SPECIFICATIONS

7.2.1 Special Torque Values

Valve Cover/Intake Manifold Capscrews ..... 13 lb·ft or 156 lb·in. (18 N·m)
Cylinder Head Bolts + ... 165 lb·ft (224 N·m)
Valve Adjusting Screw Nut ..... 20 lb·ft (27 N·m)

Tighten cylinder head bolts following the assembly steps listed:

1. Lubricate bolt threads, bolt head seating areas and washers with clean engine oil.
2. Tighten bolts in three (4) stages as shown in **FIGURE 7–2**

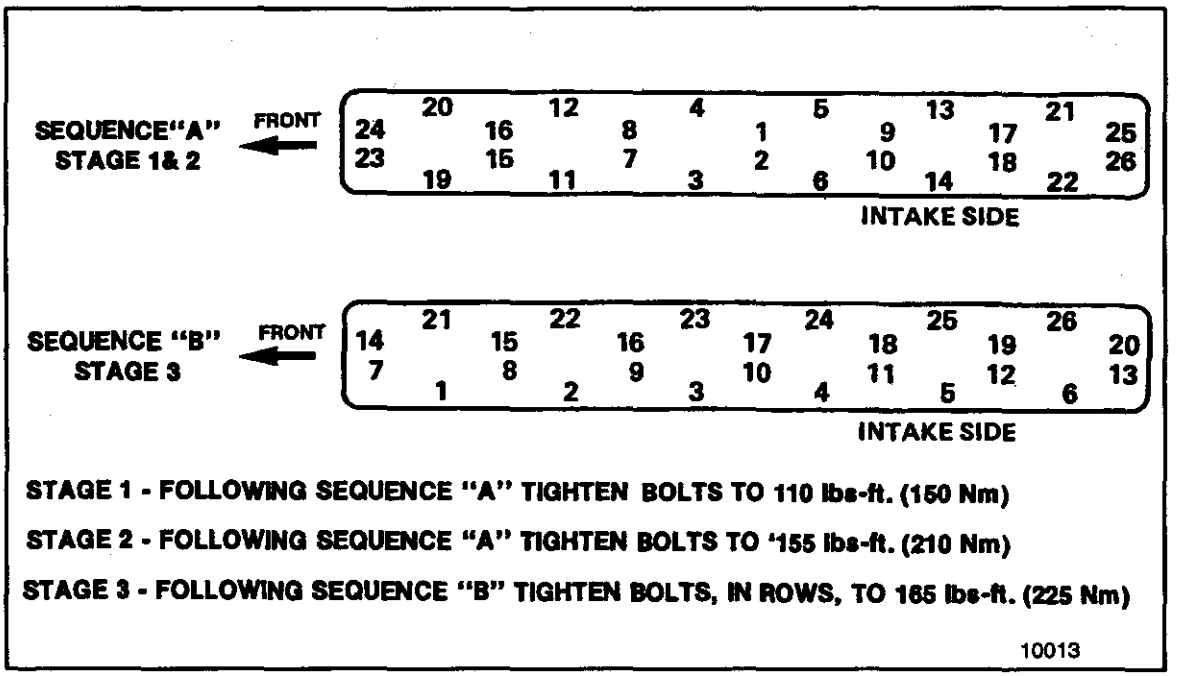


FIGURE 7–2 Sequence for Tightening Cylinder Head Bolts

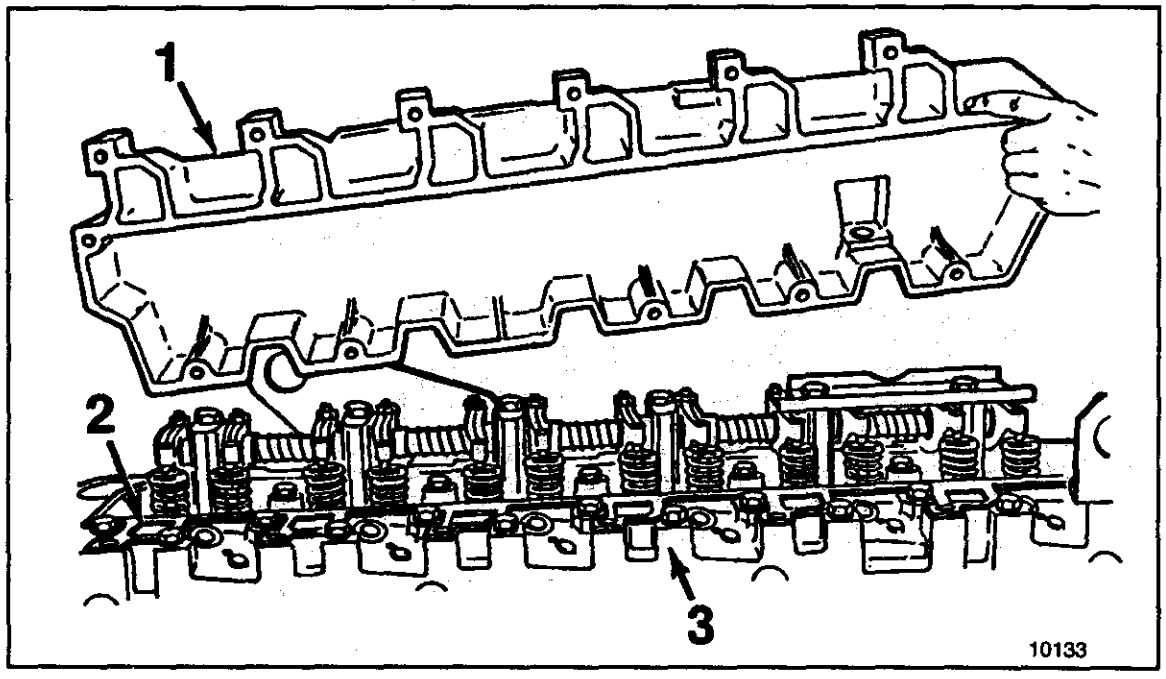
SPECIFICATIONS

7.2.2 Special Service Tools And Materials

Tool No.	Description
J39261	Nozzle liner Installer
J39262	Nozzle liner Remover
PT6390–45	Universal Valve Seat Extractor
PT63912	Universal Valve Seat Extractor
J39292	Valve Guide Installer
J41164	Valve Guide Removal Tool
PT6390–45	Valve Seat Extractor Collet
J39535	Valve Seat Installer
J–22738–02	Valve and Clutch Spring Tester

7.3 CYLINDER HEAD REMOVAL

1. Remove thirteen (13) valve cover/intake manifold mounting cap screws.
2. Remove valve cover/intake manifold from cylinder head (**FIGURE 7–3**).

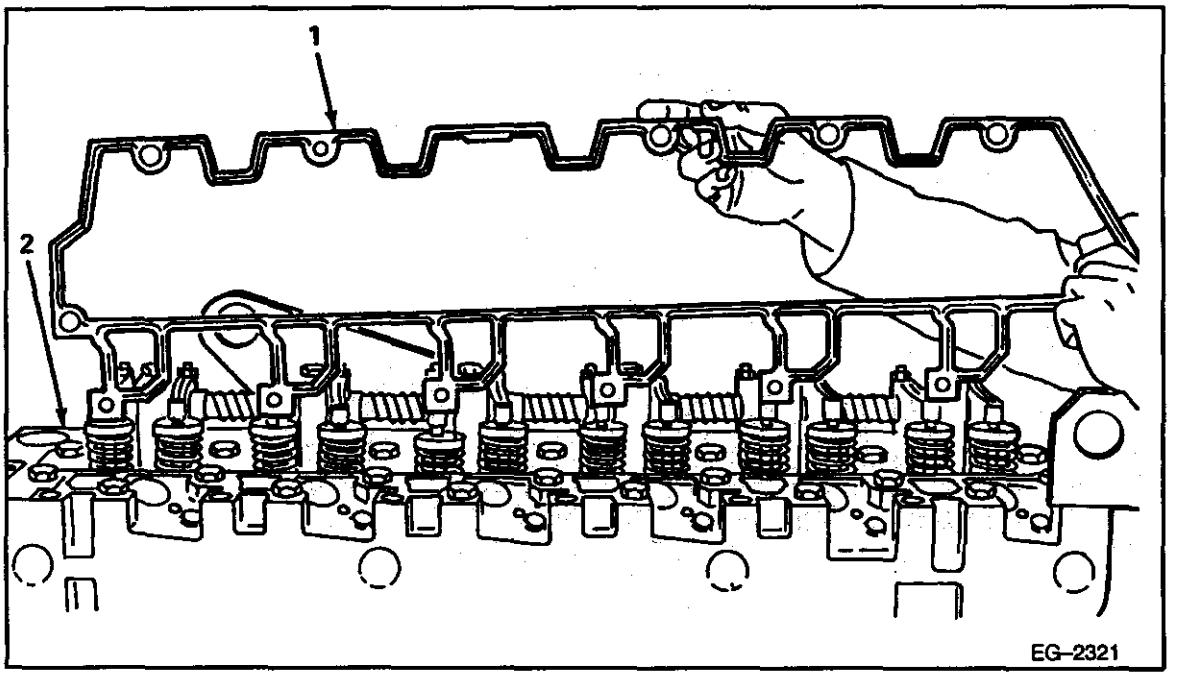


1. **Valve Cover/Intake Manifold**
2. **Cylinder Head**

FIGURE 7–3

CYLINDER HEAD REMOVAL

3. Remove valve cover/intake manifold gasket from cylinder head (**FIGURE 7–4**).

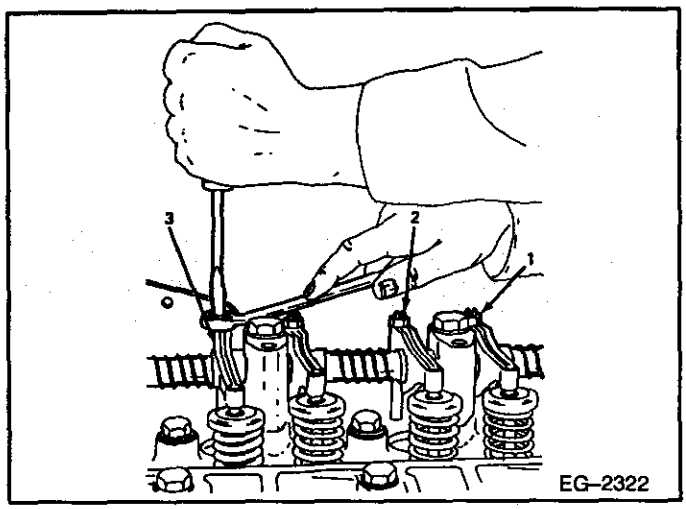


1. Gasket **2. Cylinder Head**

FIGURE 7–4

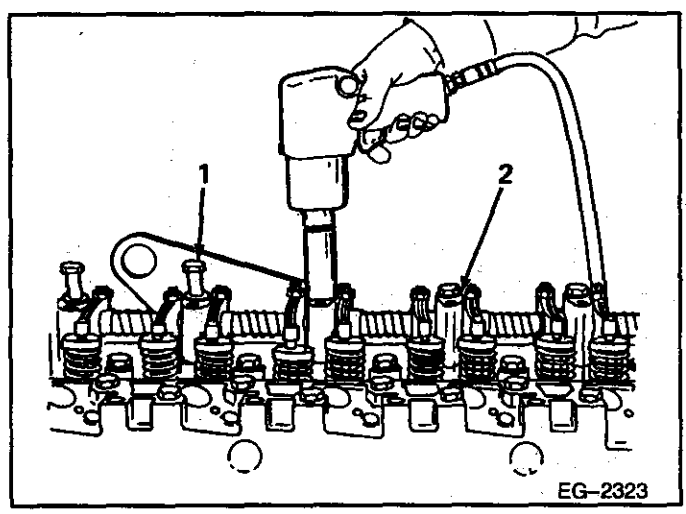
CYLINDER HEAD REMOVAL

7.3.1 Valve Removal



1. Adjusting Screw Nut
2. Adjusting Screw
3. Valve Lever

FIGURE 7–5



1. Bracket Bolt
2. Bracket

FIGURE 7–6

1. Loosen twelve (12) valve lever adjusting screw nuts (**FIGURE 7–5**).
2. Loosen twelve (12) adjusting screws (**FIGURE 7–5**) one (1) full turn.

NOTE:

Loosening valve lever adjusting screws one (1) full turn will avoid possible valve train damage during installation procedure.

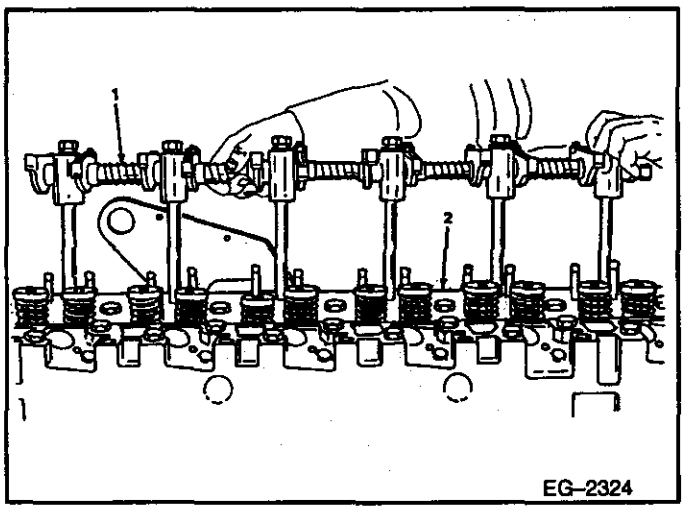
3. Remove six (6) (long bolts) valve lever bracket/stand bolts (**1, FIGURE 7–6**).

NOTE:

Loosen valve lever bracket/stand bolts alternately to reduce chance of lever shaft binding.

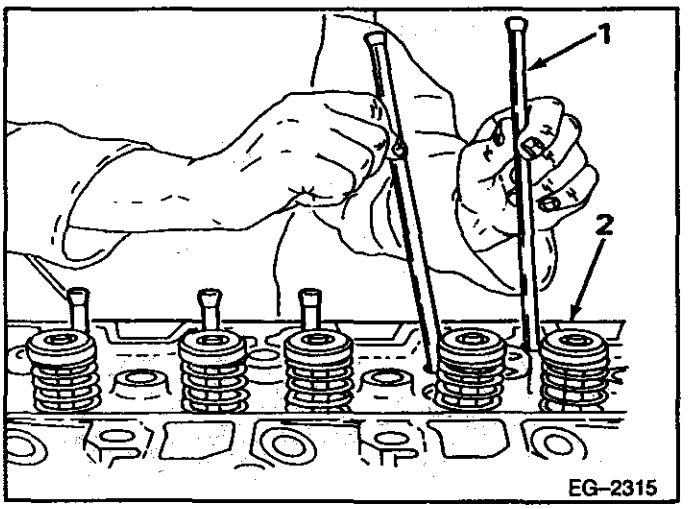
CYLINDER HEAD REMOVAL

4. Remove valve lever assembly (**1, FIGURE 7–7**) from cylinder head (**2, FIGURE 7–7**).
   a. Remove two bolts and washers holding baffle plate onto valve lever bracket. Spacer washers are loose under baffle.
5. Remove all push rods (**1, FIGURE 7–8**) from cylinder head (**2, FIGURE 7–8**).



1. **Valve Lever Shaft**
2. **Cylinder Head Assembly**

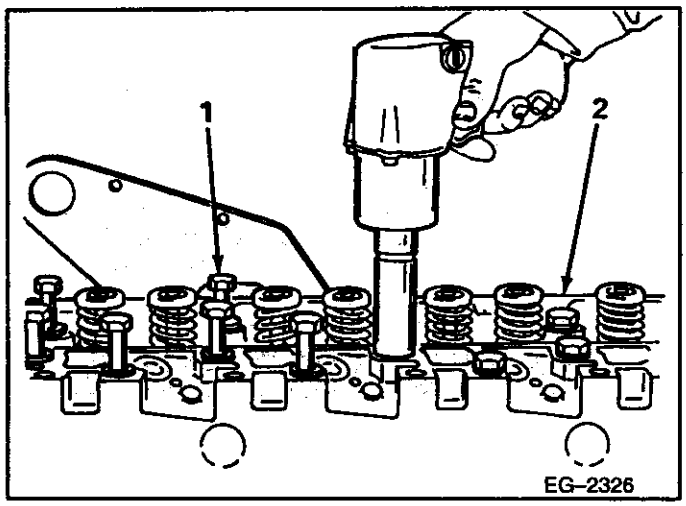
FIGURE 7–7



1. **Push Rod (12)**
2. **Cylinder Head**

FIGURE 7–8

CYLINDER HEAD REMOVAL



1. Cylinder Head Bolts
2. Cylinder Head

FIGURE 7–9

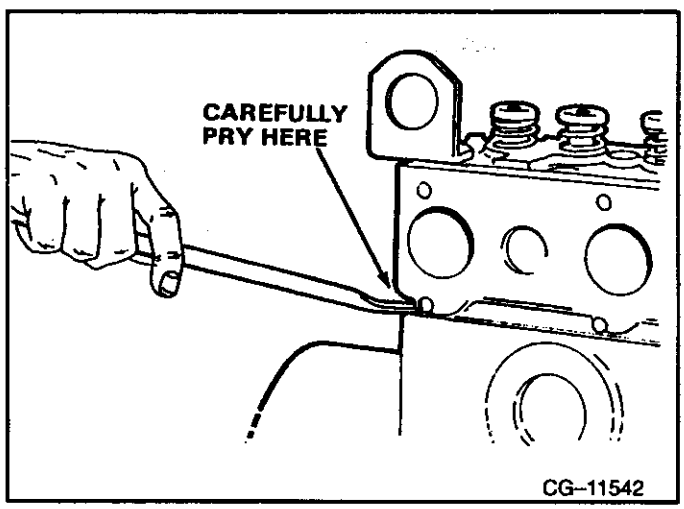


FIGURE 7–10

6. Remove remaining twenty (20) cylinder head bolts (short bolts) (**FIGURE 7–9**).

7.3.2 Cylinder Head Removal

1. Using a small pry bar, carefully pry the cylinder head loose from the gasket, so the cylinder head will lift off easily (**FIGURE 7–10**).

