Group 05
CYLINDER HEAD, VALVES, AND CAMSHAFT

PRELIMINARY VALVE CHECKS

During disassembly, inspect the valve train for the following malfunctions and causes.

Sticking Valves

Carbon deposits on valve stem
Worn valve guides
Warped valve stems
Cocked or broken valve springs
Worn or distorted valve seats
Insufficient lubrication

Warped, Worn, or Distorted Valve Guides

Lack of lubrication
Cylinder head distortion
Excessive heat
Unevenly tightened cylinder head cap screws

Distorted Cylinder Head and Cylinder Head Gasket Leakage

Improperly tightened cylinder head cap screws
Faulty gasket installation
Incorrect gasket material
Excessive oil pressure
Improper cylinder liner height above cylinder block

Worn or Broken Valve Seats

Misaligned valves
Distorted cylinder head
Carbon deposits on seats due to incomplete combustion
Valve spring tension too weak
Excessive heat
Improper valve clearance
Improper valve timing

Burned, Pitted, Worn, or Broken Valves

Worn or distorted valve seats
Worn valve guides
Insufficient cooling
Insufficient lubrication
Cocked or broken valve springs
Preignition
Improper engine operation
Improper valve train timing
Faulty valve rotators
Warped or distorted valve stems
"Stretched" valves due to excessive spring tension
Warped cylinder head
Bent push rods
Carbon build-up on valve seats
Rocker arm failure

Camshaft Failures

Scored camshaft lobes due to inadequate lubrication
Excessive end play due to thrust plate wear
Broken or warped camshaft due to improper timing

Checking Valve Clearance

Four-Cylinder Engine

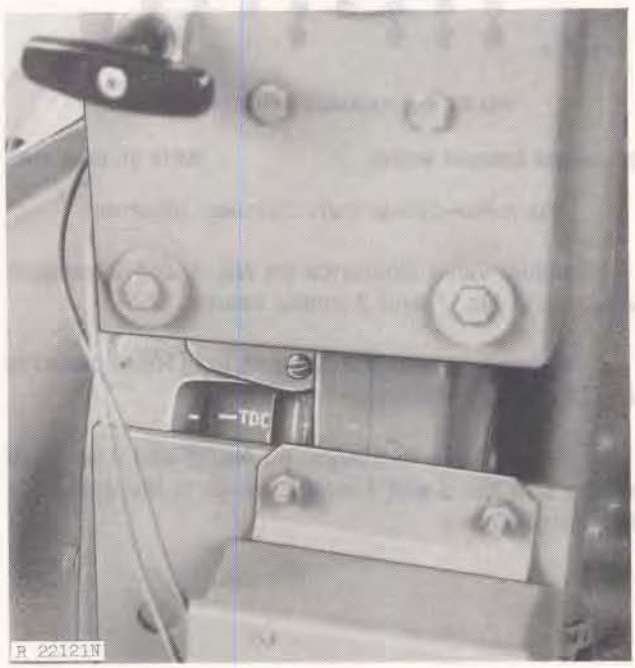


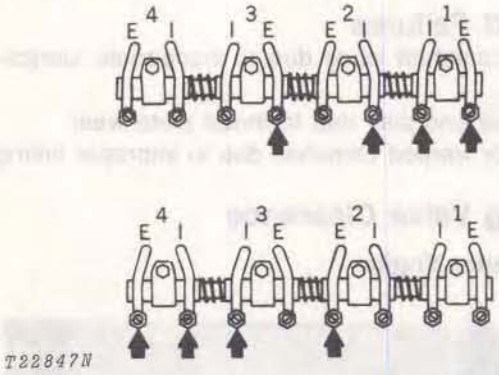
Fig. 1-Setting "TDC"

