

VARIABLE SPEED MECHANICAL GOVERNOR (ENCLOSED LINKAGE)

IN-LINE ENGINES

The variable speed mechanical governor, illustrated in Fig. 1, performs the following 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 single-weight governor is mounted on the rear end plate of the engine and is driven by a gear that extends through the end plate and meshes with either the camshaft gear or the balance shaft gear, depending upon the engine model.

Operation

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

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

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

A fuel rod, connected to the differential lever and 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 the tension on the variable speed spring in the low speed range.

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

Adjustment of the governor is covered in Section 14.

Lubrication

The governor is lubricated by oil splash from the engine gear train and by an oil line on current engines. Also, to provide increased lubrication to the governor, an oil line has been added between the control housing and the weight housing on current engines. The oil passes through the governor weight

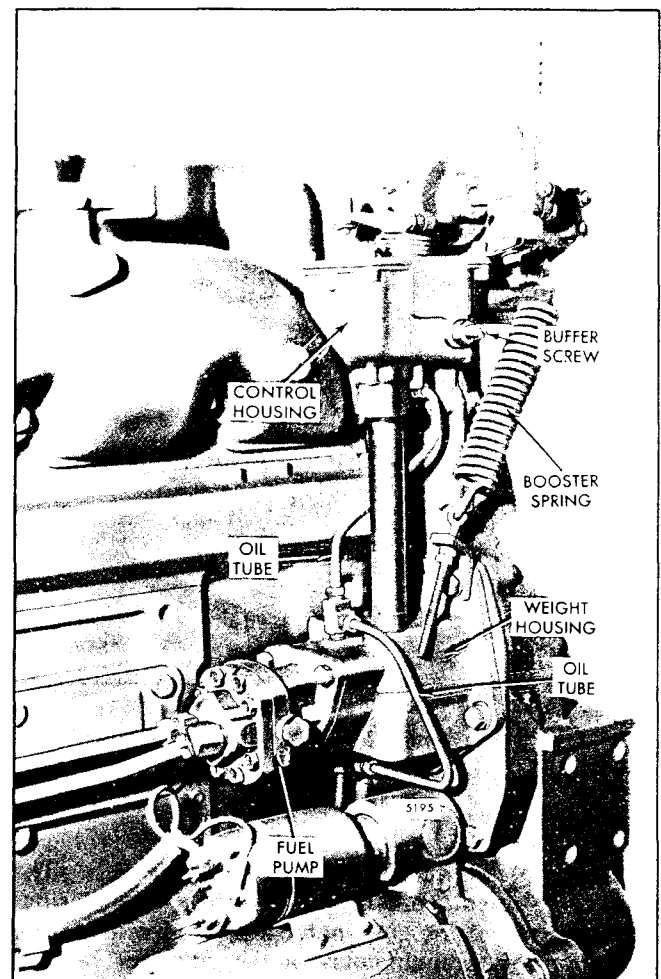


Fig. 1 - Governor Mounting

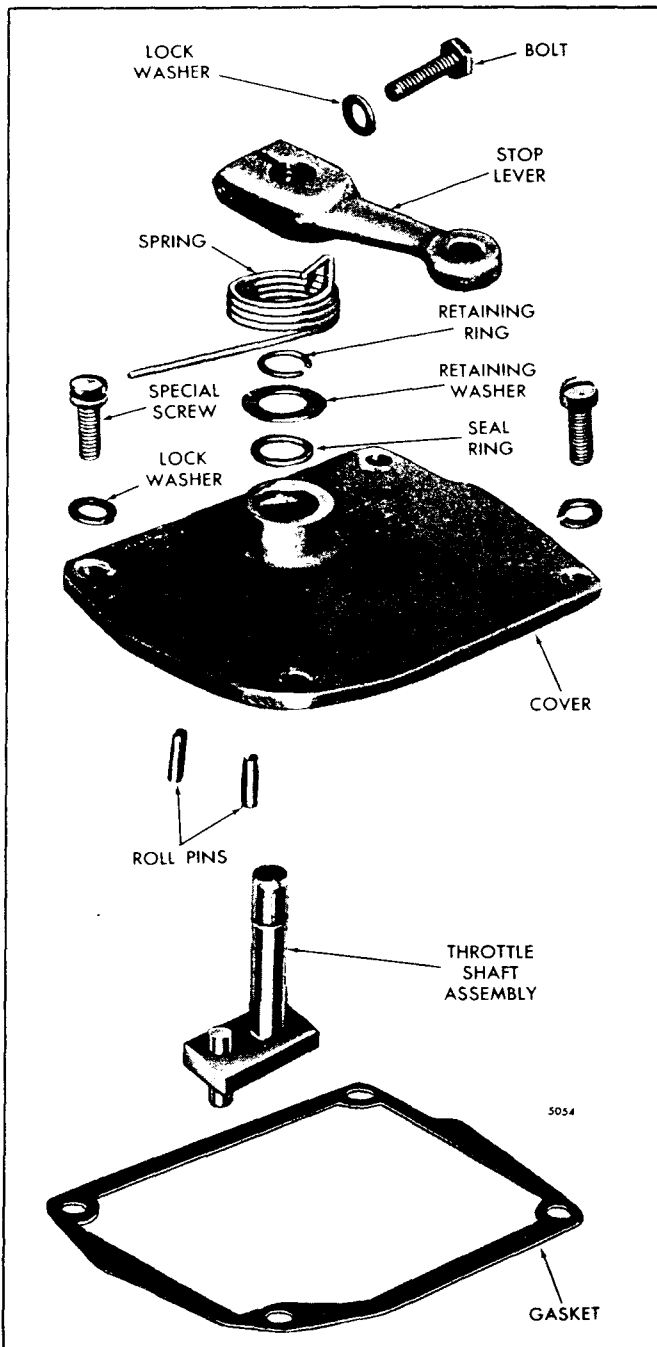


Fig. 2 - Governor Cover Details and Relative Location of Parts

housing to the shaft and weight assembly. The revolving weights distribute the oil to the various moving parts of the governor. Surplus oil drains from the governor through holes in the governor bearing retainer back to the engine gear train.

Remove Governor From Engine

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

Refer to Fig. 1 and remove the governor as follows:

1. Disconnect the throttle rod and the booster spring from the speed control lever.
2. Disconnect the retaining spring from the stop lever. Also disconnect any linkage attached to the stop lever.
3. Remove the lever retaining spring, governor cover and gasket from the governor housing.
4. Withdraw the two retaining bolts and lock washers and remove the variable speed spring housing and lever assembly and the gasket.
5. Remove the spring plunger, variable speed spring, stops, shims and spring retainer.
6. Loosen the hose clamps between the governor and the cylinder head.
7. Clean and remove the valve rocker cover.
8. Disconnect the fuel rod from the injector control tube lever.
9. Disconnect the fuel lines from the fuel pump. Then remove the fuel pump from the governor weight housing.
10. Disconnect the lubricating oil tube, if used, from the cylinder block and the governor weight housing.
11. Withdraw the five bolts from the weight housing and the two bolts from the control housing, then remove the governor and the gaskets from the engine.
12. Remove the fuel rod from the differential lever.

Disassemble Governor Cover

1. Loosen the clamping bolt and remove the stop lever from the shaft. Remove the lever retracting spring.
2. Remove the return spring from the underside of the cover (early governors).
3. Remove the retaining ring and seal retaining washer. Withdraw the throttle shaft (Fig. 2) from the cover.

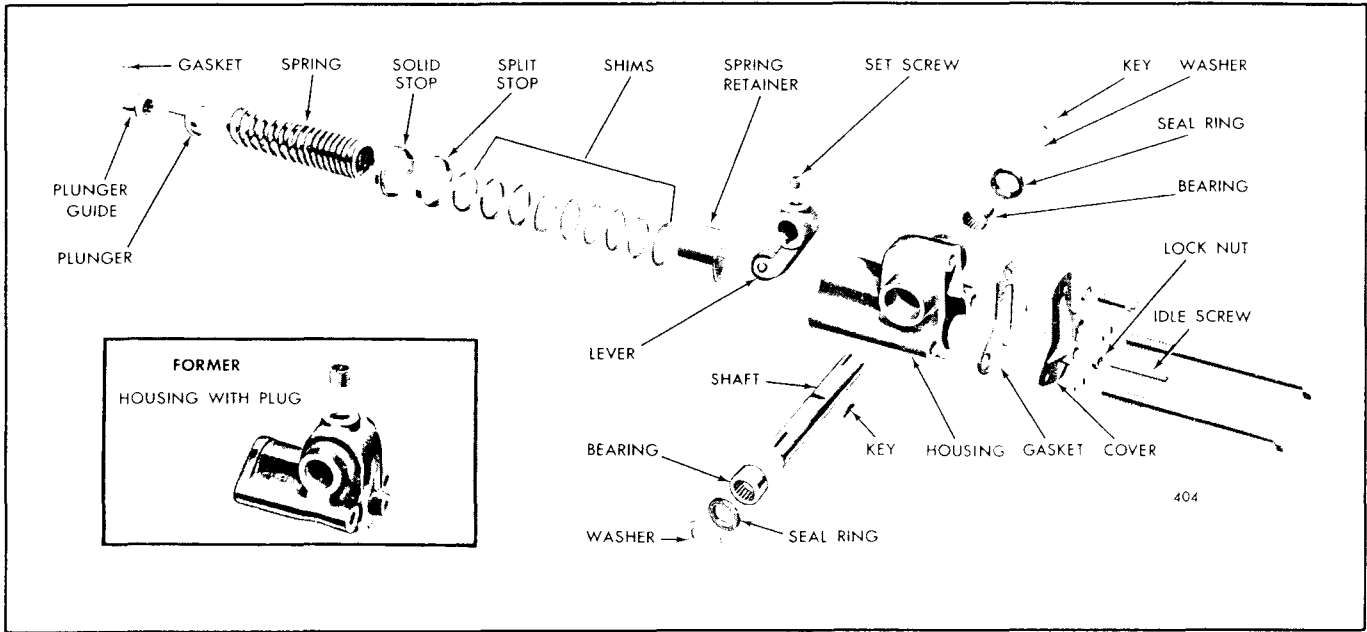


Fig. 3 - Variable Speed Spring Housing and Relative Location of Parts

4. Remove the seal ring from the cover.

Disassemble Governor Spring Housing

If the bearings or lever require replacement, disassemble the spring housing as follows:

1. Loosen the clamp bolt and remove the speed control lever from the shaft. Remove the Woodruff key.
2. Loosen the clamp bolt and remove the booster spring lever, if used. Remove the Woodruff key.
3. Remove the plain washer and seal ring. If a booster

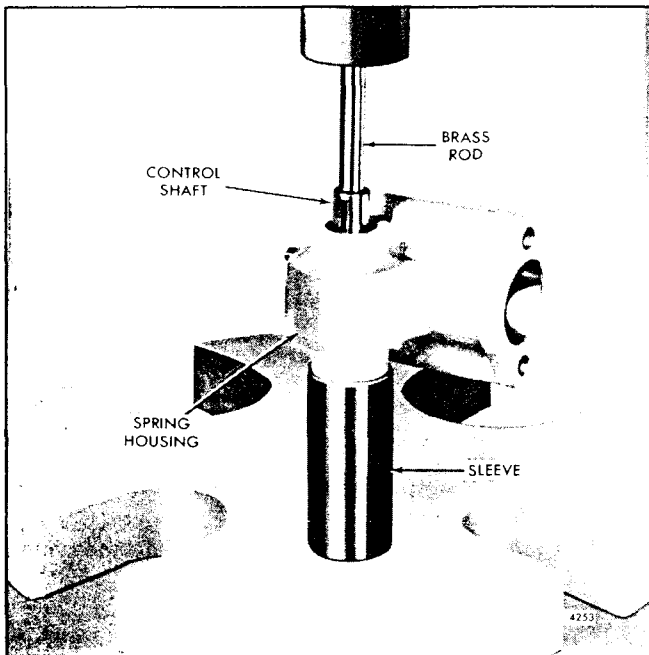


Fig. 4 - Removing Shaft and Bearing from Spring Housing

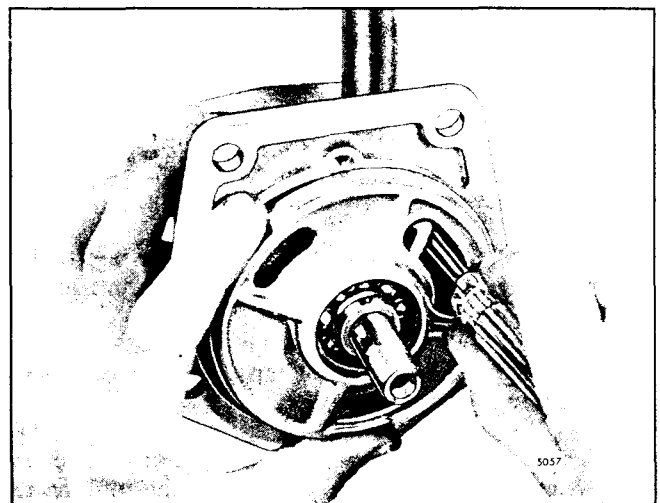


Fig. 5 - Removing or Installing Operating Shaft Fork

spring lever is used, a washer and seal ring is used at each end of the shaft (Fig. 3).

4. On current governors, remove one screw and lock washer and remove the spring housing cover and gasket. Then remove the set screw from the spring lever.

On former governors, remove the pipe plug from the housing and, working through the opening, remove the set screw from the spring lever.

5. Support the spring housing in an arbor press. Use a brass rod to press the shaft, bearing and plug (if used) from the housing (Fig. 4).

6. Remove the spring lever.

7. Press the second bearing from the housing.

Disassemble Control Housing

1. Remove the governor drive gear retaining nut. Then remove the gear, key and spacer from the shaft.

2. Remove the small flat head screw (Fig. 7) which holds the bearing retainer in place.

3. Turn the bearing retainer until the large opening is centered over the fork on the governor operating shaft (Fig. 5).

4. Lift up on the weight shaft to provide clearance for a $5/16$ " electrician's socket wrench. Then remove the two retaining screws and washers and withdraw the governor operating fork.

5. Remove the shaft and weight assembly from the governor weight housing.

6. Remove the buffer screw and lock nut.

7. Remove the upper bearing retaining screw and washer and withdraw the operating shaft and lever assembly from the governor control housing.

8. Insert a rod (approximately 18 " long) in the control housing and knock the plug from the bottom of the weight housing.

9. Remove the snap ring and tap the lower operating shaft bearing from the housing.

10. Remove the spring pin and washer from the pin in the operating shaft lever, then remove the differential lever.

11. If necessary, press the bearing and operating shaft lever from the operating shaft.

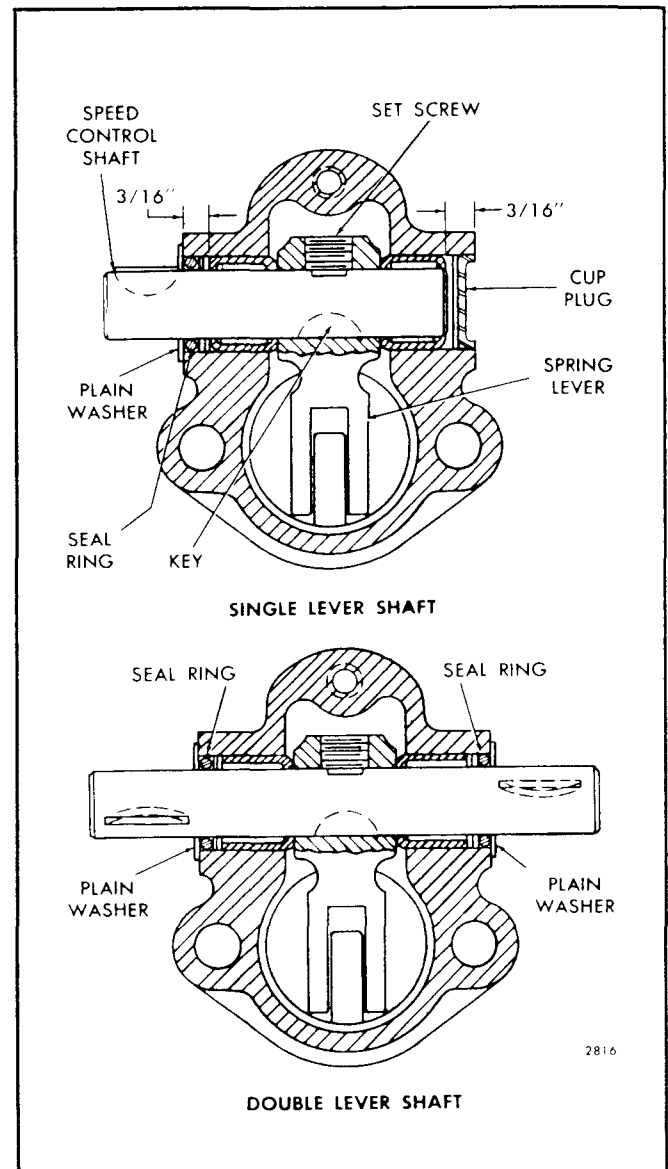


Fig. 6 - Governor Variable Speed Spring Housing

12. If necessary, disassemble the control housing from the weight housing.

Disassemble Weight Shaft Assembly

1. Press the bearing retainer (Fig. 7) from the weight shaft.

2. If necessary, remove the snap ring and press the bearing from the retainer.

3. Remove the weight pin retainers and drive the pins out of the carrier and weights. Remove the weights.

NOTE: The weight pin hole in the carrier is larger at the side where the pin retainers are located.

4. Slide the riser and bearing assembly from the shaft. Do not attempt to remove the bearing since the riser and bearing are serviced only as an assembly.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

Inspect all of the governor components and replace worn or damaged parts.

The governor cover and throttle shaft have been revised to eliminate the shaft return spring formerly located beneath the cover. An external stop lever retracting spring is used on current governor assemblies. If the cover is to be replaced, install a new current cover and lever assembly and the new spring.

Revolve the ball bearings slowly by hand. Replace bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

The lower governor drive components have been revised to reduce the clearance between the riser and the weight shaft. With this change, additional lubrication is provided to the governor by an oil tube connected between the oil gallery in the cylinder block and the governor weight housing. When replacing the riser assembly, shaft and carrier assembly or the complete governor assembly, the new oil tube must be installed to provide adequate lubrication.

Current engines have an oil line extending from the weight housing to the control housing to provide increased lubrication for the governor components. When replacing a control housing on a former governor, it will be necessary to include the oil line and fittings or the tapped hole in the housing must be plugged. Also the buffer screw assembly with the "Perma-tite" lock nut and the copper washers for the spring housing attaching bolts must be used.

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

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

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

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

Examine the variable speed spring lever roller and pin for excessive wear. The current 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. The former ball type bearing (with two washers) rides on a soft bearing pin that is swaged at both ends to retain the bearing in the spring lever.

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.

The current variable speed spring plunger guide incorporates a replaceable bushing.

Assemble Governor Cover

1. Lubricate the throttle shaft with engine oil and slide the shaft through the cover, with the pin in the shaft located between the roll pins in the underside of the cover.

2. Install a new seal ring in the counterbore at the top of the cover. Place the seal retaining washer (Fig. 2) over the shaft and lock the shaft in place with the retaining ring.

3. If a torsion-type stop lever retracting spring (Fig. 2) is used, place it over the cover hub with the hooked end up. Then place the stop lever on the shaft and tighten the clamping bolt.

NOTE: The lever retracting spring on early governors was located on the underside of the governor cover and worked against a pin in the throttle shaft assembly. On later governors, the retracting spring is located on top of the cover, connected between the stop lever and a bracket on the cover.

Assemble Governor Spring Housing

1. 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.

2. 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.

NOTE: Do not use impact tools to install needle bearings.

3. 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. 8, then press the bearing in the housing until the shoulder on the installer contacts the housing.

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

4. Install the current roller type bearing and pin in the spring lever. Press the pin below the surface of the lever and stake it at three places on both sides of the lever. The former ball-type bearing (with two washers) is swaged at both ends to retain the bearing in the spring lever.

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

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

7. Insert the correct end of the, single or double lever type, speed control lever shaft (Fig. 6) 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.

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

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

10. 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. 8, then press the bearing in the housing until the shoulder on the installer contacts the housing.

11. If a single lever shaft was installed in the spring housing, apply a thin coat of sealing compound to the outside diameter of a new cup plug. Start the 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 plug in flush with the outside face of the housing.

12. Clamp the spring housing assembly in a bench vise equipped with soft jaws. Then tighten the spring lever retaining set screw to 12-15 lb-ft torque.

13. Stake the edge of the 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 on former governors.

14. 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.

15. 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.

16. Place the speed control lever 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.

Assemble Control Housing

1. If necessary, assemble the control housing to the weight housing using a good quality sealant between the tube and the housings.

2. Install the lower governor operating shaft bearing, with the number side facing out, in the weight housing (Fig. 9). Install the snap ring to secure the bearing. Lubricate the bearing with engine oil.

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

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

5. Place the operating shaft lever on the shaft with the flat on the shaft registering with the flat in the lever. Press the lever tight against the bearing.

6. Lubricate the bearing with engine oil. Insert the lever and shaft assembly in the control housing and guide the lower end of the shaft into the bearing in the weight housing.

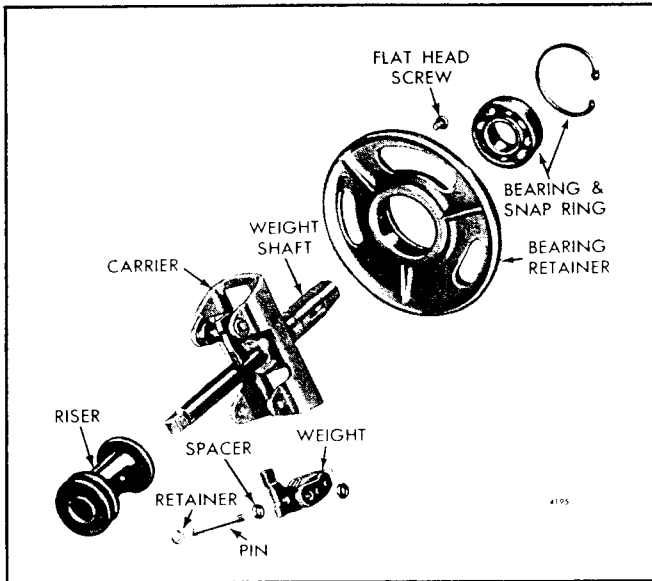


Fig. 7 - Governor Weight Details and Relative Location of Parts

7. Install the upper bearing retaining screw and washers.

8. Place the fork against the operating shaft, with the two cam faces of the fork facing away from the governor weights. Thread the fork attaching screws in approximately two or three turns. The screws are to be tightened after the weight and shaft assembly is installed.

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

10. Install the buffer screw and lock nut, leaving approximately .750" of the screw extending from the governor housing.

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

Assemble Weight and Shaft Assembly

1. If the weight carrier was removed from the weight shaft, press the carrier on the shaft so as to allow a clearance of .001" to .006" between the shaft shoulder and the rear face of the weight carrier.

2. Press the bearing (Fig. 7) in the retainer (press on the outer race). Then install the snap ring, with the flat side of the ring facing the bearing.

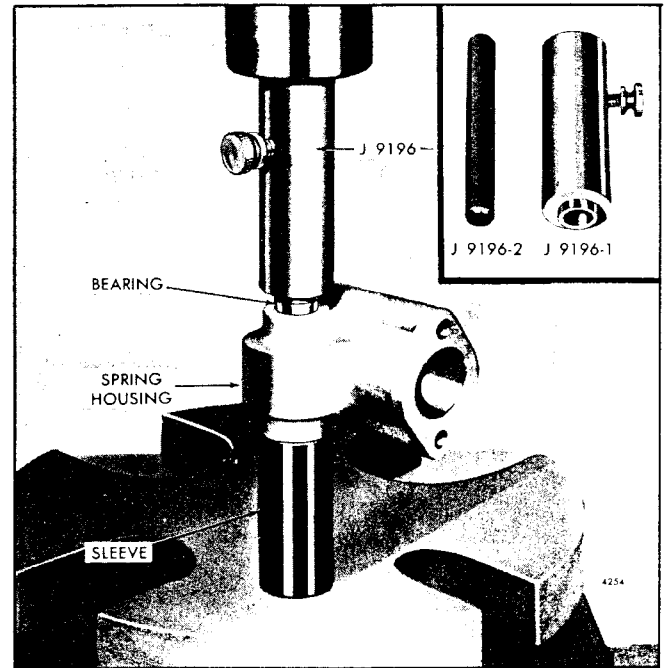


Fig. 8 - Installing Speed Control Shaft Bearings in Spring Housing

3. Press the bearing and retainer assembly on the shaft until the bearing contacts the shoulder on the shaft.

NOTE: Press on the inner race of the bearing.

4. Lubricate the shaft with clean engine oil. Then slide the riser and bearing assembly on the shaft.

5. Secure the weights to the carrier as follows:

a. Position one of the weights in the carrier. If the current steel carrier is used, place a spacer on each side of the weight.

b. Insert the serrated end of the weight pin through the larger opening in the carrier and through the weight and spacers. Then drive the pin into the smaller opening in the carrier.

c. Install a retainer in the groove of the pin.

d. Install the second weight in the same manner.

6. Slide the shaft and weight assembly into the weight housing, with the riser bearing positioned behind the operating fork.

7. Turn the bearing retainer until the large opening is over the fork on the operating shaft. Then tighten the two fork attaching screws with a 5/16" electrician's socket wrench (Fig. 5).

- d. Insert the solid stop in the counterbore of the governor housing.
 - e. Lubricate the outside diameter of the spring retainer with engine oil and insert it, solid end first, in 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 split stop in the spring housing approximately $1/16$ " from the finished face of the housing.