NOTE:

Only light force should be required on the pry bar to break the cylinder head loose from the gasket.

CYLINDER HEAD REMOVAL

2. Lift the cylinder head from the crankcase using appropriate lifting equipment (**FIGURE 7–11**).
3. Remove cylinder head gasket from block (**FIGURE 7–11**).

NOTE:

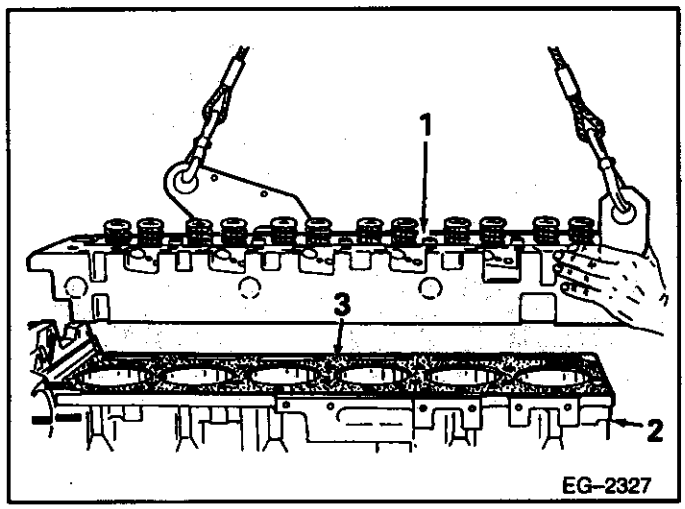
Place the cylinder head on wood blocks to protect the valves and bottom deck surface.

7.3.3 Cleaning

1. With the valves installed to protect the seats, remove deposits and gasket material from the gasket surface of the cylinder head using a rotary wire brush or sanding block with mineral spirits. **Be sure injection nozzles are removed before wire brushing to prevent injection nozzle damage. Refer to Section 15.**
2. Clean all bolt holes with appropriate size tap. Clear debris from bolt holes, oil return and water passages, using filtered compressed air.
3. Clean the cylinder head bolt threads.
4. Wash all bolts and washers with a suitable solvent and dry thoroughly.

NOTE:

Dirt in threads or damaged threads may cause binding and result in a false torque reading.



1. **Cylinder Head**
2. **Cylinder Block**
3. **Cylinder Head Gasket**

FIGURE 7–11

7.4 CYLINDER HEAD INSPECTION

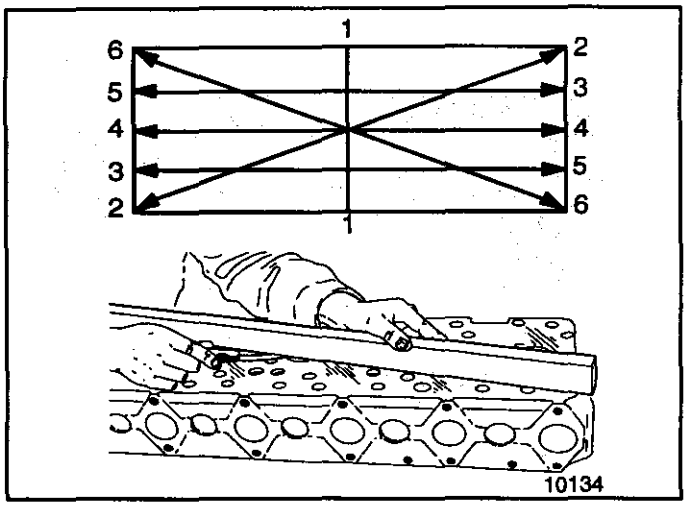


FIGURE 7–12

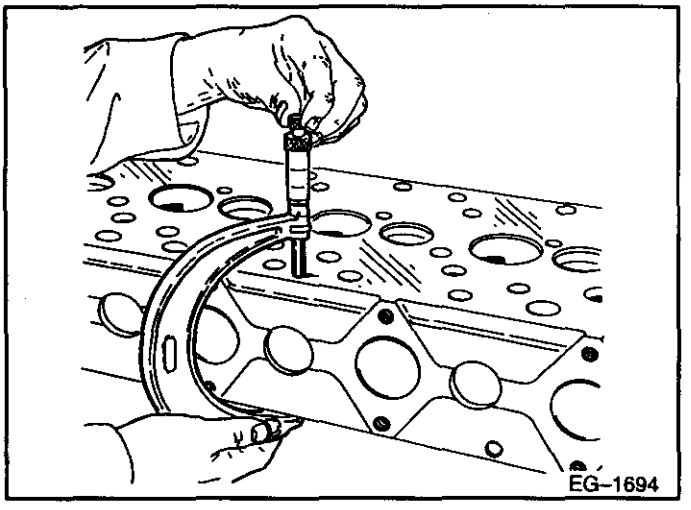


FIGURE 7–13

NOTE:

Cylinder head condition must be evaluated by inspecting for warpage, thickness, cracks and/or valve leakage.

1. Inspect For Warpage

   Using a straight edge and feeler gauge, check the cylinder head gasket surface for warpage utilizing the checking pattern shown in **FIGURE 7–12**. If specifications are **NOT** met check head thickness prior to resurfacing. The minimum deck–to–deck dimension must be maintained after resurfacing.

2. Check Thickness

   Measure cylinder head deck thickness, using a micrometer, at six locations (four corners and two center points). Refer to **FIGURE 7–13**. Refer to "Specifications." If the minimum deck to deck dimension cannot be met, replace the cylinder head.

NOTICE: **There should be no leakage. Reconditioning is not required if the cylinder head passes the mineral spirits test. If leakage is observed, the valves require reconditioning. Refer to "Cylinder Head Reconditioning" in this section. This test does not check for condition of valve guide or valve stem–to–guide clearance**

CYLINDER HEAD INSPECTION

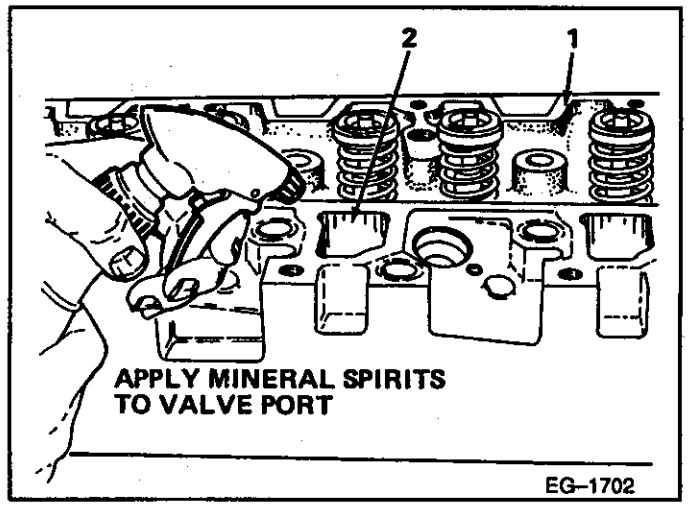
3. Check For Valve Leakage (Using Mineral Spirits)

   Visually inspect for valve leakage as follows:

   a. Position the cylinder head on wood blocks with the gasket surface facing down.

   b. Squirt mineral spirits into the the intake and exhaust ports as shown in **FIGURE 7–14.**

   Wait five minutes, use an inspection mirror and visually inspect the valve seat area for leakage of the mineral spirits. Repeat and check all intake and exhaust valves.

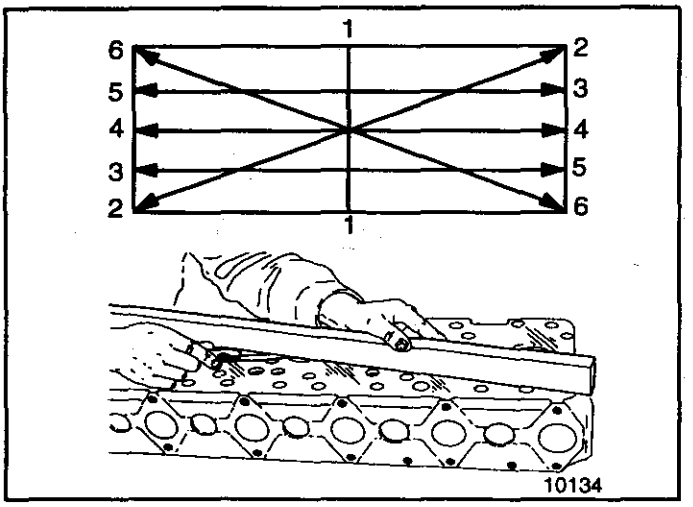


1. **Cylinder Head**
2. **Intake Port**

FIGURE 7–14

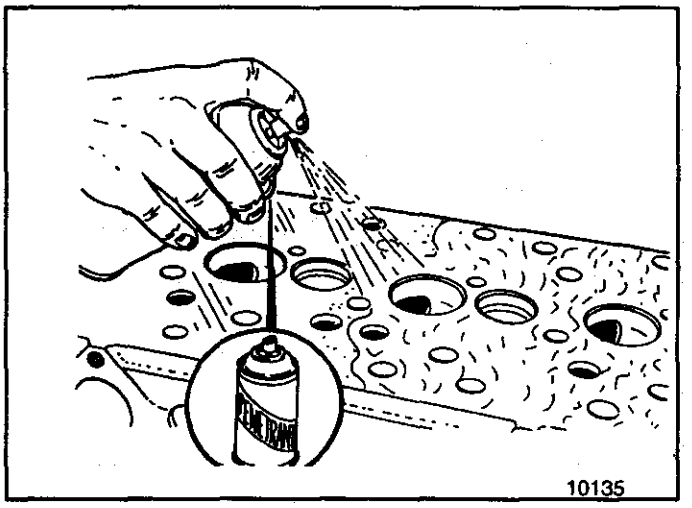
CYLINDER HEAD INSPECTION

7.4.1 Inspect For Cracks



1. Apply cleaner and wipe off

FIGURE 7–15



2. Apply dye penetrant and allow it to dry

FIGURE 7–16

(Using Dye Penetrant Method OEM – 1272)

Visually inspect for cylinder head cracks using the four step dye penetrant method as follows:

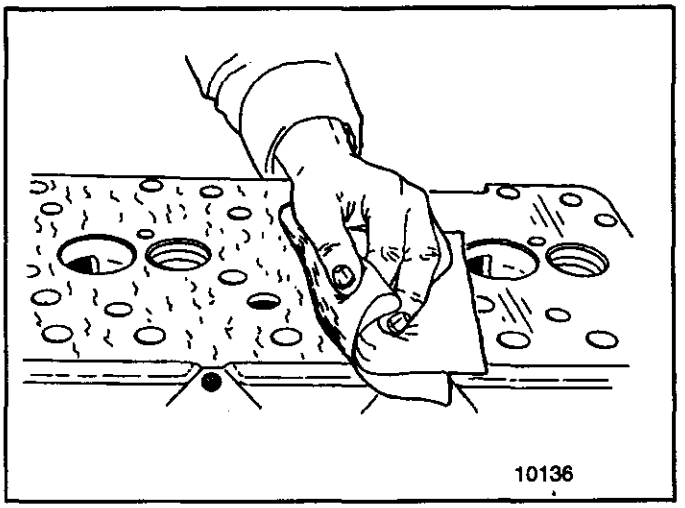
1. Spray the cleaner onto the lower deck (gasket surface) of the head and wipe dry. Refer to **FIGURE 7–15.**
2. Spray on the dye penetrant. Allow the dye to remain on the surface from one (1) to ten (10) minutes. Refer to **FIGURE 7–16.**

CYLINDER HEAD INSPECTION

3. Wipe the dye off the surface. Refer to **FIGURE 7–17.**

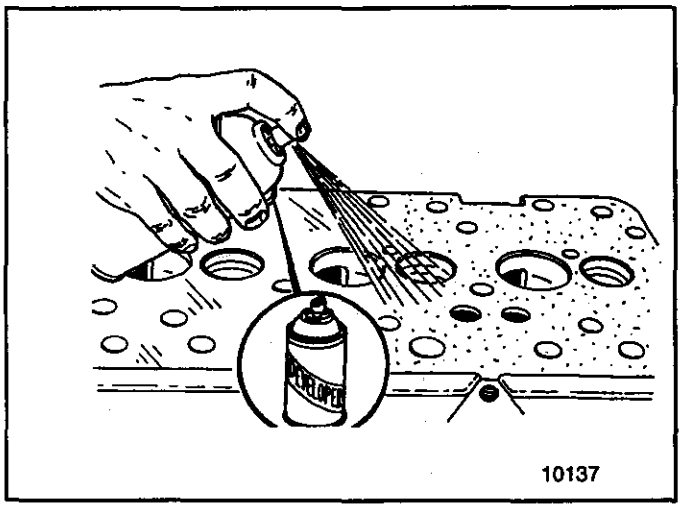
NOTE:
Dye will remain in any cracks during the "wipe off" step.

4. Spray on the developer and let dry for five to fifteen minutes. Refer to **FIGURE 7–18.**



3. Wipe off dye penetrant

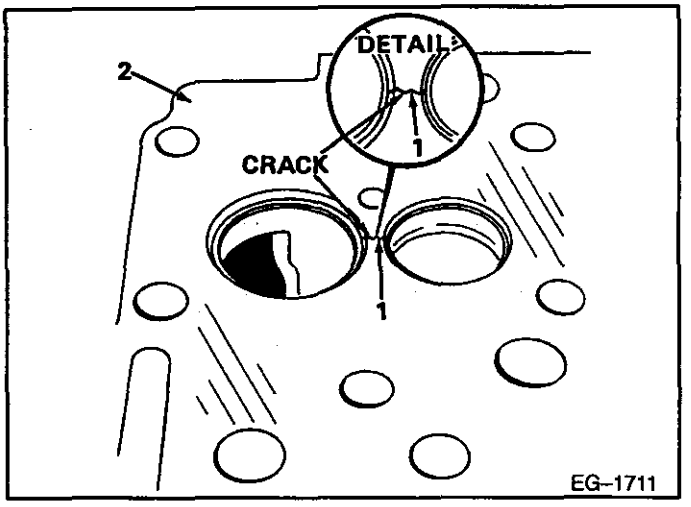
FIGURE 7–17



4. Apply developer and let dry for 5 to 15 minutes

FIGURE 7–18

CYLINDER HEAD INSPECTION



1. **Purple Line/Crack**
2. **White Developer**

FIGURE 7–19

NOTE:

Cracks will show up as purple lines against the white developer. Refer to Figure 4.16.

NOTICE: **If any cracks are present, replace the cylinder head.**

7.4.2 Pressure Check Cylinder Head

Pressure testing the cylinder head will reveal cracks in ports or nozzle liner leakage which cannot be observed using dye penetrant. Pressure–test the cylinder head as follows:

1. Reinstall injection nozzles before pressure testing.

NOTE:

Nozzle clamping seals the nozzle liner at the bottom of the bore in the head. Good nozzle liners will be condemned needlessly if nozzles are not installed prior to pressure testing.

2. Remove the valves, using a valve spring compressor. Refer to "Cylinder Head Reconditioning", in this section for valve removal instructions.

CYLINDER HEAD INSPECTION

3. Pressure test the cylinder head.
4. Fasten the pressure plate and head gasket to the cylinder head gasket surface using the twenty–four (24) mounting bolts and nuts supplied with the kit. Refer to **FIGURE 7–20.**
5. Remove thermostat and install air regulator. Secure to cylinder head with two (2) mounting bolts.
6. Remove the pipe plug next to the thermostat opening. Fill cylinder head with hot water and reinstall pipe plug. Refer to **FIGURE 7–21.**
7. Install a hose fitting to the cylinder head at the removed plug. Apply 18–20 lb/in.^{2} (124–138 kPa) air pressure and visually inspect for leaks at the:
   - ❑ Nozzle liners
   - ❑ Ports
   - ❑ Upper deck
   - ❑ Lower deck

NOTE:

If leakage is observed at any port or the upper and lower deck, REPLACE THE CYLINDER HEAD. If nozzle liner leakage is observed, follow the procedures under "Cylinder Head Reconditioning."

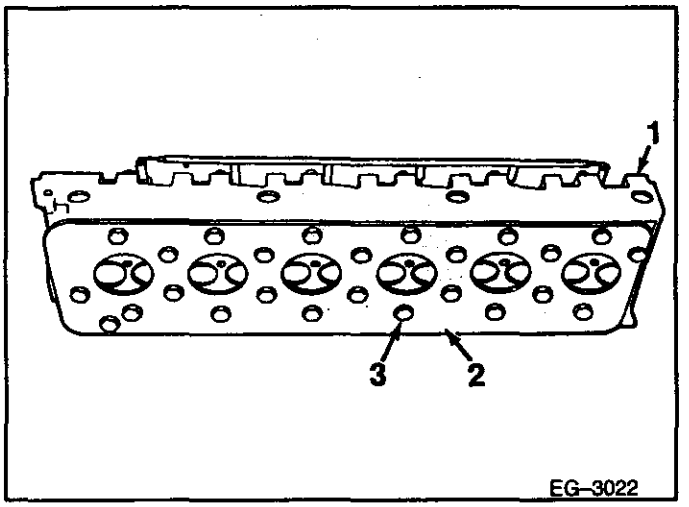
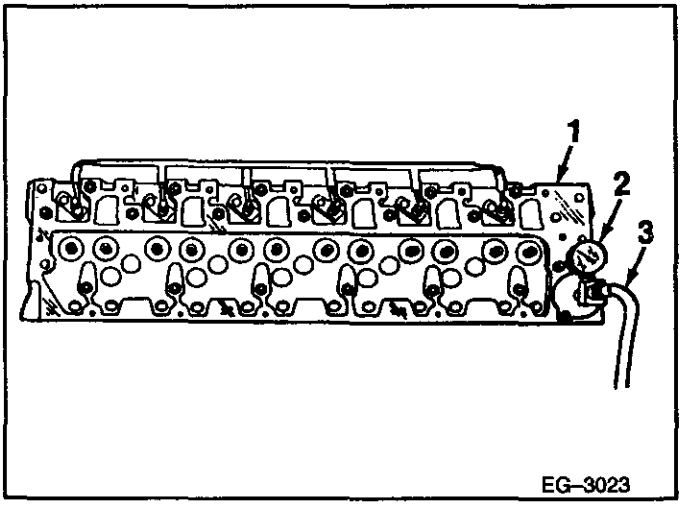


FIGURE 7–20



1. **Cylinder Head**
2. **Air Regulator**
3. **Air Hose**

FIGURE 7–21

7.5 CYLINDER HEAD RECONDITIONING

The first step in cylinder head reconditioning is the replacement of the nozzle liner.

