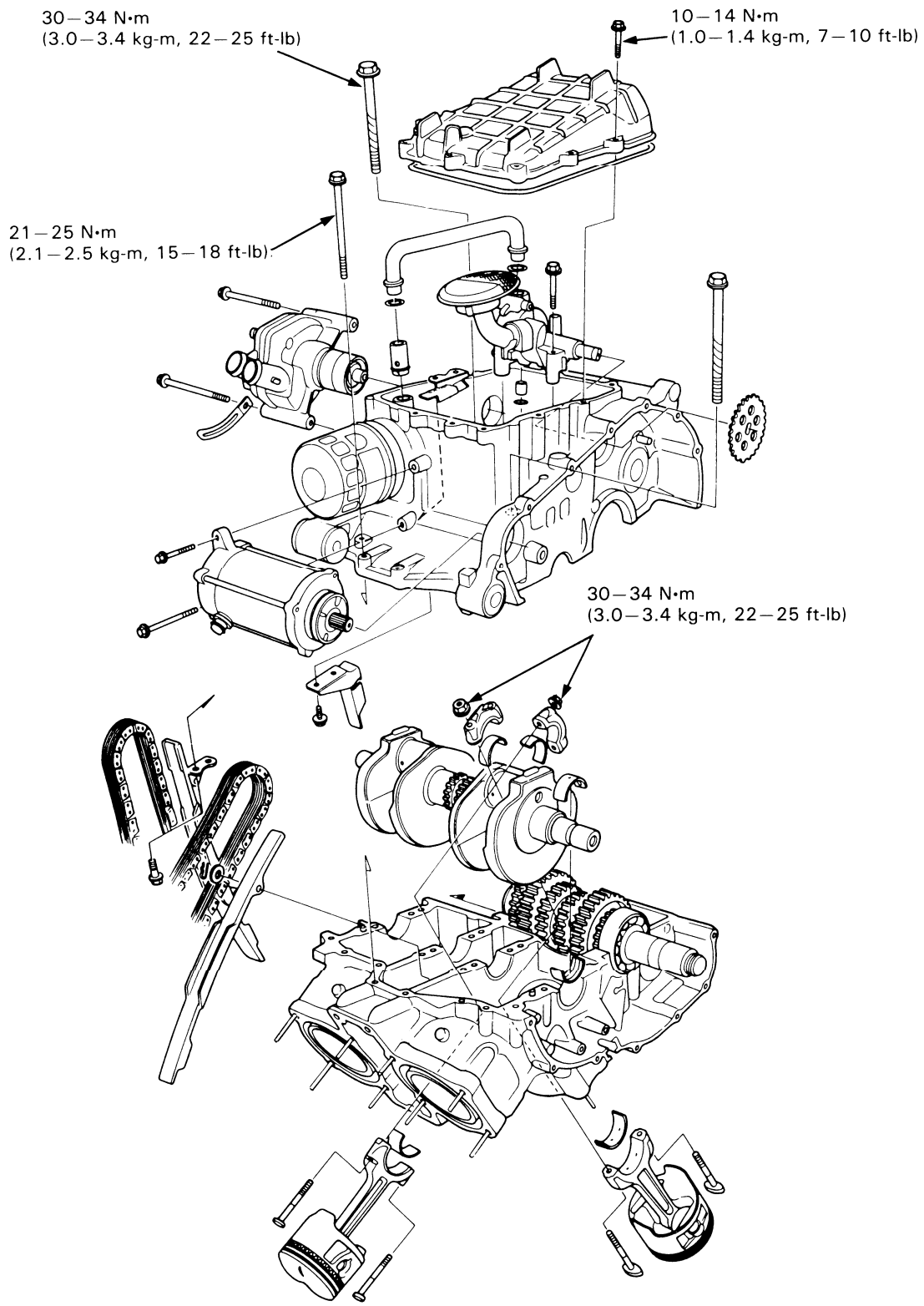

30—34 N•m
(3.0—3.4 kg-m, 22—25 ft-lb)
10—14 N•m
(1.0—1.4 kg-m, 7—10 ft-lb)
21—25 N•m
(2.1—2.5 kg-m, 15—18 ft-lb)
30—34 N•m
(3.0—3.4 kg-m, 22—25 ft-lb)

10. CRANKCASE/CRANKSHAFT/PISTON

SERVICE INFORMATION

GENERAL

- To service the piston, crankshaft, connecting rod and transmission, the crankcase halves must be separated.
- If a new crankcase is installed, perform countershaft shim selection procedures (page 11-10).
- The following parts must be removed before disassembling the crankcase.

Oil pan	Refer to section 2
Oil pump	Refer to section 2
Clutch/starter clutch	Refer to section 7
Gearshift linkage	Refer to section 7
Alternator	Refer to section 8
Cyliner heads	Refer to section 9
Starter motor	Refer to section 18
Neutral switch	Refer to section 19

- All bearing inserts are select fit and are identified by color code. Select replacement bearings from the code tables. After installing new bearings, recheck them with plastigauge to verify clearance.
- Apply molybdenum disulfide grease to the main journals and crankpins during assembly.
- Before removing the piston and connecting rod assemblies, clean the top of the cylinder of any carbon deposits.
- For servicing the piston, connecting rod and crankshaft, the crankcase assembly must be separated.

10

SPECIFICATIONS

ITEM			STANDARD	SERVICE LIMIT
Crankshaft	Connecting rod big end side clearance		0.10–0.30 mm (0.004–0.012 in)	0.40 mm (0.016 in)
	Runout		—	0.03 mm (0.001 in)
	Crankpin oil clearance		0.028–0.052 mm (0.0011–0.0020 in)	0.08 mm (0.003 in)
	Main journal oil clearance		0.020–0.044 mm (0.0008–0.0017 in)	0.08 mm (0.003 in)
Cylinder	I.D.		70.000–70.015 mm (2.755–2.756 in)	70.10 mm (2.760 in)
	Warpage		—	0.10 mm (0.004 in)
Piston	Ring-to-groove clearance	Top	0.015–0.045 mm (0.0006–0.0018in)	0.10mm (0.004 in)
		Second	0.015–0.045 mm (0.0006–0.0018 in)	0.10 mm (0.004 in)
	Ring end gap	Top	0.15–0.30 mm (0.006–0.012 in)	0.50 mm (0.020 in)
		Second	0.20–0.35 m (0.008–0.014 in)	0.50 mm (0.020 in)
		Oil (Side rail)	0.20–0.90 mm (0.008–0.035 in)	1.1 mm (0.04 in)
	Piston O.D.		69.96–69.99 mm (2.754–2.755 in)	69.85 mm (2.750 in)
	Piston-to-cylinder clearance		0.010–0.055 mm (0.0004–0.0022 in)	0.10 mm (0.004 in)
	Piston pin bore		18.002–18.008 mm (0.7087–0.7090 in)	18.1 mm (0.71 in)
	Piston pin O.D.		17.994–18.000 mm (0.7084–0.7086 in)	17.98 mm (0.708 in)
	Piston-to-piston pin clearance		0.002–0.014 mm (0.0001–0.0006 in)	0.04 mm (0.002 in)
	Connecting rod small end I.D.		18.016–18.034 mm (0.7093–0.7100 in)	18.08 mm (0.712 in)
	Piston pin-to-connecting rod clearance		0.016–0.040 mm (0.0006–0.0016 in)	0.06 mm (0.002 in)
Cam chain	Length at 13 kg (29 lb) tension		342.90–343.35 mm (13.500–13.518 in)	340.50 mm (13.405 in)