NOTE: Do not use shims with an $11/32$ " I.D. with a spring retainer which has only one air bleed hole. Shims with a $3/4$ " I.D. may be used with a spring retainer which has either one or three air bleed holes (provided only one spring is used).
 - g. Insert the variable speed spring in the spring retainer with the tightly wound end of the spring against the shims.
 - h. On former governors, insert two bolts (with lock washers) through the spring housing (through the spring housing cover and spring housing on current governors) and place a new gasket over the bolts and against the housing. On current governors, use copper washers with the two attaching bolts.
 - i. Place the spring housing in position against the governor housing, with the spring over the end of the spring plunger inside of the governor housing.
 - j. Thread the two spring housing retaining bolts into the governor housing and tighten them to 13-17 lb-ft torque.
 - k. Install the idle speed adjusting screw and lock nut in the spring housing (former governors) or in the spring housing cover (current governors). Then thread the idle speed adjusting screw in approximately 1 ".
10. Place a new gasket on the governor housing, then install the governor cover and lever assembly. Be sure the pin in the throttle shaft enters the slot in the differential lever. Secure the cover to the governor with four screws and lock washers.
- NOTE:** If a torsion-type stop lever spring (Fig. 2) is used, a special cover screw is used to hold the spring in place. If a long coil spring is used, the spring retaining bracket is held in place by one of the standard cover retaining screws.
11. Hook the stop lever spring to the lever and to the spring retaining bracket or the special cover screw.
 12. Install the fuel pump and fuel lines.
 13. Perform an engine tune-up as outlined in Section 14.

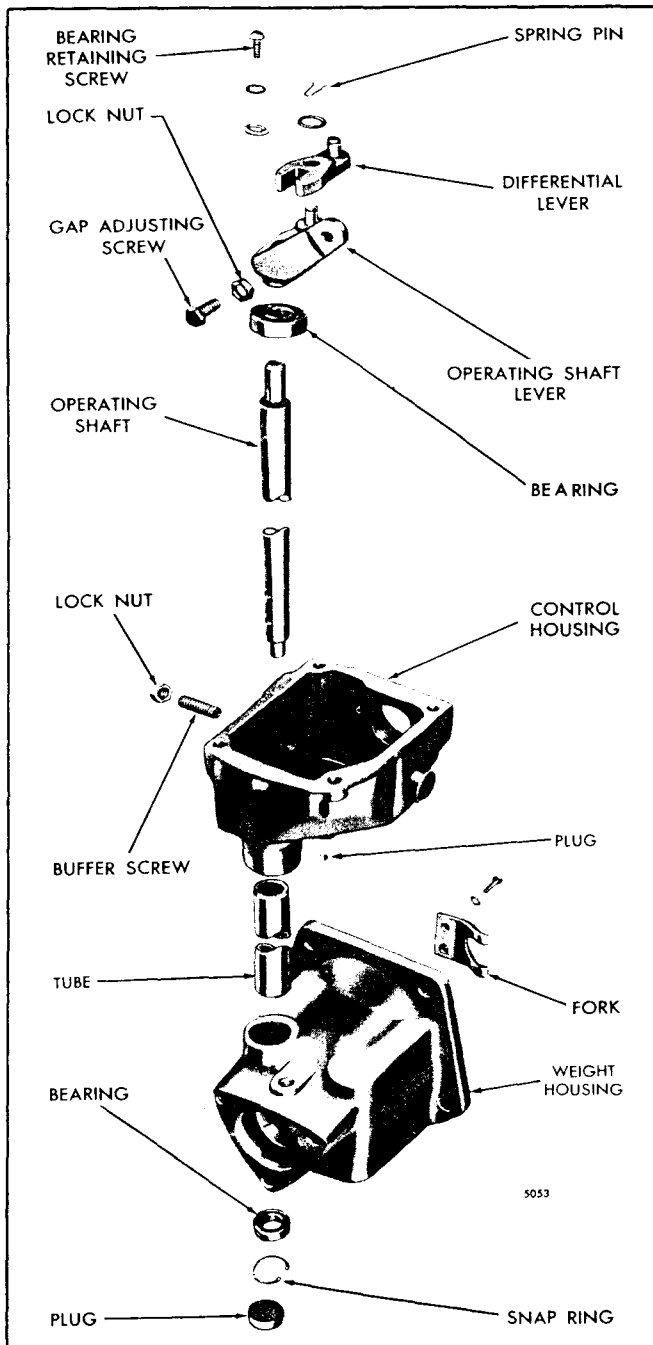


Fig. 9 - Governor Housing and Relative Location of Parts

8. Turn the bearing retainer until the counterbored notch above the large opening in the retainer and the tapped hole in the housing are aligned. Secure the bearing retainer to the housing with a flat head screw.

9. Place the governor drive gear spacer on the shaft. Install the key and start the gear on the shaft.

10. Tap the gear until the gear and spacer contact the inner race of the weight shaft bearing.

11. Install the gear retaining nut and tighten it to 125-135 lb-ft torque.

Install Governor

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

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

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

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

4. Install the three 12-point head bolts with copper washers in the governor weight housing next to the cylinder block. Install the two remaining bolts with steel washers and lock washers. Tighten the bolts to 35 lb-ft torque.

5. Install the two governor control housing attaching bolts and lock washers. Tighten the bolts to 10-12 lb-ft torque.

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

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

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

9. Refer to Fig. 3 and attach the variable speed spring and housing to the governor as follows:

a. On current governors, use a new gasket and attach the spring housing cover to the spring housing with a screw and a lock washer.

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.

VARIABLE SPEED MECHANICAL GOVERNOR (Pierce)

IN-LINE TRACTOR ENGINE

The variable speed mechanical governor (Fig. 1) performs 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 governor is mounted on the rear end plate of the engine and is driven by a gear that extends through the end plate and meshes with the balance shaft gear.

Lubrication

The governor is lubricated by oil splash, from the engine gear train, that passes through the bearing housing to the governor flyweight assembly. The oil is distributed to the various moving parts within the governor by the revolving flyweights.

Surplus oil drains from the governor assembly through holes in the governor bearing housing, back to the engine crankcase.

Operation

The governor flyweights (7), shown in Fig. 2, are mounted on the spider and shaft assembly (10) and driven by the governor drive gear (46). This gear is pressed on the spider and shaft assembly and is driven by the engine gear train. A shoulder on the flyweights bears against the riser (6), that transmits the motion of the flyweights through the riser thrust bearing (5) to the operating fork (3). The operating fork is attached to the rocker shaft (24), that rides in ball bearings (19 and 20), and transmits the motion of the flyweights to the rocker shaft lever (27). The rocker shaft lever is pinned to the rocker shaft. The rocker shaft lever is connected to the speed adjusting spring (39) that is, in turn, connected to the governor speed control lever (49). The governor speed control lever is bolted to the governor and is controlled by the engine operator when establishing the desired speed of the unit. The idle (36) and maximum (37) speed adjusting screws limit the travel of the governor speed control lever and thus the minimum and maximum engine speed settings. The linkage operating the injector fuel racks is attached to the rocker shaft lever. Movement of the rocker shaft lever increases or decreases the amount of

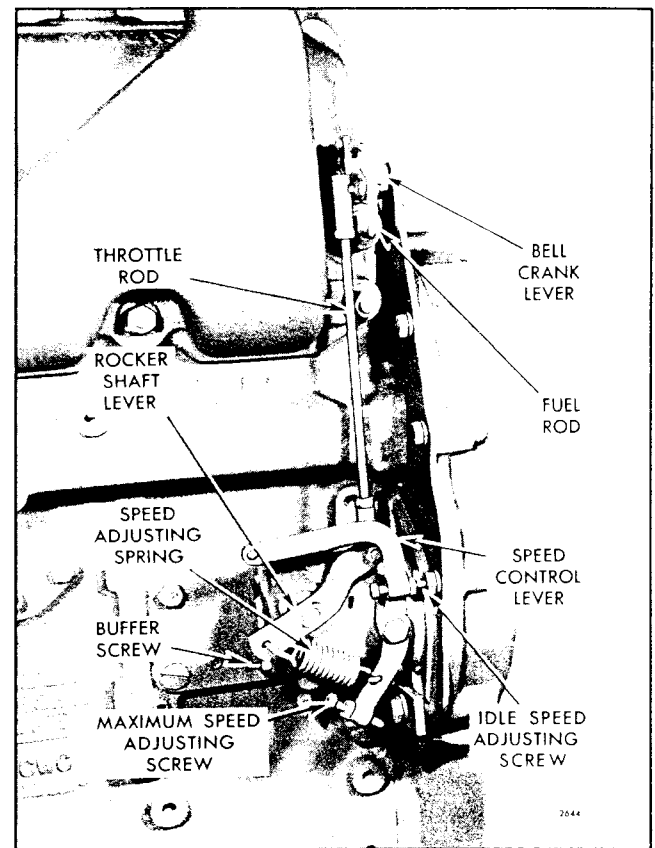


Fig. 1 - Governor Mounted on Engine

fuel delivered by the injectors to the engine. A governor buffer screw and spring assembly (42) is mounted in the governor body. The buffer screw and spring assembly bears against the operating fork and is used to stabilize engine operation at idle speed.

When the governor speed control lever is moved to an increased speed position, the tension on the speed adjusting spring is increased. The force resulting from the increased spring tension is transmitted to the rocker shaft lever and control linkage which advances the injector racks. Engine speed increases, as a result of the increased fuel, until the governor flyweight force is sufficient to balance the increased spring tension. The flyweights then move against the spring and reduce the injector rack fuel setting to an amount sufficient to maintain the higher engine speed setting.

If the governor speed control lever is moved to a decreased speed position, the tension on the speed adjusting spring will decrease and the governor

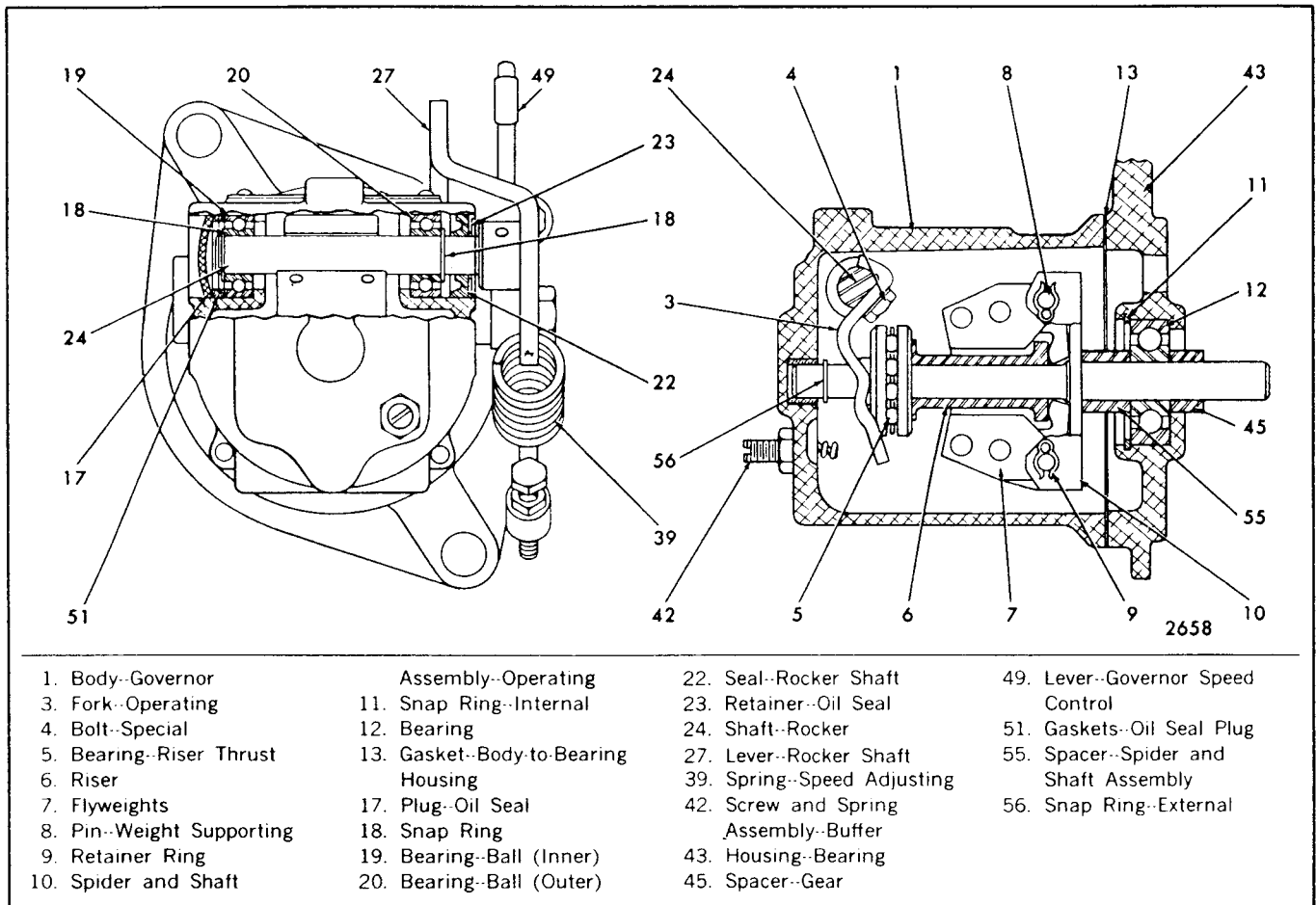


Fig. 2 - Cross-Section of Governor

flyweights will overcome the spring tension and move the rocker shaft lever to a decreased fuel position. The engine speed will be reduced until the force of the governor flyweights equals the tension of the speed adjusting spring. The engine will then operate at the desired reduced speed.

Remove Governor from Engine

The governor is mounted on the engine rear end plate as shown in Fig. 1 and is retained by two bolts. After removing the dirt from around the governor and the engine end plate, remove the governor as follows:

1. Disconnect the linkage to the governor speed control lever.
2. Disconnect the throttle rod at the rocker shaft lever.
3. Remove the two retaining bolts and withdraw the governor from the engine.

Disassemble Governor

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

Inspect for worn or damaged parts that can be repaired or replaced without complete disassembly. Refer to Fig. 2 and 3 and disassemble the governor as follows:

1. Remove the four countersunk screws (44) which retain the bearing housing (43) to the governor body and withdraw the housing. Remove the bearing housing gasket (13). The governor drive gear (46), spider and shaft assembly (10), riser (6) and three-piece thrust bearing (5) will be removed with the bearing housing.
2. Remove the thrust bearing outer race and the ball assembly (5) from the riser (6).
3. Remove the external snap ring (56) and riser (6) from the spider and shaft assembly (10).

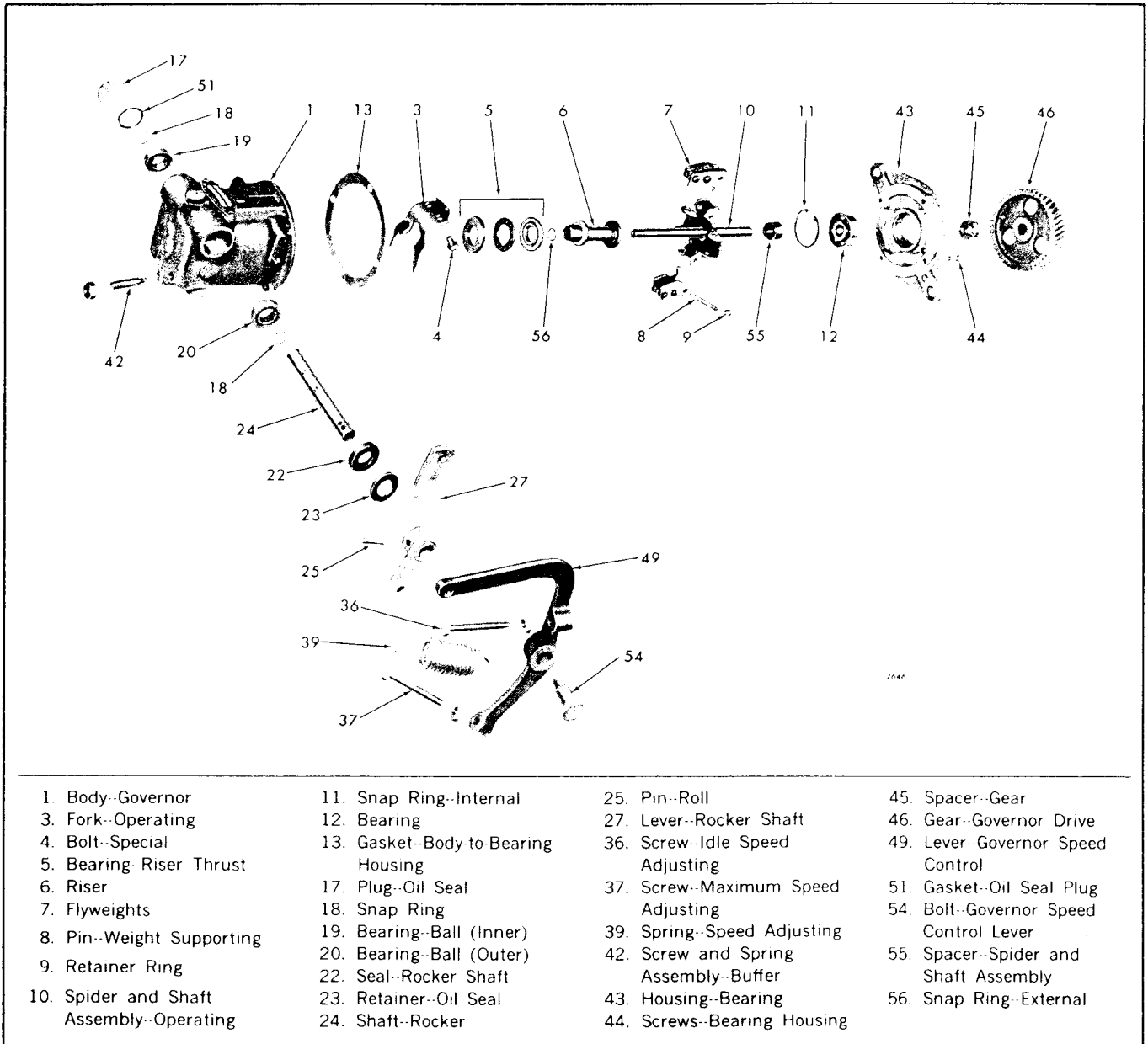


Fig. 3 - Governor Details and Relative Location of Parts

4. Carefully support the thrust bearing inner race (5) in an arbor press and gently press the riser (6) from the inner race.

5. Remove the hair pin clips or retaining rings (9) which secure the flyweights (7) on the supporting pins (8). Then gently tap out the supporting pins with a suitable punch and remove the flyweights.

6. Place the drive gear (46), bearing housing (43) and the spider and shaft assembly (10) in an arbor press, using split plates under the gear. Then press the drive gear from the shaft, using a brass rod between the ram and the shaft.

7. Remove the gear spacer (45) from the spider and shaft assembly (10).

8. Remove the spider and shaft assembly (10) from the bearing (12) and bearing housing (43); then, remove the spacer (55).

9. Remove the internal snap ring (11) which retains the bearing (12) in the bearing housing (43). Then separate the bearing from the bearing housing.

NOTE: The bearing is a light press fit in the housing.

10. Remove the bolt (54) which retains the governor speed control lever (49) to the governor body. Remove the speed adjusting spring (39) and the speed control lever.

11. If desired, the idle (36) and maximum (37) speed adjusting screws can be removed from the speed control lever at this time.

12. If desired, remove the buffer screw and spring assembly (42).

13. Remove the operating fork (3) by removing the two special bolts (4) and lock washers which retain it to the rocker shaft (24).

14. Remove the oil seal plug (17) by driving lightly with a small punch at the lower edge of the plug, thus forcing the upper edge outward. Then place a screw driver behind the plug and remove the plug. Remove the two oil seal plug gaskets (51).

NOTE: If necessary, use a chisel and cut a slot in the center of the plug; then, using a screw driver, pry the plug from the housing.

15. Remove the bearing retaining snap ring (18) from the rocker shaft (24). Then tap the rocker shaft lightly to withdraw it from the governor body.

16. Remove the inner bearing (19) from the governor body.

17. Remove the outer bearing (20) from the rocker shaft.

18. Remove the external snap ring from the rocker shaft and remove the oil seal (22) and oil seal retainer (23).

19. If desired, remove the rocker shaft lever (27) from the rocker shaft by driving out the roll pin (25) and tapping the shaft gently to facilitate removal.

Inspection

After the governor has been disassembled, thoroughly clean all of the parts in fuel oil and dry them with compressed air.

Inspect the rocker shaft bearings for excessive wear. Replace the bearings if necessary.

Inspect the bushings in the governor housing for wear. Replace the bushings if they are worn.

Inspect the rubber oil seal on the governor rocker shaft. The slightest wear on this part can cause oil

leakage. It is recommended that a new oil seal be installed when the governor is overhauled.

Inspect all of the retaining snap rings to determine if they have been damaged at the time of disassembly. Replace them if necessary.

Inspect the riser bearing surface of the flyweights for excessive wear or flat spots. If either condition exists, new flyweights must be installed. The flyweights must work freely on the supporting pins for satisfactory governor operation.

Inspect the governor operating fork for excessive wear or distortion. If either condition exists, replace the fork.

Inspect the teeth of the drive gear for signs of wear. Also examine the engine gear train. Replace any defective gears.

Inspect the spider and shaft assembly at the bushing and bearing surfaces and at the drive gear surface. Replace the shaft if it is damaged or worn.

Assemble Governor

After all of the parts have been cleaned and inspected, refer to Figs. 2 and 3 and assemble the governor as follows:

1. If removed, install the rocker shaft lever (27) on the rocker shaft (24) and secure it in place with a roll pin (25).

2. Install the oil seal retainer (23) with the lip of the retainer facing the rocker shaft lever. Install the oil seal (22) with the lip of the seal facing away from the lever.

3. Install the external snap ring (18) on the rocker shaft. Then install the outer bearing (20) with the numbered side facing the rocker shaft.

4. Slide the rocker shaft, bearing and oil seal assembly into the governor body and tap the seal retainer in flush with the bearing bore.

NOTE: Carefully slide the outer edge of the rocker shaft oil seal into the governor body.

5. Install the inner bearing (19) in the bearing bore of the governor body and onto the rocker shaft (24). Secure the inner bearing with an external snap ring (18).

6. Install two new gaskets (51) and the oil retaining plug (17).

7. Install the operating fork (3) on the rocker shaft and secure it with two special bolts (4) and lock washers.
8. Install the buffer screw and spring assembly (42) and the lock nut.
9. Attach the speed adjusting spring (39) to the rocker shaft lever (27) and to the governor speed control lever (49). Then install the speed control lever on the governor with a bolt (54).
10. Install the speed adjusting screws (36) and (37) and lock nuts.
11. Install the bearing (12) in the bearing housing (43). Press against the outer race only. Secure the bearing in place with a snap ring (11).
12. If the spider was removed from the weight shaft, press the spider on the shaft so as to allow a clearance of .001" to .006" between the shaft shoulder and the rear face of the spider.
13. Slide the spacer (55), bearing (12) and gear spacer (45) on the spider and shaft assembly.
14. Support the governor drive gear on an arbor press; then, press the spider and shaft assembly (10) into the drive gear (46) until the gear bottoms the spacer against the bearing (12).
15. Install the flyweights (7) on the spider and shaft assembly with supporting pins (8). Install the hair pin clips or retainer rings (9) in the grooves of the supporting pins.

NOTE: When viewing the spider and shaft assembly from the gear end, the right support pin hole has a smaller inside diameter. The serrated end of the supporting pin is inserted through the larger diameter hole, through the weight, and driven into the smaller hole.

16. Support the inner race of the three-piece thrust bearing (5) on an arbor press and press the riser (6) into the bearing race until the race seats on the shoulder of the riser.
17. Slide the riser (6) on the spider and shaft assembly (10) until it rests against the shoulder of the flyweights (7) and install an external snap ring (56) on the shaft.
18. Install the ball assembly and outer race of the three-piece bearing (5) on the riser.
19. Install a new gasket (13) on the bearing housing and slide the shaft assembly and bearing housing into the governor body. The end of the shaft extends into the bushing in the governor body. Align the bearing housing with the governor body so the three slotted holes in the housing are toward the top of the governor. Install the counter sunk screws (44) to secure the bearing housing to the governor body.

Install Governor on Engine

1. Attach a new gasket to the governor mounting flange.
2. Install the governor against the end plate, so the teeth of the governor drive gear mesh with the teeth of the balance shaft gear. Install the two governor attaching bolts and lock washers. Tighten the 3/8" -24 bolt to 35-39 lb-ft torque and the 7/16" -14 bolt to 46-50 lb-ft torque.
3. Connect the throttle rod to the rocker shaft lever.
4. Perform an engine tune-up as outlined in Section 14.4.4.

VARIABLE SPEED MECHANICAL GOVERNOR (Open Linkage)

IN-LINE ENGINES

The variable speed open linkage governor (Fig. 1) performs the following 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 single-weight governor is mounted on the rear end plate of the engine and is driven by a gear that extends through the end plate and meshes with either the camshaft gear or the balance shaft gear, depending upon the engine model.

Operation

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

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser and the operating shaft to the operating shaft lever. Movement of this lever is transmitted to the stop lever which changes the fuel setting of the injector racks, since the fuel rod is connected between the stop lever and the injector control tube.

The centrifugal force of the governor weights is opposed by the variable speed spring which is fastened to the end of the operating shaft lever. Load changes or movement of the speed control lever momentarily creates an unbalanced force between the revolving weights and the tension on the spring. When the forces reach a balanced condition again, the engine speed will be stabilized for the new speed setting or new load.

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

Adjustment of the governor is covered in Section 14.4.2.

