AIR SILENCER

In-Line and 6V Engines

The air silencer (Fig. 1) is attached to the intake side of the blower housing to reduce the sound level of the air entering the blower.

A perforated sheet metal partition divides the silencer into two sections. The engine side of the partition and the outer shell forms an air duct the entire length of the silencer. Air enters this duct from both ends and flows to the blower intake opening at the center. The area between the partition and the outer side of the silencer is filled with sound absorbent, flame-proof, felted cotton waste.

An air intake (blower) screen is used between the air silencer and the blower housing to prevent foreign objects from entering the blower.

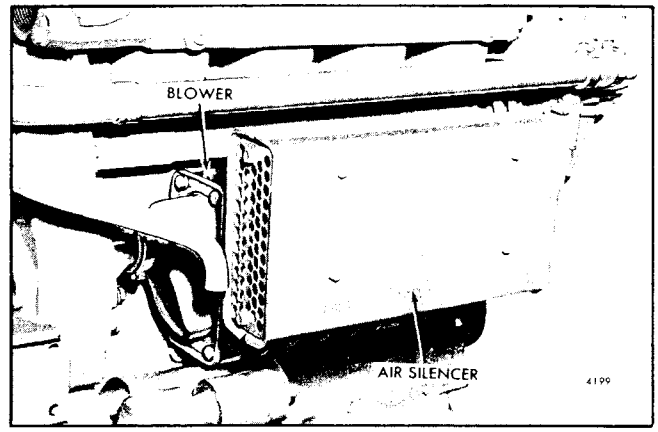


Fig. 1 - Air Silencer Mounted on In-Line Engine

Remove and Install Air Silencer

While no servicing is required on the air silencer, it may be necessary at times to remove it to clean or replace the blower screen or to perform other service operations.

1. Support the silencer and remove the attaching bolts and lock washers. Then remove the silencer and the blower screen. On the 6V engine, the air silencer adaptor must be removed to gain access to the blower screen.

2. Clean the blower screen with fuel oil and dry it with compressed air.

3. Place the blower screen on the 6V engine blower housing and install the air silencer adaptor.

4. Place the lock washers over the bolts and slide the bolts through the bolt holes in the silencer.

5. Place the blower screen (In-line engines) over the projecting bolts and position the silencer against the blower housing. Then tighten the bolts.

8V Engine

The air silencer (Fig. 2) is mounted on a support attached to the flywheel housing. The air outlet end is attached to the air inlet housing with a hose and clamps. An air filter element of polyurethane foam is used on the current air silencer inlet screen.

Remove Air Silencer

While no servicing is required on the air silencer, it may be necessary to remove it to perform other service operations.

1. Remove the air filter element, if used.

2. Loosen the clamps and slide the hose back on the air inlet housing.

3. Loosen the lower bolts which secure the mounting straps to the silencer support bracket. Then, while holding the silencer, remove the bolts and washers. Remove the silencer.

4. If necessary, remove the breather pipe clip from the silencer mounting strap. Then remove the bolts and washers and remove the mounting straps.

Install Air Silencer

1. If previously removed, attach the mounting straps to the top of the silencer support bracket with two 7/16" - 14 bolts, washers and nut (one bolt threads into the flywheel housing). Do not tighten the bolts at this time.

2. Position the air silencer under the mounting straps and install the 3/8" -16 bolts, lock washers, washers and nuts. Do not tighten the bolts at this time.

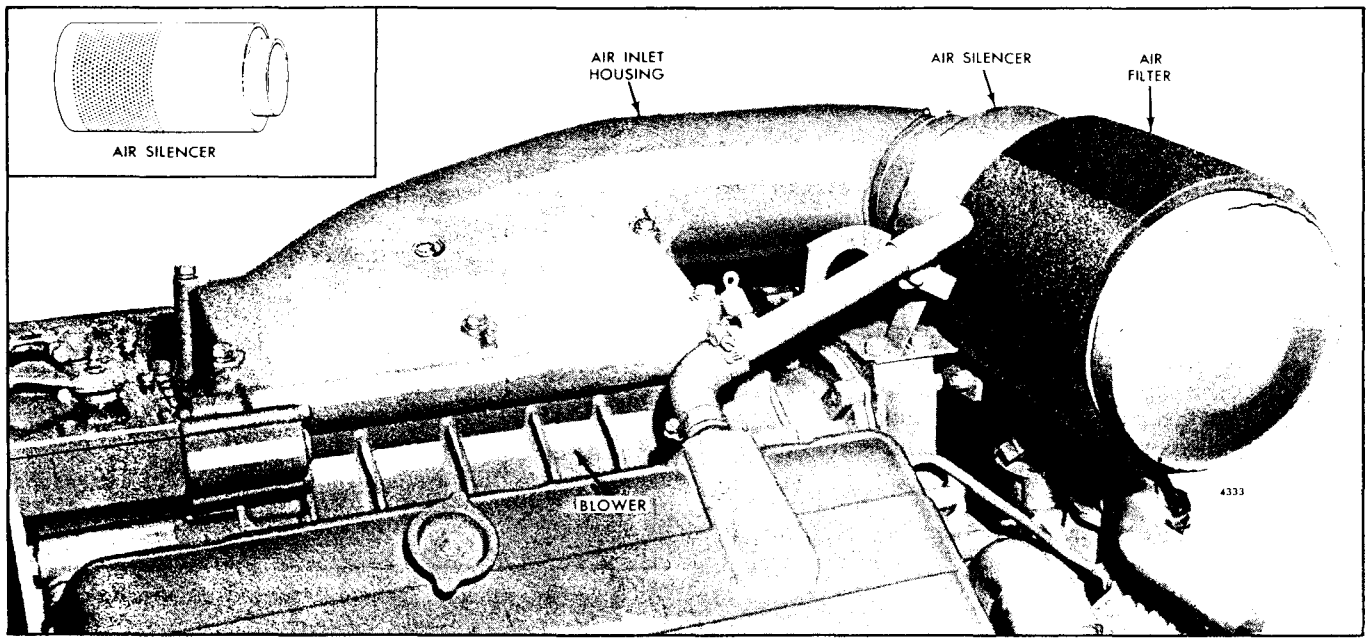


Fig. 2 - Air Silencer Mounted on 8V Engine

3. Align the silencer with the air inlet housing, slide the hose in place and tighten the clamps.

4. Tighten the mounting strap bolts at this time.

5. Install the breather pipe clip.

6. Slide the air filter element (if used) over the silencer air inlet screen.

AIR SHUT-DOWN HOUSING

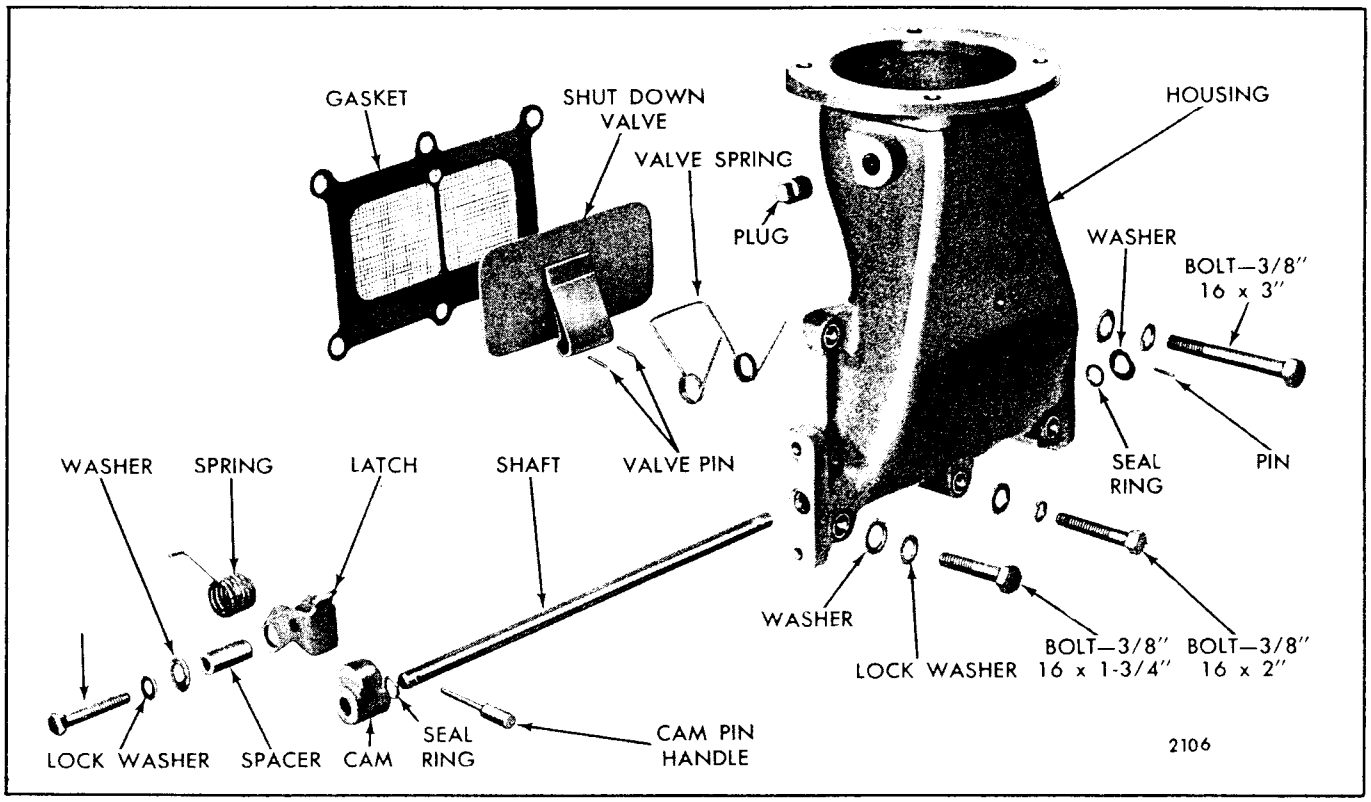


Fig. 1 - Typical In-Line Air Shut-Down Housing Details and Relative Location of Parts

The air shut-down housing on the in-line engine is mounted on the side of the blower, while the V-type engine has the air shut-down housing mounted on the top of the blower. The housing serves as a mounting for the air cleaner or the ducting for an air cleaner mounted away from the engine. The air shut-down housing contains an air shut-off valve that shuts off the air supply and stops the engine whenever abnormal operating conditions require an emergency shut-down.

Remove Air Shut-Down Housing

1. Disconnect and remove the air ducts between the air cleaner and the air shut-down housing.

2. Disconnect the control wire from the air shut-off cam pin handle.

3. Remove the bolts and washers that retain the housing to the blower and remove the housing from the blower. Remove the air shut-down housing gasket from the blower.

NOTE: Cover the blower opening to prevent dirt or foreign material from entering the blower.

Disassemble Air Shut-Down Housing

Refer to Fig. 1 and disassemble the air shut-down housing as follows:

1. Remove the pin from the end of the shut-down shaft. Then remove the washer from the shaft and the seal ring from the housing.

2. Remove the two pins that secure the shut-off valve to the shaft.

3. Remove the bolt, lock washer and plain washer which attach the latch to the housing. Then remove the latch, latch spring and spacer.

4. Note the position of the air shut-off valve spring and the valve (Fig. 2); then withdraw the shaft from the housing to release the valve and the spring. Remove the valve and spring and the seal ring from the housing.

5. Remove the cam pin handle and withdraw the cam from the shaft.

Inspection

Clean all of the parts thoroughly, including the blower screen, with fuel oil and dry them with compressed air. Inspect the parts for wear or damage. The face of the shut-down valve must be perfectly flat to assure a tight seal when it is in the shut-down position.

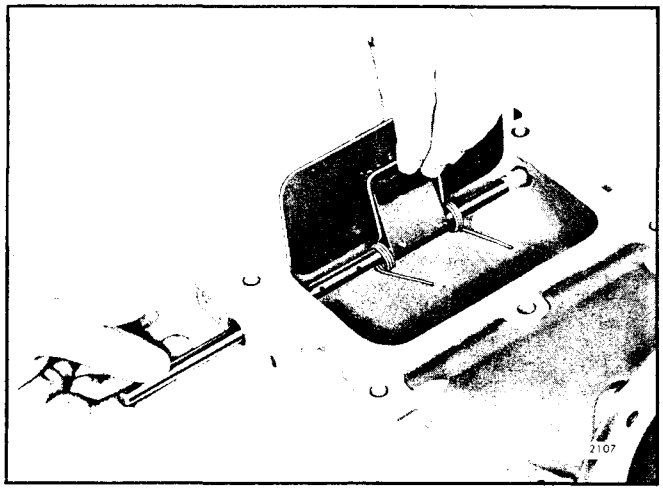


Fig. 2 - Installing Air Shut-Off Valve Spring and Valve

Assemble Air Shut-Down Assembly

The holes for the cam pin handle and the retaining pins must be drilled, using a 1/8" diameter drill, at the time a new service shaft or air shut-off valve(s) is assembled. The valve(s) must be in the same plane within .03" when in the stop position (flush with the housing face). Refer to Figs. 1 and 2 and proceed as follows:

1. Place the valve(s) and spring in position in the housing (Fig. 2) and slip the shaft in place. The shaft must extend .70" from the side of the housing where the shut-down latch is assembled.

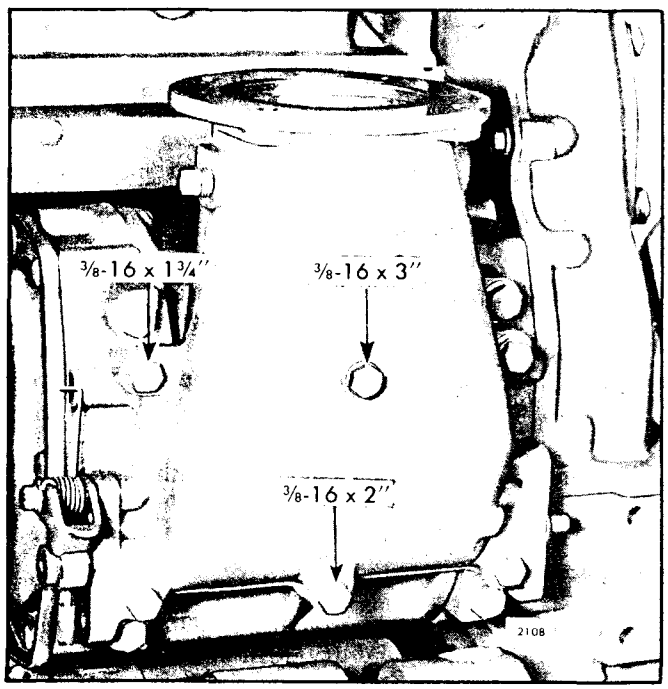


Fig. 3 - Location of Air Shut-Down Housing Mounting Bolts (In-Line Engines)

2. Install a new seal ring at each end of the shaft. Be sure the seals are seated in the counterbores of the housing.

3. Install the cam and cam pin handle on the shaft.

4. Install a washer and retaining pin at the other end of the shaft.

5. Assemble the spacer (bushing), spring and latch to the shut-down housing with the 1/4" -20 bolt, lock washer and plain washer.

a. Align the notch on the bushing with the notch on the latch and lock the bushing in this position.

b. Install the pins in the valve(s) to retain it to the shaft with the cam release latch set and the valve(s) in the run position.

c. Level the valve(s) in the shut-down position.

d. Adjust the bushing so the valve(s) contacts the housing when the cam release latch is set.

Install Air Shut-Down Housing (In-Line Engines)

1. Place the blower screen and gasket assembly in position with the screen side of the assembly toward the blower.

2. Refer to Figs. 1 and 3 and secure the air shut-down housing to the blower with bolts, washers and lock washers as follows:

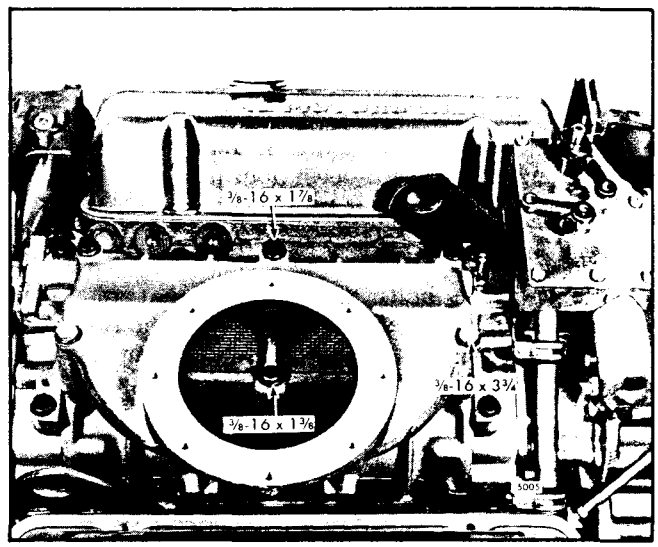


Fig. 4 - Location of Air Shut-Down Housing Mounting Bolts (6V Engines)

a. Install and finger tighten the six attaching bolts shown in Fig. 3.

b. Tighten the two center bolts to 16-20 lb-ft torque.

c. Then tighten the four corner bolts to 16-20 lb-ft torque.

CAUTION: A power wrench should not be used to tighten the above bolts.

3. Reset the air shut-down to the run position.

4. Start and run the engine at idle speed and no load. Trip the air shut-down. If the engine does not stop, check it for air leakage between the valve and the gasket. If necessary, reposition the valve.

Install Air Shut-Down Housing (6V Engines)

1. Place the blower screen and gasket assembly in position with the screen side of the assembly toward the blower.

2. Refer to Fig. 4 and mount the air inlet housing on the blower and secure it with bolts, washers and lock washers. Tighten the bolts to 16-20 lb-ft torque.

3. Reset the air shut-down to the run position.

4. Start and run the engine at idle speed and no load. Trip the air shut-down. If the engine does not stop, check it for air leakage between the valves and the gasket. If necessary, reposition the valves.

Install Air Shut-Down Housing and Adaptor (8V Engines)

1. Place the blower screen and gasket assembly in position with the screen side of the assembly toward the blower.

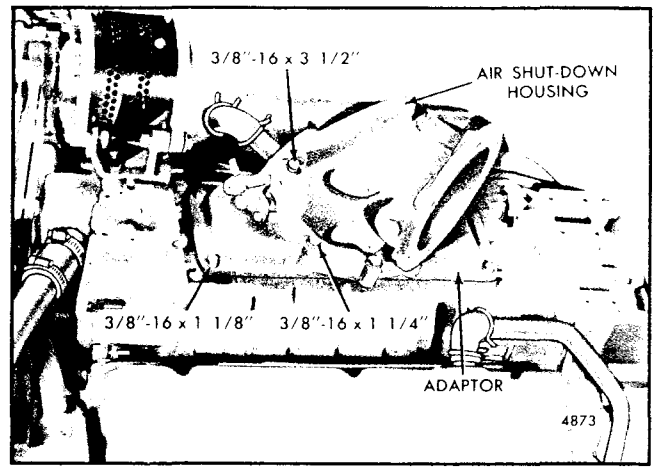


Fig. 5 - Location of Air Shut-Down Housing and Adaptor Mounting Bolts

2. Refer to Fig. 5 and install the air shut-down housing adaptor on the screen and gasket assembly. Install the six bolts and lock washers and tighten them to 16-20 lb-ft torque.

3. Affix a new gasket on the top of the air inlet housing adaptor, then place the air shut-down housing on top of the gasket. Install the six bolts and lock washers and tighten them to 16-20 lb-ft torque.

4. Reset the air shut-down to the run position.

5. Start and run the engine at idle speed and no load. Trip the air shut-down. If the engine does not stop, check it for air leakage between the valves and the gasket. If necessary, reposition the valves.

BLOWER

IN-LINE AND 6V ENGINES

The blower supplies the fresh air required for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow double-lobe rotors revolve in a housing bolted to the side of the in-line engines (Fig. 1) or on top of the cylinder block between the cylinder banks on the 6V engine (Fig. 2). The revolving motion of the rotors provides a continuous and uniform displacement of air.

The blower rotors are pinned to the rotor shafts. The rotor shafts are steel and the blower end plates are aluminum, providing for a compatible bearing arrangement.

Gears located on the splined end of the rotor shafts space the rotor lobes with a close tolerance. Since the lobes of the two rotors do not touch at any time, no lubrication is required.

Lip type oil seals are used in both the front and rear end plates on current engines. The seals prevent air leakage past the blower rotor shaft bearing surfaces and also keep the oil, used for lubricating the blower rotor gears, from entering the rotor compartment. Former blowers used a ring type oil seal consisting of a fiber washer, "O" ring, retainer and seal spring in each end of the blower rotors.

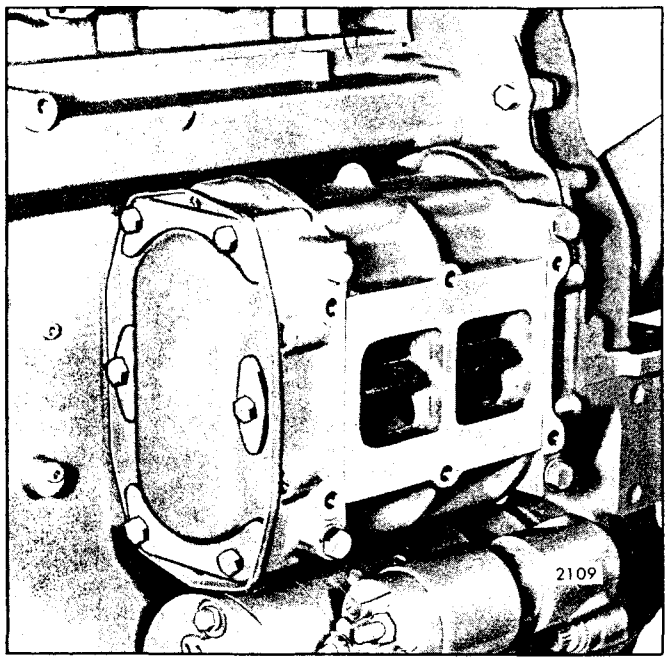


Fig. 1 - Blower Mounting (3-53 Engine)

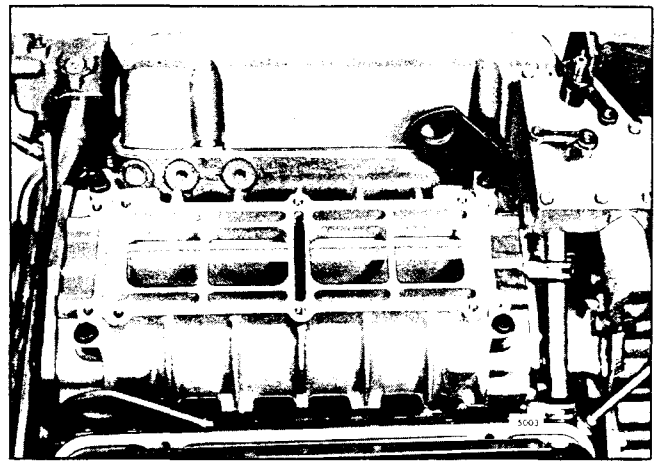


Fig. 2 - Blower Mounting (6V-53 Engine).

Inspect Blower (Attached to Engine)

The blower may be inspected without removing it from the engine. However, the air cleaner and the air inlet housing must be removed.

CAUTION: When inspecting the blower with the engine running, keep your fingers and clothing away from the moving parts of the blower and run the engine at low speeds only.

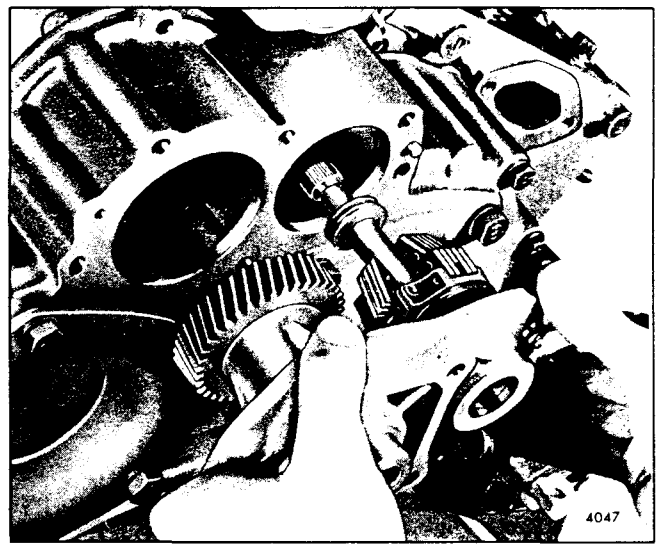


Fig. 3 - Removing/Installing Blower Drive Support (6V-53 Engine)

Dirt or chips drawn through the blower will make deep scratches in the rotors and housing. Burrs around such abrasions may cause interference between the rotors or between the rotors and the blower housing.

Leaky oil seals are usually indicated by the presence of oil on the blower rotors or inside surfaces of the blower housing. Run the engine at low speed and direct a light into the rotor compartment and toward the end plates and the oil seals. A thin film of oil radiating away from a seal indicates an oil leak.

A worn blower drive resulting in a loose, rattling sound within the blower may be detected by running the engine at approximately 500 rpm.

Loose rotor shafts or worn rotor shaft bearing surfaces will result in contact between the rotor lobes, the rotors and the end plates, or the rotors and the housing.

Excessive backlash between the blower rotor gears usually results in the rotor lobes rubbing throughout their entire length.

Remove Blower

Before removing the blower from the engine, remove the air shut-down housing as outlined in Section 3.3.

2 and 3-53 ENGINE BLOWER

1. Remove the six bolts, special washers and reinforcement plates which secure the blower to the engine end plate and the flywheel housing. *Note the location of the two shorter bolts.* Then remove the front end plate cover and gasket from the blower.

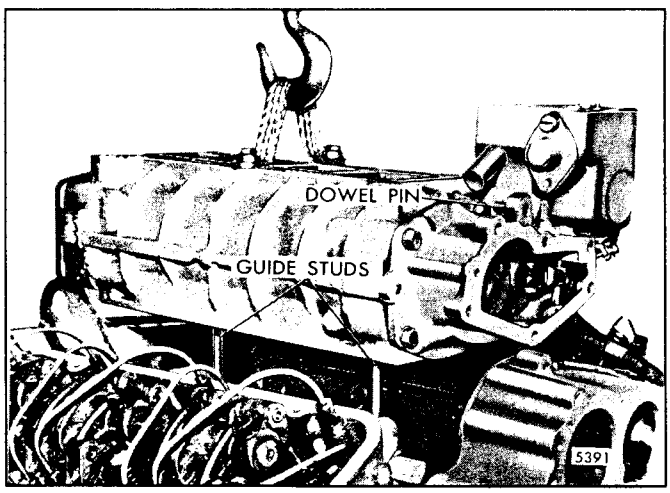


Fig. 4 - Removing/Installing Blower (6V-53 Engine)

2. Remove the four blower-to-block bolts and special washers and lift the blower away from the engine.

4-53 ENGINE BLOWER

1. Loosen the clamp retaining the cover-to-support seal.

2. Remove the four blower-to-block bolts and special washers and lift the blower away from the engine, being careful not to damage the serrations on the blower drive shaft.

6V-53 ENGINE BLOWER

1. Disconnect the linkage to the governor control levers.

2. Remove the screws and lock washers which attach the governor cover to the governor housing. Remove the cover and gasket.

3. Remove the two bolts and lock washers which hold

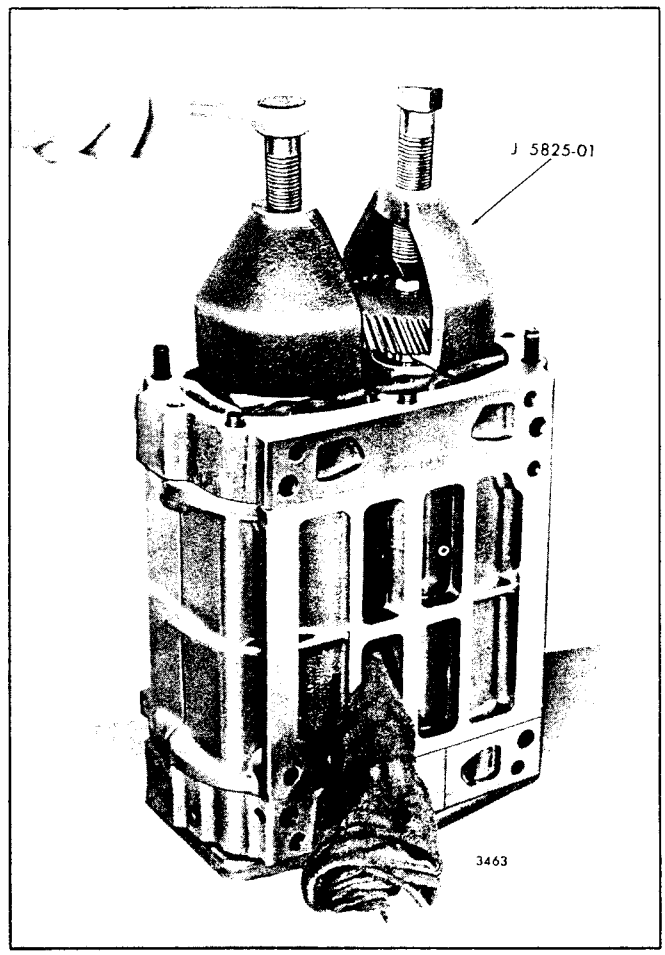


Fig. 5 - Removing Blower Rotor Gears

the spring housing to the governor housing. Remove the spring housing and gasket.

4. Remove the spring assembly from the governor.

5. Loosen the hose clamps and slide the hoses back on the fuel rod covers.

6. Clean and remove the valve rocker cover from each cylinder head.

7. Disconnect the lower fuel rod from each injector control tube lever and also from each upper fuel rod.

8. Remove the threaded pins connecting the fuel rods to the control link lever. Remove the upper fuel rods.

9. Remove the blower drive cover plate. Remove the snap ring and withdraw the blower drive shaft from the housing.

10. Remove the two bolts and copper washers securing the blower drive support assembly. Then withdraw the drive assembly until the splined end of the drive shaft is free from the drive plate (Fig. 3). Turn the drive assembly slightly so the serrated end of the governor weight shaft will pass around the governor operating fork. Remove the drive support from the engine.

11. The governor is doweled to the cylinder block rear end plate. Use a suitable tool to press or drive the dowel pin from the end plate.

12. Remove the four bolts and flat washers which attach the blower to the top face of the cylinder block. Lift the blower and governor assembly from the engine (Fig. 4).

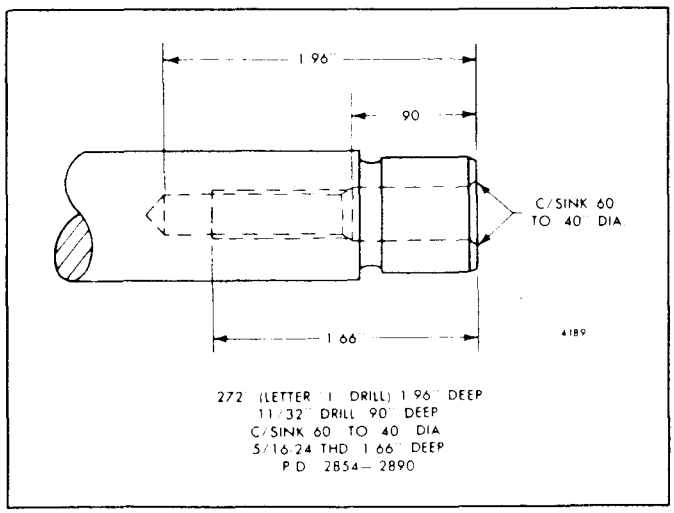


Fig. 6 - Dimensions for Reworking 6V Blower Rotor Shafts

13. Remove the six bolts and lock washers which attach the governor housing to the blower rear end plate. Remove the governor and gasket.

Disassemble Blower

2 and 3-53 ENGINE BLOWER

1. Wedge a clean cloth between the rotors to prevent their turning. Then remove the blower gear retaining bolts and washers.

2. For identification, mark the R.H. helix gear. Then remove the gears with pullers J 5825-01 as follows:

a. With the pullers in place under the gears (Fig. 5), place a brass bar, approximately 1 " long and 5/8 " diameter, between the point of each puller bolt and blower rotor shaft.

CAUTION: If the brass bar is larger than 5/8 " diameter, the serrations in the blower drive gear may be damaged.

b. Alternately turn the bolt in each puller until the gears are off the shafts.

3. Remove the rotor shims and the gear spacers and place them with their respective gears to ensure correct re-assembly.

4. At the other end of the blower, remove the three thrust plate bolts, the thrust plate and three spacers from the front end plate. Remove the bolts and thrust washers (refer to Fig. 7).

5. Remove the two screws that retain the end plate to the blower housing. Tap the end plate off of the dowel pins and housing with a soft (plastic) hammer, being careful not to damage the mating surfaces of the end plate and the housing.

6. Remove the rotors from the blower housing.

7. Remove the retaining screws and remove the rear end plate as in Step 5.

8. Remove and discard the lip type oil seals from the end plates on current blowers. Remove the seal washer, "O" ring, retainer and retainer spring from each rotor shaft on former blowers.

4-53 and 6V-53 ENGINE BLOWERS

1. Refer to Fig. 8 and remove the six bolts, special washers and reinforcement plates which secure the front end plate cover and the front end plate to the blower housing. Then remove the end plate cover and gasket from the end plate.

