BE PARTS
& SERVICE
SMART

ENGINE SERVICE

ENGINE SERVICE

Perkins

200 Series Perkins

Isuzu

Continued on Next Page

ENGINE SERVICE (Cont'd)

Page Number

7A ENGINE SERVICE - PERKINS (4.154)

TROUBLESHOOTING

The following troubleshooting chart is provided as an assistance in locating and correcting problems which are most common. Many of the recommended procedures must be done by authorized Bobcat Service Personnel only.

PROBLEM	CAUSE
Slow cranking speed.	1, 2, 3, 4
Engine will not start.	2, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 30, 31, 32
Difficult to start.	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 28, 30, 31, 32
No power from engine.	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 23, 24, 25, 26, 30, 31, 32
Engine is mis-firing.	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 24, 25, 27, 28, 29, 31
Too much fuel consumption.	11, 13, 14, 18, 19, 20, 22, 23, 24, 26, 27, 28, 30, 31, 32
Black exhaust.	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 26, 27, 28, 30, 31, 32
Blue/white exhaust.	4, 11, 18, 19, 20, 24, 26, 30, 32, 33, 53
Low oil pressure.	4, 34, 35, 36, 37, 38, 40, 42, 55
Engine knocking.	9, 14, 16, 18, 19, 22, 25, 27, 28, 30, 32, 34, 43, 44, 56
Engine running rough.	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 25, 27, 28, 29, 32, 43, 56
Vibration.	13, 14, 20, 24, 25, 28, 29, 32, 43, 45, 46
High oil pressure.	4, 36, 39
Overheating.	11, 13, 14, 16, 18, 19, 23, 24, 43, 47, 48, 49, 50, 54
Too much crankcase pressure.	25, 30, 32, 33, 43, 52
Poor compression.	11, 19, 24, 27, 28, 30, 31, 32, 33, 44, 56
Start and stop.	10, 11, 12

KEY TO CORRECT THE CAUSE

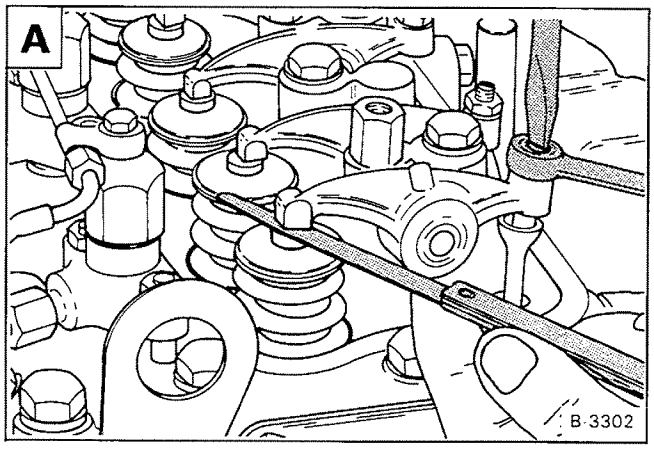
1. Battery capacity low.
2. Bad electrical connections.
3. Faulty starter motor.
4. Incorrect grade of oil.
5. Low cranking speed.
6. Fuel tank empty.
7. Faulty stop control operation.
8. Plugged fuel line.
9. Faulty fuel lift pump.
10. Plugged fuel filter.
11. Restriction in the air cleaner.
12. Air in fuel system.
13. Faulty fuel injection pump.
14. Faulty fuel injectors.
15. Incorrect use of ether start unit.
16. Faulty ether start unit.
17. Broken fuel injection pump drive.
18. Incorrect fuel injection pump timing.
19. Incorrect valve timing.
20. Poor compression.
21. Plugged fuel tank vent.
22. Incorrect type or grade of fuel.
23. Exhaust pipe restriction.
24. Cylinder head gasket leaking.
25. Overheating.
26. Cold running.
27. Incorrect tappet adjustment.
28. Sticking valves.
29. Incorrect high pressure fuel pipes.
30. Worn cylinder bores.
31. Worn valves and seats.
32. Broken, worn or sticking piston rings.
33. Worn valve stems or guides.
34. Worn or damaged bearings.
35. Not enough oil in the oil pan.
36. Switch is defective.
37. Oil pump worn.
38. Pressure relief valve is sticking open.
39. Pressure relief valve is sticking closed.
40. Broken relief valve spring.
41. Faulty suction pipe.
42. Plugged oil filter.
43. Piston seizure.
44. Incorrect piston height.
45. Faulty engine mounting.
46. Incorrect alignment of flywheel.
47. Faulty thermostat.
48. Restriction in the water jacket.
49. Loose alternator belt.
50. Plugged radiator.
51. Faulty water pump.
52. Plugged breather pipe.
53. Damaged valve stem oil deflectors.
54. Coolant level to low.
55. Plugged oil pump pipe strainer.
56. Broken valve spring.

VALVE CLEARANCE

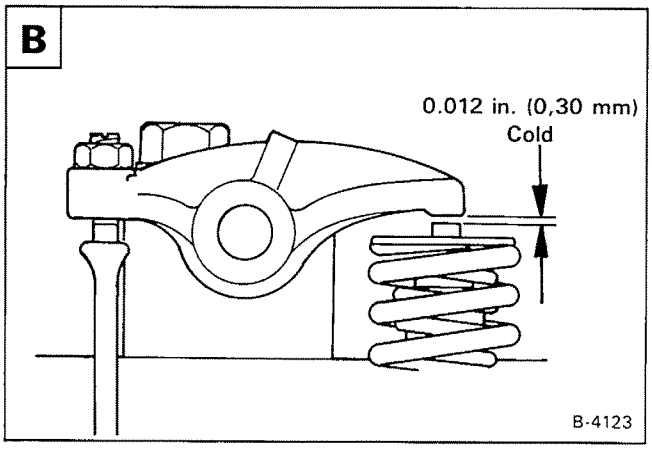
Adjustment

Make the valve clearance adjustment with engine stopped and cold.

Put the correct size feeler gauge between the rocker arm and the valve stem and turn the adjustment bolt until the clearance is correct [A].



The correct clearance is 0.012" (0,30 mm) with the engine cold [B].



Use the following sequence to set the valves:

a. With the rocker arm rocking on No. 4, set clearance at No. 1 valves.

b. With the rocker arm rocking on No. 2, set clearance at No. 3 valves.

c. With the rocker arm rocking on No. 1, set clearance at No. 4 valves.

d. With the rocker arm rocking on No. 3, set the clearance at No. 2 valves.

ENGINE COMPRESSION

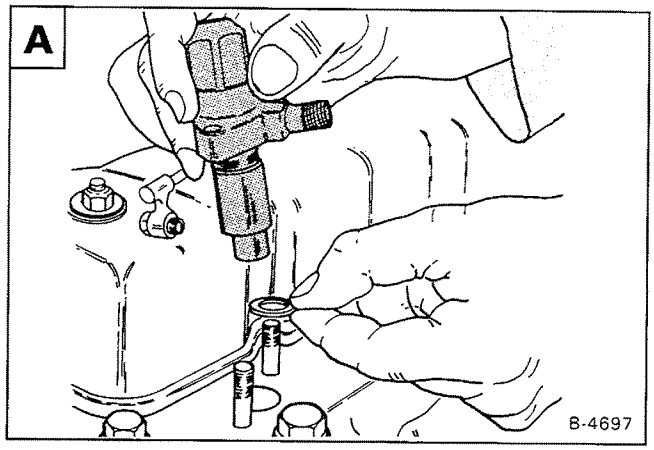
Checking

The tools listed will be needed to do the following procedure:

MEL-10630 — Engine Compression Kit

The engine must be at operating temperature.

Remove the fuel injectors (See Page 7A—11) [A].

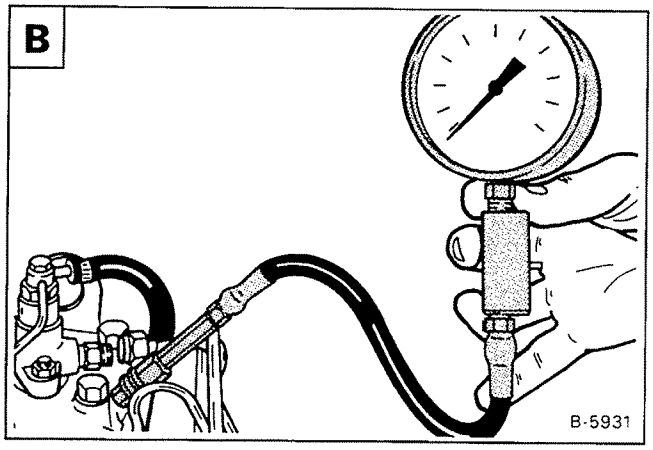


Install the correct compression adapter into the engine.

Connect the compression gauge [B].

The engine must be turning at about 300 RPM.

The compression must be between 300 - 500 PSI (2069 - 3448 kPa) with no more than 50 PSI (345 kPa) difference between cylinders.



FUEL FILTER

Removal and Installation

See the Service Schedule (Page 1—1) for the correct sequence when to replace the fuel filter.

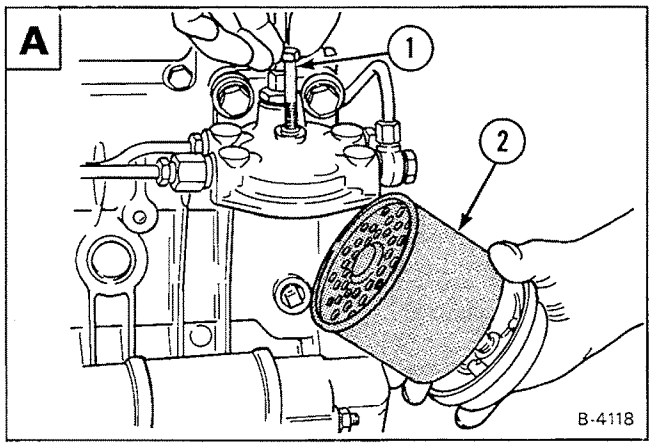
Clean the area around the fuel filter.

Remove the bolt at the top of the fuel filter housing (Item 1) [A].

Remove the fuel filter element (Item 2) [A].

Lubricate the O-rings before installation.

Remove the air from the fuel system (See Page 7A—6).

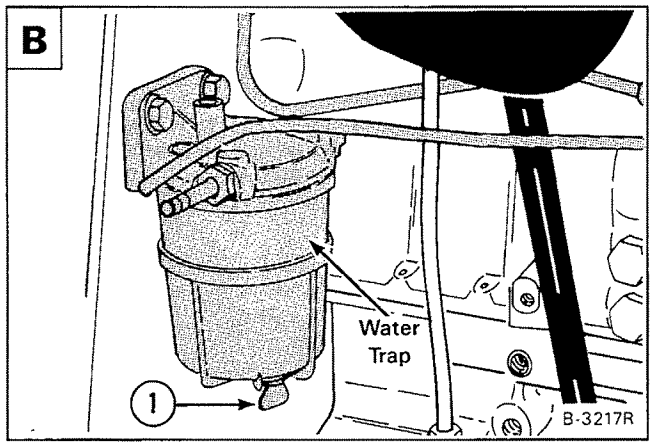


Water Trap

The water trap is located between the fuel tank and the fuel lift pump. See the Service Schedule (Page 1—1) for the correct sequence when to service the water trap.

To clean the water trap:

Loosen the thumb screw (Item 1) at the bottom of the filter housing and drain the water from the filter [B]. Tighten the thumb screw when all the water is removed.



FUEL LIFT PUMP

Checking

Install a gauge to the outlet side of the lift pump. Turn the engine for 10 seconds.

STANDARD PRESSURE - 6 PSI (41 kPa)
MINIMUM PRESSURE ACCEPTED - 3.75 PSI (26 kPa)

Removal and Installation

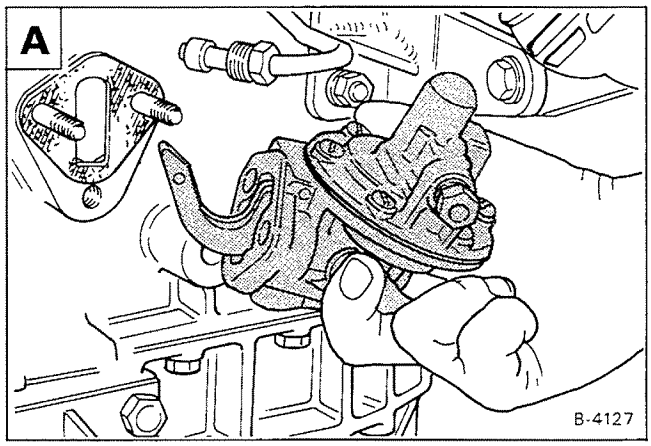
Turn the fuel valve at the fuel tank to the "OFF" position.

Disconnect the inlet and outlet tubelines from the lift pump.

Remove the two nuts and washers that hold the lift pump to the engine block.

Remove the lift pump from the engine block [A].

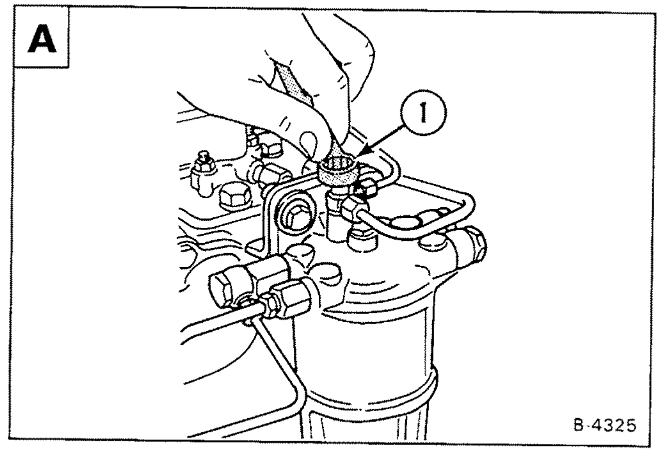
NOTE: Make sure to "Open" the fuel shut-off valve at the fuel tank after installation is completed.



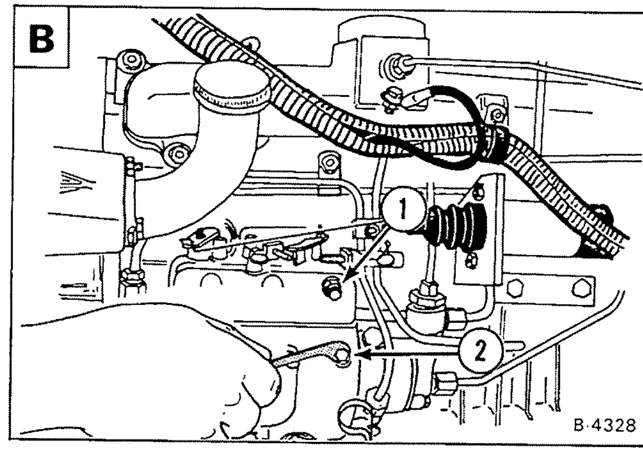
REMOVING AIR FROM FUEL SYSTEM

Procedure

Loosen the bolt (Item 1) at the top of the fuel filter [A].



Loosen the plug at the top (Item 1) and the side (Item 2) of the fuel injection pump [B].



Operate the fuel lift pump lever pushing fuel and air through the vent plugs [C].

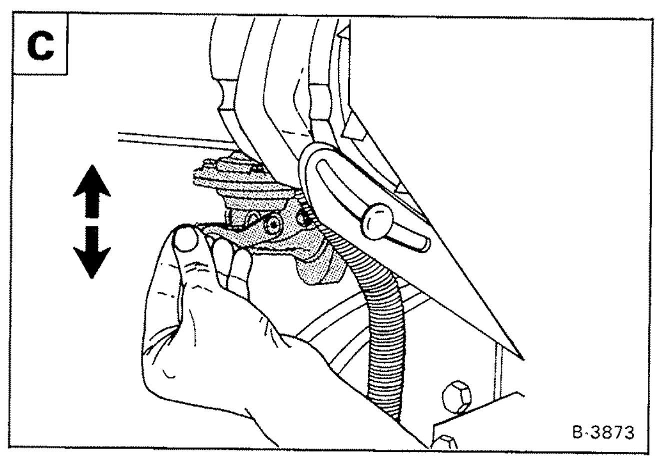
NOTE: **If the lift pump will not pump fuel, rotate the engine crankshaft a small amount.**

When all the air is removed from the fuel system, close the vents in the following order:

a. Final Fuel Filter (Item 1) [A].

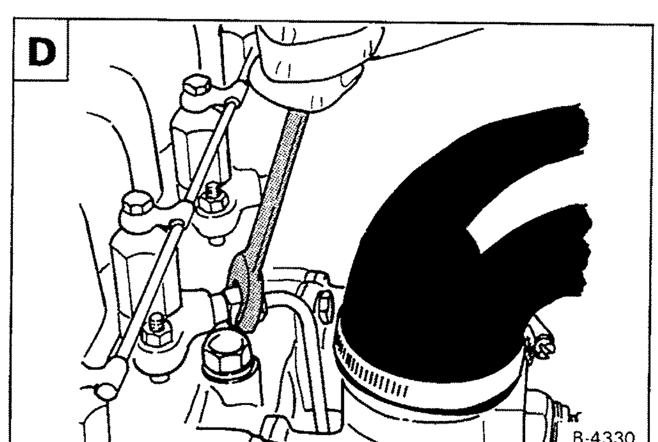
b. Injection Pump side plug (Item 2) [B].

c. Injection Pump top plug (Item 1) [B].



Loosen all the fittings at the fuel injectors high pressure lines [D].

Move the throttle to half open position. Turn the engine with the starter until fuel shows at the fittings. Tighten the fittings to 15 ft.-lbs. (20 Nm) torque.



FUEL INJECTION PUMP

The injection pump contains parts which have a very close tolerance and its operation has a direct effect on the performance of the engine.

IMPORTANT

If you do not have the correct equipment and trained personnel, adjustment or maintenance must not be done.

I-2028-0284

Removal and Installation

Disconnect the throttle control linkage (Item 1) at the pump [A].

Disconnect the linkage (Item 2) from the electrical fuel shut-off solenoid [A].

IMPORTANT

Do not bend the tubelines when removing or installing them on the injector pump or on the injectors.

I-2029-0284

Disconnect the high pressure fuel lines at the fuel injection pump and injectors. Remove all the high pressure tubelines.

Installation: Tighten the fittings to 15 ft.-lbs. (20 Nm) torque.

Disconnect the low pressure lines at the fuel filter and injection pump.

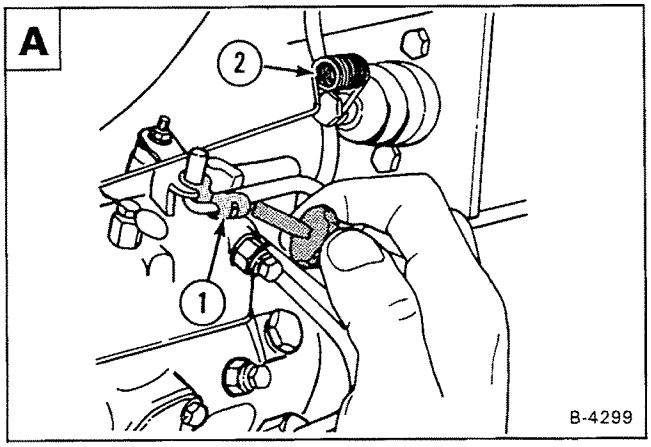
Remove the cover at the timing cover [B].

Remove the three bolts at the gear for the injection pump.

Remove the nuts and washers from pump mounting flange. Remove the injection pump.

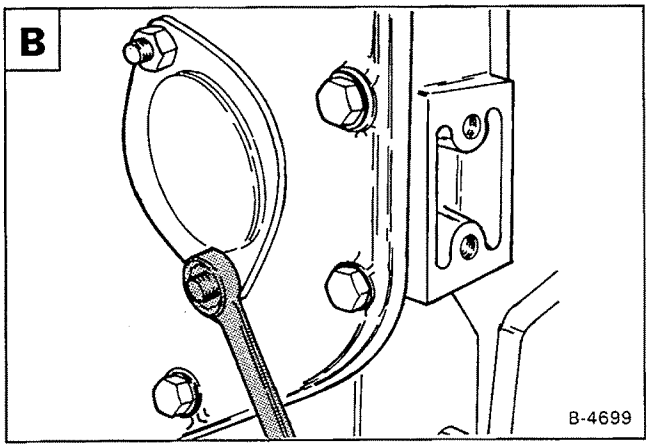
Installation: Make sure the injection pump shaft is in correct alignment with the dowel pin (Item 1) [C]. Align the timing marks on the outside of the mounting flange, tighten the nuts [D].