TORQUE VALUES

Crankcase 9 mm bolt	30—34 N•m (3.0—3.4 kg-m, 22—25 ft-lb)
8 mm bolt	21—25 N•m (2.1—2.5 kg-m, 15—18 ft-lb)
6 mm bolt	10—14 N•m (1.0—1.4 kg-m, 7—10 ft-lb)
Connecting rod cap nut	30—34 N•m (3.0—3.4 kg-m, 22—25 ft-lb)

TROUBLESHOOTING

Excessive noise
- Worn main bearing
- Worn crankpin bearing
- Worn piston or cylinder
- Worn piston pinor hole
- Worn rod small end

Low compression or uneven compression
- Worn cylinder or piston rings
- Broken piston ring

Excessive smoke
- Worn cylinder, piston or piston rings
- Improperly installed piston rings
- Damaged piston or cylinder

Overheating
- Excessive carbon build-up on piston head
- Blocked or restricted flow of coolant
- Sticking thermostat

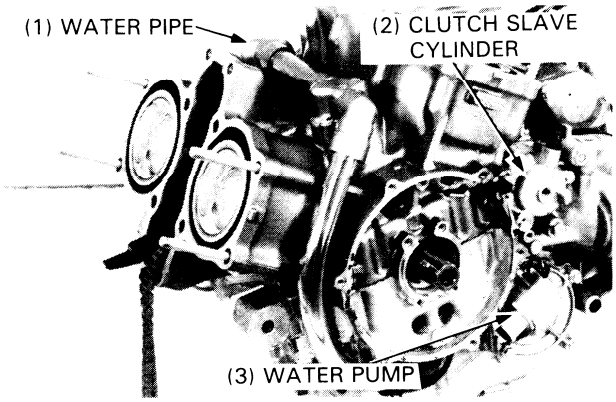
Knocking or abnormal noise
- Worn pistons and cylinders
- Excessive carbon build-up on piston head

CRANKCASE DISASSEMBLY

Remove the water pipe cap bolts, water pipe and caps (page 9-5).

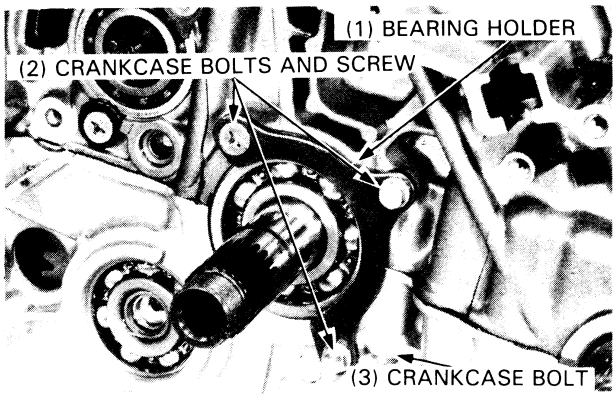
Remove the water pump (page 6-8).

Remove the clutch slave cylinder (page 7-8).



Remove the mainshaft bearing holder by removing the screw and bolts.

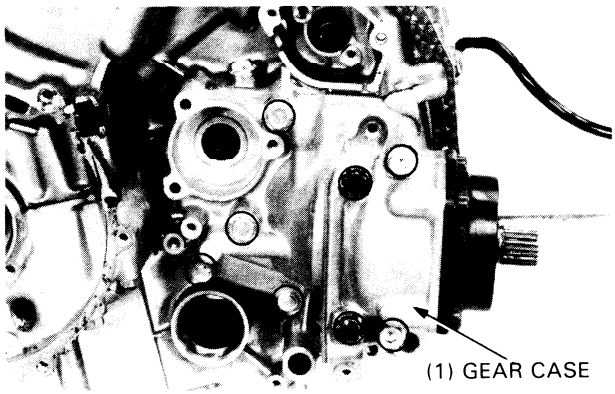
Remove the crankcase bolt located below the holder.



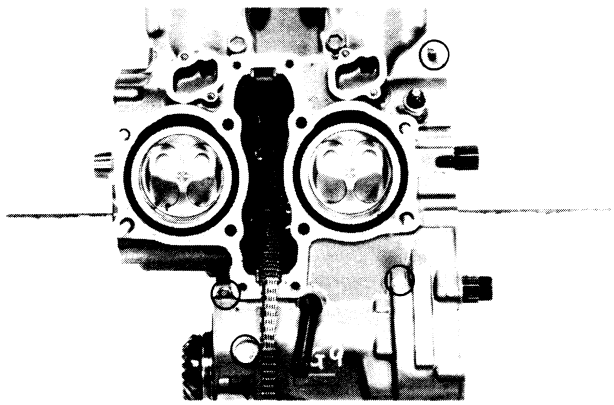
Remove the output gear case mounting bolts and output gear case.
Measure the thickness of the output gear case gasket and note it.

NOTE

- Index the bearing holder to the case for ease of reinstallation.
- Do not pry the output gear case mounting surfaces apart.



Remove the upper crankcase bolts.



Turn the engine over and remove the eight lower crankcase bolts and fourteen crankshaft main journal bolts.

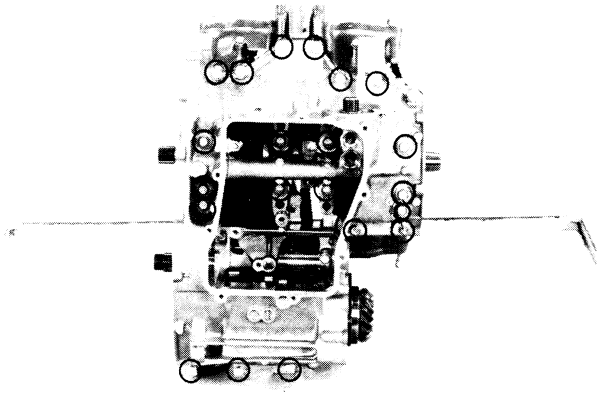
NOTE

- Remove the bolts in two or more steps and in a crisscross pattern to prevent damage to the crankcase.

Separate the lower crankcase from the upper crankcase.

NOTE

- Do not pry the crankcase mating surfaces apart.
- Tap the crankcase lightly to loosen it.



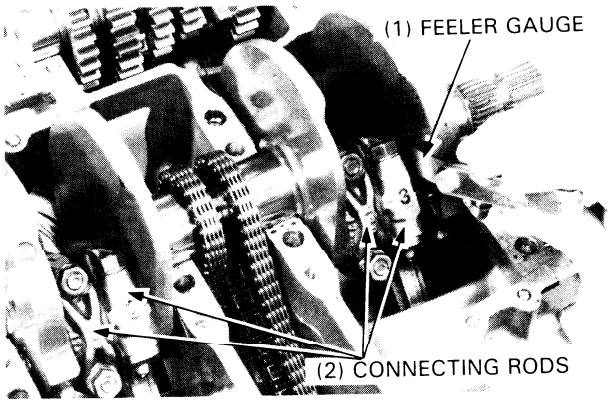
CONNECTING ROD REMOVAL

CONNECTING ROD BIG END SIDE CLEARANCE INSPECTION

Check the connecting rod side clearance.

SERVICE LIMIT: 0.40 mm (0.016 in)

If either side clearance exceeds the service limit, replace the rod.
Recheck clearances.
If still beyond the limit, replace the crankshaft.
Inspect the crankshaft for rough spots or damage.



