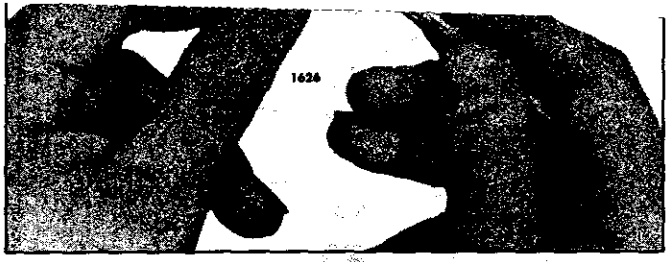


Fig. 17 – Cleaning Spray Tip Orifices Using Tool J 4298–1

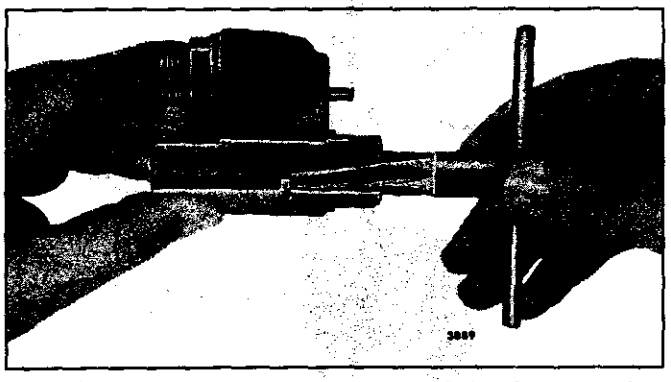


Fig. 18 – Cleaning Injector Body Ring with Tool J 21089

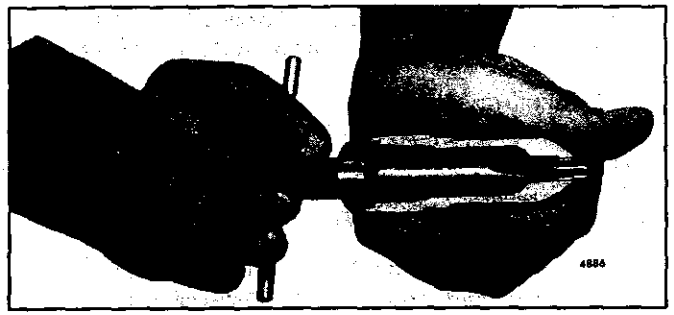


Fig. 19 – Cleaning Injector Nut Spray Tip Seat Using Tool J 4986–01

injury, wear adequate eye protection and do not exceed 40 psi (276 kpa) air pressure.

Clean and brush all of the passages in the injector body, using fuel hole cleaning brush J 8152 and rack hole cleaning brush J 8150. Blow out the passages and dry them with compressed air.

Carefully, insert reamer (J 21089) into the ring bore of the injector body (Fig. 18). Turn the reamer in a clockwise direction and remove any burrs inside the ring bore. Then, wash the injector body in clean solvent and dry it with compressed air.

Carefully, insert reamer J 4986–01 in the injector nut (Fig. 19). Turn it in a clockwise direction a few turns, then remove the reamer and check the face of the seat for reamer contact over the entire surface. If necessary, repeat the reaming procedure until the reamer does make contact with the entire face of the seat.

Wash the injector nut in clean solvent and dry it with compressed air. Carbon deposits on the spray tip seating surfaces of the injector nut will result in poor sealing and consequent fuel leakage around the spray tip.

When handling the injector plunger, do not touch the finished plunger surfaces with your fingers. Wash the plunger and bushing with clean solvent and dry them with compressed air. Be sure the high pressure bleed hole in the side of the bushing is not plugged. If this hole is plugged, fuel leakage will occur at the upper end of the bushing where it will drain out of the injector body vent and rack holes, during engine operation, causing a serious oil dilution problem. *Keep the plunger and bushing together as they are mated parts.*

After washing, submerge the parts in a clean receptacle containing clean test oil. *Keep the parts of each injector assembly together.*

Inspect Injector Parts (Visual and Dimensional)

NOTICE: Injector components manufactured after January 1, 1988 may or may not be blued, at the discretion of the manufacturer. Bluing has no effect on a part's performance or service life.

1. Follower:

   Measure between the top of the follower and the slot. This dimension must be 1.647 ± .002" (Fig. 20).

   Check the stop pin groove in the side of the follower to be sure it is smooth and not damaged. The follower should not be reused if there is more than .002" wear on the top or if there is any other visible damage or wear.

2. Follower Spring:

   Examine the outside diameter of the follower spring coils for wear caused by the rocker arms contacting the coils. If worn, do not reuse.

   Also, inspect for damage from rust pitting, nicks or notches in the coils, broken coils, broken coil ends and notches under the coil ends. If damaged, do not reuse.

   Check the follower spring tension with spring Tester J 29196.

   The current injector follower spring (.142" diameter wire) has a free length of approximately 1.504" and should be replaced when a load of less than 70 lbs. will compress it to 1.028". The former spring wire was .120" diameter.

   It is recommended that at the time of overhaul, all injectors in an engine be converted to incorporate the current spring (.142" diameter wire). However, in the event that one or two injectors are changed, the remaining injectors need not be reworked to incorporate the current spring.

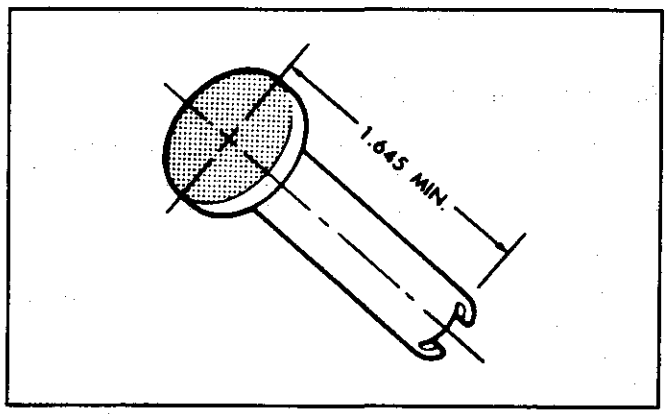


Fig. 20 – Injector Follower

3. Injector Body:

   Inspect the injector body threads, the bushing seating surface and the filter cap gasket sealing surfaces fordamage. Then, inspect the rack hole, body seal ring sealing surface, clamp radius and dowel pin.

4. Filter Caps:

   Check the condition of the jumper line sealing surfaces on the filter caps, the copper gasket sealing surfaces, the threads and the fuel passage.

5. Control Rack

   Check the injector control rack for straightness, the teeth for wear and the width of the notch in the clevis. Also, check the rack for nicks, burrs, rust and hardness.

   The notch in the clevis should be .3125" to .3145". A .250" inside diameter bushing may be used to check the rack for straightness. A slightly bent rack will not pass freely back and forth through the bore of the bushing.

6. Gear and Gear Retainer:

   Inspect the gear and the gear retainer for nicks, burrs or rust and the gear teeth for wear.

7 & 8 Plunger Bushing Assembly

Effective with injectors manufactured in October, 1985, the P & B (plunger and bushing) assemblies of all fuel injectors have a revised finish on the inside diameter of the bushing that provides greater resistance to scoring during injector operation.

Revised P & B assemblies are identified with a black locating pin at the top of the bushings. Injector assemblies containing revised P & B's are date stamped on the body with a "10–85" (for October, 1985) or later build date. Revised P & B assemblies are physically interchangeable with early P & B assemblies. However, because of the increased resistance to scoring provided by the revised assemblies, DDC recommends using the revised assemblies when rebuilding fuel injectors.

NOTICE: Do not attempt to install the plunger of one P & B into the bushing of another P & B and vise–versa. Since the components of P & B assemblies are supplied as precision matched sets, any attempt to mix them can result in P & B seizure and serious injector damage.

Check the bushing lapped sealing surface for scratches, the bushing internal diameter for scoring, the condition of the dowell pin and check for corrosion or varnish (Fig. 21).

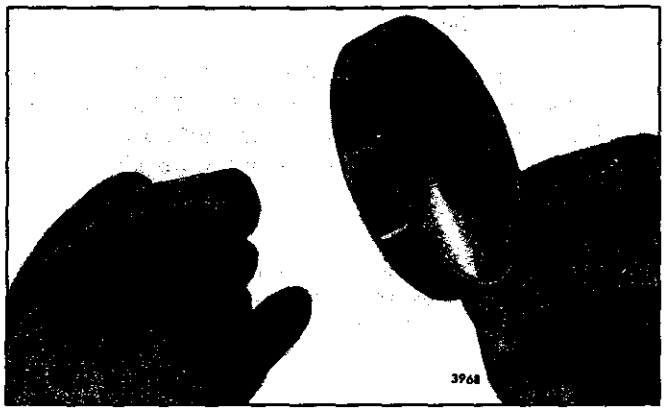


Fig. 21 – Examining Sealing Surface with a Magnifying Glass

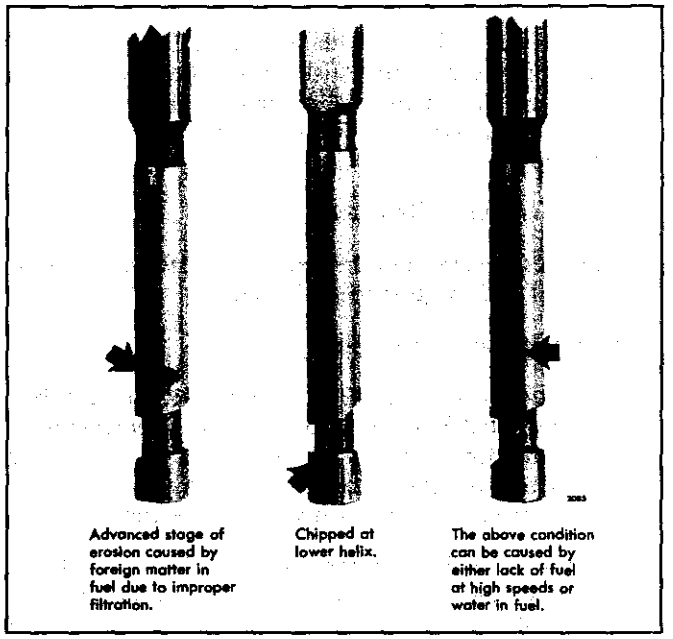


Fig. 22 – Unusable Injector Plungers

Check the plunger for corrosion or varnish, scoring, scratching or wear and chips along the edge of the helix (Fig. 22).

9. Valve Seat:

   Inspect for cracks, corrosion or varnish and scratches on the lapped sealing surfaces.

10. Check Valve Cage:

    Inspect the check valve cage for cracks, flatness and scratches on the lapped surfaces or for corrosion, varnish and wear.

11. Injector Valve (Crown):

    Inspect the injector valve for scratches on the lapped surface.

12. Valve Spring:

    Check the injector valve spring for wear on the coil ends, broken coil ends and notches under the coil ends. Then, check for corrosion, nicks and cavitation erosion on the inside at approximately 1–1/2 coils from the end.

13. Valve Stop:

    Inspect the valve stop for rust, burrs and varnish.

14. Check Valve:

    Inspect the check valve for cracks and scratches on the lapped surfaces or for corrosion and varnish.

15. Spray Tip:

    Check for cracks, enlarged spray holes and oxide scale on the spray hole end. Then, check the nut–to–tip sealing surface and the lapped sealing surface for scratches. Do not reuse if there is scale, cracks or enlarged spray holes.

16. Spill Deflector:

    Inspect both ends of the spill deflector for sharp edges or burrs.

17. Nut:

    Check the nut for damaged threads, the condition of the seal ring seating area, the condition of spray tip seating area and the spray tip hole for being corroded irregularly.

18. Part Thickness:

    Check the minimum thickness of the parts (see Table 1).

Part Name	Minimum Thickness
Spray Tip (shoulder)	.199"
Check Valve Cage	.163"—.165"
Check Valve	.022"
Valve Spring Cage	.602"

TABLE 1 – MINIMUM THICKNESS (Used Parts)

Recondition Injector

If any of the injector parts listed below cannot be reconditioned satisfactorily, use new parts. All parts must be cleaned to be free of rust, varnish and carbon before reuse.

1. Follower:
   - Resurface or replace if worn beyond dimensional limits.
2. Follower spring:
   - Reuse unless damaged, worn or won't meet test specifications.

3. Injector Body:
   - Lap bushing seat.
   - Reblue.
   - Repair damaged threads.
   - Replace body if the clamp radius is badly worn or if the threads are less than 90% good.
4. Filter Caps:
   - Recondition tapered seat.
   - Clean and deburr hole.
   - Reblue.
   - Replace if the threads or sealing surfaces are damaged.
5. Control Rack:
   - Deburr teeth – check for straightness.
   - Replace if bent or the teeth show significant wear.
6. Gear and Gear Retainer
   - Deburr.
   - Replace if cracked or significantly worn.
7. Bushing:
   - Replace if scored, cracked or if residue cannot be removed.
   - Lap the check valve seat (sealing) surface.
8. Plunger:
   - Clean – remove varnish.
   - Replace if scored, chipped or scratched.
9. Valve Seat:
   - Lap both flat (sealing) surfaces.
   - Lap edge of hole (Fig. 23).
   - Replace.
10. Check Valve Cage:
    - Lap both flat sealin surfaces.
    - Replace if cracked of too thin (see Table 1).
11. Injector Valve (Crown)
    - Replace.
12. Valve Spring:
    - Replace. Do not reuse unless there is absolutely no wear or damage.
13. Valve Stop
    - Remove rust, burrs or varnish.
    - Replace.
14. Check Valve:
    - Lap both flat (sealing) surfaces.
    - Replace if scratched, cracked of badly worn.

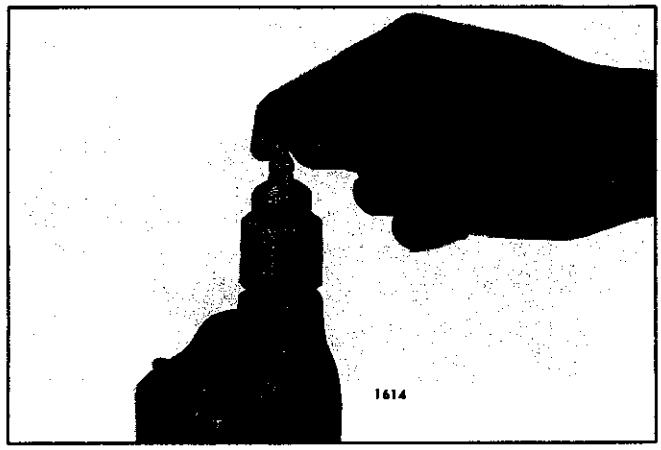


Fig. 23 – Lapping Edge of Hole in Valve Seat Using Tool J 7174

15. Spray Tip:
    - Lap flat sealing surface.
    - Replace if beyond flow limits i.e., eroded spray holes.
16. Spill Deflector:
    - Remove burrs.
    - Reuse if the ends are smooth and even and the deflector is not cracked.
17. Nut:
    - Remove carbon from the seat.
    - Reblue.
    - Replace if the threads are damaged more than 10% or if the small I.D. is badly eroded.

Normally, new service replacement parts do not require lapping prior to use. Wash the service parts in clean solvent to remove the solidified preservative. If the new parts become nicked or burred during handling, then lapping will be necessary to provide adequate sealing between the flat parts.

The sealing surface of current parts are precision lapped by a new process which leaves the surface with a dull satin–like finish; the lapped surface on former spray tips was bright and shiny. It is not recommended or necessary to lap the surface of a new current spray tip.

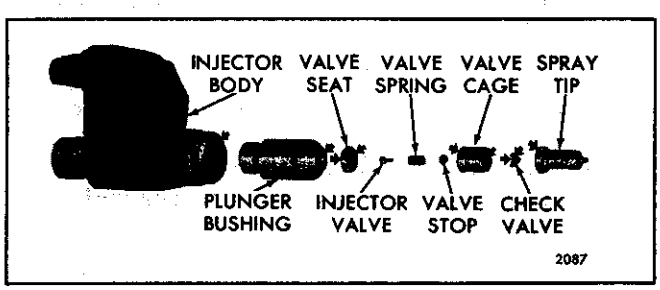


Fig. 24 – Sealing Surfaces Which May Require Lapping

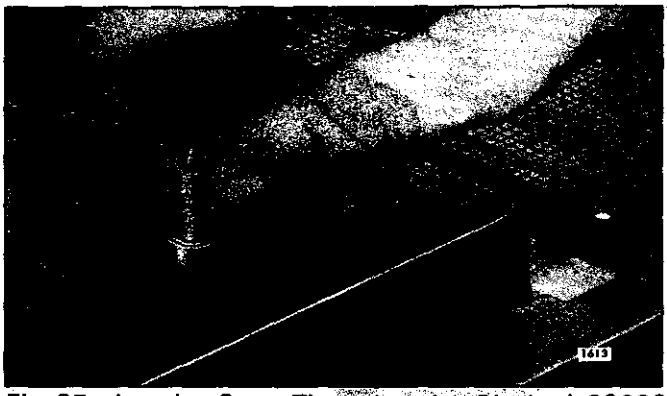


Fig. 25 – Lapping Spray Tip on Lapping Blocks J 22090

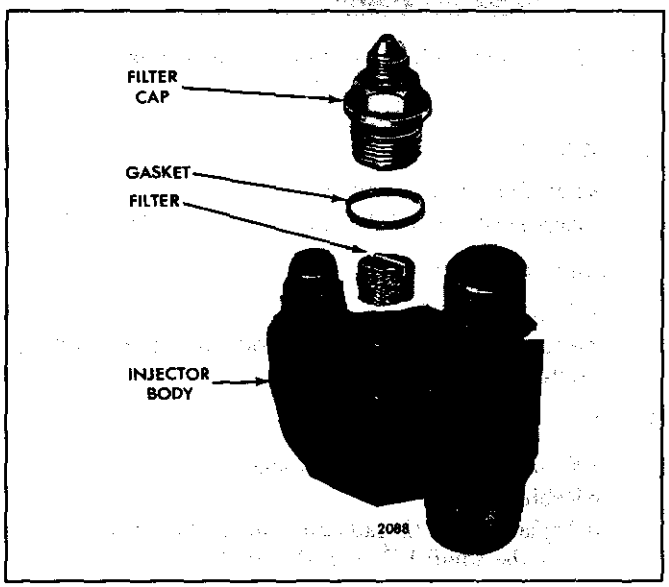


Fig. 26 – Details of Injector Filters and Caps and Their Relative Location

Lapping Injector Parts

If necessary, lap the sealing surfaces indicated in (Fig. 24) as follows:

1. Clean the lapping blocks (J 22090) with compressed air. Do not use a cloth or any other material for this purpose.
2. Spread a good quality 600 grit dry lapping powder on one of the lapping blocks.
3. Place the part to be lapped flat on the block (Fig. 25) and, using a figure eight motion, move it back and forth across the block. Do not press on the part, but use just enough pressure to keep the part flat on the block. It is important that the part be kept flat on the block at all times.
4. After each four or five passes, clean the lapping powder from the part by drawing it across a clean piece of tissue placed on a flat surface and inspect the part. *Do not lap excessively.*
5. When the part is flat, wash it in clean solvent and dry it with compressed air.
6. Place the dry part on the second block. After applying lapping powder, move the part lightly across the block in a figure eight motion several times to give it a smooth finish. *Do not lap excessively.* Again, wash the part in cleaning solvent and dry it with compressed air.
7. Place the dry part on the third block. Do not use lapping powder on this block. Keep the part flat and move it across the block several times, using the figure eight motion. Lapping the dry part in this manner gives the "mirror" finish required for easy inspection.
8. Wash all of the lapped parts in clean solvent 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.

Assemble Injector

1. Secure the body in vise J 22396–1.
- 2. Insert new filter(s) in the top of the body (Fig. 26). The current production service filter (stainless steel wire mesh pellet) is installed dimple end down, slotted end up. The former service filter (fiberglass–filled nylon cone) was installed with the pointed (cone) end up.

   Insert a new filter in the inlet side (located over the injector rack) in an offset injector. No filter is required at the outlet side (Fig. 27).
- 3. Place a new gasket on each filter cap. Lubricate the threads and install the filter caps (Fig. 28). Using a 9/16" deep socket and a torque wrench tighten the filter caps as follows:

   Non–blued cap on non–blued body ..... 62 lb–ft (84 N·m) torque

   Blued cap on blued body ..... 70 lb–ft (95 N·m) torque

   Non–blued cap on blued body or blued cap on non–blued body ..... 62 lb–ft (84 N·m) torque
4. Install clean shipping caps to protect the sealing surfaces and to prevent dirt from entering the injector.
5. Lubricate thread protector J 29197 with injector test oil. Remove the injector from the vise and hold the injector body, bottom end up. Place the protector over the threads of the injector body.

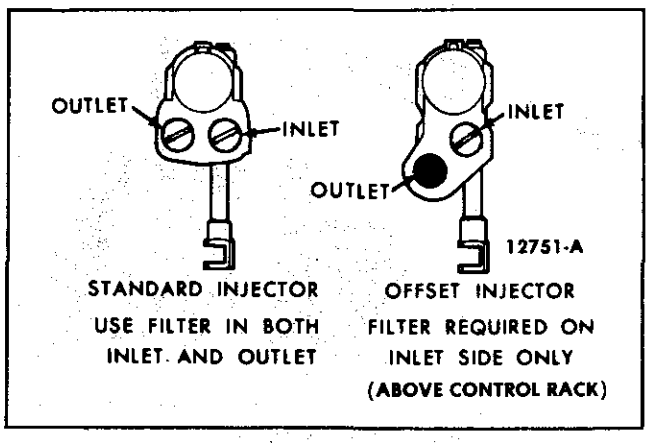


Fig. 27 – Location of Filter in Injector Body

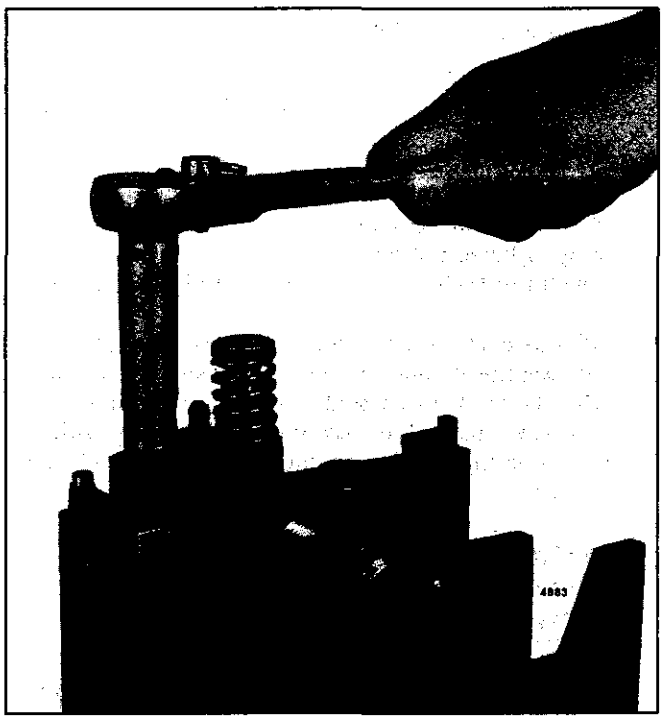


Fig. 28 – Installing Filter Cap

6. Lubricate the new seal ring and place the new seal over the nose of the protector and down onto the shoulder of the injector body. Do not allow the seal to roll or twist.

- A new round (in cross–section) injector nut seal ring replaced the former diamond–shaped ring, effective with injectors manufactured approximately November 1, 1987. Only the round seal ring is serviced.

7. Remove the protector (J 29197).

8. Slide the control rack into the injector body.

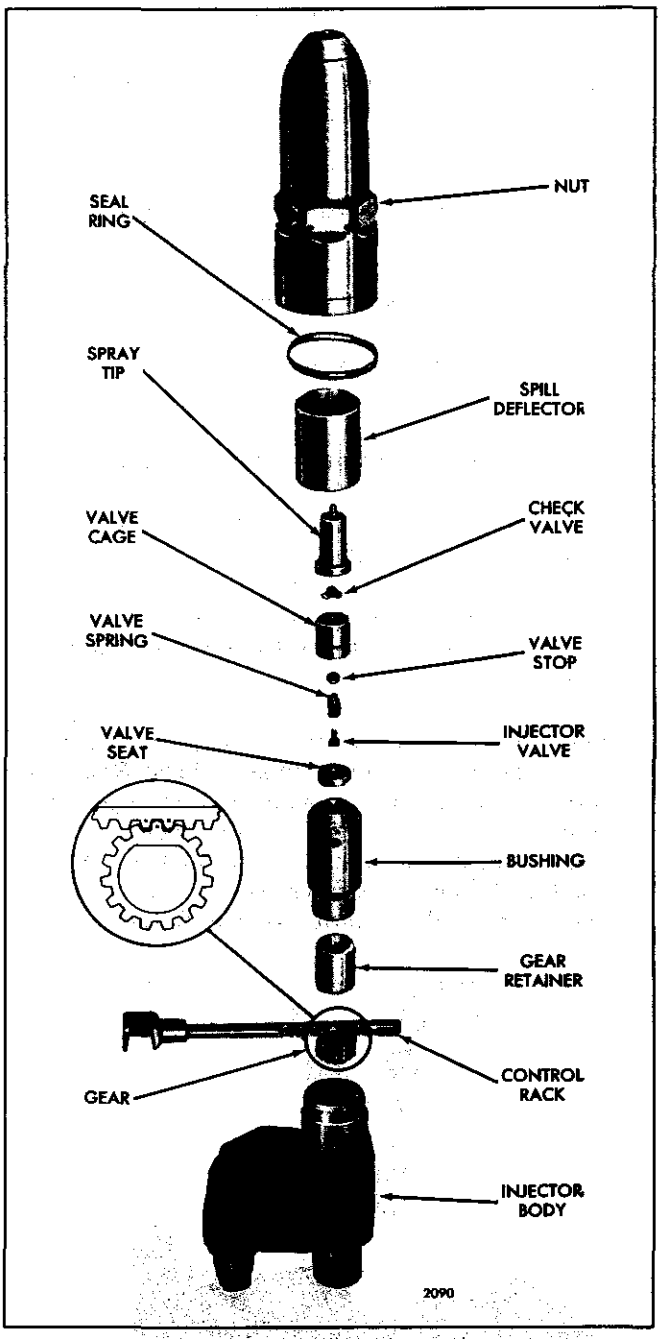


Fig. 29 – Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

9. Refer to (Fig. 29) and note the marked teeth on the control rack and gear. Then, look into the body bore and move the rack until you can see the drill marks. Hold the rack in this position.

10. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack (Fig. 29).

11. Place the gear retainer on top of the gear.

12. Align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.

13. Support the injector body, bottom end up, in injector vise J 22396–1.

14. Install the spill deflector over the barrel of the bushing.

15. Insert the valve stop, valve spring and injector valve into the valve cage.

16. Place the valve seat centrally on the top of the bushing.

17. Place the valve cage and related parts (injector valve down) on top of the valve seat.

18. Locate the check valve centrally on the cage and place the spray tip over the check valve and against the valve cage.

19. Lubricate the threads in the injector nut and carefully thread the nut on the injector body by hand. Rotate the spray tip between your thumb and first finger while threading the nut on the injector body (Fig. 30). Tighten the nut as tight as possible by hand. At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.

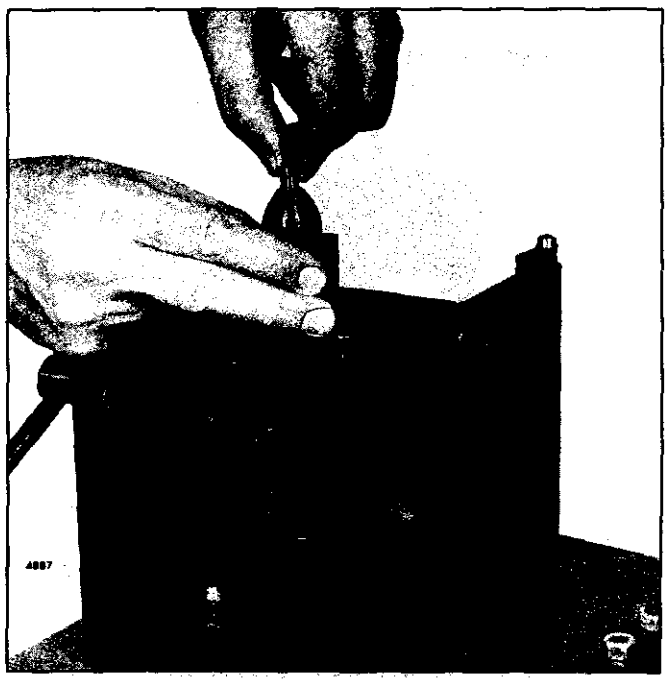


Fig. 30 – Tightening Injector Nut by Hand

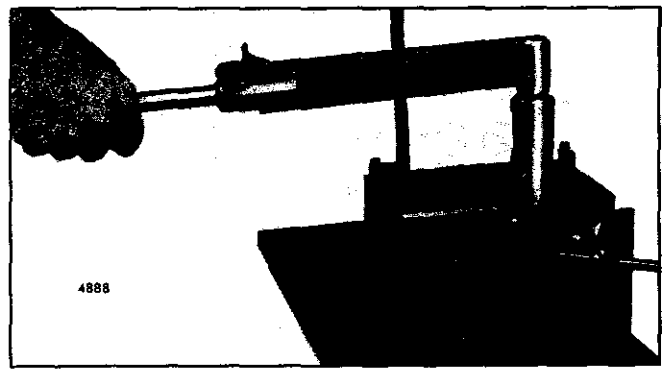


Fig. 31 – Tightening Injector Nut with Torque Wrench Using Tool J 4983–01

• 20. Use socket J 4983–01 and a torque wrench to tighten the injector nut as follows:

Non–blued nut on
non–blued body ..... 50 lb–ft (68 N·m) torque

Blued nut on
blued body ..... 80 lb–ft (108 N·m) torque

Non–blued nut on blued
body or blued nut on
non–blued body ..... 65 lb–ft (88 N·m) torque

21. After assembling a fuel injector, always check the area between the nut and the body. If the seal is still visible after the nut is assembled, try another nut and a new seal which may allow assembly on the body without extruding the seal and forcing it out of the body–nut crevice.

NOTICE: Do not exceed the specified torque. Otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul.

22. Turn the injector over and push the rack all the way in.

23. Place the follower spring on the injector body.

24. Refer to (Fig. 32) and place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin.

25. Refer to (Fig. 33) and slide the head of the plunger into the follower.

26. Align the slot in the follower with the stop pin hole in the injector body.

27. Align the flat side of the plunger with the flat in the gear.

28. Insert the free end of the plunger in the injector body. Press down on the follower and at the same time press the stop pin into position. When in place, the spring will hold the stop pin in position.

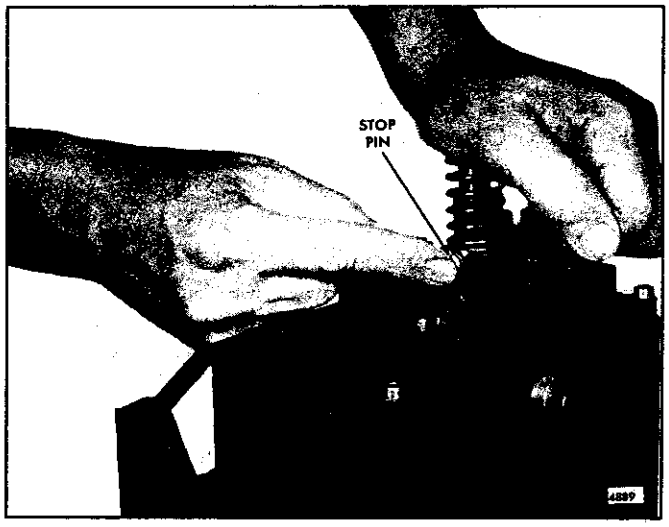


Fig. 32 – Installing Injector Follower Stop Pin

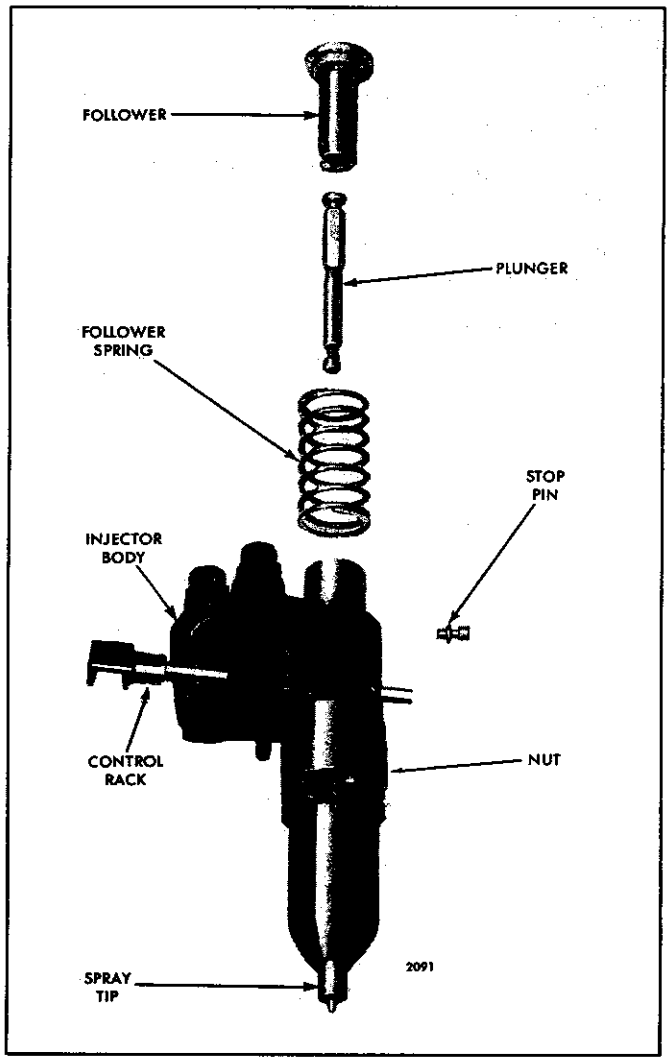


Fig. 33 – Injector Plunger, Follower and Relative Location of Parts

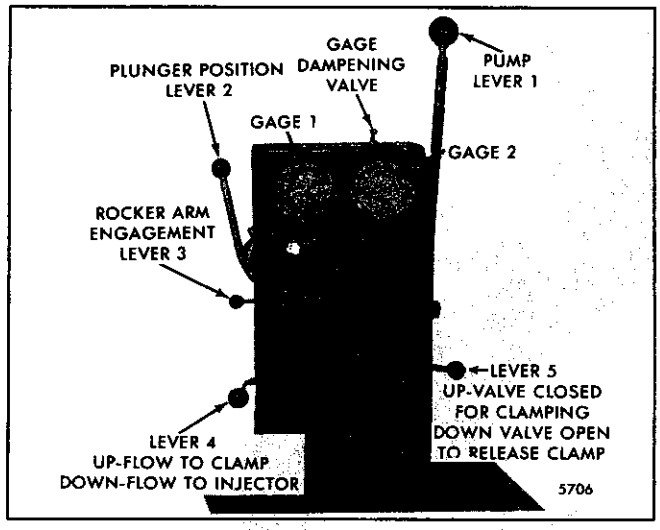


Fig. 34 – Injector in Position for Testing with Tester J 23010–A

Check Injector Output

Perform the injector fuel output test using Calibrator J 22410–A as outlined in Section 2.0 – Shop Notes.

Check Atomization and Spray Pattern

This test determines spray pattern uniformity and atomization.

1. Clamp the injector properly and purge the air from the system (Fig. 34).
2. Move lever 4 down.
3. Position the injector rack in the *full–fuel* position.
4. Place pump lever 1 in the *vertical* position.
5. Move lever 3 to the *forward detent* position.
6. The injector follower should be depressed rapidly using pump lever 1 (at 40 to 80 strokes per minute) to simulate operation in the engine. Observe the spray pattern to see that all spray orifices are open and dispersing the test oil evenly. The beginning and ending of injection should be sharp and the test oil should be finely atomized with no drops of test oil forming on the end of the tip.

Check Pressure Holding and Test for Leaks

This test determines if the body–to bushing mating surfaces in the injector are sealing properly and indicates proper plunger–to–bushing fit.

1. Clamp the injector properly in Tester J 23010–A and purge the air from the system (Fig. 34).
2. Close The Thru–Flow valve, but do not overtighten.
3. Move lever 2 to the rear, *horizontal* position.

Fig. 35 – Checking Rack for Freeness in Tester J 29584

4. Operate pump lever 1 until gage 1 slowly reaches 100–200 psi (689–1378 kPa), check for injector nut seal ring leaks. Then, move lever 2 until the plunger closes both bushing parts. Operate pump lever 1 and increase the gage reading to 1500–2000 psi (10 335–13 780 kPa). Check for leaks at the filter cap gaskets and the body plugs. Allow the plunger to go back to the *normal* position. Operate pump lever 1 and bring the pressure up to 500 psi (3445 kPa). Note the time for the pressure to drop from 450 psi to 250 psi (3100 kPa to 1723 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.

5. To unclamp the injector use the following procedure:

   a. Open the Thru–Flow valve to release the pressure in the system.

   b. Move lever 5 *down* to release the clamping pressure.

   c. Swing out the adaptor plate and remove the injector after the seals in the clamping head are free and clear of the injector filter caps.

   d. Carefully, return lever 5 to the *up (horizontal)* position.

Check Rack Freeness and Spray Tip Concentricity

Place the injector in Tester J 29584 (Fig. 35) and check rack freeness.

With the injector control rack held in the *no–fuel* position, operate the handle to depress the follower to the bottom of its stroke. Then, very slowly release the pressure on the handle while moving the control rack up and down until the follower reaches the top of its travel. If the rack falls freely the injector passes the test.

If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times, if necessary. Generally, this will free the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts or to remove dirt.

To assure correct alignment, check the concentricity of the spray tip as follows:

1. Place the injector in Tester J 29584 (Fig. 35) and adjust the dial indicator to zero.

2. Rotate the injector 360° and note the total runout as indicated on the dial.

3. If the total runout exceeds .008", remove the injector from the gage. Loosen the injector nut, center the spray tip and tighten the nut to 55–65 lb–ft (75–88 N·m) torque. Recheck the spray tip concentricity. If, after several attempts, the spray tip cannot be positioned satisfactorily, replace the injector nut.

Box and Store Injector

If the reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an *upright* position to prevent test oil leakage.

Install Injector

Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stresses from being exerted against the spray tip.

Use injector tube bevel reamer J 5286–9 or a cylinderical wire brush (Section 2.1.4), to clean the carbon from the injector tube. Exercise care to remove ONLY the carbon so that the proper tip protrussion is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.

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)

*Not serviced. Available from Jacobs Manufacturing Company.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it runs out of the outlet filter cap.

Install the injector in the engine as follows:

1. Insert the injector into the injector tube with the dowel in the injector body registering with the locating hole in the cylinder head.
2. Slide the rack control lever over so that it fully engages the injector rack clevis.
3. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt. Tighten the bolt to 20–25 lb–ft (27–34 N·m) torque. Make sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

   NOTICE: Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.

4. Move the rocker arm assembly into position and secure the rocker arm brackets to the cylinder head by tightening the bolts to the torque specified in Section 2.0 – Specifications.

   NOTICE: On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridges are not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Refer to *Install Rocker Arm and Shaft* in Section 1.2.1 and note the position of the exhaust valve bridges before, during and after tightening the rocker shaft bolts.

• 5. Install fuel pipes:

   Remove the shipping caps. Align the fuel pipes and connect them to the injectors and the fuel connectors.

   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.

   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: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to Fuel Jumper Line Maintenance & Pressurize Fuel System – Check for Leaks in Section 2.0 – Shop Notes).

   An indication of fuel leakage at the fittings of the fuel injector supply lines and connector nut seals could be either low lubricating oil pressure (dilution) or fuel odor coming from the crankcase breathers or an open oil filler cap. When any of the above are detected, remove the valve rocker cover.

   A close inspection of the rocker cover, cylinder head, fuel lines and connectors will usually show if there is a fuel leakage problem. Under normal conditions, there should be a coating of lubricating oil throughout the cylinder head area and puddles of oil where the fuel pipes contact the connectors and where the fuel connectors contact the cylinder head. If these areas do not have the normal coating of lubricating oil, it is likely that fuel oil is leaking and washing off the lubricating oil.

   Remove and replace the leaking fuel pipes and/or connectors. Use new gasket(s) and reinstall the rocker cover. Then, drain the lubricating oil and change the oil filter elements. Refer to Section 13.3 (Lubrication Specifications) and refill the crankcase to the proper level with the recommended grade of oil.

6. Perform a complete engine tune–up as outlined in Section 14. However, if only one injector has been removed and replaced and the other injectors and the governor adjustment have not been disturbed, it will only be necessary to adjust the valve clearance and time the injector for the one cylinder, and to position the injector rack control levers.

FUEL INJECTOR

MECHANICAL UNIT INJECTOR (MUI)

NEEDLE VALVE

The fuel injector (Figs. 1 and 2) is a lightweight compact unit which enables quick, easy starting directly on diesel fuel and permits the use of a simple open type combustion chamber. The simplicity of design and operation provides for simplified controls and easy adjustment. No high pressure fuel lines or complicated air–fuel mixing or vaporizing devices are required.