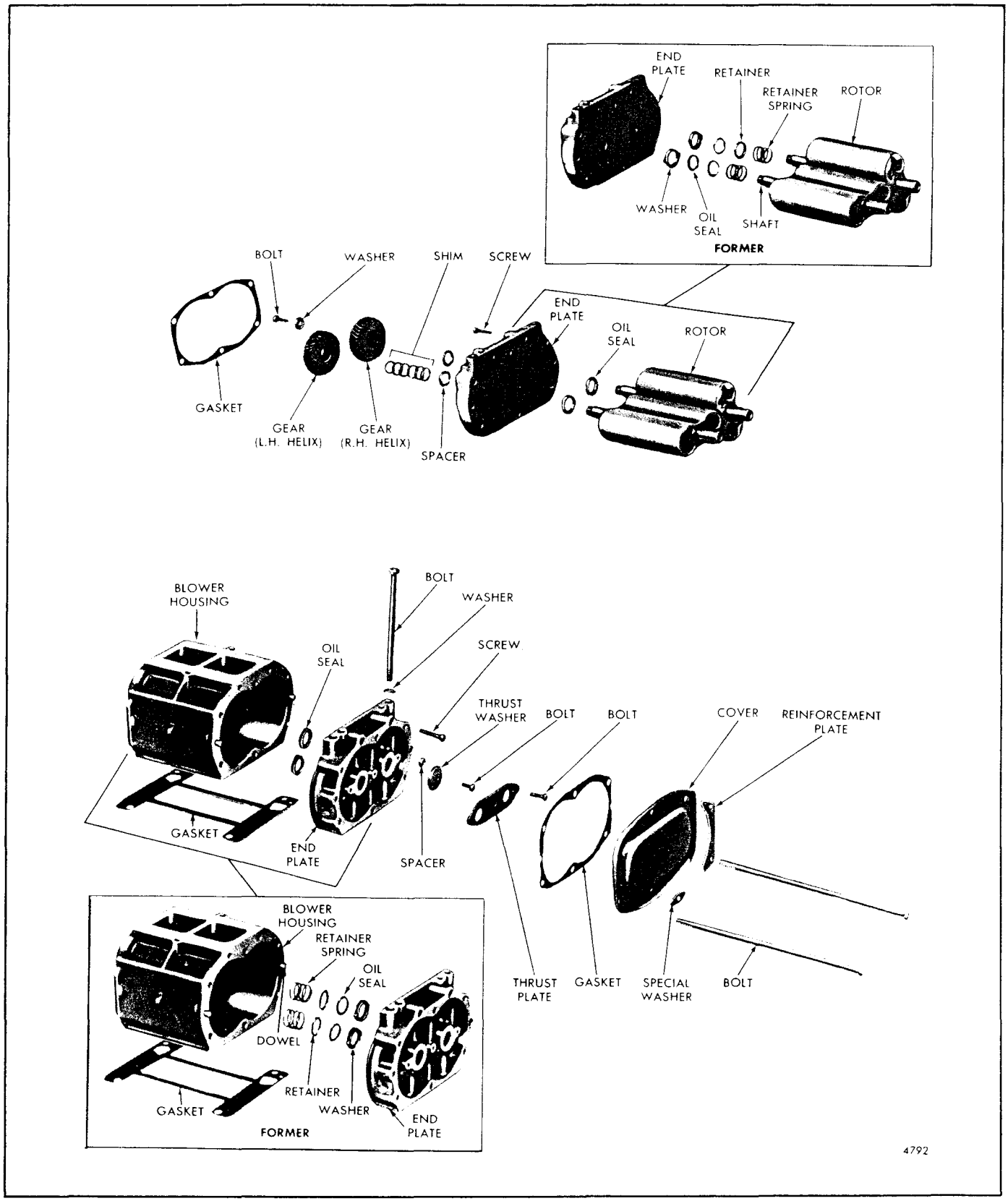


Fig. 7 - Typical Blower Details and Relative Location of Parts (3-53 Engine Blower)

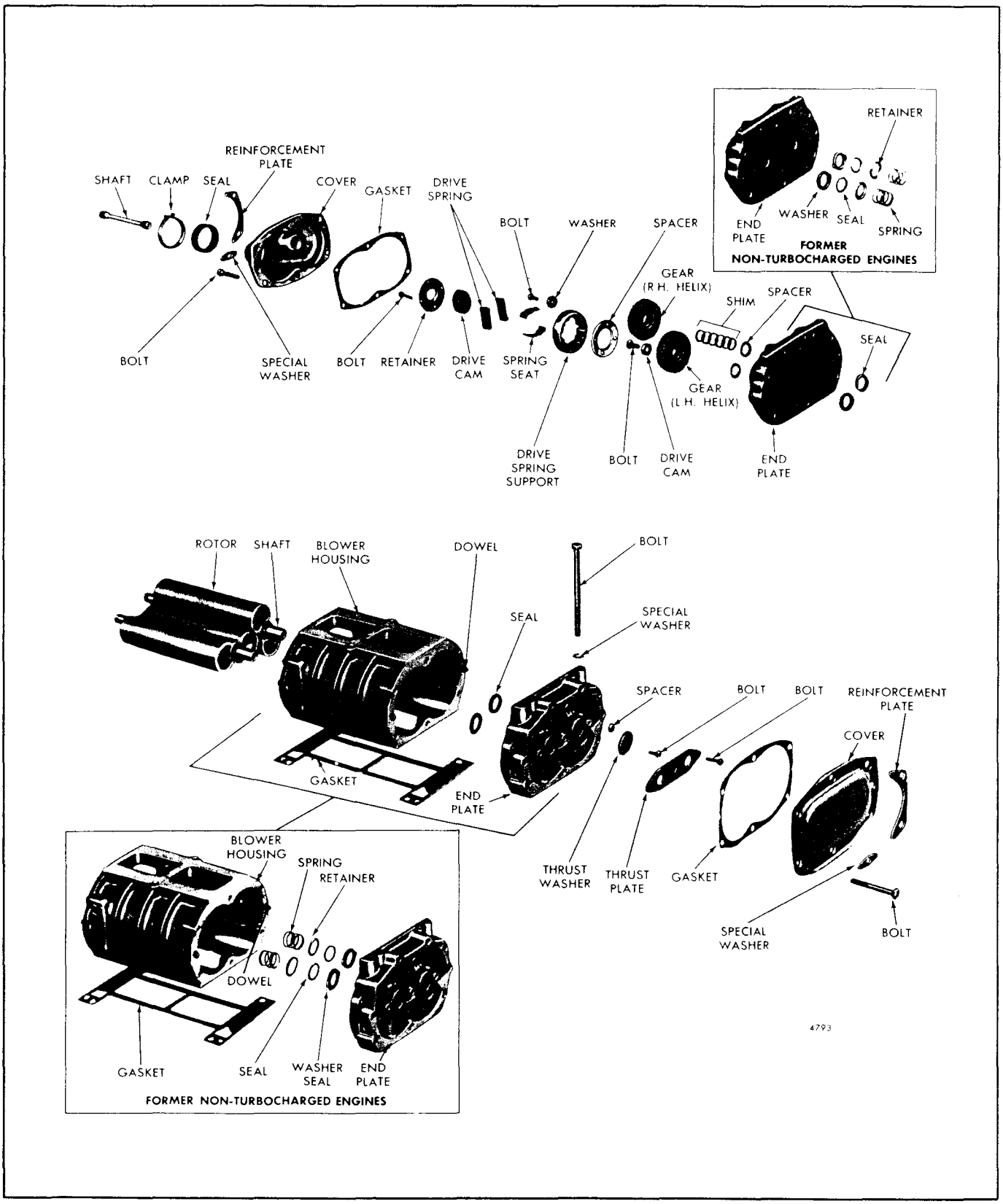


Fig. 8 - Typical Blower Details and Relative Location of Parts (4-53 Engine Blower)

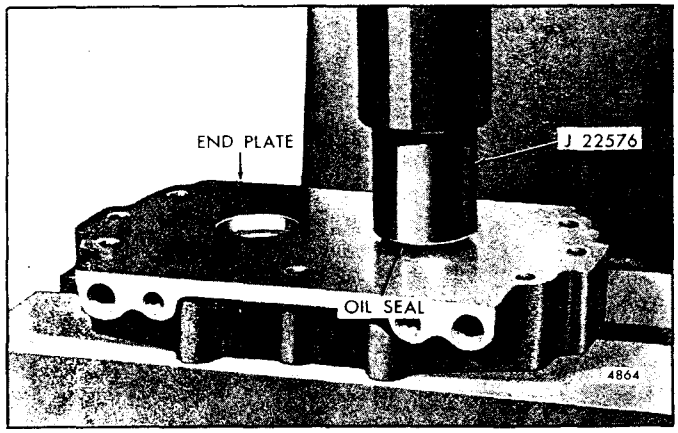


Fig. 9 - Installing Lip Type Oil Seal in End Plate

2. On a 4-53 engine blower, remove the six bolts, special washers and reinforcement plates which secure the rear end plate cover and the rear end plate to the blower housing. Then remove the end plate cover and gasket from the end plate.

NOTE: On the 6V engine, this step is accomplished by removing the governor.

3. Wedge a clean cloth between the rotors to prevent their turning and remove the four bolts that hold the blower drive cam retainer and blower drive spring support to the gear. Separate the retainer, support and spacer from the gear.

NOTE: On the 6V engine, the governor drive plate must also be removed from the opposite gear.

4. On a 4-53 engine blower, remove the retaining bolts and the washer and the blower drive cam pilot from the blower gears. On the 6V engine blower, a cam pilot is used on both gears.

5. For identification, mark the upper gear on the 4-53 blower or the left-hand gear on the 6V blower.

6. Use two pullers J 4794-01 to remove the two gears simultaneously.

7. Remove the rotor shims and the gear spacers and place them with their respective gears to ensure correct re-assembly.

8. At the other end of the blower, remove the three thrust plate bolts, the thrust plate and three spacers from the front end plate. Remove the bolts and thrust washers.

9. Tap the end plate off of the dowel pins and housing with a soft (plastic) hammer, being careful not to damage the mating surfaces of the end plate and the housing.

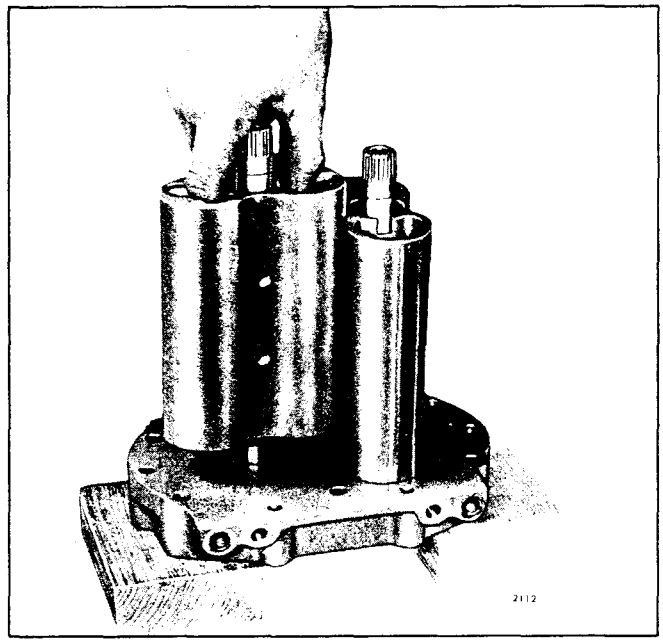


Fig. 10 - Installing Blower Rotors in Front End Plate

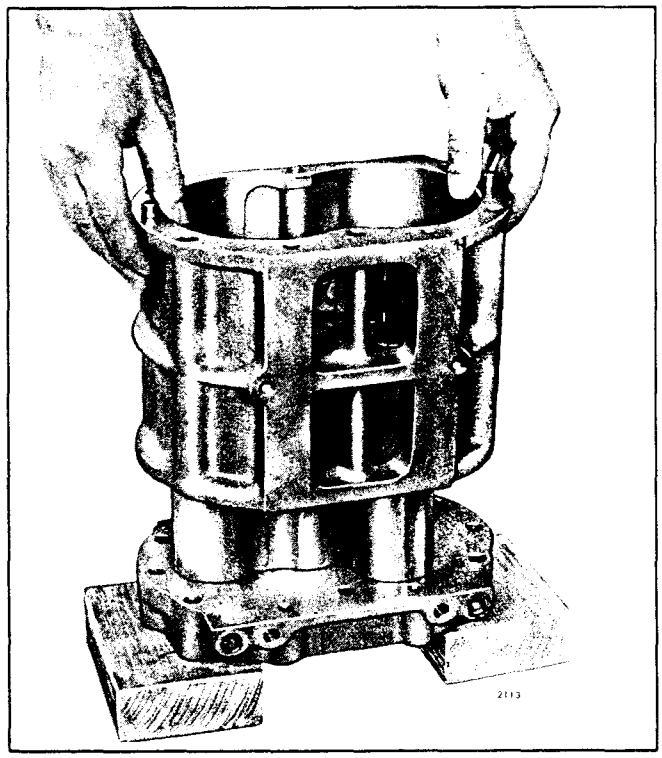


Fig. 11 - Installing Blower Housing Over Rotors

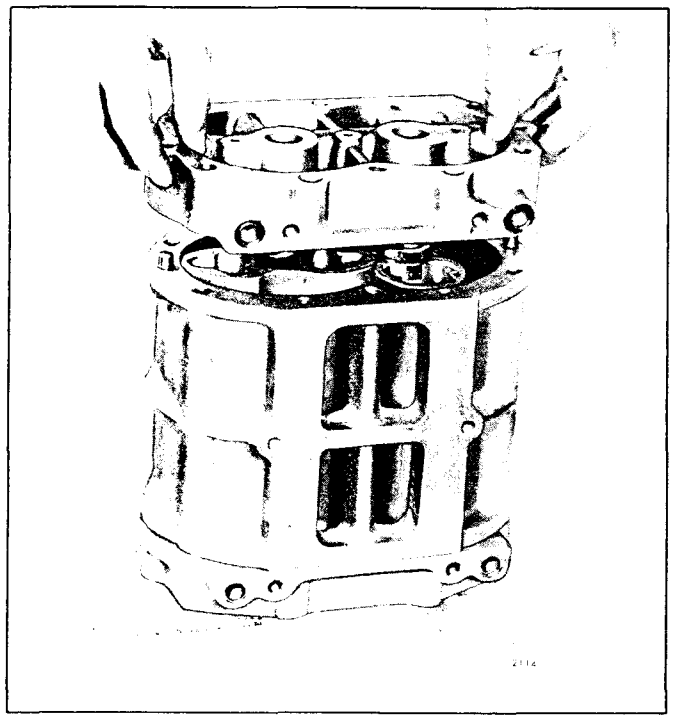


Fig. 12 - Installing Rear End Plate

10. Remove the rotors from the blower housing.

11. Remove the rear end plate as in Step 9.

12. Remove and discard the lip type oil seals from the end plates on current blowers. Remove the seal washer, "0" ring, retainer and retainer spring from each rotor shaft on former blowers.

13. If required, disassemble the blower drive spring support by driving the cam from the support with a brass drift, permitting the springs and spring seats to fall free.

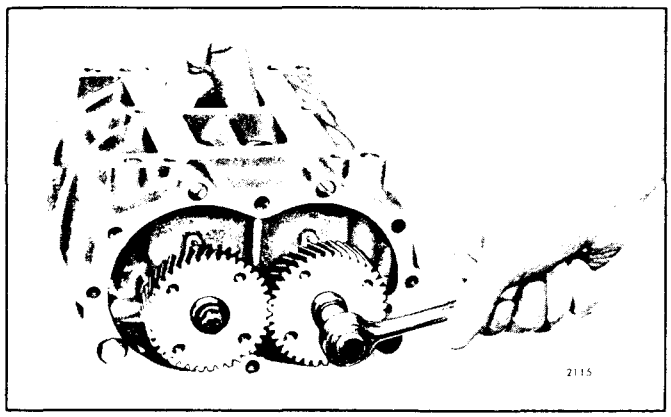


Fig. 13 - Installing Blower Rotor Gears

Inspection

Clean and dry all of the parts thoroughly.

The finished inside face of each end plate must be smooth and flat. Slight scoring may be cleaned up with a fine grit emery cloth. If the surface is badly scored, replace the end plate.

Inspect the surfaces of the rotors and the blower housing. Remove burrs or scratches with an oil stone.

Examine the rotor shaft, gear or drive coupling for burred or worn serrations.

Inspect the blower gears for excessive wear or damage.

Check the bearing and oil seal contact surfaces of the rotor shafts and end plates for scoring, wear or nicks.

If an oil seal sleeve is used on the rotor shaft, it can be replaced as follows:

a. Place sleeve remover J 23679-2 over the rotor shaft and behind the oil seal sleeve.

b. Back out the center screw of one gear puller J 21672-7 and attach the puller to the sleeve remover with three 1/4 "-20 x 3 " bolts and flat washers.

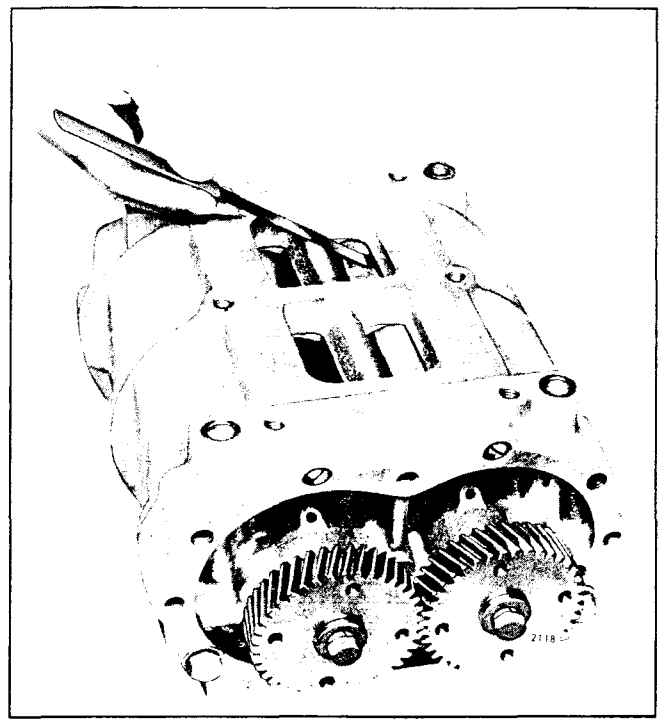


Fig. 14 - Measuring Rotor Lobe to Housing Clearance

c. Turn the puller screw clockwise and pull the sleeve off of the shaft.

d. Support the rotor, gear end up, on the bed of an arbor press.

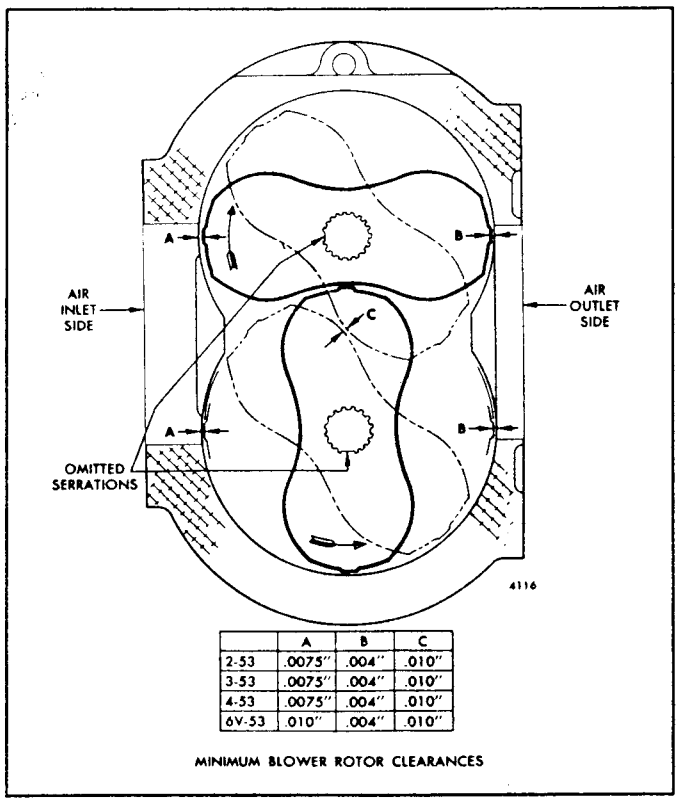
e. Start a new sleeve straight on the shaft.

f. Place sleeve installer J 23679-1 on top of the sleeve and press the sleeve on the shaft until the step in the installer contacts the shoulder on the shaft.

NOTE: The step in the sleeve installer properly positions the sleeve on the shaft.

The rotor assemblies for the 6V engine blower have been revised to permit the use of longer (1-3/4 ") gear retention bolts. The former bolts were 7/8 " long. If a former blower is removed for repair or overhaul, rework the rotor shafts as illustrated in Fig. 6.

To replace the former "0" ring oil seals by the current lip type oil seals, rework the end plates by following the instructions given in *Shop Notes* in Section 3.0.



	A	B	C
2-53	.0075"	.004"	.010"
3-53	.0075"	.004"	.010"
4-53	.0075"	.004"	.010"
6V-53	.010"	.004"	.010"

MINIMUM BLOWER ROTOR CLEARANCES

Fig. 15 - Minimum Blower Rotor Clearance

Assemble Blower

Refer to Figs. 7 and 8 and assemble the blower as follows:

1. Install new lip type oil seals in each end plate in *current blowers* as follows:

a. Place the end plate on the bed of an arbor press.

b. Lubricate the outer diameter of the seal and, using installer J 22576, press the seal (lip facing down) into the counterbored hole until the shoulder on the installer contacts the end plate (Fig. 9).

NOTE: A step on the seal installer will position the oil seal below the finished face of the end plate within the .002 " to .008 " specified.

2. Install the ring type oil seals on the rotor shafts of *former blowers* as follows:

a. Install a retainer spring on each shaft of each rotor. Then place an "0" ring retainer (dished side up) on each spring.

b. Lubricate the "O" rings with clean engine oil, then slide one ring on each shaft.

c. Lubricate and place a seal on each shaft. Note that the tangs on each seal are flush with one side of the seal; this side of the seal must face toward the rotor.

3. Place the front end plate on two wood blocks. Then install the rotors, gear end up, on the end plate (Fig. 10). On the former blowers, be sure that the ring type oil seals are properly positioned on the rotors.

4. Install the blower housing over the rotors (Fig. 11).

NOTE: To prevent inadequate lubrication or low oil pressure, care must be exercised in the assembly of the front and rear blower end plates to the blower housing. The rear end plate for the *2 and 3-53 blower* does not have tapped holes for the thrust washer plate bolts and no thrust washer lubricating oil holes. The rear end plate for the *6V-53 blower* does not have tapped holes for the thrust washer plates and is the only cover that has the horizontal oil passage drilled through into the pocket on the left side of the end plate for supplying oil to the blower drive gear support bearing.

5. Place the rear end plate over the rotor shafts (Fig. 12). On the former blowers, be sure that the ring type oil seals are properly positioned on the rotors. Then secure each end plate to the 3-53 blower housing with two end plate retaining screws and two cover

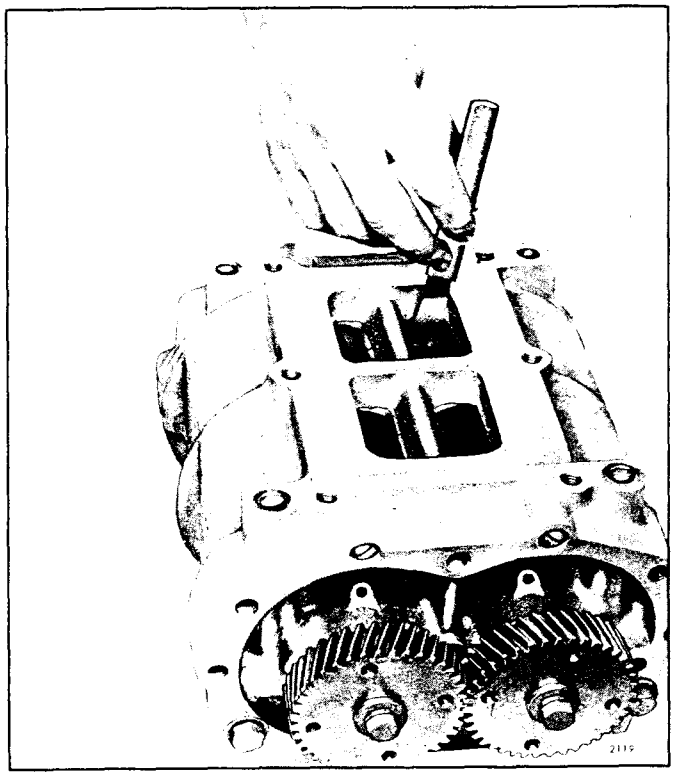


Fig. 16 - Measuring Rotor Lobe to End Plate Clearance

bolts and plain washers. Secure each end plate to the 4-53 or 6V blower with four end plate cover bolts and plain washers.

6. Attach the two thrust washers to the front end of the blower with the washer retaining bolts. If 5/16 "-24 bolts are used, tighten them to 25-30 lb-ft torque; if 3/8 " - 24 bolts are used, tighten them to 54-59 lb-ft torque.

7. Attach the three spacers and the thrust plate to the front end of the blower. Tighten the three bolts to 7-9 lb-ft torque. Then check the clearance between the thrust plate and the thrust washers. The specified clearance is .001 " to .003 ".

NOTE: The current thrust plate is .260 " thick. The former plate was .180 " thick.

8. Position the rotors so that the missing serrations on the gear end of the rotor shafts are 90 ° apart. This is accomplished by placing the rotors in a "T" shape, with the missing serration in the upper rotor facing to the left and the missing serration in the lower rotor facing toward the bottom (Fig. 14). Install the shims and spacers in the counterbore in the rear face of the rotor gears. Then place the gears on the ends of the shafts with the missing serrations in alignment with the missing serrations on the shafts.

9. Tap the gears lightly with a soft hammer to seat them on the shafts. Then rotate the gears until the punch marks on the face of the gears match. If the marks do not match, re-position the gears.

10. Wedge a clean cloth between the blower rotors. Use the gear retaining bolts and plain washers to press the gears on the rotor shafts (Fig. 13). Turn the bolts uniformly until the gears are tight against the shoulders on the shafts.

11. Remove the gear retaining bolts and washers. Then proceed as follows:

2 and 3-53 Blower -- Place the gear washers on the gears and start the gear retaining bolts in the rotor shafts. Tighten the bolts to 25-30 lb-ft torque.

4-53 Blower -- Place the blower drive cam pilot in the counterbore of the upper gear and start the gear retaining bolt in the rotor shaft. Place the gear washer on the face of the lower gear and start the gear retaining bolt in the rotor shaft. Tighten the bolts to 25-30 lb-ft torque.

6V Blower -- Place a pilot in the counterbore of each gear and start the 12-point bolt in the right-hand rotor shaft and start the hex head bolt in the left-hand rotor shaft. Tighten the bolts to 25-30 lb-ft torque.

12. Check the backlash between the blower gears, using a suitable dial indicator. The specified backlash is .0005 " to .0025 " with new gears or a maximum of .0035 " with used gears.

13. Time Blower Rotors

After the blower rotors and gears have been installed, the blower rotors must be timed. When properly positioned, the blower rotors run with a slight clearance between the rotor lobes and with a slight clearance between the lobes and the walls of the housing.

The clearances between the rotors may be established by moving one of the helical gears out or in on the shaft relative to the other gear by adding or removing shims between the gear hub and the rotor spacers.

It is preferable to measure the clearances with a feeler gage comprised of two or more feelers, since a combination is more flexible than a single feeler gage. Take measurements from both the inlet and outlet sides of the blower.

a. Measure the clearance between the rotor lobes and

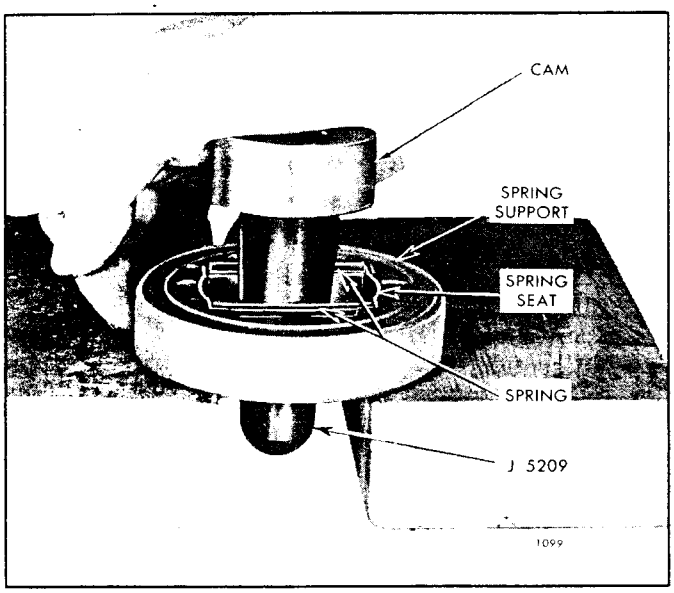


Fig. 17 - Inserting Cam in Blower Drive Support

the housing as shown in Fig. 14. Take measurements across the entire length of each rotor lobe to be certain that a minimum clearance of .004 " exists at the *air outlet side* of all blowers and a minimum clearance of .0075 " (in-line engine blower) or .010 " (6V engine blower) exists at the *air inlet side* of the blower (Fig. 15).

b. Measure the clearance between the rotor lobes, across the length of the lobes, in a similar manner. By rotating the gears, position the lobes so that they are at their closest relative position (Fig. 15). The clearance between the lobes should be a minimum of .010 ".

c. Measure the clearance between the end of the rotor and the blower end plate as shown in Fig. 16. Refer to the chart for the required minimum clearances.

NOTE: Push and hold the rotor toward the end plate at which the clearance is being measured.

After timing the rotors, complete assembly of the blower.

14. Remove the bolts and washers used to temporarily secure the front end plate to the housing. Then install the front end plate to the blower with six bolts and special washers and two reinforcement plates and tighten the bolts to 20-25 lb-ft torque.

NOTE: The current front and rear end plate gaskets on the 4-53 engine blower are identical and may be used in either position. Formerly these gaskets were not interchangeable. The gasket used between the blower and the governor housing on the 6V engine is not interchangeable with the front end plate cover gasket.

BLOWER ROTOR END CLEARANCES (Minimum)		
Engine	Front End Plate	Rear End Plate
2-53	.006"	.006"
3-53	.006"	.008"
4-53	.006"	.009"
6V-53	.008"	.012"

15. Assemble the blower drive spring support as follows:

a. Place the drive spring support on two blocks of wood (Fig. 17).

b. Position the drive spring seats in the support.

c. Apply grease to the springs to hold the leaves together, then slide the two spring packs (15 leaves per pack) in place.

d. Place the blower drive cam over the end of tool J 5209, insert the tool between the spring packs and press the cam in place.

16. Install the drive spring support coupling on the rotor gear at the rear end of the blower.

IMPORTANT: Effective with engine serial number 4D-14120, the blower assembly for the 4-53 engine has been revised by the use of a new longer drive gear pilot and the addition of a drive coupling spacer (Fig. 18). Tighten the 5/16 "-24 drive gear pilot bolt to 25-30 lb-ft torque. Prior to the above change, a shorter drive coupling was used and no spacer was required.

NOTE: The coupling is placed on the upper rotor gear on the in-line engine blower and on the left-hand gear on the 6V engine blower. A spacer is placed between the gear and the coupling on the 6V engine blower.

17. Secure the cam retainer to the coupling with four 1/4 "-28 bolts and tighten them to 14-18 lb-ft torque.

18. On the 6V engine blower, install the governor drive plate on the right-hand rotor gear with four bolts and tighten them to 8-10 lb-ft torque.

19. Remove the bolts and washer used to temporarily secure the rear end plate to the 4-53 engine blower. Then install the rear end plate cover and gasket and secure the cover and end plate to the blower with six bolts and special washers and two reinforcement plates and tighten the bolts to 20-25 lb-ft torque.

NOTE: This step is accomplished on the 6V engine blower by securing the governor to the end plate with six bolts.

Install Blower

Examine the inside of the blower for any foreign material. Also revolve the rotors by hand to be sure that they turn freely. Then install the blower on the engine as follows:

3-53 ENGINE BLOWER

1. Affix a new blower-to-block gasket on the side of the cylinder block. Use Scotch Grip Rubber Adhesive No. 4300, or equivalent, only on the block side of the gasket.

2. Position the blower front end plate and gasket on the end of the blower and install six bolts with two special washers on the center bolts and the reinforcement plates on the two top and two bottom bolts. Install a new engine end plate to blower gasket over the threaded ends of the bolts. Apply Scotch Grip Rubber Adhesive No. 4300, or equivalent, to the engine end plate side of the gasket.

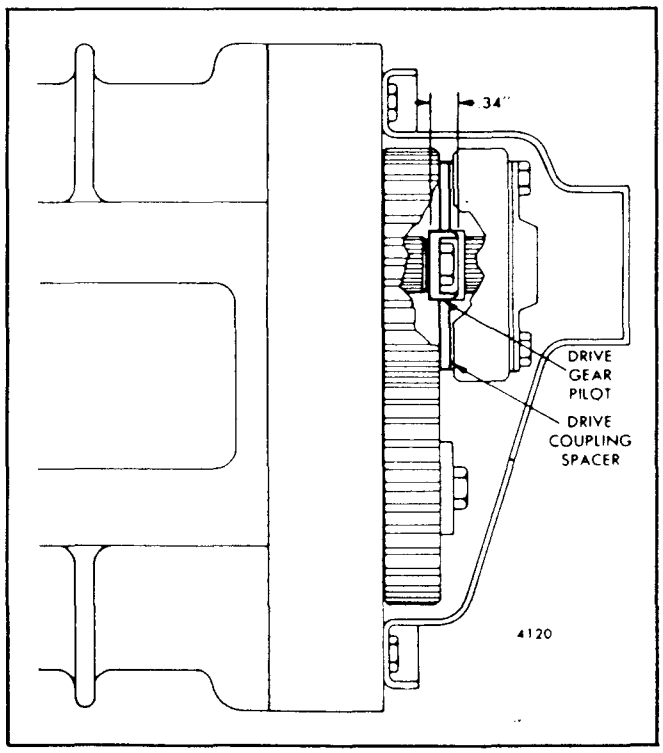


Fig. 18 - Current Pilot and Spacer Used on 4-53 Blower

NOTE: The current front and rear end plate gaskets are identical and may be used in either position. Formerly these gaskets were not interchangeable due to a difference in thickness.

3. Place the blower on the cylinder block locating flanges and, while holding the blower in place, thread the six bolts finger tight in the rear engine end plate and flywheel housing. Then install the blower-to-block mounting bolts and washers and tighten them to 10-15 lb-ft torque.

4. Tighten the center blower-to-end plate bolts first and then the top and bottom bolts to 20-25 lb-ft torque. Then tighten the blower-to-block bolts to 55-60 lb-ft torque.

5. Check the backlash between the upper rotor gear and the camshaft or balance shaft gear. The backlash should be .003 " to .007 ".

6. Install the air shut-down housing (Section 3.3).

4-53 ENGINE BLOWER

1. Affix a new blower-to-block gasket on the side of the cylinder block. Use Scotch Grip Rubber Adhesive No. 4300, or equivalent, only on the block side of the gasket.

2. Install the seal and clamp on the blower rear end plate cover.

3. Slide one end of the blower drive shaft into the drive cam.

4. Position the blower on the side of the cylinder block. Use care so that the blower gasket is not damaged or dislocated during installation of the blower.