7.5.1 Nozzle Liner Replacement

NOTICE: **Replace the nozzle liner only if leakage is present.**

NOTE:

Use nozzle liner remover J39262 (FIGURE 7–22).

1. Insert a nozzle liner puller adapter threaded into the liner to be removed. Refer to FIGURE 7–23.

NOTE:

This grips the nozzle liner by threading into it. Start the adapter into the nozzle liner by striking it with a hammer. Then screw the nozzle liner puller adapter into the liner using a wrench.

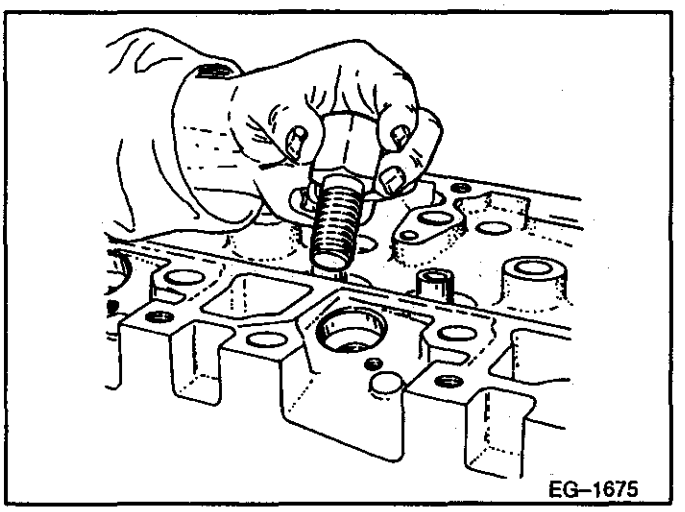


FIGURE 7–22

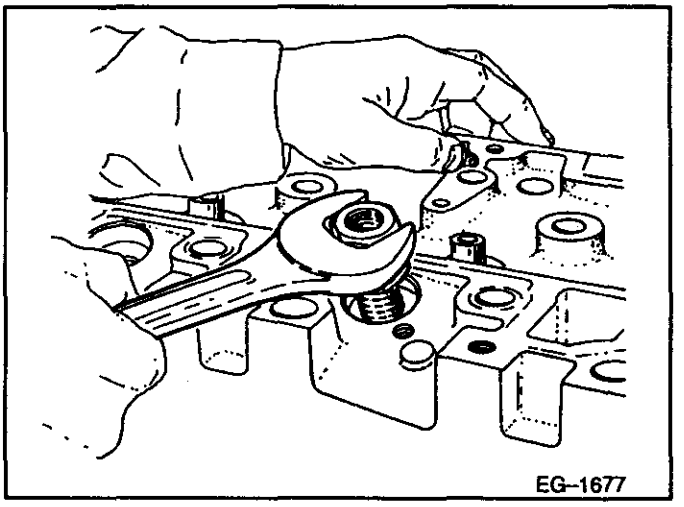


FIGURE 7–23

CYLINDER HEAD RECONDITIONING

2. Connect a slide hammer to the adapter and pull the liner from its bore. Refer to **FIGURE 7–24.**
3. Discard the liner.
4. Clean the nozzle bore at the top and bottom using a rotary wire brush. Blow out with filtered compressed air.
5. Apply Loctite® 262 or equivalent to the nozzle liner contact points (2 places). Refer to **FIGURE 7–25.**

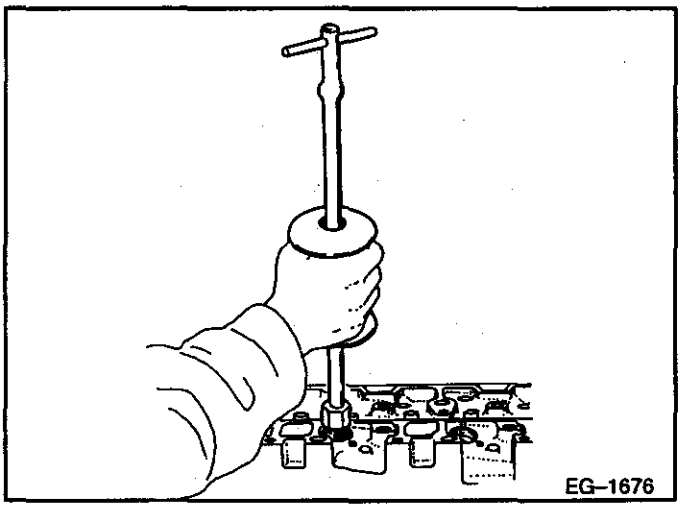


FIGURE 7–24

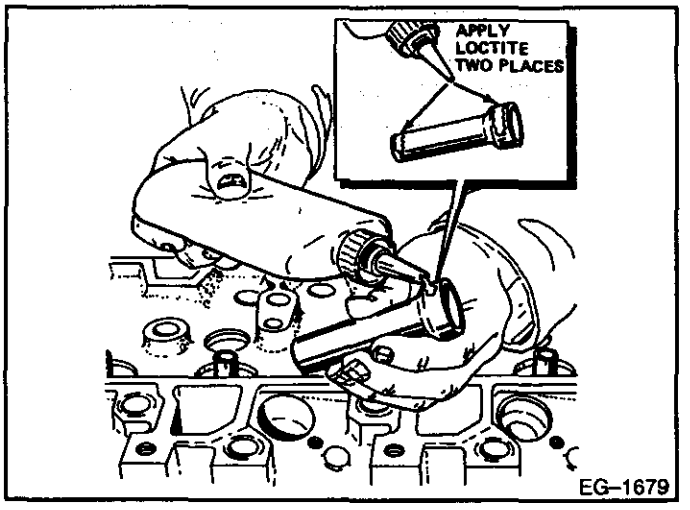


FIGURE 7–25

CYLINDER HEAD RECONDITIONING

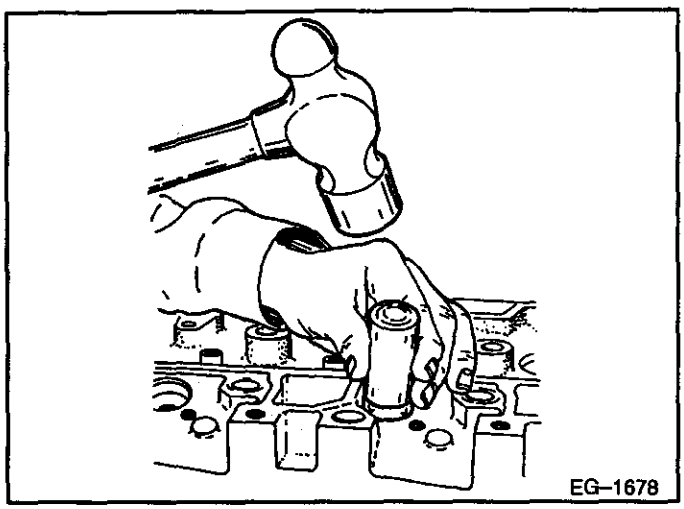


FIGURE 7–26

6. Install the nozzle liner using the nozzle liner installer J39261. Drive the liner until it bottoms in the bore. Refer to **FIGURE 7–26.**

NOTE:

If performing a nozzle liner installation in chassis, be sure to drain the coolant before replacing the nozzle liners in chassis. When installing nozzle liners in chassis, piston should be bottom dead center or installation tool may contact piston.

7.5.2 Valve And Valve Guide Reconditioning

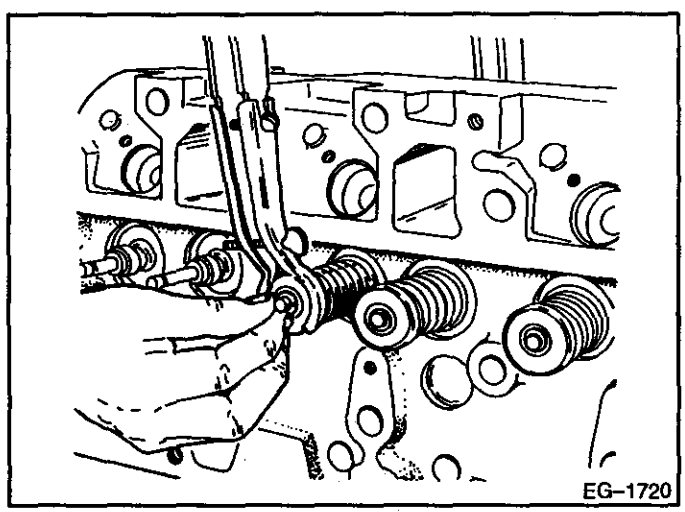


FIGURE 7–27

The first step in reconditioning the valve and valve guide is to remove the valves.

7.5.2.1 Remove Valves

1. Using a valve spring compressor tool, remove the valves as follows:
2. Install the valve spring compressor over the valve to be removed and compress the spring.
3. Remove the valve spring locks (keepers). Refer to **FIGURE 7–27.**
4. Remove the valve spring compressor tool.

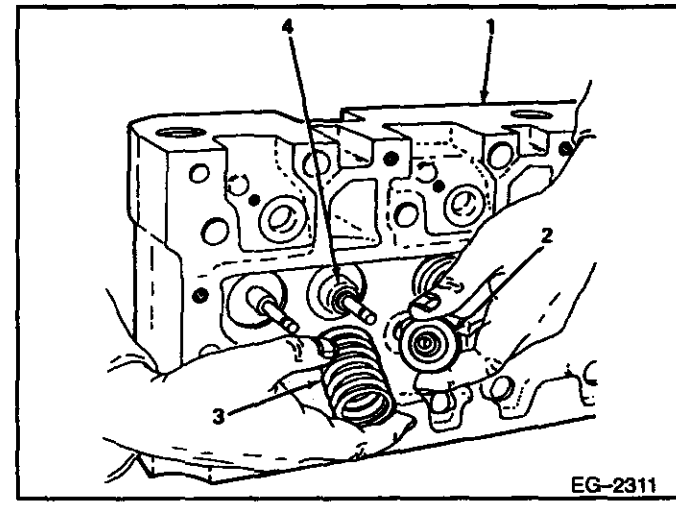
CYLINDER HEAD RECONDITIONING

5. Remove the valve rotator, valve spring, valve seal and valve as shown in **FIGURE 7–28.** If the nylon rotator seal becomes dislodged from the rotator and sticks to the valve stem, remove the seal from the valve stem with your fingers. Discard all 12 rotator seals.

NOTE:

Separate the intake and exhaust springs at time of removal. The spring rates are different and cannot be mixed on cylinder head reassembly.

6. Remove valve stem seal assemblies and valves. Discard all 12 stem seal assemblies due to damage from removal across the valve keeper grooves.

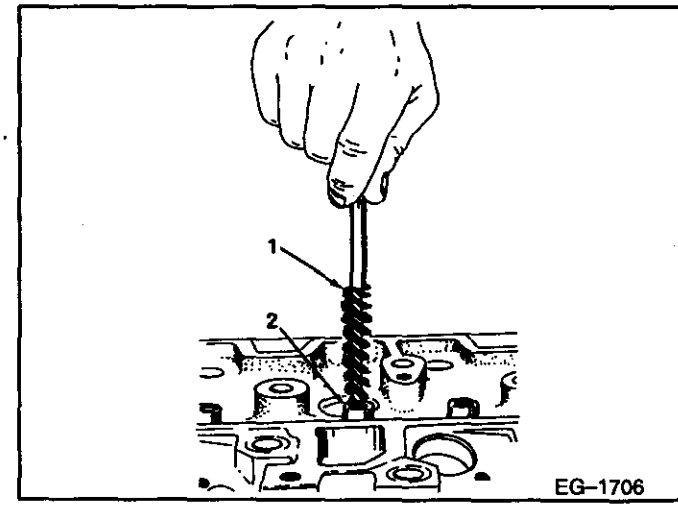


1. Cylinder Head
2. Valve Rotator with Nylon Seal
3. Spring
4. Valve Stem Seal

FIGURE 7–28

7.5.2.2 Clean Valve Guides

1. With valves removed, clean all valve guides using a nylon brush, soap and water. Refer to **FIGURE 7–29.**

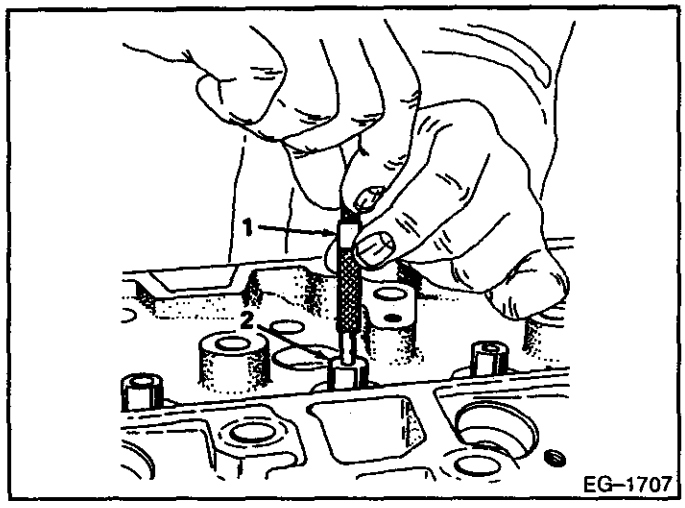


1. Brush
2. Valve Guide

FIGURE 7–29

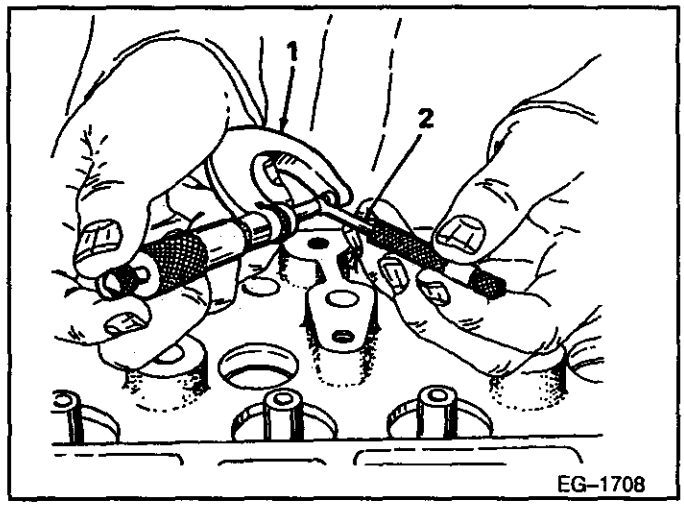
CYLINDER HEAD RECONDITIONING

7.5.2.3 Inspect Valve Guides



1. Ball Gauge.

FIGURE 7–30



1. Micrometer
2. Ball Gauge

FIGURE 7–31

1. Position an inspection light at the bottom of the valve guide bores and visually examine the walls for burning, cracking. Replace any guides which do not pass the visual inspection.
2. Measure each valve guide using a ball gauge and outside micrometer as shown in **FIGURE 7–30 and FIGURE 7–31.**

~ If valve guide exceeds specifications, replace the guide.

NOTE:

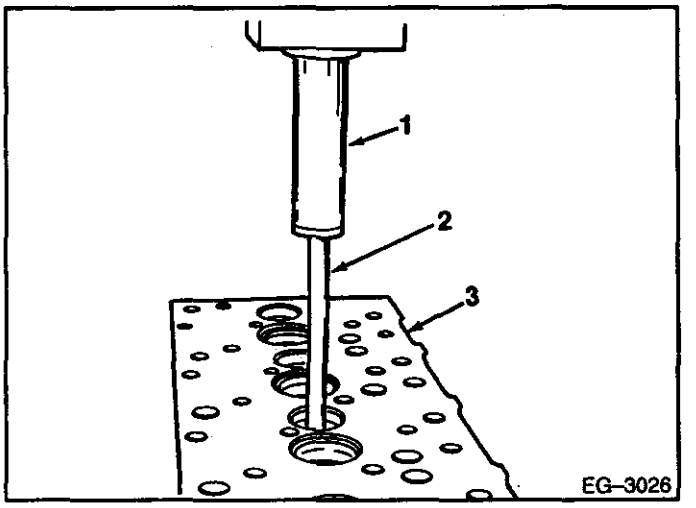
Measure the valve guides within 0.025 inch (0.64 mm) of each end of the guide and 90 degrees from the crankshaft center–line. Record valve guide i.d. readings so valve–to–guide running clearance may be determined later (FIGURE 7–31).

