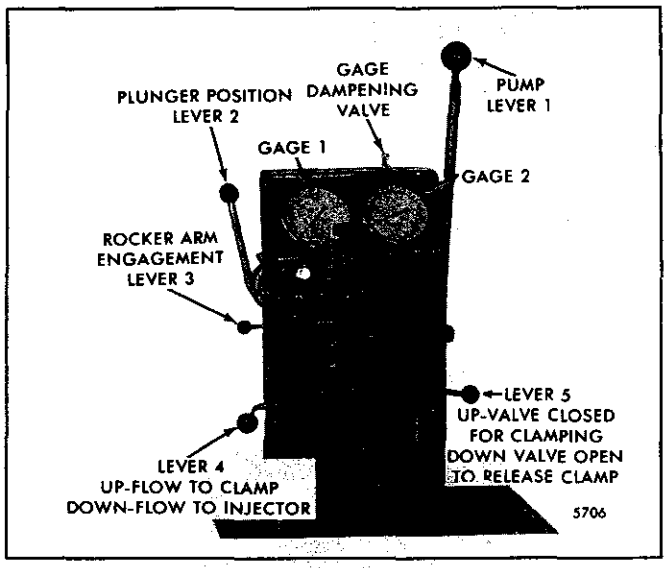

Fig. 3 – Injector in Position for Testing with J 23010–A

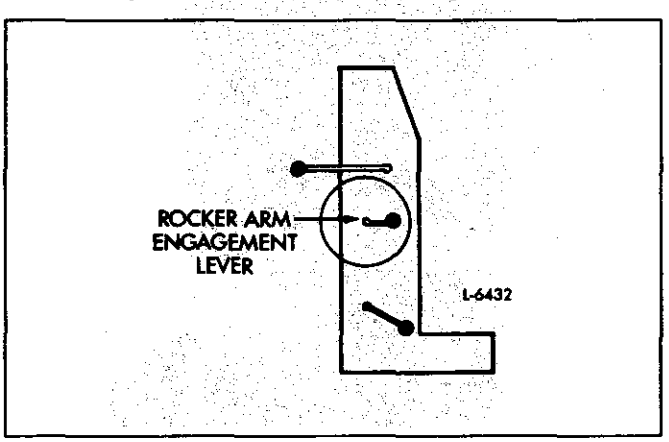

Fig. 4 – Position of Rocker Arm Engagement Lever

4. Hold the clamping head in position over the filter caps and, with the left hand, operate pump lever 1 evenly to move the clamping head *down* to seal the filter caps. The Thru–Flow valve should still turn freely. If it does not, turn the valve counterclockwise until it rotates freely and reapply clamping pressure.

   NOTICE: Excessive force on lever 1 during clamping can damage the seals in the valves operated by levers 4 and 5.

Purging Air from the System

Move lever 4 down and operate pump lever 1 to produce a test oil flow through the injector. When air bubbles no longer pass through the clear discharge tubing, the system is free of air and is now ready for testing.

Check the injector for leaks as follows:

1. Operate pump lever 1 until gage 1 slowly reaches 100–200 psi (689–1378 kPa). Check for injector nut seal ring leaks. Then, increase gage reading to 1500–2000 psi (10 335–13 780 kPa). Cheek for leaks at the filter cap gaskets and the body plugs.
2. Note the time for the pressure to drop from 1500 psi to 1000 psi (10 335 kPa to 6890 kPa). This should not occur in less than 7 seconds. This test determines if the body–to–bushing mating surfaces in the injector are sealing properly.

Injector Valve Opening, Atomization and Spray Pattern Test

This test determines spray pattern uniformity and the relative pressure at which the valve opens and injection begins.

1. Position the injector rack in the *full–fuel* position.
2. Place pump lever in the *vertical* position.
3. Move the rocker arm engagement lever to the forward detent (Fig. 4).
4. Turn the gage damping valve knob (Fig. 3) clockwise to the *closed* position, then open the vlave slightly to control the rate of return of the gage hand. This valve is deleted on the current testers.
5. Operate the pump lever uniformly and observe the spray pattern produced.

Some experimentation may be necessary to determine the most effective rate at which the injector should be stroked. The correct rate is the one that produces the highest gage reading, too fast or too slow will give low readings.

The highest pressure indication will be reached just before injection ends. Use the following reference values to determine the relative acceptability of the injector (138 Min. – 162 Max.).

The reference values obtained when pop testing the needle valve injectors are to be used as a troubleshooting and diagnosis aid. This allows comparative testing of injectors without disassembly. Exact valve opening pressure values can only be determined by the needle valve tip test using the J 23010–A tester and tip tester adaptor on the J 22640 auxiliary tester.

Unclamping the Injector

1. Open the Thru–Flow valve to release pressure in the system.
2. Move lever 5 *down* to release the clamping pressure.
3. Swing out the adaptor plate and remove the injector after the nylon seals in the clamping head are free and clear of the injector filter caps.
4. Carefully, return lever 5 to the *up (horizontal)* position.

CHECKING INJECTOR TESTER J 23010–B OR J 9787

The injector tester J 23010–B or J 9787 should be checked monthly to be sure that it is operating properly. The following check can be made very quickly using test block J 9787–49.

Fill the supply tank in the injector tester with clean injector test oil J 26400. Open the valve in the fuel supply line. Place the test block on the injector locating plate and secure the block in place with the fuel inlet connector clamp. Operate the pump handle until all of the air is out of the test block, then clamp the fuel outlet connector onto the test block. Break the connection at the gage and operate the pump handle until all of the air bubbles in the fuel system disappear. Tighten the connection at the gage. Operate the pump handle to pressurize the tester fuel system to 2400–2500 psi (16 536–17 225 kPa.) Close the valve on the fuel supply line. After a slight initial drop, the pressure should remain steady. This indicates that the injector tester is operating properly. Open the fuel valve and remove the test block.

If there is a leak in the tester fuel system, it will be indicated by a drop in pressure. The leak must be located, corrected and the tester rechecked before checking an injector.

Occasionally, dirt will get into the pump check valve in the tester, resulting in internal pump valve leakage and the inability to build up pressure in the tester fuel system. Pump valve leakage must be corrected before an injector can be properly tested.

When the above occurs, loosen the fuel inlet connector clamp and operate the tester pump handle in an attempt to purge the dirt from the pump check valve. A few quick strokes of the pump handle will usually correct a dirt condition. Otherwise, the pump check valve must be removed, lapped and cleaned, or replaced (J 9787). The pump check valve in J 23010–A must be replaced.

If an injector tester supply or gage line is damaged or broken, install a new replacement line (available from the tester manufacturer). Do not shorten the old lines or the volume of test oil will be altered sufficiently to give an inaccurate valve holding pressure test.

If it is suspected that the lines have been altered, i.e. by shortening or replacing with a longer line, check the accuracy of the tester with a master injector on which the pressure holding time is known. If the pressure holding time does not agree with that recorded for the master injector, replace the lines.

INJECTOR SPRAY TIP TESTER (J 22640–A)

Valve Opening, Spray Pattern and Atomization.

1. Operate the pump handle until a clear flow of test oil is obtained at the tip mounting pedestal.
2. Place the tip assembly, valve spring with cage and check valve cage on top of the pedestal. Tighten the injector nut (Fig. 5).

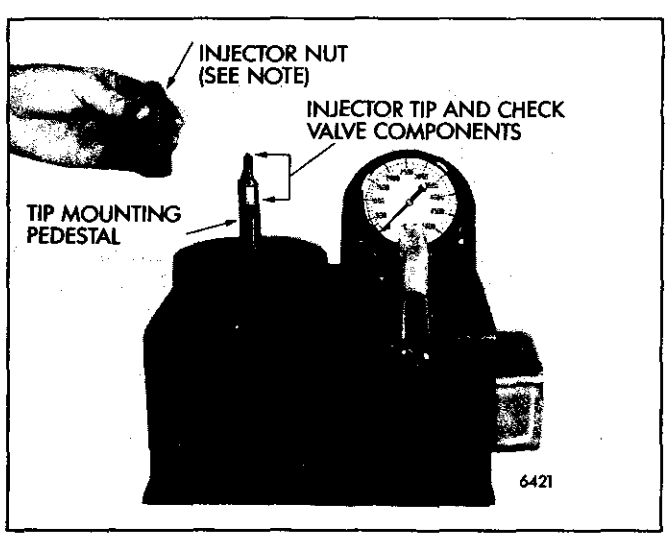

Fig. 5 – Installing Injector Nut

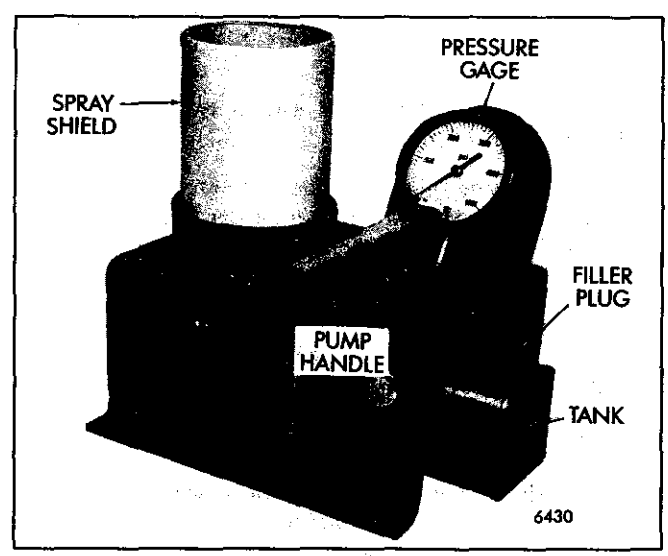

Fig. 6 – Tester J 22640–A with Shield Installed

3. Place the shield on the tester and operate the pump handle until the needle valve has opened several times to purge air from the system (Fig. 6).

   CAUTION: Do not operate the tester without the shield. The fuel spray can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

4. Operate the pump lever rapidly with smooth even strokes (40 strokes per minute) simulating the action of the tip functioning in the engine. Note the pressure at which the test oil delivery occurs. Test oil delivery should occur between 2200 and 3300 psi (15 158 and 22 737 kPa). When using the high V.O.P. spring, the oil delivery will occur at 2900–3900 psi (19 981–26 871 kPa). The beginning and ending of delivery should be sharp and the test oil should be a finely atomized spray.

If the valve opening pressure is below the minimum specified limits or atomization is poor, the cause is usually a weak valve spring or poor needle valve seat.

If the valve opening pressure is within specified limits, proceed to check for spray tip leakage as follows:

When testing for spray tip leakage, be sure to use the proper spring for the valve tip being tested.

a. Actuate the pump lever several times and hold the pressure at 1500 psi (10 335 kPa) for 15 seconds.

b. Inspect the spray tip for leakage. There should be no fuel droplets, although a slight wetting at the spray tip is permissable.

Field Modification Kit (J 22640–51) consists of a pump and reservoir with hardware which is used to convert auxiliary tester J 22640 to J 22640–A. Tester J 22640 was previously connected to the pump of the pop stand.

INJECTOR SPRAY TIPS

Due to a slight variation in the size of the small orifices in the end of each spray tip, the fuel output of an injector may be varied by replacing the spray tip.

Flow gage J 25600 may be used to select a spray tip that will increase or decrease fuel injector output for a particular injector after it has been rebuilt and tested on the calibrator.

Field Modification Kit (J 25600–103) upgrades plunger and bushing/tip flow gage J 25600 to J 25600–A. The kit includes adaptors for Series 53 plunger and bushings. A newly designed spray tip receiver/holder is included with the kit along with instruction decals to be applied to the tester. This kit greatly upgrades the function of J 25600 by improving operation and repeatability.

CHECK INJECTOR OUTPUT

Perform the injector fuel output test in calibrator J 22410–A (Fig. 7).

1. Before testing injector output, be sure calibrator test oil is supplied to the injector fitting located over the rack. To change the flow from the calibrator, exchange the positions of the braided and the clear fuel lines (Fig. 8).

2. Place the cam shaft index wheel and fuel flow lever in their respective positions. Turn on the test fuel oil heater switch to preheat the test oil to 95–105°F (35–40°C).

3. Place the proper injector adaptor between the tie rods and engage it with the fuel block locating pin. Then, slide the adaptor forward and up against the fuel block face.

4. Place the injector seat J 22410–226 into the permanent seat (cradle handle in the *vertical* position). Clamp the injector into position by operating the injector clamp–up valve.

   Set the counter (Fig. 9) at the appropriate number of strokes, 500 or 1,000. If for any reason this setting has been altered, reset the counter for the correct number of strokes. Calibrators with Serial No. 1175 or lower were manufactured as 1,000 stroke machines, but may have been converted to 500 stroke machines with a conversion kit (J 22410–516). Refer to the calibrator instruction manual for information on setting the counter and any additional information required.

5. Pull the injector rack out to the *no–fuel* position.

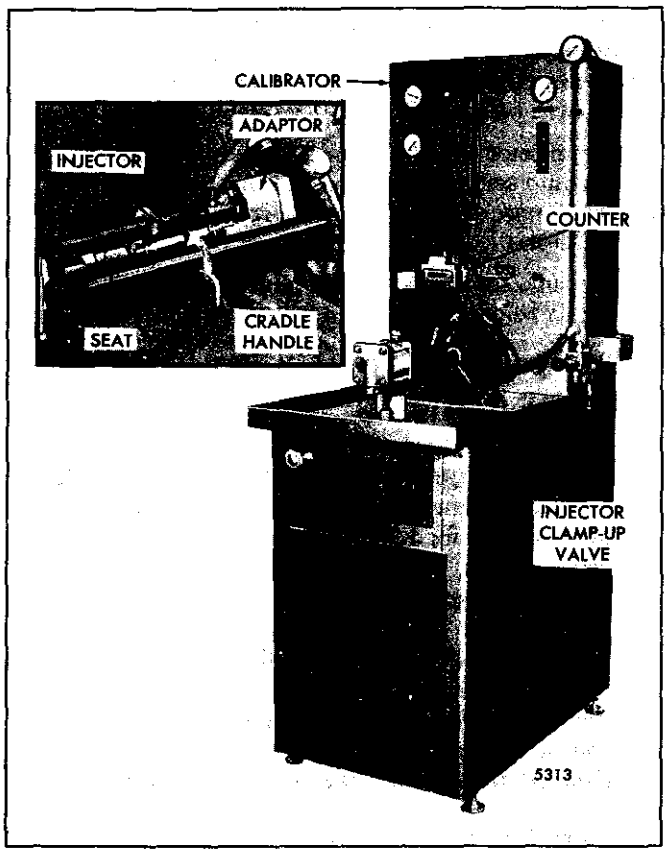

Fig. 7 – Injector in Calibrator J 22410–A

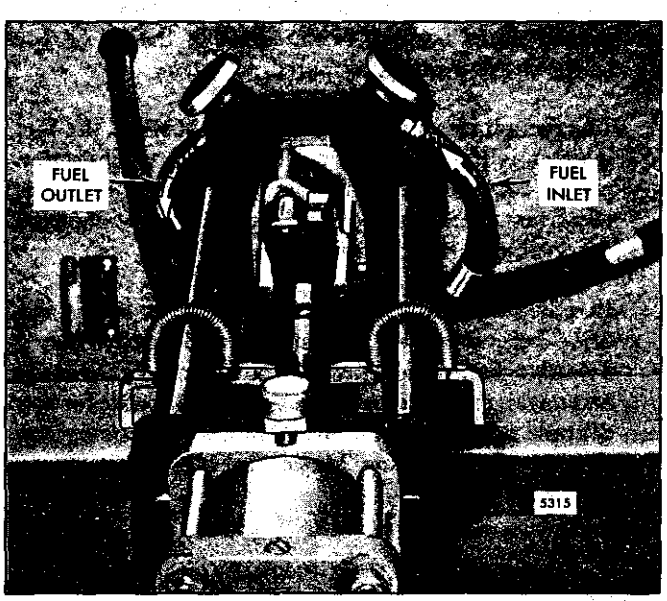

Fig. 8 – Position of Calibrator Fuel Flow Pipes

6. Turn on the main power control circuit (vial light) switch. Then, start the calibrator by turning on the motor starter switch. The low oil pressure warning buzzer will sound briefly until the lubricating oil reaches the proper pressure.

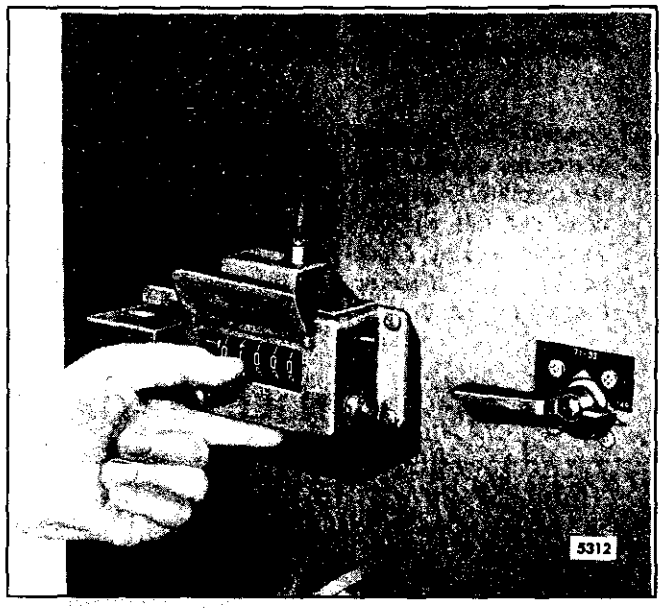

Fig. 9 – Setting Calibrator Stroke Counter

Injector	Calibrator	
	Min.	Max.
5A50	53	58
5A55	56	61
5A60	63	68
5A72	70	75
5C50	52	57
5C55	59	64
5C60	66	71
5D45	47	52
5E50	51	56
5E55	58	63
5E60	65	70
C40	42	47
C45	47	52
C50	50	55
M40	40	45
M55	55	60
M60	60	65
N40	42	47
N45	47	52
N50	50	55
6815	55	60
7005	85	91

TABLE 1

7. After the calibrator has started, set the injector rack into the *full–fuel* position. Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.

8. After the air is purged, press the red button on the test switch. This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after the correct number of preset strokes are counted.

9. Shut the calibrator off when two consecutive tests show the same output. Usually, 3 tests are sufficient.

10. Observe the vial readings and refer to Table 1 to determine whether the injector fuel output falls within the specified limits. If the quantity of fuel in the vial does not fall within the specified limits, refer to *Troubleshooting Chart 6* for the cause and remedy. See *Injector Calibrator Readings* for different factors that may affect the injector calibrator output reading.

The calibrator may be used to check and select a set of injectors which will inject the same amount of fuel in each cylinder at a given throttle setting, thus resulting in a smooth running, well balanced engine.

An injector which passes all of the above tests may be put back into service. However, an injector which fails to pass one or more of the tests must be rebuilt and checked on the calibrator.

Any injector which is disassembled and rebuilt must be tested again before being placed in service.

INJECTOR CALIBRATOR READINGS

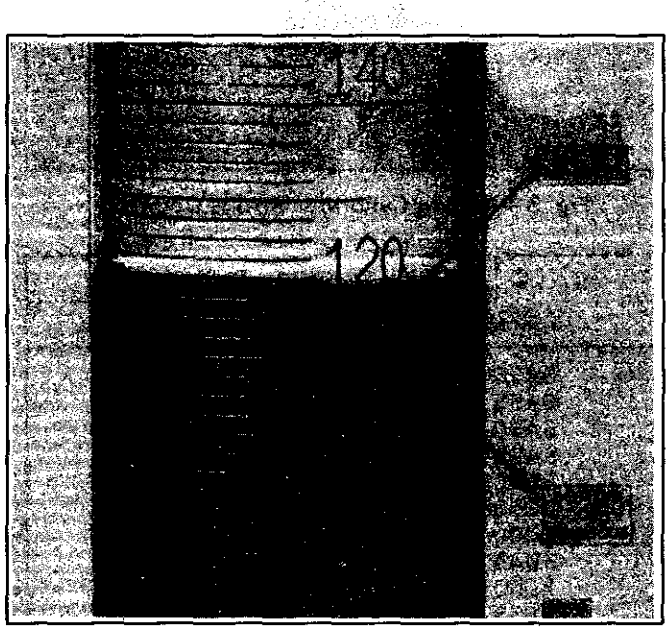

Fig. 10 – Checking Fuel Output

Several factors affect the injector calibrator output readings. The four major items are:

1. **Operator Errors:** If the column of liquid in the vial is read at the top of the meniscus instead of at the bottom, a variation of 1 or 2 points will result. Refer to (Fig. 10).
2. **Air In Lines:** This can be caused by starting a test before the air is purged from the injector and lines, or from an air leak on the vacuum side of the pump.
3. **Counter Improperly Set:** The counter should be set to divert the injector output at 1,000 strokes, but must be reset for 1,200 strokes to check 35 and 40 cu. mm injectors. It is possible that in returning to the 1,000 stroke setting, an error could be made.

   This should not be confused with counter overrun that will vary from 2 to 6 digits, depending upon internal friction. The fuel diversion is accomplished electrically and will occur at 1,000 strokes (if properly set) although the counter may overrun several digits.

4. **Test Oil:** A special test oil is supplied with the calibrator and should always be used. If regular diesel fuel oil (or any other liquid) is used, variations are usually noted because of the effect of the oil on the solenoid valve and other parts.

   The fuel oil introduced into the test oil when the fuel injector is placed in the calibrator for a calibration check contaminates the test oil. Therefore, it is important that the test oil and test oil filter be changed every six months, or sooner, if required.

   In addition, other malfunctions such as a slipping drive belt, low level of test oil, a clogged filter, a defective pump or leaking line connections could cause bad readings. A frequent check should be made for any of these tell–tale conditions. Calibrator accuracy can only be verified using Master Injectors J 26298 or J 35369.

INJECTOR PLUNGERS

The fuel output and the operating characteristics of an injector are, to a great extent, determined by the type of plunger used. Three types of plungers are illustrated in (Fig. 11). The beginning of the injection period is controlled by the upper helix angle. The lower helix angle retards or advances the end of the injection period. Therefore, it is imperative that the correct plunger is installed whenever an injector is overhauled. If injectors with different type plungers (and spray tips) are mixed in an engine, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

Injector plungers cannot be reworked to change the output or operating characteristics. Grinding will destroy the hardened case and result in chipping at the helices and seizure or scoring of the plunger.

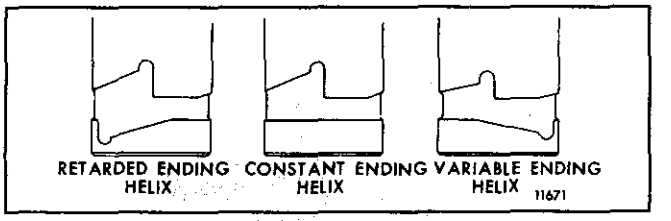

Fig. 11 – Types of Injector Plungers

MASTER INJECTOR CALIBRATING KIT

Use Master Injector Calibrating Kit J 26298 or J 35369 to determine the accuracy of the injector calibrator.

With the test fluid temperature at 100°F ± 1° (38°C ± 1°) and each injector warm after several test cycles, run the three injectors contained in the kit. Several readings should be taken with each injector to check for accuracy and repeatability. If the output readings are within 2 percent of the values assigned to the calibrated masters, the calibrator can be considered accurate. Injector testing can be carried out now without any adjustment of figures. However, when testing new injectors for output, any difference between the calibrator and the masters should be used to compute new injector calibration. If more than a 2 percent variation from the masters is noted, consult the calibrator manufacturer for possible causes.

The calibrated masters should only be used to qualify injector output calibration test equipment.

PLUNGER/BUSHING AND TIP FLOW GAGE

The injector fuel output is largely dependent upon the combined output of its plunger/bushing and spray tip assemblies. To assist in the rebuilding of fuel injectors that will calibrate within specified limits, it is desirable to preselect and match plunger/bushings and tips according to their output prior to assembly into the injector.

The J 25600–A Plunger/Bushing and Tip Flow Tester, using low pressure air, has the capabilities to measure the output of plunger/bushing and spray tip assemblies. The flow (output) of the spray tip can be correlated to high pressure fuel flow during calibration however, used spray tips because of the worn condition of their spray holes will often flow higher then indicated on a low pressure air tester.

Records should be maintained which indicate the output values of both plunger/bushing and spray tip assemblies being matched with resultent calibration in order to develop a useful matching chart.

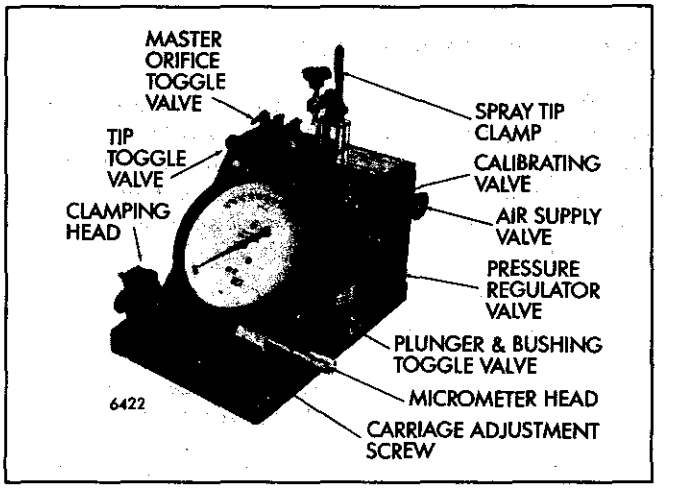

Fig. 12 – Plunger/Bushing and Tip Flow Gage J 25600–A

Installation

Place the flow gage unit in a clean well lighted area that has an air supply of 40 psi (276 kPa), but not more than 150 psi (1034 kPa). Turn off the air supply valve (on the rear of the flow gage) and connect your air line. Familiarize yourself with the various components on the unit (Fig. 12).

Regulated Pressure Adjustment

1. Set all toggle valves in the *closed* position (Fig. 12).
2. Open the calibrating valve approximately 4 turns.

NOTICE: DO NOT use this valve as an air shutoff. Tight closing of this valve may result in valve seat damage.

3. Turn the pressure regulator knob in a counterclockwise direction until it spins freely.
4. Open the air supply valve approximately 3 turns. The pressure regulator is a constant bleed type (.04 cubic feet per minute), the air supply valve is provided as a convenient shutoff to avoid compressed air waste when the flow gage is not in use.