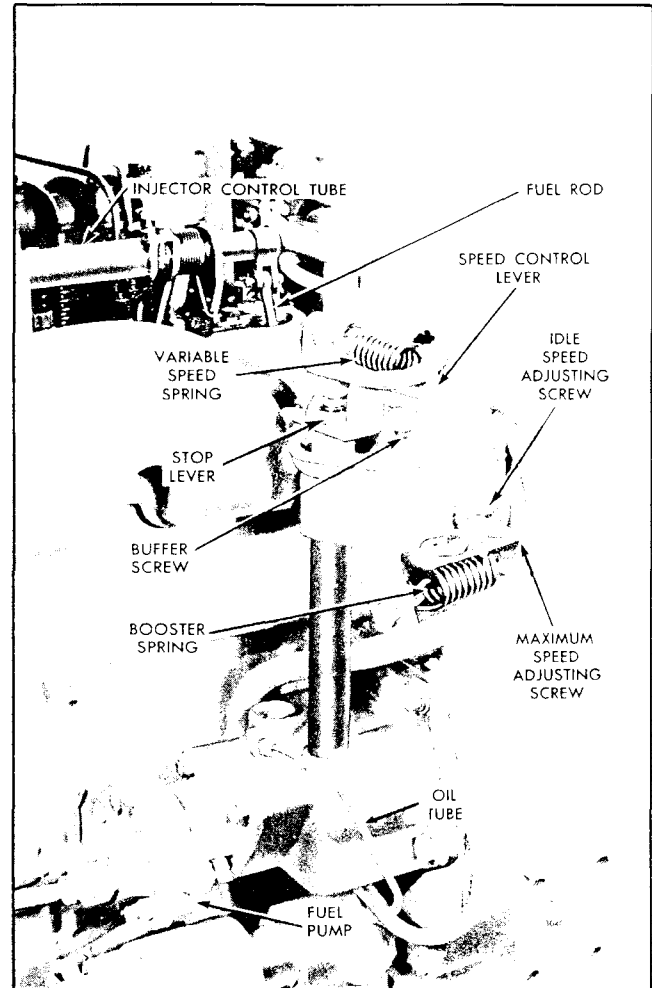


Fig. 1 - Variable Speed Open Linkage Governor Mounted on Engine

Lubrication

The governor is lubricated by oil splashed from the engine gear train. The oil passes through the governor weight housing to the shaft and weight assembly. The revolving weights distribute the oil to the various moving parts of the governor. The surplus oil drains back to the engine crankcase through holes in the governor bearing retainer.

The clearance between the riser tube and the weight shaft has been reduced with the use of current governor assemblies. To ensure adequate lubrication of the riser tube, an oil tube has been added between the oil gallery in the cylinder block and the top of the weight housing to supply oil under pressure.

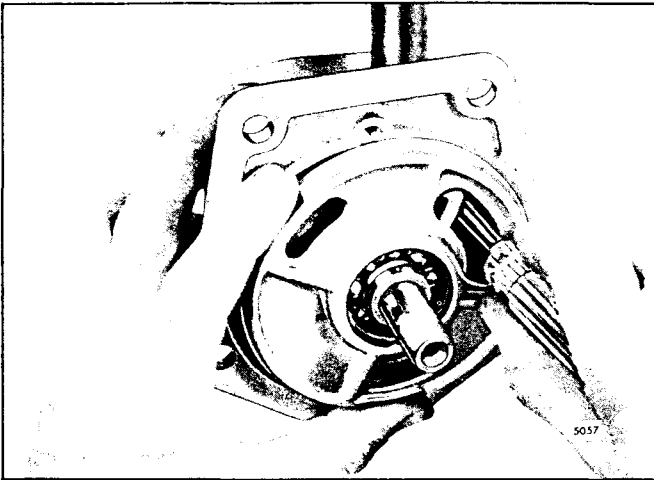


Fig. 2 - Removing or Installing Operating Shaft Fork

Remove Governor From Engine

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

Refer to Fig. 1 and remove the governor as follows:

1. Disconnect the fuel rod from the stop lever.
2. Disconnect the throttle control rod from the speed control lever.
3. Disconnect the fuel lines and remove the fuel pump from the governor weight housing.
4. Remove the governor lubricating oil tube, if used.
5. Withdraw the five bolts from the weight housing and the two bolts from the control housing; then, remove the governor and gasket from the engine.

Disassemble Weight Housing

1. Remove the governor drive gear retaining nut. Then remove the gear, key and spacer from the shaft.
2. Remove the small flat head screw (Fig. 3) which holds the bearing retainer in place.
3. Turn the bearing retainer until the large opening is centered over the fork on the governor operating shaft (Fig. 2).
4. Lift up on the weight shaft to provide clearance for a 5/16" electrician's socket wrench. Then remove the two retaining screws and washers and withdraw the governor operating fork.

5. Remove the shaft and weight assembly from the governor weight housing.

6. Inspect the bushing in the weight housing. If the bushing is worn or pitted, press it out of the housing and install a new bushing.

Disassemble Weight Shaft Assembly

1. Press the bearing retainer (Fig. 3) from the weight shaft.
2. If necessary, remove the snap ring and press the bearing from the retainer.
3. Remove the weight pin retainers and drive the pins out of the carrier and weights. Remove the weights.

NOTE: The weight pin hole in the carrier is larger at the side where the pin retainers are located.

4. Slide the riser and bearing assembly from the shaft. Do not attempt to remove the bearing since the riser and bearing are serviced only as an assembly.

Disassemble Control Housing

1. Remove the outer nut on the variable speed spring eye bolt. Then remove the spring and eye bolt.
2. Pry the plug from the bottom of the weight housing.
3. Remove the snap ring from the lower end of the operating shaft and tap the shaft and lever assembly out of the control housing.

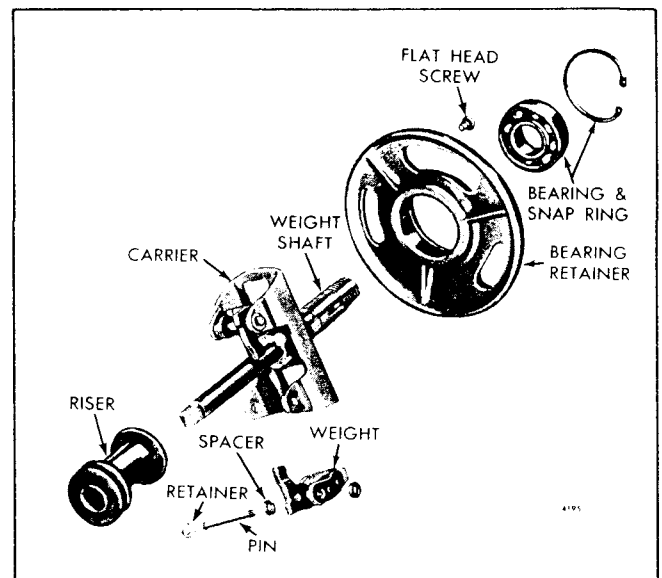


Fig. 3 - Governor Weight Details and Relative Location of Parts

4. Remove the snap ring and press the lower operating shaft bearing out of the weight housing.
5. Withdraw the outer nut and remove the booster spring and eye bolt.
6. Drive the pin from the speed control lever and remove the lever from the shaft.
7. Slide the shaft and booster spring bracket from the housing.
8. Remove the buffer screw.
9. Disengage the small spring between the operating shaft lever and the stop lever.
10. Remove the retaining ring and washer and lift the stop lever from the operating shaft.
11. Drive the pin from the operating shaft lever and remove the lever from the shaft.
12. Slide the bearing shield from the operating shaft.
13. Press the bearing from the operating shaft.

Inspection

Clean all of the parts (except the shielded upper operating shaft bearing) with fuel oil and dry them with compressed air.

Revolve the ball bearings slowly by hand. Replace bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

The lower governor drive components have been revised to reduce the clearance between the riser and the weight shaft. With this change, additional lubrication is provided to the governor by an oil tube connected between the oil gallery in the cylinder block and the governor weight housing. When replacing the riser assembly, shaft and carrier assembly, or the complete governor assembly, the new oil tube must be installed to provide adequate lubrication.

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

Inspect the weight carrier, weights and retaining pins for wear.

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

Inspect the bushings in the control housing. If they are worn, drive the bushings out and install new ones.

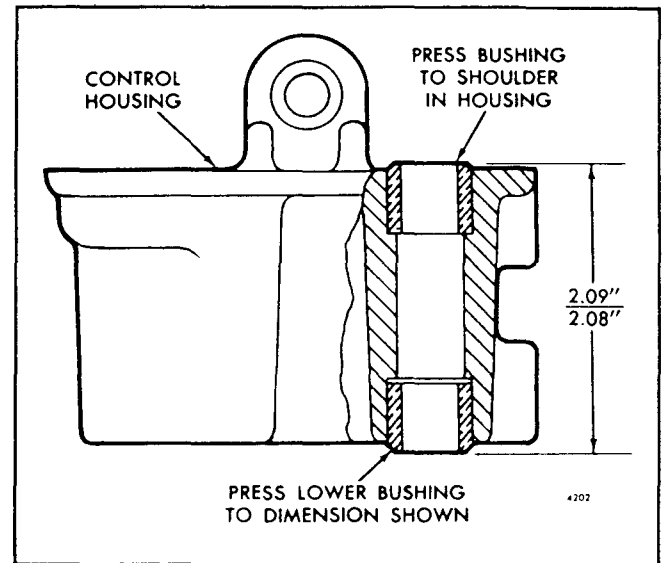


Fig. 4 - Bushings in Control Housing

Press the upper bushing in until it contacts the shoulder in the housing. Press the lower bushing to the dimension shown in Fig. 4.

Assemble Control Housing

Refer to Fig. 5 and assemble the control housing as follows:

1. Start the upper bearing, number side up, on the governor operating shaft. Support the shaft on the bed of an arbor press. Place a sleeve against the inner race and press the bearing against the shoulder on the shaft.
2. Slide the bearing shield on the shaft.
3. Place the operating shaft lever on the shaft and align the retaining pin holes. Then drive the retaining pin in place to secure the lever to the shaft.
4. Place the stop lever on the operating shaft and secure it in place with the washer and retaining ring. Then hook the small spring to the stop lever and operating shaft lever.
5. Install the lower operating shaft bearing, number side out, in the weight housing. Install the snap ring to secure the bearing. Lubricate the bearing with engine oil.
6. Insert the operating shaft and lever assembly in the control housing. Tap the shaft into the lower bearing and install a snap ring on the end of the shaft.
7. Apply a good quality sealant around the edge of the plug and tap it in place in the weight housing.

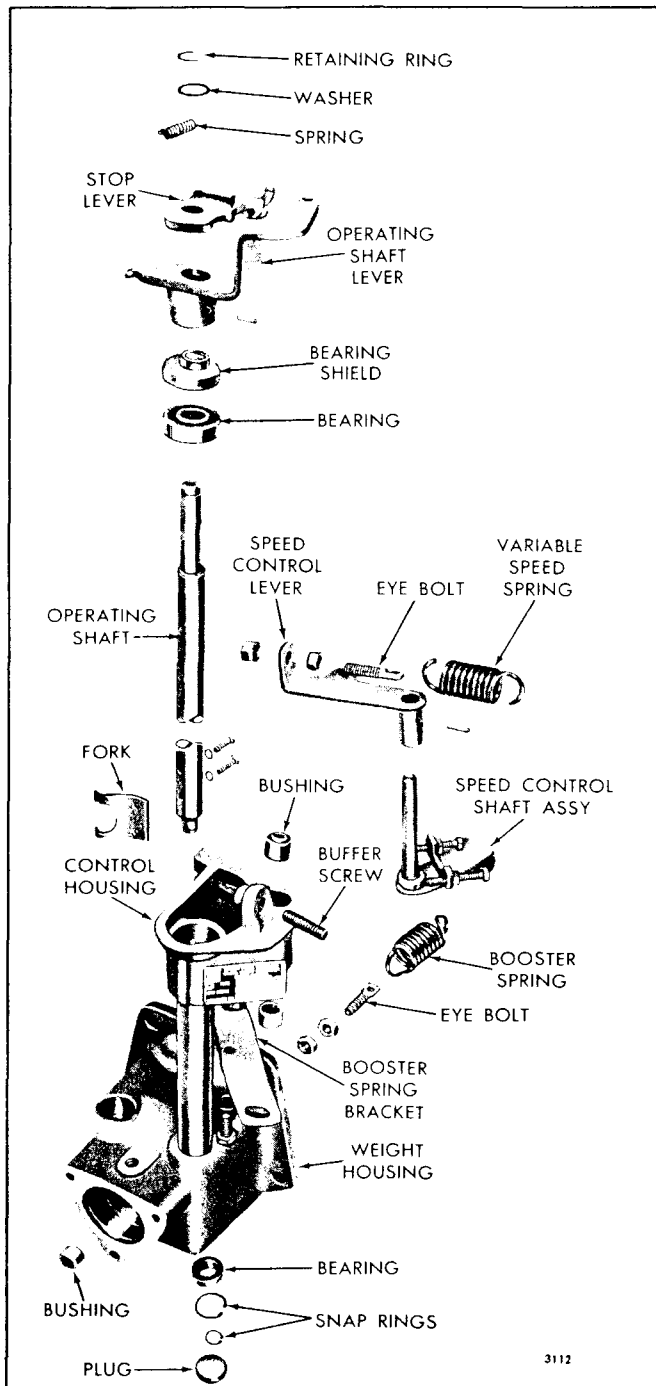


Fig. 5 - Governor Housing Details and Relative Location of Parts

8. Place the fork against the operating shaft, with the two cam faces of the fork facing away from the governor weights. Thread the fork attaching screws in approximately two or three turns. The screws are tightened after the weight and shaft assembly is installed.

9. Install the booster spring bracket.

10. Slide the speed control shaft assembly in the control housing. Then place the speed control lever on the shaft and tap the pin in place to secure the lever.

11. Install the booster spring and the variable speed spring.

12. Install the buffer screw.

Assemble Weight and Shaft Assembly

1. If the weight carrier was removed from the weight shaft, press the carrier on the shaft so as to allow a clearance of .001" to .006" between the shaft shoulder and the rear face of the weight carrier.

2. Press the bearing (Fig. 3) in the retainer (press on the outer race). Then install the snap ring with the flat side of the ring facing the bearing.

3. Press the bearing and retainer assembly on the shaft until the bearing contacts the shoulder on the shaft.

NOTE: Press on the inner race of the bearing.

4. Lubricate the shaft with clean engine oil. Then slide the riser and bearing assembly on the shaft.

5. Secure the weights to the carrier as follows:

- a. Position one of the weights, with a spacer on each side, in the carrier.
- b. Insert the serrated end of the weight pin through the larger opening in the carrier and through the weight and spacers. Then drive the pin into the smaller opening in the carrier.
- c. Install a retainer in the groove of the pin.
- d. Install the second weight in the same manner.

6. Slide the shaft and weight assembly into the weight housing, with the riser bearing positioned behind the operating fork.

7. Turn the bearing retainer until the large opening is over the fork on the operating shaft. Then tighten the two fork attaching screws with a 5/16" electrician's socket wrench.

8. Turn the bearing retainer until the counterbored notch above the large opening in the retainer and the tapped hole in the housing are aligned. Secure the bearing retainer to the housing with a flat head screw.

9. Place the governor drive gear spacer on the shaft. Install the key and start the gear on the shaft.

10. Tap the gear until the gear and spacer contact the inner race of the weight shaft bearing.

11. Install the gear retaining nut and tighten it to 125-135 lb-ft torque.

Install Governor

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

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

2. Position the governor against the engine rear end plate. The teeth on the governor drive gear must mesh with the teeth on the camshaft gear or balance shaft gear.

3. Install the three 12-point head bolts with copper washers in the governor weight housing next to the cylinder block. Install the two remaining bolts with steel washers and lock washers. Tighten the bolts to 35 lb-ft torque.

4. Install the two governor control housing attaching bolts and lock washers. Tighten the bolts to 35 lb-ft torque.

5. Attach the fuel rod to the stud on the stop lever.

6. Install the fuel pump and fuel lines.

7. If required, install the governor lubricating oil tube and fittings.

8. Perform an engine tune-up as outlined in Section 14.4.2.

VARIABLE SPEED MECHANICAL GOVERNOR

8V ENGINE

The variable speed mechanical governor, illustrated in Fig. 1, performs 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 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.

As shown in Fig. 2, the governor is mounted on the front end of the blower and driven by one of the

blower rotors. The governor assembly consists of three subassemblies:

1. Control housing cover.
2. Variable speed spring housing and shaft.
3. Control and weight housing.

Operation

Two manual controls are provided on the 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.

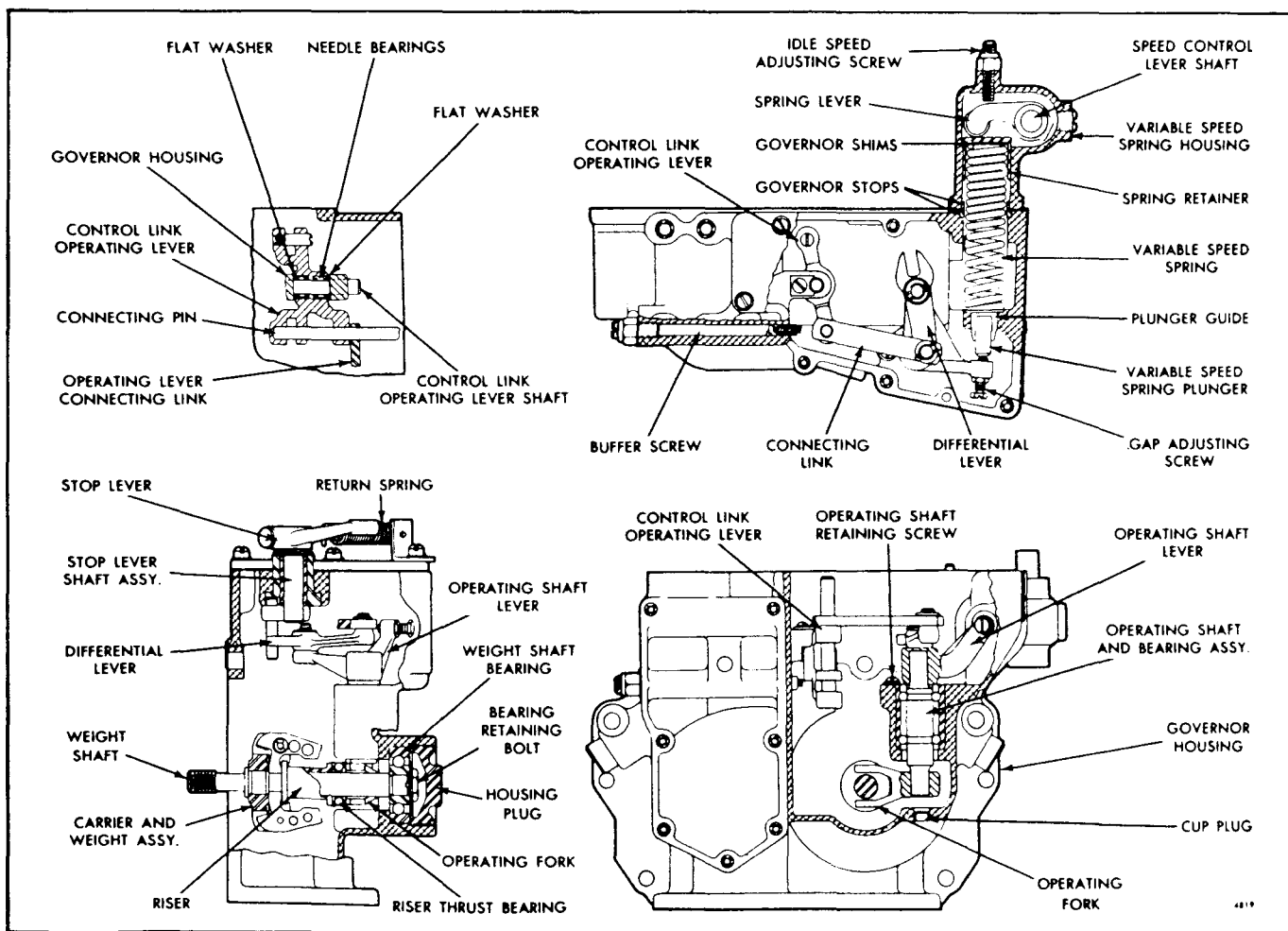


Fig. 1 - Cross Sections of Variable Speed Mechanical Governor

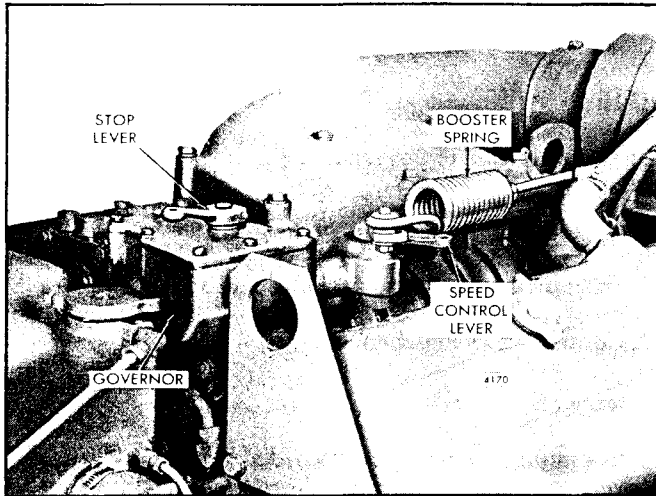


Fig. 2 - Variable Speed Governor Mounting

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser (Fig. 1) and operating shaft to the operating shaft lever. 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.

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

Adjustment of the governor is covered in the *Engine Tune-Up* section of this manual.

Lubrication

The governor is lubricated by a spray of oil from a passage in the blower end plate. The revolving

governor weights distribute this oil to all parts of the governor which require lubrication. Excess oil returns to the engine crankcase through passages in the blower end plate and the cylinder block.

Remove Governor From Engine

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 and governor must be removed together as outlined under *Remove Blower* in Section 3.4.1. Then remove the governor from the blower as outlined under *Remove Accessories from Blower* in Section 3.4.1.

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.

With the governor cover removed from the governor housing, refer to Fig. 1 and disassemble the cover as follows:

1. Disassemble the governor cover:
 - 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.
 - c. Remove the snap ring from the groove in the stop lever shaft and remove the two seal ring retainers.
 - 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 thoroughly in clean fuel oil and inspect the bushing for wear and damage. If the bushing is satisfactory for further use, removal is unnecessary. If worn excessively or damaged, replace the bushing.
 - 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 on top of the stop shaft bushing and under the ram of the press, then press the bushing out of the cover (Fig. 3).

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

- 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, 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.

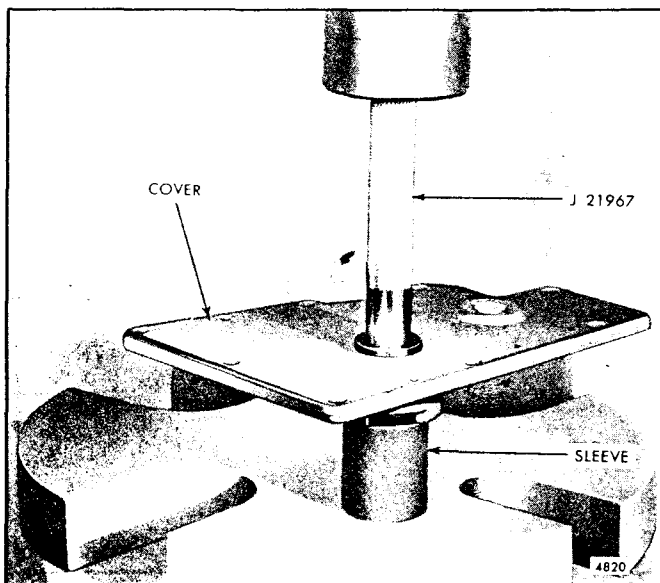


Fig. 3 - Removing Stop Lever Shaft Bushing from Governor Cover

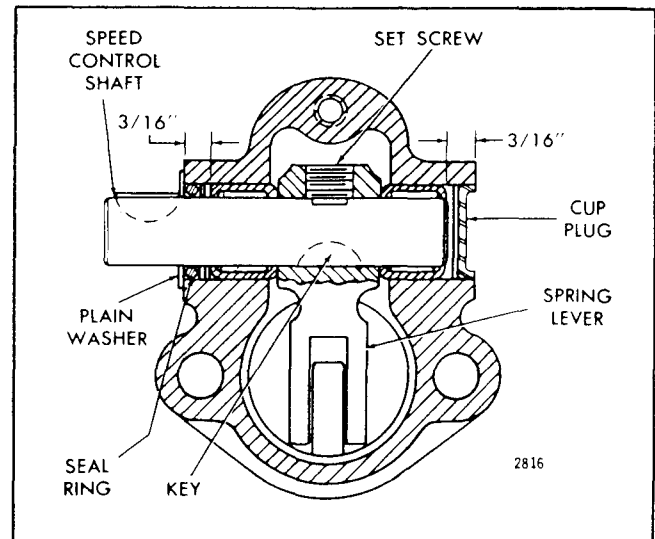


Fig. 4 - Cross Section of Governor Spring Housing and Lever Assembly

- c. On the former spring housing, remove the pipe plug in the top of the spring housing. On the current spring housing, remove one screw and lock washer and remove the spring housing cover and gasket. Then remove the set screw from the spring lever (Fig. 4).
- 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 in the side of the housing over the opening of the sleeve.
- e. Place a small brass rod on the end of the shaft and under the ram of the press as shown in Fig. 5 and press the plug and bearing out of the spring housing.
- f. Remove the spring lever from the spring housing and the bearing from the speed control shaft. If necessary, remove the Woodruff key from the shaft.

NOTE: 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 reuse the bearing.

- 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.

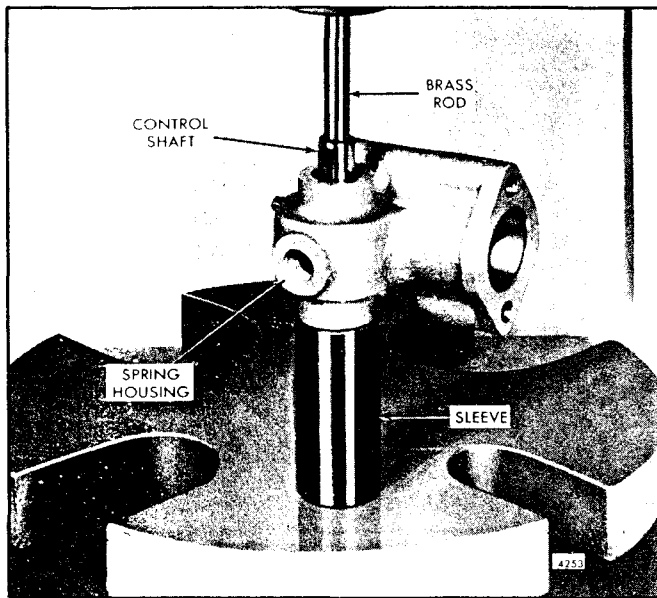


Fig. 5 - Removing Speed Control Shaft, Bearing and Cup plug from Governor Spring Housing

- 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 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. Place a 1/4" brass rod in the bearing retainer bolt hole in the weight carrier shaft, then tap the shaft out of the weight shaft bearing with a hammer. Catch the shaft and weight carrier assembly by hand to prevent it from falling and being damaged.
 - e. Slide the governor riser thrust bearing and riser from the weight shaft.
- NOTE:** 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. Disassemble the governor weights and shaft assembly as follows:
 - 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. 6 and press the shaft out of the weight carrier assembly.
 - b. Remove the weight pin retainer from each weight pin (Fig. 12). Clamp the weight carrier assembly in a vise equipped with soft jaws, then drive the pin out of the carrier and weights by tapping on the grooved end of the pins with a small punch and hammer. Remove the weights from the carrier.
 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.