REMOVAL

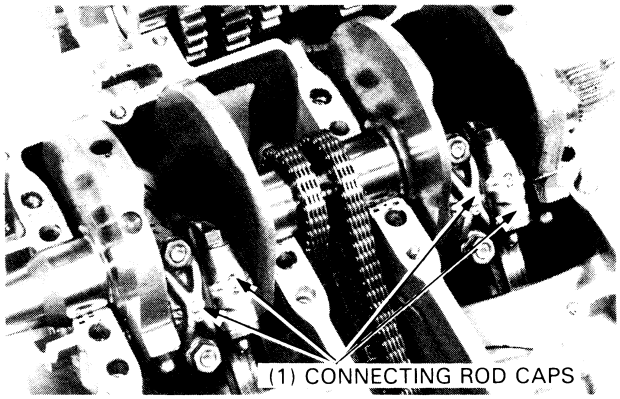
CAUTION

- *Do not interchange the bearing inserts. They must be installed in their original positions or the correct bearing oil clearance may not be obtained causing engine damage.*

NOTE

- Mark the pistons, connecting rods and bearing caps to indicate the correct cylinder and position on the crankpins before removal.

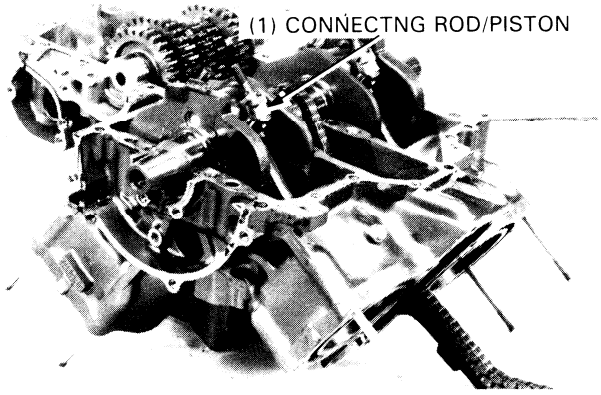
Remove the connecting rod bearing caps and note their locations.



Push the connecting rods and pistons out through the top of the cylinder bores.

CAUTION

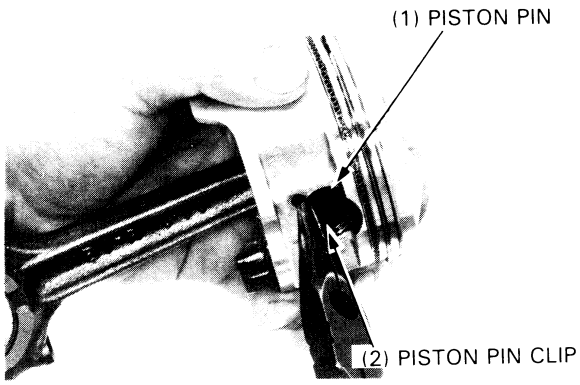
- *On engines with high mileage, inspect the cylinders for a ridge just above the highest point of ring travel. Any ridge must be removed with an automotive type ridge reamer before removing the pistons to allow the pistons and rings to pass through the cylinder.*



PISTON REMOVAL

Remove the piston pin clips. Push the piston pin out and remove the piston.

Mark the piston pins to indicate their correct piston position.



INSPECTION

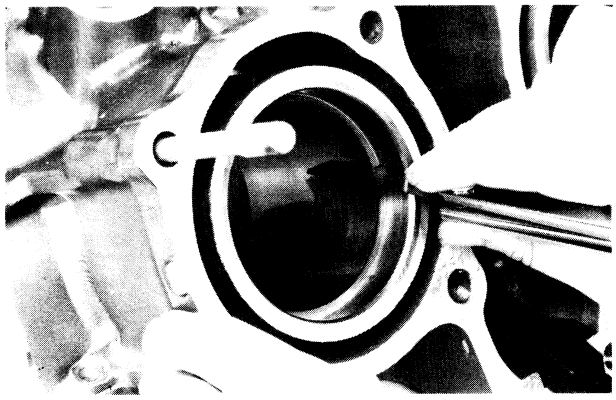
Piston Ring
Inspect the piston sliding surfaces for abnormal wear or damage.
Inspect the piston for cracks or other damage and the ring grooves for excessive wear and carbon build-up.
Clean the piston crown, removing all carbon deposits.
Measure the piston ring-to-groove clearance.

SERVICE LIMIT (Top/Second): 0.10 mm (0.004 in)

Remove the piston rings and mark them to indicate the correct cylinder and piston position.

Using a piston, push the ring squarely into the cylinder and measure the end gap.

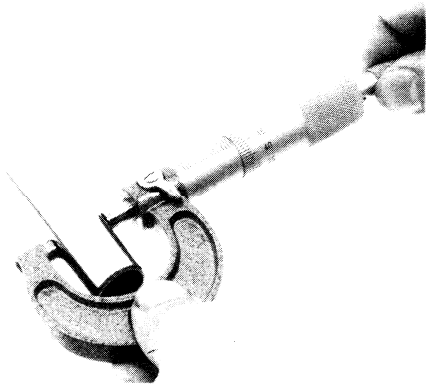
SERVICE LIMITS:
TOP/SECOND: 0.50 mm (0.020 in)
OIL (Side rail): 1.1 mm (0.04 in)



If the gap exceeds the service limit, measure the cylinder I.D. Replace the piston ring if the cylinder I.D. is within specification.

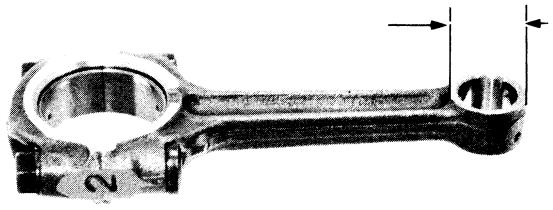
Piston Pin
Measure each piston pin O.D.

SERVICE LIMIT: 17.98 mm (0.708 in)



Connecting Rod Small End
Measure the connecting rod small end I.D. If the reading exceeds the service limit, replace the rod.

SERVICE LIMIT: 18.08 mm (0.712 in)



Examine the rods for bends, cracks or other damage. Replace if necessary.

Calculate the connecting rod-to-piston pin clearance.

SERVICE LIMIT: 0.06 mm (0.002 in)

Piston
Measure each piston pin bore.

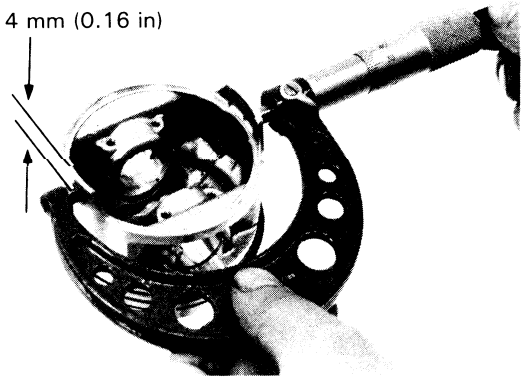
SERVICE LIMIT: 18.1 mm (0.71 in)

Calculate the piston pin-to-piston clearance.

SERVICE LIMIT: 0.04 mm (0.002 in)

Measure and record the piston O.D. at a point 4.0 mm (0.16 in) from the bottom, and 90° to the piston pin bore.

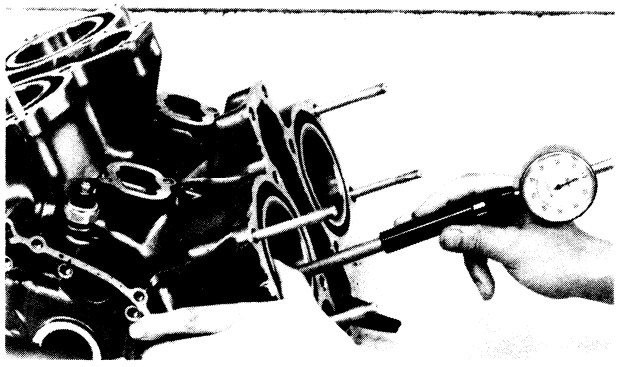
SERVICE LIMIT: 69.85 mm (2.750 in)



Compare this measurement against the service limit and calculate piston-to-cylinder clearance.