5. Secure the blower to the cylinder block with bolts and washers. Tighten the bolts to 55-60 lb-ft torque.

6. Slide the seal and clamp back against the blower drive gear support and tighten the clamp to hold the seal in place.

7. Check the backlash between the blower drive gear and the camshaft gear. The backlash should be .003 " to .007 ".

8. Install the air shut-down housing (Section 3.3).

6V-53 ENGINE BLOWER

1. Install a new blower-to-block seal ring and two new blower-to-block gaskets. Affix the gaskets to the cylinder block and engine end plate with Scotch Grip Rubber Adhesive No. 4300, or equivalent.

2. Install the blower and governor assembly on the engine as follows:

a. To install the blower and governor on the engine without disturbing the gaskets and seal, use guide studs (Fig. 4). Install the guide studs in the end blower bolt holes in the cylinder block.

b. While lowering the blower and governor assembly over the guide studs, push the blower away from the governor housing gasket attached to the rear end plate.

c. Remove the guide studs and install the blower to block bolts and flat washers. Tighten the bolts finger tight only.

d. Press or drive the governor housing dowel pin into the rear end plate with a suitable tool.

3. Tighten the blower to block bolts to 10-15 lb-ft torque.

4. Install the blower drive support as follows:

a. Affix a new gasket to the blower drive support.

b. Position the light governor weights (high speed-limiting speed governor) in a horizontal position to provide clearance (Fig. 3). Turn the operating shaft fork away from the blower, if necessary, for additional clearance.

c. Move the blower drive assembly into the openings in the flywheel housing until the blower drive gear enters the housing. Then turn the drive assembly slightly so that the serrated end of the governor weight shaft may pass around behind the governor operating fork, permitting the fork to slip into place between the serrated end of the shaft and the riser bearing.

d. Push the drive support assembly up against the flywheel housing; the serrations in the governor weight shaft and in the governor drive plate on the blower timing gear must mesh. The blower drive gear must also mesh with the mating gear.

5. Secure the small end of the blower drive support to the flywheel housing with two 3/8 "-16 bolts and copper washers. Tighten the bolts to 20-25 lb-ft torque.

6. Insert the blower drive shaft into the blower gear shaft. If necessary, turn the crankshaft so that the serrations on the blower drive shaft register with the serrations in the blower drive cam and the blower drive gear shaft.

7. Install the snap ring in the blower drive gear shaft to secure the blower drive shaft.

8. Attach a new gasket to the blower drive support cover. Then secure the cover to the support with four 3/8 "-16 bolts and lock washers. Tighten the bolts to 20-25 lb-ft torque.

9. Tighten the blower-to-block bolts to 55-60 lb-ft torque.

10. Insert the upper fuel rods through the fuel rod covers and attach the rods to the governor control link lever.

11. Attach the lower fuel rods to the injector control tube levers and upper fuel rods.

12. Slide the fuel rod cover hoses in place and secure them with hose clamps.

13. Install the spring assembly in the governor.

14. Install the air shut-down housing (Section 3.3).

BLOWER (8V)

The blower, designed especially for efficient diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow three-lobe rotors revolve with very close clearances in a housing mounted between the two banks of cylinders and bolted to the top deck of the cylinder block. To provide continuous and uniform displacement of air, the rotor lobes are made with a helical (spiral) form (Fig. 1).

Two rotor gears, located on the drive end of the rotor shafts, space the rotor lobes with a close tolerance; therefore, as the lobes of the two rotors do not touch at any time, no lubrication is required.

Lip type oil seals located in the blower end plates prevent air leakage and also keep the oil, used for lubricating the rotor gears and rotor shaft bearings, from entering the rotor compartment.

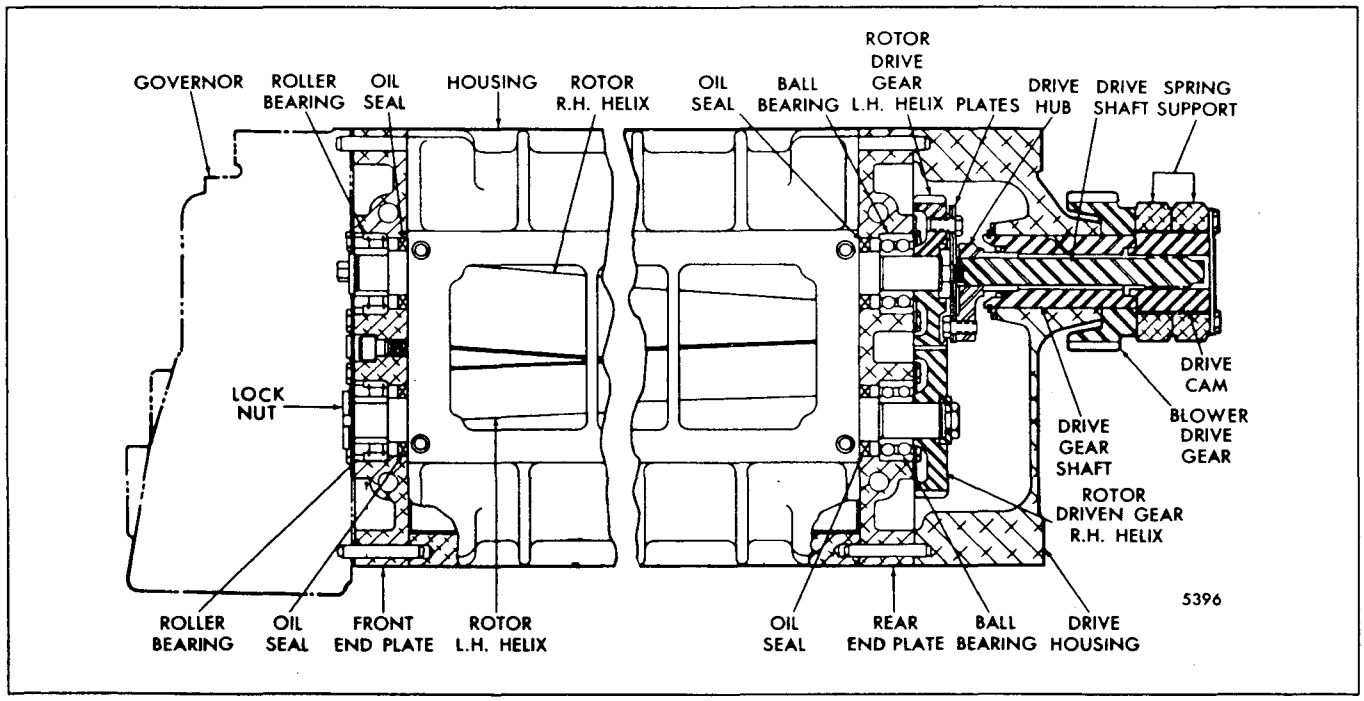
Effective with engine serial number 8D-4508, new blowers are used on the 8V engines. The current blowers differ from the former blowers in that the double-row ball bearings are now in the rear end plate (gear end) rather than the front end plate and the roller bearings are in the front end plate.

On the current blower, new rotors are used which have a counterbore for a cup plug in the balance holes to increase blower efficiency. Each rotor is supported in the end plates by a roller bearing in the front end plate and a two-row ball bearing at the gear end. The oil seal sleeves have been discontinued in the rear position of the non-turbocharged engine blower. The same oil seal is now used in both the front and rear end plates. The oil seal sleeves will continue to be used in both the front and rear end plates (four positions) in the turbocharged engine blower.

The right-hand helix rotor of an 8V blower is driven at approximately twice (2.205:1) engine speed by the blower drive shaft. The blower drive shaft is splined at one end to two flexible couplings attached to the blower drive gear and at the other end to a hub attached to the left-hand helix rotor drive gear. The mating right-hand helix rotor driven gear drives the left-hand helix rotor.

A flexible coupling, formed by an elliptical cam driven by four bundles of leaf springs which ride on four spring seats, is attached to the rear face of the blower drive gear and prevents the transfer of torque fluctuations to the blower.

The blower rotors are timed by the two rotor gears at the rear end of the rotor shafts. This timing must be correct, otherwise the required clearance, obtained by



• Fig. 1 - Current Blower and Drive Assembly

the use of shims behind the rotor gears, between the rotor lobes will not be maintained.

Normal rotor gear wear causes a decrease of rotor-to-rotor clearance between the leading edge of the right-hand helix (drive) rotor and the trailing edge of the left-hand helix (driven) rotor. Clearance between the opposite sides of the rotor lobes is increased correspondingly.

While the rotor lobe clearance may be corrected by adjustment, rotor gear backlash cannot be corrected. When rotor gears have worn to the point where the backlash exceeds .004 ", replace the gears.

Lubrication

The blower bearings, rotor gears and governor drive mechanism are pressure lubricated by means of oil passages in the top deck of the cylinder block which lead from the main oil galleries to an oil passage in each blower end plate (Fig. 2). The oil flows upward to the horizontal oil passage in the end plate and leaves through a small orifice just below each bearing bore in the end plate. The oil is ejected from these orifices against the rotor gears at the rear end of the blower and the governor weights at the front end of the blower.

The bearings are splash lubricated by oil thrown by the rotor gears and governor weights. Oil which collects at the bottom of each end plate overflows into two drain passages which lead back to the crankcase via oil passages in the cylinder block.

The blower drive support bearing receives oil under pressure from the horizontal oil passage in the blower rear end plate (Fig. 2) which leads to the oil passage in the blower drive support housing.

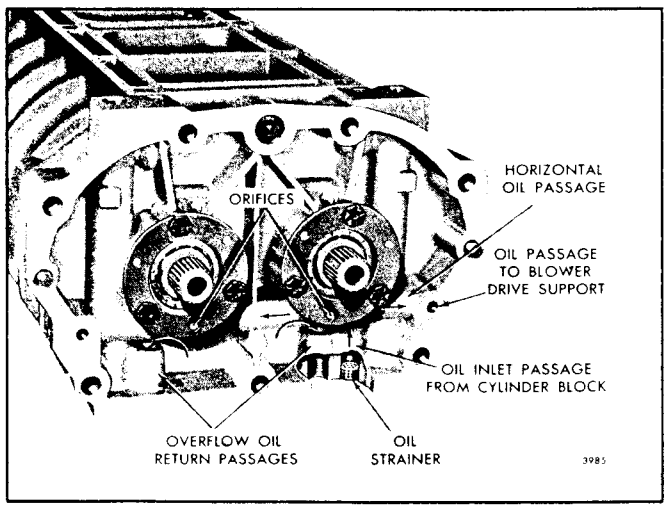


Fig. 2 - Blower Lubrication

Inspection

The blower may be inspected without being removed from the engine. However, the air silencer and adaptor, or the air inlet housing, air shut-down housing and adaptor must first be removed.

> **CAUTION:** When inspecting a blower on an engine with the engine running, keep fingers and clothing away from the moving parts of the blower and run the engine at low speeds only.

Dirt or chips, drawn through the blower, will make deep scratches in the rotors and housing and throw up burrs around such abrasions. If burrs cause interference between the rotors or between the rotors and the housing, remove the blower from the engine and remove the burrs to eliminate the interference, or replace the rotors if they are badly scored.

Leaky oil seals are usually manifest by the presence of oil on the blower rotors or the inside surfaces of the housing. This condition may be checked by running the engine at low speed and directing a light into the rotor compartment at the end plates and the oil seals. A thin film of oil radiating away from the seals is indicative of an oil leak.

A worn blower drive usually results in a rattling noise inside the blower and may be detected by grasping the right-hand helix rotor firmly and attempting to rotate it. Rotors may move from 3/8 " to 5/8 ", measured at the lobe crown, with a springing action. When released, the rotors should move back at least 1/4 ". If the rotors cannot be moved as directed above, or if the rotors move too freely, inspect the flexible blower drive coupling and replace it if necessary. The drive

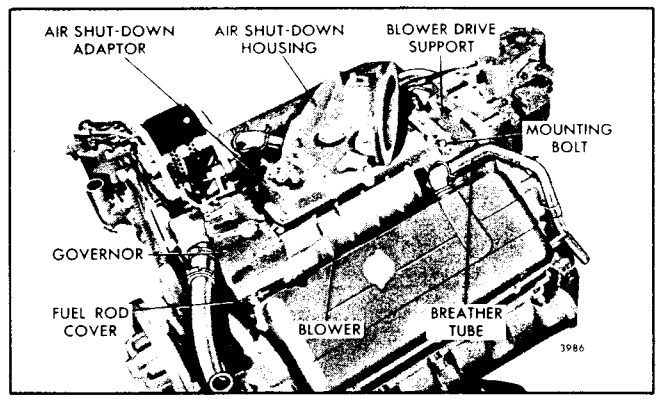


Fig. 3 - Typical Blower Mounting

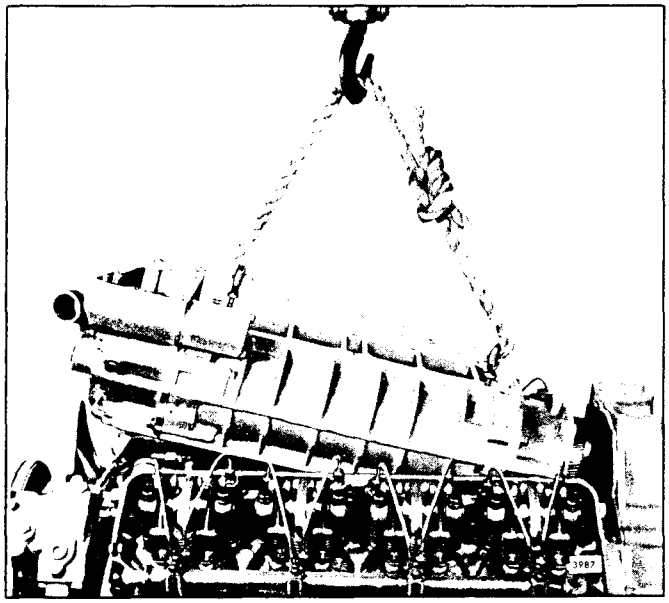


Fig. 4 - Removing Blower From Engine

coupling is attached to the left-hand helix rotor drive gear.

Loose rotor shafts or damaged bearings will cause rubbing and scoring between the crowns of the rotor lobes and the mating rotor roots, between the rotors and the end plates, or between the rotors and the housing. Generally, a combination of these conditions exists. A loose shaft usually causes rubbing between the rotors and the end plates. Worn or damaged bearings will cause rubbing between the mating rotor lobes at some point or perhaps allow the rotor assemblies to rub the blower housing. This condition will usually show up at the end where the bearings have failed.

Excessive backlash between the rotor gears usually results in rotor lobes rubbing throughout their entire length.

Inspect the blower inlet screen periodically for accumulation of dirt which, after prolonged operation, may affect the air flow. Servicing of the screen consists of thoroughly washing it in fuel oil and cleaning it with a stiff brush until the screen is free of all dirt deposits.

To correct any of the above conditions, remove the blower from the engine and either repair or replace it.

Remove Blower

The engine governor components are assembled in a combination governor housing and blower front end plate cover. The blower drive components are assembled in a combination blower drive housing and blower rear end plate cover. Therefore, when removing the blower assembly from the engine, the governor and blower drive support assemblies will also be removed at the same time. Refer to Fig. 1 and proceed as follows:

1. Disconnect the throttle control rods from the governor levers.

2. Remove the six bolts and lock washers securing the air shut-down housing to the air inlet adaptor. Remove the shut-down housing and gasket.

3. Remove the six bolts and lock washers securing the air inlet adaptor to the blower housing. Remove the air inlet adaptor and blower screen and gasket assembly.

4. Loosen the battery-charging generator adjusting strap bolt. Also loosen the nuts on the bolts securing the generator to its mounting bracket. Then remove the generator drive belts from the generator pulley.

5. While supporting the generator, remove the two nuts, lock washers and bolts securing the generator to the generator mounting bracket. Then lift the generator off the engine.

6. Remove the four bolts and lock washers securing the generator mounting bracket to the governor housing.

7. Loosen the governor housing breather tube hose clamp at the forward face of the governor and the breather tube clamp at the water pump attaching bolt. Remove the tube, hose and hose clamps from the governor and the engine.

8. Remove the four bolts and lock washers securing the water by-pass tube to the thermostat housing. Slide the

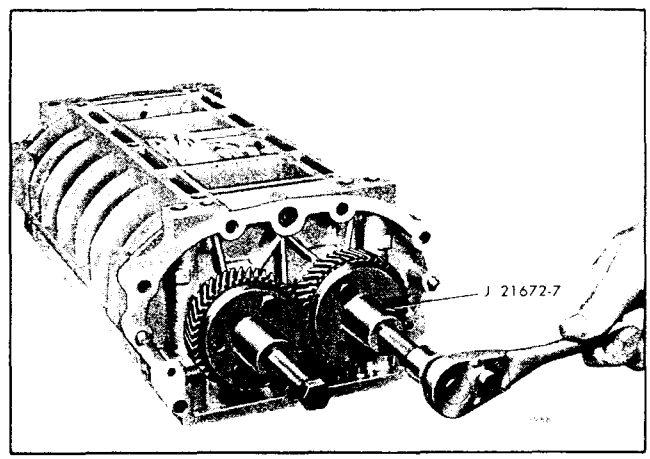


Fig. 5 - Removing Rotor Gears

tube back on one of the thermostat housings, then lift the opposite end of the tube up and remove it from the thermostat housing.

9. Disconnect and remove the fuel oil supply and return lines connecting the fuel manifolds and the cylinder heads.

10. Remove the valve rocker cover breather tube hose clamp on each rocker cover and the tube clamp attached to the rear face of the flywheel housing; then remove the breather tubes from the engine.

11. If an air compressor is attached to the rear face of the flywheel housing, it may be removed as follows:

a. Disconnect the air compressor water inlet and outlet tubes from the air compressor. Then disconnect the oil supply line from the air compressor.

b. While supporting the air compressor, remove the four bolts and lock washers securing the air compressor to the rear face of the flywheel housing. Then remove the air compressor and gasket. If necessary, remove the air compressor drive coupling.

12. Remove the five bolts and lock washers securing the blower drive hole cover to the flywheel housing. Remove the cover and gasket.

13. Remove the two bolts securing the blower drive shaft retainer to the blower drive coupling support, then remove the retainer.

14. Pull the blower drive shaft out of the blower drive hub and cam. If necessary, use a pair of small nose pliers.

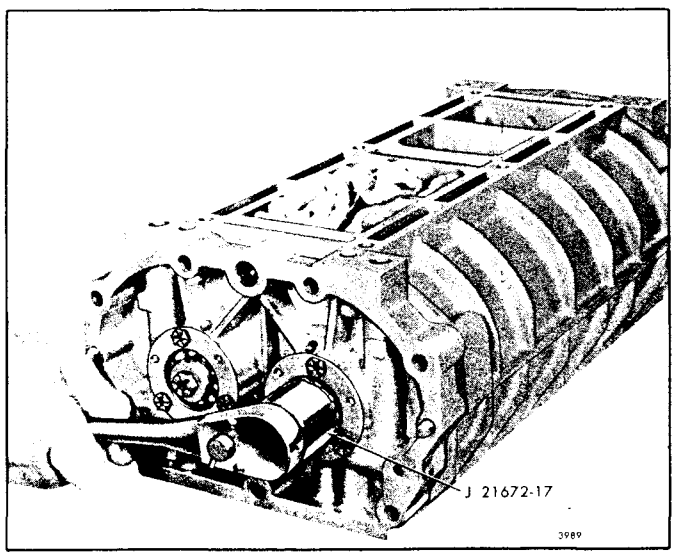


Fig. 6 - Removing Rotor Bearing Retaining Nut

15. Remove the two remaining bolts and flat washers securing the blower drive couplings to the blower drive gear, then remove the blower drive couplings.

16. Remove the five bolts, lock washers and one plain washer securing the blower drive support housing to the engine end plate.

17. Disconnect and remove the fuel oil supply line between the fuel oil pump and the fuel oil filter.

18. Clean and remove the valve rocker cover from each cylinder head.

19. Remove the eight screws and lock washers securing the governor cover to the governor housing.

20. Disconnect the fuel rods from the injector rack control tube levers and the governor and remove the fuel rods.

21. Loosen the hose clamps and slide the fuel rod cover hose down against each cylinder head.

22. Remove the two 7/16"-14 x 7/8" bolts, lock washers and plain washers securing the governor housing to the cylinder block.

23. Remove the two bolts and special washers from each blower end plate securing the blower assembly to the cylinder block.

24. Thread eyebolts in diagonally opposite air inlet adaptor-to-blower bolt holes. Attach a rope sling and a chain hoist to the eyebolts. Then lift the blower assembly, at an angle, from the cylinder block as shown in Fig. 4 and place it on a bench.

Remove Accessories from Blower

Remove the accessories from the blower as follows:

1. Remove the six bolts, lock washers, plain washers and one socket head bolt securing the blower drive support housing to the blower rear end plate.

2. Tap each end of the blower drive support housing with a plastic hammer to loosen it from the gasket and dowel pins. Then remove the drive support assembly and gasket.

3. Remove the three self-locking bolts (current blowers) or four self-locking bolts (former blowers) securing the blower drive hub to the left-hand helix rotor drive gear.

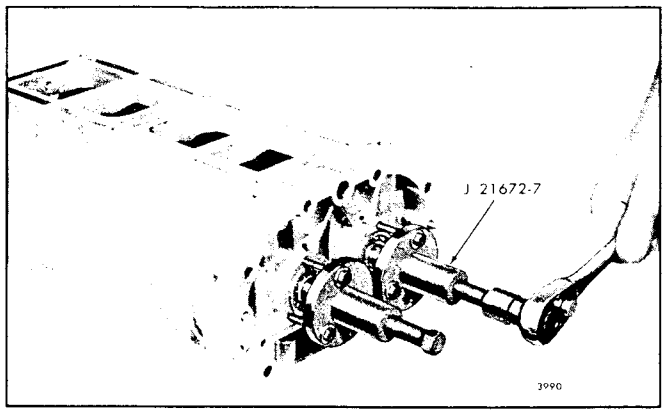


Fig. 7 - Removing Blower Rotors from Front End Plate Ball Bearings (Former Blower)

4. Remove the seven bolts and lock washers securing the breather body to the governor housing. Remove the breather body and gasket.

5. Remove the seven bolts and copper washers, two inside and five outside, securing the governor assembly to the blower front end plate.

6. Tap the governor housing with a plastic hammer to loosen it from the gasket and dowel pins. Then remove the governor assembly and gasket.

Disassemble Blower

Cover the air inlet and outlet openings and clean the exterior of the blower with fuel oil and dry it with compressed air.

Refer to Figs. 3 and 10 and disassemble the blower as follows:

1. Place a clean folded shop towel between the rotors and a towel between the rotor and housing to prevent the rotors from turning.

2. Remove the two bolts and pilots (43) securing the blower rotor gears to the blower rotor shafts.

3. Remove the blower rotor gears with pullers J 21672-7 (Fig. 5). Both rotor gears must be pulled at the same time as follows:

a. Back the center screws out of both pullers, then place the flange end of the pullers against the rotor gears. Align the large holes in the puller flanges with the 3/8 "-24 tapped holes in the gears. Secure the pullers to the gears with four 3/8 "-24 x 1 " bolts.

b. With the shop towels between the blower rotors and housing to prevent them from turning, turn the puller screws uniformly clockwise and pull the gears from the rotor shafts as shown in Fig. 5.

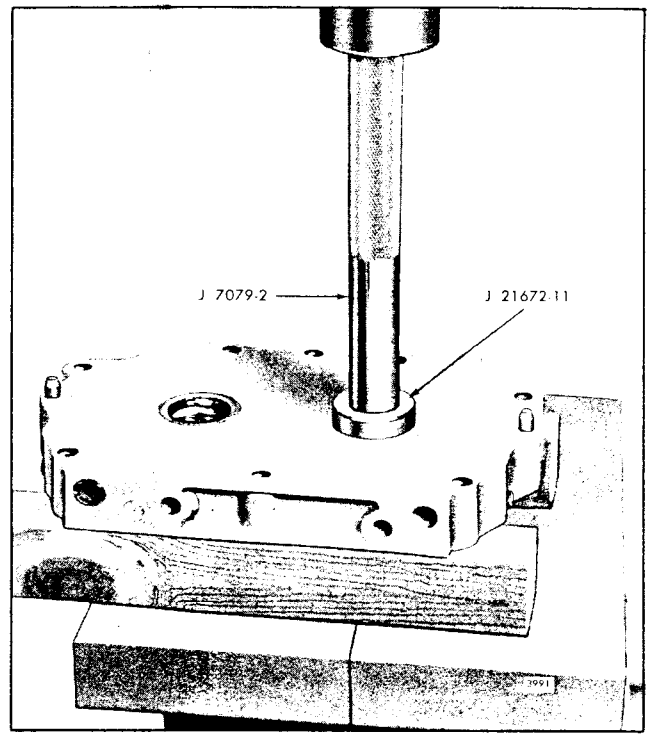


Fig. 8 - Removing Oil Seal and Roller Bearing from Rear End Plate (Former Blower)

4. Remove the shims from the rotor shafts and note the number and thickness of the shims on one or both of the rotor shafts.

5. Remove the bolts securing the rotor shaft bearing retainers (71) to the rear end plate, then remove the retainers.

6. Remove the bolt and special washer (80) securing the ball bearing (former blower) or roller bearing (current blower) on the right-hand helix rotor shaft at the front end of the blower.

7. Bend the tang of the bearing retainer nut lock washer (81) up out of the notch in the bearing lock nut (82). Then remove the bearing lock nut with spanner wrench J 21672-17 as shown in Fig. 6.

8. Remove the bolts securing the rotor shaft bearing retainers to the front end plate, then remove the retainers.

9. Remove the socket head bolt (50) securing the blower rear end plate to the blower housing. Tap each end of the rear end plate with a plastic hammer to

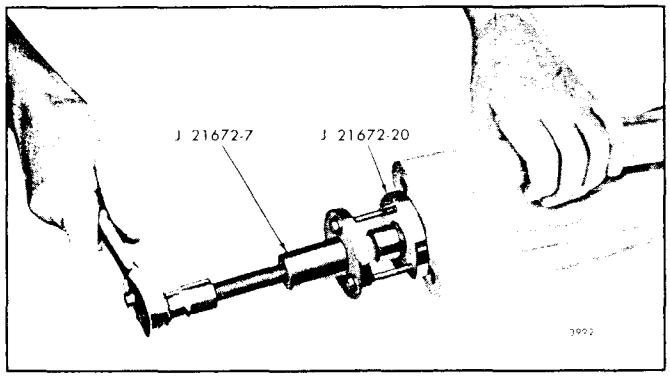


Fig. 9 - Removing Oil Seal Sleeve and Roller Bearing Inner Race from Rotor Shaft

loosen it from the blower housing, then remove the end plate and bearings from the rotor shafts.

10. Remove the blower rotors from the ball bearings (former blowers) and from the roller bearings (current blowers) in the front end plate and the blower housing as follows:

a. Back the center screw out of both pullers J 21672-7, then attach the pullers to the blower front end plate with six 1/4 "-20 x 1-1/2 " or longer bolts as shown in Fig. 7.

b. Remove the shop towels from between the blower rotors and the housing.

c. Turn the puller screws uniformly clockwise and push the rotor shafts out of the ball bearings (former blower) or roller bearings (current blower) in the end plate. Then slide the rotors out of the blower housing.

d. Remove the pullers from the blower front end plate.

11. Remove the socket head bolt securing the blower front end plate to the blower housing. Tap each end of the front end plate with a plastic hammer to loosen it and remove it from the blower housing.

12. Inspect the rotor shaft oil seals. If the seals are scored or hard, remove the bearings and oil seals from the blower end plates as follows:

a. Support the blower end plate, inner face up, on two wood blocks on the bed of an arbor press as shown in Fig. 8.

b. Place the oil seal remover J 21672-11 with handle J 7079-2 on top of the oil seal and under the ram of the press, then press the oil seal and bearing out of the end plate as shown in Fig. 8. Discard the oil seal.

c. Remove the remaining oil seals and bearings from the end plates in the same manner as outlined in items "a" and "b" above.

CAUTION: When the roller bearings are removed from the rear end plate, each bearing must be tagged to be sure it will be installed in the same bearing bore in the end plate that it was removed from.

NOTE: Oil seal sleeves have been discontinued in the rear position of the current non-turbocharged engine blower. The oil seal sleeves will continue to be used in both the front and rear end plates (four positions) in the turbocharged engine blower.

13. If the roller bearings or the oil seal sleeves are to be replaced, the roller bearing inner races and oil seal sleeves may be removed from the rotor shafts as follows:

The roller bearing inner race may be removed separately or the oil seal sleeve and inner race may be removed together.

a. Place the roller bearing inner race and oil seal sleeve remover J 21672-20 over the rotor shaft behind the oil seal sleeve as shown in Fig. 9.

b. Back out the center screw of one gear puller J 21672-7, then attach the puller to the oil seal sleeve remover with three 1/4 "-20 x 3 " bolts and flat washers as shown in Fig. 9.

c. Turn the puller screw clockwise and pull the roller bearing inner race and oil seal sleeve off of the rotor shaft.

d. Remove the roller bearing inner race and oil seal sleeve from the remaining rotor shaft.

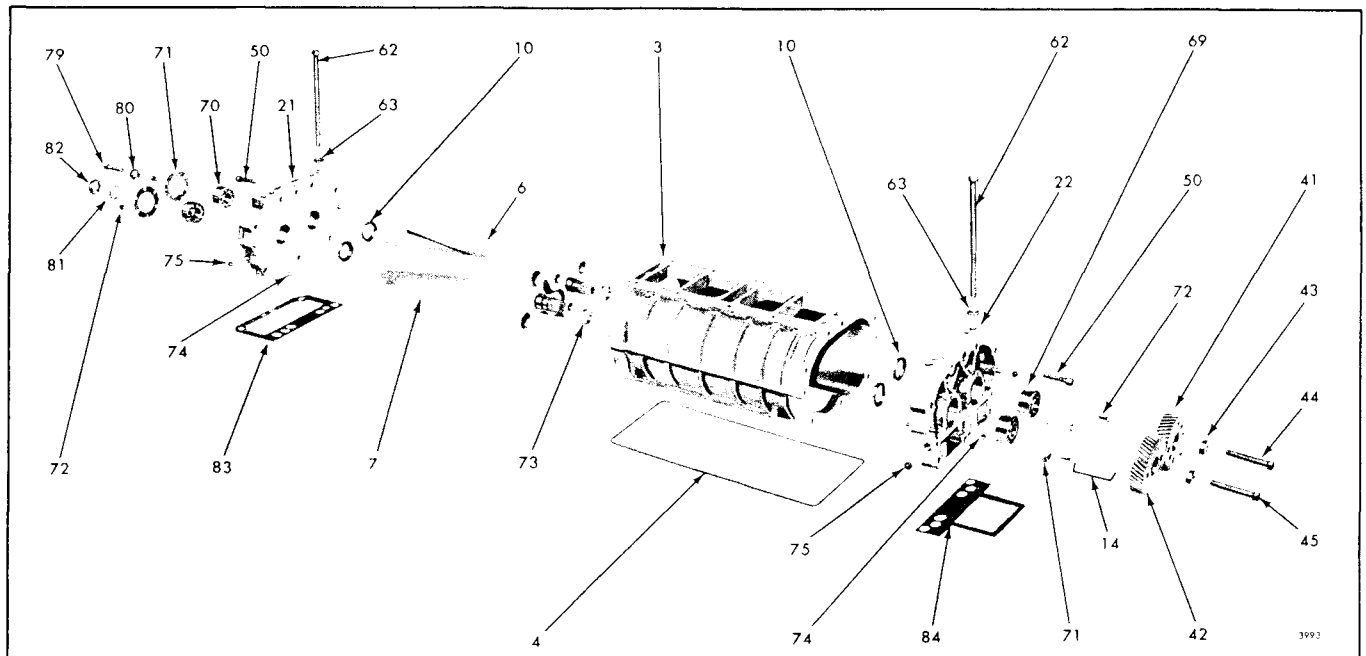
CAUTION: Be sure and tag or place each roller bearing inner race with its mating roller bearing. Do not intermix the inner races and roller bearings.

Inspection

Wash all of the blower parts in clean fuel oil and dry them with compressed air.

Examine the bearings for any indications of corrosion or pitting. Lubricate each bearing with light engine oil. Then while holding the bearing inner race from turning, revolve the outer race slowly by hand and check for rough spots.

The double-row ball bearings are pre-loaded and have



3. Housing--Blower
4. Gasket
6. Rotor Assy.--R.H. Helix
7. Rotor Assy.--L.H. Helix
10. Oil Seal--Rotor Shaft
14. Shims
21. Plate--Front End
22. Plate--Rear End
41. Gear--Rotor Drive L.H. Helix
42. Gear--Rotor Driven R.H. Helix
43. Pilot--Rotor Gear
44. Bolt--Drive Gear
45. Bolt--Driven Gear
50. Bolt--Socket Head
62. Bolt--Blower-to-Block
63. Washer--Special
69. Bearing--Rotor Rear (Roller)
70. Bearing--Rotor Front (Ball)
71. Retainer--Bearing
72. Bolt--Bearing Retainer
73. Sleeve--Oil Seal
74. Strainer--End Plate Oil Passage
75. Plug--Pipe
79. Bolt
80. Washer
81. Lock Washer
82. Nut
83. Gasket
84. Gasket

Fig. 10 - Blower Details and Relative Location of Parts (8V-53) (Former Blower)

no end play. A new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

Examine the rotor shafts and the oil seal sleeves (used on former blowers and turbocharged engine blowers) for wear.

Inspect the blower rotor lobes, especially the sealing ribs, for burrs and scoring. If the rotors are slightly scored or burred, they may be cleaned up with emery cloth.

Examine the rotor shaft serrations for wear, burrs or peening. Also inspect the bearing contact surfaces of the shafts for wear and scoring.

Inspect the inside surface of the blower housing for burrs and scoring. If the inside surface of the housing is slightly scored or burred, it may be cleaned up with emery cloth.

Check the finished ends of the blower housing for flatness and burrs. The end plates must set flat against the blower housing.

The finished inside face of each end plate must be smooth and flat. If the finished face is slightly scored or burred, it may be cleaned up with emery cloth.

Examine the serrations in the blower rotor gears for wear and peening; also check the teeth for wear, chipping or damage. If the gears are worn to the point where the backlash between the gear teeth exceeds .004 " or damaged sufficiently to require replacement, both gears must be replaced as a set.

NOTE: The left-hand helix rotor drive gear in the current blower has three bolt holes. The gear in the former blower has four bolt holes. This is due to the bolting arrangement (three bolt holes current drive hub, four bolt holes former drive hub) of the drive hub.