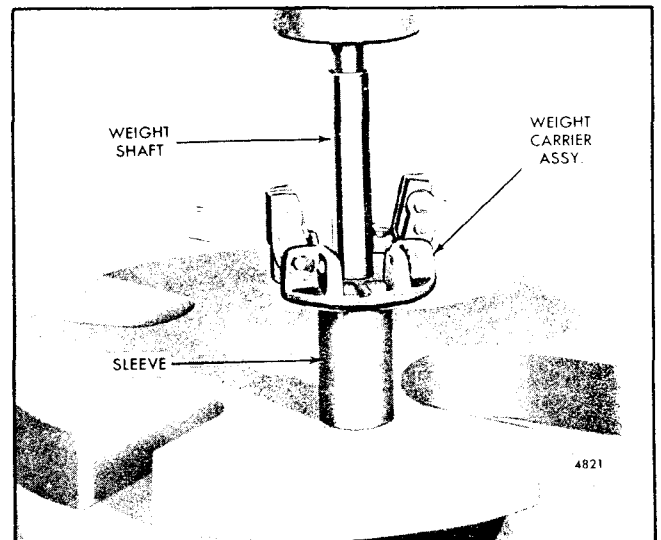


Fig. 6 - Removing Governor Weight Shaft from Weight Carrier Assembly

- 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.

NOTE: Do not lose the two flat washers located between the top and bottom of the lever assembly and the governor housing.

- d. Remove the cup plug in the bottom of the governor housing by tapping it out of the housing, toward the operating fork, with a 1/4" rod and hammer.
- e. Remove the operating shaft and bearing assembly retaining screw, lock washer and flat washer securing the shaft and bearing assembly in the governor housing.
- f. Support the governor housing, bottom side up, on two wood blocks on the bed of an arbor press as shown in Fig. 7. Place a 9/16" open end wrench under the operating fork and the boss of the housing, then insert a rod through the cup plug hole in the housing and against the end of the operating shaft and press the shaft and bearing assembly out of the operating fork.
- g. Remove the governor operating shaft lever, shaft and bearing assembly from the governor housing.
- h. Examine the operating shaft bearing for wear and rough spots and, if replacement is necessary, remove the operating shaft lever from the shaft with a small puller.

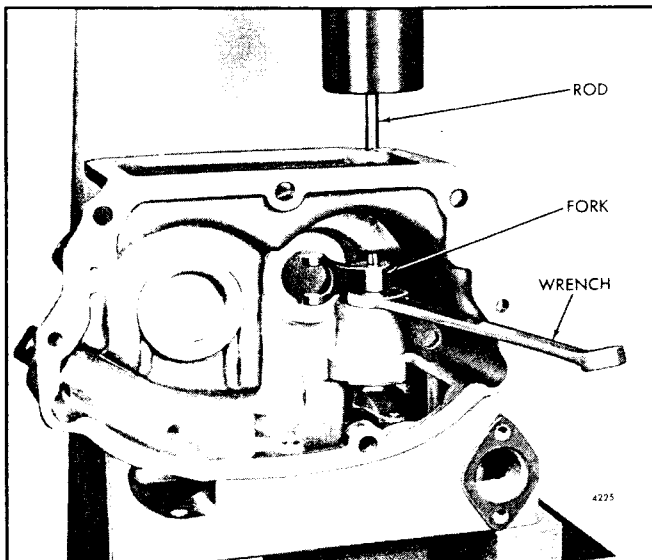


Fig. 7 - Removing Governor Operating Fork from Operating Shaft and Bearing Assembly

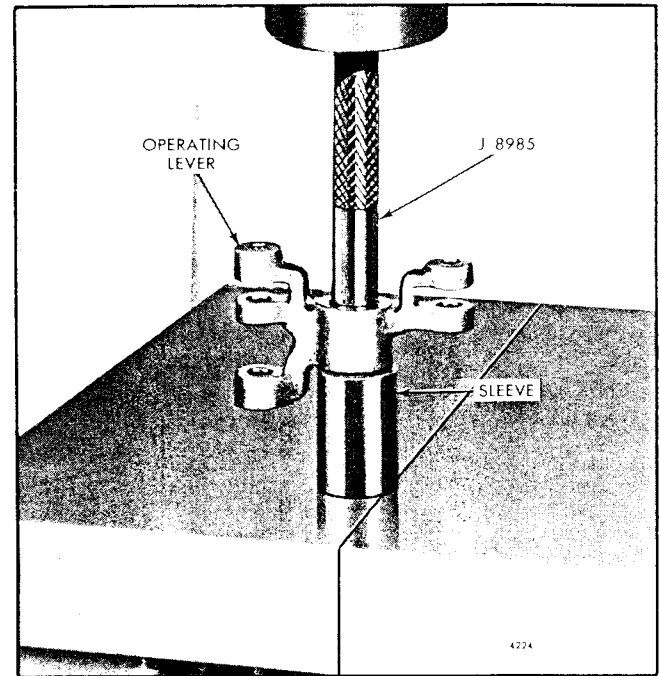


Fig. 8 - Removing Control Link Operating Lever Bearings

- i. Remove the buffer screw from the governor housing and, if desired, remove the lock nut from the screw.
- j. Remove the bolts, lock washers and plain washers securing the breather hole cover to the governor housing, then remove the cover and gasket.
- k. 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 needle bearings are satisfactory for further use, removal is unnecessary.
- l. 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 under the ram of the press, then press both bearings out of the lever as shown in Fig. 8.

Inspection

Wash all of the governor parts (except the operating shaft bearing) in clean fuel oil and dry them with compressed air.

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

Examine the governor weight shaft bearing for any indications of corrosion or pitting. Lubricate the

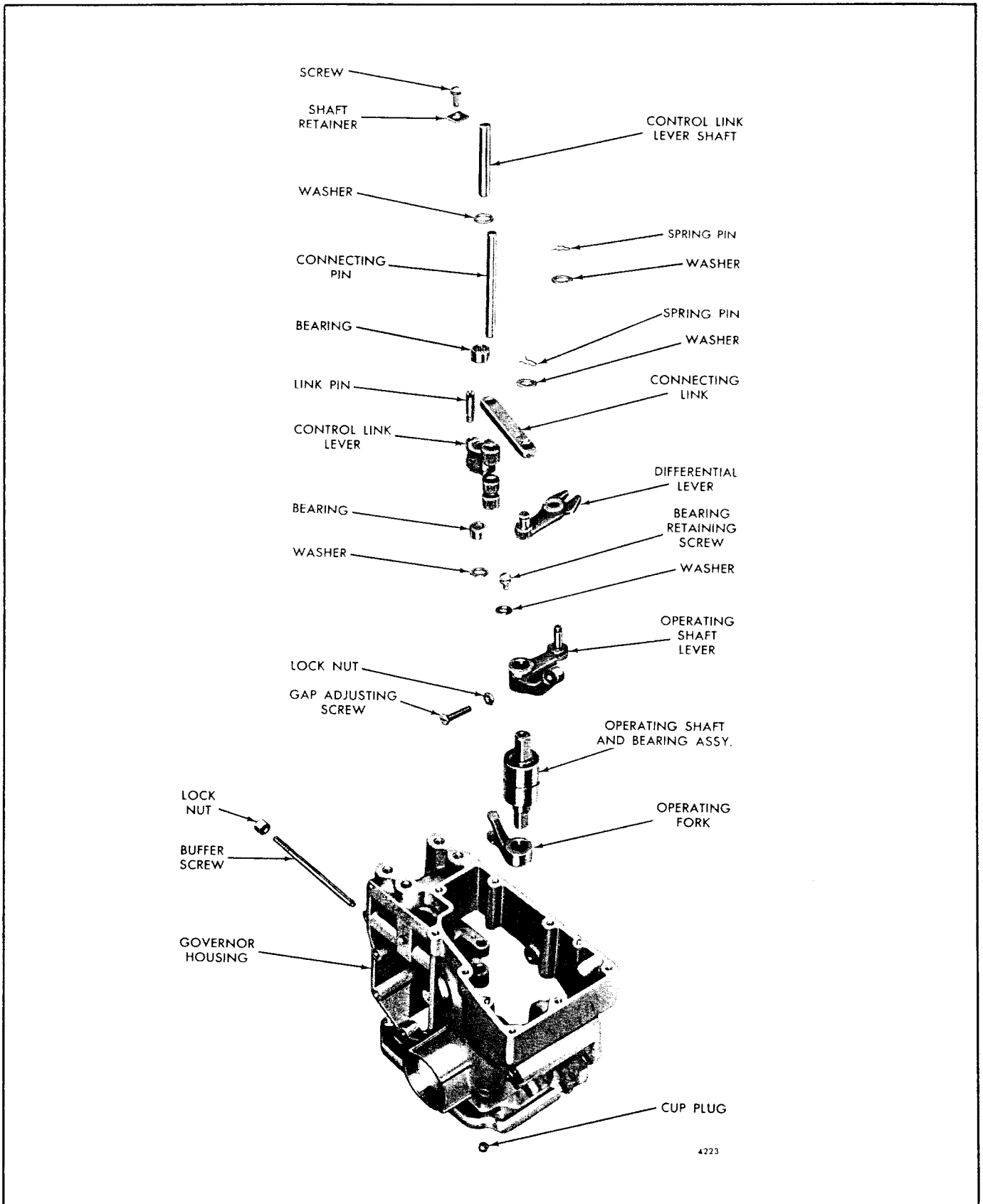


Fig. 9 - Governor Housing and Operating Shaft Details and Relative Location of Parts

bearing with light engine oil; then, while holding the bearing inner race from turning, revolve the outer race by hand and check for rough spots.

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

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

NOTE: 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 weight carrier pins and pin holes in the weights for wear.

Examine the speed control shaft and needle bearing in the spring housing for excessive wear.

Inspect the variable speed spring roller bearing and pin for wear.

Inspect the serration on the end of the governor weight shaft and in the blower rotor shaft for wear.

Examine the variable speed spring lever roller and pin for excessive wear. The current 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. The former ball type bearing (with two washers) rides on a soft bearing pin that is swagged at both ends to retain the bearing in the spring lever.

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 governor parts that are excessively 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, 9, 12, 14 and 16 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:

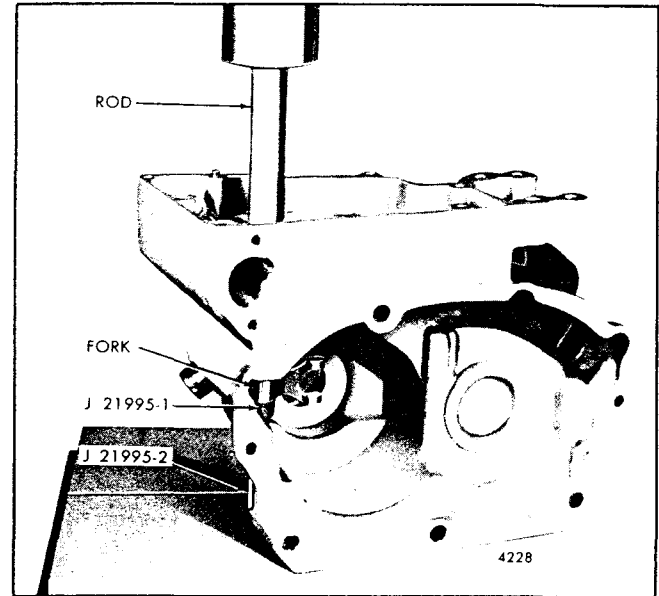


Fig. 10 - Installing Governor Operating Shaft Fork on Operating Shaft and Bearing Assembly

- a. If removed, lubricate the inside diameter of the operating shaft lever with engine oil, then start the lever on the upper end (short protruding end) of the shaft with the flat surface in the lever in alignment with the flat surface of the shaft. Support the lever, shaft and bearing assembly on the bed of an arbor press and press the lever flush with the top end of the shaft.
- b. Lubricate the outside diameter of the shaft bearing with engine oil, then insert the shaft, bearing and lever assembly in the bearing bore in the governor housing.
- c. Lubricate the inside diameter of the governor operating fork with engine oil, then start the fork on the lower end of the shaft with the flat surface in the fork in alignment with the flat surface on the shaft, and the finished cam surface of the fork facing toward the rear face of the governor housing.
- d. Insert the threaded end of the governor fork installing pin J 21995-1 through the cup plug hole in the bottom of the housing, then thread the knurled disc J 21995-2 on the end of the rod.
- e. Support the housing, lever, shaft, fork and installer, right side up, on the bed of an arbor press as shown in Fig. 10, with the end of the installer pin resting on the bed of the press and the disc centered under the bottom of the operating fork. Then place a short rod on the top end of the operating shaft and under the ram of the press and press the shaft into the fork until

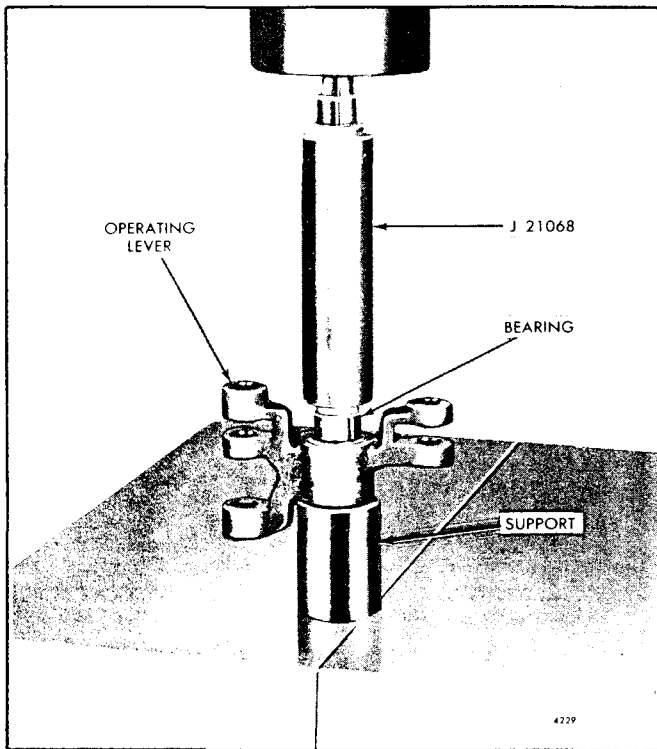


Fig. 11 - Installing Control Link Operating Lever Bearings in Lever

the fork is flush with the end of the shaft. Remove the fork installer disc and rod from the housing.

- f. Install the operating shaft and bearing assembly retaining flat washer, lock washer and screw in the governor housing and tighten the screw securely.
- g. Apply a good sealant to the outside diameter of a new cup plug. Start the cup plug, solid end first, straight in the plug hole in the bottom of the housing, then support the governor housing on the bed of an arbor press and press the plug in flush with the bottom face of the housing (Fig. 1).
- h. Place the differential lever over the pivot pin in the operating lever, pin in lever up, and secure it in place with a plain washer and spring retainer.
- i. If previously removed, install the governor gap adjusting screw and lock nut in the tapped hole in the operating shaft lever.
- j. 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 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 21068 (Fig. 11) in the bearing and under the ram of the press. Then

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.

- k. 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). Then install the operating lever shaft with the slot in the side at one end of the shaft up.
- l. 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.
- m. 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.
- n. If removed, thread the lock nut on the buffer screw and thread the buffer screw into the governor housing.
- o. Affix a new gasket to the breather hole cover, then attach the cover to the governor housing with bolts, lock washers and plain washers.

2. Assemble the governor weight and shaft assembly as follows:

If the governor weight carrier assembly was removed from the weight shaft, the 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 on the bed of an arbor press as shown in Fig. 13.
- b. Lubricate the weight carrier surface of the weight shaft with engine oil. Insert the non-splined end of the shaft through the carrier and into the sleeve, then press the shaft straight into the carrier until the shoulder on the shaft is tight against the carrier.
- c. Clamp the weight carrier and shaft assembly in a vise equipped with soft jaws.
- d. Place a governor weight in position in the carrier, then insert a weight pin, grooved end first, into

the smallest pin hole in the carrier, through the weight and into the opposite hole in the carrier, then tap the knurled end of the pin into the carrier just enough to permit the pin retaining ring to be installed in the pin groove. Install the retaining ring.

e. Install the remaining governor weight in the weight carrier in the same manner as described in Step "d".

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

a. Lubricate the weight shaft with engine oil, then slide the governor riser over the end of the shaft and against the fingers of the weight.

b. Lubricate the governor riser thrust bearing with engine oil, then place the thrust bearing over the end of the weight shaft with the bearing race which has the smallest 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. Lubricate the weight shaft bearing with engine oil, then place the 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

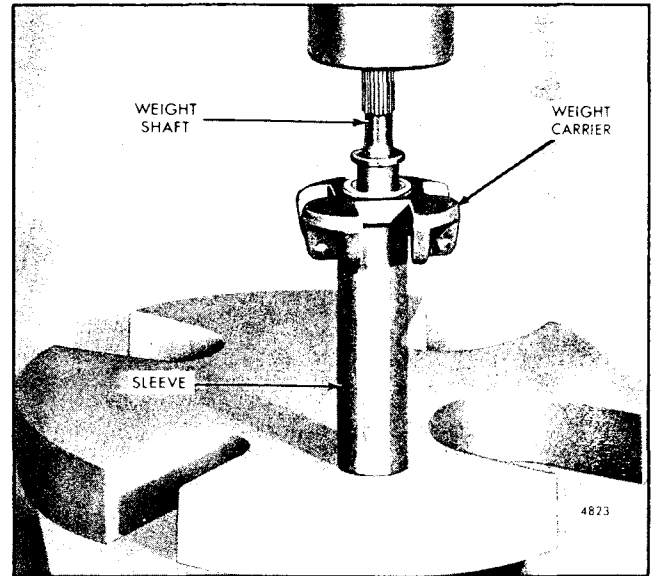


Fig. 13 - Installing Governor Weight Shaft in Weight Carrier

inner race. Bring the ram of the press down on the sleeve 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

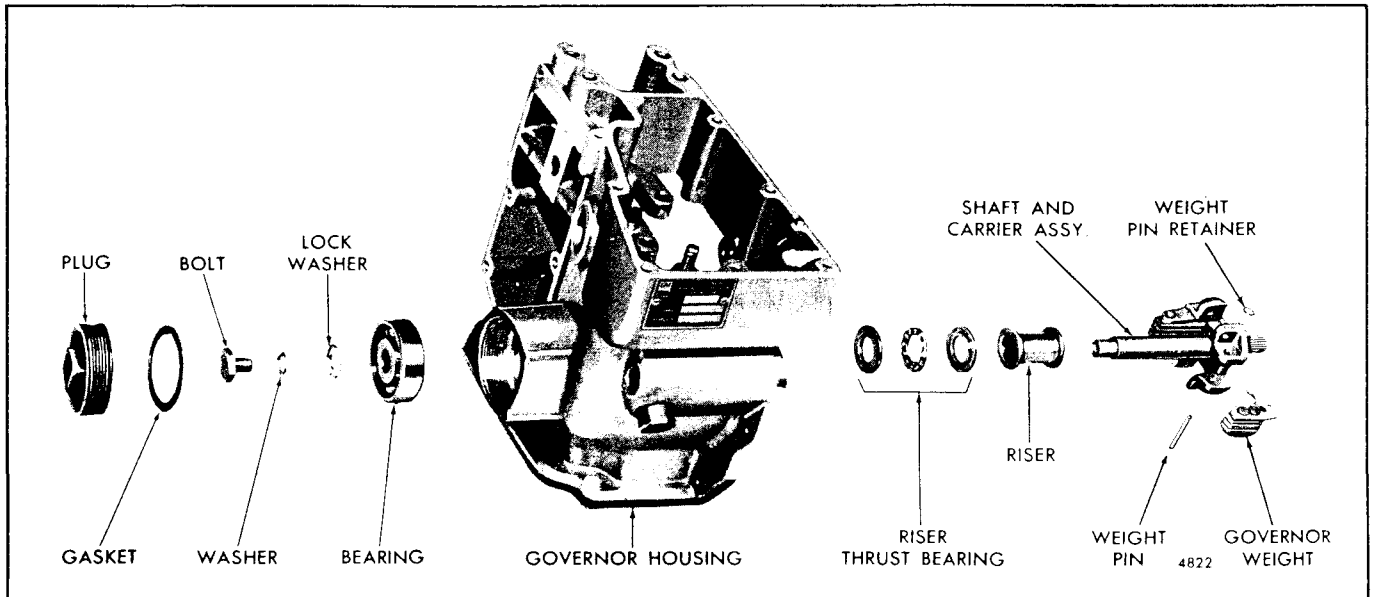


Fig. 12 - Governor Housing and Weight Details and Relative Location of Parts

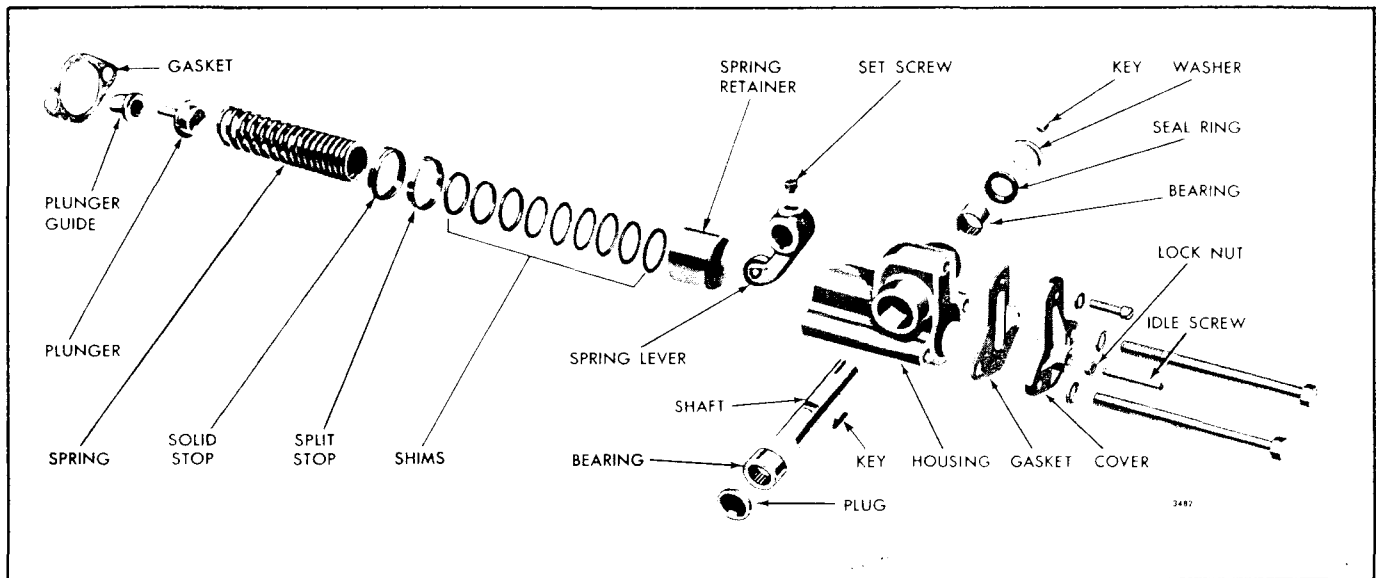


Fig. 14 - Variable Speed Spring Housing and Shaft Details and Relative Location of Parts

retainer bolt to 15-19 lb-ft 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 good quality 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. Clean the plug with solvent to remove any oil or grease before applying the sealant. Tighten the plug to 45 lb-ft torque.

NOTE: Rotate the governor weight assembly to see that there is no bind. If a 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. 4 and 14 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. 4.
- 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.

NOTE: Do not use impact tools to install needle bearings.

- 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. 15, then press the bearing in the housing until the shoulder on the installer contacts the housing.

