
Piston and connecting rod assemblies

13

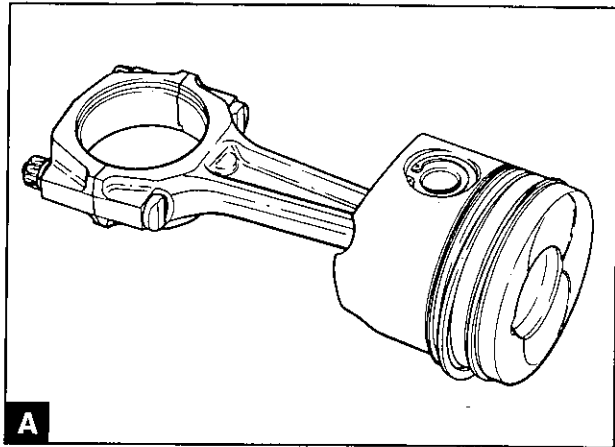
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General description

The combustion chamber in the top of the piston has a special "swirl lip" at the top to give an efficient mix of fuel and air. There are cut-outs in the top of the pistons for higher rated engines (A) to ensure that there is clearance for the valves and for the glow plugs.

The pistons have two compression rings and an oil control ring. The groove for the top ring is machined in a hard metal insert to reduce wear of the groove. Axial location of the fully floating gudgeon pin is by circlips. There is a steel insert in the piston skirt to control piston expansion.

The connecting rods are machined from "H" section forgings of steel. The location of the bearing caps to the connecting rods is made by tight fit connecting rod bolts.



Big end bearing

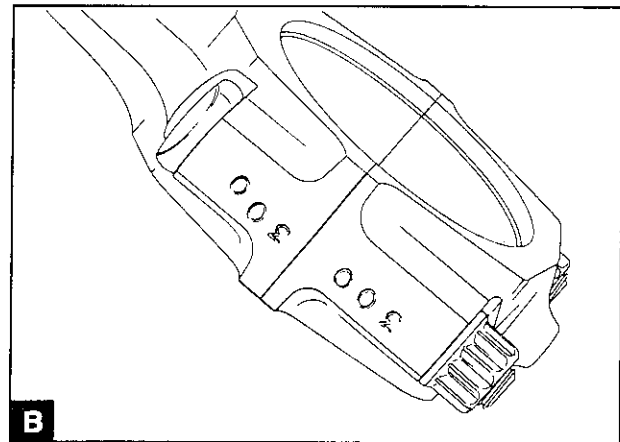
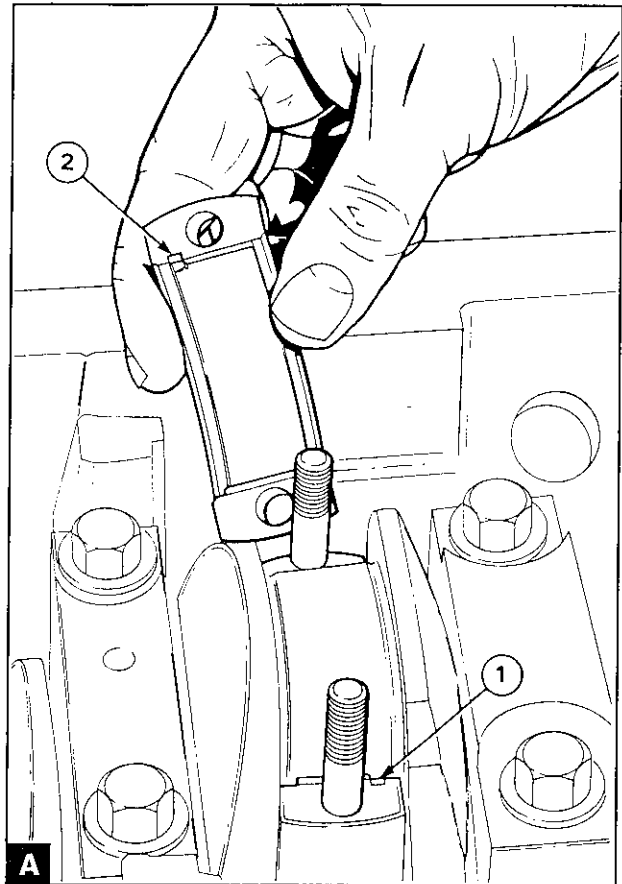
To remove and to fit **13A-01**

To remove

- 1 Drain the engine lubricating oil.
- 2 Remove the lubricating oil sump, operation 18A-03.
- 3 Remove the lubricating oil strainer and suction pipe, operation 18A-04.
- 4 Turn the crankshaft until the relevant connecting rod is at its lowest position.
- 5 Release the nuts and remove the bearing from the cap but keep it with its relevant cap.
- 6 Remove the lower half bearing from the cap but keep it with its relevant cap.
- 7 Fit a suitable length of rubber or plastic hose to each connecting rod bolt to protect the big end. Carefully push the connecting rod up the cylinder bore just enough to allow access to the upper half bearing. Remove the bearing from the connecting rod and cap together.

To fit

- 1 Clean the bearing faces of the connecting rod and the crank pin.
- 2 Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil. Fit the upper half bearing to the connecting rod with the location tag fitted correctly in its recess (A1). Fit the connecting rod to the crankpin. Ensure that the assembly number on the connecting rod (B) is on the same side as the other connecting rods.
- 3 Clean, lubricate and fit the lower half bearing into the cap. Ensure that the location tag is fitted correctly in its recess (A2). Remove the protection hoses from the connecting rod bolts and ensure that the bolts have not been moved. Fit the cap to the connecting rod. Ensure that the assembly number on the cap is the same as that on the connecting rod (B) and that both of the assembly numbers are on the same side.
- 4 Fit new nuts to the connecting rod bolts and tighten them gradually and evenly to the recommended torque of 47 Nm (35 lbf ft) 4,8 kgf m.
- 5 Ensure that the crankshaft turns freely.
- 6 Fit the lubricating oil strainer and suction pipe, operation 18A-04.
- 7 Fit the lubricating oil sump, operation 18A-03 and fill the sump to the correct level with lubricating oil of an approved grade.



To inspect **13A-02**

Check the bearings and the crank pin for wear or other damage.

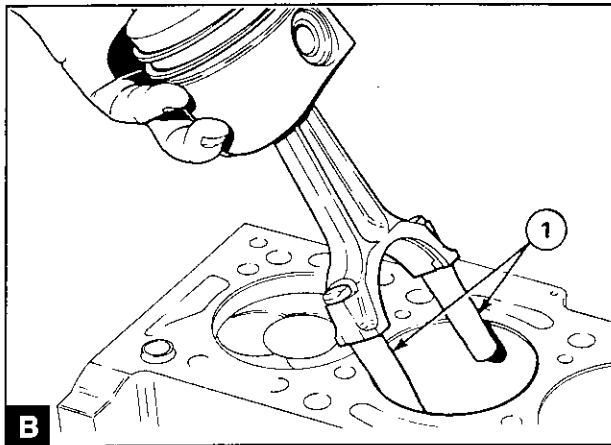
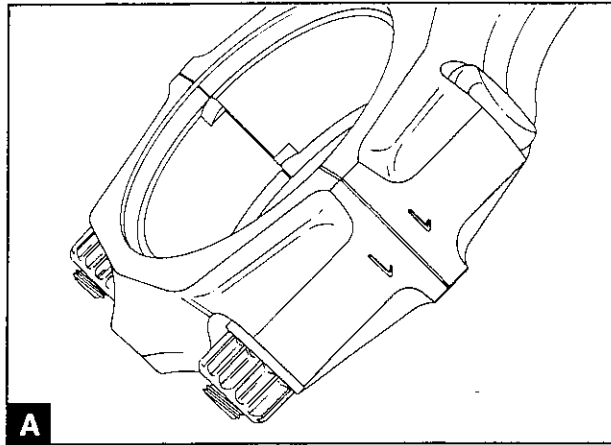
Piston and connecting rod assembly

To remove and to fit

13A-03

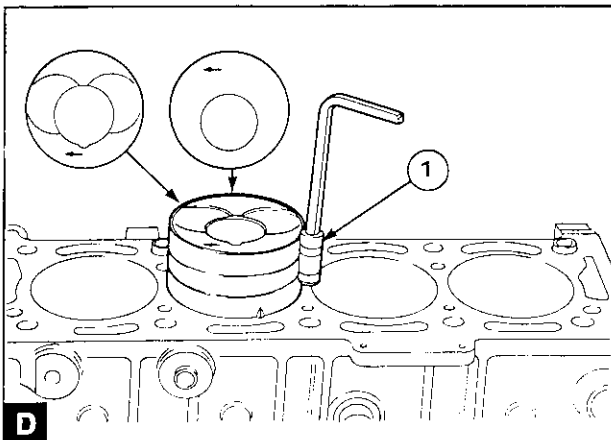
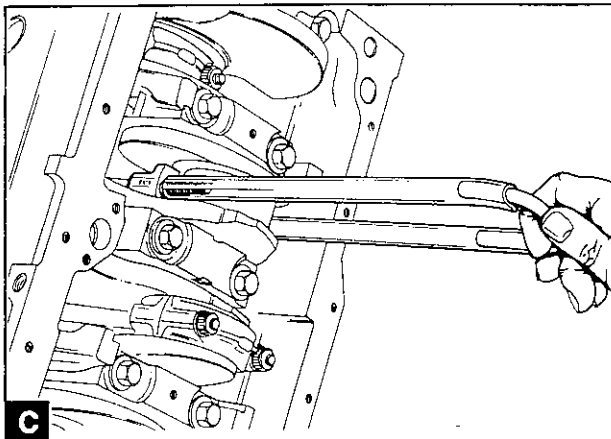
To remove

- 1 Drain the lubricating oil and the cooling system.
- 2 Remove the cylinder head assembly, operation 12A-07.
- 3 Turn the crankshaft until all the pistons are the same height in their bores. Put a suitable clean rag on the top of the piston to fill the bore. Remove all carbon from the top of the cylinder bore with a coarse grade of emery cloth. The emery cloth should be wet with lubricating oil to hold the debris. Obtain a smooth surface to the cleaned area with a fine grade of emery cloth. Clean the bore and remove the rag protection.
- 4 Remove the lubricating oil sump, operation 18A-03.
- 5 If necessary, remove the lubricating oil strainer and suction pipe, operation 18A-04.
- 6 Check that all the connecting rods and their caps are marked with their relevant cylinder number (A). If they are not marked, mark them 1 to 4 with number 1 at the timing case end of the engine.
- 7 Remove the big end cap and the big end bearings from the connecting rods, operation 13A-01. Keep the bearings and cap together to ensure that they can be fitted in their original positions.
- 8 Fit protection sleeves made of rubber or plastic to the connecting rod bolts (B1). Push the piston and the connecting rod out through the top of the cylinder bore. A suitable tool can be made for this operation with a "U" bend of metal tube and two lengths of plastic pipe (C).
- 9 Inspect the crank pin for damage.



To fit

- 1 Ensure that the piston, the cylinder bore, the crank pin and the big end of the connecting rod are clean. Lubricate the piston and the cylinder liner with clean engine lubricating oil.
- 2 Turn the crankshaft until the relevant crank pin is at its lowest position. Lubricate the crank pin with clean engine lubricating oil.
- 3 Fit a suitable length of rubber or plastic hose to each connecting rod bolt to protect the big end. Fit the upper half bearing to the connecting rod. Ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil.
- 4 Ensure that the gaps of the piston rings are 120° apart and compress the rings with the piston ring compressor (D1). Ensure that the protrusions which are pressed in one edge of the tool are at the bottom.
- 5 Enter the assembly into its correct bore. When the piston is fitted, the arrow on the top of the piston must be towards the front (timing case end) of the engine (D). In this position the combustion bowl in the top of the piston will be towards the fuel injection pump side of the engine. There are also front indicators on the bottom of the piston and on the connecting rod and these must be on the same side, see 13A.07/B.



6 Push the piston and connecting rod assembly through the bore and onto the crank pin. Turn the connecting rod until the arrow on the top of the piston is towards the front of the engine.

7 Remove the protection hoses from the big end bolts. Clean the connecting rod cap and the lower half bearing. Fit the bearing to the cap with the location tag fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil. Fit the cap and ensure that the assembly number is the same as that on the connecting rod and that the numbers are on the same side. Fit new nuts to the big end bolts and tighten them gradually and evenly to 47 Nm (35 lbf ft) 4,8 kgf m.

