

# 12 - ENGINE

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## 12 - ENGINE

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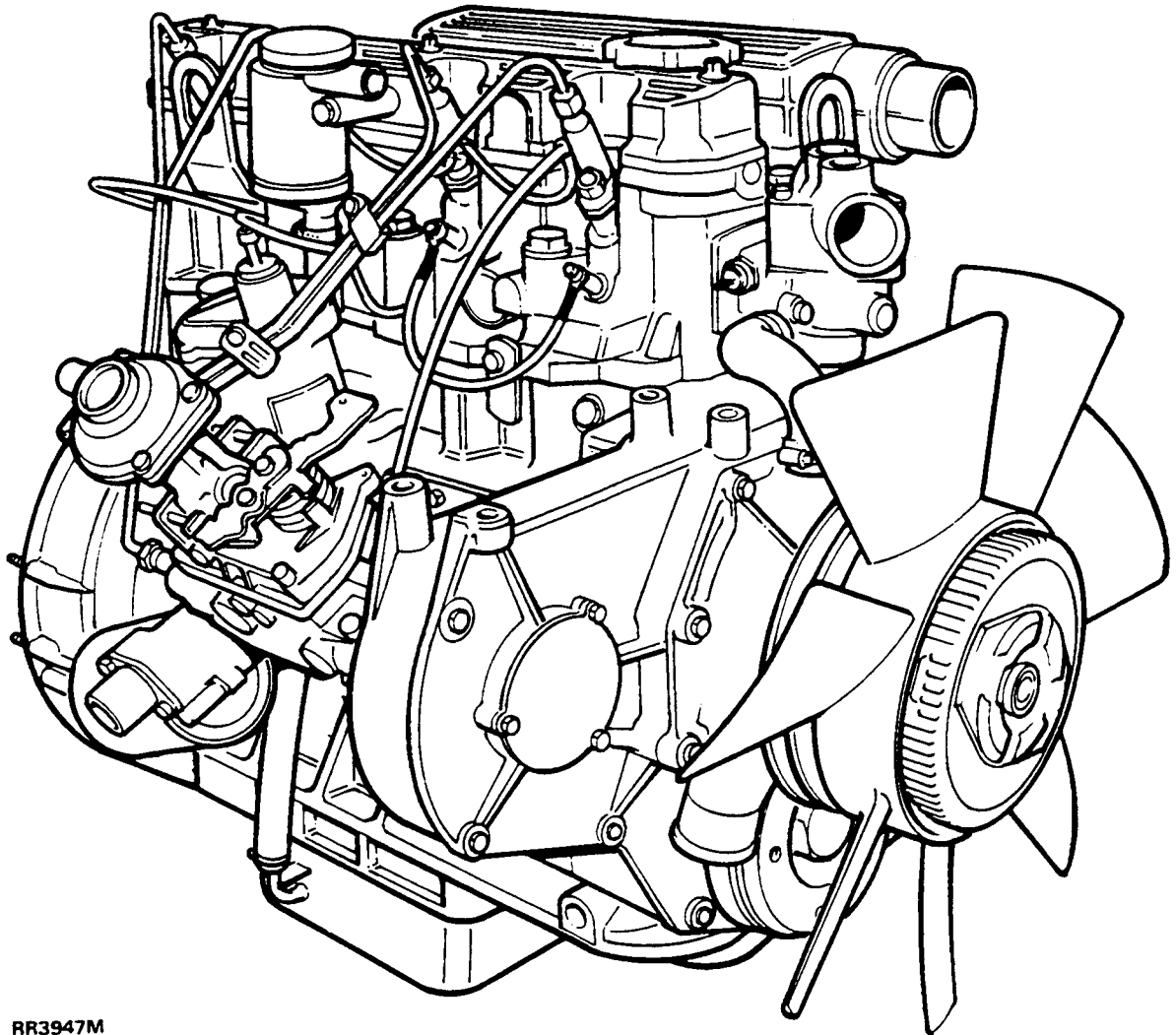
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**DESCRIPTION**


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RR3947M

**200 Tdi engine**

The four cylinder turbocharged direct injection engine is an optional power unit for both Range Rover and Discovery.

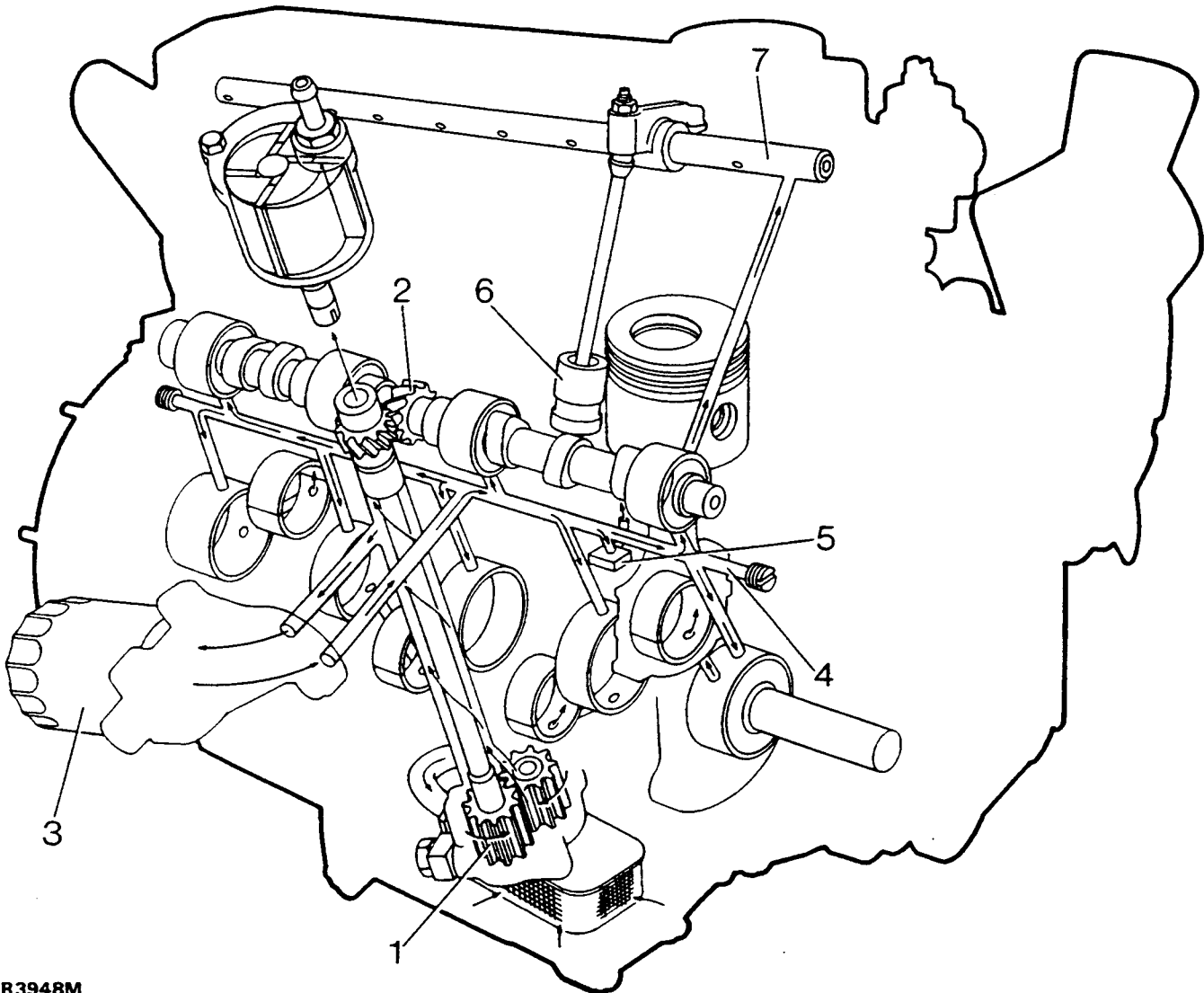
The engine consists of three main castings, cylinder block, ladder frame and cylinder head. The cast iron cylinder block includes the integral cylinders, line bored main bearing locations and caps and bearing locations for support of the camshaft. The cast aluminium ladder frame is bolted to the bottom face of the cylinder block, providing additional rigidity and noise suppression.

The cast aluminium cylinder head is secured to the cylinder block with eighteen bolts. The head gasket is selected from three different thicknesses to ensure optimum combustion efficiency and performance.

Crankshaft end float is controlled by two selective half thrust washers, one each side of the centre main bearing.

The roller tappet camshaft and fuel injection pump are driven off the front of the crankshaft by a totally enclosed toothed rubber timing belt.

## Lubrication system - RR3948M



RR3948M

The lubrication system employs a submerged gear type oil pump (1) driven by the camshaft and skew gear (2). Oil drawn into the gears through the steel gauze filter is pumped up the cavity between the pump body and the vertical drive shaft to the external oil filter (3).

After passing through the filter, the oil flows through the distribution oil gallery (4) and drillings in the cylinder block to lubricate the crankshaft main and big end bearings and the camshaft bearings. The thrust side of each cylinder is lubricated direct from the distribution gallery by separate oil jet tubes (5).



Lubrication to the front camshaft bearing continues through more drillings in the cylinder block to lubricate the roller tappets (6). The rocker shaft (7) is lubricated via a vertical drilling in the cylinder head. The clearance around the pushrods and large ports in the camshaft chamber allows oil drainage to lubricate the skew gear and return to the sump.

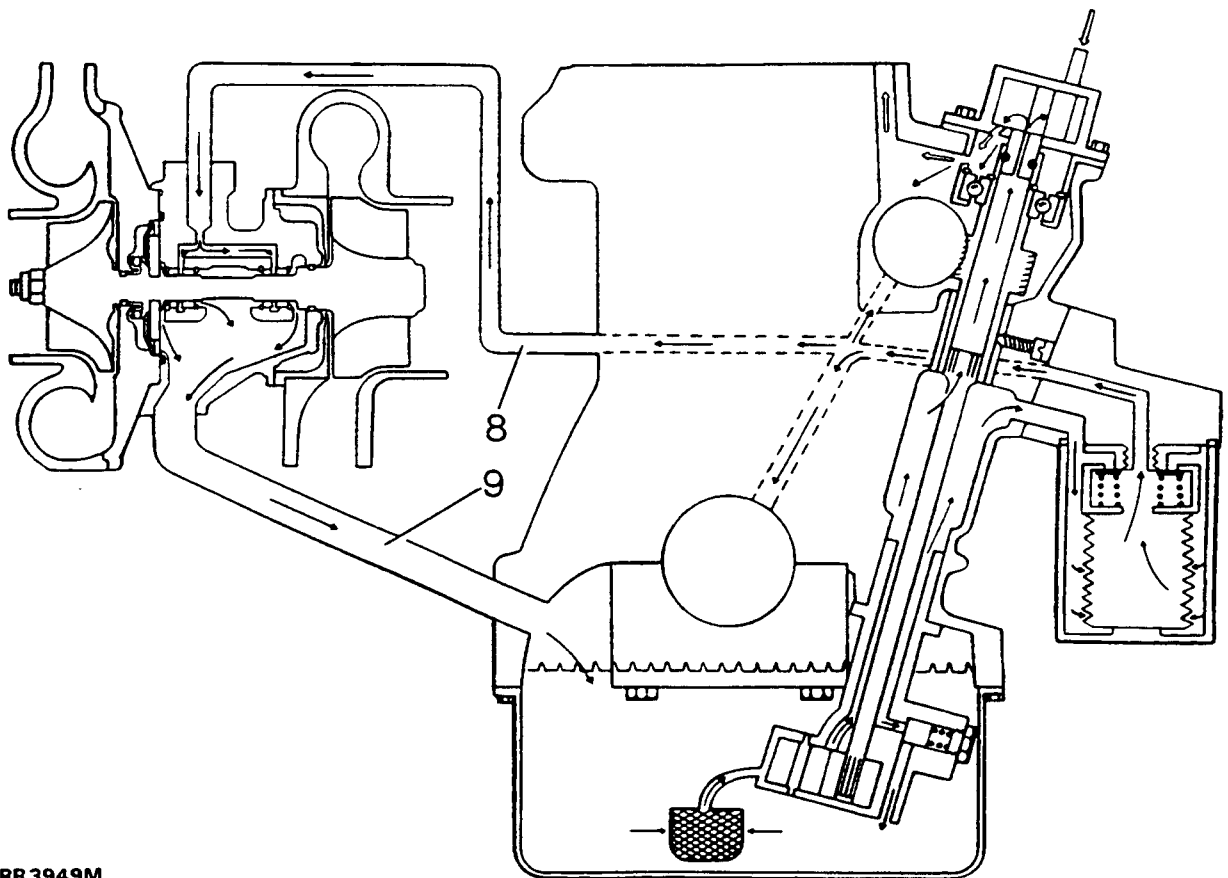
Three of the four camshaft bearing lubrication drillings in the cylinder block are drilled externally. These drillings which are visible on the right hand side of the block are blanked off by each bearing and sealed using an aluminium plug and silicon sealant.

The oil which is pumped up between the vertical drive shaft and pump body is unfiltered. This oil lubricates the skew gear bush and passes through the centre of the skew gear to lubricate the brake servo vacuum pump.

System pressure is controlled by a non adjustable pressure relief valve located in the pump body.

### Turbocharger lubrication - RR3949M

The turbocharger bearings are lubricated with filtered oil from the gallery in the cylinder block (8) at pump pressure. After lubricating the bearings the oil returns to the sump via a large diameter drain hose (9). As the turbocharger bearings are subject to extremely high speeds and temperatures, it is essential that they are well sealed, cooled and lubricated.



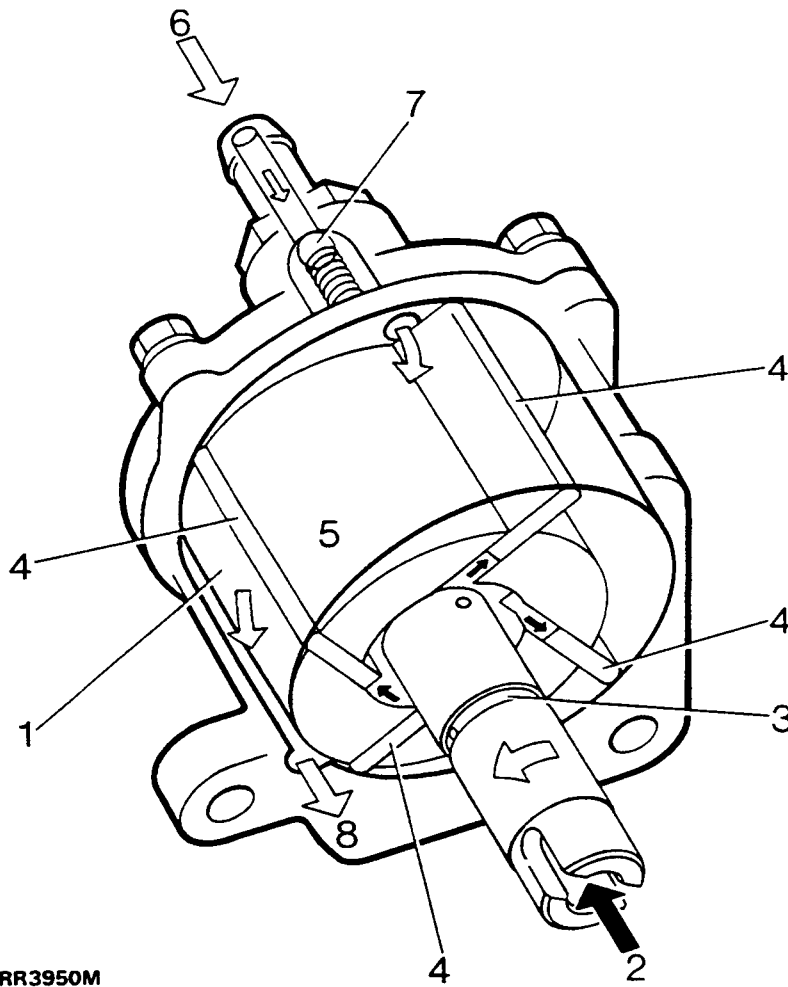
RR 3949M

Brake servo vacuum pump - RR3950M

Lubrication

The brake servo vacuum pump rotor (1) is lubricated with unfiltered oil direct from the engine oil pump. Oil is supplied via the centre of the skew gear (2), where it lubricates the vacuum pump shaft (3) and is fed into slots behind each of the four carbon vanes (4).

Oil pressure behind the vanes exerts a force which ensures that they follow the contours of the pump chamber (5) to form a good seal. An 'O' ring is fitted inside the hollow skew gear to form a seal with the pump shaft to prevent pressure leakage. The condition of this 'O' ring should be checked if low oil pressure occurs, before continuing with any further diagnosis.





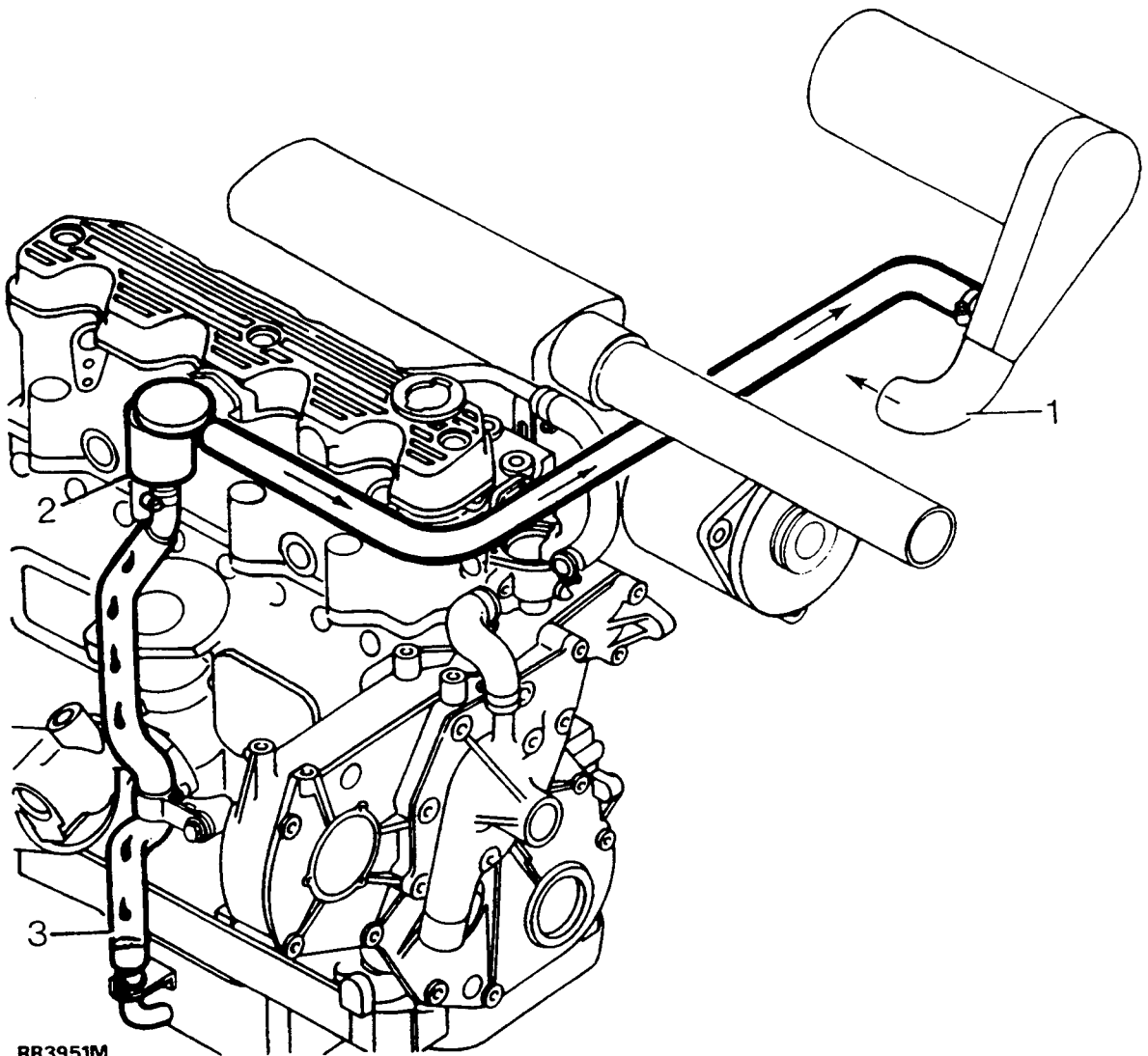
## Operation

With the brake servo hose connected and the vacuum pump operating, the pump will be producing a depression ready to operate the brakes. Each time the brakes are applied and released the pump will draw a small volume of air (6) from the servo chamber past valve (7) and discharge it through the pump outlet (8) into the cylinder block. Provided the vacuum pump is not pumping an excessive volume of air, the crankcase ventilation system will not be affected. However, if the engine is operated with a faulty brake servo, damaged or disconnected vacuum hose, the pump can force an uncontrolled volume of air into the crankcase ventilation system causing pressure build up.

## Crankcase ventilation system - RR3951M

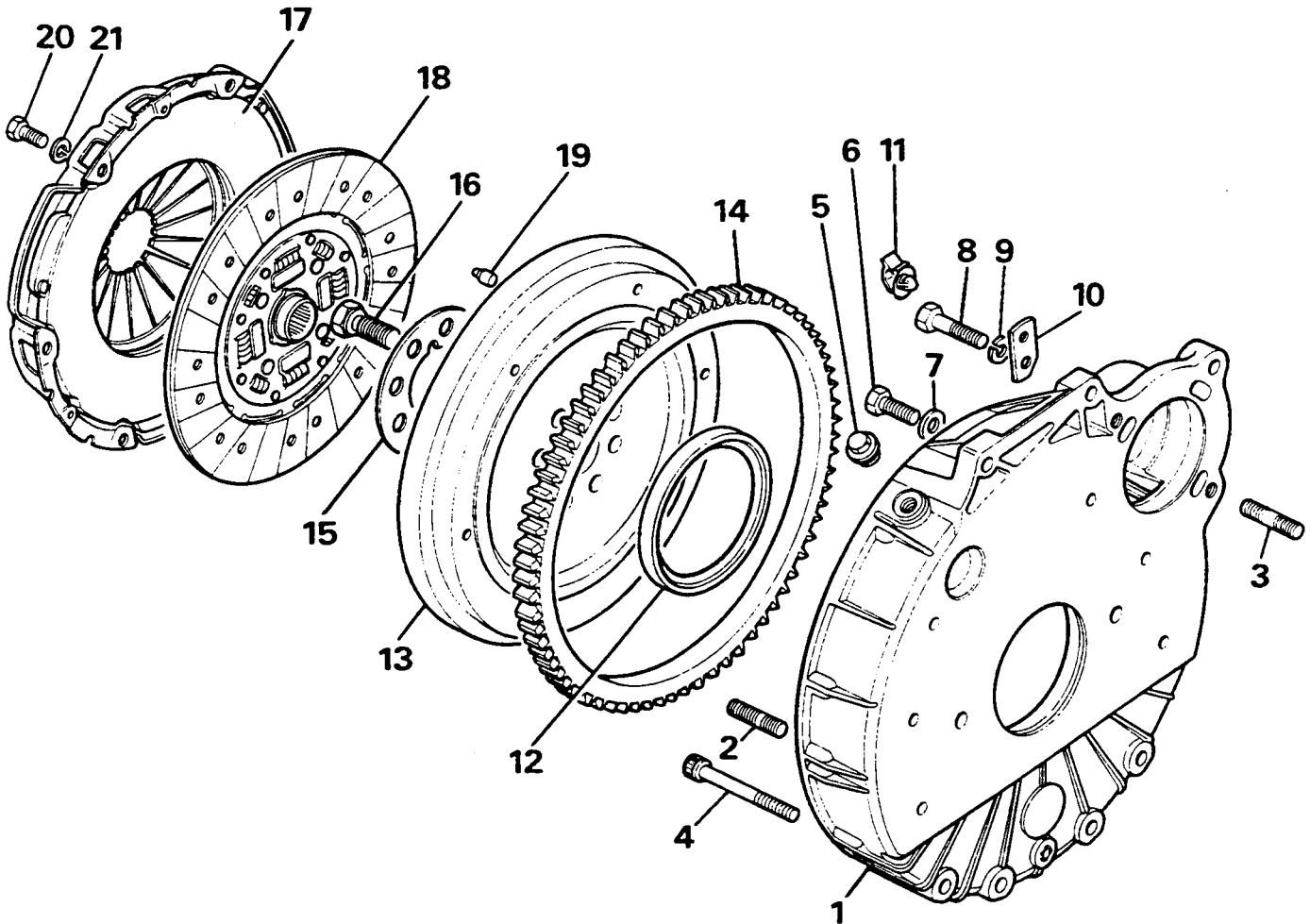
The crankcase ventilation system is associated with drainage of lubricant to the sump and is designed to separate the oil from the gaseous atmosphere before the residue is fed into the inlet system and burned in the combustion chamber.

Oil laden air in the engine is drawn from the rocker cover by depression created in the air intake (1). The breather cyclone (2), fitted to the rocker cover, acts as an oil separator. It controls the rate at which air is purged from the sump and extracts the oil. The oil extracted drains back down hose (3) to the sump. The remaining air is controlled by a diaphragm valve in (2), before passing, via the turbocharger, into the engine where it is burned.



### CLUTCH AND FLYWHEEL HOUSING COMPONENTS

- |                               |                                 |
|-------------------------------|---------------------------------|
| 1. Clutch housing             | 12. Oil seal                    |
| 2. Clutch housing stud (9)    | 13. Flywheel                    |
| 3. Starter motor stud (1)     | 14. Starter ring                |
| 4. Allen bolts (4)            | 15. Reinforcing plate           |
| 5. Plug (2)                   | 16. Bolt flywheel to crankshaft |
| 6. Screw housing to block (6) | 17. Clutch cover                |
| 7. Washer (6)                 | 18. Clutch plate                |
| 8. Bolt housing to block (2)  | 19. Dowel                       |
| 9. Spring washer (2)          | 20. Screw                       |
| 10. Bracket (2)               | 21. Spring washer               |
| 11. Harness clip (2)          |                                 |



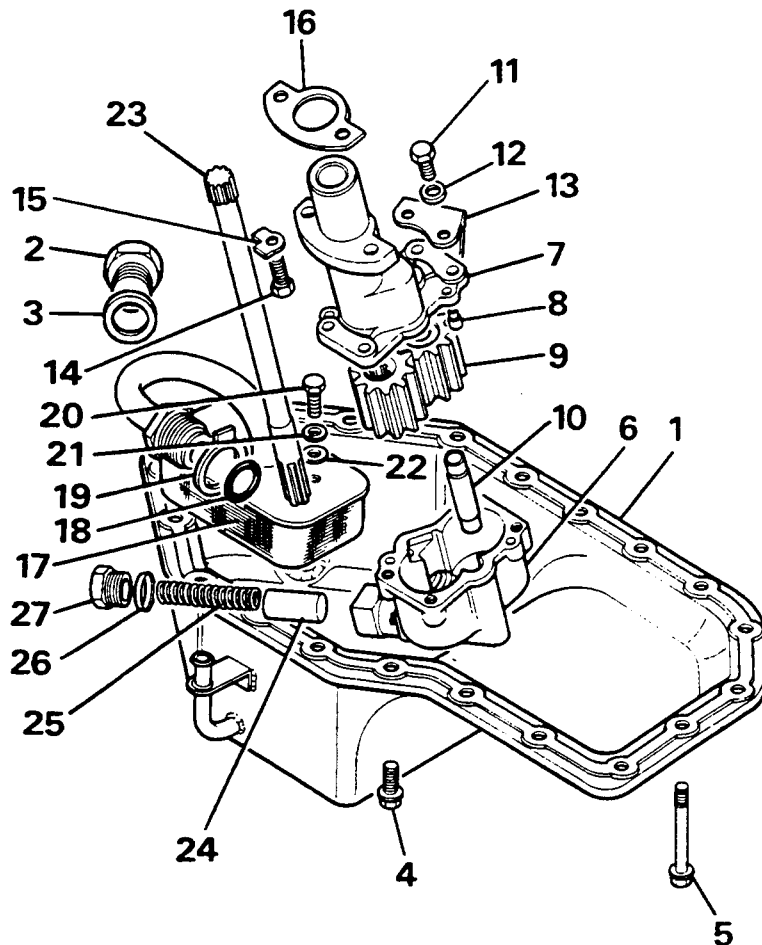
ST3066M





## SUMP AND OIL PUMP COMPONENTS

- |                           |                        |
|---------------------------|------------------------|
| 1. Sump                   | 15. Lock washer        |
| 2. Drain plug             | 16. Gasket             |
| 3. Joint washer           | 17. Filter             |
| 4. Flange bolt M8x20 (8)  | 18. 'O' ring           |
| 5. Flange bolt M8x60 (12) | 19. Lock washer        |
| 6. Oil pump housing lower | 20. Screw              |
| 7. Oil pump housing upper | 21. Spring washer      |
| 8. Dowel                  | 22. Plain washer       |
| 9. Oil pump gears         | 23. Drive shaft        |
| 10. Spindle               | 24. Oil relief plunger |
| 11. Screw                 | 25. Spring             |
| 12. Spring washer         | 26. Joint washer       |
| 13. Support bracket       | 27. Oil relief plug    |
| 14. Screw                 |                        |



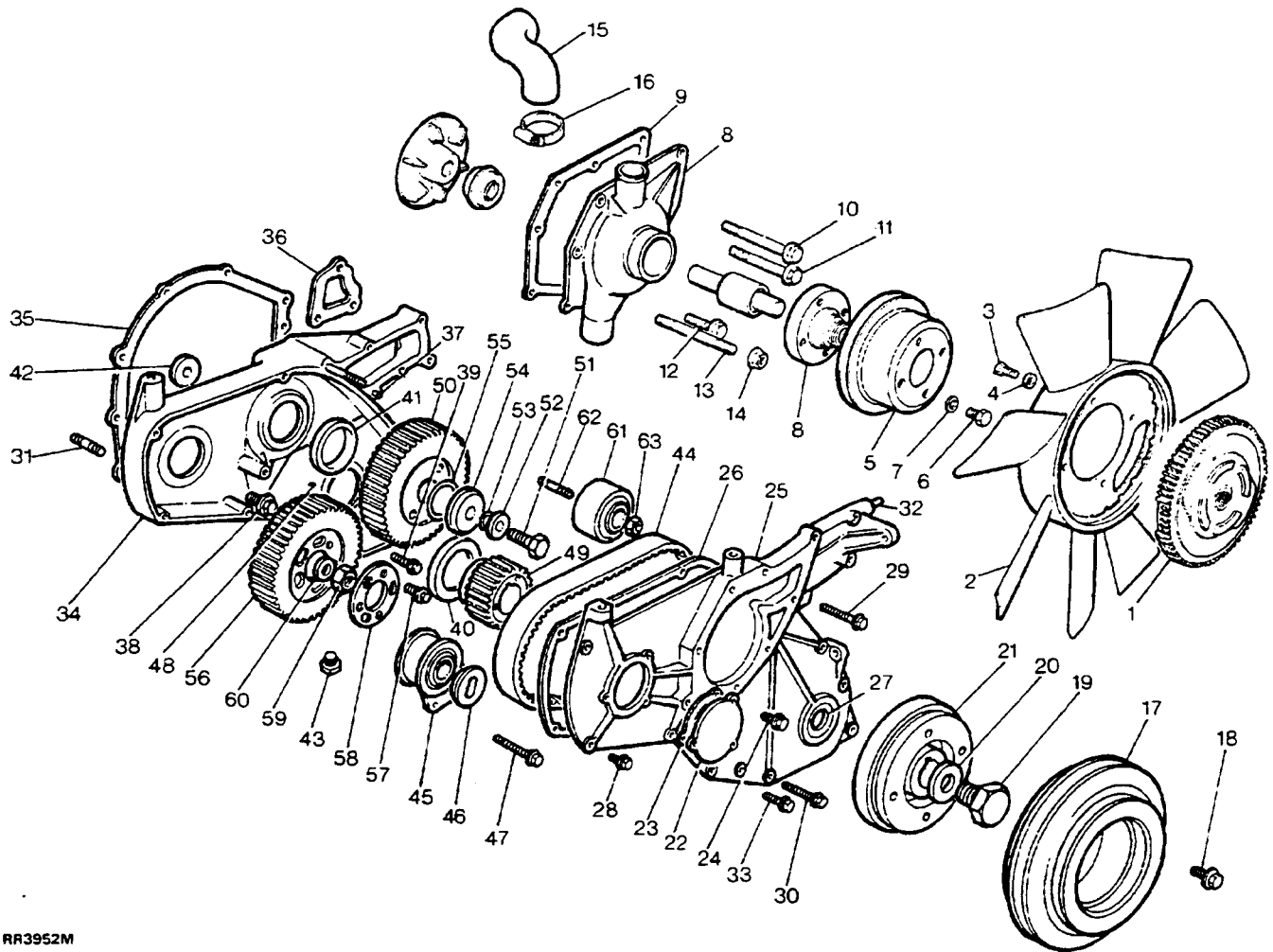
ST3065M

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**FRONT COVER COMPONENTS**

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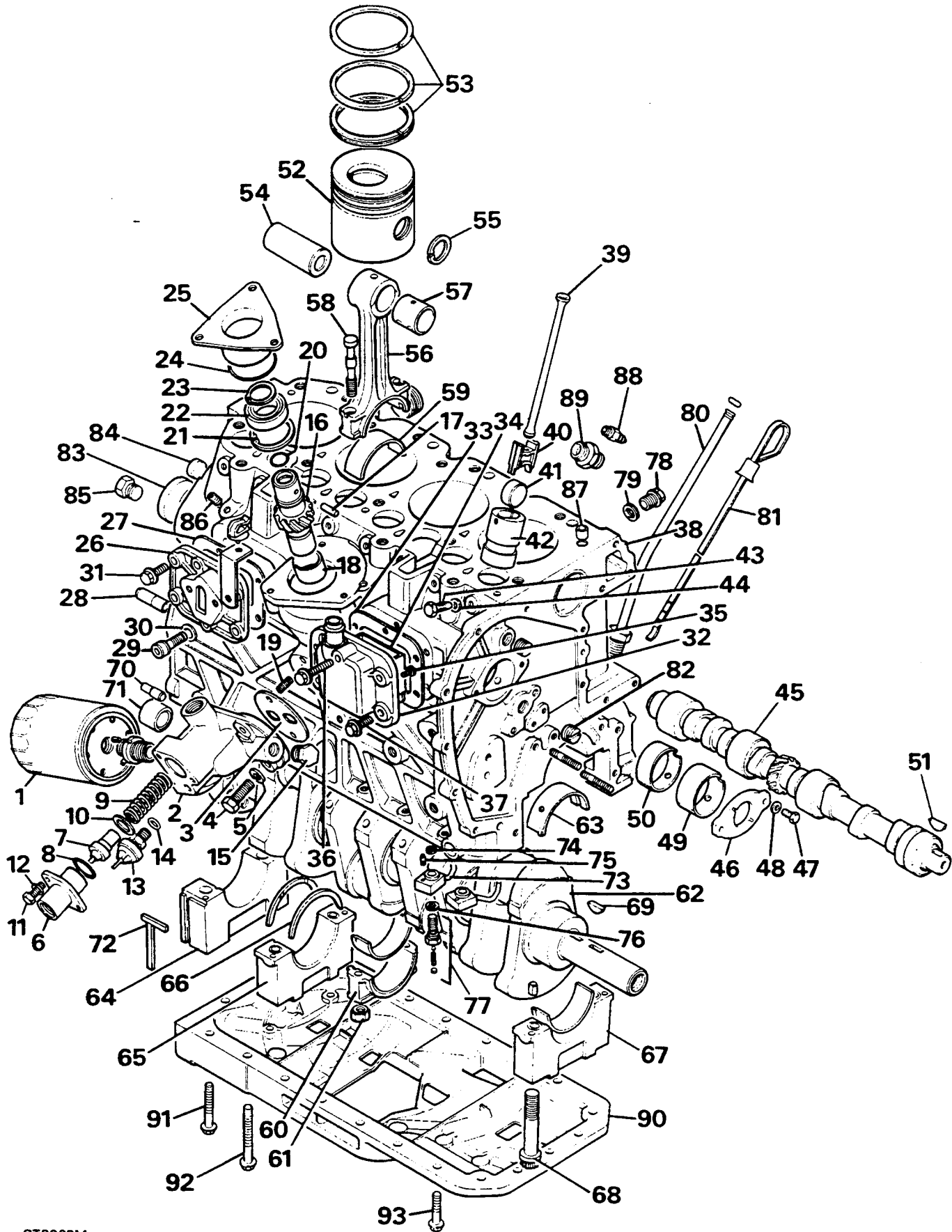
1. Viscous unit
2. Fan assembly
3. Bolt (4)
4. Plain washer (4)
5. Pulley
6. Screw (3)
7. Spring washer (3)
8. Water pump assembly
9. Gasket
10. Flange bolt M8x55 (2)
11. Flange bolt M8x110 (1)
12. Flange screw M8x25 (3)
13. Stud M8x110
14. Flange nut M8
15. By-pass hose
16. Hose clip
17. Crankshaft pulley
18. Flange bolts M8x20 (4)
19. Crankshaft pulley bolt
20. Washer
21. Torsional vibration damper
22. Inspection plate
23. Gasket
24. Flange screw M6x20 (3)
25. Front cover plate
26. Gasket
27. Cover plate seal
28. Flange screw M8x25 (3)
29. Flange bolt M8x90 (2)
30. Flange bolt M8x80 (4)
31. Stud injection pump to front cover M8x92 (3)
32. Stud M8x35 (1)
33. Flange bolt M8x35
34. Front cover
35. Front cover gasket
36. Front cover/water inlet gasket
37. Front cover dowel
38. Flange screw M8x25 (1)
39. Flange bolt M8x70 (1)
40. Crankshaft oil seal
41. Camshaft oil seal
42. Gasket block front face
43. Wading plug
44. Timing belt
45. Timing belt tensioner assembly
46. Slotted washer
47. Flange bolt M10x70
48. Tensioner pivot pin
49. Crankshaft gear wheel
50. Camshaft gear wheel
51. Bolt
52. Washer
53. 'O' ring
54. Retaining plate
55. 'O' ring
56. Injection pump timing gear
57. Flange screw (3)
58. Retaining plate
59. Nut
60. Spring washer (3)
61. Idler pulley
62. Stud
63. Nut



RR3952M

**CYLINDER BLOCK COMPONENTS**

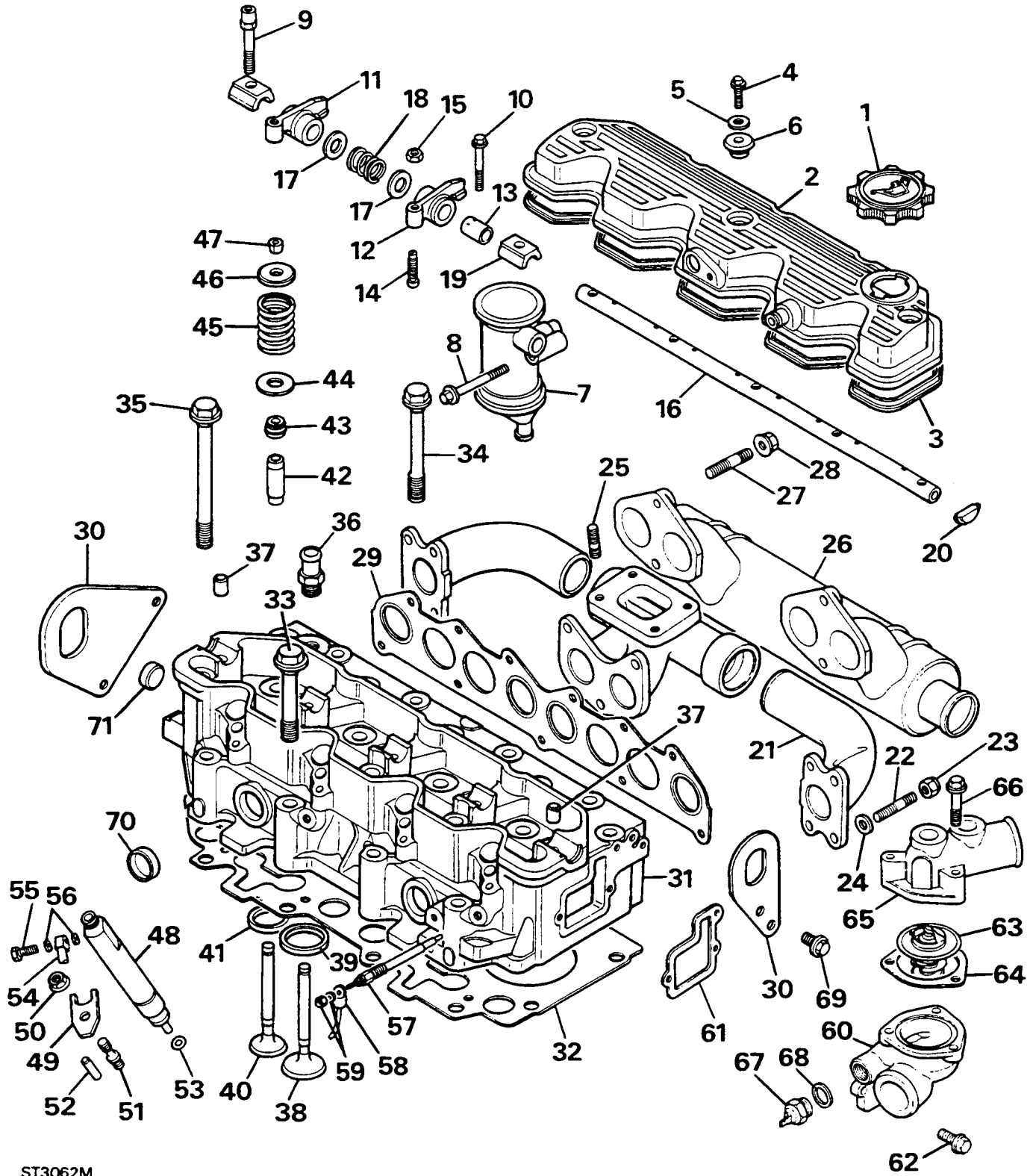
1. Oil filter element
2. Oil filter adaptor
3. Gasket
4. Screw (2)
5. Spring washer (2)
6. Oil cooler adaptor
7. Thermostat bulb
8. 'O' ring
9. Spring
10. Washer
11. Screw (2)
12. Washer (2)
13. Oil pressure switch
14. Copper washer
15. Blanking plug
16. Skew gear
17. Dowel pin
18. Bush
19. Locking screw
20. 'O' ring
21. Snap ring external
22. Deep groove bearing
23. Snap ring internal
24. 'O' ring bearing housing
25. Bearing housing
26. Rear side cover
27. Gasket
28. Dowel flywheel housing (2)
29. Socket screw (2)
30. Washer (2)
31. Flange bolts (6)
32. Front side cover breather
33. Gasket
34. Baffle plate
35. Screw No.6 (2)
36. Flange bolt M8x40(1)
37. Flange screw M8x25 (5)
38. Cylinder block
39. Pushrod
40. Tappet slide
41. Roller follower
42. Tappet guide
43. Set bolt
44. Washer
45. Camshaft
46. Locking plate
47. Screw (2)
48. Spring washer (2)
49. Camshaft bearing - front
50. Camshaft bearing - inter/rear (3)
51. Camshaft key
52. Piston
53. Piston rings
54. Gudgeon pin
55. Circlip (8)
56. Connecting rod
57. Gudgeon pin bush
58. Connecting rod bolt
59. Big end bearing
60. Big end bearing cap
61. Connecting rod nut
62. Crankshaft
63. Crankshaft main bearing
64. Main bearing cap - rear
65. Main bearing cap - centre
66. Thrust washers
67. Main bearing cap (3)
68. Main bearing cap bolt
69. Crankshaft key
70. Crankshaft dowel
71. Crankshaft bush
72. Packing strip
73. Jet adaptor
74. Joint washer
75. Dowel
76. Joint washer
77. Relief valve assembly
78. Drain plug
79. Joint washer
80. Dipstick tube
81. Dipstick
82. Oil gallery plug
83. Cup plug (5)
84. Cup plug
85. Oil gallery plug
86. Camshaft oil feed plug (3)
87. Ring dowel (2)
88. Oil feed adaptor
89. Oil drain adaptor
90. Ladder frame
91. Flange bolt M8x125 (3)
92. Flange bolt M8x60 (4)
93. Flange screw M8x30 (3)



ST3063M

**CYLINDER HEAD COMPONENTS**

1. Oil filler cap
2. Rocker cover
3. Rocker cover gasket
4. Flange headed bolt
5. Washer
6. Sealing washer
7. Breather cyclone
8. Flange headed screw
9. Rocker shaft bolt (3)
10. Rocker shaft bolt (2)
11. Rocker arm RH
12. Rocker arm LH
13. Rocker arm bush
14. Tappet adjuster screw
15. Locknut
16. Rocker shaft
17. Rocker shaft spacer
18. Rocker shaft spring
19. Rocker shaft clamp
20. Rocker shaft seal
21. Exhaust manifold
22. Manifold stud exhaust
23. Self locking nut
24. Plain washer
25. Stud turbocharger mounting
26. Inlet manifold
27. Manifold stud inlet
28. Flange nut
29. Manifold gasket
30. Engine lifting brackets
31. Cylinder head
32. Cylinder head gasket
33. Head bolts M12 short (4)
34. Head bolts M12 long (10)
35. Head bolts M10 (4)
36. Adaptor cooling system
37. Ring dowel
38. Valve inlet
39. Valve seat insert
40. Valve exhaust
41. Valve seat insert
42. Valve guide
43. Valve steam seal
44. Valve spring seat
45. Valve spring
46. Valve spring cup
47. Split cotters
48. Injector
49. Injector clamp
50. Injector clamp nut
51. Injector clamp stud
52. Injector clamp dowel
53. Injector sealing washer
54. Spill return pipe
55. Banjo bolt 6mm
56. Copper washer
57. Glow plug
58. Glow plug cable
59. Nut and washer
60. Thermostat housing
61. Gasket
62. Flange screw (3)
63. Thermostat
64. Gasket
65. Thermostat housing cover
66. Flange bolt M6x40 (3)
67. Thermal transmitter
68. Joint washer
69. Flange bolt
70. Cup plug (1)
71. Cup plug (2)



ST3062M




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**ENGINE**


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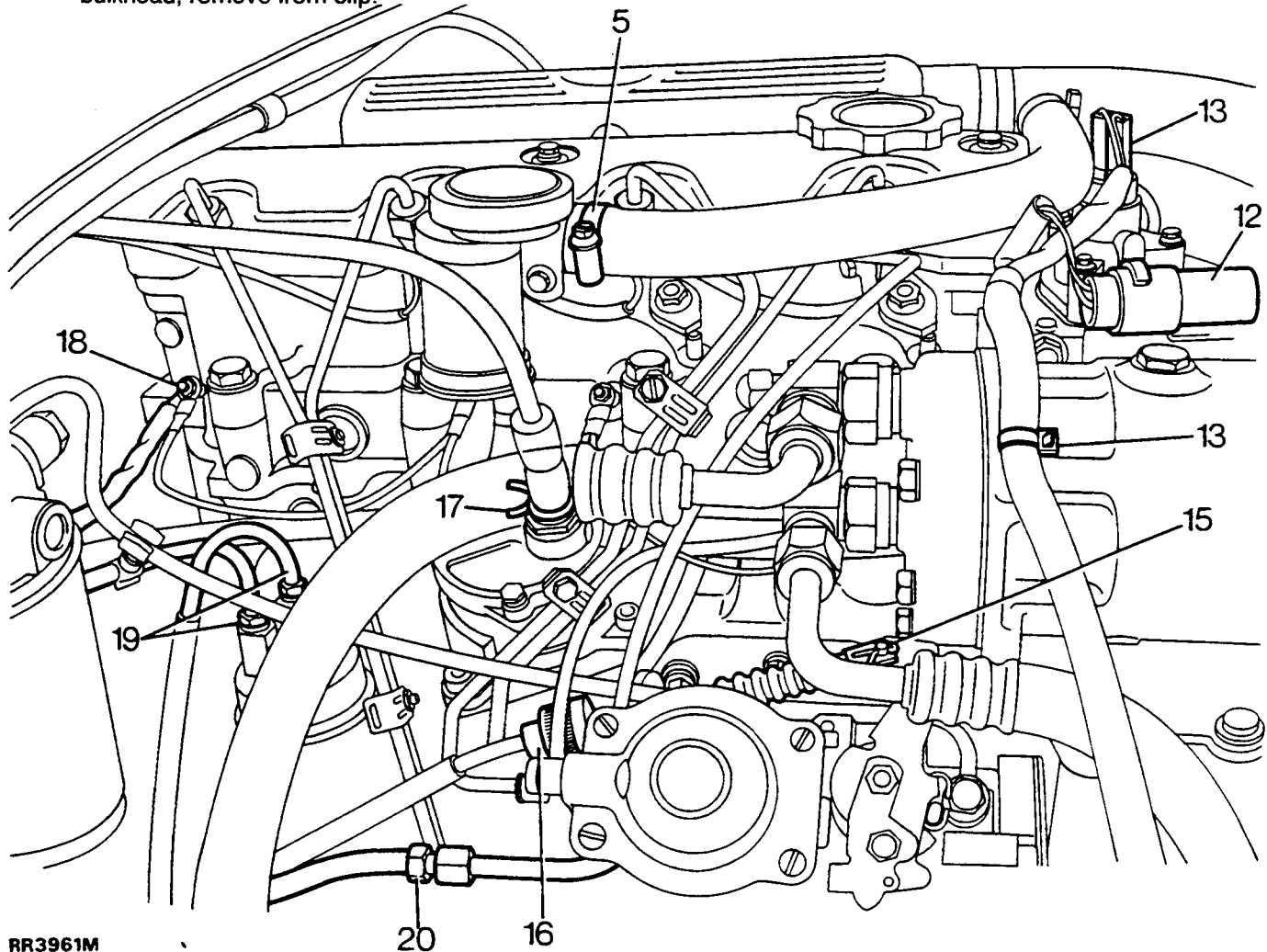
Service repair no - 12.41.01

**Remove**



**CAUTION: Seal all exposed pipe ends against ingress of dirt after disconnection.**

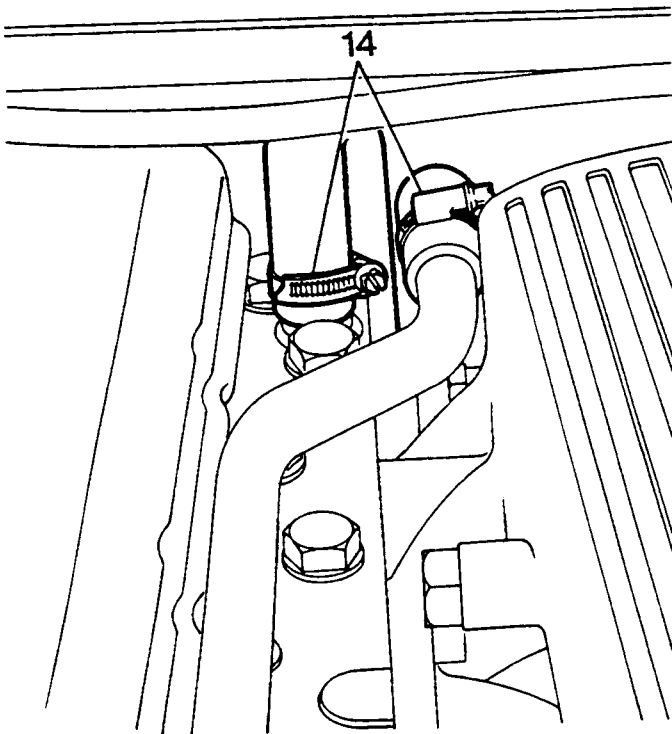
1. Park vehicle on level ground, apply park brake.
2. Remove bonnet *See CHASSIS AND BODY, Repair, Bonnet*
3. Remove radiator assembly, *See COOLING SYSTEM, Repair, radiator/oil coolers*
4. Remove air cleaner hose from turbocharger.
5. Remove air cleaner hose from breather cyclone.
6. Remove power steering pump inlet and outlet hoses.
7. Disconnect engine electrical harness at bulkhead, remove from clip.
8. Disconnect positive battery lead, remove from chassis clips.
9. Discharge air conditioning system, *See AIR CONDITIONING, Repair, Discharging system*
10. Remove high and low pressure hoses from compressor.
11. Remove hose from receiver drier unit.
12. Disconnect compressor clutch multi-plug.
13. Disconnect temperature sensor connection. Remove wiring clip from compressor.



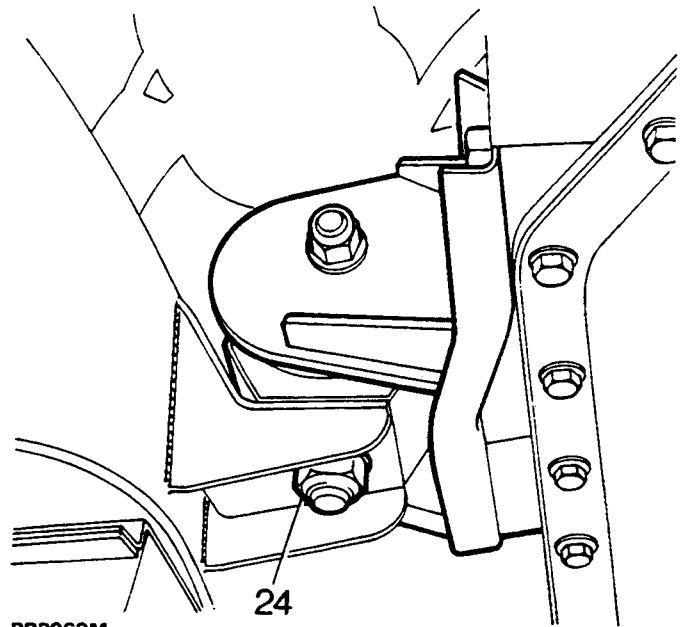
RR3961M



14. Disconnect both heater hoses at rear of engine.



RR3960M



RR3962M

15. Remove split pin securing inner throttle cable to injection pump.
16. Depress tags on outer cable adjusting nut, remove cable from bracket.
17. Disconnect pipe from vacuum pump.
18. Disconnect heater plug feed wire.
19. Remove both pipes from fuel lift pump.
20. Remove spill return pipe from injection pump.
21. Loosen clip, disconnect exhaust down pipe.
22. Remove clip securing transmission breather pipes to rear of cylinder head.
23. Remove starter motor heat shield, disconnect starter earth lead.

24. Remove nuts and plain washers securing front engine mountings to chassis.
25. Support gearbox.
26. Remove bell housing insulation.
27. Remove engine to bell housing fixings, leaving starter motor attached to engine.
28. Fit lifting chains to engine. Carefully raise engine to pull it away from transmission.
29. Ensure all connections to engine have been removed.
30. Remove engine.

### Refit

31. Clean bell housing.
32. Apply hylomar to bell housing mating face.
33. Lubricate splines of gearbox primary pinion using Rocol MV 3.
34. Raise vehicle.
35. Lower engine into position. Locate primary pinion into clutch, engage bell housing dowels.
36. Fit engine to bell housing fixings, tighten to **40 Nm**.
37. Raise engine, refit front engine mountings to chassis.
38. Remove gearbox support, lower engine.
39. Tighten front engine mounting nuts.
40. Reverse removal procedure 1 to 24.

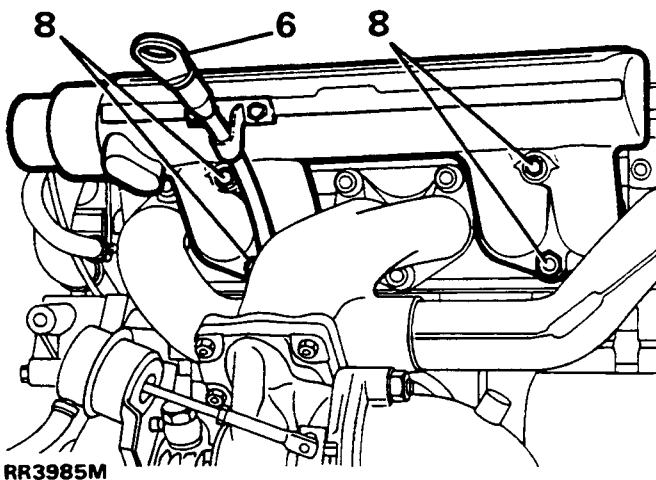


## CYLINDER HEAD GASKET

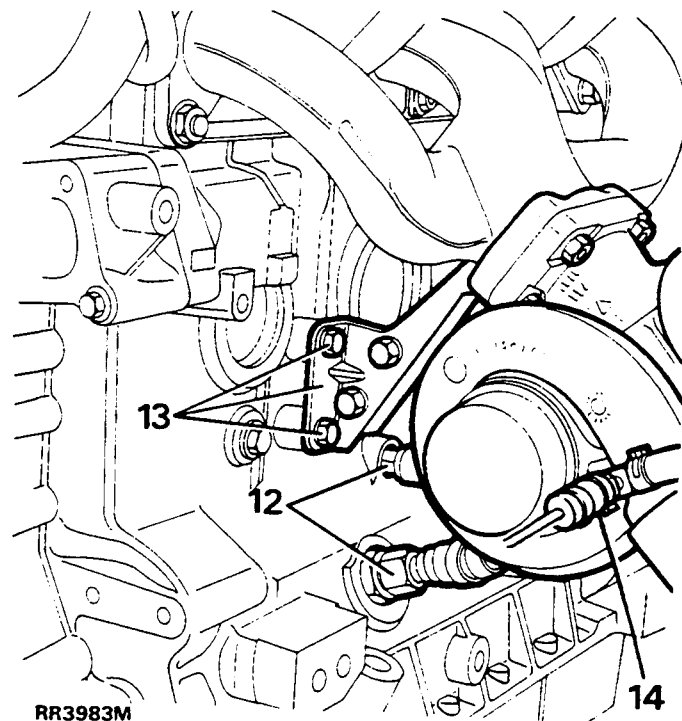
Service repair no - 12.29.02

### Remove

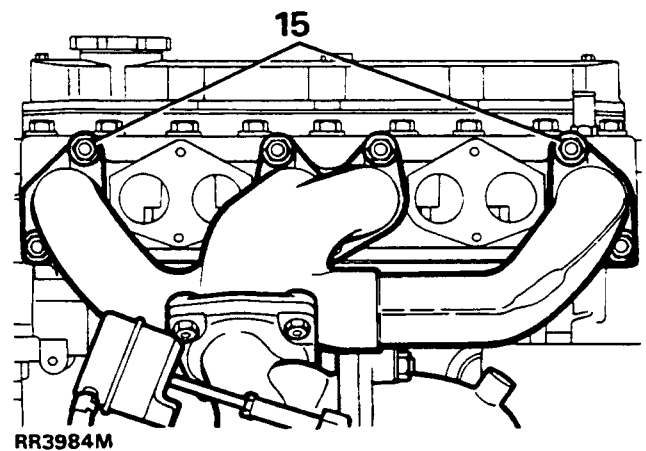
1. Disconnect the battery negative lead.
2. Drain cooling system.
3. Remove radiator top hose. *See GENERAL SPECIFICATION DATA, Information, 200 Tdi engine*
4. Remove intercooler hose from inlet manifold.
5. Remove turbocharger intake hose.
6. Remove dipstick.



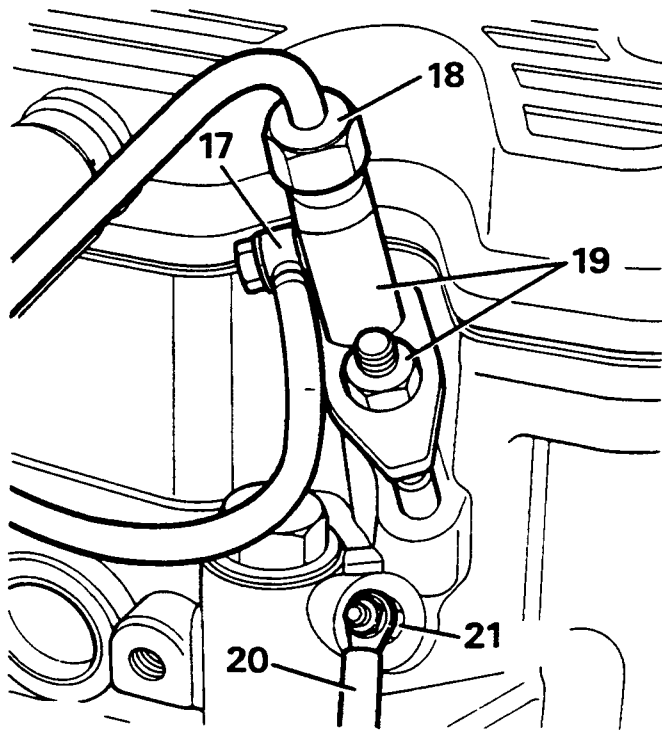
7. Release dipstick tube securing nut from cylinder block.
8. Remove two bolts and two nuts and remove inlet manifold with dipstick tube.
9. Disconnect heater hose and by-pass hose from thermostat housing.
10. Disconnect heater hoses from rear of cylinder head.
11. Remove two nuts securing heater rail to exhaust manifold studs.
12. Disconnect turbocharger lubrication hoses from block.



13. Remove two bolts securing support bracket to block.
14. Disconnect pipe to injection pump.



15. Disconnect exhaust front pipe from manifold.
16. Evenly loosen and remove seven nuts and washers. Remove exhaust manifold complete with turbocharger.
17. Disconnect spill return pipe.



RR3986M

18. Remove injector pipes.
19. Mark each injector to ensure they are reassembled in original position. Remove injectors. Retain injectors in separate plastic bags to avoid damage.
20. Disconnect glow plug wiring.
21. Remove glow plugs and sealing washers.
22. Remove rocker cover **See rocker cover**
23. Evenly release five rocker shaft retaining bolts. Remove rocker shaft keeping bolts in place. Remove valve stem caps.
24. Remove pushrods, retain in original order.
25. Remove clip securing engine breather hose to lifting eye.
26. Disconnect water temperature sensor.
27. Remove clip securing transmission breather pipes to back of cylinder head
28. Evenly loosen eighteen cylinder head bolts. Remove bolts leaving two at rear in position.
29. With assistance remove cylinder head.



**NOTE:** If cylinder head overhaul is required **See Overhaul, Overhaul and fit cylinder head**

### Refit

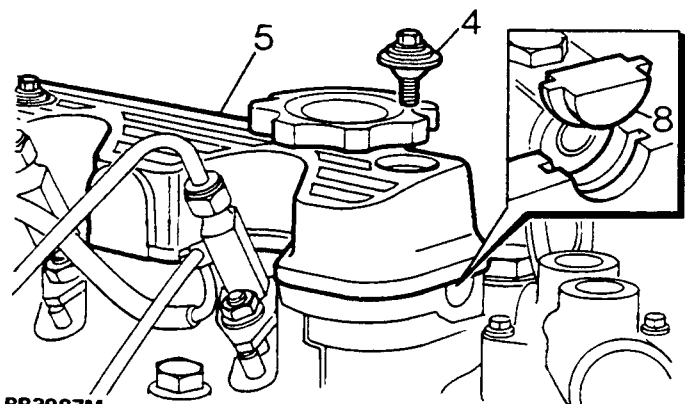
30. Clean mating faces of cylinder head and block.
31. Fit cylinder head **See Overhaul, Overhaul and fit cylinder head**
32. Fit rocker shaft **See rocker shaft**
33. Fit rocker cover **See rocker cover**
34. Fit injectors, pipes and heater plugs **See Overhaul, injectors, pipes and heater plugs**
35. Fit manifolds. Tighten fixings to 23 Nm.
36. Reverse removal procedure.

## ROCKER COVER

Service repair no - 12.29.40

### Remove

1. Disconnect the battery negative lead.
2. Disconnect air cleaner hose from breather canister.
3. Disconnect oil drain hose from bottom of canister.
4. Remove three rocker cover bolts, washers and sealing washers.
5. Remove rocker cover.
6. Inspect rocker cover gasket. Unless there is evidence of damage or leaks this may be refitted.
7. Clean mating faces of rocker cover and cylinder head.
8. Examine half moon seals. If fitting new ones, clean grooves in cylinder head. Glue seals in place.



RR3987M

### Refit

9. Fit gasket to rocker cover.
10. Fit rocker cover. Secure with bolts, washers and sealing washers. Tighten bolts to 4 Nm.
11. Connect hoses and tighten clips.



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**ROCKER SHAFT**

---

Service repair no - 12.29.54

**Remove**

1. Remove rocker cover *See rocker cover*
2. Loosen five rocker shaft retaining bolts.
3. Remove rocker shaft. Do not remove retaining bolts at this stage, especially two end bolts, to keep assembly together when it is removed.

**Refit**

4. Overhaul rocker shaft and refit *See Overhaul, overhaul and fit rocker shaft*
5. Refit rocker cover.

---

**FLYWHEEL**

---

Service repair no - 12.53.07

**Remove**

1. Remove clutch assembly *See CLUTCH, Repair, clutch assembly*
2. Remove flywheel *See Overhaul, remove flywheel and housing*

**Refit**

3. Examine flywheel, overhaul as necessary and refit *See Overhaul, Overhaul and fit flywheel*
4. Refit clutch assembly. *See CLUTCH, Repair, clutch assembly*

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**REAR MAIN OIL SEAL**

---

Service repair no - 12.21.90

**Remove**

1. Remove clutch assembly. *See CLUTCH, Repair, clutch assembly*
2. Remove flywheel and housing *See flywheel*
3. Remove rear main oil seal.

**Refit**

4. Fit new oil seal *See Overhaul, Fitting rear main oil seal to Flywheel Housing*
5. Fit flywheel housing *See Overhaul, Overhaul and fit Flywheel*
6. Refit flywheel *See Overhaul, Overhaul and fit flywheel*
7. Refit clutch assembly. *See CLUTCH, Repair, clutch assembly*

## FRONT COVER OIL SEALS

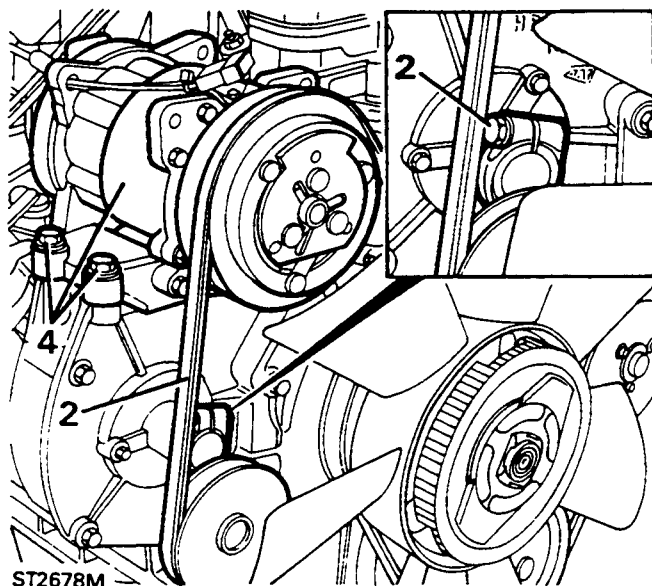
Service repair no - 12.65.05 - Cover plate oil seal

Service repair no - 12.65.10 - Front cover gasket

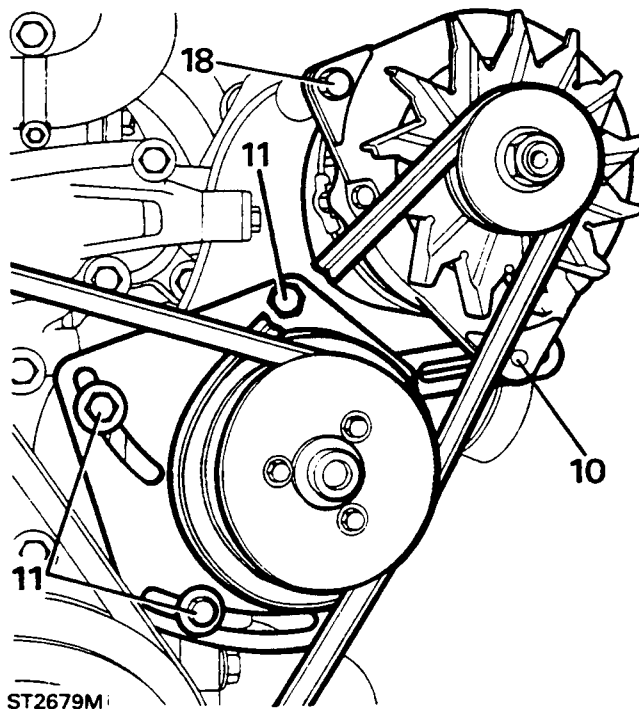
## Remove

## Air conditioning models - to gain access.

1. Disconnect the battery negative lead.
2. Release compressor drive belt tensioning pulley. Remove belt from compressor pulley.
3. Disconnect the two electrical leads from thermostat housing sensor.
4. Remove the four bolts securing compressor to engine and move compressor aside taking care not to strain hoses.



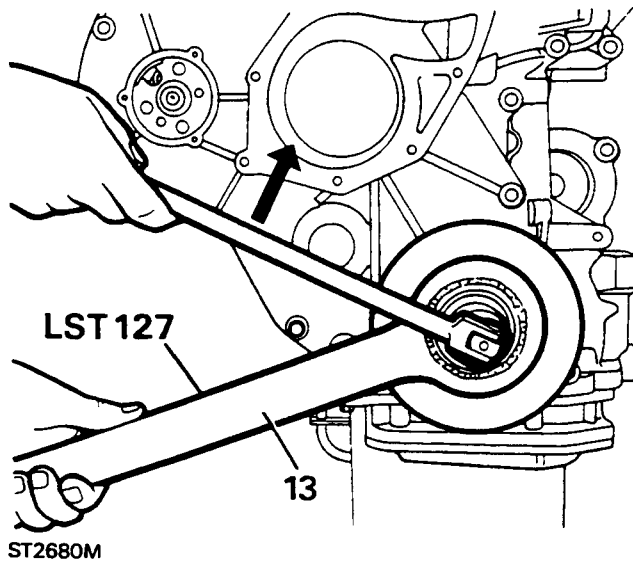
7. Disconnect intercooler to manifold hose at the manifold.
8. Remove top hose.
9. Remove two nuts securing fan cowl to top of radiator and lift-out cowl.
10. Loosen alternator belt adjustment bolt.
11. Loosen PAS pump belt adjustment bolts and remove both belts.



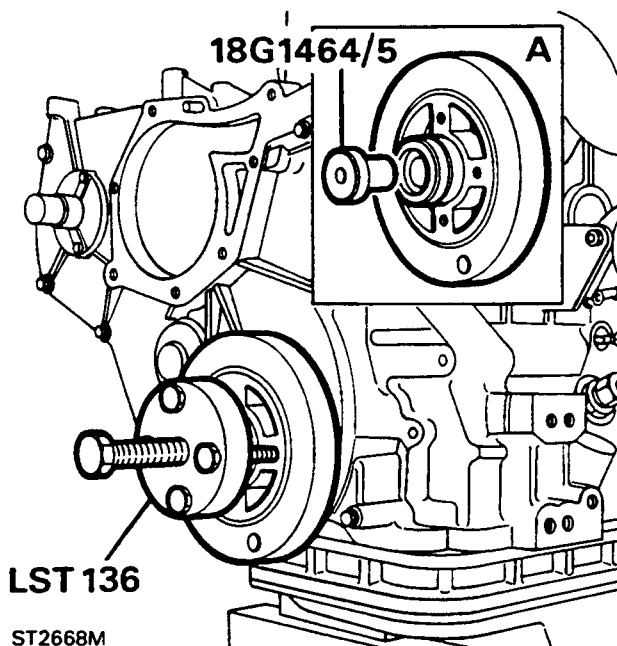
## All models - to gain access

5. Disconnect battery and drain cooling system by removing bottom hose from radiator and allowing coolant to drain into a suitable container.
6. Remove viscous coupling and fan assembly, noting that coupling is secured to water pump shaft with a left hand thread.

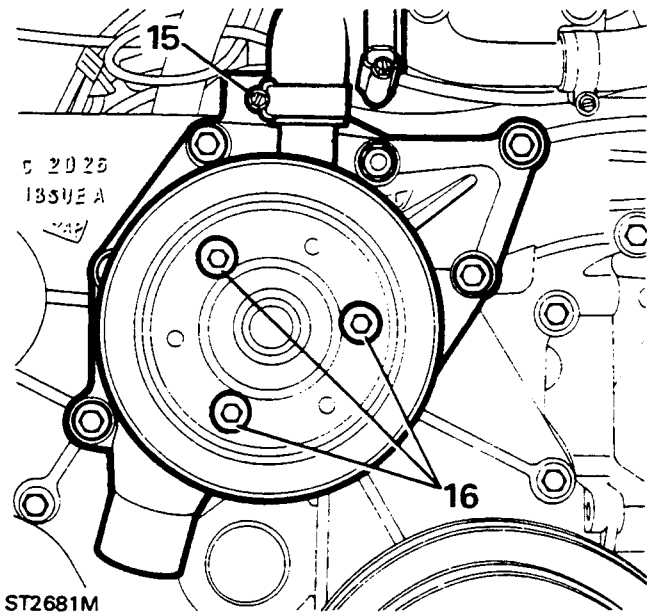
12. Remove four screws. Remove the crankshaft pulley from damper.
13. Restrain damper with special tool LST 127. Using a 30 mm socket, remove damper retaining bolt and spacer. Since this bolt is retained with Loctite and tightened to a very high torque considerable effort will be required to release it.



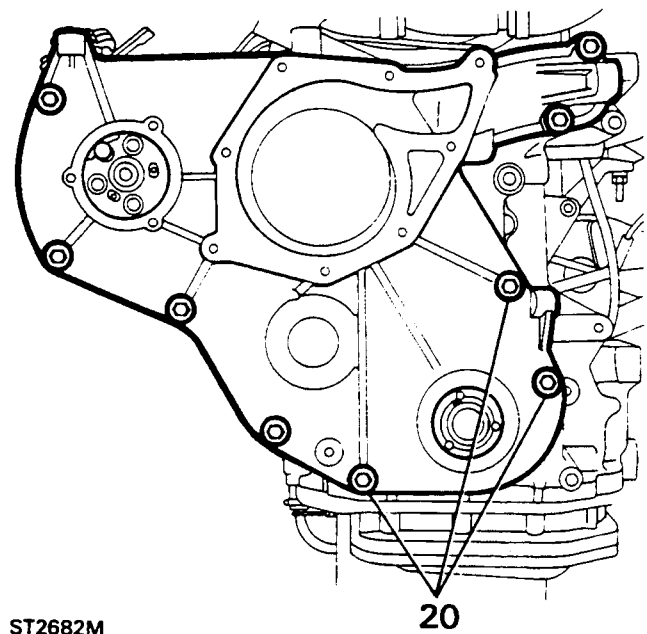
14. Since damper is also retained with Loctite, use special tool LST 136 and pressure button A from 18G 1464/5 to withdraw it from the crankshaft.



15. Disconnect bottom and by-pass hoses from water pump.  
 16. Remove three screws to remove water pump pulley. Remove seven bolts to remove water pump.  
 17. Remove air cleaner to turbo charger hose.  
 18. Withdraw pivot bolt, and remove the alternator. Similarly, remove PAS pump.



19. Remove five bolts to release common bracket.  
 20. Remove nine bolts and carefully remove cover plate from front cover.



21. Remove front cover *See Overhaul, Remove timing gear and injection pump*

#### Refit

22. Fit front cover *See Overhaul, fit the front cover*  
 23. Fit camshaft drive belt *See Overhaul, valve and injection pump timing*  
 24. Fit front cover plate and damper *See Overhaul, Fitting front cover plate and damper*  
 25. Reverse removal procedure.



## ENGINE OVERHAUL

### Engine data

For engine general specification data See **GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**

Remove engine from vehicle and clean. See **Repair, Engine**

To overhaul the engine requires the use of service tools. See **Service tools, Tdi engine**

The use of a purpose designed engine stand is recommended. Secure engine to stand. Drain the sump oil.



**NOTE:** The position of brackets, clips, harness, pipes, and hoses, and any non standard items, for assembly.

Remove the following components where applicable:-

Air conditioning compressor.

Power steering pump and alternator.

Starter motor.

Engine electrical harness.

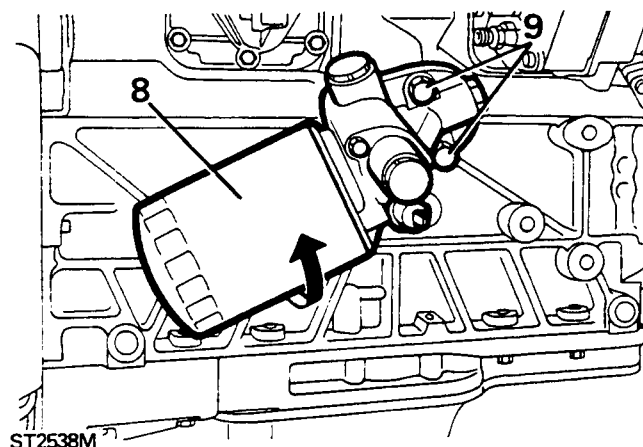
Air inlet manifold

Exhaust manifold and turbocharger

Water pump

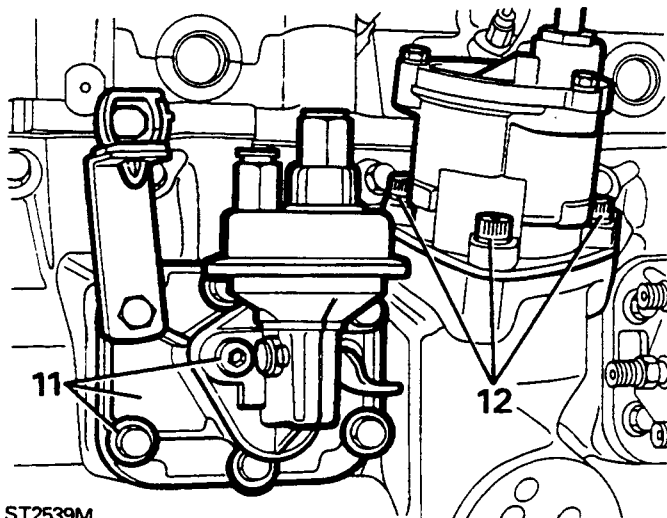
Clutch

1. Loosen all the union nuts at the injectors and injection pump and then remove the pipes from the engine.
2. Remove the spill return pipes from the injectors and injection pump and retrieve the washers.
3. Disconnect the electrical lead from the fuel cut-off switch at the rear of the injector pump.
4. Disconnect the lead from the oil pressure switch.
5. Disconnect the electrical leads from the heater plugs.
6. Remove the lead from the engine coolant temperature switch.
7. Check that all the electrical leads have been disconnected. Release the harness from the retaining clips and remove from the engine.
8. Unscrew the oil filter cartridge, anti-clockwise, using a strap wrench if necessary. Dispose of the oil safely.
9. Release the two bolts and remove the oil filter adaptor and gasket from the engine.



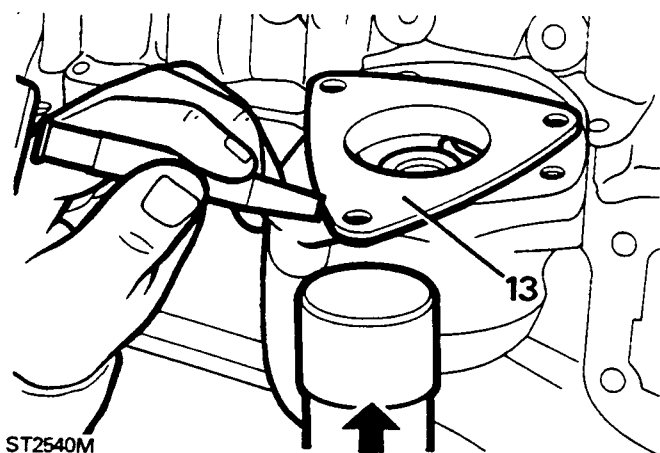
10. Remove the single bolt and pull the engine breather canister from the rocker cover. Also release the breather hose from the sump connection and remove from the engine.

11. If the fuel lift pump is suspected of being faulty it can be removed from the rear cover by releasing the two retaining screws using a 6 mm Allen key. Alternatively, it can be removed still attached to the rear cover, by removing the six bolts.
12. Mark the position of the brake servo vacuum pump with relation to the cylinder block. Using a 6 mm Allen key remove the three screws and lift out the pump.

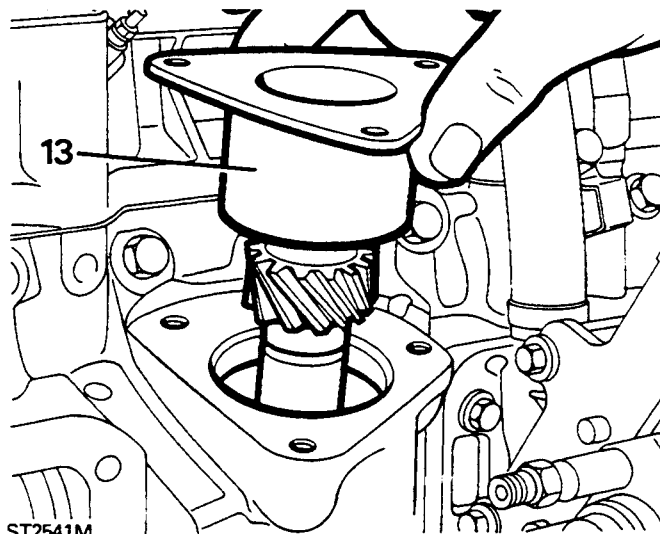


ST2539M

13. Similarly, mark the relationship of the skew gear flange with the cylinder block and the skew gear teeth with the camshaft gear teeth. To remove the skew gear assembly, tap the flange round so that the edges overlap the cylinder block. Tap the flange upwards sufficiently to enable the skew gear assembly to be lifted out.



ST2540M

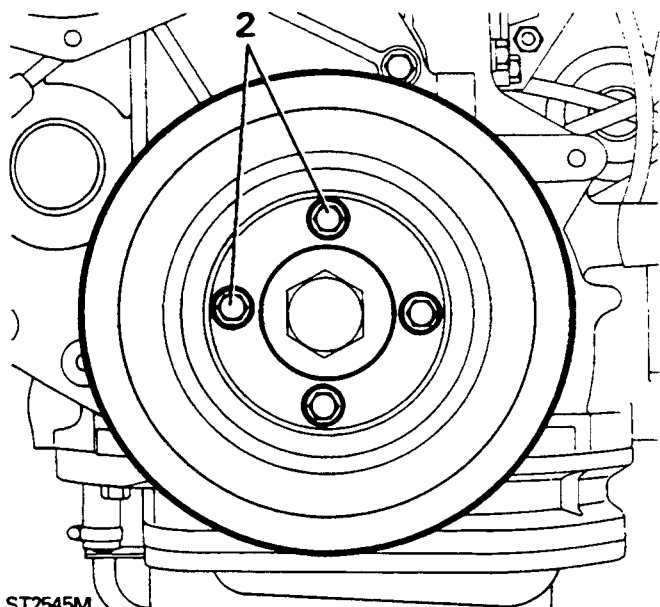


ST2541M

14. Using a length of wire or long nosed pliers withdraw the oil pump drive shaft.

## CHECK INJECTION PUMP TIMING

1. Evenly loosen and remove the three rocker shaft cover retaining bolts and remove the cover so that the position of the valves in relation to the crankshaft and pistons may be seen.
2. Release the four bolts and remove the crankshaft pulley from the damper.

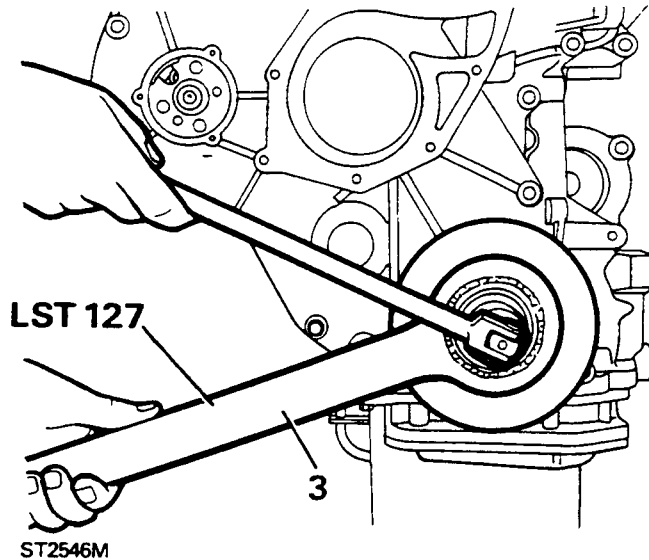


ST2545M

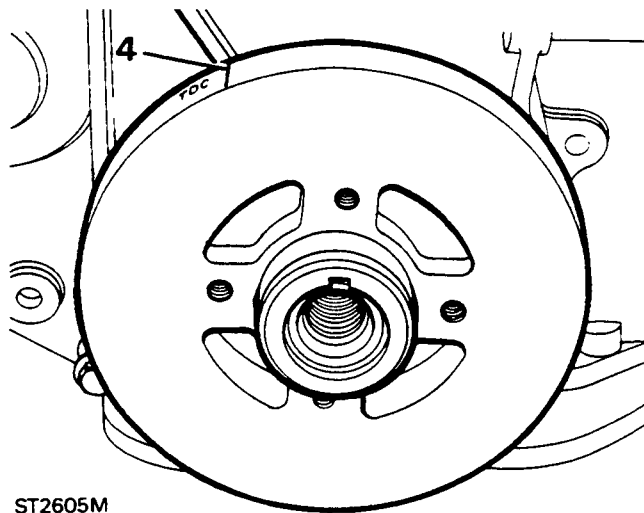




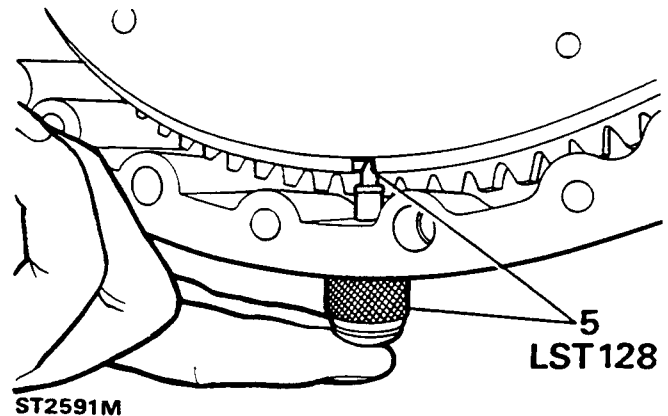
3. To remove the crankshaft damper retaining bolt use special service tool LST127 to restrain the damper and a 30 mm socket to remove the special bolt. Leave the damper in position on the crankshaft.



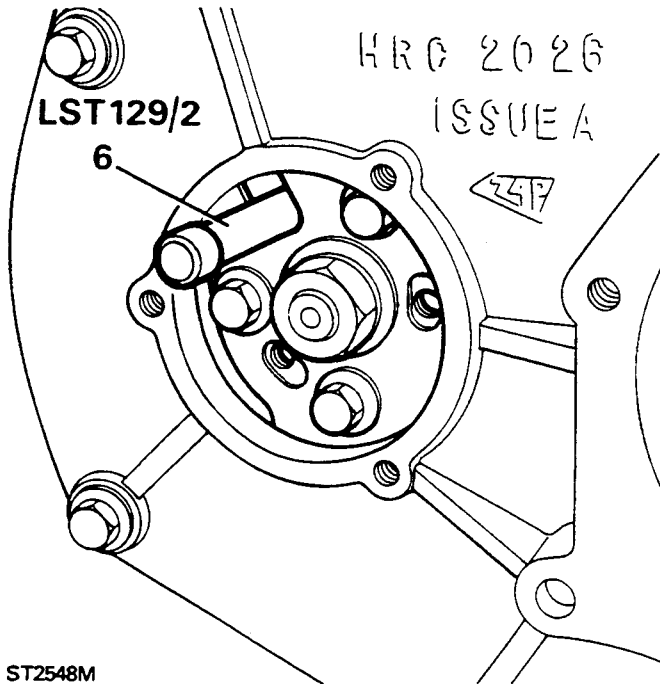
4. Use the restraining tool to turn the crankshaft in a clockwise direction to T.D.C. so that the mark on the damper is in line with the cover plate web as illustrated. The valves of number one cylinder should be closed with number four cylinder valves on the "rock". If the crankshaft is turned beyond T.D.C. continue on round until the above conditions are achieved.



5. Screw the body of the timing pin tool LST128 into the flywheel housing and check the pin can be inserted into the slot in the flywheel. Note that there are two slots in the flywheel. The narrowest slot determines T.D.C. for this direct injection engine and it is therefore important that the correct slot is used.

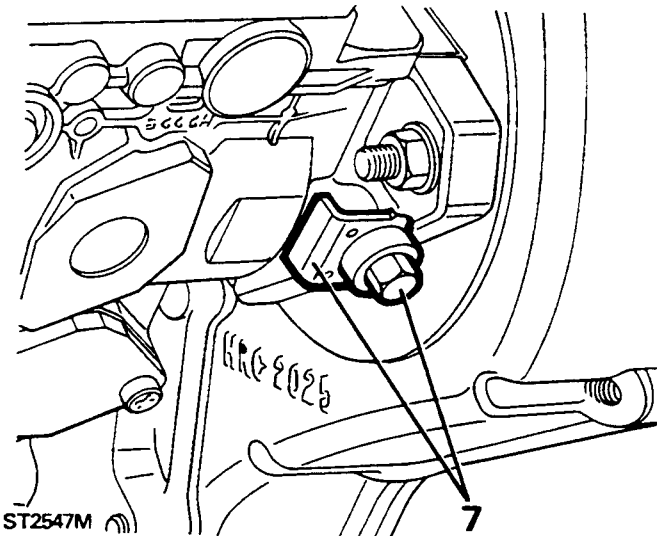


6. Remove the injection pump access cover and check the service tool timing pin can be inserted through the "U" shaped cut-out in the pump hub and into the hole in the pump body. Also the dot on the camshaft gear should align with the web on the front cover. This will confirm that the injection pump is correctly timed in relation to the valves and crankshaft and can be locked ready for removing. Leave the bolt in position in the pump.



ST2548M

7. To lock the pump, loosen the locking screw and remove the inhibiting plate. Tighten the screw to lock the pump shaft. Remove the timing pin from the flywheel housing.



ST2547M

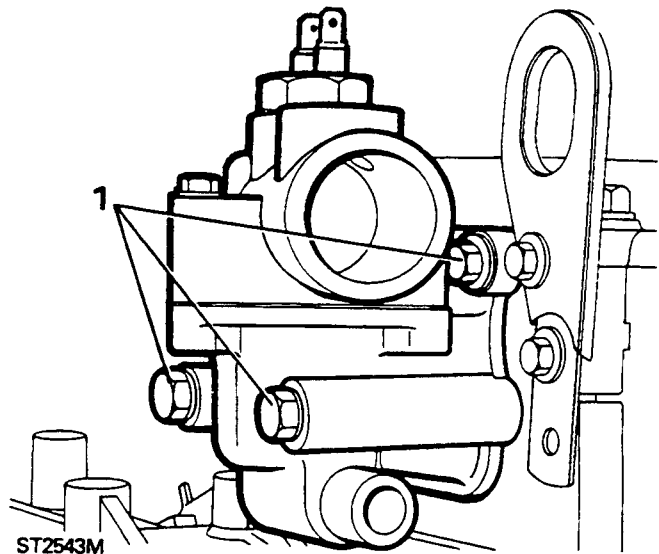


**CAUTION:** It is important to ensure that once the injection pump has been locked no attempt must be made to rotate it. Therefore do not allow the crankshaft to be turned until the pump has been removed.

8. Before dismantling the timing components, the cylinder head should be removed to avoid the possibility of damage being caused to the valves and pistons should the camshaft be inadvertently turned once the timing belt has been removed.