CYLINDER HEAD RECONDITIONING

7.5.2.4 Replace Valve Guides

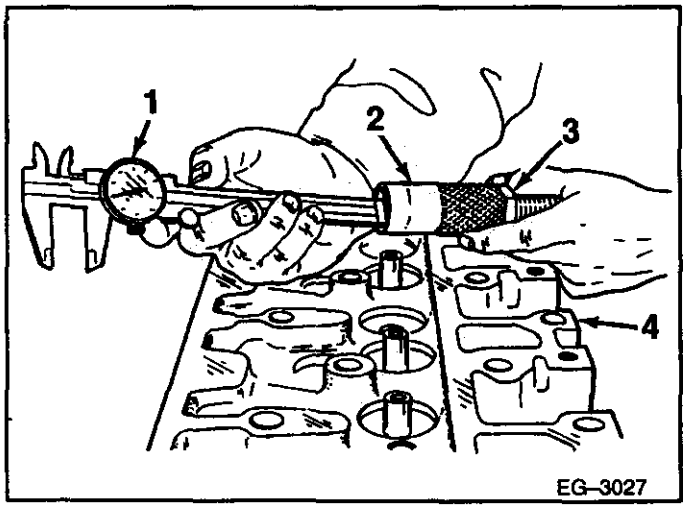
1. Remove any valve guides which do not pass the inspection criteria as follows:
   a. Insert the valve guide remover J41164 into the guide from the valve port side of the cylinder head.
   b. Press/drive out the valve guide with a hammer. Refer to **FIGURE 7–32.**
2. Install new valve guide inserts as follows:
   a. Adjust the valve guide installer tool, J39292, using a caliper as shown in **FIGURE 7–33.**

NOTICE: **Tool insert must be reversed so that flat side contacts guide. Refer to specifications for correct valve guide height (above top deck of the cylinder head) before installing valve guide. Adjust the tool to correspond to the desired valve guide height.**



1. **Valve Guide Remover Tool**
2. **Valve Guide**
3. **Cylinder Head**

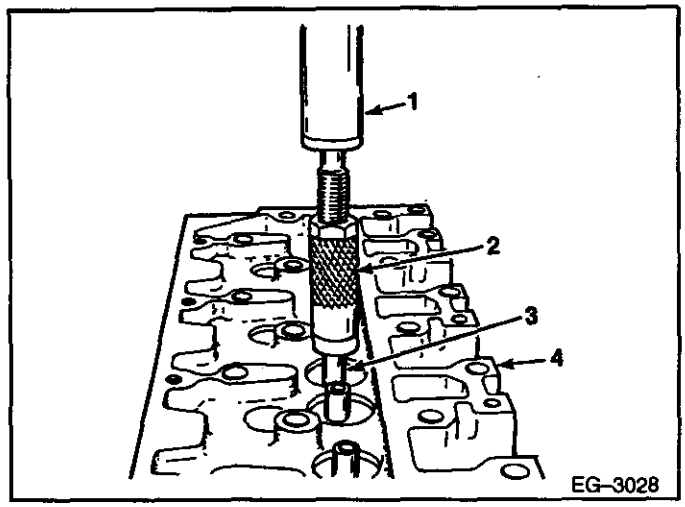
FIGURE 7–32



1. **Caliper/ Indicator**
2. **Valve Guide Installer Tool**
3. **Lock Nut**
4. **Cylinder Head**

FIGURE 7–33

CYLINDER HEAD RECONDITIONING



1. **Press**
2. **Installer Tool**
3. **Insert**
4. **Cylinder Head**

FIGURE 7–34

NOTICE: **Install the valve guide inserts with the large 15 degree chamfer end down.**

b. Lubricate the valve guide insert using clean engine oil and press into the cylinder head until the installer tool bottoms against the cylinder head. Chilling guide may facilitate installation. Refer to **FIGURE 7–34.** DO NOT hammer or pound valve guide insert into the cylinder head.

c. Deburr the valve guide, after installation, Refer to **FIGURE 7–36.**

NOTE:

DO NOT ream valve guide I.D. after installation. Service guides are provided in a finish reamed condition. Clean valve guides as described in FIGURE 7–29.

7.5.2.5 Clean Valves

Remove all carbon from the valve stems and valve heads.

7.5.2.6 Inspect Valves

1. Visually inspect each valve, replacing any that show evidence of burn marks, warpage, scuffing or bending.
2. Measure each valve stem for wear using a micrometer to measure valve stem diameter. Record the readings.

NOTE:

Measure valves at three locations 90° apart. Refer to the "Specifications" and replace valves which exceed the minimum stem diameter specification.

CYLINDER HEAD RECONDITIONING

3. Using the valve stem diameter and valve guide inside diameter measurements, recorded earlier (see "Inspect Valve Guides" in this section), determine valve stem–to–guide running clearance. Refer to "Specifications." Replace the valve or valve guide as required.

7.5.2.7 Reface Valves

NOTE:
If valves are in serviceable condition, reface the valve to the specified angle, as required. Refer to FIGURE 7–35.

1. Reface the valves as follows:

   a. Dress the cutting stone, prior to refacing the valves, using the dressing stud attachment on the grinder.

   b. Install the valve in the grinder and set to the specified angle.

   c. Grind the valve face. Remove only the minimum amount of material necessary to true up the valve face. Refer to **FIGURE 7–36.**

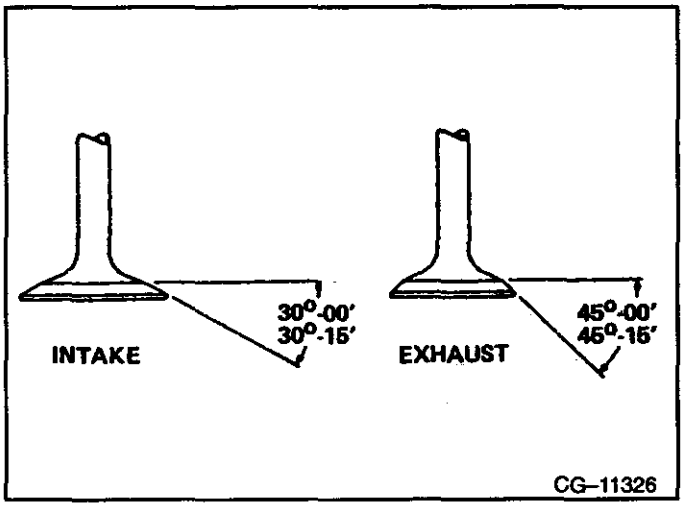


FIGURE 7–35

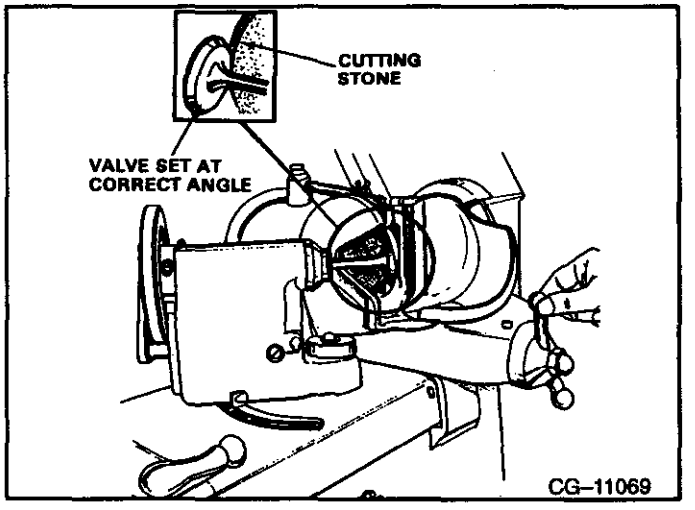


FIGURE 7–36

CYLINDER HEAD RECONDITIONING

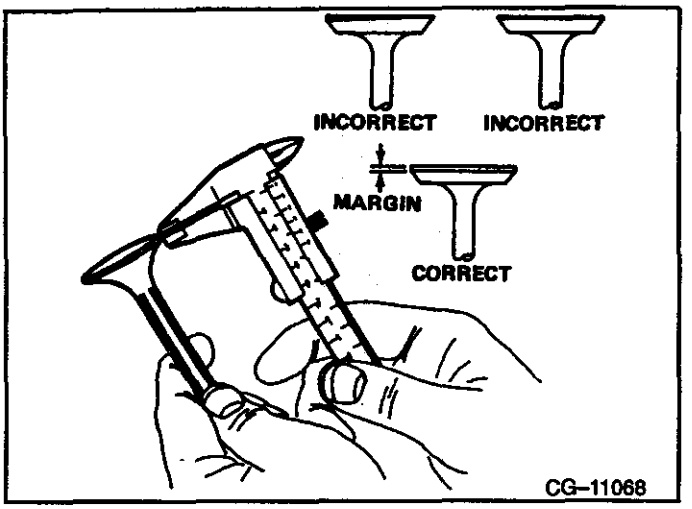


FIGURE 7–37

2. Measure valve face margin at four locations using a caliper. Refer to **FIGURE 7–37.**

NOTE:
The minimum valve face margin (see "Specifications") must be maintained across the entire valve face. An insufficient margin will NOT provide proper heat dissipation and lead to valve warpage or breakage. Intake and exhaust valve margins are different. Replace the valve if the margin is less than the specified minimum, after grinding.

3. Reface the valve stem tip as follows:

   a. Dress the cutting stone using the dressing stud on the grinder.

   b. Install the valve in the grinder as shown in **FIGURE 7–38.**

NOTICE: **When resurfacing the valve stem tip, leave sufficient material so the valve lever (rocker arm) does not contact the valve spring locks or rotators, during operation.**

   c. Touch the valve stem tip to the cutting stone removing only a minimum of material.

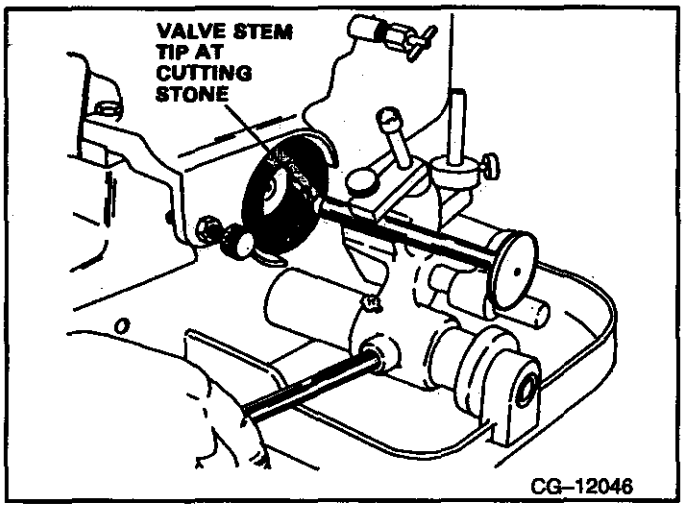


FIGURE 7–38

NOTE:
Refacing the valve stem tip provides a new wear surface for the rocker arm.

CYLINDER HEAD RECONDITIONING

4. After resurfacing valves, insert valves in clean valve guide and check valve face contact with valve seat using Prussian Blue™ (or equivalent) as follows:

   a. Spread thin film of Prussian Blue™ on valve face. Insert valve into its guide. Refer to **FIGURE 7–39.**

NOTE:
If seats are acceptable, install the valves without grinding the seats. If voids appear in the bluing, seat grinding is required.

   b. Apply pressure on exact center of valve head while making a quarter turn in the seat. Refer to **FIGURE 7–40.**

   c. Remove valve, inspect impression made on seat and on valve face.

   d. Bluing should appear around entire contact surface of valve face and valve seat to be acceptable. **CHECK SEVERAL TIMES TO PREVENT ERROR.** If acceptable, proceed with valve installation.

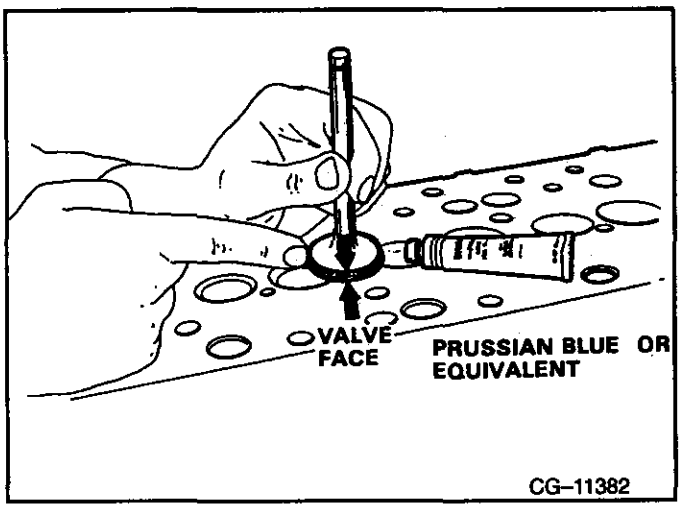


FIGURE 7–39

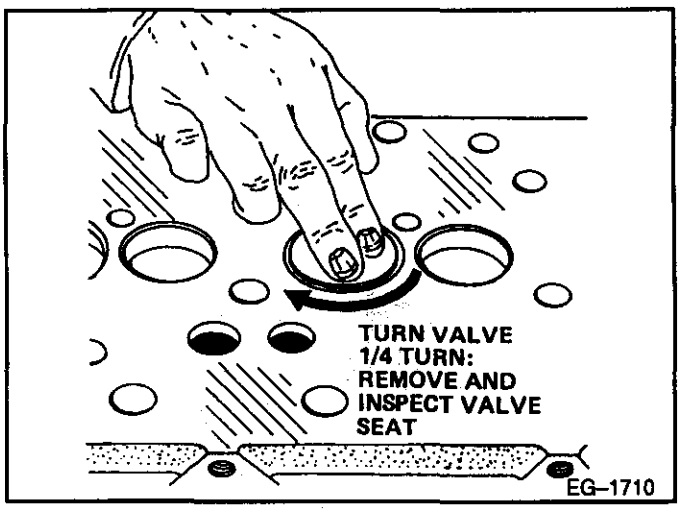


FIGURE 7–40

CYLINDER HEAD RECONDITIONING

7.5.2.8 Valve Seat Grinding

1. If required, resurface the valve seat as follows: (Refer to **FIGURE 7–41**).
   a. Lightly lubricate and install the correct size pilot into the valve guide.

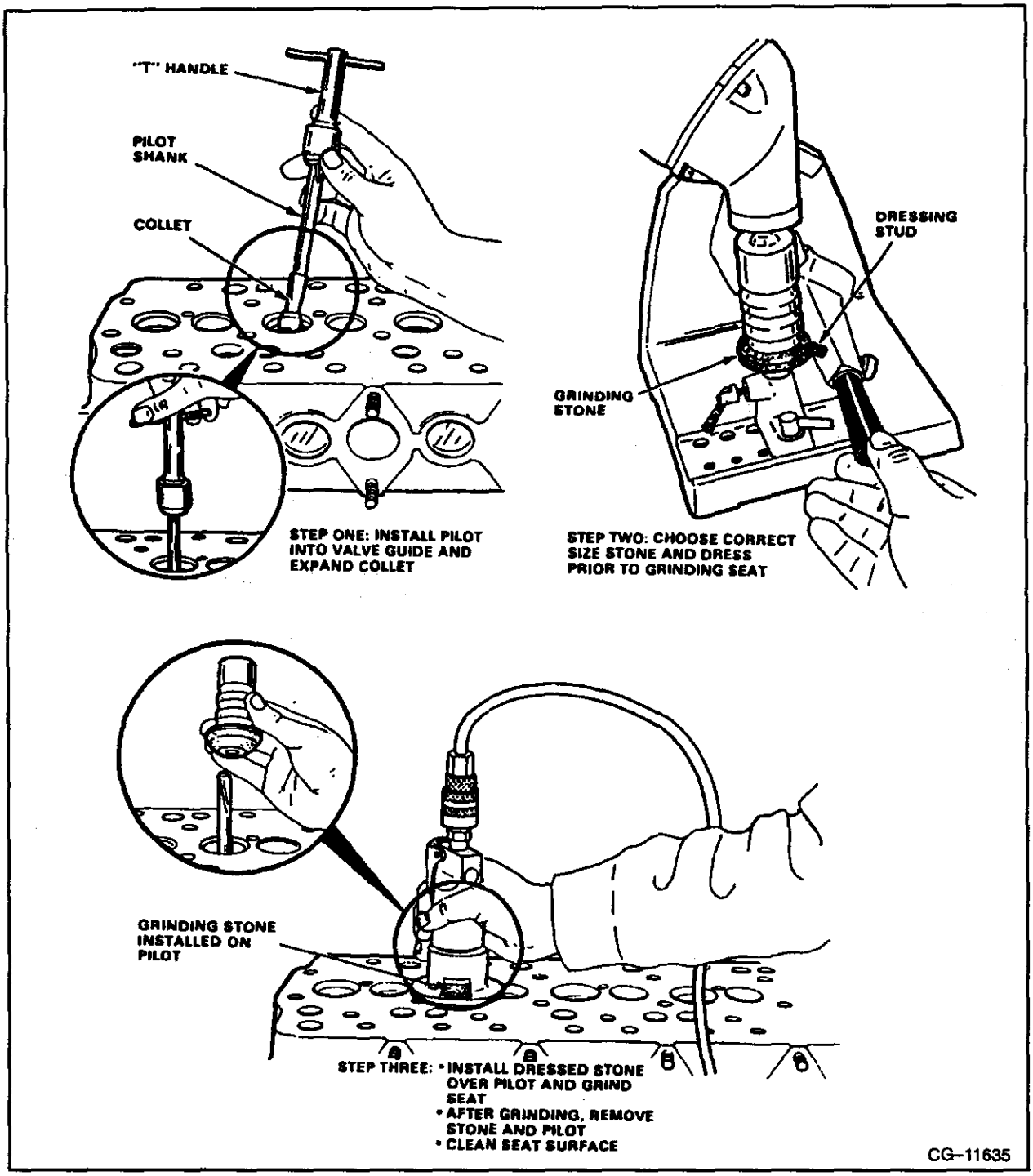


FIGURE 7–41 Grind Valve Seat

CYLINDER HEAD RECONDITIONING

b. Choose the correct angle grinding stone and dress the stone. Refer to "Specifications" for valve seat angles.

c. Install the grinding stone over the pilot.

d. Lower grinder head over pilot shank until wheel barely clears the valve seat. Turn on power. **GENTLY** apply grinding wheel to valve seat with little pressure other than weight of the wheel.

e. Raise wheel frequently to prevent overheating.

f. Grind seat to a smooth even finish.

2. After resurfacing, check valve seat width using a caliper as shown in **FIGURE 7–42.** Refer to **"Specifications"** for seat width limits. If seat widths are excessive, they may be corrected by grinding with a 15 degree smaller angle stone.

3. Check valve recession using a straightedge and feeler gauge or a surface gauge. Refer to **FIGURE 7–43** and **FIGURE 7–44.** Refer to "Specifications" for recession limits. If valve recession is excessive, install a new valve or replace the valve seat. If the valve protrudes above the deck, regrind the valve seat.

NOTE:
Clean valve guides as described in FIGURE 7–29.