8 Check that the crankshaft will turn freely.

9 Check the piston height above the top face of the cylinder block with the piston height tool (A). Put the measurement tool on a flat surface and turn the gauge dial to the zero position. Turn the crankshaft until the piston is approximately at TDC. Put the measurement tool over the cylinder bore with the plunger of the gauge in contact with the piston. Turn the crankshaft to bring the piston to its highest position and make a note of the gauge indication. The correct piston height is given in section 11C. If a new lower grade of service piston has been fitted, see operation 13A-05, the piston height can be 0,10 mm (0.004 in) below the bottom limit. The piston must not be higher than the top limit. It is not permissible to remove metal from the top of the piston.

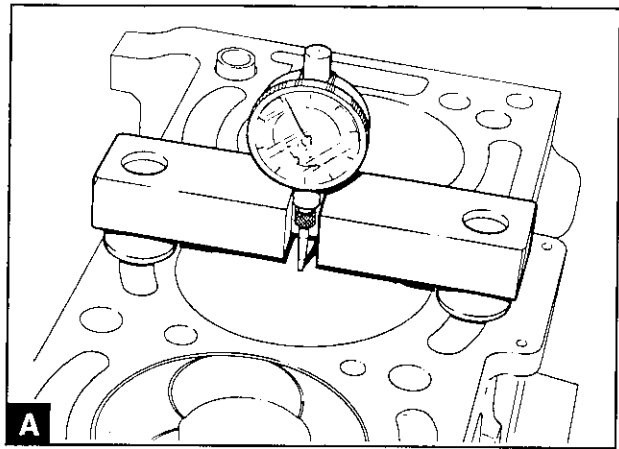
10 If necessary, fit the lubricating oil strainer and suction pipe, operation 18A-04.

11 Fit the lubricating oil sump, operation 18A-03.

12 Fit the cylinder head assembly, operation 12A-07.

13 Fill the sump to the correct level with lubricating oil of an approved grade.

14 Fill the cooling system.



13 PISTON AND CONNECTING ROD ASSEMBLIES

Piston rings

To remove and to fit

13A-04

To remove

Remove the piston rings with a suitable ring expander. Only increase the ring gaps enough to ensure that the ends of the rings do not damage the piston. Keep the rings with their relevant piston.

To fit

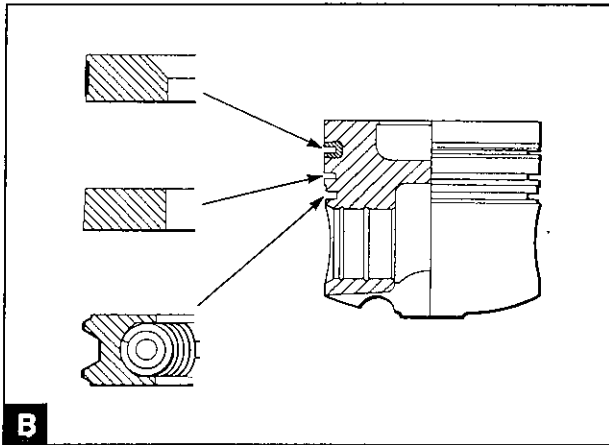
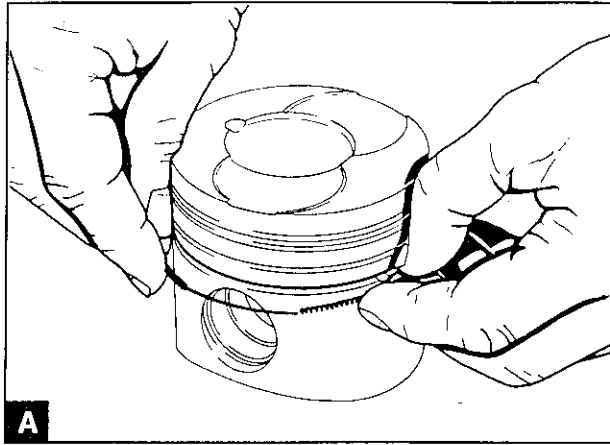
Use a suitable ring expander to fit the piston rings. Only increase the ring gaps enough to ensure that the ends of the rings do not damage the piston.

1 Fit the spring of the oil control ring in the bottom groove with the latch pin inside both ends of the spring (A). Fit the oil control ring over the spring (B). Ensure that the ring gap is at 180° to the latch pin.

2 Fit the cast iron ring with the tapered face into the second groove with the word "TOP", or the manufacturer's symbol, towards the top of the piston. New piston rings have a green identification mark. This must be on the left of the ring gap when the ring is fitted and the piston is upright.

3 Fit the barrel face ring with the molybdenum insert into the top groove. The word "TOP", the manufacturer's identification mark or the internal chamfer, must be towards the top of the piston. New piston rings have a red identification mark. This must be on the left of the ring gap when the ring is fitted and the piston is upright.

4 Ensure that the ring gaps are 120° apart.



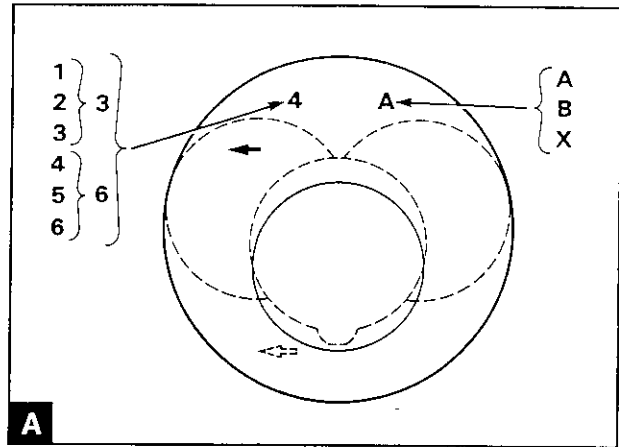
Piston and connecting rods

To dismantle and to assemble

13A-05

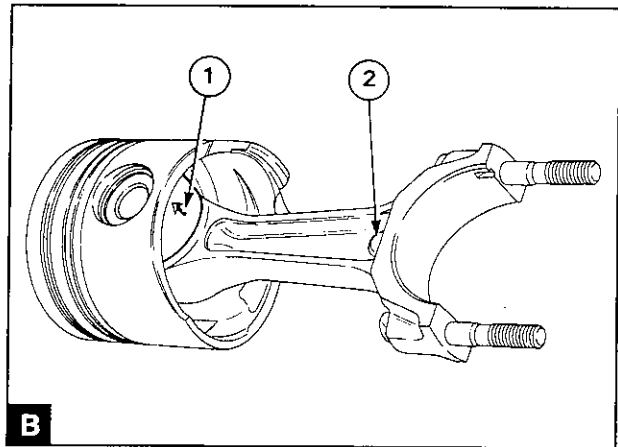
To dismantle

- 1 Remove the piston rings, operation 13A-04.
- 2 Remove the circlips which retain the gudgeon pin.
- 3 Put a temporary mark on the piston to indicate the cylinder number as shown on the connecting rod. Put the mark on the piston on the same side as the mark on the big end to ensure that they are assembled correctly.
- 4 Push the gudgeon pin out by hand. If the gudgeon pin is tight, heat the piston to 40°/50°C (100°/120°F) for easy gudgeon pin removal.



To assemble

- 1 Clean the bore of the small end bush and lubricate it with clean engine lubricating oil.
- 2 Fit a new circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.
- 3 If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder. If a new piston is to be fitted, ensure that it is of the correct height grade. In the factory, six different height grades can be used. The grades are identified by numbers which are stamped on the top of the piston (A). Number 1 is the highest piston and number 6 is the lowest piston. In service, only grades 3 and 6 will be available. Grade 3 must be used if the original piston is stamped 1, 2 or 3. Grade 6 must be used if the original piston is stamped 4, 5 or 6. Two different diameter grades "A" and "B" are also used in the factory. Only the smaller diameter piston "A" will be supplied in service for the standard size bore. A grade "X" piston will be available for bores which have been bored 0,50 mm (0.020 in) oversize in diameter in service. The diameter grades are stamped on a machined pad at the top rear of the right side of the cylinder block (16A-04/C). If a bore has been bored oversize in service, the original grade letter for that bore should be over stamped with a letter "X".
- 4 With the piston upside down, put the connecting rod in position. The location boss on the rod (B2) must be on the same side as the arrow on the bottom of the piston (B1).
- 5 Lubricate the gudgeon pin bosses with clean engine lubricating oil and push in the gudgeon pin towards the circlip. If the gudgeon pin is a tight fit in the piston, heat the piston to 40°/50°C (100°/120°F) before the gudgeon pin is fitted.
- 6 Fit a new circlip in the groove in the other gudgeon pin boss. Ensure that it fits correctly in the groove.
- 7 Fit the piston rings, operation 13A-04.



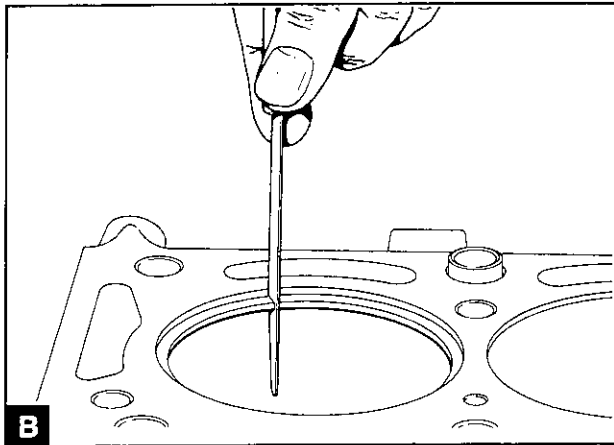
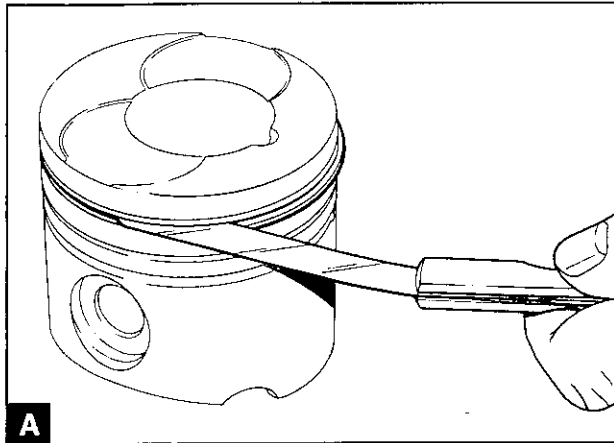
13 PISTON AND CONNECTING ROD ASSEMBLIES

Piston and rings

To inspect

13A-06

- 1 Check the piston for wear and other damage.
- 2 Check that the piston rings are free to move in their grooves and that the rings are not broken.
- 3 Remove the piston rings, operation 13A-04. Clean the piston ring grooves and the piston rings.
- 4 Fit new rings in the grooves and check for wear of the ring grooves with feeler gauges (A). Compare the piston ring clearance in the groove to that given for new components in section 11C. Renew the piston, if necessary.
- 5 Ensure that all the carbon has been removed from the top of the cylinder bores. Fit the piston rings in the top part of the bore and measure the ring gap with feeler gauges (B). The coil spring must be fitted to the oil control ring when the gap of this ring is measured. The ring gaps for new components are given in section 11C.

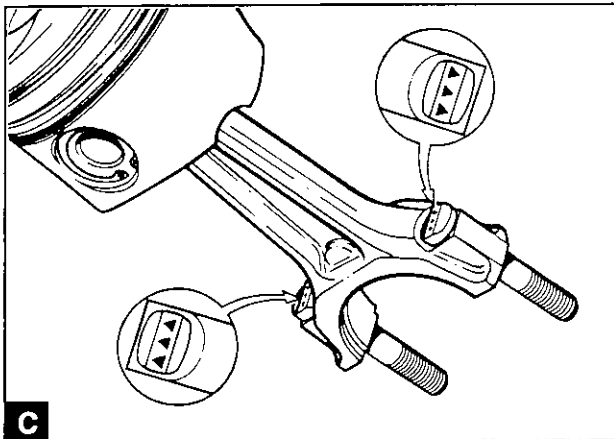


Connecting rod

To inspect

13A-07

- 1 Check the connecting rod for distortion, see section 11C.
- 2 Check the small end bush for wear or for other damage and renew it, if necessary.
- 3 Check the fit of the gudgeon pin in the small end bush and check the gudgeon pin for wear, see section 11C.
- 4 Check the condition of the big end bolts. If the thread is damaged or there are indications of stretch, the bolt must be removed from the rod and a new one fitted. The new bolt must be fitted with the location arrows (or the identification mark) on the head of the bolt towards the outside of the big end (C). Ensure that the head of the bolt is in correct contact with the connecting rod.