1. Rotate engine to position No. 1 piston at TDC of its compression stroke.

2. Turn flywheel until timing mark on flywheel lines up with mark on housing (Fig. 1).

Checking Valve Clearance—Continued

Four Cylinder Engine



VALVE CLEARANCE SPECIFICATION

Intake and Exhaust Valves	**0.018 in. (0.46 mm)**

Fig. 2-Four-Cylinder Valve Clearance Adjustment

3. Adjust valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves.

4. Rotate flywheel 360 degrees until No. 4 piston is at TDC of its compression stroke.

5. Adjust valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves to the specification listed above.

Six Cylinder Engine

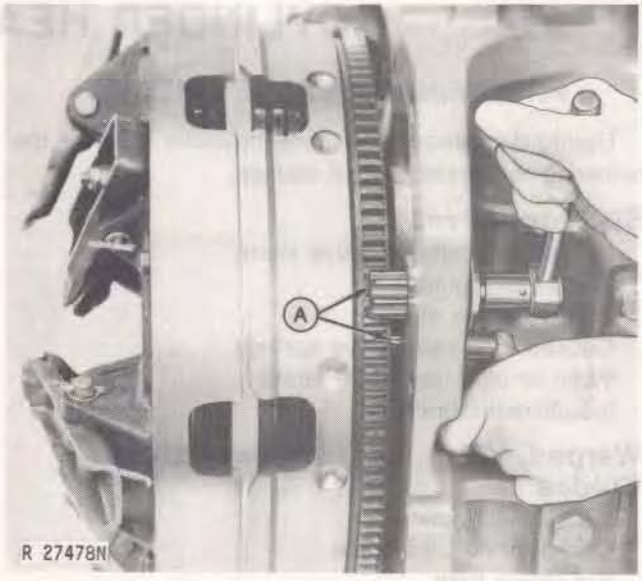
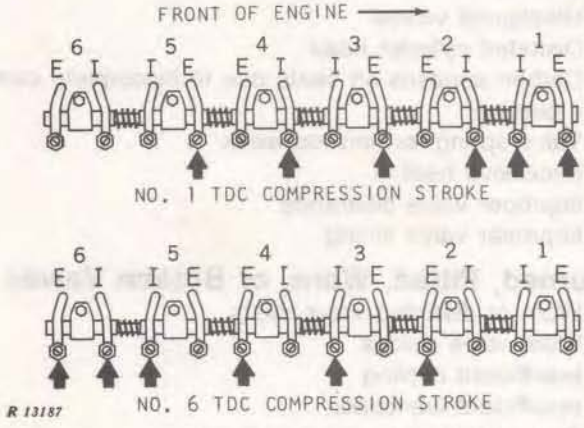


Fig. 3-Setting "TDC"

1. Use JDE-81 Engine Rotation Tool Set (A, Fig. 3) to position No. 1 piston at TDC of its compression stroke.
2. Turn flywheel until timing pin engages timing hole in flywheel and both valves on No. 1 cylinder are in the up position (rocker arms loose).



VALVE CLEARANCE SPECIFICATIONS

Intake Valves	**0.018 in. (0.46 mm)**
Exhaust Valves	**0.028 in. (0.71 mm)**

Fig. 4-Six-Cylinder Valve Clearance Adjustment

Fig. 5-Checking Valve Clearance

3. Adjust valve clearance on No. 1, 3, and 5 exhaust valves and No. 1, 2, and 4 intake valves (Fig. 5).

4. Rotate flywheel 360 degrees until No. 6 piston is at "TDC" of its compression stroke, and tool timing pin engages flywheel hole.

5. Adjust valve clearance on No. 2, 4, and 6 exhaust valves and No. 3, 5, and 6 intake valves to the specifications listed above.

Checking Valve Lift

Measuring valve lift can give an indication of wear to cam lobes, cam followers, and push rods.

1. Set valve clearance to specifications as previously indicated.

Fig. 6-Checking Valve Lift (6-Cylinder shown)

2. Place dial indicator on rotator (Fig. 6).

3. Manually turn engine in running direction (counterclockwise).

4. After rocker arm contacts valve stem, observe dial indicator reading as valve is moved to full open.

VALVE LIFT NEW PART SPECIFICATIONS

4270	
Intake Valves	0.431 to 0.461 in. (10.95 to 11.71 mm)
Exhaust Valves	0.427 to 0.457 in. (10.85 to 11.61 mm)
6404D and 6466D	
Intake Valves	0.424 to 0.454 in. (10.77 to 11.53 mm)
Exhaust Valves	0.414 to 0.444 in. (10.52 to 11.28 mm)
6404T and A; 6466T and A	
Intake Valves	0.412 to 0.442 in. (10.46 to 11.23 mm)
Exhaust Valves	0.413 to 0.443 in. (10.49 to 11.25 mm)

CYLINDER HEAD AND VALVES

Access

1. Disconnect battery ground cables and drain cooling system (not shown).

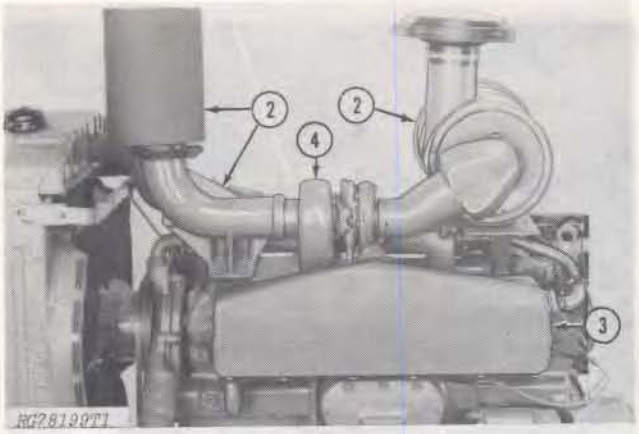


Fig. 7-Left Side Removal Steps (6466A Engine Shown)

2. Remove air cleaner, muffler and exhaust elbow.

3. Remove intercooler ("A" engines) with intake manifold.

4. Remove turbocharger ("T" and "A" engines) with exhaust manifold.

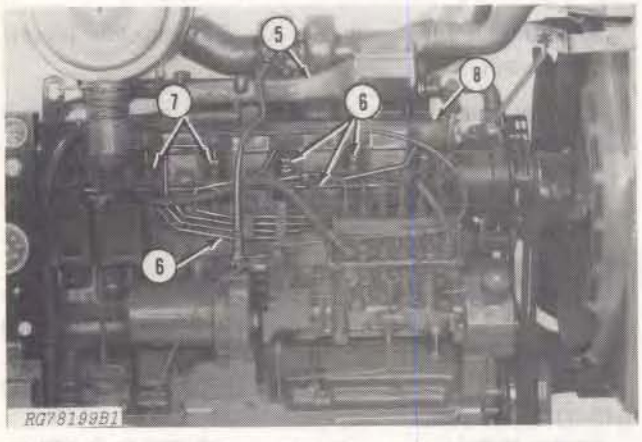


Fig. 8-Right Side Removal Steps (6466A Engine Shown)