Cylinder
Inspect the cylinder walls for scratches and wear.
Measure and record the cylinder I.D. at three levels in both an X and Y axis.
Take the maximum reading to determine the cylinder wear.

SERVICE LIMIT: 70.10 mm (2.760 in)



Calculate the piston-to-cylinder clearance. Take the maximum reading to determine the clearance.

SERVICE LIMIT: 0.10 mm (0.004 in)

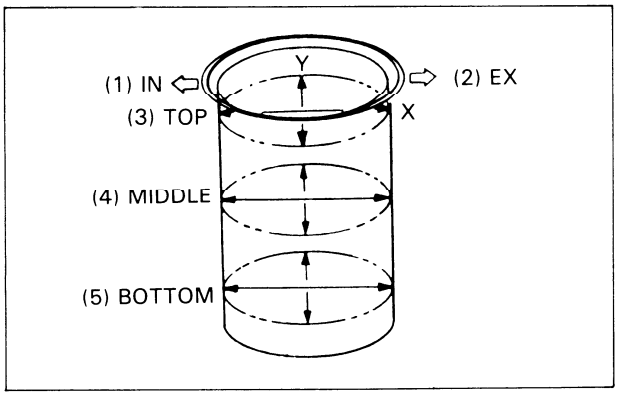
Calculate the cylinder for taper at three levels in an X and Y axis.
Take the maximum reading to determine the taper.

SERVICE LIMIT: 0.10 mm (0.004 in)

Calculate the cylinder for out-of-round at three levels in a X and Y axis. Take the maximum reading to determine the out-of-round.

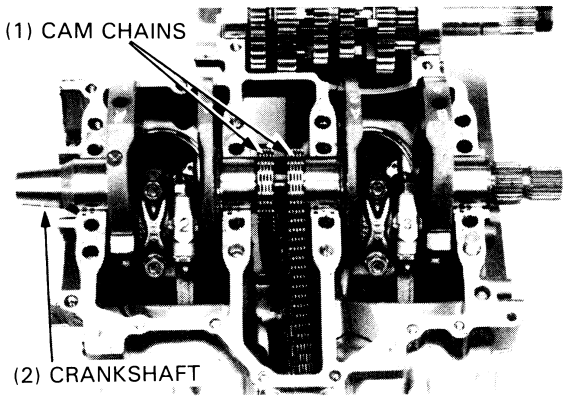
SERVICE LIMIT: 0.10 mm (0.004 in)

The cylinder must be rebored and oversize piston fitted if the service limits are exceeded.
The following oversize piston are available:
0.25, 0.50, 0.75 and 1.00 mm



CRANKSHAFT REMOVAL

Separate the crankcase (page 10-3).
Remove the bearing cap nuts and bearing caps (page 10-4).
Remove the crankshaft and cam chains.
Remove the connecting rods and pistons (page 10-5).



INSPECTION

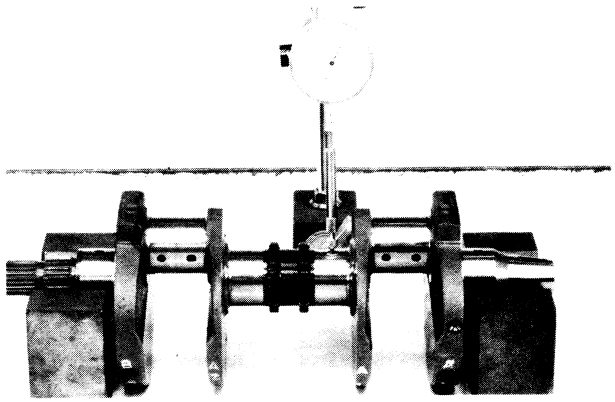
Crankshaft Runout
Support the No. 1 and No. 4 main bearing journals with V blocks.
Set a dial indicator on the No. 3 or No. 2 main bearing journals.
Rotate the crankshaft two revolutions and read the runout.

Actual runout is 1/2 of the total indicator reading.

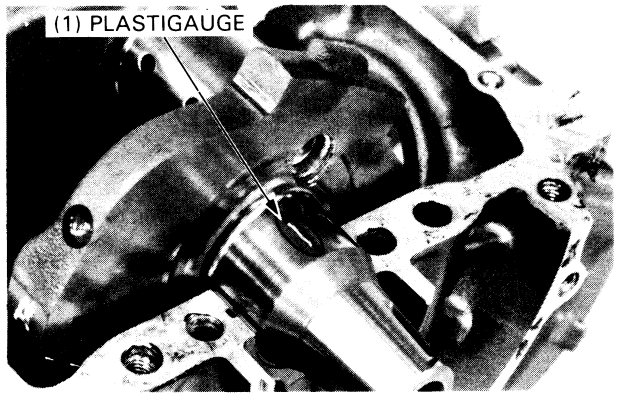
SERVICE LIMIT: 0.03 mm (0.001 in)

NOTE

- The crankshaft cannot be repaired. Replace it if the journals or crankpins are burnt, cracked, or if the runout is beyond limits.



Main Bearing Oil Clearance
Inspect the bearing inserts for unusual wear or damage.
Wipe all oil from the bearing inserts and journals.
Reinstall the upper crankcase's main bearing inserts, then carefully lower the crankshaft in place.
Put a piece of plastiguage on each journal.

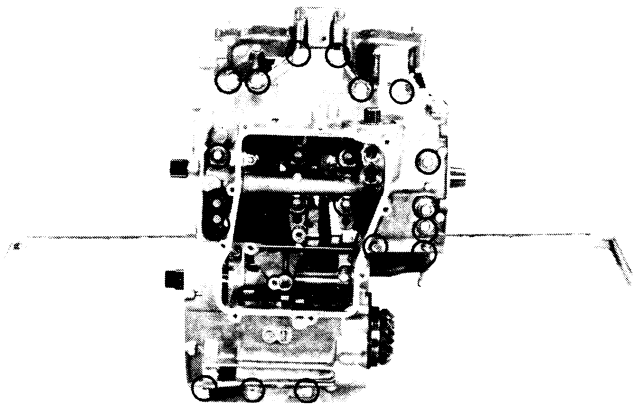


NOTE

- Do not put the plastigauge ove the oil hole in the main bearing journal of the crankshaft.
- Do not rotate the crankshaft during inspection.

Install the main bearing inserts on the correct journals in the lower crankcase, then assemble and tighten the bolts evenly in 2–3 steps in the sequence shown.

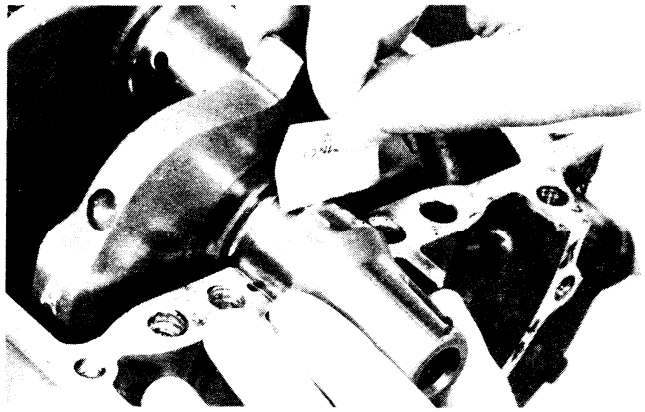
TORQUE VALUES:
8 mm bolt: 21–25 N·m (2.1–2.5 kg-m, 15–18 ft-lb)
6 mm bolt: 10–14 N·m (1.0–1.4 kg-m, 7–10 ft-lb)



Remove the lower crankcase and measure the compressed plastigauge on each journal.