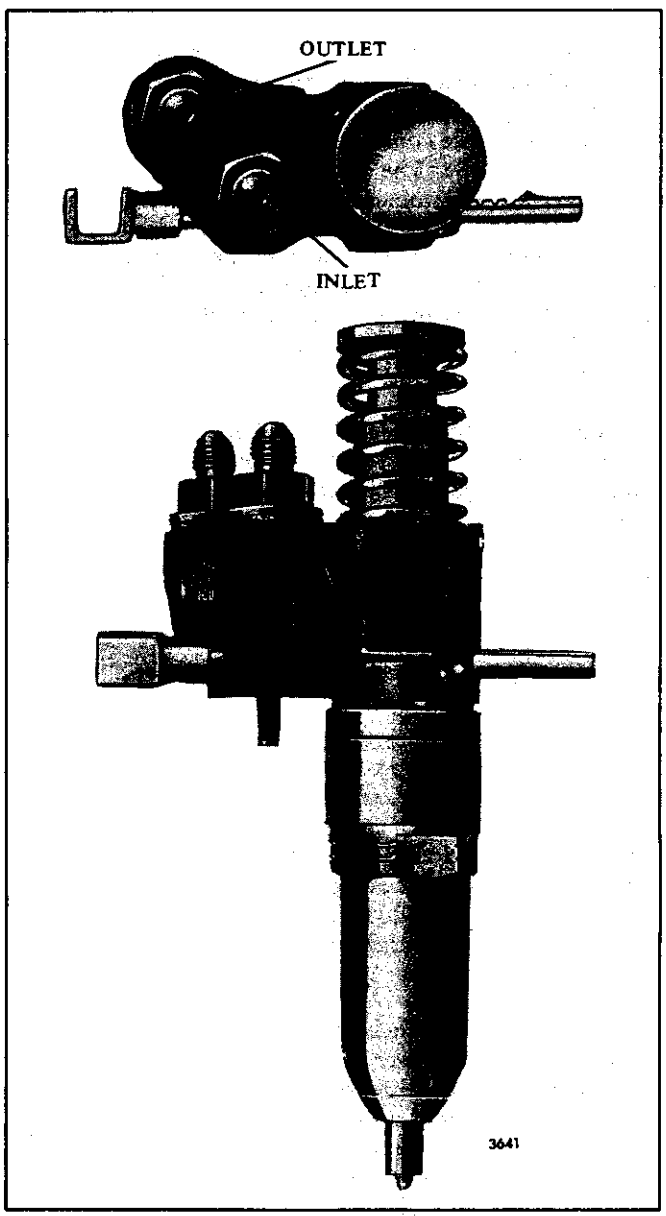


Fig. 1 – Fuel Injector Assembly

The fuel injector performs four functions (Times – Atomizes – Meters – Pressurizes):

1. Accurately times the moment of fuel injection.
2. Atomizes the fuel for vaporization and mixing with the air in the combustion chamber.
3. Meters and injects the correct amount of fuel required to maintain engine speed and to handle the load.
4. Creates the high pressure required for proper fuel injection.

Combustion required for satisfactory engine operation is obtained by injecting, under pressure, a small quantity of accurately timed, metered and finely atomized fuel oil into the combustion chamber.

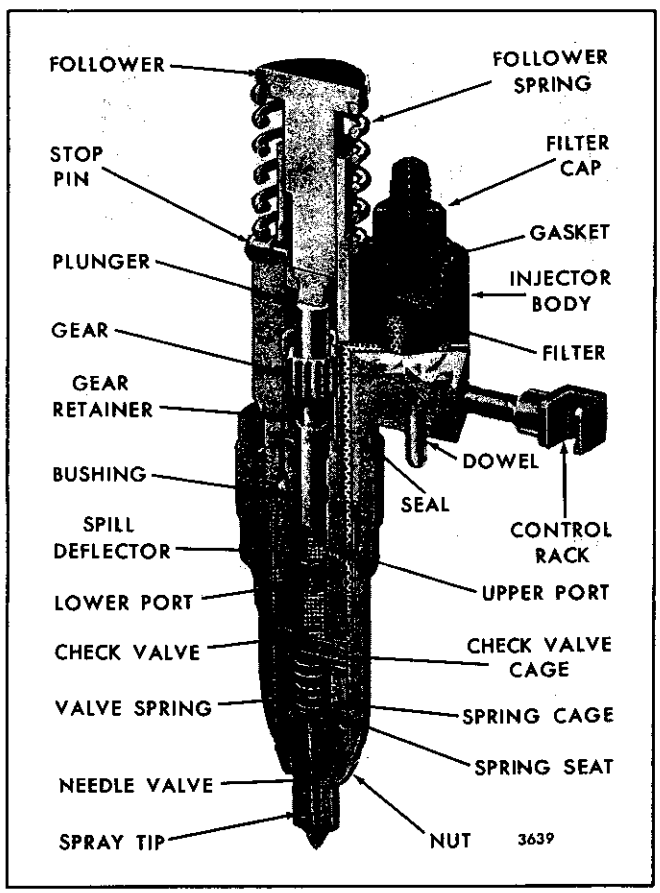


Fig. 2 – Cutaway View of Fuel Injector

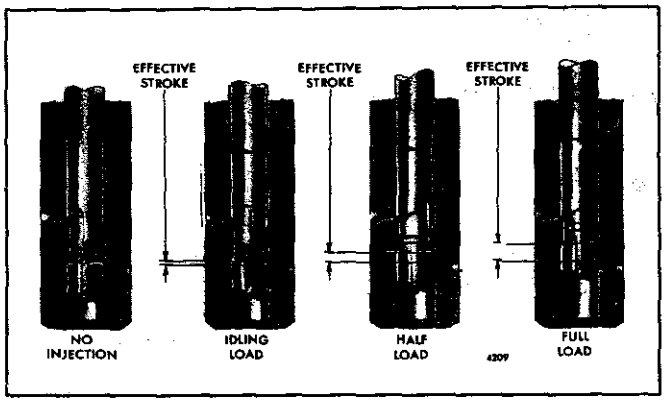


Fig. 3 – Fuel Metering from No Load to Full Load

Metering and timing during fuel injection is accomplished by an upper and lower helix machined in the lower end of the injector plunger. (Fig. 3) illustrates the fuel metering from no load to full load by rotation of the plunger in the bushing.

(Fig. 4) illustrates the phases of injector operation by the vertical travel of the injector plunger.

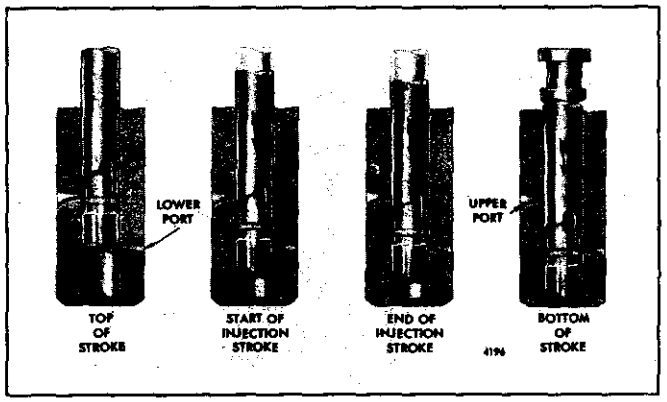


Fig. 4 – Phases of Injector Operation Through Vertical Travel of Plunger

The continuous fuel flow through the injector serves, in addition to preventing air pockets in the fuel system, as a coolant for those injector parts subjected to high combustion temperatures.

To vary the power output of the engine, injectors having different fuel output capacities are used. The fuel output of the various injectors is governed by the effective stroke of the plunger and the flow rate of the spray tip.

Since the helix angle and the plunger design determines the operating characteristics of a particular injector, it is imperative that the specified injectors are used for each engine. If injectors of different types are mixed in an engine, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

Each fuel injector has a circular disc pressed into a recess at the front side of the injector body for identification purposes (Fig. 1).

Each injector control rack (Fig. 2) is actuated by a lever on the injector control tube which, in turn, is connected to the governor by means of a fuel rod. These levers can be adjusted independently on the control tube, thus permitting a uniform setting or fine tuning of all injector racks.

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder.

- New O–ring sealed fuel pipes are used on the mechanical unit injectors in marine engines, effective with units built approximately April, 1988. These fuel pipes feature a three–piece connector (collar, nut, o–ring seal) at both ends (Fig. 38). The primary sealing element is the replaceable fluoroelastomer (Viton) O–ring seal.

- To conform with this change, new connectors are installed in the cylinder head and new fuel injectors with redesigned filter caps are used. The connectors and caps have a 1/2" – 20 female thread to accept the 1/2"–20 male thread on the fuel pipe nuts.

- Flared tube design and O–ring design fuel pipes are not interchangeable on a part–for–part basis. The new pipes, connectors, and injector filter caps must be used together to insure interchangeability. The injector filter cap is not compatible with the former nylon cone fuel inlet filter. It must be used with the current stainless steel mesh pellet filter.

Operation

Fuel, under low pressure, enters the injector at the inlet side through a filter cap and filter positioned over the racks (Fig. 2). From the filter, the fuel passes through a drilled passage into the supply chamber, that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing. The plunger operates up and down in the bushing, and is supplied fuel through the two funnel–shaped ports in the bushing wall.

The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the follower spring (Fig. 5). In addition to the reciprocating motion, the plunger can be rotated around its axis by the gear which meshes with the control rack. To accomplish fuel metering, an upper helix and a lower helix are machined in the lower part of the plunger. The helix relationship to the ports changes with the rotation of the plunger.

As the plunger moves downward, under pressure of the injector rocker arm, some of the fuel under the plunger moves into the supply chamber through the lower port until the port is covered by the lower end of the plunger. The fuel below the plunger continues to move up through a central passage in the plunger into the fuel metering recess and into the supply chamber through the upper port until that port is covered by the upper helix of the plunger. With the upper and lower ports both covered, the remaining fuel trapped under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

When sufficient pressure is built up, it opens the flat check valve. The fuel in the check valve cage, spring cage, tip passages and tip fuel cavity is compressed until the pressure force acting upward on the needle valve is sufficient to open the valve against the downward force of the valve spring. As soon as the needle valve lifts off of its seat, the fuel is forced through the small orifices in the spray tip and atomized into the combustion chamber.

When the lower land of the plunger uncovers the lower port in the bushing, the fuel pressure below the plunger is relieved and the valve spring closes the needle valve, ending injection.

A pressure relief passage has been provided in the spring cage to permit bleed–off of fuel leaking past the needle pilot in the tip assembly.

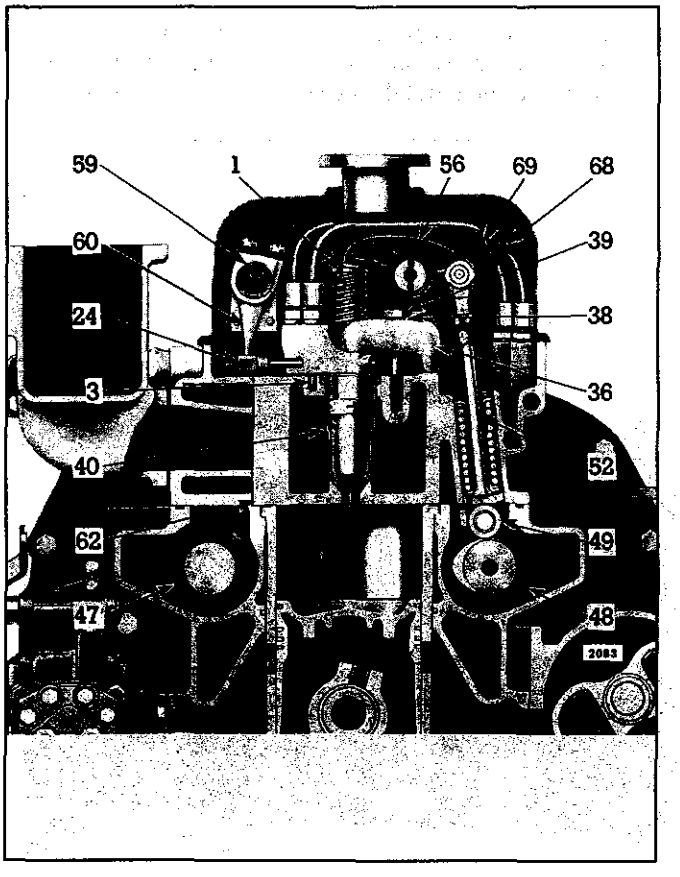


Fig. 5 – Fuel Injector Mounting

A check valve, directly below the bushing, prevents leakage from the combustion chamber into the fuel injector in case the valve is accidentally held open by a small particle of dirt. The injector plunger is then returned to its *original* position by the injector follower spring. (Fig. 4) shows the various phases of injector operation by the vertical travel of the injector plunger.

On the return upward movement of the plunger, the high pressure cylinder within the bushing is again filled with fuel oil through the ports. The constant circulation of fresh cool fuel through the injector renews the fuel supply in the chamber, helps cool the injector and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with accurate metering of the fuel.

The fuel injector outlet opening, through which the excess fuel oil returns to the fuel return manifold and then back to the fuel tank, is directly adjacent to the inlet opening.

Changing the position of the helices, by rotating the plunger, retards or advances the closing of the ports and the beginning and ending of the injection period. At the same time, it increases or decreases the amount of fuel injected into the cylinder. (Fig. 3) shows the various plunger positions from no load to full load. With the control rack pulled out all the way (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the rack in this position, all of the fuel is forced back into the supply chamber and no injection of fuel takes place. With the control rack pushed all the way in (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a maximum effective stroke and maximum injection. From this *no injection* position to *full injection* position (full rack movement), the contour of the upper helix advances the closing of the ports and the beginning of injection.

General Instructions for Injector Care and Overhaul

The fuel injector is one of the most important and precisely built parts of the engine. The injection of the correct amount of fuel into the combustion chamber at exactly the right time depends upon this unit. Because the injector operates against high compression pressure in the combustion chamber, efficient operation demands that the injector assembly is maintained in first–class condition at all times. Proper maintenance of the fuel system and the use of the recommended type fuel filters and clean water–free fuel are the keys to trouble–free operation of the injectors.

Due to the close tolerances of various injector parts, extreme cleanliness and strict adherence to service instructions is required.

Perform all injector repairs in a clean, well lighted room with a dust free atmosphere. An ideal injector room is slightly pressurized by means of an electric fan which draws air into the room through a filter. This pressure prevents particles of dirt and dust from entering the room through the

doors and windows. A suitable air outlet will remove solvent fumes along with the outgoing air.

Provide the injector repair room with a supply of filtered, moisture–proof compressed air for drying the injector parts after they have been cleaned. Use wash pans of rust–proof material and deep enough to permit all of the injector parts to be completely covered by the cleaning solvent, when submerged in wire baskets of 16 mesh wire screen. Use baskets which will support the parts so as to avoid contact with the dirt which settles at the bottom of the pans.

Rags should never be used for cleaning injector parts since lint or other particles will clog parts of the injector when it is assembled. A lint–free paper tissue is a suitable material for wiping injector parts.

When servicing an injector, follow the general instructions outlined below:

1. Whenever the fuel pipes are removed from an injector, cover the filter caps with shipping caps to keep dirt out of the injectors and prevent damage. Also, protect the fuel pipes and fuel connectors from damage and the entry of dirt or other foreign material.
2. After an injector has been operated in an engine, do not remove the filter caps or filters while the injector is in the engine. Replace the filters only at the time of complete disassembly and overhaul of an injector.
3. Whenever an injector has been removed and reinstalled or replaced in an engine, make the following adjustments as outlined in Section 14:
   a. Time the injector.
   b. Position the injector control rack.
4. Whenever an engine is to be out of service for an extended period, purge the fuel system, then fill it with a good grade of rust preventive (refer to Section 15.3).
5. When a reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an *upright* position to prevent test oil leakage.

   NOTICE: Make sure that new filters have been installed in a reconditioned injector which is to be placed in stock. This precaution will prevent dirt particles from entering the injector due to a possible reversal of fuel flow when installing the injector in an engine other than the original unit.

Remove Injector

1. Clean and remove the valve rocker cover. Discard the gasket.
2. Remove the fuel pipes from both the injector and the fuel connectors (Fig. 5).

   NOTICE: Immediately after removal of the fuel pipes from an injector, cover the filter caps with shipping caps to prevent dirt from entering the injector. Also, protect the fuel pipes and fuel connectors from entry of dirt or foreign material.
3. Crank the engine to bring the upper ends of the push rods of the injector and valve rocker arms in line horizontally. If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left–hand direction of rotation because the bolt could be loosened.

   CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep their hands and clothing away from the moving parts of the engine as there is a remote possibility the engine could start.
4. Remove the two rocker shaft bracket bolts and swing the rocker arms away from the injector and valves (Fig. 6).
5. Remove the injector clamp bolt, special washer and clamp.
6. Loosen the inner and outer adjusting screws or adjusting screw and locknut on the injector rack control lever and slide the lever away from the injector.

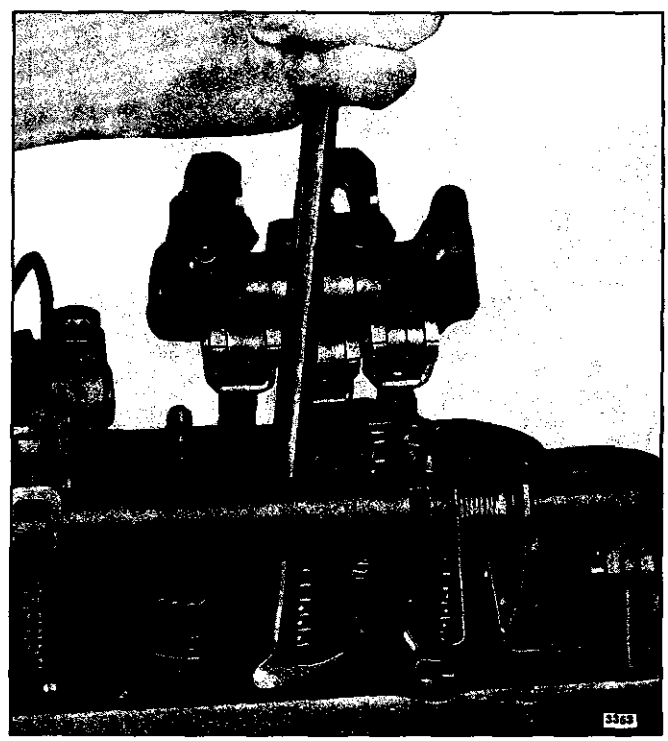


Fig. 6 – Removing Injector from Cylinder Head

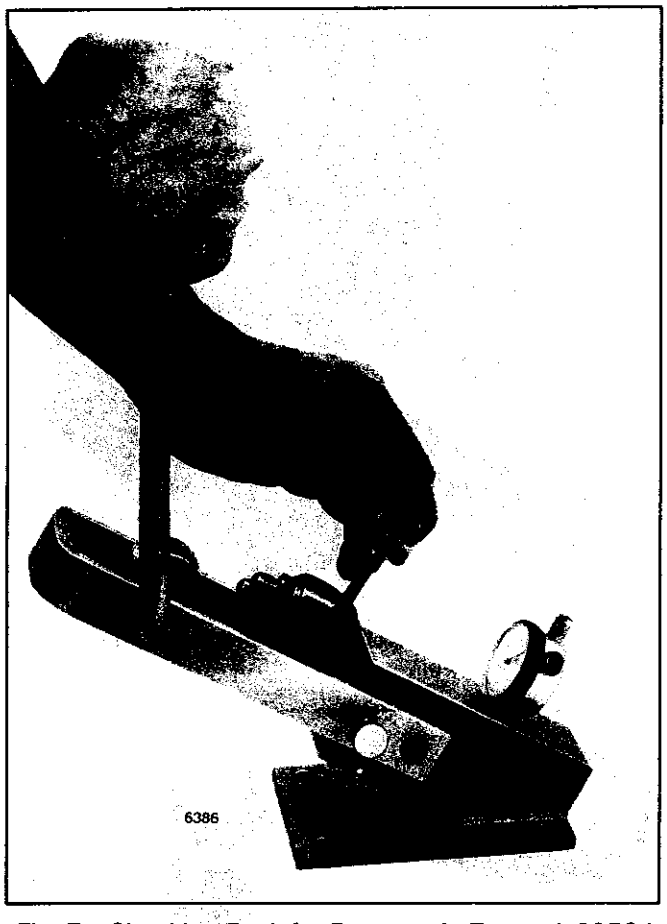


Fig. 7 – Checking Rack for Freeness in Tester J 29584

7. Lift the injector from its seat in the cylinder head (Fig. 6).
8. Cover the injector hole in the cylinder head to keep foreign material out.
9. Clean the exterior of the injector with clean solvent 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.

Inspect and Test Prior to Reuse

This inspection and test process is necessary if the injector is being considered for reuse rather than complete overhaul. Submerge the injector in clean solvent to wash it. Blow dry with compressed air.

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

1. Inspect the following injector parts for external wear, rust and corrosion.
   - Follower spring
   - Injector body
   - Body nut
   - Spray tip
   - Injector rack
   - Filter caps
2. Inspect the following parts for wear or abrasion deterioration.
   - Top of the follower
   - Follower spring
   - Injector body
   - Spray tip orifices
3. Check the rack for freeness and the plunger movement in Tester J 29584.

   With the injector control rack held in the *no–fuel* position, operate the handle to depress the follower to the bottom of its stroke. Then, very slowly release the pressure on the handle while moving the control rack up and down until the follower reaches the top of its travel (Fig. 7). If the rack falls freely, the injector passes the test. If the injector fails the rack freeness test, either the plunger is scored or there is a misalignment of the body, bushing or nut due to irregular or dirty parts.
4. Check the injector for leaks using Tester J 23010–A as outlined in Section 2.0 – Shop Notes.
5. Check the spray pattern, atomization and valve opening pressure using Tester J 23010–A as outlined in Section 2.0 – Shop Notes.
6. Perform injector fuel output test using Calibrator J 22410–A as outlined in Section 2.0 – Shop Notes.

   If the injector passes the above tests, it can be reused.

If the results of the above tests reveal marginal performance, removal of the plunger may assist with further diagnosis of internal injector problems. Plungers that reveal scratches, score marks, abnormal wear, helix chipping or other obvious damage would indicate that the injector should not be reused.

Disassemble Injector

1. Support the injector upright in injector holding fixture J 22396 (Fig. 8) and remove the filter caps, gaskets and filters.

   Whenever a fuel injector is disassembled, discard the filters and gaskets and replace with new filters and gaskets. In the offset injector, a filter is used in the inlet side only. No filter is required in the outlet side (Fig. 9).
2. Compress the follower spring (Fig. 10). Then, raise the spring above the stop pin with a screwdriver and withdraw the pin. Allow the spring to rise gradually.

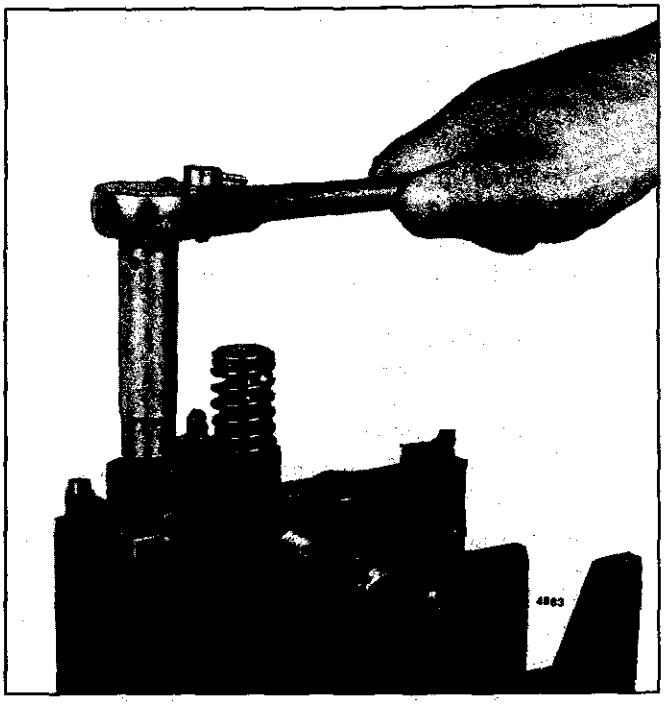


Fig. 8 – Removing Filter Cap

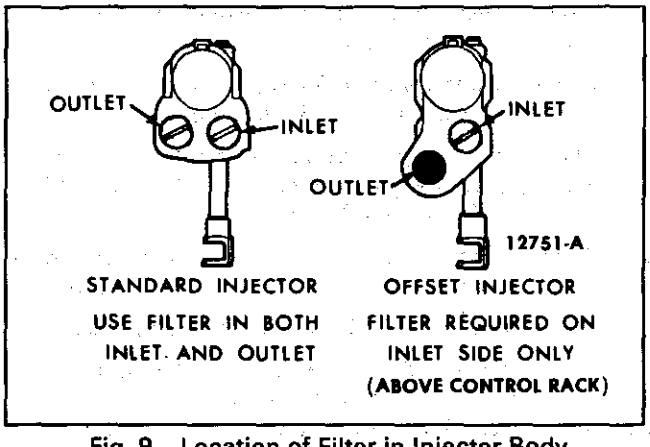


Fig. 9 – Location of Filter in Injector Body

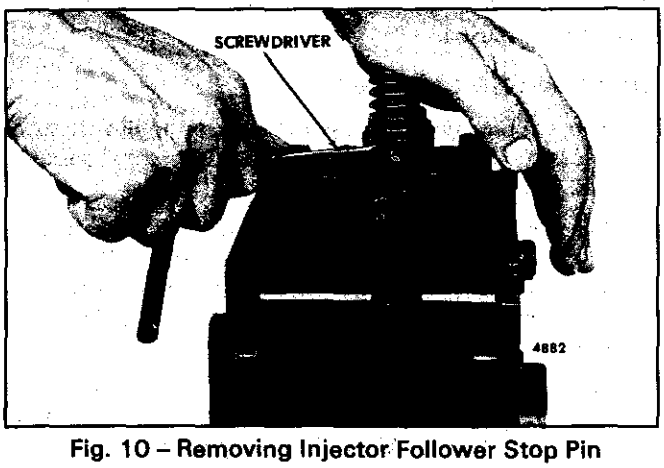


Fig. 10 – Removing Injector Follower Stop Pin

Fig. 11 – Removing or Installing Plunger Follower, Plunger and Spring

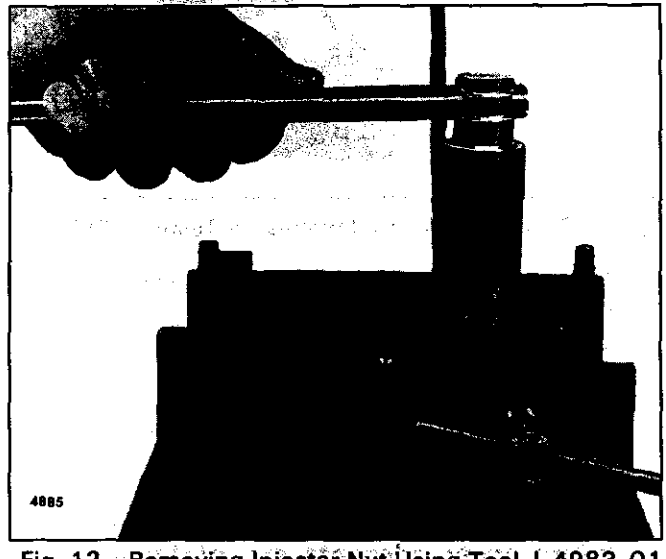


Fig. 12 – Removing Injector Nut Using Tool J 4983-01

3. Refer to (Fig. 11) and remove the plunger follower, plunger and spring as an assembly.

4. Using socket J 4983–01, loosen the nut on the injector body (Fig. 12).

5. Lift the injector nut straight up, being careful not to dislodge the spray tip and valve parts. Remove the spray tip, spring cage, valve spring, spring seat, check valve cage and check valve.

   When an injector has been in use for some time, the spray tip, even though clean on the outside, may not be pushed readily from the nut with the fingers. In this event, support the nut on a wood block and drive the

tip down through the nut, using tool J 1291–02 (Fig. 13).

6. Refer to (Fig. 14) and remove the spill deflector. Then, lift the bushing straight out of the injector body.

7. Remove the injector body from the holding fixture. Turn the body upside down and catch the gear retainer and gear in your hand as they fall out of the body.

8. Withdraw the injector control rack from the injector body. Also, remove the seal ring from the body.

Clean Injector Parts

Since most injector problems are the result of dirt particles, it is essential that a clean area be provided on which to place the injector parts after cleaning and inspection.

Wash all of the parts with a suitable cleaning solvent and dry them with clean, filtered compressed air. Use lint free towels to wipe off the parts. Clean out the passages, drilled holes and slots in all of the injector parts.

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

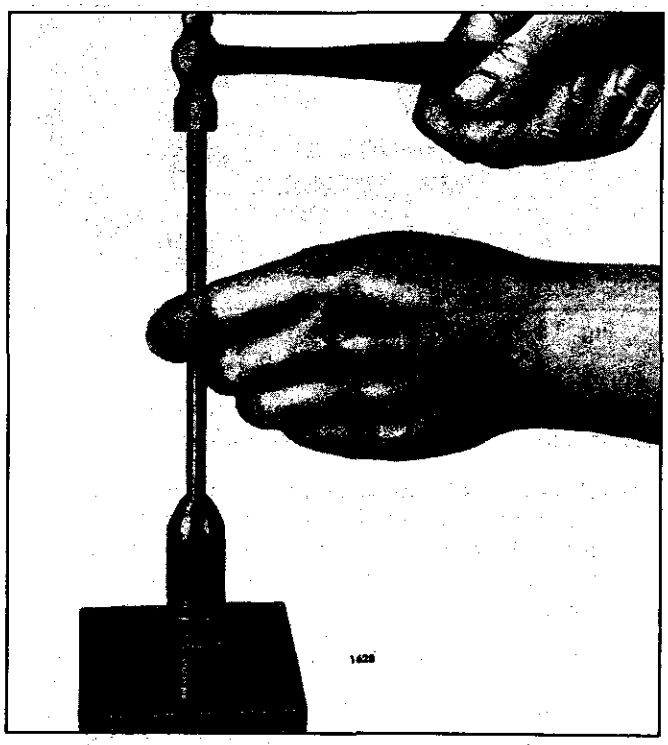


Fig. 13 – Removing Spray Tip from Injector Nut Using Tool J 1291–02

Carbon on the inside of the spray tip may be loosened for easy removal by soaking for approximately fifteen (15) minutes in a suitable solution prior to the external cleaning and buffing operation.

Clean the spray tip with tool J 24838 (Fig. 15).

NOTICE: Care must be exercised when inserting the carbon remover J 24838 in the spray tip to avoid contacting the needle valve seat in the tip.

Wash the tip in solvent and dry it with compressed air. Clean the spray tip orifices with pin vise J 4298–1 and the proper size spray tip cleaning wire. Use wire J 21460–01 to clean .0055" diameter holes and wire J 21461–01 to clean .006" diameter holes (Fig. 16).

Before using the wire, hone the end until it is smooth and free of burrs and taper the end a distance of 1/16" with stone J 8170. Allow the wire to extend 1/8" from tool J 4298–1. Ultra sonic cleaning is also an acceptable method.

The exterior surface of an injector spray tip may be cleaned by using a brass wire buffing wheel, tool J 7944. To obtain a good polishing effect and longer brush life, the buffing wheel should be installed on a motor that turns the wheel at approximately 3000 rpm. A convenient method of holding the spray tip while cleaning and polishing is to place the tip over the drill end of the spray tip cleaner tool J 24838 and hold the body of the tip against the buffing wheel. In this way, the spray tip is rotated while being buffed.

NOTICE: Do not buff the spray tip area excessively. *Do not use a steel wire buffing wheel or the spray tip holes may be distorted.*

When the body of the spray tip is clean, lightly buff the tip end in the same manner to clean the spray tip orifice area.

Wash the spray tip in clean solvent 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.

Clean and brush all of the passages in the injector body, using fuel hole cleaning brush J 8152 and rack hole cleaning brush J 8150. Blow out the passages and dry them with compressed air.

Carefully, insert reamer J 21089 in the injector body (Fig. 17). Turn it in a clockwise direction a few turns, then remove the reamer and check the face of the ring for reamer contact over the entire face of the ring. If necessary, repeat the reaming procedure until the reamer does make contact with the entire face of the ring. Clean up the opposite side of the ring in the same manner.

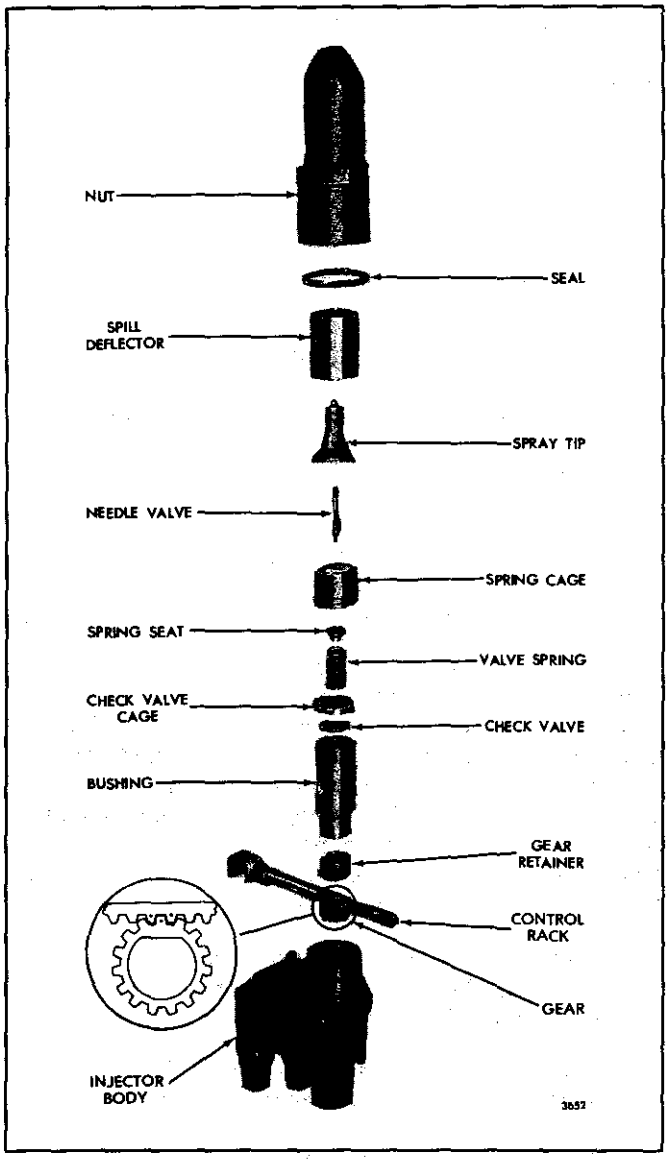


Fig. 14 – Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

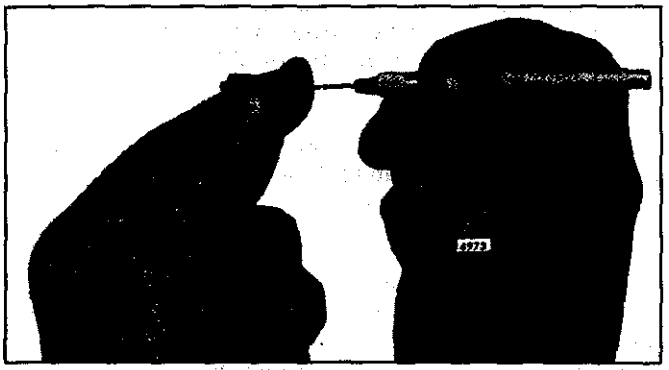


Fig. 15 – Cleaning Injector Spray Tip with Tool J 24838

Carefully, insert reamer (J 21089) into the ring bore of the injector body. Turn the reamer in a clockwise direction

Fig. 16 – Cleaning Spray Tip Orifices with Tool J 4298–1

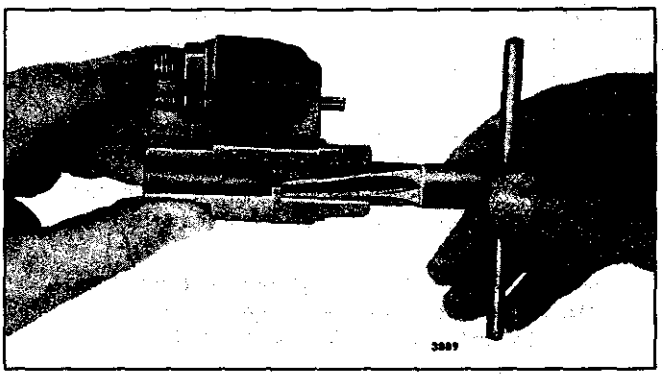


Fig. 17 – Cleaning Injector Body Ring with Tool J 21089

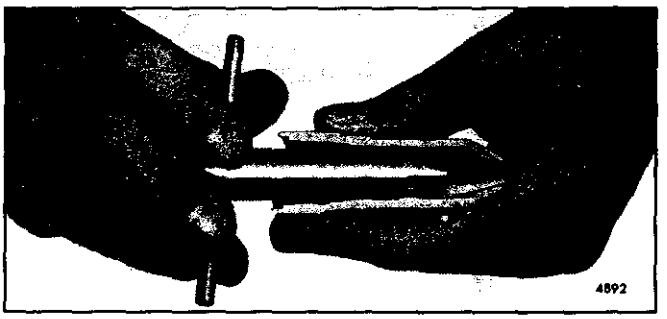


Fig. 18 – Cleaning Injector Nut Lower End with Tool J 9418–5

and remove any burrs inside the ring bore. Then, wash the injector body in clean solvent and dry it with compressed air.

- **NOTICE:** Do not damage the injector body ring during this operation. This spiral ring forms part of the injector body and is not serviced. If the ring is damaged, the injector body must be replaced.

Remove the carbon deposits from the lower end of the injector nut with reamer J 9418–5 (Fig. 18). Clean the tip seat with reamer J 9418–1. Use care to minimize removing metal or setting up burrs on the spray tip seat. Remove only enough metal to produce a clean uniform seat to prevent leakage between the tip and the nut.

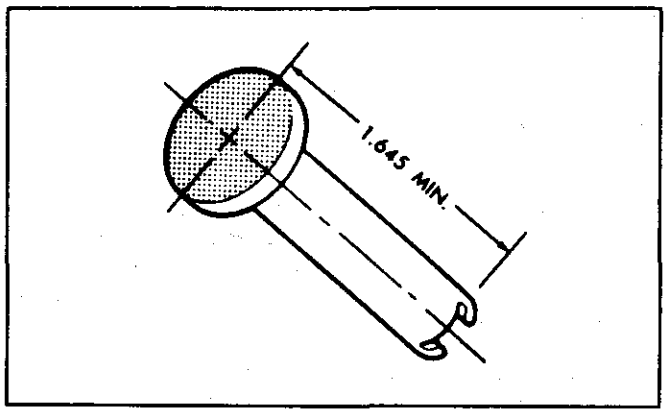


Fig. 19 – Injector Follower

Wash the injector nut in clean solvent and dry it with compressed air. Carbon deposits on the spray tip seating surfaces of the injector nut will result in poor sealing and consequent fuel leakage around the spray tip.

When handling the injector plunger, do not touch the finished plunger surfaces with your fingers. Wash the plunger and bushing with clean solvent and dry them with compressed air. Be sure the high pressure bleed hole in the side of the bushing is not plugged. If this hole is plugged, fuel leakage will occur at the upper end of the bushing where it will drain out of the injector body vent and rack holes, during engine operation, causing a serious oil dilution problem. *Keep the plunger/bushing together as they are matched parts.*

After washing, submerge the parts in a clean receptable containing clean test oil. *Keep the parts of each injector assembly together.*

Inspect Injector Parts (Visual and Dimensional)

1. Follower

   Measure between the top of the follower and the slot. This dimension must be 1.647 ± .002″ (Fig. 19).

   Check the stop pin groove in the side of the follower to be sure it is smooth and not damaged. The follower should not be reused if there is more than .002″ wear on the top or if there is any other visible damage or wear.

2. Follower Spring:

   Examine the outside diameter of the follower spring coils for wear caused by the rocker arms contacting the coils. If worn, do not reuse.

   Also, inspect for damage from rust pitting, nicks or notches in the coils, broken coils, broken coil ends and notches under the coil ends. If damaged, do not reuse.

   Check the follower spring tension with spring Tester J 29196.

   The current injector follower spring (.142″ diameter wire) has a free length of approximately 1.504″ and should be replaced when a load of less than 70 lbs. will compress it to 1.028″. The former spring wire was .120″ diameter.

   It is recommended that at the time of overhaul, all injectors in an engine be converted to incorporate the current spring (.142″ diameter wire). However, in the event that one or two injectors are changed, the remaining injectors need not be reworked to incorporate the current spring.

3. Injector Body:

   Inspect the injector body threads, the bushing seating surface and the filter cap gasket sealing surfaces for damage. Then, inspect the rack hole, body seal ring sealing surface, clamp radius and dowel pin.

4. Filter Cap:

   Check the condition of the jumper line sealing surfaces on the filter caps, the copper gasket sealing surfaces, the threads and the fuel passage.

5. Control Rack

   Check the injector control rack for straightness, the teeth for wear and the width of the notch in the clevis. Also, check the rack for nicks, burrs, rust and hardness.

   The notch in the clevis should be .3125″ to .3145″. A .250″ inside diameter bushing may be used to check the rack for straightness. A slightly bent rack will not pass freely back and forth through the bore of the bushing.

6. Gear and Gear Retainer

   Inspect the gear and the gear retainer for nicks, burrs or rust and the gear teeth for wear.

- 7. & 8. Plunger and Bushing Assembly:
  - Effective with injectors manufactured in October, 1985, the P & B (plunger and bushing) assemblies of all fuel injectors have a revised finish on the inside diameter of the bushing that provides greater resistance to scoring during injector operation.
  - Revised P & B assemblies are identified with a black locating pin at the top of the bushings. Injector assemblies containing revised P & B's are date stamped on the body with a "10–85" (for October, 1985) or later build date. Revised P & B assemblies are physically interchangeable with early P & B assemblies. However, because of the increased resistance to scoring provided by the revised assemblies, DDC recommends using the revised assemblies when rebuilding fuel injectors.
  - **NOTICE:** Do not attempt to install the plunger of one P & B into the bushing of another P & B and vise–versa. Since the components of P & B assemblies are supplied as precision matched sets, any attempt to mix them can result in P & B seizure and serious injector damage.

