

Group 0408 VENTILATING SYSTEM

GENERAL INFORMATION

The engine ventilating system prevents pressure build up in the crankcase. This allows the engine to breathe freely which is necessary for proper lubrication. It consists of a tube leading from the valve cover down the side of the engine (Fig. 1).

REMOVAL

Loosen side clamp.

Loosen upper clamp if engine is equipped with a flexible hose.

Remove ventilating hose or tube.

REPAIR

Inspect tube or hose for cracks.

Check tube for restrictions by pouring water through it.

Empty water from the tube.

Replace bent or crushed tubes. Replace broken or split hoses.

INSTALLATION

Replace O-ring in rocker arm cover.

Install tube on hose and secure with clamp.

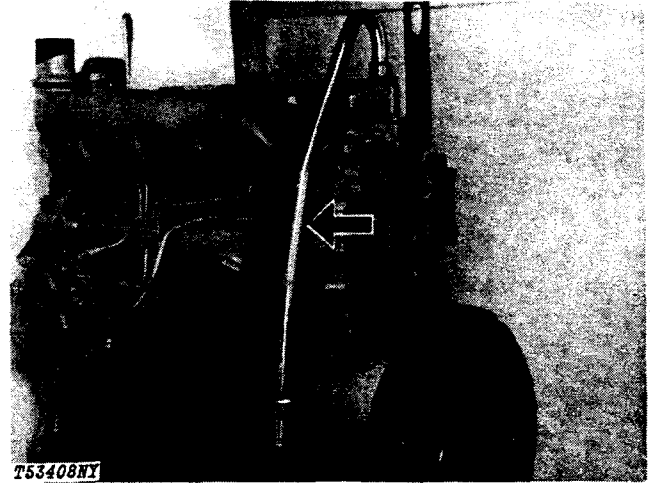


Fig. 1-Engine Ventilating Tube

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Group 0409 CYLINDER HEAD AND VALVES

REMOVAL

Remove turbocharger (Group 0416) from turbocharged engines.

Remove air inlet piping from non-turbocharged engines (Group 0520).

Remove water manifolds or thermostat housing (Group 0418).

Remove fuel filter (Group 0420).

Remove exhaust manifold (Group 0410).

Remove injection nozzles and injection lines (Group 0413).

Remove rocker arm cover, rocker arm assembly, and pushrods (Group 0402).

Remove cylinder head cap screws.

NOTE: Do not rotate crankshaft with cylinder head removed unless all cylinder liners are secured with short cap screws and large flat washers.

IMPORTANT: Do not use screwdrivers or pry bars between cylinder block and cylinder head to loosen cylinder head.

Lift cylinder head from cylinder block. If cylinder head sticks, use a soft hammer to tap the cylinder head.

Remove any gasket residue remaining on cylinder head.

Measure cylinder head deck to valve head distance with valve seated.

Cylinder head to intake valve head distance (new) (1, Fig. 1) . 0.023 to 0.047 inch (0.58 to 1.19 mm)

Cylinder head to exhaust valve head distance (new) (2) . . 0.038 to 0.072 inch (0.97 to 1.83 mm)

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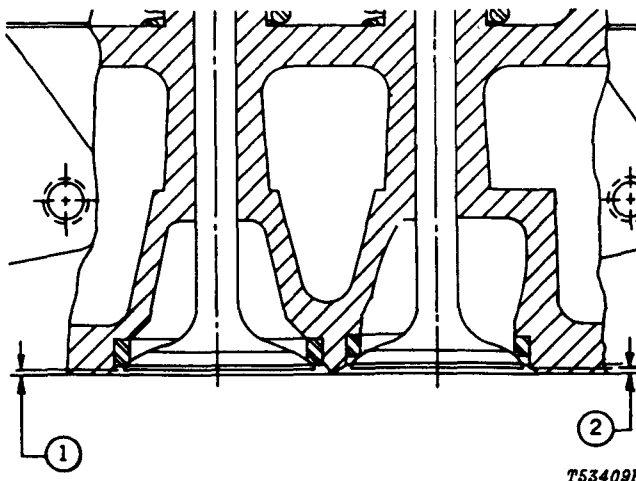


Fig. 1-Cylinder Head to Valve Head Distance

Using a valve spring compressor, compress valve springs far enough to remove retainer locks.

Release spring tension and remove valve spring cap (or rotator, if so equipped) and valve spring. Mark each part so that it can be reassembled in the same position it was removed from.

Remove valves, marking them for reassembly.

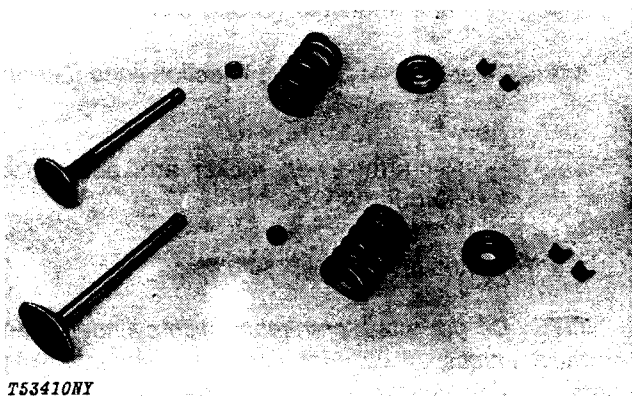


Fig. 2-Valve Removal

REPAIR

Measure cylinder head flatness (Fig. 3).

Cylinder head flatness (maximum warp) (1) 0.002 inch (0.05 mm)

Cylinder head may be resurfaced if necessary.

Maximum material removal from cylinder head (2) 0.030 inch (0.76 mm)

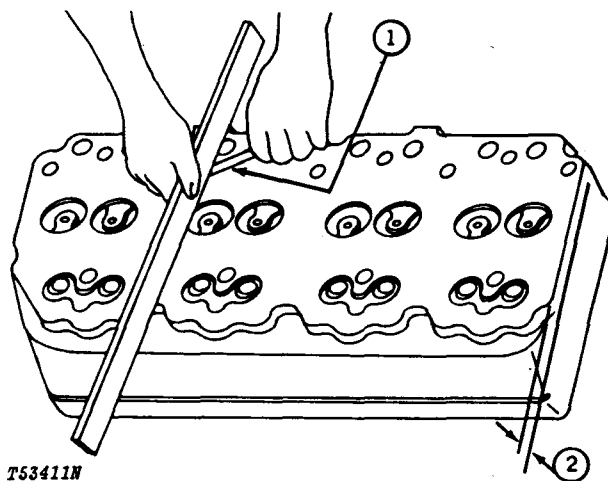
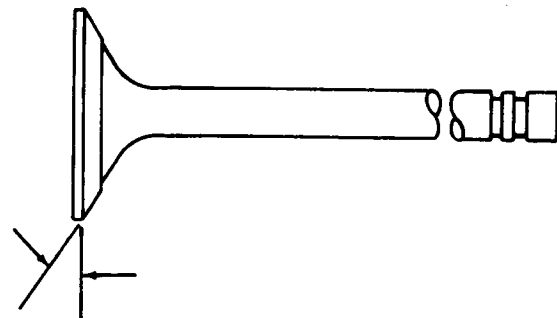


Fig. 3-Cylinder Head Flatness

If necessary to resurface valve face, grind valve face at following angle (Fig. 4):

Engine	Intake Valve	Exhaust Valve
3-164	45°	45°
4-219	45°	45°
4-276	30°	45°
6-329	45°	45°
6-414	30°	45°

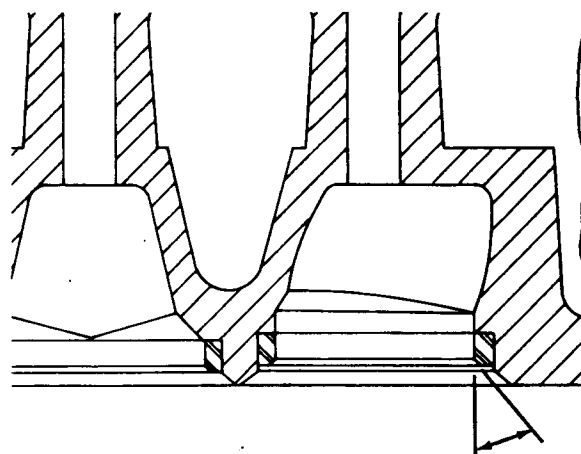


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Fig. 4-Valve Face Angle

If necessary to resurface valve seat, grind valve seat at following angle and width (Fig. 5):

Engine	Intake Valve Seat	Exhaust Valve Seat
3-164	45°	45°
4-219	45°	45°
4-276	30°	45°
6-329	45°	45°
6-414	30°	45°

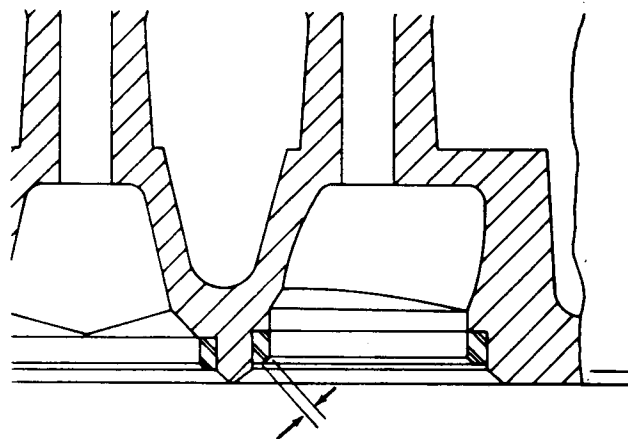


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Fig. 5-Valve Seat Angle

When resurfacing valve seats, the valve seat width must be maintained (Fig. 6).

Engine	Valve Seat Width
3-164	0.078 to 0.094 inch (1.98 to 2.39 mm)
4-219	0.063 to 0.078 inch (1.60 to 1.98 mm)
4-276	0.083 to 0.093 inch (2.11 to 2.36 mm)
6-329	0.047 to 0.078 inch (1.19 to 1.98 mm)

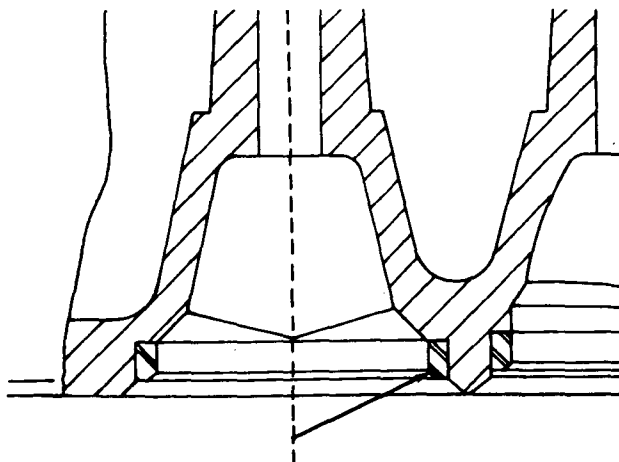


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Fig. 6-Valve Seat Width

When resurfacing valve seats, the valve seat run-out must be maintained (Fig. 7).

Valve seat
run-out (maximum) 0.002 inch
(0.05 mm)



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Fig. 7-Valve Seat Run-Out

Use JDE-77 Valve Seat Puller to remove intake valve seat inserts or JDE-87 Valve Seat Puller to remove exhaust valve seat inserts if they must be replaced on 4-276T, 6-414D or 6-414T engines (Fig. 8).

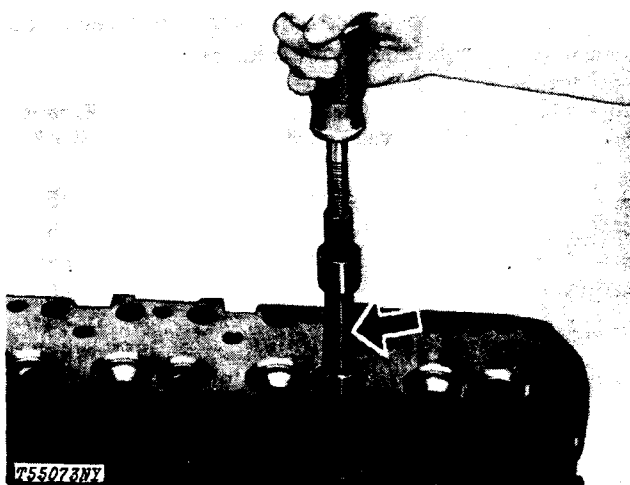


Fig. 8-JDE-77 or JDE-87 Valve Seat Puller

Use JDE-7 Driver (1, Fig. 9) with JDE-86 valve seat installer (2) (for exhaust) and JD-287 valve seat installer (2) (for intake) to install valve seat inserts. Chill the valve seat installer and valve seat insert to -20°F (-29°C) before driving into cylinder head.

Grind valve seats to obtain correct cylinder head deck to valve head distance.



Fig. 9-JDE-7 Driver and JDE-86 or JD-287 Valve Seat Installer

Measure valve stem oil clearance (Fig. 10).

Valve stem
O.D. (new) (1) 0.372 to 0.373 inch
(9.45 to 9.47 mm)

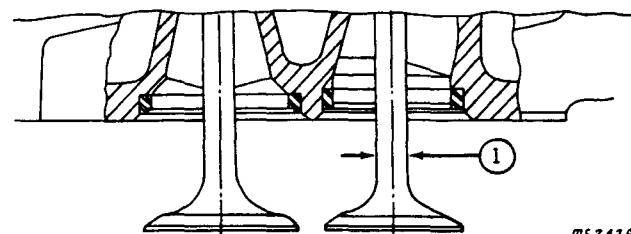
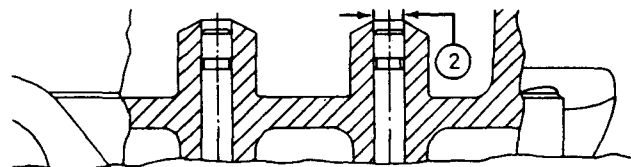
Valve guide
I.D. (new) (2) 0.375 to 0.876 inch
(9.53 to 9.55 mm)

Valve stem oil
clearance (new) 0.002 to 0.004 inch
(0.05 to 0.10 mm)

Valve stem oil
clearance (maximum) 0.006 inch
(0.15 mm)

If valve guide oil clearance is more than maximum allowable but not more than 0.008 inch (0.20 mm) valve guides can be knurled.

Use D-20002-WI Valve Guide Knurler (Fig. 11) as directed by manufacturer to knurl valve guides.



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Fig. 10-Valve Stem Oil Clearance



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Fig. 11-D-20002-WI Valve Guide Knurler

Inspect valve springs for rust, cracked coils, cocking, or any other damage.

Measure valve spring free length and compression.

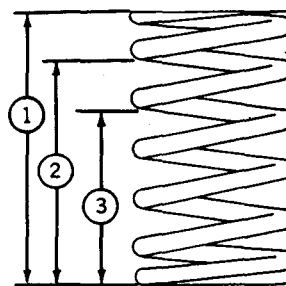
Valve spring
free length (approx.) (1, Fig. 12) 2.12 in.
(53.8 mm)

Valve spring (2) 1.81 in.
(46.0 mm)

when compressed with 54 to 62 lb.
(240 to 276 N) (24 to 28 kg)

Valve spring (3) 1.36 in.
(34.5 mm)

when compressed with 133 to 153 lb.
(592 to 681 N) (60 to 69 kg)



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Fig. 12-Valve Spring Length

ASSEMBLY

Apply AR44402, Valve Stem Lubricant, or its equivalent, to valve stems and guides. Install valves into guides from which they were removed. Valves must move freely and seat properly.

Position valve springs with end of spring correctly located in the machined counterbore (Fig. 13) of the cylinder head.

4

Install spring caps or rotators, if so equipped, and new retainer locks. "Pop" each valve three or four times by tapping the end of the valve stem with a soft mallet.



Fig. 13-Valve Spring Counterbore

INSTALLATION

IMPORTANT: Be sure all tapped holes in cylinder block are clean and free of foreign matter before installing cylinder head.

NOTE: Head gasket will fit only one way. It should not be necessary to force the gasket. The dowel pins on the cylinder head will line up gasket properly.

Install cylinder head gasket dry.

Set cylinder head in place on the cylinder block.

Inspect cap screws for thread or under head damage. Replace as necessary.

Use hardened flat washers under all cap screws. Dip cap screws in oil prior to installation. Start cylinder head to cylinder block cap screws by hand and tighten evenly, in several steps with 95 lb-ft (129 Nm) (13 kg-m) torque following applicable sequence illustrated in Fig. 14, 15 or 16.

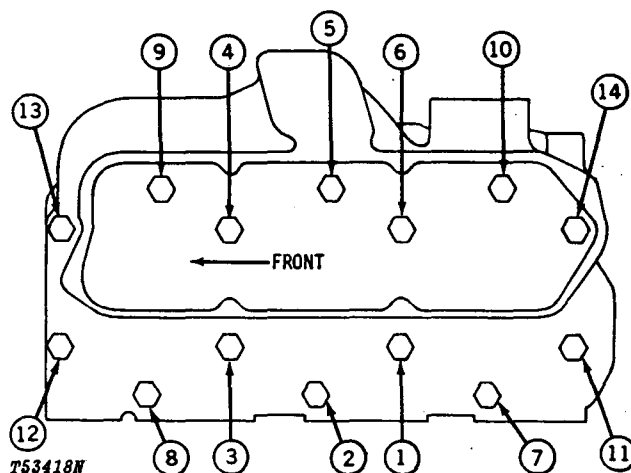


Fig. 15-Three Cylinder Cylinder Head Torque Sequence

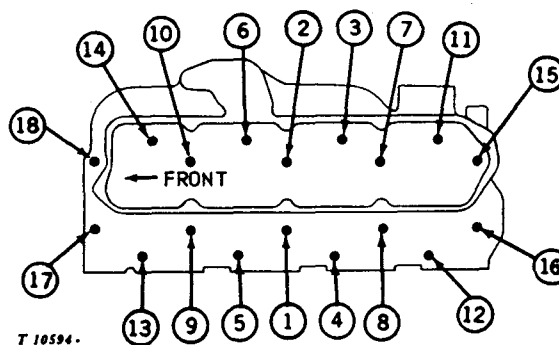


Fig. 15-Four Cylinder Cylinder Head Torque Sequence

Install valve stem wear caps making sure they turn freely.

Install pushrods, rocker arm assembly, adjust valve clearance, and install rocker arm cover (Group 0402).

Install injection nozzles and injection lines (Group 0413).

Install exhaust manifold (Group 0410).

Install fuel filter (Group 0420).

Install water manifold or thermostat housing (Group 0418).

Install air inlet piping on non-turbocharged engines (Group 0520) or turbocharger (Group 0416).

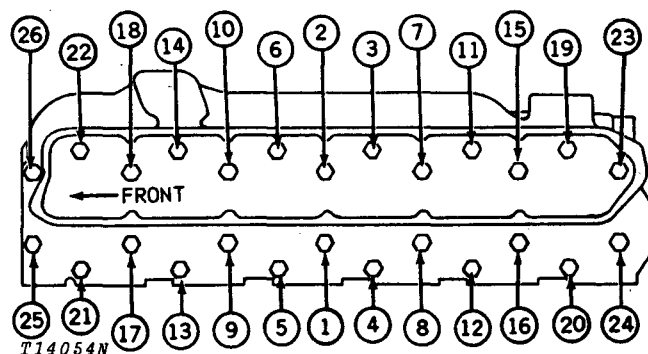


Fig. 16-6 Cylinder Head Torque Sequence

Group 0410 EXHAUST MANIFOLD

GENERAL INFORMATION

The exhaust manifold is an external pipe located on the left side of the engine, as shown in Fig. 1.

REMOVAL

Stop engine.

Allow engine time to cool.

Disconnect battery negative (-) ground.

Remove turbocharger if equipped (See Group 0416).

Disconnect or remove exhaust pipe.

Remove cap screws that hold exhaust manifold to the engine.

Remove exhaust manifold.

REPAIR

Inspect exhaust manifold for cracks and holes. Replace or repair as necessary.

Clean manifold.

INSTALLATION

Replace all gaskets.

Reinstall exhaust manifold.

Replace turbocharger if equipped (Group 0416).

Connect exhaust pipe.

Connect battery negative (-) ground.

Start engine. Check for leaks in system.

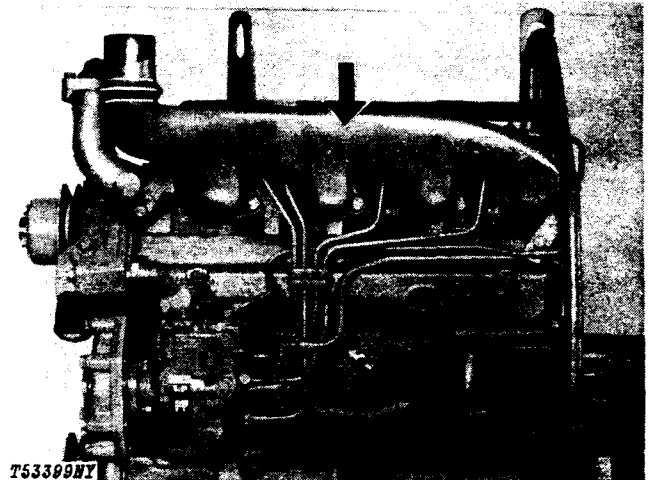


Fig. 1-Exhaust Manifold

Group 0413 FUEL INJECTION SYSTEM

FUEL INJECTION PUMP

REMOVAL

IMPORTANT: Never steam clean or pour cold water on an injection pump while the pump is running or while it is warm.

Clean the injection pump, lines, and area around the pump with cleaning solvent or a steam cleaner.