Small end bush

To remove and to fit

13A-08

- 1 Press out the old bush with a suitable adaptor.
- 2 Clean the connecting rod bore and remove any sharp edges.
- 3 Press in the new bush. Ensure that the lubrication hole in the bush is on the same side as, and is aligned with, the hole in the top of the connecting rod.
- 4 Ream the bush to get the correct clearance between the gudgeon pin and the bush, see section 11C.

Crankshaft assembly

14

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	Crankshaft pulley	
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	Front oil seal	
14A-02	To renew	14A.04
	Rear oil seal	
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	Thrust washers	
14A-04	To check crankshaft end-float	14A.06
14A-05	To remove and to fit	14A.06
	Main bearing	
14A-06	To remove and to fit	14A.07
14A-07	To inspect	14A.07
	Crankshaft	
14A-08	To remove and to fit	14A.08
14A-09	To inspect	14A.09

General description

The crankshaft is machined from a casting of spheroidal graphite iron. It has integral balance weights and five main journals.

End-float is controlled by two half thrust washers on both sides of the centre main bearing.

The main bearings have steel backs with bearing surfaces of tin aluminium. The main bearing caps are made of spheroidal graphite iron.

The front and the rear oil seals are Viton lip seals with oil return grooves on the inner face of the lip. The front seal is fitted in the front of the lubricating oil pump. For most engines, the rear oil seal is fitted directly into the flywheel housing or into the backplate.

The nose of the crankshaft has two separate keyways. The rear keyway is for the key of the lubricating oil pump which is fitted around the crankshaft. The front keyway is for the toothed pulley which drives the timing belt.

The crankshaft pulley is fastened to the toothed pulley by four cap screws and is fastened to the crankshaft by a centre setscrew.

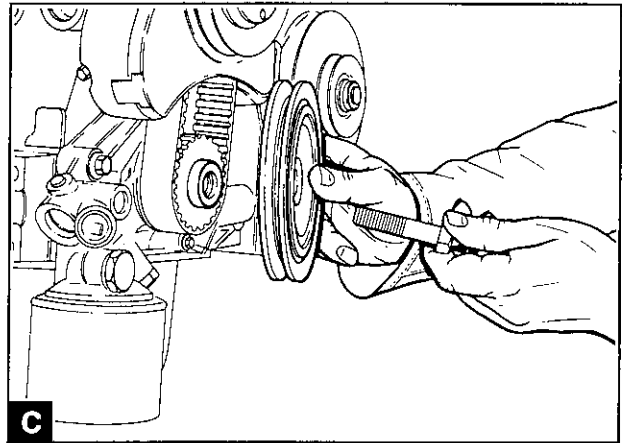
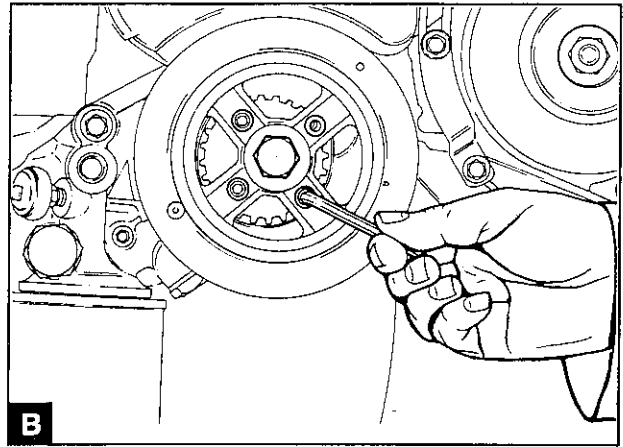
An integral damper is built into the pulley.

Crankshaft pulley

To remove and to fit

14A-01

- 1 Disconnect the battery.
- 2 Remove the drive belt of the alternator, operation 22A-03.
- 3 Remove the starter motor, operation 22B-01.
- 4 Release and remove the four cap screws which fasten the pulley to the toothed pulley (B). Release the centre setscrew of the pulley and remove the pulley (C). Use a big screwdriver or similar tool as counterhold in the flywheel ring gear.
- 5 Clean the components and check for damage. Renew damaged components.
- 6 Put the pulley in position, fit the centre setscrew and tighten it finger tight. Fit the cap screws which fasten the pulley to the toothed pulley and tighten them finger tight. Tighten the centre setscrew to 180 Nm (133 lbf ft) 18,4 kgf m and then tighten the cap screws to 10 Nm (7 lbf ft) 1,0 kgf m.
- 7 Fit the drive belt of the alternator, operation 22A-03.
- 8 Connect the battery.



Front oil seal

To renew

14A-02

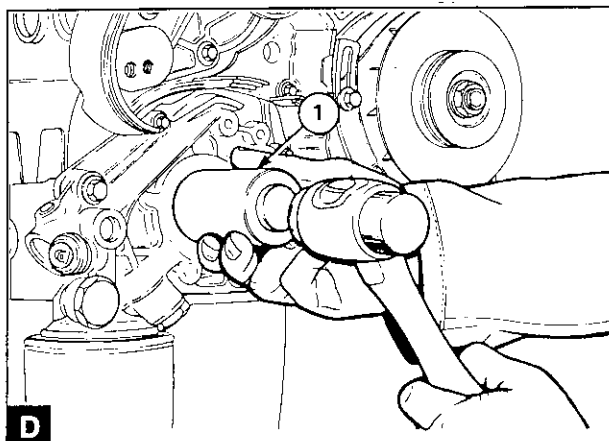
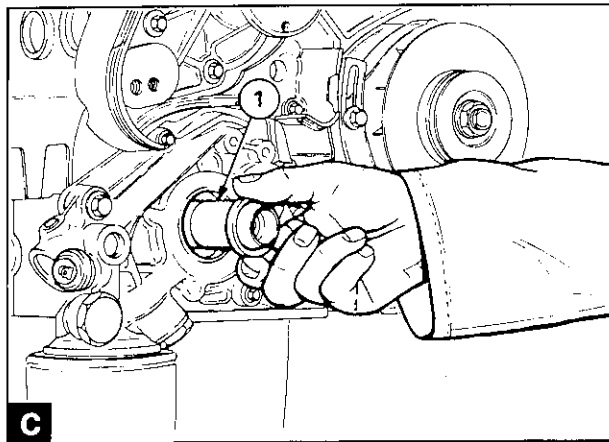
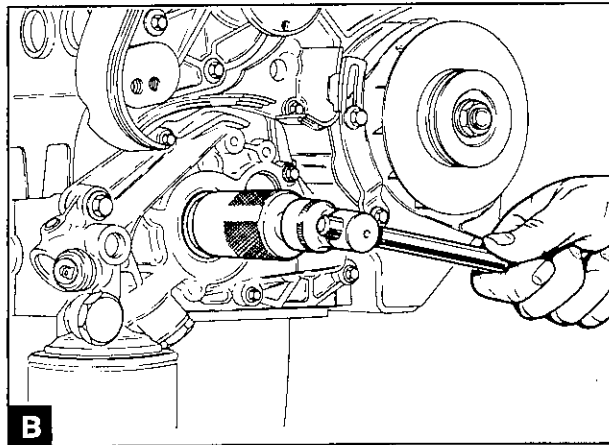
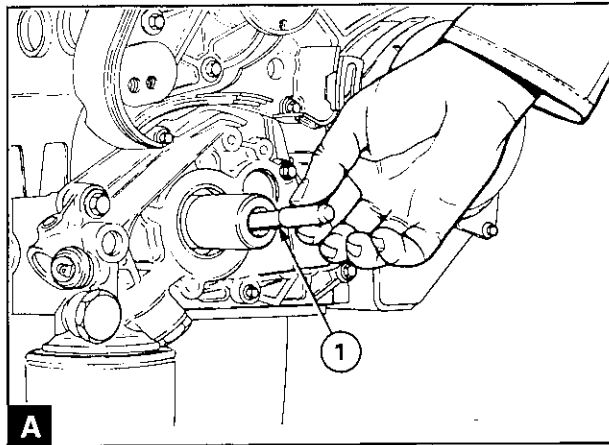
Special tools:

Remover tool for front oil seal, 885031-5

Protection sleeve, 885032-3

Replacer tool for front oil seal, 885033-1

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the top front of the camshaft cover (12A.03/A4). Turn the crankshaft until the timing hole in the front journal of the camshaft aligns with the hole in the cover.
- 3 Fit the timing pins 885037-2 to the camshaft and to the flywheel. Remove the starter motor, operation 22B-01 and fit the anti-rotation tool 885055-4 to the flywheel.
- 4 Remove the alternator drive belt, operation 22A-03 and the pulley of the water pump.
- 5 Remove the crankshaft pulley, operation 14A-01A or 14A-01B and remove the timing case cover, operation 15A-01.
- 6 Fit two screws (M6 x 50) to hold the pulley of the injection pump and remove the timing belt, operation 15A-04.
- 7 Remove the toothed pulley from the crankshaft, operation 15A-07.
- 8 Remove the front key from the crankshaft.
- 9 Fit the adaptor (A1) of tool 885031-5 into the front of the crankshaft. Release the centre screw enough to ensure that it will not reach the adaptor and enter the main tool into the seal. Turn the tool clockwise to ensure that it is tight in the seal and tighten the screw onto the adaptor to remove the seal (B). Remove the adaptor.
- 10 Ensure that the seal location and the crankshaft are clean and that they are not damaged.
- 11 Fit the protection sleeve 885032-3 (C1) to the crankshaft. Lubricate the new seal with clean engine lubricating oil. Enter the seal into its location over the protection sleeve with the lip of the seal towards the engine. Remove the protection sleeve. Use the replacer 885033-1 (D1) with a soft face hammer to fit the seal into its final position. The correct position for the seal is with the front face of the seal 0,5 mm (0.02 in) inside the housing.
- 12 Fit the key to the crankshaft and fit the toothed pulley to the crankshaft, operation 15A-07. If a brush seal is not fitted to the timing case cover, fit the crankshaft pulley, operation 14A-01A or 14A-01B.
- 13 Fit the timing belt and adjust the belt tension, see section 15.
- 14 Remove the timing pins, the pulley pins and the anti-rotation tool. Check the timing of the fuel injection pump, operation 17A-03.
- 15 Turn the crankshaft through two revolutions to ensure that there is no restriction to movement.
- 16 Fit the timing case cover, operation 15A-01. If a brush seal is fitted to the cover, fit the crankshaft pulley, operation 14A-01A or 14A-01B.
- 17 Fit the pulley of the water pump and the alternator drive belt, operation 22A-03.
- 18 Fit the starter motor and connect the battery.



Rear oil seal

To renew

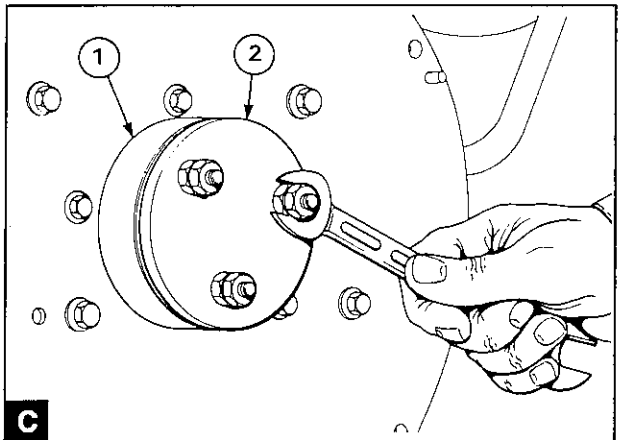
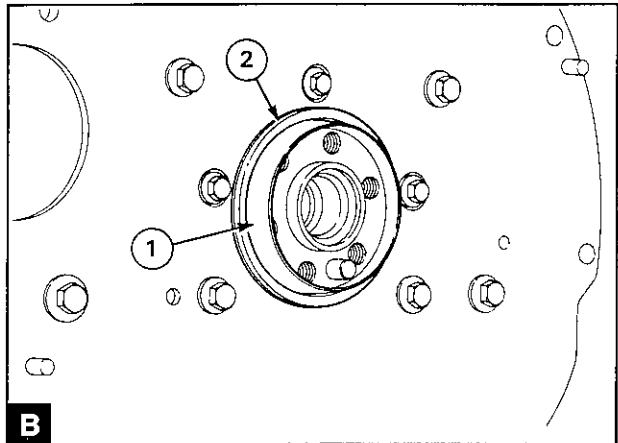
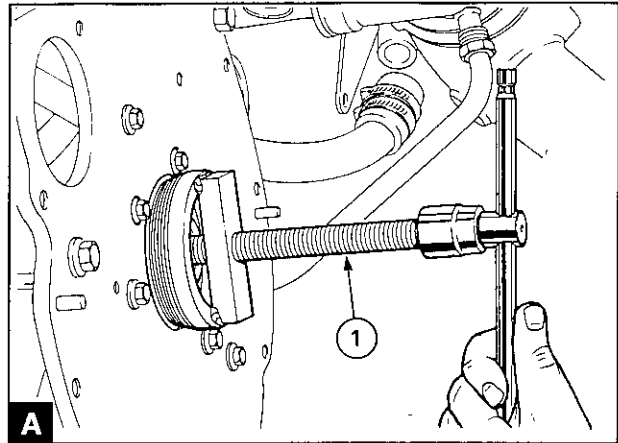
14A-03
Special tools:

Protection sleeve, 885030-7

Remover tool for rear oil seal, 885034-9

Replacer tool for rear oil seal, 885035-6

- 1 Disconnect the battery.
- 2 Remove the drive components from the rear end of the engine.
- 3 Remove the flywheel, operation 21A-01.
- 4 Check the position of the seal in the flywheel housing, in the separate seal housing or in the backplate. If the rear face of the seal is level with the rear face of the housing, the new seal can probably be pressed further into its housing; this will move the seal location area on the crankshaft flange. This is not possible if a 10 mm (0.39 in) thick backplate is fitted. If the crankshaft flange is worn and a new seal position is not available, remove the crankshaft and machine the flange, see section 11C.
- 5 Release the screw (A1) of the remover tool enough to ensure that it will not touch the crankshaft. Enter the tool into the seal and turn it clockwise to ensure that it is tight in the seal. Use a spanner on the main body of the tool to ensure that the tool is tight in the seal. Tighten the screw onto the rear of the crankshaft to remove the seal.
- 6 Clean the seal housing and the crankshaft flange.
- 7 Lubricate lightly the seal housing, the crankshaft flange and the lip of the new seal with clean engine oil.
- 8 Clean and lubricate the protection sleeve 885030-7 (B1) and fit it on the end of the crankshaft flange.
- 9 Put the seal (B2) over the sleeve with the lip towards the engine and push it along the flange until it enters the seal housing. Remove the protection sleeve.
- 10 Put the ring (C1) of tool 885035-6 on the crankshaft flange with the correct end of the ring towards the seal. If the seal is to be fitted in the forward position (see paragraph 4), fit the sleeve with the end which has a reduced diameter towards the seal. Fit the plate (C2) of tool 885035-6 and use the lock nuts to tighten the studs into the crankshaft flange. Release the lock nuts, ensure that the plate is fitted squarely to the crankshaft and use the forward nuts to press the seal into position. The nuts must be tightened gradually and evenly.
- 11 Remove the tools and fit the flywheel, operation 21A-01.
- 12 Fit the drive components to the rear end of the engine and connect the battery.



Thrust washers

To check crankshaft end-float **14A-04**

The axial movement of the crankshaft is controlled by two half thrust washers fitted both sides of the centre main bearing (B). The end-float can be checked with a feeler gauge between a thrust washer and the crankshaft. A better method is to use a dial test indicator on one end of the crankshaft to check the movement (A).

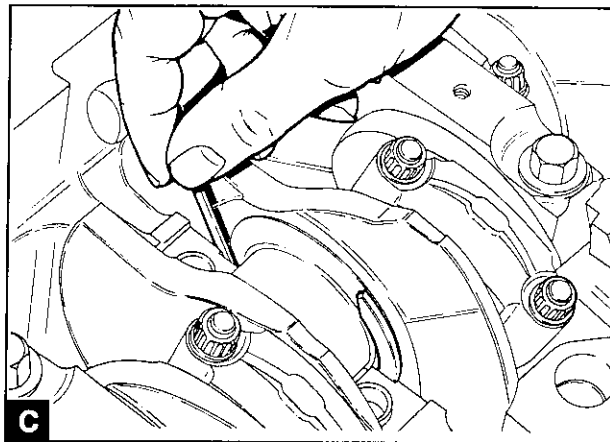
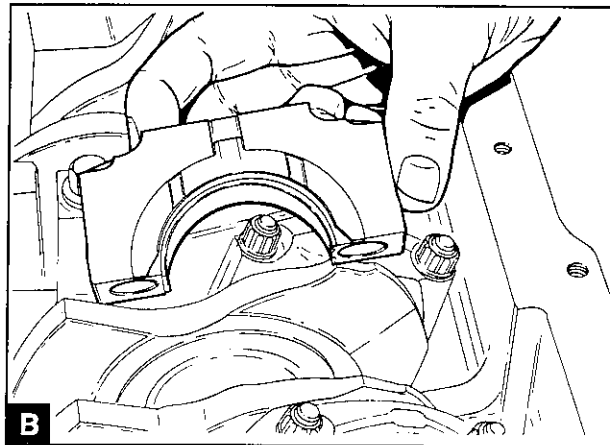
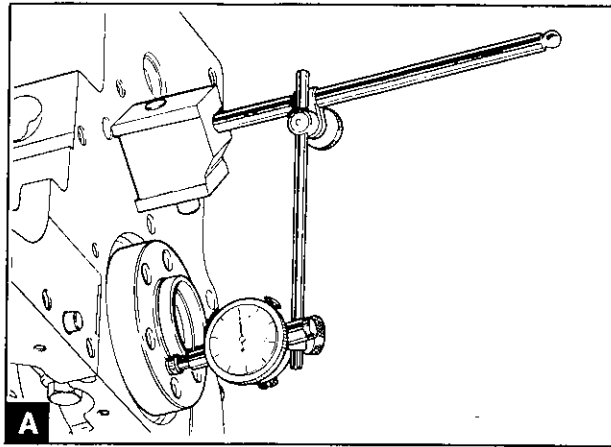
To remove and to fit **14A-05**

To remove

- 1 Drain the lubricating oil and remove the lubricating oil sump, operation 18A-03.
- 2 Where necessary, remove the lubricating oil strainer and suction pipe, operation 18A-04.
- 3 Release the setscrews of the centre main bearing and remove the main bearing cap complete with the lower half thrust washers (B).
- 4 With a suitable tool made of a soft material, press down one end of each upper half thrust washer in order to slide the washer from its recess (C). Where necessary, move the crankshaft to the front or to the rear to loosen a tight washer.

To fit

- 1 Lubricate the thrust washers with clean engine lubricating oil.
- 2 Slide the upper half thrust washers into their recesses in the cylinder block. Ensure that the sides of the thrust washers which have the grooves are against the crankshaft.
- 3 Fit the lower half thrust washers to the main bearing cap with the location tags in their recesses. Ensure that the grooves in the washers are away from the cap (B).
- 4 Ensure that the location thimbles are fitted correctly in the main bearing cap or in the cylinder block.
- 5 Ensure that the bearing is fitted correctly in the cap and that the bearing and the crankshaft journal are clean. Lubricate the bearing with clean engine lubricating oil.
- 6 Fit the cap with the location tags of both half bearings to the same side (14A.07/B1 and B2). Tighten the main bearing setscrews gradually and evenly to 112 Nm (83 lbf ft) 11,4 kgf m.
- 7 Check the crankshaft end-float.
- 8 If necessary, fit the lubricating oil strainer and the suction pipe, operation 18A-04.
- 9 Fit the lubricating oil sump, operation 18A-03, and fill it to the correct level with an approved lubricating oil.



Main bearing

To remove and to fit
(with the crankshaft in position) **14A-06**

If the front bearing is to be removed, the lubricating oil pump must also be removed. Removal of the bearing cap (with the pump in position) will damage the pump joint.

If the rear bearing cap is removed (with the flywheel housing fitted). Sealant must be applied to the bottom of the rear face of the bearing cap before it is fitted.

To remove

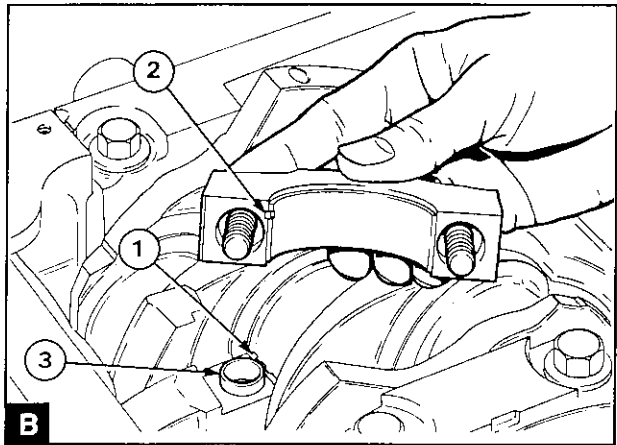
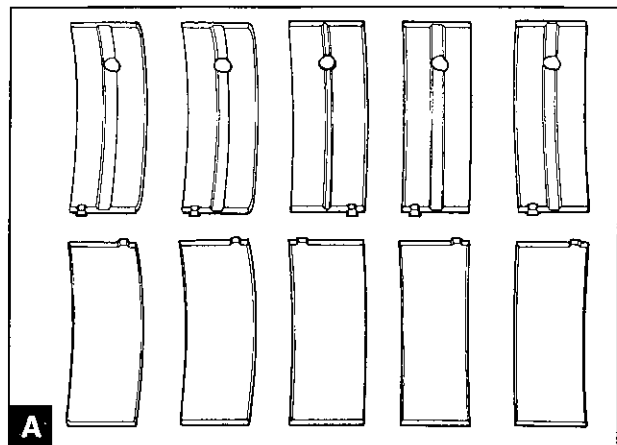
- 1 Drain the lubricating oil and remove the sump, operation 19A-03.
- 2 If necessary, remove the lubricating oil strainer and suction pipe, operation 18A-04.
- 3 Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half bearing from the cap.
- 4 With a suitable tool, push the upper half bearing from the side opposite to the location tag. This will remove the bearing tag from its recess in the bearing housing. Carefully rotate the crankshaft to release the bearing from its housing. Keep the bearing halves in their relevant positions.

To fit

- 1 Clean the upper half bearing and lubricate the bearing surface with clean engine lubricating oil.

Attention: Only the upper half bearing has lubrication holes and must be fitted to the cylinder block side. The bearings for the centre main journal are wider than the other bearings (A). The centre bearings also have the location tags in a different position.

- 2 Fit the plain end of the upper half bearing between the crankshaft journal and the side of the bearing housing which has the recess for the location tag. Slide the bearing into its housing until the tag on the bearing is fitted correctly in its recess in the housing (B1).
- 3 Clean the lower half bearing and the cap, lubricate the bearing surface with clean engine lubricating oil.
- 4 Fit the bearing into the cap with the tag of the bearing fitted correctly in the recess in the cap (B2).
- 5 Ensure that the location thimbles (B3) are fitted correctly to the cap or to the cylinder block. Fit the bearing cap with the location tags of both bearings on the same side.
- 6 Inspect the setscrews for damage and for distortion and renew them if necessary. Lightly lubricate the setscrew threads with clean engine lubricating oil. Fit the setscrews and the washers and tighten the setscrews gradually and evenly to 112 Nm (83 lbf ft) 11,4 kgf m.
- 7 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, operation 14A-03.
- 8 If necessary, fit the lubricating oil strainer and suction pipe, operation 18A-04.
- 9 Fit the lubricating oil sump, operation 18A-03 and fill it to the correct level with an approved lubricating oil.



To inspect **14A-07**

Inspect the bearings for wear and for other damage. If a bearing is worn or damaged, renew both half bearings and check the condition of the other bearings.