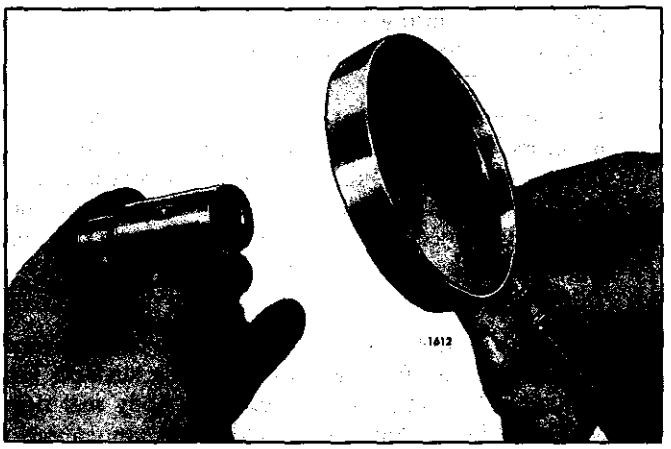


Fig. 20 – Examining Sealing Surface with a Magnifying Glass

7. Bushing:

   Check the bushing lapped sealing surface for scratches, the bushing internal diameter for scoring, the condition of the dowell pin and check for corrosion or varnish (Fig. 20).

8. Plunger:

   Check the plunger for corrosion or varnish, scoring, scratching or wear and chips along the edge of the helix (Fig. 21).

9. Check Valve:

   Inspect the check valve for cracks and scratches on the lapped surfaces or for corrosion and varnish.

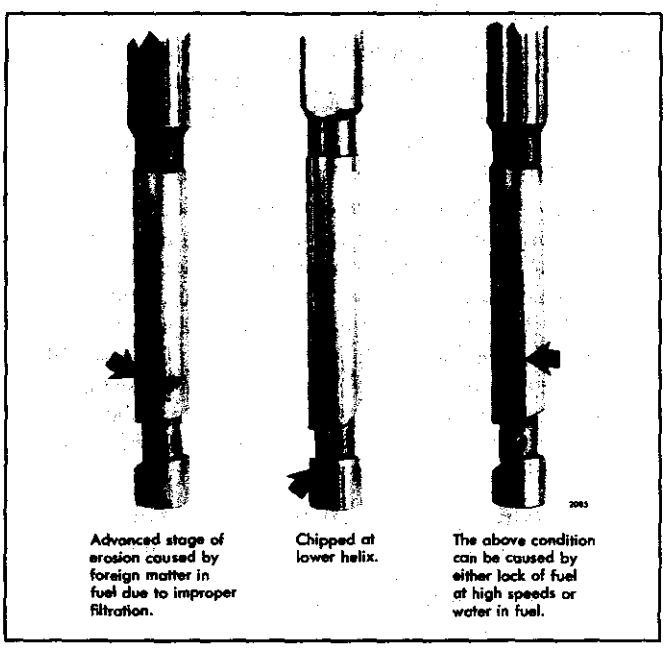


Fig. 21 – Unusable Injector Plungers

10. Check Valve Cage:

    Inspect the check valve cage for cracks and scratches on the lapped surfaces or for corrosion, varnish and wear.

11. Valve Spring:

    Check the injector valve spring for wear on the coil ends, broken coil ends and notches under the coil ends. Then, check for corrosion, nicks and cavitation erosion on the inside at approximately 1–1/2 coils from the end.

- **NOTICE:** A high V.O.P. (valve opening pressure) valve spring and seat are being used in certain high output engine injectors. The high V.O.P. spring is made of a thicker diameter wire than the standard valve spring and has a smaller inside diameter (.174" I.D. vs .184" I.D.). A no. 15 (.180") drill may be used to distinguish the two springs. The drill will fit into the standard spring, but not into the high V.O.P. spring. The high V.O.P. spring seat can be distinguished from the standard spring seat by its smaller diameter post and the groove on the end of this post. To ensure proper operation, the high V.O.P. spring and seat must be used together. *Do not mix injectors containing standard springs and seats with injectors having high V.O.P. springs and seats in the same engine.*

12. Spring Seat:

    Check the surfaces for wear.

13. Spring Cage:

    Inspect for cracks, corrosion or varnish and scratches on the lapped sealing surfaces. Also, inspect the spring seat surface and the needle valve seating surface for wear.

14. Spray Tip:

    Check for cracks, enlarged spray holes, corrosion on the outside diameter taper and oxide scale on the spray hole end. Then, check the nut–to–tip sealing surface and the lapped sealing surface for scratches. Do not reuse if there is scale, cracks or enlarged spray holes.

15. Needle Valve:

    Check the spray tip needle valve for erosion at the seat shoulder, scratches and overheating (discolored).

16. Nut:

    Check the nut for damaged threads, the condition of the seal ring seating area, the condition of spray tip seating area and the spray tip hole for being corroded irregularly.

17. Spill Deflector:

    Inspect both ends of the spill deflector for sharp edges or burrs.

18. Part Thickness:

Check the minimum thickness of the parts (see Table 1).

Part Name	Minimum Thickness
Spray Tip (shoulder)	.199"
Check Valve Cage	.163"–.165"
Check Valve	.022"
Valve Spring Cage	.602"

TABLE 1 – MINIMUM THICKNESS (Used Parts)

19. Needle Valve Lift:

Measure the needle valve lift, using tool J 9462–02 (Fig. 22) as follows:

a. Zero the indicator by placing the bottom surface of the plunger assembly on a flat surface and zero the indicator dial.

b. Place the spray tip and needle valve assembly tight against the bottom of the gage with the quill of the needle valve in the hole in the plunger.

c. While holding the spray tip and needle valve assembly tight against the gage, read the needle valve lift on the indicator. The lift should be .008" to .018". If it exceeds .018", the tip assembly must be replaced. If it is less than .008", inspect for foreign material between the needle valve and the tip seat.

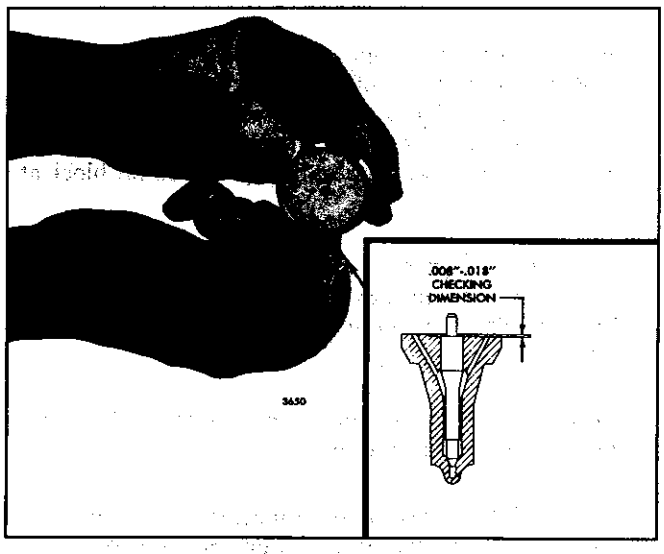


Fig. 22 – Checking Needle Valve Lift with Tool J 9462–02

d. If the needle valve lift is within limits, install a new needle valve spring and recheck the valve opening pressure and valve action. Low valve opening pressure or poor atomization with a new spring and seat indicates the spray tip and needle valve assembly should be replaced.

20. Classify Spray Tip:

Match the plunger/bushing assembly with the proper spray tip using Flow Gage J 25600–A (see Section 2.0).

Recondition Injector

If any of the injector parts listed below cannot be reconditioned satisfactorily, use new parts. Al parts must be cleaned to be free of rust, varnish and carbon before reuse.

1. Follower:
   - Resurface or replace if worn beyond dimensional limits.
2. Follower Spring:
   - Reuse unless damaged, worn or won't meet test specifications.
3. Body:
   - Lap bushing seat.
   - Reblue.
   - Repair damaged threads.
   - Replace body if the clamp radius is badly worn or if the threads are less than 90% good.
4. Filter Caps:
   - Recondition tapered seat.
   - Clean and deburr hole.
   - Reblue.
   - Replace if the threads or sealing surfaces are damaged.
5. Control Rack:
   - Deburr teeth – check for straightness.
   - Replace if the teeth show significant wear.
6. Gear and Gear Retainer:
   - Deburr.
   - Replace if cracked or significantly worn.
7. Bushing:
   - Replace if scored, cracked or if residue cannot be removed.
   - Lap the check valve seat (sealing) surface.
8. Plunger:
   - Clean – remove varnish.
   - Replace if scored, chipped or scratched.
9. Check Valve:
   - Lap both flat (sealing) surfaces.
   - Replace if scratched, cracked or badly worn.

10. Check Valve Cage:
    - Lap both flat sealing surfaces.
    - Replace if cracked or too thin (see Table 1).
11. Valve Spring:
    - Replace. Do not reuse unless there is absolutely no wear or damage.
12. Spring Seat:
    - Replace if there is a hole worn in the rounded end where the needle quill touches.
13. Spring Cage:
    - Lap both flat (sealing) surfaces.
    - Replace if cracked or too thin (see Table 1) or if the needle has worn a pocket around the small hole.
14. Spray Tip:
    - Regrind seat.
    - Lap flat sealing surface.
    - Regrind the needle conicol seat.
    - Replace if beyond flow limits i.e., eroded spray holes.
15. Nut:
    - Remove carbon from the seat and tapered I.D.
    - Reblue.
    - Replace if the threads are damaged more than 10% or if the small I.D. is badly eroded.
16. Spill Deflector:
    - Remove burrs.
    - Reuse if the ends are smooth and even and the deflector is not cracked.

Normally, new parts do not require lapping prior to use. Wash the service parts in clean solvent to remove the solitified preservative. However, if new parts become nicked or burred during handling, then lapping will be necessary to provide adequate sealing between the flat parts.

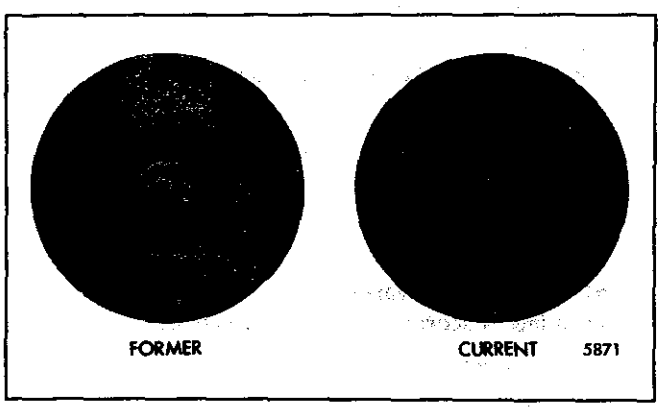


Fig. 23 – Spray Tip Sealing Surface Identification

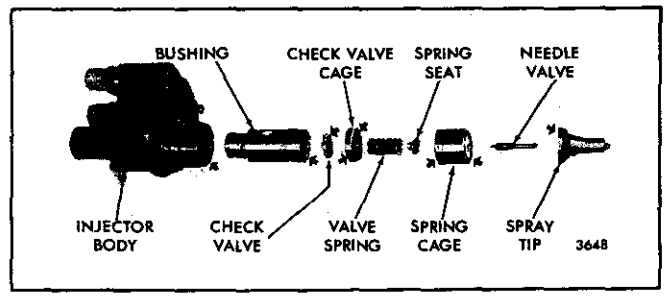


Fig. 24 – Sealing Surfaces which May Require Lapping

The sealing surface of current spray tips is precision lapped by a new process which leaves the surface with a dull satin–like finish; the lapped surface on former spray tips was bright and shiny (Fig. 23). DDC does not recommended lapping the surface of a *new* current spray tip.

Lapping Injector Parts

If necessary, lap the sealing surfaces indicated in (Fig. 24) as follows:

1. Clean the lapping blocks (J 22090) with compressed air. Do not use a cloth or any other material for this purpose.

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

2. Spread a good quality 600 grit dry lapping powder on one of the lapping blocks.

3. Place the part to be lapped flat on the block (Fig. 25) and, using a figure eight motion, move it back and forth across the block. Do not press on the part, but use just enough pressure to keep the part flat on the block. It is important that the part be kept flat on the block at all times.

4. After each four or five passes, clean the lapping powder from the part by drawing it across a clean piece of tissue placed on a flat surface and inspect the part. *Do not lap excessively.*

5. When the part is flat, wash it in cleaning solvent 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.

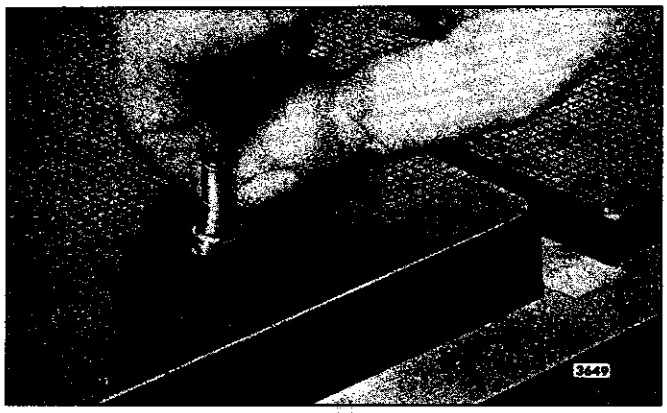


Fig. 25 – Lapping Spray Tip on Lapping Blocks J 22090

6. Place the dry part on the second block. After applying lapping powder, move the part lightly across the block in a figure eight motion several times to give it a smooth finish. *Do not lap excessively.* Again wash the part in cleaning solvent 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.

7. Place the dry part on the third block. Do not use lapping powder on this block. Keep the part flat and move it across the block several times, using the figure eight motion. Lapping the dry part in this manner gives it the "mirror" finish required for perfect sealing.

8. Wash all of the lapped parts in clean solvent 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.

Assemble Injector

1. Secure the body in vise J 22396–1.

• 2. Insert new filter(s) in the top of the body (Fig. 26). The current production service filter (stainless steel wire mesh pellet) is installed dimple end down, slotted end up. The former service filter (fiberglass–filled nylon cone) was installed with the pointed (cone) end up.

Insert a new filter in the inlet side (located over the injector rack) in an offset injector. No filter is required at the outlet side (Fig. 27).

• 3. Place a new gasket on each filter cap. Lubricate the threads and install the filter caps. Tighten injector filter caps with a 9/16" deep socket as follows:

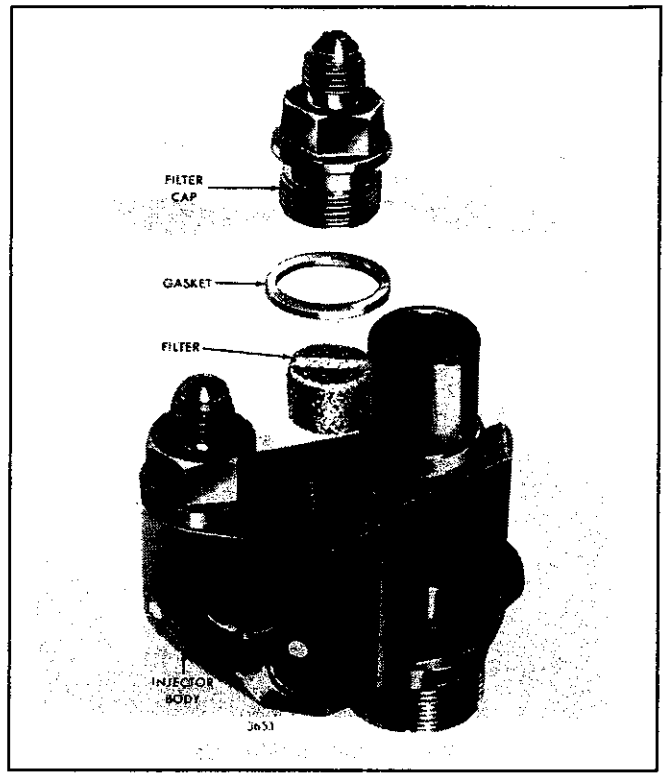


Fig. 26 – Details of Injector Filters and Caps and Their Relative Location

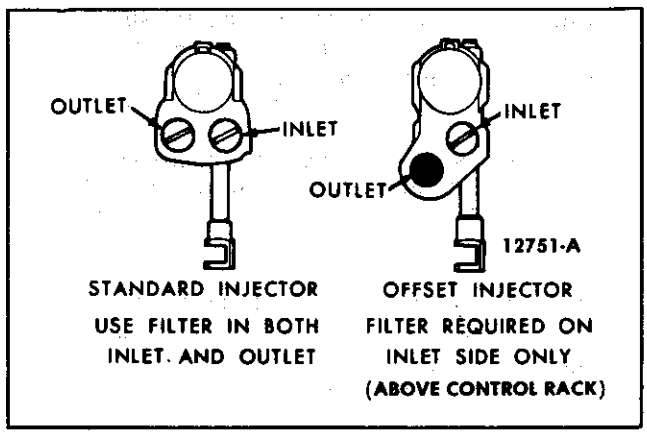


Fig. 27 – Location of Filter in Injector Body

Non–blued cap on non–blued body ..... 62 lb–ft (84 N·m) torque

Blued cap on blued body ..... 70 lb–ft (95 N·m) torque

Non–blued cap on blued body or blued cap on non–blued body ..... 62 lb–ft (84 N·m) torque

Cap for O–Ring sealed fuel pipe ..... 70 lb–ft (95 N·m) torque

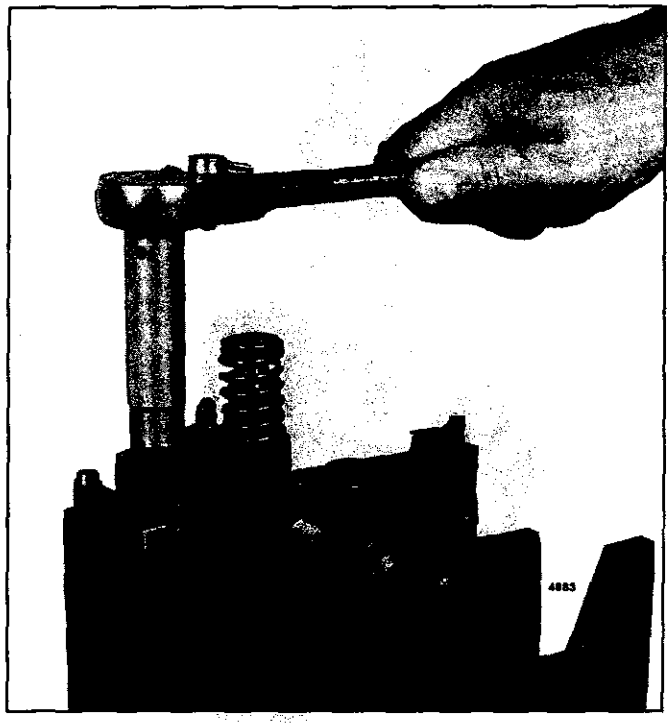


Fig. 28 – Installing Filter Cap

4. Install clean shipping caps to protect the sealing surfaces and to prevent dirt from entering the injector.

5. Lubricate the injector nut seal ring installer J 29197 with injector test oil. Remove the injector from the vise and hold the injector body, bottom end up. Place the installer over the threads of the injector body.

6. Lubricate the new seal ring and place the new seal over the nose of the protector and down onto the shoulder of the injector body. Do not allow the seal to roll or twist.

   • A new round (in cross–section) injector nut seal ring replaced the former diamond–shaped ring, effective with injectors manufactured approximately November 1, 1987. Only the round seal ring is serviced.

7. Remove the protector (J 29197).

8. Slide the control rack into the injector body.

9. Refer to (Fig. 29) and note the marked teeth on the control rack and gear. Then, look into the body bore and move the rack until you can see the drill marks. Hold the rack in this position.

10. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack (Fig. 29).

11. Place the gear retainer on top of the gear.

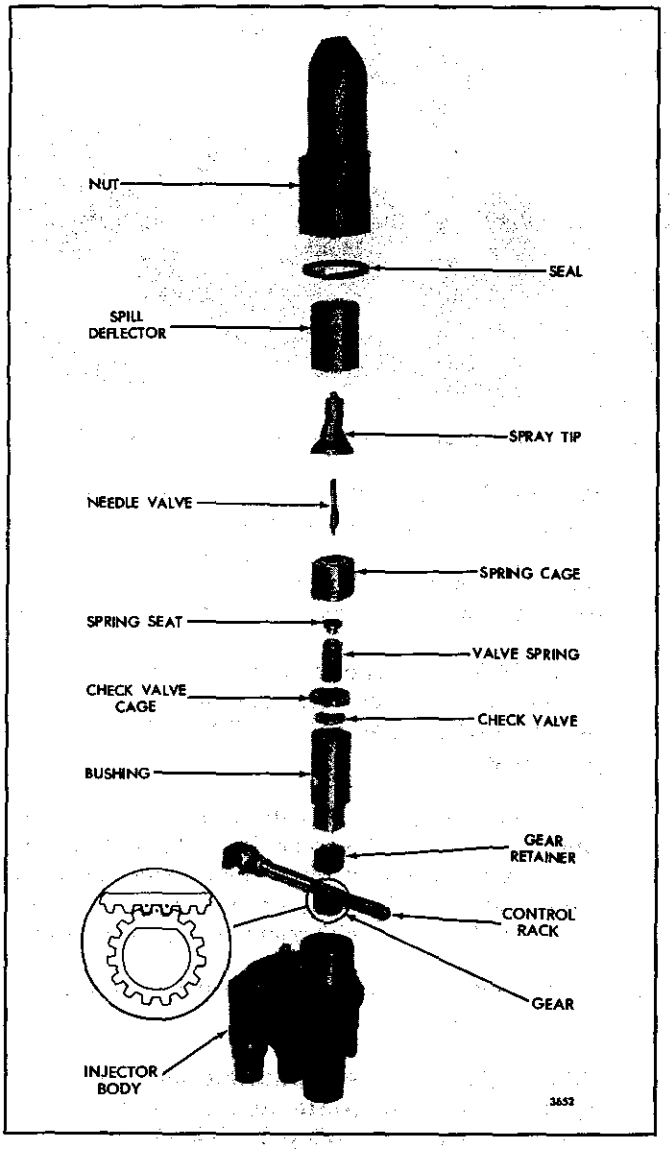


Fig. 29 – Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

12. Align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.

13. Support the injector body, bottom end up, in injector vise J 22396–1.

14. Install the spill deflector over the barrel of the bushing.

15. Perform the spray tip test, as outlined in Section 2.0 using injector tip Tester J 22640–A before proceeding with the injector assembly.

16. Place the check valve (without the .010" hole) centrally on the top of the bushing. Then, place the check valve cage over the check valve and against the bushing. The check valve cage must not rest on the check valve.

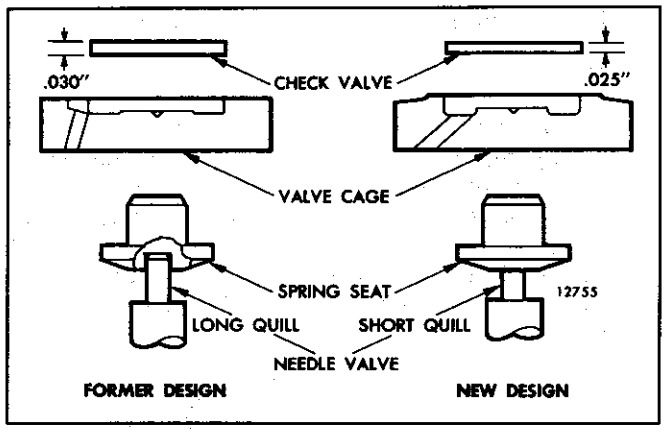


Fig. 30 – Comparison of Former and New Design Injector Parts

The former and new check valve and check valve cage are not separately interchangeable in a former injector (Fig. 30).

17. Insert the spring seat in the valve spring, then insert the assembly into the cage, spring seat first.

18. Place the spring cage, spring seat and valve spring assembly (valve spring down) on top of the check valve cage.

    Do not use new design needle valve spray tip with former design spring seat (Fig. 30).

19. Put the needle, tapered end down, into the spray tip (Fig. 31). Then, place the spray tip assembly on top of the spring cage with the quill end of the needle valve in the hole in the spring cage.

20. Lubricate the threads in the injector nut and carefully thread the nut on the injector body by hand. Rotate the spray tip between your thumb and first finger while threading the nut on the injector body (Fig. 32). Tighten the nut as tight as possible by hand. At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.

● 21. Use socket J 4983–01 and a torque wrench to tighten the injector nut as follows:

    Non–blued nut on non–blued body ..... 50 lb–ft (68 N·m) torque

    Blued nut on blued body ..... 80 lb–ft (108 N·m) torque

    Non–blued nut on blued body or blued nut on non–blued body ..... 65 lb–ft (88 N·m) torque

22. After assembling a fuel injector, always check the area between the nut and the body. If the seal is still visible after the nut is assembled, try another nut and a new seal which may allow assembly on the body without extruding the seal and forcing it out of the body–nut crevice.

    NOTICE: Do not exceed the specified torque. Otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul.

23. Turn the injector over and push the rack all the way in.

24. Place the follower spring on the injector body.

25. Refer to (Fig. 34) and place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin.

26. Refer to (Fig. 35) and slide the head of the plunger into the follower.

27. Align the slot in the follower with the stop pin hole in the injector body.

28. Align the flat side of the plunger with the flat in the gear.

29. Insert the free end of the plunger in the injector body. Press down on the follower and at the same time press the stop pin into position. When in place, the spring will hold the stop pin in position.

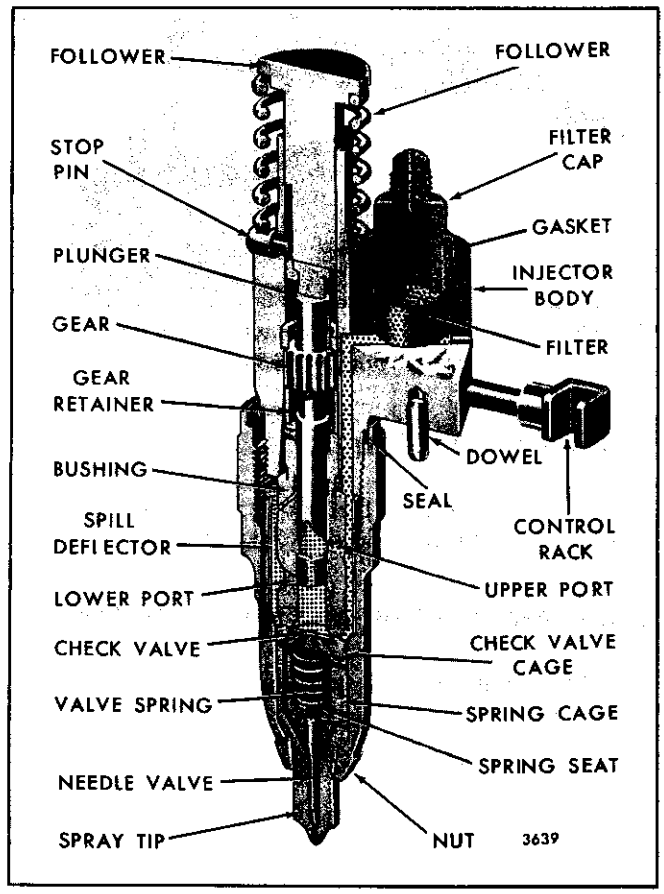


Fig. 31 – Cutaway View of Fuel Injector

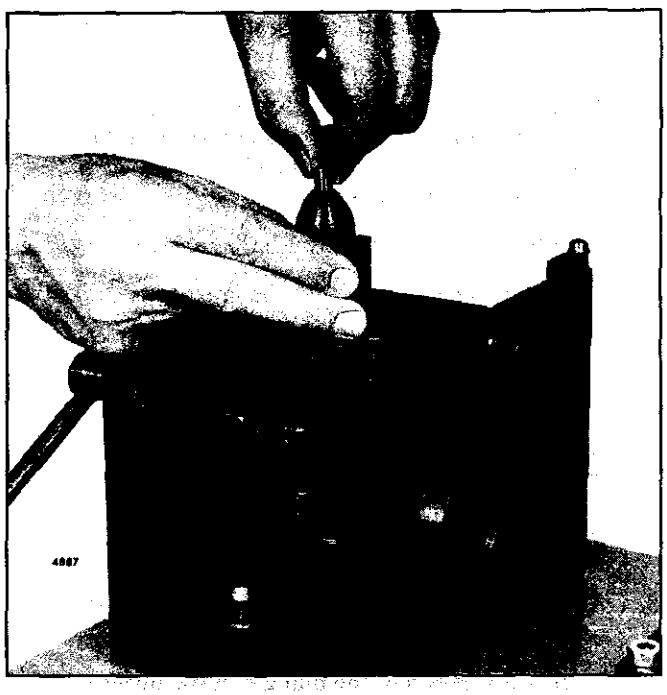


Fig. 32 – Tightening Injector Nut by Hand

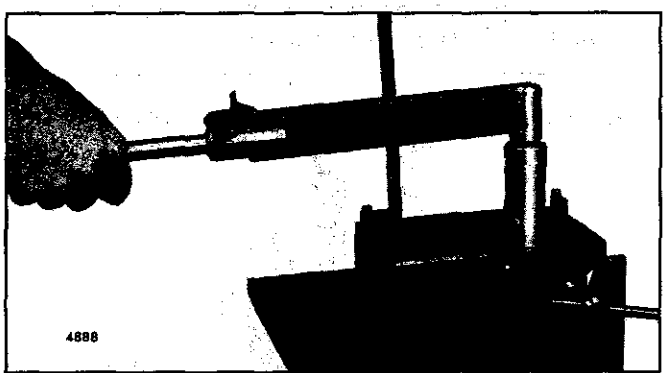


Fig. 33 – Tightening Injector Nut with Torque Wrench Using Tool J 4983-01

Check Injector Output

Perform the injector fuel output test using Calibrator J 22410-A as outlined in Section 2.0 – Shop Notes.

Check Atomization and Spray Pattern

This test determines spray pattern uniformity and atomization.

1. Clamp the injector properly and purge the air from the system (Fig. 36).
2. Move lever 4 down.
3. Position the injector rack in the *full-fuel* position.
4. Place pump lever 1 in the *vertical* position.
5. Move lever 3 to the *forward detent* position.
6. The injector follower should be depressed rapidly using pump lever 1 (at 40 to 80 strokes per minute) to simulate operation in the engine. Observe the spray pattern to see that all spray orifices are open and dispersing the test oil evenly. The beginning and ending of injection should be sharp and the test oil should be finely atomized with no drops of test oil forming on the end of the tip.

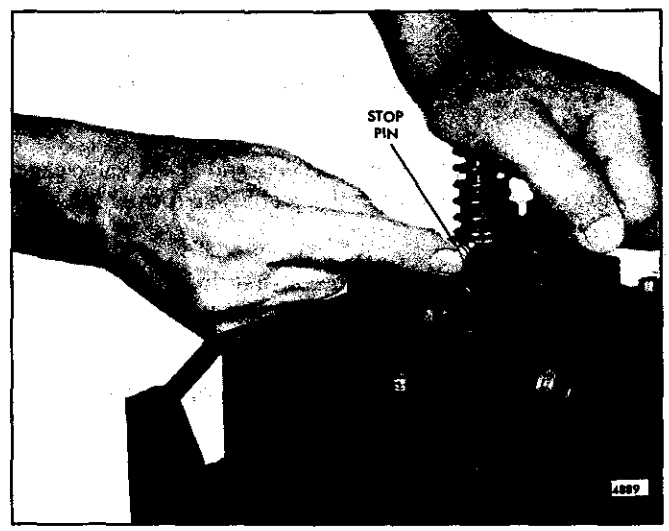


Fig. 34 – Installing Injector Follower Stop Pin

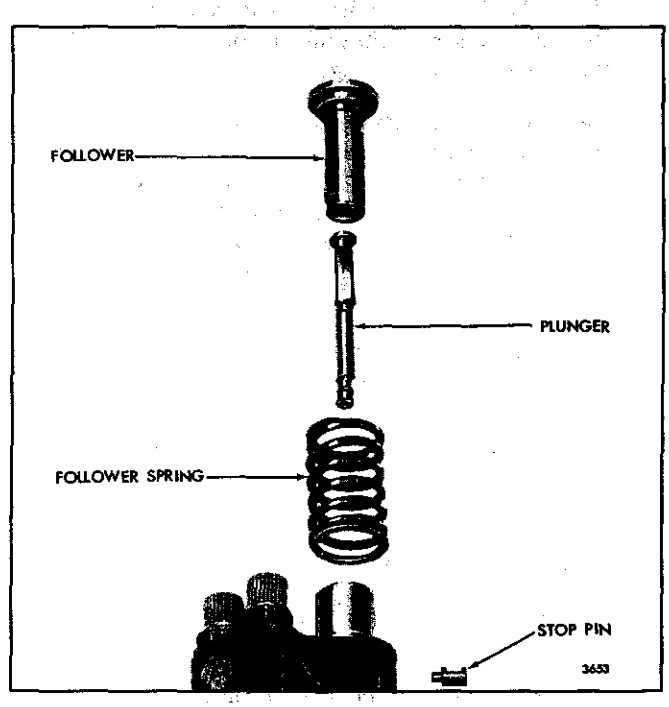


Fig. 35 – Injector Plunger, Follower and Relative Location of Parts

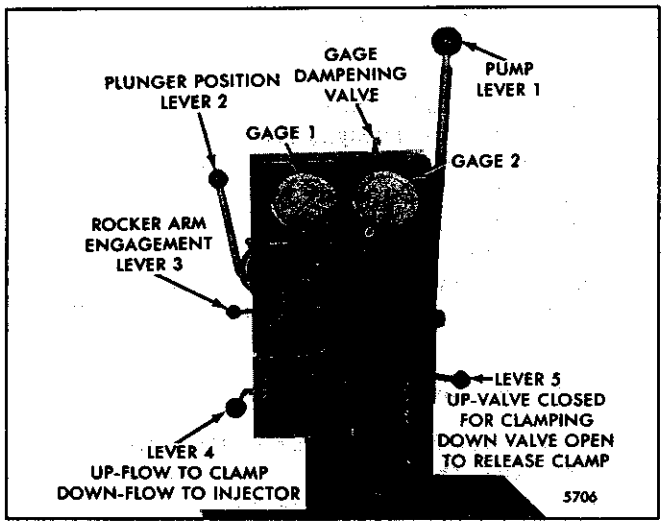


Fig. 36 – Injector in Position for Testing with Tester J 23010–A

Check Pressure Holding and Test for Leaks

This test determines if the body–to–bushing mating surfaces in the injector are sealing properly and indicates proper plunger–to–bushing fit.

1. Clamp the injector properly in Tester J 23010–A and purge the air from the system (Fig. 36).
2. Close the Thru–Flow valve, but do not overtighten.
3. Move lever 2 to the rear, *horizontal* position.
4. Operate pump lever 1 until gage 1 slowly reaches 100–200 psi (689–1378 kPa), check for injector nut seal ring leaks. Then, increase the gage reading to 1500–2000 psi (10 335–13 780 kPa). Check for leaks at the filter cap gaskets and the body plugs. 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.
5. Unclamp the injector.
6. Open the Thru–Flow valve to release pressure in the system.
7. Move lever 5 *down* to release the clamping pressure.
8. 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.
9. Carefully, return lever 5 to the *up (horizontal)* position.

Check Rack Freeness and Spray Tip Concentricity

Place the injector in Tester J 29584 (Fig. 37) and check rack freeness.

With the injector control rack held in the *no–fuel* position, operate the handle to depress the follower to the bottom of its stroke. Then, very slowly release the pressure on the handle while moving the control rack up and down until the follower reaches the top of its travel. If the rack falls freely the injector passes the test.

If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times, if necessary. Generally, this will free the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts or to remove dirt.

To assure correct alignment, check the concentricity of the spray tip as follows:

1. Place the injector in Tester J 29584 (Fig. 37) and adjust the dial indicator to zero.

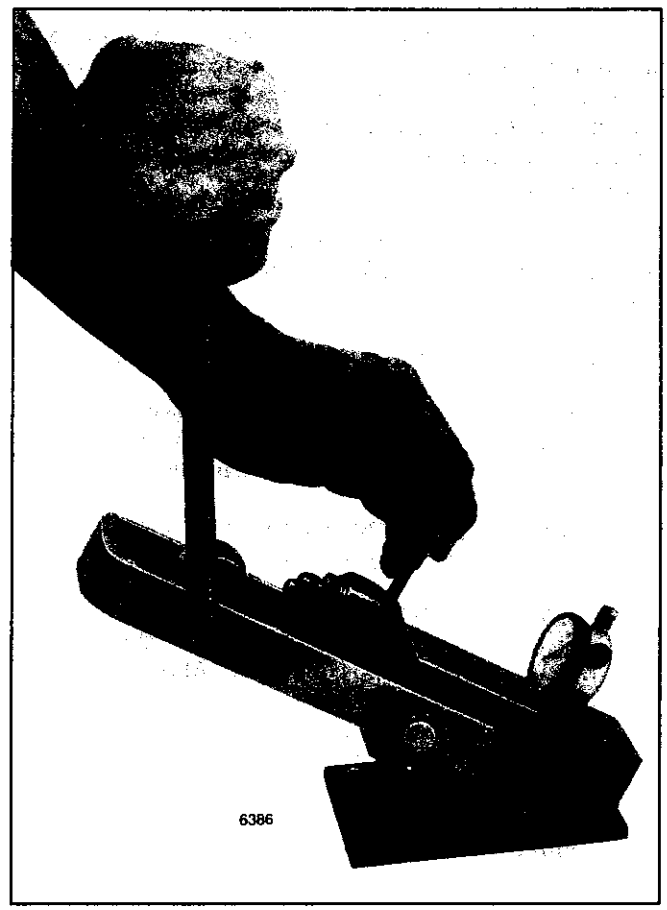


Fig. 37 – Checking Rack for Freeness in Tester J 29584

2. Rotate the injector 360° and note the total runout as indicated on the dial.

3. If the total runout exceeds .008", remove the injector from the gage. Loosen the injector nut, center the spray tip and tighten the nut to 75–85 lb–ft (102–115 N·m) torque. Recheck the spray tip concentricity. If, after several attempts, the spray tip cannot be positioned satisfactorily, replace the injector nut.

Box and Store Injector

If the reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an *upright* position to prevent test oil leakage.

Install Injector

Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stresses from being exerted against the spray tip.

Use injector tube bevel reamer J 5286–9 or a cylindrical wire brush, Section 2.1.4, to clean the carbon from the injector tube. Exercise care to remove ONLY the carbon so that the proper tip protrusion is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it runs out of the outlet filter cap.

Install the injector in the engine as follows:

1. Refer to (Fig. 5) and insert the injector into the injector tube with the dowel pin in the injector body registering with the locating hole in the cylinder head.

2. Slide the injector rack control lever over so that it registers with the injector rack.

3. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt. Tighten the bolt to 20–25 lb–ft (27–34 N·m) torque. Make sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

   NOTICE: Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.

4. Move the rocker arm assembly into position and secure the rocker arm brackets to the cylinder head by tightening the bolts to the torque specified in Section 2.0 – Specifications.

   NOTICE: On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridge is not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Refer to *Install Rocker Arm and Shaft* in Section 1.2.1 and note the position of the exhaust valve bridge before, during and after tightening the rocker shaft bolts.

5. Install fuel pipes:

   - *A. Flared end fuel pipes.* Remove the injector shipping caps. Align the fuel pipes and connect them to the injectors and the fuel connectors.

     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.

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)

*Not serviced. Available from Jacobs Manufacturing Company.

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: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to Fuel Jumper Line Maintenance & Pressurize Fuel System – Check for Leaks in Section 2.0 – Shop Notes).

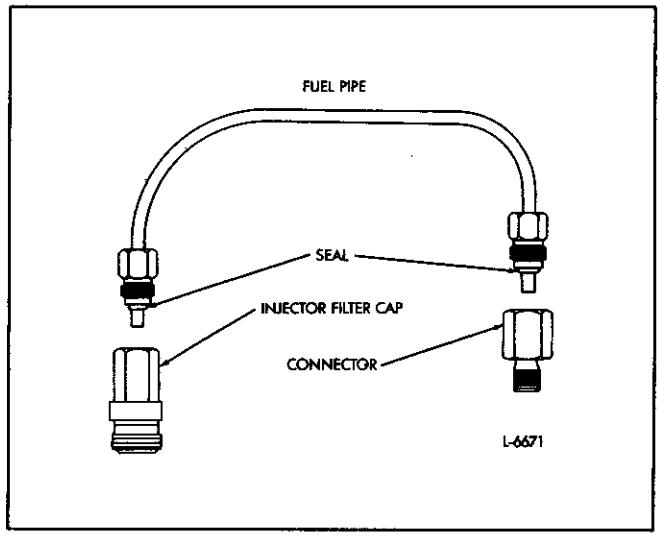
An indication of fuel leakage at the fittings of the fuel injector supply lines and connector nut seals could be either low lubricating oil pressure (dilution) or fuel odor coming from the crankcase breathers or an open oil filler cap. When any of the above are detected, remove the valve rocker cover. A close inspection of the rocker cover, cylinder head, fuel lines and connectors will usually show if there is a fuel leakage problem. Under normal conditions, there should be a coating of lubricating oil throughout the cylinder head area and puddles of oil where the fuel pipes contact the connectors and where the fuel connectors contact the cylinder head. If these areas do not have the normal coating of lubricating oil, it is likely that fuel oil is leaking and washing off the lubricating oil. Remove and replace the leaking fuel pipes and/or connectors. Use a new gasket and reinstall the rocker cover. Then, drain the lubricating oil and change the oil filter elements. Refer to Section 13.3 (Lubrication Specifications) and refill the crankcase to the proper level with the recommended grade of oil.

