

4. The procedure for measuring the lash between the bull gear and the fuel pump drive gear (if applicable) and the air compressor and power steering pump drive gear is similar to the steps just mentioned. Refer to step 3 and perform step 3[a], as the first step and refer to step 3[g], as the final step. Gear case cover must be installed to continue on checking the engine timing. Refer to section 1.10.3 and perform all of the steps under gear case cover installation.

**NOTE:**

Due to the possibility of damaging the crankshaft front oil seal, whenever the gear case cover is removed, the front crankshaft oil seal must be replaced. Replace the crankshaft front oil seal after the gear case cover is installed. Refer to section 1.8.1.

5. The procedure for measuring the lash between the accessory drive gear and air compressor pump drive gear (on vehicle without power steering) is similar to the steps just mentioned. Refer to step 3 and perform step 3[a], as the first step and refer to step 3[g], as the final step.

**NOTE:**

Lash can be measured with the gear case cover installed. Access covers are provided for checking the lash between these gears and the bull gear. For engines with no access cover for accessory drive, gear lash is to be measured off the accessory drive pulley.

6. The procedure for measuring the lash between the adjustable idler gear and camshaft drive gear is similar to the steps just mentioned. Refer to step 3 and perform step 3[a], as the first step and refer to step 3[g], as the final step.

**NOTE:**

These gears are measured and adjusted with the gear case cover installed.

7. The procedure for measuring the lash between the bull gear and the water pump drive gear is similar to the steps just mentioned. Refer to step 3 and perform step 3[a], as the first step and refer to step 3[g], as the final step.

**NOTE:**

These gears can be measured with the pump installed.

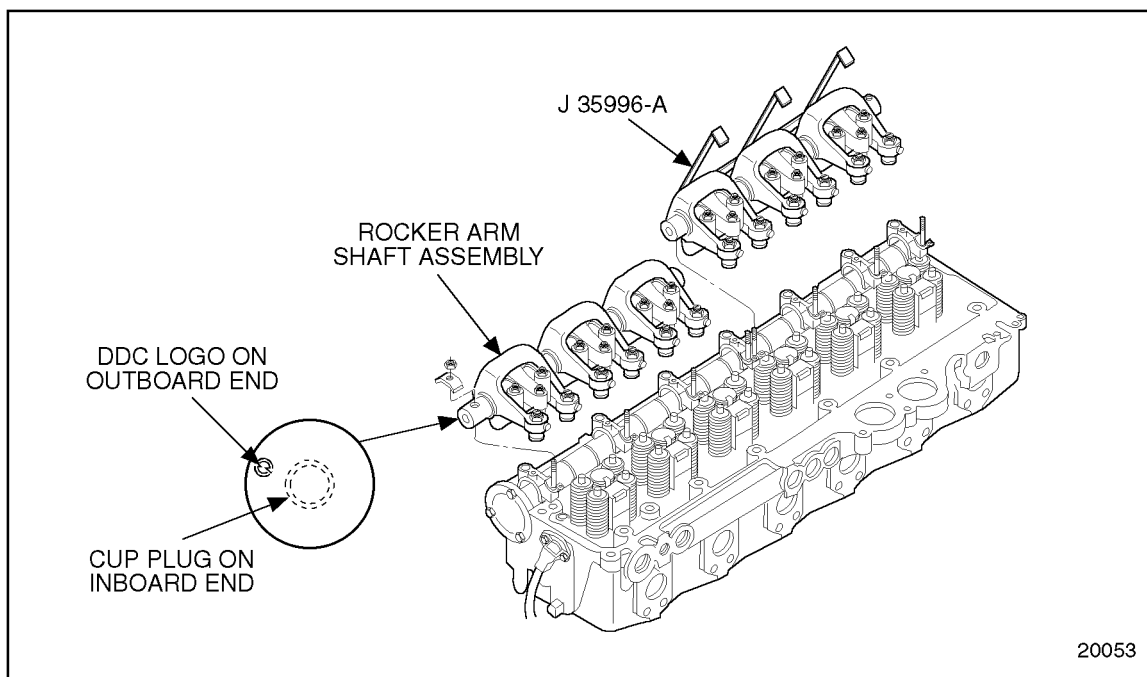
**NOTICE**

For engines equipped with the compact gear train assembly go to step 9 for measuring and adjusting gear lash procedures.

8. When measuring or adjusting the gear lash between the adjustable idler gear and the camshaft drive gear, the valve and injector spring pressures must be removed from the camshaft lobes. Use the following procedure for this adjustment:

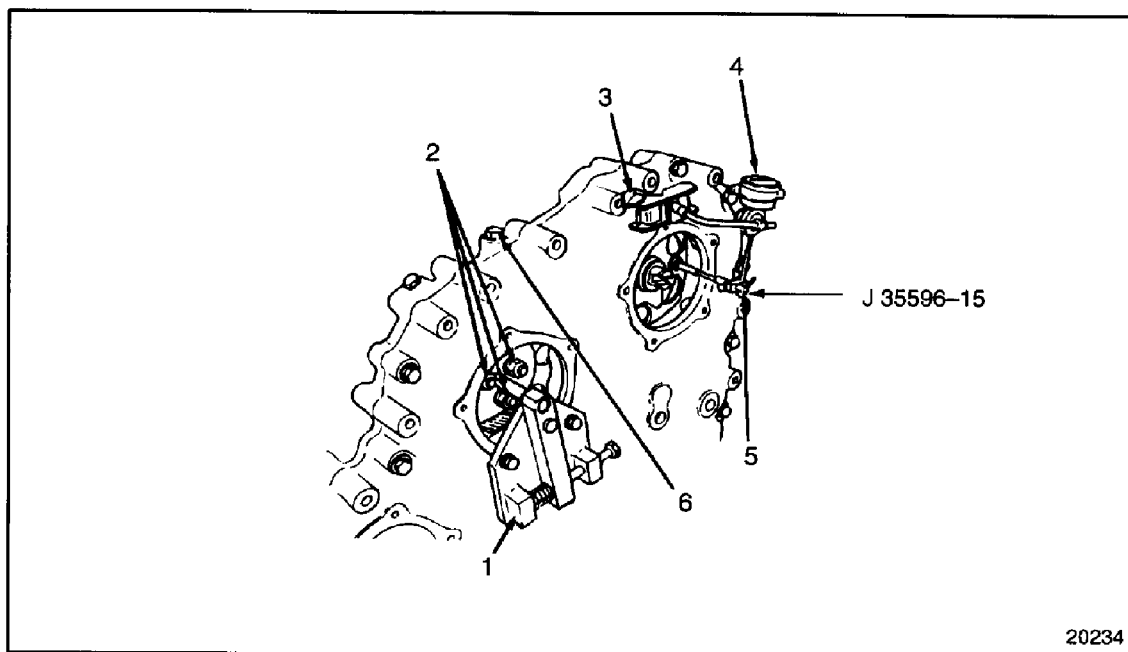
**NOTE:**

The front and rear rocker shafts look identical, but must not be interchanged due to different oil passage patterns. The outboard ends of the rocker arm shafts are marked for identification with the DDC logo. See Figure 1-330. Use care to ensure that the rocker arm shaft assemblies are replaced exactly as removed.