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

- d. Install the current roller type bearing and pin in

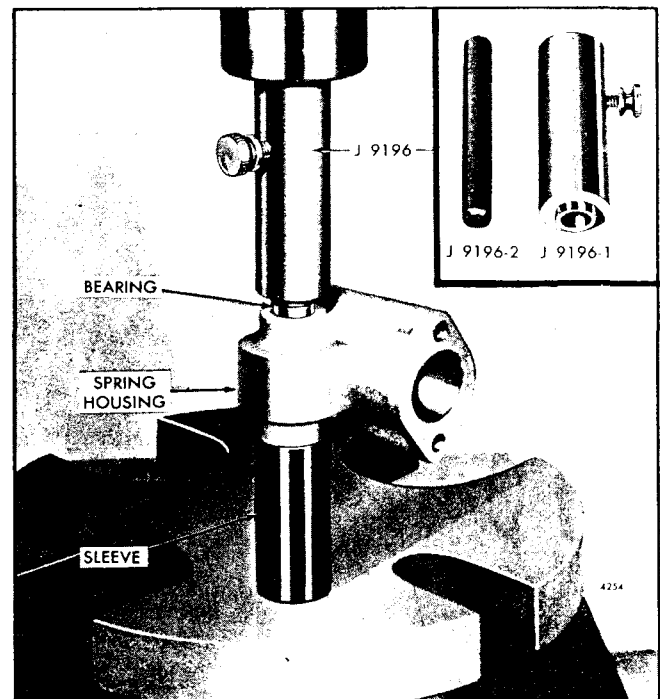


Fig. 15 - Installing Speed Control Shaft Bearing in Spring Housing

- the spring lever. Press the pin below the surface of the lever and stake at three places on both sides of the lever. The former ball type bearing (with two washers) is swagged at both ends to retain the bearing in the spring 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. 4) 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 on 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. 15, then press the bearing in the housing until the shoulder on the installer contacts the housing.
 - k. Apply a thin coat of sealing compound to the outside diameter of the cup plug. Start the cup plug, solid end first, 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 12-15 lb-ft 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 former spring housing.
 - n. 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. Place the speed control lever 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.
 - p. If removed, thread the lock nut on the idle speed adjusting screw. Then thread the idle speed adjusting screw into the spring housing or spring housing cover approximately 1".
5. Refer to Figs. 1 and 14 and attach the variable speed spring plunger guide, plunger retainer, shims, spring, stops and spring housing assembly to the governor housing as follows:
- a. On current governors, use a new gasket and attach the spring housing cover to the spring housing with a screw and lock washer.
 - b. Clamp the flange of the governor housing in a vise equipped with soft jaws.
 - c. 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.
 - d. 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).
 - e. Place the spring retainer solid stop in the counterbore of the governor housing.
 - f. 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.
 - g. 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.
 - h. 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.
 - i. Place the variable speed spring housing into position against the governor housing, with the

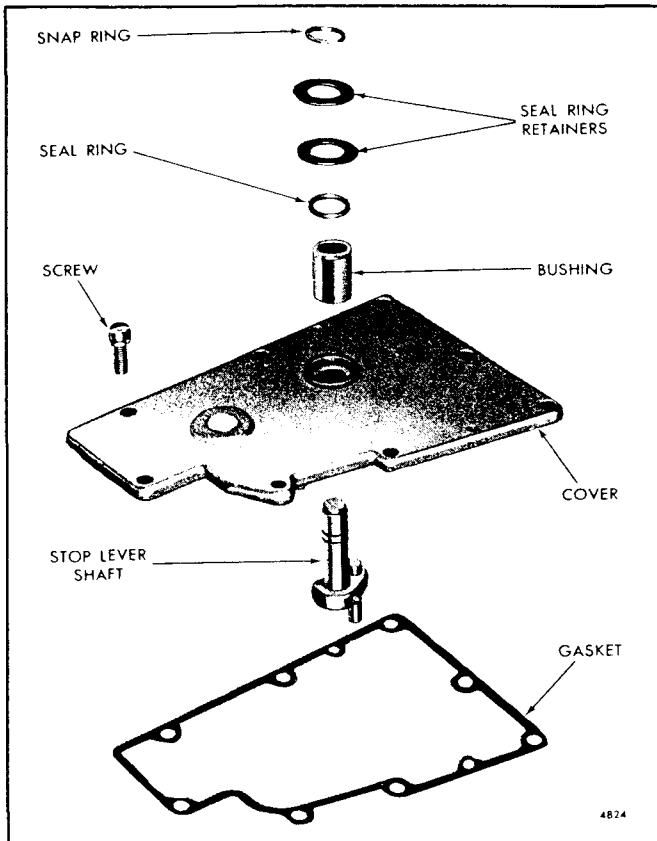


Fig. 16 - Governor Cover Details and Relative Location of Parts

speed control lever facing the top of the governor (Fig. 2) and the variable speed spring over the end of the spring plunger (Fig. 1) inside the governor housing.

- j. On former governors, insert two bolts with lock washers through the spring housing. On current governors, insert two bolts with copper washers through the spring housing cover and spring housing. Tighten the bolts to 13-17 lb-ft torque.

6. Refer to Fig. 16 for the location of the various parts and assemble the governor cover as follows:

- a. If the stop lever bushing (Fig. 16) was removed from the cover, place the cover, inner face down, on the bed of an arbor press as shown in Fig. 17. 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 under the ram of the press. Then

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 under the ram of the press. Then 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. Install the stop lever on the shaft and secure it in place with the retaining bolt and lock washer.

Install Governor on Engine

1. Refer to Section 3.4.1 and attach the governor to the blower as outlined under *Attach Accessories to Blower*.
2. Install the blower and governor assembly as outlined under *Install Blower* in Section 3.4.1.
3. Perform an engine tune-up as outlined in Section 14.

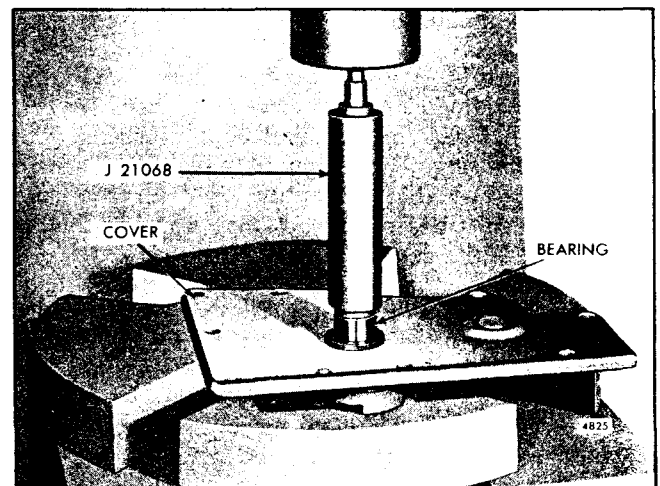


Fig. 17 - Installing Bearings in Governor Cover

CONSTANT SPEED MECHANICAL GOVERNOR

In-Line Engine

The horsepower requirements of an engine vary continually due to fluctuating loads; therefore, some means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such fluctuations. To accomplish this control, a mechanical governor of the constant speed type has been provided.

Upon starting, the engine will automatically attain approximately 50 rpm more than the predetermined speed.

As the load is applied the engine speed drops until it reaches the desired speed at full load. This speed can be adjusted by the use of shims behind the governor spring.

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

Operation

A spring on top of the governor holds the governor control lever in the *run* position. A cable from the instrument panel, when pulled, overcomes the spring and draws the injector racks to the no-fuel position (through the governor), thus stopping the engine.

The centrifugal force of the revolving flyweights is converted into linear motion which is transmitted through the riser, operating shaft, the operating shaft lever, the low speed gap screw and the plunger to the spring. The other arm of the operating lever provides a changing fulcrum on which the differential lever pivots. A fuel rod, connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The centrifugal force of the governor weights is opposed by the governor spring. Load changes create an unbalanced force between the revolving governor weights and the tension of the spring. When the two forces are equal, the engine speed stabilizes. Whenever the centrifugal force of the revolving weights overcomes the tension of the spring, the injector racks will be moved toward the no fuel position. Also, whenever the centrifugal force of the weights allows the spring to expand, the injector racks will move toward the full-fuel position.

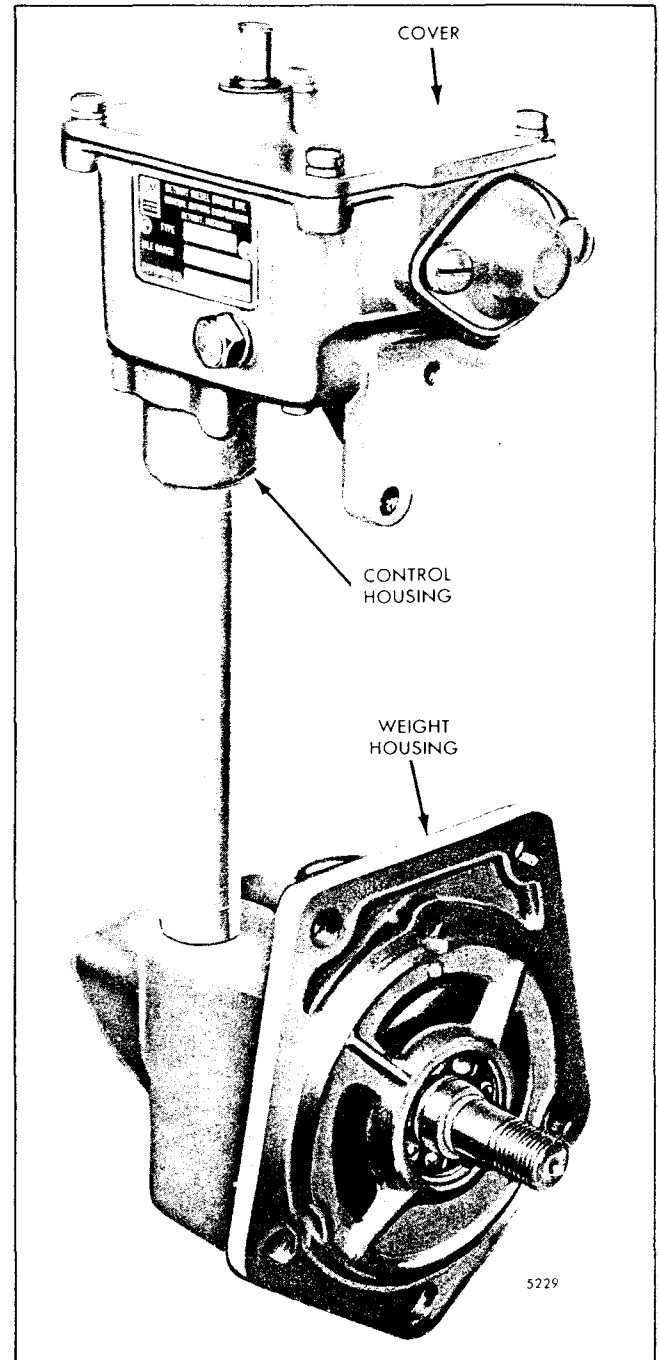


Fig. 1 - Constant Speed Governor

Adjustment for the no-load speed on a single range governor is made by varying the tension of the spring by the use of shims. The addition of shims behind the spring will raise the engine speed; likewise, the removal of shims will lower the engine speed. On a

dual range governor, the top speed is adjusted by the use of shims, the lower speed by use of an adjusting screw.

When governor difficulties are encountered which

would necessitate governor service, refer to Section 2.7.1 for the proper procedure.

When engine tune-up is necessary, refer to Section 14.6.

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, the unit should be checked 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 as outlined in Section 15.2. If a cylinder is not firing properly, the injector must be removed, tested and, if necessary, reconditioned as outlined in Section 2.1 or 2.1.1.
3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube.

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

1. If an injector rack sticks or moves too hard, it may be due to the injector hold-down clamp being too tight

or improperly positioned. To correct this condition, loosen the injector clamp bolt, reposition the clamp, and retighten the bolt to 20-25 lb-ft torque.

2. A binding injector may result from internal dirt, defective plunger and bushing or a bent injector rack. The injector must then be removed, reconditioned and tested as outlined in Section 2.1 or 2.1.1.
3. An injector rack may bind as the result of an improperly positioned control rack lever. Loosen the control rack adjusting screws. If this relieves the bind, relocate the lever on the control tube and position the rack as outlined in Section 14.7.1.
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 the 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 14.7.1.
5. A bent 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 in the pin which connects the fuel rod to the injector control tube lever.

If neither load or engine irregularities are found to be the cause of the speed variations, the trouble may be in the governor or the governor drive.

1. If the speed changes noted are in rapid oscillation, the speed droop may be too high. The speed droop may be adjusted as outlined under *Adjust Speed Droop* in Section 14.7.1. This applies only in case the governor is overhauled or where the speed droop has been changed from the original factory setting.
2. 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 blower) to vary erratically. This variation will be transmitted as a speed change to the governor which, in turn, will act to compensate for the change by moving the fuel rod. If this condition exists, inspect the blower.
3. If the speed variations are small in magnitude, the fault may lie in the governor drive. Excessive or insufficient clearance between the beveled drive gears may cause this condition.

If after making the preceding checks, the governor fails to control the engine properly, it should be removed and reconditioned.

SG HYDRAULIC GOVERNOR

The governors shown in Figs. 1 and 2 incorporate a speed droop stabilizer mechanism. Engine lubricating oil is admitted, under pressure, to an auxiliary oil pump in the governor. The auxiliary pump furnishes the necessary oil pressure to actuate the governor mechanism.

The governor is connected to the fuel injectors by a fuel rod that is attached to a lever on the injector control tube. The amount of fuel to the injectors is decreased by the governor throttle control terminal lever retracting spring and increased by the opposing action of a hydraulic power piston inside of a cylinder. Admission of oil to the cylinder is controlled by a pilot

valve. The pilot valve, in turn, is controlled by the flyweights of the governor.

The two flyweights of the governor are mounted on a vertical shaft and driven, through a set of gears, by the camshaft or balance shaft gear (depending upon the engine model). The centrifugal force of the rotating flyweights is opposed by a speeder spring located on the vertical shaft between a spring fork at the top and the arms of the flyweights at the bottom. Compression of the speeder spring, which is controlled by the throttle, determines the speed at which the governor will control the engine.

In order that the governor operation may be stable

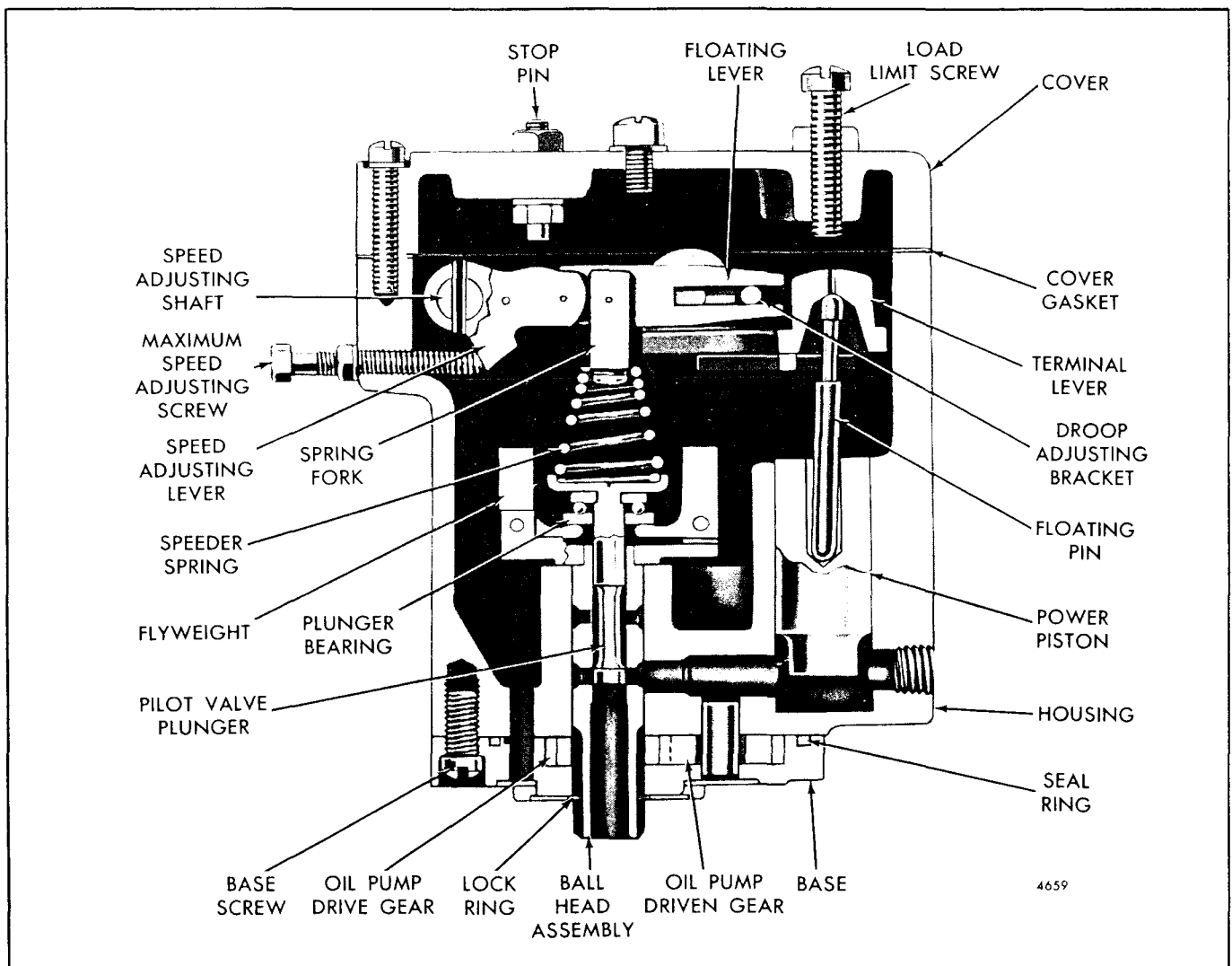


Fig. 1 - Hydraulic Governor Assembly (Current)

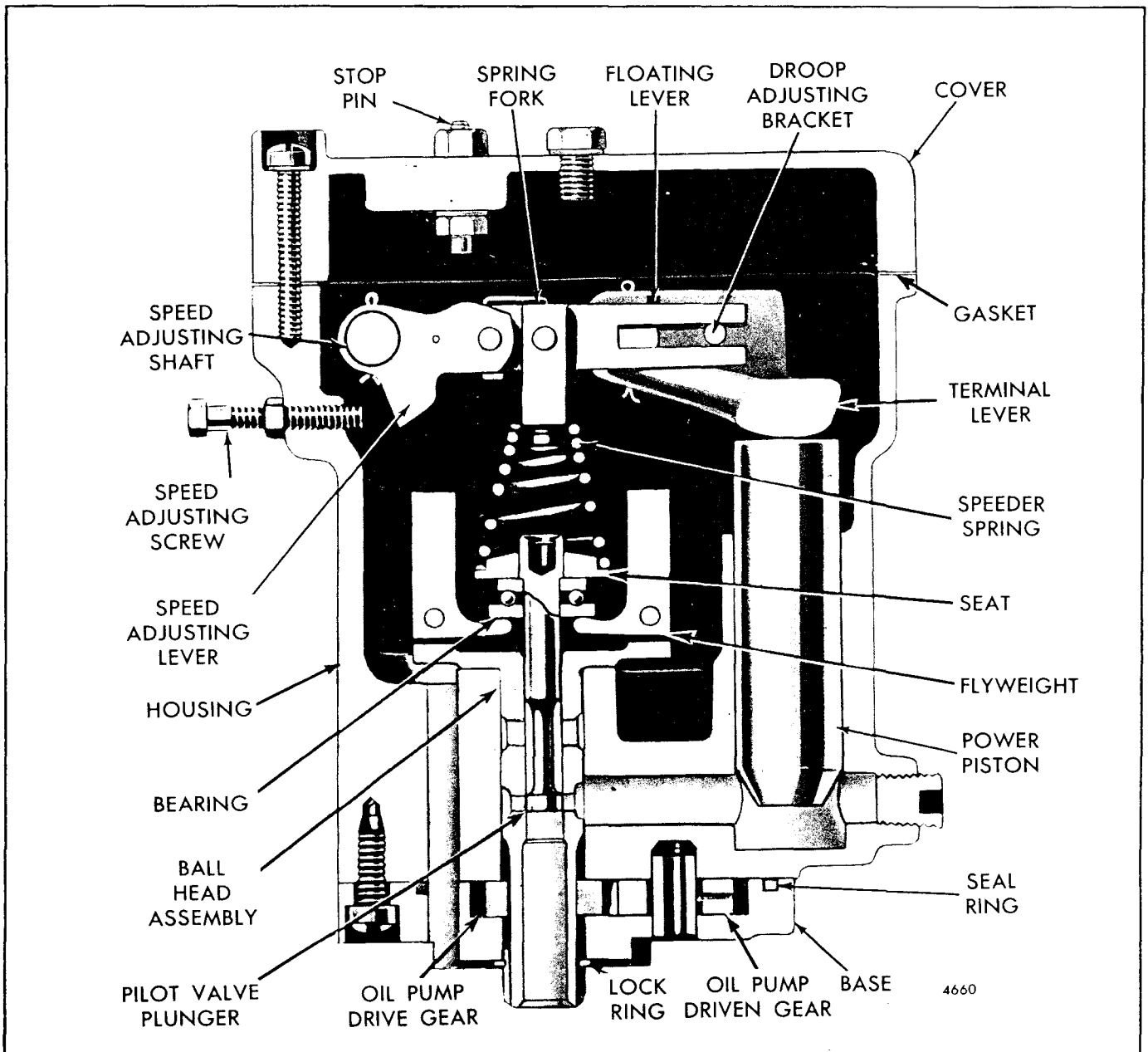


Fig. 2 - Hydraulic Governor Assembly (Former)

(that is, without hunting), an adjustable speed droop mechanism is used in the governing system. Speed droop adjustment is achieved through a slotted bracket attached to the terminal lever. Moving the droop adjusting bracket IN toward the engine increases governor droop, and OUT, away from the engine, decreases the governor droop.

When starting a cold engine, it may require several cranking periods for the lubricating oil pressure to become great enough to operate the governor and open the throttle so the engine can start. Since such a delay in starting is considered objectionable, the

starting time can be reduced by moving the throttle control terminal lever to the full-fuel position to take control of the injector fuel racks away from the governor.

The engine can be stopped, regardless of the governor, by moving the throttle control terminal lever to the no-fuel position. Considerable force must be exerted to do this as the oil pressure against the power piston must be overcome.

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 case of lubricating oil pressure failure. Should the engine fail to supply oil to the governor, the servo-piston will drop, letting the fuel rod return to the no-fuel position, and shut down the engine.

Effective with engine serial number 2D-13294, a new governor assembly (Fig. 1) replaced the former governor assembly (Fig. 2). The new governor incorporates the following revisions.

The current governor housing incorporates integral speed adjusting and terminal shaft bosses with bushings. The separate speed adjusting sleeve, terminal sleeve and spacer cap used in the former housing have been eliminated. Also the size of the tapped hole in the lower passage of the housing was increased from $5/8'' - 18$ to $11/16'' - 16$ to accommodate the new relief valve components.

The current servo-piston is shorter and the new terminal lever is actuated by a floating pin assembled between the piston and the lever. The lever cross pin actuates the fuel rod mechanism. The former lever was actuated by direct piston contact and the lever actuated the fuel rod mechanism by direct contact with the fuel rod collar.

The current adjusting shaft and lever are pinned and supported by the bushings in the housing. The former shaft was serrated at the speed adjusting lever end.

The current idler gear stud has drilled passages for supplying oil, under pressure, to the inner diameter of the current idler gear. Formerly the drilled oil passages were in the idler gear.

Operation

As the engine operates, oil from the lubricating system is admitted to the gear pump in the governor base. The governor gear pump raises the oil pressure to a value determined by the spring in the relief valve assembly opposing the relief valve plunger. The oil, now under pressure, is maintained in the annular space between the small diameter of the pilot valve plunger and the bore in the ballhead as shown in Fig. 3. For any given throttle setting, the speeder spring has a definite compression force which is opposed by the centrifugal force of the flyweights. When these two forces are in equilibrium, the land on the pilot valve plunger exactly covers the lower ports in the ballhead producing the constant speed condition as shown in Fig. 3.

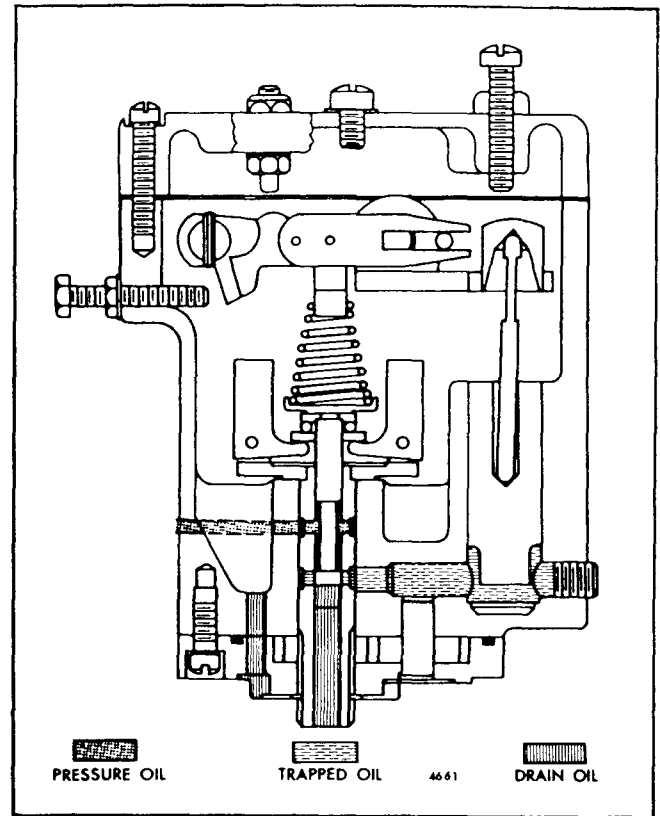


Fig. 3 - Stable Position of Governor Mechanism When Load on Engine is Constant

As a load increase is applied to the engine, the engine speed will drop and the governor flyweights will be forced inward, lowering the pilot valve plunger. Oil under pressure of the pump will now be admitted underneath the power piston which will rise. Upward movement of the piston is transmitted by the floating pin through the terminal lever and fuel rod to the injector control racks, causing the fuel setting of the engine to be increased as shown in Fig. 4.

As the power piston and terminal lever rise, the compression load on the speeder spring is reduced, allowing the flyweights to 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 ballhead, 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 5 illustrates the governor reaction as the load on the engine is decreased and the engine speed increases.

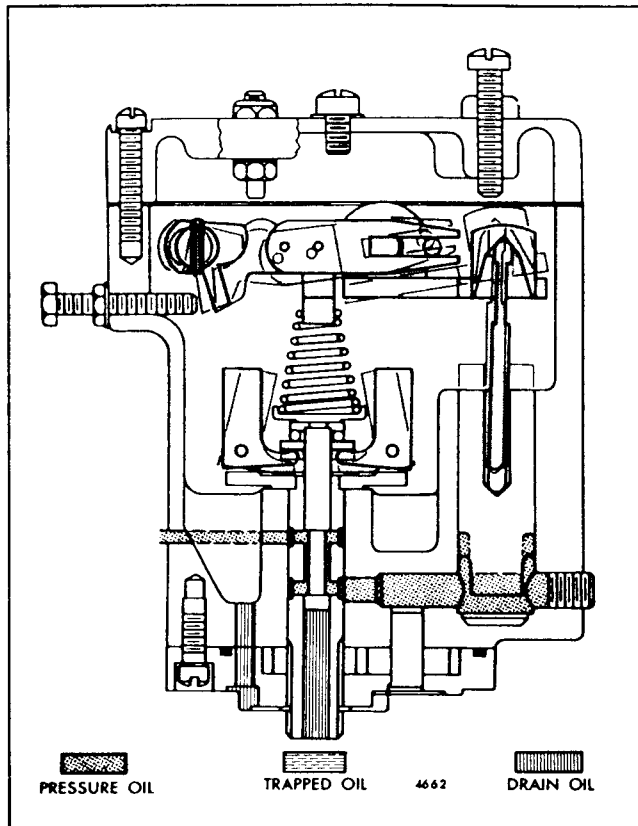


Fig. 4 - Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease

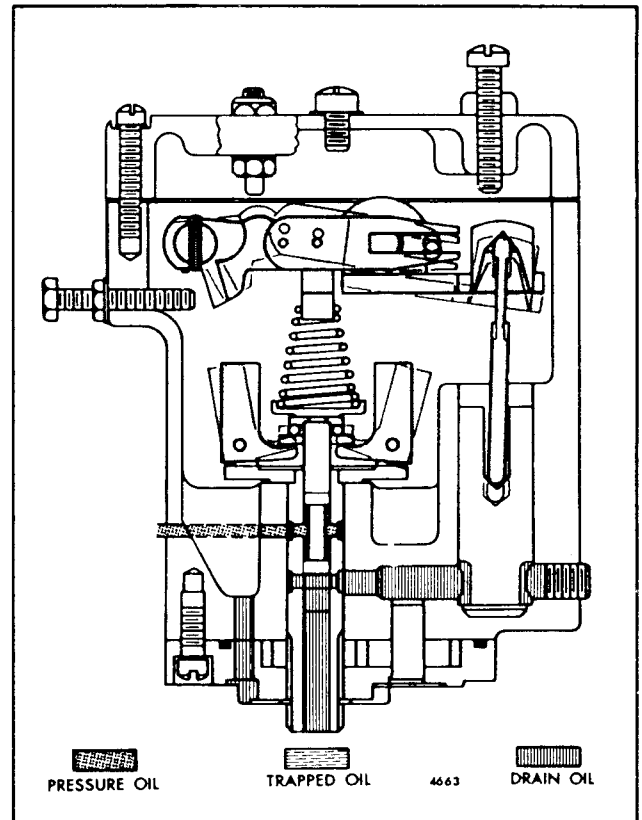


Fig. 5 - Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase

Lubrication

The governor is lubricated by oil seeping into the governor housing past the power piston and the pilot valve plunger. Oil which collects on the floor of the governor drains into the gear drive beneath the governor. After reaching a certain level in the governor drive housing, the oil returns to the crankcase through a cored passage in the governor drive housing.

