CRANKSHAFT OIL SEALS

An oil seal is used at each end of the crankshaft to prevent the lubricating oil from escaping from the crankcase. The seals also provide protection against the entrance of dirt, dust, mud or oil from the external portion of the engine (Figs. 1 and 2).

The front oil seal is pressed into the lower front cover on In-line and 6V engines. The seal is pressed into the front cover on early 8V engines; effective with engine 8D-149, the seal is pressed into the outboard bearing support.

A single-lip oil seal is used at the rear end of the crankshaft of most industrial engines. A double-lip oil seal is used in all applications where oil is on both sides of the seal; the lips of the seal face in opposite directions. The rear oil seal is pressed into the flywheel housing.

Remove Crankshaft Oil Seals

1. Remove the engine front cover, outboard bearing or the flywheel housing and remove the oil seals as follows:

2. Support the forward face of the front cover, or the outboard bearing support, on two wood blocks next to the oil seal bore. Then press or drive the oil seal out of the front cover or the outboard bearing support. Discard the oil seal.

3. Support the forward face of the flywheel housing on In-line or 6V engines and the rear face of the flywheel housing on 8V engines on two wood blocks next to the oil seal bore. Then press or drive the oil seal out of the housing. Discard the oil seal.

4. Clean the oil seal bore in the front cover, outboard bearing support or flywheel housing thoroughly before installing a new oil seal.

When necessary, the crankshaft oil seals may be removed without removing the front cover, outboard bearing support or flywheel housing. This may be done by drilling diametrically opposite holes in the seal casing and threading metal screws, backed by flat washers, into the casing. Then the seal may be removed by prying against the washers with pry bars.

Inspection

Oil leaks indicate worn or damaged oil seals. Oil seals may become worn or damaged due to improper installation, excessive main bearing clearances, excessive flywheel housing bore runout, or grooved sealing surfaces on the crankshaft. To prevent a repetition of any oil seal leaks, these conditions must be checked and corrected.

Inspect the front and rear end of the crankshaft and the crankshaft front end oil seal sleeve (8V engines) for wear due to the rubbing action of the oil seal or dirt build-up.

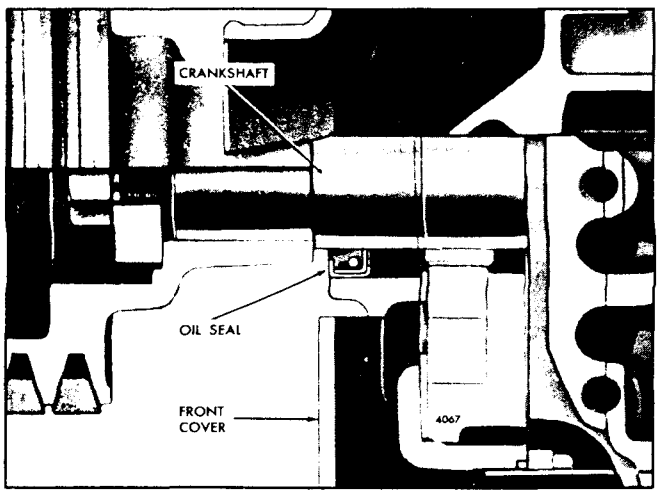

Fig. 1 - Crankshaft Front Oil Seal

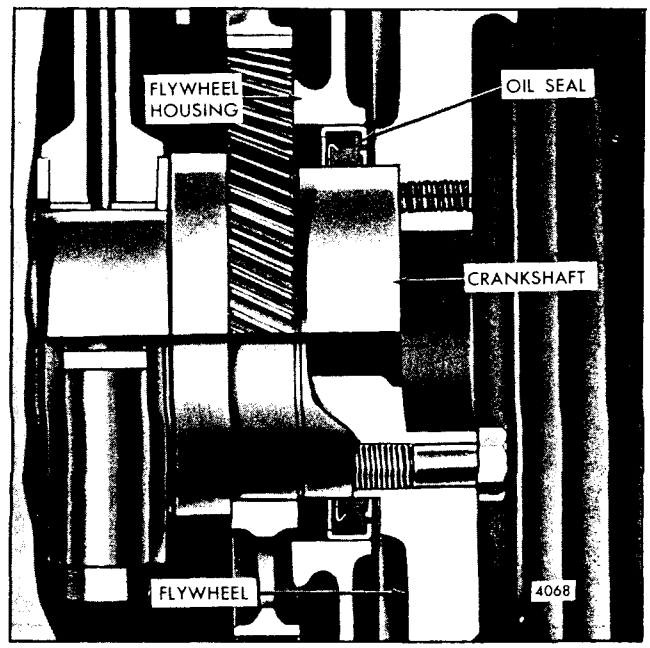

Fig. 2 - Crankshaft Rear Oil Seal (In-Line and 6V Engines)

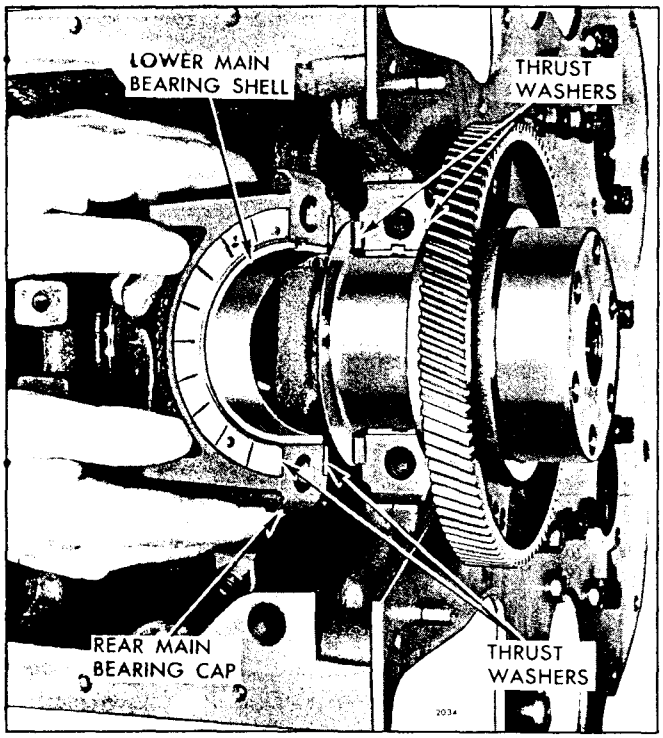

Fig. 9 - Crankshaft Thrust Washer Mounting

the cylinder block that carries the engine serial number.

3. With the lower bearing shells installed in the bearing caps, install the caps on an In-line engine, or caps and stabilizers on a V-type engine, in their original position. Lubricate the bolt threads and the bolt head contact areas with a small quantity of International Compound No. 2, or equivalent, and install them in the bearing caps. Draw the bolts up snug. Then, rap the caps sharply with a soft hammer to seat them properly and draw the bearing cap bolts uniformly tight, starting with the center cap and working alternately towards both ends of the block, to 120-130 lb-ft torque. On a V-type engine, tighten the stabilizer to cylinder block 7/16"-14 bolts to 46-50 lb-ft torque.

NOTE: If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

4. Check the crankshaft end play as outlined under *Install Crankshaft* in Section 1.3.

5. Install the lubricating oil pump intake pipe assembly.

6. Use a new gasket and install the oil pan.

7. Fill the crankcase to the proper level (indicated on the dipstick) with heavy-duty lubricating oil of the viscosity recommended (see *Lubricating Oil Specifications* in Section 13.3).

8. After installing new bearing shells, operate the engine on a run-in schedule as outlined in Section 13.2.1.

ENGINE FRONT COVER (Lower)

In-Line and 6V Engines

The engine lower front cover is mounted against the cylinder block at the lower front end of the engine (Figs. 1 and 2). It serves as a housing for the crankshaft front oil seal, the lubricating oil pump, the oil pressure regulator valve and the oil cooler by-pass valve. The clean-out openings in the periphery of the current cover incorporate tapped holes and 1/2 "-14 threaded plugs.

On all In-line and 6V engines effective with engine serial numbers 2D-13569 (except 2D-13592, 13597, 13622 and 13626), 3D-4295 (except 3D-4373), 4D-6027 and 6D-3858 (6D-3246, model 5063-5200), the oil pressure regulator valve is located on the right-hand side of the engine front cover, as viewed from the front of the engine. Prior to the above engine serial numbers, the oil pressure regulator valve was located on the left-hand side of the front cover just below the oil cooler by-pass valve.

Current 6V engines include a regulator valve with a non-replaceable stop swaged in the valve. When it becomes necessary to replace the regulator valve or plug in an early engine, both must be replaced together. Also, when the valve and plug in either side of the engine lower front cover needs to be replaced, the valve and plug in both sides of the cover must be replaced.

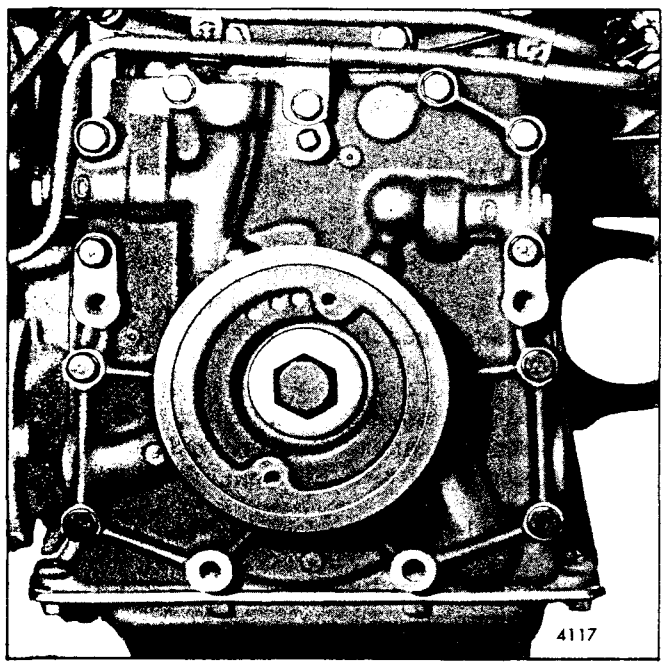

Fig. 1 - Engine Front Cover Mounting (Lower) -- In-Line Engine

Remove Engine Front Cover

1. Drain the oil and remove the oil pan.

2. Remove the crankshaft pulley as outlined in Section 1.3.7.

3. Remove the two bolts and lock washers that secure the lubricating oil pump inlet tube flange or elbow to the engine front cover.

4. Remove the bolts and lock washers that secure the engine front cover to the cylinder block.

5. Strike the cover with a soft hammer to free it from the dowels. Pull the cover straight off the end of the crankshaft.

6. Remove the cover gasket.

7. Inspect the oil seal and lubricating oil pump as outlined in Sections 1.3.2 and 4.1. Also check the oil pressure regulator valve and oil cooler by-pass valve as outlined in Sections 4.1.1 and 4.4.

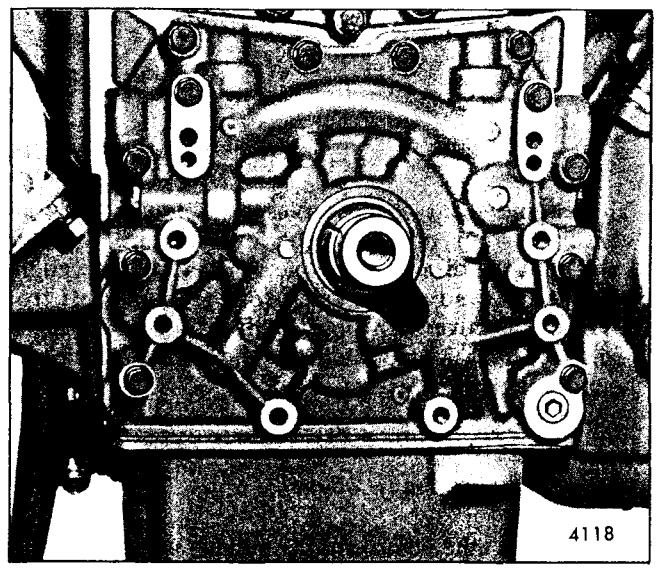

Fig. 2 - Engine Front Cover Mounting (Lower) -- 6V-Engine

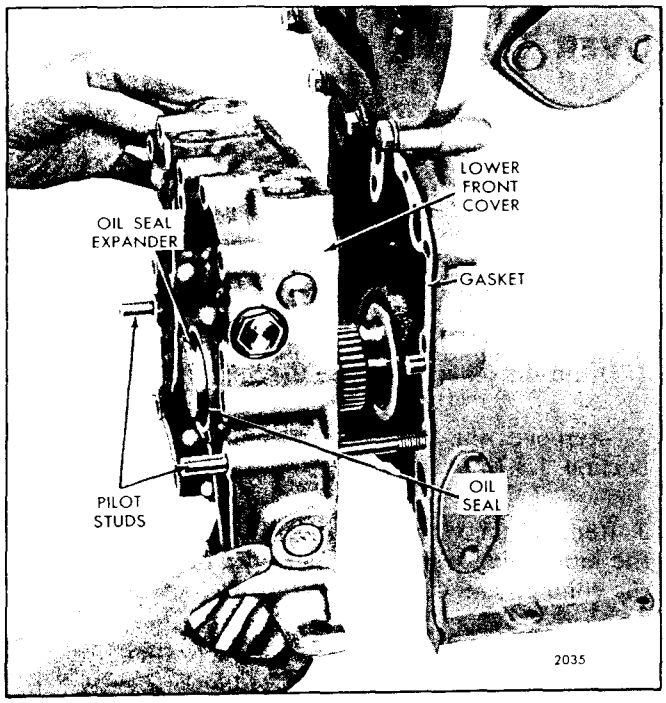

Fig. 3 - Installing Lower Engine Front Cover -- In-Line Engine

Install Engine Front Cover

1. Affix a new cover gasket to the cylinder block.

2. Install oil seal expander J 7454 over the front end of the crankshaft.

3. Thread two 3/8 "-16 pilot studs approximately 8 " long into two diametrically opposite bolt holes in the cylinder block to guide the cover in place (Fig. 3).

4. Apply a light coat of cup grease to the lip of the oil seal. Slide the engine front cover over the oil seal expander and pilot studs as shown in Fig. 3. Push the cover forward until the inner rotor of the oil pump contacts the pump drive gear on the crankshaft. Rotate the crankshaft slightly to align the teeth, then push the cover up against the gasket and block. Do not force the cover.

5. Remove the oil seal expander and pilot studs.

6. Refer to Figs. 1 and 2 and install the 3/8 "-16 bolts and lock washers. Tighten the bolts to 30-35 lb-ft torque.

7. Affix a new seal ring on the end of the lubricating oil pump inlet tube next to the flange on an In-line engine, or a new gasket to the elbow on a 6V-engine. Attach the flange or elbow to the front cover with bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

8. Affix a new oil pan gasket to the bottom of the cylinder block, then install and secure the oil pan to the block with bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

9. Install the crankshaft pulley as outlined in Section 1.3.7.

10. Refer to *Lubricating Oil Specifications* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

ENGINE FRONT COVER

8V Engine

The engine front cover serves as a housing for the camshaft front oil seals, the oil pressure regulator valve and the oil cooler by-pass valve. Prior to engine 8D-149, it served as a housing for the crankshaft front oil seal. Effective with engine 8D-149, the crankshaft front oil seal is mounted in the outboard bearing support assembly (Section 1.3.5.1).

Remove Engine Front Cover

1. Remove the crankshaft pulley as outlined in Section 1.3.7.

2. Remove the pulleys from the front ends of the camshafts as outlined in Section 1.7.

3. Remove the engine front cover, including the engine front trunnion and/or outboard bearing support assembly, if used, (Section 1.3.5.1).

4. Remove and discard the cover gaskets.

5. Remove and discard the oil seals.

6. Check the oil pressure regulator and oil cooler by-pass valves as outlined in Section 4.1.1.

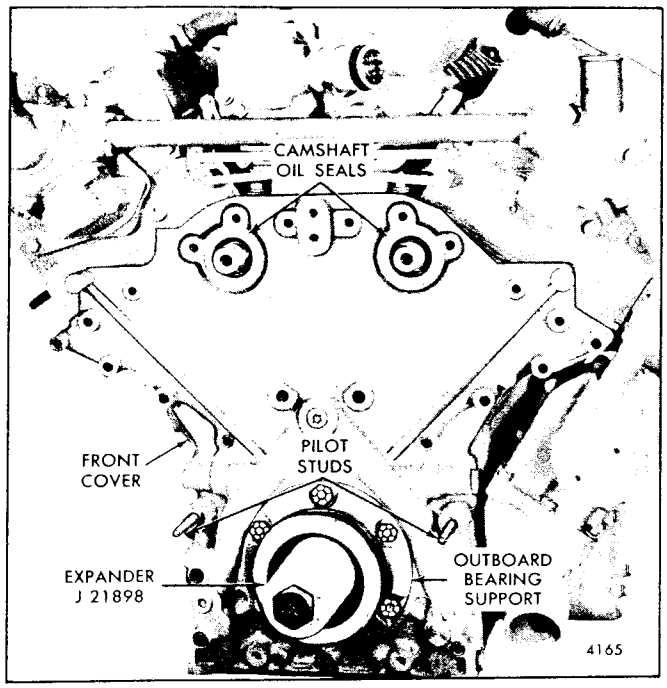

Fig. 4 - Installing Engine Front Cover - 8V-Engine

Install Engine Front Cover

CURRENT ENGINES (effective with 8D-149):

1. Install the camshaft oil seals, if removed, with installer J 21899.

2. Affix new front cover gaskets to the cylinder block.

3. Install two pilot studs (Fig. 4) into diametrically opposite bolt holes in the cylinder block to guide the engine front cover in place.

4. Slide the front cover over the pilot studs.

5. Remove the pilot studs and install the front cover attaching bolts and lock washers. Tighten the bolts to 30-35 lb-ft torque.

6. Install the outboard bearing support on the engine front cover as follows:

a. Install oil seal expander J 21898 (Fig. 4) over the end of the crankshaft. Then apply a light coat of cup grease to the lip of the oil seal and install the outboard bearing support over the oil seal expander and against the engine front cover. Remove the seal expander.

b. Install the six attaching bolts. Hold the outboard bearing support in a downward position with light hand pressure when tightening the bolts. First snug all the bolts, then tighten them to 75-85 lb-ft torque.

c. Check the outboard bearing-to-crankshaft clearance with a feeler gage. The clearance must not be less than .0035 " or more than .008 " with the bearing support in the downward position.

d. Install the front trunnion, if used.

7. Install the crankshaft front sleeve, if used.

8. Install the crankshaft pulley as outlined in Section 1.3.7.

9. Install the camshaft pulleys as outlined in Section 1.7.

FORMER ENGINES (prior to 8D-149):

1. Install the camshaft oil seals, if removed, with installer J 21899.

2. Install the crankshaft front oil seal as outlined in Section 1.3.2.

3. Affix new front cover gaskets to the cylinder block.

4. Install the oil seal expander J 21898 over the end of the crankshaft.

5. Install two pilot studs into diametrically opposite bolt holes in the cylinder block.

6. Apply a light coat of cup grease to the lip of the oil seal and guide the front cover over the pilot studs and against the cylinder block.

7. Install the front cover attaching bolts and lock washers and tighten the bolts to 30-35 lb-ft torque.

8. Remove the oil seal expander and the pilot studs.

9. Install the crankshaft front sleeve, if used.

10. Install the crankshaft pulley as outlined in Section 1.3.7.

11. Install the camshaft pulleys as outlined in Section 1.7.

CRANKSHAFT OUTBOARD BEARING SUPPORT

8V Engines

The crankshaft outboard bearing support (Fig. 1) houses the crankshaft front outboard bearing (bushing) and the crankshaft front oil seal. The support is a one-piece casting which bolts directly to the engine front cover, providing easy access for removing and installing the oil seal and bearing. A seal ring is used between the bearing support and the engine front cover.

The bearing is pressure lubricated by oil from an internal oil passage in the crankshaft.

The bearing support must be removed when replacement of the bearing or crankshaft oil seal is required.

Remove Outboard Bearing Support

1. Remove the crankshaft pulley (Section 1.3.7).

2. Remove the front trunnion (Fig. 1), if used.

3. Remove the six attaching bolts and detach the bearing support from the engine front cover.

4. Remove and discard the seal ring.

Inspection

Oil leaks are indications of worn or damaged seals.

Inspect the oil seal sleeve for wear due to the rubbing action of the oil seal or dirt build-up. The sleeve must be smooth and clean, otherwise the oil seal lip will be damaged when a new seal is installed.

The oil seal sleeve may be smoothed up with emery cloth and polished with crocus cloth wet with fuel oil. Clean up the circumference of the sleeve without disturbing the concentricity.

Excessive wear or grooving in the crankshaft oil seal sleeve may require the use of a new sleeve (refer to Section 1.3.2).

Inspect the bearing for scoring or excessive wear. The crankshaft to bearing clearance with new parts is .0035 " to .0071 " and a maximum of .0080 " with used parts. The crankshaft journal diameter (new) is 2.8770 " to 2.8780 ".

Install Outboard Bearing Support

1. If the bearing was removed, position a new bearing in the support, with the split line in the bearing toward the bottom of the support (Fig. 2), and press it in until it is flush with the rear face of the support.

NOTE: The top of the bearing support is

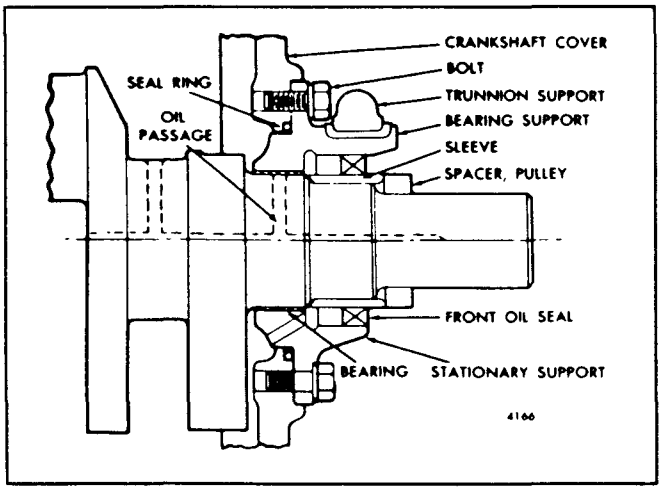

Fig. 1 - Outboard Bearing Support Assembly

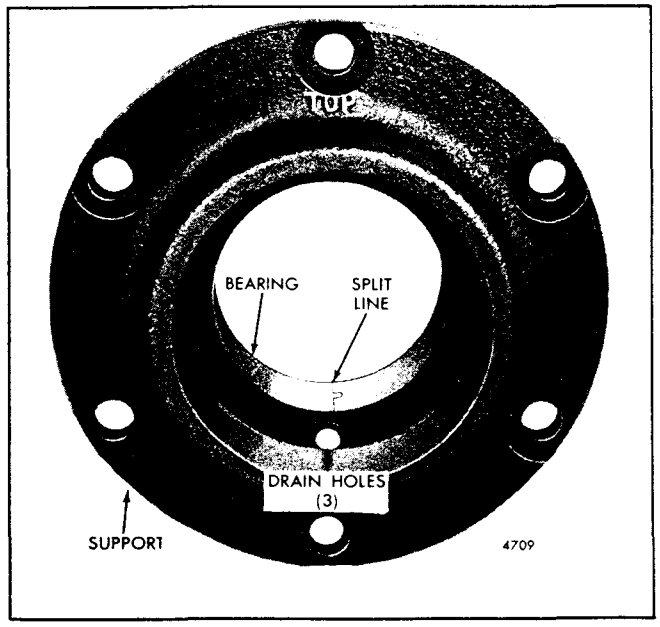

Fig. 2 - Location of Bearing in Support

identified by the word "TOP" cast in the front face of the support.

2. Install a new oil seal as outlined in Section 1.3.2.

3. Install a new seal ring on the bearing support.

4. Install the bearing support assembly on the engine front cover as outlined in Section 1.3.5.

5. Install the trunnion support.

6. Install the crankshaft pulley (Section 1.3.7).

CRANKSHAFT VIBRATION DAMPER

On certain 8V engines, a viscous type vibration damper is mounted on the front end of the crankshaft to reduce crankshaft stresses to a safe value (Fig. 1). The vibration damper is bolted to a hub which is retained on the front end of the crankshaft.

A viscous type vibration damper consists of an inertia mass (flywheel) enclosed in a fluid-tight outer case but separated therefrom by a thin wall of viscous liquid not responsive to temperature changes. Any movement of the inertia mass, therefore, is resisted by the friction of the fluid, which tends to dampen excessive torsional vibrations in the crankshaft.

The vibration damper must be removed whenever the crankshaft, crankshaft front oil seal or crankshaft front cover is removed.

Remove Vibration Damper

1. Remove the crankshaft pulley retaining bolt and washer.

2. Remove the crankshaft pulley. If required, use a suitable puller to remove the pulley.

3. Reinstall the pulley retaining bolt in the end of the crankshaft.

4. Attach puller J 4558 to the vibration damper hub, as shown in Fig. 2, with two long bolts threaded into the two 3/8" -24 tapped holes provided in the hub. Pull the damper and hub assembly, together with the outer cone, until the outer cone is loose on the crankshaft.

5. Remove the puller from the damper hub and pull the outer cone off of the crankshaft.

CAUTION: Pounding with a hammer or prying with other tools must not be resorted to when removing a viscous type damper from the crankshaft. Dents in the damper outer case may render the damper ineffective. *The damper cannot be repaired.*

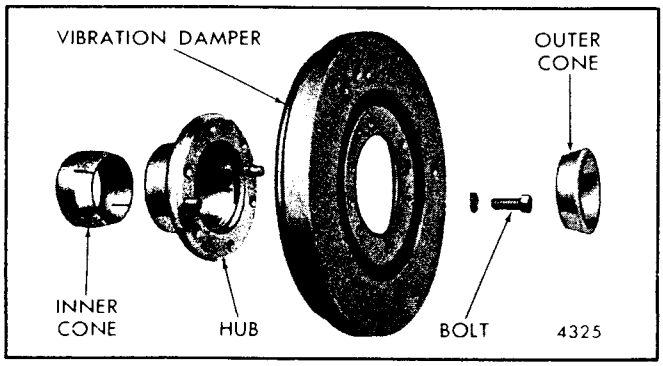

Fig. 1 - Vibration Damper Details and Relative Location of Parts

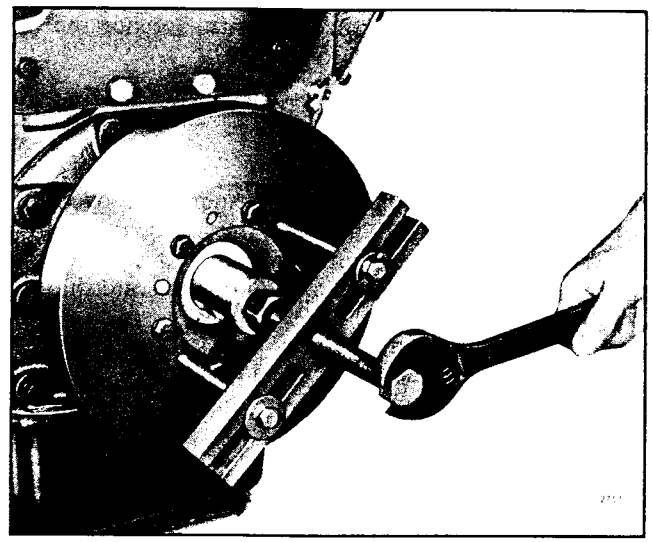

Fig. 2 - Removing Vibration Damper Outer Cone

6. Slide the vibration damper and damper hub as an assembly off of the end of the crankshaft by hand.

7. If necessary, remove the vibration damper inner cone from the crankshaft.

Inspection

Inspect the damper for dents, nicks or bulges in the outer casing. Any indications of the above are sufficient cause for rejection. Due to the close clearances between the damper internal flywheel and the outer casing, dents may render the damper ineffective. Bulges or splits indicate the fluid has ignited and expansion of the resultant gases bulged or forced the casing open at its crimped edges.

Regardless of condition, a viscous type damper must be replaced at the time of normal periodic major engine overhaul.

If damage to the vibration damper is extensive, inspect the crankshaft as outlined in Section 1.3. A loose or defective vibration damper, after extended operation, may result in a cracked crankshaft.

Inspect the damper inner and outer cones, damper hub and the end of the crankshaft for galling or burrs. Slight scratches or burrs may be removed with emery cloth. If seriously damaged, replace the parts and

refinish the end of the crankshaft. Check the outside diameter of the inner cone for wear at the crankshaft front oil seal contact surface. If worn, replace the oil seal and cone (refer to Section 1.3.2).

Install Vibration Damper

1. If removed, pilot the damper inner cone over the end of the crankshaft, through the oil seal and up against the oil slinger, with the tapered end of the cone pointing toward the front end of the crankshaft.

2. Slide the damper and hub as an assembly over the end of the crankshaft (with the long end of the hub facing the inner cone) and up against the damper inner cone. *Do not* hit the damper with a hammer to position it on the crankshaft.

3. Slide the damper outer cone over the end of the crankshaft and up against the damper hub, with the tapered end of the cone pointing toward the hub.

4. Install the pulley on the crankshaft.

5. Place the washer on the crankshaft end bolt and thread the bolt into the end of the crankshaft.

6. Tighten the crankshaft end bolt as follows:

   a. Tighten the bolt to 180 lb-ft torque.

   b. Strike the end of the bolt a sharp blow with a 2 to 3 pound lead hammer.

   c. Tighten the bolt to 290-310 lb-ft torque and strike the bolt again.

   d. Retighten the bolt to 290-310 lb-ft torque.

CRANKSHAFT PULLEY

The crankshaft pulley is secured to the front end of the crankshaft by a special washer and a bolt.

Remove Crankshaft Pulley

1. Remove the belts from the crankshaft pulley.

2. Remove the crankshaft pulley retaining bolt and special washer.

3. If a rigid type pulley is being removed from an In-line or 6V engine, install the pulley retaining bolt and puller J 4794-01 as shown in Fig. 1. Then force the pulley off the crankshaft by turning the puller center screw in.

On pulleys that do not incorporate two tapped holes in the front face of the pulley, use a two arm universal type puller.

If a puller is required to remove a rigid type pulley from an 8V engine, use a universal type puller. Three tapped holes are provided in the pulley to facilitate removal.

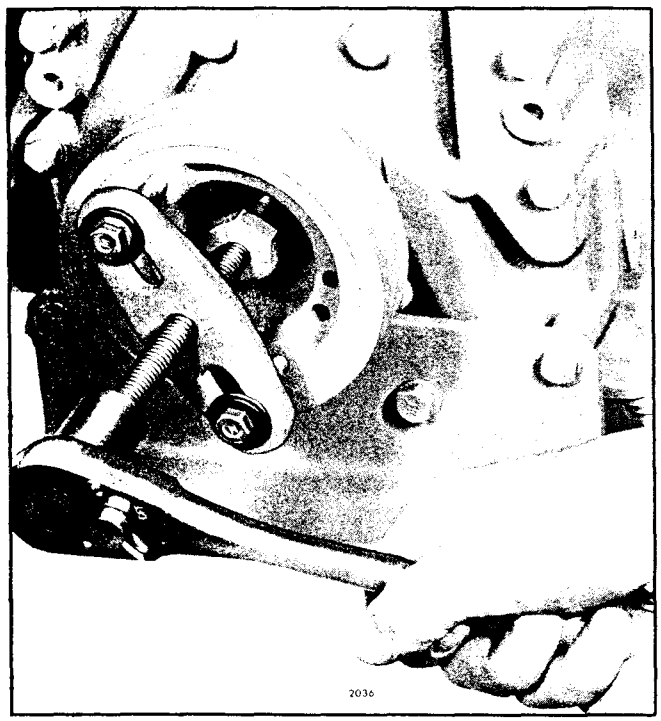

Fig. 1 - Removing Crankshaft Pulley Using Puller J 4794-01

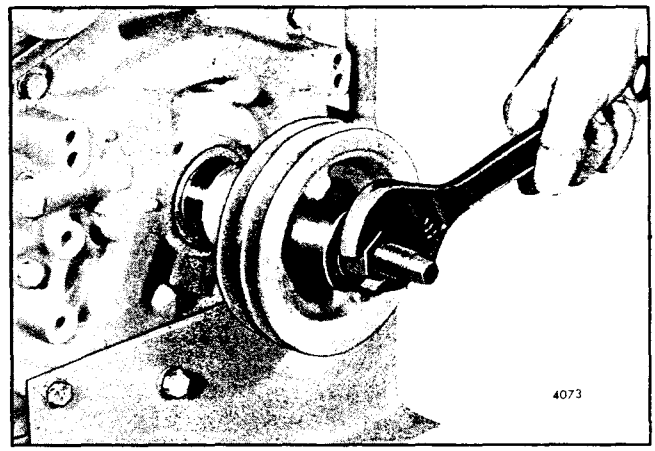

Fig. 2 - Installing Crankshaft Pulley Using Installer J 7773

4. Remove the outer and inner cones, if used.

5. If a rubber mounted pulley with an internal thread is being removed from an 8V engine, use puller J 5356. To use the tool, screw the 2-1/2 "-16 thread into the pulley hub as far as possible with the center screw backed off. Then force the pulley off the crankshaft by turning the center screw in.