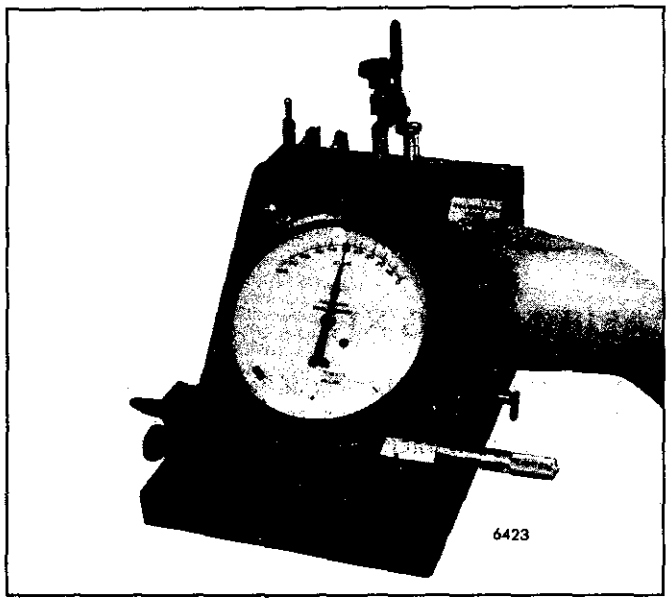

Fig. 13 – Adjusting the Calibrating Valve

5. Adjust the pressure regulator by rotating the knob in a clockwise direction until the gage needle is aligned exactly on the regulated pressure mark.

Calibration to Master Orifice

When no air is leaking through a master orifice, injector tip or plunger/bushing, the gage needle will go to the regulated pressure mark. The master orifices (A, B and C) are provided as controlled air leak passages. Flow tests are conductedfcomparing an injector tip or a plunger/bushing, to an air leak through a master orifice.

1. Be sure all toggle valves are in the *off* position. The gage needle will be at the regulated pressure mark.
2. Open master orifice valve A. The gage needle will move away from the regulated pressure mark.
3. Adjust the calibrating valve, so that the gage needle is exactly at the "set line" (Fig. 13).
4. Close the master orifice toggle valve (needle will return to the regulated pressure mark).
5. You are now ready to perform a flow measurement.

Measuring Spray Tip Flow

1. Clean all spray tips thoroughly (correct flow rate is dependent on a clean spray tip).
2. Observe the number and size of the spray tip holes marked on the narrow end of the spray tip and calibrate to orifice A. Refer to the Chart for the flow values.

TIP STAMP	NOMINAL FLOW VALUE	MASTER ORIFICE CALIBRATION
6-.006	22	
7-.006	69	
8-.0055	26	A
8-.006	48	

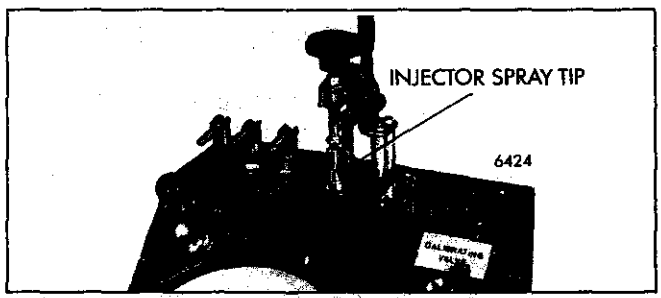

Fig. 14 – Spray Tip Installed in Tester

3. Remove the needle valve, if installed, and clamp the spray tip on the unit (Fig. 14).
4. Open the tip toggle valve and observe the gage reading.
5. The tip can now be compared to the specification sheet and sorted into groups; high, low, mean, etc.

Plunger/Bushing Effective Stroke Measurement

The reason for measuring the flow through the plunger/bushing assemblies is to measure the effective stroke (port closing to opening), in thousandths of an inch. To find the closing and opening points a controlled air leak is used ("A" master orifice is used as reference). When the plunger is moved close to the port *closed* position, the gage needle will be at the set line. At this position, the air leaking out the bushing port matches the air that would leak out the "A" orifice.

As the plunger is moved inward, the leak stops and the gage needle goes to the regulated pressure mark. When the plunger is moved further, air begins to leak again. The gage needle moves away from the regulated pressure mark and moves toward the set line. When the plunger is moved far enough to read the effective stroke, the gage needle will be at the set line again. The distance the plunger has moved as indicated on the micrometer, is the effective stroke. This stroke is measured while the plunger/bushing is held in the *full-fuel* position.

1. Select the proper cradle for the plunger/bushing to be tested and mount on the fixture (Fig. 15).
2. Calibrate to the "A" orifice, see "Calibration to Master Orifice". All plunger/bushing tests use the "A" orifice as reference.

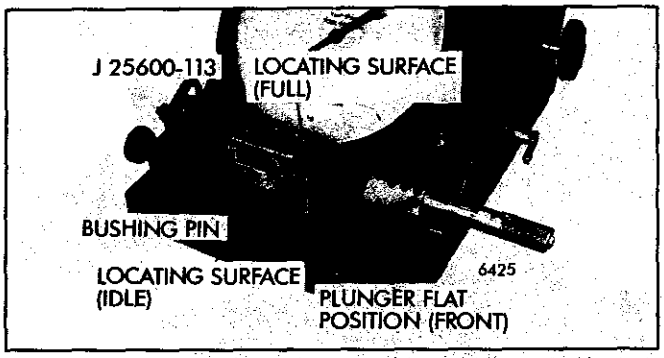

Fig. 15 Cradle Mounted on Fixture

3. Close all toggle valves, gage needle will be at the regulated pressure mark.
4. Adjust the micrometer to zero reading (all zeros).
5. Place the plunger/bushing in the cradle. Be sure the plunger flat and locating pin or slot is properly positioned (Fig. 15). To check in *full–fuel* position, rotate bushing until the bushing pin contacts the rear locating surface.
6. Adjust spring loaded button until enough force is exerted on the plunger flat to hold the plunger steady, but not enough to restrict sliding movement when air pressure is applied.
7. Hold the plunger against the micrometer and rotate the carriage adjustment screw until the plunger almost closes the port (Fig. 16).
8. Open the plunger and bushing toggle valve.
9. If the plunger has not closed the port far enough, an air leak will be heard and the gage needle will be left of the set line. If it has closed the port too far, it will be to the right of the set line, toward or at the regulated pressure mark.
10. Turn the carriage adjustment screw until the gage needle is at approximately 20.
11. Turn the carriage adjustment screw clockwise very slowly until the gage needle is exactly at the set line. Always adjust in this manner, with the needle moving from approximately 20 to the set line.
12. Turn the micrometer thimble clockwise. The gage needle will move toward, and go to the regulated pressure mark. Very little air will be heard leaking.
13. Continue turning clockwise until the gage needle begins to move away from the regulated pressure mark (air from the bushing will again be heard leaking). Turn very slowly until the gage needle reaches the set line.
14. Observe and record the micrometer reading. The number shown is the effective stroke in thousandths of an inch.
15. Turn the micrometer back to zero. Gage needle should return to or very near the set line.
16. Turn off the plunger/bushing test toggle valve.
17. Loosen the clamping knob and remove the plunger/bushing.
18. Only minor carriage adjustment will be required for other plunger/bushing of the same type.
19. Chart the stroke readings and compare to the specifications. Sort into groups, high strokes, low strokes and mean strokes.

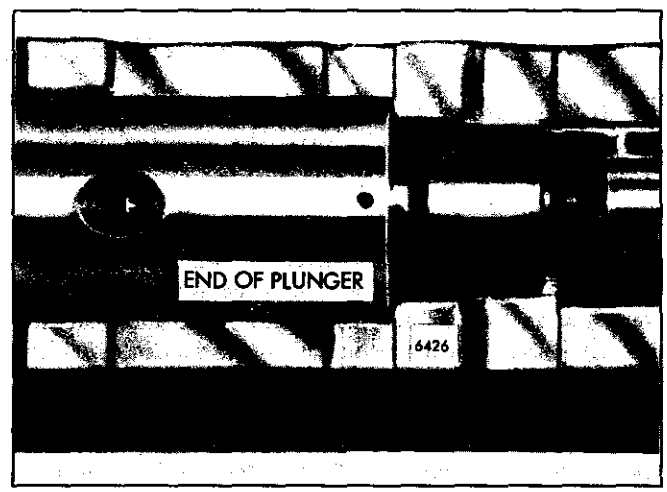

Fig. 16 – End of Plunger Shown in Port

REFINISH LAPPING BLOCKS

As the continued use of the lapping blocks will cause worn or low spots to develop in their lapping surfaces, they should be refinished from time to time.

It is good practice, where considerable lapping work is done, to devote some time each day to refinishing the blocks. The quality of the finished work depends to a great degree on the condition of the lapping surfaces of the blocks.

To refinish the blocks, spread some 600 grit lapping powder of good quality on one of the blocks. Place another block on top of this one and work the blocks together (Fig. 17). Alternate the blocks from time to time. For

example, assuming the blocks are numbered 1, 2 and 3, work 1 and 2 together, then 1 and 3, and finish by working 2 and 3 together. Continue this procedure until all of the blocks are perfectly flat and free of imperfections.

Imperfections are evident when the blocks are clean and held under a strong light. The blocks are satisfactory when the entire surface is a solid dark grey. Bright or exceptionally dark spots indicate defects and additional lapping is required.

After the surfaces have been finished, remove the powder by rinsing the lapping blocks in trichloroethylene and scrubbing with a bristle brush.

When not in use, protect the lapping blocks against damage and dust by storing them in a close fitting wooden container.

Fig. 17 – Refinishing Lapping Blocks

EFFECT OF PREIGNITION ON FUEL INJECTOR

Preignition is due to ignition of fuel or lubricating oil in the combustion chamber before the normal injection period. The piston compresses the burning mixture to excessive temperatures and pressures and may eventually cause burning of the injector spray tip and lead to failure of the injectors in other cylinders.

When preignition occurs, remove all of the injectors and check for burned spray tips or enlarged spray tip orifices.

Before replacing the injectors, check the engine for the cause of preignition to avoid recurrence of the problem. Check for oil pull–over from the oil bath air cleaner, damaged blower housing gasket, defective blower oil seals, high crankcase pressure, plugged air box drains, ineffective oil control rings or dilution of the lubricating oil.

INJECTOR TIMING

If it is suspected that a fuel injector is "out of time", the injector rack–to–gear timing may be checked without disassembling the injector.

A hole located in the injector body, on the side opposite the identification tag, may be used to visually determine whether or not the injector rack and gear are correctly timed. When the rack is all the way in (*full–fuel* position), the flat side of the plunger will be visible in the hole, indicating that the injector is "in time". If the flat side of the plunger does not come into full view (Fig. 18) and appears in the "advanced" or "retarded" position, disassemble the injector and correct the rack–to–gear timing.

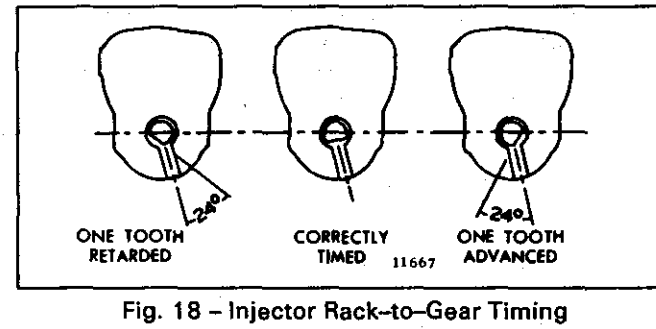

Fig. 18 – Injector Rack–to–Gear Timing

FUEL LINES

Flexible fuel lines are used to facilitate connection of lines leading to and from the fuel tank, and to minimize the effects of any vibration in the installation.

Be sure a restricted fitting of the proper size is used to connect the fuel return line to the fuel return manifold. Do not use restricted fittings anywhere else in the fuel system.

When installing fuel lines, it is recommended that connections be tightened only sufficiently to prevent leakage of fuel; thus, flared ends of the fuel lines will not become twisted or fractured because of excessive tightening. After all fuel lines are installed, run the engine long enough to determine whether or not all connections are sufficiently tight. If any leaks occur, tighten the connections only enough to stop the leak. Also, check the filter cover bolts for tightness.

LOCATING AIR LEAKS IN FUEL LINES

Air drawn into the fuel system may result in uneven running of the engine, stalling when idling, or a loss of power. Poor engine operation is particularly noticeable at the lower engine speeds. An opening in the fuel suction lines may be too small for fuel to pass through but may allow appreciable quantities of air to enter.

Check for loose or faulty connections. Also, check for improper fuel line connections such as a fuel pump suction line connected to the short fuel return line in the fuel tank which would cause the pump to draw air.

Presence of an air leak may be detected by observing the fuel filter contents after the filter is bled and the engine is operated for fifteen (15) to twenty (20) minutes at a fairly high speed. No leak is indicated if the filter shell is full when loosened from its cover. If the filter shell is only partly full, an air leak is indicated.

PRESSURIZE FUEL SYSTEM – CHECK FOR LEAKS

Always, check the fuel system for leaks after injector or fuel pipe replacement and any time the fuel connections under the rocker cover are suspected of leaking. Failure to correct a serious fuel leak in this area can lead to dilution of the lube oil and bearing and/or cylinder kit damage.

Prime and Purge

Prime and/or purge the engine fuel system before starting the fuel leak check. *Prime* the system by blocking or disconnecting the line from the fuel pump, then apply fuel under pressure (60–80 psi or 413–552 kPa) to the inlet of the secondary filter. If the system is to be *purged* of air as well, allow the fuel to flow freely from the fuel return line until a solid stream without air bubbles is observed.

Check for Leaks

Use one of the following methods to check for leaks.

Method 1. Use when the engine has been operating 20–30 minutes.

After operating the engine, shut it off and remove the rocker covers. Inspect the lube oil puddles that normally form where the fuel connectors join the cylinder head and where the fuel pipes join the fuel pipe nuts.

If there is any leakage at these connections, the lube oil puddles will be smaller or thinner than the puddles on the connectors that are not leaking. Disassemble, inspect and correct or replace the suspect part (connector washer, connector, injector or jumper line). Test and reinspect.

Method 2. Use when the engine is not operating, such as during or after repairs.

Remove the rocker covers. Pour lube oil over all fuel pipes and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form at the joining surfaces as mentioned in Method 1. Block off the fuel return line and disconnect the fuel pump supply line at the secondary filter. Install a pressure gage in the filter adaptor, then apply 60–80 psi (413–552 kPa) fuel to the outlet side of the secondary filter with the inlets plugged. Severe leaks will show up immediately. Minor leaks caused by nicks or burrs on sealing surfaces will take longer to appear. After maintaining 40–80 psi (276–552 kPa) for 20 to 30 minutes, a careful puddle inspection should reveal any suspect connectors. Inspect and repair or replace connectors as necessary. Test and reinspect.

Method 3. Use while the engine is operating at 400–600 rpm.

Apply an outside fuel source capable of 60–80 psi (413–552 kPa) to the outlet side of the secondary filter. Pour lube oil over jumper lines and connectors so that oil puddles form where lines and connectors meet. Install a valve and a pressure gage in the fuel return line. With the engine idling, close the valve enough to raise the engine fuel pressure to 70 psi (483 kPa). After ten to twenty minutes inspect the oil puddles to see if any have become smaller or run off completely. The undiluted oil will hang the same as when the oil was poured on. Repair and retest.

> **NOTICE:** With the engine at rest, as in Method 2 all injectors will leak to some extent when pressurized. The leakage occurs because there is no place else for the pressurized fuel to go. When the low and high pressure cavities in the injector are subjected to the high test pressure, fuel is forced past the plunger into the rack and gear cavity. Result: Droplets of fuel form at the rack and drip off.

Slightly worn plungers may leak more under these conditions. This leakage will not occur while the engine is running because of the dynamic and pressure conditions that exists.

If injectors are suspected of leaking and contributing to dilution of the lube oil, they should not be tested by pressurizing the fuel system as in Method 2. Injectors should be removed from the engine and tested for pressure-holding capability (see Section 2).

Points To Remember

Lube oil puddle inspection is the key to pressure testing the fuel system for internal leaks. This test can be performed any time the rocker covers are removed, after the fuel pipes and connectors have been splashed with oil and there is normal fuel pressure in the system. The weak or missing puddles show where the leaks are.

All leakage or spillage of fuel during leak detection testing further dilutes the lube oil, so the final step in maintenance of this type should include lube oil and lube oil filter changes.

DETECTING INTERNAL FUEL LEAKS

Used lube oil analysis often identifies a potential source of engine trouble before it occurs. One of the most serious conditions this test can uncover is the presence of excessive fuel in the lubricating oil. Inadequate bearing surface lubrication caused by lube oil dilution is a potential cause of engine malfunction and damage.

While used lube oil analysis can indicate the presence of fuel in engine lubricating oil, other methods must be used to determine its source. Two particularly effective methods involve the use of dye additives.

Red LTO 1140 Dye

The use of Red LTO 1140 dye (a product of Chemserve Corporation, 9505 Copland Ave., Detroit, MI 48209) is effective when bench pressure–testing complete cylinder head assemblies or when pressure testing head assemblies on new or newly overhauled *operating* engines which have *new, clean lubricating oil.* The red dye is most visible when clean lube oil is used. Prepare the dye as follows:

Mix two (2) ounces (59 ml) of Red LTO 1140 dye with five (5) gallons (18.93 liters) of clean No. 1 or No. 2 diesel fuel in a clean container. The container should be marked "Test Fuel" to prevent accidental use and be resealable to prevent contamination when not in use.

Bench Testing

1. To bench test a complete cylinder head assembly, fill a fuel system priming pump (J 5956 or equivalent) with the red dye/fuel mixture.
2. Connect the outlet hose of the priming pump to the fuel inlet manifold. Connect a drain hose from the fuel outlet back to the test fuel container. Make sure that the required restricted fitting is installed in the fuel outlet. This will allow sufficient fluid pressure to build up.
3. Prime the cylinder head fuel system and check for leaks. The test fuel will show up as bright red.
4. Eliminate the cause of any leaks discovered. Wipe off the head components and retest until no further leaks occur.

Running Test

1. To pressure test the cylinder head on a new or newly overhauled engine, isolate the fuel system so that the fuel supply and return lines are connected only to the test container.
2. Start and run the engine on the test fuel at maximum no–load speed for approximately five minutes to bring it to operating temperature. Periodically check the level in the test fuel container to ensure an adequate supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of Red LTO 1140 dye to each 2.5 gallons (9.463 liters) of make–up fuel. Three to five engines can normally be tested before replenishing the fuel.
3. Stop the engine and remove the rocker covers. Check the cylinder head and all fuel connections for any sign of fuel leakage. The test fuel will show up as bright red.
4. If any leaks are discovered, eliminate their cause. Wipe all head surfaces and fuel connections clean, then start the engine and retest.
5. When all leaks have been eliminated, replace the rocker covers, reinstall the original fuel lines and connect the engine to its normal fuel source. It is not necessary to change the fuel filter or strainer. Start and run the engine to purge any air from the system.

J 28431 Fluorescent Dye

The use of J 28431 fluorescent dye and a "black light" (ultraviolet light) is preferable when testing an engine that has been in service and has dark lubricating oil (from engine operation). Use the following procedure:

1. Mix four (4) ounces (11 ml) of fluorescent dy additive J 28431 with four (4) gallons (15.14 liters) of clean No. 1 or No. 2 diesel fuel in a clean container. The container should be marked "Test Fuel" to prevent its accidental usage and be resealable to prevent contamination when not in use.
2. Isolate the engine fuel system so that the supply and return lines are connected only to the test fuel container.
3. Start and run the engine on the test fuel at maximum no–load speed for approximately five minutes to bring

it to operating temperature. Periodically, check the level in the test fuel container to ensure an adequate supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of fluorescent dye for each gallon (3.79 liters) of make–up diesel fuel. Normally, three to five units can be tested before replenishing the fuel.

4. With the engine idling and the rocker covers removed, shine the "black light" over the head assembly. Lube oil will show up as a dull blue. A fuel leak will glow a bright yellow. This type of test is best conducted in a darkened or shadowed area. The darker the area surrounding the unit being tested, the easier it is to see the fluorescent dye.

5. If bright yellow dye is detected, determine the cause of the fuel leak and eliminate it. Wipe the cylinder head and fuel connections clean, start and idle the engine and reckeck the head area.

6. When all leaks have been eliminated, reinstall the original fuel lines and connect the engine to its normal fuel source. It is not necessary to change the fuel filter or strainer. Start and run the engine to purge any air from the fuel system.

Normal Fuel Weepage

Some fuel weepage may normally be encountered from the follower and/or rack on DDC injectors while performing this test. Special consideration must be given to this weepage and the fact that it should not be allowed to exceed the DDC guidlines for pressure holding test (see Section 2.1.1) and the specification for lube oil dilution (2.5%).

Since all leakage or spillage of fuel during leak detection testing dilutes the lube oil, the final step in maintenance of this type should include lube oil and lube oil filter changes.

• FUEL JUMPER LINE MAINTENANCE

Maintenance and service personnel should be aware that severe engine damage could result from fuel oil leakage into the lubricating oil and should therefore, follow proper procedures when removing, handling and installing fuel jumper lines (fuel pipes).

The fuel jumper lines which carry fuel to and form the fuel injectors must be handled and installed very carefully to prevent line damage that can result in severe engine damage. Severe fuel leakage, if not detected, can also result in an over–filled crankcase (oil pan) which can cause an abnormal amount of fuel and lubricating oil vapor to escape from the engine and crankcase breathers. An abnormal concentration of fuel and lube oil vapors is flammable and could ignite in a closed engine compartment.

The following are some of the conditions that can result in fuel jumper line leakage:

1. Improper handling and storage of jumper lines when servicing the engine can result in physical damage and contamination.

2. Careless use of special tool (socket) J 8932–01 during removal or installation can cause a jumper line to bend and be permanently distorted.

3. Reuse of a bent or distorted jumper line can result in excessive stress and cause the line to crack or fracture at or above the flared ends of the jumper line. A fuel leak will ultimately result.

4. Excessive tightening of the jumper line nut will distort and fracture the flared end of the jumper line, resulting in a fuel leak.

NOTICE: DDC recommends that the original fuel pipes not be reused. New flared end fuel pipes should be installed. When installing flared end fuel pipes, use fuel pipe nut wrench J 8932–01 and "clicker" type torque wrench J 24405 (calibrated in inch–pounds) to apply proper torque and avoid damaging the fuel pipes. Refer to the chart for torque specifications. Fuel leakage from damaged or improperly installed fuel pipes can cause lube oil dilution, which may result in serious engine damage.

To help insure more consistent fastening, tighten fuel pipe nuts on jumper lines to the single torque values shown below. Use fuel line nut wrench J 8932–01 and "clicker" type torque wrench J 24405 (calibrated in inch–pounds).

NOTICE: Because of their low friction surface, Endurion®–coated nuts on fuel jumper lines must be tightened to 130 ***lb–in*** (14.69 N·m) torque, instead of the 160 ***lb–in*** (18.3 N·m) required with uncoated nuts. To avoid possible confusion when tightening jumper line nuts, do not mix lines with uncoated and Endurion®–coated nuts on the same cylinder head.

Jacobs brake jumper lines and jumper lines used with load–limiting devices do not have coated nuts. Tighten these to the values shown on the Chart.

NOTICE: When installing fuel jumper lines, *Do Not Overtighten.* Damage to the jumper line flares and connector seats can result from excessive tightening, causing fuel leakage into the lubricating oil.

O-ring sealed fuel pipes may be reused if not damaged. To avoid fuel leakage, always install new seals when replacing the fuel pipes on an engine. Tighten O-ring sealed fuel pipe nuts to 143 lb-in (16.16 N·m) torque with "clicker" type torque wrench J 24405 (calibrated in inch-lbs).

Fuel Pipe Usage	Torque
Endurion®-coated	130 lb-in. (14.69 N·m)
Uncoated	160 lb-in. (18.3 N·m)
Jacobs Brakes*	120 lb-in. (13.6 N·m)
Load limiting devices	160 lb-in. (18.3 N·m)
O-Ring Sealed Pipes	143 lb-in. (16.6 N·m)

*Not serviced. Available from Jacobs Manufacturing Company.

Jumper Line Nut Torque Chart

5. Damaged threads and flare seats on the injector and cylinder head jumper line connectors can also result in fuel leakage.

6. Leaks can also occur at injector filter nut gaskets and/or cylinder head connector washers due to distortion, damage or incorrect torque.

The following troubleshooting procedure is recommended after installation of fuel jumper lines and/or connectors to determine if fuel leakage is present.

Checking for Fuel Leaks

Always check the fuel system for leaks after injector or fuel jumper line replacement and any time the fuel connections under the rocker cover are suspected of leaking. Failure to correct a fuel leak in this area can lead to dilution of the lube oil. Use one of the following methods to check for leaks.

METHOD A

Use when the engine has been operating 20–30 minutes. After operating the engine, shut it off and remove the rocker cover(s). Discard the gasket(s). Inspect the lube oil puddles that normally form where the fuel connectors join the cylinder head and where the fuel jumper lines join the fuel line nuts.

If there is any leakage at these connections, the lube oil puddles will be smaller or thinner than the puddles on the connectors that are not leaking. Disassemble, inspect and correct or replace the suspect part (connector washer, connector, injector or jumper line). Test and reinspect.

METHOD B

Use when the engine is not operating such as during or after repairs. Remove the rocker cover(s). Discard the gasket(s). Pour clean lube oil over the fuel jumper lines and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form at the joining surfaces as mentioned in Method A. Plug the fuel return line at a convenient location (cylinder head or fuel tank, for example). Disconnect the fuel pump supply line at the inlet of the secondary filter. Connect an external source of pressurized fuel (60–80 psi or 414–552 kPa) to the inlet of the secondary filter cover. Install a pressure gage (0–100 psi or 0–689 kPa) at the outlet of the filter cover. Gage installation can be accomplished by installing a "T" fitting between the filter cover and outlet line or by removing the pipe plug at the outlet in the cover. Use of a gage will allow ready reference to the fuel pressure being maintained for this test. Severe leaks are immediately visible and minor leaks take longer to appear. It may be necessary to maintain fuel pressure for a period of 20 to 30 minutes in order to find minor leaks. Leaks may be repaired by replacing damaged parts or determining if the part is loose and below torque specifications. Test and reinspect.

If injectors are suspected of leaking and contributing to dilution of the lube oil, they should not be tested by pressurizing the fuel system as in Method B. Injectors should be removed from the engine and high pressure tested as outlined in Section 2.1 or 2.1.1.

METHOD C

Use while the engine is operating at 400–600 rpm. Apply an outside fuel source capable of 60–80 psi (414–552 kPa) to the outlet side of the secondary filter. Pour lube oil over the fuel jumper lines and connectors so that oil puddles form where jumper lines and connectors meet. Install a valve and a pressure gage in the fuel return line. With the engine idling, close the valve enough to raise the engine fuel pressure to 60–80 psi (414–552 kPa). After 10–20 minutes, inspect the oil puddles to see if any have become smaller or run off completely. The undiluted oil will hang the same as when the oil was poured on. Repair and retest.

Slightly worn injector plungers may leak more under these conditions. This leakage will not occur while the engine is running because of the dynamic and pressure conditions that exist.