**Figure 1-330 Rocker Arm Shaft Identification Mark**

- [a] Install the gear lash pedestal, J 35596-15, into the threaded hole of the camshaft drive gear. See Figure 1-331. Bar the engine over until the tool is at the three o'clock position.



- |  |  |
|--|--|
| 1. Gear Lash Adjustment Tool           | 4. Dial Indicator                      |
| 2. Adjustable Idler Gear Retaining Nut | 5. Pedestal Idler Gear Hole            |
| 3. Magnetic Base                       | 6. Adjustable Idler Gear Retaining Nut |

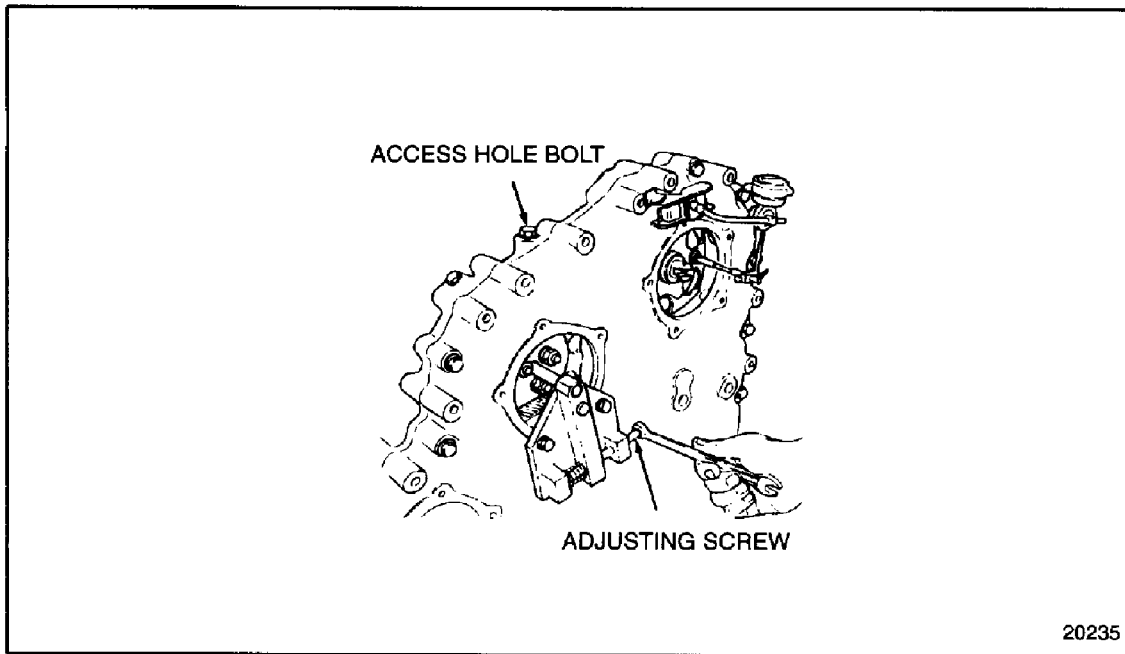
**Figure 1-331 Camshaft Drive Gear-to-Adjustable Idler Gear Lash Measurement**

**NOTE:**

Since the teeth of the camshaft drive gear are not accessible with the gear case cover installed, the lash is measured on the pedestal installed in the threaded hole, which is located exactly half-way between the center and edge of the camshaft drive gear. For this reason, the reading obtained will be exactly 1/2 of the actual gear lash.

- [b] Mount a dial indicator adaptor and dial indicator. See Figure 1-331.
- [c] Adjust the stem of the dial indicator to rest on the flat of the pedestal.
- [d] If the adjustable idler gear has been removed, torque the three flanged nuts that retain the adjustable idler gear hub to the gear case to 57-67 N·m (42-49 lb·ft) to seat the assembly before proceeding.
- [e] Loosen the three locknuts that retain the adjustable idler gear hub to the gear case until they are hand tight.
- [f] Insert the dowel portion of the gear lash adjusting tool, J 35596, through the hole in the adjustable idler gear retaining plate and into the adjustable idler gear hub, using the bottom two adjustable idler gear cover bolt holes. See Figure 1-331.

- [g] Turn the adjusting screw of the tool in a clockwise direction to force the adjustable idler gear against the camshaft drive gear, until there is zero lash between the two gears. See Figure 1-332.