### REMOVE CYLINDER HEAD

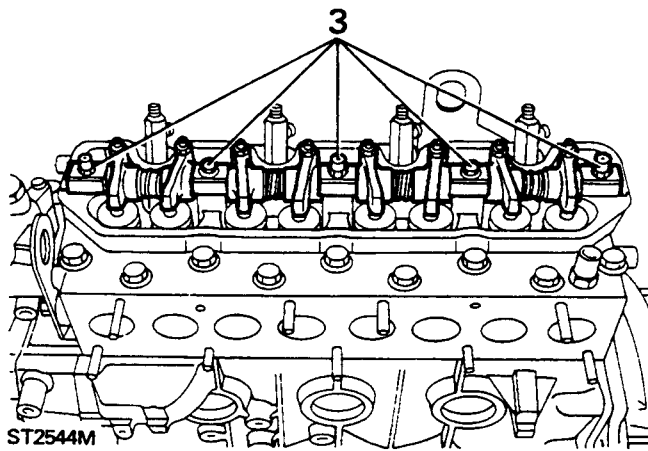
1. Remove the three bolts and remove the thermostat housing.



2. Evenly release the five rocker shaft retaining bolts but do not remove the bolts from the shaft, especially the two end ones, to prevent the assembly from falling apart when removed from the cylinder head.



## REMOVE TIMING GEAR AND INJECTION PUMP

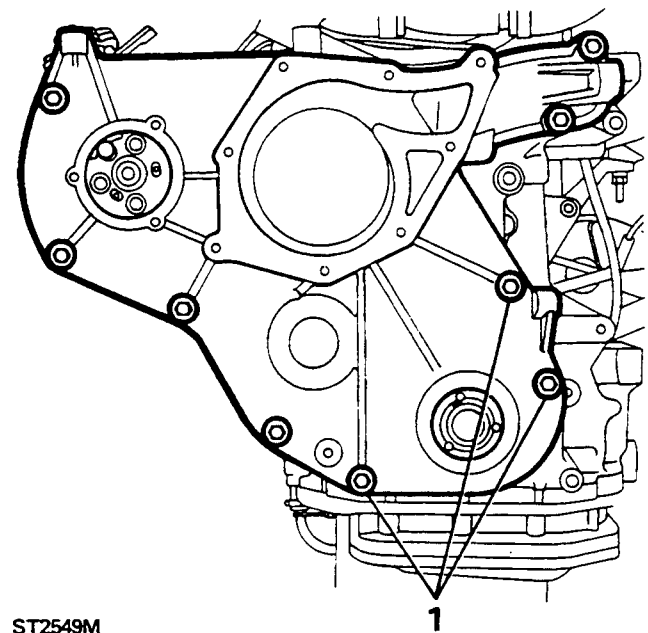
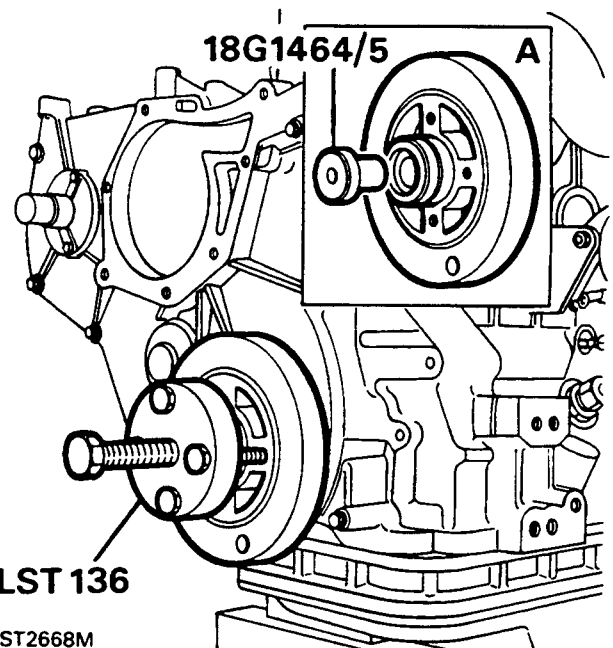


- Having removed the rocker shaft, lift-out the push rods and insert them through holes in a piece of card marked from 1 to 8 to ensure assembly to their original locations.

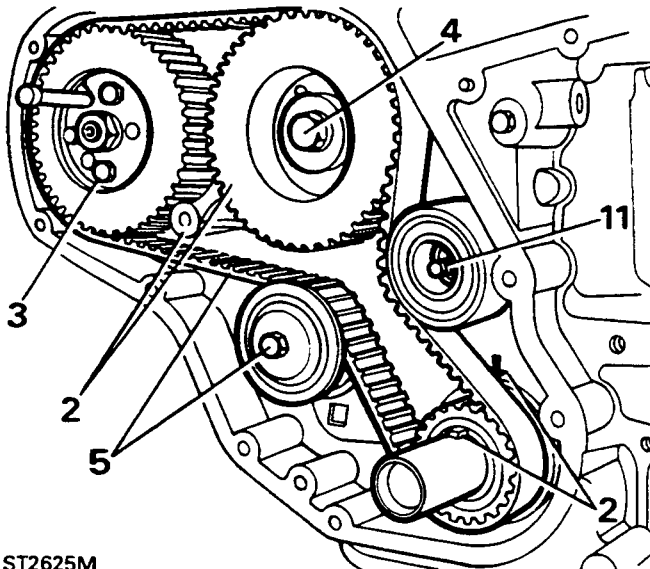


**CAUTION:** Since the injectors and heater plugs protrude below the combustion face of the cylinder head, it is important that they are removed before removing the cylinder head to avoid the possibility of damage to the injectors, heater plugs and pistons.

- Remove the valve stem caps.
- Mark each injector with the number of the cylinder to which it is fitted. Remove the injector clamp nut and carefully remove the injectors. Store in a bag to prevent contamination and damage.
- Remove the glow plugs and sealing washers and store in a safe place.
- Evenly loosen and remove the eighteen bolts retaining the cylinder head and lift the cylinder head from the cylinder block and remove the gasket. Discard the cylinder head bolts.

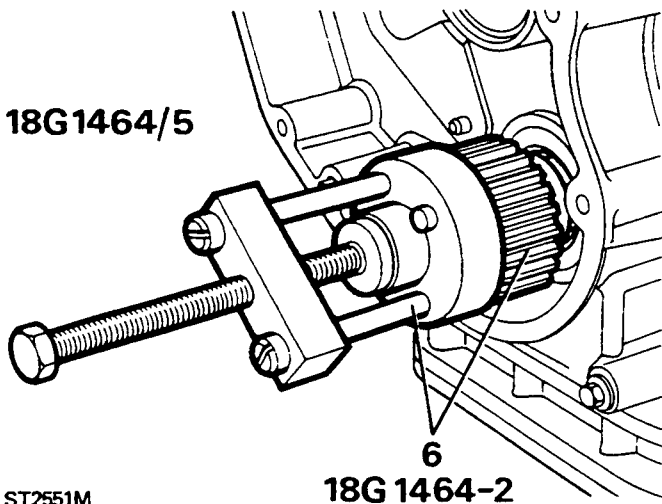


2. Check that the timing marks inside the front cover line-up with the gear wheels, ie. the arrow on the front cover aligns with the crankshaft key and the dot on the camshaft gear aligns with the front cover web.
3. Loosen the three screws securing the pump timing gear to the pump hub.
4. Temporarily fit the damper and restrain the crankshaft with service tool FR101 while the camshaft gear wheel retaining bolt is being loosened.
5. Remove the single bolt and special washer and remove the tensioner and drive belt.



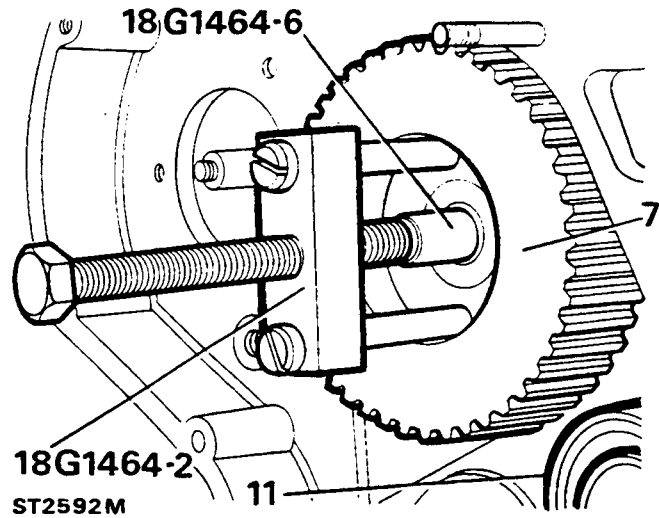
ST2625M

6. If the crankshaft gear wheel cannot be removed by hand, use special service tool 18G1462-2 and pressure button 18G1464/5. Assemble the tool as illustrated and withdraw the gear wheel.



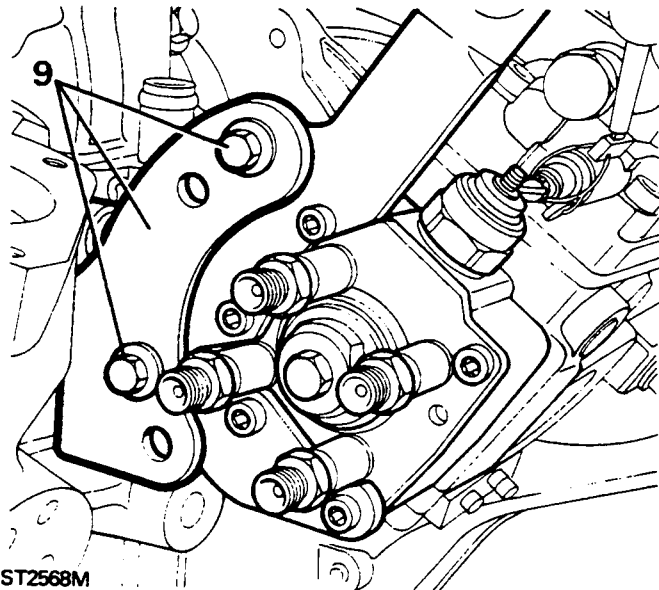
ST2551M

7. Remove the camshaft gear wheel retaining bolt. Remove gear using service tool 18G1462-2 and button 18G1464-6.



ST2592M

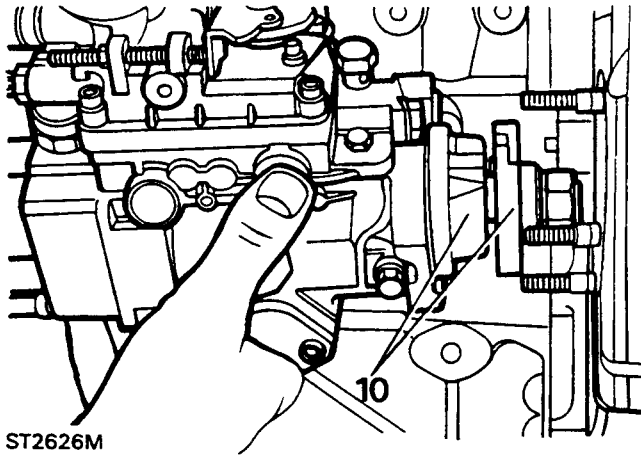
8. The timing bolt can now be withdrawn from the pump together with the three previously loosened screws and the gear removed.
9. Release the pump from the rear support bracket.



ST2568M

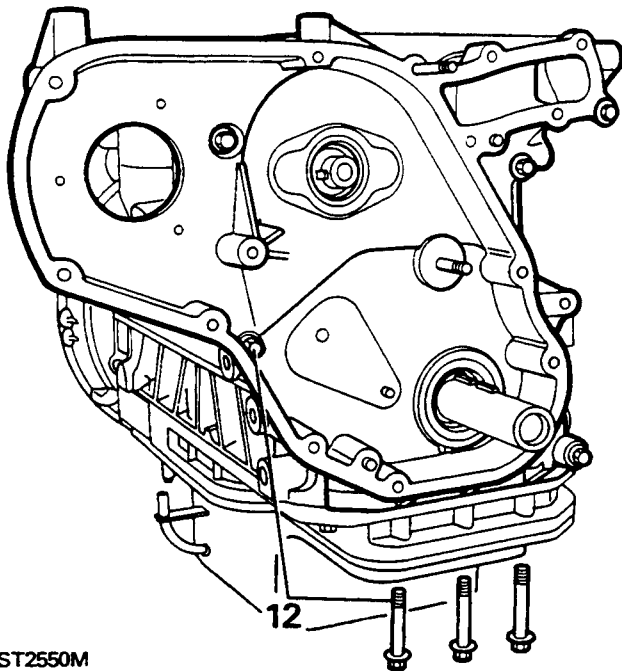


10. Remove the three nuts securing the pump flange to the front cover and withdraw the pump and gasket complete with hub.



ST2626M

11. Remove the single nut to release the static jockey pulley.  
12. To remove the front cover, release the five bolts securing it to the cylinder block front face and the three bolts that pass up through the sump and ladder frame into lower face of the cover.



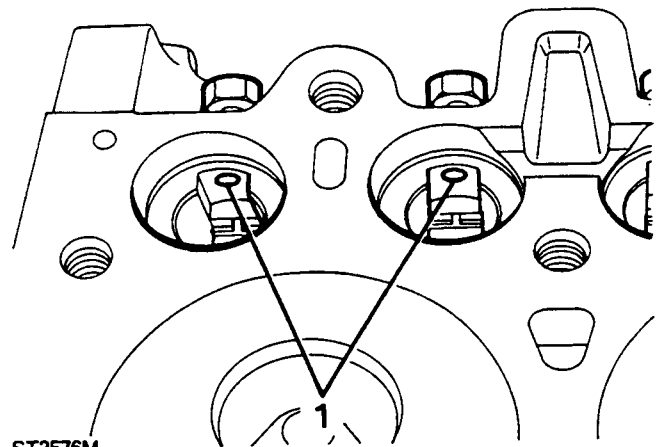
ST2550M

## REMOVING CAM FOLLOWER ASSEMBLIES



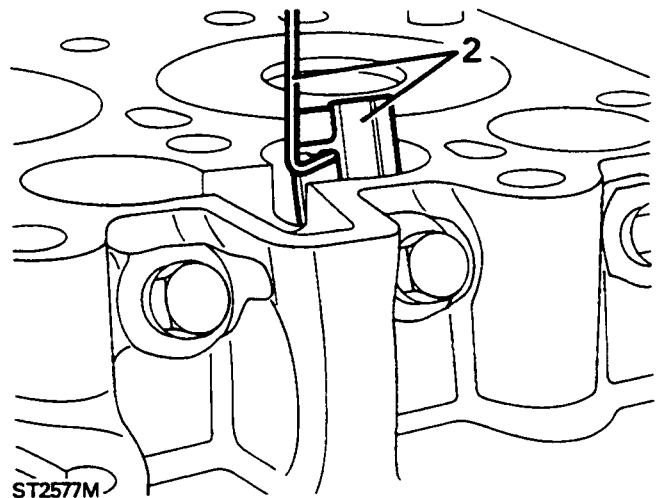
**CAUTION:** The cam followers are solid rollers held in position against the cam by a slide inside a fixed guide. If the guide is removed before the roller, the roller can fall and jam behind the camshaft. Also the roller could slip past the cam into the crankcase. It is important to follow this procedure for removal:-

1. Loosen back the guide locating screw so that the end is below the bore of the guide.



ST2576M

2. Using a length of thin wire with a hooked end lift-out the slide.



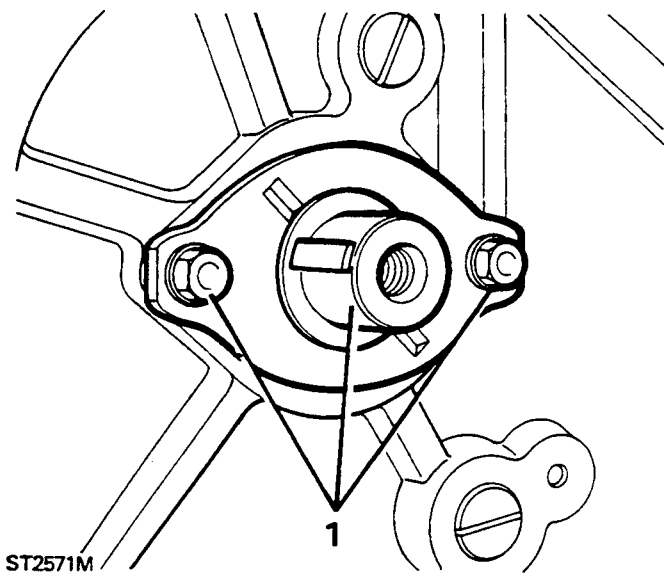
ST2577M

3. With the same piece of wire remove the roller.

4. Remove the guide locating screw and lift-out the guide.
5. As each assembly is removed, number it from one to eight, for refitting to its original location.

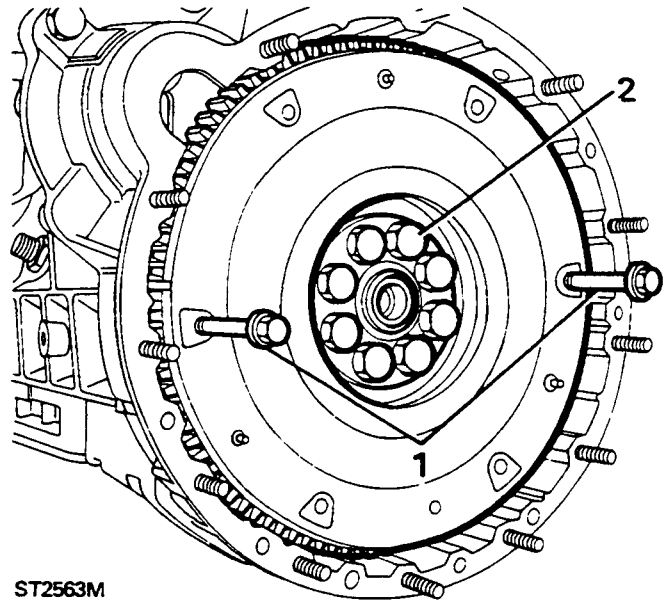
## REMOVING THE CAMSHAFT

1. Release the two screws and remove the camshaft thrust plate.

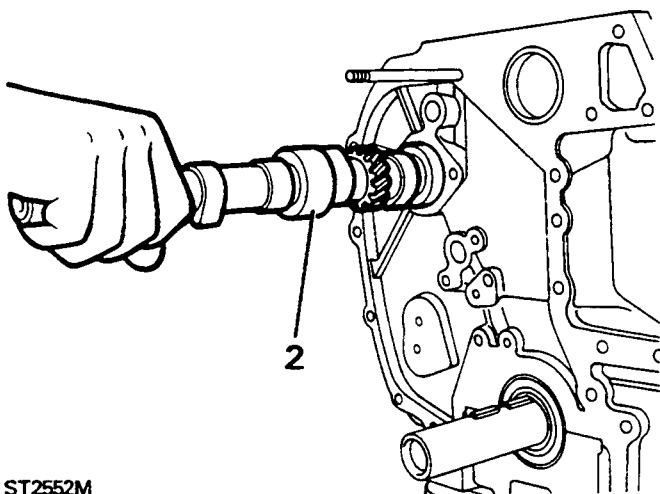


## REMOVE FLYWHEEL AND HOUSING

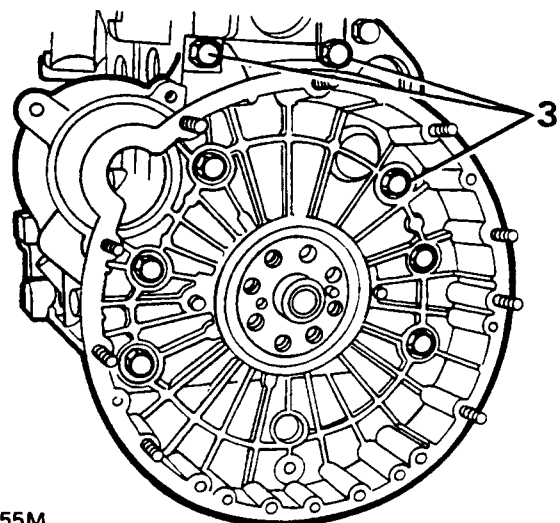
1. In the interests of safety, fit two long 8 mm bolts into the clutch bolt holes, diametrically opposite, to use as handles for lifting the flywheel off the crankshaft.
2. Temporarily fit the crankshaft damper and use service tool FR101 to restrain the crankshaft while loosening the flywheel eight retaining bolts. Remove the bolts and reinforcing plate and lift-off the flywheel.



2. Carefully withdraw the camshaft taking care not to allow the end of the shaft to drop on to the bearings as it is removed.



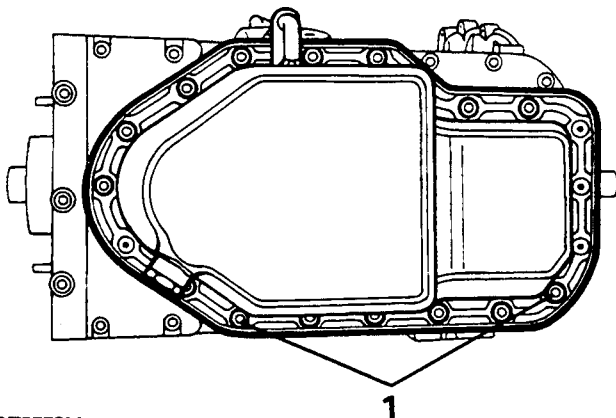
3. Remove the six internal and two external bolts and ease the flywheel housing from the two locating dowels and crankshaft. Discard the rear main oil seal, avoid damaging the seal housing.





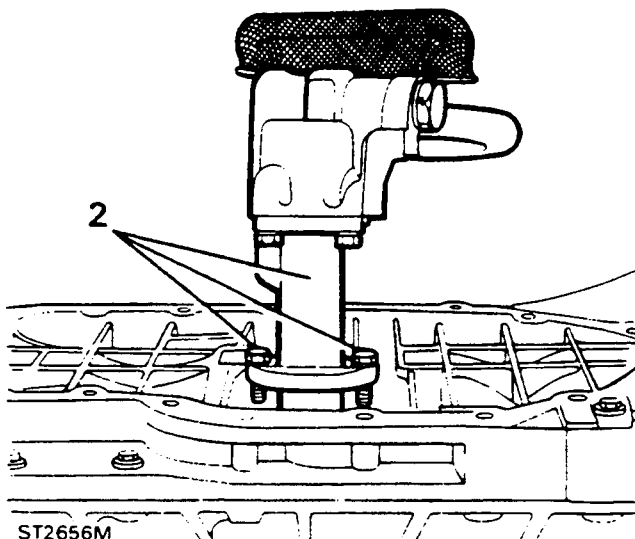
## REMOVE SUMP, OIL PUMP AND LADDER FRAME

1. Invert the cylinder block so that the sump is uppermost. Remove the remaining seventeen screws and ease the sump from the ladder frame to reveal the oil pump.



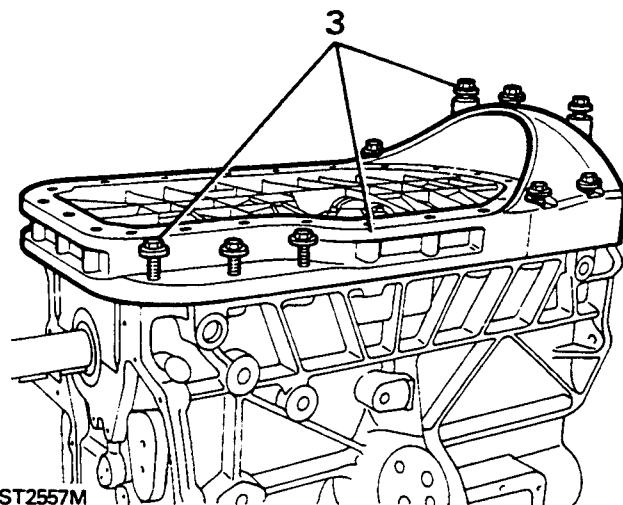
ST2553M

2. Two bolts secure the oil pump to the crankcase. Access to the right hand bolt may require the use of a socket with a universal joint. Removal of the bolts will enable the pump to be withdrawn.



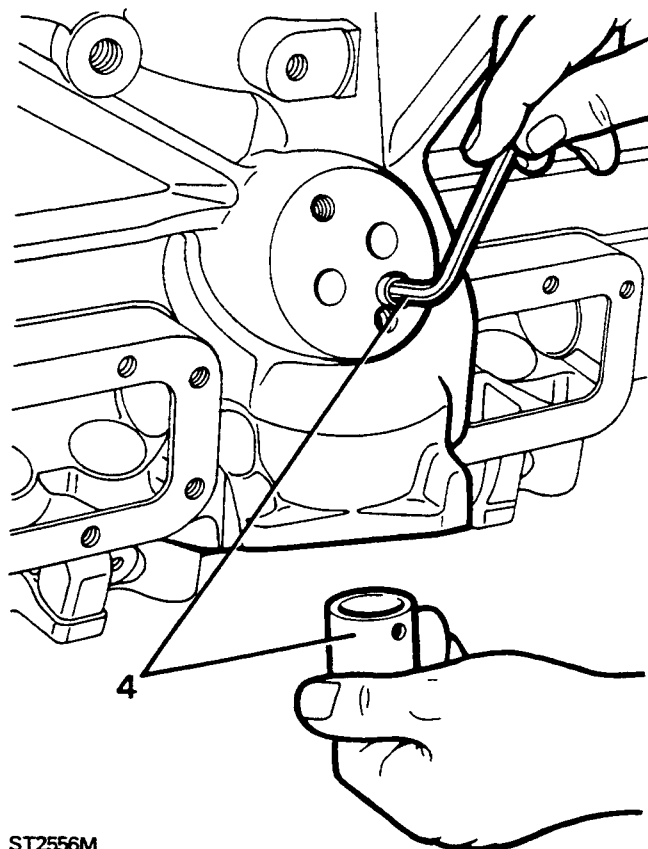
ST2656M

3. Remove the ten bolts and separate the ladder frame from the crankcase by gently tapping to break the seal.



ST2557M

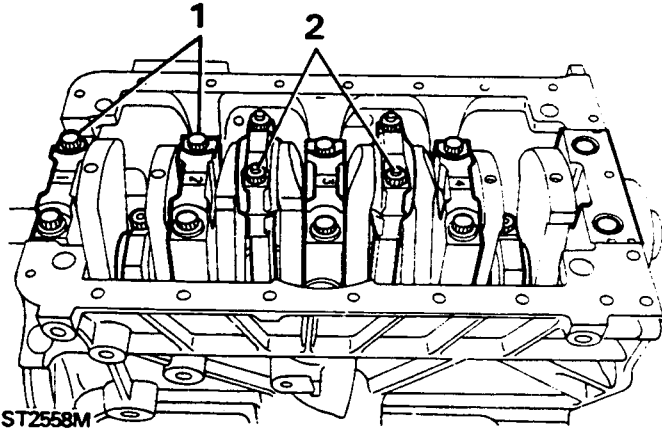
4. Using a 6 mm Allen key remove the socket headed screw retaining the skew gear bush and withdraw the bush.



ST2556M

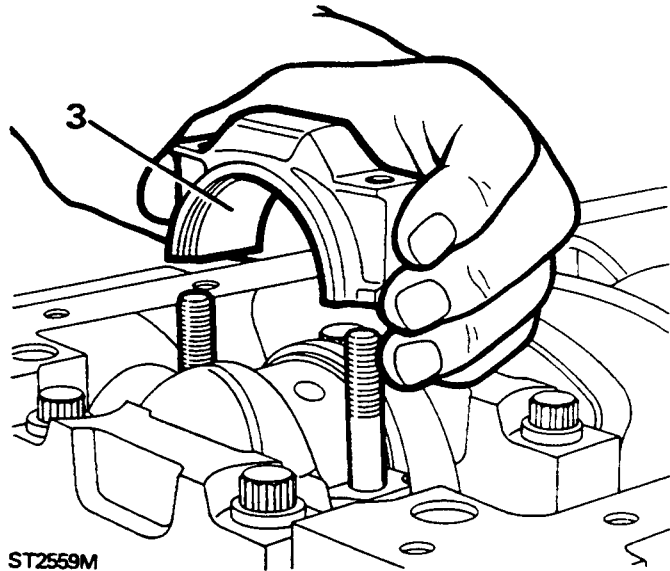
REMOVE CRANKSHAFT

1. Loosen the ten main bearing bolts with a 14 mm socket.
2. Turn the crankshaft to bring all the connecting rod caps to an accessible position and loosen the nuts using a 15 mm socket.



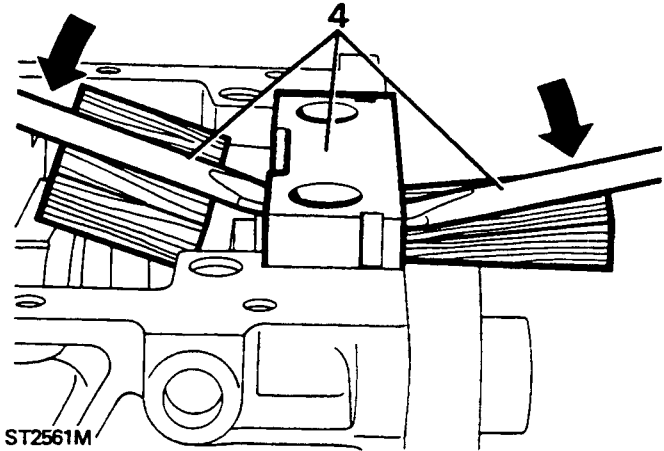
ST2558M

3. Remove the connecting rod nuts and remove the caps and lower bearing shells.



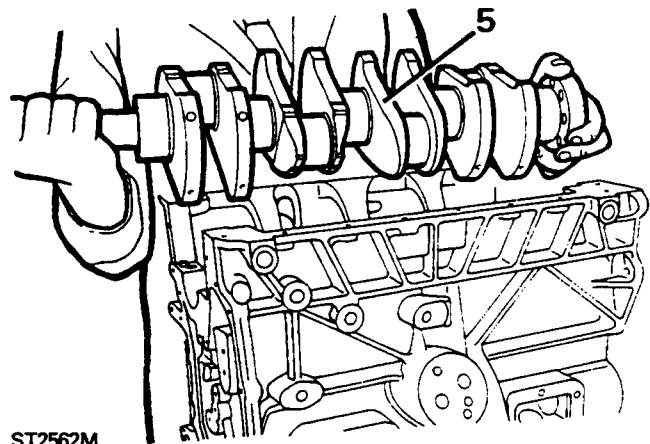
ST2559M

4. The rear main bearing cap has a "T" shaped neoprene seal each side of the main bearing cap. Difficulty may be experienced removing the cap. If so lever the cap from both sides, as illustrated. Insert a suitable bar in the hole in the inside face of the cap and lever against the crankshaft journal on the outside face. **Ensure that timber blocks are used under the levers to protect the crankshaft.**



ST2561M

5. Lift-out the crankshaft either by hand or hoist. If a hoist is used be sure to insert adequate protection between the sling and journals to avoid damage.

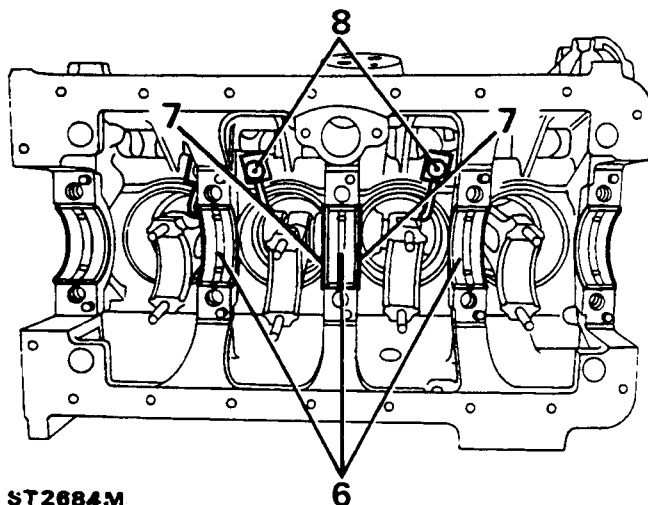


ST2562M



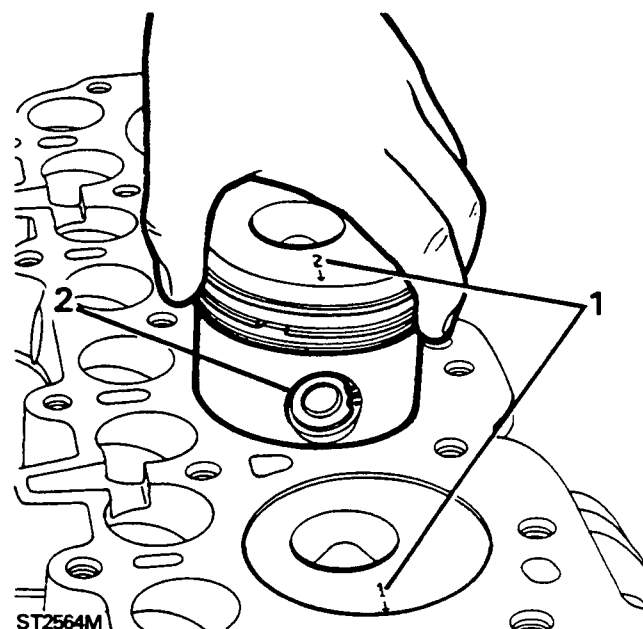


6. Remove the main bearing upper shells from the bearing saddles.
7. Remove the two thrust washers from each side of the centre saddle.
8. Remove the four jet tubes.



## REMOVE PISTONS AND CONNECTING RODS

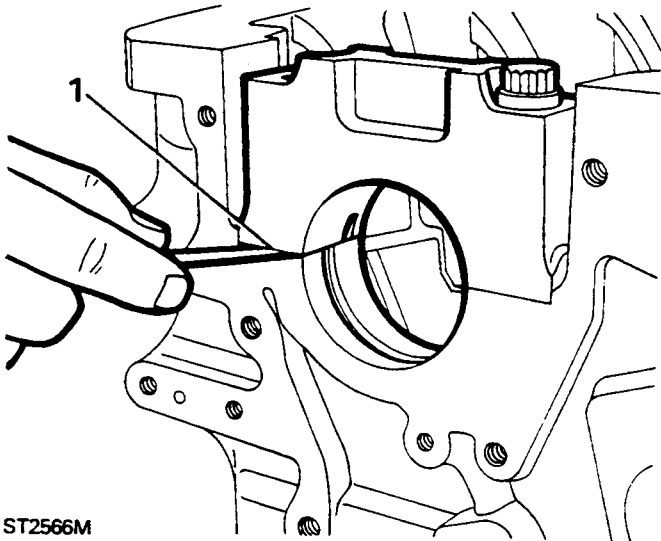
1. Before removing the piston assemblies, number each piston from one to four so that it can be identified with the bore from which it was removed.
2. Push each connecting rod and piston up the bore until it can be withdrawn from the cylinder block. As each piston assembly is removed fit the corresponding cap and bearing shell to the connecting rod noting that the shell locating tags are together on the same side as the connecting rod number.



## OVERHAUL CYLINDER BLOCK

1. Degrease the cylinder block and carry out a thorough visual examination checking for cracks and damage. To check the main bearing caps and saddles for distortion, fit the main bearing caps without bearing shells and tighten to **133 Nm**.

Loosen and remove the bolt on one side of each bearing cap and check no clearance exists at the joint face between the cap and saddle. A clearance indicates either a bent bolt, distortion of the caps, or block or that the cap has been filed or machined in an attempt to reduce the clearance due to wear in the bearings. Main bearing caps are not available separately from the cylinder block and if clearance exists the block must be renewed.



ST2566M

### Inspect cylinder bores

2. Measure the cylinder bores for ovality, taper and general wear, using any suitable equipment. However, an inside micrometer is best for checking ovality and a cylinder gauge for taper.

3. Check the ovality of each bore by taking measurements at the top of the cylinder just below the ridge at two points diametrically opposite. The difference between the two figures is the ovality of the top of the bore. Similar measurements should be made approximately 50 mm up from the bottom of the bore so that the overall ovality may be determined.
4. The taper of each cylinder is determined by taking measurements at the top and bottom of each bore at right angles to the gudgeon pin line. The difference between the two measurements is the taper.
5. To establish maximum overall bore wear, take measurements at as many points as possible down the bores at right angles to the gudgeon pin line. The largest recorded figure is the maximum wear and should be compared with the original diameter of the cylinder bore.

Maximum permissible ovality - 0,127 mm.

Maximum permissible taper - 0,254 mm.

Maximum permissible overall wear - 0,177 mm.

If these figures are exceeded the cylinders may be rebored, depending upon the condition of the bores and the amount of wear. If the overall wear, taper and ovality are well within the acceptable limits and the original pistons are serviceable new piston rings may be fitted. Deglaze the bores to give a cross-hatched finish to provide a seating for new rings. Wash the bores afterwards to remove all traces of abrasive material.

### Inspect camshaft bearings

6. Measure the internal diameter of each camshaft bearing at several points using an internal micrometer. A comparison of the bearing diameters with those of the respective camshaft journals will give the amount of clearance. The bearings should be renewed if the clearance exceeds 0,0508 mm or, if scored or pitted.



### Check crankcase main bearings

7. Discard scored, pitted, cracked and worn bearing shells.
8. To determine the maximum wear, assemble the main bearing shells and caps to the crankcase and tighten the bolts to **133 Nm**
9. Using an inside micrometer, measure each bearing at several points and note the greatest figure. The maximum wear is the difference between this figure and the smallest diameter of the corresponding crankshaft journal. The main bearing running clearance is in the data section **See GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**
10. The bearing clearances may also be determined by using 'Plastigauge'. Since this method requires the crankshaft to be fitted to the crankcase, the procedure is described under engine assembly.

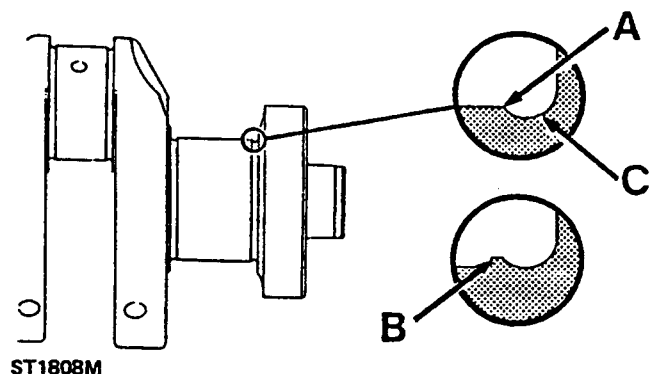
### CRANKSHAFT

1. Degrease the crankshaft and clear out the oil ways which can become clogged after long service. Examine visually, the crankpins and main bearing journals for obvious wear, scores, grooves and overheating.
2. With a micrometer, measure and note the ovality and taper of each main bearing journal and crankpin as follows.
3. **Ovality** - Take two readings at right angles to each other at various intervals. The maximum ovality must not exceed 0,040 mm
4. **Taper** - Take two readings parallel to each other at both ends of the main bearing journal and crankpin. The maximum permissible taper must not exceed 0,025 mm

5. To check for straightness, support the front and rear main bearing journals in 'V' blocks and position a dial indicator to check the run-out at the centre main bearing journal. Run-out must not exceed 0,076 mm taking into account any ovality in the centre journal. The overall wear limit should not exceed 0,114 mm for main bearing journals and 0,088 mm for crankpins.
6. A crankshaft worn beyond the limits of maximum taper, ovality and overall wear can be ground to 0,25 mm under size.



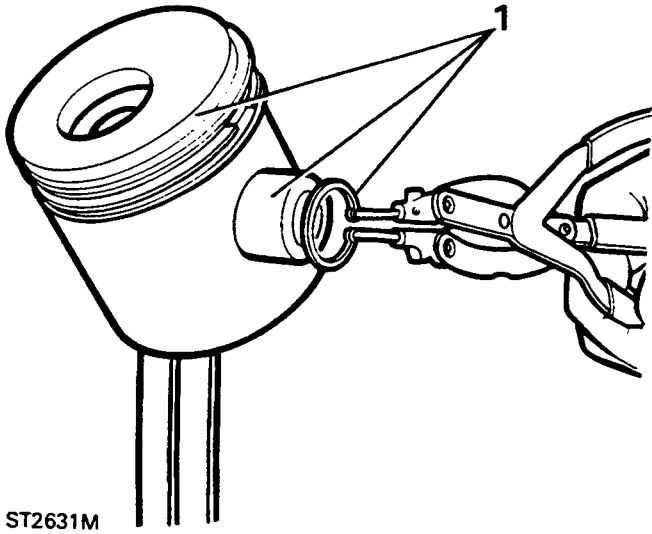
**CAUTION:** When grinding the crankshaft main bearing and crankpin journals, rotation of the grinding wheel and crankshaft must be in the same direction, anti-clockwise, viewed from the flywheel end of the crankshaft. Final finishing of the journals should be achieved by using a static lapping stone with the crankshaft rotating in a clockwise direction viewed from the flywheel end of the crankshaft. It is important to ensure that, when grinding, the stone travels beyond the edge of the journal 'A' to avoid formation of a step 'B' as illustrated. Also care must be taken not to machine or damage the fillet radii 'C'.



### PISTONS AND CONNECTING RODS

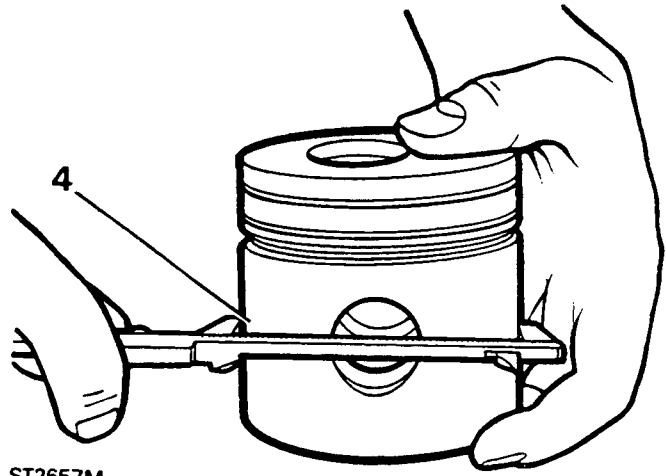
The following checks relating to pistons and rings must also be carried out prior to fitting new pistons to rebored and sleeved cylinder blocks. Until it is decided if new components are required all parts must be kept in their related sets and the position of each piston to its connecting rod should be noted.

1. Remove the piston rings and gudgeon pin from each piston and detach the connecting rod.



ST2631M

4. Using a suitable micrometer or vernier measure the pistons at the bottom of the skirt at right angles to the gudgeon pin.

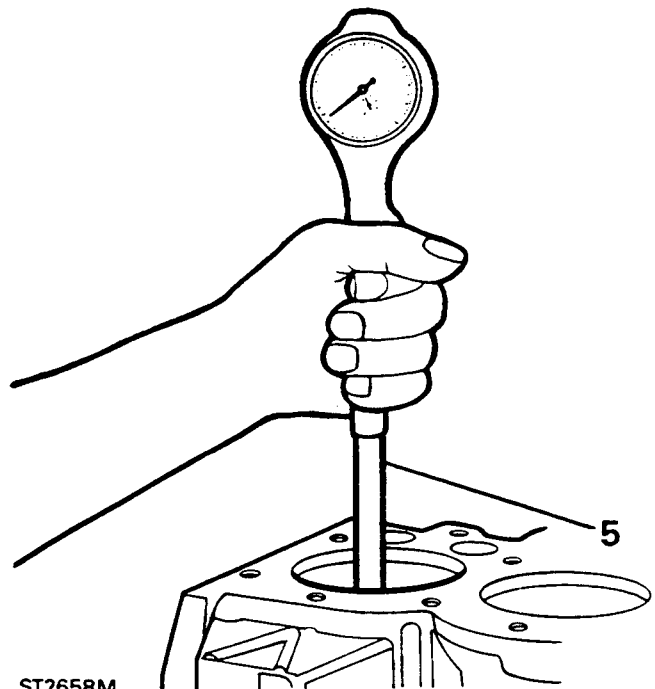


ST2657M

2. **Original pistons** - Decarbonise and degrease all components and carry out a visual examination of the piston and rings and discard any which are unserviceable. Pistons which appear serviceable should be subjected to a more detailed examination described under 'New pistons'.
3. **New pistons** - Original pistons fitted to new engines at the factory are specially graded to facilitate assembly. The grade letter on the piston crown should be ignored when ordering new pistons. Genuine Land Rover service standard size pistons are supplied 0,025 mm oversize to allow for production tolerance on new engines. When fitting new pistons to a standard size cylinder block the bores must be honed to accommodate the pistons with the correct clearances. In addition Land Rover pistons are available 0,50 and 1,01 mm oversize for fitting to rebored cylinder blocks.

Clearance limits for new standard size pistons in a standard cylinder bore measured at right angles to the gudgeon pin are in the data section. **See GENERAL SPECIFICATION DATA, Information, 200 Tdi engine**

5. With an inside micrometer or cylinder gauge measure the diameter of the bore at approximately half-way down and note the reading.
6. The clearance is determined by subtracting the piston diameter from the bore diameter.



ST2658M

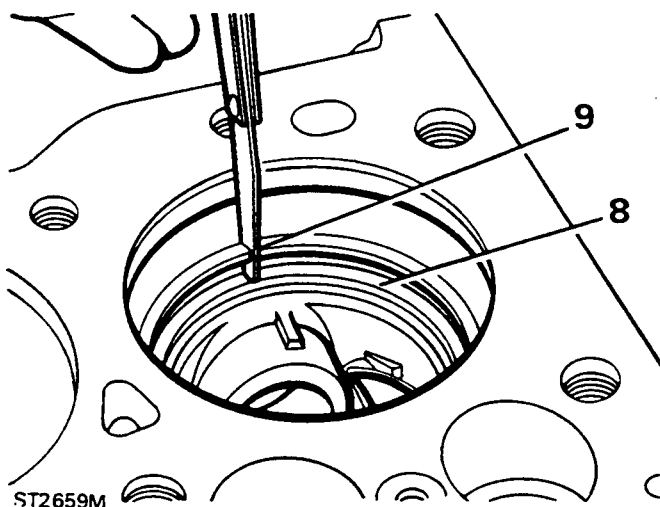


7. If gauge equipment is not available the clearance can be assessed by placing a long, suitably sized, feeler gauge down the thrust side of the bore and inserting the appropriate piston, 'upside down', in the bore and position it with the gudgeon pin parallel to the crankshaft axis. Push the piston down the bore and stop at the tightest point and whilst holding the piston still, slowly withdraw the feeler gauge. If a steady resistance of approximately 2,5 kg is felt, the clearance is satisfactory.

### Inspect piston rings

Normally when an engine is being overhauled the piston rings are discarded unless the pistons have been removed for a different purpose and the engine has only completed a small mileage. Before refitting the piston the rings should be examined for wear and damage. In addition the rings must be checked for side clearance in the pistons and gap in the bores. The latter two checks must be made when fitting new rings to new and used pistons.

8. **Check gap** - When checking the ring gap in worn bores, which are within the acceptable taper and ovality limits, the ring must be inserted squarely into the bottom of the bore at the lowest point of the piston travel. To ensure squareness of the ring push the ring down into the bore to the correct position with a piston. With newly machined bores, the ring may be inserted squarely into any position in the bore.



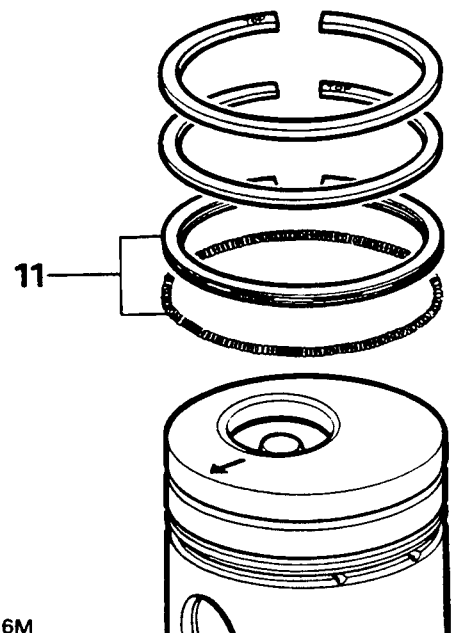
9. Measure the gaps of all the rings, in turn, including the oil control ring assembly.

The correct gaps are listed in the data section **See GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**

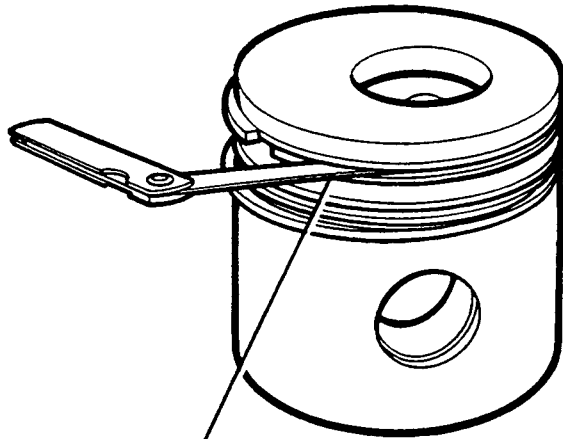
If any gap is less than that specified, remove the ring, and file the ends square, whilst holding the ring in a filing jig or vice. Should any gap be excessively wide and not likely to close up to within the specified limits when hot, an oversize ring should be fitted.

### Check piston side ring clearance

10. It is important that clearances are correct. Rings that are too tight will bind when hot, impairing the radial pressure causing possible loss of compression. Excessive clearance will allow the rings to rock in the grooves and the resulting pumping action could cause excessive oil consumption and eventually broken rings.
11. Fit the oil control ring expander to the bottom groove, then fit the oil control ring ensuring that it fits over the expander. Fit the second, narrow, compression ring with the word "TOP" uppermost. Likewise fit the first compression ring to the top groove, word "TOP" uppermost.
12. After fitting each ring, roll it around the piston groove to ensure that it is free and does not bind.



13. Measure the clearance between the rings and piston grooves. Clearances in excess of the figures given in data section are unacceptable and the rings or the pistons should be renewed.



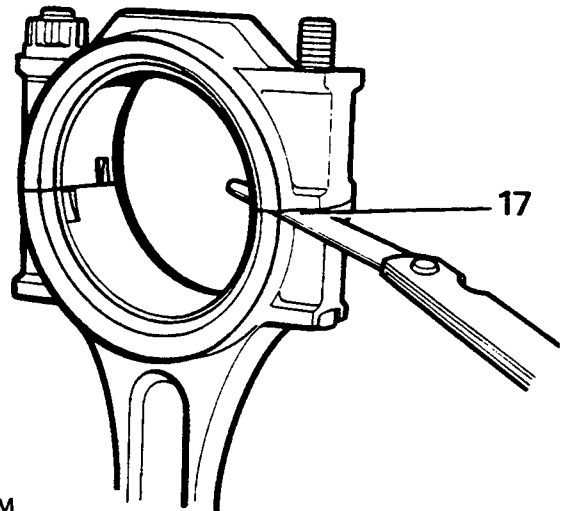
ST2632M

### Inspect gudgeon pins

14. Check the gudgeon pins for wear, cracks, scores and overheating.
15. The gudgeon pin fit into the piston must be tight push fit at a temperature of 20°C. Check the gudgeon pin for ovality and taper using a micrometer.

### Connecting rod inspection

16. Check the connecting rods and caps for distortion as follows; fit the correct cap, less the bearing shells, to each connecting rod as denoted by the number stamped near the joint faces. This number also indicates the crankshaft journal to which it must be fitted.
17. Tighten the nuts to **59 Nm** and release the nut on one side only. Check that no clearance exists between the joint faces. If there is a gap the connecting rod is distorted and should be renewed.



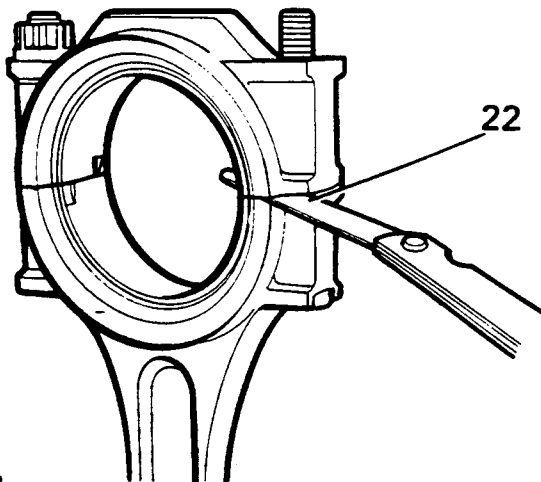
ST2633M

18. Use a connecting rod alignment gauge to check the rods for bend and twist. The maximum allowable for both conditions must not exceed 0,127 mm
19. Examine and check the small-end bush for wear. If necessary renew the bush. The correct clearance of the gudgeon pin in the small-end bush is given in the data section. **See GENERAL SPECIFICATION DATA, Information, 200 Tdi engine**
20. When renewing a bush, ensure that the oil hole in the bush lines up with the hole in the connecting rod. Finish the bush to the correct size and clearance.
21. Connecting rod bearings that are worn, pitted, scored and show signs of overheating must be discarded. If more than one of the bearings show these signs they must all be renewed. When fitting new or used bearings to serviceable crankpins the clearances must be checked.

### Connecting rod bearing nip and clearance

New bearing halves are supplied with a protective coating and must be degreased before fitting.

22. Fit the bearing halves to the connecting rod and cap and secure the assembly to **59 Nm** Loosen the nut on one side only and check the clearance between the joint faces with a feeler gauge.



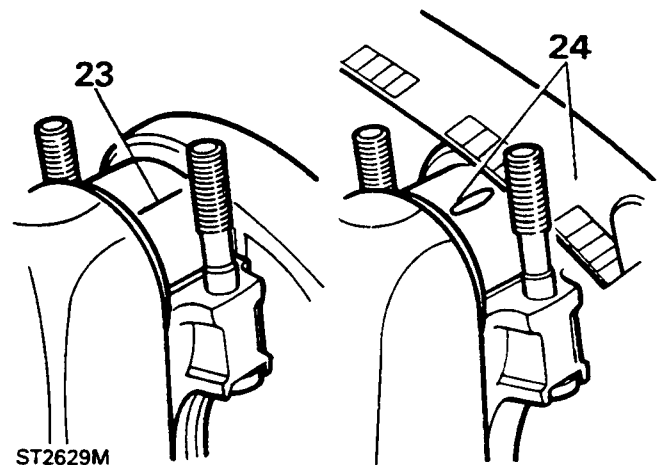
ST2630M

The clearance should be 0,10 to 0,20 mm The bearing nip can be adjusted by the selective assembly of the bearing shells which are available in slightly varying thicknesses. Do not file or machine the rods to vary the bearing nip.

Make a final check to prove the clearance by inserting a 0,063 mm shim paper between the crankpin and one half of the bearing and tighten. The connecting rod should resist rotation and move freely with the shim paper removed. Alternatively, the bearing clearances can be determined by using 'Plastigauge'. This consists of a thin piece of plastic material. When this material is squeezed between the bearing and crankpin the width of the plastic is measured by a scale gauge which indicates clearance.

23. Wipe any oil from the crankpins and place a piece of 'Plastigauge' across the centre of the bearing in the connecting rod cap. Assemble the rod to the appropriate crankpin and tighten to the correct torque. Do not rotate the connecting rod or the crankshaft during this operation.

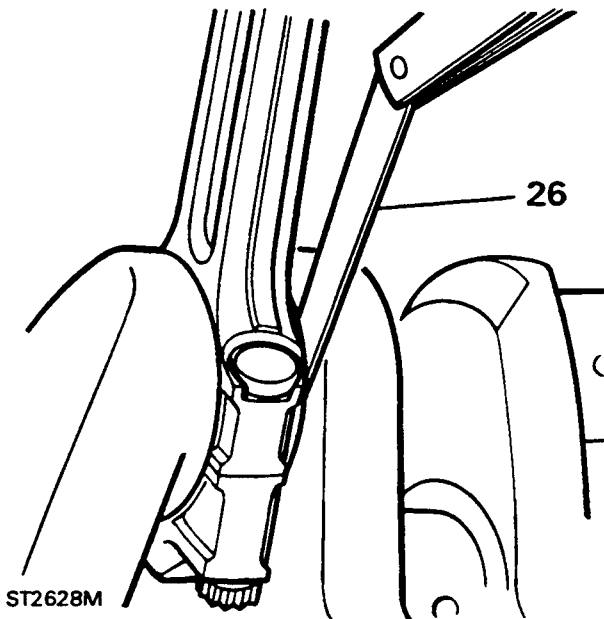
24. Remove the connecting rod cap and bearing shell and using the scale supplied measure the flattened 'Plastigauge' at its widest point. The graduation that most closely corresponds to the width of the 'Plastigauge' indicates the bearing clearance. The correct clearance with new or overhauled components is given in the data section. See **GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**
25. Wipe off the 'Plastigauge' with an oily rag. Do not scrape it off otherwise it may damage the crankpins.



ST2629M

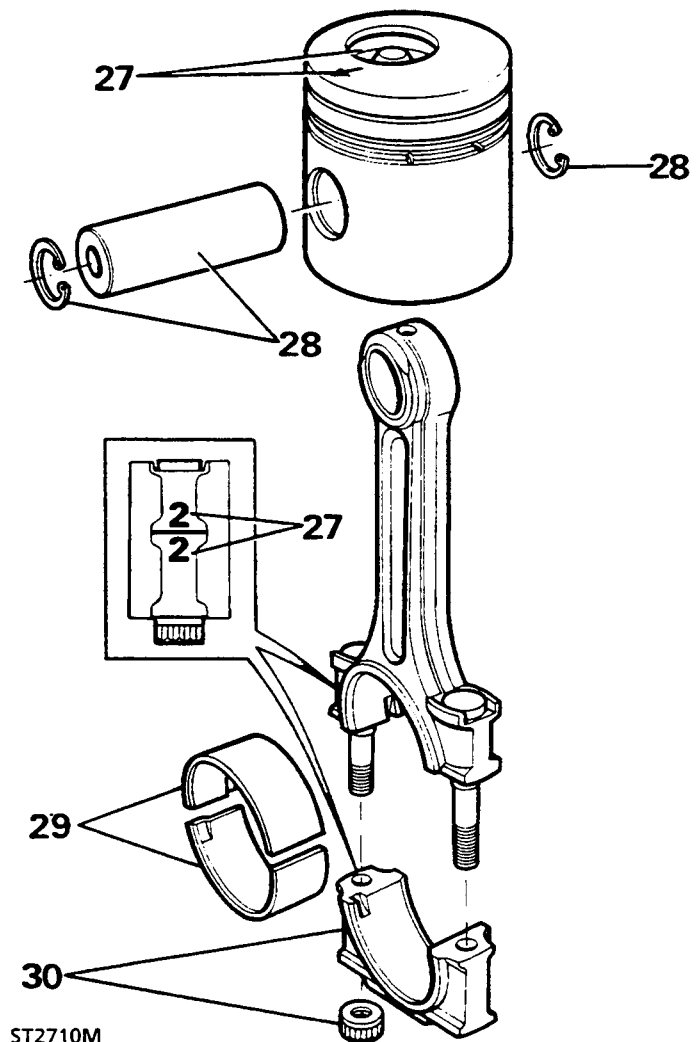
## Connecting rod end-float

26. Fit the connecting rods complete with bearings to their respective crankpins. Move the connecting rod to one side and check the clearance, with a feeler gauge, on the opposite side. The correct clearance is given in the data section **See GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**



## Assembling pistons to connecting rods

27. The piston must be assembled to the connecting rod so that the arrow on the piston crown points to the front of the engine and the off-set combustion chamber bearing shell tags and connecting rod number are all on the same, right hand side of the cylinder block viewed from the rear of the engine (camshaft side).
28. Insert a circlip in one side of the gudgeon pin boss and assemble the piston to the connecting rod with the gudgeon pin. Secure the assembly with a circlip on the opposite side of the piston.
29. Fit the bearing shells to the connecting rod and cap. Ensure that the tags locate correctly in the cut-outs.
30. Assemble the cap to the rod and secure temporarily with the two nuts until ready for fitting to the cylinder block.





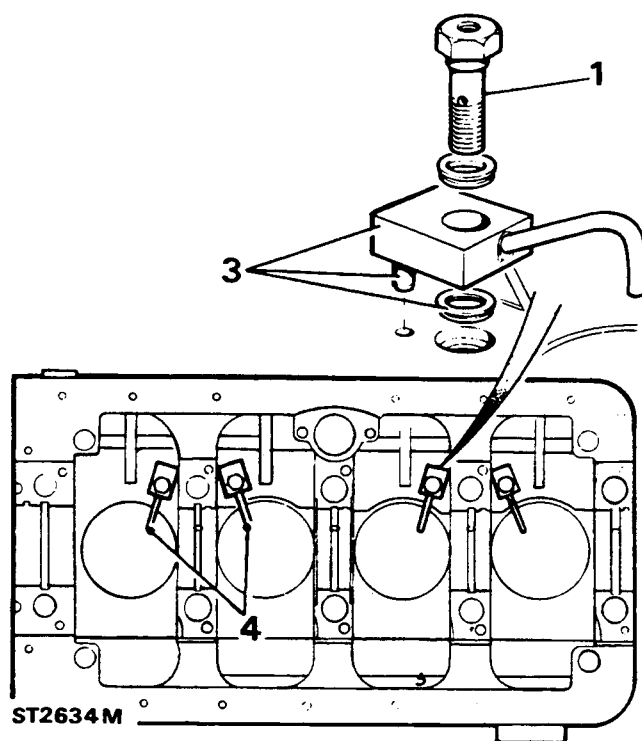


## FIT JET TUBES TO CYLINDER BLOCK

Oil jet tubes are fitted to lubricate the pistons and bores directly from the main oil gallery.

1. The jet tubes are 'handed' and can only be fitted one way. It is important to note that the jet retaining bolt contains a non-return valve and therefore on no account must an ordinary bolt be used.
2. Clean the recess in the cylinder block using an air line, if available, to remove any swarf.
3. Assemble and fit the jet tube assemblies ensuring that the pegs locate in the holes in the cylinder block, and that the larger diameter washer fits under the bolt head. Tap the jet blocks down to ensure that the locating dowel is fully home. Fit and tighten the retaining bolts to **17 Nm**

When the crankshaft and pistons have been fitted, slowly turn the crankshaft and check that no fouling occurs.



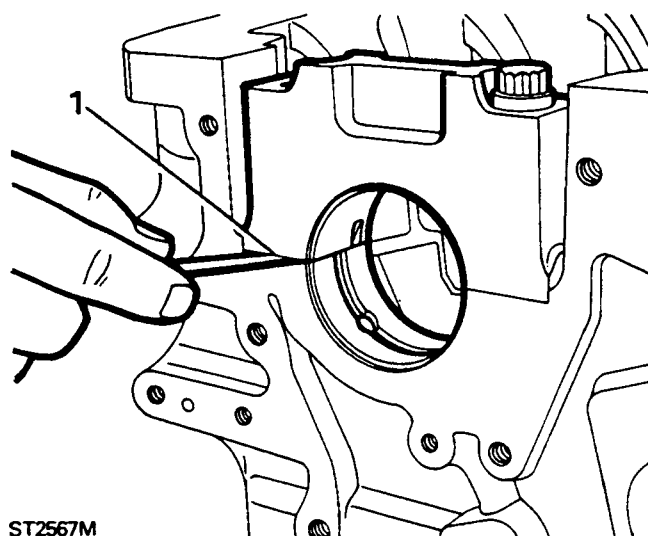
## FIT CRANKSHAFT

### Main bearing nip and clearance

New main bearing halves are supplied with a protective coating and must be degreased before fitting.

1. Fit the bearing halves in the crankcase saddles and caps and secure the caps to the crankcase and tighten to **133 Nm**

Loosen the bolts on one side of the caps only and, with a feeler gauge, check the gap between the joint faces. The clearance or nip must be within 0,10 to 0,15 mm. The bearing nip can be adjusted by selective assembly of the bearing halves available in varying thicknesses. Do not file or machine the caps or saddles to achieve the correct clearance. Note that the rear main bearings are wider than the remaining four.

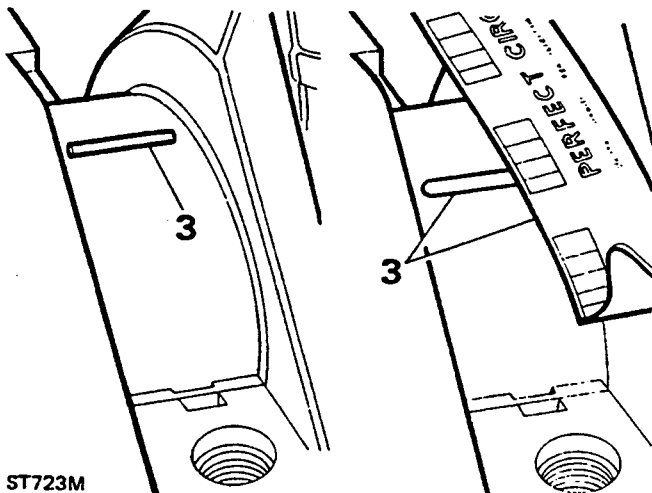


2. To make a final check that the clearance is correct, leave the bearing halves in the crankcase saddles and carefully lower the crankshaft into position. Check each bearing in turn by inserting a 0,063 mm shim paper between the bearing cap and crankshaft journal and tighten the bolts to **133 Nm**. If the clearance is correct, there should be a slight increase in the resistance to the rotation of the crankshaft. As an alternative 'Plastigauge' may be used to check the clearance in the same manner as with the connecting rod bearings. This material may also be used to determine the amount of wear in used bearings and journals.

3. Locate the crankshaft in position on the upper bearing halves in the crankcase and wipe any oil from the journals since 'Plastigauge' is soluble in oil. Place a piece of 'Plastigauge' across the lower half of each crankshaft journal or lower bearing cap shell. Fit the cap and tighten to the correct torque. Remove the cap and bearing and using the scale supplied with the 'Plastigauge' measure the flattened 'Plastigauge' at its widest point. The graduation that most closely corresponds with the width of the 'Plastigauge' indicates the bearing clearance.

The correct clearance with new or overhauled components is included in the data section **See GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**

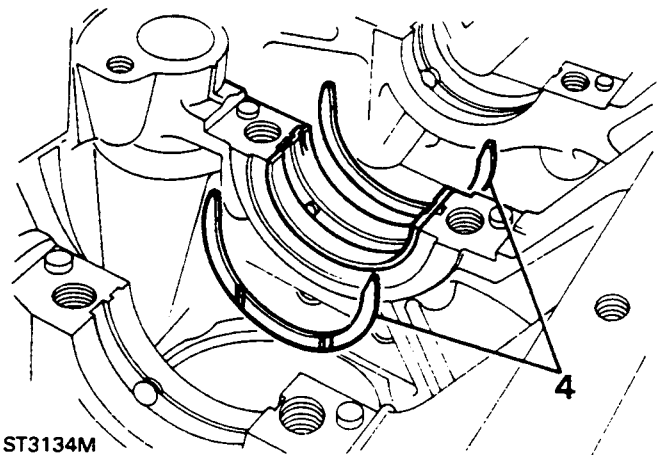
If fitting new bearings use selective assembly to obtain the correct clearance. Wipe off, not scrape the 'Plastigauge' with an oily rag from the journals or bearings.



ST723M

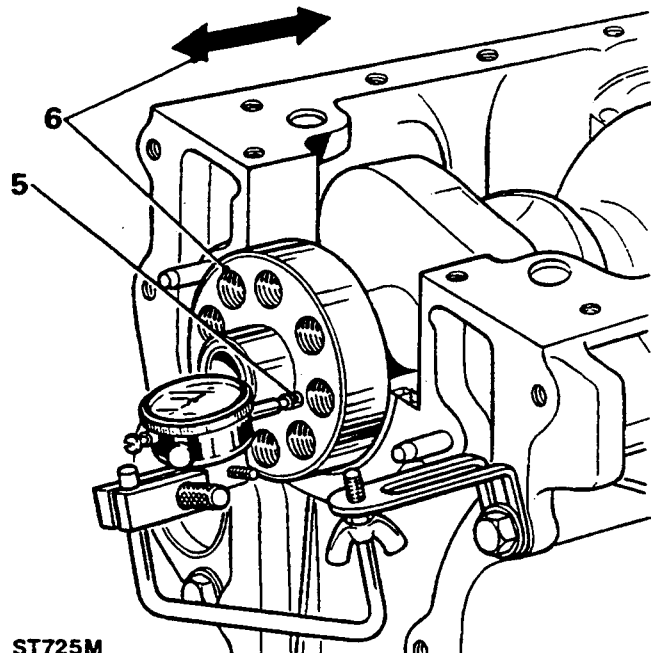
### Adjust crankshaft end-float

4. Lift out the crankshaft and insert a standard size thrust washer both sides of the centre main bearing saddle with the grooves towards the crankshaft.



ST3134M

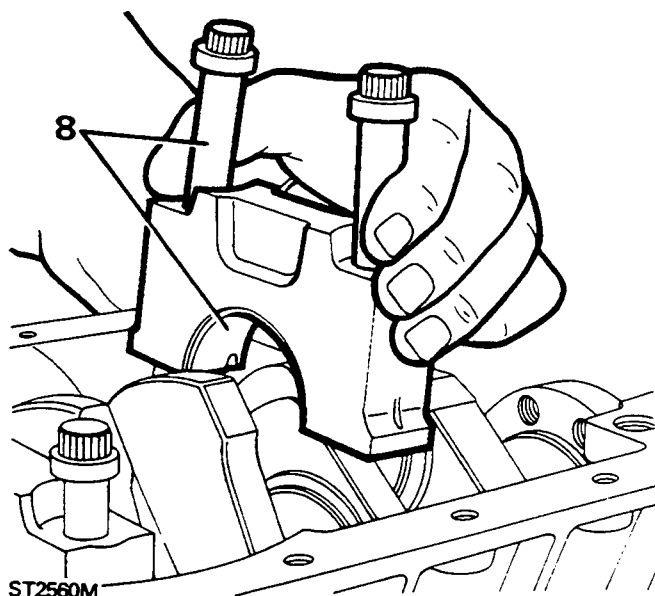
5. Place the crankshaft in position in the crankcase and mount a dial test indicator to read-off the end of the crankshaft. A feeler gauge may be used instead of an indicator.
6. Determine the end-float by moving the crankshaft away from the indicator and zero the dial. Move the crankshaft in the opposite direction and note the indicator reading. Alternatively measure the clearance with a feeler gauge. The end-float should be 0,05 to 0,15 mm



ST725M



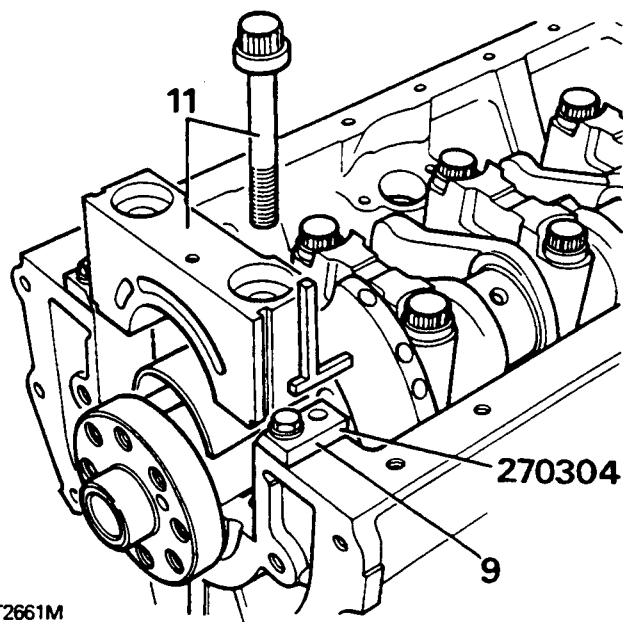
7. If adjustment is required substitute with oversize thrust washers. Variation of thrust washer thicknesses at each side of the crankshaft journal must not exceed 0,08 mm to ensure that the crankshaft remains centralised.
8. Lubricate the crankshaft main journals with clean engine oil and fit the appropriate bearing caps and lower shells to the crankcase with the exception of number five bearing. Ensure that the caps locate properly over the dowels. Using new bolts evenly tighten to **133 Nm**.



ST2560M

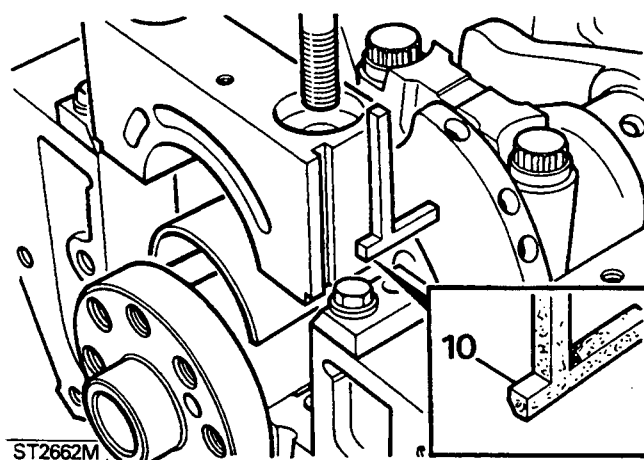
#### Fit rear main bearing cap

9. Ensure that number five main bearing cap is clean and free from old seal material. Attach the seal guides number 270304 to the crankcase, as illustrated, and ensure that they are parallel to the crankcase edge.



ST2661M

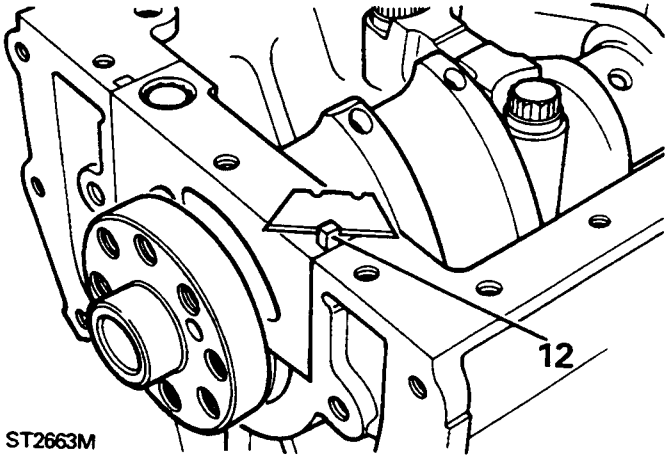
10. To prevent any seal material becoming trapped between the bearing cap and crankcase, chamfer the inner edge of the seal 0,40 to 0,80 mm wide as illustrated. Smear the seals with engine oil and fit them to the bearing cap.



ST2662M

11. Fit the bearing cap and lower shell to the crankcase and secure with new bolts and tighten to **133 Nm**. Remove seal guides.

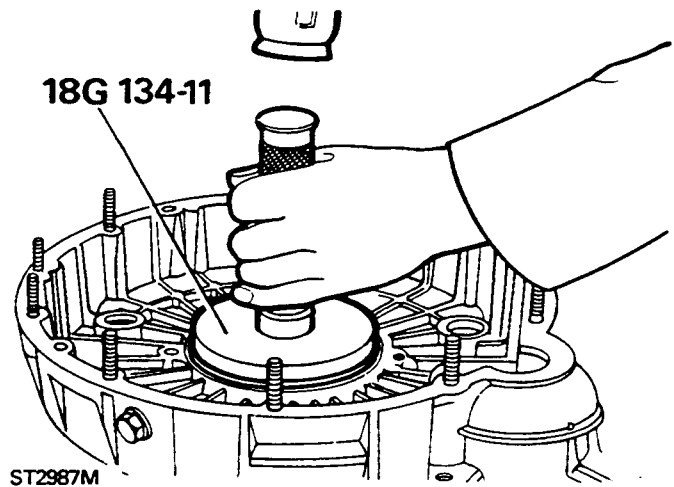
12. To allow for shrinkage after fitting leave the seals standing proud of the crankcase face then using a sharp blade, trim the seals off to approximately 0,80 mm above the crankcase face.



## FITTING REAR MAIN OIL SEAL TO FLYWHEEL HOUSING

**NOTE:** The oil seal is manufactured from PTFE and is supplied with a former to maintain the correct shape which must not be removed until the seal is to be fitted.

1. Make sure the seal housing is clean and dry and free from burrs. Do not touch the seal lip and ensure that the outside diameter is clean and dry.
2. Using seal replacer 18G134-11 and with the lip side leading fit the seal. Fit the seal to the bottom of the housing.

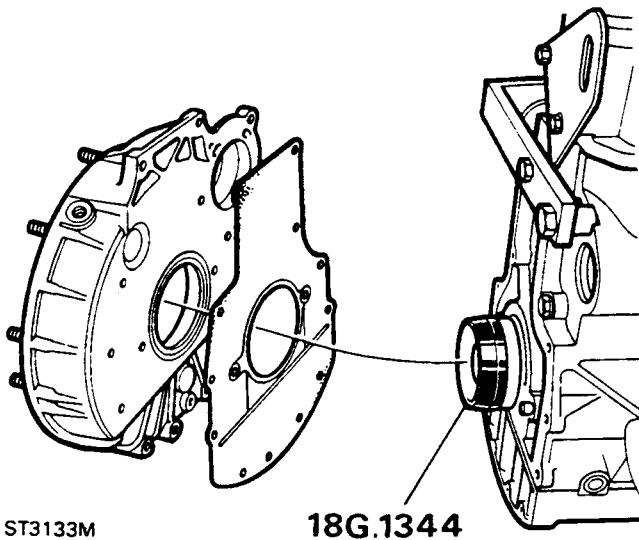


### Fitting flywheel housing

3. Examine the seal guide, number 18G1344 ensuring that it is perfectly smooth and not damaged or scratched. Also check that the crankshaft oil seal journal is smooth and clean.



4. Locate the seal guide on to the crankshaft and lubricate the seal, guide and journal.
5. Position the gasket on the cylinder block over the two dowels. The gasket will only fit one way round.
6. Fill the annular groove with RTV sealant.
7. Place the seal guide over the crankshaft flange and using the two dowels as a guide to ensure initial squareness, fit the flywheel housing and remove the seal guide.
8. Secure the housing with the retaining bolts and tighten evenly to **45 Nm**

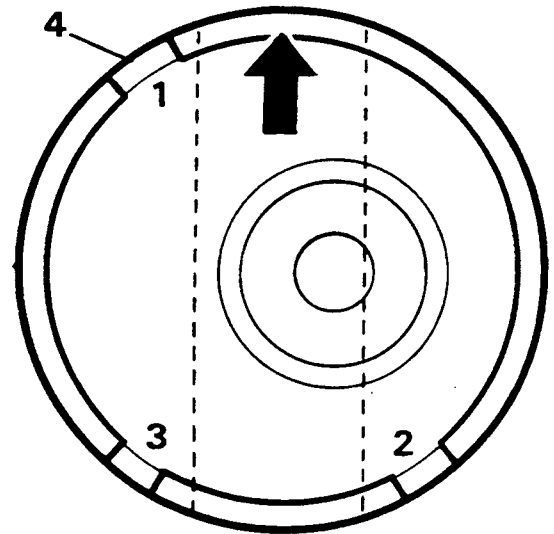


ST3133M

18G.1344

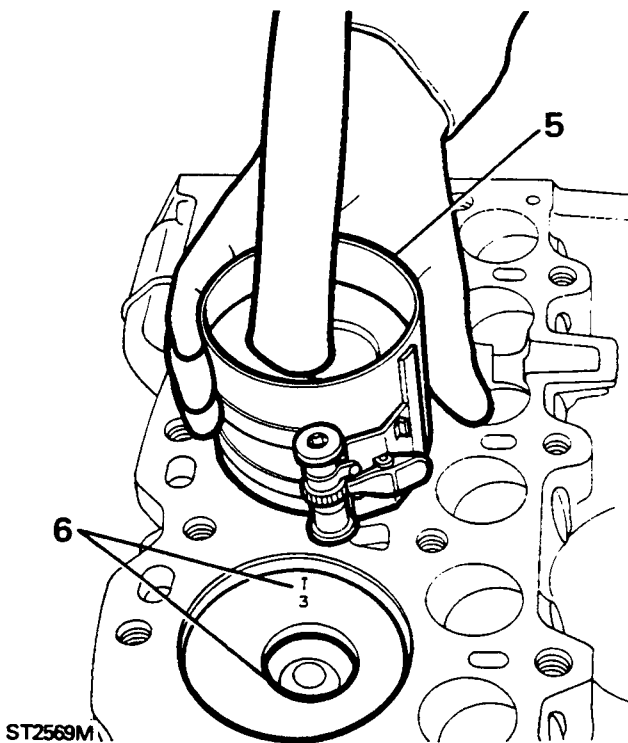
## FIT THE CONNECTING RODS AND PISTONS

1. Invert the cylinder block so that the combustion face is uppermost. Turn the crankshaft to position numbers one and four crankpins at bottom dead centre to facilitate fitting the connecting rods.
2. When fitting the connecting rods and pistons ensure that bolts do not foul and damage the crankpins. It is recommended that rubber or soft plastic sleeves are placed over the threads.
3. The connecting rod bolts have eccentric heads which locate in a recess in the connecting rod. It is essential that the head of each new bolt is properly located before tightening.
4. Stagger the compression rings so that the gaps are equidistantly spaced around the piston but, arranged so, that no gap is positioned on the thrust side of the piston i.e. opposite the camshaft. Turn the oil control ring so that the gap is to the left of the gudgeon pin.

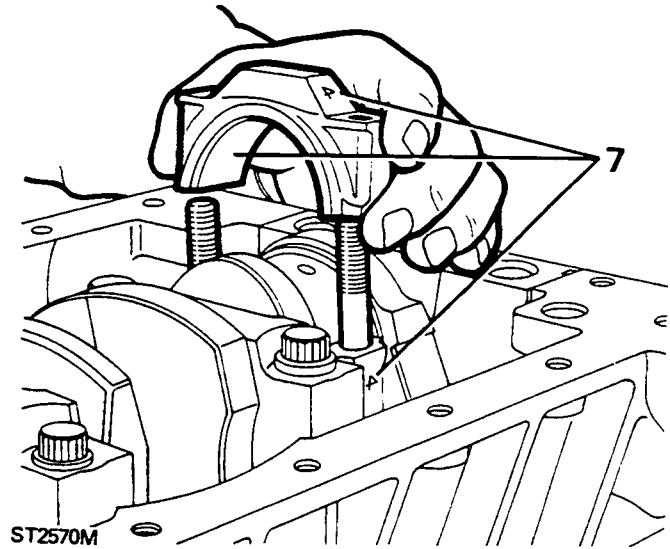


ST2669M

5. Lubricate the cylinder walls, piston rings and crankpins. Compress the piston rings with a suitable compressor tool and carefully lower the connecting rod into the bore ensuring that the piston is assembled in accordance with instruction 27 under "Assemble pistons to connecting rods".
6. The arrow must point to the front of the engine and the offset combustion chamber in the piston crown must be towards the camshaft side of the cylinder block, with the bearing tag also on the camshaft side. Sharply tap the piston into the bore so that the whole of the piston is just below the surface of the cylinder block.

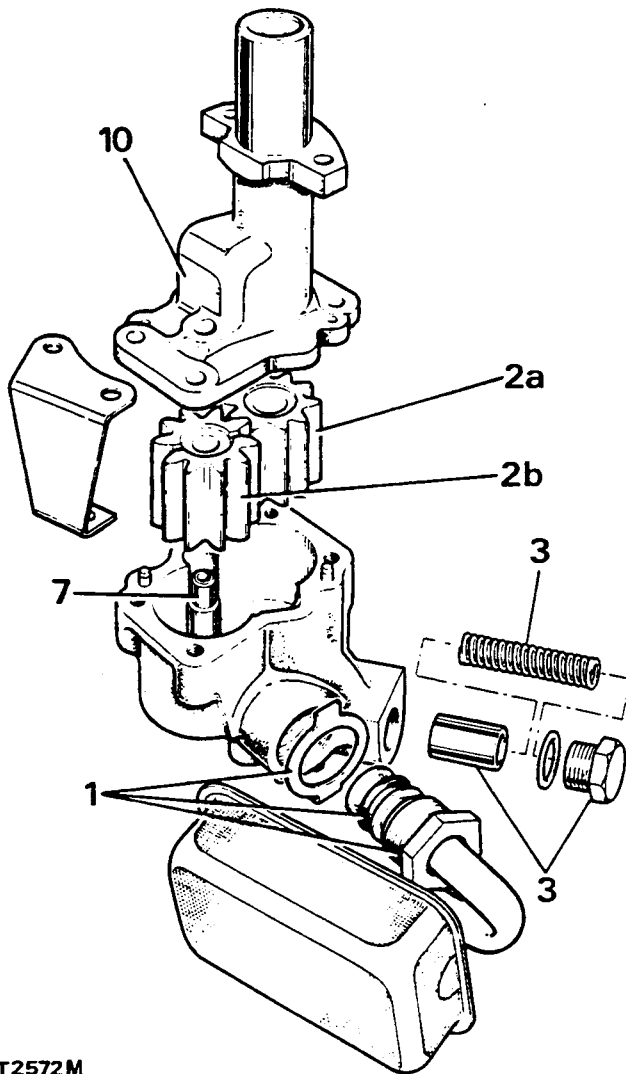


7. Check that the bearing shell is properly located in the connecting rod and pull the rod onto the crankpin. Locate the bearing shell correctly and fit the cap so that the identification numbers are together on the camshaft side of the engine. Fit and tighten new nuts to the correct torque **59 Nm**. Repeat the foregoing instructions for fitting the remaining piston and connecting rod assemblies.



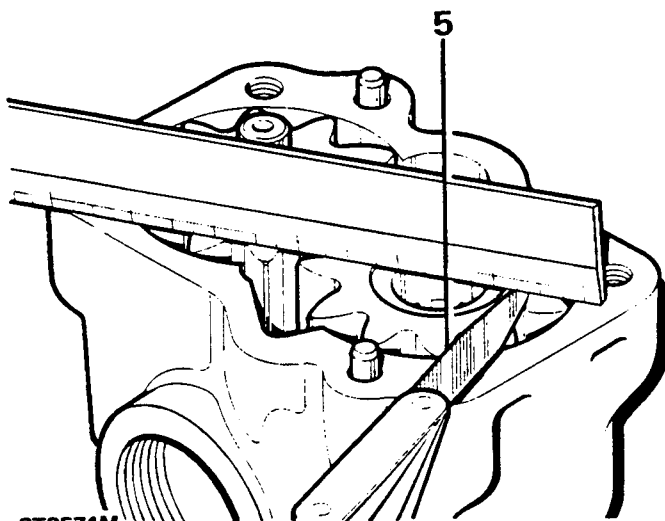
## OVERHAUL THE OIL PUMP

1. Bend back the lock washer and release the nut securing the strainer to the oil pump body and remove the strainer and sealing ring.
2. Remove four bolts and washers and lift off the oil pump cover and lift out the driven and idler gears.
  - (a) driven gear
  - (b) idler gear
3. Remove the oil pressure relief valve plug and sealing washer. Withdraw the relief valve spring and plunger and examine for wear and scores.
4. Examine the gears for wear, scores and pits. If the gears appear serviceable check for end-float as follows:
5. Clean the pump body and assemble the gears. Place a straight edge across the pump body face, as illustrated, and using a feeler gauge, measure the clearance between the body and gears. Check also the backlash between the gears. The correct clearances are given in the data section **See GENERAL SPECIFICATION DATA, Information, 200 Tdi Engine**



ST2572M

6. A worn, but serviceable gear, must not be matched with a new one, always renew gears in pairs.

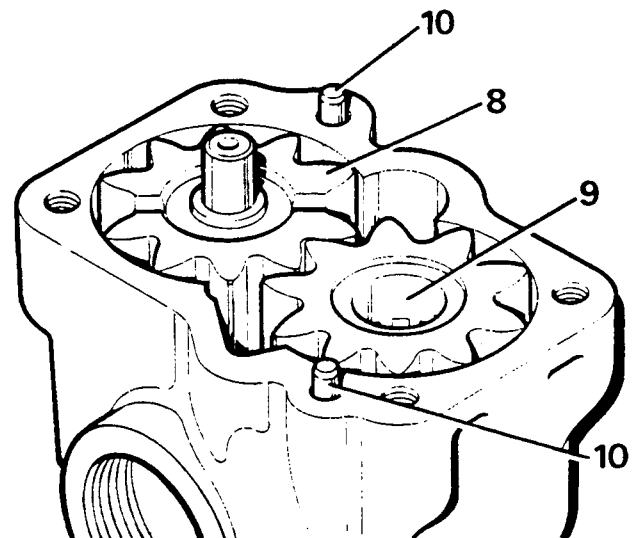


ST2574M

7. If necessary renew idler gear spindle by driving-out the spindle from the pump body and driving or pressing-in a new spindle up to the shoulder of the spindle.

#### Assemble the oil pump

8. Fit the idler gear to the spindle.
9. Fit the driven gear with the plain part of the bore uppermost.
10. Check the pump cover for wear and scores, and if necessary fit a replacement, locating it over the two pegs. Loosely secure with the four bolts until the strainer is fitted.



ST2573M

11. Hold relief valve bore vertically and insert the plunger with the solid end first. Fit the spring, sealing washer and plug.
12. Fit a new 'O' ring to the oil strainer pipe and insert into the pump body and loosely secure with the lock washer and nut.
13. Secure the strainer bracket to the pump body and tighten the four screws.
14. Tighten the strainer pipe nut and secure with the lock tab.

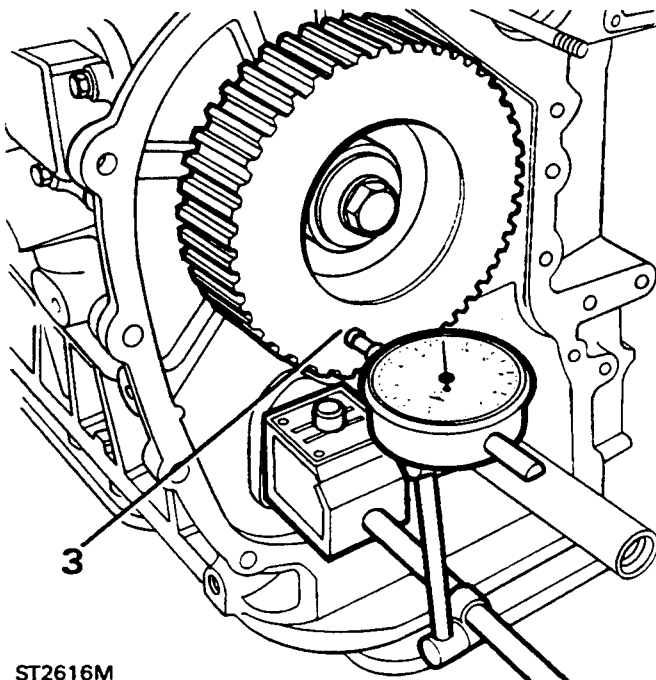
**EXAMINE AND FIT THE CAMSHAFT**

1. Mount the camshaft on "V" blocks on a surface plate and examine the cams for wear, scores, pitting and chipped edges. Examine the journals for obvious wear and scores and signs of overheating, in particular, check the thrust face of the front journal and the thrust plate. If the journals are visibly serviceable, check with a dial indicator or micrometer for overall wear, ovality, taper and run-out.



**CAUTION:** If the skew gear is worn and requires renewal, the camshaft must also be renewed even though the camshaft gear may appear satisfactory. Once the two gears have run together they become a matched pair.

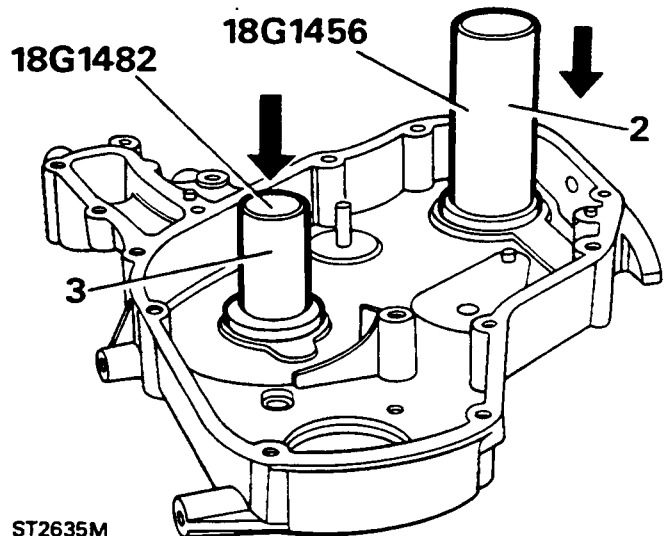
2. Lubricate the camshaft bearings and journals with clean engine oil and carefully insert the camshaft into the cylinder block. Fit the thrust plate and secure with the two bolts and tighten to **9 Nm**.
3. To check the camshaft end-float, temporarily fit the camshaft gear and mount a dial test indicator so that the stylus rests in a loaded condition upon the machined face of the gear. Zero the dial and move the camshaft back and forward and note the reading. The end-float should be within 0,06 to 0,13 mm. If the end-float is outside these limits, fit different thrust plates until the correct tolerance is achieved.