**3-164D, 4-219D, 4-276D and
6-329D Engines**

Fuel Injection Pump Only

Position crankshaft so that number one piston is at top dead center on compression stroke.

⚠ CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin causing serious personal injury.

If injured by escaping fuel, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

To relieve high pressure in the fuel system, slightly crack fuel injection line connections at each injection nozzle with two wrenches (Fig. 1).

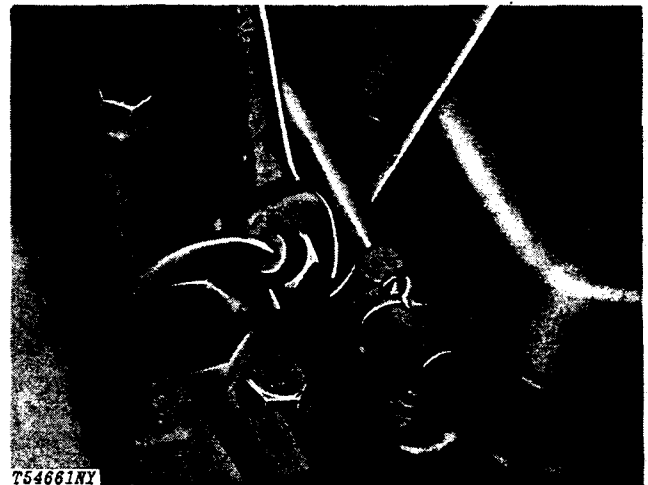


Fig. 1-Crack Injection Lines at Nozzles

Disconnect fuel supply line (1, Fig. 2), fuel return line (2), and fuel injection lines (3). Plug or cap all openings.

Disconnect throttle linkage (4) and wire throttle lever in high idle position.

Remove nuts (5) attaching injection pump to engine front plate.

4

Slide pump in a straight line away from the front plate.

Injection pump drive gear and shaft will remain on front plate.

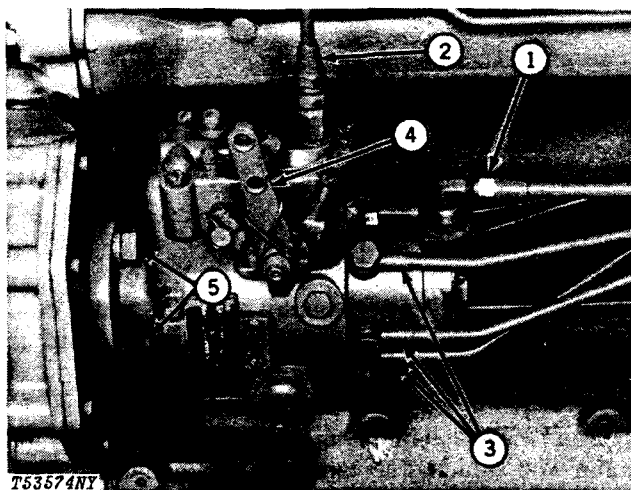


Fig. 2-Fuel Injection Pump Removal

Injection Pump Drive Shaft

Remove injection pump (Group 0413).

Remove injection pump gear cover.

Remove thrust pin (1, Fig. 3) and thrust spring.

Loosen nut (2) to the end of the drive shaft.

Using a brass drift, drive the drive shaft to the rear.

Remove nut and pull drive shaft out being careful not to drop the woodruff key.

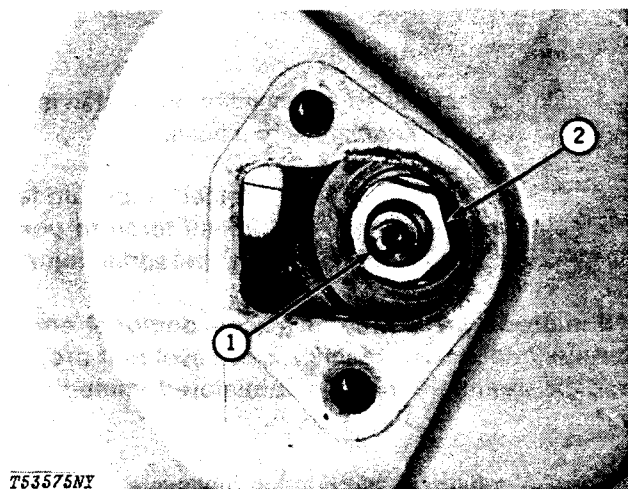


Fig. 3-Drive Shaft Removal

Injection Pump Drive Gear and Shaft

Remove timing gear cover (Group 0402).

Using JD-254 Timing Tool, check to see that drive gear timing marks align with timing tool (Fig. 4).

Slide drive gear and shaft forward to remove them.

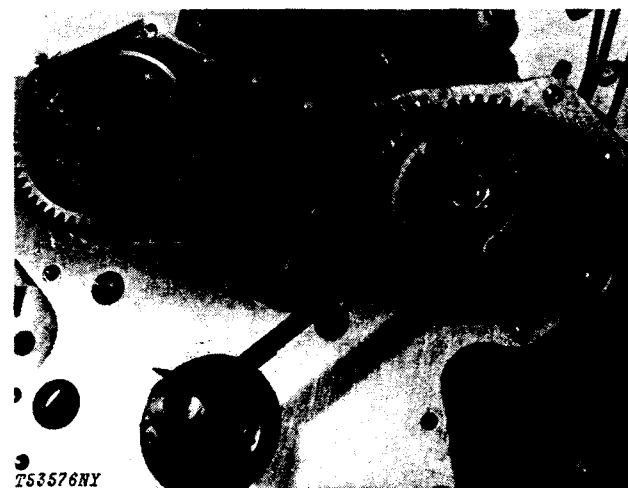


Fig. 4-JD-254 Timing Tool

4-276T, 6-414D, and 6-414T Engines

Remove timing hole cover and install 19918 Timing Window on injection pump.

Rotate crankshaft to position number one piston at top dead center on compression stroke. The timing marks on the governor weight retainer and cam ring should align.

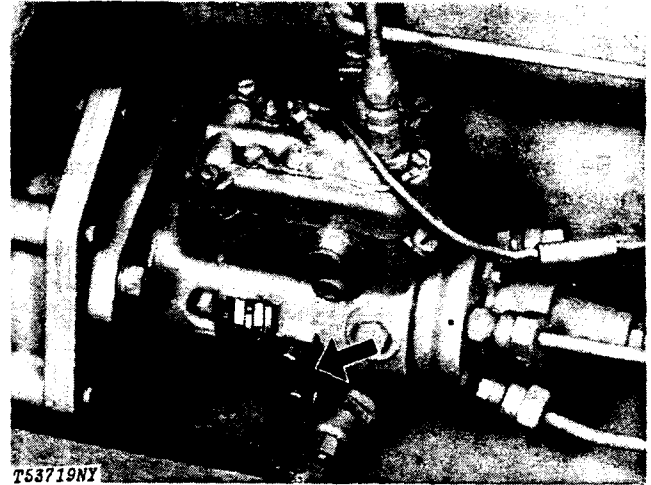


Fig. 5-19918 Timing Window

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin causing serious personal injury.

If injured by escaping fuel, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

To relieve high pressure in the fuel system, slightly crack fuel injection line connectors at each injection nozzle.



Fig. 6-Crack Injection Lines at Nozzles

Disconnect throttle linkage (1, Fig. 7).

Disconnect fuel supply line (2) and fuel return line (3).

IMPORTANT: When removing injection lines, do not turn pump outlet fittings. Turning these fittings may damage pump internally.

Using two wrenches, disconnect injection lines (4).

Plug or cap all openings.

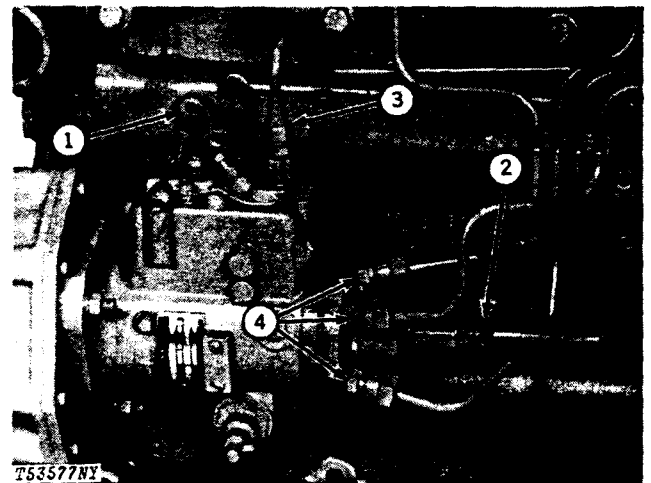


Fig. 7-Fuel Injection Pump Removal

Remove injection pump gear cover from timing gear cover.

Remove drive gear nut (1, Fig. 8).

Remove injection pump attaching nuts (2) and remove injection pump from front plate.

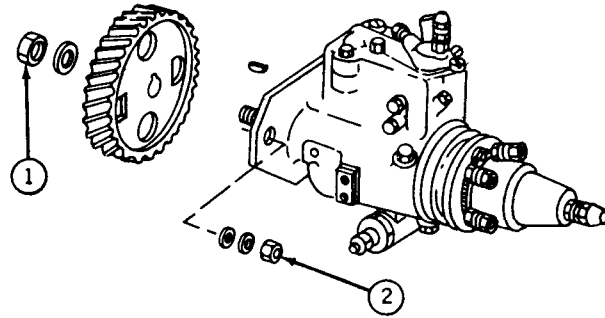


Fig. 8-Drive Gear Nut

REPAIR

3164D, 4219D, 4276D, and 6329D Engines

Roosa-Master Model JDB (Fig. 9)

For injection pump repair information, refer to SM-2045, "Testing and Servicing Fuel Injection Pumps and Nozzles".

For test stand specifications, see Group 0499.

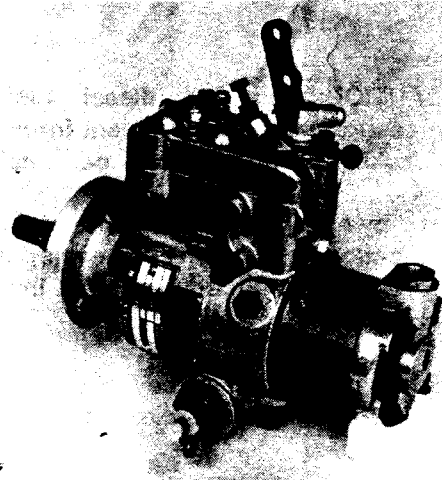


Fig. 9-Roosa-Master Model JDB

Drive Shaft and Gear

Remove thrust pin (1, Fig. 10) and thrust spring (2) from shaft.

Remove nut (3) from end of shaft.

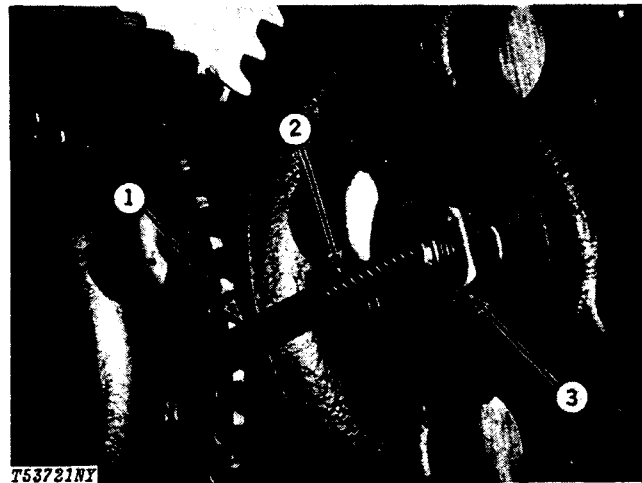


Fig. 10-Drive Shaft and Gear

Support gear and press shaft from gear (Fig. 11).

Inspect gear for cracked and broken teeth.

For drive shaft repair information, refer to SM-2045 "Testing and Servicing Fuel Injection Pumps and Nozzles".

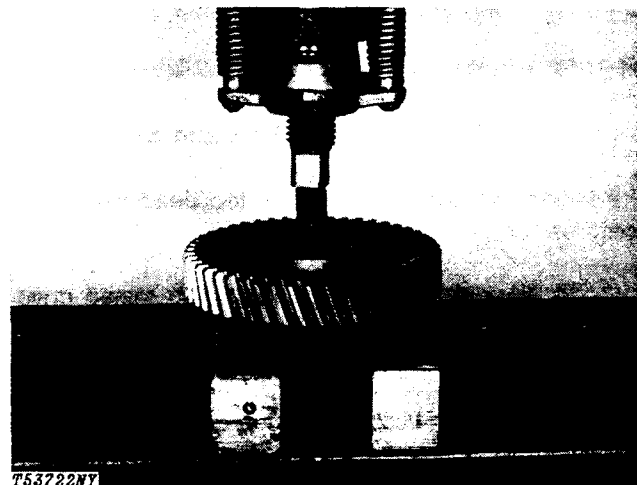


Fig. 11-Separate Gear and Shaft

When installing drive gear on drive shaft, tighten nut (Fig. 12) with 35 lb-ft (47 Nm) (5 kg-m) torque.

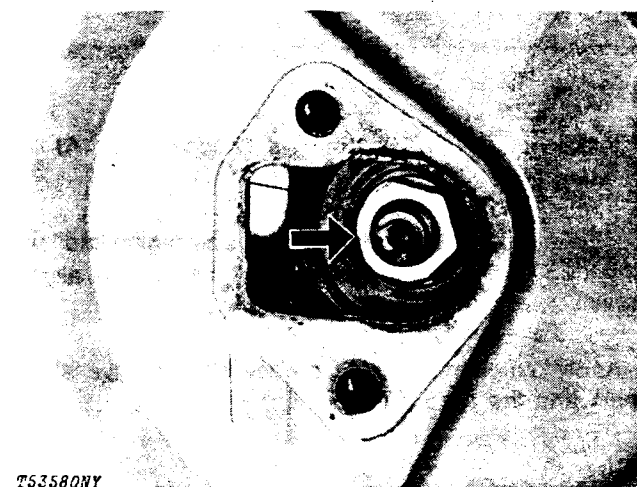


Fig. 12-Injection Pump Drive Gear Nut

4276T, 6416D, and 6414T Engines

Roosa-Master Model DM (Fig. 13)

For injection pump repair information, refer to TM-1109, "Fuel Injection Equipment - Roosa-Master (Industrial)".

For test stand specifications, see Group 0499.

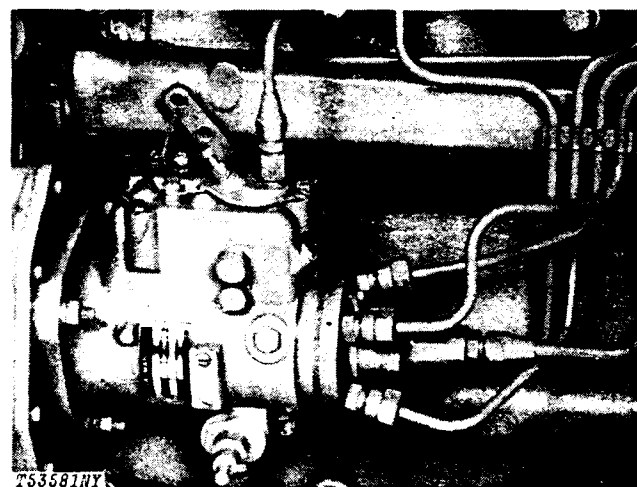


Fig. 13-Roosa-Master Model DM

INSTALLATION

3164D, 4219T, 4276D, and 6329D Engines

Injection Pump Drive Gear and Shaft

Position number one piston at top dead center on compression stroke.

Using JD-254 Timing Tool (Fig. 14), install drive gear and shaft with timing marks on gear in alignment with the timing tool.

Install timing gear cover (Group 0402).

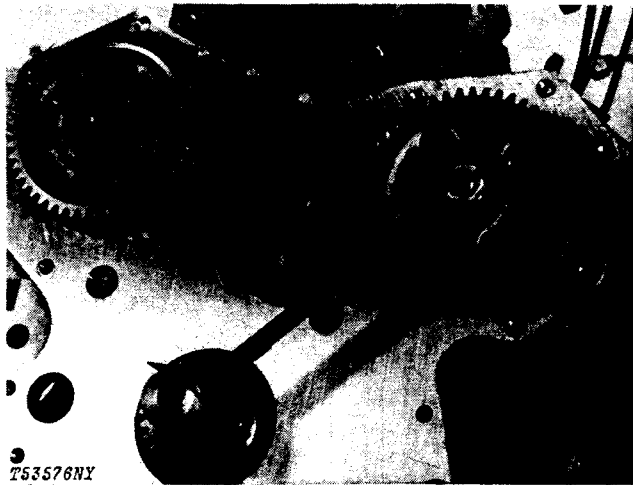


Fig. 14-JD-254 Timing Tool

Fuel Injection Pump

Position number one piston at top dead center on compression stroke.

Install JD-259 (13366) Timing Window (Fig. 15) on injection pump timing hole.

Rotate injection pump drive shaft until timing lines on cam ring and governor weight retainer are in alignment.

Apply a coating of light grease to the drive shaft seals and the area around them.

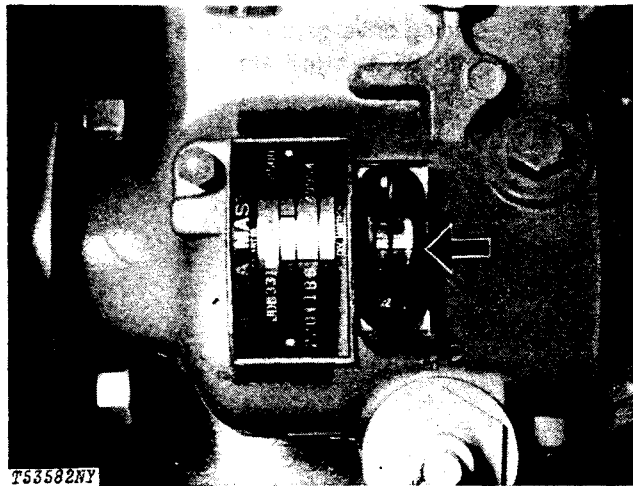


Fig. 15-JD-259 (13366) Timing Window

IMPORTANT: Do not invert drive shaft seal lips. If resistance is felt, stop and inspect position of seal. If seal has been forced back, replace seal.

Using JD-256 (13371) Drive Shaft Seal Compressing Tool (Fig. 16), compress seal on drive shaft and slide pump into place.

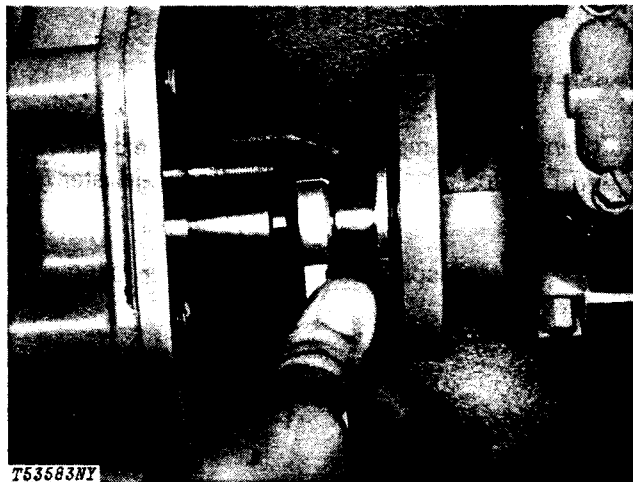


Fig. 16-JD-256 (13371) Drive Shaft Seal Compressing Tool

Install pump attaching nuts finger tight.

Rotate pump counterclockwise (viewed from fly-wheel end) then in opposite direction until timing lines (Fig. 17) on cam ring and governor weight retainer are aligned.

Tighten pump attaching nuts.

Rotate crankshaft counterclockwise (viewed from front end) approximately 180°. Reverse crankshaft rotation and reposition number one piston at top dead center on compression stroke.

Check timing lines on injection pump. If not aligned, retune pump.

IMPORTANT: Do not use washers other than those specified.

Connect injection lines to injection pump using NEW washers (Fig. 18).

Injection line to injection pump screw torque	35 lb-ft (47 Nm) (5 kg-m)
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Connect fuel supply line (1, Fig. 19) and fuel return line (2).

Fuel supply line connection torque (1)	20 lb-ft (27 Nm) (3 kg-m)
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Fuel return line connection torque (2)	20 lb-ft (27 Nm) (3 kg-m)
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Connect throttle linkage, remove timing window, and install timing hole cover.

Bleed the fuel system (Group 0413).

See Group 9010 for adjustments.

