SECTION 2

FUEL SYSTEM AND GOVERNORS

CONTENTS

FUEL SYSTEM

The fuel system (Fig. 1) includes the fuel injectors, fuel pipes (inlet and outlet), fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter and fuel lines.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Leaving the pump under pressure, the fuel is forced through the fuel filter and into the inlet fuel manifold, then through fuel pipes into the inlet side of each fuel injector.

The fuel manifolds are identified by the words "IN" (top passage) and "OUT" (bottom passage) which are cast or stamped in several places in the side of the cylinder head. This aids installation of the fuel lines.

Surplus fuel returns from the outlet side of the injectors to the fuel return manifold and then back to the supply tank.

All engines are equipped with a restrictive fitting in the fuel outlet manifold in one of the cylinder heads on 6 and 8V engines (two of the cylinder heads on 12 and 16V engines) to maintain the fuel system pressure. Refer to Section 13.2 for the size fitting required.

A check valve may be installed in the supply line between the fuel tank and the fuel strainer to prevent fuel from draining back when the engine is shut down.

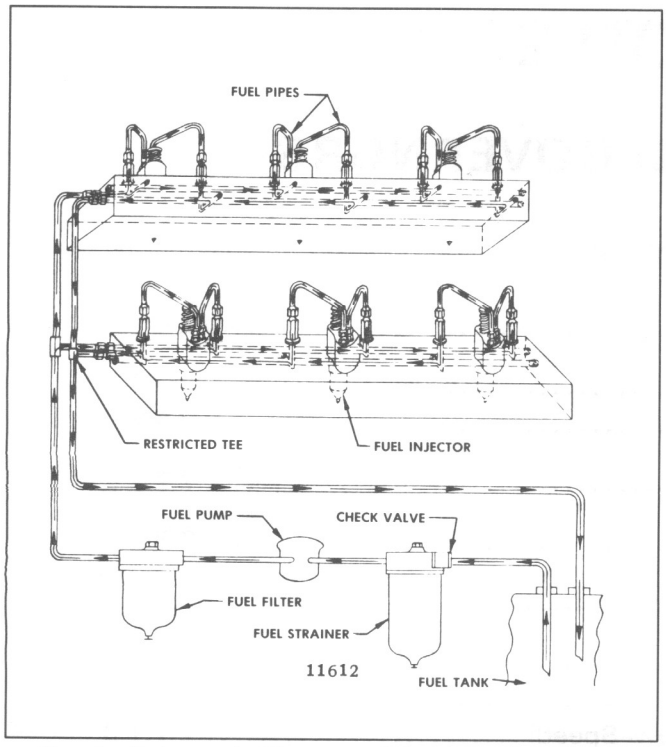

Fig. 1 – Schematic Diagram of Typical Fuel System

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.

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

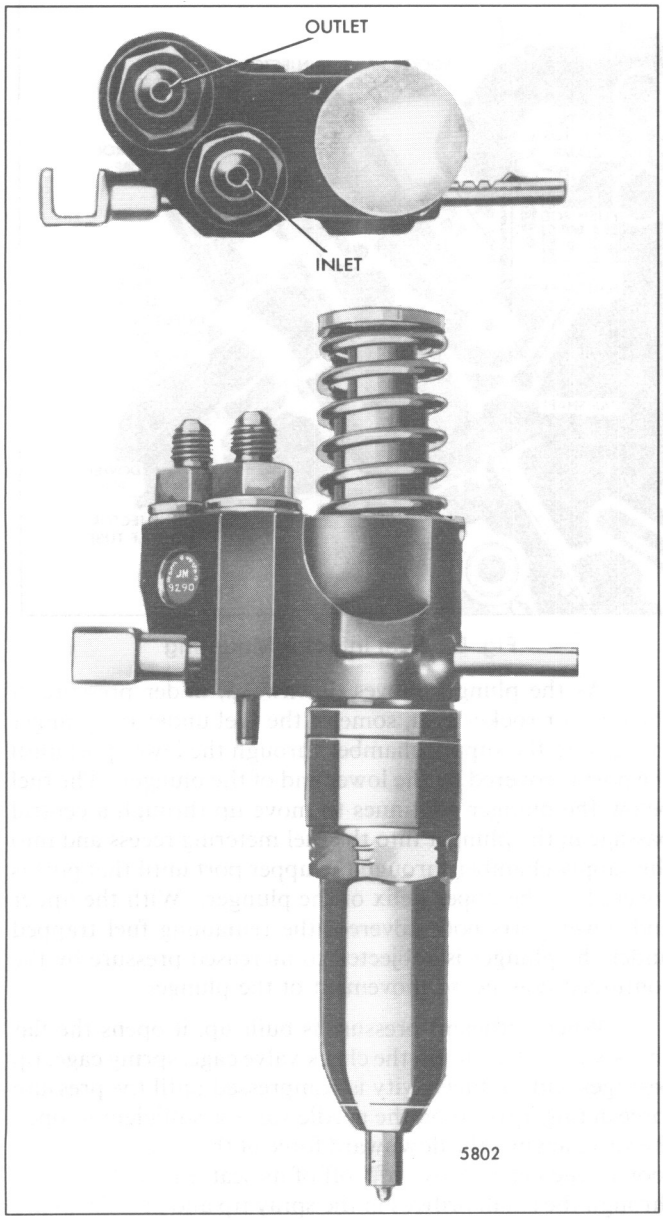

Fig. 1 – Fuel Injector Assembly

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.

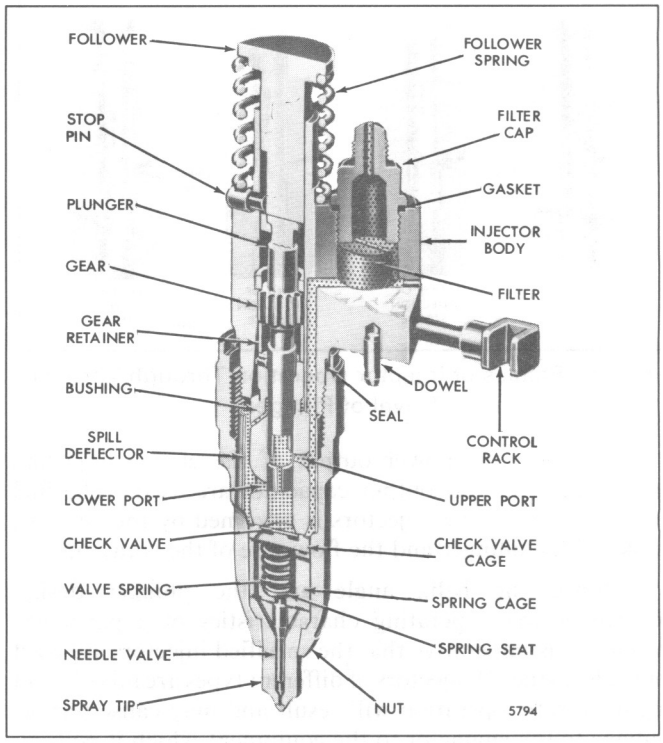

Fig. 2 – Cutaway View of Fuel Injector

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.

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.

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.

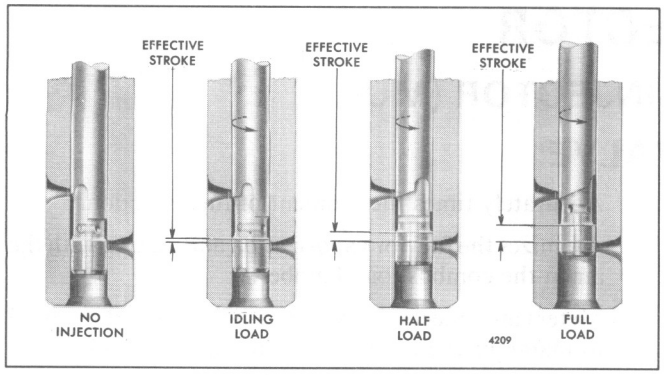

Fig. 3 – Fuel Metering from No Load to Full Load

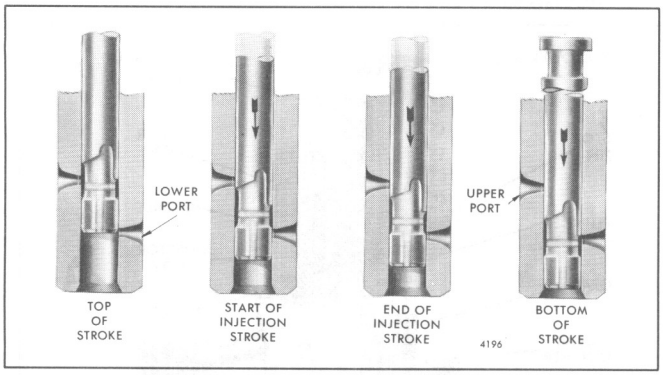

Fig. 4 – Phases of Injector Operation Through Vertical Travel of Plunger

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.

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.

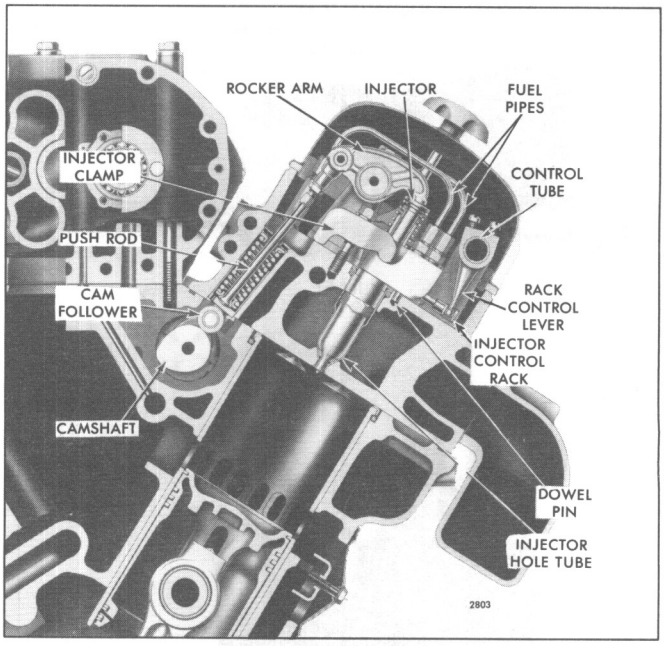

Fig. 5 – Fuel Injector Mounting

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.

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.

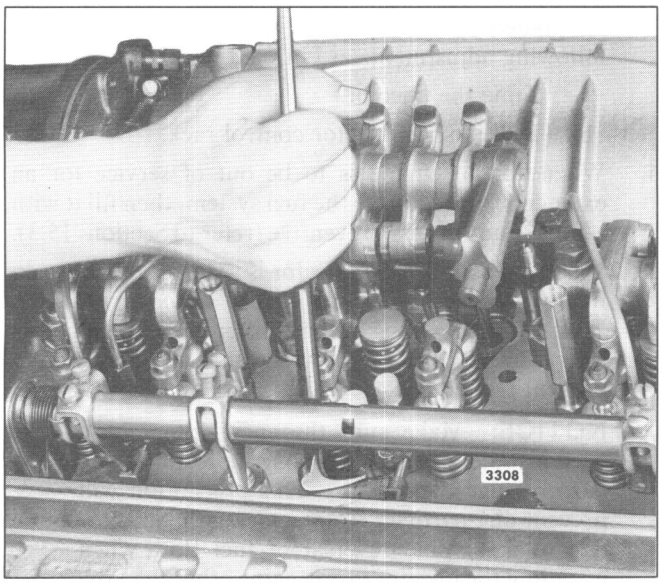

Fig. 6 – Removing Injector from Cylinder Head

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.

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.

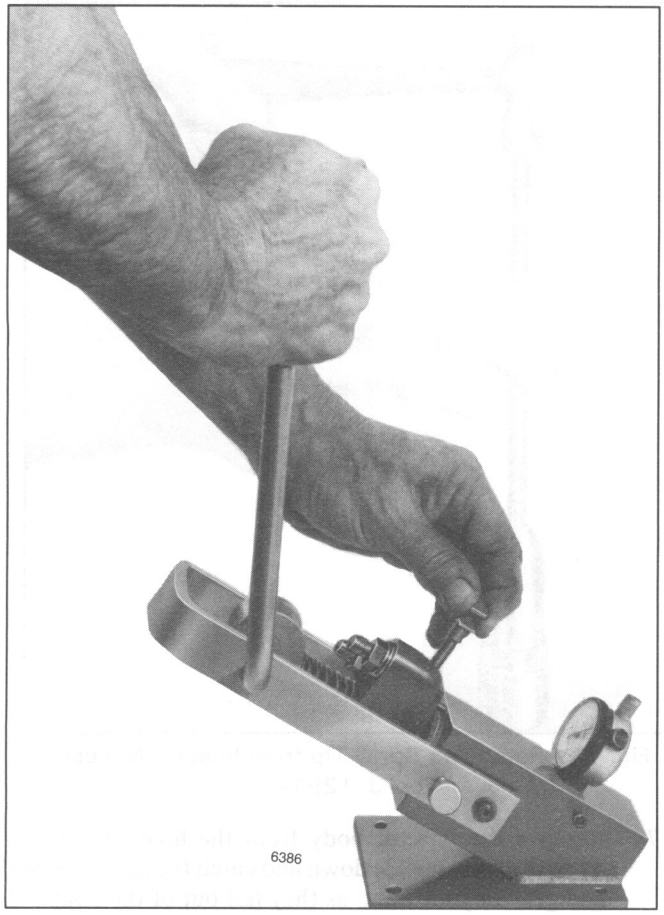

Fig. 7 – Checking Rack for Freeness in Tester J 29584

If the results of the above tests reveal marginal performance, removal of the plunger may assist with further diagnosis of internal injector problems. Plunger 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.
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).

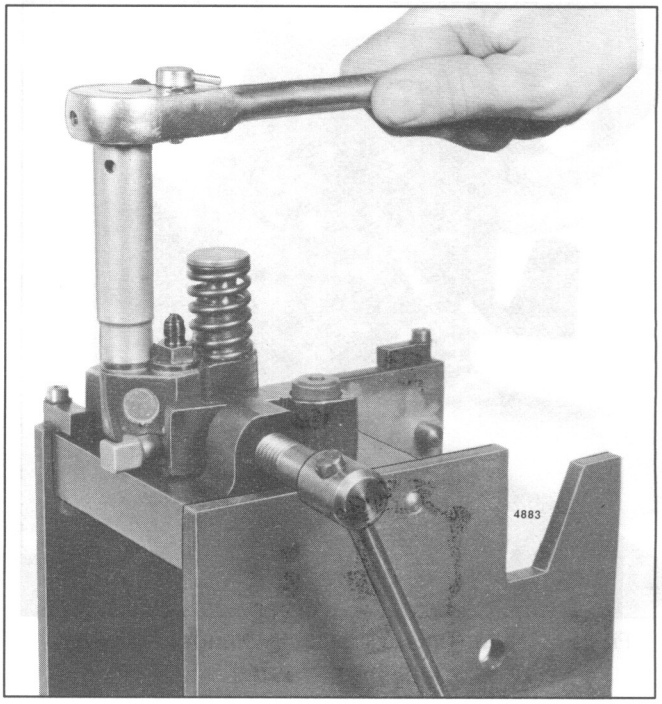

Fig. 8 – Removing Filter Cap

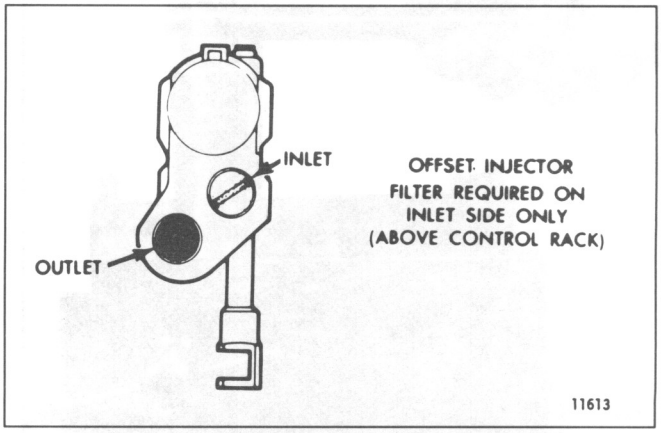

Fig. 9 – Location of Filter in Injector Body

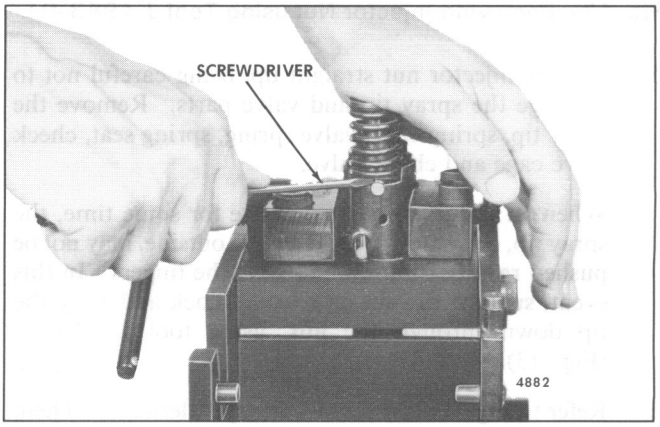

Fig. 10 – Removing Injector Follower Stop Pin

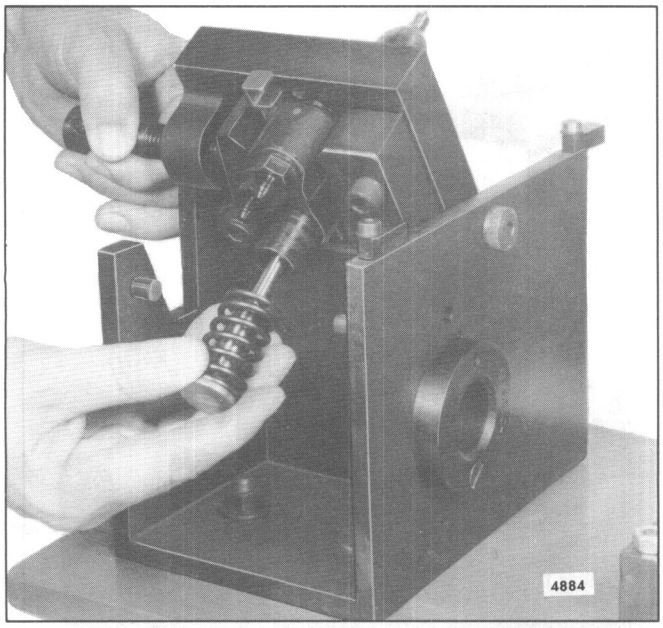

Fig. 11 – Removing or Installing Plunger Follower, Plunger and Spring

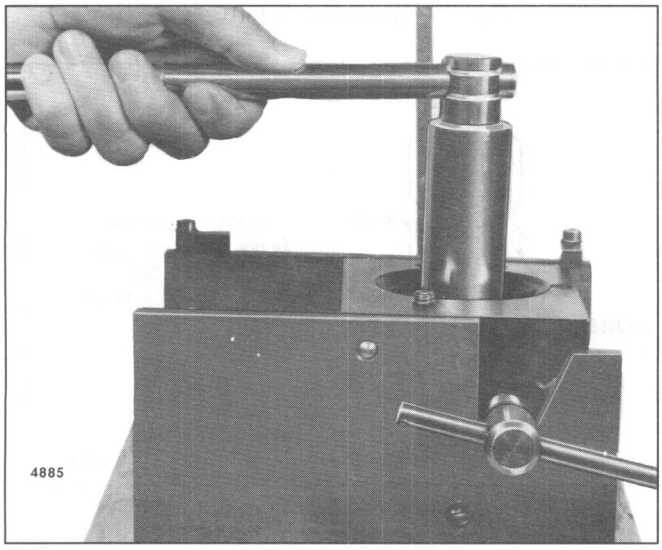

Fig. 12 – Removing Injector Nut using Tool J 4983–01

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.

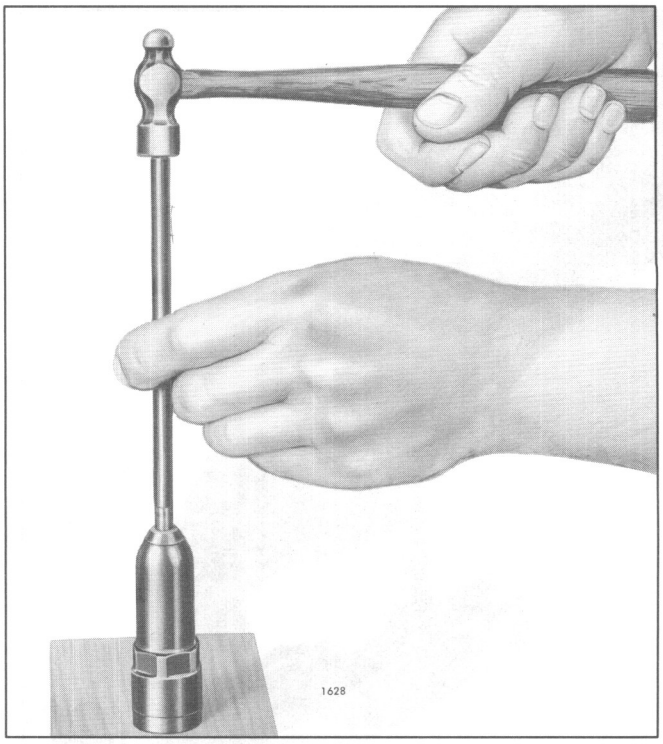

Fig. 13 – Removing Spray Tip from Injector Nut using Tool J 1291–02

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.

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

Use lint free towels to wipe off the parts. Clean out the passages, drilled holes and slots in all of the injector parts.

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.

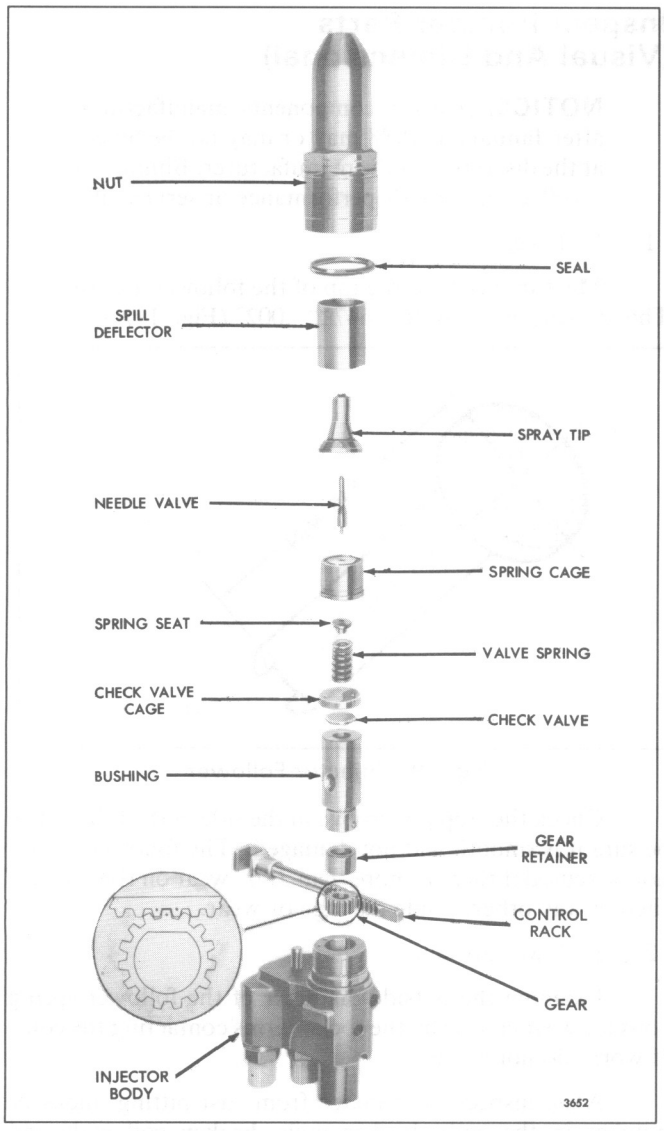

Fig. 14 – Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

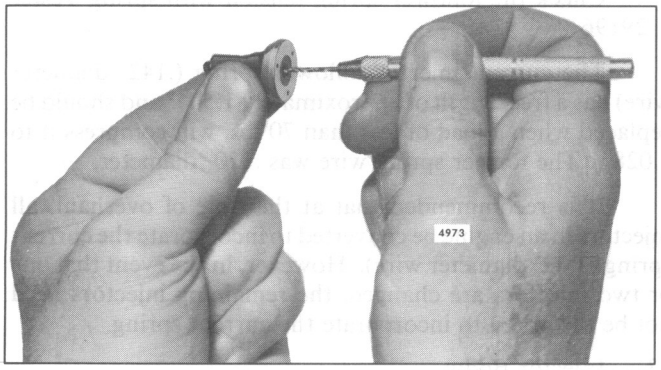

Fig. 15 – Cleaning Injector Spray Tip with Tool J 24838

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).

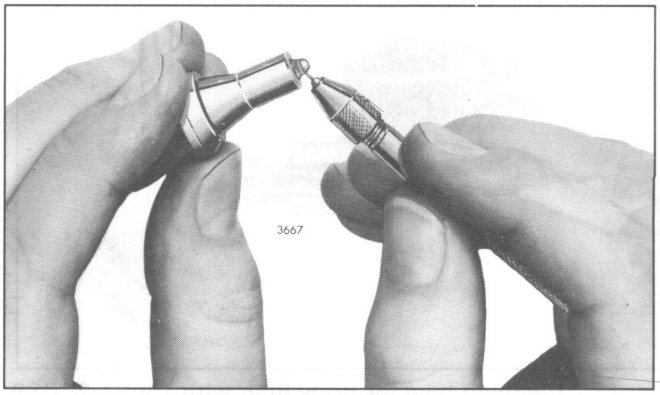

Fig. 16 – Cleaning Spray Tip Orifices with Tool J 4298–1

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.

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.

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.

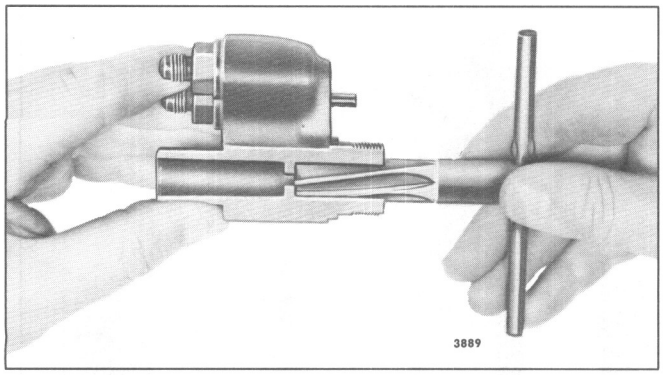

Fig. 17 – Cleaning Injector Body Ring with Tool J 21089

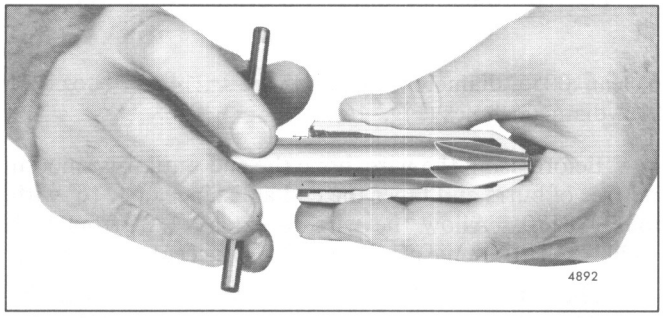

Fig. 18 – Cleaning Injector Nut Lower End with Tool J 9418–5

Carefully, insert reamer (J 21089) into the ring bore of the injector body. Turn the reamer in a clockwise direction and remove any burrs inside the ring bore. Do not dislodge the ring. Then, wash the injector body in clean solvent and dry it with compressed air.

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.

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)

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. 19).

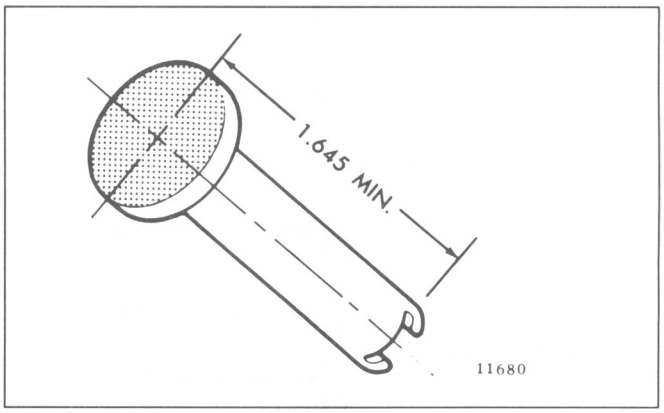

Fig. 19 – Injector Follower

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 (1.42" 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 of 1985, P&B (plunger and bushing) assemblies 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 bushing. New 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 components of P&B assemblies are supplied as matched sets, any attempt to mix them can result in P&B seizure and serious injector damage.

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.

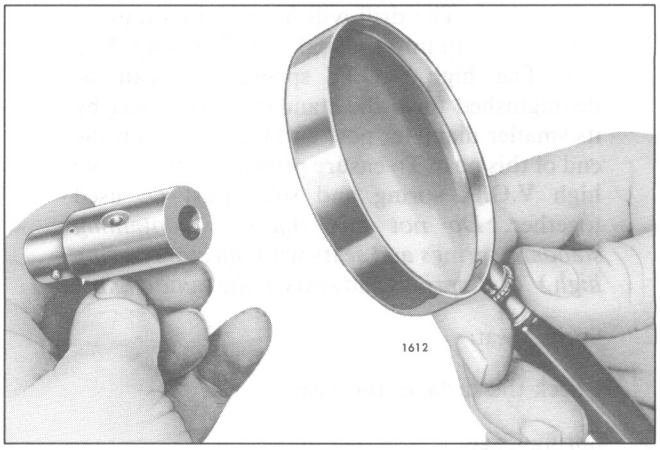

Fig. 20 – Examining Sealing Surface with a Magnifying Glass

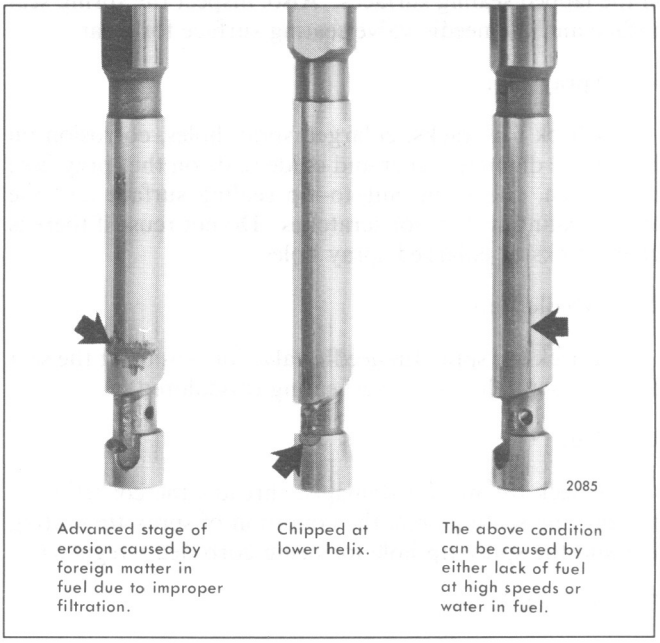

Fig. 21 – Unusable Injector Plungers

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 (Fig. 31). The high V.O.P. spring seat can be distinguished form 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).

19. Needle Valve Lift:

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)

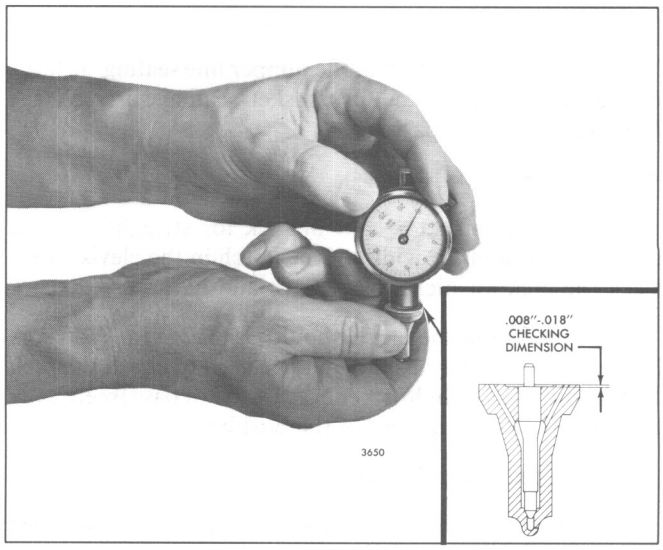

Fig. 22 – Checking Needle Valve Lift with Tool J 9462–02

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.

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 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. 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. Body:

   ■Lap bushing seat.

   ■Reblue (*optional*).

   ■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 (*optional*).

   ■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:

   ■If scored, cracked or if residue cannot be removed, replace plunger and bushing assembly.

   ■Lap the check valve seat (sealing) surface.

8. Plunger:

   ■Clean – remove varnish.

   ■If scored, chipped or scratched, replace plunger and bushing assembly.

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., erroded spray holes.

15. Nut:

    ■ Remove carbon from the seat and tapered I.D.

    ■ Reblue (*optional*).

    ■ Replace if the threads are damaged more than 10% or if the small I.D. is badly erroded.

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.

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). It is not recommended to lap the surface of a *new* current spray tip.

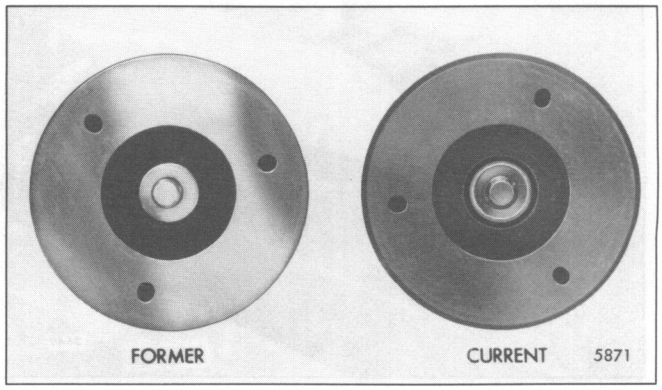

Fig. 23 – Spray Tip Sealing Surface Identification

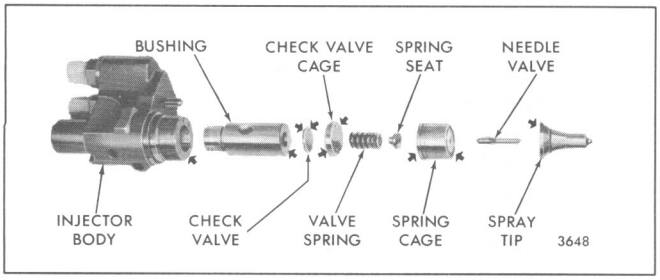

Fig. 24 – Sealing Surfaces which may Require Lapping

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 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.

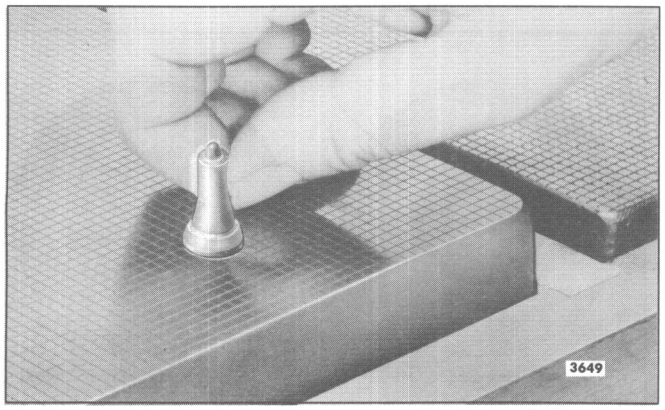

Fig. 25 – Lapping Spray Tip on Lapping Blocks J 22090

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.
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.

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 filter (stainless steel wire mesh pellet) is installed dimple end down, slotted end up. The current service filter (fiberglass–filled nylon cone) must be 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 the filter caps to 65–75 lb–ft (88–102 N•m) torque with a 9/16" deep socket (Fig. 28).

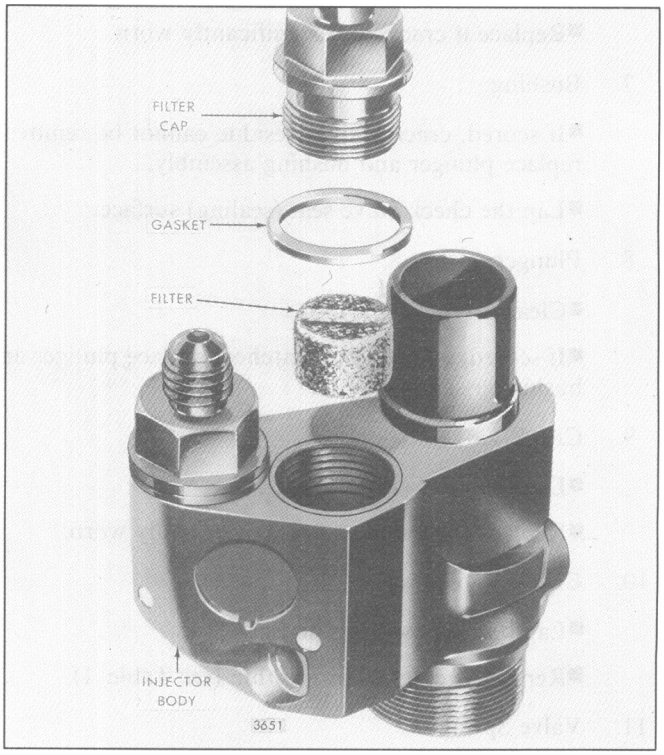

Fig. 26 – Details of Injector Filters and Caps and Their Relative Location

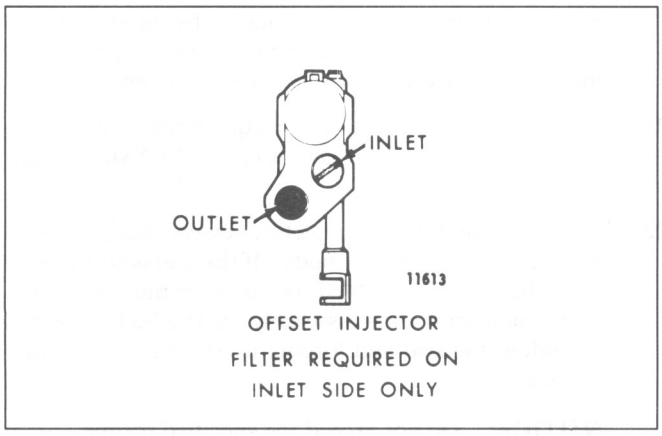

Fig. 27 – Location of Filter in Injector Body

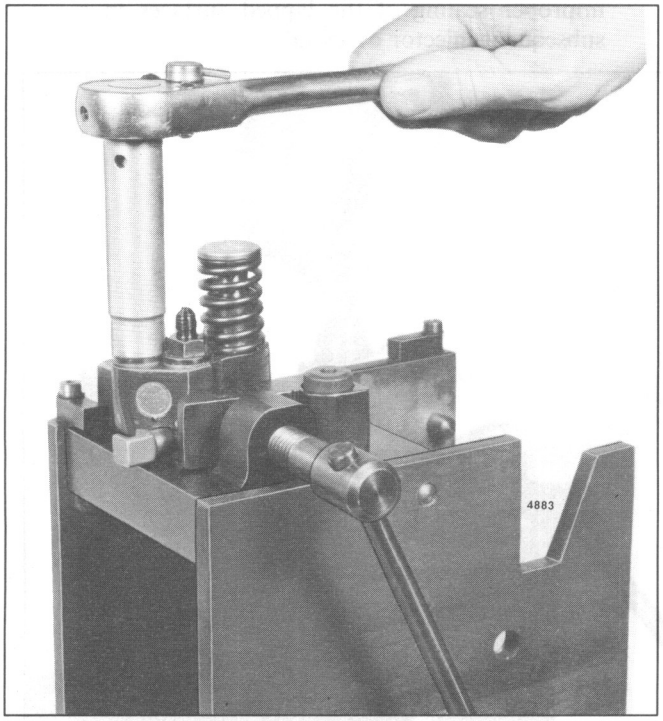

Fig. 28 – Installing Filter Cap

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 is serviced.

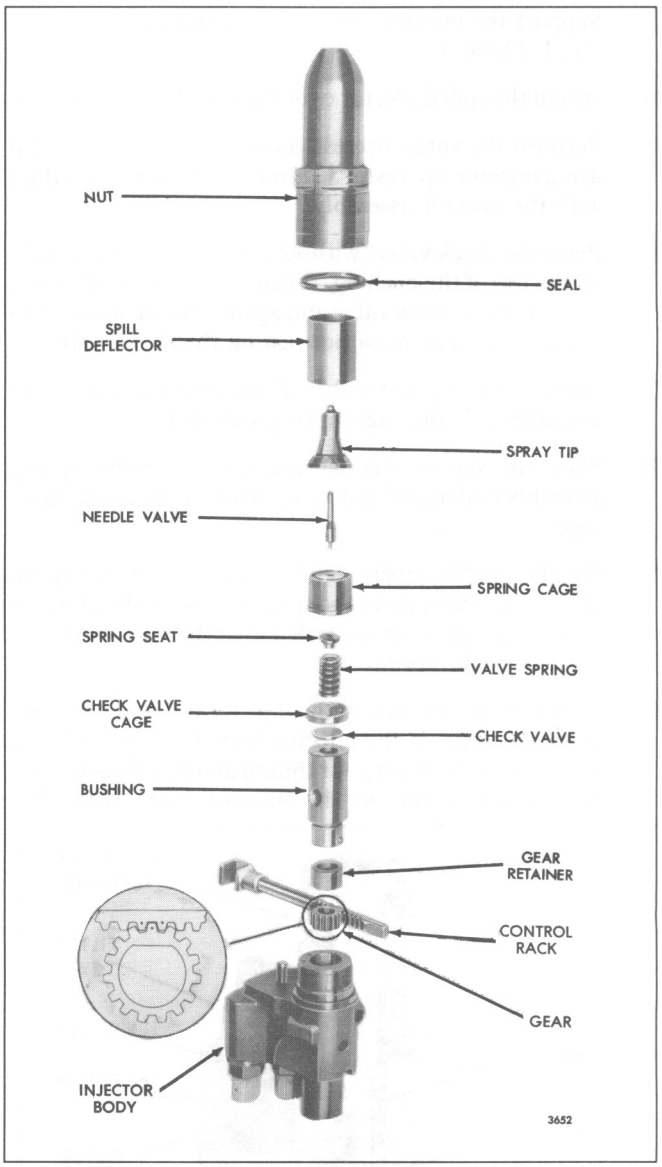

Fig. 29 – Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

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.

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.

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.

19. Put the needle, tapered end down, into the spray tip (Fig. 30). 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. 31). 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 to 75–85 lb–ft (102–115 N•m) torque (Fig. 32).

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.

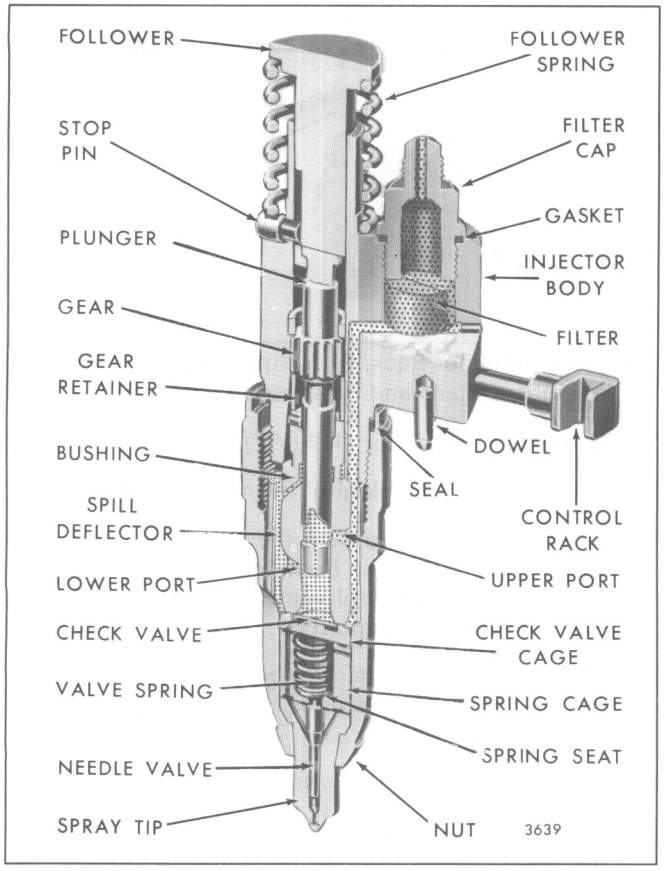

Fig. 30 – Cutaway View of Fuel Injector

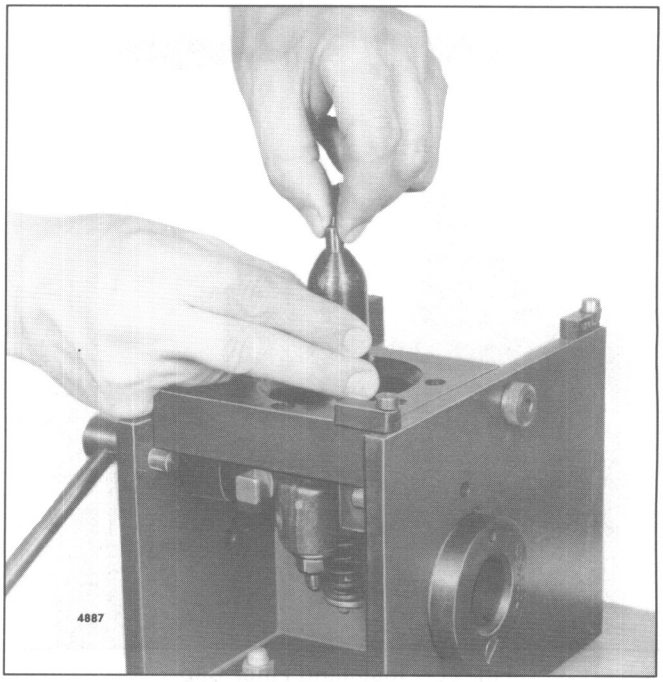

Fig. 31 – Tightening Injector Nut by Hand

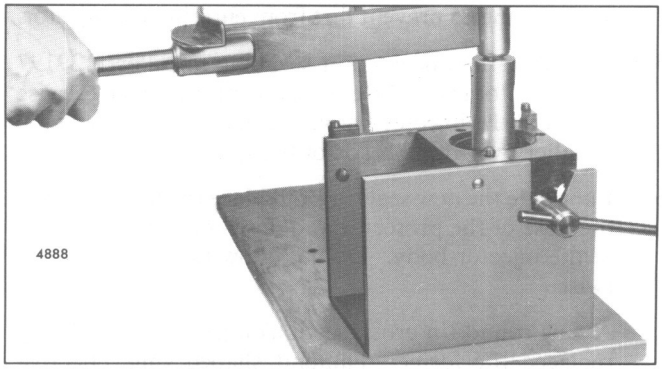

Fig. 32 – Tightening Injector Nut with Torque Wrench using Tool J 4983–01

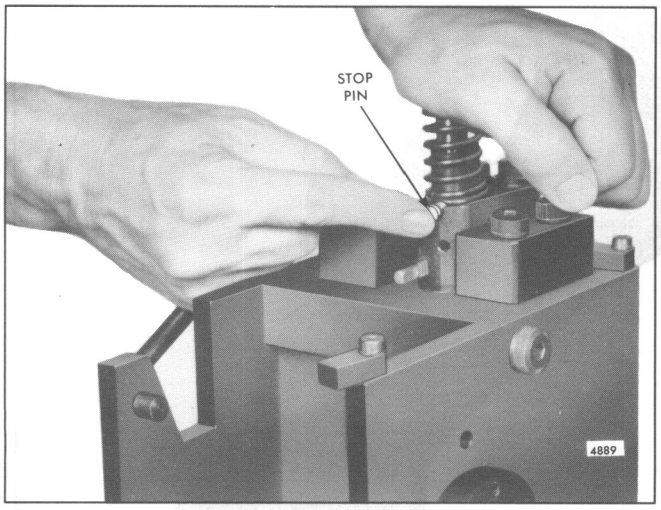

Fig. 33 – Installing Injector Follower Stop Pin

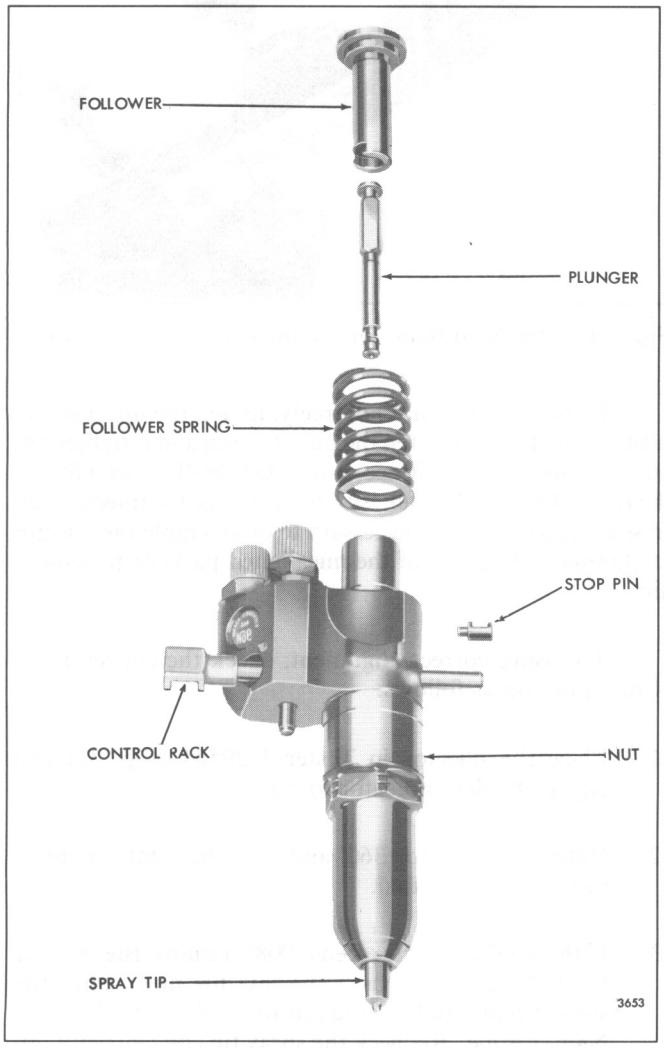

Fig. 34 – Injector Plunger, Follower and Relative Location of Parts

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. 33 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. 34 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.

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. 35).
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.

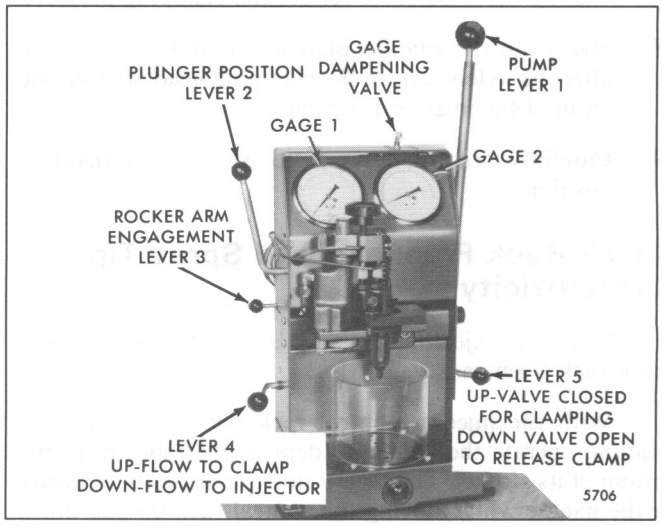

Fig. 35 – Injector in Position for Testing with Tester J 23010–A

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. 35).
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 clean 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. 36) 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.

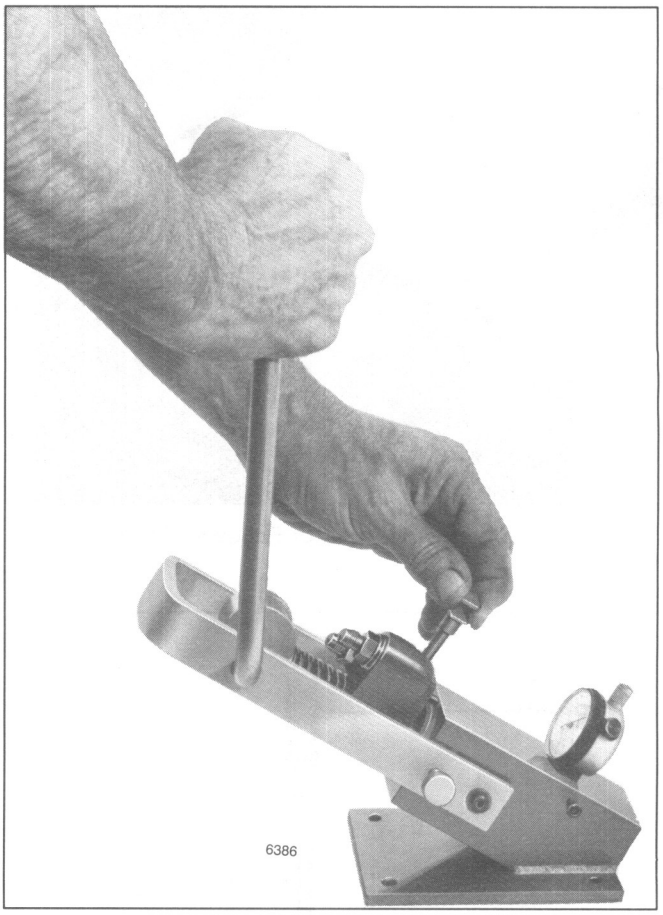

Fig. 36 – Checking Rack for Freeness in Tester J 29584

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. 36) 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 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. 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.

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

Jumper Line 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)
DDEC Engines	145 lb-in. (15.6 N·m)

**Not serviced. Available from Jacobs Manufacturing Company.*

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•**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 and Reuse & 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.

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.

FUEL INJECTOR TUBE

The bore in the cylinder head for the fuel injector is directly through the cylinder head water jacket (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 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 distinguished 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 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.

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 enable 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 now 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 senstive 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 to 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 cylinder head as outlined in Section 1.2.

2. Place the injector tube installer J 5286–4C in the injector tube. This tool or installer J 5486–20 may be used with semi–finished, service–only injector hole tubes (identified by the number "606" stamped on the top flange). 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).

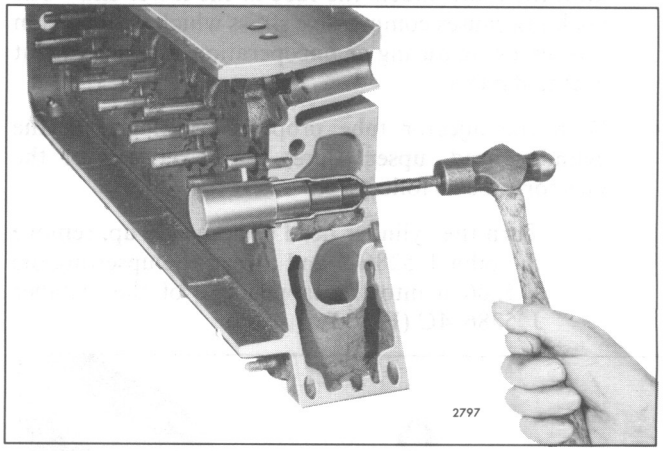


Fig. 1 – Removing Injector Tube with Tools J 5286–4C and J 5286–5

3. Tap on the end of the pilot to loosen the injector tube. Then, lift the injector tube, installer 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.

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".

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 properlyinstall the tube. If there is no clearance at the flange, the tube will buckle slightly during installation until the toolcontacts the tube at the lower end. The buckling causes compressive stress which will result in tube cracking during engineoperation and subsequent engine damage.

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. 3).

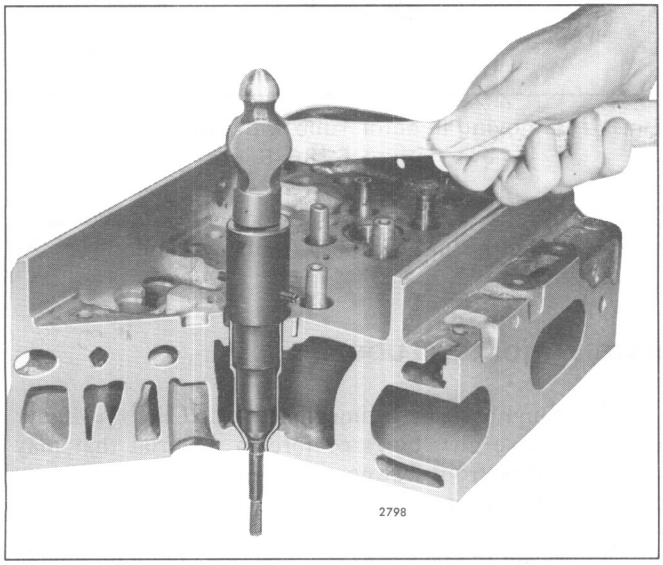


Fig. 2 – Installing Injector Tube with Tools J 5286–4C and J 5286–5

   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.

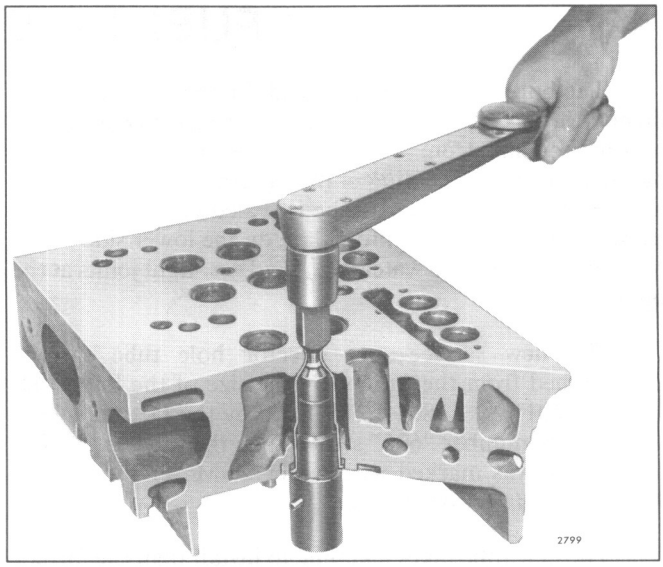


Fig. 3 – Upsetting Injector Tube with Tools J 5286–4C and J 5286–6

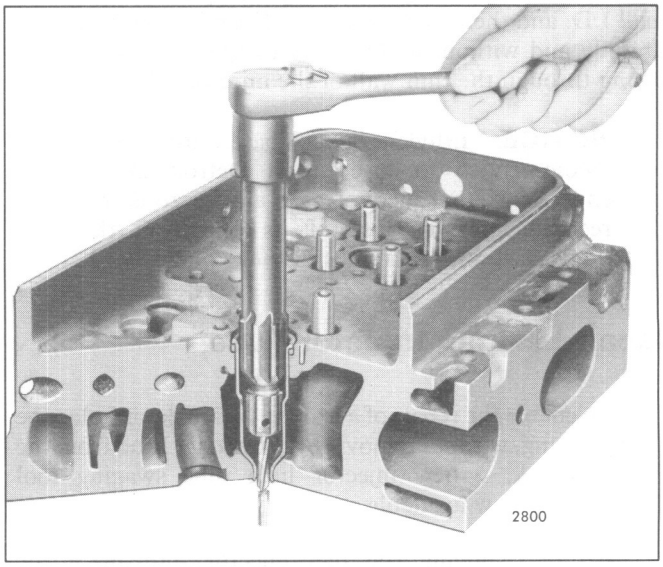


Fig. 4 – Reaming Injector Tube for Injector Body Nut and Spray Tip with Tool J 22525–1

Ream Injector Tube

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

First, *hand reamed,* (Fig. 4) 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,* (Fig. 5) to provide a good seating surface for the bevel or the lower end of the injector nut.

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.

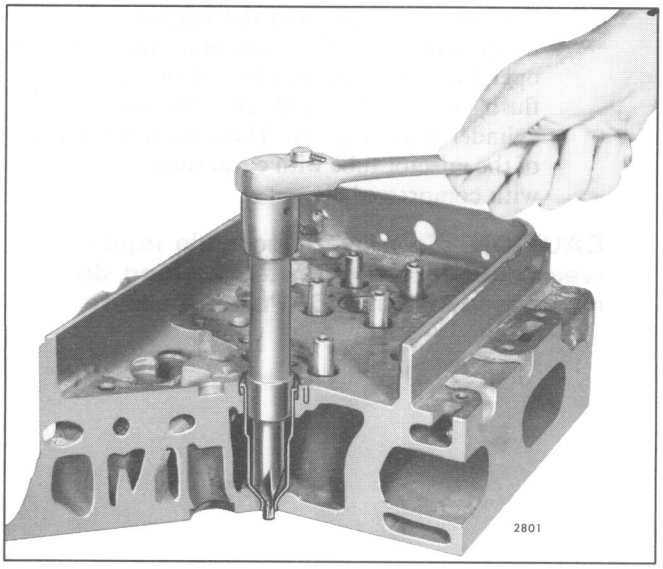


Fig. 5 – Reaming Injector Tube for Injector Nut with Tool J 5286–9

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. 4). 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.

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. 6.

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. 7).

NOTICE: 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. 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.

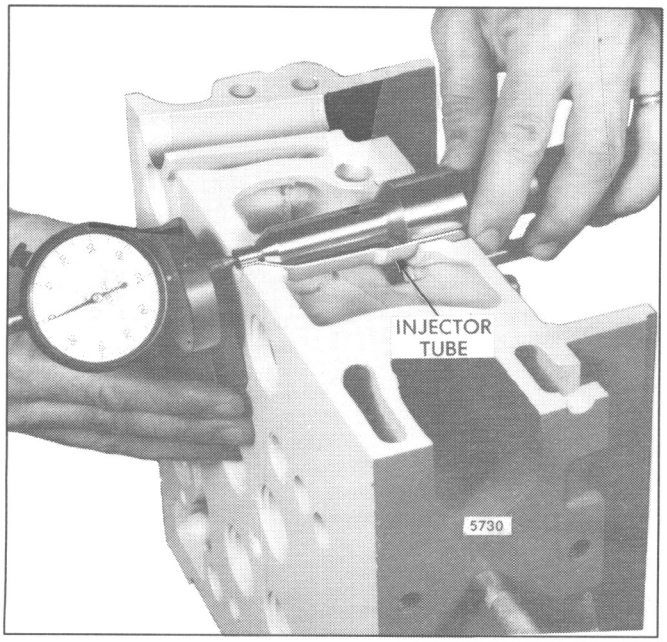


Fig. 6 – Measuring Relationship of Bevel Seat of Injector Tube to Fire Deck of Cylinder Head with Tool J 25521 and Gage J 22273

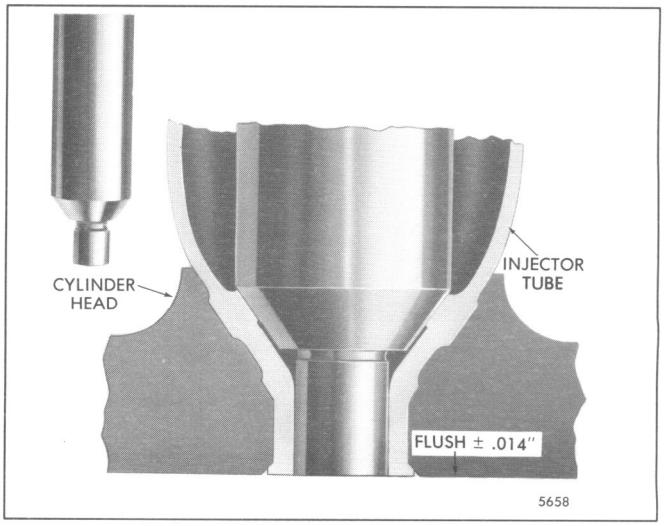


Fig. 7 – Measuring Relationship of Gage to Fire Deck of Cylinder Head with Tool J 25521

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. 7). 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.

FUEL PUMP

The positive displacement gear–type fuel pump (Fig. 1) transfers fuel from the supply tank to the fuel injectors. 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.

The fuel pump is attached to the governor housing with three nylon patch bolts which prevents the oil in the governor housing from seeping out around the bolt threads. The pump is driven off the end of the right–hand helix blower rotor by means of a drive coupling fork attached to the end of the pump drive shaft and mating with a drive disc attached to the blower rotor (Fig. 2). The fuel pump is a left–hand rotating pump. Regardless of engine rotation, the pump will always rotate in a left–hand rotation.

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 means of two dowels. The dowels aid in maintaining gear shaft alignment. The mating surface 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.

