GROUP 9 — ENGINE

SECTION 0 — INDEX

SERVICE BULLETIN REFERENCE

DATE	NUMBER	SUBJECT	CHANGES

SECTION 2 — ENGINE TUNING

GENERAL INFORMATION

Engine tuning is one of the most important of the maintenance services, it determines whether or not the vehicle will perform with maximum economy and efficiency. It is therefore important that this service be performed on the engine at the intervals specified in the Lubrication and Maintenance Section or more often if conditions warrant.

The following paragraphs outline in general the tuning procedures.

COMPRESSION TEST

An engine without reasonably high and uniform compression cannot be effectively tuned. The compression of each cylinder should be tested before any other tuning operations are performed. The engine must be at operating temperature when performing the compression test.

Compression pressure with engine warm, spark plugs removed, wide open throttle at minimum cranking speed of 130 R.P.M. should be within the specified limits.

(1) Remove any foreign matter from around spark plugs by blowing out plug area with compressed air, then loosen all plugs one turn.

(2) Start the engine and accelerate to 1000 R.P.M. to blow out loosened carbon. Stop engine and remove plugs, note cylinder from which each plug was removed for future reference.

NOTE: Clearing out carbon in this manner is important in preventing false compression readings due to particles of carbon becoming lodged under the valves.

(3) Remove air cleaner and block throttle and choke in wide open position.

(4) Connect remote control starter switch to the starter solenoid.

(5) Insert the compression gauge firmly in spark plug opening, and crank engine through at least four compression strokes to obtain highest possible reading.

(6) Test and record compression of each cylinder. Compression should read within the limits indicated in the specifications.

(7) If one or more cylinders read low or uneven, inject about a tablespoon of engine oil on top of pistons in low reading cylinders. Crank engine several times and re-check compression. If compression comes up but does not reach normal, rings are worn. If compression does not improve, valves are sticking or seating poorly. If two adjacent cylinders show low compression, and injecting oil does not improve condition, the cause may be a head gasket leak between the cylinders.

VALVE CLEARANCE

Manual Adjustment

The valve to rocker clearance should be set in accordance with specifications and procedure set out in Engine Section of this manual.

IGNITION SYSTEM

Spark Plugs

(1) Remove the spark plugs. Examine firing ends of plugs for evidence of oil fouling, gas fouling, burned or over-heating conditions. Oil fouling is usually identified by wet, sludgy deposits caused by excessive oil consumption. Gas fouling is usually identified by dry, black fluffy deposits, caused by incomplete combustion. Burned or over-heated spark plugs are usually identified by a white burned or blistered insulator nose, and badly burned electrodes. Incorrect fuel, inefficient cooling, incorrect ignition timing, or incorrect spark plug heat range for operating conditions, normally are the cause. Normal conditions are usually identified by white, powdery deposits, or rusty-brown to greyish-tan powdery conditions.

(2) Clean the spark plugs with a suitable sand blast cleaner following the manufacturer's instructions.

(3) Remove carbon and other deposits from the threads with a stiff wire brush.

(4) Dress the electrodes with a small file to secure flat, parallel surfaces on both the centre and the side electrode.

(5) Adjust the spark plug gap by bending the ground electrode, use a wire gauge, and adjust the gap to the specified clearance.

(6) Install and tighten to specified torque.

Distributor Cap, Rotor and Wires

(1) Remove wires from distributor cap and examine cap and rotor for cracks, carbon tracks, electrode wear or other damage. Use a small round stiff bristle brush if necessary, to clean corrosion from the wire terminal towers.

WARNING: Care should be taken not to damage the "supressor" type cables during removal or installation. The correct method of detaching this type of cable is to grasp the rubber insulator of the end of cable and remove by a combined twisting and pulling action. Pulling on the lead away from the end could result in a break in the carbon trace inside the cable resulting in an open circuit.

(2) Using a weak solution of liquid soap or detergent diluted with warm water, thoroughly scrub the inner and outer surfaces of the distributor cap. Flush with hot water, shake out excess water and dry thoroughly. Do not use compressed air to dry or blow out the water.

(3) Inspect the spark plug cables and coil high tension cable for worn, cracked or damaged insulation, or any condition that may cause current leakage. Check cables for open circuit, loose terminals and high resistance. Replace cable if the resistance exceeds specifications or if the terminal has pulled off. Check for hardened or split cable nipples and replace if necessary.

Distributor Resistance

Excessive resistance of the ignition primary circuit from the distributor side of the coil, through the points and the distributor ground will prevent the coil from producing sufficient output for good over-all ignition.

NOTE: The following service operations can best be performed with the distributor mounted in a reliable distributor tester.

Distributor Point Replacement

If the distributor shaft appears to have excessive side play, measure and replace parts as necessary **(see Group 8—Electrical).**

Excessive wear changes the point gap, causing dwell variations which will affect ignition timing and engine performance.

(1) Remove the old contact points and install a new set.

(2) Align the contacts to provide centre contact by bending the stationary contact bracket only. **Never bend movable arm to obtain alignment.**

(3) After aligning the points, adjust the point gap to specifications using feeler gauges.

(4) Test the breaker arm spring tension, by hooking a spring scale on the breaker arm. Pull the scale in a straight line at right angles to the point surfaces and read the scale as the points start to separate.

(5) If the spring tension is not within specifications a new breaker set must be installed.

(6) Lubricate the breaker lever pivot with one drop of light engine oil. Apply a small amount of heat resisting grease to a clean cloth and very lightly wipe over the distributor cam.

CAUTION: Excessive lubricant on the cam may be thrown off when hot and find its way between the contact points, causing ignition failure.

Points Dwell Test

Correct distributor point dwell is essential for good ignition performance and point life. **(See Group 8—Electrical for details).**

Electronic Ignition

Electronic ignition generally does not require any maintenance, if necessary refer to Group 8 — Electrical test procedures.

Distributor Advance Test

Check the performance of the centrifugal advance mechanism using a reliable stroboscope-type distributor tester.

If the advance is not in accordance with the specifications new springs should be installed. **(See Group 8—Electrical).**

Vacuum Diaphragm Leak Test

(1) Check vacuum diaphragm for leakage (as outlined in Group 8—Electrical—Distributor overhaul) and replace if necessary.

(2) Observe breaker plate whilst performing the leak test, to check response of breaker plate to vacuum advance. There should be instant response to the pull of the diaphragm, moving the plate without drag or bind.

Vacuum Advance

(1) Check vacuum advance as shown in Group 8—Electrical.

(2) If the vacuum advance is above or below specifications, the unit must be replaced as no adjustment is provided.

IGNITION COIL

When testing a coil designed to operate with an external ballast resistor, include the resistor in the test.

Test coil according to coil tester Manufacturer's instructions. Test coil primary resistance. Test ballast resistor resistance. Test coil secondary resistance. Replace any coil or ballast resistor that does not meet specifications.

Every time an ignition coil is replaced because of a burned tower, carbon tracking, or any evidence of arcing at the tower, the nipple or boot on the coil end of the secondary cable, replace cable. Any arcing at the tower will carbonize the nipple so that placing it on a new coil will invariably cause another coil failure.

If secondary cable shows any signs of damage, cable should be replaced with a new cable with a neoprene nipple since the old cable can cause arcing, and therefore, ruin a new coil.

Condenser (B.P.I. only)

Test the capacity of the condenser with a reliable condenser tester. Refer to specifications for condenser capacity in microfarads.

Ignition Timing

To obtain maximum engine performance, the distributor must be correctly positioned on the engine to give correct ignition timing.

The ignition timing test will indicate the timing of the spark at No. 1 cylinder at idle (only). Test procedures are as follows:

(1) Disconnect the vacuum hose at distributor.

(2) Connect the secondary lead of Power Timing Light to No. 1 spark plug, red primary lead to positive terminal of battery and black primary lead to the negative battery terminal.

NOTE: Do not puncture the wires, boots or nipples with test probe — always use adapters. Breaking of the rubber insulation may permit secondary voltage to arc to ground.

(3) Start the engine and set the idle to specified R.P.M., engine at normal operating temperature.

(4) Using a timing light, observe the position of timing mark on the crankshaft damper, and check against specifications.

(5) Loosen the distributor hold down lock plate screw and rotate the distributor housing so that the timing mark on the pulley, aligns with the specified mark on timing plate.

(6) Tighten the distributor hold down lock plate screw after the timing has been set and re-check timing adjustment with the timing light.

(7) When the spark timing is correct re-connect the vacuum hose to the distributor.

NOTE: As the engine speed is increased the timing mark on the pulley should appear to move in direction opposite to engine rotation and away from the pointer on the timing chain case cover. This will indicate that the distributor advance mechanisms are operative.

BATTERY

Electrolyte Test

The specific gravity of the battery electrolyte indicates the state of charge of the battery. Do not take hydrometer readings immediately after refilling the battery with distilled water. If the hydrometer readings do not comply with specifications proceed to examine the battery according to instructions in Group 8 — Electrical.

STARTER AND CABLES

Current Resistance and Current Draw Test

Test the battery. If it tests 1.210 specific gravity or less, engine at normal operating temperature, charge the battery. Test the circuit resistance and the starter current draw as follows:

(1) Disconnect the positive battery lead from the battery terminal post.

(2) Connect an 0 to 300 scale ammeter between the disconnected lead and the battery terminal post.

(3) Connect a test voltmeter with .10 volt scale divisions between the battery positive post and the starter switch terminal at the starter.

(4) Crank the engine and observe the readings of the voltmeter and the ammeter. The voltage should not exceed .12 volt per 100 amperes of current. The current should not exceed specifications. A reading of voltage that exceeds .12 volt per 100 amperes indicates there is high resistance caused by loose circuit connections, defective cables, burned starter relay or solenoid switch contacts. A current that is high and is combined with slow cranking speed, indicates that the starter should be removed and repaired (refer Group 8 — "Electrical" for details of starter repair).

COOLING SYSTEM AND BELTS

(1) Check level of coolant, inspect the entire system for leaks. Inspect the condition of the hoses and replace soft or cracked hoses.

(2) Inspect belts and adjust tension if required (refer Group 7 — Cooling).

MANIFOLD

Inspect for evidence of leaking intake manifold gaskets. With the engine idling, squirt kerosene or light engine oil around the gasket areas. A leak will generally be indicated by a change in engine R.P.M. and/or excessive smoke from the exhaust Tighten manifold bolts or replace gaskets as necessary.

FUEL SYSTEM

Carburettor Air Cleaner

(1) Remove the air cleaner assembly from the carburettor and remove cover and filter element.

(2) Clean the housing and cover with compressed air.

(3) Using low pressure compressed air, gently clean paper element by holding air nozzle at least 50 mm (2") from the side screen.

After cleaning, examine element for punctures. Discard an element that has small pin point punctures. Examine soft plastic sealing rings on both sides of element for smoothness and uniformity.

Throttle Control

(1) Before setting the throttle control, make sure no binding exists in any part of the control. Make sure the choke is fully open and the fast idle cam is released.

(2) Adjust the control (refer Group 14 — Fuel System).

Automatic Choke Unit

To function correctly, it is important that all parts be clean and move freely.

(1) Move the choke valve open and closed, to check for free movement, and possible interference between the choke arm and bottom of air cleaner.

(2) If choke plate is difficult to operate, free-up the choke shaft and/or linkage with a suitable solvent.

Apply the solvent through the opening in the carburettor air horn. Operate the choke plate back and forth until gum formation is flushed out and the choke plate moves freely.

Fuel Pump

If the fuel pump fails to supply fuel properly to the carburettor, test the pump on the vehicle (refer Group 14 — Fuel) and if it does not comply with specifications remove for service (or replacement in case of sealed units).

Carburettor

(1) Warm up engine to normal operating temperature, then using a tachometer, set the engine idle speed with idle speed adjusting screw.

(2) Adjust the idle mixture screws to conform to specifications, then reset idle speed. Refer "Fuel System", Group 14.

(3) Adjust the fast idle speed to specifications. Refer to procedure set out in "Fuel System", Group 14.

NOTE: It is important that the fast idle speed is correctly adjusted for cold weather operation.

SECTION 3 — SERVICE DIAGNOSIS

Condition	Possible Cause	Correction
ENGINE WILL NOT START	(a) Weak battery.	(a) Test the battery specific gravity and recharge or replace as necessary.
	(b) Corroded or loose battery connections.	(b) Clean and tighten the battery connections. Apply a coat of petroleum jelly to the terminals
	(c) Faulty coil or condenser.	(c) Test and replace if necessary.*
	(d) Dirty or corroded distributor contacts.	(d) Clean or replace as necessary.*
	(e) Moisture on ignition wires and distributor cap.	(e) Wipe wires and cap clean and dry.
	(f) Incorrect spark plug gap.	(f) Set the gap to specification.
	(g) Incorrect ignition timing.	(g) Refer to "Ignition Timing."*
	(h) Faulty ignition cables.	(h) Replace any cracked or shorted cables.
	(i) Dirt or water in fuel line or carburettor.	(i) Clean the lines and carburettor.**
	(j) Carburettor flooded.	(j) Adjust the float level—check seats.**
	(k) Faulty fuel pump.	(k) Repair or replace pump**
	(l) Carburettor percolating. No fuel in the carburettor.	(l) Measure the float level. Adjust the bowl vent.** Inspect the operation of the manifold control valve.
	(m) Faulty starting motor.	(m) Refer to "Starting Motor".*
	(n) Faulty ignition control unit.	(n) Test and replace if necessary.
ENGINE STALLS	(a) Idle speed set too low.	(a) Adjust carburettor.**
	(b) Idle mixture too lean or too rich.	(b) Adjust carburettor.**
	(c) Incorrect carburettor float setting.	(c) Adjust float setting.**
	(d) Incorrect choke adjustment.	(d) Adjust choke.
	(e) Leak in intake manifold.	(e) Inspect intake manifold and gasket. Replace as necessary.
	(f) Dirty, burned or incorrectly gapped distributor contacts.	(f) Replace contacts and adjust.*
	(g) Worn or burnt distributor rotor.	(g) Install a new rotor.
	(h) Incorrect ignition wiring.	(h) Install correct wiring.
	(i) Faulty coil or condenser.	(i) Test and replace if necessary.*
ENGINE LOSS OF POWER	(a) Incorrect ignition timing.	(a) Refer to "Ignition Timing."**
	(b) Worn or burned distributor rotor.	(b) Install a new rotor.
	(c) Leaking vacuum diaphragm.	(c) Install a new vacuum advance unit.
	(d) Worn distributor shaft or cam.	(d) Remove and repair distributor.*
	(e) Dirty or incorrectly gapped spark plugs.	(e) Clean plugs and set gap to specifications
	(f) Dirt or water in fuel line or carburettor.	(f) Clean lines and carburettor.**
	(g) Incorrect carburettor or float setting.	(g) Adjust float level.**
	(h) Faulty fuel pump.	(h) Repair or replace pump**
	(i) Incorrect valve timing.	(i) Refer to "Checking Valve Timing."***
	(j) Blown cylinder head gasket.	(j) Install a new head gasket.***
	(k) Low compression.	(k) Test the compression of each cylinder.***
	(l) Burned, warped, pitted valves.	(l) Install new valves.***
	(m) Plugged or restricted exhaust system.	(m) Install new parts as necessary.

*Refer to the "Electrical and Instruments" Group 8 for service procedures.
**Refer to the "Fuel System" Group 14 for service procedures.
***Refer to the "Engine" Group 9.

SERVICE DIAGNOSIS

Condition	Possible Cause	Correction
	(n) Faulty ignition cables.	(n) Replace any cracked or shorted cables.
	(o) Faulty coil or condenser.	(o) Test and replace as necessary.*
ENGINE MISSES ON ACCELERATION	(a) Dirty, burned, or incorrectly gapped distributor contacts.	(a) Replace the contacts and adjust.*
	(b) Dirty, or gap too wide in spark plugs.	(b) Clean the spark plugs and set gap to specifications.
	(c) Incorrect ignition timing.	(c) Refer to "Ignition Timing."*
	(d) Dirt in carburettor.	(d) Clean the carburettor.**
	(e) Carburettor accelerator pump faulty.	(c) Install a new pump.**
	(f) Burned, warped or pitted valves.	(f) Install new valves.***
	(g) Faulty coil or condenser.	(g) Test and replace if necessary.*
ENGINE MISSES AT HIGH SPEEDS	(a) Dirt or water in fuel line or carburettor.	(a) Clean the lines and the carburettor.**
	(b) Dirty jets in carburettor.	(b) Clean the jets.**
	(c) Dirty or incorrectly gapped distributor contacts.	(c) Clean or replace as necessary.*
	(d) Dirty or gap too wide in spark plugs.	(d) Clean the spark plugs and set gap to specifications.
	(e) Worn distributor shaft or cam.	(e) Remove and repair the distributor.*
	(f) Worn or burned distributor rotor.	(f) Install a new rotor.
	(g) Faulty coil or condenser.	(g) Test and replace as necessary.*
	(h) Incorrect ignition timing.	(h) Refer to "Ignition Timing."*
NOISY VALVES	(a) Worn rocker arms.	(a) Replace arms and check oil supply holes.
	(b) Worn valve guides.	(b) Replace guides and if necessary install new valves.
	(c) Worn or damaged camshaft lobes.	(c) Replace cam shaft.
	(d) Excessive valve seat or valve face run-out.	(d) Re-cut valves and seats.
	(e) Incorrect valve clearance.	(e) Re-adjust valve clearance.
CONNECTING ROD NOISE	(a) Insufficient oil supply.	(a) Check engine oil level.
	(b) Low oil pressure.	(b) Check the engine oil level.***
	(c) Thin or diluted oil.	(c) Change oil to correct viscosity.
	(d) Excessive bearing clearance.	(d) Measure the bearings for correct clearances or failures.***
	(e) Connecting rod journals out-of-round.	(e) Remove the crankshaft and regrind journals.***
	(f) Misaligned connecting rods.	(f) Remove the bent connecting rods.***

*Refer to the "Electrical and Instruments" Group 8 for service procedures.
** Refer to the "Fuel System" Group 14 for service procedures.
*** Refer to the "Engine" Group 9.

SERVICE DIAGNOSIS

Condition	Possible Cause	Correction
MAIN BEARING NOISE	(a) Insufficient oil supply.	(a) Check the engine oil level.***
	(b) Low oil pressure.	(b) Check the engine oil level. Inspect the oil pump relief valve, damper and spring.***
	(c) Thin or diluted oil.	(c) Change the oil to correct viscosity.
	(d) Excessive bearing clearance.	(d) Check the bearings for correct clearances or failures.***
	(e) Excessive end play.	(e) Check the respective end thrust bearing for wear on flanges.
	(f) Crankshaft journals out-of-round or worn.	(f) Remove the crankshaft and regrind journals.***
	(g) Loose flywheel.	(g) Tighten to the correct torque.
OIL PUMPING AT RINGS	(a) Worn, scuffed, or broken rings.	(a) Hone cylinder bores and install new rings.***
	(b) Carbon in oil ring slots.	(b) Install new rings.***
	(c) Rings fitted too tight in grooves.	(c) Remove the rings. Check the grooves. If groove is not proper width, replace the pistons.***
	(d) Compression rings installed upside down.	(d) Remove and reassemble correctly.
OIL PRESSURE DROP	(a) Low oil level.	(a) Check the engine oil level.
	(b) Faulty oil pressure sending unit.	(b) Install a new sending unit.
	(c) Thin or diluted oil.	(c) Change the oil to correct viscosity.
	(d) Oil pump relief valve stuck.	(d) Remove the valve and inspect.
	(e) Oil pump suction tube loose, bent or cracked.	(e) Remove the oil pan and install a new tube if necessary.
	(f) Clogged oil filter.	(f) Install a new oil filter.
	(g) Excessive bearing clearance.	(g) Check the bearings.***

*Refer to the "Electrical and Instruments" Group 8 for service procedures.
**Refer to the "Fuel System" Group 14 for service procedures.
***Refer to the "Engine" Group 9.

SECTION 3D — ENGINE ASSEMBLY: SATURN TYPE FOUR CYLINDER (4G3)

SPECIFICATIONS

ENGINE GENERAL

Type	In line OHC
Number of Cylinders	Four
Bore — 1,6 Litre	76,9 mm (3.0276")
Stroke	86,0 mm (3.386")
Displacement — 1,6 Litre	1597 cm^3 (97.4 $in.^3$)
RAC Power Rating — 1,6 Litre	14,7
Compression Ratio	8,5:1
Compression Pressure @ 250 R.P.M.	1050 kPa (150 p.s.i.)
Maximum Variation between Cylinders	10%
Spark Plug Type	N12Y
Firing Order	1, 3, 4, 2
Direction of Rotation	Clockwise Observed From Front of Vehicle

CYLINDER HEAD

Material	Aluminium Alloy
Type	Hemispherical Combustion Chambers, Cross Flow Design
Maximum Allowable Distortion	0,05 mm (0.002")
Cylinder Head Height (Between Block and Rocker Cover Gasket Surface)	88,5 mm (3.484")
Maximum Allowable Re-machining of Surface	0,30 mm (0.012")
Inlet Valve Seat Insert Hole Diameter	
— 0,3 mm (0.012") Oversize	39,300 to 39,325 mm (1.5472" to 1.5482")
— 0,6 mm (0.024") Oversize	39,600 to 39,625 mm (1.5590" to 1.5600")
Exhaust Valve Seat Insert Hole Diameter	
— 0,3 mm (0.012") Oversize	34,300 to 34,325 mm (1.3504" to 1.3514")
— 0,6 mm (0.024") Oversize	34,600 to 34,625 mm (1.3622" to 1.3632")
Inlet and Exhaust Valve Seat Insert Height	
— 0,3 mm (0.012") Oversize	7,40 to 7,60 mm (0.2913" to 0.2992")
— 0,6 mm (0.024") Oversize	7,70 to 7,90 mm (0.3031" to 0.3110")
Valve Guide Hole Diameter	
— 0,05 mm (0.002") Oversize	13,05 to 13,07 mm (0.5138" to 0.5145")
— 0,25 mm (0.010") Oversize	13,25 to 13,27 mm (0.5216" to 0.5224")
— 0,50 mm (0.020") Oversize	13,50 to 13,52 mm (0.5315" to 0.5323")
Camshaft/Camshaft Bearing Clearance	0,05 to 0,09 mm (0.0020" to 0.0035")

VALVES

Material — Inlet	Heat Resisting Steel Special Alloy Seat
— Exhaust	Heat Resisting Austenitic Steel, Special Alloy Seat
Head Diameter — Inlet	38,0 mm (1.496")
— Exhaust	31,0 mm (1.220")
Stem Diameter	8,0 mm (0.315")
Stem Diameter Wear Limit — Inlet	0,10 mm (0.004")
— Exhaust	0,15 mm (0.006")
Valve Face Angle	45°

Valve Head Thickness — New	1,50 mm (0.059")
— Wear Limit	1,00 mm (0.039")
Valve Length — Inlet	105,90 mm (4.169")
— Exhaust	102,50 mm (4.035")
— Wear Limit	0,50 mm (0.020")
Valve Seat Contact Width	0,90 to 1,30 mm (0.035" to 0.051")
Valve Stem to Guide Clearance — Inlet	0,025 to 0,055 mm (0.0010" to 0.0022")
— Exhaust	0,050 to 0,085 mm (0.0020" to 0.0033")
Valve Clearance (Hot) — Inlet	0,15 mm (0.006")
— Exhaust	0,25 mm (0.010")
Installed Height Between Spring Seat and Retainer	37,30 mm + 1,0 mm (1.469" + 0.039")
Valve Stem Seal Installed Dimension	14,70 to 15,10 mm (0.579" to 0.595")

VALVE GUIDES

Outside Diameter	13,00 to 13,10 mm (0.512 to 0.516")
Inside Diameter	8,000 to 8,018 mm (0.3150" to 0.3157")
Length — Inlet	44,0 mm (1.73")
— Exhaust	48,0 mm (1.89")
Installed Height	13,70 to 14,30 mm (0.5394" to 0.5630")
Cylinder Head Hole Size for Oversize Guides	
— 0,05 mm (0.002")	13,05 to 13,07 mm (0.5138" to 0.5145")
— 0,25 mm (0.010")	13,25 to 13,27 mm (0.5216" to 0.5224")
— 0,50 mm (0.020")	13,50 to 13,52 mm (0.5315" to 0.5323")

VALVE SPRINGS

Number	8
Free Length	45,85 mm - 1,0 mm (1.805" - 0.039")
Load	28 kg/37,30 mm (61 lbs./1.47")

VALVE TIMING

Set Valve Clearance to	
Inlet Opens	24° BTDC
Inlet Closes	64° ABDC
Duration	268°
Exhaust Opens	67° BBDC
Exhaust Closes	21° ATDC
Duration	268°
Overlap	45°

CAMSHAFT

Material	Grey Cast Iron
Camshaft Bearings	5
Bearing Clearance	0,05 to 0,09 mm (0.002" to 0.0035")
Journal Diameter	34,0 mm (1.34")
End Float	0,05 to 0,15 mm (0.002" to 0.006")
Camshaft Bend	0,02 mm (0.0008") or less
Height of Cam Lobe — Inlet	36,36 mm (1.4316")
— Exhaust	36,41 mm (1.4336")
Nominal Cam Lift	5,5 mm (0.216")
Rocker Arm to Rocker Shaft Clearance	0,013 to 0,043 mm (0.0005" to 0.0017")

SPROCKET CAMSHAFT

Material — Chain Drive	Cast Iron
— Belt Drive	Sintered Alloy
Number of Teeth — Chain Drive	36
— Belt Drive	48

GEAR — CAMSHAFT DRIVE

Material — Chain Drive	Cast Iron
— Belt Drive	Sintered Alloy
Number of Teeth — Chain Drive	18
— Belt Drive	24

SPROCKET — OIL PUMP

Material	Sintered Alloy
Number of Teeth	24

TIMING CHAIN

Type	Duplex Roller
Number of Links	96
Pitch	9,525 mm (0.375")
Chain Tensioner Spring — Free Length	55,4 mm (2.181")
— Load	12,6 kg/38,4 mm (25.6 lbs./1.496")
Timing Chain Length (Gear Centre to Centre)	285,8 to 289,0 mm (11.25" to 11.38")

TIMING BELT

Type	Toothed Rubber
Number of Teeth	120
Length	1143,0 mm (45.0")
Width	19,1 mm (0.75")
Pitch	9,525 mm (0.375")

CYLINDER BLOCK

Material	Alloy Cast Iron
Maximum Allowable Distortion Upper Face	0,05 mm (0.002")
Height of Block (Between Cylinder Head and Oil Pan Gasket Surface)	285,2 mm (11.228")
Maximum Allowable Re-machining of Surface	0,20 mm (0.008")
Cylinder Bore Diameter — 1.6 Litre	76,9 mm (3.0276")
Maximum Bore Oversize	1,20 mm (0.047")
Maximum Diameter Difference Between Cylinders	0,02 mm (0.0008")
Maximum Ovality	0,01 mm (0.0004")
Maximum Taper	0,01 mm (0.0004")
Main Bearing Tunnel Bore Diameter	61,0 mm (2.401")

PISTONS

Material	Aluminium Alloy Tin Plated
Type	Solid Skirt
Piston Pin Hole	19,0 mm (0.7483")

Mass of Pistons — 1,60 Litre	0,274 kg (9.665 oz.)
Piston Diameter (Measured 2,0 mm (0.079") from the bottom of the piston)	
— 1,6 Litre	76,87 to 76,88 mm (3.0264" to 3.0268")
	76,88 to 76,89 mm (3.0268" to 3.0272")
	76,89 to 76,90 mm (3.0272" to 3.0276")
Piston to Bore Clearance	0,02 to 0,04 mm (0.0008" to 0.0016")
Piston Oversizes	0,25 mm (0.010")
	0,50 mm (0.020")
	0,75 mm (0.030")
	1,00 mm (0.039")

PISTON PIN

Type	Press Fit in Conrod
Material	Cold Forged Chrome Molybdenum Steel
Diameter	19,001 to 19,007 mm (0.7481" to 0.7483")
Length	64,0 mm (2.520")
Offset in Piston	1,0 mm (0.039")
Clearance in Piston	0,001 to 0,013 mm (0.00004" to 0.0005")

PISTON RINGS

Number	3
Ring Gap — New — Compression and Scraper	0,20 to 0,40 mm (0.008" to 0.016")
— Oil Ring	0,20 to 0,50 mm (0.008" to 0.020")
— Service Limit (All)	1,00 mm (0.039")
Side Clearance — New — Compression	0,03 to 0,07 mm (0.0012" to 0.0028")
— Scraper	0,02 to 0,06 mm (0.0008" to 0.0024")
— Oil Ring (1,4 litre)	0,025 to 0,075 mm (0.001" to 0.003")
— Service Limit — Compression and Scraper	0,10 mm (0.004")
— Oil Ring (1,4 litre)	0,15 mm (0.006")

CONNECTING RODS

Material	Drop Forged Steel
Length Between Centres	153,7 mm (6.051")
Conrod Mass	0,670 kg (23.633 oz.)
Small End Bore Diameter	18,974 to 18,985 mm (0.7470" to 0.7474")
Big End Bore Diameter	48,0 mm (1.890")
Conrod Bearing Clearance	0,010 to 0,060 mm (0.0004" to 0.0024")
Conrod Bearing Undersizes	0,25 mm (0.010")
	0,50 mm (0.020")
	0,75 mm (0.030")
Conrod Bend or Distortion (within)	0,03 mm (0.0012")
Conrod Side Clearance on Journal	0,10 to 0,25 mm (0.004" to 0.010")

CRANK SHAFT

Type	Drop Forged Steel
Number of Main Bearings	5
Main Bearing Journals	
— Standard Diameter	57,0 mm (2.2441")
— Maximum Allowable Ovality	0,01 mm (0.0004")
— Maximum Allowable Taper	0,01 mm (0.0004")

CRANK SHAFT (Continued)

Main Bearing Clearance — Journal	0,020 to 0,070 mm (0.0008" to 0.0028")
Bearing Material	Tri-metal
Main Bearing Undersizes — Rework Diameter	
— 0,25 mm (0.010")	56,735 to 56,750 mm (2.2337" to 2.2342")
— 0,50 mm (0.020")	56,485 to 56,500 mm (2.2238" to 2.2244")
— 0,75 mm (0.030")	56,235 to 56,250 mm (2.2140" to 2.2146")
Main Bearing Journal Length — All except No. 3	28,90 to 29,00 mm (1.137" to 1.141")
— No. 3	29,00 to 29,05 mm (1.141" to 1.143")
Connecting Rod Bearing Journal	
— Standard Diameter	45,00 mm (1,7717")
— Maximum Allowable Ovality	0,01 mm (0.0004")
— Maximum Allowable Taper	0,01 mm (0.0004")
Conrod Journal Length	28,35 to 28,40 mm (1.116" to 1.118")
Conrod Bearing Undersizes — Rework Diameter	
— 0,25 mm (0.010")	44,735 to 44,750 mm (1.7612" to 1.7618")
— 0,50 mm (0.020")	44,485 to 44,500 mm (1.7514" to 1.7520")
— 0,75 mm (0.030")	44,235 to 44,250 mm (1.7415" to 1.7421")
Crank shaft End Float	0,050 to 0,175 mm (0.002" to 0.007")
End Float Controlled by	No. 3 Bearing
Pinion Pilot Bearing	Roller Bearing
Outside Diameter	32 mm (1.260")
Inside Diameter	15 mm (0.590")
Flywheel out of Round (Max.)	0,13 mm (0.005")

SPECIAL TOOLS

E0102	Compressor — Valve Spring
E192	Compressor — Piston Ring
E9M20	Cylinder Head Bolt Remover/Installer
E9M25	Camshaft Seal Installer
E9M30	Kit — Remover/Installer Valve Guide and Oil Seal
E9M50	Remover/Installer — Piston Pin
E9M60	Remover/Installer Crank shaft Rear Oil Seal
E9M55	Spanner — Belt Tensioner Nut and Bolt

TORQUE SPECIFICATIONS

APPLICATION	Nm	lbs./ft.	lbs./in.
Camshaft Bearing Caps	18-19	13-14	
Camshaft Sprocket	60-77	44-57	
Connecting Rod Cap	31-34	23-25	
Chain Tensioner Plug	49-58	36-43	
Crankshaft Pulley — Chain Drive	60-68	44-50	
— Belt Drive	10-12	8-9	96-108
Crankshaft Sprocket Bclt (Belt Drive)	59-69	43-51	
Cylinder Block to Engine Mounting	39-49	29-36	
Cylinder Head Attaching Bolts — Cold	69-73	51-54	
— Hot	79-83	58-61	
Drive Plate to Crankshaft Bolts (Auto. Trans.)	113-122	83-90	
Engine Rear Support Bracket to Body	9	7	84
Flywheel to Crankshaft Bolts	127-137	94-101	
Front Insulator to Engine Bracket	14-19	10-14	
Front Insulator to Sub Frame	30-39	22-29	
Heater Joint	20-38	15-28	
Inlet/Exhaust Manifold	15-19	11-14	
Main Bearing Cap	49-53	36-39	
Oil and Temperature Gauge Unit	30-38	22-28	
Oil Filter	11-12	8-9	96-108
Oil Pan	7-8	5-6	60-72
Oil Pan Drain Plug	58-77	43-57	
Oil Pump Cover — Chain Drive	15-20	11-15	
— Belt Drive	15-18	11-13	
Oil Pump Sprocket Nut (Belt Drive)	34-39	25-29	
Rear Insulator to Engine Support Bracket	5-9	4-7	48-84
Rear Insulator to Transmission — Manual	20-23	15-17	
— Automatic	13-16	10-12	
Rocker Cover	5-7	4-5	48-60
Spark Plug	20-28	15-21	
Belt Tensioner — Nut and Bolt	20-28	15-21	

NOTE: Torque figures quoted are for clean, dry threads in good condition.

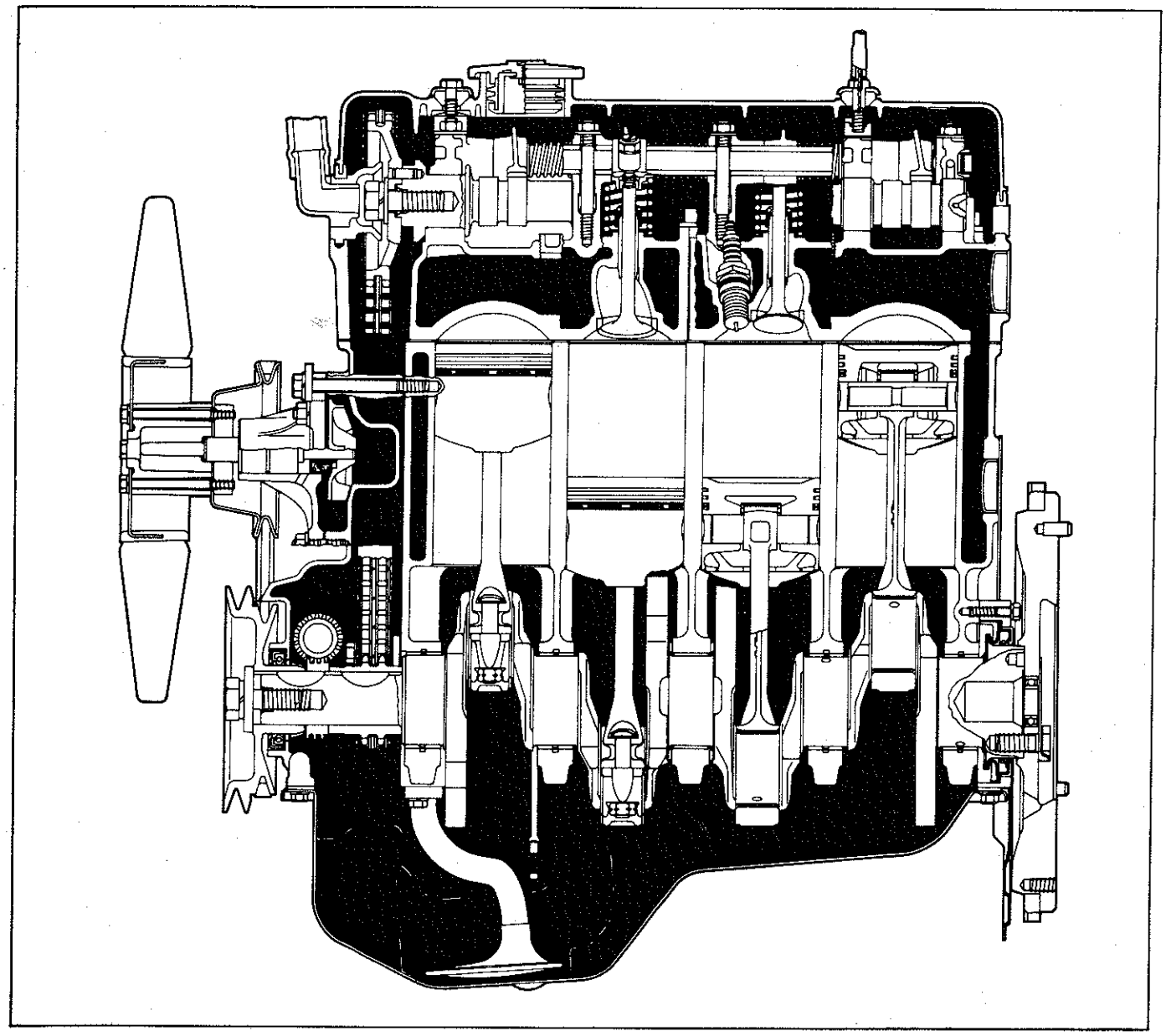


Fig. 1—Saturn engine (with chain drive camshaft) longitudinal view

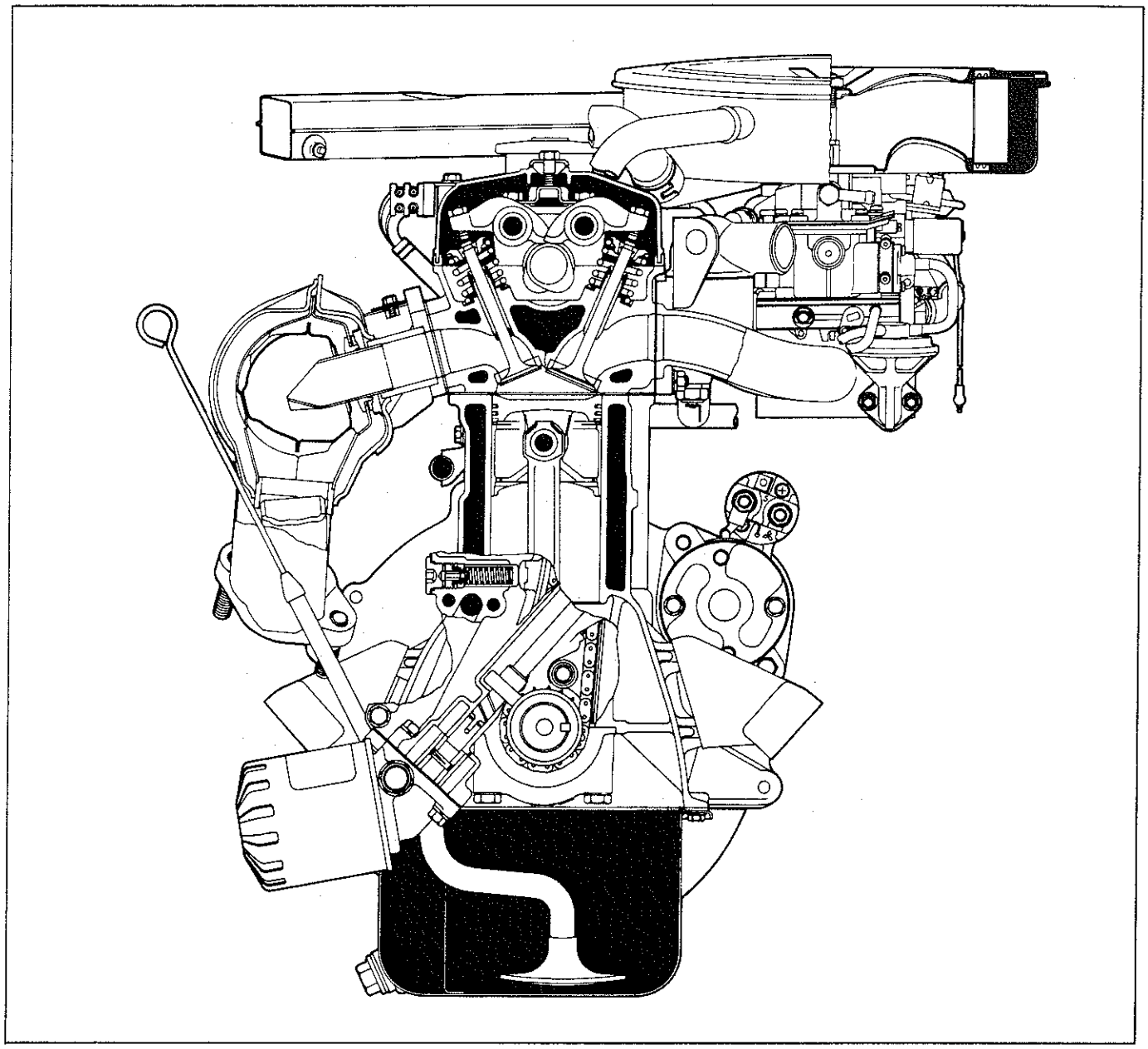


Fig. 2—Saturn engine (with chain drive camshaft) front section

GENERAL INFORMATION

The Saturn engine is a four cylinder, over head cam, cross flow design with hemispherical combustion chambers.

