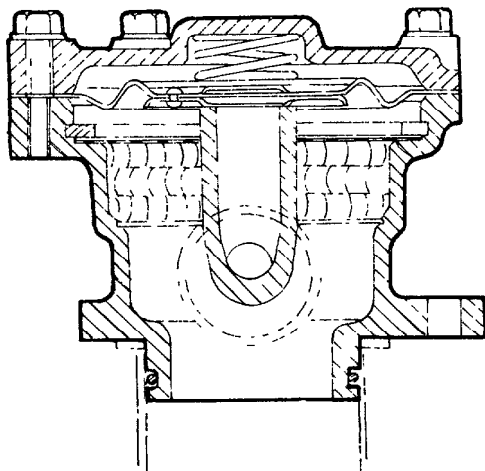
1 Suction rose - 2 Oil pump - 3 Control gear

Engine lubrication is obtained by means of a gear type pump (2) controlled by crankshaft gears. On oil filter housing are fitted relief and by-pass valves. Lubrication pressure (engine warm)

- governed speed bar 4.5 to 6.5
- idle speed bar ≥ 1.1

BREATHER PIPE GOVERNOR

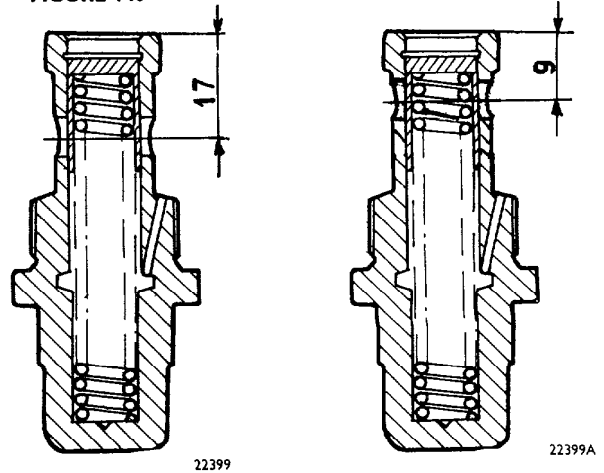
FIGURE 139



BREATHER PIPE GOVERNOR SECTION

Oil vapors which are generated inside the engine during running, get into a breather pipe governor, where a part of them are condensed and again put into circulation, while the other part, is sucked by the engine and burnt. When, inside the breather adjuster, oil vapour pressure exceeds a given value, these vapours are released outside. Breather adjuster does not require overhauling; it is sufficient to clean its whole interior.

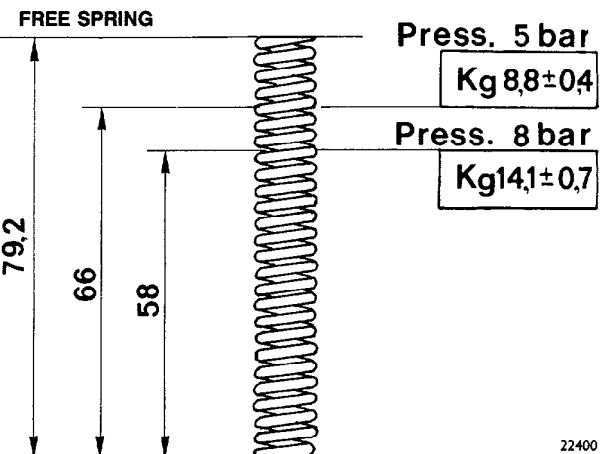
FIGURE 140



SECTION THROUGH OVERPRESSURE VALVE

SECTION THROUGH ADJUSTER VALVE

FIGURE 141



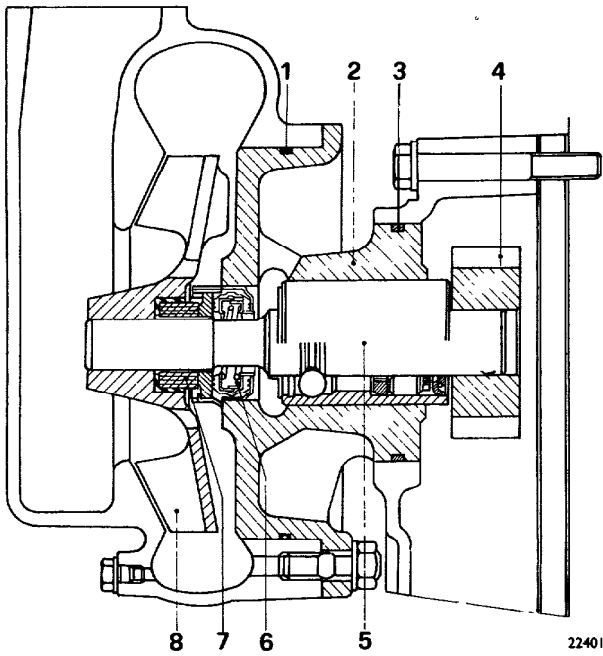
BY-PASS VALVE SPRING CHECK - DETAILS

NOTE - Adjuster and overpressure valves only differ between themselves in the distance of the 4 oilway holes from the valve body edge. For adjuster valve the distance is 9 mm while for overpressure valve it is 17 mm. So make sure not to exchange them on assembly.

COOLING SYSTEM

Engine cooling system consists of a centrifugal pump driven by crankshaft via "V" belts and a fan directly mounted on that same shaft. Two thermostats on cylinder head outlet end control engine running temperature. A multipurpose inhibiting filter provides protection against rust, corrosion and foreign matters.