Check the blower drive shaft serrations for wear or peening. Replace the shaft if it is bent.

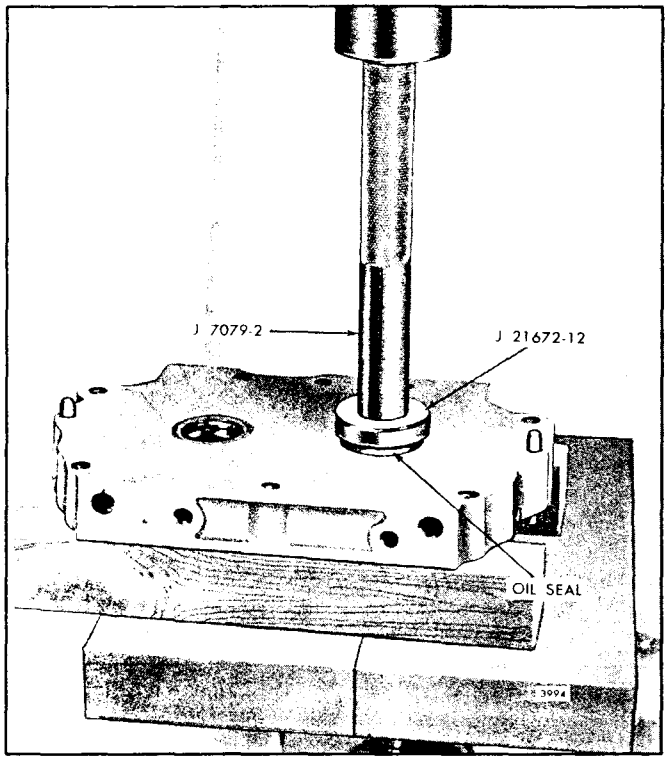


Fig. 11 - Installing Oil Seal in Rear End Plate (Former Blower)

Inspect the blower drive coupling springs (pack) and the cam for wear.

Replace all worn or excessively damaged blower parts.

Clean the oil strainer in the vertical oil passage at the bottom of each blower end plate and blow out all oil passages with compressed air.

Assemble Blower

The lobes on the *driving* blower rotor form a right-hand helix and the teeth on its gear form a left-hand helix while the lobes on the *driven* blower rotor form a left-hand helix and the teeth of its gear form a right-hand helix. Hence, a rotor with right-hand helix lobes must be used with a gear having left-hand helix teeth and vice versa.

NOTE: New rotors with a different helix angle have been incorporated in the 8V engine blowers. The former and new rotors must not be mixed in a blower assembly. The proper clearances cannot be obtained in a mix of the former and new rotors.

With this precaution in mind, proceed with the blower assembly, referring to Figs. 10 through 20 as directed in the text:

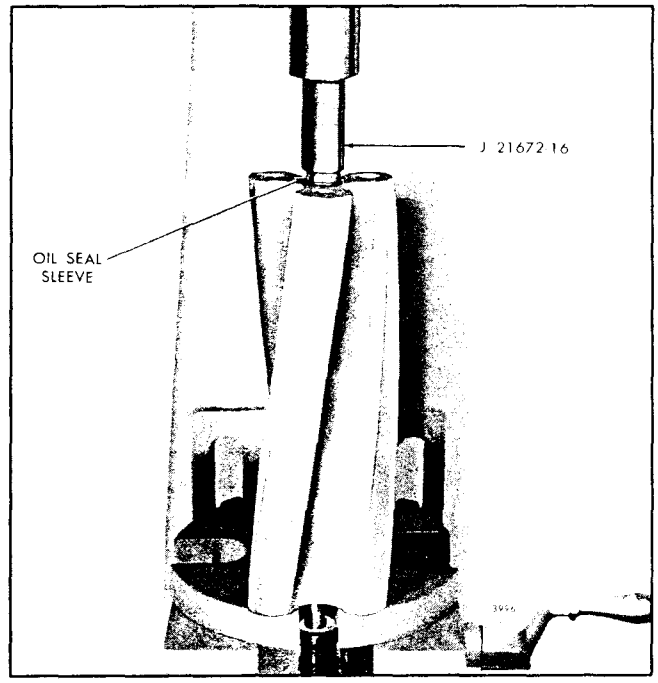


Fig. 12 - Installing Oil Seal Sleeve on Rotor Shaft (Former Blower)

1. If removed, press a new oil strainer into the vertical oil passage at the bottom of each end plate from flush to .015 " below the bottom surface (Fig. 2). Also, if removed, install a pipe plug in the horizontal oil passage at each end of both end plates.

2. Install new oil seals in the blower end plates as follows:

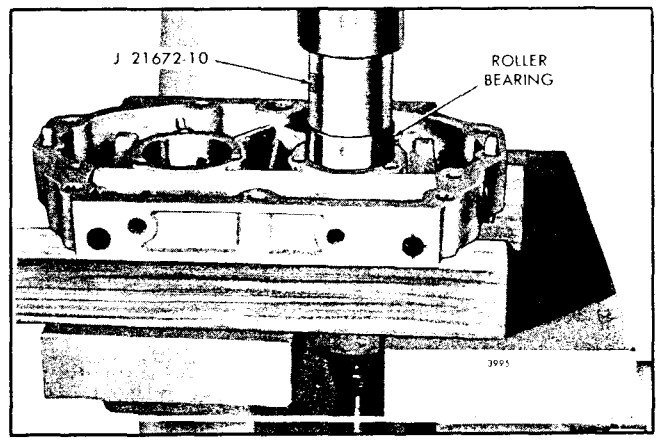


Fig. 13 - Installing Roller Bearing in Rear End Plate (Former Blower)

a. Support the blower rear end plate, finished surface facing up, on wood blocks on the bed of an arbor press.

CAUTION: The rotor shaft oil seals used in the former blower end plates have two different inside diameters. Install the oil seal with the largest inside diameter in the former blower rear end plate. On current blowers, the oil seal sleeves have been discontinued in the rear position, therefore the same oil seal is now used in both the front and rear end plates.

NOTE: The rear end plate may be identified by the bolt guide sleeve pressed into the right-hand bolt hole in the bottom of the end plate.

b. Start the large inside diameter oil seal straight into the bore in the rear end plate with the lip of the seal facing down (toward the bearing bore).

c. Place the oil seal installer J 21672-12 with handle J 7079-2 on top of the oil seal as shown in Fig. 11. Then press the oil seal straight into the end plate until the shoulder on the installer contacts the end plate.

d. Install the second oil seal in the rear end plate and the oil seals in the front end plate in the same manner.

NOTE: The oil seals must be flush to .010 " below the finished surface of the end plate.

3. If removed, install the rear end plate oil seal sleeve and the roller bearing inner race on the gear end of each blower rotor shaft as follows:

a. Support the blower rotor, gear end up, on the bed of an arbor press as shown in Fig. 12.

b. Start the oil seal sleeve straight on the sleeve surface of the shaft.

c. Place the oil seal sleeve installer J 21672-16 on top of the oil seal sleeve. Then press the sleeve on the shaft until the step in the installer contacts the shoulder on the shaft.

NOTE: The step in the installer properly positions the oil seal sleeve on the rotor shaft.

d. Install the remaining oil seal sleeve on the shaft of the second blower rotor.

e. Press a roller bearing inner race on the gear end of each blower rotor shaft with installer J 21672-16.

CAUTION: When installing a roller bearing inner race, note the tags previously placed on the bearings and races at the time of removal and install the bearing inner races, numbered end up, on the rotor shafts in their original positions. Do not intermix the races and bearings.

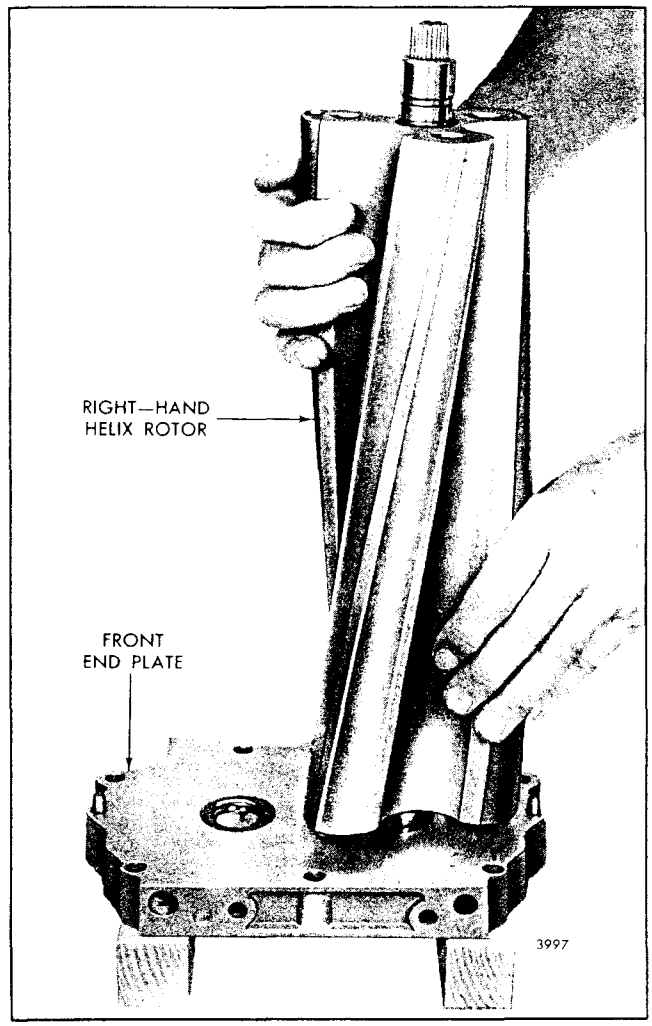


Fig. 14 - Installing Blower Rotor in Front End Plate

4. Install the roller bearings in the rear end plate as follows:

a. Support the rear end plate (inner face down) on two wood blocks on the bed of an arbor press as shown in Fig. 13.

NOTE: The rear end plate may be identified by the bolt guide sleeve pressed into the right-hand bolt hole in the bottom of the end plate.

b. Lubricate the outside diameter of a roller bearing with engine oil. Note the tag previously placed on

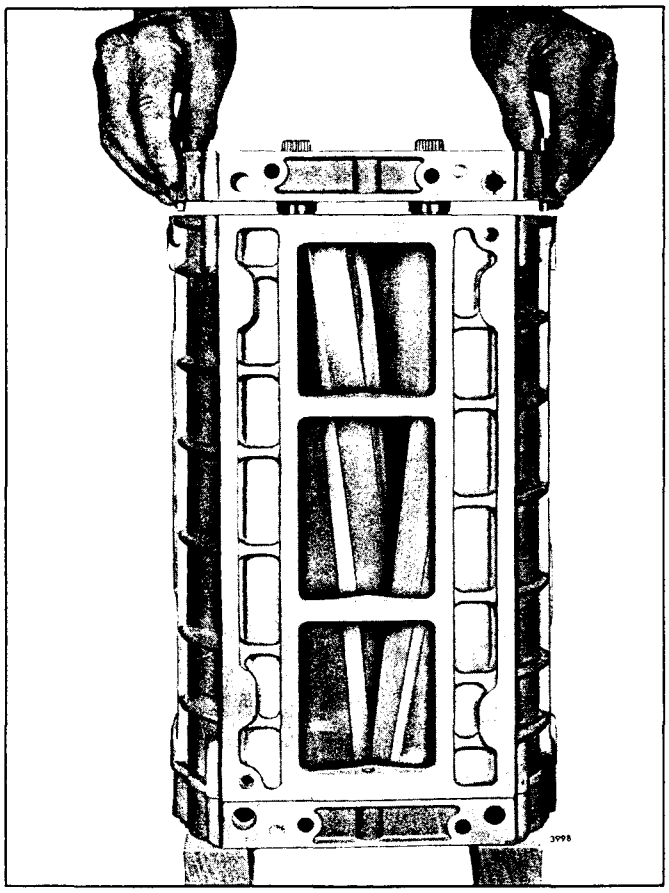


Fig. 15 - Installing Rear End Plate on Blower Rotors and Mounting

the bearing at the time of removal, then start the bearing, numbered end up, straight into the bearing bore in the end plate.

CAUTION: Be sure the bearing installed in the end plate will mate with its inner race on the rotor shaft.

c. Place the bearing installer J 21672-12 on top of the roller bearing, then press the bearing straight into and against the shoulder in the end plate.

d. Install the remaining roller bearing in the rear end plate in the same manner.

5. Install the blower rotors in the front end plate.

The rotors must be assembled in the blower housing with the omitted serrations in the rotor shafts aligned as shown in Fig. 20.

The front end plate should be attached to the front end of the blower housing first. The rear end plate is attached to the blower housing after the rotors are in place. The front end plate does not incorporate the bolt guide sleeve in the counterbored bolt hole in the bottom of the end plate. Install the blower rotors in the front end plate as follows:

a. Check the dowel pins. The dowel pins must project .380 " from the flat inner face of the front end plate to assure proper alignment of the end plate with the housing.

b. Hold the right-hand helix rotor in a vertical position, gear end up, with the omitted serration in the splines of the shaft facing to the right as shown in Fig. 20. Then start the end of the shaft straight into the oil seal in the right-hand shaft opening in the end plate as shown in Fig. 14 and lower it until the lobes of the rotor contact the end plate.

c. Position the left-hand helix rotor so the lobes of the rotors are in mesh and the omitted serration in the splines of the rotor shaft is facing in the same direction as the omitted serration in the right-hand helix rotor shaft. Then start the end of the shaft straight into the oil seal in the left-hand shaft opening in the end plate and lower it until the lobes contact the end plate.

6. Position the blower housing over the rotors, rear end of housing up, with the bottom of the housing facing toward the bottom of the end plate (Fig. 15). Lower the housing over the rotors and start it straight on the dowel pins in the front end plate, then push it down tight against the end plate. If necessary, tap the housing lightly with a plastic hammer.

NOTE: The blower housing is marked **REAR** near the top on the outside face of the housing and must be at the gear end of the rotors when assembled to the front end plate.

7. Install the blower rear end plate on the rotor shafts and housing as follows:

a. Check the dowel pins. The dowel pins must project .380 " from the flat inner face of the rear end plate to assure proper alignment of the end plate with the housing.

b. Lubricate the inside diameter of the roller bearings with engine oil.

c. Position the rear end plate over the top of the rotor shafts with the inner face of the end plate facing the rotors and the **TOP** side of the end plate facing the top side of the blower housing.

d. Lower the end plate straight over the rotor shafts until the dowel pins in the end plate contact the blower housing (Fig. 15), then carefully work the dowel pins into the dowel pin holes in the housing

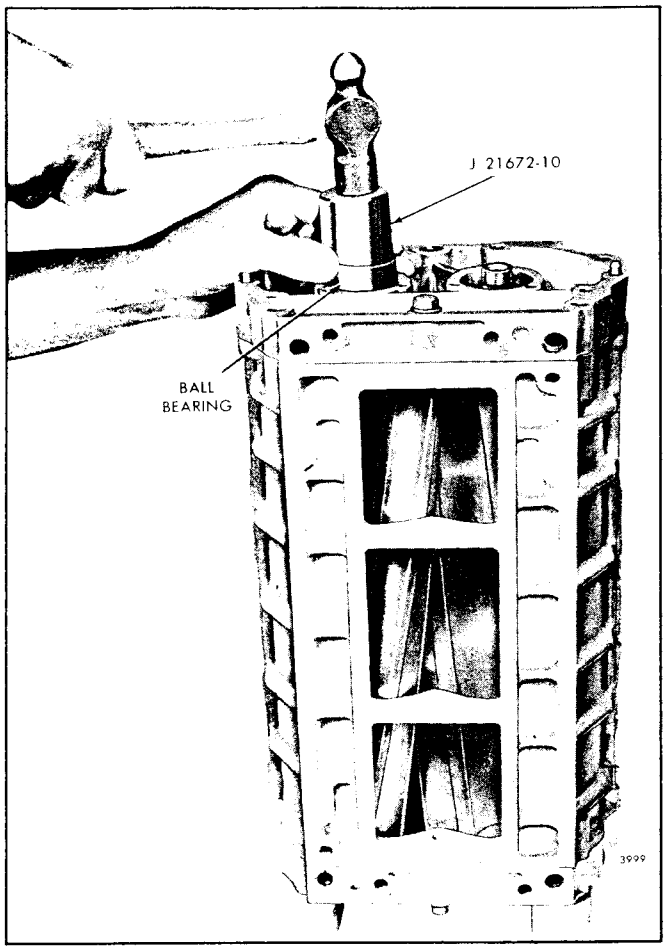


Fig. 16 - Installing Ball Bearings on Rotor Shafts and in Front End Plate (Former Blower)

and push the end plate tight against the housing. If necessary, tap the end plate lightly with a plastic hammer.

e. Install the 3/8"-16 socket head bolt in the counterbored bolt hole at the top of the end plate. Then install a 3/8"-16 hex head bolt with a flat washer in the center bolt hole at the bottom of the end plate.

f. Place the bearing retainers on top of the bearings and the end plate, then install the retainer bolts. Tighten the bolts to 7-9 lb-ft torque.

8. Reverse the blower housing, rotors and end plates on the wood blocks.

9. Install a 3/8"-16 socket head bolt in the counterbored bolt hole at the top of the end plate. Then install a 3/8"-16 hex head bolt with a flat washer in the center bolt hole at the bottom of the end plate.

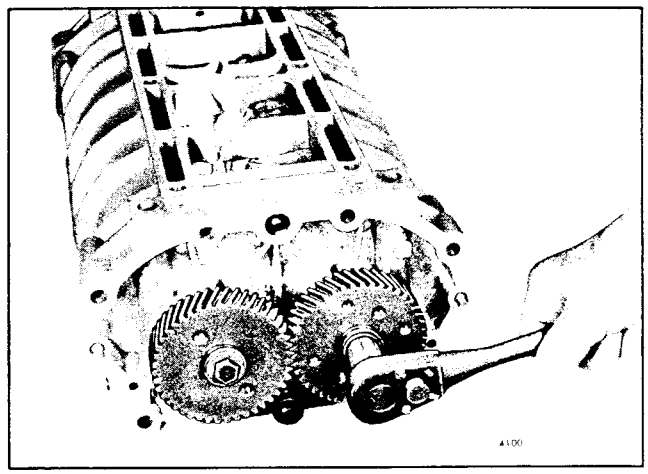


Fig. 17 - Installing Blower Rotor Gears

10. Install the ball bearings on the blower rotor shafts and in the front end plate as follows:

a. Lubricate one of the ball bearings with light engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

b. Place installer J 21672-10 on top of the bearing and tap the bearing straight on the shaft and into the front end plate as shown in Fig. 16.

c. Install the second ball bearing on the remaining rotor shaft in the same manner.

d. Place the bearing retainers on top of the bearings and the end plate, then install the retainer bolts. Tighten the bolts to 7-9 lb-ft torque.

11. Place the blower assembly on a bench and make a preliminary check of the rotor-to-end plate and rotor-to-housing clearances at this time with a feeler gage as shown in Fig. 21. Refer to Fig. 19 for minimum blower clearances.

12. Install the blower rotor gears on the rotor shafts as follows:

a. Place the blower assembly on the bench, with the top of the housing up and the rear end (serrated end of rotor shafts) of the blower facing the outside of the bench.

b. Rotate the rotors to bring the omitted serrations on the shafts in alignment and facing to the right (Fig. 20).

c. Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

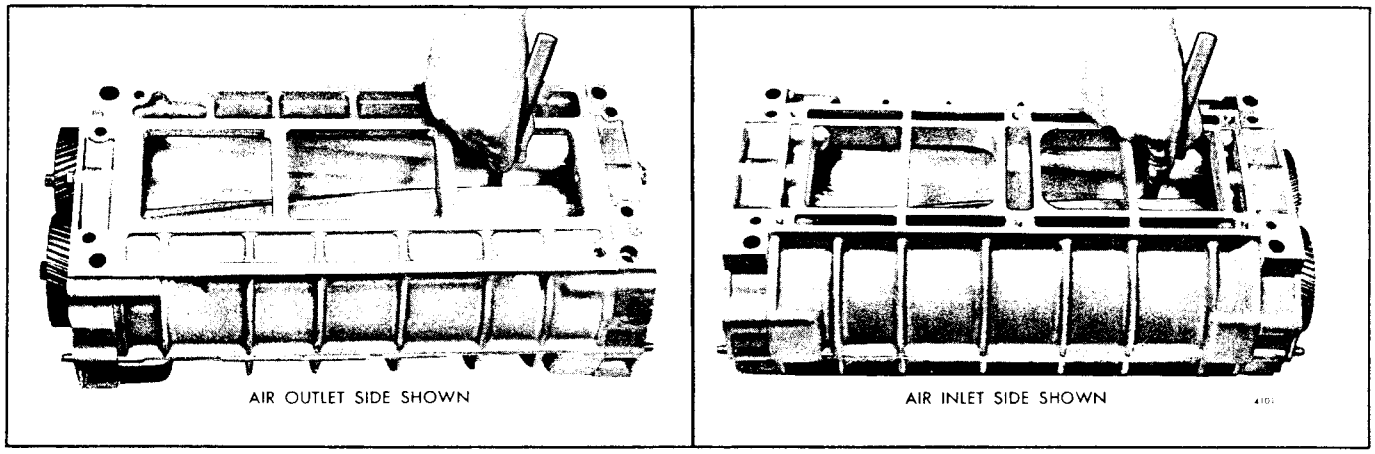
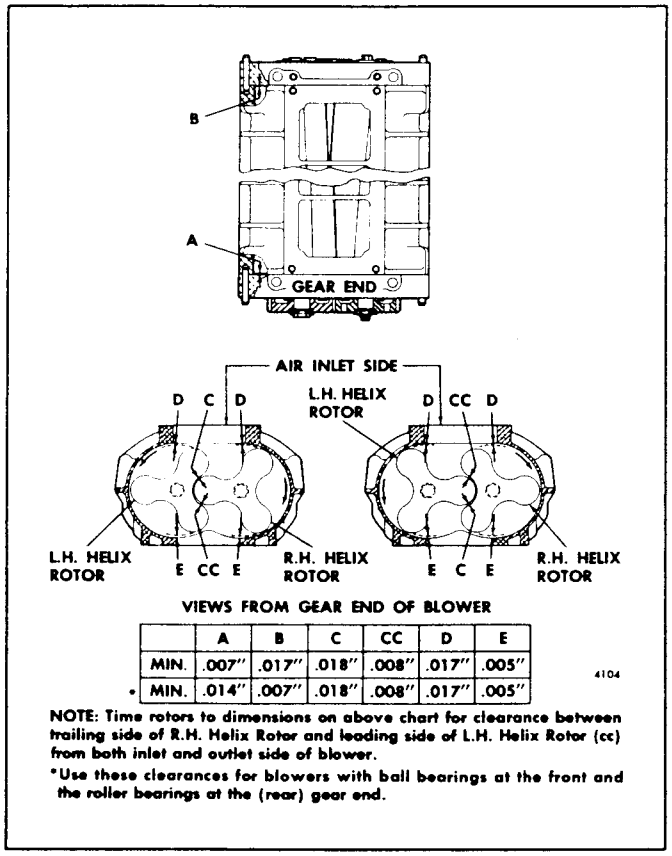


Fig. 18 - Measuring Clearance Between Blower Rotor Lobes

d. Lubricate the serrations of the rotor shafts with light engine oil.

e. Place the teeth of the rotor gears in mesh so that the omitted serrations inside the gears are in alignment and facing the same direction as the serrations on the shafts.



	A	B	C	CC	D	E
MIN.	.007"	.017"	.018"	.008"	.017"	.005"
• MIN.	.014"	.007"	.018"	.008"	.017"	.005"

NOTE: Time rotors to dimensions on above chart for clearance between trailing side of R.H. Helix Rotor and leading side of L.H. Helix Rotor (cc) from both inlet and outlet side of blower.

•Use these clearances for blowers with ball bearings at the front and the roller bearings at the (rear) gear end.

• Fig. 19 - Chart of Minimum Blower Clearances

NOTE: A center punch mark placed in the end of each rotor shaft at the omitted serrations will assist in aligning the gears on the shafts.

f. Start the left-hand helix gear on the right-hand helix rotor and the right-hand helix gear on the left- hand helix rotor, with the omitted serrations in the rotor gears in line with the omitted serrations on the rotor shafts.

g. Place the rotor gear pilots (43) on two 3/8 "-24 x 2-3/4 " bolts, then thread a bolt into the end of each rotor shaft. Place a clean shop towel between the rotors and one between the rotor and the housing (Fig. 17) to prevent the gears from turning. Then draw the gears approximately halfway on the rotor shafts.

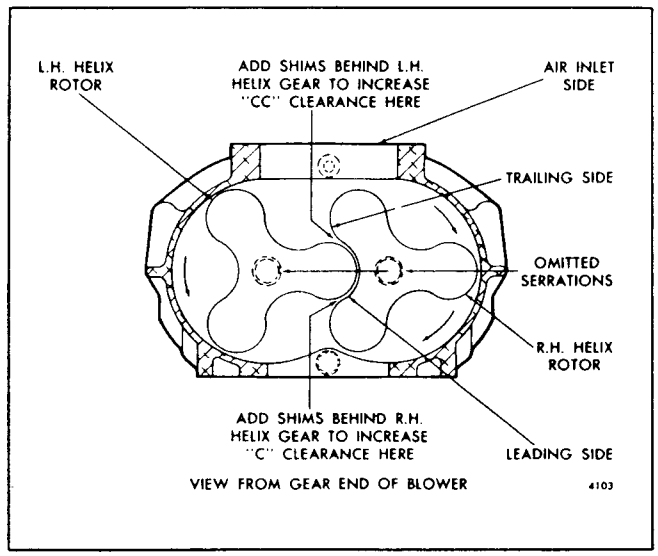


Fig. 20 - Diagram Showing Proper Location of Shims for Correct Rotor Lobe Clearances

TROUBLE SHOOTING

TURBOCHARGER

CONDITION	PROBABLE CAUSE	SUGGESTED REMEDY
NOISY OPERATION OR VIBRATION	WHEEL SHAFT BEARINGS ARE NOT BEING LUBRICATED	Supply required oil pressure. Clean or replace oil line. If trouble persists, overhaul turbocharger.
	IMPROPER CLEARANCE BETWEEN TURBINE WHEEL AND HOUSING	Remove, disassemble, and inspect turbocharger.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
ENGINE WILL NOT DELIVER RATED POWER	CLOGGED AIR INTAKE SYSTEM	Check air cleaner and clean air intake ducts.
	FOREIGN MATERIAL LODGED IN COMPRESSOR OR TURBINE WHEELS	Remove, disassemble and clean turbocharger.
	EXCESSIVE DIRT BUILD-UP IN COMPRESSOR	Thoroughly clean compressor assembly. Clean air cleaner and check for leaks.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
	ROTATING ASSEMBLY BEARING SEIZURE	Remove and overhaul turbocharger.

SPECIFICATIONS

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts.

ENGINE PART (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Blower			
Backlash--rotor gears (all)	.0005 "	.0025 "	.0035 "
Backlash between upper rotor and camshaft or balance shaft gear (2,3-53)	.0030 "	.0070 "	
Backlash between blower drive gear and camshaft gear	.0030 "	.0070 "	
Oil seal (below end plate surface) (8V)	flush	.0100 "	
Oil strainer (below end plate surface) (8V)	flush	.0150 "	
Pin--dowel (projection beyond inside face of front or rear end plate) (8V)	.3800 "		
Clearances:			
Thrust plate and thrust washer (in-line, 6V)	.0010 "	.0030 "	
Rotor to air outlet side of housing:			
In-line and 6V	.0040 "		
8V	.0050 "		
Rotor to air inlet side of housing:			
In-line	.0075 "		
6V	.0100 "		
8V	.0170 "		
Rotor to front end plate:			
In-line	.0060 "		
6V	.0080 "		
+8V (former)	.0070 "		
†8V (current)	.0170 "		
Rotor to rear (gear) end plate:			
2-53	.0060 "		
3-53	.0080 "		
4-53	.0090 "		
6V	.0120 "		
+8V (former)	.0140 "		
†8V (current)	.0070 "		
Trailing edge of R.H. helix rotor to leading edge of L.H. helix rotor (8V)	.0080 "		
Leading edge of R.H. helix rotor to trailing edge of L.H. helix rotor (8V)	.0180 "		
Turbocharger (TE0675)			
Rotating shaft axial end play	.0040 "	.0070 "	
Rotating shaft radial movement	.0030 "	.0070 "	
Turbine wheel rotor shaft journal bearing:			
Inside diameter	.6268 "	.6272 "	
Outside diameter	.9780 "	.9785 "	
Turbine wheel shaft journal diameter	.6251 "	.6254 "	
Bearing bore diameter in center housing	.9827 "	.9832 "	

+ This clearance applies to former blowers with the ball bearings in the front end plate and roller bearings in the rear end plate.

†This clearance applies to current blowers with the roller bearings in the front end plate and ball bearings in the rear end plate.

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	TORQUE (lb-ft)	THREAD SIZE	TORQUE (lb-ft)
1/4 -20	7-9	9/16-12	90-100
1/4 -28	8-10	9/16-18	107-117
5/16-18	13-17	5/8 -11	137-147
5/16-24	15-19	5/8 -18	168-178
3/8 -16	30-35	3/4 -10	240-250
3/8 -24	35-39	3/4 -16	290-300
7/16-14	46-50	7/8 - 9	410-420
7/16-20	57-61	7/8 -14	475-485
1/2 -13	71-75	1 - 8	580-590
1/2 -20	83-93	1 -14	685-695

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)
Blower drive coupling to rotor gear bolt (in-line and 6V)	1/4 "-28	14-18
Blower drive gear pilot bolt (in-line and 6V)	5/16 "-24	25-30
Blower timing gear-to-rotor shaft bolts (in-line and 6V)	5/16 "-24	25-30
Blower thrust washer retaining bolt (in-line and 6V)	5/16 "-24	25-30
Front end plate cover bolts (4-53 and 6V-53)	3/8 " -16	20-25
Air inlet adaptor-to-blower bolts	3/8 " -16	16-20
Air inlet housing-to-adaptor or blower housing bolts	3/8 " -16	16-20
Governor-to-blower front end plate bolts	3/8 " -16	20-24
Blower drive support-to-blower rear end plate bolts	3/8 " -16	20-24
Flywheel housing-to-blower drive support bolts	3/8 " -16	20-24
Blower drive gear cover bolt	3/8 " -16	20-24
Blower-to-engine rear end plate and flywheel housing bolts (2-53 and 3-53)	3/8 " -16	20-25
	3/8 " -24	20-25
Blower thrust washer retaining bolt (in-line and 6V)	3/8 " -24	54-59
Blower timing gear-to-rotor shaft bolts (8V)	3/8 " -24	50-55
Rotor shaft ball bearing retaining bolt (8V)	3/8 " -24	50-55
Blower end plate-to-block bolts	7/16 "-14	55-60
Rotor shaft ball bearing retaining nut (8V)	.781 "-32	60-65

SERVICE TOOLS

TOOL NAME	TOOL NO.
BLOWER	
Blower clearance feeler gage set	J 1698-02
Universal puller (4-53 and 6V-53)	J 4794-01
Blower drive cam installer	J 5209
Gear puller (2 and 3-53)	J 5825-01
Handle	J 7079-2
Blower end plate counterbore set:	J 9533
Fixture	J 9533-1
Cutting tool - holder	J 9533-2
Cutting tool - roughing	J 9533-3
Cutting tool - finishing	J 9533-4
Blower service tool set:	J 21672
Gear pullers	J 21672-7
Rotor shaft ball bearing installer	J 21672-10
Oil seal and bearing remover	J 21672-11
Oil seal and roller bearing installer	J 21672-12
Oil seal sleeve and roller bearing inner race installer	J 21672-16
Spanner wrench	J 21672-17
Oil seal sleeve and roller bearing inner race remover	J 21672-20
Oil seal installer	J 22576
Oil seal sleeve installer (in-line and 6V)	J 23679-1
Oil seal sleeve remover (in-line and 6V)	J 23679-2
TURBOCHARGER	
Magnetic base indicator set	J 7872
Magnetic clamp	J 7872-2
Swivel adaptor	J 7872-3
Dial indicator	J 8001-3

h. Remove the two bolts and pilots that were used to draw the rotor gears half-way on the rotor shafts.

i. Lubricate the threads of the rotor gear retaining bolts with engine oil.

j. Place a pilot on each rotor gear retaining bolt with the counterbored side facing away from the bolt head.

k. Thread the hex head bolt in the left-hand helix rotor shaft and the twelve point head bolt in the right- hand helix rotor shaft and draw the rotor gears into position tight against the shims and the bearing inner races as shown in Fig. 17. Tighten the bolts to 50-55 lb-ft torque.

l. Check the back lash between the rotor gears. The backlash should be .0005 " to .0025 " with new gears. Replace the gears if the backlash exceeds .0035 ".

13. Install the 3/8 "-24 x 2 " bolt with special flat washers in the right-hand helix rotor shaft at the front end of the blower. Tighten the bolt to 50-55 lb-ft torque.

14. Place the bearing retainer nut lock washer over the end of the left-hand rotor shaft with the tang in the inner diameter of the washer in the notch in the shaft. Then thread the bearing lock nut on the shaft. Tighten the lock nut to 50-60 lb-ft torque with spanner wrench J 21672-17.

15. Bend the tang of the lock washer over the notch of the bearing retainer nut.

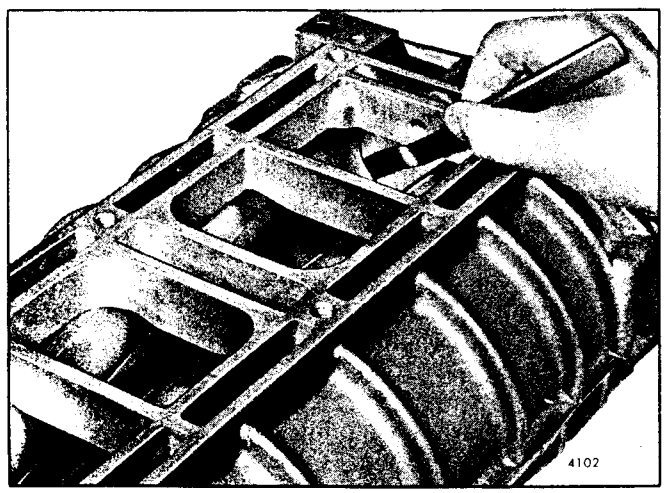


Fig. 21 - Measuring End Clearance Between Blower Rotors and End Plate

Timing Blower Rotors

After the blower rotors and rotor gears are installed, the blower rotors must be timed.