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Fig. 17-Injection Pump Timing Lines

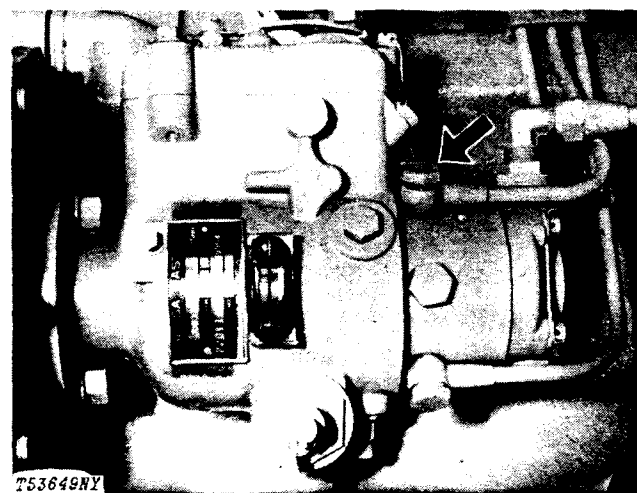


Fig. 18-Injection Line to Injection Pump Screw Torque

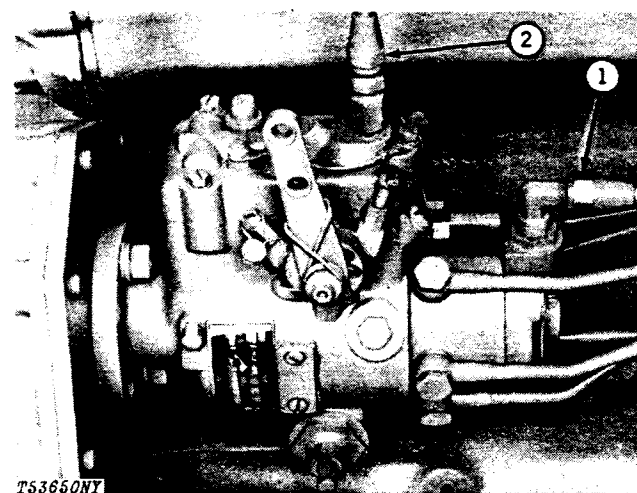


Fig. 19-Fuel Supply and Return Lines

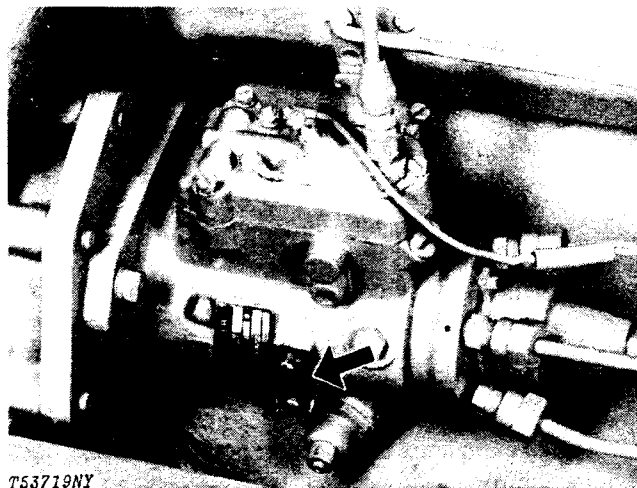
4276T, 6414D, and 6414T Engines

Position number one piston at top dead center on compression stroke.

Remove timing hole cover and install 19918 Timing Window (Fig. 20) on injection pump.

Check pump mounting flange packing for damage or wear. Replace if necessary.

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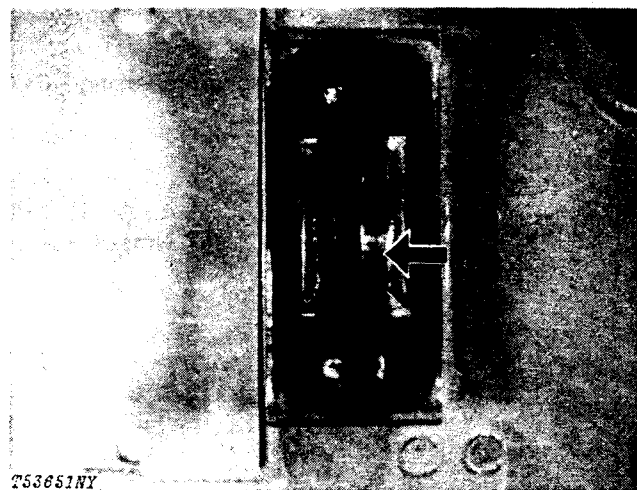


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Fig. 20-19918 Timing Window

Rotate pump drive shaft and align timing lines (Fig. 21) on governor weight retainer and cam ring.

Position pump on engine front plate making sure Woodruff key enters drive gear.

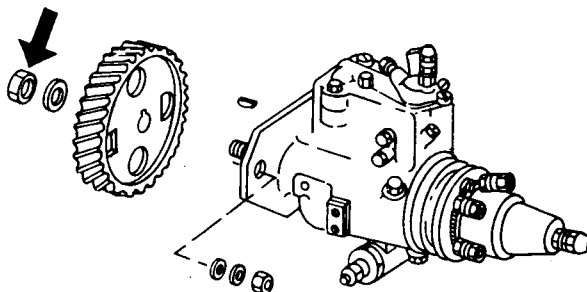


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Fig. 21-Injection Pump Timing Lines

Install washer and nut on oiled pump drive shaft (Fig. 22).

Injection pump drive
gear nut torque (oiled) 150 lb-ft
(203 Nm) (21 kg-m)



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Fig. 22-Injection Pump Drive Gear Nut

Install pump attaching nuts (Fig. 23) finger tight.

Rotate injection pump housing counterclockwise (viewed from flywheel end) as far as possible.

Rotate crankshaft counterclockwise (viewed from front end) approximately 180°. Reverse rotation and reposition number one piston at top dead center on compression stroke.

Rotate injection pump housing clockwise (viewed from flywheel end) until timing lines align.

Tighten injection pump attaching nuts (Fig. 23).

Injection pump attaching
nut torque 20 lb-ft
(27 Nm) (3 kg-m)

Rotate crankshaft counterclockwise (viewed from front end) approximately 180°. Reverse rotation and reposition number one piston at top dead center on compression stroke.

Injection pump timing lines should be aligned. If not, retime injection pump.

Connect fuel supply line (1, Fig. 24), fuel return line (2) and fuel injection lines (3).

Fuel line
connection torque (1) 20 lb-ft
(27 Nm) (3 kg-m)

Fuel return line 20 lb-ft
(27 Nm) (3 kg-m)

Fuel injection line
connector torque 35 lb-ft
(47 Nm) (5 kg-m)

Connect throttle linkage, remove timing window, and install timing hole cover.

Bleed the fuel system (Group 0413).

See Group 9010 for adjustments.

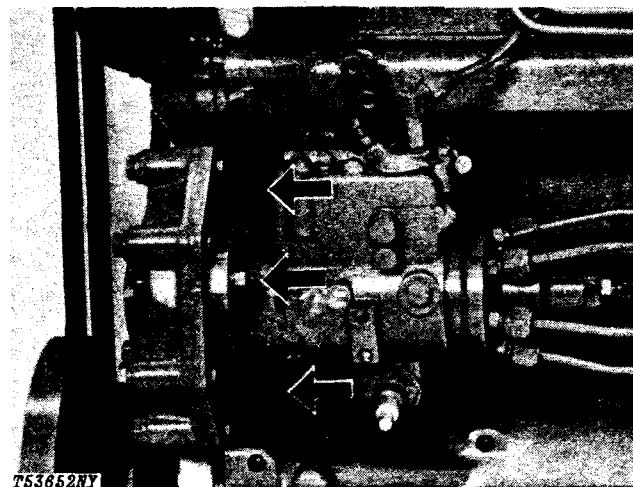


Fig. 23-Injection Pump Attaching Nuts

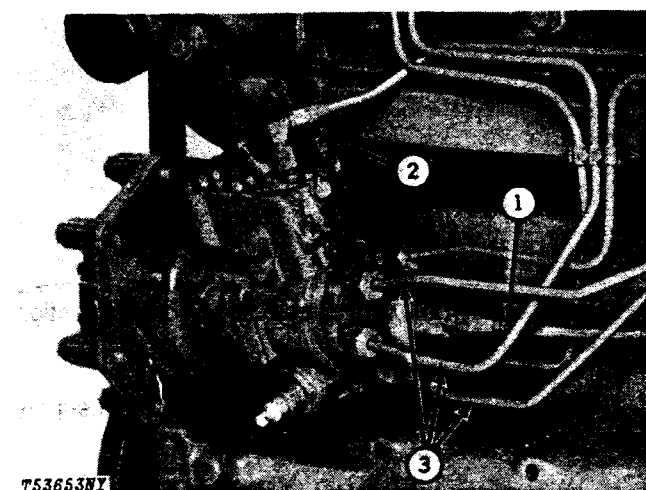
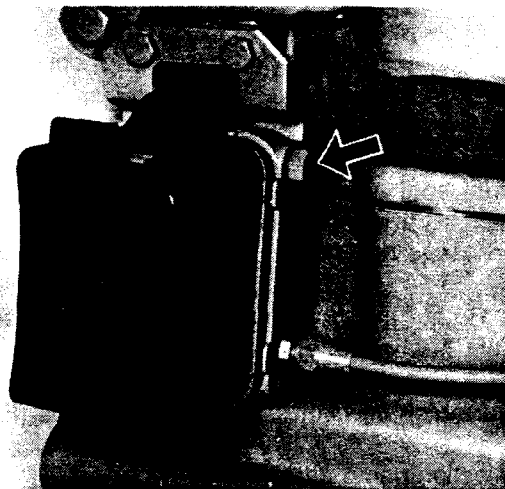


Fig. 24-Fuel Supply and Return Lines

BLEEDING

Loosen fuel filter bleed screw (Fig. 25).

4

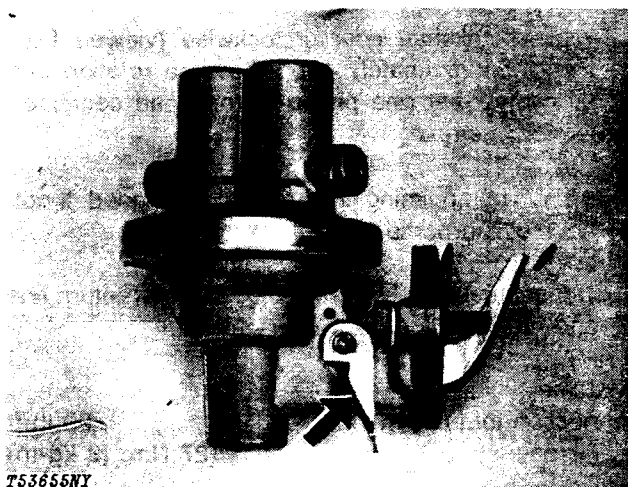


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Fig. 25-Fuel Filter Bleed Screw

Pump primer lever, located on fuel transfer pump, until no air flows from bleed screw.

Tighten the bleed screw.



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Fig. 26-Fuel Transfer Pump Primer Lever

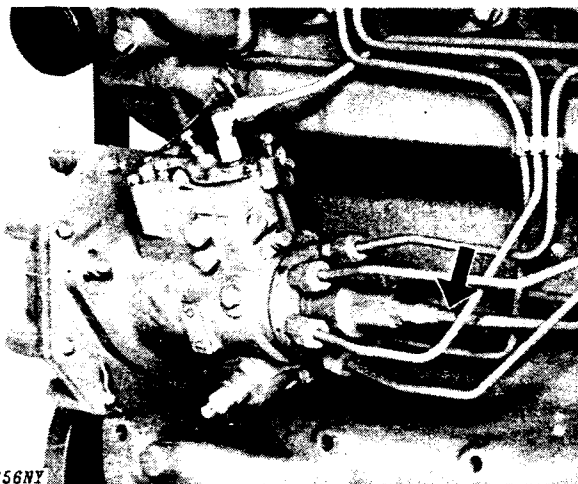
Slightly crack fuel supply line connection at injection pump (Fig. 27).

Pump primer lever until no air flows from fuel supply line connection.

Tighten line connection.

Fuel supply line
connection torque 20 lb-ft
(27 Nm) (3 kg-m)

Leave primer lever positioned toward the cylinder block.



T53656NY

Fig. 27-Fuel Supply Line Connection

FUEL INJECTION NOZZLES

REMOVAL

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin causing serious personal injury.

If injured by escaping fuel, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

To relieve high pressure in the fuel system, slightly crack fuel injection line connectors at each injection nozzle with two wrenches (Fig. 28).

Disconnect nozzle from fuel injection line at nozzle inlet connector (1, Fig. 29) and unscrew hex fitting (2) from leak off connector (3).

Remove nozzle hold down cap screw and washer (4), clamp (5), and spacer (6).

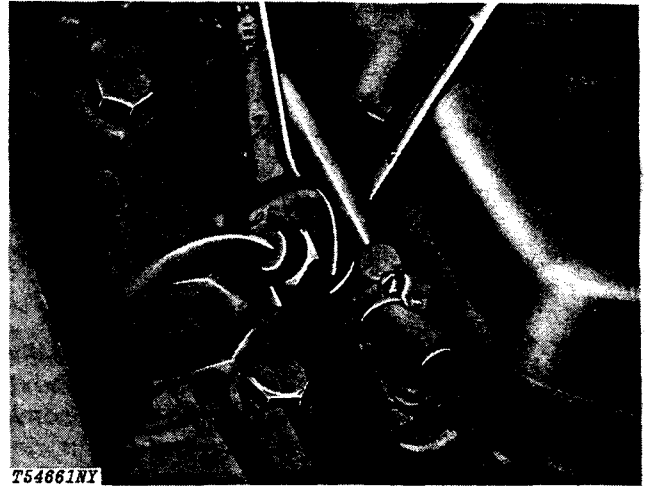


Fig. 28-Crack Injection Lines at Nozzles

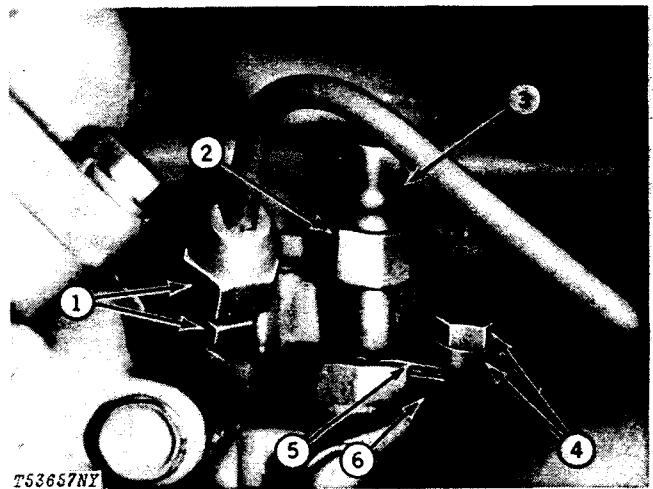


Fig. 29-Injection Nozzle Removal

IMPORTANT: Do not use screw driver or pry bars to remove injection nozzles from cylinder head.

Pull injection nozzle from cylinder head. If nozzle cannot be easily removed, use JDE-38 Nozzle Puller (Fig. 30) to remove it.

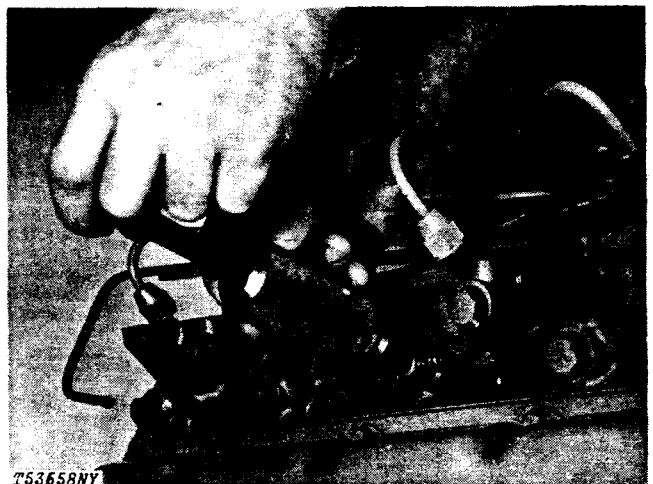


Fig. 30-JDE-38 Nozzle Puller

REPAIR

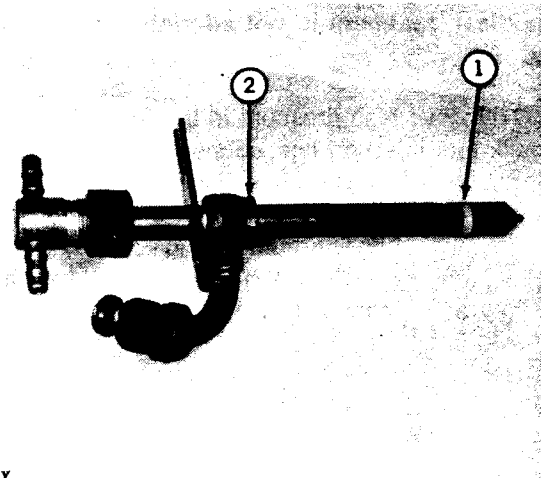
IMPORTANT: Do not attempt to test or disassemble nozzles unless the proper service tools are available. See TM-1109 "Fuel Injection Equipment-Roosa Master" (Industrial) for repair and testing procedures necessary to service injection nozzles.

For test stand specifications, see Group 0499.

- 4** Remove carbon seal (1, Fig. 31) and seal washer (2) from nozzle.

IMPORTANT: Do not scrape or otherwise damage the Teflon coating on the nozzle body above the carbon seal groove. This coating will become discolored during normal service, but this is not harmful. Do not use a motor-driven brush to clean the nozzle body.

Clean the exterior of nozzle by soaking in clean solvent or diesel fuel. Then clean the spray tip with a brass wire brush.

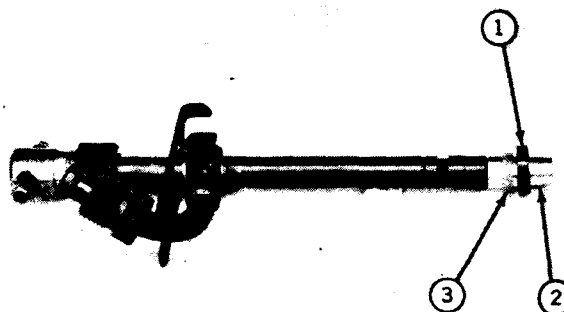


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Fig. 31-Seal Removal

Position JD-258 (16477) pilot (2, Fig. 32) over nozzle tip and place new carbon seal (3) over pilot.

Use a new seal washer (1) to help slide the carbon seal into place in its groove.



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Fig. 32-JD-258 (16477) Pilot

Using JDE-39 Nozzle Bore Cleaning Tool (Fig. 33), clean the cylinder head nozzle bore.

Use compressed air to remove debris from nozzle bore.

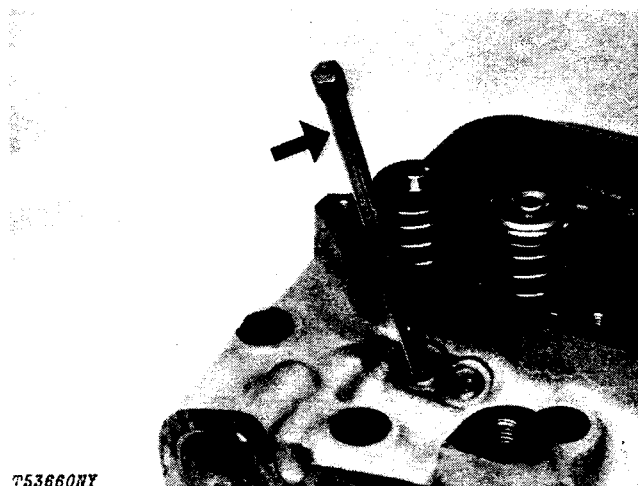


Fig. 33-JDE-39 Nozzle Bore Cleaning Tool

INSTALLATION

Install injection nozzle in cylinder head bore with a twisting motion.

Install spacer (6, Fig. 34), clamp (5), and cap screw and washer (4).

Connect injection line to nozzle inlet connector (1) and hand tighten.

Screw hex fitting (2) onto leak off connector (3).

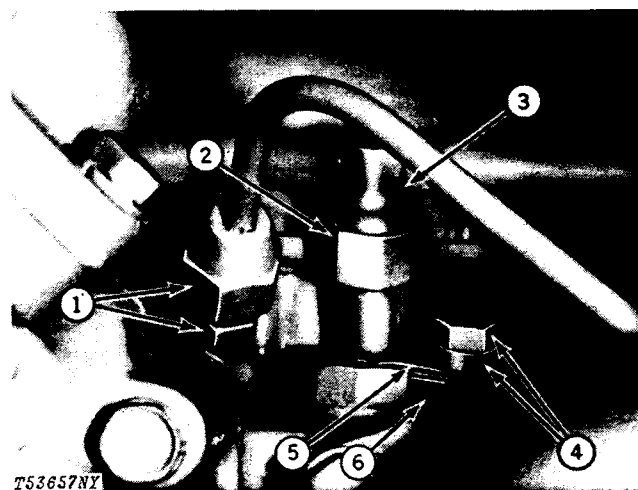


Fig. 34-Injection Nozzle Installation

Tighten nozzle hold down cap screw (1, Fig. 35) and inlet connector (2).

Nozzle hold down cap screw torque (1)	20 lb-ft (27 Nm) (3 kg-m)
--	------------------------------

Nozzle inlet connector torque (2)	35 lb-ft (47 Nm) (5 kg-m)
--	------------------------------

Bleed the fuel injection system (Group 0413).

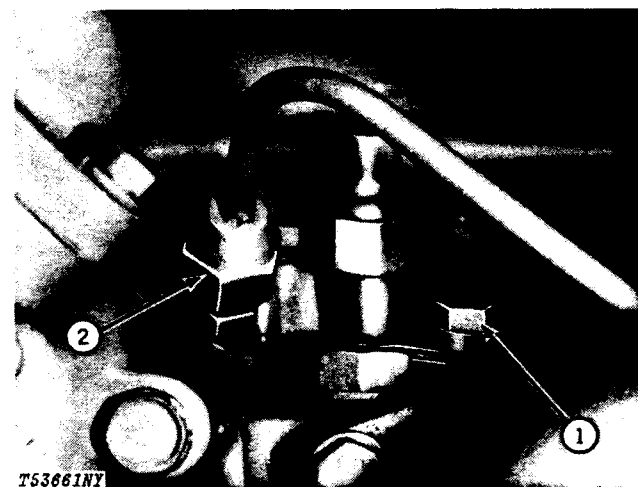


Fig. 35-Nozzle Hold Down and Inlet Connector Torque

Group 0414 INTAKE MANIFOLD

GENERAL INFORMATION

The intake manifold will be located on the right side of the engine cylinder head. The manifold will either be cast into the head or it will consist of an external manifold (Fig. 1). It may be fed directly from the air cleaner or from a turbocharger.