- *B. O–ring sealed fuel pipes.* Inspect fuel pipes and connectors (Fig. 38) carefully. Fuel pipes may be reused if they are not twisted, bent, distorted or otherwise damaged. O–ring design fuel pipes are not interchangeable with flared tube design fuel pipes on a part–for–part basis. O–ring design fuel pipe connectors and injector filter caps have a 1/2″ – 20 female thread to accept the 1/2″ – 20 male thread on the fuel pipe nuts. These parts *must* be used together to insure interchangeability.

NOTICE: To avoid fuel leakage, always use new O–ring seals when replacing the fuel pipes on an engine. Do not reuse seals.

Remove the injector shipping caps. Align the fuel pipes and connect them to the injector filter caps and the cylinder head connectors. Using "clicker" type torque wrench J 24405 (calibrated in inch–pounds), tighten the O–ring sealed fuel pipe nuts to 143 ***lb–in*** (16.16 N·m) torque.

6. Perform a complete engine tune–up as outlined in Section 14. However, if only one injector has been removed and replaced and the other injectors and the governor adjustment have not been disturbed, it will only be necessary to adjust the valve clearance and time the injector for the one cylinder, and to position the injector rack control lever.



● Fig. – 38 O–Ring Sealed Fuel Pipes, Connectors, Injector Filter Caps

FUEL INJECTOR TUBE

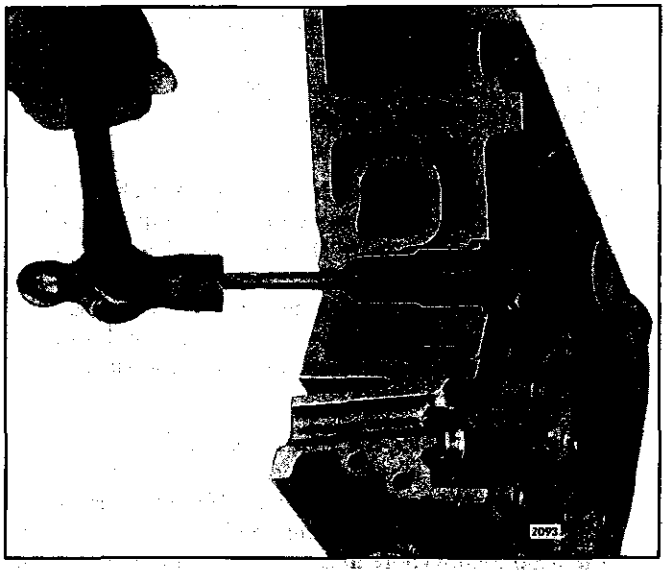


Fig. 1 – Removing Injector Tube Using Tools J 5286–4A and J 5286–5

The bore in the cylinder head for the fuel injector is directly through the cylinder head water jacket as shown in Fig. 1. To prevent coolant from contacting the injector and still maintain maximum cooling of the injector, a tube is pressed into the injector bore. This tube is sealed at the top with a neoprene ring (former) or fluorelastomer (current) and upset into a flare on the lower side of the cylinder head to create water–tight and gas–tight joints at the top and bottom.

• The new service–only injector hole tube can be distinquished from the former by the size of the large I.D. (1.198"–1.201" vs. 1.180" –1.183") and by the Detroit Diesel logo plus the number "606" stamped on the top flange. The former tube was marked with either "GM" or the Detroit Diesel logo on the top flange.

• The new tube takes less time to install than the former tube because the larger I.D. (inside diameter) of the new tube does not require reaming. Reaming is only necessary at the small I.D. and the injector nut seat. Reaming must be done carefully and without undue force or speed so as to avoid cutting through the thin wall of the injector tube.

NOTICE: Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base antifreeze is not recommended because of its effect on the fluoroelastomer seal rings in the cylinder head.

• Repair Leaking Injector Tube

To permit the repair of a leaking fuel injector hole tube at the seal ring, without removing the cylinder head from the cylinder block, a new injector hole tube swaging tool J 28611–A is available.

Before removing the fuel injector, pressurize the cooling system at the radiator to verify the injector tube seal ring leak. Then, with the fuel injector removed, insert the swaging tool into the fuel injector hole tube. The tool is tapered and flanged to prevent damage to the cylinder head or injector tube. Hit the top of the tool moderately with a one pound hammer two or three blows, seating the tool. This will cause the top edge of the injector hole tube to expand, thus increasing the crush on the injector tube seal ring and seal the leak. Install the fuel injector and again pressurize the cooling system to verify the leak has been stopped.

This tool was designed mainly for use on engines built between July, 1973 and August, 1977 with fuel injector hole tube seal rings that may be pressure sensitive and, if so, could take a heat set. The result being a coolant leak at the seal ring.

The use of the swaging tool, as stated above, will restore tension the the seal ring.

Remove Injector Tube

When removal of an injector tube is required, use injector tube service tool set J 22525 as follows:

1. Remove, disassemble and clean the sylinder head, as outlined in Section 1.2.
2. Place the injector tube installer J 5286–4A in the injector tube. Insert the pilot J 5286–5 through the small opening of the injector tube and thread the pilot into the tapped hole in the end of the installer (Fig. 1).
3. Tap on the end of the pilot to loosen the injector tube. Then lift the injector tube, and pilot from the cylinder head.

Install Injector Tube

Thoroughly clean the injector tube hole in the cylinder head to remove dirt, burrs or foreign material that may prevent the tube from seating at the lower end or sealing at the upper end. Then, install the tube as follows:

1. Lubricate the new injector tube seal ring with engine oil and place it in the counterbore in the cylinder head.

NOTICE: DO NOT lubricate the outside of the injector tube or inside the cylinder head injector tube bore to facilitate installation of the tube. Lubricant will cause the tube to turn during reaming or rolling operations possibly damaging the injector tube or reamers.

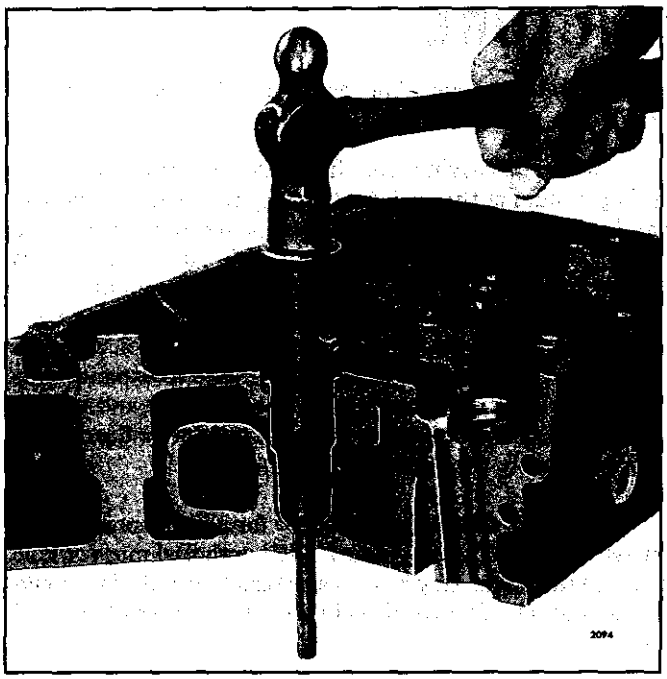


Fig. 2 – Installing Injector Tube Using Tools J 5286–4A and J 5286–5

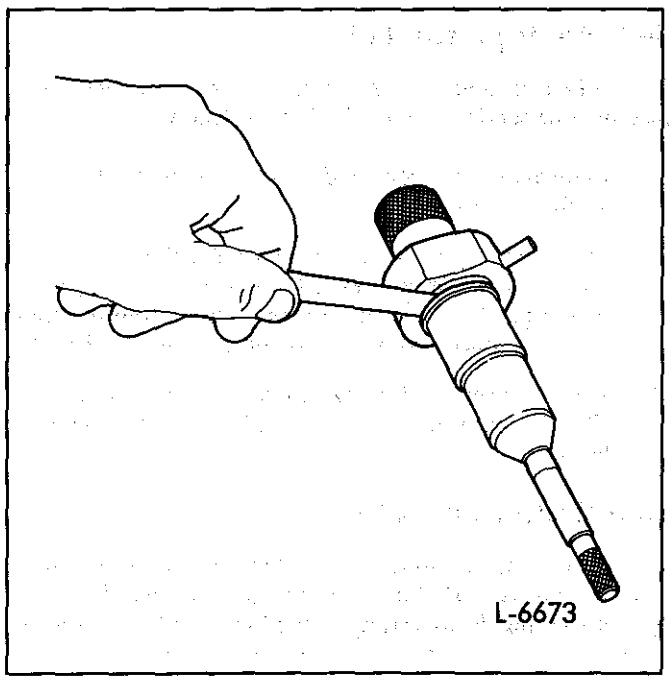


Fig. 3 – Measuring Clearance Between Installation Tool and Top of Hole Tube Flange

• 2. Place the installer J 5286–4C in the injector tube. Then, insert the pilot J 5286–5 through the small opening of the injector tube and thread it into the tapped end of the installer (Fig. 2). For proper installation of any injector hole tube, the tool must contact the tube at the bottom before it touches the flange at the top. The clearance at the top, between the flange and the tool, should be .001" to .010" (Fig. 3).

3. Slip the injector tube into the injector bore and drive it in place (Fig. 2). Sealing is accomplished between the head counterbore (inside diameter) and outside diameter of the injector tube. The tube flange is merely used to retain the seal ring.

• During installation the tube will stretch slightly before the tool contacts the flange, thus allowing the tool to properly install the tube. If there is no clearance at the flange, the tube will buckle slightly during installation until the tool contacts the tube at the lower end. The buckling causes compressive stress which will result in tube cracking during engine operation and subsequent engine damage.

It is permissable for the tube flange at the O–ring seal end to protrude up to .120" above the cylinder head casting without sealing being affected. Sealing is accomplished by compressing the O–ring seal between the head counterbore and the outside diameter of the injector tube. The tube flange is merely used to retain the seal ring in the head counterbore.

4. With the injector tube properly positioned in the cylinder head, upset (flare) the lower end of the injector tube as follows:

   a. Turn the cylinder head bottom side up, remove the pilot J 5286–5 and thread the upsetting die J 5286–6 into the tapped end of the installer J 5286–4C (Fig. 4).

   b. Then, using a socket and torque wrench, apply approximately 30 lb–ft (41 N·m) torque on the upsetting die.

   c. Remove the installing tools and ream the injector tube as outlined below.

Ream Injector Tube

After an injector tube has been installed in a cylinder head, it must be finished in three operations:

First, *hand reamed,* as shown in Fig. 5, to receive the injector body nut and spray tip.

Second, *spot–faced* to remove excess stock at the lower end of the injector tube.

Third, *hand reamed,* as shown in Fig. 6, to provide a good seating surface for the bevel or the lower end of the injector nut.

• The new tube takes less time to install than the former tube because the large I.D. (inside diameter) of the new tube does not require reaming. Reaming is only necessary at the small I.D. and the injector nut seat. Reaming must be done carefully and without undue force or speed so as to avoid cutting through the thin wall of the injector tube.

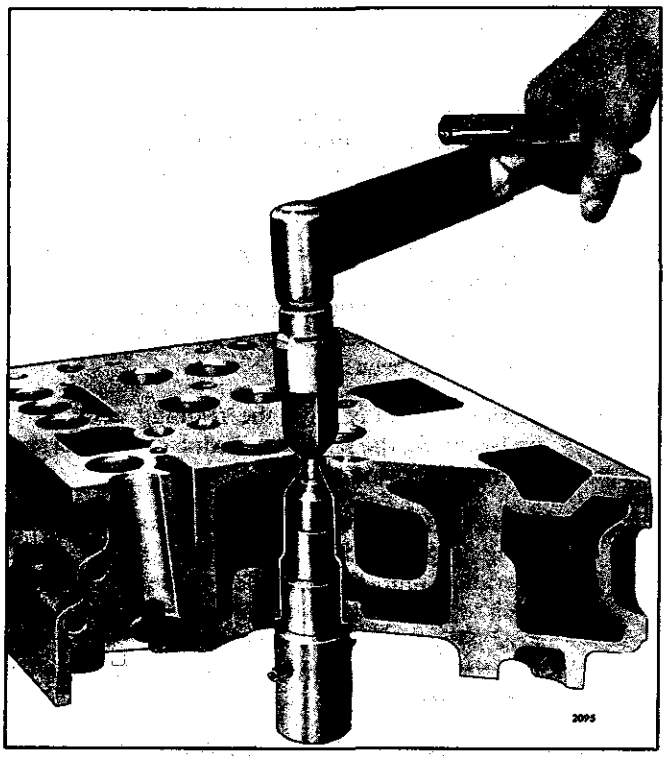


Fig. 4 – Upsetting Injector Tube Using Tools J 5286–4A and J 5286–6

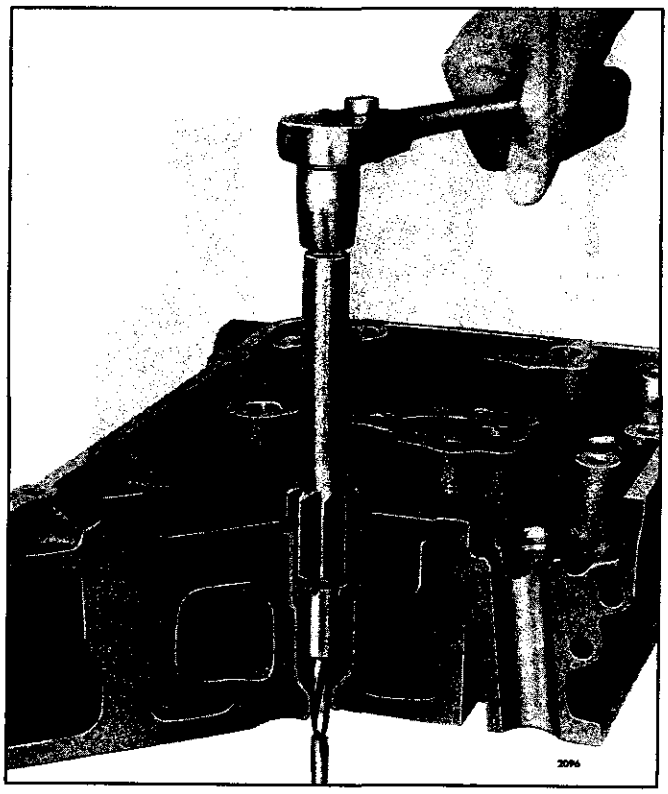


Fig. 5 – Reaming Injector Tube for Injector Body Nut and Spray Tip Using Tool J 22525–1

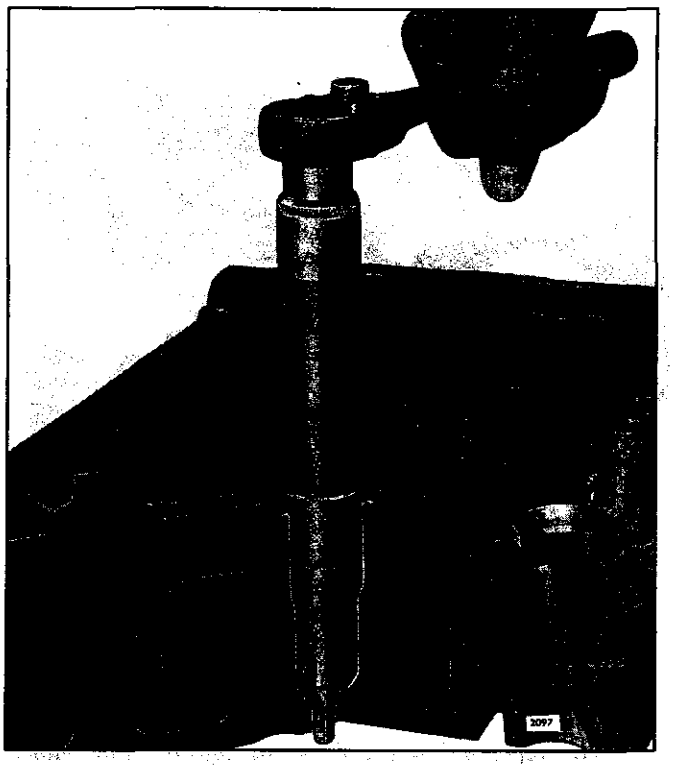


Fig. 6 – Reaming Injector Tube for Injector Nut Using Tool J 5286–9

NOTICE: The reamer should be turned in a *clockwise direction* only, both when inserting and when withdrawing the reamer, because movement in the opposite direction will dull the cutting edges of the flutes.

1. Ream the injector tube for the injector nut and spray tip. With the cylinder head right side up and the injector tube free from dirt, proceed with the first reaming operation as follows:

   a. Place a few drops of light cutting oil on the reamer flutes, then carefully position the reamer J 22525–1 in the injector tube.

   b. Turn the reamer in a clockwise direction (withdrawing the reamer frequently for removal of chips) until the lower shoulder of the reamer contacts the injector tube (Fig. 5). Clean out all of the chips.

2. Remove excess stock:

   a. With the cylinder head bottom side up, insert the pilot of cutting tool J 5286–8 into the small hole of the injector tube.

   b. Place a few drops of cutting oil on the tool. Then, using a socket and a speed handle, remove the excess stock so that the lower end of the injector tube is from flush to .005" below the finished surface of the cylinder head.

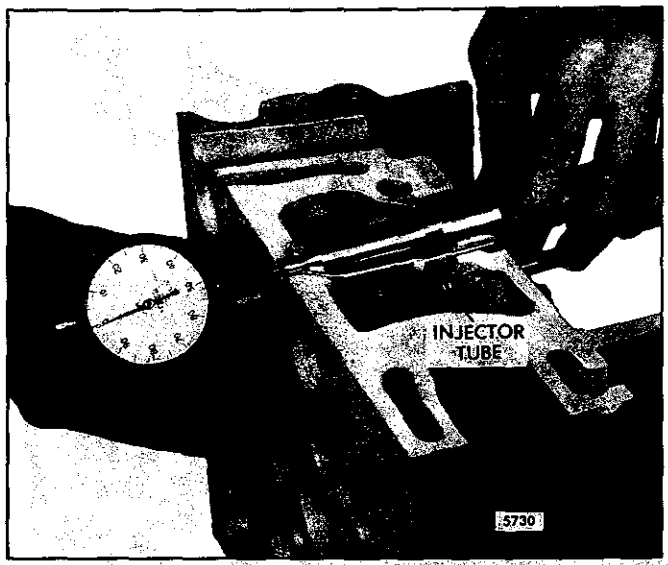


Fig. 7 – Measuring Relationship of Bevel Seat in Injector Tube to Cylinder Head Fire Deck Using Tools J 22273 and J 2

3. Ream the bevel seat in the injector tube:

   The tapered lower end of the injector tube must provide a smooth and true seat for the lower end of the injector nut to effectively seal the cylinder pressures and properly position the injector tip in the combustion chamber. Therefore, to determine the amount of stock that must be reamed from the bevel seat of the tube, refer to Fig. 7.

   Install gage J 25521 in the injector tube. Zero the sled gage dial indicator J 22273 to the fire deck. Gage J 25521 should be flush to ±.014" with the fire deck of the cylinder head (Fig. 8).

   Any fire deck resurfacing work must be done prior to final injector tube seat gaging. Refer to Section 1.2 for resurfacing instructions.

With the first reaming operation completed and the injector tube spot-faced, wash the interior of the injector tube with clean solvent and dry it with compressed air.

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

Then perform the second reaming operation as follows:

a. Place a few drops of cutting oil on the bevel seat of the tube. Carefully lower the reamer J 5286–9 into the injector tube until it contacts the bevel seat.

b. Make a trial cut by turning the reamer steadily without applying any downward force on the reamer. Remove the reamer, blow out the chips and look at the bevel seat to see what portion of the seat has been cut.

c. Proceed carefully with the reaming operation, withdrawing the reamer occasionally to observe the reaming progress.

d. Remove the chips from the injector tube and, using gage J 25521, continue the reaming operation until the shoulder of the spray tip is flush to ±.014" with the fire deck of the cylinder head (Fig. 8). Then wash the interior of the injector tube with clean solvent and dry it with compressed air.

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

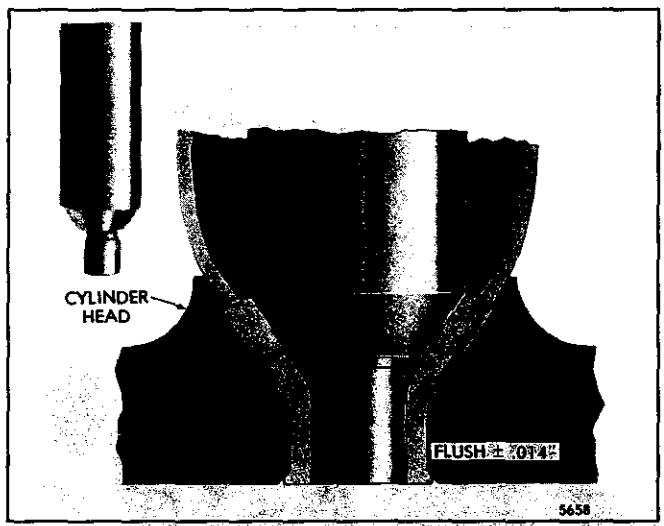


Fig. 8 – Measuring Relationship of Gage to Cylinder Head Fire Deck Using Tool J 25521

FUEL PUMP

The positive displacement gear–type fuel pump transfers fuel from the supply tank to the fuel injectors (Fig. 1). The pump circulates an excess supply of fuel through the injectors which purges the air from the system and cools the injectors. The unused portion of fuel returns to the fuel tank by means of a fuel return manifold and fuel return line.

On the In–line engine, the fuel pump is mounted on the governor weight housing and is driven through a drive coupling by the governor weight shaft. On the V–type engine, the fuel pump is mounted on the flywheel housing and is driven by the accessory drive gear.

Certain engine applications use a high–capacity fuel pump with 3/8" wide gears to increase fuel flow and reduce fuel spill temperature. The high–capacity fuel pump and the standard fuel pump with 1/4" wide gears may not be completely interchangeable; therefore, when replacing a standard pump with a high–capacity pump, the appropriate fuel lines and connections must be used.

The fuel pump cover and body are positioned by two dowels. The dowels aid in maintaining gear shaft alignment. The mating surfaces of the pump body and cover are perfectly flat ground surfaces. No gasket is used between the cover and body since the pump clearances are set up on the basis of metal–to–metal contact. A very thin coat of sealant provides a seal against any minute irregularities in the mating surfaces. Cavities in the pump cover accommodate the ends of the drive and driven shafts.

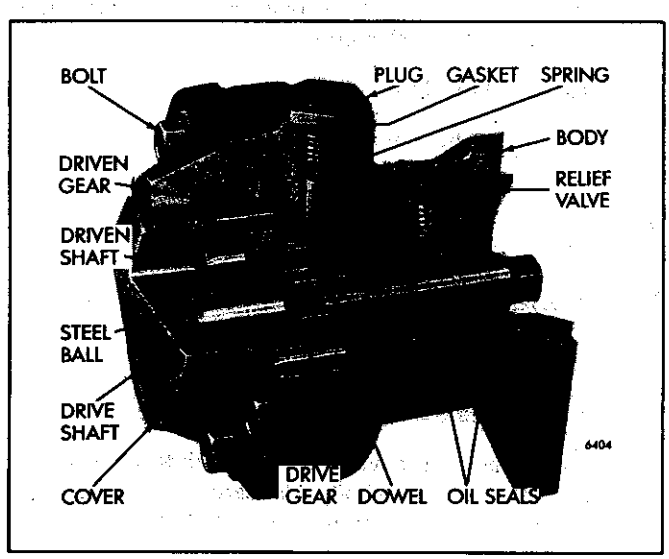


Fig. 1 – Typical Fuel Pump Assembly

The fuel pump body is recessed to provide running space for the pump gears (Fig. 2). Recesses are also provided at the inlet and outlet positions of the gears. The small hole "A" permits the fuel oil in the inlet side of the pump to lubricate the relief valve at its outer end and to eliminate the possibility of a hydrostatic lock which would render the relief valve inoperative. Pressurized fuel contacts the relief valve through hole "B" and provides for relief of excess discharge pressures. Fuel reenters the inlet side of the pump through hole "C" when the discharge pressure is great enough to move the relief valve back from its seat. Part of the relief valve may be seen through hole "C". The cavity "D" provides escape for the fuel oil which is squeezed out of the gear teeth as they mesh together on the discharge side of the pump. Otherwise, fuel trapped at the root of the teeth would tend to force the gears apart, resulting in undue wear on the gears, shafts, body and cover.

Two oil seals are pressed into the bore in the flanged side of the pump body to retain the fuel oil in the pump and the lubricating oil in the blower timing gear compartment (Fig. 3). A small hole "E" (Fig. 2) serves as a vent passageway in the body, between the inner oil seal and the suction side of the pump, which prevents building up any fuel oil pressure around the shaft ahead of the inner seal.

A higher temperature material lip type seal is now being used in the fuel pumps. The new fuel pump seal is made of a polyacrylate material, whereas the former seal is made of nitrile. The new fuel pumps (with the polyacrylate seals) will have the seals installed with the lips of the seals facing in the opposite direction of each other (Fig. 3). The former fuel pumps have the seals installed with both seal lips facing the mounting flange end of the pump. Both the polyacrylate and former nitrile seals are interchangeable in a fuel pump. Only the polyacrylate seals and fuel pumps with polyacrylate seals will be serviced.

Some fuel oil seepage by the fuel pump seals can be expected, both with a running engine and immediately after an engine has been shut down. This is especially true with a new fuel pump and/or new pump seals, as the seals have not yet conformed to the pump drive shaft. Fuel pump seals will always allow some seepage. Tapped holes in the pump body are provided to prevent fuel oil from being retained between the seals. Excessive fuel retention between the seals could provide enough pressure to cause engine oil dilution by fuel, therefore, drainage of the excess fuel oil is mandatory. However, if leakage exceeds one drop per minute, replace the seals.

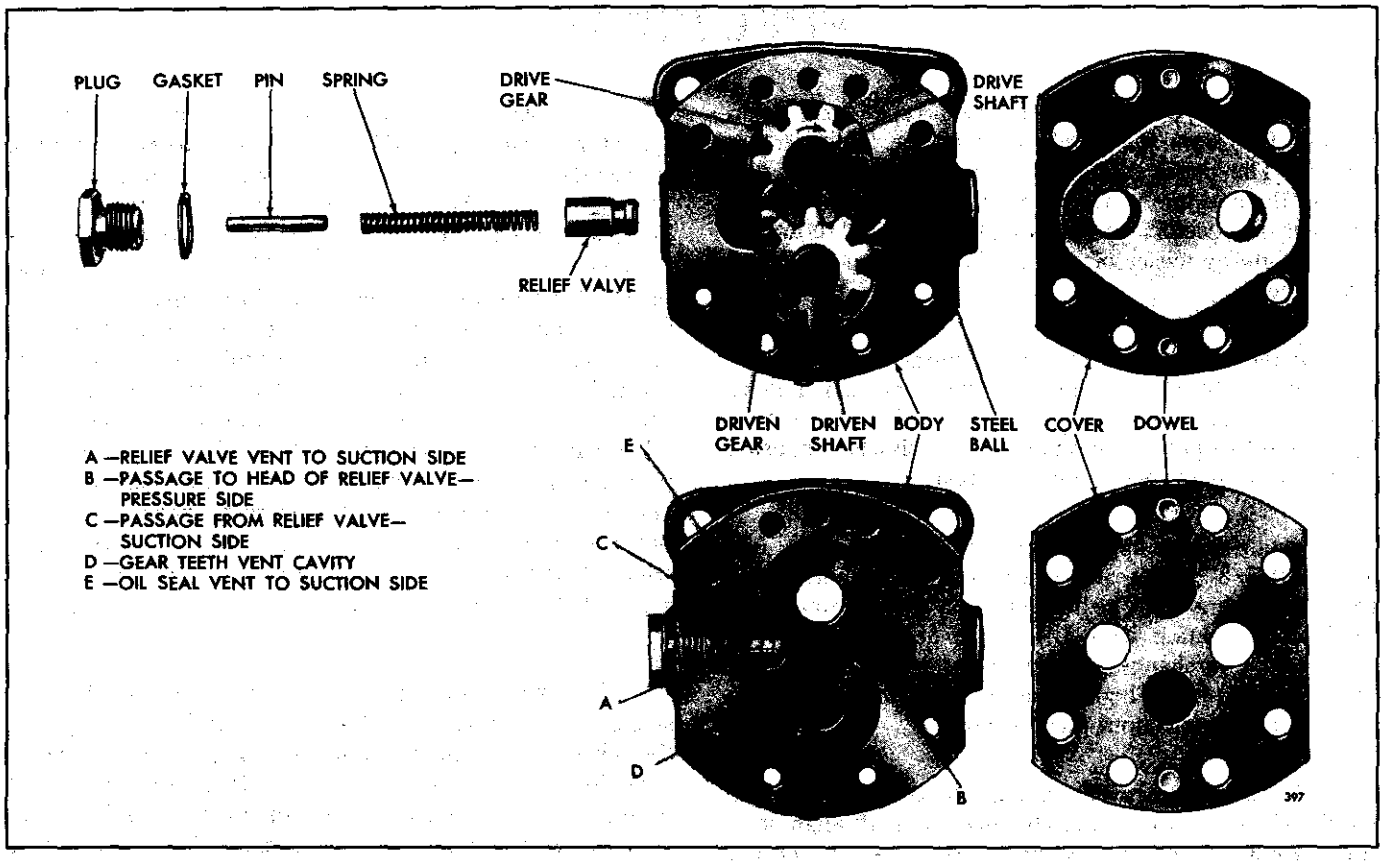


Fig. 2 – Fuel Pump Valving and Rotation (Right Hand Pump Shown)

The drive and driven gears are a line–to–line to a .001" press fit on their shafts. The drive gear is provided with a gear retaining ball to locate the gear on the shaft.

A spring–loaded relief valve incorporated in the pump body normally remains in the closed position, operating only when pressure on the outlet side (to the fuel filter) reaches approximately 65 psi (448 kPa).

Operation

In operation, fuel enters the pump on the suction side and fills the space between the gear teeth which are exposed at that instant. The gear teeth then carry the fuel oil to the discharge side of the pump and, as the gear teeth mesh in the center of the pump, the fuel is forced out into the outlet cavity. Since this is a continuous cycle and fuel is continually being forced into the outlet cavity, the fuel flows from the outlet cavity into the fuel lines and through the engine fuel system under pressure.

The pressure relief valve relieves the discharge pressure by by–passing the fuel from the outlet side of the pump to the inlet side when the discharge pressure reaches approximately 65 to 75 psi (448 to 517 kPa).

The fuel pump should maintain the fuel pressure at the fuel inlet manifold (see Section 13.2).

Remove Fuel Pump

1. Disconnect the fuel lines from the inlet and outlet openings of the fuel pump.
2. Disconnect the drain tube, if used, from the fuel pump.
3. Remove the three pump attaching bolts and withdraw the pump.
4. Check the drive coupling fork and, if broken or worn, replace it with a new coupling.

Disassemble Fuel Pump

With the fuel pump removed from the engine and mounted in holding fixture J 1508–10 as shown in Fig. 4, refer to Figs. 1 and 6 and disassemble the pump as follows:

1. Remove the eight cover bolts and withdraw the pump cover from the pump body. Use care not to damage the finished faces of the pump body and cover.
2. Withdraw the drive shaft, drive gear and gear retaining ball as an assembly from the pump body.

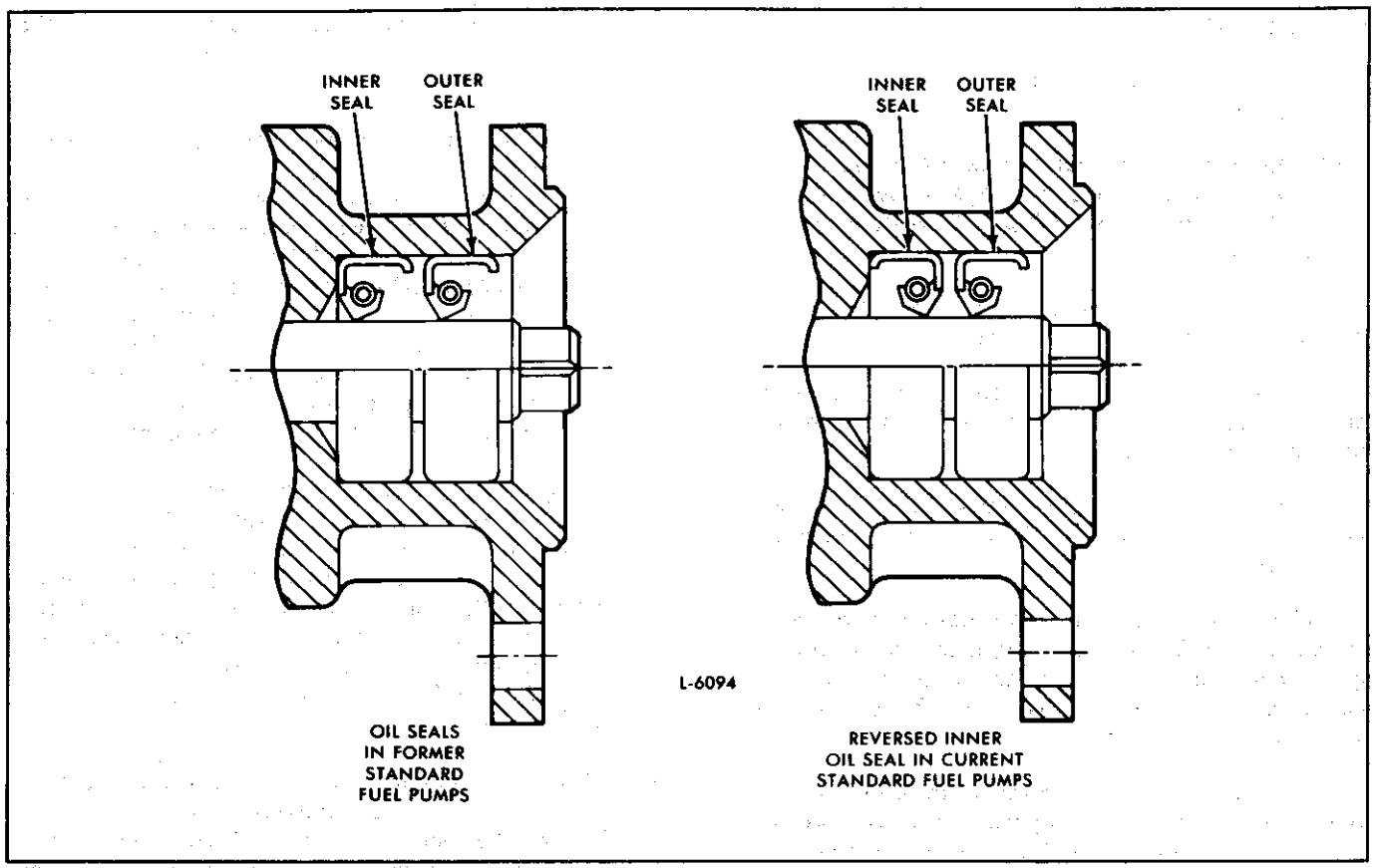


Fig. 3 – Fuel Pump Oil Seal Arrangements

3. Press the drive shaft just far enough to remove the steel locking ball. Then invert the shaft and gear assembly and press the shaft from the gear. *Do not misplace the steel ball.* Do not press the squared end of the shaft through the gear as slight score marks will damage the oil seal contact surface.

4. Remove the driven shaft and gear as an assembly from the pump body. *Do not remove the gear from the shaft.* The driven gear and shaft are serviced only as an assembly.

5. Remove the relief valve plug and copper gasket.

6. Remove the valve spring, pin and relief valve from the valve cavity in the pump body.

7. If the oil seals need replacing, remove them with oil seal remover J 1508–13 (Fig. 5). Clamp the pump body in a bench vise and tap the end of the tool with a hammer to remove the outer and inner seals.

NOTICE: Observe the position of the oil seal lips before removing the old seals to permit installation of the new seals in the same position (Fig. 3).

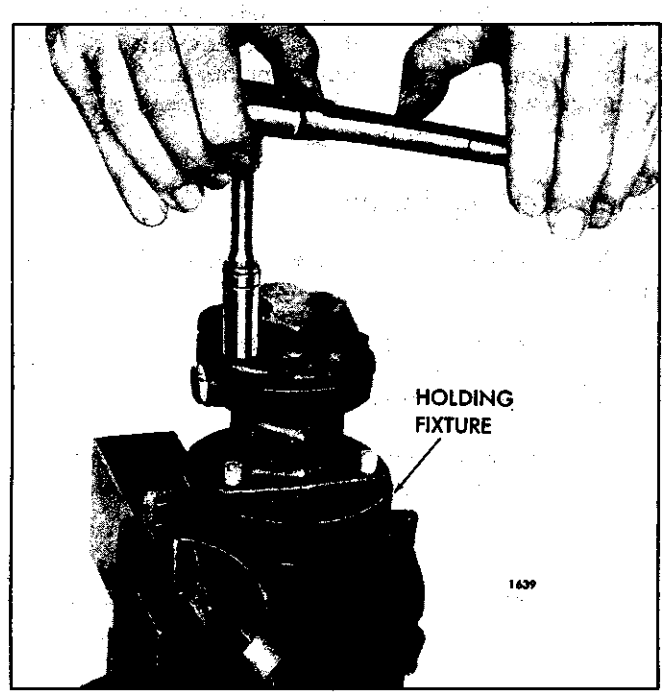


Fig. 4 – Removing Fuel Pump Cover

Inspection

Clean all of the 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.**

Oil seals, once removed from the pump body, must be discarded and replaced with new seals.

Check the pump gear teeth for scoring, chipping or wear. Check the ball slot in the drive gear for wear. If necessary, replace the gear.

Inspect the drive and driven shafts for scoring or wear. Replace the shafts if necessary. The driven shaft is serviced as a gear and shaft assembly only.

The mating faces of the pump body and cover must be flat and smooth and fit tightly together. Any scratches or slight damage may result in pressure leaks. Also, check for wear at areas contacted by the gears and shafts. Replace the pump cover or body, if necessary.

The relief valve must be free from score marks and burrs and fit its seat in the pump body. If the valve is scored and cannot be cleaned up with fine emery cloth or crocus cloth, it must be replaced.

Current standard fuel pumps (with 1/4" wide gears) incorporate a 1/8" shorter pump body with three drain holes, a 1/8" shorter drive shaft and a cover with a 3/8" inlet opening. When replacing a former pump, a 3/8" x 1/4" reducing bushing is required for the inlet opening and the unused drain holes must be plugged.

Assemble Fuel Pump

Refer to Figs. 1, 2, 3 and 6 and assemble the pump as follows:

1. Lubricate the lips of the oil seals with a light coat of vegetable shortening, then install the oil seal in the pump body as follows:

   a. Place the inner oil seal on the pilot of the installer handle J 1508–8 so that the lip of the seal will face toward the shoulder on the tool.

      When replacing the former nitrile fuel pump seals with the current polyacrylate seals, install them with the seal lips facing each other (Fig. 3).

   b. With the pump body supported on wood blocks (Fig. 7), insert the pilot of the installer handle in the pump body so the seal starts straight into the pump flange. Then drive the seal in until it bottoms.

   c. Place the shorter end of the adaptor J 1508–9 over the pilot and against the shoulder of the installer handle. Place the outer oil seal on the pilot of the installer handle with the lip of the seal facing the adaptor. Then insert the pilot of the installer handle into the pump body and drive the seal in (Fig. 8) until the shoulder of the adaptor contacts the pump body. Thus the oil seals will be positioned so that the space between them will correspond with the drain holes located in the bottom of the pump body.

2. Clamp the pump body in a bench vise (equipped with soft jaws) with the valve cavity up. Lubricate the outside diameter of the valve and place it in the cavity with the hollow end up. Insert the spring inside of the valve and the pin inside of the spring. With a new gasket in place next to the head of the valve plug, place the plug over the spring and thread it into the pump body. Tighten the 1/2"–20 plug to 18–22 lb–ft (24–30 N·m) torque.

3. Install the pump drive gear over the end of the drive shaft which is not squared (so the slot in the gear will face the plain end of the shaft). This operation is very important, otherwise fine score marks caused by pressing the gear into position from the square end of the shaft may cause rapid wear of the oil seals. Press the gear beyond the gear retaining ball detent. Then place the ball in the detent and press the gear back until the end of the slot contacts the ball.

4. Lubricate the pump shaft and insert the square end of the shaft into the opening at the gear side of the pump body and through the oil seals as shown in Fig. 9.