1. The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

2. If the left-hand helix gear is moved out, the right-hand helix rotor will turn clockwise when viewed from the gear end. If the right-hand helix gear is moved out, the left-hand helix rotor will turn counterclockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

3. Moving the gears *out* or *in* on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

4. The clearance between the rotor lobes may be checked with 1/2 " wide feeler gages in the manner shown in Fig. 18. When measuring clearances of more than .005 ", laminated feeler gages that are made up of .002 ", .003 " or .005 " feeler stock are more practical and suitable than a single feeler gage. Clearances should be measured from both the inlet and outlet sides of the blower.

5. A specially designed feeler gage set J 1698-02 for the blower clearance operation is available. Time the rotors as follows:

a. Time the rotors to pass an .008 " feeler gage at the closest point between the *trailing* edge of the right-hand helix rotor and the *leading* edge of the left-hand helix rotor ("CC" clearance) measured from both the inlet and outlet sides as shown in Figs. 18 and 21.

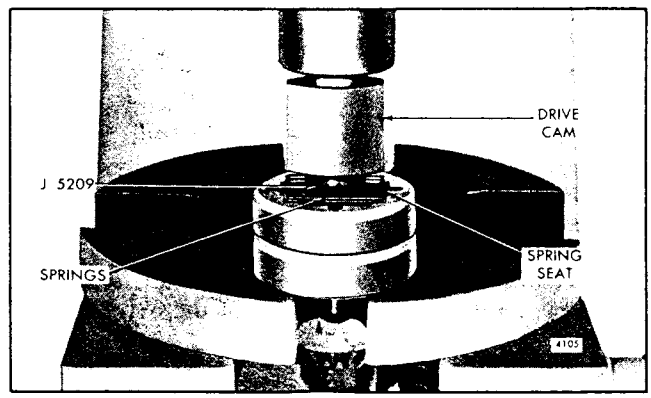


Fig. 22 - Inserting Blower Drive Cam in Springs

b. Then check the clearance between the *leading* edge of the right-hand helix rotor and the *trailing* edge of the left-hand helix rotor ("C" clearance) for the minimum clearance of .018 ". Rotor-to-rotor measurements should be taken 1 " from each end and at the center of the blower.

6. After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear as shown in Fig. 20 to produce the desired result. When more or less shims are required, both gears must be removed from the rotors. Placing a .003 " shim in back of a rotor gear will revolve the rotor .001 ".

7. Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

8. Determine the minimum clearances at points "A" and "B" shown in Fig. 19. Insert the feeler gages, as shown in Fig. 21, between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making 12 measurements in all. Refer to Fig. 19 for the minimum clearances.

9. Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side -- 12 measurements in all. Refer to Fig. 19 for the minimum clearances.

Attach Accessories to Blower

On the former blowers, the drive hub is attached to the left-hand helix gear with four bolts. On the current blowers, a new drive hub is used with three bolt holes and utilizing two steel plates. The plates are bolted between the left-hand helix rotor drive gear and the drive hub to provide a flexible drive connection. On former blowers, the right-hand helix rotor gear is separately interchangeable, but the current drive hub and attaching parts must be included to replace the left-hand helix rotor gear.

1. On the former blower, attach the blower drive hub to the left-hand helix rotor gear with four bolts. On the current blower, bolt two steel plates between the left-hand helix rotor drive gear and the drive hub. Tighten the bolts to 15-19 lb-ft torque.

2. If removed, install the blower drive hub oil seal in the groove in the outside diameter of the drive hub.

3. Attach the blower drive support assembly to the blower assembly as follows:

a. Affix a new gasket to the blower rear end plate. Then place the blower drive support assembly over the two dowel pins in the rear end plate and against the gasket.

b. Attach the blower drive support assembly to the rear end plate with six bolts, lock washers, plain washers and one socket head bolt. Tighten the bolts to 20-24 lb-ft torque.

4. Attach the governor assembly to the blower assembly as follows:

a. Affix a new gasket to the blower front end plate.

b. Position the governor assembly in front of the blower, then start the weight shaft straight into the end of the rotor shaft. If necessary, rotate the weight shaft or rotor shaft to align the splines. Now push the governor assembly on the dowel pins in the end plate and against the gasket.

c. Attach the governor to the front end plate with seven bolts and copper washers (two bolts inside and five outside). Tighten the bolts to 20-24 lb-ft torque.

Install Blower

1. Affix a new governor housing gasket (83), Fig. 10, to the cylinder block.

2. Affix a new blower drive support housing gasket (84) to the cylinder block. Also affix a new gasket to the cylinder block rear end plate.

NOTE: Use Scotch Grip Rubber adhesive No. 4300, or equivalent, on the governor housing and blower drive support housing gaskets to prevent them from slipping when the blower assembly is lowered into position.

3. Place the blower housing-to-cylinder block seal ring in the groove in the top of the cylinder block.

4. If removed, place a fuel rod cover tube hose and clamp on each fuel rod cover tube at the side of each cylinder head.

5. Thread eyebolts in two diagonally opposite tapped holes in the top of the blower housing. Then attach a rope sling and a chain hoist to the eyebolts as shown in Fig. 4.

6. Lift the blower assembly at a slight angle and position it over the top of the cylinder block. Then lower the assembly on the cylinder block and mesh the blower drive gear with the camshaft gear.

7. Install two 7/16 "-14 x 7-1/2 " bolts and special

washers in each blower end plate. Tighten the bolts to 60-65 lb-ft torque.

8. Install the two 7/16 "-14 x 7/8 " governor housing-to-cylinder block bolts and copper washers. Tighten the bolts to 46-50 lb-ft torque.

9. Install the five blower drive support housing-to-engine end plate bolts, lock washers and one plain washer. Tighten the bolts to 20-24 lb-ft torque.

10. If disassembled, install the springs and blower drive cam in the two blower drive coupling supports as follows:

a. Place the drive spring supports on a bench. Then place the drive spring seats inside the support.

b. Lubricate the springs with engine oil. Then place the spring packs, consisting of 15 leaves per pack, in between the spring seats as shown in Fig. 22.

c. Place the second drive spring support on top of the first drive spring support, then install the spring seats and spring packs in the second support as outlined in Steps "a" and "b" above.

d. Place the two drive spring supports, with springs, over a small opening in the bed of an arbor press so the spring seats and the ends of the spring packs will rest on the bed of the arbor press.

e. Place the blower drive cam, the protruding end of the cam down, over the end of the installer J 5209. Insert the tapered end of the installer in between the spring packs and under the ram of the press, then press the cam into place between the spring packs as shown in Fig. 22. Catch the installer by hand after it passes through the spring packs.

11. Attach the blower drive coupling supports to the blower drive gear as follows:

a. Insert the blower drive coupling supports through the opening in the rear face of the flywheel housing, with the protruding end of the drive cam facing the drive shaft (Fig. 1).

b. Align the bolt holes in the supports with the holes in the blower drive gear, then thread two bolts with flat washers in two diametrically opposite holes, finger tight only. Install the two remaining bolts finger tight only.

c. Insert the blower drive shaft, flat end first, through the blower drive cam and into the blower drive hub. Then tighten the two bolts with the flat washers to 8 - 10 lb-ft torque.

d. Check the blower drive shaft for alignment and freeness by sliding the shaft in and out of the splines in the drive hub and cam. If the drive shaft binds, loosen the two bolts with flat washers and move the blower drive support coupling slightly and retighten the bolts.

e. Remove the two bolts without the flat washers. Place the blower drive shaft retainer against the end of the blower drive support, then install the two bolts and tighten them to 8-10 lb-ft torque.

12. Affix a new gasket to the blower drive gear hole cover, then place the cover in position against the flywheel housing and install the five bolts and lock washers. Tighten the 5/16 "-18 bolts to 13-17 lb-ft torque and the 3/8 "-16 bolt to 20-24 lb-ft torque.

13. Slide the fuel rod cover tube hoses up on the cover tubes in the governor housing and tighten the hose clamps.

14. Install the governor fuel rods and connect them to the governor and injector rack control levers.

15. Place the governor cover on the governor housing and secure it in place with eight screws and lock washers.

16. Connect the fuel oil supply line to the fuel oil pump and the fuel oil filter.

17. Connect the fuel oil supply and return lines to the fuel manifold fittings in the cylinder heads.

18. Place the water by-pass tube with seal rings and flanges in between the two thermostat housings and secure it in place with four bolts and lock washers. Tighten the bolts to 7-9 lb-ft torque.

19. Connect the blower housing breather tube and hose to the breather housing with a hose clamp, then attach the tube clamp at the lower end of the tube to one of the water pump attaching bolts.

20. Attach the air compressor (if used) to the engine flywheel housing as follows:

a. Affix a new gasket to the bolting flange of the air compressor.

b. Install the air compressor drive coupling in the drive plate attached to the rear face of the camshaft gear.

c. Place the air compressor in position at the rear of the flywheel housing and guide the teeth on the drive coupling into the teeth in the drive plate on the air compressor, then push the air compressor against the flywheel housing. If necessary, rotate

the crankshaft to align the teeth of the drive coupling and the drive plate.

d. Install the four bolts and lock washers and tighten them to 71-75 lb-ft torque.

e. Connect the water inlet and outlet tubes to the air compressor. Then connect the oil supply line to the air compressor and the cylinder block.

21. If removed, attach the battery-charging generator mounting bracket to the top of the governor housing with four bolts and lock washers. Tighten the bolts to 30-35 lb-ft torque.

22. Attach the battery-charging generator to the mounting bracket. Install the generator drive belts, then tighten the generator mounting bolts and adjust the drive belt tension.

23. Use new gaskets and install a valve rocker cover on each cylinder head.

24. Attach a valve rocker cover breather tube to each rocker cover with a hose clamp, then secure the breather tube clamp at the lower end of each tube to the flywheel housing.

25. Place the blower screen and gasket assembly in position on top of the blower, with the screen side of the assembly toward the blower. Then place the air inlet adaptor on the blower screen. Install the six bolts and lock washers and tighten them to 16-20 lb-ft torque.

26. Affix a new gasket to the top of the air inlet adaptor, then place the air shut-down housing on top of the gasket. Install the six bolts and lock washers and tighten them to 16-20 lb-ft torque.

27. Connect the throttle control rods to the governor levers.

28. Attach any other accessories that were removed from the engine.

29. Adjust the governor and injector rack control levers as outlined in Section 14. Check for and repair any coolant or oil leaks detected when performing the tune-up.

TURBOCHARGER (Airesearch)

The TE0675 turbocharger (Figs. 1 and 2) is designed to increase engine efficiency and power output. Power to drive the turbocharger is extracted from the waste energy in the engine exhaust gas.

The turbocharger consists of a turbine wheel and shaft, a compressor wheel, a center housing which serves to support the rotating assembly, bearings, seals, a turbine housing and a compressor housing.

The turbine wheel is located in the turbine housing and is mounted on one end of the turbine shaft. The compressor wheel is located in the compressor housing and is mounted on the opposite end of the turbine wheel shaft to form an integral rotating assembly.

The rotating assembly consists of the turbine wheel and shaft assembly, thrust ring, thrust spacer, compressor wheel and wheel retaining nut. The rotating assembly is supported on two pressure lubricated bearings which are retained in the center housing by retaining rings. Internal oil passages are drilled in the center housing to provide lubrication to the turbine wheel shaft bearings and thrust bearing, thrust ring and thrust spacer.

The oil is sealed off from the compressor and the turbine by seal arrangements at both ends of the center housing. Oil drains from the center housing by gravity.

The turbine housing is a heat resistant alloy casting which encloses the turbine wheel and provides a flanged engine exhaust gas inlet and an axially-located turbocharger exhaust gas outlet. The turbine housing is bolted to the turbine end of the center housing, thus providing a compact and vibration free assembly.

The compressor housing which encloses the compressor wheel provides an ambient air inlet and a compressed air discharge outlet. The compressor housing is bolted to the compressor end of the center housing.

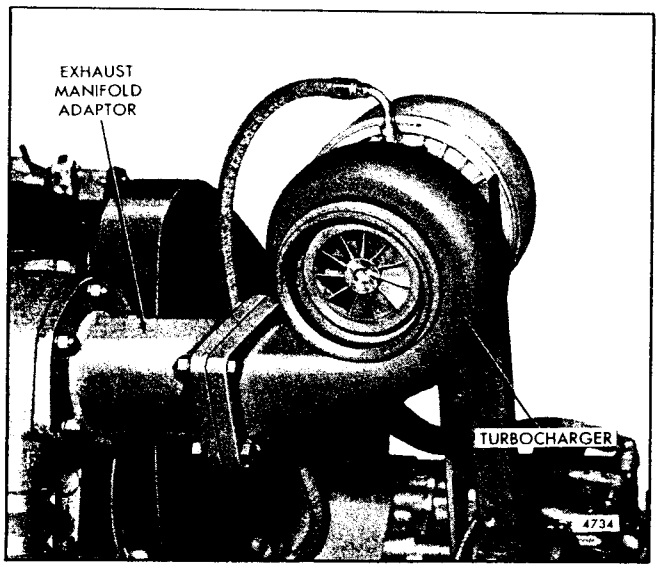


Fig. 1 - Turbocharger Mounting

Operation

The turbocharger is mounted on the exhaust outlet flange of the engine exhaust manifold. After the engine is started, the exhaust gases flowing from the engine and through the turbine housing cause the turbine wheel and shaft to rotate (Fig. 3). The gases are discharged into the atmosphere after passing through the turbine housing.

The compressor wheel, which is mounted on the opposite end of the turbine wheel shaft, rotates with the turbine wheel. The compressor wheel draws the ambient air into the compressor housing, compresses the air and delivers it to the engine blower.

During operation, the turbocharger responds to the engine load demands by reacting to the flow of the engine exhaust gases. As the power output of the engine increases, the flow of exhaust gases increases and the speed and output of the rotating assembly increases proportionately, delivering more air to the engine blower.

Certain engines are equipped with an intercooler to

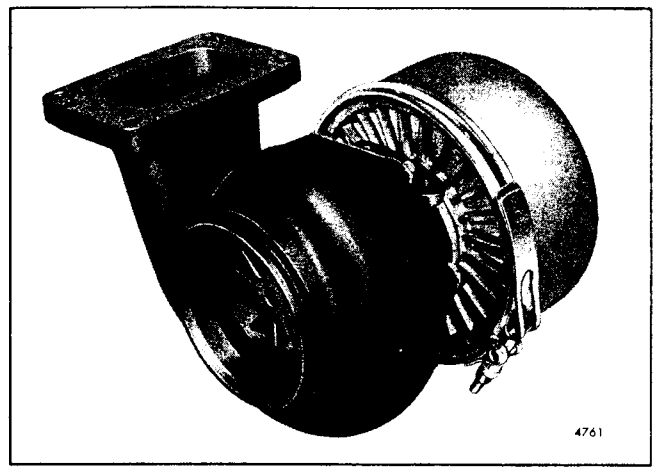


Fig. 2 - Turbocharger Assembly

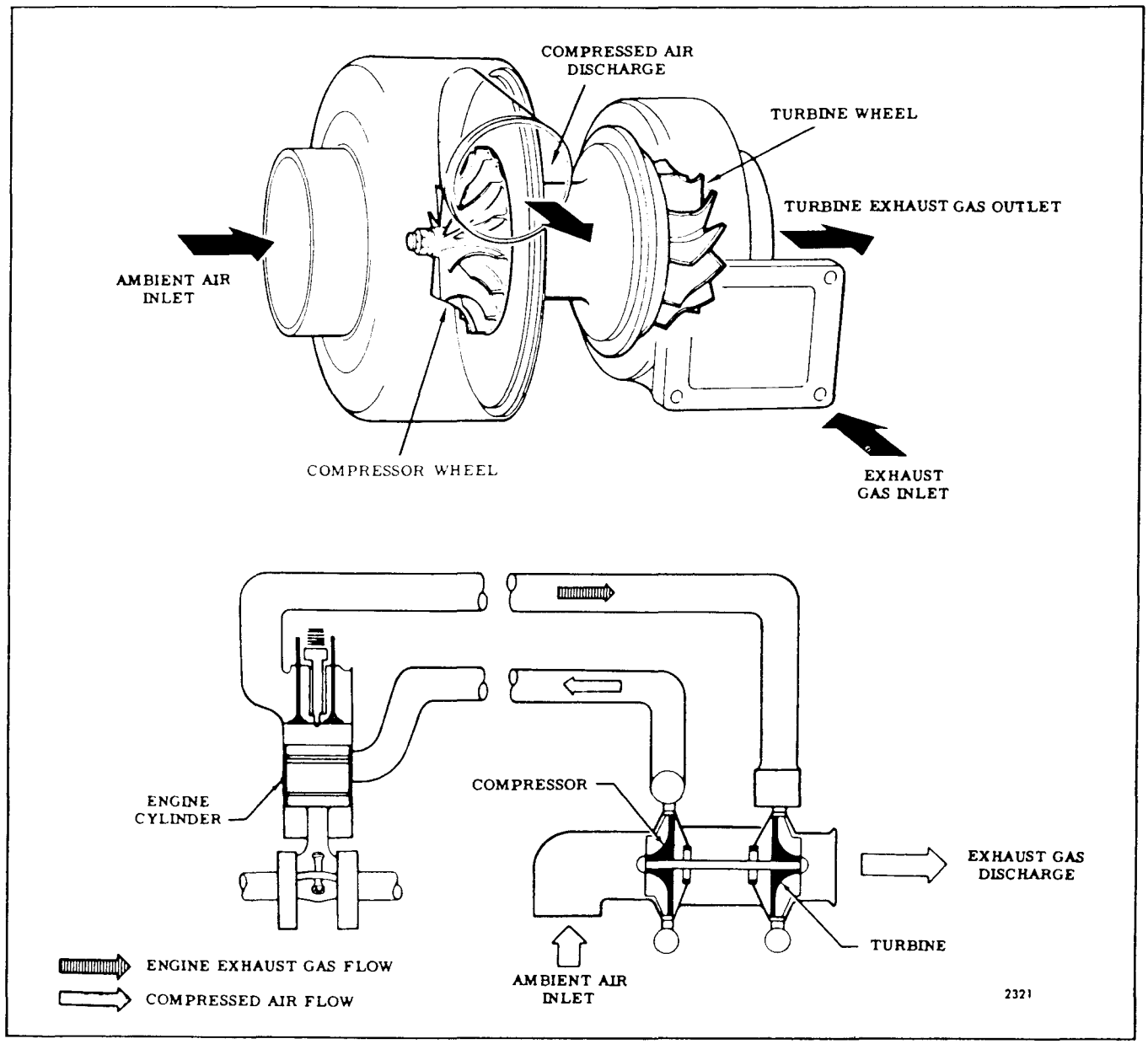


Fig. 3 - Schematic Flow Diagram

reduce the temperature of the discharge air from the turbocharger before it enters the engine blower (Section 3.5.2).

Lubrication

Lubricating oil for the turbocharger is supplied under pressure through an external oil line extending from the engine cylinder block to the top of the center housing. From the oil inlet in the center housing, the oil flows through the drilled oil passages in the housing to the shaft bearings, thrust ring, thrust bearing and thrust plate. The oil returns by gravity to the engine oil pan through an external oil line extending from the bottom of the turbocharger center housing to the side of the cylinder block.

Minimum oil flow to the turbocharger with the engine at idle is achieved at 10 psi with an oil temperature of 200 °F.

Before the initial engine start, when a new or overhauled turbocharger is installed, the turbocharger must be pre-lubricated as outlined under *Install Turbocharger*.

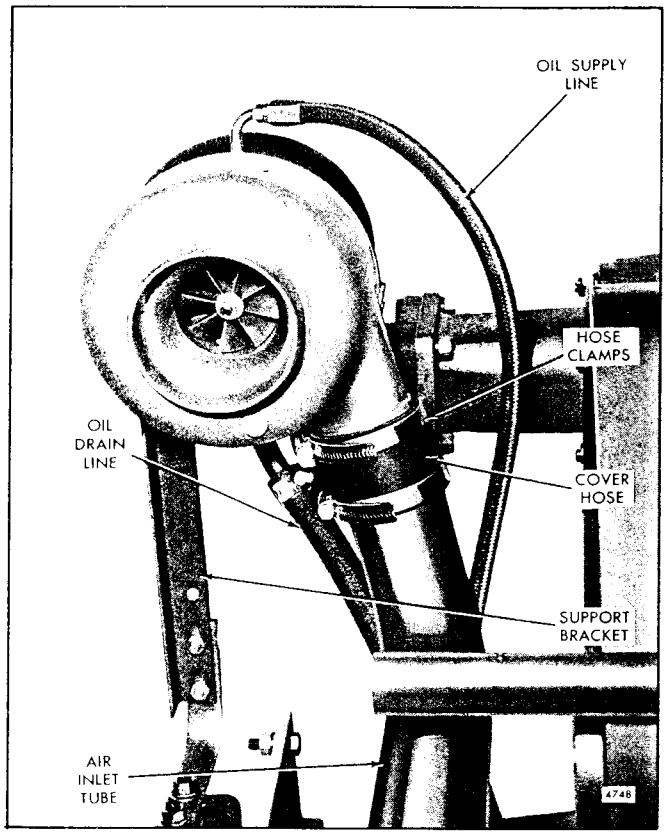


Fig. 4 - Turbocharger Support Bracket, Oil Lines and Air Inlet Tube

Periodic Inspection

A periodic inspection of the turbocharger should be made along with periodic engine inspection.

1. Inspect the oil inlet and oil return lines to make certain all of the connections are tight and the lines are not dented, restricting the flow of oil to and from the center housing.

> **CAUTION:** Be sure the oil lines are filled with oil. Refer to *Install Turbocharger.*

2. Inspect all of the air ducting and connections for leaks. Make the inspection both with the engine running and shut down. Check for leaks at the manifold connection, the turbine inlet and the exhaust manifold gasket.

> **CAUTION:** Do not operate the turbocharger if leaks are found in the ducting or if the air cleaner is not filtering efficiently. Dust leaking into the air ducting can damage the turbocharger and the engine.

3. Remove the air inlet duct and compressor housing and check for dirt or dust build-up. Remove all such foreign matter and determine and correct the cause. Refer to *Troubleshooting Turbocharger* in Section 3.0. Uneven deposits left on the compressor wheel can affect the balance and cause premature bearing failure.

> **NOTE:** It is not necessary to disassemble the turbocharger center housing and rotating assembly to remove dirt and dust build-up.

4. With the compressor housing removed, push the compressor wheel toward the turbine end and turn the rotating assembly by hand. Check for binding or rubbing. Listen carefully for unusual noises. If binding or rubbing is evident, remove the turbocharger for disassembly and inspection.

Remove Turbocharger

1. Refer to Fig. 4 and remove the turbocharger support bracket.

2. Disconnect the oil supply line and the oil drain line from the turbocharger.

3. Cover the end of each oil inlet and oil outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entrance of foreign material.

4. Loosen the two hose clamps securing the cover hose to the turbocharger and the air inlet tube and slide the cover hose down over the inlet tube.

5. Remove the four bolts, nuts and lock washers securing the turbocharger to the exhaust manifold adaptor and remove the turbocharger and gasket. Refer to Fig. 1.

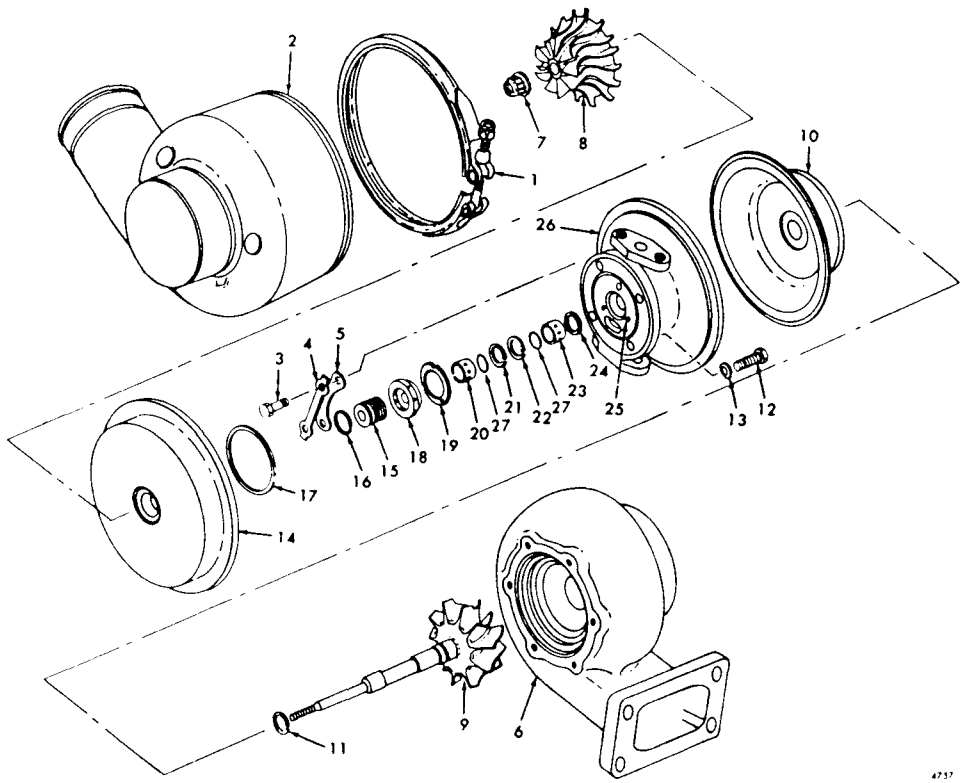
Disassemble Turbocharger

Clean the exterior of the turbocharger with a non-caustic cleaning solvent before disassembly, then proceed as follows:

> **CAUTION:** Exercise care when removing the center and turbine housings to prevent damage to the compressor or turbine wheel.

1. Loosen the "V" band coupling (1) securing the compressor housing (2) to the backplate assembly (14) and remove the compressor housings and "V" band.

2. Remove the eight bolts (3) securing the four lockplates (4) and turbine housing clamps (5) to the center housing (26) and turbine housing (6). Remove the turbine housing from the center housing.



1. Coupling--"V" Band
2. Housing--Compressor
3. Bolt
4. Lockplate
5. Clamp--Turbine Housing
6. Housing--Turbine
7. Nut--Self-Locking
8. Wheel--Compressor
9. Shaft--Turbine Wheel Assembly
10. Shroud--Turbine Wheel
11. Ring--Piston
12. Screw
13. Lockplate
14. Backplate Assembly
15. Spacer--Thrust
16. Ring--Piston
17. Ring--Seal
18. Collar--Thrust
19. Bearing--Inboard Thrust
20. Bearing
21. Ring--Retaining
22. Ring--Retaining
23. Bearing
24. Ring--Retaining
25. Pin--Groove
26. Housing--Center
27. Spacer

Fig. 5 - Turbocharger Details and Relative Location of Parts

NOTE: Tap the housing with a soft headed hammer if force is needed for removal.

3. Position the turbine wheel (9) of the center housing assembly in a suitable holding fixture (Fig. 6).

4. Remove the wheel nut (7) from the shaft.

CAUTION: To prevent the possibility of bending the turbine wheel shaft, remove the compressor wheel nut from the shaft with a double universal socket and tee handle.

5. Place the center housing and rotating assembly in a oven, furnace or hot oil bath that has been preheated to 350 °F.-375 °F. for no longer than 10 minutes.

6. Remove the compressor wheel (8) from the wheel shaft assembly (9).

7. Withdraw the wheel shaft assembly (9) and wheel shroud (10) from the center housing.

8. Remove the piston seal (11) from the wheel shaft assembly (9).

9. Remove the screws (12) and lock tabs (13) securing the backplate assembly (14) to the center housing (26) and remove the backplate assembly.

10. Remove the seal ring (17) from the groove in the center housing.

11. Remove the thrust spacer (15) and piston ring (16) from the backplate assembly.

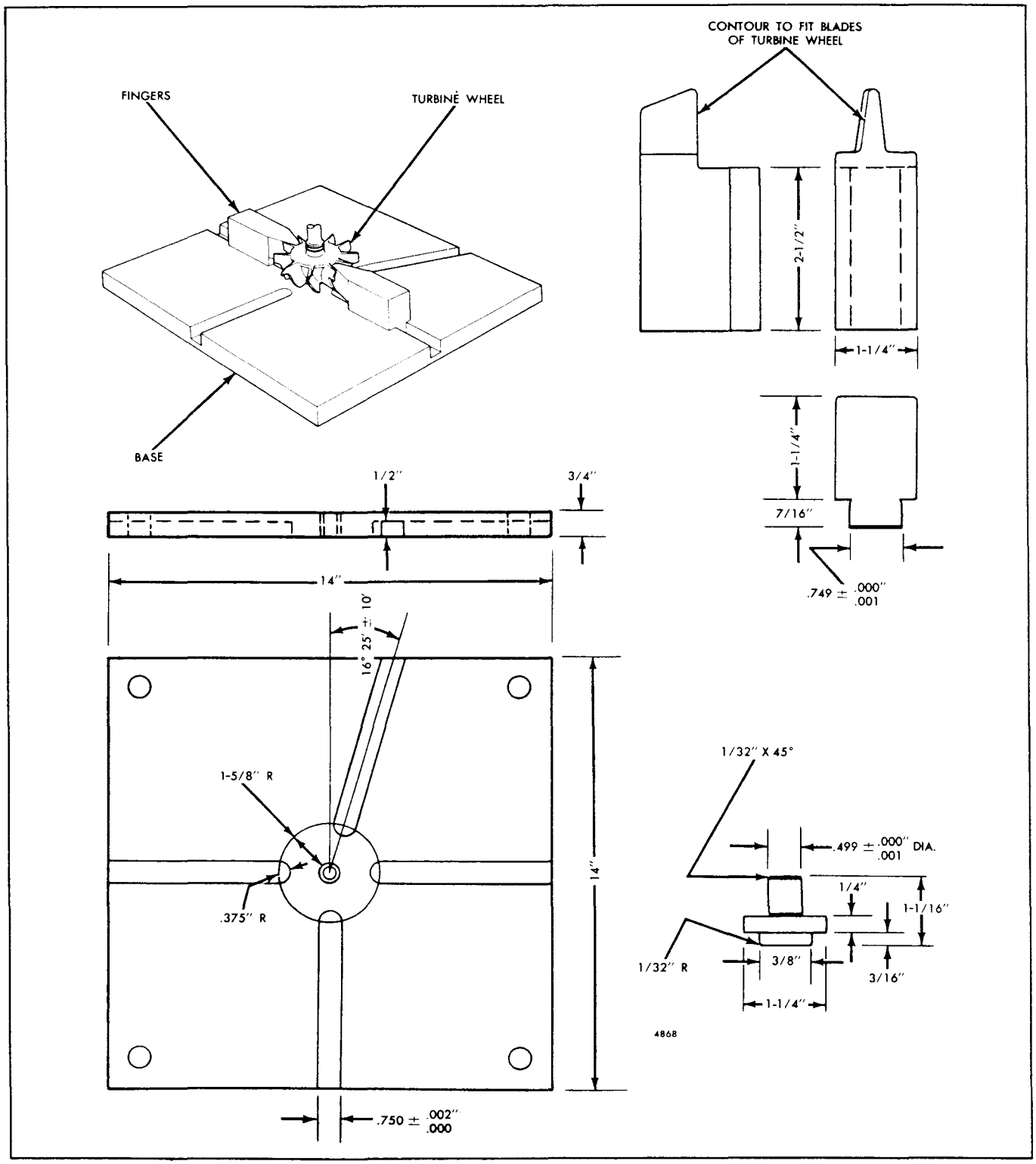


Fig. 6 - Turbocharger Holding Fixture

12. Remove the thrust collar (18), inboard thrust bearing (19), bearing (20), spacer (27) if used, and retaining ring (21) from the center housing.

13. Remove the retaining ring (22), spacer (27) if used, bearing (23) and retaining ring (24) from the center housing.

Cleaning

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

Soak all of the parts in a non-caustic cleaning solvent for about 25 minutes. After soaking, use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

Inspection

Inspect all of the parts for signs of damage, corrosion or deterioration. Check for nicked, crossed or stripped threads.

Visually check the turbine wheel for signs of rubbing. Also check the turbine wheel vanes for worn or feathered edges.

Inspect the shaft for signs of scoring, scratches or seizures with the bearings.

Check the compressor wheel for signs of rubbing or damage from foreign material. Check to see that the wheel bore is not galled. The wheel must be free of dirt and other foreign material.

Inspect the seal parts for signs of rubbing or scoring of the running faces.

Inspect the housing for contact with the rotating parts. The oil and air passages must be clean and free of obstructions.

Minor surface damage may be burnished or polished. Use a silicone carbide abrasive cloth for aluminum parts or a crocus abrasive cloth for steel parts.

Replace the bearings and thrust washer if they show signs of nicks, scores, shellac deposits or foreign material imbedment. It is recommended that when one bearing needs replacement that both rotor shaft bearings be replaced at the same time. The current bearing and spacer are serviced only as a kit.

Assemble Turbocharger

Check each part prior to installation to ensure cleanliness. As the parts are assembled, cover the openings to prevent entry of dirt or other foreign material.

Refer to Fig. 5 for parts orientation and proceed as follows:

1. Lubricate the bearings (20 and 23) with clean engine oil.

2. Install a new retaining ring (24), bearing (23), spacer (27) and new retaining ring (22) in the turbine housing end of the center housing (26).

3. Install a new retaining ring (21), spacer (27) and bearing (20) in the center housing.

4. Install a new piston ring (16) on the thrust spacer (15) and gently insert the spacer into the backplate assembly (14).

> **CAUTION:** Do not force the piston ring into place.

5. Position the inboard thrust bearing (19) against the center housing with the hole and cut-outs in the bearing in alignment with the pins (25) in the center housing.

6. Install the thrust collar (18) snugly against the thrust bearing (19). Lubricate the thrust collar and bearing with clean engine oil.

7. Install a new seal ring (17) in the groove in the backplate assembly (14).

8. Align the oil feed holes in the center housing (26) and the backplate assembly and install the backplate, using four bolts (12) and new lockplates (13). Tighten the bolts to 75-90 **lb-in** torque and bend the lockplate tangs up against the side of the bolt heads.

9. Install a new piston ring (11) on the wheel shaft assembly (9).

10. Position the wheel shroud (10) against the center housing (26) and insert the wheel shaft assembly (9) through the wheel shroud and into the center housing.

> **CAUTION:** Be careful not to scuff or scratch the bearings when installing the shaft. Do not use force to compress the piston ring into place. A gentle rocking and pushing action will allow the piston ring to seat and the shaft to bottom. A thin tool may be used as an aid in compressing the piston ring if difficulty is encountered.