Inspection

The appearance of the rubber bushing does not determine the condition of a rubber mounted crankshaft pulley. Check for failure of the rubber bushing by locking the crankshaft and applying pressure to the crankshaft pulley. If the pulley cannot be rotated, the bushing is in satisfactory condition. If necessary, replace the rubber bushing.

Install Crankshaft Pulley

1. Lubricate the end of the crankshaft to facilitate pulley installation.

2. Slide the inner cone (Fig. 3), if used, on the crankshaft.

3. On an 8V engine, install two Woodruff keys (if removed) in the keyways in the front end of the crankshaft.

4. Start the pulley straight on the end of the crankshaft.

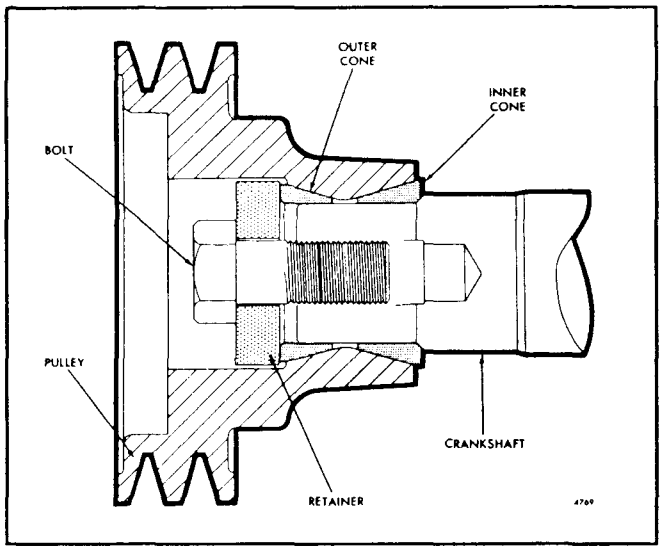

Fig. 3 - Cone Mounted Pulley

5. Install a rigid type pulley on an In-line or 6V engine with installer J 7773 as shown in Fig. 2. Then remove the installer.

6. Slide a rigid type pulley on an 8V engine. If necessary, hold a block of wood against the hub of the pulley and tap the pulley on the crankshaft with a hammer.

7. Slide the outer cone (Fig. 3), if used, on the crankshaft.

8. Place the washer on the crankshaft bolt and thread the bolt into the front end of the crankshaft.

9. On certain 4-53 and 6V-53 engines, a splined crankshaft pulley is used. Place a drive flange washer over the splined end of the crankshaft. Align the splines and tap the pulley on the crankshaft with a plastic hammer. Place another drive flange washer on the bolt and thread it into the end of the crankshaft. Tighten the 3/4 "-16 bolt to 290-300 lb-ft torque.

10. On in-line engines with cone mounted pulleys NOT stamped with the letter "A", tighten the 3/4 "-16 bolt to 290-300 lb-ft torque.

11. On all in-line and 6V engines with the rigid type pulleys and cone mounted pulleys stamped with the letter "A", tighten the 3/4 "-16 bolt to 200-220 lb-ft torque.

12. When pulleys stamped with the letter "U" (in a square box) are used, tighten the 3/4 "-16 bolt to 290-310 lb-ft torque.

13. On 8V engines, tighten the 1 "-14 crankshaft bolt to 290-310 lb-ft torque.

14. Install and adjust the belts.

FLYWHEEL

The flywheel is attached securely to the rear end of the crankshaft with six self-locking bolts. The bolt heads are prevented from "biting" into the flywheel by a scuff plate, which is used between the flywheel and the heads of the bolts. On an 8V engine, two dowels are provided in the rear end of the crankshaft for locating the flywheel. A ring gear is shrunk onto the rim of the flywheel.

The flywheel is machined to permit a true alignment of a power take-off or clutch with the flywheel, and the center bore of the flywheel provides for installation of a pilot bearing. The power take-off driving ring or clutch is bolted securely to the flywheel.

An oil seal ring, which provides an oil tight connection between the crankshaft and the flywheel, is fitted into a groove on certain flywheels.

On Torqmatic converter units, the flywheel is part of the converter and is covered in the *Torqmatic Converter Service Manual.*

The rugged construction of the flywheel makes necessity for service very remote. However, the flywheel must be removed for other service operations such as removing and replacing the ring gear.

Remove Flywheel (Transmission Removed)

1. If a clutch housing is attached to the flywheel housing, remove the flywheel as follows:

   a. Remove the flywheel attaching bolts and the scuff plate.

   b. Lift the flywheel off the end of the crankshaft and out of the clutch housing.

2. If a clutch housing isn't used, remove the flywheel as follows:

   a. Remove the flywheel attaching bolts and the scuff plate while holding the flywheel in position by hand; then, reinstall one bolt.

   CAUTION: When removing or installing the attaching bolts, hold the flywheel firmly against the crankshaft by hand to prevent it from slipping off the end of the crankshaft. The flywheel is NOT doweled to the crankshaft, except on 8V engines.

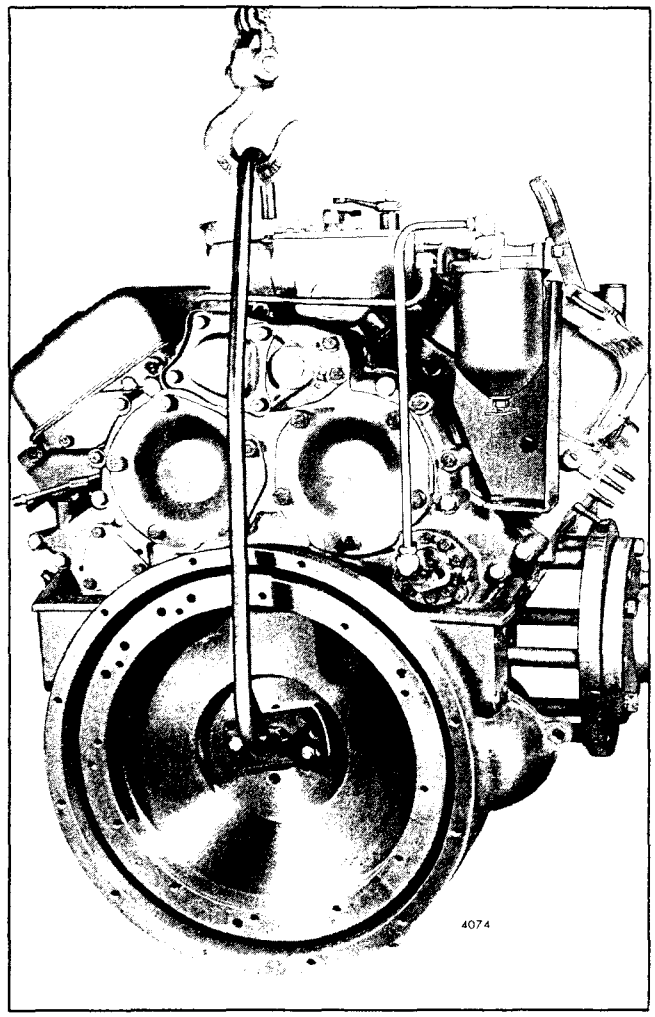

Fig. 1 - Removing Flywheel with Tool J 6361-01

   b. Attach flywheel lifting tool J 6361-01 to the flywheel with two 3/8" -16 bolts of suitable length as shown in Fig. 1.

   c. Attach a chain hoist to the lifting tool.

   d. Remove the remaining flywheel attaching bolt.

   e. Move the upper end of the tool back and forth to loosen the flywheel; then, withdraw the flywheel.

   f. If equipped with a clutch pilot bearing, remove the bearing from the flywheel (see Section 1.4.1).

Inspection

Check the clutch contact face of the flywheel for cracks, scoring or overheating. If the flywheel clutch surface is scored, it may be refaced. However, do not

remove more than .020" of metal from the flywheel and maintain all radii when refacing the flywheel.

If the contact face of the clutch wear plate shows signs of overheating or excessive scoring, replace the wear plate.

The flywheel seldom wears to the point of requiring service or replacement. However, the flywheel ring gear may become worn due to normal usage or damage by improper use of the starting motor to the extent that it must be replaced. Examine the teeth on the ring gear. If replacement is necessary, remove the ring gear as outlined below.

Remove Ring Gear from Flywheel

1. Support the flywheel, crankshaft side down, on a solid flat surface or a hardwood block which is slightly smaller than the inside diameter of the ring gear. Before removing the gear, note the chamfer, if any, on the gear teeth so that the new gear may be installed in the same position.

2. Drive the ring gear off of the flywheel with a suitable drift and hammer. Work around the circumference of the ring gear to avoid binding the gear on the flywheel.

Install Ring Gear on Flywheel

1. Support the flywheel, ring gear side up, on a solid flat surface.

2. Rest the ring gear on a flat *metal* surface and heat the gear uniformly with an acetylene torch, keeping the torch moving around the gear to avoid hot spots.

CAUTION: Do not, under any circumstances, heat the gear over 400°F.; excessive heating may destroy the original heat treatment.

NOTE: Heat indicating "crayons", which are placed on the ring gear and melt at a predetermined temperature, may be obtained from most tool vendors. Use of one of these "crayons" will insure against overheating the gear.

3. Use a pair of tongs to place the gear on the flywheel with the chamfer, if any, facing the same direction as on the gear just removed.

4. Tap the gear in place against the shoulder on the flywheel. If the gear cannot be tapped into place readily, remove it and apply additional heat, heeding the caution about overheating.

Install Flywheel

1. On an 8V engine, check the extension of the dowels from the end of the crankshaft. The dowels must not extend more than 1/2" from the crankshaft.

2. If a pilot bearing is used in the bore of the flywheel and was removed, install the bearing. Install a new seal ring if one was previously used.

3. Mount the flywheel, using lifting tool J 6361-01 and a chain hoist, in position against the rear end of the crankshaft.

4. Apply a small quantity of International Compound No. 2, or equivalent, to the bolt threads and bolt head contact areas of the flywheel attaching bolts.

5. While holding the flywheel in place by hand, remove the flywheel lifting tool and install the flywheel attaching bolts and scuff plate. Tighten the bolts on all engines, except 8V engines, to 110-120 lb-ft torque. On an 8V engine, tighten the bolts to 180-190 lb-ft torque.

6. Mount a dial indicator on the flywheel housing or clutch housing and check the runout of the flywheel at the clutch contact face. Maximum allowable runout is .001" total indicator reading per inch of radius (the radius is measured from the center of the flywheel to the outer edge of the clutch contact face of the flywheel).

CLUTCH PILOT BEARING

The clutch pilot bearing is pressed into the bore of the flywheel assembly and serves as a support for the inner end of the clutch drive shaft.

On most applications, the clutch pilot bearing is held in place on one side by a shoulder in the flywheel and on the other side by a bearing retainer.

On certain applications, the clutch pilot bearing is held in place on one side by a bearing retainer, placed between the flywheel and the end of the crankshaft, and on the other side by the flywheel bolt scuff plate.

Lubrication

A double sealed clutch pilot bearing is sealed and prepacked with grease and requires no further lubrication. A single shielded clutch pilot bearing should be packed with all purpose grease such as Shell Alvania No. 2, or equivalent, if not previously packed by the manufacturer.

Remove Clutch Pilot Bearing (Transmission Removed)

With the flywheel attached to the crankshaft, the clutch pilot bearing may be removed as follows:

1. Remove the flywheel attaching bolts and scuff plate while holding the flywheel in position by hand, then reinstall two bolts to hold the flywheel in place.

> **CAUTION:** When removing or installing the attaching bolts, hold the flywheel firmly against the crankshaft by hand to prevent it from slipping off the end of the crankshaft. The flywheel is NOT dowelled to the crankshaft, except on an 8V engine.

2. With the clutch pilot bearing remover adaptor J 5901-2 attached to slide hammer J 5901-1, insert the fingers of the adaptor through the pilot bearing and tighten the thumb screw to expand the fingers against the inner race of the bearing.

3. Tap the slide hammer against the shoulder on the shaft and pull the pilot bearing out of the flywheel.

Inspection

Wipe the prepacked double sealed bearing clean on the outside and then inspect it. *Shielded bearings must not be washed*; dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Hold the inner race and revolve the outer race slowly by hand to check for free rolling of the balls on the races. Rough spots on the bearing are sufficient cause for rejecting it.

Install Clutch Pilot Bearing

1. Lubricate the outside diameter of the bearing with clean engine oil.

2. Start the pilot bearing straight into the bore of the flywheel, with the numbered side of the bearing facing away from the crankshaft.

3. Place bearing installer J 3154-04, with suitable adaptor plates, against the pilot bearing. Then, drive the bearing straight into and against the shoulder in the flywheel.

4. Install the flywheel as outlined in Section 1.4.

ENGINE DRIVE SHAFT FLEXIBLE COUPLING

The engine drive shaft flexible coupling is of the spring-loaded type having a splined hub to match with the splines on the transmission drive line shaft used on certain applications. The coupling, bolted to the engine flywheel, serves as a drive and also dampens out torque fluctuations between the engine and the transmission.

Remove Coupling (Transmission Removed)

1. Remove the eight 3/8"-16 x 7/8" bolts which attach the coupling to the flywheel and remove the coupling.

Inspection

Wash the coupling in clean fuel oil and dry it with comrpessed air. Check for broken or worn springs. Springs may be replaced by removing the six bolts, lock washers, nuts and spacers holding the two plates together, and removing the smaller plate. After replacing the springs, bolt the plates together and tighten the nuts to 25-30 lb-ft torque.

Examine the hub splines for wear and check the flatness of the mounting plate (the plate which bolts to the flywheel). Since the plates, spacers and hubs are manufactured in matched sets, worn hubs or plates cannot be replaced individually, but must be replaced by a complete flexible coupling assembly.

Install Coupling

1. Align the bolt holes in the coupling with the tapped holes in the flywheel. Since one bolt hole is offset, the coupling can be attached in only one position. Install the eight 3/8"-16 x 7/8" bolts and tighten them securely.

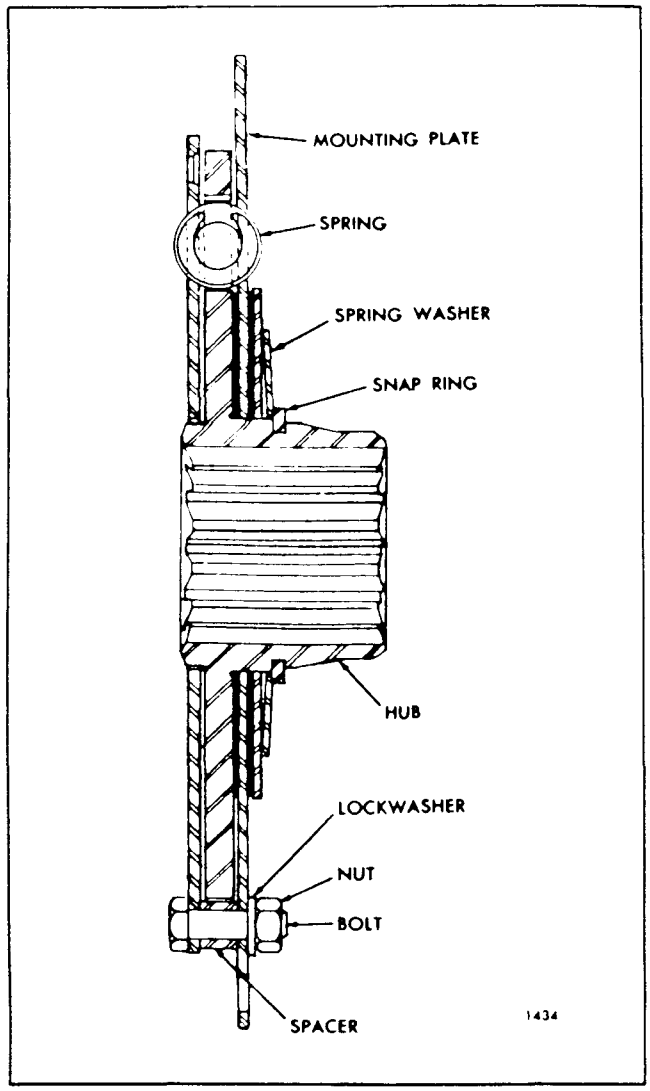

Fig. 1 - Engine Drive Shaft Flexible Coupling

FLYWHEEL HOUSING

The flywheel housing is a one-piece casting mounted against the rear end of the cylinder block. The flywheel housing provides a cover for the gear train and flywheel and also serves as a support for the starting motor and transmission.

The crankshaft rear oil seal, which is pressed into the housing, may be removed or installed without removing the housing (Section 1.3.2).

Remove Flywheel Housing

1. Remove the engine from its base as outlined in Section 1.1.

2. Remove the starter from the flywheel housing or the clutch housing.

3. Remove the flywheel.

4. Remove the oil pan.

5. Remove the clutch housing, if used.

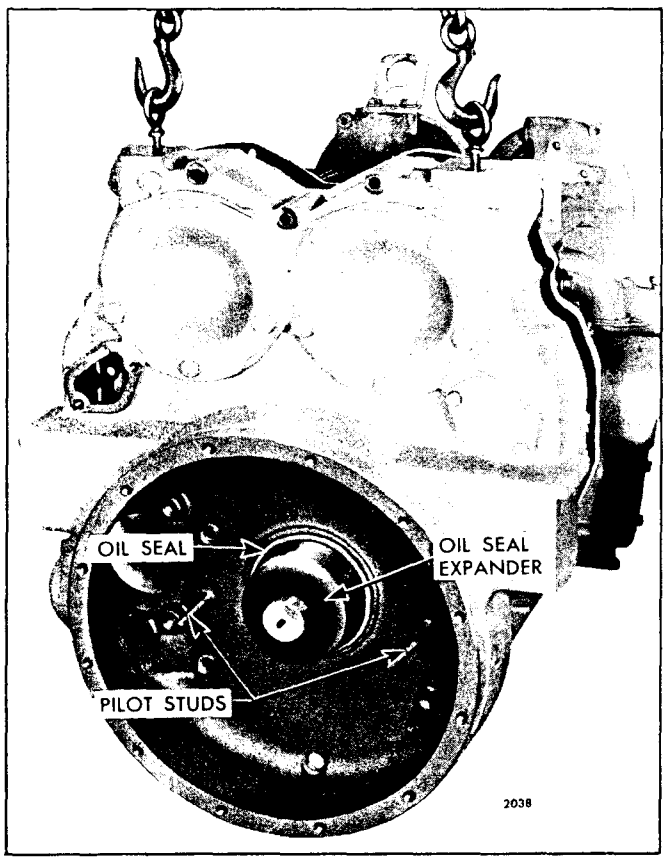

Fig. 1 - Installing Flywheel Housing

6. Remove the fuel pump, if it is mounted on the flywheel housing.

7. Remove the blower drive cover on 6V and 8V engines, the blower drive shaft retainer ring and the blower drive shaft on the 6V engine.

8. Remove the governor and blower drive support (6V engine).

9. Remove all of the bolts from the flywheel housing. Don't forget the blower-to-flywheel housing bolts on the 2-53 or 3-53 engines.

> **NOTE:** When removing the flywheel housing bolts, note the location of the various size bolts, lock washers, flat washers and copper washers so they may be reinstalled in their proper location.

10. To guide the flywheel housing until the oil seal clears the end of the crankshaft, thread two pilot studs J 7540 into the cylinder block (Fig. 1).

11. Thread eyebolts into the tapped holes in the pads (if provided) on the top or sides of the flywheel housing and attach a chain hoist with a suitable sling to the eyebolts. Then strike the front face of the housing alternately on each side of the engine with a soft hammer to loosen and work it off the dowel pins.

12. Remove all traces of the old gaskets from the cylinder block rear end plate and the flywheel housing.

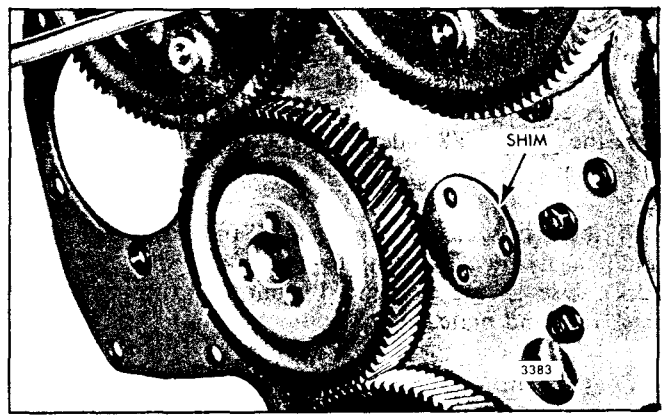

Fig. 2 - Location of Shim

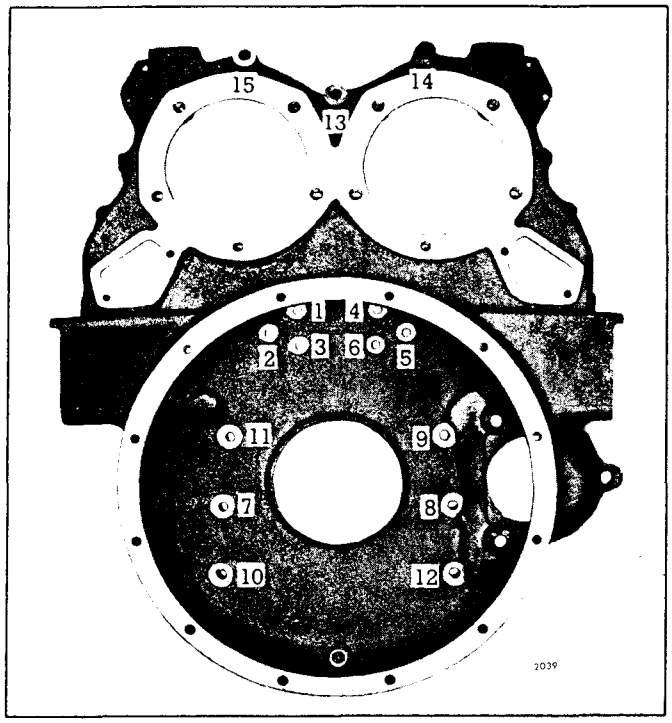

Fig. 3 - Flywheel Housing Bolt Tightening Sequence (Operation 1)--In-Line Engine

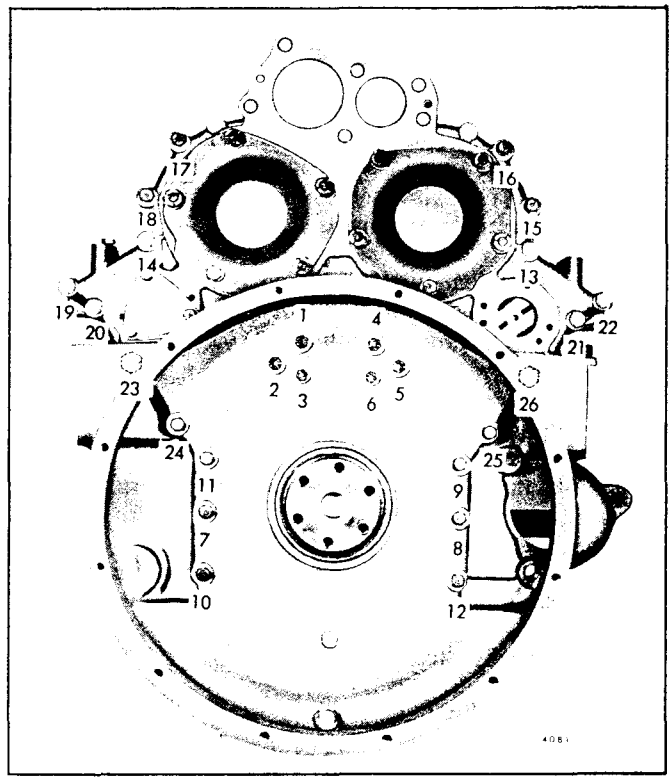

Fig. 4 - Flywheel Housing Bolt Tightening Sequence (Operation 1)--6V Engine

Inspection

Clean and inspect the flywheel housing for cracks or any other damage. Replace the housing if it is damaged.

Inspect the crankshaft rear oil seal as outlined in Section 1.3.2.

Install Flywheel Housing

1. Lubricate the gear train teeth with clean engine oil.

2. Affix a new flywheel housing gasket to the rear face of the cylinder block rear end plate. The V-type engines employ two gaskets (one large and one small). Affix the small (7/8 " dia.) gasket near the top of the end plate.

3. If the flywheel housing has an integral cast hub, install a flywheel housing-to-end plate shim (.015 " thick). Use grease to affix the shim to the cylinder block rear end plate (Fig. 2).

4. Coat the lip of the crankshaft oil seal lightly with engine oil (single-lip seal) or vegetable shortening (double-lip seal). Do not scratch or nick the sealing edge of the oil seal.

5. On In-line and 6V engines, to pilot the oil seal on the crankshaft successfully, use oil seal expander

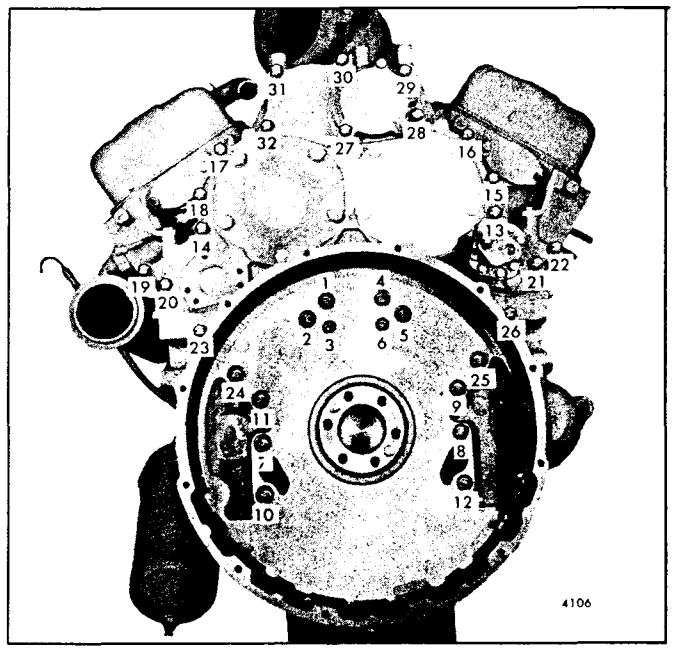

Fig. 5 - Flywheel Housing Bolt Tightening Sequence (Operation 1)--8V Engine

J 9769 (standard size seal) or J 21278 (oversize seal) on the end of the crankshaft. On 8V engines, use oil seal expander J 22425. Also thread two pilot studs J 7540 into the cylinder block to guide the housing in place (Fig. 1).

6. With the housing suitably supported, position it over the crankshaft and up against the cylinder block rear end plate and gasket(s).

7. Install all of the flywheel housing bolts, lock washers, flat washers and copper washers in their proper location -- finger tight only.

NOTE: If the engine is equipped with a clutch housing, do not install the six bolts numbered 7 through 12 (Fig. 3) until the clutch housing is installed.

8. On an In-line right hand rotation engine, start at No. 1 (No. 4 on left hand rotation engine) and draw the bolts up snug in the sequence shown in Fig. 3. On V engines, start at No. 4 on a right-hand rotation engine (No. 1 on a left-hand rotation engine) and draw the bolts up snug in the sequence shown in Fig. 4 and 5.

9. Refer to Fig. 6 for the final bolt tightening sequence on an In-line engine. Then start at No. 1 and tighten the bolts to the specified torque.

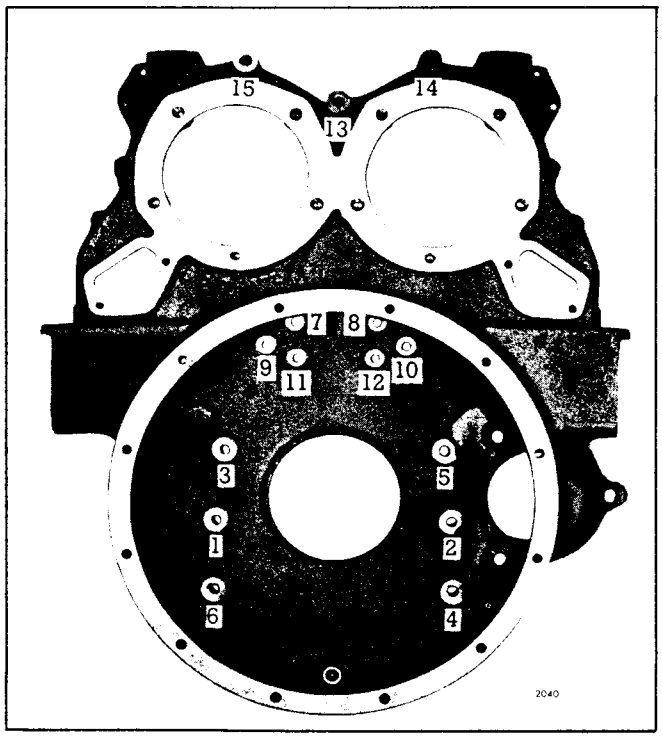

Fig. 6 - Flywheel Housing Bolt Tightening Sequence (Operation 2)--In-Line Engine

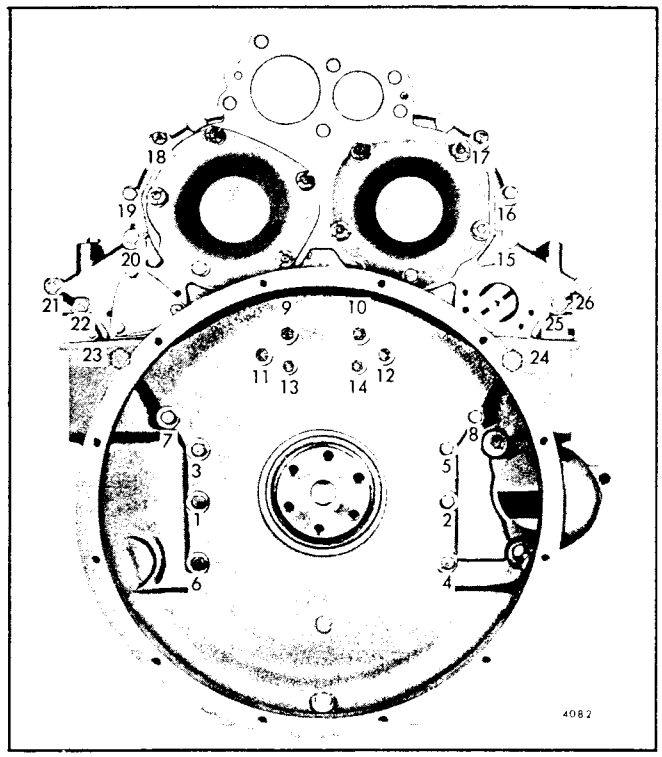

Fig. 7 - Flywheel Housing Bolt Tightening Sequence (Operation 2)--6V Engine

a. Tighten the 5/16 "-18 bolts (numbers 11 and 12) to 19-23 lb-ft torque and the 3/8 "-16 bolts

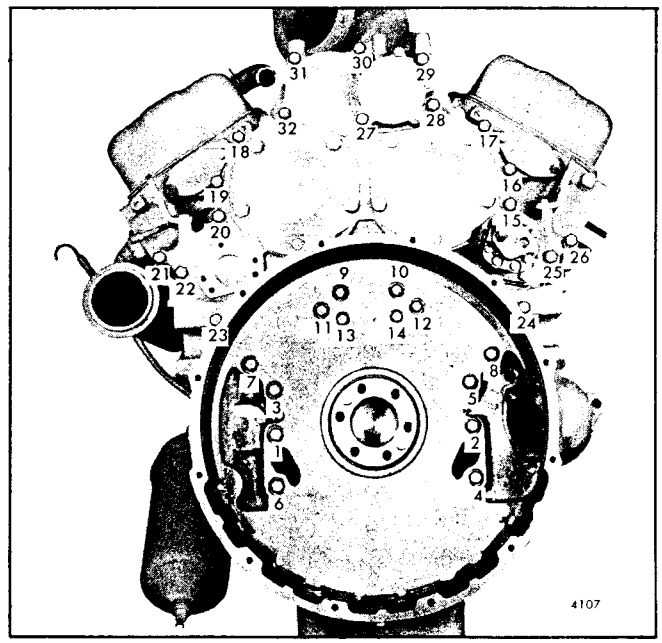

Fig. 8 - Flywheel Housing Bolt Tightening Sequence (Operation 2)--8V Engine

(numbers 7 through 10) to 40-45 lb-ft torque. Tighten the remaining 3/8 "-16 and 3/8 "-24 bolts to 25-30 lb-ft torque.