SERVICE LIMIT: 0.08 mm (0.003 in)

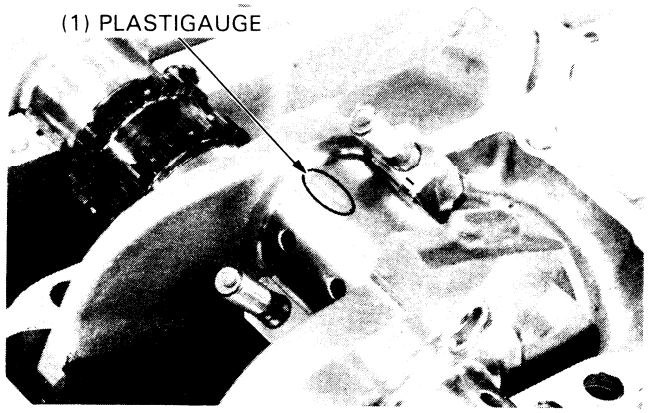
If main bearing clearance is beyond tolerance, select a replacement bearing (page 10-9).



Crankpin Oil Clearance
Inspect the bearing inserts for unusual wear or damage.
Wipe all oil from the bearing inserts and crankpins.
Put a piece of plastigauge on each crankpin.

NOTE

- Do not put the plastigauge over the oil hole in the crankpin.

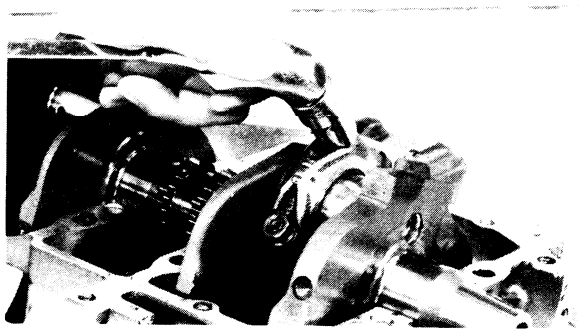


Install the bearing caps and connecting rods on the correct crankpins and tighten them evenly.

TORQUE: 30–34 N·m (3.0–3.4 kg-m, 22–25 ft-lb)

NOTE

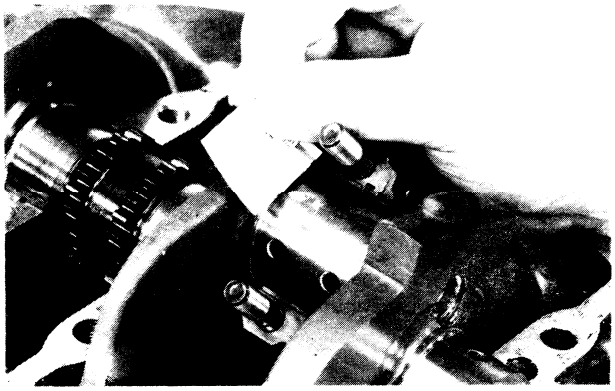
- Do not rotate the crankshaft and connecting rods during inspection.



Remove the caps and measure the compressed plastigauge on each crankpin.

OIL CLEARANCE SERVICE LIMIT: 0.08 mm (0.003 in)

If the rod bearing clearance is beyond tolerance, select replacement bearings as follows:



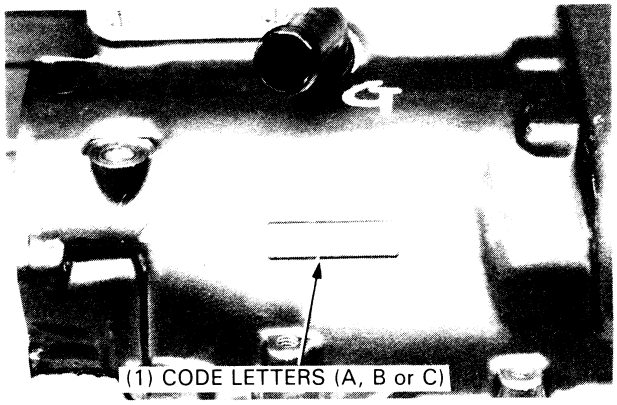
BEARING SELECTION

MAIN BEARING

Determine and record crankcase I.D. code letters.

NOTE

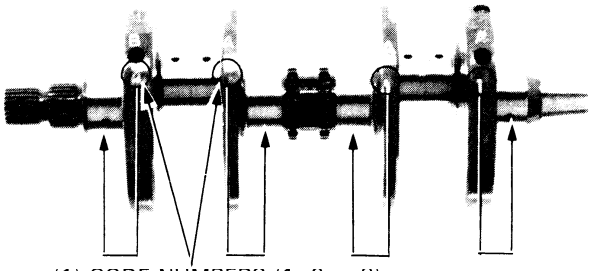
- Letters (A, B or C) on the upper rear crankcase are the codes for the main journal I.D. from left to right.



Determine and record the corresponding main journal O.D. code numbers (or measure the main journal O.D.).

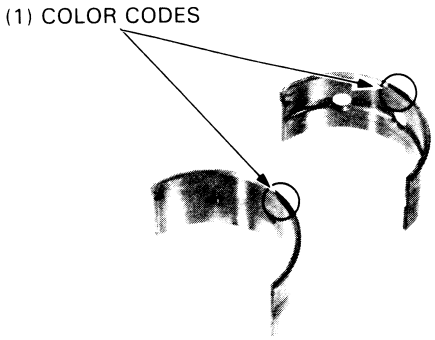
NOTE

- A number 1, 2 or 3 on each crank weight is the code for the adjacent main journal O.D.



Cross reference the case and journal codes to determine the replacement bearing.

			MAIN JOURNAL O.D. CODE No.		
			1	2	3
			36.000–36.008 mm	35.992–36.000 mm	35.984–35.992 mm
CASE I.D. CODE LETTERS	A	39.000 39.008 mm	E (Yellow)	D (Green)	C (Brown)
	B	39.008–39.016 mm	D (Green)	C (Brown)	B (Black)
	C	39.016–39.024 mm	C (Brown)	B (Black)	A (Blue)



MAIN BEARING INSERT THICKNESSES:

A (Blue): 1.506–1.510 mm (0.0593–0.0594 in)
B (Black): 1.502–1.506 mm (0.0591–0.0593 in)
C (Brown): 1.498–1.502 mm (0.0590–0.0591 in)
D (Green): 1.494–1.498 mm (0.0588–0.0590 in)
E (Yellow): 1.490–1.494 mm (0.0587–0.0588 in)

CAUTION

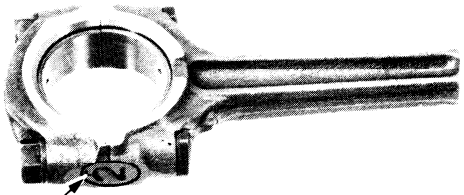
- *After selecting new bearings, recheck the clearance with plastigage. Incorrect clearance can cause major engine damage.*

CONNECTING ROD BEARING INSERTS

Determine and record the corresponding rod I.D. code number.

NOTE

- Number 1, 2 or 3 on each connecting rod is the code for each connecting rod I.D.



(1) CODE NUMBER (1, 2 or 3)

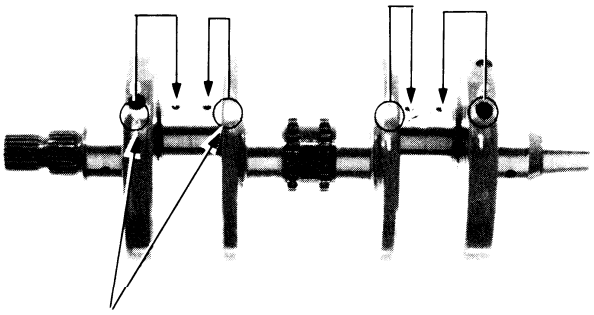
Determine and record the corresponding crankpin O.D. code number (or measure the crankpin O.D.)