ST2616M

**FIT THE FRONT COVER**

1. Clean the front cover and remove the crankshaft and camshaft oil seals taking care not to damage the seal housings. Examine the cover for damage, cracks and distortion. Check the mating face of the cylinder block and the cover plate for burrs.
2. Place the front cover, cylinder block face downwards on a flat surface and lubricate a new crankshaft oil seal. With the lip side leading, drive-in the seal, squarely, using service tool 18G1456. The back of the seal should be approximately 0,5 mm below the inner face of the cover.
3. Similarly, lubricate and drive-in a new camshaft oil seal, lip side leading using special service tool 18G1482. The seal should be approximately 1,0 mm below the inner face of the cover.



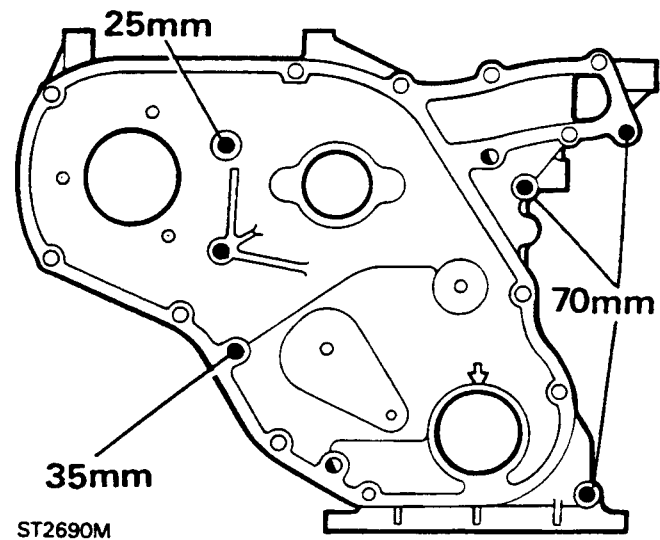
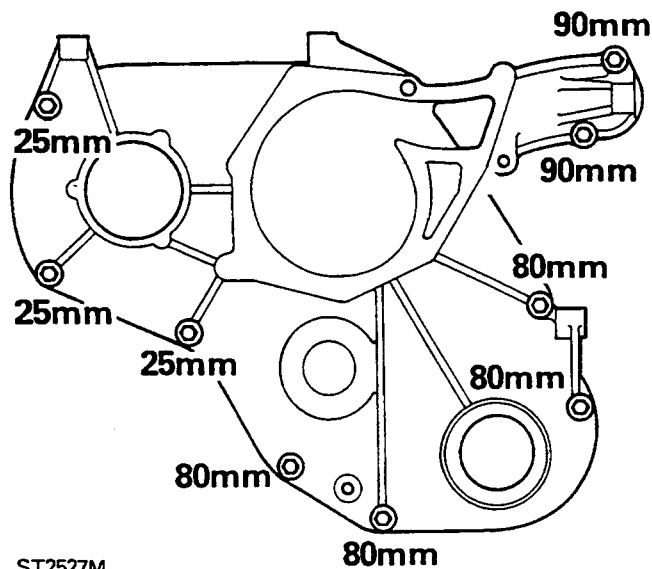
ST2635M

4. Clean the front face of the cylinder block and use a little grease to hold in position a new joint washer.
5. Also fit a new joint washer to the coolant aperture and to the tapped hole for the jockey pulley clamp bolt.





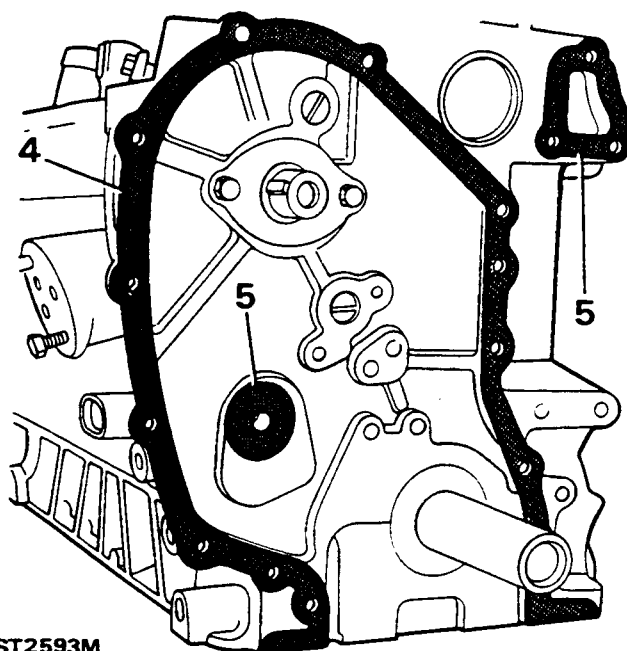
6. Taking care not to damage the oil seals fit the front cover locating it over the single stud. Secure with the five retaining bolts tightening evenly to the correct torque. The correct bolt length for each hole is given in the following chart.

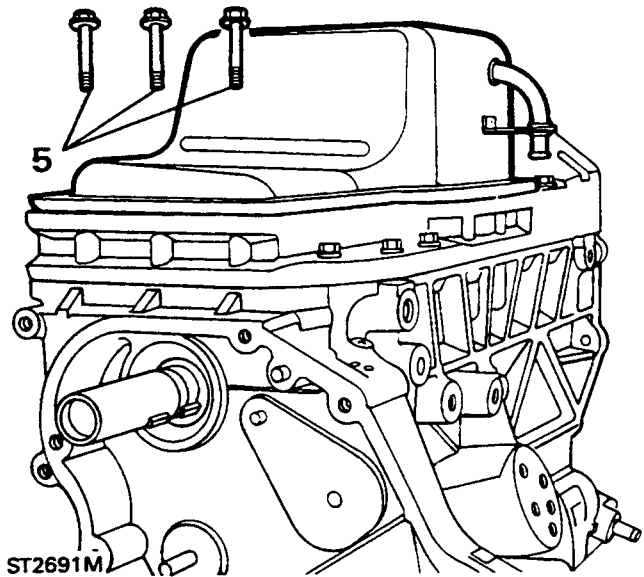
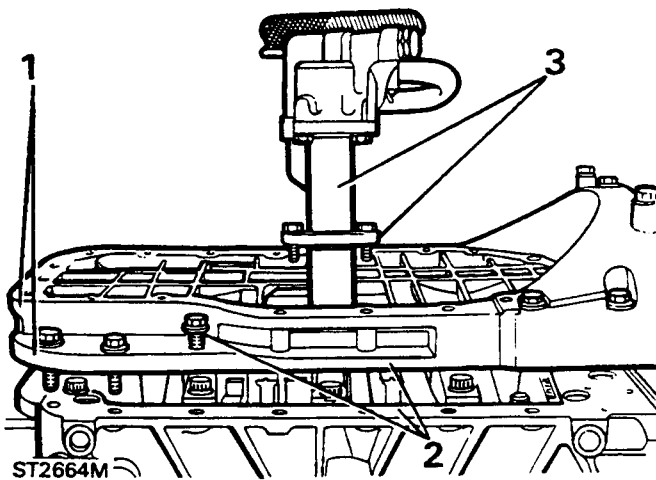


#### FIT LADDER FRAME, OIL PUMP AND SUMP

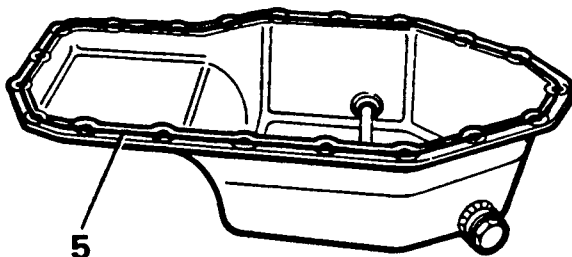
The sealant used cures within 15 minutes and as some of the retaining bolts are common to the sump it is important that the ladder frame, oil pump and sump are fitted together without delay. Before applying sealant coat both faces with Hylogrip Primer to clean and hasten curing.

1. Clean both sides of the ladder frame and remove all traces of old sealant. Check the frame is not distorted and is free from burrs and damage on the mating faces that could cause oil or bypass gas to leak.
2. Apply 'Hylogrip 2000' to the mating face with crankcase. Apply 'Hylosil RTV' to joint line of crankcase to flywheel housing. Loosely fit the ladder frame. Fit 4 bolts securing flywheel housing to ladder frame tighten to **45 Nm**. Tighten 10 ladder frame to crankcase bolts to **25 Nm**.
3. Fit the oil pump and strainer assembly to the crankcase location and tighten the two bolts to **25 Nm**





4. Clean the sump and remove all traces of old sealant. Examine the sump for damage, such as dents, and distortion. Check that the drain plug threads in the sump are not stripped or damaged so that an oil leak could occur.
5. Apply 'Hylosil RTV' to the sump mating face with the ladder frame. Fit the 20 bolts and tighten to **25 Nm**. Note that the three long bolts pass through the sump and ladder frame into the front cover.



ST2665M

## OVERHAUL AND FIT FLYWHEEL

1. Normal wear and scores on the flywheel clutch face can be repaired by machining provided that the overall width of the flywheel is not reduced below 36,96 mm. Examine the ring gear and if the teeth are chipped and worn the gear can be renewed.

### Reface the flywheel

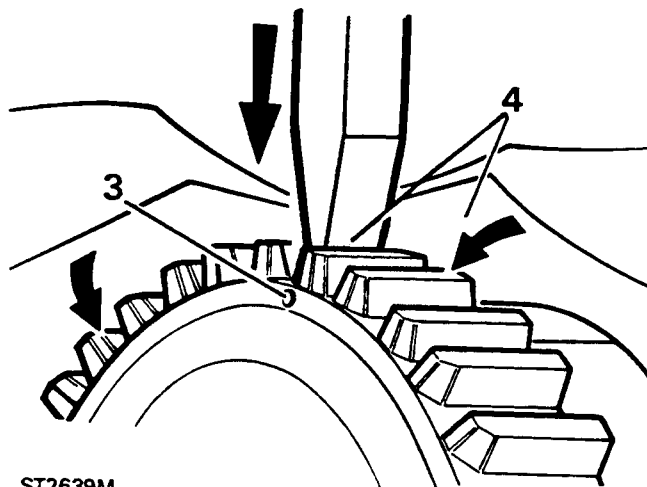
2. Remove the clutch cover locating dowels. Machine the flywheel over the entire clutch face removing only the minimum of material necessary to achieve a smooth surface parallel with the crankshaft mating face and within the above dimensions.
3. To renew the ring gear, drill a 8 mm hole between the root of any two teeth and the inner diameter of the ring gear deep enough to weaken the gear. Take care not to allow the drill to enter the flywheel.



**WARNING:** Wear industrial goggles to protect the eyes from flying fragments.

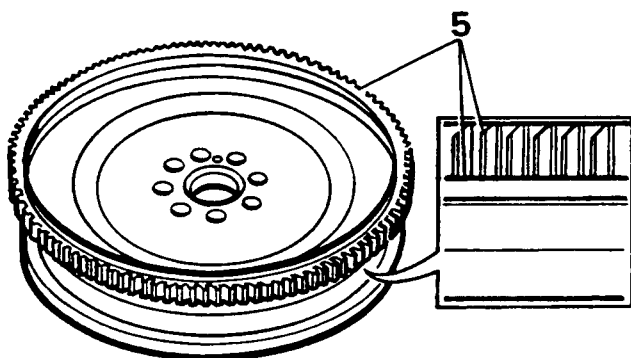


4. Secure the flywheel in a soft jawed vice and cover it with a cloth to avoid personal injury. Place a cold chisel above the drilled hole and strike it sharply to split the ring gear.



ST2639M

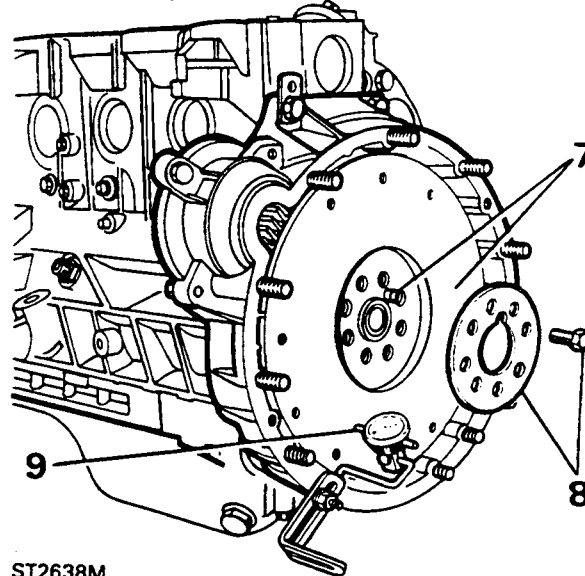
5. Heat the new ring uniformly to between 225°C and 250°C but do not exceed the higher figure. Place the flywheel, clutch face down, on a flat surface and locate the heated ring gear with the square edge of teeth downwards towards the flywheel clutch face and chamfered edge of the teeth uppermost.
6. Press the starter ring firmly against the flange until the ring contracts sufficiently to grip the flywheel. Allow the ring to cool naturally. Do not hasten cooling in anyway otherwise distortion may occur.



ST2640M

### Fitting flywheel

7. Make sure the crankshaft and flywheel mating faces are clean and free from burrs and imperfections that could prevent the flywheel running true. Check that the dowel is in position in the crankshaft and that it is undamaged.
8. Offer up the flywheel to the crankshaft and secure with the reinforcing plate and retaining bolts. Temporarily fit the damper to front of crankshaft and use special service tool FR101 or LST127 to restrain the crankshaft whilst the eight retaining bolts are being tightened to **146 Nm**.
9. To check the flywheel for possible run-out, mount a dial test indicator so that the stylus rests, in a loaded condition, on the clutch pressure face at a radius of 114 mm from the centre of the flywheel. Turn the flywheel, and check that run-out does not exceed 0,05 to 0,07 mm. Should any run-out be excessive, remove the flywheel, and check again for irregularities on flywheel and crankshaft mating faces and dowel. Should excessive run-out persist the flywheel should be checked on independent equipment in case the flywheel is at fault.



ST2638M

## VALVE AND INJECTION PUMP TIMING

1. Examine the gear wheels for wear and damage. Cleanliness and accuracy are vital when carrying out the following instructions. The gear wheels must be free from oil and grease. Drive belts which have not been stored and treated in the following manner should not be used. Drive belts must be stored on edge on a clean flat surface and in such a manner that bends are not less than 50 mm radius.

When a belt is handled, it must not be bent at an acute angle or an arc of less than 25 mm in diameter, as damage may be caused to the glass fibre reinforcement and premature failure could result.

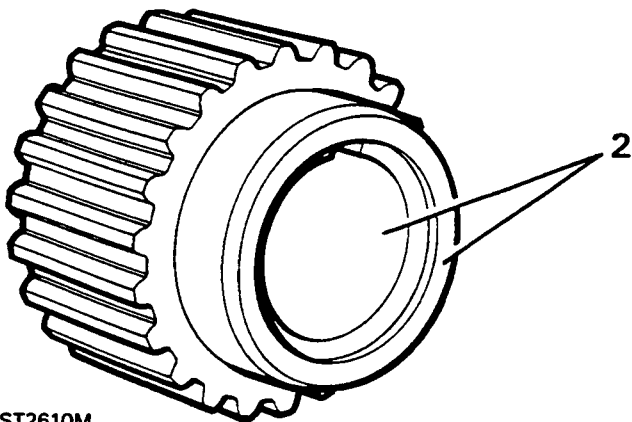
During use, a belt develops a wear pattern, therefore, if it has to be re-used, before removal, mark the direction of rotation, using soft chalk or a similar marker, and refit the belt so that it runs in the original direction.

Belts must be dry and **FREE FROM ANY OIL OR OTHER CONTAMINATION.**

Do not turn the crankshaft by applying leverage to the camshaft pulley or its retaining bolt.

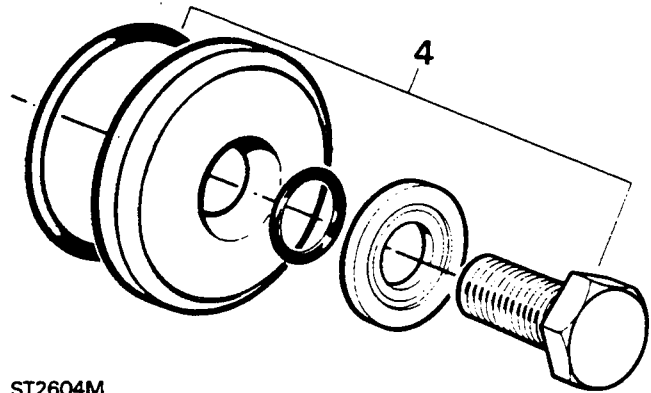
To remove a belt always use clean hands, or a recommended tool - **NEVER** use a lever.

2. Fit the gearwheel to the crankshaft.



ST2610M

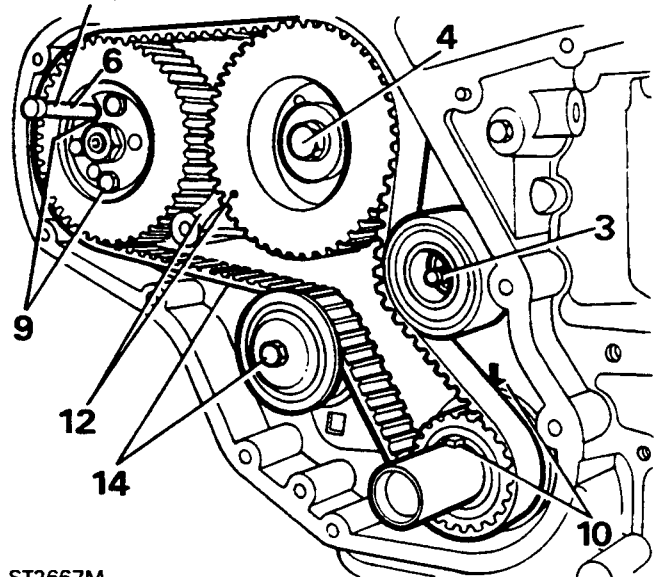
3. Fit the static tensioner and secure with the single nut and tighten to **45 Nm**.
4. Fit the camshaft gear and secure with the special bolt, washer and 'O' rings.



ST2604M

5. Fit the front side cover.
6. Insert timing pin in the pump hub and body.
7. Fit the injection pump and secure with the three nuts and tighten evenly to **25 Nm**.
8. Fit the pump rear support bracket to the front side cover and secure to the pump with two bolts and nuts.
9. Fit the gear to the injection pump hub with the reinforcing plate and three bolts so that the 'U' shaped slot lines up with the timing pin. Do not fully tighten the three bolts at this stage.
10. Turn the crankshaft so that numbers one and four pistons are at T.D.C. and the woodruff key is aligned with the cast on arrow inside the front cover.

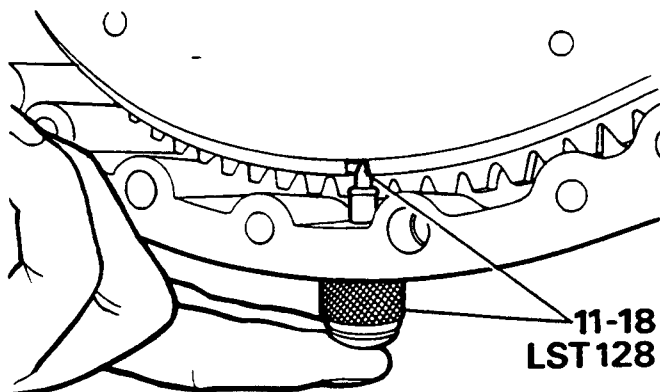
## LST 129



ST2667M

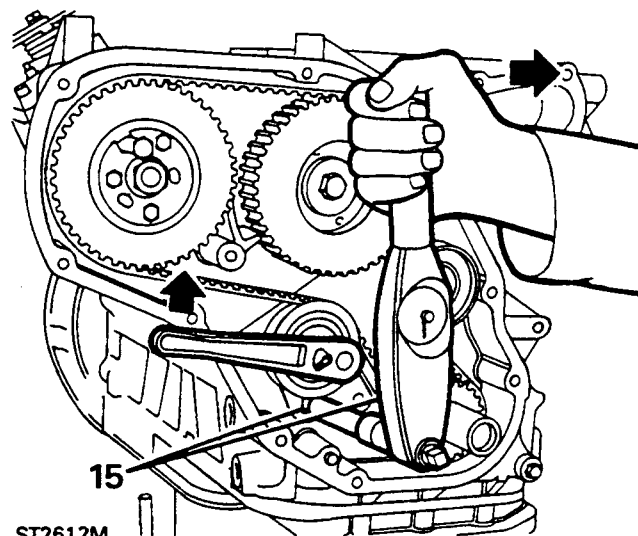


11. Screw the body of timing pin LST128 into the bottom of the flywheel housing and check that the pin will locate into the flywheel slot. It is important to note that there are two slots in the flywheel and that the narrowest is the one that must be used for this direct injection engine.



ST2641M

12. Rotate the camshaft so that the cams are positioned with number one cylinder valves closed and number four cylinder valves on the "rock". The centre dot on the camshaft gear should now be aligned with the front cover web as shown.
13. Feed the drive belt over the gears keeping it tight on the drive side without moving the gears.
14. Fit the belt tensioner with the special washer and single bolt.
15. Insert a 13 mm square drive extension into the hole in the tensioner support plate and with a dial type torque wrench held vertically, tension the belt to 18 to 20 Nm whilst tightening the tensioner clamp bolt to **25 Nm**. Do not use a "break" type torque wrench.



ST2612M

16. Tighten the three bolts that secure the pump gear and reinforcing plate to the pump hub to **25 Nm** and remove the timing pin.



**CAUTION:** Unlock the injection pump and fit the keeper plate before attempting to turn the crankshaft. Also ensure that the flywheel timing pin LST128 is clear of the flywheel slot.

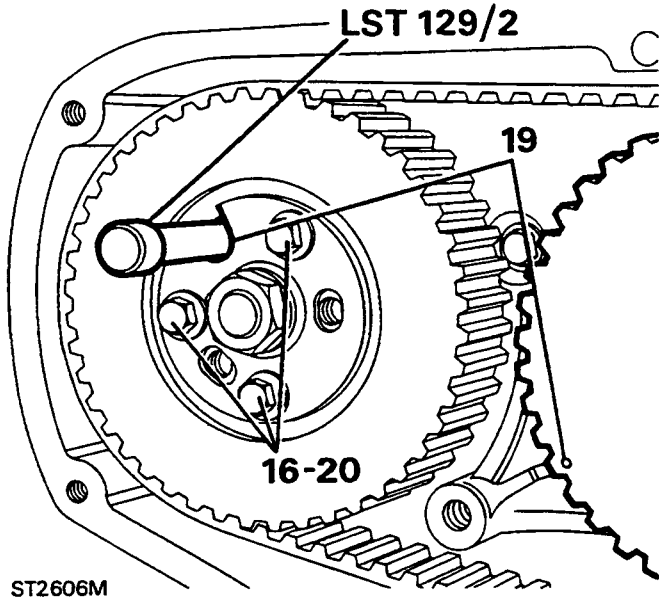
17. Rotate the crankshaft two complete revolutions and loosen the tensioner clamp bolt and tension the belt again, as previously described.



**CAUTION:** The double tensioning procedure is vital otherwise the belt could fail resulting in serious damage to the engine. If a new belt is not available and it is necessary to fit the old one, it should only be torqued to 16 to 18 Nm

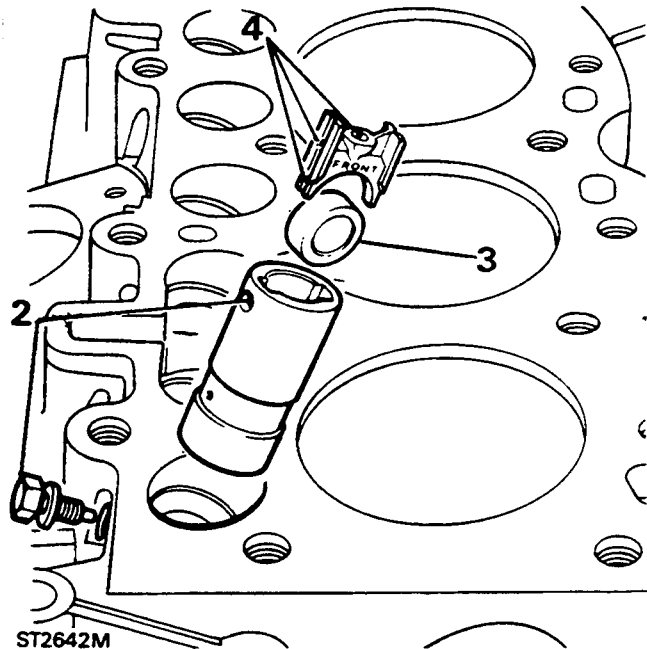
18. Turn the crankshaft again in a clockwise direction until the flywheel timing pin locates in the T.D.C. slot.

19. Insert the timing pin in the pump hub and check that the crankshaft key aligns with the arrow on the front cover. Also check that the dot on the camshaft gear aligns with the front cover web.
20. If the timing pin cannot be inserted fully into the pump hub slot, it is necessary to loosen the three pump gear retaining bolts and slightly turn the hub, in the appropriate direction, to allow the pin to locate. Retighten the bolts.



### FIT CAM FOLLOWER ASSEMBLIES

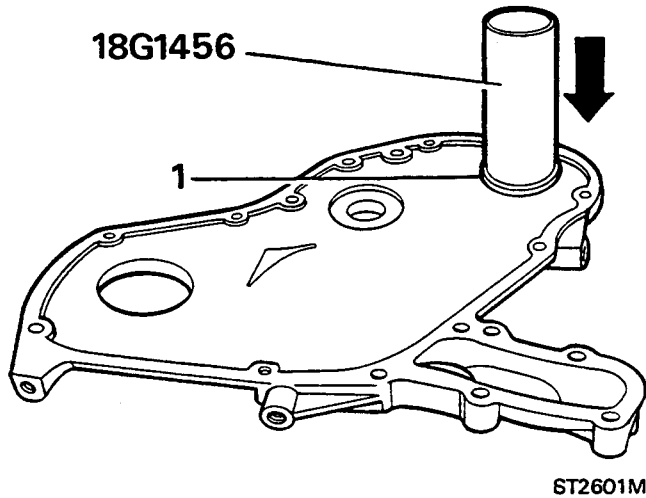
1. Examine all the components for wear and damage, particularly the rollers. Renew any component that is worn. Ensure that the tappet slides move freely in the guides. If the same parts are being refitted, ensure that they are returned to their original positions.
2. Insert the tappet guides into the cylinder block and align the locating screw holes and fit new micro encapsulated screws but do not allow the ends of the screws to protrude into the bore of the guide until the slides and rollers are fitted.
3. Fit the tappet rollers ensuring that they are fitted in accordance with the marks made during removal. New rollers, however, may be fitted either way around.
4. Before fitting the tappet slides make sure the oilways are clear to the tappet bearing surface, the cross drilling and the oil feed to the push rod. Insert the tappet slides with the word 'FRONT' or 'F' towards the front of the engine.
5. Finally tighten the screws securing the guides to 14 Nm.



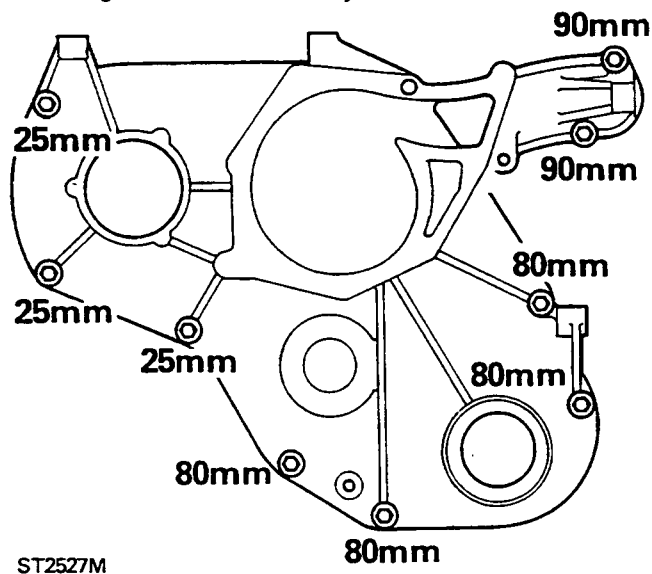


## FITTING FRONT COVER PLATE AND DAMPER

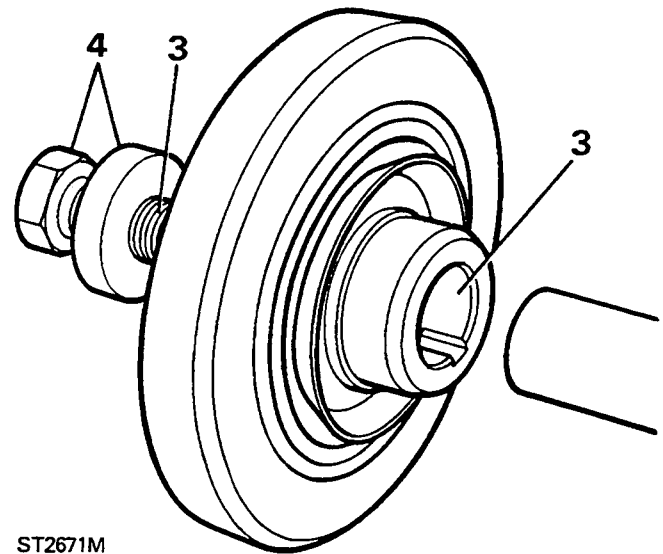
1. Remove the old ingress seal from the front cover plate and clean the seal housing. With the inside of the cover uppermost use special service tool 18G1456 to drive-in a new seal, lip side leading, so that when fitted the lip faces away from the crankshaft.



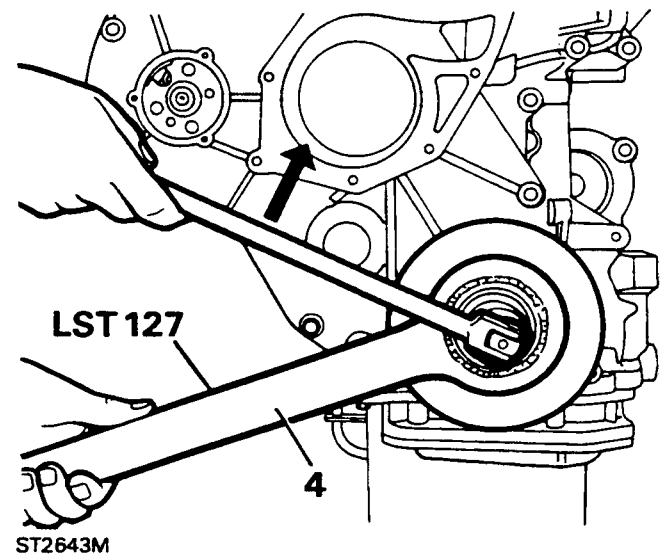
2. Clean the front cover and cover plate mating faces and apply Hylogrip Primer to both faces. The primer acts as a cleaner and a curing agent for the sealant. Apply a bead of Hylogrip 2000 to the cover plate and fit the plate to the front cover. Secure the cover with the nine retaining bolts. Since the bolts are of varying lengths, the following chart shows the correct positions. Tighten the bolts evenly to **25 Nm**.



3. Clean off the old Loctite and smear the in-board half of the inside diameter of the damper with Loctite 242.



4. Fit the damper to the crankshaft with the distance piece and special bolt. Using service tool LST127 restrain the damper whilst pulling the damper into position with the bolt. Remove the bolt, apply Loctite 242 to threads and fit and tighten to **341 Nm**.



## OVERHAUL AND FIT CYLINDER HEAD



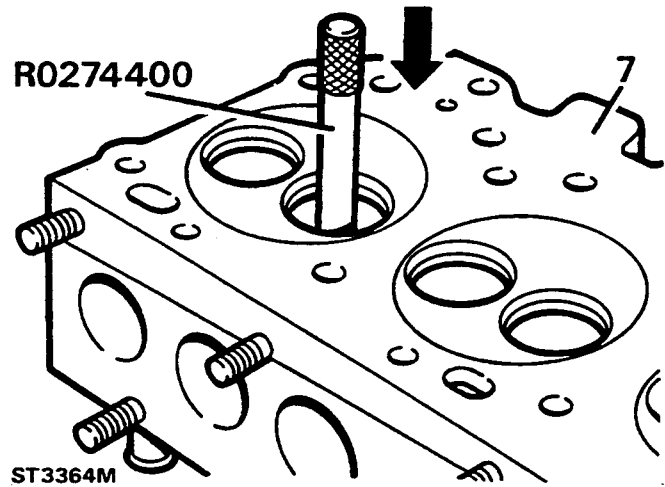
**CAUTION:** Since the cylinder head is manufactured from an aluminium alloy care must be taken to ensure that the combustion face, in particular, is not damaged or scratched by resting it on a hard or abrasive surface while carrying out the overhaul operations.

1. Using valve spring compressor MS1519A or a suitable alternative, remove the valve and spring assemblies keeping them identified with their original locations for possible refitting.
2. Discard the valve springs and valve guide oil seals. Remove carbon deposits from the valves and combustion chambers and degrease all parts ready for examination.
3. Examine the cylinder head for damage and distortion. Inspect the valve seat inserts for damage. Seat inserts that are beyond repair and require renewal should only be attempted by skilled specialists in this work. However, refacing of the seats can be carried out using valve seat cutting equipment as described later.
4. Examine the valve guides for wear and damage. Check for stem wear by inserting a new valve, in each guide in turn, approximately 8 mm above the seat and if movement across the head exceeds 0,15 mm, the guide should be renewed.

5. Inspect the valves for wear and damage. Valve heads that are burnt and cracked should be renewed. Valves which are bent and distorted should also be renewed. Check the stems for wear by inserting in a new guide and checking the movement across the valve head when held approximately 8 mm above the seat. If movement exceeds 0,15 mm the valve should be discarded.

## Renew valve guides

6. Support the cylinder head, to enable valve guides to be driven out.
7. Using service tool R0274400, drive out the inlet and exhaust valve guides.



8. Clean the bores from which the guides were removed.
9. Heat the cylinder head to a temperature of 120°C.

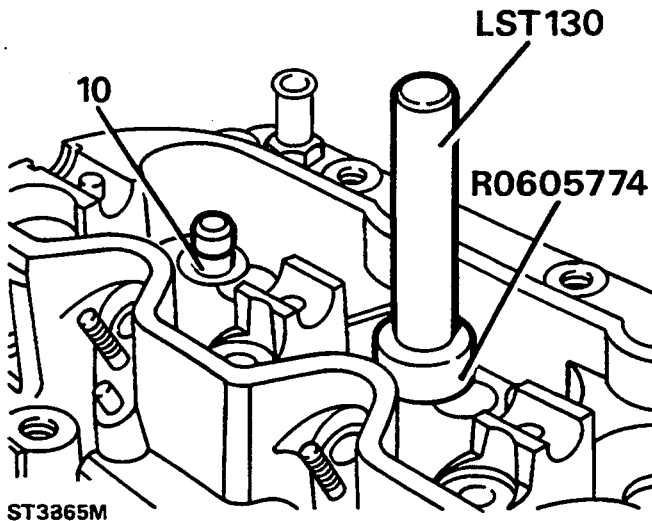


**NOTE:** Only service valve guides must be used for this operation, standard valve guides are not suitable.





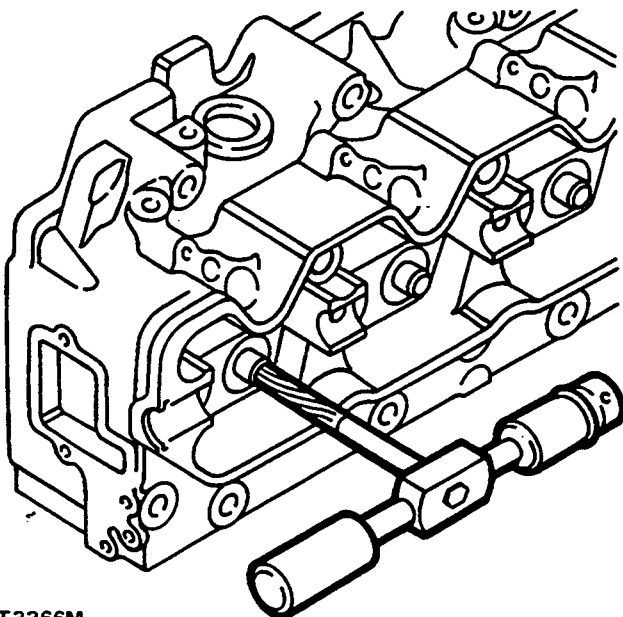
10. Lubricate then fit valve guides using service tools LST130, height gauge RO605774 and a press.



11. To ensure a uniform internal diameter for the total length of the guide, hand ream the guides with 18G 1636.



**CAUTION:** After the cutting edges of the reamer have passed through the guide detach the wrench and withdraw reamer from combustion side of head. Under no circumstances should the reamer be withdrawn back through the guide.



### Reface valve seat inserts

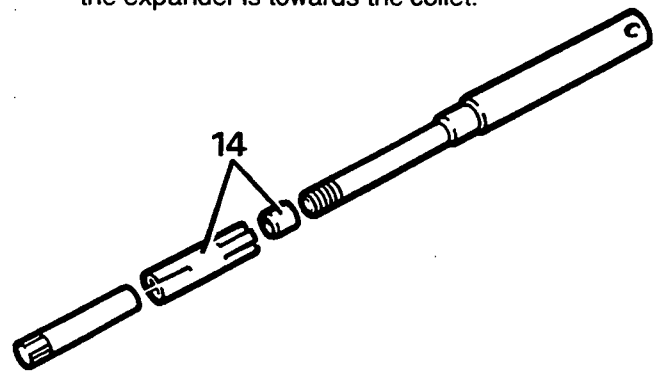
Exhaust valve seat faces should be recut to 45°. Inlet valve seat faces should be recut to 60°.

12. The special set of hand tools recommended for refacing valve seat inserts comprise expandable pilots, MS150-8, that fit tightly into new or worn guides to ensure that the valve seat is concentric with the valve guide.
13. The refacing tool, MS621 has 45° cutters for use on exhaust valve seats, and MS627 has 60° cutters for use on the inlet valve seats. The handle set MS76B is common to both cutting heads.



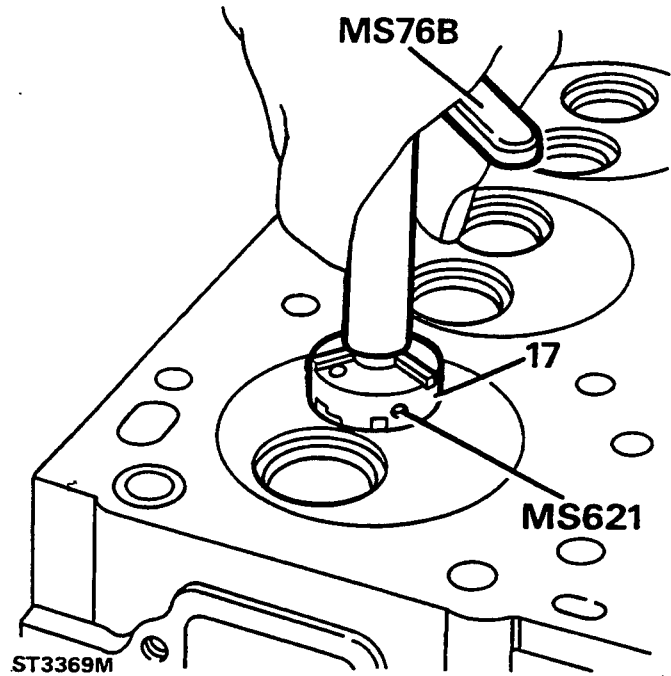
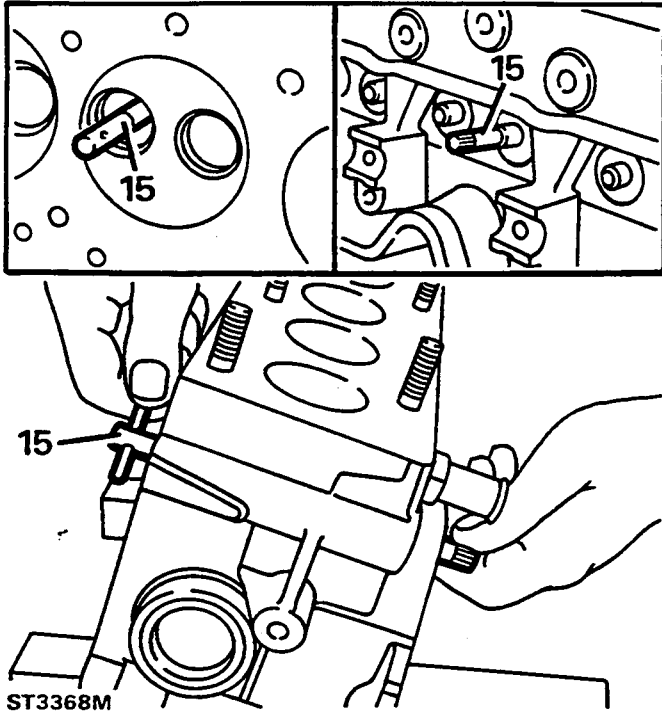
**NOTE:** Cutter MS621 is a double ended tool having cutters of 30° and 45°. Ensure that the 45° cutter is used in this application.

14. Loosely assemble the pilot in the sequence illustrated, ensuring that the chamfered end of the expander is towards the collet.



ST3367M

15. Insert the assembled pilot into the valve guide, from the combustion face side of the cylinder head, until the shoulder contacts the valve guide and the whole of the collet is inside the valve guide. Expand the collet in the guide by turning the tommy bar clockwise whilst holding the knurled knob.



#### Reface valve head faces

Exhaust valve head faces should be reground to an angle of  $45^{\circ} 00'$  -  $44^{\circ} 30'$  to give an included angle of  $90^{\circ}$ .

Inlet valve head faces should be reground to an angle of  $60^{\circ} 30'$  -  $60^{\circ} 00'$  to give an included angle of  $120^{\circ}$ .

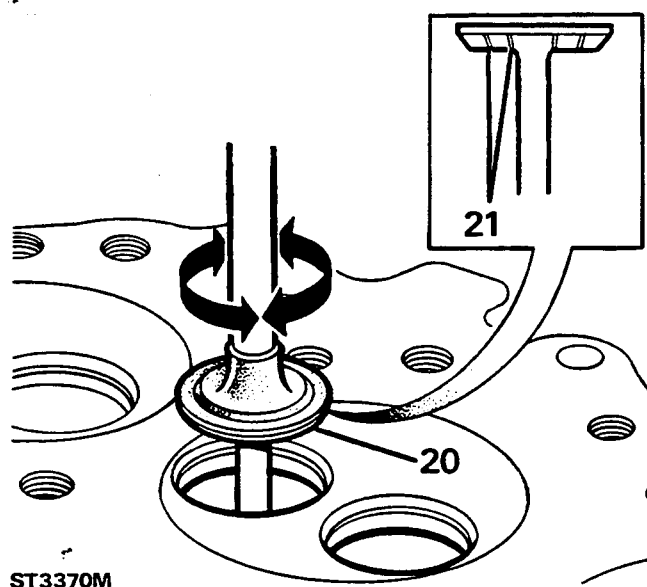
16. Using the appropriate cutter for the valve seat being refaced, ensure that the cutter blades are correctly fitted to the head with the angled end of the blade downwards facing the work. Check that the blades are adjusted so that the middle of the blade contacts the area of material to be cut. Use the key provided to make any adjustments.
17. Fit the wrench to the cutter head and turn clockwise using only very light pressure. Continue cutting to approximately the centre of the existing seat.
18. To check the effectiveness of the cutting operation use engineers blue. Smear a small quantity of blue round the valve seat and revolve a properly ground valve against the seat. A continuous fine line should appear round the valve. If there is a gap of not more than 12 mm it can be corrected by lapping.

19. Valves that are satisfactory for further service can be refaced. This operation should be carried out using a valve grinding machine. Only the minimum of material should be removed from the valve face to avoid thinning of the valve edge. The valve is refaced correctly when all pits are removed and the face concentric with the stem.



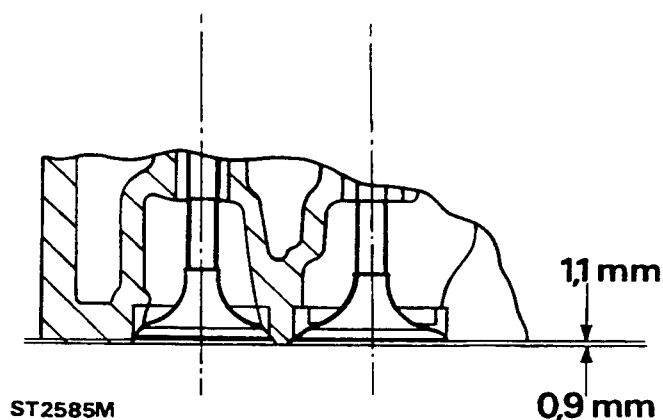
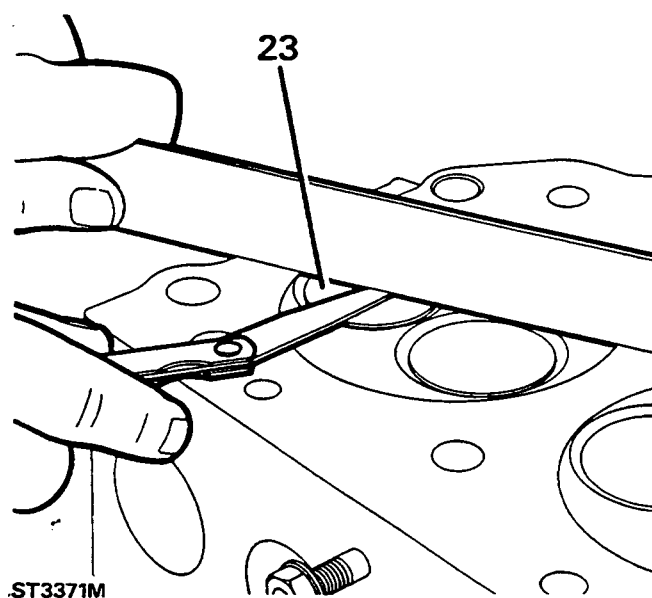
### Lap-in valves

20. To ensure a gas tight seal between the valve face and valve seat it is necessary to lap-in the appropriate valve to its seat. It is essential to keep the valve identified with its seat once the lapping-in operation has been completed. Unless the faces to be lapped are in poor condition it should only be necessary to use fine valve lapping paste. Smear a small quantity of paste on the valve face and lubricate the valve stem with engine oil. Insert the valve in the appropriate guide and using a suction type valve lapping tool employ a light reciprocating action while occasionally lifting the valve off its seat and turning it so that the valve returns to a different position on the seat.



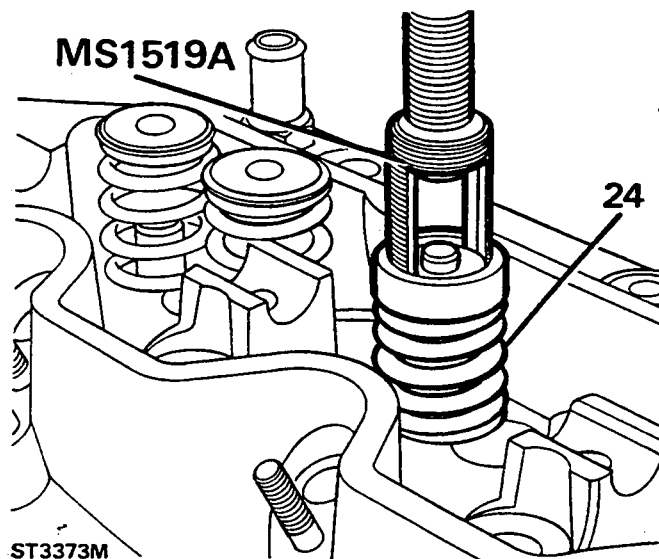
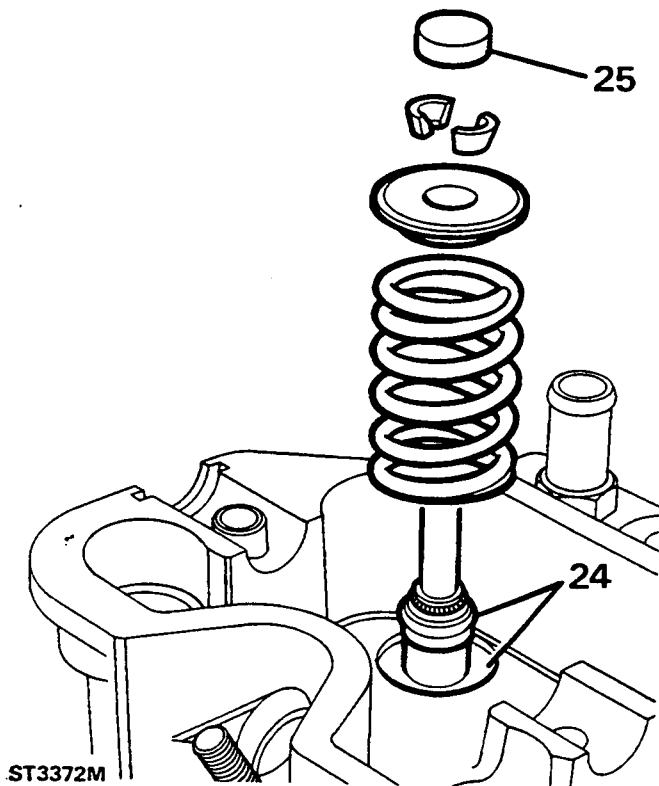
21. Continue the operation until a continuous matt grey band round the valve face is obtained. To check that the lapping operation is successful, wipe off the valve paste from the valve and seat and make a series of pencil lines across the valve face.
22. Insert the valve into the guide and while pressing the valve onto the seat revolve the valve a quarter of a turn a few times. If all the pencil lines are cut through no further lapping is required. Wash all traces of grinding paste from the valves and cylinder head.

23. Position the cylinder head with the combustion face uppermost and insert the valves into their respective guides. To check the valve head stand-down or the correct dimension of the valve head below the combustion face, use either a dial test indicator or a straight edge and feeler gauge. Hold the straight edge across the centre of each valve in turn and measure the gap between the valve head and straight edge. The correct dimension should be 1,1 to 0,9 mm Using a dial gauge zero the gauge on the combustion face then move the stylus across to the valve head and note the reading.



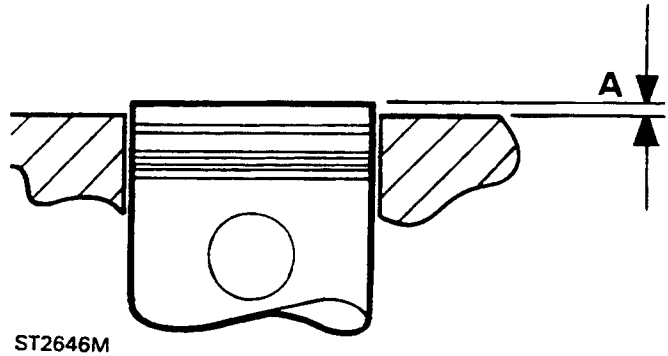
**Assemble valves to cylinder head**

24. Insert the valves into their respective guides. Place the steel spring plate over the valve guide, followed by the oil seal with the garter spring uppermost. Ensure that the seal fits over the valve guide. Fit the spring and cup and secure with the multi-groove butting cotters whilst compressing the assembly with the special service tool MS1519A or a suitable alternative.
25. Fit new caps to the valve tips.



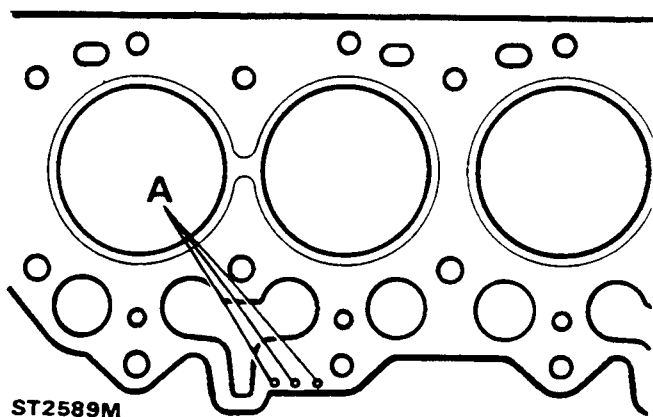
**Fitting cylinder head**

When the pistons are at T.D.C. they protrude above the top of the cylinder block. The amount of protrusion determines the thickness of cylinder head gasket that must be fitted. The height of all the pistons above the cylinder block must be measured and the thickness of the gasket selected is based upon the largest value of dimension 'A'. This dimension, however, must not exceed 0,8 mm

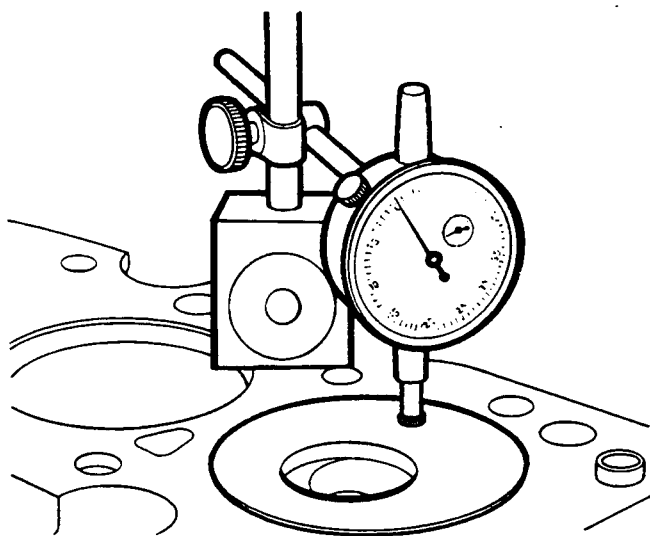


Three thicknesses of gasket are available and each size can be recognised by the number of identification holes punched in the side of the gasket as illustrated. The table below gives the details of the gaskets available. The thickness of gasket fitted can be seen when the cylinder head is fitted since the identification holes can be seen protruding from the right hand side of the engine towards the rear.

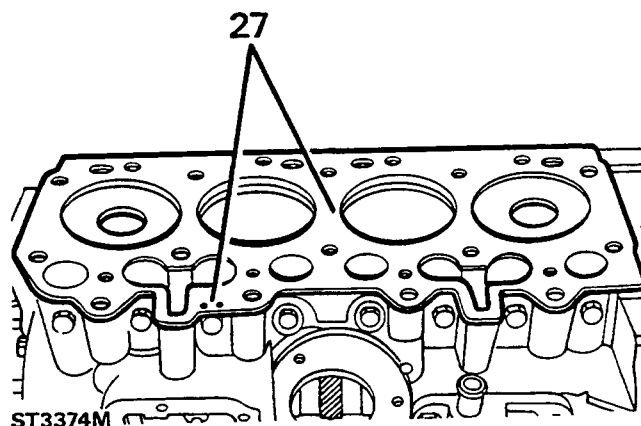
No. of holes	Metric	Imperial	Gasket
1	0,60 / 0,50	0.0196 / 0.0236	ERR 0382
2	0,70 / 0,61	0.024 / 0.0275	ERR 0383
3	0,80 / 0,71	0.0279 / 0.0314	ERR 0384



26. Clean the cylinder block combustion face and turn the crankshaft so that number one and number four pistons are at T.D.C. Use a dial test indicator to determine the highest travel of the piston then zero the gauge and move the stylus over to the cylinder block and note the reading. Repeat the procedure on the remaining pistons. The highest figure obtained will determine the gasket to fit.



27. Place the cylinder head gasket in position on the cylinder block so that the identification holes are towards the rear on the right-hand side.
28. Clean the cylinder head face and if preferred, guide studs may be fitted to the cylinder block to facilitate the lowering of the head into position. Locate the head over the two dowels.

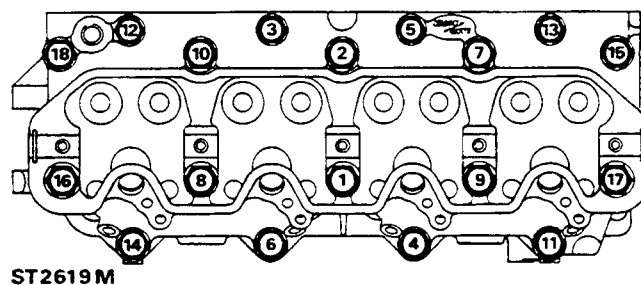


29. Lubricate the new bolt threads and fit loosely into their location.



**NOTE: Always fit new cylinder head bolts.**

30. Tighten all the bolts down in the sequence shown to Tighten to **40 Nm**.



Bolt sizes:

M10 locations - 3, 5, 12 and 13

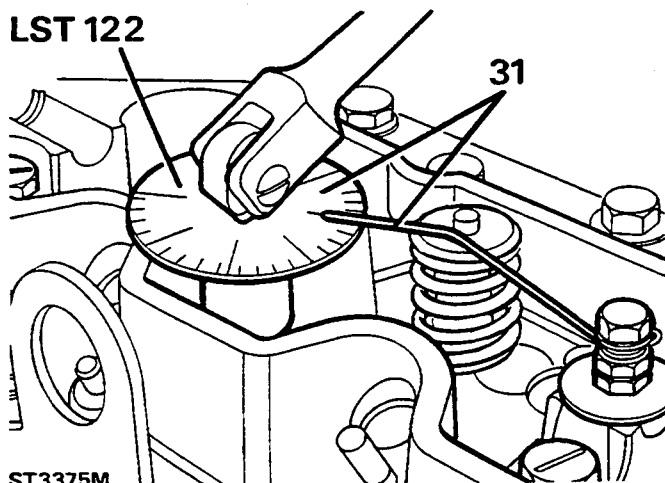
M12 locations - 1, 2, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17 and 18

31. Attach the service tool degree disc LST122 to a power bar. Make a suitable pointer from welding rod and attach it to a bolt screwed into a rocker shaft securing bolt hole. Tighten all the bolts down through an angle of  $60^\circ$  strictly in the sequence illustrated. As each bolt is tightened scribe a line across the head with a piece of chalk or crayon to identify which bolts have been tightened. Again, in the correct sequence, tighten the bolts a further  $60^\circ$  and scribe another line across each bolt head as it is tightened. Re-positioning of the pointer will, be necessary to reach all bolts.



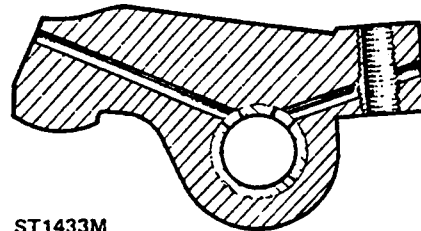
**CAUTION:** It is important that the double torquing procedure is observed and that on no account should the total angle of  $120^\circ$  be performed in one operation otherwise damage and distortion of the cylinder head may occur.

LST 122

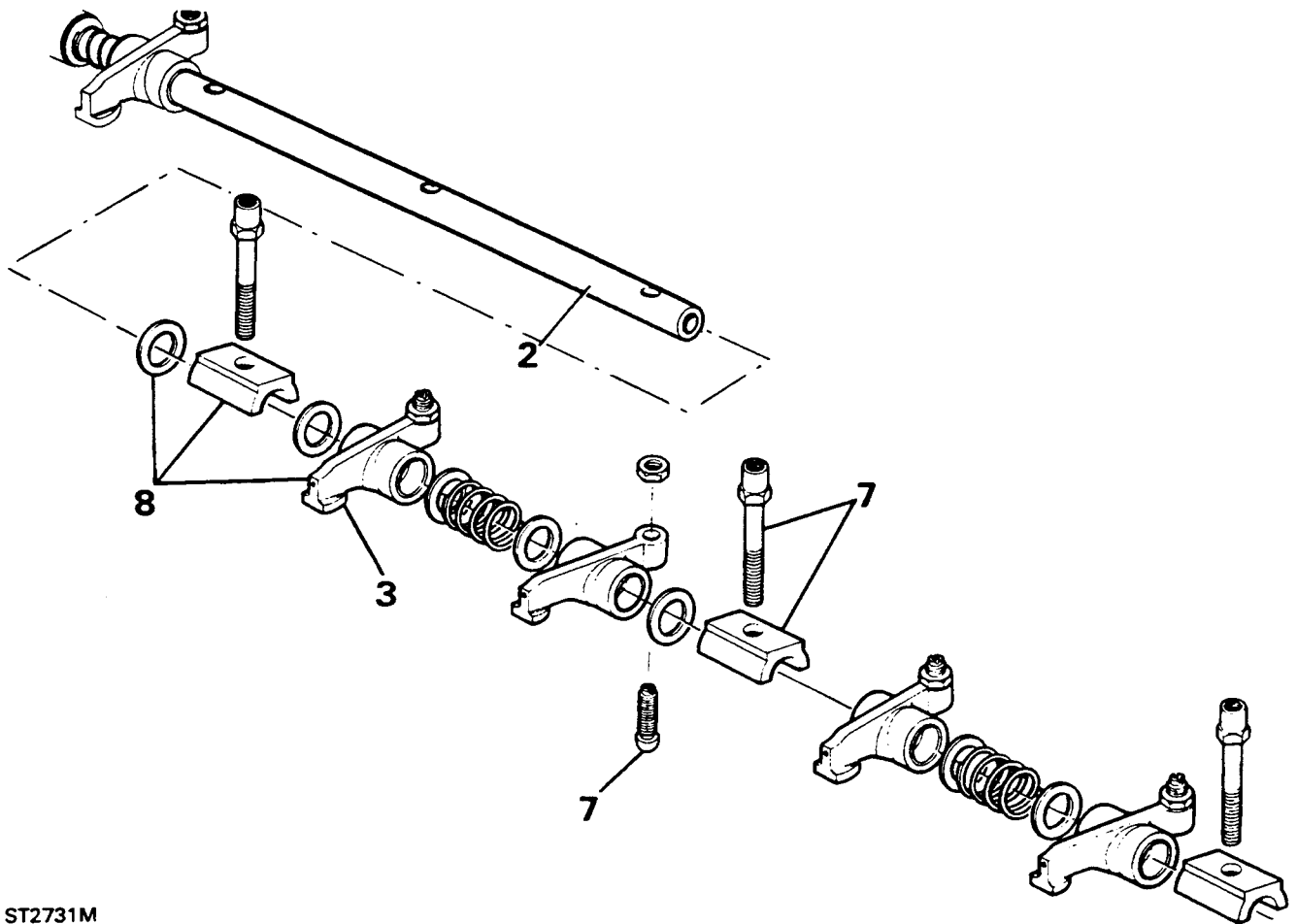


### OVERHAUL AND FIT ROCKER SHAFT

1. Remove the five rocker shaft retaining bolts and withdraw the bearing caps, rockers, washers and springs from the shaft.
2. Examine the rocker shaft for wear and discard it if the bearing surface is worn, scored or pitted. Check also that the oilways are clear.
3. Inspect the rockers and discard if the pads are worn. It is not permissible to grind pads in an attempt to reclaim rockers.
4. Renew bushes if the clearance between shaft and bush is in excess of 0,101 to 0,127 mm. Press in replacements ensuring that the pre-drilled oil holes coincide with the holes in the rockers.
5. The following cross section of a rocker shows the oil drillings.



6. Finish the bushes to 18,018 to 18,00 mm after fitting.
7. Examine the tappet adjustment screws and check that the ball end is not worn or pitted and that the lubrication hole is clear.



ST2731M

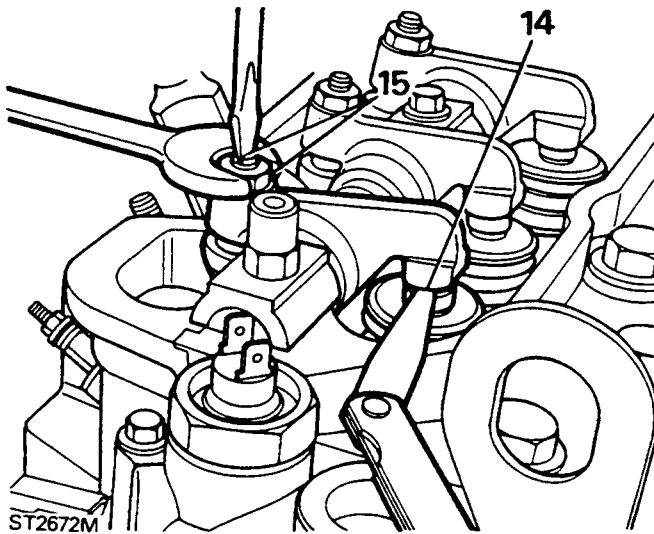
8. Assemble the rockers, bearing caps, new springs and washers to the shaft noting where the washers are fitted. Hold the assembly together with the five rocker shaft retaining bolts.

#### Fitting rocker shaft assembly

9. Examine the push rods and renew any that are bent or where the ball or cup ends are worn or pitted.
10. Fit the push rods to the engine ensuring that the ball-end locates properly in each camfollower slide.
11. Fit the rocker shaft assembly to the cylinder head and secure in position with the five retaining bolts. Ensure that the tappet adjusting screws locate in the cup ends of the push rods. Evenly tighten the securing bolts to **30 Nm**

## Adjust tappet clearances

12. If the crankshaft is rotated with excessive valve clearances, it is possible that the push rods may become dislodged from the tappet seating and fracture the tappet slide. To prevent damage, eliminate all clearance from any loose rockers before turning the crankshaft to adjust clearances.
13. Turn the engine over until number eight valve (counting from front of engine) is fully open.
14. Using a 0,20 mm feeler gauge check the clearance between the valve tip and rocker pad of number one valve.

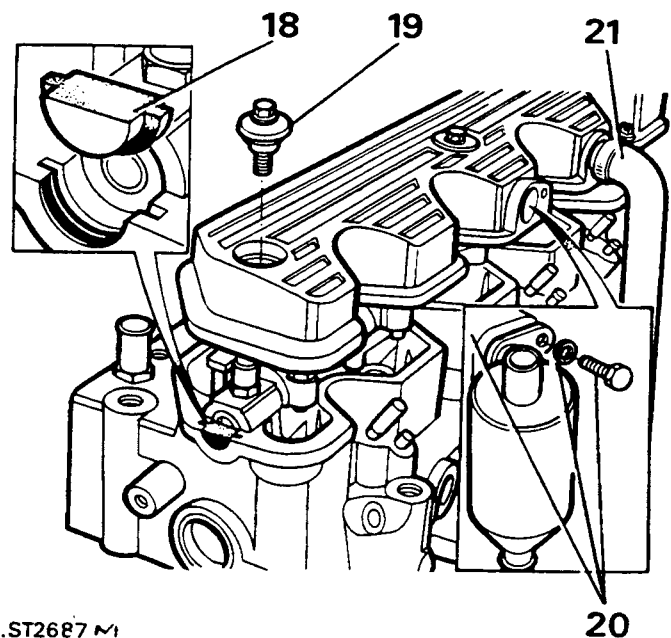


15. Adjust the clearance by loosening the lock nut and turning the tappet adjusting screw clockwise to reduce clearance and anti-clockwise to increase clearance. Recheck the clearance after tightening the lock nut.
16. Continue to check and adjust the remaining tappets in the following sequence:

Set No. 3 tappet with No. 6 valve fully open.  
 Set No. 5 tappet with No. 4 valve fully open.  
 Set No. 2 tappet with No. 7 valve fully open.  
 Set No. 8 tappet with No. 1 valve fully open.  
 Set No. 6 tappet with No. 3 valve fully open.  
 Set No. 4 tappet with No. 5 valve fully open.  
 Set No. 7 tappet with No. 2 valve fully open.

## Fitting rocker cover

17. Fit existing seal to the rocker cover, renew if damaged or leaks were evident.
18. Apply superglue to the half-moon groove both ends of the cylinder head and then fit the rubber seal.
19. Fit the rocker cover and secure with the three bolts and special conical washers and tighten evenly to **4 Nm**.
20. If removed, fit the cyclone engine breather to the rocker cover with a new seal and secure with the single bolt.
21. Fit the breather hose that runs between the rocker cover and front side cover.

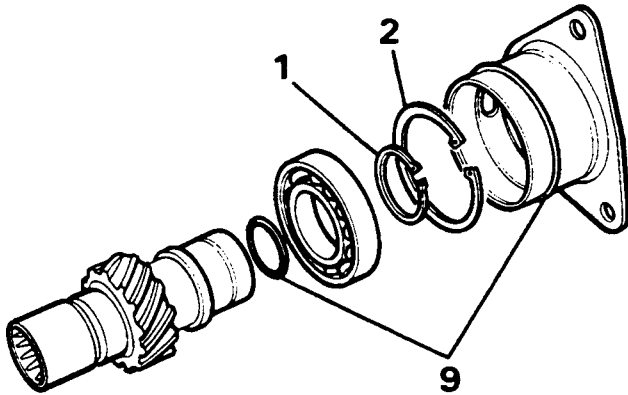






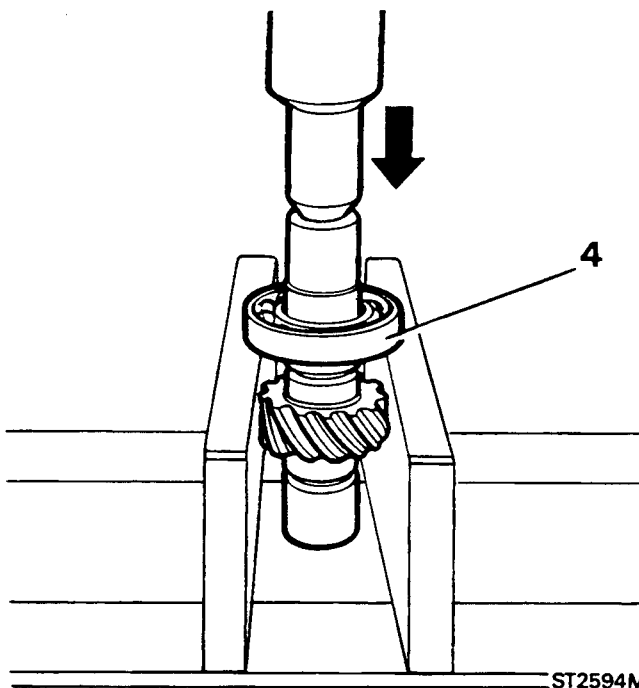
## OVERHAUL AND FIT SKEW GEAR ASSEMBLY

1. Remove the circlip from the skew gear shaft.
2. Remove the circlip retaining the bearing in the housing. Remove bearing only if necessary.



ST2584M

3. Press the bearing and shaft assembly from the housing.
4. Press the bearing from the shaft.



ST2594M

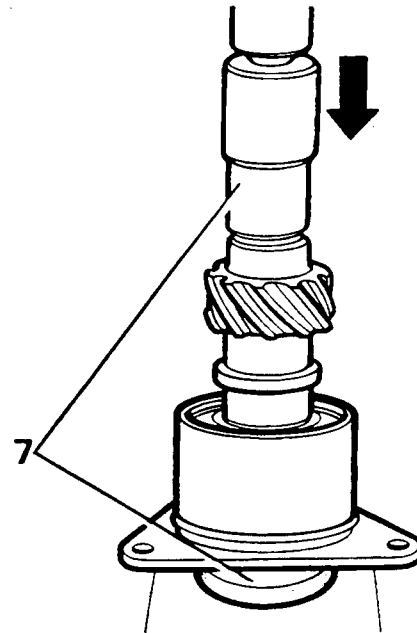
5. Examine all components especially the bearing and skew gear for wear and damage and renew if necessary.



**CAUTION:** If the skew gear is to be refitted, the teeth must mesh with the same teeth on the camshaft. If either the skew gear or the camshaft are renewed, the mating component must also be renewed.

### Assemble

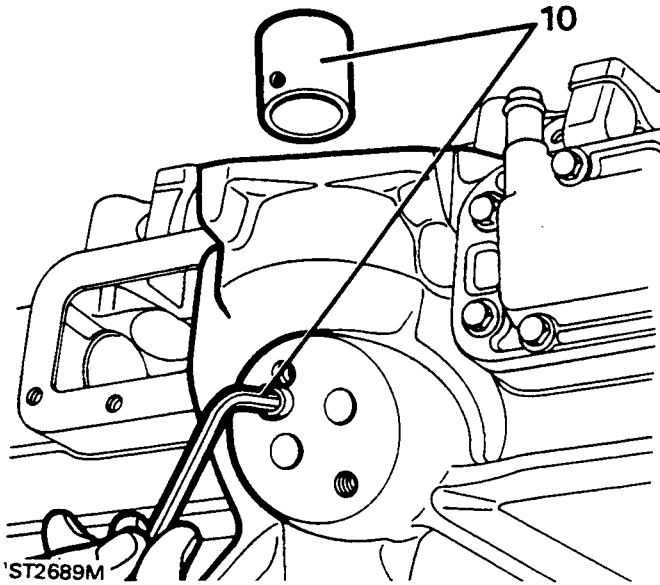
6. Press the bearing into the housing up to the shoulder.
7. Support the outside diameter of the bearing with a suitable tube and press the skew gear shaft on to the bearing.



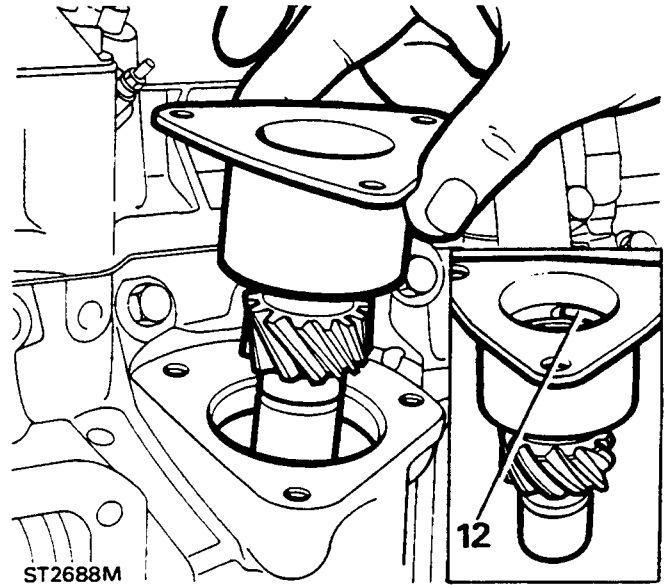
ST2595M

8. Secure the assembly with the two circlips.
9. Fit new 'O' rings to the inside diameter of the skew gear shaft and the outside diameter of the housing.

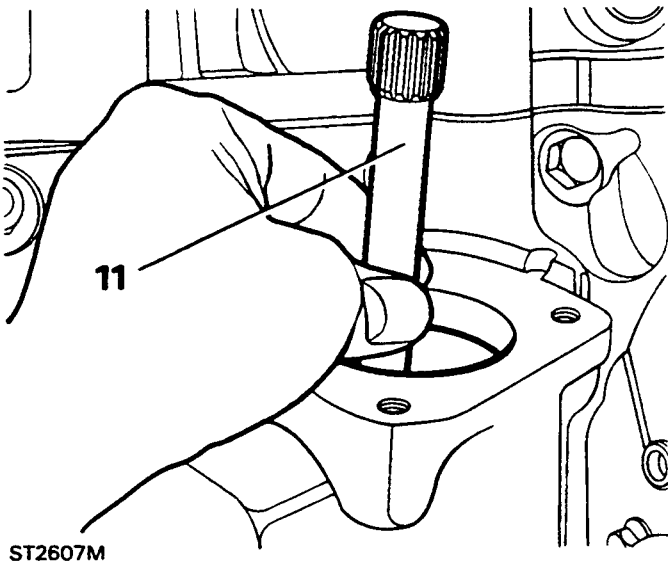
10. Fit a new skew gear bush to the cylinder block and secure with the socket headed screw. Ensure that the screw locates correctly into the hole in the bush.



12. Fit the skew gear assembly so that the slot is towards the front of the engine.



11. Fit the oil pump drive shaft, long-spline end into the pump.



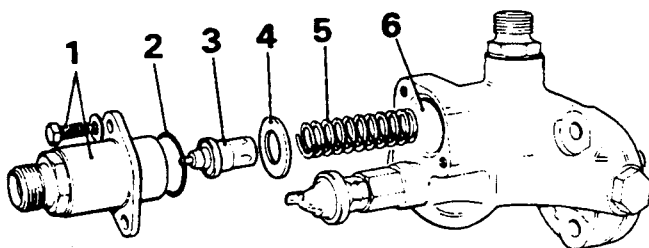
13. Using a new gasket fit the vacuum pump so that the outlet is towards the front of the engine. Ensure that the cross-pin in the skew gear shaft locates in the end of the groove in the end of the pump shaft. Secure with the three screws and tighten evenly.



## OVERHAUL AND FIT OIL FILTER ADAPTOR

### Renew oil temperature thermostat

1. Remove the two bolts and carefully withdraw the thermostat extension housing.
2. Remove the 'O' ring.
3. Withdraw the thermostat.
4. Remove the washer.
5. Remove the spring.
6. Clean the adaptor housing with lint-free cloth.

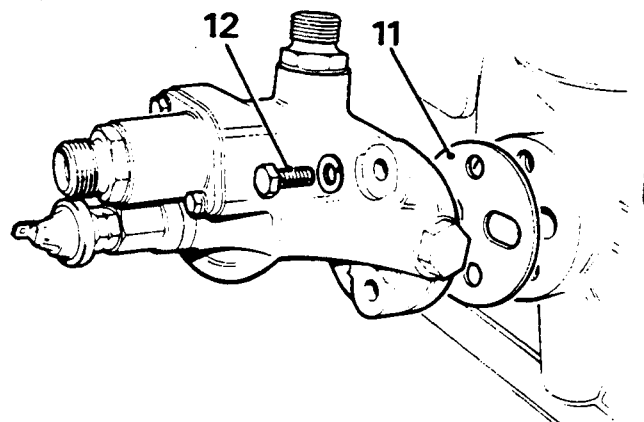


ST2596M

7. Fit the spring and washer.
8. Fit a new thermostat with the pin uppermost.
9. Fit the extension housing using a new 'O' ring. Ensure that the pin protruding from the thermostat locates in the hole in the extension housing.
10. Secure the housing with the two bolts and washers.

### Fit oil adaptor

11. Using a new joint washer fit the oil filter adaptor. Ensure that the retaining bolts pass through the two small holes in the joint washer.
12. Tighten the two retaining bolts evenly to **45 Nm**.

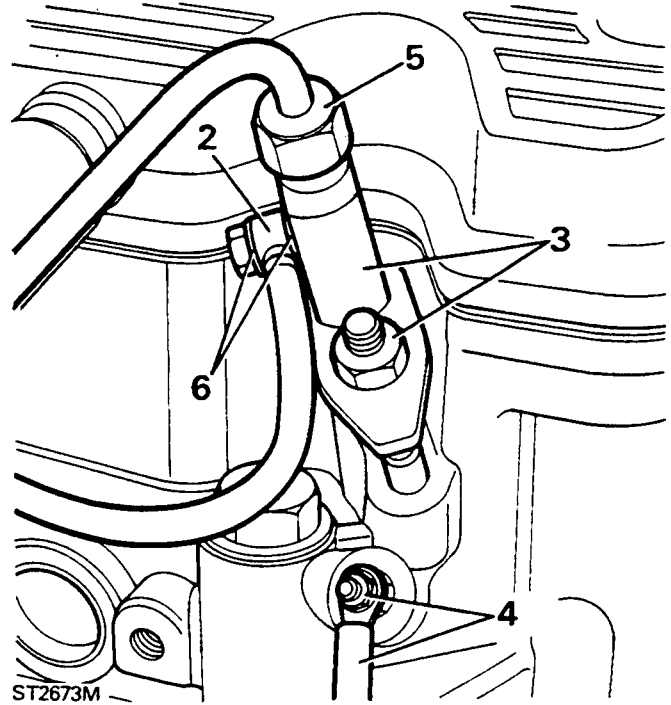


ST2597M

13. Smear a little clean engine oil on the rubber washer of the new filter, then screw the filter on clockwise until the rubber sealing ring touches the machined face, then tighten a further half turn by hand only.
14. Do not overtighten.

## FIT FUEL LIFT PUMP AND REARSIDE COVER

1. If the fuel lift pump was separated from the side cover, fit the pump to the cover first using a new joint washer between the pump flange and rear cover, evenly tighten the nuts.
2. Place a new cover plate joint washer in position and fit the cover and pump assembly to the cylinder block.
3. Ensure that the pump actuating lever rides on top of the camshaft.
4. Secure the cover, evenly tighten the retaining bolts.

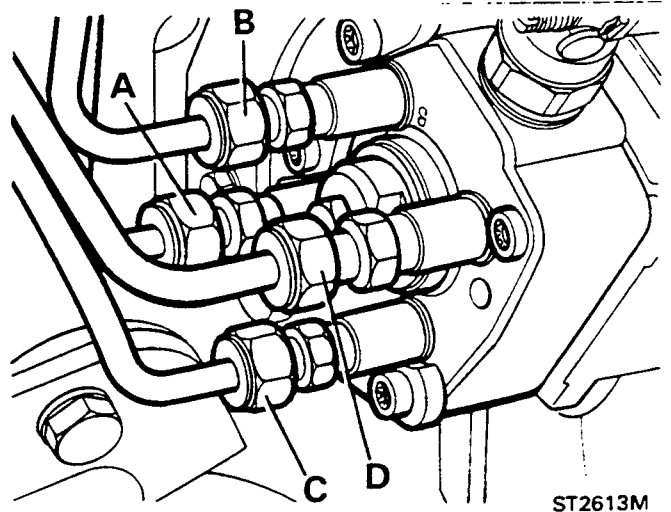


## FIT INJECTORS, PIPES AND HEATER PLUGS

1. Ensure injector locations are clean. Grease a new copper washer to hold it in position on the injector.
2. Fit injectors with spill return outlet facing to rear of engine.
3. Secure injector with a clamp and nut. Fit clamps with convex side fitted uppermost. Tighten the nuts to **20 Nm**
4. Fit the four glow plugs and tighten to **23 Nm**. Fit electrical connections to glow plugs and secure with single nut and washer. Tighten to **2 Nm**. Ensure the terminal and the insulation clears the cylinder head and breather cyclone.

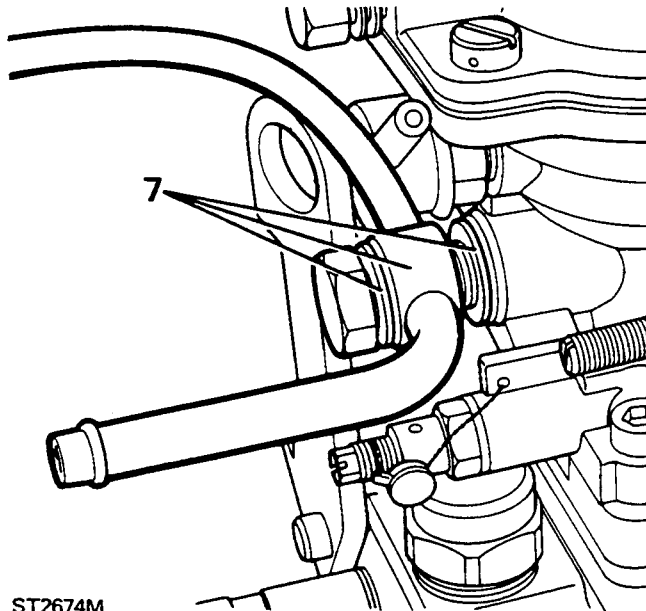
5. Fit loosely all injector fuel supply pipes, then tighten evenly to **24 Nm**. From the front of the engine connect the pipes as follows:

- A. To number 1 injector.
- B. To number 2 injector.
- C. To number 3 injector.
- D. To number 4 injector.





6. Fit the spill return rail to the injectors, with copper washers fitted each side of the retaining union screw. The inner washer locates in a recess in the injector.
7. Fit the spill return rail to the rear of the injector pump and secure with a copper washer each side of the banjo and the union bolt.



ST2674M

Fit clutch *See CLUTCH, Repair, Clutch assembly*

Fit the starter motor

Fit air inlet manifold

Fit exhaust manifold and turbocharger

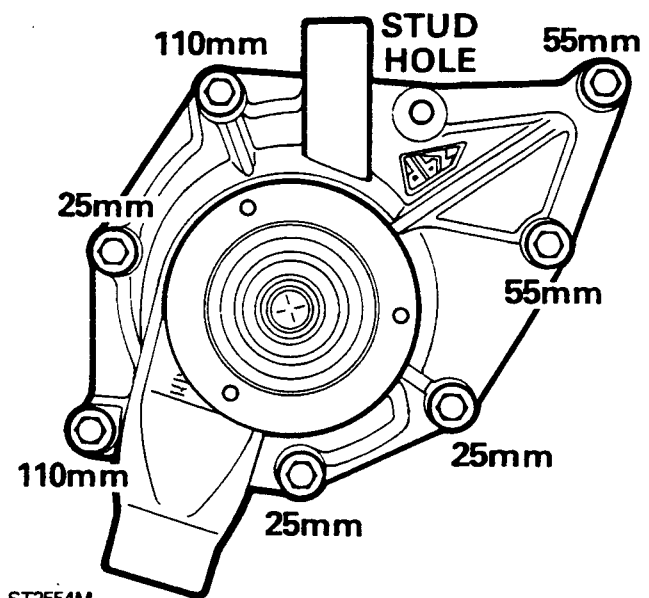
Fit thermostat and housing

Fit alternator

Fit power steering pump

## FIT WATER PUMP

1. The water pump is not serviceable. Check condition of the bearings.
2. Check the pump body for signs of coolant or oil leaks. If there is any evidence of leakage, the pump should be renewed.
3. Grease and position a new joint washer on the timing cover.
4. Apply Loctite 572 thread lubricant sealant to the long bolts which penetrate into cylinder block.
5. Fit the pump and secure with the 7 bolts as shown. Tighten the bolts to 27 Nm.



ST2554M

6. Connect hose to water pump and thermostat housing and secure with clips.
7. Fit the fan blades to the viscous coupling with the four screws.
8. Fit viscous coupling assembly to water pump spindle. Note it is a left-hand thread.

Fit air conditioning compressor - *See ELECTRICAL, Repair, See Air Conditioning.*

Fit and tension drive belts *See SECTION 10, Maintenance, Under Bonnet maintenance*

Fit engine to vehicle *See Repair, Engine*

**Before starting engine**

1. Check sump and cylinder block drain plugs are fitted.
2. Add correct lubricant to high mark on the dipstick. **See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids**
3. Check that all pipes and hoses are secure and that all electrical connections are made.
4. Fill the cooling system with correct mixture of coolant **See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Anti-Freeze**
5. Start and run the engine for up to ten minutes. Check for oil, fuel and coolant leaks. Stop engine and allow to cool. Recheck the oil and coolant levels.
6. Recheck the tension of the drive belts.



## TORQUE VALUES



**NOTE:** Torque wrenches should be regularly checked for accuracy to ensure that all fixings are tightened to the correct torque.