NOTE: Prior to Engine Serial Numbers 2D-903, 3D-011 and 4D-103, the bolts numbered 7 through 12 in Fig. 3 were all 5/16 "-18 bolts and must be tightened to 19-23 lb-ft torque.

b. On the two, three and four cylinder engines, tighten the two-5/16 "-18 bolts that secure the top of the governor to the flywheel housing to 10-12 lb-ft torque.

10. Refer to Fig. 7 or 8 for the final bolt tightening sequence for V engines; then, start at No. 1 and tighten the bolts to the specified torque. Tighten the 5/16 "-18 bolts (numbers 13 and 14) to 19-23 lb-ft torque and the 3/8 "-16 bolts (numbers 9 through 12) to 40-45 lb-ft torque. Tighten the remaining 3/8 "-16 and 3/8 "-24 bolts to 25-30 lb-ft torque.

NOTE: On an 8V engine when tightening the flywheel housing bolts, the idler gear hub bolts should always be tightened first. Also turn the crankshaft by hand while tightening the idler gear hub bolts to prevent any bind or brinelling of the rollers and races of the tapered roller bearing.

11. On a 6V engine, install the blower and governor drive support assembly as outlined in Section 2.7.1.1 or 2.7.2.1.

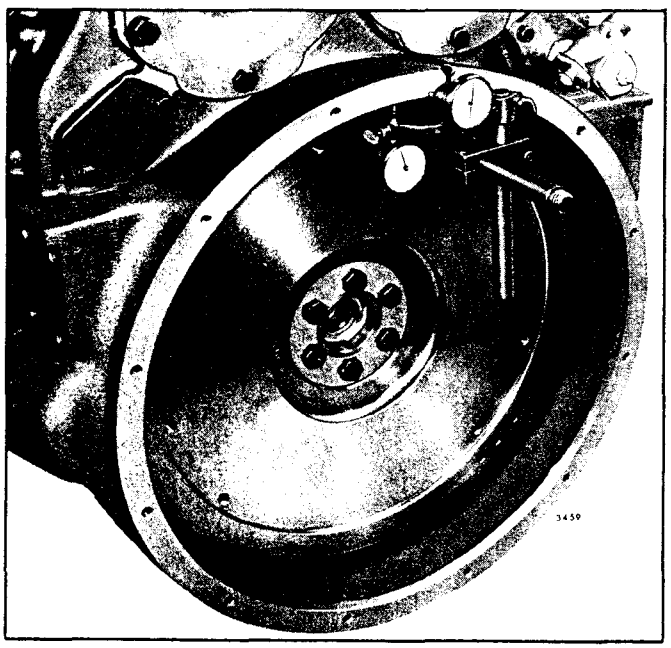

Fig. 9 - Checking Flywheel Housing Concentricity with Tool J 9737

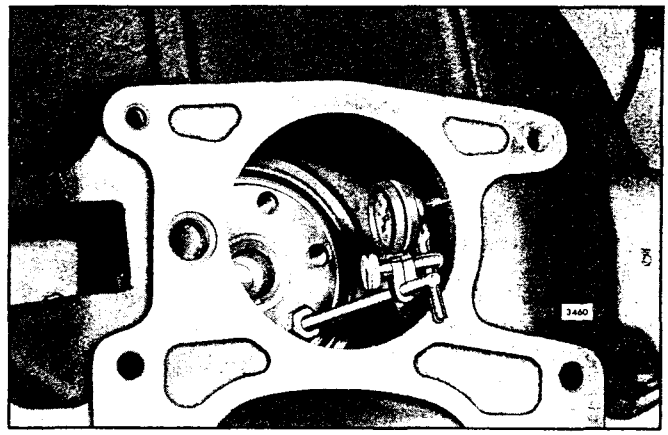

Fig. 10 - Checking Bore Runout

12. Check the flywheel housing concentricity and bolting flange face with tool J 9737 as follows:

a. Refer to Fig. 9 and thread the base post J 9737-3 tightly into one of the tapped holes in the flywheel. Then assemble the dial indicators on the base post with the attaching parts provided in the tool set.

b. Position the dial indicators straight and square with the flywheel housing and make sure each indicator has adequate travel in each direction.

NOTE: If the flywheel extends beyond the flywheel housing bell, the housing bore and face must be checked separately. Use the special adaptor in tool set J 9737 to check the housing bore.

c. Tap the front end of the crankshaft with a soft hammer or pry it with a pry bar to ensure end play is in one direction only.

d. Adjust each dial indicator to read zero at the twelve o'clock position. Then rotate the crankshaft one full revolution, taking readings at 45° intervals (8 readings each on the flywheel housing bore and bolting flange face). Stop and remove the wrench or cranking bar before recording each reading to ensure accuracy. The maximum total indicator reading must not exceed .013 " for either the bore or face.

e. If the run-out exceeds the maximum limits, remove the flywheel housing and check for dirt or foreign material (such as old gasket material) between the flywheel housing and the end plate and between the end plate and the cylinder block.

f. Reinstall the flywheel housing and tighten the attaching bolts in the proper sequence and to the

specified torque. Then recheck the run-out. If necessary, replace the flywheel housing.

13. Install the clutch housing, if used. Tighten the 3/8 "-16 attaching bolts to 30-35 lb-ft torque and the 3/8 "-24 nuts to 35-39 lb-ft torque.

a. Install tool J 9748 in one of the crankshaft bolt holes.

b. Install the dial indicator J 8001-3 and position it to read the bore runout of the housing (Fig. 10). Now check the runout by rotating the crankshaft. The runout should not exceed .008 ".

c. Reposition the dial indicator to read the face runout and rotate the crankshaft. The maximum allowable runout is .008 ".

d. If the bore or face runout is excessive, loosen the housing attaching bolts and nuts slightly and tap the housing with a soft hammer in the required direction until the runout is within limits. Tighten the attaching bolts and nuts evenly to 30-35 and 35-39 lb-ft torque respectively. Then recheck the runout.

14. Install the fuel pump (V-type engine), if removed.

15. Install the flywheel.

16. Use a new gasket and install the oil pan. On 8V engines, if the flywheel housing and oil pan include outriggers for the installation of reinforcement bolts, be sure the oil pan butts up against the flywheel housing before tightening the oil pan bolts. Install and tighten the 1/2 "-13 reinforcement bolts.

17. Remove the engine from the overhaul stand and install all accessories previously removed.

18. Install the transmission.

19. Install the engine in the unit.

20. Fill the crankcase with lubricating oil.

21. Refill the cooling system.

PISTON AND PISTON RINGS

The trunk type malleable iron piston (Fig. 1) is plated with a protective coating of tin which permits close fitting, reduces scuffing and prolongs piston life. The top of the piston forms the combustion chamber bowl and is designed to compress the air into close proximity to the fuel spray.

The piston is cooled by a spray of lubricating oil directed at the underside of the piston head from a nozzle in the top of the connecting rod, by fresh air from the blower to the top of the piston and indirectly by the water jacket around the cylinder.

Each piston is balanced to close limits by machining at a balancing rib, provided on the inside at the bottom of the piston skirt.

Two bushings, with helical grooved oil passages, are pressed into the piston to provide a bearing for the hardened, floating piston pin. After the piston pin has been installed, the hole in the piston at each end of the pin is sealed with a steel retainer. Thus, lubricating oil returning from the underside of the piston head and working through the grooves in the piston pin bushings is prevented from reaching the cylinder walls.

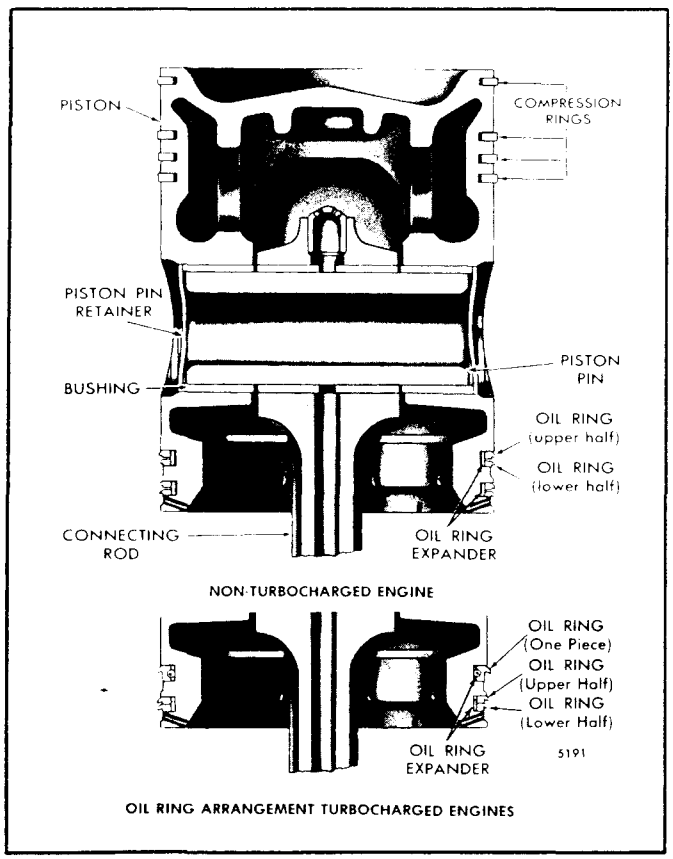

Fig. 1 - Typical Piston Assembly

The piston pin is subject to downward loading only since the piston is at all times under pressures of compression or expansion in the two-stroke cycle. Consequently, free movement of the piston pin is desirable to secure perfect alignment and uniform wear. The piston pin is therefore assembled with a full floating fit in both the connecting rod and the piston bushings. Rotation of the pin and positive lubrication through the helical bushing grooves reduce wear to a minimum. Moreover, worn clearances can be comparatively large and still be satisfactory.

Each piston is fitted with six piston rings. Four compression rings are placed above the piston pin and two oil control rings are placed below the pin to scrape off the excess lubricating oil thrown onto the cylinder liner by the crankshaft and the lower end of the connecting rod. Two piece oil control rings are used in both the upper and lower positions on the piston for non-turbocharged engines. On turbocharged engines, a one piece oil control ring is used in the upper position (Fig. 1) and the two piece ring is used in the lower position.

Equally spaced holes are drilled just below each oil control ring land to permit the excess oil that is scraped off the cylinder walls to return to the crankcase.

Inspect Piston Rings

When an engine is hard to start, runs uneven or lacks power, the cause may be worn or sticking compression rings which must be replaced to restore uniform compression pressure in the cylinders.

The compression rings may be inspected through the ports in the cylinder liners after removing the air box covers. If the rings are free and are not worn to the extent that the plating or grooves have disappeared, the compression should be within operating specifications. Refer to Section 15.2 for the procedure for checking the compression pressure.

However, if excessive wear on any part of the piston assembly is indicated by inspection through the cylinder liner ports, the piston and connecting rod must be removed in the following manner:

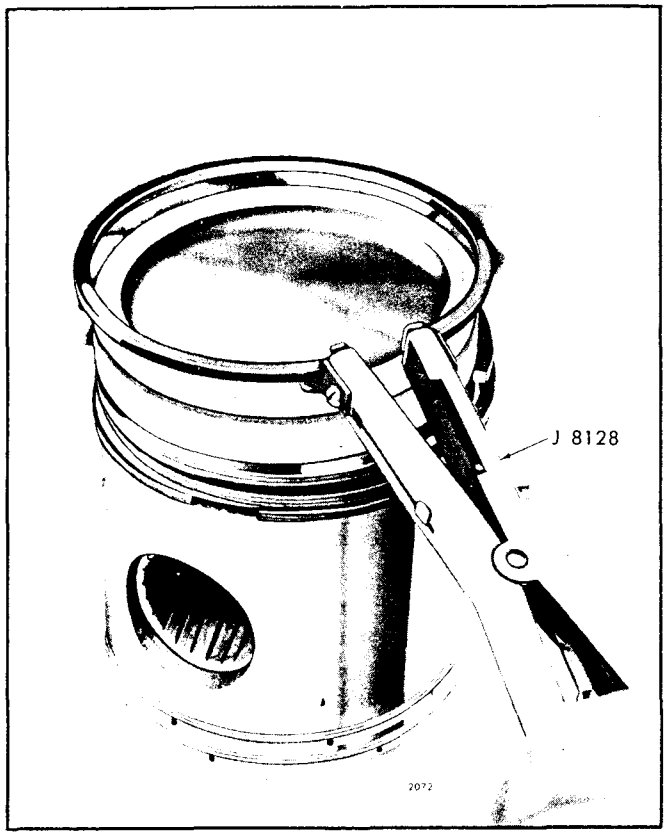

Fig. 2 - Removing or Installing Piston Ring

Remove Piston and Connecting Rod

1. Drain the lubricating system and remove the oil pan.

2. Remove the cylinder head as outlined in Section 1.2.

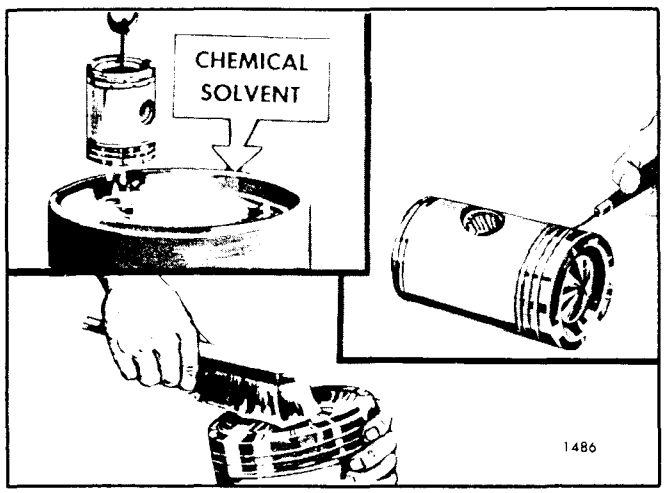

Fig. 3 - Cleaning Piston

3. Remove the carbon from the upper inner surface of the cylinder liner.

4. If there is a ridge in the cylinder liner at the top of the piston ring travel, remove the ridge with a ridge cutter.

> **NOTE:** Move the piston to the bottom of its travel and place a cloth on top of the piston to collect the cuttings.

5. After the ridge is removed, turn the crankshaft until the piston is at the top of its stroke and carefully remove the cloth with the cuttings.

6. Refer to Figs. 1 and 2 in Section 1.6.1 and remove the bearing cap and the lower bearing shell from the lower end of the connecting rod; then push the piston and rod assembly out through the top of the cylinder block. The piston and rod cannot be removed from the bottom of the block.

7. Reassemble the bearing cap and the bearing shell to the connecting rod.

Disassemble Piston and Connecting Rod

1. Secure the connecting rod in a vise equipped with soft jaws and remove the piston rings with tool J 8128 as shown in Fig. 2.

2. Punch a hole through the center of one of the piston pin retainers with a narrow chisel or punch and pry the retainer from the piston, being careful not to damage the piston or bushings.

3. Withdraw the piston pin from the piston, thus freeing the connecting rod.

4. The other piston pin retainer may be driven out from the inside, using a brass rod or other suitable tool.

Clean Piston

Clean the piston with fuel oil and dry it with compressed air. If fuel oil will not remove the carbon deposits, use a chemical solvent that will not attack the piston pin bushings or the tin coating on the piston (Fig. 3).

The upper part of the piston, including the ring lands and grooves, is not coated with tin and may be wire-brushed to remove any hard carbon. However, use care to avoid damage to the tin coating on the piston skirt. Clean the ring grooves with a suitable tool or a piece of an old piston ring that has been ground to a bevel edge.

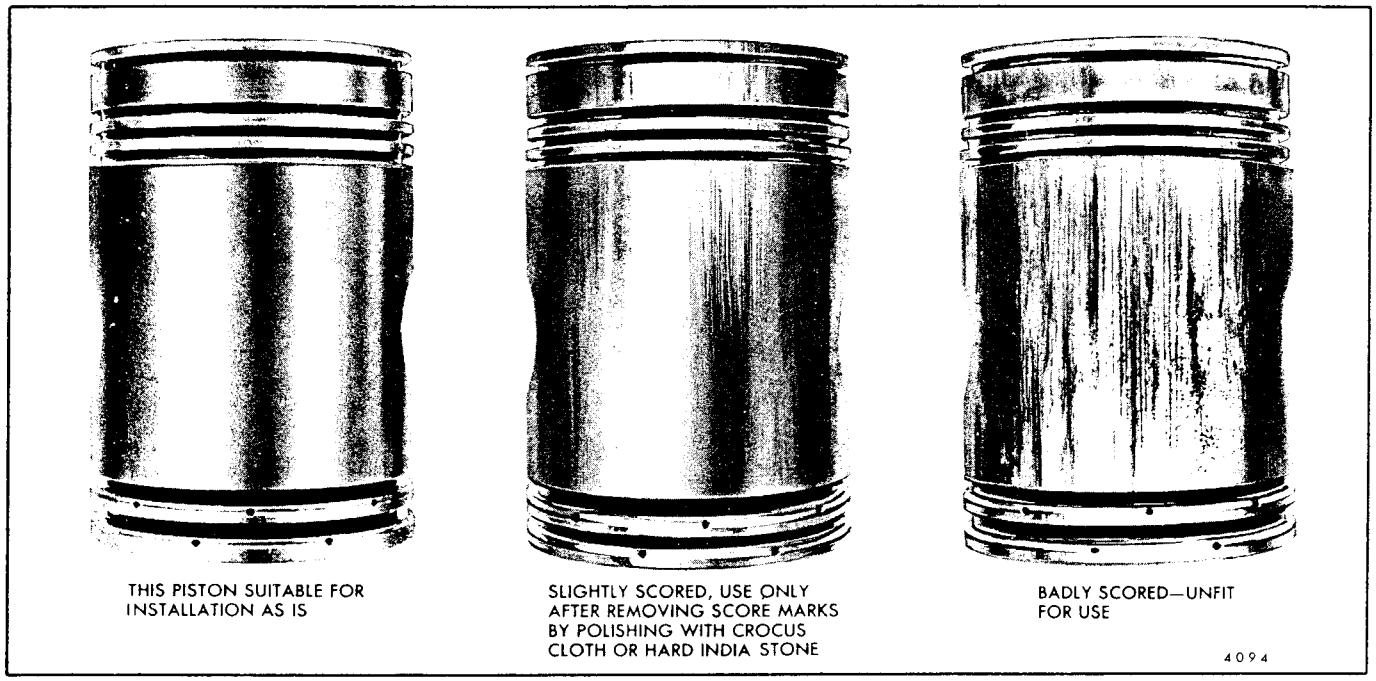

Fig. 4 - Comparison of Pistons

Clean the inside surfaces of the piston and the oil return holes in the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

Inspection

The presence of the tin coating on the piston and the original grooves in the piston rings indicates very little wear.

An excessively worn or scored piston, rings or cylinder liner may be the result of abnormal maintenance or operating conditions which should be corrected to avoid recurrence of the failure. Proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will, in turn, reduce the rate of wear. Extended periods of operation at idle speed or the use of improper lubricating oil or fuel should be avoided, otherwise heavy carbon formation and sticking rings will result. Always maintain the lubricating oil and engine coolant at the specified levels to avoid overheating the engine.

Examine the piston for scoring, overheating, cracks and damaged ring grooves. Replace the piston, if necessary. A piston with light score marks may be cleaned up and reused. Refer to Fig. 4 for a comparison of pistons.

Check for cracks across the struts in the piston as outlined in Section 1.3 under *Crankshaft Inspection.*

Other factors that contribute to piston failure are oil leaks into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and dilution of the lubricating oil.

Inspect and measure the piston pin and piston pin bushings. The piston pin-to-bushing clearance with new parts is .0025 " to .0034 ". A maximum clearance of .010 " is allowable with worn parts. The piston pin bushings in the connecting rod are covered in Section 1.6.1.

Inspect the piston pin for signs of fretting. When re-using a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing any part of the piston pin surface is not recommended as it will result in very rapid bushing wear.

Remove Bushings from Piston

1. Place the piston in the holding fixture J 1513-1 so that the bushing bores are in alignment with the hole in the fixture base.

> **CAUTION:** Do not remove the bushings from the pistons used in turbocharged engines because they are not serviced separately.

2. Drive each bushing from the piston with the bushing remover J 4972-4 and handle J 1513-2 in the manner illustrated in Fig. 5.

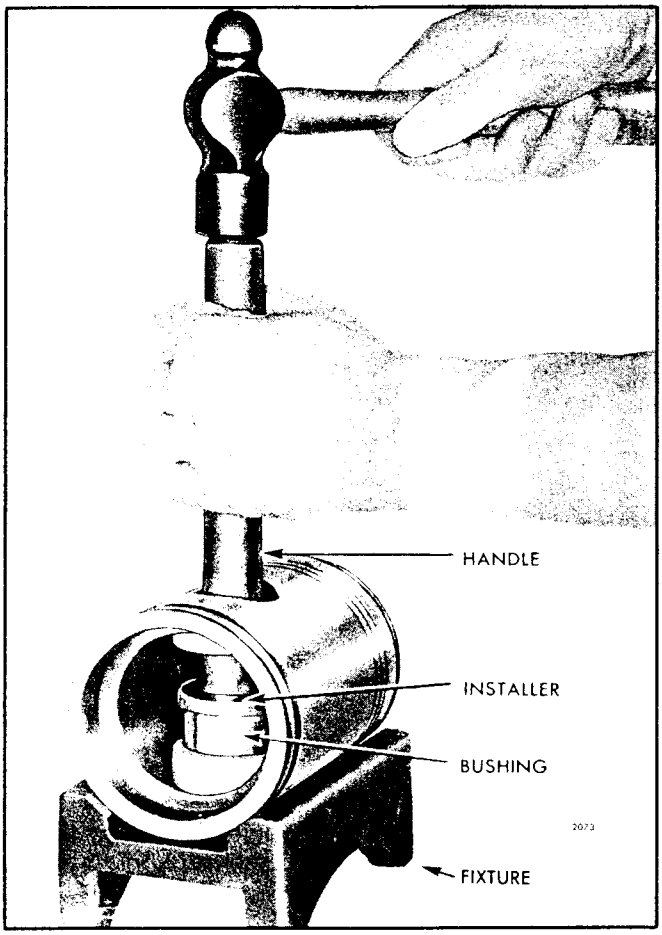

Fig. 5 - Removing or Installing Piston Pin Bushings

Install Bushings in Piston

1. Place the spacer J 7587-1 in the counterbore in the fixture J 1513-1 (small end up).

2. Place the piston on the fixture so that the spacer protrudes into the bushing bore.

3. Insert the installer J 4972-2 in a bushing, then position the bushing and installer over the lower bushing bore.

NOTE: Locate the joint in the bushing toward the bottom of the piston (Fig. 6).

4. Insert the handle J 1513-2 in the bushing installer and drive the bushing in until it bottoms on the spacer.

5. Install the second bushing in the same manner.

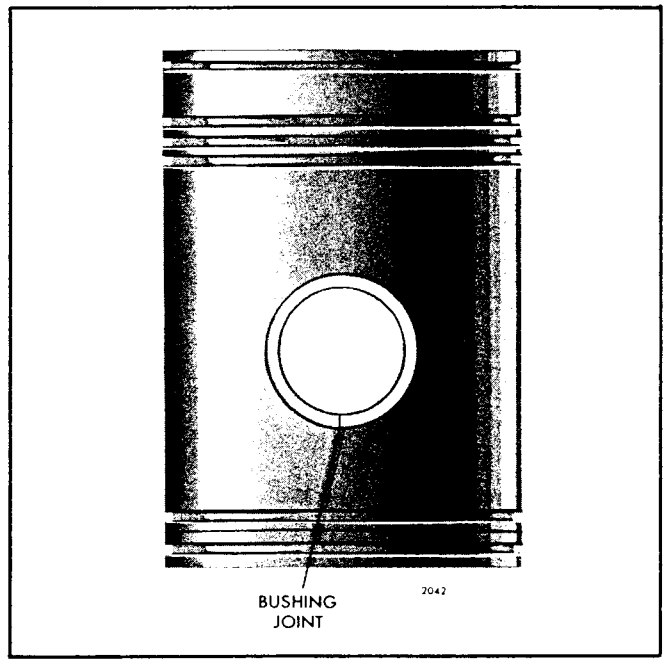

Fig. 6 - Location of Joint in Piston Pin Bushings

Ream Bushings in Piston

1. Clamp the reaming fixture J 5273 in a vise (Fig. 7), then insert the guide bushing J 4970-5 in the fixture and secure it with the set screw.

2. Place the piston assembly in the fixture and insert

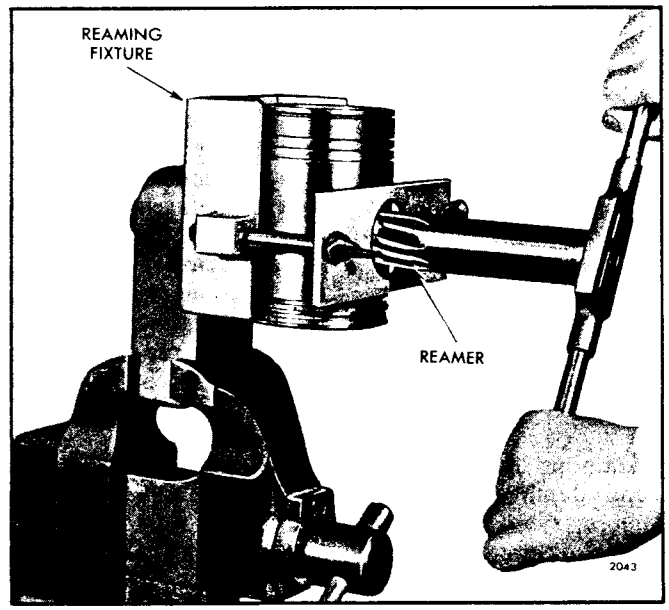

Fig. 7 - Reaming Piston Pin Bushings

the pilot end of the reamer J 4970-4 through the clamping bar, bushings and into the guide bushing.

3. With the piston, fixture and reamer in alignment, tighten the wing nuts securely.

4. Ream the bushings by turning the reamer in a clockwise direction only, when reaming or withdrawing the reamer. For the best results, use only moderate pressure on the reamer.

5. Withdraw the reamer and remove the piston from the fixture. Blow out the chips and check the inside diameter of the bushings. The inside diameter of the bushings must be 1.3775 " to 1.3780 ".

Fitting Piston

Piston and cylinder liner measurements should be taken at room temperature (70 °F.).

Measure the piston skirt diameter in the area between the bottom of the compression ring grooves and the top of the oil control ring grooves, except near the piston pin bore.

The diameter of a new non-turbocharged engine piston is 3.8699 " to 3.8721 " and the diameter of a new turbocharged engine piston is 3.8669 " to 3.8691 ". The inside diameter of a new cylinder liner (non-turbocharged or turbocharged engines) is 3.8752 " to 3.8767 ". Therefore, with new parts, the piston to liner clearance for non-turbocharged engines is .0031 " to .0068 " and should not exceed .010 " with used parts. With turbocharged engines, the piston to liner clearance is .0061 " to .0098 " and should not exceed .012 " with used parts.

After inspecting and installing the cylinder liner (new or used) as outlined in Section 1.6.3, check the piston-to-liner clearance. Check this clearance in four places, 90 ° apart, while holding the piston upside down in the cylinder liner (Fig. 8).

Feeler gage set J 5438 may be used for checking the piston-to-liner clearance. The spring scale, attached to the appropriate feeler gage, is used to measure the force in pounds required to withdraw the feeler gage from between the piston and liner.

The clearance will be .001 " greater than the thickness of the feeler gage used, i.e., a .004 " thick feeler gage will indicate a clearance of .005 " when it is withdrawn at a pull of six pounds. The feeler gage must be perfectly flat and free of nicks and bends.

If any bind between the piston and liner is detected, remove the piston and inspect the piston and liner for burrs. Remove the burrs with a fine hone (a flat one is preferable) before proceeding with the clearance check.

Fitting Piston Rings

Use new piston rings whenever a piston is removed for inspection or replacement.

The current top compression (fire) ring can be identified by the bright chrome on the bottom side and oxide (rust color) on the top. The former ring had a plain metal color on both sides.

Insert one piston ring at a time far enough down in the cylinder liner to be within the normal area of ring travel. Use a piston to push the ring down to be sure it is parallel with the top of the liner. Then measure the ring gap with a feeler gage as shown in Fig. 9. Refer to Section 1.0 for the specified ring gap.

If the piston ring gap is below the specified limits, it may be increased by filing or stoning the piston ring in such a direction that the file or stone will cut from the outside (chrome plated) surface of the ring toward the inside surface. This will prevent any chipping or peeling of the chrome plate. The ends of the ring must

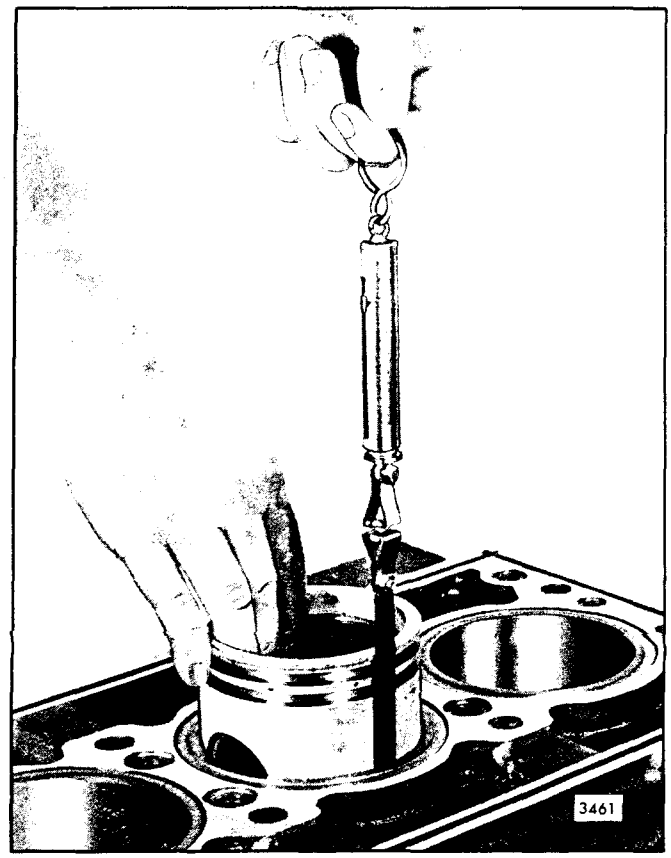

Fig. 8 - Measuring Piston-to-Liner Clearance

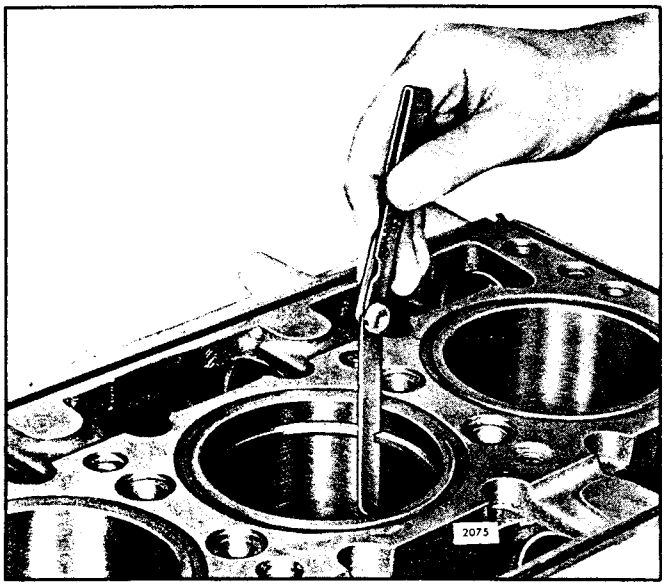

Fig. 9 - Measuring Piston Ring Gap

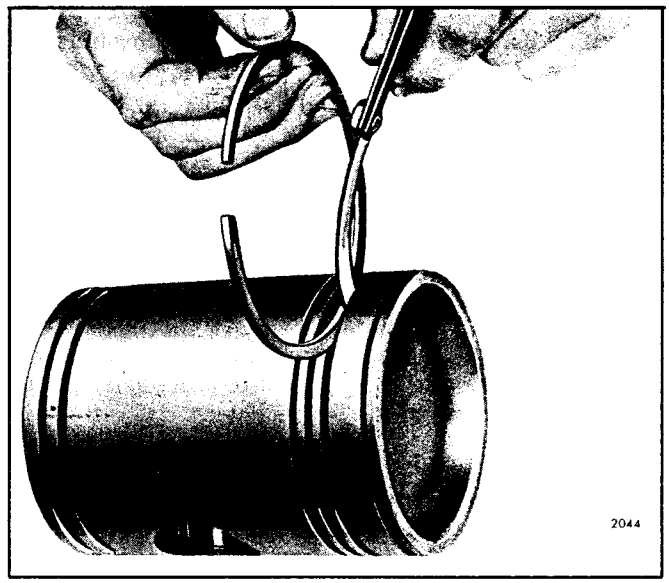

Fig. 10 - Measuring Piston Ring Side Clearance

remain square and the chamfer must be approximately .015 " on the outer edge.

