Loose or improperly seated injector tubes may result in compression leaks into the cooling system and also result in loss of engine coolant. The tubes must be tight to be properly seated. Refer to Section 2.14.

If a coolant leak develops at an injector hole tube, swaging tool J 28611 may be used to repair the leak without removing the cylinder head. Pressurize the cooling system at the radiator to verify existence of the leak. Then remove the injector and insert the tool in the injector tube. Strike the tool moderately two or three times with a one pound hammer. This will expand the top edge of the tube, increasing the "crush" on the seal ring. Install the injector and pressurize the cooling system again to determine if the leak has been stopped.

Overtightened injector clamp bolts may also cause head cracks. Always use a torque wrench to tighten the bolts to the specified torque.

Other conditions which may eventually result in cylinder head cracks are:

1. Excess fuel in the cylinders caused by leaking injectors.

2. Slipping fan belts can cause overheating by reducing air flow through the radiator.

3. Accumulation of dirt on the radiator core which will reduce the flow of air and slow the transfer of heat from the coolant to the air.

4. Inoperative radiator cap which will result in loss of coolant.

Remove Cylinder Head

Certain service operations on the engine require removal of the cylinder head:

1. Remove and install pistons.

2. Remove and install cylinder liners.

3. Remove and install exhaust valves.

4. Remove and install exhaust valve guides.

5. Recondition exhaust valves and valve seat inserts.

6. Replace fuel injector tubes.

7. Install new cylinder head gaskets and seals.

8. Remove and install camshaft.

Due to the various optional and accessory equipment used, only the general steps for removal of a cylinder head are covered. If the engine is equipped with accessories that affect cylinder head removal, note the position of each before disconnecting or removing them to ensure correct re-installation. Then remove the cylinder head as follows:

1. Drain the cooling system.

2. Disconnect the exhaust piping at the exhaust manifold. On turbocharged engines, remove the connections from the exhaust manifold to the turbocharger. Remove the turbocharger, if necessary.

3. Disconnect the fuel lines at the cylinder head.

4. Loosen the hose clamps and remove the hose attached to the thermostat housing cover.

5. Loosen the hose clamps at each end of the water bypass tube and remove the tube.

6. Remove the thermostat housing assembly.

7. Clean and remove the valve rocker cover and governor cover.

8. Disconnect the fuel rod from the injector control tube lever and the governor. Remove the fuel rod.

9. Loosen the fuel rail cover hose clamps. Then slide the hose up on the fuel rail cover toward the governor.

10. Remove the exhaust manifold.

11. Remove the water manifold, if used.

12. Remove the injector control tube and brackets as an assembly.

13. If the cylinder head is to be disassembled for reconditioning of the exhaust valves and valve seat inserts or for a complete overhaul, remove the fuel pipes and injectors at this time. Refer to Section 2.3 for removal of the injectors.

14. Check the torque on the cylinder head bolts before removing the head. Then remove the bolts and washers and lift the cylinder head from the cylinder block with tool J 22062-01 (Fig. 5). If interference is encountered between the rear end of the right-bank cylinder head and any of the flywheel mounting bolts, loosen the bolts. Checking the torque before removing the head bolts and examining the condition of the compression gaskets and seals after the head is removed may reveal the causes of any future gasket problems.

NOTE: When removing the cylinder head assembly on a vehicle, protect the cam followers

Inspect Cylinder Head

1. Pressure check the cylinder head as follows:

a. Seal off the water holes in the head with steel plates and suitable rubber gaskets secured in place with bolts and washers as shown in Fig. 6. Drill and tap one of the cover plates for an air hose connection.

b. Install scrap or dummy injectors to ensure proper seating of the injector tubes. Dummy injectors may be made from old injector nuts and bodies -- the injector spray tips are not necessary. Tighten the injector clamp bolts to 20-25 lb-ft (27-34 Nm) torque.

c. Apply 40 psi (276 kPa) air pressure to the water jacket. Then immerse the cylinder head in a tank of water, previously heated to 180-200 °F (82-93 °C), for about twenty minutes to thoroughly heat the head. Observe the water in the tank for bubbles which indicate a leak or crack. Check for leaks at the top and bottom of the injector tubes, oil gallery, exhaust ports, fuel manifolds and at the top and bottom of the cylinder head.

d. Relieve the air pressure and remove the cylinder head from the water tank. Then remove the plates, gaskets and injectors and dry the head with compressed air.

e. If the pressure check revealed any cracks, install a new cylinder head.