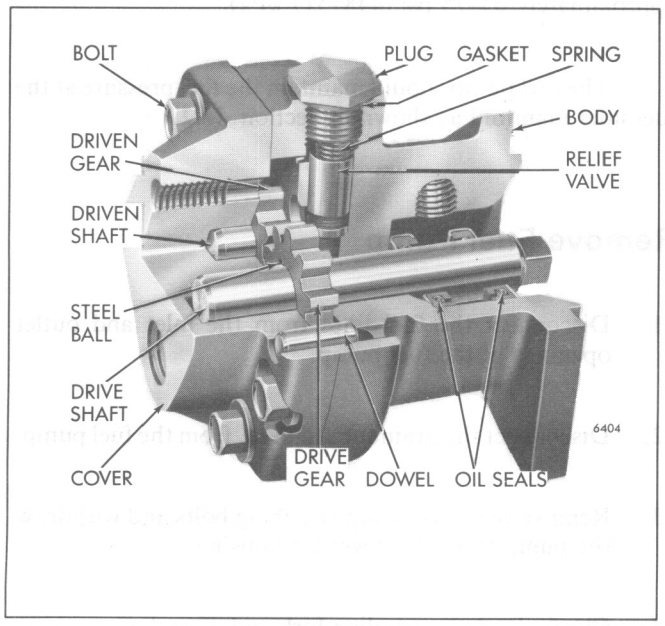


Fig. 1 – Typical Fuel Pump Assembly

The fuel pump body is recessed to provide running space for the pump gears (Fig. 3). 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 governor housing (Fig. 4). A small hole "E" (Fig. 3) 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 the same as the high lift fuel pumps, with the lips of the seals facing in the opposite direction of each other (Fig. 4). The former fuel pumps have the nitrile seals installed with both seal lips facing the mounting flange end of the pump. Both the polyacrylate and 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 retension between the seals could

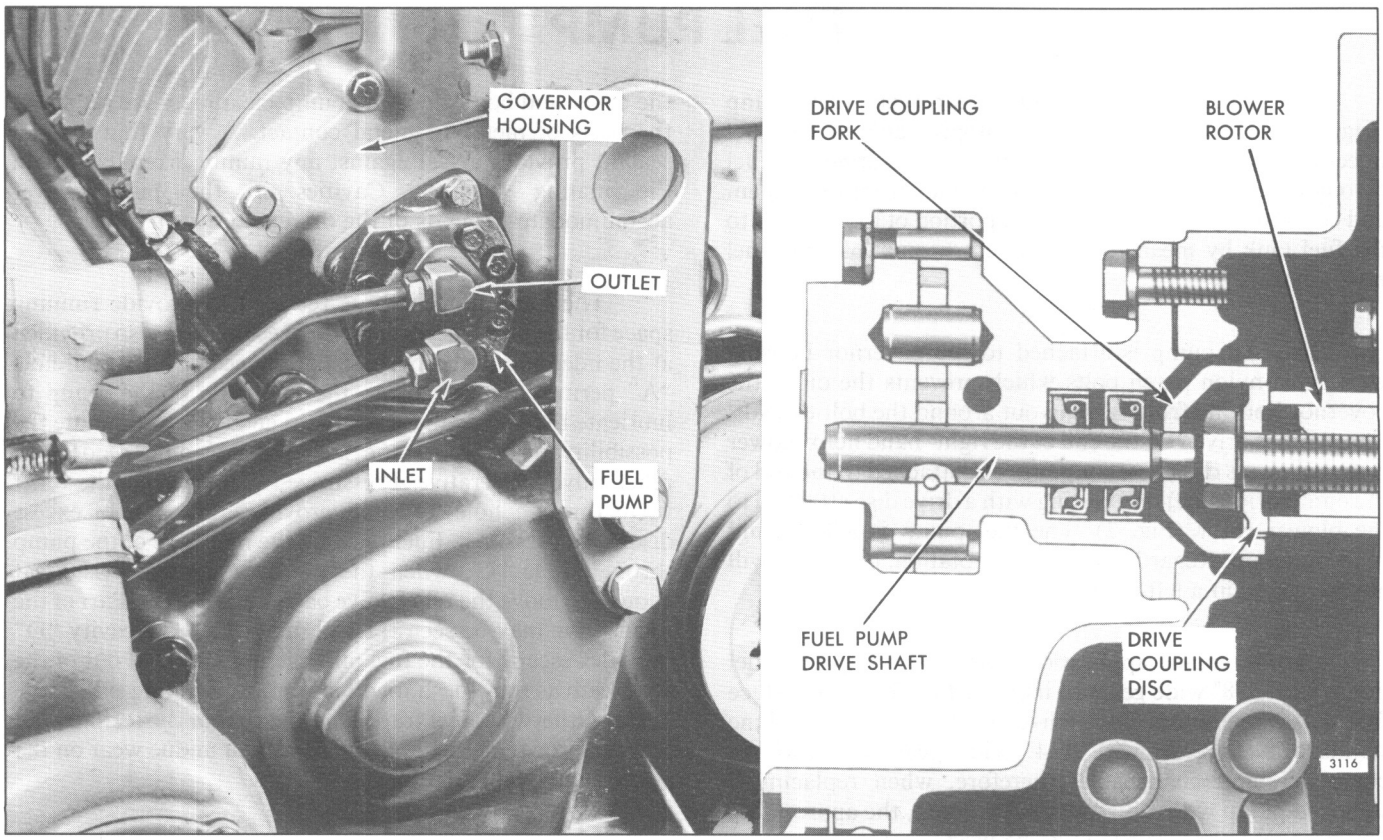


Fig. 2 – Typical Fuel Pump Mounting and Drive

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.

The drive and driven gears are a line–to–line to .001" press fit on their shafts. The drive gear is provided with a gear retaining ball to locate the gear on the shaft (Fig. 2).

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 oil 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 bypassing the fuel from the outlet side of the pump to the inlet side when the discharge pressure reaches approximately 65–75 psi (448–517 kPa).

The fuel pump should maintain the fuel pressure at the fuel inlet manifold as shown in 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 from the governor housing.

4. Check the drive coupling fork and, if broken or worn, replace it with a new coupling.

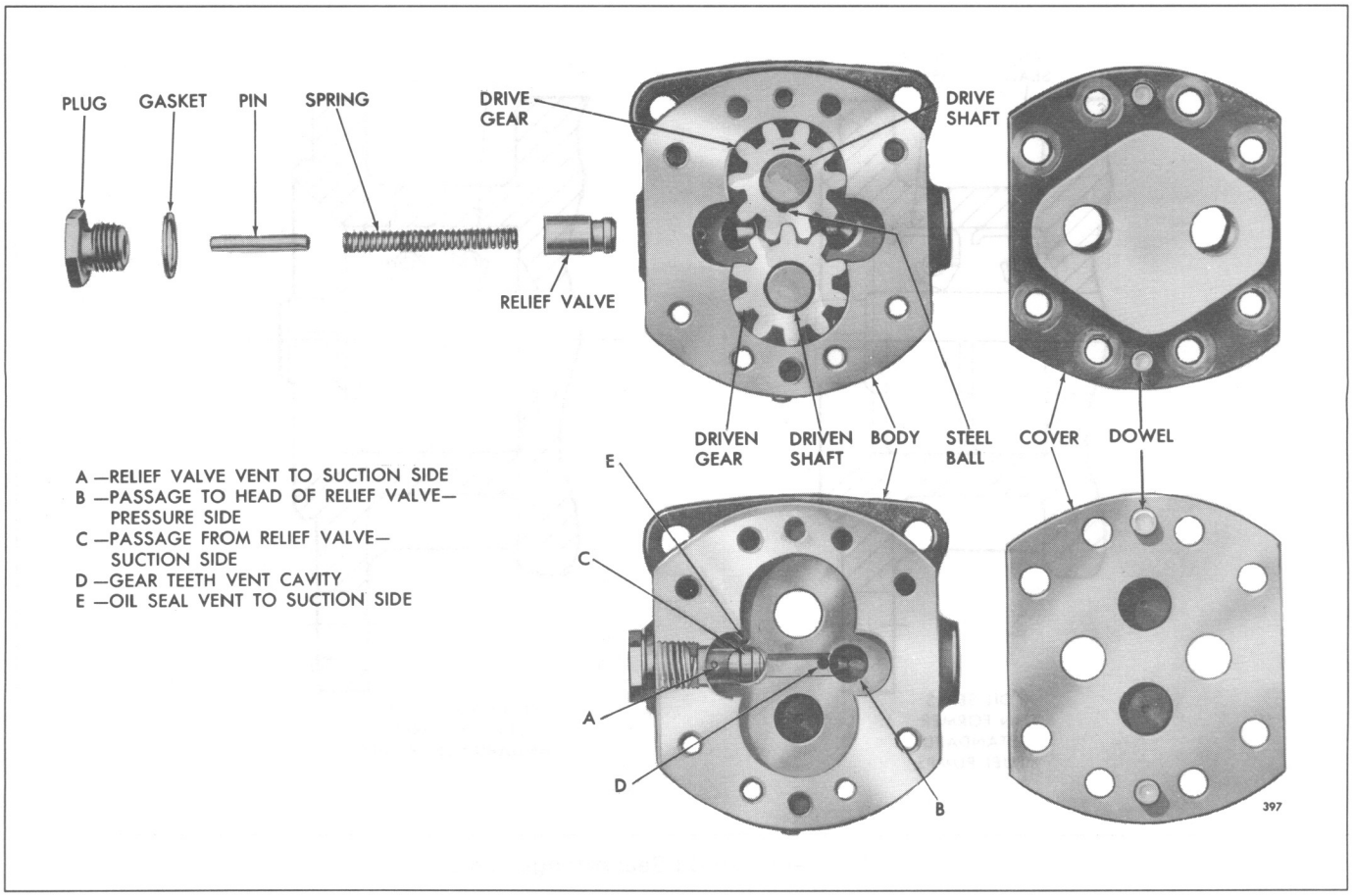


Fig. 3 – Fuel Pump Valving and Rotation

Disassemble Fuel Pump

With the fuel pump removed from the engine and mounted in holding fixture J 1508–10 as shown in Fig. 5, refer to Figs. 1 and 7 and disassemble the pump, as follows:

1. Remove 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.
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. 6). 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.

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.

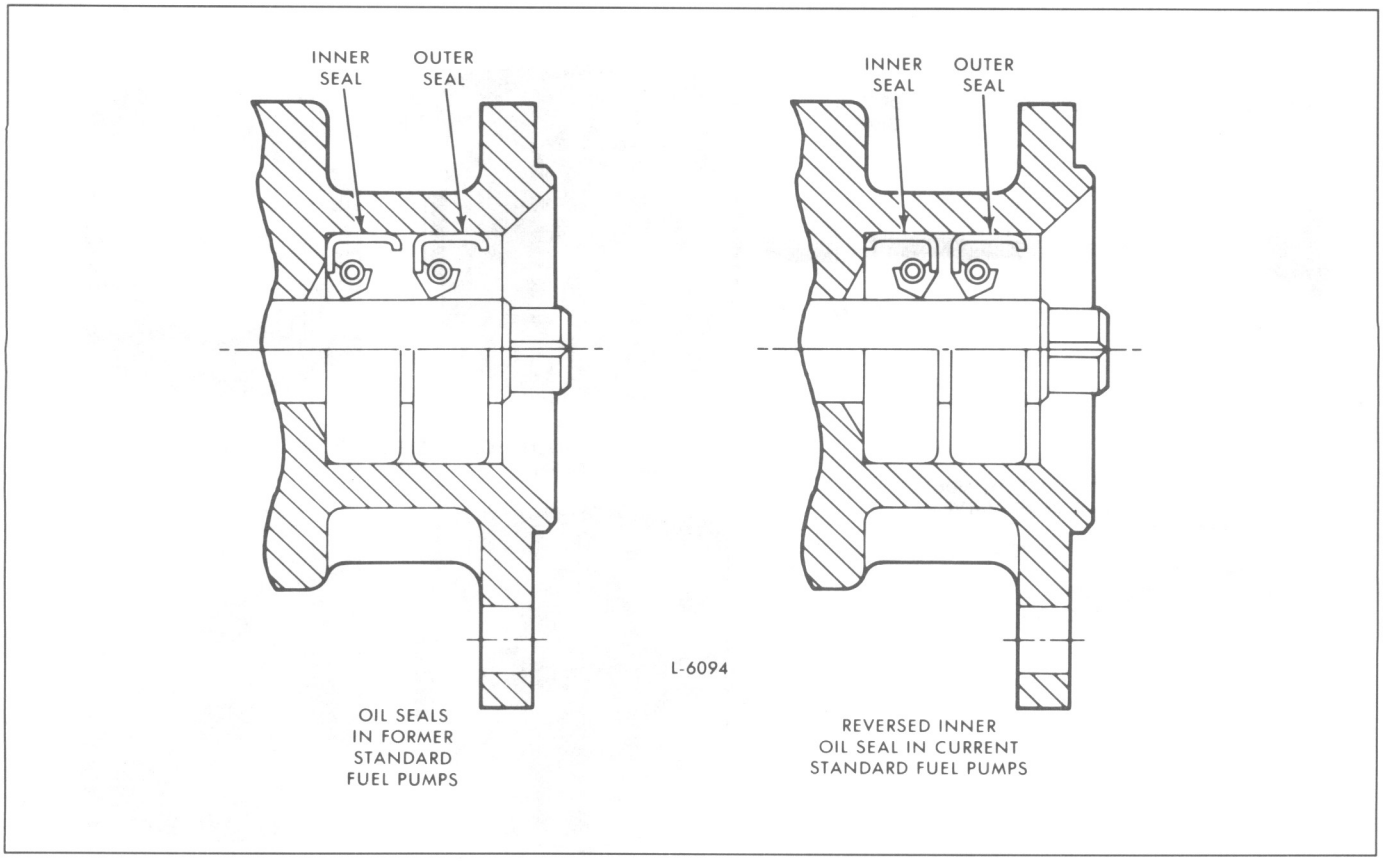


Fig. 4 – Fuel Pump Oil Seal Arrangements

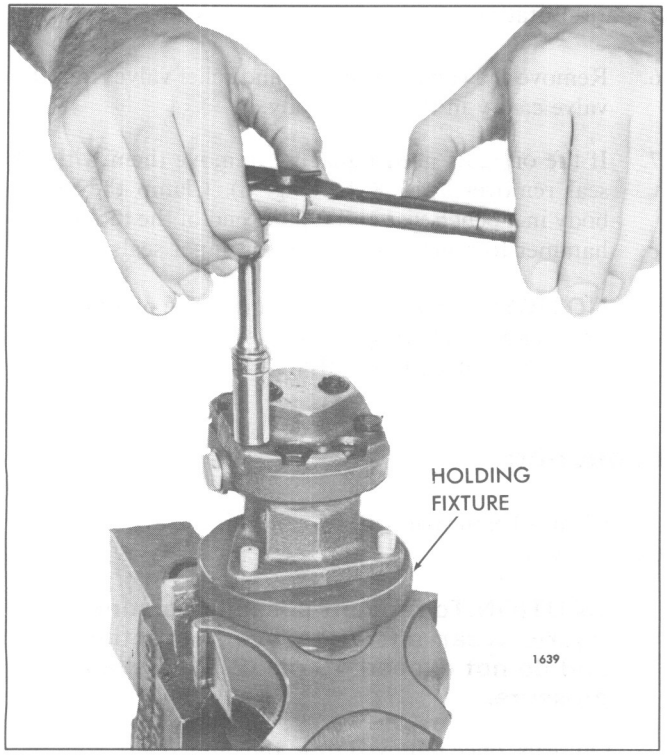


Fig. 5 – Removing Fuel Pump Cover

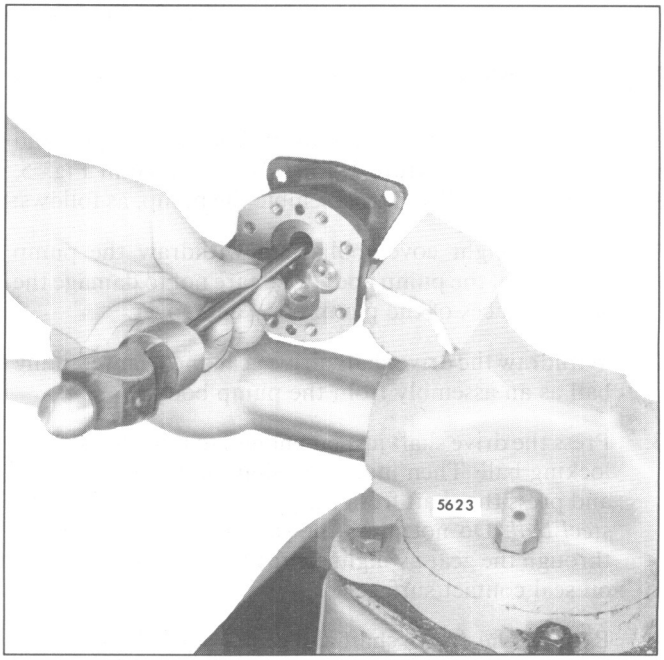


Fig. 6 – Removing Oil Seals using Tool J 1508–13

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, 3 and 7 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 seals 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 in the same direction as the original seal which was removed.

   NOTICE: When replacing the former nitrile fuel pump seals with the current polyacrylate seals, install them with the seal lips facing each other (Fig. 4).

   b. With the pump body supported on wood blocks (Fig. 8), 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

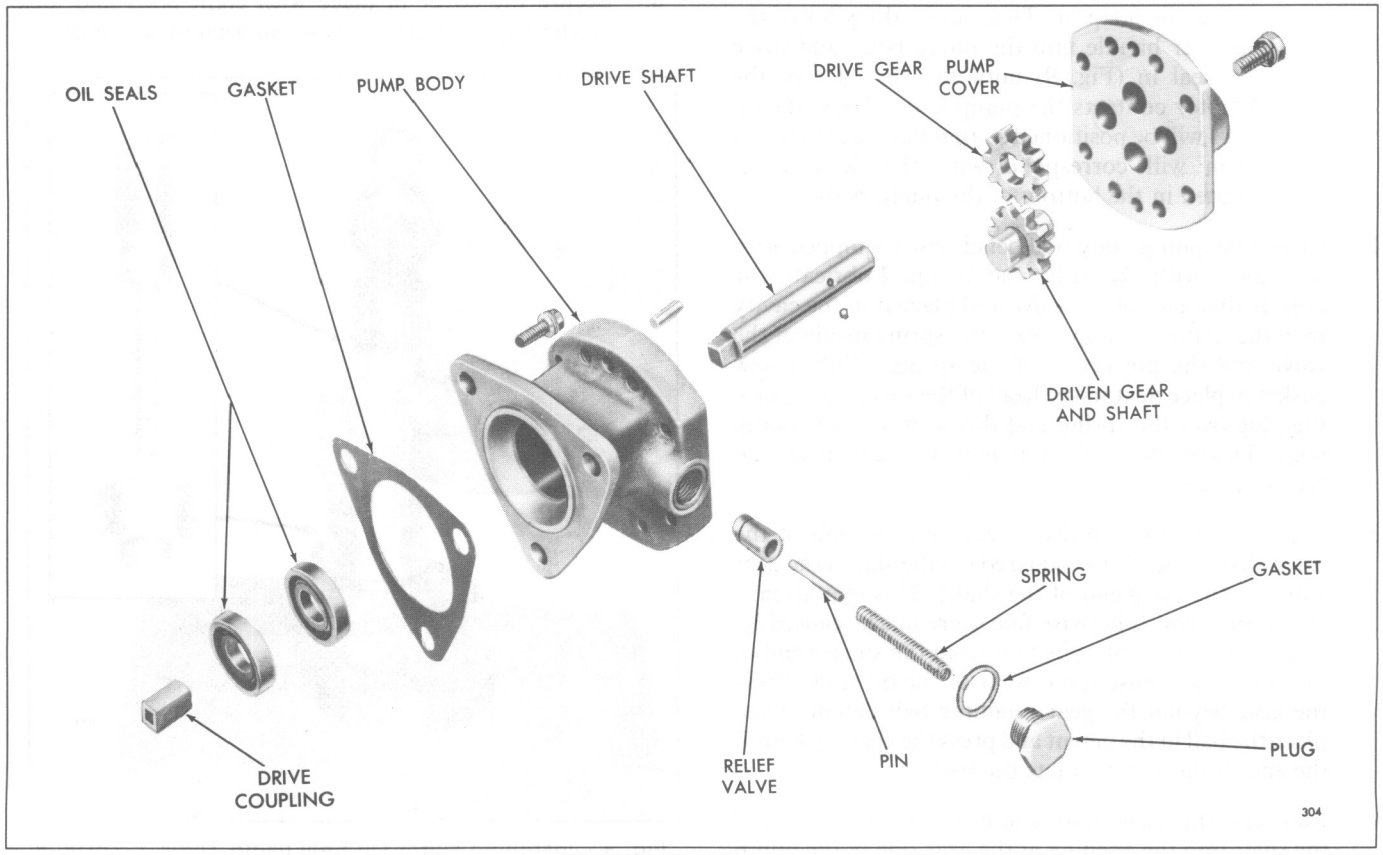


Fig. 7 – Fuel Pump Details and Relative Location of Parts

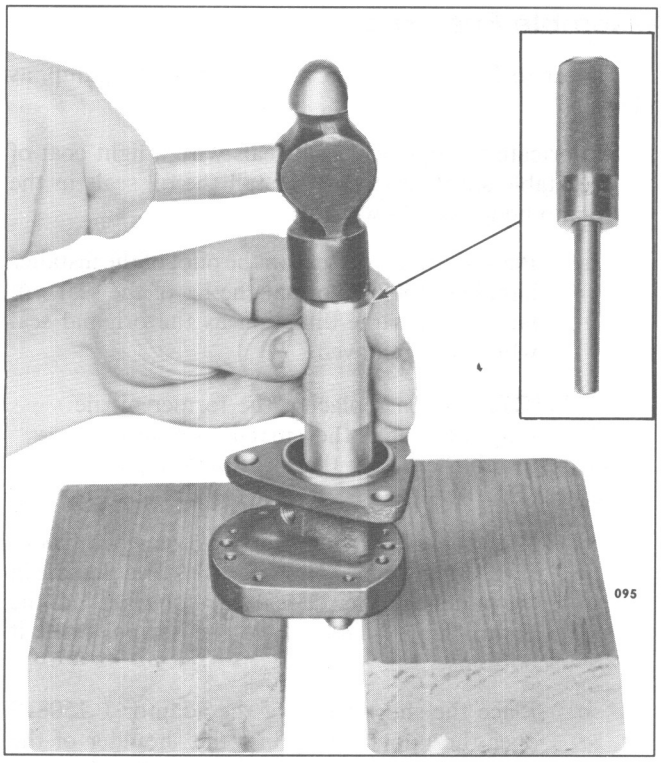


Fig. 8 – Installing Inner Oil Seal using Tool J 1508–8

facing the adaptor. Then insert the pilot of the installer handle into the pump body and drive the seal in (Fig. 9) 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 fuel 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 (Fig. 10).

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 efficiency of the pump. Use care that sealant is not squeezed into the gear compartment, otherwise damage to the gears and shafts may result.

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

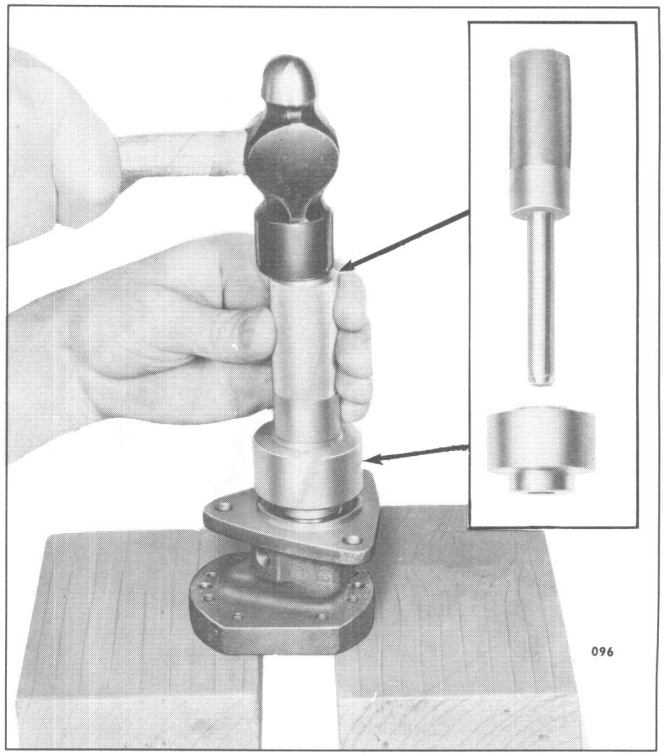


Fig. 9 – Installing Outer Oil Seal using Tools J 1508–8 and J 1508–9

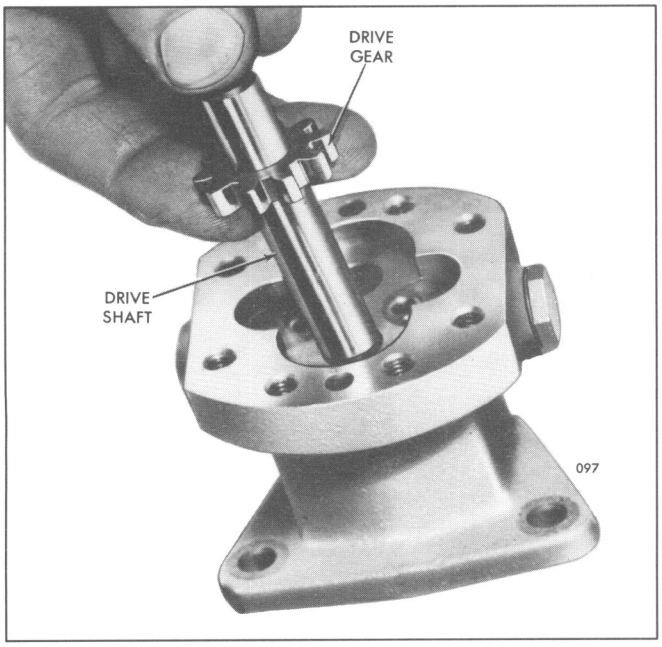


Fig. 10 – Installing Fuel Pump Drive Shaft and Gear Assembly

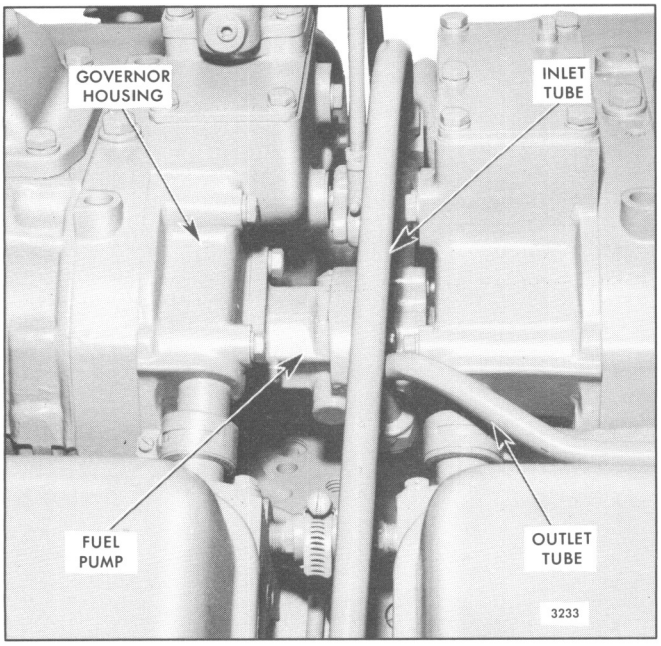


Fig. 11 – Typical Fuel Pump Mounting (16V Engine)

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

The pump must always be installed with the inlet opening in the pump cover (marked "L.H. IN") next to the balance weight cover on 6V and 8V engines. Refer to Fig. 2 and note that the fuel pump is bolted to the governor housing and is driven by the drive coupling fork and the drive disc which is attached to the blower rotor. Refer to Fig. 11 when installing the fuel pump on a 12V and 16V engine. Install the pump, as follows:

1. Affix a new gasket to the pump body mounting flange. Then place the drive coupling fork on the square end of the drive shaft.

2. Place the fuel pump against the governor housing, being certain that the drive coupling fork registers with the slots in the drive disc.

3. Secure the pump to the governor housing with three nylon patch bolts.

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

4. 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 1/4" fittings to 14 – 16 lb–ft (19 – 22 N•m), 3/8" fittings to 18 –22 lb–ft (24 – 30 N•m), and 1/2" fittings to 20 – 25 lb–ft (27 – 34 N•m) torque.

5. Connect the inlet and outlet fuel lines to the fuel pump elbows.

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

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

FUEL STRAINER AND FUEL FILTER

(BOLT–ON TYPE)

A fuel strainer (primary) and fuel filter (secondary), Figs. 1 and 2, 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 moisture, sludge and other course debris. The fuel filter is installed between the fuel pump and the fuel inlet manifold. The replaceable paper–type (cellulose) element (Fig. 4) 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.

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 *Trouble Shooting* in Section 15.2 for corrective measures.

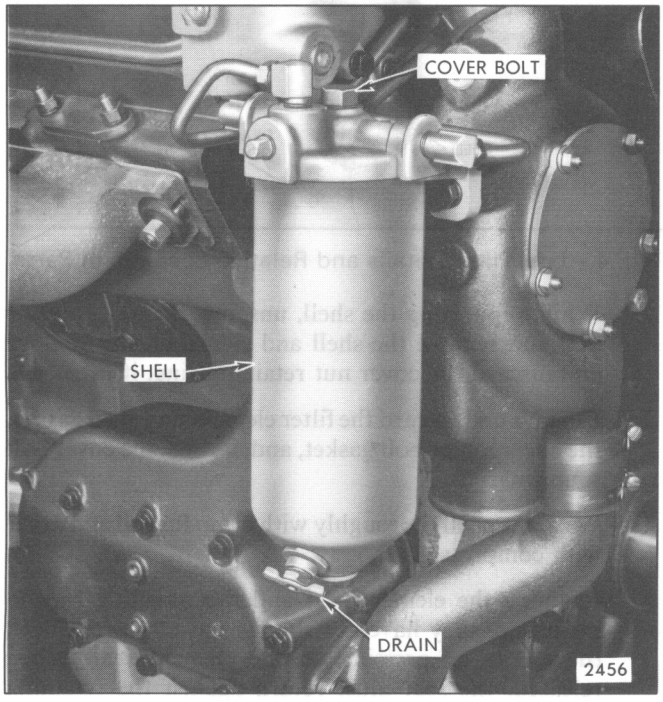


Fig. 1 – Typical Mounting of Fuel Filter

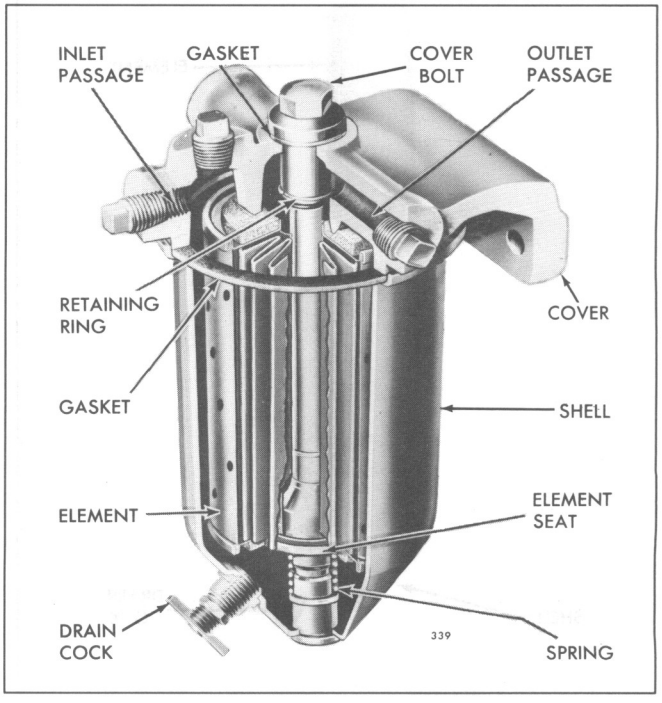


Fig. 2 – Fuel Filter Assembly

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.

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.

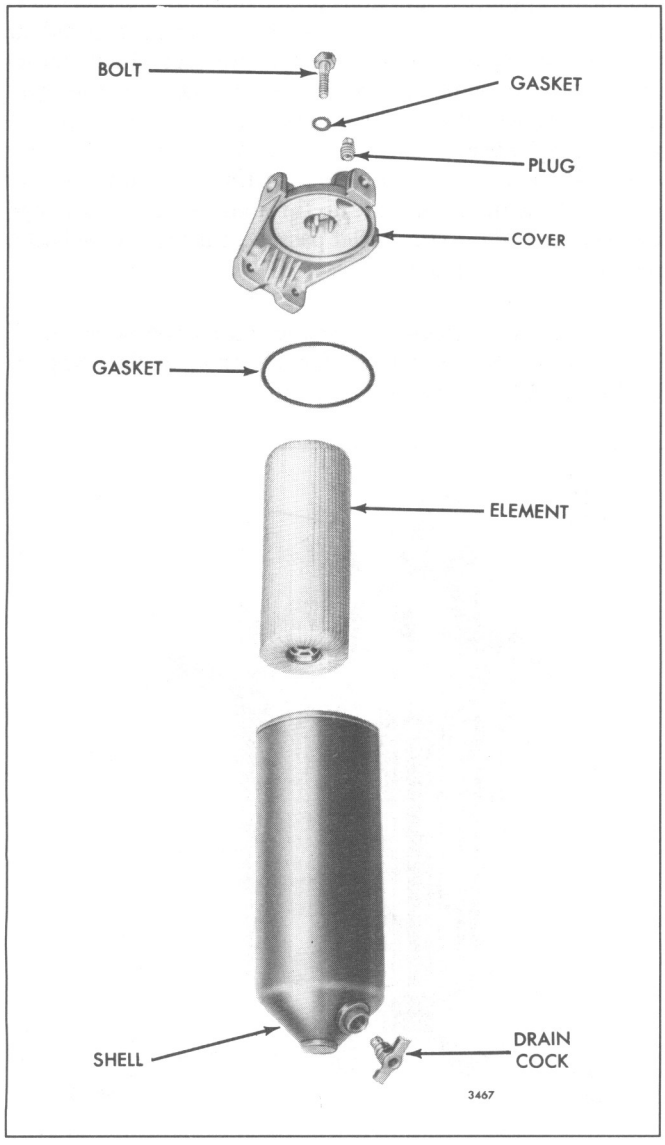


Fig. 3 – Typical Fuel Strainer Details

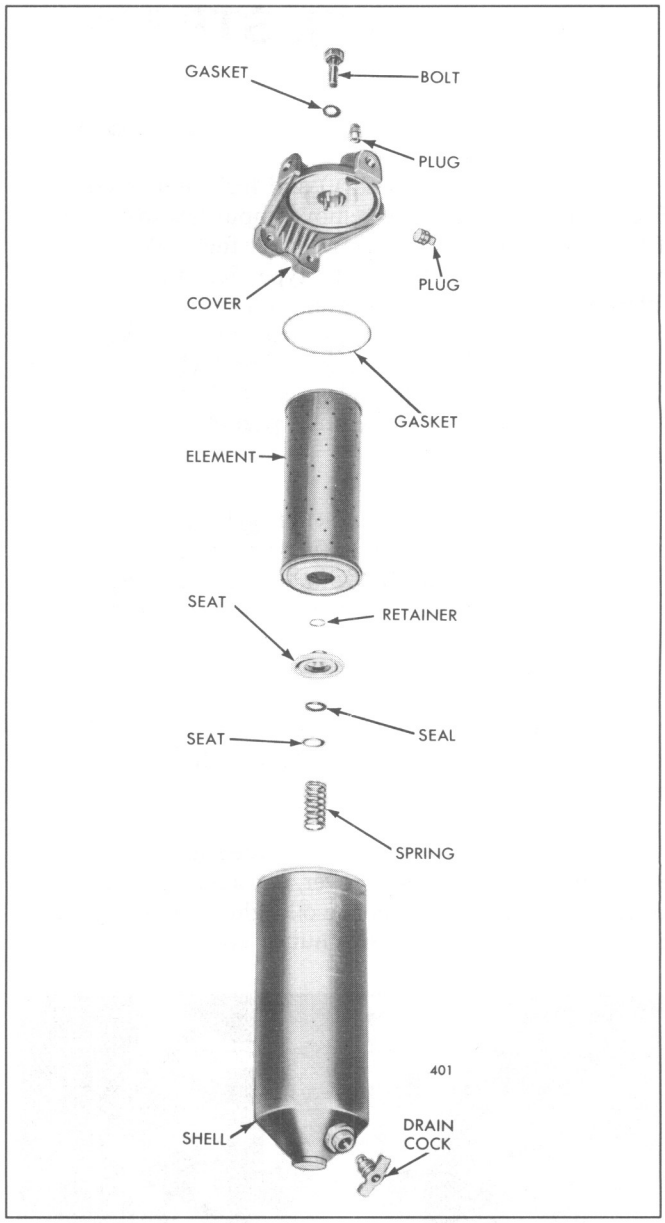


Fig. 4 – Fuel Filter Details and Relative Location of Parts

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.
4. Wash the shell thoroughly with clean fuel oil and dry it with compressed air.
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.

NOTICE: 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.

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.

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

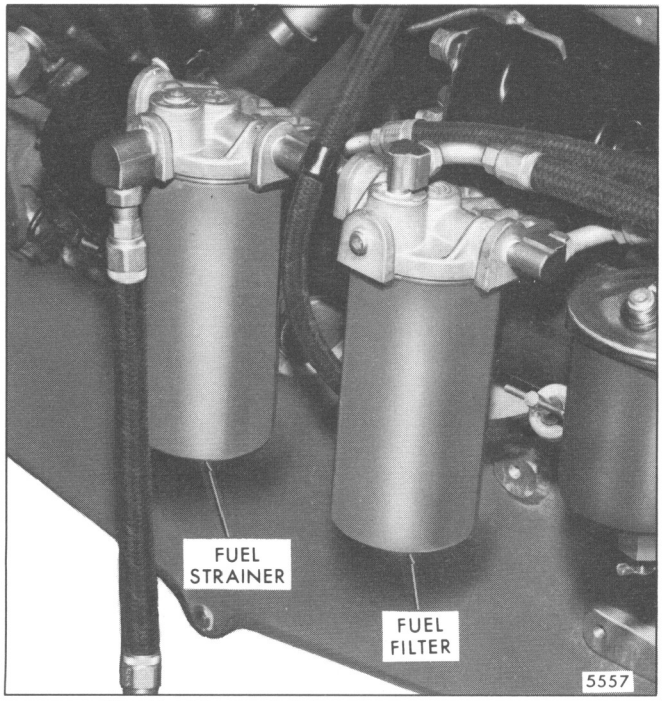


Fig. 5 – Typical Spin–On Filter Mounting

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.

4. Start the engine and check for leaks.

FUEL COOLER

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 (32.2°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 (227 grams) of oxalic acid to each 2–1/2 gallons (1.893 litres) 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 and, 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

CAUTION: 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.

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.

Install Fuel Cooler

Reverse the procedure for removing the fuel cooler.

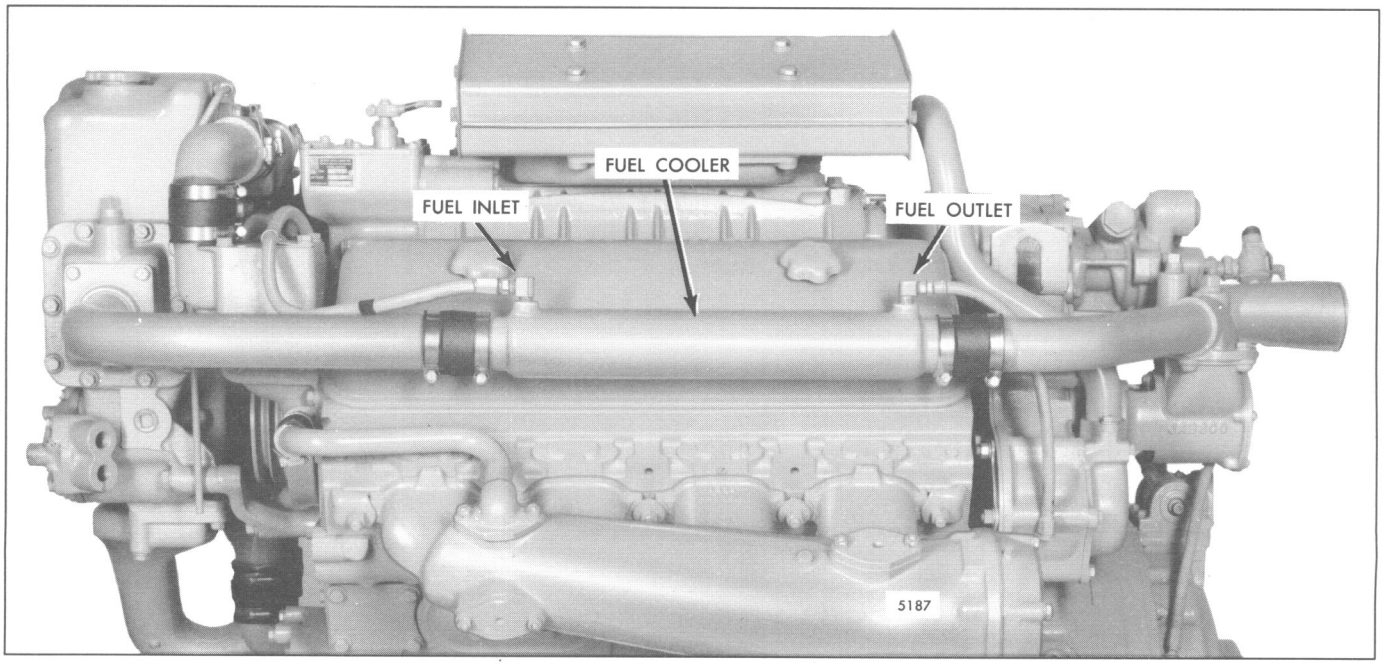


Fig. 1 – Fuel Cooler Mounting

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 governor is mounted on the front end of the blower and is driven by one of the blower rotors. 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.

Each type of governor has an identification plate located on the control housing, containing the governor assembly number, type, idle speed range and manufactured dated. 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 2.1.1.
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 2.1.1.
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

The limiting speed mechanical governors used on the V–92 engines performs the following two functions:

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

The limiting speed governors illustrated in Figs. 1 and 2 are double weight type.

A new double weight limiting speed governor is now being used to improve the performance of certain Series 92 engines. The new double weight limiting speed governor includes the lighter weight Fuel Squeezer engine weight system. These new double weight governors should replace the former single weight governors in cases where performance problems are being encountered.

A tamper–resistant double weight limiting speed governor is provided for highway vehicle engines (refer to Section 2.0).

The limiting speed governor illustrated in Fig. 3 is a single weight type and was utilized on 6V and 8V engine applications, except Fuel Squeezer and coach engines that require low idle speed control (below 500 rpm).

Each governor has an identification plate located on the governor housing, containing the governor assembly number, type and idle range speed.

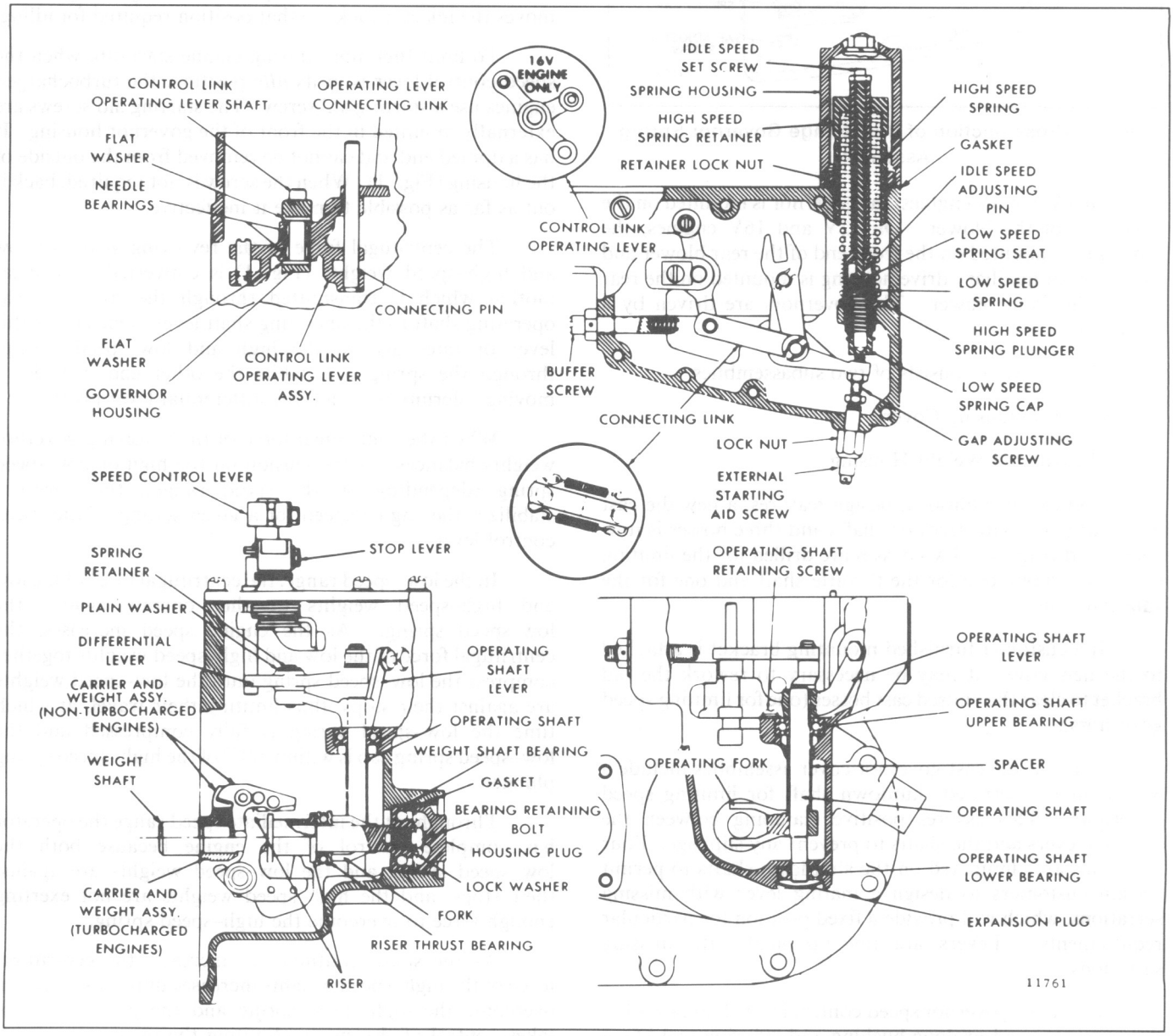


Fig. 1 – Cross Section of Double Weight Limiting Speed Mechanical Governor

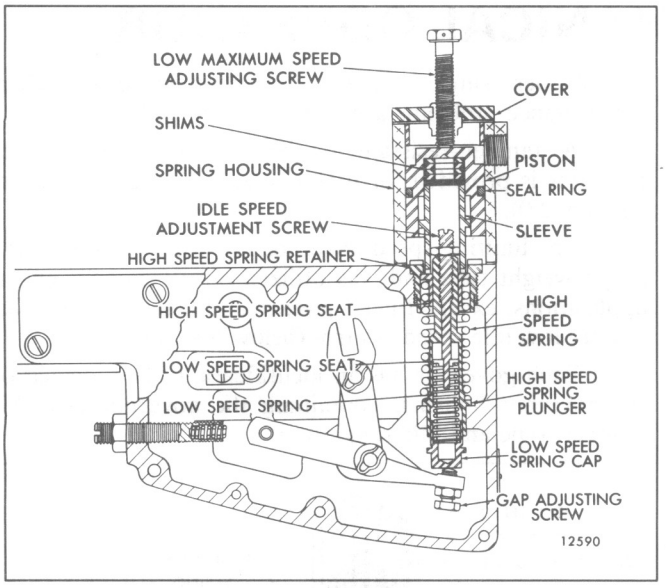


Fig. 2 – Cross Section of Dual Range Governor Spring Assembly

On 6V and 8V engines, the governor is mounted on the front end of the blower. On 12V and 16V engines, the governor is mounted on the front end of the rear blower and the governor auxiliary drive housing is mounted on the rear end of the front blower. The governors are driven by a blower rotor.

The governor consists of two subassemblies.

1. Control Housing Cover.
2. Control and Weight Housing.

To provide additional design features, a new die cast governor cover with serrated shafts and three bosses is now being used (Fig. 4). Two bosses are drilled for the limiting speed governors, one for the throttle shaft and one for the shutdown shaft.

If a customer furnished mounting bracket is attached to the new cover, it may be necessary to rework the old bracket to clear the unused cast bosses (one for limiting speed governors).

The new die cast governor cover assemblies include a 3/8" diameter serrated shutdown shaft for limiting speed governors. This assures positive clamping between the serrated levers and the shafts to prevent any slippage. Four serrations are eliminated on the shutdown shafts to permit certain customers to design a mating lever with missing serrations, which will provide a fixed position for particular requirements. Levers are not provided with missing serrations.

To reduce governor speed control lever shaft assembly stop pin wear and prolong bushing and "0" ring seal life, a yieldable speed control lever is available. This newly designed yieldable speed control lever cannot be used with the former stamped cover assemblies; however, a service yieldable speed control lever is available for use with the stamped cover.

The former and new cover and shaft assemblies are interchangeable on a governor. When only a former cover needs replacing, it will be necessary to replace the cover and shaft assembly. Only the new cover is serviced separately.

Operation (Standard Double–Weight Governor) – Fig. 1

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

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. The starting aid screws are externally mounted in the front of the governor housing. It has a domed end and cannot be removed from the outside of the housing (Fig. 1). When the screw is not required, back it out as far as possible to make it ineffective.

The centrifugal force of the revolving governor low and high–speed weights (Fig. 1) is converted into linear motion which is transmitted through the riser and the 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 compress 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 .002" 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 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.

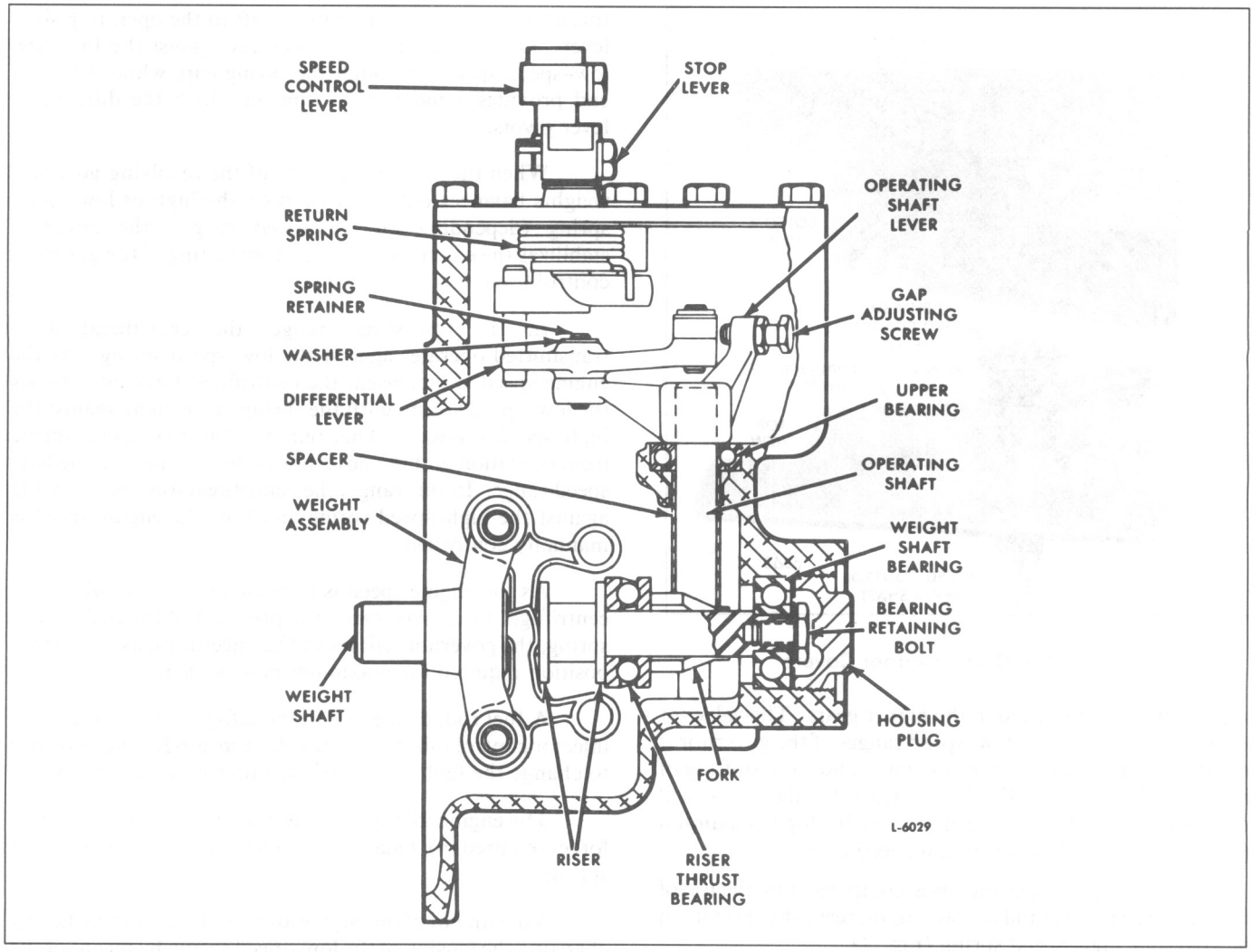


Fig. 3 – Cross–Section of Single Weight Limiting Speed Mechanical Governor

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

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 adjusting screw. Refer to Section 14.3 (6V and 8V engines) or 14.3.1 (12V and 16V engines) for the idle speed adjustment.

The engine maximum no–load speed is determined by the force exerted by the high–speed spring. When the governor speed 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 the high–speed spring retainer. Movement of the high–speed spring retainer will increase or decrease the tension on the high–speed spring. Refer to Section 14.3 (6V and 8V engines) or 14.3.1 (12V and 16V engines) for the maximum no–load speed adjustment.

Operation (Double Weight Dual High–Speed Range Governor) – Fig. 2

The mechanical double weight limiting speed dual range governor has been designed for use in applications that require a high maximum speed part of the time and a low maximum speed the remainder of the time.

This governor in vehicle application, due to its dual speed feature, permits a high engine speed in the lower gear ratios for maximum vehicle acceleration while providing a

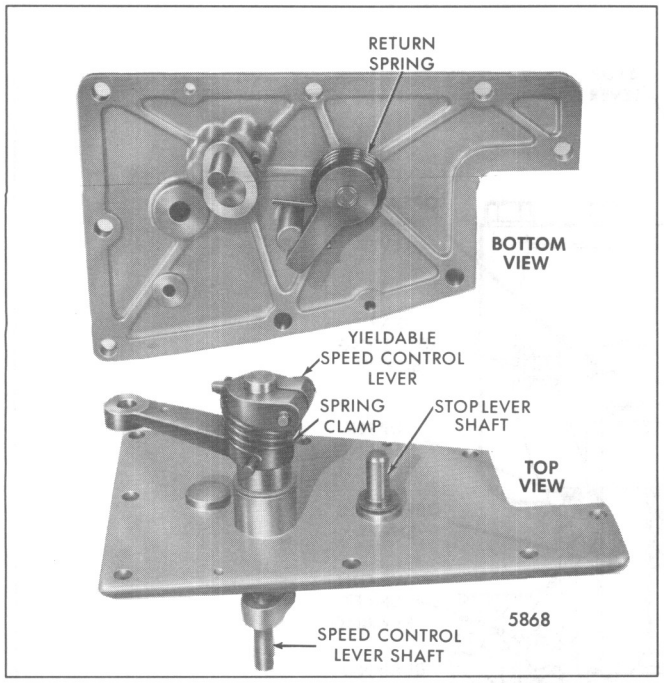


Fig. 4 – Die Cast Governor Covers

conservative vehicle speed in the higher gears. The valve for controlling the high and low–speed ranges of the governor is usually connected to the transmission. Thus, the shifting of the transmission from the lower gears to high gear will automatically shift the governor from its high maximum speed range to the low maximum speed range.

The two speed operation is accomplished by the use of air or oil pressure behind a piston to increase the tension on the governor high–speed spring (Fig. 2).

On current engines the spring assembly has been revised to include a shorter sleeve and a longer idle speed adjustment set screw. The new sleeve (1.64") and the new set screw (5/16"–24 x 2") must be used together in the spring assembly. Do not mix with the former sleeve (1.84") and set screw (5/16"–24 x 1 1/2").

The removal of air pressure from behind the piston permits the governor high–speed spring to force the piston against the low maximum speed adjusting screw that retains enough tension in the governor high–speed spring to operate the engine at the desired lower speed.

A seal ring is used to prevent leakage of air pressure past the piston assembly. The cylinder is lubricated at the time the piston assembly is installed by spreading an all purpose grease throughout the cylinder bore.

Operation (Single–Weight Governor) – Fig. 3

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 sha lever. One end of the 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 governor control lever.

In the low–speed range, the centrifugal force transmitted operates against the low–speed spring. As the engine speed is increased, the centrifugal force compresses the low–speed spring until the spring cap is tight against the high–speed plunger. This removes the low–speed spring from operation and the governor is then in the intermediate speed range. In this range, the centrifugal force is operating against the high–speed spring and thus the engine speed is manually controlled.

As the engine speed is increased to a point where the centrifugal force overcomes the pre–load of the high–speed spring, the governor will move the injector racks out to that position required for maximum no–load 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 control racks.

The engine idle speed is determined by the centrifugal force required to balance out tension on the low–speed spring.

Adjustment of the engine idle speed is accomplished by changing the tension of the low–speed spring by means of the idle adjusting screw. Refer to Section 14.3 for the idle speed adjustment.

The maximum no–load speed is determinded by the centrifugal force required to balance out the tension on the high–speed spring.

Adjustment of the maximum no–load speed is accomplished by the high–speed spring retainer. Movement of the high–speed spring retainer nut will increase or decrease the tension on the high–speed spring. Refer to Section 14.3 for the maximum no–load speed adjustment.

Lubrication

The governor is lubricated by a spray of lubricating oil from the blower end plate. The governor weights distribute this oil to all parts of the governor assembly requiring lubrication.

Oil returning from the governor is directed through passages in the blower end plate and cylinder block to the engine oil pan.

Remove Governor From Engine (6V And 8V Engines)

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Open the drain cocks and drain the engine cooling system.
2. Remove any accessories attached to the cylinder head, governor or front end of the engine that interfere with the removal of the governor assembly. On "TA" engines, see Section 3.4.1 and remove the blower.
3. Disconnect the control linkage from the speed control and stop levers (Fig. 5).
4. Remove the eight screws and lock washers securing the governor cover to the housing. Lift the cover and gasket from the housing.
5. Remove the fuel rods from the control link operating lever assembly (Fig. 1) and the injector control tube levers as follows:
   a. Remove the valve rocker covers from the cylinder heads. Discard the gaskets.
   b. Remove the right bank fuel rod by removing the screw type pin, in the control link operating lever, and the clevis pin in the control tube lever and withdraw the fuel rod from the governor.
   c. Remove the left bank fuel rod by removing the clevis pin in the control tube lever and lift the connecting pin up out of the control link operating lever approximately three–quarters of an inch. Then, withdraw the fuel rod from the governor.
6. Loosen the hose clamps at each end of the water bypass tube. Slide the hoses and clamps onto the bypass tube and remove the tube from the engine.
7. Disconnect and remove the fuel oil lines attached to the fuel pump and the crossover fuel oil line attached to each cylinder head.
8. Loosen the hose clamps on the fuel rod cover tube hoses next to each cylinder head and slide each hose and clamp up on the tube in the governor housing.
9. Note the location of the two copper, one plain and eight lock washers on the governor–to–blower bolts before removing them. Then, remove the ten bolts and washers (two inside and eight outside) securing the governor and fuel pump assembly to the blower.
10. Tap the sides of the governor housing lightly with a plastic hammer to loosen the governor from the blower. Then, pull the governor and fuel pump assembly straight out from the dowels in the blower end plate. Remove the governor–to–blower gasket.

The fuel pump drive coupling fork may stay on either the fuel pump or the blower rotor shaft. Remove the drive coupling fork.

11. Remove the three bolt and seal assemblies securing the fuel pump assembly to the governor housing. Remove the fuel pump and gasket from the governor housing.

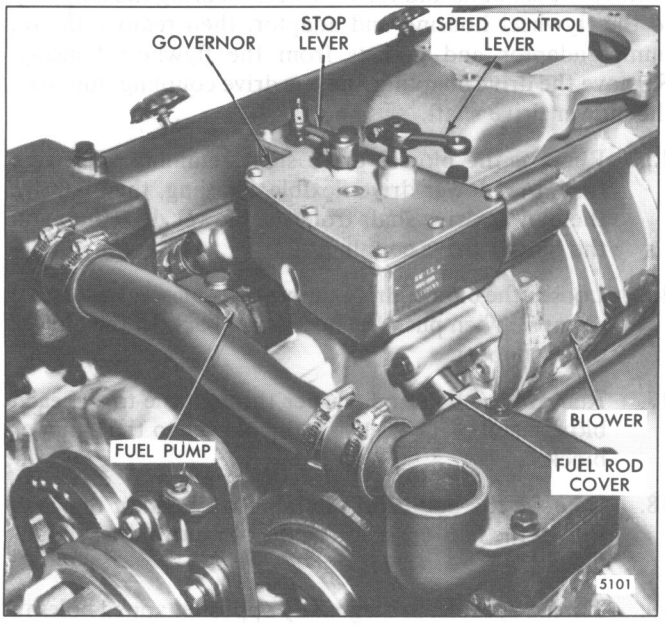


Fig. 5 – Limiting Speed Mechanical Governor Mounting (6V and 8V Engines)

Remove Governor From Engine (12V And 16V Engines)

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

The blower assembly must be removed in order to remove the governor.

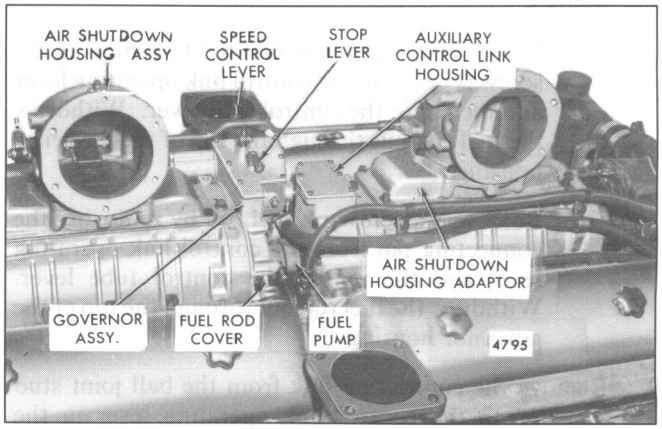


Fig. 6 – Limiting Speed Governor Mounting (12V and 16V Engines)

1. Disconnect the linkage attached to the governor speed control and stop levers (Fig. 6).
2. On a non–turbocharged engine, disconnect the air inlet tube attached to the air shutdown housing on each blower.

On a turbocharged engine, disconnect the tube from the turbocharger and the air shutdown housing on the rear blower.

On a marine engine, remove the air silencers from both air shutdown housings.

3. On a non–turbocharged engine, remove the air shutdown housings and the air shutdown adaptor from the rear blower.

On a marine engine, remove the air shutdown housings from the blowers.

Remove the two air shutdown housings, with attaching rod, as a unit.

On a turbocharged engine, disconnect the shutdown rod from the lever on the rear air shutdown housing. Then, remove the air shutdown housing and the air shutdown adaptor as an assembly from the blower.

4. Cover the top of the blower with masking tape to prevent the entry of foreign material.
5. Remove the rear cylinder head rocker covers. Discard the gaskets.
6. Remove the governor housing cover screws and lock washers, then remove the cover and gasket from the housing.
7. Remove the governor auxiliary control link housing cover screws and lock washers, then remove the cover and gasket from the housing.
8. Disconnect the fuel rods from the control link operating lever and the injector control tube levers as follows:
    a. Remove the right bank fuel rod by removing the screw type pin in the control link operating lever and the pin in the control tube lever. Withdraw the fuel rod out through the top of the governor housing.
    b. Remove the left bank fuel rod by removing the connecting pin from the control link operating lever and the pin in the control tube lever. Withdraw the fuel rod out through the top of the governor housing.
9. Remove the connecting link from the ball joint stud attached to the control link operating lever in the governor housing and the auxiliary control link housing by lifting or prying each end of the connecting link off of the ball joint studs. Then, remove the connecting link from the governor housing.
10. Loosen the fuel rod cover hose clamp at each side of the governor housing, then slide each hose against the governor housing. Tighten each clamp to retain it on the hose.
11. Loosen the hose clamp between the governor housing and the auxiliary control link housing, then slide the hose forward against the auxiliary control link housing. Tighten the clamp to retain it on the hose.
12. Disconnect the fuel pump inlet and outlet tubes or hoses from the fuel pump. Then, if necessary, remove the fuel pump from the governor housing.
13. Disconnect the blower drive support oil tube from the fitting in the blower drive support. Loosen the two bolts securing the oil tube seal ring retaining plate to the blower end plate, then push the oil tube into the end plate.
14. Remove the six bolts and lock washers securing the flywheel housing hole cover, at the blower drive support, then remove the cover and gasket.