REMOVAL

Stop engine.

Disconnect battery negative (-) cable.

Allow engine to cool.

Remove air cleaner hose.

Remove turbocharger if equipped (Group 0416).

Remove air cleaner supports if equipped.

Disconnect cold weather starting fluid tube if equipped.

REPAIR

Inspect manifold for cracks.

Clean and inspect all passages.

INSTALLATION

Using new gaskets install air intake manifold on cylinder head.

Install air cleaner support and air cleaner.

Install turbocharger (Group 0416) if equipped.

Connect battery negative (-) cable.

Make sure all connections are tight and sealed to prevent unfiltered air entry into engine.



Fig. 1-Intake Manifold Location

Group 0415 ENGINE BALANCER

GENERAL INFORMATION

Two types of balancer shafts are used (Fig. 1). They are mounted in the lower half of the cylinder block and each rotates in three pressure-lubricated replaceable bushings.

The balancer shafts rotate in opposite directions to reduce engine vibration. Thrust of the balancer shafts is absorbed by thrust plates fastened to the front of the cylinder block.

REMOVAL

Remove fan belts, alternator, and fan.

Remove oil pan.

Disconnect oil cooler lines.

Use a pulley puller to remove the crankshaft pulley.

Remove the timing gear cover.

Remove weights from the balancer shafts (2, Fig. 1), if equipped.

Remove oil pump gear and lower idler gear.

Remove balancer shafts and identify as left and right.

Remove balancer shaft gears (4, Fig. 1) by pressing them off.

Remove balancer shaft thrust plates (3, Fig. 1).

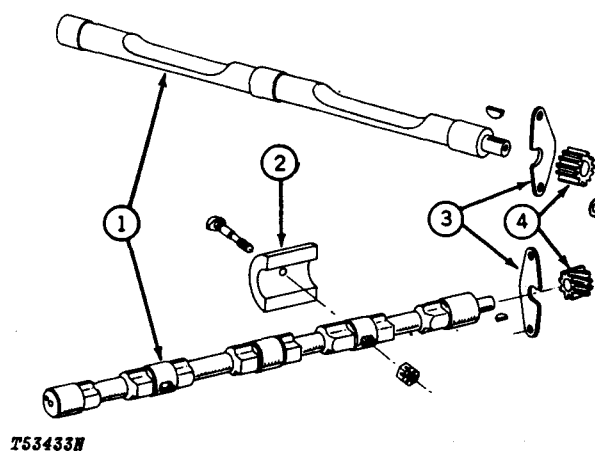


Fig. 1-Engine Balancer Shafts

REPAIR

Determine if balancer shaft journals (2, Fig. 2) are within 1.500 to 1.501 in. (38.09 to 38.11 mm) and bushings (1, Fig. 2) are within 1.502 to 1.504 in. (38.15 to 38.20 mm). Check journal and bushings for scuffing or other damage. Replace shafts or bushings as required.

4

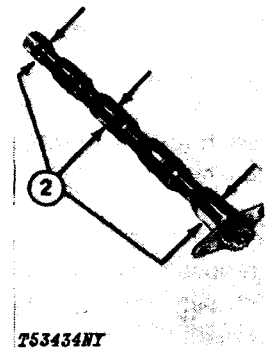


Fig. 2-Balancer Shaft Journals and Bushings Measurement

The first two bushings can be replaced using JD-249 Tool, Fig. 3.

To remove the third bushing the flywheel housing must be removed, see Group 0433.

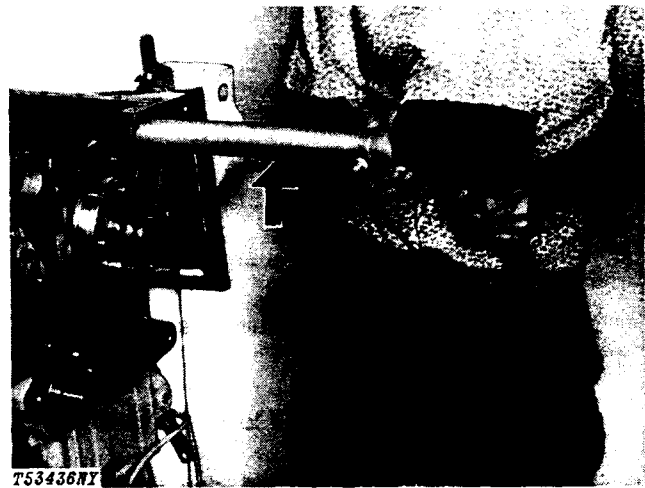


Fig. 3-Bushing Removal

IMPORTANT: Be sure that hole in each bushing lines up with upper oil lead hole in cylinder block.

Press all bushings in from the front of the engine until flush with bushing bore chamfer in block using JD249 Tool.

Inspect balancer shaft gears for worn, cracked or broken teeth.

Installing Drive Gear

It may be necessary to place thrust plate on the shaft before installing the gear on the shaft depending on the type of thrust plate used.

Position balancer shaft drive gear on front of balancer shaft so slot in gear lines up with special key, and timing mark on front of gear faces away from balancer shaft. Press on gear using JD-247 Holding Tool to support shaft as shown in Fig. 4. Press gear on shaft with thrust plate in position. Clearance between thrust plate and gear should be 0.002 to 0.010 in. (0.05 to 0.25 mm).

INSTALLATION

Apply a light film of oil to balancer journals and bushings.

Secure thrust plates to front plate with hardware and tighten with 35 lb-ft (47 Nm) (5 kg-m).

Install balancer shafts in their respective bores. Time balancer shafts as shown in Fig. 5 using JD254 Timing Tool.

With a dial indicator check balancer shaft for end play of no more than 0.010 in. (0.25 mm) or no less than 0.0020 in. (0.051 mm)

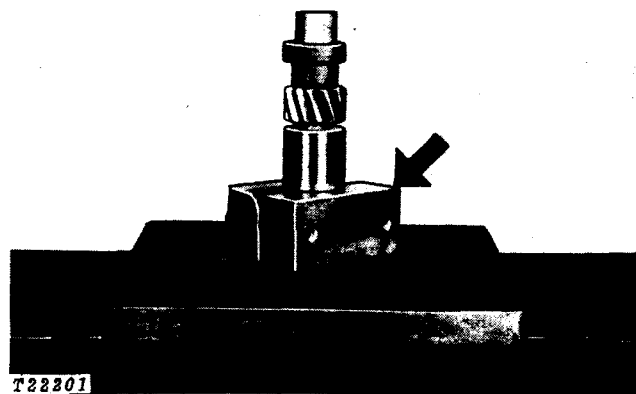


Fig. 4-Replacing Balancer Shaft Gear



Fig. 5-Timing Balancer Shaft

Install balancer shaft weights if used being sure weights are installed on the machine surfaces of the shaft. Run the balancer shaft bolts through the weights and then through the shafts as shown in Fig. 6. Tighten special nuts to 43 lb-ft (58 Nm) (6 kg-m).

Replace oil pump gear and lower idler gear if necessary.

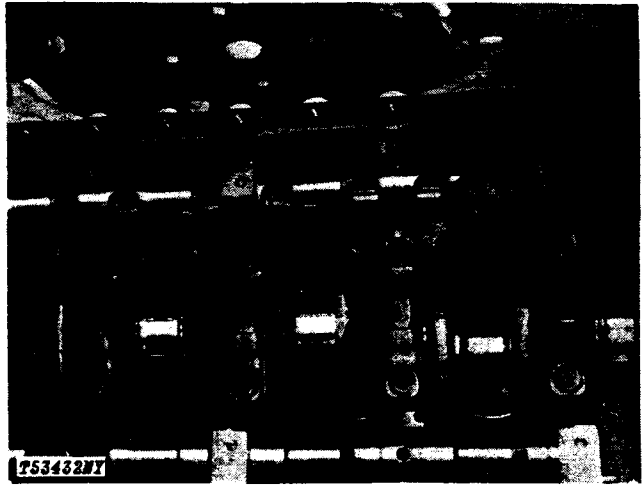


Fig. 6-Installing Balancer Shaft Weights

Install timing gear cover and crankshaft pulley (Fig. 7).

Install engine oil cooler coolant hose.

Install fan, alternator and fan belts.

Adjust fan belts as described in Group 0433.

Install engine oil pan. Use a new gasket.

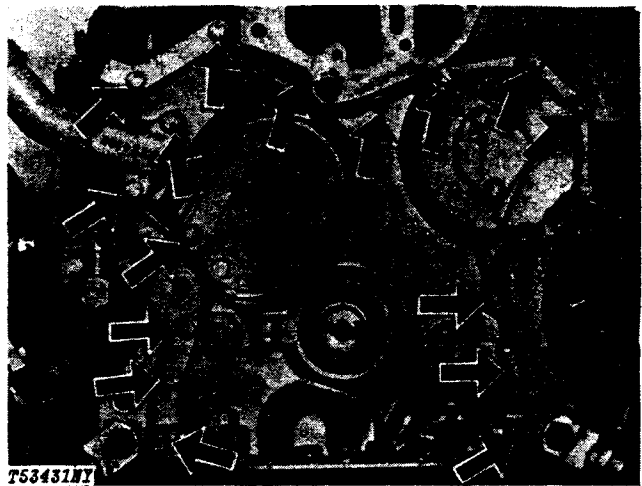


Fig. 7-Installing Timing Gear Cover

Group 0416 TURBOCHARGER

GENERAL INFORMATION

The turbocharger is located on the left side of the 4-276T and the 6-414T engines as shown in Fig. 1.



For theory of turbocharger operation, refer to FOS Manual—ENGINES.

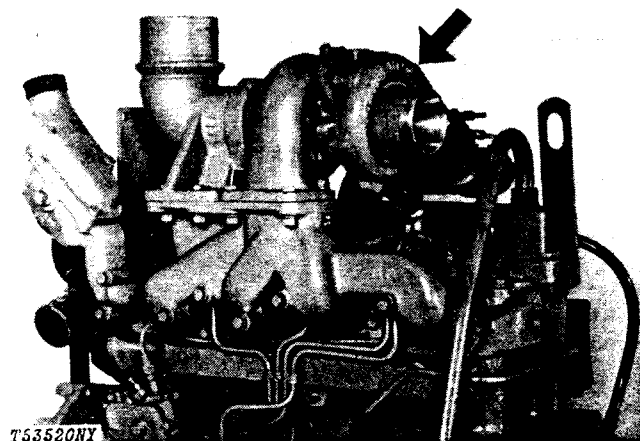


Fig. 1-Turbocharger

REMOVAL

Stop engine and allow exhaust system time to cool.

Remove engine enclosers until turbocharger is accessible.

Disconnect the air intake hose (1, Fig. 2) at turbocharger.

Remove exhaust elbow (2) and adapter (3).

Disconnect the inlet oil line (4) and return oil line (5) at turbocharger.

Remove the turbocharger mounting flange stud nuts (6). Loosen, but do not remove compressor housing cap screws (7).

Lift turbocharger off exhaust manifold, and disengage turbocharger and coupling (8) from intake manifold.

Cover all openings and clean exterior of turbocharger with a pressure spray of cleaning solvent. Dry turbocharger.

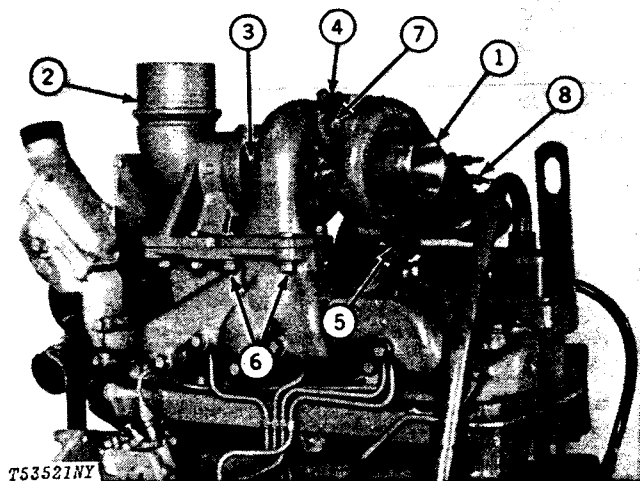


Fig. 2-Turbocharger Removal

TESTING

Radial Bearing Movement

Fasten a plunger dial indicator to the turbocharger housing mounting flange as shown in Fig. 3.

Apply side pressure on the turbine shaft back and forth, equal pressures should be applied simultaneously (Fig. 3).

4

The total movement should be 0.003 to 0.006 in. (.08 to 0.15 mm).

Axial Bearing Movement (Bearing End Play)

Remove compressor housing-to-center housing cap screws (7, Fig. 6), lock plates (6) and clamps (5).

Fasten dial indicator to turbine housing so that the indicator tip rests on the end of the shaft (Fig. 4).

Move the shaft back and forth axially by hand. The total axial movement of the shaft should be 0.001 to 0.004 in. (0.03 to 0.10 mm). If not repair or replace unit.

REPAIR

As each part is removed, place it in a clean protective container.

Refer to Fig. 6 for part identification and relationship.

Scribe a line on the mating surfaces of the turbine housing (1, Fig. 5) and center housing (2) to aid in alignment during reassembly.

Remove the turbine housing-to-center housing cap screws (5, Fig. 5), lock plates (3), and clamps (4). Carefully remove turbine housing.

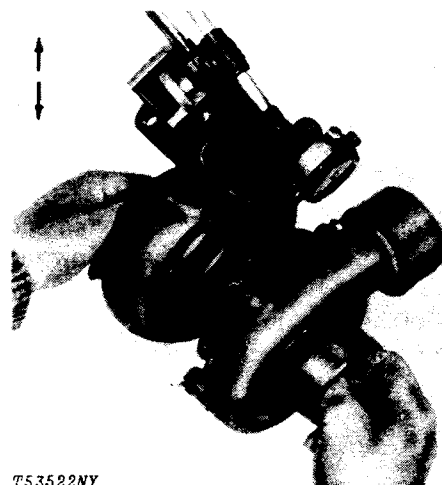


Fig. 3-Radial Bearing Movement Check

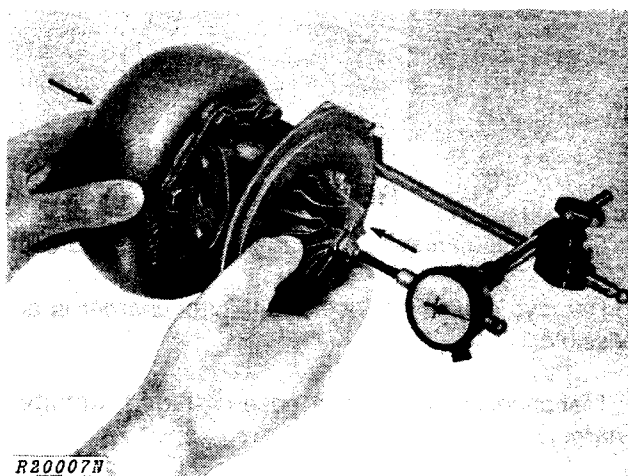


Fig. 4-Axial Bearing Movement Check

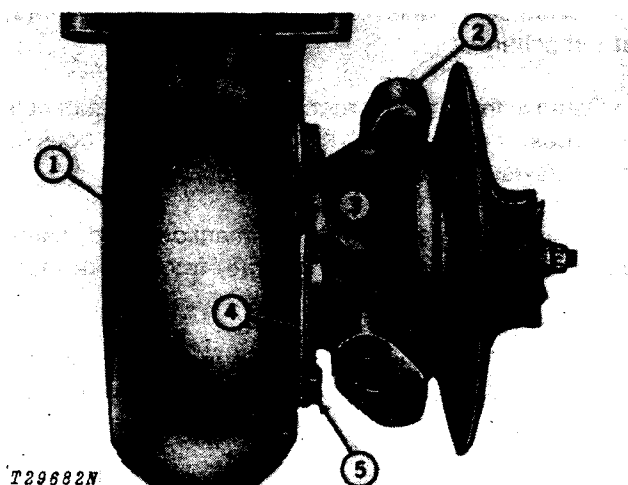
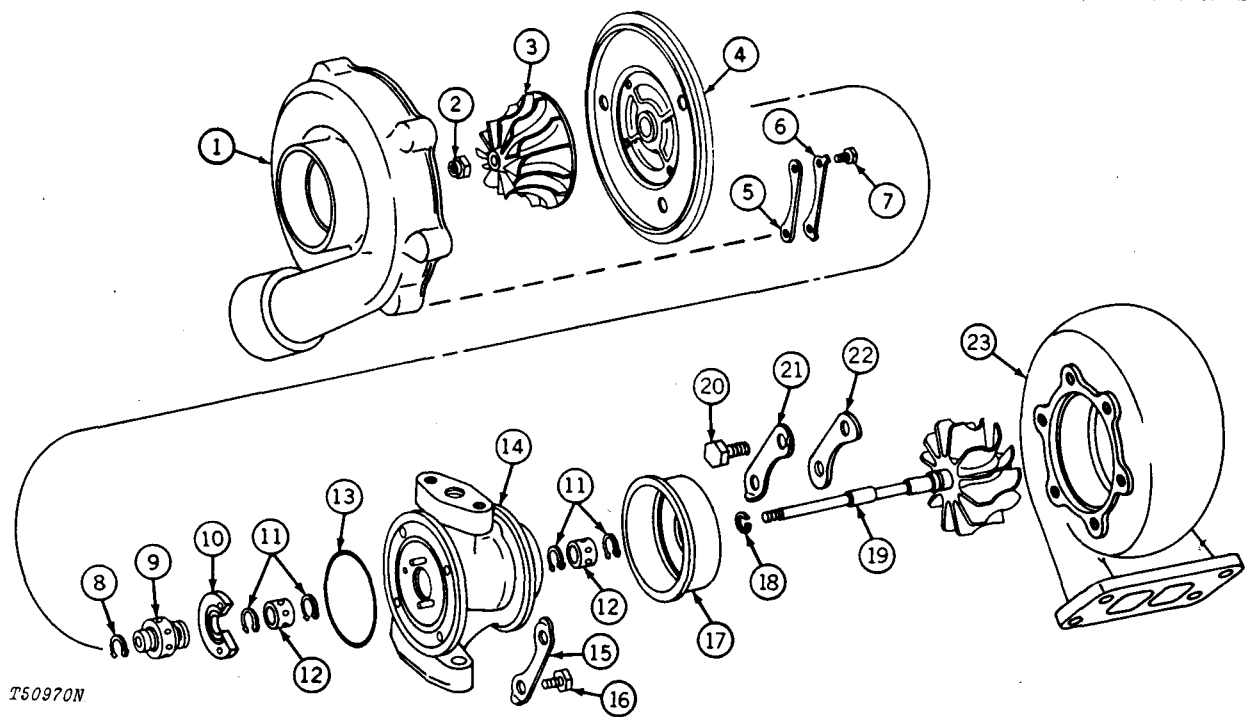


Fig. 5-Turbine Housing Removal



T50970N

- 1—Compressor Housing
- 2—Lock Nut
- 3—Impeller
- 4—Backplate Assembly
- 5—Clamp (3 used)
- 6—Lock Plate (3 used)
- 7—Cap Screw (6 used)
- 8—Piston Ring

- 9—Thrust Collar
- 10—Bearing
- 11—Retaining Ring (4 used)
- 12—Bearing (2 used)
- 13—O-Ring
- 14—Center Assembly Housing
- 15—Lock Plate (2 used)
- 16—Cap Screw (4 used)

- 17—Wheel Shroud
- 18—Piston Ring
- 19—Turbine Wheel with Shaft
- 20—Special Bolt (6 used)
- 21—Lock Plate (3 used)
- 22—Clamp (3 used)
- 23—Turbine Housing

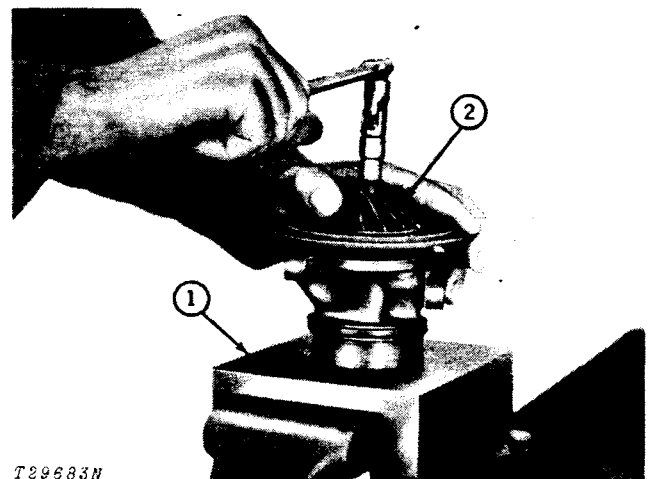
Fig. 6-Turbocharger Exploded View

Mount a suitable holding fixture (1, Fig. 7) (see Group 0499 Special Tools - Turbocharger) in a vise.

Insert the turbine wheel into the fixture.

Use a double universal socket to remove the compressor wheel retaining nut to avoid possible bending of the shaft.