METHOD D

Fluorescent dye fuel leak testing. When testing an engine that has been in service, it will be preferable to use the fluorescent dye and black light method of testing. Proceed as follows:

1. Mix 4 oz. of fluorescent additive J 28431 with 4 gallons (15 liters) of clean diesel fuel (#1 or #2) in a clean container. The container should be marked "Test Fuel" and be resealable so that it won't be contaminated when not being used.
2. Isolate the engine fuel system so that the supply and return fuel lines are connected only to the test fuel container. It will be necessary to intermittently check the fuel level to maintain an adequate supply.
3. Warm up the engine by operating it at maximum no–load speed for approximately 15 minutes.
4. With the engine idling and the rocker cover removed, shine the black light over the head assembly. The lube oil will show a dull blue. If a fuel leak is present, the fuel with the fluorescent dye will glow a bright yellow.
5. After the cause of the fuel leak has been determined and corrected, wipe the area and fuel connections clean and recheck with the black light. When no leaks are present, reassemble the unit withe original fuel lines and normal fuel source. It is not necessary to change the fuel filters. Run the engine to purge the air from the fuel system.

With the engine at rest, all injectors will leak to some extent when pressurized. The leakage occurs because there is no other place for the pressurized fuel to go. When the low and high pressure cavities in the injector are subjected to the high test pressure, fuel is forced past the plunger into the rack and gear cavity. Result: Droplets of fuel form at the rack and drip off. Special consideration must be given to this weepage. If considered to be excessive, the injector should be removed and tested for pressure holding capabilities.

NOTICE: Since all leakage or spillage of fuel during leak detection testing dilutes the lube oil, the final step in maintenance of this type should include lube oil and lube oil filter changes.

Use new gasket(s) and reinstall the valve rocker cover(s).

POINTS TO REMEMBER

1. Lube oil puddle inspection is one method of testing the fuel system for internal leaks. The missing puddles show where the leaks are. This test can be performed any time the rocker covers are removed, after the fuel jumper lines and connectors have been splashed with clean lube oil and there is normal fuel pressure in the system.
2. All leakage or spillage of fuel during leak detection testing further dilutes the lube oil.
3. The final step in maintenance of this type should include lube oil filter changes if a fuel leak is detected.
4. Oil level above the dipstick "full" mark or a decrease in lube oil consumption may indicate internal fuel leaks.
5. Improper storage, handling or installation of jumper lines can cause fuel leakage, resulting in lube oil dilutuion and severe engine damage.

TROUBLESHOOTING

FUEL PUMP

The fuel pump is so constructed as to be inherently trouble free. By using clean, water–free fuel and maintaining the fuel filters in good condition, the fuel pump will provide long satisfactory service and require very little maintenance.

However, if the fuel pump fails to function satisfactorily, first check the fuel level in the fuel tank, then make sure the fuel supply valve is open. Also, check for external fuel leaks at the fuel line connections and filter gaskets. Make certain that all fuel lines are connected in their proper order.

Next, check for a broken pump drive shaft or drive coupling. Insert the end of a wire through the pump flange drain hole, then crank the engine momentarily and note whether the wire vibrates. Vibration will be felt if the pump shaft rotates.

All fuel pump failures result in no fuel or insufficient fuel being delivered to the fuel injectors and may be indicated by uneven running of the engine, excessive vibration, stalling at idling speeds or a loss of power.

The most common reason for failure of a fuel pump to function properly is a sticking relief valve. The relief valve, due to its close fit in the valve bore, may become stuck in a fully open or partially open position due to a small amount of grit or foreign material lodged between the valve and its bore or seat. This permits the fuel to circulate within the pump rather than being forced through the fuel system.

Therefore, if the fuel pump is not functioning properly, remove the relief valve plug, spring and pin and check the movement of the valve within the valve bore. If the valve sticks, recondition it by using fine every cloth to remove any scuff marks. Otherwise, replace the valve. Clean the valve bore and the valve components. Then, lubricate the valve and check it for free movement throughout the entire length of its travel. Reinstall the valve.

After the relief valve has been checked, start the engine and check the fuel flow at some point between the restricted fitting in the fuel return manifold at the cylinder head and the fuel tank.

CHECKING FUEL FLOW

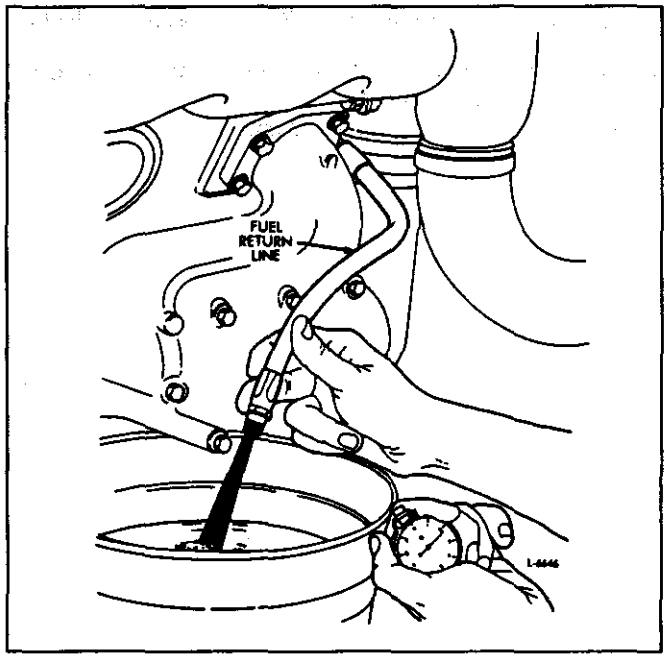

Fig. 24 – Measuring Fuel Flow

1. Disconnect the fuel return hose from the fitting at the fuel tank and hold the open end in a convenient receptacle (Fig. 24).
2. Start and run the engine at 1,200 rpm and measure the fuel flow. Refer to Section 13.2 for the specified quantity per minute.
3. Immerse the end of the fuel hose in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate air being drawn into the fuel system on the suction side of the pump. If air is present, tighten all fuel line connections between the fuel tank and the fuel pump.
4. If the fuel flow is insufficient for satisfactory engine performance, then:
   a. Replace the element in the fuel strainer. Then, start the engine and run it at 1,200 rpm to check the fuel flow. If the flow is still unsatisfactory, perform Step "b" below:
   b. Replace the element in the fuel filter. If the flow is still unsatisfactory, do as instructed in Step "c".
   c. Substitute another fuel pump that is known to be in good condition and again check the fuel flow. When changing a fuel pump, clean all of the fuel lines with compressed air and be sure all fuel line connections are tight. Check the fuel lines for restrictions due to bends or other damage.

If the engine still does not perform satisfactorily, one or more fuel injectors may be at fault and may be checked as follows:

1. Run the engine at idle speed and cut out each injector in turn by holding the injector follower down with a screwdriver. If a cylinder has been misfiring. there will be no noticeable difference in the sound and operation of the engine when that particular injector has been cut out.
2. Stop the engine and remove the fuel pipe between the fuel return manifold and the injector.
3. Hold a finger over the injector fuel outlet and crank the engine with the starter. A gush of fuel while turning the engine indicates an ample fuel supply; otherwise, the injector filters are clogged and the injector must be removed for service.

AIR-OPERATED VARIABLE HIGH SPEED GOVERNORS

The most common condition is that the minimum rpm is too high. This is especially true on kit installations to an unknown governor. The most frequent causes are these:

1. Lack of enough air pressure to completely overcome the high-speed spring preload.

Series 53 engines require 90 psi (621 kPa) or more. This air pressure is required at the governor after the regulator. The regulator must have an operating range of 0–120 psi (0–827 kPa).

2. An interaction between the idle circuit and the high speed circuit.

Many Detroit Diesel Corporation governors were designed to idle as low as 350 rpm. If these older design governors are being modified, a low minimum control with the VHS cannot be obtained, especially if a high normal idle is used. All engines supplied by Detroit Diesel Corporation with the VHS feature installed as original equipment have a compatible governor which will allow control from no-load to within 100 rpm of idle.

NOTICE: Minimum certified idle values should not be violated.

Single weight governors capable of accepting the VHS are also capable of reducing the minimum rpm to within 100 rpm of idle.

3. Idle screw protrudes beyond VHS position, or elastic stop nut is not tight.

Determine if the idle screw or piston hits the VHS cover.

If idle screw hits the VHS cover, raise the idle until the screw is flush with the end of the piston. In certain cases the idle screw may have to be shortened to meet the criteria of being flush and acquire the desired idle speed.

If the piston hits first, the elastic stop nut is not properly adjusted. Readjust, making sure that the piston is bottomed, then proceed to adjust the elastic stop nut (See Section 2.7.1.5).

4. Engine overshoot.

This usually relates to the non-synchronized engagement of the throttle lock and the regulated air supply to the VHS housing. A variable orifice (needlevalve type) in one of the air supply lines will provide capability for synchronization as follows:

In cases of *overshoot,* the variable orifice is installed in the supply line to the throttle lock.

In case of *undershoot,* the variable orifice is installed in the regulated air pressure line to the VHS housing.

5. Lowered idle or no load.

Usually caused by air from the air supply leaking into or being trapped in the VHS housing. Any pressure in the VHS housing will lower both the no load and idle. Recheck the air plumbing.

6. Lack of normal power.

The elastic stop nut is screwed in too tight, pulling the high speed plunger off its seat. This will cause low power but no change in the no-load rpm. Readjust the elastic stop-nut.

7. No-load increased.

Interference of the piston and idle screw. Check to be sure that the screw is free as it protrudes through the piston.

CROWN VALVE INJECTORS

Chart 1

LOW OR HIGH VALVE OPENING PRESSURE

LOW VALVE OPENING PRESSURE	HIGH VALVE OPENING PRESSURE
Probable Cause	Probable Cause
1. WORN OR ERODED VALVE SEAT	8. CARBON OR FOREIGN MATERIAL IN SPRAY TIP
2. VALVE SEAT CHIPPED AT POINT OF CONTACT	9. CARBON IN SPRAY TIP ORIFICES
3. CRACKED VALVE SEAT	
4. WORN VALVE OR VALVE STOP	
5. WORN OR BROKEN VALVE SPRING	
6. DIRT OR FOREIGN MATERIAL IN INJECTOR	
7. WORN VALVE STOP SEAT IN CAGE	

SUGGESTED REMEDY

1. A worn or eroded valve seat may be lapped, but not excessively as this would reduce thickness of the part causing a deviation from the valve stack-up dimension.
2. If the valve seat is chipped at the point of contact with the valve, lap the surface of the seat and the I.D. of the hole. Mount tool J 7174 in a drill motor and place the valve seat on the pilot of the tool, using a small amount of lapping compound on the lapping surface. Start the drill motor and apply enough pressure to bring the seat to the point of lap. Check the point of lap contact after a few seconds. If the edge of the hole appears sharp and clear, no further lapping is required. Excessive lapping at this point will increase the size of the hole and lower the injector valve opening pressure.
3. Replace the valve seat.
4. Replace the valve or valve stop.
5. Replace the spring. Check the valve cage and valve stop for wear; replace them, if necessary.
6. Disassemble and clean the injector.
7. Replace the valve cage.
8. Carbon in the tip should be removed with tip reamer J 1243 which is especially designed and ground for this purpose.
9. Check the size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

CROWN VALVE INJECTORS

Chart 2

INSUFFICIENT INJECTOR HOLDING TIME

Probable Cause

1. POOR BUSHING TO BODY FIT
2. INJECTOR NUT NOT TIGHTENED TO SPECIFIED TORQUE
3. CRACKED VALVE PARTS
4. VALVE SEAT CHIPPED AT POINT OF CONTACT
5. WORN OR ERODED VALVE SEAT
6. WORN OR BROKEN VALVE SPRING
7. WORN VALVE
8. DEFECTIVE SEAL RING
9. BODY PLUG LEAKS
10. FILTER GASKETS LEAK
11. POOR SEALING SURFACES ON FUEL FITTINGS
12. DIRT OR FOREIGN MATERIAL IN INJECTOR

SUGGESTED REMEDY

1. Lap the injector body.
2. Tighten the nut to 55–65 lb–ft (75–88 N·m) torque. Do not exceed the specified torque.
3. Replace the valve parts.
4. If the valve seat is chipped at the point of contact with the valve, lap the surface of the seat and the I.D. of the hole. Mount tool J 7174 in a drill motor and place the valve seat on the pilot of the tool, using a small amount of lapping compound on the lapping surface. Start the drill motor and apply enough pressure to bring the seat to the point of lap. Check the point of lap contact after a few seconds. If the edge of the hole appears sharp and clear, no further lapping is required. Excessive lapping at this point will increase the size of the hole and lower the injector valve opening pressure.
5. A worn or eroded valve seat may be lapped, but not excessively as this would reduce the thickness of the part causing a deviation from the valve stack–up dimension.
6. Replace the spring. Check the valve cage and valve stop for wear; replace them, if necessary.
7. Replace the valve.
8. Replace the seal ring.
9. Install new body plugs.
10. Replace the filter gaskets and tighten the filter caps to 65–75 lb–ft (88–102 N·m) torque.
11. Clean up the sealing surfaces or replace the filter caps, if necessary.
12. Disassemble the injector and clean all of the parts.

CROWN VALVE INJECTORS

Chart 3

INCORRECT INJECTOR OUTPUT

Probable Cause

1. SPRAY TIP OR ORIFICES PARTIALLY PLUGGED
2. SPRAY TIP ORIFICES ENLARGED
3. CARBON BUILD–UP IN SPRAY TIP
4. WORN PLUNGER AND BUSHING
5. CRACKED VALVE PARTS
6. CRACKED BUSHING
7. IMPROPERLY LAPPED SURFACES
8. FOREIGN MATERIAL BETWEEN VALVE AND SEAT
9. RACK AND GEAR NOT IN TIME

SUGGESTED REMEDY

1. Clean the orifices with tool J 4298–1, using the proper size wire.
2. Replace the spray tip.
3. Clean the injector tip with tool J 1243.
4. After the possibility of an incorrect or faulty tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

   NOTICE: The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the *Fuel Output Check Chart*, try changing the spray tip. However, use only a tip specified for the injector being tested.
5. Replace the cracked parts.
6. Replace the plunger and bushing assembly.
7. Lap the sealing surfaces.
8. Disassemble the injector and clean all of the parts.
9. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth of the rack.

NEEDLE VALVE INJECTORS

Chart 4

LOW OR HIGH VALVE OPENING PRESSURE

LOW VALVE OPENING PRESSURE	HIGH VALVE OPENING PRESSURE
Probable Cause	Probable Cause
1. WORN OR ERODED NEEDLE VALVE OR VALVE SEAT IN SPRAY TIP	6. CARBON OR FOREIGN MATERIAL IN SPRAY TIP
2. WORN OR DAMAGED NEEDLE VALVE QUILL	7. CARBON IN SPRAY TIP ORIFICES
3. WORN OR DAMAGED NEEDLE VALVE SPRING SEAT	
4. WORN OR BROKEN VALVE SPRING	
5. DIRT OR FOREIGN MATERIAL IN INJECTOR	

SUGGESTED REMEDY

1. Replace the needle valve and spray tip assembly.
2. Replace the needle valve and spray tip assembly.
3. Replace the spring seat.
4. Replace the valve spring.
5. Disassemble the injector and clean all of the parts.
6. Remove the carbon in the spray tip with tip reamer J 9464–01 which is especially designed and ground for this purpose.
7. Check the size of the spray tip orifices. Then, using tool J 4298–1 with the proper size wire, clean the orifices.

NEEDLE VALVE INJECTORS

Chart 5

INSUFFICIENT INJECTOR HOLDING TIME

Probable Cause

1. POOR BUSHING TO BODY FIT
2. INJECTOR NUT NOT TIGHTENED TO SPECIFIED TORQUE
3. EXCESSIVE PLUNGER TO BUSHING CLEARANCE
4. CRACKED SPRAY TIP
5. WORN OR ERODED NEEDLE VALVE
6. WORN OR ERODED NEEDLE VALVE SEAT IN SPRAY TIP
7. WORN OR BROKEN NEEDLE VALVE QUILL
8. WORN OR BROKEN VALVE SPRING
9. WORN OR DAMAGED VALVE SPRING SEAT
10. DEFECTIVE SEAL RINGS
11. BODY PLUG LEAKS
12. FILTER GASKETS LEAK
13. POOR SEALING SURFACES ON FUEL FITTINGS
14. DIRT OR FOREIGN MATERIAL IN INJECTOR

SUGGESTED REMEDY

1. Lap the injector body.
2. Tighten the injector nut to 75–85 lb–ft (102–115 N·m) torque. Do not exceed the specified torque.
3. Replace the plunger and bushing.
4. 5, 6 and 7. Replace the needle valve and spray tip assembly.
8. Replace the valve spring.
9. Replace the valve spring seat.
10. Replace the seal rings.
11. Install new body plugs.
12. Replace the filter cap gaskets and tighten the filter caps to 65–75 lb–ft (88–102 N·m) torque.
13. Clean up the sealing surfaces or replace the filter caps, if necessary. Replace the filter if a cap is replaced.
14. Disassemble the injector and clean all of the parts.

NEEDLE VALVE INJECTORS

Chart 6

INCORRECT INJECTOR OUTPUT

Probable Cause

1. SPRAY TIP OR ORIFICES PARTIALLY PLUGGED
2. SPRAY TIP ORIFICES ENLARGED
3. CARBON BUILD–UP IN SPRAY TIP
4. WORN PLUNGER AND BUSHING
5. WORN OR DAMAGED NEEDLE VALVE QUILL
6. WORN OR DAMAGED NEEDLE VALVE SPRING SEAT
7. WORN OR BROKEN VALVE SPRING
8. CRACKED CHECK VALVE GAGE, SPRING CAGE OR SPRAY TIP
9. CRACKED BUSHING
10. IMPROPERLY LAPPED SURFACES
11. FOREIGN MATERIAL BETWEEN VALVE AND SEAT
12. RACK AND GEAR NOT IN TIME
13. SPRAY TIP–PLUNGER AND BUSHING COMBINATION PROVIDES INCORRECT OUTPUT

SUGGESTED REMEDY

1. Clean the spray tip as outlined under *Clean Injector Parts.*
2. Replace the needle valve and spray tip assembly.
3. Clean the spray tip with tool J 1243.
4. After the possibility of an incorrect or faulty spray tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

   NOTICE: The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the *Fuel Output Check Chart,* try changing the spray tip. However, use only a tip specified for the injector being tested.
5. Replace the needle valve and spray tip assembly.
6. Replace the spring seat.
7. Replace the valve spring.
8. Replace the cracked parts.
9. Replace the plunger and bushing assembly.
10. Lap the sealing surfaces.
11. Disassemble the injector and clean all of the parts.
12. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth on the rack.
13. Replace the spray tip and the plunger and bushing assembly to provide the correct output.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb–ft)	N·m	THREAD SIZE	280M OR BETTER TORQUE (lb–ft)	N·m
1/4–20	5–7	7–9	1/4–20	7–9	10–12
1/4–28	6–8	8–11	1/4–28	8–10	11–14
5/16–18	10–13	14–18	5/16–18	13–17	18–23
5/16–24	11–14	15–19	5/16–24	15–19	20–26
3/8–16	23–26	31–35	3/8–16	30–35	41–47
3/8–24	26–29	35–40	3/8–24	35–39	47–53
7/16–14	35–38	47–51	7/16–14	46–50	62–68
7/16–20	43–46	58–62	7/16–20	57–61	77–83
1/2–13	53–56	72–76	1/2–13	71–75	96–102
1/2–20	62–70	84–95	1/2–20	83–93	113–126
9/16–12	68–75	92–102	9/16–12	90–100	122–136
9/16–18	80–88	109–119	9/16–18	107–117	146–159
5/8–11	103–110	140–149	5/8–11	137–147	186–200
5/8–18	126–134	171–181	5/8–18	168–178	228–242
3/4–10	180–188	244–254	3/4–10	240–250	325–339
3/4–16	218–225	295–305	3/4–16	290–300	393–407
7/8–9	308–315	417–427	7/8–9	410–420	556–569
7/8–14	356–364	483–494	7/8–14	475–485	644–657
1–8	435–443	590–600	1–8	580–590	786–800
1–14	514–521	697–705	1–14	685–695	928–942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
 Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
 Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
 Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
 Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
 Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb–ft)	(lb–in)	(N·m)
Governor Control Housing to Flywheel Housing	5/16–18	10–12		14–16
Blower Drive Assembly to Flywheel Housing	3/8–16	20–25		27–34
Injector Clamp Bolt	3/8–16	20–25		27–34
Rocker Arm Bracket Bolts	7/16–14	50–55		68–75
Governor Drive Gear Retaining Nut (In–line engine)	5/8–18	125–135		170–183
•Fitting, Fuel Pump Inlet/Outlet	1/4–	14–16		19–22
•Fitting, Fuel Pump Inlet/Outlet	3/8–	18–22		24–30
•Fitting, Fuel Pump Inlet/Outlet	1/2–	20–25		27–34
Connector, Cyl. Head Fuel (Flared End Fuel Pipe)	3/8–24	20–28		27–28
•Connector, Cyl. Head Fuel (0–ring sealed fuel pipe)	3/8–24	37		50
•Fuel pipe nut (Endurion® coated)	3/8–24		130 lb–in	14.69
•Fuel pipe nut (uncoated)	3/8–24		160 lb–in	18.3
•Fuel pipe nut (load limiting device)	3/8–24		160 lb–in	18.3
•Fuel pipe nut (Jacobs Brake)	3/8–24		120 lb–in	13.6
•Fuel pipe nut (0–ring sealed fuel pipe)	1/2–20		143 lb–in	16.16
•Injector Filter Caps				
Non–blued cap on non–blued body	5/8–24	62		84
Blued cap on blued body	5/8–24	70		95
Non–blued cap on blued body or blued cap on non–blued body	5/8–24	62		84
•Injector Filter Cap (0–ring sealed fuel pipe)	1/2–20	70		95
•Injector Nut (crown valve)	15/16–24	55–65		75–88
•Injector Nut (needle valve)				
Non–blued nut on non–blued body	15/16–24	50		68
Blued nut on blued body	15/16–24	80		108
Non–blued nut on blued body or blued nut on non–blued body	15/16–24	65		88

SERVICE TOOLS

	TOOL NAME	TOOL NO.
	INJECTOR	
	Auxiliary injector tester (N injectors)	J 22640–A
•	Field modification kit (converts 22640 tester to 22640–A tester)	J 22640–51
	Fuel pipe socket	J 8932–01
	Fuel system primer	J 5956
	Injector body reamer	J 21089
	Injector body thread reconditioning set	J 22690
	Injector calibrator	J 22410–A
	Injector nut seal ring installer	J 29197
	Injector service set (includes *tools)	J 1241–07
	Injector service set (N injectors – includes #tools)	J 23435–02
	*Deburring tool	J 7174
	#*Fuel hole brush	J 8152
	#*Injector nut socket wrench	J 4983–01
	#*Injector nut and seat carbon remover set	J 9418
	#*Injector spray tip driver	J 1291–02
	*Injector tip cleaner	J 1243–01
	#*Pin vise	J 4298–1
	#*Rack hole brush	J 8150
	#*Spray tip carbon remover	J 9464–01
	#*Spray tip seat remover	J 4986–01
	*Spray tip wire (.005″)	J 21459–01
	#*Spray tip wire (.0055″)	J 21460–01
	#*Spray tip wire (.006″)	J 21461–01
	#*Wire sharpening stone	J 8170
	Injector test oil (Available in 5, 15, 30 and 55 gallons)	J 26400
	Injector tester	J 9787
	Injector tester	J 23010–A
	Injector tester modification package (J 23010–A only)	J 23010–194
	Injector tip concentricity gage	J 5119
	Injector vise and rack freeness tester	J 22396
	Injector vise jaws (offset body)	J 8912
	Injector vise jaws (standard body)	J 1261
	Lapping block set	J 22090–A
•	Master injector calibrating kit	J 35369
	Polishing compound (N injectors)	J 23038
	Polishing stick set (N injectors)	J 22964
	Spray tip flow gage	J 25600–A
	Spray tip gage (N injectors)	J 9462–02
	Spring tester	J 22738–02
	Wire brush (brass)	J 7944
	INJECTOR TUBE	
	Injector tube service tool set	J 22525–A
	Injector tube service tool set (for power equipment)	J 22515–A

TOOL NAME	TOOL NO.
FUEL PUMP	
Fuel pump primer	J 5956
Fuel pump tool kit	J 34607
Fuel pump tool set	J 1508–D
Fuel pump wrench	J 4242
MECHANICAL GOVERNOR	
Adjustable spanner wrench	J 5345
Control link operating lever bearing remover/installer	J 8985
Governor cover bearing installer	J 21068
Governor cover bearing remover/installer	J 21967–01
Governor weight spacer (6V–53 engine)	J 8984
Spring retainer nut wrench	J 5895
Variable speed spring housing bearing installer set	J 9196

SECTION 3

AIR INTAKE SYSTEM

CONTENTS

Air Intake System 3

Air Cleaner 3.1

Air Silencer 3.2

Air Shutdown Housing 3.3

Blower (In-Line and 6V-53) 3.4
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Turbocharger (Airesearch) 3.5
Turbocharger (Schwitzer) 3.5.1.1
Turbocharger Intercooler 3.5.2

Shop Notes – Troubleshooting Specifications
Service Tools 3.0

AIR INTAKE SYSTEM

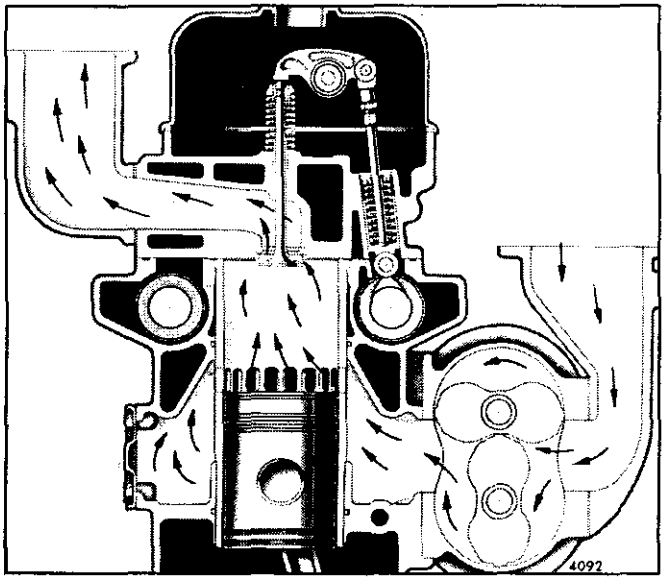


Fig. 1 – Air Flow Through Blower and Engine (In-Line Engine)

In the scavenging process employed in the Series 53 engines, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burned gases through the exhaust valve ports. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, therefore, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air cleaner, is picked up by the blower rotor lobes and carried to the discharge side of the blower as indicated by the arrows in Figs. 1 and 2. The continuous discharge of fresh air from the blower enters the air chamber of the cylinder block and sweeps through the intake ports of the cylinder liners.