Crankshaft

To remove and to fit

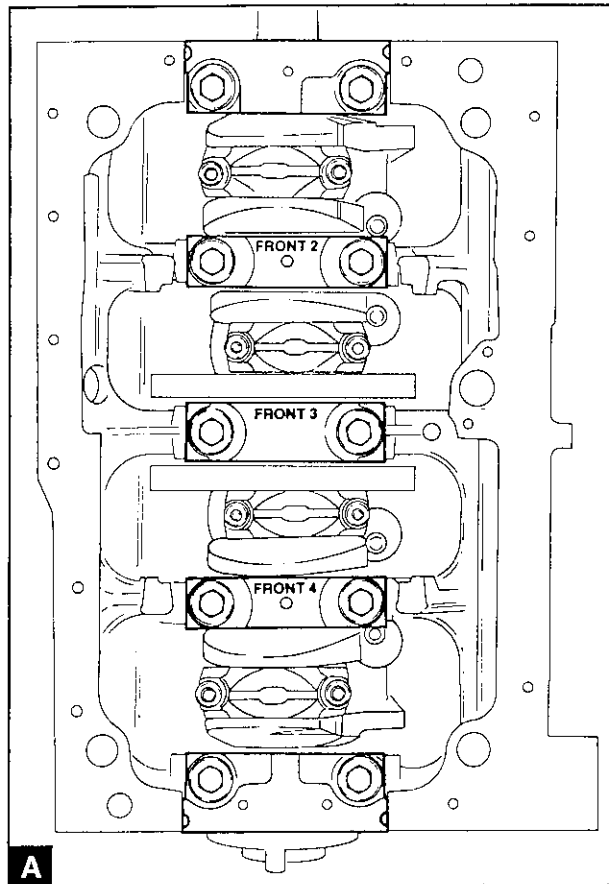
14A-08

To remove

- 1 Drain the lubricating oil and the coolant.
- 2 Remove the lubricating oil sump, operation 18A-03. Remove the lubricating oil suction pipe and strainer, operation 18A-04.
- 3 Remove the crankshaft pulley, operation 14A-01. Remove the water pump pulley.
- 4 Remove the timing case cover, operation 15A-01.
- 5 Remove the flywheel and the flywheel housing, section 21.
- 6 Turn the crankshaft until all the pistons are equally up their bores.
- 7 Make temporary alignment marks on the timing belt and on suitable teeth of the crankshaft pulley, the camshaft pulley and the fuel injection pump pulley. This is to ensure that the belt can be fitted again the same position.
- 8 Remove the timing belt, the toothed pulleys and the timing case, section 15.
- 9 Remove the lubricating oil pump, operation 18A-06.
- 10 Measure the crankshaft end-float to check if new thrust washers are needed.
- 11 Ensure that all the connection rod caps are marked with their relevant cylinder number. Remove the caps and the lower half big end bearings, operation 13A-01.
- 12 The inner main bearing caps are marked 2, 3 and 4 and also have the word "FRONT" to indicate the correct fitted position (A). Remove the main bearing caps, the lower half bearings and the thrust washers and keep the bearings with their relevant caps. Slide out the upper half thrust washers.
- 13 Remove the crankshaft.
- 14 Remove the upper half main and big end bearings and keep them with their relevant caps.

To fit

- 1 Ensure that all lubricating oil passages are clean and free from restriction. Clean the sealant grooves in the sides of the front and the rear main bearing caps.
- 2 Clean the main bearing housings and the upper half bearings. Fit the bearings with the location tags fitted correctly in their recesses. The upper half main bearings have oil holes and grooves and the centre bearing is wider than the others. Lubricate the bearings with clean engine lubricating oil.
- 3 Ensure that the journals of the crankshaft are clean and lubricate them with clean engine lubricating oil. Carefully lower the crankshaft into position on the bearings.
- 4 Clean and lubricate the upper half thrust washers and slide them into their recesses on both sides of the bearing housing. Ensure that the lubrication grooves of the thrust washers are towards the crankshaft.
- 5 Clean the bearing caps and the lower half bearings. Fit the bearings to the caps with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.
- 6 Ensure that the location thimbles for the main bearing caps are fitted correctly in the caps or in the cylinder block.



7 Clean the lower half thrust washers and lubricate them with clean engine lubricating oil. Fit the thrust washers to the centre main bearing cap with the oil grooves of the thrust washers away from the bearing. Ensure that the location thimbles for the cap are in position. Fit the cap to the cylinder block with the word "FRONT" to the timing case end of the block. Fit and tighten the cap setscrews gradually and evenly to 112 Nm (83 lbf ft) 11,4 kgf m.

8 Fit the remainder of the caps into their correct positions. Numbers 2 and 4 caps are stamped with their position number and the word "FRONT". The word "FRONT" must be towards the timing case end of the engine (14A.08A). The front and rear caps are not stamped with a number; the front cap has a single threaded hole in its bottom face; the rear cap has two threaded holes in its bottom face. Fit and tighten the cap setscrews gradually and evenly to 112 Nm (83 lbf ft) 11,4 kgf m.

9 Check the crankshaft end-float and renew the thrust washers if necessary.

10 Remove the protection sleeves from the big end bolts.

11 Fit the connecting rod caps, see operation 13A-03.

12 Fit the lubricating oil suction pipe, the sump and the oil sump section 18.

13 Fit the flywheel housing and fit the flywheel, see section 21.

14 Apply sealant into the groove in each side of the front and the rear main bearing caps (A). Apply the sealant until it completely fills the grooves and also comes out of the gaps between the cap and the cylinder block. Remove sealant from around the fastener holes for the lubricating oil sump. Fit the sump, operation 18A-03, within five minutes of the sealant application.

15 Fit the timing case and the timing pulleys, see section 15. Fit the timing belt, operation 15A-04, with the temporary marks on the belt aligned with the marked teeth of the timing pulleys. Remove the temporary timing marks and adjust the belt tension, operation 15A-03.

16 Check the timing of the fuel injection pump, operation 17A-03.

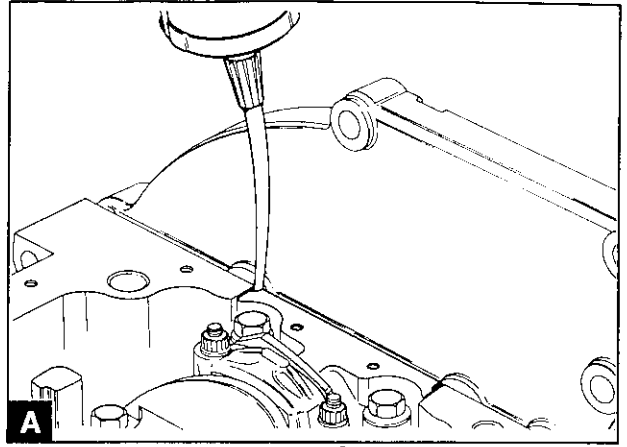
17 Fit the timing case cover, operation 15A-01.

18 Fit the crankshaft pulley, operation 14A-01.

19 Fit the water pump pulley.

20 Fit the starter motor, operation 22B-01.

21 After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil. Fill the cooling system.



To inspect

14A-09

Check the crankshaft for wear and other damage. The maximum permissible wear and ovality on the crankshaft journals and on the crank pins is 0,03 mm (0.001 in).

The main journals and the crankpins of standard size crankshafts can be machined to 0,30 mm (0.012 in) undersize on diameter, see section 11C. Special undersize bearings are available.

The seal location area of the rear flange can be machined to remove the wear marks, if the seal has been used in both positions, see section 11C.

Timing case and drive assembly

15

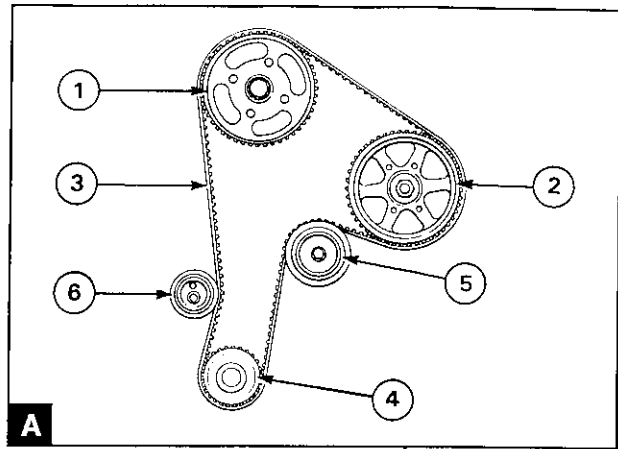
	General description	15A.02
	Timing case cover	
15A-01	To remove and to fit	15A.03
	Timing belt	
15A-02	To check the belt condition and tension	15A.04
15A-03	To adjust the tension	15A.04
15A-04	To remove and to fit	15A.05
	Toothed pulley for fuel injection pump	
15A-05	To remove and to fit	15A.06
	Toothed pulley for camshaft	
15A-06	To remove and to fit	15A.07
	Toothed pulley for crankshaft	
15A-07	To remove and to fit	15A.08
	Timing case	
15A-08	To remove and to fit	15A.09

General description

Toothed pulleys are fitted to the camshaft (A1) and to the fuel injection pump (A2). These pulleys are driven through a toothed belt (A3) by a similar pulley fitted to the crankshaft (A4). The pulleys are made of sintered 2% copper iron and the belt is made of glass fibre and neoprene. A plain idler pulley (A5) ensures the correct belt engagement and an adjustable tensioner pulley (A6) controls the belt tension.

The pulley of the fuel injection pump has two keyways, one for turbocharged engines and the other for naturally aspirated engines.

The timing pulleys and belt are contained in a timing case and cover which are made off glass filled polypropylene.



Timing case cover

To remove and to fit

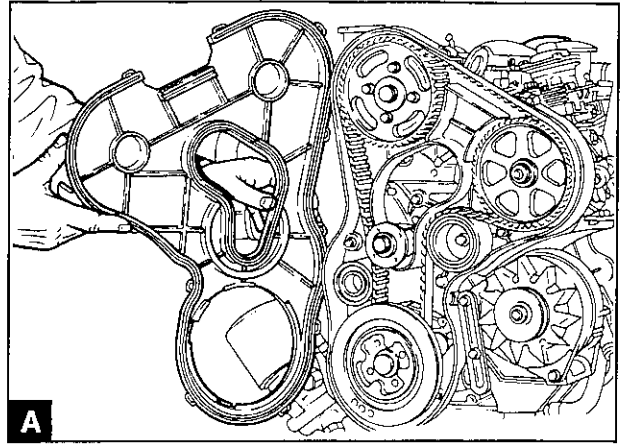
15A-01

To remove

- 1 Disconnect the battery.
- 2 Remove the alternator drive belt, operation 22A-03.
- 3 Remove the pulley of the water pump.
- 4 Remove the access panel from the timing case (15A.04/A).
- 5 Release the clips of the cover and remove the cover (A).

To fit

- 1 Ensure that the cover is clean and that all spring clips are fastened to the timing case.
- 2 Fit the cover on to the timing case and ensure that all the fastener clips are pressed into position.
- 3 Fit the access panel to the timing case and to the cover.
- 4 Fit the water pump pulley.
- 5 Fit the alternator drive belt, operation 22A-03.
- 6 Connect the battery.



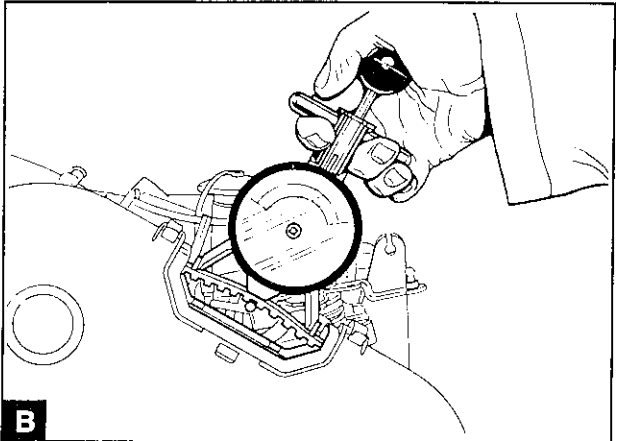
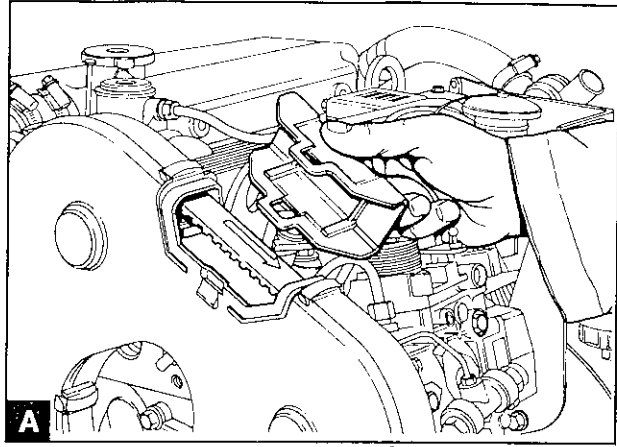
Timing belt

To check the belt condition and tension **15A-02**

Special tool:

Tension gauge, 885036-4

- 1 Remove the access panel from the top of the timing case (A).
- 2 Make a temporary mark on the belt to ensure that the complete belt will be checked. Check the teeth for wear and damage and check the belt for cracks and oil contamination. Turn the crankshaft to check all the teeth and the complete belt. If necessary, renew the belt, operation 15A-04. Remove the temporary mark.
- 3 Press down the ball end of the tension gauge and fit the gauge over the belt. Ensure that the foot of the gauge is under the belt and between two of the belt teeth (B). Release the ball end slowly and check the gauge reading. Move the crankshaft by a small amount in each direction until a constant reading is obtained. The correct reading for a new belt is 95/105 lbf and for a used belt the correct reading is 80 lbf. If the tension of a used belt has reduced to 60 lbf or below, adjust the tension to 80 lbf, operation 15A-03.
- 4 When the tension is correct, fit the access panel to the timing case.