FIGURE 142



22401

LONGITUDINAL SECTION OF WATER PUMP

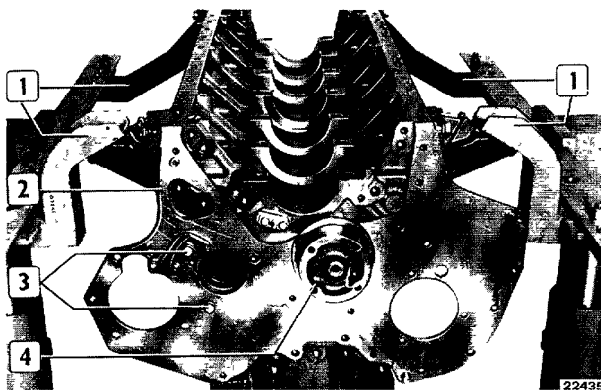
- 1 Seal - 2 Pump body - 3 Seal - 4 Control gear - 5 Bearing - 6 Seal gasket
- 7 Seal ring - 8 Wheel

NOTE — Before washing the engine block, disconnect front plate to avoid damaging it

Engine block lift up and transport is carried out by means of a pair of eyebolts 99360504

ENGINE ASSEMBLY

FIGURE 35

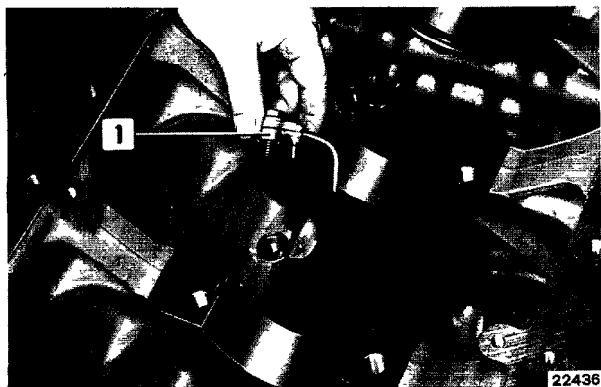


Install engine block on rotating stand 99322230 using brackets 99361032 (1) Insert cylinder sleeves and check their position as to the engine block as described in the relevant paragraph.

Install camshaft bushings as described.
Place rear seal cap, previously coated with sealant

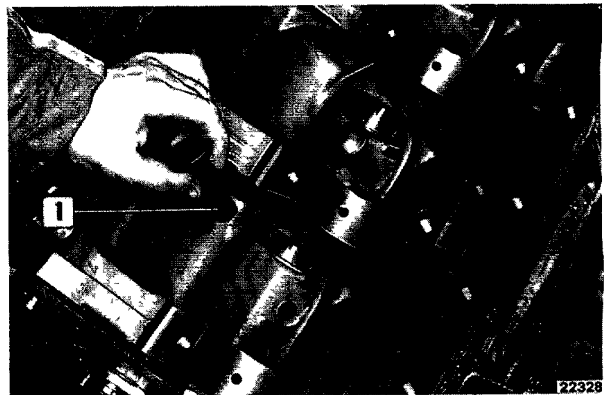
NOTE - When assembling front plate (2), so as to position exactly, key support (4) for intermediate gear in its housing, then tighten screws (3) at prescribed torque

FIGURE 36



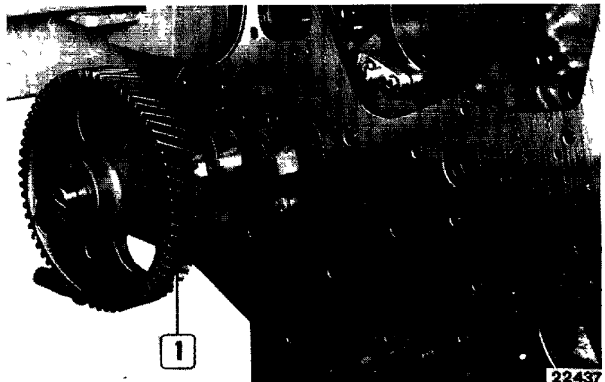
Assemble oil nozzles (1)

FIGURE 37



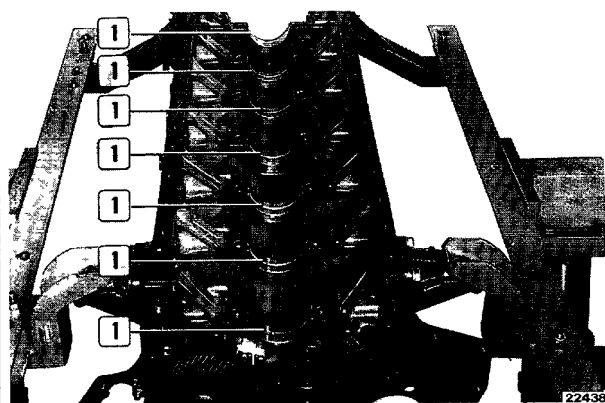
Lubricate tappets (1) and fit in their seats

FIGURE 38



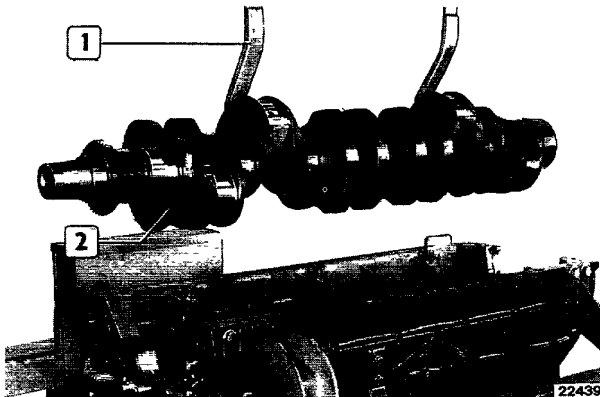
Lubricate camshaft support brackets and install camshaft (1) taking care not to damage support brackets
Fix to front plate by means of specific plate and screws

FIGURE 39



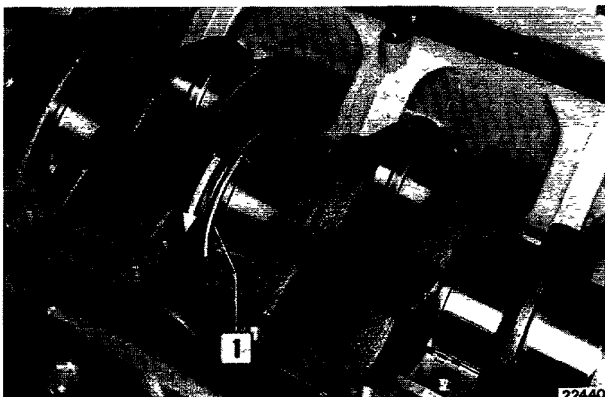
Insert main bearing halves (1) (with lubrication hole) in their housings
Lubricate them

FIGURE 40



Install crankshaft (2) using tool 99360500 (1) and a hoist.