NOTE

- The letters A, B or C on each crank weight is the code for each crankpin O.D.

Cross reference the crankpin and rod codes to determine the replacement bearing color.

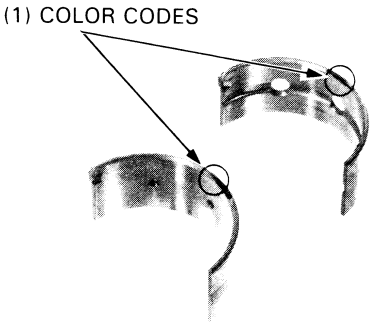
			CRANKPIN O.D. CODE LETTERS		
			A	B	C
			35.992–36.000 mm	35.984–35.992 mm	35.976–35.984 mm
CONNECTING ROD I.D. CODE No.	1	39.000–39.008 mm	E (Yellow)	D (Green)	C (Brown)
	2	39.008–39.016 mm	D (Green)	C (Brown)	B (Black)
	3	39.016–39.024 mm	C (Brown)	B (Black)	A (Blue)



(1) CODE LETTERS (A, B or C)

BEARING INSERT THICKNESSES:

A (Blue): 1.502–1.506 mm (0.0591–0.0593 in)
B (Black): 1.498–1.502 mm (0.0590–0.0591 in)
C (Brown): 1.494–1.498 mm (0.0588–0.0590 in)
D (Green): 1.490–1.494 mm (0.0587–0.0588 in)
E (Yellow): 1.486–1.490 mm (0.0585–0.0587 in)



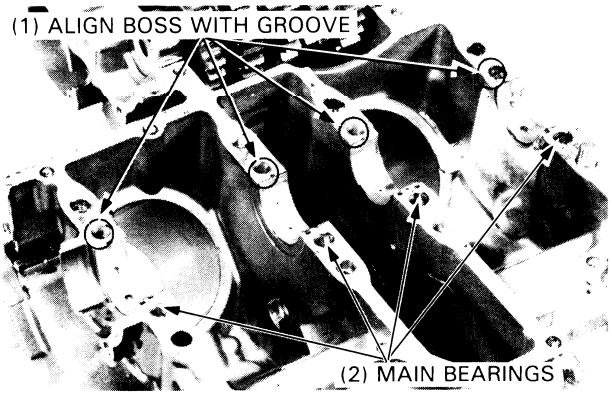
(1) COLOR CODES

CAUTION

- *After selecting new bearings, recheck clearance with plastigauge. Incorrect clearance can cause major engine damage.*

BEARING INSTALLATION

Install the main bearing into the lower crankcase and bearing caps.



(1) ALIGN BOSS WITH GROOVE

(2) MAIN BEARINGS

CAUTION

- *The bearing tabs should be aligned with the grooves in the case and caps.*

Install the main bearings into the upper crankcase.

Apply molybdenum disulfide grease to the upper and lower main bearing.

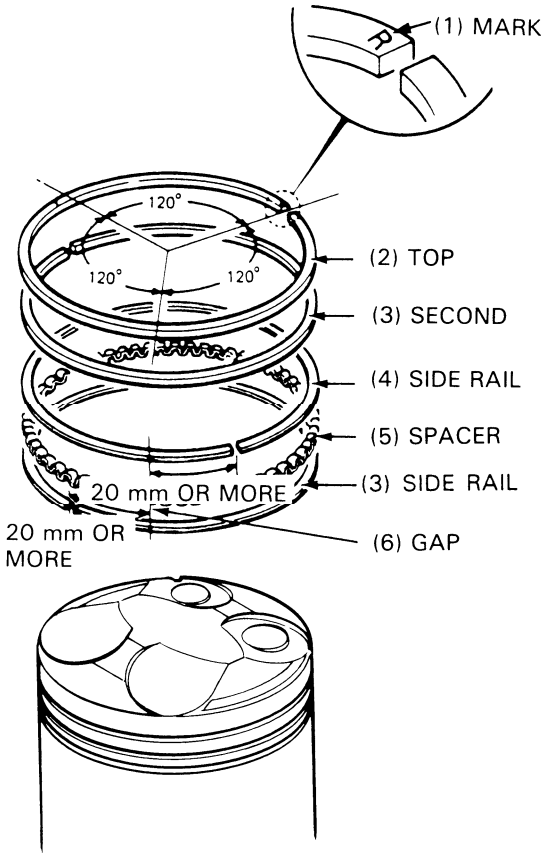
PISTON AND ROD INSTALLATION

PISTON RING INSTALLATION

Clean the piston heads, ring lands and skirts.
Carefully install the piston rings onto the piston and stagger the ring end gaps as shown.

NOTE

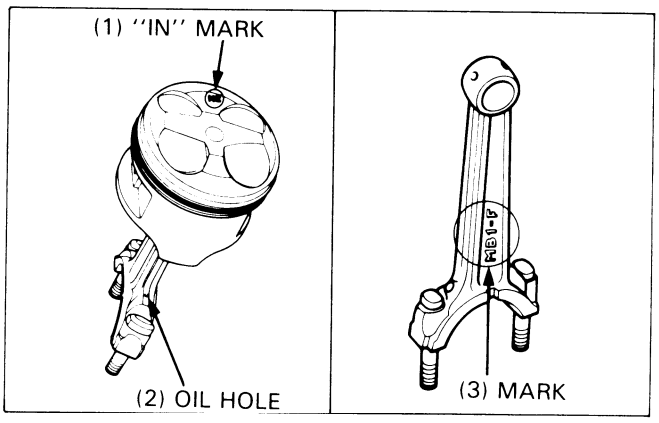
- Be careful not to damage the piston and rings during assembly.
- All rings should be installed with the markings facing up.
- Space the ring end gaps 120 degrees apart.
- Do not align the side rail gaps.
- After installing the rings they should rotate freely, without sticking.



PISTON AND CONNECTING ROD ASSEMBLY

Coat the rod small end with molybdenum disulfide grease.
Assemble the pistons and connecting rods with the piston and piston clips as follows.

Front
Note that the front cylinder connecting rods are marked "MB1-F".
The front piston must be installed so that the oil hole in the front connecting rod is on the opposite side to the "IN" mark on the front piston.



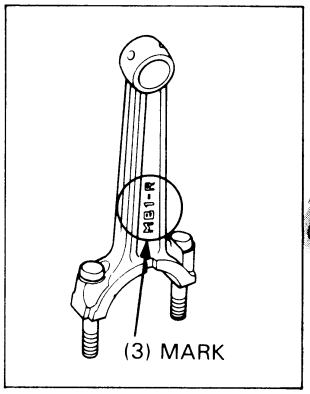
Rear

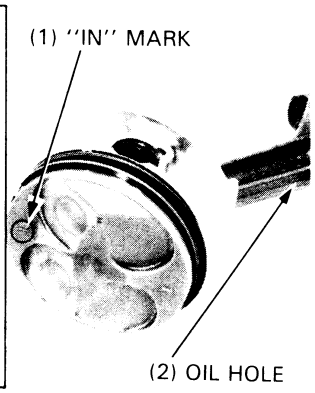
Note that the rear cylinder connecting rods are marked "MBI—R".

Install the pistons on the rear rods so that the intake "IN" mark is facing the same direction as the oil hole in the rod.

NOTE

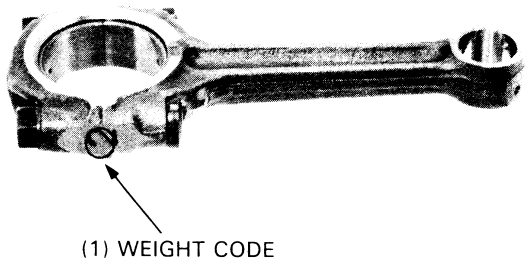
- Do not interchange the pistons, piston pins or connecting rods.
- Make sure that the piston pin clips are properly seated.