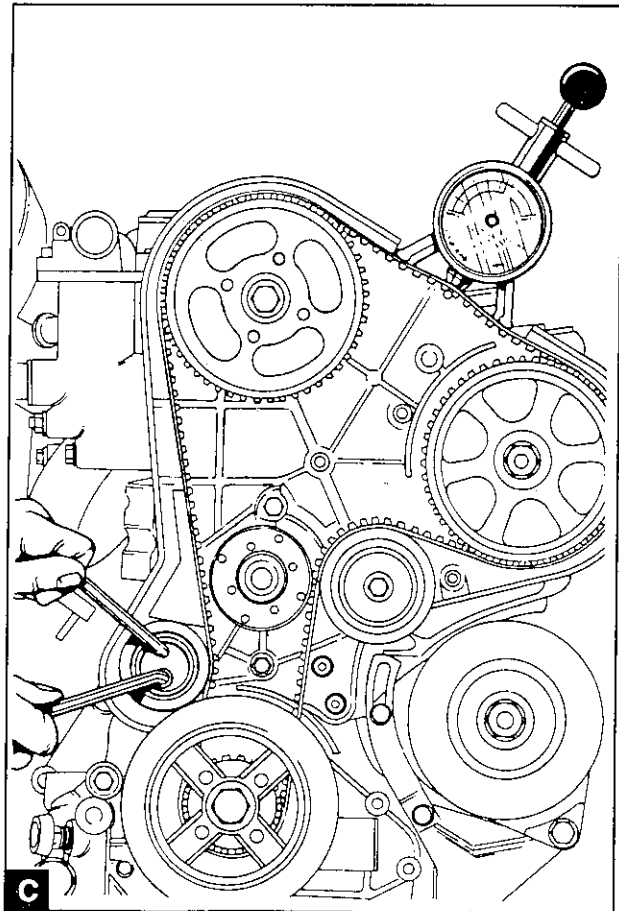
To adjust the belt tension **15A-03**

Special tools:

Timing pins, 885037-2

Tension gauge, 885036-4

- 1 Fit the timing pins to the camshaft and to the flywheel, operation 17A-01.
- 2 Remove the timing case cover, operation 15A-01.
- 3 Fit the tension gauge between the pulleys of the fuel injection pump and the camshaft.
- 4 Release the four setscrews of the camshaft pulley to allow the pulley to turn on its hub.
- 5 Loosen the capscrew which fastens the belt tensioner pulley. Adjust the belt tension with an allen key fitted in the hexagonal adjustment hole in the pulley (C). The correct tension for a new belt is 100 lbf and the correct tension for a used belt is 80 lbf. When the tension is correct, tighten the capscrew to 45 Nm (32 lbf ft) 4,4 kgf m and check the tension again.
- 6 Tighten the setscrews of the camshaft pulley to the correct torque, see section 11B and ensure that the tension is still correct.
- 7 Remove the timing pins from the camshaft and from the flywheel.
- 8 Turn the crankshaft through two revolutions and check the tension again.
- 9 Check the timing of the fuel injection pump, operation 17A-03.
- 10 Fit the cover to the timing case, operation 15A-01.



To remove and to fit**15A-04**

Special tools:

Timing pins, 885037-2

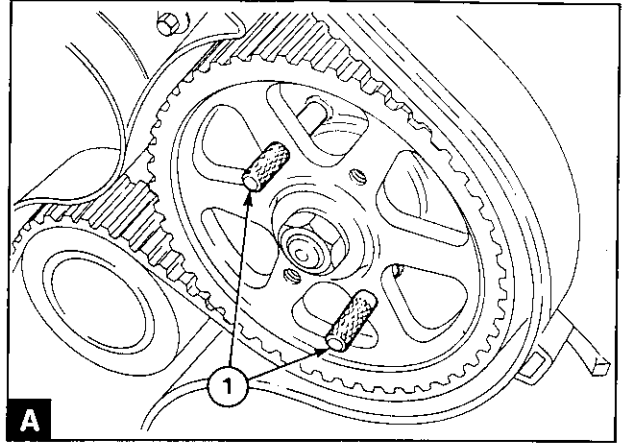
Anti-rotation tool, 885055-4

To remove

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the camshaft cover. Turn the crankshaft until the timing hole in the camshaft aligns with the hole in the cover. Fit the timing pins 885037-2 into the camshaft and into the flywheel.
- 3 Remove the starter motor and fit the anti-rotation tool 885055-4 to the flywheel.
- 4 Remove the timing case cover, operation 15A-01.
- 5 Fit two screws (M6 x 50) (A1) through the plain holes in the pulley of the fuel injection pump and into the pump support bracket.
- 6 Remove the belt tensioner pulley and the idler pulley.
- 7 Remove the timing belt. Do not bend the belt to an acute angle as this can damage the belt and cause failure. Put the belt on its edge in a circle on a flat surface. Do not hang it.
- 8 Inspect the teeth of the belt for wear. Check the complete belt for oil consumption, cracks and other damage. Renew the belt if a fault is found.

To fit

- 1 Fit the timing belt over the toothed pulleys of the crankshaft, the camshaft and the fuel injection pump. Ensure that the direction arrows on the belt indicate a clockwise direction from the front (15A.04/A).
- 2 Fit the idler pulley and tighten the pulley setscrew to 43 Nm (32 lbf ft) 4,4 kgf m.
- 3 Put the tensioner pulley in position and engage the pulley capscrew. There are two threaded holes for the capscrew and it must be fitted in the hole which will allow correct adjustment of the belt tension. Tighten the capscrew to hold the pulley but do not tighten it fully.
- 4 Remove the location pins from the toothed pulley of the fuel injection pump and adjust the belt tension, operation 15A-03.
- 5 Tighten the setscrews of the camshaft pulley to the correct torque, see section 11B and remove the anti-rotation tool.
- 6 **Remove the timing pins from the camshaft and from the flywheel.**
- 7 Check the timing of the fuel injection pump, operation 17A-03.
- 8 Turn the crankshaft through two revolutions to check that there is no restriction to movement.
- 9 Fit the timing case cover, operation 15A-01 and fit the access panel.
- 10 Fit the setscrew in the timing hole in the camshaft cover.
- 11 Fit the starter motor, operation 22B-01.
- 12 Connect the battery.





Toothed pulley for fuel injection pump

To remove and to fit

15A-05

Special tools:

Timing pins, 885037-2

Pulley remover, 885027-3

Adaptors for use with 885027-3, 885029-9

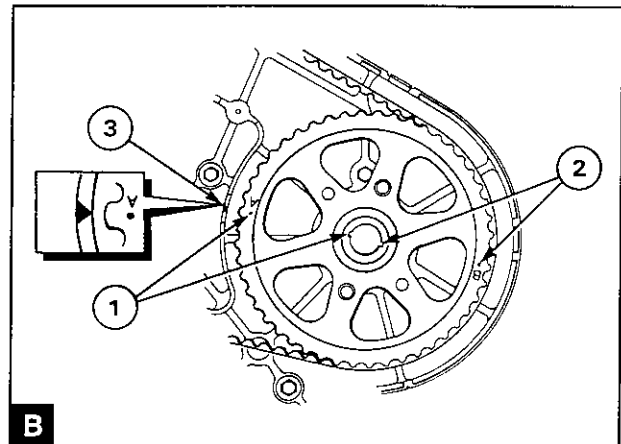
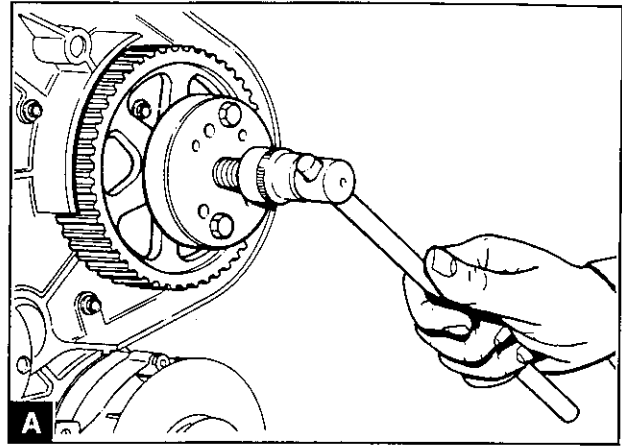
Anti-rotation tool, 885055-4

To remove

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the camshaft cover. Turn the crankshaft until the timing hole in the camshaft aligns with the hole in the cover and fit the timing pins 885037-2 into the camshaft and into the flywheel.
- 3 Remove the starter motor and fit the anti-rotation tool 885055-4 to the flywheel.
- 4 Remove the timing case cover, operation 15A-01.
- 5 Release and remove the pulley nut of the fuel injection pump. Loosen the setscrews of the camshaft pulley.
- 6 Remove the timing belt, operation 15A-04.
- 7 Remove the pulley with the pulley remover 885027-3 and adaptors 885029-9. Ensure that the key is not lost.
- 8 Check the pulley for wear, cracks and other damage. Renew it if necessary.

To fit

- 1 Ensure that the key is correctly fitted in the shaft of the fuel injection pump.
- 2 Put the pulley in position on the shaft with the correct keyway in engagement with the key. There are two keyways and two marked teeth "A" and "B" on the pulley. Use the keyway which is on the same side as the tooth marked "A" for MD22 and MD22L engines. For TMD22 use the keyway which is on the same side as the tooth marked "B". Ensure that the marks on the pulley are towards the front of the engine.
- 3 Fit the spring washer and the pulley nut, hold the pulley to prevent movement and tighten the nut to press the pulley into position.
- 4 Ensure that the relevant marked tooth (see paragraph 2) of the pulley is near to the arrow on the timing case (B3). Fit two screws (M6 x 50) through the plain holes in the pulley and into the pump support bracket.
- 5 Fit the timing belt, operation 15A-04. Remove the pulley location pins and adjust the belt tension, operation 15A-03.
- 6 Tighten the pump pulley nut to 60 Nm (44 lbf ft) 6,1 kgf m and remove the anti-rotation tool.
- 7 **Remove the timing pins from the camshaft and from the flywheel.**
- 8 Check the timing of the fuel injection pump, operation 17A-03.
- 9 Turn the crankshaft through two revolutions to check that there is no restriction to movement.
- 10 Fit the timing case cover, operation 15A-01 and fit the access panel.
- 11 Fit the setscrew in the timing hole in the camshaft cover.
- 12 Fit the starter motor, operation 22B-01.
- 13 Connect the battery.



Toothed pulley for camshaft

To remove and to fit

15A-06

Special tools:

Timing pins, 885037-2

Pulley remover, 885027-3

Adaptors for use with 885027-3, 885029-9

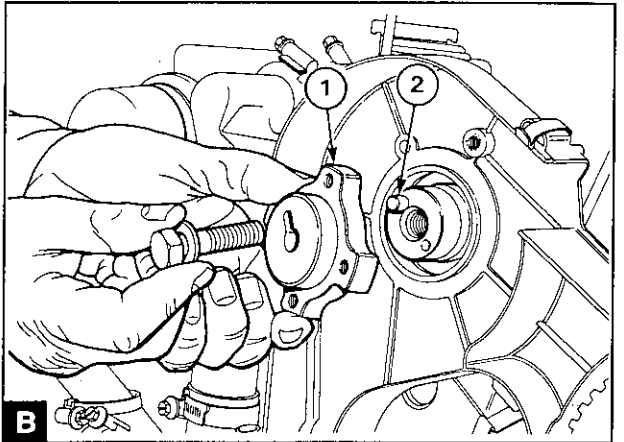
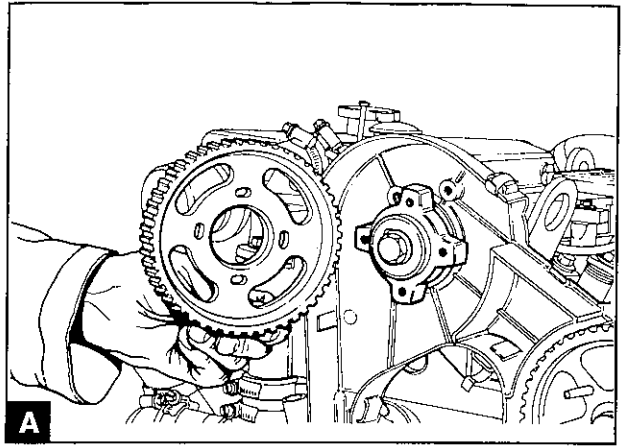
Anti-rotation tool, 885055-4

To remove

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the camshaft cover. Turn the crankshaft until the timing hole in the camshaft aligns with the hole in the cover. Fit the timing pins 885037-2 into the camshaft and into the flywheel.
- 3 Remove the starter motor and fit the anti-rotation tool 885055-4 to the flywheel.
- 4 Remove the timing case cover, operation 15A-01.
- 5 Fit two screws (M6 x 50) through the plain holes in the pulley of the fuel injection pump and into the pump support bracket.
- 6 Loosen the setscrews which fasten the pulley to the hub.
- 7 Remove the timing belt, operation 15A-04.
- 8 Remove the pulley setscrews and remove the pulley. If necessary, remove the pulley hub (B1) and its dowel (B2).
- 9 Check the pulley for wear, cracks and other damage. Renew it if necessary.