On an engine equipped with a rear mounted battery–charging alternator, loosen and remove the alternator drive belt. Then, remove the alternator drive pulley nut and pulley from the alternator drive shaft. Remove the bolts and lock washers securing the alternator drive assembly to the flywheel housing, then remove the drive assembly, gasket and drive coupling from the flywheel housing.

On an engine equipped with a hydraulic oil pump, remove the six bolts and lock washers securing the oil pump to the flywheel housing and adaptor, then remove the oil pump, adaptor and gaskets from the flywheel housing. Remove the drive coupling and the drive coupling hub from the blower drive shaft.

15. Remove the blower drive shaft retaining snap ring from the blower drive flexible coupling, then remove the blower drive shaft from the blower drive hub and the blower drive coupling.
16. Loosen the blower drive support–to–blower hose (seal) clamps. Then push the hose (seal) back on the blower drive support.
17. Remove the bolt and washer through the top of each blower end plate, securing the blower to the cylinder block.
18. Remove the bolts and retaining washers on the each side of the blower, securing the blower to the cylinder block.
19. Thread eyebolts in diagonally opposite tapped holes in the top of the blower housing. Then, attach a rope sling and chain hoist to the eyebolts.

20. Lift the blower assembly slightly and move it forward to detach the blower from the hose (seal). Then, lift the blower away from the engine and place it on a bench. Remove the blower to cylinder block gasket.

21. With the blower and governor assembly removed from the engine, remove the ten bolts, lock washers, plain washer and copper washers securing the governor assembly to the blower end plate. Slide the governor assembly forward off of the dowel pins in the end plate, then remove the governor to blower end plate 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.

1. Disassemble the governor cover (Fig. 7 or 8) as follows:

All current Fuel Squeeezer engines have a governor cover with an extended hub and a longer speed control shaft (3.30" long). The cover also incorporates two hardened steel roll pins in the speed control shaft hub (Fig. 8).

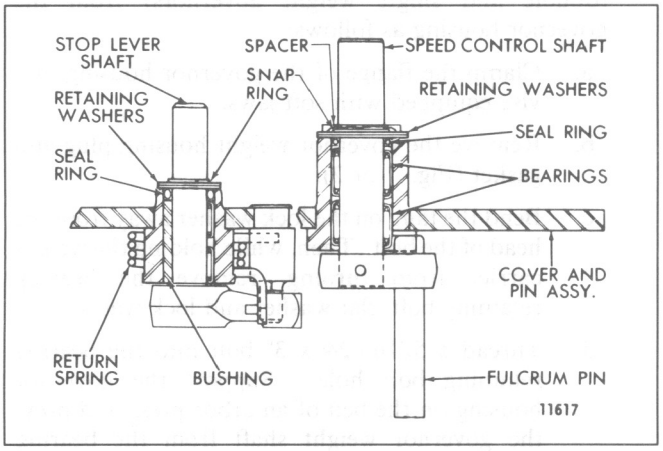


Fig. 7 – Cross Section of Former Governor Cover

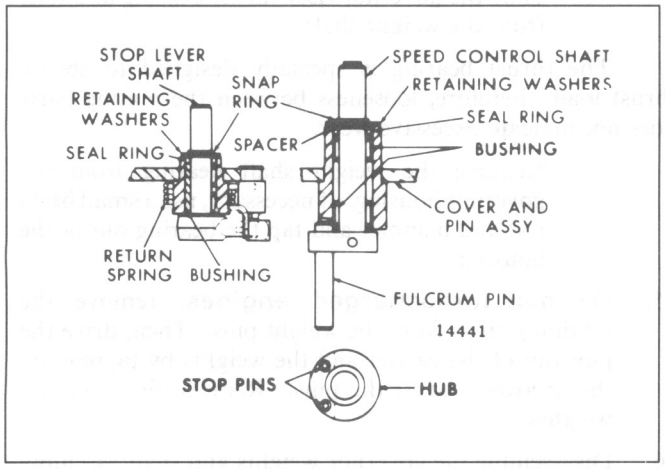


Fig. 8 – Cross–Section of Current Governor Cover

a. Remove the lubrication fitting from the speed control shaft.

b. Loosen the speed control lever retaining bolt and lift the control lever from the speed control shaft.

c. Remove the spacer (if used), snap ring and two seal ring retaining washers, and seal ring from the speed control shaft. Withdraw the shaft from the cover.

d. Loosen the bolt securing the stop lever to the stop lever shaft and remove the stop lever.

e. Remove the snap ring, two seal ring retaining washers, and seal ring from the stop lever shaft. Withdraw the lever shaft and the lever shaft return spring from the cover.

f. Wash the cover assembly thoroughly in clean fuel oil and inspect the needle bearings and bushings for wear or damage. If the bearings and bushings are satisfactory for further use, removal is unnecessary.

g. If needle bearing removal is necessary, place the inner face of the cover over the opening on the bed of an arbor press. Place remover J 21967–01 on the top of the bearing and under the ram of the press, then press both bearings out of the cover (Fig. 9).

h. Remove the bushing or bearings from the stop lever shaft opening using remover J 8985 (Fig. 10).

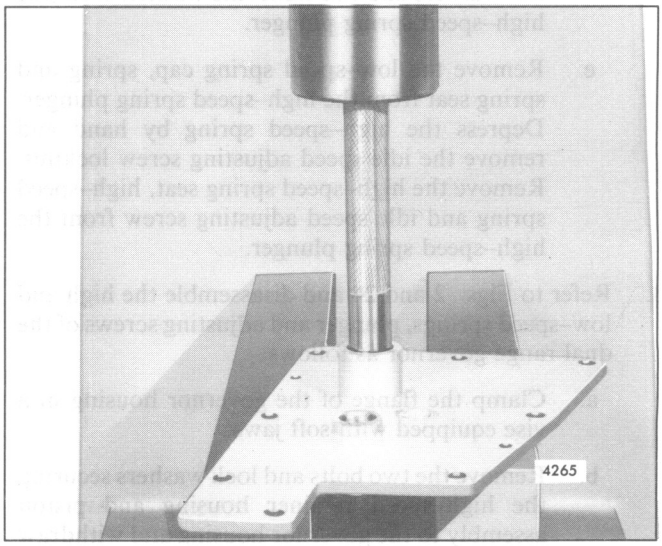


Fig. 9 – Removing Speed Control Shaft Bearing from Governor Cover using Tool J 21967–01

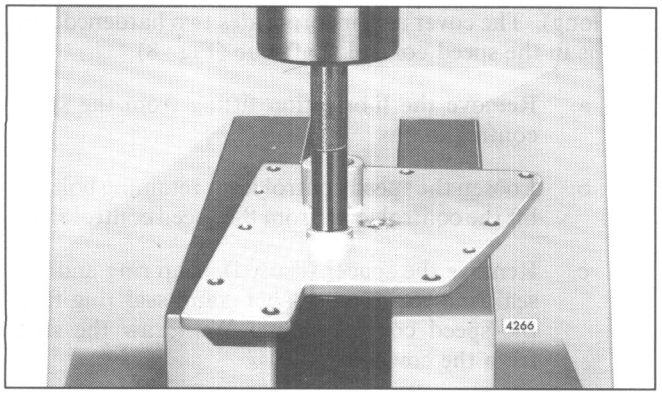


Fig. 10 – Removing Stop Lever Shaft Bushings from Governor Cover using Tool J 8985

2. Refer to Figs. 1 and 22 and disassemble the high and low–speed springs, plunger and adjusting screw (except dual–range governors):

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

   b. Remove the two bolts and copper washers securing the high–speed spring retainer housing to the governor housing and withdraw the retainer housing and gasket.

   c. Loosen the high–speed spring retainer locknut (Fig. 1) with a spanner wrench (J 5345–5). Then, remove the high–speed spring retainer, idle speed adjusting screw, high–speed spring, spring plunger, low–speed spring, spring seat and spring cap as an assembly.

   d. For Fuel Squeezer engines refer to Fig. 22 and loosen the set screw in the Belleville spring retainer nut. Then, remove the retainer nut, two flat washers and two Belleville washers from the high–speed spring plunger.

   e. Remove the low–speed spring cap, spring and spring seat from the high–speed spring plunger. Depress the high–speed spring by hand and remove the idle speed adjusting screw locknut. Remove the high–speed spring seat, high–speed spring and idle speed adjusting screw from the high–speed spring plunger.

3. Refer to Figs. 2 and 24 and disassemble the high and low–speed springs, plunger and adjusting screws of the dual range governor as follows:

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

   b. Remove the two bolts and lock washers securing the high–speed retainer housing and piston assembly to the governor housing and withdraw the rtainer housing, piston, shims and sleeve as an assembly from the governor housing (Fig. 2).

   Current governors have a blocking ring in the spring housing to prevent removal of the seal from the rear end (cover end) of the spring housing, thus preventing seal ring damage.

   c. Remove the sleeve, shims, cover, cover gasket, piston and seal ring assembly from the high–speed spring retainer housing. Remove the retainer housing gasket.

   d. Remove the high–speed spring retainer with tool J 5345–5 and withdraw the retainer, idle speed adjusting screw, high–speed spring, spring plunger, low–speed spring, spring seat and spring cap as an assembly from the housing.

   e. Remove the low–speed spring cap, spring and spring seat from the high–speed spring plunger. Depress the high–speed spring by hand and remove the idle speed adjusting screw locknut. Remove the high–speed spring seat, high–speed spring and idle speed adjusting screw from the high–speed spring plunger.

4. Remove the governor weights and shaft assembly (double and single weight governors) from the governor housing as follows:

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

   b. Remove the governor weight housing plug and gasket (Fig. 1 or 2).

   c. Bend the tang on the lock washer away from the head of the bolt. Then, while holding the weight carrier from turning, remove the bearing retaining bolt, flat washer and lock washer.

   d. Thread a 5/16"–24 x 3" bolt into the bearing retaining bolt hole. Support the governor housing on the bed of an arbor press and press the governor weight shaft from the bearing (Fig. 11).

   e. Slide the governor riser thrust bearing and riser from the weight shaft.

The thrust bearing is specially designed to absorb thrust load; therefore, looseness between the mating parts does not indicate excessive wear.

   f. Remove the weight shaft bearing from the governor housing. If necessary, use a small brass rod and hammer and tap the bearing out of the housing.

5. On **non–turbocharged engines**, 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.

6. Disassemble the governor weights and shaft assembly on **turbocharged engines** as follows:

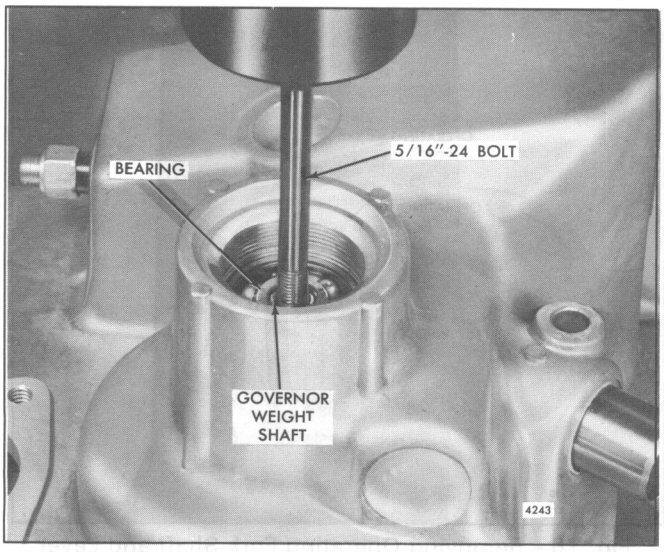


Fig. 11 – Removing Governor Weight Shaft Assembly from Governor Housing

a. If removal of the weights from the carrier is necessary, remove the retainers and press the weight pins from the low–speed weights (Fig. 12). The high–speed weights are not a press fit.

b. If removal of the weight carrier from the weight shaft is necessary, support the shaft, weight carrier and sleeve on the bed of an arbor press and press the shaft out of the weight carrier (Fig. 13).

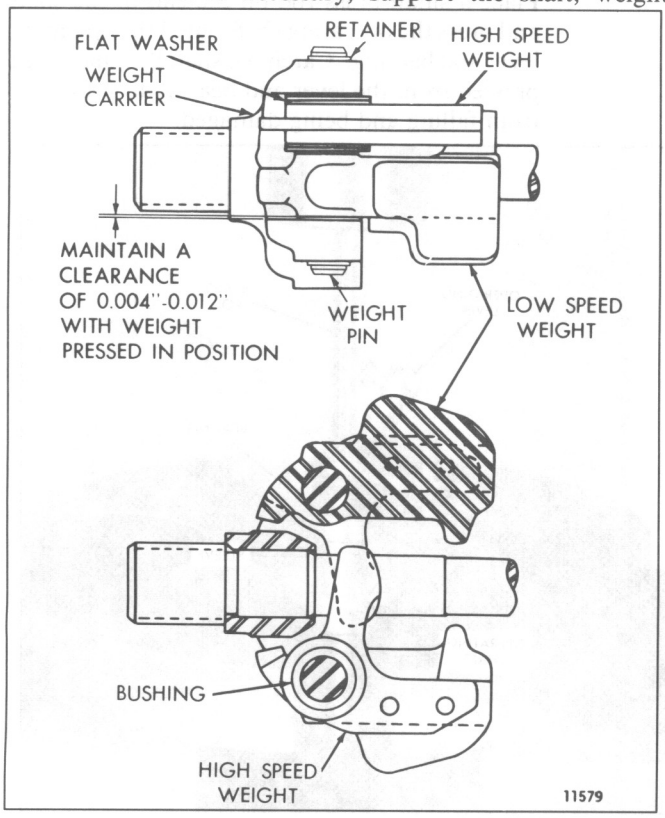


Fig. 12 – Cross Section of Governor Weight Assemblies (Turbocharged Engines)

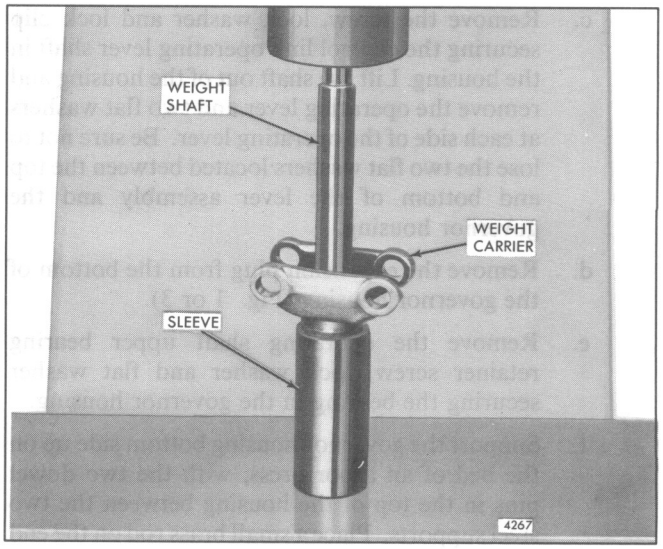


Fig. 13 – Removing Governor Weight Shaft from Weight Carrier

c. Position the high–speed governor weight on a sleeve on the bed of an arbor press and press the bearing from the weight using replacer J 8985 (Fig. 14).

7. Remove the governor linkage and operating shaft from the governor housing as follows:

a. Remove the spring retainer and plain washer securing the connecting link to the differential lever and remove the connecting link.

b. Remove the spring retainer and plain washer securing the differential lever to the operating shaft lever and remove the differential lever. Remove the low–speed gap adjusting screw from the operating shaft lever, if necessary.

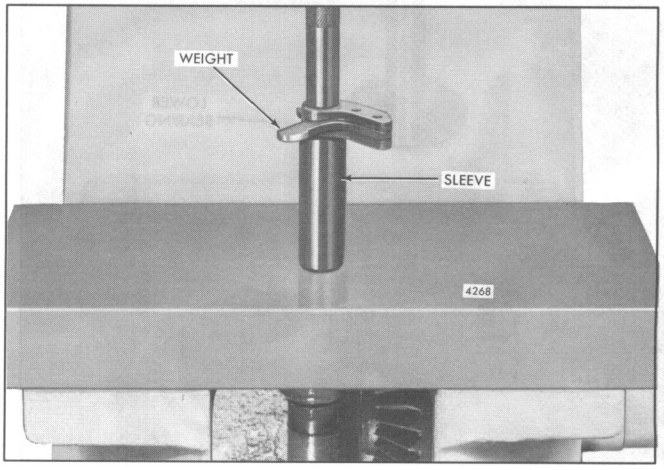


Fig. 14 – Removing Governor Weight Bearings using Tool J 8985

c. Remove the screw, lock washer and lock clip securing the control link operating lever shaft in the housing. Lift the shaft out of the housing and remove the operating lever and two flat washers at each side of the operating lever. Be sure not to lose the two flat washers located between the top and bottom of the lever assembly and the governor housing.

d. Remove the expansion plug from the bottom of the governor housing (Fig. 1 or 3).

e. Remove the operating shaft upper bearing retainer screw, lock washer and flat washer securing the bearing in the governor housing.

f. Support the governor housing bottom side up on the bed of an arbor press, with the two dowel pins in the top of the housing between the two steel supports. Place a small brass rod on the end of the operating shaft and press the shaft out of the bearing (Fig. 15).

g. With the housing still supported on the bed of the press, place a 9/16" open end wrench under the operating fork (Fig. 16). Place a brass rod on the end of the shaft and press the fork off of the operating shaft. Remove the shaft, operating lever and bearing as an assembly from the housing.

h. Remove the operating shaft lower bearing from the bottom of the governor housing.

i. Slide the governor operating shaft spacer from the shaft.

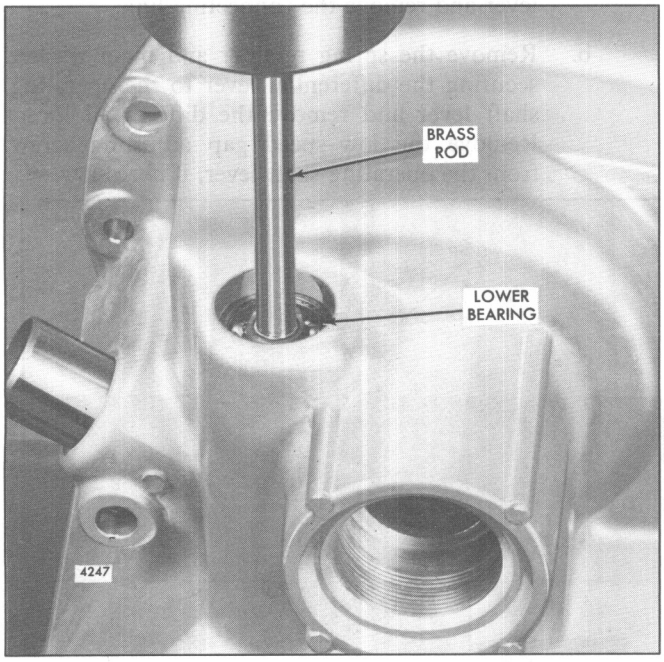


Fig. 15 – Removing Operating Shaft from Operating Shaft Lower Bearing

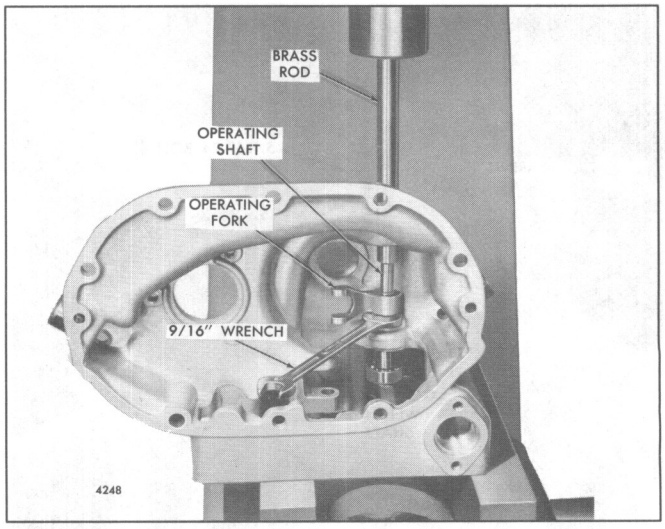


Fig. 16 – Removing Operating Fork Shaft and Lever Assembly from Governor Housing

j. Place a short 9/16" inside diameter sleeve over the end of the operating shaft and rest it against the inner race of the bearing on the operating shaft.

k. Support the operating shaft, lever, bearing and sleeve on a large washer or plate, with a 5/8" hole, on the bed of an arbor press (Fig. 17). Place a small brass rod on the end of the shaft and press the operating shaft out of the operating lever and bearing. Catch the shaft by hand when pressed from the lever and bearing to prevent it from falling and being damaged.

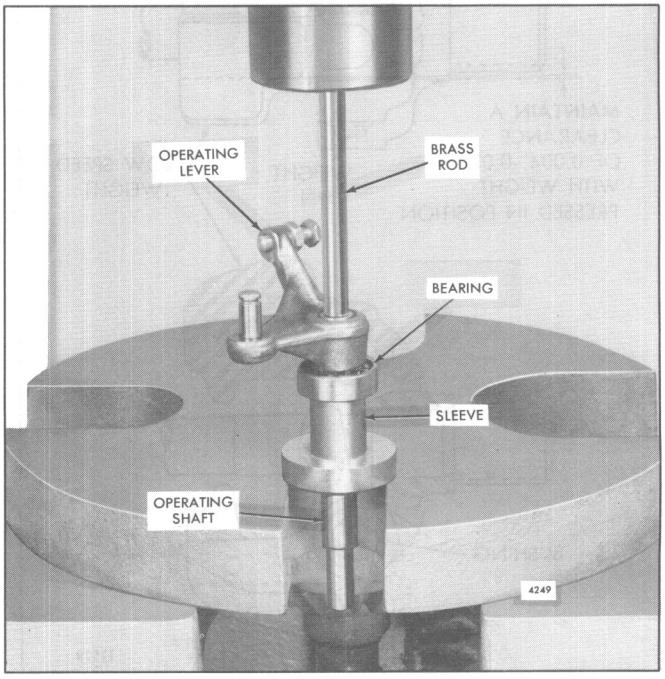


Fig. 17 – Removing Operating Lever and Upper Bearing From Operating Shaft

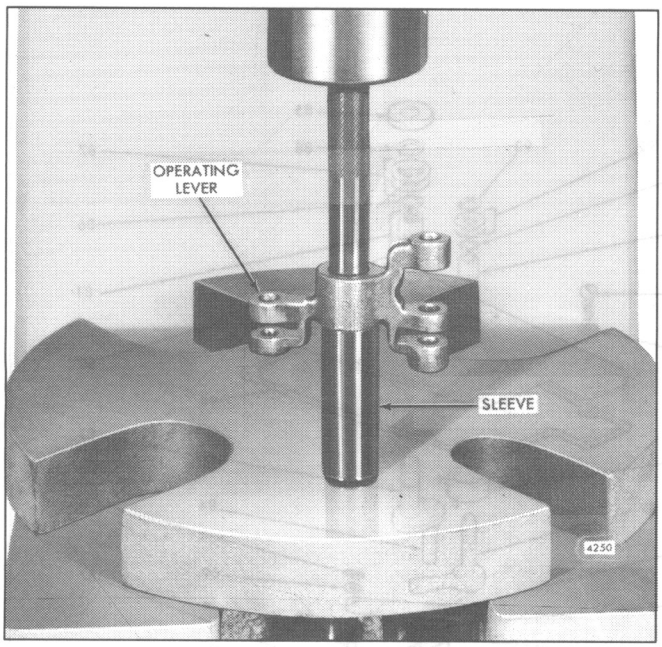


Fig. 18 – Removing Operating Lever Needle Bearings using Tool J 8985

NOTICE: Be sure that the bearing inner race is resting on the sleeve because the bearing could be damaged.

l. Wash the control link operating lever (containing the bearings) thoroughly in clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory for further use, removal is unnecessary.

m. If removal of the needle bearing is necessary, support the control link operating lever on a sleeve and rest the sleeve on the bed of an arbor press. Place tool J 8985 on top of the bearing and press both bearings out of the lever (Fig. 18).

8. Remove the buffer screw from the governor housing.

9. Remove the external starting aid screw from the governor housing, if necessary.

Inspection

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

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

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

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

Examine the weight carrier pins and bushings in the weights for wear.

Examine the control link operating lever shaft and needle bearings for wear or damage.

If the speed control and stop lever shaft are worn excessively due to worn or damaged needle bearings and bushing, replace the shafts, needle bearings and bushing in the cover.

Inspect the spring seats, plunger, adjusting screws, lock nuts, pins, seal rings and any other parts in the governor housing for wear or defects that might affect governor operation.

When replacing a limiting speed governor housing (with or without a starting aid screw), only the current governor housing assembly with the external starting aid screw is serviced.

If the external starting aid screw is not required, back it out as far as possible to make it ineffective.

Replace all of the parts that are worn or damaged.

Assemble Governor

With all of the governor parts cleaned and inspected and the necessary new parts on hand, refer to Figs. 1 and 19 (double weight governors) or Fig. 3 (single weight governors) and assemble the governor as follows:

1. If removed, install the external starting aid screw in the governor housing.

2. Install the operating shaft and governor linkage in the governor housing as follows:

a. Lubricate the inside diameter of the governor operating shaft upper bearing with engine oil. Start the bearing, numbered side up, straight on the large end of the operating shaft. Support the bearing and operating shaft on a 9/16" inside diameter sleeve on the bed of an arbor press, with the inner race of the bearing resting on the sleeve, then press the shaft into the bearing until 1/4" of the shaft protrudes through the bearing.

Install the bearing, numbered side up, on the shaft and press it tight against the bearing washer.

b. Lubricate the inside diameter of the governor operating shaft lever with engine oil. Start the lever, pivot pin in operating lever facing up, straight on the operating shaft with the flat on the shaft registering with the flat surface in the lever. Support the operating lever, bearing and shaft on the bed of an arbor press with a steel support directly under the center of the lever, then press the operating shaft through the bearing and lever until the end of the shaft contacts the steel support. The upper end of the shaft must be flush with the top surface of the lever.

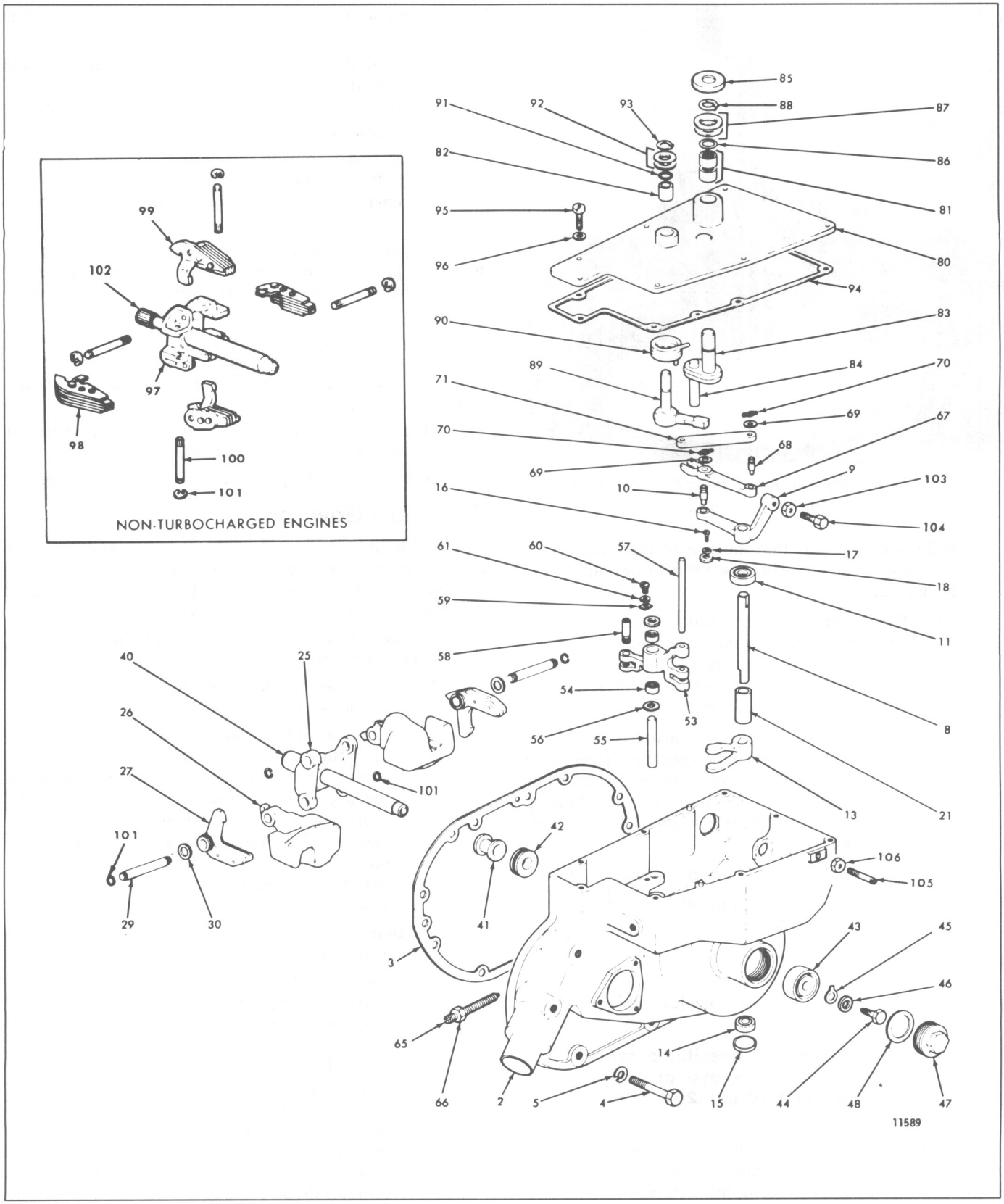


Fig. 19 – Limiting Speed Double Weight Governor Details and Relative Location of Parts

2. Housing--Governor
3. Gasket--Housing to Blower
4. Bolt--Housing to Blower
5. Lock Washer
8. Shaft--Governor Operating
9. Lever--Operating Shaft
10. Pin--Shaft Lever
11. Bearing--Operating Shaft (Upper)
13. Fork--Operating Shaft
14. Bearing--Operating Shaft (Lower)
15. Plug--Expansion
16. Screw--Bearing Retaining
17. Lock Washer
18. Flat Washer
19. Screw--Starting Aid Adjusting (Internal)
20. Screw--Gap Adjusting (Internal)
21. Spacer--Operating Shaft
25. Carrier--Governor Weight
26. Weight--Low Speed
27. Weight--High Speed
29. Pin--Weight
30. Flat Washer
31. Screw--Weight Pin Set
40. Shaft--Weight Carrier
41. Riser--Governor
42. Bearing--Riser Thrust
43. Bearing--Weight Carrier Shaft End
44. Bolt--Bearing Retainer
45. Lock Washer--Special
46. Flat Washer
47. Plug--Governor Housing
48. Gasket--Housing Plug
53. Lever--Control Link Operating
54. Bearing--Operating Lever
55. Shaft--Operating Lever
56. Washer--Operating Lever Shim
57. Pin--Fuel Rod Connecting (Long)
58. Pin--Fuel Rod Connecting (Short)
59. Clip--Operating Lever Shaft Lock
60. Screw--Lock Clip
61. Lock Washer
65. Screw--Buffer
66. Lock Nut--Buffer Screw
67. Lever--Governor Differential
68. Pin--Differential Lever
69. Washer--Differential Lever and Connecting Link Flat
70. Retainer--Spring
71. Link--Operating Lever Connecting
80. Cover--Governor Housing
81. Bearing--Speed Control Shaft
82. Bushing--Stop Lever Shaft
83. Shaft--Speed Control Lever
84. Pin--Fulcrum Lever
85. Spacer--Speed Control Shaft
86. Ring--Control Shaft Seal
87. Washer--Seal Ring Retainer
88. Snap Ring--Speed Control Shaft
89. Shaft--Stop Lever
90. Spring--Stop Lever Shaft Return
91. Ring--Stop Shaft Seal
92. Washer--Seal Ring Retainer
93. Snap Ring--Stop Shaft
94. Gasket--Governor Housing Cover
95. Screw--Housing Cover
96. Lock Washer
97. Carrier--Governor Weight
98. Weight--Low Speed
99. Weight--High Speed
100. Pin--Weight
101. Ring--Weight Pin Retainer
102. Shaft--Weight Carrier
103. Locknut
104. Screw, Gap Adjusting (External)
105. Screw, Starting Aid Adjusting (External)
106. Locknut

Fig. 19 – Limiting Speed Double Weight Governor Details and Relative Location of Parts

c. Place the operating shaft spacer over the lower end of the shaft and slide it against the upper bearing inner race.

d. Insert the end of the governor operating shaft, bearing, spacer and lever assembly through the upper bearing bore in the governor housing with the lever positioned (Figs. 1 or 3).

e. Lubricate the inside diameter of the governor operating shaft fork with engine oil, then place the operating fork over the lower end of the shaft with the finished cam surfaces on the fork fingers facing the rear of the governor housing and the flat on the shaft registering with the flat surface in the fork.

f. Support the governor housing and operating shaft assembly on the bed of an arbor press with the upper end of the operating shaft resting on a steel support (Fig. 20). Place a 7/16" inside diameter sleeve over the end of the shaft and against the fork, then press the fork tight against the shaft spacer on the shaft.

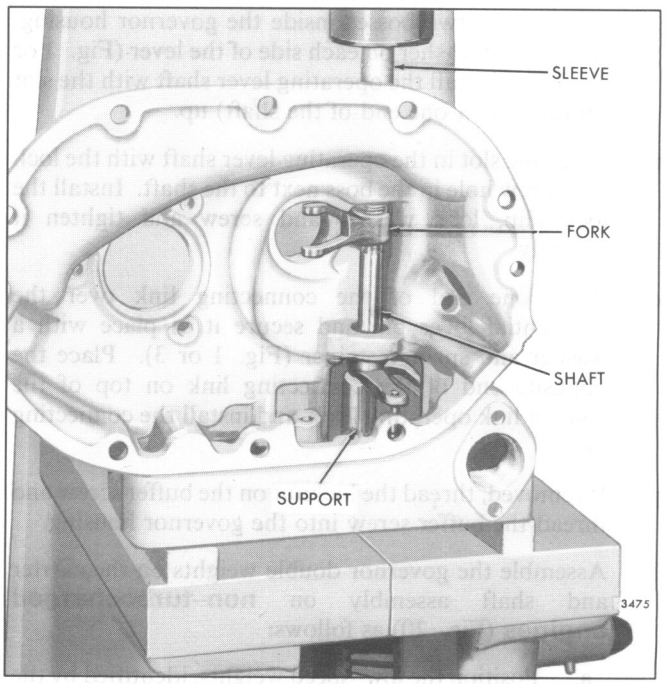


Fig. 20 – Installing Governor Operating Shaft Fork on Shaft

g. Lubricate the governor operating shaft lower bearing with engine oil. Start the bearing, numbered side up, straight in the governor housing and over the end of the operating shaft.

h. Support the governor housing and operating shaft assembly on the bed of an arbor press with the upper end of the operating shaft resting on a steel support

(Fig. 20). Place a 7/16" inside diameter sleeve on the inner race of the bearing and press the bearing on the shaft until it seats on the shoulder in the housing.

i. Install the governor operating shaft upper bearing retaining flat washer, lock washer and screw in the governor housing (Fig. 1 or 3).

j. Apply a thin coat of good quality sealant around the edge of a new expansion plug. Place the plug, concave side up, in the opening in the housing next to the lower operating shaft bearing. Tap the center of the plug with a hammer to secure the plug in the housing.

k. Place the differential lever over the pivot pin in the operating lever, pin in the lever up, and secure it in place with a plain washer and spring retainer.

l. If removed, place the control link operating lever on the bed of an arbor press with steel support under the bearing bore. Lubricate the bearing with engine oil and start the bearing, numbered end up, straight into the bore of the lever. Insert the pilot end of installer J 8985 in the bearing and press the bearing into the lever until it is flush with the top surface of the lever. Reverse the lever on the press and install the second bearing in the same manner.

m. Lubricate the control link operating lever needle bearings with Shell Alvania No. 2 grease, or equivalent. Place the operating lever in position between the two bosses inside the governor housing. Insert a flat washer on each side of the lever (Fig. 1 or 3). Then, install the operating lever shaft with the slot (in the side at one end of the shaft) up.

n. Align the slot in the operating lever shaft with the lock clip screw hole in the boss next to the shaft. Install the lock clip, lock washer and screw and tighten it securely.

o. Place one end of the connecting link over the differential lever pin and secure it in place with a washer and spring retainer (Fig. 1 or 3). Place the opposite end of the connecting link on top of the control link operating lever and install the connecting pin.

p. If removed, thread the locknut on the buffer screw and thread the buffer screw into the governor housing.

3. Assemble the governor double weights on the carrier and shaft assembly on **non–turbocharged engines** (Fig. 20) as follows:

   a. Position the low–speed weights, identified by the short cam arm, on opposite sides of the weight carrier.

   b. 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.

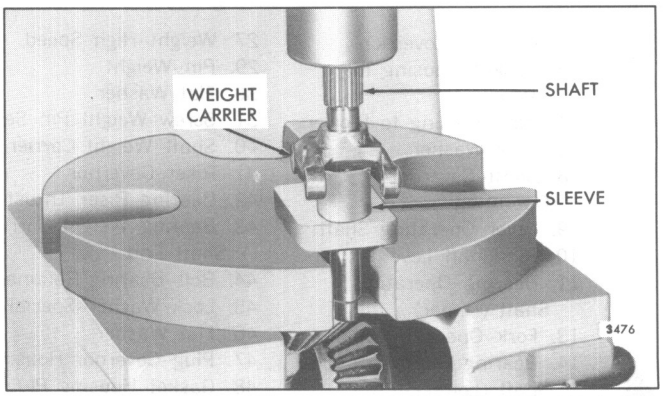


Fig. 21 – Installing Governor Weight Shaft in Weight Carrier

   c. Install the high–speed weights on the carrier in the same manner.

   d. Lubricate the weight shaft with clean engine oil.

4. Assemble the governor double weight and shaft assembly on **turbocharged engines** (Fig. 20) as follows:

   If the governor weight carrier assembly was removed from the weight shaft, the low and high–speed weights must be removed from the carrier before attempting to install the carrier on the shaft.

   a. Support the weight carrier (rear face up) on a sleeve and a steel support (with 1" hole) over an opening in the bed of an arbor press (Fig. 21).

   b. Lubricate the weight shaft with engine oil. Then, insert the non–splined end of the shaft through the carrier, sleeve and hole in the steel support. Press the shaft straight into the carrier until the shoulder on the shaft is tight against the carrier.

   c. Refer to Fig. 12 and install a retainer on either end of the weight pin. Note the match marks placed on the weight carrier and weights at the time of disassembly. Then, slide the weight pin through the carrier, flat washer and the high–speed weight and its bushing.

   d. Place the low–speed weight in position. Then, press the weight pin through the low–speed weight and carrier until the retainer bottoms against the carrier. Maintain a clearance of .004"–.012" with the weight pressed in position. To maintain this clearance, insert a .004"–.012" shim between the low–speed weight and carrier while pressing the pin into position.

   e. Remove the shim and install the second weight pin retainer.

f. Install the second pair of weights (three pair of weights in the 12V and 16V turbocharged engine governor) in the carrier in the same manner as described above.

5. Assemble the governor–single weights as follows (Fig. 3):

a. Install the retainer in the groove of the weight pin. Place a flat washer over the pin and against the lock ring.

b. Start the pin through the opening in the weight carrier. Place a second washer over the pin and against the projecting arm of the weight carrier.

c. Position the governor weight between the projecting arms of the weight carrier. Push the pin through the governor weight.

d. Place the third flat washer over the pin and against the weight.

e. Then, push the pin completely through the weight carrier and place the fourth flat washer over the pin and against the projecting arm of the weight carrier. Install a second lock ring in the groove of the weight carrier pin.

f. Install the second governor weight in a similar manner.

6. Install the governor weight and shaft assembly in the governor housing as follows:

a. Slide the governor riser on the weight shaft and against the fingers of the high–speed weight.

b. Place the governor riser thrust bearing over the weight shaft with the bearing race having the smaller inside diameter against the riser. Incorrect installation of the bearing will result in erratic operation of the governor.

c. Insert the weight carrier and shaft assembly in the governor housing. Then, support the splined end of the shaft and the governor housing on the bed of an arbor press with the upper end of the shaft under the ram of the press.

d. Place the weight shaft bearing in the governor housing (numbered side up) and start it straight on the end of the weight carrier shaft. Place a sleeve with a 1/2" inside diameter on top of the bearing inner race and press the bearing into the housing and against the shoulder on the shaft.

e. Place the special lock washer on the end of the weight carrier shaft with the tang on the inner diameter of the washer in the notch in the end of the shaft.

f. Place the flat washer on the bearing retainer bolt and thread the bolt into the shaft. Clamp the splined end of the weight carrier shaft in the soft jaws of a bench vise and tighten the bearing retainer bolt to 15–19 lb–ft (20–26 N•m) torque. Bend the tang on the lock washer against the head of the bolt.

g. Place a gasket against the weight shaft bearing. Apply a sealant such as Loctite grade H, HV or HVW, or equivalent, on the threads of the governor housing and the plug and thread the plug into the housing. Tighten the plug to 45 lb–ft (61 N•m) torque.

Rotate the governor weight assembly to see that there is no bind. If bind exists, remove the housing plug and check to see if the weight shaft bearing is fully seated in the governor housing.

7. Refer to Figs. 1 and 22 or 23 and assemble the high and low–speed spring, plunger and adjusting screw (except dual–range governors):

a. If removed, thread the retainer locknut on the high–speed spring retainer approximately 1–1/2". Place the high–speed spring on the high–speed spring plunger with the close wound coils inside the spring retainer and the spring against the shoulder of the plunger.

Current TA engines operating at 1750 rpm full load use a high–speed spring with one orange and one blue strip for identification. Engines operating at 1950–2100 rpm full load use a high–speed spring with two pink stripes for identification.

b. Insert the high–speed spring and plunger assembly in the high–speed spring retainer. Thread the idle speed adjusting screw into the threaded end of the plunger approximately 1/2". Then, thread the locknut on the idle speed adjusting screw.

c. Place the low–speed spring in the low–speed spring cap and the small end of the low–speed spring seat in the opposite end of the spring.

d. Insert the low–speed spring seat, spring and cap assembly into the high–speed spring plunger and over the idle speed adjusting pin.

e. For Fuel Squeezer engines, install the bushing in the end of the high–speed spring retainer (if removed) and align the two flat washers and two Belleville spring washers (Fig. 23). Then, install the set screw in the Belleville spring retainer nut and thread the retainer nut onto the high–speed plunger.

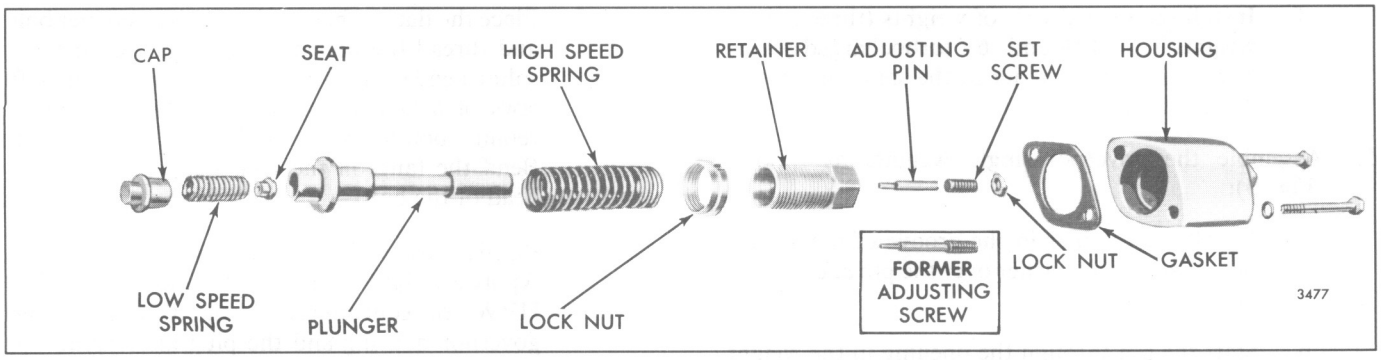


Fig. 22 – High and Low–Speed Springs and Plunger Details and Relative Location of Parts

f. Affix a new high–speed spring retainer housing gasket to the governor housing.

g. Insert the spring, plunger and retainer assembly into the opening in the governor housing and thread the retainer into the housing approximately one inch.

h. Install the high–speed spring retainer housing after the governor assembly has been installed on the engine and the governor adjustment procedures performed as outlined in Section 14.3 (6V and 8V engines), Section 14.3.5 (Fuel Squeezer Engines) or 14.3.1 (12V and 16V engines).

8. Refer to Figs. 2 and 24 and assemble the high and low–speed springs, plunger and adjusting screws (dual–range governor):

a. Thread the idle speed adjusting screw into the threaded end of the high–speed spring plunger approximately 1/2".

b. Place the high–speed spring guide in the end of the high–speed spring. Next, place the high–speed spring and guide over the end of the idle speed adjusting screw and plunger. Then, thread the locknut on the idle speed adjusting screw and against the spring guide.

c. Place the low–speed spring in the low–speed spring cap and the small end of the low–speed spring seat in the opposite end of the spring.

d. Insert the low–speed spring seat, spring and cap assembly into the high–speed spring plunger and over the idle speed adjusting screw.

e. Place the high–speed spring retainer over the high–speed spring guide. Then, insert the springs, plunger and retainer assembly into the opening in the governor housing and thread the retainer into the housing. Tighten the retainer in the housing with tool J 5345–5.

f. If removed, install the piston blocking ring in the outer end of the high–speed spring retainer housing with the ring gap straddling the threaded hole and flush with the outside face of the housing.

g. Place the piston seal ring in the groove in the speed adjusting piston.

h. Apply a thin coat of grease on the inside diameter of the retainer housing. Then, insert the solid end of the speed adjusting piston in the retainer housing.

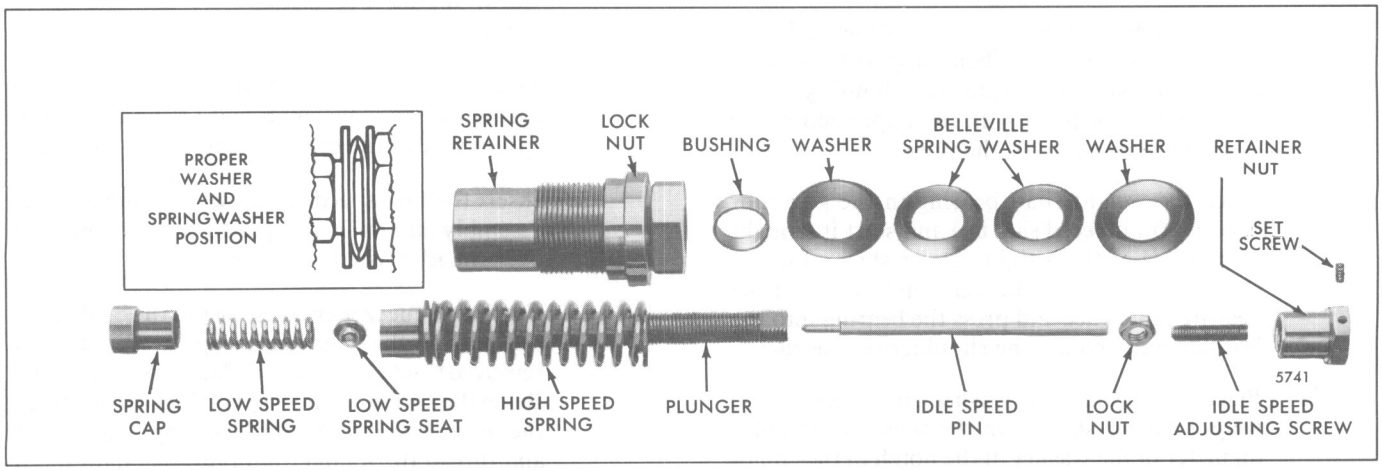


Fig. 23 – High and Low–Speed Springs and Plunger Details including Belleville Washers (Fuel Squeezer Engines)

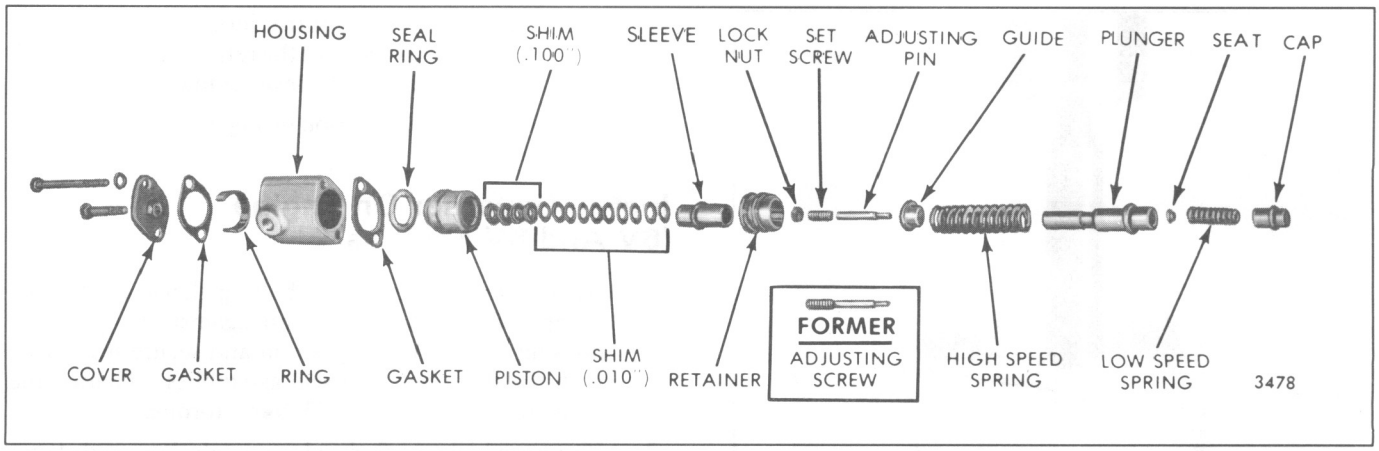


Fig. 24 – High and Low–Speed Springs, Plunger and Piston Details and Relative Location of Parts (Dual–Range)

i. Install the four thick and the ten thin high–speed spring shims down inside the speed adjusting piston. Then, insert the small end of the piston sleeve inside the piston and against the shims.

j. Affix a new high–speed spring retainer housing gasket to the governor housing.

k. If removed, thread the low maximum speed adjusting screw into the high–speed spring retainer housing cover approximately one inch. Then, affix a new gasket to the inside face of the cover.

l. Attach the high–speed spring retainer housing with piston, shims, sleeve and cover to the governor housing with two bolts and lock washers. Tighten the bolts to 13–17 lb–ft (18–23 Nm) torque.

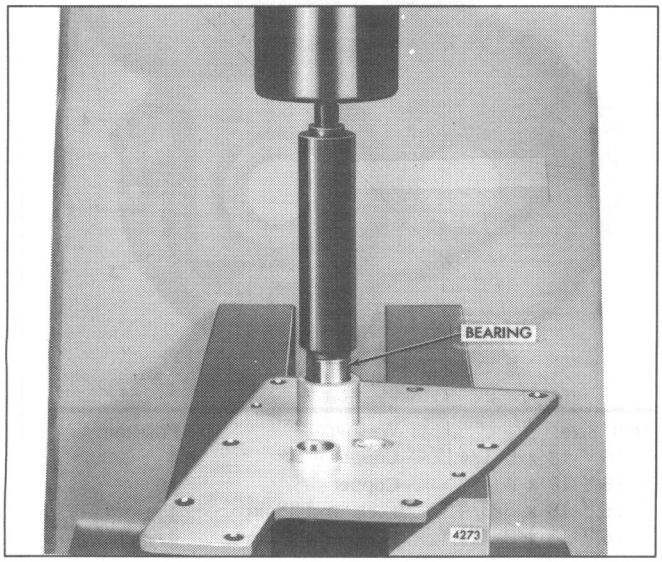


Fig. 25 – Installing Bearings in Governor Cover

9. Assemble the governor cover (Fig. 7 or Fuel Squeezer engine cover (Fig. 8) as follows:

a. If the speed control lever shaft needle bearing were removed from the cover, place the cover, inner face down, on two steel supports on the bed of an arbor press. Lubricate the outside diameter of a bearing with engine oil and start the bearing, numbered end up, straight in the bore in the cover boss.

b. Place the correct end of the bearing installer J 21068 in the bearing (Fig. 25). Installer J 21068 has a pilot on each end; one end is for the speed control shaft upper bearing and the other is for the stop shaft bushing or upper bearing. Then, press the bearing into the bore until the stop on the installer contacts the cover boss.

c. Reverse the governor cover, inner face up, on the bed of the arbor press. Lubricate the outside diameter of the lower bearing with engine oil and start the bearing, numbered end up, straight in the bore in the cover boss.

d. Place the bearing installer J 21068 in the bearing and press the bearing in the bore until it is flush with the face of the boss.

e. On a governor cover equipped with stop lever shaft needle bearing, install the needle bearings in the same manner as described in Steps a, b, c and d above. Use the small pilot end of installer J 21068 to install the bearings.

f. On a governor equipped with a stop lever shaft bushing, install the bushing in the cover (Fig. 26) in the same manner as described in Steps a and b above. Use the small pilot end of installer J 21068 to install the bushing.

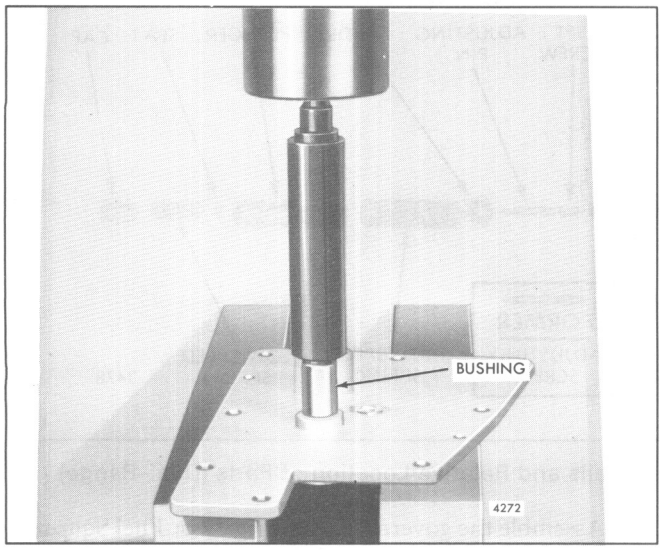


Fig. 26 – Installing Bushing in Governor Cover

g. Lubricate the stop lever shaft needle bearings or bushing with Shell Alvania No. 2 grease, or equivalent.

h. Place the stop lever shaft return spring over the boss on the inner face of the cover (Fig. 7 or 8). Insert the shaft part way through the bearings or bushing and hook the end of the return spring over the end of the lever, then push the shaft up in the cover. Position the end of the lever on the right side of the stop pin (Fig. 7 or 8).

New seal rings made of a Viton material are being used for the speed control lever shaft and for the stop lever shaft.

i. Place a new seal ring over the shaft and push it into the bearing bore and against the bearing or bushing. Place the two seal ring retainer washers on the shaft and against the cover boss, then install the snap ring in the groove in the shaft.

j. Install the stop lever on the shaft and secure it in place with the retaining bolt and lock washer.

k. Lubricate the speed control shaft needle bearings with Shell Alvania No. 2 grease, or equivalent. Then, insert the speed control shaft through the bearings.

l. Place the seal ring over the shaft and push it into the bearing bore and against the bearing. Place the two seal ring retainer washers on the shaft and against the cover boss. Then, install the snap ring in the groove in the shaft.

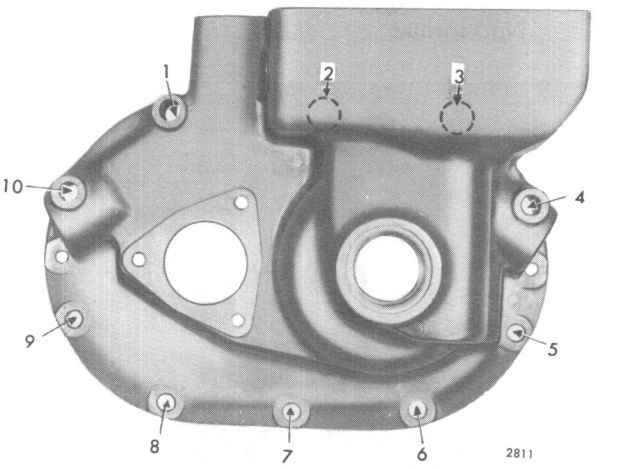
m. Install the spacer on the speed control shaft (slip fit) against the retaining washers and over the snap ring.

n. Install the speed control lever on the shaft and secure it in place with the retaining bolt and lock washer. Be sure the lever contacts the spacer.

o. Install the lubrication fitting in the speed control shaft.

Install Governor On Engine (6V And 8V Engines)

1. Affix a new gasket to the bolting flange of the fuel pump. Place the fuel pump against the governor housing in its *original* position and secure it in place with the three bolt and seal assemblies. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.
2. If removed, place a fuel rod cover tube hose and clamp on each fuel rod cover tube at each side of the governor housing.
3. Affix a new gasket to the forward face of the blower end plate.
4. Place the fuel pump drive fork on the fuel pump shaft. Position the governor and fuel pump assembly in front of the blower. Rotate the fuel pump fork until the prongs of the fork align with the slots in the drive disc. Rotate the weight shaft and align the splines on the shaft with the splines in the blower rotor.
5. Push the governor straight in over the dowels in the blower end plate and against the gasket.
6. Refer to Fig. 27 for the locations, and install the bolts, lock washers, copper washers and plain washer securing the governor to the blower. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.



Bolt Size:	Washer:	Position:
5/16"-18 x 5 1/4"	Copper	4
5/16"-18 x 4	Copper	10
5/16"-18 x 3 3/4"	Lock and Plain	1
5/16"-18 x 2 1/4"	Lock and Plain	2-3-5-6-7-8-9

Fig. 27 – Location and Size of Governor Retaining Bolts

7. Slide each fuel rod cover tube hose down on the cover tube attached to the cylinder heads and tighten the hose clamps.

8. Install and connect the crossover fuel oil line to each cylinder head and connect the fuel oil lines to the fuel pump.

9. Place the water bypass tube between the two thermostat housings and slide the hoses part way on the thermostat housings. Position the bypass tube so it clears the governor, fuel pump and fuel oil lines. Then, tighten the hose clamps.

10. Install the fuel rods between the cylinder heads and the governor as follows:

    a. Insert the lower end of the left–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    b. Raise the connecting pin up in the control link operating lever (Fig. 1). Insert the end of the fuel rod between the two bosses on the lever and insert the connecting pin through the fuel rod and into the lower boss.

    c. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

    d. Insert the lower end of the right–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    e. Remove the short screw pin from the control link operating lever. Insert the end of the fuel rod between the two bosses on the lever and install the screw pin. Tighten the pin securely.

    f. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

11. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the speed control shaft assembly in the slot of the differential lever and the dowel pins in the housing in the dowel pin holes in the cover.

12. Install the eight governor cover attaching screws and lock washers. The short cover attaching screw, with the drilled head, goes in the corner hole next to the high–speed spring retainer housing. Tighten the screws securely.

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.

13. Using a new gasket reinstall the cylinder head rocker covers.

14. Install all of the accessories that were removed from the cylinder head, governor or the front end of the engine.

15. Connect the control linkage to the speed control and stop levers.

16. Close the drain cocks and fill the cooling system.

17. Perform the governor and injector rack control adjustment as outlined in Section 14.3.

Install Governor On Engine (12V And 16V Engines)

1. Affix a new governor housing gasket to the forward face of the blower end plate. Position the governor in front of the end plate. Align the splines of the weight shaft with the splines in the blower rotor, then push the weight shaft in the rotor and slide the governor housing over the dowel pins in the end plate and against the gasket.

2. Refer to Fig. 27 for the bolt location and install the bolts, lock washers, plain washer and copper washers which secure the governor to the blower. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

3. Affix a new blower housing gasket to the cylinder block with a good grade of gasket cement to prevent the gasket from shifting when the blower is lowered into position.

4. Thread eyebolts in diagonally opposite tapped holes in the top of the blower housing. Then, attach a rope sling and chain hoist to the eyebolts.

5. Lift the blower and governor assembly, at a slight angle, and position it on top of the cylinder block, with the flange of the rear end plate cover inside the blower drive shaft cover hose.

6. Thread a 7/16"–14 x 8–1/4" bolt and special washer finger tight in the center hole of each blower end plate. Then, install the 3/8"–16 x 5–1/2" bolts and retaining washers finger tight at each side of the blower housing. The lip at the beveled end of the bolt retaining washer goes in the small recess in the housing just above the bolt slot.

7. Tighten the bolts as follows:

   a. First, tighten the blower–to–block end plate bolts to 40–60 lb–ft (54–81 N•m) torque.

   b. Then, tighten the blower housing–to–block side angle bolts uniformly to 30–35 lb–ft (41–47 N•m) torque in 5 lb–ft (7 N•m) increments.

   c. Recheck the torque on the blower–to–block end plate bolts.

8. Slide the blower drive support–to–blower hose (seal) and clamps into position and tighten the clamps.

9. Insert the blower drive shaft through the blower drive flexible coupling and into the blower drive coupling and install the retaining snap ring in the groove in the coupling.

10. Affix a new gasket to the flywheel housing hole cover, then attach the cover to the flywheel housing with six bolts and lock washers.

    On an engine equipped with a rear mounted battery–charging alternator, affix a new gasket to the alternator drive assembly. Place the alternator drive coupling on the drive hub, then place the drive assembly into position and align the slots in the drive coupling with the drive hub on the blower drive gear. Place the drive assembly against the flywheel housing and install the bolts, lock washers and alternator adjusting strap. Install the alternator drive pulley and drive belt.

    On an engine equipped with a hydraulic oil pump, refer to *M. MH. Marine Service Manual* – Form 00SA1984.

11. Connect the blower drive support oil tube to the fitting in the blower drive support. Then, tighten the two seal ring retaining plate bolts to 13–17 lb–ft (18–23 N•m) torque.

12. Affix a new gasket to the fuel pump flange, then install the fuel pump drive fork and fuel pump on the governor housing. Connect the fuel pump inlet and outlet tubes or hoses to the fuel pump.

13. Slide the governor housing to auxiliary control link housing hose and clamp into position between the two housings and tighten the hose clamp.

14. Slide the fuel rod cover hose down on the cover tube attached to the cylinder head at each side of the governor housing and tighten the hose clamps.

15. Place the control link operating lever connecting link in position in the governor and auxiliary housings and connect it to the ball joint studs in the control link operating levers.

16. Install the fuel rods between the cylinder heads and the governor as follows:

    a. Insert the lower end of the left–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    b. Raise the connecting pin up in the control link operating lever (Fig. 1). Insert the end of the fuel rod between the two bosses on the lever and insert the connecting pin through the fuel rod and into the lower boss.

    c. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

    d. Insert the lower end of the right–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    e. Remove the short screw pin from the control link operating lever. Insert the end of the fuel rod between the two bosses on the lever and install the screw pin. Tighten the pin securely.

    f. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

17. Place a new auxiliary control link housing cover gasket on the housing, then install the cover and secure it in place with screws and lock washers.

18. Place a new governor housing cover gasket on the housing, then install the cover and secure it in place with 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.

19. Using new gaskets reinstall the cylinder head rocker covers.

20. On a non–turbocharged engine, remove the cover from the top of the blower. Place the blower screen, wire side down, on top of the blower and install the air shutdown adaptor. Then, attach the air shutdown housings and gaskets to the adaptors.

    On a turbocharged engine, remove the cover from the top of the blower. Place the blower screen, wire side down, and install the air shutdown adaptor and air shutdown housing as an assembly on the blower. Then, attach the shutdown rod to the lever on the shutdown housing.

    On a marine engine, remove the cover from the top of the blowers. Place the blower screen, wire side down, on top of the blower and install the air shutdown housings.

21. On a non–turbocharged engine, connect the air inlet tubes to the air shutdown housings.

    On a turbocharged engine, attach the air inlet tube to the rear air shutdown housing and the turbocharger. On a marine engine, install the air silencers on the air shutdown housings.