A



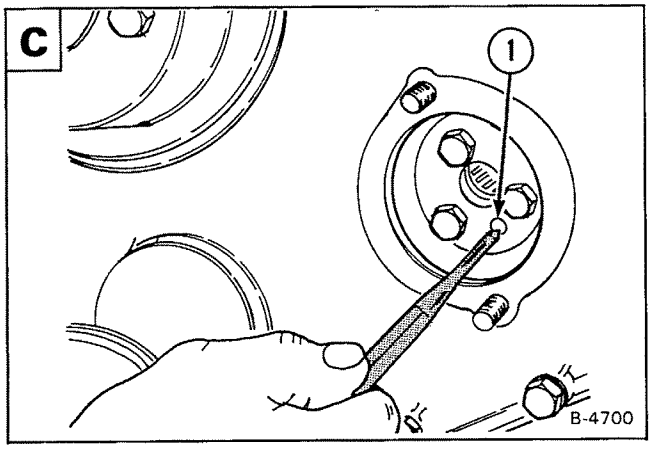
B-4299

B



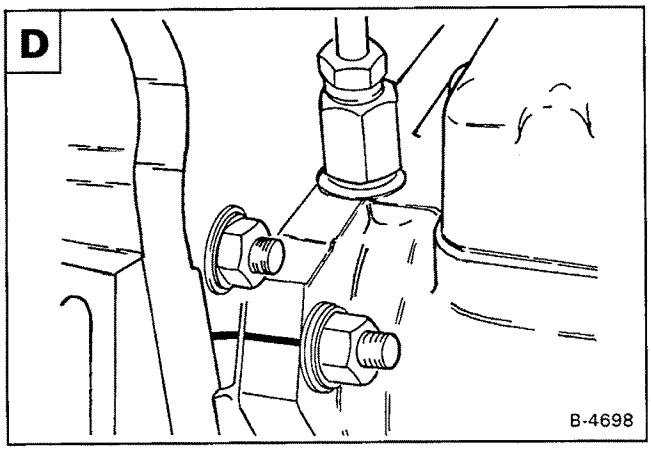
B-4699

C



B-4700

D



B-4698

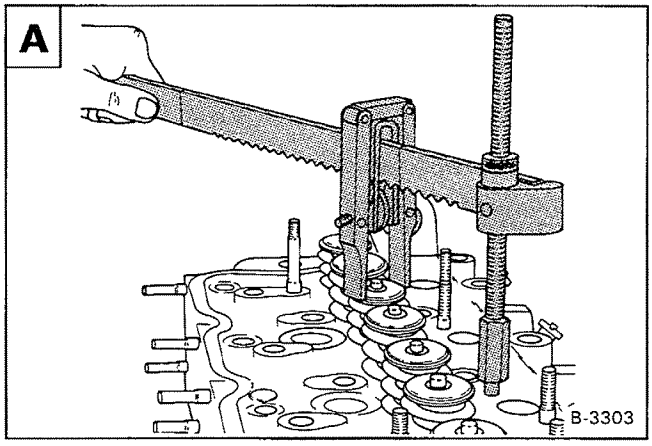
ENGINE TIMING TO INJECTION PUMP (USING DIAL INDICATOR)

Procedure

To see the timing mark on the inside of the injection pump, you will have to break the manufacture's seal on the inspection cover.

Remove the valve cover. Rotate the crankshaft until No. 1 piston is at TDC, compression stroke (both rocker arms of No. 4 cylinder are moving).

Loosen the adjustment bolt of the No. 1 cylinder exhaust rocker arm. Move the rocker arm to the side. Remove the push rod. Remove the exhaust valve spring [A].

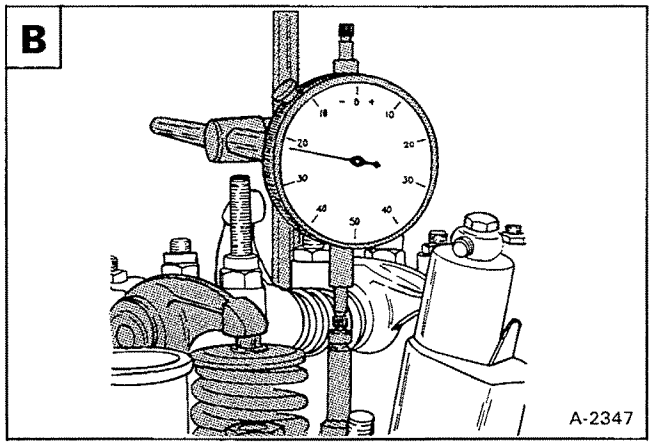


Put the head of the exhaust on top of the piston crown. Install a dial indicator at the valve stem [B].

Rotate the crankshaft backward and forward a small amount to find TDC and zero the dial indicator.

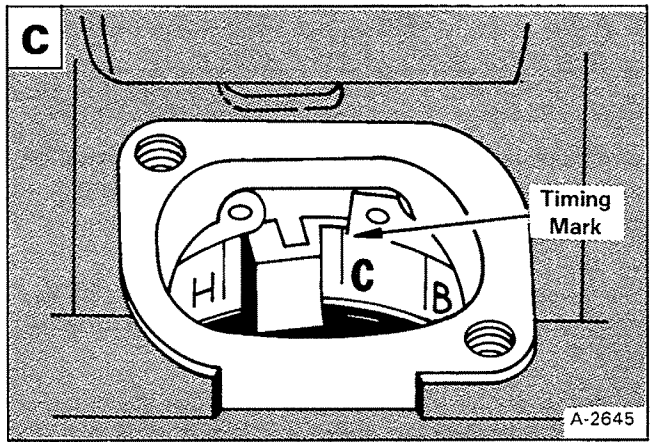
Turn the crankshaft in the opposite direction of normal rotation until the dial indicator show the piston movement of 0.150" (3,8 mm) down.

NOTE: This is equal to 18° angle movement of the front pulley BTDC and is the static timing point.



The"C" line on the rotor of the fuel injection pump must be in alignment with the edge of the snap ring [C].

NOTE: DO NOT move the snap ring in the pump. It is put in this position by the manufacturer.



If the timing is not correct, do the following:

a. Loosen the nuts at the mounting flange.

b. Turn the pump to align the timing marks [C].

c. Remove the old timing mark at the mounting flange and make a new timing mark.

Repeat the above steps to make sure the timing is correct.

NOTE: Make sure to adjust the exhaust valve clearance before installation of the valve cover.

ENGINE TIMING TO INJECTION PUMP (USING TIMING TOOL)

Procedure

The tool listed will be needed to do the following procedure:

MEL-1056 — Timing Tool

Remove the valve cover. Turn the engine crankshaft until No. 1 cylinder is at TDC, compression stroke (both rocker arms are moving at No. 4 cylinder).

Align the TDC bolt with the mark in the front pulley [A].

Remove the fuel injection pump (See Page 7A—7).

Loosen the screw (Item 1) on the timing tool [B]. Set the correct angle at the gauge according to the Injection Pump Code in the chart as listed.

ENGINE AND INJECTION PUMP TIMING MARKS			
Injection Pump Code	Eng. Checking Angle	Injection Pump Marking Angle	Degrees BTDC
AJ46E	286-1/2	298	18
AJ47	286-1/2	298	18
LJ42	281	290	18
LJ44E	281	290	18
LJ47	281	290	18
LJ51	281	290	18

Install the adapter into the gear [C]. Make sure the dowel pin is in correct alignment. Install the three bolts and tighten.

Move the plate (with V-notch) over the mounting flange [D]. Turn the timing tool in opposite direction of engine rotation to remove gear play.

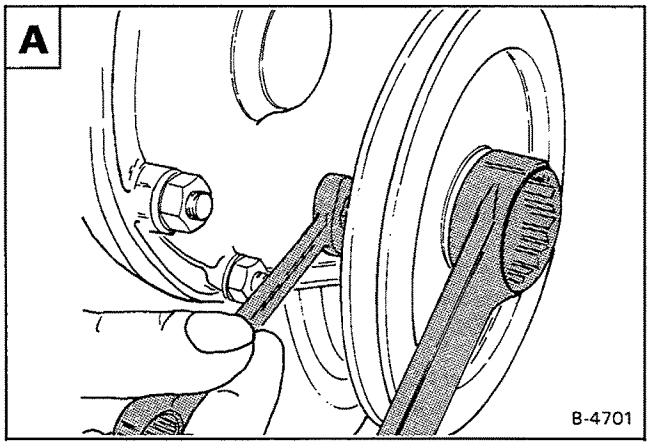
The engine flange timing mark must be in alignment with the V-notch of the timing tool plate.

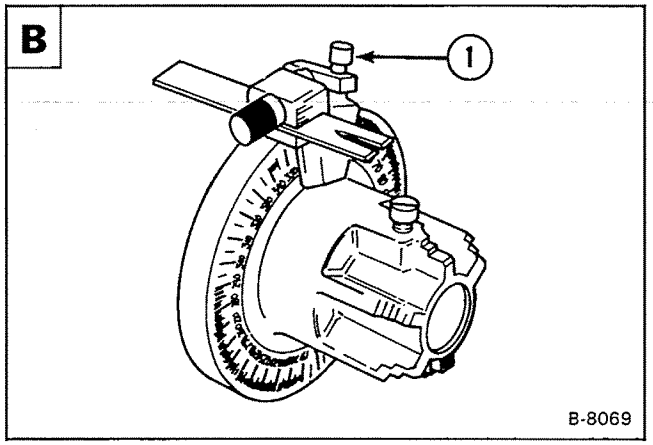
NOTE: If the marks are 180° apart, the No. 1 cylinder is not at TDC.

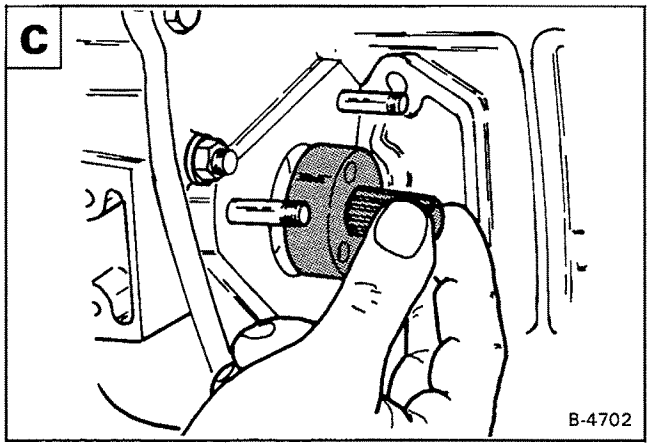
If the mark is not correct, remove the old timing mark. Make a new timing mark on the mounting flange.

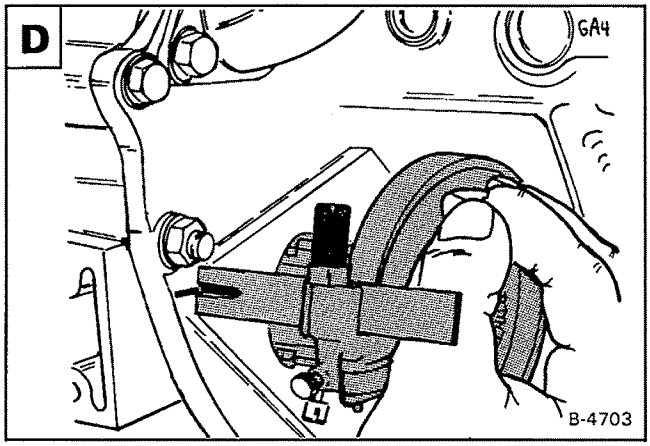
IMPORTANT

Make sure to turn the TDC bolt out of the front pulley after the timing procedure is done.









CHECKING TIMING MARK ON INJECTION PUMP FLANGE

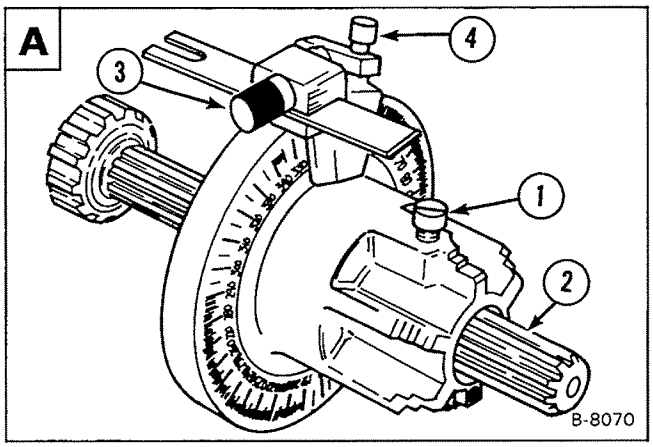
Procedure

Loosen the screw (Item 1) and install the shaft (Item 2) into the timing tool [A].

Loosen the screw (Item 3) and turn the plate in the opposite direction [A].

Loosen the screw (Item 4) and set the gauge to the correct angle according to Injection Pump Code as listed in the chart (See Page 7A—9).

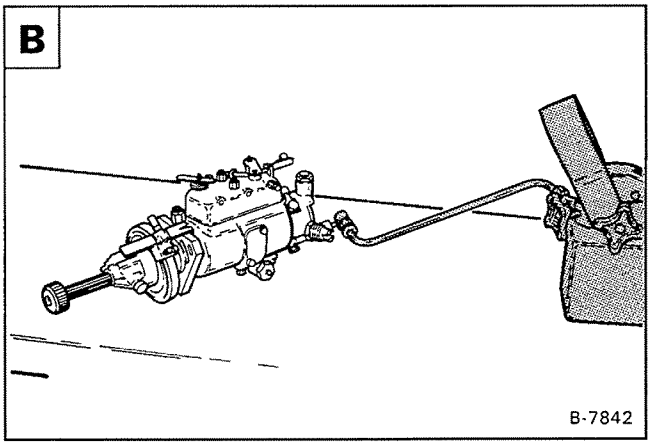
Locate and mark the No. 1 port at the injection pump. Install the timing tool on the injection pump.



Connect a test pump to the No. 1 port [B].

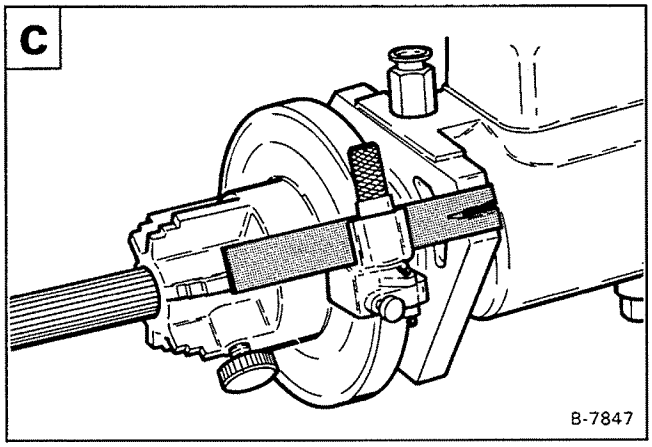
Operate the test pump until the pressure is at 440 PSI (3033 kPa) maximum.

Turn the tool in the normal rotation of the pump. When the pump reaches the No. 1 port there will be resistances or will not turn.



Move the plate over the mounting flange [C].

NOTE: The mark on the mounting flange is put on at the factory. The mark will almost always be correct. If it is not, you must remove the old mark and make a new mark.



FUEL INJECTOR NOZZLES

⚠ WARNING

Diesel fuel or hydraulic fluid under pressure can penetrate skin or eyes causing serious injury. Fluid leaks under pressure may not be visible. Use a piece of cardboard or wood to find leaks. Do not use bare hand. Wear safety goggles. If fluid enters skin or eyes, get immediate medical attention.

W-2074-1285

Some problems caused by faulty injector nozzles:

The engine is hard to start or will not start.

Rough engine operation and idle. The engine will not have full power. The engine exhaust smoke is black, white or blue.

Removal and Installation

Remove the high pressure fuel lines (Item 1) [A].

IMPORTANT

Do not bend the tubelines when removing or installing them on the injector pump or on the injectors.

I-2029-0284

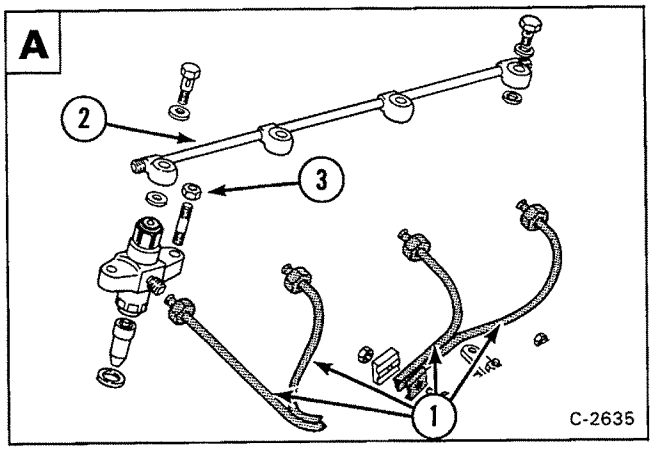
Remove the fuel return line (Item 2) [A].

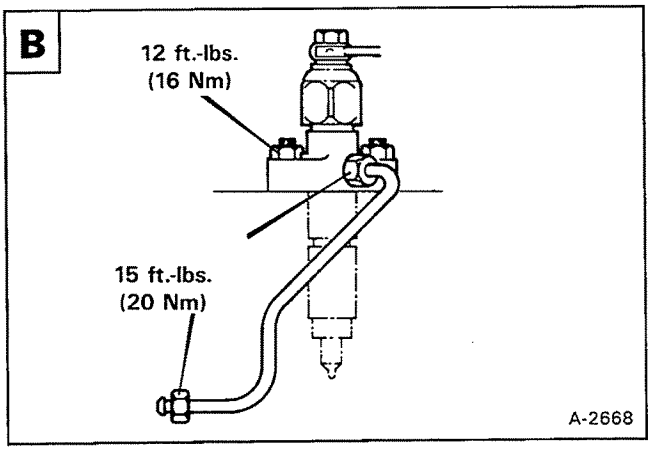
Remove the nuts from the mounting flange (Item 3) [A].

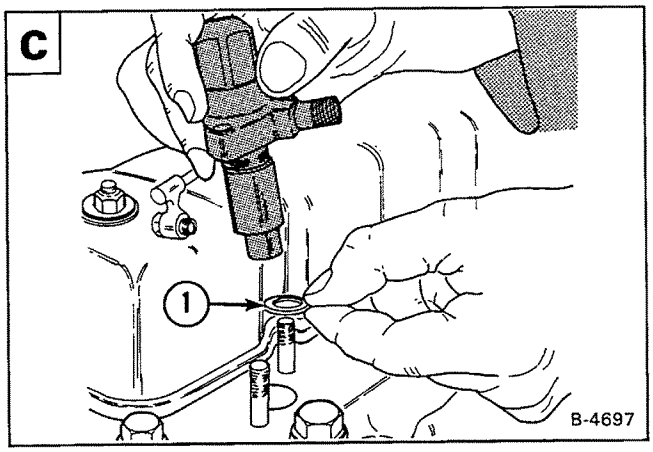
Installation: Tighten the nuts to 12 ft.lbs. (16 Nm) torque [B].

Remove the fuel injector nozzle from the cylinder head.

Installation: Always replace the copper washer (Item 1) with a new copper washer when installing the fuel injector nozzle [C].







Checking

IMPORTANT

Do not disassemble or test the fuel injector nozzles unless you have the correct service and testing tools.

I-2027-0284

The tools listed will be needed to do the following procedure:

MEL-10018 — Injector Nozzle Tester
MEL-10019 — Accessory Set

Connect the nozzle to a test pump, in a down position [A].

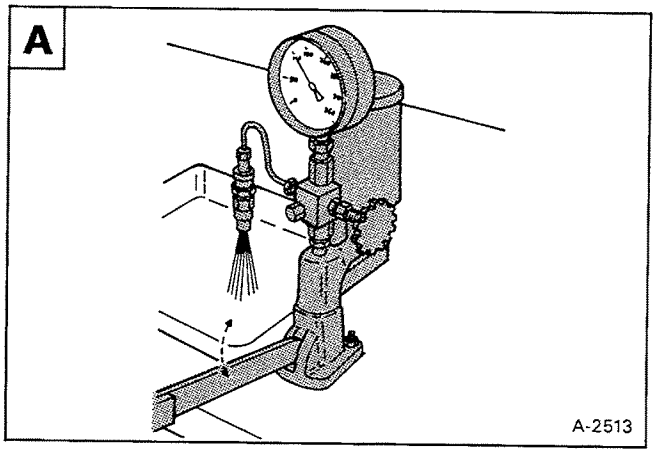
Operate the test pump until the nozzle valve opens:

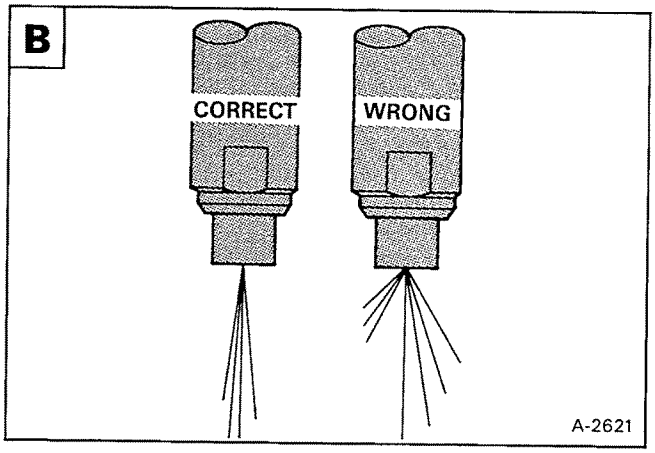
SETTING PRESSURE - 2205 PSI (15203 kPa)
WORKING PRESSURE - 1985 PSI (13687 kPa)

If the pressure is not correct, replace or clean the nozzle.

Check for inside leakage:

Operate the test pump to almost opening pressure. Record pressure and check pressure decrease for six seconds. The nozzle has a defect if the pressure deceases more than 740 PSI (5163 kPa).





⚠ WARNING

Do not test fuel injector nozzles unless you have correct service and testing tools. Keep away from fuel coming from the nozzles. Wear safety goggles. Fuel under pressure can penetrate skin or eyes and cause serious injury. If fuel enters skin or eyes, get immediate medical attention.

W-2075-1285

Checking nozzle spray pattern [B]:

Does not come out the side of nozzle.

Does not have drops coming from nozzle.

Does not have a solid stream coming from the nozzle.

Any of the above conditions show a defect or dirty injector nozzle. Clean or replace any nozzle that does not operate correctly.

ENGINE

Removal and Installation

Lift and block the loader (See Page 1—2 for the correct procedure).

Raise the operator cab (See Page 1—7 for the correct procedure).

Remove the batteries (See Page 6—2 for the correct procedure).

Disconnect all the wires at the two solenoids.

Disconnect the engine wire harness [A].

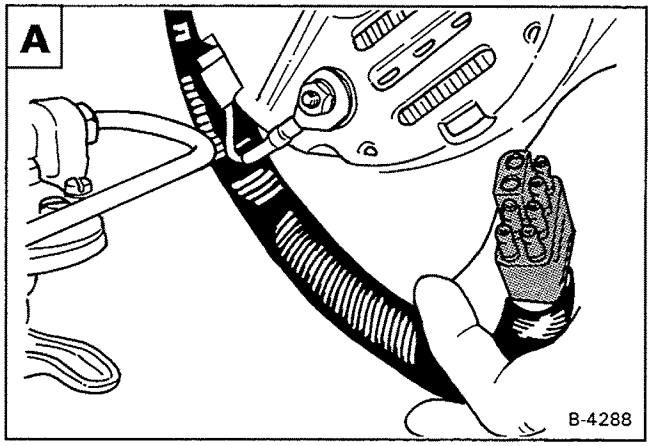
Disconnect the ground wire at the left side of the engine.