The cylinder head is made of aluminium alloy, being light in weight and ensuring maximum cooling effect. Hemispherical combustion chambers permit the use of large diameter valves helping improve fuel combustion efficiency and minimising differences in combustion chamber volume, thus ensuring smooth engine operation. The cross flow design permits the intake gases to be drawn into the cylinder and exhaust gases to be driven out from the cylinder in one direction, thus improving the effect of combustion chamber scavenging and spark plug cooling.

The camshaft is chain driven (early type) belt driven (later type) by the crankshaft and is supported in the cylinder head by five journals and retaining caps.

The cylinder block is made of alloy cast iron, with good wear resistance characteristics. The drop forged steel crankshaft is supported by five main journals, thrust being taken by the centre bearing.

ENGINE REMOVAL

(1) Drain the cooling system.

(2) Disconnect the battery negative lead.

(3) Remove radiator hoses, heater hoses, automatic transmission cooler pipes (if applicable) and remove radiator.

(4) Disconnect all wiring to alernator, distributor, coil, starter motor, sending unit, cut off solenoid and transmission.

(5) Remove air cleaner and disconnect all vacuum lines, fuel lines and linkages.

(6) Disconnect exhaust pipe, propeller shaft and gear linkages.

(7) Remove the gear lever (manual trans. vehicles).

(8) Disconnect clutch cable and speedo cable.

(9) Remove the engine hood (Refer Group 23).

(10) Drain engine and transmission oil.

(11) Disconnect all engine mountings.

(12) Install a suitable engine lifting bracket and remove the engine and transmission with a suitable lifting hoist.

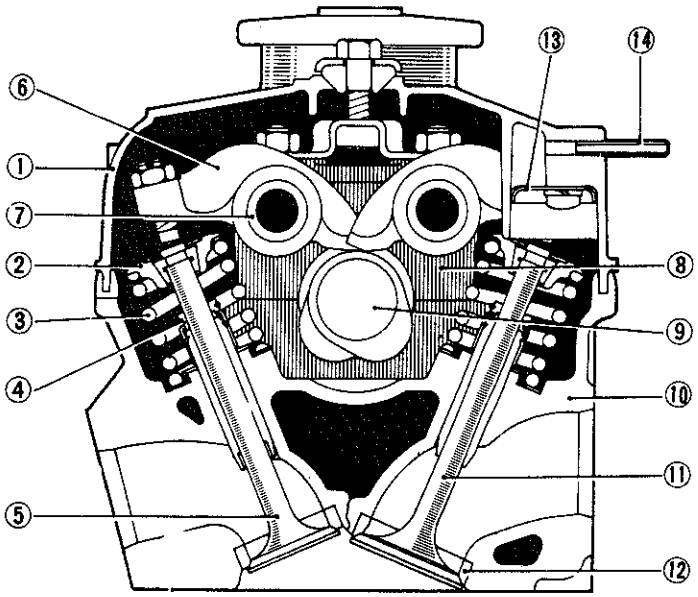
Installation

(1) Install engine lifting bracket on engine, attach hoist and install engine into vehicle being careful not to damage any engine or body components.

(2) Align engine mounts, position engine and tighten mounts to specification.

(3) Remove hoist and lifting bracket.

(4) Replace all fuel lines, vacuum hoses, electrical wiring, exhaust pipe, throttle control, clutch cable, propeller shaft and air cleaner.



1 Rocker cover
2 Valve spring retainer
3 Valve spring
4 Stem seal
5 Exhaust valve
6 Rocker arm
7 Rocker arm shaft
8 Camshaft bearing cap
9 Camshaft
10 Cylinder Head
11 Intake valve
12 Valve seat ring
13 Baffle plate
14 Nipple (Blowby gas)

Fig. 3—Sectional view cylinder head

(5) Replace radiator, shroud, radiator hoses, heater hoses and transmission cooler pipes (if applicable).

(6) Replace gear lever (manual trans.) and reconnect transmission linkages.

(7) Fill radiator using rain water or demineralized water and adding corrosion inhibitor (or antifreeze if required).

(8) Fill engine crankcase with the correct grade and quantity of first grade engine oil.

(9) Refill transmission with the correct type and quantity of oil.

(10) Refit engine hood and adjust clearance margins ensuring it closes correctly and securely.

(11) Run engine and check for leaks at oil lines, fuel lines, coolant hoses and oil pan.

(12) Adjust all linkages and settings to specifications.

CYLINDER HEAD

The aluminium alloy cylinder head has hemispherical combustion chambers and is of a cross flow design. An overhead camshaft is supported by five journals and operates the valves through two rocker shafts. Inlet valves are on the left, exhaust valves are on the right. The stem and head of the exhaust valves are welded and the valve face is stellited.

Removal (Chain Drive Camshaft Type)

NOTE: Prior to removing cylinder head allow the engine to cool otherwise cylinder head warpage may occur.

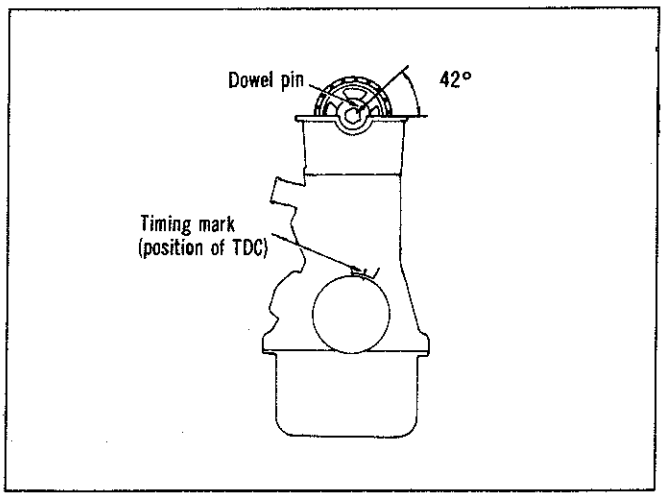


Fig. 4—Position TDC on No. 1 piston

(1) Disconnect the battery negative (ground) terminal.

(2) Drain the water from the radiator and cylinder block.

(3) Disconnect exhaust pipe from manifold.

(4) Disconnect throttle cable, kickdown linkage (if applicable), fuel supply line, vacuum hoses, electrical leads, radiator and heater hoses, etc.

(5) Manually rotate engine to the top dead centre position with No. 1 piston on the compression stroke.

(6) If the cylinder head is to be disassembled, the inlet and exhaust manifolds can be removed for easier handling of the cylinder head.

(7) Remove the rocker arm cover.

(8) Ensure that No. 1 piston is at top dead centre on the compression stroke by aligning the crankshaft pulley timing mark on the TDC "T" mark of the timing plate. The camshaft dowel pin should be in the position shown in Fig. 4.

(9) With a suitable marking pencil, mark the timing chain in line with the camshaft dowel pin. Tie the sprocket with a steel wire as shown in Fig. 5.

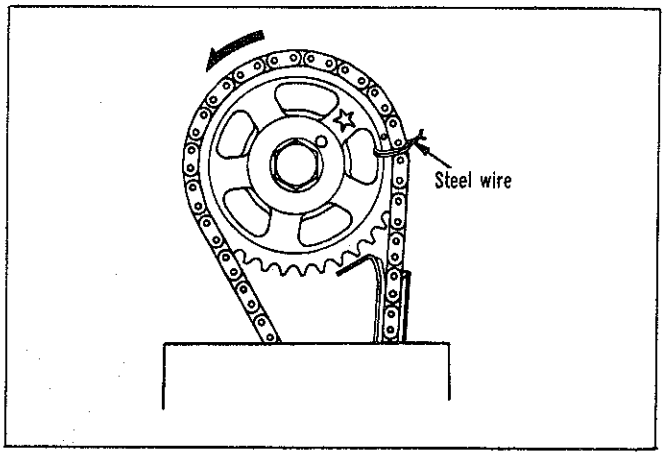


Fig. 5—Tying sprocket and chain

(10) Remove the camshaft sprocket bolt and remove the sprocket from the camshaft.

NOTE: Do not remove the sprocket from the timing chain, as this will necessitate timing chain cover removal to realign the timing gears.

(11) Loosen the cylinder head bolts using Tool E9M20, in two stages to prevent cylinder head warpage — use order shown in Fig. 6.

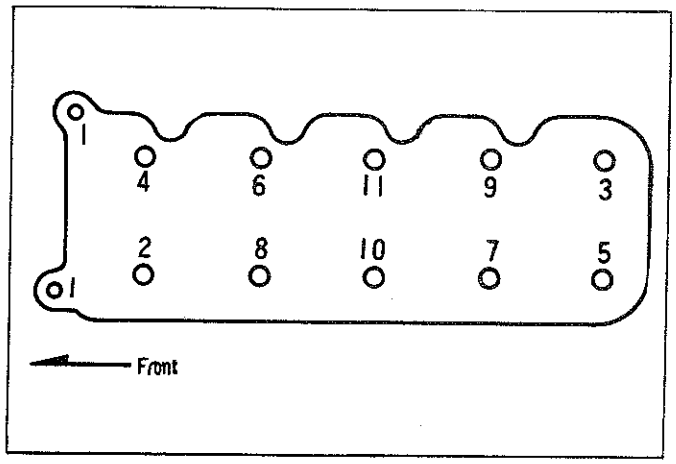


Fig. 6—Cylinder head bolt removal sequence

(12) Remove the cylinder head from the cylinder block by raising it vertically over the timing chain and sprocket.

NOTE: The cylinder head is positioned on the block by two dowel pins. When removing the head, do not twist or slide it or the camshaft sprocket may dislodge from the chain.

(13) Clean head thoroughly and inspect for damaged surfaces, components, cracks, water leaks, etc.

Installation (Chain Drive Camshaft Type)

(1) Ensure that the joint surface between the top of the chain cover and cylinder block is flat.

(2) Apply sealant to the two joint surfaces as shown in Fig. 7.

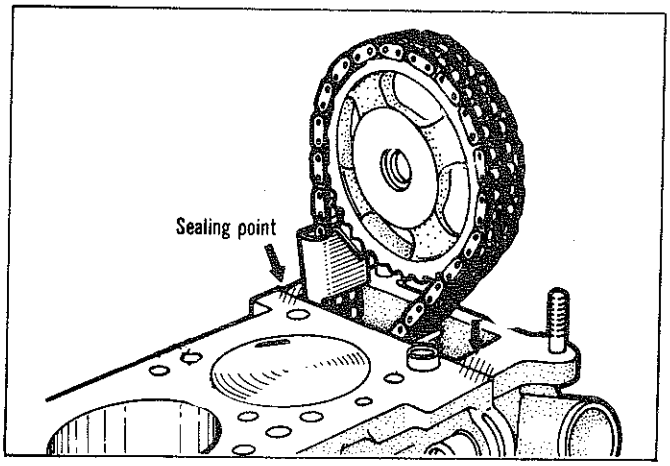


Fig. 7—Sealing points

(3) Fit the cylinder head gasket to the cylinder block locating it correctly on the dowel pins.

NOTE: Use only jointing compound part numbers P49355, 4067481 (Hylomar) on the cylinder head gasket.

(4) Install the cylinder head locating it on the dowel pins. Do not slide the head across the dowel pins as damage to the head surface may occur. Care must also be taken to avoid dislocation of the camshaft sprocket from the timing chain.

(5) Tighten the cylinder head bolts in three stages to the specified torque and in the sequence shown in Fig. 8.

(6) Install the camshaft sprocket onto the camshaft, rotating the camshaft to align the dowel pin to the sprocket. Ensure that the sprocket mating mark is aligned with the timing chain **plated** link. Temporarily tighten the sprocket bolt.

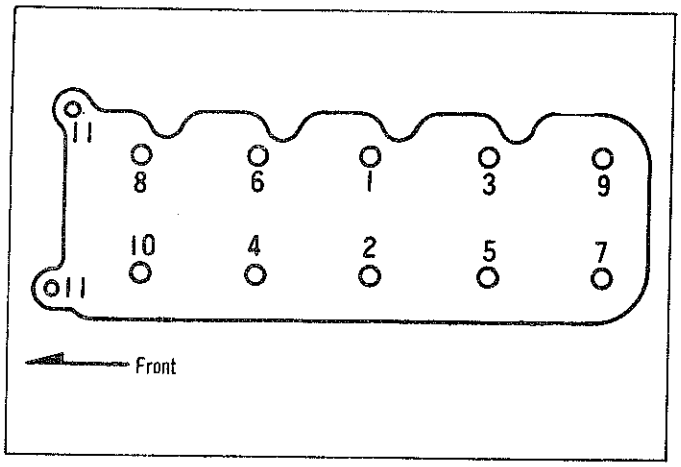


Fig. 8—Cylinder head bolt tightening sequence

(7) Turn the crankshaft back 90° and tighten the sprocket bolt to the specified torque.

(8) Adjust the valve clearances to specification.

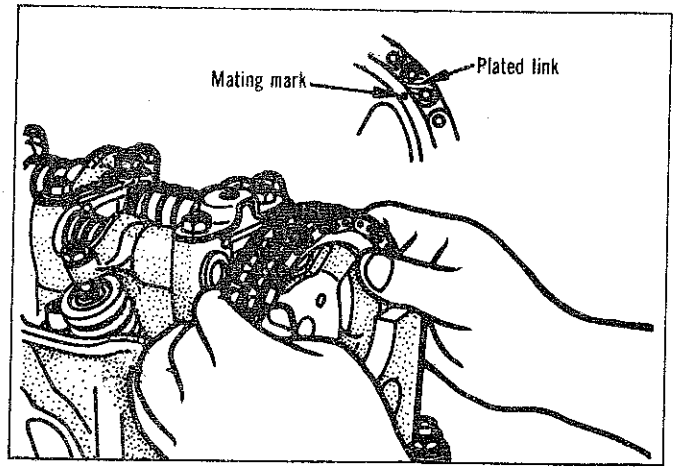


Fig. 9—Installing camshaft sprocket

(9) Install the breather and gasket to cylinder head, applying sealer to the contact surfaces—Refer Fig. 10.

(10) Install the rocker shaft cover and tighten the retaining bolts to specification.

(11) Install the intake and exhaust manifolds using new gaskets. Apply sealer to both sides of the inlet manifold around the coolant passages. Tighten the manifold nuts to the specified torque.

(12) Connect all linkages, fuel lines, vacuum hoses, breather hoses, electrical leads, radiator and heater hoses, etc.

(13) Reconnect exhaust pipe.

(14) Fill the radiator using rain water or demineralized water and adding corrosion inhibitor (or anti-freeze if required).

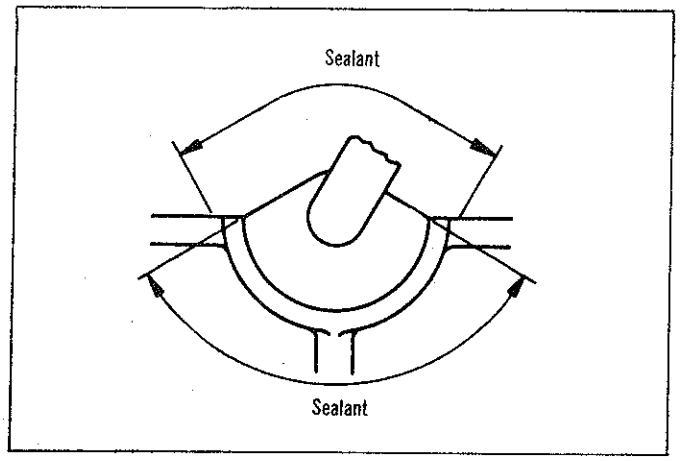


Fig. 10—Breather sealing points

(15) Connect battery cable and start engine. Run engine until normal operating temperature is reached and check for water or oil leaks.

NOTE: Cylinder head bolts must be retorqued after 800 km (500 miles).

Cylinder Head Removal
(Belt Drive Camshaft Type)

NOTE: Prior to removing cylinder head allow the engine to cool otherwise cylinder head warpage may occur.

(1) Disconnect the battery negative (ground) terminal.

(2) Drain the water from the radiator and cylinder block.

(3) Disconnect exhaust pipe from manifold.

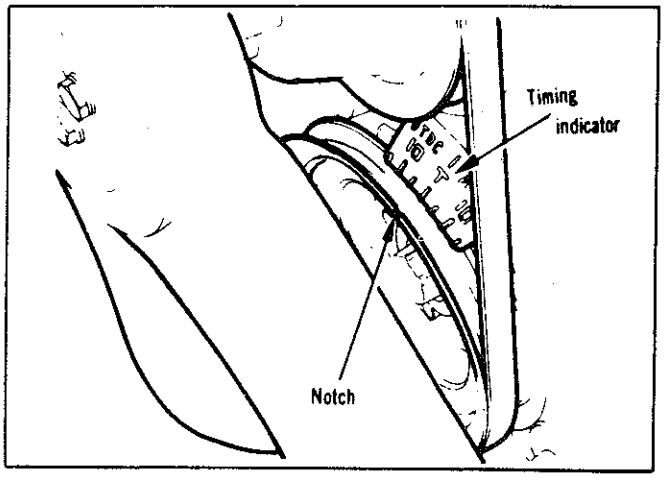


Fig. 11—Position TDC on No. 1 piston

(4) Disconnect throttle cable, kick down linkage (if applicable), fuel supply line, vacuum hoses, electrical leads, radiator and heater hoses, etc.

(5) Manually rotate engine to the top dead centre position with No. 1 piston on compression stroke.

NOTE: DO NOT rotate engine anti-clockwise as the timing belt may jump the sprocket teeth.

(6) If the cylinder head is to be disassembled, the inlet and exhaust manifolds can be removed for easier handling of the cylinder head.

(7) Remove the rocker arm cover.

(8) Remove the timing belt upper front cover, retain bolts and remove the cover (Fig. 12).

(9) With a suitable marking pen, mark the belt in line with the camshaft sprocket timing mark.

(10) Remove the camshaft sprocket retaining bolt and remove the sprocket from the shaft, keeping the sprocket and belt in mesh at all times.

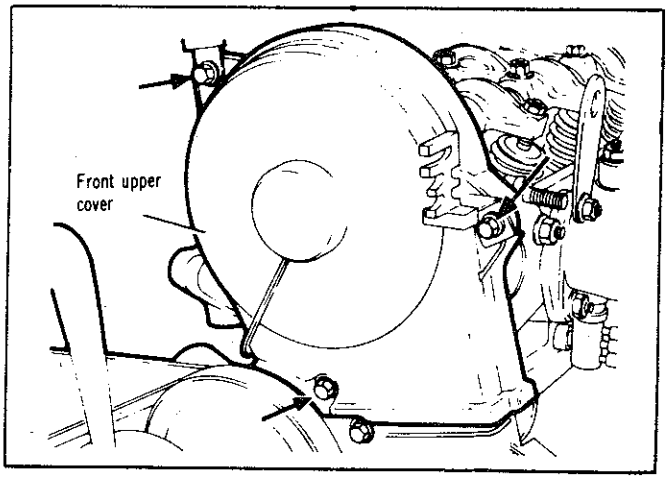


Fig. 12—Removing timing belt upper front cover bolts

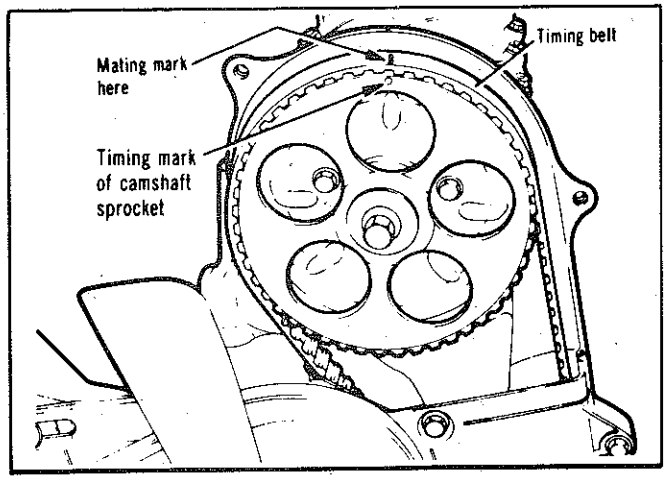


Fig. 13—Timing belt mating marks

(11) Rest the sprocket on the sprocket holder (Fig. 14). If the clearance between the sprocket and holder is excessive, pack the holder with a piece of old belt or similar packing, thus preventing the belt and sprocket falling out of mesh.

NOTE: Do not rotate the engine while the camshaft sprocket is removed, as belt timing will be lost, making it necessary to remove the lower cover to retime the belt.

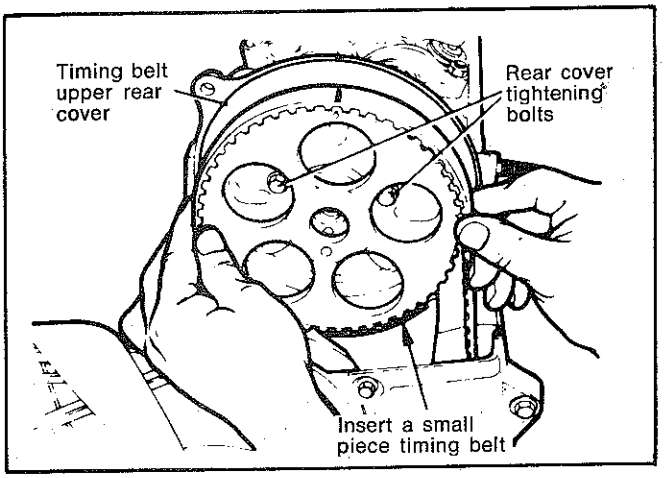


Fig. 14—Camshaft sprocket removal

(12) Remove the three bolts retaining the upper rear cover (Fig. 14), then remove the cover.

(13) Loosen the cylinder head bolts using Tool E9M20, in two stages to prevent cylinder head warpage — use sequence shown in Fig. 15.

(14) Remove the cylinder head from the cylinder block being careful not to dislodge the camshaft sprocket.

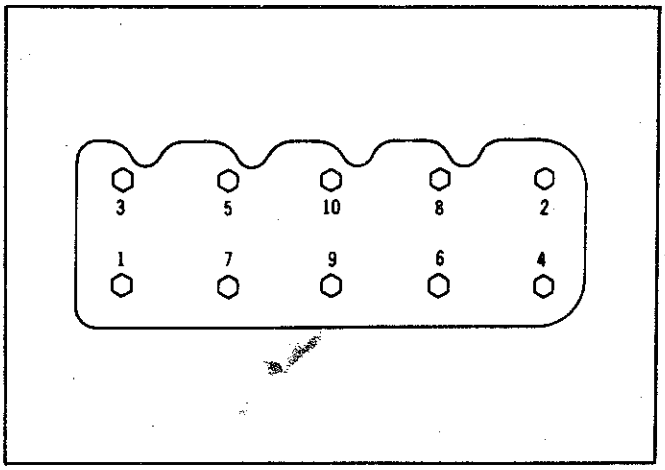


Fig. 15—Cylinder head bolt removal sequence

(15) Clean head thoroughly and inspect for damaged surfaces, components, cracks, water leaks, etc.

Installation (Belt Drive Camshaft Type)

(1) Position the new cylinder head gasket to the block locating it correctly onto the dowel pins. Ensure there are no old gasket pieces left on the block or head surfaces.

(2) Install the cylinder head assembly onto the cylinder block and tighten head bolts to the specified torque in three stages and in the sequence shown in Fig. 16.

NOTE: Be careful not to dislodge the camshaft sprocket from the holder.

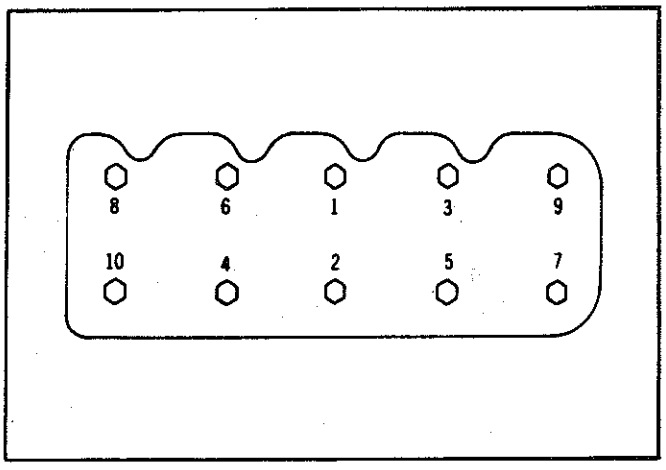


Fig. 16—Cylinder head bolt tightening sequence

(3) Install the timing belt upper rear cover and tighten the bolts securely.

(4) Lift the camshaft sprocket and install it on the camshaft. If difficulty is experienced in locating the sprocket, insert a suitable lever through the top hole of the sprocket and rest the end under the ridge portion of the upper rear cover, carefully pry the sprocket up.

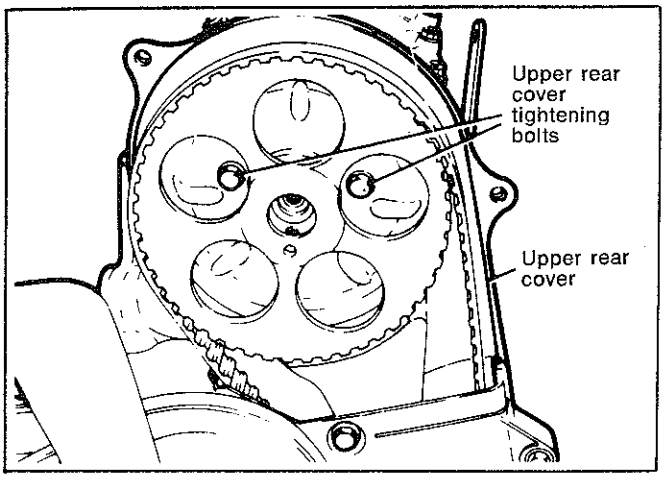


Fig. 17—Installing upper rear timing belt cover

(5) If the sprocket dowel pin hole does not align with the camshaft dowel pin, rotate the **camshaft** by lightly tapping either of the two projections located at the rear of the No. 2 exhaust cam of the camshaft.

NOTE: Ensure that the crankshaft is not rotated during sprocket installation.

(6) Tighten the camshaft sprocket retaining bolt.

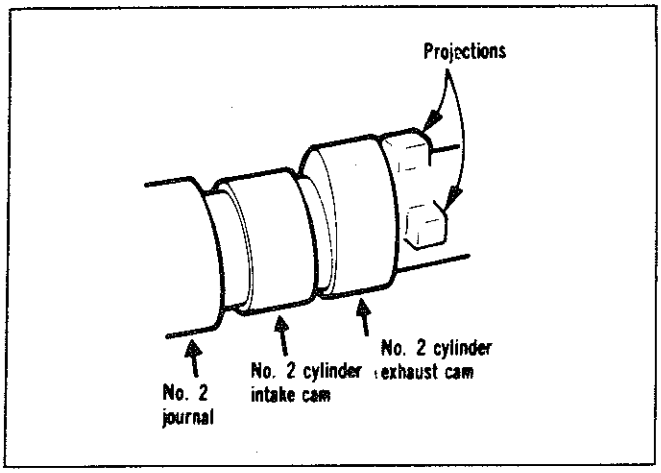


Fig. 18—Camshaft turning projections

NOTE: Ensure the camshaft belt mark made at removal is aligned with the mating mark on the sprocket.

(7) Install the timing belt upper front cover.

(8) Adjust the valve clearance to specification.

(9) Install the rocker arm cover gasket to the cover.

(10) Apply sealer to the area shown in Fig. 19.

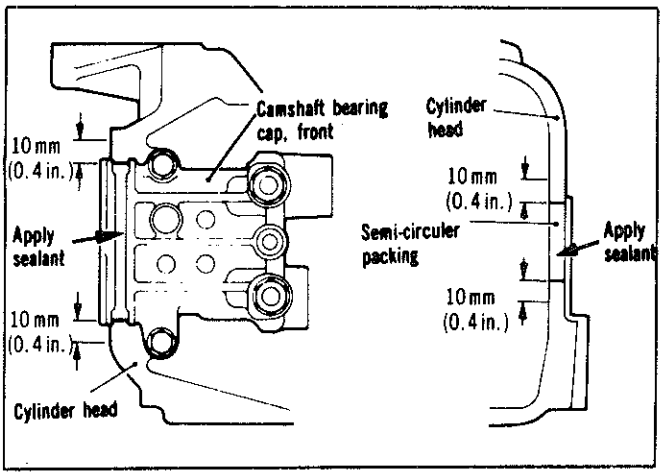


Fig. 19—Rocker arm cover sealing points

(11) Install the rocker arm cover and tighten the bolts to specification.

(12) Install the intake and exhaust manifolds using new gaskets. Apply sealer to both sides of the inlet manifold around the coolant passages. Tighten the manifold nuts to the specified torque.

(13) Install the distributor.

(14) Connect all linkages, fuel lines, vacuum hoses, breather hoses, electrical leads, radiator and heater hoses, etc.

(15) Reconnect exhaust pipe.

(16) Fill the radiator using rain water or demineralized water and adding corrosion inhibitor (or anti-freeze if required).

(17) Connect battery cable and start engine. Run engine until normal operating temperature is reached and check for water or oil leaks.

NOTE: Cylinder head bolts must be retorqued after 800 km (500 miles).

VALVE CLEARANCE ADJUSTMENT

NOTE: Valve clearances must be adjusted with the engine warm and stationary.

(1) Remove air cleaner and rocker shaft cover.

(2) Set No. 1 piston to top dead centre (T.D.C.) on compression stroke.

(3) Loosen the valve adjusting lock nuts.

(4) Adjust the valve clearance on No. 1 inlet and exhaust, No. 2 inlet and No. 3 exhaust to the specified dimension.

(5) Tighten the locknuts.

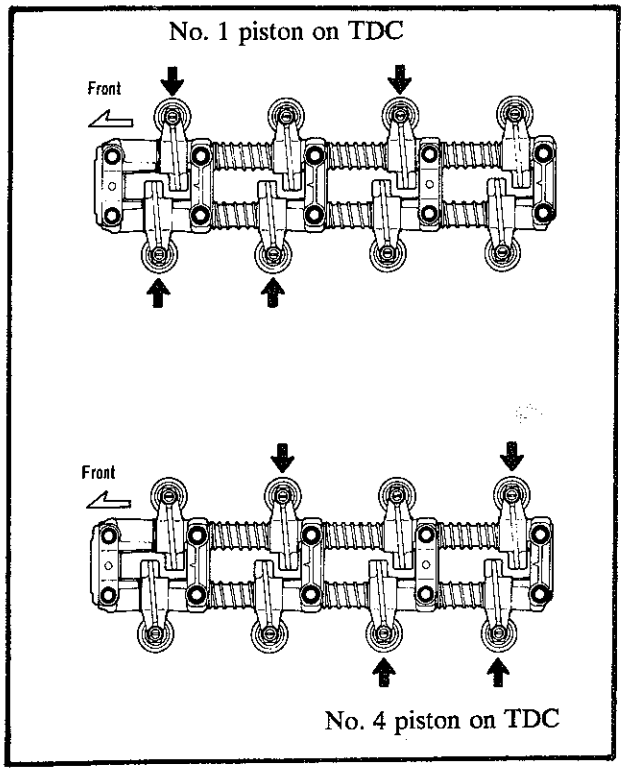


Fig. 20—Valve clearance adjustment sequence

(6) Rotate the engine once and align the crankshaft pulley with the TDC mark, i.e. No. 4 on TDC.

(7) Adjust the valve clearance on No. 4 inlet and exhaust, No. 3 inlet and No. 2 exhaust to the specified dimension.

(8) Install the rocker cover and air cleaner assembly.

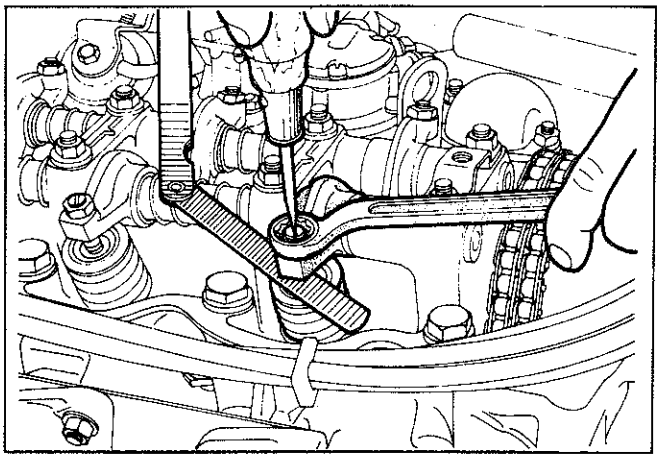


Fig. 21—Adjusting valve clearances

CYLINDER HEAD DISASSEMBLY

With cylinder head removed from engine and inlet and exhaust manifolds removed, proceed as follows:

(1) Remove spark plugs.

(2) Remove camshaft bearing cap nuts.

(3) Holding the front and rear caps, remove the rocker arm shaft assemblies.

(4) Disassemble the caps, rocker arms, springs, shafts and wave washers keeping them in the order of removal. Care should be taken not to lose the camshaft cap locating dowel pins.

(5) Remove the camshaft.

(6) Using a valve spring compressor, remove the collets, spring retainers, springs, spring seats and valves, keeping them in the order of removal.

(7) With the aid of a screwdriver, remove the valve stem seals—Refer fig. 22.

NOTE: Valve stem seals should not be re-used.

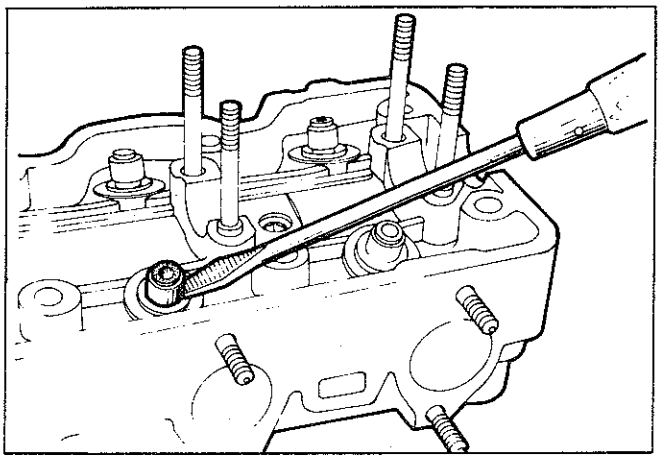


Fig. 22—Removing valve stem seals

Cleaning and Inspection

Check the cylinder head for water leakage and damage before cleaning.

Clean each part carefully removing all pieces of dirt, oil, grease and carbon deposits. Clean oil holes and passages using compressed air ensuring they are not clogged.

Care should be taken not to damage valve seats, cylinder head surface and camshaft journals.

Using a straight edge and feeler gauge, check the cylinder head for distortion as shown in Fig. 23.

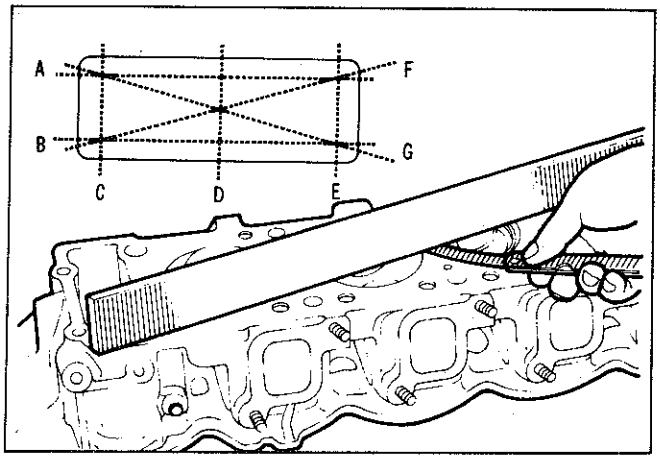


Fig. 23—Check cylinder head distortion

If cylinder head distortion exceeds the specified limit it must be resurfaced.