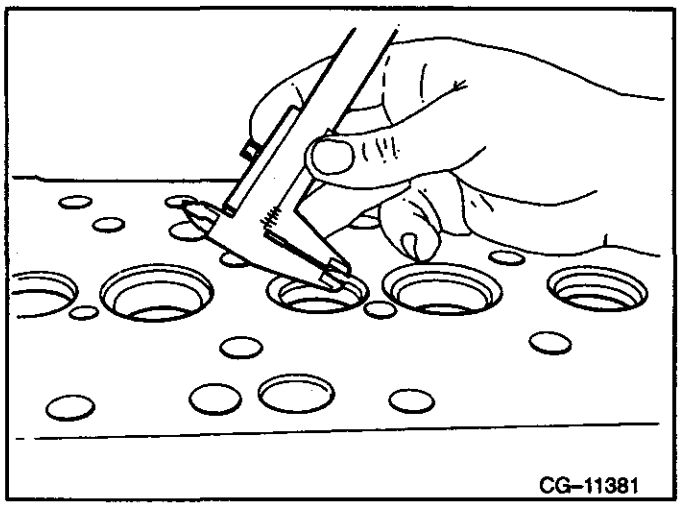
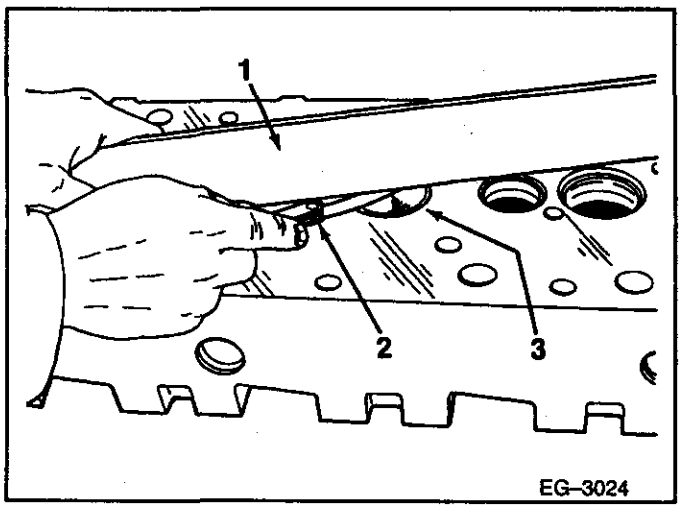


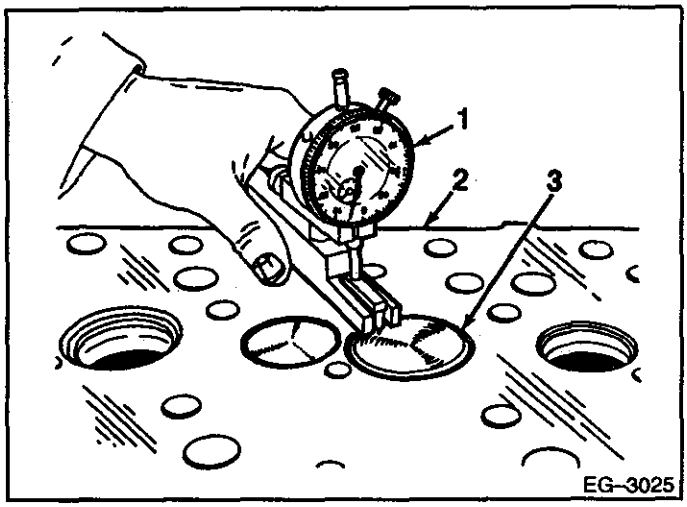
FIGURE 7–42



1. **Straightedge**
2. **Feeler Gauge**
3. **Valve**

FIGURE 7–43

CYLINDER HEAD RECONDITIONING



1. **Dial Indicator**
2. **Cylinder Head**
3. **Valve**

FIGURE 7–44

NOTICE: **If a new valve will not correct an excessive recession condition, the valve seat must be replaced and reground. If the valve face protrudes above the deck, the valve seat will have to be reground deeper into the head. After regrinding any seat, recheck the seat width (see FIGURE 7–44) and confirm valve seat contact using Prussian Blue™ (see FIGURE 7–45 and FIGURE 7–40).**

4. After resurfacing the valve seat, check the seat for runout, using an appropriate dial indicator. Valve seat runout should not exceed limits shown in "Specifications."

NOTICE: **If valve seat runout, concentricity and/or seat width cannot be maintained, replace and resurface the valve seats.**

CYLINDER HEAD RECONDITIONING

7.5.2.9 Valve Seat Replacement

1. **USE A VALVE SEAT PULLER** to remove defective valve seat inserts as follows:

NOTE:

These instructions are general in nature. Follow the instructions that apply to the tool.

a. Cut a groove in insert using stone.

b. Choose the appropriate size pin collet and position the collet at the valve seat insert.

c. Expand the pin collet by turning the small handle at the top of the bridge assembly. Refer to **FIGURE 7–46.**

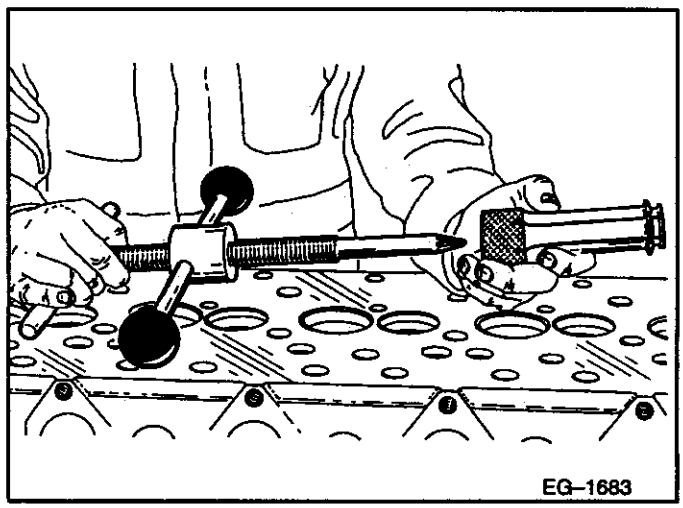


FIGURE 7–45

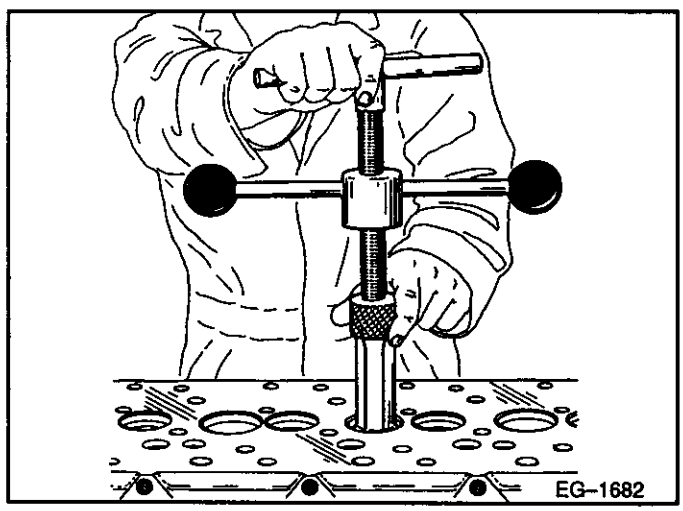


FIGURE 7–46

CYLINDER HEAD RECONDITIONING

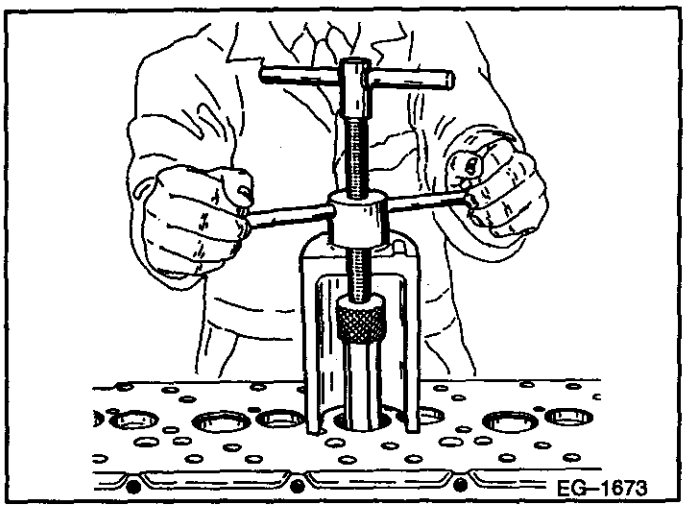


FIGURE 7–47

d. Turn the large handle on the bridge assembly to pull the valve seat insert from the cylinder head. Refer to **FIGURE 7–47.**

e. Unlock the pin collet by turning the small handle and discard the valve seat insert.

2. Select the appropriate size valve seat insert. Refer to "**Valve Seat Insert Chart.**"

VALVE SEAT INSERT CHART

Oversize Insert	Diameter Of Cylinder Head Counterbore Intake	Exhaust
Standard*	1.996 – 1.997 in.	1.624 – 1.625 in.
.002 in.*	1.998 – 1.999 in.	1.626 – 1.627 in.
.015 in.	2.011 – 2.012 in.	1.639 – 1.640 in.

* STANDARD AND .002 IN. OVERSIZE SERVICE INSERT DO NOT REQUIRE INSERT COUNTERBORE ENLARGEMENT BEFORE INSTALLING.

NOTICE: **Standard service valve seat inserts are provided in the cylinder head overhaul package. If the seat is damaged beyond the standard or .002 in. diameter, it will be necessary to machine the insert counterbore in the cylinder head for an oversize seat insert. Standard size inserts do not require counterbore enlargement.**

a. Chill the valve seat insert in a freezer for 30 minutes before installing.

CYLINDER HEAD RECONDITIONING

NOTE:
Chilling the valve seat insert prevents peeling of metal from the cylinder head counterbore during installation.

b. Align the insert to avoid cocking.

c. Press the insert into its counterbore using J39535 for the intake and exhaust valve seat inserts. Refer to **FIGURE 7–48.**

3. Grind the new valve seat(s) to the specified angles and width. Refer to "Valve Seat Grinding" in this section.

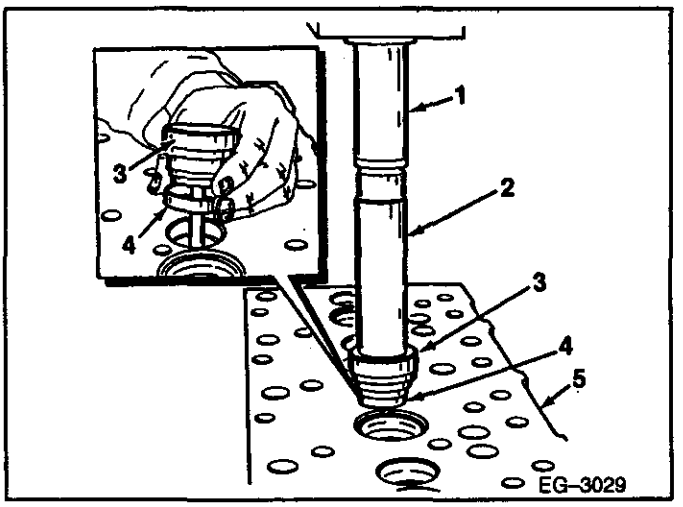


FIGURE 7–48

7.5.3 Cleaning and Inspecting Valve Springs

1. Clean all valve springs and seats in a suitable solvent.
2. Visually inspect valve springs for rust, pitting and cracks. Look for spring distortion.
3. Spring ends must be flat and square to prevent lateral loads on valve stem. Refer to **FIGURE 7–49.**

NOTE:
Out of square springs place a side load on the stem causing rapid guide wear.

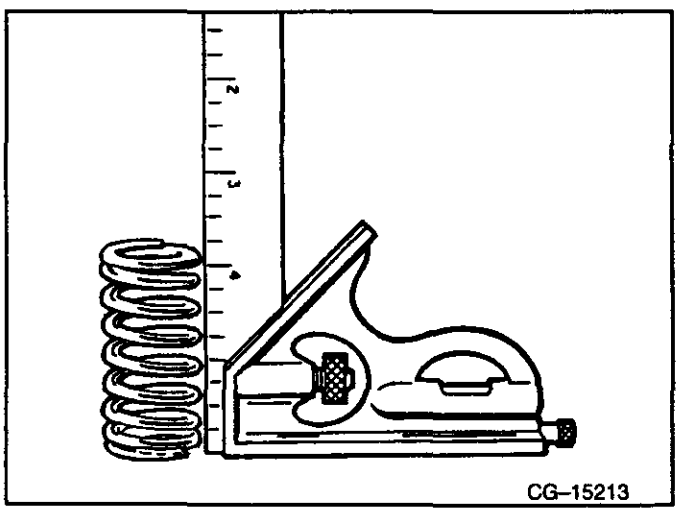


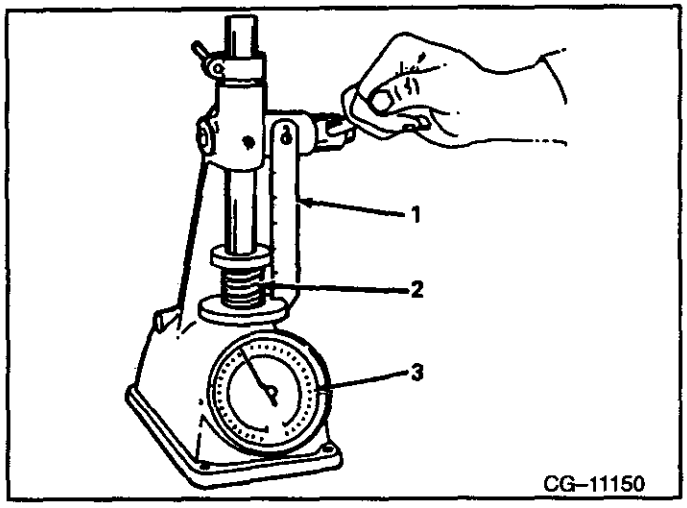
FIGURE 7–49

7.5.3.1 Installing the Valve Seat

Install the valve seat insert as follows:

1. Measure valve spring tension using valve spring tester J22738–02.

CYLINDER HEAD RECONDITIONING



1. **Scale**
2. **Valve Spring**
3. **Load Indicator**

FIGURE 7–50

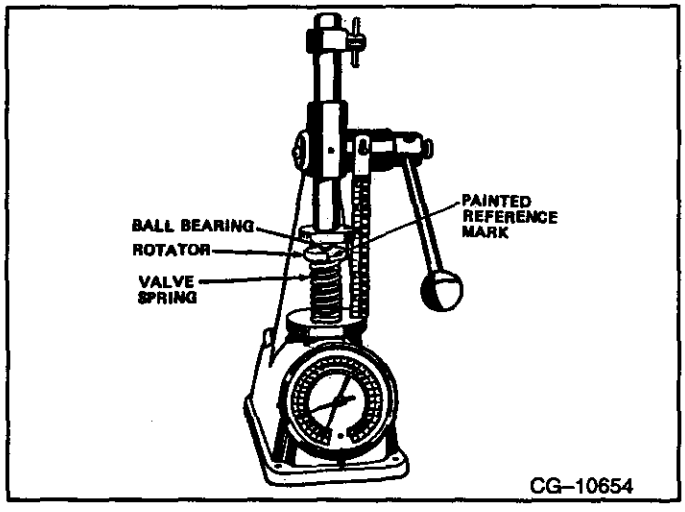


FIGURE 7–51

2. Measure maximum spring length in use (valve closed). Refer to **FIGURE 7–50** and "Specifications."
3. Measure minimum spring length in use (valve open).

NOTE:
Apply the appropriate test load to each spring and determine if test length is achieved.

4. Replace any valve spring which is rusted, pitted, cracked, bent or incapable of meeting tension requirements.

7.5.4 Cleaning and Inspecting Valve Rotators

1. Clean rotators in a clean solvent.
2. To properly test the rotator for function, a valve spring load must be applied to the rotator.

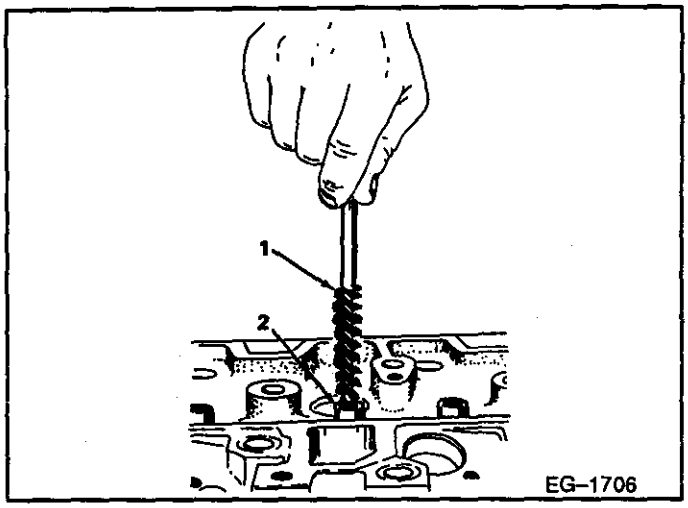
NOTE:
The rotator must be lubricated with clean engine oil prior to testing.

3. Place the valve spring with the rotator in the spring tester J22738–02. Place a ball bearing between the rotator and ram of the spring tester. The ball bearing must be large enough to prevent the ram from touching any part of the rotator.
4. Paint a reference line on the rotator.
5. Compress the valve spring rapidly with even pressure and observe the rotator as it turns. (Refer to **FIGURE 7–51**.) Replace any rotator which does **NOT** turn.

CYLINDER HEAD RECONDITIONING

7.5.4.1 Cleaning and Inspecting Valve Spring Locks

1. Clean valve spring locks in a suitable solvent.
2. Visually inspect inside and outside of the valve spring locks for wear.
3. Replace any worn spring locks, as required.



1. Brush
2. Valve Guide

FIGURE 7–52

7.6 CYLINDER HEAD REASSEMBLY

1. Clean valve faces and seats with a suitable cleaning solvent to remove all dirt or foreign material. Blow dry all new and used components using filtered compressed air.
2. Thoroughly clean all valve guides, prior to valve installation, as follows:
   a. Coat a brush with soap and water as shown in **FIGURE 7–52.**

NOTE:
Brush must have a slightly larger diameter than the I.D. of the valve guide.

   b. Insert brush into valve guide bore and clean with a turning motion to insure removal of any deposits.
   c. Dry with filtered compressed air.