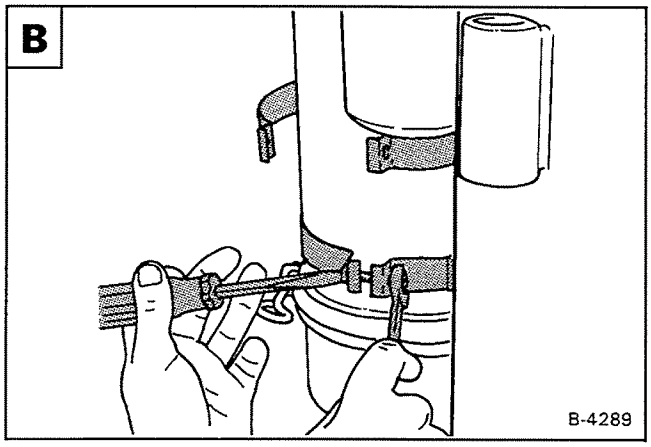
Remove the air cleaner hose at the intake manifold.

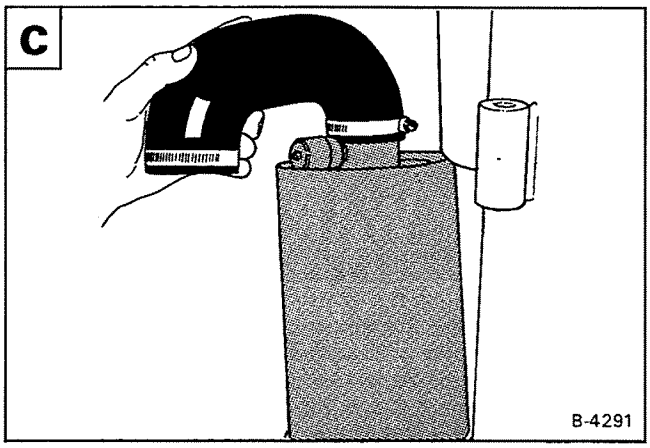
Remove the bolts and nuts at the air cleaner clamps [B].

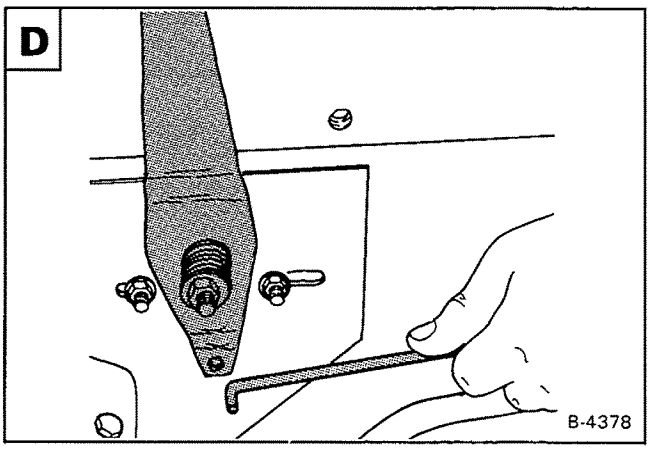
Remove the air cleaner assembly from the engine compartment [C].

Disconnect the throttle linkage at the throttle lever [D].



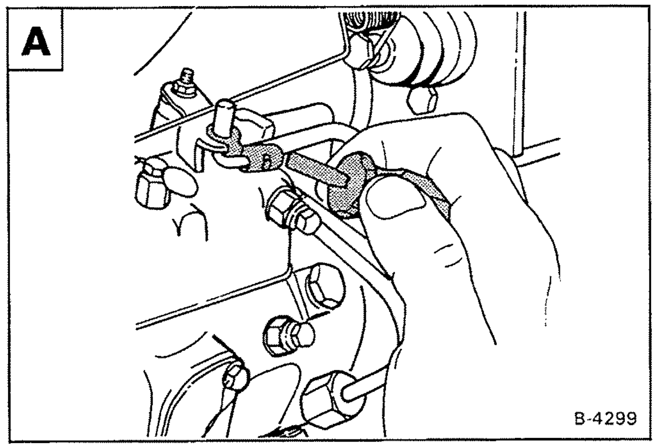






ENGINE (Cont'd)

Disconnect the throttle linkage at the injection pump [A].

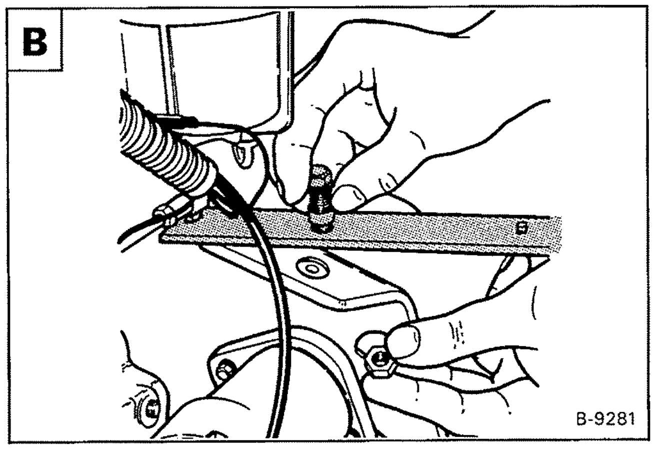


Remove the bolt and nut at the cross lever [B].

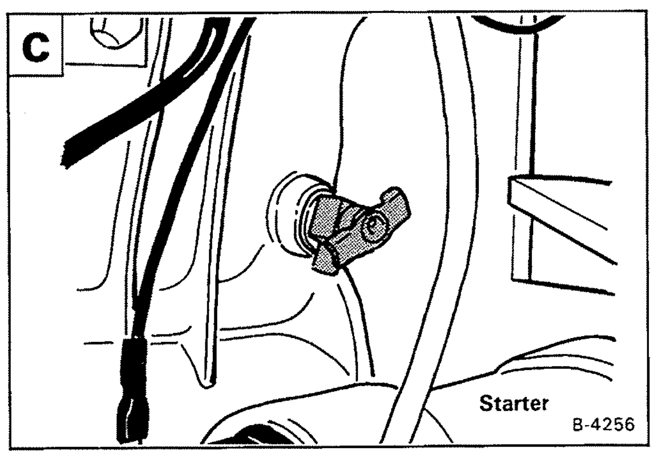
Remove the throttle linkage assembly.

Remove the rear grill.

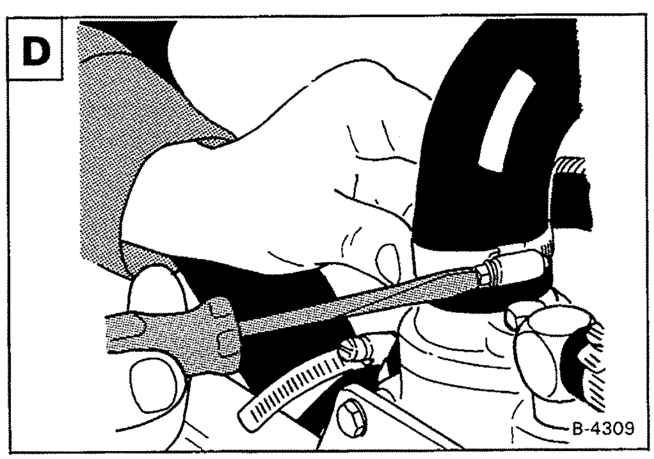
Remove the radiator cap.



Open the coolant drain on the engine block (above the starter) [C]. Put a hose over the end of the coolant drain and drain into a container.



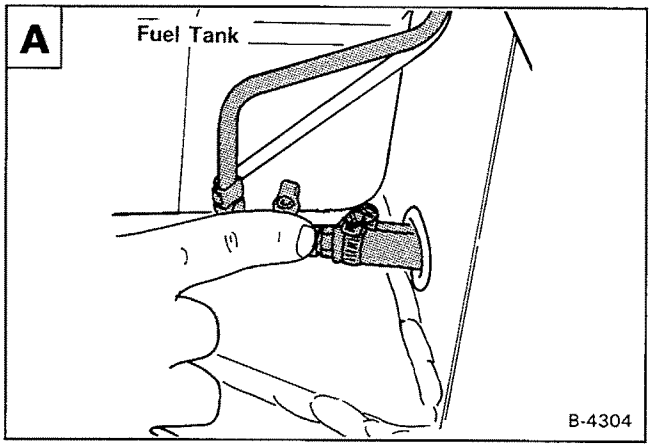
Remove the both radiator hoses [D].



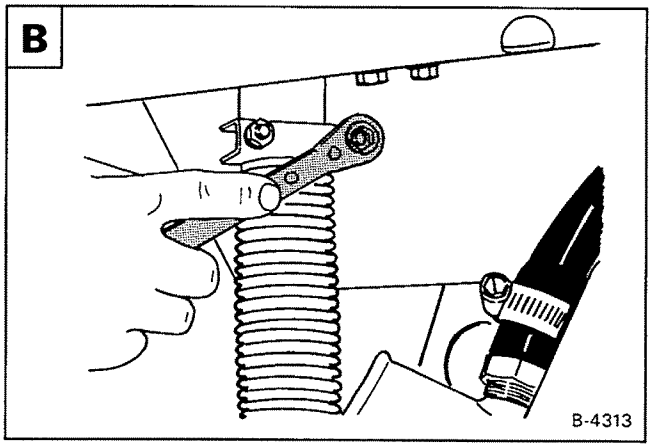
Turn the fuel shut-off valve to the "OFF" position at the fuel tank [A].

Disconnect the fuel line at the water trap filter.

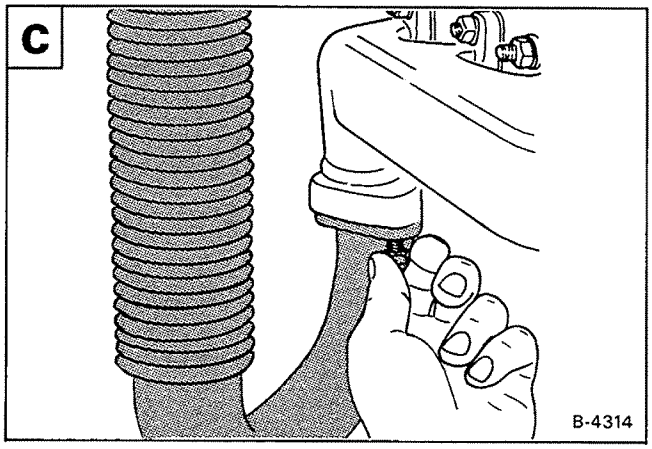
Disconnect the fuel return hose at the fuel injector nozzles.



Remove the exhaust pipe at the muffler [B].

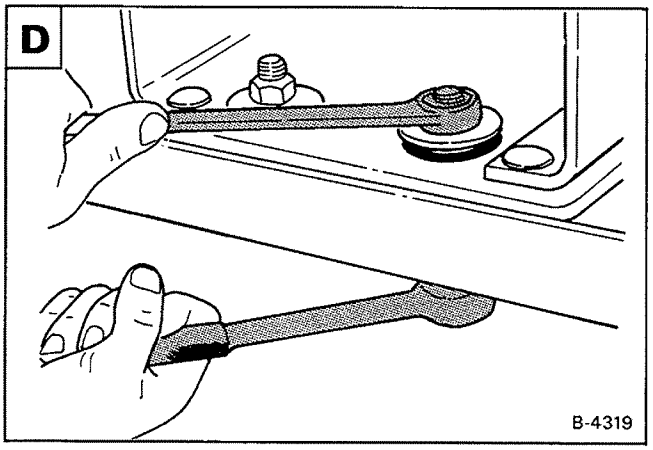


Remove the exhaust pipe at the exhaust manifold [C].



Remove the rear engine mounting bolts, washers and nuts (both sides) [D].

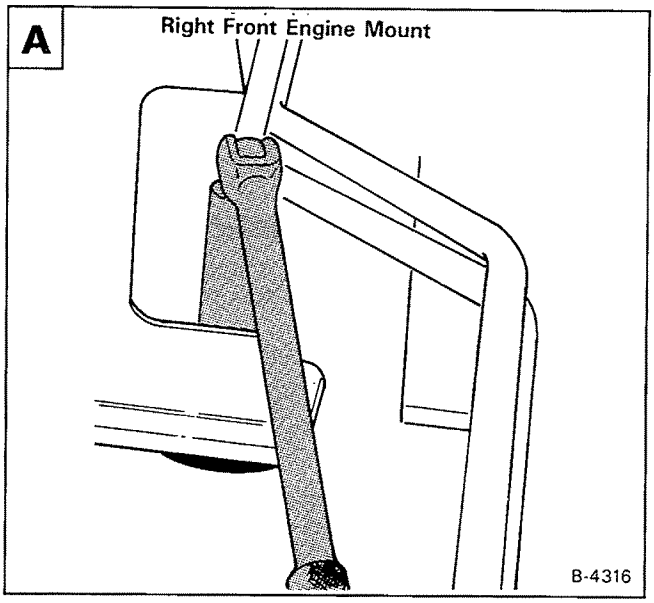
Installation: Add liquid adhesive (LOCTITE) to the bolt threads and tighten to 125 - 140 ft.-lbs. (169 - 190 Nm) torque.



Remove the front engine mount bolts, washers and nuts (both sides) [A].

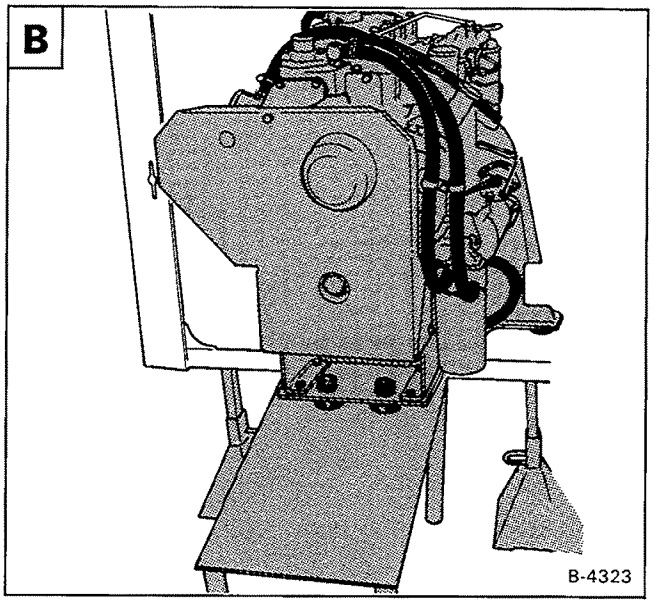
Installation: Add liquid adhesive (LOCTITE) to the bolt threads and tighten to 125-140 ft.-lbs. (169-190 Nm) torque.

Lift the rear of the engine over the edge of the loader frame with pry bars.



Slide the engine out of the loader [B].

Installation: Move the engine into the loader until the universal joint is in the blower housing. Have a second person reach behind the blower housing (at the hydrostatic pump) and guide the universal joint on the splines of the hydrostatic pump shaft, while the engine is moved toward the front of the loader.



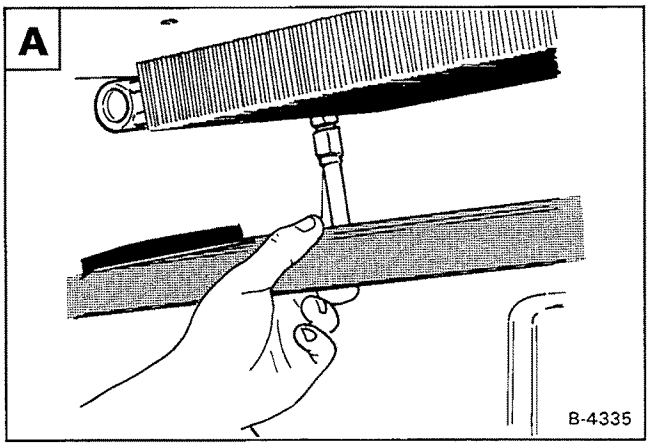
RADIATOR

Removal and Installation

Remove the rear grill.

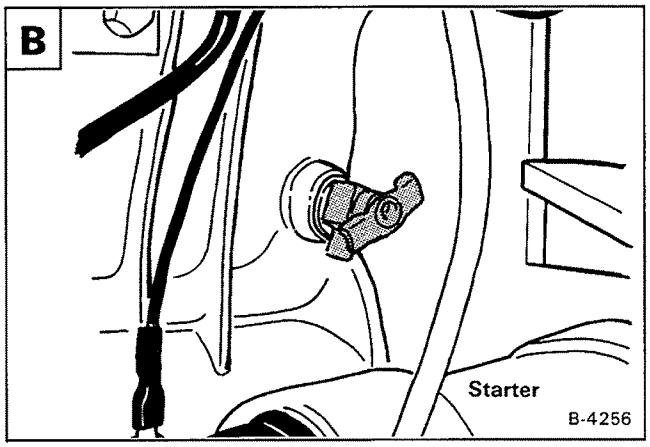
Remove the bolts at the cover on the blower housing. Remove the cover from the blower housing [A].

Remove the radiator cap.



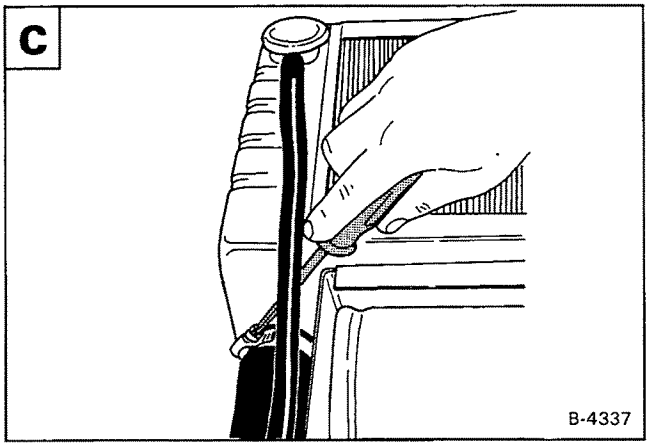
Open the coolant drain on the engine block (above the starter) [B]. Put a hose over the end of the coolant drain and drain into a container.

Remove the oil cooler (See Page 7A—18).



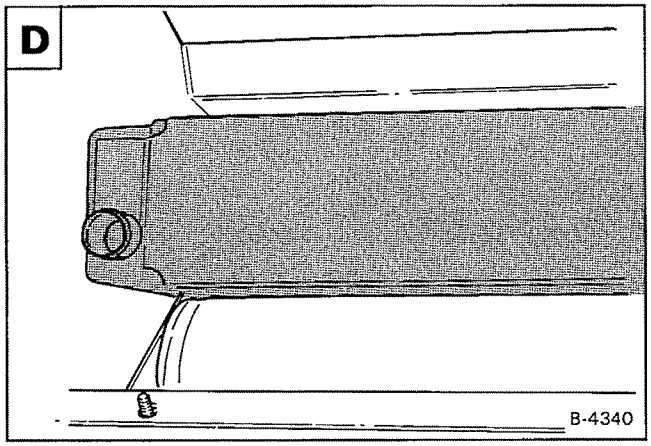
Disconnect the radiator hoses (both sides) [C].

Remove the bolts at the bottom of the radiator.



Lift the radiator up and over the muffler shield [D].

Remove the radiator from the loader.

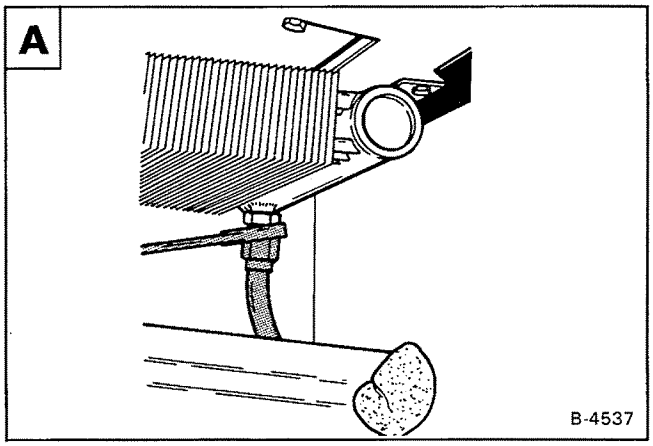


OIL COOLER

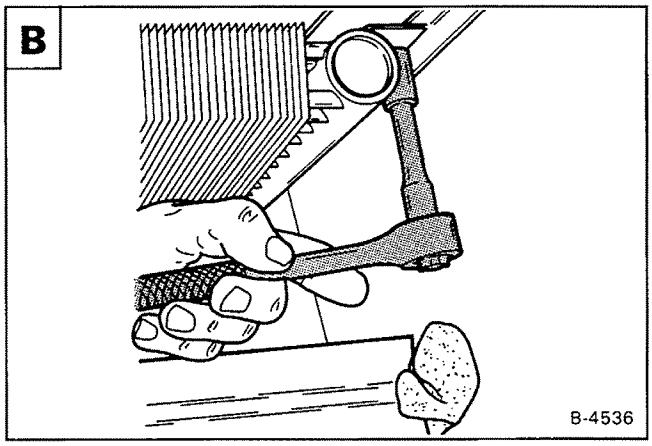
Removal and Installation

Remove the engine from the loader (See Page 7A—13).

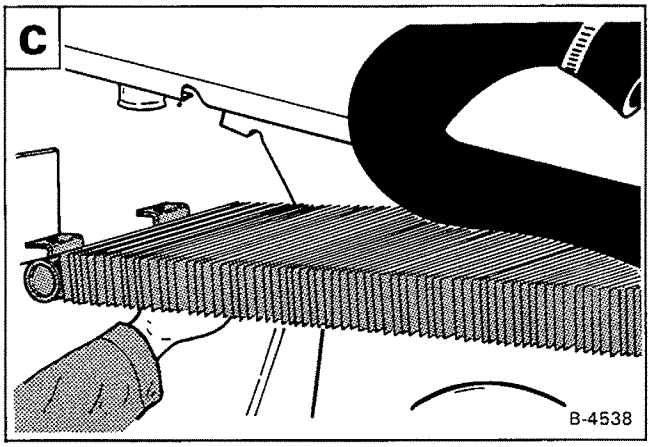
Disconnect the tubelines from the oil cooler (both sides) [A].