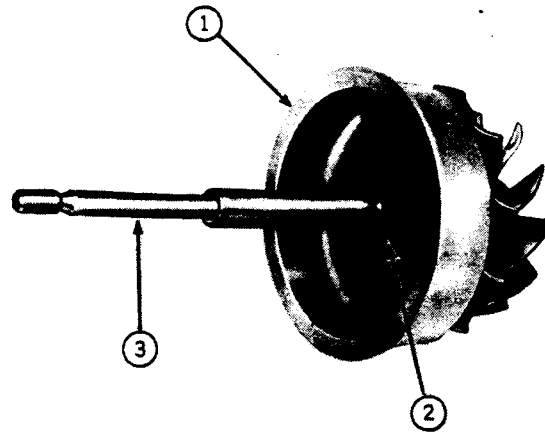
Remove the impeller (2, Fig. 7) from the shaft.



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Fig. 7-Removing Compressor (Impeller)

Remove the turbine wheel and shaft assembly (3, Fig. 8) from the center housing keeping it centered until it is clear of the housing. Fig. 8 shows the turbine wheel assembly (1). The piston ring (2) can now be removed.



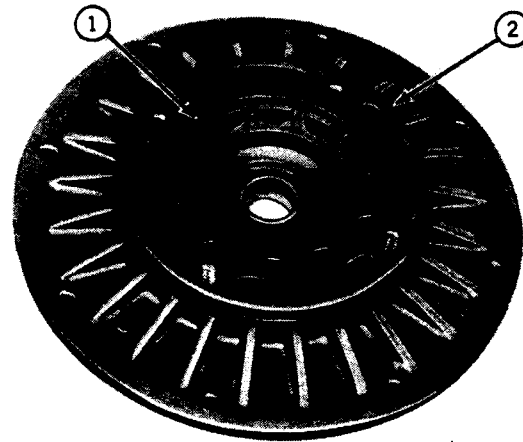
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Fig. 8-Shaft and Wheel Assembly

Remove the back plate to center housing cap screw (16, Fig. 6) and lock plates (15).

Carefully remove back plate by tapping with a soft mallet.

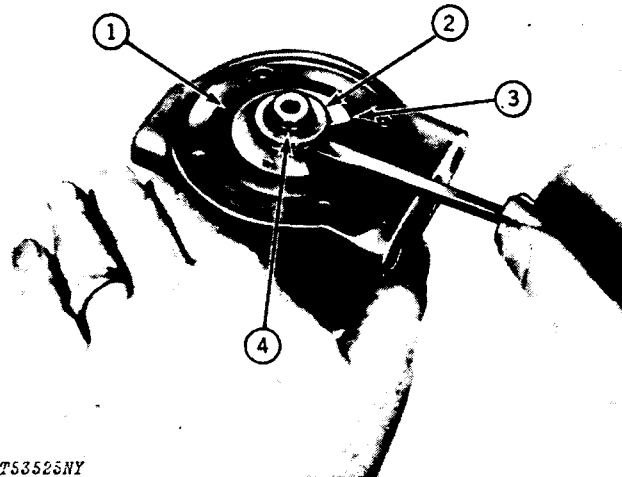
IMPORTANT: Back plate (2, Fig. 9) and the spring (1) are sold only as an assembly. The installed depth of the spring is a controlled dimension. Therefore, do not remove or replace the spring by itself. Cleaning can be done without removing the spring from the back plate.



T53524NY

Fig. 9-Back Plate Assembly

Remove the thrust collar (2, Fig. 10) and thrust washer (3) as shown in Fig. 10. Remove the O-ring (1) from housing and piston ring (4) from thrust collar.



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Fig. 10-Removing Thrust Collar and Thrust Washer

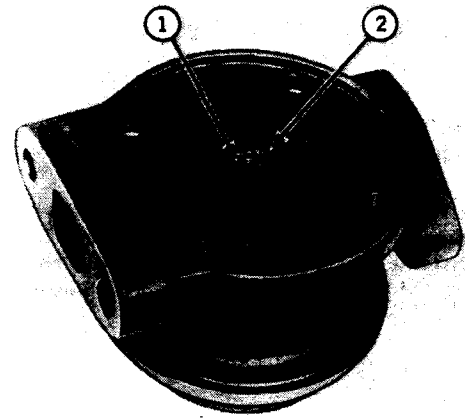
Remove retaining rings (2, Fig. 11) and bearings (1) from both sides of the center housing.

Cleaning

Before cleaning, inspect parts for signs of burning, rubbing, or other damage which might not be evident after cleaning.

Soak all parts in clean carbon solvent for approximately 25 minutes. After soaking use a stiff bristle brush to remove all dirt particles. Dry parts thoroughly.

NOTE: Normally, a light accumulation of carbon deposits will not affect turbine wheel operation.



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Fig. 11-Retaining Ring and Bearing Removal

Inspection

Replace the following parts: O-ring (13, Fig. 6), lock plates (6, 15, and 21) piston rings (8 and 18), retaining rings (11), and all damaged nuts and bolts.

NOTE: If bearings and thrust washers show signs of nicks, scores, shellac deposits, or foreign material imbedment, replace them.

After cleaning, if any of the parts in the assembly show signs of rubbing, scoring, scratches, or seizure, replace them.

Assembly

Be sure each part is clean before assembling. As parts are assembled, cover openings to prevent entry of dirt or other foreign material.

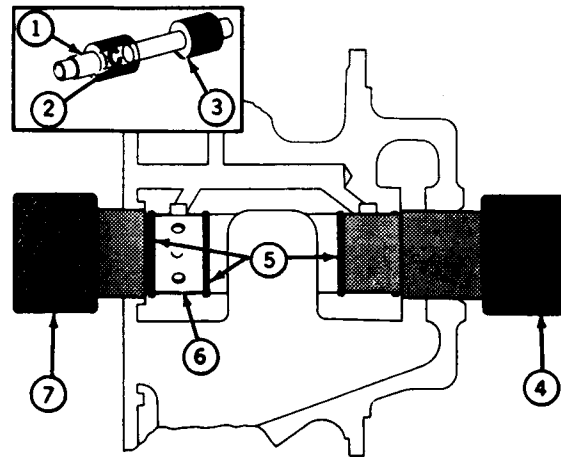
NOTE: If any particle falls into the turbocharger during assembly, remove the particle immediately, even if extensive disassembly is required.

Check piston ring clearance (18, Fig. 6) in turbine wheel ring groove. Inspect for burrs or foreign matter.

Install bearing retaining rings (Fig. 12) using JD274 Retaining Ring Assembly Tool. Lubricate bearings with clean engine oil and insert in place.

- | | |
|----------------------------|-------------------------------|
| 1—Sleeve Tool | 4—Inner Ring Sleeve (JD274-1) |
| 2—Retaining Ring | 5—Retaining Ring Installed |
| 3—Ring Installer (JD274-3) | 6—Bearing Installed |
| | 7—Outer Ring Sleeve (JD274-2) |

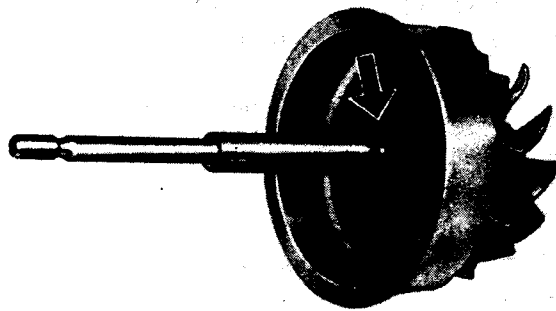
Fig. 12 Legend



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Fig. 12-JD-274 Retaining Ring Assembly Tool

Install piston ring on turbine wheel shaft (Fig. 13). With turbine wheel shaft upright, guide through the wheel shroud and bearings. Do not use force to compress piston ring in place. A gentle rocking and pushing action will allow the piston ring to seat and the shaft to bottom. A thin tool, such as a dental pick or JDH-6 O-Ring Seal Hook may be used as an aid in compressing the ring if difficulty is encountered.



T53826NY

Fig. 13-Piston Ring

Install piston ring (1, Fig. 14) on thrust collar (2). Place thrust collar, with channeled side toward center housing, over shaft (3), and flat against the center housing, (4), engaging the pins in the back side of the thrust washer.

IMPORTANT: Back plate and spring are sold only as an assembly. The installed depth of the spring is a controlled dimension. Therefore, do not replace or remove the spring.

Be sure that the thrust spring is installed in back plate.

Align mounting holes of center housing and back plate and install back plate over shaft and thrust collar (Fig. 15). Use care not to break piston ring when engaging seal in back plate bore. Back plate is easily installed if open end of piston ring is engaged in back plate bore first.

Install back plate-to-center housing cap screws (Fig. 15) and lock plates. Tighten cap screws to 75 to 90 lb-in. (8.47 to 10.17 Nm) (0.86 to 1.04 kg/m), and bend corners of lock plates against head of cap screw.

Install compressor wheel and tighten lock nut (Fig. 16) to 18 to 20 lb-in. (2.03 to 2.26 Nm) (0.21 to 0.23 kg/m), then tighten through an angle of 90°.

Check axial bearing movement and radial bearing movement. If bearing end play is not within 0.001 to 0.004 in. (0.03 to 0.10 mm) or if bearing clearance is not within 0.003 to 0.006 in. (0.08 to 0.15 mm), reinspect parts and replace as necessary.

Make sure there is clearance between wheel shroud and turbine wheel.

Install compressor housing on center housing (Fig. 16), but do not tighten cap screws at this time. Leave the cap screws finger tight until turbocharger has been mounted.

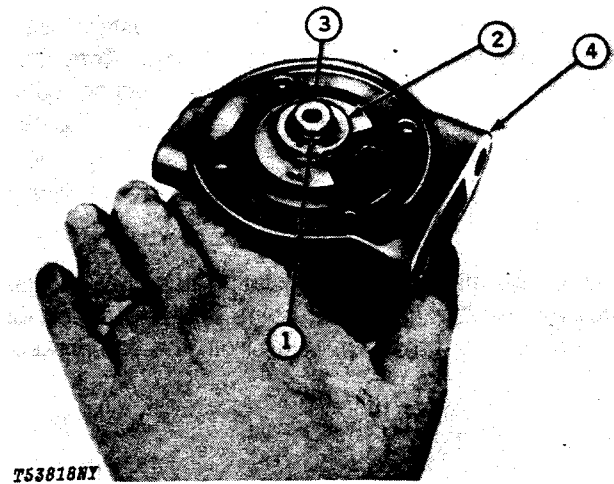


Fig. 14-Install Piston Ring On the Thrust Collar.

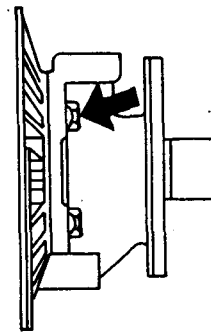


Fig. 15-Back Plate Cap Screws

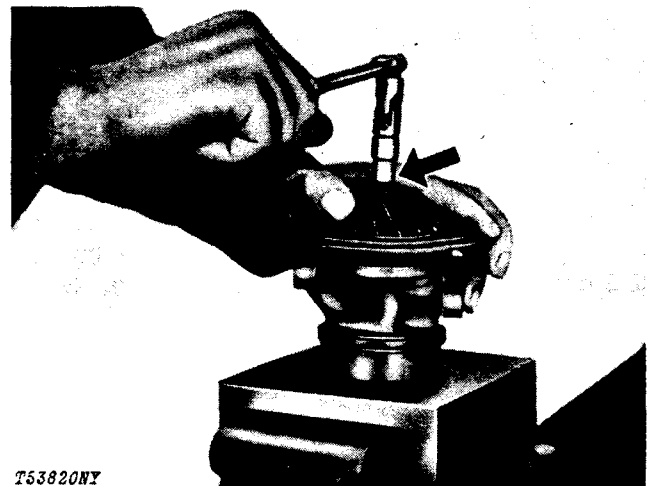


Fig. 16-Compressor Wheel Nut Torque

Orient turbine housing to center housing using scribe lines made during disassembly. Coat bolt threads with a high temperature, anti-seizing compound. Install lock plates, clamps and bolts. Tighten bolts (Fig. 17) to 140 to 170 lb-in. (15.8 to 19.2 Nm) (1.6 to 2.0 kg-m), and bend corners of lock plates against head of cap screw.

After assembly, push the rotating assembly as far away from the turbine end and check for binding. Repeat check, pushing from the compressor end.

INSTALLATION

Fill the center housing with new engine oil through the oil drain hole.

Turn the rotating assembly by hand to lubricate the bearings and thrust washer.

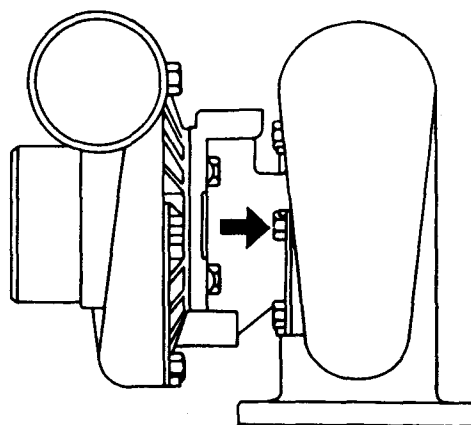
Install new O-rings on turbocharger to intake coupling. Use a small amount of AR54749 Soap Lubricant or an equivalent on O-rings.

Using a new gasket, install turbocharger on engine.

Check alignment of compressor housing to intake manifold (Fig. 18). If necessary, rotate compressor housing so manifold coupling is radially centered in compressor housing and intake manifold.

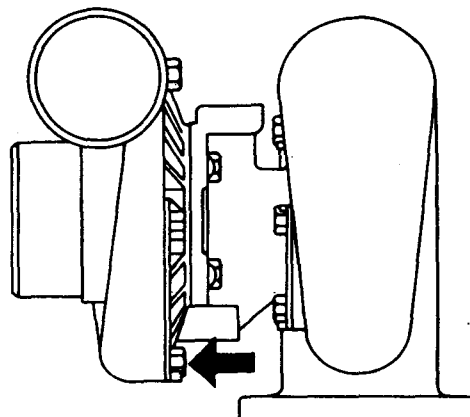
Tighten the mounting stud nuts, then tighten the back plate-to-compressor housing cap screws (Fig. 18) to 100 to 130 lb-in (11.3 to 14.7 Nm) (1.15 to 1.50 kg-m). Bend the corners of the lock plates against heads of cap screws.

When installing turbocharger exhaust adapter (3, Fig. 19) and exhaust elbow (4) be certain that the installation does not apply a force on the turbine housing (2). The exhaust adapter must have 0.03 inch (0.8 mm) minimum end play (1) and rotate freely.



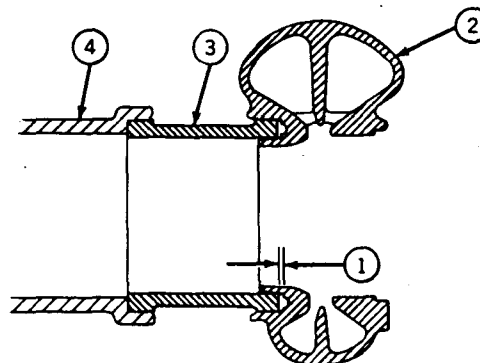
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Fig. 17-Turbine Housing Bolt



T53822N

Fig. 18-Compressor Housing Cap Screw



T50951N

Fig. 19-Exhaust Adapter Clearance

Install a 100 mesh or finer screen in the turbocharger oil inlet if engine internal parts have been replaced or repaired. Remove screen from oil inlet during 100 hour engine oil change.

Using new gaskets, connect oil inlet and outlet lines to the turbocharger (Fig. 20).

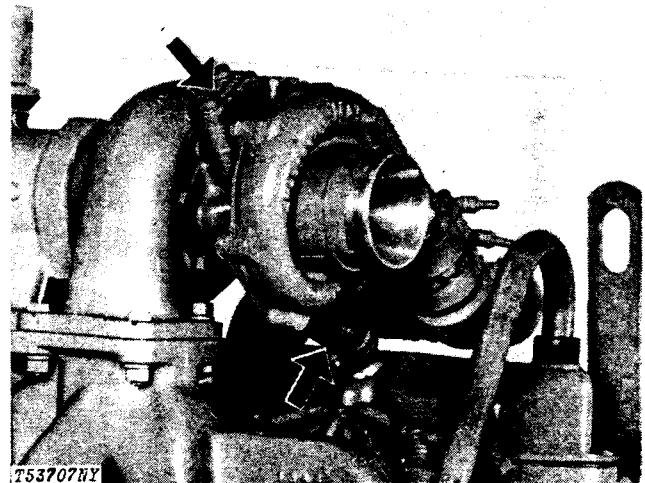


Fig. 20-Connecting Turbocharger Oil Lines.

IMPORTANT: Since the greatest amount of suction occurs between the air cleaner and turbocharger, it is essential that the hose connections are tight to prevent entry of dirt into the engine.

Inspect the air cleaner-to-turbocharger hoses to see that they are in good condition. If they are not, replace with new ones. Install air intake pipe, and tighten hose clamps securely.

Connect battery negative (-) cables to batteries.

IMPORTANT: When starting engine with a new or repaired turbocharger, hold the engine shut-off knob out and crank the engine with the starter until the engine oil pressure gauge registers sufficient pressure. Run engine at low idle, and check oil inlet connection for leaks.

Group 0417 WATER PUMP

GENERAL INFORMATION

The centrifugal-type water pump is attached at front of the engine.

REMOVAL

Disconnect battery negative (-) cable at the battery terminal.

Allow engine to cool.

Drain cooling system.

Remove alternator, fan belts, and fan.

Disconnect cooling system bypass hose at top of water pump (Fig. 1).

Disconnect lower radiator hose at water pump and engine oil cooler hose at lower rear of water pump (1, Fig. 2).

Remove water pump attaching hardware (2, Fig. 2) and remove water pump from engine.

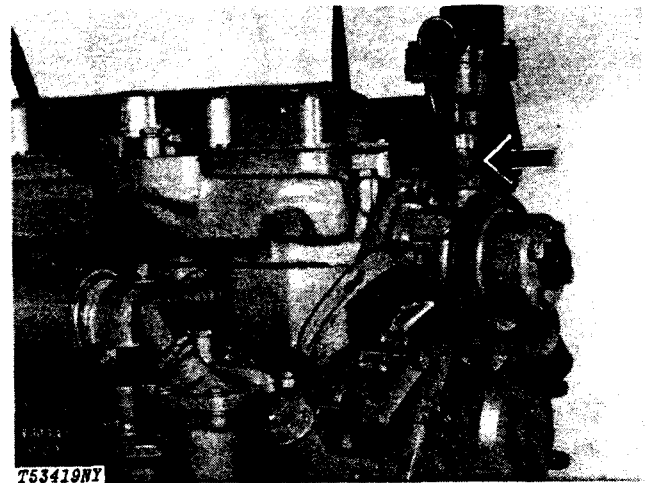


Fig. 1-Bypass Hose

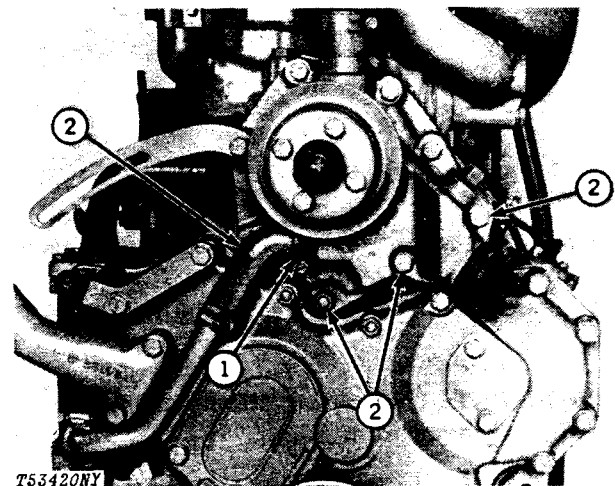
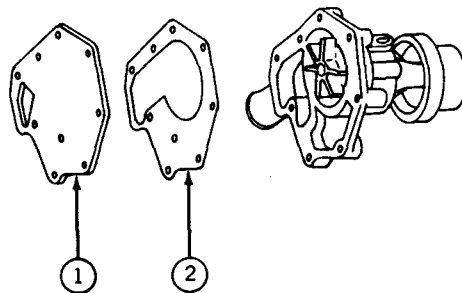


Fig. 2-Water Pump Removal

REPAIR

Remove cover plate (1, Fig. 3) and gasket (2) from pump housing.

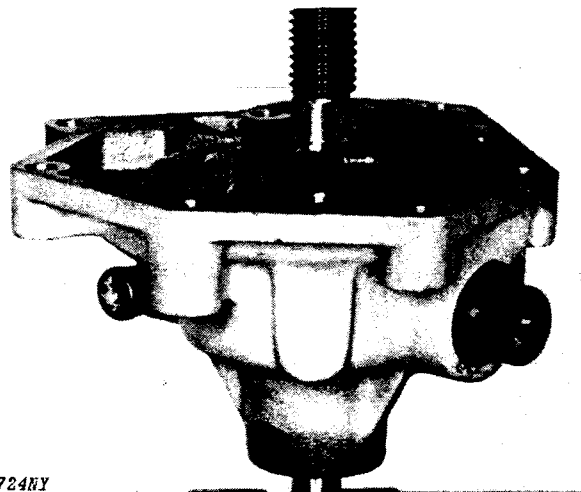


T53717N

Fig. 3-Cover Plate Removal

Support the pump housing from the pulley side (Fig. 4). The lower flange on the fan pulley should be a minimum of 3.00 in. (76 mm) above the press rails. The pulley must be free to travel down a minimum of 3.00 in. (76 mm) during bearing removal.

IMPORTANT: Do not attempt to press shaft from pulley end. A flange in the bearing bore prevents bearing passage through housing.



T53724NY

Fig. 4-Pump Placement and Bearing Removal

Select a drift which is slightly smaller than the bearing shaft at the impeller end. Press the bearing and pulley out of the housing as one piece from impeller end.