Check the cylinder head manifold mounting surfaces for flatness or damage.

VALVE GUIDES

Check the valve stem to guide clearance. If the clearance exceeds the specified limit replace the guide with the next oversize guide. Valve guides are shrunk into position, therefore when replacement is necessary the following procedure must be adopted.

(1) Using Tool No. E9M30 remove defective guide towards cylinder block surface.

NOTE: This operation should be conducted with the cylinder head temperature raised to 250°C (480°F).

(2) With the cylinder head at normal temperature, ream the head as specified for the oversize guide.

(3) Heat the cylinder head to 250°C (480°F), and insert the guides quickly. Using Tool No. E9M30, install guides to the specified dimension.

(4) After guide is installed check the inside diameter and ream to specification if necessary.

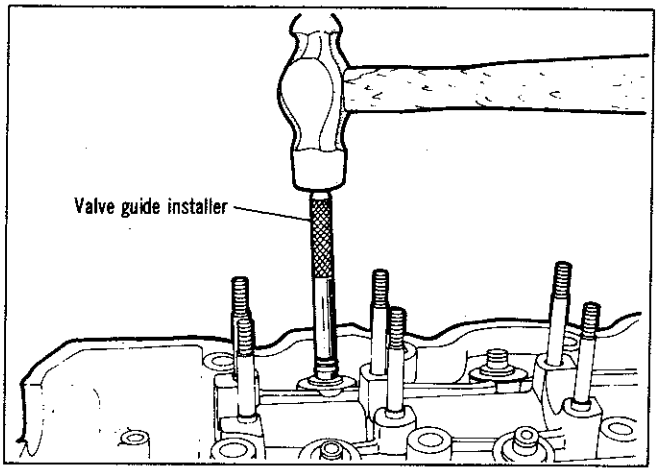


Fig. 24—Removing valve guides

VALVE SEAT INSERT

The valve seat should be checked for overheating and improper contact with the valve face. If faulty it must be re-cut or replaced.

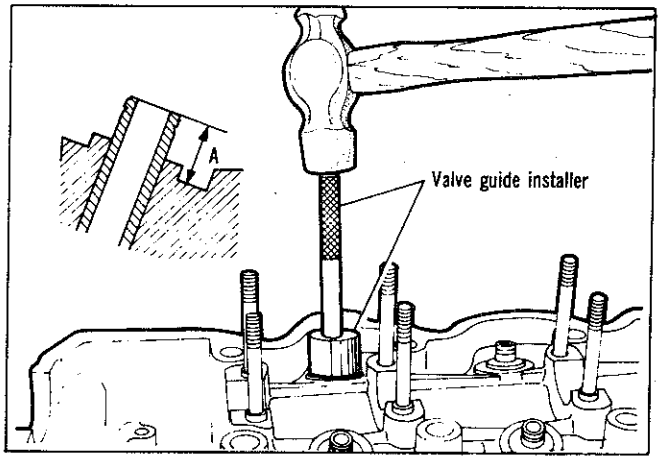


Fig. 25—Installing valve guides

Re-Cutting Valve Seat

(1) Check valve guide for wear, if faulty replace guide as previously described.

(2) Re-condition the seat using either a seat grinder or seat cutter.

(3) The valve seat contact width should be as specified, at the centre of the valve face and as shown in Fig. 26.

(4) After cutting, lap the valve and valve seat lightly with a fine lapping compound.

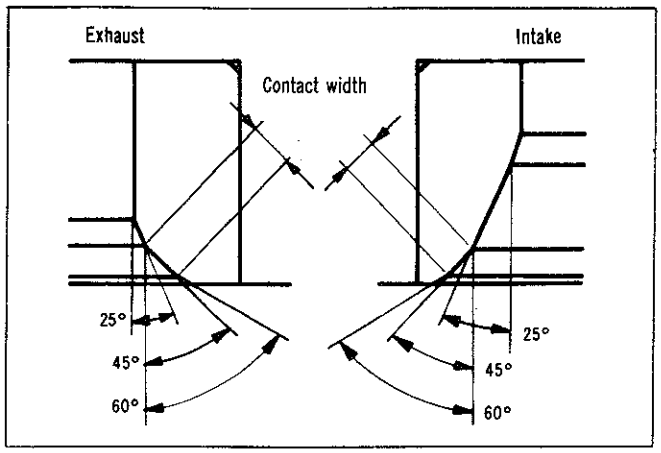


Fig. 26—Valve seat angles

Replacing Valve Seat Insert

Check the valve seat insert "sinkage" by measuring the installed height of the valve spring between the spring retainer and seat. If the sinkage exceeds the specified limit, replace the seat insert as follows:

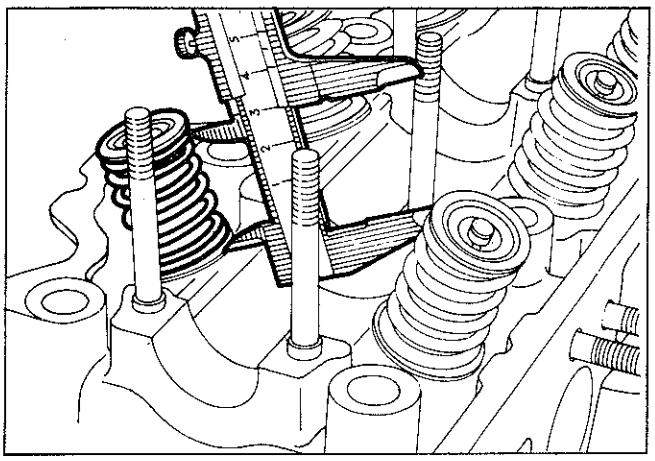


Fig. 27—Checking valve spring installed height

(1) Thin down the valve seat insert by cutting, with a suitable cutter, to within 0,5 to 1,0 mm (0.020" to 0.040") of the cylinder head. Refer to Fig. 28 (A).

(2) Remove the valve seat insert and cut the seat insert bore diameter and height to the dimension shown in specifications, Refer Fig. 28 (B) .

(3) Heat the cylinder head to 250°C (480°F) and press in the new valve seat insert.

(4) Cut the insert to form a new seat as described in Re-cutting Valve Seat.

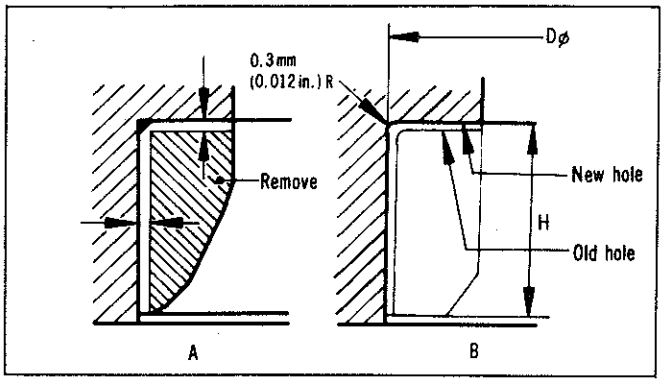


Fig. 28—Replacing valve seat insert

VALVES

Check each valve for wear, damage and deformation of the head and stem (B), Refer Fig. 29.

If the stem tip (A) is pitted it must be re-ground. Remove only sufficient material to restore tip flatness.

If the thickness of the valve face (C) is less than the specified limit, the valve must be replaced.

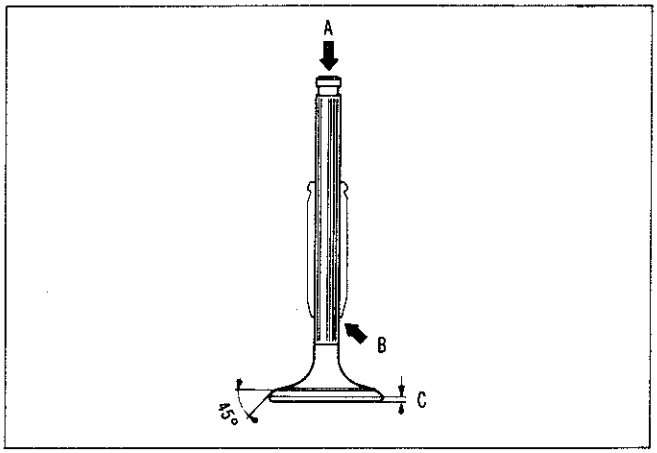


Fig. 29—Valve check points

VALVE SPRINGS

Check the free length and tension of each valve spring. If they are not within specifications replace the spring.

Using a square, check the squareness of each spring. If the spring is excessively out of square, replace the spring.

CAMSHAFT AND CAMSHAFT BEARING CAP

(1) Check the camshaft for bending by supporting it at the ends and mounting a dial indicator at the No. 2 or No. 3 journal. Rotate the camshaft once. Half of the total indicator reading is the amount of camshaft bend, if this exceeds the specified limit the camshaft should be repaired or replaced.

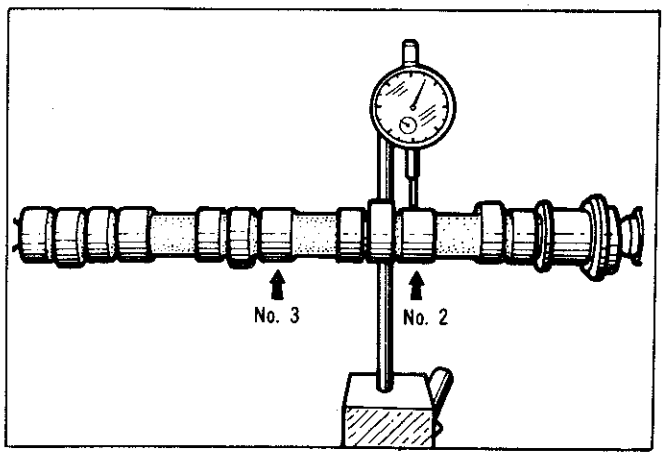


Fig. 30—Checking camshaft for bending

(2) Check the cam lobes and profile for damage. If the lobe or profile are damaged, or worn excessively (see specifications), replace the camshaft.

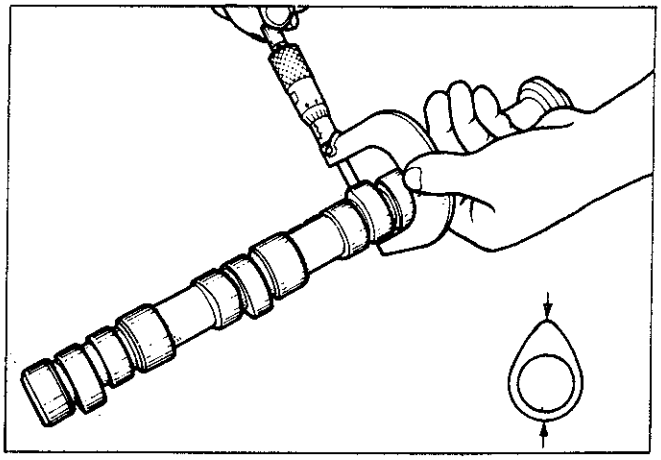


Fig. 31—Checking cam lobe height

(3) Check the camshaft caps for damage on the inner surface. If the caps are excessively damaged the cylinder head must be replaced.

Check the camshaft journal to cap clearance by installing the caps to the cylinder head and measuring the cap inside diameter and the camshaft journal outside diameter as shown in Figs. 32 and 33. If the clearance exceeds the specified limit and the journals are worn, replace the camshaft. If the caps are worn replace the cylinder head.

NOTE: The cap retaining nuts must be tightened to the specified torque prior to measuring internal diameter.

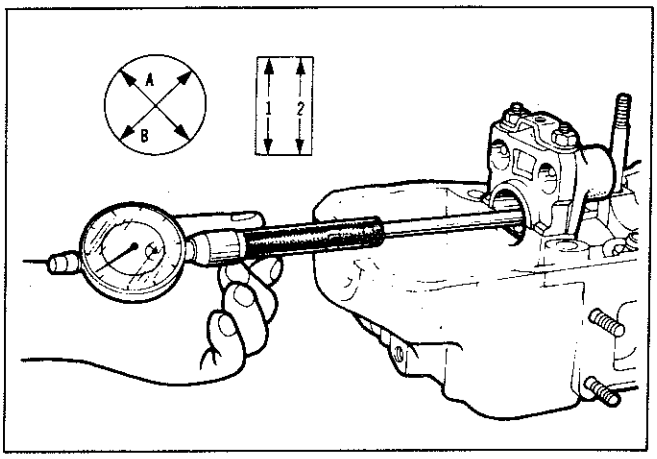


Fig. 32—Measuring camshaft cap diameter

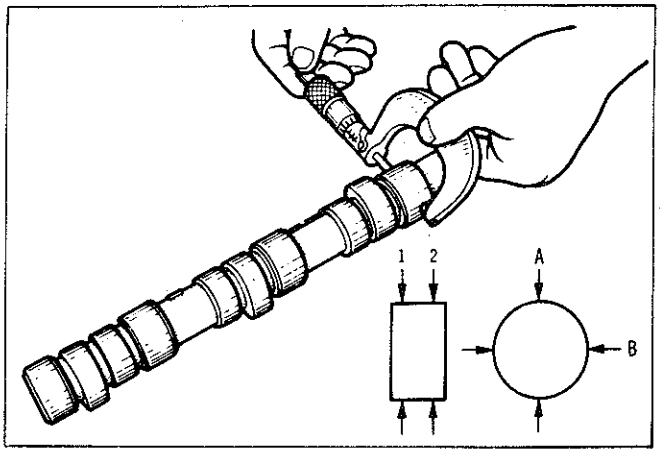


Fig. 33—Measuring camshaft journal diameter

(4) Check the camshaft end float, if it exceeds the specified limit check the camshaft and cylinder head for wear and replace the faulty component.

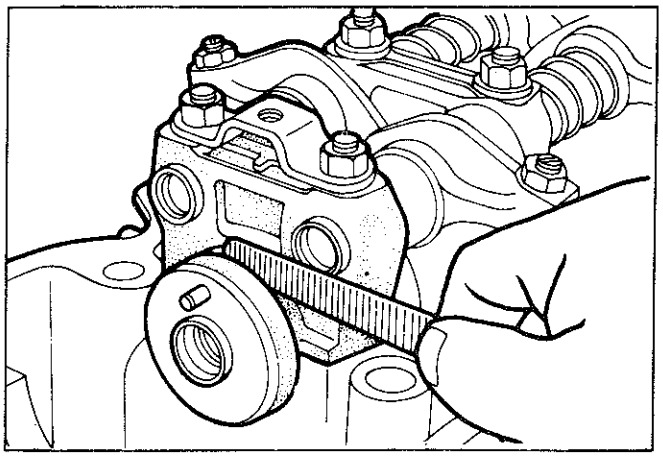


Fig. 34—Checking camshaft end float

ROCKER ARMS AND ROCKER ARM SHAFTS

(1) Check if rocker arm to cam lobe contact face and adjusting screw to valve contact face is damaged or worn. If only slight wear is evident they can be corrected with an oil stone. If they are severely worn or damaged they must be replaced.

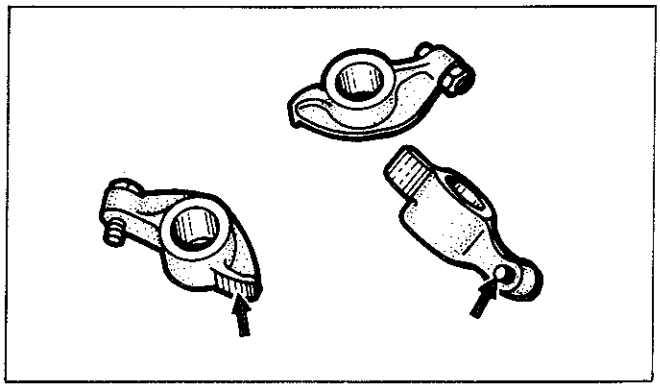


Fig. 35—Checking the rocker arms

(2) Check the clearance between the rocker arms and rocker arm shaft, if they exceed the specified limit replace the arms or shafts.

(3) Check the rocker arm shafts for damage and bend, if faulty they must be replaced.

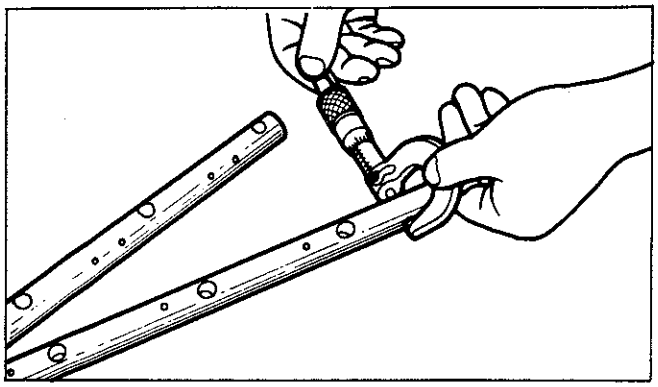


Fig. 36—Measuring rocker arm shafts diameter

NOTE: As a running change the cast iron rocker arms were replaced with assemblies made from die cast aluminium plus the introduction of oil grooves in the L.H. rocker shaft (refer Fig. 39). The early rocker arms can be used on the later rocker shaft, the later type rocker arms MUST NOT be used on the early non grooved shaft.

CYLINDER HEAD RE-ASSEMBLY

When assembling cylinder head ensure all parts are thoroughly cleaned and that all moving parts are lubricated with engine oil prior to assembly.

(1) Install the valve spring seats.

(2) Install the valve stem seals over the valve guides using Tool No. E9M30C. The seal is installed to the specified position by the tool. Failure to position the seal correctly will cause damage to the seal resulting in oil passing the seal.

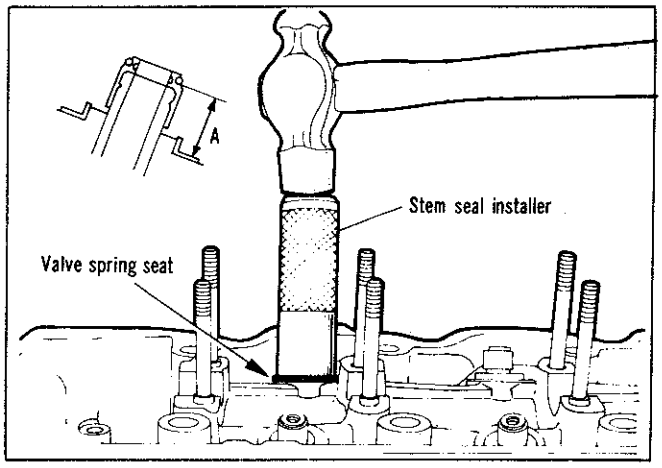


Fig. 37—Installing valve stem seals

NOTE: Old stem seals must not be reused.

(3) Apply engine oil to the valve stems and install the valves into the guides. Do not use excessive force to press the valve stem past the valve stem seal.

(4) Ensure the valve moves smoothly in the guide.

(5) Install valve springs and spring retainers.

NOTE: Install valve springs with the enamel identification marks facing the rocker arms.

(6) Using a valve spring compressor install the valve collets.

NOTE: When compressing the spring, take care that the spring retainer is not forced against the valve stem seal.

(7) Position the camshaft onto the cylinder head and check end float.

(8) Install the caps, rocker arms springs and wave washers onto both rocker arm shafts. The caps must be installed with the indicating arrow facing the front of the engine and in the order they were removed. The springs

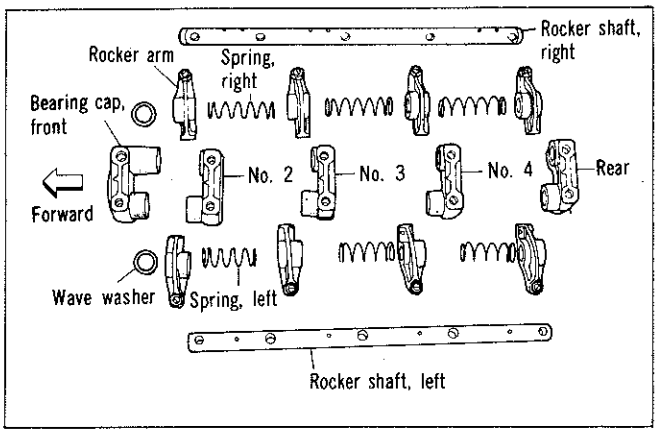


Fig. 38—Rocker arm shaft assemblies (chain drive camshaft type)

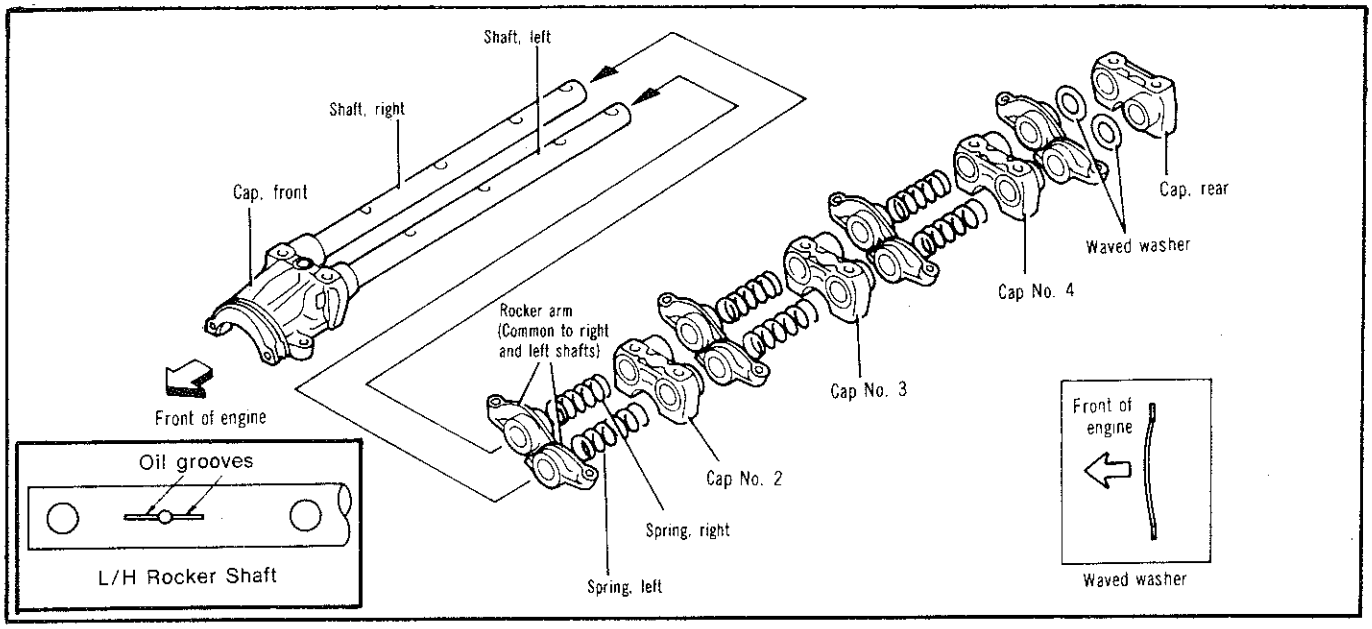
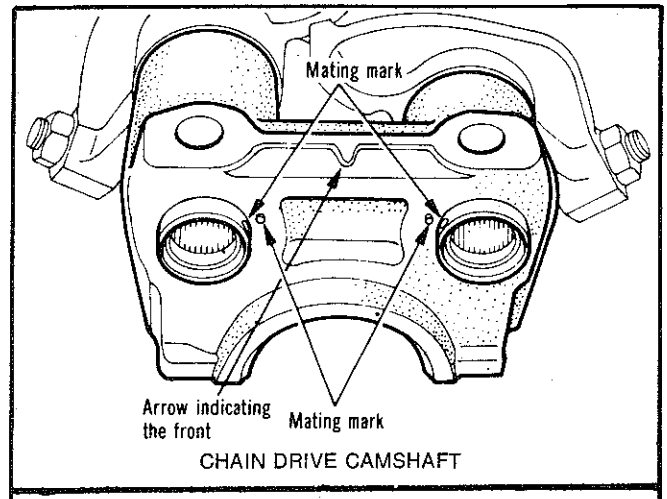


Fig. 39—Rocker arm shaft assemblies (belt drive camshaft type)



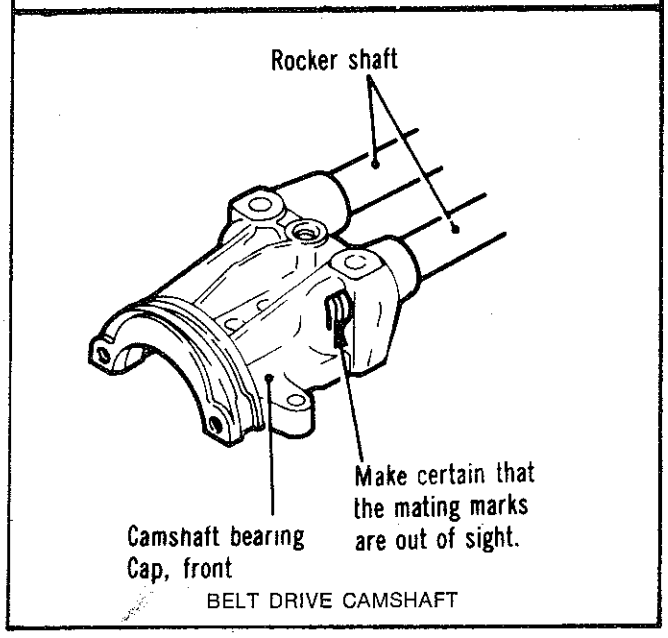


Fig. 40—Rocker arm shaft to cap alignment

must also be fitted onto the correct shaft, right hand shaft springs are shorter, left hand springs are longer. On later engines the shorter spring is used on both left hand and right hand shafts. The right hand shaft has 8 oil holes, the left hand shaft as 4 oil holes, on later engines fitted with aluminium rockers the shafts also have grooves at the oil holes. See inset Fig. 39.

NOTE: When assembling the rocker arm shafts to the caps align the mating marks on the shafts and cap.

Install the wave washers with the convex side facing the front of the engine.

(9) Position the camshaft, with the sprocket locating key/dowel, as shown in Fig. 41.

(10) Install the cap dowel bushings and position the rocker shaft assembly onto the cylinder head.

(11) Install the rocker arm cover attaching brackets to the front and No. 4 camshaft caps (if applicable).

(12) Install cap retaining nuts and tighten in two stages to the specified torque. Tightening order — No. 3, 2, 4, front and rear.

(13) Install spark plugs.

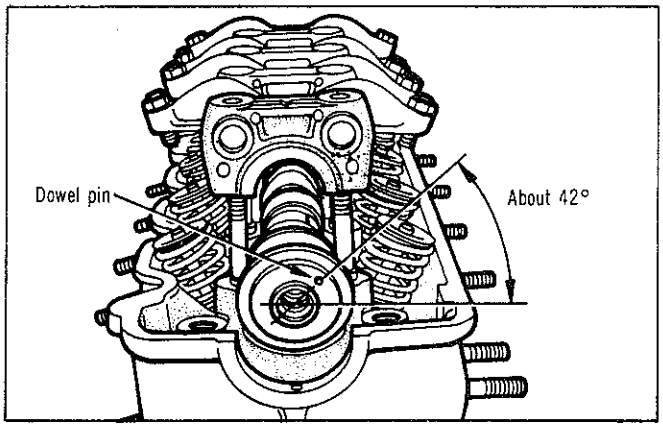


Fig. 41—Positioning camshaft for installation

Belt Drive Camshaft Type

(14) Install the distributor drive gear.

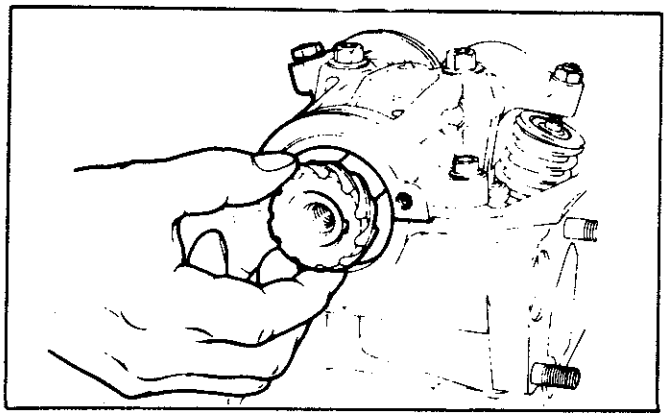


Fig. 42—Installing distributor drive gear

(15) Using Tool No. E9M25 install the camshaft front oil seal, align the hole in the tool with the camshaft keyway.

NOTE: Lubricate the seal lip with engine oil prior to installation.

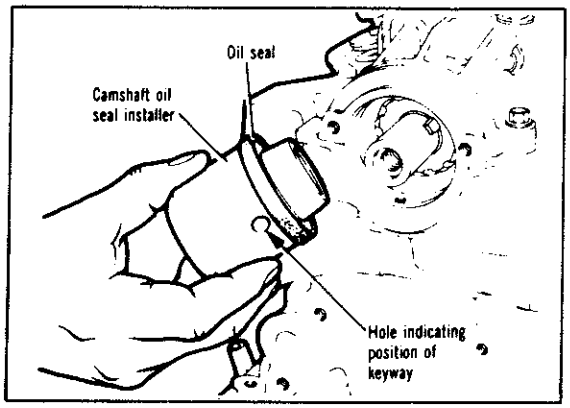


Fig. 43—Installing camshaft oil seal

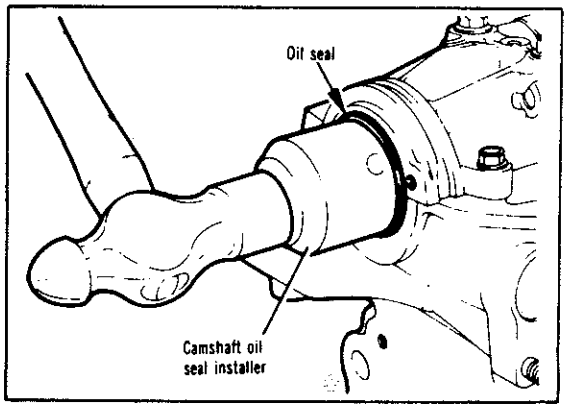


Fig. 44—Positioning oil seal

(16) The seal is correctly installed when the tool just comes into contact with the distributor gear.

(17) Lubricate the camshaft spacer and install it to the camshaft being careful not to roll the lip of the seal when inserting the spacer through the seal.

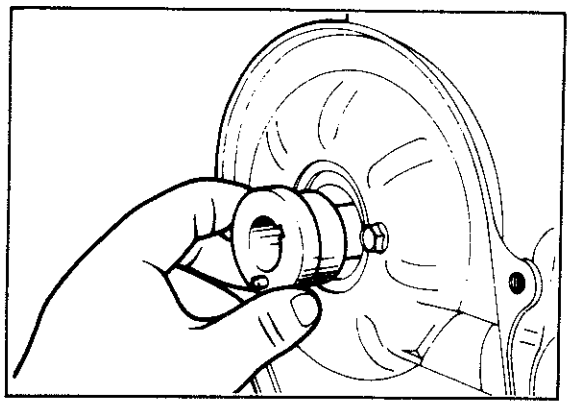


Fig. 45—Installing camshaft spacer

CAMSHAFT DRIVE

Chain Type

Removal

(1) Drain cooling system and remove radiator, hoses, fan and alternator.

(2) Rotate the engine to T.D.C. with No. 1 piston on compression and remove distributor.

(3) Drain engine oil and remove engine oil pan bolts allowing oil pan to clear timing chain cover.

(4) Remove the crankshaft pulley.

(5) Remove the two bolts attaching the cylinder head to the timing chain cover.

(6) Remove the tensioner retaining plug on the right of the timing case and remove the spring and plunger.

(7) Remove the chain case retaining bolts and remove the case being careful not to damage the cylinder head gasket.

(8) Remove the rocker shaft cover and remove the camshaft sprocket retaining bolt and remove the sprocket and chain.

(9) If necessary the crankshaft sprocket and chain guides can be removed.

Installation

(1) Install the timing chain guides.

(2) Install the camshaft and crankshaft sprockets onto the timing chain with the sprocket mating marks aligned with the plated links on the chain.

(3) With the sprocket and chain mating marks aligned, install the crankshaft sprocket onto the crankshaft.

(4) Align camshaft dowel pin with the camshaft sprocket and install sprocket onto camshaft. Tighten sprocket bolt to the specified torque.

(5) Install the chain cover applying sealer to the gasket surfaces.

(6) Install the tensioner plunger, spring and retaining plug.

(7) Install the crankshaft pulley and tighten the retaining bolt to the specified torque.

(8) Install the engine oil pan, tighten retaining bolts to the specified torque.

(9) Install the rocker shaft cover, fan, radiator, hoses, alternator and distributor, readjust fan belt.

(10) Fill the cooling system with rain or demineralized water, add corrosion inhibitor (or anti-freeze if required).
(11) Fill the engine with the correct grade and quantity of first grade engine oil.

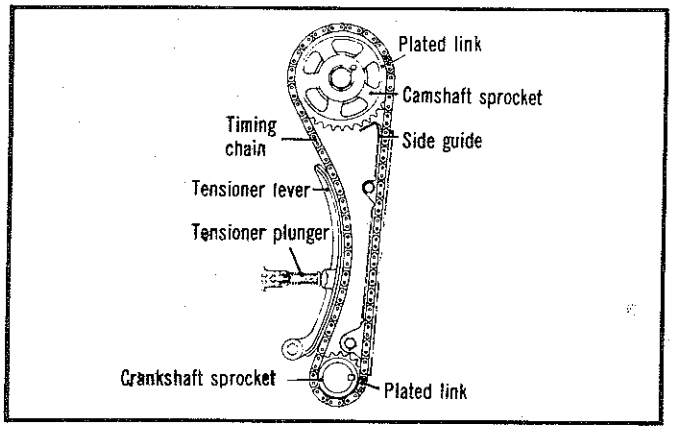


Fig. 46—Timing chain drive

Belt Type

Removal

(1) Rotate the engine to T.D.C. with No. 1 piston on compression stroke.

NOTE: DO NOT rotate engine anti-clockwise as the timing belt may jump the sprocket teeth.

(2) Remove the fan, water pump pulley, belt and crankshaft pulley.
(3) Remove the front upper and lower timing belt covers.
(4) Remove the crankshaft sprocket bolt.
(5) Slightly loosen the belt tensioner mounting bolt and nut and push the tensioner fully away from the belt and tighten the adjusting nut to prevent the tensioner from returning.
(6) Suitably mark the timing belt to show direction of rotation and then remove belt.
(7) The sprockets can now be removed if necessary.

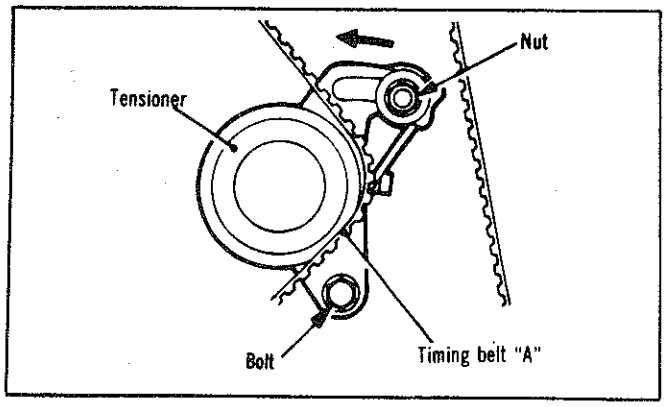


Fig. 47—Timing belt tensioner

Inspection

Check the belt and sprockets for wear or damage and replace any faulty components.

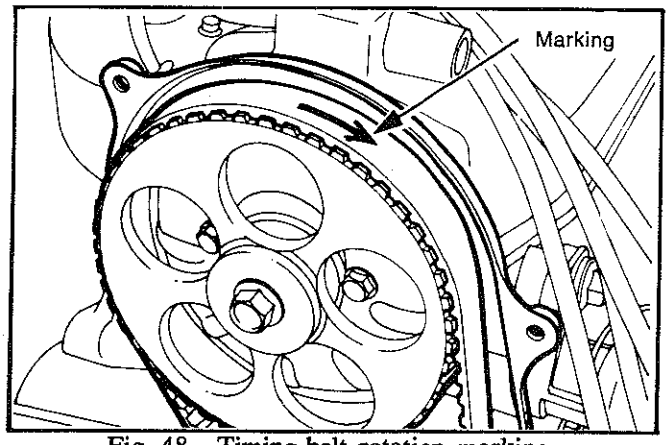


Fig. 48—Timing belt rotation marking

Installation

(1) Install the crankshaft spacer, flange and sprocket and tighten the bolt to specification.
(2) Install the tensioner assembly if removed, ensuring the straight end of the spring is seated against the water pump.

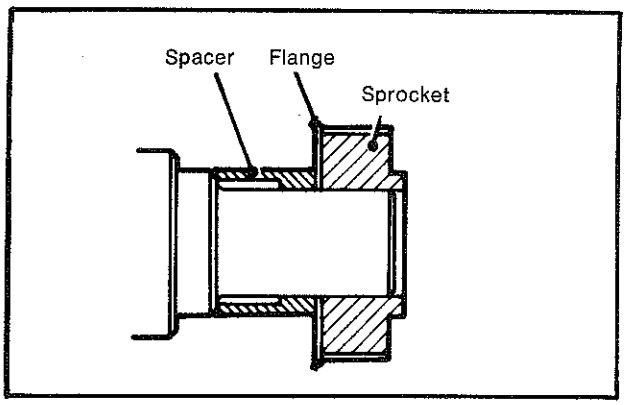


Fig. 49—Crankshaft sprocket assembly

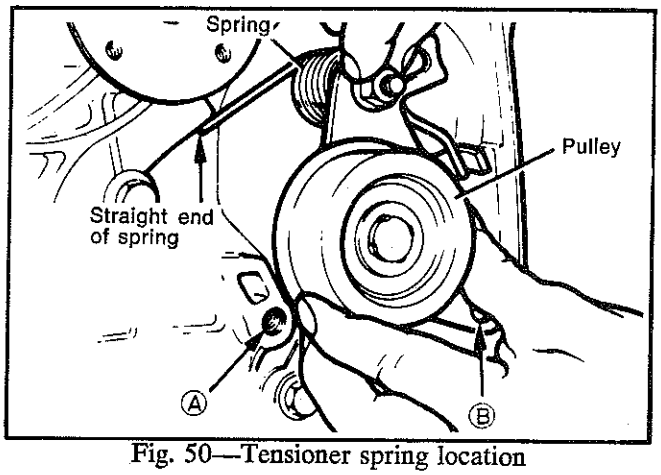


Fig. 50—Tensioner spring location

(3) Attach the other end of the spring to the hook of the tensioner. Install the tensioner to the stud and then install the washer and flange nut. Position the tensioner to align the hole 'B' with the hole 'A' (Fig. 50), and install the retaining bolt. Position the tensioner towards the water pump and temporarily tighten the flange nut.