NOTE: Perform valve guide bore cleaning on:

1. New service valve guides.
2. Valve guides installed in new service cylinder heads (less valves).
3. Valve guides presently installed in cylinder head, which meet bore specifications.

CYLINDER HEAD REASSEMBLY

4. Lubricate the valve stems with clean engine oil and insert the valves into the valve guides.
5. Lubricate the I.D. of the new valve stem seal assemblies with clean engine oil and install them over the valve and valve guide as shown in **FIGURE 7–53.** Be sure the seal assemblies are seated down against the cylinder head spring pockets.
6. Install the valve spring over the stem seal assembly.

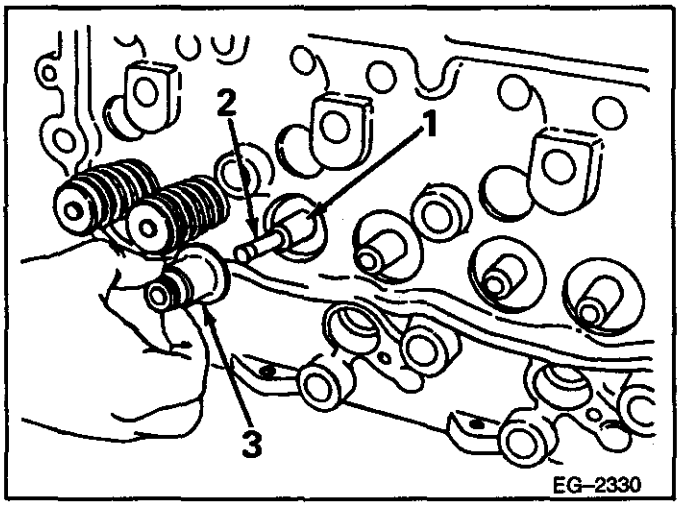
NOTE:

Be sure to install proper valve spring at proper valve location. Failure to properly locate the springs could cause engine damage.

NOTE:

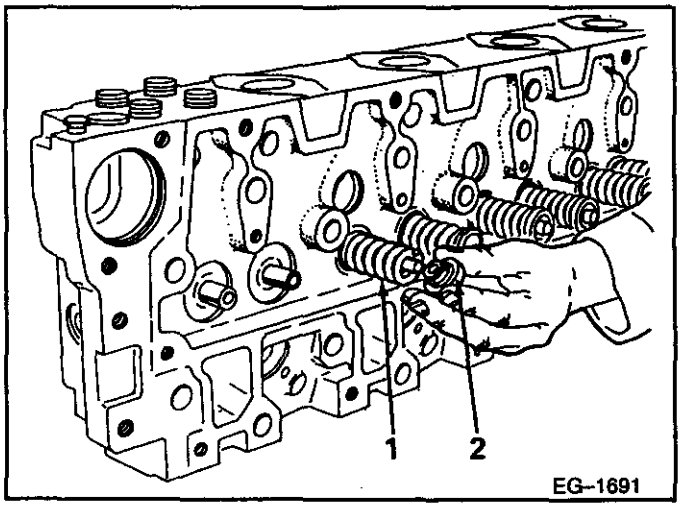
Snap new rotator seals into bottom side (rotator cone) of valve rotators before installing rotator assembly on engine.

7. Install the rotator assembly over the valve spring. Refer to **FIGURE 7–54.**



1. Valve Guide
2. Valve Stem
3. Stem Seal Assembly

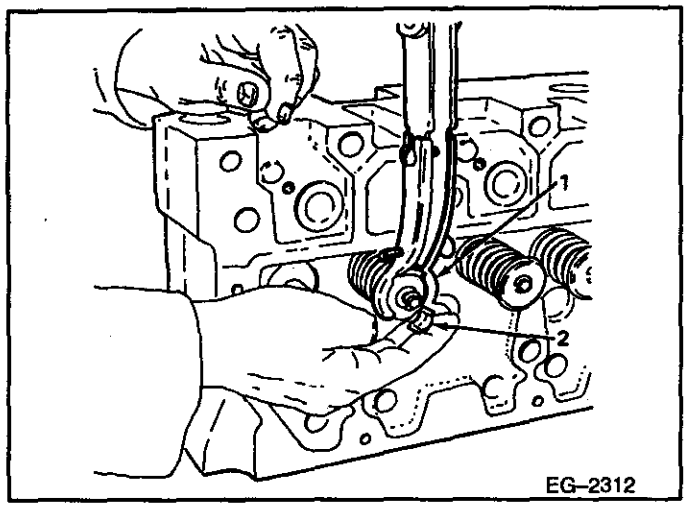
FIGURE 7–53



1. Valve Spring
2. Valve Rotator

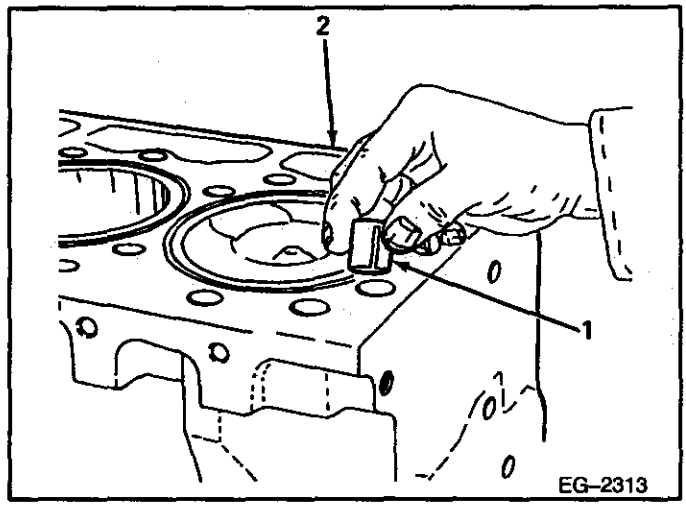
FIGURE 7–54

CYLINDER HEAD REASSEMBLY



1. Spring Compressor
2. Spring Lock (Keepers)

FIGURE 7–55



1. Dowel Ring
2. Crankcase

FIGURE 7–56

8. Compress the valve spring and install the spring locks (keepers) as shown in **FIGURE 7–55.**

7.6.1 Cylinder Head Installation

Install the cylinder head assembly as follows:

1. Clean and dry the cylinder head gasket surfaces.

2. Clean all cylinder head bolt holes using an appropriate tap and blow out bolt holes with filtered compressed air.

NOTE:
Prior to cylinder head installation, check cylinder liner protrusion.

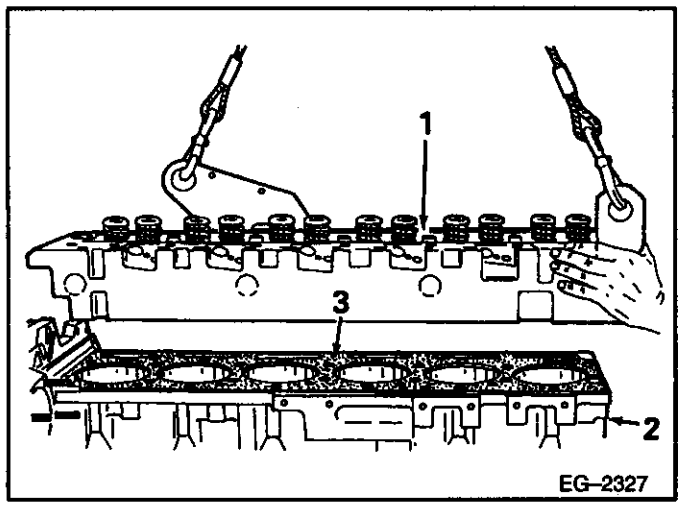
3. Install the dowel rings into the crankcase top deck. Refer to **FIGURE 7–56.**

NOTE:
The dowel rings are used to locate the cylinder head gasket.

4. Install a new cylinder head gasket over the "locating" dowel rings.

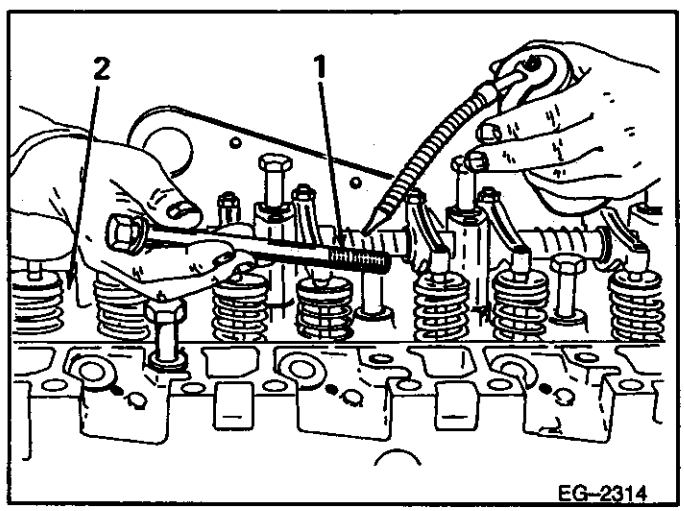
CYLINDER HEAD REASSEMBLY

5. Carefully lower the cylinder head onto the gasket. Refer to **FIGURE 7–57**.
6. Lubricate the cylinder head bolt threads, washers and under head seating area using clean engine oil. Refer to **FIGURE 7–58**.



1. **Cylinder Head**
2. **Crankcase**
3. **Cylinder Head Gasket**

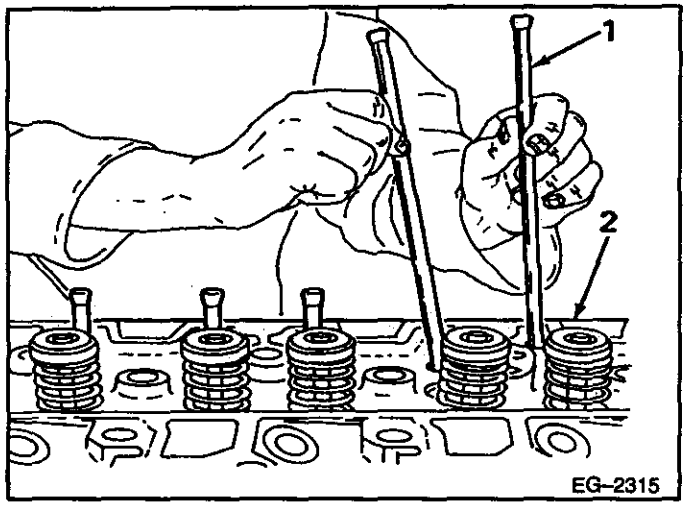
FIGURE 7–57



1. **Cylinder Head Bolt**
2. **Cylinder Head**

FIGURE 7–58

CYLINDER HEAD REASSEMBLY



1. **Push Rod**
2. **Cylinder Head**

FIGURE 7–59

NOTE:
Lubricate both long and short bolts.

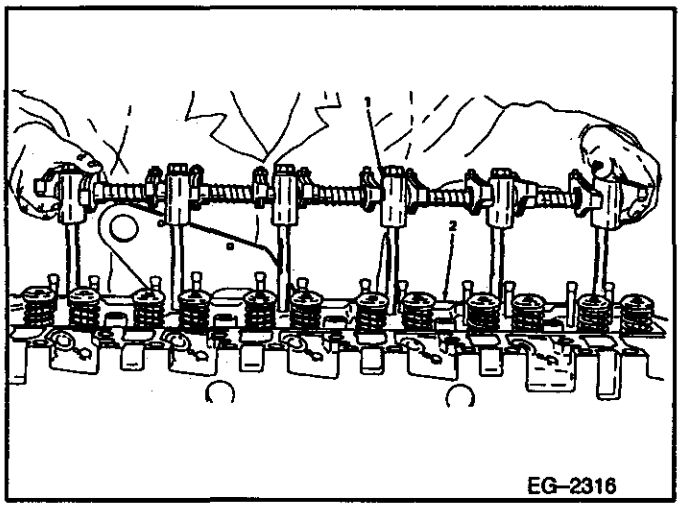
7. Run twenty (20) cylinder head mounting bolts in finger–tight.
8. Install the push rods with the cup end up as shown in **FIGURE 7–59**.

CYLINDER HEAD REASSEMBLY

9. Install valve lever (rocker arm) assembly onto the cylinder head using six (6) cylinder head mounting bolts as follows:
   a. Insert the rocker arm and shaft assembly with the long cylinder head bolts into their respective bolt holes. Refer to **FIGURE 7–60.**
   b. Run the long cylinder head bolts in finger– tight (except the two end bolts). Place a 0.005 in. (0.013mm) feeler gauge between the outside brackets and the rocker levers to prevent binding. Finger–tighten the remaining two end bolts. Refer to **FIGURE 7–61.**
10. Tighten the cylinder head bolts in three stages as specified under "Special Torque Values" in this section.

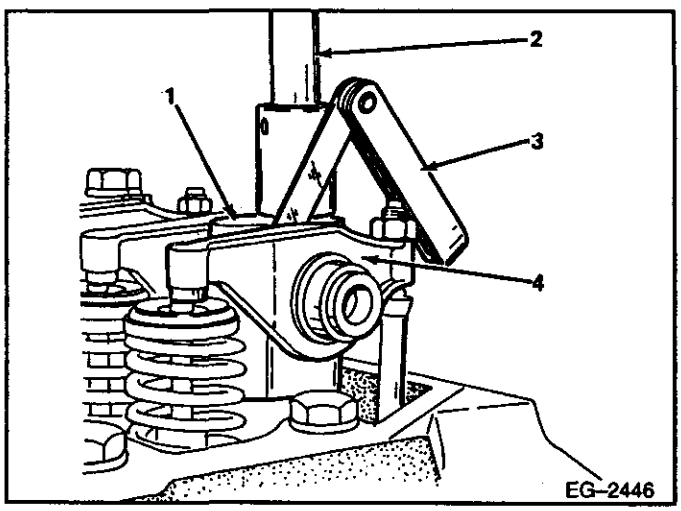
NOTE:
Check the two end rocker arms for freedom of movement after tightening the cylinder head bolts.

11. Remove the two 0.005 in. (0.013 mm) feeler gauges.



1. **Rocker Shaft Bracket**
2. **Cylinder Head**

FIGURE 7–60



1. **Bracket**
2. **Wrench**
3. **Feeler Gauge**
4. **Rocker Lever**

FIGURE 7–61

CYLINDER HEAD REASSEMBLY

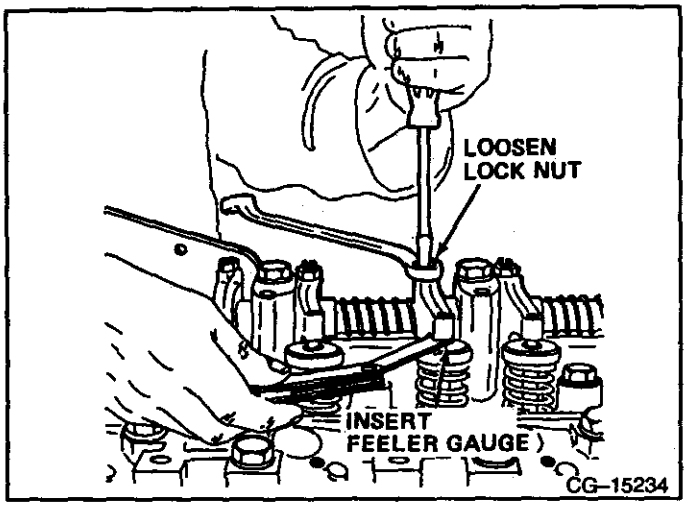


FIGURE 7–62

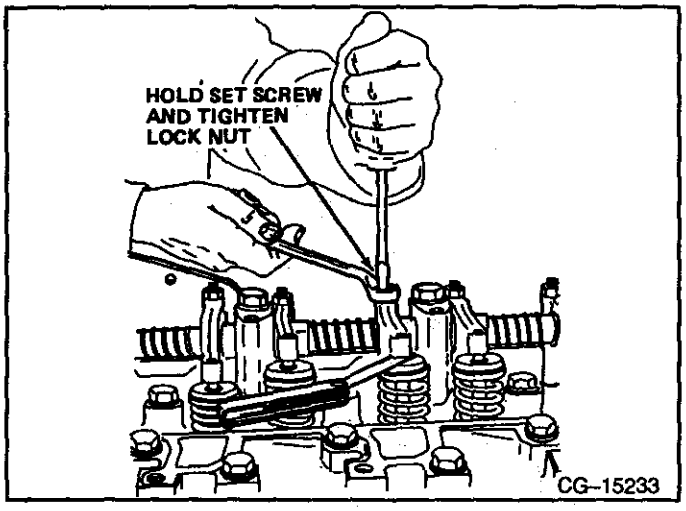


FIGURE 7–63

12. Adjust valve lash as follows:

NOTE:
All valves are adjusted by rotating the engine only twice.

a. Rotate the crankshaft until the #1 piston is on the compression stroke and the timing pointer on the front cover is in line with the TDC mark on the vibration damper.

NOTE:
Confirm that the #1 piston is on the compression stroke by turning both push rods by hand to verify that both valves are closed. The valves are closed when the push rods are loose and can be turned easily.

b. Set valve lash by loosening the lock nut and turning the valve adjustment screw with the appropriate size feeler gauge inserted between the rocker arm and valve stem tip. Tighten the valve adjustment screw until the valve lever can support the feeler gauge. Refer to **FIGURE 7–62** and "Specifications" for valve lash.

c. Tighten the lock nut once the valve adjustment is set. Remove the feeler gauge. Refer to **FIGURE 7–63.**

13. Install baffle assembly. Be sure that deflectors are securely attached to baffle. If necessary replace deflector using multi–purpose adhesive sealant.