	Nm
<b>ENGINE</b>	
Bearing cap to cylinder block.....	133
Camshaft thrust plate to cylinder block.....	9
Clutch cover plate to flywheel.....	34
Connecting rod to cap .....	59
Dipstick tube assembly to cylinder block .....	25
Dipstick mounting bracket to inlet manifold .....	9
Engine mounting foot to cylinder block M10 .....	45
Engine mounting foot to cylinder block M12 .....	85
Housing flywheel to cylinder block.....	45
Flywheel to crankshaft .....	146
Ladder frame to cylinder block .....	25
Oil filter adaptor to cylinder block .....	45
Oil pressure switch .....	17
Oil pump cover to pump body.....	24
Oil pump relief valve plug .....	30
Oil pump to cylinder block .....	25
Oil pump strainer to oil pump.....	45
Oil jet assembly to cylinder block .....	17
Oil strainer to mounting bracket.....	25
Plug - blanking oil gallery.....	37
Plug - drain oil sump .....	45
Plug - drain cylinder block .....	25
Plug - drain flywheel housing.....	12
Plug - inlet manifold (boost take-off).....	25
Side cover to cylinder block.....	27
Starter motor to flywheel housing .....	45
Sump to ladder frame .....	25
Sump to ladder frame/cylinder block .....	25
Sump to cylinder block/front cover .....	22
Brackets - exhaust manifold to cylinder block .....	25
Vacuum pump to cylinder block.....	25
Vertical drive shaft gear to cylinder block .....	25
Alternator and heat shield to mounting bracket .....	25
Adjusting link to alternator .....	25
Adjusting link to PAS pump plate .....	25
Breather cyclone to rocker cover .....	9
Engine lifting bracket to cylinder head.....	25
Electrical harness clip to cylinder head .....	25
Exhaust manifold to cylinder head.....	23
Glow plug terminal nut .....	2
Glow plug to cylinder head .....	23
Heater stud (water) to cylinder head .....	23
Injector clamp stud to cylinder head .....	8
Injector clamp to injector nut.....	20
Inlet manifold to cylinder head .....	23
Rocker cover to cylinder head .....	4
Rocker shaft to cylinder head .....	30

Tappet adjusting nut .....	24
Thermostat housing to cylinder head .....	25
Water outlet to thermostat housing .....	9
Water temperature switch to thermostat housing .....	17
Cowl mounting bracket to front cover .....	25
Fan assembly to water pump hub .....	25
Front cover plate to cylinder block .....	25
Front cover plate to front cover .....	25
Front cover to cylinder block .....	25
Injector pump to front cover .....	25
Injector pump stud to front cover .....	8
Injector pump to support bracket .....	25
Tensioner (timing belt) to cylinder block .....	45
Timing pulley to camshaft .....	45
Timing pulley to injector pump hub .....	25
TV damper pulley to crankshaft .....	347
Water pump to cylinder block .....	27
Water pump to cylinder block - stud .....	27
Water pump to front cover .....	25
Oil drain adaptor to cylinder block - Turbocharger .....	25
Oil drain pipe to turbo .....	40
Oil feed pipe adaptor to cylinder block - Turbocharger .....	25
Oil feed pipe to turbo .....	19
Outlet elbow to turbocharger - nut .....	24
Outlet elbow to turbocharger - stud .....	25
Turbocharger to exhaust manifold .....	24
Belt tensioner assembly to front cover plate compressor .....	15
Compressor to mounting bracket .....	45
Compressor mounting bracket to front cover and plate .....	45
Banjo bolt - fuel pump .....	12
Banjo bolt - boost pipe .....	12
Banjo bolt - spill rail .....	25
Banjo bolt - fuel filter .....	17
Banjo bolt - injector spill rail .....	2
Fuel lift pump to fuel filler unions .....	12
Fuel lift pump to cylinder block .....	25
Injector pipes to injectors and injector pump .....	24
P.A.S. pump to mounting plate .....	15
P.A.S. pump mounting plate to front cover	
P.A.S. pump pulley to hub .....	15
Tappet guide retaining screw .....	14

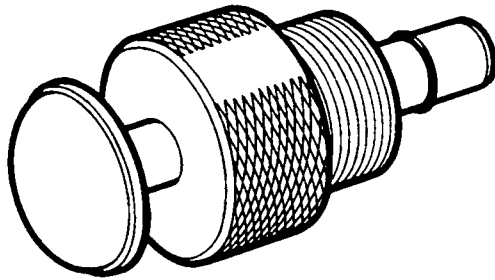




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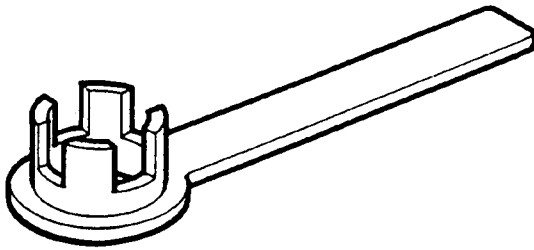
**Tdi ENGINE**

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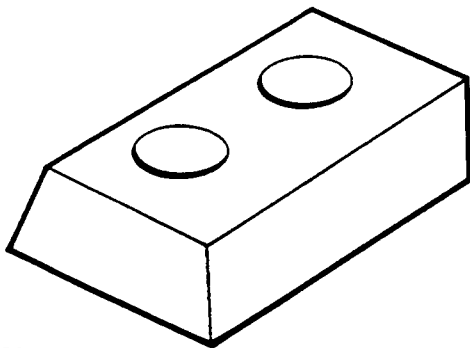
LST128

LRT-12-044 Flywheel timing pin  
LST 128



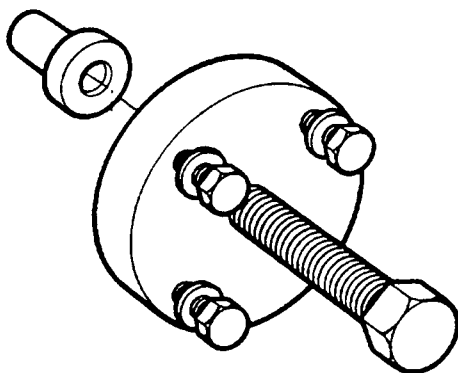
LST127

LRT-12-043 Crankshaft damper restraining tool  
LST 127



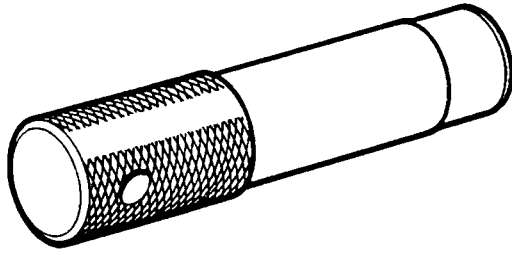
RO270304

LRT-12-035 Rear main cap seal guide  
RO 270304A



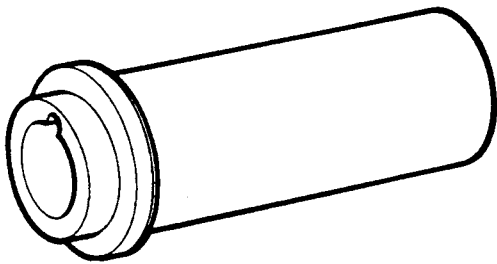
LST136

LRT-12-049 Crankshaft damper tool  
LST 136



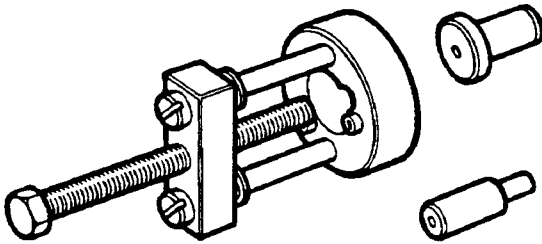
LRT-12-040 Mandrel, clutch plate  
RO 605022

RO605022



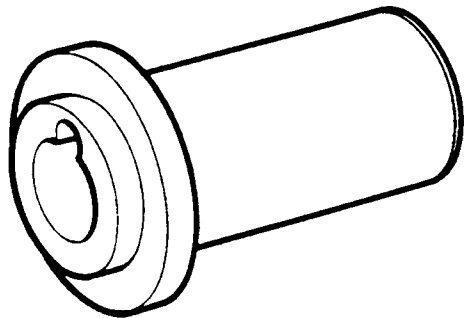
LRT-12-028 Replacer, crankshaft front seal  
18G 1456

18G1456



LRT-12-031 Remover, crankshaft/camshaft gear  
18G 1464

18G1464

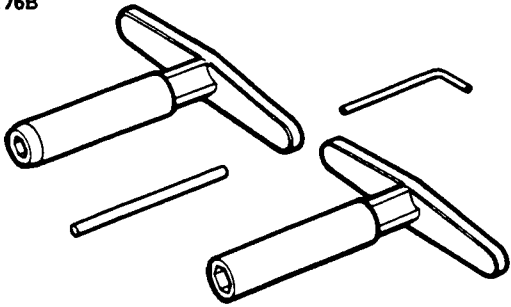


LRT-12-032 Replacer, camshaft oil seal  
18G 1482

18G1482

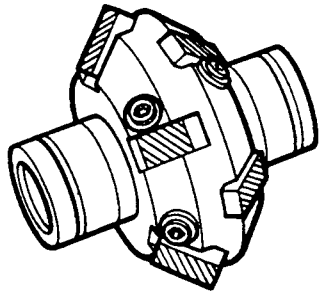


MS.76B



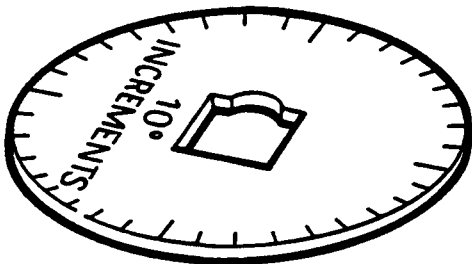
LRT-12-501 Handle set, seat cutter MS 76B

MS621



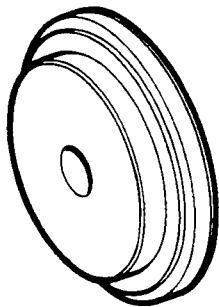
LRT-12-504 Valve seat cutter MS 621

LST122

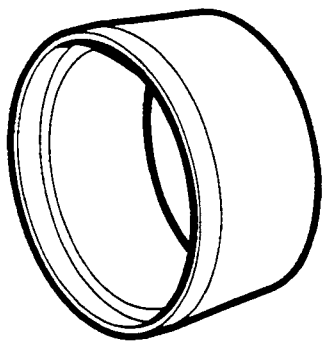


LRT-12-007 Degree plate LST 122

18G13411

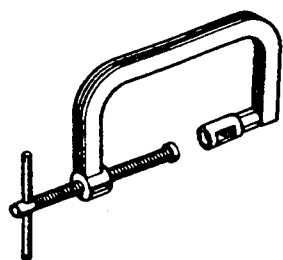


LRT-12-008 Adaptor, crankshaft rear seal 18G134-11



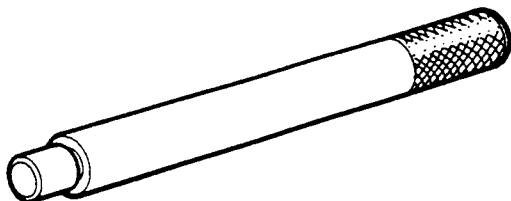
RO1014

LRT-12-015 Crankshaft rear seal saver  
18G 1344



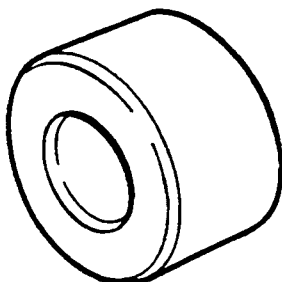
MS1519A

LRT-12-034 Valve spring compressor  
MS 1519A



RO274400

LRT-12-036 Drift, valve guide removal  
RO 274400

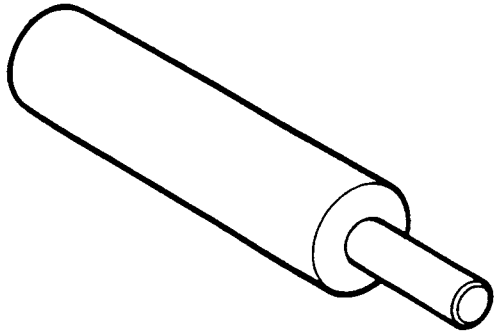


605774A

LRT-12-515 Distance piece, valve guide fitting  
RO 605774A  
LST 130

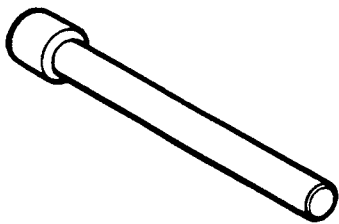


LRT-12-046 Valve guide drift



LST130

LRT-12-045 Retainer injection pump & timing pin  
LST 129



LST129

# 12 - ENGINE

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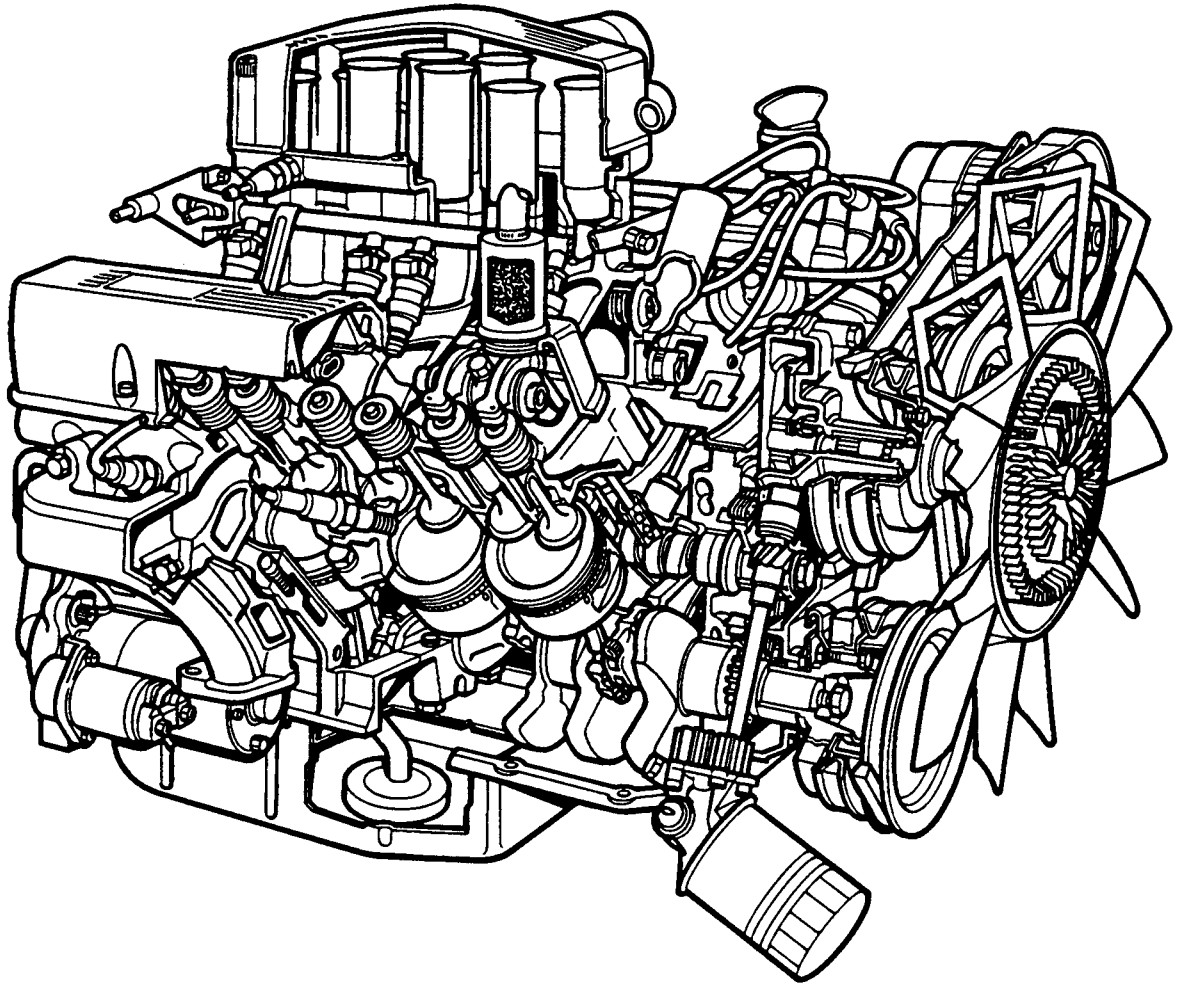


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## DESCRIPTION

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The V8 engine has cast aluminium cylinder heads and cylinder block. The two banks of steel cylinder liners which are pressed down to stops in the block, are set at 90° to one another. The three ringed aluminium pistons transmit the power through the connecting rods to a cast iron five bearing crankshaft, which drives the centrally located camshaft via an inverted tooth chain.

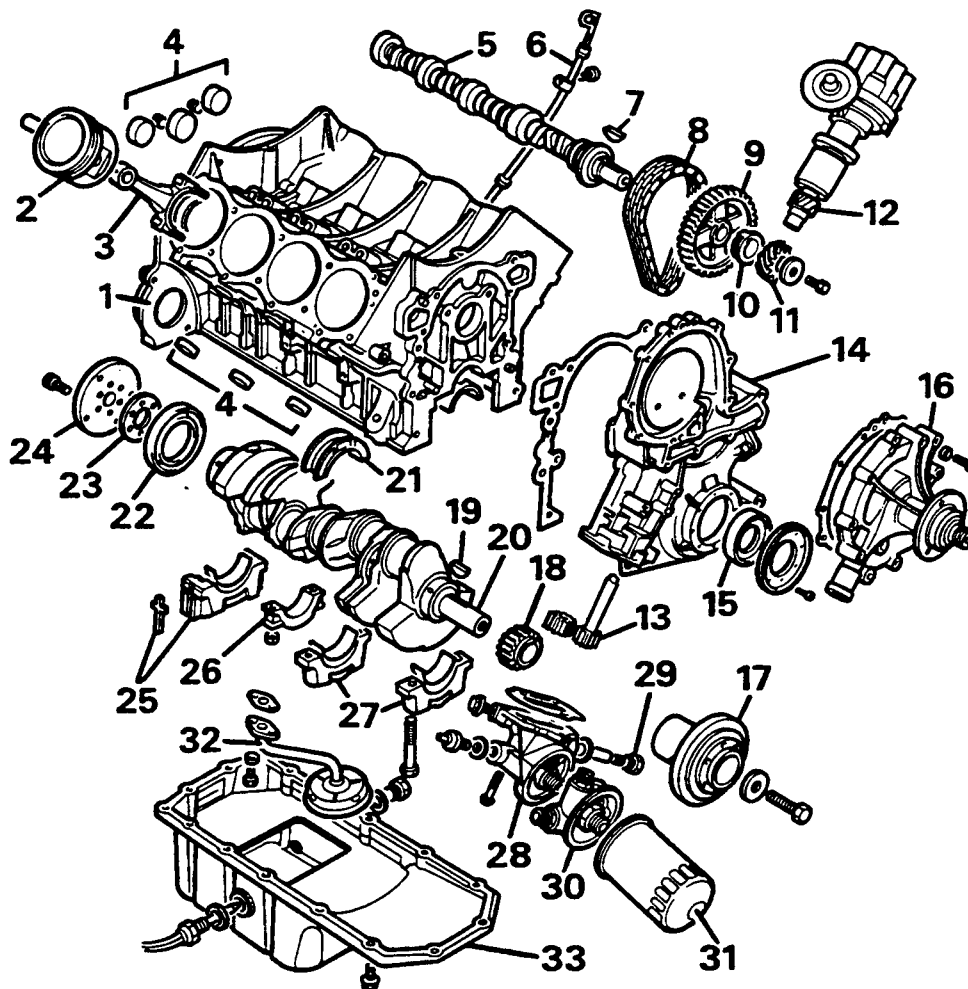


**RR3523M**

The electronic ignition distributor and lubrication oil pump are driven by a skew gear off the front of the camshaft. The overhead inlet and exhaust valves are operated by rocker shafts, pushrods and self adjusting hydraulic tappets.

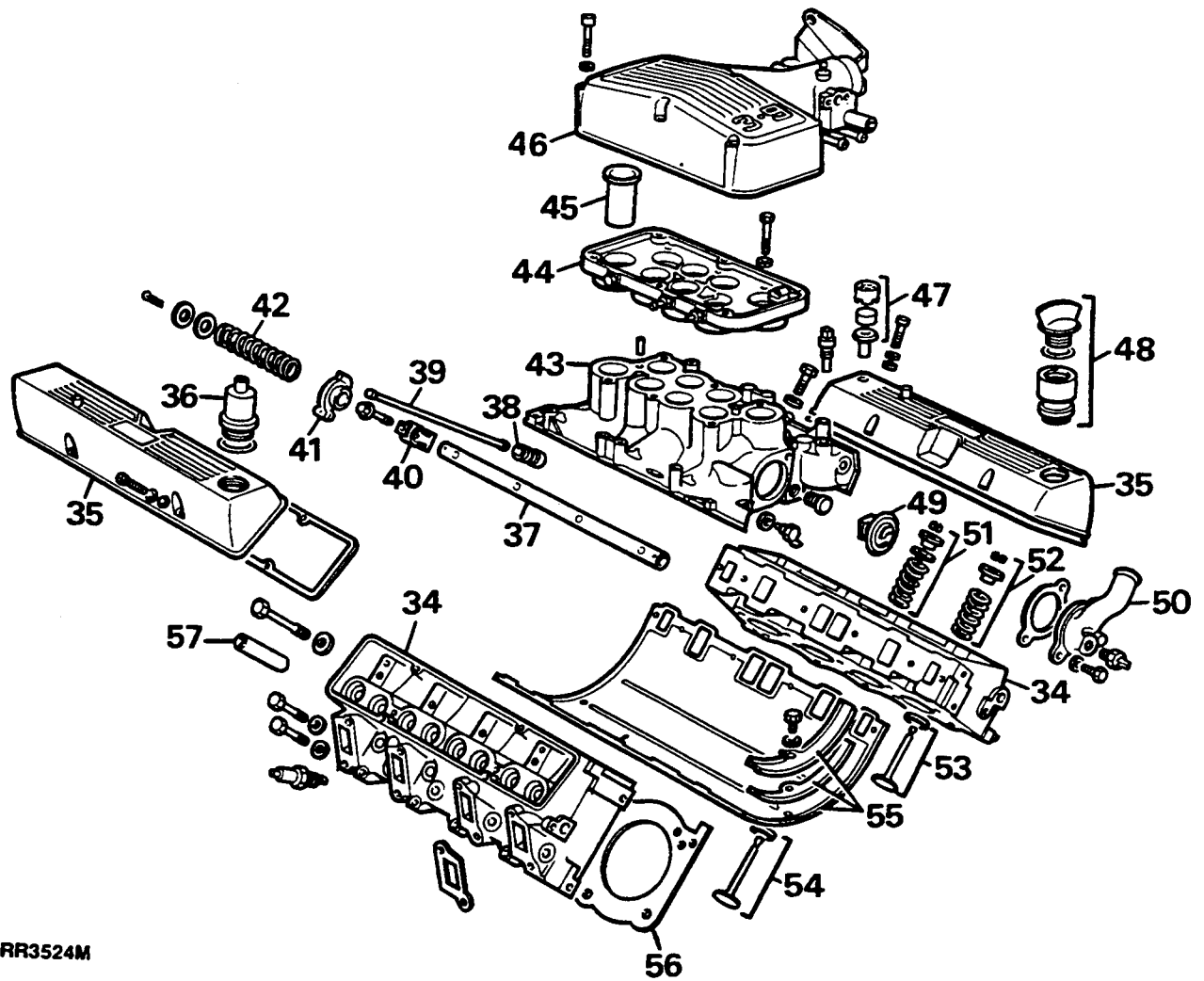
Electronic fuel injection ensures that engine performance, economy and exhaust emissions are automatically correct for the demands of highway and off road operation.





RR3627M

- |                                     |   |
|-------------------------------------|---|
| 1. Cylinder block                   | 18. Crankshaft sprocket                         |
| 2. Pistons and gudgeon pins (8)     | 19. Crankshaft sprocket key                     |
| 3. Connecting rods (8)              | 20. Crankshaft                                  |
| 4. Core plugs                       | 21. Centre main bearing shells (2)              |
| 5. Camshaft                         | 22. Crankshaft rear oil seal                    |
| 6. Dipstick                         | 23. Spacer                                      |
| 7. Camshaft key                     | 24. Adaptor plate                               |
| 8. Timing chain                     | 25. Rear main bearing cap, shell and side seals |
| 9. Camshaft sprocket                | 26. Connecting rod caps                         |
| 10. Distance piece                  | 27. Main bearing caps and shell bearings        |
| 11. Distributor/oil pump drive gear | 28. Oil pump cover                              |
| 12. Distributor                     | 29. Oil pressure relief valve                   |
| 13. Oil pump gears                  | 30. Oil cooler/filter adaptor                   |
| 14. Front cover                     | 31. Oil filter                                  |
| 15. Front cover oil seal            | 32. Oil pump suction pipe/strainer              |
| 16. Water pump                      | 33. Sump  |
| 17. Crankshaft damper/pulley        |   |



RR3524M

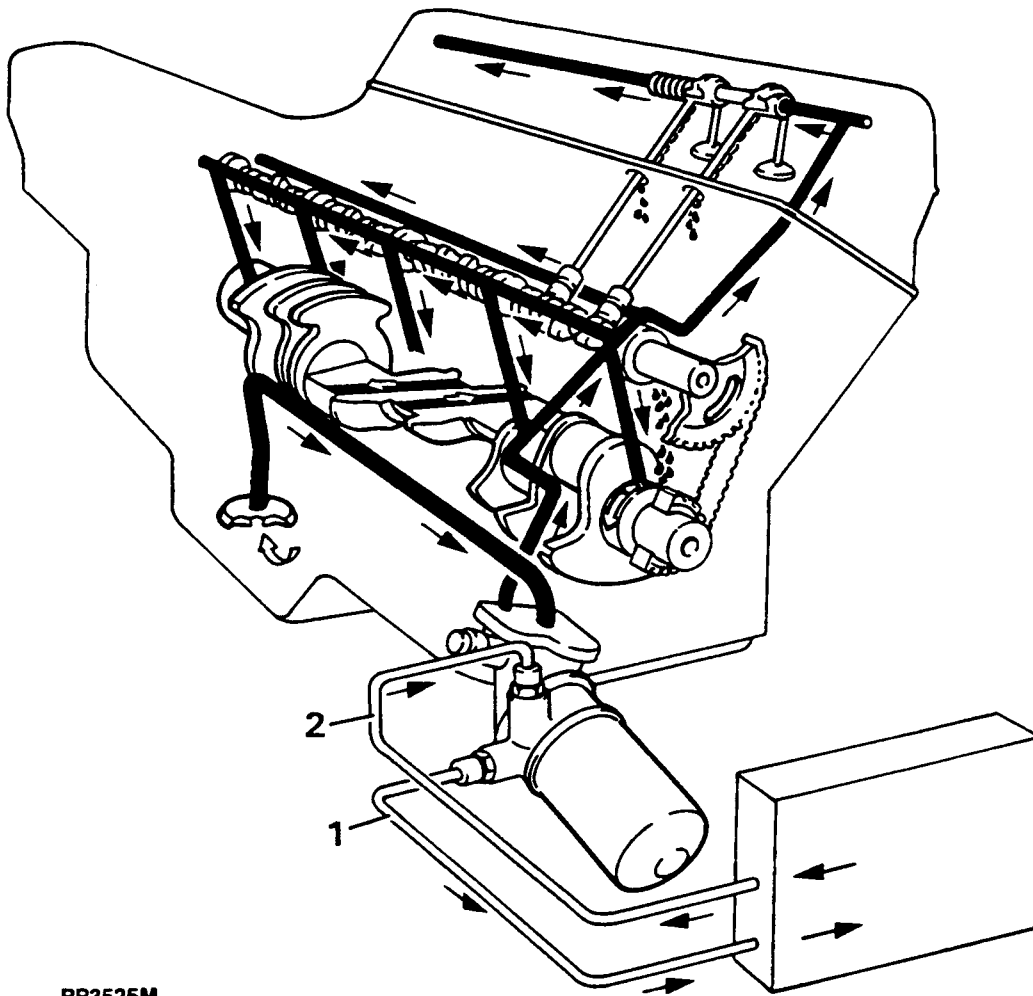
- |  |   |
|--|---|
| 34. Cylinder heads (2)                 | 46. Plenum chamber upper                          |
| 35. Rocker covers (2)                  | 47. Air filter                                    |
| 36. Oil separator                      | 48. Oil filler                                    |
| 37. Rocker shafts (2)                  | 49. Thermostat                                    |
| 38. Hydraulic tappets (8)              | 50. Thermostat cover                              |
| 39. Pushrods (8)                       | 51. Inlet valve spring, cap, seal and collets (8) |
| 40. Rocker brackets (8)                | 52. Exhaust valve spring, cap, collets (8)        |
| 41. Rocker arms (4) left and (4) right | 53. Inlet valve and seat (8)                      |
| 42. Rocker shaft springs (6)           | 54. Exhaust valve and seat (8)                    |
| 43. Inlet manifold                     | 55. Tappet cover gasket and seals                 |
| 44. Plenum chamber lower               | 56. Cylinder head gaskets (2)                     |
| 45. Ram pipes (8)                      | 57. Valve guides (16)                             |

## Lubrication system

The V8 full flow lubrication system uses an external gear pump which is driven from the front of the camshaft via the distributor drive shaft. The oil pump gears are housed in the timing cover and the pressure relief valve, warning light switch and filter are fitted to the gear cover.

Oil drawn through the centrally located steel gauze strainer in the sump, is pumped under pressure through an oil cooler located in the lower half of the main coolant radiator. The cooled oil then passes through the filter, before being distributed from the main gallery via drillings, to the various components in the engine.

Lubrication to the thrust side of the cylinders is by oil grooves machined in each connecting rod big end joint face, which are timed to align with holes in the big end journals on the power and exhaust strokes.



RR3525M

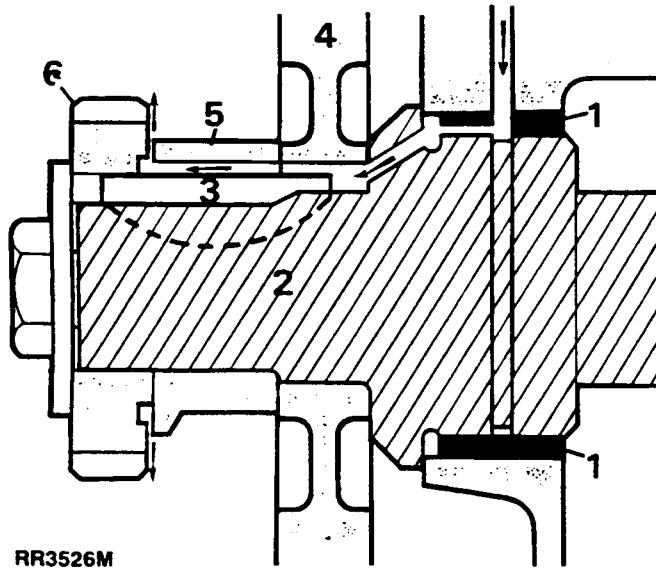
## Lubrication system

1. Oil to cooler
2. Oil from cooler



### Distributor/oil pump drive and timing chain lubrication

The distributor/oil pump drive, and timing chain are lubricated from the camshaft front bearing. The feed to the timing chain is channelled along the camshaft sprocket, key and spacer where it sprays onto the chain.

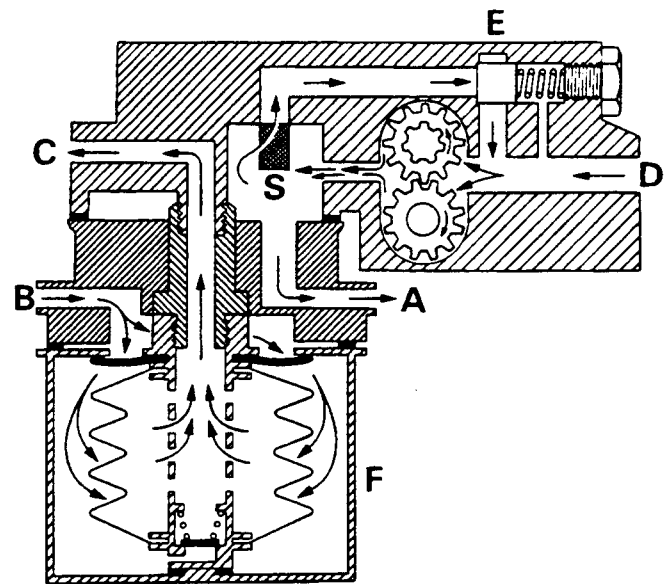


RR3526M

1. Bearing
2. Camshaft
3. Key
4. Cam gear
5. Spacer
6. Distributor/oil pump drive gear

### Filtered oil

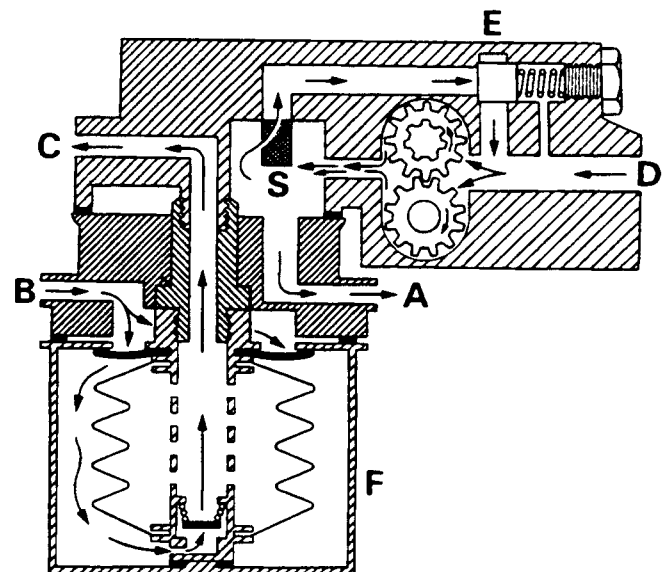
Lubrication pressure is controlled by the pressure relief valve E which allows excess pressure to escape into the pump suction gallery D. The oil is then pumped through the cooler via connections A and B before passing through the anti-siphon valve and into the filter. Filtered oil is supplied to the engine bearings by port C.



RR3528M

### Unfiltered oil

Any blockage of the filter element will open the by-pass valve and maintain an un-filtered oil supply to the bearings.



RR3529M

### Hydraulic tappets

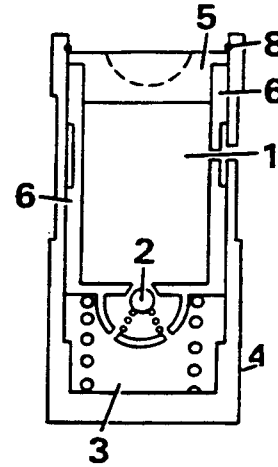
The purpose of the hydraulic tappet is to provide maintenance free and quiet operation of the inlet and exhaust valves. It achieves its designed purpose by utilizing engine oil pressures to eliminate the mechanical clearance between the rockers and the valve stems.

### Operation

During normal operation, engine oil pressure present in the upper chamber 1, passes through the non-return ball valve 2 and into the lower (high pressure) chamber 3.

When the cam begins to lift the outer sleeve 4, the resistance of the cylinder valve spring felt through the push rod and seat 5, causes the inner sleeve 6, to move downwards inside the outer. This slight downward movement of the inner sleeve 6, closes the ball valve 2 and increases the hydraulic pressure in the high pressure chamber 3, sufficient to ensure that the push rod opens the cylinder valve fully.

As the tappet assembly moves off the peak of the cam to the closing side, the ball valve 2 opens to equalize the pressure in both chambers which ensures that the cylinder valve fully closes when the tappet is on the back of the cam.



RR3531M

1. Upper chamber
2. Non-return ball valve
3. Lower chamber (high pressure)
4. Outer sleeve
5. Pushrod seat
6. Inner sleeve
7. Spring
8. Clip



## ENGINE OIL PRESSURE TEST

### Service tools:

LRT-12-052: Pressure test equipment



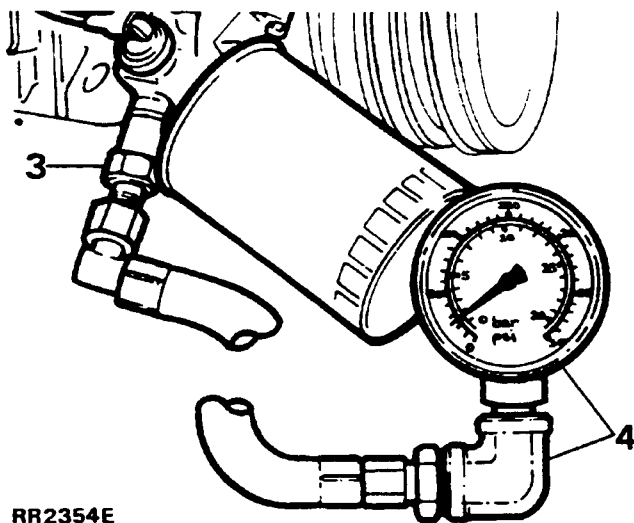
**WARNING:** Use suitable exhaust extraction equipment, if test is being carried out in workshop.



**WARNING:** If vehicle has been running, engine oil will be hot, care must be taken when fitting equipment to prevent personal injury due to scalding.

### Test

1. Check lubricant is to correct level.
2. Place vehicle on a ramp.
3. Disconnect the battery negative lead. Remove oil pressure switch.
4. Fit the test gauge.
5. Reconnect the battery negative lead.
6. Start and run engine to normal operating temperature.
7. At a steady engine speed of 2400 rev/min - minimum engine oil pressure reading should be - 1.76 kg/cm<sup>2</sup>.
8. If there is no oil pressure, check for air lock in system. *See SECTION 10, Maintenance, Service schedule*
9. If the pressure is low. *See Overhaul, Remove and overhaul oil pump*



RR2354E



**NOTE:** Excessive lubrication pressure can effect engine performance by over-pressurising the hydraulic tappets causing the valves to be held open. *See Description and operation, Description*

## CYLINDER COMPRESSION - TEST

### Equipment:

Compression pressure gauge

### Test

1. Start and run engine until normal engine operating temperature is achieved (thermostat open).
2. Remove all spark plugs.
3. Disconnect both coil negative (WB) leads
4. Insert compression gauge, crank engine until reading stabilises.
5. Expected readings, throttle fully open, battery fully charged - 8.13:1 compression ratio: 150 - 160 psi 9.35:1 compression ratio: 170 - 180 psi
6. If compression is appreciably less than correct figure, or varies by more than 10%, piston rings or valves may be faulty.
7. Low pressure in adjoining cylinders may indicate a faulty head gasket.

**ENGINE NOISES**

Excessive or obtrusive noise from the engine compartment originates from three main sources:

- A. The exhaust system, which makes an unmistakable and easy to diagnose noise.
- B. External components emit the greatest variety of noises, but are also easy to diagnose by simply disconnecting the appropriate drive belt.
- C. Engine internal mechanical noises which can vary in volume and pitch and may be a combination of, tapping - knocking or rumbling, are the most difficult to diagnose. The following is therefore a guide to diagnosis of engine internal mechanical noises only.

**Engine internal mechanical noises.**

**Single or multiple, light tapping noise, particularly when engine is cold. See Description and operation, Description**

1. Is engine oil level correct?  
NO - Top up to correct level. **See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids**  
YES - Continue.
2. Is the lubricating oil pressure correct?  
NO - **See Engine oil pressure test**  
YES - Suspect valve operating mechanism.
3. To confirm diagnosis, remove the rocker covers and with the engine idling, insert a feeler gauge of 0,015 mm between each rocker and valve stem. A faulty valve operating mechanism will emit a different noise when the feeler gauge is inserted. **See Repair, Rocker shaft renew**

**Heavy knocking noise (particularly on load and when engine is hot). See Description and operation, Description**

1. Is engine oil level correct?  
NO - Top up to correct level. **See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids**  
YES - Continue.
2. Is the lubricating oil pressure correct?  
NO - **See Engine oil pressure test**  
YES - Drain engine oil and filter, and examine for metallic contamination.
3. Is the oil contaminated with metal particles?  
YES - Suspect faulty big end bearings. To confirm diagnosis, short out the ignition to each spark plug in turn. The noise will disappear or be reduced when the cylinder with the faulty big end is shorted out.
4. If noise is not conclusively diagnosed, check the security of the flywheel and crankshaft front pulley. Temporarily release the drive belts to reduce general noise level and use a stethoscope to locate source of noise.

**Heavy rumbling noise (particularly during hard acceleration). See Description and operation, Description**

1. Is engine oil level correct?  
NO - Top up to correct level. **See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids**  
YES - Continue.
2. Is the lubricating pressure correct?  
NO - **See Engine oil pressure test**  
YES - Drain engine oil and filter, and examine for metallic contamination.
3. Is the oil contaminated with metal particles?  
YES - Suspect faulty main bearings. If noise is not conclusively diagnosed, check the security of the flywheel and crankshaft front pulley. Temporarily release the drive belts to reduce general noise level and use a stethoscope to locate source of noise.



## ENGINE STARTING PROBLEMS

### Engine fails to crank in park or neutral (Automatic Transmission)

1. Is battery in good state of charge?  
NO - See *INTRODUCTION, Information, Jump starting*  
YES - Continue.
2. Is automatic transmission inhibitor switch faulty or gear selection linkage incorrectly adjusted?  
YES - See *AUTOMATIC GEARBOX, Repair, Inhibitor switch* See *AUTOMATIC GEARBOX, Repair, Gear lever selector cable setting*  
NO - See *ETM, B1*  
If problem is not diagnosed repeat tests, starting at 1.

### Engine fails to crank (Manual Transmission)

1. Is battery in good state of charge?  
NO - See *INTRODUCTION, Information, Jump starting*  
YES - See *ETM, B1*  
If problem is not diagnosed repeat tests, starting at 1.

### Engine cranks but fails to start

1. Is the cranking speed fast enough (120 rev/min)?  
NO - See *INTRODUCTION, Information, Jump starting*  
If necessary also See *ETM, B1*  
YES - Continue.
2. Is there combustion in any cylinder?  
NO - See *ELECTRICAL, Fault diagnosis, Lucas constant energy ignition system 35DLM8-preliminary checks* See *ETM, A1*  
YES - Continue.
3. Are the fuel supply, tank, pump, ventilation and emission control systems in correct working order or the fuel contaminated?  
NO - See *FUEL SYSTEM, Repair, Fuel filter* See *FUEL SYSTEM, Repair, Fuel tank - 1991 onwards* See *FUEL SYSTEM, Repair, Fuel pump - Pre 1991* See *EMISSION CONTROL, Description and operation, Emission control*  
If problem is not diagnosed repeat tests, starting at 2.

## ENGINE RUNNING PROBLEMS

### Engine runs at high speed but will not idle (stops) Engine idle speed erratic. Engine starts but stops immediately

#### Engine stalls. Engine misfires/hesitation

1. Electronic fuel injection. See *ETM, A1* See *ELECTRICAL, Fault diagnosis, Lucas constant energy ignition system 35DLM8-preliminary checks*  
Check brake vacuum connections. See *BRAKES, Description and operation, Brake servo unit*  
Check heater/ventilation unit vacuum connections. See *HEATING AND VENTILATION, Description and operation, Heating and ventilation unit*  
If problem is not diagnosed continue.
2. Are HT leads correctly routed and clipped?  
NO - See *ELECTRICAL, Repair, Distributor*  
YES - Continue.
3. Is fuel supply, tank, pump, ventilation and emission control systems in correct working order or the fuel contaminated?  
NO - See *FUEL SYSTEM, Repair, Fuel filter* See *FUEL SYSTEM, Repair, Fuel tank - 1991 onwards* See *FUEL SYSTEM, Repair, Fuel pump - Pre 1991* See *EMISSION CONTROL, Description and operation, Emission control*  
If problem is not diagnosed repeat tests, starting at 1.

### Engine lacks power/poor performance

1. Is throttle travel restricted or cable incorrectly adjusted?  
YES - Check thickness of carpets. See *FUEL SYSTEM, Repair, Throttle cable* See *FUEL SYSTEM, Repair, Throttle pedal*  
NO - Continue.
2. Are the Ignition and Electronic Fuel Injection systems in order?  
NO - See *ETM, A1* See *ELECTRICAL, Fault diagnosis, Lucas constant energy ignition system 35DLM8-preliminary checks* See *ELECTRICAL, Repair, Distributor*  
YES - Continue.



3. Are fuel supply, tank, pump, ventilation and emission control systems in correct working order or the fuel contaminated?  
 NO - See **FUEL SYSTEM, Repair, Fuel filter**  
 See **FUEL SYSTEM, Repair, Fuel tank - 1991 onwards** See **FUEL SYSTEM, Repair, Fuel pump - Pre 1991** See **EMISSION CONTROL, Description and operation, Emission control**  
 YES - Suspect valves held open by hydraulic tappets due to high oil pressure. See **Engine oil pressure test**

4. Is oil pressure high?  
 YES - Remove oil filter and cooler adaptor and check pressure relief valve strainer gauze for blockage and that the relief valve is not stuck closed. See **Description and operation, Description**  
 NO - Carry out cylinder compression tests to determine condition of head gaskets and valves. See **Cylinder compression - test**

5. Are cylinder compressions satisfactory?  
 NO - For overhaul See **Overhaul, Remove and overhaul cylinder heads**  
 YES - Check brake vacuum connections. See **BRAKES, Description and operation, Brake servo unit**

Check heater/ventilation unit vacuum connections. See **HEATING AND VENTILATION, Description and operation, Heating and ventilation unit**

If problem is not diagnosed - Continue.

6. Are the brakes binding?  
 YES - Investigate cause of binding.  
 NO - Continue.
7. Automatic Transmission only. Is the Torque Converter and Transmission operating correctly? Carry out Road test, Static tests and Stall tests to determine condition of Automatic transmission. If problem is not diagnosed; repeat tests starting at 1.

#### Engine backfires into exhaust system

1. Are there any leaking joints/connections or holes in the exhaust system?  
 YES - See **MANIFOLD AND EXHAUST SYSTEM, Repair, Exhaust system complete**  
 NO - Continue.
2. Is distributor fitted correctly, HT leads in correct firing order and routed correctly?  
 NO - See **ELECTRICAL, Repair, Distributor**  
 YES - Continue.
3. Is air/fuel ratio correct?  
 NO - Check electronic fuel injection. See **ETM, A1**  
 Check brake vacuum connections. See **BRAKES, Description and operation, Brake servo unit**  
 Check heater/ventilation unit vacuum connections. See **HEATING AND VENTILATION, Description and operation, Heating and ventilation unit**  
 Check the crankcase and fuel tank ventilation system. See **EMISSION CONTROL, Description and operation, Emission control**  
 YES - Continue.
4. Are cylinder compressions satisfactory?  
 NO - Carry out compression test to check for leaking gaskets, valves etc. See **Cylinder compression - test**  
 For overhaul. See **Overhaul, Remove and overhaul cylinder heads**  
 If problem is not diagnosed; repeat tests starting at 1.

#### Engine backfires into inlet system

1. Is the Distributor, HT connections and routing correct?  
 NO - See **ELECTRICAL, Repair, Distributor**  
 YES - Continue.



2. Is air fuel ratio correct?  
NO - Check electronic fuel injection. **See ETM, A1**  
Check brake vacuum connections. **See BRAKES, Description and operation, Brake servo unit**  
Check heater/ventilation unit vacuum connections. **See HEATING AND VENTILATION, Description and operation, Heating and ventilation unit**  
Check the crankcase and fuel tank ventilation system. **See EMISSION CONTROL, Description and operation, Emission control**  
YES - Continue.
3. Are cylinder compressions satisfactory?  
NO - Carry out compression test to check for leaking gaskets valves etc. **See Cylinder compression - test**  
For overhaul **See Overhaul, Remove and overhaul cylinder heads**  
If problem is not diagnosed: repeat tests starting at 1.

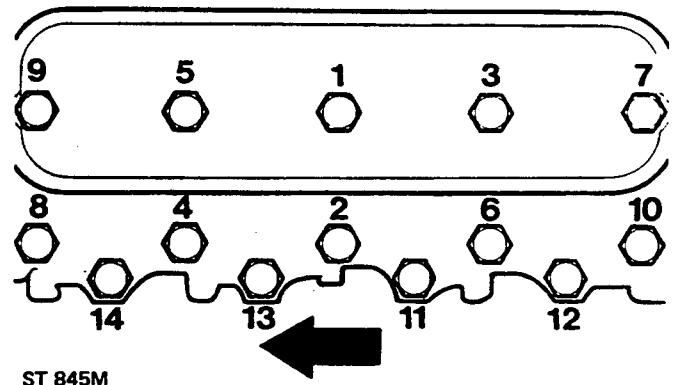


## CYLINDER HEAD GASKETS - RENEW

Service repair no - 12.29.01

1. Drain cooling system. *See COOLING SYSTEM, Adjustment, Coolant*
2. Remove inlet manifold. *See FUEL SYSTEM, Repair, Intake manifold*
3. Remove alternator. *See ELECTRICAL, Repair, Alternator*
4. Remove rocker shafts. *See rocker shaft renew*
5. Remove push rods.
6. Remove power steering pump belt.
7. Remove alternator bracket.
8. Remove both exhaust manifolds.
9. Remove air cleaner assembly. *See FUEL SYSTEM, Repair, Air cleaner*
10. Remove air flow meter. *See FUEL SYSTEM, Repair, Air flow sensor*
11. Remove earth leads from rear of left hand cylinder head
12. Right hand cylinder head - remove breather pipe from lifting bracket.
13. Loosen cylinder head bolts, reversing tightening sequence.
14. Remove cylinder heads.
15. Remove cylinder head gaskets.
16. Clean exhaust mating faces.
17. Clean head and block faces.
18. Fit new cylinder head gaskets, word TOP uppermost. DO NOT use sealant.
19. Oil cylinder bores.
20. Clean threads of head bolts and coat with Loctite 572.
21. Locate cylinder heads on block.

22. Locate cylinder head bolts in position illustrated.  
Long bolts - 1, 3, and 5.  
Medium bolts - 2, 4, 6, 7, 8, 9 and 10  
Short bolts - 11, 12, 13, and 14



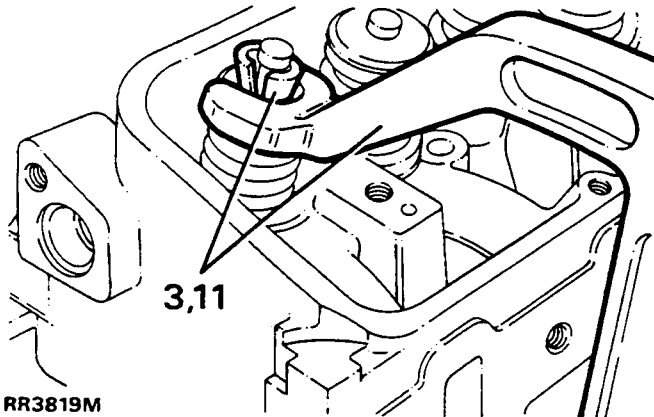
**NOTE:** Left hand cylinder head illustrated, arrow points to front of vehicle.

23. Tighten bolts progressively in sequence, see illustration number ST845M. Finally tighten to torque:  
Outer row **60 Nm**  
Centre row **90 Nm**  
Inner row **90 Nm**.
24. When all bolts have been tightened, re-check for correct torque.
25. Reverse removal procedure. Operations 12 to 1.

## CYLINDER HEADS - RENEW

Service repair no - 12.29.15

1. Remove cylinder heads and gaskets. See **cylinder head gaskets - renew**
2. Remove spark plugs.
3. Using spring compressor 18G 106A, remove valves, collets, springs and caps.



4. From left hand cylinder head, remove earth lead studs.
5. Remove PAS pump pivot stud.
6. Right hand cylinder head, remove rear lifting bracket.
7. Fit lifting bracket to new right hand cylinder head.
8. Fit PAS pump pivot stud, earth lead studs to new left hand cylinder head.
9. Regrind valves.
10. Lubricate valve stems, fit valves, springs, and caps. Fit new seals to inlet valve stems only.
11. Using spring compressor 18G 106A, compress springs, fit collets. Tap valve to check correct collet seating.
12. Fit spark plugs.
13. Fit cylinder heads with new gaskets. See **cylinder head gaskets - renew**

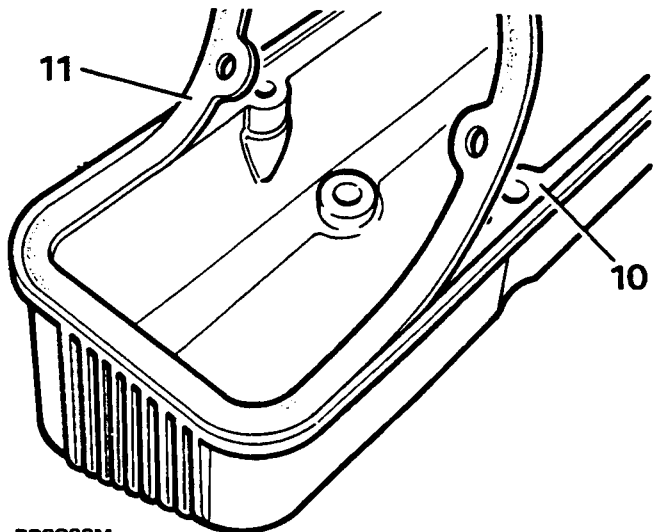
## ROCKER COVER - RIGHT HAND - RENEW

Service repair no - 12.29.41

1. Disconnect the battery negative lead.
2. Disconnect purge pipe from charcoal canister at plenum.
3. Remove breather pipe from rocker cover.
4. Remove coolant pipes from inlet manifold.
5. Remove spark plug leads from plugs and retaining clips.
6. Remove four rocker cover bolts. Moving fuel pipes aside, remove rocker cover.
7. Discard rocker cover gasket.
8. Remove plug lead retaining clips from rocker cover, fit to new rocker cover.
9. Clean and dry rocker cover and cylinder head mating faces, using Bostik cleaner 6001.



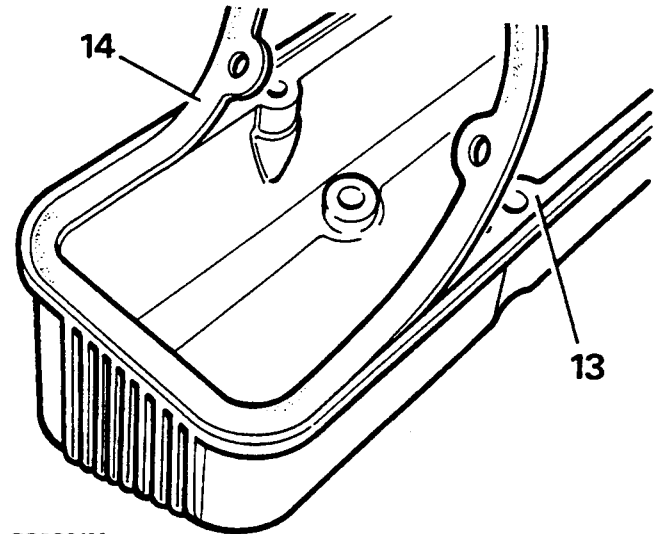
**NOTE: Gasket fits one way round only. It must be fitted accurately, first time. Subsequent movement will destroy bonding.**



10. Apply Bostik 1775 impact adhesive to rocker cover seal face and gasket, using a brush to ensure an even film. Allow adhesive to become touch dry.



11. Place one end of gasket into cover recess with edge firmly against recess wall, holding remainder of gasket clear. Work around cover, pressing gasket into place ensuring edge firmly contacts recess wall.
12. Allow cover to stand for thirty minutes before fitting.
13. Fit rocker cover to cylinder head with four screws, short screws inboard, tighten to **8 Nm**.
14. Position fuel pipes.
15. Fit breather pipe to rocker cover, tighten clip.
16. Fit coolant pipes to inlet manifold, tighten bolts.
17. Fit spark plug leads to plugs and retaining clips.
18. Connect purge pipe from charcoal canister at plenum, tighten clip.



RR3821M

## ROCKER COVER - LEFT HAND - RENEW

Service repair no - 12.29.40

1. Remove air flow sensor. *See FUEL SYSTEM, Repair, Air flow sensor*
2. Remove plenum chamber. *See FUEL SYSTEM, Repair, Plenum chamber*
3. Remove dipstick.
4. Remove spark plug leads from plugs and retaining clips.
5. Disconnect HT lead from coil.
6. Remove alternator heat shield from rocker cover.
7. Remove air flow meter harness clip.
8. Remove dipstick tube clip.
9. Remove four rocker cover bolts, remove rocker cover.
10. Discard gasket
11. Remove plug lead retaining clips from rocker cover, fit to new rocker cover.
12. Clean and dry rocker cover and cylinder head mating faces, using Bostik cleaner 6001.



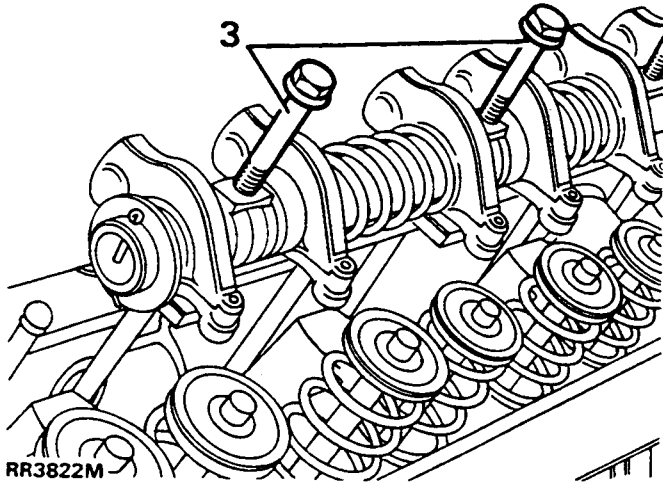
**NOTE:** Gasket fits one way round only. It must be fitted accurately, first time. Subsequent movement will destroy bonding.

13. Apply Bostik 1775 impact adhesive to rocker cover seal face and gasket, using a brush to ensure an even film. Allow adhesive to become touch dry, approximately fifteen minutes.
14. Place one end of gasket into cover recess with edge firmly against recess wall, holding remainder of gasket clear. Work around cover, pressing gasket into place ensuring edge firmly contacts recess wall.
15. Allow cover to stand for thirty minutes before fitting.
16. Fit rocker cover to cylinder head with four screws, short screws inboard. Tighten to **8 Nm**.
17. Locate and tighten dipstick tube clip.
18. Fit and tighten air flow meter harness clip.
19. Fit alternator heat shield to rocker cover.
20. Connect HT lead to coil.
21. Connect spark plug leads to plugs and retaining clips.
22. Fit dipstick.
23. Fit plenum chamber.
24. Fit air flow meter.

## ROCKER SHAFT RENEW

Service repair no - 12.29.29

1. Remove rocker covers as required. *See rocker cover - right hand - renew* or *See Rocker cover - left hand - renew*
2. Loosen four rocker shaft fixings



3. Remove rocker shaft assembly.



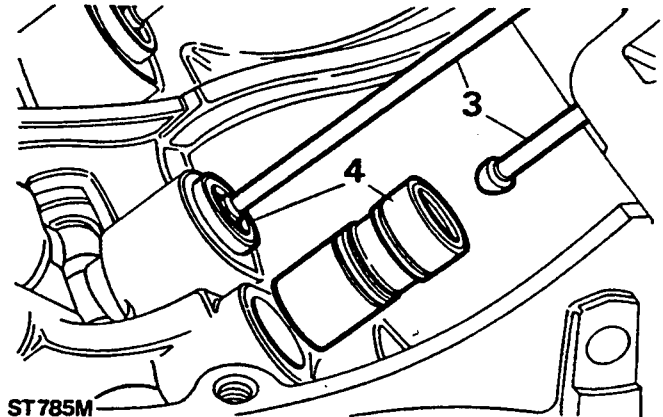
**NOTE:** Each rocker shaft is notched at **ONE** end. Notch must be uppermost and towards front of engine on right hand side, towards rear on left hand side.

4. Clean rocker pedestal locations on cylinder head.
5. Fit rocker shaft assembly, locating push rods to rockers.
6. Tighten rocker shaft fixings to **38 Nm**.
7. Fit rocker covers.

## HYDRAULIC TAPPETS RENEW

Service repair no - 12.29.57

1. Remove rocker shafts. *See rocker shaft renew*
2. Remove inlet manifold. *See FUEL SYSTEM, Repair, intake manifold*
3. Remove push rods, retain in removal sequence.



4. Remove hydraulic tappets
5. Fit tappets, push rods and rocker assemblies. *See Overhaul, fit tappets, push rods and rocker assemblies*
6. Fit inlet manifold.
7. Reverse removal procedure.



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**CRANKSHAFT PULLEY ASSEMBLY**

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Service repair no - 12.21.01

1. Remove viscous coupling. *See COOLING SYSTEM, Repair, viscous coupling, fan blades, pulley and fan cowl*
2. Remove water pump drive belt.
3. Remove alternator drive belt.
4. Remove power steering pump drive belt.
5. Raise vehicle on ramp.
6. Remove bell housing bottom cover.
7. Remove engine undertray. *See CHASSIS AND BODY, Repair, engine undertray*
8. With assistance to stop flywheel rotation, remove crankshaft pulley assembly retaining bolt.
9. Remove crankshaft pulley assembly.
10. If required: Place assembly in vice and remove pulleys.
11. Fit pulleys to torsional vibration damper.
12. Lubricate seal face of assembly.
13. Fit pulley assembly.
14. With assistance to stop flywheel rotation, fit retaining bolt, tighten to **280 Nm**.
15. Reverse removal procedure 1 to 7.

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**FRONT COVER OIL SEAL - RENEW**

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Service repair no - 12.21.14

1. Remove crankshaft pulley. *See crankshaft pulley assembly*  
Do not remove pulleys.
2. Remove eight screws and remove mud excluder.
3. Fit button of 18G1328 to crankshaft, fit extractor to seal.
4. Turn centre bolt of extractor to remove seal.
5. Remove seal from extractor.
6. Clean seal seating.
7. Lubricate outside diameter of seal.
8. Locate seal in front cover.
9. Fit adaptor 18G1291/5 to 18G1291/4.
10. Fit tool to seal.
11. Fit and tighten centre bolt to crankshaft, tighten centre locknut to seat seal.
12. Slacken locknut and remove tool.
13. Lubricate seal lip.
14. Fit mud excluder and tighten screws.
15. Fit crankshaft pulley assembly.

## FRONT COVER GASKET

Service repair no - 12.65.04

## Remove and refit

## Remove

1. Remove crankshaft pulley. *See crankshaft pulley assembly*  
Do not remove pulleys.
2. Remove water pump pulley.
3. Release distributor cap clips.
4. Release plug leads from plugs and clips.
5. Place cap and leads to one side.
6. Turn engine until No. 1 piston is at T.D.C.
7. Check position of rotor arm.
8. Remove fixings securing power steering pump bracket to water pump bracket.
9. Remove power steering pump bracket from water pump.
10. Remove clips securing wiring to alternator tensioner.
11. Disconnect distributor feed wire.
12. Pivot power steering pump away from front cover, tighten pivot to retain in position.
13. Disconnect vacuum pipe from distributor.
14. Remove water pump bottom hose.
15. Disconnect oil pressure switch.
16. Disconnect heater hose at water pump.
17. Remove alternator tensioner from water pump, move tensioner aside.
18. Mark distributor position to front cover.
19. Remove distributor clamp, remove distributor.
20. Remove fixings sump to front cover.
21. Loosen four adjacent sump fixings.
22. Remove alternator support strut from front cover, move strut aside.
23. Loosen remaining front cover fixings and remove front cover.
24. Remove front cover gasket.

## Refit

25. Clean timing cover, clean block face.
26. Lightly grease gasket faces.
27. Fit new gasket to block face.
28. Apply Hylosil to sump gasket.
29. Clean threads of cover fixing bolts, apply Loctite 372 to threads.
30. Fit timing cover, fit fixing bolts. Tighten to **28 Nm**.
31. Fit alternator support strut to front cover.
32. Tighten sump to timing cover fixings to **10 Nm**.
33. Tighten sump fixings to **10 Nm**.
34. Lubricate distributor 'O' ring.
35. Fit distributor in position marked.
36. Align oil pump drive, if distributor does not seat correctly.
37. Fit distributor clamp. Tighten to **20 Nm**.
38. Locate alternator tensioner on water pump bracket.
39. Connect heater hose, tighten clip.
40. Connect oil pressure switch.
41. Connect bottom hose, tighten clip.
42. Connect vacuum pipe to distributor.
43. Loosen power steering pump pivot, lower pump.
44. Connect distributor feed wire.
45. Connect wire ties to alternator tensioner.
46. Fit power steering pump bracket to water pump. Tighten to **28 Nm**.
47. Fit power steering pump to bracket.
48. Position distributor cap. Fit plug leads to plugs and clips.
49. Clip distributor cap in position.
50. Fit water pump pulley. Tighten to **10 Nm**.
51. Fit crankshaft pulley. *See crankshaft pulley assembly*
52. Tension drive belts correctly.
53. Check ignition timing.
54. Refill cooling system.






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**TIMING CHAIN AND CHAINWHEELS**


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Service repair no - 12.65.12

**Remove and refit**

**Remove**

1. Remove front cover. *See front cover gasket*
2. Remove retaining bolt and washer, remove distributor drive gear and spacer.
3. Ensure number one piston is at TDC.
4. Remove chainwheels and chain as an assembly.

**Refit**

5. Clean chainwheels and chain.
6. Fit chainwheels to chain, aligning timing marks.
7. Ensure camshaft key is fitted parallel to shaft axis to ensure adequate lubrication to distributor drive gear.
8. Engage chainwheel assembly on camshaft and crankshaft keys, ensure chain wheels are fully located.
9. Check alignment of timing marks with straight edge.
10. Fit spacer with flange to front,
11. Fit distributor drive gear with groove towards spacer.
12. Fit retaining bolt and washer. Tighten to **58 Nm**.
13. Fit front cover. *See front cover gasket*

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**FLYWHEEL**


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Service repair no - 12.53.07

**Remove and refit**

**Remove**

1. Remove gearbox and clutch. *See CLUTCH, Repair, clutch assembly*
2. Slacken starter motor bolts.
3. Lock flywheel, remove flywheel bolts and flywheel.

**Refit**

4. Clean components for reassembly.
5. Fit flywheel.
6. Lock flywheel, fit flywheel bolts. Tighten to **80 Nm**.

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**FLEXIBLE DRIVE PLATE AND RING GEAR**


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Service repair no - 12.53.13

**Remove and refit**

**Remove**

1. Remove transmission. *See AUTOMATIC GEARBOX, Repair, ZF Auto with Borg Warner Transfer Gearbox*
2. Remove flexible drive plate and ring gear assembly. *See Overhaul, remove flexible drive plate and ring gear assembly*

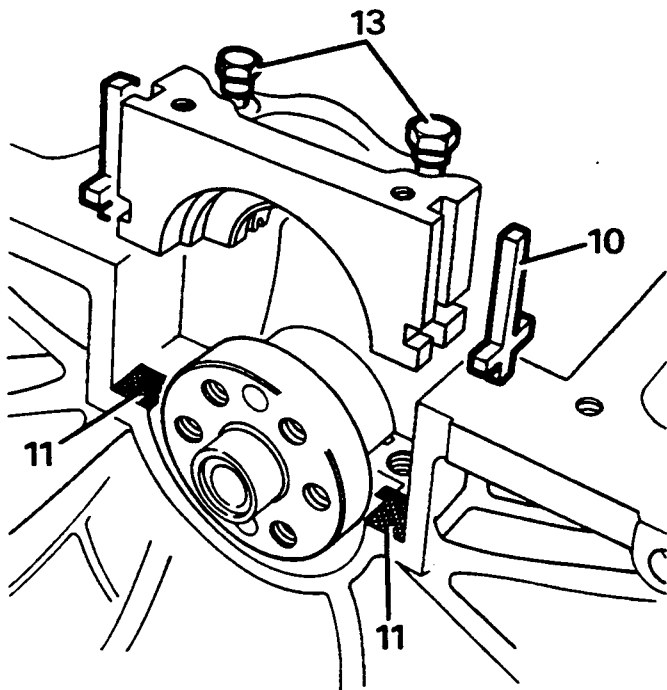
**Refit**

3. Clean all components for reassembly.
4. Fit ring gear and flexible drive plate assembly. *See Overhaul, fit ring gear and flexible drive plate assembly*
5. Fit transmission.

## CRANKSHAFT REAR OIL SEAL

Service repair no - 12.21.20

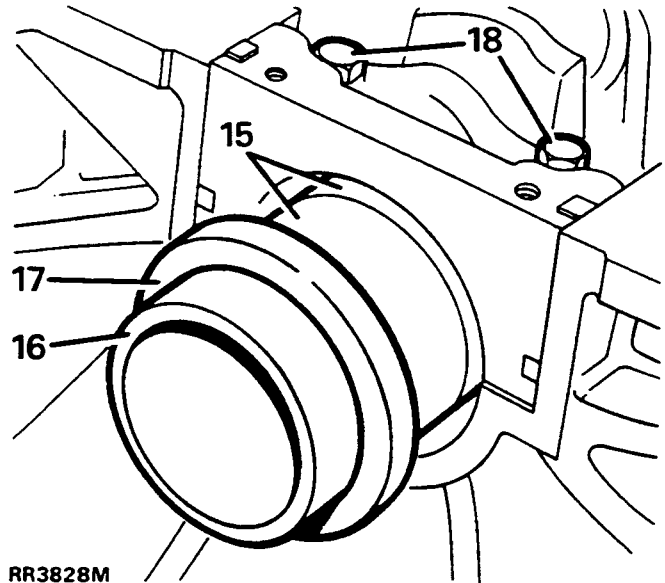
1. Remove engine. *See Overhaul, engine removal*
2. Automatic transmission, remove drive plate. *See Overhaul, Remove flexible drive plate and ring gear assembly*  
OR manual transmission, remove flywheel. *See Overhaul, Remove and overhaul flywheel - manual gearbox models only*
3. Remove dipstick.
4. With assistance, invert engine, support on blocks.
5. Remove sump.
6. Remove rear main bearing cap.
7. Remove cross seals from cap.
8. Remove crankshaft rear oil seal.
9. Clean main bearing cap and oil seal area of block.
10. Fit new cross seals to bearing cap.
11. Apply Hylomar SQ32M to block as illustrated.



RR3827M

12. Lubricate bearing shell and cross seals using clean engine oil.
13. Fit bearing cap, do not tighten bolts.
14. Ensure cap is fully home and seated squarely on the block.

15. Ensure oil seal guide RO1014 and crank journal are scrupulously clean. Coat seal guide and oil seal journal with clean engine oil.



RR3828M

**CAUTION:** Do not handle oil seal lip, check it is not damaged. Ensure outside diameter remains clean and dry.

16. Position oil seal guide RO1014 on crankshaft flange.

**NOTE:** Lubricant coating must cover seal guide outer surface completely to ensure that oil seal lip is not turned back during assembly. Position oil seal, lipped side towards engine, on seal guide. Seal outside diameter **MUST** be clean and dry.

17. Push oil seal fully and squarely by hand into recess in cap and block until it contacts machined step in recess. Remove seal guide.
18. Tighten rear main bearing cap to **90 Nm**.
19. Fit sump. *See Overhaul, Fit sump*
20. Reposition engine, fit dipstick.
21. Fit flywheel, or automatic drive plate.
22. Fit engine to vehicle.



## ENGINE REMOVAL

### Remove and refit

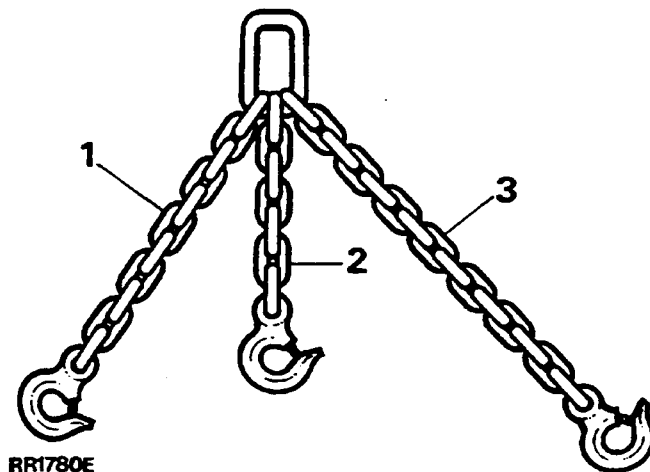
#### Remove

1. Park vehicle on level ground and apply park brake.
2. De-pressurize fuel system. *See FUEL SYSTEM, Repair, Depressurising fuel system*
3. Remove bonnet. *See CHASSIS AND BODY, Repair, Bonnet*
4. Remove battery. *See ELECTRICAL, Repair, Battery*
5. Remove radiator/oil coolers. *See COOLING SYSTEM, Repair, Radiator/oil coolers*
6. Place an absorbent cloth around fuel feed hose at fuel rail and release compression nut. Remove feed hose from rail, seal end of pipes with masking tape to prevent ingress of dirt.
7. Release fuel return hose clamp and remove hose from pressure regulator, seal both openings with masking tape to prevent ingress of dirt.
8. Remove vacuum hose from rear of regulator.
9. Manual vehicles: Disconnect throttle cable from bracket. Automatic vehicles: Detach throttle bracket from plenum chamber and lay assembly to one side. *See FUEL SYSTEM, Repair, Plenum chamber DO NOT DISTURB KICK DOWN CABLE SETTING.*
10. Remove ram housing. *See FUEL SYSTEM, Repair, Ram housing*
11. Remove air flow sensor. *See FUEL SYSTEM, Repair, Air flow sensor*
12. Remove air cleaner assembly. *See FUEL SYSTEM, Repair, Air cleaner*
13. Remove alternator. *See ELECTRICAL, Repair, alternator*
14. Release air conditioning compressor from its mounting and lay to one side. DO NOT discharge air conditioning system. *See AIR CONDITIONING, Repair, compressor*



**NOTE:** Release bolts securing compressor mounting bracket to engine and remove bracket to enable temporary lifting eye ETC 5964 to be fitted. Secure lifting eye to mounting bracket fixing points with suitable bolts of equivalent size, pitch and thread. Leave lifting eye attached until engine is reinstalled in vehicle.

15. Place drain tray underneath vehicle.
16. Disconnect hose from reservoir to power steering pump. Secure hose end above level of fluid reservoir to avoid unnecessary loss of fluid.
17. Disconnect power steering pump to power steering box hose. Seal hose and pump openings with masking tape to prevent ingress of dirt. Wipe away any fluid spillage from chassis or steering box.
18. Disconnect fuel temperature and coolant temperature sensor multi-plugs.
19. Disconnect leads from coil.
20. Identify each injector multi-plug for re-assembly and disconnect plugs from injectors.
21. Manoeuvre harness from behind fuel rails and place to one side clear of engine assembly.
22. Remove two clamps securing gearbox oil cooler pipes to engine block.
23. Remove engine mounting fixings on both sides of cylinder block.
24. Fit lifting chains to engine lifting eyes as shown in illustration RR1780E.



1. L/H Front chain 356 mm total overall length.
2. R/H Front chain 330 mm total overall length.
3. R/H Rear chain 457 mm total overall length.



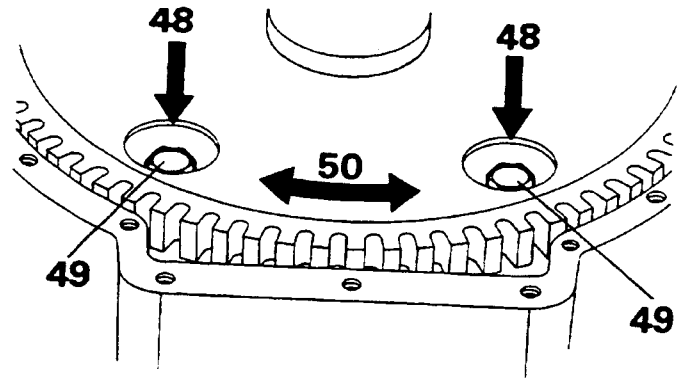
**NOTE:** All chain dimensions are measured from end of lifting hook to end of last link in chain.

4. Fit chain lifting eye to a suitable engine hoist. Raise hoist high enough to enable engine mountings to be removed, and withdraw rubber mountings.
5. Lower hoist until engine rests securely on engine mounting brackets. Remove lifting chains and hoist.
6. Disconnect two heater hoses located on top of right hand rocker cover.
7. Remove ground strap from rear of left hand cylinder head. **DO NOT** remove from retaining clip.
8. Remove all electrical harnesses from retaining clips at rear of engine.
9. Remove transmission breather pipes from retaining clip on rear lifting eye.
10. Remove top two bolts securing bell housing to cylinder block.
11. Raise front of vehicle, lower vehicle on to axle stands.
12. Remove bell housing bottom cover. Remove gasket from bell housing face.
13. Remove nuts securing exhaust downpipes to manifolds, remove heat shield from right hand side downpipe.
14. Remove electrical leads from starter motor solenoid. Disconnect multi-plug from oil level sensor on side of sump, if fitted.



**NOTE:** Instructions 37, 38 and 39 refer to automatic vehicles only.

15. With assistance rotate engine at crankshaft pulley until two access holes in drive plate/ring gear assembly are visible.
16. Remove two bolts visible through access holes. Mark one access hole and one bolt hole to ensure unit is reassembled in its original position
17. Rotate crankshaft 180° until two remaining access holes are visible, remove two bolts.



RR1808E

18. Remove remaining bell housing to cylinder block bolts.
19. Remove starter motor ground strap from chassis.
20. Remove stands and lower vehicle.
21. Position hydraulic trolley jack under bell housing to support gearbox when engine and gearbox are separated.
22. Fit lifting chains to engine. Carefully raise hoist a little, ease engine and gearbox apart, steady engine on hoist.
23. Ensure no components remain that will prevent engine being removed.
24. Slowly raise engine clear of engine compartment. Move engine away from vehicle and place on a suitable engine stand.

### Refit

25. Fit lifting chains to engine. Raise engine using hoist.
26. Lower engine into engine compartment. Ensure all components are clear of engine assembly.
27. Automatic vehicles: With assistance, manoeuvre engine until bottom two engine and bellhousing bolt holes align. Ensure that two cylinder block dowels locate in bell housing.  
Manual vehicles: Lower engine into position. Locate primary pinion into clutch. Engage bell housing dowels.
28. Fit two bolts and partially tighten.
29. Remove jack and lower hoist until engine rests securely on engine mounting brackets.
30. Fit top two bell housing securing bolts. Tighten to **40 Nm**.



31. Fit remaining bell housing to cylinder block bolts. Tighten to **40 Nm**.
32. Automatic vehicles: With assistance, rotate crankshaft pulley, line up marked holes in drive plate and torque converter. Fit two bolts. Tighten to **40 Nm**.
33. Rotate crankshaft 180° and fit remaining two bolts tighten to correct torque, **40 Nm**.
34. Fit new gasket and refit bottom cover, tighten bolts to **9 Nm**.
35. Fit new exhaust flange gaskets, fit exhaust to manifold.
36. Refit all harnesses, ground straps breather pipes and hoses at rear of engine.
37. Raise engine and refit engine mounting rubbers, tighten nuts to **20 Nm**.
38. Remove temporary lifting eye ETC 5964 and reverse instructions 1 to 23, ensuring that all electrical plugs and harnesses are fitted in correct locations.

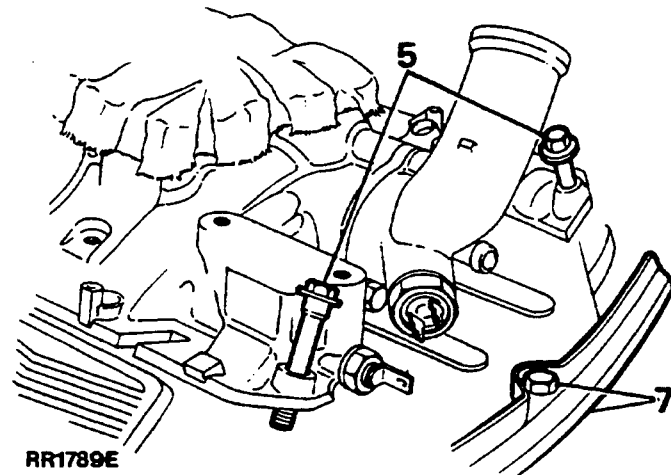
## ENGINE - DISMANTLE AND OVERHAUL

Service repair no - 12.41.02

Remove engine from vehicle. *See Engine removal*  
For safe and efficient working secure engine to an approved engine stand. Drain engine oil into a suitable container.

### Remove intake manifold

1. Release hose clamp at water pump
2. Detach retaining clips from top of injectors.
3. Remove four bolts securing fuel rail to manifold.
4. Withdraw fuel rail and injectors.

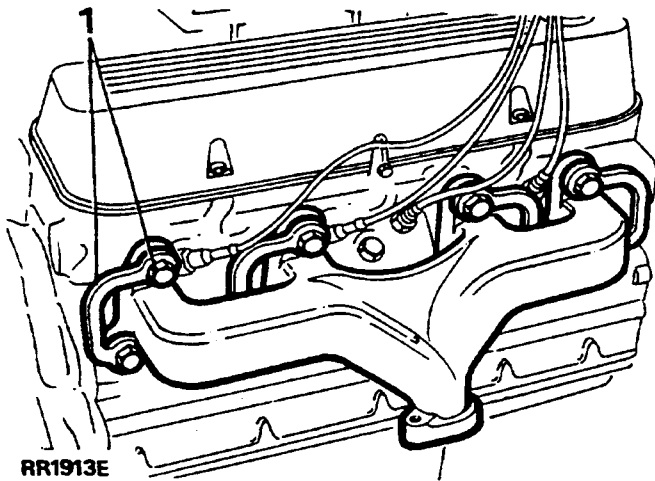


RR1789E

5. Evenly loosen and remove twelve bolts securing intake manifold to cylinder heads.
6. Lift intake manifold from cylinder heads.
7. Remove surplus coolant, remove gasket clamp bolts, remove clamps.
8. Lift off gasket and seals.

### Remove exhaust manifolds

1. Bend back lock tabs, remove eight bolts securing each manifold, and withdraw manifolds and gaskets.

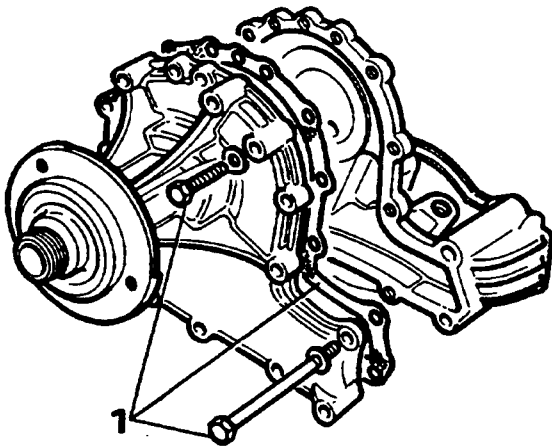


### Remove water pump

1. Remove fifteen bolts, pump and joint washer.



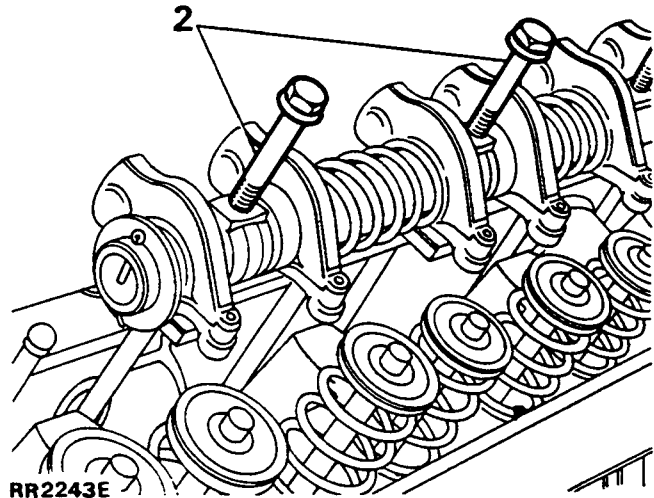
**NOTE:** The water pump is not serviceable. In event of failure, fit a new water pump assembly.



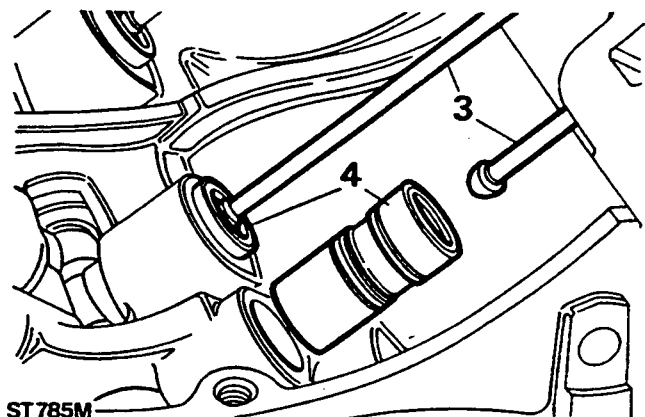
### REMOVE AND OVERHAUL ROCKER SHAFTS AND VALVE GEAR

Service repair no - 12. 29. 55.

1. Remove spark plug leads from spark plugs and retaining clips. Release four screws and lift off rocker covers.
2. Remove four rocker shaft retaining bolts and lift off assembly.



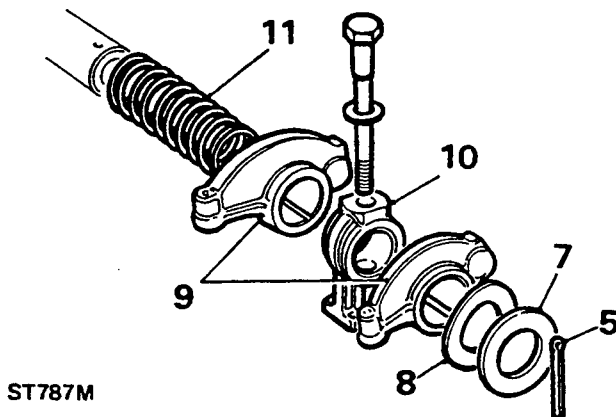
3. Withdraw pushrods and retain in sequence removed.
4. Remove hydraulic tappets. Retain with their respective pushrods. If a tappet cannot be removed leave in position until camshaft is removed.





### Dismantle rocker shafts

5. Remove split pin from one end of rocker shaft.
6. Withdraw following components and retain in correct sequence for re-assembly:
  7. A plain washer.
  8. A wave washer.
  9. Rocker arms.
  10. Brackets.
  11. Springs.
12. Examine each component for wear, in particular rockers and shafts. Discard weak or broken springs.

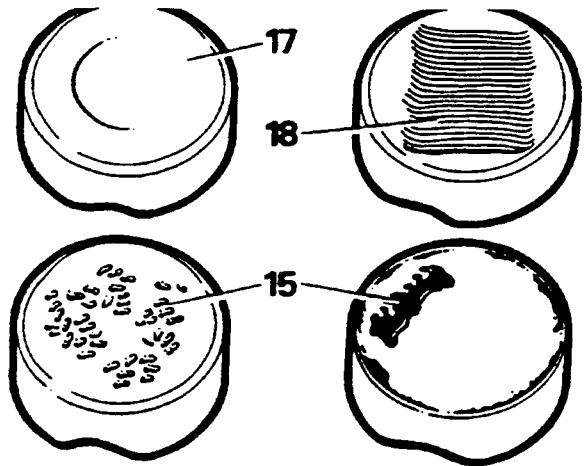


ST787M

### Inspect tappets and pushrods

13. Hydraulic tappet: inspect inner and outer surfaces of body for blow holes and scoring. Fit a new hydraulic tappet if body is roughly scored or grooved, or has a blow hole extending through wall in a position to permit oil leakage from lower chamber.
14. The prominent wear pattern just above lower end of body should not be considered a defect unless it is definitely grooved or scored. It is caused by side thrust of cam against body while tappet is moving vertically in its bore.
15. Inspect cam contact surface of tappets. Fit new tappets if surface is excessively worn or damaged.
16. A hydraulic tappet body that has been rotating will have a round wear pattern. A non-rotating tappet body will have a square wear pattern with a very slight depression near centre.

17. Tappets **MUST** rotate, a circular wear condition is normal. Tappets with this wear pattern can be refitted provided there are no other defects.
18. If a tappet is not rotating check camshaft lobes for wear. Fit new tappet ensuring it rotates freely in cylinder block.

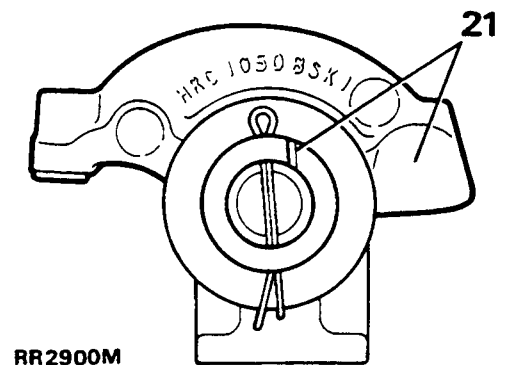


RR750M

19. Fit a new hydraulic tappet if area of pushrod contact is rough or damaged.
20. Fit a new pushrod if it is bent or has a rough or damaged ball end or seat.

### Assemble rocker shafts

21. Assemble rocker shafts with identification groove at one o'clock position with push rod end of rockers to the right.

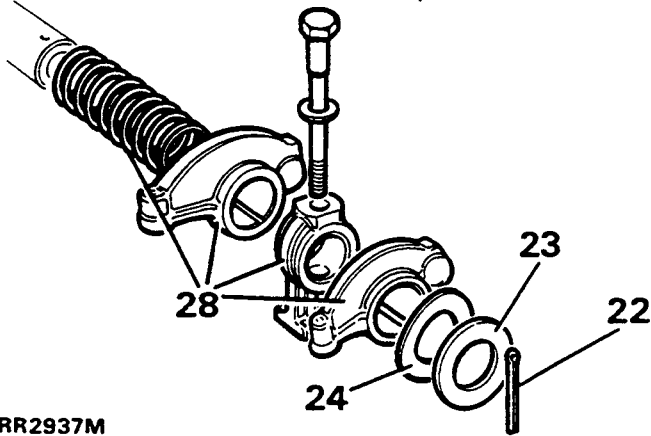


RR2900M



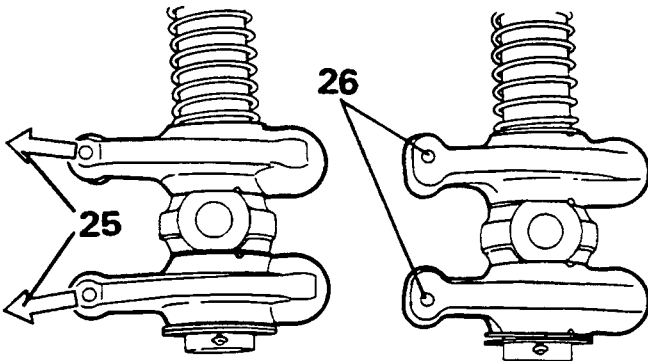
**CAUTION:** If incorrectly assembled shafts and rockers are fitted to engine, oil supply to rocker shafts will be restricted.

22. Fit new split pin to one end of rocker shaft.
23. Slide a plain washer over the long end of the shaft to contact the split pin.
24. Fit a wave washer to contact plain washer.



RR2937M

25. Early type rocker arms are angled. They must be fitted so that valve end of rocker arms angle away from each other as shown.
26. On later type rocker arms the valve end is offset and must be fitted as shown.
27. Early and late rocker arms are interchangeable provided complete set is changed.



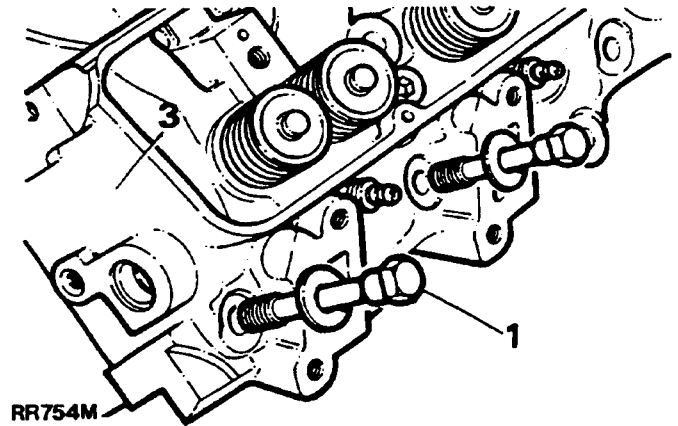
RR2899M

28. Assemble rocker arms, brackets and springs to rocker shaft.
29. Compress the springs, fit wave washer, plain washer and split pin to end of rocker shaft.
30. Fit locating bolts through brackets. Place assemblies to one side.

## REMOVE AND OVERHAUL CYLINDER HEADS

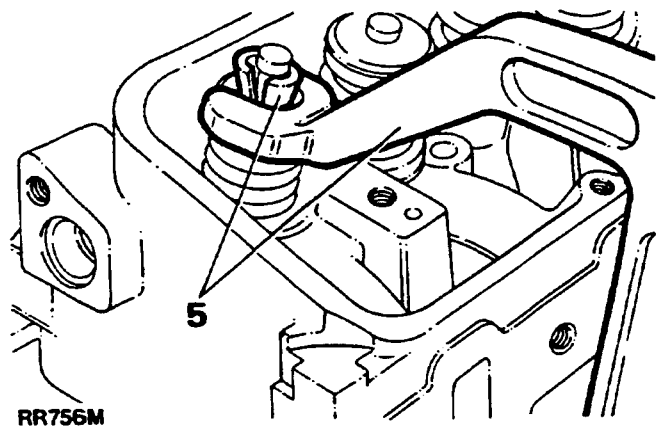
Service repair no - 12.29.05.

1. Evenly loosen fourteen cylinder head bolts, reversing tightening order.
2. Mark heads LH and RH for reassembly.
3. Lift off cylinder heads, discard gaskets.



## Dismantle cylinder heads

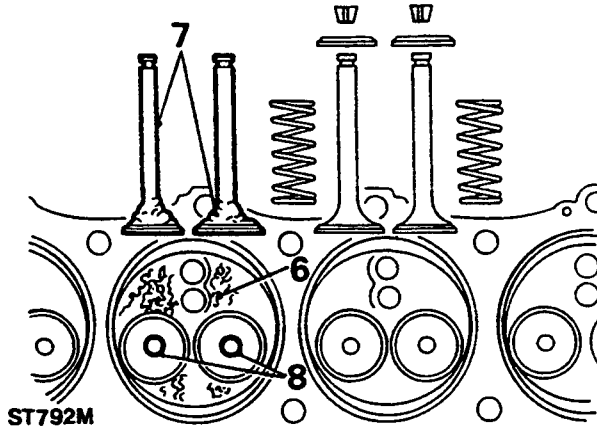
4. Remove spark plugs.
5. Using valve spring compressor 18G 106A or a suitable alternative, remove valves, springs, retain in sequence for refitting. Discard inlet valve stem seals.





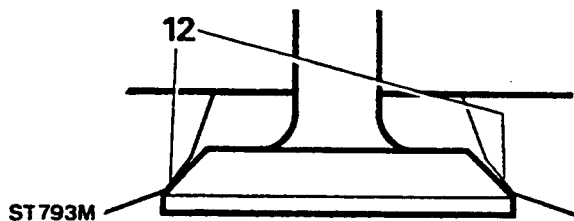
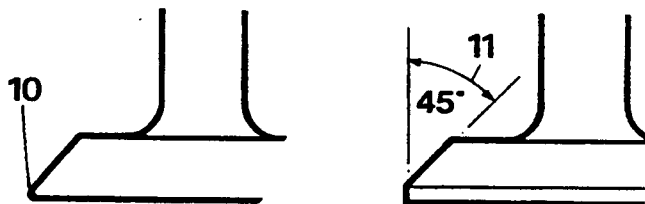


6. Clean combustion chambers using a soft wire brush.
7. Clean valves.
8. Clean valve guide bores.



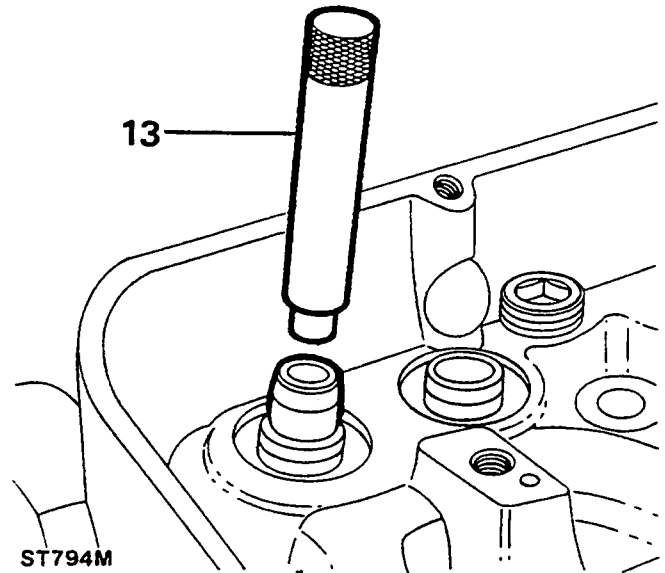
ST792M

9. Grind or fit new valves as necessary.
10. If a valve has to be ground to a knife-edge to obtain a true seat, fit a new valve.
11. Correct angle for valve seating face is  $45^\circ \pm 1/4$ .
12. Correct angle for seat is  $46^\circ \pm 1/4$  and seat witness towards outer edge.