CONNECTING ROD SELECTION

If a connecting rod requires replacement, you should select a rod with the same weight code as the original. But if that is unavailable, you may use one of the others specified in the following chart.



Install the bearing inserts on the connecting rods and bearing caps, aligning the tabs on the inserts with the grooves in the rods and caps.

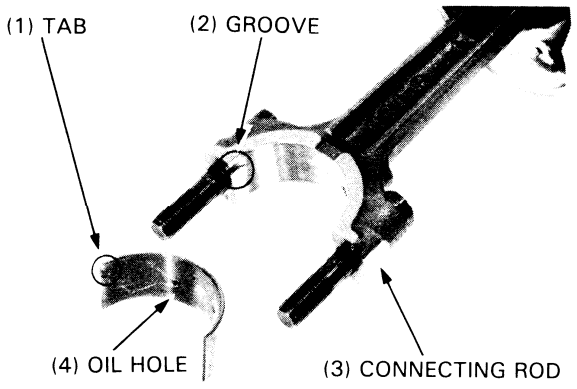
		REAR CONNECTING ROD				
		A	B	C	D	E
FRONT CONNECTING ROD	A	X	X	X	O	O
	B	X	X	O	O	O
	C	X	O	O	O	X
	D	O	O	O	X	X
	E	O	O	X	X	X

O: CORRECT
X: INCORRECT

Align the oil hole in the crankpin bearing inserts with the oil holes in the connecting rod and install the insert.

Align the notches on the crankpin bearing inserts with the grooves in the connecting rod and cap and install the inserts. Apply molybdenum disulfide grease to the crankpin bearings.

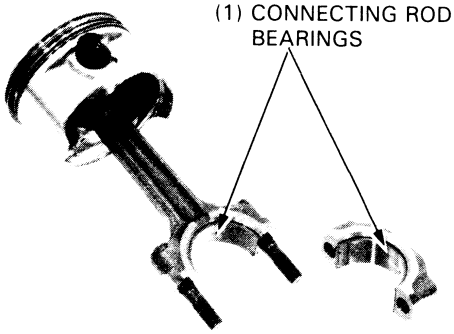
Apply molybdenum disulfide grease to the connecting rod bearings.



Stagger the piston ring end gaps 120° apart (page 10-11). Compress the piston rings with a ring compressor and insert the piston and rod into the cylinder until the rod seats on the crankpin.

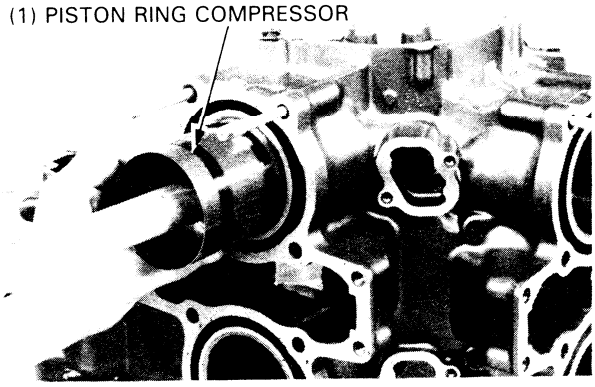
NOTE

- Be careful not to damage the pistons or rings during assembly.



Coat the cylinders, piston rings/grooves and pistons with oil. To prevent damaging the crankshaft, slip short sections of rubber hose over the rod bolts before installation.
Install the rod and piston assemblies into the cylinders from the top of the crankcase. Be sure each assembly is returned to its original position as noted during removal.

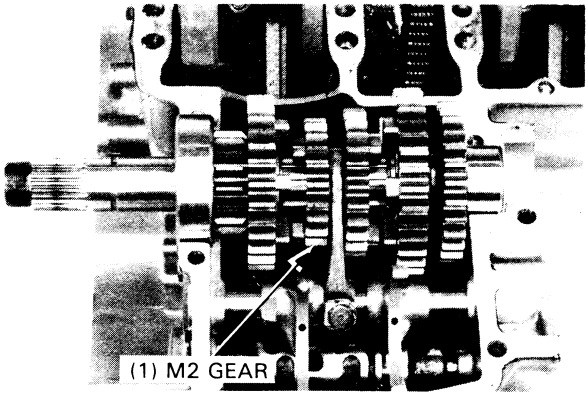
Compress the piston rings with a ring compressor and insert the piston and rod into the cylinder until the rod seats on the crankpin.



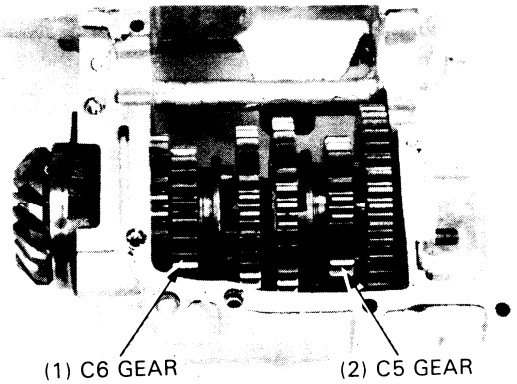
CRANKCASE ASSEMBLY

Install the mainshaft assembly.

Apply molybdenum disulfide grease to the shift fork groove of the M2 gear.



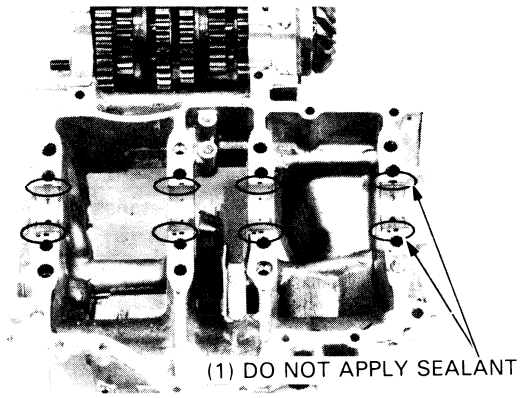
Apply molybdenum disulfide grease to the shift fork groove of the C5 and C6 gears.
Clean the oil passages and orifice with compressed air.

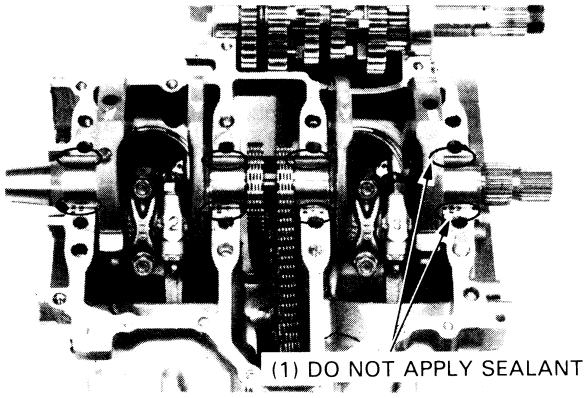


Clean the crankcase mating surfaces.
Apply liquid sealant to the mating surface of the lower and upper crankcase.