Remove Governor

Refer to Figs. 1, 2, 6 and 7 and remove the governor as follows:

1. Remove the throttle control terminal lever retracting spring from the terminal lever.
2. Disconnect the fuel rod from the throttle control terminal lever.
3. Remove the nut and lock washer securing the

throttle control rod assembly to the throttle control lever.

4. Disconnect the oil inlet tube assembly from the governor oil inlet plug.
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 and remove the governor assembly and gasket.

Disassemble Governor (Current)

Before removing any parts from the governor, wash the unit thoroughly in clean fuel oil, dry it with compressed air and inspect it for worn or damaged parts that may be repaired or replaced without completely disassembling the governor.

Governor disassembly need be carried out only as far

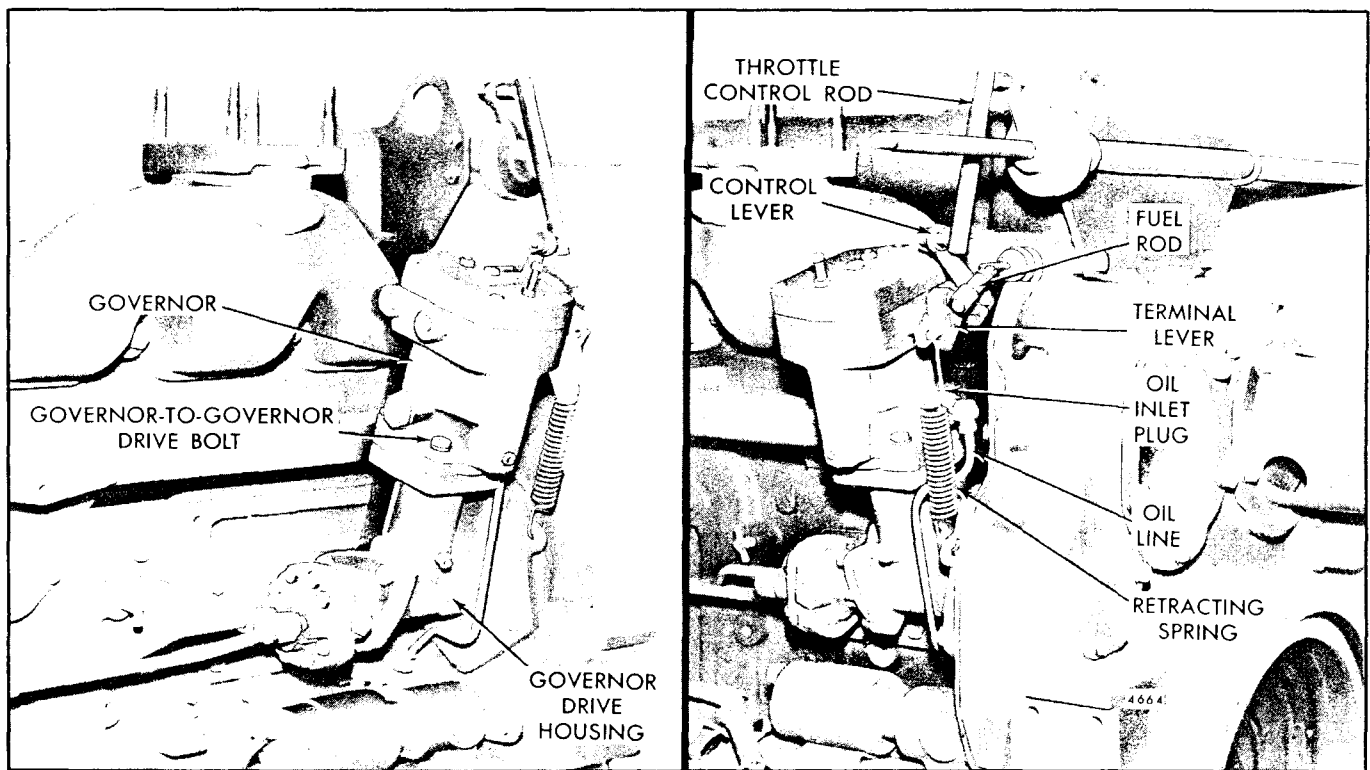


Fig. 6 - Hydraulic Governor Mounting

as necessary to correct the difficulties which interfere with proper governor operation.

Refer to Figs. 1, 7 and 11 for the location of the various parts and disassemble the governor as follows:

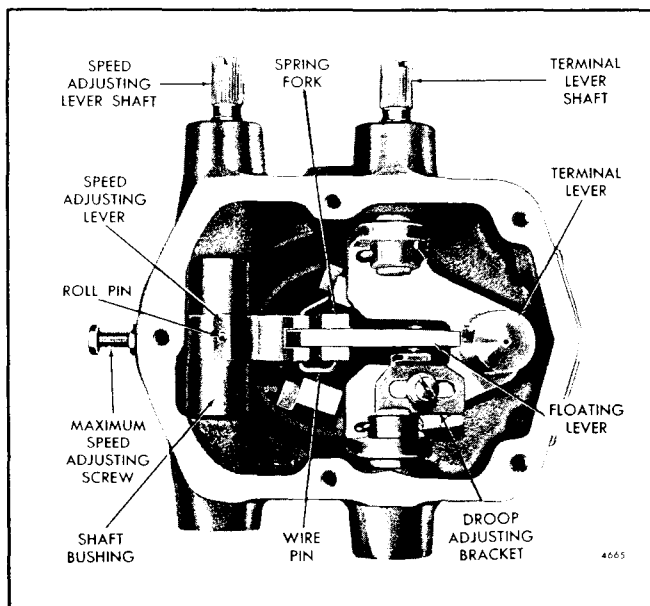


Fig. 7 - Top View of Governor With Cover Removed

1. Note and record the position of the throttle control lever on the speed adjusting shaft. Loosen the bolt securing the lever to the shaft, then slide the lever off the shaft.
2. Note and record the position of the throttle control terminal lever on the governor terminal lever shaft. Loosen the bolt securing the lever to the shaft, then slide it off the shaft.
3. If necessary, remove the oil inlet elbow from the governor housing oil inlet plug.
4. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws (Fig. 8).
5. 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.
6. Remove the three cover screws, then remove the cover and gasket from the housing.
7. Loosen the maximum speed adjusting screw lock nut and remove the adjusting screw from the governor housing.

CAUTION: If the maximum speed adjusting screw is not removed, the speed adjusting lever

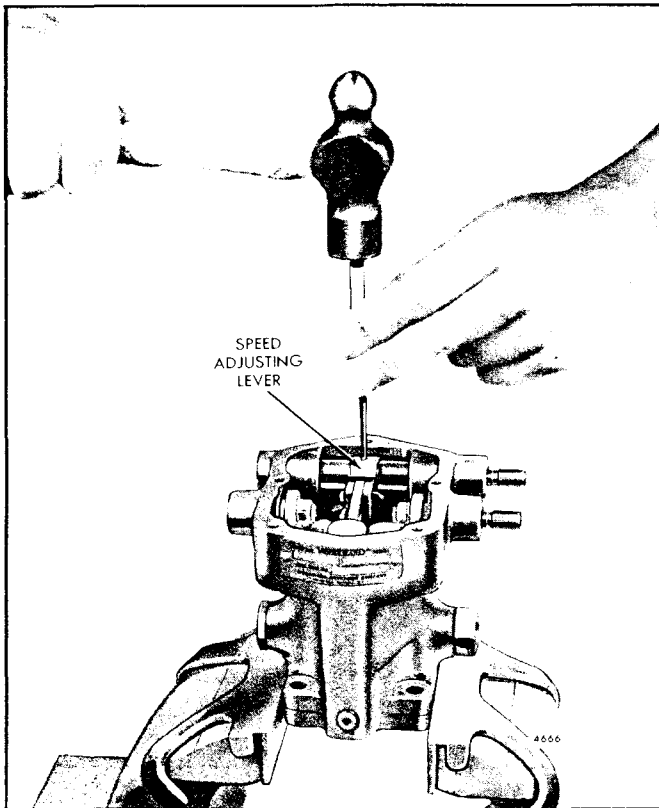


Fig. 8 - Removing Speed Adjusting Lever Roll Pin

spring pin will hit the screw when it is being removed from the adjusting lever.

8. 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. 8.

9. 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 the governor housing.

10. Remove the speed droop adjusting bracket screw, lock washer and plain washer from the terminal lever; then remove the droop adjusting bracket from the speed adjusting floating lever and the terminal lever.

11. 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. 9.

12. Remove the pilot valve plunger thrust bearing and the roll spring pin from the governor housing.

13. On a governor equipped with a synchronizing motor, slide the speed adjusting lever retracting spring

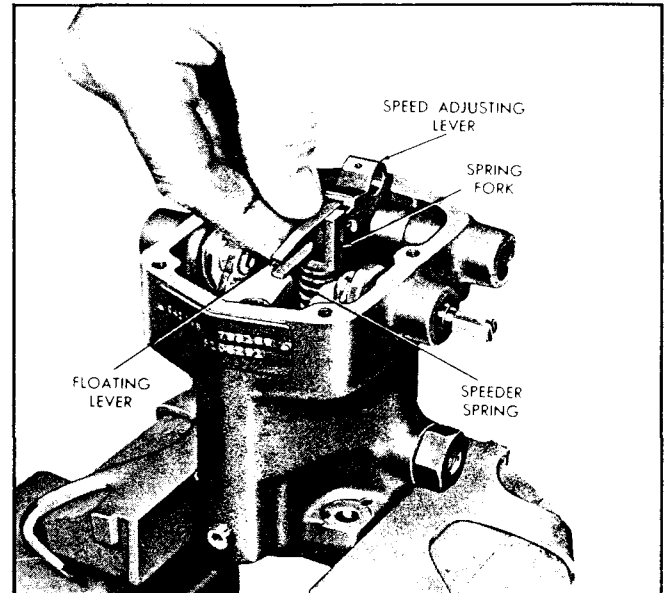


Fig. 9 - Removing Speed Adjusting Lever, Floating Lever, Spring Fork, Speeder Spring and Pilot Valve Plunger Assembly

off of the speed adjusting shaft bushing and remove it from the housing.

14. If necessary, the speed adjusting lever, floating lever, spring fork, speeder spring and pilot valve plunger and spring seat assembly may be disassembled as follows:

- a. Straighten the bent end of the wire pin securing the speed adjusting lever and spring fork to the speed adjusting floating lever.
- b. Pull the pin out of the speed adjusting lever,

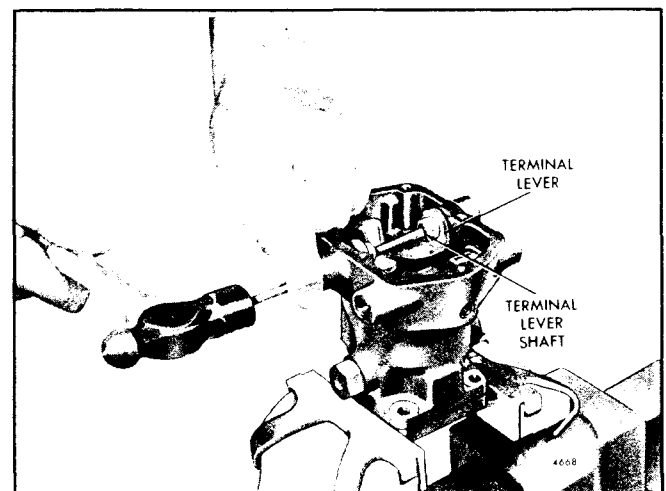


Fig. 10 - Removing Cup Plug from Governor Housing

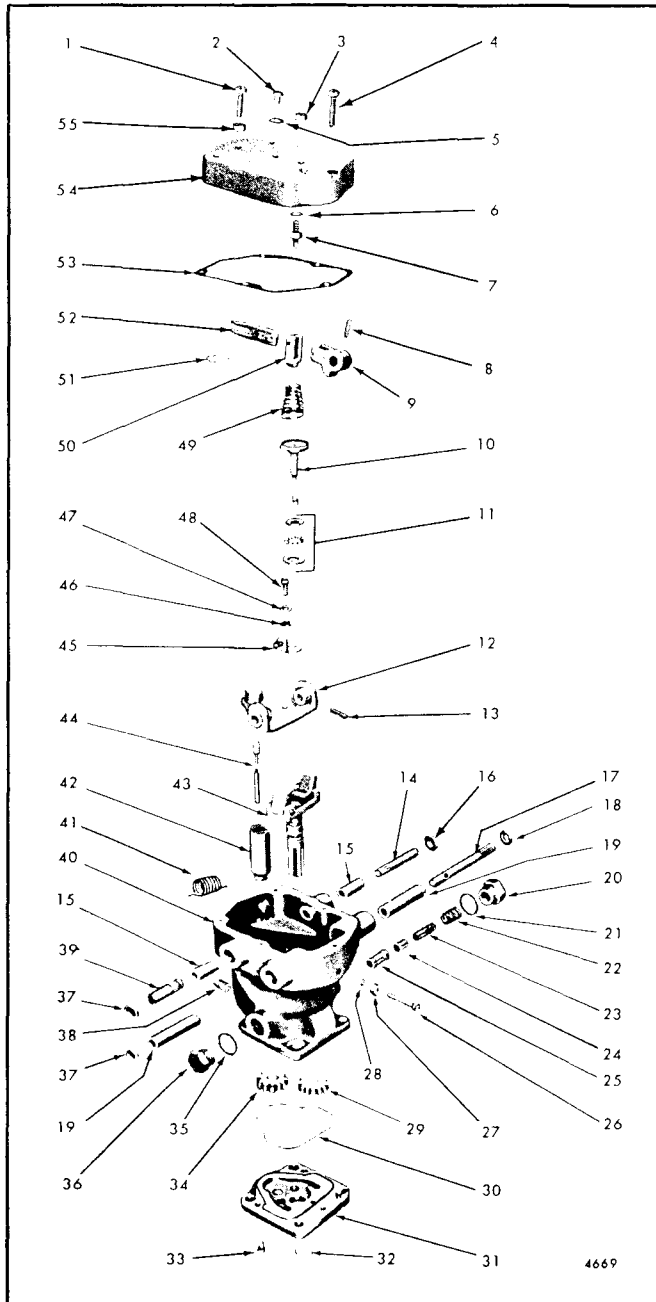


Fig. 11 - Hydraulic Governor Details and Relative Location of Parts (Current)

- | | |
|--------------------------------------|--|
| 1. Screw--Load Limit | 27. Nut--Adjusting Screw |
| 2. Screw--Cover Hole | 28. Copper Washer--Maximum Speed Adjusting Screw |
| 3. Nut--Stop Pin | 29. Gear--Oil Pump Drive |
| 4. Screw--Cover | 30. Ring--Base to Housing Seal |
| 5. Copper Washer | 31. Base--Governor |
| 6. Copper Washer | 32. Lock Ring |
| 7. Pin--Speed Adjusting Lever Stop | 33. Screw--Base to Housing |
| 8. Pin--Speed Adjusting Lever Roll | 34. Gear--Oil Pump Driven |
| 9. Lever--Speed Adjusting | 35. Gasket--Plug |
| 10. Plunger--Pilot Valve | 36. Plug--Dummy Hole |
| 11. Bearing--Plunger | 37. Plug--Housing Cup |
| 12. Lever--Terminal | 38. Plug--Housing |
| 13. Pin--Cotter | 39. Shaft--Terminal Lever (Long) |
| 14. Shaft--Terminal Lever (Long) | 40. Housing--Governor |
| 15. Bushing--Terminal Lever Shaft | 41. Spring--Retracting (Syn. Motors Only) |
| 16. Seal--Terminal Lever Shaft Oil | 42. Piston--Power |
| 17. Shaft--Speed Adjusting | 43. Ball Head Assy. |
| 18. Seal--Speed Adjusting Shaft Oil | 44. Pin--Terminal Lever to Piston |
| 19. Bushing--Speed Adjusting Shaft | 45. Bracket--Droop Adjusting |
| 20. Plug--Oil Inlet | 46. Lock Washer |
| 21. Gasket--Plug | 47. Washer--Plain |
| 22. Spring--Sleeve Retaining Plunger | 48. Screw--Bracket |
| 23. Spring--Relief Valve | 49. Spring--Speeder Fork--Spring |
| 24. Plunger--Relief Valve | 50. Pin--Spring Fork Wire |
| 25. Sleeve--Relief Valve Plunger | 51. Lever--Floating |
| 26. Screw--Maximum Speed Adjusting | 52. Gasket--Cover |
| | 53. Cover--Governor |
| | 54. Nut--Load Limit Screw |

Fig. 11 - Hydraulic Governor Details and Relative Location of Parts (Current)

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

15. Remove the two cotter pins securing the terminal lever to the terminal lever shafts.

16. Place a 1/4" brass rod, approximately 5" long, against the inner end of the terminal lever shaft, then drive the governor housing cup plug out of the boss at the side of the housing as shown in Fig. 10.

CAUTION: Use care when removing the cup plugs; do not damage the serrations inside the terminal lever with the rod.

17. Remove the remaining governor housing cup plug from the boss in the opposite side of the housing in the same manner as outlined in Step 16.

18. Push the terminal lever shafts out of the terminal lever and housing with the brass rod. Then lift the terminal lever out of the housing.

19. Remove the terminal lever-to-power piston pin 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.

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

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

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

23. Remove the three screws securing the governor base 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 from the governor base or housing.

26. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise.

27. Remove the oil inlet plug, gasket, relief valve plunger sleeve retaining spring and relief valve plunger spring from the governor housing.

28. Remove the dummy hole plug and gasket 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 and the relief valve plunger sleeve out of the governor housing. Catch the plunger and sleeve by hand when removing them.

NOTE: 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 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 with a hammer.

30. If necessary, remove the speed adjusting shaft oil seal from the governor housing.

Disassemble Governor (Former)

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

air, and inspect it for worn or damaged parts that may be repaired or replaced without completely disassembling the governor.

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

Refer to Figs. 2 and 18 for the location of the various parts and disassemble the governor as follows:

1. Note and record the position of the throttle control lever on the speed adjusting shaft. Loosen the bolt securing the lever to the shaft, then slide the lever off the shaft.

2. Note and record the position of the throttle control terminal lever on the governor terminal lever shaft. Loosen the bolt securing the lever to the shaft, then slide it off the shaft.

3. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws.

4. If necessary, remove the oil inlet elbow from the oil inlet plug.

5. Remove the three cover screws, then remove the cover and gasket from the housing.

6. Loosen the maximum speed adjusting screw lock nut and remove the adjusting screw and nut from the governor housing.

7. Remove the speed droop adjusting bracket bolt, lock washer and plain washer from the terminal lever; then, remove the droop adjusting bracket from the speed adjusting floating lever and terminal lever.

8. Remove the two cotter pins securing the terminal lever to the terminal lever shafts.

9. Drive on the lower edge of the terminal lever shaft sleeve cup plug with a small punch and hammer as shown in Fig. 10 to force the upper edge out of the sleeve. Then pull the plug out of the sleeve with a pair of pliers.

10. Place a small rod, slightly curved on one end, against the inner end of the terminal lever shaft and push the shaft out of the terminal lever and shaft sleeve.

11. Place a 1/4" rod, approximately 6" long, through the terminal shaft sleeve, terminal lever and against the end of the second terminal lever shaft. Then drive the cup plug out of the terminal lever shaft sleeve in the opposite side of the governor housing with a hammer.

12. Push the terminal lever shaft out of the terminal lever and sleeve. Then remove the rod and terminal lever from the housing.

13. Remove the speed adjusting shaft sleeve and gasket from the governor housing. Then remove the speed adjusting shaft cap and gasket from the opposite side of the housing.

14. Remove the speed adjusting shaft, floating lever, spring fork, speeder spring, speed adjusting lever, pilot valve plunger and plunger bearing from the governor housing.

15. If necessary, the speed adjusting shaft, speed adjusting lever, floating lever, spring fork, speeder spring and pilot valve plunger and spring seat assembly may be disassembled as follows:

- a. Remove the cotter pin securing the speed adjusting lever to the speed adjusting shaft and pull the shaft out of the lever.
- b. Straighten the bent end of the wire pin securing the speed adjusting lever and spring fork to the speed adjusting floating lever.
- c. Pull the wire pin out of the speed adjusting lever and floating lever with a pair of pliers. Then, remove the two spring fork pins from the spring fork, floating lever and speed adjusting lever.
- d. Insert a small screw driver between the spring and fork and pry the speeder spring from the spring fork.
- e. Work a small screw driver around under the speeder spring and remove the spring from the pilot valve plunger and spring seat assembly.

16. Remove the relief valve assembly and gasket from the side of the governor housing. Then, remove the dummy hole plug and gasket from the opposite side of the housing.

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

NOTE: 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.

18. Place the governor housing bottom side up on a bench.

19. Remove the lock ring from the groove in the shaft of the ball head with a pair of snap ring pliers; then remove the ball head and flyweight assembly from the housing.

20. Remove the three screws securing the governor base to the governor housing.

21. 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.

22. Remove the oil pump drive and driven gears from the governor base or housing.

23. Inspect the terminal lever shaft sleeve bushings for wear or scoring and, if necessary, remove the sleeve and bushing assemblies from the governor housing as follows:

- a. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise.
- b. Insert a 5/16" bolt, approximately 5" long, through one of the terminal lever shaft sleeves, then thread a 5/16" nut, approximately 1/4" from the end, on the bolt inside of the housing.
- c. Place the threaded end of the bolt inside the sleeve in the opposite side of the housing. Then drive the sleeve and bushing assembly out of the governor housing with a hammer.
- d. Reverse the bolt in the governor housing and remove the remaining terminal lever shaft sleeve and bushing assembly.

24. If necessary, remove the pipe plug in the forward face of the governor housing.

Inspection

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

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 cylinder (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 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. Also check the pin

seats in the terminal lever and power piston for wear and scoring.

Examine the ends of the terminal lever cross pin and the holes in the terminal lever for wear and scoring.

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 flat areas and rounding off the edges of the ball head.

NOTE: The pilot valve plunger, power piston and ball head assembly must operate freely in their respective bores.

Examine the pilot valve 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 support pins for satisfactory governor operation.

Inspect the terminal lever and speed adjusting lever shaft bushings in the governor housing. If scored or worn excessively, replace the bushings.

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 plunger in the former governors did not incorporate four relief holes and the sleeve and washer were separate pieces.

Inspect the bushings in the terminal lever and speed adjusting shaft sleeve in a former governor.

Check the speed adjusting lever retracting spring for fractured coils.

Replace all of the governor parts that are excessively worn or damaged.

Assemble Governor (Current)

Refer to Figs. 1 and 11 and assemble the governor as follows:

1. If removed, install new speed adjusting lever and terminal shaft bushings in the governor housing to the specified dimensions shown in Fig. 12.

2. Lubricate the two oil pump gears and place them in their respective positions in the governor base.

3. Place a new seal ring in the groove of the governor base, with the wide side of the seal down in the groove.

4. Set the governor housing 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 base seal ring.

5. Lubricate the outside diameter of the ball head with engine oil; then insert the end of the ball head and flyweight assembly straight into and through the bore of the governor housing, drive gear and base.

CAUTION: It is important when installing the driven gear stud that it be installed with the arrow on the stud pointing towards the relief valve side of the governor. Also, that the shaft of the arrow is parallel to a line through the center of the governor and the relief valve.

6. Insert three screws through the governor base and thread them into the governor housing. Turn the ball head assembly while tightening the screws to make sure the ball head assembly revolves freely.

If a bind exists, loosen the 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.

NOTE: To install a current design governor base on a former design housing or a former design base on a current design housing, No. 3 taper dowel pins must be used. Refer to Fig. 13 for fabrication of tools necessary to properly align the base and the housing and proceed as follows:

a. Position the dummy gear over the idler gear stud.