5. Remove water manifold.

6. Remove fuel lines and leak-off line. Plug openings to prevent contamination.

7. Remove fuel injection nozzles.

8. Remove rocker arm cover.

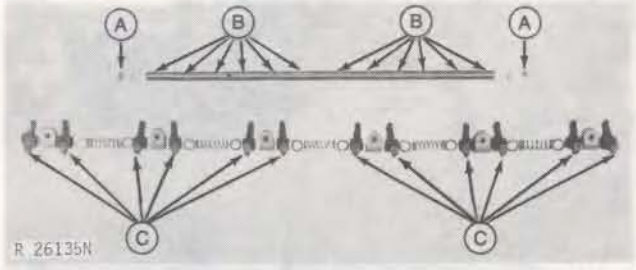
ROCKER ARM ASSEMBLY

Removal

NOTE: 6466T (072864-) and A (068223-) engines use a one-piece rocker arm shaft clamp in place of the Nos. 1 and 2 and 5 and 6 clamps.

1. Remove rocker arm shaft clamp cap screws.

NOTE: When removing rocker arm shaft components, identify for reassembly into original position.



A—End Plugs
B—Oil Holes
C—Adjusting Screws

Fig. 9-Rocker Arm Shaft Components (6-Cylinder Shown)

2. Remove rocker arm shaft end plugs and slide components from shaft (Fig. 9).

Inspection and Repair

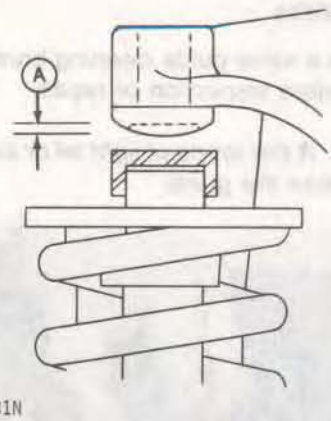
1. Inspect rocker arm shaft for scratches, scores, or excessive wear at points of rocker arm contact.

NOTE: Wear could indicate weak valve springs, bent push rods, or loose rocker arm shaft clamps.

2. Be sure that all oil holes are open and clean (B, Fig. 9).

3. Check rocker arm adjusting nut and screw for damage (C, Fig. 9).

4. Check for cups or concave wear on ends of rocker arms where they contact valve tips (A, Fig. 10).



A—Worn Area

Fig. 10-Rocker Arm Wear

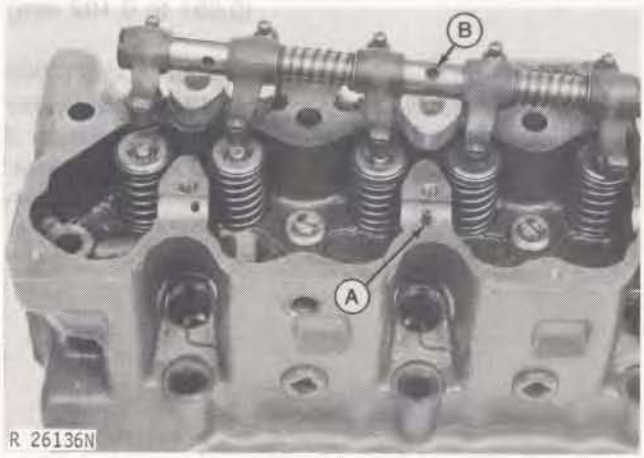
5. Examine spacer springs on shaft between rocker arms, and be sure they are strong enough to exert a positive pressure on arms.

NOTE: If the rocker arm has been damaged by a valve failure, replace it and the push rod when replacing valves.

Assembly and Installation

1. Assemble parts on rocker arm shaft in reverse of sequence removed.

2. Make sure rocker arm shaft end plugs are firmly seated in end of shaft.



A—Spring Pin **B—Locating Hole**

Fig. 11-Rocker Arm Shaft Locating Holes

3. Position rocker arm shaft on head, insuring that spring pin (A, Fig. 11) and locating hole (B) in rocker arm shaft line up.

4. Tighten rocker arm shaft clamp cap screws to 55 ft-lbs (75 Nm) (7.5 kgm).

VALVES, VALVE SPRINGS, VALVE ROTATORS, AND WEAR CAPS

Removal

1. Remove rocker arm assembly as previously described.

2. Remove head.

NOTE: When removing valves, valve springs, and valve rotators, identify for reassembly into original positions.