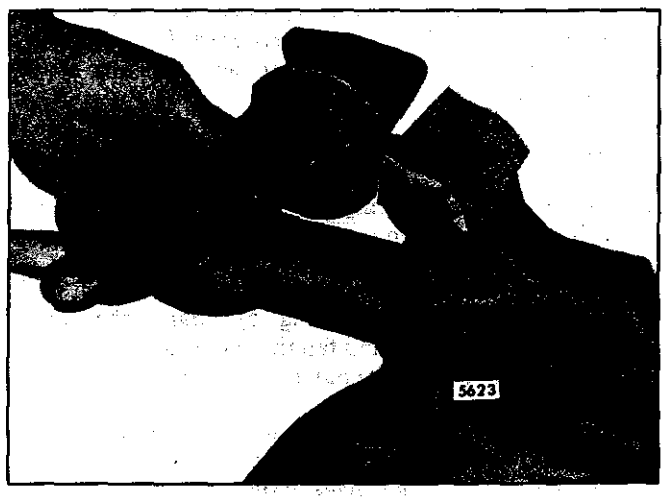


Fig. 5 – Removing Oil Seals Using Tool J 1508–13

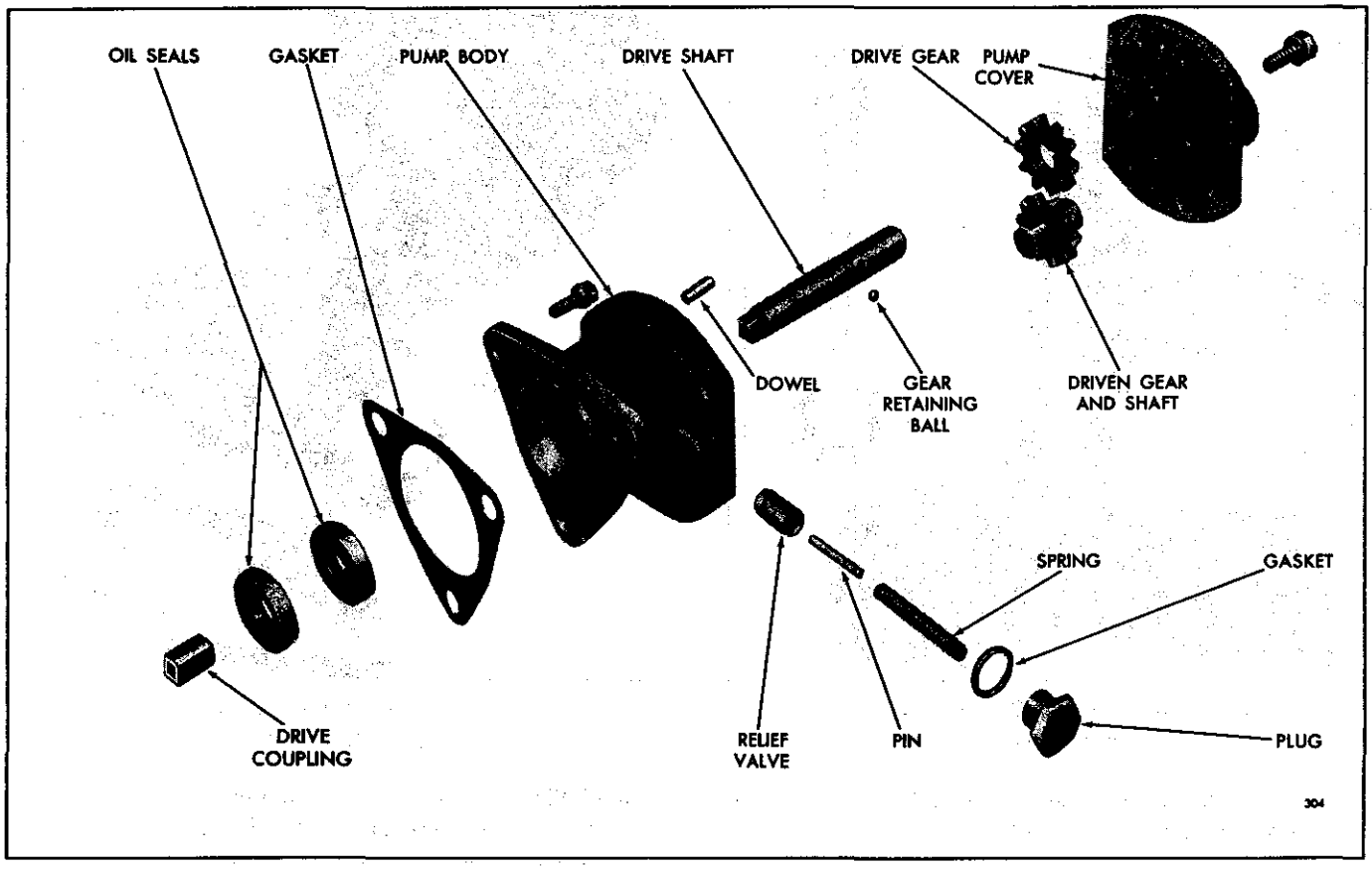


Fig. 6 – Fuel Pump Details and Relative Location of Parts (Right Hand Pump Shown)

5. Place the driven shaft and gear assembly in the pump body.

   NOTICE: The driven gear must be centered on the shaft to give proper end clearance. Also, the chamfered end of the gear teeth of the production gear must face the pump body. If a service replacement gear with a slot is used, the slot must face toward the pump cover.

6. Lubricate the gears and shafts with clean engine oil.

7. Apply a thin coat of quality sealant on the face of the pump cover outside of the gear pocket area.

   Then place the cover against the pump body with the two dowel pins in the cover entering the holes in the pump body. The cover can be installed in only one position over the two shafts.

   NOTICE: The coating of sealant must be extremely thin since the pump clearances have been set up on the basis of metal–to–metal contact. Too much sealant could increase the clearances and affect the efficiency of the pump. Use care that sealant is not squeezed into the gear compartment, otherwise damage to the gears and shafts may result.

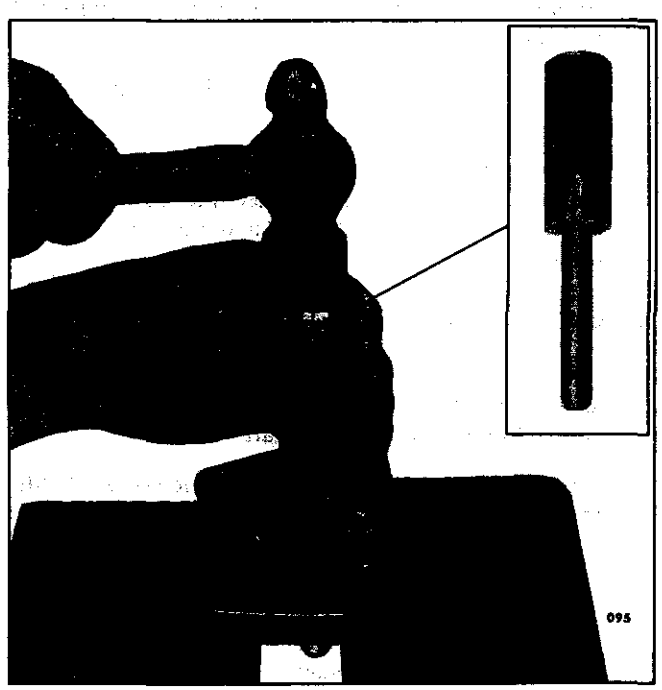


Fig. 7 – Installing Inner Oil Seal Using Tool J 1508–8

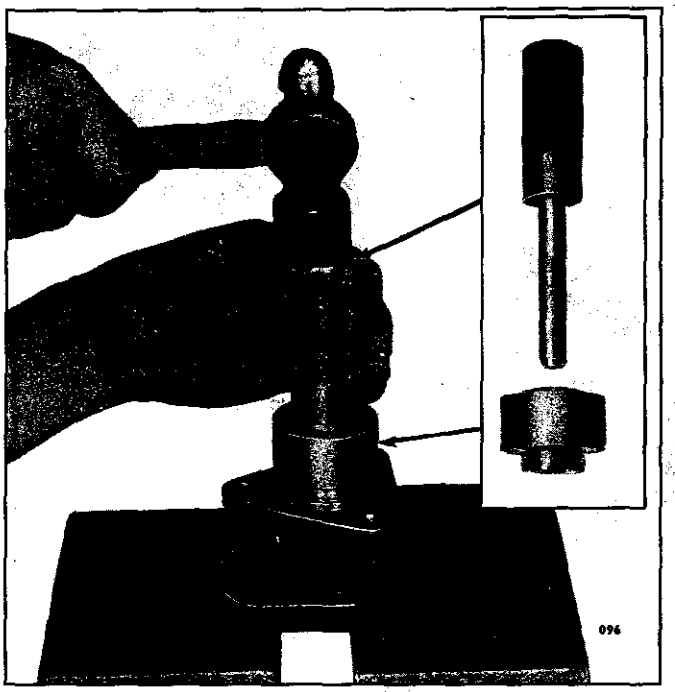


Fig. 8 – Installing Outer Oil Seal Using Tools J 1508–8 and J 1508–9

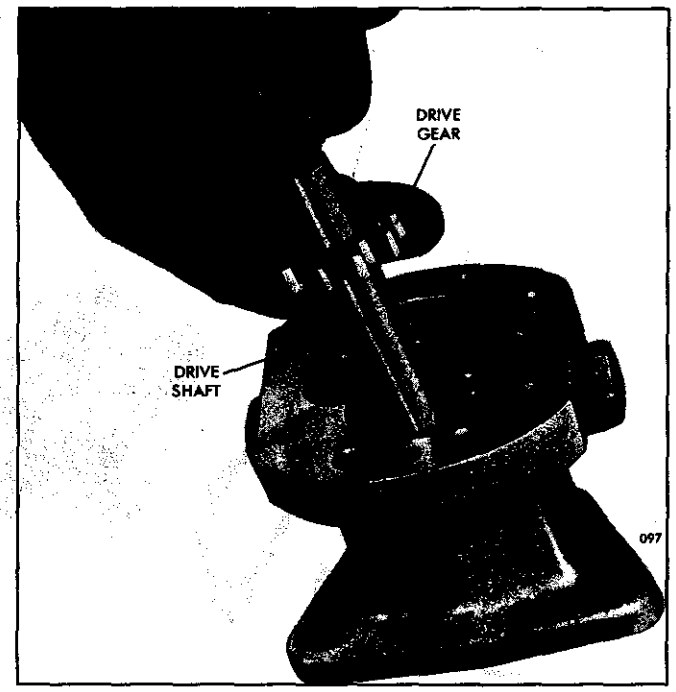


Fig. 9 – Installing Fuel Pump Drive Shaft and Gear Assembly

8. Secure the cover in place with eight bolts and lock washers, tightening the bolts alternately and evenly.

9. After assembly, rotate the pump shaft by hand to make certain that the parts rotate freely. If the shaft does not rotate freely, attempt to free it by tapping a corner of the pump.

10. Install 1/8" pipe plugs in the upper unused drain holes.

11. If the pump is not to be installed immediately, place plastic shipping plugs in the inlet and outlet openings to prevent dirt or other foreign material from entering the pump.

Install Fuel Pump

1. Affix a new gasket to the pump body mounting flange and locate the pump drive coupling over the square end of the fuel pump drive shaft.

2. Install the fuel pump on the engine and secure it with three nylon patch bolts.

   To provide improved sealing against leakage, nylon patch bolts are used in place of the former bolt and seal assemblies.

• 3. If removed, install the inlet and outlet elbows in the pump cover. Before installing, coat the threads lightly with Gasoila, Permatex 2, or an equivalent non–hardening sealant.

• **NOTICE:** Do not use Teflon tape or paste on fittings, since this can result in fuel pump cover damage (cracking) before the required torque is reached.

• To prevent sealant from entering the fuel system, do not apply it to the first two (2) threads of the fittings. Tighten fittings to the low end of the torque. If necessary, continue tightening until alignment is achieved, but do not exceed maximum torque. Tighten fittings to the following values:

Fitting Size	Torque
1/4"	14–16 lb-ft. (19–22 N·m)
3/8"	18–22 lb-ft. (24–30 N·m)
1/2"	20–25 lb-ft. (27–34 N·m)

4. Connect the inlet and outlet fuel lines to the fuel pump.

5. Connect the fuel pump drain tube, if used, to the pump body.

6. If the fuel pump is replaced or rebuilt, prime the fuel system before starting the engine using Primer J 5956. This will prevent the possibility of pump seizure upon initial starting.

FUEL PUMP DRIVE

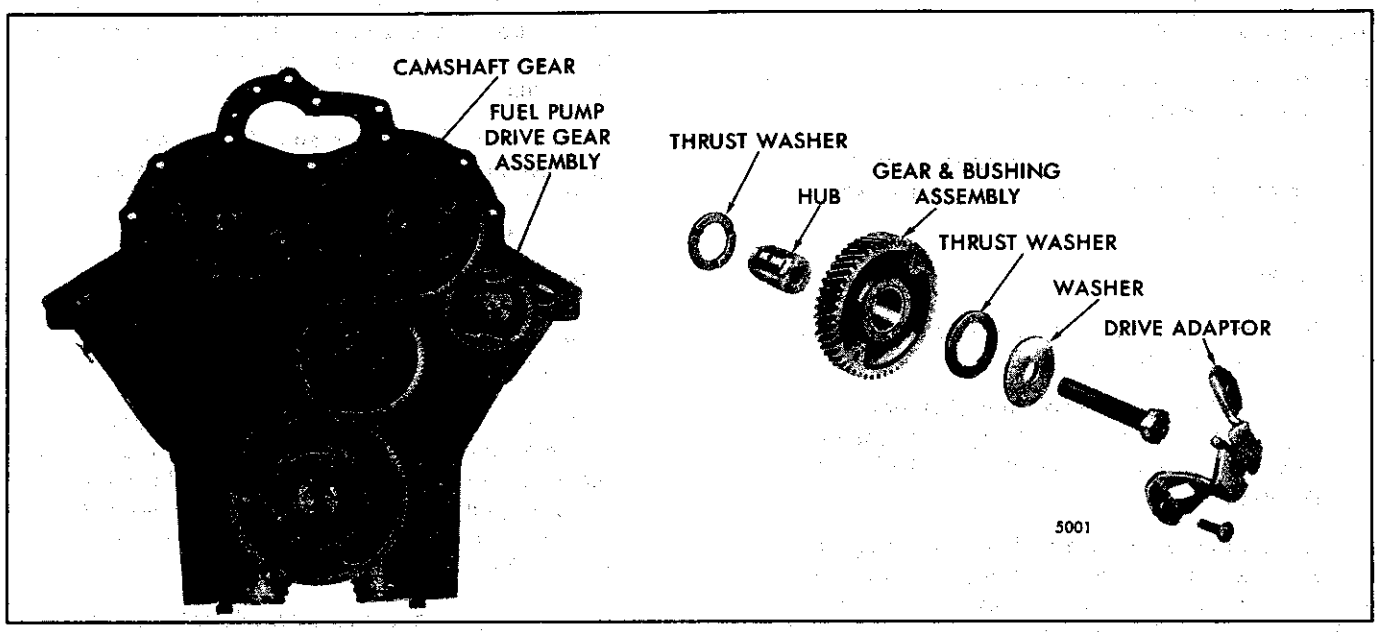


Fig. 1 – Typical Fuel Pump Drive Gear Mounting and Details (V–Type Engine)

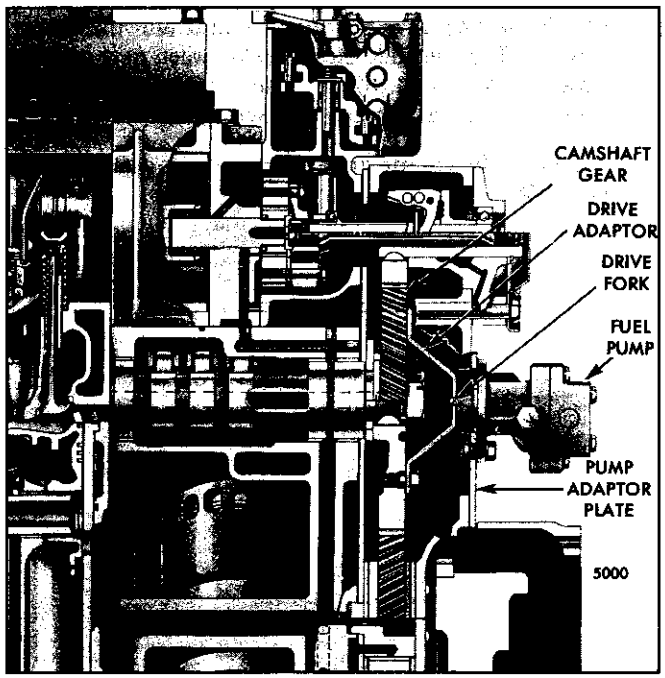


Fig. 2 – Camshaft Drive for Fuel Pump (6V Engine Shown)

On some V–type engines, the fuel pump is mounted on the flywheel housing and is driven by an accessory drive gear. The fuel pump drive consists of a gear, stationary hub and drive adaptor (Fig. 1). The fuel pump drive gear rotates on the stationary hub attached to the cylinder block and is driven at approximately twice the engine speed by the camshaft gear. On other V–type engines, the fuel pump may be driven by either camshaft by means of a drive fork and drive adaptor (Fig. 2), in the same manner as the pump mounted on the flywheel housing of the In–line engines.

The fuel pump on In–line engines is driven by the governor weight shaft by means of a drive coupling. On some engines, the fuel pump is mounted on an adaptor plate attached to the flywheel housing. A drive adaptor attached to the balance shaft gear registers with a drive fork on the fuel pump shaft to provide a drive for the pump. Servicing of the fuel pump and drive on an In–line engine is covered in Section 2.2; the following applies only to a V–type engine.

To reduce the level of engine noise in the Series 53 engines, the pitch and pressure angle of the gear train and accessory drive gears has been changed. Refer to Section 1.7.1.

Lubrication

The fuel pump drive gear bearing (bushing type) is pressure lubricated. Lubricating oil from the oil gallery in the cylinder block flows through a drilled passage in the block, around the gear retaining bolt, and through another drilled hole in the gear hub to the bearing.

Remove Fuel Pump Drive Gear (V–Type Engine)

With the flywheel housing removed, remove the fuel pump drive gear as follows:

1. Remove the bolts and detach the fuel pump drive adaptor from the gear.
2. Loosen the fuel pump drive gear retaining bolt and remove the bolt and washer, gear, thrust washers and hub from the engine.

Inspection

Wash the drive gear and its related parts 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 thrust washers, hub and drive gear bearing for wear or scoring. Parts which are excessively worn or scored must be replaced. A pre–finished drive gear bearing (bushing type) is available for service. A new bushing should be pressed in flush to .010" below the gear face (both sides). Examine the gear teeth and, if they are excessively worn, scored or pitted, replace the gear and bushing assembly.

Install Fuel Pump Drive Gear (V–Type Engine)

Install the fuel pump drive gear and its related parts on the engine as outlined below:

1. Lubricate the drive gear bearing, thrust washers and hub with engine oil.
2. Assemble the fuel pump drive gear and thrust washers on the hub. The oil grooves in the thrust washers *must face toward the gear.* Note the position of the oil hole in the hub.

   Do not mix the former and the current hardened gears on the same engine. Mixing the gears will result in the excessive gear wear and may lead to serious engine damage.

   - **NOTICE:** The hardened gears are used on 6V turbocharged automotive engines. This change became effective with engine serial number 6D–229616.
3. Install the hub and gear assembly on the engine with the small diameter of the hub entering the rear end plate and the counterbore in the cylinder block, and the fuel pump drive gear teeth in mesh with the camshaft gear teeth. The oil hole in the hub should be toward the bottom of the engine.
4. Secure the gear and hub assembly in place with the gear retaining bolt and washer. Tighten the 1/2"–13 bolt to 71–75 lb–ft (96–102 N·m) torque.
5. Check the clearance between the gear and the thrust washer. The specified clearance between new parts is between .005" and .018". The maximum clearance between used parts must not exceed .022".
6. Attach the fuel pump drive adaptor to the gear with the two bolts.

FUEL STRAINER AND FUEL FILTER

(BOLT–ON TYPE)

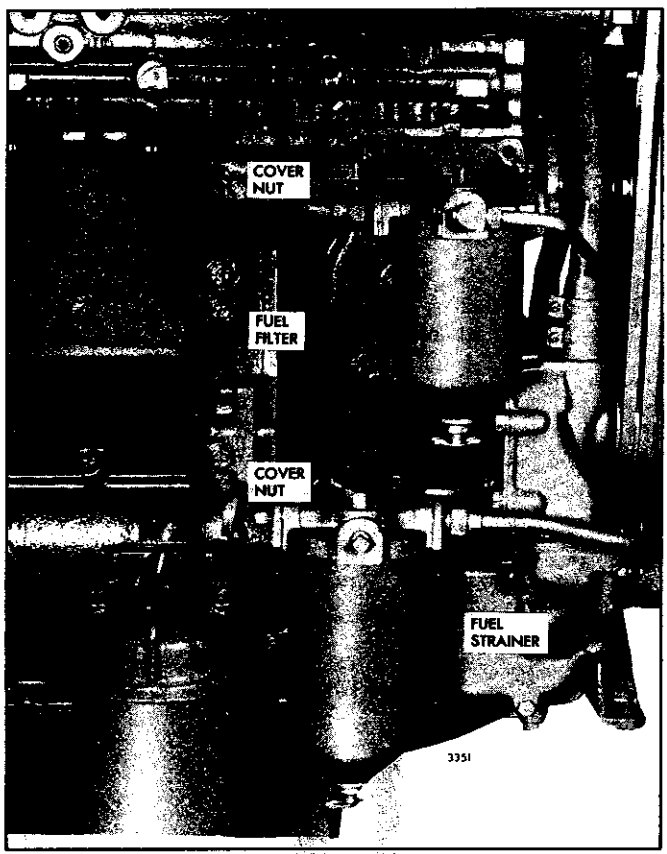


Fig. 1 – Typical Fuel Strainer and Fuel Filter Mounting

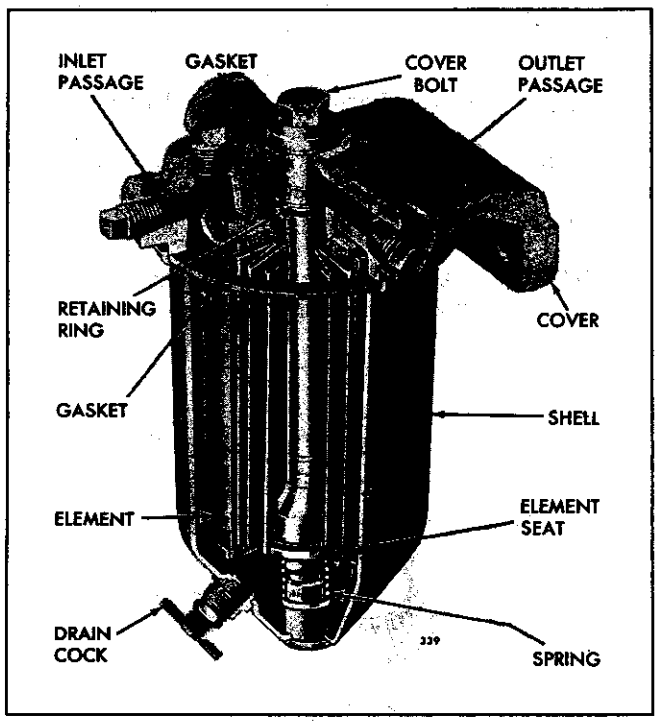


Fig. 2 – Fuel Filter Assembly

• A fuel strainer (primary) and fuel filter (secondary), Fig. 1, are used to remove impurities from the fuel. The fuel strainer is located between the fuel tank and the fuel pump. The replaceable density–type element is capable of filtering out particles of 30 microns (a micron is approximately .00004″). The fuel filter is installed between the fuel pump and the fuel inlet manifold. The replaceable paper–type (cellulose) element (Fig. 2) can remove particles as small as 10 microns. Fiberglass elements can remove particles as small as 5 microns.

> **NOTICE:** A fuel tank of galvanized steel should never be used for fuel storage, as the fuel oil reacts chemically with the zinc coating to form powdery flakes which quickly clog the fuel filter and cause damage to the fuel pump and the fuel injectors.

The fuel strainer and fuel filter are essentially the same in construction and operation, and they will be treated as one in this section.

The filter and strainer, illustrated in Figs. 3 and 4, consist basically of a shell, a cover, and a replaceable filtering element. The assembly is made oil tight by a shell gasket, a cover nut or bolt, and a cover nut or bolt gasket.

The central stud is a permanent part of the shell and, when the unit is assembled, extends up through the cover where the nut or bolt holds the assembly together.

A filter element sets over the central stud inside the shell and is centered in the shell by the stud.

The former and current cover assemblies are visibly different. The cast letter "P" (primary) has been added to the top of the strainer cover and the letter "S" (secondary) has been added to the top of the filter cover.

Operation

Since the fuel strainer is between the fuel supply tank and the fuel pump, it functions under suction. The fuel filter, placed between the fuel pump and the fuel inlet manifold in the cylinder head, operates under pressure. Fuel enters through the inlet passage in the cover and into the shell surrounding the filter element. Pressure or suction created by the pump causes the fuel to flow through the filter element where dirt particles are removed. Clean fuel flows to the

interior of the filter element, up through the central passage in the cover and into the outlet passage, then to the fuel inlet manifold in the cylinder head.

If engine operation is erratic, indicating shortage of fuel or flow obstructions, refer to *Troubleshooting* in Section 15.2 for corrective measures.

Replace Fuel Strainer Or Filter Element

The procedure for replacing an element is the same for the fuel strainer or fuel filter. Refer to Figs. 3 and 4 and replace the element as follows:

NOTICE: Only filter elements designed for fuel oil filtration should be used to filter the fuel.

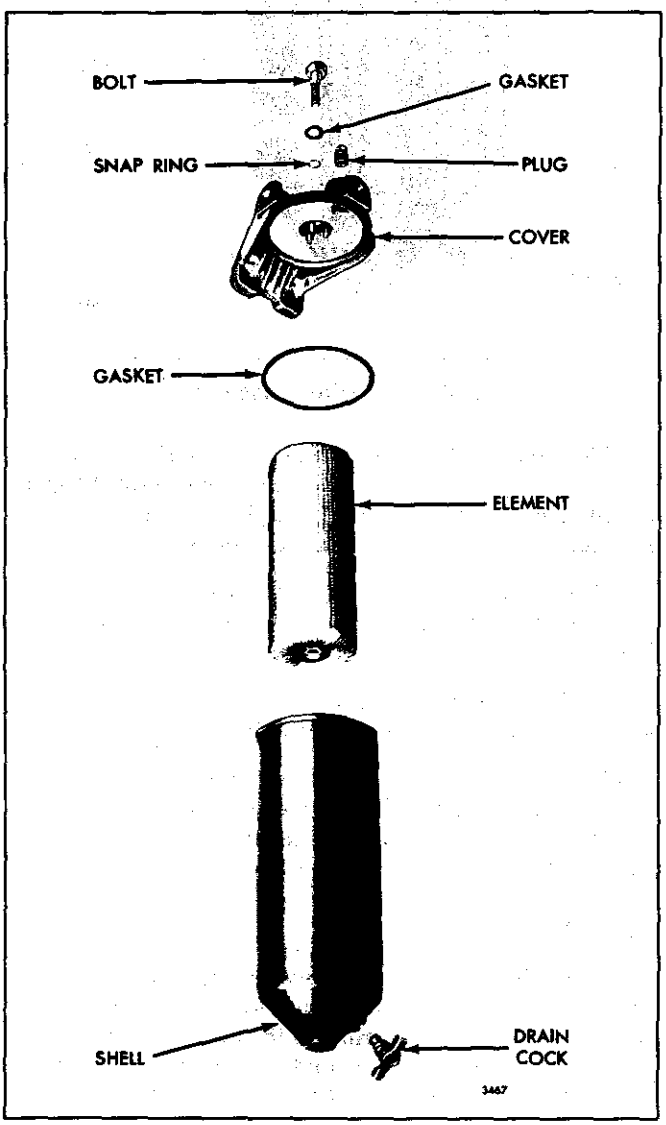


Fig. 3 – Fuel Strainer Details and Relative Location of Parts

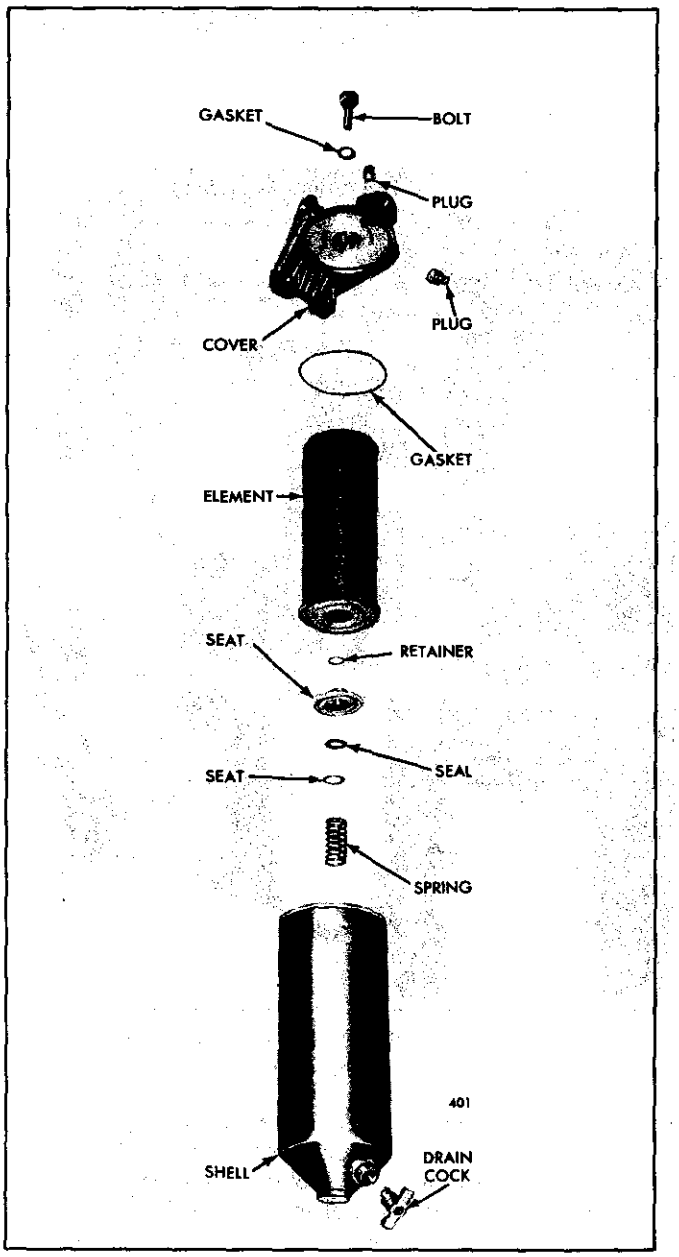


Fig. 4 – Fuel Filter Details and Relative Location of Parts

1. With the engine stopped, place a container under the strainer or filter and open the drain cock. Loosen the cover nut or bolt just enough to allow the fuel oil to drain out freely. Then close the drain cock.

   NOTICE: The wiring harness, starting motor or other electrical equipment must be shielded during the filter change, since fuel oil can permanently damage the electrical insulation.

2. While supporting the shell, unscrew the cover nut or bolt and remove the shell and element. Also remove and discard the cover nut retaining ring, if used.

3. Remove and discard the filter element and shell gasket, the cover nut or bolt gasket, and, if used, the cover bolt snap ring.

   Current strainers and filters do not incorporate the cover bolt snap ring. This was eliminated to facilitate replacement of the bolt gasket with each element replacement.

4. Wash the shell thoroughly with clean 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.

5. Examine the element seat and the retaining ring to make sure they have not slipped out of place. Check the spring by pressing on the element seat. When released, the seat must return against the retaining ring.

   The element seat, spring, washer and seal can not be removed from the strainer shell. If necessary, the shell assembly must be replaced. However, the components of the filter shell are serviced. Examine the filter retainer seal for cracks or hardening. If necessary, replace the seal.

   The current strainer and filter elements include the element, the cover gasket and cover bolt gasket. The strainer element also includes both the former and current bolt gaskets.

6. Place a new element over the center stud and push it down against the element seat. Make sure the drain cock is closed, then fill the shell about two–thirds full with clean fuel oil.

   Thoroughly soak the density–type *strainer* element in clean fuel oil before installing it. This will expel any air entrapped in the element and is conducive to a faster initial start.

7. Place a new shell gasket in the recess of the shell; also place a new gasket on the cover nut or bolt.

8. Place the shell and element in position under the cover. Then thread the cover bolt (or nut) in the center stud.

9. With the shell and the gasket properly positioned, tighten the cover bolt or nut just enough to prevent fuel leakage.

10. Remove the pipe plug at the top of the cover and complete filling of the shell with fuel. Fuel system primer J 5956 may be used to prime the entire fuel system.

11. Start the engine and check the fuel system for leaks.

FUEL STRAINER AND FUEL FILTER

(SPIN–ON TYPE)

A spin–on type fuel strainer and fuel filter (Fig. 5) is used on certain engines. The spin–on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly (Fig. 6). No separate springs or seats are required to support the filters.

- Replaceable paper type (cellulose) elements can remove particles as small as 10 microns. Fiberglass elements can remove particles as small as 5 microns.

The filter covers incorporate a threaded sleeve to accept the spin–on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin–on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

Filter Replacement

A 1" diameter twelve–point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows:

1. Unscrew the filter (or strainer) and discard it.

2. Fill a new filter replacement cartridge about two–thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

3. Install the new filter assembly and tighten it to one–half of a turn beyond gasket contact.

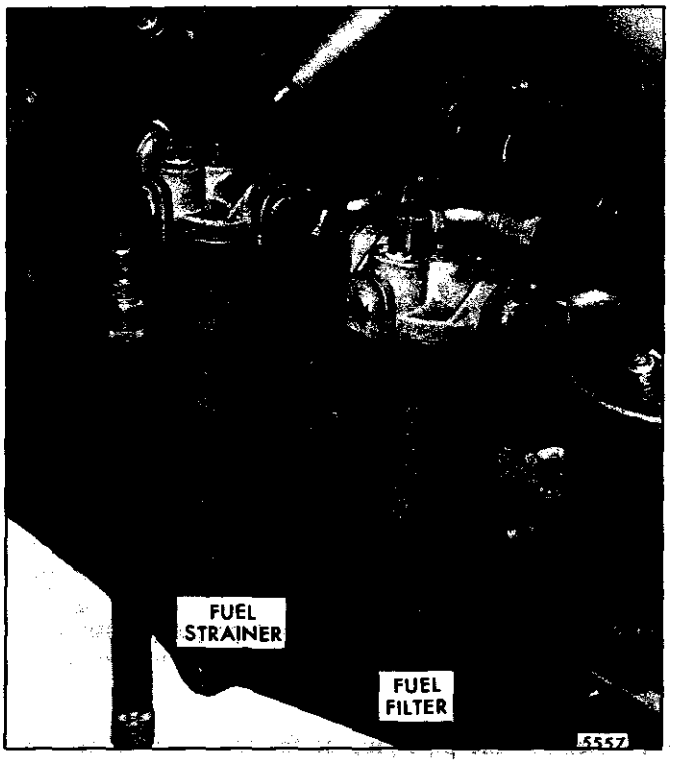


Fig. 5 – Typical Spin–On Filter Mounting

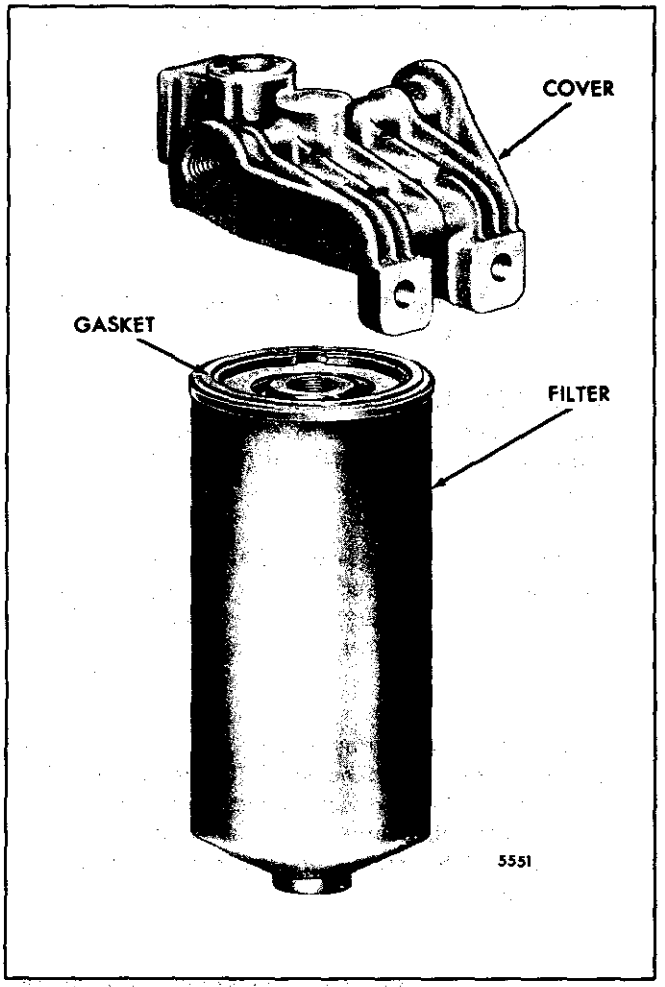


Fig. 6 – Spin–On Filter Details

FUEL COOLER (V Engines)

A fuel cooler may be mounted in the raw water system, between the heat exchanger and the raw water pump, so that the fuel leaving the engine is cooled before it returns to the fuel tank.

Fuel continually cycling through an engine causes the fuel in the tank to become heated after extended operation. Excessive fuel temperatures can affect engine operation. An increase in the fuel inlet temperature above 90°F (32°C) will result in a brake horsepower loss of approximately 2% per 20°F (11°C) increment fuel temperature increase.

Remove Fuel Cooler

1. Disconnect the flexible hoses at the fuel cooler.

2. Loosen the hose clamps and slide the hoses back on the raw water pump tubes.

Clean Fuel Cooler

Clean the oil side of the cooler core first, then immerse it in the following solution: Add 1/2 pound of oxalic acid to each 2–1/2 gallons (9.5 liters) of a solution composed of 1/3 muriatic acid and 2/3 water. The cleaning action is evident by the bubbling and foaming.

Watch the process carefully. When bubbling stops (this usually takes from 30 to 60 seconds), remove the core from the cleaning solution and thoroughly flush it with clean, hot water. After cleaning, dip the core in light oil.

Pressure Test Fuel Cooler

After the fuel cooler has been cleaned, check it for leaks by plugging one of the fuel openings with a 1/4" pipe plug and attaching an air hose to the other opening. Apply approximately 100 psi (689 kPa) air pressure and submerge the cooler in a container of heated water (180°F or 82°C). A leak will be indicated by air bubbles in the water. If leaks are indicated, replace the cooler.

- **CAUTION: To avoid personal injury when making this pressure test, be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of the cooler core.**

Install Fuel Cooler

Reverse the procedure for removing the fuel cooler.

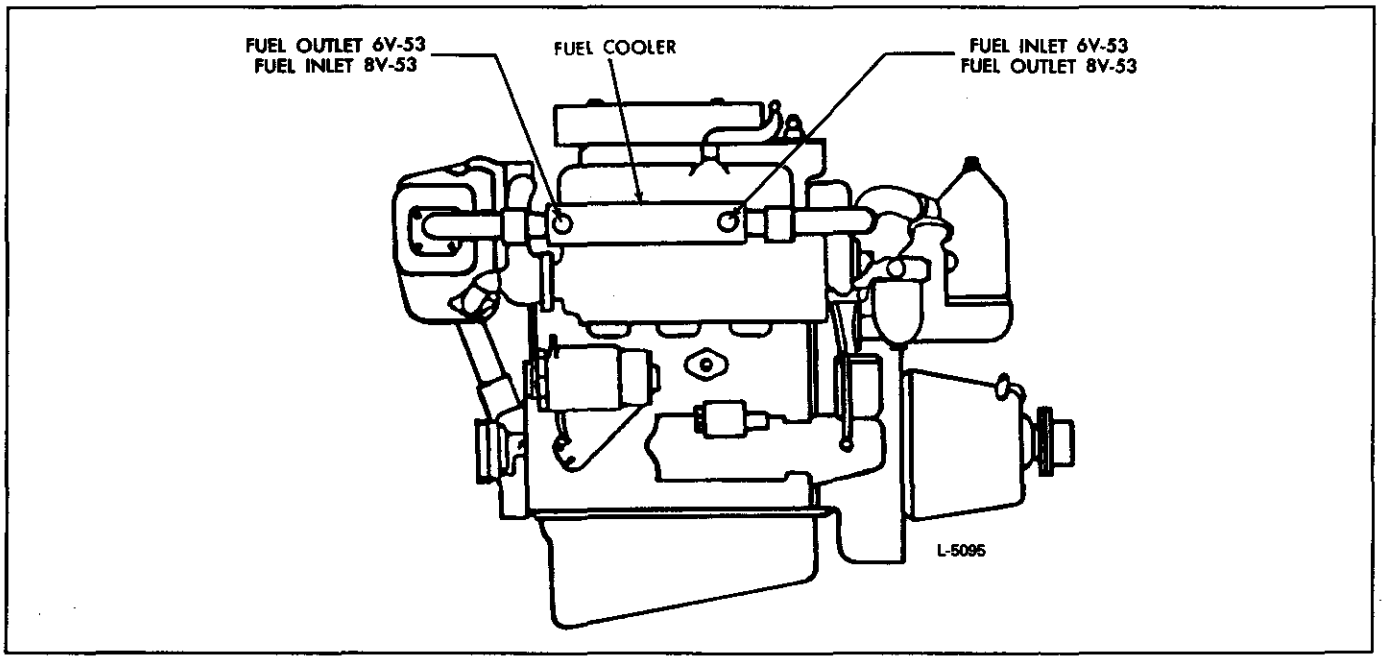


Fig. 1 – Fuel Cooler Mounting (V Engines)

MECHANICAL GOVERNORS

Horsepower requirements on an engine may vary due to fluctuating loads. Therefore, some method must be provided to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. To accomplish this control, a governor is introduced in the linkage between the throttle control and the fuel injectors. The following types of mechanical governors are used:

1. Limiting Speed Mechanical Governor.

2. Variable Speed Mechanical Governor.

Engines requiring a minimum and maximum speed control, together with manually controlled intermediate speeds, are equipped with a limiting speed mechanical governor.

Engines subjected to varying load conditions that require an automatic fuel compensation to maintain a near constant engine speed, which may be changed manually by the operator, are equipped with a variable speed mechanical governor. However, a variable speed governor cannot be used on an engine equipped with an Allison vehicle transmission. Each type of governor has an identification plate located on the control housing, containing the governor assembly number, type, idle speed range and drive ratio. The maximum engine speed, not shown on the identification plate, is stamped on the option plate attached to the valve rocker cover.

Check Governor Operation

Governor difficulties are usually indicated by speed variations of the engine. However, it does not necessarily mean that all such speed fluctuations are caused by the governor. Therefore, when improper speed variations are present, check the engine as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.