Check the ring clearances in the piston grooves as illustrated in Fig. 10. Refer to Section 1.0 for the specified ring clearances and allowable wear limits.

Install Compression Rings on Piston

With the connecting rod assembly inspected and assembled to the piston as outlined in Section 1.6.1, refer to Fig. 1 for the proper location of the piston rings on the piston.

IMPORTANT: Lubricate the piston rings and piston with engine oil before assembling.

Assemble the compression rings on the piston with tool J 8128, as shown in Fig. 2, and stagger the ring gaps around the piston. When installing the compression or oil control rings, do not spread the rings more than is necessary to slip them on the piston to avoid overstressing the rings.

NOTE: When installing the top compression (fire) ring with the tapered face, be sure and install the ring with the mark "TOP" toward the top of the piston.

Install Oil Control Rings on Piston (Non-Turbocharged Engines)

Install the oil control rings by hand, with the scraping edge of each ring down, as follows:

1. Install an expander in the upper oil ring groove (Fig. 1), being careful not to overlap the ends.

NOTE: The oil control ring expander must be completely seated in the oil ring groove. The ends of the expander can very easily be overlapped. If this occurs, the oil control rings will protrude slightly and be broken when the piston ring compressor is installed over the piston and rod assembly, or when the piston and rod assembly is installed in the cylinder liner.

2. Install the top oil ring with the gap 180 ° from the ends of the expander.

3. Check the ends of the expander to be sure they are not overlapped.

4. Install the bottom oil ring with the gap 45 ° from the gap of the top oil ring. Recheck to be sure the ends of the expander are not overlapped.

NOTE: Do not, at any time, cut off or grind the ends of the oil ring expander to prevent the ends from overlapping. Cutting off or grinding the ends of the expander will decrease the tension on the oil control rings and result in high lubricating oil comsumption.

5. Install the second set of oil control rings and expander in the same manner as described above.

Install Oil Control Rings on Piston (Turbocharged Engines)

Install the upper oil control ring by hand with the scraper edge down as follows:

1. Install an oil ring expander (circular abutment) in the upper oil ring groove of the piston (Fig. 1). The expander must be completely seated in the groove.

CAUTION: Open the expander just enough to allow it to slip over the piston.

2. Install the upper oil control ring (one piece) in the piston upper oil ring groove.

Install the lower oil control rings (two pieces) by hand with the scraper edge of each ring down in the same manner as described above for the non-turbocharged engines.

CONNECTING ROD

Each connecting rod (Figs. 1 and 2) is made of steel forged to an "I" section with a closed hub at the upper end and a cap at the lower end. The rod is drilled to provide lubrication to the piston pin at the upper end and is equipped with an oil spray nozzle for cooling the underside of the piston head on engines equipped with an an oil cooler. Engines that are not equipped with an oil cooler do not use nozzle type connecting rods.

NOTE: Never intermix nozzle type connecting rods in an engine with non-nozzle type connecting rods.

A helically-grooved bushing is pressed into each side of the connecting rod at the upper end. A cavity of approximately 1/8" between the inner ends of these bushings, registering with the drilled oil passage in the connecting rod, forms a duct around the piston pin. A portion of the oil from this duct lubricates the piston pin and bushings, the remainder of the oil is forced out of the spray nozzle. The piston pin floats in both the piston and connecting rod bushings.

Service connecting rod assemblies include the lower bearing cap, bolts, nuts, spray nozzle (if used) and the upper piston pin bushings pressed in place and bored to size.

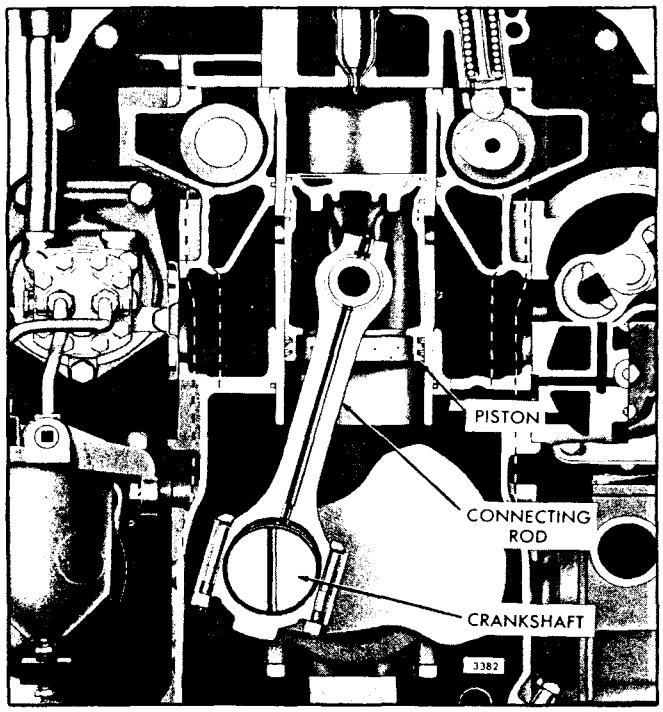

Fig. 1 - Connecting Rod Mounting

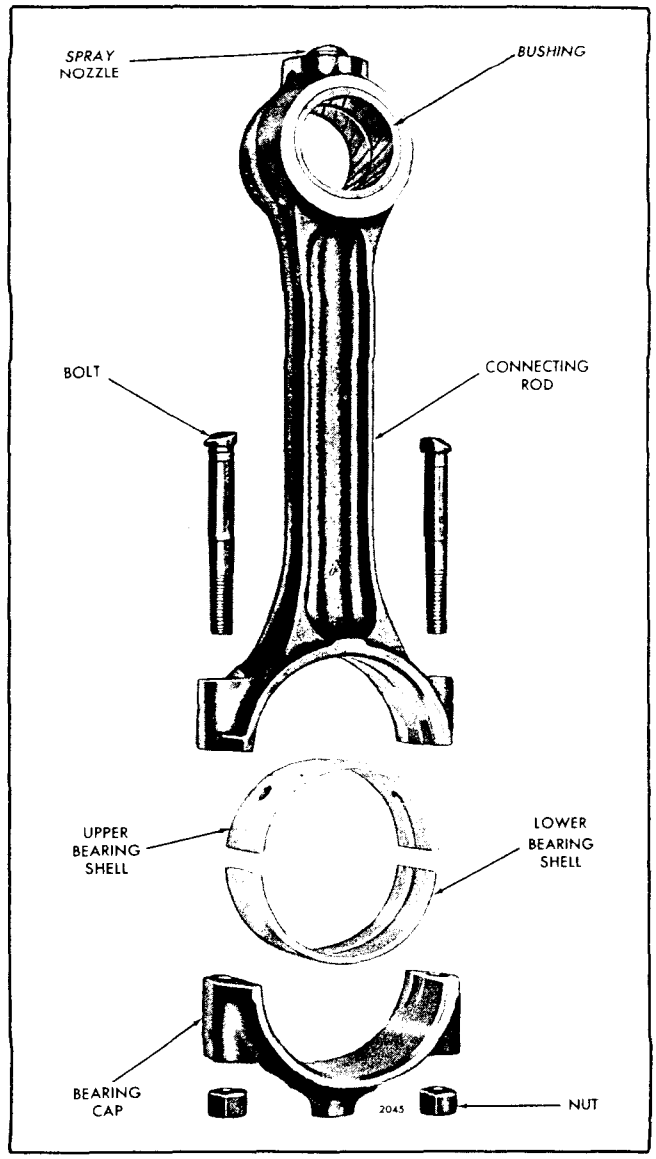

Fig. 2 - Typical Connecting Rod Details and Relative Location of Parts

Disassemble Connecting Rod from Piston (Rod and Piston Assembly Removed from Engine)

Disassemble the piston and connecting rod as outlined in Section 1.6.

Inspect Connecting Rod and Piston Pin

Clean the connecting rod and piston pin with fuel oil and dry them with compressed air.

Blow dry compressed air through the oil passage in the connecting rod and the spray nozzle to be sure the holes are open.

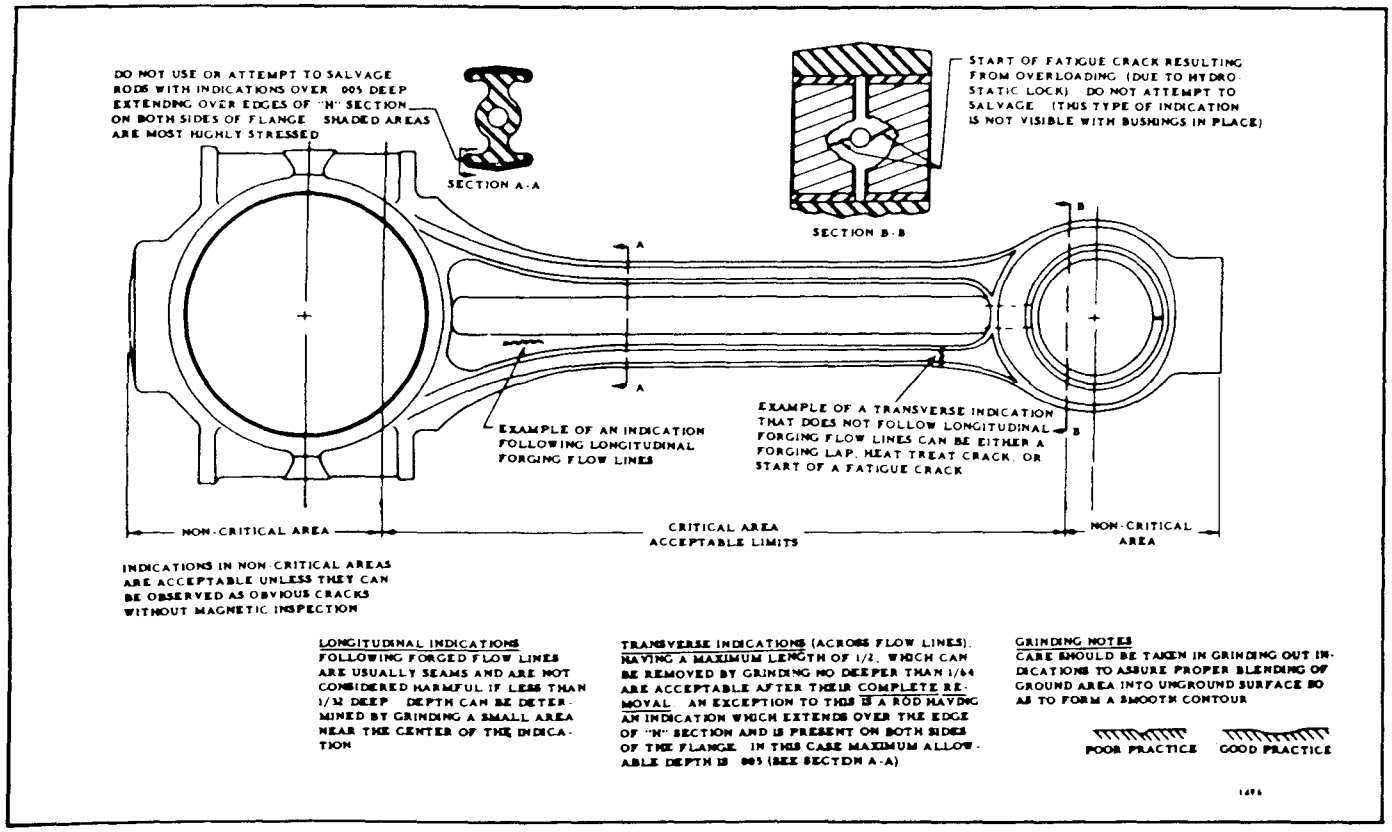

Fig. 3 - Magnetic Particle Inspection Limits for Connecting Rod

Check the connecting rod for cracks (Fig. 3) as outlined in Section 1.3 under *Crankshaft Inspection.*

Check the connecting rod bushings for signs of scoring, overheating or other damage. Bushings that have overheated may become loose and creep together, thus blocking off the lubricating oil to the piston pin, bushings and spray nozzle.

Check the clearance between the piston pin and the connecting rod bushings. If the clearance exceeds .010" with used parts, replace the piston pin and/or the bushings.

Remove Bushings from Connecting Rod

If it is necessary to replace the connecting rod bushings, remove them as follows:

1. Clamp the upper end of the connecting rod in holder J 7632 (Fig. 4) so that the bore in the bushings is aligned with the hole in the base of the holder.

2. Set the bushing remover J 4972-4 in the connecting rod bushing, insert handle J 1513-2 in the remover and drive the bushings from the rod.

Replace Spray Nozzle

If it is necessary to replace the spray nozzle, remove the old nozzle as follows:

1. Remove the piston pin bushings from the connecting rod as outlined above.

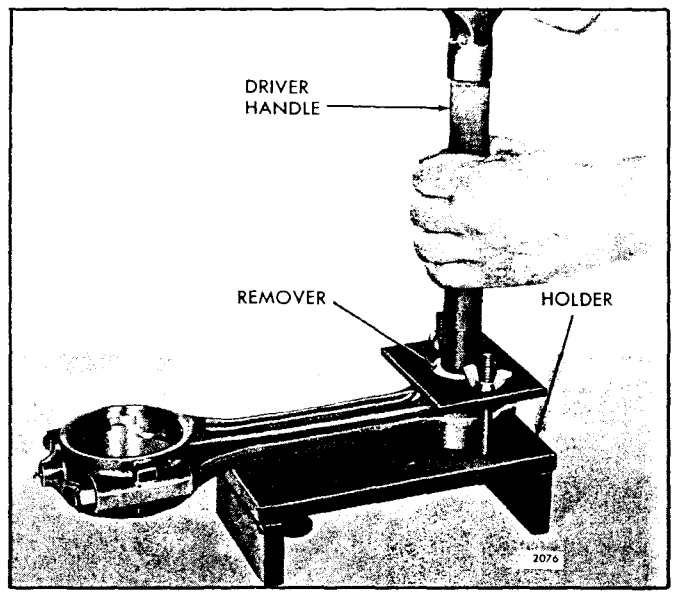

Fig. 4 - Removing or Installing Bushings

2. Place the connecting rod, spray nozzle remover J 8995 and a short sleeve in an arbor press as shown in Fig. 5.

NOTE: The orifice in the lower end of the drilled passage in the connecting rod is not serviced separately, and it is not necessary to remove it when replacing the spray nozzle.

3. Press the spray nozzle out of the connecting rod.

Install a new spray nozzle in the connecting rod as follows:

1. Start the spray nozzle, with the holes positioned as shown in Fig. 6, straight into the counterbore in the top of the connecting rod.

2. Support the connecting rod in an arbor press. Then, place a short, 3/8" I.D. sleeve on top of the spray nozzle and under the ram of the press.

3. Press the spray nozzle into the connecting rod until it bottoms in the counterbore.

Install Bushings in Connecting Rod

1. Clamp the upper end of the connecting rod assembly in holder J 7632 so that the bore for the bushings aligns with the hole in the base of the tool.

2. Start a new bushing straight into the bore of the connecting rod.

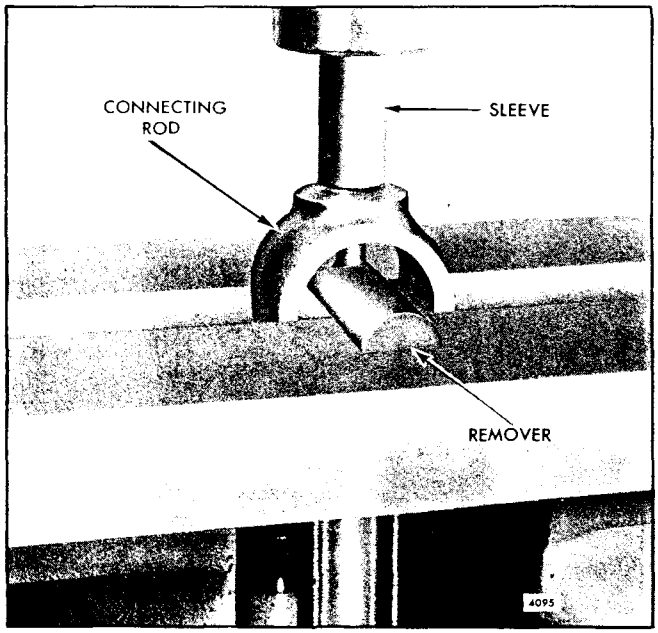

Fig. 5 - Removing Spray Nozzle from Connecting Rod

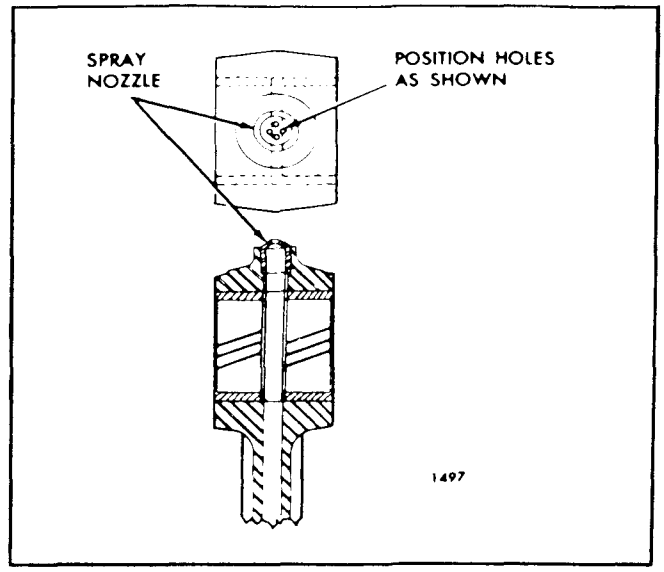

Fig. 6 - Location of Spray Nozzle in Connecting Rod

NOTE: When installing a bushing in the connecting rod, locate the joint at the top of the connecting rod (Fig. 7).

3. Insert installer J 4972-2 in the bushing, then insert handle J 1513-2 in the installer and drive the bushing into the connecting rod until the flange of the installer bottoms on the connecting rod (Fig. 4).

4. Turn the connecting rod over in the holder and install the second bushing in the same manner.

Ream Bushings in Connecting Rod

The bushings must be finished reamed after being installed in the connecting rod. Refer to Fig. 8 and ream the bushings as follows:

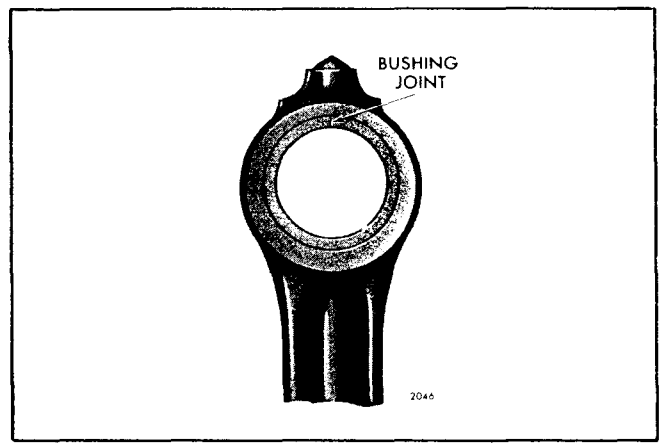

Fig. 7 - Location of Joint in Piston Pin Bushings

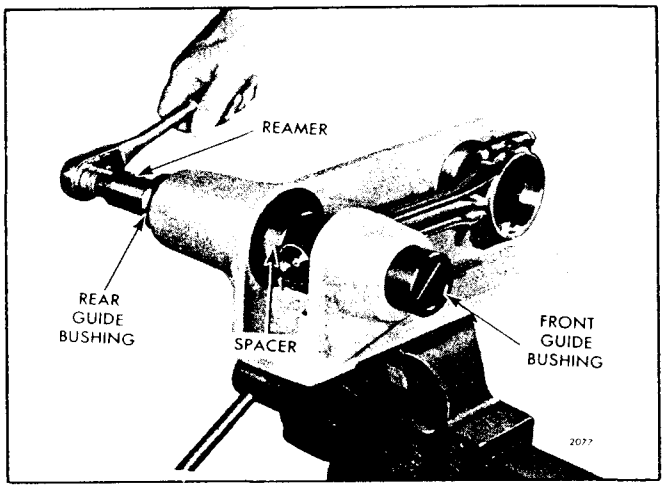

Fig. 8 - Reaming Piston Pin Bushings

1. Clamp reaming fixture J 7608-4 in a vise.

2. Slide sleeve J 7608-5 on the arbor of the fixture (V-type engine connecting rod).

3. Place the crankshaft end of the connecting rod on the arbor of the fixture. Tighten the nuts on the 3/8" - 24 bolts (In-line and V-type engines) to 40-45 lb-ft torque. Tighten the nuts on the 5/16" -24 bolts (early 6V engines) to 24-28 lb-ft torque.

4. Install the front guide bushing J 4971-6 in the fixture (pin end out).

5. Install spacer J 7608-3 in the fixture.

6. Align the upper end of the connecting rod with the hole in the reaming fixture.

7. Install the rear guide bushing J 1686-5 on the reamer J 7608-21; then, slide the reamer and bushing into the fixture.

8. Turn the reamer in a clockwise direction only, when reaming or withdrawing the reamer. For best results, use only moderate pressure on the reamer.

9. Remove the reamer and the connecting rod from the fixture, blow out the chips and measure the inside diameter of the bushings. The inside diameter of the bushings should be 1.3760" to 1.3765".

Assemble Connecting Rod to Piston

1. Apply clean engine oil to the piston pin and bushings.

2. Rest the piston in the holding fixture (Fig. 9).

3. Place a new piston pin retainer in the piston; then, place the crowned end of the installer J 4895-01 on the retainer and strike the tool just hard enough to deflect the retainer and seat it evenly.

CAUTION: Do not drive too hard on the retainer or the bushing may be moved inward and result in reduced piston pin end clearance.

4. Slide the piston pin into the piston and the upper end of the connecting rod. The piston pin will slip readily into position without forcing it if the clearances are correct.

5. Install the second piston pin retainer as outlined above.

6. After the piston pin retainers have been installed, check for piston pin end clearance by *cocking* the connecting rod on the pin and shifting the pin in its bushings.

7. One important function of the piston pin retainer is to prevent the oil, which cools the underside of the piston and lubricates the piston pin bushings, from reaching the cylinder walls. Check the retainers for proper sealing as follows:

a. Place the piston and connecting rod assembly upside down on a bench.

b. Pour clean fuel oil in the piston to a level above the piston pin bosses.

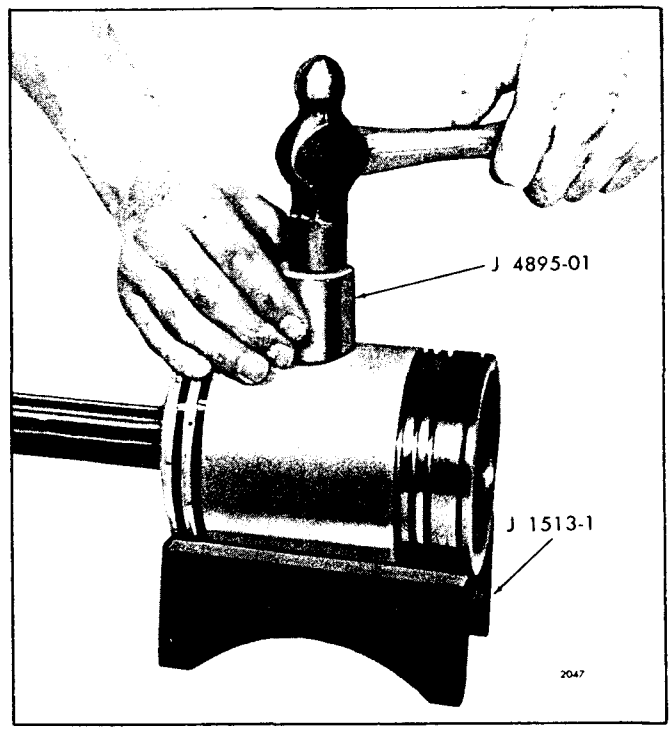

Fig. 9 - Installing Piston Pin Retainer with Tool J 4895-01

c. Dry the external surfaces of the piston in the area around the retainers and allow the fuel oil to set for about fifteen minutes.

d. Check for seepage of fuel oil around the retainers. If the fuel oil leaks around the retainers, install new retainers. In extreme cases it may be necessary to replace the piston.

e. After the leakage test is completed, empty the fuel oil from the piston, dry the parts with compressed air and lubricate the piston pin with clean engine oil.

8. Install the piston rings on the piston as outlined in Section 1.6.

9. Install the piston and connecting rod assembly in the engine as outlined in Section 1.6.3.

CONNECTING ROD BEARINGS

The connecting rod bearing shells are of the replaceable precision type and consist of an upper shell seated in the connecting rod and a lower shell seated in the connecting rod cap (Fig. 2, Section 1.6.1). The bearing shells are located by and prevented from end wise or radial movement by a tang at the parting line at one end of each shell. The current connecting rod bearing shells used in the V-type engines incorporate a relief groove in each end of the shell to provide clearance for the 3/8" connecting rod bolts.

The connecting rod bearing caps are numbered 1, 2, 3, etc. on an In-line engine and 1R, 1L, 2R, 2L, etc. on the V-type engine, with matching numbers stamped on the connecting rod. Each bearing cap (and bearing shell) must be installed on its original connecting rod.

Since the upper and lower connecting rod bearing shells are different, they must not be interchanged. The upper bearing shell has two short oil grooves and two oil holes; each groove begins at the end of the shell and terminates at an oil hole. The lower bearing shell has a continuous oil groove from one end of the shell to the other. These grooves maintain registry with the oil holes in the crankshaft journals, thereby providing a constant supply of lubricating oil to the connecting rod bearings and to the piston pin bushings and spray nozzle through the oil passage in the connecting rod.

Remove Bearing Shells from Connecting Rod (Connecting Rod, Piston and Liner in Place)

1. Drain the engine lubricating oil.

2. Remove the oil pan.

3. Disconnect and remove the oil pump inlet tube assembly.

4. Remove one connecting rod bearing cap. Push the connecting rod and piston assembly up into the cylinder liner far enough to permit removal of the upper bearing shell. Do not pound on the edge of the shell with a sharp tool.

5. Inspect the upper and lower bearing shells as outlined under *Inspection.*

6. Install the bearing shells and bearing cap before another cap is removed.

Inspection

Visual inspection, as well as dimensional measurements, should be made to determine whether the used bearings are satisfactory for further service or must be replaced.

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil which results in scratching, etching, scoring or excessive wear. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no lubricating oil.

Check the oil filter elements for heavy sludge deposits. If necessary, replace the elements.

After removal, clean the bearings and inspect them for scoring, pitting, flaking, etching and dirt grooving. If any of these defects are present, the bearings must be discarded. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are NOT detrimental to this type of bearing. The bearings should not be replaced for these minor surface imperfections. The upper bearing shells, which carry the load, will normally show signs of distress before the lower shells do.

Inspect the back of the bearing shells for bright spots which indicate they have been moving in their supports. If such spots are present, discard the bearing shells. Also inspect the connecting rod bearing bores for burrs, foreign particles, etc.

Measure the thickness of the bearing shells at point "C", 90° from the parting line, as shown in Fig. 6, Section 1.3.4. Use a micrometer and ball attachment J 4757 as illustrated in Fig. 7, Section 1.3.4.

The minimum thickness of a worn standard bearing shell should not be less than .123" . In addition to this thickness measurement, check the clearance between the connecting rod bearing shells and the crankshaft journal. This clearance may be checked with the crankshaft in place by squeezing a soft plastic measuring strip between the crankshaft journal and the bearing shells (see *Shop Note* in Section 1.0).

One connecting rod bearing shell should not be replaced. If one bearing shell requires replacement, both the upper and lower shells should be replaced.

Inspect the crankshaft journals, as outlined in Section 1.3, for wear before replacement bearings are installed.

Bearing shells in .010" , .020" and .030" undersize are available for service with crankshafts which have worn or have been ground to a smaller journal diameter.

Bearing shells which are .002" undersize are available to compensate for slight journal wear in those cases where it is unnecessary to regrind the crankshaft.

NOTE: Bearing shells are NOT reworkable from one undersize to another under any circumstances.

The following table gives the minimum bearing shell thickness for used standard and various undersize bearings, and the crankshaft connecting rod journal diameters corresponding to each bearing size.

Nominal Size of Bearing	Minimum New Bearing Shell Thickness	Crankshaft Connecting Rod Journal Diameters
In-Line Engine		
Standard	.1245"	2.499"-2.500"
.002" Undersize	.1255"	2.497"-2.498"
.010" Undersize	.1295"	*2.489"-2.490"
.020" Undersize	.1345"	*2.479"-2.480"
.030" Undersize	.1395"	*2.469"-2.470"
V-Type Engine		
Standard	.1247"	2.749"-2.750"
.002" Undersize	.1257"	2.747"-2.748"
.010" Undersize	.1297"	*2.739"-2.740"
.020" Undersize	.1347"	*2.729"-2.730"
.030" Undersize	.1397"	*2.719"-2.720"

*Dimension of Reground Crankshaft

Install Connecting Rod Bearing Shells (Connecting Rod, Piston and Liner in Place)

1. Rotate the crankshaft until the connecting rod journal is at the bottom of its travel, wipe the journal clean and lubricate it with clean engine oil.

2. Install the upper bearing shell - the one with the short groove and oil hole at each parting line - in the connecting rod. Be sure the tang on the shell fits in the groove in the rod.

If there is a visible difference in the color of new upper and lower bearing shells, it is due to a change in the manufacturing process and they should not be rejected on the basis of the dissimilar appearance.

3. Pull the piston and rod assembly down until the upper rod bearing seats firmly on the crankshaft journal.

4. Place the lower bearing shell - the one with the continuous oil groove - in the bearing cap, with the tang of the shell in the groove of the cap, and lubricate it with clean engine oil.

5. Note the identifying marks on the cap and the rod and assemble the cap to the rod. Tighten the nuts on the 3/8" -24 bolts (In-line and "V" engines) to 40-45 lb-ft torque. Tighten the nuts on the former 5/16" -24 bolts (6V engine) to 24-28 lb-ft torque.

6. Install the lubricating oil pump inlet tube assembly. Replace the inlet tube seal ring or elbow gasket if hardened or broken.

7. Install the oil pan.

8. Refer to the *Lubricating Oil Specifications* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

9. If new bearings were installed, operate the engine on the run-in schedule as outlined in Section 13.2.1.

CYLINDER LINER

The cylinder liners (Fig. 1) are of the replaceable wet type, made of hardened alloy cast iron, and are a slip fit in the cylinder block. The current liner is centrifugally cast, while the former liner was sand cast.

They are inserted in the cylinder bores from the top of the cylinder block. The flange of each liner rests on a counterbore in the top of the block.

A synthetic rubber seal ring, recessed in the cylinder block bore, is used between the liner and the block to prevent water leakage into the air box.

The upper portion of the liner is directly cooled by water surrounding the liner. The center portion of the liner is air cooled by the scavenging air which enters the cylinder through eighteen equally spaced ports. On 6V (aluminum) and 8V-53 engines, the lower portion of the liner is cooled by water inside the cylinder block water-jacket surrounding the liner. However, regardless of the type of cooling, the current cylinder liner is applicable to all engines.

The angle of the ports in the cylinder liner creates a uniform swirling motion to the intake air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

The wear on a liner and piston is directly related to the amount of abrasive dust and dirt introduced into the engine combustion chamber through the air intake. This dust, combined with lubricating oil on the cylinder wall, forms a lapping compound and will result in rapid wear. Therefore, to avoid pulling contaminated air into the cylinder, the air cleaners must be serviced regularly according to the surroundings in which the engine is operating.