CYLINDER HEAD REASSEMBLY

7.6.1.1 Valve Lash Adjustment Sequence

WITH	ADJUST VALVES											
No. 1 Piston at T.D.C. (Compression)	INT 1	EXH 2	INT 3			EXH 6	INT 7			EXH 10		
No. 6 Piston at T.D.C. (Compression)				EXH 4	INT 5			EXH 8	INT 9		INT 11	EXH 12

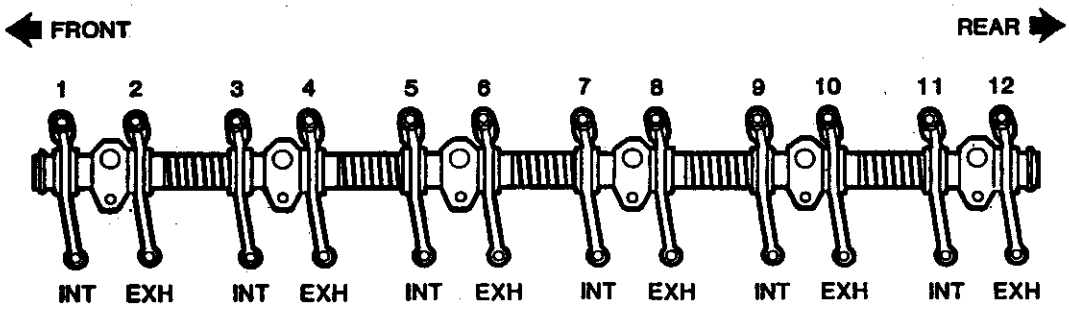


FIGURE 7–64

Six valves are adjusted when the #1 piston is at TDC (compression) and the remaining six are adjusted when the #6 piston is at TDC (compression). Refer to **FIGURE 7–64.**

1. Install gasket onto the cylinder head and align valve cover/intake manifold cover and gasket. Tighten valve cover/intake manifold mounting bolts to specified torque. See "Special Torque Values." Refer to **FIGURE 7–65.**

NOTE:
Be sure valve cover gasket is aligned before tightening.

2. Reinstall the following: (Refer to appropriate manual section for installation procedures.)

- ❑ Thermostat
- ❑ Exhaust manifold
- ❑ Turbocharger
- ❑ Fuel injection nozzles
- ❑ Fuel leak–off lines (low pressure)
- ❑ Injection lines (high pressure)

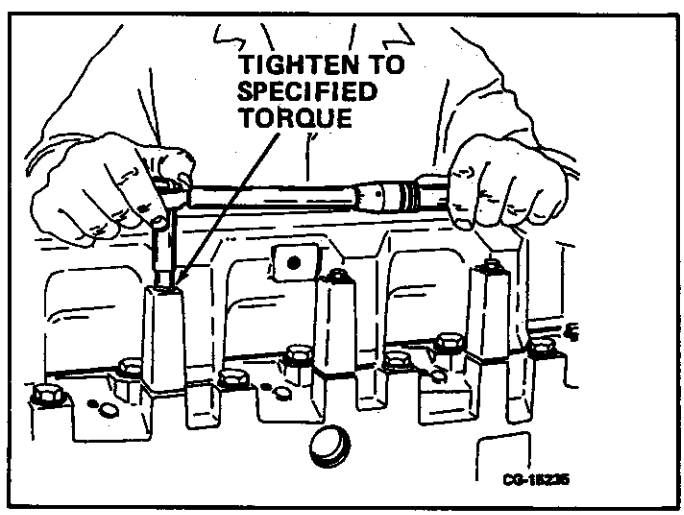


FIGURE 7–65

8 ROCKER ARM ASSEMBLY, CAMSHAFT, TAPPETS & PUSH RODS

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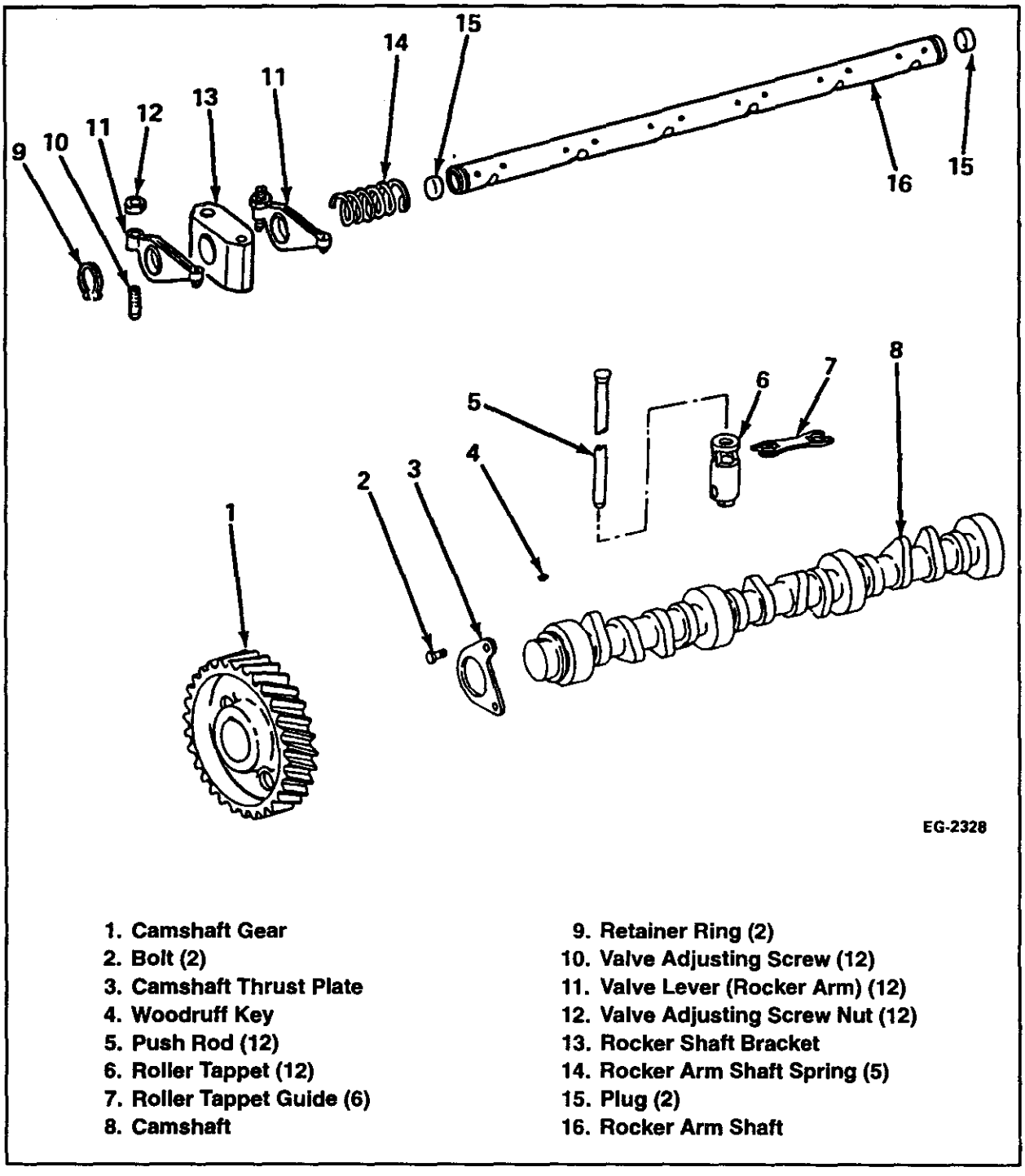
8.1 ROCKER ARM ASSEMBLY, CAMSHAFT, TAPPETS AND PUSH RODS EXPLODED VIEW



1. Camshaft Gear
2. Bolt (2)
3. Camshaft Thrust Plate
4. Woodruff Key
5. Push Rod (12)
6. Roller Tappet (12)
7. Roller Tappet Guide (6)
8. Camshaft
9. Retainer Ring (2)
10. Valve Adjusting Screw (12)
11. Valve Lever (Rocker Arm) (12)
12. Valve Adjusting Screw Nut (12)
13. Rocker Shaft Bracket
14. Rocker Arm Shaft Spring (5)
15. Plug (2)
16. Rocker Arm Shaft

FIGURE 8–1 Rocker Arm Assembly, Camshaft, Tappets and Push Rods (Exploded View).

8.2 SPECIFICATIONS

DIMENSION	VALUES
CAMSHAFT	
Cam Lobe Lift (Total):	
Intake	0.3177 in. (8.070 mm)
Exhaust	0.2901 in. (7.369 mm)
Maximum Permissible Cam Lobe Wear	0.020 in. (0.51 mm)
Camshaft Running Clearance	0.002 in. (0.05 mm)/0.007 in. (0.18 mm)
Maximum Permissible Camshaft Running Clearance	0.008 in. (0.20 mm)
Bushing I.D. (Installed in Crankcase)	2.2845 in. (58.026 mm)/ 2.2880 in. (58.115 mm)
Bushing Journal Diameter	2.2814 in. (57.948 mm) /2.2825 in. (57.976 mm)
Service Bushings Furnished to Size	Yes
Thrust Plate Thickness (New)	0.274 in. (6.96 mm)/0.276 in. (7.01 mm)
End Clearance	0.005 in. (0.13 mm)/0.013 in. (0.33 mm)
VALVE LEVER AND SHAFT ASSEMBLY	
Valve Lever Shaft Diameter	0.8491 in. (21.567 mm)/ 0.8501 in. (21.593 mm)
Valve Lever Clearance on Shaft	0.0019 in. (0.048 mm)/ 0.0049 in. (0.124 mm)
Valve Lever Bushing (I.D.)	0.852 in. (21.64 mm)/0.854 in. (21.69 mm)
Bracket Orifice I.D.	0.042 in. (1.07 mm)
TAPPETS ROLLER	
Diameter	1.1195 in. (28.435 mm)/ 1.1200 in. (28.448 mm)
Length	2.923 in. (74.24 mm)/2.953 in. (75.01 mm)
Side Clearance (Roller to Tappet Body)	0.012 in. (0.30 mm)/0.026 in. (0.66 mm)
Tappet Clearance in Crankcase	0.0025 in. (0.064 mm)/ 0.0040 in. (0.102 mm)

SPECIFICATIONS

DIMENSION	VALUES
PUSH ROD	
Length	10.5898 in. (268.980 mm)/ 10.6198 in. (269.743 mm)*
Maximum Run–Out (T.I.R.)	0.020 in. (0.51 mm)
VALVE LEVER SHAFT SPRINGS	
Number of Springs	5
Free Length	4.06 in. (103.1 mm)
Test Length	2.07 in. (52.6 mm)
Test Load	7 lbs (31 N)
O.D	1.02 in. (25.9 mm)

* Length is measured over 0.3125 inch diameter gauge ball to theoretical end of ball.

8.2.1 Special Service Tools

TOOL NO	DESCRIPTION
J39537	Camshaft Bushing Service Set
J41167	Lower Idler Gear Socket (3/4 inch Drive 20 mm 12 Point)
J22738–02	Valve And Clutch Spring Tester

8.2.2 Special Torque Values

Camshaft Thrust Plate Bolt	19 lb·ft or 228 lb·in. (26 N·m)

8.3 ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

First remove the crankcase breather tube. Refer to the appropriate manual section for removal procedures.

NOTICE: **The rocker arm assembly cannot be removed and reinstalled without complete removal of the cylinder head. Removal of the six cylinder head bolts may break the cylinder head gasket seal. To insure the proper gasket seal, a new cylinder head gasket should be installed and all cylinder head bolts be torque sequenced as outlined in Section 7.**

1. Remove valve lever (rocker arm) assembly as follows: (Refer to **FIGURE 8–2.**)

   a. Loosen valve lever (rocker arm) adjusting screw nuts to loosen adjusting screw 1/2 turn.

NOTE:

Loosening valve lever (rocker arm) adjusting screw 1/2 turn will avoid possible valve train damage during installation.

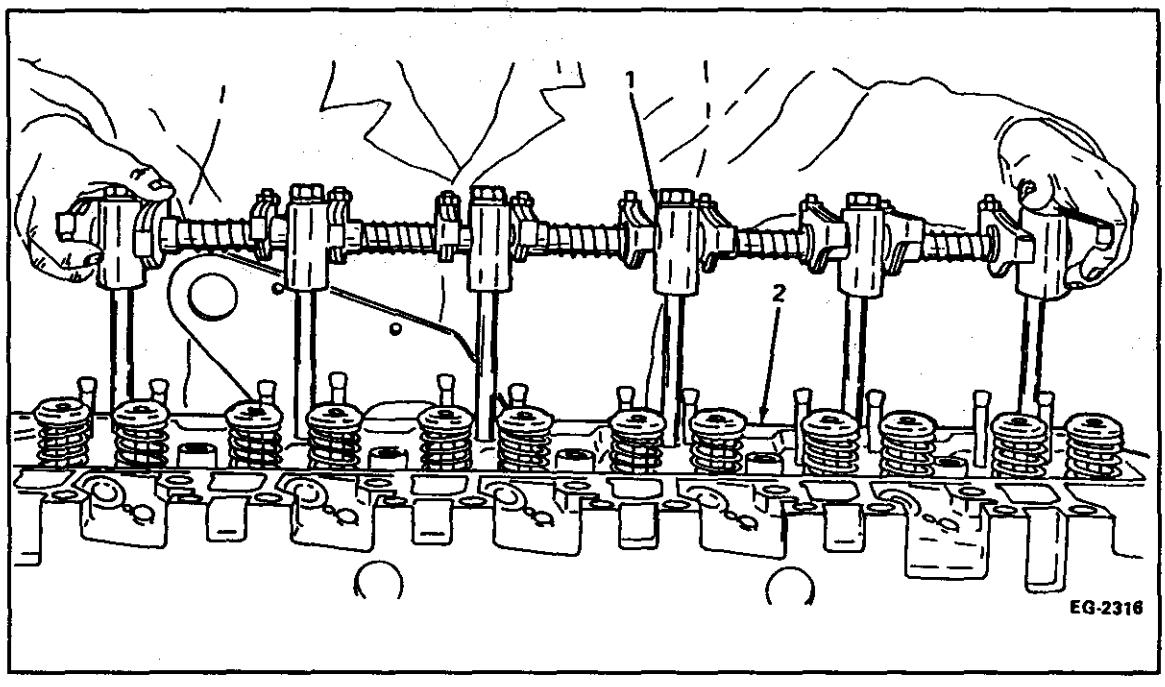
   b. Loosen valve lever (rocker arm) bracket bolts (long cylinder head bolts).

   c. Lift valve lever (rocker arm) assembly from the cylinder head.

2. Remove six long bolts and washers from valve lever (rocker arm) assembly and set aside.

NOTE:

At this stage of disassembly, measure camshaft lobe lift. Refer to "Camshaft" in this section for camshaft lobe lift measurement procedure.



1. **Rocker Shaft Bracket**
2. **Cylinder Head**

FIGURE 8–2

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

8.3.1 Measure Camshaft Lobe Lift

NOTE:
Camshaft wear can be measured without complete engine tear down. With the rocker arm assembly removed and the push rods in place, measure camshaft lobe lift as follows:

1. Mount a magnetic base dial indicator on the cylinder head.
2. Place dial indicator tip on top of push rod and rotate engine until push rod is at its lowest point of travel (base circle). Then "zero" indicator. Refer to **FIGURE 8–3** for step one.
3. Rotate the engine and bring the push rod to its highest point of travel. Record the indicator reading. Refer to **FIGURE 8–4** for step two.
4. Repeat this procedure for all lobes.

NOTICE: **Intake and exhaust valve lobe lift specifications are different. If wear is greater than 0.020 in. (0.51 mm), replace the camshaft.**

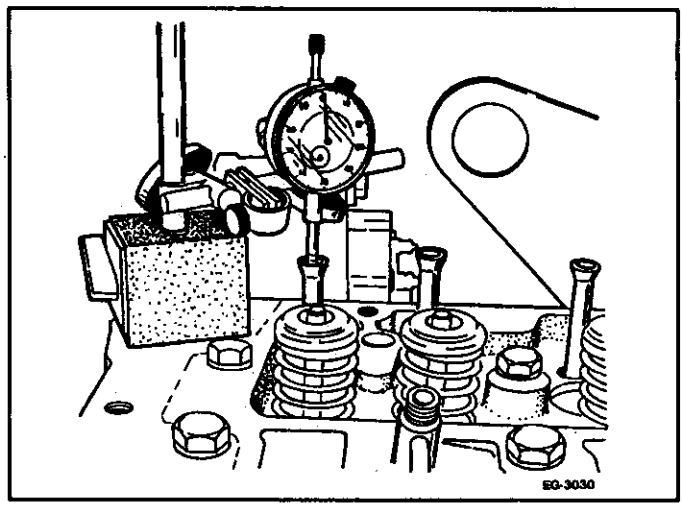


FIGURE 8–3

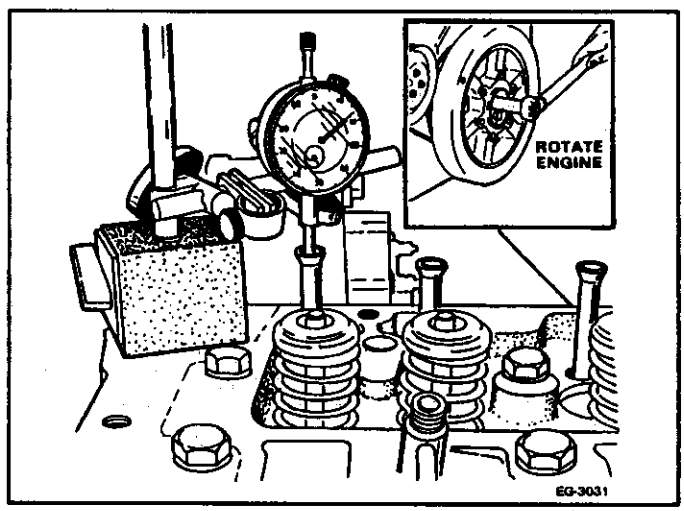


FIGURE 8–4

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

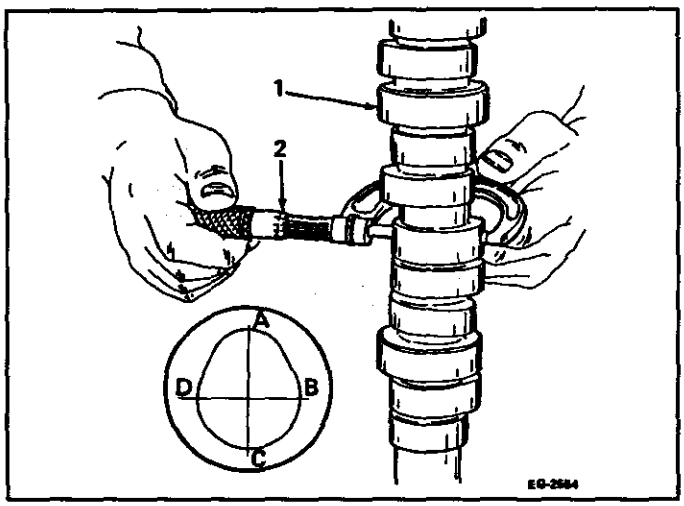


FIGURE 8–5

NOTE:

If a complete engine overhaul is scheduled, camshaft lobe wear can be determined by measuring lobes with a micrometer when the camshaft is removed (FIGURE 8–5). Refer to "Camshaft Cleaning and Inspection" in this section for details.