22. Connect the linkage, that was removed, to the governor speed control and stop levers.

23. Perform an engine tune–up as outlined in Section 14.3.1.

LIMITING SPEED MECHANICAL GOVERNOR

(Variable Low–Speed)

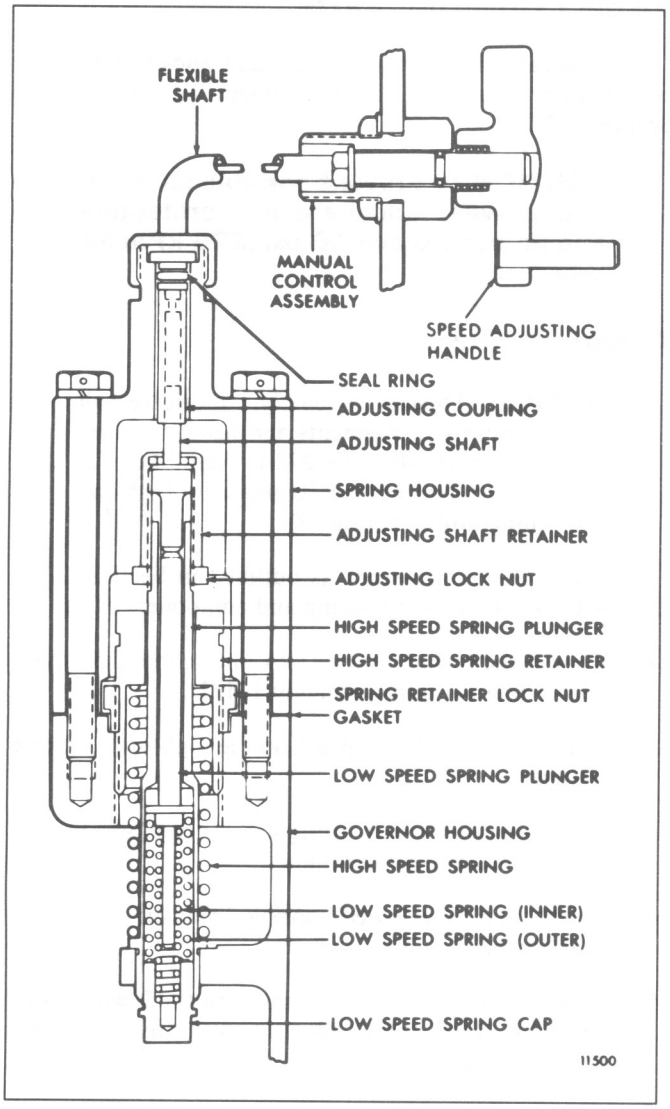


Fig. 1 – Cable Operated Governor Spring Housing and Components

The variable low–speed limiting speed mechanical governor is used on highway vehicle engines where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, grain and liquids) and a high idle speed range is desired during auxiliary operation.

The current governor is a single–weight type and provides an idle speed range of 500 to 1800 rpm. The governor is mounted on the front end of the blower and is driven by one of the blower rotors.

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.

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 function 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).

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 GOVENOR

Remove Governor

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.

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, 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 copper 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 speed 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.

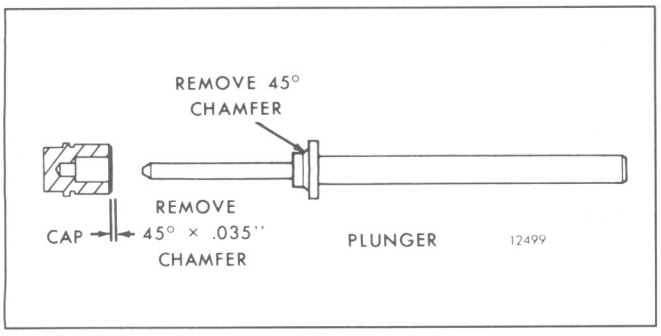


Fig. 2 – Rework Former Plunger and Cap

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.

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

Assemble Governor

NOTICE: 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, then assemble the spring housing and components (Fig. 1).

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.

   NOTICE: Place a new 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, then connect the manual control flexible shaft to the governor spring housing (Fig. 1). 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.

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, 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 gaskets.

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. Discard the gasket.

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.

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

Assemble Governor

NOTICE: 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, then assemble the spring housing and components as follows (Fig. 3):

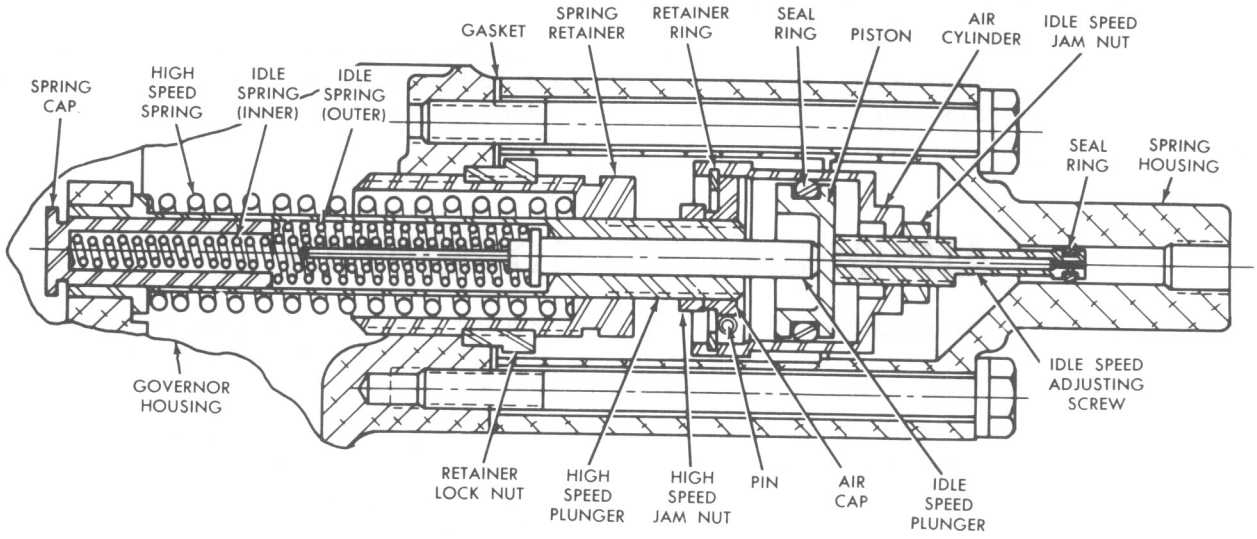
1. Thread the spring retainer lock nut on the high–speed spring retainer approximately 1–1/2".

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

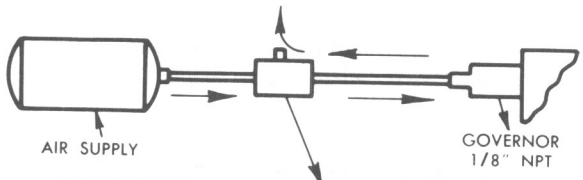
3. Insert the high–speed spring and plunger assembly in the high–speed spring retainer.

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

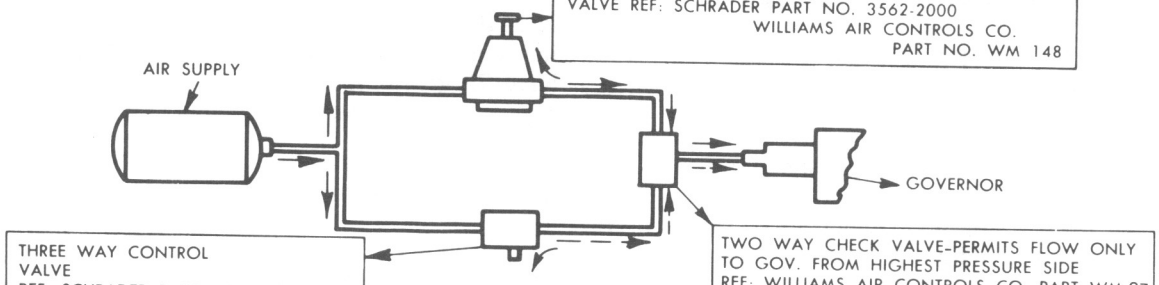
5. Place the inner and outer springs in the lower end of the high–speed spring plunger, over the low–speed spring plunger.



AIR OPERATED VARIABLE LOW SPEED LIMITING SPEED GOVERNOR



THREE WAY CONTROL VALVE FOR MAXIMUM AND MINIMUM IDLE CONTROL OR THREE WAY PRESSURE REGULATING VALVE FOR VARIABLE IDLE SPEED CONTROL. GOVERNOR IDLE CYLINDER MUST BE VENTED TO OBTAIN MINIMUM IDLE.



OPTIONAL COMBINATION CONTROL TO PROVIDE EITHER MAXIMUM & MINIMUM IDLE CONTROL OR VARIABLE IDLE SPEED CONTROL. AGAIN, THREE WAY TYPE VALVES ARE USED TO VENT GOVERNOR WHENEVER THE VALVES ARE CLOSED TO THE SUPPLY

12750

OPTIONAL COMBINATION AIR CONTROLS

Fig. 3 – Air Operated Variable Low Speed Limiting Speed Governor and Air Controls

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.

   NOTICE: Place the new spring housing gasket in position before installing the assembly.

7. Thread the 1/2"–20 high–speed spring jam nut on the threaded end of the plunger approximately 1/2".

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 on the high–speed spring plunger and against the high–speed spring plunger and jam nut.

10. Place a new seal ring on the idle speed 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.

    NOTICE: Be sure and lubricate the bore of the spring housing with grease as stated in the above notice.

Intall Governor

Install the governor as outlined in Section 2.7.1, then connect the air controls to the governor spring housing (Fig. 3).

Adjust the governor as outlined in Section 14.3.3.

LIMITING SPEED MECHANICAL GOVERNOR

(VARIABLE HIGH SPEED)

The air operated variable high speed limiting speed mechanical governor is provided for highway vehicle applications where the same engine powers both the vehicle and auxiliary equipment, for unloading bulk products (such as cement, grain or liquids) and where a variable speed range is desired during auxiliary constant speed operation.

Operation

The idle speed range for these governors is the same as for the standard limiting speed governors. The normal no–load speed range is the same as for the standard limiting speed governor. A variable high speed limiting governor will control engine RPM from any normal no–load speed down to near idle speed. Also, in addition to the high speed control kit, a regulated air supply and an air cylinder to move the throttle to the wide open throttle position is required.

Install Control Housing

Without disturbing the engine tune–up, install a high speed control housing assembly on a standard limiting speed governor having a long spring pack, as follows (Fig. 1):

1. Loosen the two bolts and copper washers and remove the spring retainer housing.

2. Remove the idle speed adjustment screw and replace it with the longer high speed control idle speed screw and reset the idle speed RPM to the previous setting.

NOTICE: If the governor has the former one piece idle speed screw, replace it with the current idle speed pin and long screw.

The engine tune–up procedure for the high speed control governor is the same as stated in Section 14.3 except the idle speed adjustment is made, using the longer idle speed screw.

3. Assemble the high speed control housing as follows:

   a. Install the small ring in the spring housing and the large seal ring on the piston.

   b. Lubricate the piston and inside of housing with engine oil and install the piston in the housing.

4. Slide the housing and piston assembly over the spring retainer and idle speed screw.

5. Install the idle screw self–locking nut and make the following adjustments:

   a. Place a .010" feeler gage between the VHS housing gasket and the main governor housing.

   b. Adjust the elastic stop nut, while holding the idle screw stationary, until a slight drag is felt on the shim (Fig. 2). This adjustment is made easily with Tool J 28598–A. c. Remove the shim.

6. Install the gasket and either flat or tamper–resistant cover with two copper washers and two 5/16"–18 x 4 1/2" bolts (flat cover). Tighten the bolts.

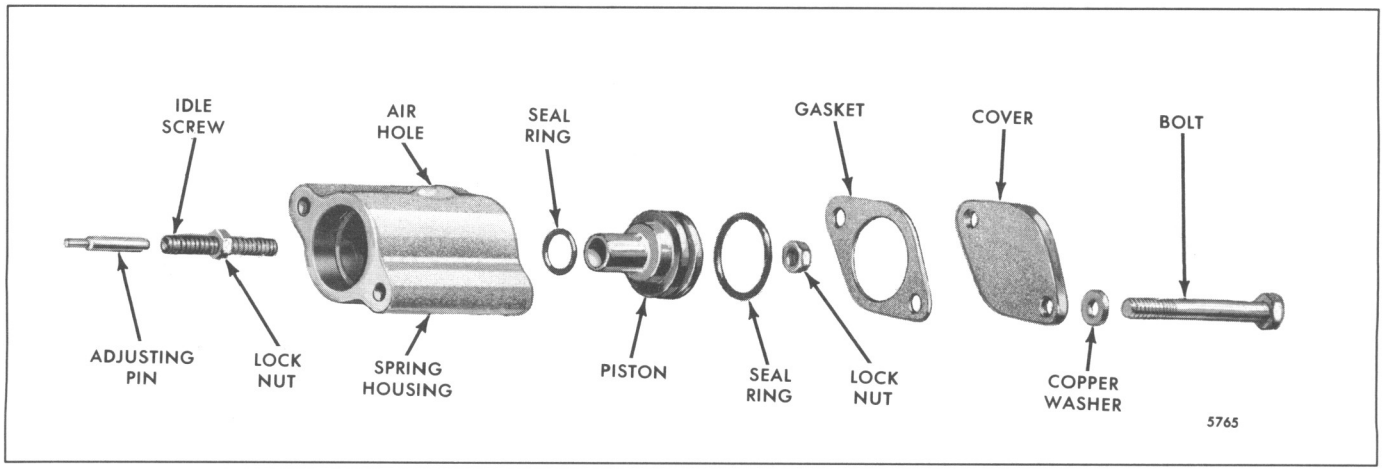


Fig. 1 – Air Operated Variable High Speed Limiting Speed Mechanical Governor Components

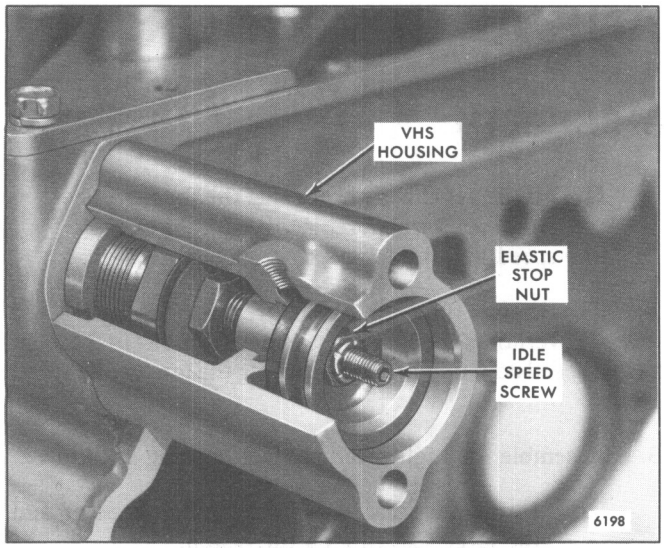


Fig. 2 – Adjust Elastic Stop Nut using Tool J 28598–A

Install the air cylinder on the governor cover so that it does not interfere with the throttle linkage when no air pressure is applied and moves the speed control lever to the wide open throttle position with full air pressure applied (Fig. 3).

Supply air should only be taken from the accessory air supply. At no time should supply air be taken from the service brake system. However all air supply components should be plumbed and mounted in compliance with the recommendations for the air brake system. Both air cylinders must be vented to insure rapid disengagement.

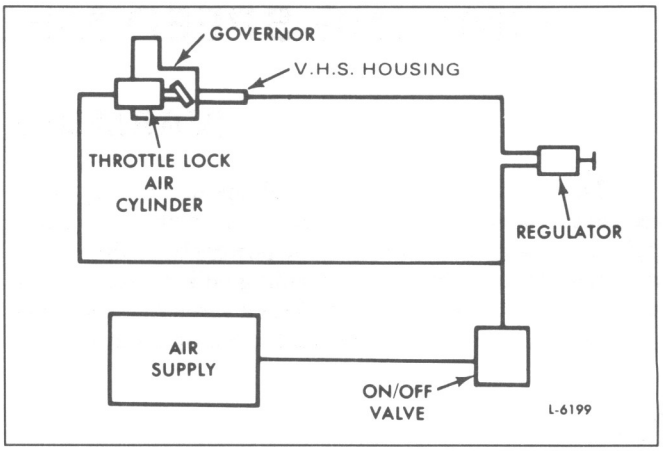


Fig. 3 – Schematic Drawing of Limiting Speed Mechanical Governor (Variable High Speed)

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks move to the no fuel postion when the governor stop lever is placed in the stop position. Engine over–speed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

CAUTION: An over–speeding engine can result in engine damage which could cause personal injury.

VARIABLE SPEED MECHANICAL GOVERNOR

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

1. Controls the engine idle speed.
2. Limits the maximum no–load speed.
3. Holds the engine at any constant speed, between idle and maximum, as desired by the operator.

The mechanical engine governor is identified by a name plate attached to the governor housing. The letters S–W.–V.S. stamped on the name plate denote a single–weight variable speed governor.

On 6V and 8V engines, the governor is mounted on the front end of the blower. On a 12V and 16V engines, the governor is mounted on the front end of the rear blower and the governor auxiliary drive housing is mounted on the rear

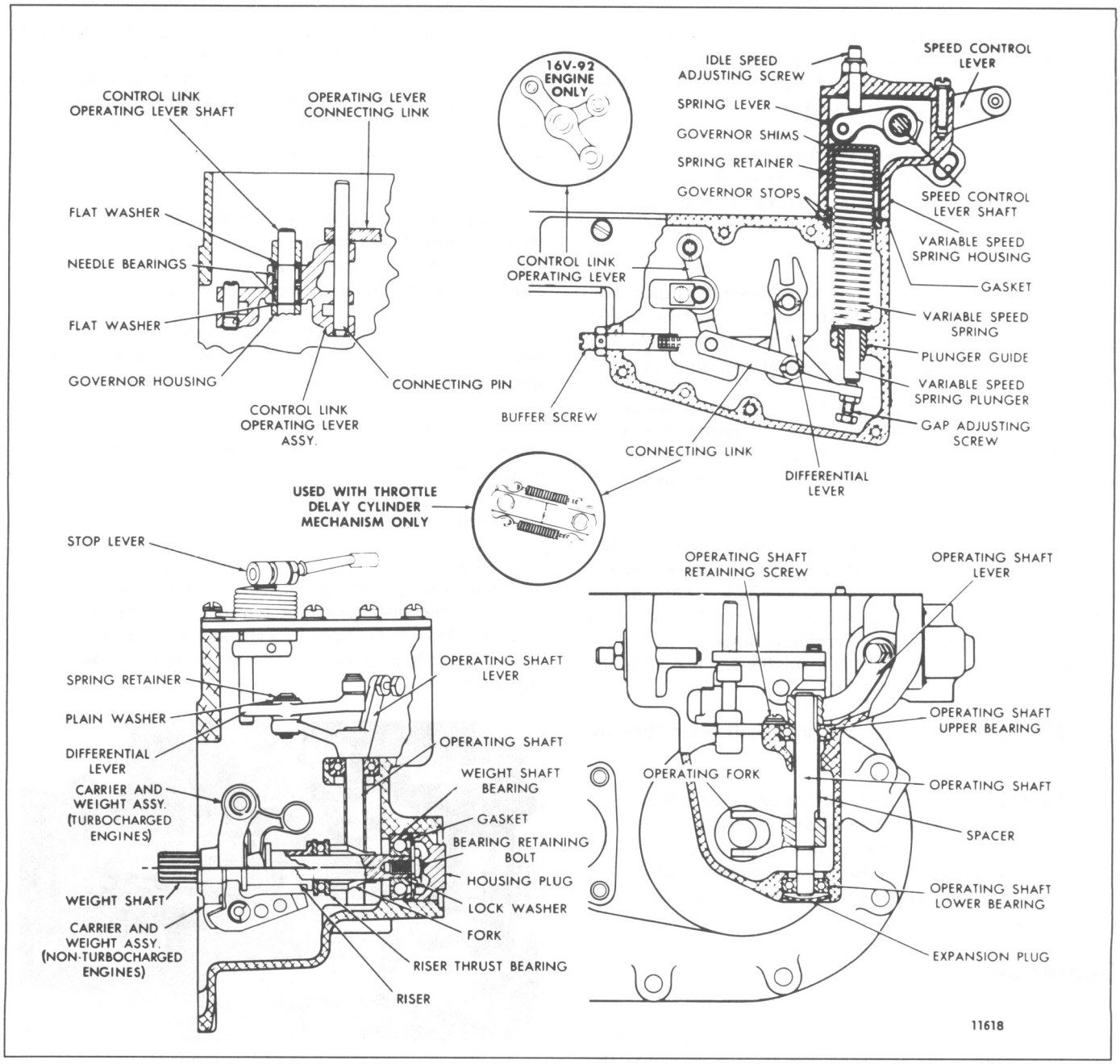


Fig. 1 – Cross Sections of Variable Speed Mechanical Governor

end of the front blower. The governors are driven by a blower rotor. The governor assembly consists of three subassemblies.

1. Control Housing Cover.
2. Variable Speed Spring Housing and Shaft.
3. Control and Weight Housing.

For 12V and 16V turbocharged engines, the governor has three weights and a heavier variable speed spring (Fig. 9).

To provide additional design features, a new die cast governor cover with serrated shafts and three bosses is now being used. One boss is drilled for the variable speed governor shutdown (run/stop) shaft.

> **NOTICE:** If a customer furnished mounting bracket is attached to the new cover, it may be necessary to rework the old bracket to clear the unused cast bosses (two for variable speed governors).

The new die cast governor cover assemblies include a 1/2" diameter serrated shutdown shaft for variable speed governors. This assures positive clamping between the serrated levers and the shafts to prevent any slippage.

Four serrations are eliminated on the shutdown shafts to permit certain customers to design a mating lever with missing serrations, which will provide a fixed position for particular requirements. Levers are not provided with missing serrations.

To reduce governor speed control lever shaft assembly stop pin wear and prolong bushing and "0" ring seal life, a yieldable speed control lever is available. This newly designed yieldable speed control lever cannot be used with the former stamped cover assemblies; however, a service yieldable speed control lever is available for use with the stamped cover.

The former and new cover and shaft assemblies are interchangeable on a governor.

> **NOTICE:** When only a former cover needs replacing, it will be necessary to replace the cover and shaft assembly. Only the new cover is serviced separately. The former control shafts and levers will continue to be serviced for the former governors.

Operation

Two manual controls are provided on the variable speed governor: a governor stop lever and a speed control lever. For starting, the governor stop lever is moved to the RUN position; this moves the injector control racks to the FULL–FUEL position. Upon starting, the governor moves the injector racks out to the position required for idling. The engine speed is then controlled manually by movement of the speed control lever.

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 (Fig. 1). One end of the operating shaft lever bears against the variable speed spring plunger, while the other end provides a changing fulcrum on which the differential lever pivots.

The centrifugal force of the governor weights is opposed by the variable speed spring. Load changes or movement of the speed control lever create an unbalanced force between the revolving governor weights and tension on the variable speed spring. When the two forces are equal, the engine speed stabilizes for a setting of the speed control lever.

Fuel rods connected to the injector control tube levers and the control link operating lever assembly are operated by the differential lever through the operating lever connecting link. This arrangement 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 centrifugal force required to balance out the tension on the variable speed spring in the low speed range.

Adjustment of the engine idle speed is accomplished by changing the tension on the variable speed spring by means of the idle speed adjusting screw. Refer to Section 14.4 (6V and 8V engines) or 14.4.1 (12V and 16V engines) for the idle speed adjustment.

Adjustment of the maximum no–load speed is accomplished by varying the tension on the variable speed spring by the installation or removal of stops and shims (Fig. 1). Refer to Section 14.4 (6 and 8V engines) or 14.4.1 (12V and 16V engines) for the maximum no–load speed adjustment.

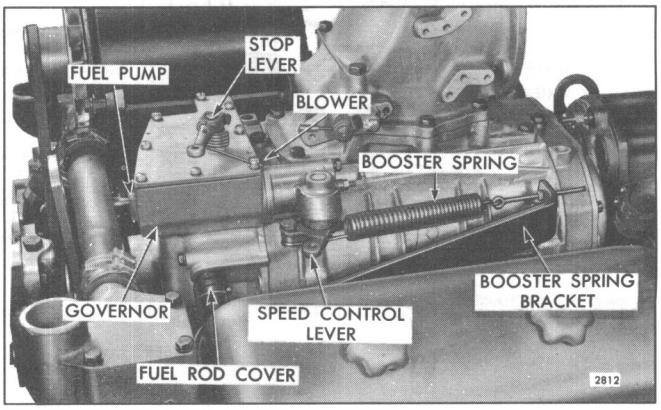


Fig. 2 – Variable Speed Governor Mounting (6V and 8V Engines)

Lubrication

The governor is lubricated by a spray of lubricating oil from the blower end plate. The governor weights distribute this oil to all parts of the governor assembly requiring lubrication.

Oil returning from the governor is directed through passages in the blower end plate and cylinder block to the engine oil pan.

Remove Governor From Engine (6V and 8V Engines)

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Open the drain cocks and drain the engine cooling system.

2. Remove any accessories attached to the cylinder head, governor or front end of the engine that interfere with the removal of the governor assembly.

3. Disconnect the control linkage from the speed control and stop levers (Fig. 2).

4. Remove the end of the stop lever return spring from behind the head of the special governor cover attaching screw. Then remove the eight screws and lock washers securing the governor cover to the housing. Lift the cover and gasket from the housing.

5. Remove the fuel rods from the control link operating lever assembly and the injector control tube levers as follows (Fig. 1):

   a. Remove the valve rocker covers from the cylinder heads.

   b. Remove the right bank fuel rod by removing the screw type pin, in the control link operating lever, and the clevis pin in the control tube lever and withdraw the fuel rod from the governor.

   c. Remove the left–bank fuel rod by removing the clevis pin in the control tube lever and lift the connecting pin up out of the control link operating lever approximately three–quarters of an inch. Then withdraw the fuel rod from the governor.

6. Loosen the hose clamps at each end of the water bypass tube. Slide the hoses and clamps onto the bypass tube and remove the tube from the engine.

7. Disconnect and remove the fuel oil lines attached to the fuel pump and the crossover fuel oil line attached to each cylinder head.

8. Loosen the outer booster spring adjusting nut and remove the booster spring from the speed control lever.

9. Loosen the hose clamps on the fuel rod cover tube hoses next to each cylinder head and slide each hose and clamp up on the tube in the governor housing.

10. Note the location of the two copper, one plain and eight lock washers on the governor to blower bolts before removing them. Then remove the ten bolts and washers (two inside and eight outside) securing the governor and fuel pump assembly to the blower.

11. Tap the sides of the governor housing slightly with a plastic hammer to loosen the governor from the blower. Then pull the governor and fuel pump assembly straight out from the dowels in the blower end plate. Remove the governor to blower gasket.

    NOTICE: The fuel pump drive coupling fork may stay on either the fuel pump or the blower rotor shaft. Remove the drive coupling fork.

12. Remove the three bolt and seal assemblies securing the fuel pump assembly to the governor housing. Remove the fuel pump and gasket from the governor housing.

Remove Governor From Engine (12V and 16V Engines)

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect the linkage attached to the governor speed control and stop levers.

2. On a non–turbocharged engine, disconnect the air inlet tube attached to the air shutdown housing on each blower.

   On a turbocharged engine, disconnect the tube from the turbocharger and the air shutdown housing on the rear blower.

   On a marine engine, remove the air silencers from both air shutdown housings.

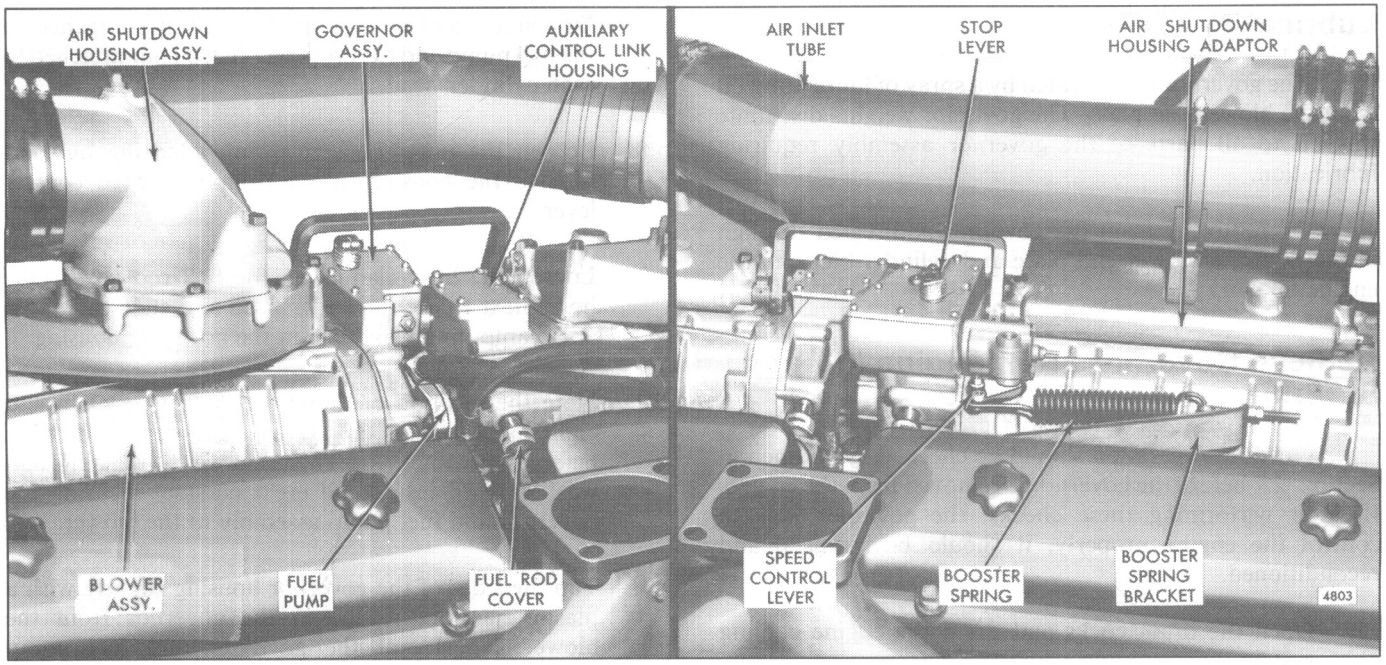


Fig. 3 – Variable Speed Governor Mounting (12V and 16V Engines)

3. On a non–turbocharged engine, remove the air shutdown housings and the air shutdown adaptor from the rear blower.

   NOTICE: Remove the two air shutdown housings, with attaching rod, as a unit from the adaptors or the blowers.

   On a turbocharged engine, disconnect the shutdown rod from the lever on the rear air shutdown housing. Then remove the air shutdown housing and the air shutdown adaptor as an assembly from the blower.

4. Cover the top of the blower with masking tape to prevent the entry of foreign material.

5. Remove the rear cylinder head rocker covers.

6. Remove the end of the stop lever return spring from behind the head of the special governor cover attaching screw. Then remove the eight screws and lock washers securing the governor cover to the housing. Lift the cover and gasket from the housing.

7. Remove the governor auxiliary control link housing cover screws and lock washers, then remove the cover and gasket from the housing.

8. Disconnect the fuel rods from the control link operating lever and the injector control tube levers as follows:

   a. Remove the right bank fuel rod by removing the screw type pin in the control link operating lever and the pin in the control tube lever. Withdraw the fuel rod out through the top of the governor housing.

   b. Remove the left bank fuel rod by removing the connecting pin from the control link operating lever and the pin in the control tube lever. Withdraw the fuel rod out through the top of the governor housing.

9. Remove the connecting link from the ball joint stud attached to the control link operating lever in the governor housing and the auxiliary control link housing by lifting, or prying each end of the connecting link off of the ball joint studs. Then remove the connecting link from the governor housing.

10. Loosen the fuel rod cover hose clamp at each side of the governor housing. Then slide each hose against the governor housing. Tighten each clamp to retain it on the hose.

11. Loosen the hose clamp between the governor housing and the auxiliary control link housing. Then slide the hose forward against the auxiliary control link housing. Tighten the clamp to retain it on the hose.

12. Disconnect the fuel pump inlet and outlet tubes or hoses from the fuel pump. Then remove the fuel pump from the governor housing.

13. Loosen the outer booster spring adjusting nut and remove the booster spring from the speed control lever. Then remove the booster spring bracket from the cylinder head.

14. Disconnect the blower drive support oil tube from the fitting in the blower drive support. Loosen the two bolts securing the oil tube seal ring retaining plate to the blower end plate, then push the oil tube into the end plate.

15. Remove the six bolts and lock washers securing the flywheel housing hole cover, at the blower drive support, then remove the cover and gasket.

On an engine equipped with a rear mounted battery–charging alternator, loosen and remove the alternator drive belt. Then remove the alternator drive pulley nut and pulley from the alternator drive shaft. Remove the bolts and lock washers securing the alternator drive assembly to the flywheel housing, then remove the drive assembly, gasket and drive coupling from the flywheel housing.

On an engine equipped with a hydraulic oil pump, remove the six bolts and lock washers securing the oil pump to the flywheel housing and adaptor, then remove the oil pump, adaptor and gaskets from the flywheel housing. Remove the drive coupling and the drive coupling hub from the blower drive shaft.

16. Remove the blower drive shaft retaining snap ring from the blower drive coupling, then remove the blower drive shaft from the blower drive hub and the blower drive support.

17. Loosen the blower drive support–to–blower hose (seal) clamps. Then push the hose (seal) back on the blower drive support.

18. Remove the bolt and washer through the top of each blower end plate securing the blower to the cylinder block.

19. Remove the bolts and retaining washers on each side of the blower securing the blower to the cylinder block.

20. Thread eyebolts in diagonally opposite tapped holes in the top of the blower housing. Then attach a rope sling and chain hoist to the eyebolts.

21. Lift the blower assembly slightly and move it forward to detach the blower from the hose (seal). Then lift the blower away from the engine and place it on a bench. Remove the blower to cylinder block gasket.

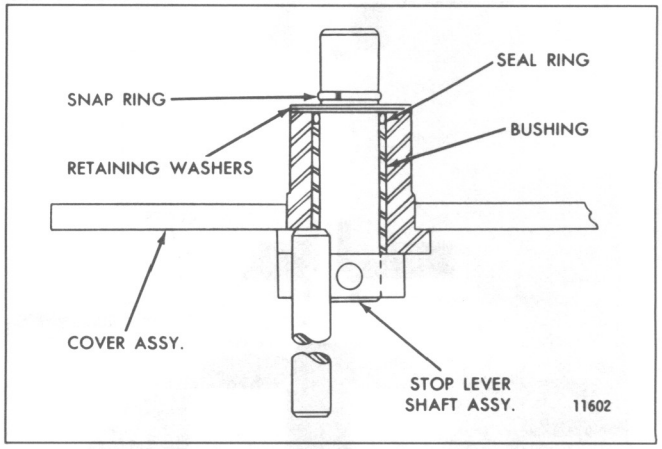


Fig. 4 – Cross Section of Governor Cover Assembly

22. With the blower and governor assembly removed from the engine, remove the ten bolts, lock washers, plain washer and copper washers securing the governor assembly to the blower end plate. Slide the governor assembly forward off of the dowel pins in the end plate, then remove the governor to blower end plate gasket.

Disassemble Governor

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

1. Disassemble the governor cover as follows (Fig. 4):

   a. Clamp the cover assembly in a vise equipped with soft jaws.

   b. Loosen the stop lever retaining bolt and pull the lever from the shaft. Remove the return spring from the shaft.

   c. Remove the snap ring from the groove in the stop lever shaft and remove the two seal ring retaining washers.

   d. Pull the stop lever shaft out of the cover and remove the seal ring (on top of the bushing) from the cover.

   e. At this stage of disassembly, wash the cover assembly (containing the bushing) thoroughly in clean fuel oil and inspect the bushing for wear and damage. If the bushing is satisfactory for further use, removal is unnecessary.

   f. If bushing removal is necessary, support the inner face of the cover over the opening in the bed of an arbor press. Place the remover J 21967–01 on top of the stop shaft bushing and press the bushing out of the cover (Fig. 5).

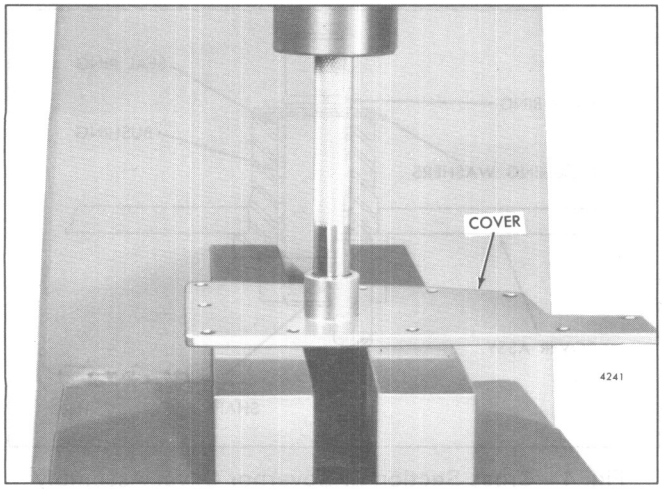


Fig. 5 – Removing Stop Lever Shaft Bushing from the Governor Cover using Tool J 21967-01

2. Remove the variable speed spring, spring plunger and spring housing assembly from the governor housing as follows:

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

   b. Remove the two bolts and lock washers securing the variable speed spring housing to the governor housing. Then withdraw the spring housing, spring retainer, shims, split stop and spring as an assembly from the governor housing. Remove the spring housing gasket.

   c. Remove the variable speed spring, split stop, shims and spring retainer from the spring housing. Then remove the spring plunger from the plunger guide.

   d. Remove the spring retainer solid stop from the governor housing.

   e. If necessary, remove the variable speed spring plunger guide from the governor housing with a small brass rod and hammer.

3. Disassemble the variable speed spring housing:

   a. Loosen the bolt securing the speed control lever to the speed control shaft and pull the lever from the shaft.

   b. Remove the Woodruff key and flat washer from the speed control shaft.

   c. Remove the pipe plug in the top of the variable speed spring housing. Then remove the variable speed spring lever set screw from the speed control shaft and spring lever (Fig. 6).

   d. Place a 3/4" inside diameter sleeve approximately 1-1/2" long on the bed of an arbor press. Support the spring housing assembly on top of the sleeve with the cup plug (if used) in the side of the housing over the opening of the sleeve.

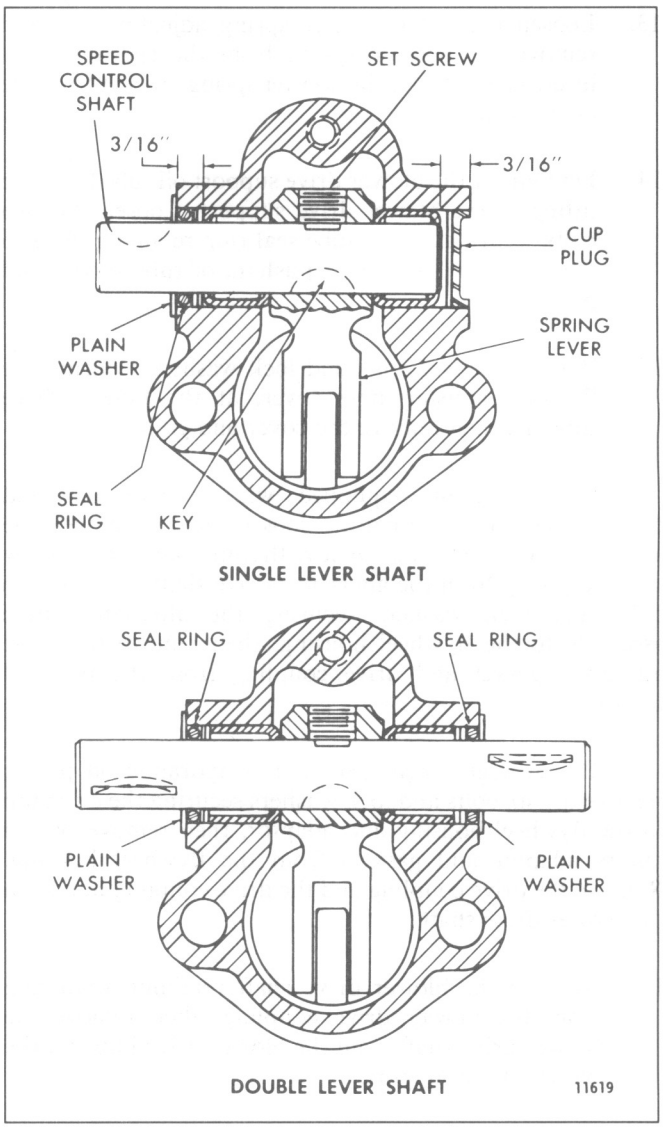


Fig. 6 – Cross Section of Governor Variable Speed Spring Housing

   e. Place a small brass rod on the end of the shaft, as shown in Fig. 7, and press the plug (if used) and bearing out of the spring housing.

   f. Remove the spring lever from the spring housing and the bearing from the speed control shaft. Discard the bearing. If necessary, remove the Woodruff key from the shaft.

NOTICE: Due to the Woodruff key in the speed control shaft, the inner end of the needle bearing will be damaged when pressing the bearing and cup plug out of the spring housing. Do not attempt to reuse the bearing.

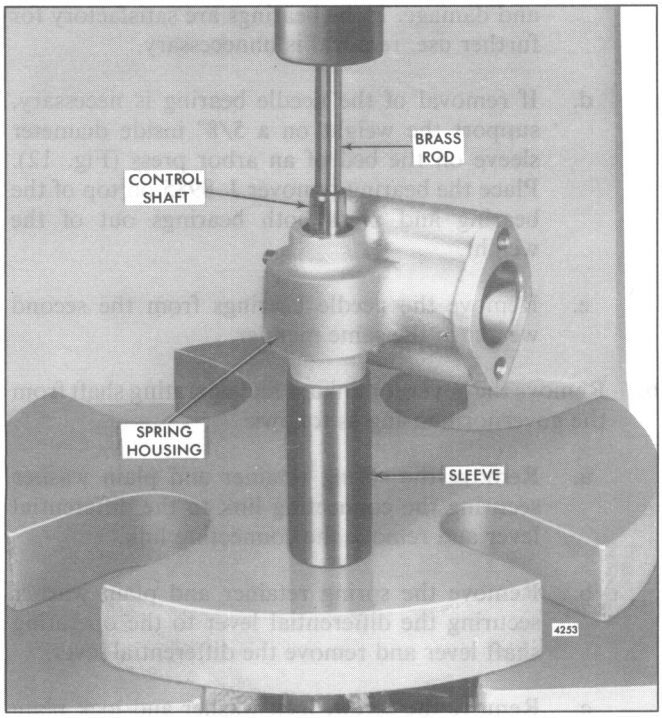


Fig. 7 – Removing Speed Control Shaft, Bearing and Cup Plug from Variable Speed Spring Housing

g. At this stage of disassembly, wash the spring housing (containing the remaining bearing) thoroughly in clean fuel oil and inspect the needle bearing for wear and damage. If the bearing is satisfactory for further use, removal is unnecessary.

h. If removal of the needle bearing is necessary, support the spring housing, bearing side down, on top of the 3/4" inside diameter sleeve on the bed of the arbor press. Insert the bearing remover J 21967–01 through the housing and rest it on top of the bearing, then press the bearing out of the housing.

4. Remove the governor weight and shaft assembly from the governor housing as follows:

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

b. Remove the governor weight housing plug and gasket (Fig. 1).

c. Bend the tang on the lock washer away from the head of the bolt. Then, while holding the weight carrier from turning, remove the bearing retaining bolt, flat washer and lock washer.

d. Thread a 5/16"–24 x 3" bolt into the bearing retaining bolt hole. Support the governor housing on the bed of an arbor press and press the governor weight shaft from the bearing as shown in Fig. 8.

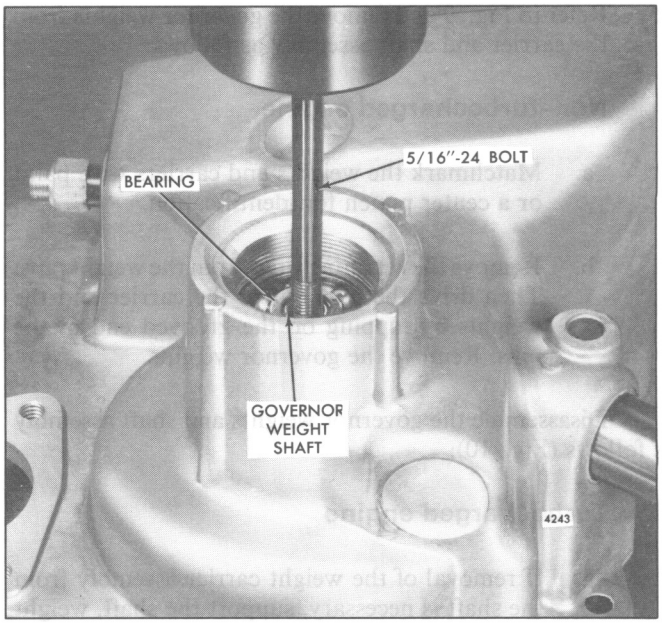


Fig. 8 – Removing Governor Weight Shaft Assembly from Governor Housing

e. Slide the governor riser thrust bearing and riser from the weight shaft.

NOTICE: The thrust bearing is specially designed to absorb thrust load; therefore, looseness between the mating parts does not indicate excessive wear.

f. Remove the weight shaft bearing from the governor housing. If necessary, use a small brass rod and hammer and tap the bearing out of the housing.

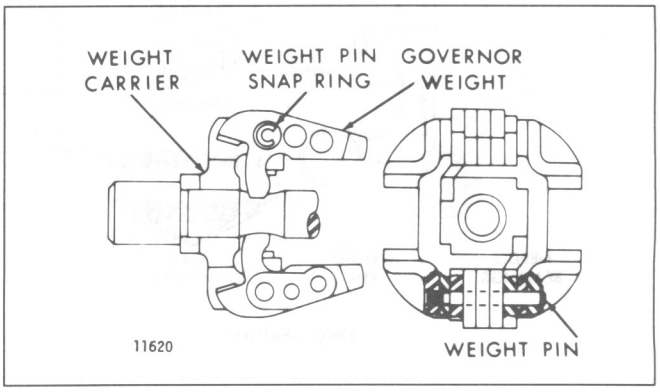


Fig. 9 – Cross Section of Governor Weight Assembly (Non–Turbocharged Engines)

5. Refer to Fig. 9 and remove the governor weights from the carrier and shaft assembly as follows:

Non–turbocharged engine

a. Matchmark the weights and carriers with paint or a center punch for identification.

b. 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.

Disassemble the governor weights and shaft assembly as follows (Fig. 10):

Turbocharged engine

a. If removal of the weight carrier assembly from the shaft is necessary, support the shaft, weight carrier and sleeve on the bed of an arbor press as shown in Fig. 11, and press the shaft out of the weight carrier assembly.

b. Refer to Fig. 10 and remove the lock ring from the weight pin with a pair of snap ring pliers. Then remove the weight pin, flat washers and weight assembly from the weight carrier. Remove the second weight from the carrier in the same manner.

c. At this stage of disassembly, wash the weights (containing the needle bearing) thoroughly in clean fuel oil and inspect the bearings for wear and damage. If the bearings are satisfactory for further use, removal is unnecessary.

d. If removal of the needle bearing is necessary, support the weight on a 5/8" inside diameter sleeve on the bed of an arbor press (Fig. 12). Place the bearing remover J 8985 on top of the bearing and press both bearings out of the weight.

e. Remove the needle bearings from the second weight in the same manner.

6. Remove the governor linkage and operating shaft from the governor housing as follows:

a. Remove the spring retainer and plain washer securing the connecting link to the differential lever and remove the connecting link.

b. Remove the spring retainer and plain washer securing the differential lever to the operating shaft lever and remove the differential lever.

c. Remove the screw, lock washer and lock plate securing the control link operating lever shaft in the housing. Lift the shaft up out of the housing and remove the operating lever and two flat washers at each side of the operating lever.

NOTICE: Be sure not to lose the two flat washers located between the top and bottom of the lever assembly and the governor housing.

d. Remove the expansion plug from the bottom of the governor housing (Fig. 1).

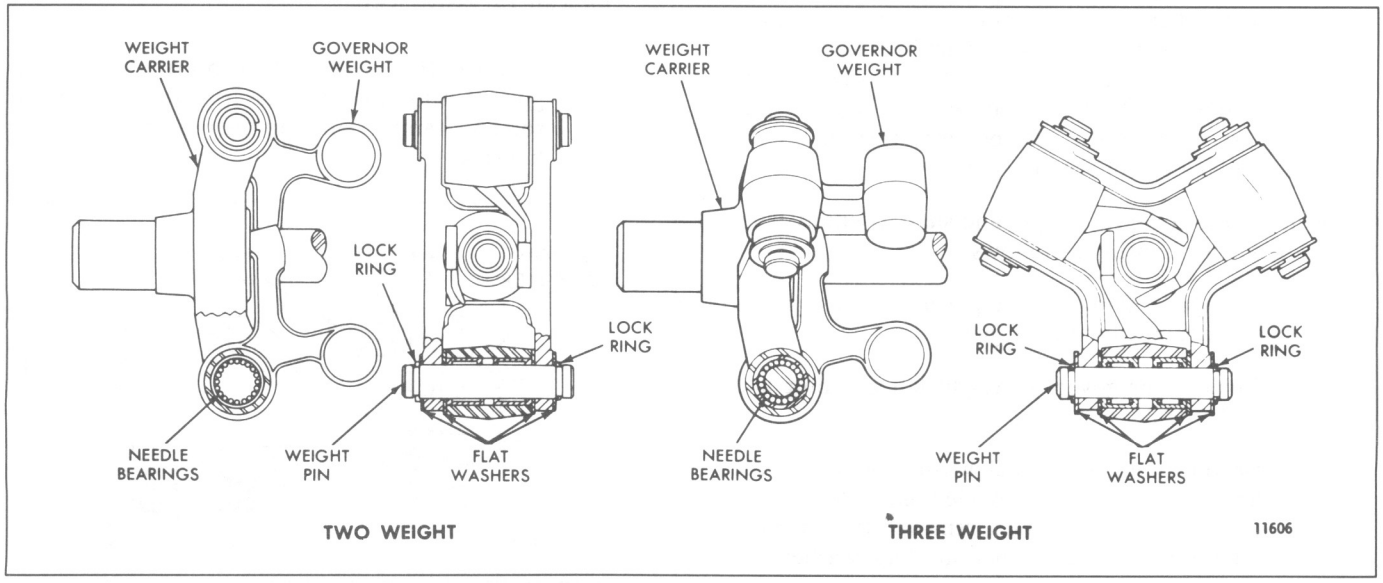


Fig. 10 – Cross Section of Governor Weight Assemblies (Turbocharged Engines)

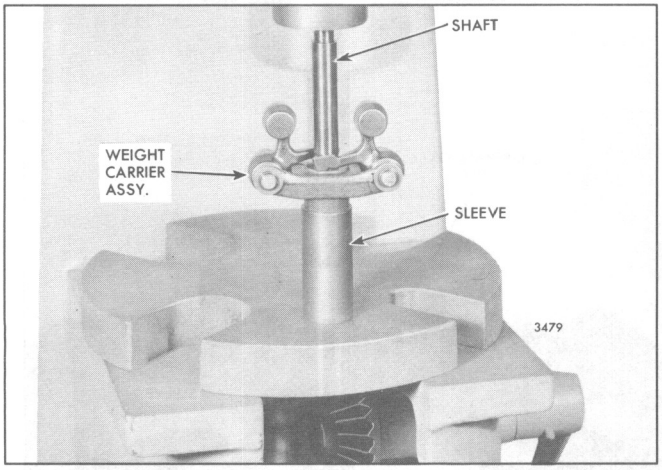


Fig. 11 – Removing Governor Weight Shaft from Weight Carrier Assembly

e. Remove the operating shaft upper bearing retaining screw, lock washer and flat washer securing the bearing in the governor housing.

f. Support the governor housing bottom side up on the bed of an arbor press, with the two dowel pins in the top of the housing between the two steel supports. Refer to Fig. 13 and place a small brass rod on the end of the operating shaft and press the shaft out of the bearing.

g. With the housing still supported on the bed of the press, place a 9/16" open end wrench under the operating fork as shown in Fig. 14. Place a brass rod on the end of the shaft and press the fork off of the operating shaft. Remove the shaft, operating lever and bearing as an assembly from the housing.

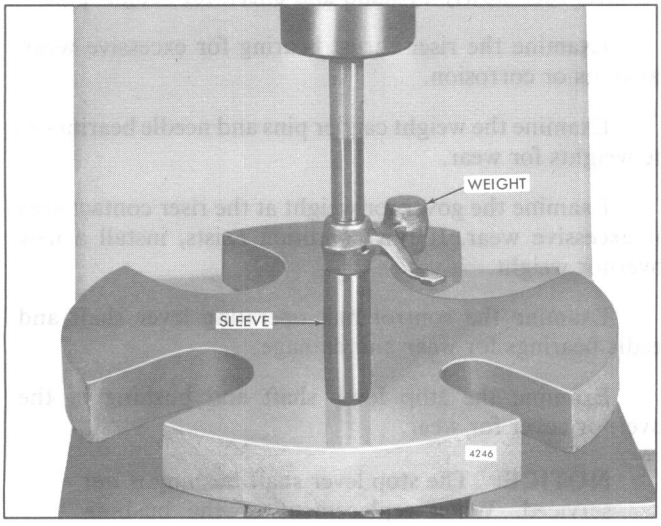


Fig. 12 – Removing Governor Weight Bearings using Tool J 8985

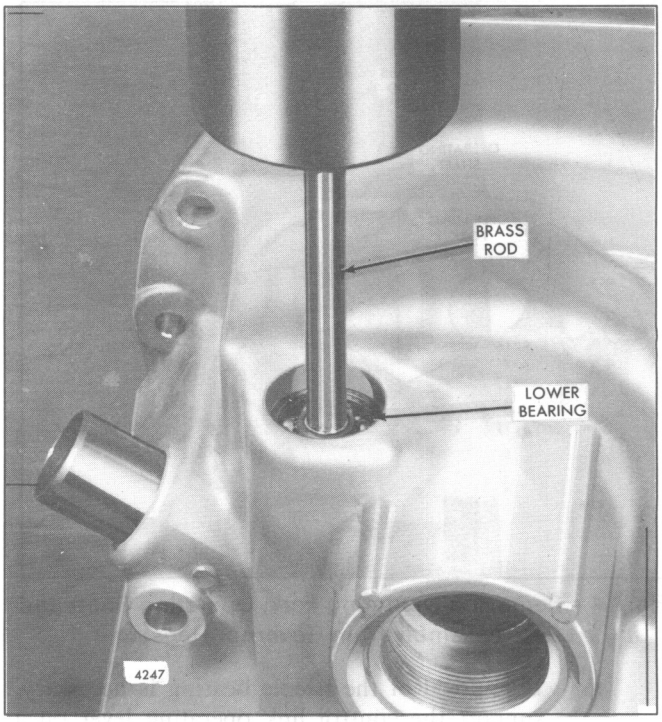


Fig. 13 – Removing Operating Shaft from Operating Shaft Lower Bearing

h. Remove the operating shaft lower bearing from the bottom of the governor housing.

i. Slide the governor operating shaft spacer from the shaft.

j. Place a short 9/16" inside diameter sleeve over the end of the operating shaft and rest it against the inner race of the bearing on the current operating shaft, or the flat washer under the bearing on the former operating shaft.

k. Support the operating shaft, lever, bearing and sleeve on a large washer or plate, with a 5/8" hole, on the bed of an arbor press as shown in Fig. 15. Place a small brass rod on the end of the shaft and press the operating shaft out of the operating lever and bearing. Catch the shaft by hand when pressed from the lever and bearing to prevent it from falling and being damaged.

NOTICE: Be sure that the bearing inner race is resting on the sleeve or the bearing may be damaged.

l. At this stage of disassembly, wash the control link operating lever (containing the bearings) thoroughly in clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory for further use, removal is unnecessary.

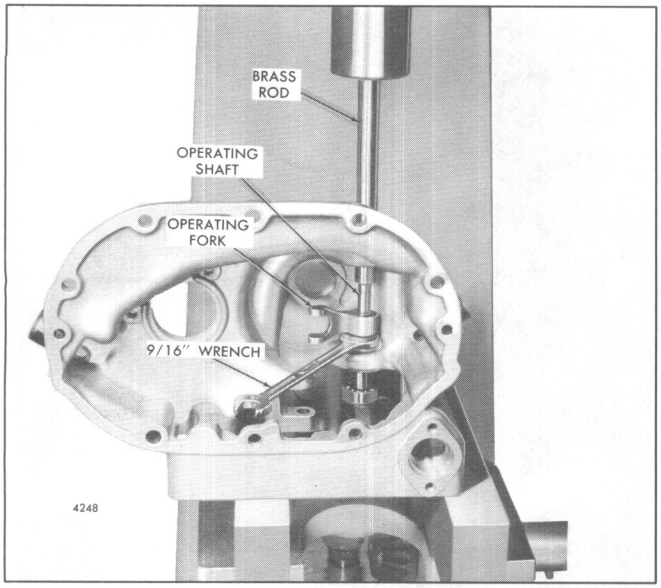


Fig. 14 – Removing Operating Fork, Operating Shaft and Lever Assembly from Governor Housing

m. If removal of the needle bearing is necessary, support the control link operating lever on a sleeve and rest the sleeve on the bed of an arbor press. Place tool J 8985 on top of the bearing and press both bearings out of the lever as shown in Fig. 16.

7. Remove the buffer screw from the governor housing.

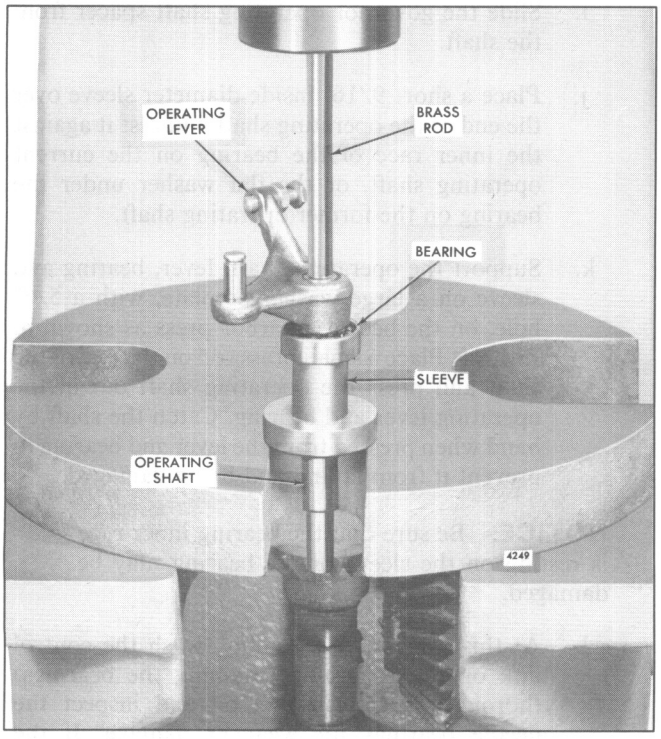


Fig. 15 – Removing Operating Lever and Upper Bearing from Operating Shaft

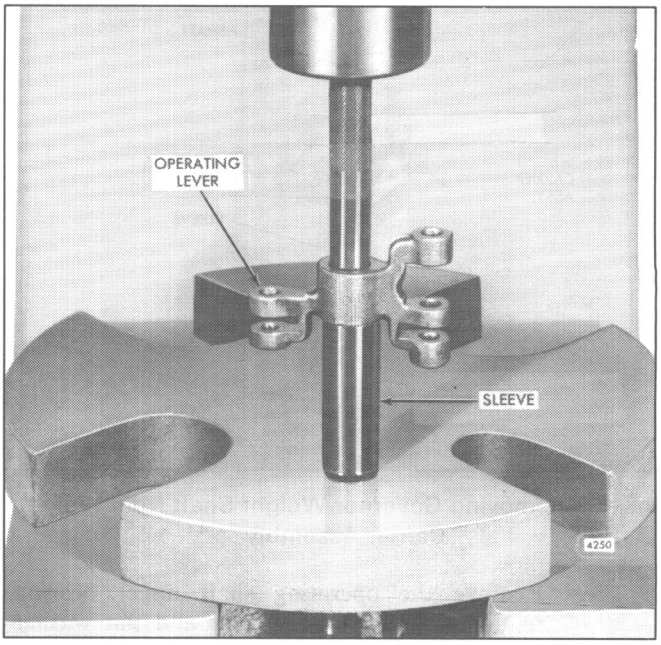


Fig. 16 – Removing Operating Lever Needle Bearings using Tool J 8985

Inspection

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

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

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

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

Examine the weight carrier pins and needle bearings in the weights for wear.

Examine the governor weight at the riser contact area for excessive wear. If this condition exists, install a new governor weight.

Examine the control link operating lever shaft and needle bearings for wear and damage.

Examine the stop lever shaft and bushing in the governor cover for wear.

NOTICE: The stop lever shaft bushing is not serviced. When replacement of the bushing becomes necessary, it must be replaced with two needle bearings.

Examine the speed control lever shaft and needle bearings in the variable speed spring housing for wear.

Examine the variable speed spring lever roller and pin for excessive wear. The roller type bearing rides on a hardened bearing pin which is a press fit in the spring lever and is staked at three places on both sides.

Examine the variable speed spring plunger, guide and spring retainer for wear or score marks. If the retainer or plunger are scored slightly, clean them up with crocus cloth. Replace the retainer, plunger and guide if scored excessively.

Inspect the adjusting screw, lock nut, pins, seal rings and any other parts in the governor housing for wear or defects that might affect the governor operation.

Replace all of the parts that are worn or damaged.

Assemble Governor

With all of the governor parts cleaned and inspected and the necessary new parts on hand, the governor may be assembled.

Refer to Figs. 1 and 17 for the location of the various parts and assemble the governor as follows:

1. Install the operating shaft and governor linkage in the governor housing as follows:

   a. Lubricate the inside diameter of the governor operating shaft upper bearing with engine oil. Start the bearing, numbered side up, straight on the large end of the operating shaft. Support the bearing and operating shaft on a 9/16" inside diameter sleeve on the bed of an arbor press, with the inner race of the bearing resting on the sleeve. Then press the shaft into the bearing until 1/4" of the shaft protrudes through the bearing.

   b. Lubricate the inside diameter of the governor operating shaft lever with engine oil. Start the lever, pivot pin in the operating lever facing up, straight on the operating shaft with the flat on the shaft registering with the flat surface in the lever. Support the operating lever, bearing and shaft on the bed of an arbor press with a steel support directly under the center of the lever, then press the operating shaft through the bearing and lever until the end of the shaft contacts the steel support.

   NOTICE: The upper end of the shaft must be flush with the top surface of the lever.

   c. Place the operating shaft spacer over the lower end of the shaft and slide it against the upper bearing inner race.

   d. Insert the end of the governor operating shaft, bearing, spacer and lever assembly through the upper bearing bore in the governor housing with the lever positioned as shown in Fig. 1.

   e. Lubricate the inside diameter of the governor operating shaft fork with engine oil. Then place the operating fork over the lower end of the shaft, with the finished cam surfaces on the fork fingers facing the rear of the governor housing and the flat on the shaft registering with the flat surface in the fork.

   f. Support the governor housing and operating shaft assembly on the bed of an arbor press with the upper end of the operating shaft resting on a steel support as shown in Fig. 18. Place a 7/16" inside diameter sleeve over the end of the shaft and against the fork. Then press the fork tight against the shaft spacer on the shaft.

   g. Lubricate the governor operating shaft lower bearing with engine oil. Start the bearing, numbered side up, straight in the governor housing and over the end of the operating shaft.

   h. Support the governor housing and operating shaft assembly on the bed of an arbor press with the upper end of the operating shaft resting on a steel support as shown in Fig. 18. Place a 7/16" inside diameter sleeve on the inner race of the bearing and press the bearing on the shaft until it seats on the shoulder in the housing.

   i. Install the governor operating shaft upper bearing retaining flat washer, lock washer and screw in the governor housing (Fig. 1).

   j. Apply a thin coat of good quality sealant around the edge of a new expansion plug.

   Place the plug, concave side up, in the opening in the housing next to the lower operating shaft bearing. Tap the center of the plug with a hammer to secure the plug in the housing.

   k. Place the differential lever over the pivot pin in the operating lever, with the pin in the lever up, and secure it in place with with a plain washer and spring retainer.