**Figure 1-332 Adjustable Idler Gear-to-Camshaft Drive Gear Lash Adjustment**

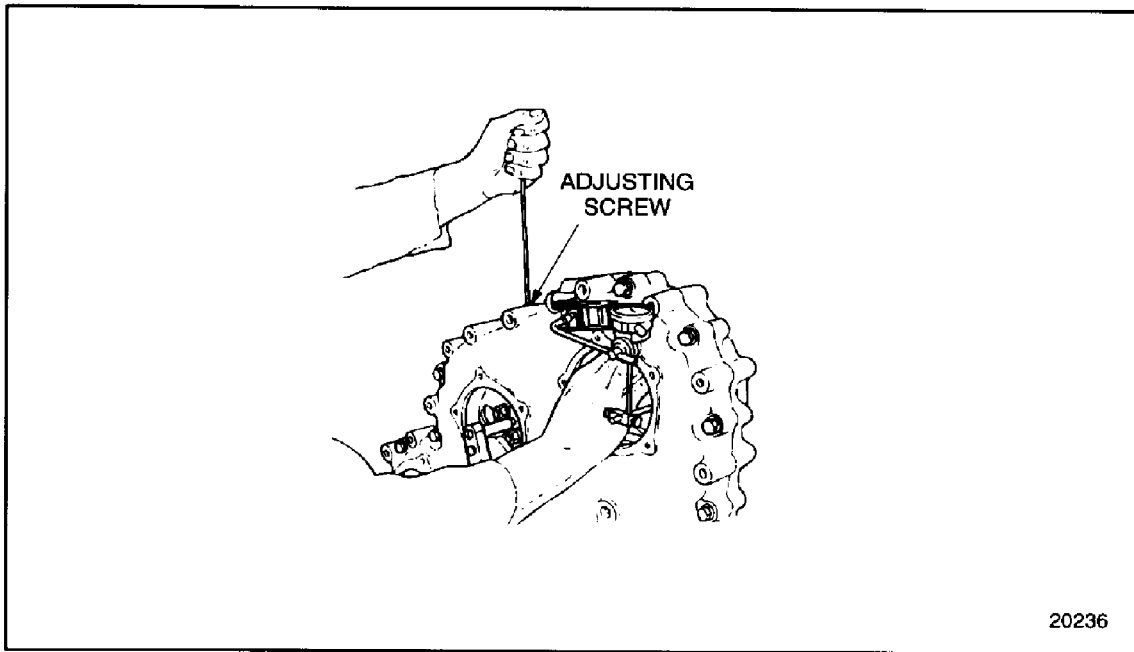
- [h] Zero the dial indicator.
- [i] Hold the adjustable idler gear by inserting a screwdriver through the hole provided in the gear case. Engage one of the adjustable idler gear teeth and apply pressure on the screwdriver to move the gear in a counterclockwise direction. This will prevent the gear from moving.
- [j] Attempt to turn the camshaft drive gear, and watch the dial indicator pointer.

**NOTE:**

If there is zero lash between the two gears, the dial indicator pointer will not move from zero.

- [k] Turn the adjusting screw of the gear lash adjusting tool, J 35596, approximately 1-1/2 turns or until the proper gear lash is obtained.

- [l] When checking gear lash, hold the adjustable idler gear stationary . Refer to step 8[i] as the first step and refer to step 8[j] as the final step, and rotate the camshaft drive gear with your right hand. See Figure 1-333.



**Figure 1-333      Checking Adjustable Idler Gear-to-Camshaft Drive Gear Lash**

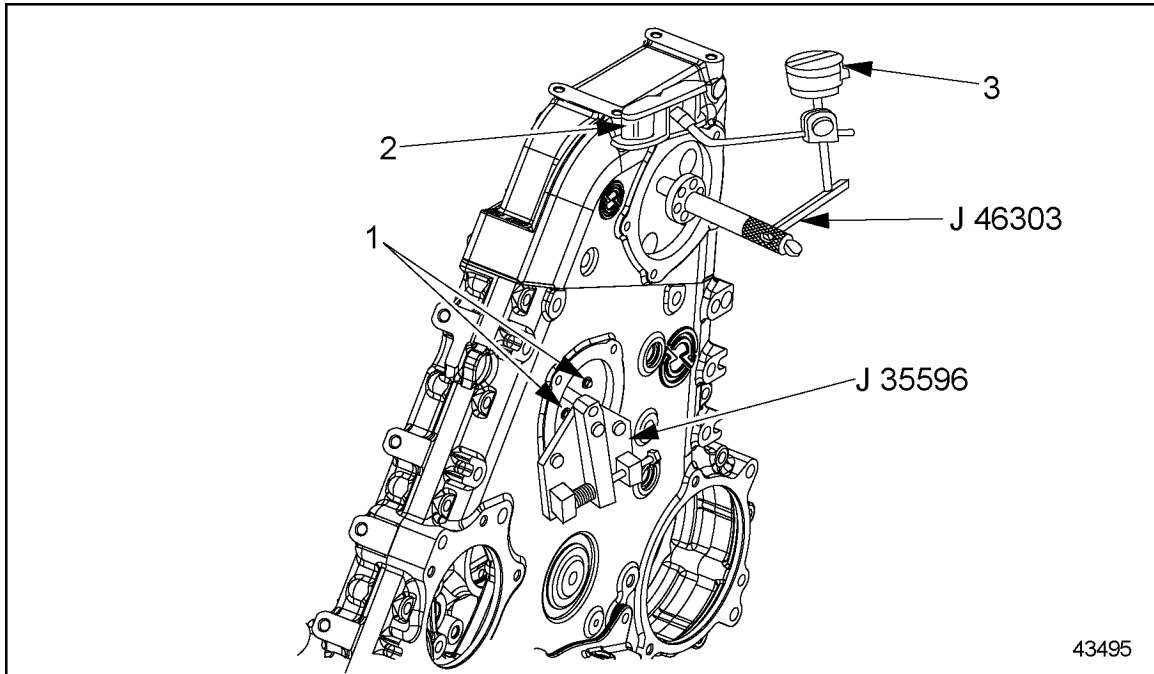
**NOTE:**

Remember to multiply the reading obtained by two to get the actual lash measurement. The specification of gear lash is 0.051-0.229 mm (0.002 -0.009 in.) with a maximum of 0.305 mm (0.012 in.) for used parts.

- [m] Check the gear lash with the pedestal at the 3, 6, 9 and 12 o'clock positions, exactly as previously performed.
- [n] When the proper readings of 0.025-0.114 mm (0.001-0.0045 in.) are obtained at all four (4) positions, hold the idler gear. Refer to step 8[i] as the first step and refer to step 8[j] as the final step, and torque the top two adjustable idler gear flanged nuts to 57-67 N·m (42-49 lb·ft).
- [o] Check the gear lash again as outlined above, with the flanged nuts torqued, to ensure that gear lash is still within limits. If not correct repeat the procedure.
- [p] If proper lash measurement cannot be obtained, replace gear(s) with new part(s). Refer to section 1.24.2, refer to section 1.25.2, refer to section 1.27.2 and refer to section 1.26.2.
- [q] Remove the gear lash adjusting tool from the gear case.
- [r] Torque the bottom adjustable idler gear flanged nut to 57-67 N·m (42-49 lb·ft) torque.
- [s] Remove the dial indicator and pedestal from the gear case.