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

8.3.2 Disassembly

1. Place valve lever (rocker arm) assembly on a clean flat surface.
2. Using a snap ring tool, remove valve lever (rocker arm) retainer ring at end of shaft. Refer to **FIGURE 8–6.**
3. Slide the rocker arm components off shaft as shown in **FIGURE 8–7.**

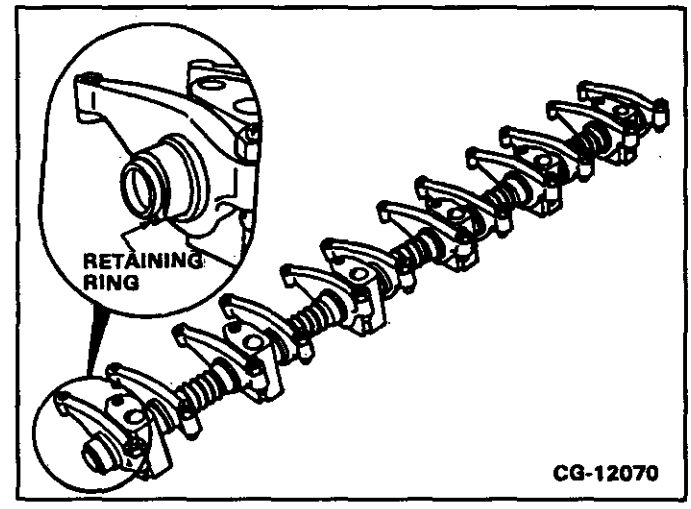
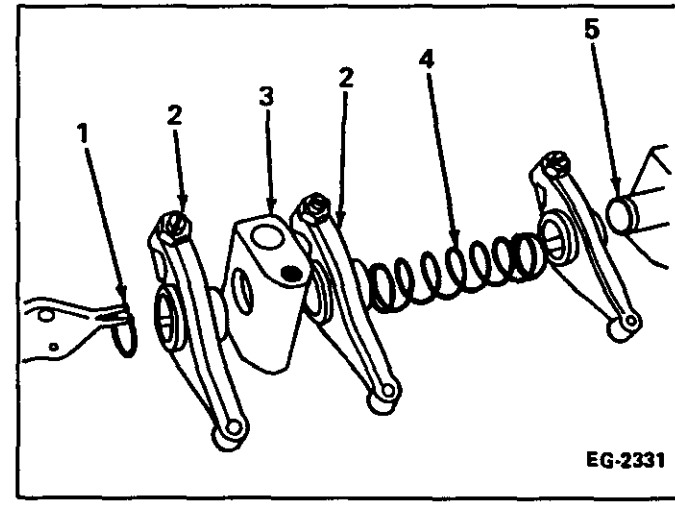


FIGURE 8–6

8.3.2.1 Cleaning and Inspection

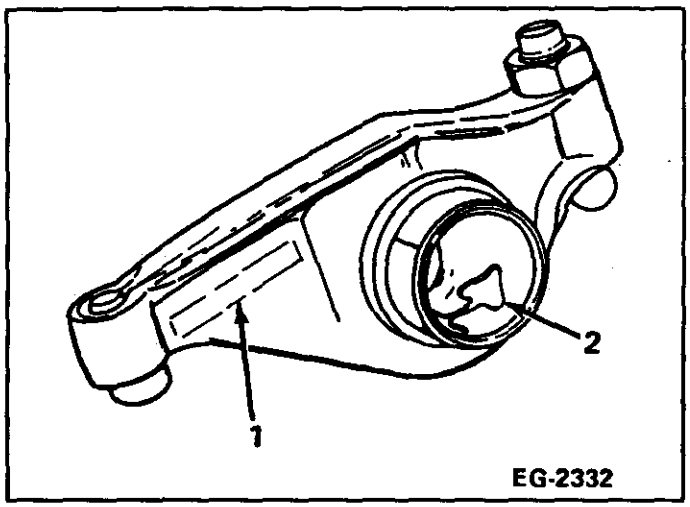
1. Immerse all components in a suitable solvent.
2. Remove and dry using filtered compressed air.
3. Visually inspect valve lever (rocker arm) shaft and rocker arm bushings for scoring or signs of excessive wear. If visibly damaged, replace shaft and/or valve lever (rocker arm), as required.



1. **Retaining Ring**
2. **Valve Lever**
3. **Bracket**
4. **Spring**
5. **Shaft**

FIGURE 8–7

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY



1. **Part Number Location**
2. **Oil Spreader Groove**

FIGURE 8–8

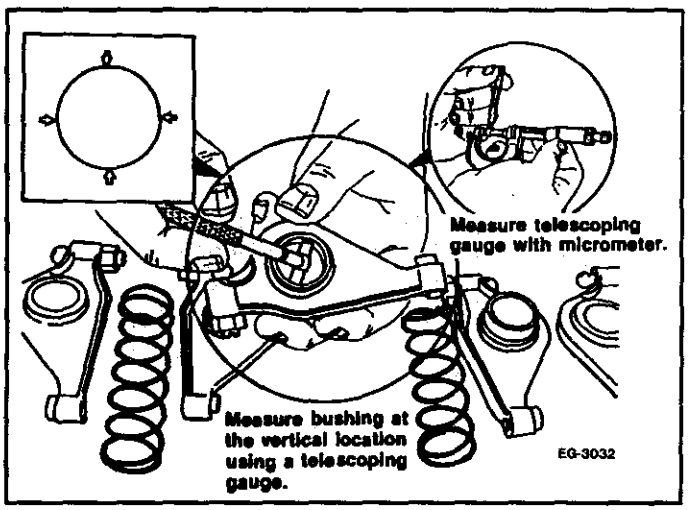


FIGURE 8–9

NOTE:

Valve levers have an oil spreader groove on the bushing. The oil spreader groove (0.011in. – 0.018 in. [0.028–0.046 mm] depth), located opposite the oil hole, aids in oil dispersion over the entire bushing surface. Refer to FIGURE 8–8.

4. Measure valve lever bushings using a telescoping gauge and outside micrometer as shown in **FIGURE 8–9**. Measure bushings at two locations and record readings.
5. Measure the valve lever shaft with a micrometer. If more than 0.005 in. (0.13mm) difference is found between the valve lever bushing I.D. and the valve lever shaft O.D., replace the valve lever and/or shaft; whichever part is worn.

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

6. If valve levers are within specifications, they may be reused. Prior to assembly, assure oil hole in valve levers and bushings is open by running a wire through oil hole. Remove any blockage before reassembly. Refer to **FIGURE 8–10.**
7. Inspect all valve lever shaft bracket orifices for blockage. Run a wire through each to assure they are open. Refer to **FIGURE 8–11.**
8. Inspect rocker arm shaft springs as follows:
   a. Visually inspect for rust, pitting and cracks. Replace as required.
   b. Measure free length (no load applied).

Replace rocker arm shaft springs which do not meet "Specifications".

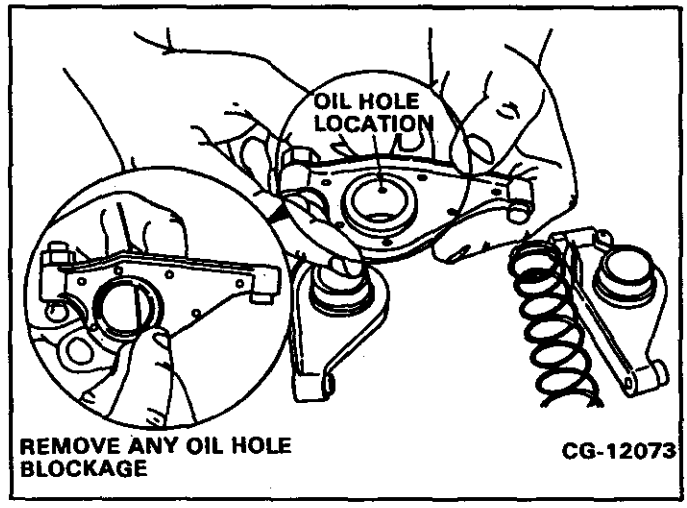
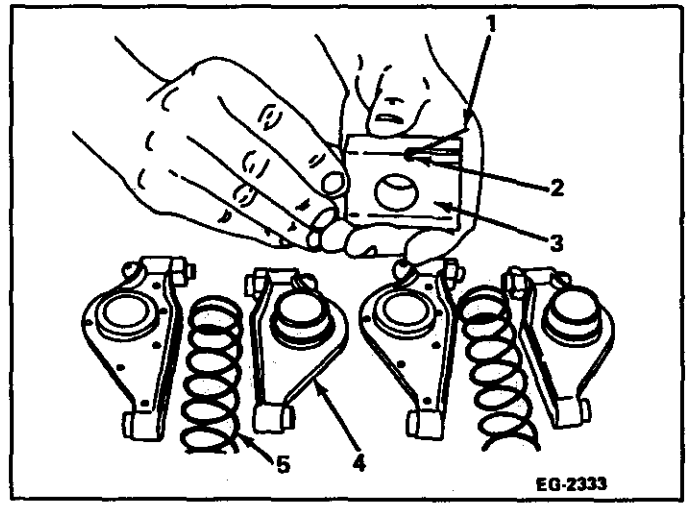


FIGURE 8–10



1. **Cleaning Wire**
2. **Orifice**
3. **Bracket**
4. **Valve Lever**
5. **Spring**

FIGURE 8–11

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

8.3.3 Reassembly

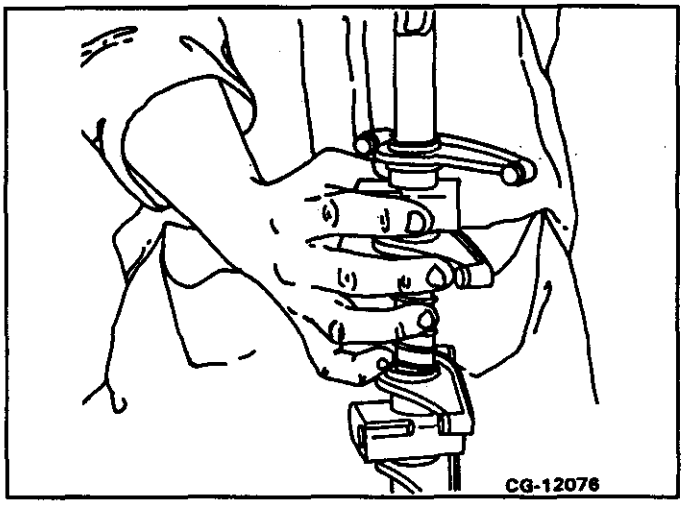
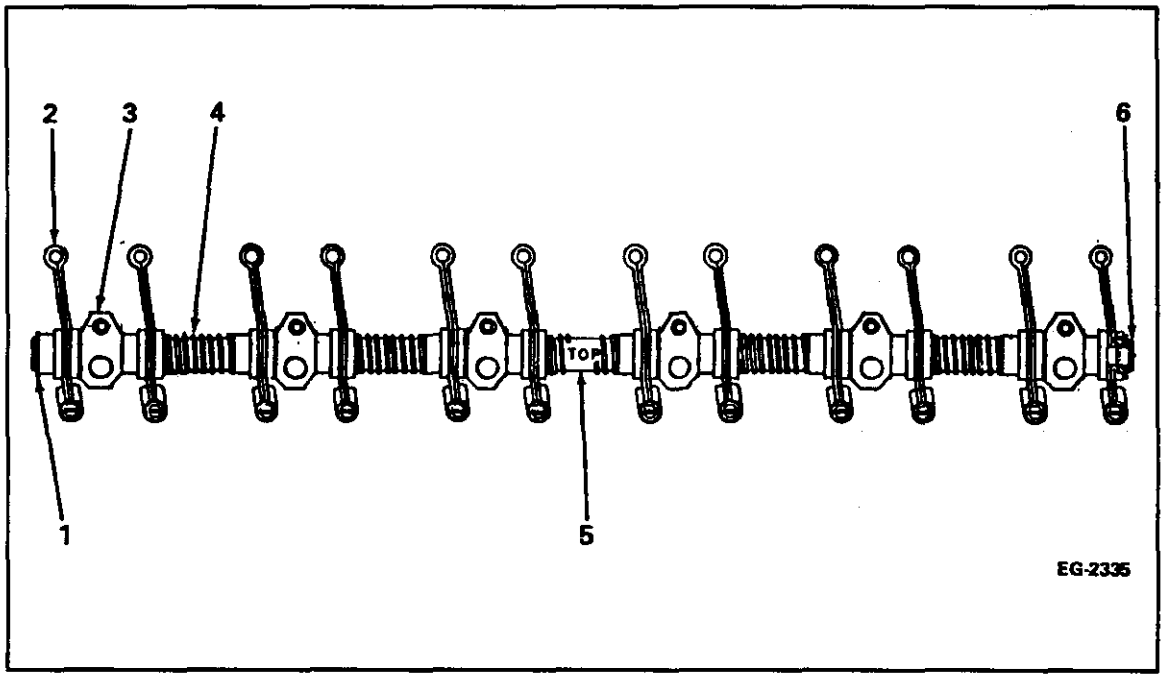


FIGURE 8–12

1. Lubricate all valve lever bushings with clean engine oil, install a retaining ring at one end of shaft and assemble components with rocker arm shaft in the vertical position. Refer to **FIGURE 8–12.**
2. Arrange valve lever assembly components as shown in **FIGURE 8–13.**



1. **Retaining Ring**
2. **Valve Lever**
3. **Bracket**
4. **Spring**
5. **Shaft**
6. **Cup Plug**

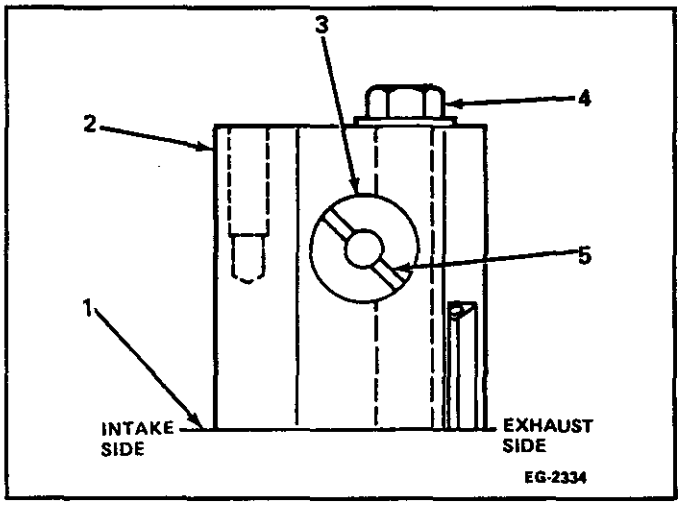
FIGURE 8–13

ROCKER ARM REMOVAL, DISASSEMBLY AND REASSEMBLY

NOTE:

The valve lever shaft is marked with the word "TOP". This should face up at all times. The brackets must line up over the shaft bolt grooves. An end view position of shaft to bracket is shown in FIGURE 8–14.

3. When all components are placed on the valve lever shaft, in the correct order, install the second retaining ring to secure the components. Refer to **FIGURE 8–15**.



1. Cylinder Head
2. Bracket
3. Rocker Arm Shaft
4. Mounting Bolt
5. Shaft Hole Position

FIGURE 8–14

NOTE:

Cup plugs (at each end of the shaft) are replaceable. Refer to Figure 5.13. Do not disturb unless damaged, leaking, hard part failure or contaminated oil. If replacement is required, pry damaged plug out and press in a new cup plug.

NOTICE: **The rocker arm assembly cannot be removed and reinstalled without complete removal of the cylinder head. Removal of the six cylinder head bolts may break the cylinder head gasket seal. To insure the proper gasket seal, a new cylinder head gasket should be installed and all cylinder head bolts be torque sequenced as outlined in Section 7.**

1. Install the valve lever assembly as outlined in Section 7.
2. Adjust valve lash as outlined in Section 7.
3. Reinstall the valve cover/intake manifold assembly.
4. Reinstall the crankcase breather tube.

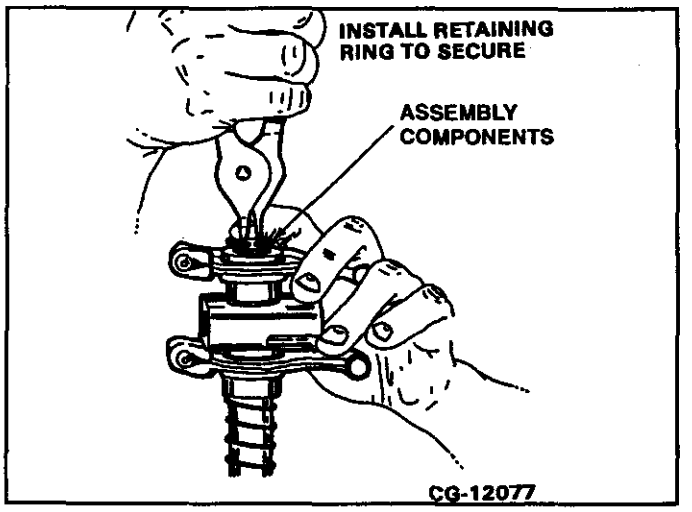


FIGURE 8–15