FIGURE 41



On center main bearing place thrust washers (1) with the grooves facing crankshaft shoulder

FIGURE 42



Lubricate bearing halves, insert them on main bearing caps and fit them on the inherent supports, also position thrust washers (2) on center bearing main cap (1)

**NORMS TO ASSEMBLE
SELF-CENTERING
HALF-WASHERS**

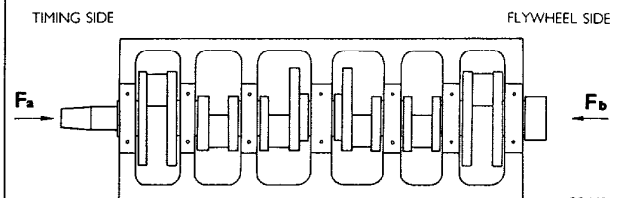
FIGURE 43



Tighten main bearing caps screws (2) at 80 Nm. Loosen the two screws from main center bearing cap (1) and tighten at 15 Nm torque

NOTE - Main bearing cap screws may be re-used until thread dia. is not less than 17.4 mm measured at 50 mm from end

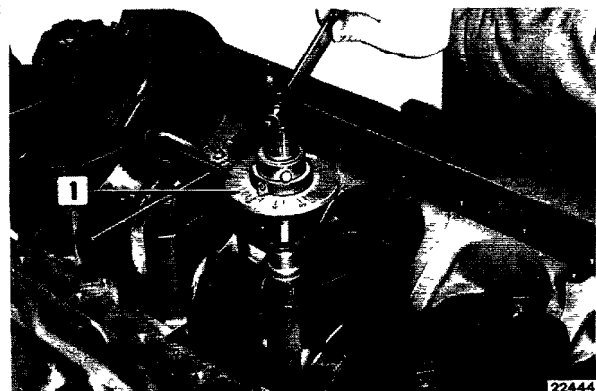
FIGURE 44



Apply 2500 N axial thrust (arrow) on crankshaft front end and release.

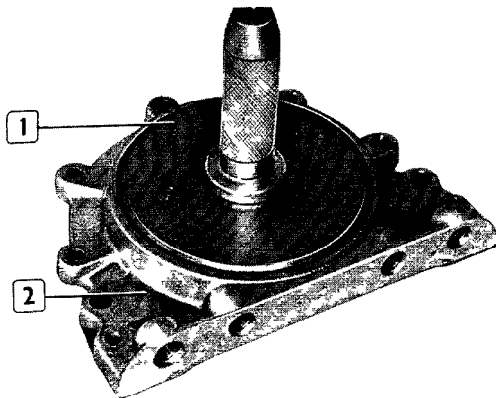
Carry out same operation on crankshaft rear end. Tighten center main bearing cap screws at prescribed torque ($117.5 + 90^\circ \pm 5^\circ$).

FIGURE 45



Finish tightening screws of other main bearing caps using tool 99395202 (1) to tighten at required torque

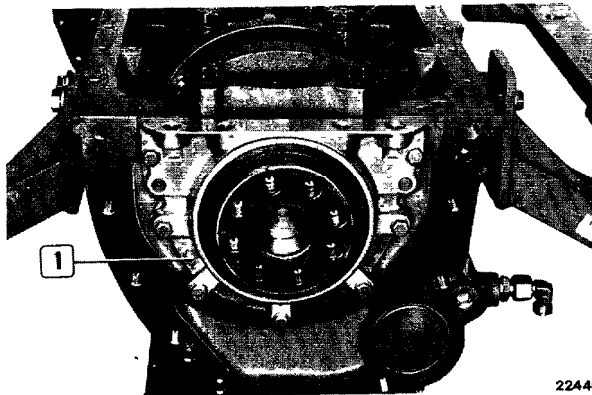
FIGURE 46



22445

Fit the seal ring on rear cover (2) using installer (1)

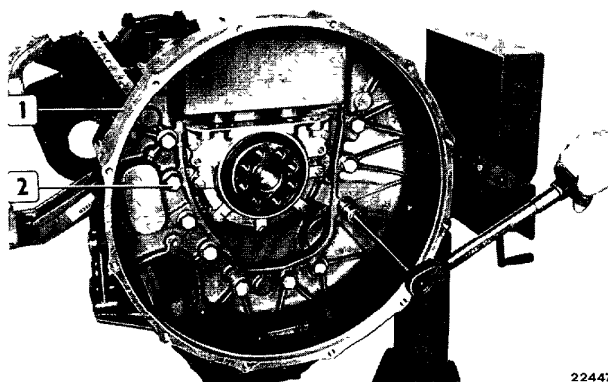
FIGURE 47



22446

Install rear cover (1) and relevant gasket on engine block.

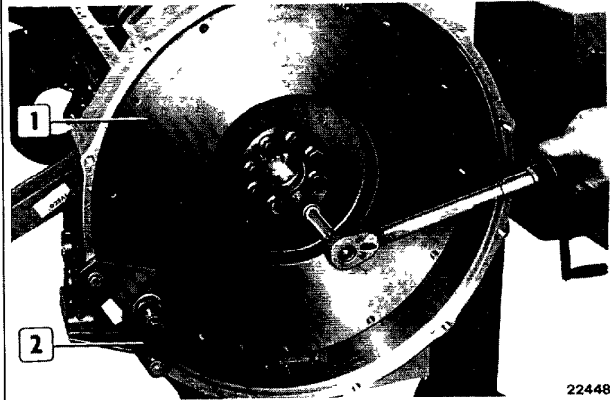
FIGURE 48



22447

Install rear support (1) Screw down screws (2) at 142.5 Nm (14.5 kgm) by means of torque wrench.