3. Use a valve spring compressor to remove valves from head.

Inspection And Repair

Valve Springs

1. Inspect valve springs for alignment, wear, and damage.

2. Place springs on a flat surface to see that they are square and parallel.

3. Check valve spring tension on a spring tester.

VALVE SPRING NEW PART SPECIFICATIONS

Compression	Height
54 to 62 lbs.	1.81 in.
(240.2 to 275.8 N)	(45.9 mm)
133 to 153 lbs.	1.36 in.
(591.6 to 680.5 N)	(34.5 mm)

Valves, Rotators and Wear Caps

1. Insure that valve rotators will turn freely in one direction. If defective, replace with new.

2. Replace valve wear caps if pitted or worn.

3. Visually check valve face and stem for wear or damage.

4. Perform the following cleaning procedure before measuring or repairing valves.

Cleaning Valves

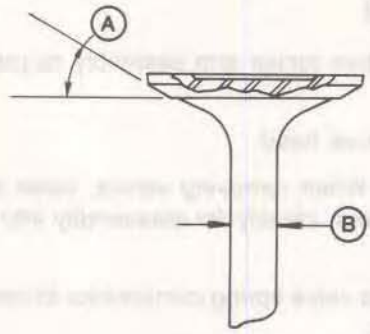
1. Hold each valve firmly against a wire wheel on a bench grinder.

2. Make sure all carbon is removed from the valve head, face and stem.

IMPORTANT: Any carbon left on the stem will affect alignment in valve refacer if valves need to be refaced.

3. Polish the valve stems with steel wool or fine emery cloth to remove any scratch marks left by the wire brush.

Inspection and Repair—Continued



A—44-1/2° (4270D, 6404D)
29-1/2° (6404T, A and 6466)

B—0.3715 to 0.3725 in. (9.43 to 9.46 mm)

Fig. 12-Valve Specifications

4. Compare valve stem O.D. (B, Fig. 12) with valve guide I.D. to determine stem-to-guide clearance.

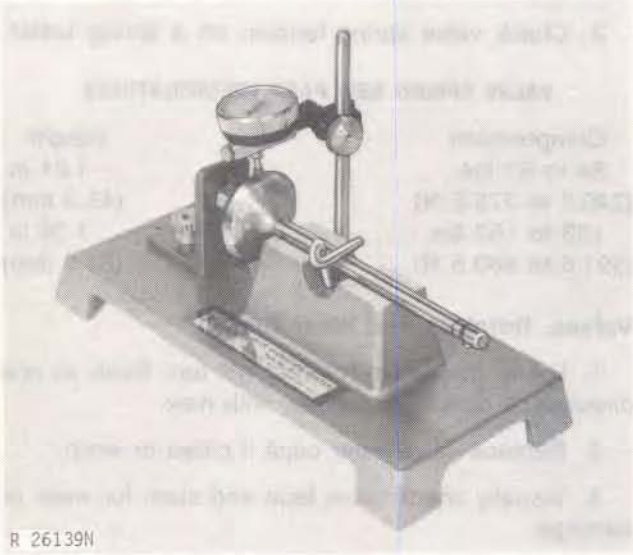


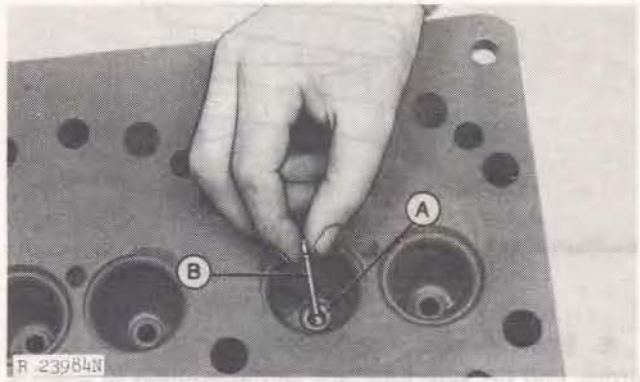
Fig. 13-Inspecting Valves

5. Use D-05058ST Valve Inspection Center (Fig. 13) to determine if valves are out of round, bent or warped.

Valve Guides

1. Use a valve guide cleaning brush to clean valve guides before inspection or repair.

NOTE: A few drops of light oil or kerosene will help to fully clean the guide.



A—Valve Guide **B—Telescope Gauge**

Fig. 14-Checking Valve Guide

2. Measure valve guides for wear (Fig. 14).

VALVE GUIDE NEW PART SPECIFICATIONS

I.D. of guide in a new head	0.3745 to 0.3755 in. (9.512 to 9.537 mm)
New guide-to-valve stem clearance	0.0020 to 0.0040 in. (0.051 to 0.102 mm)

NOTE: Worn guides can allow a clearance of 0.006 in. (0.15 mm) and still be acceptable. Worn guides may be knurled to return them to specified clearance if valve-to-guide clearance is 0.010 in. (0.25 mm) or less. If clearance exceeds 0.010 in. (0.25 mm), install oversize valves.

A—Knurler
B—Reamer
C—Speed Reducer
D—Lubricant

Fig. 15-Knurling Valve Guides

3. Use No. D-20002WI Knurling Tool Set to knurl valve guides (Fig. 15).

NOTE: Use tool set exactly as directed by the manufacturer.