(4) Align the camshaft and crankshaft sprocket timing marks (Fig. 51 and 52).

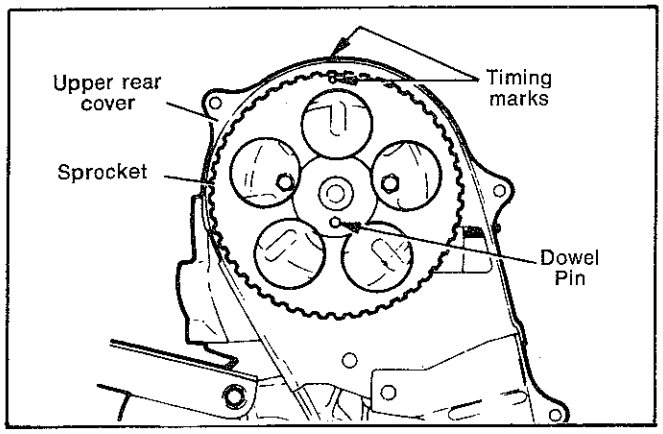


Fig. 51—Camshaft sprocket timing marks

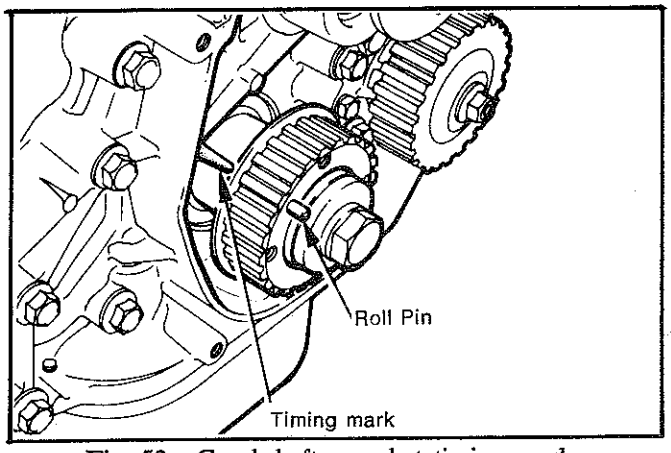


Fig. 52—Crankshaft sprocket timing marks

(5) Noting the previously marked direction of rotation, install the timing belt by fitting it to the crankshaft sprocket, oil pump and camshaft sprocket in that order, ensuring there is no "slack" on the tension side of the belt.

(6) Loosen the tensioner mounting bolt and nut and allow the tensioner alone to tension the belt. Check to ensure the belt is fully meshed with the sprockets especially around the camshaft sprocket. If the belt is loose on the sprocket, push the tensioner in the direction of the arrow (Fig. 53) until belt mesh is achieved.

(7) Tighten the tensioner mounting nut and then the bolt in that order.

NOTE: If the bolt is tightened first, excessive belt tension will result.

(8) Temporarily install the crankshaft pulley, to prevent the belt from coming off, rotate the crankshaft clockwise one complete turn to settle the belt.

NOTE: DO NOT rotate the crankshaft anti-clockwise or twist and shake the belt while rotating the crankshaft.

(9) Loosen the tensioner bolt and nut, thus allowing the tensioner to set itself, then tighten the nut and bolt, in that order, to the specified torque.

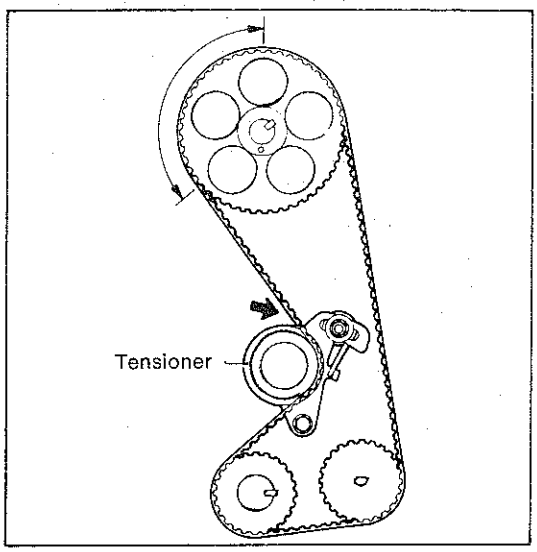


Fig. 53—Tensioning drive belt

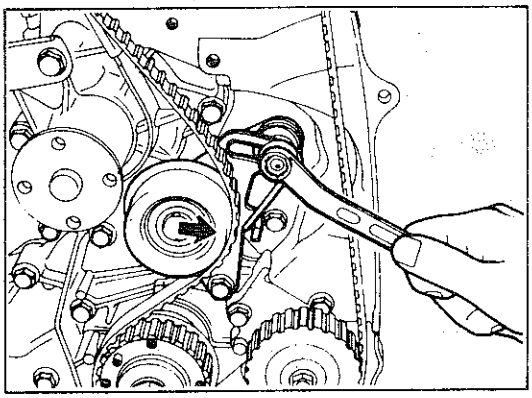


Fig. 54—Tightening belt tensioner

(10) Check the belt tension between the camshaft and oil pump sprocket by pulling the belt out as shown in Fig. 55. The clearance between the belt and rear cover should be approximately 12 mm (0.5"). Readjust if necessary.

(11) Remove the temporarily installed crankshaft pulley.

(12) Install the front upper and lower belt cover.

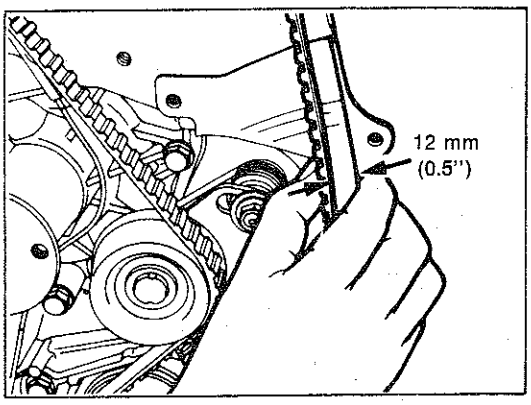


Fig. 55—Timing belt tension

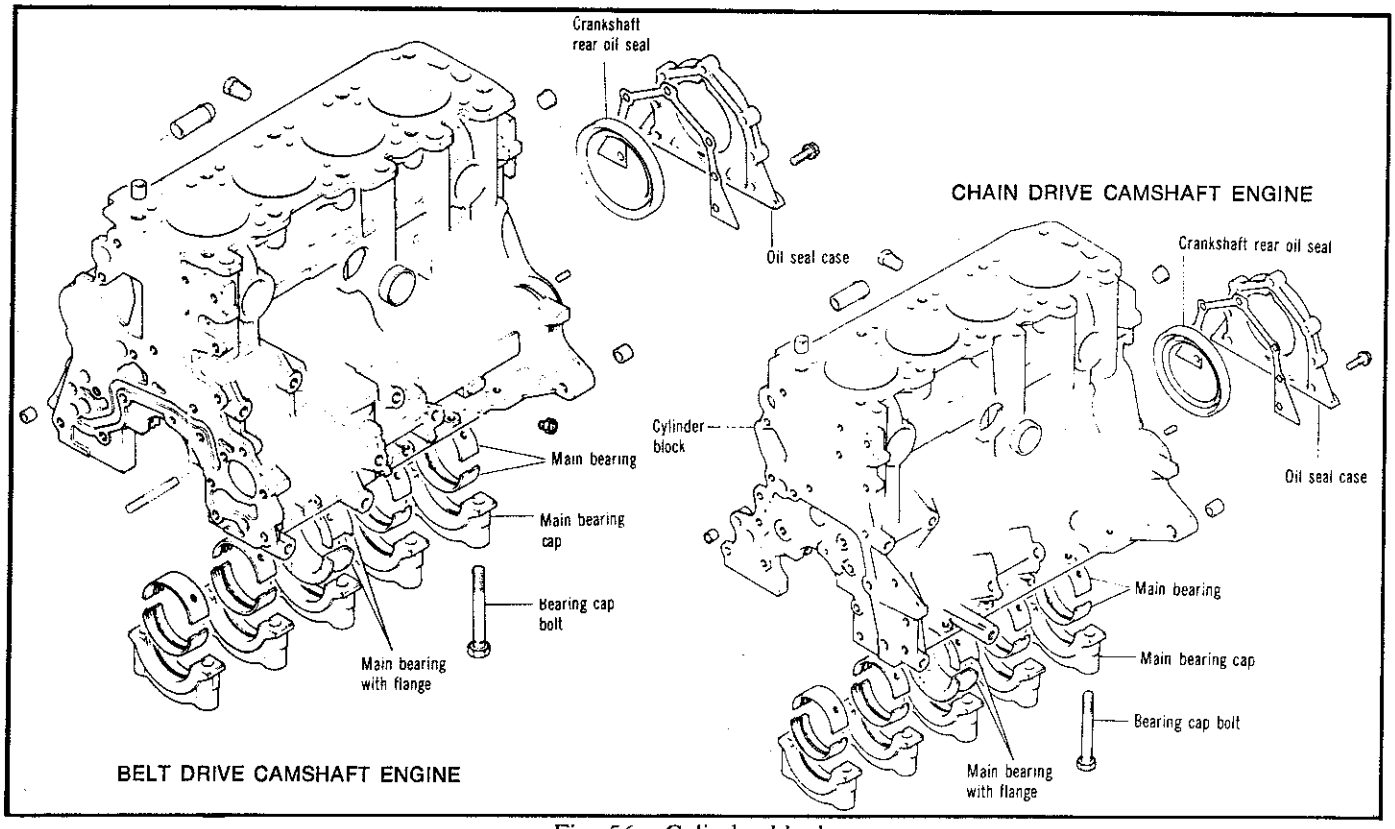


Fig. 56—Cylinder block

(13) Install the crankshaft pulley, fan pulley, belt and fan, tighten the bolts to specification.

NOTE: Ensure the crankshaft pulley is correctly positioned on the location lug.

For in situ belt adjustment on later model engines — refer to page 9 - 3D - 32.

CYLINDER BLOCK DISASSEMBLY

The cylinder block can be disasembled with the engine either in or out of the vehicle. This mainly depends on the amount of reconditioning required.

The following description details the disassembly with the engine removed from the vehicle and transmission removed from the engine.

(1) Remove the cylinder head assembly as described under Cylinder Head Removal.

(2) Remove the oil pan and oil screen.

(3) Remove the camshaft drive chain/belt as previously described.

(4) Remove the flywheel and clutch assembly or torque converter drive plate.

(5) Remove the alternator and adjusting strap.

Belt Drive Type

- Remove the oil pump sprocket by winding a used belt around the sprocket to stop it from turning while removing the bolt.

NOTE: Do not use a screw driver to hold the sprocket or try to remove the bolt while the timing belt is installed.

- Remove the rear timing belt cover.
- Remove the water pump.
- Remove the oil pump.
- Remove the front case retaining bolts and remove the case. If the case is stuck to the block, insert a screw driver in the slot provided at the top of the case and lever the case from the block, DO NOT lever the case in any other position as casting damage may occur.

(6) Remove the crankshaft rear oil seal assembly.

(7) With the cylinder block on its side, remove the connecting rod caps.

NOTE: Later model engines do not have the cylinder number stampings on the rod or cap. Mark the rod and cap with the appropriate cylinder number as an aid to assembly.

(8) With the aid of a soft piece of wood push the piston and rod assembly out through the top of the cylinder block, keeping the piston assemblies and caps in the order removed.

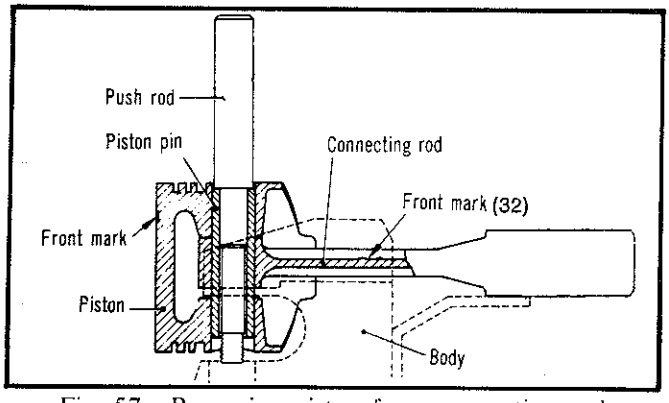


Fig. 57—Removing piston from connecting rod

NOTE: Prior to removing the piston and rod assemblies, remove all carbon deposits and/or cylinder ridge from the cylinder bore.

(9) Remove the piston rings from the pistons keeping them in order of removal.

(10) Remove the pistons from the rods using Tool No. E9M50.

(11) Remove the crankshaft bearing caps and lower bearings, keeping them in removed order.

(12) Remove the crankshaft and the upper bearing halves.

NOTE: The main bearings (except the centre one) are interchangeable, however, if they are to be reused they should be installed in the original position.

Cleaning and Inspection

Before cleaning, check the cylinder block for water leakage, cracks or damage.

When cleaning, remove all traces of oil, grease, dirt, carbon and scale from all components. Clean out all oil passages by blowing with compressed air.

Checking Cylinder Block

(1) Check the cylinder bores for scatches, rust, corrosion, cracks or any defects or damage, if faulty the block must be rebored or replaced.

(2) Check the upper surface of the cylinder block for distortion using a straight edge and feeler gauges. If it is not within specifications the surface must be refaced. If refacing is necessary, an equivalent amount must be removed from the timing chain case to maintain a flat gasket surface.

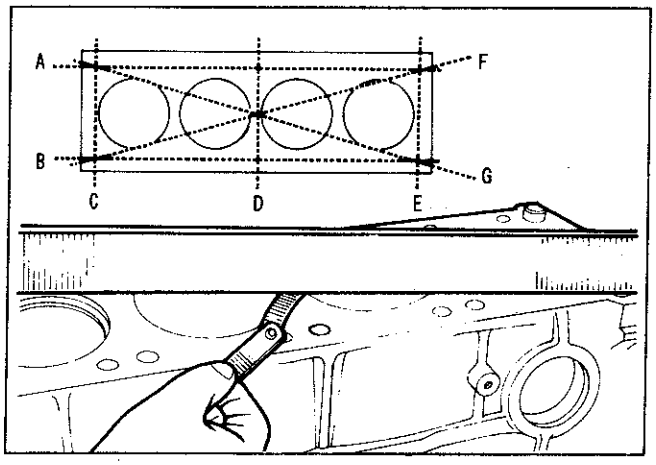


Fig. 58—Checking cylinder block for distortion

(3) Measure the cylinder bore size at three levels. If the wear exceeds the specified limit the cylinders must be re-bored to the next piston size.

NOTE: If only one cylinder requires re-boring, all the cylinders MUST be re-bored.

(4) If the cylinder does not require re-boring, remove the ridge at the top of the cylinder and hone the bores if necessary.

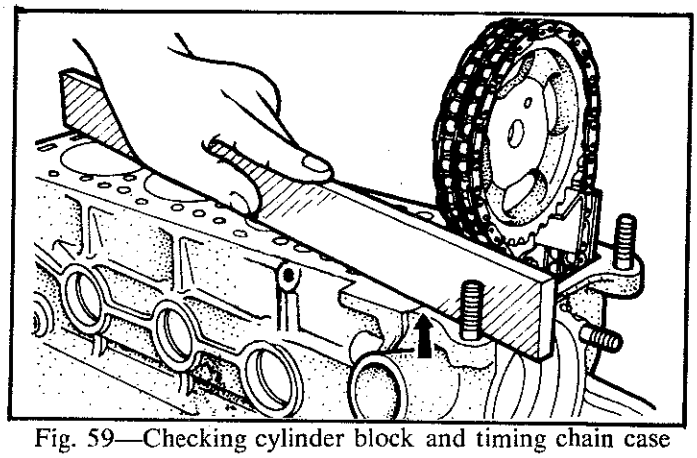


Fig. 59—Checking cylinder block and timing chain case step

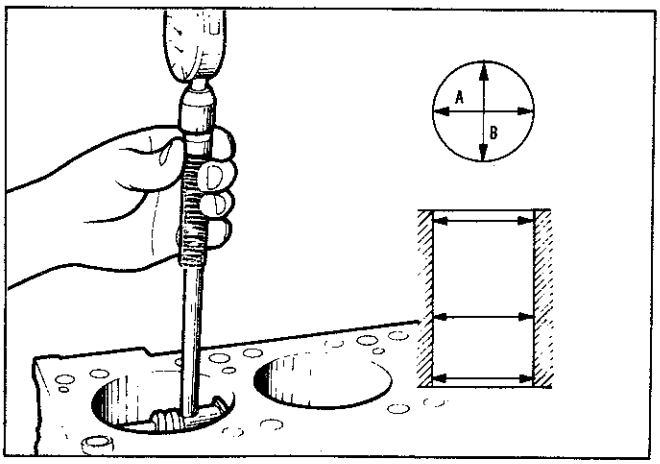


Fig. 60—Measuring cylinder bores

Cylinder Boring

(1) The piston size to be used should be determined by the cylinder which has the largest bore size.

(2) Check the outside diameter of each oversize piston at the skirt and across the thrust faces. The measurement should be taken at a point 2,0 mm (0.079") from the bottom of the piston.

(3) To determine the cylinder re-bore size proceed as follows:

(a) Measure the diameter of the piston.

(b) Allow piston to bore clearance.

(c) Honing margin = 0,02 mm (0.0008") or less.

(d) Finished re-boring size = a + b — c = a + 0 to 0,02 mm (0.0008").

(4) The cylinder should be re-bored to the size obtained by the calculation.

(5) The final cut should not be greater than 0,05 mm (0.002").

NOTE: Do not attempt to cut too much from the bore at one time.

(6) To prevent heat distortion of the bores when re-boring, the cylinders should be bored in the following sequence: 2-4-1-3 or 3-1-4-2.

(7) The cylinder bore size will vary immediately after re-boring, due to the heat generated by the cutting operation, therefore care should be taken when measuring the bore size.

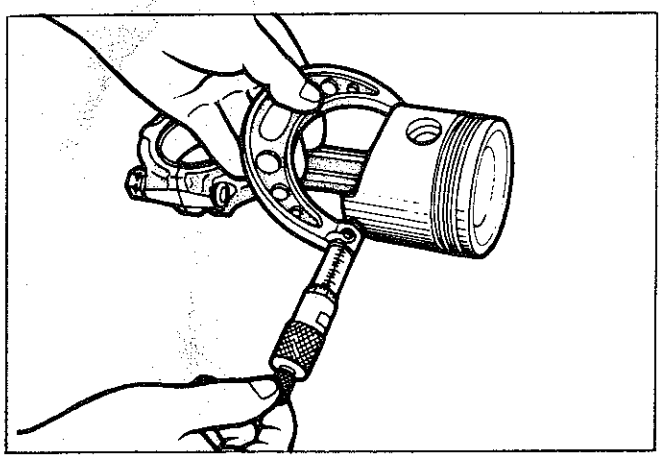


Fig. 61—Measuring piston diameter

(8) After cutting, the bore should be honed accurately to the finished size. The bores should be honed until all traces of the cutting operation are removed. The honing angle should be between 30° and 45°.

(9) Check the piston to cylinder wall clearance.

PISTONS, PISTON PINS AND PISTON RINGS

(1) Check the pistons for seizure, nicks, wear, cracks and any other defect. Replace any faulty pistons.

(2) Check the piston pin to piston pin hole fit. The pin must be a smooth hand press fit into the piston hole. Replace any piston and pin assembly that is defective.

(3) Check the piston rings for breakage, damage and abnormal wear. Replace any defective rings.

NOTE: If a piston is replaced, new rings should also be fitted.

(4) Measure the piston ring side clearance by placing the ring in its respective piston groove and checking the clearance with a feeler gauge. If it exceeds the specified limit, recheck the clearance with a new piston ring. If the clearance is still excessive replace the piston and rings, if it is within specification, replace the rings only.

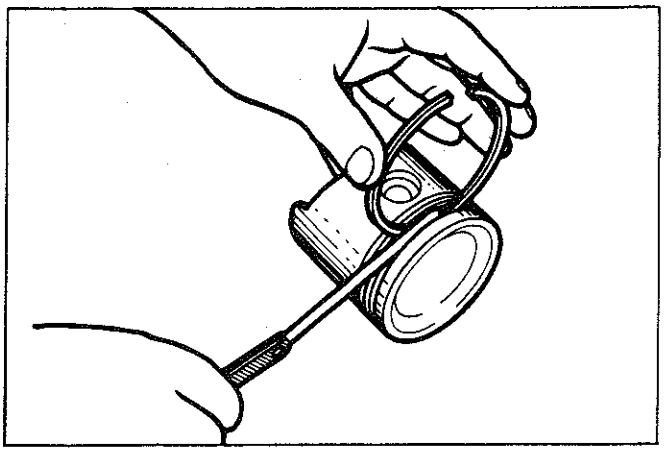


Fig. 62—Measuring piston ring side clearance

(5) Measure the piston ring end gap by inserting the ring into the cylinder and positioning it at right angles to the cylinder wall by pressing it down with a piston. Remove the piston and measure the ring gap using a feeler gauge. If the gap exceeds the specified limit, replace the piston rings.

NOTE: If the cylinders are not being re-bored, the ring gap measurement should be made at the lower part of the cylinder, the area having the least wear. When replacing the piston rings, be sure to use rings of the same size.

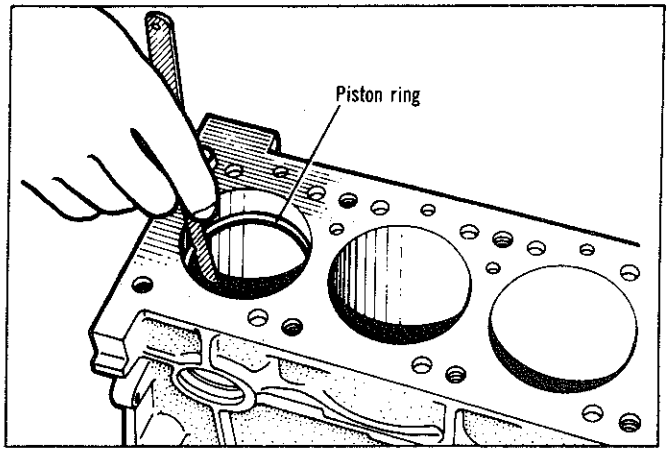


Fig. 63—Measuring piston ring gap

CONNECTING RODS

(1) Check the connecting rod for damage at the thrust faces at either end and for step wear or severely rough surface of the inside diameter of the small end. Replace faulty rods.

NOTE: When using a new connecting rod, the cylinder number should be stamped or marked on the big end.

(2) Measure the connecting rod small end diameter, if not within specifications, replace the rod.

(3) Using a connecting rod aligner, check the rod for bend and twist. If a rod falls just outside the specified limit it can be straightened by using a press. A rod that is severely bent or distorted must be replaced.

(4) Measure the connecting rod side clearance by assembling the rod and bearing onto the crankshaft and tightening the bolts to the specified torque. Measure the clearance between the connecting rod and crankshaft using feeler gauges. If this exceeds the specified limit, replace the rod.

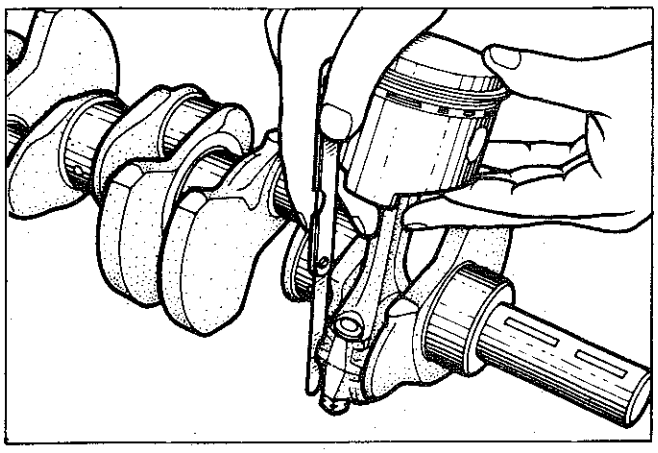


Fig. 64—Measuring connecting rod side clearance

CRANKSHAFT

(1) Check the crankshaft journals for damage, uneven wear and cracks. Check all oil holes for clogging.

(2) Check the crankshaft for bending by supporting it between centres and positioning a dial indicator on the centre journal. Rotate the shaft once noting the total indicator reading. Half of the reading is the amount of bend, if this exceeds the specified limit, repair or replace the crankshaft.

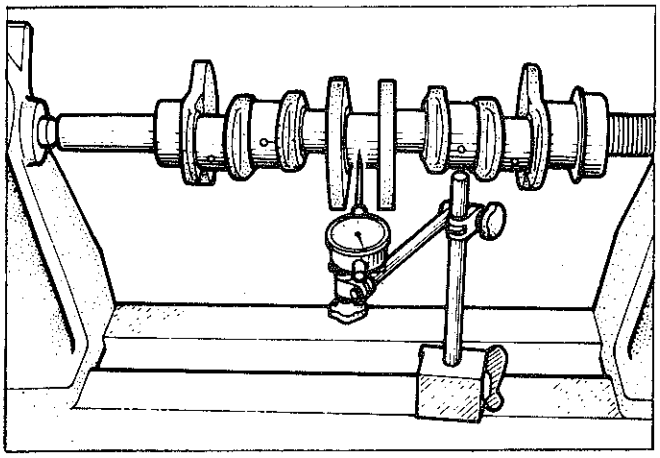


Fig. 65—Measuring crankshaft bend

(3) Measure the crankshaft journal diameters as shown in Fig. 66. If they are excessively out of round, tapered or worn they must be re-ground to the next undersize.

NOTE: Grinding of crankshaft journals must only be done AFTER checking/repairing crankshaft bend.

NOTE: Whenever crankshaft journals are re-ground, the correct undersize bearings must be fitted.

(4) When grinding the crankshaft, care must be taken to ensure the crankshaft journal fillet radii are 2,5 mm (0.098").

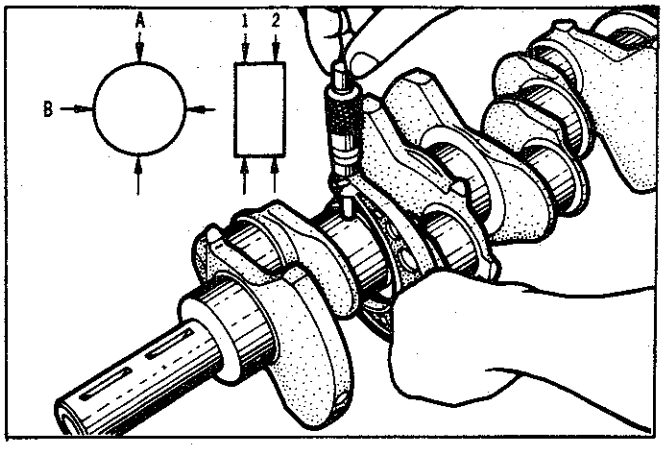


Fig. 66—Measuring crankshaft journal diameter

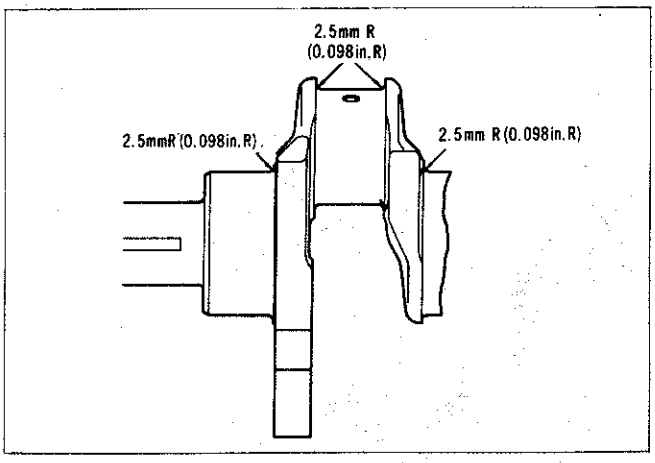


Fig. 67—Crankshaft journal fillet radii

(5) Check the crankshaft end float by assembling the crankshaft, bearings and caps to the cylinder block. Insert a feeler gauge between the centre bearing and crankshaft, if the end float exceeds the specified limit, replace the centre bearing.

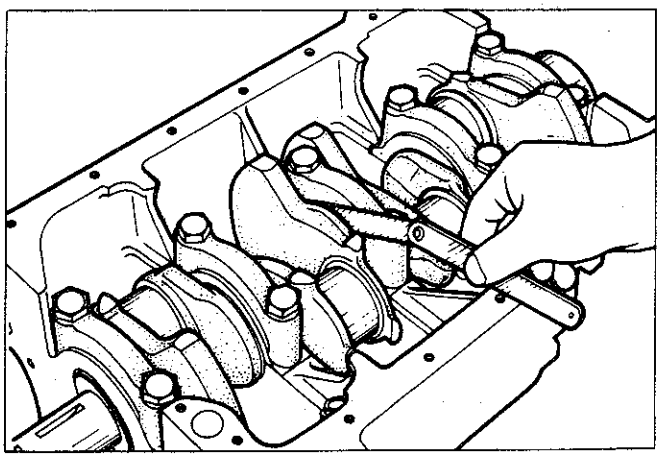


Fig. 68—Measuring crankshaft end float

MAIN AND CONNECTING ROD BEARINGS

(1) Check all bearings for peeling, melting, seizure and improper contact. Replace any faulty bearings.

(2) Checking the journal to bearing clearance can be done using either of two methods:

(a) measuring journal and bearing diameters;

(b) using the plastigauge method.

Measuring Diameters

(1) Measure the outside diameter of the main and connecting rod journals, Fig. 66.

(2) Assemble the bearings and caps and measure the bearing inside diameter, Fig. 69. The clearance is the difference between the respective bearing and journal diameter.

(3) If the clearance is not within specification and the journal diameter is within specification the bearings must be replaced.

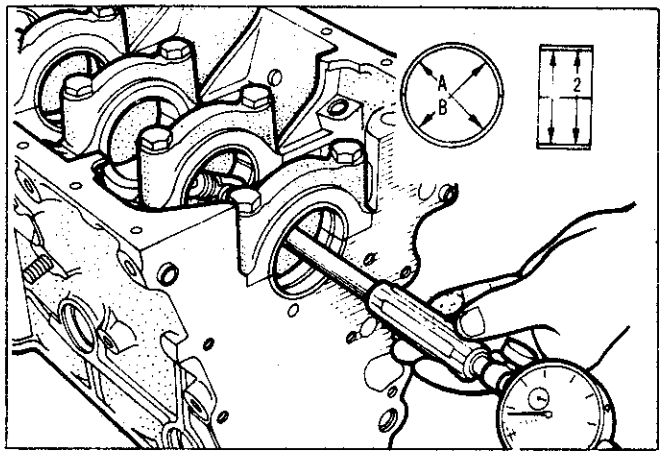


Fig. 69—Measuring bearing diameter

Plastigauge Method

(1) Remove all oil, grease and dirt from the bearings and journals.

(2) Cut a piece of plastigauge the length of the bearing width and place it across the bearing, away from the oil hole.

(3) Install the crankshaft/connecting rod, bearings and caps and torque them to specifications.

NOTE: Do not rotate the crankshaft or connecting rod during this operation.

(4) Remove the caps and measure the width of the plastigauge at the widest part using the scale printed on the plastigauge packet.

(5) If the clearance is not within specification and the journal diameter is within specification the bearings must be replaced.

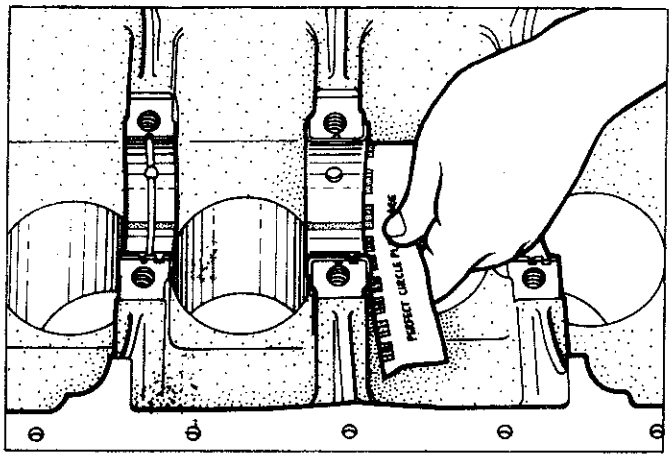


Fig. 70—Checking bearing clearance using plastigauge

SPROCKET, CHAIN, TENSIONER AND GUIDE

(Chain Drive)

(1) Check sprockets for teeth damage and wear.

(2) Check the chain for roller play, wear, damage, disconnected links, etc.

(3) Check the chain tensioner rubber for wear and the tensioner spring length specification.

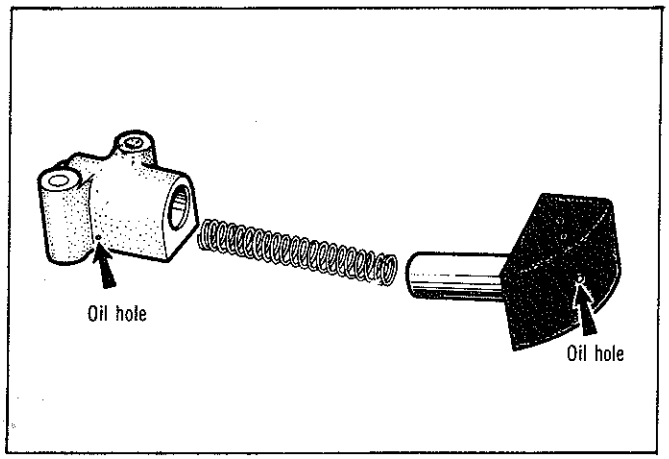


Fig. 71—Tensioner assembly

(4) Check the chain guide for wear and damage. If the guide is severely worn or damaged it should be replaced.

(5) Check the chain stretch using two sprockets as shown in Fig. 72. Stretch the chain and measure the distance between the sprocket centres. If the distance is greater than specified replace the chain.

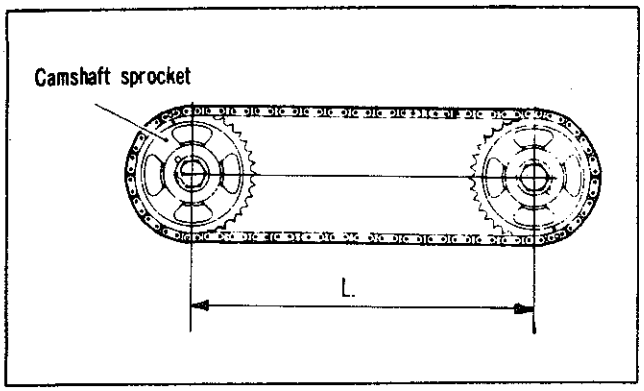


Fig. 72—Checking timing chain stretch

SPROCKETS, BELT AND TENSIONER (Belt Drive)

(1) Check sprockets for wear, cracks or damage, replace as necessary. Check the oil pump sprocket and camshaft spacer for wear on the oil seal contacting surface.

(2) Check the tensioner for light and, smooth pulley rotation, looseness or noise. Check spring for tension and breakage.

(3) Check the timing belt for worn, damaged or torn teeth/backing. Replace belt if contaminated by oil or dust. Slightly affected belts can be cleaned by wiping with a cloth, **do not use any form of solvent.**

(4) Check timing belt covers for deformation and cracks, replace as necessary. Check that the rubber seals are held securely in the grooves.

FLYWHEEL AND RING GEAR

(1) Check the flywheel surface for wear or damage, if excessively worn or damaged, replace the flywheel.

(2) Check the flywheel surface run-out, if it exceeds the specified limit replace the flywheel.

(3) Check the ring gear for damage, cracking and wear, replace if necessary.

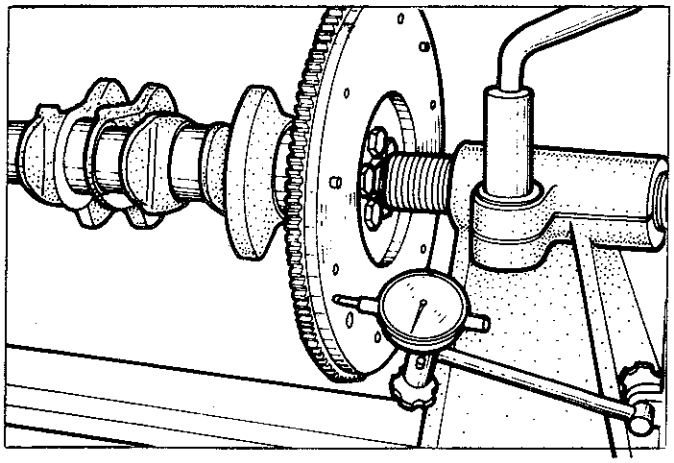


Fig. 73—Checking flywheel surface run-out

Ring Gear Replacement

(1) Remove the ring gear by tapping it around the circumferance with a hammer and drift.

NOTE: Do not attempt to remove the ring gear by heating.

(2) Install the ring gear by heating it on a gas ring to 260 to 280°C (500 to 536°F) and shrinkage-fit it on the flywheel.

OIL SEALS, OIL PAN AND OIL SCREEN

(1) Check the front and rear crankshaft seals for damaged and worn lips. Replace the seal if defective.

(2) Check the oil pan for damage and cracks, repair or replace the oil pan as necessary.

(3) Check the oil screen for failure, damage and cracks. Check the O-ring for defects. Replace any faulty parts.

(4) Refer to Group 10 Engine Oiling for oil pump servicing.