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

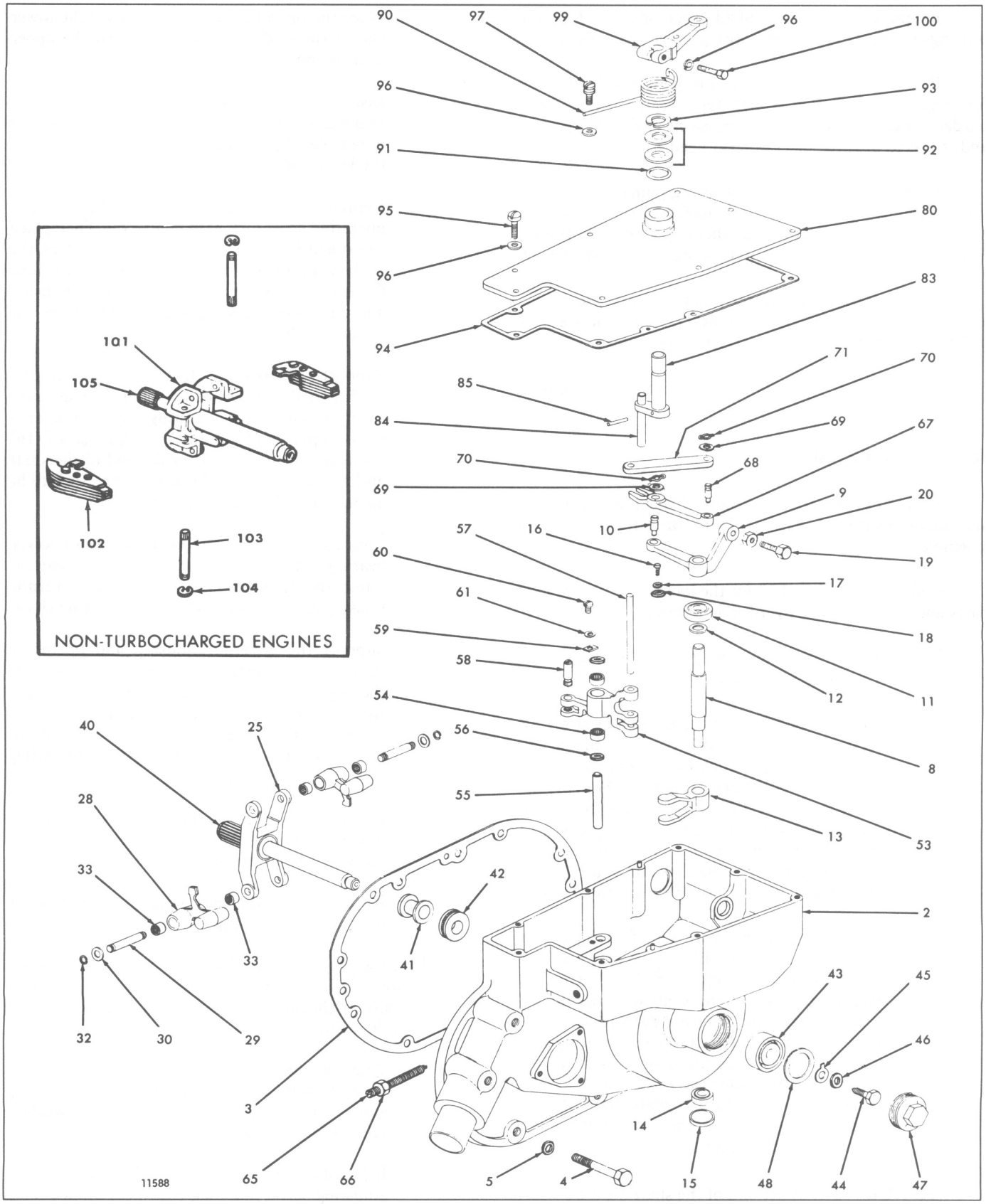


Fig. 17 – Variable Speed Governor Details and Relative Location of Parts

2.	Housing—Governor	25.	Carrier—Governor Weight	56.	Washer—Operating Lever Shim	83.	Shaft—Stop Lever
3.	Gasket—Housing to Blower	28.	Weight—Governor	57.	Pin—Fuel Rod Connecting (Short)	84.	Pin—Fulcrum Lever
4.	Bolt—Housing to Blower	29.	Pin—Weight	58.	Pin—Fuel Rod Connecting (Long)	85.	Pin—Stop Lever Shaft
5.	Lock Washer	30.	Flat Washer	59.	Clip—Operating Lever Shaft Lock	90.	Spring—Stop Lever Shaft Return
8.	Shaft—Governor Operating	32.	Snap Ring—Weight Pin	60.	Screw—Lock Clip	91.	Ring—Stop Shaft Seal
9.	Lever—Operating Shaft	33.	Bearing—Weight	61.	Lock Washer	92.	Washer—Seal Ring Retainer
10.	Pin—Shaft Lever	40.	Shaft—Weight Carrier	65.	Screw—Buffer	93.	Snap Ring—Stop Shaft
11.	Bearing—Operating Shaft (Upper)	41.	Riser—Governor	66.	Lock Nut—Buffer Screw	94.	Gasket—Governor Housing Cover
13.	Fork—Operating Shaft	42.	Bearing—Riser Thrust	67.	Lever—Governor Differential	95.	Screw—Housing Cover
14.	Bearing—Operating Shaft (Lower)	43.	Bearing—Weight Carrier Shaft End	68.	Pin—Differential Lever	96.	Lock Washer
15.	Plug—Expansion	44.	Bolt—Bearing Retainer	69.	Washer—Differential Lever and Connecting Link Flat	97.	Screw—Housing Cover Special
16.	Screw—Bearing Retaining	45.	Lock Washer—Special	70.	Retainer—Spring	99.	Lever—Governor Stop
17.	Lock Washer	46.	Flat Washer	71.	Link—Operating Lever Connecting	100.	Bolt—Stop Lever
18.	Flat Washer	47.	Plug—Governor Housing	80.	Cover—Governor Housing	101.	Carrier—Governor Weight
19.	Screw—Gap Adjusting	48.	Gasket—Housing Plug			102.	Weight—Governor
20.	Lock Nut	53.	Lever—Control Link Operating			103.	Pin—Weight
21.	Spacer—Operating Shaft	54.	Bearing—Operating Lever			104.	Ring—Weight Pin Retainer
		55.	Shaft—Operating Lever			105.	Shaft—Weight Carrier

Fig. 17 – Variable Speed Governor Details and Relative Location of Parts

m. If removed, place the control link operating lever on the bed of an arbor press, with a steel support under the bearing bore. Lubricate the outer surface of the bearing with engine oil and start the bearing, numbered end up, straight into the bore of the lever. Insert the pilot end of installer J 8985 in the bearing and press the bearing into the lever until it is flush with the top surface of the lever. Reverse the lever on the press and install the second bearing in the same manner.

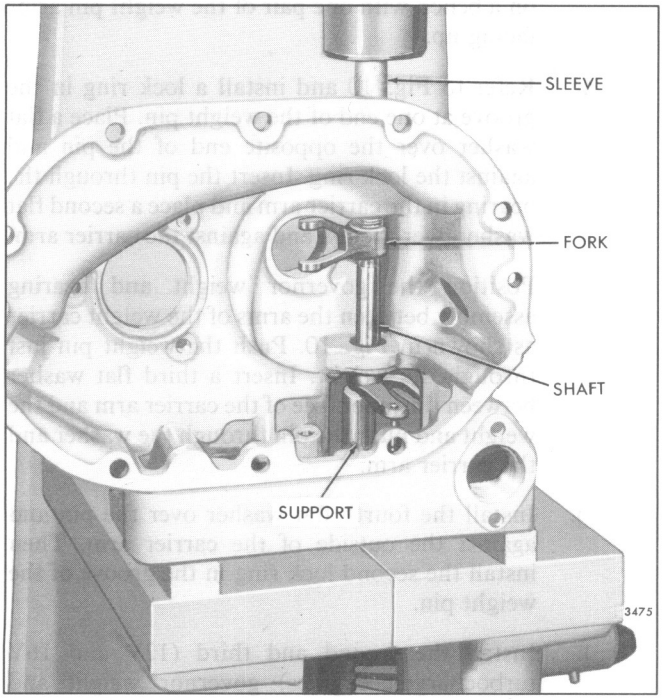


Fig. 18 – Installing Governor Operating Shaft Fork on Shaft

n. Lubricate the control link operating lever needle bearings with Shell Alvania No. 2 grease, or equivalent. Place the lever in position between the two bosses inside the governor housing. Insert a flat washer on each side of the lever (Fig. 1). Then install the control link operating lever shaft with the slot (in the side at one end of the shaft) up.

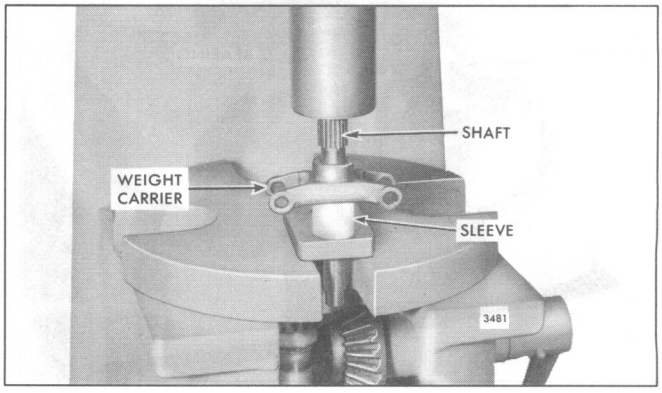


Fig. 19 – Installing Governor Weight Shaft in Weight Carrier

o. Align the slot in the control link operating lever shaft with the lock clip screw hole in the boss next to the shaft. Install the lock clip, lock washer and screw and tighten the screw securely.

p. Place one end of the connecting link over the differential lever pin and secure it in place with a plain washer and spring retainer (Fig. 1). Place the opposite end of the connecting link on top of the control link operating lever and install the connecting pin.

q. If removed, thread the lock nut on the buffer screw and thread the buffer screw (Fig. 1) into the governor housing.

2. Assemble the governor weights and carrier and shaft assembly as follows:

Non–turbocharged engines

a. Refer to Fig. 9 and position the weights on opposite sides of the weight carrier. Note the matchmarks placed on the weight carrier and weights at the time of disassembly.

b. 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.

c. Lubricate the weight shaft with clean engine oil.

Assemble the governor weight and shaft assembly as follows:

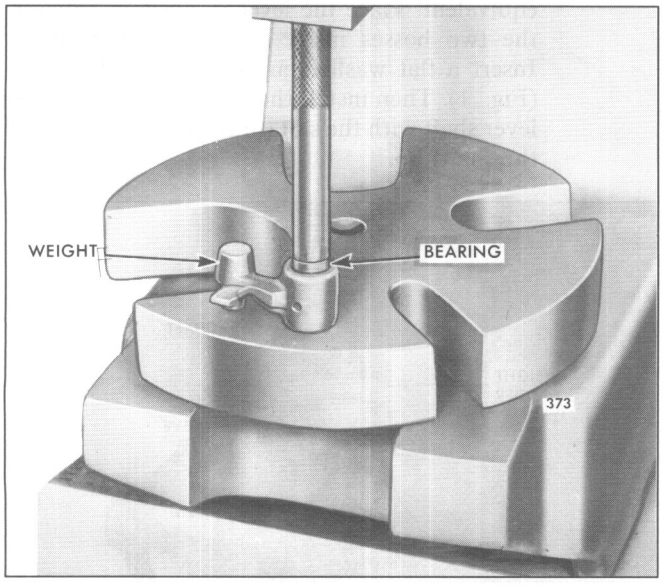


Fig. 20 – Installing Bearings in Governor Weight using Tool J 8985

Turbocharged engine

a. Support the weight carrier (rear face up) on a sleeve and a steel support (with a 1" hole) over an opening in the bed of an arbor press as shown in Fig. 19.

b. Lubricate the weight shaft with engine oil. Then insert the non–splined end of the shaft through the carrier, sleeve and hole in the steel support. Press the shaft straight into the carrier until the shoulder on the shaft is tight against the carrier.

c. If removed, place the governor weight, either end up, on the bed of an arbor press. Lubricate the outer surface of the bearing with engine oil and start the bearing, numbered end up, straight into the bore of the weight.

d. Insert the pilot end of installer J 8985 in the bearing and under the ram of the press as shown in Fig. 20. Then press the bearing straight in the weight until it is flush with the top of the weight. Reverse the weight on the press and install the second bearing in the same manner.

e. Install the bearings in the second weight in the same manner as described in Steps c and d above.

f. Lubricate the needle bearings with Shell Alvania No. 2 grease, or equivalent.

g. Position the weight carrier and shaft assembly on a bench with one pair of the weight pin arms facing up.

h. Refer to Fig. 10 and install a lock ring in the groove at one end of the weight pin. Place a flat washer over the opposite end of the pin and against the lock ring. Insert the pin through the bearing in the carrier arm and place a second flat washer over the pin and against the carrier arm.

i. Position the governor weight and bearing assembly between the arms of the weight carrier as shown in Fig. 10. Push the weight pin just through the weight. Insert a third flat washer between the inner face of the carrier arm and the weight and push the pin through the washer and the carrier arm.

j. Install the fourth flat washer over the pin and against the outside of the carrier arm. Then install the second lock ring in the groove of the weight pin.

k. Install the second and third (12V and 16V turbocharged engines) governor weight and bearing assemblies in the carrier in the same manner as described in Steps h, i and j above.

3. Install the governor weight and shaft assembly in the governor housing as follows:

   a. Slide the governor riser on the weight shaft and against the fingers of the high speed weight.

   b. Place the governor riser thrust bearing over the weight shaft with the bearing race having the smaller inside diameter against the riser.

   c. Insert the weight carrier and shaft assembly in the governor housing. Then support the splined end of the shaft and the governor housing on the bed of an arbor press with the upper end of the shaft under the ram of the press.

   d. Place the weight shaft bearing in the governor housing (numbered side up) and start it straight on the end of the weight carrier shaft. Place a sleeve with a 1/2" inside diameter on top of the bearing inner race and press the bearing into the housing and against the shoulder on the shaft.

   e. Place the special lock washer on the end of the weight carrier shaft with the tang on the inner diameter of the washer in the notch in the end of the shaft.

   f. Place the flat washer on the bearing retainer bolt and thread the bolt into the shaft. Clamp the splined end of the weight carrier shaft in the soft jaws of a bench vise and tighten the bearing retainer bolt to 15–19 lb–ft (20–26 N•m) torque. Bend the tang on the lock washer against the head of the bolt.

   g. Place a gasket in the housing and against the bearing. Apply a Loctite sealant grade HV, or equivalent, to the full 360° circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb–ft (61 N•m) torque.

NOTICE: Rotate the governor weight assembly. If bind exists, remove the housing plug and check to see if the weight shaft bearing is fully seated in the governor housing.

4. Refer to Figs. 6 and 21 for the location of the parts and assemble the variable speed spring housing as follows:

   a. Lubricate the speed control lever shaft needle bearings with Shell Alvania No. 2 grease, or equivalent. Then start one of the bearings, numbered end up, straight in the bearing bore in the right hand side of the spring housing as viewed in Fig. 6.

   b. Install the needle bearing pilot rod J 9196–2 in the installer body J 9196–1 and secure it in place with the retaining screw.

   c. Place the pilot rod end of the bearing installer assembly in the bearing. Support the spring housing, bearing and installer on a short sleeve on the bed of an arbor press as shown in Fig. 22. Then press the bearing in the housing until the shoulder on the installer contacts the housing.

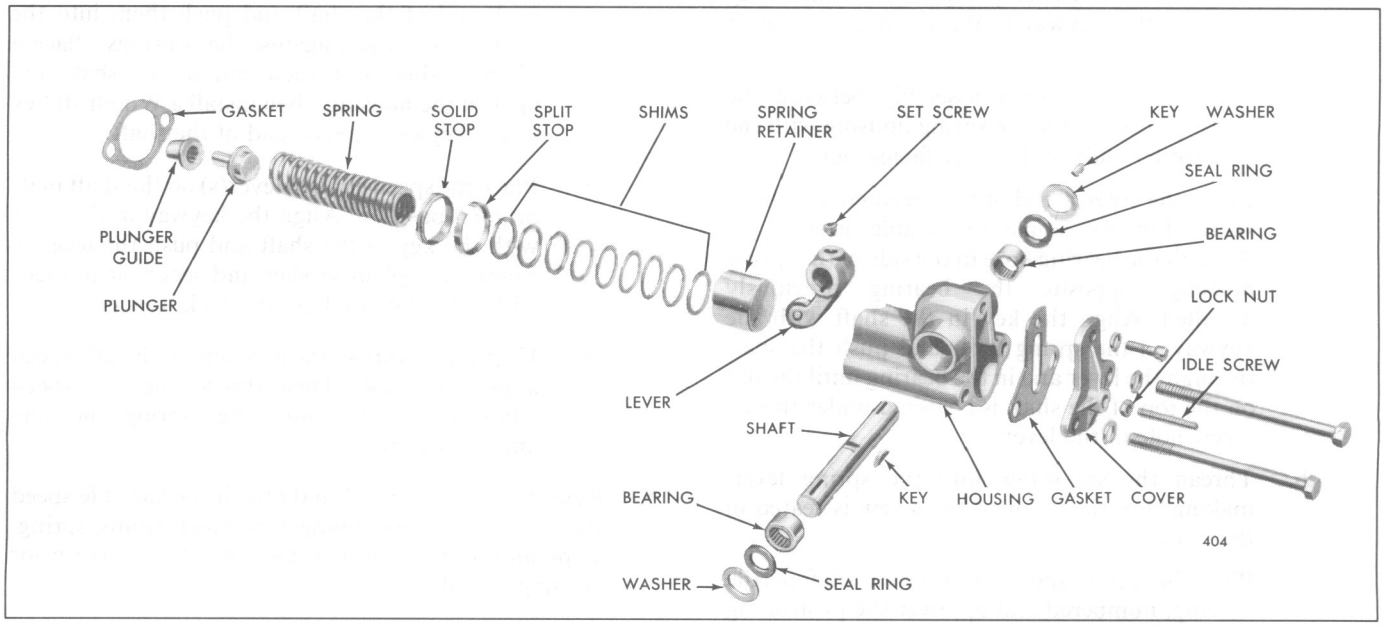


Fig. 21 – Variable Speed Spring Housing Details and Relative Location of Parts

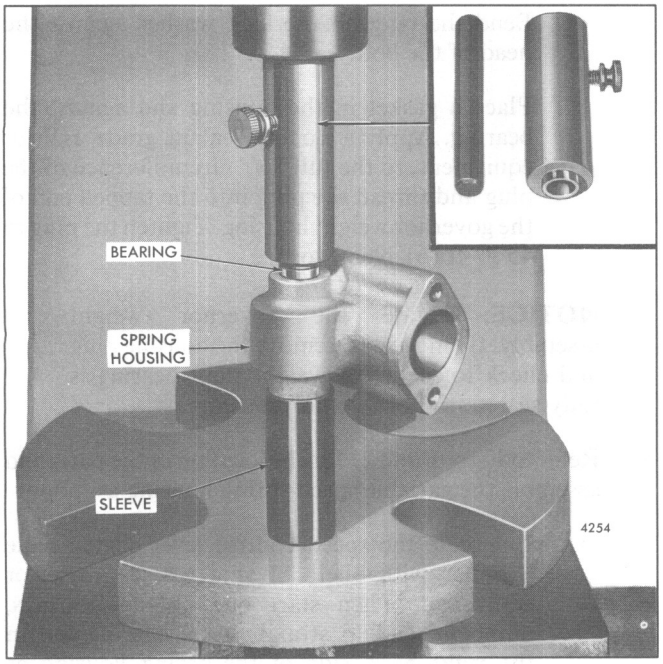


Fig. 22 – Installing Speed Control Shaft Bearings in Spring Housing using Tool J 9196

NOTICE: When the shoulder on the installer body contacts the housing, the bearing will be properly positioned in the housing.

d. Install the roller type bearing and pin in the spring lever. Press the pin below the surface of the lever and stake at three places on both sides of the lever.

e. If removed, install the spring lever Woodruff key in the center keyway in the speed control lever shaft.

f. Place the spring lever assembly between the bearing bores inside the spring housing with the arm (roller end) of the lever facing out.

g. Insert the correct end of the speed control lever shaft (Fig. 6), single or double lever type, through the bearing bore in the side of the spring housing, opposite the bearing previously installed. Align the key in the shaft with the keyway in the spring lever and push the shaft through the lever and in the bearing until the flat on the top of the shaft is centered under the set screw hole in the lever.

h. Thread the set screw into the spring lever, making sure the point of the screw is seated in the flat on the shaft.

i. Place the second speed control lever shaft needle bearing, numbered end up, over the protruding end of the shaft and start it straight in the bore of the housing.

j. Remove the bearing pilot rod J 9196–2 from the installer body J 9196–1 and place the installer body over the end of the shaft and against the bearing. Support the spring housing, bearings and installer on a short sleeve on the bed of an arbor press as shown in Fig. 22. Then press the bearing in the housing until the shoulder on the installer contacts the housing.

k. If a single lever shaft was installed in the spring housing, apply a thin coat of sealing compound to the outside diameter of the cup plug. Start the cup plug straight in the bearing bore in the housing, then support the spring housing, bearings and shaft assembly on a sleeve on the bed of an arbor press and press the cup plug in flush with the outside face of the housing.

l. Clamp the spring housing assembly in a bench vise equipped with soft jaws. Then tighten the spring lever retaining set screw to 5–7 lb–ft (7–10 N•m) torque.

m. Stake the edge of the spring lever set screw hole with a small center punch and hammer to retain the set screw in the lever. Then install the plug in the spring housing.

n. On a single lever shaft, place a seal ring over the end of the shaft and push it into the bearing bore and against the bearing. Place the plain washer over the shaft and against the housing, then install the Woodruff key in the keyway in the shaft.

o. On a double lever shaft, place a seal ring over each end of the shaft and push them into the bearing bores and against the bearings. Place a plain washer over each end of the shaft and against the housing, then install a Woodruff key in the keyway at each end of the shaft.

p. Place the speed control lever(s) on the shaft in its original position. Align the keyway in the lever with the key in the shaft and push the lever in against the plain washer and secure it in place with the retaining bolt and lock washer.

q. If removed, thread the lock nut on the idle speed adjusting screw. Then thread the idle speed adjusting screw into the spring housing approximately 1".

5. Refer to Figs. 1 and 21 and attach the variable speed spring plunger guide, plunger, retainer, shims, spring, stops and spring housing assembly to the governor housing as follows:

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

b. If removed, start the variable speed spring plunger guide straight in the boss inside the governor housing and tap it into place with a small brass rod and hammer.

c. Lubricate the small end of the variable speed spring plunger with engine oil. Then insert the plunger in the plunger guide inside the governor housing (Fig. 1).

d. Place the spring retainer solid stop in the counterbore of the governor housing.

e. Lubricate the outside diameter of the variable speed spring retainer with engine oil. Insert the spring retainer, solid end first, into the spring housing and against the spring lever.

f. Place the same amount of shims in the spring retainer that were removed, thin shims first. Then insert the spring retainer split stop in the spring housing approximately 1/16" from the finished face of the housing.

NOTICE: Be sure to use shims with an 11/32" inside diameter and a spring retainer with three bleed holes when a two–spring assembly is used. On the one–spring assembly, either spring retainer may be used with shims which have a 3/4" I.D. However, do not use the 11/32" I.D. shims with a spring retainer which has only one air bleed hole.

g. Affix a new gasket to the forward face of the spring housing. Then insert the variable speed spring into the spring housing and spring retainer with the tightly wound end of the spring against the shims in the retainer. If a two spring assembly is used, insert the inner spring inside the outer spring.

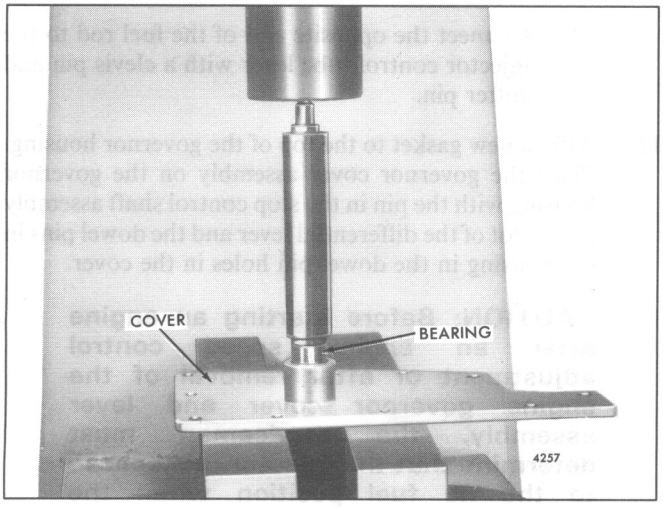


Fig. 23 – Installing Bearings in Governor Cover using Tool J 21068

h. Place the variable speed spring housing into position against the governor housing with the speed control lever facing the bottom of the governor (Fig. 2), and the variable speed spring over the end of the spring plunger (Fig. 1) inside the governor housing.

i. Install the two spring housing retaining bolts and lock washers. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

6. Refer to Figs. 4 and 17 for the location of the various parts and assemble the governor cover as follows:

a. If the stop lever bushing (Fig. 4) was removed from the cover, place the cover, inner face down, on two steel supports on the bed of an arbor press as shown in Fig. 23. Refer to "NOTE" under *Inspection*, then lubricate the new needle bearing with engine oil and start the bearing, numbered end up, straight in the bearing bore in the cover boss.

b. Place the correct end of the installer J 21068 in the bearing and press the bearing into the cover until the stop on the installer contacts the boss on the cover.

c. Reverse the cover, inner face up, on the bed of an arbor press. Lubricate the second bearing with engine oil and start the bearing, numbered end up, straight in the bore in the cover boss.

d. Place the bearing installer J 21068 in the bearing and press the bearing in the bore until it is flush with the face of the boss.

e. Lubricate the stop lever shaft needle bearings with Shell Alvania No. 2 grease, or equivalent. Then insert the stop shaft through the bearings in the cover.

f. Place the seal ring over the shaft and push it into the bearing bore and against the bearing. Place the two seal ring retainer washers on the shaft and against the cover boss. Then install the snap ring in the groove in the shaft.

g. Place the stop shaft lever return spring over the stop shaft with the hooked end of the spring facing up. Install the stop lever on the shaft and secure it in place with the retaining bolt and lock washer.

Install Governor On Engine (6V and 8V Engines)

1. Affix a new gasket to the bolting flange of the fuel pump. Place the fuel pump against the governor housing in its original position and secure it in place with the three bolt and seal assemblies. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

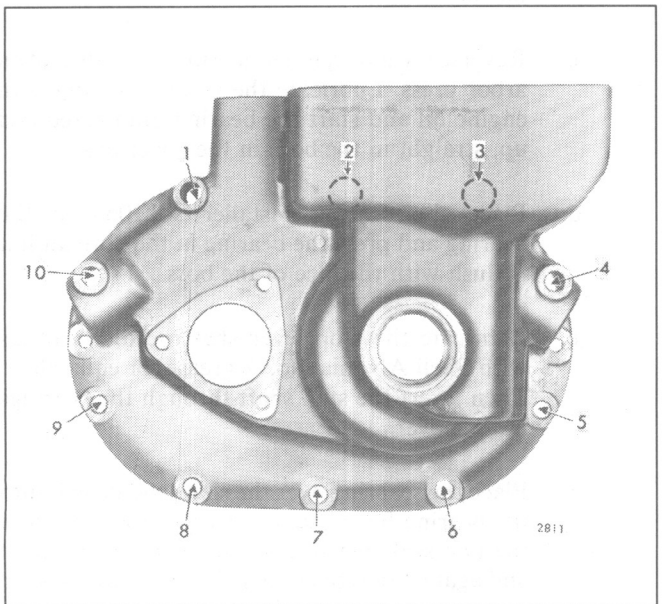
2. If removed, place a fuel rod cover tube hose and clamp on each fuel rod cover tube at each side of the governor housing.

3. Affix a new gasket to the forward face of the blower end plate.

4. Place the fuel pump drive fork on the fuel pump shaft. Position the governor and fuel pump assembly in front of the blower. Rotate the fuel pump fork until the prongs of the fork align with the slots in the drive disc. Rotate the weight shaft and align the splines on the shaft with the splines in the blower rotor.

5. Push the governor straight back over the dowels in the blower end plate and against the gasket.

6. Refer to Fig. 24 for the location and install the bolts, lock washers, copper washers and plain washer which secure the governor to the blower. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.



Bolt Size	Washer:	Position:
5/16"–18 x 5 1/4"	Copper	4
5/16"–18 x 4"	Copper	10
5/16"–18 x 3 3/4"	Lock and Plain	1
5/16"–18 x 2 1/4"	Lock	2–3–5–6–7–8–9

Fig. 24 – Location and Size of Governor Retaining Bolts

7. Slide each fuel rod cover tube hose down on the cover tubes attached to the cylinder heads and tighten the hose clamps.

8. Install and connect the crossover fuel oil line to each cylinder head and connect the fuel oil lines to the fuel pump.

9. Place the water bypass tube between the two thermostat housings and slide the hoses part way on the thermostat housings. Position the bypass tube so it clears the governor, fuel pump and fuel oil lines. Then tighten the hose clamps.

10. Install the fuel rods between the cylinder heads and the governor as follows:

    a. Insert the lower end of the left–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    b. Raise the connecting pin up in the connecting link lever (Fig. 1). Insert the end of the fuel rod between the two bosses on the lever and insert the connecting pin through the fuel rod and into the lower boss.

    c. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

    d. Insert the lower end of the right–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    e. Remove the short screw pin from the control link operating lever. Insert the end of the fuel rod between the two bosses on the lever and install the screw pin. Tighten the pin securely.

    f. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

11. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the stop control shaft assembly in the slot of the differential lever and the dowel pins in the housing in the dowel pin holes in the cover.

CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman 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.

12. Refer to Fig. 2 for the location of the stop lever return spring special screw. Then install the eight governor cover attaching screws and lock washers. Tighten the screws securely.

    NOTICE: The short cover attaching screw with the drilled head goes in the corner hole next to the variable speed spring housing.

13. With the hooked end of the stop lever return spring in position on the lever, place the extending end of the spring behind the special cover attaching screw as shown in Fig. 2.

14. Attach the booster spring to the speed control lever and tighten the outer booster spring adjusting nut on the eyebolt (Fig. 2).

15. Install all of the accessories that were removed from the cylinder head, governor or the front end of the engine.

16. Connect the control linkage to the speed control and stop levers.

17. Close the drain cocks and fill the cooling system.

18. Perform the governor and injector rack control adjustment as outlined in Section 14.4.

Install Governor On Engine (12V and 16V Engines)

1. Affix a new governor housing gasket to the forward face of the blower end plate. Position the governor in front of the end plate. Align the splines of the weight shaft with the splines in the blower rotor. Then push the weight shaft in the rotor and slide the governor housing over the dowel pins in the end plate and against the gasket.

2. Refer to Fig. 24 for bolt location and install the bolts, lock washers, plain washer and copper washers which secure the governor to the blower. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

3. Affix a new blower housing gasket to the cylinder block with a good grade of gasket cement to prevent the gasket from shifting when the blower is lowered into position.

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

5. Lift the blower and governor assembly, at a slight angle, and position it on top of the cylinder block, with the flange of the rear end plate cover inside the blower drive shaft cover hose.

6. Thread a 7/16"–14 x 8–1/4" bolt and special washer finger tight in the center hole of each blower end plate. Then install the 3/8"–16 x 5–1/2" bolts and retaining washers finger tight at each side of the blower housing.

   NOTICE: The lip at the beveled end of the bolt retaining washer goes in the small recess in the housing just above the bolt slot.

7. Tighten the bolts as follows:

   a. First, tighten the blower–to–block end plate bolts to 40–60 lb–ft (54–81 N•m) torque.

   b. Then tighten the blower housing–to–block side angle bolts uniformly to 30–35 lb–ft (41–47 N•m) torque in 5 lb–ft (7 N•m) increments.

   c. Recheck the blower–to–block end plate bolts.

8. Slide the blower drive support–to–blower hose (seal) and clamps into position and tighten the clamps.

9. Insert the blower drive shaft through the blower drive coupling and into the blower drive hub and install the retaining snap ring in the groove in the flexible coupling.

10. Affix a new gasket to the flywheel housing hole cover, then attach the cover to the flywheel housing with six bolts and lock washers.

On an engine equipped with a rear mounted battery–charging alternator, affix a new gasket to the alternator drive assembly. Place the alternator drive coupling on the drive hub, then place the drive assembly into position and align the slots in the drive coupling with the drive hub on the blower drive gear. Place the drive assembly against the flywheel housing and install the bolts, lock washers and alternator adjusting strap. Install the alternator drive pulley and drive belt.

On an engine equipped with a hydraulic oil pump, refer to *the "install oil pump" section in the manufacturer's service manual for the Marine Gear, Reduction Gear or Transmission used on the engine.*

11. Connect the blower drive support oil tube to the fitting in the blower drive support. Then tighten the two seal ring retaining plate bolts to 13–17 lb–ft (18–23 N•m) torque.

12. Affix a new gasket to the fuel pump flange, then install the fuel pump drive fork and fuel pump on the governor housing. Connect the fuel pump inlet and outlet tubes or hoses to the fuel pump.

13. Slide the governor housing–to–auxiliary control link housing hose and clamp into position between the two housings and tighten the hose clamp.

14. Slide the fuel rod cover hose down on the cover tube attached to the cylinder head at each side of the governor housing and tighten the hose clamps.

15. Place the control link operating lever connecting link in position in the governor and auxiliary housings and connect it to the ball joint studs in the control link operating levers.

16. Install the fuel rods between the cylinder heads and the governor as follows:

    a. Insert the lower end of the left–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    b. Raise the connecting pin up in the connecting link lever (Fig. 1). Insert the end of the fuel rod between the two bosses on the lever and insert the connecting pin through the fuel rod and into the lower boss.

    c. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

    d. Insert the lower end of the right–bank fuel rod down through the top of the governor housing and through the fuel rod cover tubes to the injector control tube lever.

    e. Remove the short screw pin from the control link operating lever. Insert the end of the fuel rod between the two bosses on the lever and install the screw pin. Tighten the pin securely.

    f. Connect the opposite end of the fuel rod to the injector control tube lever with a clevis pin and cotter pin.

17. Place a new auxiliary control link housing cover gasket on the housing, then install the cover and secure it in place with screws and lock washers.

18. Place a new governor housing cover gasket on the housing, then install the cover and secure it in place with screws and lock washers.

19. If removed, attach the booster spring bracket to the cylinder head. Then attach the booster spring to the speed control lever (Fig. 3) and tighten the outer booster spring adjusting nut on the eyebolt.

    CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman 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.

20. Install the cylinder head rocker covers.

21. On a non–turbocharged engine, remove the cover from the top of the blower. Place the blower screen, wire side down, on top of the blower and install the air shutdown adaptor. Then attach the air shutdown housings and gaskets to the adaptors.

    On a turbocharged engine, remove the cover from the top of the blower. Place the blower screen, wire side down, and install the air shutdown adaptor and air shutdown housing as an assembly on the blower. Then attach the shutdown rod to the lever on the shutdown housing.

22. On a non–turbocharged engine, connect the air inlet tubes to the air shutdown housings.

    On a turbocharged engine, attach the air inlet tube to the rear air shutdown housing and the turbocharger.

    On a marine engine, install the air silencers on the air shutdown housings.

23. Connect the linkage to the governor speed control and stop levers.

24. Perform an engine tune–up as outlined in Section 14.4.1.

HYDRAULIC 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.

Engines, subjected to varying load conditions that require an automatic fuel compensation to maintain more nearly constant engine speed with a minimum speed droop, are equipped with a hydraulic governor.

In the hydraulic governor, the fuel is decreased by the action of the governor throttle control terminal lever retracting spring and increased by the opposing action of the power piston. A pilot valve controls the admission of oil flow to the power piston and the movement of the pilot valve in turn is controlled by the governor flyweights. The centrifugal force of these flyweights is opposed by the speeder spring compression which may be varied and yet accurately set and held at any speed between idle and maximum speed. The speed droop, which is the difference between no–load speed and full–load speed, is adjustable to within a very small percentage at maximum speed.

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 appear, check the unit 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 and test the injector and, if necessary, replace or recondition it.

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 rods connected to the injector control tube levers, the mechanism must be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, locate and correct it as follows:

   a. If an injector rack sticks or moves too hard, check the injector hold–down clamp. If it is too tight or improperly positioned, loosen the clamp bolt, reposition the clamp and re–tighten the bolt to 20–25 lb–ft (27–34 N•m) torque.

   b. An internal dirt accumulation, a defective plunger and bushing or a bent injector control rack can result in bind. To correct this condition, remove the injector, then recondition and test it.

   c. An improperly positioned control rack lever will result in a binding injector rack. To relieve the bind, loosen the control rack lever adjusting screws. Then relocate the lever on the control tube and position it as outlined in Section 14.

   d. If the injector control tube binds in its support brackets, it will prevent free movement of the injector control racks to their no–fuel position. Loosen and re–align the control tube supporting brackets, then tighten the bolts to correct this condition. Reposition the injector racks after re–aligning the support brackets.

   e. Replace an injector control tube return spring which has been bent or otherwise distorted. When the injector control tube and the injector racks are free from bind, the control tube will return to the no–fuel position by action of the return spring.

   NOTICE: Never stretch or tamper with an injector control tube return spring to change its tension. Use a new spring.

   f. Check for bind in the pins which connect the fuel rods to the injector control tube levers. If necessary, remove the pins and polish them with fine emery cloth.

4. If neither load, engine irregularities or bind are found to be the cause of the speed variations, the trouble is probably in the governor or governor drive. Check as follows:

   a. If the speed changes noted are in rapid oscillation (governor hunting), adjust the speed droop of the governor as outlined in Section 14. This applies only if the governor is overhauled or where the speed droop has been changed from the original factory setting.

   b. Worn blower rotor bearings or rubbing of the rotors on the housing will cause the load on the blower drive coupling (between the gear train and the blower) to vary erratically. This variation in load will be transmitted as a speed change to the governor. The governor will act to compensate for the change by moving the fuel rods. If this condition exists, inspect the blower.

c. If the speed variations are small in magnitude, check the governor drive. Excessive or insufficient clearance between the bevel drive gears can cause this condition.

d. If the speed variations are large and erratic and unaffected (except, perhaps, in magnitude) by changes in the speed droop adjustment, or if the governor fails to control the speed at all, replace or overhaul the governor.

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

To be certain whether the governor or engine is at fault, install a new governor (with the same part number) and check the performance of the engine.

SG HYDRAULIC GOVERNOR

The governor (Fig. 1) is a hydraulic type with a speed droop stabilization mechanism. Hydraulic action is transmitted by oil admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.

To stabilize the governor, a speed droop adjustment is incorporated in the governor mechanism. The speed droop is regulated by a droop adjusting bracket attached to the top of the terminal lever. To decrease the governor droop move the droop adjusting bracket IN and move it in the opposite direction to increase the governor droop.

The governor operates in such a manner that the amount of fuel supplied to the injectors is increased by the hydraulically operated power piston and decreased by action of the fuel rod spring.

The governor is located at the front of the 6 and 8V engines (Fig. 5) and at the center of the 12V and 16V engines (Fig. 6). It is mounted on the governor drive housing which also serves as the blower front cover (rear blower on the 12V and 16V engine).

The governor is driven by one of the blower rotors through a horizontal drive shaft and bevel gear and a vertical driven sleeve and bevel gear, both mounted on ball bearings and retained in the governor drive housing.

The injector control tubes are actuated by the governor through a linkage consisting of the fuel rods, vertical link, and levers, connected as shown in Fig. 2 in Section 2.8.3.

Two pairs of fuel rods are used on the 12V and 16V engines. Each pair of rods is connected to a shaft and lever assembly. The two shaft and lever assemblies, mounted on self–aligning bearings, are connected to a common lever to which the vertical link is attached.

When starting a cold engine, time is required to develop sufficient oil pressure to operate the governor and thus move the injector control racks to the full–fuel position so the engine can start. Since this delay is undesirable, the starting time can be shortened by moving the governor operating lever to the full–fuel position, to take control of the injector racks away from the governor. On certain installations, an oil reservoir is provided to supply the governor with sufficient oil to overcome the delay in governor operation upon starting the engine.

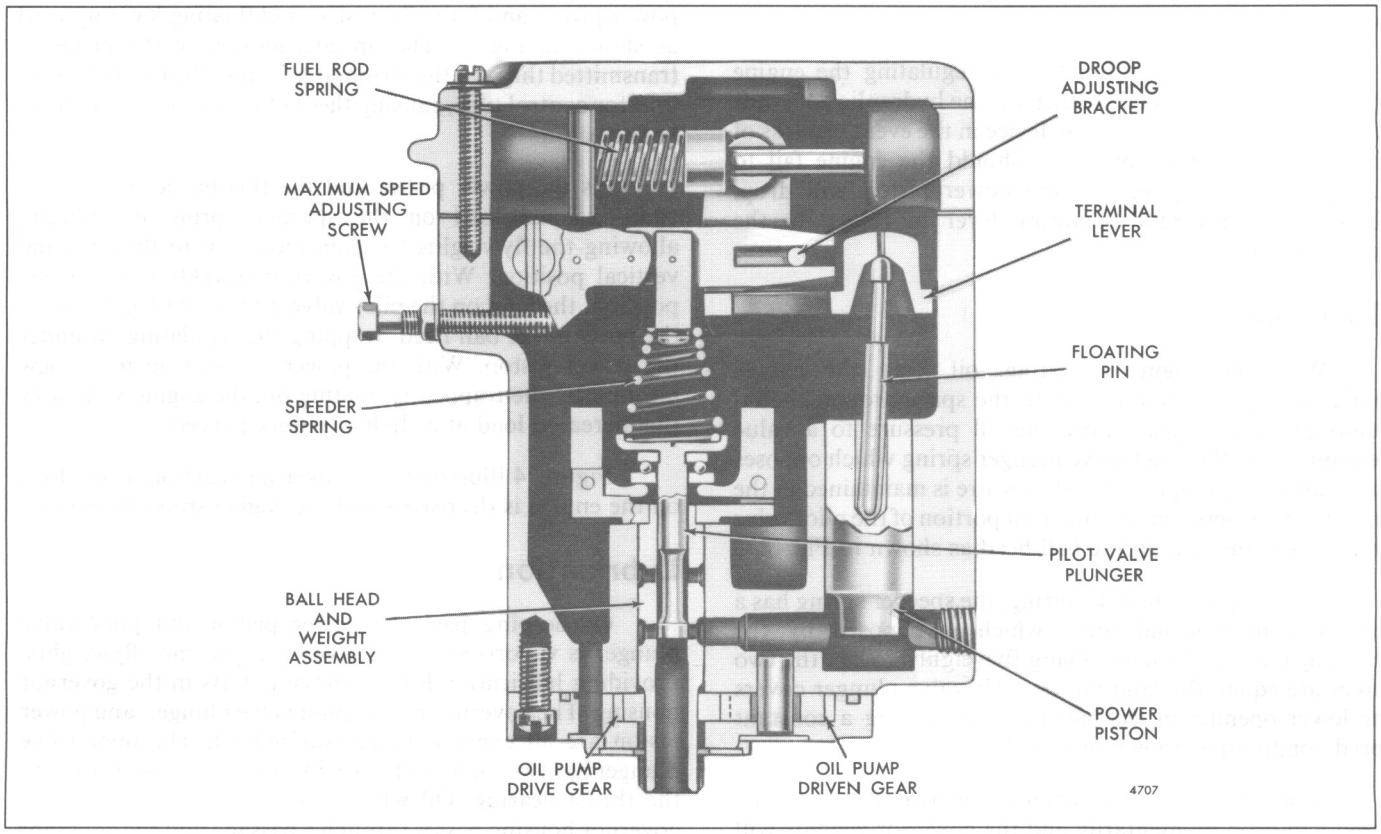


Fig. 1 – Hydraulic Governor Assembly

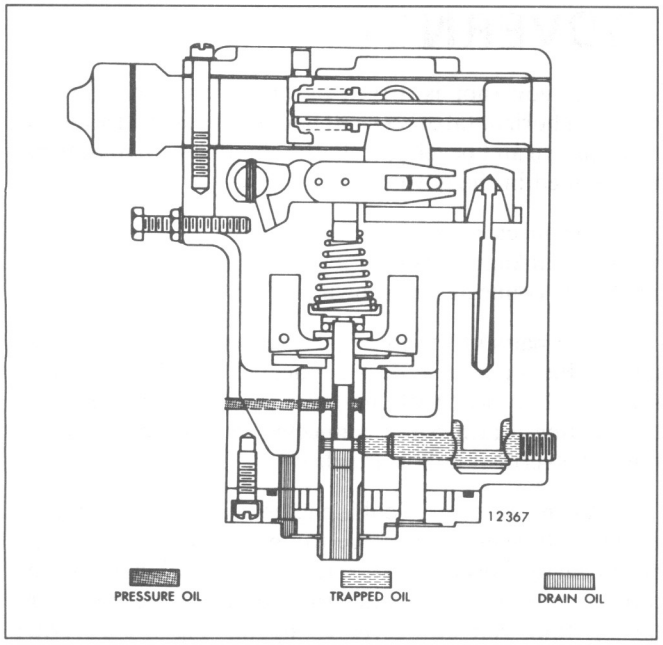


Fig. 2 – Position of Governor Mechanism when Load is Constant

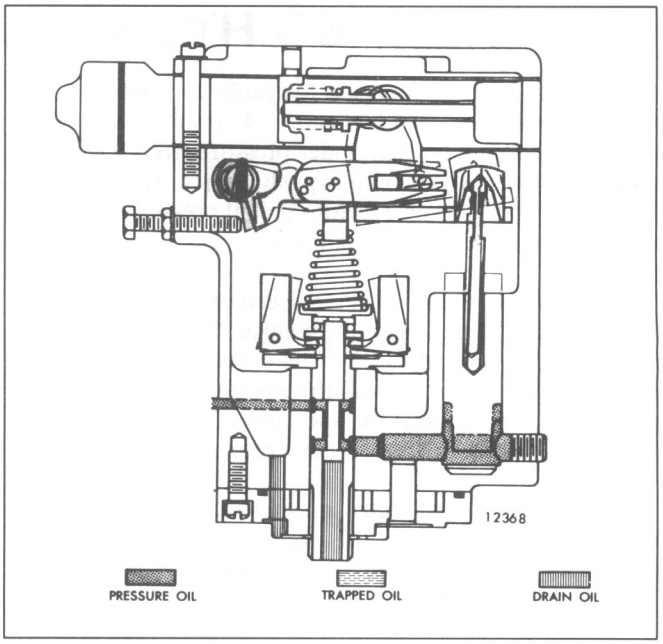


Fig. 3 – Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease

The engine can be stopped, regardless of the governor, by moving the governor operating lever to the no–fuel position.

In addition to its function of regulating the engine speed under varying load conditions, the hydraulic governor acts as an automatic shutdown device in the event of a loss of engine lubricating oil pressure. Should the engine fail to supply oil to the governor, the power piston will drop, allowing the governor operating lever to return to the no–fuel position.

Operation

With the engine operating, oil from the engine lubrication system is admitted to the space around the oil pump gears. The gears raise the oil pressure to a value determined by the relief valve plunger spring which opposes the relief valve plunger. The oil pressure is maintained in the annular space between the undercut portion of the pilot valve plunger and the bore in the ball head as shown in Fig. 2.

For any given throttle setting, the speeder spring has a definite compressional force which is opposed by the centrifugal force of the revolving flyweights. When the two forces are equal, the land on the pilot valve plunger covers the lower opening in the ball head, producing a constant speed condition as shown in Fig. 2.

When the load on an engine is increased, the engine speed will drop momentarily and the governor weights will be forced inward by the speeder spring permitting the pilot valve plunger to uncover the lower port in the ball head. With this port uncovered, oil, under pressure of the governor pump, will be admitted to the cavity at lower end of the power piston and force the piston and floating lever upward as shown in Fig. 3. The upward motion of the piston is transmitted through the terminal lever and the fuel rod to the injector control tube, causing the fuel setting of the engine to be increased.

As the power piston and the floating lever rise, the compressional load on the speeder spring is reduced, allowing the flyweights to again move out to their normal vertical position. With the governor weights in a vertical position, the land on the pilot valve plunger will again cover the ports in the ball head, trapping the regulating oil under the power piston. With the power piston held in its new position by the trapped regulating oil, the engine will carry the increased load at a slightly reduced speed.

Figure 4 illustrates the governor reaction as the load on the engine is decreased and the engine speed increases.

Lubrication

Oil seeping past the power piston and pilot valve plunger is vaporized by the revolving governor flyweights, providing lubrication for the moving parts in the governor housing. The governor pump, pilot valve plunger, and power piston are all exposed to pressurized oil. The pilot valve plunger has two oil holes to provide additional lubrication to the thrust bearing. Oil which collects on the floor of the governor housing passes through a passage into the governor drive housing, providing lubrication for the governor drive and driven shaft beveled gears and their bearings.

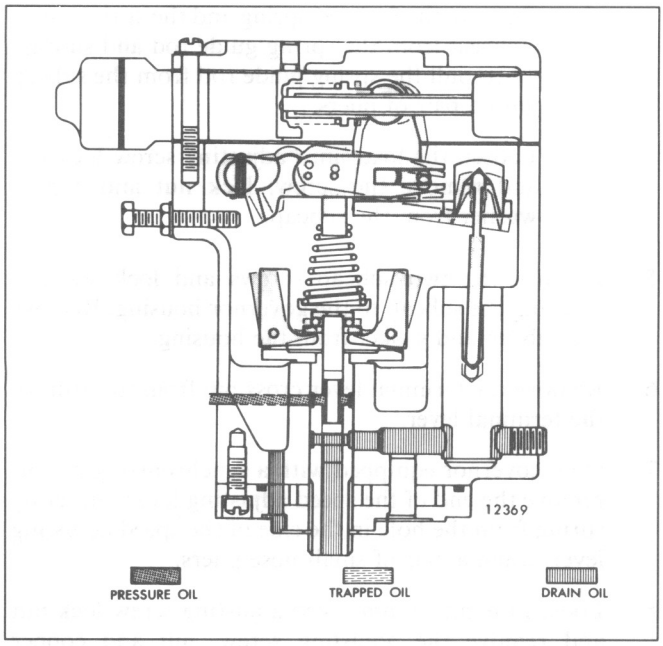


Fig. 4 – Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase

Remove Governor

Refer to Figs. 5 and 6 and remove the governor as follows:

1. Remove the nut, lock washer and bolt securing the speed control lever to the speed adjusting shaft. Then, pull the lever with link assembly attached from the shaft.

2. Mark the position of the governor operating lever on the terminal lever shaft. Loosen the bolt securing the lever to the shaft then pull the lever with link assembly attached from the shaft.

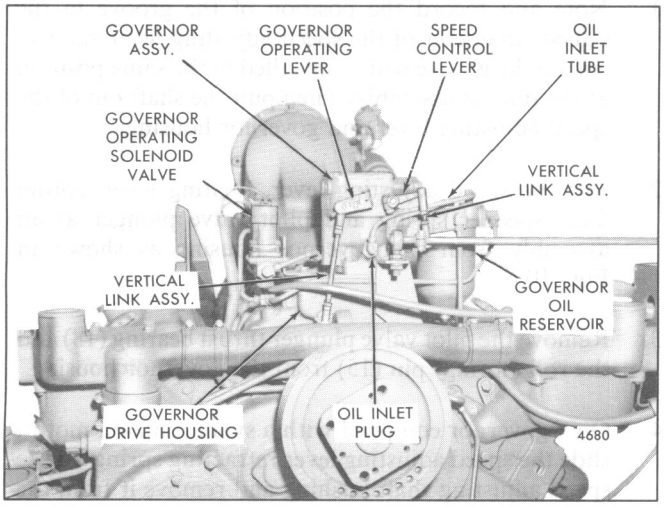


Fig. 5 – Typical Hydraulic Governor Mounting

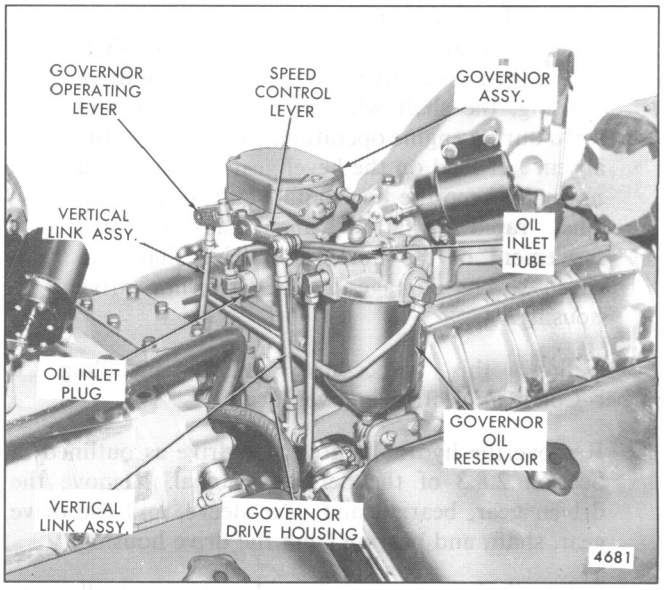


Fig. 6 – Hydraulic Governor Mounted on 16V Engine

The surplus oil returns to the engine crankcase through connecting drilled passages in the blower end plate and cylinder block.

3. If the governor is equipped with a governor operating solenoid valve assembly, disconnect and remove the oil tube from the valve assembly and governor housing.

4. Disconnect and remove the oil inlet tube assembly from the governor oil inlet elbow, and the governor oil reservoir if used.

5. On a governor equipped with a synchronizing motor, tag and disconnect the wires from the motor.

6. Remove the four bolts and lock washers securing the governor assembly to the governor drive housing or housing cover. Then lift the governor away from the drive housing or cover and remove the gasket.

• *Before a Barber–Coleman electronic governor is installed on an engine previously equipped with a hydraulic governor, the vertical driven gear, bearing, and gear sleeve and the horizontal drive gear, shaft, and bearing must be removed form the governor drive housing.*

These components serve no useful purpose when the hydraulic governor is replaced by the electronic governor and *will cause severe engine damage if not removed.* Because the horizontal drive shaft is splined to the blower rotor shaft, both governor shafts will continue to rotate when the engine is operated. However, with the hydraulic governor removed, the horizontal and vertical shafts and bearings will no longer receive adequate support or lubrication and will quickly wear out.

NOTICE: Do not remove only the vertical shaft and bearing. If the horizontal drive shaft and bearing assembly is left in the governor drive housing, the shaft will move freely back and forth during engine operation. This is due to the absence of load on the bevel gear which would normally keep the horizontal shaft in position. The rapid rotation and back-and-forth movement of the horizontal drive shaft can cause severe damage to the governor drive housing.

Follow this procedure before installing a Barber–Coleman electronic governor:

1. Remove the hydraulic governor drive as outlined in Section 2.8.3 of the Service Manual. Remove the driven gear, bearing and gear sleeve, and the drive gear, shaft, and bearing from the drive housing.
2. Reinstall the governor drive housing and all parts previously removed, except the drive and driven gears and related components, following procedures in Section 2.8.3 of the Service Manual.
3. Install the Barber–Coleman electronic governor per the manufacturer's instructions, and perform the engine tune-up as outlined in Section 14 of the Service Manual.

Disassemble Governor

Before removing any parts from the governor, wash it thoroughly in clean fuel oil and dry it with compressed air.

Governor disassembly need be carried out only as far as necessary to correct the difficulties which interfere with proper governor operation.

Refer to Figs. 1 and 12 for the location of the various parts and disassemble as follows:

1. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws (Fig. 9).
2. If necessary, remove the oil inlet elbow or fitting from the oil inlet plug.
3. Remove the three cover screws, then remove the cover and gasket from the housing.
4. To facilitate the removal of the governor subcap, disassemble the subcap before removal from the governor housing. Refer to Figs. 7 and 8 and proceed as follows:
   a. Remove the two screws and lock washers securing the spring pad cover to the subcap, then remove the cover from the spring guide rod. Remove the cover gasket.
   b. Remove the fuel rod spring and the spring guide rod seat from the spring guide rod and subcap. Then pull the spring guide rod from the subcap with a pair of pliers.
   c. Loosen the load limit adjusting screw lock nut and remove the screw, lock nut and copper washer from the subcap.
5. Remove the two subcap screws and lock washers securing the subcap to the governor housing. Remove the subcap and gasket from the housing.
6. Remove the terminal lever cross pin from the arms of the terminal lever.
7. On a governor equipped with a synchronizing motor, remove the end of the speed adjusting lever retracting spring from the hole in the side of the speed adjusting lever, using a pair of small nose pliers.
8. Loosen the maximum speed adjusting screw lock nut and remove the adjusting screw, nut and copper washer from the governor housing.

   NOTICE: If the maximum speed adjusting screw is not removed, the speed adjusting lever roll (spring) pin will hit the screw when it is being removed from the speed adjusting lever and shaft.

9. Remove the speed droop adjusting bracket screw lock washer and plain washer from the terminal lever, then remove the droop adjusting bracket from the floating lever and the terminal lever.
10. Remove the speed adjusting lever roll (spring) pin from the speed adjusting lever and the lever shaft with a small punch and hammer as shown in Fig. 9.
11. Note and record the position of the groove in the outside diameter of the speed adjusting lever shaft to ensure the groove will be installed in the same position at the time of assembly. Then pull the shaft out of the speed adjusting lever and governor housing.
12. Lift the speed adjusting lever, floating lever, spring fork, speeder spring and pilot valve plunger as an assembly from the governor housing as shown in Fig. 10.
13. Remove the pilot valve plunger thrust bearing (18) and the roll (spring) pin (15) from the governor housing.
14. On a governor equipped with a synchronizing motor, slide the speed adjusting lever retracting spring off the speed adjusting shaft bushing and remove it from the housing.

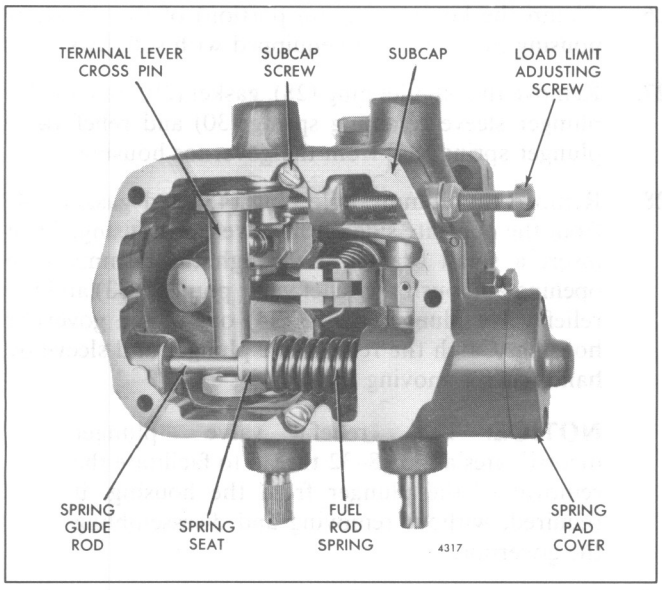


Fig. 7 – Top View of Governor with Cover Removed

15. If necessary, the speed adjusting lever (16), floating lever (55), spring fork (53), speeder spring (52) and pilot valve plunger and spring seat assembly, may be disassembled as follows:

    a. Straighten the bent end of the wire pin (54) securing the speed adjusting lever and spring fork to the speed adjusting floating lever.

    b. Pull the pin out of the speed adjusting lever, floating lever and spring fork with a pair of pliers.

    c. Insert a small screw driver between the spring and fork and pry the speeder spring from the spring fork.

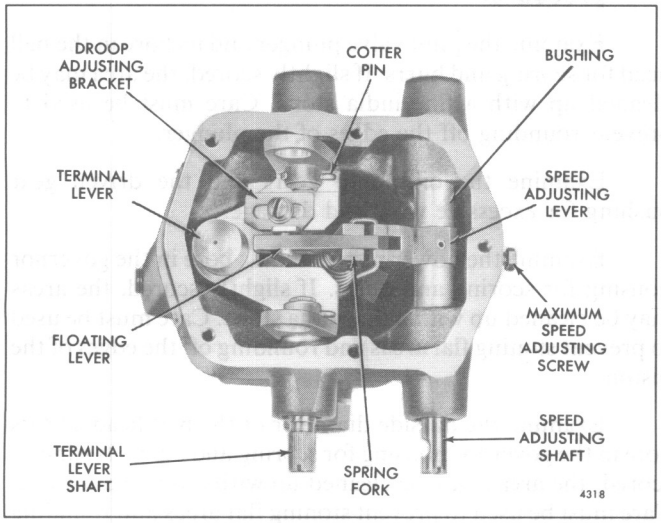


Fig. 8 – Top View of Governor with Subcap Removed

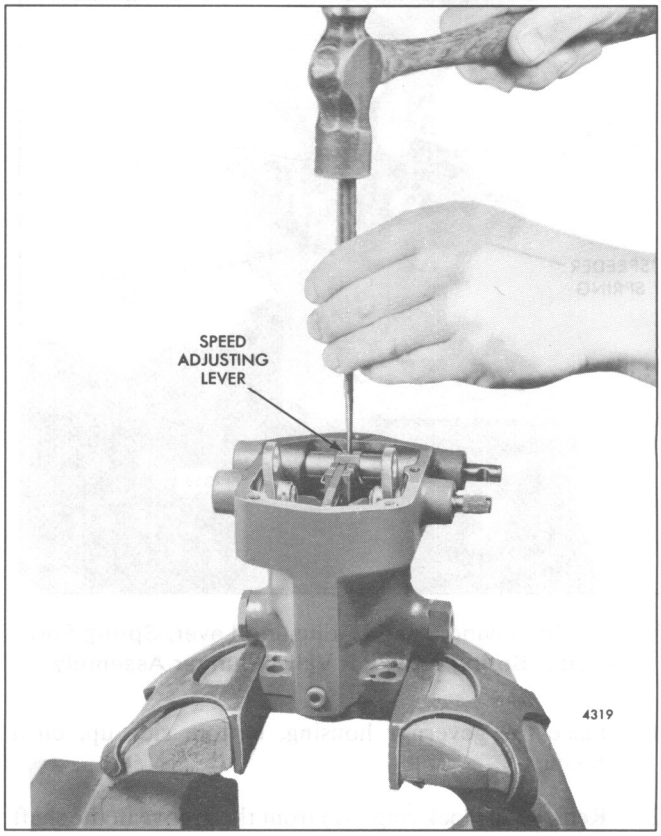


Fig. 9 – Removing Speed Adjusting Lever Roll Pin

    d. Work a small screw driver under the speeder spring and remove the spring from the pilot valve plunger and spring seat assembly.

16. Remove the two cotter pins securing the terminal lever to the terminal lever shafts. Then pull the long terminal lever shaft from the terminal lever and the governor housing.

17. Place a 1/4" brass rod approximately 5" long through the terminal lever shaft opening in the governor housing and terminal lever and against the inner end of the second terminal lever shaft. Then drive the governor housing cup plug out of the housing boss as shown in Fig. 11.

18. Push the terminal lever shaft out of the terminal lever and housing with the brass rod. Remove the brass rod and lift the terminal lever out of the housing.

19. Remove the terminal lever–to–power piston pin (47) from the piston.

20. Remove the governor housing from the bench vise. Turn the governor upside down and remove the power piston from the housing.

NOTICE: It may be necessary to tap the face of the governor housing lightly on a wood block to jar the piston out of the housing.

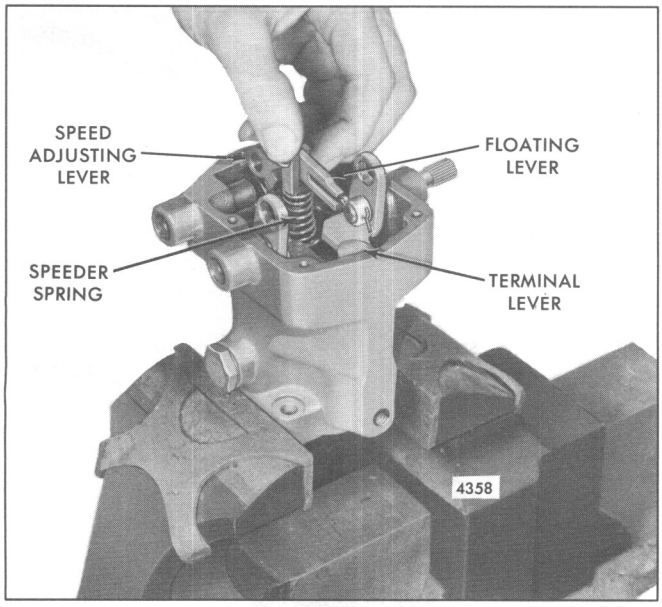


Fig. 10 – Removing Speed Adjusting Lever, Spring Fork, Speeder Spring and Pilot Valve Plunger Assembly

21. Place the governor housing, bottom side up, on a bench.

22. Remove the lock ring (41) from the groove in the shaft of the ball head (22) with a pair of snap ring pliers, then remove the ball head and flyweight assembly from the housing.

23. Remove the three screws (42) securing the governor base (40) to the governor housing.

24. Tap the edge of the governor base lightly with a plastic hammer to loosen it, then remove the base and seal ring from the governor housing and dowel pins.

25. Remove the oil pump drive and driven gears (38) and (63) from the governor base or housing.

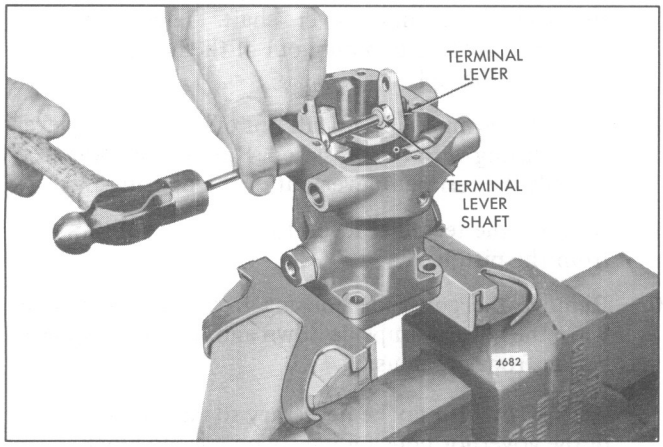


Fig. 11 – Removing Cup Plug from Governor Housing

26. Clamp the bottom (square portion) of the governor housing in a bench vise equipped with soft jaws.

27. Remove the oil inlet plug (28), gasket (29), relief valve plunger sleeve retaining spring (30) and relief valve plunger spring (34) from the governor housing.

28. Remove the dummy hole plug (43) and gasket (44) from the opposite side of the governor housing. Then insert a small brass rod through the dummy hole opening and push the relief valve plunger (33) and the relief valve plunger sleeve (34) out of the governor housing. Catch the relief valve plunger and sleeve by hand when removing them.