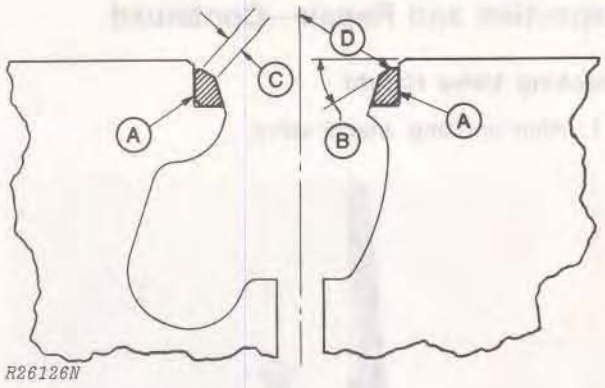
Valve Seats

Fig. 16-Cleaning Valve Seats

1. Use an electric hand drill with wire cleaning brush (Fig. 16) and remove all carbon.

2. Check seats for cracks, pits, or excessive wear.

3. Recondition valve seat by grinding.



A—Valve Seat Insert
B—Valve Seat Angle (4270D, 6404D) ..... 45°
(6404T, A and 6466) ..... 30°
C—Valve Seat Width ..... 0.083 to 0.093 in. (2.11 to 2.36 mm)
D—Valve Seat Runout (Maximum) ..... 0.002 in. (0.05 mm)

Fig. 17-Valve Seat Specifications

Grinding Valve Seats

Fig. 18-Grinding Valve Seats

1. Do not grind too long. Only a few seconds are required to recondition the average valve seat. Avoid the natural tendency to grind off too much.

2. Do not use too much pressure. While grinding, support the weight of the driver to avoid excess pressure on the stone.

3. Keep the work area clean.

4. Check the seat width and contact pattern between the seat and valve with blueing.

Inspection and Repair—Continued

Checking Valve Height

1. After grinding, install valve.

Fig. 19-Checking Valve Height

2. Use a dial indicator to check valve height (Fig. 19).

Valve Height Specification
(In relation to cylinder head surface)

4270D, 6404D, 6466D
Intake Valve ..... 0.038 to 0.050 in. below (0.96 to 1.27 mm below)
Exhaust Valve ..... 0.054 to 0.068 in. below (1.37 to 1.72 mm below)

6404T and A,
6466T and A . 0.038 in. above to 0.006 in. below (0.96 mm above to 0.15 below)

NOTE: If valve face protrudes, check valve face angle and valve seat angle. If valve is recessed, install either new valves, valve seats, or both, to obtain proper valve height.

Replacing Valve Seat Inserts

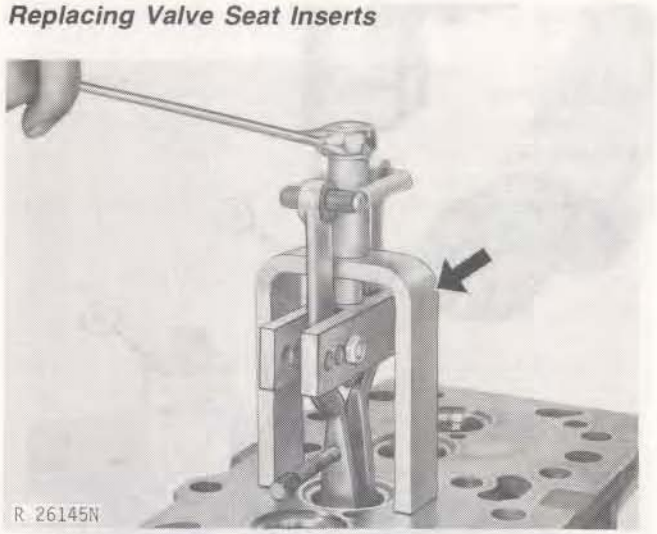
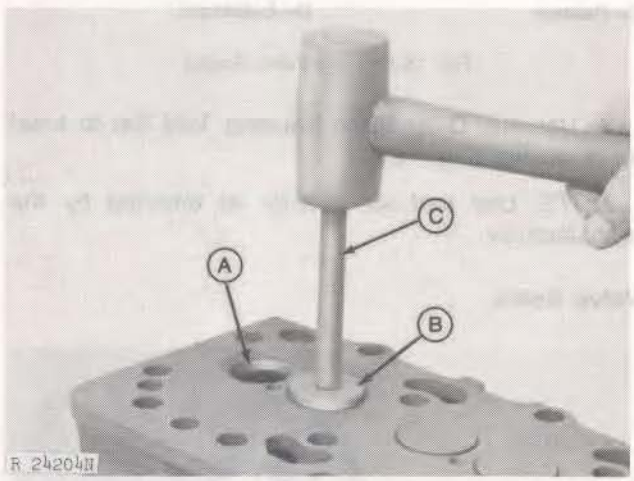


Fig. 20-Removing Valve Seats

1. Remove valve seats with JDE-41296 Valve Seat Puller (Fig. 20).



A—Insert **C—JDE-7 Driver**
B—Replacement Ring

Fig. 21-Installing Valve Seat Inserts

2. Select the proper Replacement Ring from the following table:

Valve Seat	Ring
4270D, 6404D and T, 6466D	
Intake	JDE-67
Exhaust	JDE-66
6404A, 6466T and A	JDE-79

3. Chill both new insert (A, Fig. 21) and Ring (B) to −20°F (−29°C) in dry ice.

4. Use JDE-7 Driver (C) and proper Ring to drive inserts into place.

5. Grind valve seats.

Installing Oversize Inserts

In some cases, the outside diameter of the valve seat bore may become damaged and require machining. In this case, oversize inserts are available in 0.010 in. (0.25 mm) oversize only.