Remove the four bolts at the side brackets of the oil cooler [B].



Drop the oil cooler down and pull it towards you to remove it from the loader [C].



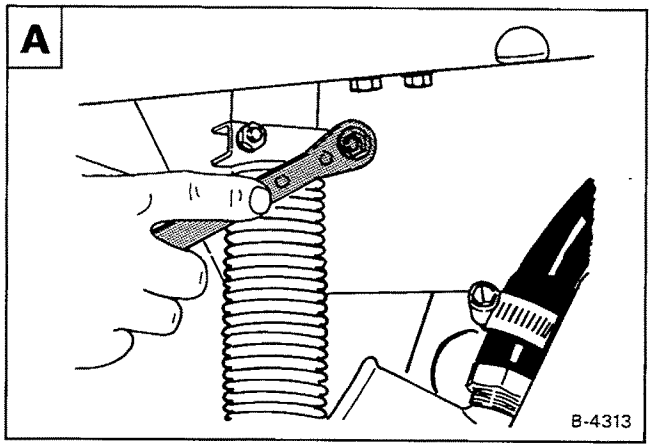
ENGINE MUFFLER

Removal and Installation

Remove the rear grill.

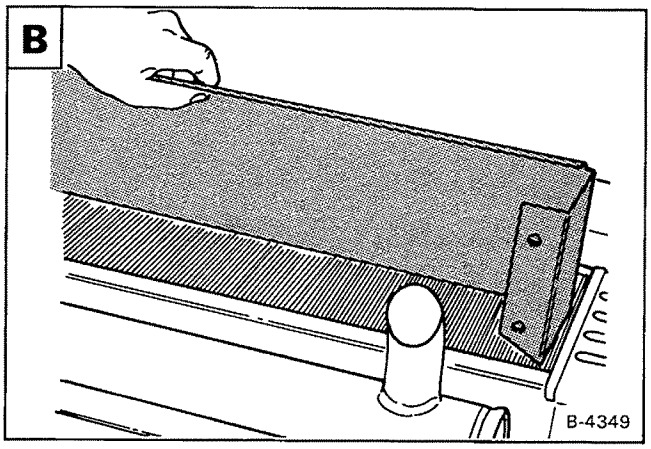
Remove the bottom cover at the blower housing.

Disconnect the exhaust pipe at the muffler [A].



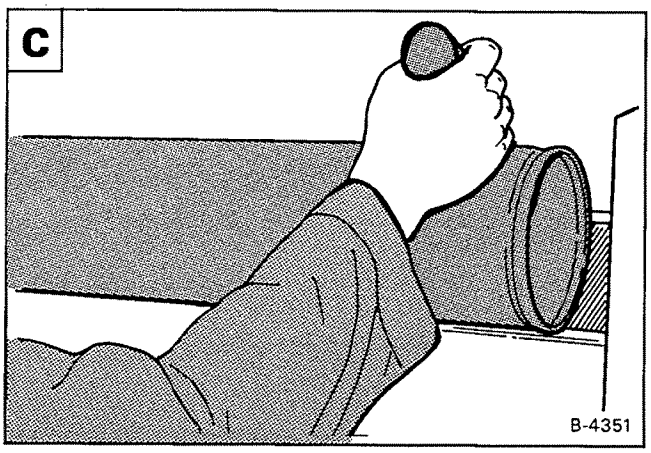
Remove the bolts at the heat shield.

Remove the heat shield [B].



Remove the bolts at the bottom of the muffler.

Remove the muffler from the loader [C].



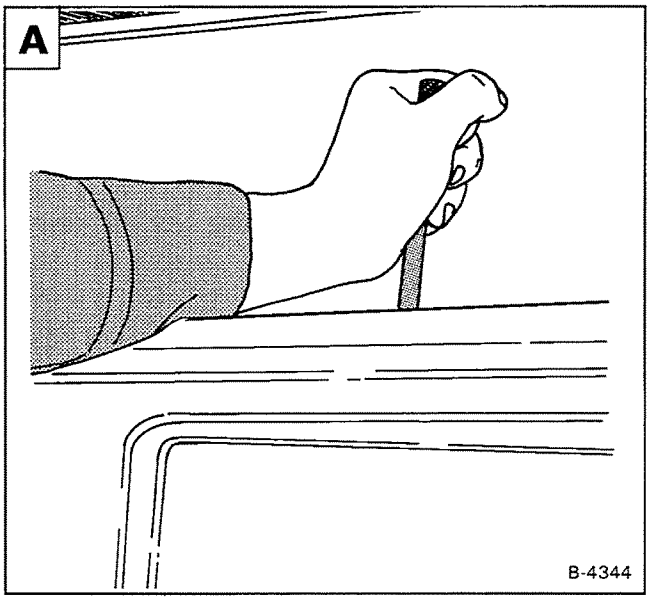
ENGINE BLOWER HOUSING

Removal and Installation

Remove the engine from the loader (See Page 7A–13).

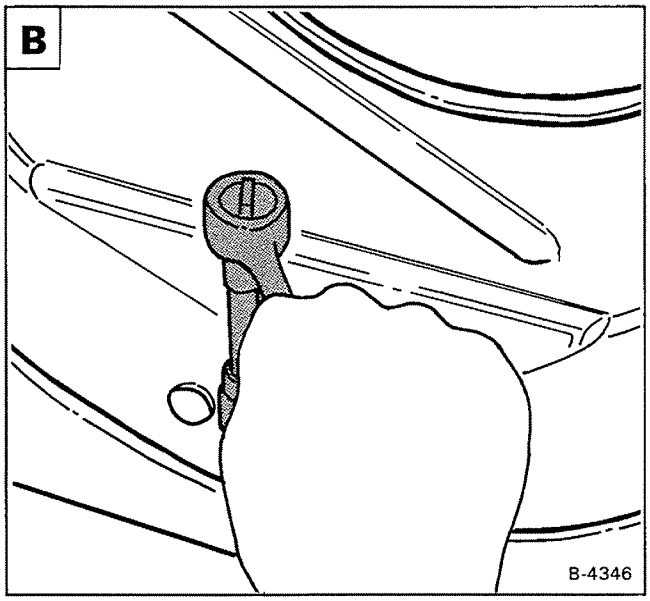
Remove the cover at the blower housing.

Remove the bolts along the top edge of the blower housing [A].

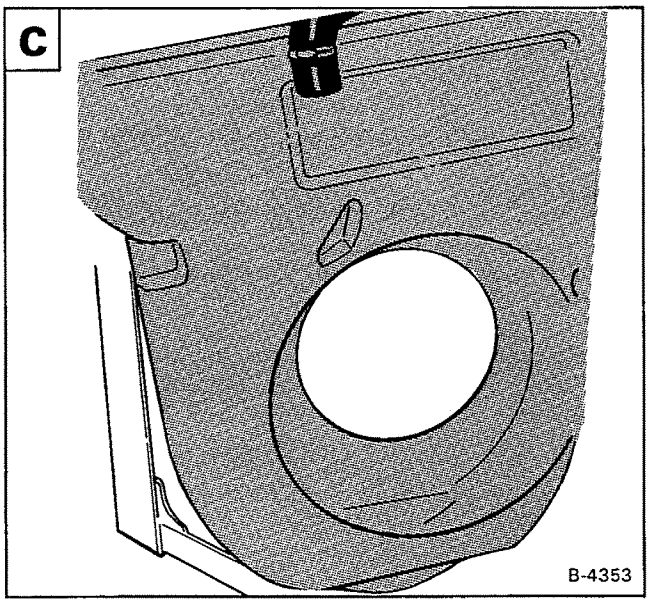


Remove the bolt at the bottom of the blower housing [B].

NOTE: If a rivet is used to hold the blower housing, use a punch and hammer to remove the rivet.



Remove the blower housing from the loader [C].

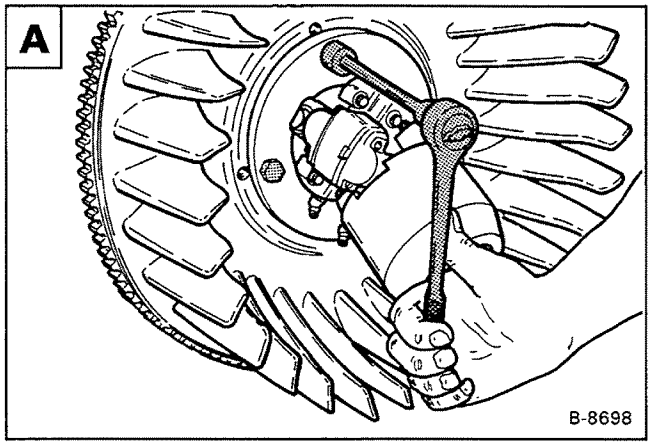


ENGINE FLYWHEEL & U-JOINT

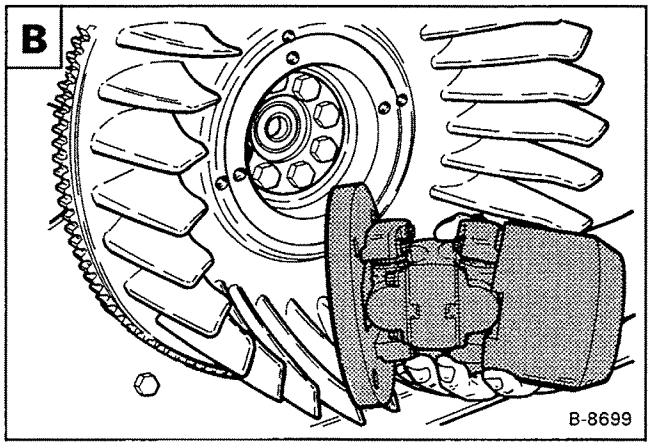
Removal and Installation

Remove the four bolts at the u-joint mounting flange [A].

Installation: Tighten the bolts to 25-28 ft.-lbs. (34-38 Nm) torque.

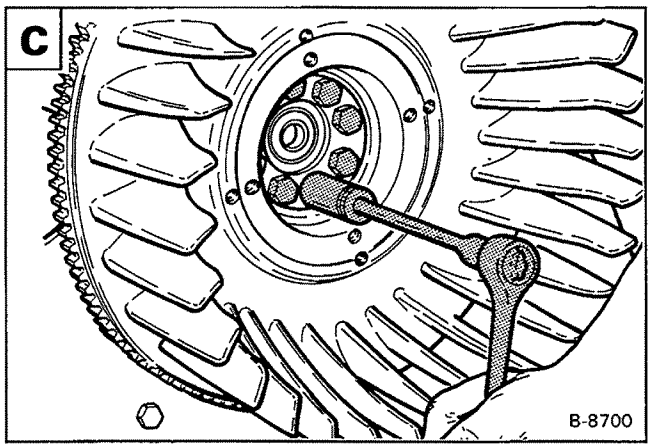


Remove the u-joint from the flywheel [B].



Remove the bolts from the flywheel [C].

Installation: Tighten the bolts to 83-90 ft.-lbs. (113-122 Nm) torque.



Remove the washer [D].

Remove the flywheel from the crankshaft flange.

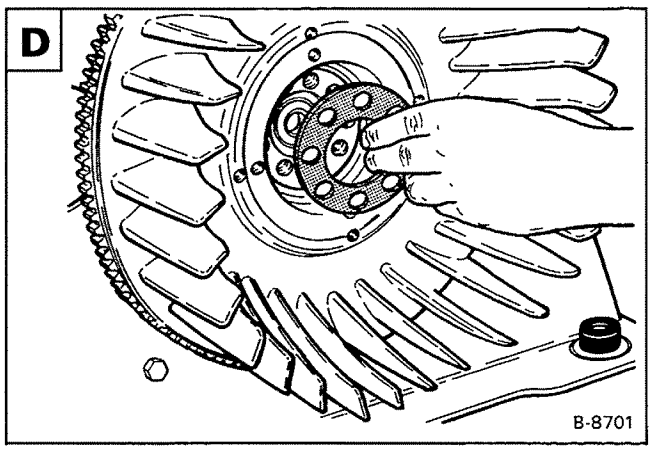
Flywheel Ring Gear

The ring gear on the flywheel is an interference fit. Heat the ring gear enough to expand it and hit it with a hammer, evenly, to remove it.

Clean the outer surface of the flywheel to give a smooth fit.

Clean the new ring gear and heat it to a temperature of 450-500°F. (232-260°C.).

Fit the ring gear over the flywheel. Make sure the gear is on its seat correctly.



CYLINDER HEAD

Removing the Cylinder Head

Clean all the debris from the engine and cylinder head.

Remove the coolant from the engine and radiator. Remove the radiator hoses.

Remove the fuel injectors and fuel tubelines (See Page 7A—11).

Remove the fuel filter and bracket.

Remove the valve cover.

Remove the nuts from the support brackets of the rocker arms.

Remove the rocker arms. Remove the push rods.

Loosen and remove the cylinder head bolts.

NOTE: When removing the head, do not use a sharp tool between the head and engine block. Always put the cylinder head on a flat surface such as wood to prevent damage to the machined surface.

Remove the head from the engine block.

See page 7A—24 for removing and reconditioning the valves.

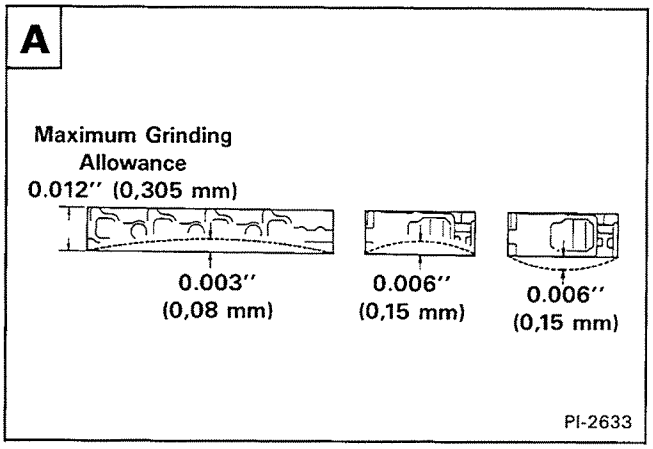
Cylinder Head Surface Alignment

Check the surface of the head with a straight edge [A].

A maximum of 0.012" (0,305 mm) can be removed from the surface. After milling the head, install a fuel injector nozzle. The nozzle must not extend more than 0.175" (4,4 mm) beyond the surface. Replace the cylinder head if this dimension is over the limit.

IMPORTANT

DO NOT add washers under injector nozzles to bring them back into specifications.

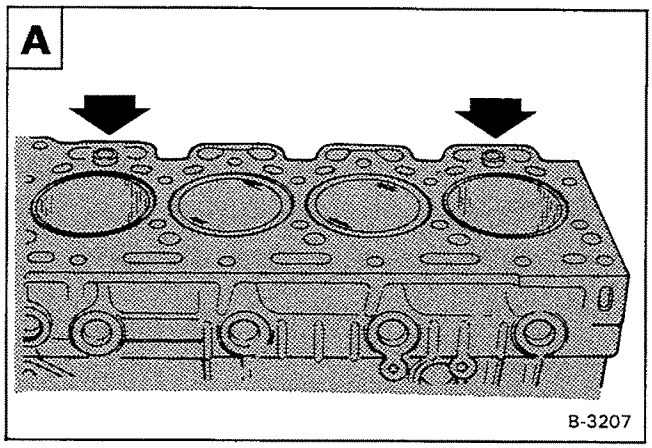


Installing the Cylinder Head

Install a new head gasket. Install it dry, no gasket cement is needed.

When the new head gasket is installed, make sure it is positioned correctly over the dowel pins and the markings "TOP" and "FRONT" are located correctly [A].

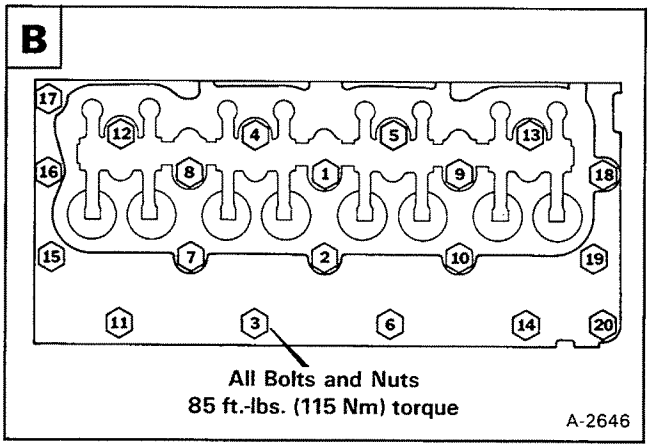
Put oil on the threads of the head bolts. Install the head bolts.



Tighten the bolts in the correct sequence [B]. Do this in a three step procedure to 85 ft.-lbs. (115 Nm) torque.

Example: First tighten all bolts to 30 ft.-lbs. (41 Nm) torque, then 65 ft.-lbs. (88 Nm) torque and then the final torque.

To reduce the risk of early cylinder head gasket failure, after a cylinder head has been fitted, the loader is to be operated under a partially load for about a half an hour. Then re-torque the bolts again. It is not a good practice to just run the engine without a load to bring it to operating temperature.



Install the push rods. Install the rocker arms and support brackets.

Adjust the valve clearance (See Page 7A—2).

Install the valve cover.

Install the fuel injector nozzles and fuel tubelines.

Install the fuel filter and bracket.

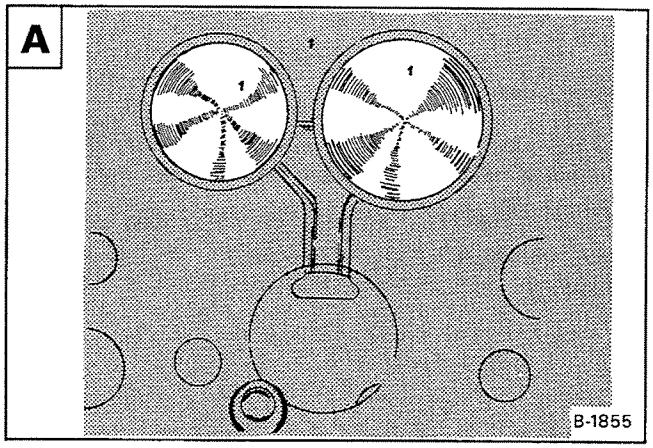
Install radiator hoses.

Add coolant to the engine and radiator.

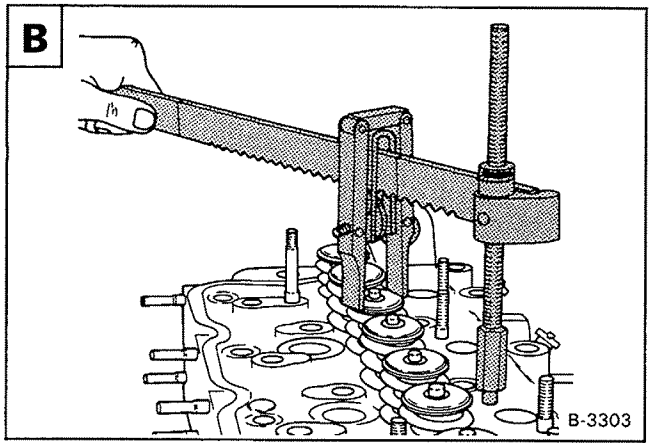
VALVES

Removal of the Valves

Mark the valves so they are put in the original position on assembly [A].



Use a valve spring compressor and remove the valve spring locks [B].



Remove the valve spring and valve from the head [C].

Repeat this procedure for each valve.

Installing the Valves

Make sure the cylinder head is clean.

Put oil on the valve guides and valve stems.

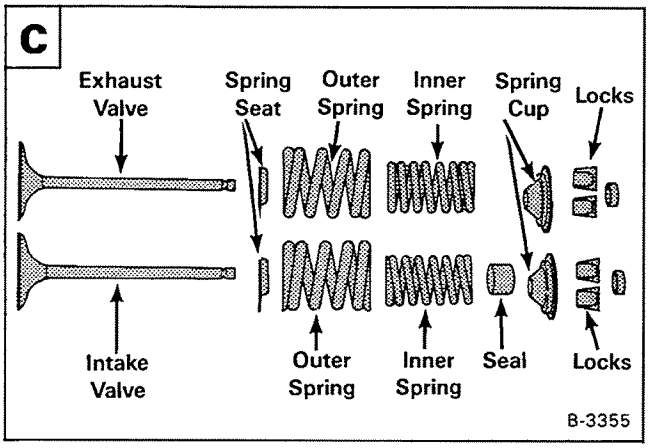
Put each valve in its correct location.

Assemble the valve springs and cups [C].

The intake valve is fitted with a rubber seal.

Use a valve spring compressor and install the valve springs and valve stem locks.

Tap the valve stem with a hammer a small amount to seat the valve stem lock.



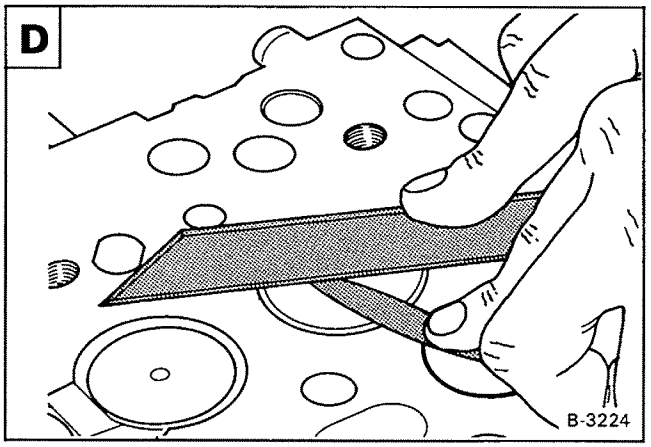
Reconditioning the Valves and Valve Seats

Use the correct equipment to grind the valves and valve seats.

The angle of the intake and exhaust valves is 45°.