ST793M

13. Check valve guides and fit replacements as necessary. Using valve guide remover 274401, drive out old guides from valve spring seat face of cylinder head.



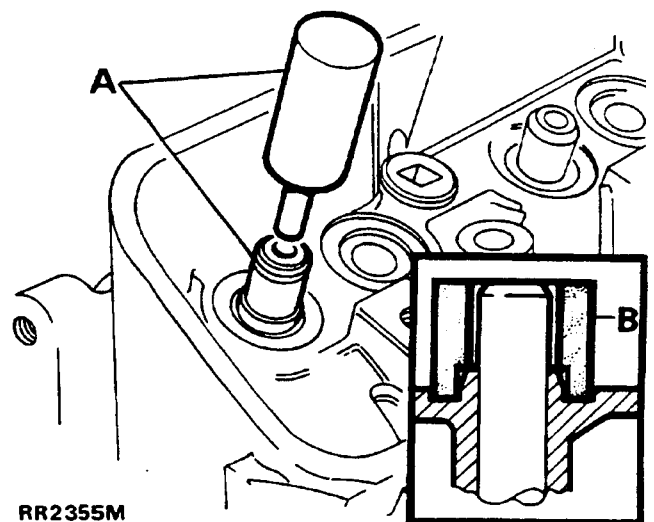
ST794M

#### Fit new valve guides



**NOTE:** Service valve guides are 0,025 mm larger on outside diameter than original equipment to ensure interference fit.


14. Lubricate new valve guide and place in position.
  - A. Using guide drift LRT-12-038 partially drive guide into cylinder head.
  - B. Remove drift LRT-12-038 and place distance piece LRT-12-515 over valve guide. Drift guide into head until distance piece contacts spring seat.
  - C. Alternatively drift guide into cylinder head until it protrudes 19 mm above valve spring recess in head.



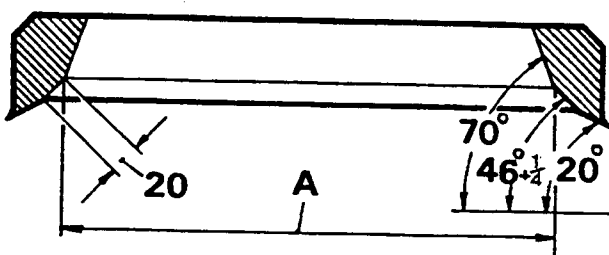
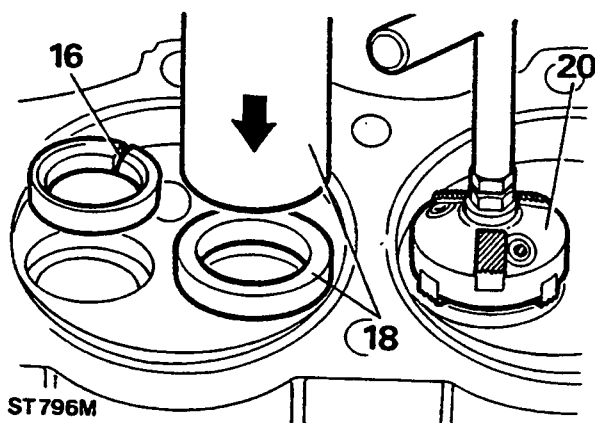
RR2355M

## Examine and fit new valve seats

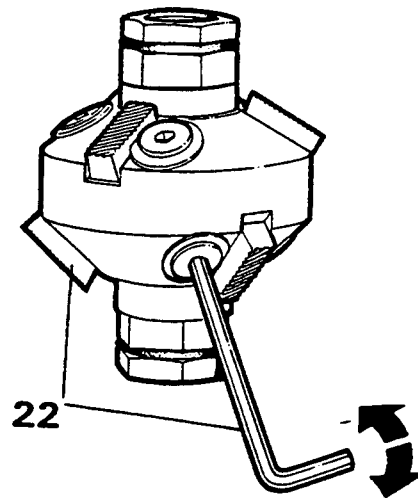
15. Check valve seats for wear, pits and burning. Fit new inserts if necessary.
16. Remove old seat inserts by grinding them until thin enough to be cracked and pried out.
17. Heat cylinder head evenly to approximately 65°C.
18. Press new insert into recess in cylinder head.

 **NOTE: Service valve seat inserts are available in two over-sizes 0.25 and 0.50 mm larger on outside diameter to ensure interference fit.**

19. Using service tool MS621 if necessary, cut valve seats to  $46^\circ \pm 1/4$ .
20. Nominal seat width is 1,5 mm. If seat exceeds 2,0 mm it should be reduced to the specified width by the use of 20° and 70° cutters.
21. The inlet valve seat diameter: 'A' is 37,03 mm and exhaust valve seat is 31,50 mm.



22. Ensure cutter blades are correctly fitted to cutter head with angled end of blade downwards, facing work, as illustrated. Check that cutter blades are adjusted so that middle of blade contacts area of material to be cut. Use key provided in hand set MS76. Use light pressure and remove only minimum material necessary.

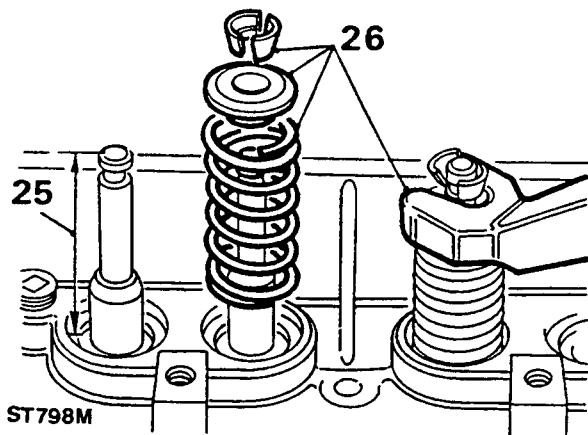


ST1024M

23. Coat valve seat with a small quantity of 'engineers' blue, revolve a properly ground valve against seat. A continuous fine line should appear round valve. If there is a gap of not more than 12 mm it can be corrected by lapping.
24. Alternatively, insert a strip of cellophane between valve and seat, hold valve down by stem, slowly pull out cellophane. If there is a drag, seal is satisfactory in that spot. Repeat in at least eight places. Lapping-in will correct a small open spot.

## Re-assemble valves to cylinder head

25. Before fitting valves and springs, check height of each valve above head. Measure height of stem above valve spring seat surface, holding head firmly against seat. This dimension must not exceed 47.63 mm. If necessary fit a new valve or grind end of valve stem.
26. Lubricate valve stems. Fit new inlet valve stem seals and springs. Fit caps, compress springs using LRT-12-034 and fit collets.



### Reclaiming cylinder head threads

Damaged or stripped threads in cylinder head can be salvaged by fitting Helicoils as follows:

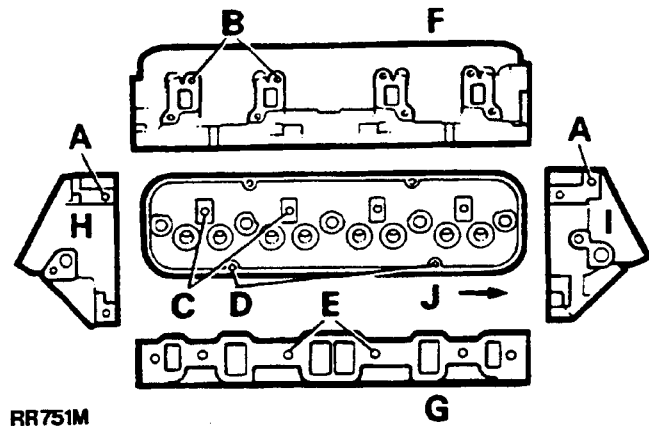
**Holes A** - These three holes may be drilled 0.3906 in dia. x 0.937 + 0.040 in deep. Tapped with Helicoil Tap No. 6 CPB or 6CS x 0.875 in (min) deep (3/8 UNC 1.5D insert).

**Holes B** - These eight holes may be drilled 0.3906 in dia. x 0.812 + 0.040 in deep. Tapped with Helicoil Tap No. 6 CBB 0.749 in (min) deep (3/8 UNC 1.5D insert).

**Holes C** - These four holes may be drilled 0.3906 in dia x 0.937 + 0.040 in deep. Tapped with Helicoil Tap No. 6 CPB or 6CS x 0.875 in (min) deep (3/8 UNC 1.5D insert).

**Holes D** - These four holes may be drilled 0.261 in dia x 0.675 + 0.040 in deep. Tapped with Helicoil Tap No. 4 CPB or 4CS x 0.625 in (min) deep (1/4 UNC 1.5D insert).

**Holes E** - These six holes may be drilled 0.3906 in dia x 0.937 + 0.040 in deep. Tapped with Helicoil Tap No. 6 CPB or 6CS x 0.875 in (min) deep (3/8 UNC 1.5D insert).



RR751M



**NOTE:** Right-hand cylinder head illustrated.

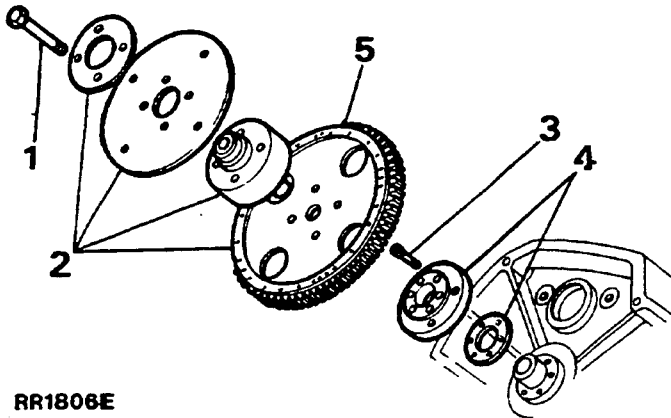
- F Exhaust manifold face
- G Intake manifold face
- H Front face
- I Rear face
- J Front of engine

## REMOVE FLEXIBLE DRIVE PLATE AND RING GEAR ASSEMBLY



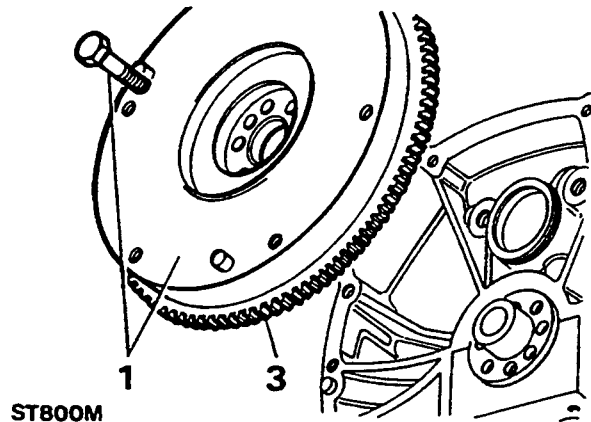
**NOTE:** Scribe each component with an identification line to enable re-assembly in original position.

1. Remove four retaining bolts.
2. Withdraw clamp ring, flexible drive plate, hub aligner and ring gear assembly.
3. Remove six socket head bolts securing crankshaft adaptor plate and shim to crankshaft flange.
4. Withdraw crankshaft adaptor plate and shim.
5. Inspect ring gear assembly for distortion, cracks, chipped or badly worn teeth. If ring gear is in poor condition fit a new assembly.

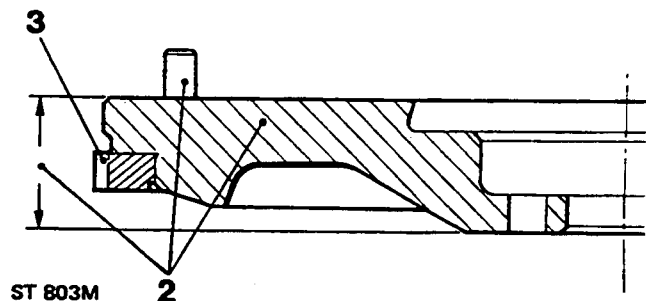


## REMOVE AND OVERHAUL FLYWHEEL - MANUAL GEARBOX MODELS ONLY

1. Remove retaining bolts and withdraw flywheel from crankshaft.



2. Examine flywheel clutch face for cracks, scores and overheating. The flywheel can be refaced provided minimum thickness does not go below 39.93 mm (1.572 in). Remove three dowels before machining.
3. Examine ring gear for worn, chipped and broken teeth. Renew as follows:

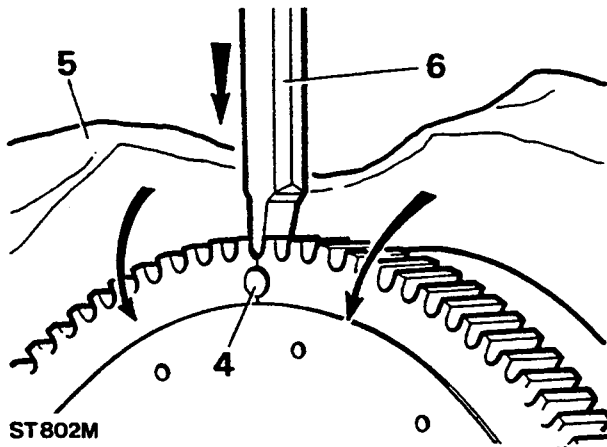


4. Drill a 10 mm diameter hole axially between roots of any tooth and inner diameter of starter ring sufficiently deep to weaken ring. DO NOT allow drill to enter flywheel.
5. Secure flywheel in a vice using soft jaws and place a cloth over flywheel to protect operator from flying fragments.

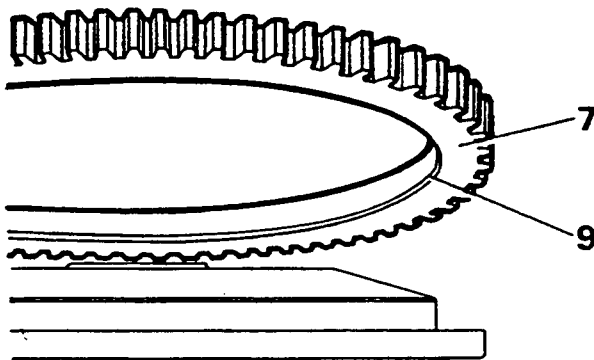


**WARNING:** Take adequate precautions against flying fragments when splitting ring gear.

- Place a chisel as shown, strike it sharply to split starter ring gear.



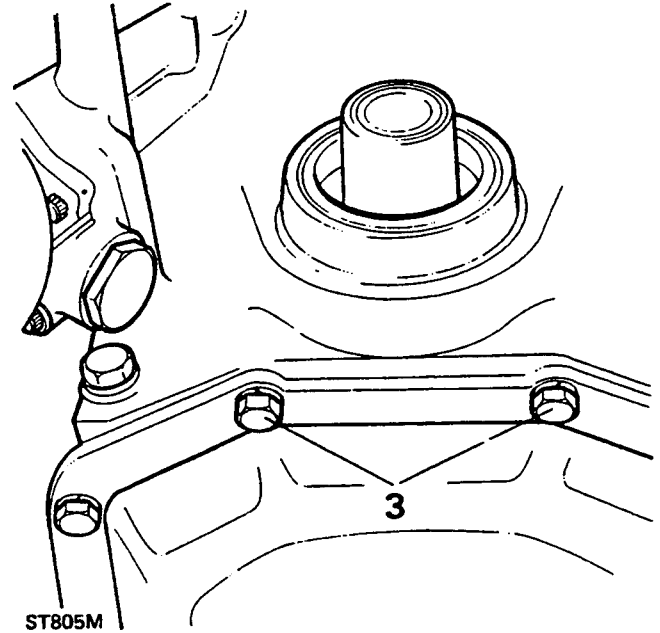
- Heat new ring gear uniformly to between 170°C and 175°C, DO NOT EXCEED higher temperature.
- Place flywheel, clutch side down, on flat surface.
- Locate heated starter ring gear in position on flywheel, with chamfered inner diameter towards flywheel flange. If starter ring gear is chamfered both sides, it can be fitted either way round.
- Press starter ring gear firmly against flange until ring contracts sufficiently to grip flywheel.
- Allow flywheel to cool gradually. DO NOT HASTEN cooling in any way, distortion may occur.
- Fit new clutch assembly location dowels to flywheel.



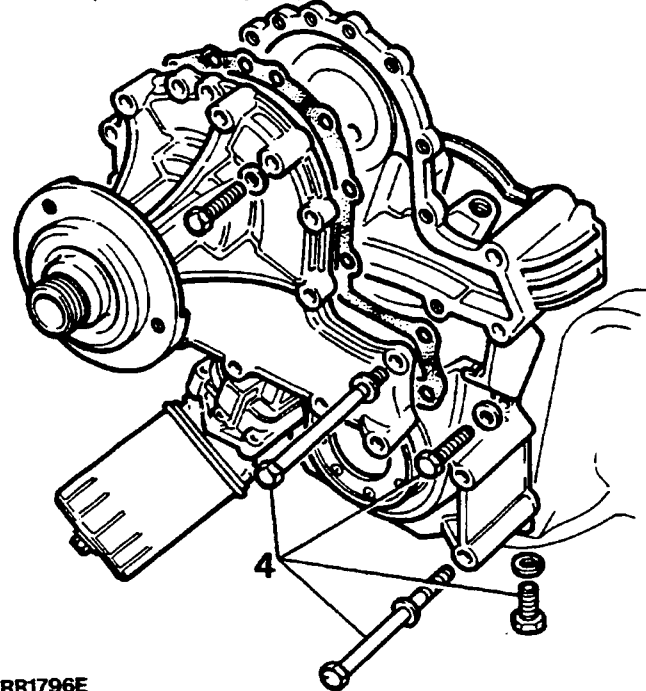
ST804M

## REMOVE TIMING GEAR COVER AND WATER PUMP

- Place an oil drip-tray beneath timing cover, remove oil filter element.
- Remove crankshaft pulley bolt and special washer, withdraw pulley.



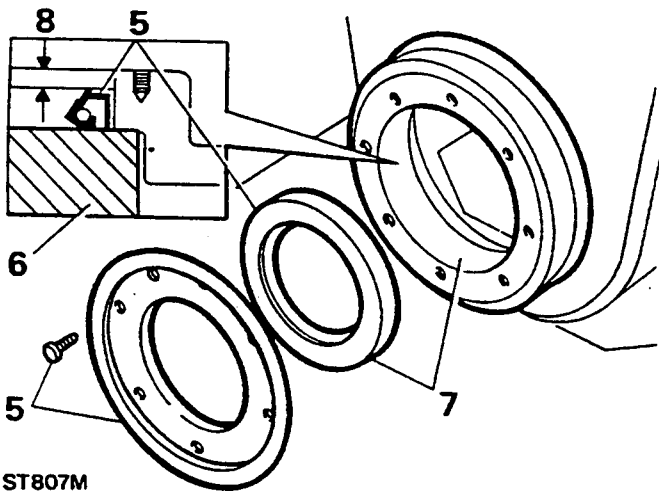
- Remove two bolts securing sump to bottom of timing cover.
- Remove timing cover bolts and withdraw cover complete with oil pump.



RR1796E

## Fit new timing cover oil seal

5. Remove seven drive screws and withdraw mud shield and oil seal.
6. Position gear cover with front face uppermost and underside supported across oil seal housing bore on a suitable wooden block.
7. Enter oil seal, lip side leading, into housing bore.
8. Press in oil seal until plain face is approximately 1,5 mm below gear cover face.
9. Fit mud shield and securing screws.



## DISTRIBUTOR REMOVE

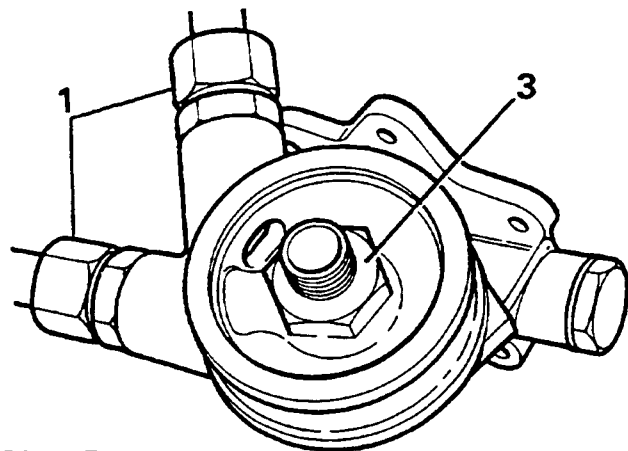
1. Release single nut securing distributor clamp.
2. Remove clamp, withdraw distributor.
3. If necessary overhaul distributor. See *ELECTRICAL, Overhaul, Distributor-Lucas 35DLM8*

## REMOVE ENGINE OIL COOLER ADAPTOR PLATE

1. Remove both oil cooler pipes.
2. Mark position of adaptor plate/oil pump cover.
3. Remove centre fixing and withdraw adaptor plate.

## Refit

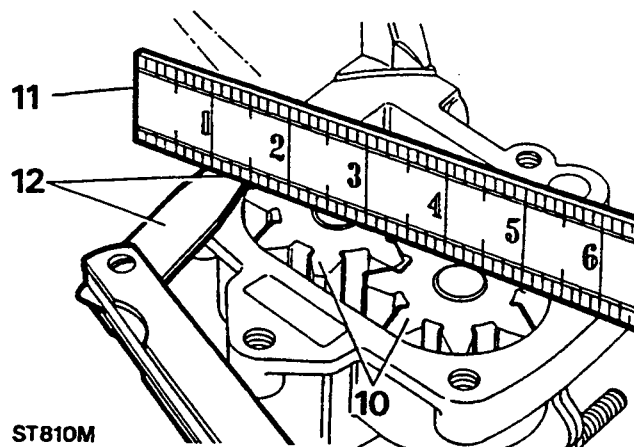
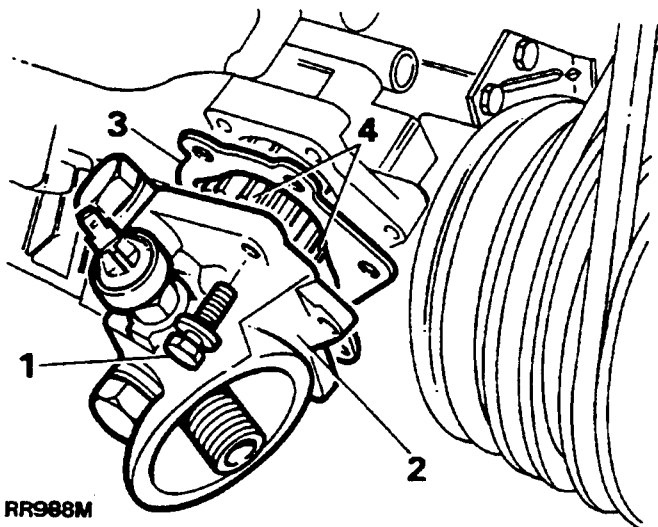
4. Reverse the removal procedure, lining up the location marks to ensure pipe runs are correct. Ensure the pipes and centre fixing are tightened to the specified torque. See *Specifications, torque, Torque values*





## REMOVE AND OVERHAUL OIL PUMP

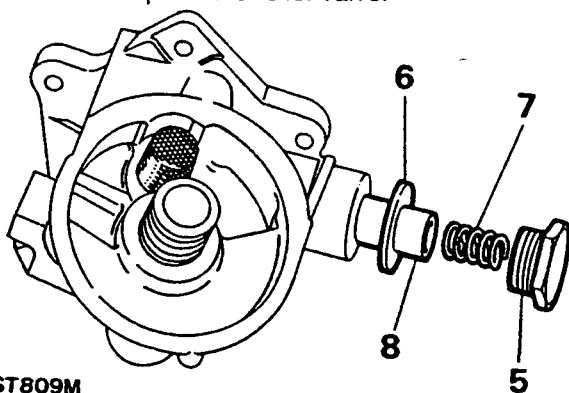
1. Remove bolts from oil pump cover.
2. Withdraw oil pump cover.
3. Lift off cover and remove gasket.
4. Withdraw oil pump gears.



13. Check oil pressure relief valve for wear/scoring.
14. Check sides of relief valve spring for wear or signs of collapse.
15. Clean wire screen filter for relief valve.
16. Check relief valve is an easy slide fit with no perceptible side movement in its bore.

### Dismantle pump

5. Unscrew plug from pressure relief valve.
6. Remove sealing washer from plug.
7. Withdraw spring from relief valve.
8. Withdraw pressure relief valve.



### Assemble pump

17. Insert relief valve spring.
18. Locate sealing washer on relief valve plug.
19. Fit relief valve plug. Tighten to **40 - 47 Nm**.
20. Fully pack oil pump gear housing with Petroleum Jelly. No other grease is suitable.
21. Fit oil pump gears ensuring that Petroleum Jelly is forced into every cavity between teeth of gears.

**IMPORTANT: Unless pump is fully packed with Petroleum Jelly it may not prime itself when engine is started.**

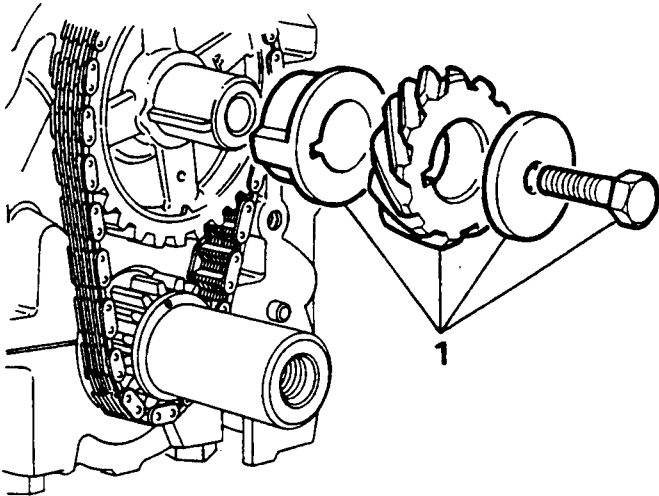
22. Place new gasket on oil pump cover.
23. Locate oil pump cover in position.
24. Fit special fixing bolts. Tighten to **13 Nm**.

### Examine pump

9. Check oil pump gears for wear/scoring.
10. Fit oil pump gears and shaft into front cover.
11. Place a straight edge across gears.
12. Check clearance between straight edge and front cover. If less than 0.05 mm, check front cover gear recess for wear.

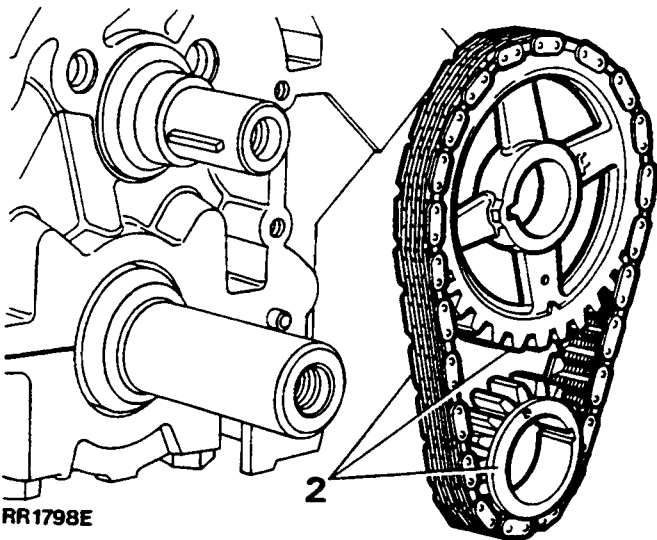
**REMOVE TIMING CHAIN SPROCKET AND CAMSHAFT**

1. Remove retaining bolt and washer. Withdraw distributor drive gear and spacer.



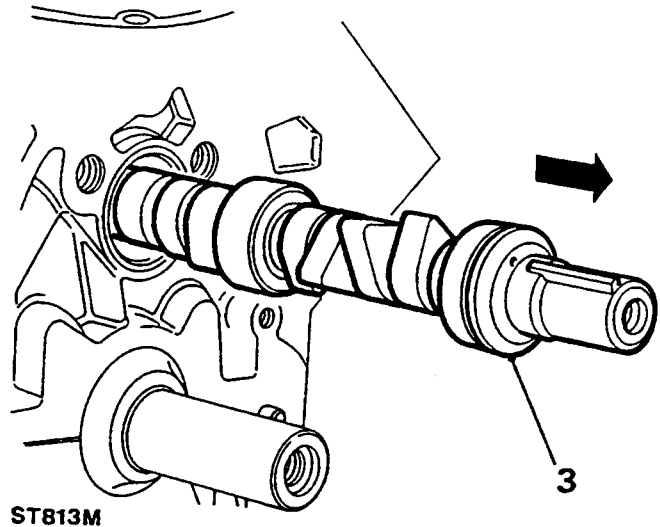
RR1797E

2. Withdraw sprocket complete with timing chain.



RR1798E

3. Withdraw camshaft, taking particular care not to damage bearings in cylinder block.



**Examine components**

4. Visually examine all parts for wear. Fit a new camshaft if bearing journals and cams show signs of wear, pits, scores and overheating.
5. Examine links and pins of timing chain for wear. Compare its condition with a new chain. Inspect teeth of sprockets, if necessary fit a new sprocket.
6. Measure camshaft journals for overall wear, ovality and taper. Diameters of journals are as follows, from front of shaft:

- Number 1 journal 45,4 to 45,3 mm
- Number 2 journal 44,6 to 44,5 mm
- Number 3 journal 43,84 to 43,81 mm
- Number 4 journal 43,07 to 43,05 mm
- Number 5 journal 42,31 to 42,29 mm

7. To check camshaft for straightness rest two end journals i.e. numbers 1 and 5 on 'V' blocks and mount a dial gauge on centre journal. Rotate shaft and note reading. If run out is more than 0,05 mm fit a new camshaft.

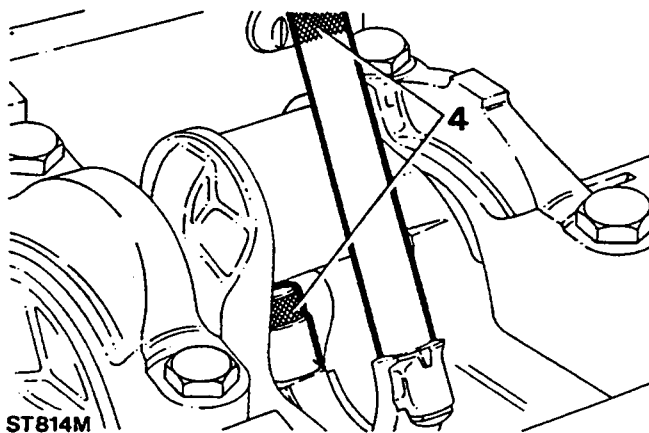




## REMOVE AND OVERHAUL CONNECTING RODS AND PISTONS

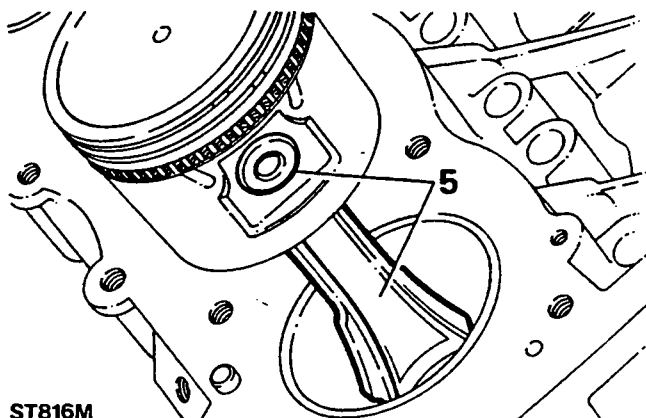
### Remove

1. Withdraw retaining bolts and remove sump.
2. Remove sump oil strainer.
3. Remove connecting rod caps, retain in sequence for reassembly.
4. Screw guide bolts LRT-12-041 onto connecting rods.



ST814M

5. Push connecting rod and piston assembly up cylinder bore, withdraw it from top. Retain connecting rod and piston assemblies in sequence with respective caps.
6. Remove guide bolts LRT-12-041 from connecting rod.



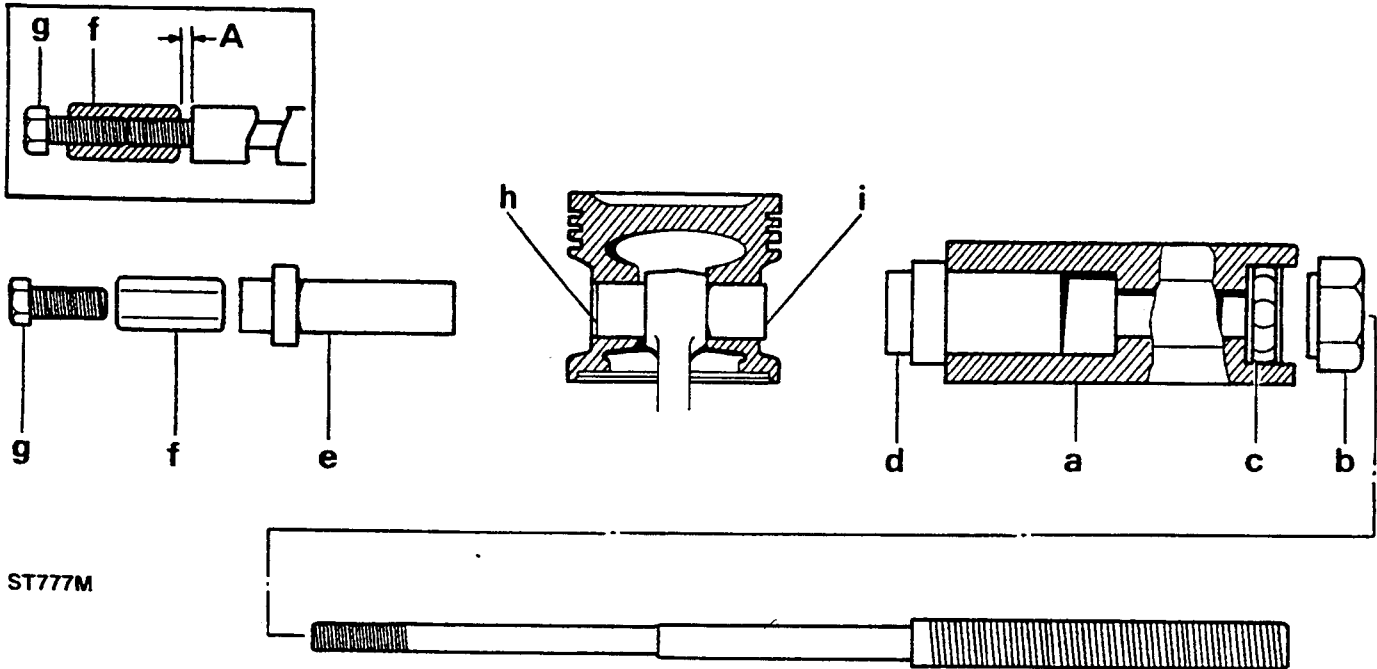
ST816M

### Overhaul



**NOTE:** Retain connecting rods, caps and bearing shells in sets, in correct sequence. Remove piston rings over crown of piston. If same piston is to be refitted, mark it relative to its connecting rod to ensure that original assembly is maintained.

7. Withdraw piston pin, using tool LRT-12-013:
  - a. Clamp hexagon body of LRT-12-013 in vice.
  - b. Position large nut flush with end of centre screw.
  - c. Push screw forward until nut contacts thrust race.
  - d. Locate piston adaptor LRT-12-013 with its long spigot inside bore of hexagon body.
  - e. Fit remover/replacer bush of LRT-12-013 on centre screw with flanged end away from piston pin.
  - f. Screw stop-nut about half-way onto smaller threaded end of centre screw, leaving a gap 'A' of 3 mm (1/8 in) between nut and remover/replacer bush.
  - g. Lock stop-nut securely with lock screw.
  - h. Check that remover/replacer bush is correctly positioned in bore of piston.
  - i. Push connecting-rod to right to expose end of piston pin, which must be located in end of adaptor 'd'.
  - j. Screw large nut up to thrust race.
  - k. Hold lock screw and turn large nut until piston pin has been withdrawn from piston. Dismantle tool.



### Original pistons

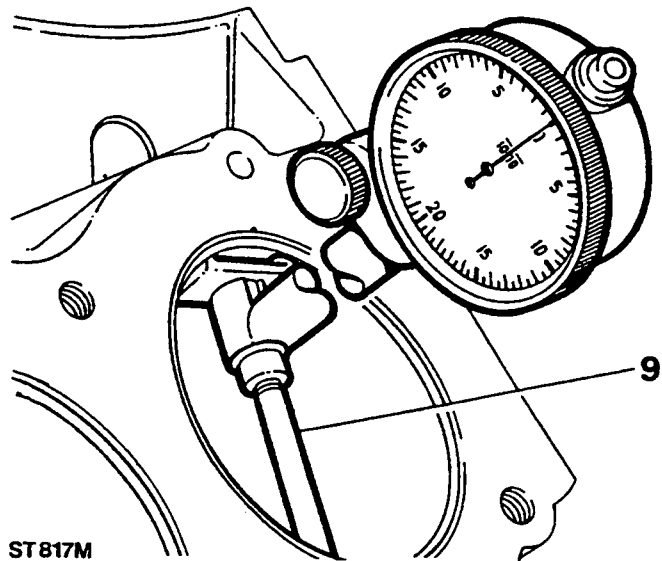
8. Remove carbon deposits, particularly from ring grooves. Examine pistons for signs of damage or excessive wear, refer to 'new pistons' for method of checking running clearance. Fit new pistons if necessary.

### New pistons

NOTE: Pistons are available in service standard size and in oversizes of 0,25 mm (0.010 in) and 0,50 mm (0.020 in). Service standard size pistons are supplied 0,0254 mm (0.001 in) oversize. When fitting new service standard size pistons to a cylinder block, check for correct piston to bore clearance, honing the bore if necessary. Bottom of piston skirt-bore clearance should be 0,018 to 0,040 mm (0.0007 to 0.0016 in).

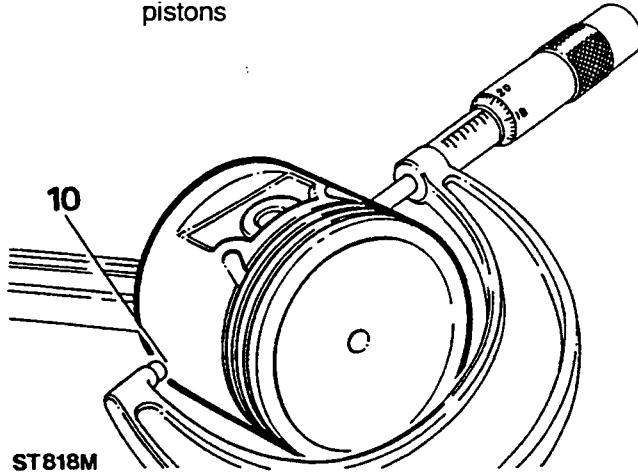
NOTE: Piston and cylinder block temperature must be same to ensure accurate measurement. When reboring cylinder block, crankshaft main bearing caps must be fitted and tightened to 70 Nm.

9. Check cylinder bore dimension at right angles to piston pin 40 to 50 mm from top.





10. Check piston dimension at right angles to piston pin:
  - a) At bottom of skirt on 3.5 litre pistons
  - b) 62 mm from top of piston on 3.9 litre pistons
  - c) 58 mm from top of piston on 4.2 litre pistons

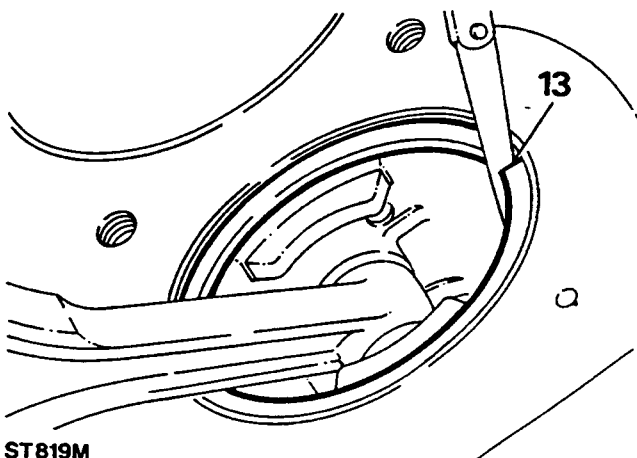


ST818M

11. The piston dimension must be 0.018 to 0.033 mm smaller than cylinder.
12. If new piston rings are to be fitted without reboring, deglaze cylinder walls with a hone without increasing bore diameter, to provide a cross-hatch finish. After honing, thoroughly clean piston bores to remove all traces of foreign matter.
13. Check compression ring in applicable cylinder, held square to bore with piston. Gap limits: 0.44 to 0.56 mm. Use a fine-cut flat file to increase gap if required. Select a new piston ring if gap exceeds limit.

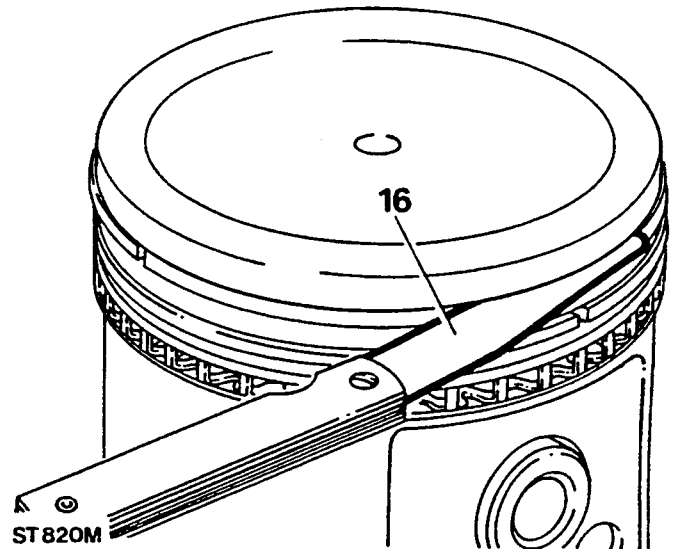


**NOTE:** Gapping does not apply to oil control rings.



ST819M

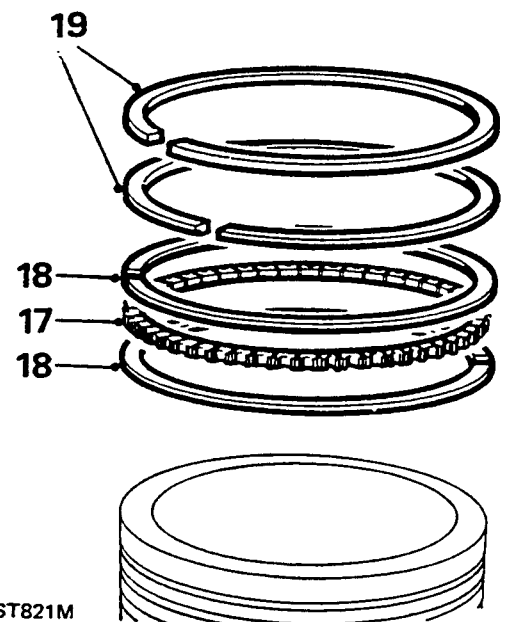
14. Temporarily fit compression rings to piston.
15. The ring marked 'TOP' must be fitted with marking uppermost into second groove. The chrome ring fits top groove and can be fitted either way round.
16. Check compression ring clearance in piston groove. Clearance limits: 0.05 to 0.10 mm.



ST820M

#### Fit piston rings

17. Fit expander ring into bottom groove making sure that ends butt and do not overlap.
18. Fit two ring rails to bottom groove, one above and one below expander ring.
19. Fit second compression ring with marking 'TOP' uppermost. Fit chrome ring into top groove, either way round.




ST821M

## Examine connecting rods

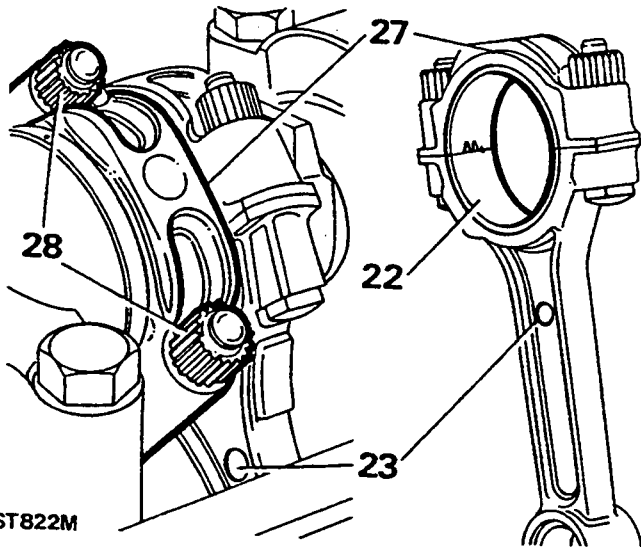
20. Check alignment of connecting rod.
21. Check connecting rod small end, piston pin must be a press fit.

## Check crankshaft bearings


22. Locate bearing upper shell into the connecting rod.
23. Locate connecting rod and bearing onto its crankshaft journal.

 **NOTE: Domed shape boss on connecting rod must face towards front of engine on right hand bank of cylinders and towards rear on left hand bank.**

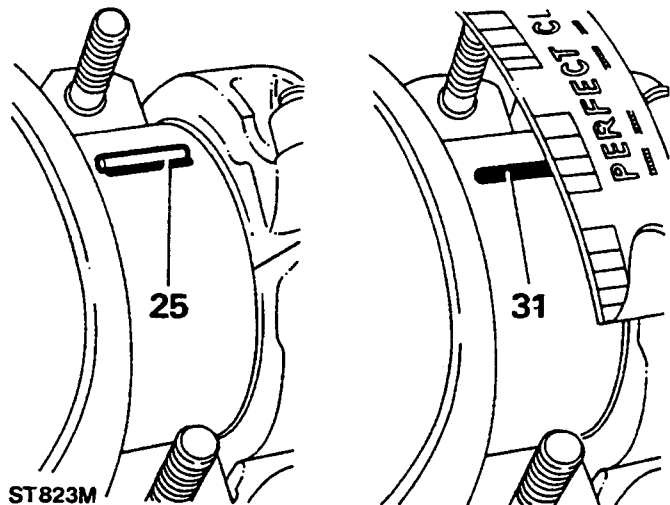
24. When both connecting rods are fitted, bosses will face inwards towards each other.



25. Place a piece of Plastigauge (P61) across centre of lower half of crankshaft journal.
26. Locate bearing lower shell into connecting rod cap.
27. Locate cap and shell onto connecting rod.

 **NOTE: Note that rib on edge of cap must be on same side as domed shape boss on connecting rod.**

28. Secure connecting rod cap. Tighten to **50 Nm**.
29. Do not rotate crankshaft while Plastigauge is in use.



30. Remove connecting rod cap and shell.
31. Using scale printed on Plastigauge packet, measure flattened Plastigauge at its widest point.
32. The graduation most closely corresponding to width of Plastigauge indicates bearing clearance.
33. Correct bearing clearance with new or overhauled components is 0.015 to 0.055 mm.
34. If a bearing has been in service, fit a new bearing if clearance exceeds 0.08 mm.
35. If a new bearing is being fitted, use selective assembly to obtain correct clearance.
36. Wipe off Plastigauge with an oily rag. **DO NOT** scrape it off.

 **NOTE: It is important that connecting rods, caps and bearing shells be retained in sets, and in correct sequence.**

## Assembling pistons to connecting rods

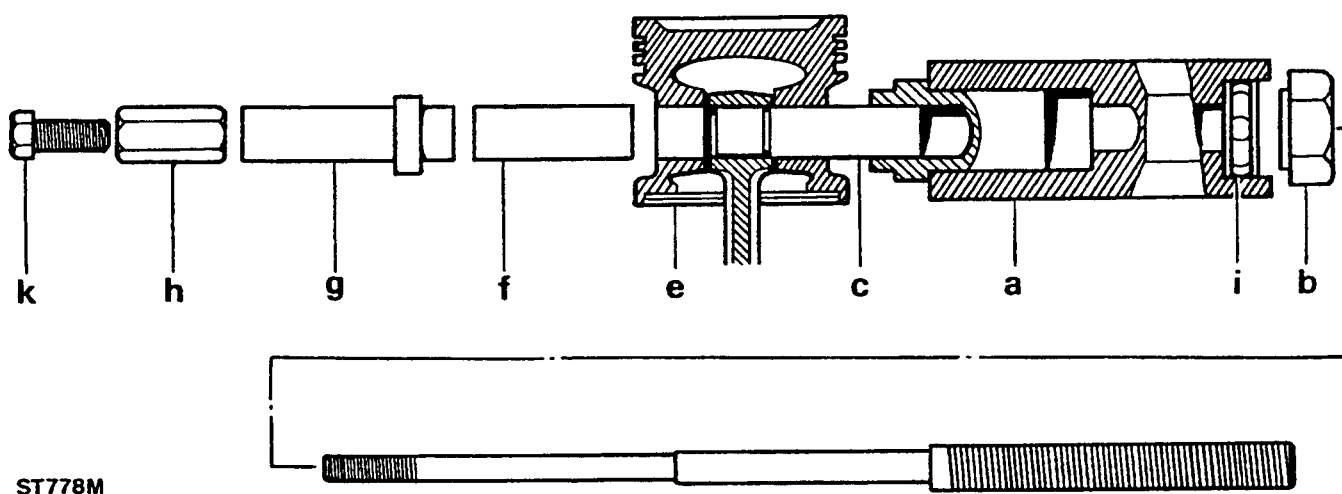
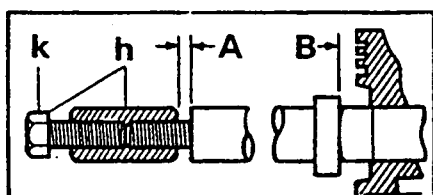
37. Using tool LRT-12-013 refit each piston to its connecting rod as follows:
  - a. Clamp hexagon body of LRT-12-013 in a vice, with adaptor LRT-12-014 positioned as instruction 7d.
  - b. Remove large nut of LRT-12-013 and push the centre screw approximately 50 mm into body until shoulder is exposed.
  - c. Slide parallel guide sleeve, grooved end last, onto centre screw and up to shoulder.



- d. Lubricate piston pin and bores of connecting rod and piston with graphited oil (Molykote 2). Also lubricate ball race and centre screw of LRT-12-013.
- e. Fit connecting rod and piston together onto tool, with markings aligned if fitting original pair, with connecting rod around sleeve up to groove.
- f. Fit piston pin into piston bore, up to connecting rod.
- g. Fit remover/replacer bush LRT-12-015 with its flanged end towards piston pin.
- h. Screw stop nut onto centre screw and adjust nut to obtain an 0.8 mm end float 'A' on whole assembly, and lock nut securely with screw.
- i. Slide assembly back into hexagon body and screw large nut up to thrust race.
- j. Set a torque spanner to **16 Nm**. This represents minimum load for an acceptable interference fit of piston pin in connecting rod.
- k. Using torque spanner and socket on large nut, and holding lock screw, pull piston pin in until flange of remover/replacer bush is 4 mm 'B' from face of piston. This flange must not be allowed to contact piston.



**CAUTION:** If torque spanner has not reached at least 16 Nm. throughout pull, fit of piston pin to connecting rod is not acceptable and necessitates fitting new components. The large nut and centre screw of tool must be kept well oiled.



38. Remove tool and check that piston moves freely on piston pin and that no damage has occurred during pressing.

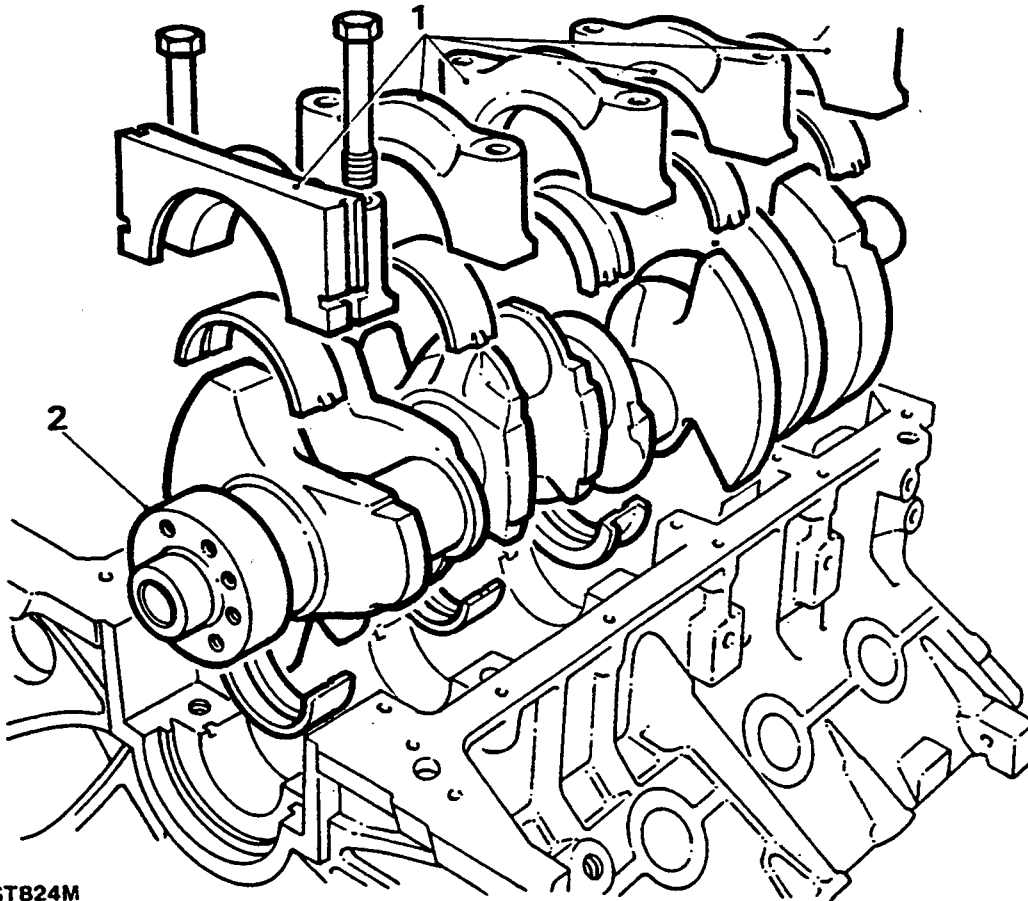
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**REMOVE AND OVERHAUL CRANKSHAFT**

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**Remove**

1. Remove main bearing caps and lower bearing shells. Retain in pairs and mark with number of journal until it is decided if bearing shells are to be refitted.
2. Lift out crankshaft and rear oil seal.

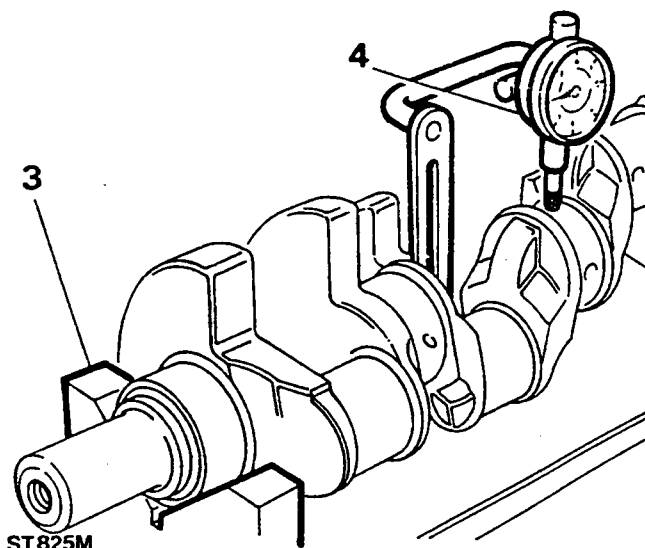


ST824M



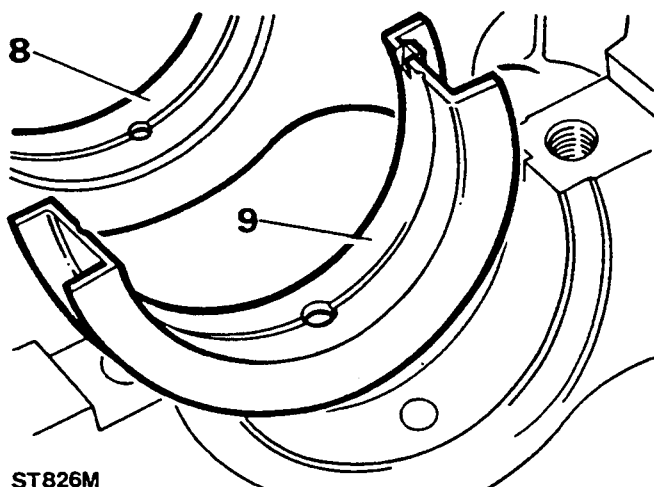
### Inspect and overhaul crankshaft

3. To check for straightness, place crankshaft on vee-blocks at numbers one and five main bearing journals.
4. Using a dial indicator, check run-out at centre main bearing journal.



ST825M

5. Total run-out at each journal should not exceed 0.08 mm.
6. If crankshaft is bent it is not suitable for regrinding and should be renewed.
7. Check each crankshaft journal for ovality. If ovality exceeds 0.040 mm around crankshaft journal, regrind or fit a new crankshaft.
8. Crankshaft main and connecting rod bearings are available in following undersizes:  
0.25mm  
0.50mm



ST826M

9. The centre main bearing shell, which controls crankshaft thrust, has thrust faces increased in thickness when more than 0.25 mm undersize, as shown in following chart.
10. When a crankshaft is to be reground, thrust faces on either side of centre main journal must be machined in accordance with dimensions in charts that follow:

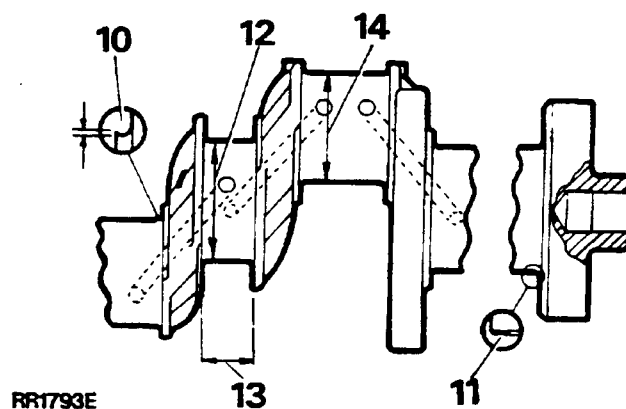
Main bearing journal size Thrust face width

Main bearing journal size	Thrust face width
Standard	Standard
0.25 mm undersize	Standard
0.50 mm undersize	0.25 mm oversize

11. For example: If fitting a 0.50 mm undersize bearing, 0.125 mm must be machined off each thrust face of centre journal, maintaining correct radius.

### Crankshaft dimensions

12. Radius for all journals except rear main bearing is 1.90 to 2.28 mm.
13. Radius for rear main bearing journal is 3.04 mm.
14. Main bearing journal diameter, see following chart.
15. Thrust face width, and connecting rod journal diameter, see following chart.



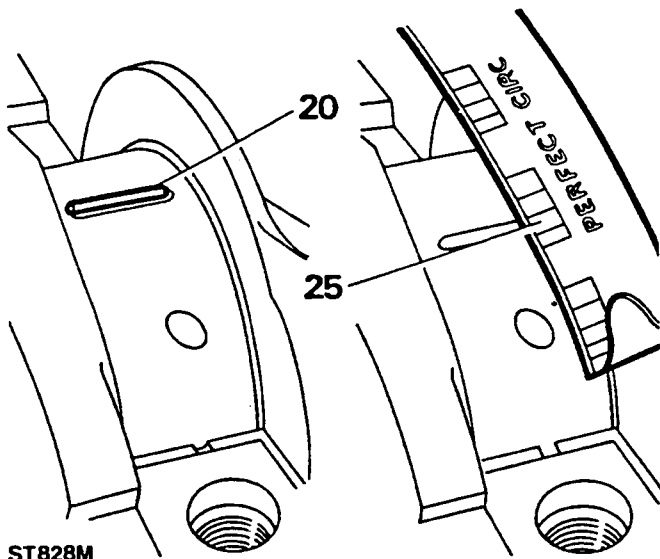
RR1793E

## Crankshaft dimensions-millimetre

Crankshaft Grade	Diameter '12'	Width '13'	Diameter '14'
Standard	58.400-58.412	26.975-27.026	50.800-50.812
0.254 U/S	58.146-58.158	26.975-27.026	50.546-50.558
0.508 U/S	57.892-57.904	27.229-27.280	50.292-50.304

## Check main bearing clearance

16. Remove oil seals from cylinder block and rear main bearing cap.
17. Locate upper main bearing shells (with oil hole and oil grooves) into cylinder block.
18. Locate flanged upper centre main bearing shell.
19. Place crankshaft in position on bearings.
20. Place a piece of Plastigauge across centre of crankshaft main bearing journals.
21. Locate lower shells into main bearing caps.
22. Fit numbers one to four main bearing caps and shells. Tighten to **70 Nm**.
23. Fit rear main bearing cap and shell. Tighten to **90 Nm**. Do not allow crankshaft to rotate while Plastigauge is in use.
24. Remove main bearing caps and shells.
25. Using scale printed on Plastigauge packet, measure flattened Plastigauge at widest point.
26. Graduation most closely corresponding to width of Plastigauge indicates bearing clearance.
27. Correct bearing clearance with new or overhauled components is 0.023 to 0.065 mm.
28. If correct clearance is not obtained initially, select a suitable bearing to give required clearance.
29. Wipe off Plastigauge with an oily rag. Do NOT scrape it off.
30. Maintain bearing shells and caps in sets, in the correct sequence.



ST828M

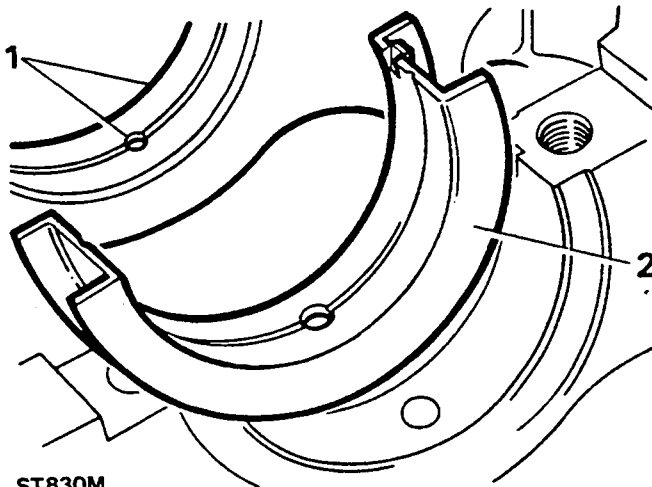




## ASSEMBLING ENGINE

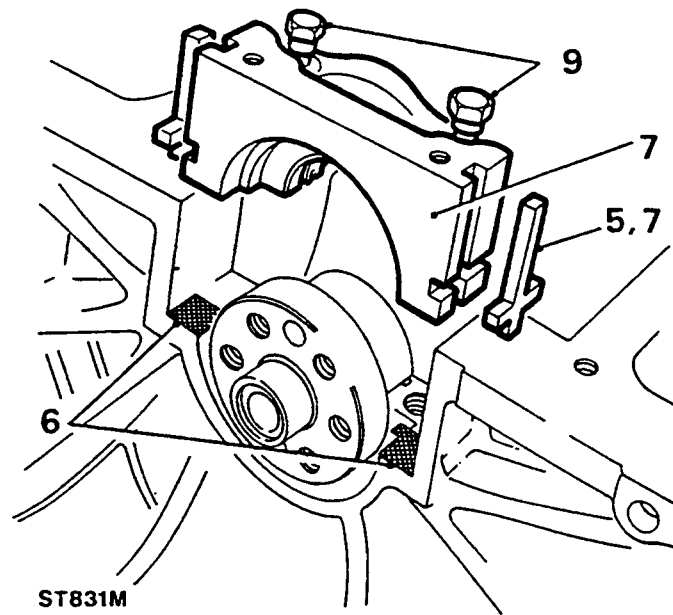
### FIT CRANKSHAFT AND MAIN BEARINGS

1. Locate upper main bearing shells (with oil holes and grooves) in cylinder block.
2. Locate the flanged upper centre main bearing shell.
3. Lubricate crankshaft main bearing journals and bearing shells with clean engine oil and lower crankshaft into position.



ST830M

4. Lubricate lower main bearing shells and fit numbers one to four main bearing caps and shells only, leave the fixing bolts finger-tight.
5. Fit cross shaped side seals to grooves each side of rear main bearing cap. Do not cut side seals, they must protrude 1.5 mm approximately above bearing cap parting face.
6. Apply Hylomar SQ32M jointing compound to rearmost half of rear main bearing cap parting face or, if preferred, to equivalent area on cylinder block as illustrated.
7. Lubricate bearing half and bearing cap side seals with clean engine oil.
8. Carefully fit bearing cap assembly.
9. Do not tighten fixings, but ensure that cap is fully home and squarely seated on cylinder block.



ST831M



**CAUTION:** Do not handle oil seal lip, check it is not damaged and ensure that outside diameter remains clean and dry.

10. Position seal guide LRT-12-010 on crankshaft flange.
11. Ensure that oil seal guide and crankshaft journal are scrupulously clean. Coat seal guide and oil seal journal with clean engine oil.

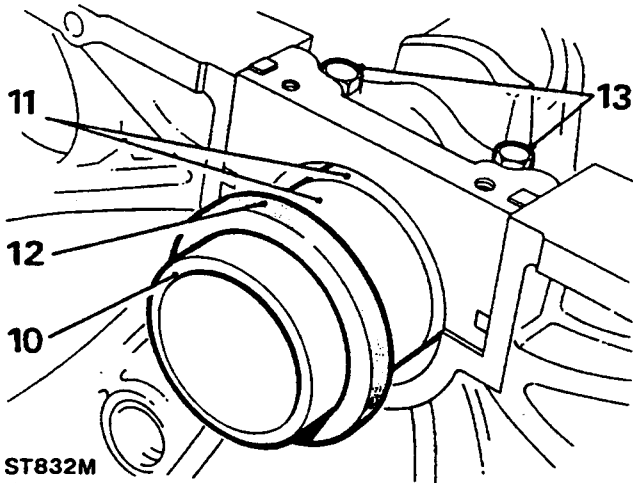


**NOTE:** Lubricant coating must cover seal guide outer surface completely to ensure that oil seal lip is not turned back during assembly.

Position oil seal, lipped side towards the engine, on to seal guide. Seal outside diameter must be clean and dry.

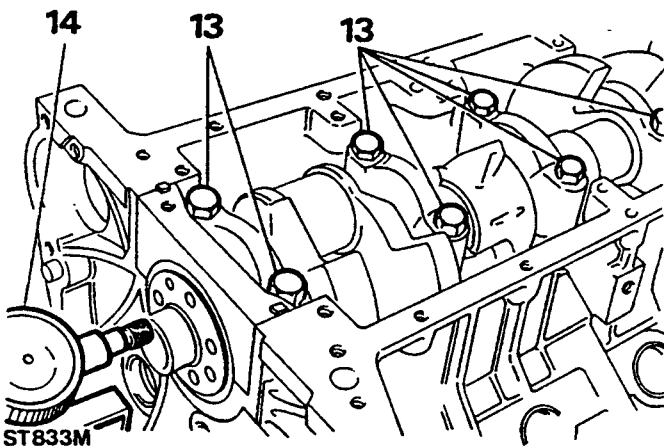
12. Push oil seal fully and squarely by hand into recess formed in cap and block until it contacts machined step in recess. Withdraw seal guide.

## FIT CONNECTING RODS AND PISTONS



ST832M

13. Tighten cap bolts to correct torque, numbers one to four bearings **70 Nm**, rear main bearing **90 Nm**.
14. Check crankshaft end-float, 0.10 to 0.20 mm.

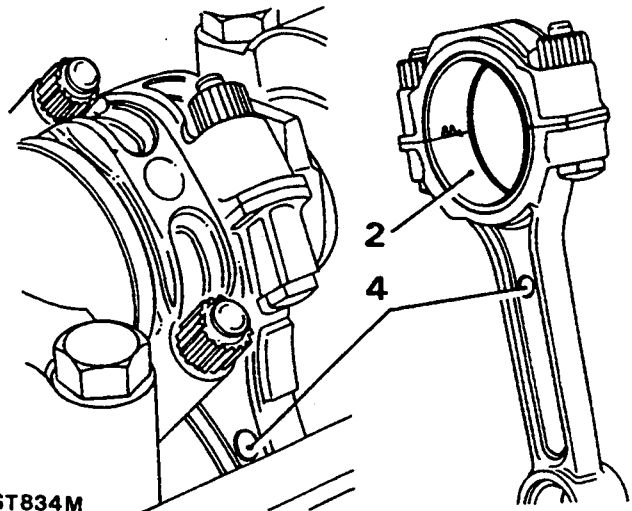


ST833M



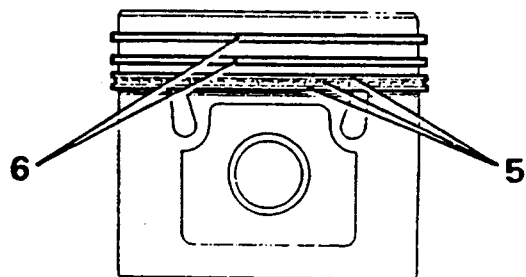
**CAUTION:** Do not exceed 1,000 engine rev/min for 15 seconds when first starting engine, otherwise crankshaft rear oil seal will be damaged.

1. Locate applicable crankshaft journal at B.D.C.
2. Place bearing upper shell in connecting rod.
3. Retain upper shell by screwing guide bolts 605351 onto connecting rods.
4. Insert connecting rod and piston assembly into respective bore, noting that domed shape boss on connecting rod must face towards front of engine on right hand bank of cylinders and towards rear on left hand bank. When both connecting rods are fitted, bosses will face inwards towards each other.



ST834M

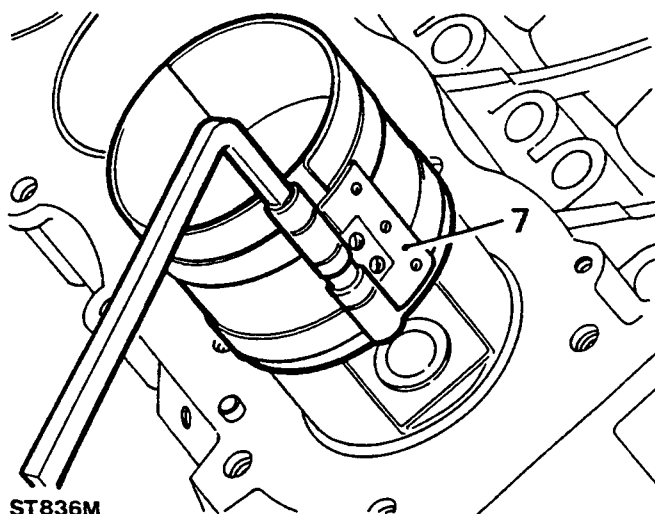
5. Position oil control piston rings with ring gaps all at one side, between piston pin and piston thrust face. Space gaps in ring rails approximately 25 mm each side of expander ring joint.
6. Position compression rings with ring gaps on opposite sides of piston between piston pin and piston thrust face.



ST835M

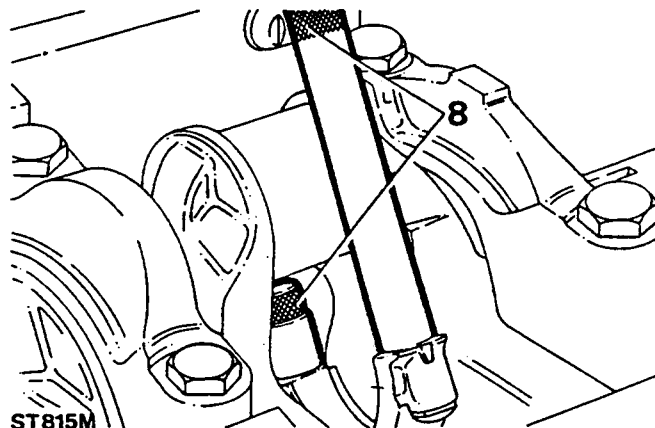


7. Using a piston ring compressor, locate piston into cylinder bore, until piston crown is just below cylinder block top face.



ST836M

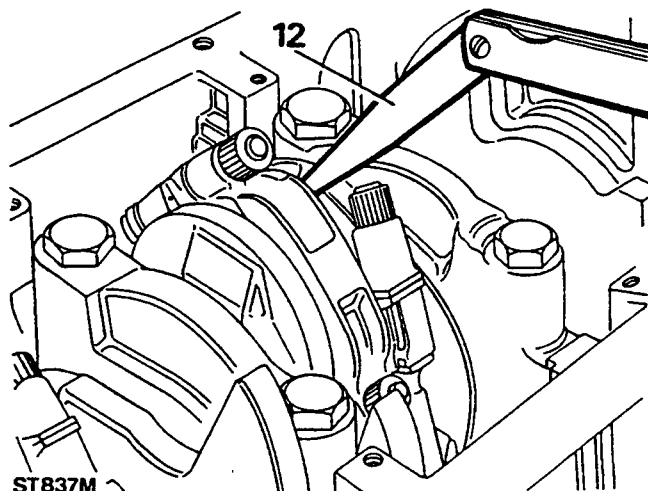
8. Pull connecting rods on to crankpins using the guide bolts. Use extreme care to prevent scratching crank pins.



ST815M

9. Place bearing lower shell in connecting rod cap.  
 10. Locate cap and shell onto connecting rod, noting that rib on edge of cap must be towards front of engine on right hand bank of cylinders and towards rear on left hand bank.  
 11. Check that connecting rods move freely sideways on the crankshaft. Tightness indicates insufficient bearing clearance or misaligned connecting rod.

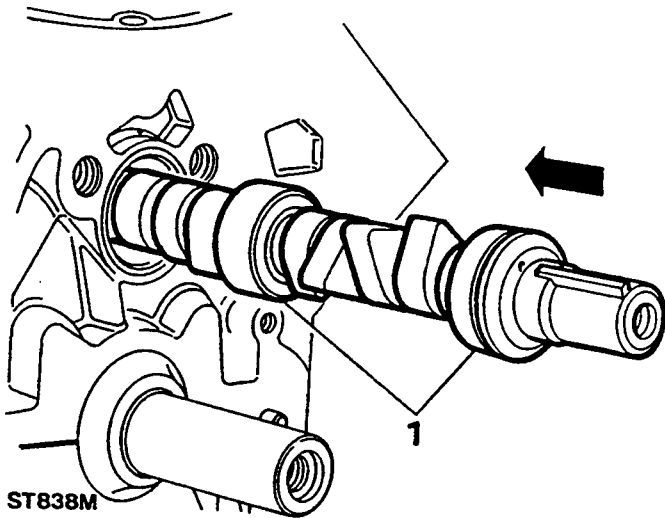
12. Check end-float between connecting-rods on each crankshaft journal. Clearance limits: 0.15 to 0.37 mm.  
 13. Tighten connecting rod nuts to the correct torque, **50 Nm**. *Fit oil strainer and joint washer.*



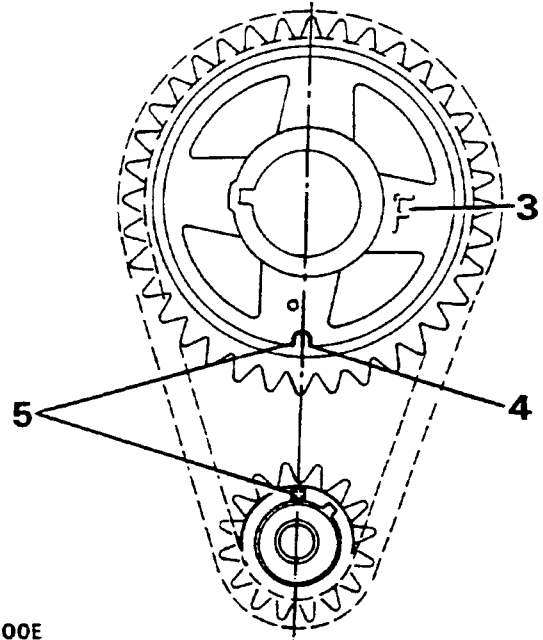
ST837M

## FIT CAMSHAFT TIMING CHAIN AND SPROCKET

1. Lubricate camshaft journals and carefully insert camshaft into cylinder block.

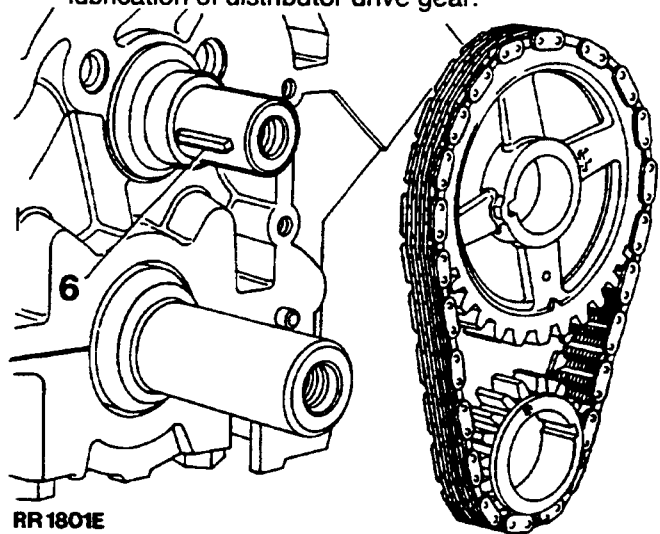


2. Turn crankshaft to bring number one piston to TDC.
3. Temporarily fit camshaft sprocket with marking 'F' or 'FRONT' outward.
4. Turn camshaft until mark on camshaft sprocket is at six o'clock position, remove sprocket without disturbing camshaft.
5. Encircle sprockets with chain keeping timing marks aligned.



RR1800E

6. Fit sprocket assembly to camshaft and crankshaft key locations. Check that camshaft key is parallel to shaft axis to ensure adequate lubrication of distributor drive gear.



RR1801E

**CAUTION:** The space between key and keyway acts as an oilway for lubrication of drive gear. Ensure that key is seated to full depth of keyway. Overall dimension of shaft and key must not exceed 30.15 mm, dimension A below.

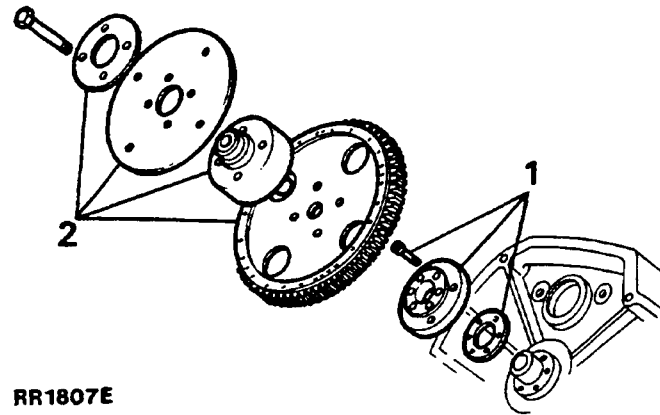


## FIT RING GEAR AND FLEXIBLE DRIVE PLATE ASSEMBLY - AUTOMATIC VEHICLES

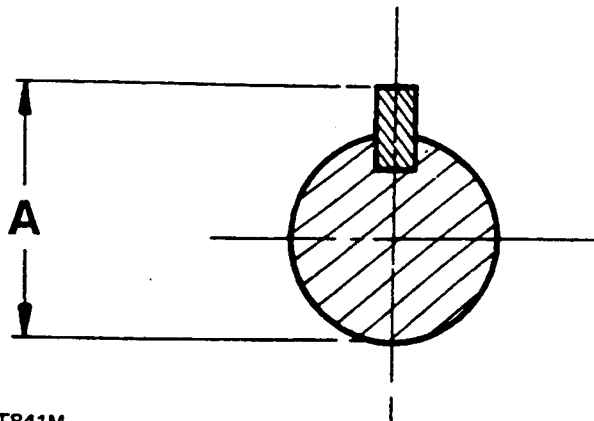


**NOTE:** Ensure components are aligned using previously scribed lines.

1. Fit shim and crankshaft adaptor plate. Secure with six socket head bolts, do not fully tighten.
2. Fit ring gear assembly, hub aligner and flexible drive plate. Secure with four bolts and clamping ring, do not fully tighten.

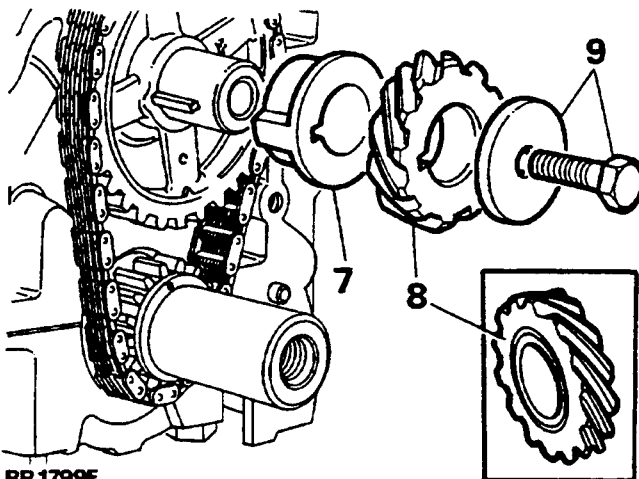


RR1807E



ST841M

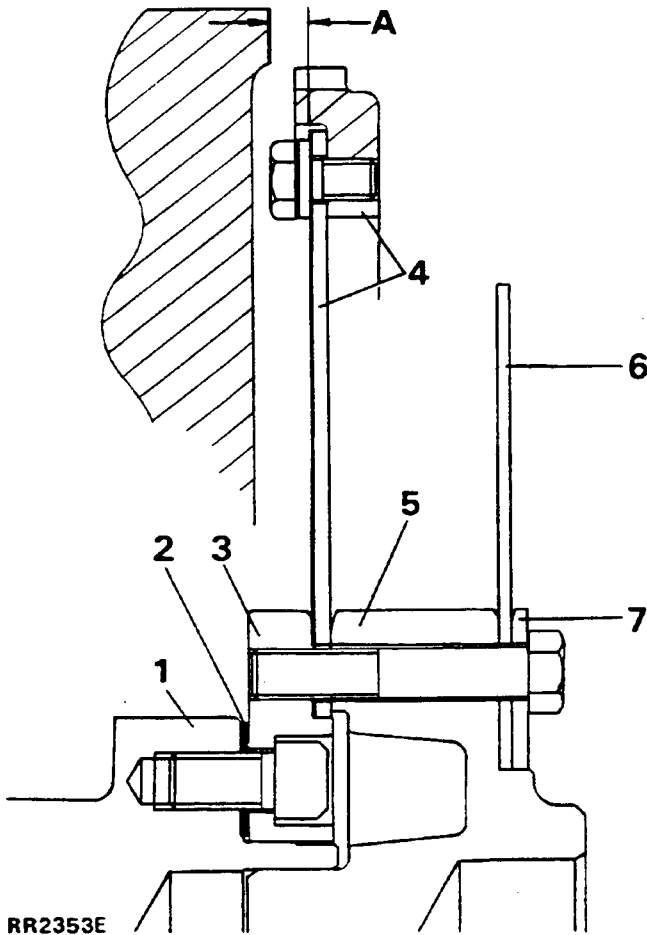
7. Check timing marks line up, fit spacer with flange to front.
8. Fit the distributor drive gear. Ensure that annular grooved side is fitted to rear, towards spacer.
9. Fit bolt and washer, tighten to correct torque, 60 Nm.



RR 1799E

3. To prevent distortion to flexible drive plate when bolted to torque converter, check setting height of drive plate as follows.
4. To prevent excessive clearance, a shim is fitted between crankshaft drive flange and crankshaft adaptor plate. Setting height, dimension A, measured between front face of ring gear drive plate and engine cylinder block to gearbox mating face, should be 8.08 to 8.20 mm. Select appropriate shim to maintain dimension A, as shown.

PART NO.	DIMENSION (MM)
FRC 7084	1.20 - 1.25
FRC 7085	1.30 - 1.35
FRC 7086	1.40 - 1.45
FRC 7087	1.50 - 1.55
FRC 7088	1.60 - 1.65
FRC 7089	1.70 - 1.75
FRC 7090	1.80 - 1.85
FRC 7091	1.90 - 1.95
FRC 7092	2.00 - 2.05
FRC 7093	2.10 - 2.15

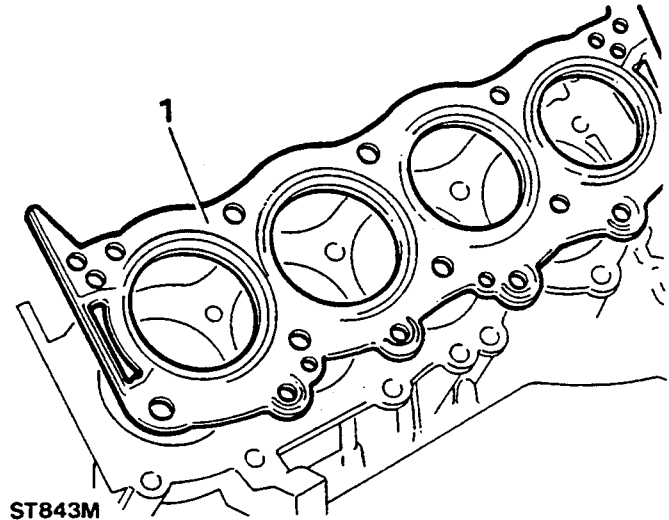


RR2353E

1. Crankshaft flange.
  2. Shim.
  3. Crankshaft adaptor flange.
  4. Drive plate and ring gear assembly.
  5. Hub aligner.
  6. Flexible drive plate.
  7. Clamp ring.
5. Remove four bolts, clamp ring, flexible drive plate, hub aligner and ring gear assembly.
  6. Remove six socket head bolts and crankshaft adaptor.
  7. Fit appropriate shim, refit adaptor and six socket head bolts. Tighten to **84 Nm**.
  8. Fit ring gear assembly, hub aligner, flexible drive plate and clamp ring.
  9. Coat threads of four securing bolts with Loctite 270. Fit bolts and tighten to correct torque, **40 Nm**.

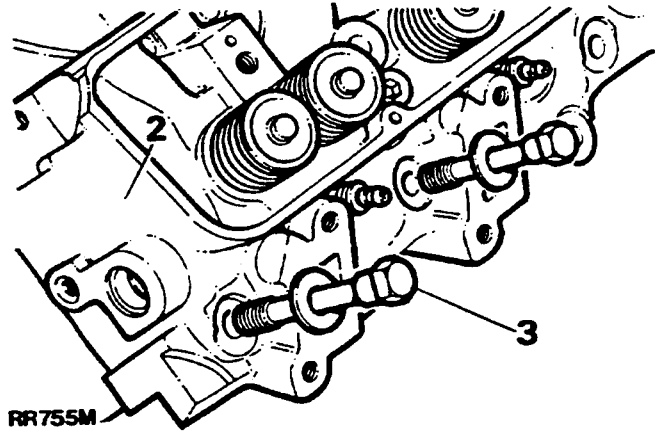
### FIT CYLINDER HEADS

1. Fit new cylinder head gaskets with word 'TOP' uppermost. Do NOT use sealant.



ST843M

2. Locate cylinder heads on dowels.
3. Clean threads of cylinder head bolts, coat with engine oil.



RR755M

4. Locate the cylinder head bolts in position illustrated and fit dipstick tube.

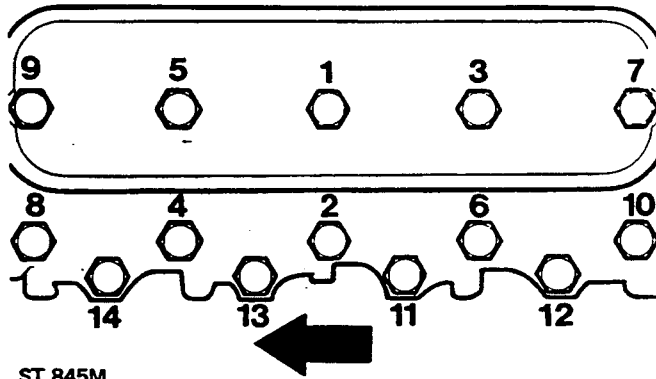
Long bolts - 1, 3 and 5.

Medium bolts - 2, 4, 6, 7, 8, 9 and 10.

Short bolts - 11, 12, 13 and 14.



5. Tighten head bolts progressively in sequence shown. Finally tighten to correct torque, outer row **60 Nm** centre and inner row **90 Nm**.
6. Re-check torques when all bolts have been tightened.



ST 845M



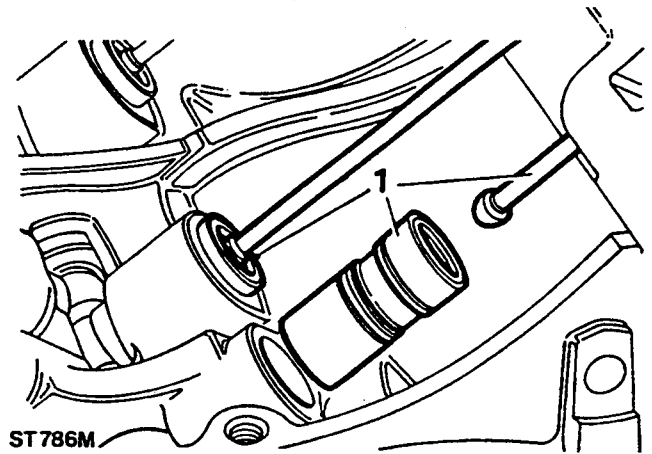
**NOTE:** Left-hand cylinder head illustrated. Arrow points to front of vehicle.

### FIT TAPPETS, PUSH RODS AND ROCKER ASSEMBLIES



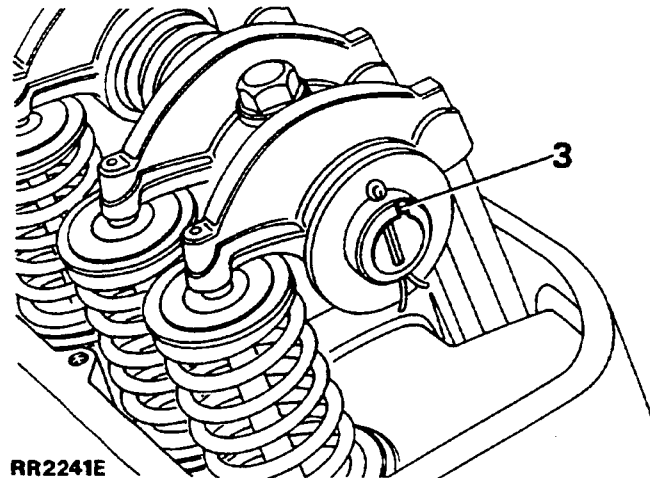
**NOTE:** Immerse tappets in clean engine oil. Before fitting, pump inner sleeve of tappet several times using a pushrod, to reduce tappet noise when engine is started.