11. Heat the compressor wheel in an oven or hot oil bath to 325-375 °F. for no more than 10 minutes.

12. Position the turbine wheel (9) of the center housing assembly in the holding fixture (Fig. 6).

13. Position the compressor wheel over the shaft and install the wheel retaining nut. Tighten the nut to 120 **lb-in** torque. After the compressor wheel has cooled to room temperature, remove the retaining nut.

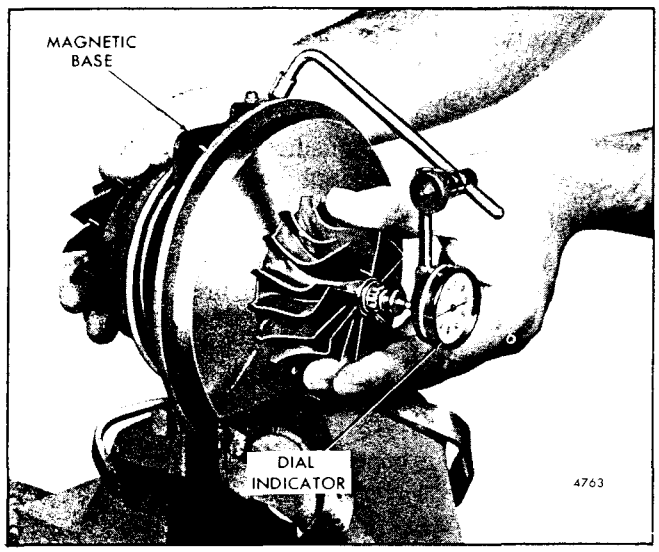


Fig. 7 - Checking Bearing Axial End Play

14. Check the face of the retaining nut and the wheel face to make sure they are smooth and clean. Lightly oil the shaft threads and washer face and reinstall the nut. Tighten the nut to 18-20 **lb-in** torque. Continue to tighten until the shaft increases in length .008 "-.009 ".

CAUTION: Tighten the retaining nut in such a manner so as not to impose a bending load on the shaft.

15. Check bearing axial end play:

a. Clamp the center housing assembly in a bench vise equipped with soft jaws as shown in Fig. 7.

b. Fasten the dial indicator and magnetic base (J 7872) to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side.

c. Move the shaft axially back and forth by hand. The total indicator reading should be between .004 " and .007 ". If the dial indicator readings do not fall within the specified limits, repair or replace the rotating assembly.

16. Position the turbine housing (6) against the center housing (26) and secure it in place with four clamps (5), four lockplates (4) and eight bolts (3). Tighten the bolts to 160-190 **lb-in** torque. Bend the lockplate tabs up against the flat on the bolt heads.

17. Position the compressor housing (2) against the center housing (26) and secure it in place with the "V" band coupling (1). Tighten the nut on the coupling to 30-45 **lb-in** torque.

18. After assembly, push the rotating assembly as far as possible from the turbine end. Then rotate the assembly and check for bind. Push the rotating assembly in the opposite direction and repeat the check.

19. Check shaft radial movement:

a. Position the magnetic base J 7872-2 with the swivel adaptor J 7872-3 on the flat surface of the turbine housing inlet flange as shown in Fig. 8.

b. Fasten the extension rod J 22758 to the dial indicator J 8001-3 and attach the dial indicator to the swivel adaptor.

c. Insert the extension rod into the oil drain tube mounting pad opening so that it is against the wheel shaft and is perpendicular to the shaft.

CAUTION: Make sure the extension rod does not make contact with the sides of the center housing, otherwise it will be impossible to obtain an accurate reading.

d. Grasp each end of the rotating assembly and, applying equal pressure at each end, move the rotating shaft first toward and then away from the dial indicator, creating a transverse movement in the shaft. The dial indicator displacement should be more than .003 " and less than .007 ". If the displacement does not fall within the specified limits, disassemble and repair or replace the rotating assembly.

20. If it is to be stored, lubricate the turbocharger internally and install protective covers on all openings.

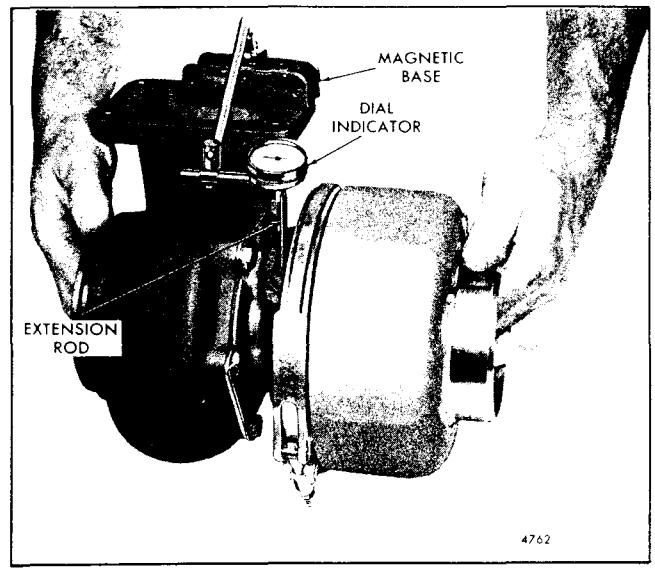


Fig. 8 - Checking Shaft Radial Movement

Install Turbocharger

If a turbocharger is to be installed on a new or overhauled engine, operate the engine for approximately one hour *before* the turbocharger is installed. This must be done to ensure that no foreign material is carried from the engine into the turbocharger lubrication system.

1. Position the turbocharger, using a new gasket, against the exhaust manifold adaptor and secure it in place with four bolts, lock washers and nuts (Fig. 1).

2. Slide the cover hose (Fig. 4) over the end of the turbocharger air outlet opening and tighten the two hose clamps.

3. Install the turbocharger support bracket.

4. Install the oil drain line from the opening in the bottom side of the center housing (Fig. 4) to the cylinder block.

5. Attach the oil inlet line at the cylinder block.

6. Before starting the engine, make sure that there is lubricating oil in the turbocharger.

a. Clean the area around the oil inlet opening, then pour about four ounces of engine oil in the oil inlet opening of the center housing. Turn the rotating assembly by hand to coat the bearings, thrust ring and thrust bearing with oil.

b. Fill the oil supply line with lubricating oil.

c. Use a socket wrench on the wheel nut to keep the compressor wheel from turning and start the engine.

d. As soon as oil appears at the end of the oil supply line, connect the oil supply line to the center housing (Fig. 4).

NOTE: The oil pressure should be at a minimum of 10 psig.

e. After the line is connected, release the compressor wheel.

7. Check all ducts and gaskets for leaks.

8. Operate the engine at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, shut down immediately and correct the cause.

NOTE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

TURBOCHARGER INTERCOOLER

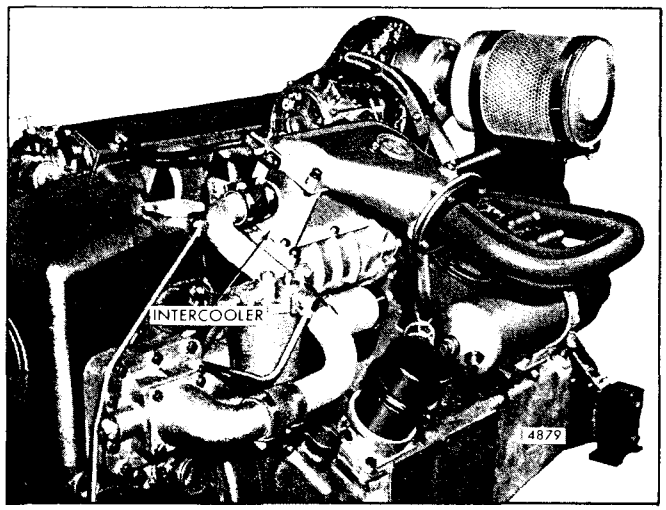


Fig. 1 - Turbocharger Intercooler Mounting

The turbocharger intercooler is mounted on the air inlet side of the engine blower and is used to reduce the temperature of the compressed air from the turbocharger before the air enters the engine blower. This permits a more dense charge of air to be delivered to the engine. The cooling is accomplished by the raw water from the heat exchanger passing through the cells of the intercooler core. The compressed air enters the intercooler via the air inlet housing and circulates past the cooler core of the intercooler.

Remove Intercooler

1. Drain the raw water system.

2. Loosen the two hose clamps on the hose connecting the raw water inlet tube to the inlet end of the intercooler (Fig. 1).

3. Remove the four 5/16 "-18 x 1 " bolts and lock washers that retain the air inlet tube flange to the air inlet housing.

4. Disconnect the connection between the outlet end of the intercooler and the raw water discharge line.

5. Disconnect the manual shutdown, if used.

6. Remove the six bolts, nuts, washers and lock washers that retain the air inlet housing to the intercooler and remove the air inlet housing and the screen and gasket assembly.

NOTE: The bolts are not all the same length and their location should be noted during removal to facilitate installation.

7. Remove the six bolts and lock washers that retain the intercooler to the blower and remove the intercooler. Note the location of the two shorter bolts.

8. Remove the gasket from the side of the blower.

Clean Intercooler

Check all of the intercooler tubes to be sure they are free of obstructions.

If the tubes contain dirt or any other foreign material, they can be cleaned with a small brush or by use of a suitable solvent cleaning solution. Flush the core thoroughly with water to remove the solvent.

Install Intercooler

1. Affix a new gasket to the side of the blower.

2. Mount the intercooler assembly on the blower with the six bolts and lock washers and tighten the bolts to 16-20 lb-ft torque.

3. Affix a new air inlet screen and gasket assembly on the intercooler.

4. Mount the air inlet housing on the intercooler with the six bolts, nuts, washers and lock washers and tighten the nuts to 35-39 lb-ft torque.

5. Affix a new gasket on the air inlet housing flange and secure the air inlet tube flange to the air inlet housing with the four 5/16 "-18 x 1 " bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

6. Connect the raw water inlet tube to the inlet end of the intercooler with the hose and clamps. Tighten the clamps securely.

7. Connect the raw water discharge line to the outlet end of the cooler.

8. Connect the manual shutdown, if used.

9. Fill the raw water system. Then start the engine and check for air or water leaks.

SHOP NOTES - TROUBLE SHOOTING - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REWORKING BLOWER END PLATES FOR IN-LINE AND 6V ENGINES

On non-turbocharged engines built prior to serial numbers 2D-20911, 3D-34008, 4D-36457 and 6D-24899, when oil is detected on the blower rotors or inside surface of the housing, the blower end plate can be reworked to accommodate a new lip type oil seal or a steel insert.

NOTE: Slight phonographic grooves can actually improve sealing. Unless wear is considerable and oil leakage is evident, the end plate need not be reworked.

Rework Blower End Plate

Use tool kit J 9533 to rework the end plate.

NOTE: On some prior serviced blowers, the end plates may have been reworked to accommodate a steel insert. In such cases, proceed as follows but omit Step 10.

1. Adjust the tool holder J 9533-2 and cutting tool J 9533-3 for the proper counterbore depth as follows:

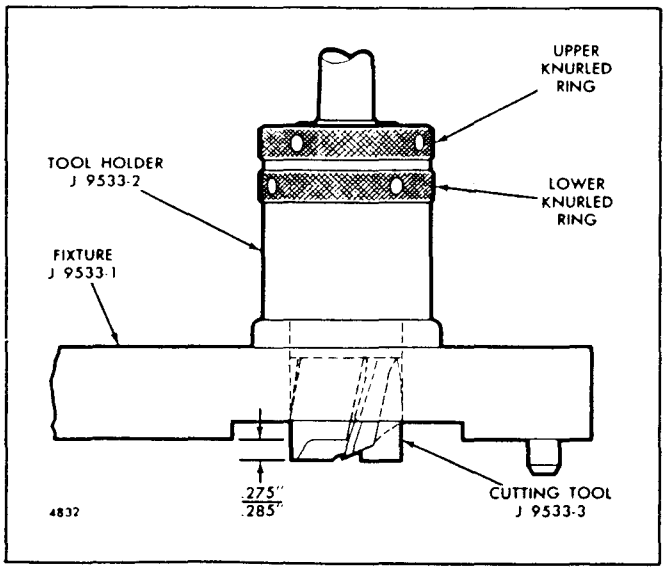


Fig. 1 - Adjustment of Tool Holder

a. Insert the rough cutting tool J 9533-3 in the tool holder as shown in Fig. 1.

b. Position the holder and the cutting tool in the fixture J 9533-1.

c. Loosen the "upper knurled ring" on the tool holder.

d. Rotate the "lower knurled ring" to raise or lower the cutting tool. Turn the "lower knurled ring" until there is a distance of .275 " - .285 " between the end of the cutting tool and the bottom of the fixture.

e. Tighten the "upper knurled ring".

2. Place fixture J 9533-1 on the blower end plate.

3. Clamp the fixture and the end plate loosely to the bed of a drill press.

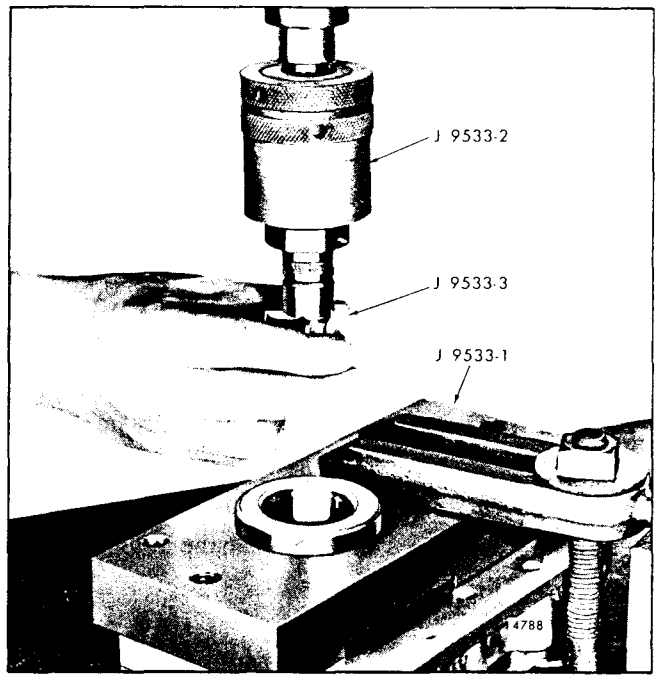


Fig. 2 - Install Cutting Tool in Holder

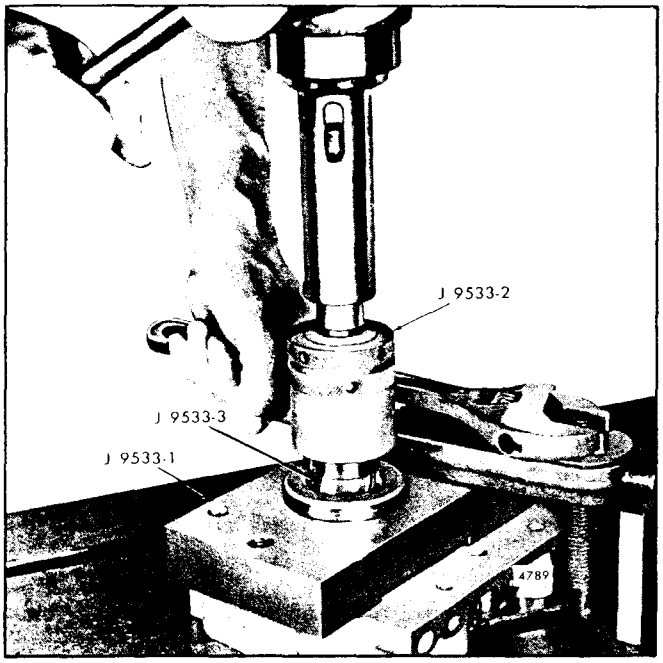


Fig. 3 - Positioning Cutting Tool in Fixture Guide

4. Install tool holder J 9533-2 in the drill press and insert the rough cutting tool J 9533-3 in the holder (Fig. 2).

5. Position the cutting tool in the fixture guide as shown in Fig. 3. Operate the drill press at 75-100 rpm so as to center the cutting tool in the rotor shaft hole. Tighten the clamp.

6. Lubricate the cutting tool and the area of the end plate that is being reworked with a lubricant (oleum or fuel oil).

7. Operate the drill press at 300-350 rpm and slowly counterbore the hole until the collar of the tool holder is approximately 1/16 " from the fixture guide. Then reduce the speed of the drill press to 75-100 rpm and continue counterboring until the collar contacts the top of the guide.

NOTE: Raise the cutting tool periodically during the drilling operation and apply additional lubricant.

8. Stop the drill press and remove the rough cutting tool.

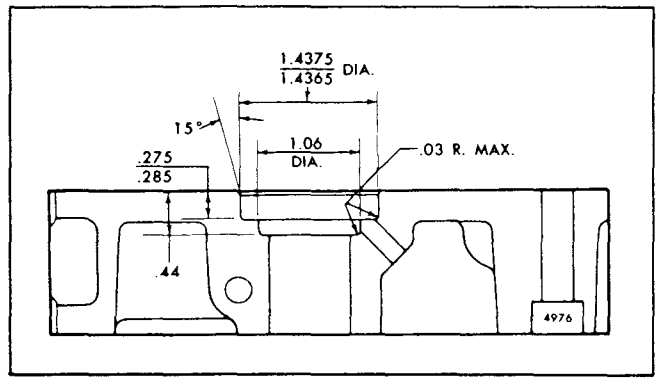


Fig. 4 - End Plate Oil Drain Back Counterbore

9. Insert the finish cutting tool J 9533-4 in the holder. Lubricate the cutting tool and the end plate. Operate the drill press at 75-100 rpm and finish-cut the counterbore. Feed the cutting tool into the work slowly.

10. Remove the finish cutting tool and install an end mill to machine the additional 1.06 " diameter counterbore. The total depth of the combined counterbores is .44 " (Fig. 4). The additional counterbore provides proper oil drain back from the oil seal area.

11. Remove the fixture from the end plate. Wipe the cuttings from the end plate and fixture and dry the plate and fixture with compressed air. Remove any burrs from the edge of the oil hole.

12. Thoroughly clean the cutting tool and the end mill flutes and repeat the procedures for the adjacent rotor shaft hole.

13. Place the blower end plate on the bed of an arbor press. Use installer J 22576 to press the seal (lip facing down) into the counterbored hole until the shoulder on the installer contacts the end plate.

NOTE: A step under the shoulder of the installer will position the oil seal below the finished face of the end plate within the .002 " to .008 " specified.

Steel Inserts

To install steel inserts in the blower end plates, follow Steps 1 through 9 and 11 and 12. Press the inserts flush to .003 " above the blower end plate surface.

REWORKING BLOWER FRONT END PLATES - 6V ENGINES

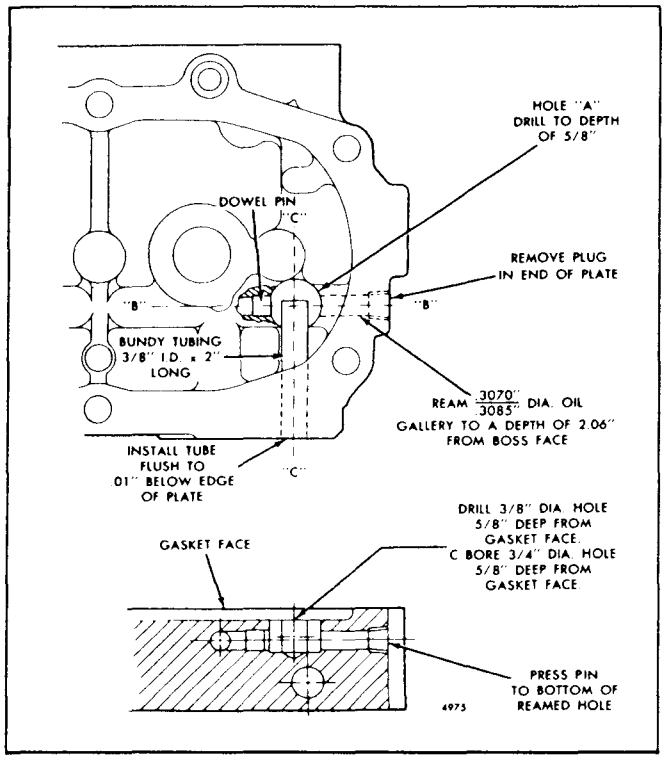


Fig. 5 - Dimensions for Reworking Front End Plate (6V Engine)

When rebuilding a 6V blower assembly in the field, the front end plate can be reworked to provide improved lubrication, when desirable, in the area of the thrust washers. The rework procedure is as follows:

1. Remove the pipe plug from the horizontal oil gallery (B-B) of the end plate. Place a reamer in the chuck of the drill press and ream a .3070 " - .3085 " diameter hole 2.06 " deep from the boss face (Fig. 5). Remove the metal cuttings from the hole.

2. Install the copper-plated dowel pin to the full depth of the reamed portion of the horizontal oil gallery.

3. Locate and mark the center of hole "A" as shown in Fig. 5. The center of hole "A" is where the center line (B-B) of the horizontal oil gallery intersects with the center line (C-C) of the drain hole. Clamp the end plate on the bed of the press and center drill at the location marked. Then drill a 3/8 " diameter hole 5/8 " deep from the gasket face of the end plate. Lubricate the drill and the area of the end plate that is being reworked with oleum or fuel oil.

4. Place either an end mill or a 3/4 " counterbore reamer (remove the pilot from the reamer) in the chuck of the drill press and counterbore a 3/4 " diameter hole 5/8 " deep from the gasket face of the end plate.

5. Wash the end plate in clean fuel oil to remove the metal cuttings and dry it with compressed air.

6. Cut a piece of 3/8 " I.D. Bundy tubing 2.00 " long. Coat the tubing with Gasola or an equivalent type sealant. Press the tubing into the oil drain hole in the end plate flush to .010 " below the edge of the plate. It is important that the area around the tube be oil tight.

7. Reinstall the pipe plug in hole (B-B).

8. When assembling the blower, apply a liberal amount of Lubriplate, or equivalent, on the surfaces of the thrust washers. This will provide lubrication of the thrust washers during initial start-up of the engine.

SECTION 4

LUBRICATION SYSTEM

CONTENTS

LUBRICATION SYSTEM

IN-LINE AND 6V ENGINES

The engine lubrication systems, illustrated in Figs. 1 and 2, include an oil intake screen and tube assembly, an oil pump, an oil pressure regulator valve, a full flow oil filter with a by-pass valve, an oil cooler and oil cooler by-pass valve.

The rotor type oil pump is bolted to the back of the engine lower front cover and is driven directly by the crankshaft. The pump width varies for the In-line engines and the 6V engine, but otherwise is of identical design. By rotating the pump 180 °, it can be used for either right-hand or left-hand rotation engines.

Lubricating oil from the pump passes from the lower front engine cover through short gallery passages in the cylinder block. From the block, the oil flows to the full flow filter, then through the oil cooler and back into the front engine cover and cylinder block oil galleries for distribution to the various engine bearings. The drain from the cylinder head and other engine parts leads back to the oil pan.

Clean engine oil is assured at all times by the use of a replaceable element type full flow filter. With this type filter, which is installed between the oil pump and the oil cooler, all of the oil is filtered before entering the engine. Should the filter become plugged, the oil will flow through a by-pass valve, which opens at approximately 18-21 psi, directly to the oil cooler. By-pass filters are used in certain applications when additional filtration is required (Section 4.2).

On current engines, the oil cooler by-pass valve is located on the right-hand side of the engine front cover and the oil pressure regulator valve is located on the left-hand side as viewed from the rear of the engine (Figs. 1 and 2). On former engines, both valves were located on the right-hand side of the cover (Figs. 1 and 2).

If the cooler becomes plugged, the oil flow will be to a by-pass valve in the lower engine front cover and then to the cylinder block oil galleries. The by-pass valve opens at approximately 52 psi in the current In-line engines and 6V engines. In the former In-line engines, the by-pass valve opens at approximately 30 psi.

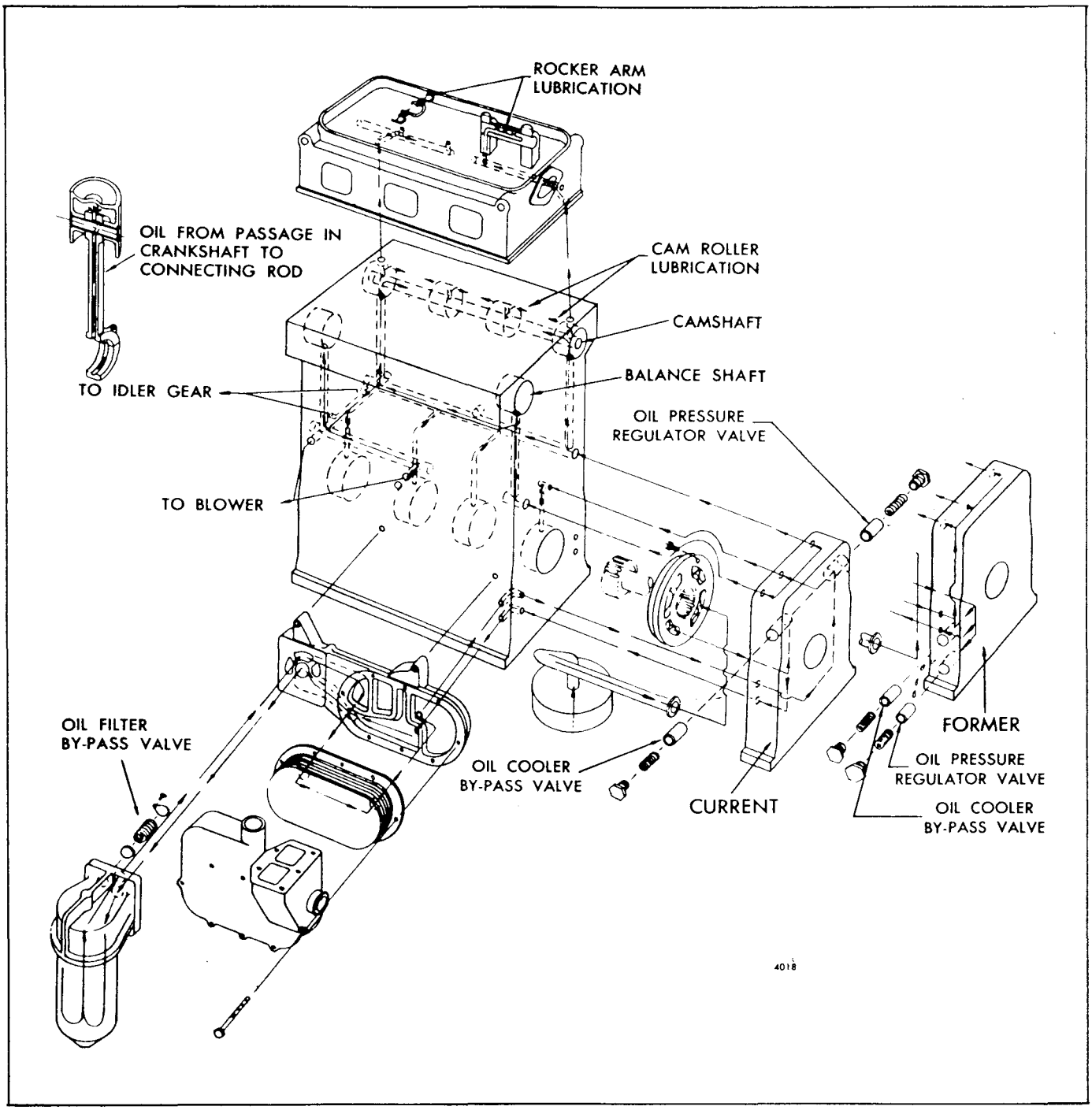


Fig. 1 - Schematic Diagram of Typical In-Line Engine Lubrication System

NOTE: The by-pass valve opens at approximately 32 psi on 6V marine engines prior to engine number 6D-11074 and all 6V engines prior to engine number 6D-17960.

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by means of a regulator valve located in the lower front engine cover. The regulator valve, located in the pump outlet passage, opens at 51 psi on In-line engines or 52 psi on 6V engines and returns excess oil directly to the crankcase.

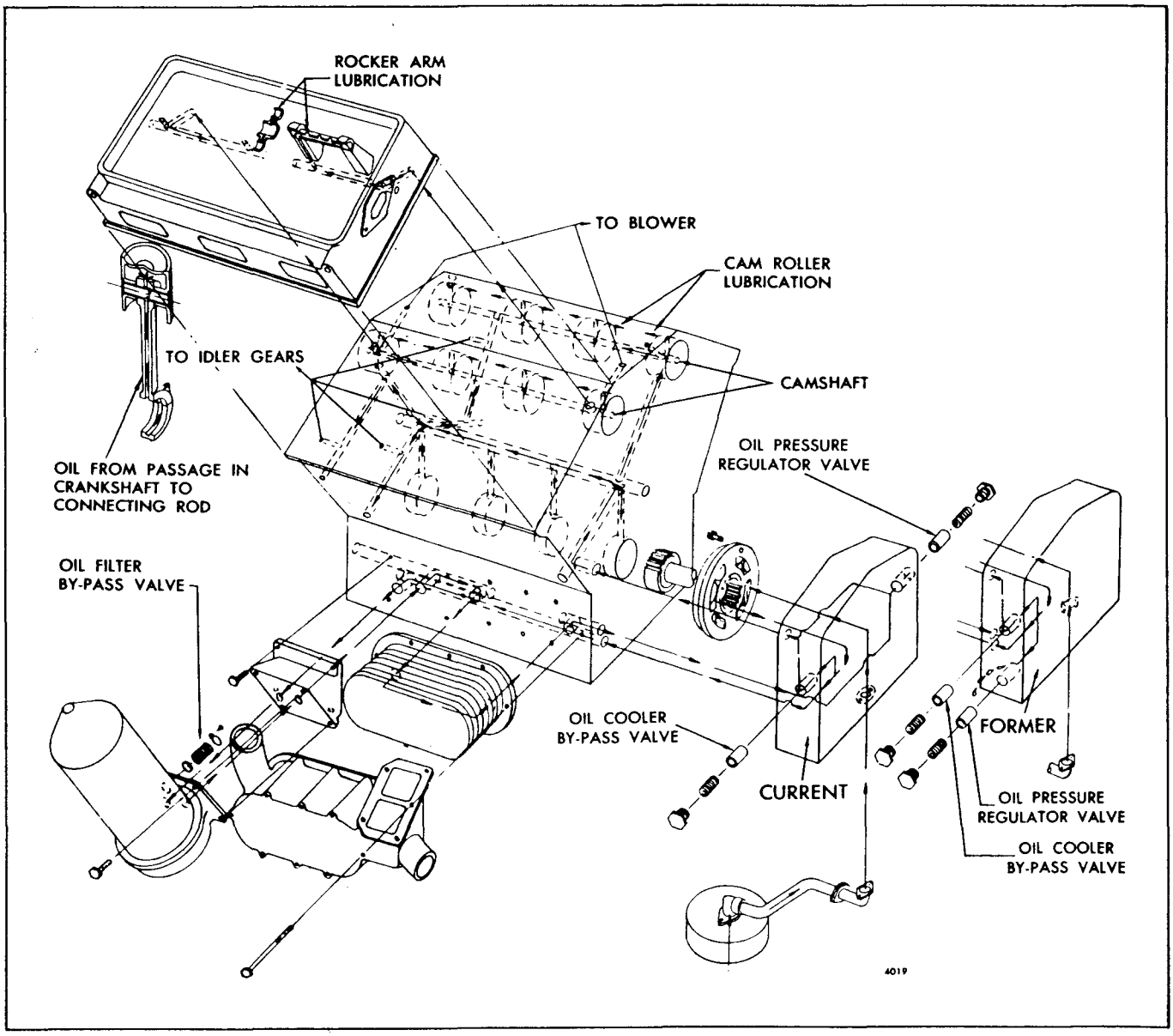


Fig. 2 - Schematic Diagram for 6V-53 Engine Lubrication System

Lubricating Oil Distribution

Oil from the oil cooler on the In-line engine is directed to the lower engine front cover and then to a longitudinal main oil gallery in the cylinder block. As shown in Fig. 1, this gallery distributes the oil, under pressure, to the main bearings and to a horizontal transverse passage at one end of the block and to vertical passages at each corner of the block which provide lubrication for the balance shaft and camshaft bearings. The camshaft bearings incorporate small slots through which lubricating oil is directed to the cam follower rollers.

On a 6V engine, oil from the pump enters a passage in the cylinder block and flows under pressure to the filter and oil cooler and returns through a passage in the block to the lower engine front cover. From a passage in the cover, the oil flows to the longitudinal main oil gallery in the block which distributes the oil, under pressure, to the main bearings. Oil passages branching off from the main oil gallery direct oil to the camshaft end bearings, idler gear and accessory drive gear bearings, blower, and cylinder heads.

In addition, oil is forced through an oil passage in each camshaft which lubricates the camshaft intermediate bearings. All of the camshaft bearings incorporate small slots through which lubricating oil is directed at the cam follower rollers.

Oil for lubricating the connecting rod bearings, piston pins, and for cooling the piston head is provided through the drilled crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pocket through a communicating passage into the flywheel housing. Some oil spills into the flywheel housing from the bearings of the camshafts, balance shaft (In-line engine), idler gears and accesssory drive gears (6V engine).

Drilled oil passages on the camshaft side of the cylinder head (Figs. 1 and 2) are supplied with oil from the bores located at each end of the cylinder block. Oil from these drilled passages enters the drilled rocker shaft brackets at the lower ends of the drilled bolts and lubricates the rocker arm bearings and push rod clevis bearings.

Excess oil from the rocker arms lubricates the lower ends of the push rods and cam followers, then drains to cam pockets in the top of the cylinder block, from which the cams are lubricated. When these pockets are filled, the oil overflows through holes at each end of the cylinder block and then through the flywheel housing and front cover to the crankcase.

The blower bearings are pressure lubricated by oil from drilled passages in the cylinder block which connect matching passages in the blower end plates which, in turn, lead to the bearings. On current engines, lubricating oil is supplied directly to the front and rear right bank camshaft end bearings and supplies oil to the blower bearings. On former engines, the blower bearings received lubrication indirectly via the right rear camshaft end bearing only. Excess oil returns to the crankcase via drain holes in the blower end plates which lead to corresponding drain holes in the cylinder block (In-line engines) or the governor housing (6V engine).

The blower drive gear hub in a 6V engine is pressure lubricated through a connecting passage from the rear blower end plate, through the governor housing and into the blower and governor drive support.

Four tapped oil pressure take-off holes (three at the rear and one at the front) are provided in a 6V cylinder block.