CYLINDER BLOCK REASSEMBLY

When assembling the cylinder block the following procedures should be observed:

- **Thoroughly clean all components especially oil holes, bearings, housings, bores and cylinder walls.**
- **Apply engine oil to sliding and rotating parts such as cylinder walls, pistons, bearings and gears prior to installation.**
- **Gaskets and oil seals should be replaced with new parts.**
- **Apply sealant to gaskets as required.**
- **Torque all bolts to specification and in the specified sequence where necessary.**
- **Check all oil clearances, thrust clearances and backlash where necessary.**

(1) Install main bearings, upper, to the cylinder block. If reusing the main bearings install them in their original position.

(2) Position crankshaft onto cylinder block and apply oil to journals.

NOTE: On later engines, changes were made to the crankshaft, main bearing shells and caps. This involved the use of additional oil holes in the crankshaft main bearing journals and the deletion of oil grooves in the lower main bearing shells and caps.

CAUTION: Lower main bearings and caps with the oil groove are used with the old crankshaft and may be used with the new crankshaft. For engines with the lower main bearing and cap without the groove, the new crankshaft MUST be used.

(3) Install bearing caps and bearings, tightening the cap bolts to specification and in the sequence of: centre, No. 2, No. 4, front and rear.

NOTE: The caps must be installed with the arrow mark facing the front of the engine and in the correct order.

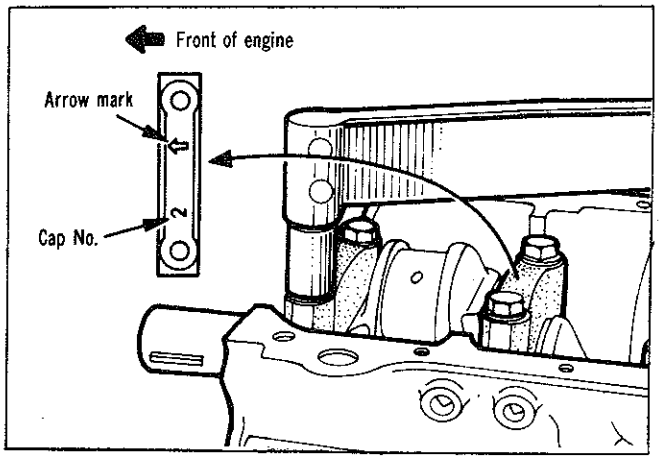


Fig. 74—Installing main bearing caps

(4) Ensure the crankshaft rotates lightly and smoothly and that the end float is within specifications.

(5) Using Tool No. E9M50 set the piston pin positively between the push rod and guide bar.

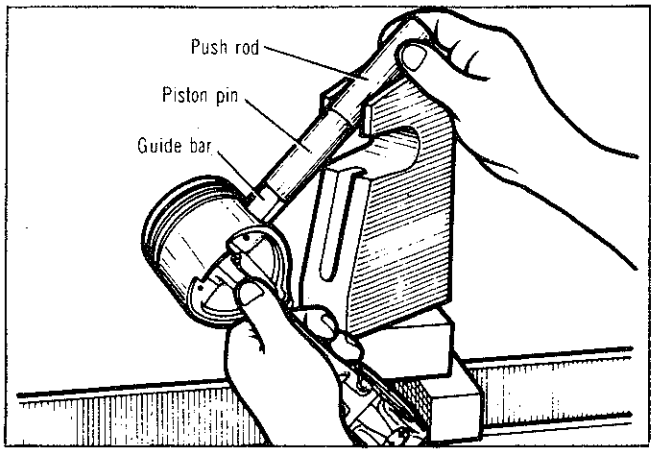


Fig. 75—Fitting piston pin onto tool

(6) Lubricate the outer surface of the piston pin and small end bore of the connecting rod.

(7) With the connecting rod and piston front marks aligned (arrow on piston, numerals on connecting rod), insert the piston pin, guide bar and push rod into the piston.

(8) Insert the guide bar in the slot provided in tool support, with the flat side of the guide bar aligned with the inner wall of the slot. Sit the connecting rod small end to rest positively on the tool support. Turn the piston pin assembly half a turn.

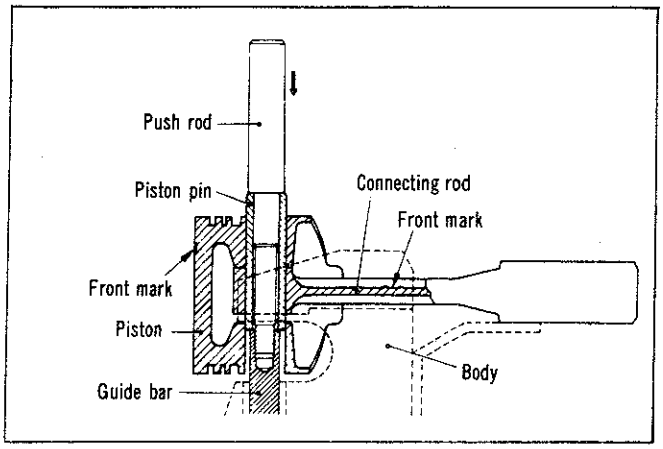


Fig. 76—Piston and connecting rod assembled into tool

(9) With the aid of a press, install the piston pin until the top end of the guide bar bottoms in the tool base. The force required to install the pin must be between 4900 to 14700 N (1102 to 3306 lbs.).

NOTE: If the force required to fit the pin is not as specified, the piston pin must be removed and the pin and connecting rod diameters checked.

(10) With the piston assembled to the connecting rod ensure that the piston moves freely and lightly.

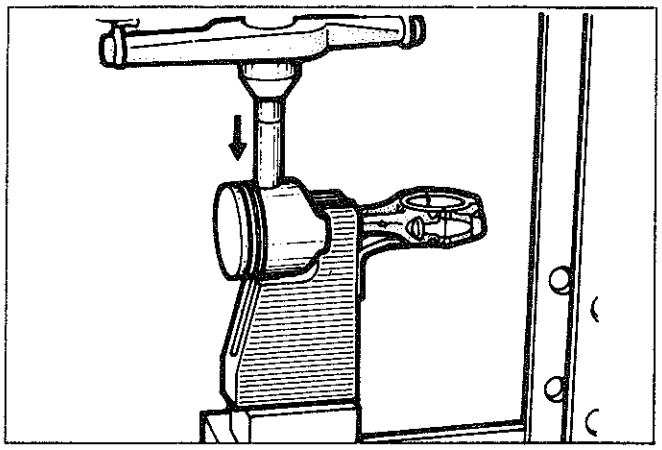


Fig. 77—Installing piston pin

(11) Install the piston rings in the following order:

(a) Install the oil ring expander.

(b) Fit one end of the oil ring top side rail into the groove and "peel" the ring into the groove. (Refer Fig. 78). Fit the lower side rail in a similar manner.

NOTE: Ensure that both upper and lower side rails can be turned freely in the piston and that the markings on the side rails face the top of the piston.

(c) Install the No. 2 piston ring and then No. 1 piston ring.

NOTE: Piston rings must be installed with the markings of the ring facing the top of the piston.

(8) Position the piston rings so that the ring gaps are as far from each other as possible and that they do not align with the piston pin and thrust side of the piston. Refer Fig. 80.

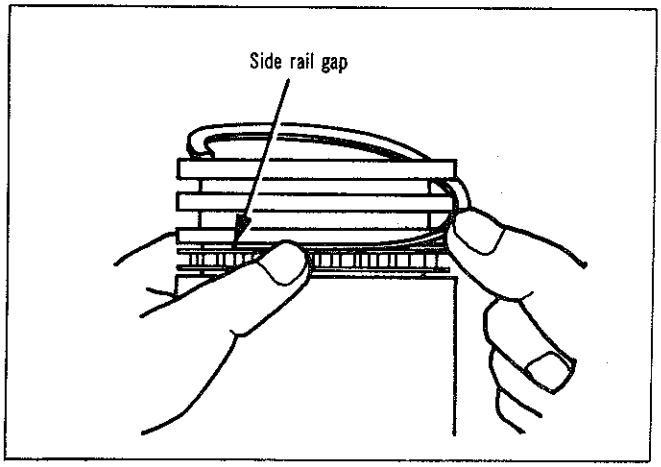


Fig. 78—Fitting oil ring side rail

(9) Apply a liberal amount of engine oil to the piston and rings.

(10) Compress the rings using a piston ring compressor. Install the piston and connecting rod assembly into the cylinder ensuring the piston front mark is facing the front of the engine and the assemblies are fitted into the correct cylinder.

NOTE: It is advisable to fit plastic covers or masking tape around the connecting rod bolts to protect the cylinder walls and crankshaft journals from damage.

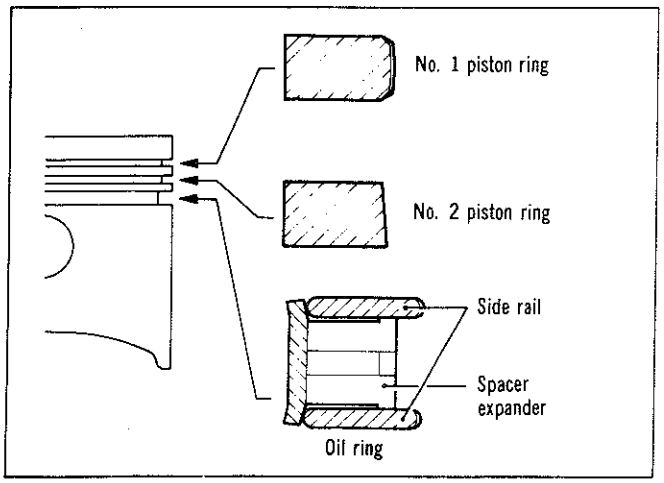


Fig. 79—Order of piston ring installation

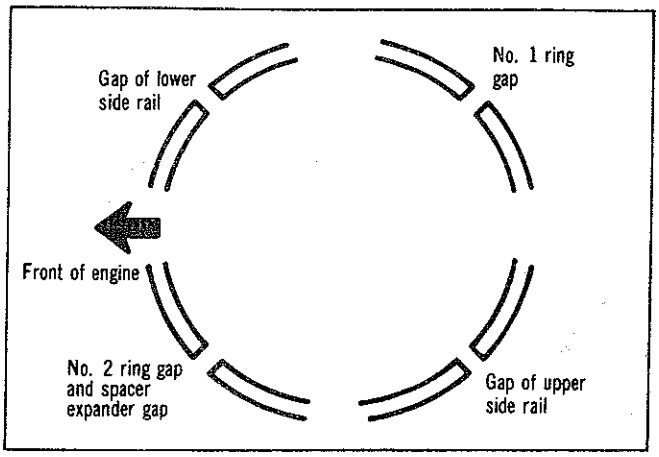


Fig. 80—Piston ring gap position

(11) Install the connecting rod caps in the correct order, with the cylinder number marks on the cap, aligned with the numbers on the connecting rod. Tighten the cap bolts to the specified torque.

(12) Check the connecting rod big-end side clearance.

(13) Install the crankshaft rear oil seal case. If the oil seal has been removed from the case, install a new oil seal to the case, ensuring it is properly seated into the case and that the oil hole in the separator faces the bottom of the case (refer Figs. 82 and 83). The use of Tool E9M60 will ensure correct installation of the seal. Later models are not fitted with the separator and have the seal fitted from the rear of the case (refer Fig. 84).

NOTE: The crankshaft oil seal lip should be lubricated with engine oil prior to installation.

(14) Install the flywheel (or torque convertor drive plate) tightening the bolts to the specified torque. Bend the bolt locking tabs to securely hold the bolts.

NOTE: Do not reuse old locking tabs.

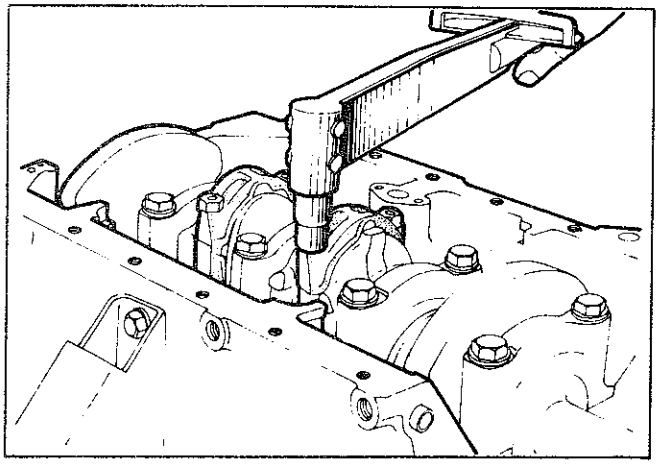


Fig. 81—Tighten connecting rod bearing caps

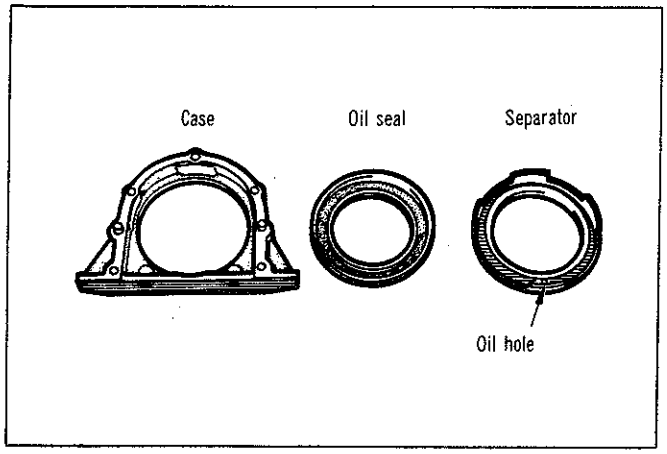


Fig. 82—Rear crankshaft seal assembly (early type)

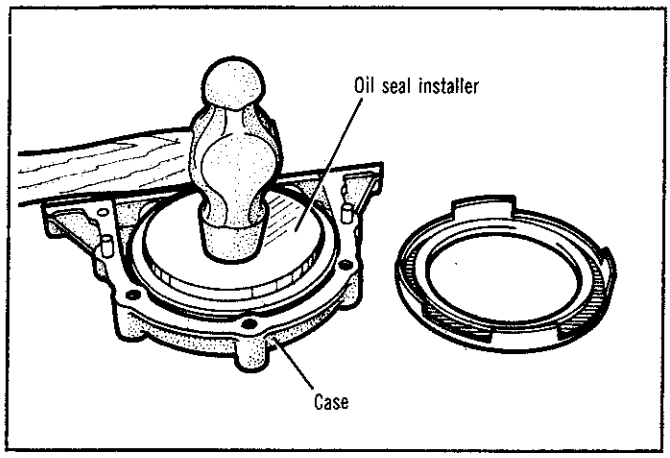


Fig. 83—Installing oil seal into case (early type)

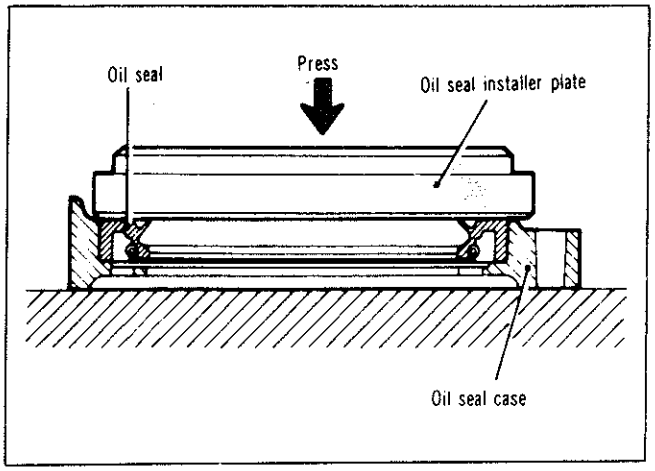


Fig. 84—Installing oil seal into case (late type)

(15) Install the drive chain/belt, sprockets and timing cover as previously described under Camshaft Drive Chain/Belt.

(16) Install the oil screen.

(17) Install the oil pan with a new gasket, coating both sides of the entire gasket with a sealant. Extra sealant should be applied to the block to chain case and rear oil seal case to block joint faces. Tighten the oil pan bolts in a criss-cross pattern.

(18) Install the oil pressure switch.

(19) Set the engine upright and install the cylinder head assembly as previously described under Cylinder Head.

(20) Install the engine mounting brackets and install engine into vehicle as previously described.

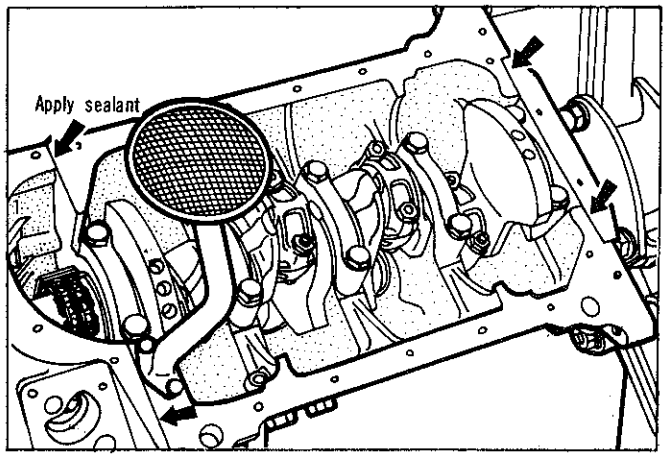


Fig. 85—Sealant application points

BELT ADJUSTMENT

On later models adjusting holes are provided in the lower cover to allow external adjustment of belt tension should it become loose or noisy. To adjust the belt tension with the cover in place proceed as follows:

(1) Remove the timing belt front upper cover.

(2) Turn the crankshaft clockwise until "A" mark on camshaft sprocket is aligned with the timing mark on the upper cover. If the camshaft sprocket has no "A" mark, align the under upper timing mark with the second tooth from the timing mark "O" on the camshaft sprocket. This position corresponds to the "A" mark position (Fig. 86).

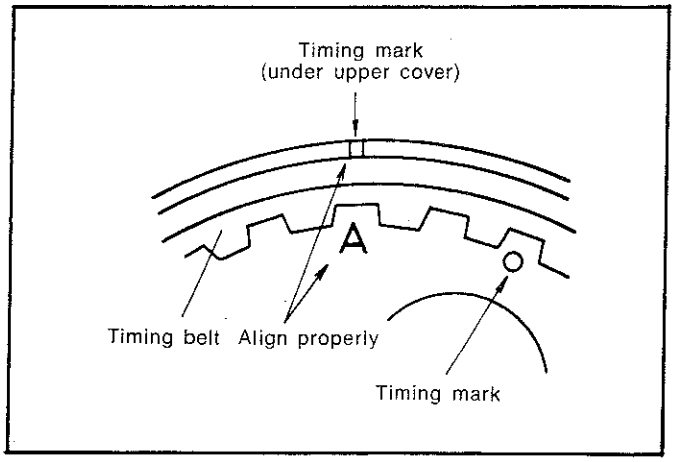


Fig. 86—Aligning timing marks

NOTE: After setting the timing marks as previously described, the camshaft is positioned a little past T.D.C. of No. 1 cylinder and therefore the slack side of the timing belt gathers on the tensioner side. When aligning the "A" mark, be careful not to turn the crankshaft counterclockwise, otherwise the belt on the tensioner side will become too tight, resulting in maladjustment.

(3) Remove fan belt, remove access cover (2 places) by inserting a screw driver in the slot provided and pry off (Fig. 87).

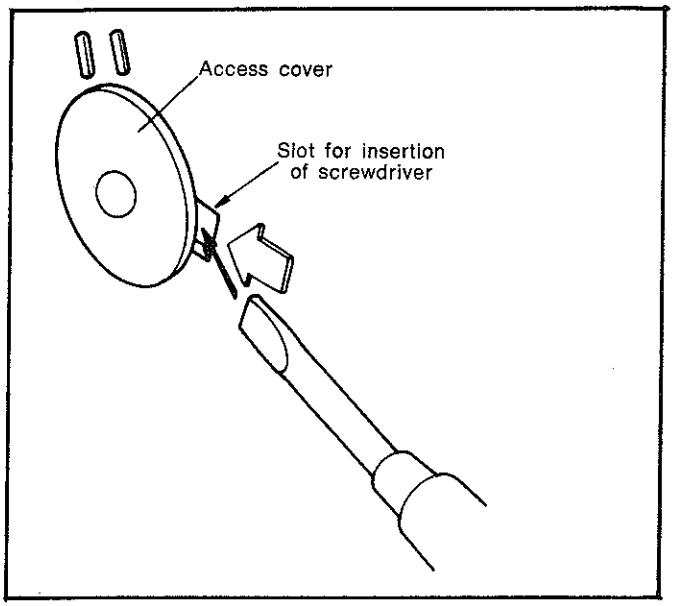


Fig. 87—Removing access cover

(4) Using a special tool E9M55 loosen the upper attaching nut and then the lower bolt.

NOTE: Loosen the bolt and nut by 180° to 200°, if loosened more than needed they can drop into the cover.

(5) Insert a screw driver from above the timing belt cover, slightly push tensioner bracket towards tensioning direction and then release (Fig. 88). The belt tension will be automatically adjusted with tension spring tension.

(6) Tighten tensioner upper attaching nut first and then tighten the lower bolt, using special tool E9M55.

NOTE: If the bolt is tightened first, the belt tension can become excessive.

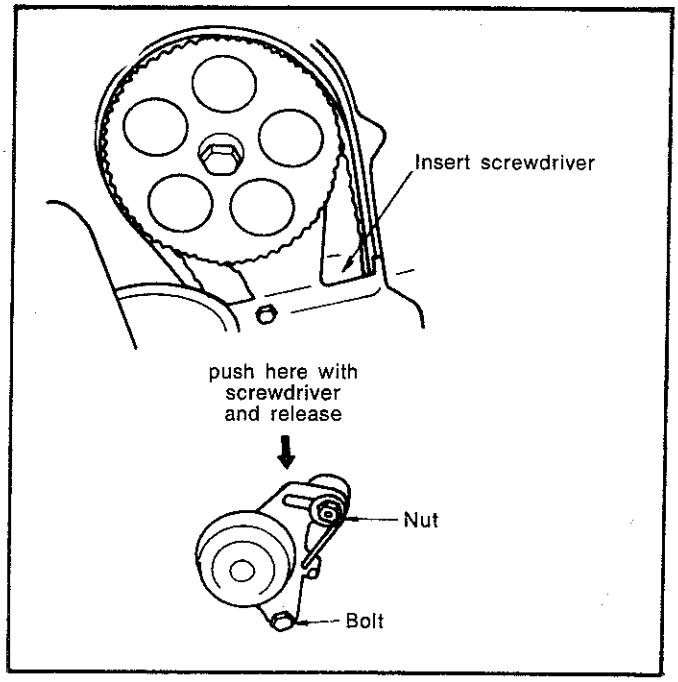


Fig. 88—Adjusting belt tensioner

(7) Install the two access covers to their respective adjusting holes. The cover can easily be installed by sliding the cover with its hook placed between the locating pins (Fig. 89), refit the fan belt.

(8) Replace timing belt front upper cover.

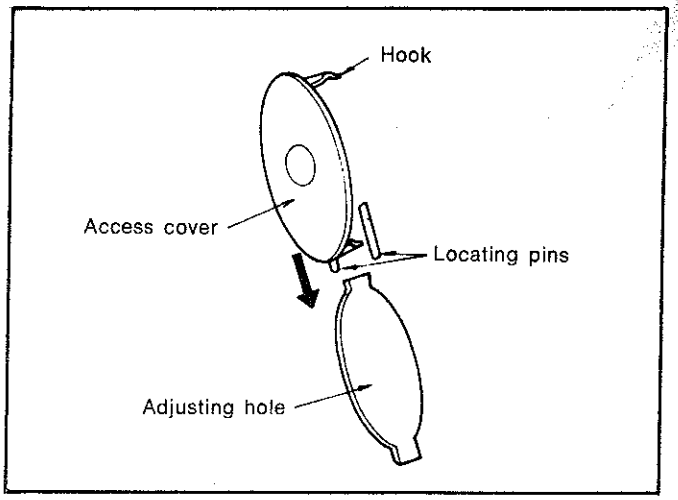


Fig. 89—Installing access covers

SECTION 3E — ENGINE ASSEMBLY: ASTRON TYPE FOUR CYLINDER

SPECIFICATIONS

ENGINE GENERAL

Type		In line OHC with Counter Balance Shafts
Number of Cylinders		Four
Engine No. — 1,85 Litre	(Imported)	51
	(Early Local)	M324 (Later) M334
— 2,0 Litre	(Imported)	52
	(Early Local)	M421, M425, (Later) M431, M434, M435
— 2,6 Litre	(Imported)	54
	(Local)	M531
Bore — 1,85 Litre		81,0 mm (3.189")
— 2,0 Litre		84,0 mm (3.307")
— 2,6 Litre		91,1 mm (3.587")
Stroke — 1,85/2,0 litre		90,0 mm (3.543")
— 2,6 litre		98,0 mm (3.858")
Displacement — 1,85 Litre		1855 cm^3 (113.2 $in.^3$)
— 2,0 Litre		1995 cm^3 (121.7 $in.^3$)
— 2,6 Litre		2555 cm^3 (155.8 $in.^3$)
RAC Power Rating — 1,85 Litre		16,2
— 2,0 Litre		17,4
— 2,6 Litre		20,5
Compression Ratio — 1,85 Litre		8.5:1
— 2,0 Litre		9.5:1
— 2,6 Litre		8.2:1
Compression Pressure @ 250 R.P.M. — 1,85 Litre		1050 kPa (150 p.s.i.)
— 2,0 Litre		1310 kPa (190 p.s.i.)
— 2,6 Litre		1170 kPa (170 p.s.i.)
Maximum Variation Between Cylinders		10%
Spark Plug Type — 1,85 Litre		N12Y
— 2,0 Litre		N9Y
— 2,6 Litre		N12Y
Firing Order		1, 3, 4, 2
Direction of Rotation		Clockwise Observed From Front of Vehicle

CYLINDER HEAD

Material	Aluminium Alloy
Type	Hemispherical Combustion Chambers, Cross Flow Design
Maximum Allowable Distortion	0.05 mm (0.002")
Cylinder Head Height (Between Block and Rocker Cover Gasket Surface)	90,0 mm (3.543")
Maximum Allowable Re machining of Surface	0,30 mm (0.012")
Inlet Valve Seat Insert Hole Diameter	
— 0,05 mm (0.002") Oversize	44,050 to 44,075 mm (1.7342" to 1.7352")
— 0,3 mm (0.012") Oversize	44,300 to 44,325 mm (1.7441" to 1.7451")
— 0,6 mm (0.024") Oversize	44,600 to 44,625 mm (1.7559" to 1.7569")
Exhaust Valve Seat Insert Hole Diameter	
— 0,05 mm (0.002") Oversize	38,050 to 38,075 mm (1.4980" to 1.4990")
— 0,3 mm (0.012") Oversize	38,300 to 38,325 mm (1.5079" to 1.5089")
— 0,6 mm (0.024") Oversize	38,600 to 38,625 mm (1.5197" to 1.5207")
Inlet and Exhaust Valve Seat Insert Height	
— 0,3 mm (0.012") Oversize	7,90 to 8,10 mm (0.3110" to 0.3189")
— 0,6 mm (0.024") Oversize	8,20 to 8.40 mm (0.3228" to 0.3307")
Valve Guide Hole Diameter	
— 0,05 mm (0.002") Oversize	13,05 to 13,07 mm (0.5138" to 0.5145")
— 0,25 mm (0.010") Oversize	13,25 to 13,27 mm (0.5216" to 0.5224")
— 0,50 mm (0.020") Oversize	13,50 to 13,52 mm (0.5315" to 0.5323")
Camshaft/Camshaft Bearing Clearance	0,05 to 0,09 mm (0.0020" to 0.0035")

VALVES	
Material — Inlet — 1,85/2,0 Litre	Heat Resisting Steel of JIS STD (SUH3B)
— 2,6 Litre	As above plus "Sur-sulf" coated
— Exhaust	Heat Resisting Austenitic Steel, Stellite Faced
Head Diameter — Inlet	43,0 mm (1.693")
— Exhaust	35,0 mm (1.378")
Stem Diameter	8,0 mm (0.315")
Stem Diameter Wear Limit — Inlet	0,10 mm (0.004")
— Exhaust	0,15 mm (0.006")
Valve Face Angle	45°
Valve Head Thickness — Inlet	1,20 mm (0.0472")
— Exhaust	2,00 mm (0.0787")
Valve Seat Contact Width	0,90 to 1,30 mm (0.035" to 0.051")
Valve Stem to Guide Clearance — Inlet	0,025 to 0,055 mm (0.0010" to 0.0022")
— Exhaust	0,050 to 0,085 mm (0.0020" to 0.0033")
Valve Clearance (Hot) — Inlet	0,15 mm (0.006")
— Exhaust	0,25 mm (0.010")
Installed Height Between Spring Seat and Retainer	40,40 mm + 1,0 mm (1.590" + 0.039")
Valve Stem Seal Installed Dimension	14,70 to 15,10 mm (0.579" to 0.595")
VALVE GUIDES	
Outside Diameter	13,00 to 13,10 mm (0.512" to 0.516")
Inside Diameter	8,000 to 8,018 mm (0.3150" to 0.3157")
Length — Inlet	47,0 mm (1.850")
— Exhaust	52,0 mm (2.047")
Installed Dimension	13,70 to 14,30 mm (0.5394" to 0.5630")
Cylinder Head Hole Size for Oversize Guides	
— 0,05 mm (0.002")	13,05 to 13,07 mm (0.5138" to 0.5145")
— 0,25 mm (0.010")	13,25 to 13,27 mm (0.5216" to 0.5224")
— 0,50 mm (0.020")	13,50 to 13,52 mm (0.5315" to 0.5323")
VALVE SPRINGS	
Number	8
Free Length	47, 47 mm - 1,0 mm (1.869" - 0.039")
Load/Compressed Height	28 kg/40,40 mm (61 lbs/1.59")

VALVE TIMING	**1,85/2,0 Litre**	**2,6 Litre**
Inlet Opens	24° BTDC	25° BTDC
Inlet Closes	64° ABDC	59° ABDC
Duration	268°	264°
Exhaust Opens	59° BBDC	64° BBDC
Exhaust Closes	25° ATDC	20° ATDC
Duration	264°	264°
Overlap	49°	45°

CAMSHAFT	
Material	Grey Cast Iron
Camshaft Bearings	5
Bearing Clearance	0,05 to 0,09 mm (0.002" to 0.0035")
Journal Diameter	34,0 mm (1.339")
End Float	0,10 to 0,20 mm (0.004" to 0.008")
Camshaft Bend	0,02 mm (0.0008") or less
Height of Cam Lobe — 1,85/2,0 Litre — Inlet	42,18 mm (1.6605")
— Exhaust	42,25 mm (1.6630")
— 2,6 Litre — Inlet	42,50 mm (1.6732")
— Exhaust	42,56 mm (1.6756")
Nominal Cam Lift — 1,85/2,0 Litre	10,0 mm (0.400")
— 2,6 Litre	10,5 mm (0.413")
Rocker Arm to Rocker Shaft Clearance	0,013 to 0.043 mm (0.0005" to 0.0017")
SPROCKET CAMSHAFT	
Material	Cast Iron
Number of Teeth	38

GEAR — CAMSHAFT DRIVE

Material	Grey Cast Iron
Number of Teeth	19

SPROCKET — COUNTER BALANCE SHAFTS

Material	Carbon Steel
Number of Teeth	17

GEAR — COUNTER BALANCE SHAFT DRIVE

Material	Grey Cast Iron
Number of Teeth	34

TIMING CHAIN

Type	Duplex Roller
Number of Links	102
Pitch	9,525 mm (0.375")
Chain Tensioner Spring Length	
— Unloaded	65,71 mm (2.587")
— Loaded at 2,0 kg (4.4 lbs)	36,91 mm (1.453")

COUNTER BALANCE SHAFTS DRIVE CHAIN

Type	Single Roller
Number of Links	90
Pitch	8,0 mm (0.315")
Chain Adjuster	Manual adjustment of chain guide

COUNTER BALANCE SHAFTS

Front Journal Diameter	23,0 mm (0.9055")
Rear Journal Diameter	43,0 mm (1.6922")
Journal to Bearing Clearance — Front	0,02 to 0,06 mm (0.0008" to 0.0024")
— Rear	0,043 to 0,086 mm (0.0017" to 0.0034")

CYLINDER BLOCK

Material	Alloy Cast Iron
Maximum Allowable Distortion Upper Face	0,05 mm (0.002")
Height of Block (Between Cylinder Head and Oil Pan Gasket Surface)	316,0 mm (12.441")
Maximum Allowable Re-machining of Surface	0,20 mm (0.008")
Cylinder Bore Diameter — 1,85 Litre	81,0 mm (3.189")
— 2,00 Litre	84,0 mm (3.3071")
— 2,60 Litre	91,1 mm (3.5870")
Maximum Bore Oversize	1,20 mm (0.047")
Maximum Diameter Difference Between Cylinders	0,02 mm (0.0008")
Maximum Ovality	0,01 mm (0.0004")
Maximum Taper	0,01 mm (0.0004")
Main Bearing Tunnel Bore Diameter (Early Block)	70,00 mm (2.7559") (Later block) 64,01 mm (2.5200")

PISTONS

Material	Aluminium Alloy Tin Plated
Type	Closed Slipper (Elliptically Turned)
Piston Pin Hole	22,0 mm (0.866")
Mass of Pistons — 1,85 Litre	361 ± 3 g (12.734 ± 0.106 oz.)
— 2,00 Litre	400 ± 3 g (14.109 ± 0.106 oz.)
— 2,60 Litre	420 ± 3 g (14.815 ± 0.106 oz.)
Piston Diameter (Measured 2,0 mm (0,079") from the bottom of the piston)	
— 1,85 Litre Grade A	80,97 to 80,98 mm (3.1878" to 3.1882")
B	80,98 to 80,99 mm (3.1882" to 3.1886")
C	80,99 to 81,00 mm (3.1886" to 3.1890")
— 2,00 Litre Grade A	83,97 to 83,98 mm (3.3059" to 3.3063")
B	83,98 to 83,99 mm (3.3063" to 3.3067")
C	83,99 to 84,00 mm (3.3067" to 3.3071")

PISTONS Continued	
— 2,60 Litre Grade A	91,07 to 91,08 mm (3.5854" to 3.5858")
B	91,08 to 91,09 mm (3.5858" to 3.5862")
C	91,09 to 91,10 mm (3.5862" to 3.5866")
Piston Bore Clearance — 2,00 Litre	0,03 to 0,05 mm (0.0012" to 0.0020")
— 2,60 Litre	0,02 to 0,04 mm (0.0008" to 0.0016")
Piston Oversizes	0,25 mm (0.010")
	0,50 mm (0.020")
	0,75 mm (0.030")
	1,00 mm (0.039")
PISTON PIN	
Type	Press Fit in Connecting Rod
Material	Cold Forged Chrome Molybdenum Steel
Diameter	22,0 mm (0.866")
Length — 1,85 Litre	72,0 mm (2.835")
— 2,00 Litre (Imported)	75,0 mm (2.953")
— 2,00 Litre (Local)	72,0 mm (2.835")
— 2,60 Litre	79,0 mm (3.110")
Offset in Piston	1,0 mm (0.039")
Clearance in Piston	0,005 to 0,009 mm (0.0002" to 0.0004")
PISTON RINGS	
Number	3
Ring Gap — New — Compression	0,249 to 0,399 mm (0.0098" to 0.0157")
— Scraper and Oil Ring	0,249 to 0,449 mm (0.0098" to 0.0177")
— Service Limit (All)	1,00 mm (0.039")
Side Clearance — New — Compression	0,061 to 0,100 mm (0.0024" to 0.0039")
— Scraper	0,020 to 0,061 mm (0.0008" to 0.0024")
— Service Limit — Compression	0,15 mm (0,006")
— Scraper	0,12 mm (0.005")
CONNECTING RODS	
Material	Drop Forged Steel
Length Between Centres	166,0 mm (6.535")
Conrod Mass	0,831 kg (29.251 oz.)
Small End Bore Diameter	21,974 to 21,985 mm (0.8651" to 0.8655")
Big End Bore Diameter	56,00 mm (2.20")
Conrod Bearing Clearance	0,015 to 0,056 mm (0.0006" to 0.0022")
Conrod Bearing Undersizes	0,25 mm (0.010")
	0,50 mm (0.020")
	0,75 mm (0.030")
Conrod Bend or Distortion (within)	0,025 mm (0.001")
Conrod Side Clearance on Journal	0,10 to 0,25 mm (0.004" to 0.010")
Bearing Material	Triple Layer Steel Backed
CRANKSHAFT	
Material	Drop Forged Steel
Number of Main bearings	5
Main Bearing Journals	
— Standard Diameter (Early crank)	66,0 mm (2.5984") (Later crank) 60,0 mm (2.3622")
— Maximum Allowable Ovality	0,01 mm (0.0004")
— Maximum Allowable Taper	0,01 mm (0.0004")
Main Bearing Clearance — All Except Centre Journal	0,016 to 0,045 mm (0.0006" to 0.0018")
— Centre Journal	0,028 to 0,057 mm (0.0011" to 0.0022")
Bearing Material	Triple Layer Steel Backed
Main Bearing Undersizes — Rework Diameter (Early Crank)	
— 0,25 mm (0.010")	65,735 to 65,750 mm (2.5880" to 2.5886")
— 0,50 mm (0.020")	65,485 to 65,500 mm (2.5781" to 2.5787")
— 0,75 mm (0.030")	65,235 to 65,250 mm (2.5683" to 2.5689")

CRANKSHAFT (Continued)

Main Bearing Undersizes — Rework Diameter (Later Crank)	
— 0,25 mm (0.010")	59,735 to 59,750 mm (2.3518" to 2.3524")
— 0,50 mm (0.020")	59,485 to 59,500 mm (2.3419" to 2.3425")
— 0,75 mm (0.030")	59,235 to 59,250 mm (2.3321" to 2.3327")
Main Bearing Journal Length — All except No. 3	31,00 to 31,05 mm (1.220" to 1.222")
— No. 3	30,90 to 31,10 mm (1.216" to 1.224")
Connecting Rod Bearing Journal	
— Standard Diameter	53,00 mm (2.0866")
— Maximum Allowable Ovality	0,01 mm (0.0004")
— Maximum Allowable Taper	0,01 mm (0.0004")
Conrod Journal Length	28,35 to 28,40 mm (1.116" to 1.118")
Conrod Bearing Undersizes — Rework Diameter	
— 0,25 mm (0.010")	52,735 to 52,750 mm (2.0762" to 2.0768")
— 0,50 mm (0.020")	52,484 to 52,500 mm (2.0663" to 2.0669")
— 0,75 mm (0.030")	52,235 to 52,250 mm (2.0565" to 2.0571")
Crankshaft End Float	0,050 to 0,178 mm (0.002" to 0.007")
End Float Controlled by	No. 3 Bearing
Pinion Pilot Bearing	Roller Bearing
Outside Diameter	32,0 mm (1.260")
Inside Diameter	15,0 mm (0.590")
Dynamic Balance in Relation to Centre Line	34 g/cm (0.47 oz./inch)
Flywheel out of Round	0,127 mm (0.005")

SPECIAL TOOLS

E192	Compressor — Piston Ring
E0102	Compressor — Valve Spring
E9A5	Counter-balance Shaft Bearing Installer
E9A6	Counter-balance Shaft Bearing Puller
E9M30C	Installer Valve Stem Seal
E9M30	Kit-Remover/Installer Valve Guide and Oil Seal Installer
E9A7	Remover/Installer — Piston Pin

TORQUE SPECIFICATIONS

APPLICATION	Nm	lbs./ft.	lbs./ins.
Camshaft Bearing Caps	18-19	13-14	
Camshaft Sprocket	49-58	36-43	
Connecting Rod Cap	45-46	33-34	
Counter-balance Chamber Cover	4-5	3-4	36-48
Counter-balance Shaft Bolts	30-38	22-28	
Crankshaft Pulley	108-127	80-94	
Cylinder Block to Engine Mounting	44-54	33-40	
Cylinder Head Attaching Bolts —			
Initial Torque (new gasket)	108-113	79-83	
Cold	88-98	65-72	
Hot	98-110	72-80	
Cylinder Head to Timing Chain Cover	12	9	108
Engine Support Bracket to Body	10	7	84
Flywheel or Drive Plate	127-137	94-101	
Front insulator to Engine Bracket	14-19	10-14	
Front Insulator to Sub Frame	30-39	22-29	
Heater Joint	20-38	15-28	
Inlet/Exhaust Manifold	15-19	11-14	
Main Bearing Cap	73-83	54-61	
Oil and Temperature Gauge Unit	30-38	22-28	
Oil Filter	11-12	8-9	96-108
Oil Pan	6-8	5-6	60-72
Oil Pan Drain Plug	58-77	43-57	
Oil Pump Cover	15-19	11-14	
Rear Insulator to Engine Support Bracket	14-19	10-14	
Rear Insulator to Transmission — Manual	20-23	15-17	
— Automatic	13-15	10-12	
Rocker Cover	5-7	4-5	48-60
Spark Plug	24-28	18-21	

NOTE: Torque figures quoted are for clean, dry threads in good condition.