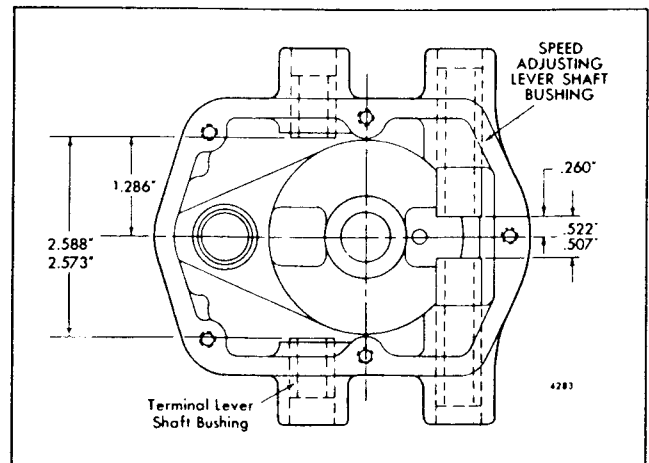


Fig. 12 - Location of Speed Adjusting Lever and Terminal Lever Shaft Bushings in Governor Housing

- b. Position the base against the governor housing and align them with the tapered arbor.
 - c. Enlarge the dowel pin holes to .200"- .212" diameter and taper ream to allow for a No. 3 tapered pin. Always drill from the base to the housing and be sure the tapered pin is flush with the bottom of the governor mounting flange.
7. Install the ball head lock ring in the groove of the ball head shaft with a pair of snap ring pliers.
8. Refer to Fig. 14 and install the relief valve plunger, plunger sleeve, plunger retaining spring, sleeve retaining spring, oil inlet plug and dummy 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 of the plunger sleeve.
- b. Determine the type of governor being assembled, right-hand or left-hand, then insert the relief valve plunger and sleeve assembly straight into the proper opening in the side of the governor housing, 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 between the soft jaws of a bench vise. Then tighten the oil inlet plug and dummy hole plug securely.

9. Lubricate the power piston 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.

10. Install the terminal lever, terminal lever shafts, cotter pins and cup plugs in the governor housing as follows:

- a. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws.
- b. Lubricate one of the terminal lever shafts with

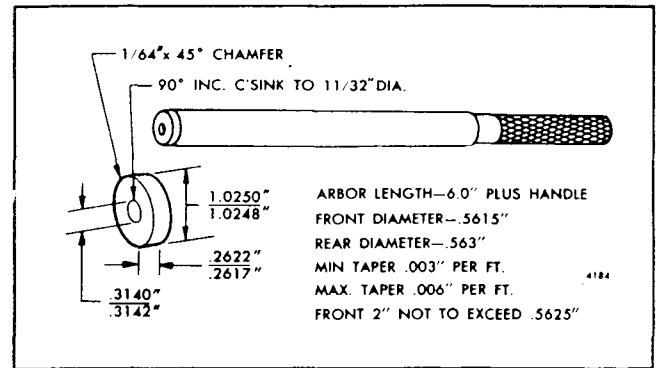


Fig. 13 - Fabrication of Governor Housing-to-Base Alignment Tool

engine oil. Place the terminal lever in between the ends of the two bushings inside of the governor housing; then insert the serrated end of the shaft into the 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.

- c. Install a cotter pin through the terminal lever and shaft and bend the ends over against the side of the terminal lever.
 - d. 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 b and c.
 - e. Apply a thin coat of sealing compound to the outside diameter of a new governor housing cup plug. Start the plug, open end out, straight into one of the shaft openings, then press the plug in flush with the outside face of the housing boss.
 - f. Install the second new governor housing cup plug in the boss at the opposite side of the housing in the same manner as described in Step e.
11. Lubricate the terminal lever-to-power piston pin 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.
12. If disassembled, the speed adjusting lever, floating lever, spring fork, speeder spring and the pilot valve plunger may be assembled as follows:
- a. Place the non-slotted end of the speed adjusting

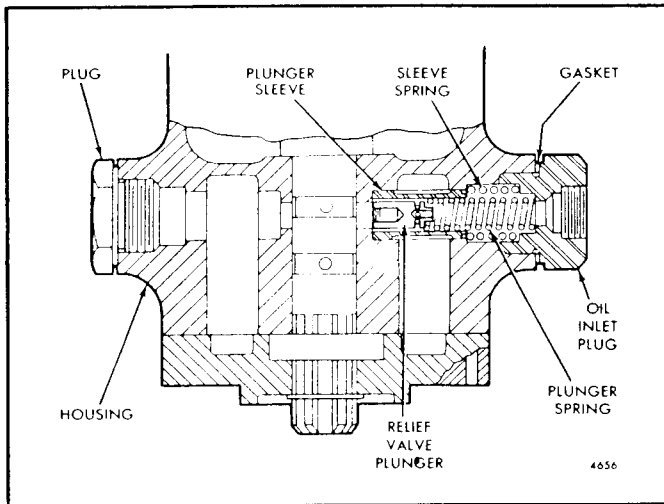


Fig. 14 - Location of Oil Relief Valve Plunger, Plunger Sleeve, Springs, Oil Inlet Plug and Dummy Plug in Governor Housing (R.H. Governor Shown)

floating lever in the slot on the speed adjusting lever 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.
- 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 the floating lever.
- d. Push the wire pin in against the speed adjusting lever and spring fork and bend the protruding end of the 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.

13. Remove the governor housing from the bench vise and place it on its side, oil inlet plug side up, on a work bench with the top of the housing facing out.

14. On a governor equipped with a synchronizing motor, place the speed adjusting lever retracting

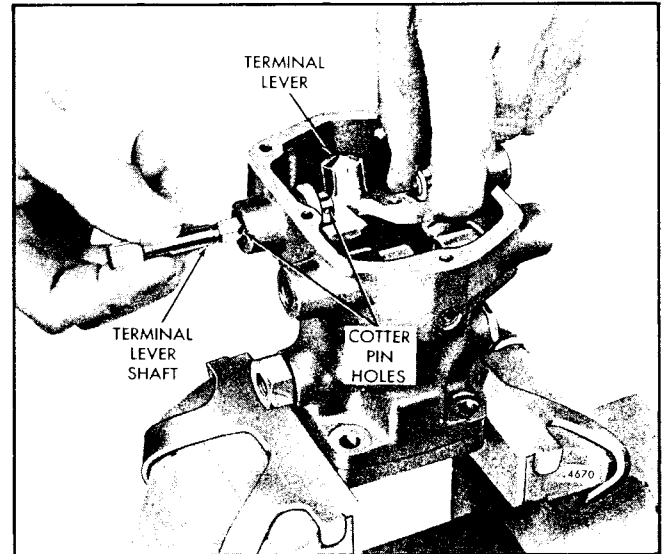


Fig. 15 - Installing Terminal Lever Shaft in Governor Housing and Terminal Lever

spring over the speed adjusting lever shaft bushing in the governor housing, with the hooked end of the spring over the slot between the two shaft bushings. See inset in Fig. 16.

15. 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.

16. 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

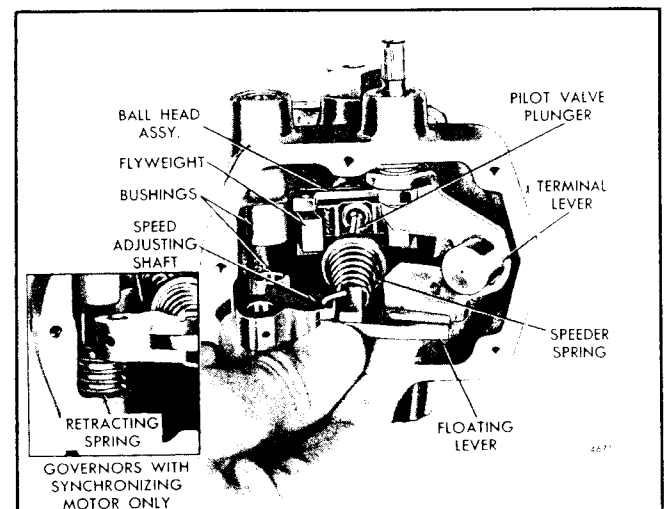


Fig. 16 - Installing Speed Adjusting Lever, Floating Lever, Speeder Spring and Pilot Valve Plunger Assembly

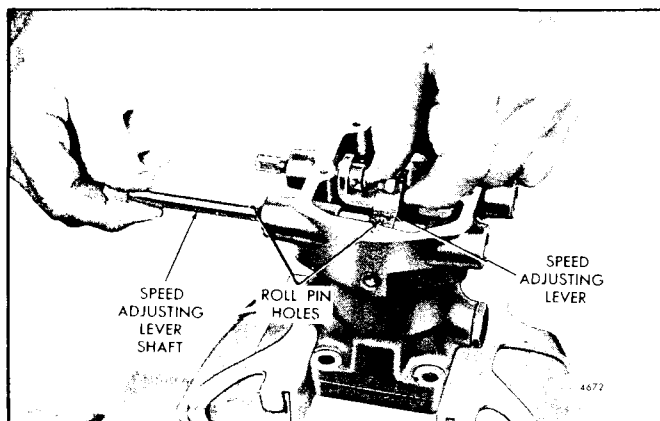


Fig. 17 - Installing Speed Adjusting Lever Shaft in Governor Housing and Adjusting Lever

inside the housing (Fig. 11). 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.

17. Install the speed adjusting lever shaft, roll (spring) pin and cup plug 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 machined 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 in the housing, from the oil inlet plug side, with the roll pin hole in the shaft and lever in alignment (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.

CAUTION: 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 (see inset in Fig. 16).

- d. Start the speed adjusting lever roll (spring) pin straight into 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 clockwise 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.

- f. If removed, apply a thin coat of sealing compound to the outside diameter of the speed adjusting lever shaft cup plug. Start the plug, open end out, straight into the boss in the opposite side of the governor housing, then press the plug in flush with the edge of the boss.
- g. If removed, apply a thin coat of sealing compound to the outside diameter of the speed adjusting shaft oil seal. Place the oil seal, lip of seal facing in, over the end of the speed adjusting shaft and start it in the bore in the housing, then press the seal in flush with the edge of the boss.

18. Place the flat side of the speed droop adjusting bracket against the top (bolting) surface of the terminal lever, with the pin in the bracket in the slot of the speed adjusting floating lever. Secure the bracket to the terminal lever with a flat washer, lock washer, and screw.

19. If removed, thread the lock nut on the maximum speed adjusting screw. Place the copper washer on the adjusting screw, then thread the screw approximately half way in the governor housing.

20. If removed, place a copper washer over the threaded end of the speed adjusting lever stop pin. Insert the threaded end of the stop pin through the hole in the governor cover and secure it in place with a nut.

21. Affix a new governor cover gasket to the bottom face of the cover. Place the cover on the governor housing and secure it in place with the three screws with lock washers.

22. If removed, thread a lock nut on the load limit screw then thread it approximately half-way in the governor cover (Fig. 1).

23. Place the throttle control terminal lever on the governor 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 torque.

24. Place the throttle control lever with the throttle control rod assembly attached, on the speed adjusting lever shaft in the same position it was in at the time of removal, then tighten the retaining bolt to 7-9 lb-ft torque.

25. If removed, install the oil inlet tube elbow in the oil inlet plug.

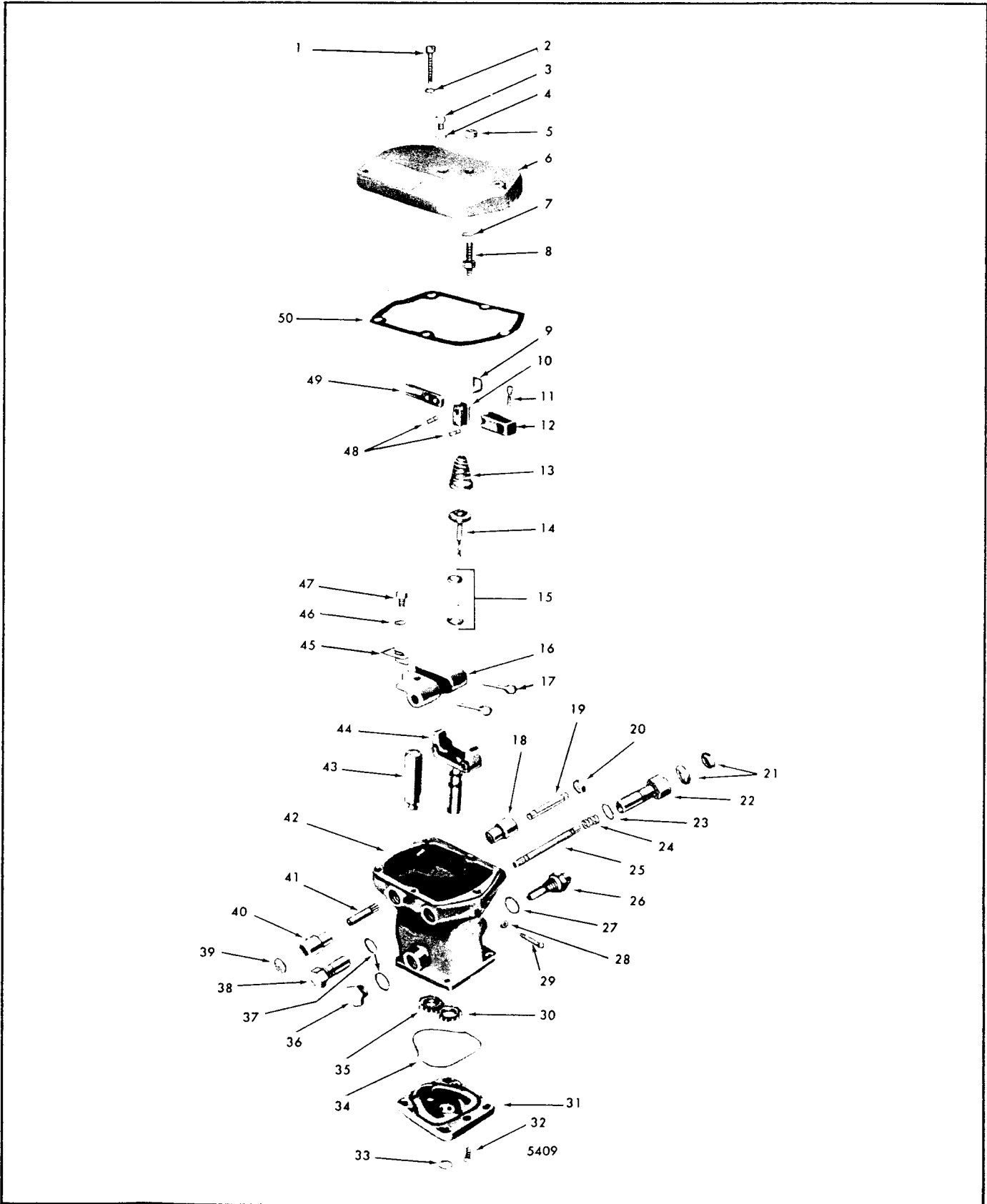


Fig. 18 - Hydraulic Governor Details and Relative Location of Parts (Former)

1. Screw--Cover	14. Plunger--Pilot Valve	26. Valve Assy.--Relief	38. Cap--Speed Adjusting Shaft
2. Lock Washer	15. Bearing--Plunger	27. Gasket--Relief Valve	39. Nut--Adjusting Screw
3. Bolt	16. Lever--Terminal	28. Nut--Adjusting Screw	40. Sleeve--Shaft
4. Washer--Copper	17. Pin--Cotter	29. Screw--Maximum Speed Adjusting	41. Shaft--Terminal Lever
5. Nut--Stop Pin	18. Sleeve--Shaft	30. Gear--Oil Pump Drive	42. Housing--Governor
6. Cover--Governor	19. Shaft--Terminal Lever	31. Base--Governor	43. Piston--Power
7. Washer--Copper	20. Plug--Sleeve	32. Screw--Fil. Head	44. Ball Head Assy.
8. Pin--Speed Adjusting Lever Stop	21. Seal--Speed Adjusting Shaft Oil	33. Lock Ring	45. Bracket--Droop Adjusting
9. Pin--Spring Fork Wire	22. Sleeve--Speed Adjusting Shaft	34. Ring--Housing to Base Seal	46. Washer--Plain
10. Fork--Spring	23. Gasket--Sleeve	35. Gear--Oil Pump Driven	47. Bolt--Bracket
11. Pin--Cotter	24. Spring--Speed Adjusting	36. Plug--Dummy Hole	48. Pin--Spring Fork
12. Lever--Speed Adjusting	25. Shaft--Speed Adjusting	37. Gasket--Plug and Sleeve	49. Lever--Floating
13. Spring--Speeder			50. Gasket--Cover

Fig. 18 - Hydraulic Governor Details and Relative Location of Parts (Former)

Assemble Governor (Former)

Refer to Figs. 2 and 18 and assemble the governor as follows:

1. If removed, install the terminal lever shaft and bushing assemblies in the governor housing as follows:
 - a. Place a support plate, of the proper length, between the inside faces of the housing adjacent to each terminal lever shaft sleeve opening.
 - b. Support the governor housing on its side on the bed of an arbor press so it is level.
 - c. Start the small end of the terminal lever shaft sleeve straight in the opening in the housing, then press the sleeve in the housing until the shoulder on the sleeve contacts the housing.
 - d. Reverse the governor housing on the bed of the arbor press and install the remaining terminal lever shaft sleeve. Then remove the support plate.
2. If removed, install the pipe plug in the governor housing.
3. Lubricate the two oil pump gears with engine oil, and place them in their respective positions in the governor base.
4. Place a new seal ring in the groove in the governor base, with the wide side of the seal down in the groove.
5. Set the governor housing 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.

CAUTION: It is important when installing the driven gear stud that it be installed with the arrow on the stud pointing towards the relief valve side of the governor. Also, that the shaft of the arrow is parallel to a line through the center of the governor and the relief valve.

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 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 revolves freely.

If a bind exists, loosen the 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.

NOTE: To install a current design governor base on a former design housing or a former design base on a current design housing, No. 3 tapered dowel pins must be used. Refer to Fig. 13 for fabrication of tools necessary to properly align the base and the housing and proceed as follows:

- a. Position the dummy gear over the idler gear stud.
- b. Position the base against the governor housing and align them with the tapered arbor.
- c. Enlarge the dowel pin holes to .200"-.212" diameter and taper ream to allow for a No. 3 tapered pin. Always drill from the base to the housing and be sure the tapered pin is flush with the bottom of the governor mounting flange.

8. Install the ball head lock ring in the groove in the ball head shaft with a pair of snap ring pliers.
9. Determine the type of governor being assembled, right-hand or left-hand, then place a new gasket on the relief valve assembly and thread it into the proper opening in the side of the governor housing.
10. Place a new gasket on the dummy hole plug and thread it into the opening in the housing opposite the relief valve assembly.
11. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise. Then tighten the relief valve assembly and dummy hole plug securely.
12. Lubricate the power piston 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.
13. If disassembled, refer to Figs. 2 and 18 and assemble the speed adjusting lever, floating lever, spring fork, speeder spring, pilot valve plunger and speed adjusting shaft as follows:
 - a. Place the non-slotted end of the speed adjusting floating lever in the slot of the speed adjusting lever so the pin holes are in alignment.
 - b. Insert the pin through the pin holes in the levers, with the small pin hole in the pin and floating lever in alignment, then insert the long end of the wire pin through the floating lever and pin.
 - c. Place the speed adjusting floating lever in the slot of the spring fork so the pin holes are in alignment.
 - d. Insert the second pin through the pin holes in the spring fork and floating lever, with the small pin hole in the pin and floating lever in alignment, then insert the short end of the wire pin through the floating lever and pin. Push the wire pin in against the floating lever and bend the long end of the wire pin over against the floating lever.
 - e. Insert the serrated end of the speed adjusting shaft into the speed adjusting lever with the cotter pin hole in the shaft and lever in alignment and the machined slot in the non-splined end of the shaft in the same position it was in at the time of removal. Align the pin holes in the shaft and lever and install the cotter pin. Bend the ends of the cotter pin over.
 - f. Press the lower end of the spring fork into the small end of the speeder spring; then insert the large end of the spring in the spring seat of the pilot valve plunger.
14. 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.
15. Hold the bearing against the bottom of the spring seat and start the end of the speed adjusting shaft through the proper opening, relief valve assembly side, in the governor housing. Then start the end of the pilot valve plunger straight in the opening in the ball head assembly and push it in until the bearing race rests on the flyweights.

CAUTION: Do not damage the plunger by applying undue pressure.

On a governor equipped with a synchronizing motor, place the speed adjusting lever retracting spring over the speed adjusting lever shaft and place the hooked end of the spring over the top of the speed adjusting lever before installing the assembly in the governor housing.
16. If removed, apply a thin coat of sealing compound to the outside diameter of the new speed adjusting shaft oil seals, then press the oil seals in the speed adjusting shaft sleeve with the lip of the inner seal facing down and the lip of the outer seal facing up.
17. Place a gasket on the speed adjusting shaft sleeve. Lubricate the speed adjusting shaft with engine oil, then start the small end of the sleeve over the end of the shaft and thread it into the governor housing. Tighten the sleeve securely.
18. Place a gasket on the speed adjusting shaft cap and thread the cap into the opposite side of the governor housing and over the end of the speed adjusting shaft. Tighten the cap securely.
19. On a governor equipped with a synchronizing motor, rotate the speed adjusting lever retracting spring clockwise around the shaft sleeve 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.
20. Install the terminal lever, terminal lever shafts, cotter pins and cup plugs in the governor housing as follows:
 - a. Place the flat side of the droop adjusting bracket against the inside face of the terminal lever boss as shown in Fig. 2 and secure it to the terminal lever with a flat washer, lock washer and bolt.
 - b. Place the terminal lever between the ends of the

- terminal lever shaft sleeves in the governor housing with the convex bearing surface resting on the power piston and the droop adjusting bracket pin in the slot of the floating lever as shown in Fig. 2.
- c. Lubricate one of the terminal lever shafts with engine oil. Insert the serrated end of the shaft into the bushing in the sleeve 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 sleeve 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 terminal lever shaft sleeve cup plug. Start the plug, open end out, straight into one of the shaft sleeves; then press the plug in flush with the end of the sleeve.
 - g. Install the second new terminal lever shaft sleeve cup plug in the sleeve at the opposite side of the housing in the same manner as outlined in Step f.
21. If removed, thread the lock nut on the maximum speed adjusting screw. Place the copper washer on the adjusting screw, then thread the screw approximately half way in the governor housing (Fig. 2).
 22. If removed, place a copper washer over the threaded end of the speed adjusting lever stop pin. Insert the threaded end of the stop pin through the hole in the governor cover and secure it in place with a nut.
 23. Affix a new governor cover gasket to the bottom face of the cover. Place the cover on the governor housing and secure it in place with the three screws with lock washers.
 24. Place the throttle control terminal lever on the governor 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 torque.
 25. Place the throttle control lever with the throttle control rod assembly attached, on the speed adjusting lever shaft in the same position it was in at the time of removal, then tighten the retaining bolt to 7-9 lb-ft torque.
 26. If removed, install the oil inlet tube elbow in the oil inlet plug.

Install Governor

Refer to Fig. 6 and proceed as follows:

1. Affix a new gasket to the top of the governor drive housing.
2. Position the governor over the governor drive housing with the throttle control levers facing the rear of the engine. Turn the ball head assembly slightly to align splines of the ball head shaft with the splines in the driven shaft sleeve; then enter the shaft straight in the sleeve and rest the governor on the gasket.
3. Install the governor to drive housing bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.
4. Connect the oil inlet tube assembly to the oil inlet elbow.
5. Attach the throttle control rod assembly to the throttle control cross shaft lever.
6. Attach the fuel rod to the throttle control terminal lever.
7. Attach the throttle control terminal lever retracting spring to the terminal lever.
8. On a governor equipped with a synchronizing motor, connect the wires to the motor.

After the governor has been installed, the engine must be tuned-up as outlined under *Engine Tune-Up Procedures* in Section 14.

HYDRAULIC GOVERNOR DRIVE

The governor drive assembly (Fig. 1) consists of a horizontal drive shaft and bevel drive gear and a vertical driven sleeve and bevel driven gear mounted on ball bearings and contained in the governor drive housing.

A second ball bearing is mounted in the drive housing to support the drive gear end of the horizontal drive shaft and is retained in the housing by a snap ring.

The vertical driven gear, bearing and sleeve are retained in the governor drive housing by two conical set screws, copper washers and elastic stop nuts.

The horizontal drive shaft is driven by the governor drive gear which is keyed to and retained on the drive shaft by a self-locking nut and driven by either the camshaft gear or the balance shaft gear, depending upon the engine model.

The governor drive housing is attached to the forward face of the cylinder block end plate as shown in Fig. 2. The engine fuel pump is attached to the forward end of the drive housing and is driven by the governor drive shaft.

The governor is attached to the top of the governor drive housing and is driven through splines on the lower end of the ball head which register with splines in the upper end of the driven gear sleeve.

Lubrication

The governor drive beveled gears and bearings are lubricated by the surplus oil from the governor which

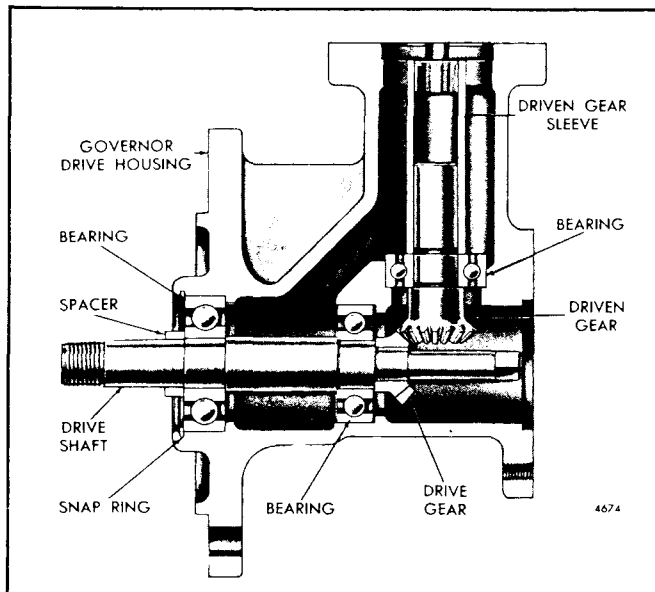


Fig. 1 - Hydraulic Governor Drive Assembly

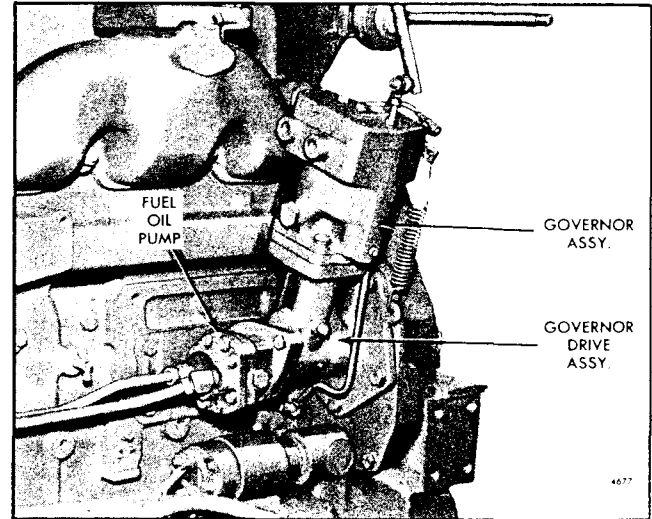


Fig. 2 - Hydraulic Governor Drive Mounting

spills over the moving parts inside of the drive housing. The surplus oil returns to the crankcase through a cored passage in the drive housing.