1. Remove valve seats with JDE-41296 Valve Seat Puller.

2. Machine seat diameter to 1.7585 to 1.7595 in. (44.67 to 44.69 mm).

3. Replace inserts as previously indicated.

Cylinder Head

1. Thoroughly clean the cylinder head.

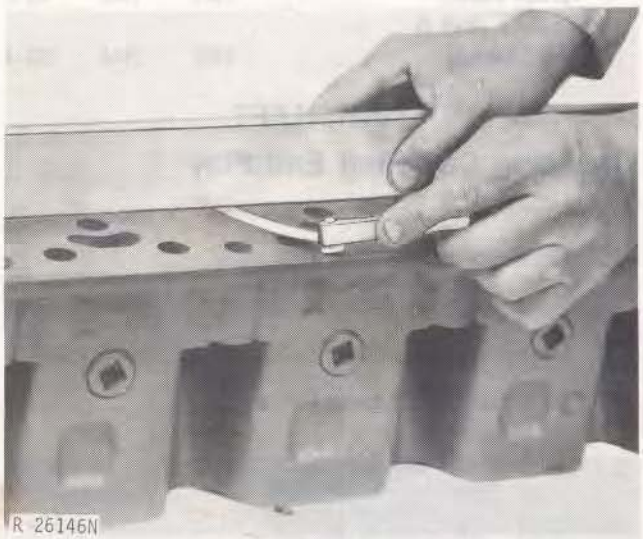


Fig. 22-Checking Cylinder Head

2. Use a straight edge to check the head for level (Fig. 22).

3. Warpage should not exceed 0.001 in. (0.02 mm) for every 5 in. (127 mm) of head length.

Assembly

1. Apply AR44402 Lubricant to valve stems and guides.

NOTE: New exhaust and intake valves are color coded green and yellow respectively on 6404T and A. Valves are coded black and red respectively on 6404D and 4270D.

2. Install valves in guides from which they were removed.

NOTE: Valves must move freely and seat properly.

3. Install valve springs making certain that cylinder head end of spring is located correctly in machined counter bore of the head.

4. Install rotators.

5. Compress valve springs with valve spring compressor.

6. Install retainer locks on valves.

7. Strike the end of each valve three or four times with a soft mallet to insure proper positioning of the retainer locks.

Installation

NOTE: See page 20-10-10 before installing cylinder head gasket on 6404D and 6466D engines.

1. Install cylinder head gasket dry.

2. Place cylinder head in correct position on block.

3. Dip cap screws and washers in clean engine oil.

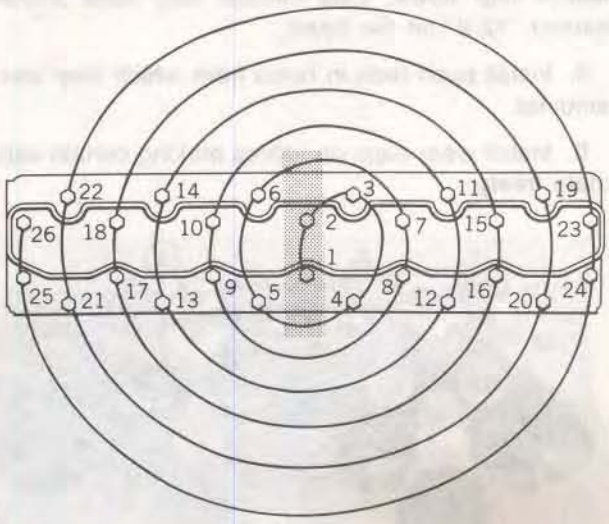


Fig. 23-Cylinder Head Cap Screw Tightening Sequence (Start at No. 1)

Installation—Continued

4. Install cap screws and tighten to the following specifications using the sequence shown in Fig. 23.

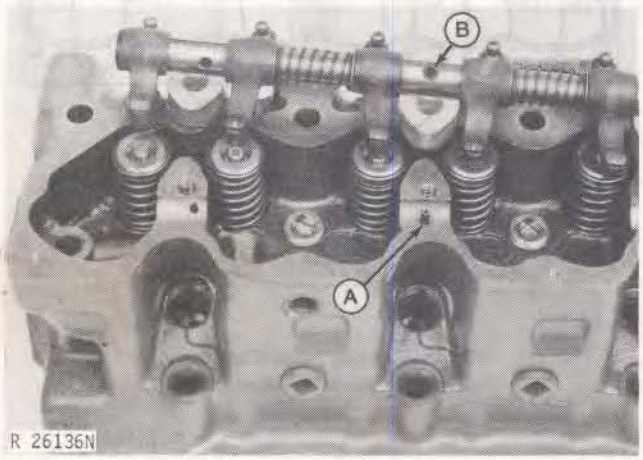
CYLINDER HEAD CAP SCREW TORQUES

	ft-lbs	Nm	kgm
Initial			
4270D	115	156	15.6
6404D	105	142	14.2
6404T and A	80	108	10.8
6466D, T and A	105	142	14.2
Second			
4270D	130	180	18.0
6404D	130	180	18.0
6404T and A	115	156	15.6
6466D, T and A (plain head)	115	156	15.6
6466D, T, and A ("12.9" head)	130	180	18.0

NOTE: Early model 6466 engines may have a plain headed cap screw. Late models may have screws marked "12.9" on the head.