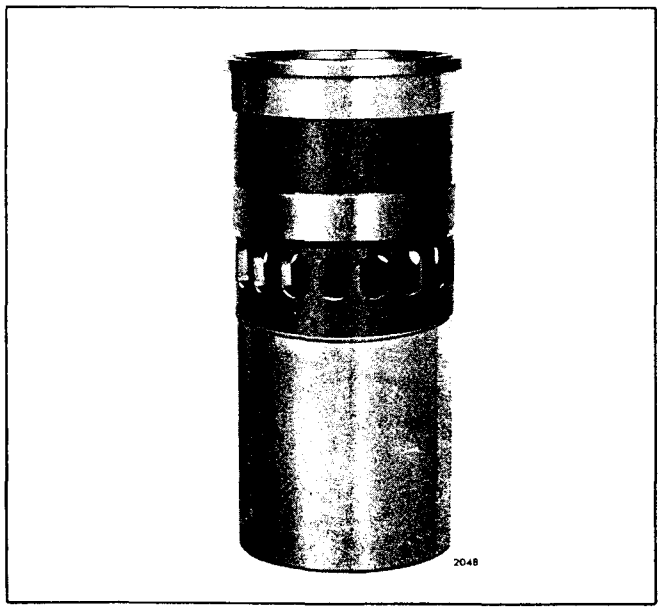

Fig. 1 - Cylinder Liner

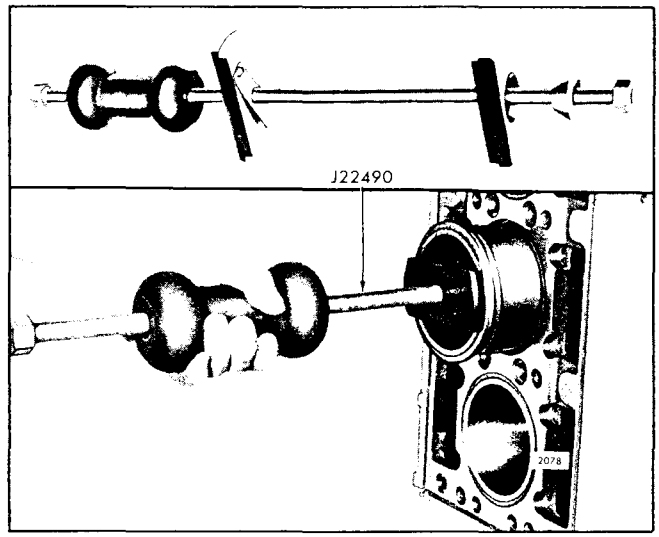

Fig. 2 - Removing Cylinder Liner

If the worn clearance between the piston and cylinder liner becomes excessive or should the liner be badly scored resulting in unsatisfactory engine performance, the cylinder liner must be replaced.

Remove Cylinder Liner

If necessary, a cylinder liner or liners may be removed from the cylinder block as follows:

1. Remove the piston and connecting rod assembly as outlined in Section 1.6 under *Remove Piston and Connecting Rod.*

2. If the engine has been in service for an extended period, considerable effort may be required to loosen the liner from its position. When this condition exists, remove the liner with tool set J 22490 (Fig. 2) as follows:

   a. Slip the lower puller clamp up the puller rod and off its tapered seat. Cock the clamp so it will slide down through the liner. The clamp will drop back onto its seat in a horizontal position after it clears the bottom of the liner.

   b. Slide the upper puller clamp down against the top edge of the liner.

   c. With the tool in place, strike the upset head on the upper end of the puller rod a sharp blow with the puller weight, thus releasing the liner. Remove the liner.

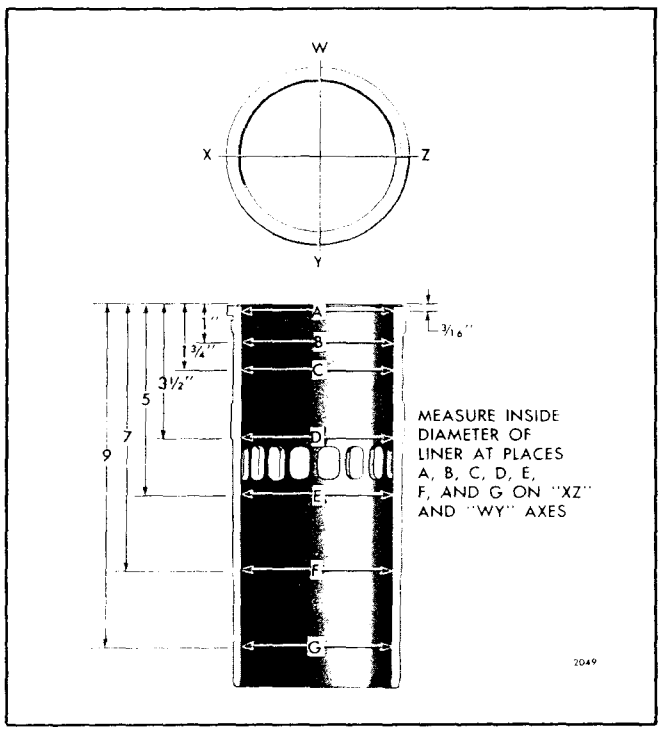

Fig. 3 - Cylinder Liner Measurement Diagram

d. Remove the cylinder liner seal ring from the groove in the cylinder block bore.

If tool J 22490 is unavailable, tap the liner out with a hardwood block and hammer.

CAUTION: To avoid damage to the top land of the piston, do not at any time try to loosen the cylinder liner by inserting a long bolt or rod through the port openings in the cylinder liner and turning the crankshaft, thus pushing the liner up with the piston.

Inspect Used Cylinder Liner

When the cylinder liner is removed from the cylinder block, it must be thoroughly cleaned and then checked for:

Cracks

Scoring

Poor contact on outer surface

Flange irregularities

Inside diameter

Out-of-roundness

Taper

A cracked or excessively scored liner must be discarded. A slightly scored liner may be cleaned-up and re-used.

Install the liner in the cylinder block and measure the inside diameter of the liner at the various points shown in Fig. 3. If the taper exceeds .002" or the out-of-round exceeds .003", replace the liner. To check these dimensions, use dial bore gage J 5347 (Fig. 4) which has a dial indicator calibrated in .0001" increments. Set the gage on zero with master ring J 8385.

NOTE: Dial bore gage master setting fixture J 23059 may be used in place of master ring J 8385.

Hone Used Cylinder Liner

If the taper or out-of-round do not exceed the limits, hone the liner to remove any step or ridge at the top of the ring travel and to remove the glaze caused by the rubbing action of the piston rings.

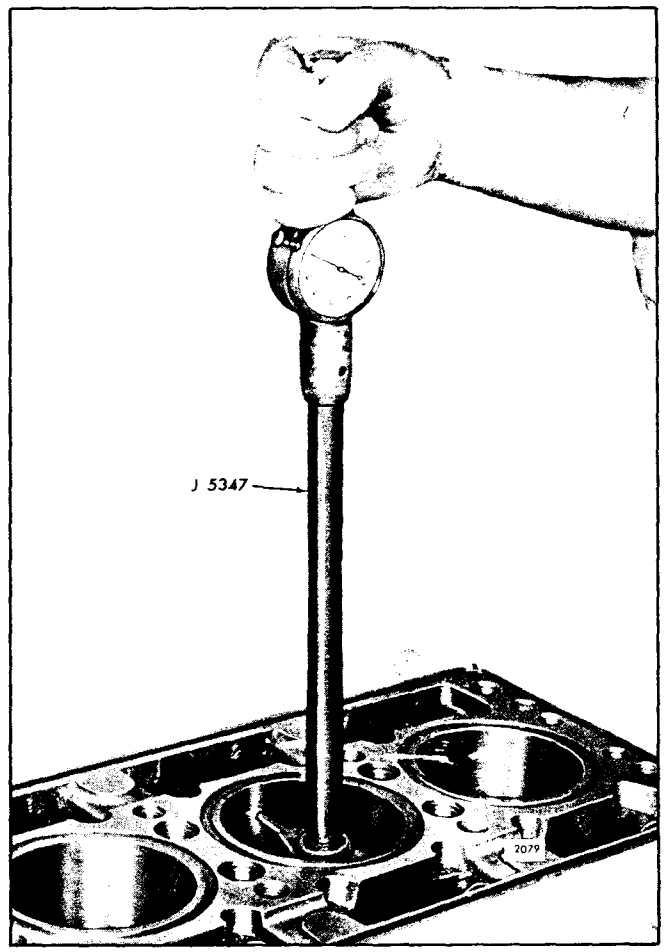

Fig. 4 - Checking Bore of Cylinder Liner

Whenever a liner is honed, it must be placed in a fixture (a scrap cylinder block makes an excellent honing fixture). However, if it is necessary to hone a liner in the cylinder block that is to be used in building up the engine, the engine must be dismantled and then, after honing, the cylinder block and other parts must be thoroughly cleaned to ensure that all abrasive material is removed.

Work the hone J 5902-01, equipped with 120 grit stones J 5902-14, up and down the full length of the liner a few times so a "criss-cross" pattern with the hone marks on a 45° axis will result.

After the liner has been honed, remove it from the fixture and clean it thoroughly. Then, dry it with compressed air and check the entire surface for burrs.

After honing, the liner must conform to the same limits on taper and out-of-round as a new liner, and the piston-to-liner clearance must be within the specified limits shown in Section 1.0.

Inspect New Cylinder Liner

Both the former and current liners can be intermixed in In-line or 6V engines. Only the current liner can be used in 8V engines.

Install the cylinder liner in the block and measure the inside diameter at the various points shown in Fig. 3. Use dial bore gage J 5347 and set the gage on zero with master ring J 8385.

> **NOTE:** Dial bore gage master setting fixture J 23059 may be used in place of master ring J 8385.

A new cylinder liner is 3.8752" to 3.8767" on the inside diameter, and should be straight from top to bottom within .001" and round within .002" total indicator reading when the liner is in place in the block. Refer to Section 1.0 for the specified piston-to-liner clearance.

> **NOTE:** Do not modify the surface finish in a new service cylinder liner. Since the liner is properly finished at the factory, any change will adversely affect the seating of the piston rings.

Fitting Cylinder Liner in Block Bore

1. Wipe the inside and outside of the liner clean. Also, make sure the block bore and counterbore are clean so the liner flange will seat properly. Then, slide the liner into the block until the flange rests on the bottom of the counterbore in the block.

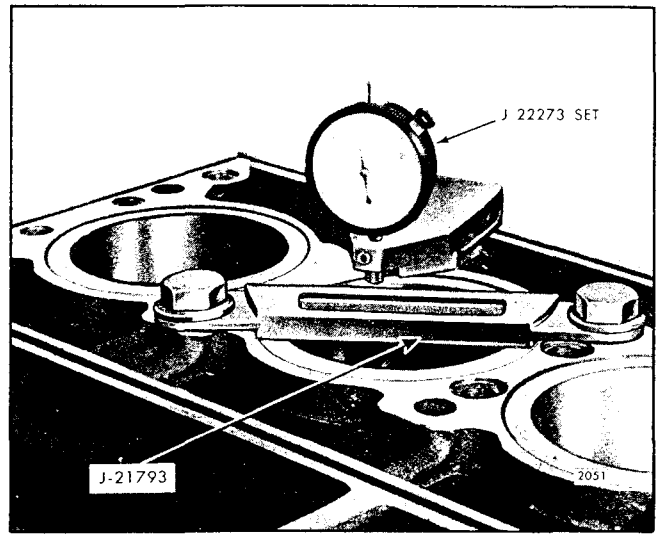

Fig. 5 - Checking Distance of Liner Flange Below Top Face of Block

> **CAUTION:** Do not drop or slam the liner flange against the bottom of the counterbore in the block.

2. Tap the liner lightly with a soft hammer to make certain the liner flange seats on the bottom of the counterbore.

3. Clamp the liner in place with hold-down clamp J 21793 and measure the distance from the top of the liner flange to the top of the block with dial indicator set J 22273 (Fig. 5). The top of the liner flange should be .0465" to .050" below the top of the block, and there must not be over .0015" difference between any two adjacent liners when measured along the cylinder longitudinal center line. If the above limits are not met, install the liner in another bore and recheck, or use a new liner.

4. Matchmark the liner and the block with chalk or paint, so the liner may be reinstalled in the same position in the same bore. Place the matchmark on the engine serial number side of the block (In-line engine) or on the outer edge of the block (V-type engine).

5. Remove the hold-down clamp and the liner.

Install Piston and Connecting Rod Assembly

1. With the piston assembled to the connecting rod and the piston rings in place, as outlined in Sections 1.6 and 1.6.1, apply clean engine oil to the piston, rings and the inside of the piston ring compressor J 6883.

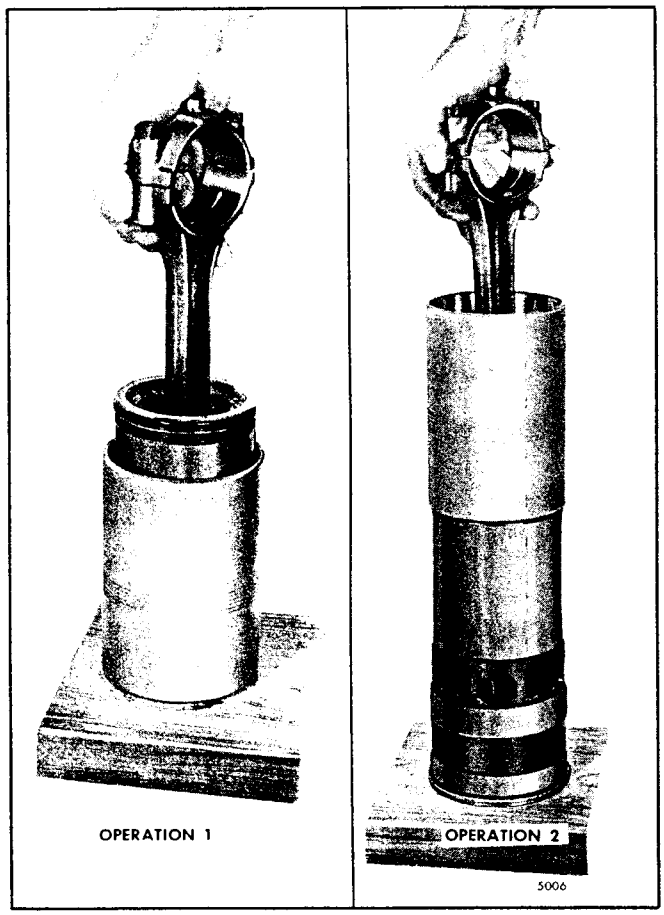

Fig. 6 - Installing Piston and Connecting Rod Assembly in Ring Compressor and Cylinder Liner

NOTE: Inspect the ring compressor for nicks or burrs, especially at the non-tapered inside diameter end. Nicks or burrs on the inside diameter of the compressor will result in damage to the piston rings.

2. Place the piston ring compressor on a wood block (tapered end up).

3. Position (stagger) the piston ring gaps properly on the piston. Make sure that the oil control ring expanders are not overlapped.

4. Start the top of the piston straight into the ring compressor; then, push the piston down until it contacts the wood block (see Operation 1, Fig. 6).

5. Note the position of the matchmark on the liner and place the liner on a wood block.

6. Place the ring compressor and the piston and rod assembly on the liner, so the numbers on the rod and cap are aligned with the matchmark on the liner (see Operation 2, Fig. 6).

NOTE: The numbers, or number and letter, on the side of the connecting rod and cap identify the rod with the cap and indicate the particular cylinder in which they are used. If a new service connecting rod is to be installed, the same identification numbers, or number and letter, must be stamped or etched in the same location as on the connecting rod that was replaced.

7. Push the piston and rod assembly down into the liner until the piston is out of the ring compressor.

CAUTION: Do not force the piston into the liner. The peripheral abutment type expanders apply considerably more force on the oil ring than the standard expander. Therefore, extra care during the loading operation must be taken to prevent ring breakage.

8. Remove the connecting rod cap and the ring compressor.

9. Push the piston down into the liner until the compression rings pass the liner ports.

Install Cylinder Liner, Piston and Connecting Rod Assembly

After the piston and connecting rod assembly have been installed in the liner, the entire assembly may be installed in the engine as follows:

1. Make sure the seal ring grooves in the cylinder block are clean. Then, install the seal ring.

NOTE: The current cylinder block has an additional seal ring groove approximately 1/8"

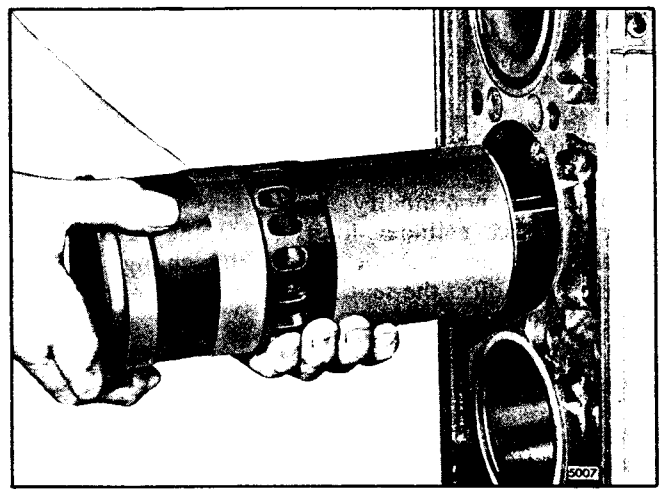

Fig. 7 - Installing Piston, Connecting Rod and Liner Assembly in Cylinder Block

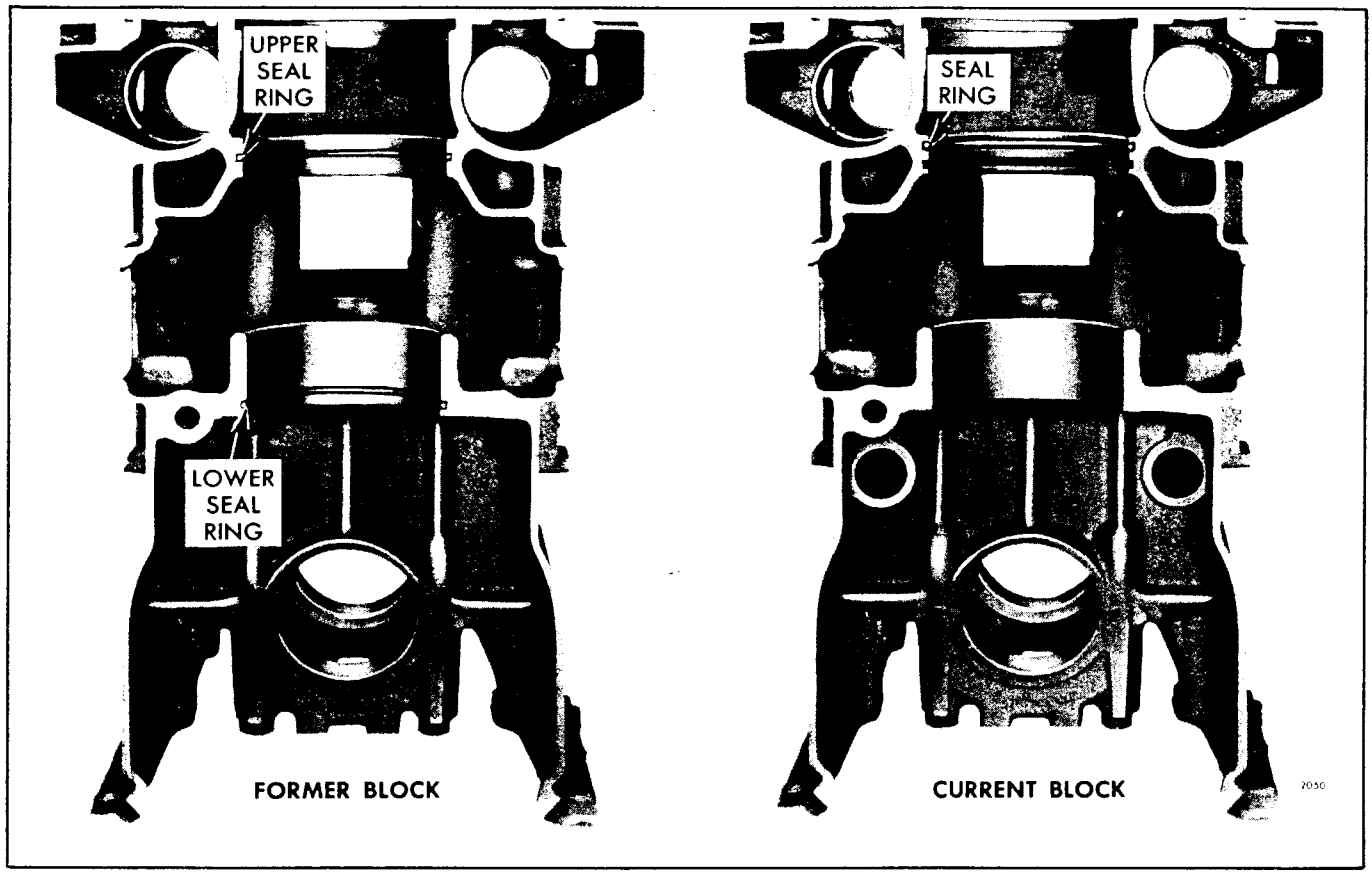

Fig. 8 - Cylinder Liner Seal Ring Locations in Cylinder Block Bores

below the original top groove (Fig. 8). This groove will permit further use of the cylinder block where corrosion or erosion of the upper seal ring groove has occurred. The lower seal ring groove in the current cylinder block has been eliminated. Reinstallation of the lower seal ring is not necessary in the former cylinder block.

2. Apply hydrogenated vegetable type shortening or permanent type antifreeze solution to the inner surface of the seal ring.

3. If any of the pistons and liners are already in the engine, use hold-down clamps (Fig. 5) to retain the liners in place when the crankshaft is rotated.

4. Rotate the crankshaft until the connecting rod journal of the particular cylinder being worked on is at the bottom of its travel, wipe the journal clean, and lubricate it with clean engine oil.

5. Install the upper bearing shell -- the one with a short groove at each parting line -- in the connecting rod. Lubricate the shell with clean engine oil.

6. Hold the piston, rod and liner in line with the block bore (Fig. 7) so the identification number on the rod is facing the outer edge of the block (V-type engine) or the engine serial number side (In-line engine). Also, align the matchmarks on the liner and block. Now slide the entire assembly into the block bore and seal rings, being careful not to damage the seal rings.

7. Pull or push the piston and connecting rod down until the upper bearing shell seats firmly on the crankshaft journal. Use care so the bearing shell will not be dislodged from the rod.

CAUTION: On a V engine, the distance from the center of the connecting rod bolts to the sides of the rod are not equal. Therefore, to avoid cocking the rods, the narrow sides of the rods must be together when attached to the crankshaft.

8. Place the lower bearing shell -- the one with the continuous oil groove -- in the connecting rod cap with the tang on the bearing in the notch in the cap. Lubricate the bearing shell with clean engine oil.

9. Install the bearing cap and shell on the connecting rod with the numbers on the cap and the rod adjacent to each other. On the 3/8" -24 bolts (In-line and "V" engines), tighten the nuts to 40-45 lb-ft torque. Tighten the nuts on the 5/16" -24 bolts (early 6V engines) to 24-28 lb-ft torque.

NOTE: Rework of an old 6V-53 rod assembly to utilize 3/8" bolts is not recommended.

IMPORTANT: The new 6V-53 rod assembly with 3/8" bolts should be used for replacement at the time of normal overhaul.

10. Check the connecting rod side clearance. The clearance between the side of the rod and the crankshaft should be .006" to .012" with new parts on an In-line or .008" to .016" clearance between the connecting rods on a V-type engine.

11. Remove the liner hold-down clamps.

12. Install new compression gaskets and water and oil seals as outlined in Section 1.2. Then, install the cylinder head.

13. Install any other parts which were removed from the engine.

14. After the engine has been completely reassembled, refer to the *Lubricating Oil Specifications* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

15. Close all of the drains and fill the cooling system.

16. If new parts such as pistons, rings, cylinder liners or bearings were installed, operate the engine on the RUN-IN schedule given in Section 13.2.1.

ENGINE BALANCE AND BALANCE WEIGHTS

In the balance of two-cycle engines, it is important to consider disturbances due to the reciprocating action of the piston masses. These disturbances are of two kinds: unbalanced forces and unbalanced couples. These forces and couples are considered as primary or secondary according to whether their frequency is equal to engine speed or twice engine speed. Although it is possible to have unbalanced forces or couples at frequencies higher than the second order, they are of small consequence in comparison to the primary forces and couples. Even the secondary forces and couples are usually of little practical significance.

The reciprocating masses (the piston and upper end of the rod) produce an unbalanced couple due to their arrangement on the crankshaft. On a V-type engine, this unbalanced couple tends to move the ends of the engine in an elliptical path; on an In-line engine, it tends to rock the engine from end to end in a vertical plane. This couple is cancelled by incorporating an integral crankshaft balance component and by placing balance weights at the outer ends of the camshafts (V-type engine) or at the outer ends of the balance shaft and camshaft (In-line engine). This balance arrangement produces a couple that is equal and opposite in magnitude and direction to the primary couple.

On the camshafts (V-type engine) or balance shaft and camshaft (In-line engine), each set of weights (weights on the outer ends of each shaft comprise a set) rotates in an opposite direction with respect to the other. When the weights on either end of the engine are in a vertical plane, their centrifugal forces are in the same direction and oppose the primary couple. When they are in a horizontal plane, the centrifugal forces of these balance weights oppose each other and are, therefore, cancelled. The front balance weights act in a direction opposite to the rear balance weights; therefore, rotation will result in a couple effective only in a vertical plane. This couple, along with that built into the crankshaft, forms an elliptical couple which completely balances the primary couple.

The balance weights are integral with the gears and the circular balance weights (pulleys) on the shafts. Additional weights are attached to the camshaft and balance shaft gears on two, three and four cylinder engines.

Both the rotating and primary reciprocating forces and couples are completely balanced in the engines. Consequently, the engines will operate smoothly and in balance throughout their entire speed range.

Remove Front Balance Weights

1. Remove the nut at each end of both shafts as outlined in Section 1.7.2.

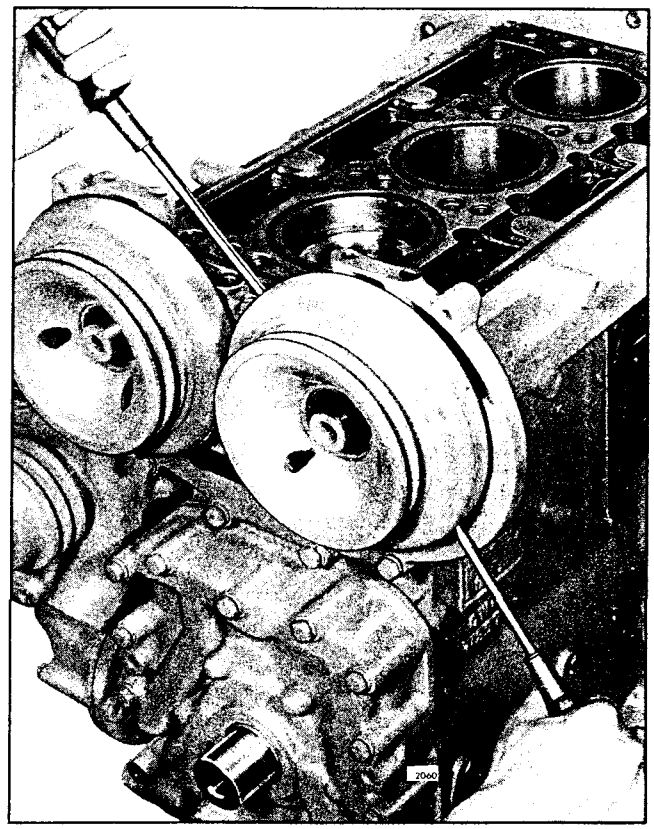

Fig. 1 - Removing Front Balance Weight (Pulley Type)

2. Force the balance weight off the end of each shaft, using two screw drivers or pry bars between the balance weight and the upper front cover as shown in Fig. 1.

Install Front Balance Weights

1. Reinstall the Woodruff keys in the shafts, if they were removed.

2. Align the keyway in the balance weight with the key in the shaft; then, slide the weight on the shaft. If the weight does not slide easily onto the shaft, loosen the thrust washer retaining bolts at the opposite end of the shaft; then, to prevent possible damage to the thrust washer, support the rear end of the shaft while tapping the weight into place with a hammer and a sleeve. Retighten the thrust washer retaining bolts to 30-35 lb-ft torque. Install the other weight in the same manner.

3. Wedge a clean rag between the gears. Refer to Fig. 1, Section 1.7.2, and, tighten the gear retaining nuts to 300-325 lb-ft torque. Then tighten the front balance weight retaining nuts to 300-325 lb-ft torque. Remove the rag from the gears.

GEAR TRAIN AND ENGINE TIMING

A train of helical gears, completely enclosed between the engine end plate and the flywheel housing, is located at the rear of the Series 53 engines.

The gear train on an In-line engine (Fig. 1) consists of a crankshaft gear, an idler gear, a camshaft gear, and a balance shaft gear. The governor drive gear, the upper blower rotor gear for the two and three cylinder engines, and the blower drive gear for the four cylinder engine are driven by the camshaft gear or balance shaft gear, depending upon the engine model.

The gear train on a 6V engine (Fig. 2) or an 8V engine (Fig. 3) consists of a crankshaft gear, an idler gear and two camshaft gears. The accessory drive (fuel pump drive--Section 2.2.1) gear is driven by a camshaft gear.

On In-line and 6V engines, the crankshaft gear is pressed on and keyed to the end of the crankshaft. On 8V engines, the crankshaft gear is keyed and bolted to the end of the crankshaft.

The idler gear rotates on a stationary hub.

The camshaft and balance shaft gears on In-line engines and the camshaft gears on 6V and 8V engines are pressed on and keyed to their respective shafts and each gear is secured by a retaining nut and lock plate.

The crankshaft, idler, camshaft and balance shaft gears on In-line and 6V engines are completely interchangeable with each other; however, the 8V crankshaft gear, idler gear and camshaft gears are not interchangeable with the In-line and 6V engine gears.

On In-line engines, the camshaft and balance shaft gears have additional weights attached to the rear face of each gear. Different size weights are used on the three and four cylinder engines. These weights are important in maintaining perfect engine balance. Additional balance weights are not required on 6V camshaft gears. On early 8V engines, the camshaft gears have additional weights attached to the rear face of each gear. On current 8V engines, additional balance weights are not required.