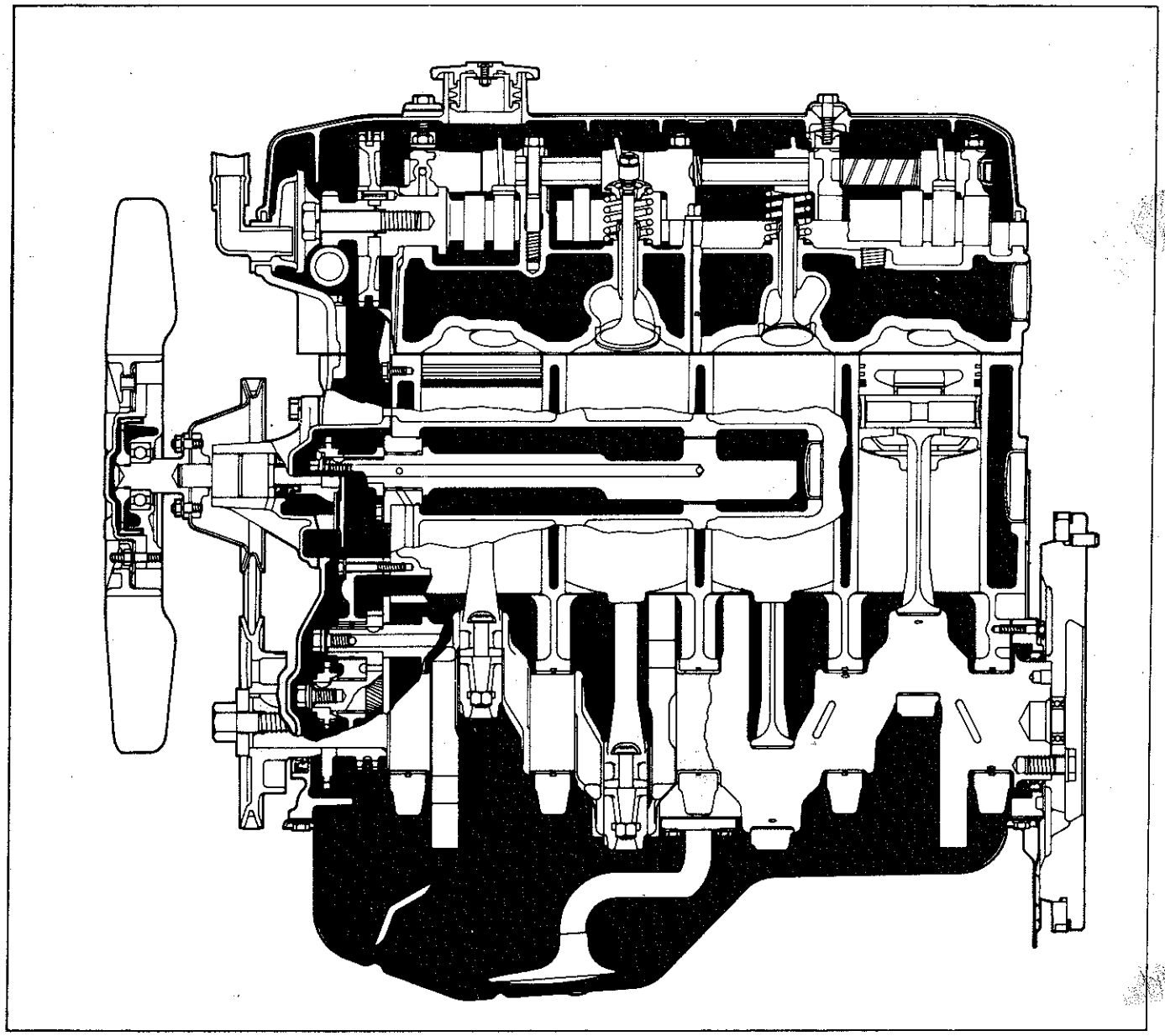


Fig. 1—Astron engine longitudinal section

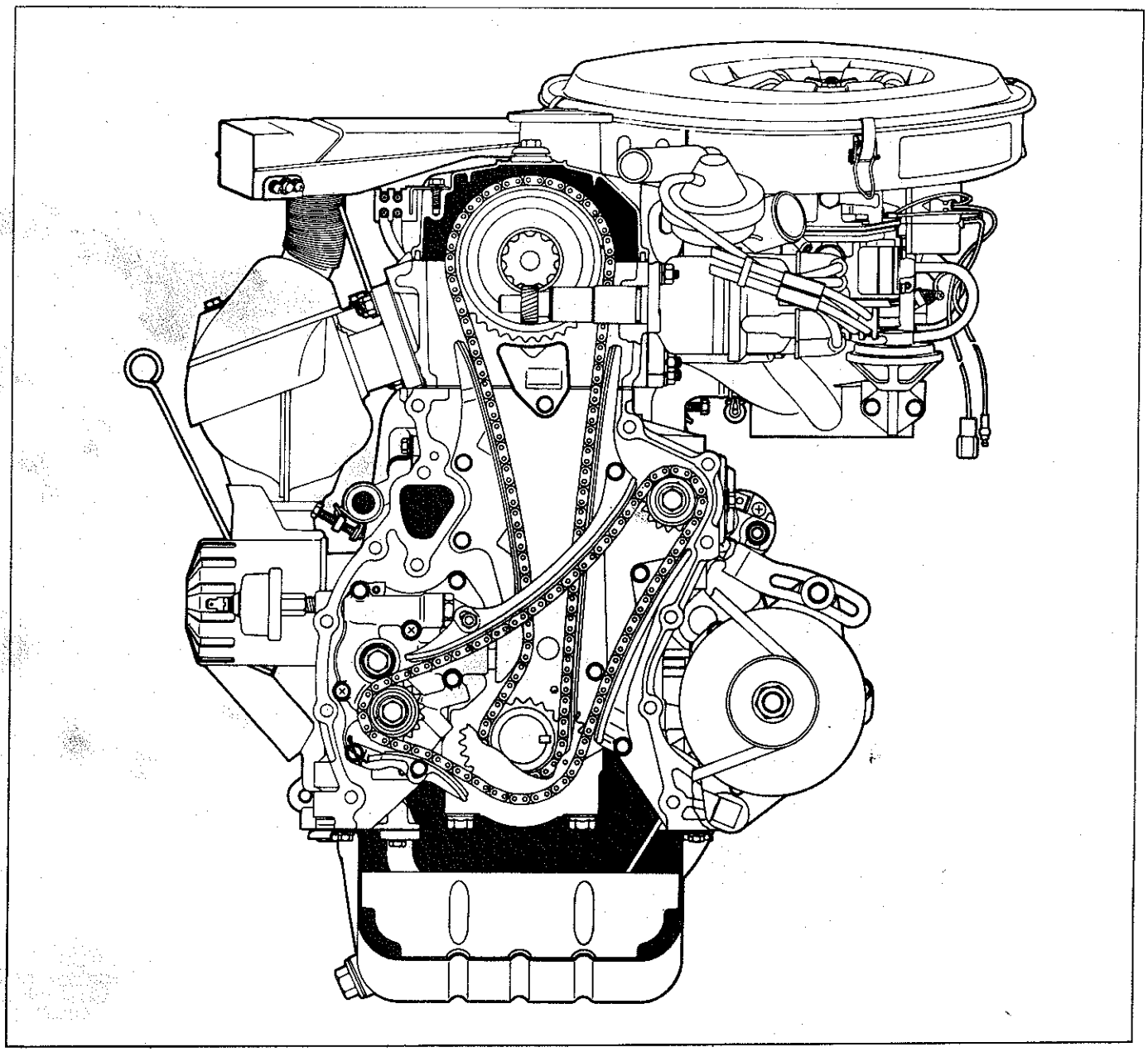


Fig. 2—Astron engine front section

GENERAL INFORMATION

The Astron engine is a four cylinder, over head cam, cross flow design with hemispherical combustion chambers. Two counter balance shafts are incorporated in the cylinder block to reduce engine noise and vibration.

The cylinder head is made of aluminium alloy, being light in weight and ensuring maximum cooling effect. Hemispherical combustion chambers permit the use of large diameter valves helping improve fuel combustion efficiency and minimising differences in combustion chamber volume, thus ensuring smooth engine operation. The cross flow design permits the intake gases to be drawn into the cylinder and exhaust gases to be driven out from the cylinder in one direction, thus improving the effect of combustion chamber scavenging and spark plug cooling.

The camshaft is chain driven by the crankshaft and is supported in the cylinder head by five journals and retained by caps.

The cylinder block is made of alloy cast iron, with good wear resistance characteristics. The crankshaft is supported by five main journals, thrust being taken by the centre bearing.

Two counter balance shafts are incorporated in the cylinder block to cancel vertical and secondary vibrating forces of the engine. The shafts are chain driven from the crankshaft at twice crankshaft speed and in opposite direction to each other. The left hand shaft is mounted in the upper section of the block and rotates in the same direction as the crankshaft. The right hand shaft mounted in the lower section of the block, rotates in the opposite direction to the crankshaft. The right hand shaft rotational direction is reversed by means of a gear drive which in turn is used as the engine oil lubrication pump.

ENGINE REMOVAL

(1) Drain the cooling system.

(2) Disconnect the battery negative lead.

(3) Remove radiator hoses, heater hoses, automatic transmission cooler pipes (if applicable) and remove radiator.

(4) Disconnect all wiring to alternator, distributor, coil, starter motor, sending units, cut off solenoid and transmission.

(5) Remove air cleaner and disconnect all vacuum lines, fuel lines and linkages.

(6) Disconnect exhaust pipe, propellor shaft and gear linkages.

(7) Remove the gear lever (manual trans. vehicles).

(8) Disconnect clutch cable and speedo cable.

(9) Remove the engine hood (Refer Group 23).

(10) Drain engine and transmission oil.

(11) Disconnect all engine mountings.

(12) Install a suitable engine lifting bracket and remove the engine and transmission with a suitable lifting hoist.

Installation

(1) Install engine lifting bracket on engine, attach hoist and install engine into vehicle being careful not to damage any engine or body components.

(2) Align engine mounts, position engine and tighten mounts to specification.

(3) Remove hoist and lifting bracket.

(4) Replace all fuel lines, vacuum hoses, electrical wiring, exhaust pipe, throttle control, clutch cable, propellor shaft and air cleaner.

(5) Replace radiator, shroud, radiator hoses, heater hoses and transmission cooler pipes (if applicable).

(6) Replace gear lever (manual trans.) and reconnect transmission linkages.

(7) Fill radiator using rain water or demineralised water and adding corrosion inhibitor (or antifreeze if required).

(8) Fill engine crankcase with the correct grade and quantity of first grade engine oil.

(9) Refill transmission with the correct type and quantity of oil.

(10) Refit engine hood and adjust clearance margins ensuring it closes correctly and securely.

(11) Run engine and check for leaks at oil lines, fuel lines, coolant hoses and oil pan.

(12) Adjust all linkages and settings to specifications.

CYLINDER HEAD

The aluminium alloy cylinder head has hemispherical combustion chambers and is of a cross flow design. An overhead camshaft is supported by five journals and operates the valves through two rocker shafts. Inlet valves are on the left, exhaust valves are on the right. The stem and head of the exhaust valves are welded and the valve face is stellited.

Removal

NOTE: Prior to removing cylinder head allow the engine to cool otherwise cylinder head warpage may occur.

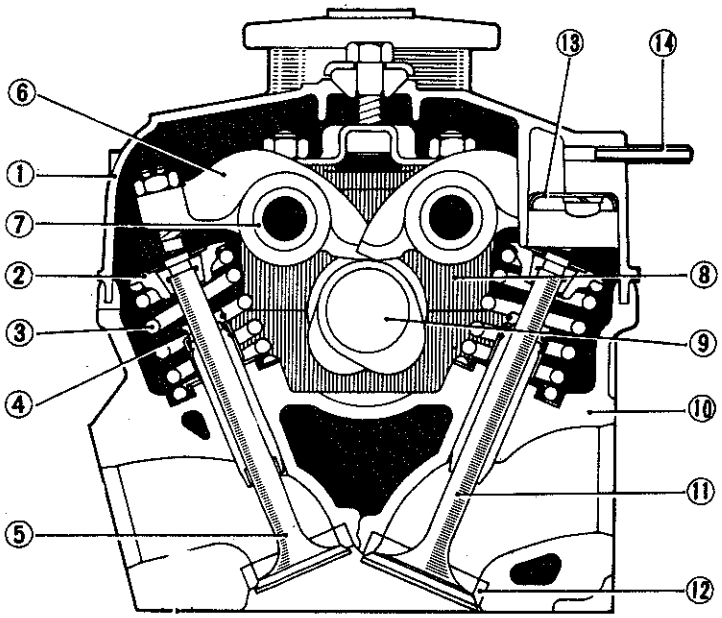
(1) Disconnect the battery negative (ground) terminal.

(2) Drain the water from the radiator and cylinder block.

(3) Disconnect exhaust pipe from manifold.

(4) Disconnect throttle cable, kickdown linkage (if applicable), fuel supply line, vacuum hoses, electrical leads, radiator and heater hoses, etc.

(5) Manually rotate engine to the top dead centre position with No. 1 piston on the compression stroke.



1 Rocker cover
2 Valve spring retainer
3 Valve spring
4 Stem seal
5 Exhaust valve
6 Rocker arm
7 Rocker arm shaft
8 Camshaft bearing cap
9 Camshaft
10 Cylinder Head
11 Intake valve
12 Valve seat ring
13 Baffle plate
14 Nipple (Blowby gas)

Fig. 3—Sectional view cylinder head

(6) Remove distributor.

(7) If the cylinder head is to be disassembled, the inlet and exhaust manifolds can be removed for easier handling of the cylinder head.

(8) Remove the rocker arm cover.

(9) Ensure that No. 1 piston is at top dead centre on the compression stroke by aligning the crankshaft pulley timing mark on the TDC "T" mark of the timing plate. The camshaft dowel pin should be in the upper most position as shown in Fig. 4.

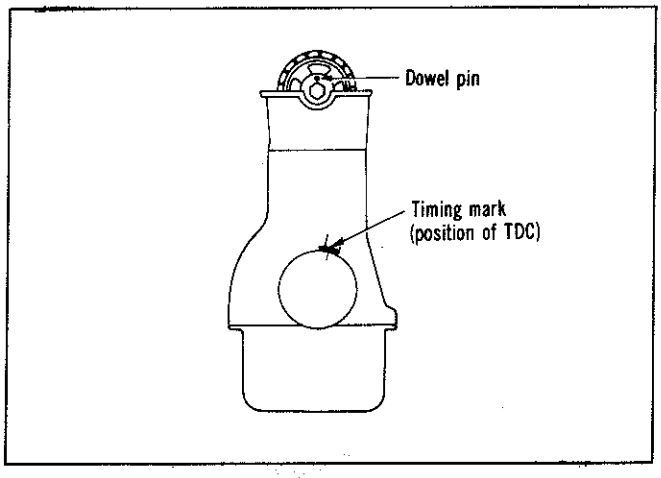


Fig. 4—Position TDC on No. 1 piston

(10) With a suitable marking pencil, mark the timing chain in line with the camshaft dowel pin.

(11) Remove the camshaft sprocket bolt and distributor drive gear and remove the sprocket from the camshaft.

NOTE: Do not remove the sprocket from the timing chain, as this will necessitate timing chain cover removal to realign the timing gears.

(12) Loosen the cylinder head bolts in two stages to prevent cylinder head warpage — use order shown in Fig. 5.

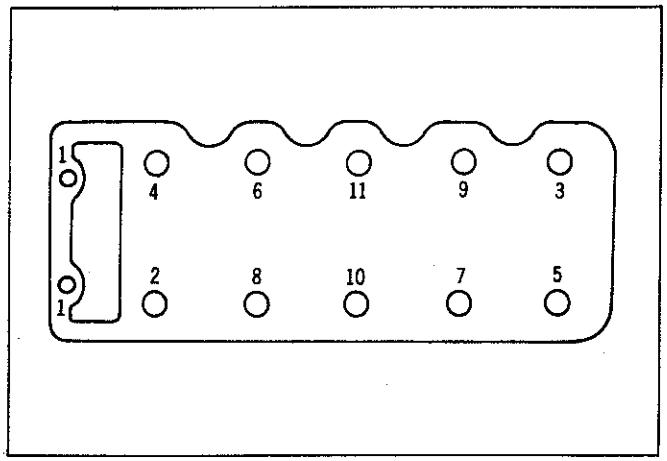


Fig. 5—Cylinder head bolt removal sequence

(13) Remove the cylinder head from the cylinder block by raising it vertically over the timing chain and sprocket.

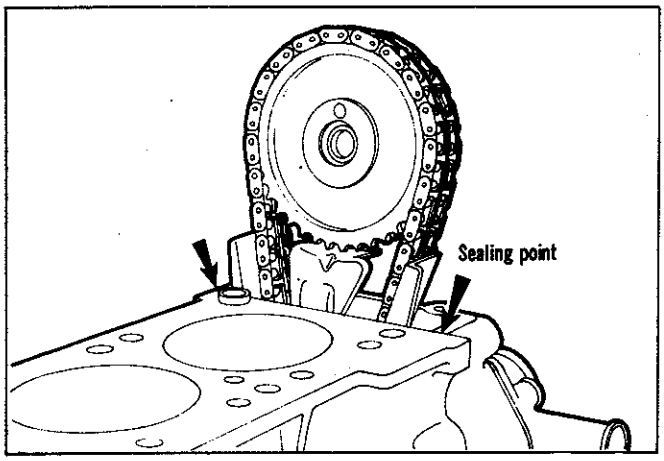


Fig. 6—Sealing points

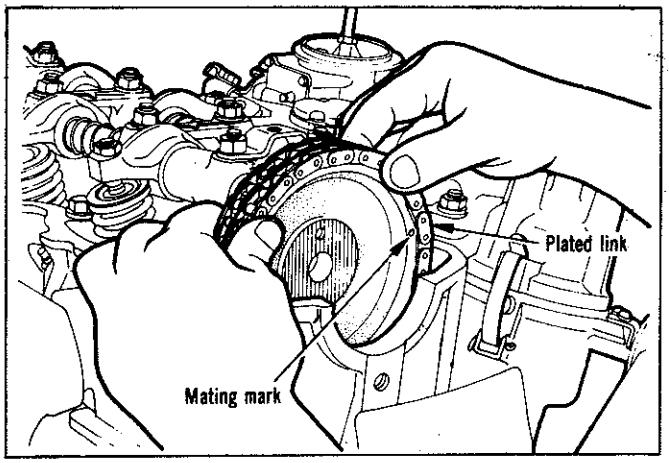


Fig. 8—Installing camshaft sprocket

NOTE: The cylinder head is positioned on the block by two dowel pins. When removing the head, do not twist or slide it or the camshaft sprocket may be dislodged from the chain.

(14) Clean head thoroughly and inspect for damaged surfaces, components, cracks, water leaks, etc.

Installation

(1) Ensure that the joint surface between the top of the chain cover and cylinder block is flat.

(2) Apply sealant to the two joint surfaces as shown in Fig. 6.

(3) Fit the cylinder head gasket to the cylinder block locating it correctly on the dowel pins.

NOTE: Use only jointing compound part numbers P49355, 4067481 (Hylomar) on the cylinder head gasket.

(4) Install the cylinder head locating it on the dowel pins. Do not slide the head across the dowel pins as damage to the head surface may occur. Care must also be taken to avoid dislocation of the camshaft sprocket from the timing chain.

(5) Tighten the cylinder head bolts in three stages to the specified torque and in the sequence shown in Fig. 7.

(6) Install the camshaft sprocket and distributor drive onto the camshaft, rotating the camshaft to align the dowel pin to the sprocket. Ensure that the sprocket mating mark is aligned with the timing chain **plated** link. Temporarily tighten the sprocket bolt.

(7) Turn the crankshaft back 90° and tighten the sprocket bolt to the specified torque.

(8) Adjust the valve clearances to specification.

(9) Install the breather and gasket to cylinder head, applying sealer to the contact surfaces—Refer Fig. 9.

(10) Install the rocker shaft cover and tighten the retaining bolts to specification.

NOTE: It has been established that over tightening of the rocker cover bolts can result in distortion of No. 4 camshaft journal with subsequent danger of camshaft seizure.

(11) Install the intake and exhaust manifolds using new gaskets. Apply sealer to both sides of the inlet manifold around the coolant passages. Tighten the manifold nuts to the specified torque.

(12) Install the distributor.

(13) Connect all linkages, fuel lines, vacuum hoses, breather hoses, electrical leads, radiator and heater hoses, etc.

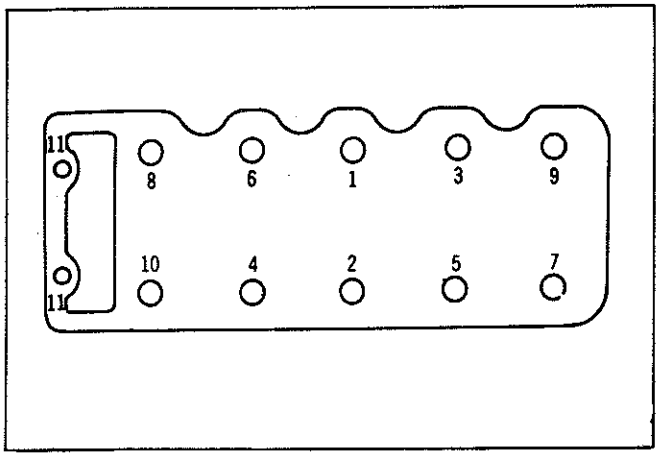


Fig. 7—Cylinder head bolt tightening sequence

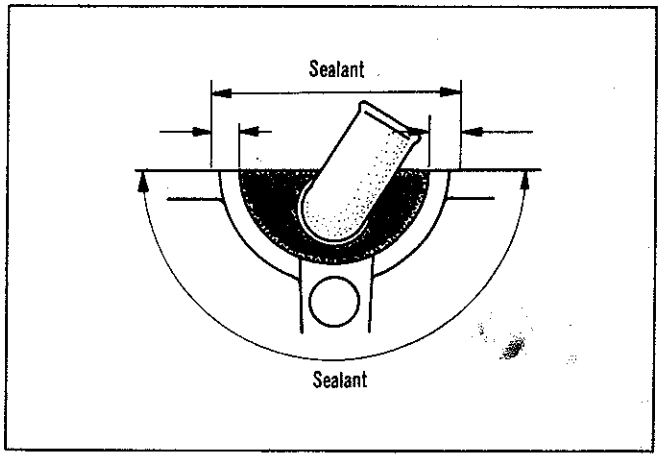


Fig. 9—Breather sealing points

(14) Reconnect exhaust pipe.

(15) Fill the radiator using rain water or demineralised water and adding corrosion inhibitor (or anti-freeze if required).

(16) Connect battery cable and start engine. Run engine until normal operating temperature is reached and check for water or oil leaks.

NOTE: Cylinder head bolts must be retorqued after 800 km (500 miles).

VALVE CLEARANCE ADJUSTMENT

NOTE: Valve clearances must be adjusted with the engine warm and stationary.

(1) Remove air cleaner and rocker shaft cover.

(2) Set No. 1 piston to top dead centre (T.D.C.) on compression stroke.

(3) Loosen the valve adjusting lock nuts.

(4) Adjust the valve clearance on No. 1 inlet and exhaust, No. 2 inlet and No. 3 exhaust to the specified dimension, tighten lock nuts.

(5) Tighten the locknuts.

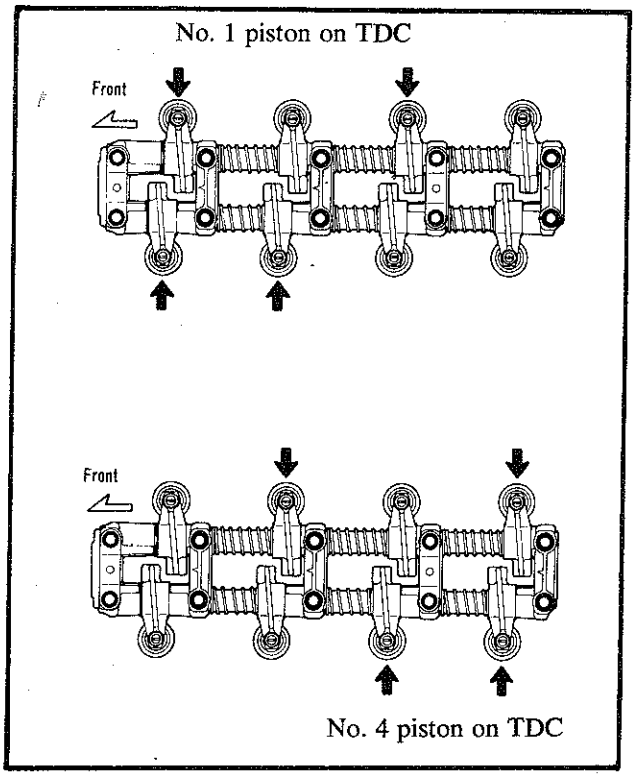


Fig. 10—Valve clearance adjustment sequence

(6) Rotate the engine once and align the crankshaft pulley with the TDC mark, i.e. No. 4 on TDC.

(7) Adjust the valve clearance on No. 4 inlet and exhaust, No. 3 inlet and No. 2 exhaust to the specified dimension.

(8) Install the rocker cover and air cleaner assembly.

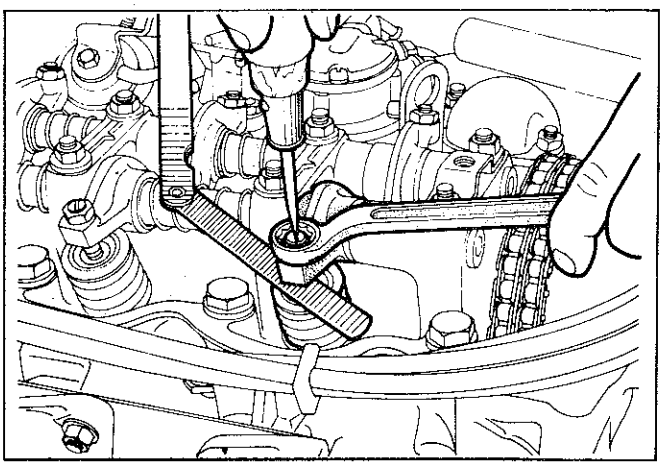


Fig. 11—Adjusting valve clearances.

CYLINDER HEAD ASSEMBLY

With cylinder head removed from engine and inlet and exhaust manifolds removed, proceed as follows:

(1) Remove spark plugs.

(2) Remove camshaft bearing cap nuts.

(3) Holding the front and rear caps, remove the rocker arm shaft assemblies.

(4) Disassemble the caps, rocker arms, springs, shafts and wave washers keeping them in the order of removal. Care should be taken not to lose the camshaft cap locating dowel pins.

(5) Remove the camshaft.

(6) Using a valve spring compressor, remove the collets, spring retainers, springs, spring seats and valves, keeping them in the order of removal.

(7) With the aid of a screwdriver, remove the valve stem seals—Refer fig. 12.

NOTE: Valve stem seals should not be re-used.

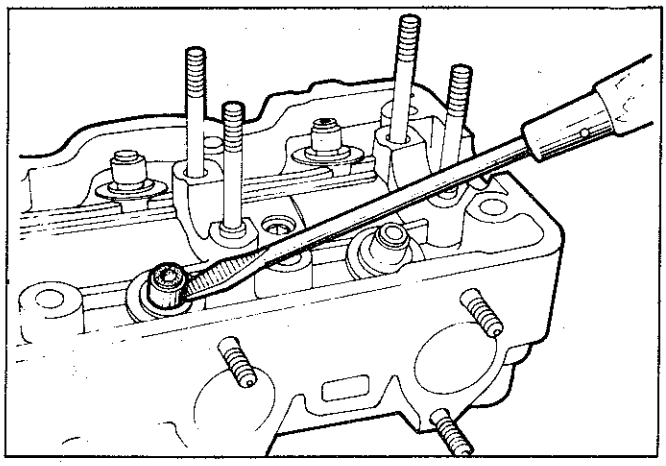


Fig. 12—Removing valve stem seals

Cleaning and Inspection

Check the cylinder head for water leakage and damage before cleaning.

Clean each part carefully removing all pieces of dirt, oil, grease and carbon deposits. Clean oil holes and passages using compressed air ensuring they are not clogged.

Care should be taken not to damage valve seats, cylinder head surface and camshaft journals.

Using a straight edge and feeler gauge, check the cylinder head for distortion as shown in Fig. 13.

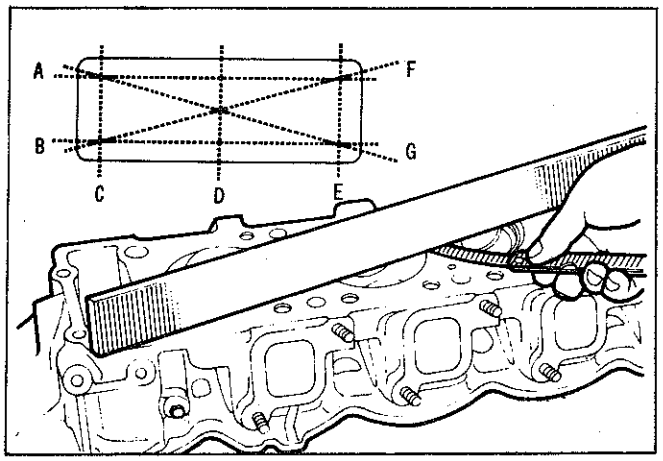


Fig. 13—Check cylinder head distortion

If cylinder head distortion exceeds the specified limit it must be resurfaced.

Check the cylinder head manifold mounting surfaces for flatness or damage.

VALVE GUIDES

Check the valve stem to guide clearance. If the clearance exceeds the specified limit replace the guide with the next oversize guide. Valve guides are shrunk into position, therefore when replacement is necessary the following procedure must be adopted.

(1) Using Tool No. E9M30 remove defective guide towards cylinder block surface.

NOTE: This operation should be conducted with the cylinder head temperature raised to 250°C (480°F) for M.M.C. cylinder heads and 180C° (356°F) for Australian cylinder heads. M.M.C. cylinder heads can be identified by an oil gallery plug at the R.H.F. of the cylinder head, Australian cylinder heads do not have this plug fitted.

CAUTION: Correct identification of the cylinder head before heating is imperative or serious damage can occur.

(2) With the cylinder head at normal temperature, ream the head as specified for the oversize guide.

(3) Heat the cylinder head to the correct temperature (see note), and insert the guides quickly. Using Tool No. E9M30, install guides to the specified dimension.

(4) After guide is installed check the inside diameter and ream to specification if necessary.

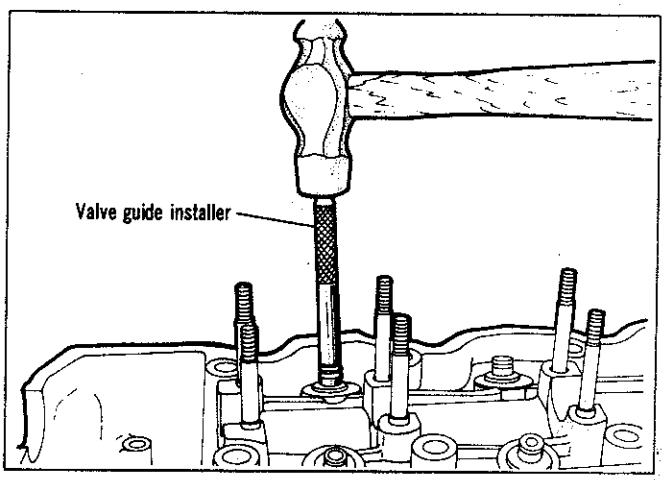


Fig. 14—Removing valve guides

VALVE SEAT INSERT

The valve seat should be checked for overheating and improper contact with the valve face. If faulty it must be re-cut or replaced.

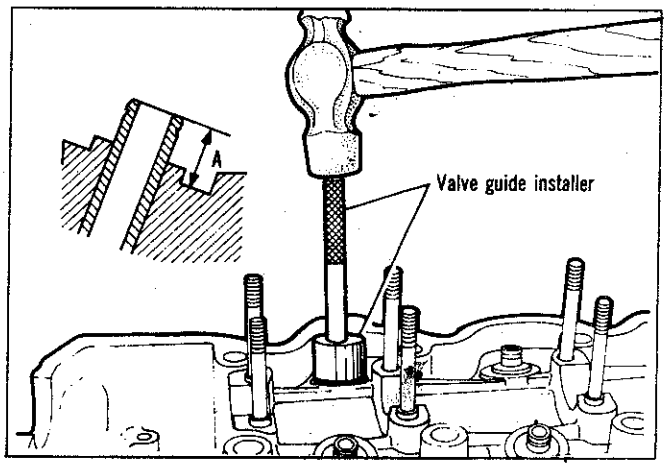


Fig. 15—Installing valve guides

Re-Cutting Valve Seat

(1) Check valve guide for wear, if faulty replace guide as previously described.

(2) Re-condition the seat using either a seat grinder or seat cutter.

(3) The valve seat contact width should be as specified, at the centre of the valve face and as shown in Fig. 16.

(4) After cutting, lap the valve and valve seat lightly with a fine lapping compound.

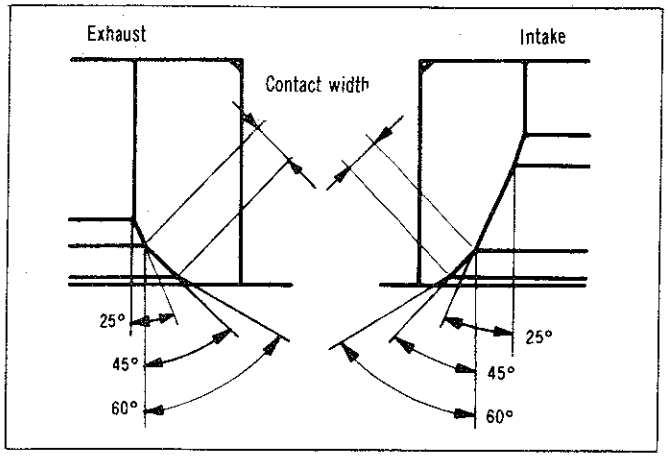


Fig. 16—Valve seat angles

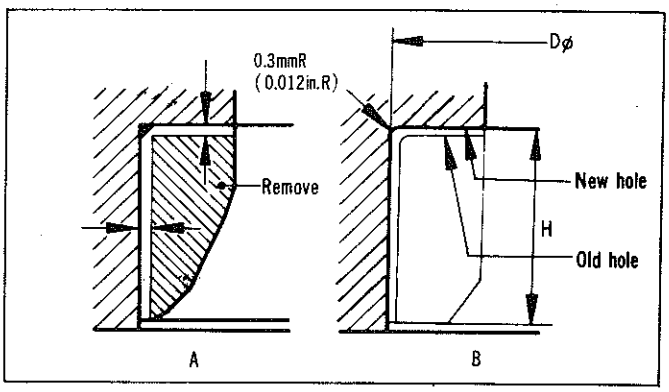


Fig. 18—Replacing valve seat insert

Replacing Valve Seat Insert

Check the valve seat insert "sinkage" by measuring the installed height of the valve spring between the spring retainer and seat. If the sinkage exceeds the specified limit. replace the seat insert as follows:

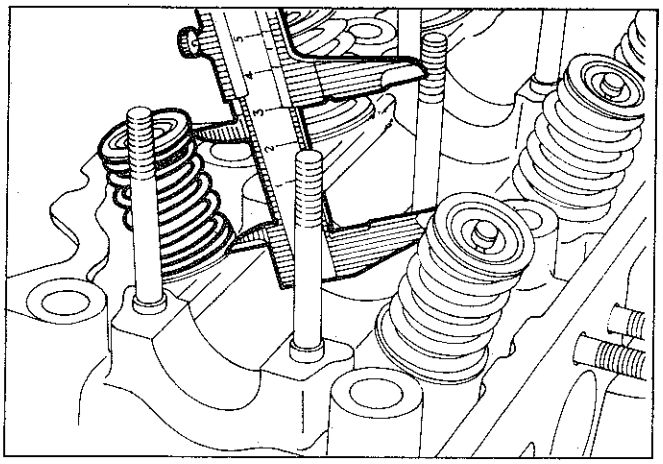


Fig. 17—Checking valve spring installed height

(1) Thin down the valve seat insert by cutting, with a suitable cutter, to within 0,5 to 1,0 mm (0.020" to 0.040") of the cylinder head. Refer to Fig. 18 (A).