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

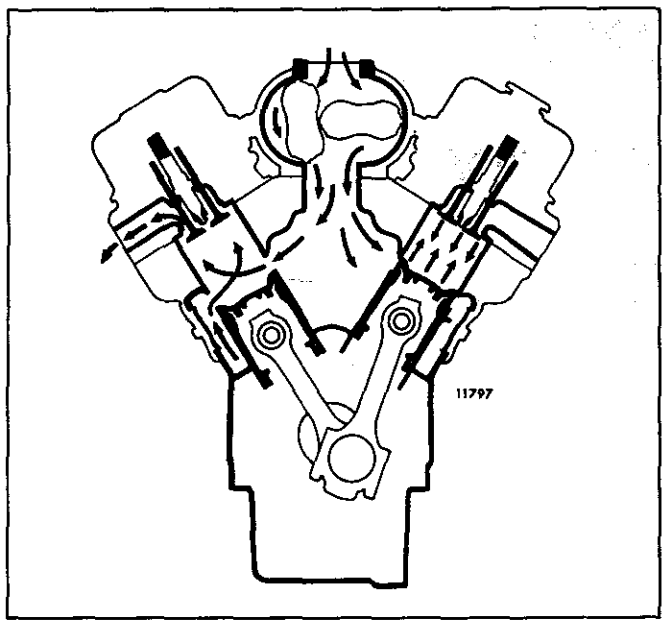


Fig. 2 – Air Flow Through Blower and Engine (V-Type Engine)

AIR CLEANER

The air cleaner is designed to remove foreign matter from the air, pass the required volume of air for proper combustion and scavenging and maintain their efficiency for a reasonable period of time before requiring service.

The importance of keeping dust and grit–ladden air out of an engine cannot be over–emphasized since clean air is so essential to satisfactory engine operation and long engine life. The air cleaner must be able to remove fine materials such as dust and blown sand as well as coarse materials such as chaff, sawdust, or lint from the air. It must also have a reservoir capacity large enough to retain the material separated from the air to permit operation for a reasonable period before cleaning and servicing are required.

Dust and dirt entering an engine will cause rapid wear of piston rings, cylinder liners, pistons and the exhaust valve mechanism with a resultant loss of power and high lubricating oil consumption. Also, dust and dirt which is allowed to build–up in the air cleaner passages will eventually restrict the air supply to the engine and result in heavy carbon deposits on pistons and valves due to incomplete combustion.

Air Cleaner Mounting

Air cleaner mountings vary in accordance with the air cleaner installation and the engine units on which they are employed. The light duty oil wetted type, oil bath type and the dry type air cleaners are mounted on the air inlet housing. Heavy duty air cleaners are remotely mounted from the air inlet housing and are connected to it by air tight ducts.

Current design heavy duty air cleaners may be mounted in parallel to the same air inlet elbow for additional air cleaner capacity. Some earlier installations introduced an additional cleaner into the system between the main cleaner and the blower inlet. The heaviest cleaning job was imposed upon the main cleaner, whereas the additional cleaner, called the after cleaner, filters out any dirt particles that may have passed through the main cleaner.

Air Cleaner Maintenance

Although the air cleaner is highly efficient, this efficiency depends upon proper maintenance and periodic servicing.

Damaged gaskets, loose hose connections or leaks in the duct work, which permit dust–laden air to completely bypass the cleaner and enter the engine directly, will lower the efficiency of the air cleaner. If the air cleaner is not serviced periodically, the engine will not receive a sufficient amount of clean air.

No set rule for servicing an air cleaner can be given since it depends upon the type of air cleaner, the condition of the air supply and the type of application. An air cleaner operating in severe dust will require more frequent service than an air cleaner operating in comparatively clean air. The most satisfactory service period should be determined by frequently inspecting the air cleaner under normal operating conditions, then setting the service period to best suit the requirements of the particular engine application.

The following maintenance procedure will assure efficient air cleaner operation.

1. Keep the air cleaner tight on the air intake pipe to the engine.

2. Keep the air cleaner properly assembled so the joints are strictly oil and air tight.

3. Repair any damage to the air cleaner or related parts immediately.

4. Inspect and clean or replace the air cleaner element as operating conditions warrant. In the dry type cleaner, it is possible to clean and reuse the element several times as long as the paper is not ruptured in the process. In an oil bath type cleaner keep the oil at the level indicated on the air cleaner sump. Overfilling may result in oil being drawn through the element and into the engine, thus carrying dirt into the cylinders and also resulting in excessive engine speed.

5. After servicing the air cleaner, remove the air inlet housing and clean accumulated dirt deposits from the blower screen and the inlet housing. Keep all air intake passages and the air box clean.

6. Where a rubber hose is employed, cement it in place. Use a new hose and hose clamps, if necessary, to obtain an air tight connection.

7. Carefully inspect the entire air system periodically. Enough dust–laden air will pass through an almost invisible crack or opening to eventually cause damage to an engine.

OIL BATH TYPE AIR CLEANER

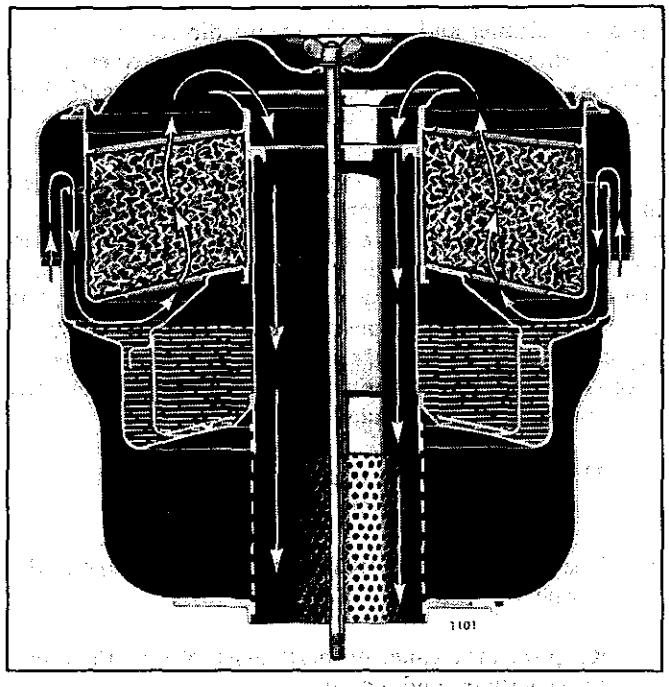


Fig. 1 – Light Duty Oil Bath Type Air Cleaner

Light Duty Oil Bath Type Air Cleaner

The light duty oil bath type air cleaner consists essentially of a wire screen element supported inside a sylindrical housing which contains an oil bath directly below the element (Fig. 1). Air drawn through the cleaner passes over the top of the oil bath. The air stream direction reverses when the air impinges on the oil in the sump and is then directed upwards by baffles. During this change in the direction of air flow, much of the foreign matter is trapped by the oil and is carried to the sump where it settles out. The air passes upward through the metal–wool elements where more dust and the entrained oil are removed. A second change of air direction, at the top of the cleaner directs the air downward through the center tube and into the blower inlet housing.

Service (Light–Duty)

To service the light duty air cleaner, loosen the wing bolt and remove the cleaner from the air inlet housing. The cleaner may then be separated into two sections. The upper section contains the metal–wool elements and the lower section is made up of the oil sump, removable baffle and the center tube.

The upper shell and metal–wool elements may be cleaned by soaking the entire section in kerosene or fuel oil. This will loosen the oil and dust in the elements and facilitate flushing out the dirt. The oil should be emptied from the sump, the baffle removed, and the sump and baffle cleaned in kerosene or fuel oil to remove all sediment. A lintless cloth should be pushed through the center tube of the cleaner before the baffle is installed and the sump refilled to the oil level mark with clean engine oil. NEVER use cotton waste to wipe the center tube. Use the same viscosity and grade of oil that is used in the engine crankcase. All gaskets and sealing surfaces should be checked and cleaned to ensure air–tight seals.

After the filter element has been thoroughly drained of the flushing fluid, the cleaner should be assembled. However, before installing the cleaner on the engine, the air inlet housing and blower inlet screen should be checked for the presence of dirt accumulations. If the service period has been too long, or dust–laden air has been leaking past the seals, the inlet housing and screen will be dirty. This will serve as a good check on the maintenance of the air cleaner installation. When installing the cleaner (and its seal) on the inlet housing, be sure that the cleaner seats properly, then tighten the wing bolt securely until the cleaner is rigidly mounted.

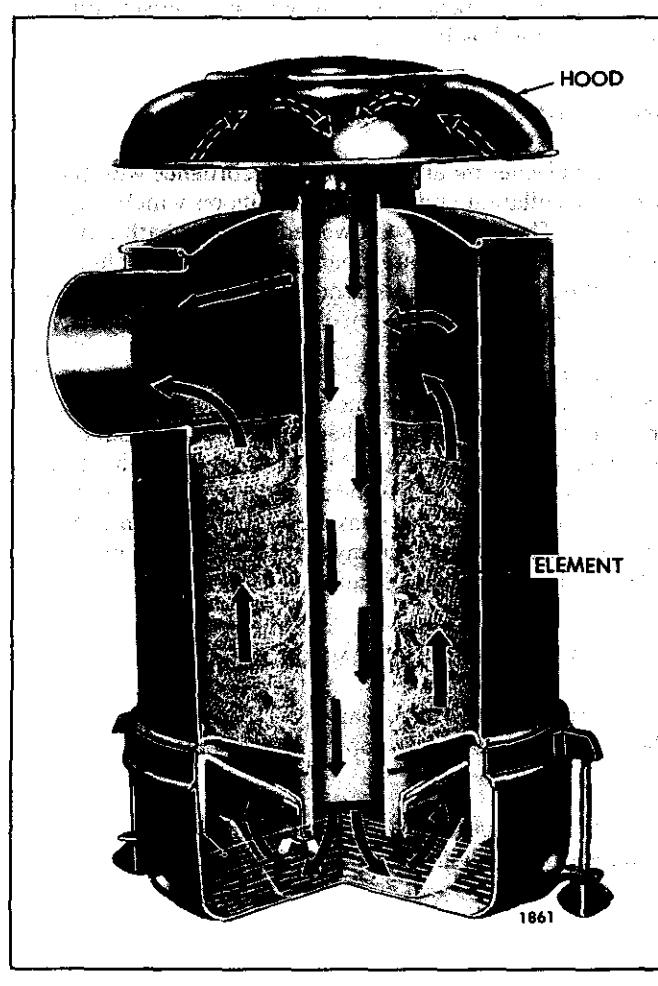


Fig. 2 – Heavy Duty Oil Bath Type Air Cleaner

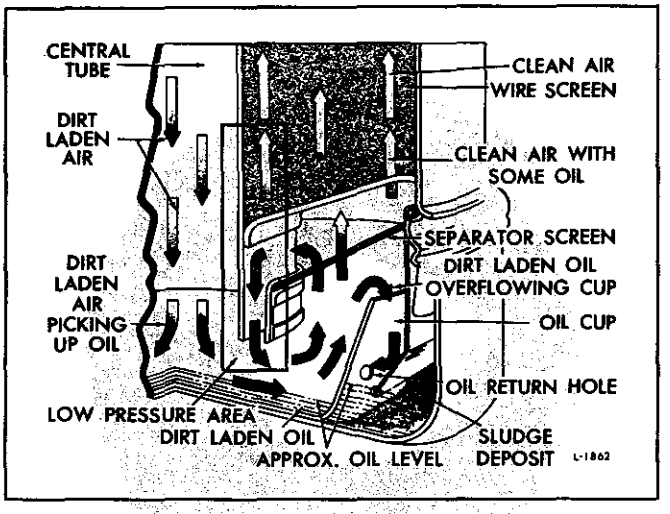


Fig. 3 – Air Flow Through Heavy Duty Oil Bath Air Cleaner

Heavy Duty Type Air Cleaner

In all heavy duty air cleaners air is drawn through the air inlet hood, which acts as a cleaner and down through the center tube (Fig. 2). At the bottom of the tube, the direction of air flow is reversed and oil is picked up from the oil reservoir cup. The oil laden air is carried up into the separator screen where the oil which contains the dirt particles is separated from the air by collecting on the separator screen.

A low pressure area is created toward the center of the air cleaner as the air passes a cylindrical opening formed by the outer perimeter of the central tube and the inner diameter of the separator screen (Fig. 3). This low pressure is caused by the difference in air current velocity across the opening. The low pressure area, plus the effect of gravity and the inverted cone shape of the separator screen, causes the oil and dirt mixture to drain to the center of the cleaner cup. This oil is again picked up by the incoming air causing a looping cycle of the oil, however, as the oil is carried toward another cycle, some of the oil will overflow the edge of the cup carrying the dirt with it. The dirt will be deposited in the outer area surrounding the cup. Oil will then flow back into the cup through a small hole located in the side of the cup. Above the separator screen, the cleaner is filled with a wire screen element which will remove any oil which passes through the separator screen. This oil will also drain to the center and back into the pan. The clean air then leaves the cleaner through a tube at the side and enters the blower through the air inlet housing.

An air inlet hood or pre–screener must be used with the heavy duty air cleaners, depending upon operating conditions. This equipment normally requires cleaning more frequently than the main air cleaner. The usual installation employs an air inlet hood which serves only to prevent rain, rags, paper, leaves, etc., from entering the air cleaner. The smaller cleaners employ a spherical–shaped hood. Air enters the hood through a heavy screen which forms the lower portion of the hood, and the air is reversed in the hood and pulled downward into the air cleaner. The hood is mounted on the air cleaner inlet tube and is held in place by the fit of the hood in the inlet tube.

The larger cleaners use a dome–shaped hood. A heavy screen inside the dome guards against large pieces of foreign material entering the cleaner. The hood is mounted on the air inlet tube of the cleaner and is secured to it by a screw–clamp. As previously mentioned, the hoods serve only to prevent rain and large pieces of foreign material from entering the cleaner. The openings in the hoods should be kept clear to prevent excessive restriction to air flow.

A pre–screener should be used on the inlet tube of the air cleaner instead of the inlet hood for those operations in which the air cleaner elements load up with lint or chaff. The purpose of the pre–screener is to remove as much of the lint or chaff as possible before the air enters the cleaner.

Service (Heavy–Duty)

The air inlet hoods used on heavy–duty air cleaners are not intended to do any cleaning. However, some dirt will collect on the heavy screens and in the hood itself. Therefore, it will be necessary to remove the hood occasionally for cleaning by brushing or with compressed air.

Some applications may be equipped with a pre–screener. The pre–screener catches the lint and chaff on the screen surrounding the shell. This screen can be removed by unhooking the retaining springs, and cleaned by brushing or with compressed air. The shell can be cleaned, if necessary, by wiping it with a lintless cloth. The pre–screener may then be assembled and installed on the cleaner inlet tube.

Although the pre–screener will remove most of the lint and chaff from the air, some may still find its way into the main cleaner. Therefore, it is essential that the fixed element of the main cleaner be checked, each time the cleaner is serviced, to prevent excessive lint deposits.

When the oil sump is removed on some heavy–duty air cleaners, a tray type screen attached to the tube will be visible. It may be removed by loosening the wing nuts and rotating the tray so that it unlocks from the tube. On other heavy duty models, the tray rests on the lip of the inner oil cup of the sump and is not retained by wing nuts.

The efficiency of the tray type oil bath air cleaner can be greatly reduced unless the fibrous material caught in the tray is removed. It is extremely important that the tray be cleaned regularly and properly.

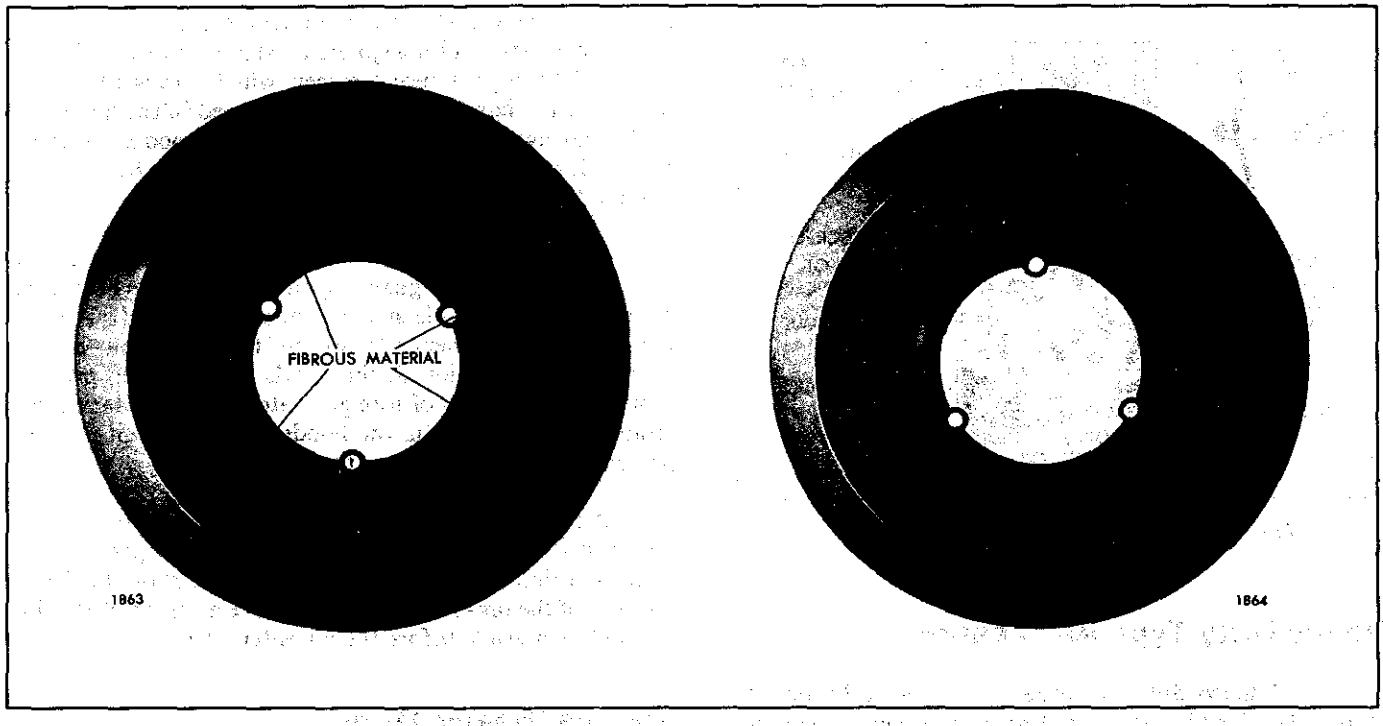


Fig. 4 – Comparison of Air Cleaner Trays

If a tray is plugged with lint or dirt, wash the tray in a solvent or similar washing solution and blow out with high velocity compressed air or steam (Fig. 4). An even pattern of light should be visible through the screens when a clean tray is held up to the light (Fig. 4). It may be necessary, as a last resort, to burn off the lint. Extreme care must be taken not to melt the galvanized coating in the tray screens. Some trays have equally spaced holes in the retaining baffle. Check to make sure that they are clean and open.

It is advisable to have a spare tray on hand to replace the tray that required cleaning. Having an extra tray available makes for better servicing and the plugged tray can be cleaned thoroughly at leisure.

Check for dirt accumulation in air cleaner center tube. Remove dirt by passing a lintless cloth through the center tube. Some tubes have a restricted portion at the lower end and care must be exercised not to damage this end.

Check oil sump for any dirt accumulation in both the inner and outer cups and clean if necessary.

At some regular period of engine service, remove the entire air cleaner from the engine and clean the fixed element. This can be done by passing a large quantity of clean solvent through the air outlet and down into the fixed element. When clean, allow element to dry thoroughly before installing cleaner.

When all of the components have been cleaned, the cleaner is ready for assembly. The removable screen should be installed and the oil sump should be filled with clean engine oil to the indicated level and installed on the cleaner. Care should be exercised that all gaskets and joints are tight. All connections from the cleaner to the engine should be checked for air leaks to prevent any air bypassing the air cleaners.

If it is found that unfiltered air is being admitted into the engine through the duct work of an air cleaner installation, the following procedure may be used for finding air leaks in an air duct system. The air cleaning system does not have to be dismantled, thus effecting a saving in time.

To make this check, it is necessary that suitable plugs be provided to block the air cleaner system inlet and outlet. The air cleaner inlet plug should contain a suitable air connection and shutoff valve to maintain two pounds pressure in the air duct system. The outlet plug need only be of sufficient size to form a completely air–tight seal at the outlet end of the system. Then check the system as follows:

1. Remove the air inlet hood or pre–screener.
2. Insert the plug (with the fitting for the air hose) in the air cleaner inlet to form an air–tight seal.
3. Insert the other plug in the outlet end of the system to form an air–tight seal.
4. Attach an air hose to the plug in the air cleaner inlet and regulate pressure not to exceed 2 psi (14 kPa).
5. Brush a soapsuds solution on all air duct connections. Any opening which would allow dust to enter the

engine can then be detected by the escaping air causing bubbles in the soapsuds solution. All leaks thus discovered should be remedied until the system checks "air–tight".

6. Remove plugs and install air inlet hood or pre–screener.

A rotational type of service program may be followed on heavy duty air cleaner installations that employ a main and after cleaner, in accordance with the following procedure, since the heaviest cleaning job is imposed upon the main cleaner.

1. Remove and clean the sump and removable screen of the main cleaner.
2. Check all joints and tubes of the main cleaner and ensure that they are air–tight.
3. Install the cleaned removable screen on the main cleaner.
4. Remove the sump of the after cleaner and install it on the main cleaner.
5. Remove and clean the removable screen of the after cleaner.
6. Check all joints and tubes of the after cleaner and ensure that they are air–tight.
7. Install the remaining screen and sump on the after cleaner.

The design and function of the heavy duty air cleaners is such that the fixed elements tend to be self–cleaning. However, it may be necessary, occasionally, to remove the entire cleaner from its mountings and clean these elements. If the fixed elements require too frequent cleaning, it is advisable to relocate the air intake to provide a cleaner air supply.

Proper selection of air cleaners and good air cleaner maintenance go "hand–in–hand" in providing long engine life and trouble–free operations.

DRY TYPE AIR CLEANER

UNITED SPECIALTIES AIR CLEANER

The dry type United Specialties air cleaner shown in Fig. 5 consists of a body, dust unloader and element clamped to a base.

Air is drawn through the cleaner intake pipe and is automatically set into a circular motion. This positive spinning of the dirty air "throws out" the heavier particles of dust and dirt where they are collected in the dust port and then expelled through the dust unloader. The circular action continues even during low air intake at engine idle speed.

Service

Service the dry type United Specialties air cleaner as follows:

1. Loosen the clamp screw and check the dust unloader for obstruction or damage. Refer to Section 15.1 for maintenance.
2. Unlock the spring clamps that hold the cleaner body to the cleaner base which is bolted to the air inlet housing. Remove the body and then remove the element from the cleaner base.
3. Clean the paper pleated air cleaner element as follows:
   a. For a temporary expedient in the field, tap the side or end of the element carefully against the palm of your hand.

   NOTICE: Do not tap the element against a hard surface. This could damage the element.

   b. Compressed air can be used when the major contaminant is dust.

   - **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

     The compressed air should be blown through the element in a direction opposite to the normal air flow. Insert the nozzle inside of the element and gently tap and blow out the dust with air. When cleaning the dust from the outside of the element, hold the nozzle at least 6" from the element.

   c. If allowed, further cleaning (washing, drying, inspection) must be done per the recommendations of the filter element manufacturer.

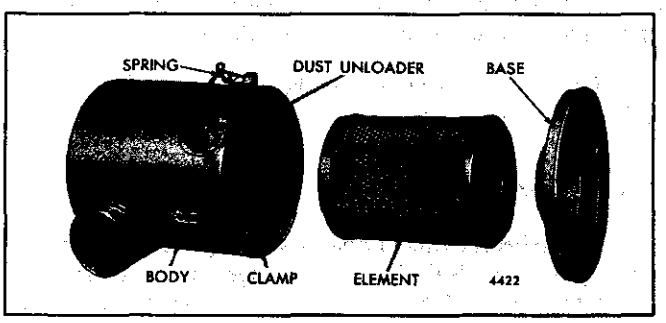


Fig. 5 – United Specialties Dry Type Air Cleaner

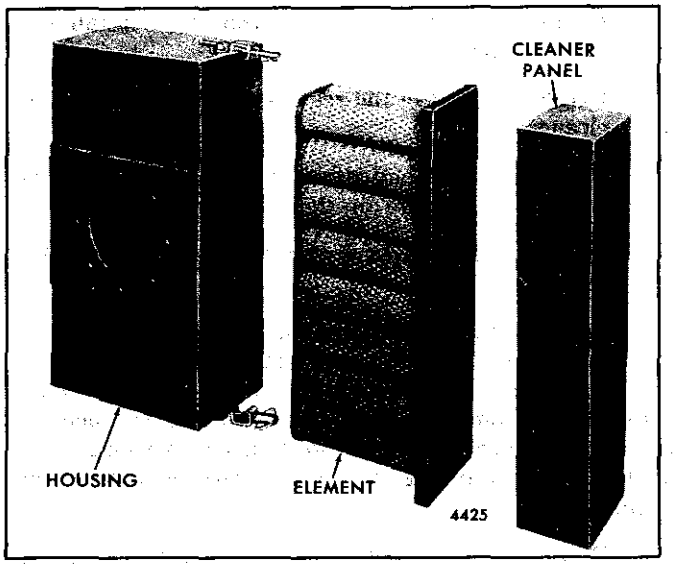


Fig. 6 – Farr Dry Type Air Cleaner

4. Inspect the cleaned element with a light bulb after each cleaning for damage or rupture. The slightest break in the element will admit sufficient airborne dirt to cause rapid failure of piston rings. Replace the element if damaged.

5. Inspect the gasket on the end of the element. If the gasket is damaged or missing, replace the element.

6. Install the element on the base with the gasket side of the element down against the base. Place the body over the element and the base and tighten the spring clamps by hand.

   Replace the element per the manufacturer's recommendations (normally after 1 year of service), or any time damage is noted.

7. Install the dust unloader and tighten the clamp.

FARR AIR CLEANER

The Farr dry type air cleaner illustrated in Fig. 6 is designed to provide highly efficient air filtration under all operating conditions and is not affected by engine speed. The cleaner assembly consists of a cleaner panel with a replaceable impregnated paper filter element.

The cleaner panel and replaceable filter element are held together in a steel housing with fasteners.

Operation

The deflector vanes impart a swirling motion to the air entering the air cleaner and centrifuge the dust particles against the walls of the tubes. The dust particles are then carried to the dust bin at the bottom of the cleaner by approximately 10% bleed–off air and are finally discharged into the atmosphere.

The cleaner panel is fully effective at either high or low velocities.

The remainder of the air in the cleaner reverses direction and spirals back along the discharge tubes again centrifuging the air. The filtered air then reverses direction again and enters the replaceable filter element through the center portion of the discharge tubes. The air is filtered once more as it passes through the pleats of the impregnated paper element before leaving the outlet port of the cleaner housing.

Service

The cleaner panel tends to be self–cleaning. However, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element. Overloading of the paper element will not cause dirt particles to bypass the filter and enter the engine, but will result in starving the engine for air.