- [t] Before installing the rocker arm shaft assemblies, check the torque on the end studs to ensure they were not loosened at time of removal. The torque specification is 101-116 N·m (75-86 lb·ft).
- [u] Install the rocker arm shaft assemblies to the cylinder head. Refer to section 1.3.3.
- [v] Adjust the intake and exhaust valve clearances, and fuel injector heights. Refer to section 12.2.
- [w] Install the valve rocker cover. Refer to section 1.6.8 for a one-piece valve rocker cover and refer to section 1.6.9 for two-piece and three-piece rocker covers.
- [x] Install the camshaft drive gear access cover and the gear case cover. Refer to section 1.10.3.

9. The procedures for measuring and adjusting the gear lash for the compact gear train are as follows:
  - [a] Install the gear lash pedestal tool, J 46303 onto the center of the camshaft drive gear. See Figure 1-333a. Bar the engine over until the tool is at the three o'clock position.
  - [b] Attach the magnetic base on dial indicator to the gear case cover. Adjust it so the dial indicator is positioned at a 90° angle to the measuring bar and is at the scribe line on the bar. See Figure 1-333a.



- |  |                   |
|--|-------------------|
| 1. Adjustable Idler Gear Retaining Nut | 3. Dial Indicator |
| 2. Magnetic Base                       |                   |

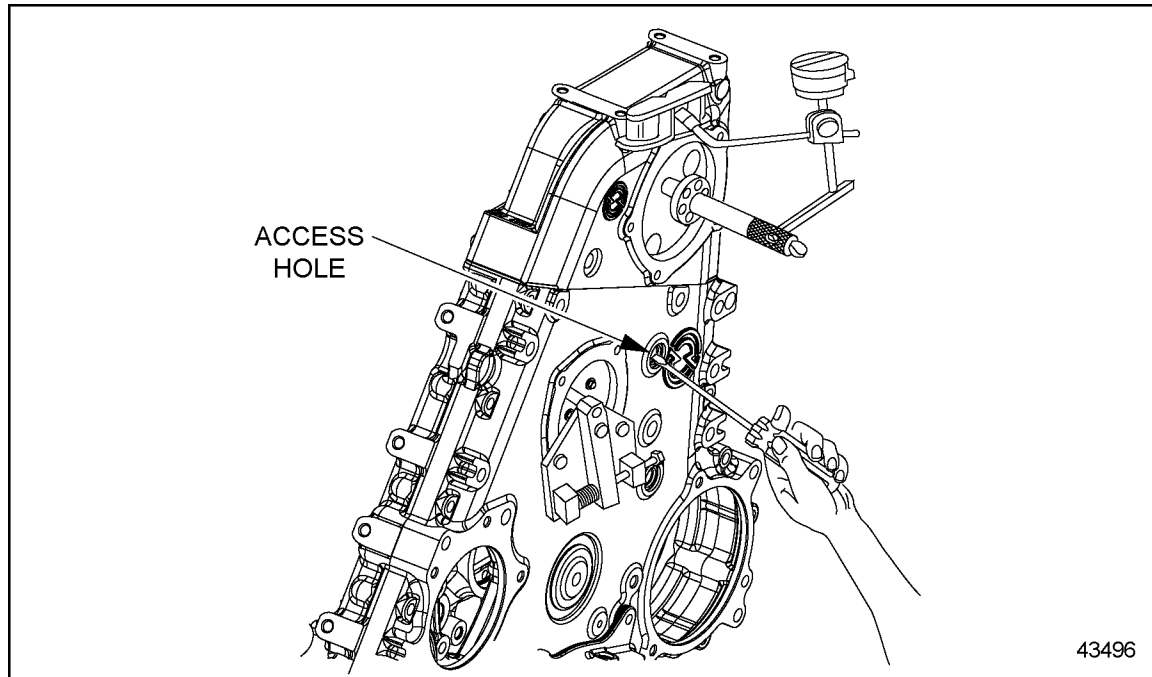
**Figure 1-333a Compact Gear Train Gear Lash Measurement**

**NOTE:**

Since the teeth of the camshaft drive gear are not accessible, the gear lash measuring adaptor has a predetermined spot where the lash measurement must be taken. The measurement bar must be installed into the magnetic base correctly and the dial indicator positioned between the marks at the end of the bar.

- [c] Adjust the stem of the dial indicator to rest on the flat of the pedestal between the scribed marks on the end bar at a 90° angle.
- [d] If the adjustable idler gear has been removed, torque the three flanged nuts that retain the adjustable idler gear hub to the gear case to 57-67 N·m (42-49 lb·ft) to seat the assembly before proceeding.

- [e] Loosen the three locknuts that retain the adjustable idler gear hub to the gear case until they are hand tight.
- [f] Insert the dowel portion of the gear lash adjusting tool J 35596 , through the hole in the adjustable idler gear retaining plate and into the adjustable idler gear hub, using the bottom two adjustable idler gear cover bolt holes. See Figure 1-333a.



**Figure 1-333b Compact Gear Train Lash Adjustment**

**NOTE:**

For Series 60 engines equipped with the compact gear train, tool J 35596 needs to be modified to fit the four bolt pattern of the idler gear cover. A simple modification to the mounting plate will allow it to be securely bolted to the cover.

- [g] Hold the adjustable idler gear by inserting a screwdriver through the access hole provided in the gear case cover. Engage between two of the idler gear teeth and apply upward pressure on the screwdriver to move the gear in a counterclockwise direction. This will prevent the gear from moving. See Figure 1-333b
- [h] Rotate the camshaft by hand and watch the dial indicator pointer.
- [i] Turn the adjusting screw of the gear lash adjusting tool J 35596 , approximately 1-1/2 turns. Gear lash should be 0.051-0.229 mm (0.002-0.009 in.). Hold the adjustable idler gear with screwdriver refer to step [g]. Repeat steps [h] and [i] until proper lash is obtained.