(2) Remove the valve seat insert and cut the seat insert bore diameter and height to the dimension shown in the specifications, Refer Fig. 18 (B).

(3) Heat the cylinder head to correct temperature (see note previous page) and press in the new valve seat insert.

(4) Cut the insert to form a new seat as described in Re-cutting Valve Seat.

VALVES

Check each valve for wear, damage and deformation of the head and stem (B).

If the stem tip (A) is pitted it must be re-ground. Remove only sufficient material to restore tip flatness.

If the thickness of the valve face (C) is less than the specified limit, the valve must be replaced.

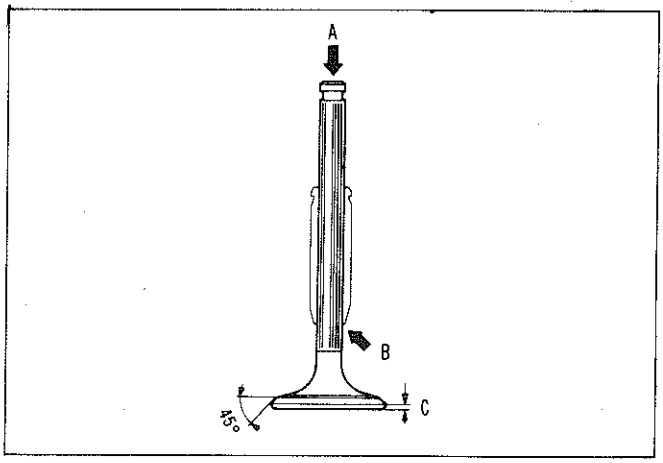


Fig. 19—Valve check points

VALVE SPRINGS

Check the free length and tension of each valve spring. If they are not within specifications replace the spring.

Using a square, check the squareness of each spring. If the spring is excessively out of square, replace the spring.

CAMSHAFT AND CAMSHAFT BEARING CAP

(1) Check the camshaft for bending by supporting it at the ends and mounting a dial indicator at the No. 2 or No. 3 journal. Rotate the camshaft once. Half of the total indicator reading is the amount of camshaft bend, if this exceeds the specified limit the camshaft should be repaired or replaced.

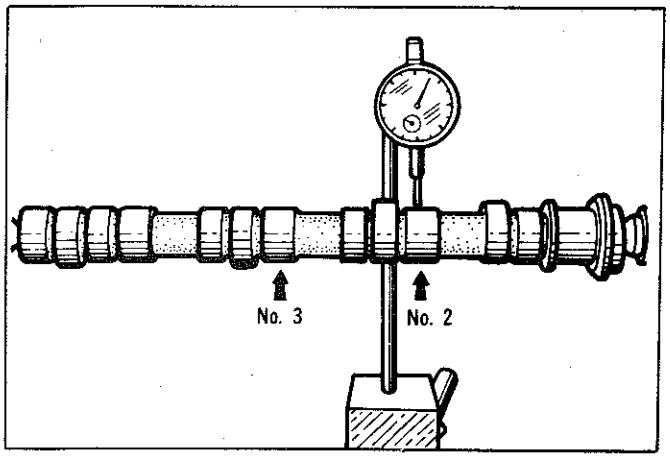


Fig. 20—Checking camshaft for bending

(2) Check the cam lobes and profile for damage. If the lobe or profile are damaged, or worn excessively (see specifications), replace the camshaft.

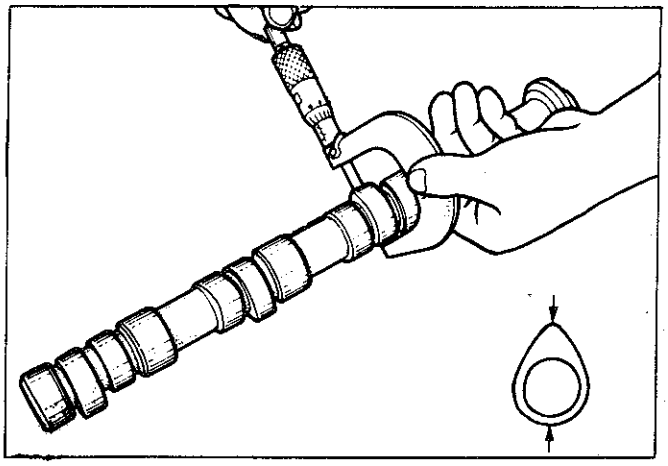


Fig. 21—Checking cam lobe height

(3) Check the camshaft caps for damage on the inner surface. If the caps are excessively damaged the cylinder head must be replaced.

Check the camshaft journal to cap clearance by installing the caps to the cylinder head and measuring the cap inside diameter and the camshaft journal outside diameter as shown in Figs. 22 and 23. If the clearance exceeds the specified limit and the journals are worn, replace the camshaft. If the caps are worn replace the cylinder head.

NOTE: The cap retaining nuts must be tightened to the specified torque prior to measuring internal diameter.

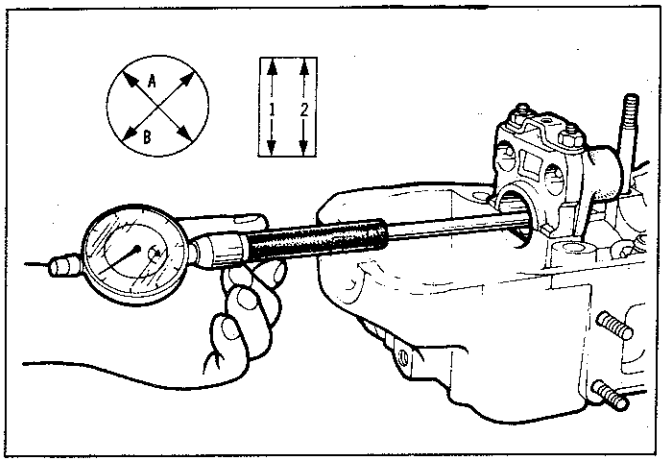


Fig. 22—Measuring camshaft cap diameter

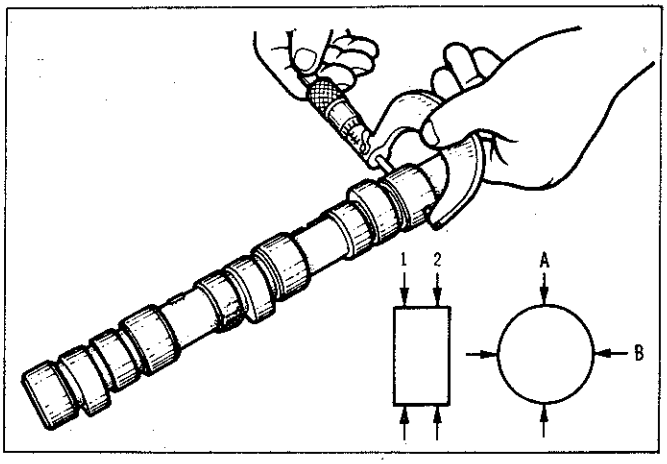


Fig. 23—Measuring camshaft journal diameter

(4) Check the camshaft end float, if it exceeds the specified limit check the camshaft and cylinder head for wear and replace the faulty component.

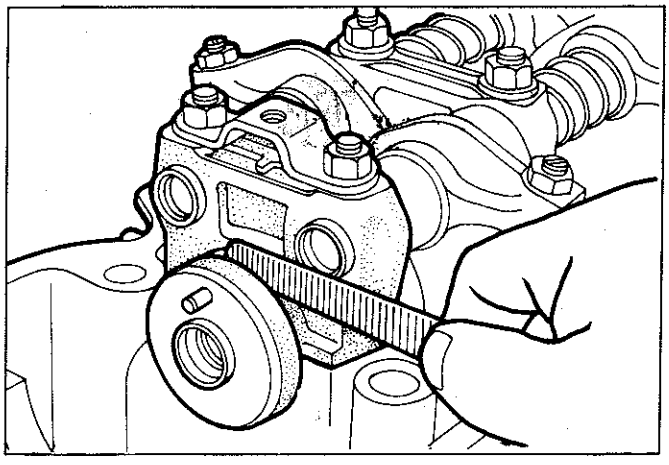


Fig. 24—Checking camshaft end float

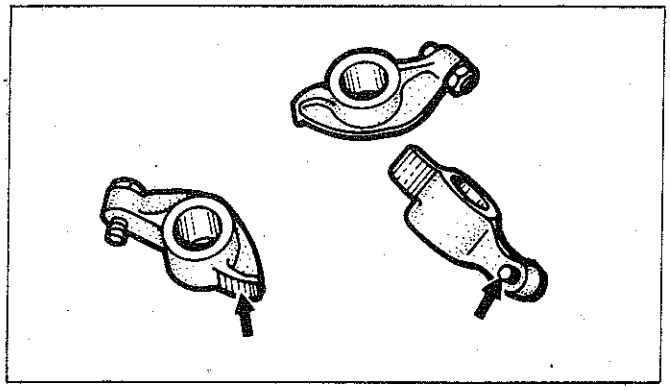


Fig. 25—Checking the rocker arms

ROCKER ARMS AND ROCKER ARM SHAFTS

(1) Check if rocker arm to cam lobe contact face and adjusting screw to valve contact is damaged or worn. If only slight wear is evident they can be corrected with an oil stone. If they are severely worn or damaged they must be replaced.

(2) Check the clearance between the rocker arms and rocker arm shaft, if they exceed the specified limit replace the arms or shafts.

(3) Check the rocker arm shafts for damage and bend, if faulty they must be replaced.

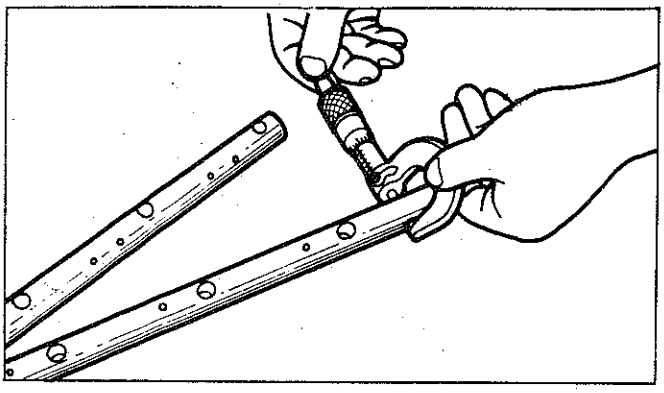


Fig. 26—Measuring rocker arm shafts diameter

NOTE: As a running change the cast iron rocker arm was replaced with assemblies made from die cast aluminium plus the introduction of oil grooves in the rocker shafts. The early rocker arms can can be used on the later rocker shafts, the later rocker arms MUST NOT be used on the early non grooved shafts.

CYLINDER HEAD REASSEMBLY

When assembling cylinder head ensure all parts are thoroughly cleaned and that all moving parts are lubricated with engine oil prior to assembly.

(1) Install the valve spring seats.

(2) Install the valve stem seals over the valve guides using Tool No. E9M30C. The seal is installed to the specified position by the tool. Failure to position the seal correctly will cause damage to the seal resulting in oil passing the seal.

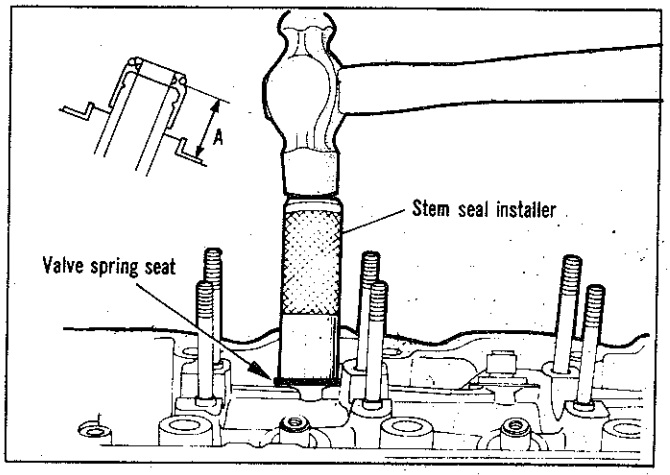


Fig. 27—Installing valve stem seals

NOTE: Old stem seals must not be reused.

(3) Apply engine oil to the valve stem and install the valves into the guides. Do not use excessive force to press the valve stem past the valve stem seal.

(4) Ensure the valve moves smoothly in the guide.

(5) Install valve springs and spring retainers.

NOTE: Install valve springs with the enamel identification marks facing the rocker arms.

(6) Using a valve spring compressor install the valve collets.

NOTE: When compressing the spring, take care that the spring retainer is not forced against the valve stem seal.

(7) Position the cam shaft onto the cylinder head and check end float.

(8) Install the caps, rocker arms, springs and wave washers onto both rocker arm shafts. The caps must be installed with the indicating arrow facing the front of the engine and in the order they were removed. The springs must also be fitted onto the correct shaft, right hand shaft springs are 82,4 mm (3.24") long, left hand springs are 64,5 mm (2.54") long, on later engines the shorter spring

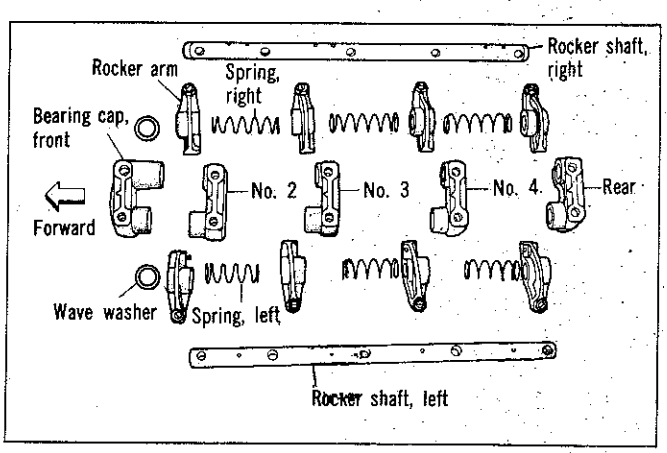


Fig. 28—Rocker arm shaft assemblies

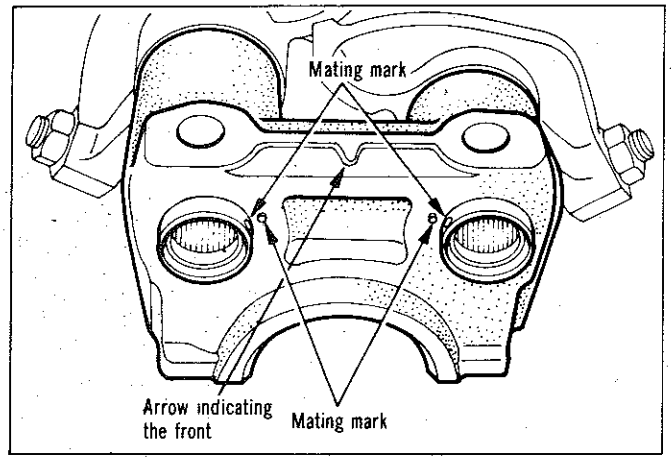


Fig. 29—Rocker arm shaft to cap alignment

is used on both L/H and R/H shafts. The right hand shaft has 12 oil holes, the left hand shaft has 4 oil holes; on later engines fitted with aluminium rockers the shafts also have grooves at the oil holes.

NOTE: When assembling the rocker arm shafts to the caps align the mating marks on the shafts and cap.

Install the wave washers with the convex side facing the front of the engine.

(9) Position the camshaft with the sprocket locating dowel in the uppermost position (Fig. 30).

(10) Install the cap dowel bushings and position the rocker shaft assembly onto the cylinder head.

(11) Install the rocker arm cover ataching brackets to the front and No. 4 camshaft caps.

(12) Install cap retaining nuts and tighten in two stages to the specified torque. Tightening order — No. 3, 2, 4, front and rear.

(13) Install spark plugs.

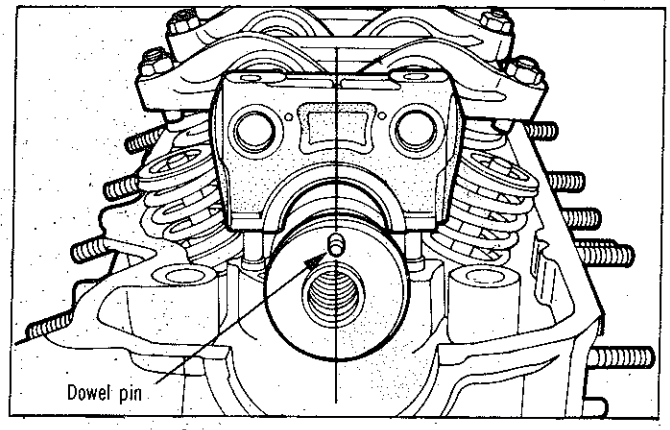


Fig. 30—Positioning camshaft for installation

CAMSHAFT AND COUNTER-BALANCE SHAFT DRIVE CHAINS

Later model engines are fitted with an access hole in the timing chain cover to the left of, and above, the crankshaft pulley. This facilitates 'in-service' adjustment of the counter-balance shaft drive chain. To adjust—

(1) Remove the cover plate.

(2) Loosen the bolt that protrudes through the opening. Loosen enough to remove drag caused by the spring washer but DO NOT remove the bolt completely.

(3) To remove slack from the chain, apply firm 'finger pressure' on the lever that protrudes through the opening.

(4) Release the pressure on the lever, re-apply light 'finger-pressure' on the lever and tighten the bolt securely. DON'T apply pressure with a screw driver (or similar tool) as this may lead to excessive chain noise and/or chain guide wear.

(5) Replace the cover gasket and refit the cover.

Removal

(1) Drain cooling system and remove radiator, hoses, fan and alternator.

(2) Rotate the engine to T.D.C. with No. 1 piston on compression.

(3) Drain engine oil and remove engine oil pan bolts allowing oil pan to clear timing chain cover.

(4) Remove the crankshaft pulley.

(5) Remove rocker cover, distributor and remove the two bolts attaching the cylinder head to the timing chain cover.

(6) Remove the timing chain cover being careful not to damage the head gasket.

(7) Remove the balancer shaft chain guides A, B and C—Refer Fig. 31.

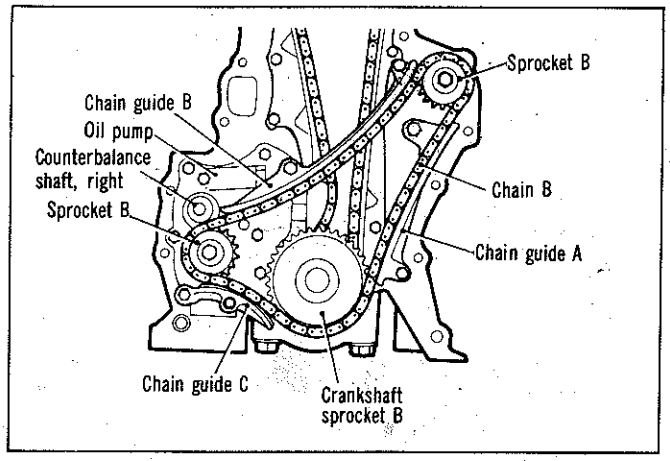


Fig. 31—Counter-balance shafts drive chain

(8) Remove the bolts retaining the counter-balance shaft sprockets "B".

(9) Remove the crankshaft sprocket "B", counter-balance shaft sprocket "B" and drive chain "B".

(10) Remove the camshaft sprocket retaining bolt and remove the sprocket holder.

(11) Depress the chain tensioner and remove the camshaft sprocket and timing chain.

(12) If necessary the crankshaft sprocket and chain guides can be removed.

(1) Install the timing chain guides and the camshaft sprocket holder.

(2) Install the chain tensioner spring and plunger onto the oil pump.

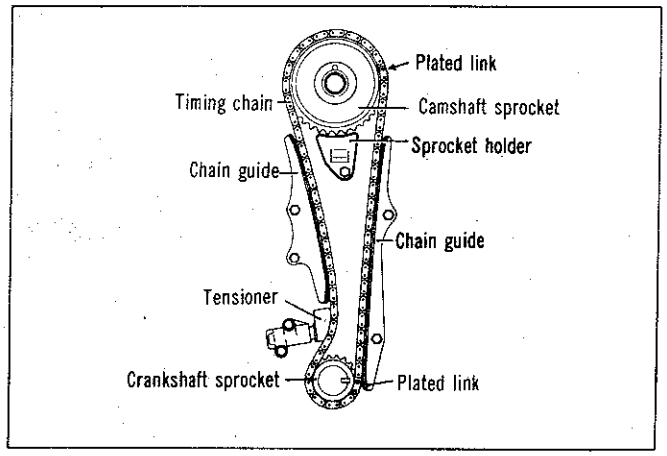


Fig. 32—Timing chain drive

(3) Install the camshaft and crankshaft sprockets onto the timing chain with the sprocket mating marks aligned with the plated links on the chain.

(4) With the sprocket and chain mating marks aligned, install the crankshaft sprocket onto the crankshaft.

(5) Align camshaft dowel pin with the camshaft sprocket and install sprocket onto camshaft. Tighten sprocket bolt to the specified torque.

(6) Install the counter-balance shaft crankshaft sprocket "B".

(7) Install the two counter-balance shaft sprockets "B" onto chain "B" aligning the mating marks on the sprockets with the plated links on the chain. (Refer Fig. 33).

NOTE: Ensure the right hand sprocket (oil pump) is installed with the chamfer side facing inward and the left hand sprocket with the chamfer facing outward.

(8) While holding the chain and sprockets assembled as above, install the chain onto the crankshaft sprocket with the plated chain link aligned with the mating mark on the crankshaft sprocket.

(9) Install the counter-balance shaft sprockets (onto the shaft) and oil pump driven gear at the same time.

(10) Install the sprocket retaining bolts and tighten to specification.

NOTE: Ensure the sprocket mating marks align with the plated chain link.

(11) Temporarily install chain guides "A", "B" and "C".

(12) Tighten the chain guide "A" mounting bolts.

(13) Tighten the chain guide "C" mounting bolts.

(14) Take-up all the chain slackness at point "P", Fig. 33. Adjust the chain guide "B", so that when the chain is pulled in the direction "Y" with finger tips, the clearance between the chain guide "B" and the chain links is 1,0 mm (0.040"). Tighten the chain guide bolts securely.

(15) Install the timing chain cover.

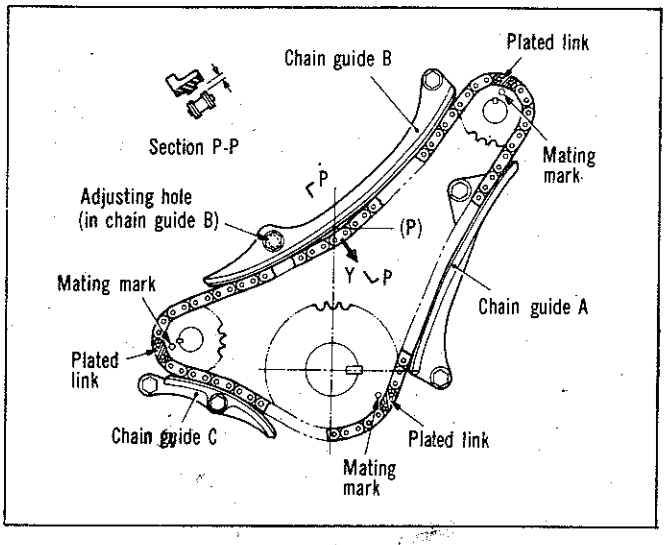


Fig. 33—Counter-balance shaft chain alignment and adjustment (early type chain guide B)

(16) Install the bolts attaching the cylinder head to the timing cover and torque to specification, install distributor and rocker shaft cover.

(17) Install the crankshaft pulley and tighten the retaining bolt to the specified torque.

(18) Install the engine oil pan, tighten retaining bolts to the specified torque.

(19) Install the fan, radiator, hoses and alternator, readjust fan belt.

(20) Fill the cooling system with rain or demineralised water, add corrosion inhibitor (or anti-freeze if required).

(21) Fill the engine with the correct grade and quantity of first grade engine oil.

(22) Reset ignition timing.

CYLINDER BLOCK DISASSEMBLY

The cylinder block can be disassembled with the engine either in or out of the vehicle. This mainly depends on the amount of reconditioning required.

The following description details the disassembly with the engine removed from the vehicle and transmission removed from the engine.

(1) Remove the cylinder head assembly as described under Cylinder Head Removal.

(2) Remove the oil pan and oil screen.

(3) Remove the counter-balance shaft and camshaft drive chains as previously described.

(4) Remove the flywheel and clutch assembly or torque convertor drive plate.

(5) Remove the bolt retaining the oil pump driven gear to the counter-balance shaft and then remove the oil pump retaining bolts and remove the pump.

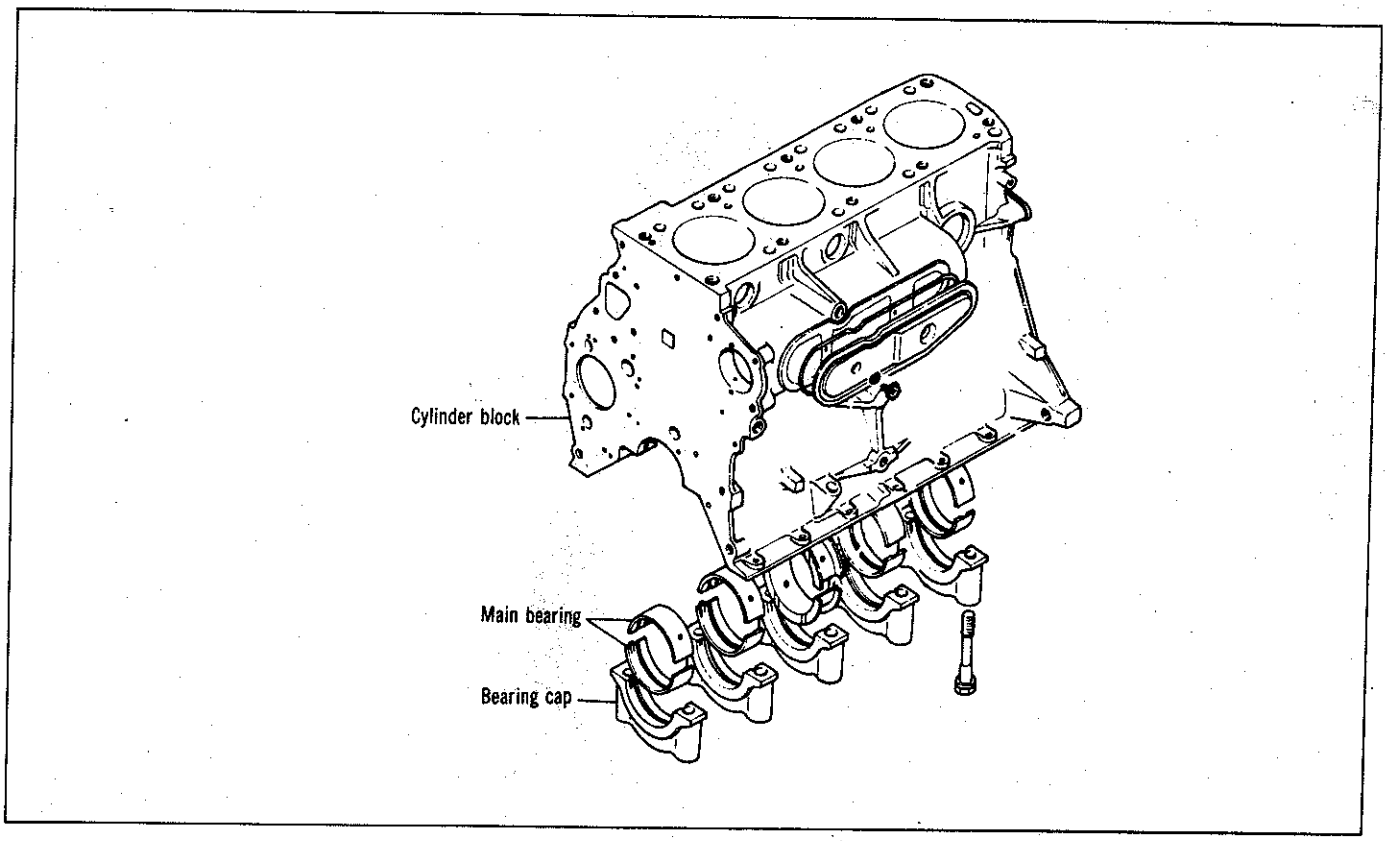


Fig. 34— Early cylinder block (showing grooved lower bearing shells and caps)

NOTE: If the bolt retaining the oil pump gear to the counter-balance shaft is difficult to remove, remove the oil pump and counter-balance shaft as an assembly and then remove the bolt.

(6) Remove the bolts securing the left hand counter-balance shaft thrust plate.

(7) Thread two 8 mm diameter bolts into the thrust plate flange holes and remove thrust plate by simultaneously turning the bolts into the flange. The bolts will pull the thrust plate away from the cylinder block.

NOTE: Later thrust plates have the threads deleted from the holes, in this situation remove the side cover plate and using a hammer and soft drift, tap out the thrust plate and shaft assembly from the inside.

(8) Withdraw the counter-balance shaft.

(9) Remove the crankshaft rear oil seal assembly.

(10) With the cylinder block on its side, remove the connecting rod caps.

NOTE: Later model fully imported engines do not have the cylinder number stampings on the rod or cap. Mark the rod and cap with the appropriate cylinder number as an aid to assembly.

(11) With the aid of a soft piece of wood push the piston and rod assembly out through the top of the cylinder block, keeping the piston assemblies and caps in the order removed.

NOTE: Prior to removing the piston and rod assemblies, remove all carbon deposits and/or cylinder ridge from the cylinder bore.

(12) Remove the piston rings from the pistons keeping them in order of removal.

(13) Remove the pistons from the rods using Tool No. E9A7.

(13) Remove the crankshaft bearing caps and lower bearings, keeping them in removed order.

(14) Remove the crankshaft and the upper bearing halves.

NOTE: The main bearings (except the centre one) are interchangeable, however, if they are to be reused they should be installed in the original position.

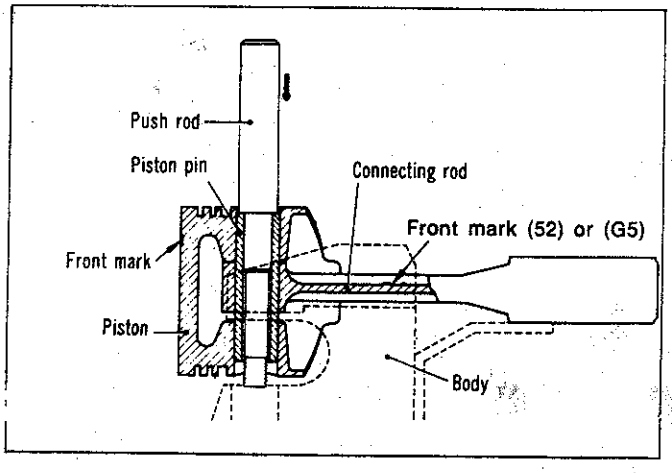


Fig. 35—Removing piston from connecting rod

Cleaning and Inspection

Before cleaning, check the cylinder block for water leakage, cracks or damage.

When cleaning, remove all traces of oil, grease, dirt, carbon and scale from all components. Clean out all oil passages by blowing with compressed air.

Checking Cylinder Block

(1) Check the cylinder bores for scratches, rust, corrosion, cracks or any defects or damage, if faulty the block must be rebored or replaced.

(2) Check the upper surface of the cylinder block for distortion using a straight edge and feeler guages. If it is not within specifications the surface must be refaced. If refacing is necessary, an equivalent amount must be removed from the timing chain case to maintain a flat gasket surface.

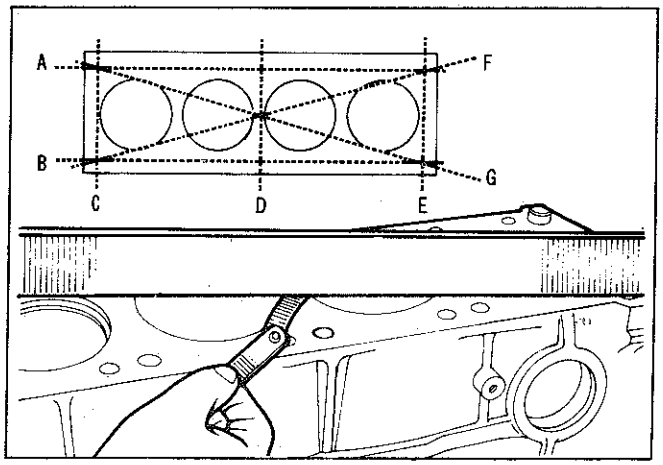


Fig. 36—Checking cylinder block for distortion

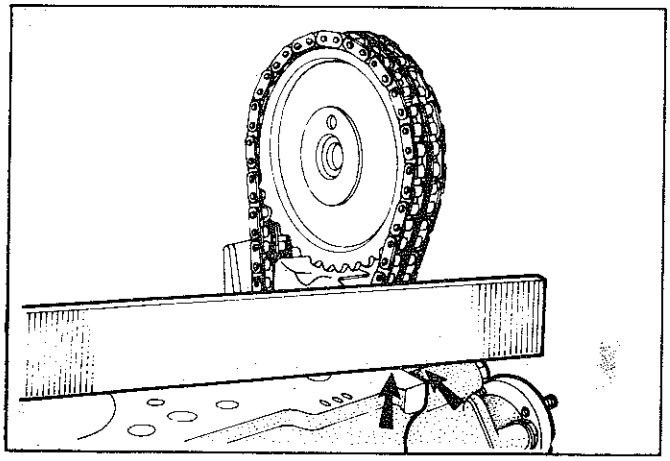


Fig. 37—Checking cylinder block and timing chain case step

(3) Measure the cylinder bore size at three levels. If the wear exceeds the specified limit the cylinders must be re-bored to the next piston size.

NOTE: If only one cylinder requires re-boring, all the cylinders MUST be re-bored.

(4) If the cylinder does not require re-boring, remove the ridge at the top of the cylinder and hone the bores if necessary.

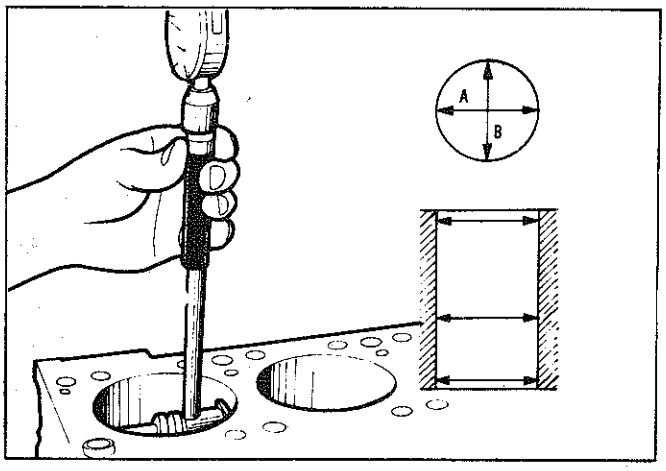


Fig. 38—Measuring cylinder bores

Cylinder Boring

(1) The piston size to be used should be determined by the cylinder which has the largest bore size.

(2) Check the outside diameter of each oversize piston at the skirt and across the thrust faces. The measurement should be taken at a point 2,0 mm (0.079") from the bottom of the piston.

(3) To determine the cylinder re-bore size proceed as follows:

(a) Measure the diameter of the piston.

(b) Allow piston to bore clearance.

(c) Honing margin = 0,02 mm (0.0008") or less.

(d) Finished re-boring size = a + b — c = a + 0 to 0,02 mm (0.0008").

(4) The cylinder should be re-bored to the size obtained by the calculation.

(5) The final cut should not be greater than 0,05 mm (0.002").

NOTE: Do not attempt to cut too much from the bore at one time.

(6) To prevent heat distortion of the bores when re-boring, the cylinders should be bored in the following sequence: 2-4-1-3 or 3-1-4-2.

(7) The cylinder bore size will vary immediately after re-boring, due to the heat generated by the cutting operation, therefore care should be taken when measuring the bore size.

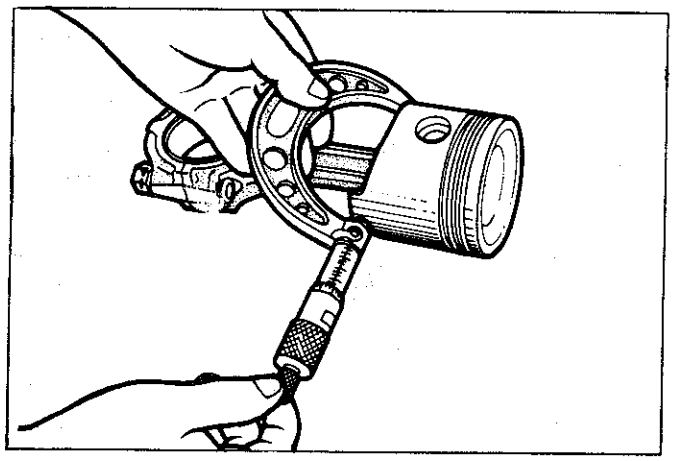


Fig. 39—Measuring piston diameter

(8) After cutting, the bore should be honed accurately to the finished size. The bores should be honed until all traces of the cutting operation are removed. The honing angle should be between 30° and 45°.

(9) Check the piston to cylinder wall clearance.

PISTONS, PISTON PINS AND PISTON RINGS

(1) Check the pistons for seizure, nicks, wear, cracks and any other defect. Replace any faulty pistons.

(2) Check the piston pin to piston pin hole fit. The pin must be a smooth hand press fit into the piston hole. Replace any piston and pin assembly that is defective.

