Section 1.24
Gear Train and Engine Timing

The gear train is completely enclosed between the gear case and gear case cover and is located at the front of the engine. The gear train consists of a camshaft drive gear, camshaft idler gear, fuel pump drive gear, air compressor and power steering pump drive gear, bull gear, oil pump drive gear, crankshaft timing gear, water pump drive gear, accessory pulley drive gear, and adjustable idler gear. The gear ratio of each gear in relationship to the crankshaft timing gear is shown directly below the gear title. See Figure "Engine Gear Train".

![Gear Train Diagram]

**Figure 1. Engine Gear Train**

The crankshaft timing gear, pressed onto the front end of the crankshaft, directly drives the bull gear and oil pump drive gear, and indirectly (through the bull gear), drives the fuel pump drive gear, air compressor and power steering pump drive gear, accessory pulley drive gear and water pump drive gear.

The camshaft idler gear is mounted to the rear of the bull gear on the same carrier, and rotates along with the bull gear at the same speed. This camshaft idler gear drives the adjustable idler gear, which in turn, drives the camshaft drive gear. See Figure "Gear Train and Related Parts".
The bull gear and camshaft idler gear are a press-fit to the bull gear and camshaft idler gear carrier. Both gears are keyed to the carrier by the same key. The carrier is supported by two tapered roller bearings, which ride on a hub bolted to the engine block by four bolts. The bull gear and camshaft idler gear assembly is retained to the hub by a left-hand threaded nut.

The camshaft idler gear drives the camshaft drive gear through an adjustable idler gear. The adjustable idler gear is supported by a bushing and is mounted on an adjustable hub secured by three studs pressed into the gear case from the rear.

The camshaft must be in time with the crankshaft timing gear. Since there are three gears between them, timing marks have been stamped or etched on the face of the gears to facilitate correct gear train timing. See Figure "Engine Gear Train and Timing Marks".
The symbol system of marking the gears makes gear train timing a comparatively easy operation. When assembling the engine, work from the crankshaft timing gear to the camshaft drive gear and line up the appropriate symbols on the gears as each gear assembly is installed on the engine.

There are no timing marks on the drive gears for the fuel pump, air compressor and power steering pump, water pump or accessory drive pulley. Therefore, it is not necessary to align these gears in any particular position during their installation.

The backlash between the various mating gears in the gear train should be 0.051 - 0.229 mm (0.002 - 0.009 in.) and should not exceed 0.305 mm (0.012 in.) backlash between worn gears.

Gear train noise is usually an indication of excessive gear lash, chipped, pitted or burred gear teeth or excessive bearing wear. Therefore, when noise develops in a gear train, the gear case cover should be removed and the gear train and its bearings inspected. A rattling noise usually indicates excessive gear lash whereas a whining noise indicates too little gear lash.

The gear train is lubricated by oil splash. The bull gear and camshaft idler gear are pressure-fed lubricating oil through two holes in the bull gear recess area of the engine block. See Figure "Gear Train Lubricating Oil Hole Locations".
These two holes are connected to the main oil gallery. The adjustable idler gear assembly is pressure-fed by an oil gallery in the gear case that indexes with a hole in the engine block. The hole in the engine block is connected to the main oil gallery.

The correct relationship between the crankshaft and the camshaft must be maintained to properly control the opening and closing of the intake and exhaust valves, and the operation of the fuel injectors and to help maintain engine balance.

The crankshaft and camshaft gears can only be mounted in one position as they are both keyed to their mating parts. Therefore, when the engine is properly timed, the timing marks on the various gears will match. See Figure "Engine Gear Train and Timing Marks".

An "out of time" engine may result in valve-to-piston dome contact, a no-start condition or loss of power.

Section 1.24.1
Repair or Replacement of Gear Train and Engine Timing

To determine if repair is possible or replacement is necessary, perform the following procedure. See Figure "Flowchart for Repair or Replacement of Gear Train and Engine Timing - Part 1 of 3".
Go to "A", see Figure "Flowchart for Repair or Replacement of Gear Train and Engine Timing - Part 2 of 3".

**Figure 5. Flowchart for Repair or Replacement of Gear Train and Engine Timing - Part 1 of 3**
Figure 6. Flowchart for Repair or Replacement of Gear Train and Engine Timing - Part 2 of 3

Go to "B", see Figure "Flowchart for Repair or Replacement of Gear Train and Engine Timing - Part 3 of 3". 

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Figure 7. Flowchart for Repair or Replacement of Gear Train and Engine Timing - Part 3 of 3

Section 1.24.2
Gear Train and Engine Timing Check Procedure

When an engine is out of time, the camshaft timing can be checked by following the camshaft timing check procedure. Refer to "1.28.6.1 Testing of Camshaft Timing for Diesel Engines". If the engine is out of time, a visual inspection of the gear train is required. Refer to "1.10.2 Removal of Engine Gear Case Cover" and perform all of the steps under "Removal of Gear Case Cover".

For engines equipped with the compact gear train refer to and perform all the steps under "Removal of Gear Case Cover".