IMPORTANT: The bearing should always be replaced if removed from pump.

Remove the impeller, which is loose, and the seal (2, Fig. 5) from the housing.

Remove ceramic insert (1, Fig. 5) and cupped rubber insert found in counter bore in the impeller.

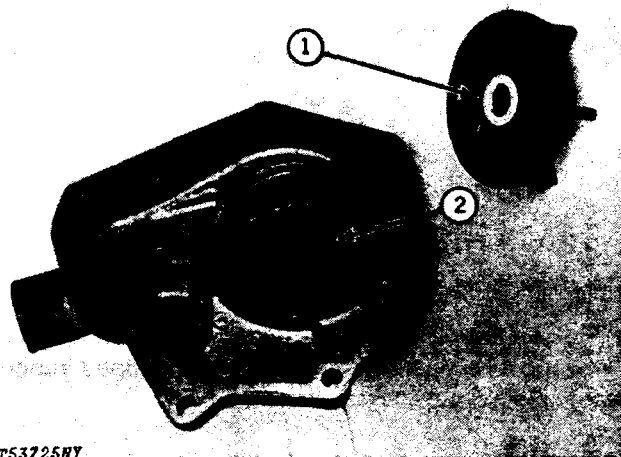
Inspect impeller, ceramic insert, and cupped rubber insert. Replace if necessary.

Inspect housing for damage behind impeller. Replace if metal has been scrapped away by impeller.

ASSEMBLY

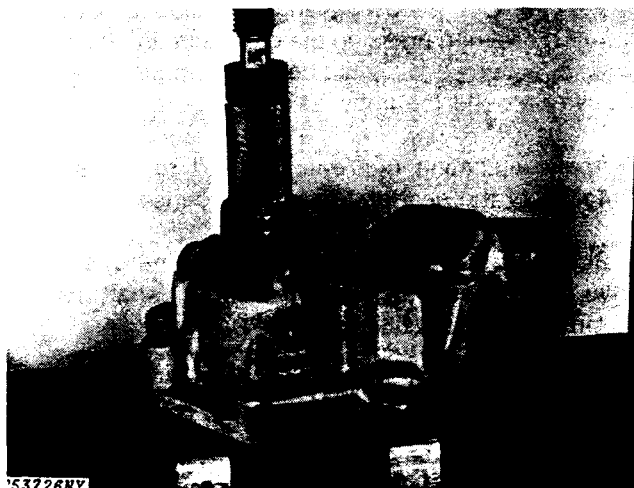
IMPORTANT: Do not press against bearing shaft.

Using a JDE-74 Water Pump Bearing Driver or any tubular-type driver that contacts only the outer race of bearing; press shaft and bearing assembly into housing until outer race is flush with pump housing (Fig. 6).



T53725NY

Fig. 5-Ceramic Insert Removal



53726NY

Fig. 6-Bearing Assembly

Sparingly coat the flange portion of the seal with joint sealing compound. Press seal into housing by hand until flange bottoms on housing (Fig. 7). Wipe away any excess joint sealing compound.

4

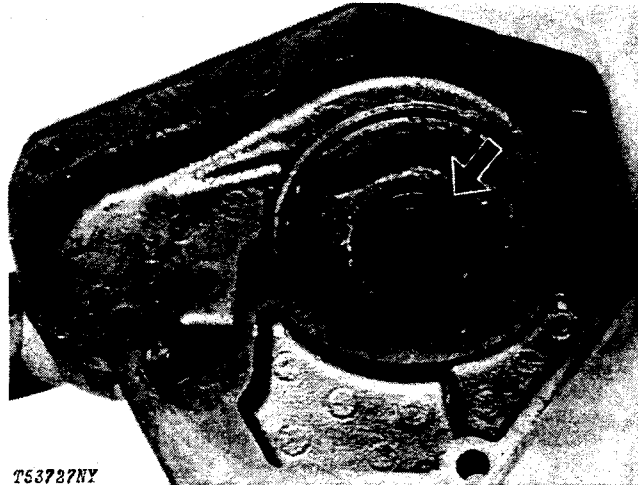


Fig. 7-Seal Replacement

Place ceramic insert in cupped rubber insert with "V" groove on ceramic insert toward cupped rubber insert. Be sure parts are dry and clean.

Dip inserts in light oil and install in impeller counterbore with cupped rubber insert against impeller. This is best accomplished by placing one side of insert in counterbore then pressing the other side in place. The sides of both inserts should be a uniform distance all of the way around the impeller counterbore.

Apply a coating of clean, light oil to the sealing surfaces of the seal and the ceramic insert.

Support pump assembly on pulley end of bearing shaft and press impeller on bearing shaft (vaness toward housing) until impeller is 0.25.

Using a support smaller than the impeller end of the bearing shaft, support impeller end of bearing shaft and press fan pulley onto opposite end of shaft to a distance from the fan surface on pulley to rear surface of housing (without cover plate or gasket) of inch (mm).

Spin the fan pulley to be sure no parts are binding or striking.

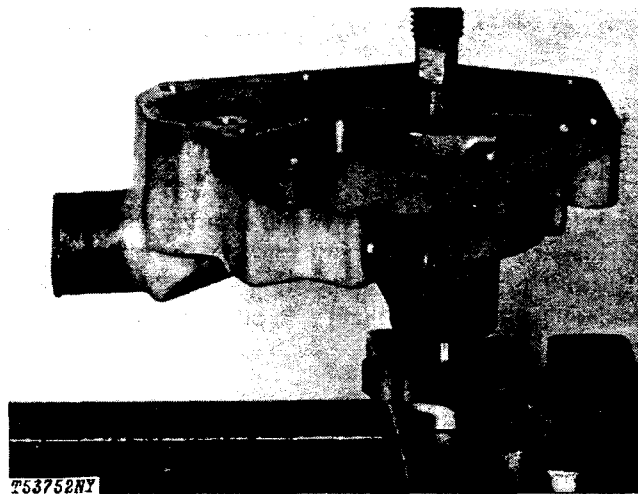


Fig. 8-Impeller Replacement

INSTALLATION

Using a new gasket, install cover plate on pump assembly. Tighten attaching cap screws to 35 lb-ft (47 Nm) (5 kg-m), Fig. 9.

Install water pump on cylinder block.

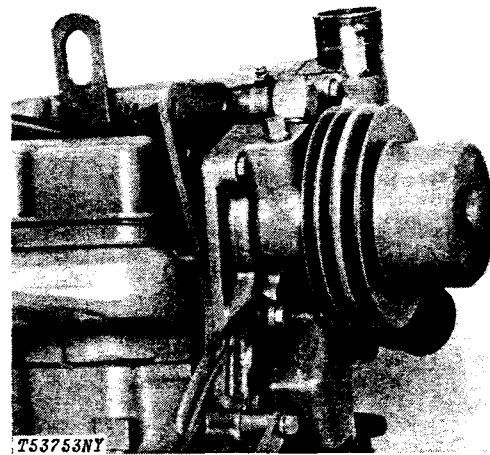


Fig. 9-Water Pump Assembly

Connect engine oil cooler hoses (if equipped with oil cooler).

Connect lower radiator hose (Fig. 10).

Connect cooling system by-pass hose to water pump.

Install alternator, fan and fan belts.

Adjust fan belts (Group 9010).

Fill cooling system.

Connect battery negative (-) cable to battery terminal.

Run engine and inspect hose connections and water pump for leaks.

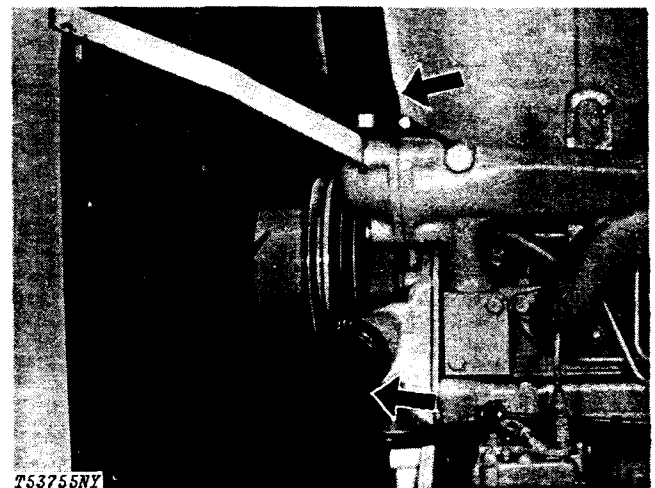


Fig. 10-Connecting Radiator Hoses

Group 0418

THERMOSTATS, HOUSINGS AND WATER PIPING

GENERAL INFORMATION

The cooling manifold is located on the left side of the engine near the valve gear cover (Fig. 1). On some engines it is cast into the block.

REMOVAL

Stop engine.

Disconnect negative (-) battery cable.

Allow engine to cool.

Drain engine coolant.

CAUTION: Do not drain engine coolant until the coolant temperature is below operating temperature. Then loosen drain cock slowly to relieve any excess pressure.

Remove upper radiator hose.

Remove thermostat housing cover.

Lift out thermostat (Fig. 2).

REPAIR

If engine is running too hot or too cold inspect thermostat for defects. Test in hot water for proper opening and closing.

Thermostat test temperature:

Engine	Code	Full Open Temperature	Opening Temperature
3-164 and 4-219	2201	183°F (84°C)	156 to 163°F (69 to 73°C)
	2202	212°F (100°C)	189 to 197°F (87 to 92°C)
	2203	213°F (101°C)	201 to 207°F (94 to 97°C)
	2204	203°F (95°C)	176 to 183°F (80 to 84°C)

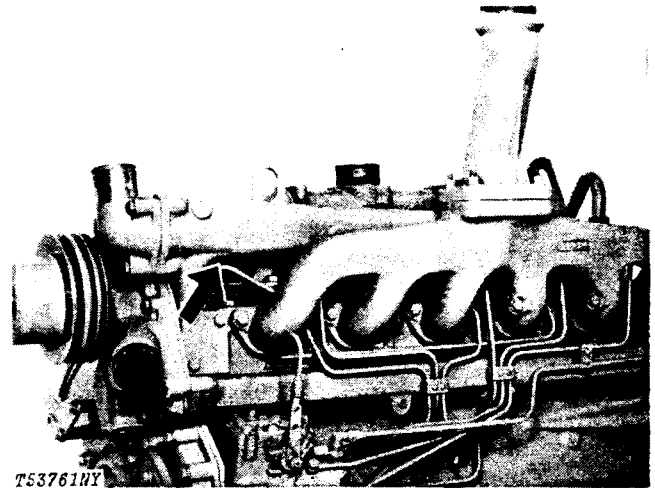


Fig. 1-Cooling Manifold Location

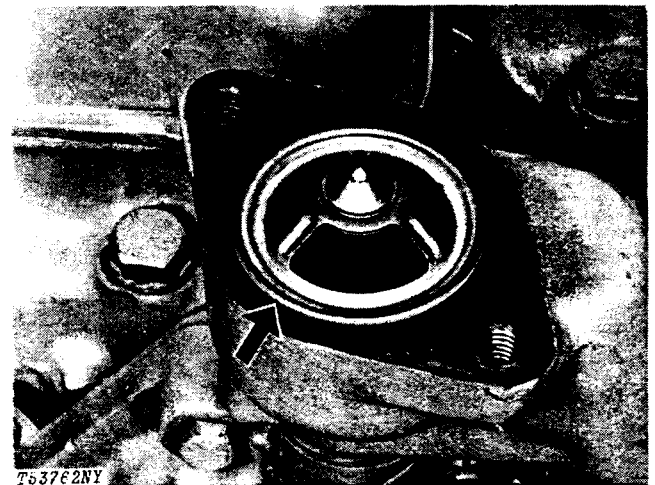


Fig. 2-Thermostat Removal

Thermostats, Housings and

test temperature continued:

Code	Full Open Temperature	Opening Temperature
2204	203°F (95°C)	176 to 182°F (80 to 83°C)
	200°F (93°C)	180 to 195°F (82 to 91°C)
2204	203°F (95°C)	176 to 182°F (80 to 83°C)

Inspect hoses for cracks or leaks.

Inspect all passages.

Replace all gaskets and o-rings.

INSTALLATION

Follow the removal procedure in reverse order.

Group 0419 OIL COOLER

3-164D, 4-219D, AND 6-329D ENGINES

Removal

Disconnect coolant lines (1, Fig. 1).

Remove oil filter (2).

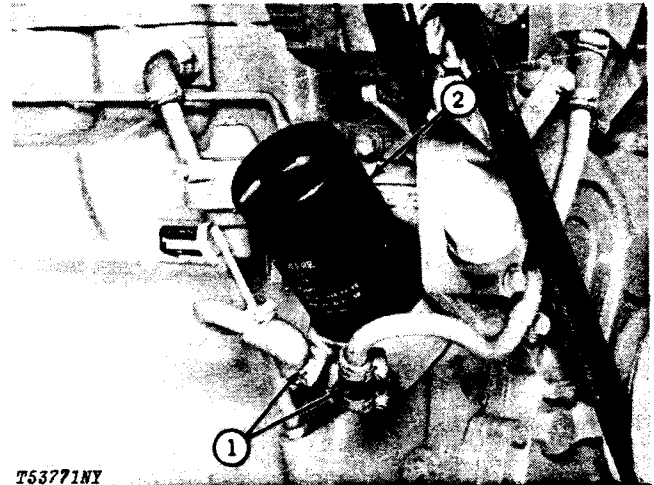


Fig. 1-Oil Cooler Lines

Unscrew oil cooler nipple (Fig. 2) and lift oil cooler off of cylinder block.

Remove four sided packing from bottom of oil cooler.

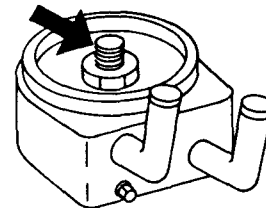


Fig. 2-Oil Cooler Nipple

Repair

Pressure check the coolant side of the oil cooler using 15 psi (1 bar) (1 kg/m) maximum air pressure.

Remove oil cooler bypass valve by driving it out the bottom of the oil cooler from the top side.

Inspect bypass valve and spring (Fig. 3) for damage and replace as necessary.

4



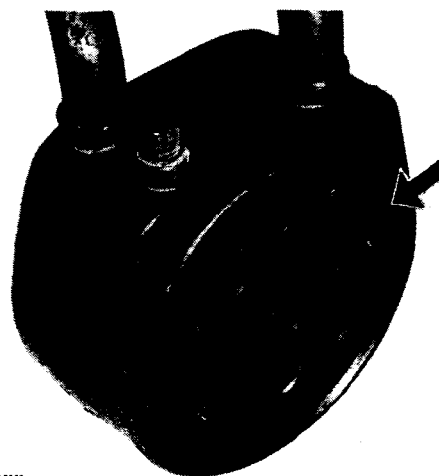
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Fig. 3-Oil Cooler Bypass Valve and Spring

Installation

Install new four sided packing (Fig. 4) on bottom of oil cooler.

Position oil cooler on engine and install oil cooler nipple.

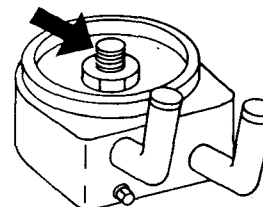


T53774NY

Fig. 4-Four Sided Packing

Oil cooler nipple torque (Fig. 5) 20 to 35 lb-ft
(27 to 47 Nm) (30 to 50 kg-m)

Connect coolant hoses to oil cooler and install new oil filter (Group 0407).



T53809N

Fig. 5-Oil Cooler Nipple

4-276D, 4-276T, 6-414D, AND 6414T ENGINES

Removal

Disconnect coolant lines (1, Fig. 6) and remove oil filter (2).

Remove oil cooler assembly attaching cap screws (3).

Remove oil filter housing (4) from oil cooler.

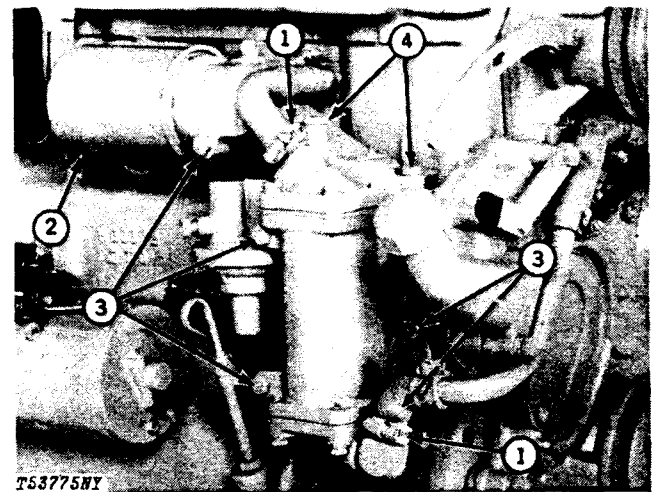


Fig. 6-Oil Cooler Assembly Removal

Repair

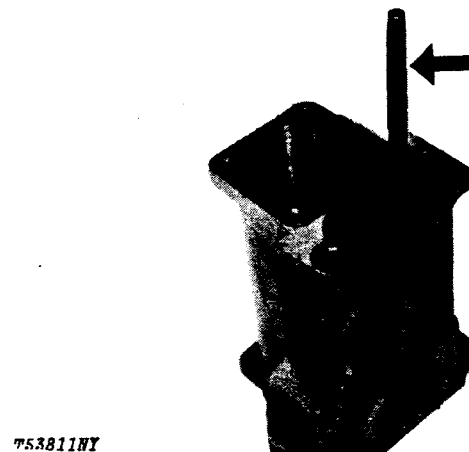
Remove top and bottom covers.

Using a suitable driver, drive oil cooler out of housing from bottom side (Fig. 7).



Fig. 7-Remove Oil Cooler

Drive oil cooler bypass valve out the bottom from the top using a pin punch against the top of the valve (Fig. 8).

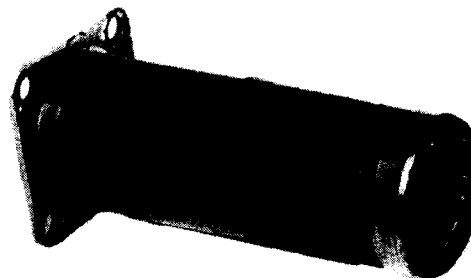


Remove 8-Remove Oil Cooler Relief Valve

Inspect oil cooler for damage or build-up of foreign material and clean as needed.

The oil cooler can be pressure checked with a maximum of 50 psi (3 bar) (4 kg/cm²) air pressure.

4



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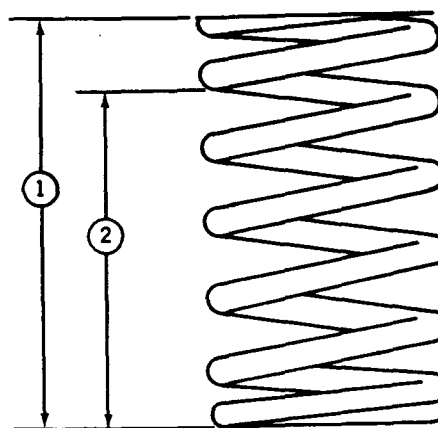
Fig. 9-Oil Cooler

Check oil cooler bypass valve spring length:

Valve spring
free length (1, Fig. 10) 2.60 inch
(66.0 mm)

Valve spring
length (2) 1.91 inch
(48.5 mm)

when compressed with 29.5 to 37.5 lb
(131 to 167 N) (13 to 17 kg)

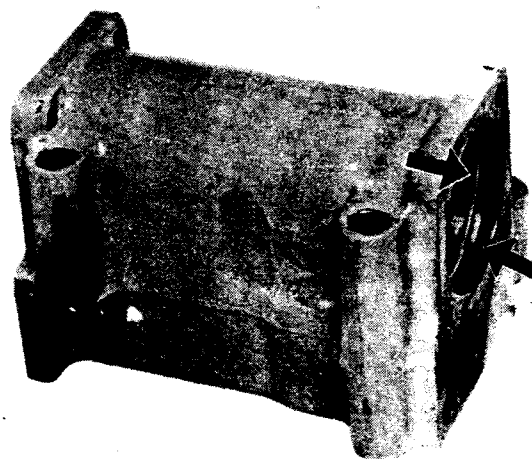


T53812N

Fig. 10-Oil Cooler Bypass Valve Spring Length

Remove O-rings from housing at bottom of oil cooler bore.

Remove all gasket residue from parts.



T53814NY

Fig. 11-Remove O-rings

Place a piece of paper (1, Fig. 13) under the brush (2, Fig. 13). Hook a spring tension scale on the head of the brush attaching screw. Pull the scale on a line parallel to the brush and note the reading when the paper is released. Minimum brush spring tension is 80 ounces (2.3 kg). Bend springs, if it is necessary, to adjust the tension.



Fig. 13-Testing Brush Spring Tension

Pinion Clearance

The pinion clearance cannot be adjusted but should be checked after reassembly of the starting motor to insure proper clearance. Improper clearance is an indication of worn parts.

To check pinion clearance use the following steps:

1. Disconnect the motor field coil connector (12, Fig. 5) from the solenoid motor terminal and insulate it carefully.
2. Connect a battery (1, Fig. 14), of the same voltage as the solenoid (2) (12 volt), from the solenoid switch terminal(s) to the solenoid frame.