    NOTICE: The relief valve plunger incorporates a No. 8–32 thread to facilitate the removal of the plunger from the housing, if required, without removing and disassembling the governor.

29. If necessary, remove the pipe plug in the forward face of the governor housing.

30. If necessary, remove the speed adjusting lever shaft hole plug in the governor housing by inserting a 1/4" brass rod through the shaft opening and tap the cup plug out of the housing boss with a hammer.

31. Inspect the speed adjusting lever shaft and terminal lever shaft oil seals and, if necessary, remove them from the governor housing.

Inspection

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

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

Examine the pilot valve plunger and its bore in the ball head for scoring and burrs. If slightly scored, the area may be cleaned up with a fine india stone. Care must be used to prevent rounding off the edges of the plunger.

Examine the oil pump gears and the driven gear bushing for excessive wear and damage.

Examine the power piston and its bore in the governor housing for scoring and burrs. If slightly scored, the areas may be cleaned up with a fine india stone. Care must be used to prevent stoning flat areas and rounding off the edges of the piston.

Examine the outside diameter of the ball head and its bore in the governor housing for scoring and burrs. If slightly scored, the areas may be cleaned up with a fine india stone. Care must be used to prevent stoning flat areas and rounding off the edges of the ball head.

NOTICE: The pilot valve plunger power piston and ball head assembly must operate freely in their respective bores.

Examine the pilot valve plunger thrust bearing for excessive wear and flat spots.

Inspect the finished radius (thrust bearing contact surfaces) of the flyweights for excessive wear or flat spots. The flyweights must operate freely on their supports for satisfactory governor operation.

Examine the ends of the power piston–to–terminal lever pin for wear and scoring. If slightly scored, clean the ends up with a fine india stone.

Inspect the speed adjusting lever shaft and terminal lever shaft oil seals in the governor housing for excessive wear.

Inspect the speed adjusting lever shaft and terminal lever shaft bushing in the governor housing for excessive wear.

Examine the relief valve plunger and the inside diameter of the plunger sleeve for wear, scratches and sludge in the grooves and holes in the plunger and sleeve. The current plunger incorporates four relief holes and is slightly larger than the former plunger. The current sleeve assembly has the washer affixed to the sleeve. When it is necessary to replace either the former plunger or the sleeve and washer a plunger kit must be used which includes the current plunger and a sleeve assembly. Also, examine the plunger and sleeve springs for fractured coils.

Examine the fuel rod spring for fractured coils.

Examine the face of the spring guide rod seat where it contacts the terminal lever cross pin for scoring and wear.

Replace all of the governor parts that are excessively worn or damaged.

Assemble Governor

Refer to Figs. 1 and 12 and assemble the governor as follows:

1. If removed, install new speed adjusting lever and terminal lever shaft bushings in the governor housing to the specified dimensions shown in Fig. 13.

2. If removed, install the pipe plug (83) in the governor housing.

3. Lubricate the two oil pump gears (38) and (63) with engine oil and place them in their respective positions in the governor base (40).

4. Place a new seal ring (39) in the groove in the governor base, with the wide side of the seal down in the groove.

5. Set the governor housing (45) on the base with the dowels in the base registering with the holes in the housing and the idler gear stud in the housing registering with the hole in the idler gear. Press the housing down against the seal ring in the base.

6. Lubricate the outside diameter of the ball head and flyweight assembly with engine oil. Then insert the end of the ball head straight into and through the bore of the governor housing, drive gear and base.

7. Insert the three screws (42) through the governor base and thread them into the governor housing. Turn the ball head assembly while tightening the three screws to make sure the ball head assembly rotates freely.

If a bind exists, loosen the three screws, tap the sides of the base lightly with a plastic hammer and tighten the screws again. Revolve the ball head assembly again and check for bind. Repeat, if necessary, until all parts rotate freely.

8. Install the ball head lock ring (41) in the groove in the ball head shaft with a pair of snap ring pliers.

9. Refer to Fig. 14 and install the relief valve plunger, plunger sleeve, plunger spring, sleeve retaining spring, oil inlet plug and dummy hole plug in the governor housing as follows:

   a. Lubricate the outside diameter of the relief valve plunger and plunger sleeve with engine oil. Then insert the relief valve plunger inside the plunger sleeve.

   b. Insert the relief valve plunger and sleeve assembly straight into the opening in the right–hand side of the governor housing, when viewed from the power piston side, with the tapped hole in the relief valve plunger facing out, and push it in against the shoulder in the housing.

   c. Place the relief valve plunger spring and the plunger sleeve retaining spring in the housing and against the plunger and sleeve.

   d. Place a gasket on the oil inlet plug, then place the plug over the ends of the springs and thread it into the governor housing.

   e. Place a gasket on the dummy hole plug and thread it into the opening in the opposite side of the governor housing.

   f. Clamp the bottom (square portion) of the governor housing and base assembly between the soft jaws of a bench vise. Then tighten the oil inlet plug and the dummy hole plug securely.

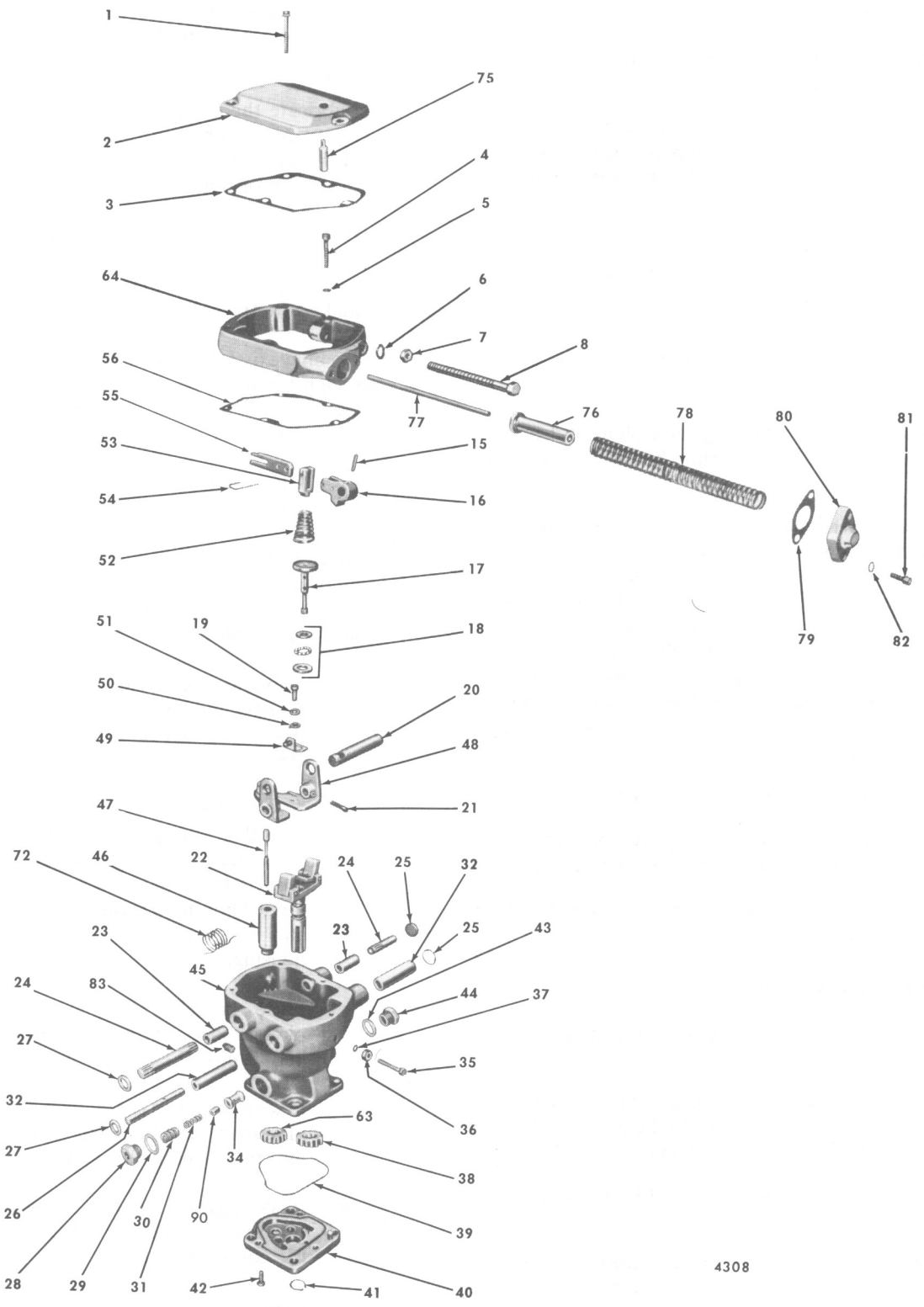


Fig. 12 – Hydraulic Governor Details and Relative Location of Parts

1. Screw—Governor Cover
2. Cover—Governor
3. Gasket—Governor Cover
4. Screw—Subcap–to–Housing
5. Lock Washer
6. Washer—Copper
7. Lock Nut
8. Screw—Load Limit Adjusting
15. Pin—Roll
16. Lever—Speed Adjusting
17. Plunger—Pilot Valve
18. Bearing—Pilot Valve Plunger Thrust
19. Screw—Droop Adjusting Bracket
20. Pin—Terminal Lever Cross
21. Cotter Pin
22. Ball–Head Assembly
23. Bushing—Terminal Lever
24. Shaft—Terminal Lever
25. Plug—Cap
26. Shaft—Speed Adjusting Lever
27. Oil Seal
28. Plug—Governor Oil Inlet
29. Gasket—Relief Valve
30. Spring—Sleeve Retaining
31. Spring—Relief Valve
32. Bushing—Speed Adjusting Lever Shaft
33. Valve—Relief
34. Sleeve—Relief Valve
35. Screw—Maximum Speed Adjusting
36. Lock Nut
37. Washer—Copper
38. Gear—Oil Pump Drive
39. Ring—Housing–to–Base Seal
40. Base—Governor
41. Lock Ring
42. Screw—Governor Base
43. Gasket—Spacer Cap
44. Plug—Dummy Hole
45. Housing—Governor
46. Piston—Power
47. Pin—Floating
48. Lever—Terminal
49. Bracket—Speed Droop Adjusting
50. Plain Washer
51. Lock Washer
52. Spring—Speeder
53. Fork—Adjusting Linkage Spring
54. Pin—Spring Fork
55. Lever—Speed Adjusting Floating
56. Gasket—Subcap–to–Housing
63. Gear—Oil Pump Driven
64. Subcap—Governor
72. Spring—Torsion (Syn. Motor Only)
75. Screw—Low Speed Stop
76. Seat—Guide Rod Spring
77. Rod—Spring Guide
78. Spring—Terminal Lever Return
79. Gasket
80. Cover—Spring Pad
81. Screw—Spring Pad
82. Washer—Internal Lock
83. Plug—Housing

Fig. 12 – Hydraulic Governor Details and Relative Location of Parts

10. Lubricate the power piston (46) with engine oil. Then insert the piston, small end down, straight into the piston bore in the governor housing and push it in until it bottoms.

11. Install the terminal lever (48), terminal lever shafts (24), cotter pins (21), cup plug (25) and oil seal (27) in the governor housing as follows:

    a. Apply a thin coat of sealing compound to the outside diameter of a new terminal lever shaft oil seal. Start the seal, with the lip of the seal facing down, straight into the terminal lever shaft opening in the oil inlet plug side of the housing, then press the seal in flush with the outside face of the boss.

    b. Clamp the bottom (square portion) of the governor housing and base assembly between the soft jaws of a bench vise.

    c. Lubricate the long terminal lever shaft with engine oil. Place the terminal lever in between the ends of the two bushings inside the governor housing. Then insert the serrated end (with the cotter pin hole) of the shaft through the oil seal and bushing in the housing, with the cotter pin holes in the shaft and terminal lever in alignment as shown in Fig. 15. Push the shaft into the lever until the two holes are in alignment.

    d. Install a cotter pin through the terminal lever and shaft and bend the ends over against the side of the terminal lever.

    e. Install the second terminal lever shaft in the housing and terminal lever at the opposite side of the governor housing in the same manner as outlined in Steps c and d.

    f. Apply a thin coat of sealing compound to the outside diameter of a new governor housing cup plug (25). Start the plug, open end out, straight into the terminal lever shaft opening in the housing. Then press the plug in flush with the outside face of the housing boss.

12. Apply a thin coat of sealing compound to the outside diameter of a new speed adjusting lever shaft oil seal. Start the seal, with the lip of the seal facing down, straight into the speed adjusting lever shaft opening in the oil inlet plug side of the housing. Then press the seal in flush with the outside face of the boss.

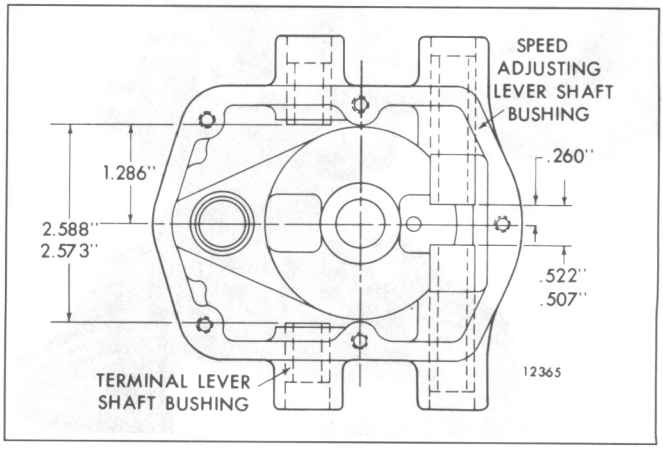


Fig. 13 – Location of Speed Adjusting Lever and Terminal Lever Shaft Bushings in Governor Housing

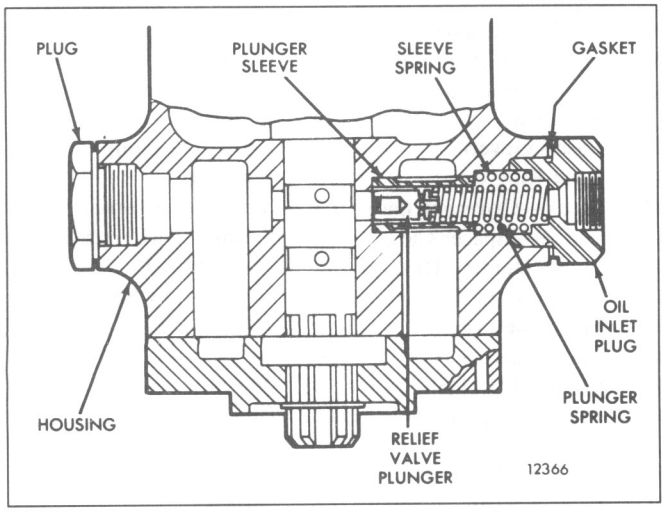


Fig. 14 – Location of Oil Relief Valve Plunger, Plunger Sleeve, Springs, Oil Inlet Plug and Dummy Plug

13. Apply a thin coat of sealing compound to the outside diameter of a new governor housing cup plug (25). Start the plug, open end out, straight into the speed adjusting lever shaft opening in the housing. Then press the plug in flush with the outside face of the housing boss.

14. Lubricate the terminal lever–to–power piston pin (47) with engine oil. Raise the edge of the terminal lever and insert the pin in the hole in the power piston, then lower the terminal lever down on the pin.

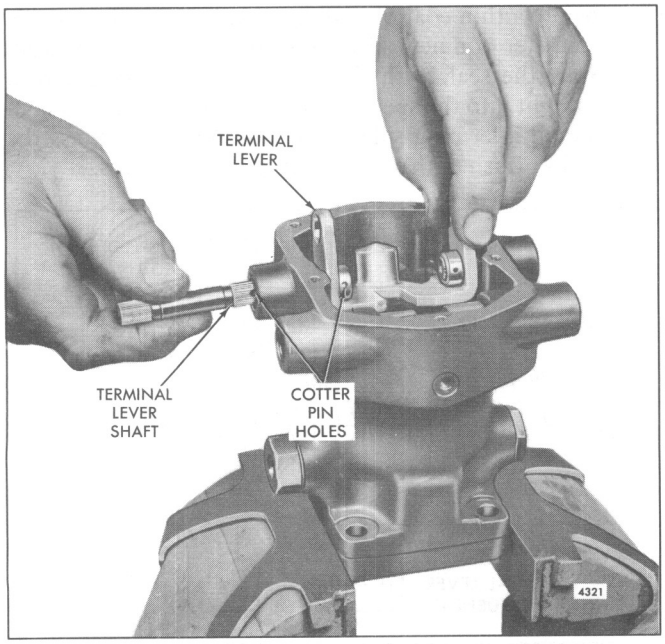


Fig. 15 – Installing Terminal Lever Shaft in Governor Housing and Terminal Lever

15. If disassembled, the speed adjusting lever (16), floating lever (55), spring fork (53), speeder spring (52) and pilot valve plunger (17) may be assembled as follows:

    a. Place the non–slotted end of the speed adjusting floating lever in the slot of the speed adjusting lever, (Fig. 1) so the pin holes are in alignment.

    b. Insert the long end of the speed adjusting lever–to–floating lever wire pin through the pin hole in the speed adjusting lever and floating lever (Fig. 17).

    c. Place the speed adjusting floating lever in the slot of the spring fork, with the pin holes in alignment. Then insert the short end of the wire pin through the hole in the spring fork and floating lever.

    d. Push the wire pin in against the speed adjusting lever and spring fork and bend the protruding end of the wire pin over toward the slotted end of the floating lever.

    e. Press the lower end of the spring fork into the small end of the speeder spring. Then insert the opposite end of the spring in the spring seat of the pilot valve plunger.

16. On a governor equipped with a synchronizing motor, place the speed adjusting lever retracting spring over the speed adjusting lever shaft bushing in the governor housing, with the hooked end over the slot between the two bushings.

17. Place the governor housing on its side, oil inlet plug side up, on a bench with the top of the housing facing out.

18. Lubricate the pilot valve plunger thrust bearing with engine oil and place it over the end of the pilot valve plunger with the smallest, outside diameter, bearing race next to the spring seat (Fig. 1).

19. Lubricate the pilot valve plunger with engine oil. Then hold the thrust bearing against the spring seat and insert the assembly in the governor housing with the speed adjusting lever facing the two bushings in the housing (Fig. 16). Start the pilot valve plunger straight into the bore of the ball head and push the assembly in until the speed adjusting lever is in position between the two bushings and the thrust bearing is resting on the lip of the flyweights (Fig. 1).

20. Install the speed adjusting lever shaft (26) and roll (spring) pin (15) in the governor housing as follows:

    a. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws.

b. Lubricate the speed adjusting lever shaft with engine oil. Rotate the shaft so the slot in the outside diameter of the shaft is in the same position it was in at the time of removal. Then insert the shaft in the shaft bushing, from the oil inlet plug side, with the roll pin hole in the shaft and lever in alignment as shown in Fig. 17.

c. While holding the speed adjusting lever, push the shaft through the bushing, lever and into the second shaft bushing until the pin holes are in alignment.

On a governor equipped with a synchronizing motor, be sure the hooked end of the speed adjusting lever retracting spring is on top of the speed adjusting lever before installing the shaft.

d. Start the speed adjusting lever roll (spring) pin (15) straight in the pin hole in the lever. Then tap the pin through the lever and shaft until it is flush with the top of the lever.

e. On a governor equipped with a synchronizing motor, rotate the speed adjusting lever retracting spring around the shaft bushing and insert the hooked end of the spring in the small hole in the side of the speed adjusting lever with a pair of small nose pliers.

21. Place the speed droop adjusting bracket in position against the top face of the terminal lever, with the pin in the bracket in the slot of the speed adjusting floating lever (Fig. 8) and secure it to the lever with a flat washer, lock washer and screw.

22. If removed, thread the lock nut on the maximum speed adjusting screw (35). Place the copper washer on the adjusting screw, then thread the screw approximately halfway in the governor housing (Fig. 1).

23. Install the terminal lever cross pin through the pin holes in the terminal lever as shown in Fig. 7, with the spring guide rod slot in the pin facing up.

24. Affix a new governor subcap gasket (56) to the top of the governor housing.

25. Place the governor subcap (64) on top of the gasket and housing with the fuel rod spring opening in the subcap facing the maximum speed adjusting screw side of the governor housing (Fig. 1). Install the two subcap screws and lock washers and tighten them securely.

26. Refer to Figs. 1, 7 and 12 and install the spring guide rod (77), spring guide rod seat (76), fuel rod spring (21), spring pad cover (80) and the load limit adjusting screw (8) in the governor subcap as follows:

a. Lubricate the spring guide rod with engine oil, then insert the end of the rod through the opening in the subcap, through the slot in the terminal lever cross pin and into the hole at the opposite end of the subcap.

b. Place the spring guide rod seat, large diameter end first, over the end of the spring guide rod and push it forward over the rod and into the notch in the terminal lever cross pin with the flat on the side of the seat adjacent to the terminal lever cross pin support.

c. Insert the end of the fuel rod spring over the end of the spring guide rod, through the opening in the subcap and ove the end of the spring guide rod seat.

d. Affix a new gasket (79) to the flat face of the spring pad cover (80).

e. Place the spring pad cover against the end of the fuel rod spring. Push in on the cover to compress the spring and at the same time, pilot the end of the spring guide rod in the hole in the flat face of the cover. Install the two screws and lock washers and tighten them securely.

f. If removed, thread the lock nut (7) on the load limit adjusting screw (8). Place the copper washer (6) over the end of the load limit adjusting screw, then thread the screw into the subcap until the end protrudes approximately 1/8" through the second boss inside the subcap (Fig. 5).

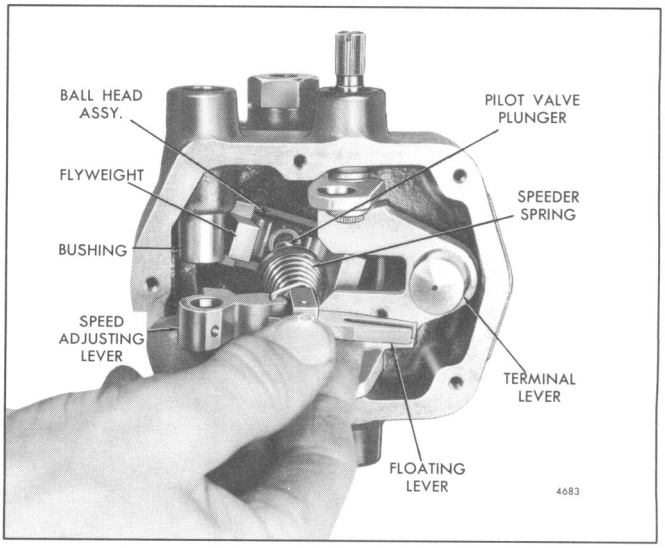


Fig. 16 – Installing Speed Adjusting Lever, Floating Lever, Speeder Spring and Pilot Valve Plunger Assembly

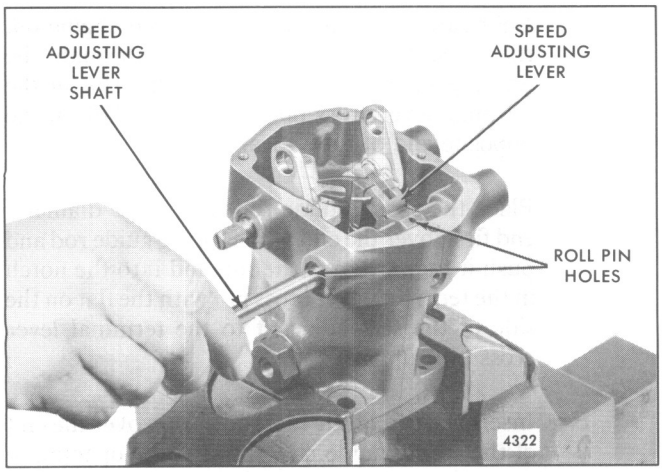


Fig. 17 – Installing Speed Adjusting Lever Shaft in Governor Housing and Adjusting Lever

27. Affix a new gasket (3) to the top face of the governor subcap, then place the governor cover on top of the gasket and install the three screws with lock washers. Tighten the screws securely.

28. If removed, install the oil inlet elbow or fitting in the oil inlet plug.

Install Governor

Refer to Figs. 5 and 6 and proceed as follows:

1. Affix a new gasket to the top of the governor drive housing or housing cover.

2. Position the governor over the governor drive housing or housing cover with the ends of the terminal lever and speed adjusting lever shafts facing the front end of the engine. Turn the ball head assembly slightly to align the splines of the ball head shaft with the splines in the driven shaft sleeve, then enter the shaft straight in the sleeve and set the governor on the gasket and drive housing or cover.

3. Install the four governor to drive housing bolts and lock washers. Tighten the bolts to 13–17 lb–ft (18–23 Nm) torque.

4. Install and connect the oil inlet tube assembly to governor oil reservoir or oil supply valve (if used) and the oil inlet elbow or fitting.

5. If the governor is equipped with a governor operating solenoid valve assembly, install and connect the oil tube to the valve assembly and the governor housing.

6. On a governor equipped with a synchronizing motor, connect the wires to the motor.

7. Place the governor operating lever, with link assembly attached, on the terminal lever shaft in the same position it was in at the time of removal, then tighten the retaining bolt to 7–9 lb–ft (10–12 Nm) torque.

8. Place the speed control lever, with link assembly attached, on the speed adjusting lever shaft and install the bolt, lock washer and nut. Tighten the bolt nut to 8–10 lb–ft (11–14 Nm) torque.

9. Position the injector control racks and make the final governor adjustments as outlined under *Engine Tune–Up Procedures* in Section 14.

PSG HYDRAULIC GOVERNOR

The governor is located at the front of the engine (Fig. 1) and is mounted on the governor drive housing which also serves as the blower front cover.

The governor is driven by one of the blower rotors through a horizontal drive shaft and bevel gear and a vertical driven shaft and bevel gear. Both shafts are mounted on ball bearings and are retained in the governor drive housing. The injector control tubes are actuated by the governor through a linkage consisting of the fuel rods, vertical link and levers connected as shown in Fig. 2.

The governor is an isochronous hydraulic type with a speed droop stabilization mechanism. Hydraulic action is transmitted by filtered oil admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.

The isochronous feature of this governor is its ability, at zero droop, to hold the engine at a constant speed regardless of the load, provided the load is within the capacity of the unit.

The governor operates in such a manner that the amount of fuel supplied to the injectors is increased by the hydraulically operated servo–motor piston and decreased by action of the terminal lever return spring.

When starting a cold engine, time is required to develop sufficient oil pressure to operate the governor and thus move the injector control racks to the full–fuel position so the engine can start. Since this delay is undesirable, the starting time can be shortened by moving the governor operating lever to the full–fuel position, to take control of the injector racks away from the governor. The engine can be stopped, regardless of the governor, by moving the governor operating lever to the no–fuel position.

In addition to its function of holding the engine speed constant under varying load conditions, the hydraulic governor acts as an automatic shutdown device in the event of a loss of engine lubricating oil pressure. Should the engine fail to supply oil to the governor, the servo–motor piston will drop, thus allowing the governor operating lever to return to the no–fuel position.

Operation

With the engine operating, oil from the engine lubricating system is admitted to the space around the governor pump gears. The pump gears raise the oil pressure to a value determined by the spring in the relief valve which opposes the relief valve plunger. The oil pressure is maintained in the annular space between the undercut portion of the pilot valve plunger and the bore in the pilot valve bushing (Fig. 3).

For any given throttle setting, the speeder spring exerts a definite force which is opposed by the centrifugal force of the revolving flyweights. When the two forces are equal, the control land on the pilot valve plunger covers the lower ports in the pilot valve bushing.

Under these conditions, equal oil pressures are maintained on both sides of the buffer piston and tension on the two buffer springs in equal. The oil pressure is also equal on both sides of the receiving compensating land of the pilot valve plunger, due to oil passing through the compensating needle valve. Thus the hydraulic system is in balance and the engine speed remains constant.

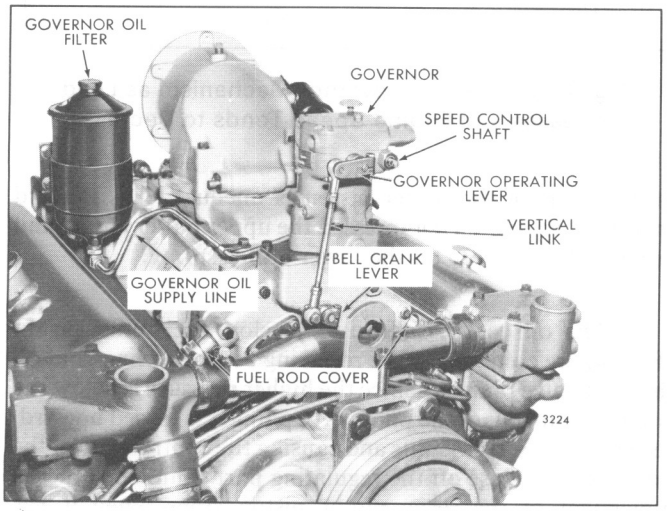


Fig. 1 – PSG Hydraulic Governor Mounting

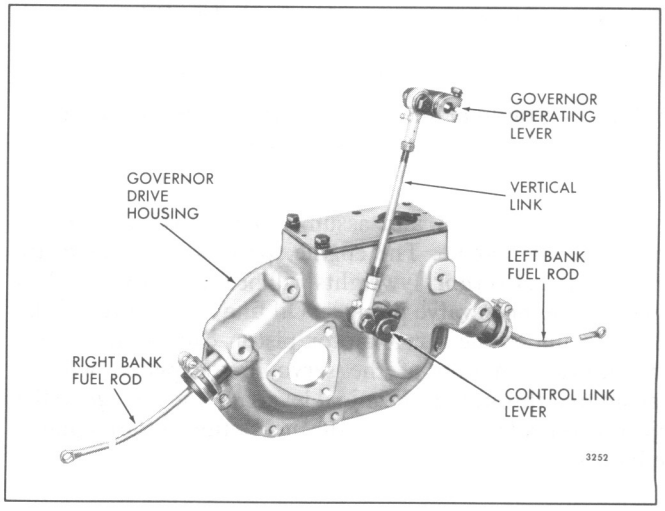
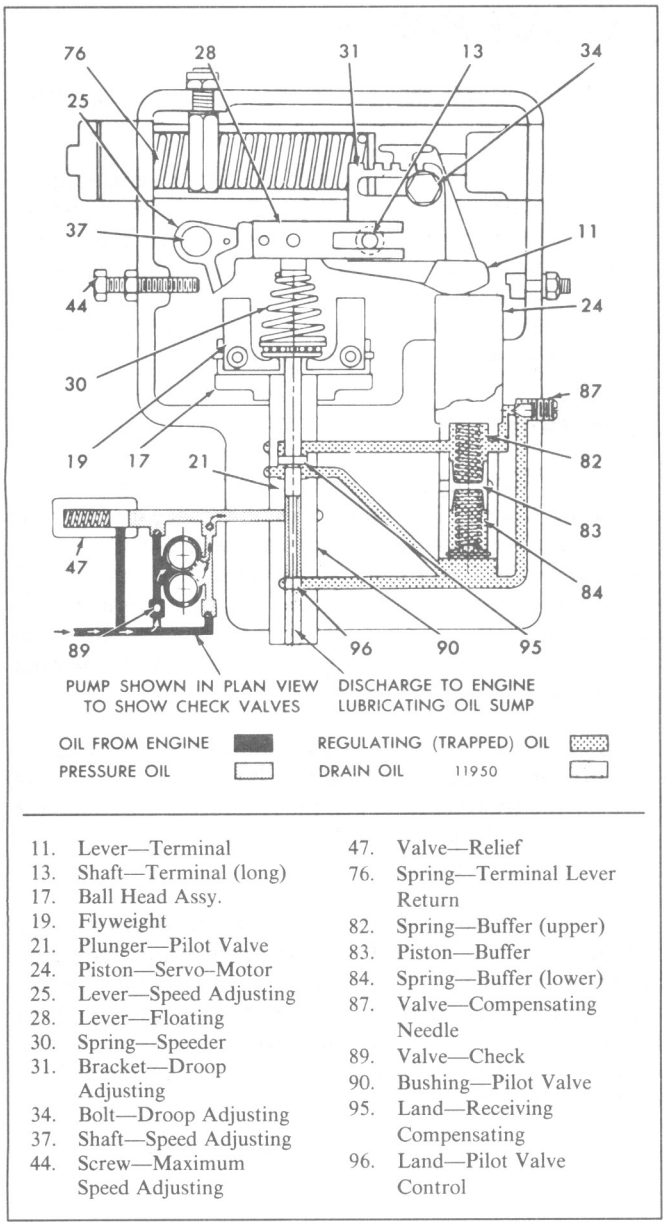
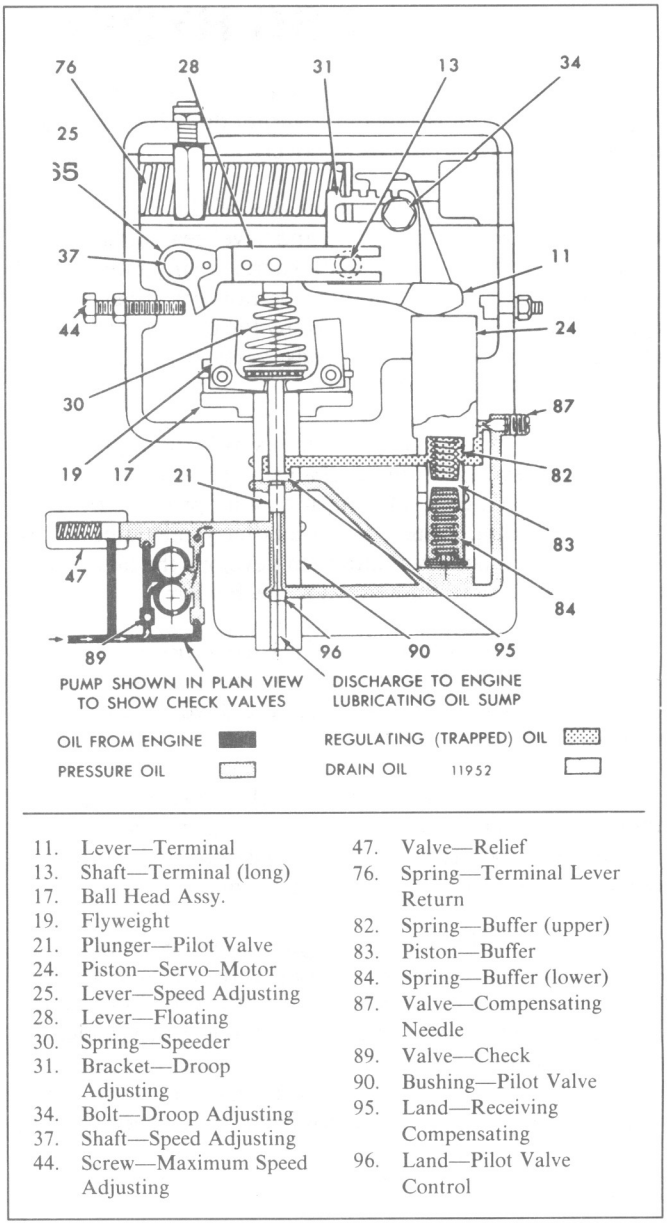


Fig. 2 – Enclosed Type Governor–to–Injector Rack Control Linkage



11. Lever—Terminal
13. Shaft—Terminal (long)
17. Ball Head Assy.
19. Flyweight
21. Plunger—Pilot Valve
24. Piston—Servo-Motor
25. Lever—Speed Adjusting
28. Lever—Floating
30. Spring—Speeder
31. Bracket—Droop Adjusting
34. Bolt—Droop Adjusting
37. Shaft—Speed Adjusting
44. Screw—Maximum Speed Adjusting
47. Valve—Relief
76. Spring—Terminal Lever Return
82. Spring—Buffer (upper)
83. Piston—Buffer
84. Spring—Buffer (lower)
87. Valve—Compensating Needle
89. Valve—Check
90. Bushing—Pilot Valve
95. Land—Receiving Compensating
96. Land—Pilot Valve Control

Fig. 3 – Stable position of Governor When Load on Engine is Constant



11. Lever—Terminal
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19. Flyweight
21. Plunger—Pilot Valve
24. Piston—Servo-Motor
25. Lever—Speed Adjusting
28. Lever—Floating
30. Spring—Speeder
31. Bracket—Droop Adjusting
34. Bolt—Droop Adjusting
37. Shaft—Speed Adjusting
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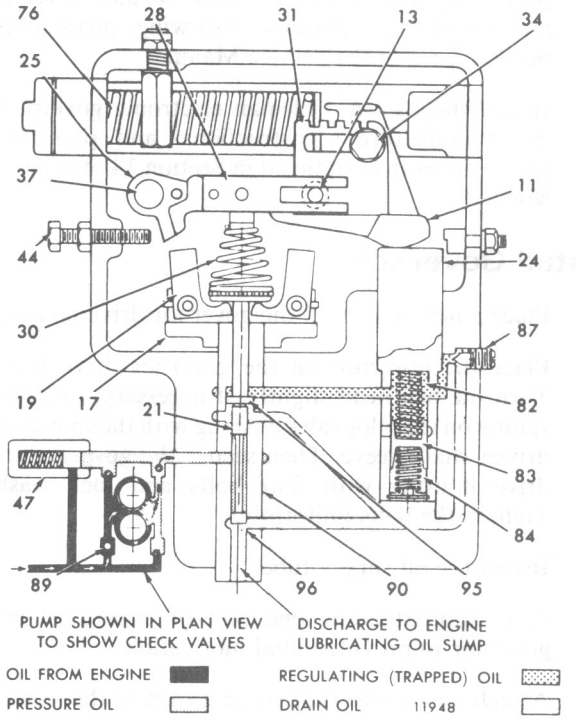
83. Piston—Buffer
84. Spring—Buffer (lower)
87. Valve—Compensating Needle
89. Valve—Check
90. Bushing—Pilot Valve
95. Land—Receiving Compensating
96. Land—Pilot Valve Control

Fig. 4 – Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease

Refer to Fig. 4 and assume that a load increase is applied to the engine. The engine speed will momentarily drop and the governor flyweights will be forced inward, thus lowering the pilot valve plunger. Oil under pressure will be admitted under the servo–motor piston causing it to rise. This upward motion of the servo–motor piston will be transmitted through the terminal lever and the linkage to the injector control tubes, causing the fuel setting of the engine to be increased.

The oil which forces the servo–motor piston upward also forces the buffer piston upward because the oil pressure at each side of the buffer piston is unequal. This upward motion of the piston compressed the upper buffer spring and relieves the pressure on the lower buffer spring.

The oil cavities above and below the buffer piston (Fig. 4) are common to the receiving compensating land on the pilot valve plunger. Since the higher pressure is below the compensating land, the pilot valve plunger is forced upward, recentering the flyweights and causing the control land of the pilot valve to close off the regulating port. Thus the upward movement of the servo–motor piston stops when it has moved far enough to make the necessary fuel correction.



11. Lever—Terminal
13. Shaft—Terminal (long)
17. Ball Head Assy.
19. Flyweight
21. Plunger—Pilot Valve
24. Piston—Servo-Motor
25. Lever—Speed Adjusting
28. Lever—Floating
30. Spring—Speeder
31. Bracket—Droop Adjusting
34. Bolt—Droop Adjusting
37. Shaft—Speed Adjusting
44. Screw—Maximum Speed Adjusting
47. Valve—Relief
76. Spring—Terminal Lever Return
82. Spring—Buffer (upper)
83. Piston—Buffer
84. Spring—Buffer (lower)
87. Valve—Compensating Needle
89. Valve—Check
90. Bushing—Pilot Valve
95. Land—Receiving Compensating
96. Land—Pilot Valve Control

Fig. 5 – Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase

Oil passing through the compensating needle valve equalizes the pressure above and below the buffer piston, thus allowing the piston to return to its center position which, in turn, equalizes the pressure above and below the receiving compensating land. The pilot valve plunger then moves to its central position and the engine speed returns to its original setting because there is no longer any excessive outward force on the flyweights.

Figure 5 illustrates the governor reaction as the load on the engine is decreased and the engine speed returns to normal. With a decrease in the load, the engine speed will momentarily increase and the flyweights will move outward, thus raising the pilot valve plunger.

This allows the oil below the buffer piston (and below the receiving compensating land) to flow to the drain passage, thus reducing the pressure on the lower side of the buffer piston and on the lower side of the receiving compensating land. This allows a downward movement of the servo–motor piston which is transmitted through the terminal lever and linkage to the injector control tubes, causing the fuel setting of the engine to be decreased.

The compensating mechanism produces stable engine operation by permitting the governor to move instantaneously in response to a load change and to make the necessary fuel adjustment to maintain the initial engine speed.

The speed changes previously described were the result of load changes. Similar governor movements occur through movement of the governor speed control lever. Movement of the speed control lever (through the vernier control and connecting linkage) changes the tension on the speeder spring, thus causing the pilot valve plunger to raise or lower.

Lubrication

Oil passes up through a drilled passage in the pilot valve plunger and is directed at the thrust bearing from where it is thrown onto the moving parts in the governor housing by the revolving flyweights. The governor pump gears, pilot valve plunger, servo–motor ppiston and buffer piston are all exposed to pressurized oil. Oil which collects on the floor of the governor housing passes through a drilled passage into the governor drive housing, thus libricating the governor drive and driven gears and shafts and their bearings. Surplus oil returns to the engine crankcase through connecting drilled passages in the blower end plate and cylinder block.

Remove Governor

Refer to Fig. 1 and remove the governor as follows:

1. Disconnect any linkage which may be attached to the governor speed control lever.
2. Drain the governor oil filter.
3. Disconnect the oil supply tube between the governor and the filter.
4. Remove the oil filter element and clean the filter housing. Install a new filter element.
5. Disconnect the vertical link assembly from the governor operating lever.
6. Disconnect the wires to the synchronizing motor, if used. Tag the wires to facilitate reassembly.
7. Remove the four bolts and lock washers that attach the governor to the governor drive housing cover. Lift the governor away from the drive housing. Remove the gasket.

• *Before a Barber–Coleman electronic governor is installed on an engine previously equipped with a hydraulic governor, the vertical driven gear, bearing, and gear sleeve and the horizontal drive gear, shaft, and bearing must be removed form the governor drive housing.*

These components serve no useful purpose when the hydraulic governor is replaced by the electronic governor and *will cause severe engine damage if not removed.* Because the horizontal drive shaft is splined to the blower rotor shaft, both governor shafts will continue to rotate when the engine is operated. However, with the hydraulic governor removed, the horizontal and vertical shafts and bearings will no longer receive adequate support or lubrication and will quickly wear out.

> **NOTICE:** Do not remove only the vertical shaft and bearing. If the horizontal drive shaft and bearing assembly is left in the governor drive housing, the shaft will move freely back and forth during engine operation. This is due to the absence of load on the bevel gear which would normally keep the horizontal shaft in position. The rapid rotation and back-and-forth movement of the horizontal drive shaft can cause severe damage to the governor drive housing.

Follow this procedure before installing a Barber–Coleman electronic governor:

1. Remove the hydraulic governor drive as outlined in Section 2.8.3 of the Service Manual. Remove the driven gear, bearing and gear sleeve, and the drive gear, shaft, and bearing from the drive housing.
2. Reinstall the governor drive housing and all parts previously removed, except the drive and driven gears and related components, following procedures in Section 2.8.3 of the Service Manual.
3. Install the Barber–Coleman electronic governor per the manufacturer's instructions, and perform the engine tune-up as outlined in Section 14 of the Service Manual.

Install Governor

1. Place a new gasket on the governor drive housing.
2. Place the governor on the governor drive housing. Turn the ball head slightly, if necessary, to align the splines on the pilot valve bushing with the splines in the driven shaft sleeve. Then secure the governor to the drive housing with four bolts and lock washers. Tighten the bolts uniformly.
3. Install the oil supply tube.
4. Pour approximately one pint of engine oil in the governor to provide initial lubrication.
5. Attach a new governor cover gasket to the subcap.
6. If previously removed, install the speed adjusting lever stop on the underside of the governor cover. Secure the lever stop to the cover with a lock nut and copper washer.
7. Before installing the governor cover or connecting the governor linkage, perform a complete engine tune–up as outlined in Section 14.

HYDRAULIC GOVERNOR DRIVE

6V AND 8V–92 ENGINES

The governor is driven by one of the blower rotors through a horizontal drive shaft and drive (bevel) gear and an integral vertical driven (bevel) gear (Fig. 1). Each gear is mounted on a ball bearing and is contained in a drive housing that also serves as the blower front cover.

Splines on the horizontal drive shaft engage the splines in the blower rotor shaft that provides the drive. Splines on the lower end of the governor ball head register with the splines in the upper end of a sleeve that is pressed on the vertical driven gear.

The fuel rod from each injector control tube is connected to a common control link lever which is enclosed in the governor drive housing.

The governor is connected to the fuel rods by a vertical link attached to the control link lever and the governor operating lever (Fig. 2).

Naturally aspirated engine drive assemblies include a reduction gear assembly.

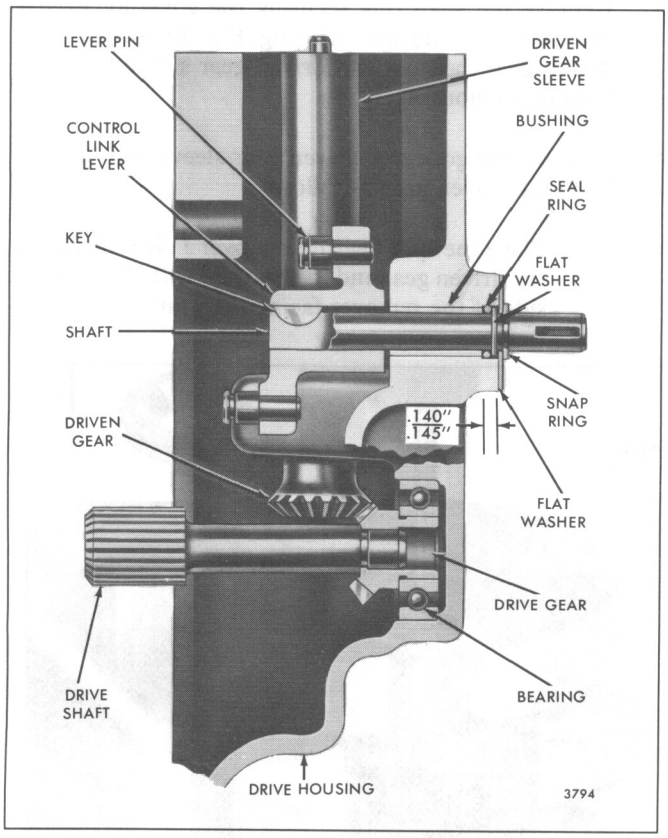


Fig. 1 – Governor Drive Assembly

Lubrication

The gears and bearings of the governor drive assembly are lubricated by surplus oil from the governor, which spills over the moving parts. The oil then returns to the engine crankcase through drilled passages in the blower end plate and cylinder block.

The rod end bearings of the vertical link assembly are lubricated with grease through the fittings provided.

Remove Governor Drive

If the governor fails to control the engine speed properly, the fault may lie in the governor drive. To function properly, there must be approximately .001" to .003" clearance between the governor drive and driven gears.

Remove the governor drive assembly, if necessary, as follows:

1. Disconnect the throttle control linkage to the governor speed control lever.

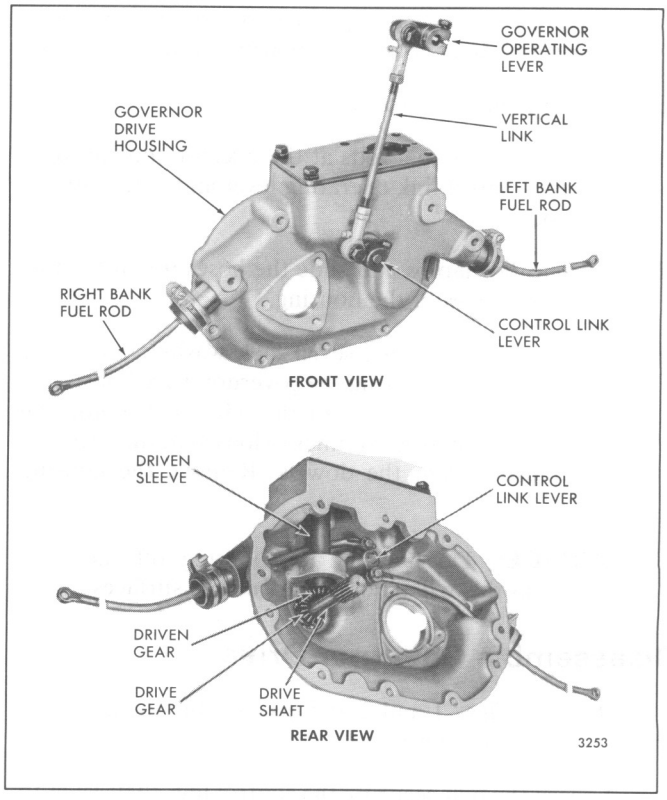


Fig. 2 – Hydraulic Governor Drive

2. Remove the bolts and lock washers that attach the vertical link assembly to the governor operating lever and the control link operating lever. Remove the link assembly.

3. If the engine is equipped with a governor oil reservoir, disconnect and remove the oil inlet, outlet and return tubes from the reservoir, governor and drive housing. Then remove the oil reservoir from the drive housing.

4. If equipped with a governor operating solenoid, disconnect and remove the oil inlet and outlet tubes from the solenoid, governor and drive housing. Tag and remove the electrical wires from the top of the solenoid. Remove the solenoid from the drive housing.

5. If the governor is equipped with a synchronizing motor, tag and remove the electrical wires from the motor terminals.

6. Remove the four bolts and lock washers securing the governor to the governor drive housing. Lift the governor from the drive housing cover and remove the governor gasket.

7. Remove the housing cover and gasket.

8. Drain the cooling system. Remove the water by–pass tube between the two thermostat housings.

9. Disconnect and remove the fuel oil inlet and outlet pipes from the fuel pump, then remove the fuel pump, gasket and drive coupling fork from the drive housing.

10. Remove the valve rocker covers.

11. Disconnect the fuel rods at the injector control tubes and the control link operating lever and withdraw the fuel rods.

12. Loosen the clamps and slide the hoses up on the fuel rod cover tubes of the housing.

13. Remove the ten bolts, seven lock washers and three copper washers securing the governor drive housing to the blower end plate. Tap the edge of the housing lightly with a plastic hammer to loosen it, then remove the housing from the dowels. Remove the housing gasket.

NOTICE: Do not pry the housing off the dowels as this will damage the finished surfaces.

Disassemble Governor Drive

Refer to Figs. 1 and 2 and disassemble the governor drive assembly as follows:

1. Loosen the bolt securing the control link shaft lever to the shaft, then remove the lever and key from the shaft.

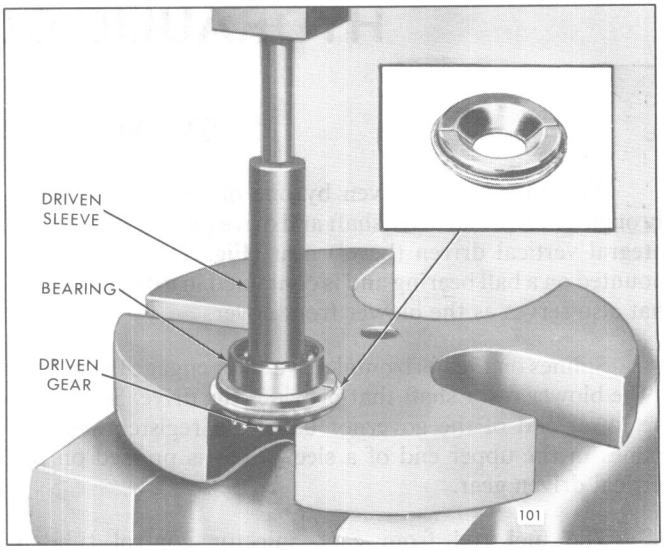


Fig. 3 – Removing Driven Sleeve and Bearing from Driven Gear

2. Remove the snap ring and flat washer that retains the control link lever and shaft assembly in the drive housing, then pull the lever and shaft assembly from the housing. Remove the small flat washer and seal ring from the bushing bore in the housing.

3. Remove the snap ring securing the governor driven gear bearing in the drive housing (Fig. 6), then pull the driven gear, bearing and driven gear sleeve from the bore in the housing.

4. Remove the governor driven gear sleeve and bearing from the driven gear as follows:

   a. Place the split bearing remover J 4685 between the driven gear and the bearing, with the beveled side of the remover facing the gear.

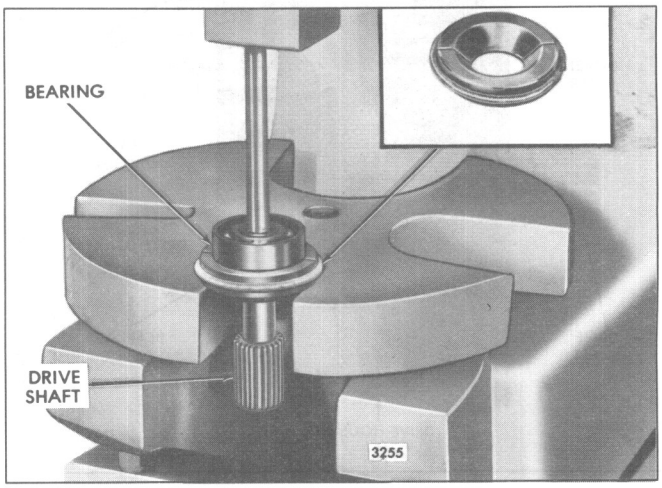


Fig. 4 – Removing Bearing from Drive Gear

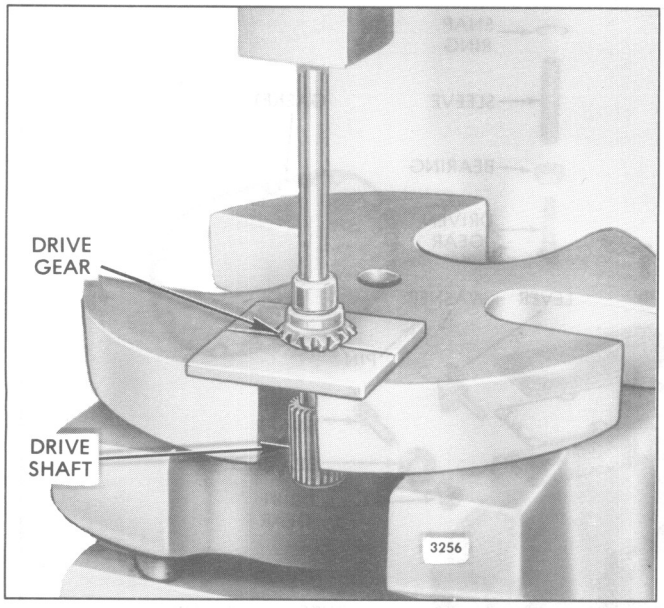


Fig. 5 – Removing Drive Gear from Drive Shaft

b. Support the driven gear assembly and remover on the bed of an arbor press (Fig. 3). Place a brass rod inside the sleeve against the end of the driven gear, then press the driven gear from the sleeve and bearing. Catch the driven gear by hand when pressed from the bearing.

5. Remove the governor drive gear, drive shaft and bearing assembly by pulling it straight out of the bore in the housing.

6. Remove the governor drive gear shaft bearing and drive gear from the drive shaft as follows:

   a. Place the split bearing remover J 4685 between the drive gear and the bearing, with the beveled side of the remover facing the gear.

   b. Support the drive gear assembly and remover on the bed of an arbor press (Fig. 4). Place a brass rod on the end of the drive shaft, then press the drive gear and shaft assembly from the bearing. Catch the drive gear and shaft by hand when pressed from the bearing.

   c. Place two split brass plates beneath the teeth of the drive gear, then support the assembly on the bed of an arbor press (Fig. 5). Place a brass rod on the end of the drive shaft, then press the drive shaft from the drive gear.

Inspection

Wash 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.

Inspect the teeth of the drive and driven bevel gears for chipping, scoring or wear. Remove any slight score marks with a stone. If the teeth are severely scored or worn, replace the gears.

Examine the drive shaft and the driven shaft sleeve for worn splines. Also check the mating parts for wear.

Check each ball bearing for indications of corrosion or pitting. Lubricate the bearing with light engine oil. Then, while holding the inner race, revolve the outer race slowly by hand. Any rough spot in the bearing is sufficient cause for rejection.

Inspect the control link operating shaft and its bushing in the governor drive housing for wear. If a new bushing is to be installed, press it in the drive housing so it will be .140" to .145" below the outside face of the housing to provide space for the seal ring (Fig. 1).

Examine the fuel rod cover hoses for damage. Replace them if necessary.

Check the fuel rod pins in the control link lever for wear and scoring.

Replace all of the governor drive parts that are excessively worn or damaged.

Assemble Governor Drive

Refer to Figs. 1 and 6 for the location of the various parts and assemble the governor drive as outlined below:

1. Install the governor drive shaft bearing and drive gear on the drive shaft as follows:

   a. Lubricate the drive shaft bearing with engine oil, then start the bearing, numbered side up, straight on the end of the drive gear.

   b. Place the beveled end of the drive gear on the bearing installer J 4683 and place the assembly on the bed of an arbor press as shown in Fig. 7. Then place a sleeve on the inner race of the bearing and press the bearing tight against the shoulder on the drive gear.

   c. Lubricate the small end of the governor drive shaft with engine oil, then start the drive gear straight on the shaft with the gear teeth facing the splined end of the shaft.

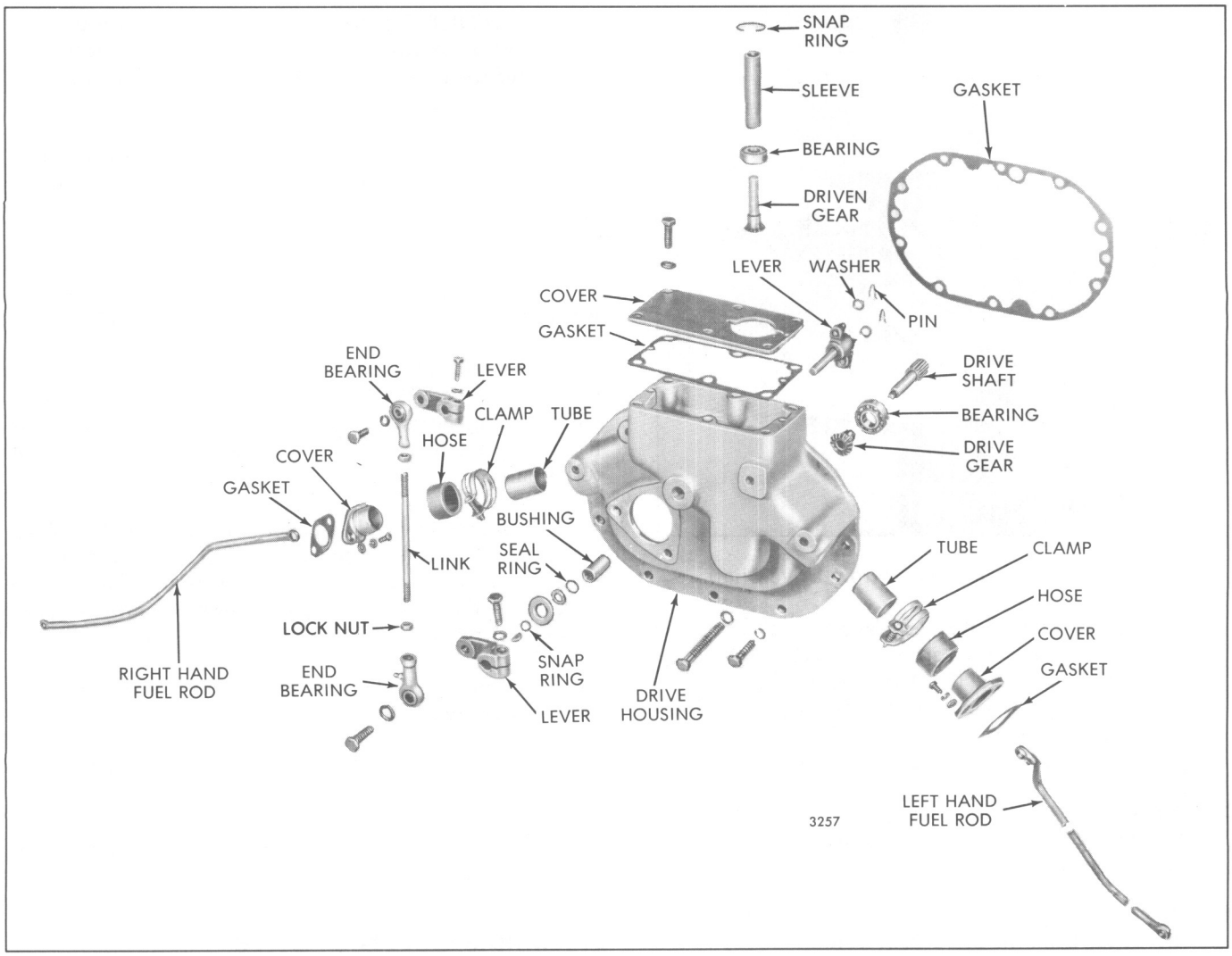


Fig. 6 – Details of Hydraulic Governor Drive and Relative Location of Parts

d. Place the drive shaft, gear and bearing assembly on the bed of an arbor press with the bearing and gear end up (Fig. 8). Then place a sleeve or a round brass bar on the inner race of the bearing and press the drive gear tight against the shoulder on the shaft.

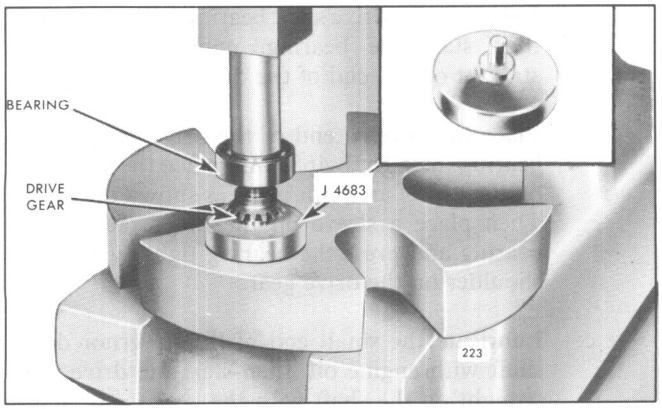


Fig. 7 – Installing Bearing on Drive Gear

2. Lubricate the governor drive shaft bearing with engine oil, then insert the drive shaft, drive gear and bearing assembly straight into the bearing bore in the drive housing (Fig. 1).

3. Install the governor driven gear bearing and sleeve on the driven gear as follows:

   a. Lubricate the driven gear bearing with engine oil, then start the bearing, numbered end up, straight on the driven gear.

   b. Lubricate the inside diameter of the driven gear sleeve with engine oil, then start the sleeve, splined end up, straight on the end of the driven gear.

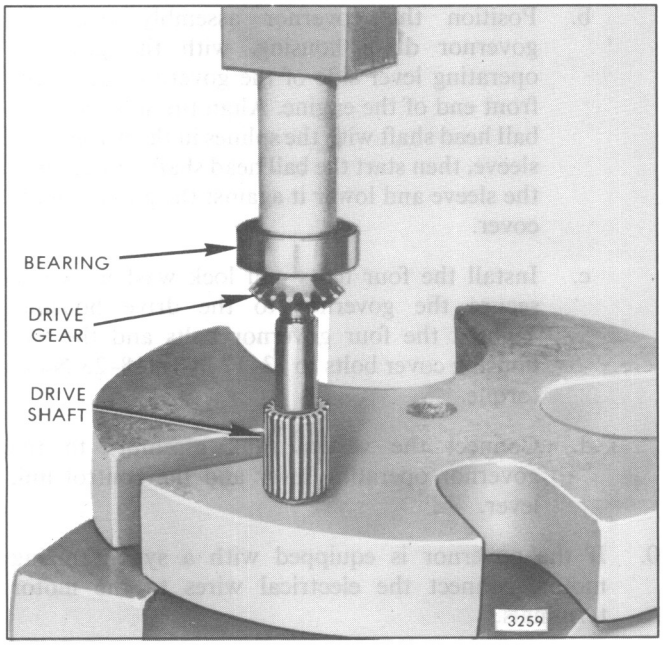


Fig. 8 – Installing Drive Gear and Bearing on Drive Shaft

c. Place the driven gear, bearing and sleeve assembly on the bed of an arbor press, with a spacer under the gear (Fig. 9) to support the gear teeth above the bed of the press. Then press the sleeve and bearing tight against the shoulder on the driven gear.

4. Lubricate the driven gear bearing with engine oil, then insert the driven gear, bearing and sleeve assembly through the top of the drive housing and start the bearing straight into the bearing bore in the housing. Push the driven gear assembly down in the housing until the teeth of the driven gear mesh with the drive gear (if necessary, rotate one of the gears slightly to align the gear teeth) and the bearing rests on the shoulder in the housing.

5. Install the snap ring in the groove in the housing next to the bearing.

6. Rotate the drive and driven gears and check for freeness and clearance between the gear teeth. The clearance should be .001" to .003".