Section 1.24.2.1
Check Engine Timing

Gear train noise is usually an indication of excessive gear lash, chipped, pitted or burred gear teeth, or excessive bearing wear. Therefore, when noise develops in a gear train, the gear case cover should be removed and the gear train and its bearings inspected. A rattling noise usually indicates excessive gear
lash. A whining noise indicates too little gear lash.

1. Check engine timing as follows:
   a. Examine all timing marks to ensure they are aligned. See Figure "Engine Gear Train and Timing Marks".
   b. It may be necessary to remove the gears to align the timing marks. Refer to "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".
   c. For engines equipped with the compact gear train remove the gears to align the timing marks. Refer to "1.32.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".

   **Note:** The gear ratio between the adjustable idler gear and the camshaft drive gear causes a "hunting-tooth" situation. Therefore, the bull gear and rocker arm assemblies should be removed to align the timing marks. See Figure "Engine Gear Train and Timing Marks".

   d. If any gears are removed or installed, or if lash between any two gears is out of specification, check the lash between the mating gears.

2. Check the crankshaft timing gear-to-oil pump idler gear lash measurement as follows:
   a. Fasten a dial indicator and magnetic base to the cylinder block so that the stem of the dial indicator rests on a tooth of the oil pump drive gear. See Figure "Crankshaft Timing Gear-to-Oil Pump Idler Gear Lash Measurement".

   **Figure 8. Crankshaft Timing Gear-to-Oil Pump Idler Gear Lash Measurement**

   **Note:** The oil pump design changed effective with 1991 model year engines. However, the oil pump gear lash measurement procedure is the same for both style pumps.

   b. Hold the crankshaft timing gear stationary, and rotate the oil pump drive gear in one direction, as far as it will go, without moving the crankshaft timing gear.
   c. Zero the dial indicator.
   d. Move the oil pump drive gear in the opposite direction, as far as it will go, without moving the crankshaft timing gear.
   e. Read and record the total gear lash.

   **Note:** The gear lash must be checked in four positions 90 degrees apart.
**Note:** The lash between the crankshaft timing gear and oil pump drive gear must be measured with the engine in a running position. See Figure "Crankshaft Timing Gear-to-Oil Pump Idler Gear Lash Measurement".

Proper lash between the crankshaft timing gear and oil pump drive gear is 0.051-0.229 mm (0.002 -0.009 in.).

The gear lash between the crankshaft timing gear and the oil pump drive gear can be adjusted utilizing shims inserted between the oil pump body and the cylinder block. See Figure "Lubricating Oil Pump Shim Installation".

![Figure 9. Lubricating Oil Pump Shim Installation](image)

**f.** Remove or install shims as necessary to obtain the proper gear lash clearance.

**Note:** When adjusting for gear tooth lash by installing or removing shims, the same number of shims must be changed under each foot so that the pump will always be level on the engine block. The insertion or removal of one 0.127 mm (0.005 in.) shim will change the gear tooth lash by approximately 0.102 mm (0.004 in.).

**Note:** If it is necessary to remove the oil pump, refer to "3.2.2 Removal of Oil Pump".

**g.** If the use of shims cannot bring gear lash within acceptable limits, the gear or gears for that gear set must be replaced.

3. Check the crankshaft timing gear-to-bull gear lash measurement as follows:
   a. Install a dial indicator and magnetic base. See Figure "Crankshaft Timing Gear-to-Bull Gear Lash Measurement".
Figure 10. Crankshaft Timing Gear-to-Bull Gear Lash Measurement

b. Adjust the stem of the dial indicator to rest on the center of a tooth on the bull gear.
c. Preload the bull gear.
d. Zero the dial indicator pointer.
e. Hold the crankshaft timing gear stationary with one hand. Rotate the bull gear and check the total gear lash in four positions of crank gear, approximately 90 degrees apart.
f. Although gear lash for the remaining gear sets is not adjustable, the lash must still be measured. Lash specifications is 0.051-0.229 mm (0.002 -0.009 in.) for new parts and a maximum of 0.305 mm (0.012 in.) for used parts.
g. If lash measurement is exceeded, replace gear with a new part.

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 3a, as the first step and refer to step 3g, as the final step.

Gear case cover must be installed to continue on checking the engine timing. Refer to "1.10.3 Installation of Gear Case Cover" 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 “1.8.1 Replacement of Oil Seal”.

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 3a, as the first step and refer to step 3g, 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 3a, as the first step and refer to step 3g, 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 3a, as the first step and refer to step 3g, as the final step.

Note: These gears can be measured with the pump installed.

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 "Rocker Arm Shaft Identification Mark". Use care to ensure that the rocker arm shaft assemblies are replaced exactly as removed.

**Figure 11. Rocker Arm Shaft Identification Mark**

a. Install the gear lash indicator (J–35596–15, part of tool set J–35596–A) into the threaded hole of the camshaft drive gear. See Figure "Camshaft Drive Gear-to-Adjustable Idler Gear Lash Measurement". Bar the engine over until the tool is at the three o'clock position.
Figure 12. 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 "Camshaft Drive Gear-to-Adjustable Idler Gear Lash Measurement".