1. Fit tappets and push rods in original positions. Ensure tappets move freely in bores.



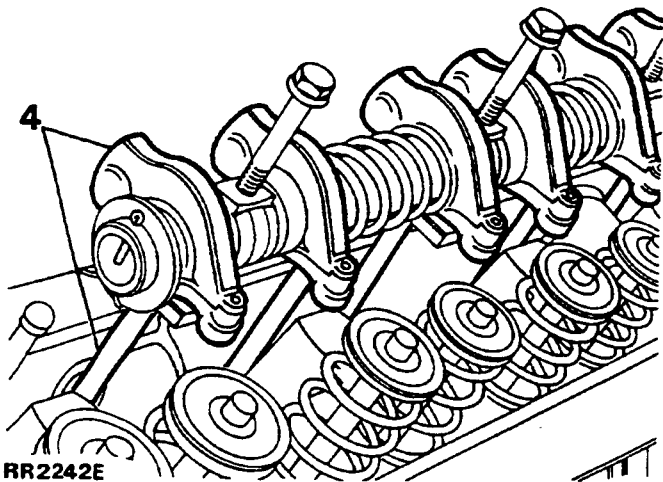
ST 786M

2. Rocker shafts are handed and must be fitted correctly to align oilways.
3. Ensure each rocker shaft is fitted with notch uppermost and towards front of engine on right hand side, towards rear on left hand side.



RR2241E

4. Fit rocker shaft assemblies. Ensure pushrods engage rocker cups. Tighten bolts to correct torque, **38 Nm**.

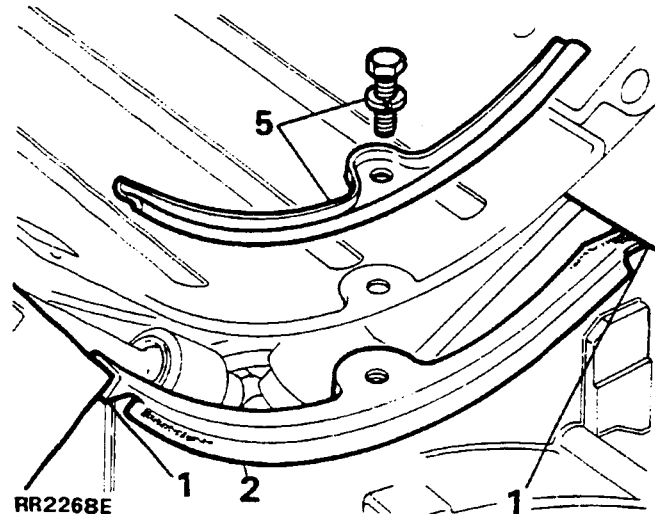


**NOTE:** Tappet noise can be expected on initial starting after overhaul or if vehicle has been standing a very long period. Run engine at 2,500 rev/min for a few minutes (subject to following caution), when noise should be eliminated.

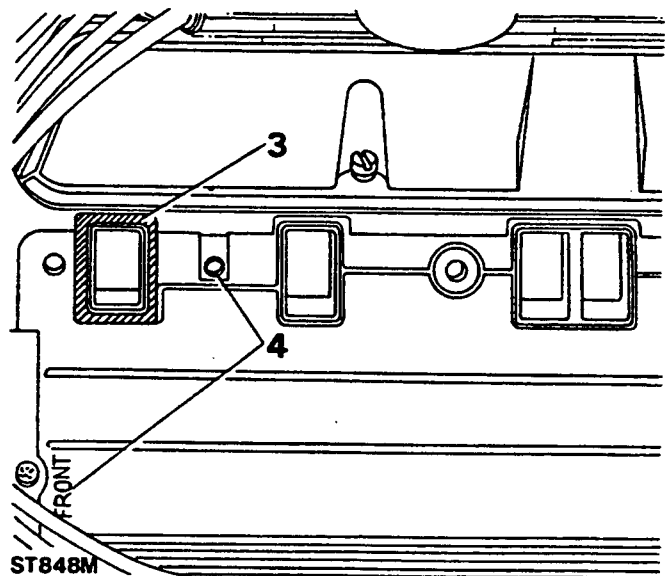
**CAUTION:** Do not exceed 1,000 engine rev/min for 15 seconds when first starting engine, otherwise crankshaft rear oil seal will be damaged.

## FIT INTAKE MANIFOLD

1. Apply globule of Hylomar SQ32M sealing compound to notches between cylinder head and block.
2. Locate NEW seals in position with ends engaged in notches.



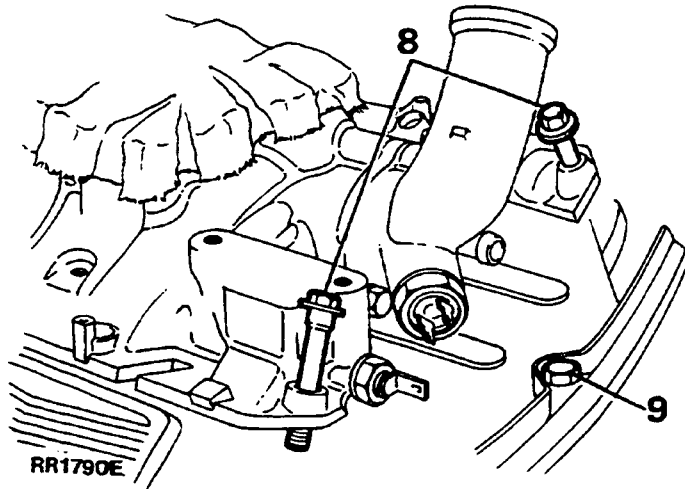
3. Apply 'Hylomar' SQ32M on corners of cylinder head, manifold gasket and manifold, around water passage joints.
4. Fit manifold gasket with word 'FRONT' to front and open bolt hole at front R.H. side.
5. Fit gasket clamps, do not fully tighten bolts.





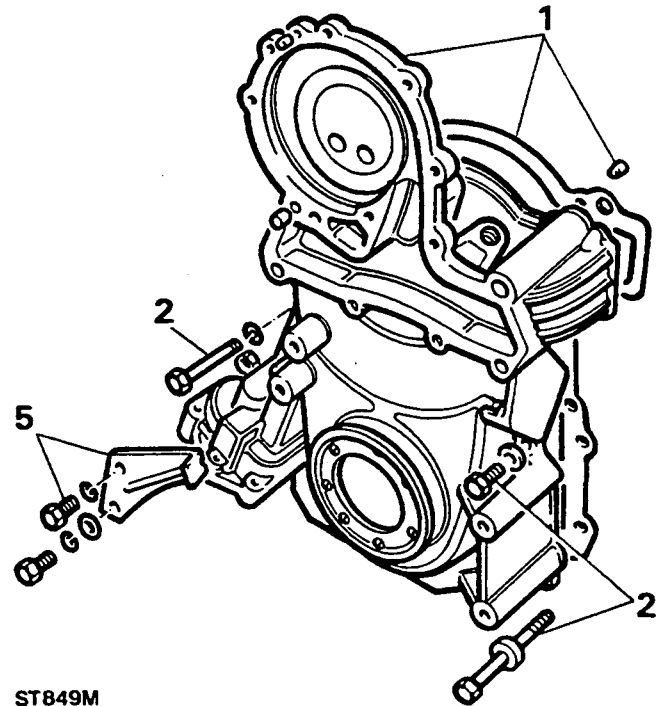


6. Locate manifold on to cylinder head.
7. Clean threads of manifold securing bolts.
8. Fit all manifold bolts, evenly tighten a little at a time, alternate sides working from centre to each end. Finally tighten to correct torque, **40 Nm**.
9. Tighten gasket clamp bolts to correct torque, **18 Nm**.



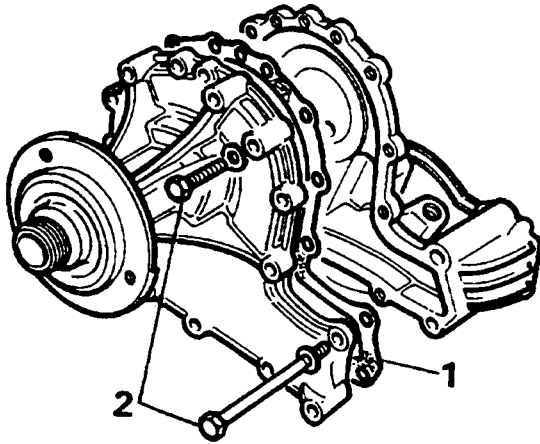
#### FIT TIMING COVER AND CRANKSHAFT PULLEY

1. Position a new timing cover joint washer, fit timing cover, locating it on two dowels.
2. Clean threads of timing cover securing bolts, coat them with Loctite 572.
3. Fit and evenly tighten timing cover bolts to correct torque, **28 Nm**.
4. Fit crankshaft pulley. Tighten retaining bolt to correct torque, **270 Nm**.
5. Fit timing pointer.



## FIT WATER PUMP

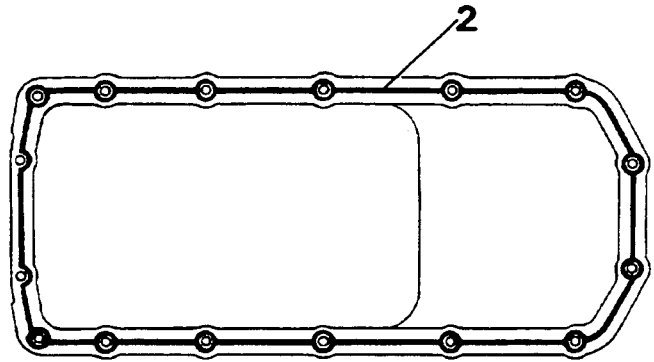
1. Lightly grease a new joint washer and place it in position on timing cover.
2. Clean threads of four long bolts and coat with Loctite 572 thread lubricant sealant. Locate water pump in position.
3. Locate alternator adjusting link on water pump.
4. Leaving alternator adjusting link loose, tighten remaining water pump housing bolts evenly to correct torque **28 Nm**.



RR1795E

## FIT SUMP

1. Remove old sealant from sump and cylinder block joint faces.
2. Apply 2 mm wide bead of Hylosil 102 to joint face of sump as shown in illustration below.



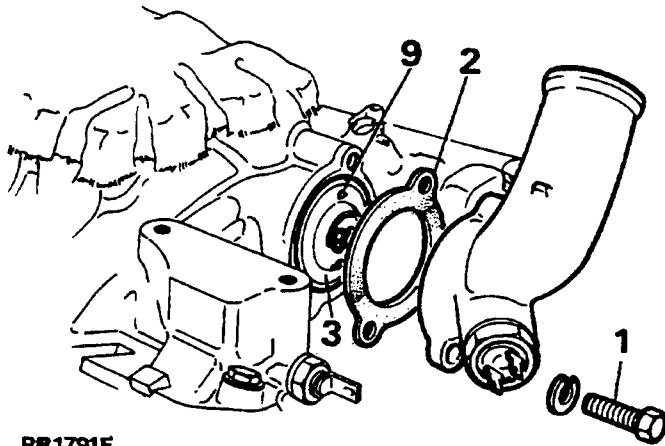
RR1867E

3. Place sump in position, fit sump bolts, evenly tighten bolts to correct torque, **10 Nm**, rear bolts **19 Nm**.
4. Tighten sump plug to correct torque, **44Nm**.
5. Allow thirty minutes sealant curing time before starting engine.



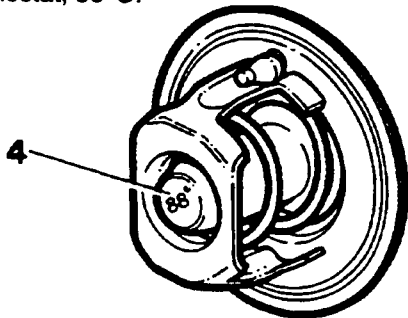
## TEST AND FIT THERMOSTAT

1. Remove two bolts securing thermostat housing to intake manifold.
2. Remove housing gasket.
3. Withdraw thermostat.



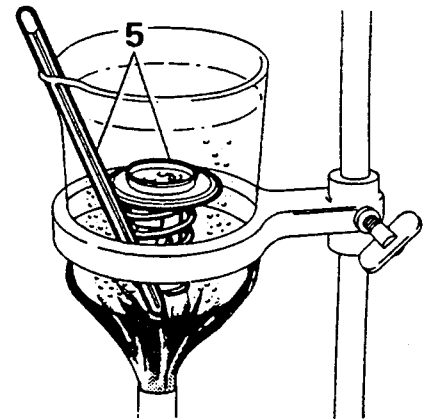
RR1791E

4. Note fully open temperature stamped on thermostat, 88°C.



RR799M

5. Place thermostat and a thermometer in a suitable container half full of water.
6. Heat water and observe temperature at which thermostat opens.
7. Discard thermostat if faulty.
8. Clean intake manifold and thermostat housing mating faces.



ST858M

9. Fit thermostat with jiggle pin uppermost.

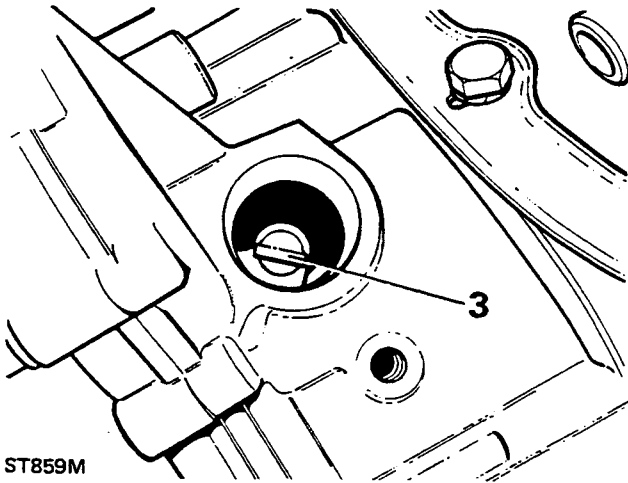


**NOTE:** Airlocks may develop in cooling system if thermostat is incorrectly positioned, with consequent loss of coolant and possible overheating.

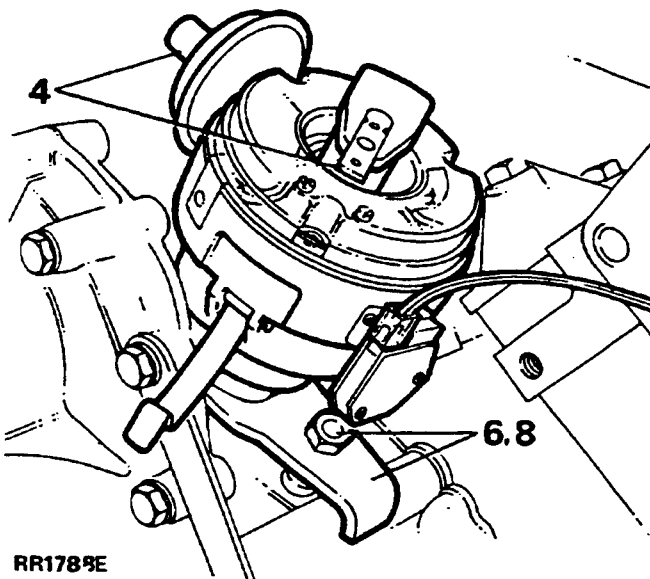
10. Fit housing with new gasket, tighten two bolts to correct torque, 28 Nm.

## FIT DISTRIBUTOR

1. Turn crankshaft to bring number one piston to 6° BTDC on compression stroke (both valves closed number one cylinder).
2. Turn distributor drive until rotor arm is approximately 30° anti-clockwise from number one spark plug lead position on cap.
3. Turn oil pump and distributor drive shaft until tongue is in approximate position illustrated.



4. Fit distributor to engine, check that centre line of rotor arm is now in line with number one spark plug lead position in distributor cap. Reposition distributor if necessary. The vacuum capsule should be at approximately 90° to camshaft.
5. If distributor does not seat correctly, oil pump drive is not engaged. Remove distributor, reset oil pump drive tongue, repeat operation.



6. Fit clamp and nut, leave loose.
7. Rotate distributor until peak on pick-up lines up with a peak on reluctor ring. Remove rotor arm for better view.

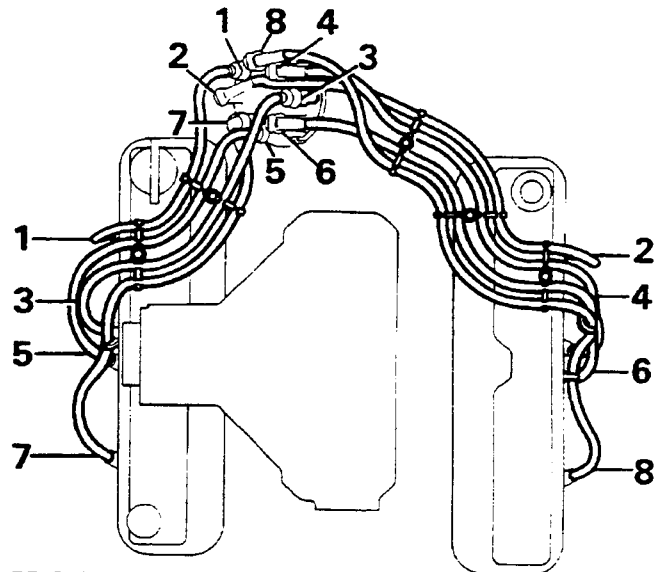


**CAUTION:** On no account must engine be started before this operation is carried out.

8. Secure distributor in this position by tightening clamp nut.
9. Fit distributor cap and spark plugs. Connect H.T. leads as shown in illustration RR1876E.



**NOTE:** This distributor setting is to enable engine to be started. When engine is refitted the ignition timing must be set using electronic equipment. See *ELECTRICAL, Adjustment, Ignition timing*



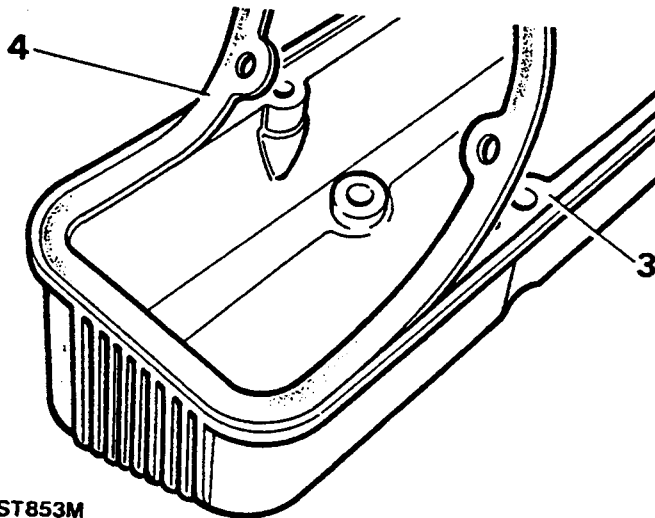


### FIT ROCKER COVERS

1. An oil baffle is fitted inside each rocker cover. Remove two screws to remove baffle for cleaning.
2. Remove old gasket and sealant from covers and cylinder heads. Clean and dry gasket mounting face, using Bostik cleaner 6001. Apply Bostik 1775 to seal face and gasket, use a brush to ensure an even film. Allow adhesive to become touch-dry, approximately fifteen minutes.



**NOTE: The gasket fits one way only, it must be fitted accurately first time. Subsequent movement would destroy bond.**

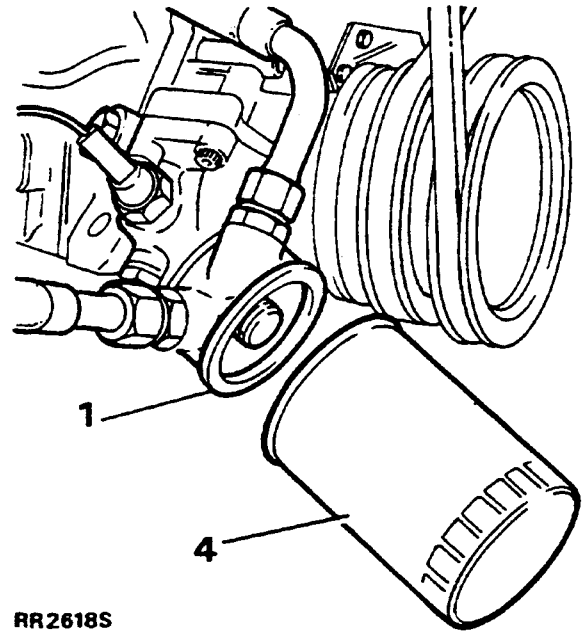


ST853M

3. Fit pilot studs in rocker cover fixing holes to guide gasket onto cover and into recess. Press gasket into place ensuring that outer edge firmly contacts recess wall.
4. Allow covers to stand for thirty minutes before fitting.
5. Secure rocker covers to cylinder heads with short screws inboard, long screws outboard. Tighten to **9 Nm**.

### FIT ENGINE OIL FILTER

1. Clean oil cooler adaptor mating face.
2. Coat sealing ring of new filter with clean engine oil.
3. Fill filter with new oil as far as possible, noting angle at which filter is to be fitted.



RR2618S

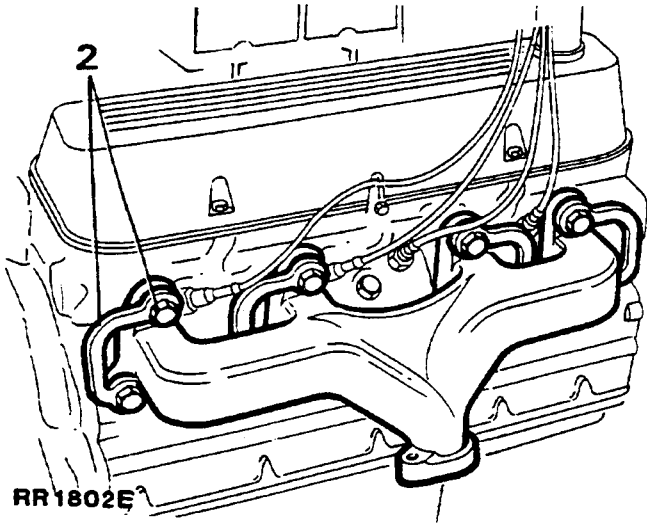
4. Screw on filter until sealing ring touches mating face, then tighten a further half turn by hand only. **DO NOT OVERTIGHTEN.**
5. Refill engine with specified grade and quantity of oil.

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**FIT EXHAUST MANIFOLD**

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1. Ensure mating surfaces of head and exhaust manifold are clean. Fit new gaskets to exhaust manifold. Coat threads of bolts with anti-seize compound.
2. Position manifold on cylinder head and fit new lockplates, securing bolts and plain washers. The plain washers are fitted between manifold and lockplates. Evenly tighten manifold bolts to correct torque, **20 Nm**. Bend over lock tabs.



RR1802E

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**MISCELLANEOUS AND NON-STANDARD ITEMS**

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Fit remaining items of equipment, miscellaneous hoses, pipes, filters, clips and brackets in position.



## TORQUE VALUES



**NOTE:** Torque wrenches should be regularly checked for accuracy to ensure that all fixings are tightened to the correct torque.

	Nm
Adaptor plate to crankshaft.....	84
Alternator mounting bracket to cylinder head .....	39
Alternator to mounting bracket .....	25
Alternator to adjusting link .....	25
Chainwheel to camshaft .....	58
Connecting rod bolt .....	51
Cylinder head:	
Outer row .....	58
Centre row .....	92
Inner row .....	92
Damper to crankshaft .....	271
Distributor clamp nut.....	21
Drive plate to converter .....	39
Engine mountings to engine and chassis .....	52
Engine mounting rubbers to brackets .....	19
Exhaust manifold to cylinder heads.....	21
Fan to viscous unit.....	29
Flexible drive plate to crankshaft adaptor plate .....	41***
Intake manifold to cylinder heads .....	38
Lifting eye to cylinder heads .....	39
Main bearing cap bolts .....	72**
Main bearing cap rear bolts .....	92**
Manifold gasket clamp bolt .....	17
Oil pump cover to timing cover .....	13
Oil plug .....	27
Oil relief valve plug .....	44
Oil sump drain plug .....	44
Oil sump to cylinder block.....	9
Oil sump rear to cylinder block .....	18
Plenum chamber to ram housing.....	25
Ram housing to intake manifold .....	24
Rocker cover to cylinder head .....	9
Rocker shaft bracket to cylinder head .....	37
Spark plug .....	21
Starter motor attachment.....	44
Thermostat housing to intake manifold.....	27
Timing cover to cylinder block .....	27*
Viscous unit to water pump hub .....	45
Water pump pulley to water pump hub .....	10*
Water pump timing cover to cylinder block.....	27
Water jacket to plenum chamber .....	13*

\* These bolts must have threads coated with Loctite 572 before assembly.

\*\* These bolts must have threads coated in lubricant EXP16A before assembly.

\*\*\* These bolts must have threads coated in sealant Loctite 270

It is essential that bolts are tightened to correct torque value.

	Nm
<b>METRIC</b>	
M5 .....	6
M6 .....	9
M8 .....	25
M10 .....	45
M12 .....	90
M14 .....	105
M16 .....	180
 <b>UNC / UNF</b>	
1/4 .....	9
5/16 .....	24
3/8 .....	39
7/16 .....	78
1/2 .....	90
5/8 .....	136



**NOTE: Torque values above are for all screws and bolts used except for those specified.**

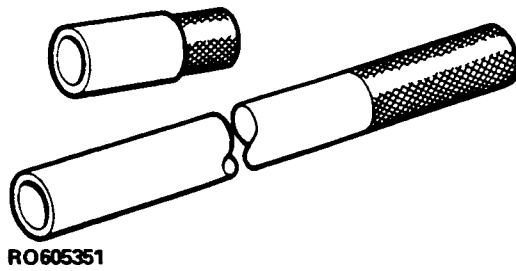




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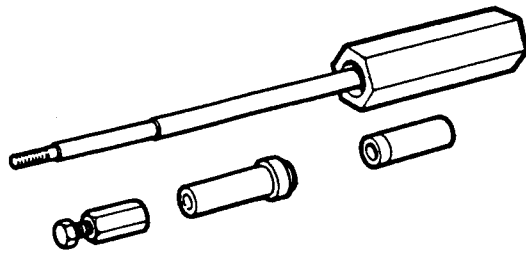
**V8 PETROL**

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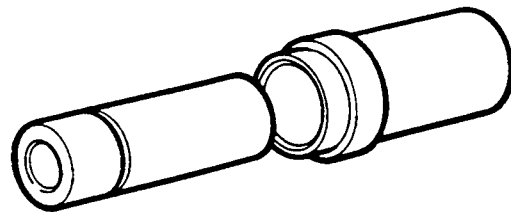
RO605351

LRT-12-041 Guide bolts  
RO605351



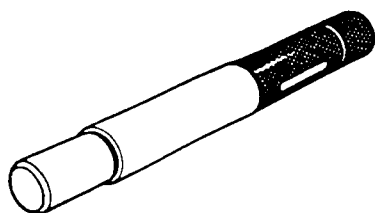
18G1150

LRT-12-013 Piston pin remover/replacer  
18G1150 - Basic tool



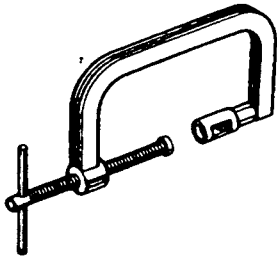
18G1150E

LRT-12-014 Adaptor remover/replacer - piston pin  
18G1150E



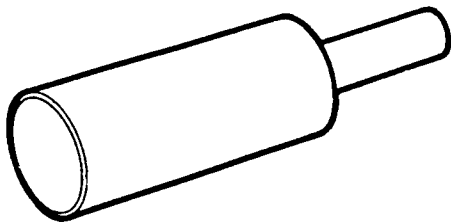
18G79

LRT-12-001 Clutch centralising tool.  
18G79



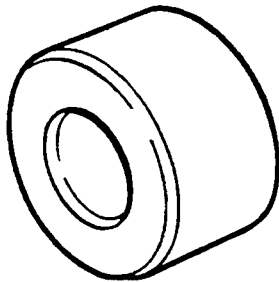
LRT-12-034 Spring compressor  
MS1519A

MS1519A



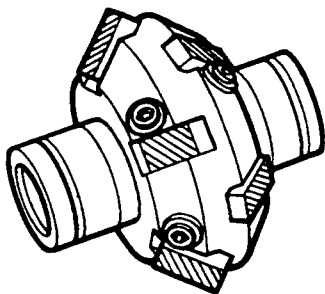
LRT-12-038 Drift - Valve guide replacement  
RO600959 - intake and exhaust

RO600959



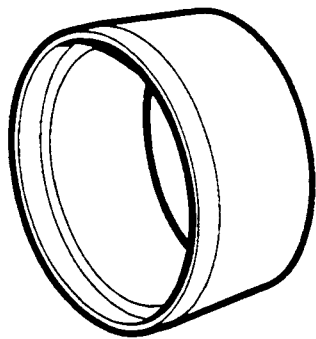
LRT-12-515 Distance piece for valve guide  
RO605774A

605774A



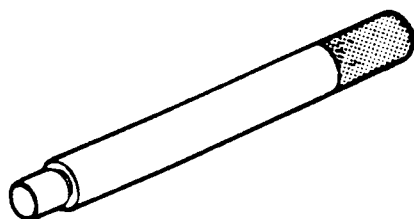
LRT-12-504 Valve seat cutter  
MS621

MS621



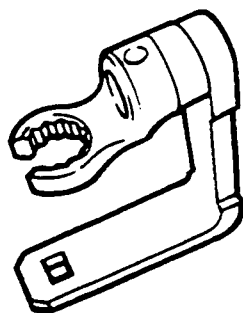
RO1014

LRT-12-010 Crankshaft rear seal sleeve  
RO1014



RO 274401

LRT-12-037 Drift for valve guide removal  
RO274401A - intake and exhaust



LST134

LRT-12-047 Torque adaptor lambda sensor  
LST 134

## 12 - ENGINE

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## 12 - ENGINE

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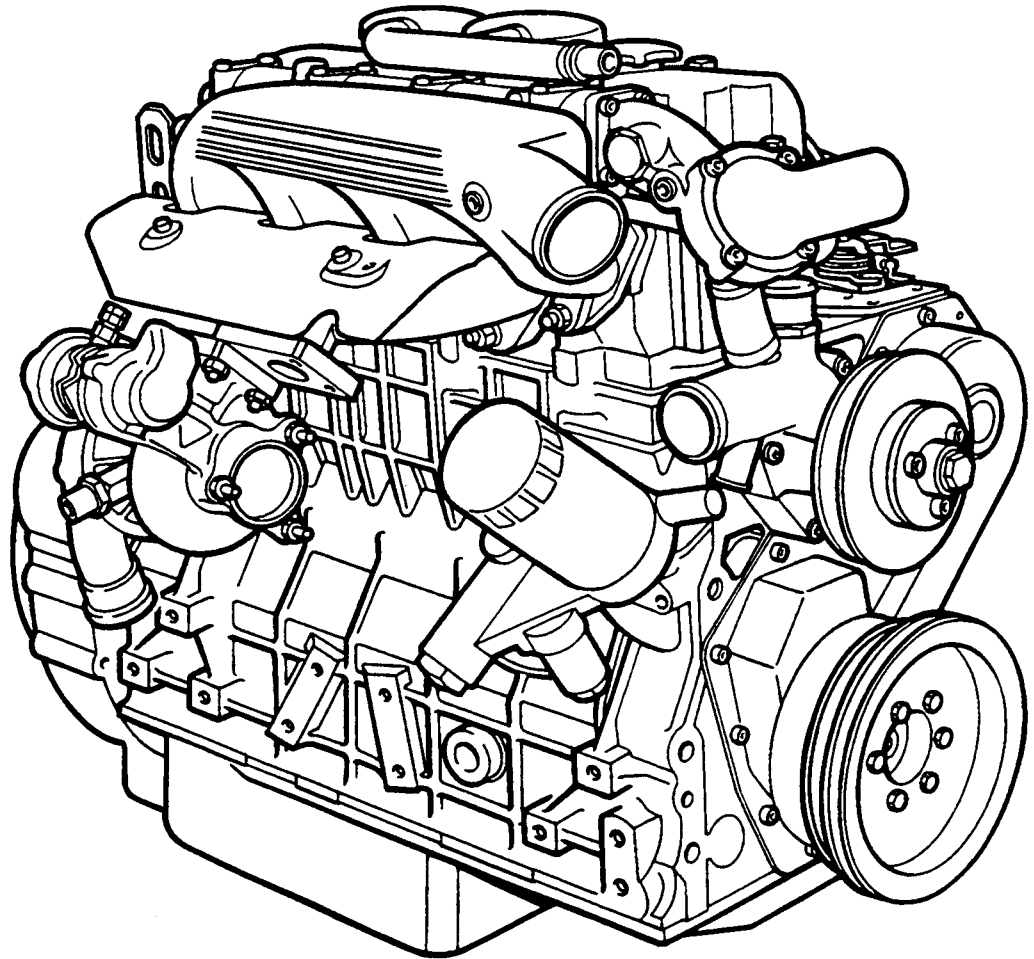


## DIESEL ENGINE VM

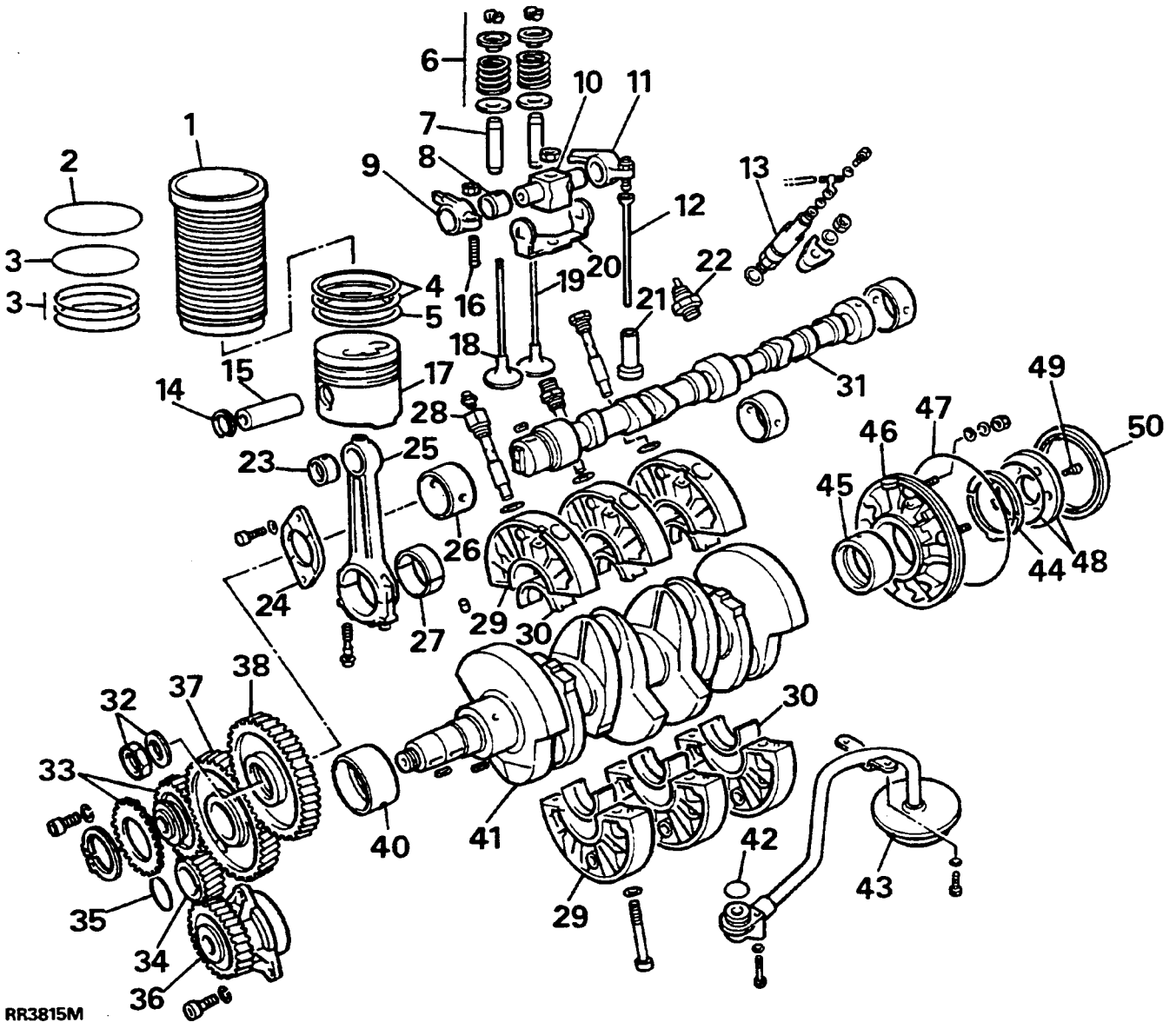
### Description

The four cylinder over head valve 2.5 litre indirect injection diesel engine, has a cast iron skirted cylinder block and five main bearing cast iron crankshaft. The crankshaft main bearings are mounted in separate aluminium housings, which are a sliding fit into the cylinder block and each is locked in position by three bolts.

The three bearing camshaft, oil pump, vacuum pump and fuel injection pump are gear driven off the front of the crankshaft. Wet, cast iron cylinder liners with shims for height adjustment and 'O' ring seals are clamped in the cylinder block, by four separate aluminium cylinder heads. The 'Nimonic' alloy pre-combustion chambers which are a press fit into each cylinder head, are retained by the clamping force on the cylinder head gasket. The low expansion alloy pistons have a kidney shaped swirl recess in the crown and transmit the the combustion force to the crankshaft via forged steel connecting rods.



RR3764M





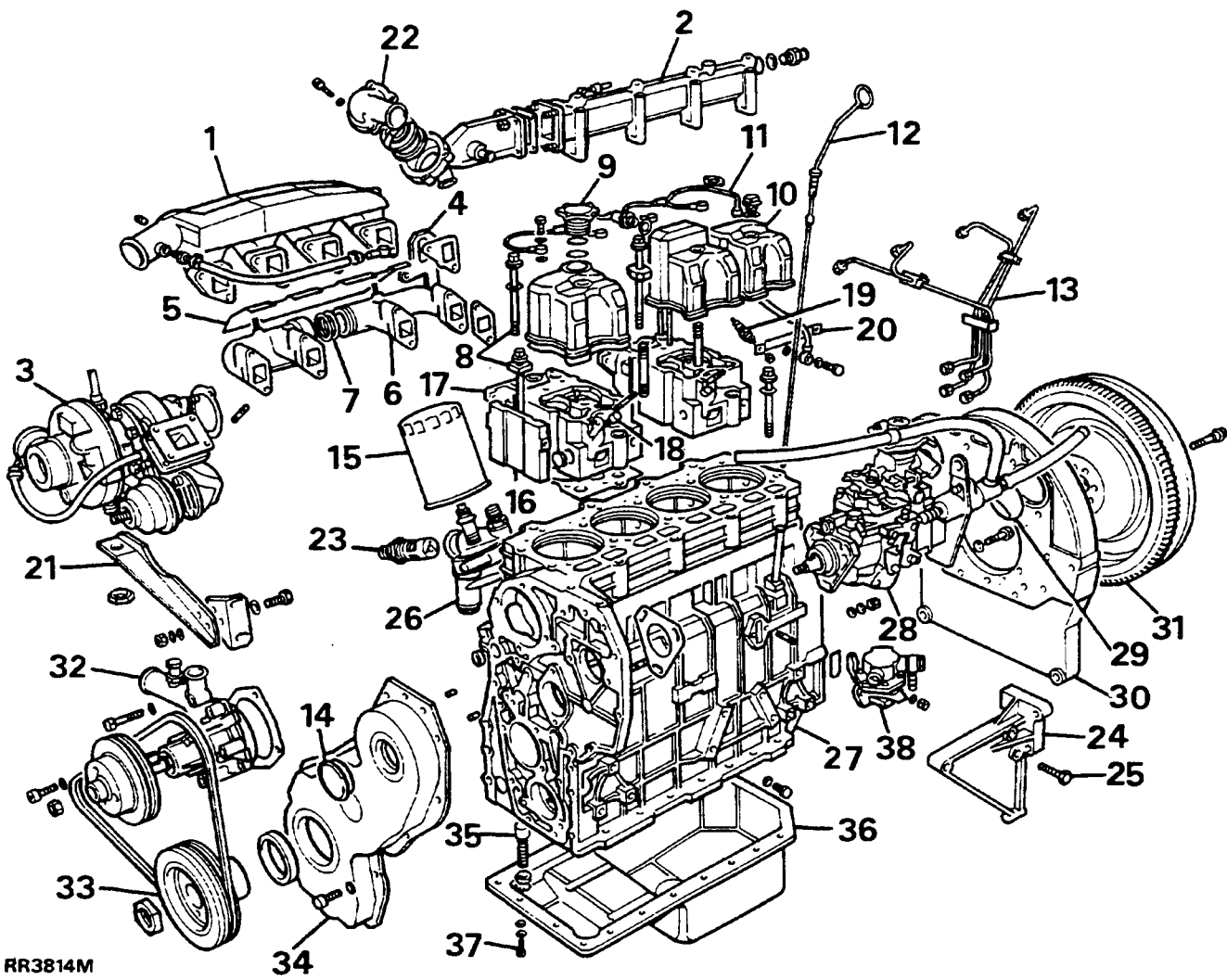
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**ENGINE INTERNAL PARTS**

---

1. Liner
2. Shim
3. 'O' ring seals
4. Compression rings
5. Oil control ring
6. Valve spring cap
7. Valve guide
8. Rocker shaft bush
9. Inlet rocker arm
10. Rocker shaft (pedestal)
11. Exhaust rocker arm
12. Push rod
13. Injector
14. Snap ring
15. Gudgeon pin
16. Valve clearance adjusting screw
17. Piston
18. Inlet valve
19. Exhaust valve
20. Spring clip
21. Tappet
22. Oil pressure switch
23. Small end bush
24. Thrust plate
25. Connecting rod
26. Camshaft bearings
27. Connecting rod bearing shell
28. Carrier location and lubrication shell
29. Central main bearing carrier
30. Central main bearing shell
31. Camshaft
32. Retaining nut and washer
33. Vacuum pump and split gear assembly
34. Crankshaft gear
35. 'O'-ring seal
36. Oil pump assembly
37. Camshaft gear
38. Fuel injection pump gear
39. N/A
40. Front main bearing
41. Crankshaft
42. 'O' ring seal
43. Oil pick-up pipe and strainer
44. Thrust washer halves
45. Rear main bearing
46. Rear main bearing carrier
47. 'O' ring seal
48. Crankshaft thrust spacer and 'O' ring seal
49. Socket headed screw
50. Crankshaft rear oil seal





RR3814M



---

**ENGINE EXTERNAL COMPONENTS**

---

- |  |                                   |
|--|-----------------------------------|
| 1. Inlet manifold                      | 21. Turbo-charger support bracket |
| 2. Engine coolant rail                 | 22. Coolant thermostat            |
| 3. Turbo-charger                       | 23. Oil thermostat                |
| 4. Engine lifting eye                  | 24. Support bracket               |
| 5. Heat shield                         | 25. Bolt                          |
| 6. Exhaust manifold                    | 26. Oil filter base adapter       |
| 7. Sealing rings                       | 27. Cylinder block                |
| 8. Cylinder head bolt and spacer block | 28. Fuel injection pump           |
| 9. Oil filler cap                      | 29. 'O' ring                      |
| 10. Rocker cover                       | 30. Flywheel housing              |
| 11. Valve gear oil feed pipe           | 31. Flywheel                      |
| 12. Dipstick                           | 32. Water pump                    |
| 13. Injector pipes                     | 33. Crankshaft pulley             |
| 14. Screw plug                         | 34. Timing cover                  |
| 15. Oil filter element                 | 35. Oil pressure relief valve     |
| 16. Cylinder head end-plate            | 36. Sump                          |
| 17. Cylinder head                      | 37. Sump pan                      |
| 18. Injector dowel                     | 38. Fuel lift pump                |
| 19. Heater plug                        | 39. Cold start device             |
| 20. Heater plug copper link            |                                   |

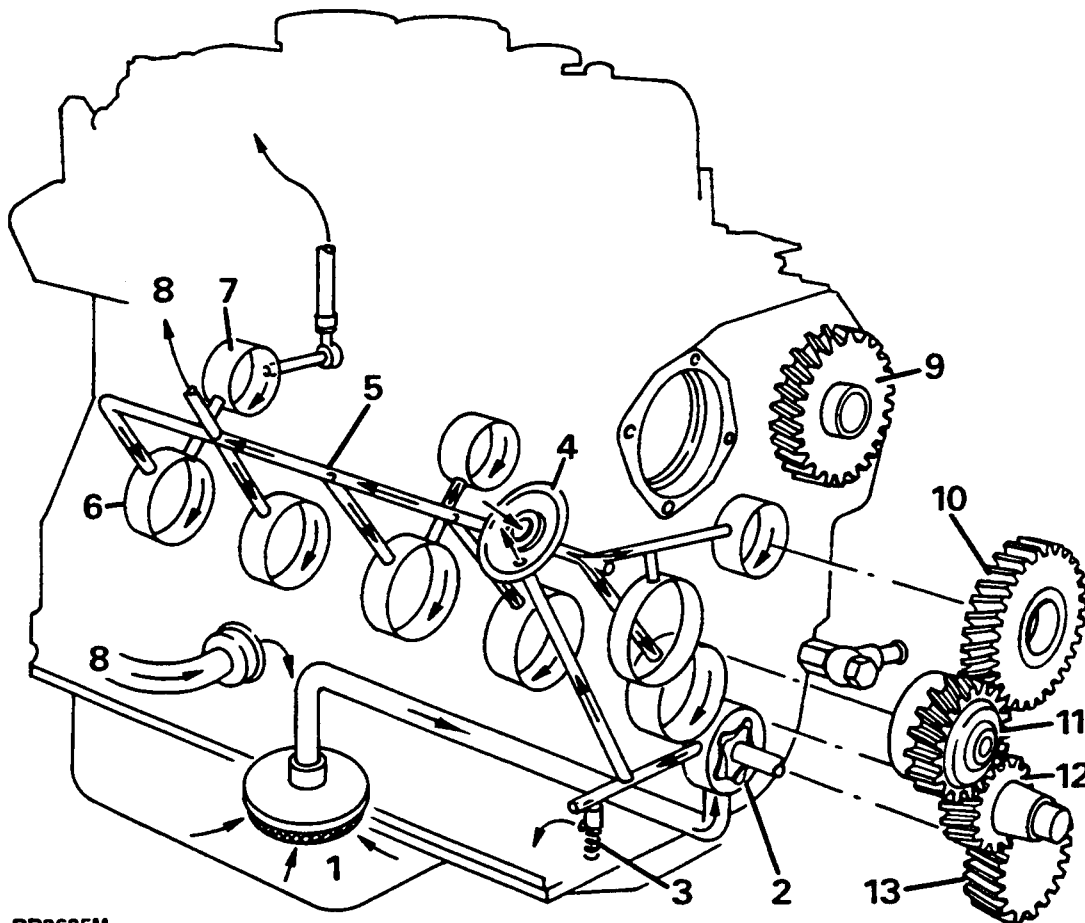
## LUBRICATION SYSTEM

### Description

The full flow lubrication system see in RR3625M, is supplied with oil by a 4/5 lobe rotary pump, which is located in the front of the cylinder block where it is gear driven from the crankshaft. The pressure relief valve is located in the cylinder block adjacent to the pump where it is retained with a circlip.

The oil filter adapter which is secured to the right side of the cylinder block, houses the by-pass valve and a thermostat to control the flow of oil through the cooler.

Oil flows through the cooler before filtering, after which it passes into the cylinder block oil gallery where it is distributed to the main bearings, camshaft bearings, vacuum pump and via an external hose to the rocker shafts. Filtered oil supplied from the oil gallery to the turbo, returns to the sump through a connection on the side of the cylinder block.



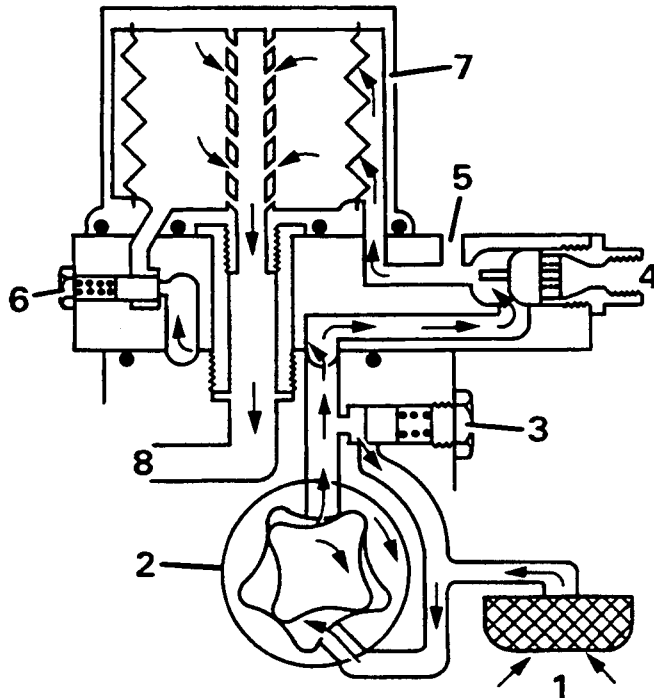
- |   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. Oil pump inlet</li> <li>2. Oil pump location</li> <li>3. Pressure relief valve</li> <li>4. Oil supply to and from filter and cooler</li> <li>5. Distribution oil gallery</li> <li>6. Main bearings (5)</li> <li>7. Camshaft bearings (3) and supply to rocker shafts</li> </ol> | <ol style="list-style-type: none"> <li>8. Turbo feed and return</li> <li>9. Injection pump gear</li> <li>10. Camshaft gear</li> <li>11. Vacuum pump/gear</li> <li>12. Crankshaft gear</li> </ol> |
|---|--|



### Filtered oil thermostat closed

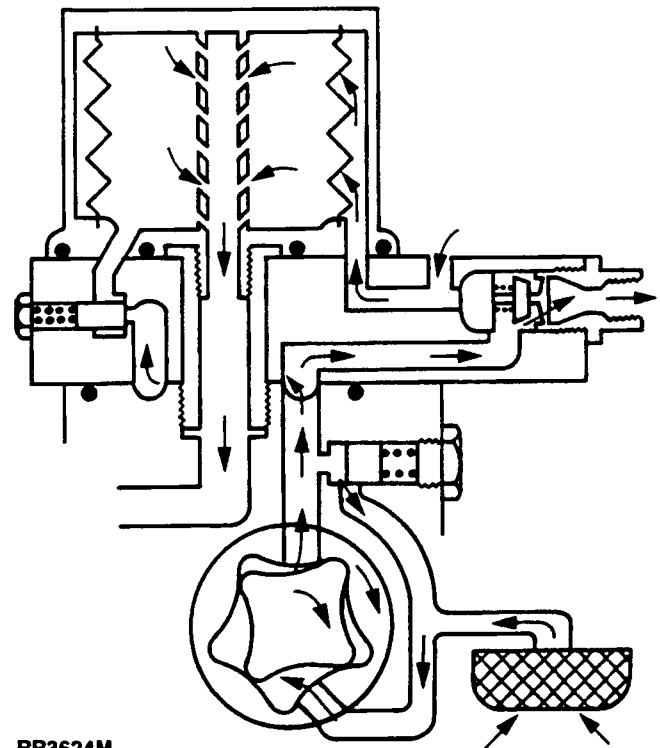
Illustration RR3622M shows oil being filtered and the thermostat closed, with no circulation through the cooler.

As the engine warms up the thermostat will open, diverting the oil through the cooler as seen in RR3624M.



RR3622M

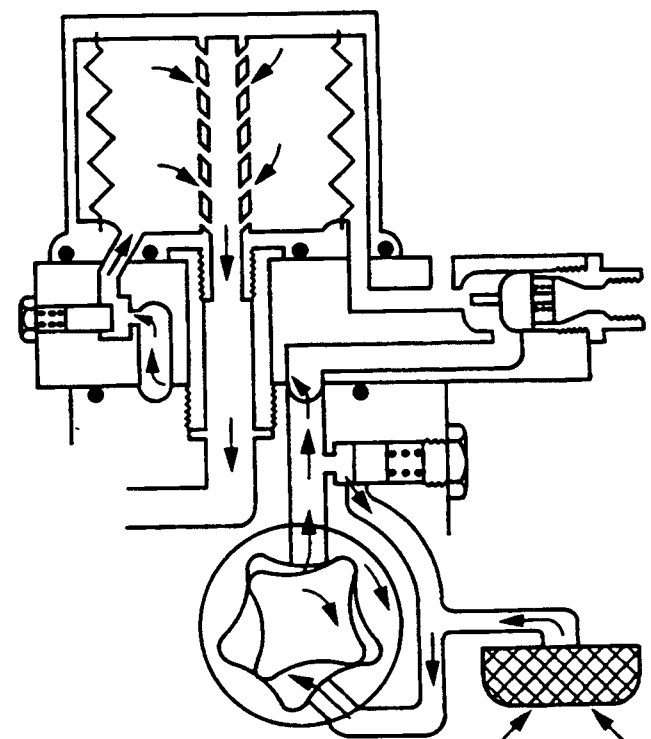
1. Oil pump inlet
2. Oil pump
3. Pressure relief valve
4. Connection to cooler
5. Connection from cooler
6. Filter by-pass valve
7. Filter
8. Oil to distribution gallery



RR3624M

### Unfiltered oil

Should the filter become blocked, the by-pass valve will lift off its seating allowing the oil to reach the engine bearings without being filtered as seen in RR3623M.



RR3623M

See *Fault diagnosis, Engine oil pressure test*

---

**VACUUM PUMP**

---

**Operation**

The brake servo vacuum pump is located in the front of the cylinder block where it transmits the drive from the crankshaft to the camshaft and injection pump. The pump which is lubricated from the oil gallery, draws air from the brake servo and discharges into the front cover of the engine as illustrated.

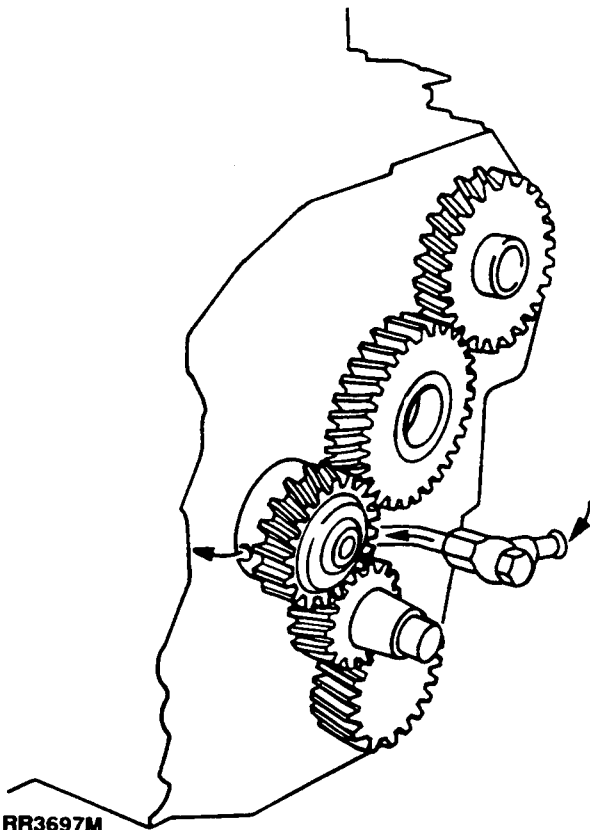
The operating efficiency of the vacuum pump depends on adequate engine lubrication pressure. The pressure is applied to the inner edge of each of the four rotor vanes to ensure that the vanes are pushed outwards and form a good seal with the pumping chamber.

With the engine running and during normal operation of the brakes, the pump draws only a small volume of air from the servo each time the brakes are applied. However, the pump is capable of pumping a very large volume of air and therefore it is not advisable to run the engine with the brake servo hose disconnected as this may cause pressurization of the crankcase ventilation system.



**CAUTION:** Do not run the engine with the brake vacuum pump brake servo hose disconnected.

For further information, *See Fault diagnosis, Vacuum pump test*



RR3697M



## TURBOCHARGER

### Description

The turbocharger is a simple and efficient means of harnessing the residual power in the exhaust gas and using that power to force more air into the combustion chambers, to increase the power output of the engine.

An increase in engine power of up to 30% may be derived from installing a turbo charger.

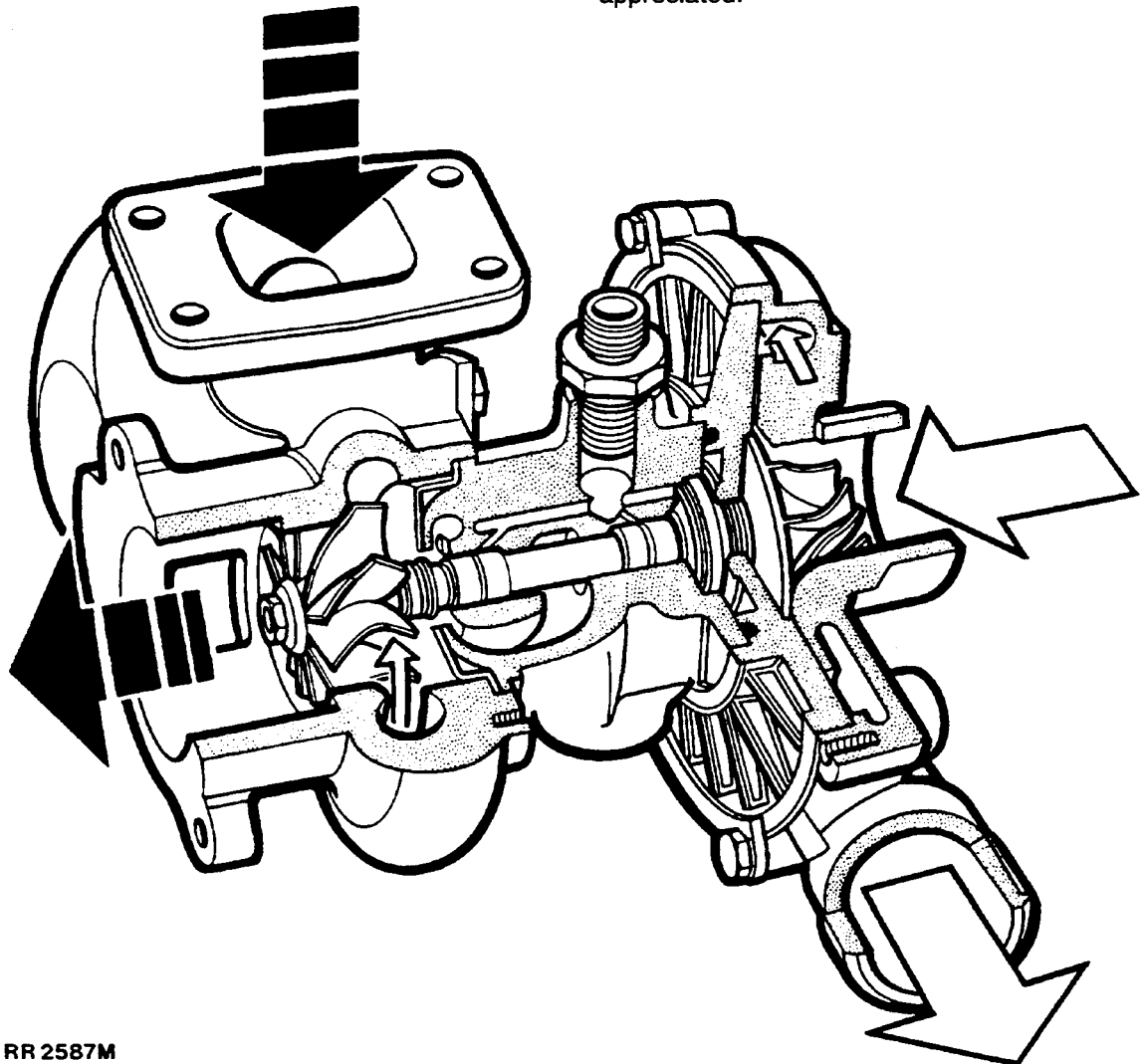
### Operation

The turbocharger shown in RR3637M consists of a single shaft 1 mounted on fully floating high speed bearings 2. The shaft has an exhaust driven turbine 3 at one end and an air compressor turbine 4 at the other.

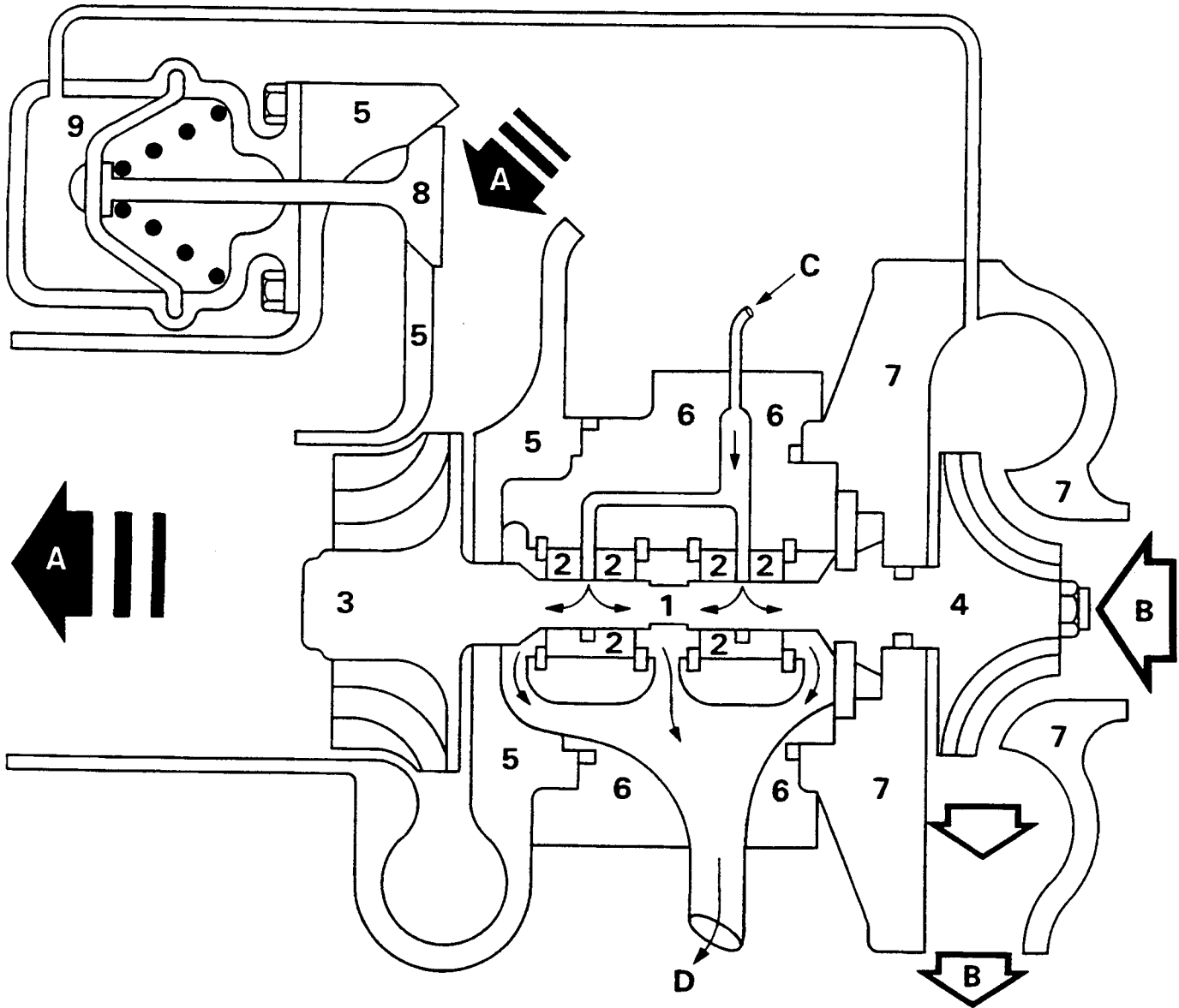
The turbo housing is made in three parts and comprises of a cast iron exhaust turbine housing 5. A cast iron bearing housing 6 and the air compressor housing 7, which because its operating temperature is lower than the other parts is usually made from aluminium.

To control the upper speed range of the turbo, a waste gate valve 8 is incorporated. The waste gate is operated by a pressure capsule 9 which is actuated by the boost pressure.

When the engine is running as seen in RR3637M, the exhaust gas A drives the turbine 3, which cause the compressor turbine 4 to accelerate the inlet air flow B to the combustion chambers. At low engine speeds the volume of extra air which the turbo provides, is usually insufficient to make a noticeable improvement in engine power. It is not until the engine approaches 2000 rev/min, that the benefit of a turbo can be appreciated.

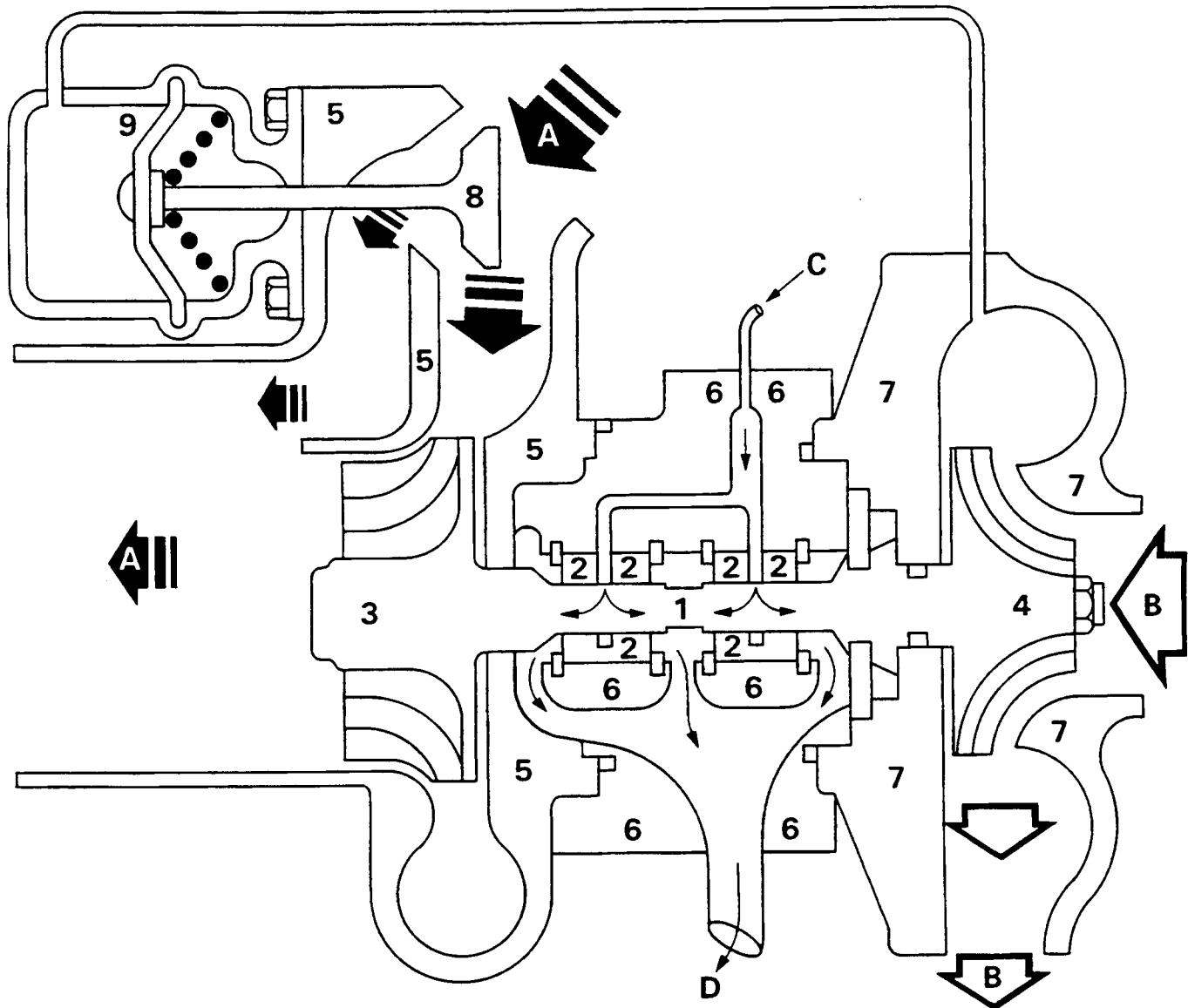


RR 2587M



RR3637M

Once the turbo begins to boost the engine rpm and power output, the improvement continues, to the extent that it becomes necessary to limit the gain. This is done automatically by the pressure capsule 9 which opens the waste gate valve 8 and diverts some of the exhaust gas away from the turbo, direct into the exhaust system, so acting as a regulator as shown in RR3638M.



RR3638M

### Lubrication

The turbo charger is supplied with filtered oil C under pressure, which lubricates, cools and stabilizes the fully floating bronze bearings 2.

Oil flows at a very high rate through the turbo which has a large diameter drain D, back to the engine sump.

When in operation the turbine shaft revolves at between 1,000 and 130,000 rev/min. Therefore it is very important that the lubricant is the correct type/grade, that it is well filtered and at the correct pressure.

### Intercooler

The intercooler is a cast aluminium radiator, situated in the air inlet system between, the turbo charger and the engine inlet manifold. It is located at the front of the vehicle and its purpose is to cool the air, which is heated as it is drawn through the turbo charger. Cooling the air in the inlet system, helps to recover some of the potential expansion of the air, which when it enters the combustion chambers, improves the combustion efficiency and power gain.





## ENGINE OIL PRESSURE TEST

### Service tools:

LRT-12-052 :-Pressure test equipment



**WARNING:** Use suitable exhaust extraction equipment, if test is being carried out in workshop.



**WARNING:** If vehicle has been running, engine oil will be hot, care must be taken when fitting equipment to prevent personal injury due to scalding.

### Test

1. Check lubricant is to correct level.
2. Place vehicle on a ramp.
3. Disconnect the battery negative lead.
4. Remove oil pressure warning light switch and fit test gauge.
5. Reconnect the battery negative lead.
6. Start and run engine to normal operating temperature.
7. At a steady engine speed of 4000 rev/min, minimum oil pressure reading should be - 3.5 kgf/cm<sup>2</sup>.



**NOTE:** Low oil pressure can effect performance of brake servo vacuum pump and turbocharger. *See Description and operation, Vacuum pump See Description and operation, Turbocharger*

## VACUUM PUMP TEST

If vacuum pump is suspected of producing insufficient vacuum - carry out following test:-



**WARNING:** Use suitable exhaust extraction equipment, if test is being carried out in workshop.

Disconnect brake servo hose at servo and connect a vacuum gauge with a maximum range of not less than 30 hg (1 bar). Start engine and check vacuum reading which should reach a minimum of 20 in hg (0,69 bar) within 30 seconds, at an engine speed of 2500 rev/min.

If there is no vacuum or reading is low, carry out following checks.

1. Check condition of brake servo hose for blockage.
2. Make a direct connection to pump and repeat test procedure.
3. Operating efficiency of vacuum pump depends on engine lubrication pressure - check pressure - if pressure is normal and pump is receiving lubricant - renew vacuum pump. **See Engine oil pressure test**

**ENGINE NOISE**

Excessive or obtrusive noise from engine compartment originates from four main sources:

**A. Exhaust/turbo**

The turbocharger assembly and exhaust system, each emit an unmistakable and characteristic noise which is easy to diagnose when a fault develops.

**B. External components**

External components emit the greatest variety of noises and those which are belt driven are also easy to diagnose, by simply disconnecting the appropriate drive belt.

**C. Fuel injection system**

Fuel injection system mechanical and hydraulic noises are more difficult to diagnose and a fault in the system can effect combustion noise 'Diesel Knock'.

**D. Engine internal mechanical**

Engine internal mechanical noises which can vary in volume and pitch and may be a combination of, tapping - knocking or rumbling, are the most difficult to diagnose.

A diesel engine generally emits more noise than a petrol engine, diagnosing the specific cause is much more difficult. Therefore, the following process and list of checks are presented in a logical sequence, in two stages 'Type of noise' and 'Location of noise'

Begin all diagnosis by carrying out stage 1 and 2, then go to - Noise symptoms A,B,C,D as appropriate.

**Stage 1 - Type of noise**

Confirm type of noise complained of, with owner/driver.

**Stage 2 - Location of noise**

Use stethoscope to locate source of noise and go to - Noise symptoms A,B,C,D, as appropriate.

**Noise symptoms - A****Exhaust/turbo**

1. Is exhaust system or gaskets blowing?  
YES - Rectify.  
NO - Continue
2. Is turbocharger excessively noisy? *See Description and operation, Turbocharger*  
YES - Check engine oil level. *See SECTION 10, Maintenance, Under vehicle maintenance See Engine oil pressure test*  
If necessary renew turbocharger. *See Turbocharger Fault Finding*  
NO - Go to Noise symptoms - B External components.

**Noise symptom - B****External components**

3. Does noise disappear with drive belts disconnected? *See SECTION 10, Maintenance, Service schedule*  
YES - Renew noisy component.  
NO - Go to Noise symptoms - C. Fuel injection system noise or Noise symptoms - D. Engine internal mechanical noise.

**Noise symptoms - C****Fuel injection system**

4. Is noise - mechanical? Hydraulic? or combustion? *See C1, C2 and C3 for noise diagnosis.* If necessary carry out all checks given in C1, C2 and C3, before making a positive diagnosis.

If fuel injection system is not suspected: Go to - Noise symptoms - D. Engine internal mechanical noise.



### C1. Fuel injection system - mechanical noise.

1. To confirm source of noise, check injection pump and each injector using a stethoscope. Release each injector pipe union one at a time, to cut out combustion and aid assessment of noise and its source.
2. Check fuel tank, sediment traps and filter for water and foreign matter contamination. Check fuel filter for evidence of metallic particles.

If diagnosis is not conclusive, go to - C2. Fuel injection system - hydraulic noise.

### C2. Fuel injection system - hydraulic noise.

1. To confirm source of noise, check injection pump and each injector, using a stethoscope. Release each injector pipe union one at a time, to cut out combustion and aid assessment of noise and its source.
2. Check that all injection pipes are correct length and type. Also ensure all pipes are correctly routed and are not stressed by misaligned clamps.
3. Hydraulic noise is usually caused by faulty injectors or incorrect operating pressures, check these before condemning injection pump.

If diagnosis is not conclusive, go to - C3. Fuel injection system - combustion noise.

### C3. Fuel injection system - combustion noise.

1. To confirm source of noise, check near each injector with stethoscope. Release each injector pipe union one at a time, to cut out combustion and aid assessment of noise source.
2. The most common causes of excessive combustion noise are, incorrect pump timing (over advanced), incorrect injector operating pressures or poor spray formation.

If diagnosis is not conclusive, repeat all checks beginning at C1 or go to:- Noise symptoms - D Engine internal mechanical noise.

### Noise symptoms - D

Engine internal mechanical noise.

Single or multiple, light tapping noise, particularly when engine is cold. *See Description and operation, Lubrication system*

1. Is engine oil level correct?  
NO - Top up to correct level. *See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids*  
YES - Continue.

2. Is lubricating pressure correct?  
NO - *See Engine oil pressure test*  
YES - Suspect valve operating mechanism. *See SECTION 10, Maintenance, Service schedule*

Heavy knocking noise (particularly on load and when engine is hot). *See Description and operation, Lubrication system*

1. Is engine oil level correct?  
NO - Top up to correct level. *See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids*  
YES - Continue.

2. Is lubricating pressure correct?  
NO - *See Engine oil pressure test*  
YES - Drain engine oil and filter, and examine for metallic contamination.

3. Is oil contaminated with metal particles?  
YES - Suspect faulty big end bearings.

To confirm diagnosis, release each injector pipe union one at a time, to cut out combustion and aid assessment of noise and its source.

If noise is not conclusively diagnosed, check security of flywheel and crankshaft front pulley. Release drive belts to reduce noise level and use a stethoscope to locate source of noise.

Heavy rumbling noise (particularly during hard acceleration) *See Description and operation, Lubrication system*

1. Is engine oil level correct?  
NO - Top up to correct level. *See LUBRICANTS, FLUIDS AND CAPACITIES, Information, Recommended lubricants and fluids*  
YES - Continue.
2. Is lubricating pressure correct?  
NO - *See Engine oil pressure test*  
YES - Drain engine oil and filter, and examine sediment for metallic contamination.
3. Is oil contaminated with metal particles?  
YES - Suspect faulty main bearings. If noise is not conclusively diagnosed, check security of flywheel and crankshaft front pulley. Temporarily release drive belts to reduce general noise level and use a stethoscope to locate source of noise.

---

## ENGINE STARTING PROBLEMS

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### Symptom - Engine fails to crank

1. Is battery in good state of charge?  
NO - *See INTRODUCTION, Information, Jump starting*  
YES - *See ETM, B1*
2. If problem is not diagnosed repeat tests, starting at 1.

### Symptom - Engine cranks but fails to start

1. Is cranking speed fast enough (120 rev/min)?  
NO - *See INTRODUCTION, Information, Jump starting*  
If necessary *See ETM, B1*  
YES - Continue.
2. Are heater plugs operating correctly?  
NO - *See ETM, A5*  
YES - Continue.
3. Is fuel supply, pump, tank ventilation and air intake systems in correct working order, or fuel contaminated?  
NO - *See FUEL SYSTEM, Repair, Fuel filter*  
*See FUEL SYSTEM, Repair, Fuel tank*  
*See FUEL SYSTEM, Repair, Fuel pump*  
YES - Continue.
4. Is there combustion in any of cylinders?  
NO - Check cylinder compressions.  
YES - If problem is not diagnosed repeat tests, starting at 2.



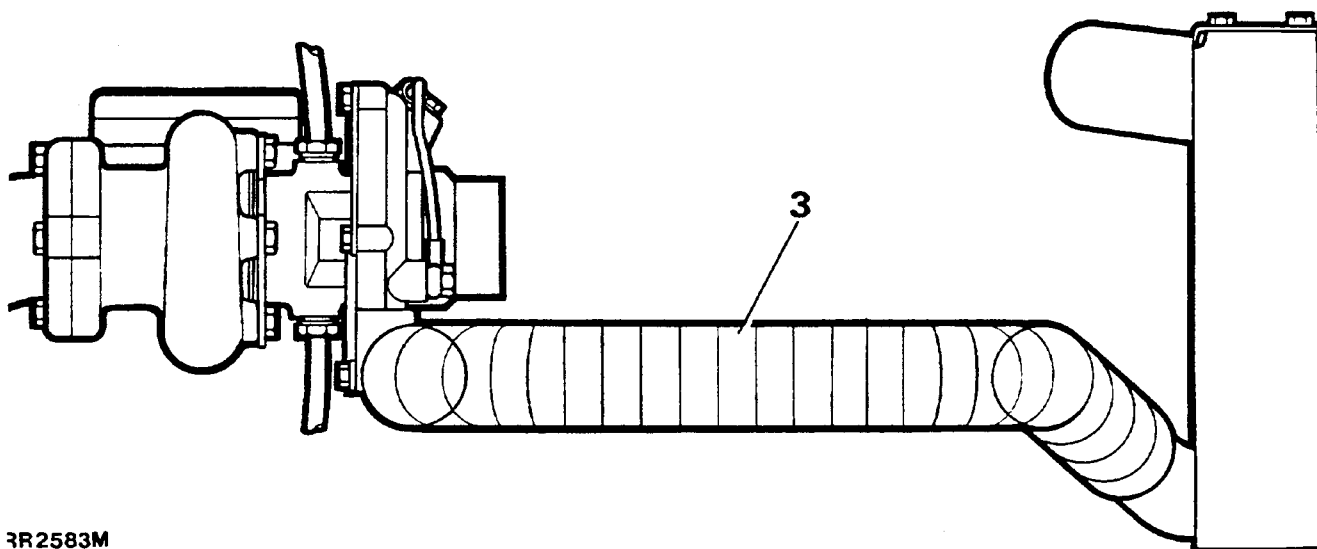
## TURBOCHARGER - CHECK

If the turbocharger unit is suspected of being faulty, the following simple test may be carried out. The assistance of a second operative is required to carry out this operation.

1. Open the bonnet.
2. Start the engine and allow it to idle.
3. Depress the turbocharger to intercooler feed pipe with one hand, the air pressure increase in the pipe may be detected as the second operative increases the engine revs.



**NOTE:** Although the above test indicates the operation of the turbocharger, it does not indicate its efficiency.



3R2583M

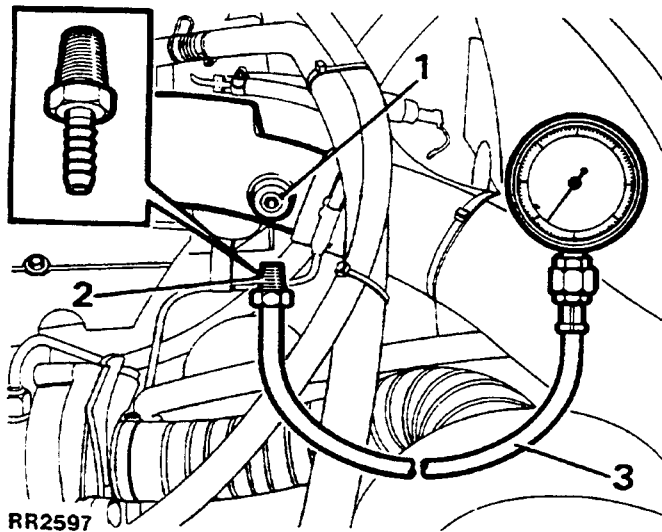
### TURBOCHARGER BOOST PRESSURE

#### Service tools:

18G.1116-1 Pressure test adaptor

#### Check

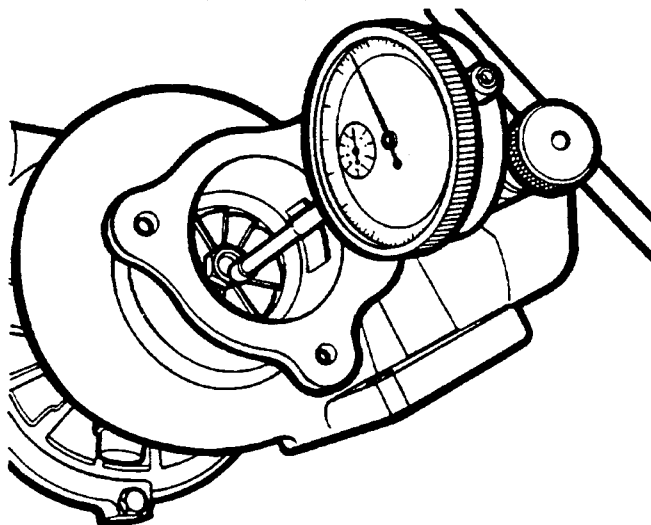
1. Remove the grub screw, located in the inlet manifold.



2. Insert adaptor 18G.1116-1 into the grub screw orifice
3. Attach a suitable pressure gauge, with sufficient length of tube to reach from the inlet manifold to the cab of the vehicle.
4. Drive the vehicle in 3rd gear at 3800 rev/min to give a satisfactory reading of 0.9 kg/cm

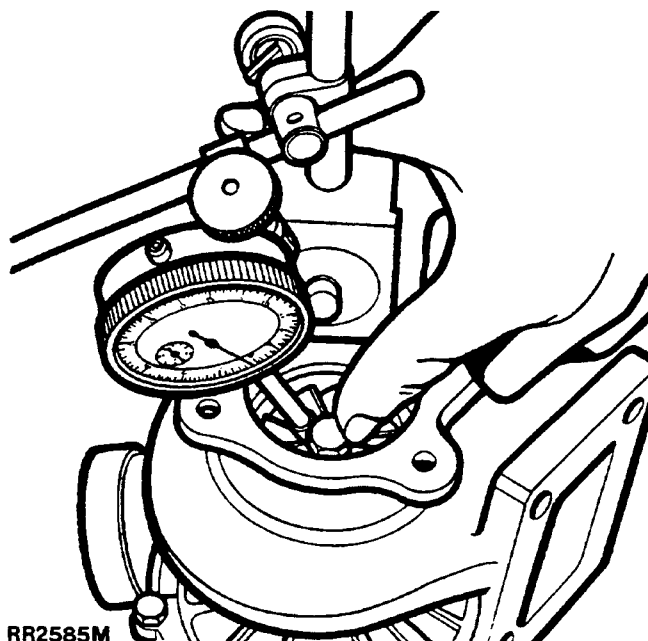
### TURBOCHARGER 'END FLOAT' CHECK

Use a dial test gauge and the set up shown in the diagram. Set the gauge to zero on the turbine wheel, and by moving the shaft in a linear motion the end play may be established. The maximum allowable end play is 0,15 mm (0.006 in).



#### Radial clearance

Push the turbine wheel to the extreme side position and set the dial test gauge to zero, on the indicator, as shown in the diagram. Check the side clearance of the turbine shaft by observing total radial movement of the turbine wheel. Maximum side clearance allowable is 0,42 mm (0.016 in).





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## AIR FILTER CHECK

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To ensure that the correct volume of air is supplied to the turbocharger unit, the air filter should be checked for cleanliness. Firstly remove the filter box from the securing brackets. Then remove the air filter from its housing. A visual inspection of the filter will verify its condition. Fit a new air filter if there are any signs of oil contamination or blockage of any description.

---

## TURBOCHARGER FAULT FINDING

---

As the exhaust gas drives the turbocharger, it is capable of speeds up to 130,000 rev/min and temperatures of up to 650°C. In order to ensure that the bearings are lubricated and cooled, the turbocharger is connected to the normal engine lubrication system. Obviously very high quality seals must be used in the turbocharger, to prevent lubricating oil entering the inlet or exhaust system.

Should oil leak past a seal into the exhaust system, dense pale blue smoke will be emitted continuously. If however the oil leaks into the inlet system it will be burnt at a higher temperature and produce a darker shade of blue smoke. The engine speed may also be permanently higher than normal, as the engine will burn the oil as extra fuel and an excessive oil leak in to the inlet system may even cause the engine to accelerate, however for this to occur the operator would have to ignore all earlier signs of impending trouble.

Blockage of the large oil drain pipe from the turbocharger, though very unlikely, is certainly the worst condition as oil under pressure would be forced past the seals and into both inlet and exhaust systems. If grey or black smoke is being emitted, the turbocharger may be partly blocked or the shaft may not be perfectly free to spin. This will cause a restriction in the air inlet and result in grey/black exhaust smoke, which usually increases at higher engine speeds.



**CAUTION:** If the driver is in the habit of accelerating the engine before switching the engine off, the turbine will continue to spin after the engine has come to rest and the lubrication to the turbine bearings ceased. It is therefore possible that this practice will cause damage or seizure of the bearings.

### Other symptoms of turbocharger faults

A change in the normal noise level is usually the first indication of a fault in the turbocharger or its hose connections. A higher pitched sound usually indicates a possible air leak into the suction side of the compressor and the inlet system, or an escape of compressed air between the compressor and the inlet manifold. Obviously an excessive escape of compressed air from the manifold is not only noisy but will also cause some loss of power.

Slight leaks from the turbine housing or exhaust manifold, whilst noisy, are easily detected and have little effect on the power output. Cyclic sounds (e.g. a continuous rubbing noise) are an indication of air restriction to the compressor or that the compressor wheel is coated in dirt.

If the waste gate valve sticks in the open position the engine will be down on power.

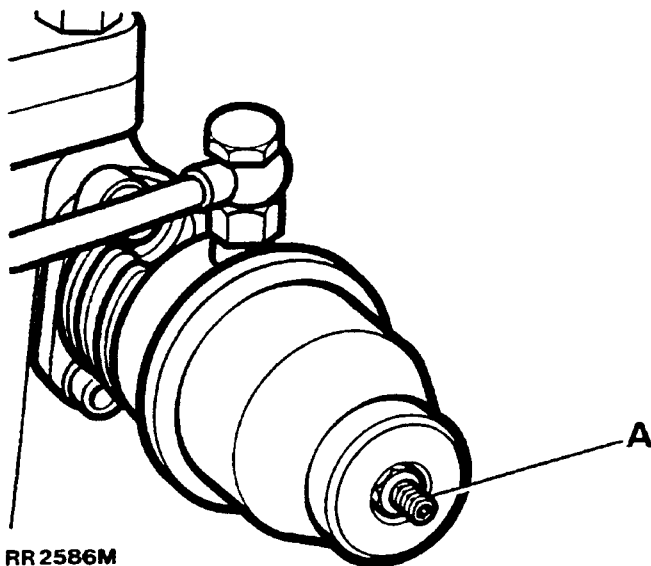


## WASTE GATE VALVE

The turbocharger waste gate diverts exhaust gas flow to by-pass the turbine when the boost pressure is higher than 0.9 kg/cm.

### Adjust

The boost pressure may be adjusted by loosening the lock nut and turning the screw marked 'A' in the diagram. Turn the screw clockwise to increase the spring load on the valve and consequently increase the boost pressure. Unscrew to decrease both spring load and boost pressure.



RR 2586M



**NOTE:** There is a small hole located in the waste gate housing. To ensure efficient operation of the waste gate diaphragm, it is necessary to clean this hole. A small piece of sturdy wire, or a similar object, is a suitable tool for this operation. Take care not to insert the wire too far in to the waste gate housing, as the diaphragm is made of a heat resistant rubber and is subsequently easily damaged.

## INJECTION PUMP TIMING

### Check and adjust

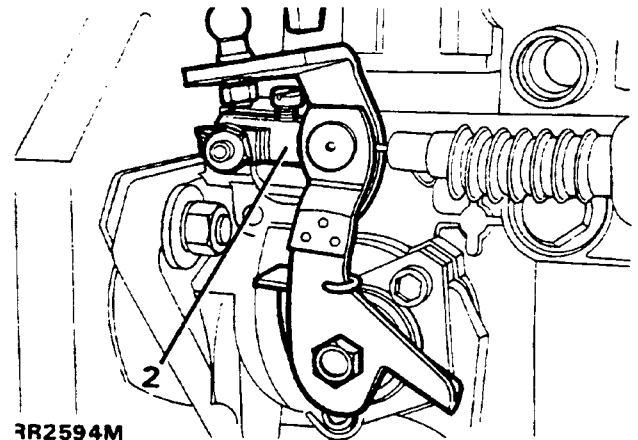
#### Service tools:

18G.1376 Timing adaptor

18G.1369A Timing gauge

When it has been established that the injection pump requires a timing check the following procedure should be followed.

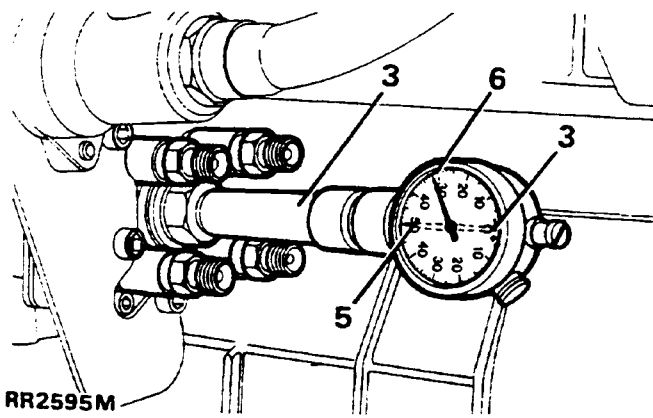
1. Attach the timing gauge 18G.1369A to the engine front cover. Rotate the engine until the mark on the crankshaft pulley lines up with the top dead centre TDC mark on the timing gauge.
2. Release the cable tensioner on the cold start mechanism to ensure an accurate result.



RR2594M

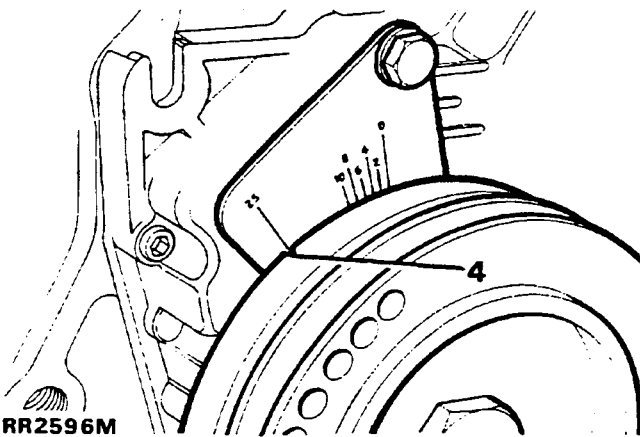
3. Remove the blanking plug from the rear of the pump assembly and insert adaptor 18G. 1376. Attach a dial test gauge to allow a reading to be obtained.