Replace the filter element as follows:

1. Loosen the wing nuts on the fasteners and swing the retaining bolts away from the cleaner panel.

2. Lift the cleaner panel away from the housing and inspect it. Clean out any accumulated foreign material.

3. Withdraw the paper filter element and discard it.

4. Install a new filter element.

5. Install the cleaner panel and secure it in place with the fasteners.

DONALDSON AIR CLEANER

The Donaldson dry type air cleaners shown in Figs. 7, 8 and 9 are designed to provide highly efficient air filtration under all operating conditions. The cleaners have a replaceable impregnated paper filter element that can be cleaned.

The fins on the element give high speed rotation to the intake air, which separates a large portion of the dust from the air by centrifugal action. The plastic fins, the element and the gasket make up a single replaceable element assembly.

The dust is swept through a space in the side of the baffle and collects in the lower portion of the body or dust cup. The dust remaining in the precleaned air is removed by the element.

The dry type cleaner *cannot be used* where the atmosphere contains oil vapors, or fumes from the breather can be picked up by the air cleaner.

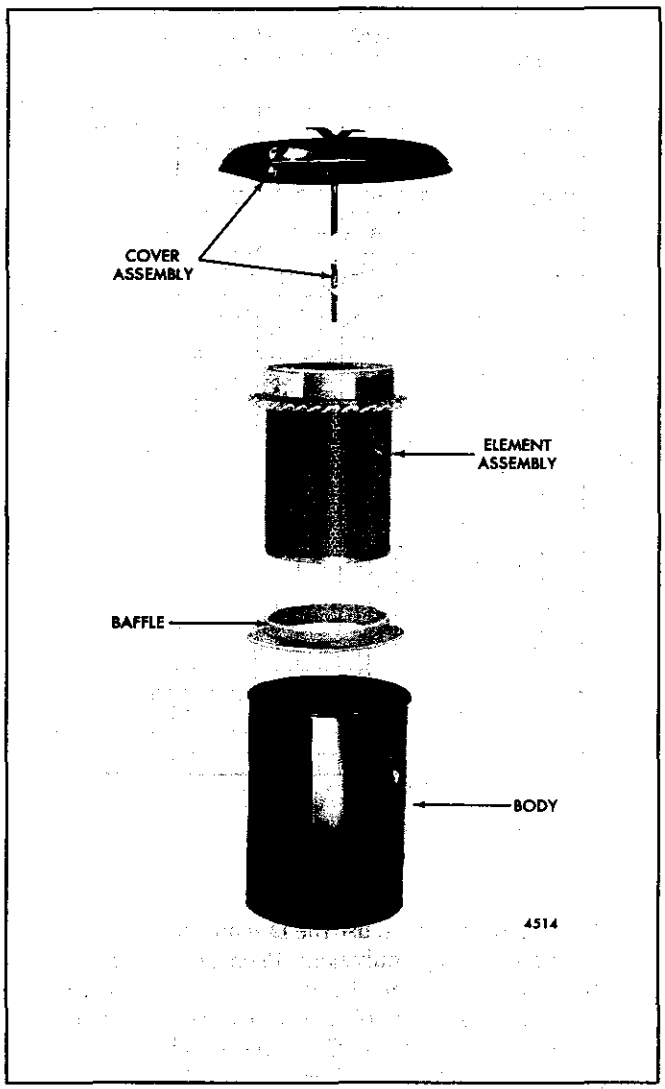


Fig. 7 – Dry Type Air Cleaner

Service (Dry Type)

The air cleaner should be serviced as operating conditions warrant. See Section 15.1 for element change intervals.

Under no engine operating conditions should the maximum allowable air intake restriction shown in Section 13.2 of the service manual be exceeded. Check restriction with a water manometer using the procedure outlined under "final RUN–IN" in Section 13.2.1. In addition, inlet restriction should be adjusted for high altitude conditions (see Table). A clogged air cleaner element will cause excessive intake restriction, reduce air supply to the engine, poor performance and higher valve and cylinder temperatures.

Disassemble the cleaner as shown in Fig. 7 as follows:

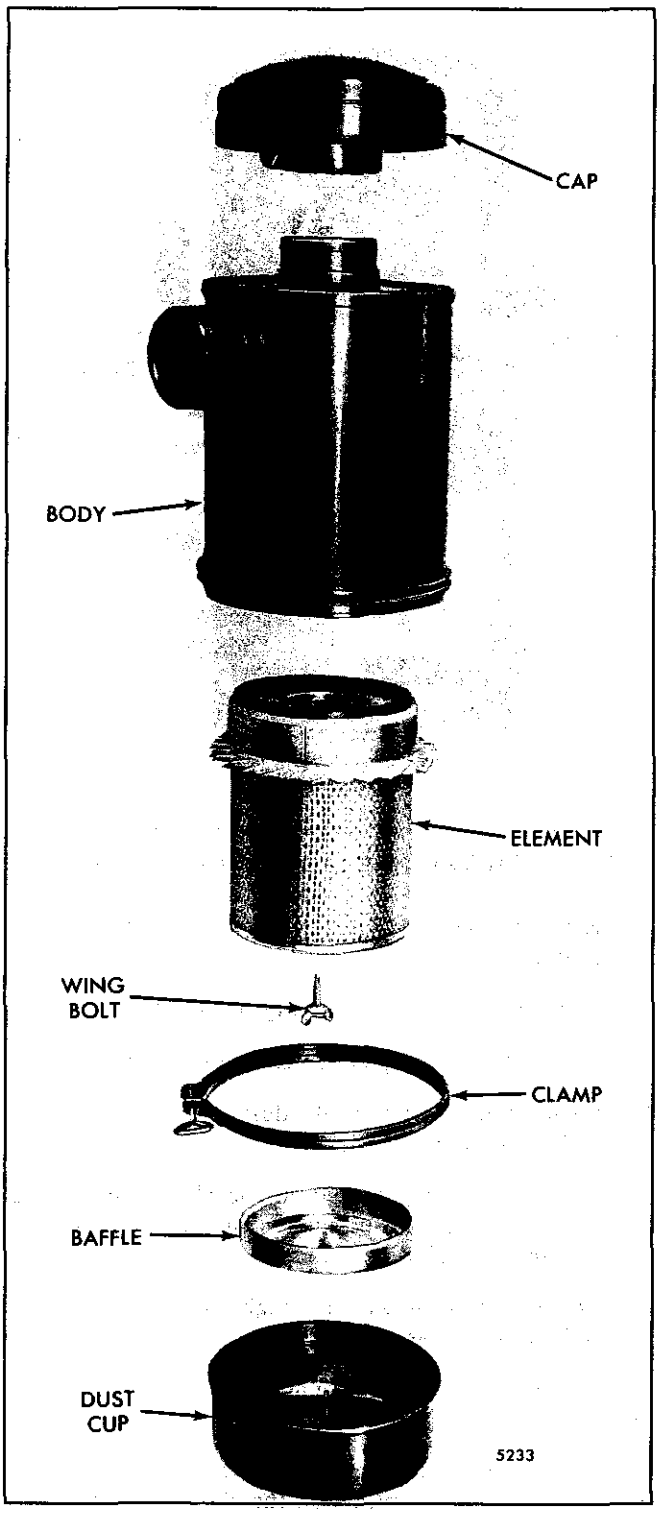


Fig. 8 – Dry Type Air Cleaner (Heavy Duty)

1. Loosen the cover bolt and remove the cover and bolt as an assembly.
2. Remove the element assembly and baffle from the cleaner body.

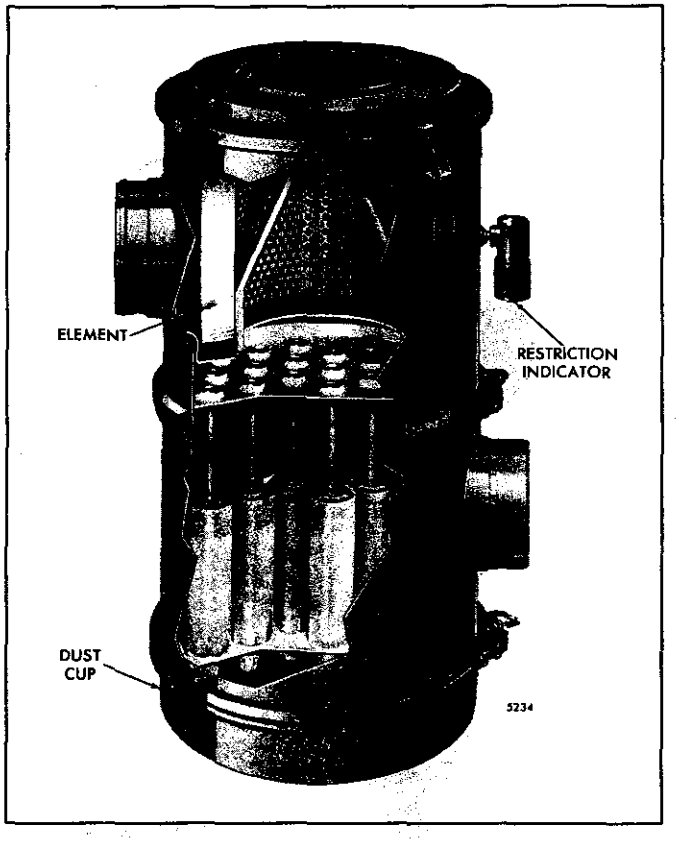
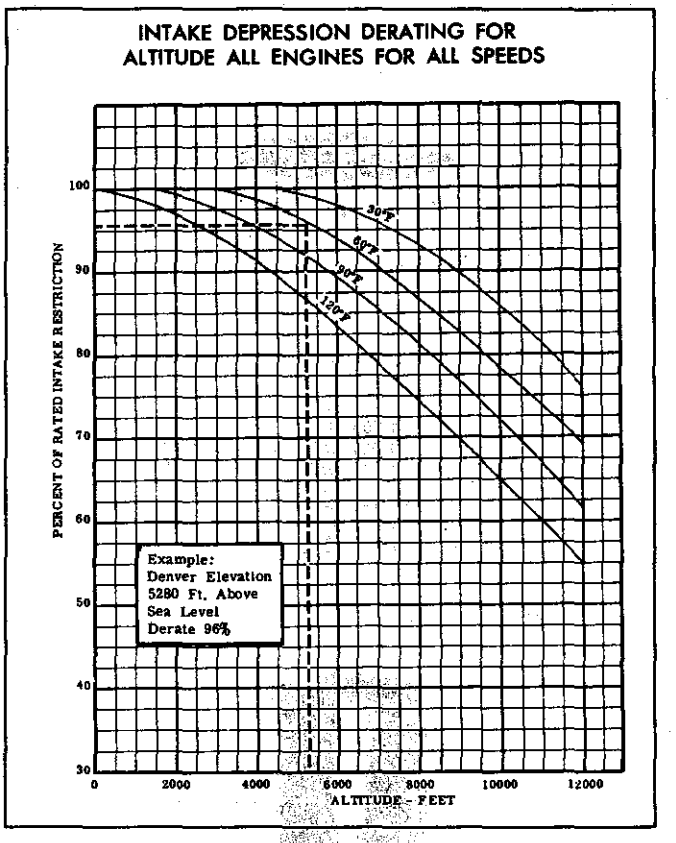


Fig. 9 – Dry Type Air Cleaner (Extra Heavy Duty)



TABLE

3. Remove the dust and clean the cleaner body thoroughly.

Disassemble the cleaner in Fig. 8 as follows:

1. Loosen the dust cup clamp and remove the dust cup.
2. Loosen the wing bolt in the dust cup and remove the baffle from the dust cup.
3. Remove the wing bolt from the cleaner body and remove the element assembly. The pre–cleaning fins are not removable.
4. Remove the dust and thoroughly clean the cleaner body, dust cup and baffle.

The paper pleated element assembly can be cleaned as follows:

1. The element can be dry cleaned by directing clean air up and down the pleats on the clean air side of the element. Maintain a reasonable distance between the nozzle and the element.

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

2. To wash the element, use the Donaldson Filter Cleaner or a non–sudsing equivalent. Proportions are 2 ounces of cleaner to 1 gallon of water. For best mixing results, use a small amount of cool tap water then add it to warm (100° F or 38° C) water to give the proper proportion. Soak the element for 15 minutes, then rinse it thoroughly with clean water from a hose (maximum pressure 40 psi or 135 kPa). Air dry the element completely before reusing (a fan or air draft may be used, but *do not heat* the element to hasten drying).

The filter manufacturer has no control over the field cleaning method or procedure. Therefore, it is the responsibility of the person or shop cleaning the element to assure the reliability of the filter after cleaning. It is also the responsibility of the installer to assure proper sealing of the gaskets.

Donaldson advises that elements used in on–highway applications should not be washed or reused. The reason for this is that on–highway trucks operate in an environment contaminated by a mixture of fine dust and exhaust carbon. To better enable dry type air cleaners to handle this type of contaminant, most on–highway truck air cleaners contain special chemically treated elements. Washing can remove the chemical treatment and shorten element life.

Consequently, on–highway air cleaner elements should not be washed and reused.

Most Donaldson primary elements used in off–highway applications do not receive the same chemical treatment. These can be cleaned and reused according to the manufacturer's recommendations. Secondary (safety) elements should not be cleaned or reused.

3. Inspect the cleaned element with a light bulb after each cleaning. Thin spots, pin holes, or the slightest rupture will admit sufficient air borne dirt to render the element unfit for further use and cause rapid failure of the piston rings. Replace the element assembly if necessary.
4. Inspect the gasket on the end of the element. If the gasket is damaged or missing, replace the element.

Reassemble the air cleaner in reverse order of disassembly. Replace the air cleaner body gasket, if necessary.

NOTICE: Do not use oil in the bottom of the cleaner body.

The element assembly should be replaced after six (6) cleanings, or annually.

Element Life

The recommended product life (shelf life plus service life) of Donaldson dry type air cleaner elements is three years. Consequently, Donaldson elements should be put into service no later than two years from the date of manufacture. Farr air cleaner elements should be put into service within one year from the date of manufacture.

AIR SILENCER

IN–LINE NATURALLY ASPIRATED 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.

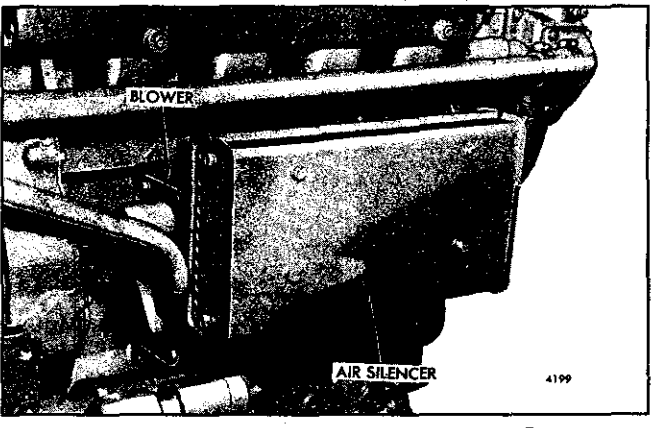


Fig. 1 – Air Silencer Mounted on In–Line Engine

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.
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.

6V TURBOCHARGED AND 8V ENGINES

The air silencer (Fig. 2) is mounted on a support bracket. On naturally aspirated 8V engines, the air outlet end is attached to the air inlet housing with a hose and clamps. On turbocharged 6V and 8V engines, the air silencer is attached to the air inlet (compressor end) of the turbocharger 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.

Install Air Silencer

1. If previously removed, attach the mounting straps to the top of the silencer support bracket. 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.
3. Align the silencer with the air inlet housing or turbocharger compressor inlet, 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.

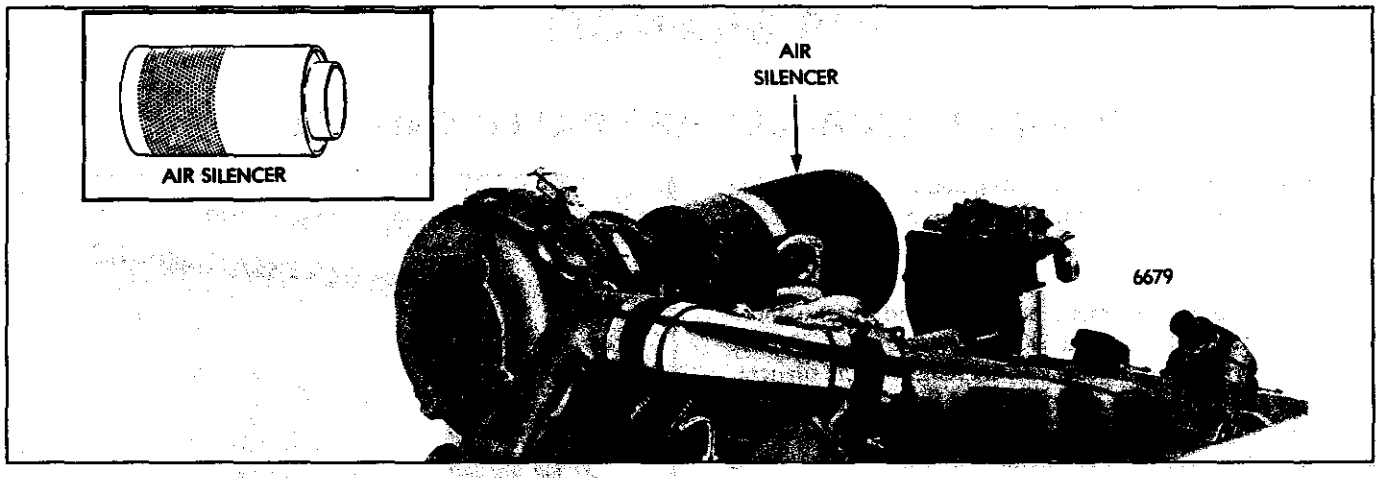


Fig. 2 – Air Silencer Mounted on 6V Turbocharged Engine

AIR SHUTDOWN HOUSING

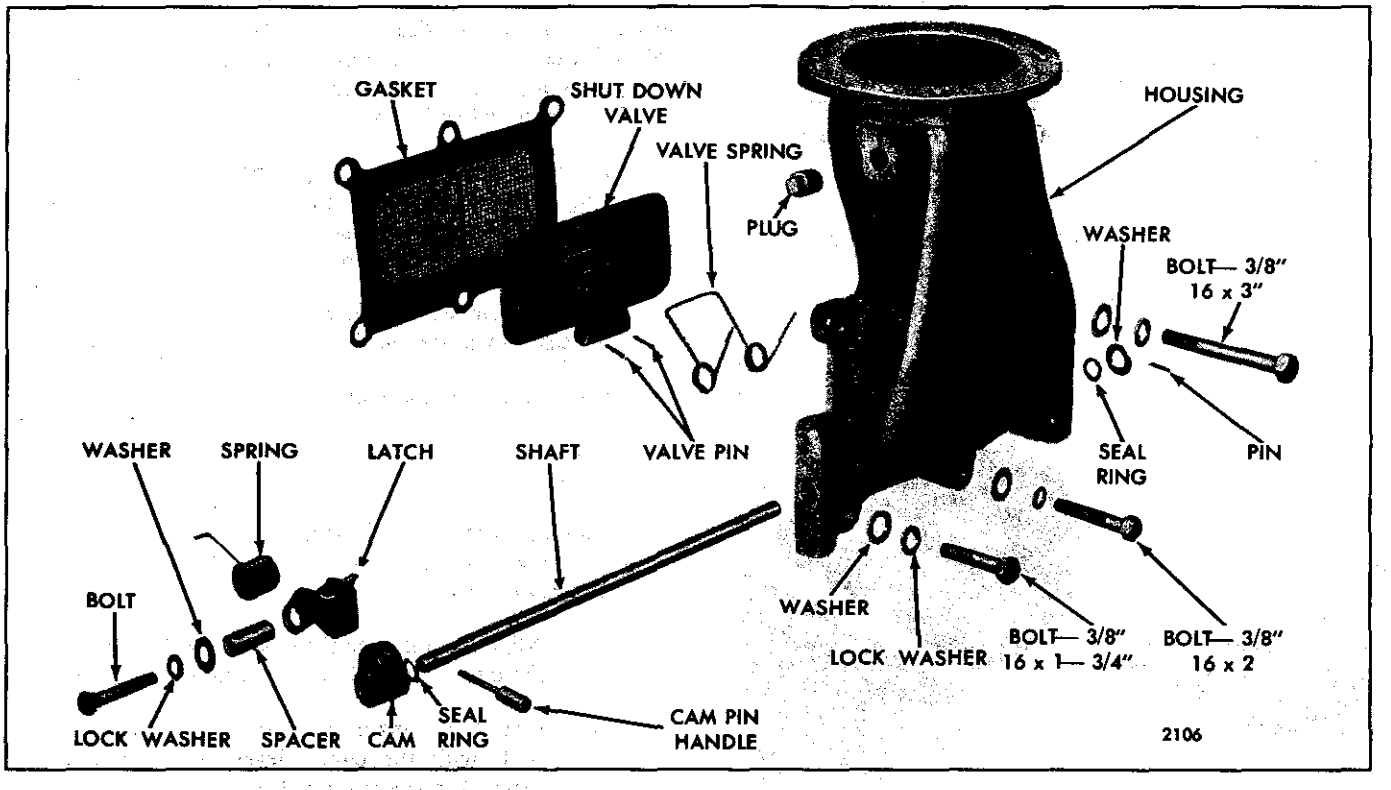


FIG. 1 – Typical In–Line Engine Air Shutdown Housing Details and Relative Location of Parts

The air shutdown housing on the in–line engine is mounted on the side of the blower, while the V–type engine has the air shutdown 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 shutdown 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 Shutdown Housing

1. Disconnect and remove the air ducts between the air cleaner and the air shutdown 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 shutdown housing gasket from the blower.

   The bolts that retain the air inlet housing to the blower are of different lengths. Mark the location of each bolt to insure proper installation later.
4. Cover the blower opening to prevent dirt or foreign material from entering the blower.

Disassemble Air Shutdown Housing

Refer to Fig. 1 and disassemble the air shutdown housing as follows:

1. Remove the pin from the end of the shutdown shaft. Then remove the washer from the shaft and the seal ring from the housing.
2. Remove the two pins that secure the air 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.

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

Inspect the parts for wear or damage. The face of the air shut–off valve must be perfectly flat to assure a tight seal when it is in the shutdown position.

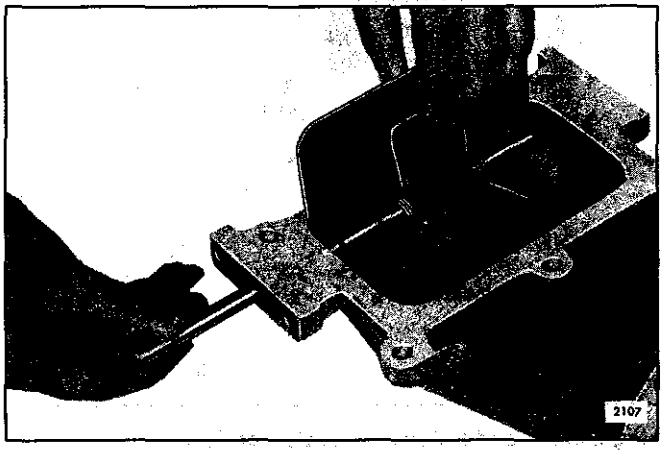


Fig. 2 – Installing Air Shut–Off Valve Spring and Valve

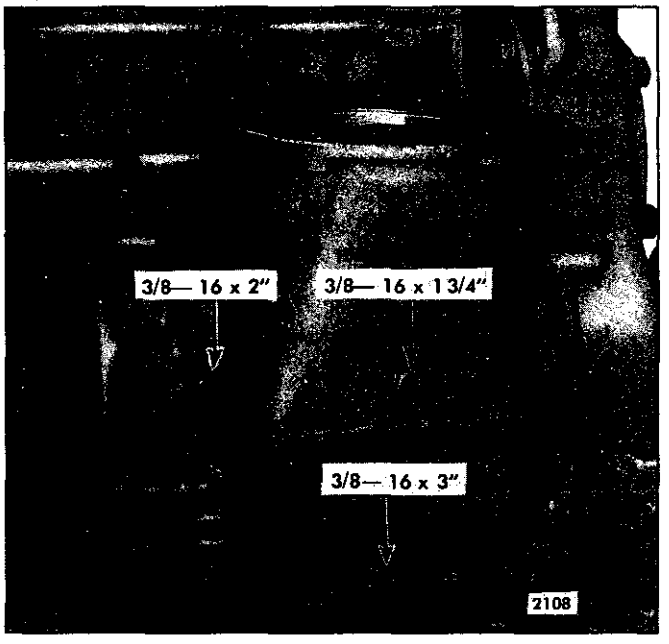


Fig. 3 – Location of Air Shutdown Housing Mounting Bolts (In–Line Engines)

Assemble Air Shutdown 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 .030" 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 .700" from the side of the housing where the shutdown latch is assembled.
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 shutdown 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 shutdown position.
   d. Adjust the bushing so the valve(s) contacts the housing when the cam release latch is set.

Install Air Shutdown 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 shutdown housing to the blower with bolts, washers and lock washers as follows:
   a. Install and finger tighten the six attaching bolts shown in Fig. 3.
   b. Tighten the two center bolts to 16–20 lb–ft (22–27 N·m) torque.
   c. Then tighten the four corner bolts to 16–20 lb–ft (22–27 N·m) torque.

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

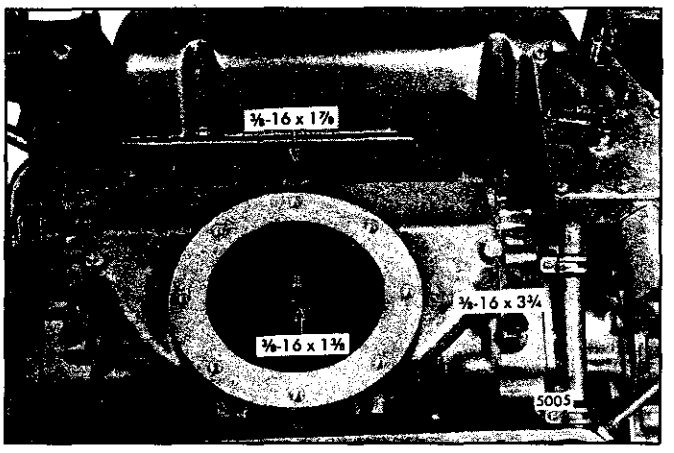


Fig. 4 – Location of Air Shutdown Housing Mounting Bolts (6V Engines)

3. Reset the air shutdown to the run position.

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

Install Air Shutdown Housing (6V–53 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 (22–27 N·m) torque.

3. Reset the air shutdown to the run position.

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

Install Air Shutdown Housing and Adaptor (8V–53 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. 5 and install the air shutdown housing adaptor on the screen and gasket assembly. Install the six bolts and lock washers and tighten them to 16–20 lb–ft (22–27 N·m) torque.