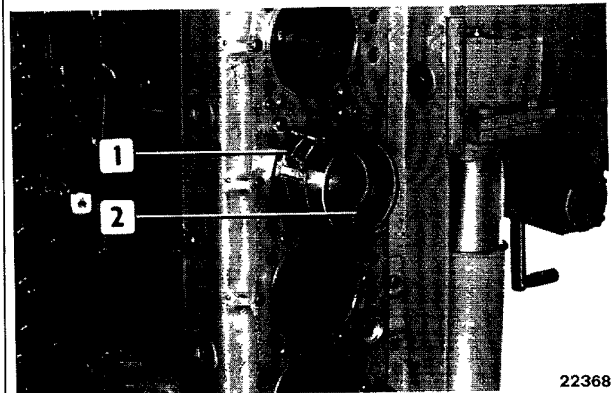
FIGURE 49



22448

Install flywheel (1) and using tool (2) tighten screws as described at relevant paragraph

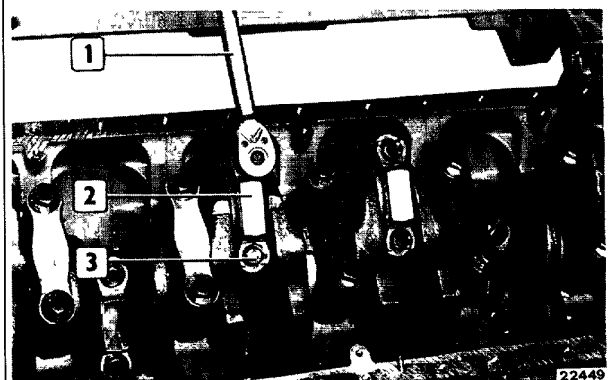
FIGURE 50



22368

Rotate engine block positioning it upright. Insert connecting rod-piston-rings assemblies (2) as indicated in the relevant chapter

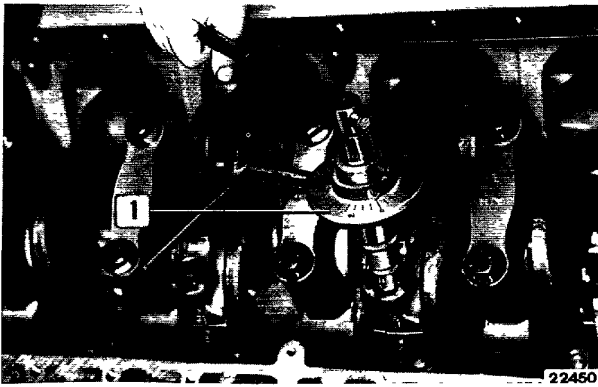
FIGURE 51



22449

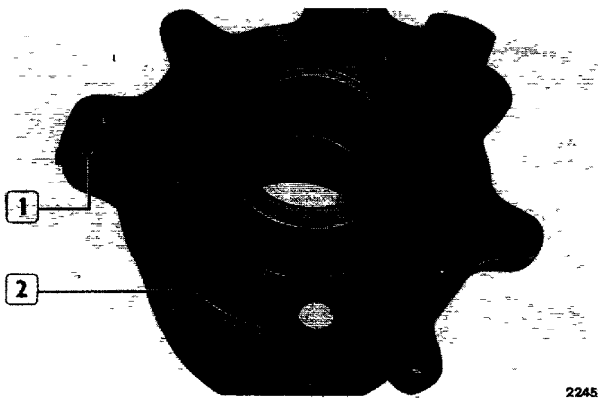
Connect connecting rods to relevant crankshaft journals, insert connecting rod caps (2) with attached bearing halves Tighten screws at a torque of 45 Nm (4.6 kgm) using torque wrench (1)

FIGURE 52



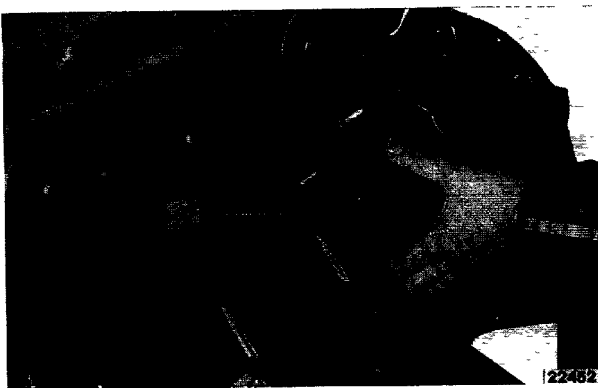
Use tool 99395202 (1) to tighten screws at $90^\circ \pm 5^\circ$

FIGURE 53



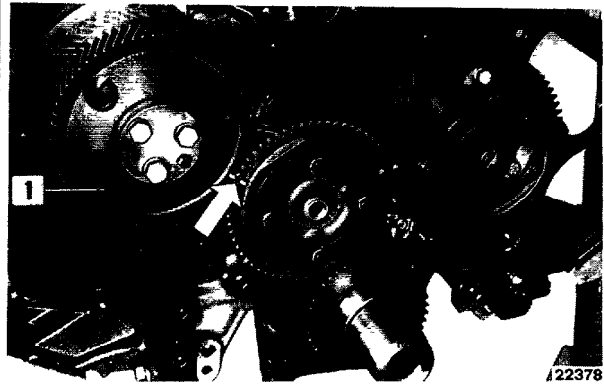
Install injection pump joint support on front plate inserting washers (1 and 2) in between

FIGURE 54



Key injection pump control joint (1)