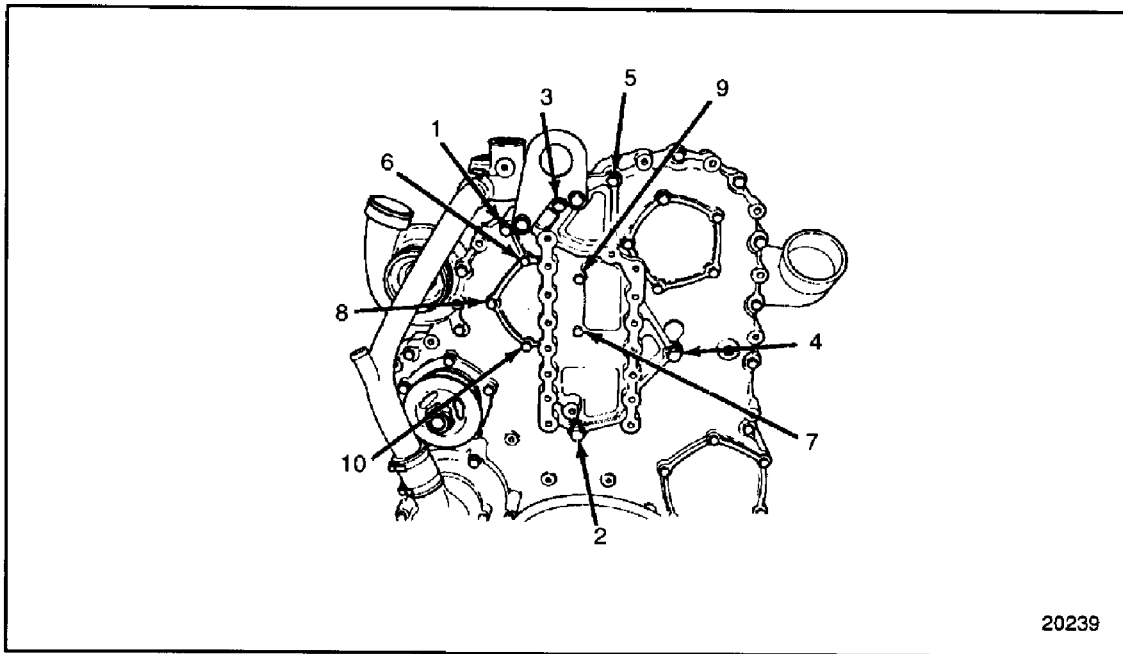
**NOTE:**

If there is zero lash between the two gears, the dial indicator pointer will not move from zero.



- [j] Check the gear lash with the pedestal at 3, 6, 9, and 12 o'clock positions, exactly as previously performed.
- [k] When the proper readings of 0.051-0.229 mm (0.002-0.009 in.) are obtained at all four positions, hold the idler gear and torque the three adjustable idler gear flanged nuts to 103-113 N·m (76-83 lb·ft.).
- [l] Remove the gear lash adjusting tool and check the gear lash again. Refer to step 9 [j]. If gear lash is not correct repeat steps 9 [e] through steps 9 [j].
- [m] If proper lash measurement cannot be obtained , replace gear(s) with new part(s).
- [n] Remove the dial indicator and pedestal from the gear case.
- [o] Before installing the rocker arm shaft assemblies, check the torque on the end studs to ensure they were not loosened at the time of removal. The torque specification is 101-116 N·m (75 -86 lb·ft).
- [p] Install the rocker arm shaft assemblies to the cylinder head. Refer to section 1.3.3.
- [q] Adjust the intake and exhaust valve clearances, and fuel injector heights. Refer to section 12.2.
- [r] Install the valve rocker cover. Refer to section 1.6.8 for a one-piece valve rocker cover and refer to section 1.6.9 for two piece and three piece rocker covers.
- [s] Install the camshaft drive gear access cover and the gear case cover.  
Refer to section 1.10.3.

10. Install the fan support bracket "if required" as follows:
- [a] Clean the mating surfaces of the fan support bracket and gear case of all old gasket eliminator. Refer to the section on "Gasket Eliminator" in the "General Information" section at the beginning of this manual.
  - [b] Apply a 1/16 in. bead of Gasket Eliminator PT-7276 (Loctite® 518), or equivalent, to the machined surface of the gear case cover surrounding the adjustable idler gear access.
  - [c] Install the fan support bracket to the gear case cover using the torque values and tightening sequence. See Figure 1-334.

**Bolt**

1-3-5

2-4

6 to 10

**Torque**

58-73 N·m (43-54 lb·ft)

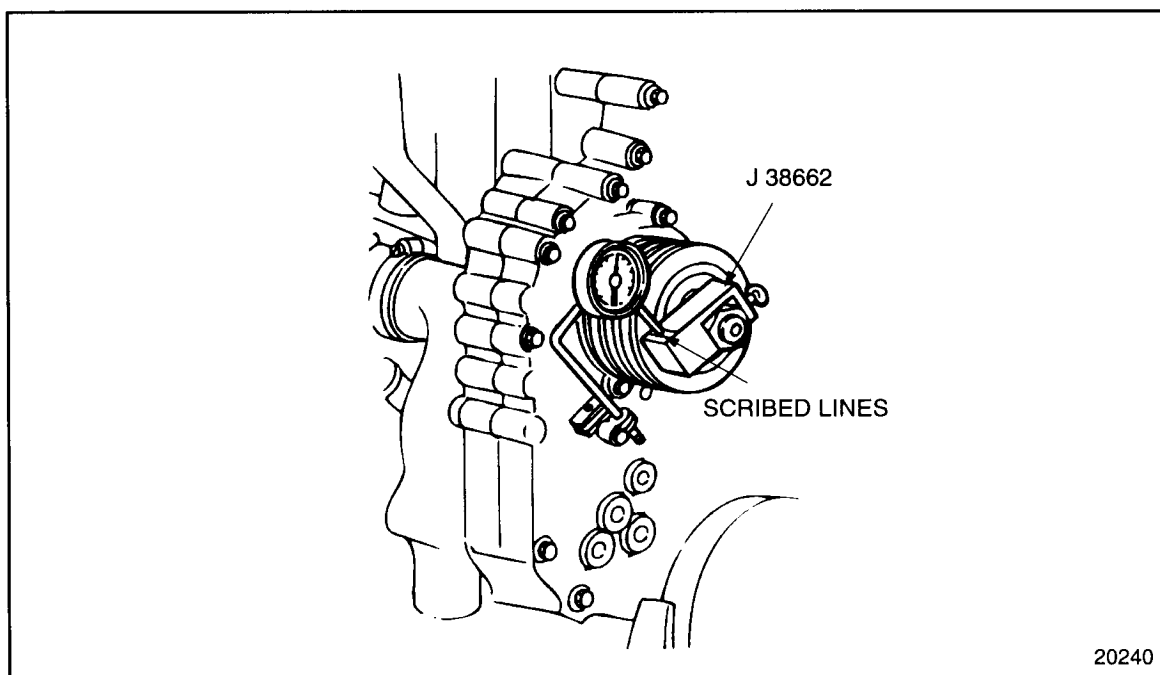
160-200 N·m (118-148 lb·ft)

30-38 N·m (22-28 lb·ft)

**Figure 1-334 Fan Support Bracket Bolt Torque Sequence**

11. Check the bull gear-to-accessory drive gear lash measurement as follows:

- [a] Install the gear lash tool, J 38662 and mount a magnetic dial indicator base and dial indicator to the gear case cover. See Figure 1-335.