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–A) 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 "Camshaft Drive Gear-to-Adjustable Idler Gear Lash Measurement".

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 "Adjustable Idler Gear-to-Camshaft Drive Gear Lash Adjustment".

<table>
<thead>
<tr>
<th>1. Gear Lash Adjustment Tool</th>
<th>4. Dial Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Adjustable Idler Gear Retaining Nut</td>
<td>5. Indicator Idler Gear Hole</td>
</tr>
</tbody>
</table>
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–A) 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 8i as the
first step and refer to step 8j as the final step, and rotate the camshaft drive gear with your
right hand. See Figure "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 (0.001-0.005 in.) are obtained at all four (4) positions, hold the idler gear. Refer to step 8i as the first step and refer to step 8j 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 "1.29.2 Removal of Camshaft Drive Gear", refer to "1.30.2 Removal of Adjustable Idler Gear Assembly", refer to "1.34.2 Removal of Crankshaft Timing Gear and Timing Wheel" and refer to "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".

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 "1.3.3 Installation of Rocker Arm Shaft Assembly".

v. Adjust the intake and exhaust valve clearances, and fuel injector heights. Refer to "13.2 Valve Lash, Injector Height (Timing) and Jake Brake® Lash Adjustments".

w. Install the valve rocker cover. Refer to "1.6.8 Installation of One-Piece Rocker Cover" for a one-piece valve rocker cover and refer to "1.6.9 Installation of Two-Piece and Three-Piece Rocker Covers" for two-piece and three-piece rocker covers.

x. Install the camshaft drive gear access cover and the gear case cover. Refer to "1.10.3 Installation of Gear Case Cover".

9. 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 "Fan Support Bracket Bolt Torque Sequence".
10. 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 "Accessory Drive Gear-to-Bull Gear Lash Measurement".

<table>
<thead>
<tr>
<th>Bolt</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3-5</td>
<td>58-73 N·m (43-54 lb·ft)</td>
</tr>
<tr>
<td>2-4</td>
<td>160-200 N·m (118-148 lb·ft)</td>
</tr>
<tr>
<td>6 to 10</td>
<td>30-38 N·m (22-28 lb·ft)</td>
</tr>
</tbody>
</table>

   **Figure 15. Fan Support Bracket Bolt Torque Sequence**

   b. Position the dial indicator to read between the scribed lines on the tool. See Figure "Accessory Drive Gear-to-Bull Gear Lash Measurement".

   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 “1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly”.
f. Remove the dial indicator and gear lash tool.

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

**Note:** The bull gear-to-water pump drive gear lash can be measured using the water pump impeller slip tester (J–35687), refer to step 11a through step 11g. Or by using the water pump gear lash tool (J–38977–A), refer to step 12. 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.

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**WARNING:**

**EYE INJURY**

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

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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), to the water pump impeller with two 5/16-18 bolts, using the instructions supplied with the tool. See Figure "Water Pump Impeller Slip Tester Method".

![Figure 17. Water Pump Impeller Slip Tester Method](http://extranet.detroitdiesel.com/power_service/literature/Content/04/040218.htm)

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 "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".
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 "4.2.3.1 Inspection of Water Pump (GCM)" gear mounted or refer to "4.3.3.1 Inspection of Front Mounted Water Pump" for front mounted water pump. Replace seal if damage is found.

12. Check the bull gear-to-water pump drive gear lash measurement for 1991 and later engines with water pump gear lash tool (J–38977–A) 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 "Water Pump Gear Lash Tool Method".

![Figure 18. Water Pump Gear Lash Tool Method](image)

   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 "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".
   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).

13. 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 13 and the following step 14, 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), 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), to the water pump impeller with two 5/16-18 bolts, using the instructions supplied with the tool. See Figure "Water Pump Drive Gear Lash Measurement".
Figure 19. 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 "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".

14. 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 "Water Pump Drive Gear-to-Bull Gear Lash Measurement".

b. Install a magnetic dial indicator base and dial indicator. See Figure "Water Pump Drive Gear-to-Bull Gear Lash Measurement".

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 "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".
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 11, and perform step 11g.
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).

15. 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 "1.33.2 Removal of Bull Gear and Camshaft Idler Gear Assembly".
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.

### Section 1.24.3

**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 "9.2.3 Installation of Alternator".
3. Install the alternator drive belts. Refer to "14.6.9 Drive Belts".
4. Install the fan and fan hub assembly. Refer to "4.6.6 Installation of the Engine Cooling Fan".
5. Adjust the alternator, fan and air conditioner compressor drive belts to the specifications. Refer to "14.6.9 Drive Belts". 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 "3.11.4 Installation of Oil Pan".
8. Fill the engine crankcase. Refer to "14.6.1 Lubricating Oil".
9. Refer to "12.7 Engine Run-in Instructions" for verification of proper gear train and engine timing.