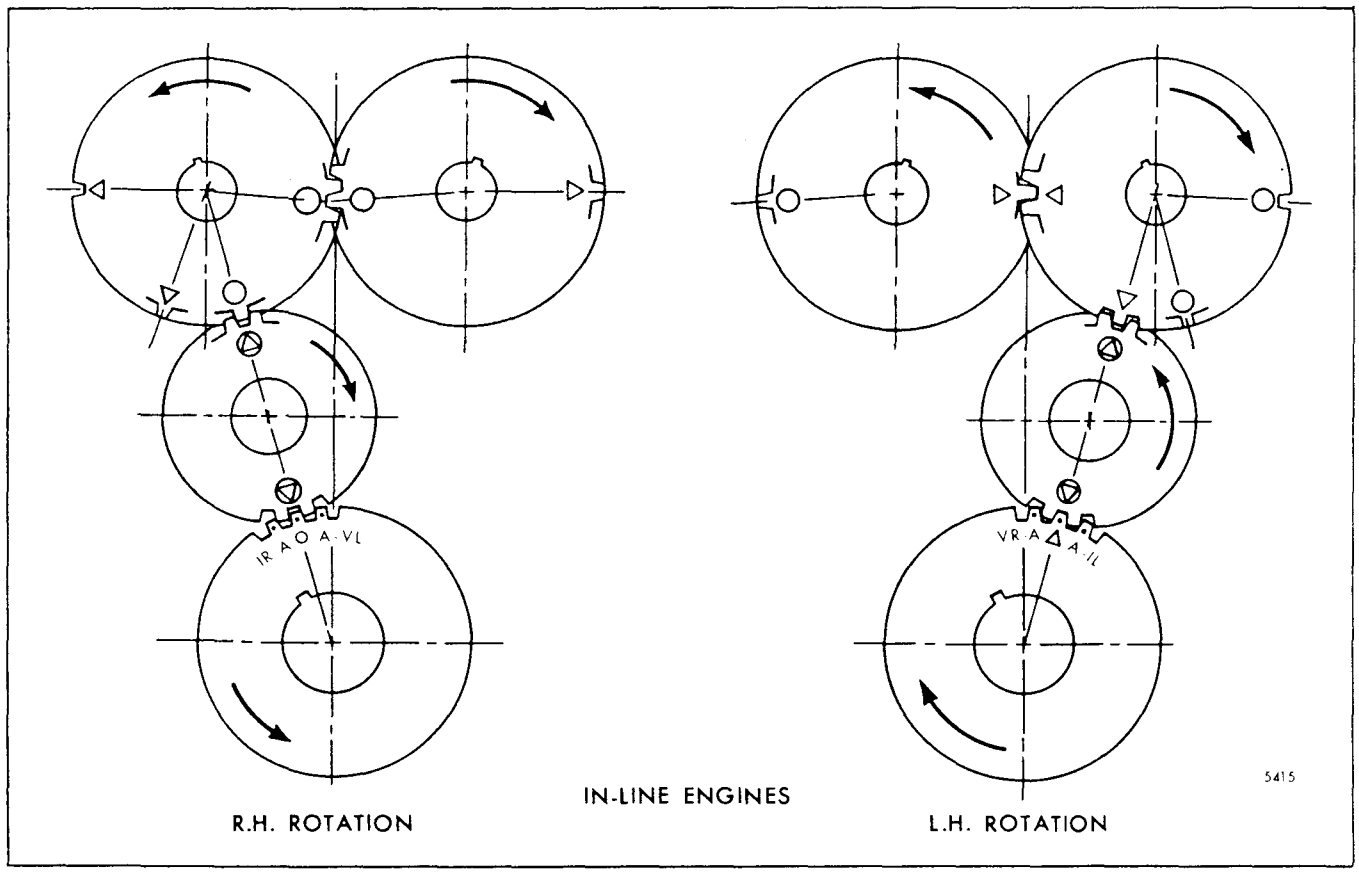

Fig. 1 - In-Line Engine Gear Train Timing Marks (Standard Timing Shown)

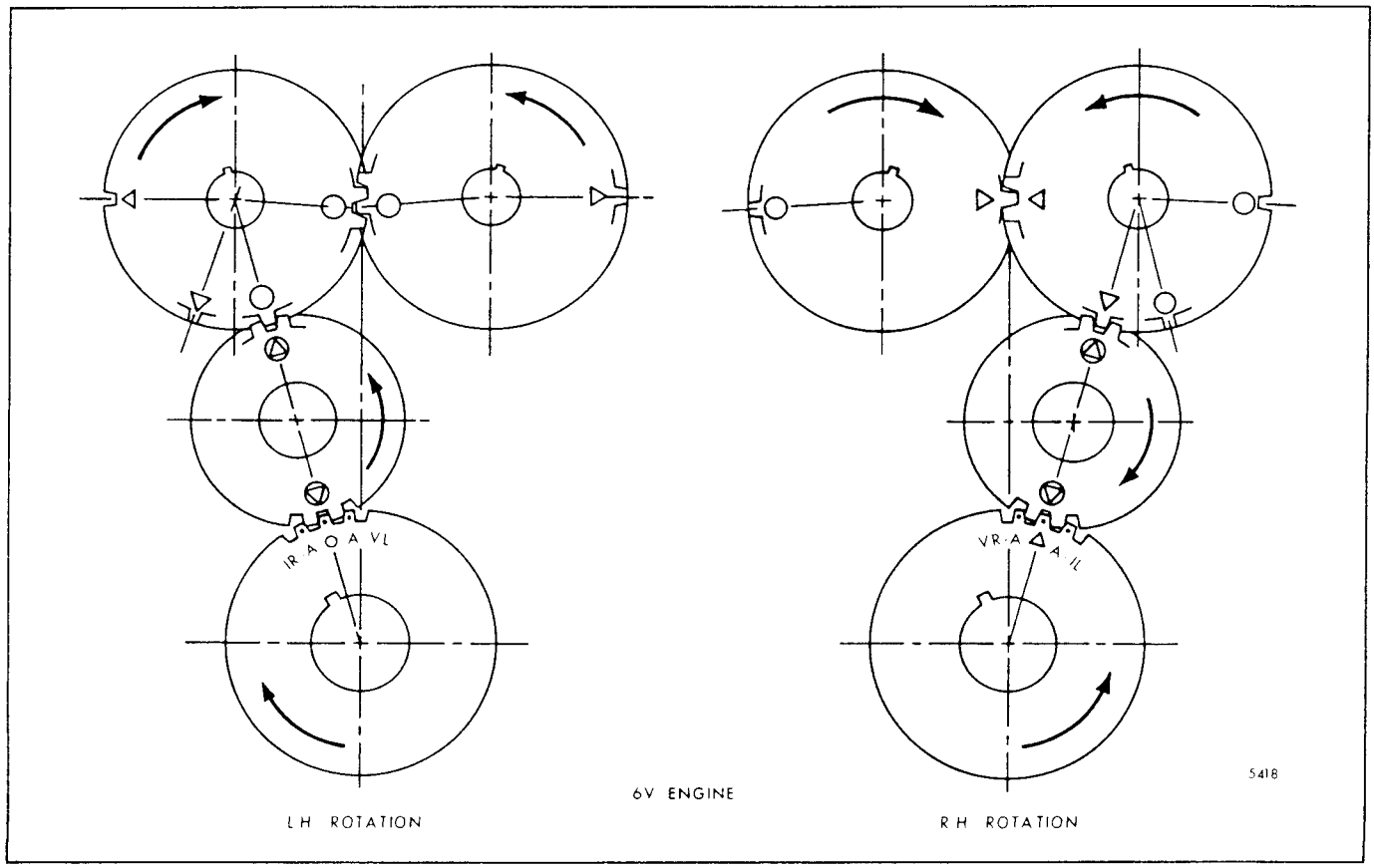

Fig. 2 - 6V Engine Gear Train Timing Marks (Standard Timing Shown)

The camshaft and balance shaft gears on an In-line engine, and the two camshaft gears on 6V and 8V engines, mesh with each other and run at the same speed as the crankshaft gear. Since the camshaft gears must be in time with each other, and the two as a unit in time with the crankshaft gear, timing marks have been stamped on the face of the gears to facilitate correct gear train timing.

The symbol system of marking the gears makes gear train timing a comparatively easy operation. When assembling the engine, it is important to remember the engine rotation. Then, working from the crankshaft gear to the idler gear and to the camshaft and/or balance shaft gear in that order, line up the appropriate circle symbols on the gears or the appropriate triangles as each gear assembly is installed on the engine. Refer to Figs. 1, 2, and 3 for a typical gear train timing arrangement.

NOTE: It is advisable to make a sketch indicating the position of the timing marks BEFORE removing or replacing any of the gears in the gear train.

The circle and the triangle are the basic timing symbols stamped on the gears. The letters stamped on the crankshaft gears identify the proper timing marks for the particular engine: "I" represents "In-line" engine, "V" represents V-type engine, "R" represents right-hand rotation engine, "L" represents left-hand rotation engine, and "A" represents advanced timing.

Effective with engine serial numbers 3D-64404, 4D-65954, 6D-66099 and 8D-3826, all Series 53 vehicle engines are built with advanced timing. The timing is advanced by aligning the proper "A" timing mark on the crankshaft gear with the circle-triangle timing mark on the idler gear.

IN-LINE ENGINE:

The camshaft and balance shaft gears are positioned so that the circle timing marks are adjacent to each other (Fig. 1). One circle-triangle timing mark on the idler gear is aligned with the second "circle" on the mating camshaft (or balance shaft) gear. The other timing mark on the idler gear is aligned with the proper timing mark on the crankshaft gear.

The crankshaft gear is stamped "IR-A" on the left

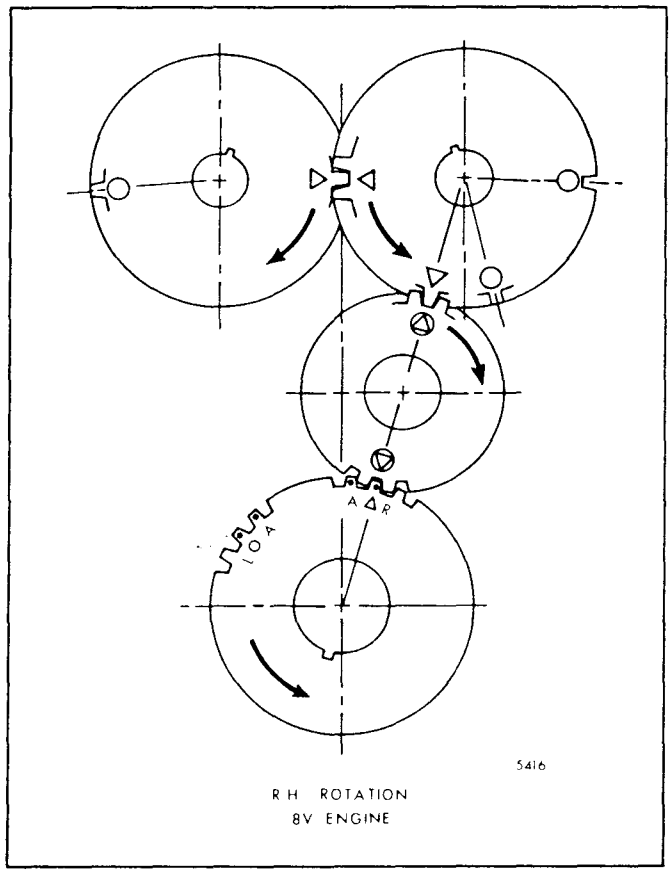

Fig. 3 - 8V Engine Gear Train Timing Marks (Standard Timing Shown)

side of the circle timing mark (Fig. 1)for a right-hand rotation engine. For *standard timing*, the circle on the crankshaft gear is aligned with the circle-triangle on the idler gear. For *advanced timing*, the "A" adjacent to the "IR" on the crankshaft gear is aligned with the circle-triangle on the idler gear.

The crankshaft timing gear is stamped "A-IL" on the right side of the triangle timing mark (Fig. 1) for a left-hand rotation engine. For *standard timing*, the "triangle" on the crankshaft gear is aligned with the circle-triangle on the idler gear. For *advanced timing*, the "A" adjacent to the "IL" on the crankshaft gear is aligned with the circle-triangle on the idler gear.

6V ENGINE:

The camshaft gears are positioned so that the triangle timing marks are adjacent to each other (Fig. 2). One circle-triangle timing mark on the idler gear is aligned with the second "triangle" on the mating camshaft gear. The other timing mark on the idler gear is aligned with the proper timing mark on the crankshaft gear.

The crankshaft gear is stamped "VR-A" on the left side of a triangle timing mark (Fig. 2)for a right-hand rotation engine. For *standard timing*, the "triangle" on the crankshaft gear is aligned with the circle-triangle on the idler gear. For *advance timing*, the "A" adjacent to the "VR" on the crankshaft gear is aligned with the circle-triangle on the idler gear.

The crankshaft timing gear is stamped "A-VL" on the right side of a circle timing mark (Fig. 2) for a left-hand rotation engine. For *standard timing*, the "circle" on the crankshaft gear is aligned with the circle-triangle on the idler gear. For *advanced timing*, the "A" adjacent to the "VL" on the crankshaft gear is aligned with the circle-triangle on the idler gear.

8V ENGINE:

The camshaft gears are positioned so that the triangle timing marks are adjacent to each other (Fig. 3). One circle-triangle timing mark on the idler gear is aligned with the second "triangle" on the mating camshaft gear. The other timing mark on the idler gear is aligned with the proper timing mark on the crankshaft gear.

The crankshaft gear is stamped "A-triangle-R". For *standard timing*, the triangle on the crankshaft gear is aligned with the circle-triangle on the idler gear. For *advanced timing*, the "A" on the crankshaft gear is aligned with the circle-triangle on the idler gear.

Refer to the *General Information* section for the various gear train arrangements.

There are no timing marks on the governor drive gear, blower rotor gears, blower drive gear or the accessory drive (fuel pump) gear. Therefore, it is not necessary to align these gears in any particular position when meshing the various gears with the camshaft or balance shaft gears.

Gear train noise is usually an indication of excessive gear lash, chipped, pitted or burred gear teeth or excessive bearing wear; therefore, when noise develops in a gear train, remove the flywheel housing and inspect the gear train and its bearings. A rattling noise usually indicates excessive gear lash whereas a whining noise indicates too little gear lash.

The backlash between the various mating gears in the gear train should be .003" to .005", except the blower rotor gears which should be .0005" to .0025". Maximum permissible backlash between worn blower gears is .0035", and should not exceed .007" clearance between all other gears in the gear train.

Lubrication

The gear train is lubricated by the overflow of oil from the camshaft and balance shaft pockets spilling into the gear train compartment. A certain amount of the oil also spills into the gear train compartment from the camshaft and balance shaft end bearings and the idler gear bearing. The blower drive gear bearing on the four cylinder In-line engine is lubricated through an external pipe leading from the cylinder block main oil gallery to the gear hub support. The idler gear bearing and the accessory (fuel pump) drive gear on a 6V or 8V engine is lubricated by oil directly from the cylinder block main oil gallery to the bearing hubs.

ENGINE TIMING

The correct relationship between the crankshaft and camshaft(s) must be maintained to properly control fuel injection and the opening and closing of the exhaust valves.

The crankshaft timing gear can be mounted in only one position since it is keyed to the crankshaft. The camshaft gear(s) can also be mounted in only one position due to the location of the keyway relative to the cams. Therefore, when the engine is properly timed, the markings on the various gears will match as shown in Figs. 1, 2, and 3.

Pre-ignition, uneven running and a loss of power may result if an engine is "out of time".

When an engine is suspected of being out of time, due to an improperly assembled gear train, a quick check can be made without removing the flywheel and flywheel housing by following the procedure outlined below.

Check Engine Timing

Access to the crankshaft pulley, to mark the top dead center position of the selected piston, and to the front end of the crankshaft or the flywheel for turning the crankshaft is necessary when performing the timing check. Then, proceed as follows:

1. Clean and remove the valve rocker cover.

2. Select any cylinder for the timing check.

3. Remove the injector as outlined in Section 2.1 or 2.1.1.

4. Carefully slide a rod, approximately 12" long, through the injector tube until the end of the rod rests on top of the piston. Place the throttle in the no-fuel position. Then, turn the crankshaft slowly in the direction of engine rotation. Stop when the rod reaches the end of its upward travel. Remove the rod and turn the crankshaft, opposite the direction of rotation, between 1/16 and 1/8 of a turn.

5. Select a dial indicator with .001" graduations and a spindle movement of at least 1". Provide an extension for the indicator spindle. The extension must be long enough to contact the piston just before it reaches the end of its upward stroke. Also, select suitable mounting attachments for the indicator so it can be mounted over the injector tube in the cylinder head.

6. Mount the indicator over the injector tube. Check to be sure the indicator spindle extension is free in the injector tube and is free to travel at least one inch.

7. Attach a suitable pointer to the engine lower front cover. The outer end of the pointer should extend out over the top of the crankshaft pulley.

8. Turn the crankshaft slowly, in the direction of engine rotation, until the indicator hand just stops moving.

9. Continue to turn the crankshaft, in the direction of rotation, until the indicator starts to move again. Now set the indicator on zero and continue to turn the crankshaft until the indicator reading is .010".

Engine	*INDICATOR READING		
	Standard	Retarded 1-Tooth	Advanced 1-Tooth
	STANDARD TIMING		
(1) 2,3,4 & 6V	.228"	.204"	.245"
(2) 3,4,6V & 8V	.206"	.179"	.232"
	ADVANCED TIMING		
(2) 3,4,6V & 8V	.232"	.206"	.258"

* Indicator readings shown are nominal values. The allowable tolerance is ± .005 in.
(1) High velocity type injector cam.
(2) Low velocity type injector cam.

TABLE 1

10. Scribe a line on the crankshaft pulley in line with the end of the pointer.

11. Slowly turn the crankshaft, opposite the direction of rotation, until the indicator hand stops moving.

12. Continue to turn the crankshaft, opposite the direction of rotation, until the indicator starts to move again. Now set the indicator on zero and continue to turn the crankshaft until the indicator reading is .010".

13. Scribe the second line on the crankshaft pulley in line with the end of the pointer.

14. Scribe a third line on the pulley half way between the first two lines. This is top dead center.

NOTE: If the crankshaft pulley retaining bolt loosened up, tighten it to the torque specified in Section 1.0.

15. Remove the dial indicator and rod from the engine.

16. Install the injector as outlined in Section 2.1 or 2.1.1. Then, refer to Section 14 and adjust the exhaust valve clearance and time the fuel injector.

17. Turn the crankshaft, in the direction of rotation, until the exhaust valves in the cylinder selected are completely open. Reinstall the dial indicator so the indicator spindle rests on the top of the injector follower. Then, set the indicator on zero. Next turn the crankshaft slowly, in the direction of rotation, until the center mark on the pulley is in line with the pointer.

18. Check the front end of the camshaft for an identification mark. For identification purposes, a letter "V" is stamped on each end of a low velocity camshaft; but a letter "V" is not stamped on a high velocity camshaft. Note the indicator reading and compare it with the dimensions listed in Table 1 for the particular camshaft in the engine.

19. Remove the dial indicator; also remove the pointer attached to the front of the engine.

20. Install the valve rocker cover.

CAMSHAFT, BALANCE SHAFT AND BEARINGS

The camshaft and balance shaft used in the In-line engines, or the two camshafts used in the V-type engines, are located just below the top of the cylinder block. The camshaft and balance shaft in the In-line engines may be positioned on either side of the engine as required by the engine rotation and accessory arrangement. The camshafts in the V-type engine are positioned according to engine rotation.

The shafts are supported by bearings (bushing type) that are pressed into bores in the cylinder block. The balance shaft is supported by front and rear bearings only, whereas the camshaft is supported by end, intermediate and center bearings. Two end bearings (front and rear), two intermediate bearings and a center bearing are used in the four cylinder and 8V engines to support the camshafts. The camshafts in the three cylinder and 6V engine are supported by two end bearings and two intermediate bearings. The two cylinder engine camshaft is supported by two end bearings and a center bearing.

To facilitate assembly, letters signifying the engine models in which a shaft may be used are stamped on the ends of the shaft. The letters on the timing gear end of the camshaft must correspond with the engine model. For example, the letters RC are stamped on a camshaft used in an RC model engine. For additional identification, a camshaft with no designation on the ends or a "7" stamped on the ends is a high-velocity high-lift camshaft. A camshaft stamped with a "V" or "V7" is a low velocity high-lift camshaft. Effective with engine 6D-60777, new camshafts stamped "V7L" are used in the 6V engine. These are low-velocity low-lift camshafts.

On 6V-53 vehicle engines where the maximum speed rating has been increased from 2600 rpm to 2800 rpm, the present low lift camshaft must be used in conjunction with the new exhaust valve springs. Refer to Section 1.2.2.

NOTE: The low lift camshaft which provides a maximum valve cam lobe lift of .276" is stamped "V7L" on both ends.

Lubrication is supplied under pressure to the camshaft and balance shaft end bearings via oil passages branching off from the main oil gallery direct to the camshaft end bearings.

In addition, oil is forced through an oil passage in each camshaft which lubricates the camshaft intermediate bearings. On the current camshafts, the intermediate journal oil grooves were eliminated and a chamfer added to the intermediate journal oil holes. When replacing a former camshaft with a current camshaft, always use new bearings.

All of the camshaft and balance shaft bearings incorporate small slots through which lubricating oil is directed to the cam follower rollers.

Remove Camshaft or Balance Shaft

Whenever an engine is being completely reconditioned or the bearings, thrust washers, or the gears need

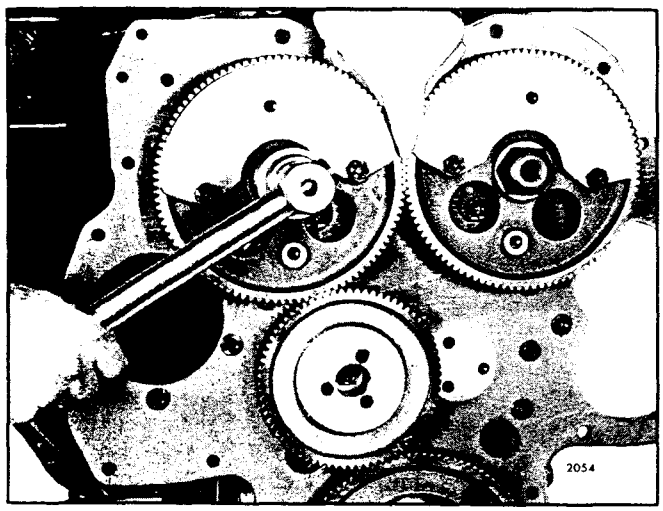

Fig. 1 - Removing or Installing Nut on Camshaft or Balance Shaft

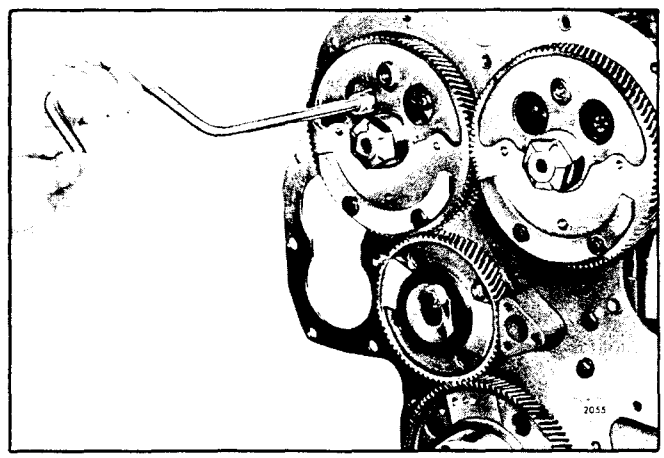

Fig. 2 - Removing or Installing Thrust Washer Retaining Bolts

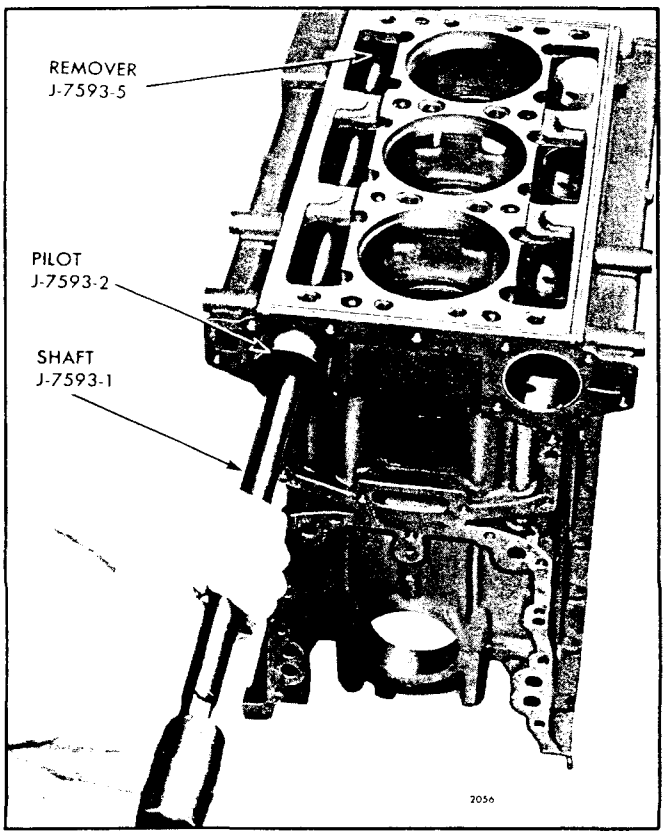

Fig. 3 - Removing End Bearing

replacing, remove the shafts from the engine in the following manner:

NOTE: Refer to *Shop Notes* in Section 1.0 to install a cup plug in the front end of the camshaft.

1. Drain the engine cooling system.

2. Remove all accessories and assemblies with their attaching parts as necessary to permit the engine to be mounted on an overhaul stand.

Procedures for removing accessories and assemblies from the engine will be found in their respective sections of this manual.

3. Mount the engine on an overhaul stand. Be sure the engine is securely mounted on the stand before releasing the lifting sling.

4. Remove the cylinder head(s). Refer to Section 1.2.

5. Remove the flywheel and the flywheel housing as outlined in Sections 1.4 and 1.5.

6. Remove the bolts which secure the gear nut retainer plates (if used) to the gears, then remove the retainer plates.

7. Wedge a clean rag between the gears as shown in Fig. 1; then, remove the nuts from each end of both shafts with a socket wrench.

8. Remove the balance weights from the front end of the shafts as outlined in Section 1.7.

9. Remove the upper engine front cover (Section 1.7.8).

10. Remove the oil slinger from the front end of both shafts.

11. Remove the two retaining bolts that secure the camshaft or balance shaft thrust washer to the cylinder block by inserting a socket wrench through a hole in the web of the gear as shown in Fig. 2.

12. Withdraw the shaft, thrust washer and gear as an assembly from the rear end of the cylinder block.

Disassemble Camshaft or Balance Shaft

1. Remove the gear from the shaft. Refer to Section 1.7.3.

2. Remove the end plugs from the camshaft, to facilitate the removal of any foreign material lodged behind the plugs, as follows:

a. Clamp the camshaft in a vise equipped with soft jaws, being careful not to damage the cam lobes or machined surfaces of the shaft.

b. Make an indentation in the center of the camshaft end plug with a 31/64 " drill (carboloy tip).

c. Punch a hole as deeply as possible with a center punch to aid in breaking through the hardened surface of the plug.

d. Then, drill a hole straight through the center of the plug with a 1/4 " drill (carboloy tip).

e. Use the 1/4 " drilled hole as a guide and redrill the plug with a 5/16 " drill (carboloy tip).

f. Tap the drilled hole with a 3/8 "-16 tap.

g. Thread a 3/8 "-16 adaptor J 8183 into the plug. Then, attach a slide hammer J 6471-1 to the adaptor and remove the plug by striking the weight against the handle.

h. Insert a length of 3/8 " steel rod in the camshaft oil gallery and drive the remaining plug out.

NOTE: If a steel rod is not available, remove the remaining plug as outlined in Steps "a" through "g".

Inspection

Soak the camshaft in clean fuel oil. Then, run a wire brush through the oil gallery to remove any foreign material or sludge. Clean the exterior of the camshaft and blow out the oil gallery and the oil holes with compressed air. Clean the camshaft bearings and related parts with fuel oil and dry them with compressed air.

Inspect the cams and journals for wear or scoring. If the cams are scored, inspect the cam rollers as outlined in Section 1.2.1.

Check the runout at the center bearing with the camshaft mounted on the end bearing surfaces. Run out should not exceed .002 ".

CAMSHAFT AND BALANCE SHAFT CYLINDER BLOCK BORE MACHINING CHART

Engine	Bearing Location	Dimension	
		Minimum	Maximum
2,3,4, 6V & 8V	End	2.385"	2.386"
2,3,4, 6V & 8V	Intermediate*	2.375"	2.376"
4-53 & 8V	Center	2.365"	2.366"

*Center Bearing 2-53 Engine only

TABLE 1

Examine both faces of the thrust washers. If either face is scored or if the thrust washers are worn excessively, replace the washers. New thrust washers are .208 " to .210 " thick.

Also, examine the surfaces which the thrust washers contact; if these surfaces are scratched but not severely scored, smooth them down with an oil stone. If the score marks are too deep to be removed, or if parts are badly worn, use new parts.

The clearance between new shafts and new bearings is .0045 " to .006 ", or a maximum of .008 " with worn parts. Excessive clearance between the shafts and the bearings will cause low oil pressure and excessive backlash between the gears.

Bearings are available in .010 " and .020 " undersize for use with worn or reground shafts.

Oversize camshaft and balance shaft bearings are available in sets, .010 " oversize on the outside diameter, to permit reuse of a cylinder block having one or more scored block bearing bores. To use the oversize bearings, the camshaft and balance shaft block bores must be carefully line-bored (machined) to the dimensions shown in Table 1.

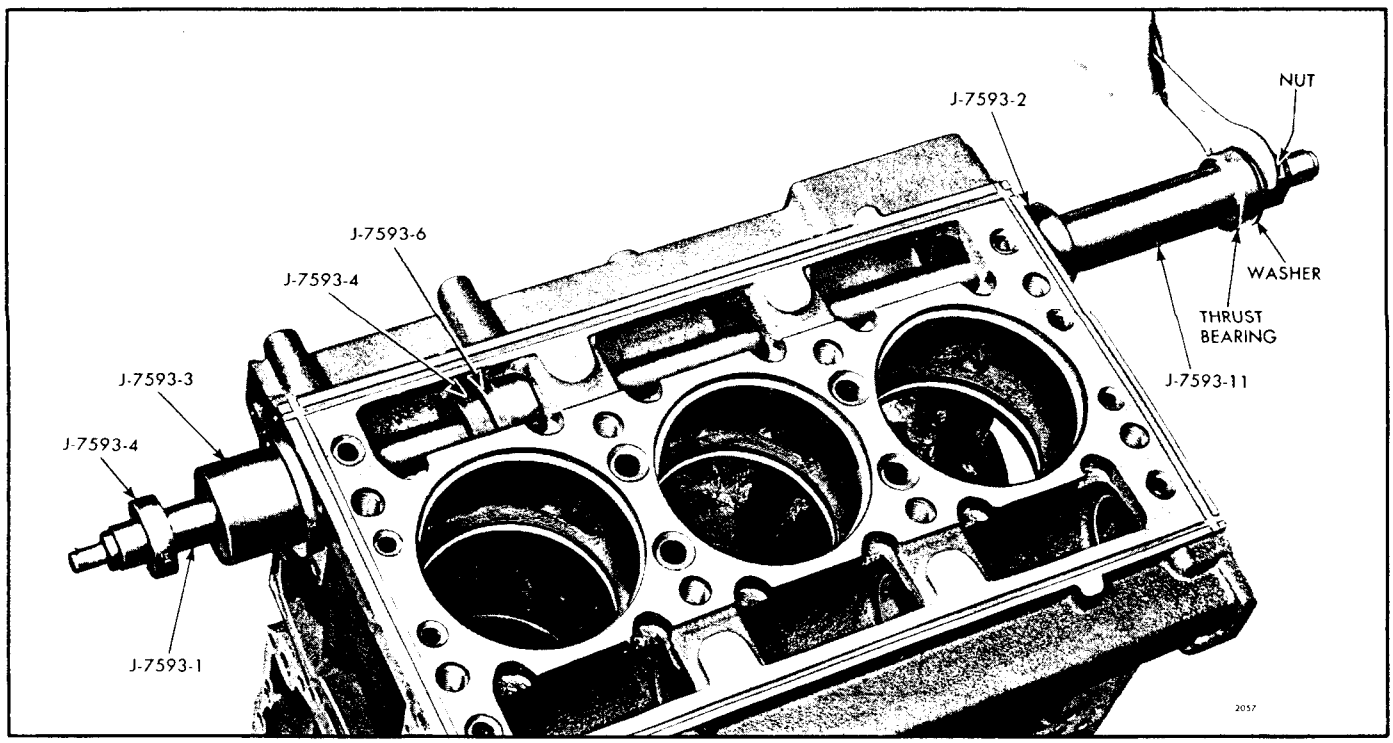

Fig. 4 - Installing Intermediate Camshaft Bearing

Remove Bearings

The end bearings must be removed prior to removing the intermediate bearings.

CAUTION: When removing the bearings be sure to note the position of the bearings in the bore with respect to the notch in the bearings. Replacement bearings must be installed in the same position.

1. Remove all accessories and assemblies with their attaching parts as is necessary so that tool set J 7593-02 may be used as shown in Fig. 3 and in A of Fig. 7.

Tool set J 7593-03, designed for use with standard size bearings, may be used to remove and install .010 " undersize and .020 " undersize bearings by reducing the pilot diameter of the pilot J 7593-2, installer J 7593-3, remover J 7593-5, installer J 7593-6, and installer J 7593-15. The pilot diameter of these tools should be reduced by .020 ". This reduction in tool diameter does not materially effect usage on standard size bearings. If the tools are used frequently, however, it may be advisable to purchase additional standard pieces. Reduced diameter tools have not been released.

2. Insert the small diameter end of the pilot J 7593-2 into the end bearing.

3. Then, with the unthreaded end of the shaft J 7593-1 started through the pilot, push the shaft through the block bore until the end of the shaft snaps into the remover J 7593-5.