**Figure 1-335 Accessory Drive Gear-to-Bull Gear Lash Measurement**

- [b] Position the dial indicator to read between the scribed lines on the tool. See Figure 1-335.
- [c] Rotate the accessory drive pulley, read and record the total gear lash.
- [d] Gear lash measurements are 0.051-0.229 mm (0.002 -0.009 in.) for new parts, and 0.305 mm (0.012 in.) for used parts.
- [e] If proper lash measurement cannot be obtained, replace gear with a new part. Refer to section 1.26.2.
- [f] Remove the dial indicator and gear lash tool.

12. Check the bull gear-to-water pump drive gear lash measurement for 1991 and later engines (with water pump impeller slip tester, J 35687-1) as follows:

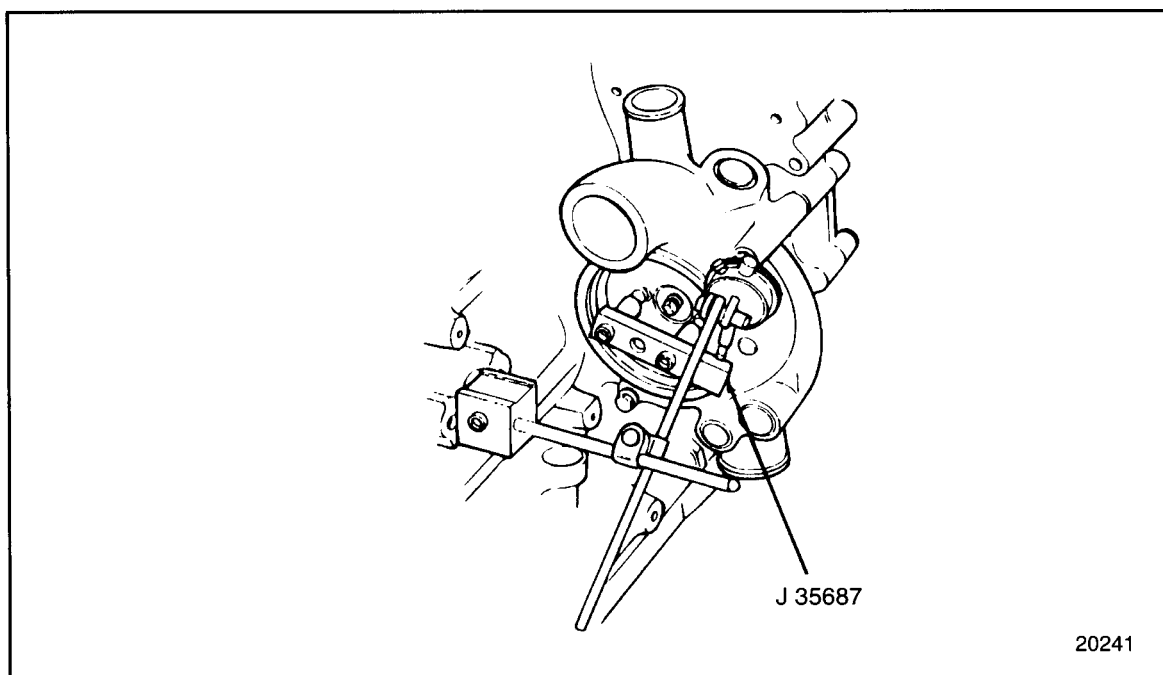
**NOTE:**

The bull gear-to-water pump drive gear lash can be measured using the water pump impeller slip tester, J 35687-1, refer to step 12[a] through step 12[g]. Or by using the water pump gear lash tool, J 38977, refer to step 13. Engines built early in 1991 will need the water pump gear lash checked with the slip tester. These engines do not have a threaded hole in the water pump drive gear retaining bolt to accept the gear lash tool.

**⚠ CAUTION:**

**To avoid injury from flying parts when working with components under spring tension, wear adequate eye protection (face shield or safety goggles).**

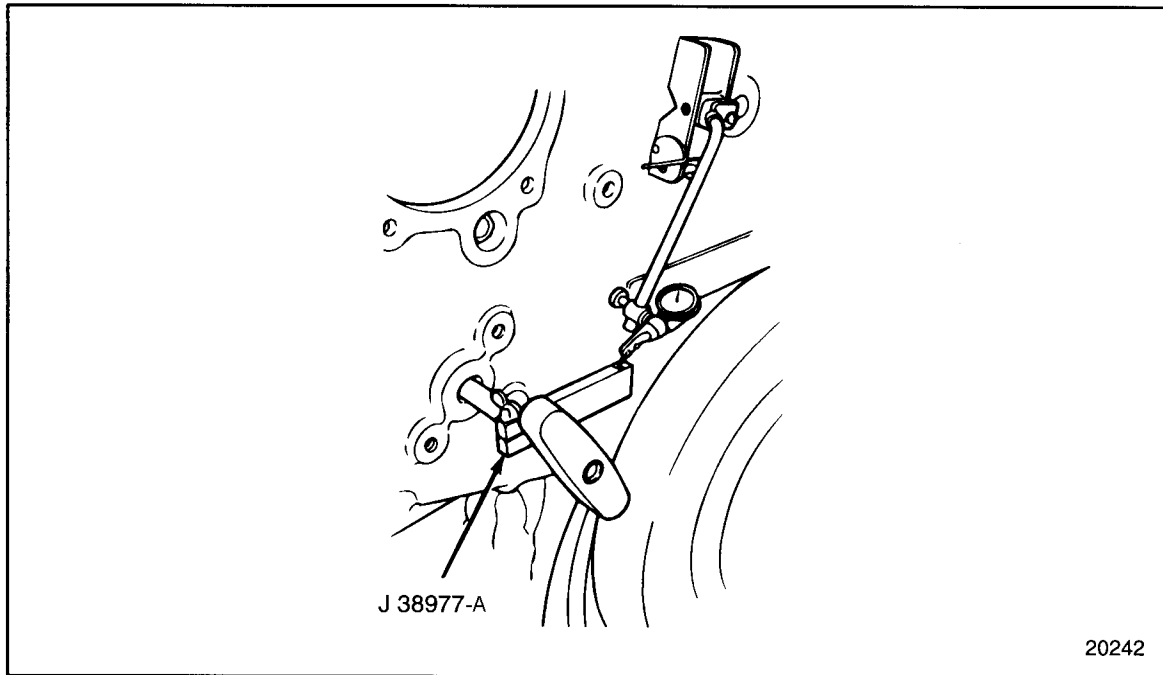
- [a] Remove the water pump cover snap ring with snap ring pliers. Remove water pump cover and seal ring.
- [b] Install the water pump impeller slip tester, J 35687-1, to the water pump impeller with two 5/16-18 bolts, using the instructions supplied with the tool. See Figure 1-336.