5. Install push rods in holes from which they were removed.

6. Install wear caps on valves making certain caps rotate freely.



A—Spring Pin **B—Locating Hole**

Fig. 24-Rocker Arm Shaft Locating Hole

7. Position rocker arm shaft on head, insuring that spring pin (A, Fig. 24) and locating hole (B) in rocker arm shaft line up.

8. Tighten rocker arm shaft clamp cap screws to 55 ft-lbs (75 Nm) (7.5 kgm).

9. Reverse access steps.

10. Run engine at 2100 RPM for 1/2 hour.

11. Retighten cylinder head cap screws to the following specifications using the sequence shown in Fig. 23.

CYLINDER HEAD CAP SCREW TORQUES

	ft-lbs	Nm	kgm
Final			
4270D and 6404D	150	204	20.4
6404T and A	130	180	18.0
6466D, T and A (plain head)	130	180	18.0
6466D, T and A ("12.9" head)	150	204	20.4

CAMSHAFT

Checking Camshaft End Play

1. Remove rocker arm cover.
2. Remove rocker arm assembly.
3. Remove push rods. Identify for reassembly.
4. Remove damper and pulley (6 cylinder engines).
5. Remove timing gear cover.

Fig. 25-Checking Camshaft End Play

1. Place a dial indicator on camshaft (Fig. 25).

2. Check camshaft end play.

CAMSHAFT END PLAY SPECIFICATIONS

New engine end play	0.0025 to 0.0085 in. (0.06 to 0.22 mm)
Allowable end play	0.0150 in. (0.38 mm)

NOTE: If end play exceeds wear specification check thrust washer thickness during disassembly.

Removal

Fig. 26-Installing Magnetic Holding Tool Set

1. Remove oil pan and oil pump.

2. Use D-15001NU Magnetic Holding Tool Set to hold cam followers away from camshaft (Fig. 26).

3. Remove four cap screws from thrust plate.

4. Carefully remove camshaft from cylinder block so that camshaft lobes do not drag in bores.

Inspection and Repair

Camshaft Gear

1. Inspect camshaft drive gear for worn or broken teeth and replace as necessary.

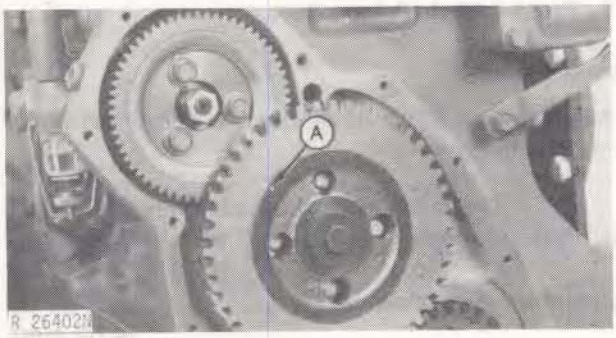


Fig. 27-6-Cylinder Camshaft Drive Gear

2. On 6-cylinder engines, inspect camshaft drive gear for slippage between the two parts of the gear.

NOTE: An indexing mark has been placed across the parting line of the two parts of the gear (A, Fig. 27). If the mark has separated, the gear should be replaced.

3. Examine crankshaft gear and injection pump drive gear for worn or broken teeth or damage.

NOTE: If either gear has failed, both gears must be replaced as a matched set.

Removing Camshaft Gear

1. Remove cap screw and special washer.

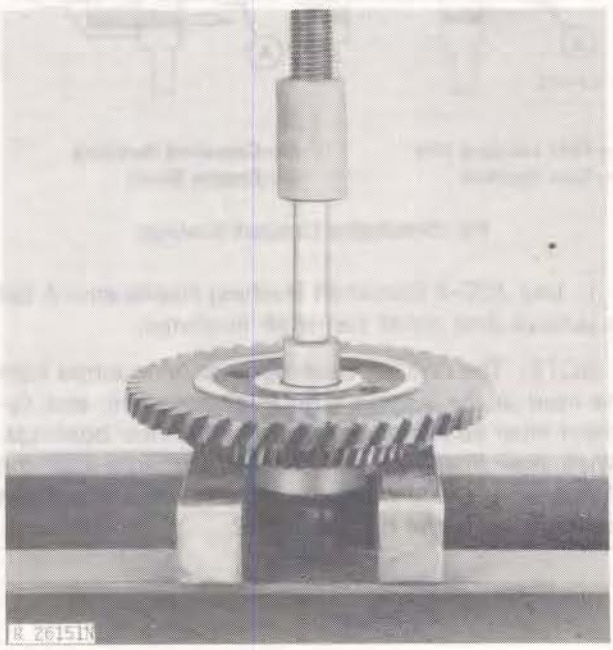


Fig. 28-Removing Camshaft Gear

Inspection and Repair—Continued

2. Support camshaft gear in a press (Fig. 28).

IMPORTANT: Prevent camshaft from striking floor when pressing camshaft from gear.

3. Press camshaft from gear.

Thrust Plate

After removal of camshaft gear, check thrust plate for proper thickness.

THRUST PLATE SPECIFICATIONS

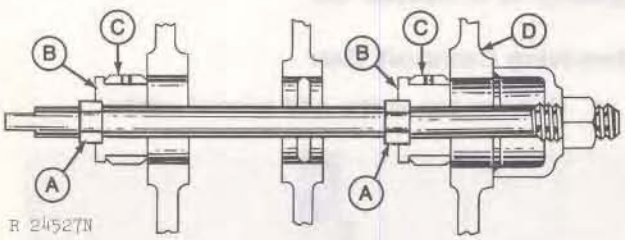
New Part Thickness	0.1860 to 0.1890 in. (4.72 to 4.80 mm)
Acceptable wear thickness	0.1820 in. (4.62 mm)

Bushings and Journals

Check camshaft bushings and journals for wear or damage.