6. To adjust the dimension, slacken the three locking nuts, which secure the pump to the front cover. Then rotate the injection pump assembly until a correct reading has been established, retighten the locking nuts. As a double check the deflection on the dial test gauge should be a further 16-18 (0,16-0,18 mm) when the engine is turned to TDC.
7. When adjustment is complete remove the service tools and refit the blanking plug to injection pump and the engine front cover bolt.
8. Finally retension the cable on the cold start mechanism and tighten the retaining screw.

4. Rotate the engine again until the pulley mark is lined up with the 25° BTDC mark. The dial on the test gauge should then be zeroed. Ensure at this stage that there is sufficient pressure being applied to the stylus to give a deflection on the indicator.



5. The engine should be turned again to 3° BTDC and the needle deflection noted. A deflection of 50 (0,5 mm) should be read.



## CYLINDER HEADS

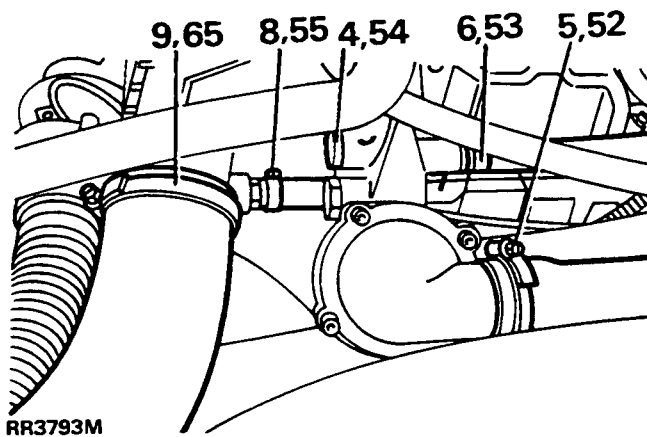
Service repair no - 12.29.01.



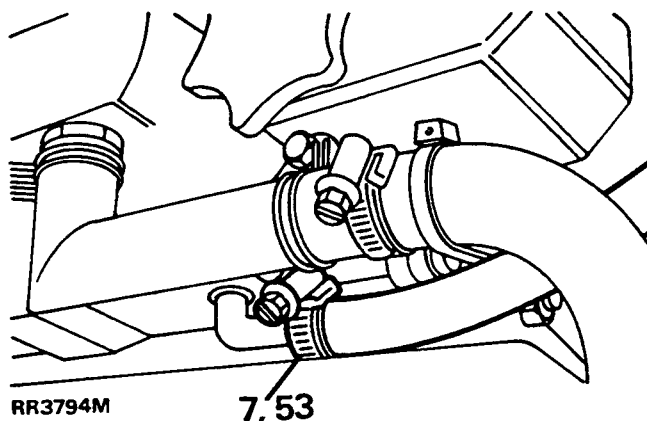
**NOTE:** Before removing cylinder heads check alignment of heads, evidence of head gasket or manifold gasket blowing and evidence of water leaks.

### Remove

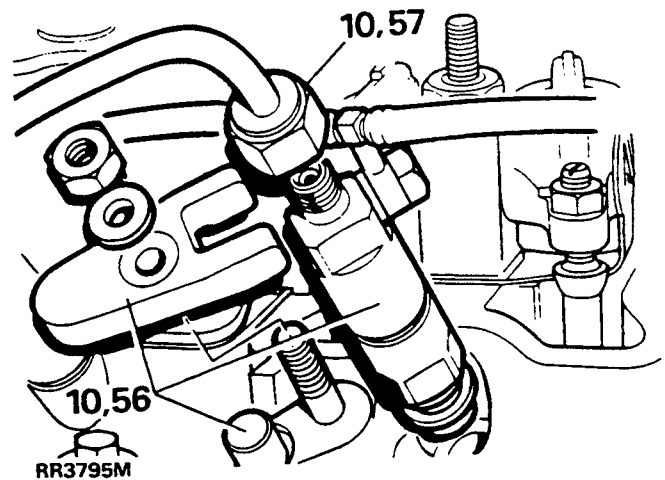
1. Disconnect the battery negative lead.
2. Remove expansion tank filler cap. Drain coolant.
3. Disconnect breather hoses from rocker covers. Disconnect brake servo hose.
4. Disconnect air conditioning temperature switch.



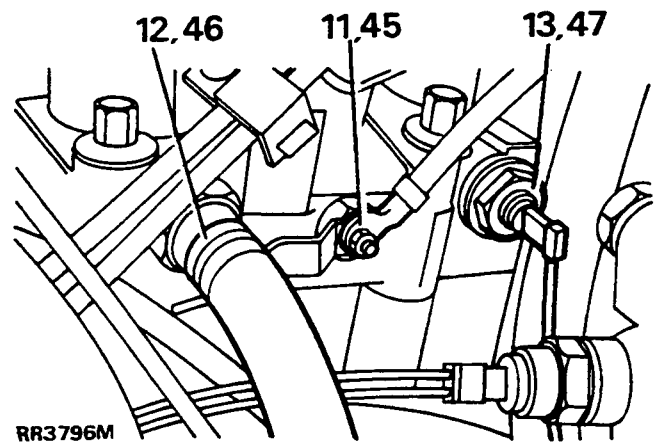
5. Disconnect by-pass hose and top hose at thermostat housing.
6. Disconnect cold start hose at water rail.
7. Disconnect bleed hose at water rail.



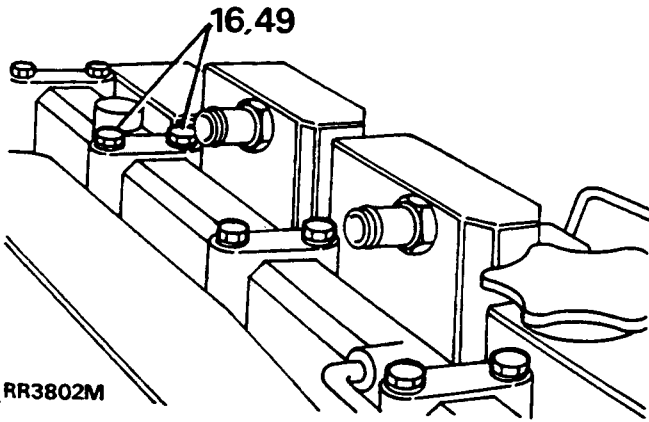
8. Disconnect vacuum pipe from inlet manifold.
9. Remove intercooler pipe.
10. Remove fuel feed pipes from injectors. Remove all injectors, with spill pipe, lay aside. Retain injector dowels.



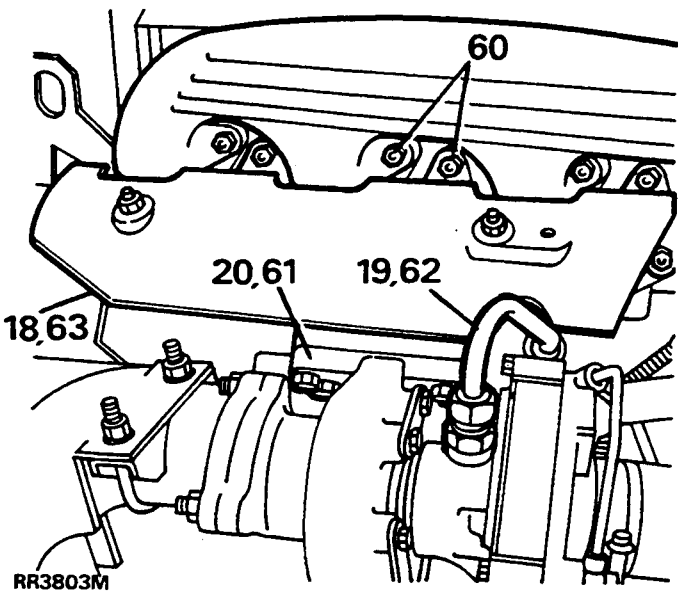
11. Remove heater plug feed wire.
12. Remove cold start hose from cylinder head.
13. Disconnect temperature sensor connector.



14. Remove rocker covers.
15. Remove rocker assemblies. Remove push rods, inspect.
16. Remove eight bolts securing water rail. Lay water rail aside on heater hose.
17. Remove oil feed banjo bolts from cylinder heads.



18. Remove exhaust heat shield.

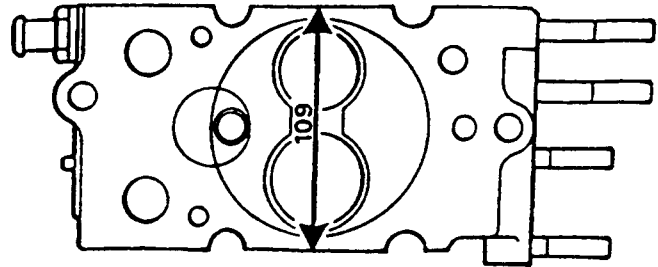


19. Remove turbocharger oil feed pipe
20. Remove four nuts securing turbocharger to exhaust manifold.
21. Remove outer cylinder head bolts.
22. Remove centre cylinder head bolts.
23. Lay cylinder head oil feed pipe against bulkhead.
24. Remove cylinder heads complete with manifolds.
25. Remove inlet and exhaust manifolds, discard gaskets. Inspect cylinder heads

**INSPECT CYLINDER HEADS**

Inspect cylinder heads, using the checks below. Any head that fails one or more check must be replaced with a new component, retaining those heads which pass all the checks.

- a) Minimum width - 109 mm.
- b) Height - 90 mm ± 0.05 mm.
- c) Inspect for cracks across valve bridge.
- d) Distortion of mating faces.



RR3810M

- e) Indentation of upper face caused by clamps.
- f) Coolant leakage.
- g) Measure end plate height - 91,26 to 91,43 mm.

If components pass above checks they may be refitted, using latest gasket and new centre bolts.

26. If new heads are being fitted, remove heater plugs, oil feed dowels, coolant adaptor and temperature transmitter. Fit these items to new cylinder heads. Fit new injector shrouds. Using an airline, check rocker oil feed drilling is free of obstruction.
27. Inspect gaskets, attempt to determine area of failure. Remove old gaskets from block. Thoroughly clean all traces of old gasket material from face of block. Check liner protrusion, **See LINER PROTRUSION CHECK**

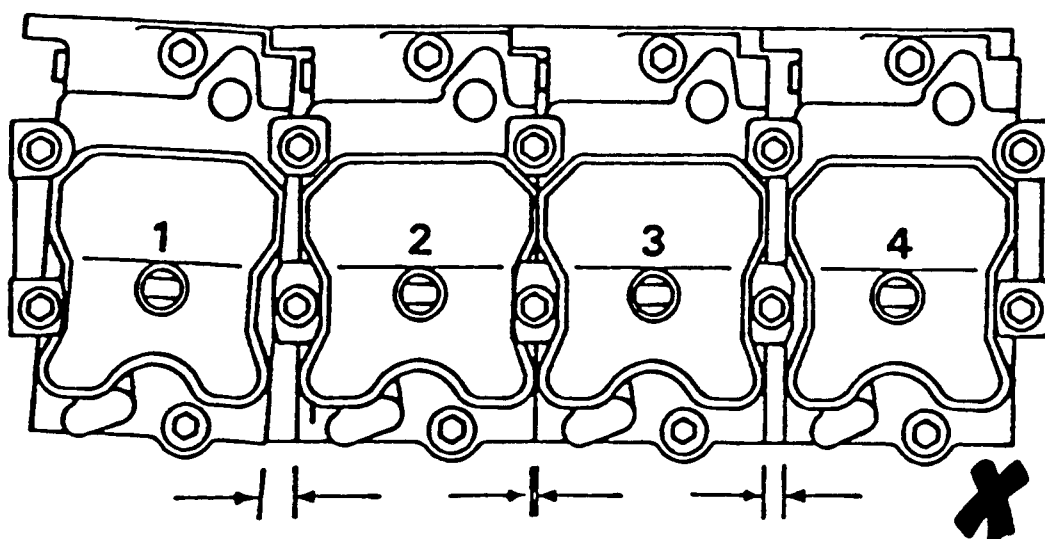
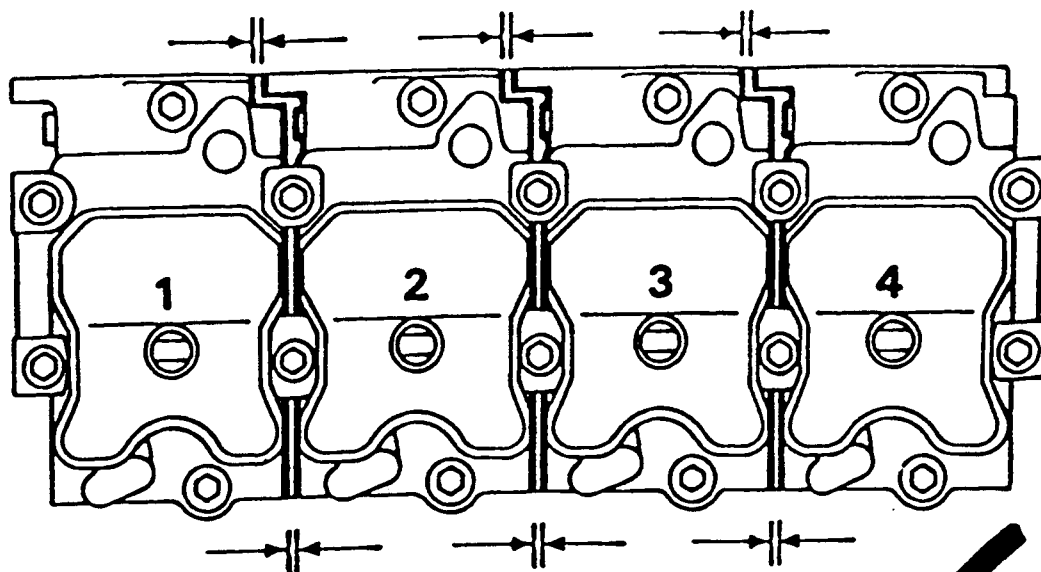


**WARNING: Failure to clean block face thoroughly could lead to head gasket failure.**

28. Remove oil filter, catching any oil spillage.
29. Remove fan assembly, left hand thread.

**Refit**

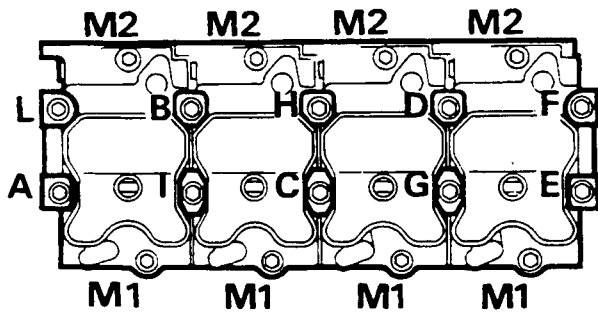
30. Fit inlet manifold loosely. Fit exhaust manifold loosely, fitting lifting eye.
31. Thoroughly clean face of new cylinder heads.
32. Determine thickness of head gasket required - **See HEAD GASKET SELECT** Fit gaskets to cylinder block correctly.



RR3809M

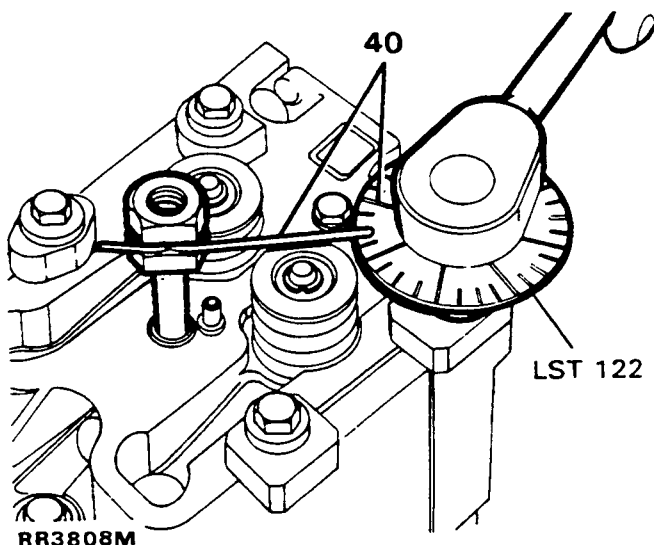
33. Fit cylinder head assembly to block, locating studs to turbocharger.
34. Align head assembly with gaskets.
35. Ensure head side holes align with gasket and holes in block. Gaps between heads should be parallel, see RR3809M.
36. Lubricate side bolts (without washers) with engine oil, fit loosely.
37. Ensure inlet manifold is fitted square to cylinder heads to bring heads into alignment.

38. Lubricate threads and underside of central bolt heads with Molybdenum Disulphide. Fit centre bolts loosely, with end plates at front and rear. Align oil feed pipe.
39. Partially tighten centre bolts, holding end plates flush with cylinder heads. Ensure gasket positions are square and have not moved.



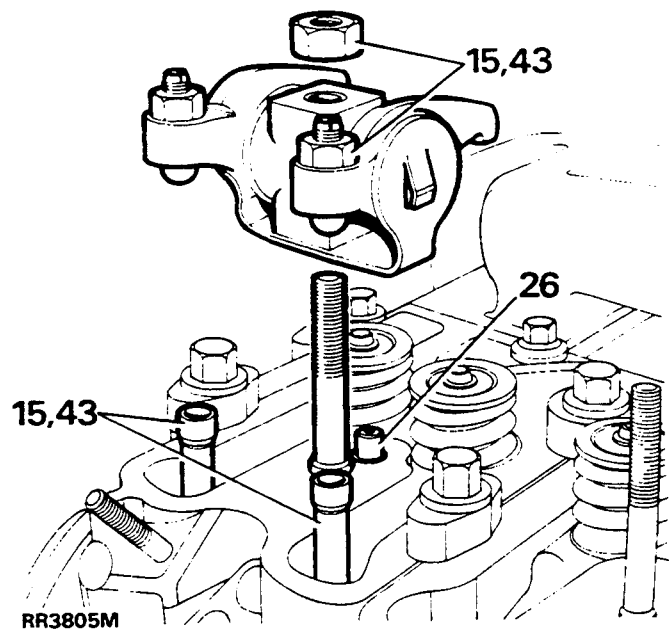
RR3804M

40. Centre bolts:
- Torque centre bolts to **30 Nm** in sequence shown, starting from bolt A. REPEAT procedure for each bolt.
  - Tighten each bolt through an angle of  $70^\circ$ , in sequence.
  - Tighten each bolt an additional  $70^\circ$  in sequence.
41. Torque side bolts to **80 Nm**, in the sequence bolts M1 then bolts M2.
42. Fit oil feed pipe, tighten bolts to **8 Nm**.



RR3808M

43. Fit push rods and rocker assemblies, tighten single fixing to **108 Nm**.



RR3805M

44. Adjust tappets.
45. Fit heater plug feed wire, tighten connector plates.
46. Fit cold start hose to cylinder head.
47. Connect temperature sensor connector.
48. Fit fan assembly.
49. Fit two rear bolts to water rail. Fit water rail attaching by-pass hose. Tighten eight bolts to **8 Nm**.
50. Tighten by pass hose clip.
51. Fit cold start hose to water rail, tighten clip.
52. Fit top hose, tighten clip.
53. Fit bleed hose to water rail, tighten clip.
54. Connect air conditioning temperature switch.
55. Connect vacuum pipe from inlet manifold, tighten clip.
56. Fit injectors with copper sealing washers. Locate dowels, tighten clamp nuts to **26 Nm**.
57. Fit fuel supply pipes to injectors, tighten to **19 Nm**.
58. Fit rocker covers, tighten to **9 Nm**.
59. Fit breather pipes to rocker covers. Connect brake servo hose.
60. Tighten exhaust and inlet manifold nuts to **32 Nm**.
61. Tighten four turbocharger to manifold nuts to **25 Nm**.
62. Fit and tighten turbocharger oil feed pipe.
63. Fit exhaust heat shield
64. Fit oil filter.
65. Fit intercooler pipe, tighten clip.



### Coolant refill

66. Remove coolant pipe from top of radiator.
67. Fill system through expansion tank until radiator is full.
68. Refit pipe to radiator and tighten.
69. Start engine, run until operating temperature is achieved, top up expansion tank as necessary.
70. Fit expansion tank filler cap, run engine for twenty minutes.

### Retorque cylinder heads

71. Allow engine to cool completely.
72. Drain coolant.
73. Remove rocker covers.
74. Remove water rail.
75. Centre bolts, starting with bolt A:
  - a) Loosen bolt, torque to **30 Nm**,
  - b) Tighten bolt through an angle of **120°**.



**NOTE:** 120° may be achieved by tightening through 60°, immediately followed by a further 60°. The total 120° **MUST BE ACHIEVED BEFORE** proceeding to next bolt.

- c) Repeat for each bolt in sequence shown.

76. Retorque outer bolts to **90 Nm. without loosening, first M1 then M2.**
77. Fit rocker assemblies, tighten single fixing to **108 Nm.**
78. Adjust tappets.
79. Fit water rail using new gaskets.
80. Fit hoses, tighten clips.
81. Check top up oil.
82. Refill cooling system. Run engine until operating temperature is reached, top up if necessary.

### RETORQUE CYLINDER HEADS

First 40,000Km (24,000 miles) only



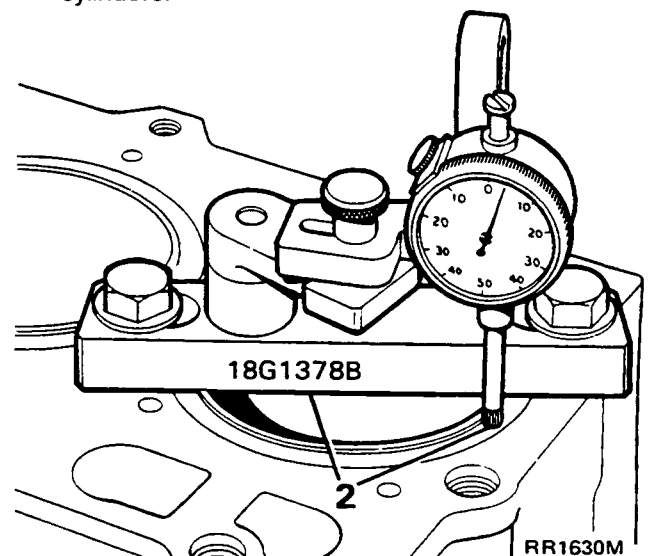
**NOTE:** These instructions must be carried out at the first 40,000 Km (24,000 miles) service **OR** 40,000 Km (24,000 miles)

**AFTER** the above procedure has been carried out. The use of new type gasket eliminates the need to retorque head bolts at 1,500 Km (1,000 miles).

1. Centre bolts, without slackening bolts, start with bolt A, tighten each bolt in sequence through 10 - 15°.
2. Side bolts: Without slackening bolts cheque that torque of each bolt is **85 - 90 Nm**. First M1 then M2.

### LINER PROTRUSION CHECK

1. Ensure face is clean
2. Correct reading:- 0,00 to 0,06 mm
3. To obtain the correct liner protrusion, attach special tool 18G 1378 B as illustrated, to the cylinder block and tighten the bolts to **30 Nm**. Fit a dial test indicator so that the stylus rests in a loaded condition on the external rim of the liner and set the dial to zero. Slide the stylus across to the cylinder block and note the reading. Repeat the above procedure to the remaining cylinders.



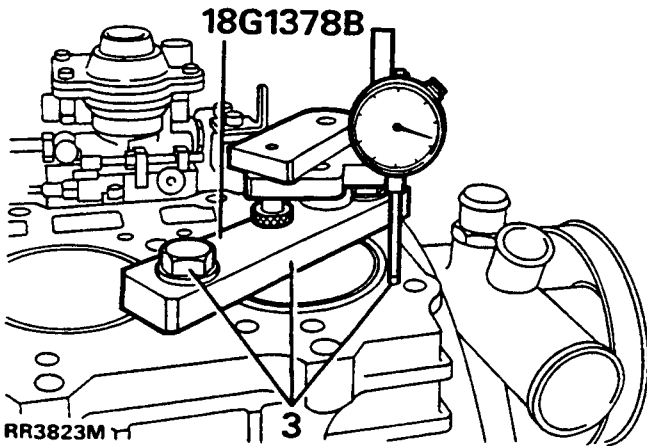
4. Remove the liners and add shims as required to achieve the protrusion.

**HEAD GASKET SELECT**

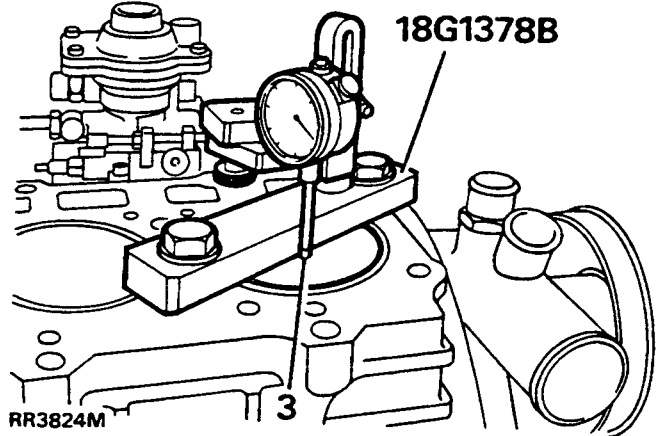
1. Before fitting the cylinder heads it is necessary to determine the thickness of gasket that must be used to achieve the correct clearance between each piston crown and cylinder head. Three thicknesses of gasket are available, see table below. The following procedure should be used to determine which size to fit. However, only one thickness of gasket must be used on all four cylinders, this being the one for the cylinder which calls for the thickest gasket.

Identification	Fitted thickness
No notch	1,42 mm ± 0.04
One notch	1,62 mm ± 0.04
Two notches	1,52 mm ± 0.04

2. Turn the crankshaft to bring number one piston to T.D.C.



3. Fit special tool 18G 1378B to the cylinder block and tighten the bolts to **30 Nm**. Attach the dial test indicator to the tool, as illustrated, and position the stylus, in a loaded condition, on the cylinder block and zero the gauge. Slide the indicator over so that the stylus rests on the piston crown and note the reading.



**Example**

Required piston clearance ..... 0,85 to 0,94 mm  
 Plus measured height ..... 0,60 to 0,60 mm

Thickness of gasket required ..... 1,45 to 1,54 mm

The nearest compressed thickness of gasket available is 1,52 mm

4. Repeat the above instruction on the remaining cylinders. The thickest gasket required is the one which must be fitted to all cylinders.



## VM ENGINE

Service repair no - 12.41.02.

Remove and refit

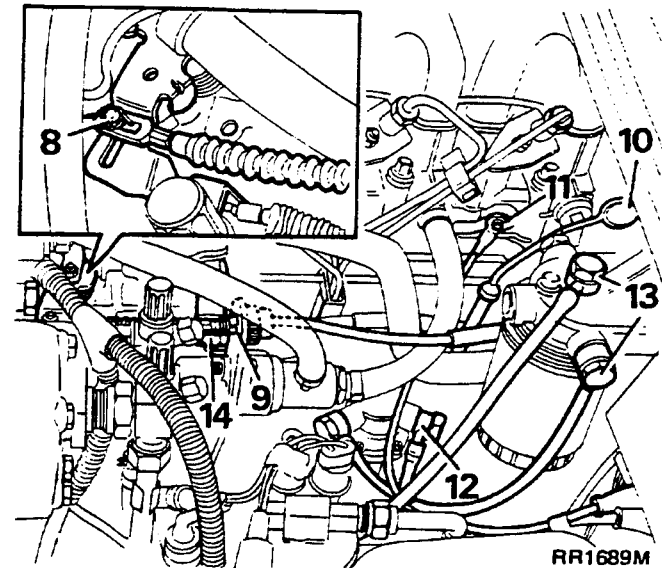
Remove



**CAUTION:** Seal all pipe ends against the ingress of dirt after disconnecting oil, fuel, fluid, vacuum or air conditioning pipelines.

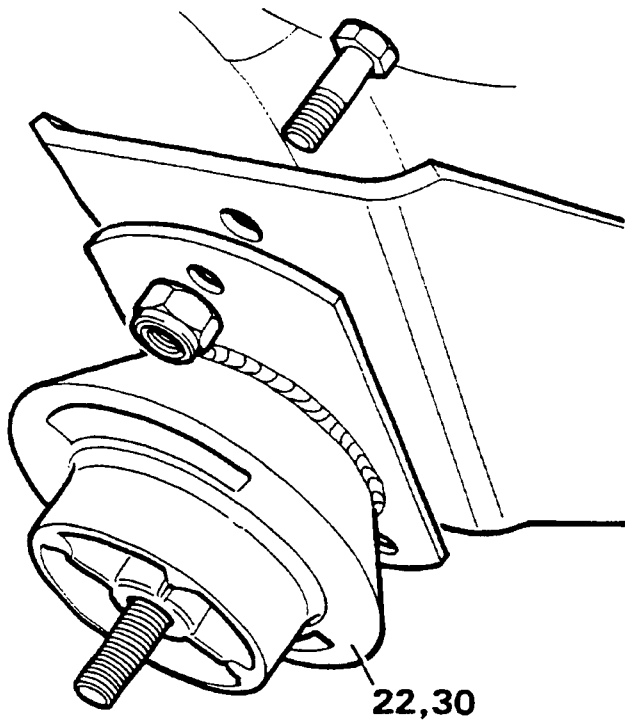
Remove

1. Remove the radiator and intercooler unit. The radiator unit has a built in engine oil cooler, access to the lower union is possible when the fan cowl is removed.
2. Remove the air cleaner assembly and connecting hoses.
3. Remove the power steering pump outlet and inlet hoses.
4. Disconnect the engine harness multiplug and, if the vehicle has air conditioning, the wiring to the compressor clutch.
5. (Air conditioning vehicles only) turn the high and low pressure compressor service valves to the OFF position (fully clockwise). Depressurise the compressor and remove the high and low pressure hoses.
6. Disconnect the heater return hose at the water pump and draw it clear.
7. Remove the heater inlet hose at the bulkhead connection.
8. Remove the split pin securing the inner throttle cable to the fuel injection pump.
9. Depress the tags on the outer cable adjusting screw to release the cable from the mounting bracket.
10. Disconnect the vacuum pipe from the vacuum pump.
11. Disconnect the glow plug feed wire.
12. Remove the main fuel line at the fuel pump, retaining the washers.

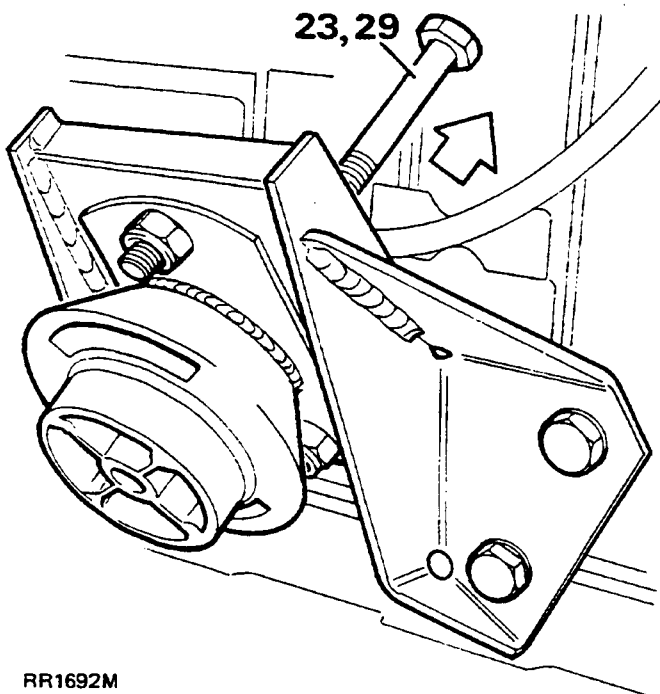


13. Remove the inlet and outlet fuel lines at the filter assembly.
14. Remove the spill return pipe union at the fuel injection pump.
15. Remove the exhaust manifold heat shield.
16. Release the exhaust flange nuts and disconnect the exhaust down pipe.
17. Remove the starter motor heat shield, wiring connections and fixings to the bell housing. Leave the starter motor attached to the engine block.
18. Remove one centre engine mounting nut from each side.
19. Remove the fixings securing the bell housing to the engine.
20. Attach a suitable lifting chain and hoist to the engine lifting hooks.
21. Raise the engine clear of the mountings and support the gearbox.
22. Remove the right hand engine mounting.





23. Remove the centre bolt from the left hand engine mounting.



24. Withdraw the engine from the gearbox and release the gearbox and transfer box breather pipes from their securing clip.  
25. Lift the engine clear of the vehicle.

### Refit

#### Before refitting the engine

Smear the splines of the primary pinion, the clutch centre and withdrawal unit abutment faces with molybdenum disulphide grease, Rocol MTS.1000. Smear the engine to gearbox joint faces with Hylomar jointing compound.

26. Attach a lifting chain and hoist to the engine lifting hooks.  
27. Lower the engine into the engine bay and locate the gearbox and transfer box breather pipes in their securing clip.  
28. Locate the primary pinion into the clutch and secure the engine to the bell housing with at least two bolts.  
29. Fit the left hand centre engine mounting bolt.  
30. Fit the right hand engine mounting and centre bolt.  
31. Lower the engine on to the mountings.  
32. Secure the fixings at both front engine mountings.  
33. Remove the lifting equipment and the gearbox support.  
34. Reverse removal procedure. 1 to 17.  
35. Prime the fuel system.

RR1692M



## DISMANTLING, OVERHAUL AND REASSEMBLY

Service repair no - 12.41.02

VM Diesel service tools See *Service tools, VM service tools*

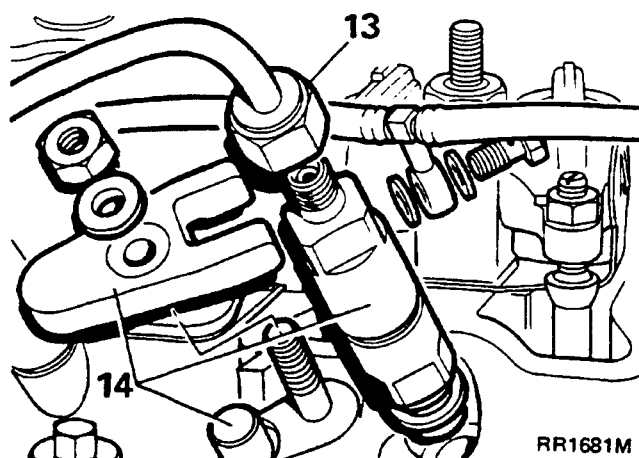
### DISMANTLING

#### Removing ancilliary equipment

Remove the engine from the vehicle. Clean the exterior and in the interests of safety and efficient working, secure the engine to a recognised engine stand and drain the oil from the sump. Before commencing make a careful note of the position of brackets, clips, harnesses, pipes, hoses, filters and other miscellaneous items to facilitate re-assembly.

1. Remove the alternator and mounting bracket.
2. Remove the starter motor.
3. Remove the power steering pump.
4. Remove the Air Conditioning Compressor and mounting brackets.
5. Remove the oil filter cartridge.
6. Remove the oil drain pipe from the turbo-charger and engine block union.
7. Remove the two socket headed bolts securing the turbo-charger support bracket to the cylinder block.
8. Disconnect the oil feed to the turbo-charger.
9. Remove the four bolts and release the turbo-charger from the exhaust manifold.
10. Remove the inlet and exhaust manifolds.
11. Remove the special nuts and lift off the four rocker covers and joint washers.
12. Release the six bolts and remove the coolant rail, complete with thermostat housing.
13. Disconnect the injector pipes from the injectors and injector pump.

14. Release the clamp nuts and remove the injectors complete with spill rail and collect the four dowels.



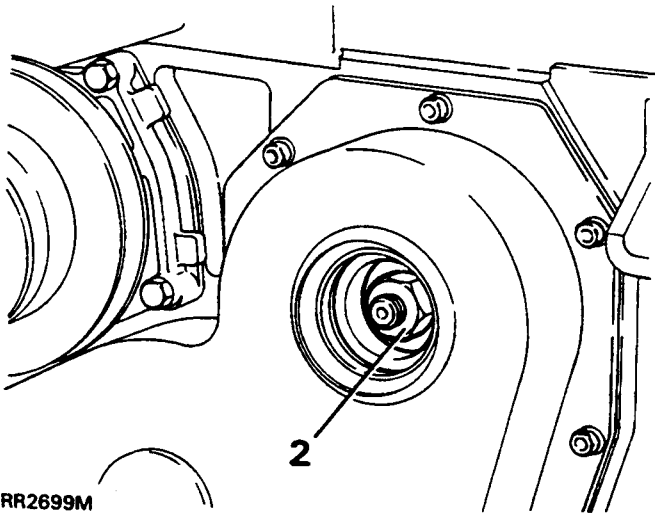
15. Turn the crankshaft in a clockwise direction to bring number one piston to T.D.C. on the firing stroke with number four cylinder valves on the "rock". This condition is necessary for removal of the injection pump at a later stage.
16. Remove the four single nuts and lift off each rocker assembly keeping them identified with their respective cylinder heads. Check that the oil feed dowels are in position in the heads and not inside the pedestals. Remove the push-rods.
17. Remove all cylinder head bolts and clamps. Lift off each cylinder head and gasket and number it according to the bore from which it was removed.
18. Withdraw the four bolts and remove the water pump complete with pulley.

#### Remove injection pump

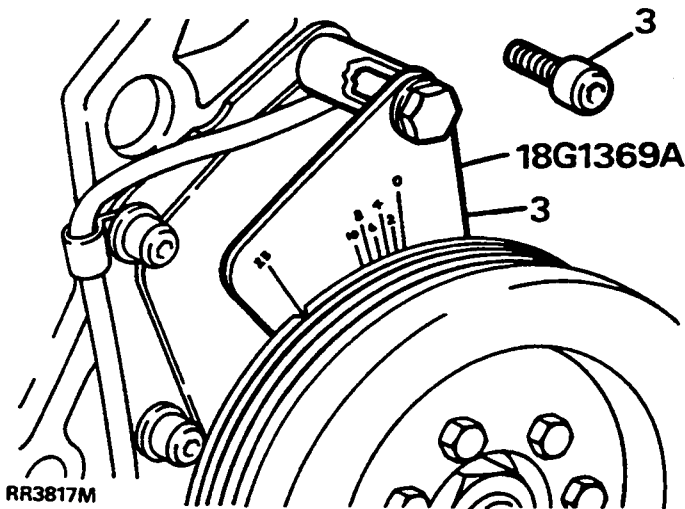
1. Using the pegged component, item 6 of special tool LST - 139 remove the injection pump drive gear access plate from front cover.
2. Remove the injection pump drive gear retaining nut and washer.



**CAUTION:** Ensure the washer is removed to prevent it from dropping inside the timing cover.

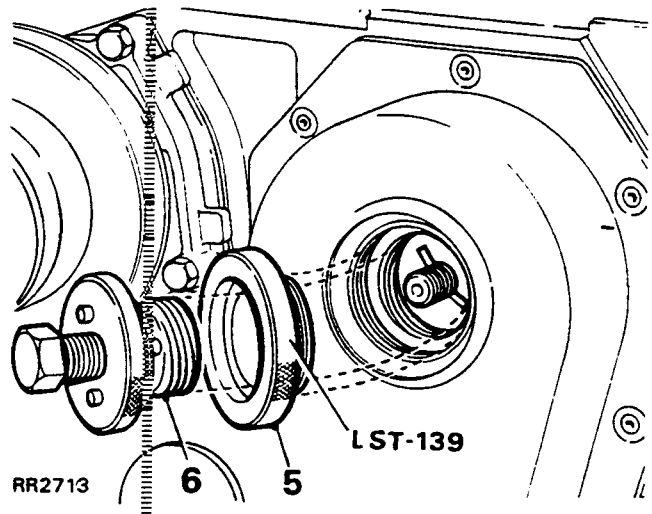


- Remove bolt from timing cover, using a 47 mm tube spacer and M6 x 55 mm bolt, fit timing gauge 18G 1369A to front cover. The 'O' on the scale should line-up with the groove in the crankshaft pulley.

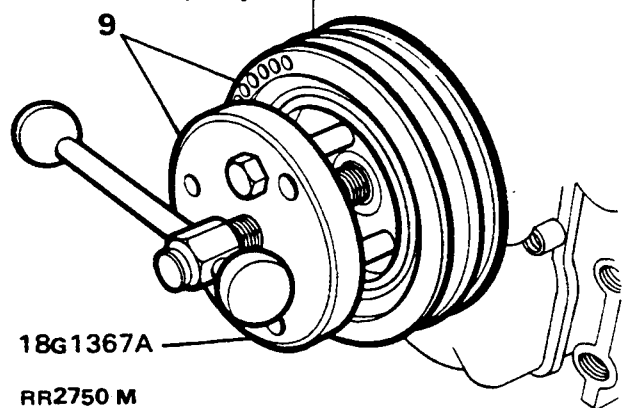


- Turn the crankshaft anti-clockwise, beyond the 25° mark on the scale, to remove backlash, and then turn it clockwise until the groove in the crankshaft pulley is aligned with the 25° B.T.D.C. mark.  
The key on the injection pump shaft should now be at the 11 o'clock position viewed from the front of the engine.

- Fit item 5 of special tool LST - 139 flush to the front cover. Lock the flywheel, and slacken the three nuts that secure the injection pump flange to the engine block.
- Fit item 6 into the injection pump drive gear. Ensure a flush fit against item 5 and the centre bolt is fully retracted.
- Turn the centre bolt of the tool until the gear releases from the taper. Retain the gear on the tool. Remove the injection pump retaining nuts and withdraw the pump complete with cold start device.



- Lock the flywheel and remove the crankshaft pulley securing nut.
- Using special tool 18G 1367A withdraw the crankshaft pulley.

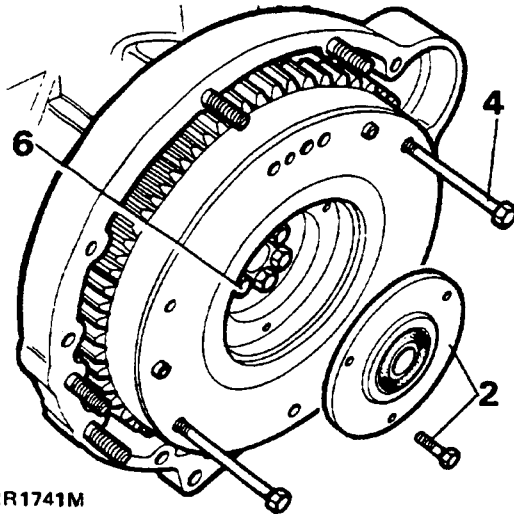


- Remove the timing cover with injection pump drive gear.
- Remove the special tool from the timing cover and injection pump drive gear.
- Reassemble the special tool LST - 139.



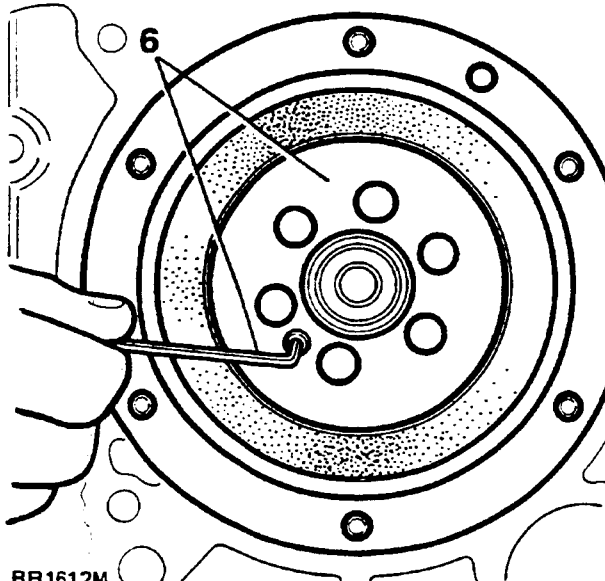
### Remove remaining components

1. Remove the clutch pressure plate and centre plate.
2. Remove the three bolts and withdraw the spigot bearing plate.
3. Remove the six bolts and lift off the flywheel.
4. To assist with the removal of the flywheel fit two 8 mm bolts approximately 100 mm (4.0") long into the clutch retaining bolt holes, diametrically opposite, and lift the flywheel from the engine.



RR1741M

5. Remove the nine bolts and six nuts and withdraw the flywheel housing.
6. Remove the single socket-headed screw and withdraw the crankshaft thrust plate and outer thrust washer halves.



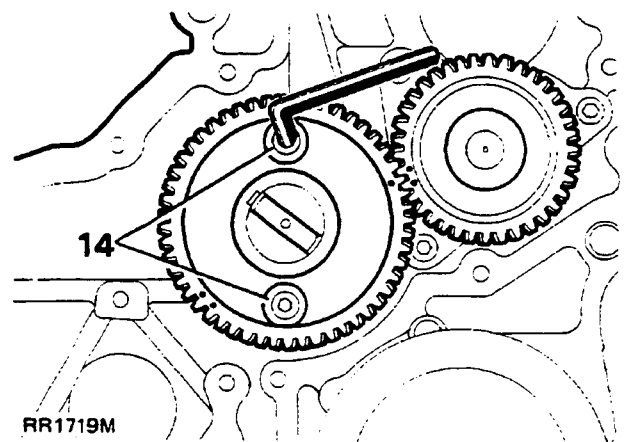
RR1612M

7. Remove the oil filter adaptor housing.
8. Remove the sump oil pan.
9. Remove the twenty-one screws and remove the sump.
10. Remove the three bolts and remove the oil pump pickup pipe and strainer and 'O' ring.



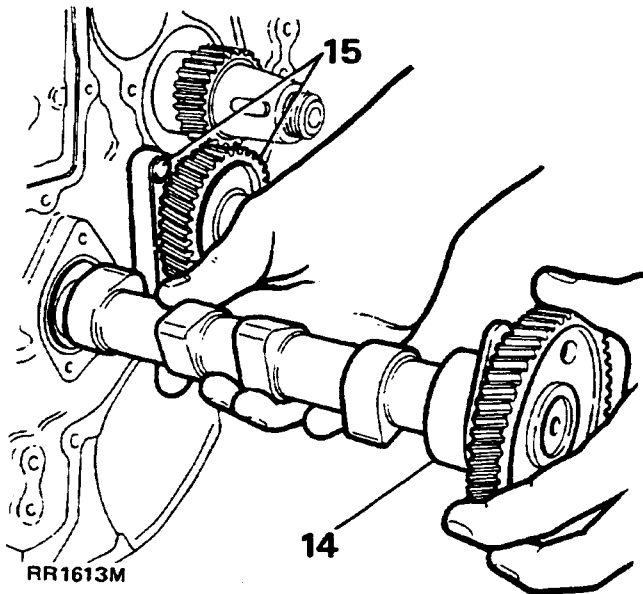
**NOTE:** Before performing the next instruction mark the top of each piston with the number of the bore commencing at the front of the engine. Unlike most engines the connecting rods are not numbered relative to the bores.

11. Turn the crankshaft to bring numbers one and four connecting rod caps to an accessible position. Remove each cap and lower bearing shell, in turn, and push the connecting rod and piston up the bore and withdraw from the top. Immediately refit the cap to the connecting rod with the number on the same side. Repeat the procedure for numbers two and three connecting rod assemblies.
12. Using a suitable piece of timber drift-out the rear main bearing carrier assembly complete with bearing shells and oil seal.
13. Remove the three screws retaining the oil pump to the crankcase and withdraw the pump complete with drive gear.
14. Position the cylinder block horizontal with the crankcase uppermost and remove the two screws securing the camshaft retaining plate to the cylinder block and carefully withdraw the camshaft complete with gear. It is necessary to have the cylinder block inverted so that the tappets will not drop, and foul the cams.

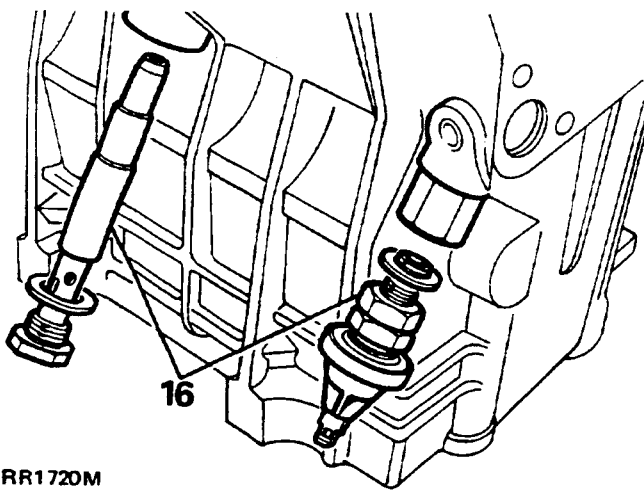


RR1719M

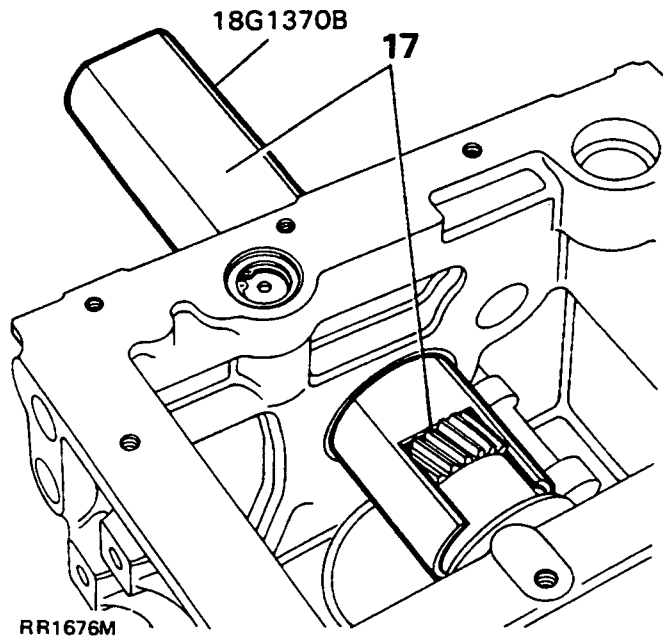
15. Remove the three screws and remove the vacuum pump and gear assembly.



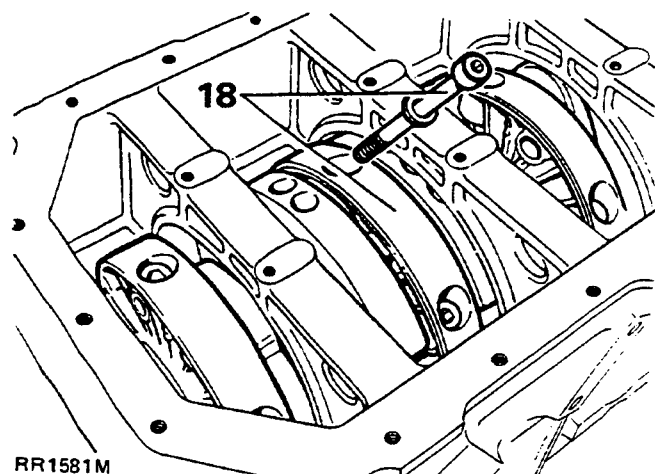
16. Mark for re-assembly and remove from the left hand side of the cylinder block the three main bearing oil feed and carrier location shafts, and identify for re-assembly. Remove the oil pressure switch.



17. To remove the crankshaft and main bearing carrier assembly from the crankcase, slide special tool 18G 1370B over the crankshaft gear, as illustrated, and with assistance withdraw the complete assembly rearwards.

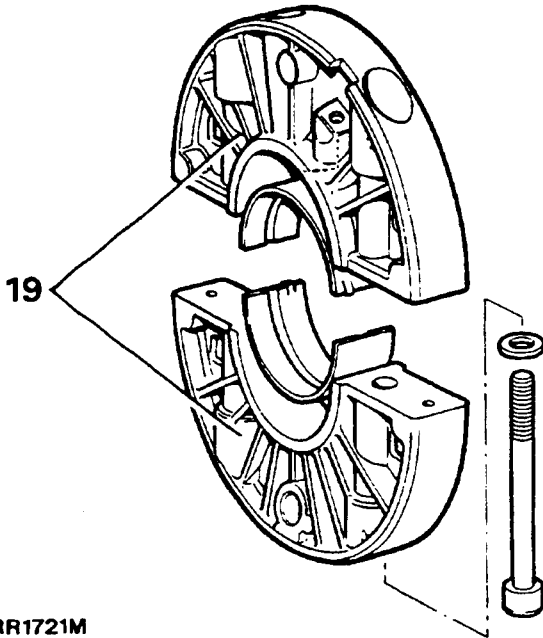


18. Should difficulty be experienced in removing the complete assembly as described above, slide the assembly rearwards sufficiently to gain access to the main bearing carrier bolts. Mark the carriers for assembly and remove the bolts, two for each carrier.

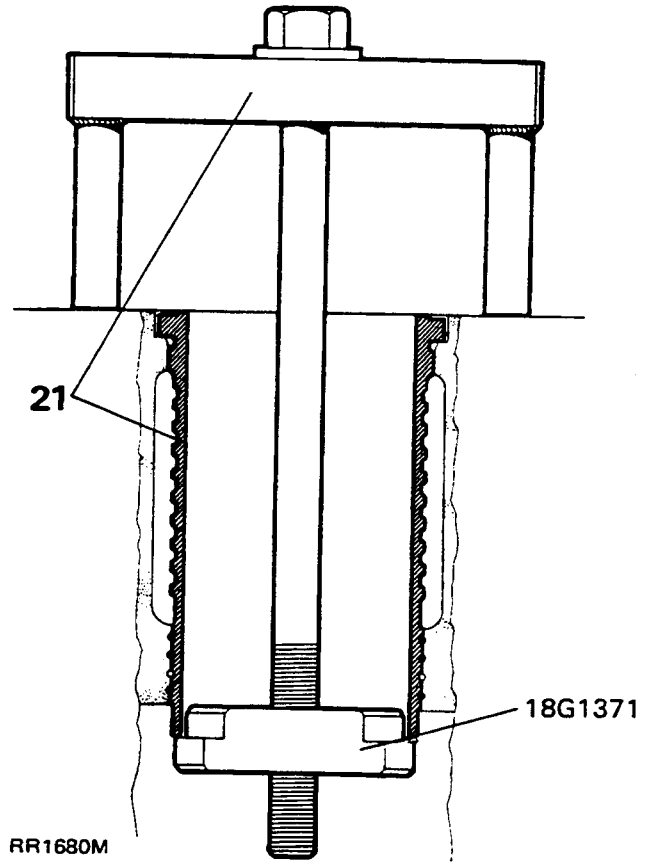




19. Separate the two halves of each carrier, remove from the crankshaft and temporarily re-assemble the carriers. Withdraw the crankshaft through the rear of the crankcase.



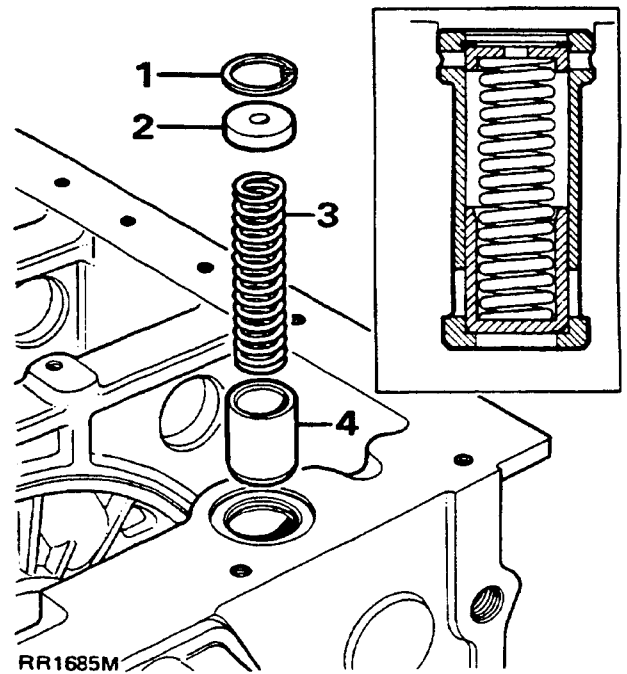
RR1721M



RR1680M

20. Remove the cam followers and identify for possible re-assembly to their original locations.  
 21. If after inspection it is necessary to renew the cylinder liners then they should be removed as follows: position special tool 18G 1371 as illustrated and turn the centre bolt clockwise to withdraw each liner from the cylinder block. Each liner is fitted with three red 'O' rings; the lower one for oil sealing and the others for coolant sealing. The shim under the lip is for achieving the correct protrusion of the liner above the cylinder block face.

22. Remove the pressure relief valve assembly by removing the circlip which will release the cap, spring and relief valve.



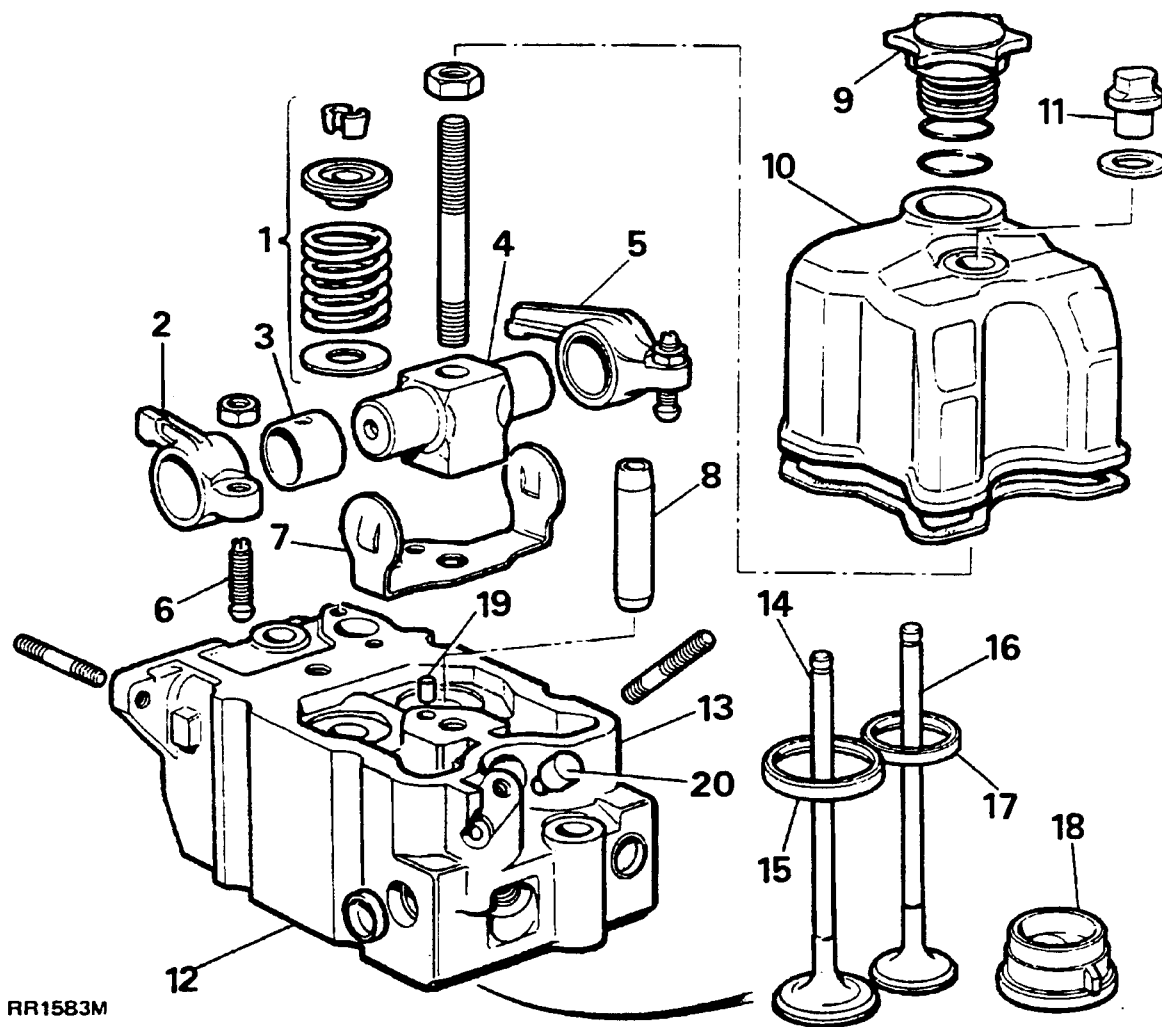
RR1685M

- |            |            |
|------------|------------|
| 1. Circlip | 3. Spring  |
| 2. Cap     | 4. Plunger |

## INSPECTION AND OVERHAUL OF COMPONENTS

### Cylinder head assemblies

Ensure that the marks made when the cylinder heads were removed are maintained and that during the following instructions the various parts of the cylinder heads are similarly identified.



RR1583M

Key to cylinder head and associated components.

- |  |  |
|--|--|
| 1. Valve spring, cap seat and cotters. | 11. Rocker cover nut.                  |
| 2. Inlet valve rocker.                 | 12. Cylinder head.                     |
| 3. Bush.                               | 13. Injector locating dowel.           |
| 4. Rocker shaft. (Pedestal)            | 14. Inlet valve.                       |
| 5. Exhaust valve rocker.               | 15. Inlet valve seat.                  |
| 6. Rocker adjusting screw.             | 16. Exhaust valve.                     |
| 7. Spring clip.                        | 17. Exhaust valve seat.                |
| 8. Valve guide.                        | 18. Pre-combustion chamber.(Hot plug.) |
| 9. Oil filler cap.                     | 19. Pedestal lubrication dowel.        |
| 10. Rocker cover.                      | 20. Injector clamp dowel               |



1. Using valve spring compressor 18G 106A or suitable alternative remove the collets, spring cups, springs and valves.
2. Remove the rocker arm pedestal stud and manifold studs.
3. Degrease and remove carbon deposits from the cylinder heads. Examine the cylinder head mating face for cracks pitting and distortion. Renew if necessary.

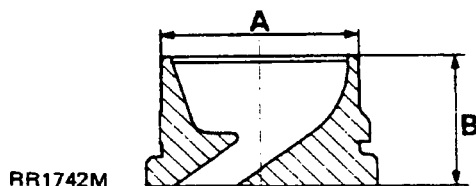
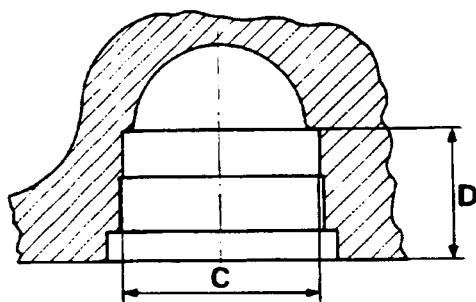


**CAUTION: The cylinder heads are plated therefore the face must not be machined.**

4. Cracked or burned hot plugs can be removed by heating the cylinder head uniformly in an oven to 150°C. Tap out the hot plug using a thin drift inserted through the injector hole. Clean-out the hot plug pocket in the cylinder head.
5. Measure the depth of seat (D) and the new hot plug height (B) to establish they meet the fitted tolerance detailed below. If necessary machine the outer face of the hot plug to suit.
6. To fit the new hot-plug cool in liquid nitrogen whilst maintaining the cylinder head at the above temperature fit the hot plug. Ensure that the small pip on the side of the hot plug locates in the groove in the side of the pocket. Allow the cylinder head to cool slowly.

A	Hot plug diameter	30,380 to 30,395 mm
B	Hot plug height	23,350 to 23,440 mm
C	Hot plug seat dia.	30,340 to 30,370 mm
D	Depth of seat	23,570 to 23,730 mm

Maximum protrusion above cylinder head    0,02 mm  
 Maximum depth below cylinder head        0,03 mm



RR1742M

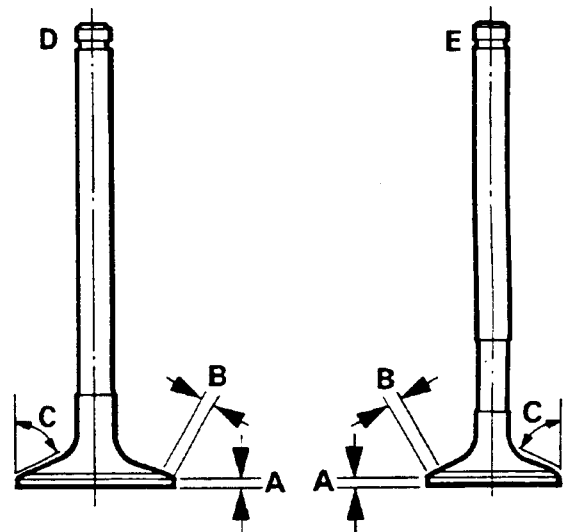
**Valves**

1. Clean the valves and renew any that are bent, have worn stems, or are burnt and damaged. Valves that are satisfactory for further service can be refaced. This operation should be carried out using a valve grinding machine. Only the minimum of material should be removed from the valve face to avoid thinning of the valve edge which must be not less than 1,30 mm (dimension A). Check the valves against the dimensions given in the data section. In addition dimensions B should be as follows:-

D Inlet valve	2,73 to 3,44 mm
E Exhaust valve	2,45 to 3,02 mm

**Angle C**

Of inlet valve D. ....	55° 30'
Of exhaust valve E. ....	45° 30'

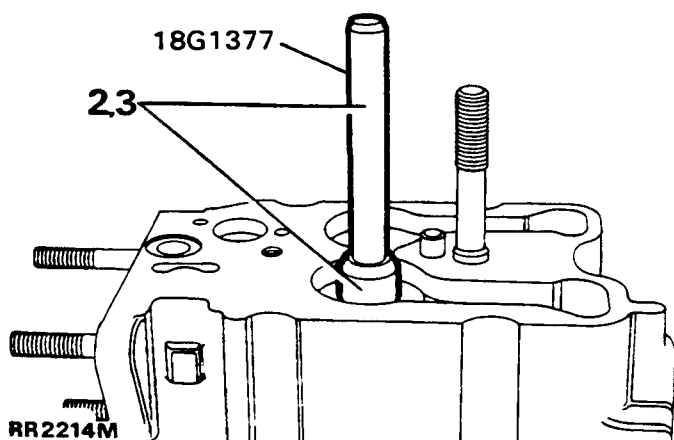


RR1702M



## Valve guides

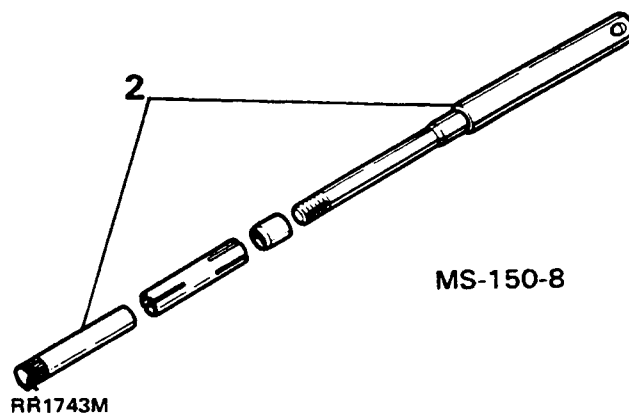
1. Visually examine the guides for damage, cracks, scores and seizure marks. Insert the appropriate servicable or new valve in the guides and check that the stem-to-guide clearance is within the tolerance given in the data.
2. To renew valve guides, heat the cylinder head to a temperature of between 80°C and 90°C and using special tool 18G 1377 without height gauge 18G 1377/2 press the guides out through the top of the cylinder head.

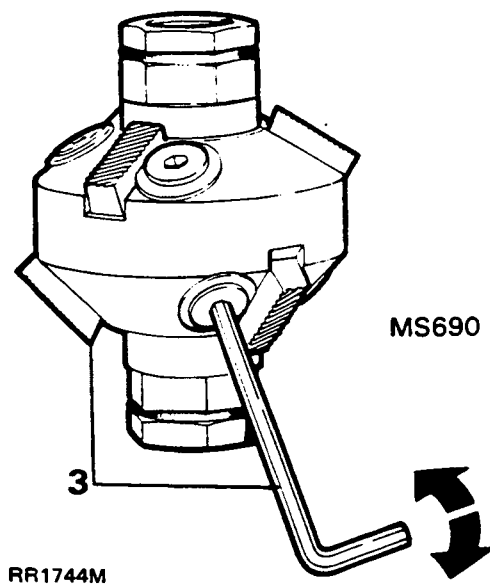


3. Whilst maintaining the above temperature and using the same tool, but with height gauge 18G 1377/2 drive-in new guides from the top of the cylinder head to the distance determined by the gauge or to dimensions in the data.

## Valve seat inserts

1. Examine the valve seat inserts for damage, wear and cracks. the seats can be restored provided they are not abnormally wide due to refacing operations. If the seat cutting operation, however, excessively lowers the valve recess or if the seat cannot be narrowed to within the limits given in the data, the insert should be renewed.
2. To recut an inlet valve seat use an expandable pilot M.S. 150-8 loosely assemble the collet, expander and nut. Ensure that the chamfered end of the expander is towards the collet. Insert the assembled pilot into the valve guide from the combustion face side of the cylinder head until the shoulder contacts the valve guide and the whole of the collet is inside the valve guide. Expand the collet in the guide by turning the tommy bar clockwise whilst holding the knurled nut.





3. Select cutter MS 690 and ensure that the cutter blades are correctly fitted to the cutter head with the angled end of the blade downwards facing the work, as illustrated. Check that the cutter blades are adjusted so that the middle of the blade contacts the area of material to be cut. Use the key provided in the hand set MS 76.
4. Fit the wrench to the cutter head, apply it to the seat to be refaced and turn clockwise using only very light pressure. Continue cutting until the width of the seat is in accordance with the dimension J in data.
5. To check the effectiveness of the cutting operation use engineer's blue or a feeler gauge made from cellophane.
6. Smear a quantity of engineer's blue round the valve seat and revolve a properly ground valve against the seat. A continuous fine line should appear round the valve. If there is a gap of not more than 12 mm it can be corrected by lapping.
7. Alternatively, insert a strip of cellophane between the valve and seat, hold the valve down by the stem and slowly pull out the cellophane. If there is a drag the seal is satisfactory at that spot. Repeat this in at least eight places. Lapping in will correct a small open spot.

8. Perform the above instructions to recut an EXHAUST valve seat using cutter MS 621 until the seat width is in accordance with dimension D in data. Check that the valve head recess is within the data limits.
9. To remove either an inlet or exhaust valve seat, hold the cylinder head firmly in a vice, wear protective goggles and grind the old insert away until thin enough to be cracked and prised out. Take care not to damage the insert pocket. Remove any burrs and swarf from the pocket. Failure to do this could cause the new insert to crack when being fitted.
10. Heat the cylinder head, uniformly in an oven, to a temperature of 150°C cool the new seat insert by dipping into liquid Nitrogen. This will enable the seat to be positioned without the use of pressure. Allow the cylinder head to cool naturally to avoid distortion.

#### Lapping in valves

1. To ensure a gas tight seal between the valve face and the valve seat it is necessary to lap-in the appropriate valve to its seat. It is essential to keep the valve identified with its seat once the lapping in operation has been completed.
2. Unless the faces to be lapped are in poor condition it should only be necessary to use fine valve lapping paste. Smear a small quantity of paste on the valve face and lubricate the valve stem with engine oil.
3. Insert the valve in the appropriate guide and using a suction type valve lapping tool employ a light reciprocating action while occasionally lifting the valve off its seat and turning it so that the valve returns to a different position on the seat.

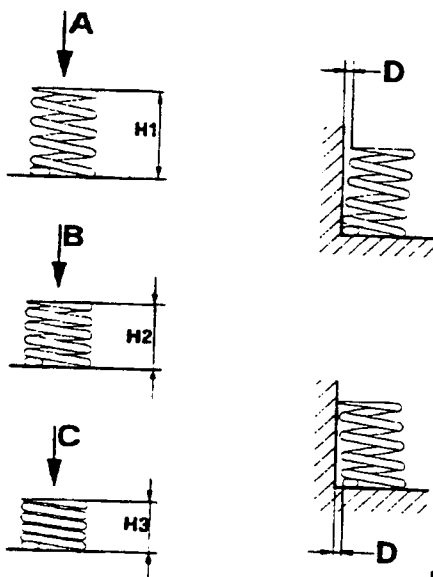
4. Continue the operation until a continuous matt grey band round the valve face is obtained. To check that the lapping operation is successful, wipe off the valve paste from the valve and seat and make a series of pencil lines across the valve face. Insert the valve into the guide and while pressing the valve onto the seat revolve the valve a quarter turn a few times. If all the pencil lines are cut through no further lapping is required.
5. Wash all traces of grinding paste from the valves and cylinder head seats.

**Valve springs.**

1. Examine the valve springs for damage and overheating and discard any that are visually faulty.
2. New and used valve springs, in the interests of uniformity, should be subjected to load and height tests as shown in the table and diagram below.

The amount of distortion D must not exceed 2,0 mm (0.078 in).

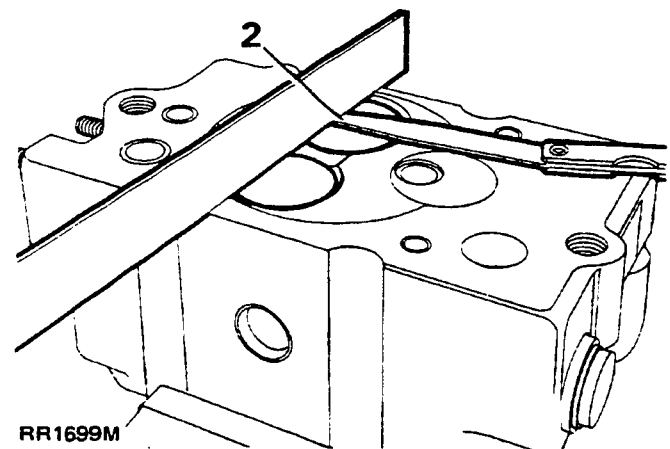
	Test load (Kg)	Height (mm)	Condition
A	0.00	H1	Free height
B	33-35	H2	Closed valve
C	88-94	H3	Open valve



RR1745M

**Assembling the cylinder head**

1. Assemble the valves to their respective positions in the cylinder head. Fit the spring plates, springs and cups and secure the assembly with the split collets using valve spring compressor 18G 106A or equivalent.
2. Using feeler gauges check the inlet and exhaust valve head stand down i.e clearance of valve heads below cylinder head combustion face, see data.



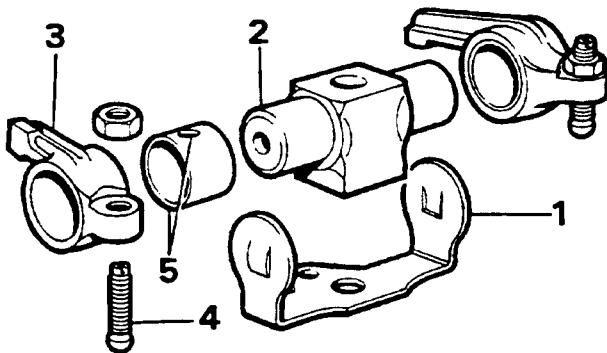
RR1699M

3. When renewing the cylinder head water jacket plugs secure them in position with Loctite 601
4. Renew the manifold retaining studs and when fitting a new pedestal stud secure it with Loctite 270.
5. Fit the rocker pedestal location and lubrication dowel into each cylinder head and ensure that the oil hole is clear. Place the heads to one side ready for assembly to the cylinder block at a later stage.



### Rocker assembly and push rods.

1. Remove the spring clip and slide the rockers from the shaft.
2. Clean and examine the rocker shafts and check for ovality, overall wear taper, and surface condition. Compare the dimensions with those given in data.
3. Examine the rockers and renew any that have worn rocker pads. It is not permissible to grind a pad in an attempt to restore a rocker.
4. Examine the rocker adjusting screws and renew any that are worn.
5. Check the internal dimensions of the bushes against the figures in data. If necessary renew the bushes ensuring that the oil hole in the bush aligns with the hole in the rocker arm. Check that the rocker arm to shaft clearance is within the figures in data.
6. Assemble the rocker-arms to the shaft noting that they are handed and that when assembled the pad ends point inwards. Retain the assembly with the spring clip and place to one side for fitting to the cylinder head at a later stage.

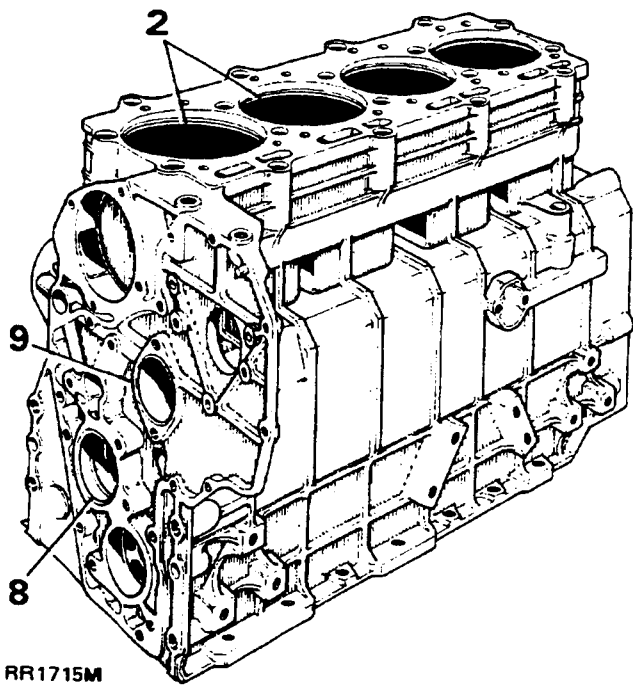


RR1688M

7. Examine the push rods and discard any that are bent or have worn or pitted ends.

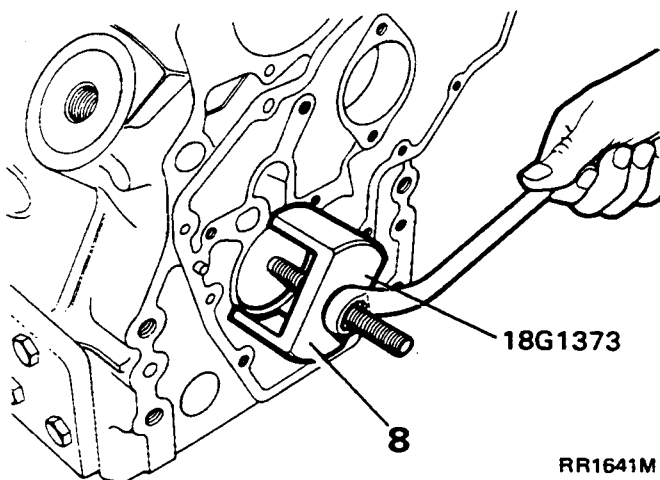
### Cylinder block

1. Clean the cylinder block with kerosene or suitable solvent and blow dry with compressed air all oil passages and water ways. Carry out a careful visual examination checking for cracks and damage.
2. Measure the cylinder liner bores for ovality, taper and general wear using any suitable equipment. An inside micrometer is best for checking ovality and a cylinder gauge for taper.
3. Check the ovality of each bore by taking measurements at the top of the cylinder just below the ridge at two points diametrically opposite. The difference between the two figures is the ovality of the top of the bore. Similar measurements should be made approximately 50 mm (2.0 in) up from the bottom of the bore so that the overall ovality may be determined.
4. The taper of each cylinder is determined by taking measurements at the top and bottom of each bore at right angles to the gudgeon pin line. The difference between the two measurements is the taper.
5. To establish maximum overall bore wear, take measurements at as many points possible down the bores at right angles to the gudgeon pin line. The largest recorded figure is the maximum wear and should be compared with the original diameter of the cylinder liner. (See **Section 04** General specification data).
6. If the cylinder bores are excessively worn outside the limits the cylinder liners must be renewed. **See ASSEMBLING ENGINE**
7. Alternatively, if the overall wear, taper and ovality are well within the acceptable limits and the original pistons are serviceable new piston rings may be fitted. It is important however, that the bores are deglazed, with a hone, to give a cross-hatched finish to provide a seating for the new rings. It is vital to thoroughly wash the bores afterwards to remove all traces of abrasive material.



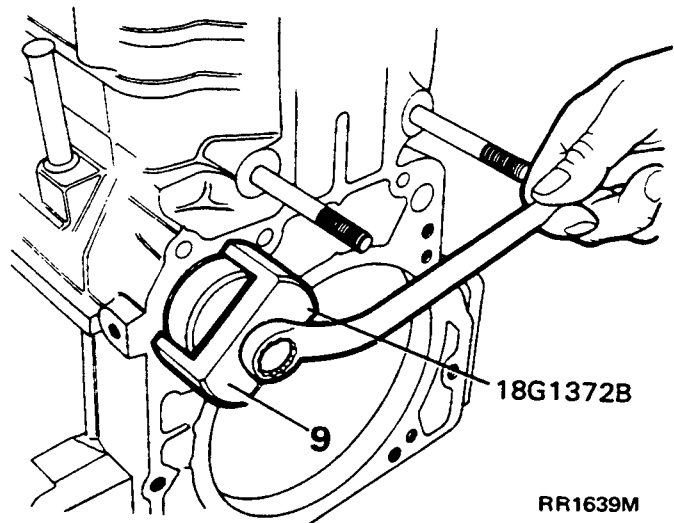
RR1715M

8. Using an inside micrometer check the front main bearings for general condition, overall wear, taper and ovality. If outside the limits given in data remove the bearing. Use special tool 18G 1373 to renew the bearing. See **ASSEMBLING ENGINE**



RR1641M

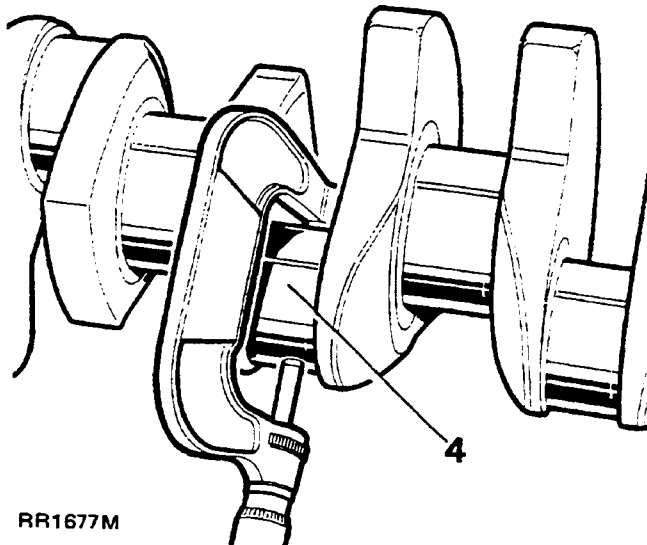
9. Measure the internal diameter of each camshaft bearing at several points using an internal micrometer. A comparison of the bearing diameters with those of the respective camshaft journals will give the amount of clearance. The bearings should be renewed if the clearance is excessive or if they are scored or pitted. Use special tool 18G 1372B as illustrated, to remove the bearings.



RR1639M

### Crankshaft

1. Identify for reassembly and remove the main bearing carriers from the crankshaft.
2. Degrease the crankshaft and clear out the oil ways, which can become clogged after long service.
3. Mount the crankshaft on "V" blocks and examine visually, the crankpins and main bearing journals, for obvious wear, scores, grooves and overheating.
4. With a micrometer, measure and note the ovality and taper of each main bearing journal and crankpin as follows:
  5. Ovality - Take two readings at right-angles to each other at various intervals.
  6. Taper - Take two readings parallel to each other at both ends of the main bearing journal and crankpin.



RR1677M

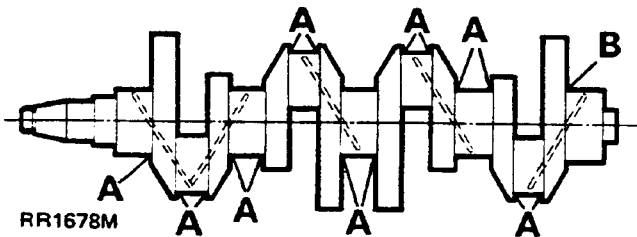
- To fit a new gear, heat in an oven to 180°C to 200°C, and press-on to the shaft up to the shoulder. Fit a new key for the crankshaft pulley.

**Crankshaft carriers**

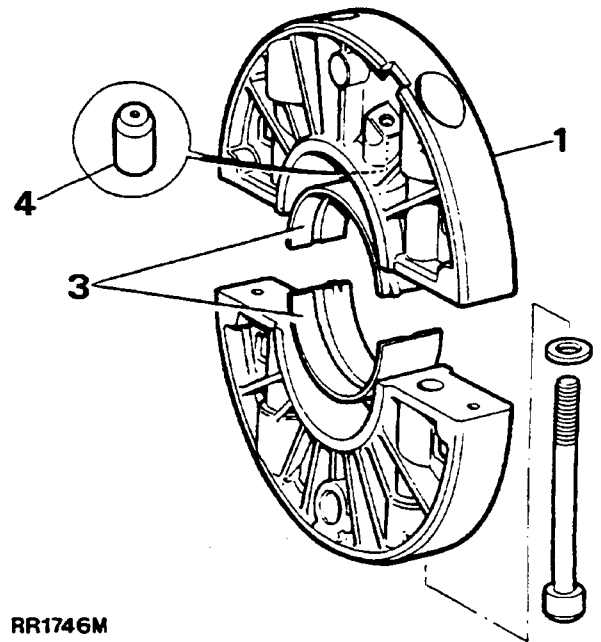
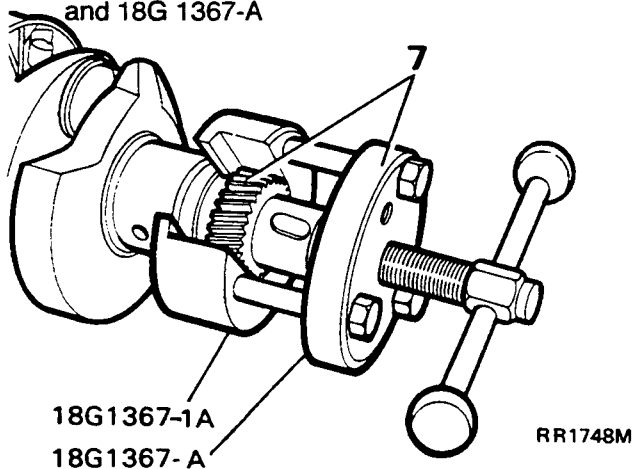
- Assemble the three main bearing carriers with the bearings fitted and tighten to the correct torque.
- Using an internal micrometer check the internal diameters of the bearings against the figures in data and renew if necessary or in any event if the crankshaft is being reground.
- Remove the bearings from the carriers, reassemble and tighten bolts to correct torque. With an internal micrometer check the carrier bore against the figures in data, and for excessive ovality.
- Check that the piston oil jets in the carriers open at the correct pressure and renew if necessary. Drift the old jet out through the carrier bore, apply a thin coat of Loctite AVX Special around the new jet before fitting.

- If the overall wear exceeds 0,01 mm (0.004 ins) for both main bearing journals and crankpins regrind and fit undersize bearings. When regrinding do not remove any material from thrust faces.
- After grinding it is important to restore the journal fillet radii as illustrated.

A = 2.7 to 3.00mm  
B = 2.5mm

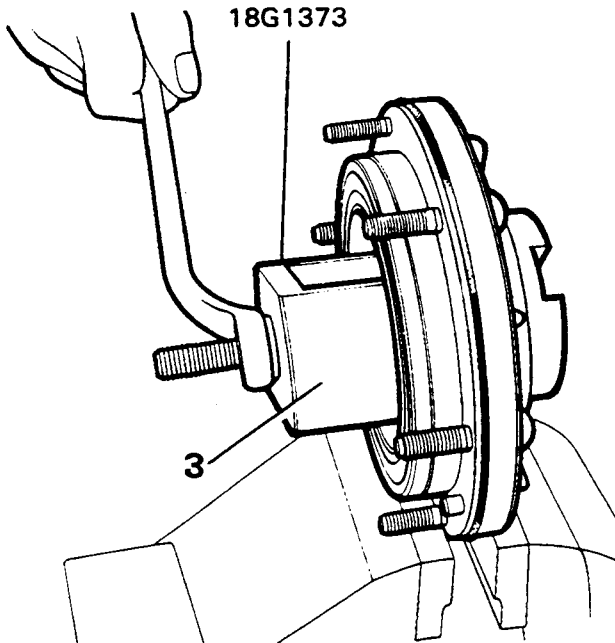


- Examine the timing gear teeth and if worn remove the gear with special tool 18G 1367-1A and 18G 1367-A



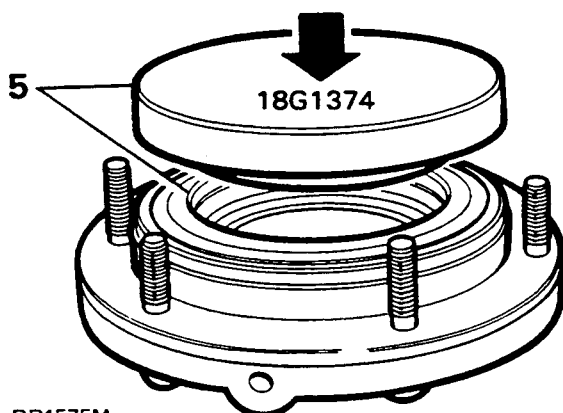
## Rear main bearing carrier

1. Extract the oil seal taking care not to damage the carrier bore.
2. Using an internal micrometer check the bearing dimensions against the figures in data.
3. If required remove the bearing using special tool 18G 1373, as illustrated.



RR1642M

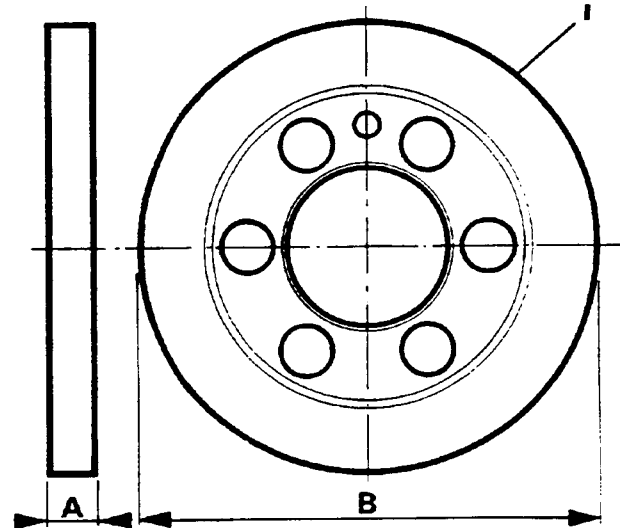
4. Check the carrier bearing bore for wear against the figures in data.
5. With special tool 18G 1374 fit a new oil seal to the rear carrier, lip side leading.



RR1575M

## Thrust spacer

1. Examine the spacer thrust face for damage, scratches, cracks and seizure marks. Ensure that outer diameter on which the seal runs is free from imperfections.
2. With micrometers check the thickness A and the diameter B at four diametrically opposite points and compare with the figures in data.



RR1703M

## Flywheel

1. Examine the flywheel clutch face for cracks, grooves and signs of over-heating. If excessive damage is evident renew or reface the fly-wheel.

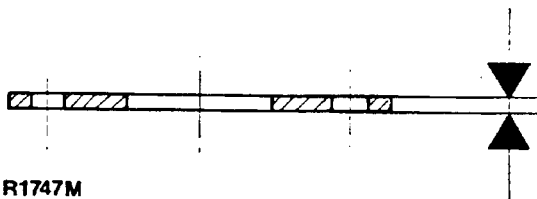
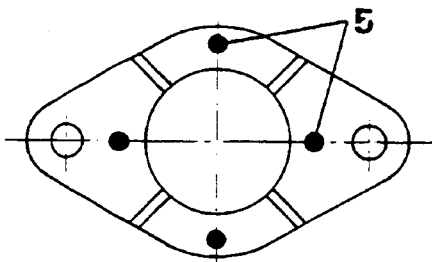
## Flywheel face run-out

2. The above check should be carried out during engine assembly. See fitting flywheel.



## Camshaft

1. Carry-out a visual examination of the cam lobes and bearing surfaces. If these are worn, scored or cracked the shaft should be renewed.
2. If visually satisfactory, carry out the dimensional checks detailed in the data section to the cams and bearing journals.
3. Check the camshaft for straightness, by mounting between centres and checking with a dial test gauge on the centre bearing journal. The shaft may be straightened under a press if the bend exceeds 0,05 mm (0.002 in). This work, however, should be entrusted to a specialist.
4. Examine the gear teeth and if worn or damaged press the shaft from the gear, together with the thrust plate.
5. Before fitting a new gear, check the thrust plate thickness at the four points illustrated. Renew the plate if the dimensions do not conform to the limits in data.