Check the valve head depth in the cylinder head after grinding [D]. The correct specifications are as follows:

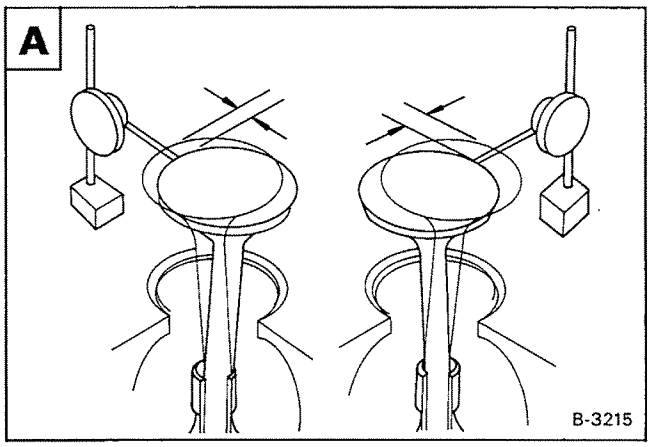
INTAKE - 0.029-0.045" (0,74-1,04 mm)
EXHAUST - 0.027-0.040" (0,69-1,02 mm)



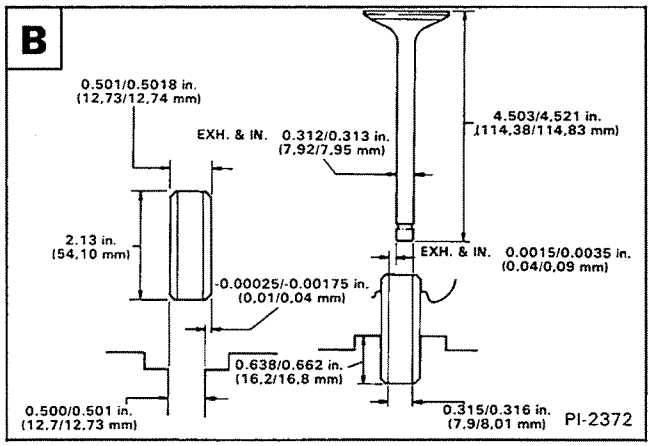
Installing Valve Guides

Check the valve guides for wear with a dial indicator [A]. If the movement is more than the listed specification, replace the guide:

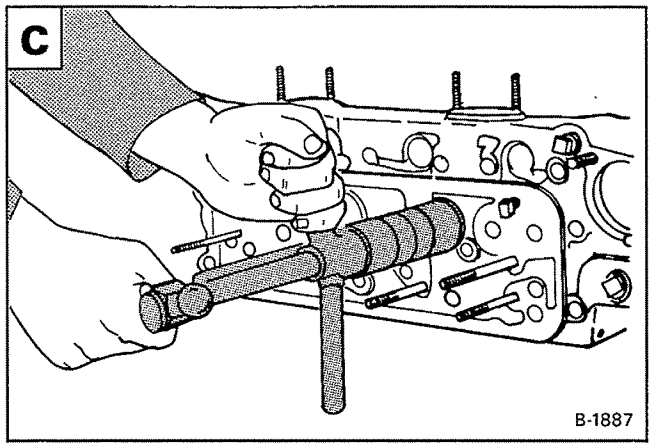
INTAKE & EXHAUST - 0.024" (0,6 mm)



NOTE: Make sure to check the valve stem for wear before replacing the valve guide [B].



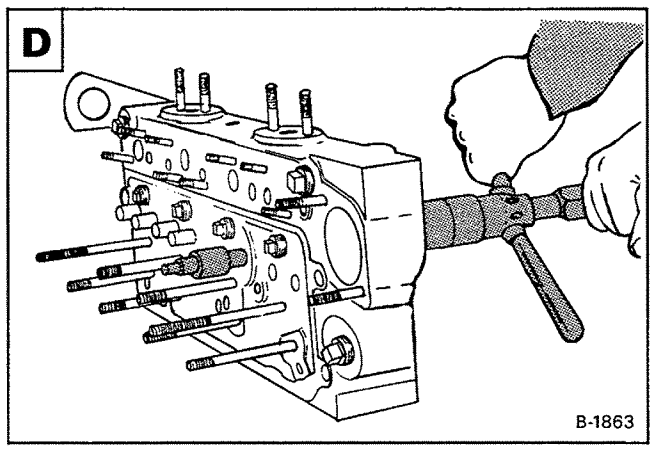
Remove the guide with a hydraulic press or hand operated tool [C].



Put oil in the bore and press in the new guide [D].

NOTE: Once the guide is started into the bore, do not stop.

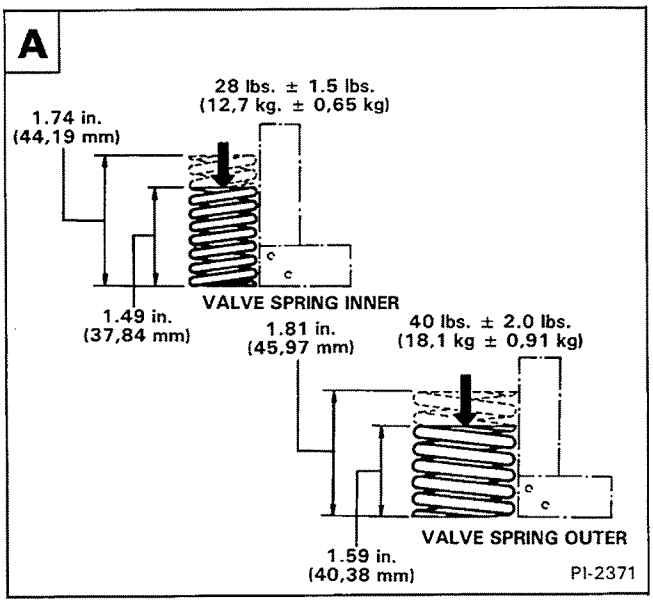
Press the guide into the head until 0.638 - 0.662" (16,2 - 16,8 mm) is above the cylinder head.



VALVES (Cont'd)

Checking the Valve Springs

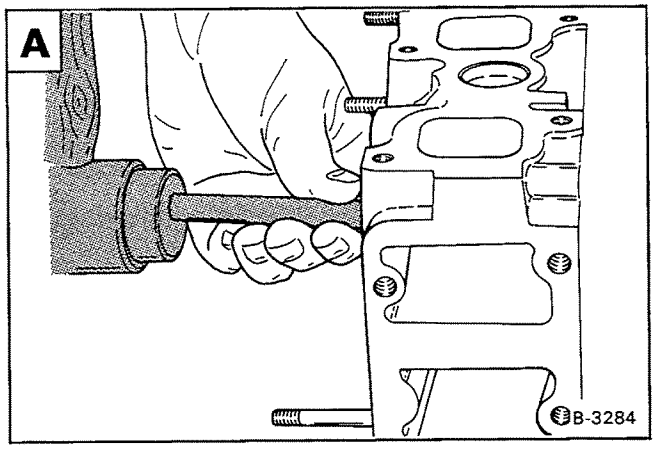
The valve springs for the intake and exhaust valves are the same. Check the spring ends for damage and check the specifications [A].



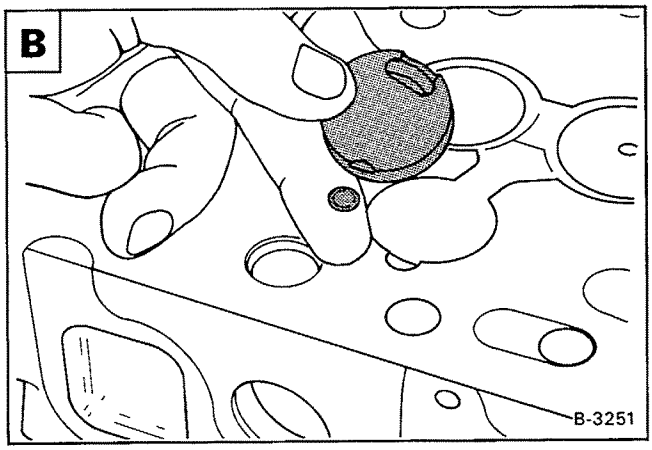
COMBUSTION CHAMBER INSERTS

Removal and Installation

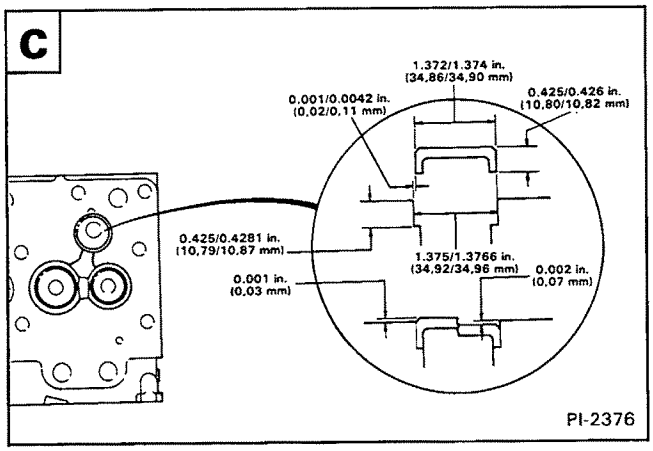
Remove the inserts, using a punch through the injector nozzle bore and hit the punch with a hammer [A].



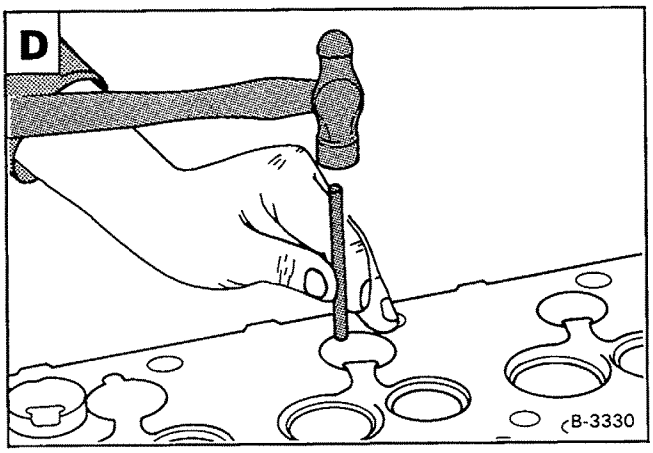
Position the new insert by putting expansion washer in the correct position [B].



Make sure to check the height of the insert to the cylinder head as shown [C].



Use a hammer and punch to set the expansion washer in position to hold the insert in the cylinder head [D].



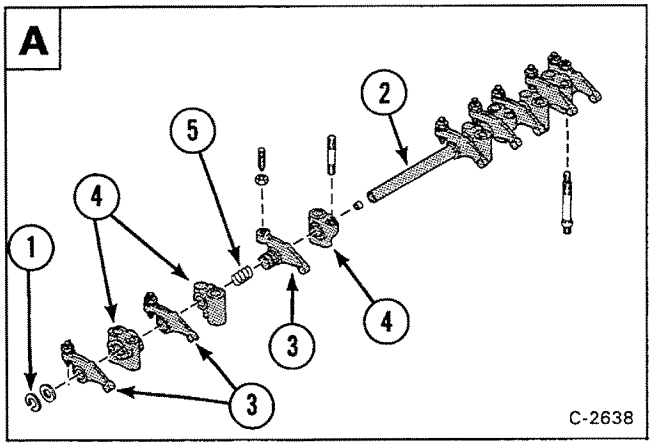
ROCKER ARMS

Disassembly

Mark the rocker arms and support bracket for correct assembly.

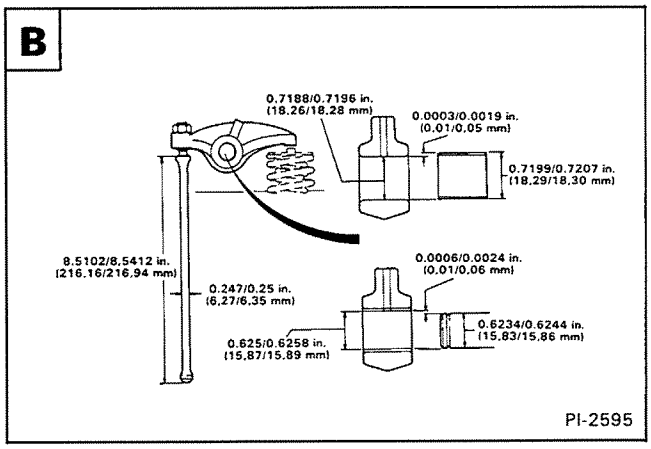
Remove the snap rings (Item 1) form each end of the shaft (Item 2) [A].

Remove the rocker arm (Item 3), bracket (Item 4) and spring (Item 5) [A].



Inspect the rocker arm bushings for wear [B].

Replace the parts as needed.

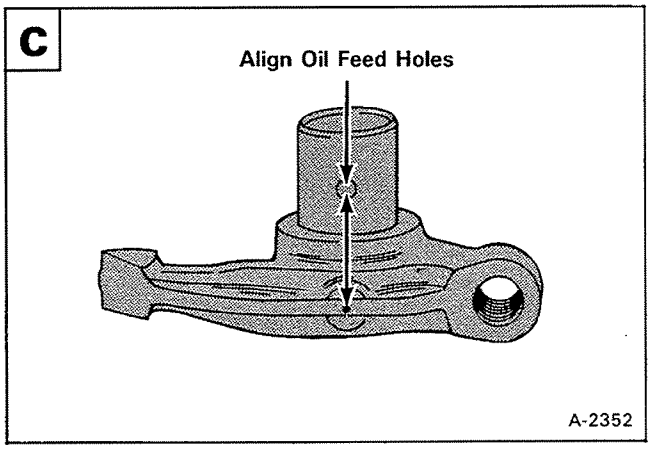


Assembly

When installing a new bushing in the rocker arms, make sure the oil holes are in alignment [C].

Reverse the order of disassembly and make sure that each set of rocker arm pair has the correct off-set.

Put oil on all the parts for protection.



PISTON AND CONNECTING RODS

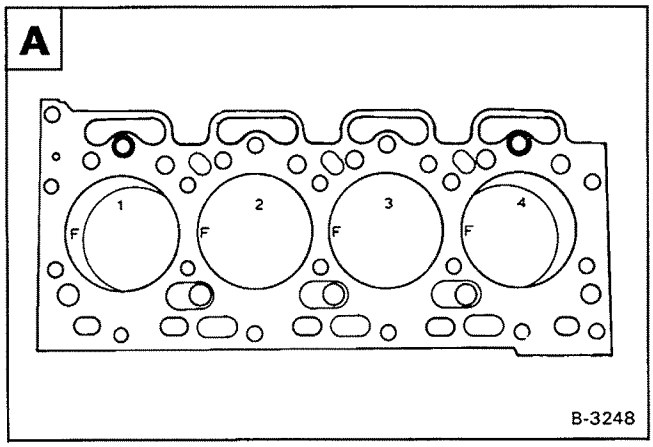
Removal

Remove the cylinder head (See Page 7A—22).

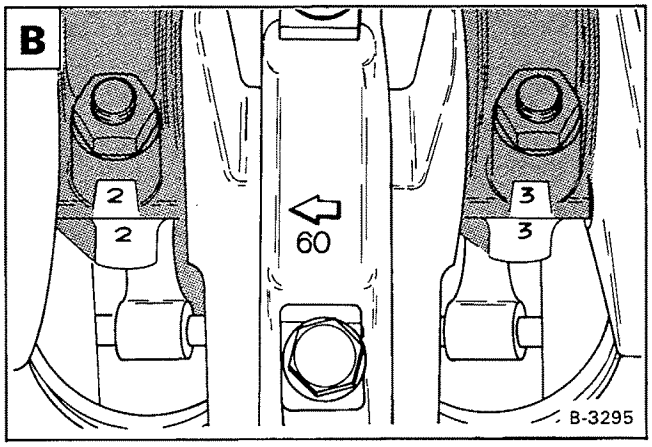
Remove the oil pan and oil pump (See Page 7A—47).

Remove the ridge and carbon deposits at the top of the cylinder bore with a ridge reamer.

Make sure the pistons have identification marks [A].

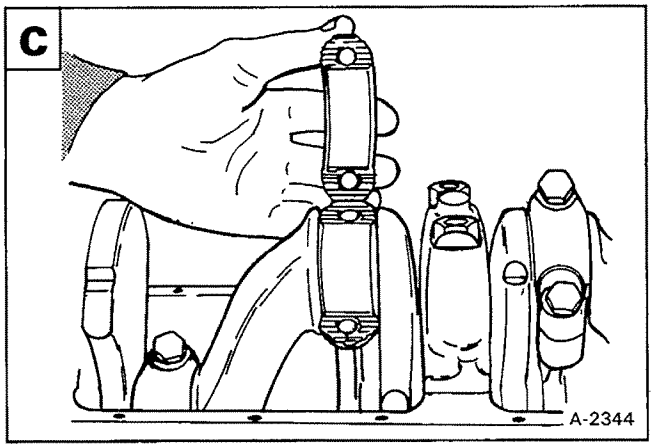


Rotate the crankshaft until a pair of connecting rods are at bottom dead center. Make sure the cab and rod have identification marks [B].



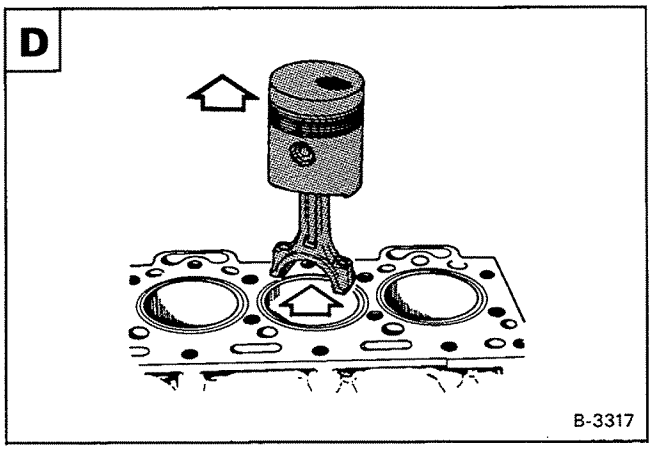
Remove the nuts and remove the bearing cap [C].

NOTE: If the bearings are to be used again, they must be identified so they are returned to their original location.



Using a hammer handle, push the piston and rod assembly out of the block [D].

After the pair has been removed, rotate the engine crankshaft and remove the other pair of pistons.



PISTON AND CONNECTING RODS (Cont'd)

Disassembly

Remove the rings from the pistons.

Remove the piston pin.

NOTE: If the piston pin does not come out easily, do not drive it out. Warm the piston in oil to a temperature of 120° F. (50° C.) and push the pin out.

Inspection

Clean all the parts in clean solvent.

Check the clearance of the new rings in the piston grooves [A].

Check the ring gap in the cylinder bore [B].

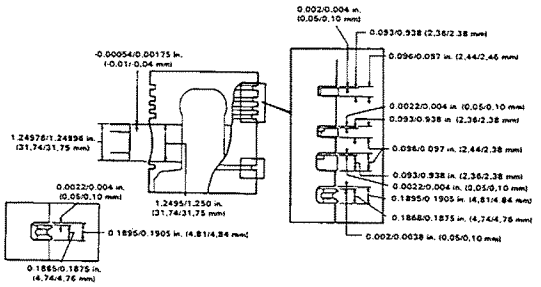
Make sure the specifications are correct [C].

Check the piston and pin bushing [D].

Replace the bushings with a hydraulic press. Remove all metal burrs from the piston bore before installing the new bushings.

Use the correct size reamer to fit the new bushing to the piston pin.

A



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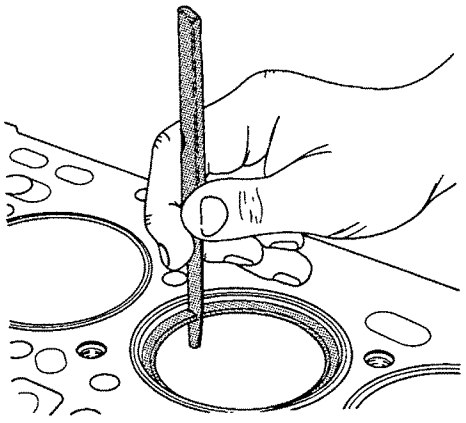
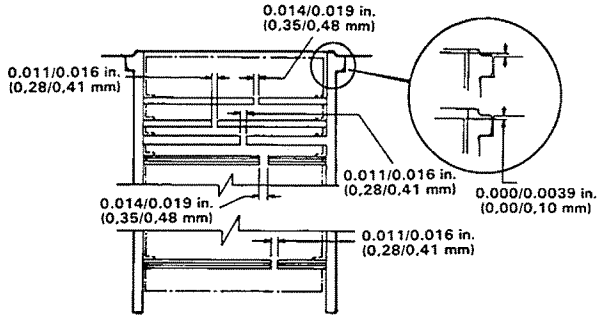
B



B-3334

C



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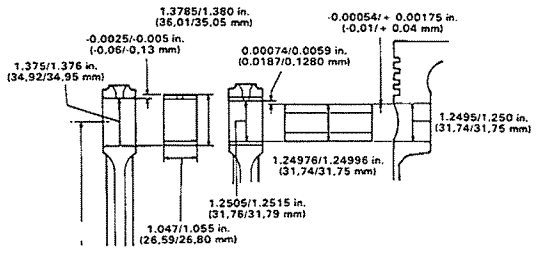
D



PI-2396R

PISTON AND CONNECTING RODS (Cont'd)

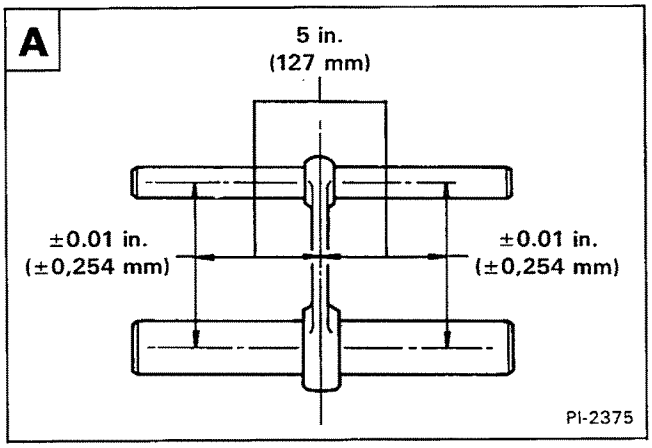
Check the connecting rod alignment [A].