2. Check the engine to be sure that all of the cylinders are firing properly (refer to Section 15.2). If any cylinder is not firing properly, remove the injector, test it and, if necessary, recondition it as outlined in Section 2.1 or 2.1.1.

3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube.

With the fuel rod connected to the injector control tube lever, the mechanism should be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, it may be located and corrected as follows:

1. If an injector rack sticks or moves too hard, it may be due to the injector hold–down clamp being too tight or improperly positioned. To correct this condition, loosen the injector clamp, reposition it and tighten the clamp bolt to 20–25 lb–ft (27–34 N·m) torque.

2. An injector which is not functioning properly may have a defective plunger and bushing or a bent injector rack. Recondition a faulty injector as outlined in Section 2.1 or 2.1.1.

3. An injector rack may bind as the result of an improperly positioned rack control lever. Loosen the rack control lever adjusting screws. If this relieves the bind, relocate the lever on the control tube and position the rack as outlined in Section 14.

4. The injector control tube may bind in its support brackets, thus preventing free movement of the injector racks to their no–fuel position due to tension of the return spring. This condition may be corrected by loosening and realigning the control tube supporting brackets. If the control tube support brackets were loosened, realigned and tightened, the injector racks must be repositioned as outlined in Section 14.

5. A bent injector control tube return spring may cause friction in the operation of the injector control tube. If the spring has been bent or otherwise distorted, install a new spring.

6. Check for bind at the pin which connects the fuel rod to the injector control tube lever; replace the pin, if necessary.

If, after making these checks, the governor fails to control the engine properly, remove and recondition the governor.

LIMITING SPEED MECHANICAL GOVERNOR

In–Line Engine

The limiting speed mechanical governor performs the following functions (Fig. 1):

1. Controls the engine idle speed.
2. Limits the maximum operating speed of the engine.

The mechanical engine governors are identified by a name plate attached to the governor housing. The letters D.W.–L.S. stamped on the name plate denote a double–weight limiting speed governor.

The governor is mounted on the rear end plate of the engine and is driven by a gear that extends through the end plate and meshes with either the camshaft gear or the balance shaft gear, depending upon the engine model.

Operation

The governor holds the injector racks in the advanced fuel position for starting when the throttle control lever is in the idle position. Immediately after starting, the governor moves the injector racks to the position required for idling.

The centrifugal force of the revolving governor low and high speed weights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever. One end of this lever operates against the high and low speed springs through the spring cap, while the other end provides a moving fulcrum on which the differential lever pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the speed control lever.

In the low speed range, the centrifugal force of the low and high speed weights together operate against the low speed spring. As the engine speed increases, the centrifugal force of the low and high speed weights together compresses the low speed spring until the low speed weights are against their stops, thus limiting their travel, at which time the low speed spring is fully compressed and the low speed spring cap is within .0015" of the high speed spring plunger.

Throughout the intermediate speed range the operator has complete control of the engine because the low speed gap is closed and the low speed weights are against their stops, and the high speed weights are not exerting enough force to overcome the high speed spring. As the speed continues to increase, the centrifugal force of the high speed weights increases until this force can overcome the high speed spring and the governor again takes control of the engine, limiting the maximum engine speed.

A fuel rod, connected to the differential lever and the injector control tube lever, provides a means for the governor to change the fuel settings of the injector rack control levers.

The engine idle speed is determined by the force exerted by the governor low speed spring. When the governor speed control lever is placed in the idle position, the engine will operate at the speed where the force exerted by the governor low speed weights will equal the force exerted by the governor low speed spring.

Adjustment of the engine idle speed is accomplished by changing the force on the low speed spring by means of the idle speed adjusting screw. Refer to the tune–up section for idle speed adjustment.

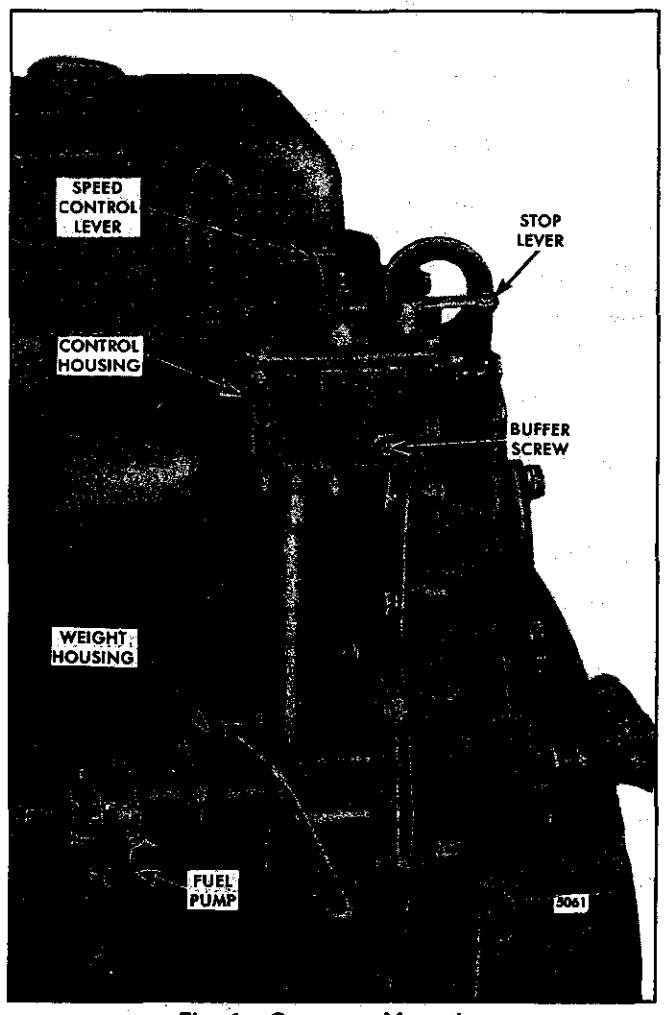


Fig. 1 – Governor Mounting

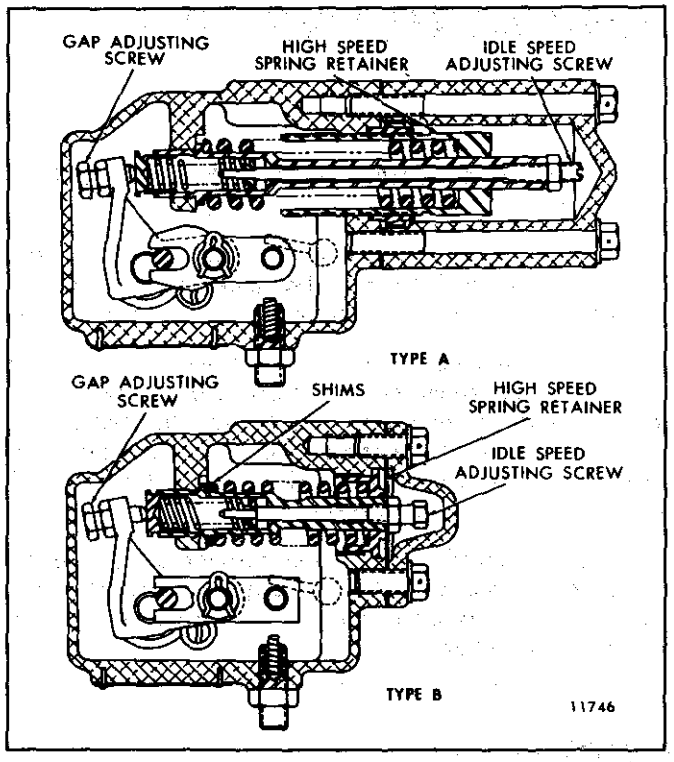


Fig. 2 – Differences Between Industrial and Vehicle Type Governor Assemblies

The engine maximum no–load speed is determined by the force exerted by the high speed spring. When the throttle control lever is placed in the maximum speed position, the engine will operate at a speed where the force exerted by the governor high speed weights will equal the force exerted by the governor high speed spring.

Adjustment of the maximum no–load speed is accomplished by changing the tension on the high speed spring. Refer to the tune–up section for the maximum no–load speed adjustment.

Lubrication

The governor is lubricated by oil splash from the engine gear train and by a pressure line on current engine models. The oil passes through the governor weight housing on to the shaft and weight assemblies. The oil is distributed to the various moving parts within the governor by the revolving weights. Surplus oil drains from the governor through holes in the governor bearing retainer back to the engine gear train.

Remove Governor from Engine

Before removing the governor from the engine, the operation should be checked as outlined in Section 2.7. If the governor fails to control the engine properly after performing these checks, remove and recondition it.

1. Disconnect the linkage to the governor control levers.
2. Remove the governor cover and gasket.
3. Detach the spring housing from the governor housing by removing the two bolts and lock washers.
4. Loosen the high speed spring retainer locknut with spanner wrench J 5895 and remove the spring assembly (Fig. 2).
5. Loosen the fuel rod cover hose clamps.
6. Clean and remove the rocker cover from the cylinder head.
7. Disconnect the fuel rod from the injector control tube lever. Remove the clip that holds the fuel rod to the differential lever and lift the fuel rod from the lever.
8. Detach the fuel pump by disconnecting the fuel lines and removing the three bolts. Also, disconnect the lubricating oil line, if used.
9. Remove the five bolts from the governor weight housing and the two bolts from the governor control housing.
10. Detach the governor and gasket from the engine.

Disassemble Governor Cover

1. Remove the return spring and clip from a single lever cover only, then loosen the governor speed control lever retaining bolt and lift the control lever from the speed control shaft (Fig. 3).
2. Remove the retaining ring and washer. Withdraw the speed control shaft from the cover.
3. Remove the seal ring from the cover. The single lever cover has the seal ring at the top of the cover. The double lever cover has the seal ring at the bottom of the cover.
4. Loosen the governor stop lever retaining bolt and lift the lever from the stop lever shaft.
5. Remove the retaining ring and washers and withdraw the stop lever shaft from the cover.
6. Remove the seal ring from the top of the cover.

Disassemble Governor Weight Housing

1. Remove the gear retaining nut from the shaft, then remove the gear, key and spacer from the shaft.
2. Remove the small screw holding the bearing retainer in place.
3. Turn the bearing support until the large opening is centered over the fork on the operating shaft.

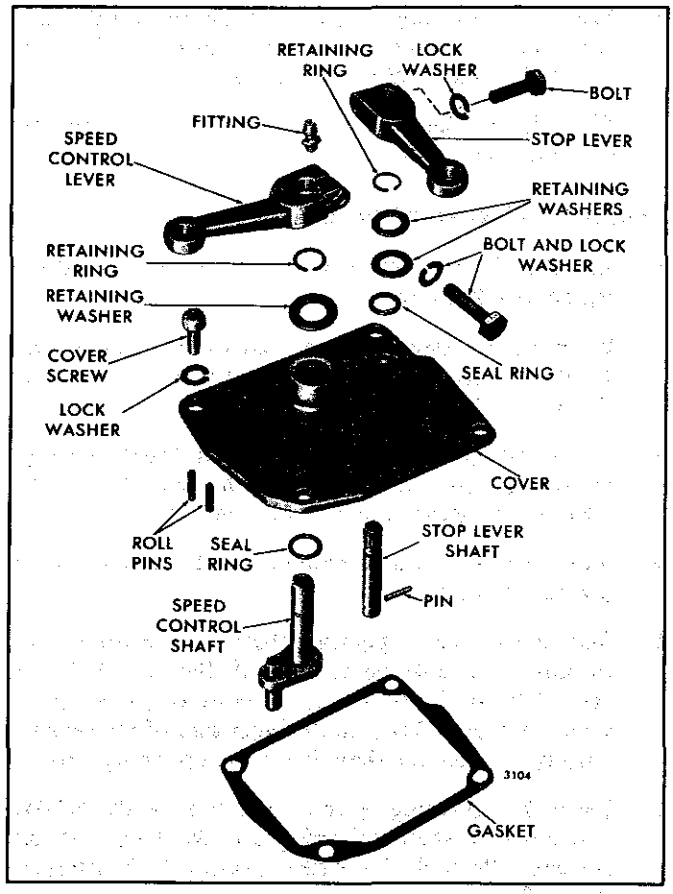


Fig.3 – Governor Cover Details and Relative Location of Parts

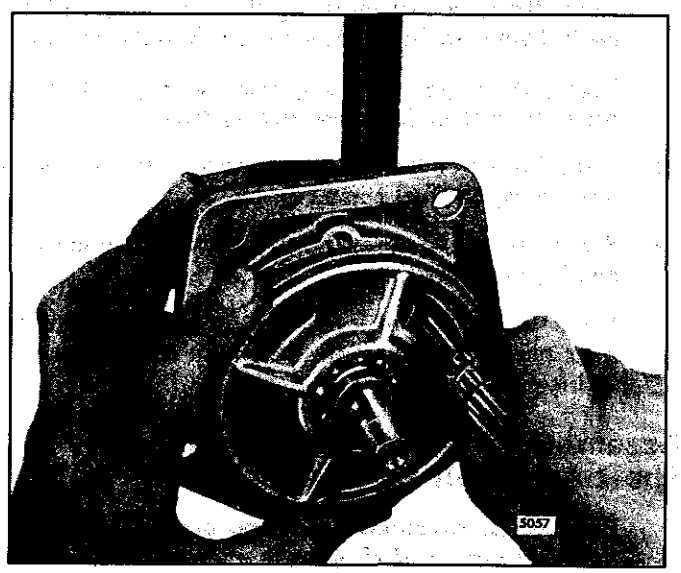


Fig. 4 – Removing Fork from Operating Shaft

4. Lift up on the weight shaft until there is enough clearance for a 5/16" socket wrench to be placed on the screws that hold the fork to the operating shaft (Fig. 4). Then remove the two screws and washers.
5. Lift the shaft and weight assembly out of the governor weight housing.
6. Remove the screw and washers holding the bearing in the control housing and lift the shaft assembly out of the housing.
7. Place a rod approximately 18" long through the control housing and knock the plug out of the bottom of the weight housing.
8. Remove the snap ring and press the bearing from the weight housing.
9. Remove the spring clip and washer from the governor operating shaft lever and remove the governor differential lever.
10. Press the bearing and operating shaft lever from the operating shaft, if necessary.
11. If necessary, disassemble the control housing from the weight housing.

Disassemble Weight Shaft Assembly

1. Press the bearing retainer from the weight shaft.
2. If necessary, remove the snap ring and press the bearing from the bearing retainer.
3. Remove the weight pin retainers from the governor weight pins, then drive the pins out of the carrier and weights. *Drive the pins out of the carrier from the weight pin retainer end.*

   Remove the governor weights. Punch mark the carrier at the retainer end of the weight pins so the pins may be placed in the proper position when reinstalling the weights in the carrier.
4. Slide the riser and bearing assembly from the shaft. Do not disassemble the bearing since the riser and bearing are serviced only as an assembly.

Inspection

Immerse all of the governor parts in a suitable cleaning fluid to loosen and remove all foreign material. Use a bristle brush and compressed air as necessary to ensure cleanliness of all parts.

- **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. Replace the bearings if rough or tight spots are detected.

The lower governor drive components have been revised to reduce the clearance between the riser and the

weight shaft. With this change, additional lubrication is provided to the governor by an oil line connected between the oil gallery in the cylinder block and the governor weight housing. When replacing the riser assembly, shaft and carrier assemblly, or the complete governor assembly, the new oil line must be installed to provide adequate lubrication.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion. If any of these conditions exist, install a new riser and bearing assembly. Examine the weight carrier pins for wear and replace them if necessary.

Inspect the weight carrier, weights and retaining pins for wear. The current single–weight carrier replaces the former double–weight carrier.

Inspect the fuel pump drive end of the weight shaft. Replace the shaft if the end is worn or rounded.

Inspect the bushing in the weight housing. Replace the bushing if it is worn excessively.

Inspect the spring seats, plungers, adjusting screws, lock nuts and other parts of the control housing for defects that might affect governor operation.

Assemble Governor Cover

New mechanical governor cover assemblies with serrated shafts are being used on In–line 53 engines.

The limiting speed governor cover assemblies include a new, longer 7/16" diameter speed control shaft and a new 3/8" diameter serrated stop lever shaft (Fig. 3). The serrations on the shafts ensure positive clamping between the serrated levers and the shafts and prevent any slippage. Four serrations on the stop lever shaft of the limiting speed governor are eliminated. This allows certain customers to design a mating lever with missing serrations which will provide a *fixed position* for particular requirements. Levers with missing serrations are not provided. The former and new cover and shaft assemblies are interchangeable on a governor, and only the new assemblies will be serviced. Since the new serrated shafts can be used with the former covers, only the new serrated shafts will be serviced.

1. Place a new seal ring in the counterbore of the cover (Fig. 2). The single lever cover has the seal ring at the top of the cover. The double lever cover has the seal ring at the bottom of the cover.
2. Lubricate the speed control shaft with engine oil, then slide the shaft through the cover. Install the washer and retaining ring on the shaft.
3. Place the speed control lever over the shaft and secure it with the bolt and lock washer.
4. On double lever covers, lubricate the stop lever shaft with engine oil, then slide the shaft through the cover.
5. Place the seal ring in the counterbore of the shaft opening, then install the washers over the shaft. Lock the shaft in place with the retaining ring.
6. Place the stop lever on the shaft and secure it with the bolt and lock washer.

Assemble Control Housing

1. Install a 1/8" pipe plug in the tapped hole in the side of the control housing.
2. If necessary, assemble the control housing to the weight housing, using a good quality sealant between the tube and the housings.
3. Install the governor operating shaft lower bearing, numbered side out, in the weight housing. Install the snap ring to secure the bearing (Fig. 5).
4. Apply a quality sealant around the edge of a new plug and tap it in place.
5. Start the governor operating shaft upper bearing over the upper end of the operating shaft. Support the lower end of the shaft on the bed of an arbor press. Use a sleeve and press down on the inner race of the bearing until it contacts the shoulder of the operating shaft.
6. Place the operating lever on the shaft with the flat surface on the shaft registering with the flat surface on the lever. Press the lever tight against the bearing on the shaft.
7. Lubricate both bearings with engine lubricating oil. Insert the lever and operating shaft assembly in the control housing. Guide the lower end into the bearing.
8. Secure the upper operating shaft bearing with the round head retaining screw and washers.
9. Place the fork on the operating shaft with the two cam faces facing the fuel pump.
10. Secure the fork to the operating shaft with two screws and lock washers.
11. Place the differential lever over the operating shaft lever pin and secure it in place with a washer and spring pin.

Assemble Governor Weight and Shaft Assembly

1. If the carrier was removed from the weight shaft, press the carrier on the shaft so as to allow a clearance of .001" to .006" between the shaft shoulder and the rear face of the carrier.
2. Press the governor weight shaft bearing into the bearing retainer by pressing on the outer race of the bearing (Fig. 6).

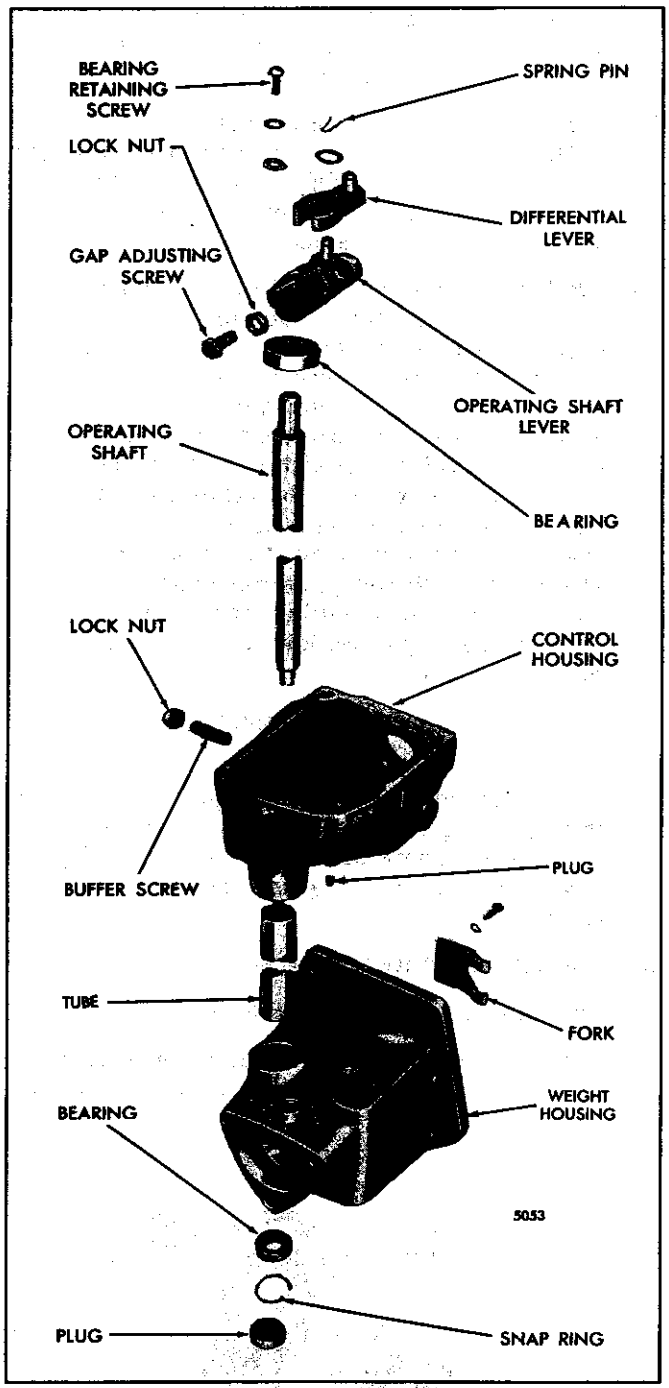


Fig. 5 – Governor Housings and Relative Location of Parts

3. Install the snap ring in the retainer with the flat side of the ring facing the bearing.

4. Press the bearing retainer on the weight shaft until the bearing is against the shoulder on the shaft.

NOTICE: To prevent any damage, press only on the inner race of the bearing.

5. Place the riser on the weight shaft.

6. Position the low speed weights, identified by the short cam arm and three center laminations, each approximately 9/64" thick, on the weight carrier. Drive the weight pins in place and install the weight pin retainers.

7. Install the high speed weights in the same way. The high speed weights are identified by the long cam arm and three center laminations; the middle lamination is 3/16" thick and the outer ones are 1/8" thick.

The weight pins must be reinstalled in the same positions from which they were removed.

8. Slide the shaft and weight assembly into the weight housing with the riser bearing placed behind the fork.

9. Turn the bearing retainer until the large opening is over the fork on the operating shaft. Tighten the two screws holding the fork to the operating shaft with a 5/16" socket wrench.

10. Turn the bearing retainer until the counterbored hole in the retainer and housing line up. Install the screw to secure the bearing retainer to the weight housing.

11. Place the drive gear spacer on the shaft. Install the key in the keyway and place the gear on the shaft.

12. Tap the gear until the spacer is against the bearing. Install the drive gear retaining nut and tighten it to 125–135 lb–ft (170–183 N·m) torque.

13. Check the backlash between the governor drive gear and the camshaft or balance shaft gear. The backlash should be .0030" to .0050" between new gears and should not exceed .0070" between used gears. If necessary, loosen and readjust the rear end plate to bring gear lash within specifications.

Install Governor

Refer to Fig. 1 and install the governor on the engine as follows:

1. Attach the fuel rod to the differential lever and secure it in place with a washer and spring pin.

2. Attach a new gasket to the governor weight housing.

3. Insert the end of the fuel rod through the hose and clamps and into the opening in the cylinder head and position the governor weight housing against the engine rear end plate; the teeth on the governor drive gear must mesh with the teeth on the camshaft gear or balance shaft gear. Refer to Section 1.0 for allowable backlash.

4. Install the three 12–point head bolts with copper washers in the governor weight housing next to the

cylinder block. Install the two remaining bolts with steel washers and lock washers. Tighten the bolts to 35 lb–ft (47 N·m) torque.

5. Install the two governor control housing attaching bolts and lock washers. Tighten the bolts to 10–12 lb–ft (14–16 N·m) torque.

6. On current engines, install the lubricating oil line and fittings to the weight housing and the cylinder block.

7. Align and tighten the hose clamps on the fuel rod covers.

8. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

9. Assemble the industrial governor spring mechanism as follows:

   a. Thread the spring retainer locknut on the retainer.

   b. Thread the idle speed adjusting screw on the governor spring plunger.

   c. Place the high speed spring over the governor spring plunger.

   d. Lubricate and install the spring plunger assembly in the spring retainer and secure it with a locknut so that approximately 1/4" of the idle speed adjusting screw extends beyond the nut.

   e. Lubricate and insert the spring seat, low speed spring and the spring cap in the open end of the spring plunger.

10. Thread the spring retainer and spring assembly into the governor housing and tighten the locknut finger tight until an engine tune–up is performed.

11. Assemble the vehicle governor spring mechanism as follows:

   a. Back off the locknut at the outer end of the adjusting screw to within 1/16" of the slotted end of the screw.

   b. Slip the shims, if used, and the high speed spring over the plunger. Position the retainer over the high speed spring and insert the adjusting screw into the plunger.

   c. Position the seat and cap on the ends of the low speed spring and insert the assembly into the hollow end of the plunger.

   d. Insert the spring and plunger assembly into the control housing and tighten the retainer nut with spanner wrench J 5895.

12. Thread the spring retainer and spring assembly into the governor; the locknut should be finger tight until an engine tune–up is performed.

13. Use a new gasket when installing the governor cover and lever assembly. Be sure the speed control shaft pin engages the slot in the differential lever and the stop lever is in the correct position. Secure the cover with four screws and lock washers.

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

14. Install the return spring and spring clip (single lever cover only).

15. Add all purpose grease to the speed control shaft through the grease fitting on top of the shaft. *At temperatures above 30°F (1°C) use a No. 2 grade grease and a No. 1 grade grease below this temperature.*

16. Connect the linkage to the governor control levers.

17. Install the fuel pump and fuel lines.

18. Perform an engine tune–up as outlined in Section 14.

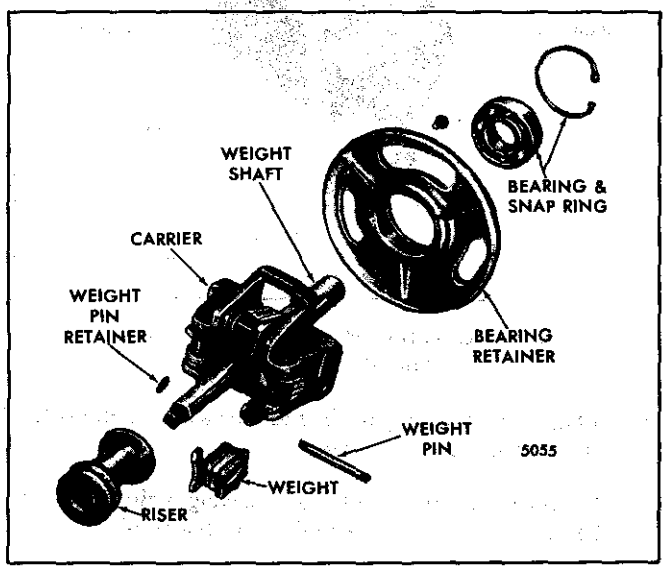


Fig. 6 – Governor Weight Details and Relative Location of Parts

LIMITING SPEED MECHANICAL GOVERNOR

6V Engine

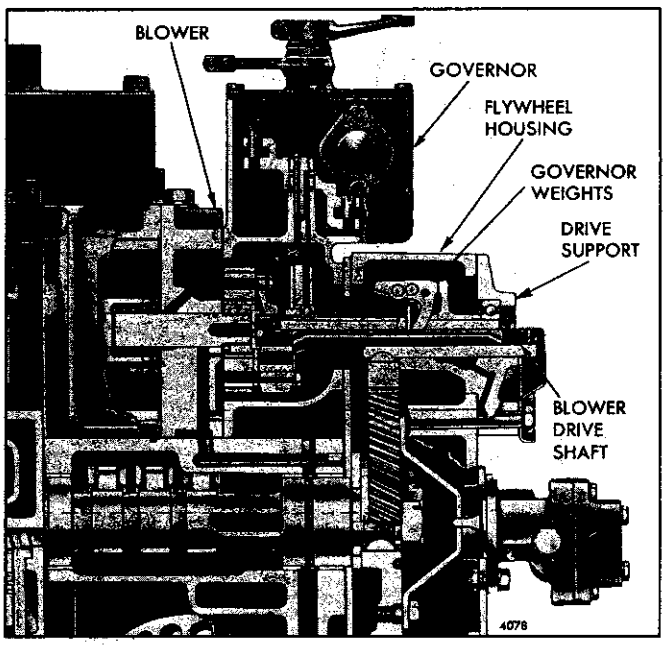


Fig. 1 – Limiting Speed Governor and Drive on 6V–53 Engine

The limiting speed mechanical governor, illustrated in Fig. 1, performs the following functions:

1. Controls the engine idle speed.
2. Limits the maximum operating speed of the engine.

The double–weight governor, identified by the letters D.W.–L.S. stamped on the governor name plate, is mounted between the engine blower and the flywheel housing (Fig. 2). One end of the governor weight shaft is splined to a drive plate attached to the driven blower timing gear to provide a means of driving the governor. The other end of the shaft is supported by a bearing in the blower drive support (Fig. 1).

The governor consists of four basic subassemblies: a cover and lever assembly, governor housing, spring housing, and a weight and shaft assembly.

Operation

Two manual controls are provided on the governor: a stop lever and a speed control lever. In the RUN position, the stop lever holds the fuel injector racks near the *full–fuel* position. When the engine is started, the governor moves the injector racks toward the idle speed position. The engine speed is then controlled manually by moving the speed control lever.

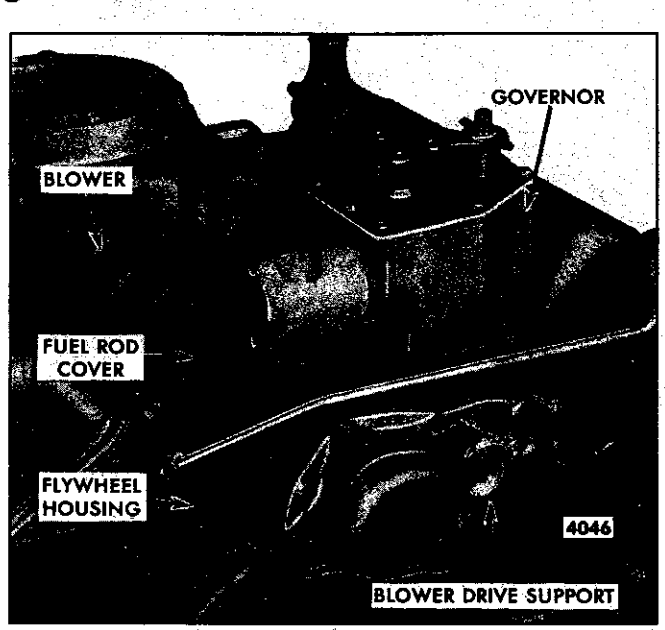


Fig. 2 – Governor Mounting on 6V–53 Engine

Current governor covers include a longer serrated shutdown shaft and lever to provide positive clamping between the serrated levers and shafts. The longer shaft also has provisions for a yieldable speed control lever.

To limit fuel input during engine start–up, when the speed control lever is in its idle position, the turbocharged engines use a starting aid screw (Fig. 7).

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever. One end of this lever bears against the governor spring cap while the other end provides a moving fulcrum on which the differential lever pivots.

In the low speed range, the centrifugal force of the low speed weights and the high speed weights operates against the low speed spring. As the engine speed increases, the centrifugal force of both pairs of weights compresses the low speed spring until the low speed weights have reached the limit of their travel, at which time the low speed spring is fully compressed and the spring cap is within .0015″ of the high speed spring plunger.

Throughout the intermediate speed range, the operator has complete control of the engine because both the low speed spring and the low speed weights are against their stops, and the high speed weights are not exerting enough force to overcome the high speed spring.

Fig. 3 – Removing or Installing Blower Drive Support

As the engine speed continues to increase, the centrifugal force of the high speed weights increases until this force overcomes the high speed spring and the governor again takes control of the engine, limiting the maximum engine speed.

Fuel rods are connected to the differential lever and the injector control tube levers through the control link lever. This arrangement provides a means for the governor to change the fuel settings of the injector control racks.

To stop the engine, the speed control lever is moved to the idle speed position and the stop lever is moved to the no–fuel position and held there until the engine stops.

Adjustment of the governor is covered in Section 14.

Lubrication

The governor is lubricated by a spray of pressurized lubricating oil from the blower rear end plate to the blower timing gears which distribute this oil to various parts of the governor. Oil splash from the gear train provides lubrication for the governor weights and shaft. Excess oil overflows into the gear train compartment and returns to the crankcase.

Remove Governor From Engine

Check the governor as outlined in Section 2.7 and, if it fails to control the engine properly, remove and disassemble it for further inspection.

Since the governor is mounted between the blower and the flywheel housing, the blower and blower drive support assemblies must also be removed. Remove the governor as follows:

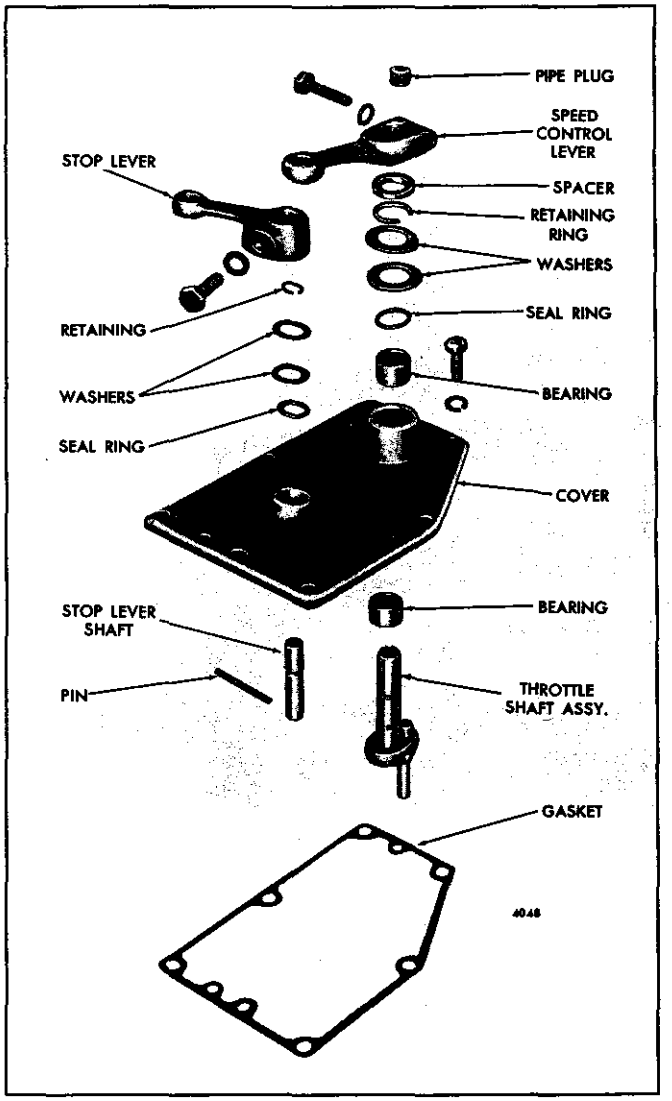


Fig. 4 – Governor Cover Details and Relative Location of Parts

1. Disconnect the linkage to the governor control levers.

2. Remove the seven attaching screws and lock washers and detach the governor cover and lever assembly from the governor housing. Remove the cover gasket.

3. Take out the two bolts and copper washers and remove the spring housing (or cover) and gasket from the governor housing.

4. Loosen the high speed spring retainer lock nut (type "A" governor, Fig. 6) with a spanner wrench. Remove the spring retainer and withdraw the spring retainer, idle speed adjusting screw, high speed spring, spring plunger, low speed spring, spring seat and spring cap as a unit.

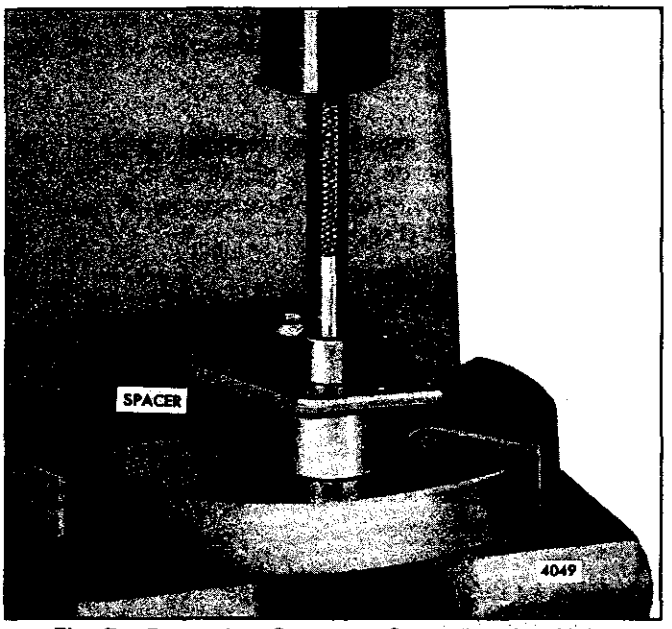


Fig. 5 – Removing Governor Cover Bearing Using Tool J 21967-01

On engines equipped with the type "B" governor (Fig. 6), remove the spring retainer with spanner wrench J 5895 and withdraw the spring assembly.

5. Loosen the hose clamps and slide the hoses back on the fuel rod covers.
6. Remove the valve rocker covers from the cylinder heads.
7. Disconnect the lower fuel rods from the injector control tube levers and from the lower (threaded) ends of the upper fuel rods.
8. Remove the threaded pins that connect the fuel rods to the control link lever and remove the upper fuel rods.
9. Remove the blower drive support (Fig. 3) as outlined in Section 3.4. The governor weight and shaft assembly will be removed with the blower drive support.
10. Check the clearance between the gear and each of the fully extended weights (Fig. 18). If this clearance is less than .100", the weights or carrier are worn and must be replaced.

NOTICE: The current weight carrier is hardened in the weight stop areas and the stop area on the low speed weights has been increased with the use of new center laminations to prevent wear which could allow the weights to open beyond limits and strike the blower drive gear.

11. Remove the governor weight shaft and carrier assembly from the blower drive support, using pry bars if necessary.
12. Remove the blower and governor housing assembly as outlined in Section 3.4.
13. Remove the six attaching bolts and lock washers and detach the governor housing from the blower rear end plate. Remove the gasket.

Disassemble Governor

Before removing any parts from the governor, wash the entire unit in clean fuel oil, dry it with compressed air and inspect for worn or damaged parts which may be repaired or replaced without complete disassembly.

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

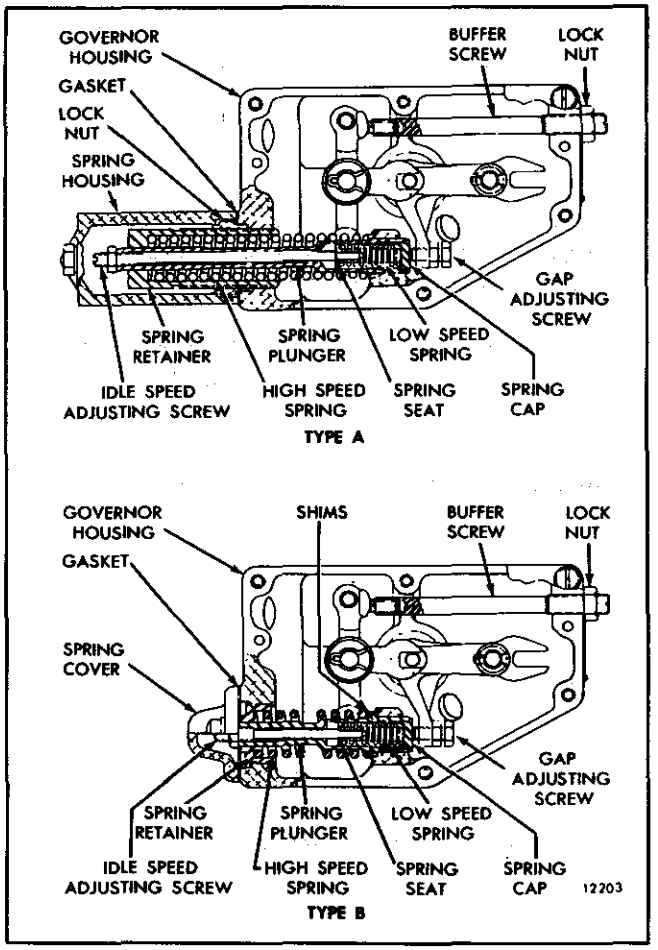


Fig. 6 – Governor Spring Assemblies

Disassemble Governor Cover

Refer to Fig. 4 and disassemble the governor cover as follows:

1. Remove the pipe plug from the throttle shaft.
2. Loosen the clamping bolt and remove the speed control lever.
3. Remove the spacer from the throttle shaft.
4. Remove the retaining ring and two seal retaining washers and withdraw the throttle shaft assembly from the cover.
5. Remove the seal ring from the cover.
6. Loosen the clamping bolt and remove the stop lever.
7. Remove the retaining ring and two seal retaining washers and withdraw the stop lever shaft from the cover.
8. Remove the seal ring from the cover.
9. Wash the governor cover with clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory, removal is unnecessary.
10. If the bearings are to be removed, place the governor cover on an arbor press and press them out with bearing remover J 21967-01 (Fig. 5).

Disassemble Governor Springs

Refer to Fig. 6 and disassemble the governor spring assembly as follows:

1. Remove the low speed spring cap, spring, and spring seat from the spring plunger.
2. Depress the high speed spring by hand and remove the idle speed adjusting screw lock nut.

The spring retainer and high speed spring (and shims) may then be withdrawn. Remove the idle speed adjusting screw from the spring plunger.