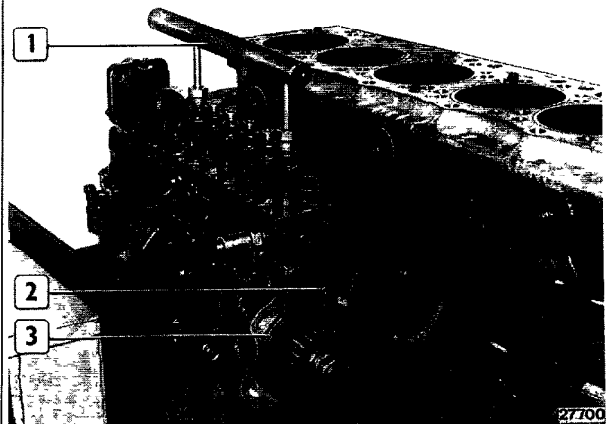
FIGURE 55



Key timing control gears as described

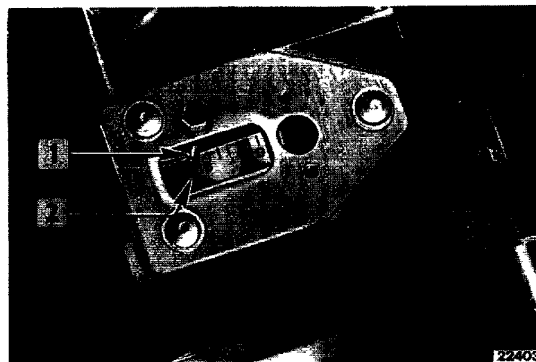
INJECTION PUMP INSTALLATION AND TIMING

FIGURE 56



Use tool 99365136 (1) to key injection pump inserting seal rings (2 and 3)

FIGURE 57

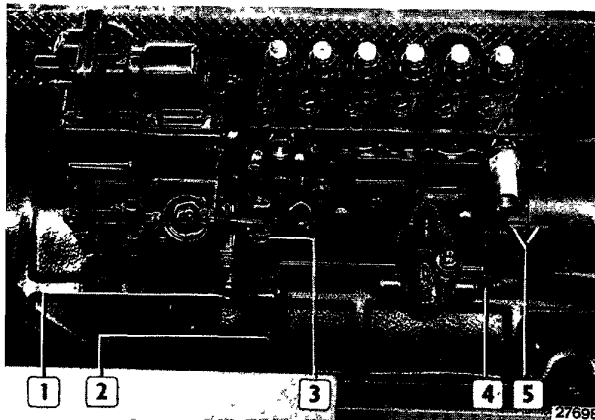


Rotate flywheel until the mark corresponding to injection advance of $25^\circ \pm 30$ (2) is coincident with reference mark (1)

Check that cylinder no 1 valves are closed, in the negative, rotate flywheel by a whole turn

From injection pump remove the inspection cap and rotate pump shaft until the tappet is positioned on beginning of delivery

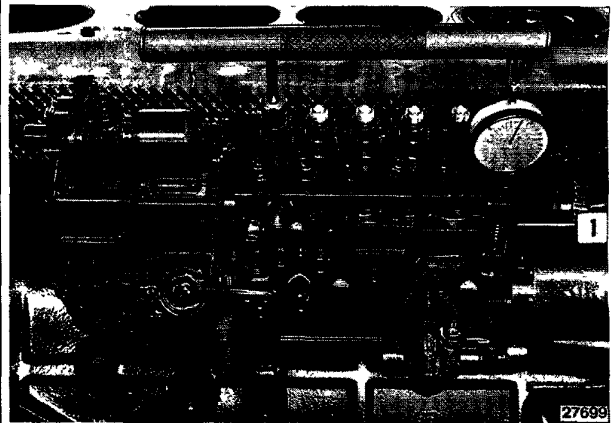
FIGURE 58



Match reference marks (5) scribed when disassembling, fasten injection pump to its support operating as follows.

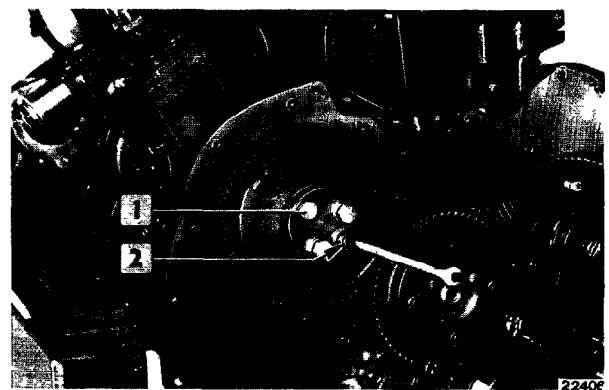
- loosely tighten nuts (4),
- position rear support (1) on cylinder block and loosely tighten the two screws (2),
- loosely tighten screw (3),
- tighten nuts (4) and screw (3) at prescribed torque;
- tighten screws (2).

FIGURE 59



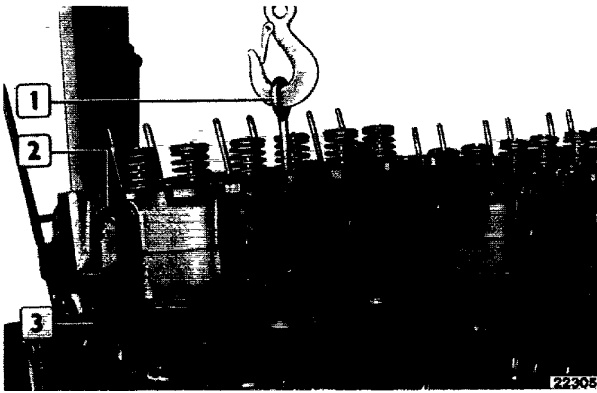
Place on injection pump tool 99365134 (1) with dial gauge and rest tool rod (2) on the top of the tappet
Reset gauge to zero when tappet is on B D C
Rotate flywheel counter-clockwise by about half a turn
Then rotate flywheel in opposite direction and check that, when the mark corresponding to injection advance of $25^{\circ} \pm 30'$ is coincident with the index on the slot, the pumping element has a beginning of delivery prestroke (to be read on dial gauge) 5 to 5,1 mm

FIGURE 60



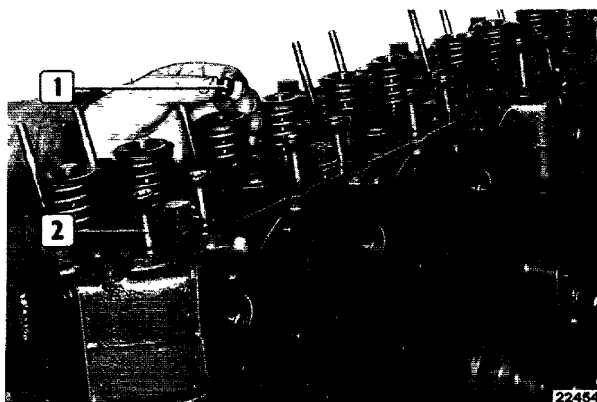
If a different value is detected, loosen screws (1) and position cam (2) so as to obtain the required prestroke. Repeat the check and tighten screws (1)

FIGURE 61



Position seal (3) and assemble cylinder heads using hook 99360510 (1); tighten screws as described

FIGURE 62



Install rocker pushrods (2) and caps (1) on valve stems.