Installation

Install the piston pin by putting the piston in clean oil at a temperature of 120° F. (50° C.).

Make sure the identification marks are located correctly at the rod and piston.

Install new snap ring on each side of the piston pin.



Install the piston rings using a expanding tool to prevent the ring from breaking [B].

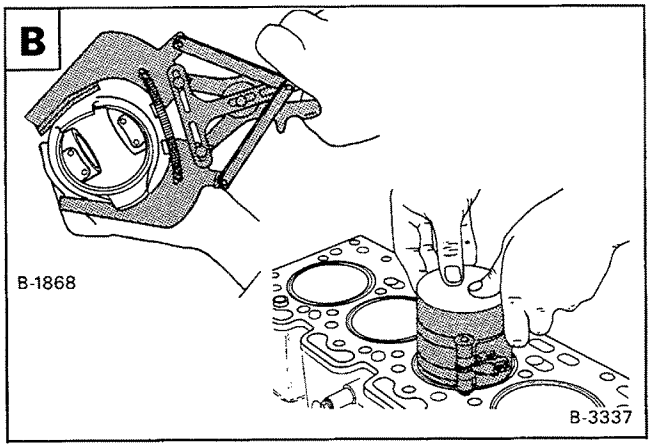
Put oil on the rings so they move freely in the piston grooves.

Position the ring gaps un-evenly around the piston.

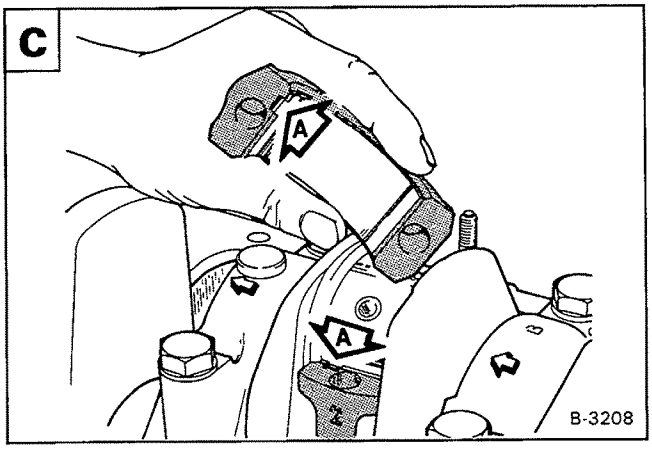
NOTE: Before the pistons are installed, check the cylinder bores.

Rotate the crankshaft until a pair of crank pins are at bottom dead center.

Using a ring compression tool, compress the rings on the piston. Make sure the "F" is to the front of the engine block and install the piston into the block [B].

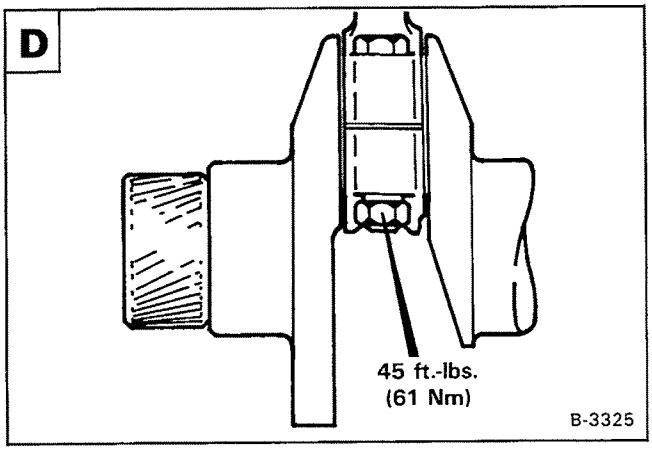


Put oil on the bearings. Install the bearing cap [C].



Tighten the nuts on the connecting rod [D].

Rotate the crankshaft to put the other pair of crank pins at bottom dead center. Repeat the procedure and install the other pair of pistons.



CYLINDER LINERS

Checking

The cylinder liners are made of cast alloy iron. They are an interference fit in the engine block and are of the dry type.

Boring of these liners to a larger size is not possible. New liners must be installed when the cylinder bores are worn over specifications.

Check the cylinder bore with an inside micrometer. Check the bores in three positions (top, center and bottom). The checks must be made at parallel and right angles to the center line of the bore, giving six dimensions for each bore.

The standard bore of the cylinder liner is 3.501 - 3.502" (88,92 - 88,95 mm). When the bore dimension is 0.006" (0,15 mm) over standard dimensions the liner must be replaced.

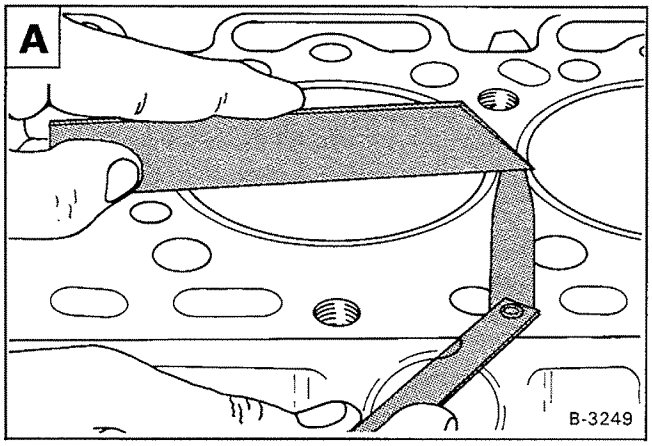
Removal and Installation

Remove all the parts from the engine. Press the cylinder liners out through the top of the engine block.
Clean the bore and remove any metal burrs in the block.

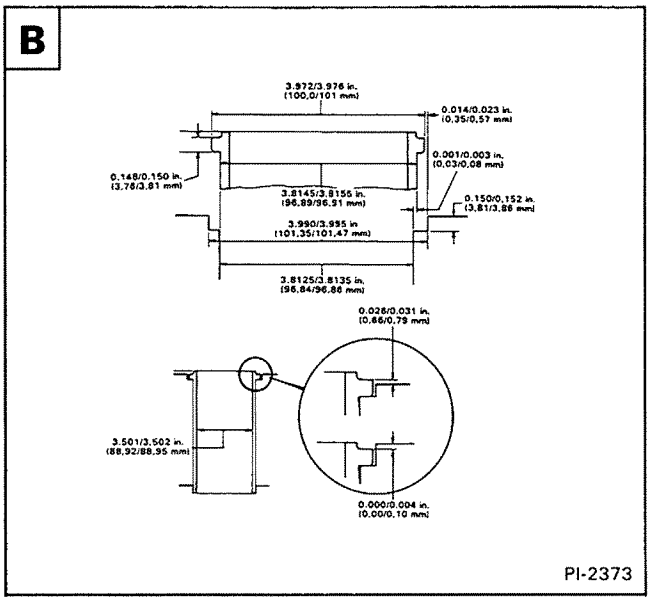
Put lubricant on the outside of the liner. Push the liner into the block.

Check the liner height in four positions for the correct height [A].

Follow the same procedure for the other cylinder liners.



Hone the cylinder bore to standard dimensions [B].



MAIN BEARINGS

The crankshaft has five main bearings. The end play is controlled by a thrust washer on both sides of the center main bearing.

Each main bearing cap has an identification mark in relation to the engine block [A].

The position of each cap can not be changed from the original location.

Removal

Remove the oil pan. Remove the oil pump (See Page 7A—47).

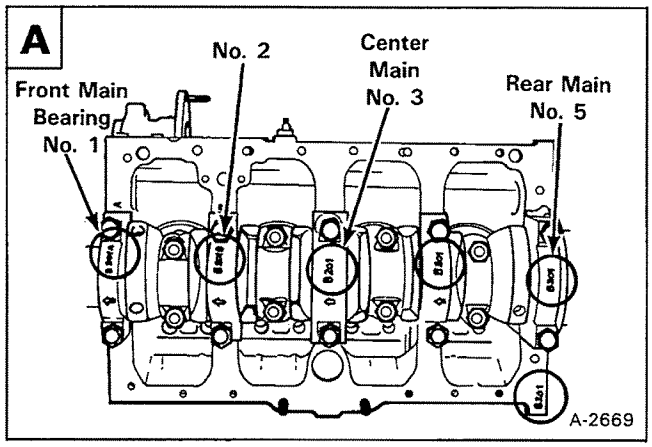
Remove the bolts from the main bearing caps.

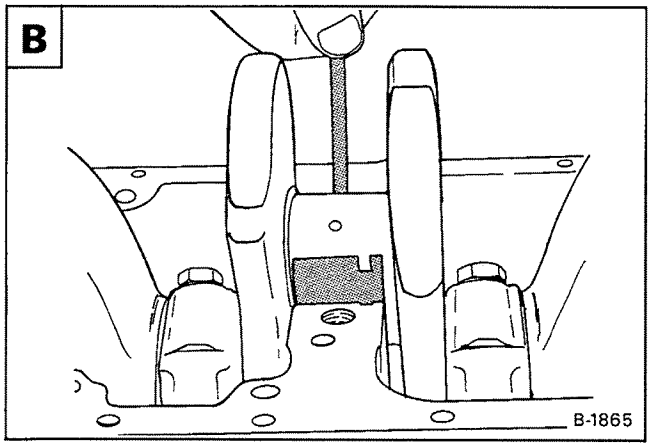
Remove the main bearing cap and remove the bearing from the cap half.

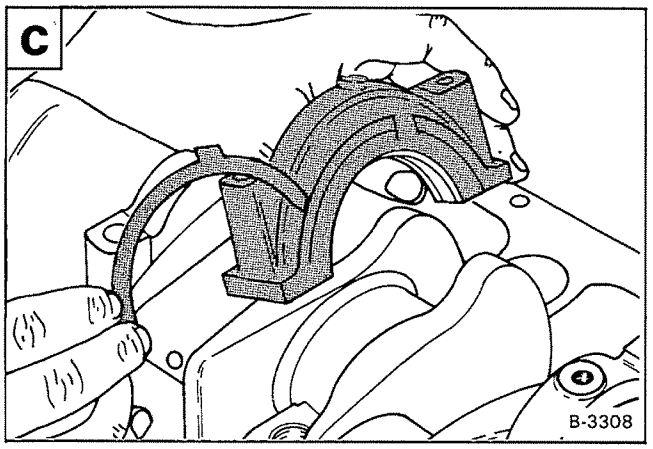
Remove the top half of the bearing by pushing on one side of the bearing and rotating the crankshaft [B].

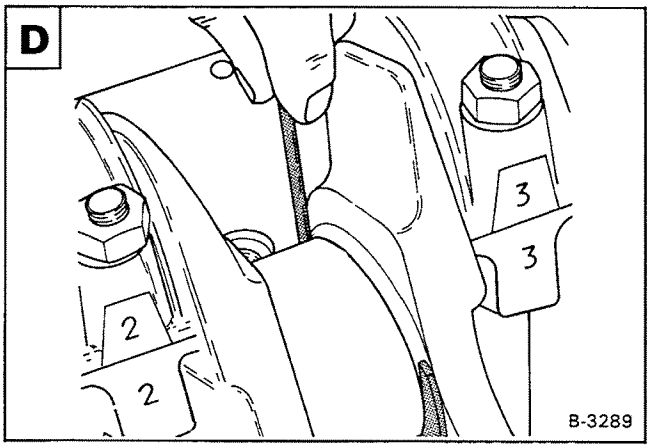
On the center main bearing, remove the cap and thrust washers from each side of the cap [C].

Remove the top half of the bearing and thrust washer by pushing on one side of the bearing and rotating the crankshaft [D].









MAIN BEARINGS (Cont'd)

Installation

Check the crankshaft journals before installing the main bearings (See Page 7A—35).

Lubricate the new bearings. Install them by putting the end without the tab into the block and rotating the crankshaft until the tab is on its seat.

Install the other bearing half in the main bearing cap. Lubricate the bearing and install it on the engine block.

Install the bolts and tighten to position the cap, then loosen them.

Install the center main bearing and thrust washers.

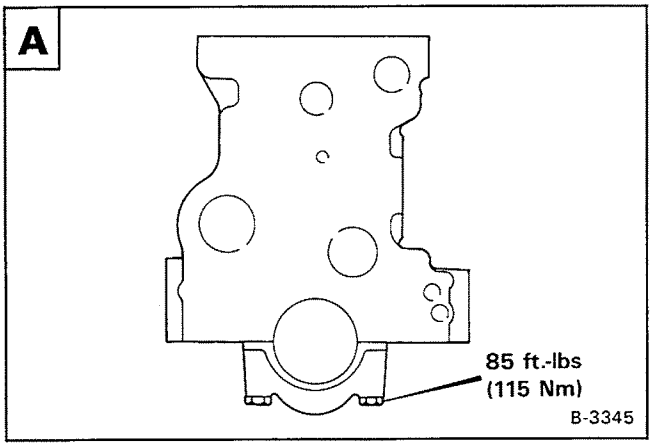
Repeat the procedure until all the main bearings are installed.

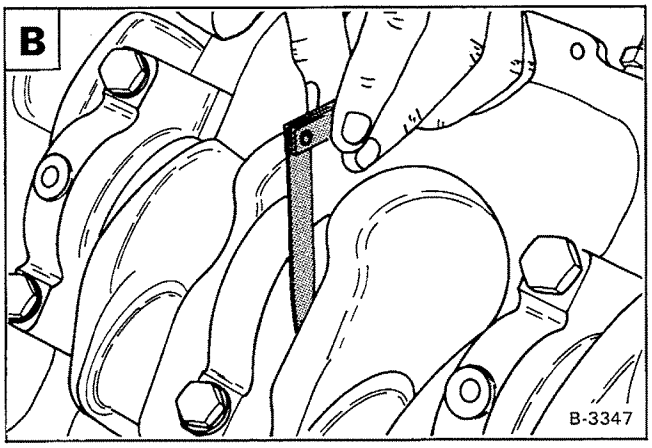
Then tighten the bolts to the correct torque [A].

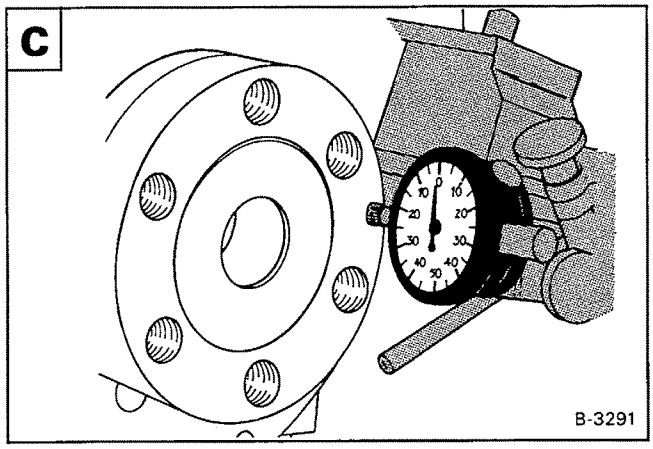
Crankshaft End Play

The end play can be checked by either a feeler gauge [B] or a dial indicator [C].

The maximum end play is 0.014" (0,35 mm). The fitting of oversize thrust washers can be used to correct the end play if its over the specifications.







CRANKSHAFT

Removal

Remove the oil pan. Remove the oil pump (See Page 7A—47).

Remove the crankshaft pulley, timing case cover, timing gears and timing case (See Page 7A—38).

Remove the flywheel (See Page 7A—21).

Remove the rear main seal (See Page 7A—37).

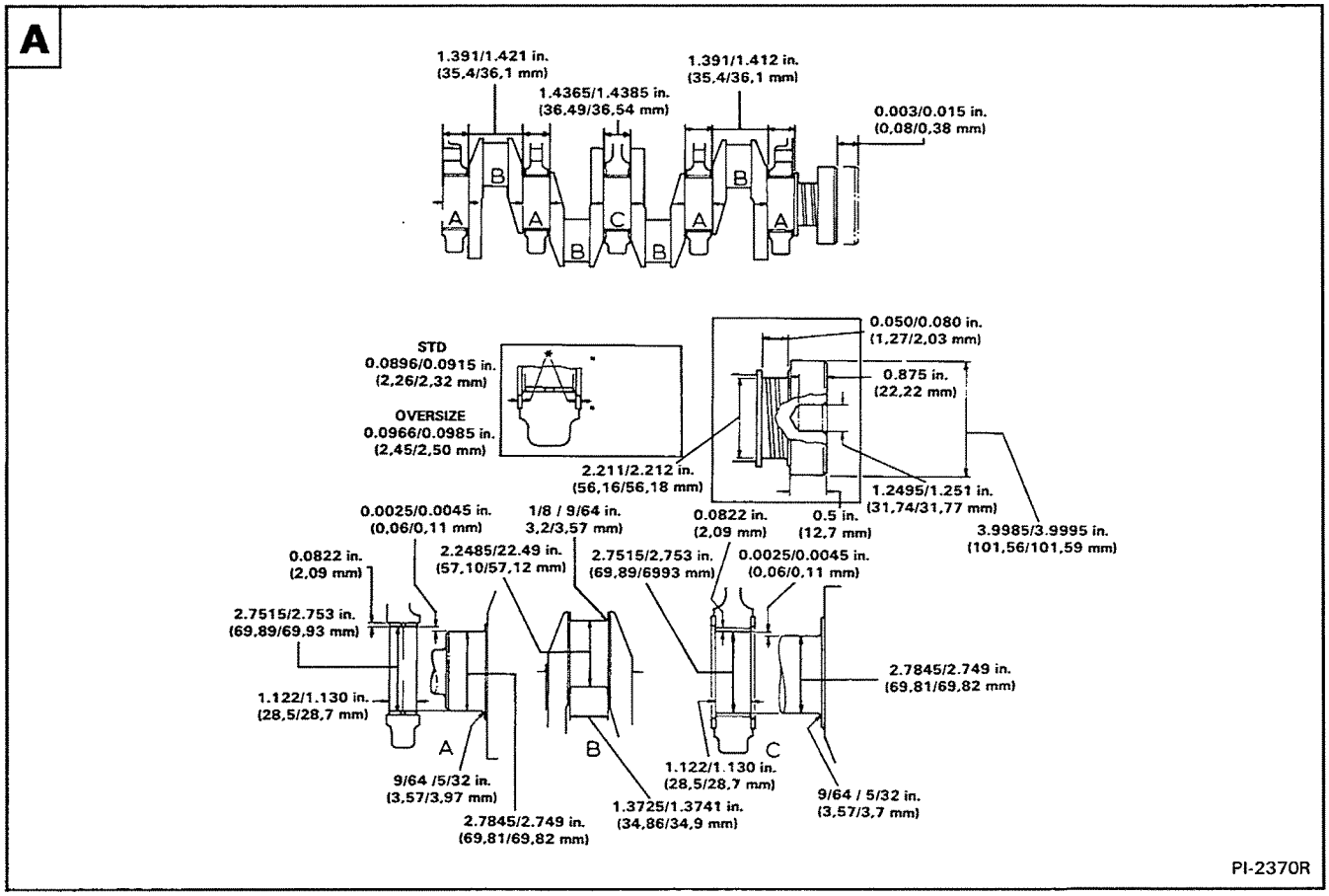
Remove the connecting rod caps (See Page 7A—30).

Remove the bolts and main bearing caps (See Page 7A—3).

Lift the crankshaft out of the engine block for inspection.

Checking

Using a micrometer, check the crankshaft for correct dimensions [A].



NOTE: You can grind the crankshaft to 0.010" (0,25 mm), 0.020" (0,51 mm) and 0.030" (0,76 mm) undersize. See Page 8A—10 for the correct specifications.

Installation

Clean the crankshaft and check that all the oil passages are clean and open.

Clean the engine block, lubricate and install the upper halves of the main bearings.

NOTE: If you do not install new bearings, always return the old bearings back to their original position.

Put the crankshaft, carefully in position.

Install the main bearing caps (See Page 7A—33).

NOTE: Make sure the lower thrust washer is in its correct location.

Check the crankshaft so that it rotates freely. Check the crankshaft end play (See Page 7A—34).

Install the rear oil seal (See Page 7A—37).

Lubricate the connecting rod bearings. Install the bearings and connecting rod caps (See Page 7A—30).

Install the oil pump.

Install the oil pan.

Install the timing case, timing gears, timing case cover and crankshaft pulley (See Page 7A—38).

Install the flywheel (See Page 7A—21).

REAR MAIN OIL SEAL

Removal and Installation

Put the housing (Item 1) in a vise and install the seal (Item 2) into the groove [A].

Using a round bar and roll and press the seal into position. Cut the seal ends off 0.010 - 0.020" (0,25 - 0,51 mm) above the housing.

Repeat this procedure for the other half of the housing (Item 3) [A].

Remove all gasket material from the engine block.

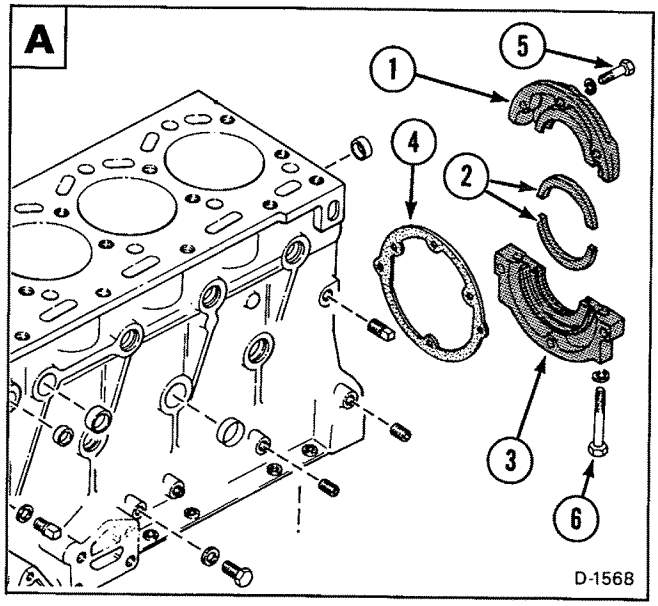
Put gasket cement on the engine block and install the gasket (Item 4) [A].