(3) Check the piston rings for breakage, damage and abnormal wear. Replace any defective rings.

NOTE: If a piston is replaced, new rings should also be fitted.

(4) Measure the piston ring side clearance by placing the ring in its respective piston groove and checking the clearance with a feeler gauge. If it exceeds the specified limit, recheck the clearance with a new piston ring. If the clearance is still excessive replace the piston and rings, if it is within specification, replace the rings only.

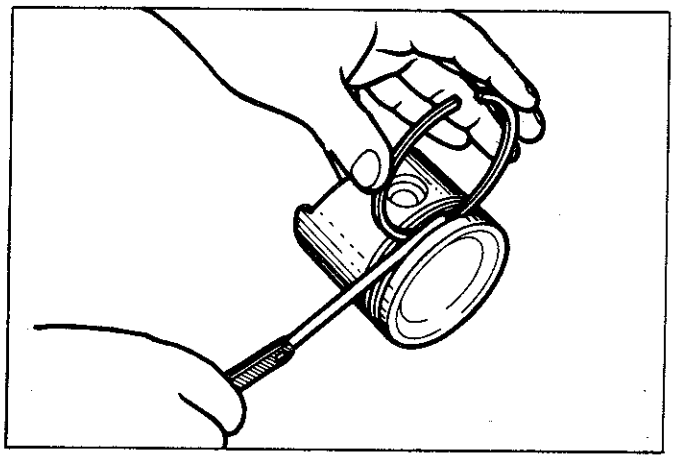


Fig. 40—Measuring piston ring side clearance

(5) Measure the piston ring end gap by inserting the ring into the cylinder and positioning it at right angles to the cylinder wall by pressing it down with a piston. Remove the piston and measure the ring gap using a feeler gauge. If the gap exceeds the specified limit, replace the piston rings.

NOTE: If the cylinders are not being re-bored, the ring gap measurement should be made at the lower part of the cylinder, the area having the least wear. When replacing the piston rings, be sure to use rings of the same size.

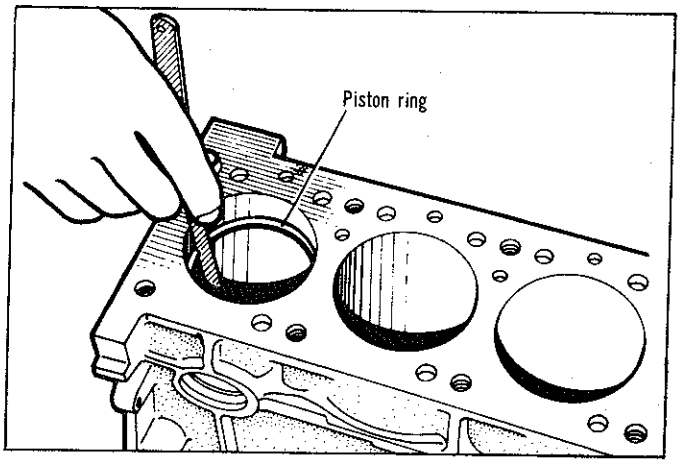


Fig. 41—Measuring piston ring gap

CONNECTING RODS

(1) Check the connecting rod for damage at the thrust faces at either end and for step wear or severely rough surface of the inside diameter of the small end. Replace faulty rods.

NOTE: When using a new connecting rod, the cylinder number should be stamped or marked on the big end.

(2) Measure the connecting rod small end diameter, if not within specifications, replace the rod.

(3) Using a connecting rod aligner, check the rod for bend and twist. If a rod falls just outside the specified limit it can be straightened by using a press. A rod that is severely bent or distorted must be replaced.

(4) Measure the connecting rod side clearance by assembling the rod and bearing onto the crankshaft and tightening the bolts to the specified torque. Measure the clearance between the connecting rod and crankshaft using feeler gauges. If this exceeds the specified limit, replace the rod.

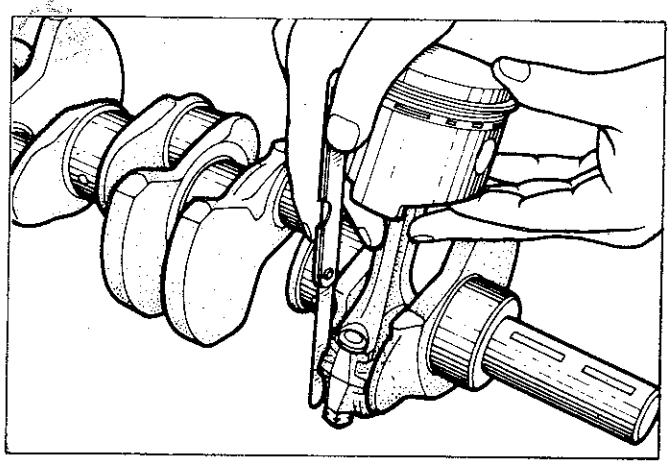


Fig. 42—Measuring connecting rod side clearance

CRANKSHAFT

(1) Check the crankshaft journals for damage, uneven wear and cracks. Check all oil holes for clogging.

(2) Check the crankshaft for bending by supporting it between centres and positioning a dial indicator on the centre journal. Rotate the shaft once noting the total indicator reading. Half of the reading is the amount of bend, if this exceeds the specified limit, repair or replace the crankshaft.

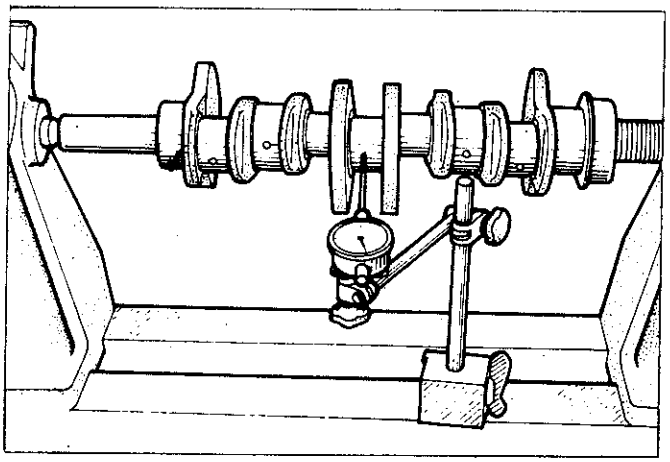


Fig. 43—Measuring crankshaft bend

(3) Measure the crankshaft journal diameters as shown in Fig. 44. If they are excessively out of round, tapered or worn they must be re-ground to the next undersize.

NOTE: Grinding of crankshaft journals must only be done AFTER checking/repairing crankshaft bend.

NOTE: Whenever crankshaft journals are re-ground, the correct undersize bearings must be fitted.

(4) When grinding the crankshaft, care must be taken to ensure the crankshaft journal fillet radii are 2,5 mm (0.098").

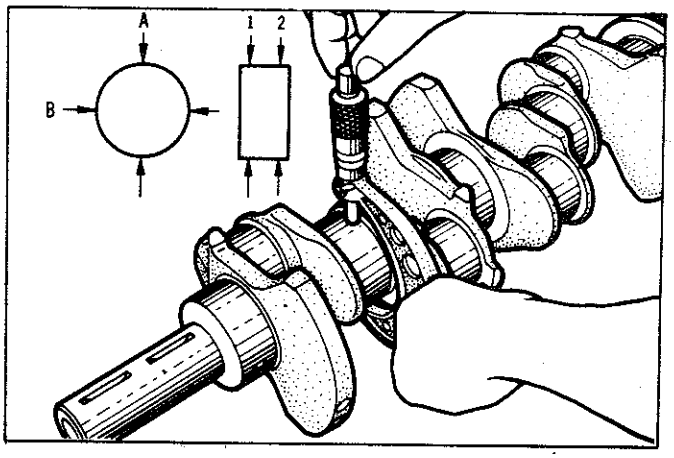


Fig. 44—Measuring crankshaft journal diameter

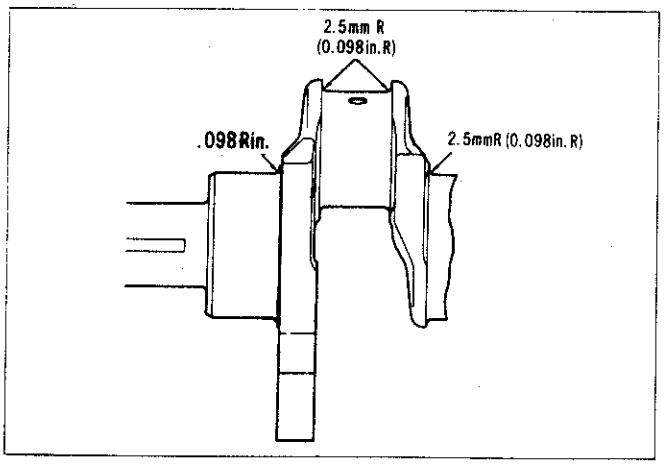


Fig. 45—Crankshaft journal fillet radii

(5) Check the crankshaft end float by assembling the crankshaft, bearings and caps to the cylinder block. Insert a feeler gauge between the centre bearing and crankshaft, if the end float exceeds the specified limit, replace the centre bearing.

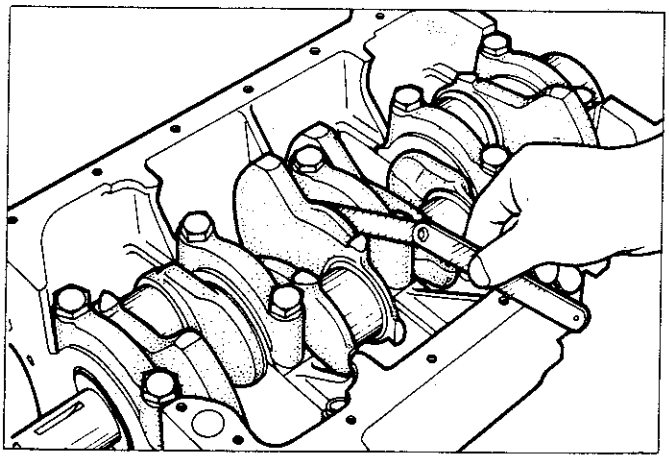


Fig. 46—Measuring crankshaft end float

MAIN AND CONNECTING ROD BEARINGS

(1) Check all bearings for peeling, melting, seizure and improper contact. Replace any faulty bearings.

(2) Checking the journal to bearing clearance can be done using either of two methods:

(a) measuring journal and bearing diameters;

(b) using the plastigauge method.

Measuring Diameters

(1) Measure the outside diameter of the main and connecting rod journals, Fig. 44.

(2) Assemble the bearings and caps and measure the bearing inside diameter, Fig. 47. The clearance is the difference between the respective bearing and journal diameter.

(3) If the clearance is not within specification and the journal diameter is within specification the bearings must be replaced.

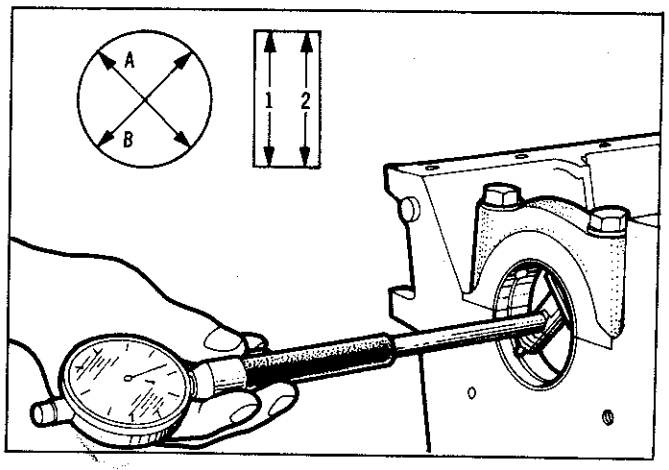


Fig. 47—Measuring bearing diameter

Plastigauge Method

(1) Remove all oil, grease and dirt from the bearings and journals.

(2) Cut a piece of plastigauge the length of the bearing width and place it across the bearing, away from the oil hole.

(3) Install the crankshaft/connecting rod, bearings and caps and torque them to specifications.

NOTE: Do not rotate the crankshaft or connecting rod during this operation.

(4) Remove the caps and measure the width of the plastigauge at the widest part using the scale printed on the plastigauge packet.

(5) If the clearance is not within specification and the journal diameter is within specification the bearings must be replaced.

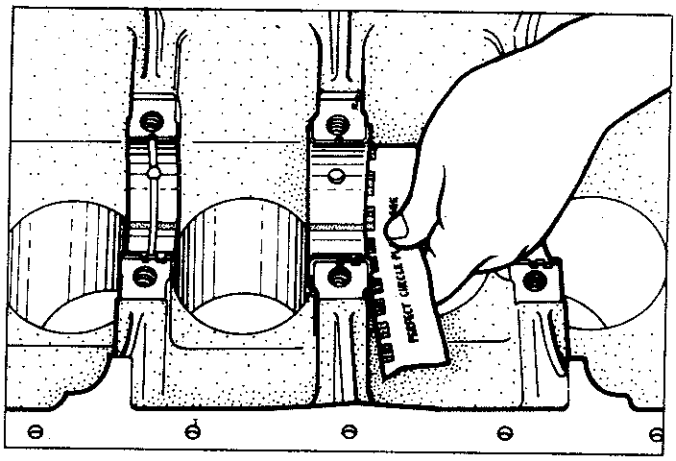


Fig. 48—Checking bearing clearance using plastigauge

COUNTER-BALANCE SHAFT AND BEARING

(1) Check the bearings for scratches and seizure, replace if faulty. The left hand shaft, bearing and thrust plate, must be replaced as an assembly if faulty. Refer Group 10—Engine Oiling for servicing of the right hand shaft front bearing.

(2) Measure the outside diameter of the shaft journal and the inside diameter of the bearing to check the clearance. If the clearance exceeds specification and the shaft journal is within specification, the bearing must be replaced.

(3) Check the oil hole for clogging.

Bearing Replacement

(1) Using Tool No. E9A6 insert the tool through the shaft hole at the front of the cylinder block until its rotatable claw portion passes beyond the bearing.

(2) Pull the tool forward to fit the claws into the bearing.

(3) Hold the shaft of the tool with a spanner and turn the nut of the tool, this will pull out the bearing.

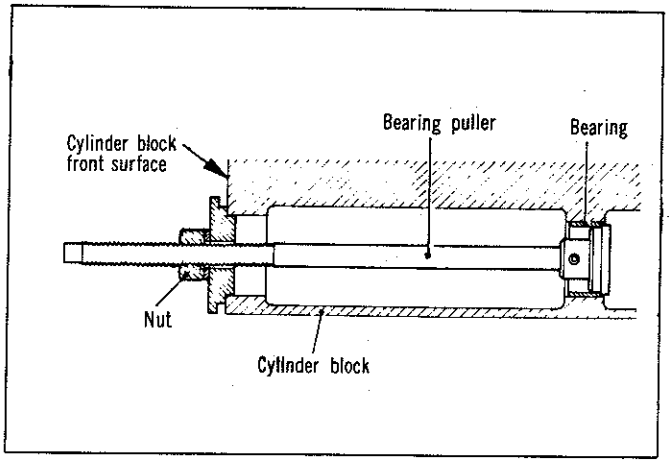


Fig. 49—Removing counter-balance shaft bearing

(4) Using Tool No. E9A5, the bearing can be press fitted to the specified position. Since the tool has no guide, extra care must be taken to align the bearing outside diameter and cylinder hole.

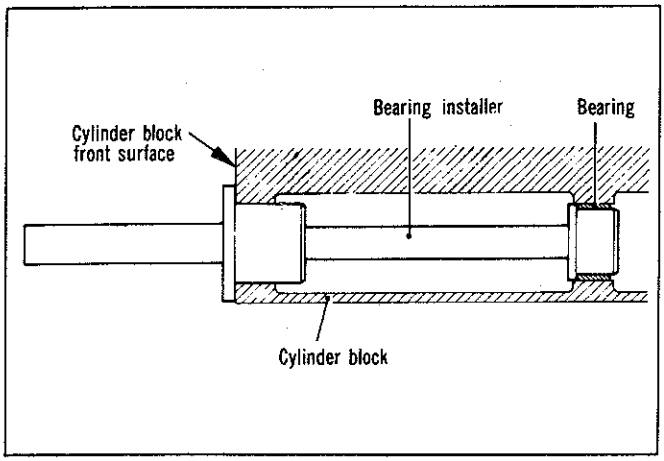


Fig. 50—Installing counter-balance shaft bearing

SPROCKET, CHAIN, TENSIONER AND GUIDE

(1) Check all sprockets for teeth damage and wear. Check counter-balance shaft sprockets for damaged cushion ring and ring guide. Ensure cushion ring rotates smoothly.

(2) Check the chain for roller play, wear, damage, disconnected links, etc.

(3) Check the chain tensioner rubber shoe for wear and the tensioner spring length specification.

(4) Check the chain guides for wear and damage. If the guides are severely worn or damaged they should be replaced.

FLYWHEEL AND RING GEAR

(1) Check the flywheel surface for wear or damage, if excessively worn or damaged, replace the flywheel.

(2) Check the flywheel surface run-out, if it exceeds the specified limit replace the flywheel.

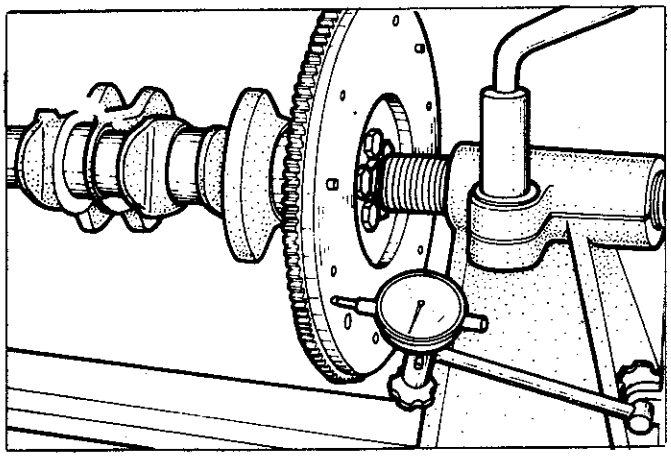


Fig. 51—Checking flywheel surface run-out

(3) Check the ring gear for damage, cracking and wear, replace if necessary.

Ring Gear Replacement

(1) Remove the ring gear by tapping it around the circumferance with a hammer and drift.

NOTE: Do not attempt to remove the ring gear by heating.

(2) Install the ring gear by heating it on a gas ring to 260 to 280°C (500 to 536°F) and shrinkage-fit it on the flywheel.

OIL SEALS, OIL PAN AND OIL SCREEN

(1) Check the front and rear crankshaft seals for damaged or worn lips. Replace the seal if defective.

(2) Check the oil pan for damage and cracks, repair or replace the oil pan as necessary.

(3) Check the oil screen for failure, damage and cracks. Check the O-ring for defects. Replace any faulty parts.

CYLINDER BLOCK REASSEMBLY

When assembling the cylinder block the following procedures should be observed:

- **Thoroughly clean all components especially oil holes, bearings, housings, bores and cylinder walls.**
- **Apply engine oil to sliding and rotating parts such as cylinder walls, pistons, bearings and gears prior to installation.**
- **Gaskets and oil seals should be replaced with new parts.**
- **Apply sealant to gasket as required.**
- **Torque all bolts to specification and in the specified sequence where necessary.**
- **Check all oil clearances, thrust clearances and backlash where necessary.**

(1) Install main bearings, upper, to the cylinder block. If reusing the main bearings, install them in their original position.

(2) Position crankshaft onto cylinder block and apply oil to journals.

NOTE: On later 2,0 litre and 2,6 litre engines changes were made to the crankshaft, main bearing shells and caps. This involved the use of additional oil holes in the crankshaft main bearing journals and the deletion of oil grooves in the lower main bearing shells and caps.

CAUTION: Lower main bearings and caps with the oil groove are used with the old crankshaft and may be used with the new crankshaft. For engines with the lower main bearing and cap without the groove, the new crankshaft MUST be used.

(3) Install the bearing caps and bearings, tightening the cap bolts to specification and in the sequence of: centre, No. 2, No. 4, front and rear.

NOTE: The caps must be installed with the arrow mark facing the front of the engine and in the correct order.

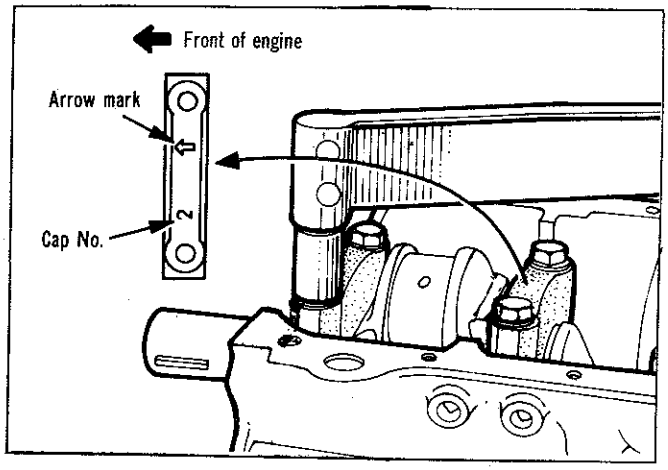


Fig. 52—Installing main bearing caps

(4) Ensure the crankshaft rotates lightly and smoothly and that the end float is within specifications.

(5) Using Tool No. E9A7 set the piston pin positively between the push rod and guide bar.

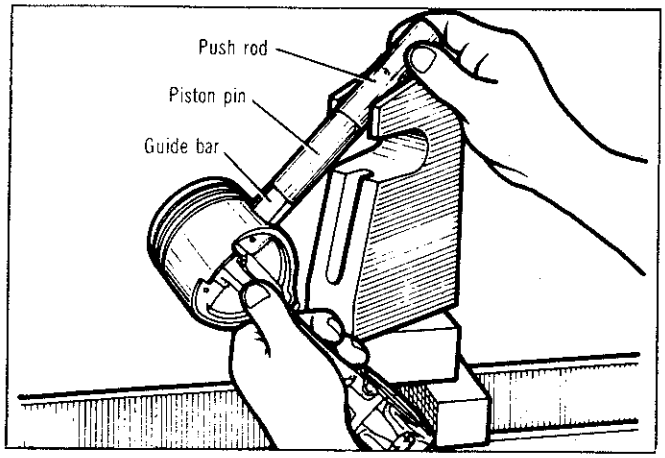


Fig. 53—Fitting piston pin onto tool

(6) Lubricate the outer surface of the piston pin and small end bore of the connecting rod.

(7) With the connecting rod and piston front marks aligned (arrow on piston, numerals on connecting rod), insert the piston pin, guide bar and push rod into the piston.

NOTE: There are three types of guides available, one for 1,85 litre, one for 2,0 litre and one for 2,6 litre engines respectively. Ensure the correct tool is used for the piston being fitted.

CAUTION: A local pin common to 1,85 litre and 2,0 litre engines was introduced as a running change, this pin is 72 mm (2.835") long and must be assembled using the 1,85 litre guide.

(8) Insert the guide bar in the slot provided in tool support, with the flat side of the guide bar aligned with the inner wall of the slot. Sit the connecting rod small end

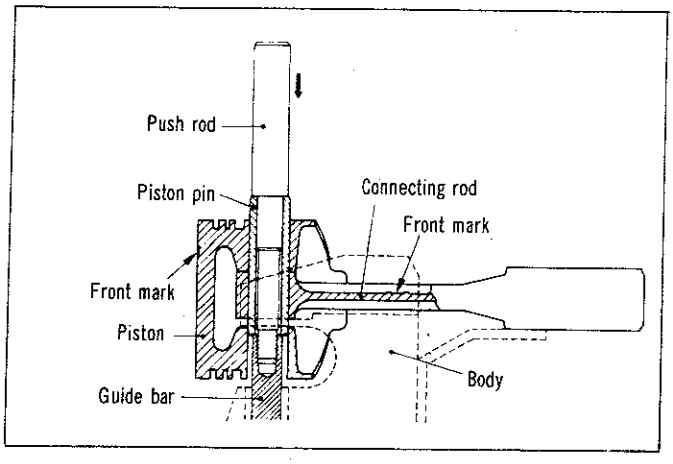


Fig. 54—Piston and connecting rod assembled into tool

to rest positively on the tool support. Turn the piston pin assembly half a turn.

(9) With the aid of a press, install the piston pin until the top end of the guide bar bottoms in the tool base. The force required to install the pin must be between 7360 to 17165 N (1654 to 3,859 lbs.).

NOTE: If the force required to fit the pin is not as specified, the piston pin must be removed and the pin and connecting rod diameters checked.

(10) With the piston assembled to the connecting rod ensure that the piston moves freely and lightly.

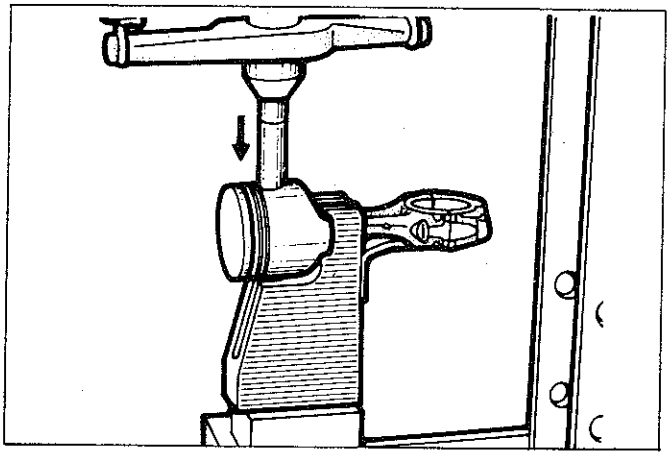


Fig. 55—Installing piston pin

(11) Install the piston rings in the following order:

(a) Install the oil ring expander.

(b) Fit one end of the oil ring top side rail into the groove and "peel" the ring into the groove. (Refer Fig. 56). Fit the lower side rail in a similar manner.

NOTE: Ensure that both upper and lower side rails can be turned freely in the piston and that the markings on the side rails face the top of the piston.

(c) Install the No. 2 piston ring and then No. 1 piston ring.

NOTE: Piston rings must be installed with the markings of the ring facing the top of the piston. On local 2,0 litre rings the No. 1 piston ring has no marking and may be fitted either way up.

(8) Position the piston rings so that the ring gaps are as far from each other as possible and that they do not align with the piston pin and thrust side of the piston. Refer Fig. 58.

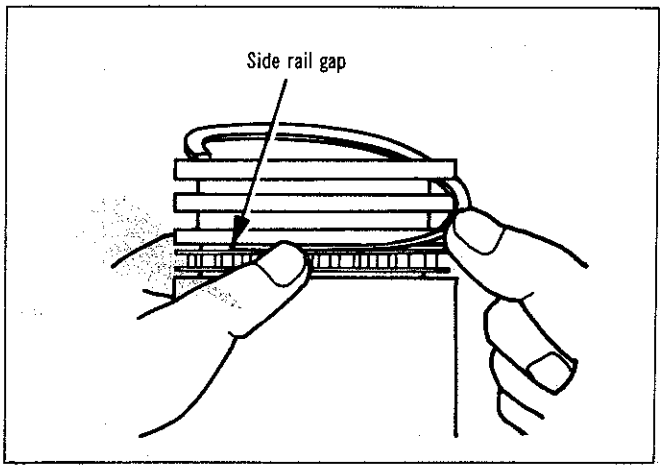


Fig. 56—Fitting oil ring side rail

(9) Apply a liberal amount of engine oil to the piston and rings.

(10) Compress the rings using a piston ring compressor. Install the piston and connecting rod assembly into the cylinder ensuring the piston front mark is facing the front of the engine and the assemblies are fitted into the correct cylinder.

NOTE: It is advisable to fit plastic covers or masking tape around the connecting rod bolts to protect the cylinder walls and crankshaft journals from damage.

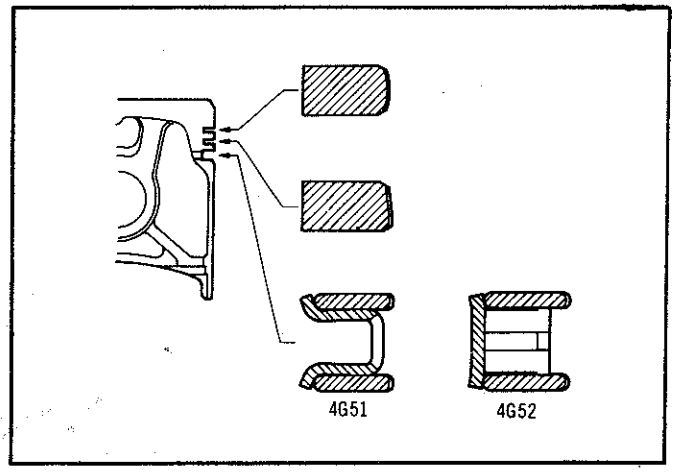


Fig. 57—Order of piston ring installation

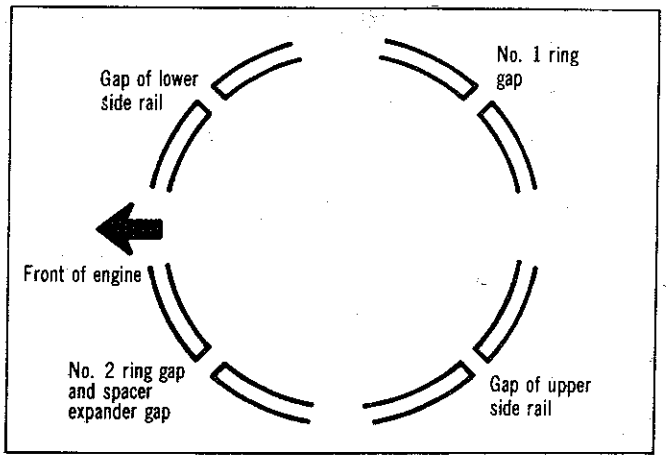


Fig. 58—Piston ring gap position

(11) Install the connecting rod caps in the correct order, with the cylinder number marks on the cap, aligned with the numbers on the connecting rod. Tighten the cap bolts to the specified torque.

(12) Check the connecting rod big-end side clearance.

(13) Install the crankshaft rear oil seal case. If the oil seal has been removed from the case, install a new oil seal to the case, ensuring it is properly seated into the case and that the oil hole in the separator faces the bottom of the case. Refer Fig. 60.

NOTE: The crankshaft oil seal lip should be lubricated with engine oil prior to installation.

(14) Install the flywheel (or torque convertor drive plate) tightening the bolts to the specified torque. Bend the bolt locking tabs to securely hold the bolts (where fitted).

NOTE: Do not reuse old locking tabs.

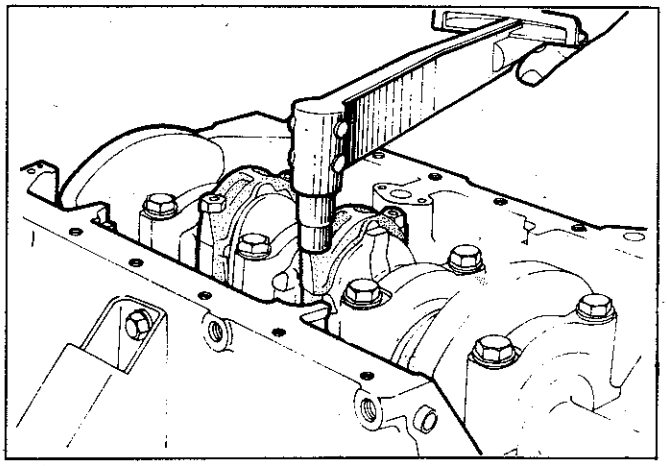


Fig. 59—Tighten connecting rod bearing caps

(15) Lubricate the right hand counter-balance shaft bearing journal, and install the shaft into the cylinder block being careful not to damage the rear bearing.

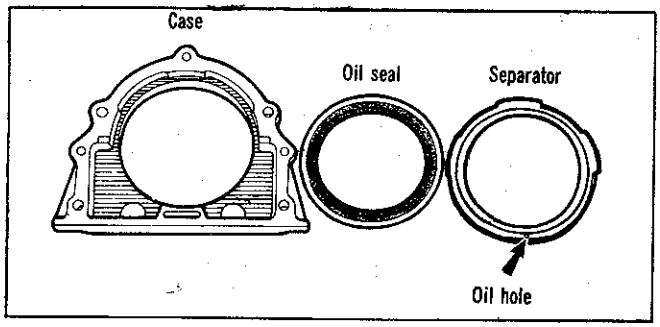


Fig. 60—Rear crankshaft seal assembly

NOTE: The counter-balance shafts are not interchangeable. The left hand shaft is identified by the key way at the forward end of the shaft, the key way on the right hand shaft is further back.

(16) Install the oil pump assembly, making sure that the keyway of the oil pump driven gear fits the woodruff key in the counter-balance shaft. Firmly tighten the oil pumps mounting bolts.

NOTE: Fill the oil pump with engine oil prior to installation.

(17) Tighten the bolt securing the counter-balance shaft to the oil pump driven gear.

NOTE: If the fit of the counter-balance shaft to the oil pump gear is tight, install the shaft to the gear first and then install the shaft and oil pump onto the cylinder block, as an assembly.

(18) Lubricate the left hand counter-balance shaft bearing journal and install the shaft into the cylinder block being careful not to damage the rear bearing.

(19) Install a new O-ring in the thrust plate taking care not to twist the O-ring.

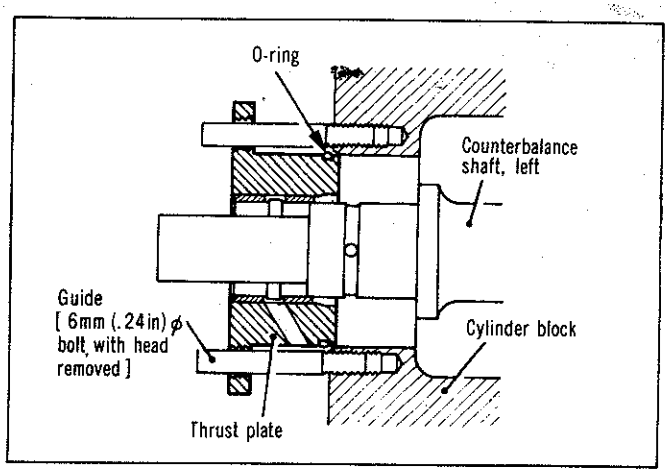


Fig. 61—Installing counter-balance shaft thrust plate

(20) Lubricate the O-ring prior to installation of the thrust plate.

(21) Install the thrust plate, using two 6 mm diameter threaded bolts, with the heads removed, as guide pins.

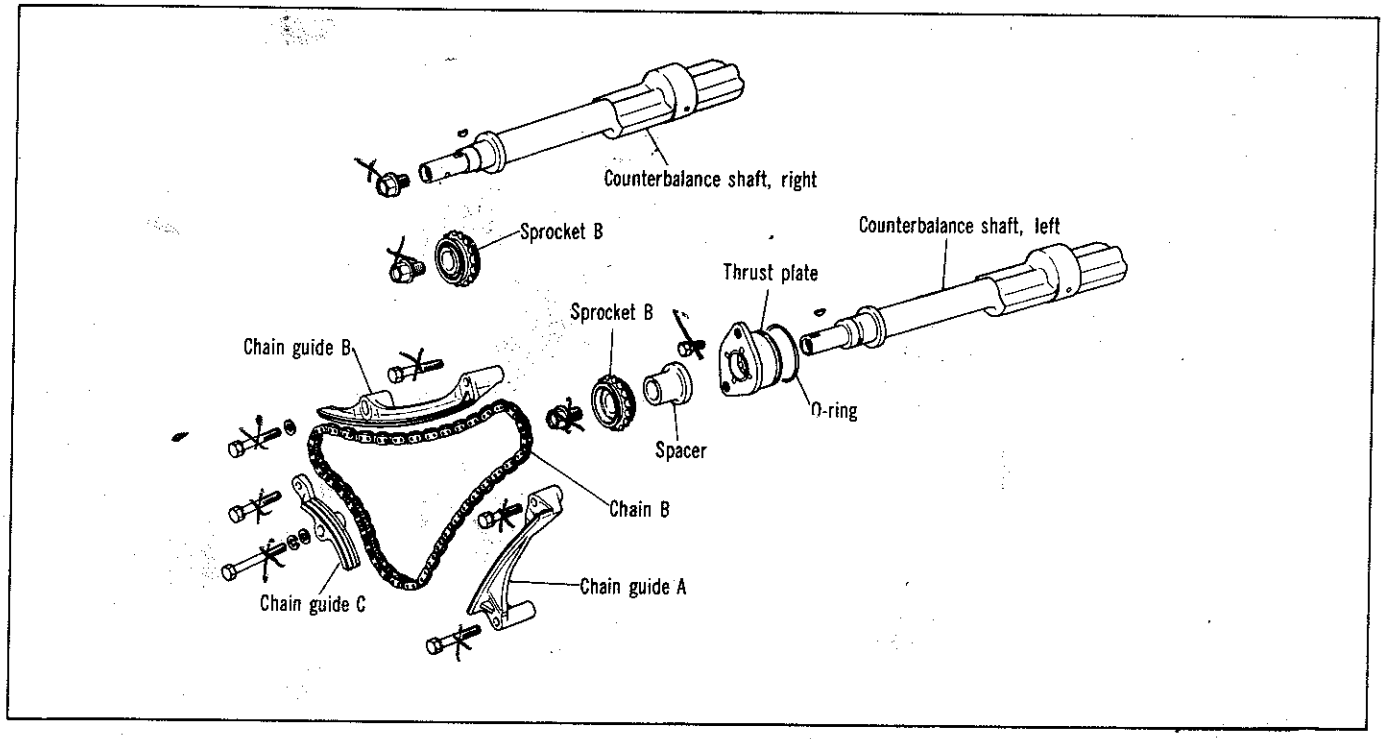


Fig. 62—Counter-balance shaft system

NOTE: Failure to use the guide pins will necessitate rotation of the thrust plate to align the bolt holes, which may cause damage or twisting of the thrust plate O-ring.

(22) Install the drive chains, sprockets and timing cover as previously described under Camshaft and Counter-Balance Shaft Drive Chains.

(23) Install the oil screen.

(24) Install the oil pan with a new gasket, coating both sides of the entire gasket with sealant. The oil pan bolts should be tightened in a criss-cross pattern.

(25) Install the oil pressure switch.

(26) Set the engine upright and install the cylinder head assembly as previously described under Cylinder Head.

(27) Install the engine mounting brackets and install engine into vehicle as previously described.