BUSHING AND JOURNAL SPECIFICATIONS

New Journal O.D.	2.3745 to 2.3755 in. (60.31 to 60.34 mm)
New Bushing I.D.	2.3775 to 2.3795 (60.39 to 60.44 mm)
Clearance Allowable	0.0060 in. (0.15 mm)



A—Tool Locking Key
B—Tool Mandrel
C—Camshaft Bushing
D—Engine Block

Fig. 29-Installing Camshaft Bushings

1. Use JDE-6 Camshaft Bushing Replacement Set to remove and install camshaft bushings.

NOTE: The first two bushings can be reached from the front of the engine. The PTO assembly and flywheel must be removed to service the rear bushings. When new bushings are installed, be sure that the elongated oil holes are to the top and are aligned with the oil holes in the cylinder block.

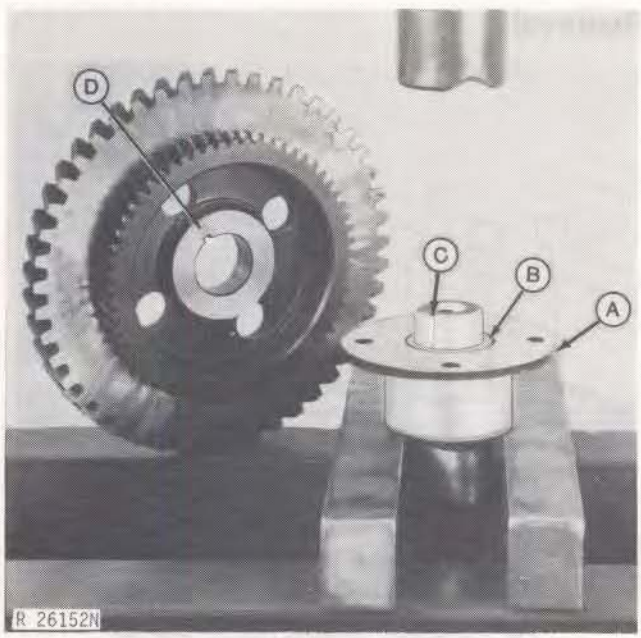
Lobes

1. Check camshaft lobes for wear or damage.

2. Check camshaft oil pump drive gear for wear or damage.

NOTE: If camshaft is replaced due to a damaged oil pump drive gear, check gear and shaft on oil pump for damage and replace if necessary. If camshaft is replaced, cam followers must also be replaced.

Assembly



A—Thrust Plate
B—Spacer
C—Woodruff Key
D—Keyway

Fig. 30-Supporting Camshaft in Press

1. Support camshaft under first journal in a hydraulic press. (Fig. 30).

2. Install thrust plate (A) and spacer (B).

3. Install Woodruff key (C).

4. Align Woodruff key (C) and keyway (D) and place gear on camshaft with timing mark facing away from camshaft.

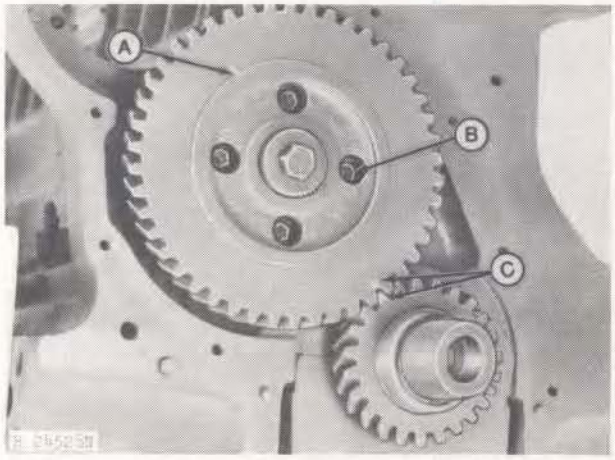
5. Press gear on until tight against camshaft shoulder.

Installation

If cam followers have been removed, reinstall using the D-15001NU (ND425) Magnetic Holding Tool Set to hold cam followers away from camshaft bore until camshaft is installed.

1. Coat camshaft with JDT405 High Temperature Grease, or equivalent.

2. Carefully install camshaft in cylinder block so that camshaft lobes do not drag in bores.



A—Location Mark **C—Timing Mark**
B—Thrust Plate Cap Screw

Fig. 31-Gear Timing

3. With No. 1 piston on TDC of its compression stroke, align timing marks (C, Fig. 31) on camshaft and crankshaft gears.

4. Turn camshaft gear to align thrust plate holes with cylinder block holes.

5. Tighten thrust plate-to-block cap screws to 20 ft-lbs (27 Nm) (2.7 kgm).

6. Install special washer on camshaft.

7. Tighten camshaft gear-to-camshaft cap screw to 85 ft-lbs (115 Nm) (11.5 kgm).

8. Check camshaft for 0.0025 to 0.0085 in. (0.06 to 0.22 mm) end play.