To fit

- 1 Ensure that the dowel (B2) is in position in the camshaft. Fit the hub and its setscrew but do not fully tighten the setscrew. If necessary, fit the pulley to the hub but do not fully tighten the setscrews.
- 2 Fit the timing belt, operation 15A-04. Remove the location pins from the pulley of the injection pump and adjust the belt tension, operation 15A-03.
- 3 Tighten the centre setscrew of the pulley to 85 Nm (63 lbf ft) 8,7 kgf m and/or tighten the setscrews which fasten the pulley to the hub to 22 Nm (16 lbf ft) 2,2 kgf m. Remove the anti-rotation tool.
- 4 **Remove the timing pins from the camshaft and from the flywheel.**
- 5 Check the timing of the fuel injection pump, operation 17A-03.
- 6 Turn the crankshaft through two revolutions to check that there is no restriction to movement.
- 7 Fit the timing case cover, operation 15A-01 and fit the access panel.
- 8 Fit the setscrew in the timing hole in the camshaft cover.
- 9 Fit the starter motor, operation 22B-01.
- 10 Connect the battery.



Toothed pulley for crankshaft

To remove and to fit

15A-07

Special tools:

Timing pins, 885037-2

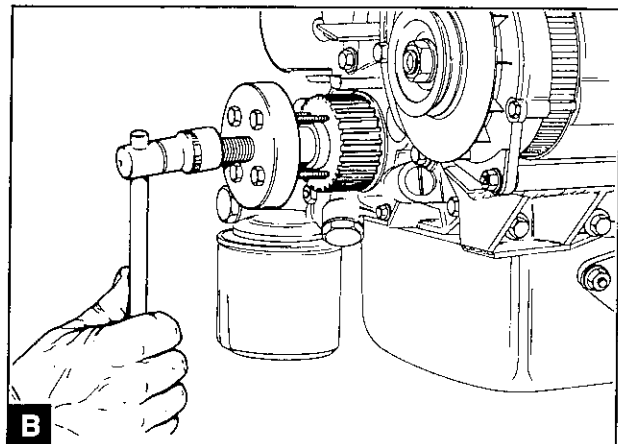
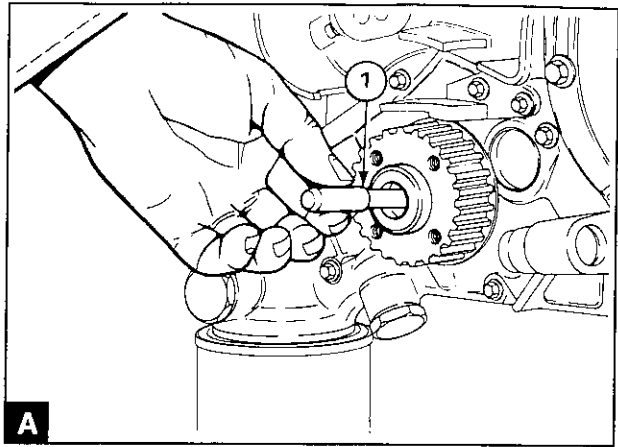
Pulley remover, 885027-3

Adaptors for use with 885027-3, 885029-9

Anti-rotation tool, 885055-4

To remove

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the camshaft cover. Turn the crankshaft until the timing hole in the camshaft aligns with the hole in the cover. Fit the timing pins 885037-2 into the camshaft and into the flywheel.
- 3 Remove the starter motor and fit the anti-rotation tool 885055-4 to the flywheel.
- 4 Remove the crankshaft pulley, operation 14A-01.
- 5 Remove the timing case cover, operation 15A-01.
- 6 Fit two screws (M6 x 50) through the plain holes in the pulley of the fuel injection pump and into the pump support bracket.
- 7 Remove the timing belt, operation 15A-04.
- 8 Remove the toothed pulley from the crankshaft. If it is tight, use remover tool 885027-3 and adaptors 885029-9. Fit the narrow end of the distance piece (A1) into the crankshaft. Fasten the main tool (B) to the pulley with the setscrews and tighten the centre screw onto the distance piece to remove the pulley.
- 9 Check the pulley for wear, cracks and other damage. Renew it if necessary.

**To fit**

- 1 Ensure that the key is fitted correctly to the crankshaft. Put the toothed pulley in position on the crankshaft with the tapped holes towards the front. Fit the crankshaft pulley, operation 14A-01A.
- 2 Fit the timing belt, operation 15A-04. Remove the location pins from the pulley of the injection pump and adjust the belt tension, operation 15A-03. Remove the anti-rotation tool.
- 3 **Remove the timing pins from the camshaft and from the flywheel.**
- 4 Check the timing of the fuel injection pump, operation 17A-03.
- 5 Turn the crankshaft through two revolutions to check that there is no restriction to movement.
- 6 Fit the timing case cover, operation 15A-01 and fit the access panel.
- 7 Fit the screw in the timing hole in the camshaft cover.
- 8 Fit the starter motor, operation 22B-01.
- 9 Connect the battery.

Timing case

To remove and to fit

15A-08

Special tools:

Timing pins, 885037-2

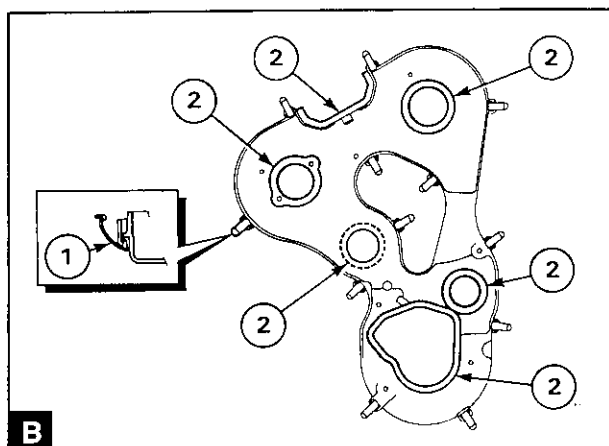
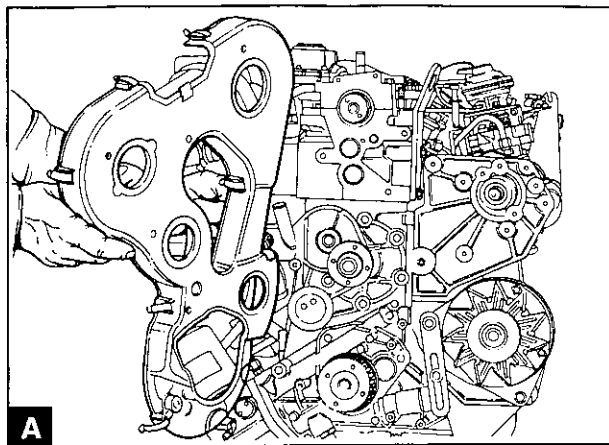
Pulley remover, 885027-3

Adaptors for use with 885027-3, 885029-9

Anti-rotation tool, 885055-4

To remove

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the camshaft cover. Turn the crankshaft until the timing hole in the camshaft aligns with the hole in the cover. Fit the timing pins 885037-2 into the camshaft and into the flywheel.
- 3 Remove the starter motor and fit the anti-rotation tool 885055-4 to the flywheel.
- 4 Remove the crankshaft pulley, operation 14A-01A.
- 5 Remove the timing case cover, operation 15A-01.
- 6 Fit two screws (M6 x 50) through the plain holes in the pulley of the fuel injection pump and into the pump support bracket.
- 7 Remove the timing belt, operation 15A-04.
- 8 Remove the toothed pulleys from the fuel injection pump, operation 15A-05 and from the camshaft, operation 15A-06.
- 9 Release the setscrews which fasten the timing case to the cylinder head, the cylinder block, the support bracket for the fuel injection pump and the lubricating oil pump. Remove the timing case (A).
- 10 Check the timing case for cracks and other damage and renew the timing case, if necessary. Ensure that all the fastener clips are fitted correctly to the timing case (B1).



To fit

- 1 Ensure that the location faces of the engine and of the timing case are clean. Put the cover in position and fasten it with the setscrews. Tighten the setscrews to the correct torque according to the thread size, see section 11B.
- 2 Fit the toothed pulleys to the fuel injection pump, operation 15A-05 and to the camshaft, operation 15A-06.
- 3 If necessary, fit the crankshaft pulley, operation 14A-01A.
- 4 Fit the timing belt, operation 15A-04. Remove the location pins from the pulley of the injection pump and adjust the belt tension, operation 15A-03. Remove the anti-rotation tool.
- 5 Remove the timing pins from the camshaft and from the flywheel.
- 6 Check the timing of the fuel injection pump, operation 17A-03.
- 7 Turn the crankshaft through two revolutions to check that there is no restriction to movement.
- 8 Fit the timing case cover, operation 15A-01 and fit the access panel.
- 9 Fit the setscrew in the timing hole in the camshaft cover.
- 10 Fit the starter motor, operation 22B-01.
- 11 Connect the battery.

Cylinder block assembly

16

General description 16A.02

Cylinder block

16A-01 To dismantle and to assemble 16A.03
16A-02 To inspect 16A.04
16A-03 To correct a glazed bore 16A.04

General description

The cylinder block is made of cast iron with sides which extend below the crankshaft for maximum support. The cylinder bores are machined directly into the block and are specially honed to reduce wear and oil consumption.

Cylinder block

To dismantle and to assemble

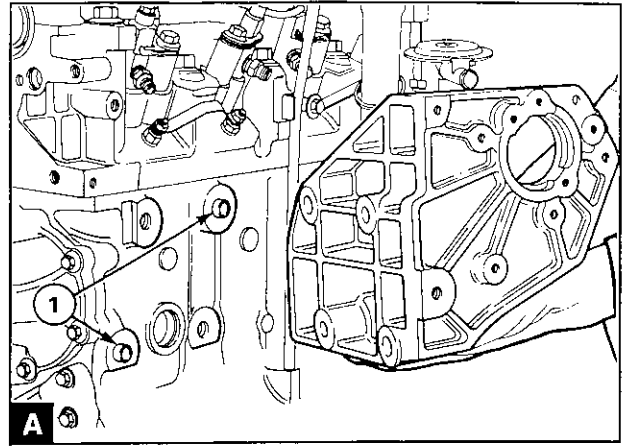
16A-01

To dismantle

- 1 Drain the cooling system and the lubricating oil.
- 2 Remove the alternator drive belt and the alternator and its mounting bracket, see section 22.
- 3 Remove the starter motor, operation 22B-01 and fit the antirotation tool to the flywheel.
- 4 Remove the crankshaft pulley, operation 14A-01A.
- 5 Remove the timing case cover, the timing belt, the toothed pulleys and the timing case, see section 15. Remove the antirotation tool.
- 6 Remove the lubricating oil pump and filter assembly, operation 18A-06.
- 7 Remove the fuel filter, the atomisers and the fuel injection pump, see section 19.
- 8 Remove the reverse gearbox.
- 9 Remove the flywheel and the flywheel housing.
- 10 Remove the cylinder head assembly, operation 12A-07.
- 11 Remove the lubricating oil cooler, operation 20A-11.
- 12 Remove the oil filler/separator assembly.
- 13 Remove the lubricating oil sump, operation 18A-03.
- 14 Remove the piston and connecting rod assemblies, operation 13A-03.
- 15 Remove the crankshaft, operation 14A-09.
- 16 Remove the mounting bracket for the fuel injection pump (A).
- 17 Remove the setscrews and washers if cooling jets are not fitted.

To assemble

- 1 Clean thoroughly the new cylinder block. Ensure that all the oil passages are clean and free from debris. Ensure that the plug is fitted in the rear end of the pressure rail.
- 2 If jets are not used, fit the setscrews and the washers to close the oil holes and tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.
- 3 Fit the bracket for the fuel injection pump. Ensure that the dowels (A1) are correctly fitted. Tighten the setscrews to 43 Nm (32 lbf ft) 4,4 kgf m.
- 4 Fit the crankshaft and, if necessary, the separate oil seal housing, see section 14.
- 5 Fit the piston and connecting rod assemblies, operation 13A-03.
- 6 Fit the lubricating oil sump, operation 18A-03.
- 7 Fit the oil filler/separator assembly.
- 8 Fit the flywheel housing and the flywheel, see section 21.
- 9 If necessary, fit the lubricating oil cooler, operation 20A-11.
- 10 Fit the cylinder head assembly, operation 12A-07.
- 11 Fit the fuel filter, the atomisers and the fuel injection pump, see section 19.
- 12 Fit the lubricating oil pump and filter assembly, operation 18A-06.
- 13 Fit the anti-rotation tool. Fit the timing case, the toothed pulleys and the timing belt, see section 15. Fit the crankshaft pulley, operation 14A-01A. Adjust the tension of the timing belt, operation 15A-01.