Lubricate the seal with grease.

Install the housing halves (Items 1 & 3). Install the bolts (Item 5) and finger tighten only.

Install the bolts (Item 6) and tighten to 48 - 72 in.-lbs. (5 - 8 Nm) torque [A].

Tighten the bolts (Item 4) to 12 ft.-lbs. (16 Nm) torque and then tighten the bolts (Item 6) to 12 ft.-lbs. (16 Nm) torque [A].



TIMING CASE COVER

Removal and Installation

Remove the alternator and belt.

Remove the crankshaft pulley bolt and washer.

Remove the pulley from the crankshaft.

Remove the bolts and nuts from the cover.

Remove the cover from the engine.

Clean the timing case cover and timing case back plate.

Remove the front seal from the cover by pushing it out through the front of the cover.

Press the new seal in from the front until the seal is seated below the front edge of the cover [A]. Make sure it is seated at the correct specification [B].

Put a new gasket on the cover. Install the cover, be carefull not to damage the front seal.

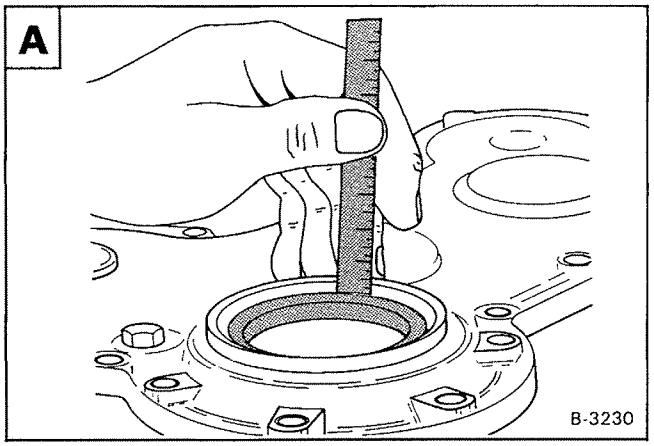
Install the bolts and nuts and finger tighten only.

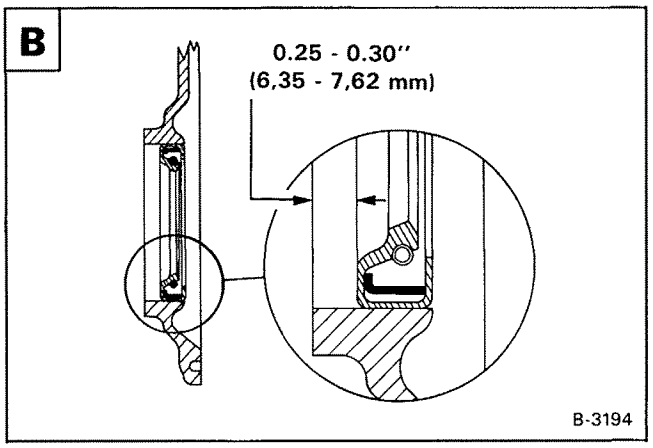
Install the crankshaft pulley to center the front seal on the pulley hub.

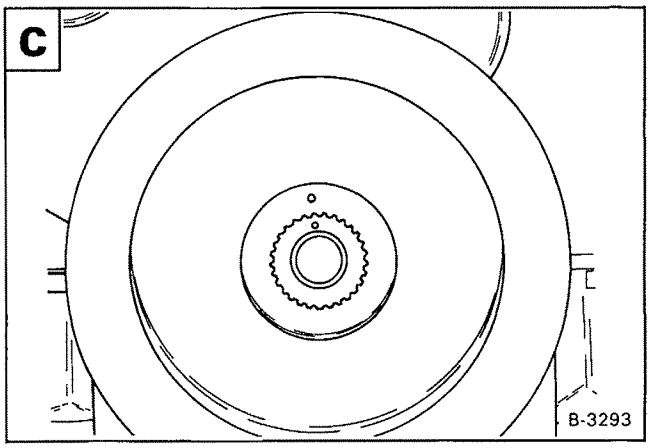
Tighten the bolts and nuts. Remove the crankshaft pulley and tighten the bolts behind the pulley.

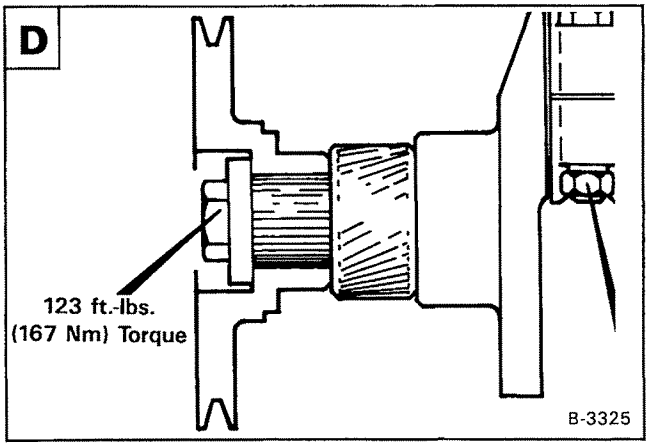
Install the crankshaft pulley with the mark on the pulley in alignment with the line on the front face of the crankshaft [C].

Install the bolt and washer and tighten [D].









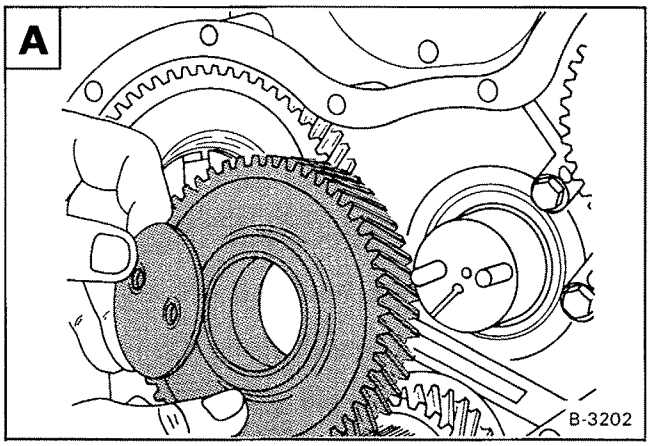
IDLER GEAR AND HUB

Removal

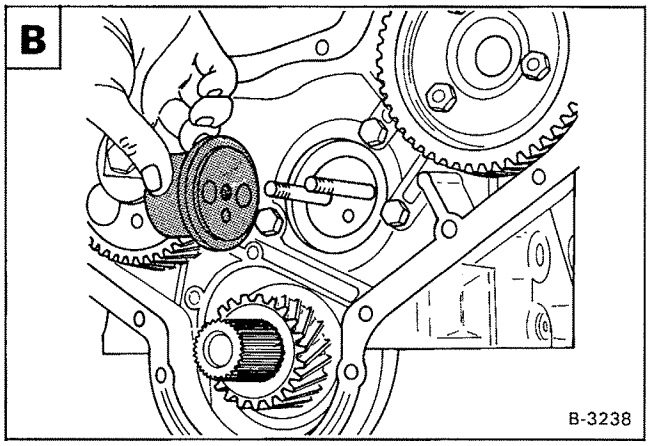
Remove the timing case cover (See Page 7A—38).

Remove the nuts at the idler gear plate.

Remove the retainer plate and gear [A].

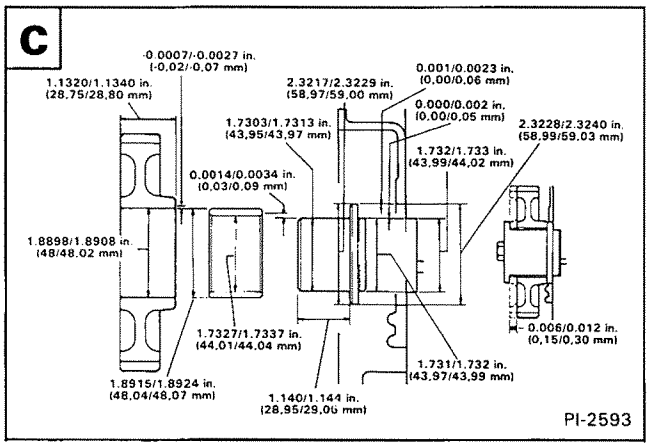


Remove the idler gear hub [B]. The idler gear hub is an interference fit, use a soft hammer to remove it.



Check the idler gear and hub [C].

Replace the parts as needed.



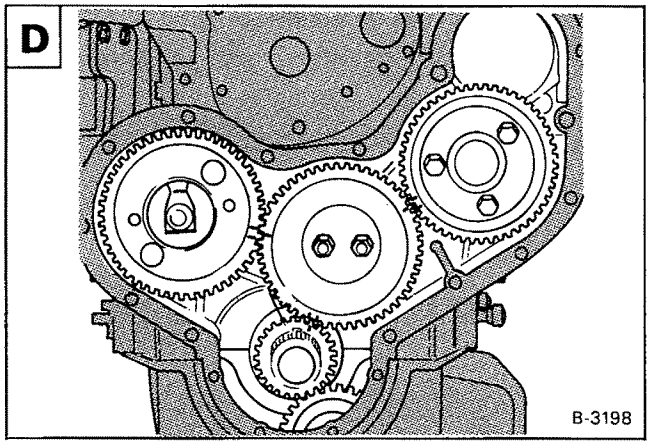
Installation

Make sure the oil passage is clean in the hub.

Turn the engine crankshaft until No. 1 piston is at TDC, compression stroke.

Install the idler gear hub [B].

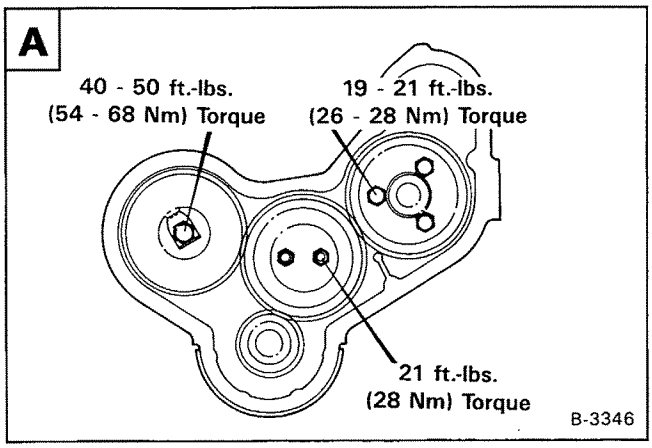
Install the idler gear. Make sure the timing marks are in alignment with the crankshaft gear, camshaft gear, fuel injection pump drive gear and idler gear [D].



IDLER GEAR AND HUB (Cont'd)

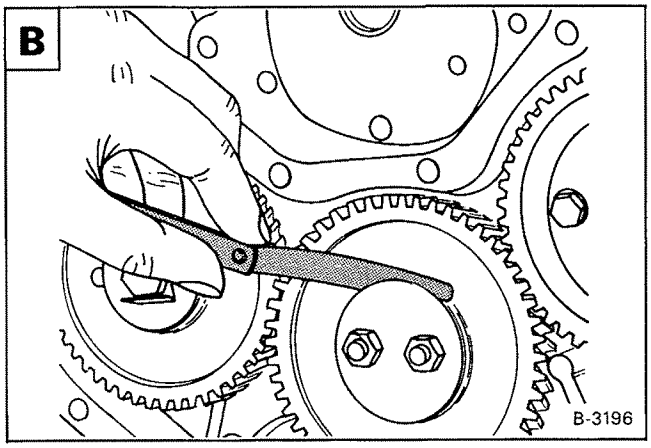
Install the retainer plate.

Tighten the nuts to the correct torque [A].



Check the clearance for end play at the idler gear [B].

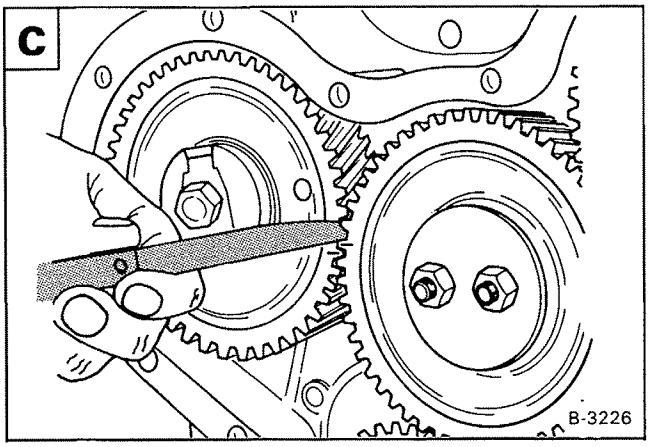
The correct end play is 0.006 - 0.012" (0,15 - 0,30 mm).

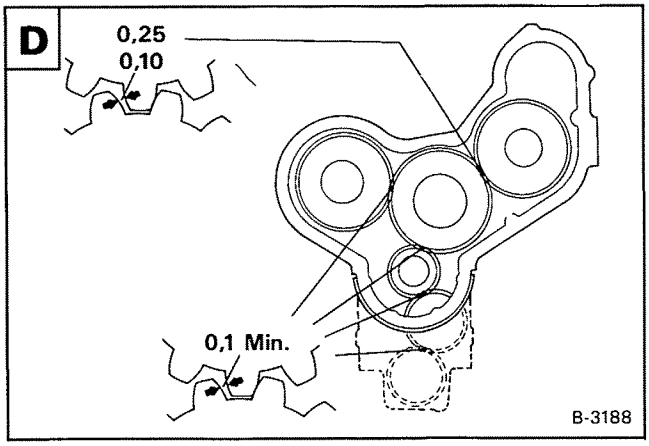


Check the clearance at the gear teeth [C] for the correct dimensions [D].

Replace any worn parts that do not meet specifications.

Install the timing case cover (See Page 7A—38).





CAMSHAFT GEAR

Removal

The tool listed will be needed to do the following procedure:

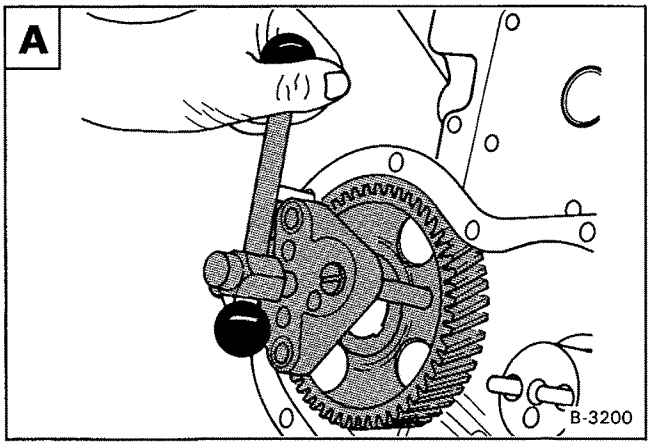
MEL-1054 — Puller

Remove the timing case cover (See Page 7A—38).

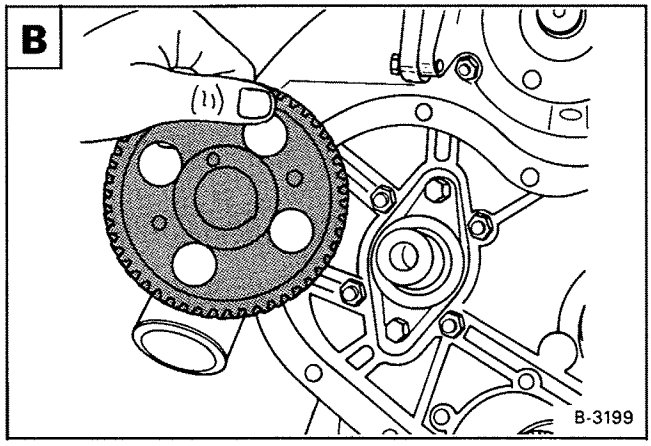
Remove the idler gear (See Page 7A—39).

Remove the bolt, tab washer and retainer washer.

Install the puller to remove the camshaft gear [A].



Remove the camshaft gear [B].



Installation

Put the gear over the end of the camshaft.

Install the retainer washer and tab washer.

Install the bolt and tighten to 40 - 50 ft.-lbs. (54 - 68 Nm) torque.

Install the idler gear (See Page 7A—39).

Install the timing case cover (See Page 7A—38).

FUEL INJECTION PUMP DRIVE GEAR

Removal and Installation

Remove the timing case cover (See Page 7A—38).

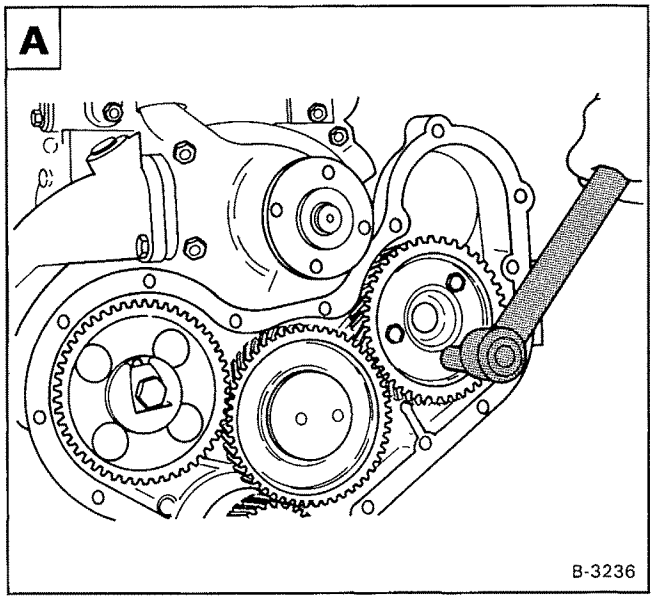
Remove the fuel injection pump (See Page 7A—7).

Remove the idler gear (See Page 7A—39).

Remove the three bolts [A].

Installation: Tighten the bolts to 19 - 21 ft.-lbs. (26 - 28 Nm) torque.

Remove the gear from the hub.



CRANKSHAFT GEAR

Removal

The crankshaft gear is an interference fit on the end of the crankshaft. A key is installed between the gear and the crankshaft.

Use a puller to remove the gear from the crankshaft.

TIMING CASE

Removal and Installation

Remove the timing case cover (See Page 7A—38).

Remove the idler gear (See Page 7A—39).

Remove the camshaft gear (See Page 7A—41).

Remove the fuel injection pump drive gear (See Page 7A—42).

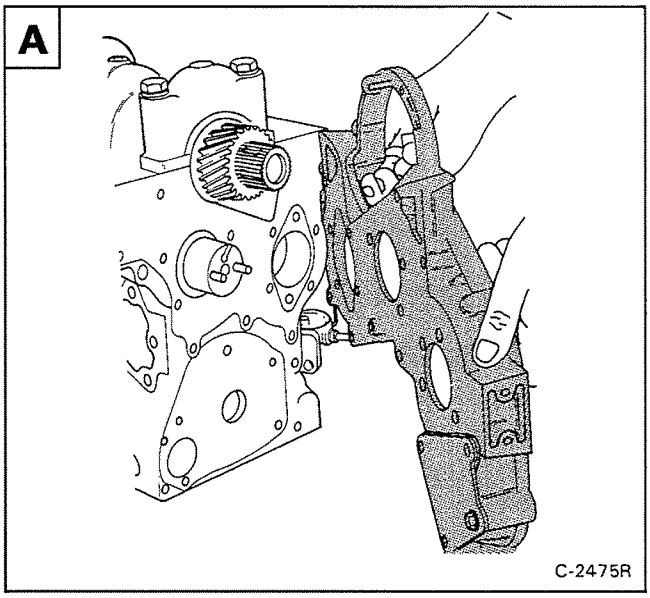
NOTE: The crankshaft gear does not have to be removed.

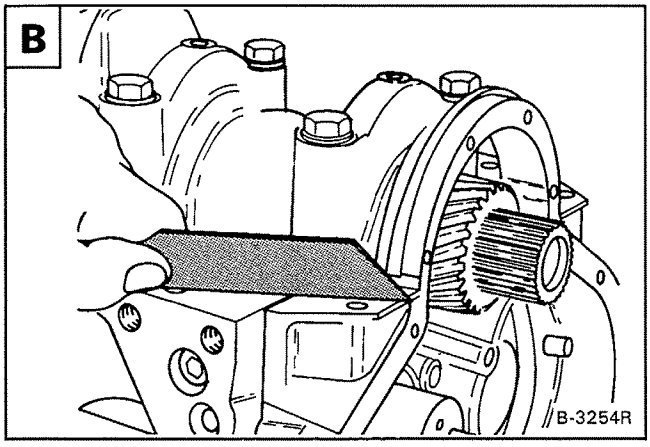
Remove the front bolts at the oil pan.

Remove the bolt and washers from the timing case.

Remove the timing case [A].

Installation: Check that the bottom of the timing case is even with the face of the oil pan attaching surface [B].





CAMSHAFT AND TAPPETS

Removal

Remove the timing case cover (See Page 7A–38).

Remove the idler gear (See Page 7A–39).

Remove the camshaft gear (See Page 7A–41).

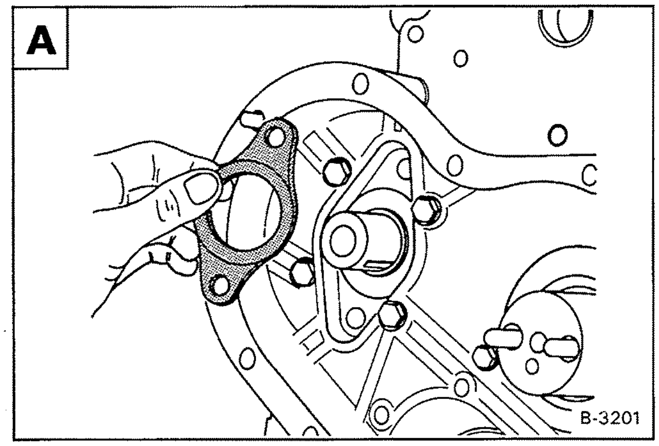
Remove the valve cover.

Remove the rocker arm assembly and push rods.