One tapped oil pressure take-off hole is provided in the lower engine front cover on some In-line engines.

In addition, tapped oil holes in the cylinder block, on the side opposite the blower, are also provided as follows: three holes in the four-cylinder block and two holes in the three-cylinder block when the blower is on the left side of the engine or three holes when the blower is on the right side of the engine.

Cleaning Lubrication System

Thorough flushing of the lubrication system is required at times. Should the engine lubrication system become contaminated by ethylene glycol antifreeze solution or other soluble material, refer to Section 5 for the recommended cleaning procedure.

8V ENGINE

The 8V engine lubrication system, illustrated in Fig. 3, includes an oil intake screen and tube assembly, an oil pump with a relief valve, an oil pressure regulator valve, a full flow oil filter with a by-pass valve, an oil cooler and an oil cooler by-pass valve.

The oil is circulated by a gear-type oil pump mounted on the number 4 and 5 main bearing caps and is driven by the crankshaft timing gear.

Lubricating oil is drawn by suction from the oil pan through the inlet screen and pipe to the pump where it is pressurized. The oil then passes from the pump to a gallery in the cylinder block, to the full-flow filter adaptor, through the filter, then through the oil cooler and into the engine front cover and cylinder block oil galleries for distribution to the various engine bearings, including the outboard bearing in the front cover. The oil drains from the cylinder head and other engine parts back to the oil pan.

A spring-loaded relief valve, located in the oil pump outlet pipe, by-passes excess oil back into the crankcase when the engine is cold or when the pressure in the engine oil gallery exceeds approximately 120 psi.

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by means of an oil pressure regulator valve in the engine front cover which opens at approximately 52 psi.

Clean engine oil is assured at all times by the use of a replaceable element type full-flow filter which is installed between the oil pump and the oil cooler. All of the oil is filtered before entering the engine. Should the filter become plugged or before the engine is at operating temperature, the oil will flow through a by-pass valve, which opens at approximately 18-21 psi, directly to the oil cooler.

The oil cooler by-pass valve, which opens at approximately 52 psi, is located in the engine front cover. If the cooler becomes clogged or before the engine reaches operating tmeperature, the oil flow will

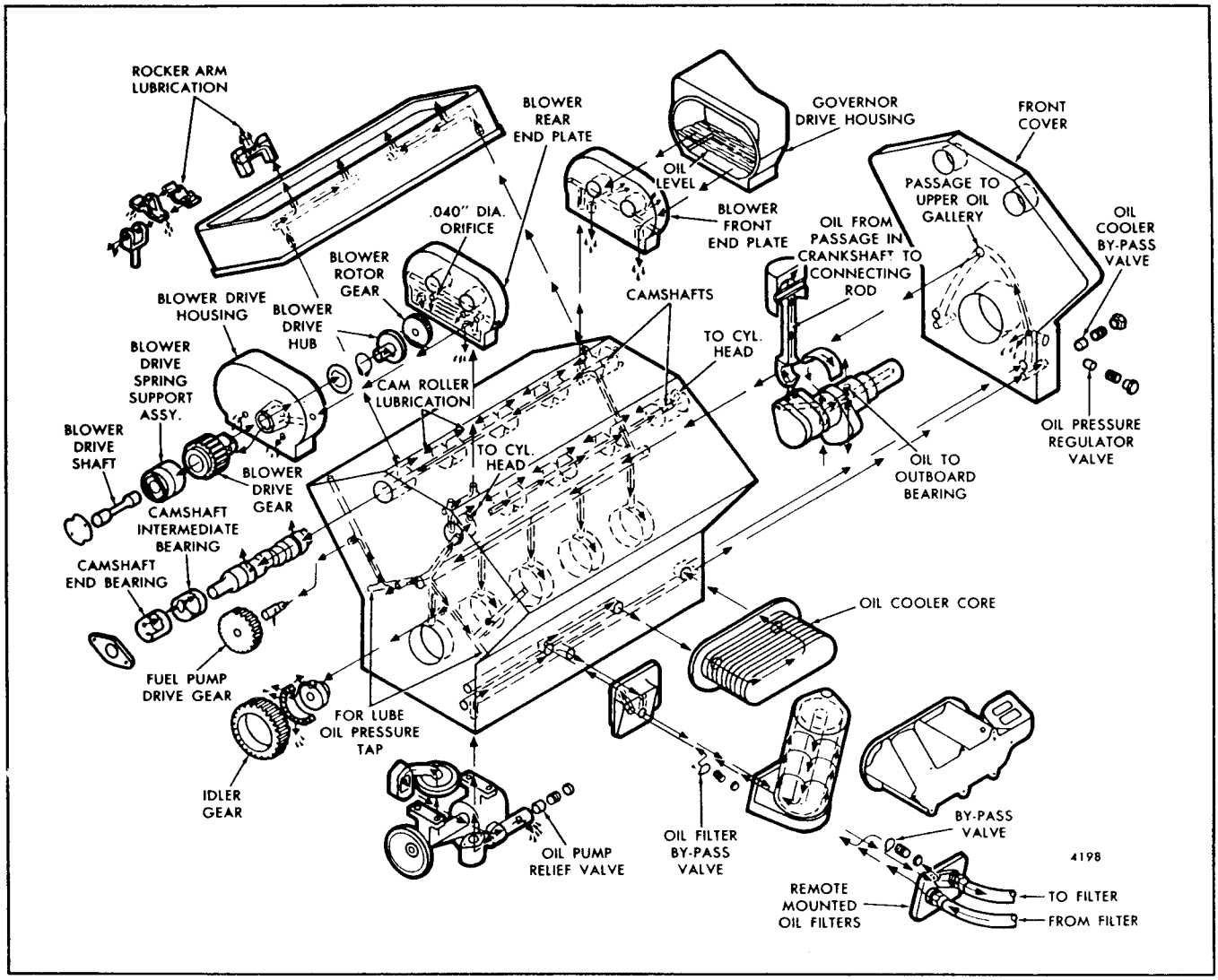


Fig. 3 - Schematic Diagram of Typical 8V-53 Engine Lubrication System

be to the by-pass valve, then through the engine front cover oil passage and the cylinder block oil galleries.

Lubricating Oil Distribution

Oil from the pump enters a passage in the cylinder block and flows under pressure to the filter and oil cooler, then through a passage in the cylinder block to the engine front cover. From a passage in the cover, the oil flows to the longitudinal main oil gallery which distributes the oil, under pressure, to the main bearings and the outboard bearing. Oil passages branching off from the main oil gallery direct oil to the camshaft end bearings, idler gear and fuel pump drive gear bearings, blower and cylinder heads.

In addition, oil is forced through an oil passage in each camshaft which lubricates the camshaft intermediate bearings. All of the camshaft bearings incorporate small slots through which lubricating oil is directed to the cam follower rollers.

Oil for lubricating the connecting rod bearings, piston pins, and for cooling the piston head is provided through the drilled crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pockets through a communicating passage into the flywheel housing. Some oil spills into the flywheel housing from the camshaft end bearings, idler gear, and fuel pump drive gear.

Drilled oil passages on the camshaft side of the cylinder heads (Fig. 3) are supplied with oil from the bores located at each end of the cylinder block. Oil from these drilled passages enters the drilled rocker

shaft brackets at the lower ends of the drilled bolts, and lubricates the rocker arm bearings and push rod clevis bearings.

Excess oil from the rocker arms lubricates the lower ends of the push rods and cam followers, then drains to cam pockets in the top of the cylinder block, from which the cams are lubricated. When these pockets are filled, the oil overflows through holes at each end of the cylinder block and then drains back through the flywheel housing and front cover to the crankcase.

Oil is forced through drilled oil passages in the cylinder block to the blower. The oil level in the blower and the governor drive is maintained by two .040 " diameter orifices in the blower end plates. Thus the rotor timing gears and the governor weights turn in oil.

The splash of the oil and the vapor created lubricate the blower bearings and supplies oil to the blower drive gear, spring pack and drive shaft. Oil is returned to the blower drive support by a groove in the drive gear hub. Excess oil helps lubricate the gear train before returning to the crankcase. Two tapped oil pressure take-off holes are located at the rear of the cylinder block.

Cleaning Lubrication System

Thorough flushing of the lubrication system is required at times. Should the engine lubrication system become contaminated by ethylene glycol antifreeze solution or other soluble material, refer to Section 5 for the recommended cleaning procedure.

OIL PRESSURE TAKE-OFF LOCATIONS

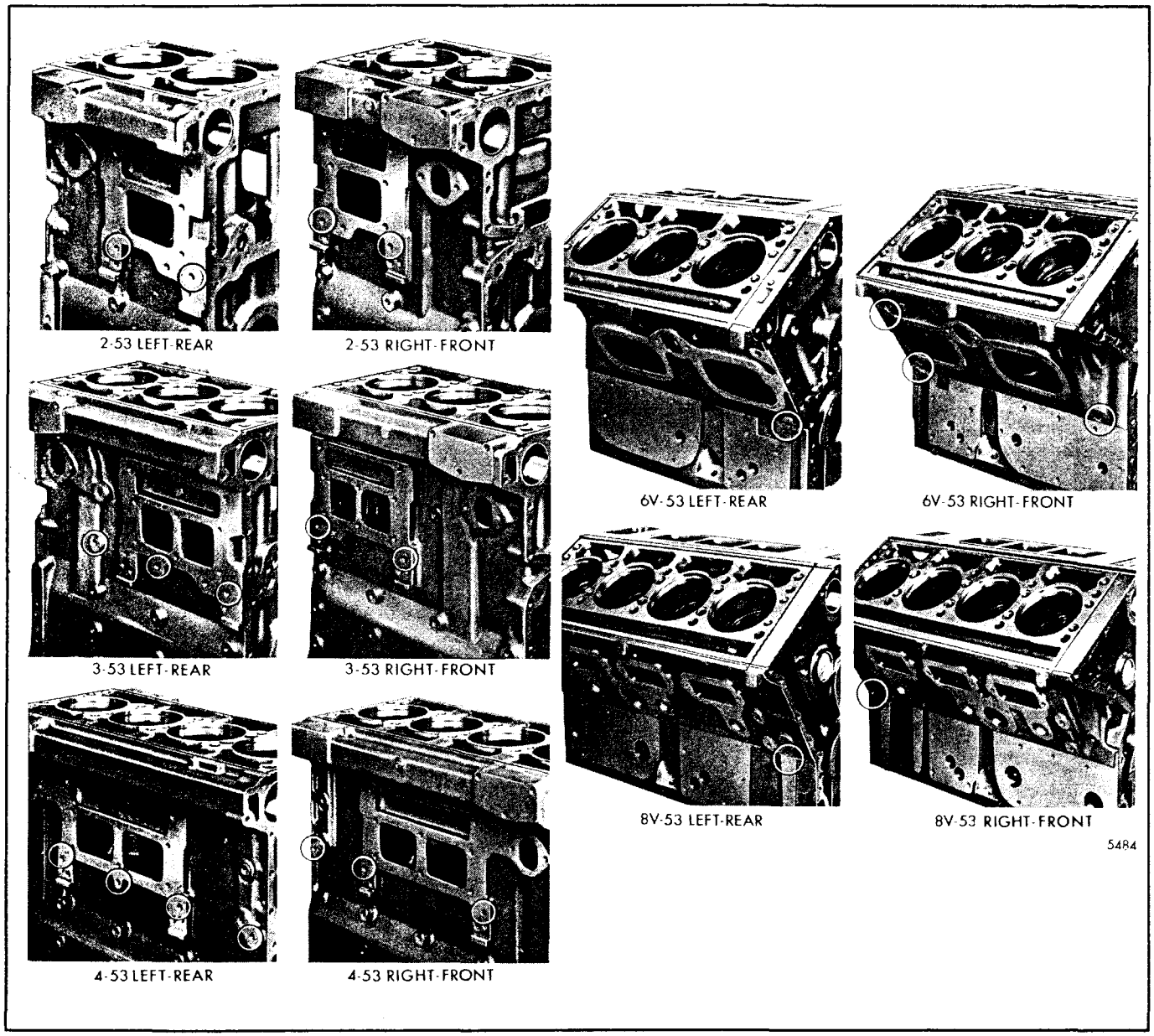


Fig. 4 - Oil Pressure Take-Off Locations

The following cylinder block illustrations show the main oil gallery pressure locations that are available for supplying oil under pressure to oil gages, Jacobs engine brake or other accessories.

LUBRICATING OIL PUMP

IN-LINE AND 6V ENGINES

The lubricating oil pump, assembled to the inside of the lower engine front cover as illustrated in Fig. 1, is of the rotor type in which the inner rotor is driven by a gear pressed on the front end of the crankshaft. The outer rotor is driven by the inner rotor. The bore in the pump body, in which the outer rotor revolves, is eccentric to the crankshaft and inner rotor. Since the outer rotor has nine cavities and the inner rotor has eight lobes, the outer rotor revolves at eight-ninths crankshaft speed. Only one lobe of the inner rotor is in full engagement with the cavity of the outer rotor at any given time, so the former can revolve inside the latter without interference.

The pump width varies for the 2, 3 and 4 cylinder In-line and 6V-53 engines, but otherwise is of identical design. By rotating the pump 180°, it can be used for either a right-hand or left-hand rotation engine.

Operation

As the rotors revolve, a vacuum is formed on the inlet side of the pump and oil is drawn from the crankcase, through the oil pump inlet pipe and a passage in the front cover, to the inlet port and then into the rotor compartment of the pump. Oil drawn into the cavities between the inner and outer rotors on the inlet side of the pump is then forced out under pressure through the discharge port into a passage in the front cover, which leads to the lubricating oil filter and cooler, and is then distributed throughout the engine.

If a check of the lubrication system indicates improper operation of the oil pump, remove and disassemble it as outlined below.

Remove Oil Pump

1. Drain the oil from the engine.

2. Remove the crankshaft pulley, fan pulley, support bracket and any other accessories attached to the front cover.

3. Remove the oil pan.

4. Refer to Fig. 2 and remove the four bolts which attach the oil pump inlet pipe and screen assembly to the main bearing cap and engine front cover or oil pump inlet elbow. Slide the flange and the seal ring on the inlet pipe and remove the pipe and screen as an assembly. Remove the oil pump inlet elbow (if used) and gasket from the engine front cover.

5. Remove the lower engine front cover.

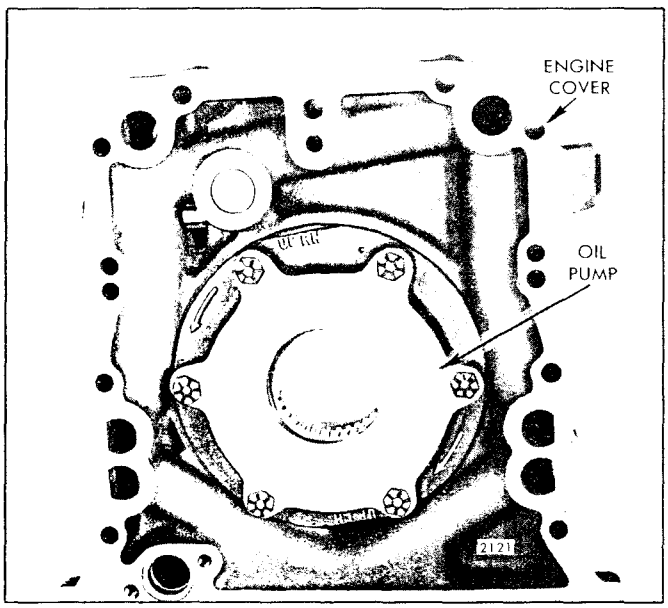


Fig. 1 - Typical Right-Hand Rotation Lubricating Oil Pump Mounting

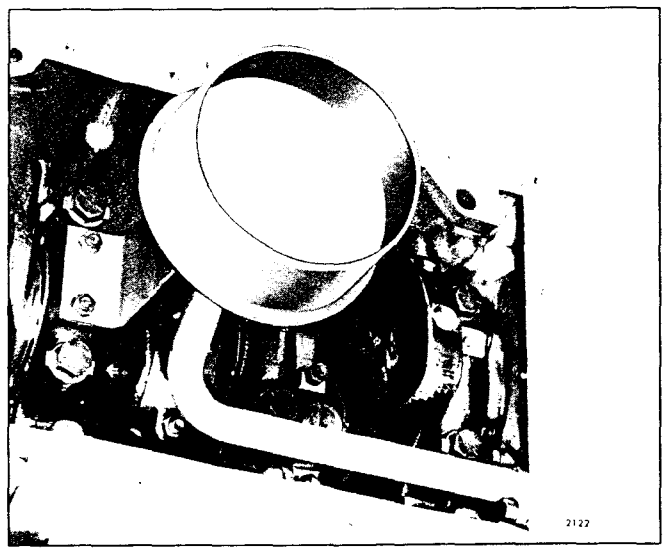


Fig. 2 - Typical Oil Pump Inlet Pipe and Screen Mounting

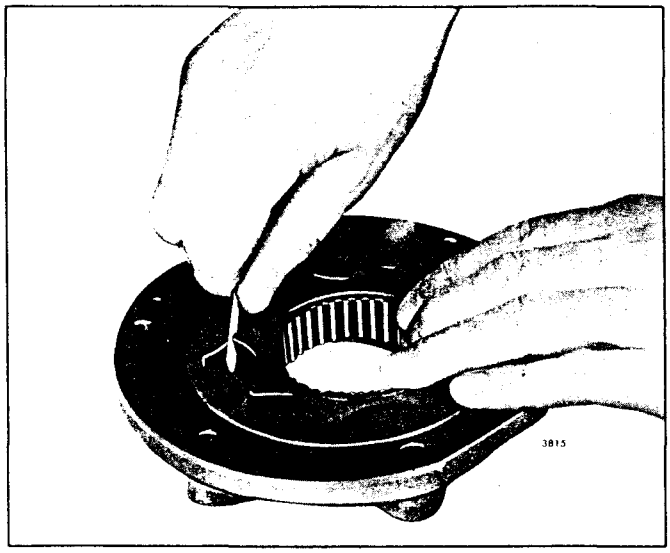


Fig. 3 - Measuring Rotor Clearance

6. Remove the six bolts and lock washers (if used) which attach the pump assembly to the engine front cover (Fig. 1) and withdraw the pump assembly from the cover.

Disassemble Oil Pump

If the oil pump is to be disassembled for inspection or reconditioning, proceed as follows:

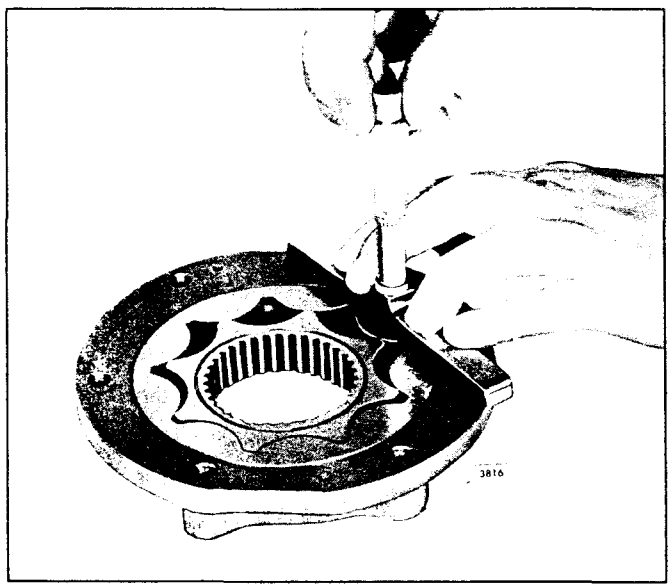


Fig. 4 - Measuring Clearance from Face of Pump Body to Side of Rotor

1. Refer to Fig. 5 or 6 and remove the two drive screws holding the pump cover plate to the pump body. Withdraw the cover plate from the pump body.

2. Remove the inner and outer rotors from the pump housing.

Inspection

Wash all of the parts in clean fuel oil and dry them with compressed air.

The greatest amount of wear in the oil pump is imposed on the lobes of the inner and outer rotors.

This wear may be kept to a minimum by using clean oil. If dirt and sludge are allowed to accumulate in the lubricating system, excessive rotor wear may occur in a comparatively short period of time.

Inspect the lobes and faces of the pump rotors for scratches or burrs and the surfaces of the pump body and cover plate for scoring. Scratches or score marks may be removed with an emery stone.

Measure the clearance between the inner and outer rotors at each lobe (Fig. 3). The clearance should not be less than .004 " or more than .011 ". Measure the clearance from the face of the pump body to the side of the inner and outer rotor with a micrometer depth gage (Fig. 4). The clearance should be not less than .001 " or more than .0035 ".

Inspect the splines of the inner rotor and the oil pump drive gear. If the splines are excessively worn, replace the parts. The rotors are serviced as matched sets, therefore, if one rotor needs replacing, replace both rotors.

Remove the oil inlet screen from the oil inlet pipe and clean both the screen and the pipe with fuel oil and dry them with compressed air. Replace the inlet pipe flange seal ring with a new seal ring if necessary.

Assemble Oil Pump

After the oil pump parts have been cleaned and inspected, refer to Fig. 5 or 6 and assemble the pump as follows:

1. Lubricate the oil pump outer rotor with engine oil and place it in the pump body.

2. Lubricate the oil pump inner rotor with engine oil and place it inside of the outer rotor.

3. Place the cover plate on the pump body and align the drive screw and bolt holes with the holes in the

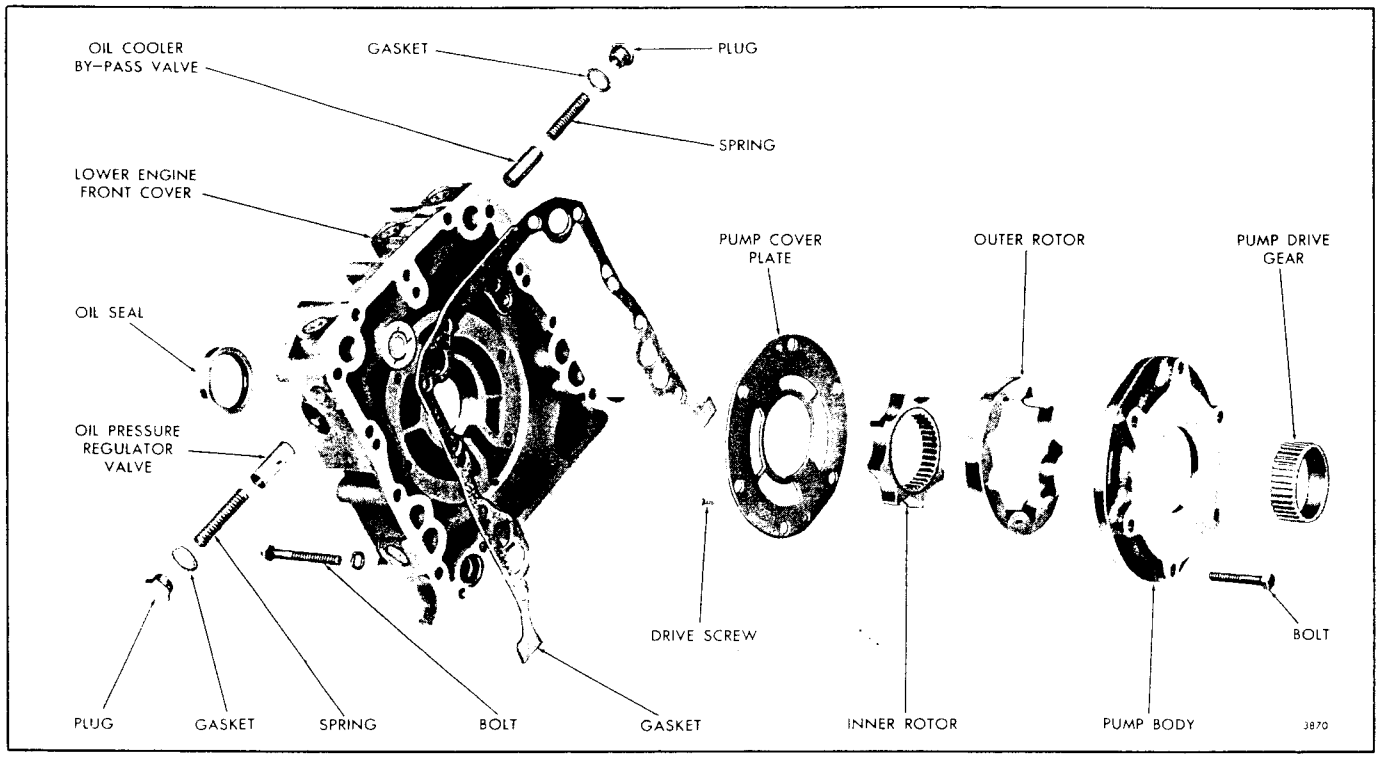


Fig. 5 - Lubricating Oil Pump Details and Relative Location of Parts (Current)

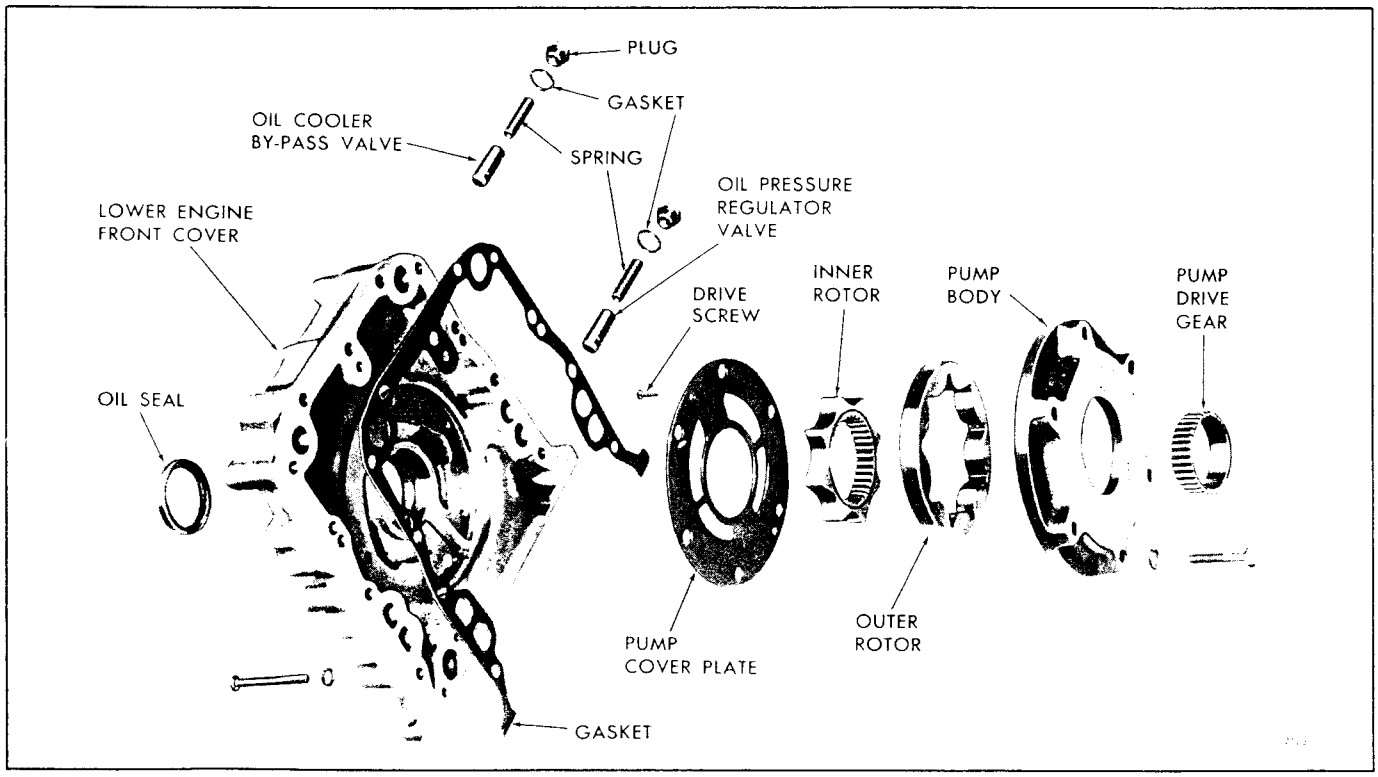


Fig. 6 - Lubricating Oil Pump Details and Relative Location of Parts (Former)

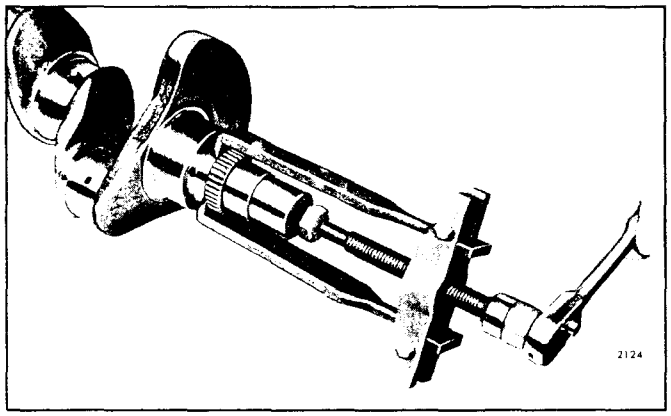


Fig. 7 - Removing Oil Pump Drive Gear

pump body. Since the holes are offset, the cover plate can be installed in only one position.

4. Install two new drive screws to hold the assembly together.

Remove Pump Drive Gear From Crankshaft

With the lower engine front cover and the lubricating oil pump removed from the engine, the oil pump drive gear may, if necessary, be removed from the end of the crankshaft as follows:

1. Thread the crankshaft pulley retaining bolt in the end of the crankshaft (Fig. 7).

2. Attach the jaws of a suitable gear puller behind the gear and locate the end of the puller screw in the center of the pulley retaining bolt.

3. Turn the puller screw clockwise to remove the gear from the crankshaft.

Install Pump Drive Gear on Crankshaft

1. Lubricate the inside diameter of a new oil pump drive gear with engine oil. Then start the gear straight on the crankshaft. Re-installation of a used gear is not recommended.

2. Position the drive gear installer J 8968-01 over the end of the crankshaft and against the drive gear and force the gear in place as shown in Fig. 8. When the end of the bore in the tool contacts the end of the crankshaft, the drive gear is correctly positioned.

3. It is important that the press fit of the drive gear to the crankshaft be checked to be sure that the gear does not slip on the crankshaft. It is recommended the press

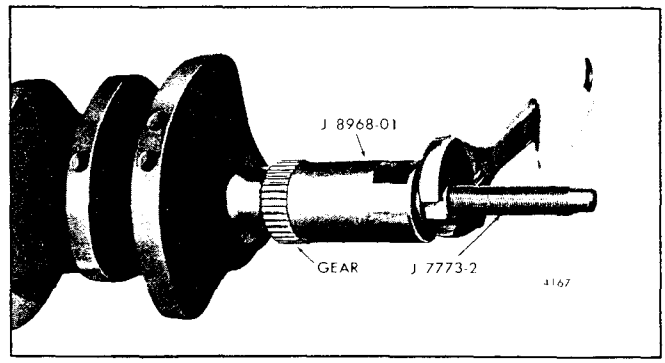


Fig. 8 - Installing Oil Pump Drive Gear

fit (slip torque) be checked with tool J 23126. On In-line or 6V engines, the drive gear should not slip on the crankshaft at 100 lb-ft torque.

CAUTION: Do not exceed these torques. If the gear slips on the shaft, it is suggested that another oil pump drive gear be installed.

Install Oil Pump

1. The markings on the pump body indicate the installation as pertaining to left or right-hand crankshaft rotation. Be sure that the letters "UP R.H." (right-hand rotation engine) or "UP L.H." (left-hand rotation engine) on the pump body are at the top (Fig. 1).

2. Insert the six bolts with lock washers (if used) through the pump body and thread them into the engine front cover. Tighten the bolts to 13-17 lb-ft torque.

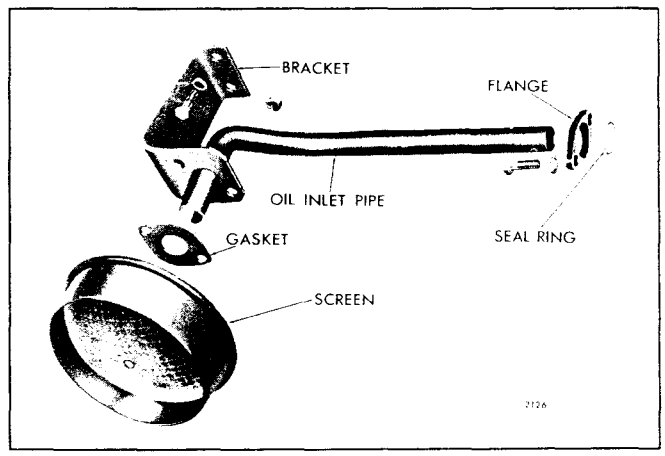


Fig. 9 - Oil Pump Inlet Pipe and Screen Details and Relative Location of Parts (In-Line Engine)

3. Install the lower engine front cover and pump assembly on the engine as outlined in Section 1.3.5.

4. Attach the oil inlet screen to the oil inlet pipe support with two lock nuts (6V engine) or two bolts and lock washers (Fig. 9).

5. Use a new gasket and attach the oil pump inlet elbow (6V engine) to the under side of the engine front cover with the two bolts and lock washers.

6. Place the oil pump inlet pipe and screen assembly in position and fasten the support to the main bearing cap with the two bolts and lock washers.

7. Slide the inlet pipe flange and seal ring against the engine front cover (or oil pump inlet elbow on the 6V engine) and secure them with the two bolts and lock washers.

CAUTION: On In-line engines, the oil pump inlet tube and water by-pass tube seals are the same size but of different material. *Be sure that the correct seal is used.* A new oil pump inlet tube seal may be identified by its white stripe.

8. Install the oil pan and refill the crankcase to the proper level.

9. Install the crankshaft pulley, fan pulley, support bracket and any other accessories that were attached to the front cover.

8V ENGINE

The oil pump (Fig. 10) on an 8V engine is mounted on the number 4 and 5 main bearing caps. The oil pump is driven by the crankshaft timing gear.

A spring-loaded relief valve, which is located in the oil pump outlet pipe assembly, by-passes excess oil back to the crankcase when the pressure in the engine oil gallery exceeds approximately 120 psi.

Effective with engine 8D-174, a new lubricating oil pump and inlet tube is used on the 8V engine. The pump has a new cover which supports the ends of the drive and driven shafts. The new drive shaft is longer and larger in diameter and the new drive gear has a larger inside diameter. When replacing an old oil pump with a new pump on an engine that has the inlet tube assembled to the pump cover, it will be necessary to install a new oil pump inlet system.