14 Remove the timing pins and the anti-rotation tool and turn the crankshaft through two revolutions. Check the timing of the fuel injection pump, operation 17A-03. Fit the timing case cover, operation 15A-01.

15 Fit the starter motor, operation 22B-01.

16 Fit the alternator and its mounting bracket and the alternator drive belt, see section 22.

17 Install the engine.

18 Fill the cooling system.

19 Fill the lubricating oil sump to the correct level with an approved lubricating oil.

20 Eliminate air from the fuel system, operation 19A-08.

To inspect

16A-02

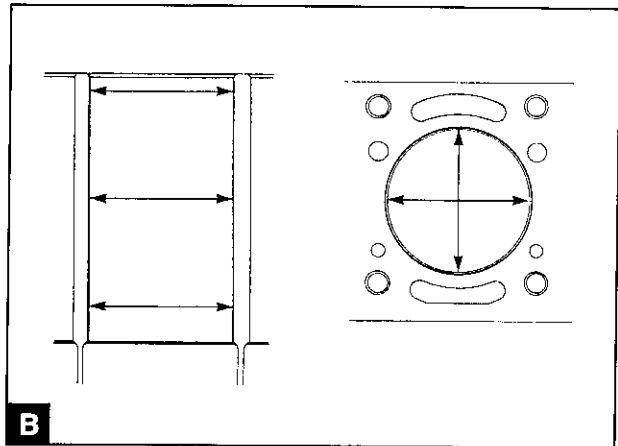
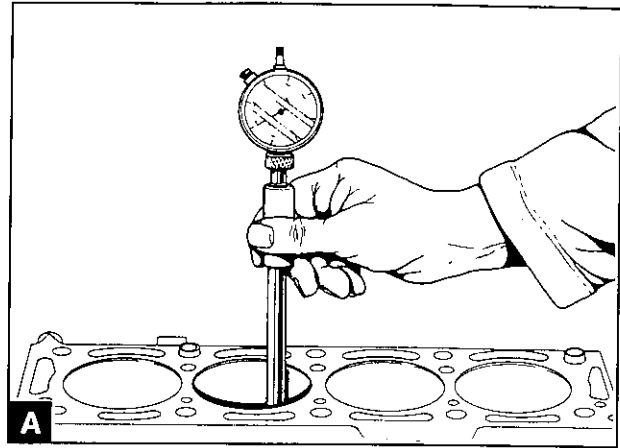
- 1 Clean the passages for the coolant and for the oil.
- 2 Check the cylinder block for cracks and for other damage.

The top face of the cylinder block cannot normally be machined as this will affect the piston height above the top face of the cylinder block. If high pistons (height grade 1) are fitted to all the bores, it may be possible to machine up to 0,26 mm (0.010 in) from the top face of the cylinder block and to fit low pistons (height grade 6). If the block is machined, the piston height must be checked to ensure that the pistons are not higher than the top limit as they could hit the valves and damage the engine.

3 Check the bores for wear (A) and other damage. The bores should be checked at the top, centre and bottom both along and across the engine (B). If a bores is damaged or worn by more than 0,15 mm (0.006 in) in diameter, the bores can be bored and honed 0,50 mm (0.0197 in) oversize in diameter and oversize pistons fitted. For best results bores should be honed at an inclusive angle of 30° to 35° with silicon carbide hones to give clean cuts. Base hone to give a roughness average of 1,5/2,0 micrometres and then plateau hone to give a roughness average of 0,7/1,4 micrometres.

After the bores have been bored oversize, stamp a letter "X" over the bore grades on the boss at the rear of the right side of the cylinder block (C).

If the surface of the bores are glazed, an engine can have high oil consumption with very little wear of the bores.



To correct a glazed bore

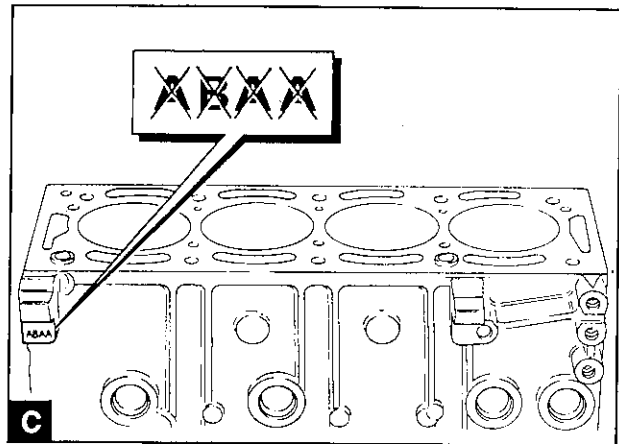
16A-03

A tool, known as a Flex-Hone, is available to correct the bore surface. This tool can be used with an electric hand drill at low speed. The pistons and connecting rods must be removed. Use covers to protect all engine components from the debris which is caused during the process.

- 1 A 3 1/2 in grade 80SC Flex-Hone can be used.
- 2 New Flex-Hones must be operated in an old bore before use in an engine to remove all loose material and sharp edges.
- 3 Lubricate lightly the bore and the Flex-Hone with clean engine lubricating oil.
- 4 Put the tool in position on top of the bore, but do not press the tool into the bore until the tool is operated.
- 5 Operate the tool and move it up and down the bore once a second for 30—50 seconds. Remove the tool while it rotates.
- 6 Clean thoroughly the bore to remove all dirt from the operation, use a hard brush and kerosene.
- 7 Dry the bores and remove carefully all the covers used to protect the components. Clean thoroughly all the engine components which have been affected by debris.
- 8 Ensure that new piston rings are fitted when the engine is assembled.

Attention: After a glazed bore has been corrected, these recommendations are advised for the first 5 hours of operation.

- Do not operate the engine at full load.
- Do not operate the engine at high speed.
- Do not allow the engine to run at low idle speed for extended periods.



Engine timing

17

General description 17A.02

Engine timing

- 17A-01 To set number 1 piston to TDC compression stroke 17A.03
- 17A-02 To check and to adjust the valve timing 17A.03
- 17A-03 To check and to adjust the timing of the fuel injection pump 17A.04

General description

Location holes for timing pins are provided in the flywheel and in the front journal of the camshaft. When these holes are aligned with the timing holes in the flywheel housing and in the camshaft cover, number 1 piston is at top dead centre (TDC) on its compression stroke.

The toothed pulley for the fuel injection pump gear has two timing marks (A and B) and two keyways. The keyway which is on the same side as the relevant timing mark must always be used.

The timing of the fuel injection pump must always be checked after the tension of the timing belt has been adjusted.

Engine timing

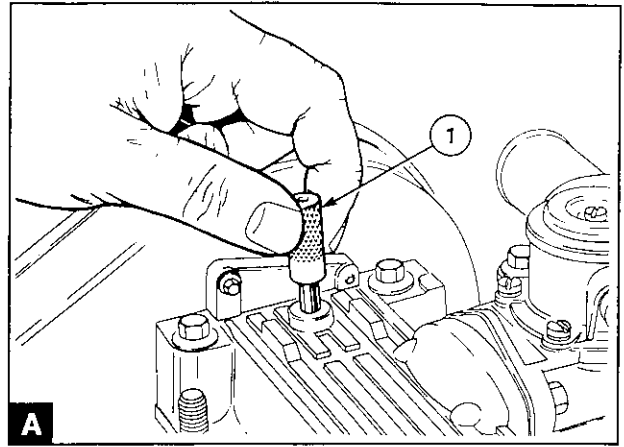
To set number 1 piston
TDC compression stroke

17A-01

Special tools:

Timing pins for camshaft and crankshaft, 885037-2

- 1 Disconnect the battery and remove the setscrew from the timing hole in the top front of the camshaft cover.
- 2 Turn the crankshaft (in the normal direction of rotation — clockwise from the front) until the timing hole in the front journal of the camshaft aligns with the timing hole in the camshaft cover.
- 3 Fit the timing pins through the camshaft cover into the camshaft (A1) and through the flywheel housing into the flywheel (B1).



To check and to adjust the valve timing 17A-02

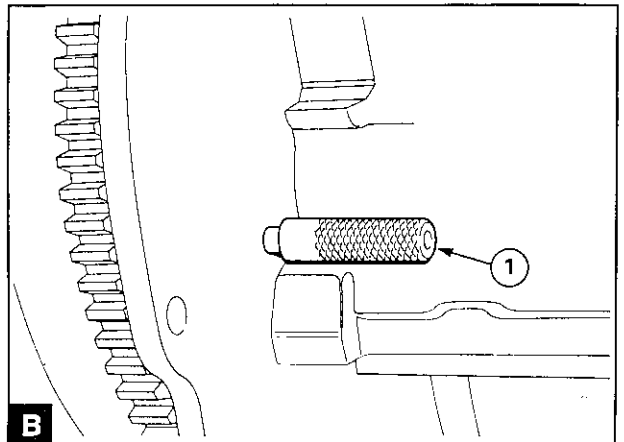
Special tools:

Timing pins for camshaft and crankshaft, 885037-2

Anti-rotation tool, 885055-4

Set the piston of number 1 cylinder to TDC compression stroke, operation 17A-01. If both the timing pins can be fitted, the valve timing is correct. If only one of the pins can be fitted, adjust the valve timing as follows:

- 1 If necessary, remove the timing pin from the flywheel, turn the crankshaft to align the timing hole in the camshaft with the hole in the camshaft cover and fit the camshaft timing pin.
- 2 Remove the timing case cover, operation 15A-01.
- 3 Loosen the four setscrews which fasten the camshaft pulley to its hub to allow the pulley to turn on the hub.
- 4 Loosen the capscrew of the belt tensioner pulley and reduce the tension on the timing belt.
- 5 Turn the crankshaft to align the timing hole in the flywheel with the hole in the flywheel housing or backplate. Fit the flywheel timing pin.
- 6 Adjust the tension of the timing belt, operation 12A-03.
- 7 Tighten the setscrews of the camshaft pulley to the correct torque, see section 11B.
- 8 Check the timing of the fuel injection pump, operation 17A-03.
- 9 **Remove the timing pins** and turn the engine through two revolutions to check that there is no restriction to movement.
- 10 Fit the timing case cover, operation 12A-01 and fit the setscrew in the timing hole in the camshaft cover.
- 11 Connect the battery.



To check and to adjust the timing of the fuel injection pump

17A-03

Special tool:

Gauge to check plunger lift of fuel injection pump 884955-6

- 1 Set the piston of number 1 cylinder to TDC on the compression stroke, operation 17A-01. **Remove the timing pins.**
 - 2 Remove the plug and the washer from the centre of the rear face of the fuel injection pump and fit the gauge. Set the gauge to indicate approximately 3,0 mm. Ensure that there is enough clearance between the gauge and the oil filler tube to allow for possible radial movement of the pump.
 - 3 Slowly turn the crankshaft (counter-clockwise from the front of the engine) until the dial gauge indicates that the fuel pump plunger is at the bottom of its stroke. Set the dial to zero.
 - 4 Slowly turn the crankshaft clockwise until the timing pin will enter the timing hole in the flywheel. In this position the dial gauge should indicate the correct plunger lift, see section 11C.
 - 5 If the reading is not within 0,05 mm (0,002 in) of the correct setting, disconnect the high-pressure fuel pipes from the pump. Ensure that a spanner is used to prevent movement of the fuel pump outlets when the high pressure pipes are removed or fitted. Loosen the nuts for the pump flange and the setscrews for the rear support bracket.
- If the reading is too low, turn the pump clockwise from the rear until the correct reading is obtained and then tighten the flange nuts and the bracket setscrews.
- If the reading is too high, turn the pump counter-clockwise from the rear past the correct setting and then clockwise to the correct position. Tighten the flange nuts and the bracket setscrews.
- Remove the timing pin from the flywheel, turn the crankshaft counter-clockwise approximately 45°. Check that the dial gauge is still set at zero and check the timing again. When the timing is correct, connect the high-pressure fuel pipes.
- 6 Remove the dial gauge and the adaptor and fit the plug and the washer to the pump. Tighten the plug to 10 Nm (7 lbf ft) 1,0 kgf m.
 - 7 Remove the timing pin from the flywheel and fit the setscrew in the timing hole in the camshaft cover.
 - 8 Connect the battery.