Disassemble Governor Housing

1. Remove the governor buffer screw and spring.
2. Remove the spring pin and washer from the control link lever pin (Fig. 7) and withdraw the control link lever and washer.
3. If the bearings require replacement, support the control link lever on a sleeve placed on the bed of an arbor press. Then, press the bearings out of the lever with tool J 8985 (Fig. 8).
4. Remove the spring pin and washer from the pin in the operating shaft lever and remove the differential lever.
5. Remove the plug at the bottom of the governor housing.
6. Remove the set screws, if used, from the governor operating fork.
7. Remove the operating shaft upper bearing retaining screw and washer.
8. Remove the operating shaft lower bearing by placing the inverted governor housing on the bed of an arbor press; use wood block(s) to prevent damage to the dowel pins in the housing. Press on the shaft, using a rod small enough to pass through the bearing, until the bearing is free of the shaft. Then, withdraw the bearing.
9. Place an end wrench between the operating fork and the governor housing; also place a rod on the end of the operating shaft and press the shaft out of the fork (Fig. 9).
10. Withdraw the operating shaft, operating shaft lever and bearings.
11. Press the shaft from the operating shaft lever and bearings.

Disassemble Governor Weights and Shaft

1. Remove the retaining rings from the governor weight pins (Fig. 10). Then, drive the pins out by tapping on a punch held against the grooved end of the pins. Remove the governor weights.
2. Press the shaft from the governor weight carrier (Fig. 11).
3. Slide the governor riser and bearing assembly from the shaft. Do not remove the bearing since the bearing and riser are serviced only as an assembly.

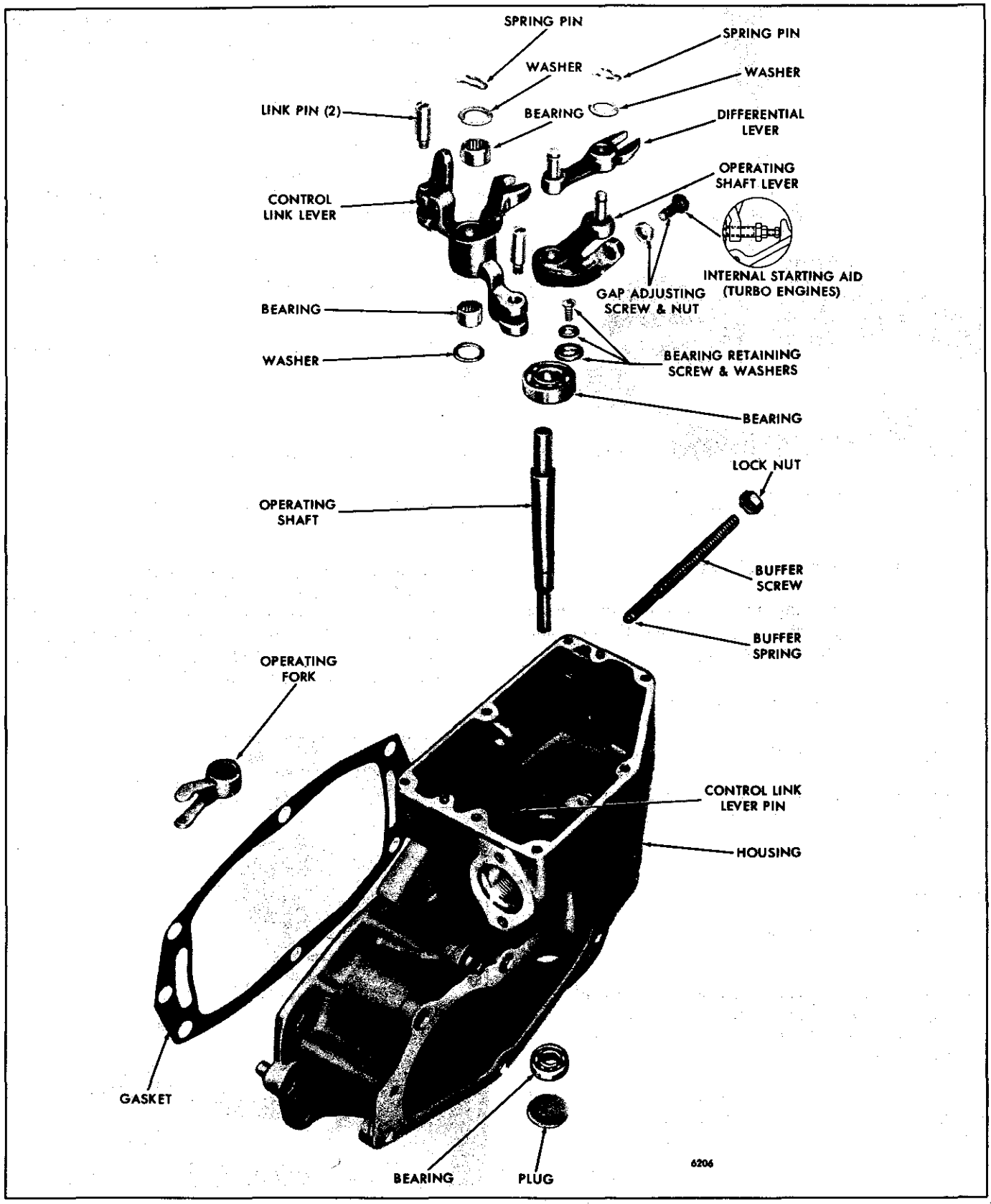


Fig. 7 – Governor Housing Details and Relative Location of Parts

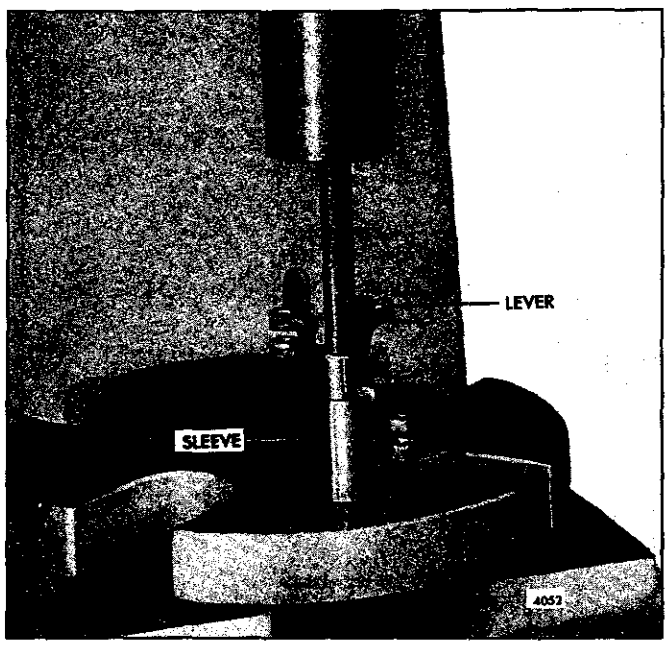


Fig. 8 – Removing Bearings from Control Link Lever Using Tool J 8985

Disassemble Blower Drive

1. Remove the snap ring and the thrust washer from the blower drive gear shaft (Fig. 12). Slide the shaft and gear from the blower drive support.

2. Press the drive gear from the shaft and remove the key.

3. Tap the governor weight shaft bearing from the blower drive support. If the bearing is a tight fit, drive the plug from the support and, using a spacer against the outer race of the bearing, press or tap the bearing from the support.

Inspection

Clean all of the parts 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 all of the bearings. Replace corroded or pitted bearings. Revolve ball bearings slowly by hand. Replace bearings which indicate rough or tight spots.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion. If any of these conditions exist, install a new riser and thrust bearing assembly.

Inspect the control link lever, needle bearings and control link lever pin for wear. Replace worn parts. If a new control link lever pin is required, remove the old pin and press the new pin in the governor housing; the pin must project 1.055″ to 1.060″ above the boss in the housing.

Examine the weight carrier, weights and pins. Replace worn parts. The current weight carrier is hardened in the weight stop areas and the stop area on the low speed weights has been increased with the use of new center laminations.

Inspect the governor springs, spring seat, spring cap, plunger, spring retainer, adjusting screws and other parts of the governor housing for wear.

Check the serrations on the governor weight shaft and the drive plate on the blower timing gear for wear. Replace worn Parts.

Assemble Governor Cover

Refer to Fig. 4 and assemble the governor cover as follows:

1. Place the cover, with the inner face down, on the bed of an arbor press. Start a needle bearing straight into the bearing bore of the cover, with the number side of the bearing up. Then, insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 13).

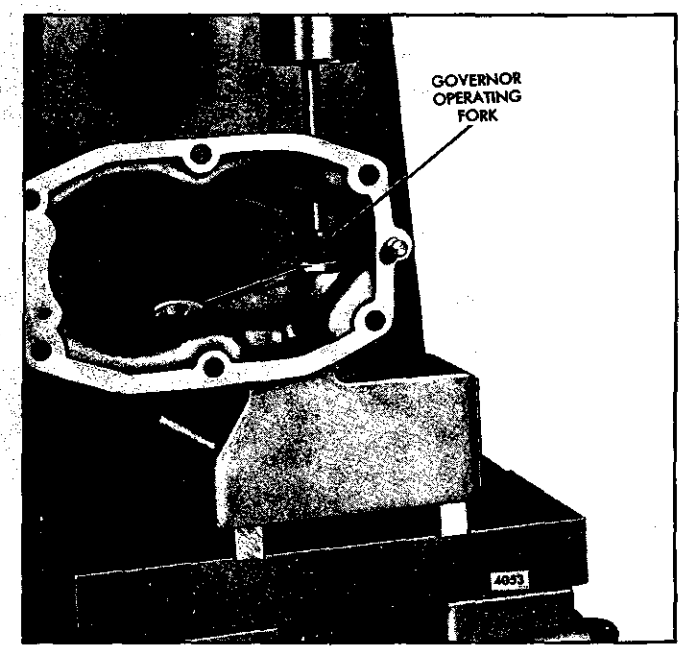


Fig. 9 – Removing Governor Operating Fork

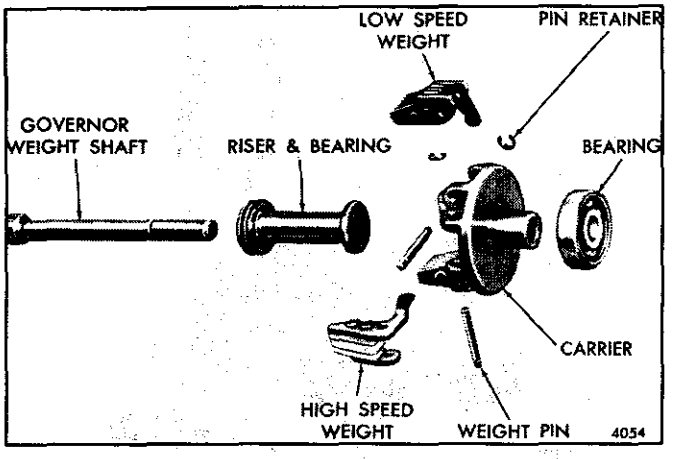


Fig. 10 – Governor Weight Details and Relative Location of Parts

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

   NOTICE: To prevent possible damage do not use impact tools to install needle bearings.

3. Install the pipe plug in the tapped hole in the throttle shaft.

4. Pack the needle bearings with grease. Then, slide the throttle shaft assembly through the bearings, with the fulcrum lever pin seated in the slot on the underside of the cover.

5. Install a new seal ring on top of the upper bearing. Then, install the two seal retaining washers and the retaining ring. A .0329" thick, 33/64" I.D. x 43/64" O.D. seal ring back–up washer is used in place of the lower washer on certain governor covers.

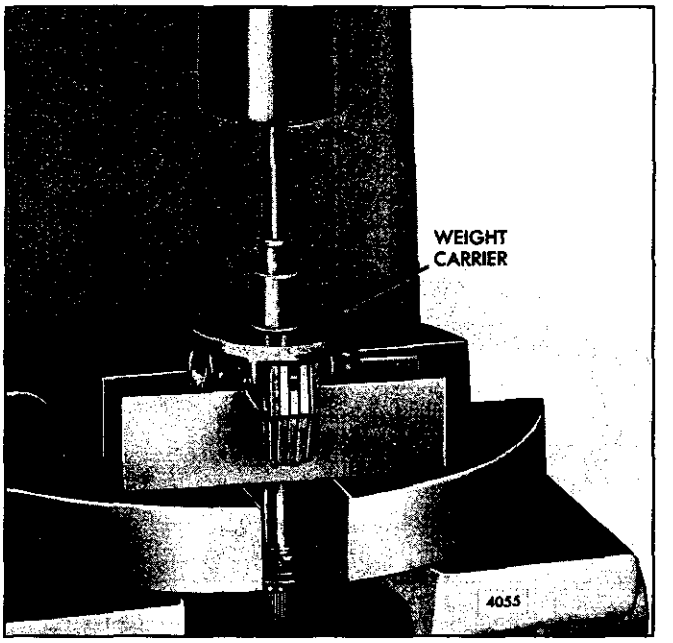


Fig. 11 – Removing Shaft from Weight Carrier

6. Lubricate the stop lever shaft with engine oil. Then, slide the shaft through the cover.

7. Install a new seal ring over the shaft. Then, install the two seal retaining washers and the retaining ring. A .0329" thick, 25/64" I.D. x 17/32" O.D. seal ring back–up washer is used in place of the lower washer on certain governor covers.

8. Install the .078" thick spacer over the speed control shaft and against the retaining ring.

9. Install the stop lever and speed control lever, then tighten the clamping bolts. Be sure the speed control lever contacts the spacer.

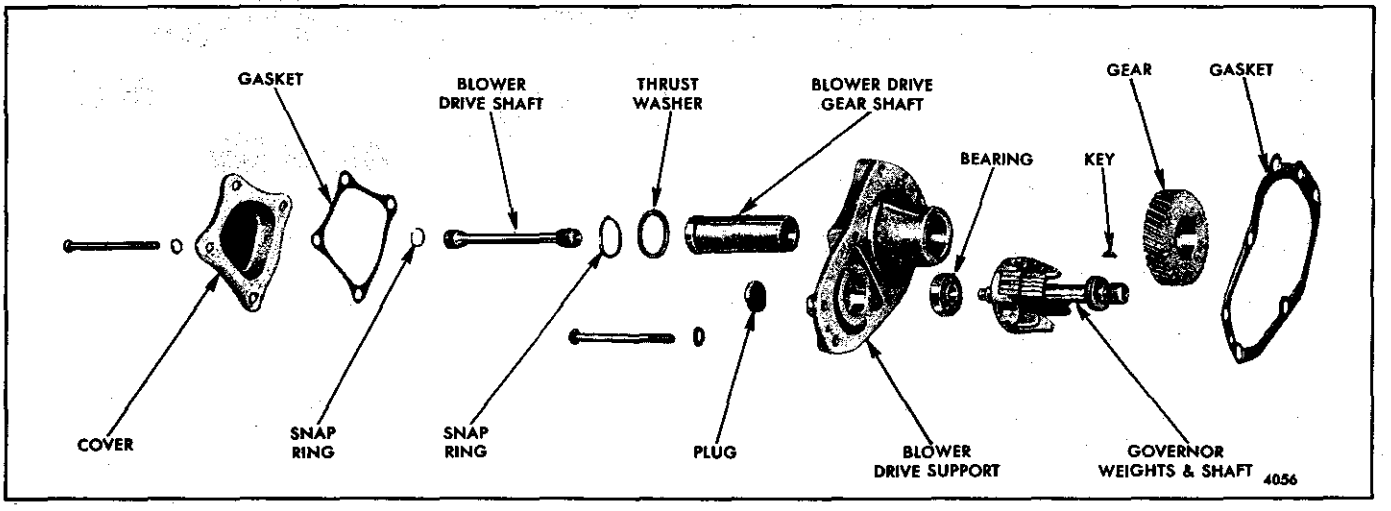


Fig. 12 – Blower Drive Support Assembly Details and Relative Location of Parts

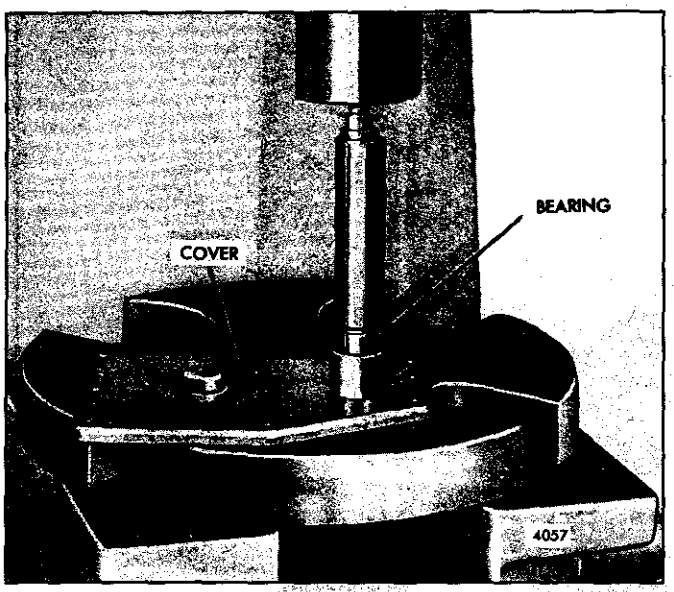


Fig. 13 – Installing Governor Cover Bearings Using Tool J 21068

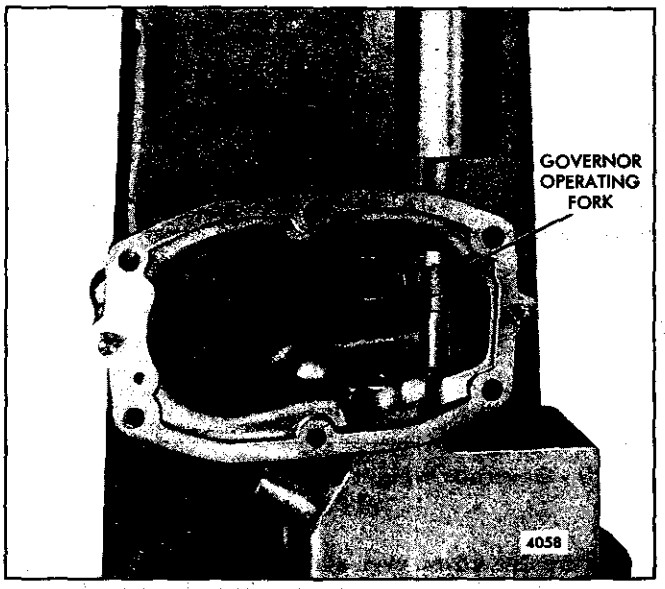


Fig. 14 – Installing Governor Operating Fork on Shaft

Assemble Governor Housing

Refer to Fig. 7 and assemble the governor housing as follows:

1. Start the upper operating shaft bearing, number side up, on the end of the shaft. Support the lower end of the shaft on an arbor press. Place a sleeve on the inner race and press the bearing against the shoulder on the shaft.

2. Start the operating shaft lever, with the pivot pin up, on the end of the shaft with the flat on the shaft registering with the flat in the lever bore. Use a sleeve to press the lever tight against the bearing.

3. Insert the lever and shaft assembly through the top of the governor housing. Position the operating fork over the lower end of the shaft, with the finished cam surfaces facing toward the rear of the governor (toward the governor drive).

4. Support the operating shaft and governor housing on the bed of an arbor press with the upper end of the shaft resting on a steel block (Fig. 14). Align the flat in the fork with the flat on the shaft, then place a sleeve over the shaft and against the fork. Press the fork tight against the shoulder on the shaft. Install the set screw and lock screw, if used, in the fork.

5. Start the lower operating shaft bearing, number side up, on the end of the shaft. Place a sleeve on the inner race and press the bearing against the shoulder in the housing.

6. Lubricate both bearings with engine oil.

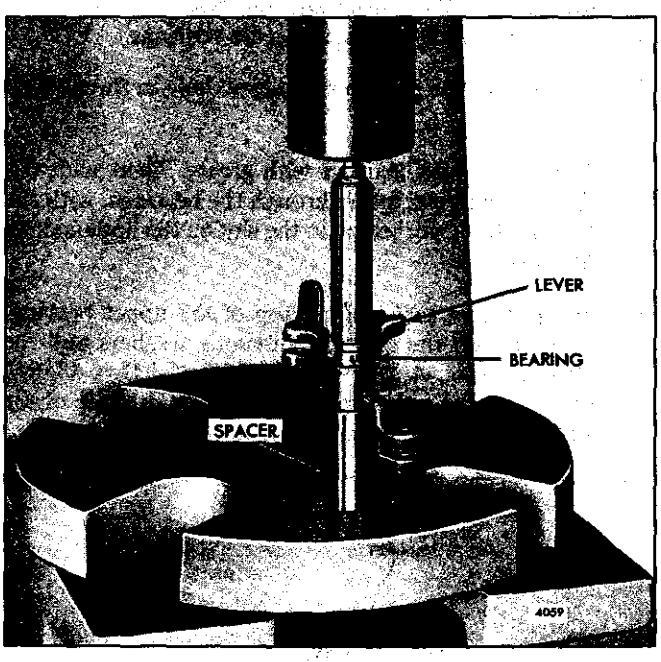


Fig. 15 – Installing Bearings in Control Link Lever Using Tool J 21068

7. Apply a good quality sealant around the edge of a new expansion plug and tap it in place in the housing.

8. Secure the upper operating shaft bearing in place with a retaining screw and flat washer.

9. Place the differential lever over the pivot pin in the operating shaft lever (Fig. 7). Secure the lever with a washer and spring pin.

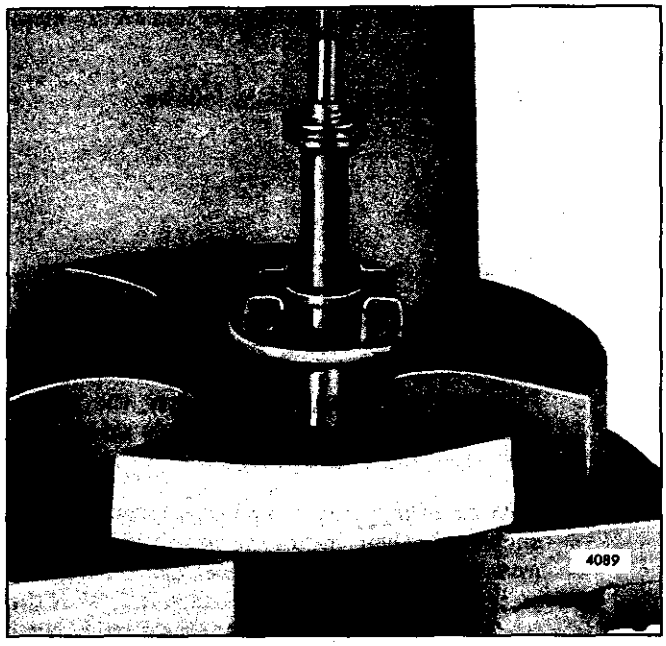


Fig. 16 – Installing Weight Carrier on Shaft Using Tool J 8984

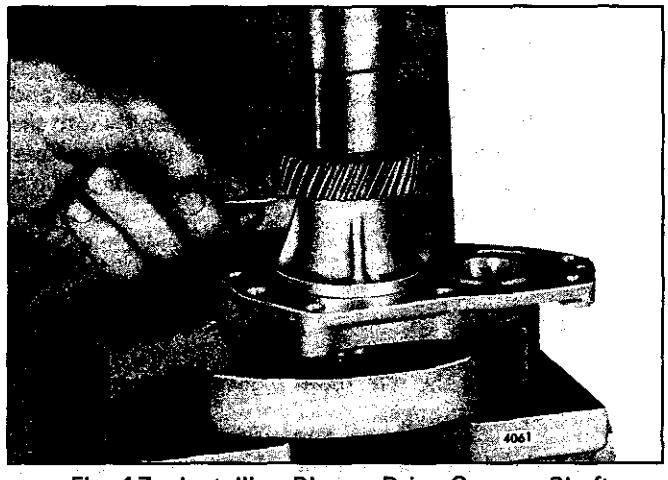


Fig. 17 – Installing Blower Drive Gear on Shaft

10. If previously removed, install the gap adjusting screw and lock nut in the tapped hole in the operating shaft lever.

11. Support the control link lever on a steel spacer on the bed of an arbor press. Start one bearing, number side up, in the lever and press it flush with the lever with tool J 21068 (Fig. 15). Invert the lever and install the second bearing in the same manner.

12. Place the washer on the control link lever pin in the housing. Pack the needle bearings with grease and install the lever, with the tapped end of the link pin holes down, over the pin in the governor housing (Fig. 7). Secure the lever with the washer and spring pin.

13. Thread the buffer screw into the governor housing until it extends 9/16" to 5/8" beyond the governor housing and install the lock nut.

NOTICE: The buffer screw on early governors threaded into a splined lock nut which was installed (inside the housing) in a drilled hole in the governor housing. The current buffer screw threads into a tapped hole in the housing and is secured with a lock nut which is installed from the outer side of the housing.

Assemble Governor Weights and Shaft

Refer to Fig. 10 and assemble the governor weights and shaft as follows:

1. Lubricate the governor weight shaft with clean engine oil and slide the riser assembly over the shaft, with the bearing end toward the serrated end of the shaft. Pack the bearing with grease.

2. Use installer J 8984 as illustrated in Fig. 16 and press the shaft into the weight carrier. The tool will properly position the carrier on the shaft.

3. Position the low speed weights, identified by the short cam arm, on opposite sides of the weight carrier. Drive the weight pins in place and install the retaining rings. To install a weight pin correctly, push the grooved end through the smaller hole in the carrier and through the weight. Then, drive the knurled end in just enough so the retaining ring can be installed on the pin.

4. Install the high speed weights in a similar manner. The high speed weights are identified by the long cam arm.

Assemble Blower Drive

Refer to Fig. 12 and assemble the blower drive as follows:

1. Place the blower drive support, with the inner face up, on the bed of an arbor press. Start the governor weight shaft bearing, numbered side up, into the bore of the support. Place a suitable sleeve against the outer race and press the bearing against the shoulder of the blower drive support.

2. Place the steel thrust washer on the end of the blower drive gear shaft and secure it in place with the snap ring.

3. Lubricate the blower drive gear shaft with engine oil and install it in the blower drive support.

4. Install the key in the shaft, then place the blower drive support on an arbor press. Lubricate the inner diameter of the blower drive gear and start it straight on the shaft, with the keyway in the gear aligned with the key in the shaft. Place a spacer over the gear and press the gear on the shaft until a .005" feeler gage may just be withdrawn (Fig. 17).

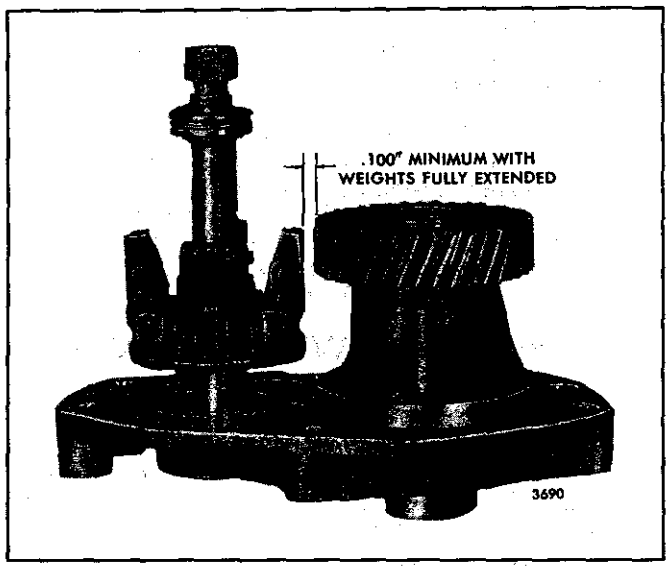


Fig. 18 – Minimum Clearance Between Blower Drive Gear and Governor Weights

5. Place a support under the inner race of the bearing in the blower drive support and start the weight end of the governor weight shaft into the bearing. Press the shaft in until the shoulder on the shaft contacts the inner race of the bearing. Press the shaft in straight to avoid brinelling the bearing.

6. Apply a good quality sealant on the edge of the cup plug and press the plug in flush with the blower drive support.

7. Check the clearance between the fully extended governor weights and the blower drive gear. This clearance must not be less than .100" (Fig. 18).

Install Governor

Install the governor on the engine as follows:

1. Attach a new gasket to the governor housing and place the housing against the blower rear end plate. Secure the governor housing to the blower with six bolts and lock washers.

2. Install the blower and governor assembly on the engine as outlined in Section 3.4.

3. Install the blower drive support assembly as outlined in Section 3.4 under *Install Blower in 6V Engine.*

4. Insert the upper fuel rods through the fuel rod covers, hoses and clamps and attach the fuel rods to the governor control link lever. Then, thread the link pins into the lever.

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

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

7. Assemble the governor springs as follows:

TYPE A (Fig. 6):

a. Thread the lock nut on the spring retainer.

b. Thread the idle speed adjusting screw into the spring plunger.

c. Place the high speed spring over the spring plunger (with the close wound coils toward the idle screw end of the plunger).

d. Lubricate the spring and plunger assembly with engine oil. Then, install the spring and plunger assembly in the spring retainer and secure it in place with a lock nut. Approximately 1/4" of the idle speed adjusting screw should extend beyond the lock nut.

e. Lubricate and insert the spring seat, low speed spring, and spring cap in the open end of the spring plunger.

f. Place a new gasket over the spring retainer and thread the retainer and spring assembly into the governor housing. Tighten the lock nut finger–tight until the engine tune–up is performed.

TYPE B (Fig. 6):

a. Thread the idle speed adjusting screw into the spring plunger.

b. Reinstall the original shims over the spring plunger.

c. Place the high speed spring over the spring plunger.

d. Lubricate the spring and plunger assembly with engine oil. Then, place the spring retainer over the plunger and secure it with a lock nut. Approximately 1/4" of the idle speed adjusting screw should extend beyond the lock nut.

e. Lubricate and insert the spring seat, low speed spring and spring cap in the open end of the spring plunger.

f. Thread the retainer and spring assembly into the governor housing. The cover and gasket are to be installed after the engine tune–up is performed.

8. Place a new gasket on the governor housing and install the cover and lever assembly. Make sure the control link lever engages the pin on the differential lever. Also, be sure the pin in the speed control shaft enters the slot in the differential lever and that the pin in the stop lever shaft is engaged between the stop on the underside of the cover and the vertical extension of the control link lever. Then, secure the cover with seven screws and lock washers.

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assemble, the technician must determine that the injector racks move to the *no-fuel* position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

9. Connect the linkage to the governor control levers after the engine tune-up is performed.

10. Perform an engine tune-up as outlined in Section 14.

LIMITING SPEED MECHANICAL GOVERNOR

8V ENGINE

The limiting speed mechanical governor, illustrated in Fig. 1, performs the following functions:

1. Controls the engine idling speed.

2. Limits the maximum operating speed of the engine.

The double–weight governor, identified by the letters D.W.–L.S. stamped on the governor name plate, is mounted on the front end of the blower and is driven by the left–hand helix blower rotor shaft (Fig. 2).

The governor consists of four basic sub–assemblies: a cover and lever assembly, governor housing, spring housing, and a weight and shaft assembly.

The turbocharged engines use a starting aid screw threaded into the gap adjusting screw. The starting aid screw is threaded in the low–speed gap adjusting screw so that its head contacts the governor housing wall (Fig. 1). Both the gap adjusting screw and the starting aid screw have a nylon locking patch on the threads in place of lock nuts.

Operation

Two manual controls are provided on the governor: a stop lever and a speed control lever. In the RUN position, the stop lever holds the fuel injector racks near the full–fuel position. When the engine is started, the governor moves the injector racks toward the idle speed position. The engine speed is then controlled manually by moving the speed control lever.

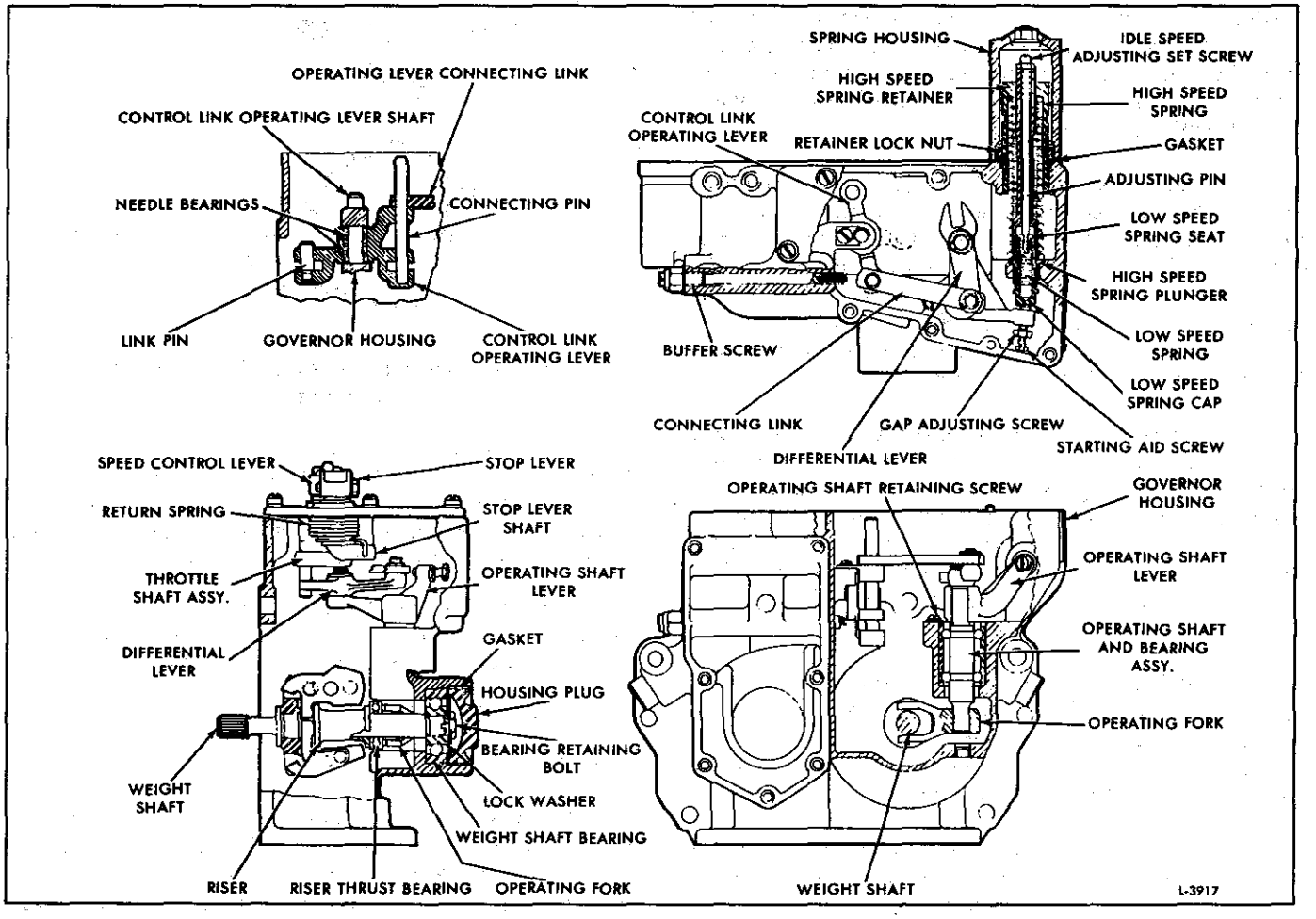


Fig. 1 – Limiting Speed Governor for 8V–53 Engine

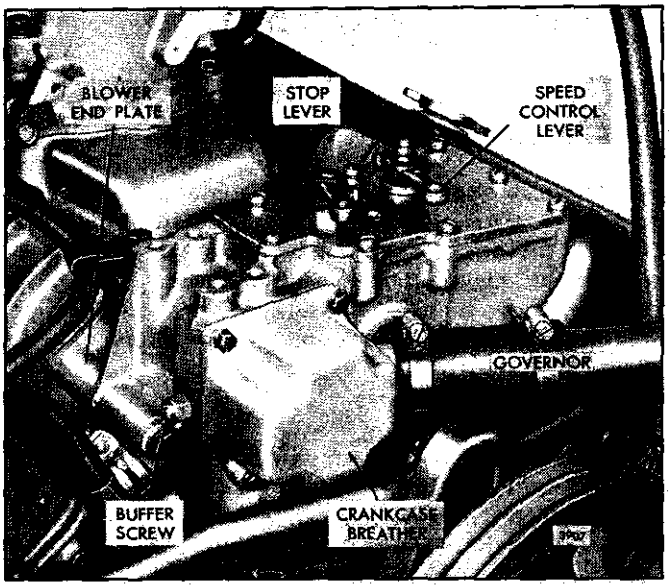


Fig. 2 – Governor Mounting

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever. One end of this lever bears against the governor spring cap while the other end provides a moving fulcrum on which the differential lever pivots.

The centrifugal force of the governor weights is opposed by the governor springs. Load changes or movement of the speed control lever momentarily creates an unbalanced force between the revolving weights and the tension on the high speed spring or low speed spring (depending on the speed range). When the forces reach a balanced condition again, the engine speed will be stabilized for the new speed setting or new load.

In the low speed range, the centrifugal force of the low speed weights and the high speed weights operates against the low speed spring. As the engine speed increases, the centrifugal force of both pairs of weights compresses the low speed spring until the low speed weights have reached the limit of their travel at which time the low speed spring is fully compressed and the spring cap is within .0015" of the high speed spring plunger.

Throughout the intermediate speed range, the operator has complete control of the engine because both the low speed spring and the low speed weights are against their stops, and the high speed weights are not exerting enough force to overcome the high speed spring.

As the engine speed continues to increase, the centrifugal force of the high speed weights increases until this force overcomes the high speed spring and the governor again takes control of the engine, limiting the maximum engine speed.

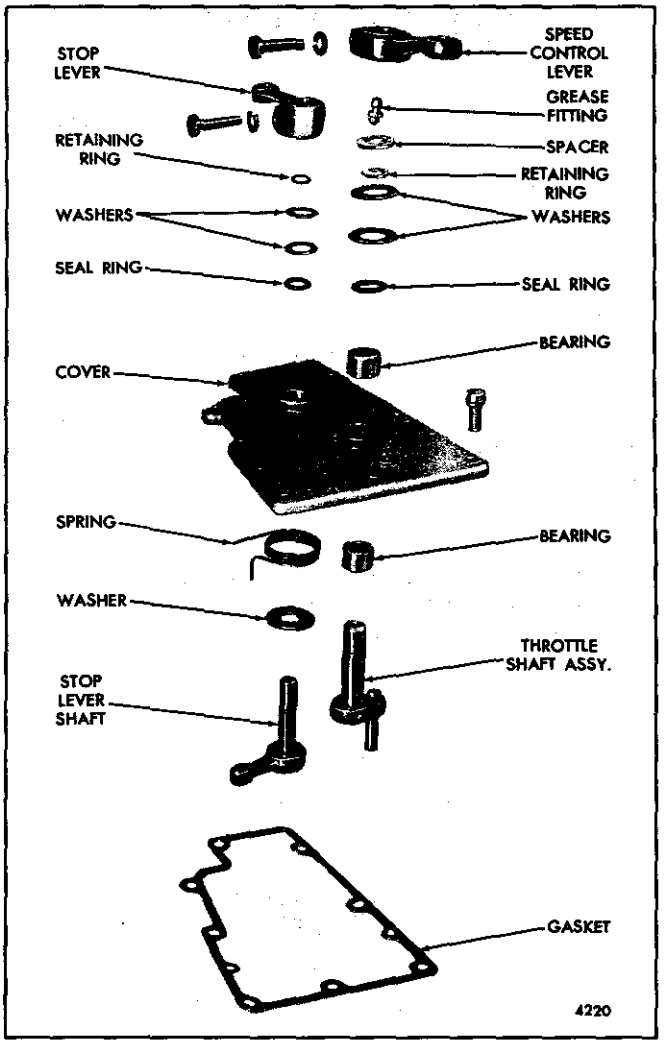


Fig. 3 – Governor Cover Details and Relative Location of Parts

Fuel rods are connected to the differential lever and the injector control tube levers through the control link operating lever and the connecting link (Fig. 1). This arrangement provides a means for the governor to change the fuel settings of the injector control racks.

To stop the engine, the speed control lever is moved to the idle speed position and the stop lever is moved to the no–fuel position and held there until the engine stops.

Adjustment of the governor is covered in Section 14.

Lubrication

The governor is lubricated by a spray of oil from a passage in the blower end plate. The revolving governor weights distribute this oil to all parts of the governor which require lubrication. Excess oil returns to the engine crankcase through passages in the blower end plate and the cylinder block.

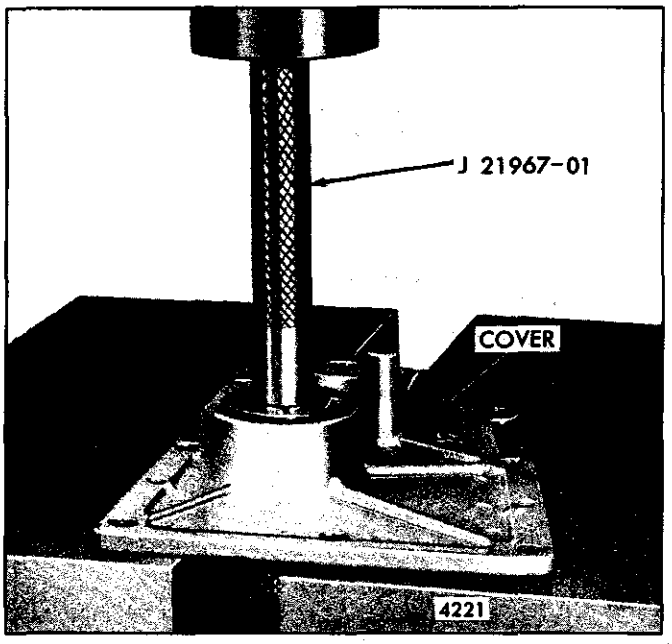


Fig. 4 – Removing Governor Cover Bearings

Remove Governor From Engine

Check the operation of the governor as outlined in Section 2.7 and if it fails to control the engine properly, remove and disassemble it for further inspection.