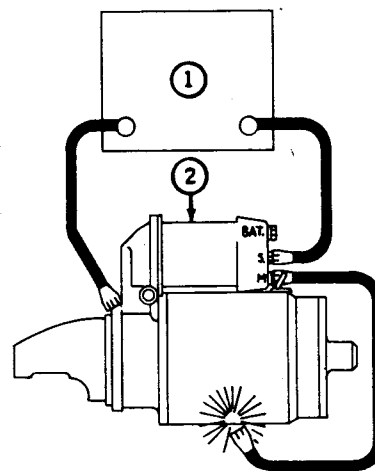


Fig. 14-Circuit For Checking Pinion Clearance

Momentarily flash a jumper lead from the solenoid motor terminal to solenoid frame. This will shift the pinion into cranking position and it will remain so until the battery is disconnected.

Push the pinion (1) back toward the commutator end as indicated by the larger arrow in Fig. 15, to eliminate slack movement.

Measure the distance between pinion and pinion stop (2). The clearance should be 0.010 inch (0.25 mm) to 0.140 inch (3.56 mm) as measured with a feeler gauge (3).

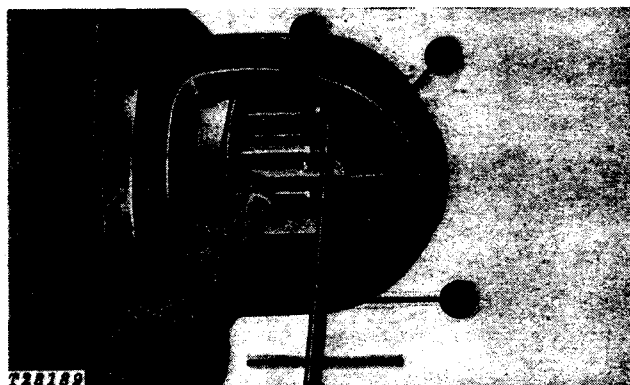


Fig. 15-Checking Pinion Clearance

INSTALLATION

Follow removal procedure in reverse order.

Connect battery positive cable and red and black wires to "BAT". Connect neutral wire to "S" terminal.

4

Bushing (Prelubricated)

Install prelubricated bushings using an arbor to prevent bearing collapse. After installation, check bushing size. Burnish bushing to size if necessary.

Wick-Lubricated Bushings

Remove pipe plugs, expansion plugs and oil wicks from housings. Press out old bushing. Press new bushing in to same depth as old bushing. Carefully drill bushing through oil wick hole using same size drill as oil wick hole.

After drilling, ream bushing to maintain proper oil clearance between shaft and bushing.

Soak new wicks in SAE 10 engine oil. Install wicks, expansion plugs and pipe plugs.

Bushing Specifications

Bushing, Overrunning Clutch ()

I.D. 0.5620 - 0.5630 in.
(14.274 - 14.300 mm)
Wear tolerance 0.5740 in.
(14.579 mm)

Bushing, Drive Housing

I.D. 0.4990 - 0.5010 in.
(12.674 - 12.725 mm)
Wear tolerance 0.5110 in.
(12.979 mm)
Oil clearance 0.0020 - 0.0050 in.
(0.050 - 0.127 mm)
Wear tolerance 0.0170 in.
(0.431 mm)

Bushing, Commutator End Frame

I.D. 0.5625 - 0.5635 in.
(14.288 - 14.312 mm)
Wear tolerance 0.5730 in.
(14.554 mm)
Oil clearance 0.0020 - 0.0050 in.
(0.050 - 0.127 mm)
Wear tolerance 0.0160 in.
(0.406 mm)

Bushing, Center Bearing

I.D. 0.7570 - 0.7620 in.
(19.227 - 19.354 mm)
Wear tolerance 0.7220 in.
(18.338 mm)
Oil clearance 0.0070 - 0.0150 in.
(0.178 - 0.381 mm)
Wear tolerance 0.0250 in.
(0.635 mm)

Solenoid Switch

Remove nuts and sealing washers from solenoid motor and "S" terminals when removing switch cover.

The "R" terminal contact finger (2, Fig. 10) height (3) above the surface of the main contact (1, Fig. 10) should be 0.0625 to 0.0938 inch (1.588 mm to 2.383 mm). Bend the finger to adjust contact height.

4

Replacement "S" terminal clips and motor terminal studs are soldered to winding leads. Use new sealing washers when assembling the solenoid.

ASSEMBLY

To assemble starting motor, reverse the disassembly procedures.

Lubricate splines and drive end of armature shaft with SAE 10 engine oil. Heavier oil may cause failure to mesh at low temperature. Lubricate the bearing surfaces of the center bearing, drive end frame, and commutator end frame with Delco-Remy lubricant No. 1960954.

With overrunning clutch in place, install pinion stop with cupped side out and retaining ring.

Proceed as follows when assembling retaining ring and pinion stop on shaft.

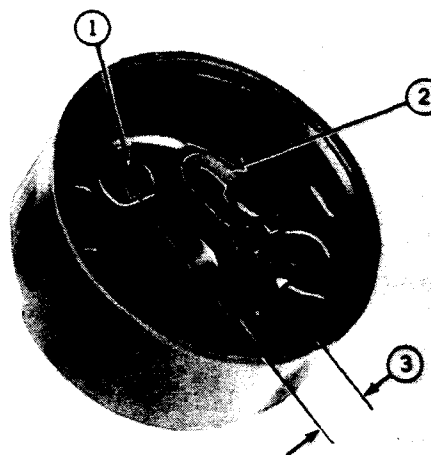
With the pinion stop placed over the shaft (cupped surface facing the end of the shaft), force the retaining ring (1, Fig. 11) over the shaft with a light hammer blow and slide ring into the groove (2, Fig. 11).

To force the pinion stop (1, Fig. 12) over the ring, place a suitable washer (2) over the shaft and squeeze with pliers. Remove the washer.

Use Permatex No. 2 sealing compound between solenoid flange and starting motor field frame.

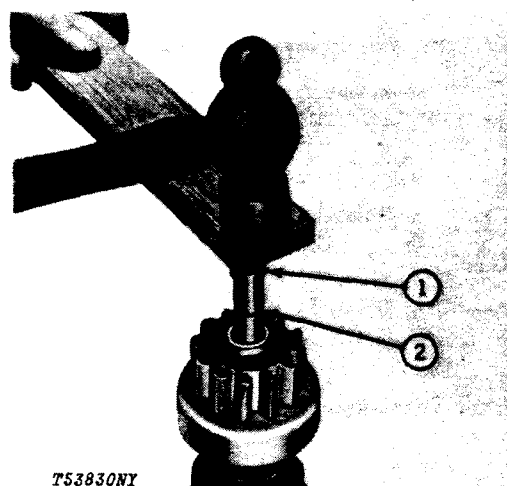
Carefully install field frame so that brush holders are not broken. Align brushes with commutator and tighten brushes.

If it is necessary to seat brushes, use No. 00 sandpaper. Clean all dust from starting motor.



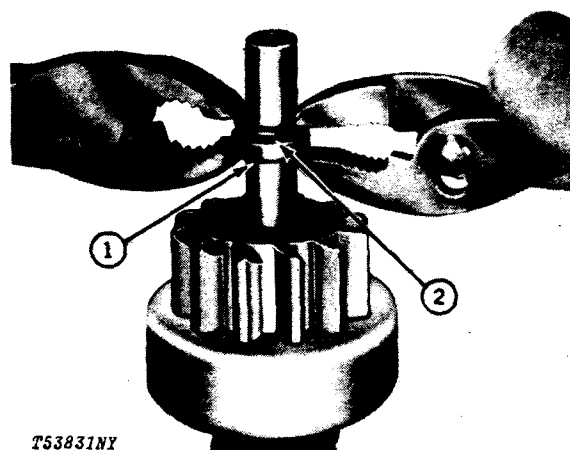
T53893NY

Fig. 10-Solenoid Servicing



T53830NY

Fig. 11-Installing Retaining Pins



T53831NY

Fig. 12-Installing Pinion Stop

Remove retaining ring. If it is badly distorted, use a new retaining ring when reassembling the clutch.

Remove armature and clutch from lever housing and separate solenoid from the housing.

Do not clean any parts in grease dissolving solvents. Wipe the drive with a clean cloth.

Checking Brushes

Inspect brushes. If they are oil soaked or are worn to approximately 5/16 inch (8 mm), replace them.

Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.

To remove brush holders, slide pivot pins out. Tighten brushes after assembling starting motor.

Armature

If the commutator is excessively worn, dirty, out of round, or if it has high insulation, it should be turned down on a lathe. Do not under cut the insulation.

The commutator may be cleaned with No. 00 sand paper. Do not use emery cloth.

The armature should be checked for short circuits, opens and grounds.

1. Short circuits are located by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature. The steel strip will vibrate on the area of the short circuit. Shorts between bars are sometimes produced by brush dust or copper between bars. Undercutting the insulation will eliminate these shorts.

Opens may be located by inspecting the points where the conductors are joined to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not badly burned, leads originally soldered to the riser bars can be resoldered.

Grounds in the armature can be detected by the use of a test lamp. If the lamp lights when one test probe is placed on the commutator and the other test probe on the armature core or shaft, the armature is grounded. If the commutator is worn, dirty, out of round, or has high insulation, the commutator should be turned down.

Field coils should be tested for grounds using a test lamp (1, Fig. 7).

Grounded Winding Test (Fig. 7)

Disconnect field coil ground connections. Connect one test probe to the field frame (1, Fig. 7) and the other to the field connector (2). If the lamp lights, the field coils are grounded and must be repaired or replaced.

Field Winding Opens Test (Fig. 8)

Connect test lamp (1, Fig. 8) to ends of field coils (2). If lamp does not light field coils are open (Fig. 8).

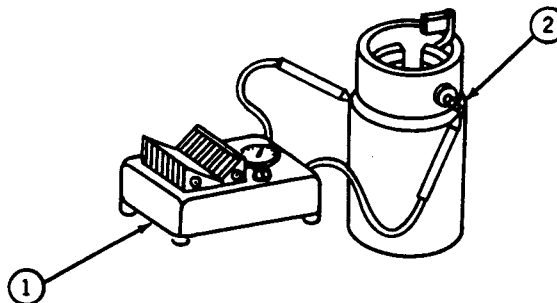
Before removing pole shoes scribe lines to be sure they are assembled in their original position.

Remove pole shoe screws.

When replacing field coils, care should be taken to prevent grounding or shorting them as they are tightened into place.

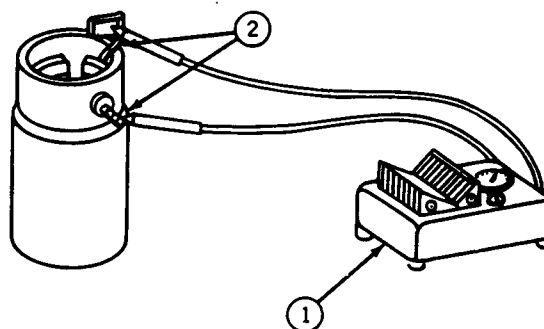
Overrunning Clutch Assembly

The pinion (2) should turn smoothly with a slight drag in the overrunning direction and lock up in the opposite direction. If not, the entire clutch and pinion assembly must be replaced as the assembly cannot be repaired except for the spring (1, Fig. 9) and collar.



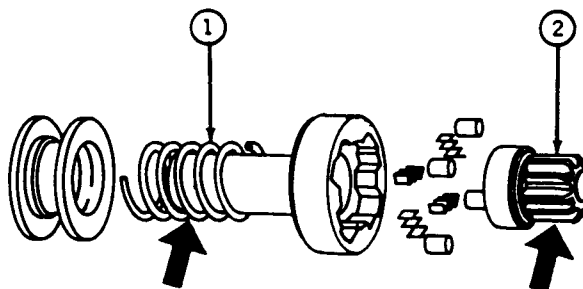
T53828N

Fig. 7-Field Winding Test Grounds



T53827N

Fig. 8-Field Winding Opens Test

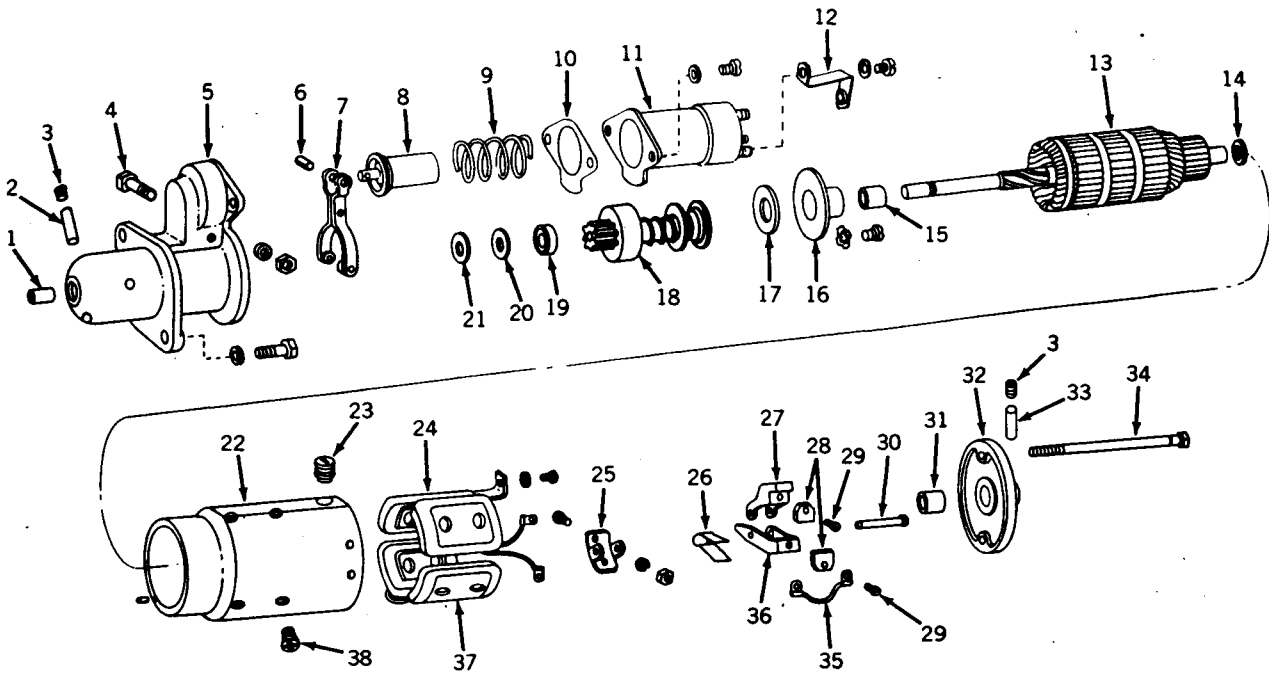


T53829N

Fig. 9-Clutch Assembly

Interpret the test results as follows:

1. Rated current draw and no load speed indicates normal condition of the starting motor.
2. Low free speed and high current draw indicates:
 - a. Too much friction - tight, dirty, or worn bearings, bent armature shaft or loose pole shoes, allowing armature to drag.
 - b. Shorted armature. This can be further checked on a growler after disassembly.
 - c. Grounded armature or fields. Check further after disassembly.
3. Failure to operate with high current draw indicates:
 - a. A direct ground in the terminal or fields.
 - b. Frozen bearings (this should have been determined by turning the armature by hand).
4. Failure to operate with no current draw indicates:
 - a. Open field circuit. This can be checked after disassembly by inspecting internal conditions and tracing circuit with a test lamp.
 - b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.
 - c. Broken brush springs, worn brushes, high insulation between the commutator bars, or other causes which would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicates:
 - a. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under no. 4.
6. High free speed and high current draw indicates shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.



T32150N

- 1—Bushing
- 2—Lubricating Wick
- 3—Plug (2 used)
- 4—Shift Lever Pivot Screw
- 5—Drive End Housing
- 6—Spring Pin
- 7—Shift Lever
- 8—Solenoid Plunger
- 9—Solenoid Return Spring
- 10—Gasket
- 11—Solenoid Assembly

- 12—Field Coil Connector
- 13—Armature
- 14—Thrust Washer
- 15—Bushing
- 16—Center Bearing
- 17—Brake Washer
- 18—Overrunning Clutch
- 19—Pinion Stop
- 20—Retaining Ring
- 21—Thrust Collar
- 22—Field Frame

- 23—Insulating Bushing
- 24—Field Coil Assembly
- 25—Brush Support
- 26—Brush Spring
- 27—Insulated Brush Holder
- 28—Brushes
- 29—Brush Mounting Screws (2 used)
- 30—Brush Pivot Pin (2 used)

- 31—Bushing
- 32—Commutator End Frame
- 33—Lubricating Wick
- 34—Through Bolts (2 used)
- 35—Brush Ground Lead (2 used)
- 36—Grounded Brush Holder
- 37—Field Pole Shoe (4 used)
- 38—Pole Shoe Screw (8 used)

Fig. 5—Delco-Remy Starting Motor

REPAIR

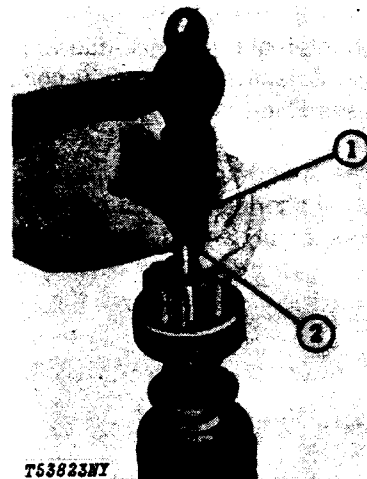
Disassemble motor only as far as necessary to make repairs (Fig. 5).

Mark position of commutator end frame with regard to main frame to aid in alignment during reassembly.

Disconnect field coil connector (12, Fig. 5) from solenoid motor terminal and remove solenoid mounting screws.

Remove commutator end frame (32, Fig. 5). Remove field frame and solenoid from drive housing (5). Separate armature (13) and clutch assembly (18) from drive housing.

Slide a standard half-inch pipe coupling onto the shaft so it butts against the pinion stop. Tap coupling, driving stop (19, Fig. 5) toward the armature end, off the retaining ring (Fig. 6).



T53823NY

Fig. 6—Forcing Retaining Ring Over Shaft

Group 0422

STARTING MOTOR AND FASTENINGS

GENERAL INFORMATION

It is possible for the engine to be equipped with either of two types of starters: a John Deere Starter or a Delco-Remy starter. Both repair procedures are contained in this section.

DELCO-REMY
STARTING MOTOR

REMOVAL

Starter is located on either right or left side of engine at the rear.

Disconnect battery negative (-) cable.

Disconnect wires from starting motor.

Remove cap screws that attach motor to flywheel housing.

NOTE: The JDE-80 starter wrench may be necessary to remove the rear attaching cap screw.

TESTING AND DIAGNOSIS

Solenoid Tests
(Starting Motor Removed)

Testing Pull-In Windings

Disconnect field connector from solenoid motor terminal. Connect ammeter in series with a carbon pile resistor to terminal "S" and to battery. Connect voltmeter (1) to terminal "S" and to solenoid motor terminal (Fig. 2). With carbon pile (2) in the off position, connect other battery post (3) to solenoid motor terminal. Quickly adjust the carbon pile (2) to obtain 5 volts. The ammeter (4) reading should be 13 to 15.5 amps.

Testing Hold-In Windings

Disconnect solenoid. Connect ammeter in series with a switch to terminal "S" and to battery. Connect voltmeter to terminal "S" and to solenoid ground. Connect carbon pile resistor across the battery. Connect other battery post to solenoid ground. Close the switch and adjust carbon pile to obtain 10 volts. The ammeter reading should be 14.5 to 16.5 amps.

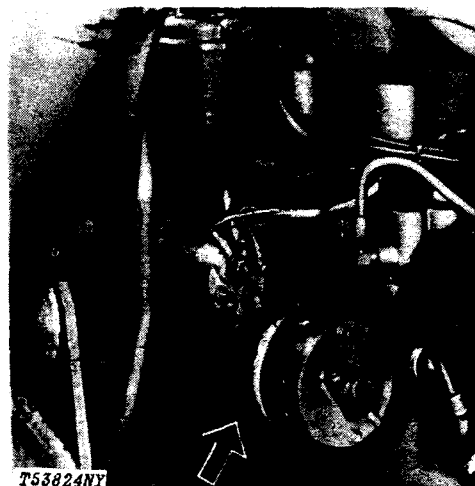


Fig. 1-Delco-Remy Starting Motor

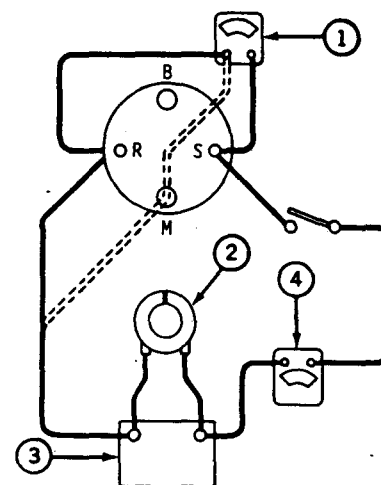


Fig. 2-Solenoid Pull-In Test

High Ammeter Reading

Windings are grounded or short circuited

Low Ammeter Reading

Excessive resistance is present (usually in a connection)

No Ammeter Reading

Windings are open circuited

To prevent overheating, do not energize the pull-in winding longer than 15 seconds. Current draw will decrease as the winding temperature increases.

If the fault cannot be repaired and the solenoid performance is questionable, replace the windings.

No Load Starting Motor Test (Fig. 3)

Place starter in a vise.

Connect the circuit in Fig. 3 starting with the battery positive terminal (2) with heavy wire to the ammeter (3) then to the "BAT." contact of the solenoid. Connect a switch across the "BAT." and S of the solenoid.

Place a voltmeter from the M terminal to the starter motor casing. Connect the starter motor casing to the negative of the battery. Connect a carbon pile to the positive and negative of the battery to adjust the voltage. Connect a tachometer to the starter motor.

The meters should read as follows (Fig. 4).