3. Affix a new gasket on the top of the air inlet housing adaptor, then place the air shutdown housing on top of the gasket. Install the six bolts and lock washers and tighten them to 16–20 lb–ft (22–27 N·m) torque.

4. Reset the air shutdown to the run position.

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

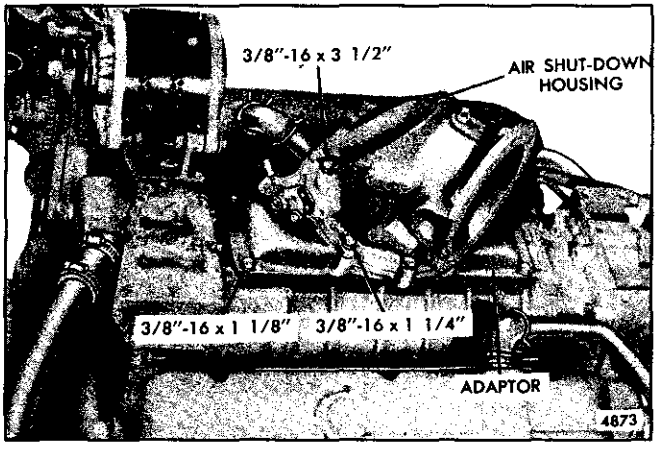


Fig. 5 – Location of Air Shutdown Housing and Adaptor Mounting Bolts (8V–53 Engines)

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.

The blower upper rotor gear of the 2–53 and 3–53 engines meshes with either the camshaft or balance shaft gear. The 4–53 and 6V engines have a blower drive gear.

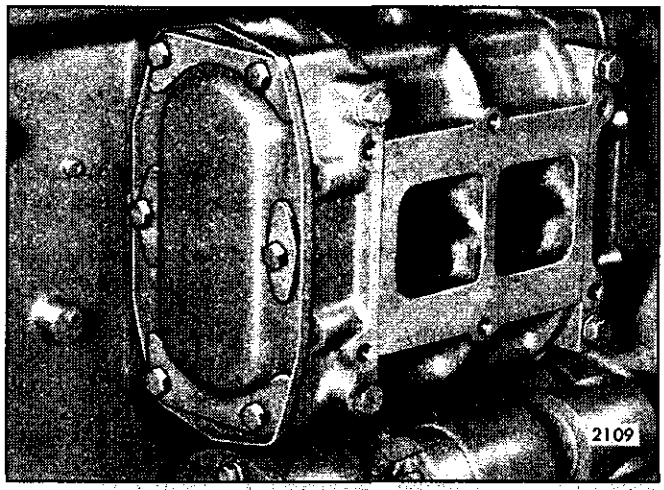


Fig. 1 – Blower Mounting (3–53 Engine)

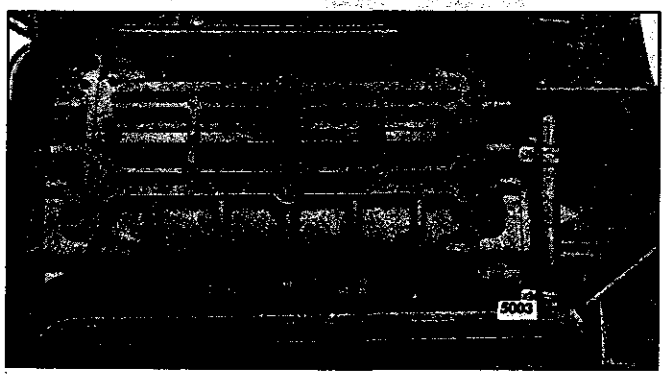


Fig. 2 – Blower Mounting (6V Engine)

Do not mix the former and the current hardened gears on the same engine. Mixing the gears will result in excessive gear wear and may lead to serious engine damage. The hardened gears are used on 3–53 turbocharged industrial and 6V turbocharged automotive engines. This change became effective with engine serial numbers 3D–193516 and 6D–229616. When replacing the former blower drive gears with the new, both gears must be changed.

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.

The Brazilian built engines used a blower assembly with a shorter housing and rotors for reduced capacity. Turbocharged engines use the Teflon® oil seal while the naturally aspirated engines built in Brazil used the polyacrylic oil seal. Only the Teflon® blower oil seal is serviced. An oversized lip type oil seal and a blower rotor shaft sleeve are available to increase life on the sealing surface of the blower rotor shaft.

Effective with engine serial numbers 4D–201579 and 6D–220736, new carbonitride–hardened blower drive shaft and a new steel induction–hardened blower coupling cam are being used in naturally aspirated and turbocharged engines. Carbonitride hardening results in added resistance to shaft and coupling spline wear. To distinguish the new shafts from the former, one end of each new shafts is stamped with the letter "H". The non–counterbored face of the new cam is stamped with the letter "S". The former and the new components are not interchangeable, and only the new components will be serviced.

Effective with engine serial numbers 3D–191032, 4D–204949 and 6D–225858, bypass blowers are used on all Series 53 turbocharged industrial engines.

A spring–loaded bypass relief valve is positioned in a passage in the front (3–53 and 4–53 engines) or rear (6V engines) blower end plate (Figs. 21 and 22). This valve is closed at start–up and during low rpm/light load operation. However, as engine speed and load increase, turbocharger speed also increases until the turbocharger provides sufficient boost pressure for scavenging and charging the engine cylinders. At 10" Hg (34 kPa) airbox pressure the valve in the passage begins to open and is fully open at 13" Hg (44 kPa). With the valve in the *open* position, incoming air is allowed to flow through the lobes of the blower and through the end plate to the airbox. The blower continues to

operate with the valve open, but requires less engine power because the pressure rise across the blower is greatly reduced. This results in decreased brake specific fuel consumption and increased fuel economy.

The bypass blower valve is externally vented back into the crankcase by means of a small hose and tube through the blower end plate. A very small amount of air bleeds past the valve and psses through the hose to help keep the valve clean and functioning properly. This has no effect on crankcase pressure.

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: To avoid personal injury 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.

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 shutdown housing as outlined in Section 3.3.

2–53 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.
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 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. Discard the gaskets.
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.

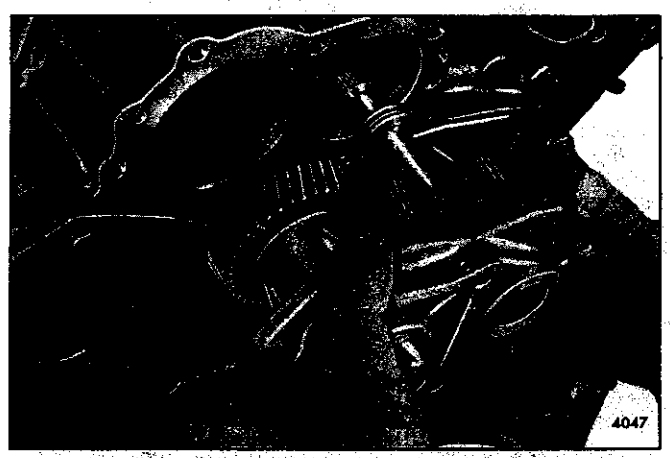


Fig. 3 – Removing/Installing Blower Drive Support (6V Engine)

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).

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

2-53 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 28483 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.

   NOTICE: 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.

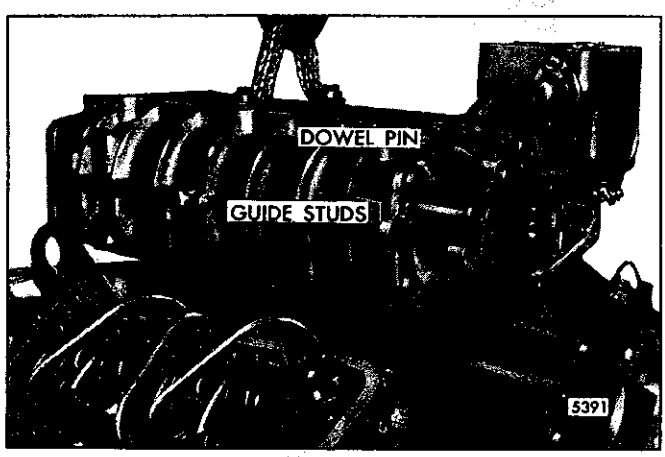


Fig. 4 – Removing/Installing Blower (6V Engine)

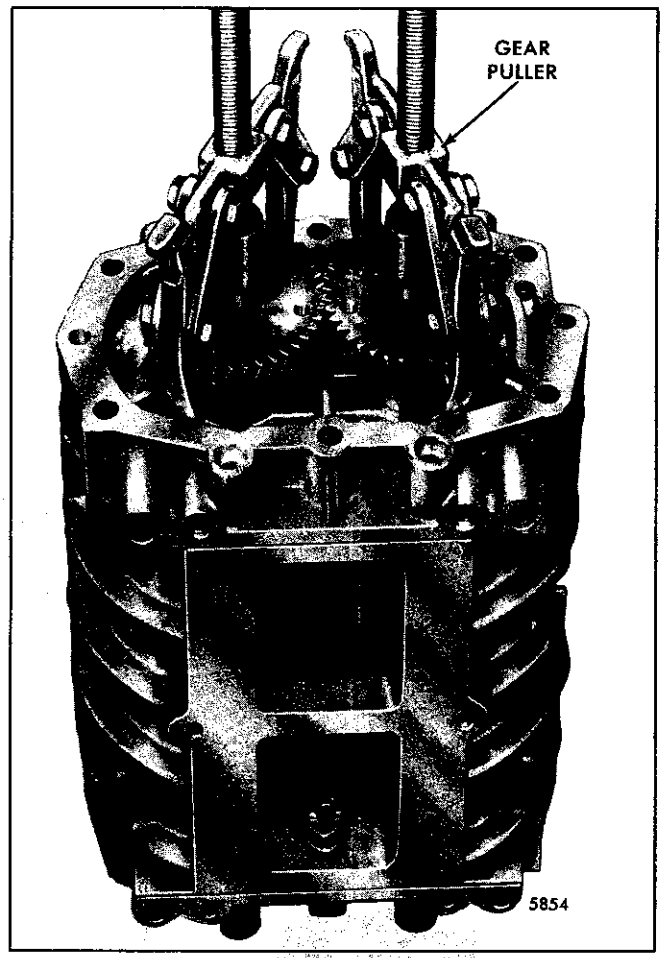


Fig. 5 – Removing Blower Rotor Gears

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

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. 6).

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.

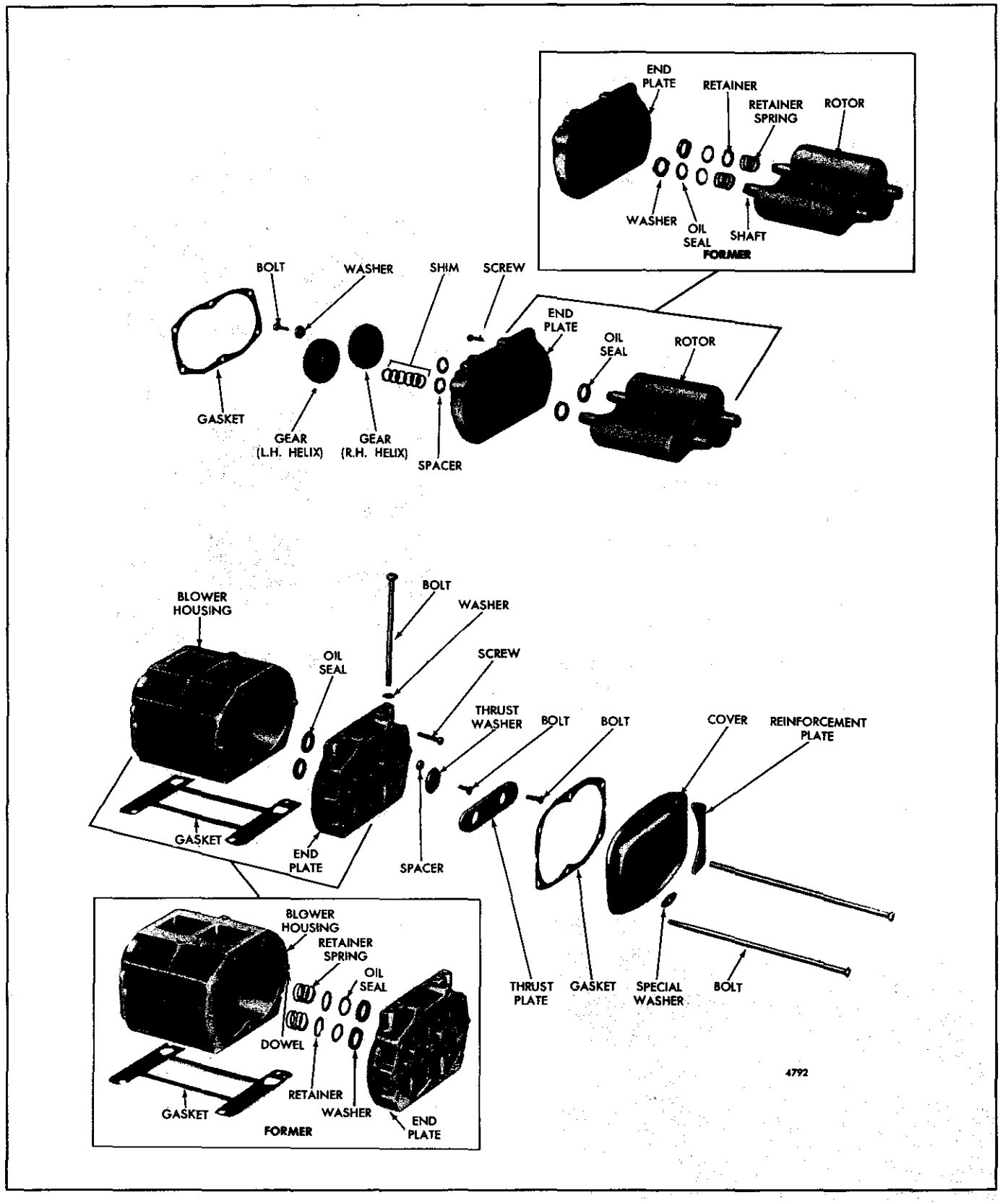


Fig. 6 – Typical Blower Details and Relative Location of Parts (3–53 Engine Blower)

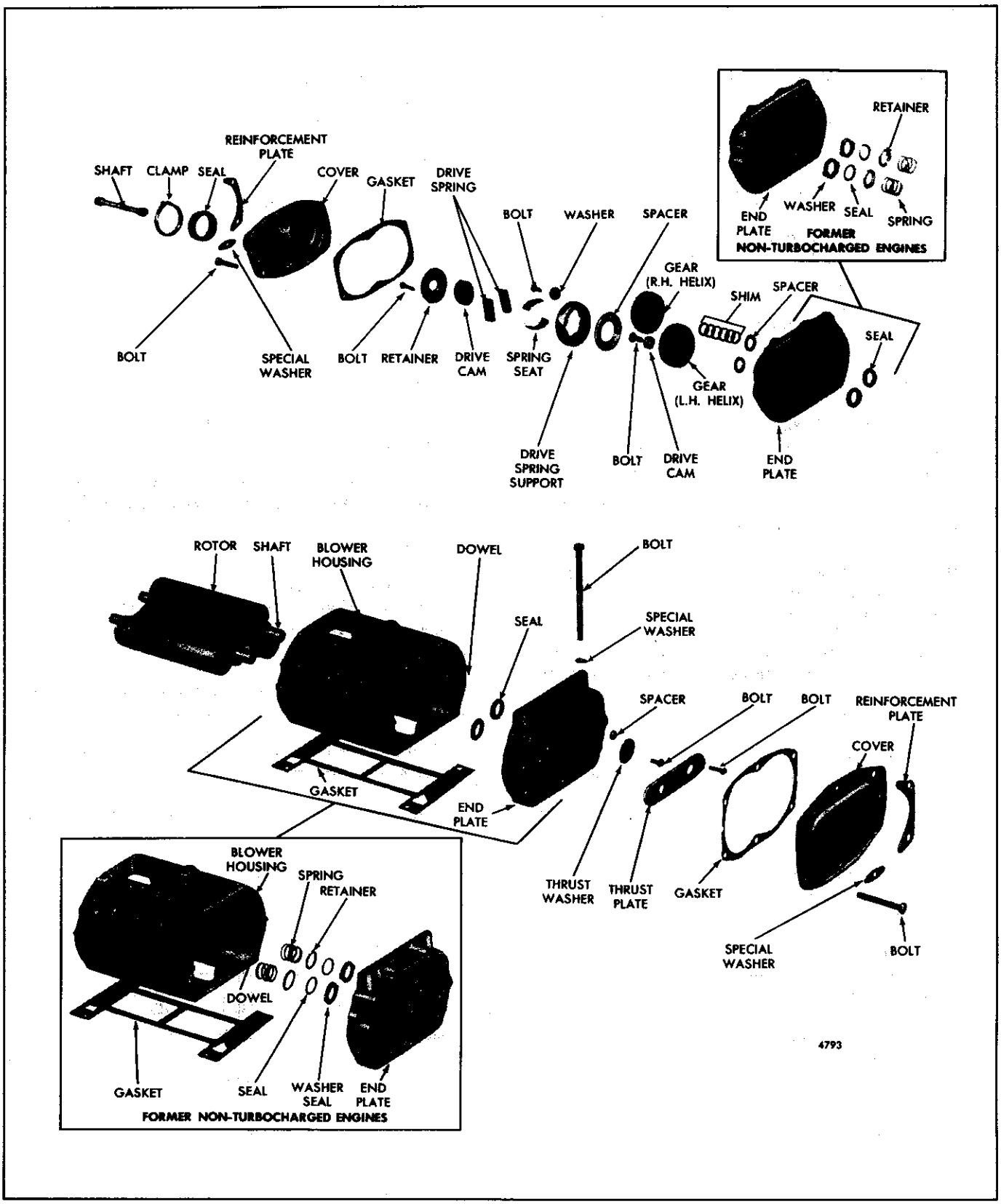


Fig. 7 – Typical Blower Details and Relative Location of Parts (4–53 Engine Blower)

9. If a bypass valve is used in the front end plate, disconnect the hose from the end plate. Remove the two bolts which secure the bypass valve in the end plate, then remove the bypass valve.

10. Clamp the bypass valve between the soft jaws of a vise and loosen the nut in the end of the valve. Remove the nut, spring and valve.

4–53 and 6V–53 ENGINE BLOWERS

1. Refer to Fig. 7 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.

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. 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. 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 28483 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 reassembly.

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.

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, "O" 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.

14. If a bypass valve is used in the front end plate, disconnect the hose from the end plate. Remove the two belts which secure the bypass valve in the end plate, then remove the bypass valve.

15. Clamp the bypass valve between the soft jaws of the vise and loosen the nut in the end of the valve. Remove the nut, spring and valve.

Inspection

Clean all of the parts thoroughly and dry with compressed air.

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

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.

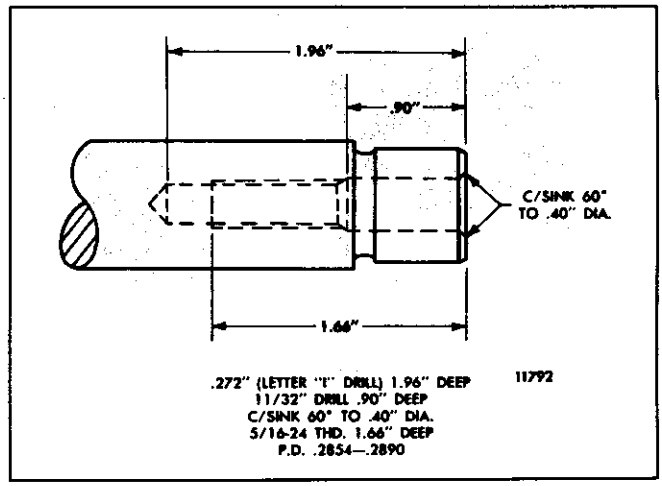


Fig. 8 – Dimensions for Reworking 6V Blower Rotor Shafts

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

If an oversize oil seal is required, a sleeve on the rotor shaft 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 21672–4 and attach the puller to the sleeve remover with three 1/4"–20 x 3" bolts and flat washers.

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. 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. 8.

Assemble Blower

Current front and rear blower end plates can now be identified either of two ways:

Knowing the machining differences, such as thrust washer drilling, governor hole drilling, counterbores drilled, etc. (Fig. 9).

End plates are stamped with the last digit of its part number (Fig. 10). The end plate with a part number ending in 99 will have both numbers stamped in the plate.

Refer to Figs. 6 and 7 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. 11). 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 *Teflon–lip oil seals* as follows:

   a. Press the oversize oil seal spacer onto the rotor shaft with installer J 23679–1 until either the shoulder of the tool or the spacer contacts the rotor.

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

NOTICE: Do not lubricate the seals, spacers, or blower rotor shafts prior to seal installation. Teflon lip seals *must* be installed dry. This allows transfer of the Teflon to the spacer surface for proper sealing.

   c. With the part number on the seal facing the rotor, start the oil seal straight into the bore in the end plate.

   d. Using installer J 22576, press the oil seal below the surface of the end plate until the shoulder of the installer contacts the end plate.

   e. Install the remaining oil seals in the end plates in the same manner.

No seal leakage should occur after the blower housing end plate Teflon oil seals are installed. If leakage does occur, the cause may be failure to install the seal dry. Teflon–lip blower end plate oil seals *must* be installed dry, without any prelubing.

3. 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 "O" 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.

4. Two 5/16" x 5/16" steel plugs are used in the blower end plates of all *turbocharged* engines to ensure that a full–pressure flow of lubricating oil is supplied to the engine and to the oil galleries in the turbocharger center housing. The plugs (if removed) must be installed in the diagonally drilled orifices which supply additional lubrication to the blower drive gears. Plugs are pressed flush to .03" below the surface of the end plates and staked in three places (Fig. 12). The plugs are not installed in the blower end plates of naturally aspirated engines.

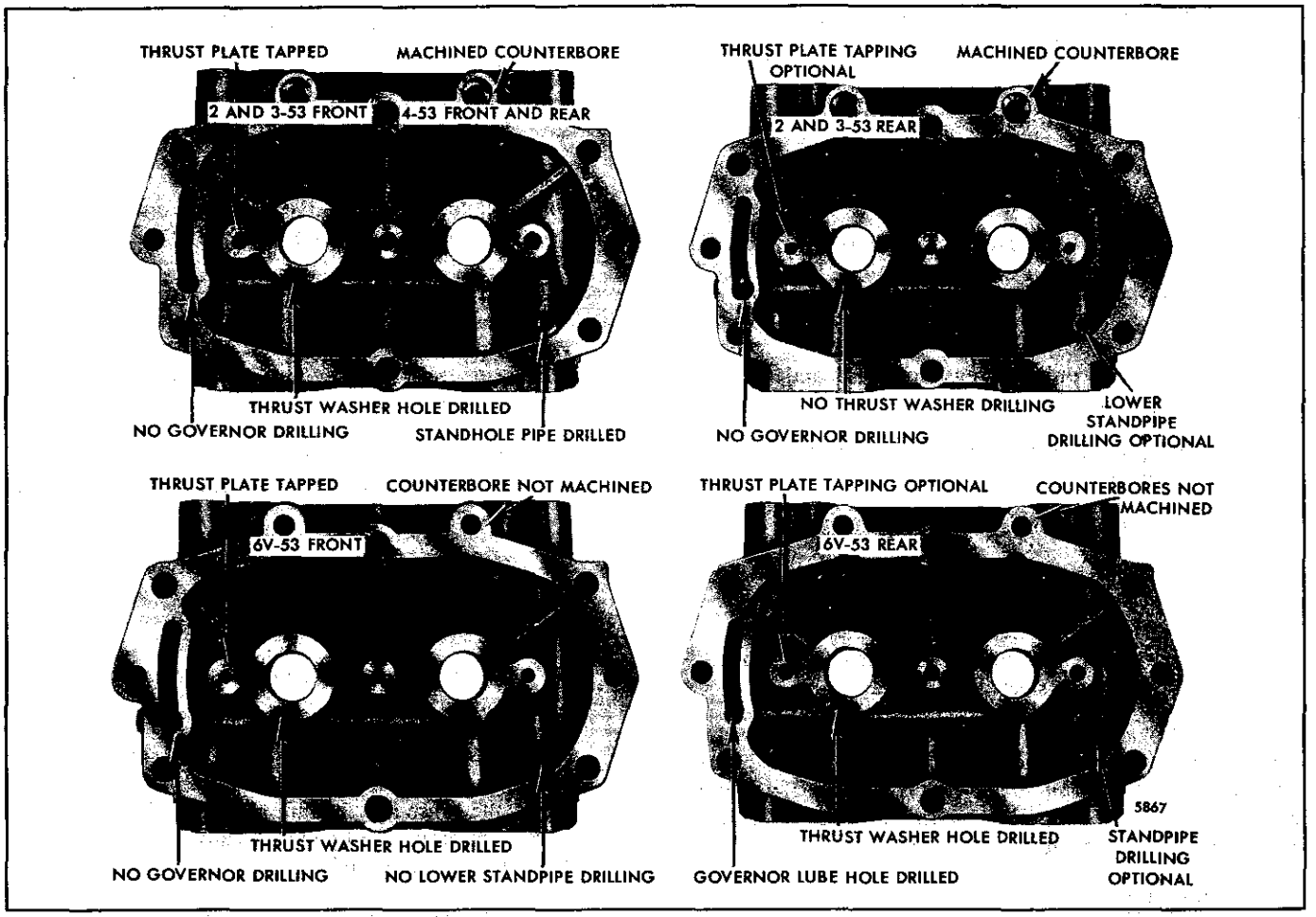


Fig. 9 – End Plate Machining Differences

NOTICE: Failure to install the plugs in the blower end plates of *turbocharged* engines can result in low engine oil pressure, inadequate turbo shaft bearing lubrication and serious engine or turbocharger damage.

5. Place the front end plate on two wood blocks. Then, install the rotors, gear end up, on the end plate (Fig. 13). On the former blowers, be sure that the ring type oil seals are properly positioned on the rotors.

6. Install the blower housing over the rotors (Fig. 14).

NOTICE: 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 *2–53 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 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.

7. Place the rear end plate over the rotor shafts (Fig. 15). 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 bolts and plain washers. Secure each end plate to the 4–53 or 6V blower with four end plate cover bolts and plain washers.

   Check the relationship of the blower end plates to the housing at the cylinder block side of the blower assembly. The protrusion of the housing with respect to the end plates should not be more than .001" above to .004" below the end plate. Excessive protrusion could distort the housing when the end plate to cylinder block bolts are tightened and cause rotor–to–housing interference.

8. 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 (34–41

N·m) torque; if 3/8"–24 bolts are used, tighten them to 54–59 lb–ft (73–80 N·m) torque.

9. Attach the three spacers and the thrust plate to the front end of the blower. Tighten the three bolts to 7–9 lb–ft (10–12 N·m) torque. Then, check the clearance between the thrust plate and the thrust washers. The specified clearance is .001" to .003" (In–line engine blower) or .0025" to .0050" (6V engine blower).