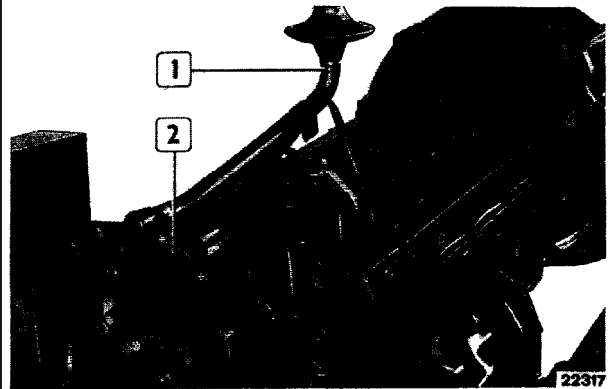
FIGURE 63



Install rocker shaft assemblies as follows. balance cylinder No. 1 valves; install rocker shaft of cylinders 1-2-3, pre-torque screws at 17 Nm (17 kgm), position tool 99395202 (1) and finish tightening at an angle of $180^\circ \pm 5^\circ$

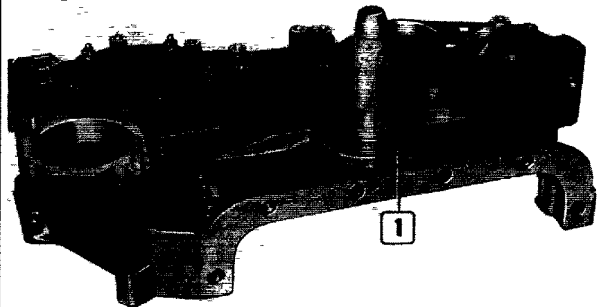
Balance cylinder No. 6 valves and install rocker shaft of cylinders 4-5-6
Tighten screws as before
Adjust rocker - valve clearance as described

FIGURE 64



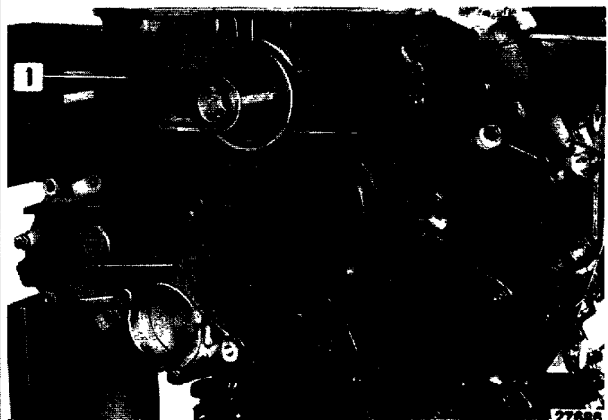
Install oil pump (2) and suction rose (1)

FIGURE 65



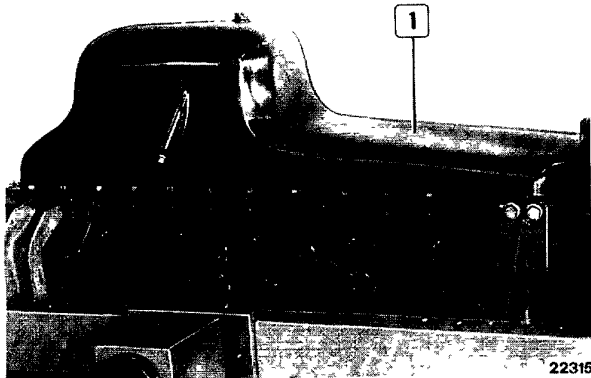
Use specific pusher hammer (1) to install timing cover.

FIGURE 66



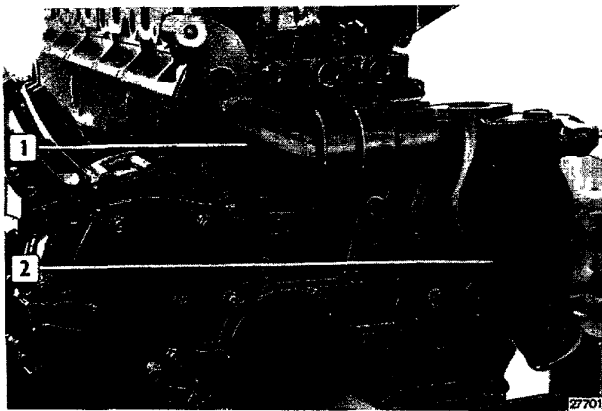
Position gasket and install timing cover (1)

FIGURE 67



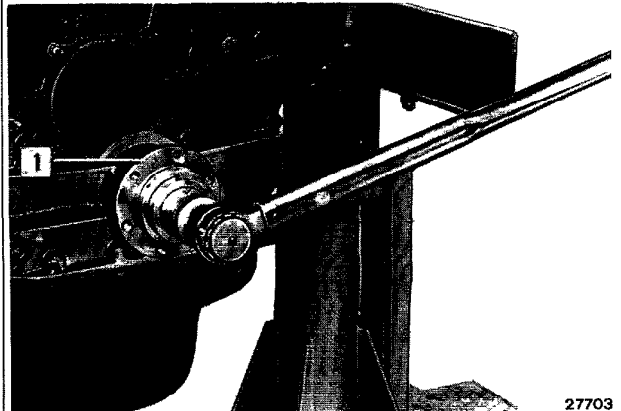
Position seal and install oil sump (1)