7. Install the governor control link lever and shaft assembly in the drive housing as follows:

   a. Lubricate the control link lever shaft with engine oil, then slide the shaft through the bushing from the inner side of the housing (Fig. 1).

   b. Place a new seal ring over the shaft and slide it into the housing against the bushing, then place the small flat washer over the shaft and slide it in against the seal ring. Place the large flat washer

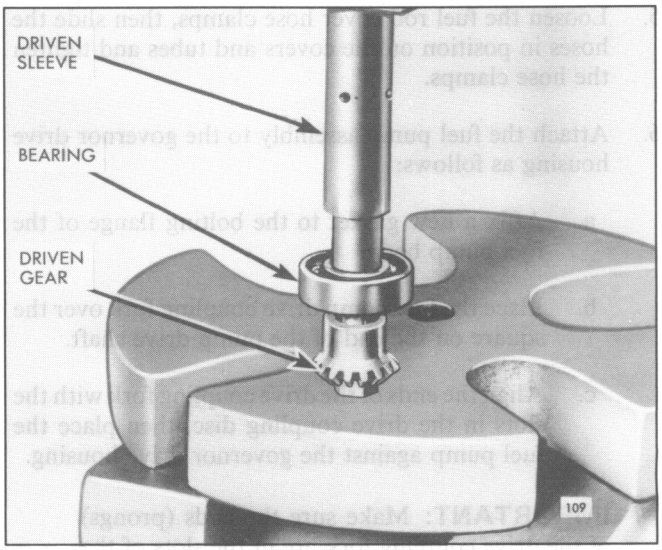


Fig. 9 – Installing Bearing and Driven Sleeve on Driven Gear

over the shaft and slide it against the housing, then install the snap ring in the groove in the shaft.

c. Install the Woodruff key in the keyway in the shaft, then slide the control link shaft lever over the shaft and key and secure it in place with a bolt and lock washer.

Install Governor Drive

After the governor drive is assembled, attach it to the blower, then attach the governor to the drive housing as outlined below:

1. Place a fuel rod cover hose and clamp on each of the fuel rod tubes in the drive housing, then tighten the hose clamp screws to retain the clamps on the hoses.

2. Affix a new gasket to the blower end plate. Then, with the splines of the governor drive shaft and the blower rotor shaft in alignment, insert the drive shaft into the rotor shaft and slide the drive housing on the dowels and against the gasket.

3. Install the ten bolts, seven lock washers and three copper washers which secure the drive housing to the blower end plate. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

   NOTICE: The three copper washers are used on the three long bolts which are exposed to the oil inside the drive housing.

4. Insert the fuel rods through the opening in the top of the drive housing, then connect them to their injector control tube levers and to the control link lever inside the housing.

5. Loosen the fuel rod cover hose clamps, then slide the hoses in position on the covers and tubes and tighten the hose clamps.

6. Attach the fuel pump assembly to the governor drive housing as follows:

   a. Affix a new gasket to the bolting flange of the fuel pump body.

   b. Place the fuel pump drive coupling fork over the square on the end of the pump drive shaft.

   c. Align the ends of the drive coupling fork with the slots in the drive coupling disc, then place the fuel pump against the governor drive housing.

   IMPORTANT: Make sure the ends (prongs) of the drive coupling fork are in the slots of the drive disc before installing and tightening the attaching bolts.

   d. Install the three bolt and seal assemblies and tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

7. Connect the fuel oil inlet and outlet pipes to the fuel pump.

8. Affix a new gasket to the top face of the governor drive housing, then place the housing cover on top of the gasket with the governor opening in the cover over the governor driven gear sleeve. Install two bolts and lock washers in the end holes, opposite the governor opening. Do not tighten the bolts at this time.

9. Attach the governor assembly to the drive housing as follows:

   a. Affix a new governor gasket to the top face of the housing cover.

   b. Position the governor assembly over the governor drive housing, with the governor operating lever side of the governor facing the front end of the engine. Align the splines of the ball head shaft with the splines in the driven gear sleeve, then start the ball head shaft straight into the sleeve and lower it against the gasket on the cover.

   c. Install the four bolts and lock washers which secure the governor to the drive housing. Tighten the four governor bolts and the two housing cover bolts to 13–17 lb–ft (18–23 N•m) torque.

   d. Connect the vertical link assembly to the governor operating lever and the control link lever.

10. If the governor is equipped with a synchronizing motor, connect the electrical wires to the motor terminals.

11. If a governor operating solenoid is used, attach the solenoid to the drive housing, then connect the oil inlet and outlet tubes to the solenoid, governor and drive housing. Also connect the electrical wires to the solenoid terminals.

12. If an oil reservoir is used, attach the reservoir to the drive housing, then connect the oil inlet, outlet and return tubes to the oil reservoir, governor and drive housing.

13. Connect the throttle control linkage to the speed control lever.

14. Lubricate the governor control linkage end bearings with grease through the fittings provided.

15. If drained, refill the cooling system.

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

GOVERNOR DRIVE FOR 12V AND 16V–92 ENGINE

The governor is driven by one of the blower rotors through a horizontal drive shaft and drive (bevel) gear and an integral driven (bevel) gear (Fig. 10). Each gear is mounted on a ball bearing and is contained in a drive housing that also serves as a front cover for the rear blower.

Splines on the horizontal drive shaft engage the splines in the blower rotor shaft that provides the drive. Splines on the lower end of the governor ball head register with the splines in the upper end of a sleeve that is pressed on the vertical driven gear.

The fuel rod from each injector control tube is connected to a pair of control link levers. One is enclosed in the governor drive housing (front cover of rear blower) and the other is enclosed in the governor control housing (rear cover of front blower).

The shafts of the two control link levers (Fig. 10) are connected together by means of a common lever and cap assembly.

The variable speed hydraulic governor is connected to the fuel rods by a vertical link attached to a common lever and cap assembly and the operating lever on the governor terminal lever shaft.

Naturally aspirated engine drive assembly includes a reduction gear assembly.

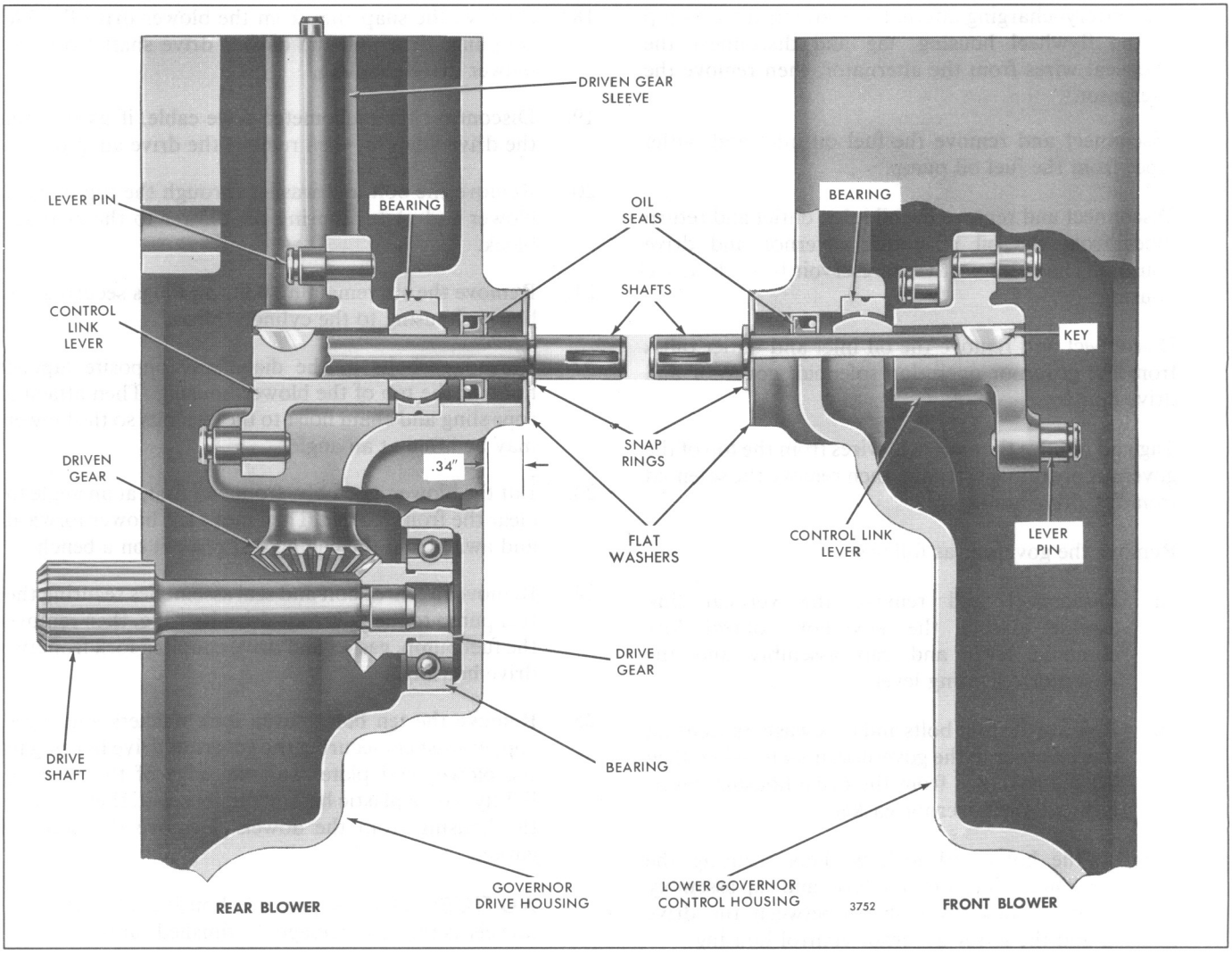


Fig. 10 – Governor Drive and Control Housing Assembly

Lubrication

The gears and bearings of the governor drive assembly are lubricated by surplus oil from the governor, which spills over the moving parts. The oil then returns to the engine crankcase through drilled passages in the blower end plate and cylinder block.

The rod end bearings of the external vertical link assembly are lubricated with grease through the fittings provided.

Remove Governor Drive

If the governor fails to control the engine speed properly, the fault may lie in the governor drive.

To function properly, there must be approximately .001" to .003" clearance between the governor drive bevel gears.

Due to the clearance between the front and rear blower assemblies, it will be necessary to remove one of the blowers in order to remove the governor drive housing or the governor control housing on the front blower.

Remove the governor drive assembly, if necessary, as follows:

1. Disconnect the throttle control linkage to the governor speed control lever.

2. Remove the air inlet pipe between the air cleaner, or turbocharger, and the air shutdown housing on the rear blower.

3. Remove the air shutdown housing from the blower, then cover the top of the blower to prevent entry of foreign material.

4. If a battery–charging alternator is attached to the top of the flywheel housing, tag and disconnect the electrical wires from the alternator, then remove the alternator.

5. Disconnect and remove the fuel oil inlet and outlet pipes from the fuel oil pump.

6. Disconnect and remove the oil inlet, outlet and return tubes from the oil reservoir, governor and drive housing. Then remove the oil reservoir from the drive housing.

7. Disconnect and remove the oil inlet and outlet tubes from the governor operating solenoid, governor and drive housing.

8. Tag and remove the electrical wires from the top of the governor operating solenoid, then remove the solenoid from the drive housing.

9. Remove the governor as follows:

   a. Disconnect and remove the vertical link assembly from the governor control link common lever and cap assembly and the governor operating lever.

   b. Remove the four bolts and lock washers securing the governor to the governor drive housing, then lift the governor from the drive housing cover. Remove the governor gasket.

10. Remove the bolts and lock washers securing the governor control link common lever and cap assembly to the control link lever shafts between the drive housing and the lower governor control housing.

11. Remove the valve rocker covers from the rear of the engine.

12. Remove the governor drive housing cover and gasket from the top of the drive housing.

13. Disconnect the fuel rods at the injector control tube levers and the control link lever inside the governor drive housing, then withdraw the fuel rods.

14. Loosen the fuel rod hose clamps and slide the hoses up on the fuel rod cover tubes in the drive housing.

15. Disconnect the blower oil pressure tube from the fitting in the blower drive support, then slide the tube forward into the blower end plate.

16. Loosen the hose clamp on the blower drive support to blower seal.

17. Remove the flywheel housing cover in back of the blower drive support.

18. Remove the snap ring from the blower drive flexible coupling, then pull the blower drive shaft from the blower drive coupling.

19. Disconnect the tachometer drive cable, if used, from the drive adaptor, then remove the drive adaptor.

20. Remove the bolt and washer through the top of each blower end plate securing the blower to the cylinder block.

21. Remove the six remaining bolts and lugs securing the blower housing to the cylinder block.

22. Thread eyebolts in the diagonally opposite tapped holes in the top of the blower housing. Then attach a rope sling and chain hoist to the eyebolts so the blower may be lifted at an angle.

23. Lift the blower assembly, front end first, at an angle to clear the front blower. Then move the blower forward and away from the engine and place it on a bench.

24. Remove the three bolt and seal assemblies securing the fuel pump to the governor drive housing, then remove the fuel pump, gasket and drive coupling fork from the drive housing.

25. Remove the ten bolts, seven lock washers and three copper washers securing the governor drive housing to the blower end plate. Tap the edge of the housing lightly with a plastic hammer to loosen it, then remove the housing from the dowels. Remove the housing gasket.

    NOTICE: Do not pry the housing off the dowels as this will damage the finished surfaces.

26. If necessary, the governor control housing may be removed from the engine front blower, at this time, by following the procedure outlined in steps 11, 12, 13, 14 and 25 above.

    NOTICE: The cover must be removed from the governor control housing in order to disconnect the fuel rods from the control link lever in the housing.

Disassemble Governor Drive

Refer to Figs. 10 and 15 and disassemble the governor drive assembly as follows:

1. Remove the Woodruff key from the keyway of the governor control link lever shaft.

2. Remove the snap ring and flat washer that retains the control link lever, shaft and bearing assembly in the drive housing, then remove the lever, shaft and bearing assembly from the housing.

NOTICE: The two governor control link lever, shaft and bearing assemblies in the governor drive housing and governor control housing are identical, except for the location of the keyway in the outer end of the shaft. If both control link lever, shaft and bearing assemblies are to be removed, be sure and tag one or both of the lever assemblies so they may be reinstalled in their respective housings.

3. If necessary, remove the control link lever shaft bearing from the shaft as follows:

   a. Support the inner end of the control link lever on a sleeve, on the bed of an arbor press, then press the shaft approximately 1/4 inch out of the lower end of the lever.

   b. Support the opposite end of the lever, next to the bearing, on the bed of an arbor press. Do not put the support under the bearing. Then press the shaft back in flush with the end of the lever.

   NOTICE: This will leave approximately 1/4 inch space between the bearing and the lever.

   c. Place two split plates between the bearing and the lever, then support the split plates, lever, shaft and bearing assembly on the bed of an arbor press as shown in Fig. 11. Press the shaft from the bearing.

   NOTICE: The hole in the split plates should be the same diameter as the shaft so the inner race of the bearing will rest on the plates when in place.

   d. If necessary, the control link lever shaft may be pressed from the control link lever.

4. Inspect the control link lever shaft oil seal for wear and damage. If necessary, the oil seal may be replaced in the governor drive housing without removing the drive and driven gear assemblies. Replace the oil seal as follows:

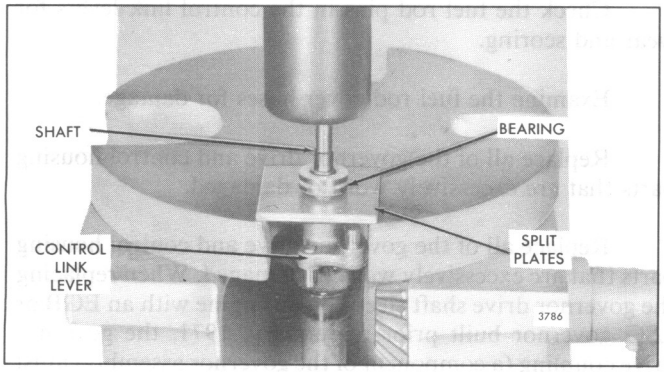


Fig. 11 – Removing Bearing from Control Link Lever Shaft

   a. Support the inner face of the drive housing on two wood blocks approximately 2" thick. Then place a short piece of 3/4" round bar stock on top of the oil seal and tap it out of the housing with a hammer.

   b. Apply a thin coat of sealing compound to the outside diameter of the new oil seal casing, then start the oil seal with the lip of the seal facing down, straight into the bore in the housing.

   c. Support the inner face of the drive housing on two wood blocks on the bed of an arbor press. Place the 3/4" round bar stock on top of the oil seal and under the ram of the press, then press the oil seal into the housing until it is .340" below the outer face of the housing (Fig. 10).

5. Remove the snap ring securing the governor driven gear bearing in the drive housing, then pull the driven gear, bearing and driven gear sleeve from the bore in the housing.

6. Remove the governor driven gear sleeve and bearing from the driven gear as follows:

   a. Place the split bearing remover J 4685 between the driven gear and the bearing, with the beveled side of the remover facing the gear.

   b. Support the driven gear assembly and remover on the bed of an arbor press (Fig. 12). Place a brass rod inside the sleeve, against the end of the driven gear, then press the driven gear from the sleeve and bearing. Catch the driven gear by hand when pressed from the bearing.

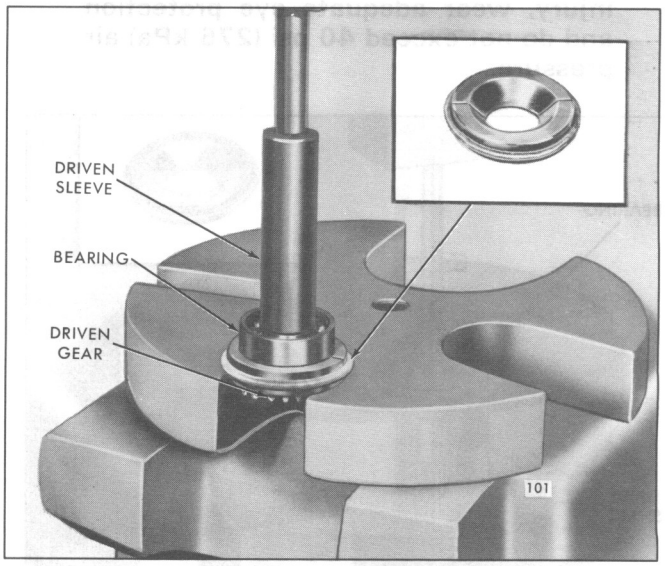


Fig. 12 – Removing Driven Sleeve and Bearing from Driven Gear

7. Remove the governor drive gear, drive shaft and bearing assembly by pulling it straight out of the bore in the housing.

8. Remove the governor drive shaft bearing and drive gear from the drive shaft as follows:

   a. Place the split bearing remover J 4685 between the drive gear and the bearing, with the beveled side of the remover facing the gear.

   b. Support the drive gear assembly and remover on the bed of an arbor press (Fig. 13). Place a brass rod on the end of the drive shaft, then press the drive gear and shaft assembly from the bearing. Catch the drive gear and shaft by hand when pressed from the bearing.

   c. Place two split brass plates beneath the teeth of the drive gear, then support the assembly on the bed of an arbor press (Fig. 14). Place a brass rod on the end of the drive shaft, then press the drive shaft from the drive gear. Catch the drive shaft by hand when pressed from the drive gear.

9. If necessary, the governor control link lever assembly and oil seal may be removed from the governor control housing and the bearing removed from the control link lever shaft by following the procedure outlined in Steps 1 through 4 above.

Inspection

Wash 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.

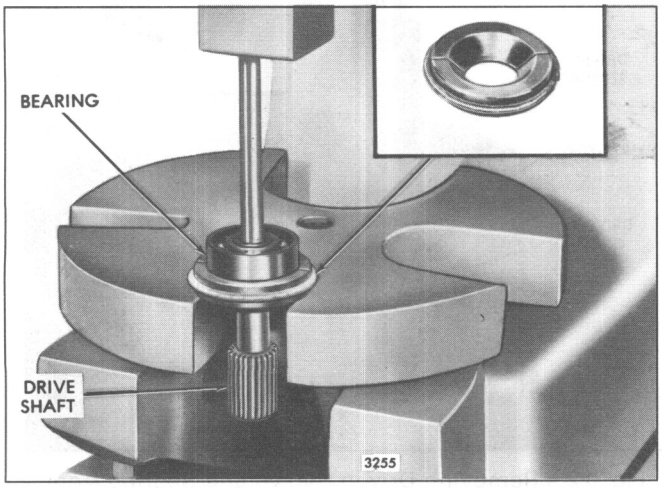


Fig. 13 – Removing Bearing from Drive Gear

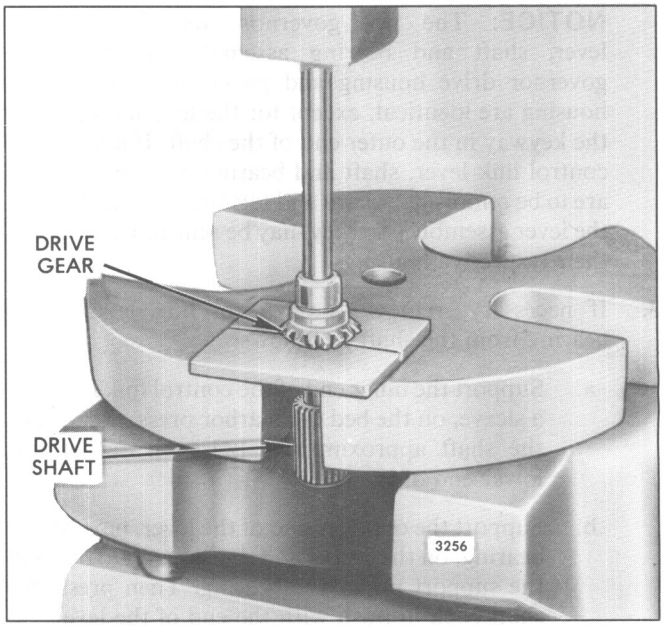


Fig. 14 – Removing Drive Gear from Drive Shaft

Inspect the teeth of the drive and driven bevel gears for chipping, scoring or wear. Remove any slight score marks with a stone. If the teeth are severely scored or worn, replace the gears.

Examine the drive shaft and the driven shaft sleeve for worn splines. Also, check the mating parts for wear.

Check each ball bearing for indications of corrosion or pitting. Lubricate the bearing with light engine oil. Then, while holding the inner race, revolve the outer race slowly by hand. Any rough spot in the bearing is sufficient cause for rejection.

Check the control link lever shaft and vertical link spherical bearings for free movement on their inner race. Also examine the control link lever shaft oil seals for wear, cracks or other damage.

Check the fuel rod pins in the control link levers for wear and scoring.

Examine the fuel rod cover hoses for damage.

Replace all of the governor drive and control housing parts that are excessively worn or damaged.

Replace all of the governor drive and control housing parts that are excessively worn or damaged. When replacing the governor drive shaft sleeve on an engine with an EGB or LSG governor built prior to January, 1971, the governor drive coupling (a component of the governor assembly) must be removed. The current governor drive shaft sleeve is 1.290" longer than the former sleeve to offset the drive coupling.

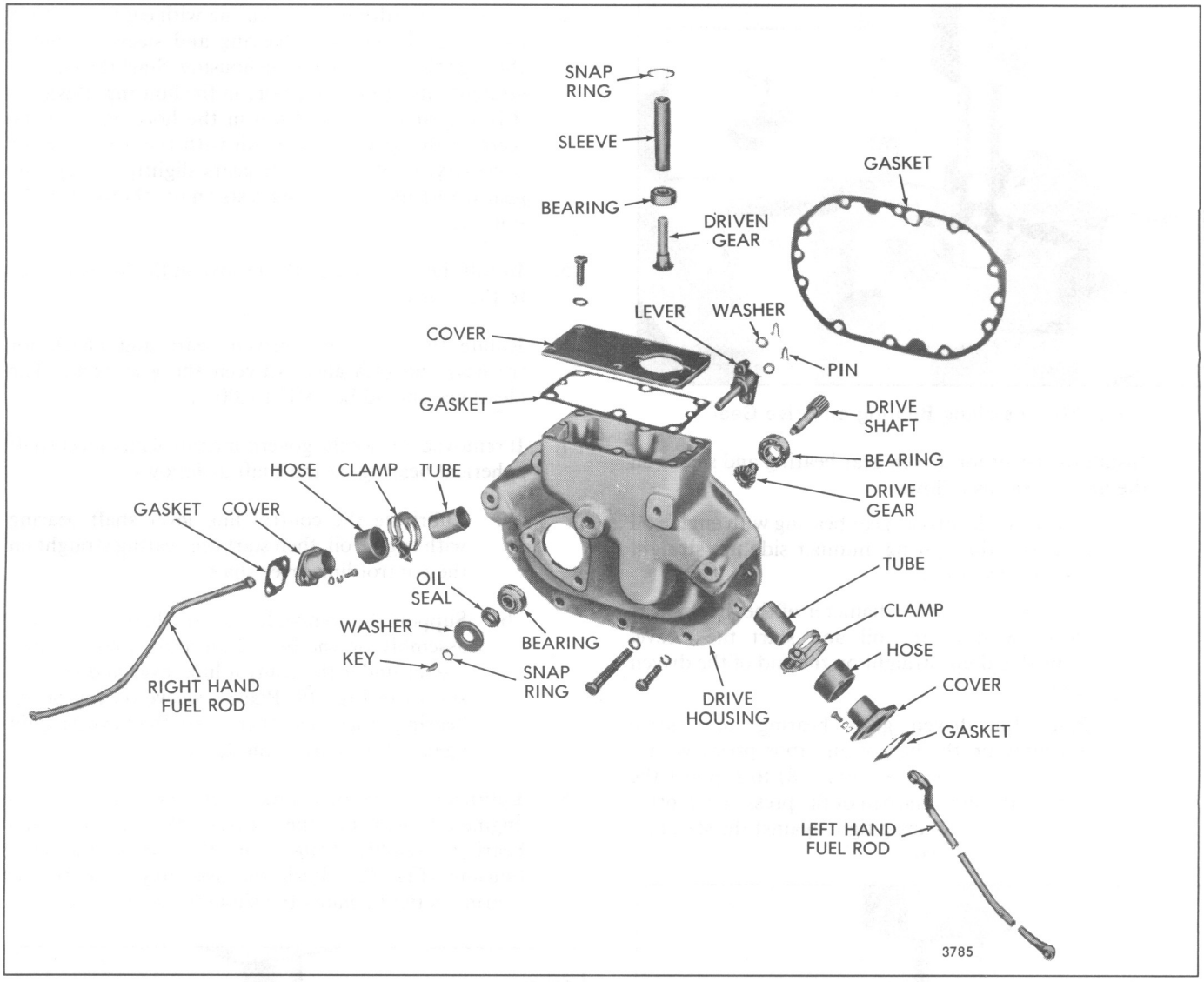


Fig. 15 – Details of Enclosed Linkage Type Hydraulic Governor Drive and Relative Location of Parts

Assemble Governor Drive

Refer to Figs. 10 and 15 for the location of the various parts and assemble the governor drive as outlined below:

1. Install the governor drive shaft bearing and drive gear on the drive shaft as follows:
   a. Lubricate the drive shaft bearing with engine oil and start the bearing, numbered side up, straight on the end of the drive gear.
   b. Place the beveled end of the drive gear on the bearing installer J 4683 and place the assembly on the bed of an arbor press as shown in Fig. 16. Then place a sleeve on the inner race of the bearing and press the bearing tight against the shoulder on the drive gear.
   c. Lubricate the small end of the governor drive shaft with engine oil, then start the drive gear straight on the shaft with the gear teeth facing the splined end of the shaft.
   d. Place the drive shaft, gear and bearing assembly on the bed of an arbor press, with the bearing and gear end up (Fig. 17). Then place a sleeve or a brass rod on the inner race of the bearing and press the drive gear tight against the shoulder on the shaft.
2. Lubricate the governor drive shaft bearing with engine oil, then insert the drive shaft, drive gear and bearing assembly straight into the bearing bore in the drive housing (Fig. 10).

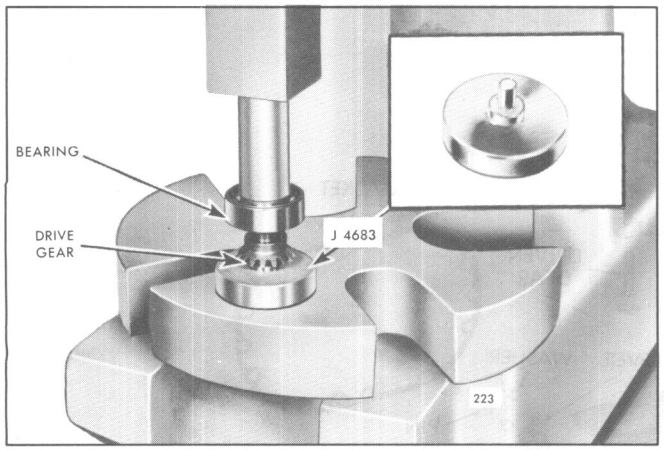


Fig. 16 – Installing Bearing on Drive Gear

3. Install the governor driven gear bearing and sleeve on the driven gear as follows:
   a. Lubricate the driven gear bearing with engine oil and start the bearing, number side up, straight on the driven gear.
   b. Lubricate the inside diameter of the driven gear sleeve with engine oil and start the sleeve, splined end up, straight on the end of the driven gear.
   c. Place the driven gear, bearing and sleeve assembly on the bed of an arbor press, with a spacer under the gear (Fig. 18) to support the gear teeth above the bed of the press. Then press the sleeve and bearing tight against the shoulder on the driven gear.

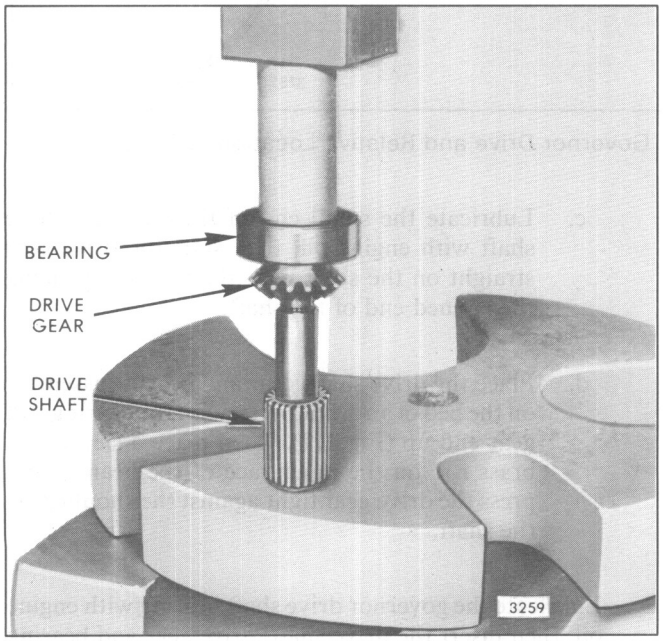


Fig. 17 – Installing Drive Gear and Bearing on Drive Shaft

4. Lubricate the driven gear bearing with engine oil, then insert the driven gear, bearing and sleeve assembly through the top of the drive housing. Start the bearing straight into the bearing bore in the housing. Push the driven gear assembly down in the housing until the teeth of the driven gear mesh with the drive gear (if necessary, rotate one of the gears slightly to align the gear teeth) and the bearing rests on the shoulder in the housing.

5. Install the snap ring in the groove in the housing next to the bearing.

6. Rotate the drive and driven gears and check for freeness and clearance between the gear teeth. The clearance should be .001" to .003".

7. If removed, install the governor control link lever shaft spherical bearing on the shaft as follows:
   a. Lubricate the control link lever shaft bearing with engine oil, then start the bearing straight on the control link lever shaft.
   b. Support the control link lever, shaft and bearing assembly on the bed of an arbor press, with a spacer under the control link lever and shaft as shown in Fig. 19. Place a sleeve on top of the bearing inner race, then press the bearing tight against the control link lever.

8. Lubricate the control link lever shaft bearing with engine oil, then start the control link lever, shaft and bearing assembly straight into the bore in the drive housing (Fig. 10). Push the assembly in until the bearing is tight against the shoulder in the housing.

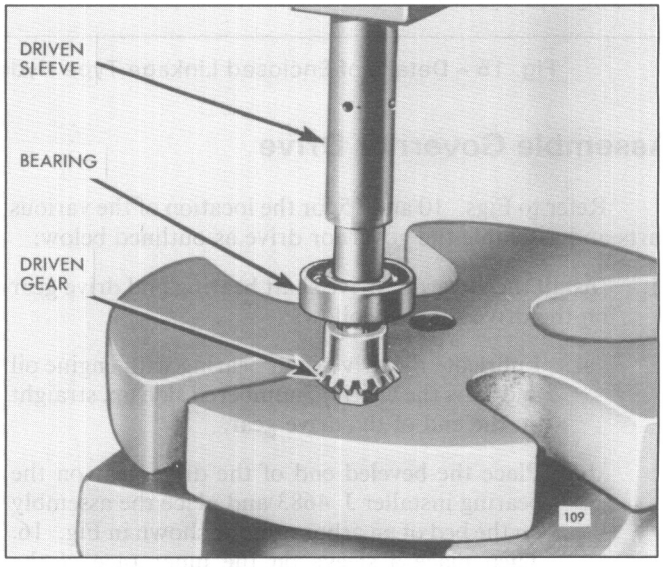


Fig. 18 – Installing Bearing and Driven Sleeve on Driven Gear

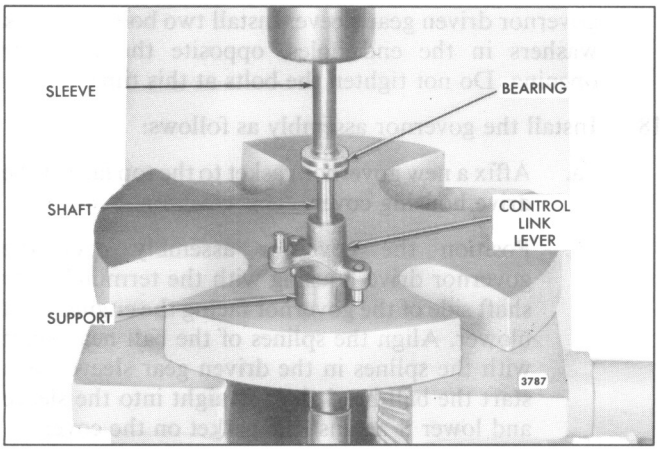


Fig. 19 – Installing Bearing on Governor Control Link Lever Shaft

Be sure to install the proper control link lever, shaft and bearing assembly in the governor drive housing. Refer to Fig. 10 and **NOTE** in Step 2 under *Disassemble Governor Drive.* When the control link lever, shaft and bearing assemblies are correctly installed, the keyway in the outer end of each shaft will face the right–hand side of the engine, as viewed from the rear, when the blower assemblies are attached to the cylinder block.

9. Install the governor control link lever shaft oil seal in the governor drive housing as follows:

   a. Wrap a thin layer of cellulose tape over the snap ring groove and keyway in the outer end of the control link lever shaft to protect the oil seal lip.

   b. Support the governor drive housing on the bed of an arbor press, with a spacer under the end of the control link lever to prevent the bearing from slipping out of the housing (Fig. 20).

   c. Apply a thin coat of sealing compound on the outside diameter of the new oil seal casing, then place the oil seal, with the lip of the seal facing down, over the end of the shaft and start it straight into the bore in the housing. Be careful not to damage the oil seal lip.

   d. Place a 23/32" outside diameter sleeve over the end of the shaft and rest it on top of the seal, then press the oil seal into the housing until it is .340" below the outer face of the housing (Fig. 10).

   e. Remove the tape from the shaft, then place the flat washer over the shaft against the housing and install the snap ring in the groove in the shaft. Install the Woodruff key in the keyway in the shaft.

Install Governor Drive

After the governor drive is assembled, it may be attached to the rear blower, the blower assembly installed on the cylinder block, and the governor attached to the drive housing by following the procedure outlined below:

1. Affix a new gasket to the rear blower front end plate. Then, with the splines of the governor drive shaft and the blower rotor shaft in alignment, insert the drive shaft into the rotor shaft and slide the drive housing on the dowels.

2. Install the ten bolts, seven lock washers and three copper washers which secure the drive housing to the blower end plate. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

   NOTICE: The three copper washers are used on the three long bolts which are exposed to the oil inside the drive housing.

3. Attach the fuel pump assembly to the governor drive housing as follows:

   a. Affix a new gasket to the bolting flange of the fuel pump body.

   b. Place the fuel pump drive coupling fork over the square on the end of the pump drive shaft.

   c. Align the ends of the drive coupling fork with the slots in the drive coupling disc, then place the fuel pump against the governor drive housing with the openings in the fuel pump inlet and outlet elbows facing up.

Make sure the ends (prongs) of the drive coupling fork are in the slots of the drive disc before installing and tightening the attaching bolts.

   d. Install the three bolt and seal assemblies and tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

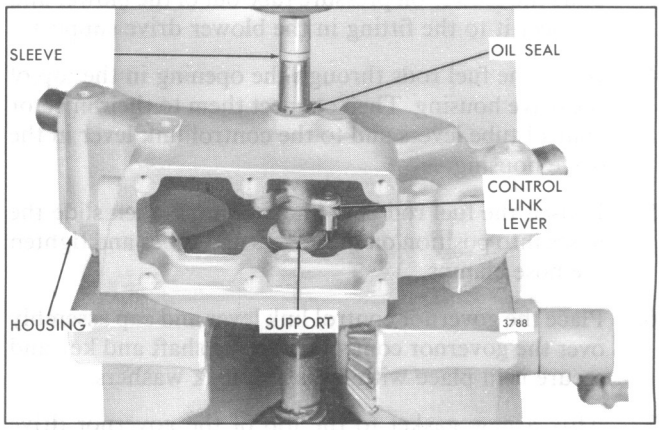


Fig. 20 – Installing Control Link Lever Shaft Oil Seal in Governor Drive

4. Place a hose and clamp on each of the fuel rod tubes in the governor drive housing, then tighten the clamp screws to retain the clamps on the hoses.

5. Affix a new blower housing gasket to the top of the cylinder block. Use a good grade of non–hardening cement to prevent the gasket from shifting when the blower is installed.

6. Thread eyebolts in diagonally opposite tapped holes in the top of the blower housing. Then attach a rope sling and chain hoist to the eyebolts so the blower may be lifted at an angle.

7. Lift the blower assembly, front end first, at an angle and position it over the top of the cylinder block. Lower the blower and start the blower seal on the rear blower end plate cover over the blower drive support. Then move the blower back and lower it against the gasket on the cylinder block.

8. Secure the blower to the cylinder block with bolts, retaining lugs and flat washers and tighten the blower side angle bolts uniformly to 30–35 lb–ft (41–47 N•m) torque in 5 lb–ft (7 N•m) increments. Tighten the blower–to–block end plate bolts to 40–45 lb–ft (54–61 N•m) torque.

9. Attach the tachometer drive adaptor, if used, to the blower, then connect the tachometer drive cable to the drive adaptor.

10. Insert the blower drive shaft through the blower drive flexible coupling and into the blower drive coupling. Then install the snap ring in blower drive flexible coupling.

11. Affix a new gasket to the flywheel housing cover, then attach the cover to the flywheel housing with bolts and lock washers.

12. Place the lower seal clamp in position on the seal and tighten the clamp screw.

13. Slide the blower oil pressure tube out of the blower and connect it to the fitting in the blower drive support.

14. Insert the fuel rods through the opening in the top of the drive housing. Then connect them to their injector control tube levers and to the control link lever in the drive housing.

15. Loosen the fuel rod cover hose clamps, then slide the hoses into position on the covers and tubes and tighten the hose clamps.

16. Place the governor control link lever and cap assembly over the governor control link lever shaft and key and secure it in place with bolts and lock washers.

17. Affix a new gasket to the top of the governor drive housing, then place the housing cover on top of the gasket with the governor opening in the cover over the governor driven gear sleeve. Install two bolts and lock washers in the end holes, opposite the governor opening. Do not tighten the bolts at this time.

18. Install the governor assembly as follows:

    a. Affix a new governor gasket to the top face of the drive housing cover.

    b. Position the governor assembly over the governor drive housing with the terminal lever shaft side of the governor facing the engine front blower. Align the splines of the ball head shaft with the splines in the driven gear sleeve, then start the ball head shaft straight into the sleeve and lower it against the gasket on the cover.

    c. Install the four bolts and lock washers which secure the governor assembly to the drive housing cover. Tighten the bolts to 13–17 lb–ft (18–23 N•m) torque.

    d. If removed, install the governor operating lever on the terminal lever shaft, then connect the vertical control link assembly to the operating lever and the governor control link common lever and cap assembly.

19. Attach the governor operating solenoid to the governor drive housing, then connect the electrical wires to the solenoid terminals.

20. Connect the oil inlet and outlet tubes to the governor operating solenoid, governor and drive housing.

21. Attach the governor oil reservoir to the governor drive housing, then connect the oil inlet, outlet and return tubes to the oil reservoir, governor and drive housing.

22. Connect the fuel oil inlet and outlet pipes to the fuel oil pump.

23. Attach the battery charging alternator to the engine flywheel housing, then connect the electrical wires to the alternator.

24. Attach the air shutdown housing to the top of the blower.

25. On industrial units, install the air inlet pipe between the air cleaner, or turbocharger, and the air shutdown housing on the rear blower.

26. On marine units, install the air inlet pipe between the air cleaner and the air shutdown housing on the rear blower.

27. Connect the throttle control linkage to the governor speed control lever.

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

Refer to Shop Notes (section 2.0) before installing a Barber–Coleman electronic governor on an engine previously equipped with a hydraulic governor.

HYDRAULIC GOVERNOR SYNCHRONIZING MOTOR

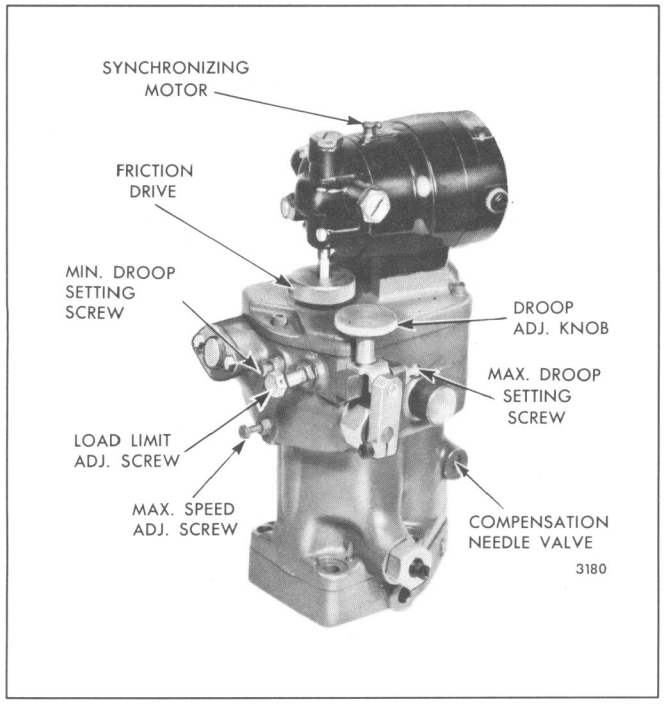


Fig. 1 – Synchronizing Motor Mounting

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 1). This motor, used in place of a vernier control knob, permits close adjustment of the engine speed from a remote control point. This feature is especially valuable when synchronizing two generators from a central control panel.

The motor is connected to the source of electrical supply through a two–way switch (Fig. 2).

The motor drive shaft and the governor speed adjusting lever are mechanically connected through a reduction gear on the motor and a friction drive.

Operation

The synchronizing motor is used to change the engine speed when the unit is running alone, or to adjust the load when the unit is operating in parallel with other units.

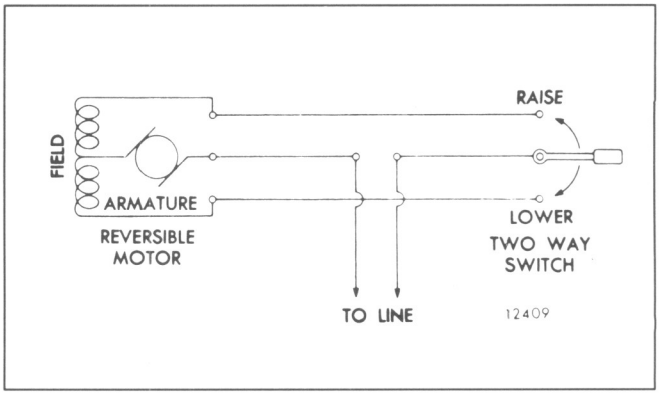


Fig. 2 – Synchronizing Motor Wiring Diagram

When the two–way control switch on the control panel is closed, the motor shaft turns the governor speed adjusting shaft by means of the reduction gear and friction drive. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated on a tachometer or frequency meter on the control panel, the switch is returned to the *off* position by the operator.

If the switch is held in the *lower* speed position too long, the synchronizing motor will continue to lower the engine speed until it ultimately shuts the engine down. If the switch is held too long in the *raise* speed position, the motor will turn the governor speed adjusting shaft until it strikes the maximum speed adjusting screw, after which the friction drive will slip and the motor will continue to run at a slightly reduced speed without further effect.

Service

The synchronizing motor is constructed to render long satisfactory service. However, if the motor is damaged or fails to operate, replace the entire motor as an assembly.

The spring washer of the friction drive must be strong enough to permit the motor to carry the speed adjusting lever up against the maximum speed adjusting screw without slipping, yet it must be loose enough to slip after the lever contacts the screw.

FUEL INJECTOR CONTROL TUBE

The fuel injector control tube assemblies are mounted on the left and right bank cylinder heads of an engine and consist of a control tube, injector rack control levers, a return spring and injector control tube lever mounted in two bracket and bearing assemblies attached to each cylinder head (Fig. 1).

The injector rack control levers connect with the fuel injector control racks and are held in position on the control tube with two adjusting screws. The return spring enables the rack levers to return to the no–fuel position. The injector control tube lever is pinned to the end of the control tube and connects with the fuel rod which connects with the engine governor. Refer to Section 14 for positioning of the injector rack control levers.

Certain engines use spring–loaded injector control tube assemblies (Fig. 2), similar to the above except they have a yield spring at each injector rack control lever and only one screw and lock nut to keep each injector rack properly positioned. This enables an engine to be brought to a lesser fuel position if there is an inoperative fuel injector rack whereas with the non–spring loaded two screw injector control tube this could not be done. The above, also permits the use of an air inlet housing with no emergency air shutoff valve as is required in some applications.

NOTICE: Do not replace the spring–loaded fuel injector control tube and lever assembly with the two screw design control tube assembly without including an air inlet housing that incorporates an emergency air shutoff valve. However, when the spring–loaded fuel injector control tube and lever assembly is installed on an engine and the emergency shutdown mechanism is removed from the air inlet housing, the shaft holes at each end of the housing must be plugged. Ream the shaft holes to .6290" and install a 5/8" cup plug at each end of the housing.

Engine shut down (normal or emergency) is accomplished on the spring–loaded fuel injector control tube (one screw design) by pulling the governor shutdown lever to the no–fuel position. With the two screw design injector control tube and lever assembly, emergency engine shut down is accomplished by tripping the air shutoff valve in the air inlet housing. Normal shut down is accomplished by pulling the governor shutdown lever to the no–fuel position. Adjustment of the single screw and locknut on each injector rack control lever can be performed the same as for the two screw design rack control lever as outlined in Section 14.

Remove Injector Control Tube

1. Remove the cotter pin and clevis pin connecting the fuel rod to the injector tube control lever.
2. Remove the two attaching bolts and lock washers at each bracket. Disengage the rack levers from the injector control racks and lift the control tube assembly from the cylinder head.

Disassemble Injector Control Tube

The injector control tube, one mounting bracket, a spacer and injector control tube lever are available as a service assembly. When any part of this assembly needs replacing, it is recommended the complete service assembly be replaced. Therefore, the disassembly and assembly procedure for these items is not included in the following:

1. Remove the bracket from the injector control tube.
2. Loosen the adjusting screws or adjusting screw and locknut at each injector rack control lever.
3. With the spring–loaded injector control tube, disconnect the yield springs at each rack lever, then roll the yield springs out of the slots and notch of the control tube.
4. Disconnect the return spring from the bracket and front or rear rack lever.
5. Then, remove the yield springs and/or return spring and rack levers from the control tube.

Inspection

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

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

Examine the control tube, control lever, control tube rack control levers and brackets for excessive wear, cracks or damage and replace them, if necessary. The bearing in the bracket is not serviced separately. Examine the yield springs and/or return spring and replace them if worn or fractured.

Assemble Injector Control Tube

With all of the parts cleaned and inspected and the necessary new parts on hand, refer to Fig. 1 or 2 and assemble as follows:

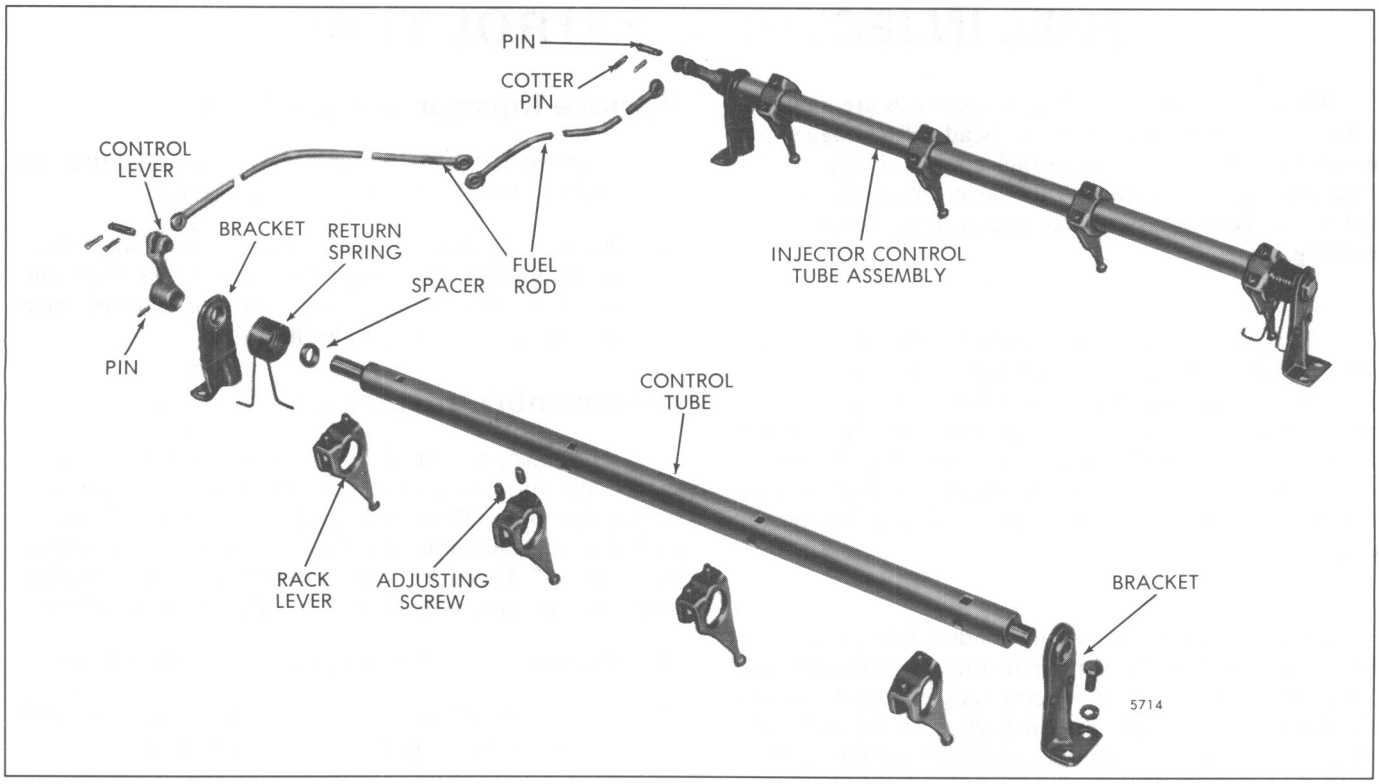


Fig. 1 – Injector Control Tube Assemblies (Non–Spring Loaded)

LEFT BANK CYLINDER HEAD

1. Install the return spring on the control tube and against the front bracket.

2. Two Screw design injector control tube:

   Install the rack control levers on the control tube, with the levers facing the rear bracket position, and turn the adjusting screws in far enough to position the levers on the control tube.

One Screw and Locknut design injector control tube:

   Install a rack control lever, with the lever facing the rear bracket position, and the odd (L. H. helix) yield spring. Then, install the R. H. helix yield springs and rack control levers with the levers facing the rear bracket.

   Attach the curled end of the yield springs to the rack control levers and roll the yield springs into the notch (odd spring) and slots (R. H. helix springs) in the control tube. Then, turn the adjusting screws and locknuts into the slots far enough to position the levers on the control tube.

3. On both designs, attach the curled end of the control tube return spring to the rack control lever and the extended end of the spring behind the front bracket.

4. On both designs, install the rear bracket on the end of the injector control tube.

RIGHT BANK CYLINDER HEAD

1. Two Screw design injector control tube:

   Install the rack control levers on the control tube, with the levers facing the front bracket position. Turn the adjusting screws into the slots in the control tube far enough to position the levers.

One Screw and Locknut design injector control tube:

   Install the rack control levers, with the levers facing the front bracket position and the R. H. helix yield springs. Then, install the odd (L. H. helix) yield spring and rack control lever, with the lever facing the front bracket position.

   Attach the curled end of the yield springs to the rack control levers and roll the springs into the notch (odd yield spring) and the slots (R. H. helix yield springs) in the control tube. Then, turn the adjusting screws and locknuts into the notch and slots far enough to position the levers on the control tube.

2. On both designs, install the control tube return spring and rear bracket on the control tube. Attach the curled end of the return spring to the rack control lever and the extended end of the spring behind the rear bracket.

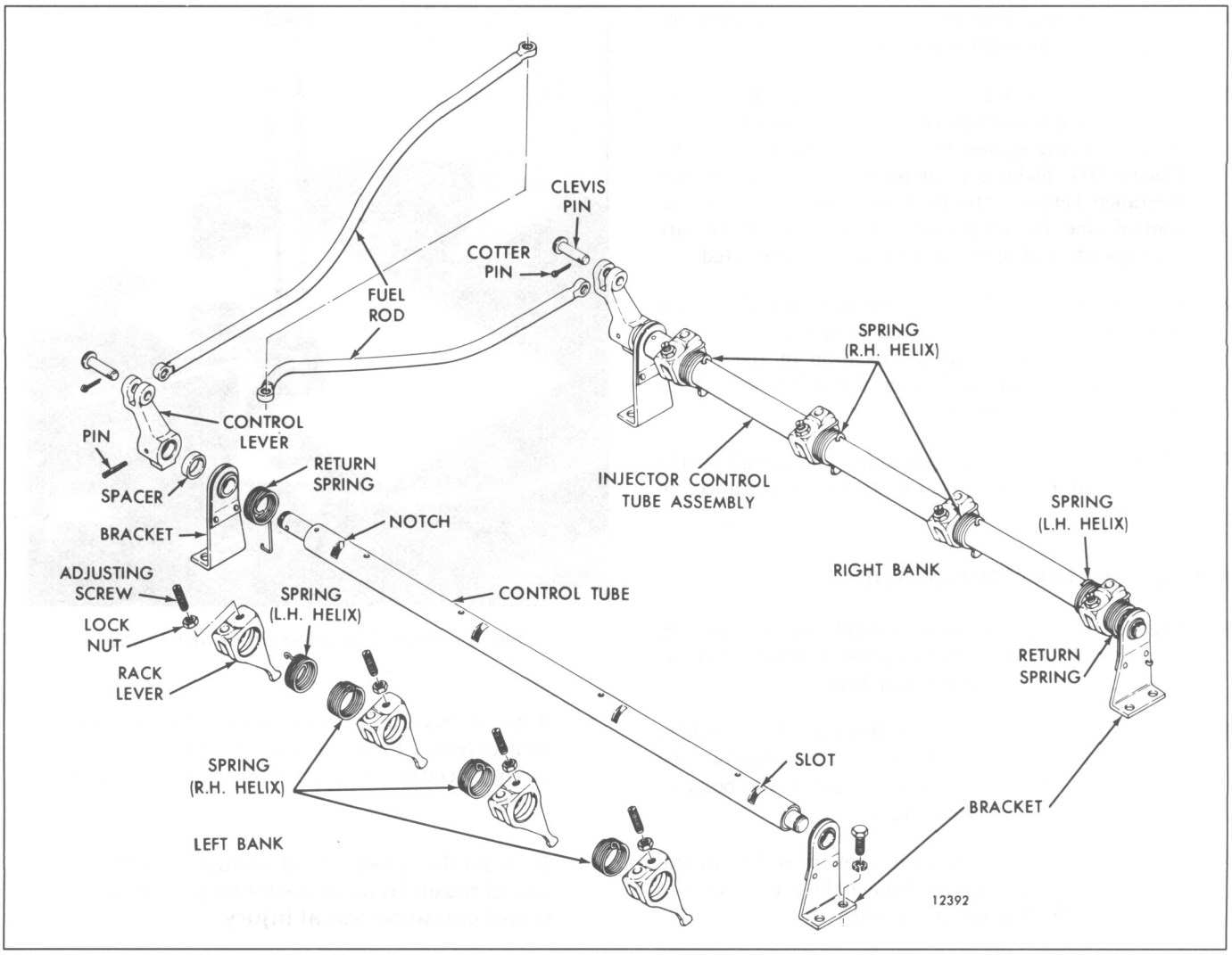


Fig. 2 – Injector Control Tube Assemblies (Spring–Loaded)

Indexing A New Replacement Control Lever To The Injector Control Tube

Use the following procedure to properly index and install a replacement control lever onto the injector control tube:

1. Remove the injector control tube from the engine. Then, loosen the adjusting screw for the rack lever closest to the control lever and slide the return spring and rack lever back 3 to 4 inches.
2. Fabricate an indexing bracket from a 5" long piece of 1/2" wide, 1/8" thick bar stock (Fig. 3). Secure the indexing bracket to the control tube with a hose clamp (Fig. 4).
3. Insert a 1/4" x 1–3/4" L. bolt through the end of the control lever. Rotate the bracket and clamp until the bracket is resting against the bolt. Tighten the clamp to hold the bracket securely against the bolt. Make sure the indexing bracket cannot be moved.

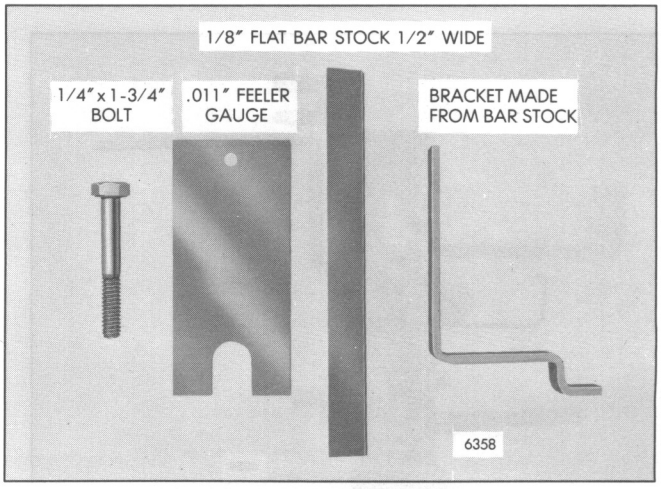


Fig. 3 – Fabricate Indexing Bracket

4. Remove the pin from the control lever and press the old lever off the control tube (Fig. 5).

5. Reinsert the 1/4" x 1–3/4" L. bolt through the end of a new lever and press the lever onto the control tube with the bolt resting against the indexing bracket (Fig. 6). Place a .011" feeler gage under the lever to get proper clearance between the lever and the spacer on the control tube. Before pressing on the lever, make sure the opposite end of the control tube is supported.

6. Position the control tube on the table of a drill press and drill a 1/8" hole through the control lever approximately 45° from the location of the former hole. (Use the replaced lever for reference). After drilling, install a new pin.

7. Clean the control tube thoroughly and install on the engine. Adjust the injector racks as outlined in Section 14.3.

Install Injector Control Tube

1. Engage the injector rack control levers with the injector control racks and place the brackets over the mounting holes on the cylinder head.

2. Install the two 1/4"–20 x 5/8" bolts and lock washers at each bracket to attach the injector control tube assembly to the cylinder head. Tighten the bolts to 10–12 lb–ft (14–16 N•m) torque.

3. Check the control tube to be sure it is free in the brackets. Tap the control tube lightly to align the bearings in the bracket, if necessary.

4. Connect the fuel rod to the injector tube control lever with a clevis pin and a new cotter pin.

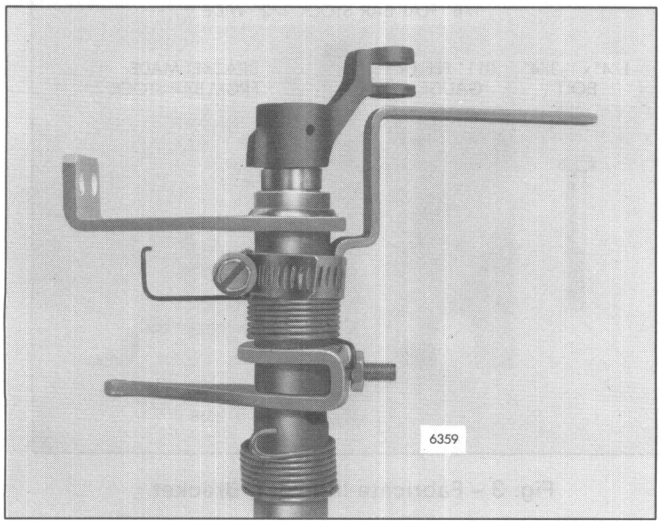


Fig. 4 – Secure Indexing Bracket to Control Tube

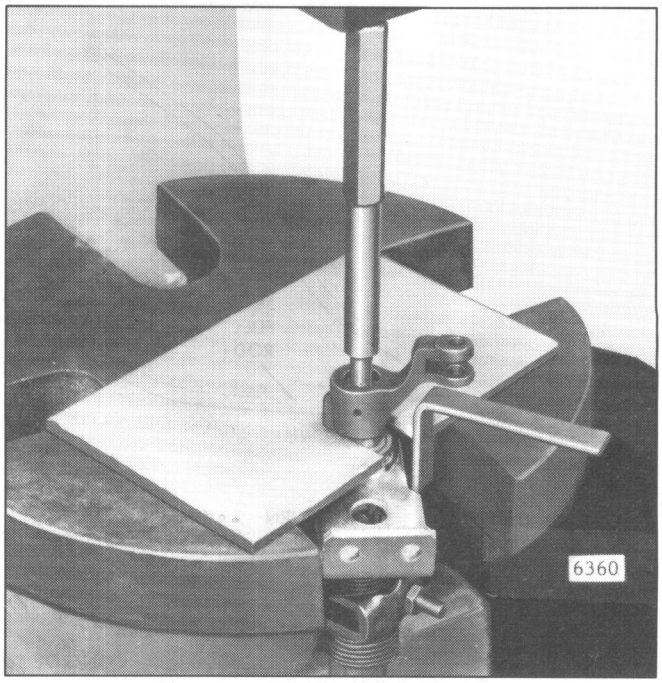


Fig. 5 – Press Old Lever off Control Tube

5. Refer to Section 14 and position the injector rack control levers. Be sure the injector rack control levers can be placed in a no–fuel position before restarting the engine.

CAUTION: Loss of shutdown control could result in a runaway engine which could cause personal injury.

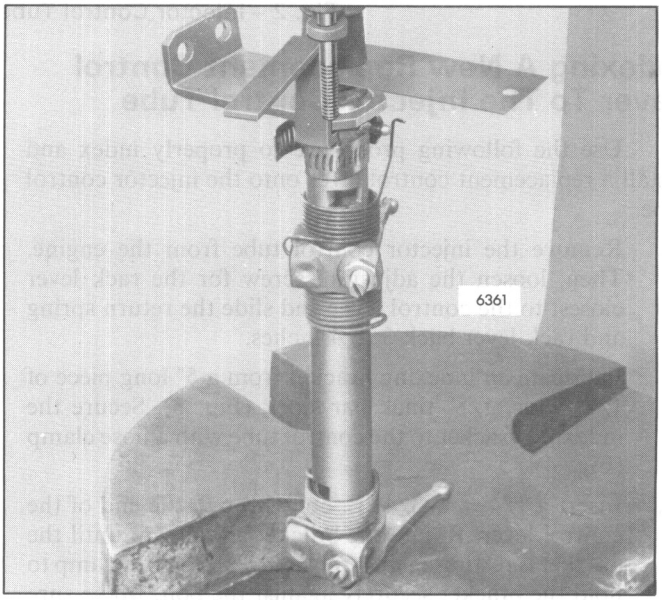


Fig. 6 – Installing New Lever

SHOP NOTES – TROUBLESHOOTING SPECIFICATIONS – SERVICE TOOLS

SHOP NOTES

INJECTOR TESTER J 23010–A

CAUTION: The fuel spray from an injector can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

Use injector test oil J 26400 in the injector tester.