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

10. 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. 16). 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.

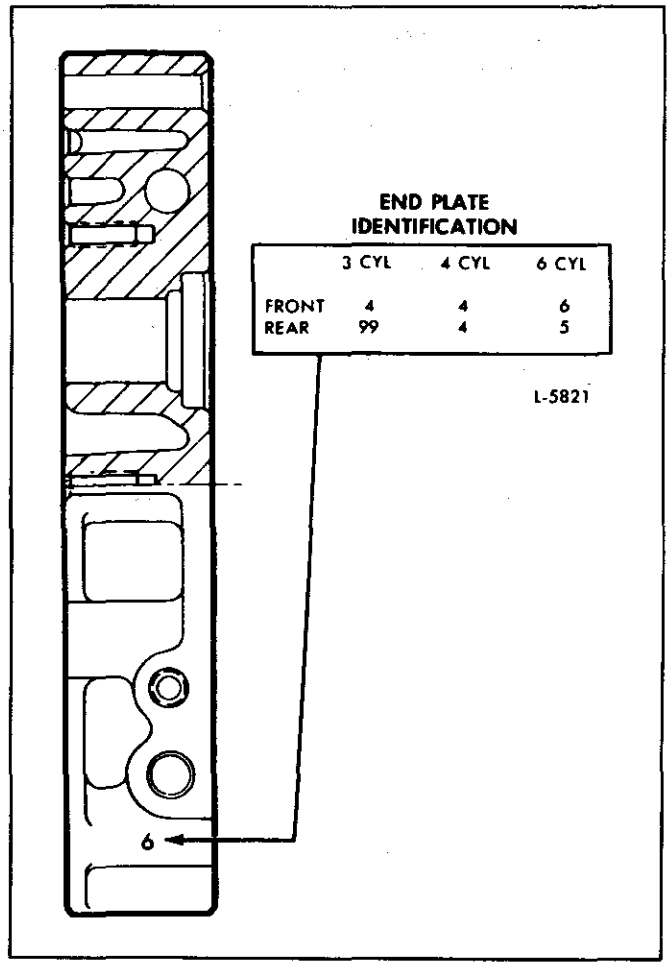


Fig. 10 – End Plate Identification

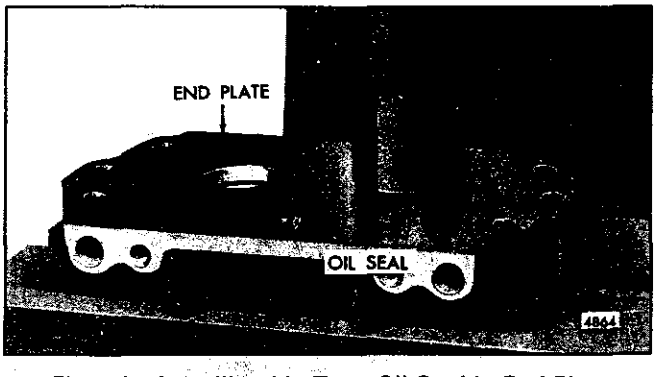


Fig. 11 – Installing Lip Type Oil Seal in End Plate with Tool J 22576

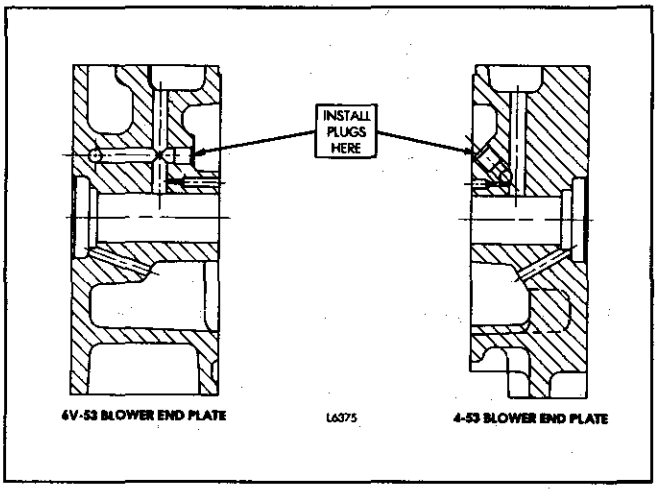


Fig. 12 – Location of Holes to be Plugged – Blower End Plates

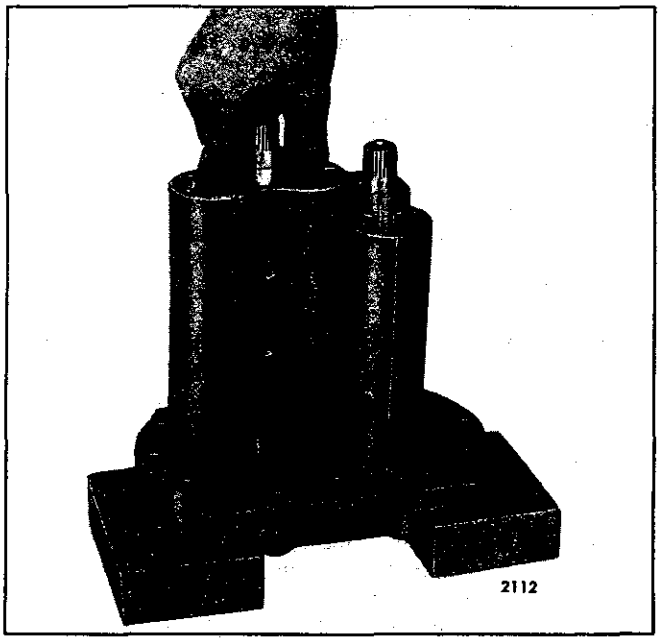


Fig. 13 – Installing Blower Rotors in Front End Plate

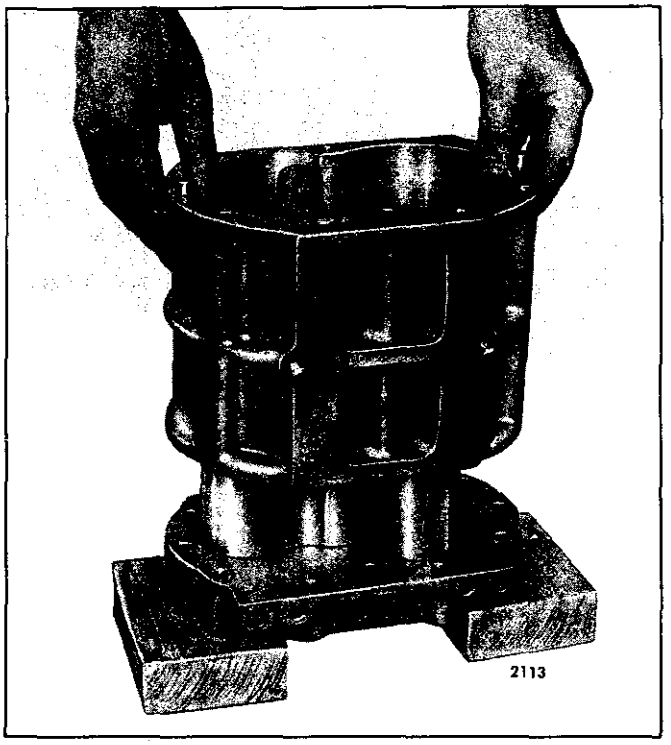


Fig. 14 – Installing Blower Housing Over Rotors

11. 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, reposition the gears.

12. 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. 17). Turn the bolts uniformly until the gears are tight against the shoulders on the shafts.

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

2–53 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 (34–41 N·m) 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 (34–41 N·m) torque.

6V–53 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 (34–41 N·m) torque.

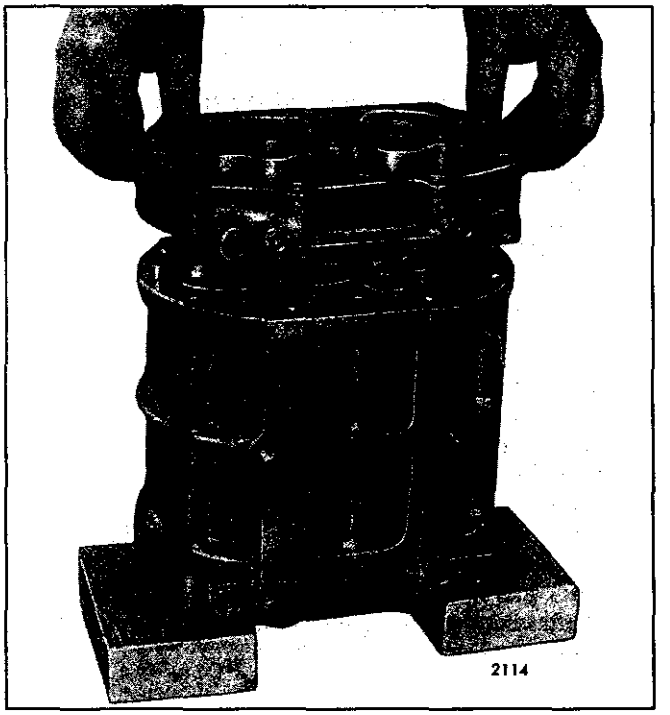
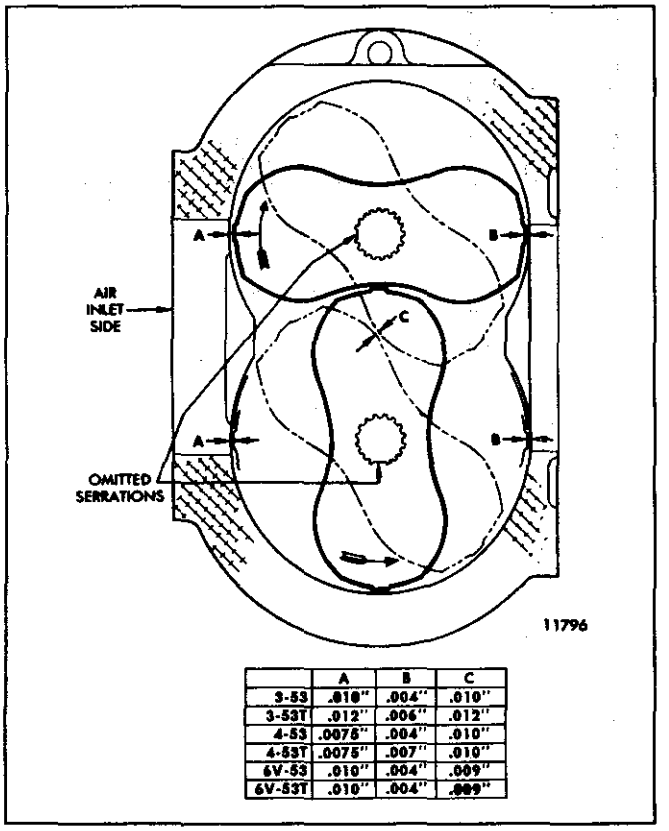


Fig. 15 – Installing Rear End Plate



	A	B	C
3-53	.010"	.004"	.010"
3-53T	.012"	.006"	.012"
4-53	.0075"	.004"	.010"
4-53T	.0075"	.007"	.010"
6V-53	.010"	.004"	.009"
6V-53T	.010"	.004"	.009"

Fig. 16 – Minimum Blower Rotor Clearance

14. 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.

15. 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. A specially designed feeler gage set J 1698–02 for the blower clearance operation is available. Take measurements from both the inlet and outlet sides of the blower.

a. Measure the clearance between the rotor lobes and the housing (Fig. 18). 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. 16).

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. 16).

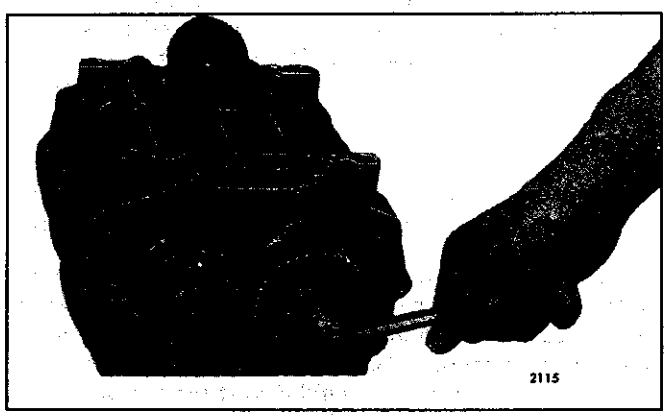


Fig. 17 – Installing Blower Rotor Gears

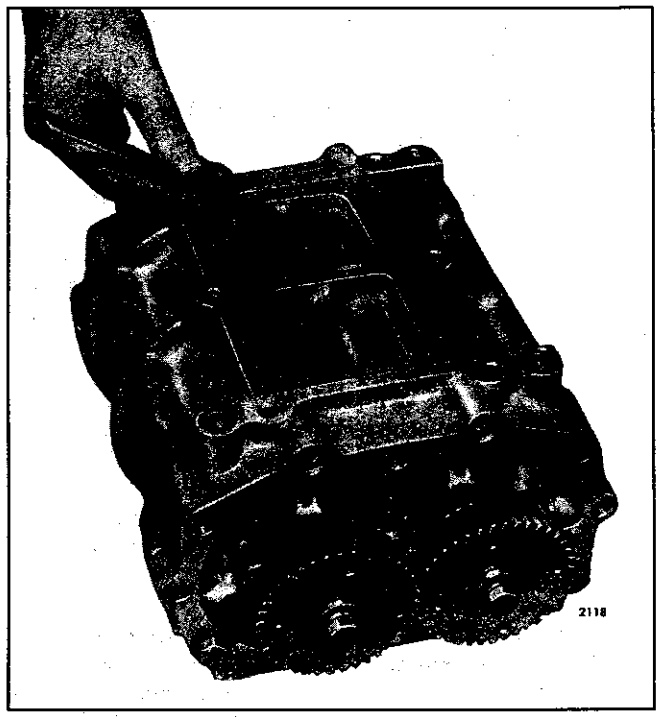


Fig. 18 – Measuring Rotor Lobe to Housing Clearance

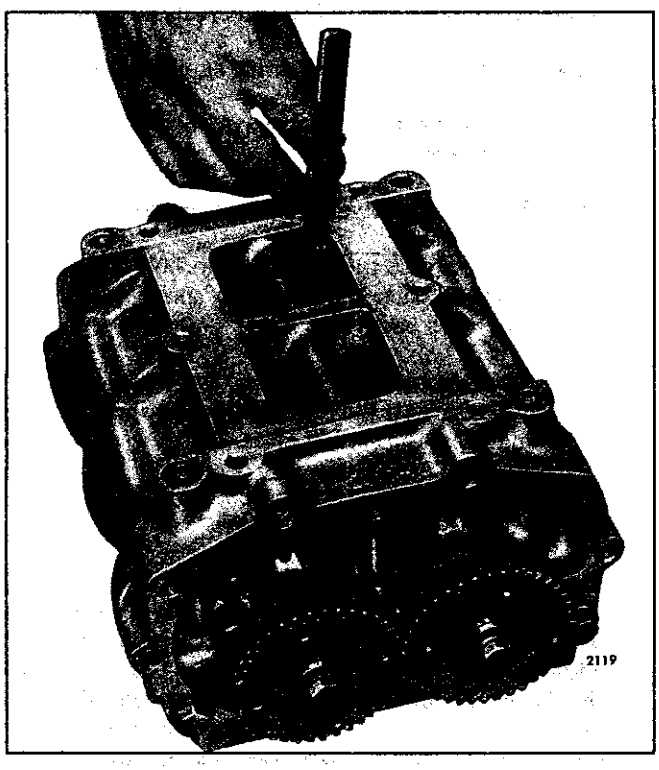


Fig. 19 – Measuring Rotor Lobe to End Plate Clearance

c. Measure the clearance between the end of the rotor and the blower end plate (Fig. 19). Refer to Table 1 for the required minimum clearances. 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.

16. 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 (27–34 N·m) torque.

Check the relationship of the blower end plates to the housing at the cylinder block side of the blower assembly. The protrusion of the housing with respect to the end plates should not be more than .001" above to .004" below the end plate. Excessive protrusion could distort the housing when the end plate to the cylinder block bolts are tightened and cause rotor to housing interference.

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.

17. Assemble the blower drive spring support as follows:

a. Place the drive spring support on two blocks of wood (Fig. 20).

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.

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

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. 21). Tighten the 5/16"–24 drive gear pilot bolt to 25–30 lb–ft (34–41 N·m) torque. Prior to the above change, a shorter drive coupling was used and no spacer was required.

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.

BLOWER ROTOR END CLEARANCES (Minimum)		
Engine	Front End Plate	Rear End Plate
3-53	.006"	.008"
3-53T	.008"	.009"
4-53	.006"	.009"
4-53T	.008"	.010"
6V-53	.008"	.010"
6V-53T	.010"	.012"

TABLE 1

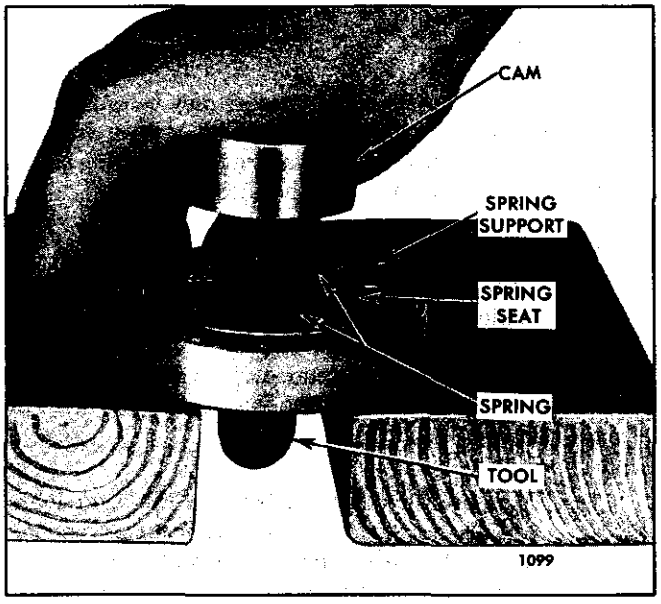


Fig. 20 – Inserting Cam in Blower Drive Support with Tool J 5209

19. Secure the cam retainer to the coupling with four 1/4"–28 bolts and tighten them to 14–18 lb–ft (19–24 N·m) torque.

20. 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 (11–14 N·m) torque.

21. 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 (27–34 N·m) torque.

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

Check the relationship of the blower end plates to the housing at the cylinder block side of the blower assembly. The protrusion of the housing with respect to the end plates should not be more than .001" above to .004" below the end plate. Excessive protrusion could distort the housing when the end plate to cylinder block bolts are tightened and cause rotor–to–housing interference.

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:

2–53 and 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. 1300, 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. 1300, or equivalent to the engine end plate side of the gasket. 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 (14–20 N·m) torque.

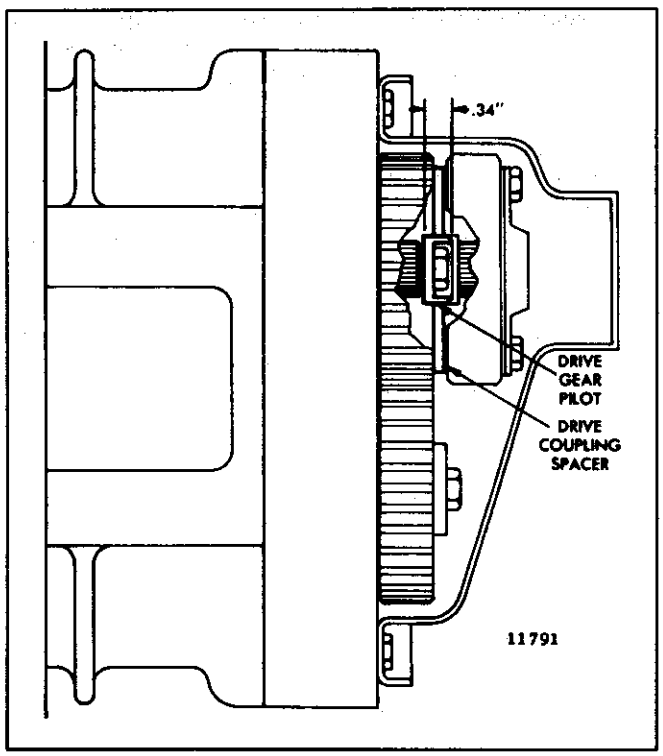


Fig. 21 – Current Pilot and Spacer Used on 4–53 Blower

4. Tighten the center blower–to–end plate bolts first, and then the top and bottom bolts to 20–25 lb–ft (27–34 N·m) torque. Then, tighten the blower–to–block bolts to 55–60 lb–ft (75–81 N·m) 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 shutdown housing (Section 3.3).
7. If used, assemble and install the blower bypass valve as follows:
   a. Install the valve in the bypass valve body with the open end facing out. Then, install the spring and nut.
   b. Clamp the bypass valve body between the soft jaws of a vise and tighten the nut to 95–105 lb–ft (129–143 N·m).
   c. Install the bypass valve assembly in the blower end plate and connect the hose.
   d. Secure the bypass valve to the blower with clamps and bolts (Fig. 22).

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. 1300, or equivalent, only on the block side of the gasket.
2. Install the seal and clamp on the blower rear end plate cover.
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 (75–81 N·m) 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 shutdown housing (Section 3.3).
9. If used, assemble and install the blower bypass valve as follows:
   a. Install the valve in the bypass valve body with the open end facing out. Then, install the spring and nut.

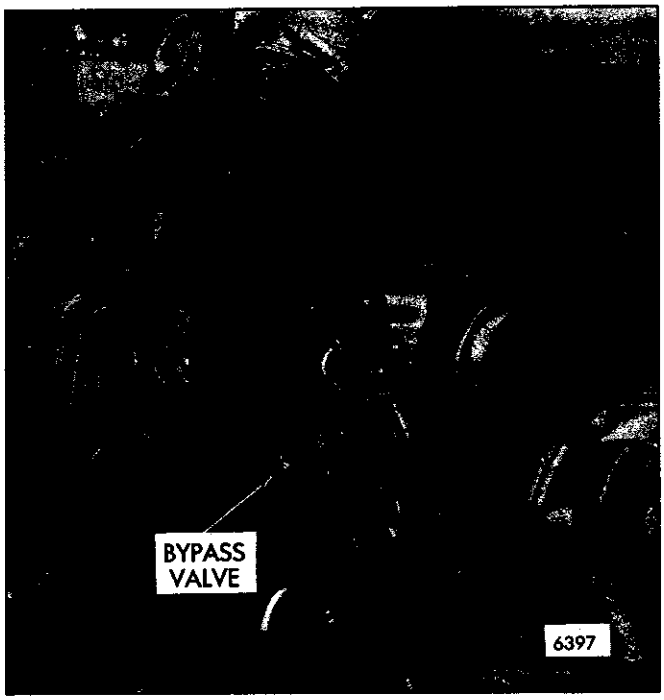


Fig. 22 – Typical Bypass Blower Valve Installation (In-Line Engine)

b. Clamp the bypass valve body between the soft jaws of a vise and tighten the nut to 95–105 lb–ft (129–143 N·m).

c. Install the bypass valve assembly in the blower end plate and connect the hose.

d. Secure the bypass valve to the blower with clamps and bolts (Fig. 22).

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. 1300, or equivalent.

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

   NOTICE: Improper bolt down sequence can cause severe stresses which could result in failure of the main governor housing.

   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. Secure the blower to the block with bolts and flat washers. Tighten the bolts to only 10–15 lb–ft (14–20 N·m) torque at this time.

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 20–24 lb–ft (27–33 N·m) 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. The blower drive support and attaching accessories must be secured to the governor housing before final torque of the blower–to–block bolts.

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 20–24 lb–ft (27–33 N·m) torque.

9. Tighten the blower–to–block bolts to 55–60 lb–ft (75–81 N·m) torque.

10. If used, assemble and install the blower bypass valve as follows:

    a. Install the valve in the bypass valve body with the open end facing out. Then, install the spring and nut.

b. Clamp the bypass valve body between the soft jaws of a vise and tighten the nut to 95–105 lb–ft (129–143 N·m).

c. Install the bypass valve assembly in the blower end plate and connect the hose.

d. Secure the bypass valve to the blower with clamps and bolts (Fig. 23).