FIGURE 68



Install water pump (2) and intake hose (1) inserting gaskets in between

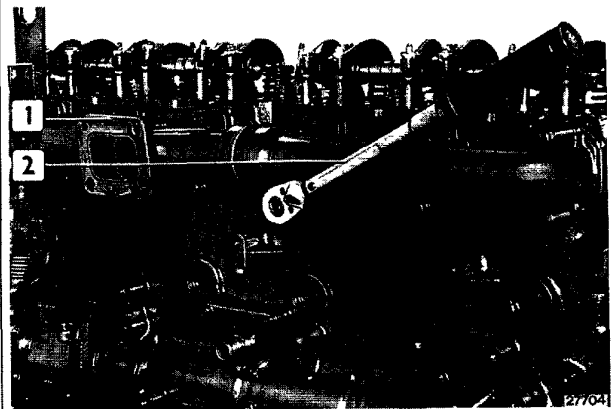
FIGURE 70



Assemble hub (1) of dampening, flywheel, stop crankshaft rotation, tighten screw as follows

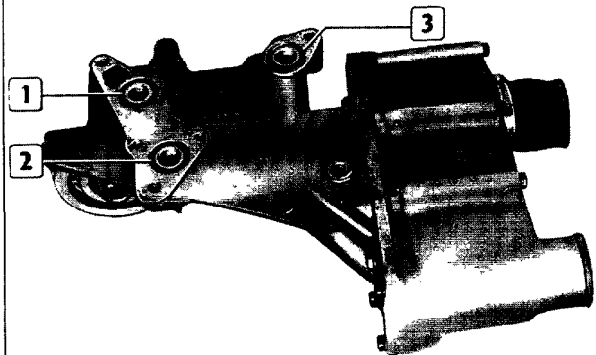
- 1st step: pre-torque of 200 Nm (20.5 kgm)
- 2nd step: torque angle of $90^\circ \pm 5^\circ$

FIGURE 71



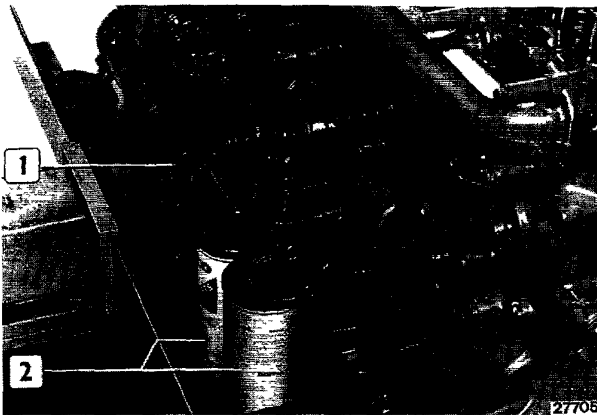
Assemble exhaust manifold (1) inserting gaskets, and use torque wrench (2) to tighten screws at prescribed torque.

FIGURE 72



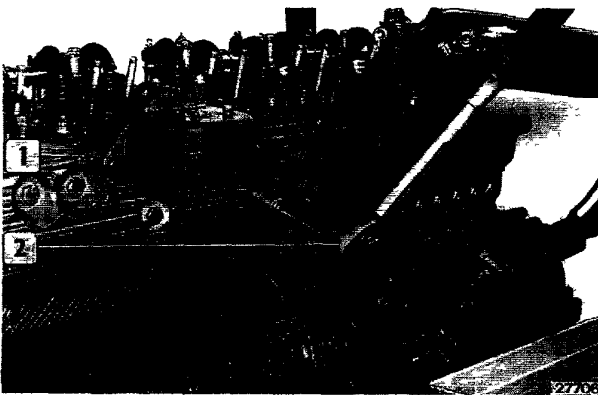
Install seals (1-2-3) on oil filter support and heat exchanger

FIGURE 73



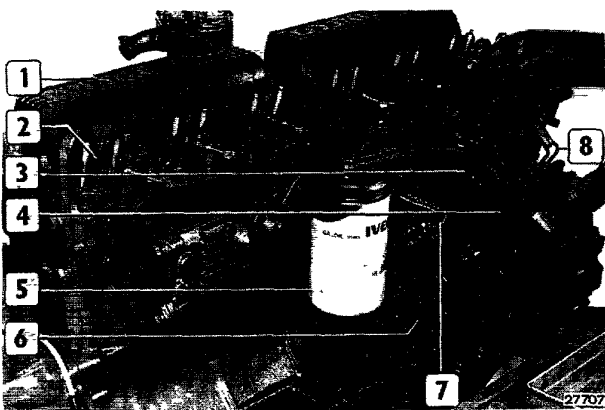
Install heat exchanger (1), tighten oil filters (2) after lubricating gasket

FIGURE 74



Install intake manifold (1) inserting gaskets; use torque wrench (2) to tighten screws at prescribed torque.

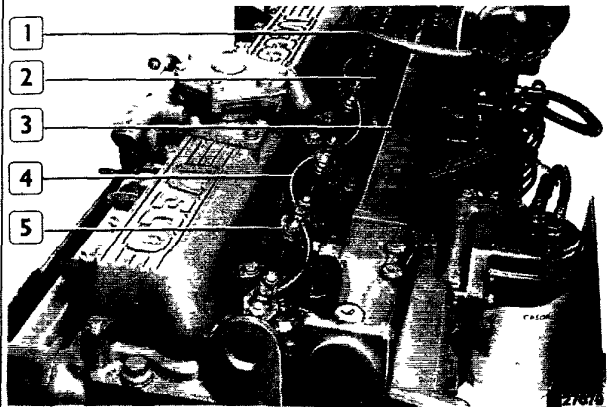
FIGURE 75



Install tappets covers (1), injectors (2) and fuel filter (5). Connect fuel delivery pipes (8) to injection pump (6)