Installing Fuel Injector In Tester

1. Select the proper clamping head (Fig. 1). Position it on the clamping post and tighten the thumb screw into the lower detent position (Fig. 2).
2. Connect the test oil delivery piping into the clamping head.
3. Connect the test oil clear discharge tubing onto the pipe on the clamping head.
4. Locate the adaptor plate on top of the support bracket by positioning the 3/8" diameter hole at the far right of the adaptor plate onto the 3/8" diameter dowel pin. This allows the adaptor plate to swing out for mounting the fuel injector.
5. Mount the injector through the large hole and insert the injector pin in the proper locating pin hole (Fig. 1).
6. Swing the mounted injector and adaptor plate inward until they contact the stop pin at the rear of the support bracket.

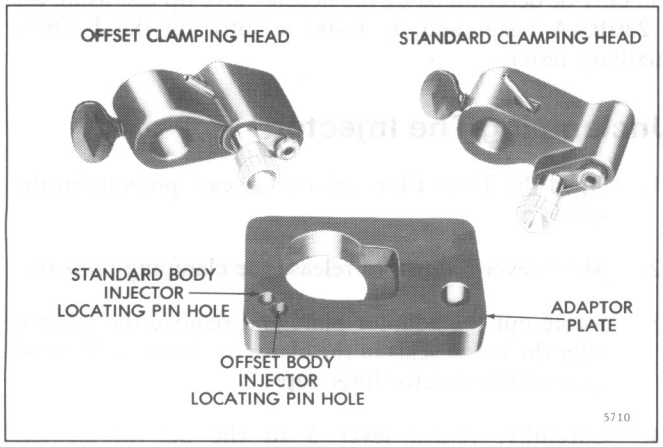


Fig. 1 – Injector Tester J 23010–A Clamping Heads

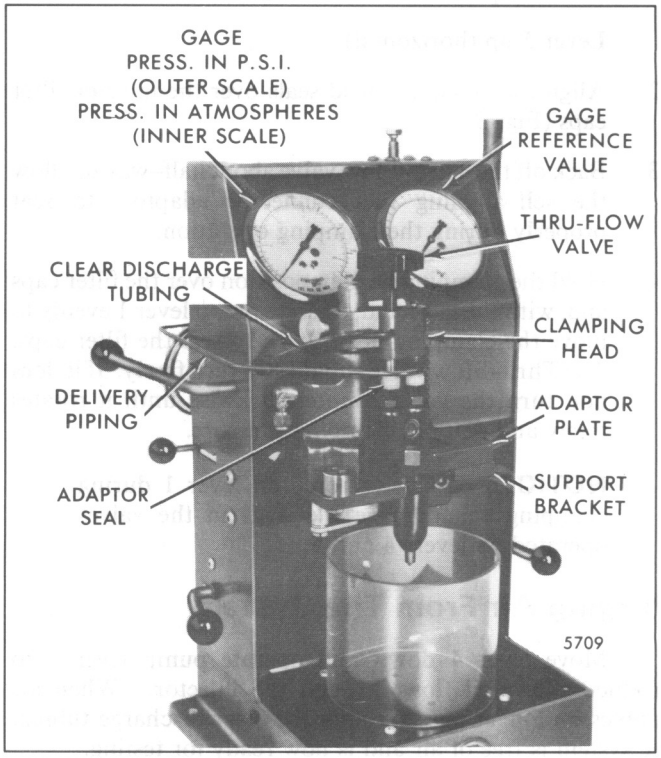


Fig. 2 – Injector Installed in Tester J 23010–A with Clamping Head

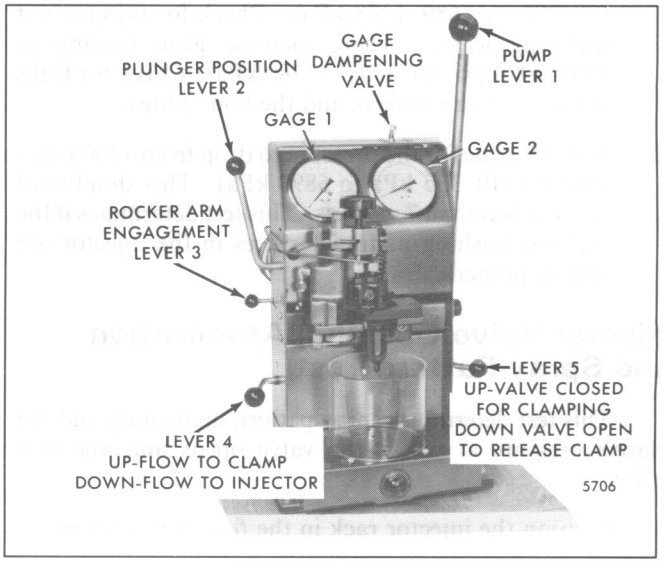


Fig. 3 – Injector in Position for Testing with J 23010–A

Clamping The Fuel Injector

1. Refer to Fig. 3 and position the injector tester levers as follows:

   Lever 2 up and to the rear

   Lever 3 in the rear detent

   Lever 4 up (horizontal)

   Lever 5 up (horizontal)

2. Align the clamping head seals over the injector filter caps (Fig. 2).

3. Back off the Thru–Flow valve about half–way to allow the self–aligning fuel connector adaptors to seat properly during the clamping operation.

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

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

Purging Air From The System

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

Check the injector for leaks as follows:

1. Operate pump lever 1 until gage 1 slowly reaches 100–200 psi (689–1378 kPa). Check for injector nut seal ring leaks. Then, increase gage reading to 1500–2000 psi (10 335–13 780 kPa). Check for leaks at the filter cap gaskets and the body plugs.

2. Note the time for the pressure to drop from 1500 psi to 1000 psi (10 335 kPa to 6890 kPa). This should not occur in less than 7 seconds. This test determines if the body–to–bushing mating surfaces in the injector are sealing properly.

Injector Valve Opening, Atomization And Spray Pattern Test

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

1. Position the injector rack in the *full–fuel* position.

2. Place pump lever in the *vertical* position.

3. Move the rocker arm engagement lever to the forward detent (Fig. 4).

4. Turn the gage damping valve knob (Fig. 3) clockwise to the *closed* position, then open the vlave slightly to control the rate of return of the gage hand. This valve is deleted on the current testers.

5. Operate the pump lever uniformly and observe the spray pattern produced.

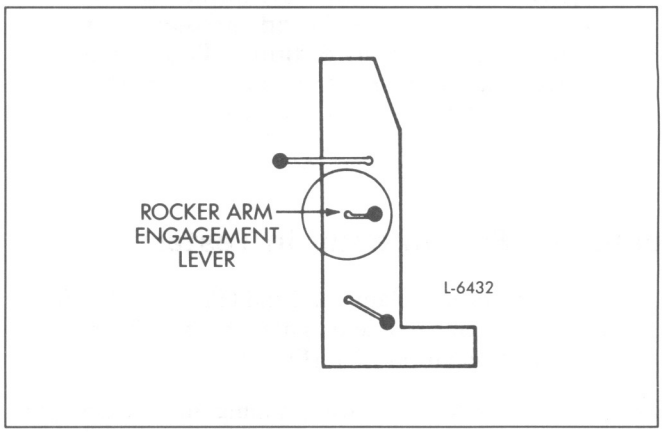


Fig. 4 – Position of Rocker Arm Engagement Lever

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

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

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

Unclamping The Injector

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

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

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

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

CHECKING INJECTOR TESTER J 23010–A OR J 9787

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

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

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

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

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

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

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

INJECTOR SPRAY TIP TESTER (J 22640–A)

Valve Opening, Spray Pattern and Atomization.

1. Operate the pump handle until a clear flow of test oil is obtained at the tip mounting pedestal.

2. Place the tip assembly, valve spring with cage and check valve cage on top of the pedestal. Tighten the injector nut (Fig. 5).

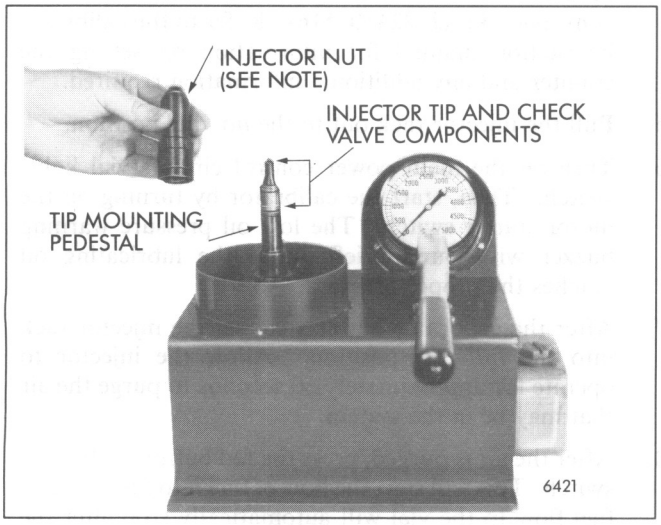


Fig. 5 – Installing Injector Nut

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

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

4. Operate the pump lever rapidly with smooth even strokes (40 strokes per minute) simulating the action of the tip functioning in the engine. Note the pressure at which the test oil delivery occurs. Test oil delivery should occur between 2200 and 3300 psi (15 158 and 22 737 kPa) except for the L–40 injector needle valve and spring which should open between 1700 and 2300 psi (11 713 and 15 847 kPa). When using the high V.O.P. spring, the oil delivery will occur at 2900–3900 psi (19 981–26 871 kPa). The beginning and ending of delivery should be sharp and the test oil should be a finely atomized spray.

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

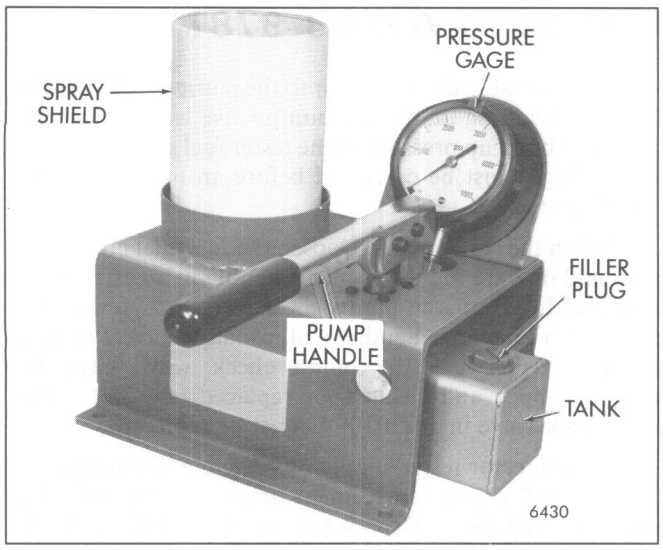


Fig. 6 – Tester J 22640–A with Shield Installed

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

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

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

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

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

INJECTOR SPRAY TIPS

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

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

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

CHECK INJECTOR OUTPUT

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

1. Before testing injector output, be sure calibrator test oil is supplied to the injector fitting located over the rack. To change the flow from the calibrator, exchange the positions of the braided and the clear fuel lines (Fig. 8).
2. Place the cam shaft index wheel and fuel flow lever in their respective positions. Turn on the test fuel oil heater switch to preheat the test oil to 95–105°F (35–40°C).
3. Place the proper injector adaptor between the tie rods and engage it with the fuel block locating pin. Then, slide the adaptor forward and up against the fuel block face.
4. Place the injector seat J 22410–226 into the permanent seat (cradle handle in the *vertical* position). Clamp the injector into position by operating the injector clamp–up valve.

   Set the counter (Fig. 9) at the appropriate number of strokes, 500 or 1,000. If for any reason this setting has been altered, reset the counter for the correct number of strokes. Calibrators with Serial No. 1175 or lower were manufactured as 1,000 stroke machines, but may have been converted to 500 stroke machines with a conversion kit (J 22410–516). Refer to the calibrator instruction manual for information on setting the counter and any additional information required.
5. Pull the injector rack out to the *no–fuel* position.
6. Turn on the main power control circuit (vial light) switch. Then, start the calibrator by turning on the motor starter switch. The low oil pressure warning buzzer will sound briefly until the lubricating oil reaches the proper pressure.
7. After the calibrator has started, set the injector rack into the *full–fuel* position. Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.
8. After the air is purged, press the red button on the test switch. This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after the correct number of preset strokes are counted.

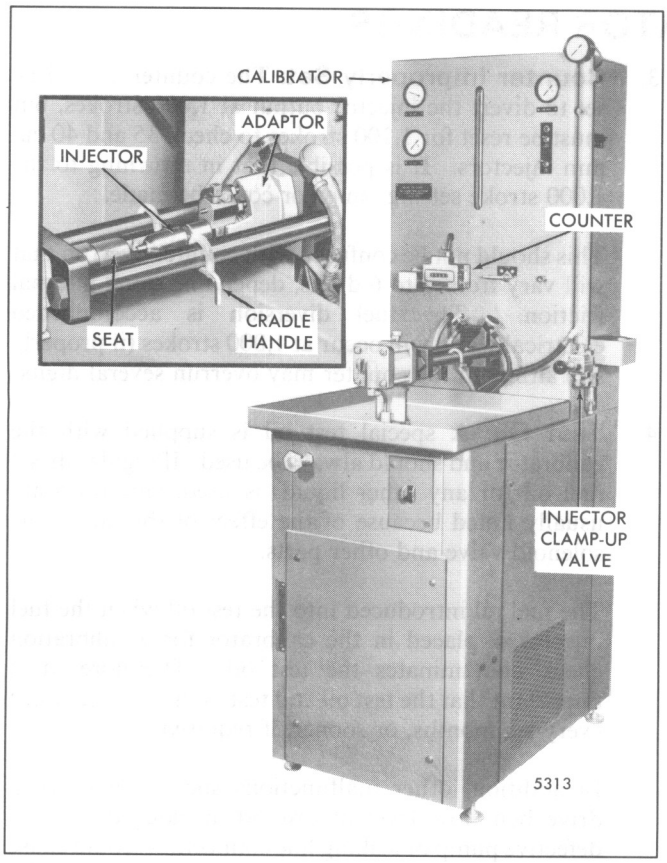


Fig. 7 – Injector in Calibrator J 22410-A

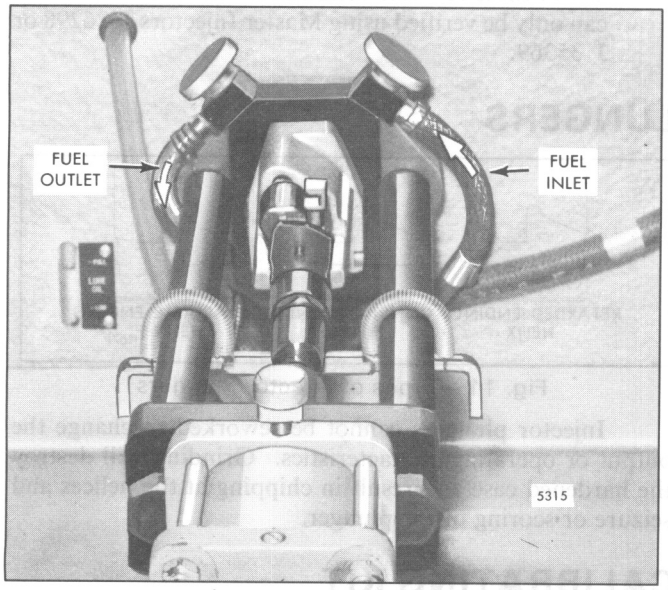


Fig. 8 – Position of Calibrator Fuel Flow Pipes

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

10. Observe the vial readings and refer to Table 1 to determine whether the injector fuel output falls within the specified limits. If the quantity of fuel in the vial does not fall within the specified limits, refer to *Troubleshooting Chart 3* for the cause and remedy. See *Injector Calibrator Readings* for different factors that may affect the injector calibrator output reading.

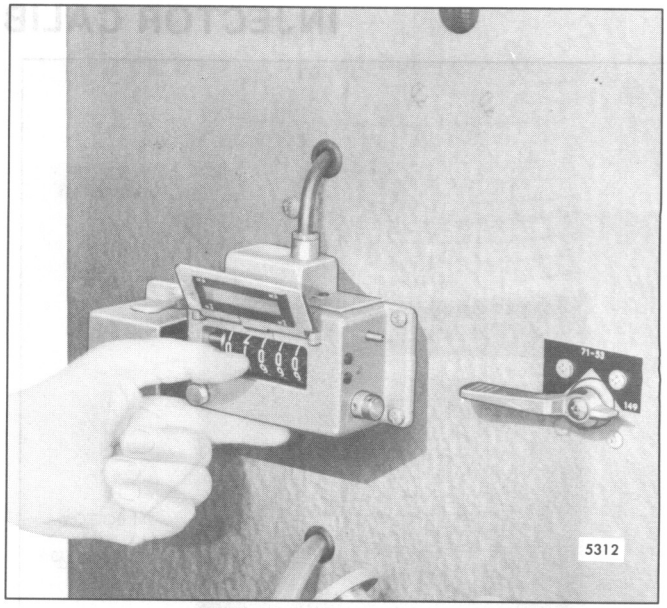


Fig. 9 – Setting Calibrator Stroke Counter

INJECTOR	MIN.	MAX.	INJECTOR	MIN.	MAX.
9270	65	75	9B90	85	91
9275	70	76	9C70	65	71
9280	75	81	9C75	70	76
9285	80	86	9C80	75	81
9290	85	91	9C90	85	91
9295	90	96	9E65	70	75
9200	95	101	9E70	75	80
9215	110	116			
9225	118	126			
9A80	75	81	9F90	85	91
9A85	80	86	7G65	67	72
9A90	85	91	7G70	72	77
9B70	65	71	7G75	77	82
9B75	70	76			
9B80	75	81			
9B85	80	86			

TABLE 1

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

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

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

INJECTOR CALIBRATOR READINGS

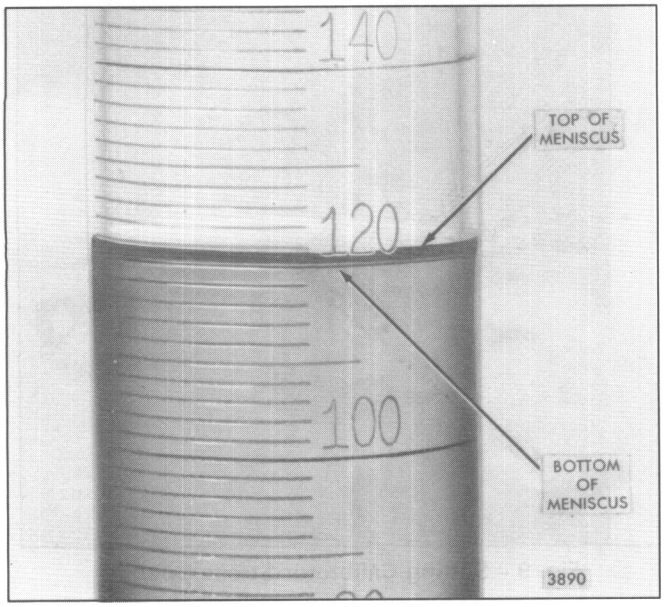


Fig. 10 – Checking Fuel Output

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

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

   This should not be confused with counter overrun that will vary from 2 to 6 digits, depending upon internal friction. The fuel diversion is accomplished electrically and will occur at 1,000 strokes (if properly set) although the counter may overrun several digits.
4. **Test Oil:** A special test oil is supplied with the calibrator and should always be used. If regular diesel fuel oil (or any other liquid) is used, variations are usually noted because of the effect of the oil on the solenoid valve and other parts.

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

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

INJECTOR PLUNGERS

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

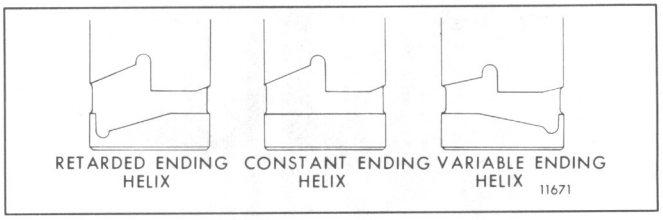


Fig. 11 – Types of Injector Plungers

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

MASTER INJECTOR CALIBRATING KIT

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

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

injector calibration. If more than a 2% variation from the masters is noted, consult the calibrator manufacturer for possible causes.

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

PLUNGER/BUSHING AND TIP FLOW GAGE

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

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

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

Installation

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

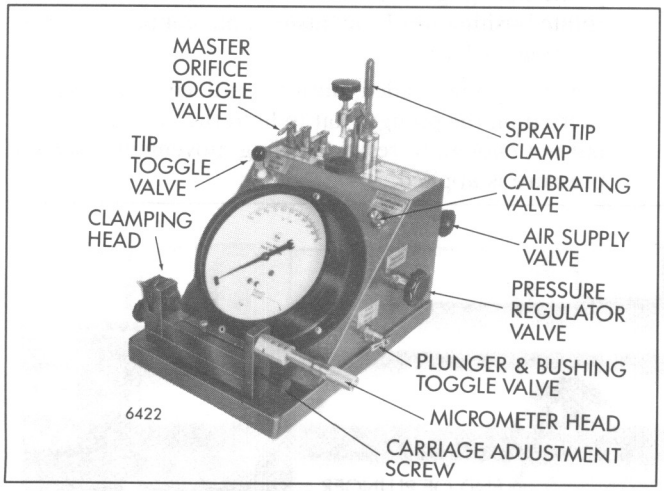


Fig. 12 – Plunger/Bushing and Tip Flow Gage J 25600–A

Regulated Pressure Adjustment

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

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

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

Calibration To Master Orifice

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

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

Measuring Spray Tip Flow

1. Clean all spray tips thoroughly (correct flow rate is dependent on a clean spray tip).
2. Observe the number and size of the spray tip holes marked on the narrow end of the spray tip and calibrate to orifice A. Refer to the Chart for the flow values.
3. Remove the needle valve, if installed, and clamp the spray tip on the unit (Fig. 14).
4. Open the tip toggle valve and observe the gage reading.
5. The tip can now be compared to the specification sheet and sorted into groups; high, low, mean, etc.

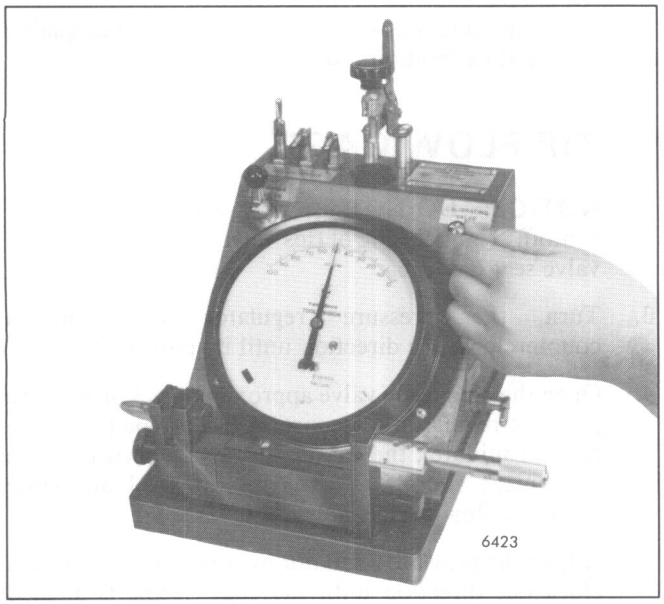


Fig. 13 – Adjusting the Calibrating Valve

TIP STAMP	NOMINAL FLOW VALUE	MASTER ORIFICE CALIBRATION
6–.006	22	A
7–.006	69	
8–.0055	26	
8–.006	48	
9–.0055	48	
9–.0058	69	

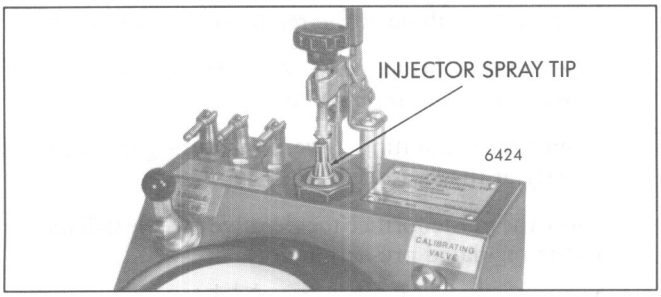


Fig. 14 – Spray Tip Installed in Tester

Plunger/Bushing Effective Stroke Measurement

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

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

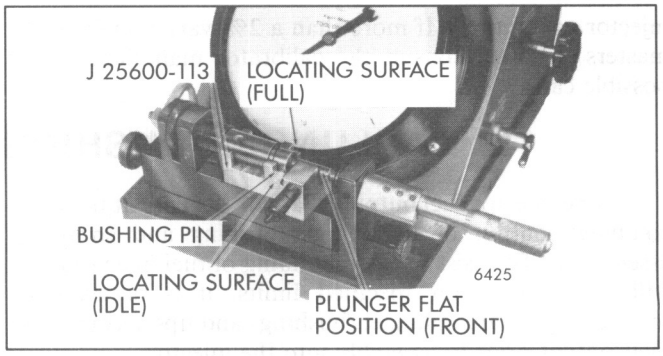


Fig. 15 Cradle Mounted on Fixture

1. Select the proper cradle for the plunger/bushing to be tested and mount on the fixture (Fig. 15).
2. Calibrate to the "A" orifice, see "Calibration to Master Orifice". All plunger/bushing tests use the "A" orifice as reference.
3. Close all toggle valves, gage needle will be at the regulated pressure mark.
4. Adjust the micrometer to zero reading (all zeros).
5. Place the plunger/bushing in the cradle. Be sure the plunger flat and locating pin or slot is properly positioned (Fig. 15). To check in *full–fuel* position, rotate bushing until the bushing pin contacts the rear locating surface.
6. Adjust spring loaded button until enough force is exerted on the plunger flat to hold the plunger steady, but not enough to restrict sliding movement when air pressure is applied.

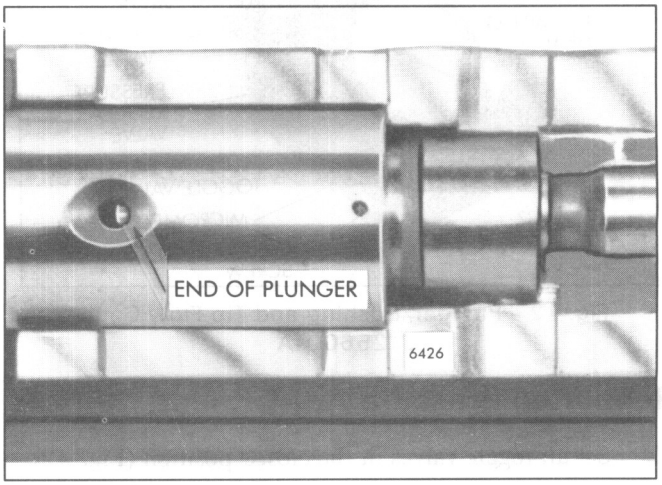


Fig. 16 – End of Plunger Shown in Port

7. Hold the plunger against the micrometer and rotate the carriage adjustment screw until the plunger almost closes the port (Fig. 16).
8. Open the plunger and bushing toggle valve.
9. If the plunger has not closed the port far enough, an air leak will be heard and the gage needle will be left of the set line. If it has closed the port too far, it will be to the right of the set line, toward or at the regulated pressure mark.
10. Turn the carriage adjustment screw until the gage needle is at approximately 20.
11. Turn the carriage adjustment screw clockwise very slowly until the gage needle is exactly at the set line. Always adjust in this manner, with the needle moving from approximately 20 to the set line.
12. Turn the micrometer thimble clockwise. The gage needle will move toward, and go to the regulated pressure mark. Very little air will be heard leaking.
13. Continue turning clockwise until the gage needle begins to move away from the regulated pressure mark (air from the bushing will again be heard leaking). Turn very slowly until the gage needle reaches the set line.
14. Observe and record the micrometer reading. The number shown is the effective stroke in thousandths of an inch.
15. Turn the micrometer back to zero. Gage needle should return to or very near the set line.
16. Turn off the plunger/bushing test toggle valve.
17. Loosen the clamping knob and remove the plunger/bushing.
18. Only minor carriage adjustment will be required for other plunger/bushing of the same type.
19. Chart the stroke readings and compare to the specifications. Sort into groups, high strokes, low strokes and mean strokes.

REFINISH LAPPING BLOCKS

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

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

To refinish the blocks, spread some 600 grit lapping powder of good quality on one of the blocks. Place another block on top of this one and work the blocks together (Fig. 17). Alternate the blocks from time to time. For example, assuming the blocks are numbered 1, 2 and 3, work 1 and 2 together, then 1 and 3, and finish by working 2 and 3 together. Continue this procedure until all of the blocks are perfectly flat and free of imperfections.

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

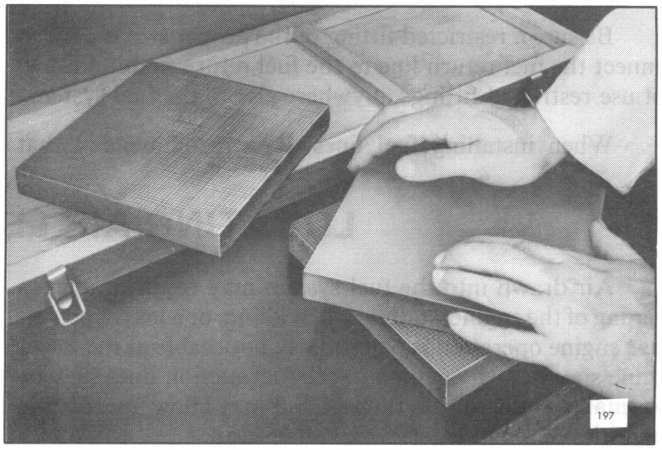


Fig. 17 – Refinishing Lapping Blocks

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

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

EFFECT OF PREIGNITION ON FUEL INJECTOR

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

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

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

INJECTOR TIMING

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

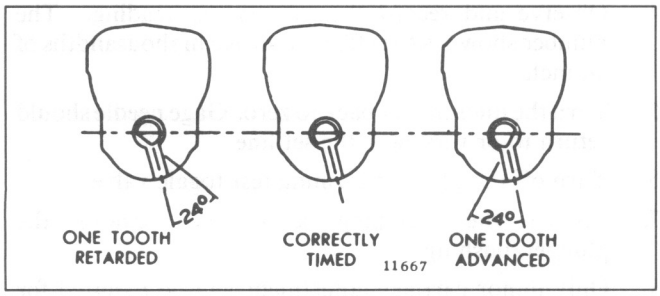


Fig. 18 – Injector Rack–to–Gear Timing

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

FUEL LINES

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

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

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

LOCATING AIR LEAKS IN FUEL LINES

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

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

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

PRESSURIZE FUEL SYSTEM – CHECK FOR LEAKS

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

Prime And Purge

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

Check For Leaks

Use one of the following methods to check for leaks.

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

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

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

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

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

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

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

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

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

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

Points To Remember

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

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

DETECTING INTERNAL FUEL LEAKS

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

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

Red LTO 1140 Dye

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

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

Bench Testing

1. To bench test a complete cylinder head assembly, fill a fuel system priming pump (J 5956 or equivalent) with the red dye/fuel mixture.
2. Connect the outlet hose of the priming pump to the fuel inlet manifold. Connect a drain hose from the fuel outlet back to the test fuel container. Make sure that

the required restricted fitting is installed in the fuel outlet. This will allow sufficient fluid pressure to build up.

3. Prime the cylinder head fuel system and check for leaks. The test fuel will show up as bright red.

4. Eliminate the cause of any leaks discovered. Wipe off the head components and retest until no further leaks occur.

Running Test

1. To pressure test the cylinder head on a new or newly overhauled engine, isolate the fuel system so that the fuel supply and return lines are connected only to the test container.

2. Start and run the engine on the test fuel at maximum no–load speed for approximately five minutes to bring it to operating temperature. Periodically check the level in the test fuel container to ensure an adequate supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of Red LTO 1140 dye to each 2.5 gallons (9.463 liters) of make–up fuel. Three to five engines can normally be tested before replenishing the fuel.

3. Stop the engine and remove the rocker covers. Check the cylinder head and all fuel connections for any sign of fuel leakage. The test fuel will show up as bright red.

4. If any leaks are discovered, eliminate their cause. Wipe all head surfaces and fuel connections clean, then start the engine and retest.

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

J 28431 Fluorescent Dye

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

1. Mix four (4) ounces (118 ml) of fluorescent dye additive J 28431 with four (4) gallons (15.14 liters) of clean No. 1 or No. 2 diesel fuel in a clean container. The container should be marked "Test Fuel" to prevent its accidental usage and be resealable to prevent contamination when not in use.

2. Isolate the engine fuel system so that the supply and return lines are connected only to the test fuel container.

3. Start and run the engine on the test fuel at maximum no–load speed for approximately five minutes to bring it to operating temperature. Periodically, check the level in the test fuel container to ensure an adequate supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of fluorescent dye for each gallon (3.79 liters) of make–up diesel fuel. Normally, three to five units can be tested before replenishing the fuel.

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

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

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

Normal Fuel Weepage

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

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

FUEL JUMPER LINE MAINTENANCE AND REUSE

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

The fuel jumper lines which carry fuel to and form the fuel injectors must be handled and installed very carefully to prevent line damage that can result in severe engine damage. Severe fuel leakage, if not detected, can also result in an over–filled crankcase (oil pan) which can cause an abnormal

amount of fuel and lubricating oil vapor to escape from the engine and crankcase breathers. An abnormal concentration of fuel and lube oil vapors is flammable and could ignite in a closed engine compartment.

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

1. Improper handling and storage of jumper lines when servicing the engine can result in physical damage and contamination.
2. Careless use of special tool (socket) J 8932–01 during removal or installation can cause a jumper line to bend and be permanently distorted.
3. Reuse of a bent or distorted jumper line can result in excessive stress and cause the line to crack or fracture at or above the flared ends of the jumper line. A fuel leak will ultimately result.
4. Excessive tightening of the jumper line nut will distort and fracture the flared end of the jumper line, resulting in a fuel leak.

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

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

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

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

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

Jumper Line 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)
DDEC Engines	145 lb-in. (15.6 N·m)

**Not serviced. Available from Jacobs Manufacturing Company.*

Jumper Line Nut Torque

5. Damaged threads and flare seats on the injector and cylinder head jumper line connectors can also result in fuel leakage.
6. Leaks can also occur at injector filter nut gaskets and/or cylinder head connector washers due to distortion, damage or incorrect torque.

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

Checking For Fuel Leaks

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

METHOD A

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

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

METHOD B

Use when the engine is not operating such as during or after repairs. Remove the rocker cover(s). Discard the gasket(s). Pour clean lube oil over the fuel jumper lines and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form at the joining surfaces as mentioned in Method A. Plug the fuel return line at a convenient location (cylinder head or fuel tank, for example). Disconnect the fuel pump supply line at the inlet of the secondary filter. Connect an external source

of pressurized fuel (60–80 psi or 414–552 kPa) to the inlet of the secondary filter cover. Install a pressure gage (0–100 psi or 0–689 kPa) at the outlet of the filter cover. Gage installation can be accomplished by installing a "T" fitting between the filter cover and outlet line or by removing the pipe plug at the outlet in the cover. Use of a gage will allow ready reference to the fuel pressure being maintained for this test. Severe leaks are immediately visible and minor leaks take longer to appear. It may be necessary to maintain fuel pressure for a period of 20 to 30 minutes in order to find minor leaks. Leaks may be repaired by replacing damaged parts or determining if the part is loose and below torque specifications. Test and reinspect.

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

METHOD C

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

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

METHOD D

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

1. Mix 4 oz. of fluorescent additive J 28431 with 4 gallons (15 liters) of clean diesel fuel (#1 or #2) in a clean container. The container should be marked "Test Fuel" and be resealable so that it won't be contaminated when not being used.

2. Isolate the engine fuel system so that the supply and return fuel lines are connected only to the test fuel container. It will be necessary to intermittently check the fuel level to maintain an adequate supply.

3. Warm up the engine by operating it at maximum no–load speed for approximately 15 minutes.

4. With the engine idling and the rocker cover removed, shine the black light over the head assembly. The lube oil will show a dull blue. If a fuel leak is present, the fuel with the fluorescent dye will glow a bright yellow.

5. After the cause of the fuel leak has been determined and corrected, wipe the area and fuel connections clean and recheck with the black light. When no leaks are present, reassemble the unit with the original fuel lines and normal fuel source. It is not necessary to change the fuel filters. Run the engine to purge the air from the fuel system.

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

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

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

POINTS TO REMEMBER

1. Lube oil puddle inspection is one method of testing the fuel system for internal leaks. The missing puddles show where the leaks are. This test can be performed any time the rocker covers are removed, after the fuel jumper lines and connectors have been splashed with clean lube oil and there is normal fuel pressure in the system.

2. All leakage or spillage of fuel during leak detection testing further dilutes the lube oil.

3. The final step in maintenance of this type should include lube oil filter changes if a fuel leak is detected.

4. Oil level above the dipstick "full" mark or a decrease in lube oil consumption may indicate internal fuel leaks.

5. Improper storage, handling or installation of jumper lines can cause fuel leakage, resulting in lube oil dilutuion and severe engine damage.

TAMPER–RESISTANT GOVERNOR FOR HIGHWAY VEHICLE ENGINES

A tamper–resistant double–weight limiting speed governor is provided for highway vehicle engines.

This governor incorporates an adaptable high–speed spring housing to make unauthorized speed setting changes extremely difficult.

The new governor spring housing has one inch of additional metal resembling two bosses cast on the bolt head of the housing (Figs. 20 and 21). These bosses are counterbored to accept the two bolts which hold the spring housing on the governor housing and to allow for the installation of plugs over the bolt heads. The plugs are secured in the counterbores by tapered pins which, when driven in place, cannot be removed when the governor is mounted on the blower. In order to remove the pins to get to the spring housing retainer bolts, the complete governor must be removed from the blower.

The governor is not tamper–resistant as furnished on an engine by the factory. The spring housing retainer bolts are removable to permit governor adjustments that may be necessary before the engine is placed in service following delivery. To make the governor tamper–resistant after initial engine start–up, two plugs, two tapered pins and the gap adjusting screw and spring cover must be added to the governor as follows:

1. Disassemble the governor spring housing and spring assemblies as follows:
   a. Remove the two bolts and washers securing the high–speed spring housing to the governor housing and withdraw the housing.
   b. Loosen the high–speed spring retainer locknut with a spanner wrench. Then, remove the high–speed spring retainer, idle speed adjusting pin and set screw, high–speed spring, spring plunger, low–speed spring, spring seat and spring cap as an assembly. Remove the gasket.
2. Remove the governor housing cover and lever assembly. Remove and discard the spring housing bolt retainer which should be lying loose in the governor housing.
3. Refer to Figs. 20 and 21 and install the gap adjusting pin and set screw and spring cover and spring assemblies in the governor housing as follows:
   a. On the current tamper–resistant governor, insert the 1–1/4" Allen head retaining screw through the unthreaded clearance hole in the gap adjusting screw and spring cover (Fig. 21) and secure the cover to the inside of the governor housing. The retaining screw sets into a counterbore in the current cover. Turn the retaining screw into the housing until the cover is secure.
   b. On the former tamper–resistant governor, place the gap adjusting screw and spring cover (Fig. 20) in the governor housing with the threaded bolt hole up and in position to receive the spring and plunger assembly.

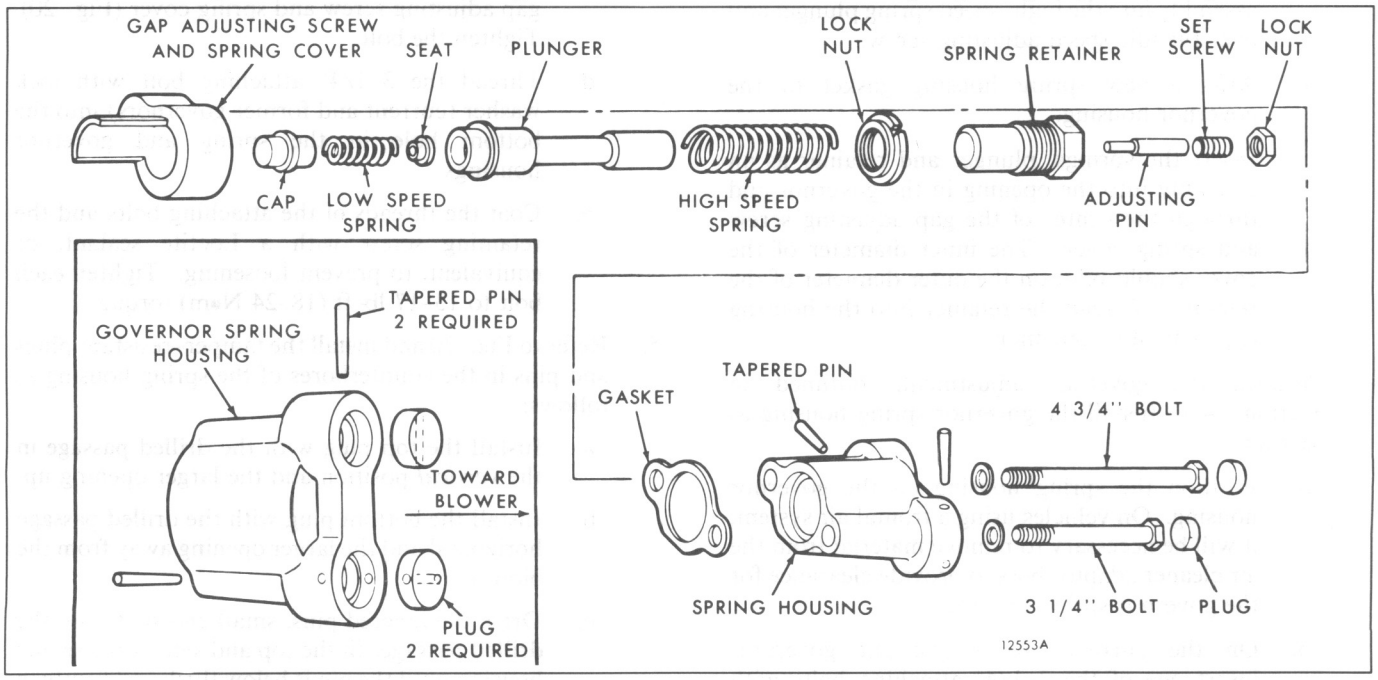


Fig. 20 – Tamper–Resistant Governor Components (Former)

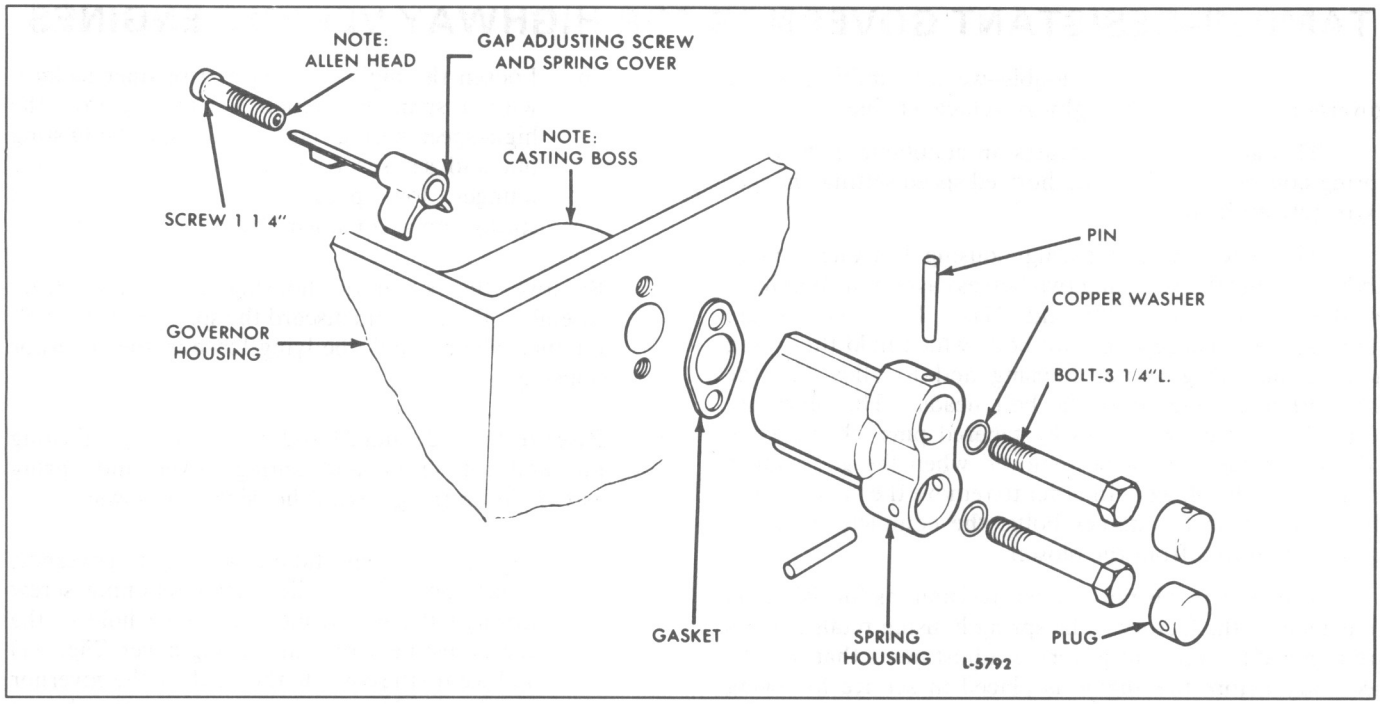


Fig. 21 – Tamper–Resistant Governor Components (Current)

c. Insert the high–speed spring and plunger assembly in the high–speed spring retainer. Thread the idle speed adjusting screw into the threaded end of the plunger approximately 1/2". Then, thread the locknut on the idle speed adjusting screw.

d. Insert the low–speed spring seat, spring and cap assembly into the high–speed spring plunger and over the idle speed adjusting screw.

e. Affix a new spring housing gasket to the governor housing.

f. Insert the springs, plunger and retainer as an assembly into the opening in the governor and through the center of the gap adjusting screw and spring cover. The inner diameter of the cover should pilot on the outer diameter of the retainer. Thread the retainer into the housing approximately one inch.

4. Perform the governor adjustments outlined in Section 14.3. Install the governor spring housing as follows:

   a. Position the spring housing on the governor housing. On vehicles using a frontal air system, it will be necessary to remove material from the air cleaner adaptor boss to provide clearance for the governor spring housing.

   b. On the current tamper–resistant governor, insert one of the 3–1/4" attaching bolts with copper washer through the top bolt hole in the spring housing and thread it into the top hole on the outside of the governor housing. Tighten the bolt.

   c. On the former tamper–resistant governor, insert the 4–3/4" attaching bolt with copper washer through the top bolt hole in the spring housing and thread it into the threaded hole in the former gap adjusting screw and spring cover (Fig. 20). Tighten the bolt.

   d. Thread the 3–1/4" attaching bolt with lock washer (current and former governors) into the bottom hole in the spring and governor housings.

   e. Coat the threads of the attaching bolts and the retaining screw with a Loctite sealant, or equivalent, to prevent loosening. Tighten each bolt to 13–17 lb–ft (18–24 N•m) torque.

5. Refer to Fig. 20 and install the tamper–resistant plugs and pins in the counterbores of the spring housing as follows:

   a. Install the top plug with the drilled passage in the *vertical* position and the larger opening up.

   b. Install the bottom plug with the drilled passage horizontal and the larger opening away from the blower.

   c. Drive the tapered pins, small end first, into the drilled passages in the top and side of the spring housing until the pin is below flush and firmly in place.

Most limiting speed governors on engines already in service can be converted to the tamper–resistant setup as follows:

1. Disassemble the governor spring housing and spring assemblies as outlined under Step 1, Items a and b above.

2. Remove the governor housing cover and lever assembly. Drill out the 5/16"–18 tapped hole in the governor housing at the spring housing top retaining bolt position to 11/32" diameter. Remove all drilled particles from the inside of the governor housing following the drilling operation.

3. Refer to Fig. 21 and install the current gap adjusting screw and spring cover and the high and low–speed spring assemblies, replacing the original retainer with the new longer retainer in the governor housing as outlined under Step 3, Items a through f above.

4. Perform the governor adjustments outlined in Section 14.3. Replace the original spring housing with the new spring housing and install the new housing and governor housing cover on the governor housing as outlined under Step 4, Items a through e above.

5. Refer to Figs. 20 or 21 and install the tamper–resistant plugs and pins in the counterbores of the spring housing as outlined under Step 5, Items a through c above.

NOTICE: If the spring housing of a former tamper–resistant governor (Fig. 20) is removed for any reason, the gap adjusting screw and spring cover will fall into the governor housing. Therefore, it is important to remove the governor cover and lever assembly and check to make sure that the gap adjusting screw and spring cover is secured by the 5/16"–18 x 4–3/4" bolt after the spring housing is reinstalled.

MODIFICATION OF GOVERNOR HOUSING TO ACCEPT CURRENT TAMPER–RESISTANT GAP ADJUSTING SCREW AND SPRING COVER

A former governor housing can be reworked to accept the new tamper–resistant gap adjusting screw and spring cover. Kent–Moore Master Thread Repair Kit J 26520 can be used.

With this procedure, two threaded inserts are installed in the governor housing, one from the inside and one from the outside. This will allow the new retaining screw to be installed on the inside of the governor housing and the new spring housing upper 3–1/4" bolt to be installed from the outside (Fig. 21).

1. Remove the governor cover, high–speed spring housing and spring pack.

2. Apply a thick coat of grease to the inside of the housing. Fit an oil soaked rag through the spring pack hole, using the grease as a seal between the housing and the rag.

3. Drill the upper high–speed spring housing bolt hole to 13/32" and tap the hole with a 7/16"–14 tap.

4. Remove the rag, making sure all of the chips are out of the housing. Then wipe the grease from the housing.

5. Thread a 5/16"–18 insert by hand from each side until the lock tabs bottom. The inserts and tab tools can be part of J 26520 master thread repair kit. The 5/16"–18 insert kit is J 26520–312 containing 20 inserts. The tab tool is J 26520–311. Then, use the 5/16" tab driver to drive the lock tabs in until flush. This will lock the insert in place. On the inside insert, use the same driver and a brass rod.

The inside of the governor housing cast boss, where the drill breaks through, may need to be filed flat. This is to prevent the gap adjusting screw and spring cover from tilting out of position when the retaining screw is tighten.

REWORK GOVERNOR HOUSING

The V–92 engine mechanical governor housing can be reworked when wear occurs at the boss that holds either the upper or lower end of the operating lever shaft.

Repair can be made by adding a bushing to the worn boss as follows (Fig. 22):

1. Refer to the drawing and bore out the hole so that the repair bushing fits tight (.4990"–.5005" diameter).

2. Shorten the bushing to a length of .380".

3. Press the bushing in the hole flush to .010" below the surface of the housing boss.

4. Ream the bushing to .3757–.3766" diameter, using a 3/8" reamer.

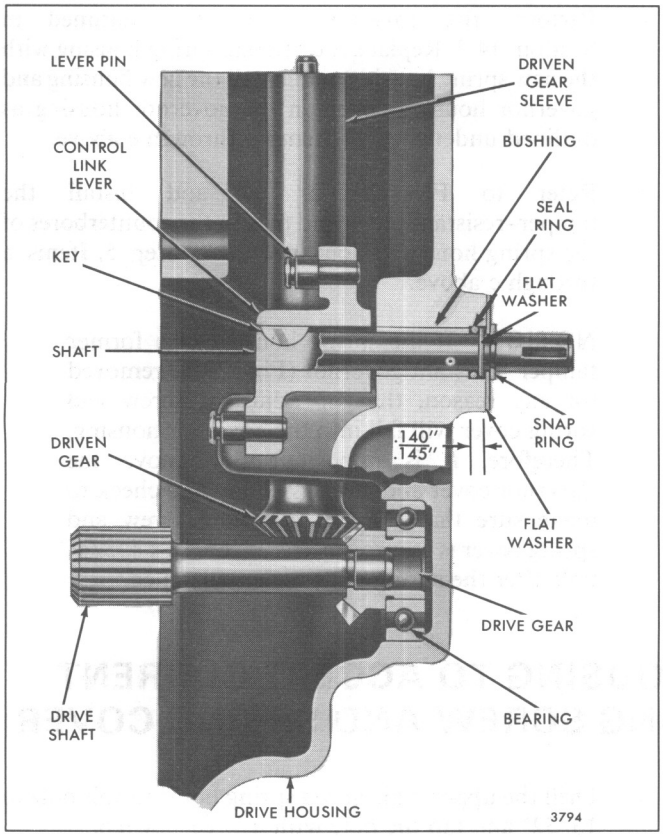


Fig. 22 – Governor Drive Assembly

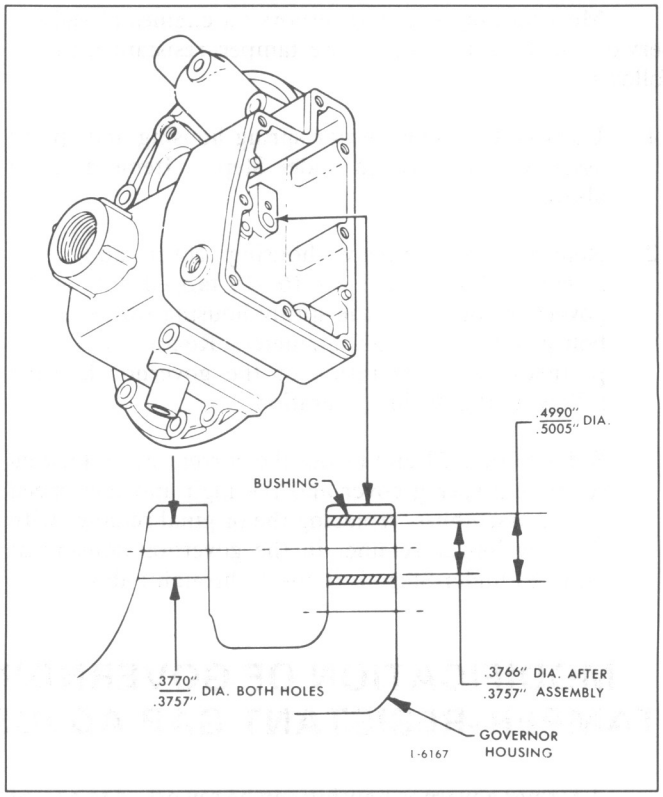


Fig. 23 – Reworking Governor Housing

After assembly of the governor, check for shaft freeness.

Careful workmanship is a must when making this repair to maintain proper geometry and fit within the governor.

Before Installing A Barber–Coleman Electronic Governor

Before a Barber–Coleman electronic governor is installed on an engine previously equipped with a hydraulic governor, the vertical driven gear, bearing, and gear sleeve and the horizontal drive gear, shaft and bearing must be removed from the governor drive housing (see Fig. 22).

These components serve no useful purpose when the hydraulic governor is replaced by the electronic governor and **will cause severe engine damage if not removed.** Because the horizontal drive shaft is splined to the blower rotor shaft, both governor shafts will continue to rotate when the engine is operated. However, with the hydraulic governor removed, the horizontal and vertical shafts and bearings will no longer receive adequate support or lubrication and will quickly wear out.

NOTICE: Do not remove only the vertical shaft and bearing. If the horizontal drive shaft and bearing assembly is left in the governor drive housing, the shaft will move freely back and forth during engine operation. This is due to the absence of load on the bevel gear which would normally keep the horizontal shaft in position. The rapid rotation and back–and–forth movement of the horizontal drive shaft can cause severe damage to the governor drive housing.

Following this procedure before installing a Barber–Coleman electronic governor:

1. Remove the hydraulic governor drive as outlined in Section 2.8.3 of the Service Manual. Remove the driven gear, bearing and gear sleeve, and the drive gear, shaft and bearing from the drive housing.

2. Reinstall the governor drive housing and all parts previously removed, except the drive and driven gears and related components, following procedures in Section 2.8.3 of the Service Manual.

3. Install the Barber–Coleman electronic governor per the manufacturer's instructions and perform the engine tune–up as outlined in Section 14 of the Service Manual.

TROUBLESHOOTING

FUEL PUMP

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

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

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

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

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

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

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

CHECKING FUEL FLOW

1. Disconnect the fuel return line from the fitting at the fuel tank and hold the open end in a convenient receptacle (Fig. 23).

2. Start and run the engine at 1200 rpm or 1800 rpm and measure the fuel flow. Refer to Section 13.2 for the specified quantity per minute.

3. Immerse the end of the fuel line in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate air being drawn into the fuel system on the suction side of the pump. If air is present, tighten all fuel line connections between the fuel tank and the fuel pump.

4. If the fuel flow is insufficient for satisfactory engine performance, then:

   a. Replace the element in the fuel strainer. Then start the engine and run it at 1200 rpm to check the fuel flow. If the flow is still unsatisfactory, perform step "b" below:

   b. Replace the element in the fuel filter. If the flow is still unsatisfactory, do as instructed in step "c".

   c. Substitute another fuel pump that is known to be in good condition and again check the fuel flow. When changing a fuel pump, clean all of the fuel

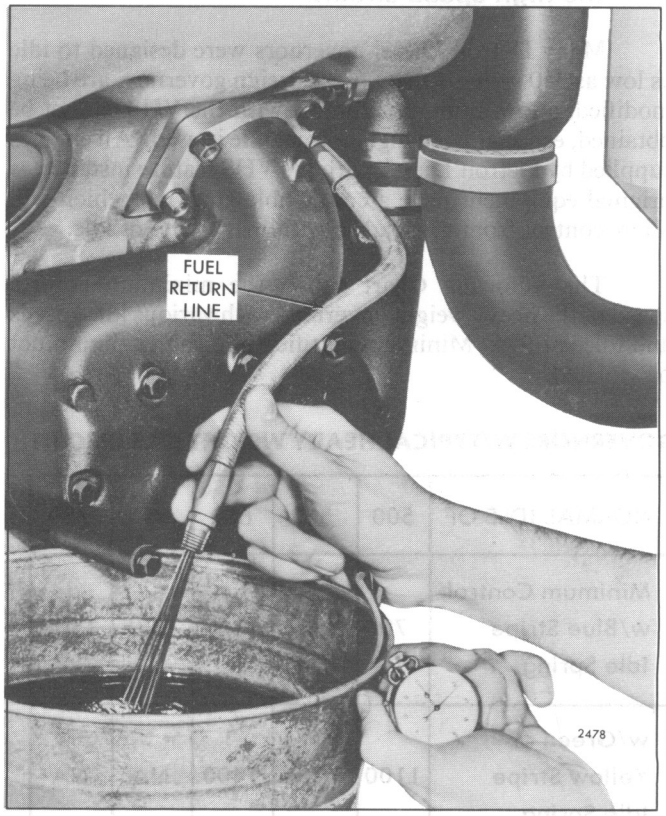


Fig. 23 – Measuring Fuel Flow From Fuel Return Manifold

lines with compressed air and be sure all fuel line connections are tight. Check the fuel lines for restrictions due to bends or other damage.

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

1. Run the engine at idle speed and cut out each injector, in turn, by holding the injector follower down with a screwdriver. If a cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine when that particular injector has been cut out.

2. Stop the engine and remove the fuel pipe between the fuel return manifold and the injector.

3. Hold a finger over the injector fuel outlet and crank the engine with the starter. A gush of fuel while turning the engine indicates an ample fuel supply; otherwise, the injector filters are clogged and the injector must be removed for service.

AIR–OPERATED VARIABLE HIGH SPEED GOVERNORS

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

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

Series 92 engines require 70 psi (483 kPa) or more. This air pressure is required at the governor after the regulator. The regulator must have an operating range of 0–120 psi (0–827 kPa).

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

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

The following Chart shows the minimum control speed of the heavy weight governors with various idle speeds and idle springs. Minimum certified idle values should not be violated.

GOVERNORS W/TYPICAL HEAVY WEIGHT IDLE CIRCUIT

NORMAL IDLE OF	500	550	600	650	750
Minimum Control w/Blue Stripe Idle Spring	700	900	1100	1375	1500
w/Green or Yellow Stripe Idle Spring	1100	1225	1400	NA	NA

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

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

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

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

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

4. Temporary engine overspeed

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

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

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

5. Lowered idle or no–load.

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

6. Lack of normal power.

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

7. No–load increased.

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

NEEDLE VALVE INJECTORS

Chart 1

LOW OR HIGH VALVE OPENING PRESSURE

LOW VALVE OPENING PRESSURE

Probable Cause

1. WORN OR ERODED NEEDLE VALVE OR VALVE SEAT IN SPRAY TIP
2. WORN OR DAMAGED NEEDLE VALVE QUILL
3. WORN OR DAMAGED NEEDLE VALVE SPRING SEAT
4. WORN OR BROKEN VALVE SPRING
5. DIRT OR FOREIGN MATERIAL IN INJECTOR

HIGH VALVE OPENING PRESSURE

Probable Cause

6. CARBON OR FOREIGN MATERIAL IN SPRAY TIP
7. CARBON IN SPRAY TIP ORIFICES

SUGGESTED REMEDY

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

NEEDLE VALVE INJECTORS

Chart 2

INSUFFICIENT INJECTOR HOLDING TIME

Probable Cause

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

SUGGESTED REMEDY

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

NEEDLE VALVE INJECTORS

Chart 3

INCORRECT INJECTOR OUTPUT

Probable Cause

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

SUGGESTED REMEDY

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

The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the *Fuel Output Check Chart,* try changing the spray tip. However, use only a tip specified for the injector being tested.

5. Replace the needle valve and spray tip assembly.
6. Replace the spring seat.
7. Replace the valve spring.
8. Replace the cracked parts.
9. Replace the plunger and bushing assembly.
10. Lap the sealing surfaces.
11. Disassemble the injector and clean all of the parts.
12. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth on the rack.
13. Replace the spray tip and the plunger and bushing assembly to provide the correct output.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

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

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

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

12252

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	(lb–ft)	(lb–in)	(N•m)
Control Tube Bracket Bolts	1/4–20	10–12		14–16
Governor Weight Shaft Bearing Retaining Bolt	5/16–24	15–19		20–26
Variable Speed Spring Lever Set Screw	5/16–24	12–15		16–20
Air Inlet Housing Adaptor–to–Blower Housing Bolt	3/8–16	16–20		22–27
Air Inlet Housing–to–Adaptor Bolt	3/8–16	16–20		22–27
Injector Clamp Bolt	3/8–16	20–25		27–34
•Fuel pipe nut (Endurion® coated)	3/8–24		130 lb–in	14.69
•Fuel pipe nut (uncoated)	3/8–24		160 lb–in	18.3
•Fuel pipe nut (load limiting device)	3/8–24		160 lb–in	18.3
•Fuel pipe nut (Jacobs Brake)	3/8–24		120 lb–in	13.6
Blower End Plate–to–Cylinder Block Bolts	7/16–24	40–45		54–61
*Rocker Arm Bracket Bolts	1/2–13	90–100		122–136
Injector Filter Caps	5/8–24	65–75		88–102
Injector Nut	15/16–24	75–85		102–115

*75–85 lb–ft (102–115 N•m) torque on the two bolts attaching a load limit or power control screw bracket (if used) to the rocker arm shaft brackets.

SERVICE TOOLS

TOOL NAME	TOOL NO.
INJECTOR	
Buffing Wheel (brass wire)	J 7944
Fuel Pipe Socket	J 8932–B
Fuel System Primer	J 5956
Injector Auxiliary Tester	J 22640–A
Injector Body Reamer	J 21089
Injector Calibrator	J 22410
Injector Carbon Remover Set	J 9418
Injector Holding Fixture	J 22396
Injector Nut Seal Ring Installer	J 29197
Injector Service Tool Set	J 23435–C
Body Brush	J 8152
Nut Socket Wrench	J 4983–01
Rack Hole Brush	J 8150
Spray Hole Cleaner Vise	J 4298–1
Spray Tip Carbon Remover (High Sack)	J 9464–01
Spray Tip Carbon Remover (Low Sack)	J 24838
Spray Tip Driver and Bushing Cleaner	J 129101
Wire Sharpening Stone	J 8170
Injector Tag Remover and Installer	J 24767
Injector Test Oil (5, 10, 30 and 55 gal.)	J 26400
Injector Tester	J 23010–B
DDEC Injector Adapter Kit	J 23010–500
Lapping Block Set	J 22090–A
Master Injector Calibrating Kit	J 35369
Neddle Valve Lift Gage	J 9462–02
Polishing Compound	J 23038
Polishing Stick Set	J 22964
Spray Tip Cleaning Wire (.007" dia. holes)	J 21462–01
Spray Tip Flow Gage	J 25600–B
Field Modification Kit	J 25600–103
Spring Tester	J 29196
Tip Conc. Gage & Rack Freeness Tester	J 29584
INJECTOR TUBE	
Cylinder Head Holding Plate Set	J 3087–01
Cylinder Liner Depth Gage	J 22273–01
Injector Protrusion Gage	J 25521
Injector Tube Service Tool Set	J 22525–B
Injector Tube Swaging Tool	J 28611–A

TOOL NAME	TOOL NO.
FUEL PUMP	
Fuel Pump Tool Set	J 1508–E
Fuel Pump Wrench	J 4242
Fuel System Primer	J 5956
MECHANICAL GOVERNOR	
Control Link Operating Lever Bearing Remover and Installer	J 8985
Governor Cover Bearing Installer	J 21068
Governor Cover Bearing Remover and Installer	J 21967–01
High Speed Spring Retainer and Installer	J 5345–12
Governor Weight Shaft Retaining Ring Installer	J 36840