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

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

13. Use new gaskets and reinstall the valve rocker covers.

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

15. Install the spring assembly in the governor.

16. Install the air shutdown housing (Section 3.3).

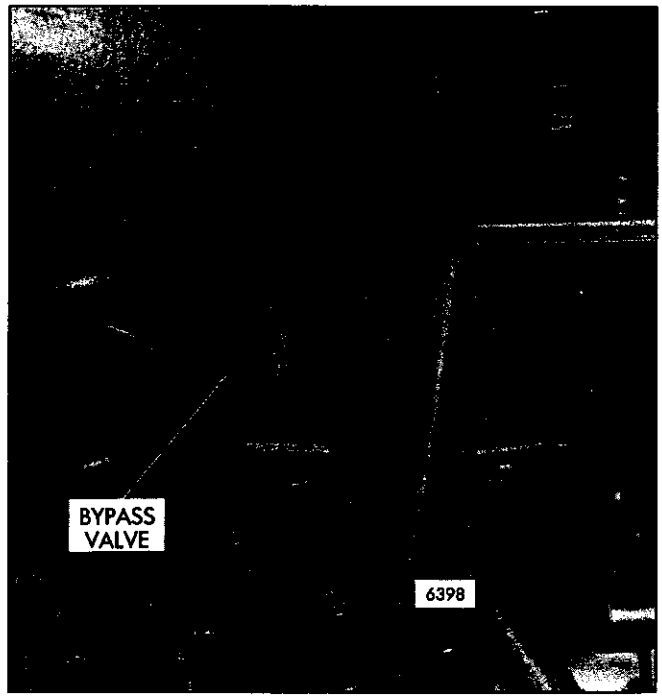


Fig. 23 – Typical Bypass Blower Valve Installation (6V Engines)

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

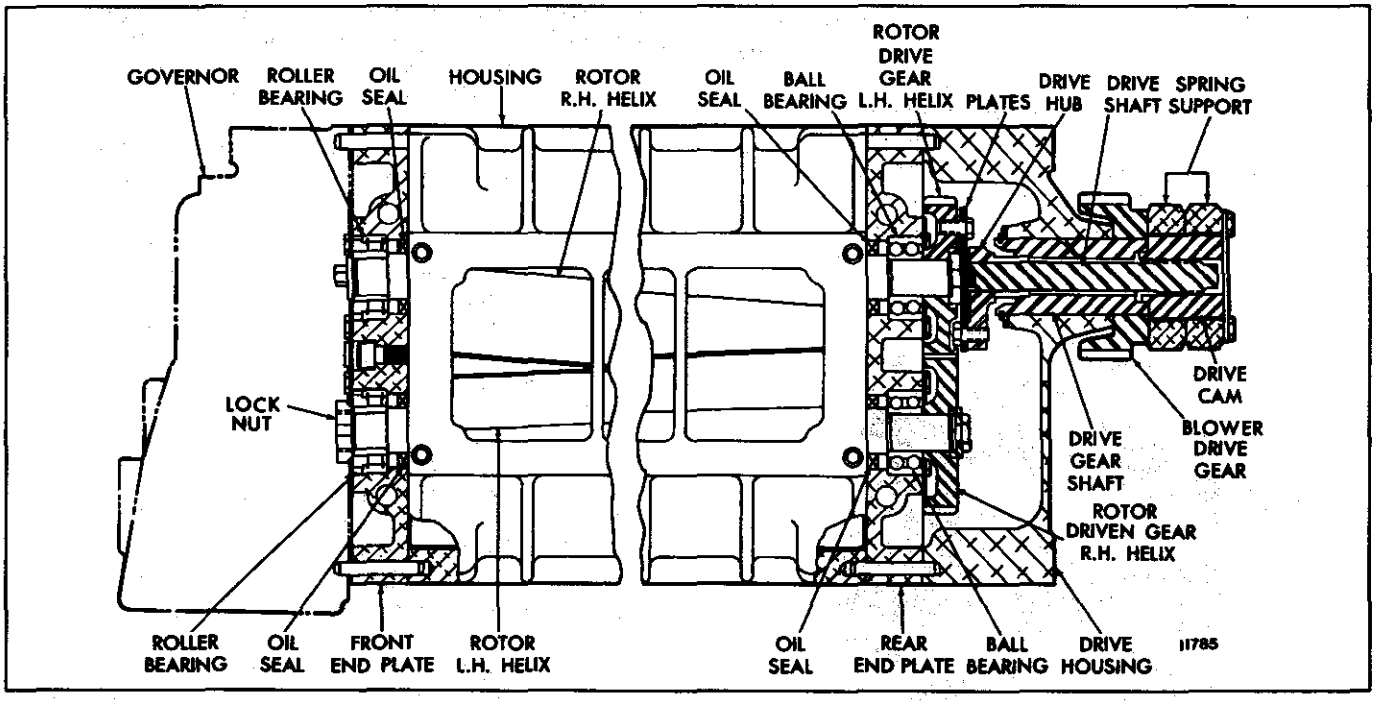


Fig. 1 – Current Blower and Drive Assembly

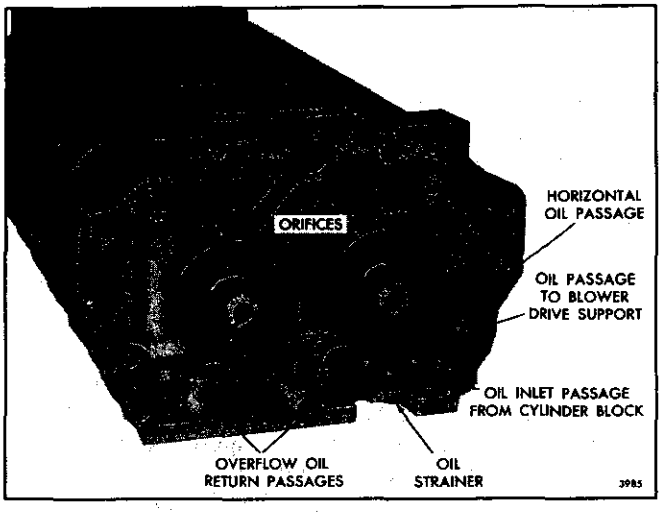


Fig. 2 – Blower Lubrication

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.

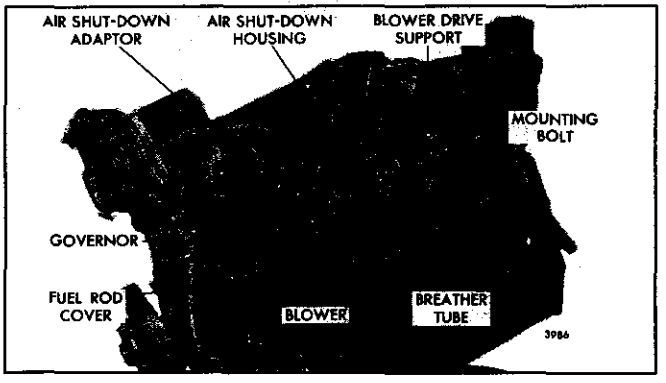


Fig. 3 – Typical Blower Mounting

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.

Inspection

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

- **CAUTION: To avoid personal injury 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.**

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 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.

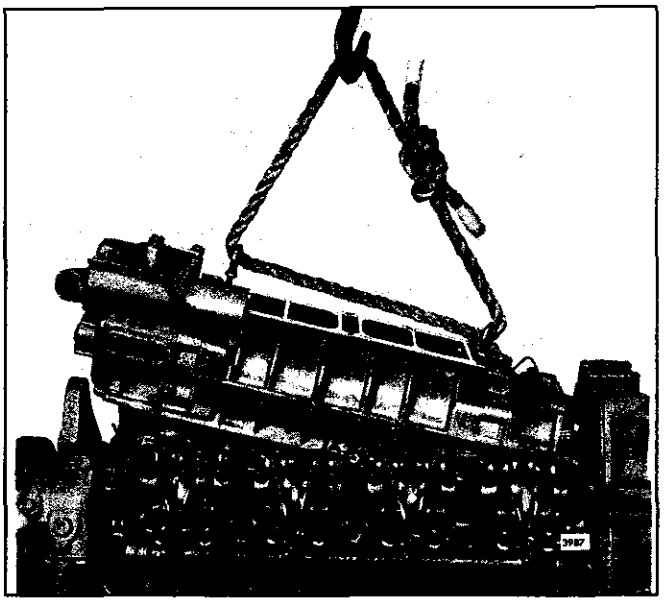


Fig. 4 – Removing Blower from Engine

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 shutdown housing to the air inlet adaptor. Remove the shutdown 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 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.
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.

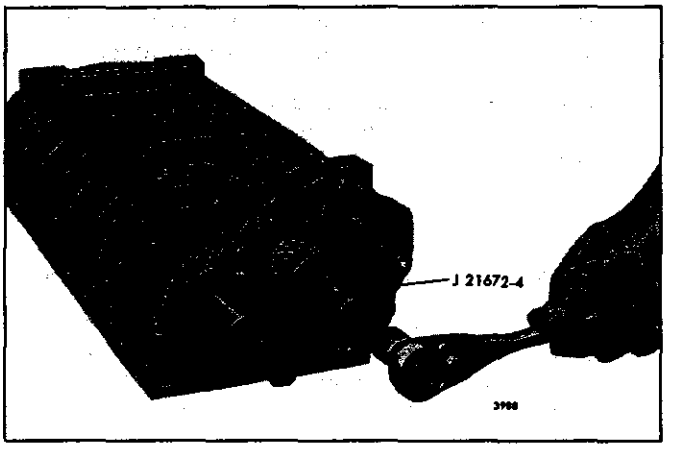


Fig. 5 – Removing Rotor Gears Using Tool J 21672–4

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.

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.

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

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.

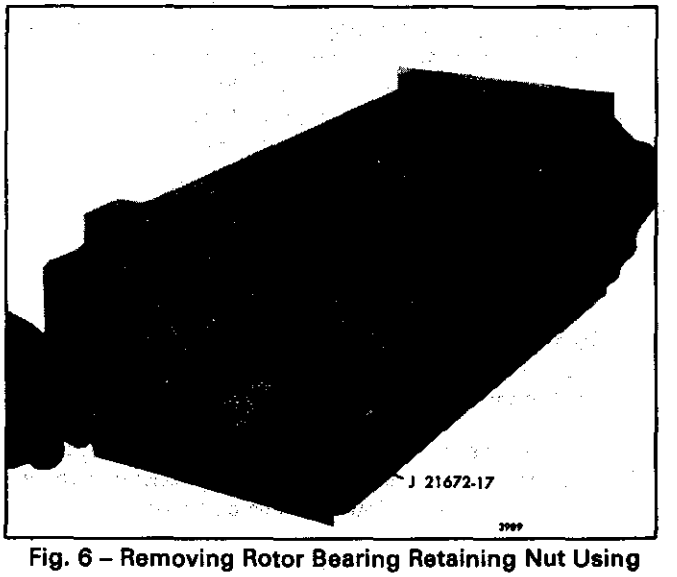


Fig. 6 – Removing Rotor Bearing Retaining Nut Using Tool J 21672–17

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.

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

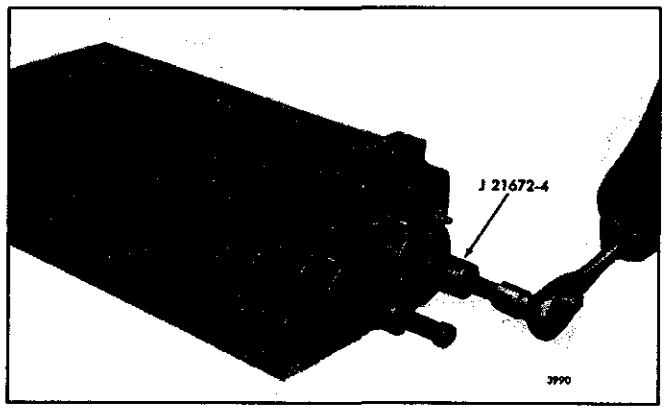


Fig. 7 – Removing Blower Rotors from Front End Plate Ball Bearings (Former Blower) Using Tool J 21672–4

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.

    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.

    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.

NOTICE: 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.

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

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 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.

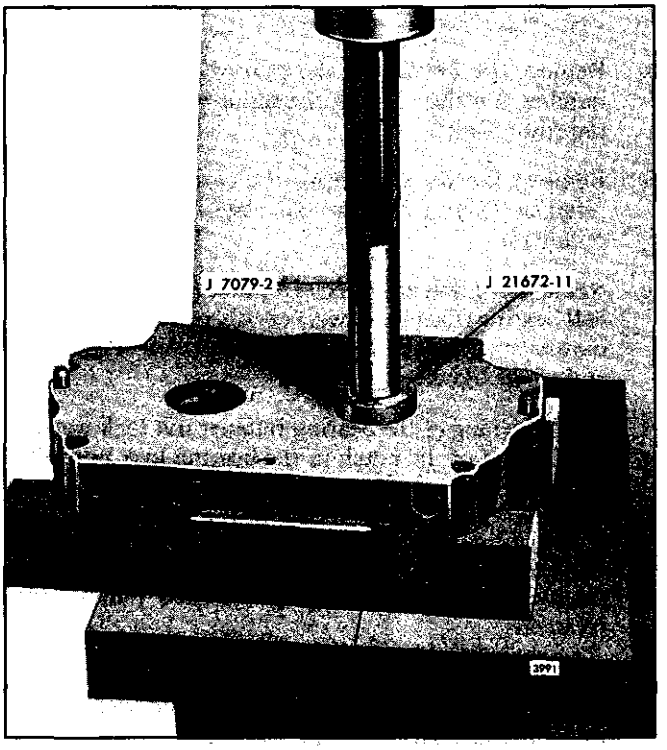


Fig. 8 – Removing Oil Seal and Roller Bearing from Rear End Plate (Former Blower) Using Tool J 7079–2

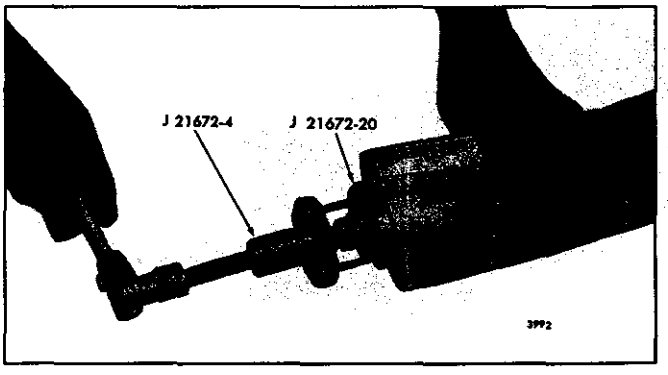
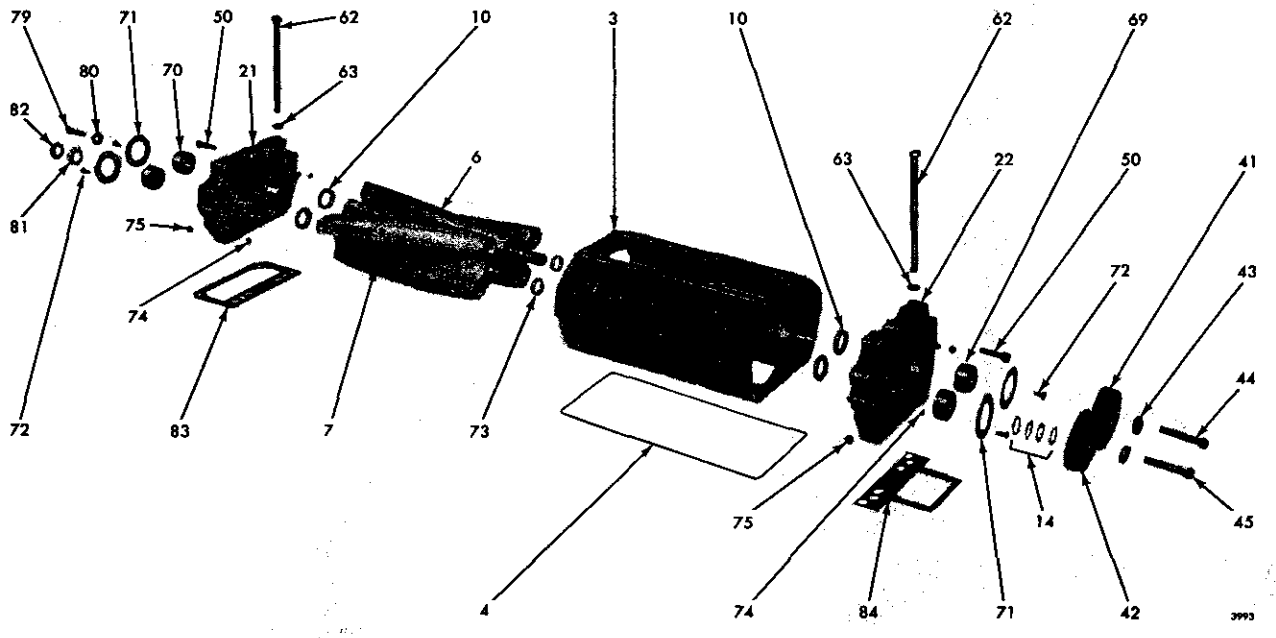


Fig. 9 – Removing Oil Seal Sleeve and Roller Bearing Inner Race from Rotor Shaft



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

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

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.

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.

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

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.

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:

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.

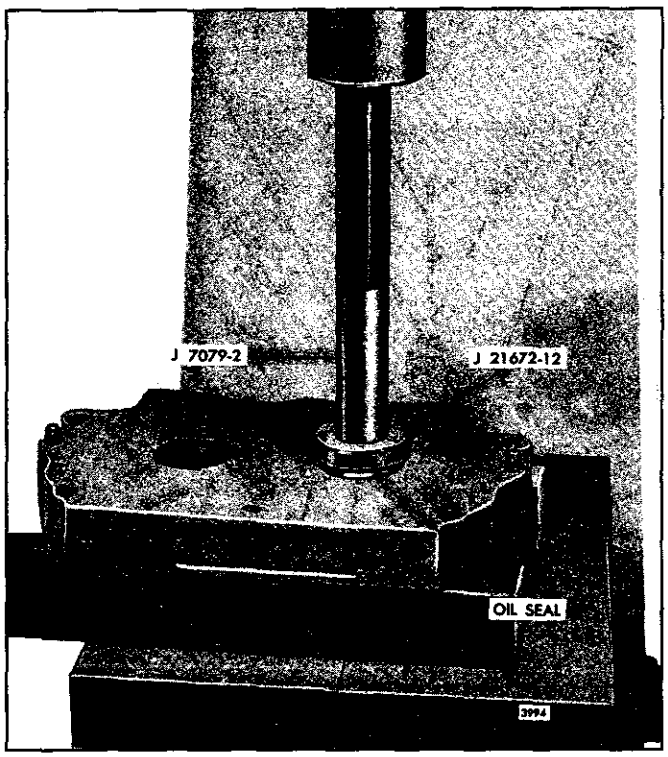


Fig. 11 – Installing Oil Seal in Rear End Plate (Former Blower)

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

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

      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.

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

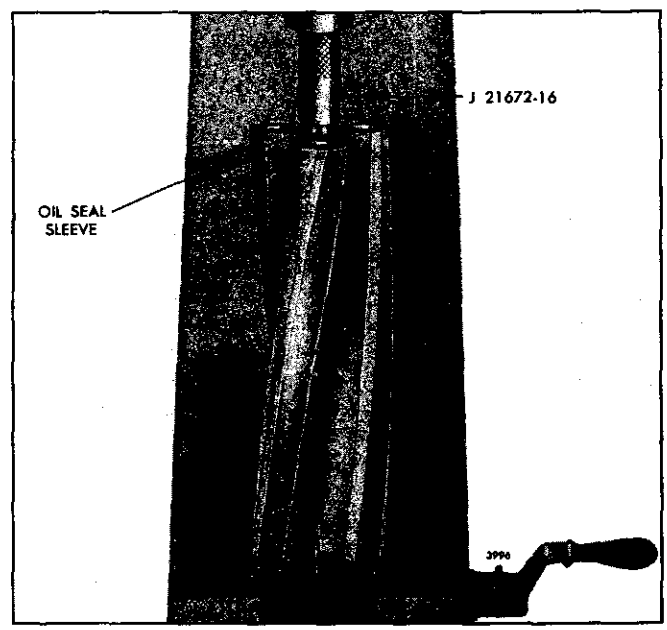


Fig. 12 – Installing Oil Seal Sleeve on Rotor Shaft (Former Blower)

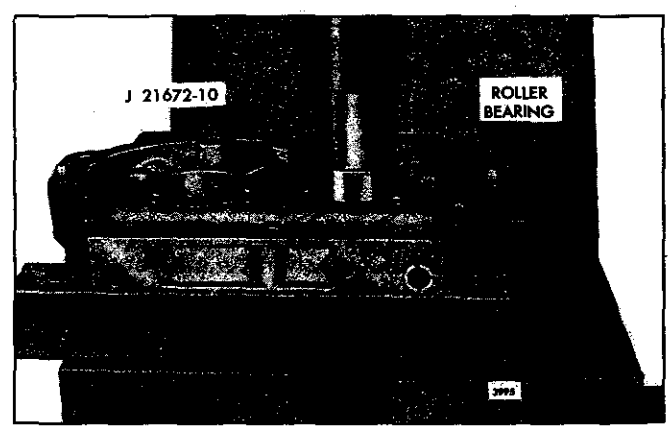


Fig. 13 – Installing Roller Bearing in Rear End Plate (Former Blower)

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.

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.

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.

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

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.

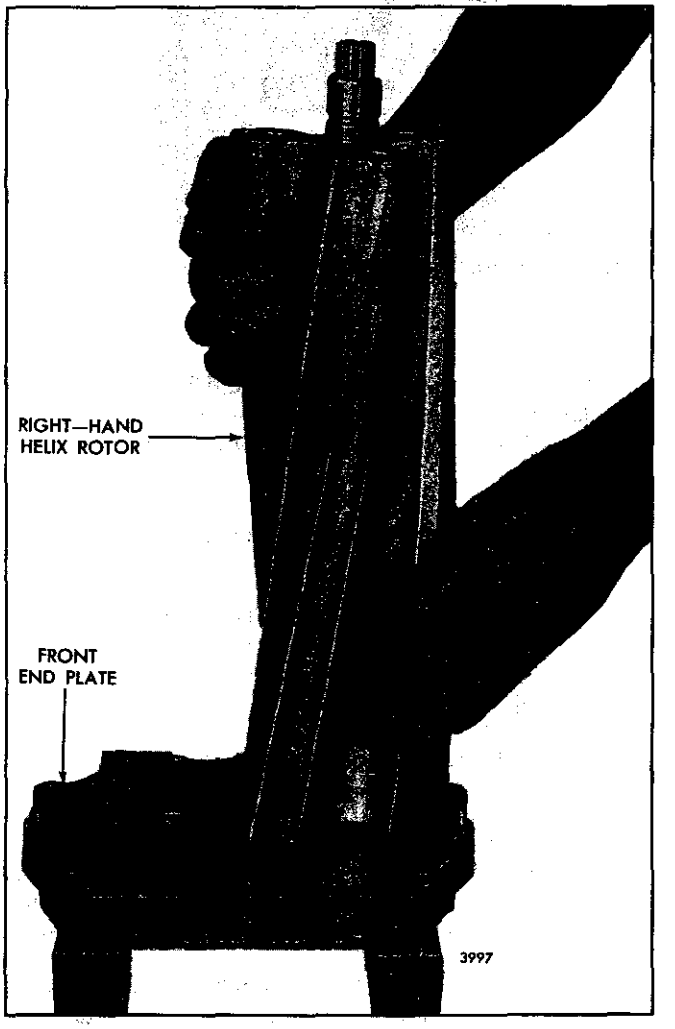


Fig. 14 – Installing Blower Rotor in Front End Plate

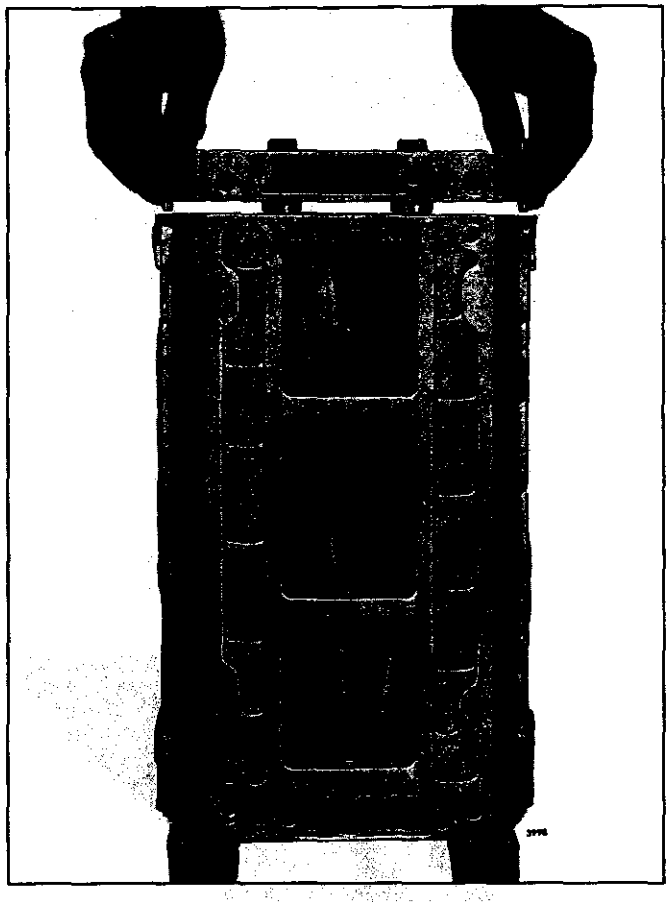


Fig. 15 – Installing Rear End Plate on Blower Rotors and Housing

*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 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 he end plate, then install the retainer bolts. Tighten the bolts to 7–9 lb–ft (10–12 N·m) 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.

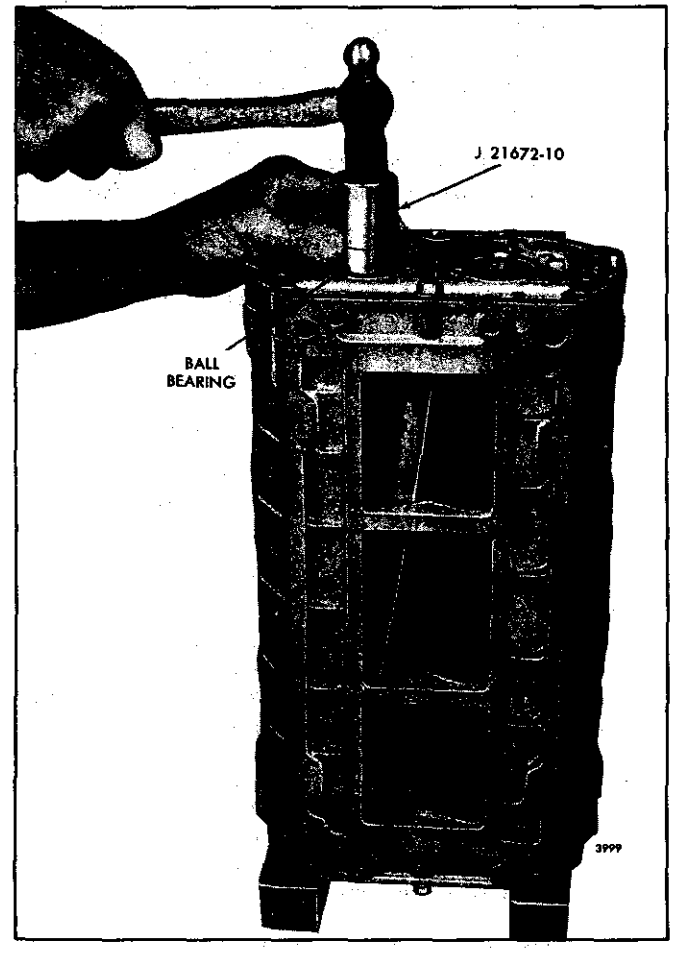


Fig. 16 – Installing Ball Bearings on Rotor Shafts and in Front End Plate (Former Blower)

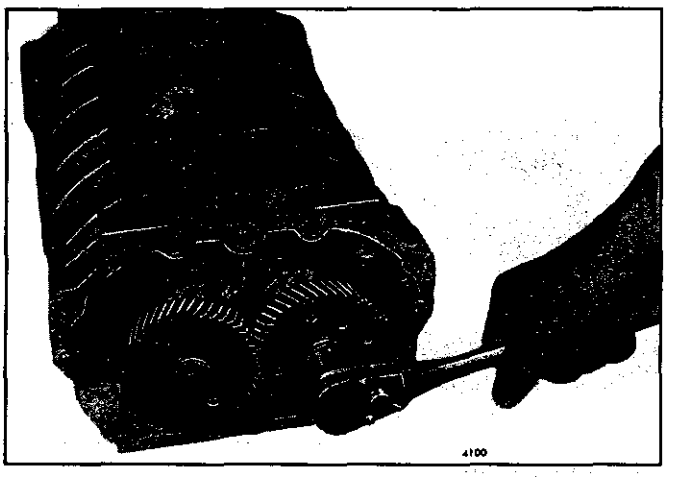


Fig. 17 – Installing Blower Rotor Gears

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 (10–12 N·m) 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.

    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 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 half–way on the rotor shafts.

    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 (68–75 N·m) torque.

    l. Check the backlash 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 (68–75 N·m) 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 (68–81 N·m) torque with spanner wrench J 21672–17.

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