**Figure 1-336 Water Pump Impeller Slip Tester Method**

- [c] One leg (the long one) of the tool has an inscribed line. Measuring with a dial indicator at this line of the tool, the gear lash measurement will be an exact 1:1 reading. Gear lash specifications are 0.051-0.229 mm (0.002 -0.009 in.).
- [d] If proper lash cannot be obtained, replace gear with a new part. Refer to section 1.26.2.
- [e] Remove the dial indicator.
- [f] Remove the tool from the water pump.
- [g] Inspect the water pump cover seal for cracks or splitting. Refer to section 4.2.3.1 gear mounted or refer to section 4.3.3 for front mounted water pump. Replace seal if damage is found.

13. Check the bull gear-to-water pump drive gear lash measurement for 1991 and later engines (with water pump gear lash tool, J 38977) as follows:
  - [a] Remove the pipe plug in the gear case cover.
  - [b] Install the water pump gear lash tool, J 38977-A, through the hole in the gear case and thread it into the special water pump drive gear retaining bolt. See Figure 1-337.



**Figure 1-337 Water Pump Gear Lash Tool Method**

- [c] The arm of this tool has an inscribed line. Measuring with a dial indicator at this line of the tool, the gear lash measurement will be an exact 1:1 reading. Gear lash specifications are 0.051-0.229 mm (0.002 -0.009 in.).
- [d] If proper lash cannot be obtained, replace the gear with a new part. Refer to section 1.26.2.
- [e] Remove the dial indicator and the gear lash tool.
- [f] Install the pipe plug in the gear case cover. Torque to 24-31 N·m (18-23 lb·ft).

14. Check the bull gear-to-water pump drive gear lash measurement of pre-1991 engines (with the water pump impeller slip tester method) as follows.

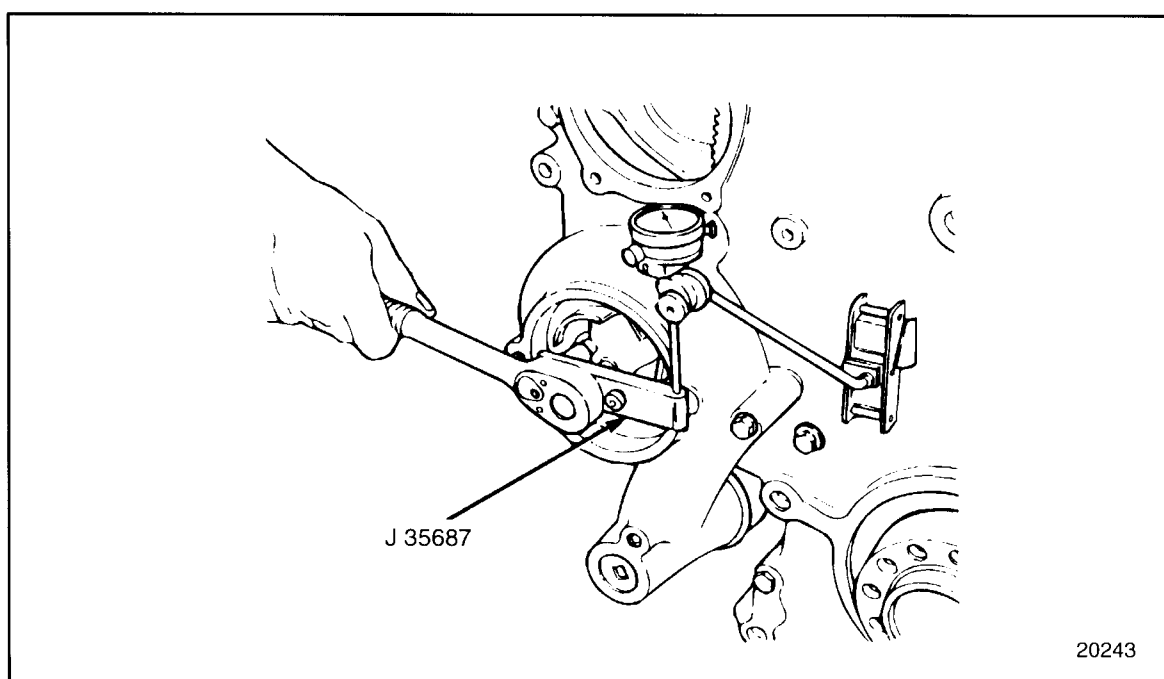
**NOTE:**

Skip step 14 and the following step 15, if the engine was built after 1990.

**NOTE:**

The bull gear-to-water pump drive gear lash can be measured using the water pump impeller slip tester, J 35687-1, or by inserting a bolt into one of the tapped holes in the water pump impeller. The lash can then be measured using a dial indicator.