CAUTION

- *Do not apply sealant to the area near the main bearings.*

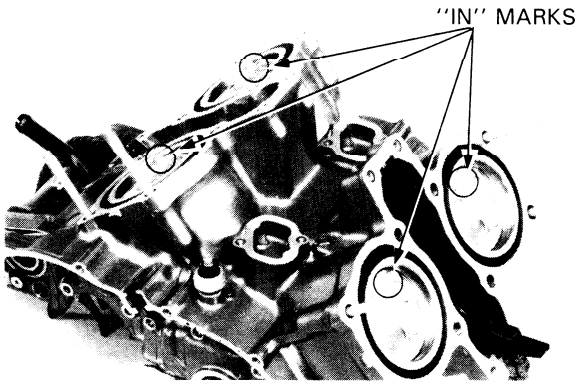




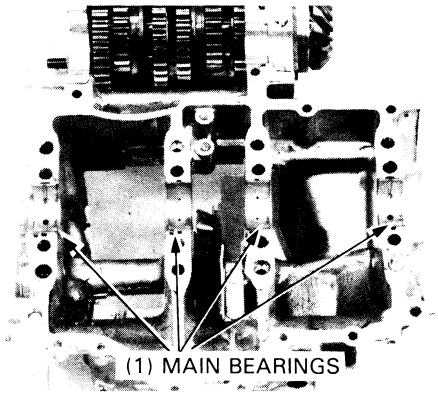
Be sure each assembly is returned to its original position as noted during removal.

NOTE

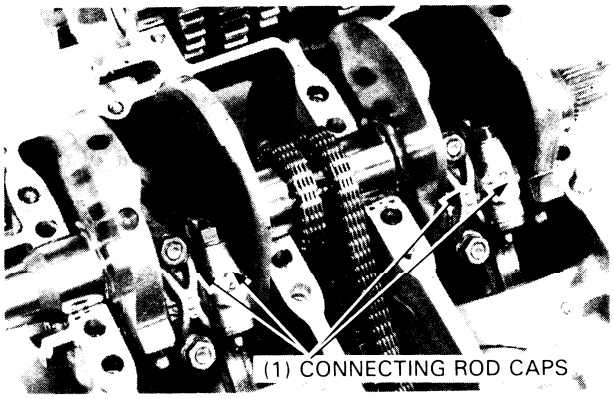
- The piston intake "IN" marks should be facing each other as shown.



Install the main bearings into the upper and lower crankcases by aligning the boss of the bearing with the groove of the crankcase.
Apply molybdenum disulfide grease to the main bearings.



Install the cam chains onto the crankshaft.
Place the crankshaft into the upper crankcase as shown.
Install the connecting rod caps.

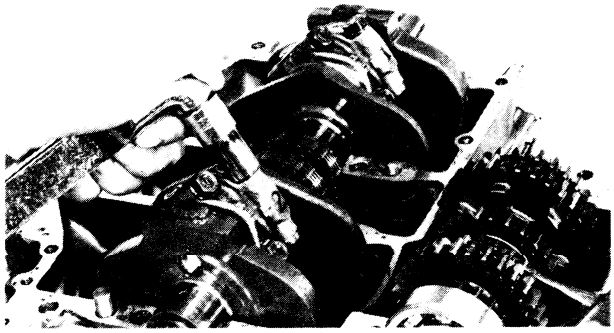


TORQUE: 30—34 N·m (3.0—3.4 kg-m, 22—25 ft-lb)

NOTE

- Be sure the bearing caps are installed in their correct locations as marked during removal.
- Tighten the nuts in two or more steps.
- After tightening the bolts, check that the rods move freely without binding.

Tighten the specified torque.



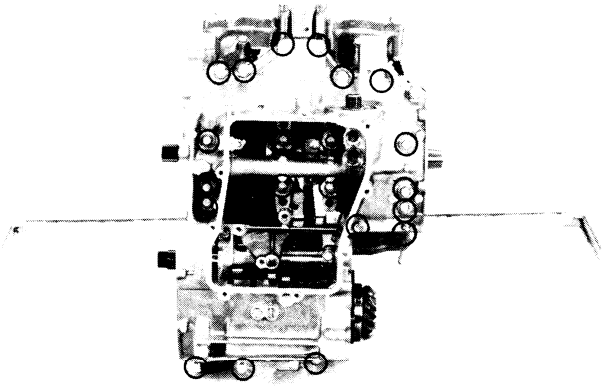
Assemble the crankcase halves, aligning the shift fork claws with the gears.

CAUTION

- *Before tightening the bolts, mark sure that the mating surface of lower and upper crank case is securely stuck.*

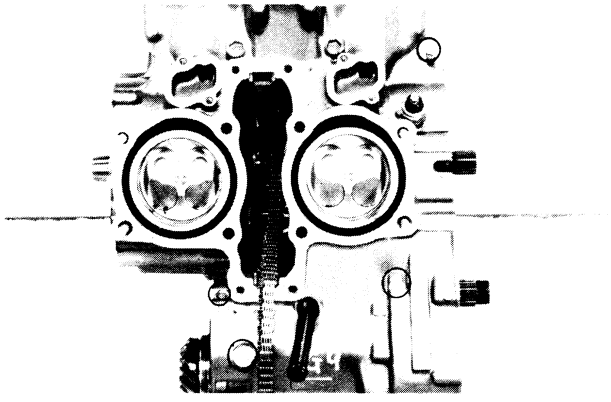
Tighten the bolts to the specified torque values in the sequence shown in 2-3 steps.

TORQUE VALUES:
9 mm bolt: 30 34 N·m (3.0 3.4 kg m, 22 25 ft lb)
6 mm bolt: 10—14 N·m (1.0—1.4 kg-m, 7—10 ft-lb)



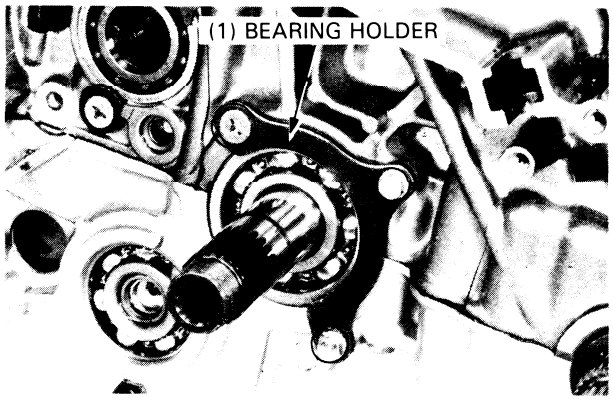
Tighten the upper crankcase bolts to the specified torque in a crisscross pattern and in 2—3 steps.

TORQUE VALUES:
8 mm bolt: 21—25 N·m (2.1—2.5 kg-m, 15—18 ft-lb)
6 mm bolt: 10—14 N·m (1.0—1.4 kg-m, 7—10 ft-lb)



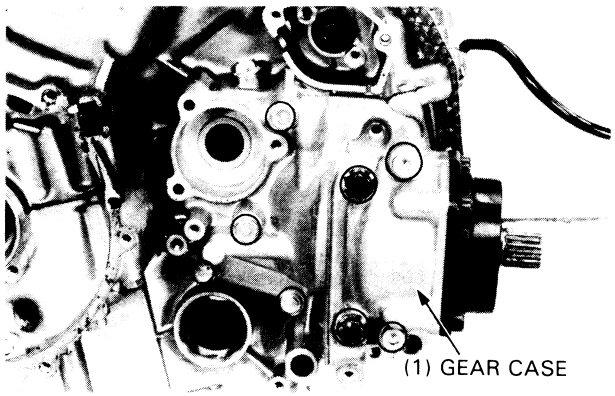
Install the mainshaft bearing holder and tighten the screw and bolts.
Apply LOCTITE® 271 or equivalent.
Tighten the screws first then the bolts.

Install a new output gear case gasket with one of the same thickness as removed.



Install the output gear case.
Install the bolts and sealing washers, and then tighten to the specified torque.

TORQUE VALUES:
Output gear case
bearing holder bolt:
30—34 N·m (3.0—3.4 kg-m, 22—25 ft-lb)
8 mm bolt/socket bolt:
21—25 N·m (2.1—2.5 kg-m, 15—18 ft-lb)
6 mm bolt:
10—14 N·m (1.0—1.4 kg-m, 7—10 ft-lb)



Install the water pump.
Install the water pipe and caps.