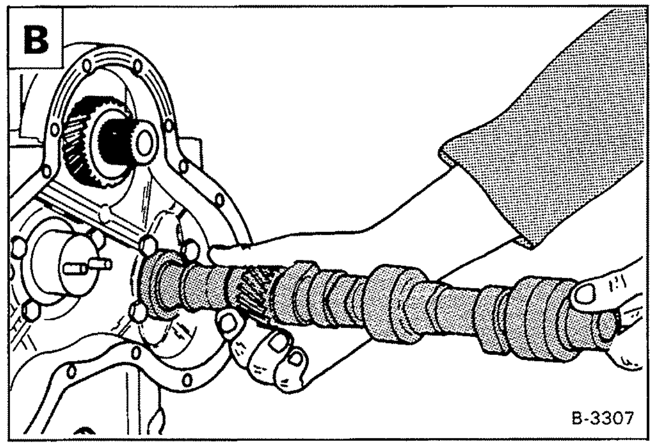
Remove the fuel lift pump (See Page 7A–5).

Turn the engine over and remove the oil pan and oil pump (See Page 7A–46).

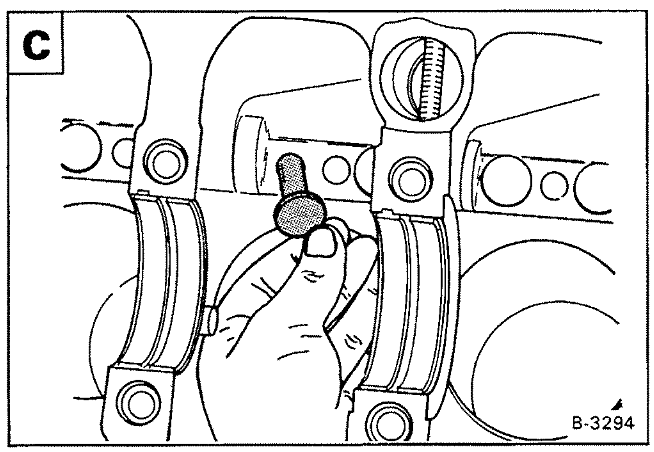
Remove the thrust plate at the camshaft [A].



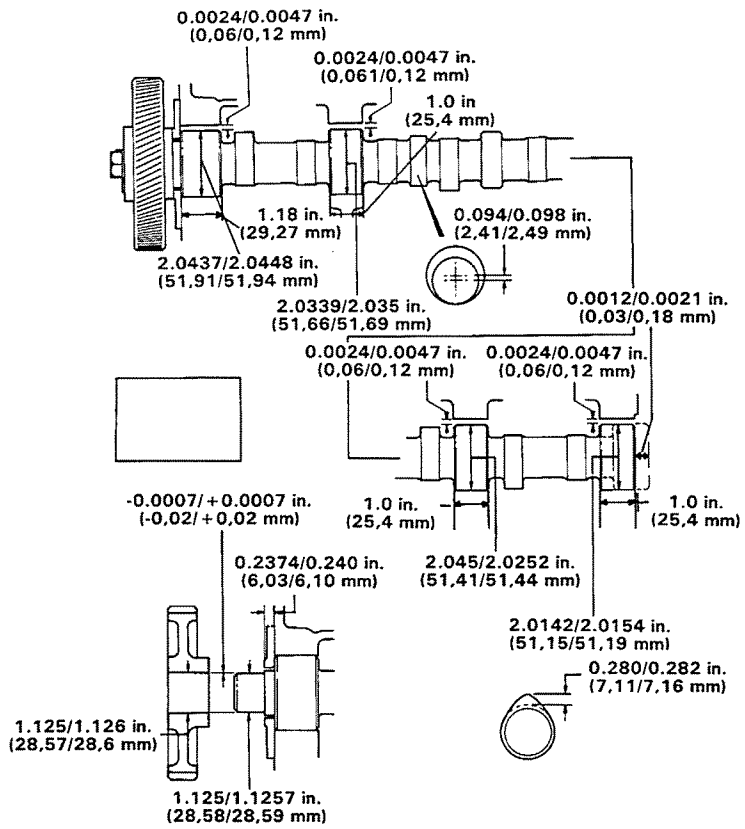
Remove the camshaft from the engine block [B].



Remove the tappets from the engine block [C].



A



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Inspection

Check the camshaft and the bearings [A].

Use the correct tools for removal and installation of the camshaft bearings.

Installation

Lubricate the tappets before installation.

Lubricate the camshaft. Carefully install the camshaft to prevent damage to the bearings.

After rocker arms are installed, make sure to set the valve clearance (See Page 7A—2).

LUBRICATION SYSTEM

Description

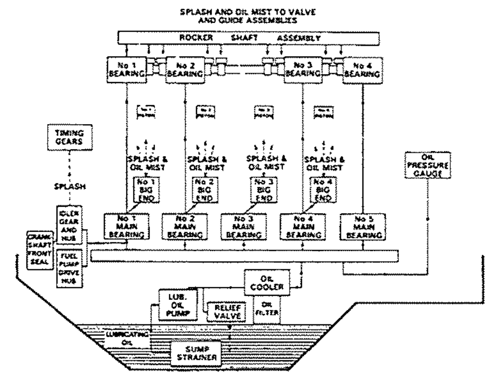
The figure shows the engine oil lubrication system [A].

The lubrication of the engine is done by a full flow oil filter to the main oil gallery from which the oil is put through small holes into the main bearing housings to each of the five main bearings.

Some of the oil is taken off at a hole at the No. 1 main bearing to lubricate the idler gear and the timing gears. Holes in the crankshaft distribute oil to the four connecting rod bearing journals from which oil splash is thrown up to lubricate the cylinder bores and the small ends of the connecting rods.

The four camshaft journals are lubricated directly by oil holes from No. 1, 2, 4 & 5 crankshaft main bearings. The oil pressure is reduced at the No. 1 journal of the camshaft and is used to lubricate the rocker shaft. The oil pump has a pressure relief valve which limits the oil pressure. The oil filter housing has a by-pass valve which prevents the engine from going without lubrication if the filter element becomes plugged.

A



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OIL PUMP

Removal and Installation

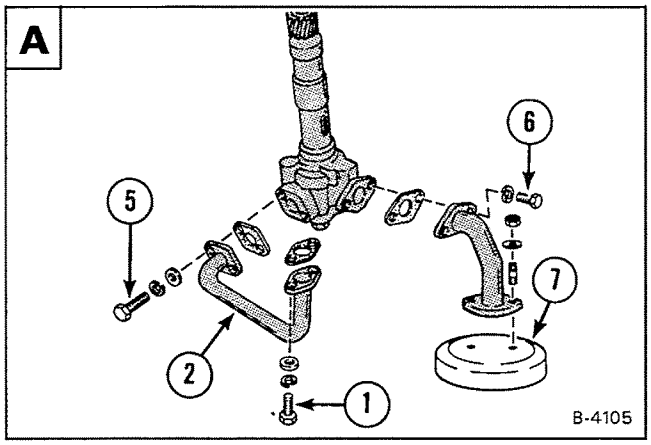
Remove the oil pan. Remove the bolts (Item 1) that fasten the oil tube (Item 2) to the block [A].

Loosen the locknut (Item 3) at the bolt (Item 4) that holds the oil pump in the block. Remove the oil pump.

Disassembly and Assembly

Remove the bolts (Item 5) and tube (Item 2) [A].

Remove the bolts (Item 6) and oil screen (Item 7) [A].



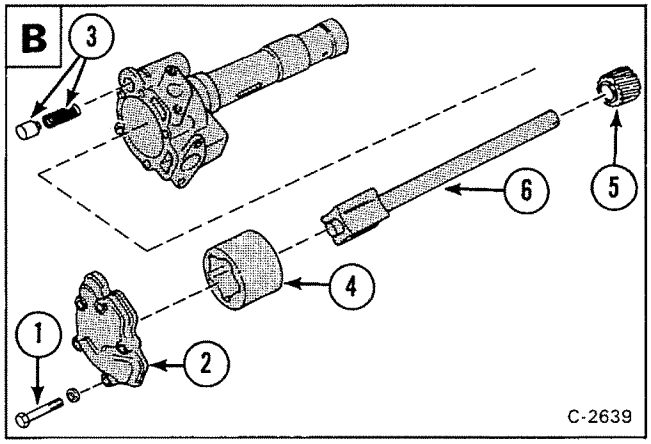
Remove the bolts (Item 1) and the end cover (Item 2) [B].

Remove the relief valve plunger and spring (Item 3) [B].

Remove the outer rotor (Item 4) [B].

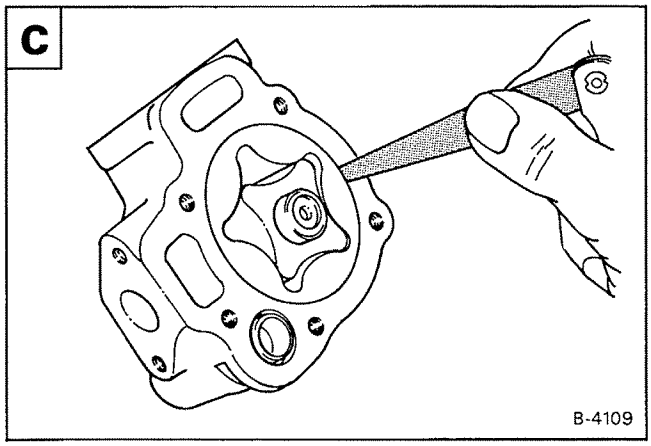
Use a puller and remove the gear (Item 5) [B].

Remove the shaft and inner rotor (Item 6) [B].

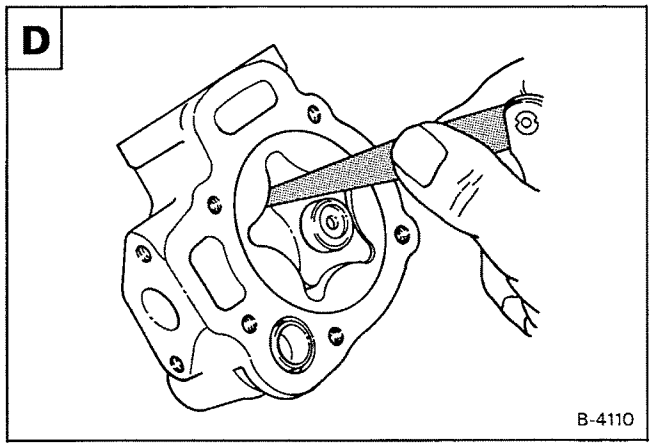


Checking

Check the clearance between the outer rotor and housing [C].



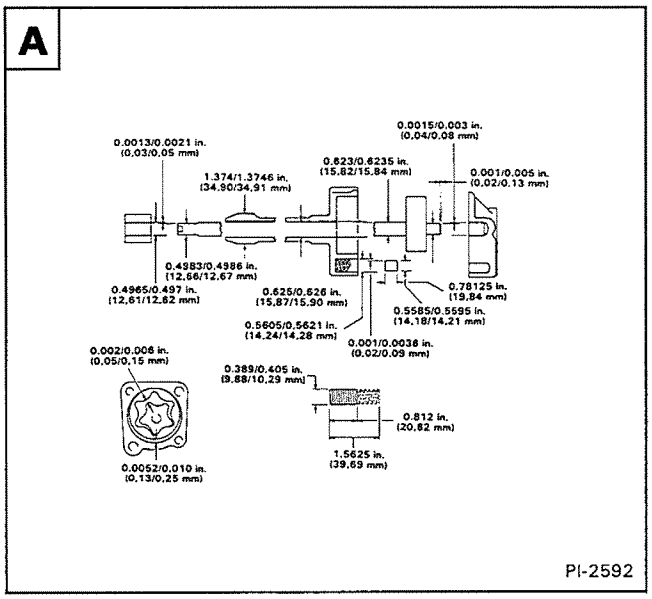
Check the clearance between the inner rotor and outer rotor [D].



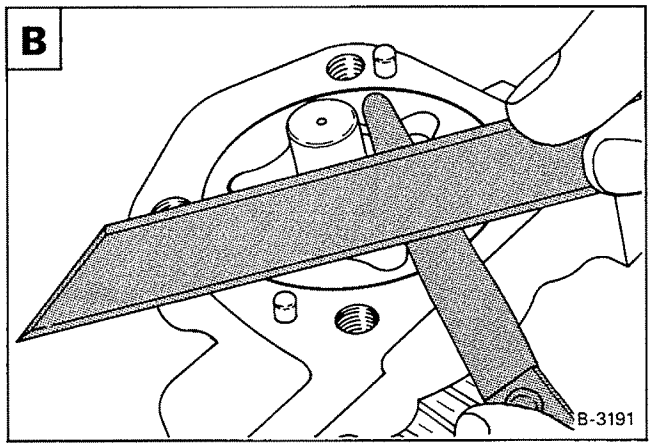
See Page 7A—48 for the specifications.

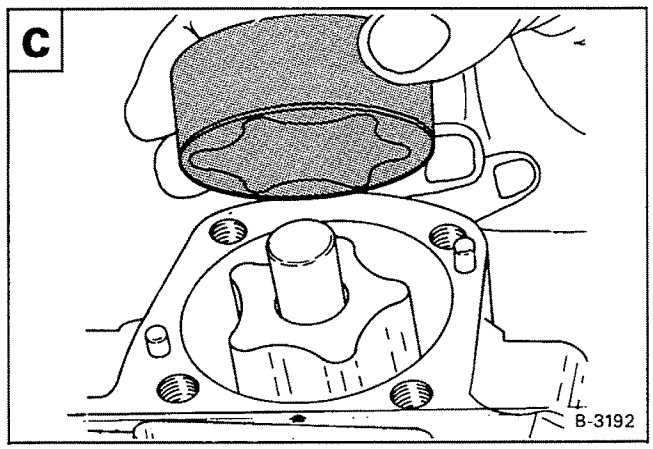
OIL PUMP (Cont'd)

Check the relief valve and plunger [A].



Installation: Check the end play of the shaft and inner rotor [B] and then install the outer rotor [C].





WATER PUMP

Removal and Installation

Remove the coolant from the cooling system. Remove the belt shield.

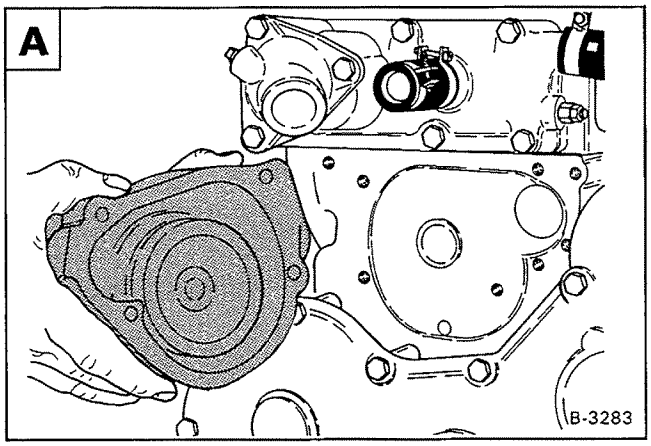
Loosen the alternator adjusting bolt and remove the alternator belt.

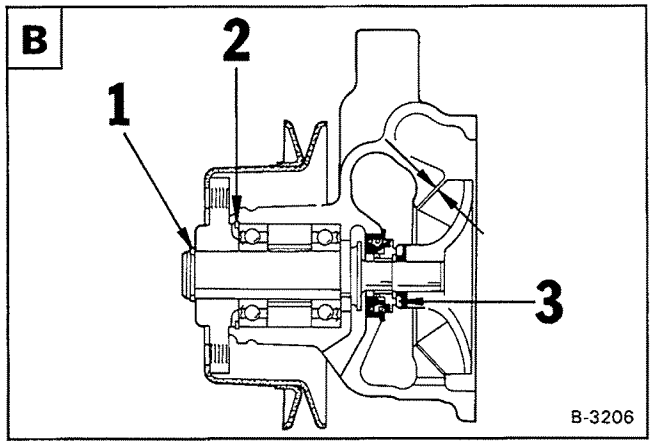
Remove the four bolts from the pulley and remove the pulley.

Remove the bolts which fasten the water pump to the engine block.

Remove the water pump [A].

Installation: Clean the block surface. Put gasket cement on the engine block and install a new gasket.





Disassembly

Remove the snap ring (Item 1) [B].

Press the complete assembly out of the impeller end of the housing.

Remove the snap ring (Item 2) [B].

Press the two shaft bearings out through the front of the housing.

Use a puller and remove the impeller from the shaft.

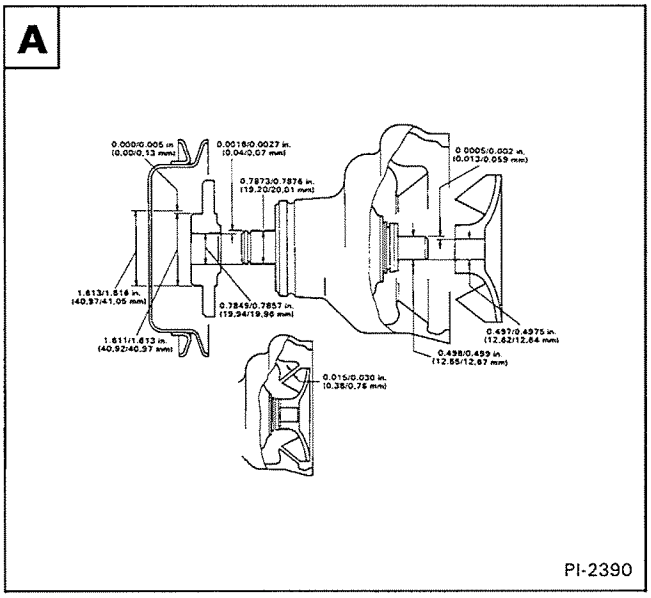
Remove the seal (Item 3) from the shaft [B].

WATER PUMP (Cont'd)

Checking

Check the water pump as listed in the specifications [A].

Replace the seals and worn parts.



Assembly

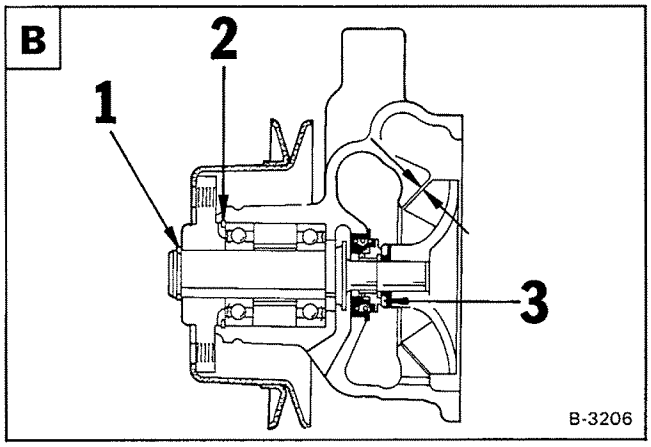
Press the two bearings and spacer (between the bearings) on the shaft.

Put grease on the spacer, about one-half to two-thirds of the area between the bearings. Put grease inside the bearings.

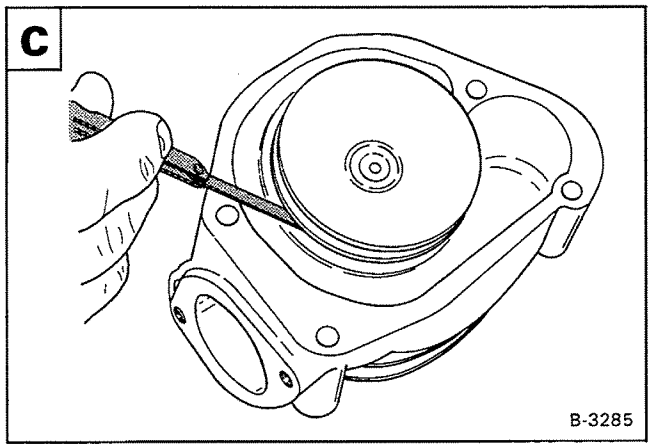
Press the complete assembly in the front of the housing. Locate it in the correct position by installing the snap ring (Item 2) [B].

Put a support under the shaft, impeller end of the shaft. Press the hub on the shaft and install the snap ring (Item 1) [B].

Install the seal over the impeller end of the shaft (with carbon surface out). Locate it in position in the flange area of the housing. Install the ceramic counterface seal with ceramic face toward the carbon seal (Item 3) [B].



Press the impeller on the shaft. Check the clearance to make sure there is 0.015 - 0.030" (0,38 - 0,76 mm) between the impeller and the housing [C].



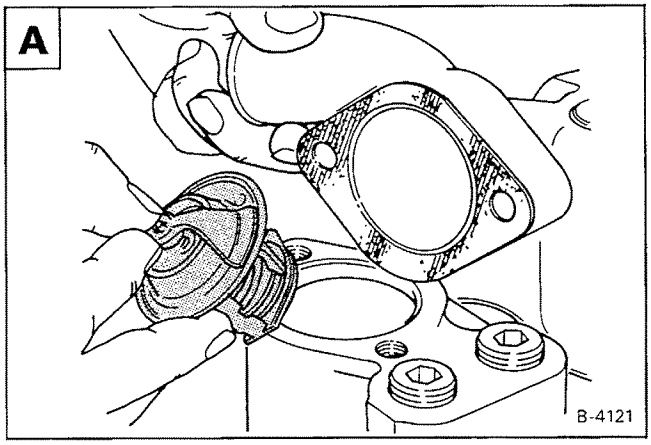
THERMOSTAT

Removal

Remove the coolant from the cooling system.

Remove the hose from the housing of the thermostat.

Remove the bolts, housing and thermostat from the engine block [A].



Testing the Thermostat

Put the thermostat in water and heat the water.

The thermostat valve must start to open at 179 - 183° F. (81 - 85° C.) and must be fully open to 0.315" (8 mm) at 185 - 200° F. (88 - 94° C.).

If the thermostat does not open in this range, replace the thermostat.

Installation

Clean the surface of the engine block and housing.

Put gasket cement on the engine block and install a new gasket.

Install the thermostat and the housing on the block and tighten the bolts.

Install the hose and tighten the clamp.

Add pre-mixed coolant of 50% ethylene glycol and 50% water to the cooling system.