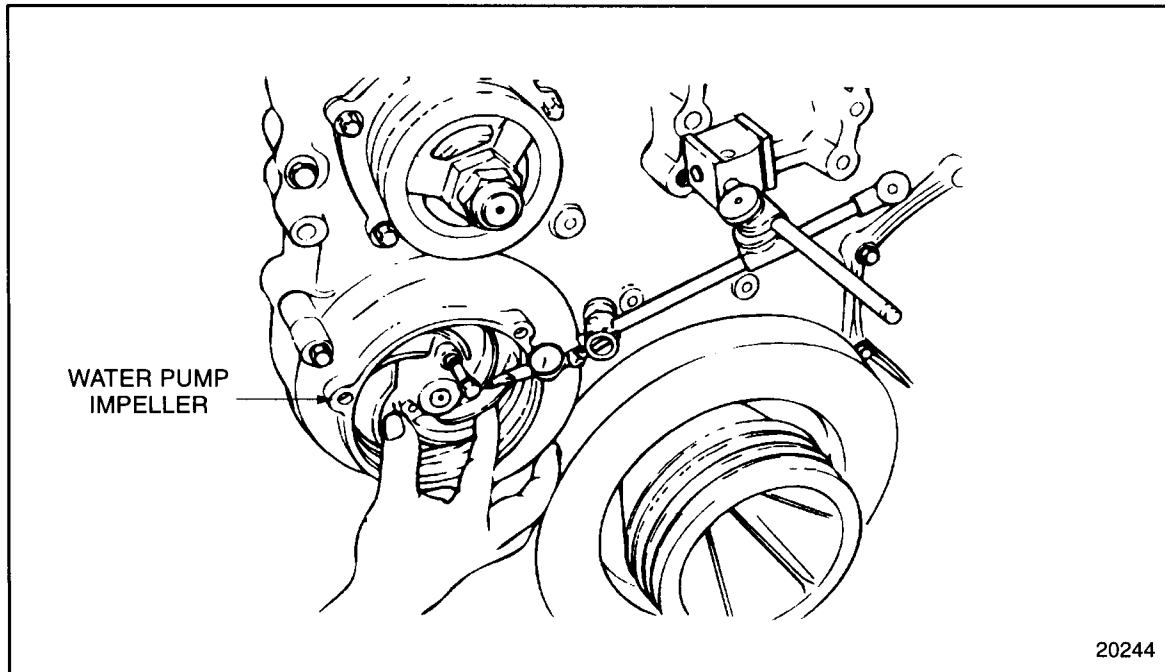
- [a] Install the water pump impeller slip tester, J 35687-1, to the water pump impeller with two 5/16-18 bolts, using the instructions supplied with the tool. See Figure 1-338.



**Figure 1-338 Water Pump Drive Gear Lash Measurement**

- [b] One leg (the long one) of the tool has an inscribed line. Measuring with a dial indicator at this line of the tool, the gear lash measurement will be an exact 1:1 reading. Gear lash specifications are 0.051-0.229 mm (0.002 -0.009 in.).
- [c] If proper lash measurement cannot be obtained, replace the gear with a new part. Refer to section 1.26.2 .

15. Check the bull gear-to-water pump drive gear lash measurement for pre-1991 engines (with the bolt method) as follows:
- [a] Install a 5/16-18 bolt and nut into one of the tapped holes in the water pump impeller. See Figure 1-339.



**Figure 1-339 Water Pump Drive Gear-to-Bull Gear Lash Measurement**

- [b] Install a magnetic dial indicator base and dial indicator. See Figure 1-339.
- [c] Position the stem of the dial indicator on a flat of the bolt.
- [d] Preload the water pump impeller.
- [e] Zero the dial indicator.
- [f] Rotate the water pump impeller, read and record the total gear lash. Multiply this reading by 2.45 to obtain actual lash. Gear lash measurements are 0.051 to 0.229 mm (0.002 -0.009 in.).
- [g] If proper lash cannot be obtained, replace the gear with a new part. Refer to section 1.26.2.
- [h] Remove the dial indicator base and dial indicator.
- [i] Remove the bolt and nut from the water pump impeller (if used).
- [j] Inspect the rubber seal ring on the water pump cover for splitting or cracks. Install a new seal, if necessary, between the water pump cover and the water pump housing. Refer to step 12, and perform step 12[g].
- [k] Install the two bolts that secure the water pump cover to the water pump housing. Torque the bolts to 30-38 N·m (22-28 lb·ft).



16. Check the bull gear-to-air compressor drive gear lash measurement as follows:
  - [a] Mount a magnetic dial indicator base and dial indicator to the gear case cover so that the stem of the dial indicator may be positioned on a tooth of the air compressor drive gear.
  - [b] Preload the drive gear in one direction.
  - [c] Zero the dial indicator.
  - [d] Rotate the air compressor drive gear, read and record the total gear lash. Gear lash measurements are 0.051-0.229 mm (0.002 -0.009 in.) for new parts, with a maximum of 0.305 mm (0.012 in.) for used gears.
  - [e] If proper lash cannot be obtained, replace the gear with a new part. Refer to section 1.26.2.
  - [f] Remove the dial indicator and magnetic base.
  - [g] Install the power steering drive coupling to the air compressor drive gear (if equipped with power steering) and insert a new O-ring on the power steering pump (if so equipped).
  - [h] Install the power steering pump to the gear case cover, meshing the drive coupling properly.
  - [i] Install and torque the power steering pump mounting bolts to 30-38 N·m (22-28 lb·ft). Tighten the five bolts alternately and evenly, in a star-shaped pattern, to progressively draw the power steering pump into the gear case cover.

**NOTE:**

Do not force the bolts. If resistance is encountered, remove the power steering pump and re-engage the drive hub with the coupling.

- [j] If the engine is not equipped with power steering, install the air compressor drive gear access cover using a new gasket.
- [k] Install and torque the retaining bolts to 30-38 N·m (22-28 lb·ft), using a star-shaped pattern.

### 1.21.3 Installation of Gear Train and Engine Timing

After all of the gear lash measurements have been taken, assemble the engine components as follows:

1. Install the air conditioner compressor and brackets (if so equipped). Install the air conditioner drive belt.
2. Install the alternator and brackets. Refer to section 8.2.3.
3. Install the alternator drive belts. Refer to section 13.13.10.
4. Install the fan and fan hub assembly. Refer to section 4.7.6.
5. Adjust the alternator, fan and air conditioner compressor drive belts to the specifications. Refer to section 13.13.10. Torque the accessory mounting bolts to specifications.
6. Install any other equipment such as hoses, brackets, lines or electrical looms that were removed to gain access to the engine gear case cover.
7. Install the engine oil pan. Refer to section 3.11.4.
8. Fill the engine crankcase. Refer to section 13.13.1.
9. Refer to section 11.8 for verification of proper gear train and engine timing.