Motor No.	Test Volts	Min. Amps	Max. Amps	Min. rpm	Max. rpm
1109251	9	20*	120*	9000	14000
1107871	9	40*	140*	8000	13000
1114381	9	124*	185*	4700	7600

*Includes Solenoid

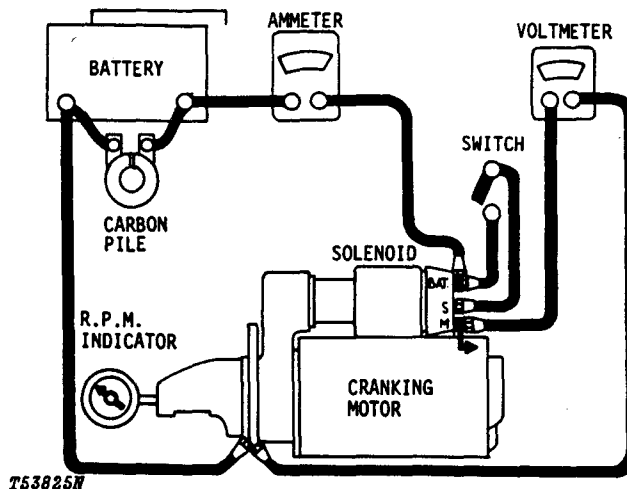


Fig. 3-No Load Starter Test Circuit

Fig. 4-Test Data For A Delco-Remy Starter

Group 0421 FUEL TRANSFER PUMP

GENERAL INFORMATION

The fuel transfer pump is located on the right side of the engine as shown on (1, Fig. 1).

REMOVAL

Disconnect and plug fuel lines (2, Fig. 1) at pump.

Remove attaching hardware.

REPAIR

To remove or install primer lever, (1, Fig. 2) compress rocker arm lever (2). And pull primer lever out.

Further disassembly of the transfer pump is not possible.

INSTALLATION

Follow removal procedure in reverse order. Bleed fuel system.

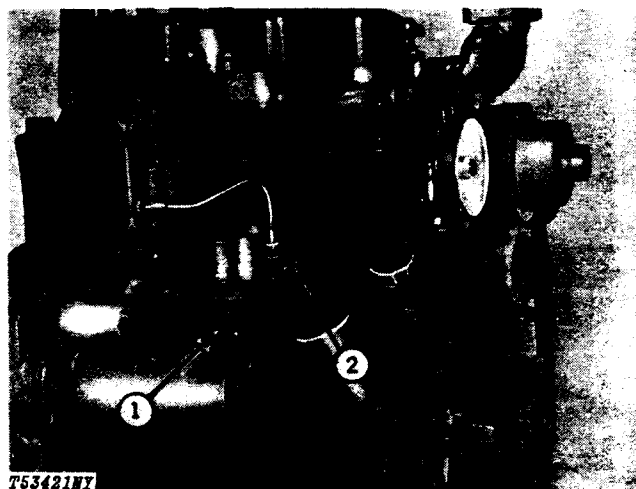


Fig. 1-Fuel Pump Location

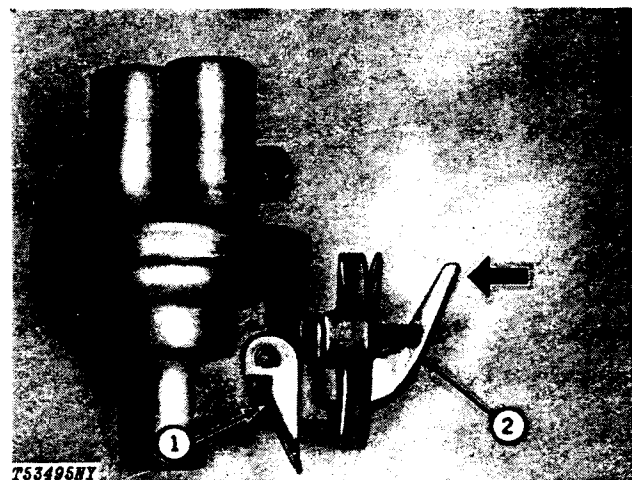


Fig. 2-Fuel Pump Removal

Group 0420 FUEL FILTER

GENERAL INFORMATION

The fuel filter is located on the right side of the cylinder block, in the upper rear corner (Fig. 1).



Fig. 1-Fuel Filter

REMOVAL

To remove filter element (3, Fig. 2), pull off retaining spring (4) and slip off filter element.

To remove filter body (7), disconnect and cap inlet line (2) and outlet hose (1). Remove cap screws securing body to mounting bracket.

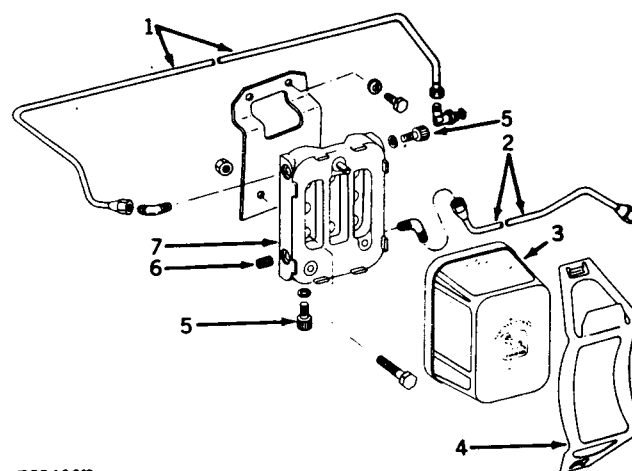


Fig. 2-Fuel Filter Assembly

INSTALLATION

Replace body on engine block.

Connect fuel inlet and outlet lines.

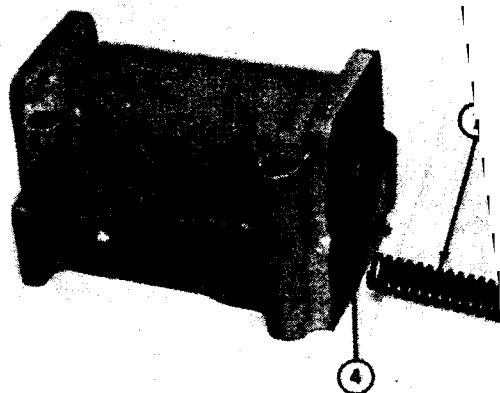
Mount and secure fuel filter on body.

Replace bleed screw (4, Fig. 2) and drain plug (5).

Bleed fuel system (Group 0413).

installation

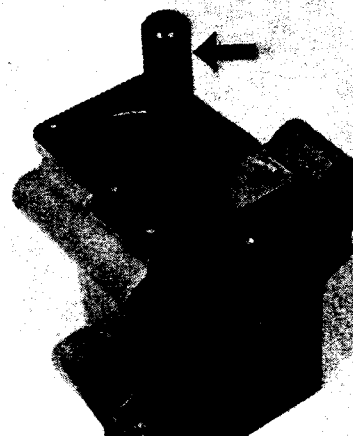
Position oil cooler relief valve spring (1, Fig. 12), valve (2), and valve seat (3) in bore in bottom of housing (4).



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Fig. 12-Install Oil Cooler Relief Valve

Using a suitable driver (Fig. 13), drive the valve seat into the housing until the seat bottoms.



T53818NY

Fig. 13-Drive Oil Cooler Relief Valve Seat

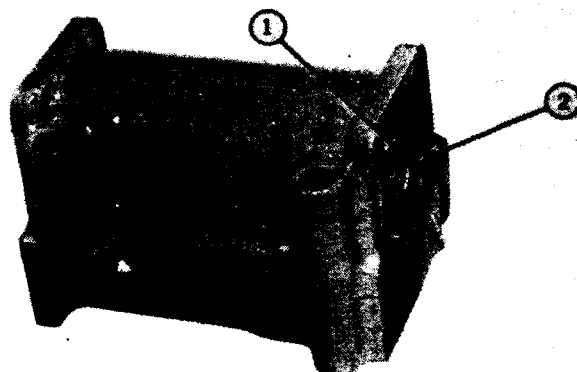
Install new O-rings in housing at bottom of oil cooler bore, red O-ring in upper groove (1, Fig. 14) and black O-ring in lower groove (2).

Using new gasket, install oil cooler in housing from top side, being careful not to shear O-rings.

Using new gaskets, install top and bottom covers and oil filter housing.

Position oil cooler assembly on engine and install screws.

Connect oil cooler coolant lines and install a new oil filter.



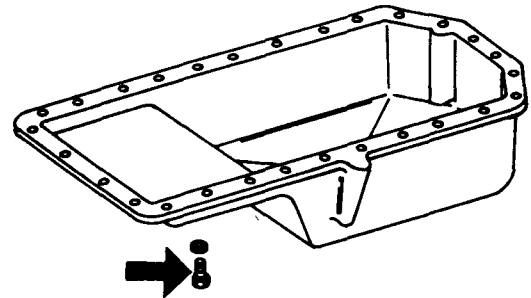
T53817NY

Fig. 14-O-Ring Installation

OILING SYSTEM (0407)

SPECIFICATIONS AND TORQUE VALUES—Continued

Oil pan cap screw torque..... 35 lb-ft
(47 Nm) (5 kg-m)



T53942N

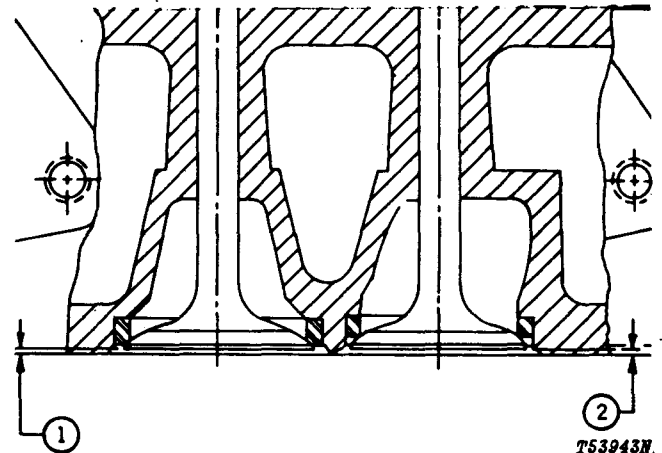
Fig. 34-Oil Pan Cap Screw Torque

CYLINDER HEAD AND VALVES (0409)

SPECIFICATIONS AND TORQUE VALUES

Cylinder head-to-intake valve
head distance (new) (1, Fig. 35) 0.023 to 0.047 inch
(0.58 to 1.19 mm)

Cylinder head-to-exhaust valve
head distance (new) (2) 0.038 to 0.072 inch
(0.97 to 1.83 mm)



T53943N

Fig. 35-Cylinder Head to Valve Head Distance

CYLINDER HEAD AND VALVES (0409)

SPECIFICATIONS AND TORQUE VALUES—Continued

Cylinder head flatness
(maximum warp) (1, Fig. 36)..... 0.002 inch
(0.05 mm)

Maximum material removal
from cylinder head (2) 0.030 inch
(0.76 mm)

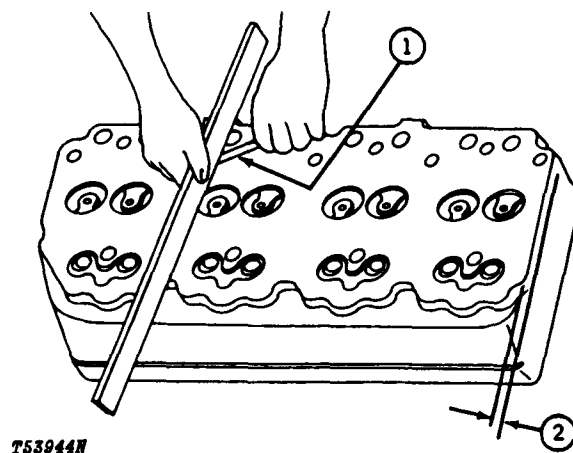


Fig. 36-Cylinder Head Flatness

Valve face angle:

Engine	Intake Valve	Exhaust Valve
3-164	45°	45°
4-219	45°	45°
4-276	30°	45°
6-329	45°	45°
6-414	30°	45°

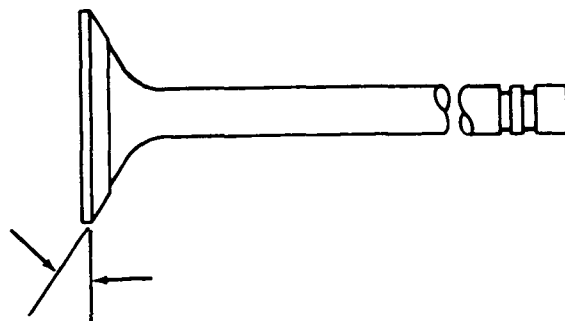


Fig. 37-Valve Face Angle

Valve seat angle:

Engine	Intake Valve Seat	Exhaust Valve Seat
3-164	45°	45°
4-219	45°	45°
4-276	30°	45°
6-329	45°	45°
6-414	30°	45°

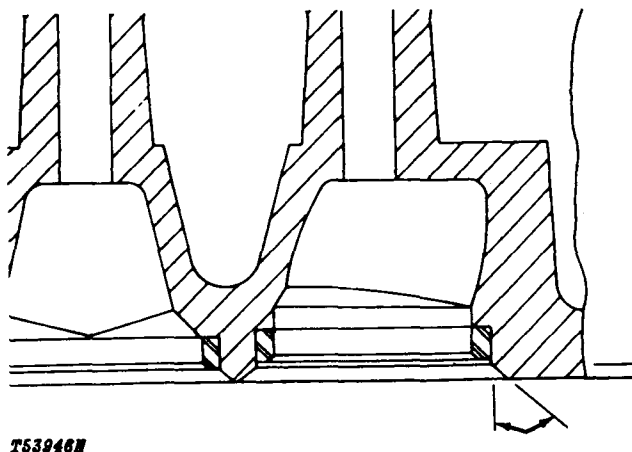
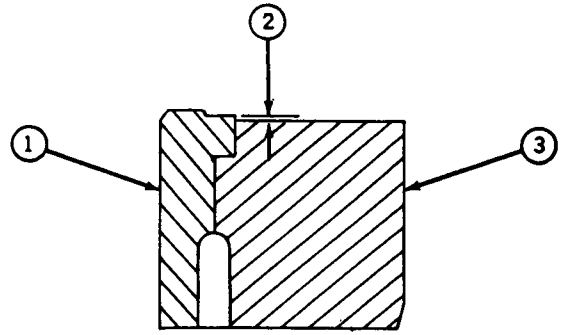


Fig. 38-Valve Seat Angle

CYLINDER BLOCK (0404)

SPECIFICATIONS AND TORQUE VALUES

Cylinder liner protrusion 0.001 to 0.004 inch
(0.03 to 0.10 mm)

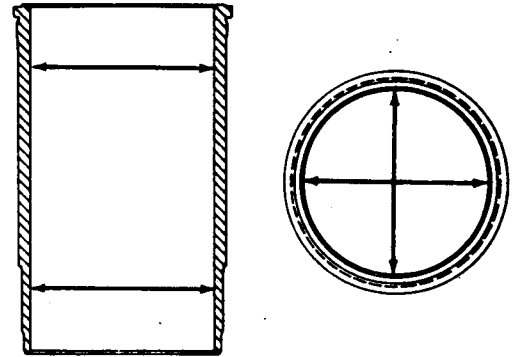


T53937N

Fig. 28-Cylinder Liner Protrusion

Cylinder liner taper (maximum) 0.002 inch
(0.05 mm)

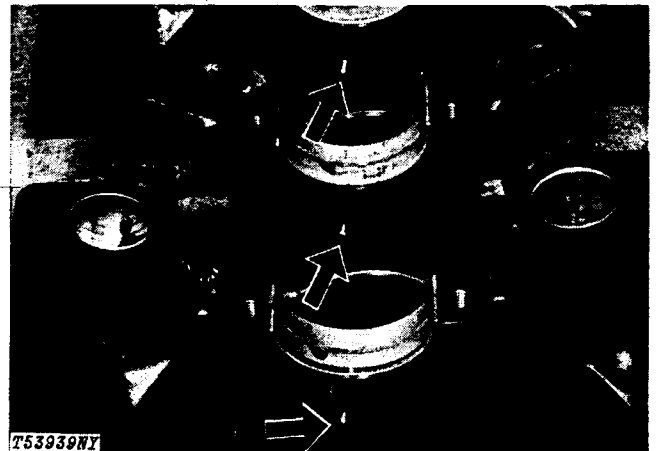
Cylinder liner out-of-round
(maximum) 0.002 inch
(0.05 mm)



T53938N

Fig. 29-Cylinder Liner Measurement

Piston cooling orifice torque 85 to 110 lb-in
(9.6 to 12.4 Nm) (0.98 to 1.27 kg-m)



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Fig. 30-Piston Cooling Orifice Torque

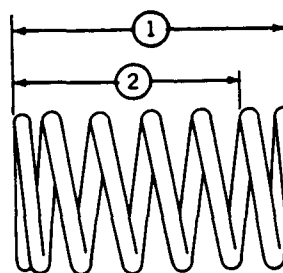
OILING SYSTEM (0407)

SPECIFICATIONS AND TORQUE VALUES—Continued

Oil pressure control spring
free length 4.68 inch
(118.9 mm)

Oil pressure control spring
length 1.68 inch
(42.7 mm)

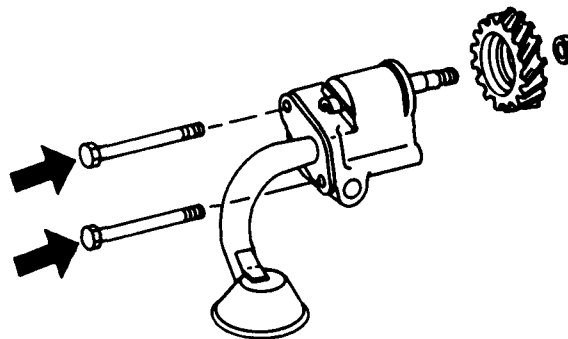
when compressed with 13.5 to 16.5 lb
(60 to 73 Nm) (6 to 7 kg)



T50940N

Fig. 31-Oil Pressure Control Spring Length

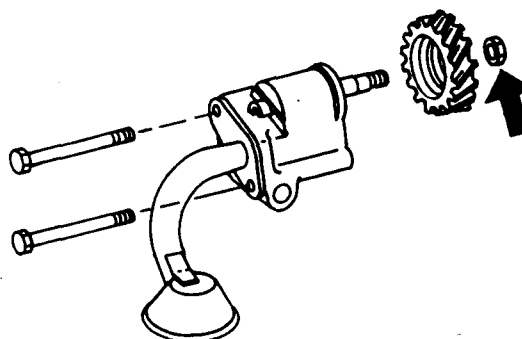
Oil pump attaching
cap screw torque 35 lb-ft
(47 Nm) (5 kg-m)



T53940N

Fig. 32-Oil Pump Attaching Cap Screw Torque

Oil pump drive gear nut
torque 35 to 45 lb-ft
(47 to 61 Nm) (5 to 6 kg-m)



T53941N

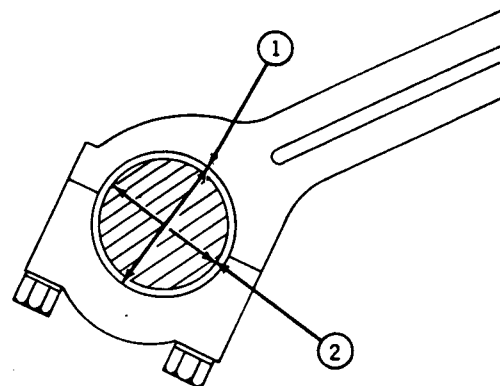
Fig. 33-Oil Pump Drive Gear Nut Torque

CONNECTING RODS AND PISTONS (0403)

SPECIFICATIONS AND TORQUE VALUES

Connecting Rod Journal and Bearing Diameter

Engine	Connecting Rod bearing assembled JD. (new) (1, Fig. 24)	Crankshaft rod journal O.D. (new) (2)
3-164	2.750 to 2.752 inch (69.85 to 69.90 mm)	2.748 to 2.749 inch (69.80 to 69.82 mm)
4-219	2.750 to 2.752 inch (69.85 to 69.90 mm)	2.748 to 2.749 inch (69.80 to 69.82 mm)
4-276	3.255 to 3.256 inch (82.68 to 82.70 mm)	3.063 to 3.064 inch (77.80 to 77.83 mm)
6-329	2.750 to 2.752 inch (69.85 to 69.90 mm)	2.748 to 2.749 inch (69.80 to 69.82 mm)
6-414	3.066 to 3.068 inch (77.88 to 77.93 mm)	3.063 to 3.064 inch (77.80 to 77.83 mm)

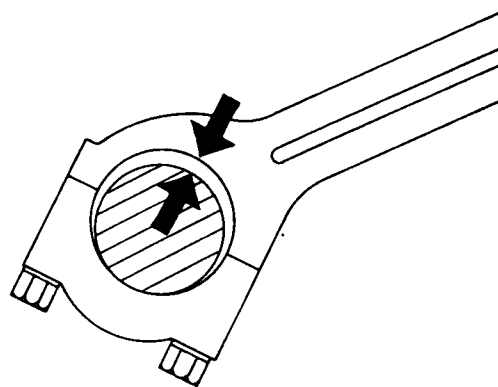


T53766H

Fig. 24-Connecting Rod Bearing Measurement

Connecting rod bearing to
crankshaft oil clearance (new) . . 0.001 to 0.005 inch
(0.03 to 0.13 mm)

Connecting rod bearing to
crankshaft oil clearance
(maximum) 0.006 inch
(0.17 mm)



T53469H

Fig. 25-Connecting Rod Oil Clearance