2. Check the bottom (fire deck) of the cylinder head for flatness:

a. Use a heavy, accurate straight-edge and feeler gages, tool J 3172, to check for transverse warpage at each end and between all cylinders. Also check for longitudinal warpage in six places as shown in Fig. 7. Refer to Table 1 for maximum allowable warpage.

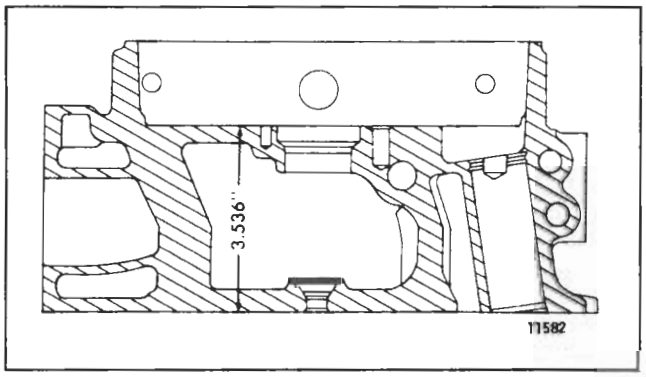

Fig. 8 - Minimum Distance Between Top and Bottom Faces of Cylinder Head

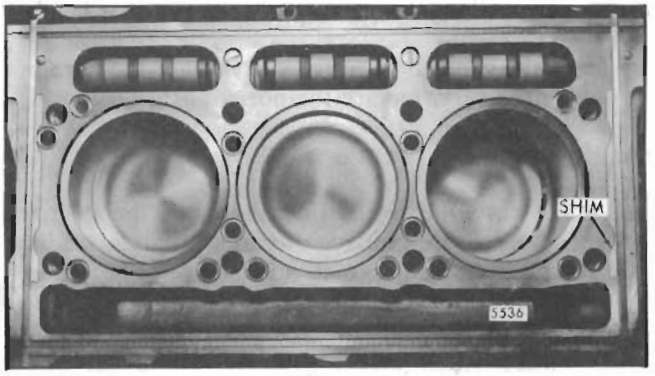

Fig. 9 - Cylinder Head Support Shims in Place

b. Use the measurements obtained and the limits given in Table 1 as a guide to determine the advisability of re-installing the head on the engine or of refacing it. The number of times a cylinder head may be refaced will depend upon the amount of stock previously removed.

c. If the cylinder head is to be refaced, remove the injector tubes prior to machining. Do not remove more than .020 " (total) of metal from the fire deck of any cylinder head. The distance from the top deck to the bottom (fire deck) of the cylinder head must not be less than 3.536 " (Fig. 8). Stamp the amount of stock removed on the face of the fire deck near the outer edge of the head, in an area not used as a sealing surface.

NOTE: When a cylinder head has been refaced, critical dimensions such as the protrusion of valve seat inserts, exhaust valves, injector tubes and injector spray tips must be checked and corrected. The push rods must also be adjusted to prevent the exhaust valves from striking the pistons after the cylinder head is re-installed in the engine. Also, de-burr the water nozzles.

3. Install new injector tubes (Section 2.1.4) if the old tubes leaked or the cylinder head was refaced.

4. Inspect the exhaust valve seat inserts and valve guides (refer to Section 1.2.2).

5. Inspect the cam follower bores in the cylinder head for scoring or wear. Light score marks may be cleaned up with crocus cloth wet with fuel oil. Measure the bore diameters with a telescope gage and micrometer and record the readings. Measure the diameter of the cam followers with a micrometer, record and compare the readings of the cam followers and bores to determine the follower-to-bore clearances (refer to Section 1.0). The cam follower- to-cylinder head clearance must not exceed .006 " with used parts (refer

to Section 1.0 for specifications). If the bores are excessively scored or worn, replace the cylinder head.