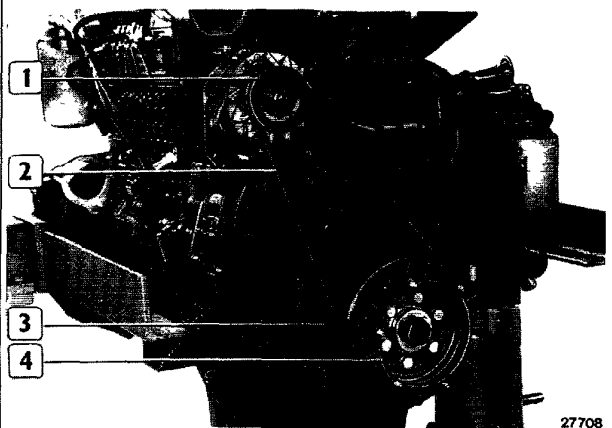
Connect fuel delivery and recovery pipes from filter (3 and 4) and L.D.A device line (7)

FIGURE 76



Fit the cylinder head coolant manifold (3). Fasten injectors by means of brackets (5). Connect fuel delivery (2) and recovery (4) lines Fit pipe (1)

FIGURE 77

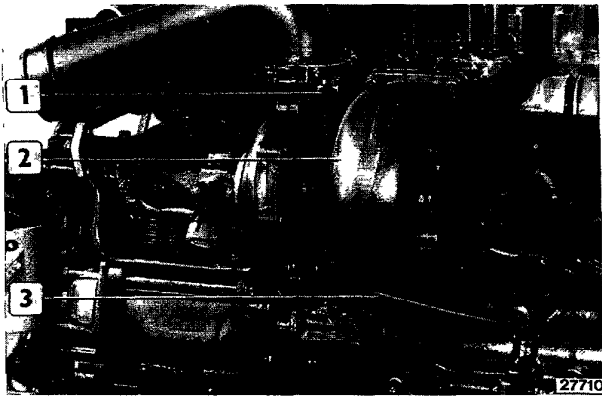


Fit inhibiting filter (5)

Install dampening flywheel (3), control pulley (4), alternator (1), drive belt (2) and tension it. Standard belt yield is 1 cm

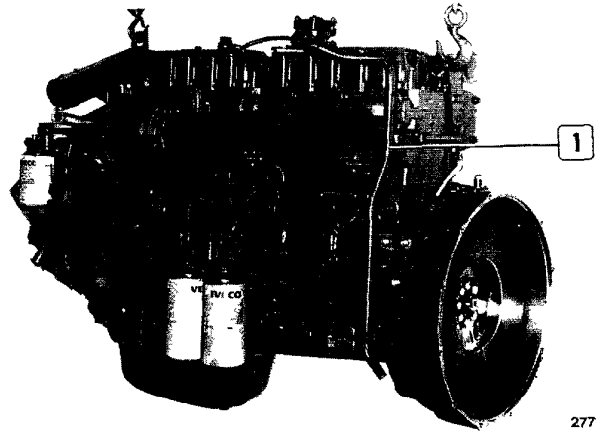
Install viscostatic fan (2), and tighten dipstick sheath (1)

FIGURE 79



Install turbocharger (1), oil delivery line (1) and oil outlet line (3).

FIGURE 80



Remove engine from stand 9932230 disconnecting brackets 99361032 and fit oil vapour breather pipe (1)

TIGHTENING TORQUE DATA

DESCRIPTION	TORQUE Nm (kgm)
Capscrew, cylinder heads ▲ <input type="checkbox"/> 1st stroke pre-torque <input type="checkbox"/> 2nd stroke pre-torque <input type="checkbox"/> 3rd stroke torque-angle	100 (10.2) 100 (10.2) 180° ± 5°
Capscrew, main bearing caps ▲ <input type="checkbox"/> pre-torque <input type="checkbox"/> torque angle	117.5 (11.9) 90° ± 5°
Nut, connecting rod caps ▲ <input type="checkbox"/> pre-torque <input type="checkbox"/> torque angle	45 (4.6) 90° ± 5°
Capscrew, flywheel ▲ <input type="checkbox"/> pre-torque <input type="checkbox"/> torque angle	100 (10.2) 60° ± 5°
Capscrew, flywheel housing	142.5 (14.5)
Capscrew, pulley to crankshaft ▲ <input type="checkbox"/> pre-torque <input type="checkbox"/> torque angle	200 (20.4) 90° ± 5°
Capscrew, intake manifold	32.5 (3.3)
Capscrew, exhaust manifold	33 (3.4)
Capscrew, turbocharger to exhaust manifold	37.5 (3.8)
Nut, injection pump	105 (10.7)
Nut, driving hub	52.5 (5.3)
Capscrew, rocker shaft supports <input type="checkbox"/> pre-torque <input type="checkbox"/> torque angle	17 (1.7) 180° ± 5°

▲ Before tightening, cover thread with UTDM oil

SPECIAL TOOLS

TOOL NO.	DESCRIPTION
99342145	Remover, injector sleeve
99350071	Socket wrench (19 mm) with 3/4" square attachment to tighten cylinder head screws
99350108	Wrench, tappet adjustment
99360138	Remover/installer, engine valve
99360184	Pliers, expander, engine piston ring
99360314	Remover/installer, cartridge filter
99360320	Rotator, on-vehicle crankshaft
99360351	Retainer, flywheel assembly
99360423	Installer, crankshaft front gasket (use with 99370006)
99360471	Connection, engine cylinder compression test (use with 99395682)
99360475	Remover/installer, injection pump bushing on camshaft support (use with 99370000)
99360481	Remover, valve guide
99360494	Installer, valve guide (use with 99360481)
99360500	Lifter, crankshaft
99360504	Eyebolt, lift, engine block
99360585	Rocking sling, engine
99360603	Compressor, standard and oversize piston installation in cylinders
99360772	Plate, threaded
99360776	Stud, set
99360778	Screw, forcing
99360782	Ring
99360790	Parts, set
99361032	Bracket, engine to revolving stand 99322230
99365063	Upsetter, injector sleeve
99370006	Handle, driver, interchangeable
99370415	Gauge, cylinder sleeve protrusion
99374225	Installer, crankshaft rear gasket (use with 99370006)
99390311	Reamer, valve guide hole
99390788	Tap, set, to thread injector sleeve
99394017	Reamer, injector sleeve lower portion (use with 99394019)
99394019	Pilot bushing
99394020	Remover, residual from injector sleeve (use with 99394019)