Effective with engine 8D-4611, a new high capacity oil pump with longer drive and driven gears is used on the 8V engines. The high capacity pump must be used in combination with the seven hole upper main bearing shells.

NOTE: The new pump can be used with the former one hole upper main bearing shells.

Remove Oil Pump

1. Remove the bolts and lock washers securing the inlet pipe and the bracket to the oil pump. Then remove the inlet pipe, screen and bracket as an assembly from the pump.

2. Remove the two bolts and lock washers securing the oil pressure relief valve to the oil pump.

3. Remove the oil pump outlet pipe-to-cylinder block bolts. Then remove the relief valve and outlet pipe as an assembly from the engine.

4. Remove the oil pump-to-bearing cap attaching bolts and lock washers and remove the pump assembly from the engine.

NOTE: Shims are used between the oil pump mounting feet and the main bearing caps. Whenever the original pump from such an engine is reinstalled, the same shims or an equal number of new (identical) shims must be placed under both the front and rear mounting feet and the number then adjusted to obtain the proper clearance between the gears.

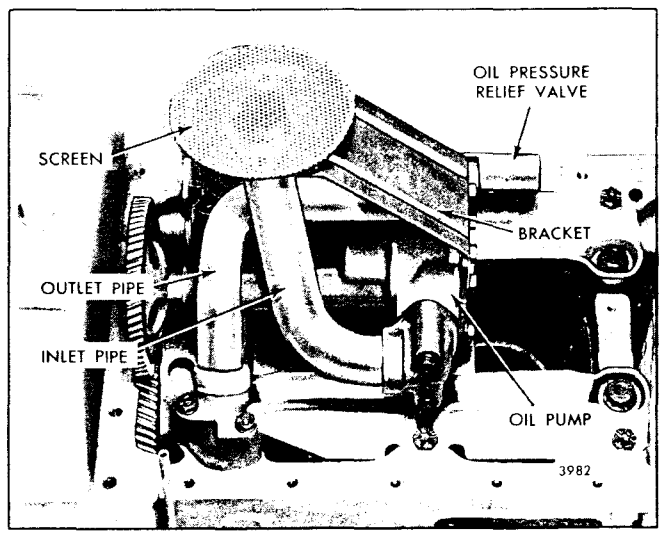


Fig. 10 - Lubricating Oil Pump Mounting (8V Engine)

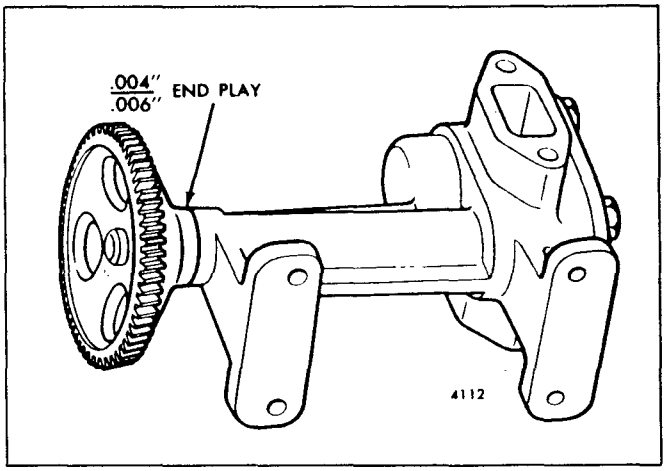


Fig. 11 - Oil Pump Gear End Play

Disassemble Oil Pump

Remove the four bolts and lock washers and pull the cover off of the shafts. Slide the pump gear from the pump body cavity.

Remove the oil pump driven gear by pressing the drive shaft through the gear.

Inspection

Wash all of the parts in clean fuel oil and dry them with compressed air.

The greatest amount of wear in the oil pump is imposed on the internal drive and driven gears. This wear may be kept to a minimum by keeping the lubricating oil clean and acid-free. If dirt and sludge are allowed to accumulate in the lubricating system, prounounced gear wear may occur in a comparatively short period of time. Proper servicing of oil filters will increase the life of the gears.

Examine the internal gear cavity of the pump body and scavenger pump, if used, for wear or scoring. Also inspect the pump cover, or the spacer between the pump and scavenger bodies, for wear. Replace parts if necessary.

Inspect the bushings in the pump body and cover (or scavenging pump body). If the bushings are worn excessively, replace the pump and cover (or scavenging pump body) unless suitable boring equipment is available for finishing the new bushings. When installing new bushings, replace all of the bushings in the pump bodies. The bushings must be located and positioned as shown in Fig. 13. Also, the gear bore and the bushing bore in both the pump body and scavenging pump body must be concentric within .001 " total indicator reading. The shaft-to-cover or scavenging pump body to bushing clearance with new parts is .001 " to .0027 ".

CAUTION: When installing the spacer between the oil pump body and the scavenging pump body, be sure the bleed hole is located on the discharge side of the oil pump assembly.

If the driven gear bushings are worn, replace the bushings. Then ream the bushings to .625 " diameter ± .0005 " after assembly.

If the gear teeth are scored or worn, install new gears. The use of excessively worn gears will result in low engine oil pressure which, in turn, may lead to serious damage throughout the engine.

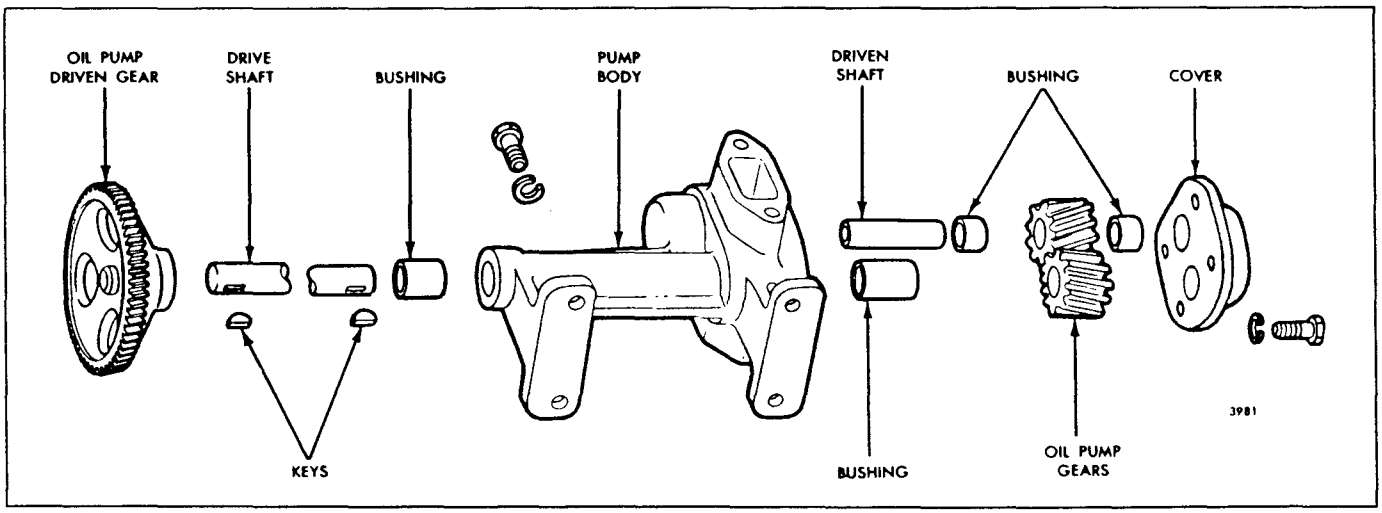


Fig. 12- Lubricating Oil Pump Details and Relative Location of Parts (8V Engine)

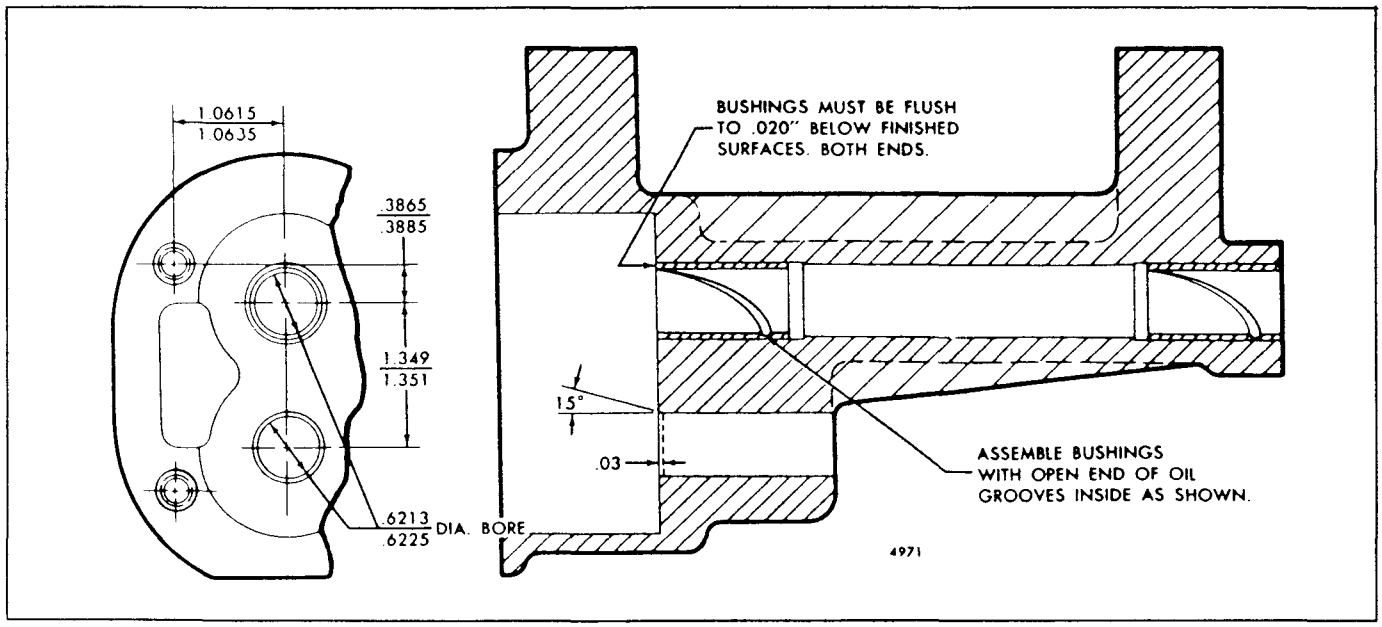


Fig. 13 - Diameter and Location of Bushings in Oil Pump Body

Inspect the external pump drive-driven gear for wear and replace it, if necessary.

Inspect the pump shafts for wear and check the keyways. Replace the shafts if necessary.

Check to be sure the pressure relief valve moves freely in the valve housing. Replace it if necessary.

Replace a pitted or fractured spring.

Assemble Oil Pump

Install the oil pump driven shaft and pump gear in the pump body. Install the other pump gear on the shaft in the pump cavity (Fig. 12).

Mount the cover on the two shafts, and fasten the cover on the pump with four bolts and lock washers.

Install a Woodruff key, if previously removed, in the shaft. Press the drive gear over the key on the shaft and place .006 " feeler stock between the gear and body. Press the gear on the shaft until the clearance between the gear and the pump body is .004 " to .006 " (Fig. 11).

Install Oil Pump

1. Place the pump on the number 4 and 5 main bearing caps and, with shims in place, fasten the pump to the main bearing caps with four bolts and lock washers. Proper gear clearance is from .005 " - .007 ".

> **CAUTION:** Always check the clearance between the crankshaft gear and the oil pump driving gear with the engine in the upright or running position.

2. Attach new gaskets to the oil pressure relief valve housing and fasten it to the pump and cylinder block with four bolts and lock washers.

3. Place a new gasket under the oil pump inlet pipe and fasten it to the pump body with two bolts and lock washers.

4. Fasten the oil pump screen bracket to the oil pump cover with two bolts, lock washers and nuts.

LUBRICATING OIL PRESSURE REGULATOR

IN-LINE AND 6V ENGINES

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of oil temperature, by a pressure regulator valve installed in the engine lower front cover as shown in Figs. 1 and 2.

The regulator assembly consists of a hollow piston type valve, a spring, gasket and plug. The valve is located in an oil gallery within the lower front cover and is held tight against a counterbored valve seat by the valve spring and plug. When the oil pressure exceeds a given value as shown in the following chart, the valve is forced from its seat and the lubricating oil is by-passed into the engine oil pan.

Engine	Front Cover	Valve Opening Pressure (psi)
In-line	Former	78
	Current	51
6V	Former	32
	Current	52

Under normal conditions, the pressure regulator valve should require very little attention. If sludge accumulates in the lubrication system, the valve may not work freely, thereby remaining open or failing to open at the normal operating pressure.

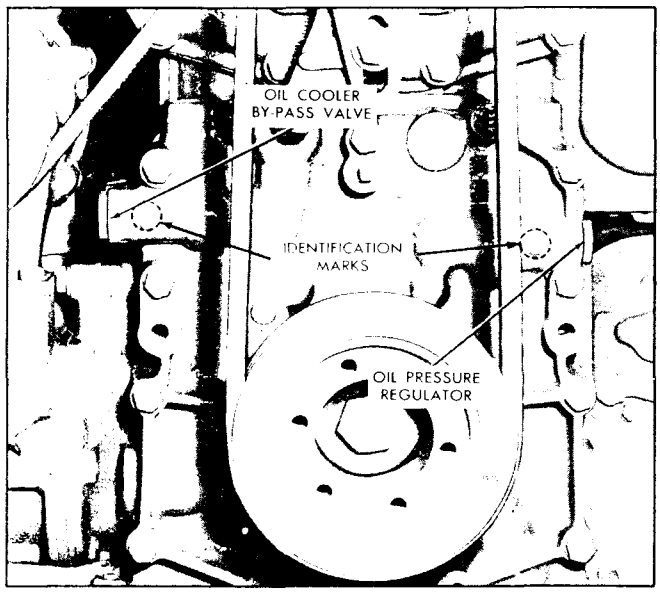


Fig. 1 - Location of Current Oil Pressure Regulator Valve -- In-line Engine Shown

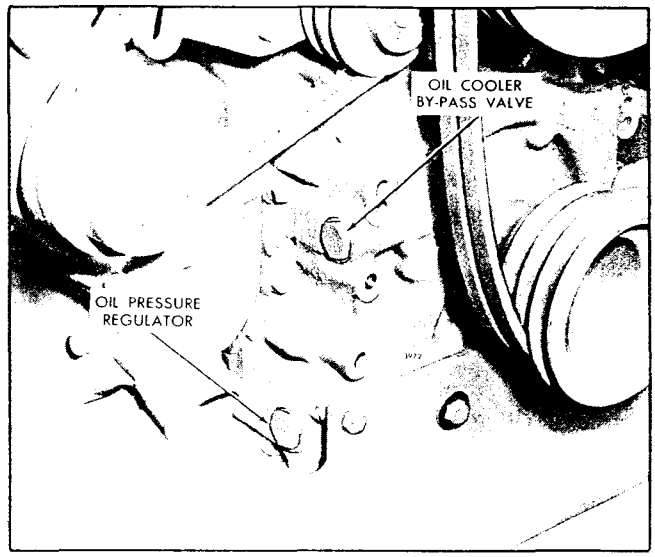


Fig. 2 - Location of Former Oil Pressure Regulator Valve -- 6V Engine Shown

Whenever the lubricating oil pump is removed for inspection, the regulator valve and spring should also be removed, thoroughly cleaned in fuel oil and inspected.

Remove Oil Pressure Regulator

1. Remove the plug and washer from the engine lower front cover.

2. Withdraw the spring and the valve from the cover.

Inspection

Clean all of the regulator parts in fuel oil and dry them with compressed air. Then inspect the parts for wear or damage.

The regulator valve must move freely in the valve bore. If the valve is scored and cannot be cleaned up with crocus cloth, it must be replaced.

Replace a fractured or pitted spring.

Install Oil Pressure Regulator

1. Apply clean engine oil to the outer surface of the valve and slide it into the opening in the engine lower front cover (closed end first).

2. Install a new copper gasket on the plug.

3. While compressing the spring, start the plug in the side of the cover; then tighten the plug.

8V ENGINE

The lubricating oil pressure regulator is located in the engine front cover (Fig. 3).

A regulator assembly consists of a piston type valve, a spring, a plug and gasket.

When the oil pressure at the valve exceeds 52 psi, the valve is forced from its seat and oil from the gallery passage in the front cover is by-passed to the crankcase.

Whenever the lubricating oil pump is removed for inspection, the regulator valve and spring should also be removed, thoroughly cleaned in fuel oil and inspected.

Remove Oil Pressure Regulator

1. Remove the plug and gasket from the engine front cover.

2. Withdraw the spring and valve from the cover.

Inspection

Clean the parts thoroughly in fuel oil, dry them with compressed air and inspect them.

Check to be sure the regulator valve moves freely in the engine cover valve bore. If the valve is scored and cannot be cleaned up with crocus cloth, it must be replaced.

Replace a pitted or fractured spring.

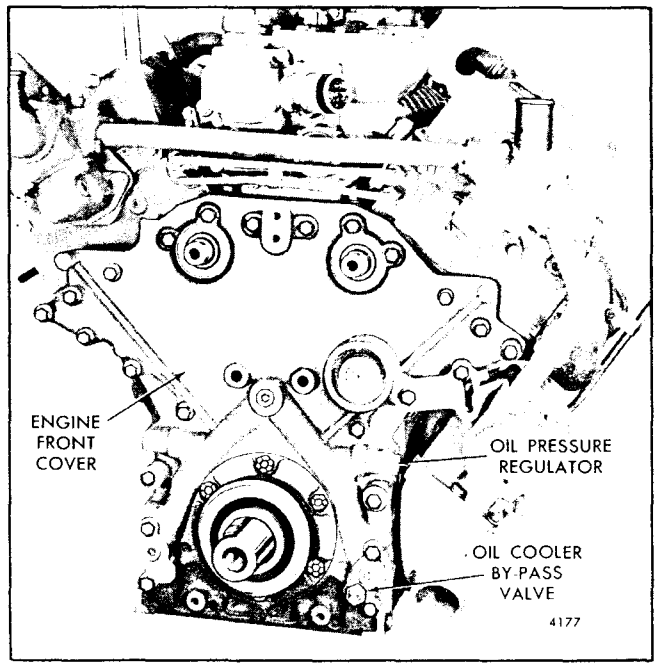


Fig. 3 - Location of Oil Pressure Regulator (8V Engine)

Install Oil pressure Regulator

1. Apply clean engine oil to the outer surface of the valve and slide it into the opening in the engine front cover (closed end first).

2. Install a new copper gasket on the plug.

3. While compressing the spring, start the plug in the side of the cover; then tighten the plug.

LUBRICATING OIL FILTERS

Series 53 engines are equipped with a full-flow type lubricating oil filter. A by-pass type oil filter may be used in addition to the full-flow type filter when additional filtration is desired.

Full-Flow Oil Filter

The full-flow type lubricating oil filter (Fig. 1) is installed ahead of the oil cooler in the lubrication system. On the two and three cylinder models, the oil filter shell is mounted in a downward or rearward position unless an adaptor is used to provide optional mounting positions. On the four cylinder models, the oil filter may be mounted with the filter shell up, down or toward the rear, except when on the blower side of the engine where the down and rearward positions are optional. On V-type engines, the filter is mounted at an angle down and towards the rear of the engine.

CAUTION: Do not reverse the flexible oil filter hoses at the filter hose adaptor on 6V and 8V marine engines equipped with a remote mounted lubricating oil filter. Refer to Fig. 2 for the proper installation of the hoses.

The filter assembly consists of a replaceable element enclosed within a shell which is mounted on an adaptor or base. When the filter shell is in place, the element is restrained from movement by a coil spring.

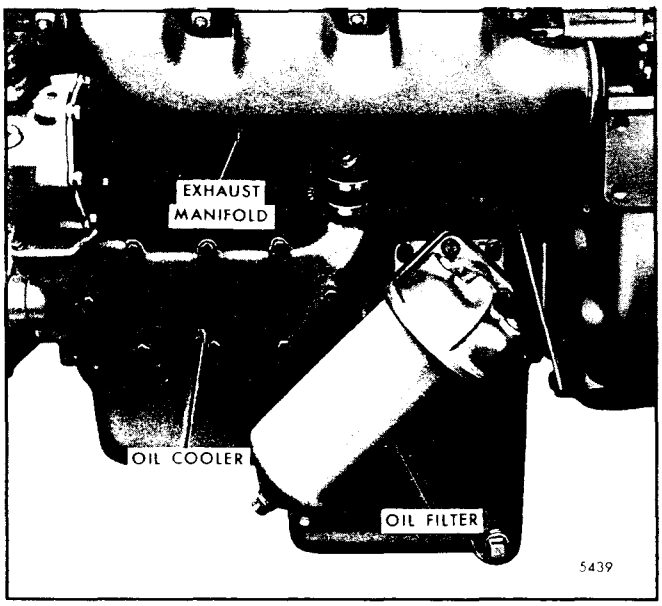


Fig. 1 - Typical Full-Flow Oil Filter Mounting (6V Engine Shown)

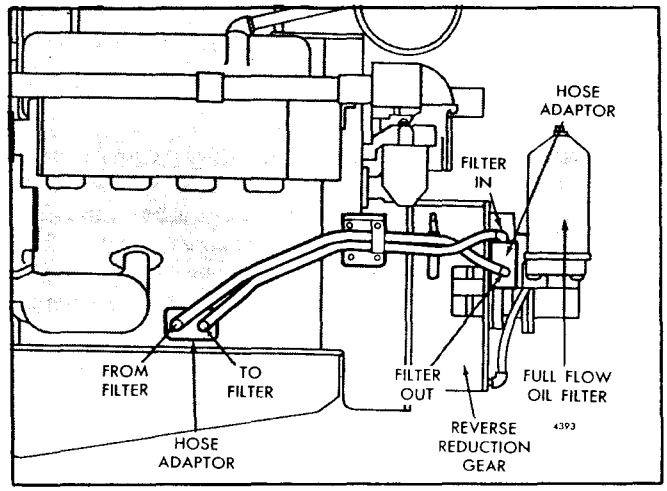


Fig. 2 - Proper Installation of Flexible Oil Filter Hoses

All of the oil supplied to the engine by the oil pump passes through the filter before reaching the various moving parts of the engine. The oil is forced by pump pressure through a passage in the filter base to the space surrounding the filter element. Impurities are filtered out as the oil is forced through the element to a central passage surrounding the center stud and out through another passage in the filter base and then to the oil cooler.

A valve, which opens at approximately 18-21 psi, is located in the filter base on engine mounted filters or in the hose adaptor (7/8 " hoses) with a remote mounted filter and will by-pass the oil directly to the oil cooler should the filter become clogged.

By-Pass Oil Filter

When additional filtration is desired, an oil filter of the by-pass type (Fig. 3) may also be installed on the engine. However, *the size of the orifice on the discharge side of the filter must not exceed .062 "* to control the oil flow rate and to provide sufficient oil pressure when the engine is running at idle speed.

When the engine is running, a portion of the lubricating oil is bled off the oil gallery and passed through the by-pass filter. Eventually all of the oil passes through the filter, filtering out fine foreign particles that may be present.

The by-pass filter assembly consists of a replaceable element contained in a shell mounted on a combination base and mounting bracket. When the shell is in place, the filter element is restrained from movement by a coil spring at the top. A hollow center stud serves as the outlet passage from the filter as well as securing the shell to the base.

On certain models, the filter assembly consists of a replaceable element contained in a shell and sealed in place by a cover. This type of filter assembly incorporates a mounting bracket attached to the filter shell. A hollow center stud serves as the outlet passage from the filter as well as positioning the filter element.

Oil Filter Maintenance

With the use of detergent lubricating oils, the color of the lubricant has lost value as an indicator of oil cleanliness or proper filter action. Due to the ability of the detergent compounds to hold minute carbon particles in suspension, heavy duty oils will always appear dark colored on the oil level dipstick.

Heavy sludge deposits found on the filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. The removal of abrasive dust, metal particles and carbon must be ensured by replacement of the oil filter elements at the time the engine oil is changed.

Selection of a reliable oil supplier, strict observation of his oil change period recommendations and proper filter maintenance will ensure trouble-free lubrication and longer engine life.

Replace Oil Filter Element

Replace the element in either the full-flow or by-pass type oil filter assembly (Figs. 3 and 4) as follows:

1. Remove the drain plug from the filter shell or the filter adaptor or base and drain the oil. If a type S-6 filter assembly is used, oil may be removed with a sump pump after the cover and element are removed.

2. Back out the center stud or the cover nut and withdraw the shell, element and stud as an assembly. Discard the filter element and the shell gasket.

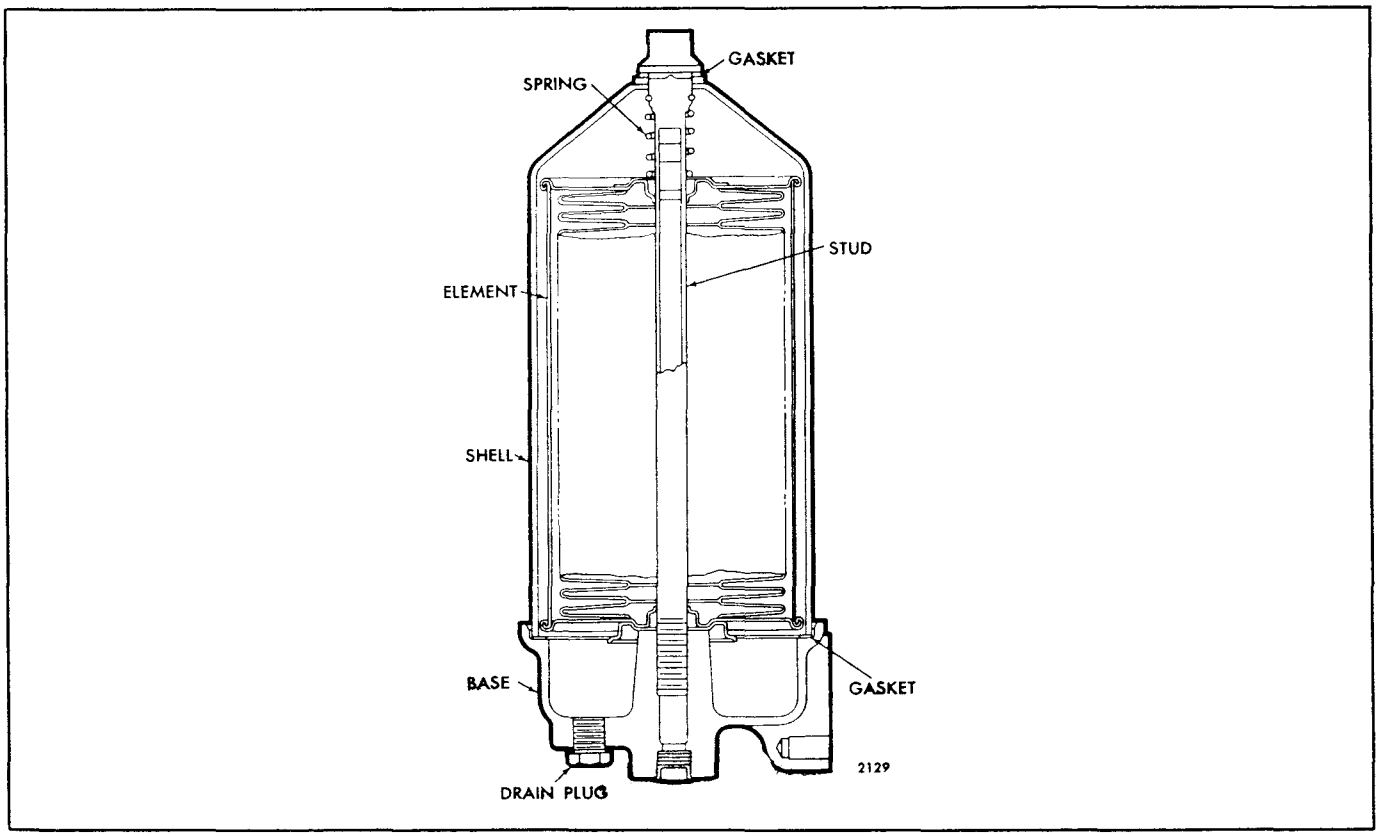


Fig. 3 - By-Pass Oil Filter Details

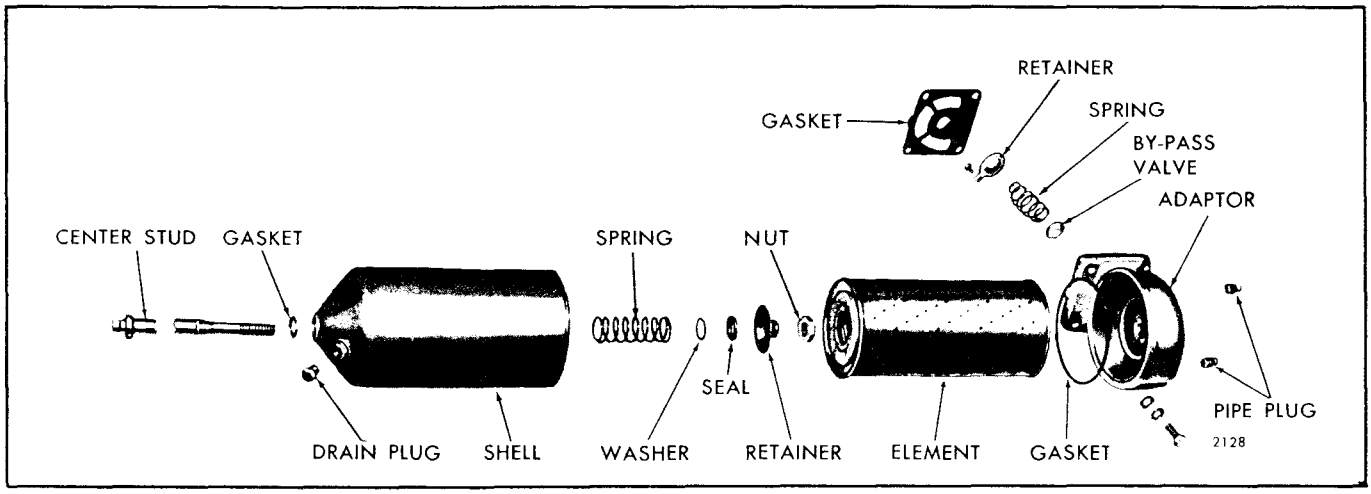


Fig. 4 - Full Flow Oil Filter Details and Relative Location of Parts

3. Remove the center stud and gasket. Retain the gasket unless it is damaged and oil leaks occurred.

4. Remove the nut or snap ring on the full-flow filter center stud.

NOTE: The center stud on the current full-flow oil filter has been revised by removing the snap ring groove and increasing the 5/8 "-18 thread length approximately 1/2 ". To conform with this change, a 5/8 "-18 nut replaces the snap ring formerly used to retain the filter spring and seal.

5. Examine the element retainer seal (Fig. 3) for hardening or cracks. If necessary, replace the seal.

6. Clean the filter shell and the adaptor or base.

7. Install the center stud gasket and slide the stud (with the spring, washer, seal and retainer installed on the full-flow filter) through the filter shell.

8. Install a new shell gasket in the filter adaptor or base.

NOTE: Before installing the filter shell gasket, be sure all of the old gasket material is removed from the filter shell and the filter adaptor or base. Also make sure the gasket surfaces of the shell and the adaptor or base have no nicks, burrs or other damage.

9. Position the new filter element carefully over the center stud and within the shell. Then place the shell, element and stud assembly in position on the filter adaptor or base and tighten the stud to 50-60 lb-ft torque.

10. Install the drain plug.

11. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected and the engine has been stopped long enough (approximately ten minutes) for the oil from various parts of the engine to drain back to the crankcase, add sufficient oil to bring it to the proper level on the dipstick.

Remove and Install By-pass Valve

1. Remove the four bolts and washers and detach the filter adaptor or filter junction housing from the oil cooler adaptor (Fig. 4).

2. Remove the plug and gasket (Fig. 5) or the screw and retainer (Fig. 6) and withdraw the spring and by-pass valve.

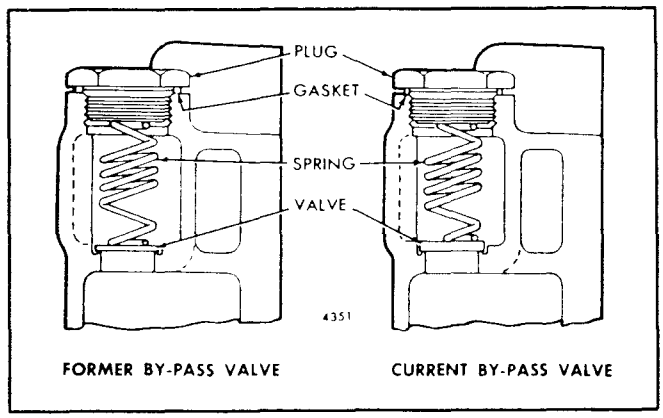


Fig. 5 - By-Pass Valve Assembly Secured by Plug

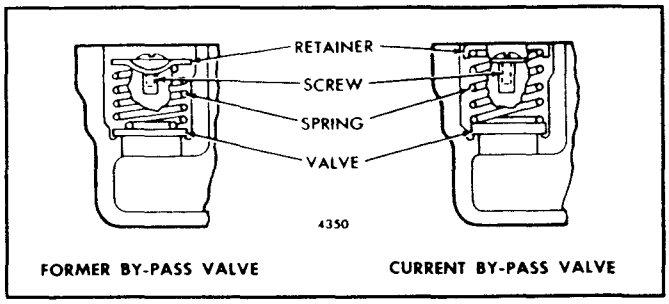


Fig. 6 - By-Pass Valve Assembly Secured by Retainer and Screw

3. Wash all of the parts in clean fuel oil and dry them with compressed air.

4. Inspect the parts for wear. If necessary, install new parts.

5. Reassemble and intall the by-pass valve. Use only the current by-pass valve and spring (Fig. 5) for service. The current thicker valve and stiffer spring increase the by-pass pressure from 13-18 psi to 18-21 psi to permit more efficient filtration. A thicker valve, stronger spring, heavier retainer and a longer retaining screw are currently used in the by-pass valve assembly shown in Fig. 6. The filter adaptors and filter junction housings have been revised by deepening the valve cavity to accommodate the thicker valve and related parts.

6. Use a new gasket and install the filter adaptor or filter junction housing.

CAUTION: The small protrusion on the gasket must mate with the boss on the filter adaptor regardless of the position in which the filter is assembled. If the gasket is not correctly positioned, the flow of oil will be obstructed.