6. Check the water hole nozzles to be sure they are not loose. If necessary, replace the nozzles as follows:

a. Remove the old nozzles.

b. Make sure the water inlet ports in the cylinder head are clean and free of scale. The intermediate nozzle holes are reamed and must not be cleaned with a drill. This could result in leakage of water into the lubricating oil. Use a soft bristle brush to clean the intermediate water nozzle holes.

c. Install new nozzles with installing tool J 24857.

d. Figure 4 shows the location and position of the nozzles in the cylinder head. The nozzles must be .004 " recessed to flush with the bottom face of the cylinder head and the sealing area of the cylinder head around the nozzles flat within .002 ".

7. Replace broken or damaged studs. Apply sealant to the threads of new studs and drive them to 10-25 lb-ft (14-34 Nm) torque (water manifold cover studs) or to 25-40 lb-ft (34-54 Nm) torque (exhaust manifold studs).

8. Pilot sleeves are used in the mounting bolt hole at each end of the cylinder head (on the camshaft side of the head). Make sure the sleeves are flush or recessed below the fire deck of the cylinder head. Replace damaged sleeves. The sleeves, which act as a hollow dowel to provide a closer fit between the mounting bolts and the cylinder head, help to guide the head in place without disturbing the seals and gaskets.

9. Inspect all other components removed from the cylinder head.

If a service replacement cylinder head is to be installed, it must be thoroughly cleaned of all rust preventive compound, particularly inside the integral fuel manifolds, before installing the plugs. A simple method of removing the rust preventive compound is to immerse the head in mineral spirits or fuel oil, then scrub the head and go through all of the openings with a soft bristle brush. A suitable brush for cleaning the various passages in the head can be made by attaching a 1/8 " diameter brass rod to brush J 8152. After cleaning, dry the cylinder head with compressed air.

A service replacement cylinder head includes the exhaust valve guides, valve seat inserts, water nozzles, injector tubes, pilot sleeves, bridge guides, valve spring seats and the necessary plugs. In addition, shims strips, studs, cover plates, gaskets, lock washers and nuts are provided to seal the water outlet openings that are not required on certain engines. A length of flexible fuel hose and fittings are also included where required.

Assemble Cylinder Head

After cleaning and inspection, assemble the cylinder head as follows:

1. Refer to the *Cylinder Head Plugging Chart* shown as a fold-out at the end of this manual and install the necessary plugs and tighten them to the specified torque (Section 1.0). Drive headless plugs flush to .0625 " below the surface of the cylinder head. The 3/8 " socket head oil gallery plug, at each end of the head, must not protrude more than .0625 ", and a .2187 " diameter rod placed in the vertical oil feed hole must pass the inner face of the plug.

NOTE: Coat the threads of the plugs with Loctite Pipe Sealant with Teflon.

2. After the following parts are cleaned and inspected, and replaced if necessary, re-install them in the old cylinder head or transfer them to the new head.

a. Exhaust valves, valve seat inserts and springs (Section 1.2.2).

b. Cam followers, guides, push rods, springs, retainers, rocker arms, shafts, brackets and other related parts (Section 1.2.1).

c. Place new washers on the fuel connectors. Then install the connectors and tighten them to 40-45 lb-ft (54-61 Nm) torque.

d. The fuel injectors, fuel pipes, injector control tube assembly and water manifold, if used, can be installed at this time or after the cylinder head is installed on the engine.

Pre-Installation Inspection

Make the following inspections just prior to installing the cylinder head whether the head was removed to service only the head or to facilitate other repairs to the engine.

1. Check the cylinder liner flange heights with relationship to the cylinder block (Section 1.6.3).

2. Make sure the piston crowns are clean and free of foreign material.

3. Make sure that each push rod is threaded into its clevis until the end of the push rod projects through the clevis. This is important since serious engine