4. Now drive the end bearing out of the cylinder block. The nearest intermediate and/or center bearings can be removed now in the same manner. The large diameter end of pilot J 7593-2 will fit into

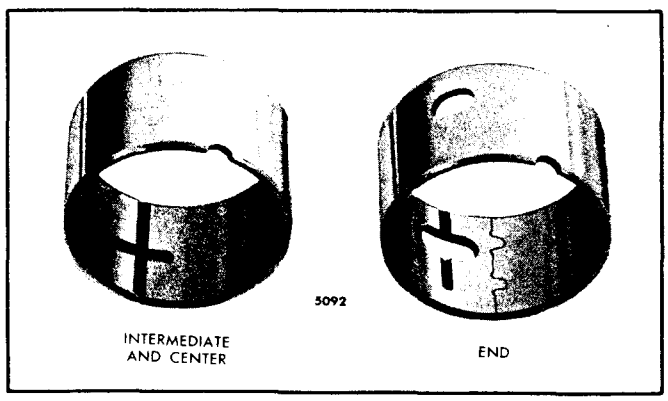

Fig. 5 - Camshaft and Balance Shaft Bearing Identification

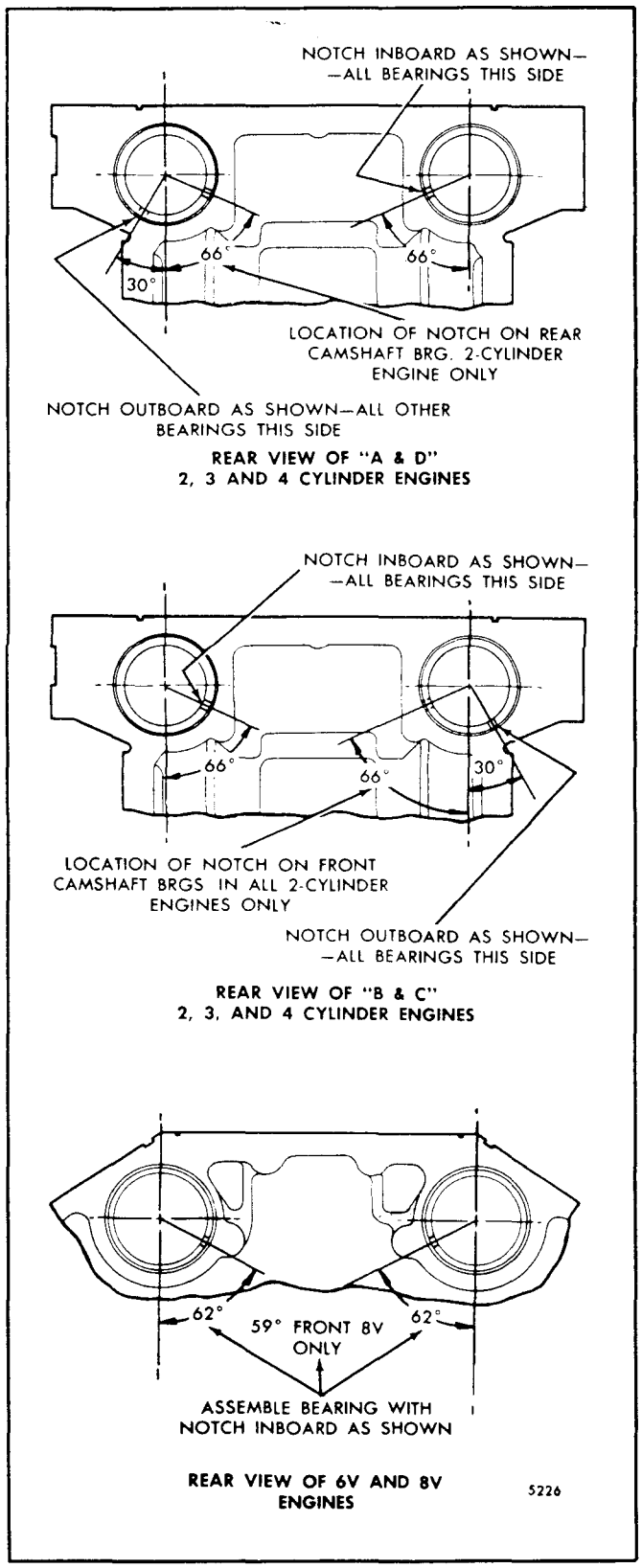

Fig. 6 - Location of Notch in Relation to Shaft Bore Centerline

the camshaft bore and is used when removing the other end bearing and any remaining bearings.

Install Intermediate and/or Center Camshaft Bearings

Camshaft center and intermediate bearings must be installed prior to installing the camshaft end bearings. On the four cylinder In-Line and 8V engine, the center, rear intermediate and rear bearings are installed in that order by pressing the bearings from the rear to the front of the block. The front intermediate and front bearings are installed by pressing the bearings from the front to the rear of the block. Bearings are similarly installed in the three cylinder and 6V engine except that there is no center bearing. The center bearing for the two cylinder block is installed by pressing the bearing from the rear to the front of the block.

NOTE: Current bearings incorporate lubrication grooves on the inner bearing surface (Fig. 5).

To properly install the camshaft and balance shaft bearings, refer to Fig. 6 for location of the notch in the bearing in relation to the camshaft or balance shaft bore centerline in the cylinder block.

Also, to facilitate assembly, the camshaft and balance shaft bearings are color coded on the side and/or end as shown in Table 2.

1. Insert pilot J 7593-2 in the bore of the block as shown in Fig. 4. Use the small end of the pilot if an end bearing has been installed. Refer to B and C of Fig. 7.

2. Insert the new intermediate or center bearing into the camshaft bore and position it correctly. Install the center bearing first.

3. Then, with the unthreaded end of shaft J 7593-1 started through the pilot, push the shaft through the entire length of the block bore.

4. Slide installer J 7593-6 on the shaft until the locating pin registers with the notch in the bearing. Then, slide installer J 7593-3 or J 7593-15 on the shaft with the large diameter inserted into the end of the block bore. Refer to C and note of Fig. 7.

5. Next, place a spacer (if required), thrust washer, plain washer and hex nut over the threaded end of the puller. The short spacer J 7593-11, shown in Fig. 4, is used on the three cylinder (In-Line) and 6V blocks. The long spacer J 7593-10 is used on the two cylinder block.

6. Align the shaft in such a way that a "C" washer, J 7593-4, can be inserted in a groove in the shaft adjacent to installer J 7593-6.

7. Place a "C" washer in the groove near the end of the shaft and, using a suitable wrench on the hex nut, draw the bearing into place until the "C" washer butts up against installer J 7593-3 and prevents the shaft from further movement.

CAMSHAFT AND BALANCE SHAFT BEARING COLOR CODE CHART

Bearing Position	Color Code		Outside Diameter	Inside Diameter
	Current	Former		
End	Brown	Black	Standard	Standard, .010" & .020" U.S. Standard (only)
	Brown	Yellow	.010" Oversize	
Inter-mediate	Orange	Red	Standard	Standard, .010" & .020" U.S. Standard (only)
	Orange	Blue	.010" Oversize	
Center (4-53-8V)	White	Green	Standard	Standard, .010" & .020" U.S. Standard*
	White	Red	.010" Oversize	

*The former red center bearing of the standard set is also used as the intermediate bearing of the oversize (O.D.) set.

Table 2

Install End Bearings

Refer to the camshaft and balance shaft color code chart and the cylinder block bore machining dimension chart when installing the end bearings.

1. Insert pilot J 7593-2 in the bore of the block as shown in "D" of Fig. 7. Use the small diameter of the pilot if a bearing has been installed.

2. Insert support J 7593-12 in the bore in the opposite end of the block; then, with the unthreaded end of the shaft started through pilot J 7593-2, push the shaft through the block and support J 7593-12.

3. Place a new end bearing on installer J 7593-3 and align the notch in the bearings with the pin on the installer. Then, slide the installer and the bearing on the shaft. Position the bearing correctly with the groove in the camshaft bore.

4. Place "C" washer J 7593-4 in the end notch in the shaft; pull the shaft back until the washer butts against the installer.

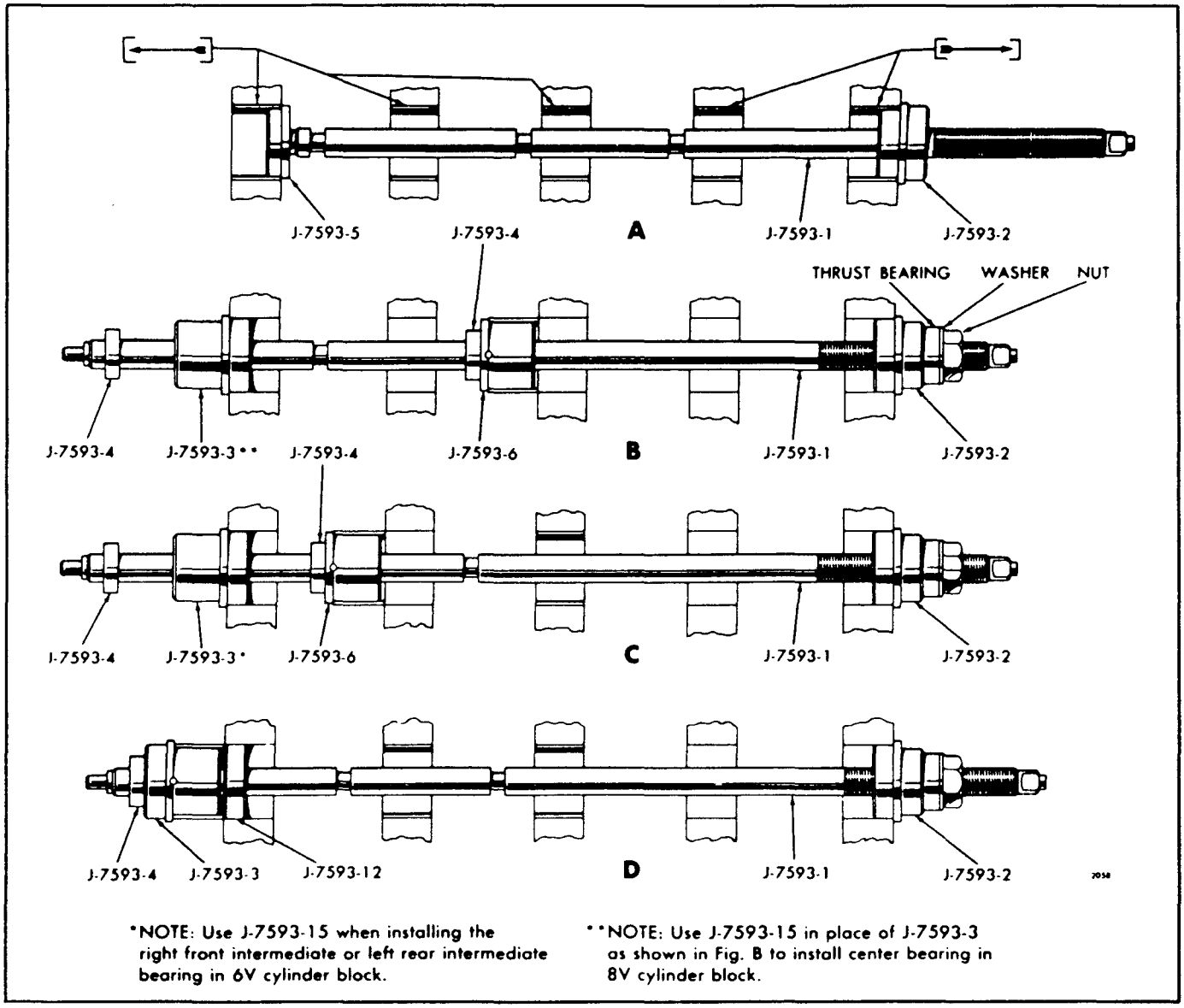

Fig. 7 - Removing and Replacing Camshaft or Balance Shaft Bearings

5. Next, place a spacer (if required), thrust washer, plain washer and hex nut over the threaded end of the shaft as shown in "D" of Fig. 7 and, using a suitable wrench on the hex nut, draw the bearing into place until the shoulder on the installer prevents the shaft from further movement. The bearing is now installed in its correct position.

Install the remaining end bearings in the same manner.

Use of tool J 7593-03 assures that the bearings are properly spaced in relation to the end of the block. The center bearing (notch end) for a four and 8V cylinder block is 10.94 " from the rear face of the block. The center bearing for the two cylinder block is 5.54 " from the rear face of the block. The intermediate bearings for the four cylinder and three cylinder block are 5.54 " from the rear and front face of the block. The right rear and left front intermediate bearings for the 6V and 8V cylinder block are 5.54 " from the rear and front face of the block; and the right front and left rear intermediate bearings are 6.66 " from the front and rear face of the block.

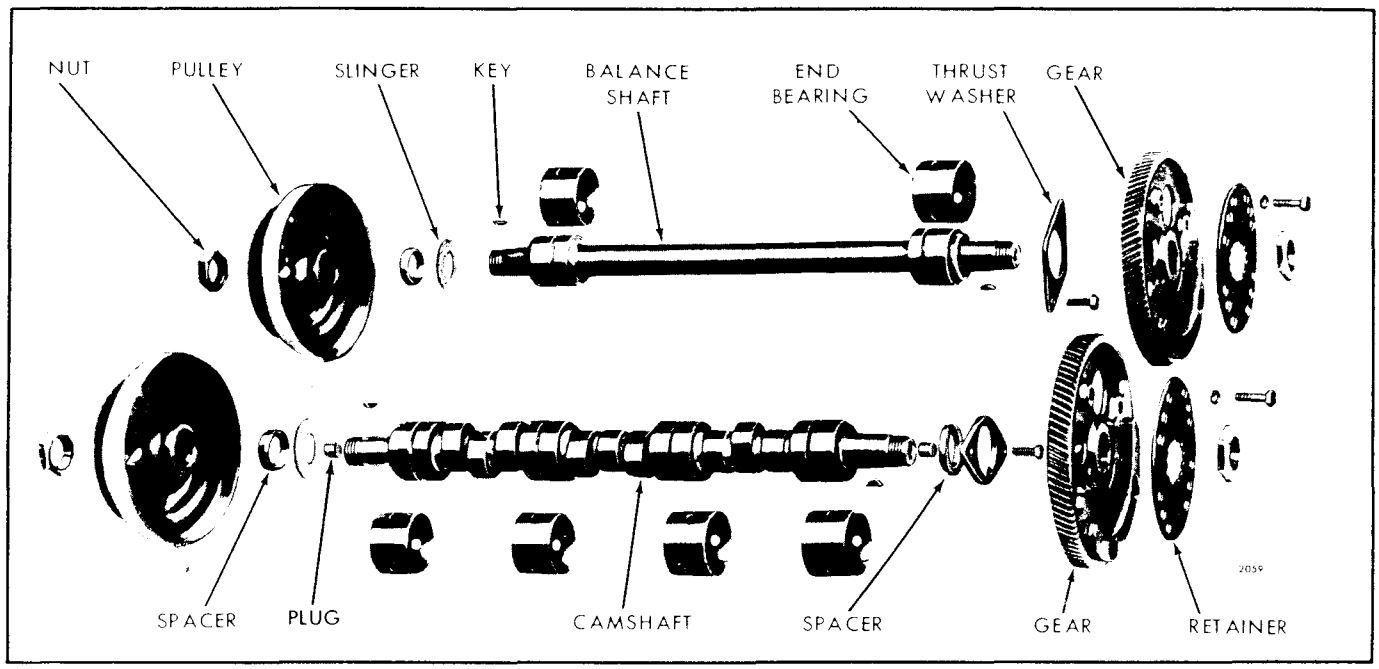

Fig. 8 - Camshaft and Balance Shaft Details and Relative Location of Parts

Assemble and Install Camshaft and Balance Shaft

Refer to Fig. 8 and assemble the camshaft and balance shaft.

1. Install new end plugs in the camshaft. Press the plugs in to a depth of 1.940 " to 2.060 ".

2. Install the gears and thrust washers on their respective shafts as outlined in Section 1.7.3.

3. Lubricate the bearings and shafts with engine oil and slide the shaft assemblies into the cylinder block being careful not to damage the bearings or the cams and journals. Make sure that the appropriate timing marks on the gears are aligned. Refer to *Gear Train and Engine Timing* in Section 1.7.1.

4. Slide an oil slinger on the front end of both shafts.

5. Install the upper engine front cover, if used, (Section 1.7.8).

6. Secure the thrust washers in place as shown in Fig. 2 and tighten the bolts to 30-35 lb-ft torque.

7. Install the front balance weights (Section 1.7).

8. Attach the gear nut retainer plates (if used) to the gears with bolts and lock washers and tighten the bolts to 35-39 lb-ft torque.

9. Check the clearance between the thrust washer and the gear on both shafts. The clearance should be .005 " to .015 ", or a maximum of .019 " with used parts.

10. Check the backlash between the mating gears. The backlash should be .003 " to .005 " and should not exceed .007 " between used gears.

11. Install the flywheel housing and other parts or assemblies that were removed from the engine as outlined in their respective sections of this manual.

CAMSHAFT AND BALANCE SHAFT GEARS

The camshaft and balance shaft gears on an In-line engine, and the two camshaft gears on a V-type engine, are located at the flywheel end of the engine and mesh with each other and run at the same speed as the crankshaft.

Since the camshaft and balance shaft gears on In-line engines and the two camshaft gears on V-type engines must be in time with each other, timing marks are stamped on the rim of each gear. Also, since these two gears as a unit must be in time with the crankshaft, timing marks are located on the idler and crankshaft gears (refer to Section 1.7.1).

Each gear is keyed to its respective shaft and held securely against the shoulder on the shaft by a nut. A gear nut retainer, with a double hexagon hole in the center, fits over the nut on some engines. The retainer is attached to the gear by bolts threaded into tapped holes in the gear.

On the two, three and four cylinder In-line engines, external weights are attached to the rear face of each gear. Different size weights are used on the two, three and four cylinder engines. The weights are important in maintaining perfect engine balance. Additional weights are not required on the 6V engine camshaft gears or on the 8V engines effective with 8D-127.

When new service gears are used on an In-line engine, or an early 8V engine, the external weights on the old gears must be transferred to the new gears. If the weights are transferred to new gears, tighten the bolts to 45-50 lb-ft torque.

Remove Camshaft and Balance Shaft Gears

1. Remove the camshaft and the balance shaft from the engine as outlined in Section 1.7.2.

2. Place the camshaft and gear assembly in an arbor press with the gear suitably supported as shown in Fig. 1.

3. Place a wood block under the lower end of the camshaft so the threads will not be damaged when the shaft is pressed from the gear.

4. Place a short piece of 3/4" O.D. brass rod between the end of the camshaft and the ram of the press; then force the camshaft out of the camshaft gear.

5. Remove the thrust washer, Woodruff key and spacer from the camshaft.

6. Remove the gear from the balance shaft in a similar manner.

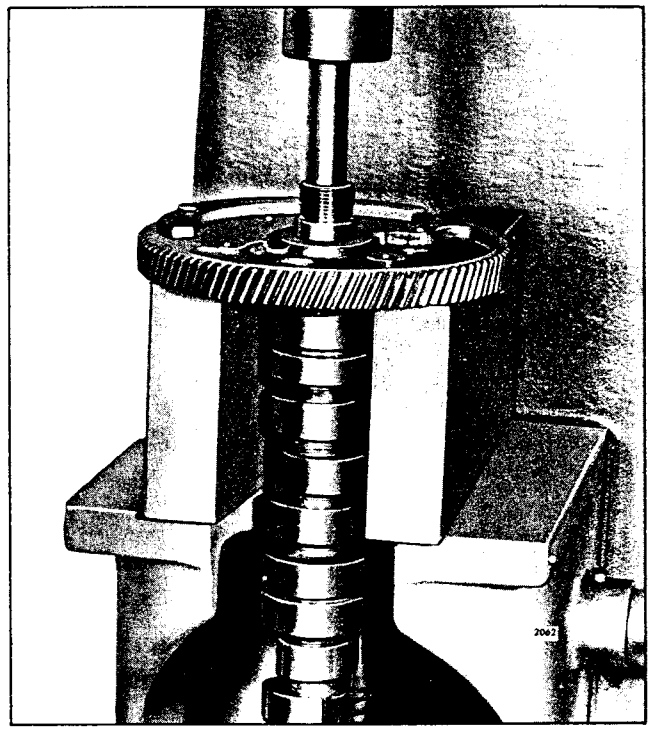

Fig. 1 - Removing Camshaft Gear

Inspection

Clean the gears with fuel oil and dry them with compressed air. Then examine the gear teeth for evidence of scoring, pitting and wear. Replace the gears if necessary.

Examine both faces of the camshaft and balance shaft thrust washer and, if either face is worn or scored, replace the washer. Also examine the surface on the camshaft and balance shaft which the thrust washer contacts. If this surface is scratched, but not severely scored, smooth it up with a fine oil stone.

Install Camshaft and Balance Shaft Gears

1. Note the letters stamped on the end of the camshaft which signify the engine models in which a camshaft may be used. The letters on the timing gear end of the camshaft must correspond with the engine model of the particular engine being assembled. Refer to the front of this manual for engine model identification.

2. Place the rear camshaft spacer over the timing gear end of the camshaft and install the Woodruff key.

3. Lubricate the thrust washer with clean engine oil and place the thrust washer over the gear end of the camshaft and the spacer.

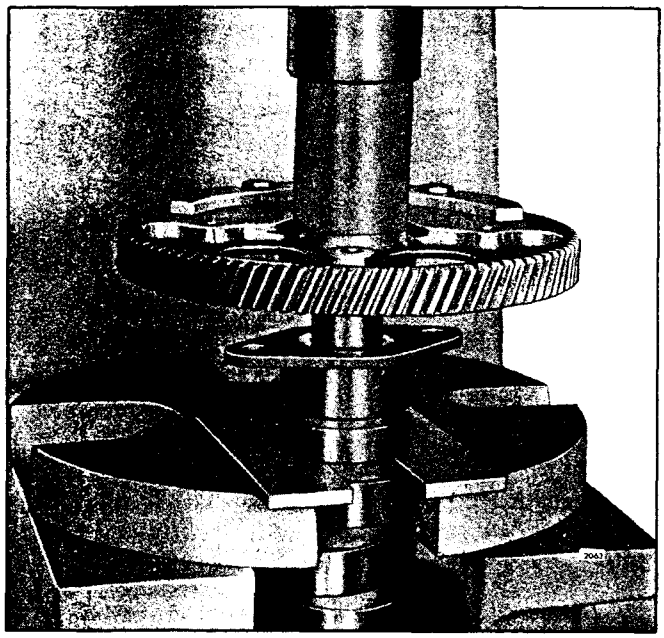

Fig. 2 - Installing Camshaft Gear

4. Start the camshaft gear over the end of the camshaft with the key in the shaft registering with the keyway in the gear.

5. Then, with the camshaft supported in an arbor press, place a sleeve on top of the gear and under the ram of the press. Bring the ram of the press down on the sleeve and press the gear tight against the spacer on the shaft (Fig. 2).

6. Measure the clearance between the camshaft thrust washer and the camshaft. This clearance should be .008" to .015" when new parts are used. With used parts, a maximum clearance of .021" is allowable.

7. Install the gear retaining nut on the camshaft by hand. Tighten the nut after the shaft is installed in the cylinder block.

8. Install the gear on the balance shaft in a similar manner. No rear spacer is used with the balance shaft gear, since the gear seats against a shoulder on the shaft.

9. Install the camshaft and balance shaft in the engine as outlined in Section 1.7.

IDLER GEAR AND BEARING ASSEMBLY

IN-LINE AND 6V ENGINES

The engine idler gear and bearing assembly, located at the flywheel end of the engine, meshes with the camshaft and crankshaft gears and rotates on a stationary hub. The hub is secured directly to the cylinder block by a bolt which passes through the hub and three bolts which pass through the flywheel housing, hub and end plate (Fig. 1).

Two timing marks (a triangle within a circle) are stamped on the idler gear diametrically opposite (180 °) to one another.

The inside diameter of the idler gear bearing is 2.186 "-2.187 " and the outside diameter of the idler gear hub is 2.1825 "-2.1835 ". Therefore, the clearance between the idler gear hub and the idler gear bearing is .0025 " to .0045 ", with a maximum allowable wear limit of .007 ".

A thrust washer is provided on both sides of the idler gear and bearing assembly. The standard thickness of the idler gear and bearing assembly is 1.233 " to 1.234 " and the standard thickness of the two thrust washers is .236 " to .240 "; thus, the clearance between the thrust washers and the idler gear is .006 " to .013 ", with a maximum allowable wear limit of .017 ".

On an In-line engine, the idler gear is positioned on the left-hand side for a right-hand rotating engine and on the right-hand side for a left-hand rotating engine as viewed from the rear. Refer to Fig. 5 under *General Description*.

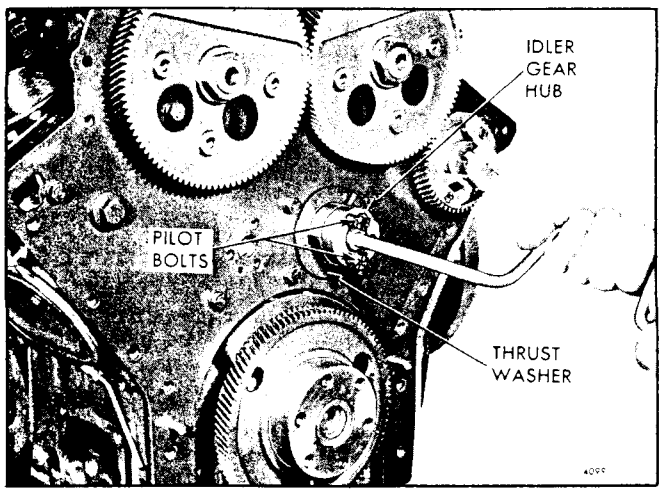

Fig. 1 - Installing Idler Gear Hub

On a 6V engine, the idler gear is positioned on the right-hand side for a right-hand rotating engine and on the left-hand side for a left-hand rotating engine, as viewed from the rear. Refer to Fig. 6 under *General Description*.

On early engines, an idler gear spacer (dummy hub) was used on the side opposite the idler gear. Currently the flywheel housing has an integral cast hub and a .015 " thick shim is used between the flywheel housing and the end plate.

Remove Idler Gear and Bearing Assembly (Flywheel Housing Removed)

1. Remove the idler gear outer thrust washer from the idler gear hub (Fig. 3).

2. Slide the idler gear straight back off of the idler gear hub.

3. Remove the bolt which secures the idler gear hub to

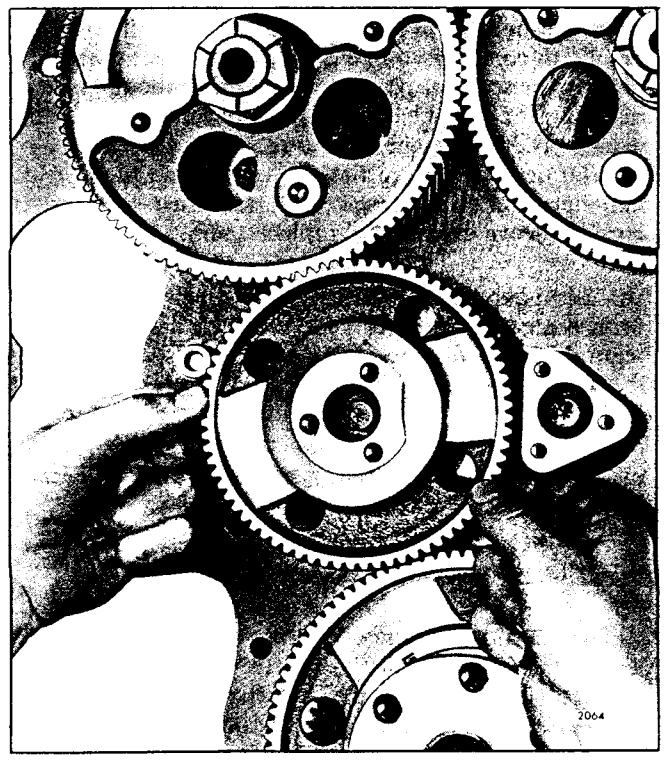

Fig. 2 - Installing Idler Gear

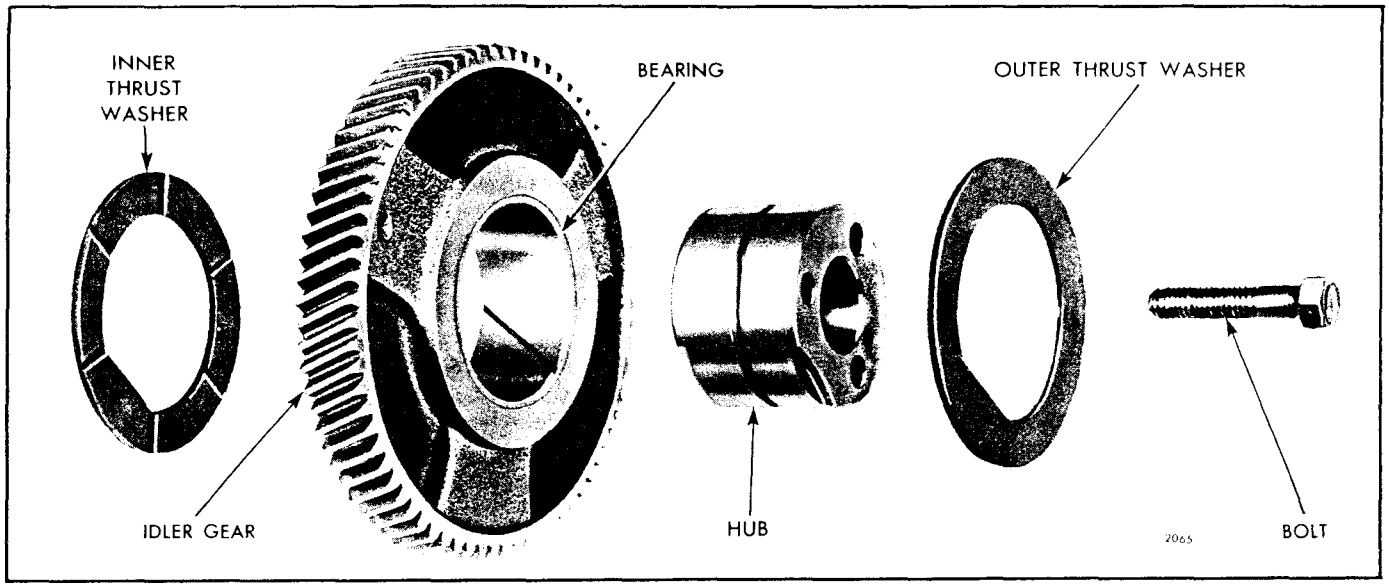

Fig. 3 - Idler Gear Details and Relative Location of Parts

the cylinder block. Then remove the idler gear hub and the idler gear inner thrust washer as an assembly.

Inspection

Wash the idler gear and bearing assembly, hub and thrust washers thoroughly in clean fuel oil and dry them with compressed air. Examine the gear teeth and bearing for scoring, pitting and wear. If the gear teeth are worn or the bearing is scored, pitted or worn excessively, replace the gear and bearing assembly or install a new bearing in the gear. Examine the outside diameter of the idler gear hub and thrust washers; if scored or worn excessively, replace them.

An idler gear bearing with two oil grooves has been incorporated in the idler gear and bearing assemblies beginning with engine serial numbers 2D-14301, 3D-6773, 4D-9458 and 6D-3334.

When a new bearing is installed in the idler gear, it must not protrude beyond the gear face on either side.

Install Idler Gear and Bearing Assembly

1. Place the inner thrust washer on the forward end of the idler gear hub with the flat in the inner diameter of the thrust washer over the flat on the end of the gear hub and with the oil grooves in the thrust washer facing the idler gear.

2. Place the small protruding end of the idler gear hub through the end plate and into the counterbore in the cylinder block.

3. Insert two 3/8 "-16 bolts through the idler gear hub and thread them into the cylinder block, as shown in Fig. 1, to be sure the bolt holes will be in alignment when the flywheel housing is installed.

4. Insert the 3/8 "-16x1-3/4 " special bolt through the center of the idler gear hub and thread it into the cylinder block. Tighten the bolt to 40-45 lb-ft torque. Then remove the two 3/8 "-16 bolts previously installed for alignment of the gear hub.

5. Lubricate the idler gear hub and idler gear bearings liberally with clean engine oil.

6. Position the crankshaft gear and the camshaft gear or balance shaft gear so that their timing marks will align with those on the idler gear. Refer to Figs. 1 and 2 in Section 1.7.1.

7. With these timing marks in alignment, install the idler gear as shown in Fig. 2.

8. Apply a thin film of cup grease to the inner face (face with the oil grooves) of the outer idler gear thrust washer. Then place the thrust washer over the end of the idler gear hub with the oil grooves in the side of the thrust washer facing the idler gear and the flat in the inner diameter of the thrust washer over the flat on the end of the idler gear hub.