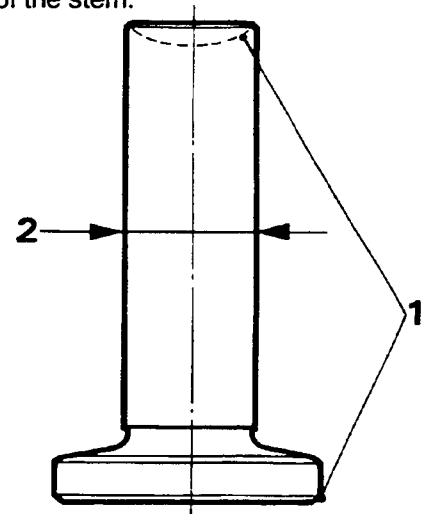


RR1747M

6. Heat the new gear in an oven to 180°C to 200°C, fit the thrust plate and press the gear onto the shaft until the gear is hard against the shoulder. If, when the gear has cooled the thrust plate turns freely on the shaft the camshaft end-float will be correct when fitted.

## Cam followers (Tappets)

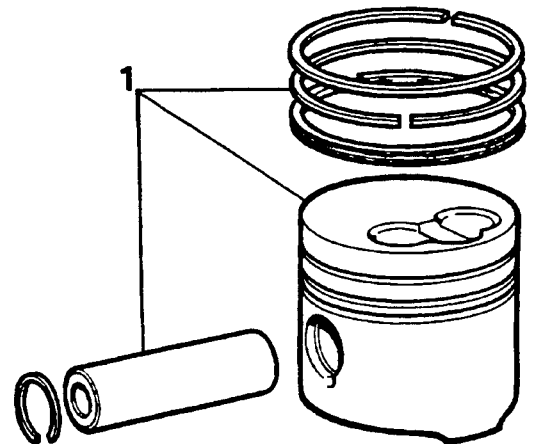
1. Examine the cam followers and discard any that are worn, pitted or scored on the cam contact face. Check also the cups in which the push rods seat.
2. Check the stem diameter for general wear, ovality and taper. Take measurements at several points round the circumference and along the length of the stem.



RR1710M

## Connecting rods and pistons

1. Whilst keeping each piston and connecting rod identified for possible refitting, separate the pistons from the rods and remove the piston rings. Degrease and decarbonise the pistons and rings ready for examination. Likewise prepare the connecting rods for inspection.

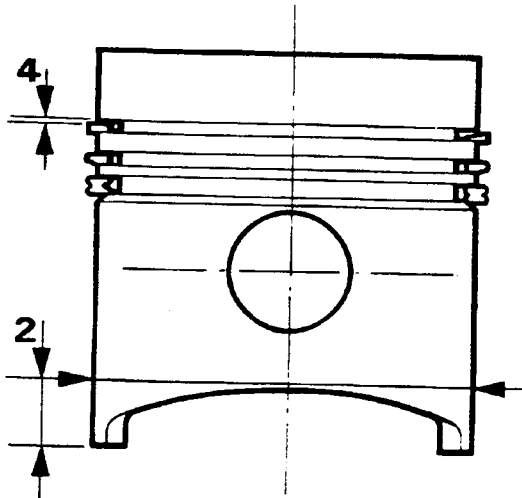


RR1683M



## Pistons and rings

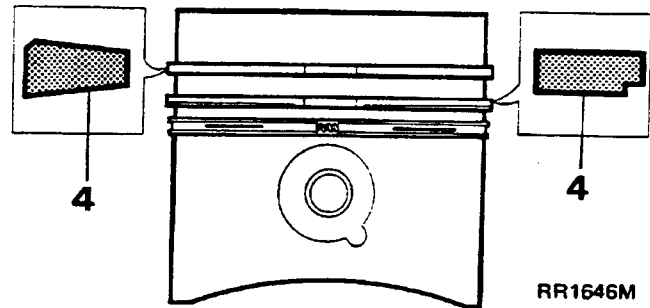
1. Examine the pistons for scores, cracks signs of overheating and general wear.
2. If visually satisfactory measure the piston skirt at right angles to the gudgeon pin 15 mm above the bottom of the piston skirt. If the wear is in excess of the maximum permitted in data and the piston to liner clearance is in excess of 0,15 mm (0.006 in) new pistons and liners must be fitted.



RR1714M

3. Check the gudgeon pins for wear, scores, pitting and signs of overheating. Check the gudgeon pin bore for ovality.

4. Examine the piston rings for damage, wear and cracks. Fit the rings to the pistons as illustrated and using a feeler gauge check the side clearance in the grooves.



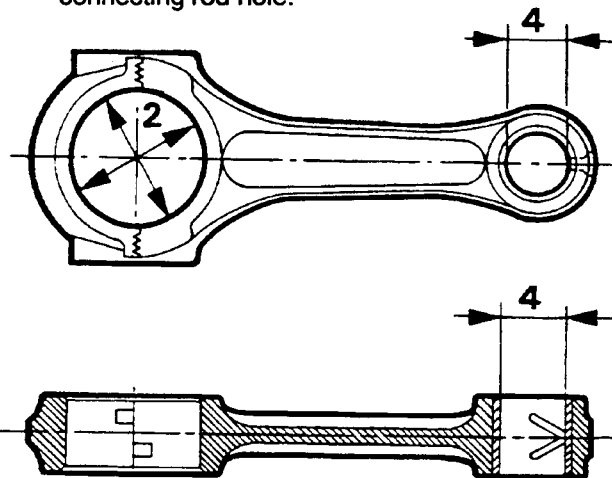
5. To check the piston ring fitted gap insert the ring squarely into the bottom of the bore at the lowest point of piston travel. To ensure squareness push the ring down the bore with a piston. Using an appropriate feeler gauge check the gaps of all the rings in turn. The correct gaps are given in data. If any gap is less than that specified, remove the ring and file the ends square whilst holding the ring in a filing jig or vice.
6. The previous instruction should also be carried out when new pistons and rings are fitted to new liners but the rings may be inserted squarely in any position in the bore.

**NOTE:** The difference in weight between the four pistons must not exceed 5 grams. When renewing pistons and liners they should all belong to the same classification A or B.



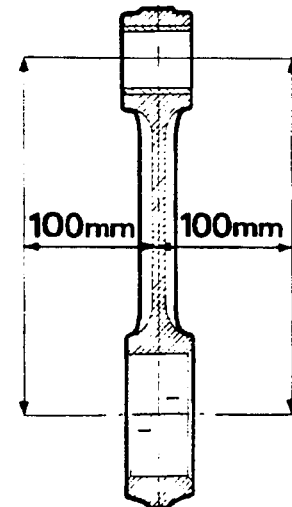
## Connecting rods

1. Examine the connecting rods and caps for cracks using a recognised crack testing process.
2. Assemble the cap and rod and tighten to the correct torque. Check the crank pin bore using an inside micrometer and three different points. The bore must be 57,563 to 57,582 mm. Renew rods if the tolerance exceeds 0,02 mm.
3. Examine the connecting rod shells and discard if worn, scored or show signs of overheating. Assemble the rods, caps and shells and tighten to the correct torque. Check the internal diameter against the figures in data.
4. Inspect the small end bush for wear against the figures in data. Check that the wear limit between bush and gudgeon pin does not exceed 0,100 mm (0.004 in). When renewing the bush ensure that the oil hole aligns with the connecting rod hole.



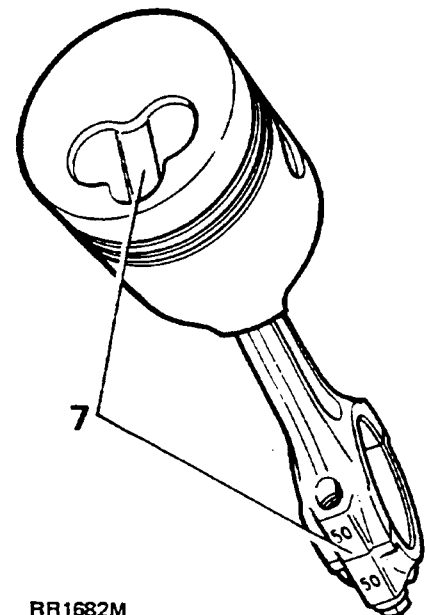
RR1712M

5. Check the rod for bend and twist, taking measurements at approximately 100 mm from the centre of the rod using a recognised alignment gauge. Twist or bend must not exceed 0,5 mm (0.019 in).



RR1713M

6. If it is necessary to renew connecting rods check that the weight difference between them does not exceed 10 grams, see letter code in data (2.4 Litre engines only).
7. Slightly warm the pistons and assemble to the connecting rods ensuring that the recess in the piston crown is on the same side as the number on the connecting rod big end. Insert the gudgeon pins and secure with the circlips.



RR1682M

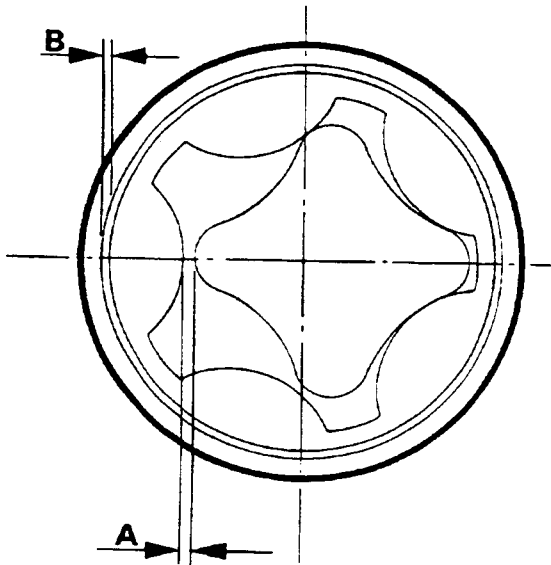
8. Fit the connecting rod bearing shells ensuring that the tags locate in the cutouts.

## Oil pump



**NOTE:** The oil pump is only supplied as an assembly complete with drive gear.

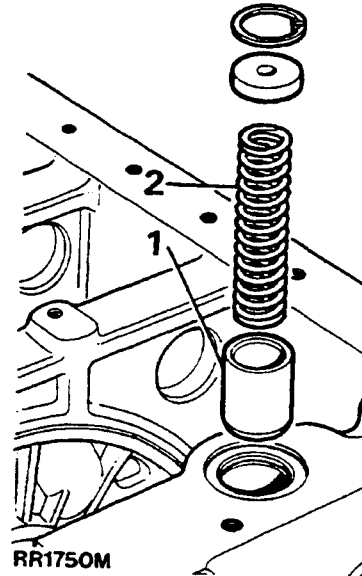
1. Dismantle the oil pump and clean with kerosene or solvent. Examine the rotors and body for wear and pitting.
2. Assemble the oil pump noting that the chamfered side of the outer rotor is fitted downwards towards the drive gear.
3. Check, with a feeler gauge, the clearance between the inner and outer rotor A.
4. Check the clearance between the pump body and outer rotor B and compare the figures in data.



RR1711M

## Oil pressure relief valve

1. Examine the plunger for scores and pitting. If necessary the valve plunger may be lapped to its seat, to restore efficiency, using fine valve grinding compound. Make sure that all trace of the compound is removed before assembling valve to the crankcase.
2. Check the free length of the spring against the figure in data.



## Vacuum pump and gear assembly

1. Inspect the gear for wear and damage. Check the vanes for wear. Examine the vacuum pump housing for scouring or damage. If the unit is worn or damaged the complete assembly should be renewed.

## Injection pump drive gear

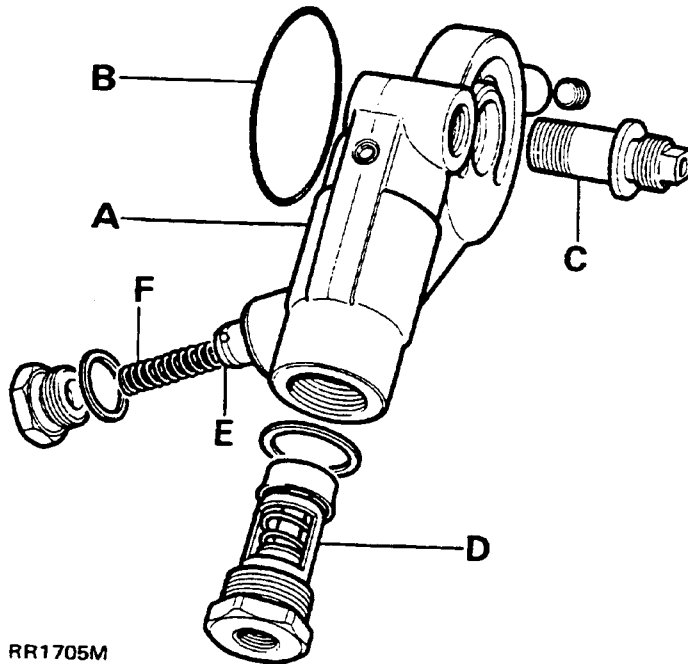
1. Check the injection pump gear for damage, wear and pitting. Examine the bore and keyways for wear. Renew if any gear is unsatisfactory.

5. Examine the gear teeth for wear, chips and pitting.



### Oil filter adaptor housing

1. This housing contains a by-pass valve which opens to maintain oil circulation when a difference in pressure exists between the filter base outlet to the oil cooler and the main oil gallery due to a restriction in the oil cooling system. A thermostat which opens at 80°C, to allow oil to pass to the oil cooler is also incorporated in the housing.



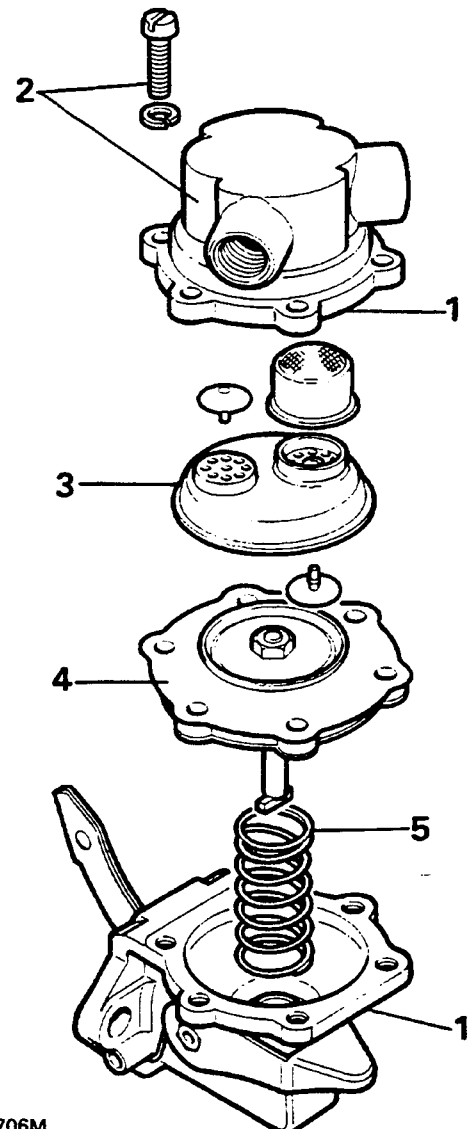
RR1705M

- A Adaptor housing.
- B 'O' ring
- C Oil filter and adaptor housing union screws
- D Thermostat
- E By-pass plunger
- F By-pass plunger spring

2. Remove the thermostat and check the opening temperature. Place the thermostat in vessel containing water and a thermometer. Apply heat and observe the temperature at which the thermostat opens. Refit or renew as necessary, using a new sealing washer.
3. Remove the by-pass valve plug and remove the spring and plunger. Check the plunger for scores and pitting. Refit or renew as necessary using a new sealing washer.

### Fuel lift pump

1. Mark the relationship of the pump cover to the body to facilitate reassembly.
2. Remove the six retaining screws and lift-off the cover.
3. Remove the valve plate.
4. Press down on the diaphragm and twist to release the diaphragm from the body.
5. Remove the diaphragm spring.
6. Clean and examine all parts. The diaphragm can be renewed if faulty.



RR1706M

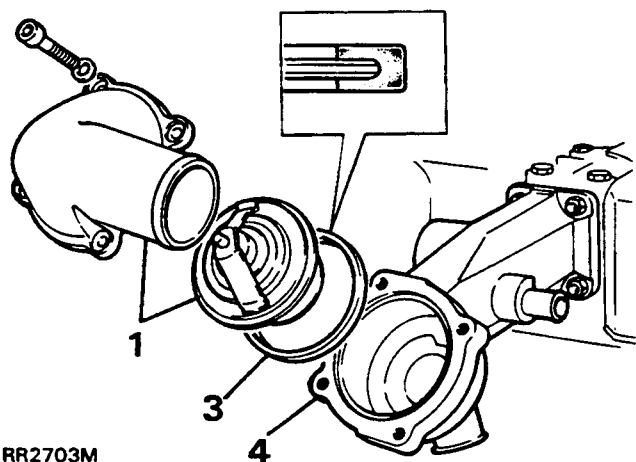
7. Reassemble the pump reversing the above procedure.

## Water pump

1. Since the water pump is not serviceable the complete assembly should be renewed if the impeller is worn and corroded or if there is excessive end float or side movement in the impeller shaft.

## Thermostat and housing

1. Remove the four socket headed screws and lift the outlet elbow clear to remove the thermostat with its fitted seal from the thermostat housing.

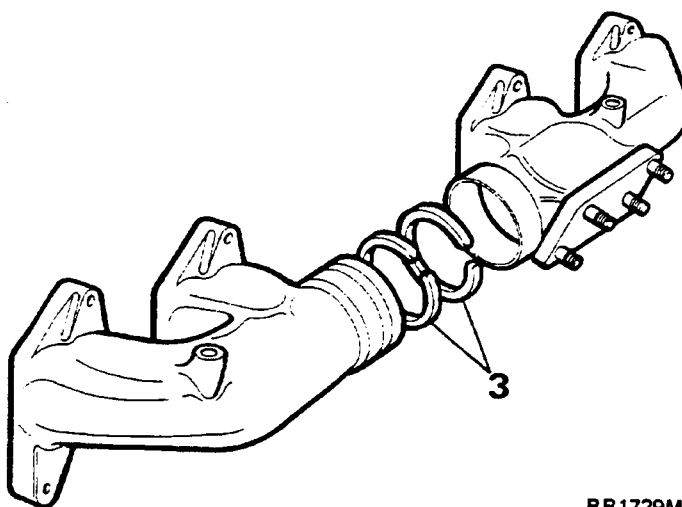


RR2703M

2. To test the thermostat, remove the seal (3) note the opening temperature stamped on the end of the thermostat and place it in a vessel containing water and a thermometer. Apply heat and observe the temperature at which the thermostat opens. Renew if necessary.
3. Fit a new joint seal onto the edge of the thermostat ensuring it is fitted evenly.
4. Refit the thermostat ensuring location of the seal into the recess of the thermostat housing.
5. Refit the outlet elbow and tighten the screws, evenly.

## Inlet and exhaust manifold

1. Examine the manifold for damage and cracks.
2. Check the mating faces with the cylinder head for distortion by mounting on a surface plate and checking with feeler gauges. If necessary, the flange faces may be machined to restore maximum surface contact with the cylinder head.
3. The exhaust manifold is manufactured in two sections and piston ring type seals are used to provide a flexible gas tight seal. Renew the rings if cracked and assemble the two sections using Vaseline on the rings to facilitate assembly.



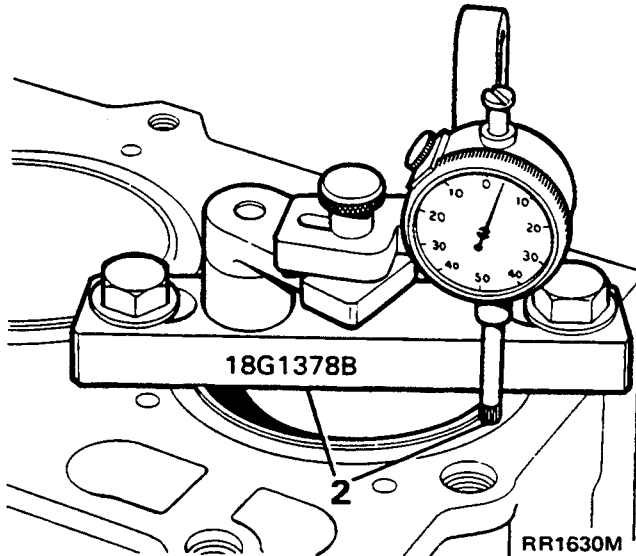
RR1729M



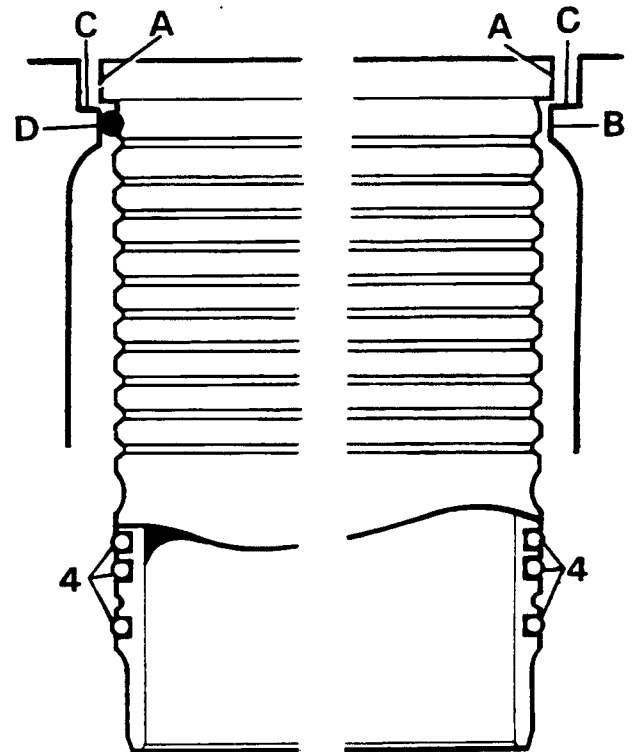
## ASSEMBLING ENGINE

### Fitting cylinder liners

1. Clean the liners and the cylinder block areas of contact. Fit the liners without 'O' rings. The liners should drop into position under their own weight, if not, further cleaning is necessary.
2. To obtain the correct liner protrusion, attach special tool 18G 1378,B as illustrated, to the cylinder block and tighten the bolts to **30 Nm (22 lbf/ft)**. Fit a dial test indicator so that the stylus rests in a loaded condition on the external rim of the liner and set the dial to zero. Slide the stylus across to the cylinder block and note the reading. Repeat the above procedure to the remaining cylinders.

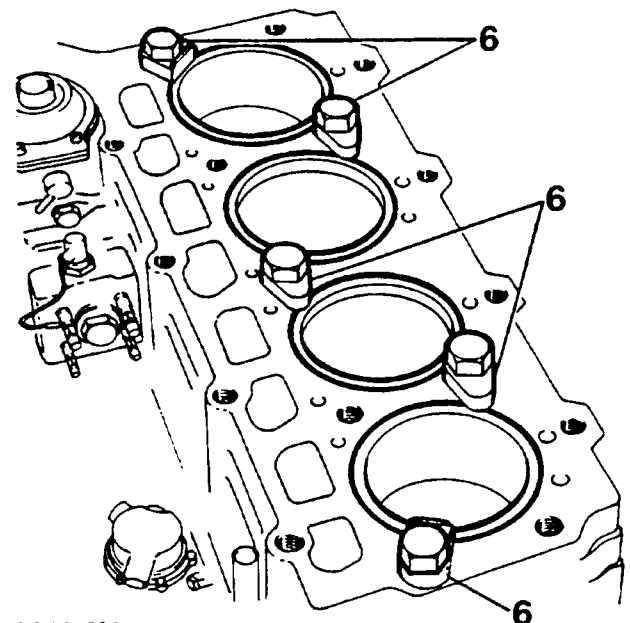


3. Remove the liners and add shims as required to achieve the protrusion given in the data Section 04.
4. Remove the liners and fit three new 'O' rings. Apply molybdenum disulphide grease, such as 'Marston's Molycote' to the 'O' ring contact area in the cylinder block.
5. Apply 'Loctite 275' to areas A and B. Avoid any sealant contacting the shim and face C. An 'O' ring is fitted to top of liner, on later 2.5 engines or when fitting new liners to 2.4 and early 2.5 engines. Fit 'O' ring seal to position D and apply Loctite to area A only. Avoid sealant contacting the shim, face C and 'O' ring.



RR3826M

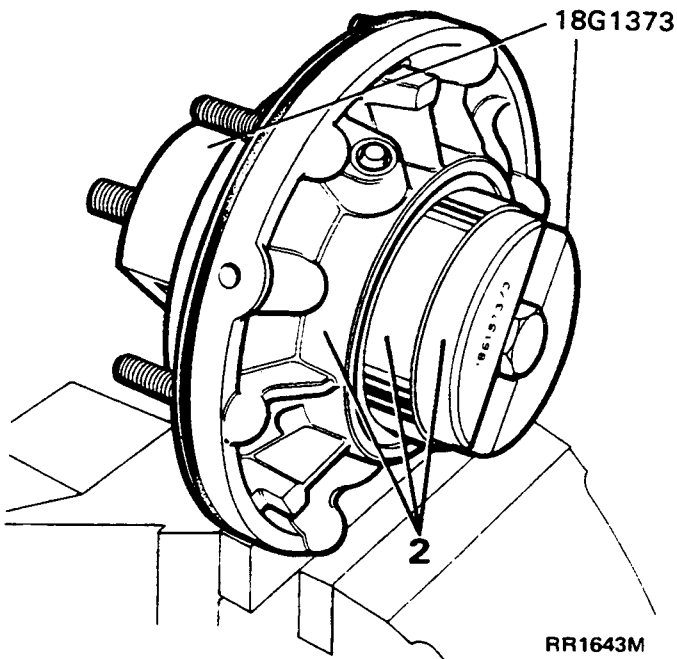
6. Fit the liners to the cylinder block and hold them in using the cylinder head spacers and slave bolts, tighten the bolts to **30 Nm (22 lbf/ft)**, leave the spacers and slave bolts in position for approximately two hours until the Loctite is set.



RR2216M

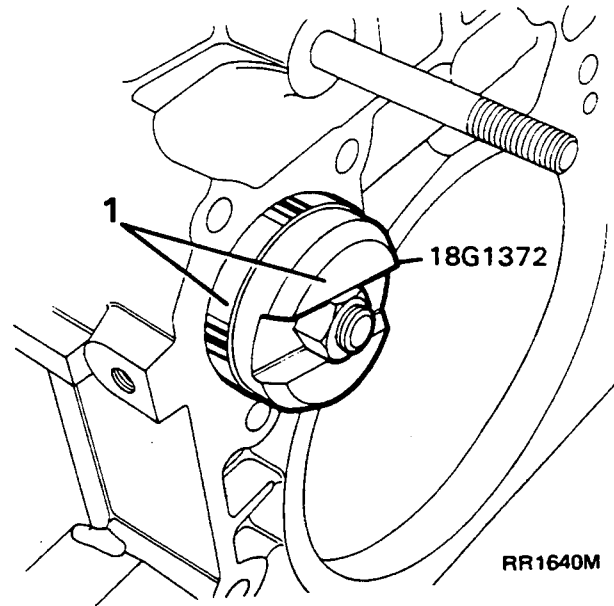
### Fitting front and rear main bearings.

1. Use special tool 18G 1373 to refit the front main bearings to the cylinder block, ensuring that the oil hole in bearing aligns with oil hole in the bearing bore.
2. Use the same tool 18G 1373 to refit the rear main bearings to the carrier assembly, ensuring that the oil holes in bearing and carrier align.



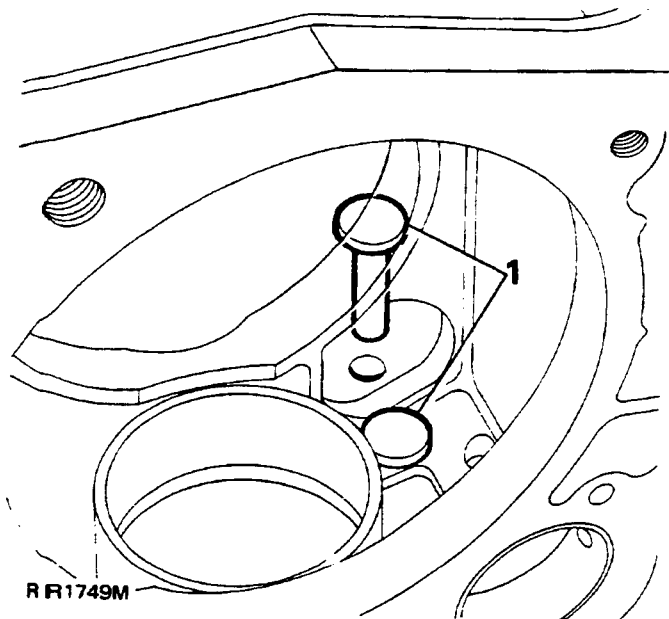
### Camshaft bearings

1. Renew the camshaft bearings in the cylinder block using special tool 18G 1372.
2. Each bearing shell has two oil holes and it is essential that these align exactly with the corresponding oil drillings in the cylinder block. The illustration shows the camshaft rear bearing being fitted.



### Fitting camshaft and followers

1. Invert the cylinder block and smear the cam followers with clean engine oil and fit them to their original locations in the cylinder block.

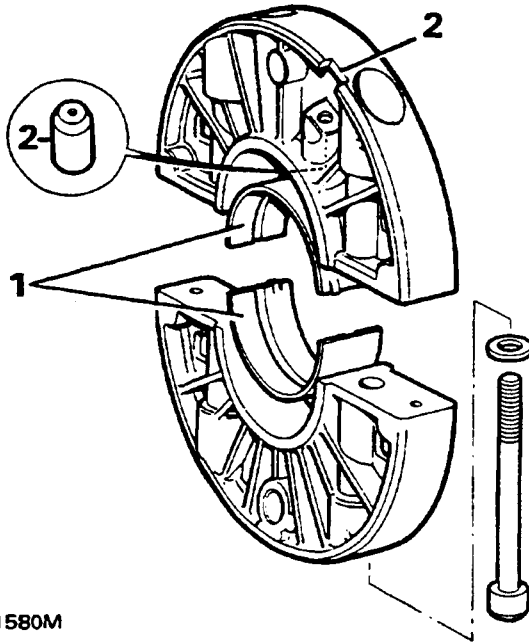


2. Smear the camshaft journals with clean engine oil and carefully insert the camshaft complete with thrust plate and gear. Temporarily secure the camshaft to the cylinder block with the two screws.



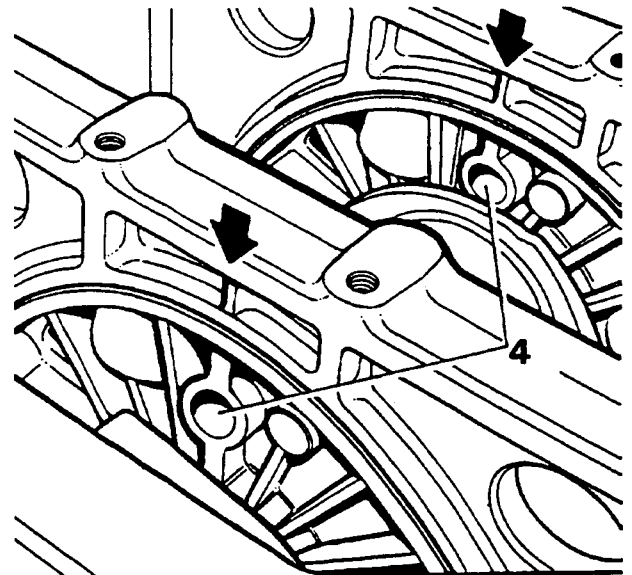
### Fitting crankshaft and carrier assembly.

1. Fit new main bearing shells to each of the carrier halves.
2. Assemble the carriers to the crankshaft journals, ensuring that the same carriers are fitted to their original locations and that the piston jet cut-a-way is towards the front of the crankshaft. Secure each carrier with the two bolts tightening evenly to the correct torque. Check that the oil jet is in position.



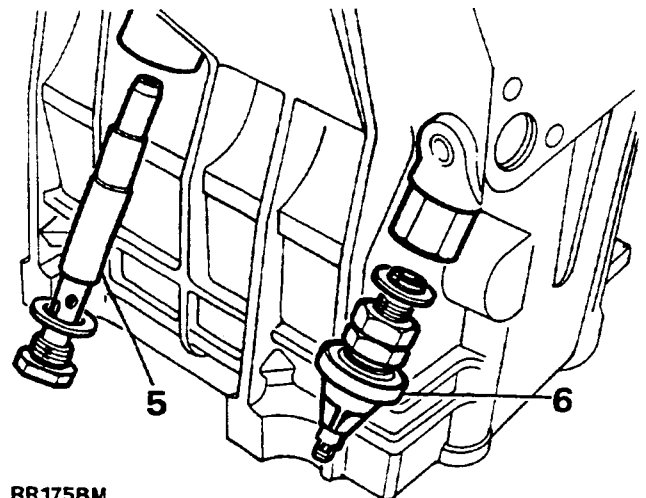
RR1580M

3. Slide special tool 18G 1370 over the crankshaft gear and, if necessary, with assistance insert the crankshaft and carrier assembly into the crankcase in the same manner as for removal.
4. Align the holes in the lower carriers, as illustrated, with the centre of the crankcase webs.



RR1722M

5. Secure each carrier assembly to the crankcase with the appropriate oil feed and carrier location shaft. Ensure that the shafts are fitted to their original locations with new washers. The correct locations are as follows:-  
Front carrier shaft - Oil feed to vacuum pump.  
Centre carrier shaft - Oil feed to turbo-charger.  
Rear carrier shaft - Blank  
Tighten the shafts to the correct torque.
6. Fit the oil pressure switch.

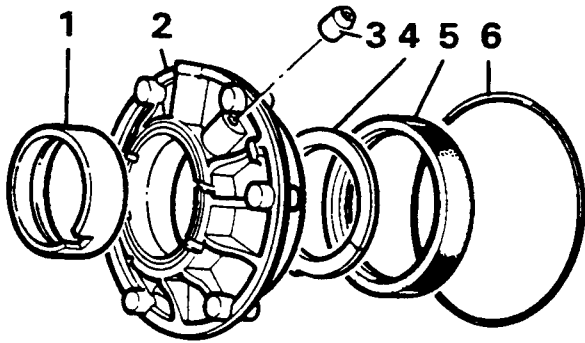


RR1758M



## Fitting rear main carrier assembly.

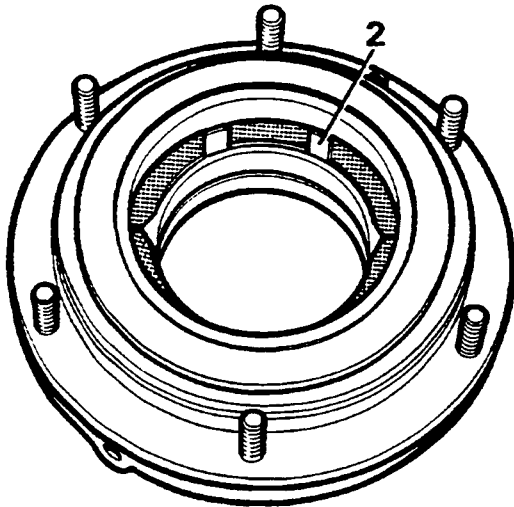
1. Fit a new 'O' ring seal to the rear main carrier.



RR2776M

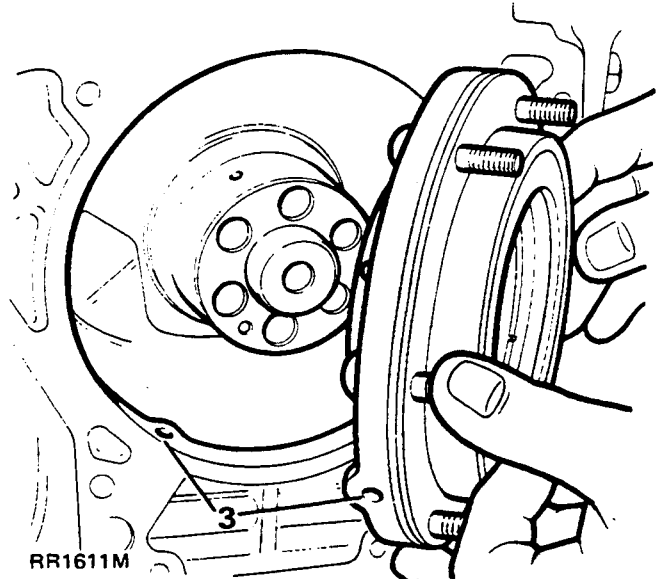
1. Bearing
2. Carrier
3. Oil jet
4. Outer thrust washers
5. Oil seal
6. 'O' ring seal

2. Fit new outer thrust halves to the oil seal side with the oil grooves outwards. Ensure that both halves are of the same thickness value and that the thrust with the tag locates in the keyway in the carrier. Hold the thrusts in position with Vaseline.



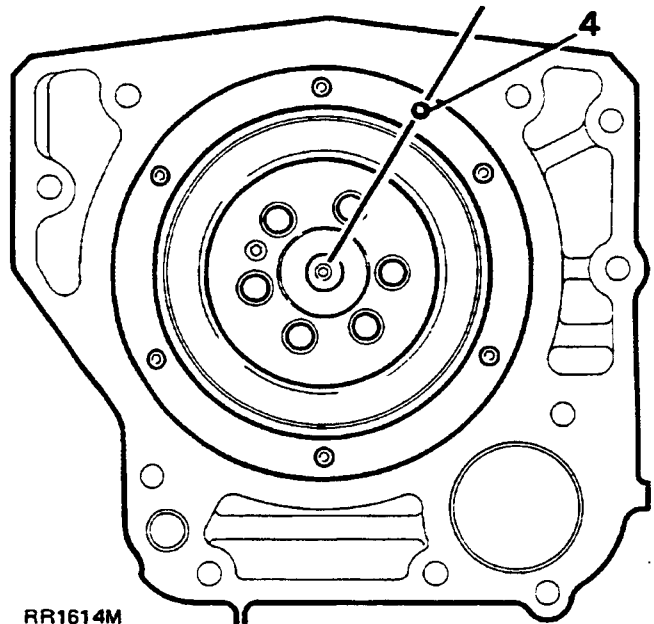
RR1572M

3. With the cylinder block still in the inverted position, lubricate the oil seal with clean engine oil and fit the carrier assembly to the crankcase. Ensure that the oil hole in the crankcase is aligned with the oil hole in the carrier as illustrated.



RR1611M

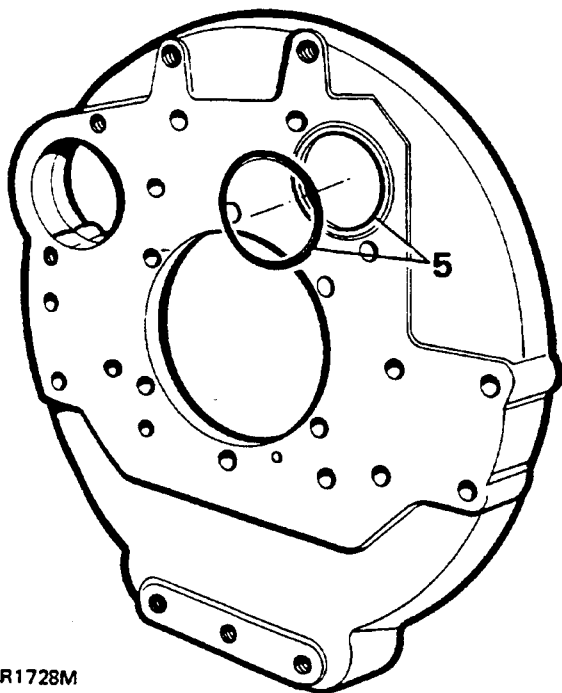
4. When correctly aligned the dowel in the carrier must be at the 1 o'clock position. Final alignment will be achieved when the flywheel housing is fitted.



RR1614M

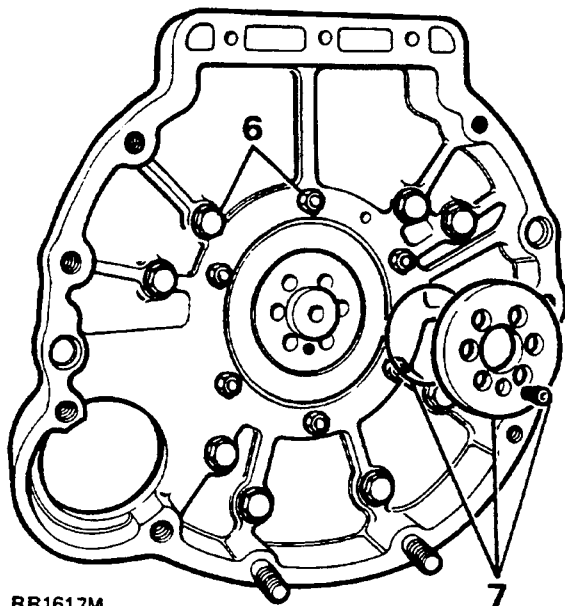


5. Fit a new 'O' ring seal to the rear of the flywheel housing.



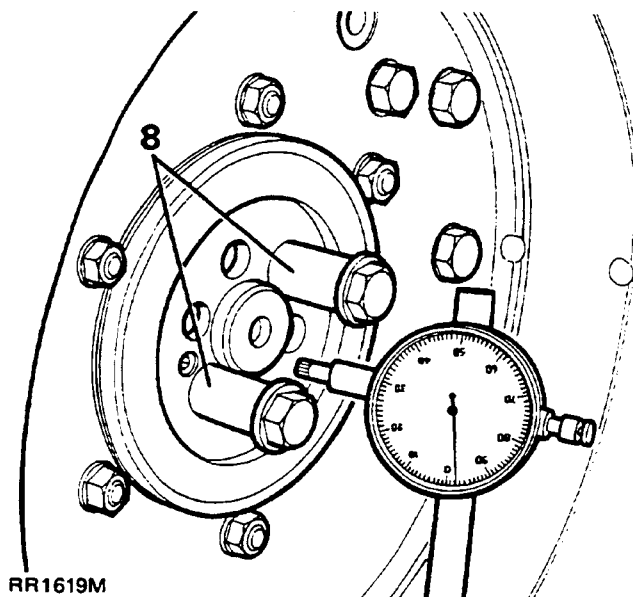
RR1728M

6. Fit the flywheel housing and secure with the nine bolts, tightening evenly to the correct torque. Fit and evenly tighten, to the correct torque, the six carrier retaining nuts.
7. Fit the thrust spacer and a new 'O' ring seal and secure with the socket headed screw.



RR1617M

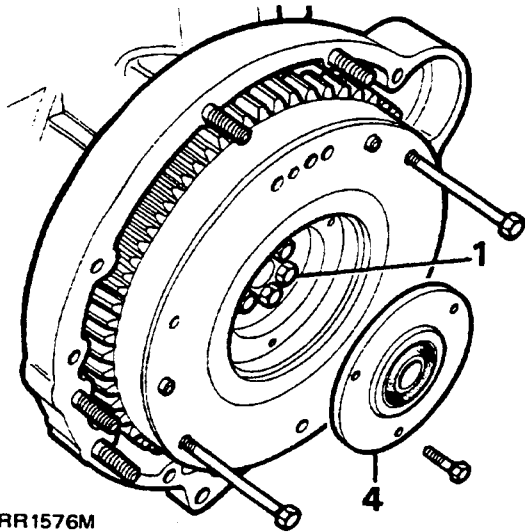
8. To check the crankshaft end-float, insert two flywheel bolts in the crankshaft using spacers equivalent to thickness of the flywheel and tighten to the correct torque. Mount a dial test indicator with the stylus resting, in a loaded condition, on the thrust spacer. Lever the crankshaft back and forth and note the reading. Adjust the end-float, if necessary, by substituting with washers of an appropriate thickness, see data section for available washers.



RR1619M

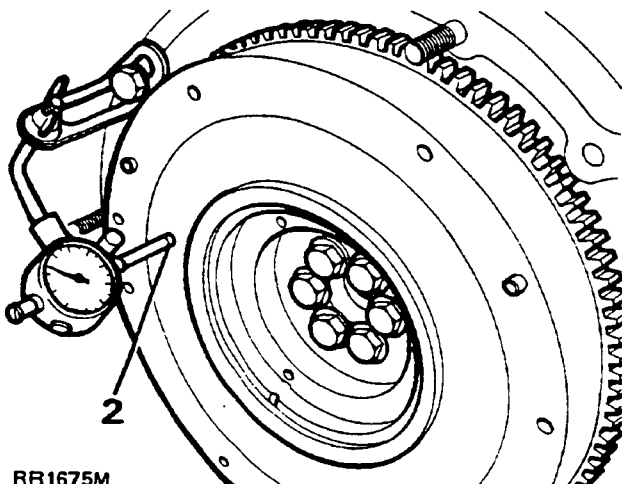
## Fitting flywheel

1. Fit the flywheel using the same method as for removal. Fit and evenly tighten the six retaining bolts to the correct torque.



## Checking flywheel face run-out

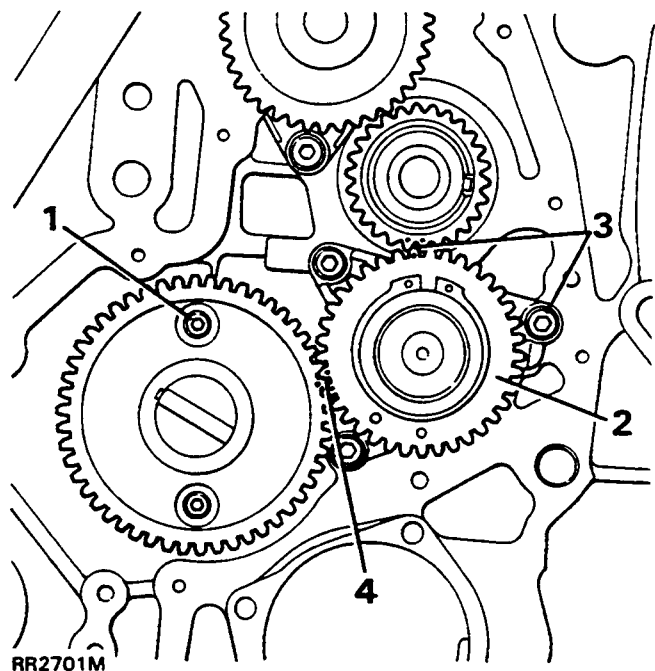
2. Mount a dial test indicator on the flywheel housing with the stylus positioned in a loaded condition on the flywheel face and zero the gauge.
3. Turn the flywheel and take readings every 90°. The difference between the highest and lowest readings taken at all four points should not exceed 0,10 mm (0.004 in) which is the maximum permissible run-out.
4. Fit the spigot bearing and plate and secure with the three bolts.



## Fitting vacuum and oil pumps

1. Whilst maintaining the cylinder block in the inverted position, remove the two socket headed screws and partially withdraw the camshaft.
2. Using a new 'O' ring seal offer the vacuum pump and gear assembly into its location.
3. Turn the crankshaft and vacuum pump gear until the dots align, as illustrated, with the single dot on the vacuum pump gear between the two dots on the crankshaft gear. Fully house the vacuum pump, tightening the three socket headed screws to the correct torque **28Nm**

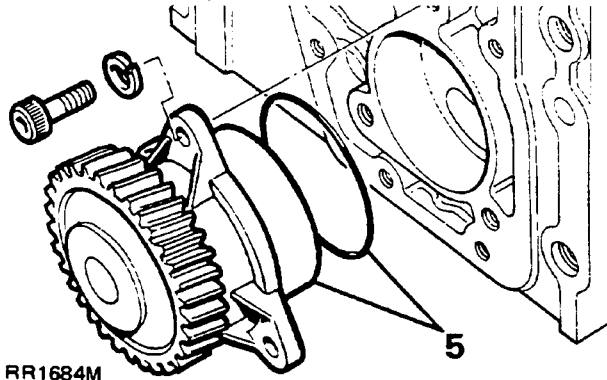
▲ **NOTE:** The screw with the smaller diameter head should be fitted closest to the camshaft gear.



4. Refit the camshaft and align the gears so that the single dot on the camshaft gear is between the two dots on the vacuum pump gear, as illustrated. Fit and tighten the two camshaft retaining screws.



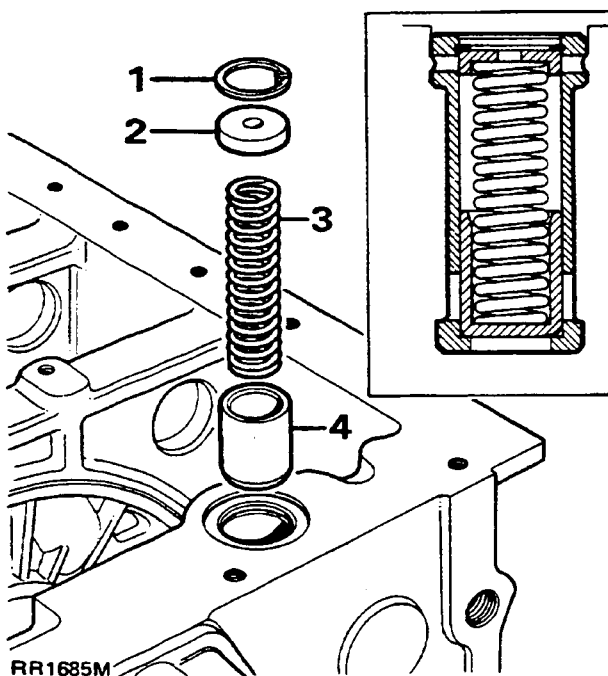
5. Fit the oil pump assembly and secure with the three socket headed screws tightening evenly to the correct torque **27Nm**



RR1684M

### Fitting oil pressure relief valve

1. Clean the valve seating in the crankcase and fit the relief valve, spring and cap and secure with the circlip using 18G 257 or suitable alternative pliers.



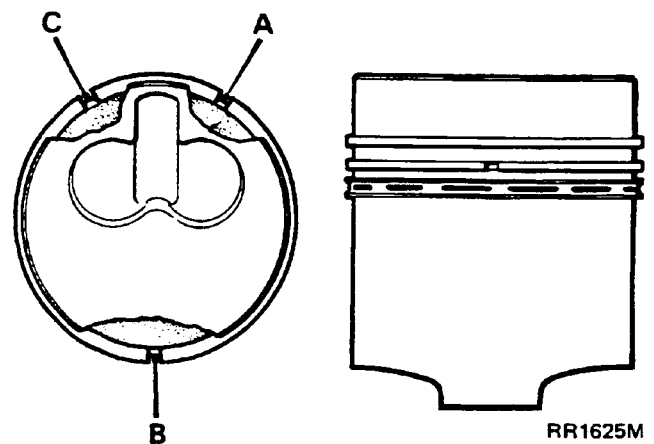
RR1685M

1. Circlip
2. Cap
3. Spring
4. Plunger

### Fitting connecting rods and pistons

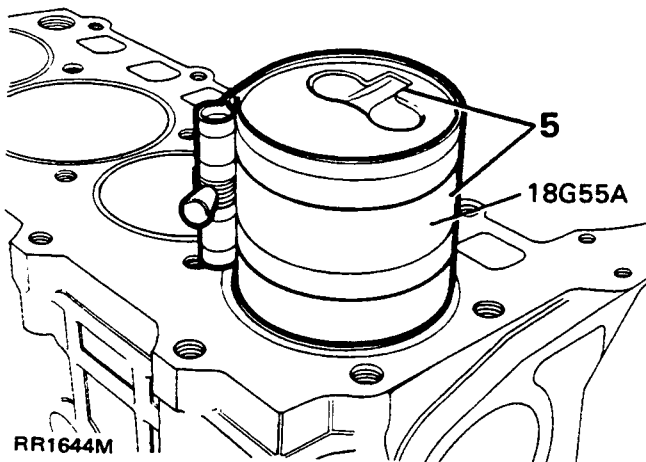
1. If the original pistons and connecting rods are being refitted ensure that they are returned to their original locations.
2. Turn the cylinder block over to an upright position.
3. Turn the crankshaft to bring numbers one and four crankpins to the B.D.C position.
4. Stagger the piston ring gaps as follows :-

- A Compression ring gap  $30^\circ$  to the right of the combustion chamber recess.
- B Scraper ring gap on the opposite side of the combustion chamber recess.
- C Oil control rings gap  $30^\circ$  to the left of the combustion chamber recess.



RR1625M

5. Check that the recess area in the piston crown is on the same side as the figures on the connecting rod. Fit the connecting rod bearing shells. Using piston ring compressor 18G 55A or a suitable alternative, insert number one and number four pistons into the cylinder bores ensuring that the recess area in the piston crown is toward the camshaft side of the engine. Tap the pistons into position in the bores.



#### Fitting cylinder heads.

1. The fitting of the cylinder heads requires a precise sequence of instructions to be carried out. It includes - checking cylinder liner protrusion - selecting head gasket thickness and tightening the head bolts in the correct order.

For these details. *See Repair, Cylinder heads*

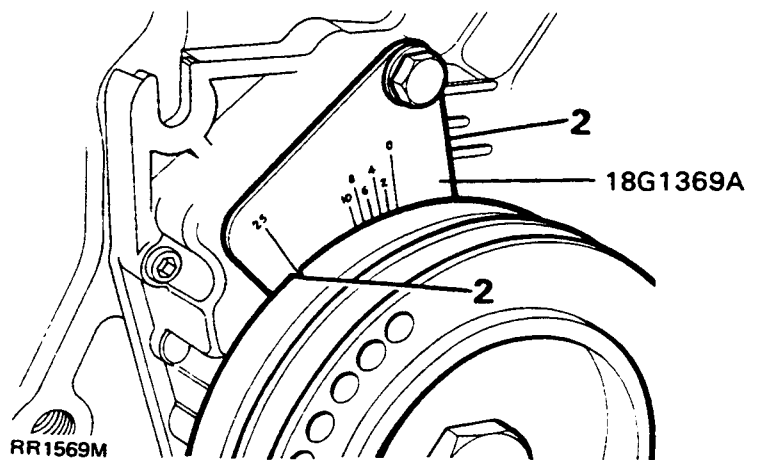
#### Fitting and timing fuel injector pump.

1. Temporarily fit the timing cover and crankshaft pulley and turn the crankshaft until the T.D.C. mark on the cover aligns with the groove in the crankshaft pulley so that number one piston is at T.D.C. on the compression stroke, with number four valves 'rocking'.
2. Attach the special timing gauge 18G 1369A to the timing cover and turn the crankshaft anti-clockwise until the pulley groove aligns with the 25° B.T.D.C. mark on the scale.

6. Turn the cylinder block over and fit the connecting rod caps so that the figures are on the same side. Apply 'Molyguard' to the threads of the NEW bolts and tighten to the correct torque.
7. Repeat the above instructions to fit number two and three pistons.

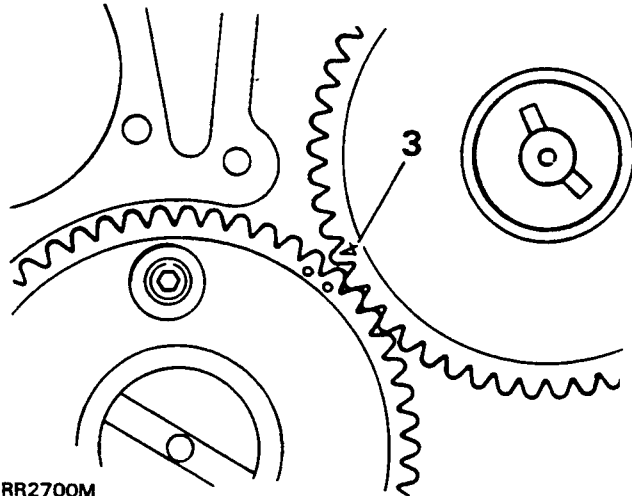
#### Fitting oil strainer and sump.

1. Fit a new 'O' ring seal to the oil pick-up pipe and insert into the crankcase. Secure the strainer end of the pipe to the crankcase with two bolts. See items 42 and 43 on illustration of engine internal components.
2. Clean the sump and crankcase mating faces and apply 'Loctite 518' to both surfaces. Secure the sump with the twenty-one bolts tightening evenly to the correct torque.



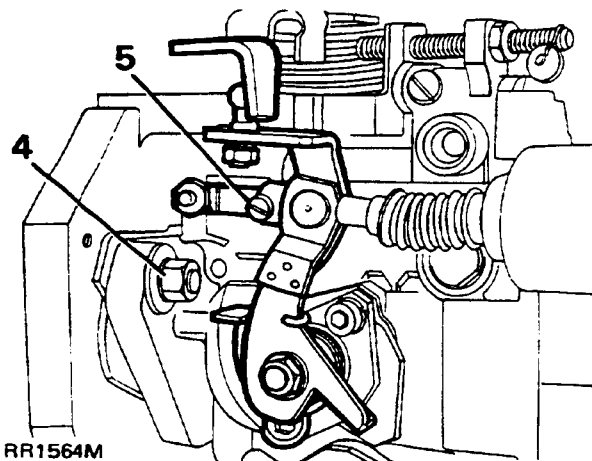


- Remove the pulley and timing cover and mesh the injection pump and camshaft gears so the tooth marked '4' is offset from the two camshaft teeth marked with dots, also the two keyways positioned exactly as illustrated.

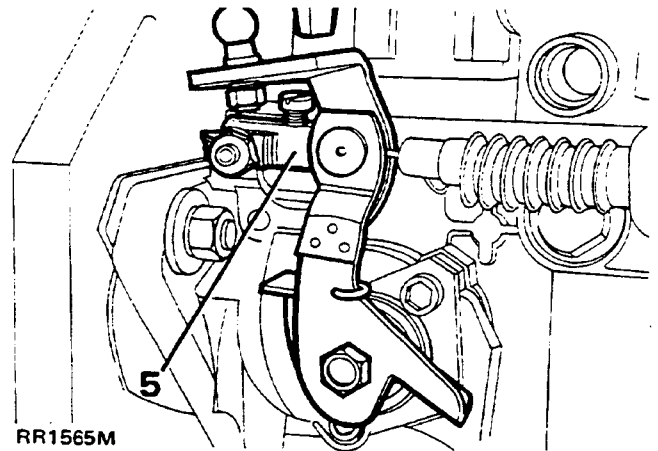


RR2700M

- Whilst holding the gear in this position fit the injection pump with a new joint washer ensure the key on the shaft is at the 11 o'clock position viewed from front of engine. Secure the three nuts, finger tight only. Fully tighten the injection pump gear retaining nut to the correct torque.
- Release the screw on the cold start cable and turn the trunnion 90° until the lever is fully released.

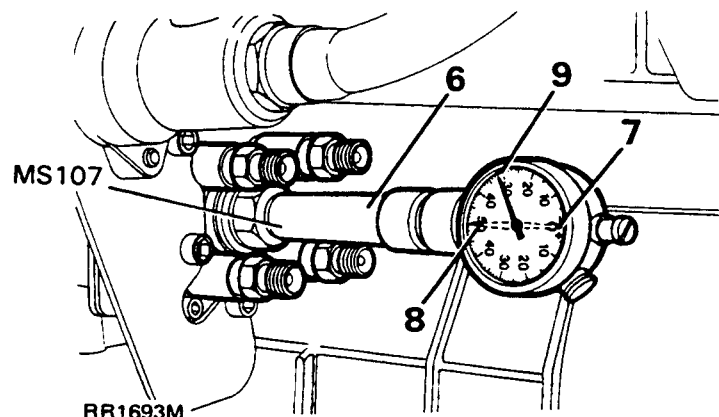


RR1564M



RR1565M

- Fit the special tool MS107 and dial test indicator to the rear of the pump.



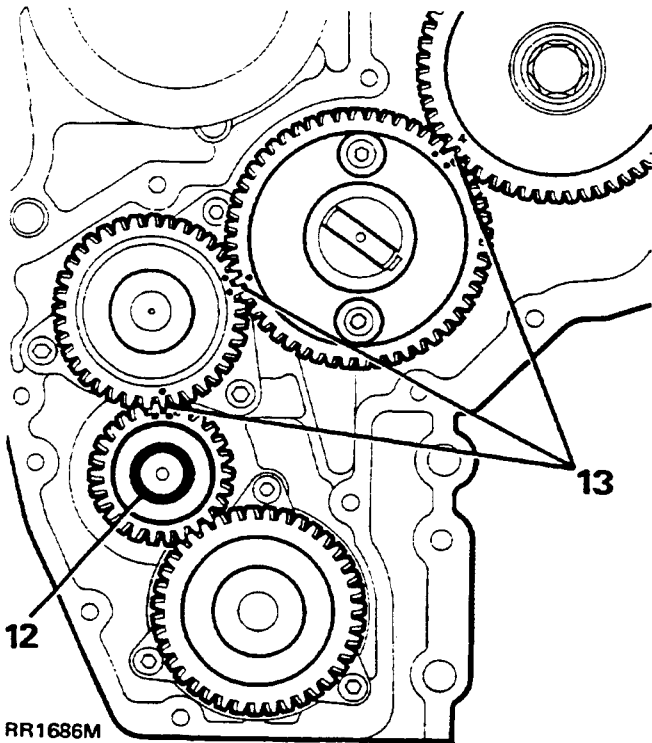
RR1693M

- Fit the timing cover and scale and crankshaft pulley and turn the crankshaft to T.D.C. Then turn crankshaft anti-clockwise until the indicator needle stops and zero the indicator. The groove on the pulley should now be approximately aligned with the 25° B.T.D.C. mark.
- Turn the crankshaft clockwise so that the pulley groove is aligned with the 3° B.T.D.C. mark. Turn the injector pump body, clockwise or anti-clockwise as necessary until the indicator reads 50 (0,5 mm).
- Tighten the pump body retaining nuts and turn crankshaft to T.D.C. and check that the dial reads 68 (0,68 mm)

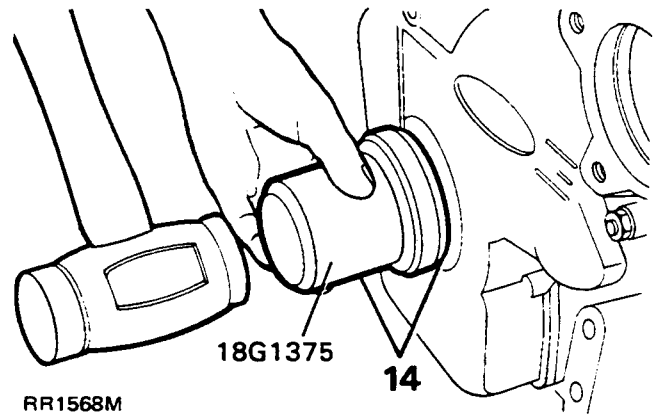
10. Move the cold start lever rearward to the normal running position prior to instruction 5, and tighten the screw. See **Maintenance Section 10** for cold start adjustment.
11. Turn the crankshaft until the T.D.C. mark on the cover or timing gauge aligns with the pulley groove.
12. Remove the pulley and timing cover and fit a new joint washer and 'O' ring seal to the crankshaft.

 **NOTE:** Hylosil RTV is used in place of a joint washer on 2.5 Litre engines.

13. At the same time check that the timing marks on the gear train all align, as illustration.



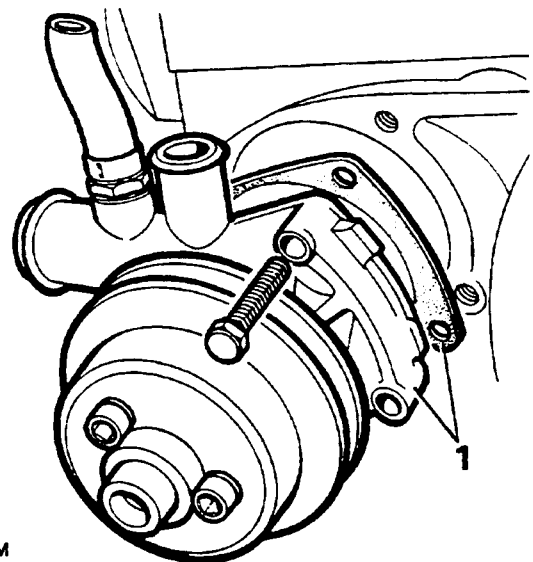
14. Fit the timing cover and secure with the twelve socket-headed screws and one bolt and tighten evenly to the correct torque. Using special tool 18G 1375 drive in a new timing cover seal, cavity side leading.



15. Fit the pump drive gear cover plate using a new 'O' ring seal. Secure with the four bolts and tighten evenly.
16. Fit the crankshaft pulley and tighten the nut to the correct torque.

### Fitting water pump

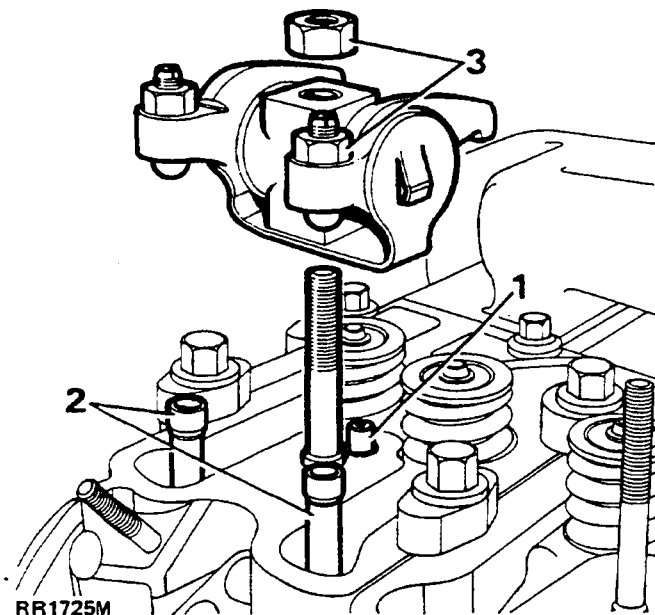
1. Using a new joint washer fit the water pump and pulley assembly and secure with the four bolts, tightening evenly to the correct torque.



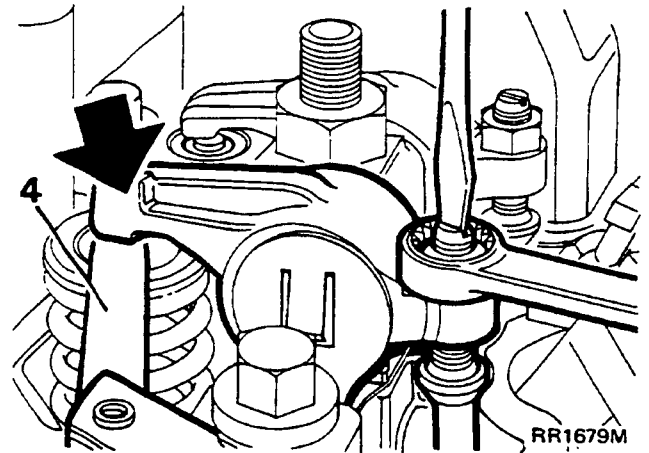


### Fitting valve rocker assemblies

1. Check that the oil feed dowels are in position in each cylinder head.
2. Fit the push rods ensuring that the ball-end locates correctly in the cam follower cup.
3. Slacken-off the tappet adjusting screws. Fit the valve rocker assemblies to the cylinder head over the oil feed dowels and locate the tappet adjusting screws in the push rod cups. Secure with the single nut and tighten to the correct torque.



4. Adjust the inlet and exhaust valve tappet clearances to 0,30 mm (0.012 in) in the following manner and sequence. The feeler gauge should be a sliding fit between the rocker and valve tip. Slacken the rocker adjusting screw locknut and turn the screw clockwise to decrease or anti-clockwise to increase the clearance. When correct hold the screw against rotation and tighten the locknut. Two sequences to adjust the clearances may be used.



#### Sequence A

With No.1 valve fully open adjust No.7 valve.  
 With No.8 valve fully open adjust No.2 valve.  
 With No.5 valve fully open adjust No.3 valve.  
 With No.4 valve fully open adjust No.6 valve.  
 With No.7 valve fully open adjust No.1 valve.  
 With No.2 valve fully open adjust No.8 valve.  
 With No.3 valve fully open adjust No.5 valve.  
 With No.6 valve fully open adjust No.4 valve.

#### Sequence B

Rotate the crankshaft until the valves of number four cylinder are rocking then adjust the clearance of number one valve. Adjust the remaining valve clearances in the following order:-

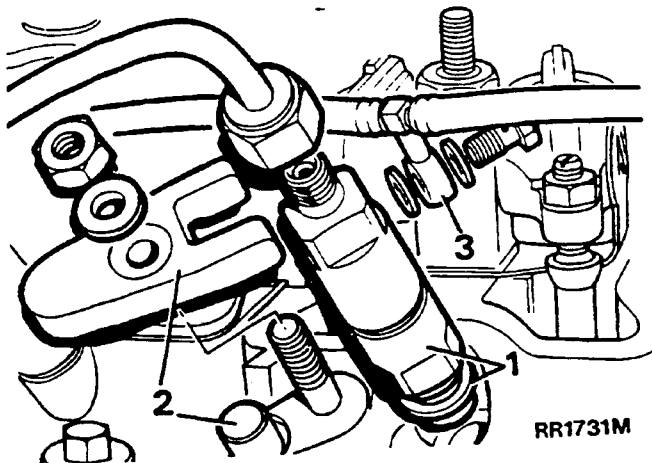
#### Adjust:-

Valves of No. 3 cyl with No. 2 valves rocking  
 Valves of No. 4 cyl with No. 1 valves rocking  
 Valves of No. 2 cyl with No. 3 valves rocking



## Fitting injectors and pipes

1. Fit the sealing washer and the injector to the cylinder head.
2. Locate the dowel and clamp and tighten the nut to the correct torque.
3. Fit the remaining injectors and spill rail using a new washer both sides of the banjo unions.



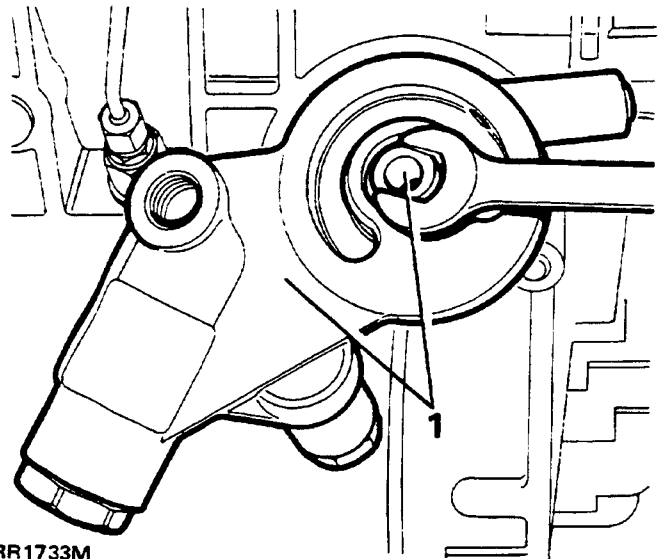
4. Fit the heater plugs and three connecting terminal bars.
5. Fit the supply pipes to the injectors and injector pump. Do not overtighten the union nuts.

## Fit rocker covers and coolant rail

1. Using new gaskets fit the rocker covers noting that the tallest covers are fitted to numbers two and three cylinders and the oil filler cap to number one cylinder. Tighten the special nuts to the correct torque.
2. Fit the engine coolant rail complete with thermostat housing to the cylinder heads using new gaskets. Tighten the eight bolts evenly to the correct torque.
3. Fit the water hose from the injector pump cold start device to number three cylinder head rocker cover and the hose from the thermostat housing to cold start device.
4. Fit the by-pass hose between thermostat housing and water pump.

## Fit oil filter adaptor

1. Fit the oil filter adaptor, using a new 'O' ring seal, to the cylinder block. Ensure that the adaptor is fitted, as illustrated, with the elongated cavity on the side facing the cylinder block at the bottom. Secure with the union screw to the correct torque.

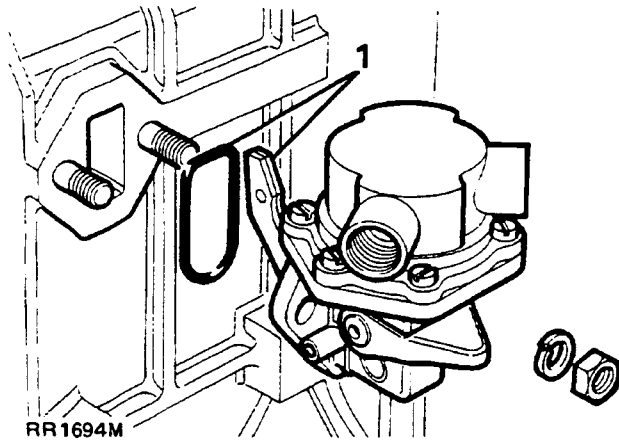


2. Smear the oil filter canister seal with clean engine oil and screw the canister on to the adaptor until contact then turn a further half turn by hand only. **See maintenance Section 10.**
3. Connect the oil feed pipe to the front main bearing carrier adaptor union and the banjo hose end to the vacuum pump.



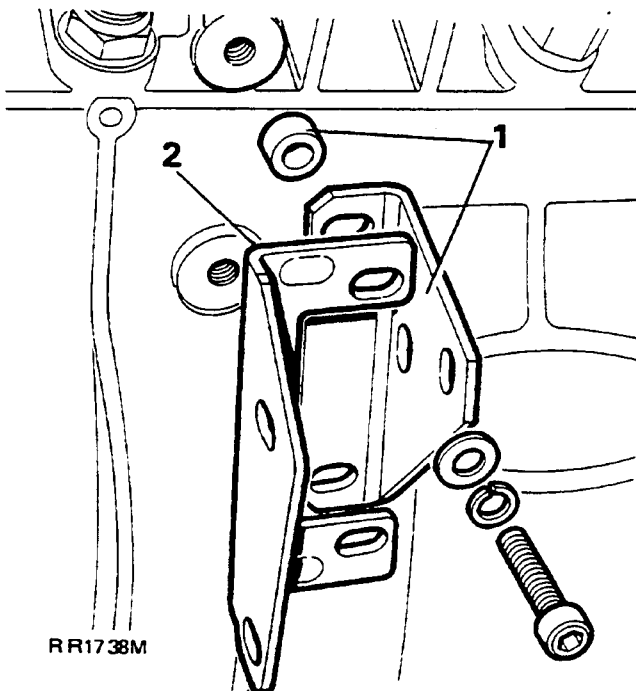
### Fit fuel lift pump

1. Using a new gasket fit the fuel lift pump to the cylinder block. Ensure that the actuating lever rides on top of the cam.

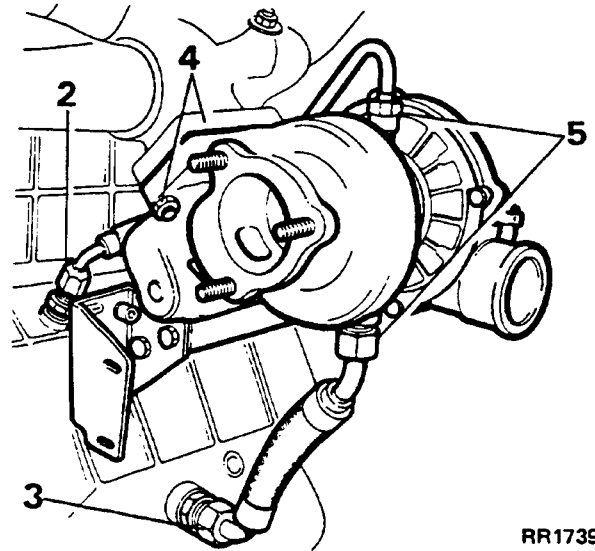


### Fit the turbocharger

1. Fit the turbocharger support bracket to the cylinder block attachment bracket.
2. Also fit the starter motor heat shield rear support bracket which shares a common fixing point on the cylinder block.



3. Fit the oil feed hose to the centre union on the cylinder block.
4. Fit the oil return hose to the crankcase union.
5. Fit a new gasket to the exhaust manifold and fit the turbo-charger and tighten the four nuts evenly to the correct torque.
6. Connect the oil feed and oil return pipes to the turbocharger.



7. Fit the heat shield to the exhaust manifold.

### Fit power steering pump

1. Fit the power steering pump and support bracket to the engine and fit the drive belt. Adjust the drive belt tension.

**Fit the alternator**

1. Right hand steer vehicles have the alternator mounted on the left side of the engine. On left hand steer vehicles the alternator is mounted on the right hand side.
2. Fit the alternator and drive belt. Adjust the belt tension.

**Fit the air conditioning compressor**

1. Fit the mounting bracket to the cylinder block and attach the compressor, noting that on R.H.S. vehicles the compressor and alternator share a common pivot belt. Fit and tension the drive belt.

**Fitting starter motor**

1. Fit the starter motor to the flywheel housing and secure with either two bolts or two nuts. Also attach the heat shield to the lower fixing, together with the earth strap.
2. Secure the rear-end of the starter motor to the rear support bracket, fitted earlier, with two bolts and attach the rear of the heat shield to the top bolt.

**Fitting clutch**

1. Clean the flywheel and clutch assembly faces.
2. Place the clutch centre friction plate in position on the flywheel with the flat side towards the flywheel.
3. Fit the clutch assembly and loosely secure with the six bolts.
4. Centralise the centre plate using special tool 18G 79 or a spare primary shaft and tighten the six bolts evenly to the correct torque.
5. Smear the splines of the centre plate with a Molybdenum disulphide grease.



## TORQUE VALUES



**NOTE:** Torque wrenches should be regularly checked for accuracy to ensure that all fixings are tightened to the correct torque.

	Nm
<b>ENGINE</b>	
Camshaft screws .....	24
Connecting rod bolts .....	81 *
Crankshaft pulley nut .....	152
Cylinder head bolts, SEE SPECIAL PROCEDURE	
Cylinder head oil pipe unions .....	8
Engine coolant rail bolts .....	8
Engine mountings .....	49
Engine sump bolts .....	11
Engine sump pan bolts .....	11
Exhaust manifold nuts .....	32
Exhaust pipe flange bolts .....	27
Flywheel bolts .....	108
Flywheel housing bolts .....	49
Fuel line unions .....	19
Heater plugs .....	23
Injection pump mounting nut.....	31
Injection pump gear nut .....	88
Injector nut .....	27
Inlet manifold nuts .....	32
Main bearing carrier bolts .....	42
Oil drain plugs .....	79
Oil filter base.....	38
Oil pump screws .....	27
Oil thermostat .....	74
Rear main bearing carrier nuts .....	27
Rocker cover nuts .....	9
Rocker shaft pedestal nuts .....	108 *
Timing cover screws .....	12
Turbo charger to manifold nuts.....	26
Vacuum pump nuts .....	21
Vacuum pump screws 2.5 Litre Engine .....	28
Valve gear oil pipe unions .....	8
Water pump screws .....	24
<b>ELECTRICAL</b>	
Alternator tie rod .....	49
Alternator bracket to crankcase .....	54
Alternator pulley nut.....	54
Alternator bottom fixing.....	54
Starter motor to flywheel housing .....	68

\* Apply Molyguard to threads before fitting.

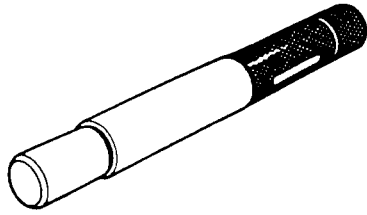


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**VM SERVICE TOOLS**

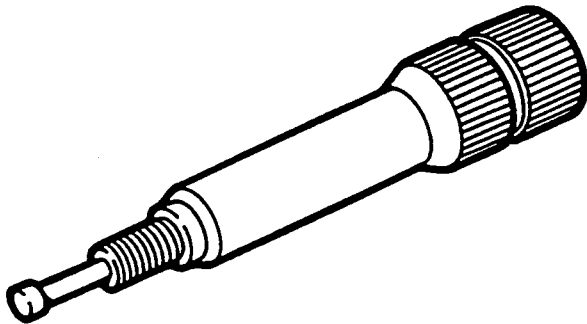
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LRT-12-001 Clutch centralising tool  
18G 79



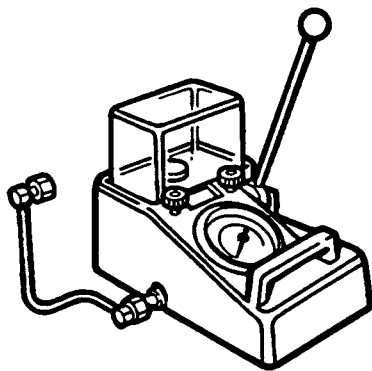
18G79

LRT-12-004 Adaptor timing injector fuel pump  
MS 107



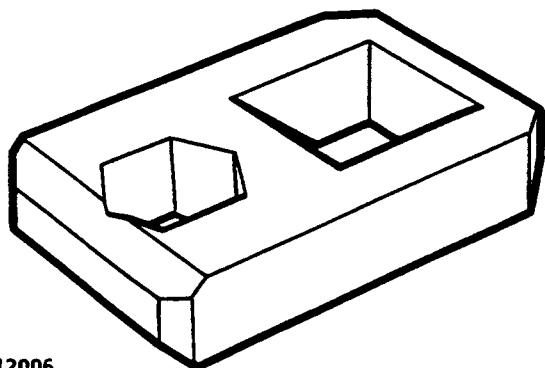
MS107

LRT-12-005 Injector tester  
LST 111



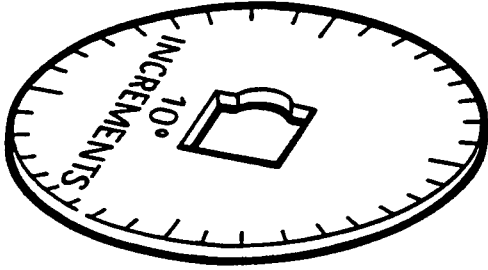
LRT12005

LRT-12-006 Adaptor cylinder head bolts  
LST 121



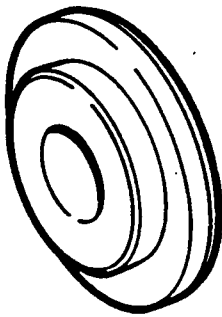
LRT12006

LRT-12-007 Angle gauge  
LST 122



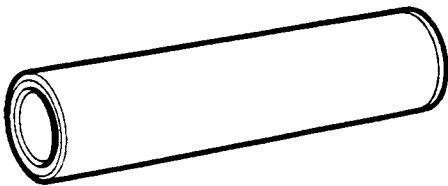
LST122

LRT-12-008 Replacer - crankshaft rear oil seal  
18G 134 -11



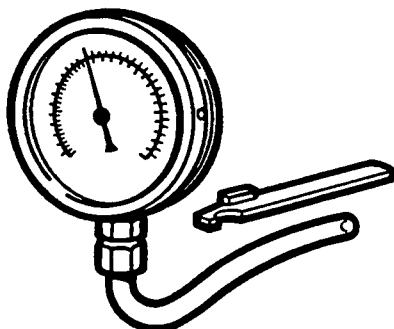
18G1374

LRT-12-009 Adaptor turbocharger spindle  
LST 191-1

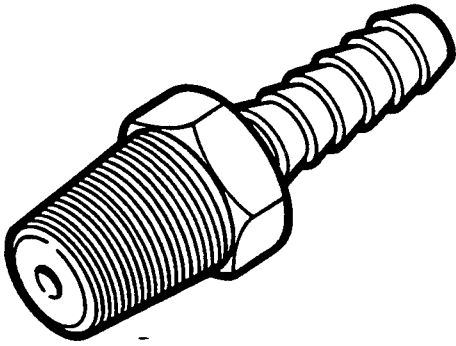


LST104

LRT-12-011 Gauge - turbo boost pressure check  
18G 1116



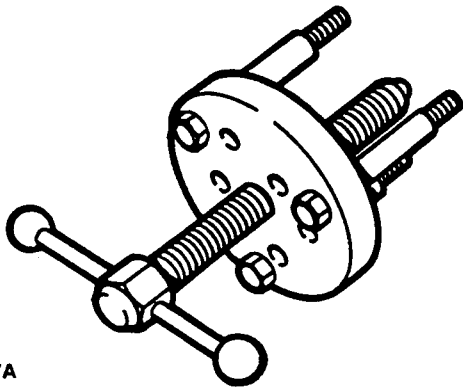
18G1116



18G11161

LRT-12-012  
18G 1116-1

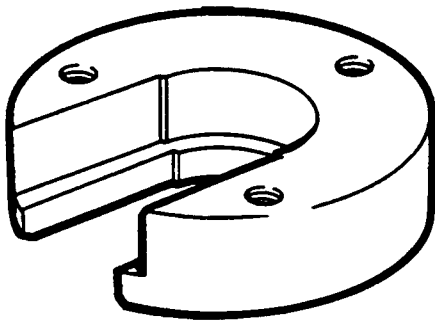
Adaptor pressure test waste gate  
valve



18G1367A

LRT-12-016  
18G 1367

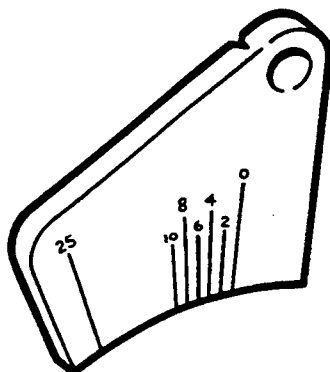
Remover crankshaft pulley



18G13671A

LRT-12-017  
18G 1367-1

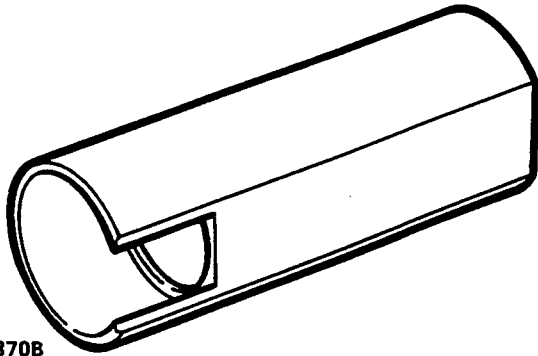
Adaptor crankshaft gear remover



18G1369A

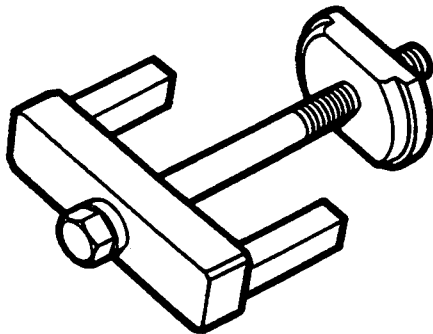
LRT-12-019  
18G 1369A

Timing gauge



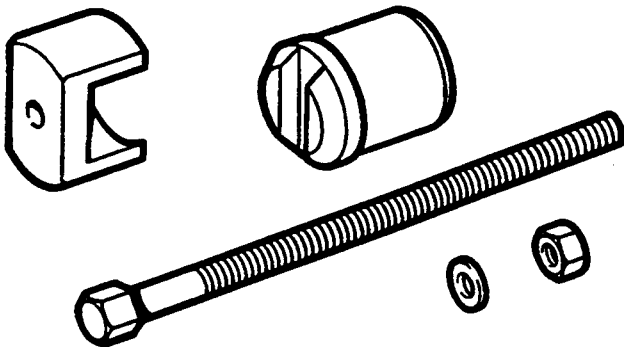
LRT-12-020    Remover replacer sleeve crankshaft  
18G 1370B

18G1370B



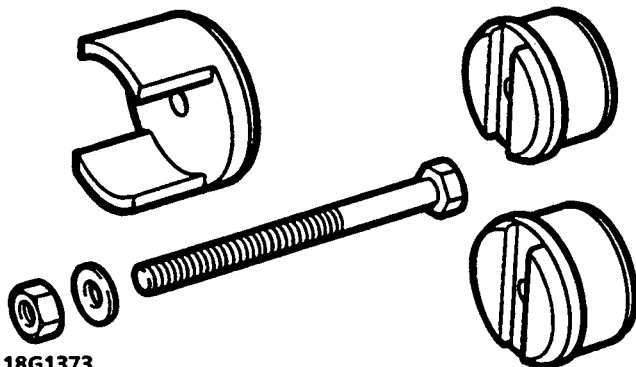
LRT-12-021    Remover cylinder liner  
18G 1371

18G1371



LRT-12-022    Remover replacer camshaft bearings  
18G 1372B

18G1372B



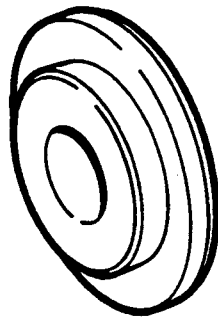
LRT-12-023    Remover replacer front and rear  
18G 1373    crankshaft bearings

18G1373



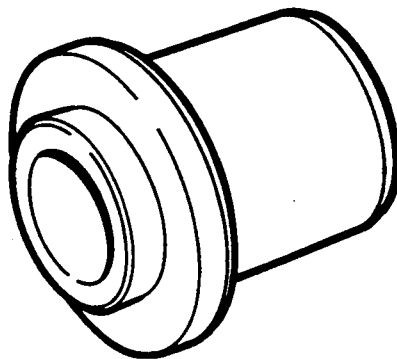


LRT-12-024 Replacer crankshaft rear oil seal  
18G 1374



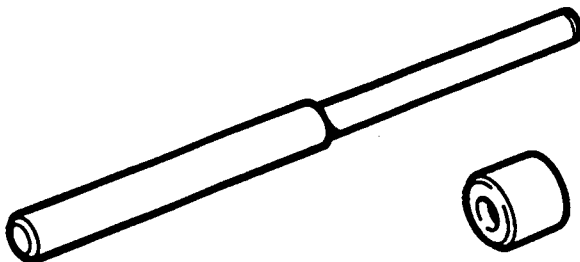
18G1374

LRT-12-025 Replacer timing cover oil seal  
18G 1375



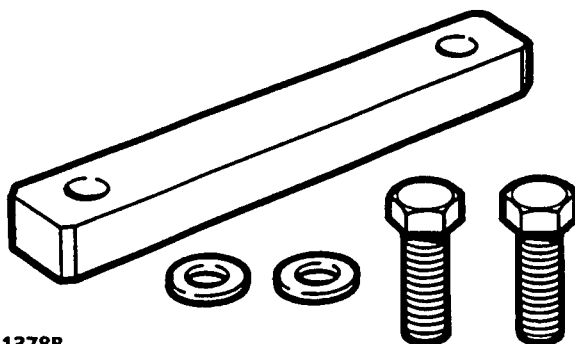
18G1375

LRT-12-026 Remover replacer valve guide  
18G 1377

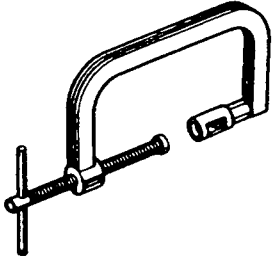


18G1377

LRT-12-027 Retainer cylinder liner  
18G 1378B

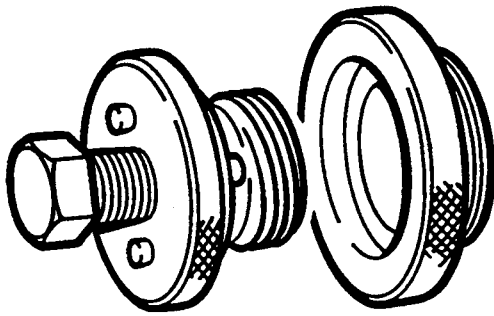


18G1378B



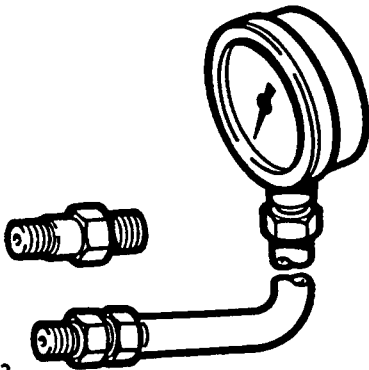
LRT-12-034 Valve spring compressor  
MS 1519A

MS1519A



LRT-12-050 Remover and holder injection  
pump drive gear  
LST 139

LST139



LRT-12-052 Engine oil pressure test equipment

LRT12052