The blower and governor must be removed together as outlined under *Remove Blower (8V–53)* in Section 3.4.1. Then remove the governor from the blower as outlined under *Remove Accessories from Blower (8V–53)* in Section 3.4.1.

Disassemble Governor

Before removing any parts from the governor, wash the entire unit in clean fuel oil, dry it with compressed air and inspect for worn or damaged parts which may be repaired or replaced without complete disassembly.

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

Disassemble Governor Cover

Refer to Fig. 3 and disassemble the governor cover as follows:

1. Loosen the clamping bolt and remove the stop lever.
2. Remove the retaining ring and withdraw the two washers from the stop lever shaft assembly.
3. Note the position of the stop lever shaft assembly and the lever return spring. Then withdraw the shaft, washer and spring
4. Remove the seal ring.
5. Loosen the clamping bolt and remove the speed control lever.
6. Remove the spacer from the throttle shaft.
7. Remove the retaining ring and withdraw the two washers from the throttle shaft assembly.
8. Withdraw the throttle shaft assembly. Remove the grease fitting from the shaft.
9. Remove the seal ring.
10. Wash the governor cover with clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory, removal is unnecessary.
11. If the bearings are to be removed, place the governor cover on an arbor press and press them out with bearing remover J 21967–01 (Fig. 4).

Disassemble Governor Springs

Refer to Fig. 5 and disassemble the governor spring housing as follows:

1. Remove the two retaining bolts and copper washers and withdraw the spring housing from the governor.
2. Loosen the spring retainer lock nut with a spanner wrench. Remove the spring and retainer assembly from the governor. Remove the fasket.
3. Remove the spring cap and low speed spring.
4. Loosen the lock nut and remove the idle speed adjusting screw. Then withdraw the high speed spring and plunger from the spring retainer.

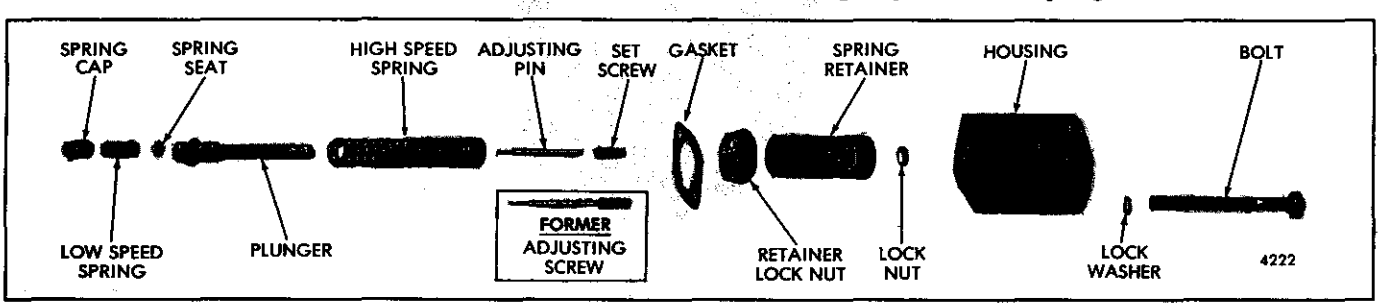


Fig. 5 – Governor Spring Assembly Details and Relative Location of Parts

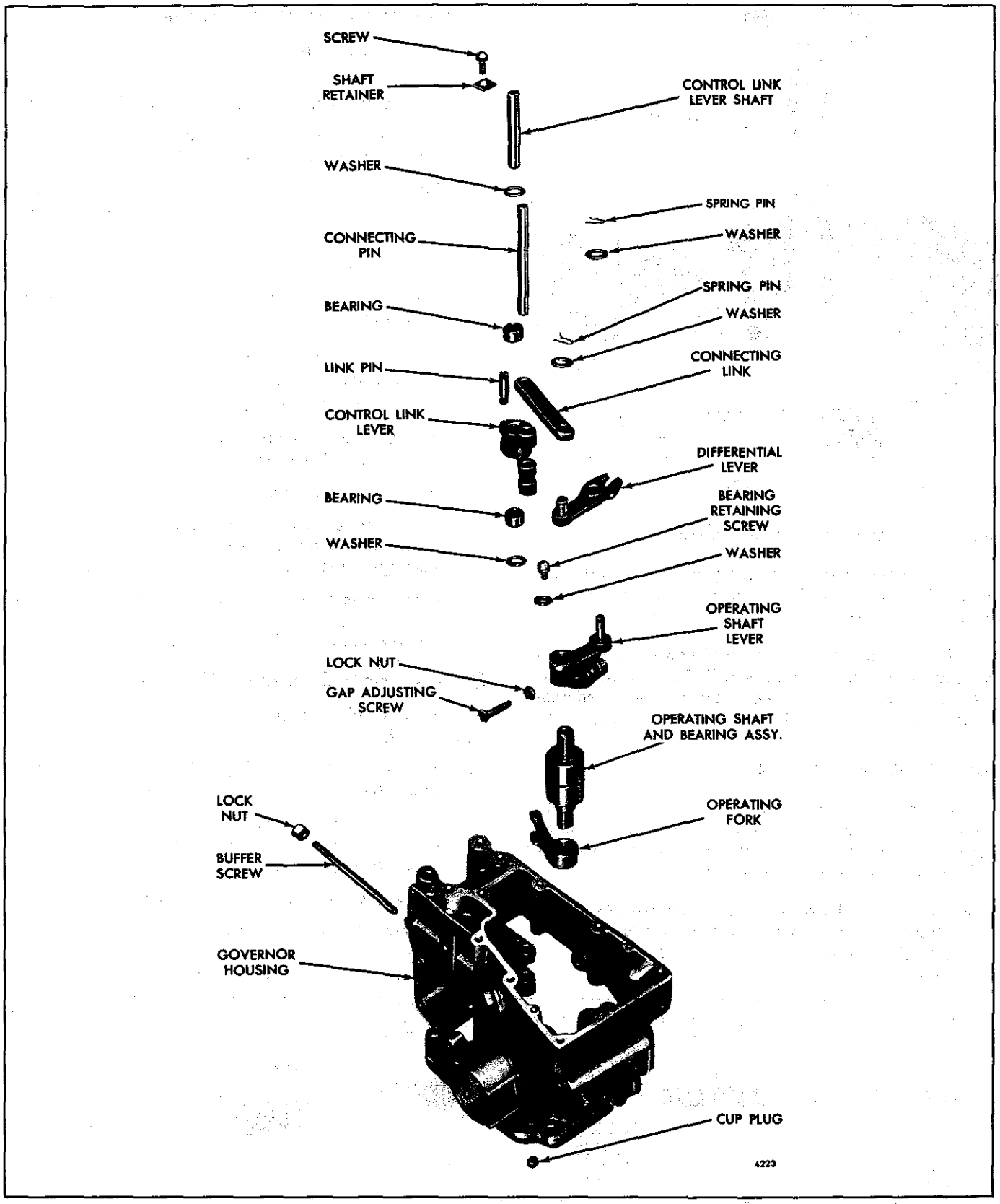


Fig. 6 – Governor Housing Details and Relative Location of Parts

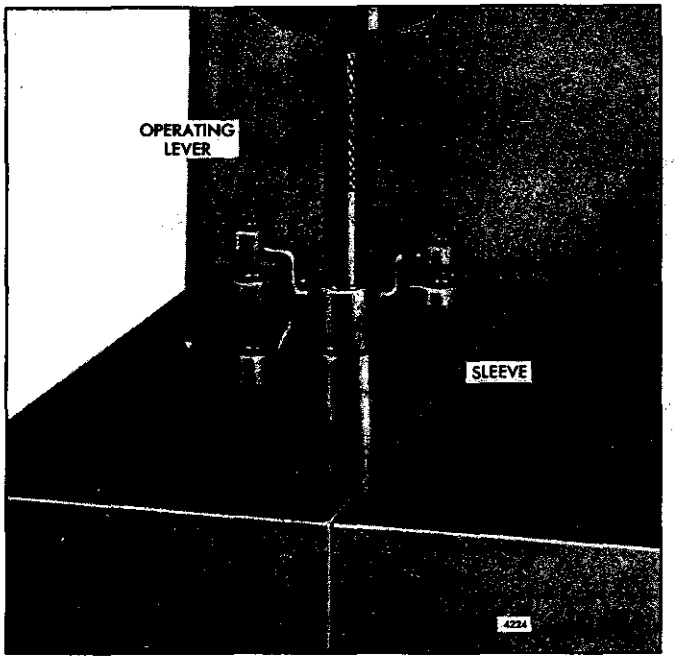


Fig. 7 – Removing Control Link Lever Bearings

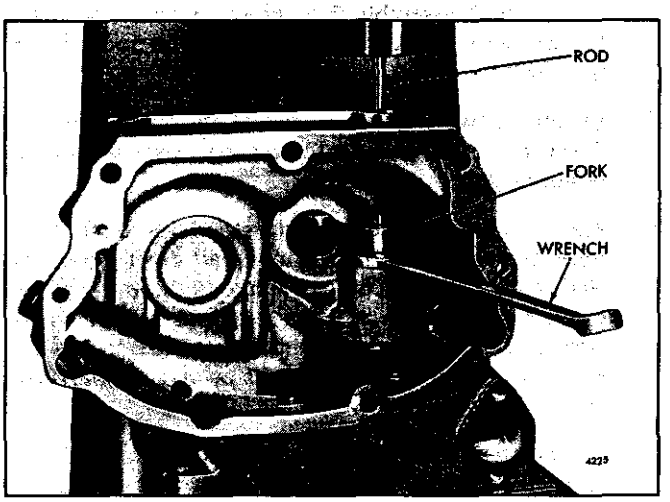


Fig. 8 – Removing Governor Operating Fork

Disassemble Governor Housing

Refer to Figs. 6 and 9 and disassemble the governor housing as follows:

1. Remove the large plug and gasket from the governor housing to provide access to the weight shaft bearing.
2. Straighten the tang on the lock washer and remove the weight shaft bearing retaining bolt, washer and lock washer.
3. Withdraw the weight, riser and shaft assembly.
4. Remove the weight shaft bearing from the governor housing.
5. Loosen the lock nut and remove the buffer screw.
6. Remove the two link pins from the control link lever.
7. Remove the spring pin and washer and remove the connecting link.
8. Remove the spring pin and washer and remove the differential lever.
9. Remove the control link lever shaft retainer and screw. Then withdraw the control link lever, shaft and two washers from the governor housing.
10. Examine the needle bearings. If they are satisfactory for further use, removal is unnecessary.
11. If the bearings require replacement, support the control link lever on a sleeve placed on the bed of an arbor press. Then press the bearings out of the lever with bearing remover J 8985 (Fig. 7).
12. Remove the operating shaft bearing retaining screw and washer.
13. Tap the small cup plug out of the housing.
14. Place the governor housing, upside down, on wood blocks on the bed of an arbor press. Then place an end wrench between the operating shaft fork and the boss in the housing. Insert a rod through the cup plug hole in the housing and against the end of the shaft, then press the shaft out of the fork (Fig. 8).
15. Withdraw the operating shaft, bearing and lever assembly.
16. If the operating shaft bearing requires replacement, use a small puller to remove the lever from the shaft.

Disassemble Governor Weights and Shaft

Refer to Fig. 9 and disassemble the governor weights as follows:

1. Remove the riser thrust bering and riser tube from the weight shaft.
2. Remove the retaining rings from the weight pins. Then drive the pins out of the carrier and the weights by tapping on the grooved end of the pins. Remove the governor weights.

Inspection

Clean all of the parts (except the operating shaft bearing) 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.**

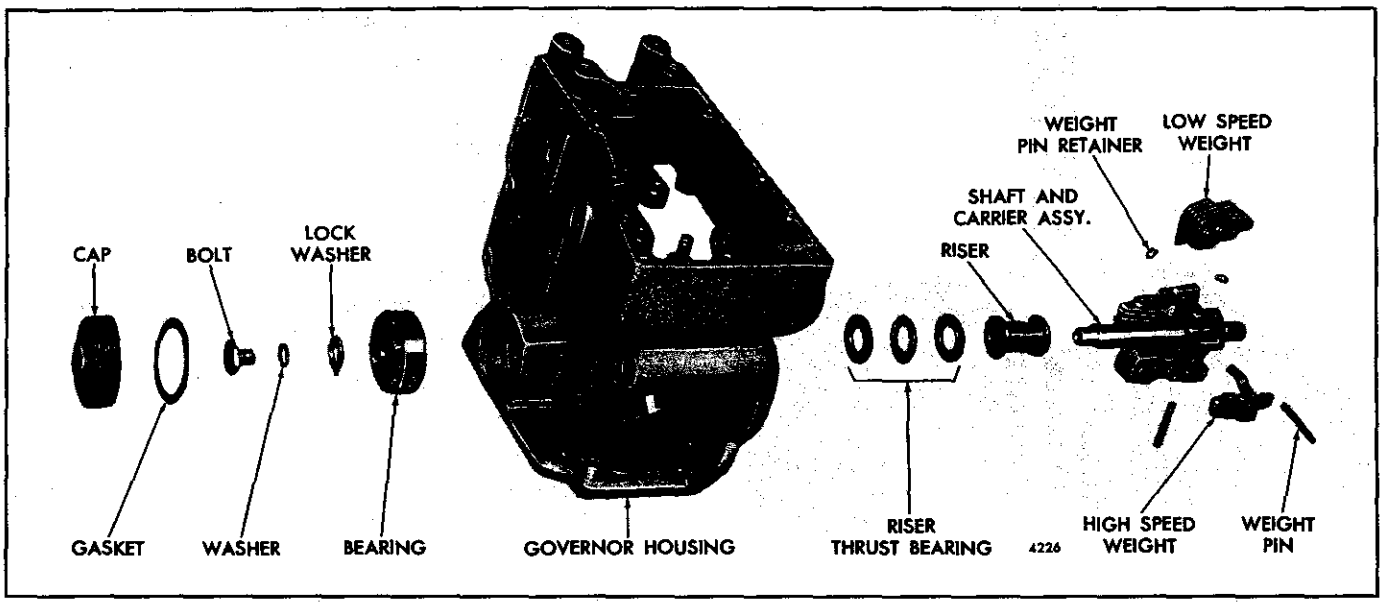


Fig. 9 – Governor Weight Details and Relative Location of Parts

NOTICE: The operating shaft bearing is sealed and must not be cleaned with fuel oil or other cleaning agent.

Inspect all bearings. Replace corroded or pitted bearings. Revolve ball bearings slowly by hand; replace bearings which indicate rough or tight spots. The operating shaft and bearing are serviced only as an assembly.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion.

Inspect all of the levers, pins, shafts, governor weights and springs. Replace worn or damaged parts.

Assemble Governor Cover

Refer to Fig. 3 and assemble the governor cover as follows:

1. Place the cover, with the inner face down, on a spacer on the bed of an arbor press. Start a needle bearing straight into the bearing bore of the cover, with the number side of the bearing up. Then insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 10).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

   NOTICE: To avoid bearing damage, do not use impact tools to install needle bearings.

3. Install the grease fitting in the throttle shaft.

4. Pack the needle bearings with grease. Then slide the throttle shaft assembly through the bearings, with the fulcrum lever pin seated in the slot on the underside of the cover.

5. Install a new seal ring on top of the upper bearing. Then install the two seal retaining washers and the retaining ring.

6. Place the large washer over the stop lever shaft. Then place the spring, with the hook end down, over the shaft. Insert the shaft in the cover with the lever against the stop in the cover; position the spring with the hook behind the lever and the upper extended end of the spring located between the lever stop and the shaft boss in the cover.

7. Install a new seal ring over the shaft. Then install the two seal retaining washers and the retaining ring.

8. Install the .078" thick spacer over the speed control shaft and against the retaining ring.

9. Install the stop lever and the speed control lever; tighten the clamping bolts. Be sure the speed control lever contacts the spacer.

Assemble Governor Housing

Refer to Fig. 6 and assemble the governor housing as follows:

1. Start the operating shaft lever on the shaft with the flat surfaces aligned and press the lever flush with the top of the shaft.

2. Insert the shaft, bearing and lever assembly in the governor housing.

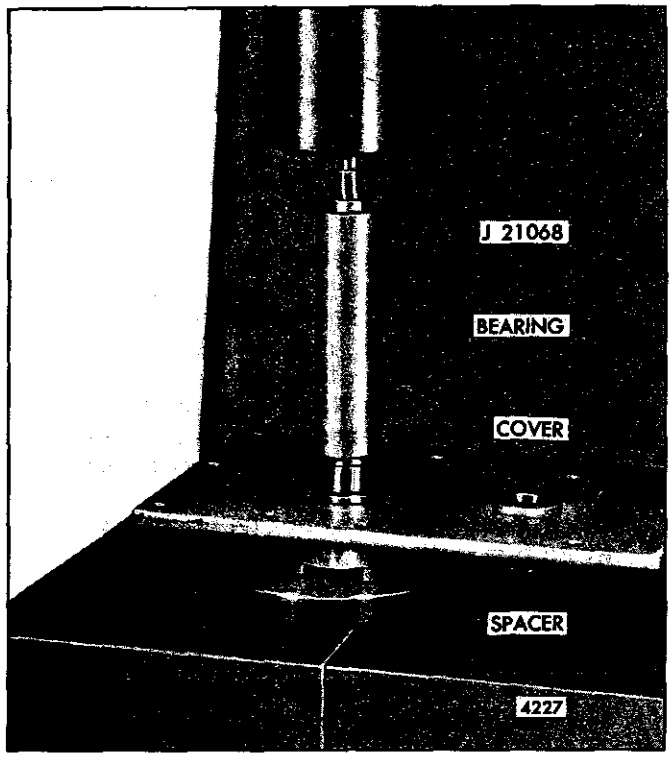


Fig. 10 – Installing Governor Cover Bearings

3. Place the housing right side up on the bed of as arbor press.

4. Align the flat surfaces and start the operating shaft fork on the shaft with the finished cam surfaces of the fork facing toward the rear of the governor. Insert the threaded end of tool J 21995–2 through the cup plug hole in the housing. Then thread the knurled nut J 21995–1 on the end of the tool so the fork rests on the nut. Use a rod of suitable length and diameter and press the shaft into the fork until the fork is flush with the end of the shaft (Fig. 11). Remove the tools.

5. Install the operating shaft bearing retaining screw and washer.

6. Apply a good quality sealant to a new cup plug and press the plug in the governor housing.

7. Place the differential lever over the pin in the operating shaft lever and secure it with a washer and spring pin.

8. If previously removed, install the gap adjusting screw and lock nut in the tapped hole in the operating shaft lever.

9. Support the control link lever on a steel spacer on the bed of an arbor press. Start one bearing, number side up, in the lever and press it flush with the lever with tool J 21068 (Fig. 12). Invert the lever and install the second bearing in the same manner.

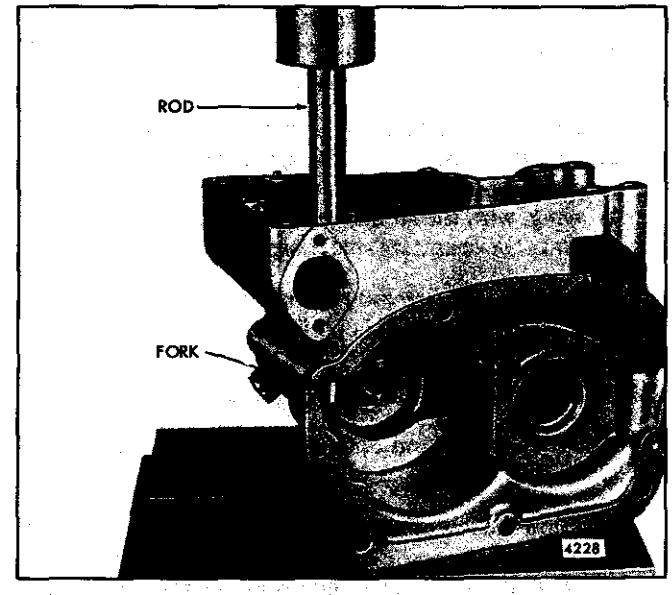


Fig. 11 – Installing Governor Operating Fork

NOTICE: To avoid bearing damage do not use impact tools to install needle berings.

10. Pack the needle bearings with grease, place a washer over each bearing and insert the control link lever between the two bosses in the housing (Fig. 1). Insert the control link lever shaft, then insert the shaft retainer in the notch of the shaft and fasten it to the housing with the retaining screw.

11. Place the connecting pin in the control link lever, then place the connecting link over the connecting pin and the pin in the differential lever. Secure the link to the differential lever with a washer and spring pin.

12. Thread the short link pin into the control link lever.

13. Install the buffer screw and lock nut.

Assemble Governor Springs

Refer to Fig. 5 and assemble the governor springs as follows:

1. Thread the lock nut on the high speed spring retainer approximately 1-1/2". Place the high speed spring over the spring plunger with the loosely wound end of the spring against the shoulder of the plunger.

2. Insert the plunger and spring assembly in the spring retainer. Thread the idle speed adjusting screw approximately 1/2" into the tapped end of the plunger. Thread the lock nut on the idle speed adjusting screw.

3. Insert the spring cap in one end of the low speed spring and the small end of the spring seat in the other end of the spring.

4. Insert the spring seat end of the spring, cap and seat assembly in the spring plunger, with the spring seat against the shoulder on the idle screw.

5. Place the spring housing gasket over the springs and against the shoulder on the spring retainer lock nut. Then thread the spring retainer in the governor housing, with the spring cap against the gap adjusting screw in the operating shaft lever. Tighten the lock nut.

6. The spring housing may be installed after the engine tune–up (Section 14) is performed.

Assemble Governor Weights

Refer to Fig. 9 and assemble the weights, shaft and riser as follows:

1. Position the low speed weights, identified by the short cam arm, on opposite sides of the weight carrier. Drive the weight pins in place and install the retaining rings. To install a weight pin correctly, push the grooved end through the smaller hole in the carrier and through the weight. Then drive the knurled end in just enough so the retaining ring can be installed on the pin.

2. Install the high speed weights in a similar manner.

3. Lubricate the weight shaft with clean engine oil and slide the riser tube on the shaft.

4. Pack the riser thrust bearing with grease. Then assemble the bearing on the weight shaft, with the bearing race having the smaller inside diameter against the riser.

5. Insert the shaft, weight and riser assembly in the governor housing.

6. Support the splined end of the shaft on the bed of an arbor press. Start the weight shaft bearing in the governor housing and over the end of the shaft. Place a sleeve against the inner race and press the bearing in the housing and against the shoulder on the shaft.

7. Place a flat washer and lock washer over the bearing retainer bolt. Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the lock washer against the flat on the head of the bolt.

8. Place a gasket against the weight shaft bearing. Clean the plug with solvent to remove any oil or grease before applying the sealant. Apply a sealant such as Loctite grade H, HV, HVW or equivalent onto the threads of the governor housing and the plug. Thread the plug into the housing and tighten the plug to 45 lb–ft (61 N·m) torque.

Install Governor

1. Refer to Section 3.4.1 and attach the governor to the blower as outlined under *Attach Accessories to Blower (8V–53).*

2. Install the blower and governor assembly as outlined under *Install Blower (8V–53)* in Section 3.4.1.

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

3. Install the crankcase breather assembly as outlined in *Ventilating System*, Section 4.8.

4. Perform and engine tune–up as outlined in Section 14.

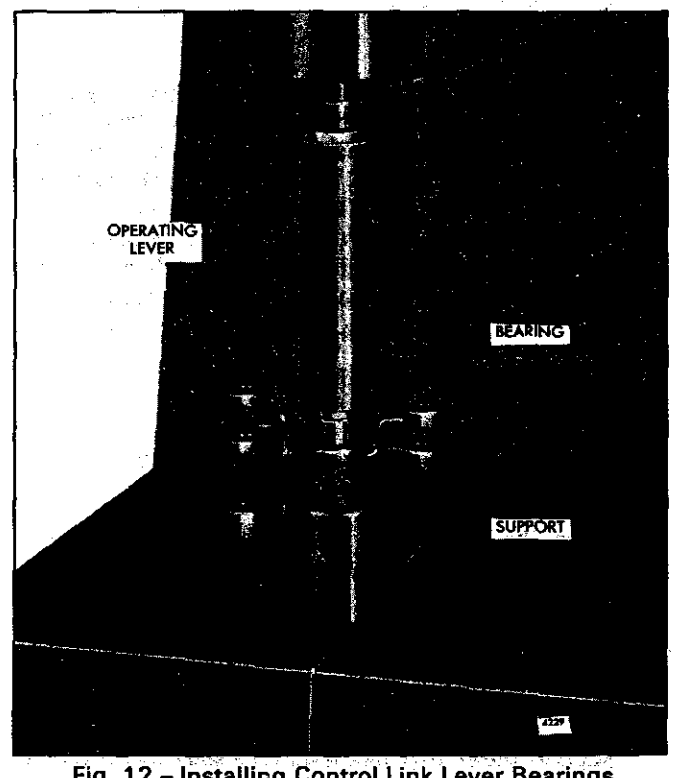


Fig. 12 – Installing Control Link Lever Bearings

LIMITING SPEED MECHANICAL GOVERNOR

(Variable Low–Speed)

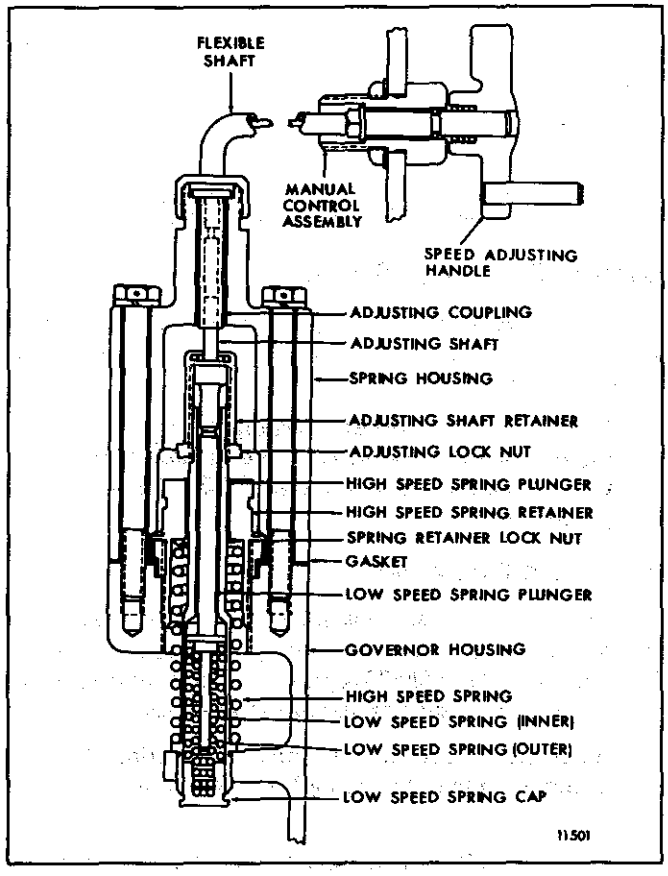


Fig. 1 – Cable Operated Governor Spring Housing and Components

The variable low–speed limiting speed mechanical governor used on In–Line and 6V–53 highway vehicle engines is of the double–weight type. It is used where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, grain or liquids) and a 500 to 1200 rpm idle speed range is desired during the auxiliary operation. A service kit is available to convert the short spring pack 6V–53 double weight limiting speed governor assembly to a cable operated variable low–speed limiting speed governor for 500–1600 rpm idle speed range for auxiliary operations.

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.L.S. stamped on the name plate denote a variable low–speed limiting speed mechanical governor.

- Conversion kits which provide existing limiting speed governors with variable low speed–limiting speed capability are available from DDC parts distributors.

Operation

During highway operation, the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the speed adjusting handle, on the cable operated governor (Fig. 1), is turned to the speed required within the above range to operate the auxiliary equipment. For the air operated governor (Fig. 3), the engine speed is changed to the speed required by increasing or decreasing the air supply pressure to the governor. The governor then functions as a variable speed governor, maintaining a constant speed when the load is constantly changing, during the unloading operation. Before resuming highway operations, the speed adjusting handle on the cable operated governor must be turned back to the stop, then turned ahead about one–quarter of a turn. The air operated governor's air supply pressure must be vented before resuming highway operations.

Lubrication

The governor is lubricated in the same manner as the limiting speed mechanical governor (Section 2.7.1 or 2.7.1.1).

Check Governor Operation

Governor difficulties should be checked out in the same manner as outlined in Section 2.7. If, after making the checks, the governor fails to control the engine or auxiliary equipment properly, it should be removed and reconditioned.

CABLE OPERATED GOVERNOR

Remove Governor From Engine

1. Disconnect the manual control flexible shaft from the governor spring housing.

2. Remove the governor following the same procedures outlined in Section 2.7.1 or 2.7.1.1.

Disassemble Governor

The variable low–speed limiting speed governor is similar to the limiting speed governor with the exception of the spring housing and its components. Therefore, disassemble the governor as outlined in Section 2.7.1 or 2.7.1.1, then disassemble the spring housing and its components (Fig. 1) as follows:

1. Clamp the flange of the governor housing in a vise equipped with soft jaws.

2. Remove the two bolts and lock washers securing the spring housing to the governor housing and withdraw the spring housing and gasket.

3. Remove the adjusting coupling from the adjusting shaft.

4. Hold the adjusting lock nut with a wrench and back off the retainer and adjusting shaft.

5. Unscrew the adjusting shaft from the retainer.

6. Unscrew the idle adjusting lock nut from the end of the high–speed spring plunger.

7. Unscrew the high–speed spring retainer lock nut and remove the high–speed spring retainer, plunger and spring along with the low–speed spring plunger, inner and outer springs and low–speed spring cap as an assembly from the governor housing.

8. Remove the high–speed spring retainer and spacer assembly and spring from the high–speed spring plunger. Remove the low–speed spring cap from the opposite end of the high–speed spring plunger and remove the low–speed spring plunger along with the inner and outer low–speed springs.

   The high–speed spring retainer on early engines did not include a spacer. If the shaft sticks in the retainer, replace it with the current retainer and spacer assembly.

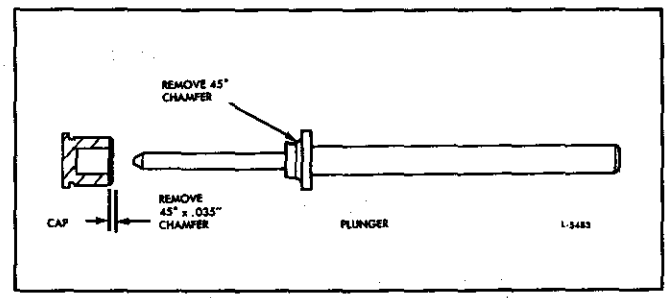


Fig. 2 – Rework Former Plunger and Cap

Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, then inspect them as outlined in Section 2.7.1 or 2.7.1.1.

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

Assemble Governor

During assembly, lubricate all spring housing components and needle bearing assemblies with MIL. G3278A, Aero Shell 7A grease, or equivalent (special grease for high and low temperature operations).

Assemble the governor as outlined in Section 2.7.1 or 2.7.1.1, then assemble the spring housing and components (Fig. 1).

To assure a 500 rpm idle speed, the spring seat chamfer has been removed from the low–speed spring plunger and cap. The internal chamfer has been removed from both ends of the coil of the outer low–speed spring. A high idle condition could be the result if an unchamfered spring did not seat properly due to the chamfer on the former plunger and cap. To correct this condition, install a current (modified) plunger and cap, or remove the 45° chamfer from the spring seat area of the plunger and also the 45° x .035" chamfer on the cap (shaded area, Fig. 2).

NOTICE: A chamfered spring should not be used with an unchamfered plunger and cap, because a severe wear condition will result.

1. Thread the spring retainer lock nut on the high–speed spring retainer approximately 1 1/2".

2. Place the high–speed spring on the high–speed spring plunger.

3. Insert the high–speed spring and plunger assembly in the high–speed spring retainer.

4. Insert the low–speed spring plunger into the high–speed spring plunger.

5. Place the inner and outer springs in the lower end of the high–speed spring plunger, over the low–speed spring plunger.

6. Install the low–speed spring cap over the end of the inner low–speed spring and into the end of the high–speed spring plunger and install the assembly in the governor housing. *Place the spring housing gasket in position before installing the assembly.*

7. Thread the idle speed adjusting lock nut on the threaded end of the high–speed spring plunger approximately 1/2".

8. Screw the adjusting shaft into the adjusting shaft retainer all the way in as shown in Fig. 1.

9. Install the adjusting retainer and shaft onto the high–speed spring plunger. Turn down the adjusting retainer against the idle speed adjusting lock nut.

10. Install the adjusting coupling and spring housing after the governor adjustments (Section 14.3.3) have been performed.

Install Governor

Install the governor as outlined in Section 2.7.1 or 2.7.1.1, then connect the manual control flexible shaft to the governor spring housing (Fig. 1).

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

Adjust the governor as outlined in Section 14.3.3.

AIR OPERATED GOVERNOR

Remove Governor From Engine

1. Disconnect the air controls from the governor spring housing.

2. Remove the governor following the same procedures outlined in Section 2.7.1 or 2.7.1.1.

Disassemble Governor

The air operated variable low–speed limiting speed governor is similar to the limiting speed governor with the exception of the spring housing and its components. Therefore, disassemble the governor as outlined in Section 2.7.1 or 2.7.1.1, then disassemble the spring housing and its components (Fig. 3) as follows:

1. Clamp the flange of the governor housing in a vise equipped with soft jaws.

2. Remove the two bolts and lock washers securing the spring housing to the governor housing and withdraw the spring housing and gasket. Discard the gasket.

3. Loosen the 5/16"–24 idle speed jam nut and remove the idle speed adjusting screw, seal ring and nut as an assembly. Discard the seal ring.

4. Hold the 1/2"–20 jam nut on the high–speed spring plunger with a wrench and unscrew the air cylinder cap, retainer ring, pin, piston, air cylinder and seal ring as an assembly from the end of the high–speed spring plunger.

   a. Disengage the retainer ring from the air cylinder and remove the air cap and piston from the air cylinder.

   b. Remove the seal ring from the piston. Discard the seal ring.

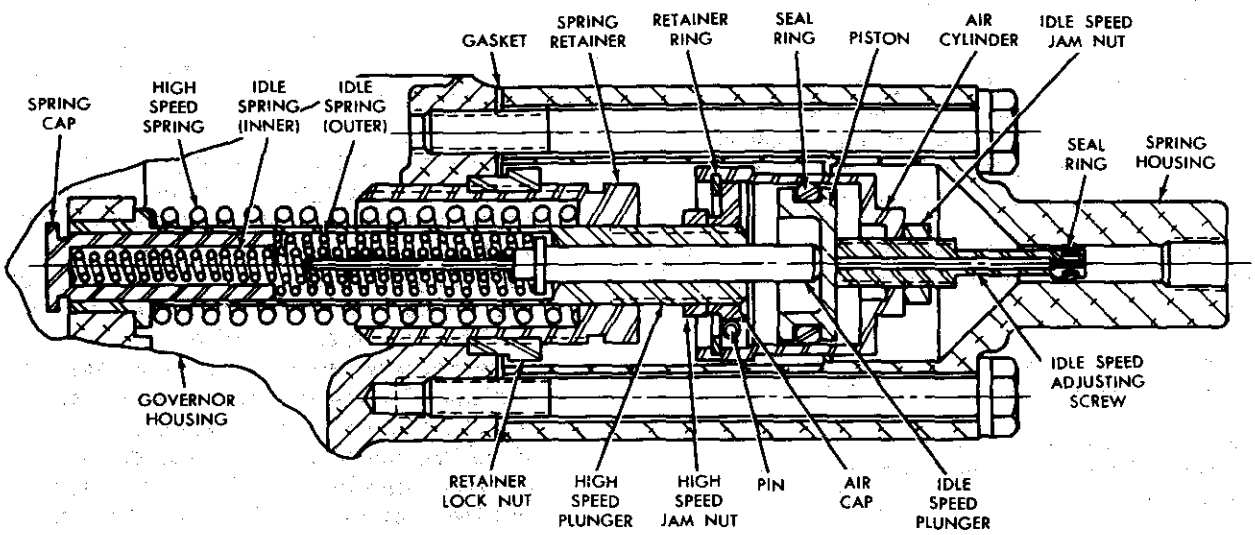
5. Unscrew the high–speed spring retainer lock nut and remove the high–speed spring retainer, plunger and spring along with the low speed spring plunger, inner and outer springs and low–speed spring cap as an assembly from the governor housing.

6. Remove the high–speed spring retainer and spacer assembly and spring from the high–speed spring plunger. Remove the low–speed spring cap from the opposite end of the high–speed spring plunger and remove the low–speed spring plunger along with the inner and outer low–speed springs.

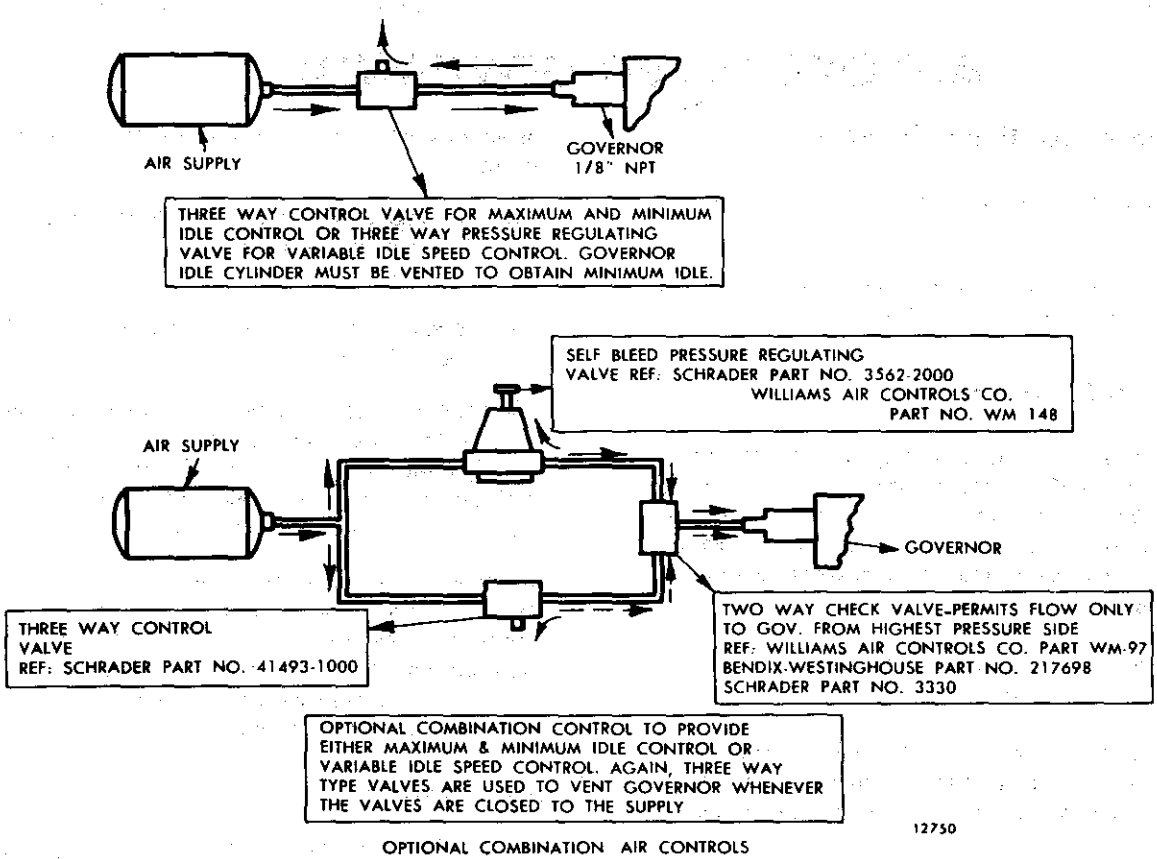
Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, then inspect them as outlined in Section 2.7.1 or 2.7.1.1.

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



AIR OPERATED VARIABLE LOW SPEED LIMITING SPEED GOVERNOR



OPTIONAL COMBINATION AIR CONTROLS

Fig. 3 – Air Operated Variable Low Speed Limiting Speed Governor and Air Controls

Assemble Governor

During assembly, lubricate all spring housing components with MIL. G3278A, Aero Shell 7A grease, or equivalent (special grease for high and low temperature operations).

Assemble the governor as outlined in Section 2.7.1 or 2.7.1.1, then assemble the spring housing and components (Fig. 3) as follows:

1. Thread the spring retainer lock nut approximately 1–1/2″ onto the high–speed spring retainer.
2. Place the high–speed spring on the high–speed spring plunger.
3. Insert the high–speed spring and plunger assembly in the high–speed spring retainer.
4. Insert the low–speed spring plunger into the high–speed spring plunger.
5. Place the inner and outer springs in the lower end of the high–speed spring plunger, over the low–speed spring plunger.
6. Install the low–speed spring cap over the end of the inner low–speed spring and into the end of the high–speed spring plunger and install the assembly in the governor housing. *Place the new spring housing gasket in position before installing the assembly.*
7. If removed, thread the 1/2″–20 high–speed spring jam nut approximately 1/2″ onto the threaded end of the plunger.
8. Place a new seal ring on the piston and assemble the piston and air cap in the air cylinder. Secure them in the air cylinder with the retainer ring.
9. Screw the air cylinder assembly onto the high–speed spring plunger and against the high–speed spring plunger and jam nut.
10. Place a new seal ring on the idle adjusting screw and install the adjusting screw and jam nut in the air cylinder.
11. Install the spring housing after the governor adjustments (Section 14.3.3) have been performed.

    Be sure and lubricate the bore of the spring housing with grease as stated previously.

Install Governor

Install the governor as outlined in Section 2.7.1 or 2.7.1.1, then connect the air controls to the governor spring housing (Fig. 3).

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

  Adjust the governor as outlined in Section 14.3.3.