9. Check the backlash between the mating gears. The backlash should be .003 " to .005 " between new gears and should not exceed .007 " between used gears.

IDLER GEAR AND BEARING ASSEMBLY

8V ENGINE

Figure 4 illustrates the mounting of the roller bearing type idler gear. When replacing any part of the gear assembly, a complete roller bearing type idler gear assembly must be used.

The idler gear is mounted on a double row, tapered roller bearing which, in turn, is supported on a stationary hub. This hub is secured directly to the cylinder block by a bolt which passes through the hub and rear end plate.

The current idler gear bearing consists of two cups, two cones and an outer and inner spacer ring. The former idler gear bearing consists of a cup, two cones and a spacer ring.

The inner races of the idler gear bearing are pressed onto the gear hub and, therefore, do not rotate. A spacer separates the two bearing inner cones. The bearing cup(s) has a light press fit in the idler gear and is held against a flanged lip inside the idler gear on one side and by a bearing retainer secured with six bolts on the other side.

Two timing marks (a triangle within a circle) are stamped on the idler gear, diametrically opposite (180 °) to one another.

A dummy hub cast into the flywheel housing is used on the side opposite the idler gear. A shim is used between the dummy hub and the rear end plate. The flywheel housing bears against the inner races of the idler gear bearing and also against the dummy hub. Three self-locking bolts are used to attach the flywheel housing at the idler gear and dummy hub locations.

Remove Idler Gear, Hub and Bearing Assembly (Flywheel Housing Previously Removed)

1. Remove the hub to cylinder block bolt and withdraw the assembly from the cylinder block rear end plate.

NOTE: Before removing the idler gear, check the idler gear, hub and bearing assembly for any perceptible wobble or shake when pressure is applied by firmly grasping the rim of the gear with both hands and rocking the gear in relation to the bearing. The bearing must be replaced if the gear wobbles or shakes. If the gear assembly is satisfactory, it is only necessary to check the pre-load before reinstallation.

Disassemble Idler Gear, Hub and Bearing Assembly

While removing or installing an idler gear bearing, the bearing MUST be rotated to avoid the possibility of damaging the bearing by brinelling the bearing cones. Brinelling refers to the marking of the cones by applying a heavy load through the rollers of a non-rotating bearing in such a way that the rollers leave impressions on the contact surfaces of the cones. These impressions may not be easily discerned during normal inspection. For example, a bearing may be brinelled if a load were applied to the inner cone of the bearing assembly in order to force the outer cone into the idler gear bore, thus transmitting the force through the bearing rollers. A brinelled bearing may have a very short life.

Refer to Fig. 4 for the location and identification of parts and disassemble the bearing as follows:

1. Remove the six bolts which secure the bearing retainer to the idler gear.

NOTE: Component parts of the idler gear

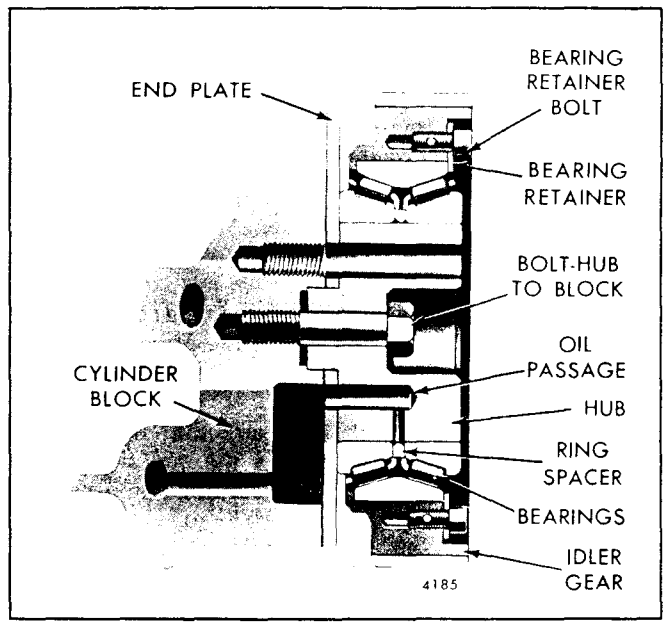

Fig. 4 - Idler Gear Mounting (Former Bearing)

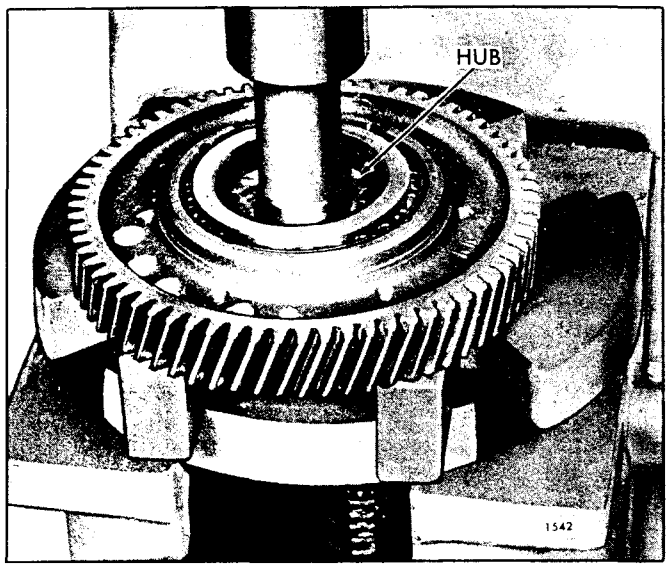

Fig. 5 - Pressing Hub Out of Bearing

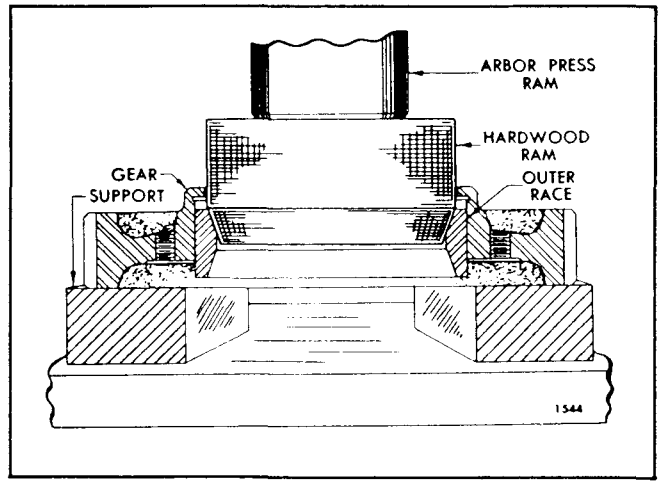

Fig. 6 - Hardwood Ram for Pressing Outer Bearing Race from Gear

bearing are mated; therefore, match-mark the parts during disassembly to ensure that they will be reassembled in their original positions.

2. Clean the idler gear and bearing assembly with fuel oil and dry it with compressed air.

3. Place the idler gear and bearing assembly in an arbor press with the bearing cone or inner race supported on steel blocks as shown in Fig. 5. While rotating the gear assembly, press the hub out of the bearing. Remove the gear assembly from the arbor press and remove the bearing cones and spacer.

4. Tap the bearing cups and spacer (current gear) or bearing cup (former gear) from the idler gear by using a brass drift alternately at four notches provided around the shoulder of the gear.

Inspection

Wash the idler gear, hub and bearing components thoroughly in clean fuel oil and dry them with compressed air.

Check the idler gear hub to ensure that no chips or foreign material is deposited in the holes so as to cause interference with the flywheel housing attaching bolts.

Inspect the bearing carefully for wear, pitting, scoring or flat spots on the rollers or cones. Replace the bearing if it is defective.

Examine the gear teeth for evidence of scoring, pitting and wear. If severely damaged or worn, replace the gear. Also inspect the other gears in the gear train.

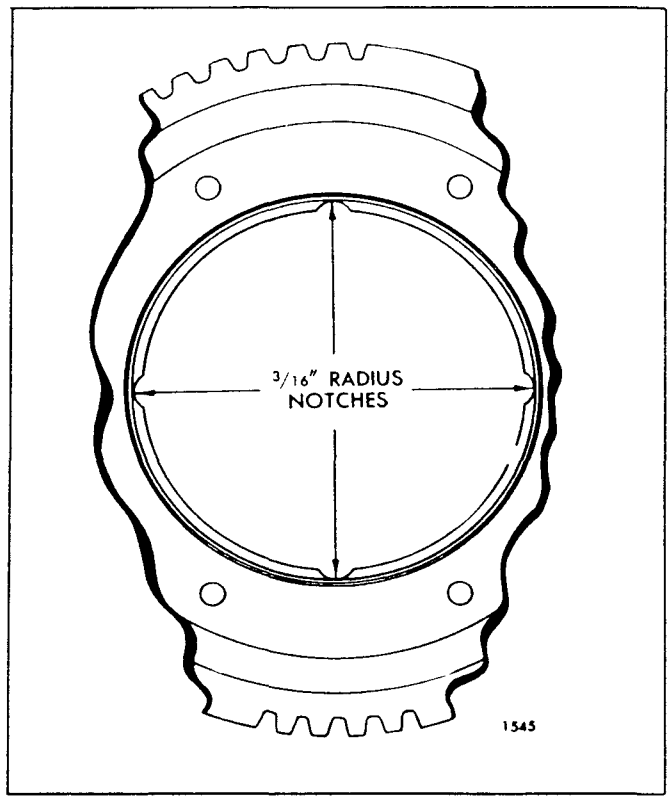

Fig. 7 - Location of Notches in Idler Gear

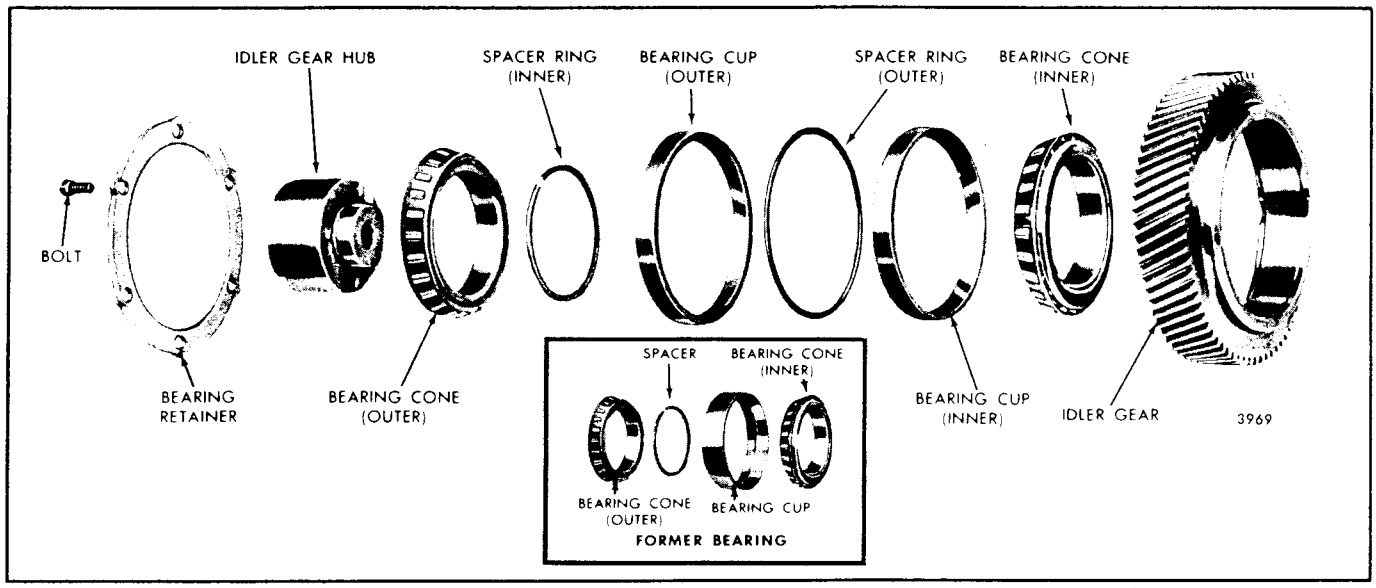

Fig. 8 - Idler Gear Details and Relative Location of Parts (Current Bearing)

Assemble Idler Gear, Hub and Bearing

CURRENT BEARING

Refer to Fig. 8 and assemble the bearing components in their *original positions* (refer to identification marks made during disassembly) as outlined below:

NOTE: The current idler gear bearing is a matched assembly. *Do not* mix the components.

1. Support the idler gear, shoulder down, on the bed of an arbor press. Start one of the bearing cups, numbered side up, squarely into the bore of the gear. Then press the bearing cup against the shoulder of the gear. Use a flat round steel plate (pre-load test plate) between the ram of the press and the bearing cup.

2. Lay the outer spacer ring on the face of the bearing cup.

3. Start the other bearing cup, numbered side down, squarely into the bore of the gear. Then press the cup tight against the spacer ring. Use a flat round steel plate (pre-load test plate) between the ram of the press and the bearing cup.

4. Press the inner bearing cone (numbered side up) on the idler gear hub, flush with the inner hub mounting face. Use the pre-load test plate (with the large center hole) between the ram of the press and the bearing.

5. Install the inner spacer ring on the idler gear hub so that the oil hole in the hub is 180 ° from the gap in the inner spacer ring.

6. Position the gear with both cups over the hub and the inner bearing cone.

7. Press the outer idler gear bearing cone over the hub while rotating the gear to seat the rollers properly between the cones. The bearing cones must be supported so as not to load the bearing rollers during this operation.

8. Before installing the gear and bearing assembly, check the pre-load.

FORMER BEARING

Assemble the bearing components in their original positions (refer to the identification marks made during disassembly) as outlined below.

1. Support the idler gear, shoulder side down, on an arbor press and start the outer bearing cone squarely into the bore of the gear. Then press the bearing cone tight against the shoulder of the gear, using a steel plate between the ram of the press and the bearing cone.

2. Support one bearing cone, numbered side down, on the arbor press and lower the idler gear and bearing cup assembly down over the bearing cone.

3. Place the spacer ring on the face of the bearing cone.

4. Place the second bearing cone, numbered side up, in the idler gear and bearing cup assembly and against the spacer ring.

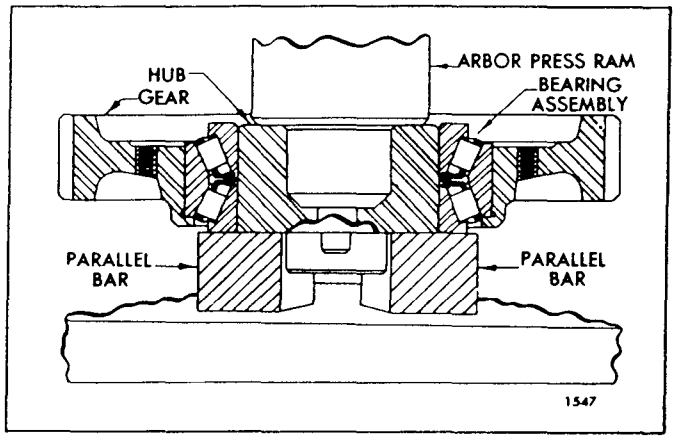

Fig. 9 - Pressing Hub into Bearing

5. Then position the idler gear hub over the bearing cones so that the oil hole in the hub is 180° from the gap in the spacer ring.

6. Press the hub into the idler gear bearing cones, while rotating the gear (to seat the rollers properly between the cones), until the face of the hub which will be adjacent to the cylinder block end plate is flush with the corresponding face of the bearing cone. The bearing cones should be supported so as not to load the bearing rollers during this operation (Fig. 9).

7. Prior to installing and securing the bearing retainer, check the pre-load of the bearing assembly as outlined below.

Check Pre-Load of Bearing

The rollers of the bearing are loaded between the bearing cup and bearing cones in accordance with design requirements to provide a rigid idler gear and bearing assembly. As the bearing cones are moved toward each other in a tapered roller bearing assembly, the rollers will be more tightly held between the cones and the cup. In the idler gear bearings, a slight pre-load is applied, by means of a selected spacer ring between the bearing cones, to provide rigidity of the gear and bearing assembly when it is mounted on its hub. This method of pre-loading is measured, in terms of "pounds-pull", by the effort required at the outer diameter of the gear to turn the bearing cup in relation to the bearing cones.

Any time an idler gear assembly has been removed from an engine for servicing or inspection, while performing engine overhaul or other repairs, the pre-load should be measured as part of the operation.

The idler gear bearing should be clean and lubricated with light engine oil prior to the pre-load test. Idler

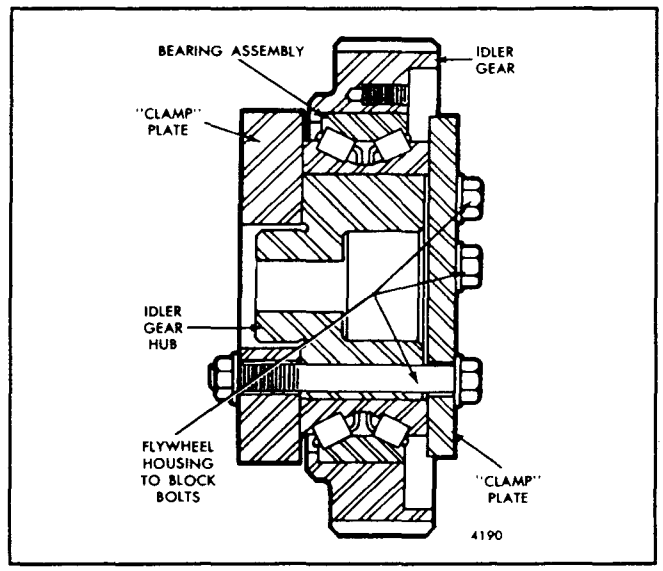

Fig. 10 - Fixture for Testing Bearing Pre-Load

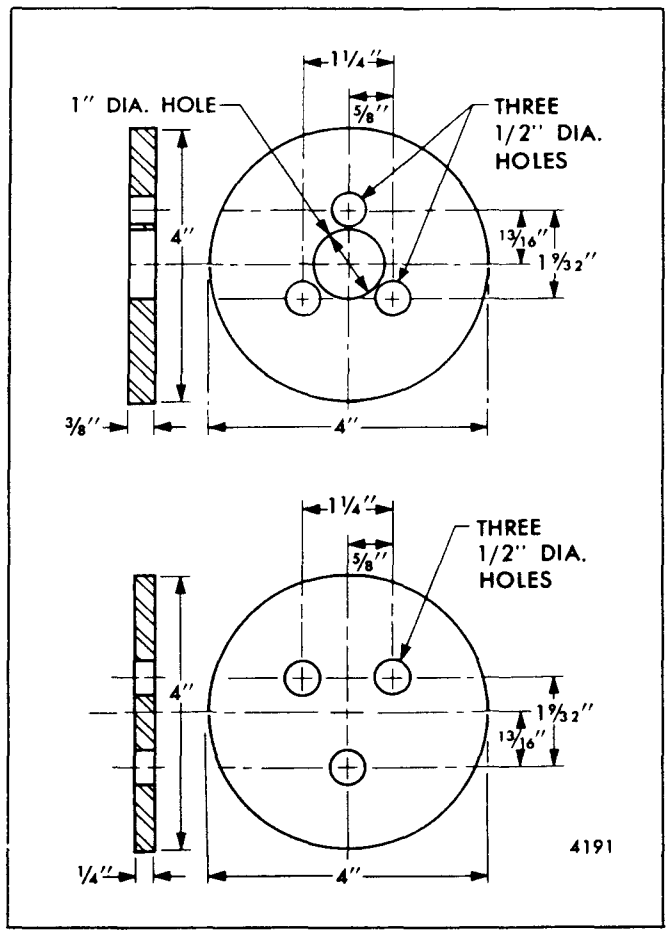

Fig. 11 - Plates for Bearing Test Fixture

gear assemblies which include new bearings should be "worked in" by grasping the gear firmly by hand and rotating the gear back and forth several times.

After the idler gear, hub and bearing are assembled together, the bearing should be checked to ascertain that the gear may be rotated on its bearing without exceeding the maximum torque specifications, nor be so loose as to permit the gear to be moved in relation to the hub by tilting, wobbling or shaking the gear.

If the mating crankshaft and camshaft gears are not already mounted on the engine, the torque required to rotate the idler gear may be checked by mounting the idler gear in position on the engine, using a round steel plate 4 " in diameter (pre-load test plate) against the hub and cone as outlined below.

1. Mount the idler gear assembly on the engine.

2. Install the center bolt through the gear hub and thread it into the cylinder block. Tighten the bolt to 40-45 lb-ft torque.

3. Place the steel plate (lower plate shown in Fig. 11) against the hub and bearing. Insert two 3/8 "-16 bolts and one 5/16 "-18 bolt through the plate and thread it into the cylinder block. Tighten the two 3/8 "-16 bolts to 40-45 lb-ft torque and the 5/16 "-18 bolt to 19-23 lb-ft torque.

4. Tie one end of a piece of lintless 1/8 " cord around a 1/8 " round piece of wood (or soft metal stock). Place the wood between the teeth of the gear, then wrap the cord around the periphery of the gear several times. Attach the other end of the cord to a spring scale, J 8129 (Fig. 12). Maintain a straight, steady pull on the scale, 90 ° to the axis of the hub, and note the pull, in pounds and ounces, required to start the gear rotating. Make several checks to obtain an average reading. If the pull is within 1-1/4 lb. minimum to 6 lbs. 12 ounces maximum and does not fluctuate more than 2 lbs. 11 ounces, the idler gear and bearing assembly are satisfactory for use.

If the crankshaft and camshaft gears are mounted on the engine, a suitable fixture which may be held in a vise can be made as shown in Fig. 10 with two plates as shown in Fig. 11. One of the plates is used to take the place of the flywheel housing and the other the cylinder block. *Engine - mounted* conditions are simulated by tightening the 3/8 "-16 attaching bolts and nuts to 40-45 lb-ft torque.

Check the pre-load as follows:

1. Clamp the idler gear between the two plates as shown in Fig. 10. Insert the bolts and tighten the three 3/8 "-16 bolts and nuts to 40-45 lb-ft torque.

2. Clamp the idler gear assembly and fixture in a vise as shown in Fig. 12.

3. Attach the cord to the idler gear and spring scale and check the pre-load as outlined in Step 4 of the previous method.

If the scale reading is within the specified 1-1/4 to 6-3/4 lbs., but fluctuates more than the permissible 2 lbs. 11 ounces, the idler gear and bearing assembly must NOT be installed on the engine. Fluctuations in scale reading may be caused by the cones not being concentric to each other, damaged cones or rollers, or dirt or foreign material within the bearings. In these cases, the bearing should be inspected for the cause of fluctuation in the scale readings and corrected or a new bearing installed.

A scale reading which exceeds the specified maximum indicates binding of the bearing rollers or rollers improperly installed. When the scale reading is less than the specified minimum, the bearing is more likely worn and the bearing should be replaced.

After the pre-load test is completed, remove the steel plates. Attach the bearing retainer to the idler gear with six self-locking bolts. Tighten the bolts to 12-15 lb-ft torque.

Install Idler Gear, Hub and Bearing Assembly

1. Position the crankshaft gear and the camshaft gear so that the timing marks will align with those on the idler gear (refer to Section 1.7.1).

2. With these marks in alignment, start the idler gear into mesh with the crankshaft gear and the camshaft gear and simultaneously rotate the gear hub so that

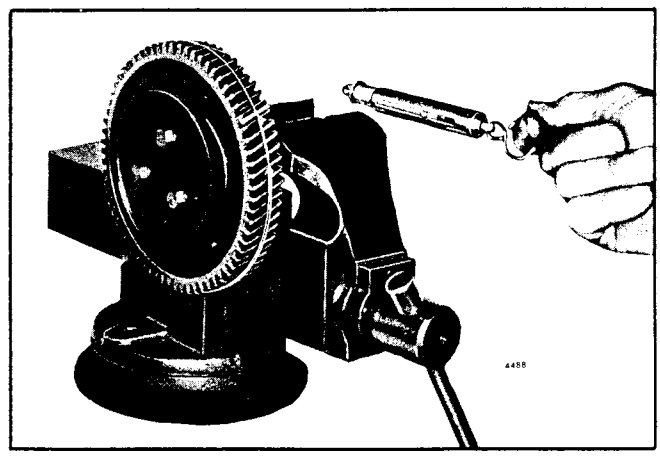

Fig. 12 - Checking Pre-Load of Idler Gear Bearing

the oil hole in the rear end plate is in line with the oil hole in the hub and the three bolt holes are in line.

3. Roll the idler gear into position and gently tap the hub until it seats against the rear end plate.

4. After making sure that the hub is tight against the rear end plate, secure the idler gear assembly in place with the 3/8 "-16 x 1-3/4 " special bolt. Tighten the bolt to 40-45 lb-ft torque.

5. Lubricate the idler gear and bearing liberally with clean engine oil.

6. Check the backlash between the mating gears. The backlash must be .003 " to .005 " between new gears and should not exceed .007 " between used gears.

CRANKSHAFT TIMING GEAR

In-line and 6V Engine

The crankshaft timing gear is keyed and pressed on the crankshaft and drives the camshaft gear (In-line or 6V engines) or balance shaft gear (In-line engines) through an idler gear.

Since the camshaft must be in time with the crankshaft, timing marks are located on the rim of the idler gear with corresponding timing marks stamped on the crankshaft gear and camshaft and balance shaft gears (refer to Section 1.7.1).

Remove Crankshaft Timing Gear (Flywheel Housing Removed)

The crankshaft timing gear is a .001 " to .003 " press fit on the crankshaft. Remove the gear as follows:

1. Remove the crankshaft rear oil seal sleeve, if used. To remove the sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off of the crankshaft.

2. Before removing the crankshaft gear, align the timing marks of the gear train and note their location so the gear can be reinstalled in its original position.

3. Attach bar type puller J 4871 to the crankshaft gear with three long bolts or hooks, flat washers and nuts through the holes in the gear as shown in Fig. 1.

4. Turn the center screw of the puller to pull the crankshaft gear off of the crankshaft.

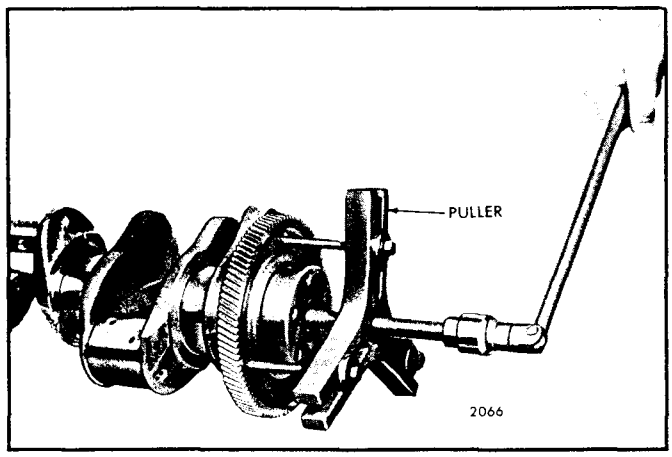

Fig. 1 - Removing Crankshaft Timing Gear

Inspection

Clean the gear with fuel oil and dry it with compressed air. Examine the gear teeth for evidence of scoring, pitting or wear. If severely damaged or worn, install a new gear. Also check the other gears in the gear train.

Install Crankshaft Timing Gear

1. If removed, install the Woodruff key in the keyway in the crankshaft.

2. Start the timing gear over the end of the crankshaft with the timing marks on the outer rim of the gear facing out and the keyway in the gear in alignment with the Woodruff key in the crankshaft.

3. Align the proper timing mark on the crankshaft gear with the corresponding mark on the idler gear (refer to Section 1.7.1).

> **NOTE:** When advanced timing is required, align the timing mark "A" with the timing mark on the idler gear.

4. Place a heavy hammer against the head of the bolt in the front end of the crankshaft. Place installer J 7557 against the rear face of the timing gear and

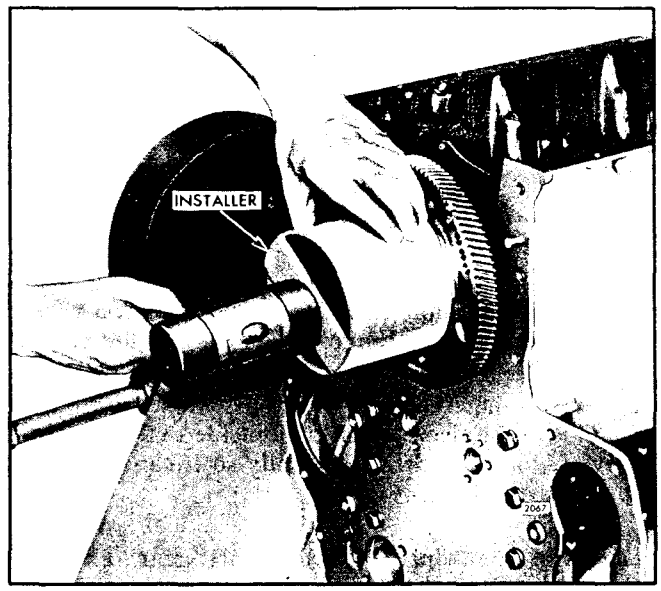

Fig. 2 - Installing Crankshaft Timing Gear

drive the gear up against the shoulder on the crankshaft as shown in Fig. 2.

5. Check the gear backlash with the mating gear. The backlash should be .003 "-.005 " with new gears or .008 " maximum with used gears.

6. Install a new crankshaft rear oil seal sleeve, if required, as outlined in Section 1.3.2.

CRANKSHAFT TIMING GEAR

8V Engine

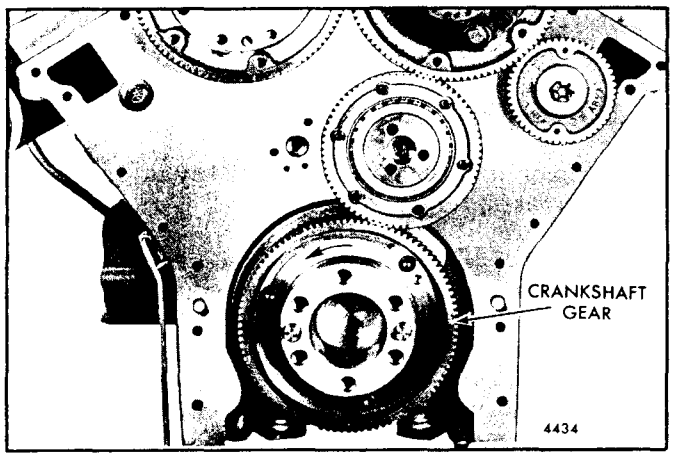

Fig. 3 - Crankshaft Timing Gear Mounting (R.H. Rotation Engine Shown)

The crankshaft timing gear on an 8V engine is keyed and fastened to the crankshaft with three 3/8 "-24 x 3/4 " socket head bolts.

Since the camshafts must be in time with the crankshaft, timing marks are located on the rim of the idler gear with corresponding timing marks stamped on the crankshaft gear and camshaft gears (refer to Section 1.7.1).

Remove Crankshaft Timing Gear (Flywheel Housing Removed)

The crankshaft timing gear is a .001 " to .003 " press fit on the crankshaft. Remove the gear as follows:

1. Remove the crankshaft rear oil seal sleeve, if used. To remove the sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off of the crankshaft.

2. Before removing the crankshaft gear, align the timing marks of the gear train and note their location so the gear can be reinstalled in its original position.

3. Remove the three socket head bolts securing the gear to the crankshaft.

4. Provide a base for the puller screw by placing a steel plate across the cavity in the end of the crankshaft. Then remove the gear with a suitable puller.

Inspection

Clean the gear with fuel oil and dry it with compressed air. Examine the gear teeth for evidence of scoring, pitting or wear. If severely damaged or worn, install a new gear. Also check the other gears in the gear train.

Install Crankshaft Timing Gear

1. If removed, install the Woodruff key in the keyway in the crankshaft.

2. Start the timing gear over the end of the crankshaft with the timing marks on the outer rim of the gear facing out and the keyway in the gear in alignment with the Woodruff key in the crankshaft.

3. Align the proper timing mark on the crankshaft gear with the corresponding mark on the idler gear (refer to Section 1.7.1).

> **NOTE:** When advanced timing is required, align the timing mark "A" with the timing mark on the idler gear.

4. Start the three 3/8 "-24 socket head bolts into the crankshaft. Then slowly draw the gear tight against the shoulder on the crankshaft by tightening the bolts uniformly to 35-39 lb-ft torque.

5. Check the backlash with the mating gear. The backlash should be .003 " to .005 " with new gears or .008 " maximum with used gears.

6. Install a new crankshaft rear oil seal sleeve, if required, as outlined in Section 1.3.2.