Remove Governor Drive

Refer to Fig. 2 and proceed as follows:

1. Remove the governor as outlined under *Remove Governor* in Section 2.8.1.
2. Disconnect and remove the fuel oil inlet and outlet tube assemblies from the fuel oil pump.
3. Remove the three bolt and seal assemblies securing the fuel oil pump to the governor drive housing, then remove the pump, drive coupling and gasket.
4. Disconnect and remove the governor oil inlet supply tube from the elbow in the cylinder block under the governor drive housing.
5. Remove the three 3/8" -24 (12 pt. hd.) bolts and copper washers and the two 3/8" -16 (hex hd.) bolts and plain washers securing the governor drive housing to the cylinder block end plate.
6. If necessary, tap the side of the drive housing with a plastic hammer to loosen it, then remove the drive assembly and gasket from the end plate.

Disassemble Governor Drive

Refer to Figs. 1 and 3 and proceed as follows:

1. Clamp the governor drive gear in a bench vise equipped with soft jaws; then, remove the nut securing the drive gear to the governor drive shaft.

2. Clamp the bolting flange of the governor drive housing in a bench vise equipped with soft jaws. Attach a suitable gear puller to the governor drive gear and pull the gear from the drive shaft.

3. Remove the key from the keyway in the drive shaft. Also, slide the spacer off the end of the shaft.

4. Loosen the two driven gear bearing retaining set screw lock nuts (Fig. 3), then back the set screws out of the housing enough to free the bearing.

5. Pull the bevel driven gear, bearing and sleeve assembly out of the drive housing with a pair of small nose pliers.

6. Remove the governor drive shaft and ball bearing retaining snap ring from the groove in the drive housing with a pair of snap ring pliers.

7. Pull the drive shaft, bearing and drive gear assembly from the drive housing. If necessary, support the drive housing on the bed of an arbor press and press the drive shaft, bearings and drive gear assembly out of the drive housing.

8. Inspect the drive shaft and driven gear ball bearings as outlined under *Inspection*. If necessary, remove the bearings from the drive shaft and driven gear as follows:

- a. Place two plates between the bevel driven gear and the driven gear bearing; then, support the driven gear assembly and plates on the bed of an arbor press, with the driven gear over the opening in the bed of the press.

NOTE: The plates may be fabricated by drilling a 3/4" hole through the center of a 1/4" x 3" x 3" steel plate, then cutting the plate in half.

- b. Place a steel rod in the opening in the end of the driven gear sleeve and against the gear shaft; then, press the driven gear from the sleeve and bearing. Catch the driven gear by hand when pressed from the sleeve and bearing.
- c. Place the two plates around the drive shaft between the two bearings; then, support the drive shaft assembly and plates on the bed of an arbor press with the threaded end of the shaft facing up.
- d. Place a short brass rod on the end of the drive shaft and press the shaft out of the rear bearing. Catch the drive shaft, forward bearing and drive gear by hand when pressed from the bearing.
- e. Remove the drive gear and forward bearing from

the drive shaft in the same manner as outlined in Steps c and d.

Inspection

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

Examine the ball bearings for corrosion and pitting. Lubricate each bearing with engine oil; then, while holding the inner race from turning, revolve the outer race slowly by hand and check for rough spots.

Inspect the teeth of the drive and driven bevel gears for chipping, scoring or wear. Remove any slight score marks with a fine India stone.

Inspect the splines in the driven gear sleeve for wear. Also, the splines on the governor ball head for wear.

Examine the teeth of the governor drive gear for chipping, scoring or wear. Remove any slight score marks with a fine India stone.

Replace all of the governor drive parts that are excessively worn or damaged.

Assemble Governor Drive

Refer to Figs. 1 and 3 and proceed as follows:

1. Install the governor drive shaft bearings and drive gear on the drive shaft as follows:

- a. Lubricate the inside diameter of the forward drive shaft bearing with engine oil and start the bearing, numbered end up, straight on the small non-threaded end of the drive shaft.
- b. Place a suitable sleeve over the end of the drive shaft and against the inner race of the bearing. Then support the drive shaft, bearing and sleeve on the bed of an arbor press.
- c. Place a short brass rod on the end of the drive shaft and press the shaft straight into the bearing until the shoulder on the shaft is tight against the bearing inner race.
- d. Lubricate the inside diameter of the bevel drive gear with engine oil and start the gear straight on the small non-threaded end of the drive shaft.
- e. Place a brass plate, with a 1/2" hole through its center, over the end of the drive shaft and against the gear teeth. Then support the drive shaft, bearing, drive gear and brass plate on the bed of an arbor press.

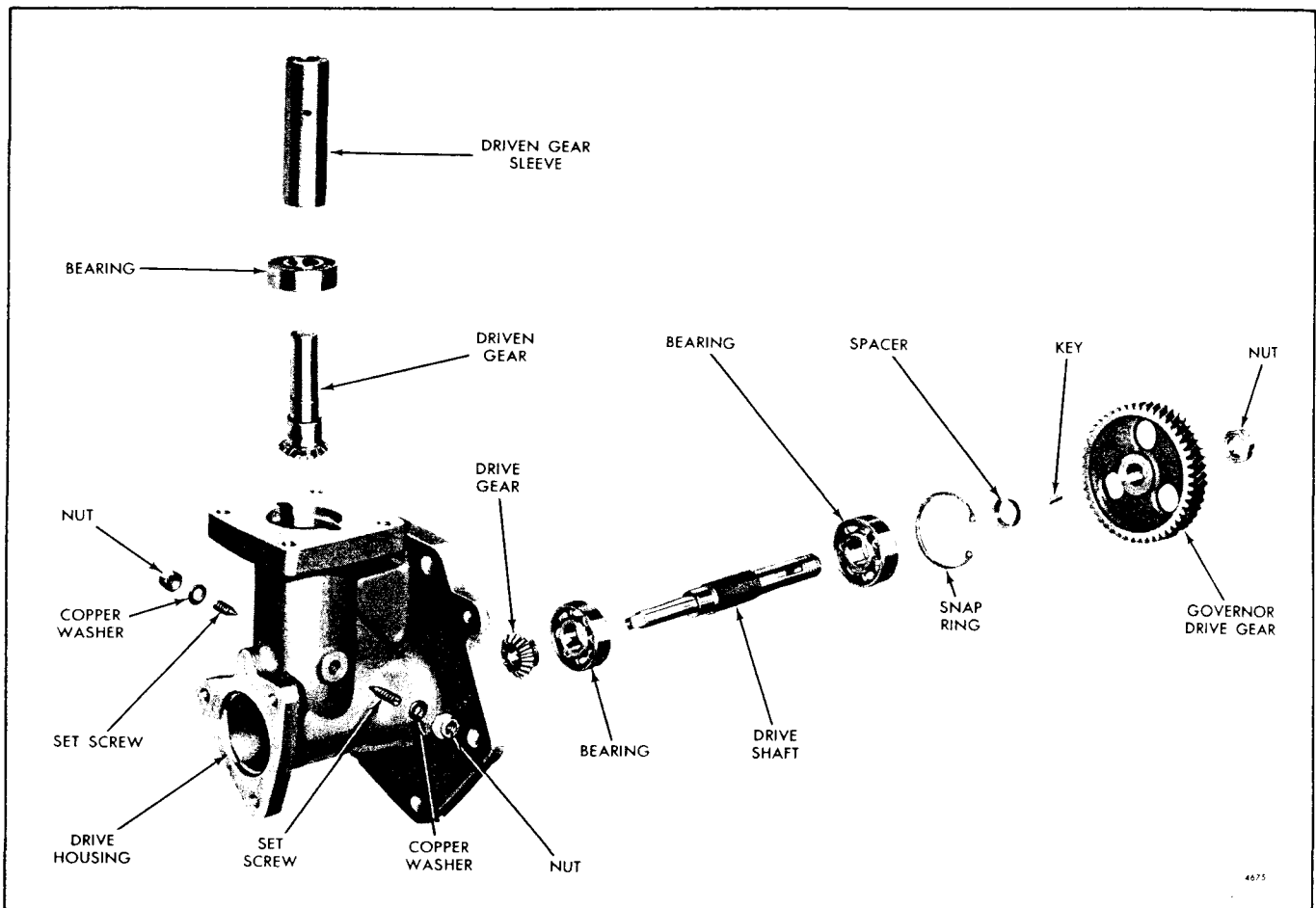


Fig. 3 - Hydraulic Governor Drive Details and Relative Location of Parts

- f. Place a short brass rod on the end of the drive shaft and press the shaft straight into the drive gear until the shoulder on the shaft is tight against the drive gear.
 - g. Lubricate the inside diameter of the rear drive shaft bearing with engine oil and start the bearing, numbered end up, straight on the threaded end of the drive shaft.
 - h. Place a suitable sleeve over the end of the drive shaft and against the inner race of the bearing. Then support the drive shaft with bearings, drive gear and sleeve on the bed of an arbor press.
 - i. Place a short brass rod on the end of the drive shaft and press the shaft straight into the bearing until the shoulder on the shaft is tight against the bearing inner race.
2. Install the governor driven shaft bearing and sleeve on the driven gear as follows:
 - a. Lubricate the inside diameter of the driven gear bearing with engine oil and start the bearing, numbered end up, straight on the driven gear.
 - b. Place a suitable sleeve over the end of the driven gear and against the inner race of the bearing. Then support the driven gear and sleeve on the bed of an arbor press.
 - c. Place a short brass rod on the center of the driven gear and press the driven gear into the bearing until the shoulder on the gear is tight against the bearing inner race.
 - d. Lubricate the inside diameter of the driven gear sleeve with engine oil and start the non-splined end of the sleeve on the small end of the driven gear.
 - e. Support the driven gear with the bearing and sleeve on the bed of an arbor press with the teeth of the driven gear facing up.
 - f. Place a short brass rod on the center of the driven gear and press the driven gear into the sleeve

until the end of the sleeve is tight against the bearing inner race.

3. Lubricate the two bearings on the drive shaft with engine oil. Insert the small end of the drive shaft into the drive shaft opening of the drive housing and start the large drive shaft bearing straight into the bearing bore of the housing. Then guide the inner bearing into its bore and push the drive shaft assembly in the housing until the bearing contacts the shoulder in the housing.

4. Install the governor drive shaft and ball bearing retaining snap ring in the groove in the housing with a pair of snap ring pliers.

5. Lubricate the driven gear bearing with engine oil. Insert the driven gear, bearing and sleeve assembly in the opening in the top of the drive housing and start the bearing straight into the bearing bore in the housing. Then push the driven gear assembly in the housing until the teeth of the drive and driven gears are in mesh and the bearing is seated on the shoulder in the housing.

6. Install the two driven gear bearing retaining set screws with copper washers and nuts in the holes in the side of the drive housing. Turn the screws in tight against the bearing and tighten the lock nuts.

7. Install the governor drive gear on the governor drive shaft as follows:

- a. Place the governor drive shaft bearing spacer over the threaded end of the drive shaft and against the bearing inner race.
- b. Install the key in the keyway in the drive shaft.
- c. Lubricate the inside diameter of the governor drive gear with engine oil and start the gear on the drive shaft with the keyway in the gear in alignment with the key in the drive shaft.
- d. Support the governor drive housing assembly with the governor drive gear on the bed of an arbor press, with a support under the small outside diameter end of drive shaft.

e. Place a suitable sleeve on top of the governor drive gear and under the ram of the press, then press the gear on the drive shaft and against the spacer.

f. Clamp the governor drive gear in a bench vise equipped with soft jaws.

g. Lubricate the threads of the governor drive gear retaining nut with engine oil. Thread the nut on the drive shaft and tighten the nut to 125-135 lb-ft torque.

Install Governor Drive

Refer to Fig. 2 and proceed as follows:

1. Affix a new gasket to the bolting flange of the governor drive housing.

2. Place the governor drive assembly in position against the cylinder block end plate with the teeth of the governor drive gear in mesh with the teeth of the camshaft or balance shaft gear, depending upon the engine model.

3. Install 3/8" -24 bolts and copper washers in the three bolt holes in the drive housing (one at the bottom and two next to the cylinder block). Then install a 3/8" -16 bolt and plain washer in each of the two remaining bolt holes in the drive housing. Tighten the 3/8" -16 bolts to 30-35 lb-ft torque and the 3/8" -24 bolts to 35-39 lb-ft torque.

4. Affix a new gasket to the bolting flange of the fuel pump assembly. Place the fuel pump drive coupling over the square end of the fuel pump drive shaft, then place the fuel pump in position against the front face of the drive housing with the drive coupling over the square end of the governor drive shaft. Install the three bolt and seal assemblies and tighten the bolts to 13-17 lb-ft torque.

5. Connect the fuel oil inlet and outlet tube assemblies to the fuel pump.

6. If removed, attach the governor oil inlet supply tube to the elbow in the cylinder block under the governor drive housing.

7. Install the governor on the drive housing as outlined under *Install Governor* in Section 2.8.1.

HYDRAULIC GOVERNOR SYNCHRONIZING MOTOR

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 as shown in the wiring diagram (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.

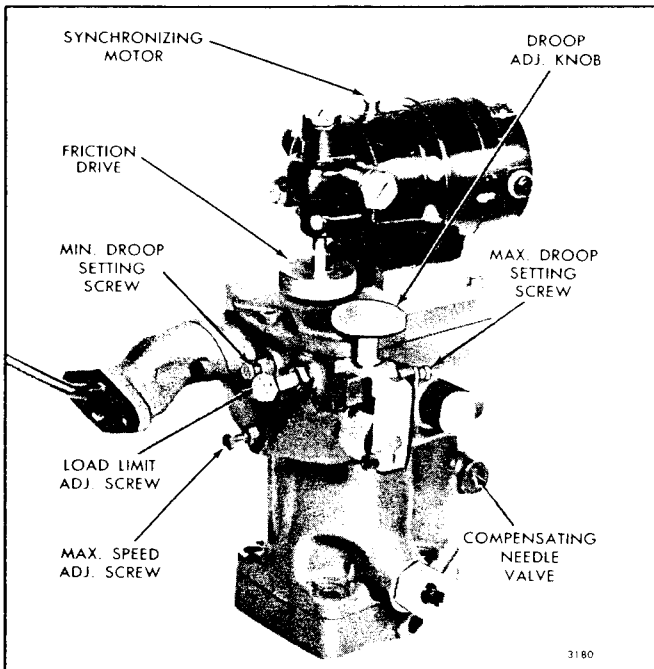


Fig. 1 - Synchronizing Motor Mounting

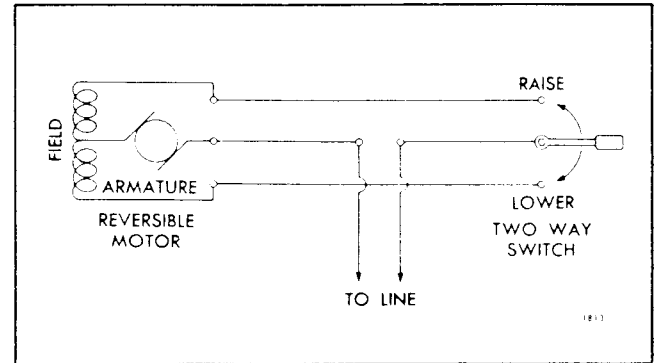


Fig. 2 - Synchronizing Motor Wiring Diagram

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. All of the components of the friction drive are available for service.

SHOP NOTES-TROUBLE SHOOTING-SPECIFICATIONS-SERVICE TOOLS

SHOP NOTES

CHECKING INJECTOR TESTER J 9787

The injector tester 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 8130. 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. Close the valve on the fuel supply line. After a slight initial drop in pressure, 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.

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.

REFINISH LAPPING BLOCKS

As the continued use of the lapping blocks will cause



Fig. 1 - Refinishing Lapping Blocks

worn or low spots to develop in their lapping surfaces, they should be refinished from time to time.

It is a 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 as shown in Fig. 1. Alternate the blocks from time to time. For example, assuming the blocks are numbered 1, 2 and 3, work 1 and 2 together, then 1 and 3, and finish by working 2 and 3 together. Continue this procedure until all of the blocks are perfectly flat and free of imperfections.

Imperfections are evident when the blocks are clean and held under a strong light. The blocks are

satisfactory when the entire surface is a solid dark grey. Bright or exceptionally dark spots indicate defects and additional lapping is required.

After the surfaces have been refinished, 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.

INJECTOR TIMING

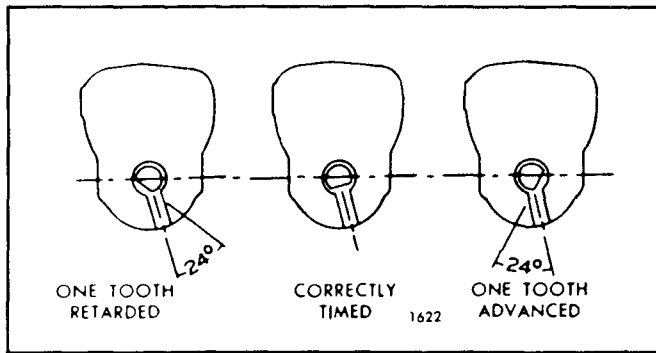


Fig. 2 - Injector Rack-to-Gear Timing

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

A hole located in the injector body, on the side opposite the identification tag, may be used to visually determine whether or not the injector rack and gear are correctly timed. When the rack is all the way in (full-fuel position), the flat side of the plunger will be visible in the hole, indicating that the injector is "in time". If the flat side of the plunger does not come into full view (Fig. 2) and appears in the "advanced" or "retarded" position, the injector should be disassembled and the rack-to-gear timing corrected.

FUEL 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 21085 may be used to select a spray tip that will increase or decrease the fuel injector output for a particular injector after it has been rebuilt and tested on the comparator.

EFFECT OF PRE-IGNITION ON FUEL INJECTOR

Pre-ignition 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 pre-ignition occurs, all of the injector

assemblies should be removed and checked for burned spray tips or enlarged spray tip orifices.

Before replacing the injectors, check the engine for the cause of pre-ignition to avoid a 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.

BLUING INJECTOR BODIES AND NUTS

The appearance of the injector body and nut of a rebuilt injector can be enhanced with an oxide finish obtained through a dipping process known as "bluing". Pre-mixed compounds are available commercially for preparing the necessary solutions. Detailed instructions are usually provided with the commercial compounds. An effective bluing solution can be prepared in the service shop by mixing the following materials:

6 lbs. of sodium hydroxide per gallon of water

3-1/2 lbs. of sodium nitrite per gallon of water

1 ounce of phosphoric acid per gallon of water

The procedure usually follows five (5) steps in sequence:

1. An alkaline solution bath (180 °-212 °F.) to preclean.

2. A hot or cold water rinse.

3. The bluing solution bath.
4. A cold water rinse.
5. An engine lubricating oil bath (180 °-212 °F.) to rust proof. The bluing tank should be a double walled, 1-1/2 " insulated type of No. 10 gage steel.

The temperature of the sodium hydroxide, sodium nitrite and phosphoric acid solution for bluing steel parts should be 295 ° to 305 °F. The boiling point of the solution is directly related to its concentration. Therefore, when the boiling point is too high, the solution is too concentrated and the volume of water is probably low. When this occurs, the boiling point can be reduced to 300 °F. by adding water. The parts should be placed in the solution for 15 to 30 minutes.

It is extremely important that the parts be free of oil before placing them in the bluing bath. Oil will produce a varied color part.

There are several important safety precautions to be followed for preparing and using the solutions. Protective clothing such as rubber gloves, rubber aprons and protective glasses contribute to the safety of personnel carrying out the procedures. When preparing the solutions, *the compounds should be added to the water* and not water added to the compounds. The dipping tanks should be properly vented and all fumes exhausted to the outside atmosphere. Since temperatures of the caustic solutions exceed the boiling point of water, any splashing encountered while adding make-up water can cause serious burns. *Always add water slowly and with extreme care.* When the parts to be dipped are cold, caution should be taken to avoid splashing that might occur when the cold parts come in contact with the hot solutions. A heavy wire-screen type basket, suitable for holding a quantity of injector bodies, is recommended for dipping the parts in the solutions.

INJECTOR COMPARATOR AND CALIBRATOR READINGS

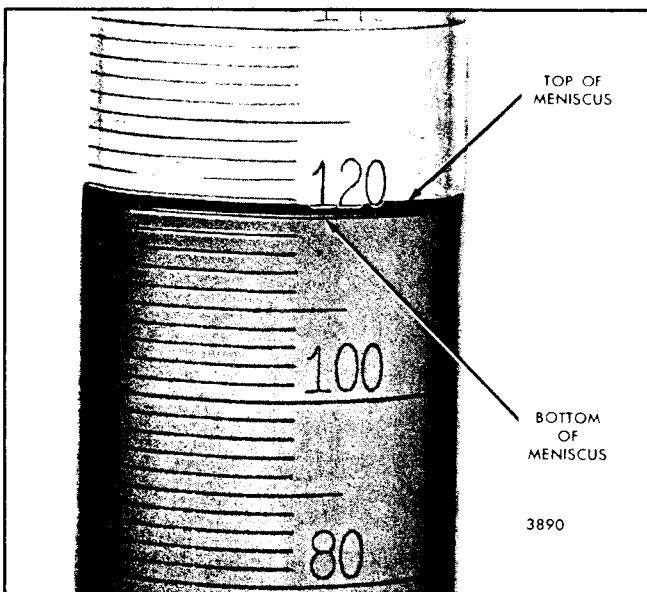


Fig. 3 - Checking Fuel Output

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

1. **Operator Errors:** If the column of liquid in the vial is read at the top of the meniscus instead of at the bottom, a variation of 1 or 2 points will result. Refer to Fig. 3.
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 is set at the factory to divert the injector output at 1,000 strokes, but must be reset for 1,200 strokes to check your 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 the comparator and should always be used. If regular diesel fuel oil (or any other liquid) is used, variations are usually noted because of the affect 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 comparator or calibrator for a calibration check contaminates the test oil. Therefore, it is important that the comparator or calibrator have the test oil and test oil filter changed every six months, or sooner if necessary.

In addition, other malfunctions such as a slipping drive belt, low level of fuel oil, a clogged filter, a defective fuel pump or leaking line connections could cause bad readings. A frequent check should be made for any of these tell-tale conditions.

FUEL INJECTOR PLUNGERS

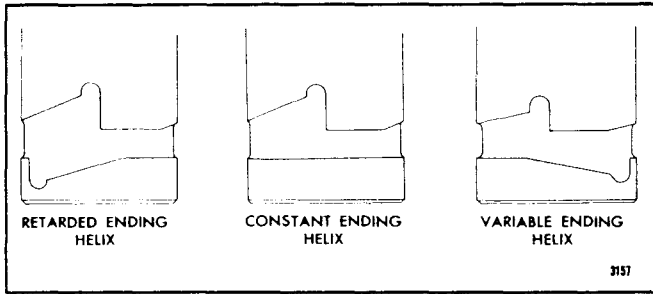


Fig. 4 - Types of Injector Plungers

injector are, to a great extent, determined by the type of plunger used. Three types of plungers are illustrated in Fig. 4. 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.

The fuel output and the operating characteristics of an

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.

REPLACING INJECTOR FOLLOWER SPRING

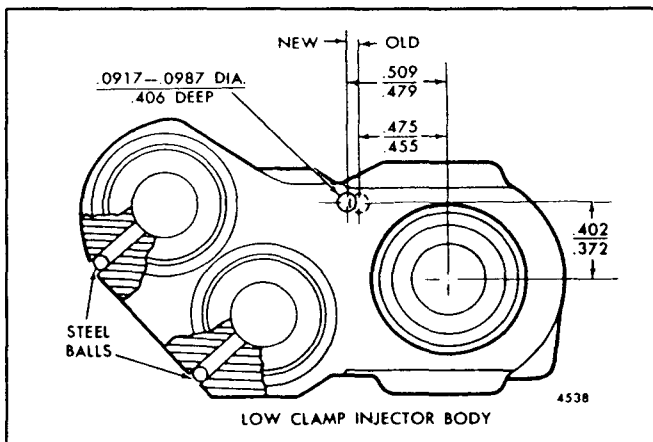


Fig. 5 - Relocating Timing Pin Hole in Injector Body

When replacing the injector follower spring (.120 " diameter wire) in a low clamp body injector built prior to June, 1965 with a new injector follower spring (.142 " diameter wire), it will be necessary to relocate the timing pin holes as illustrated in Fig. 5, or grind .022 " from the side of the injector timing gage shank, to permit continued use of the injector timing gage.

REFINISHING FACE OF INJECTOR FOLLOWER

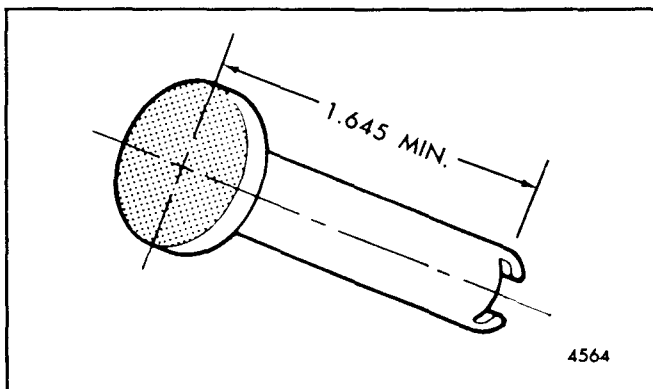


Fig. 6 - Injector Follower

When refinishing the face of an injector follower, it is extremely important that the distance between the injector face and the plunger slot is not less than the 1.645 " minimum shown in Fig. 6.

If the distance between the injector face and the plunger slot is less than 1.645 ", the height of the follower in relation to the injector body will be altered and proper injector timing cannot be realized.

NOTE: To ensure a sufficiently hardened surface for rocker arm contact, do not remove more than .010 " of metal from the injector follower head.

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 tube in the fuel tank which would cause the pump to draw air.

Presence of an air leak may be detected by observation of the fuel filter contents after the filter is bled and the engine is operated for 15 to 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.

FUEL LINES

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

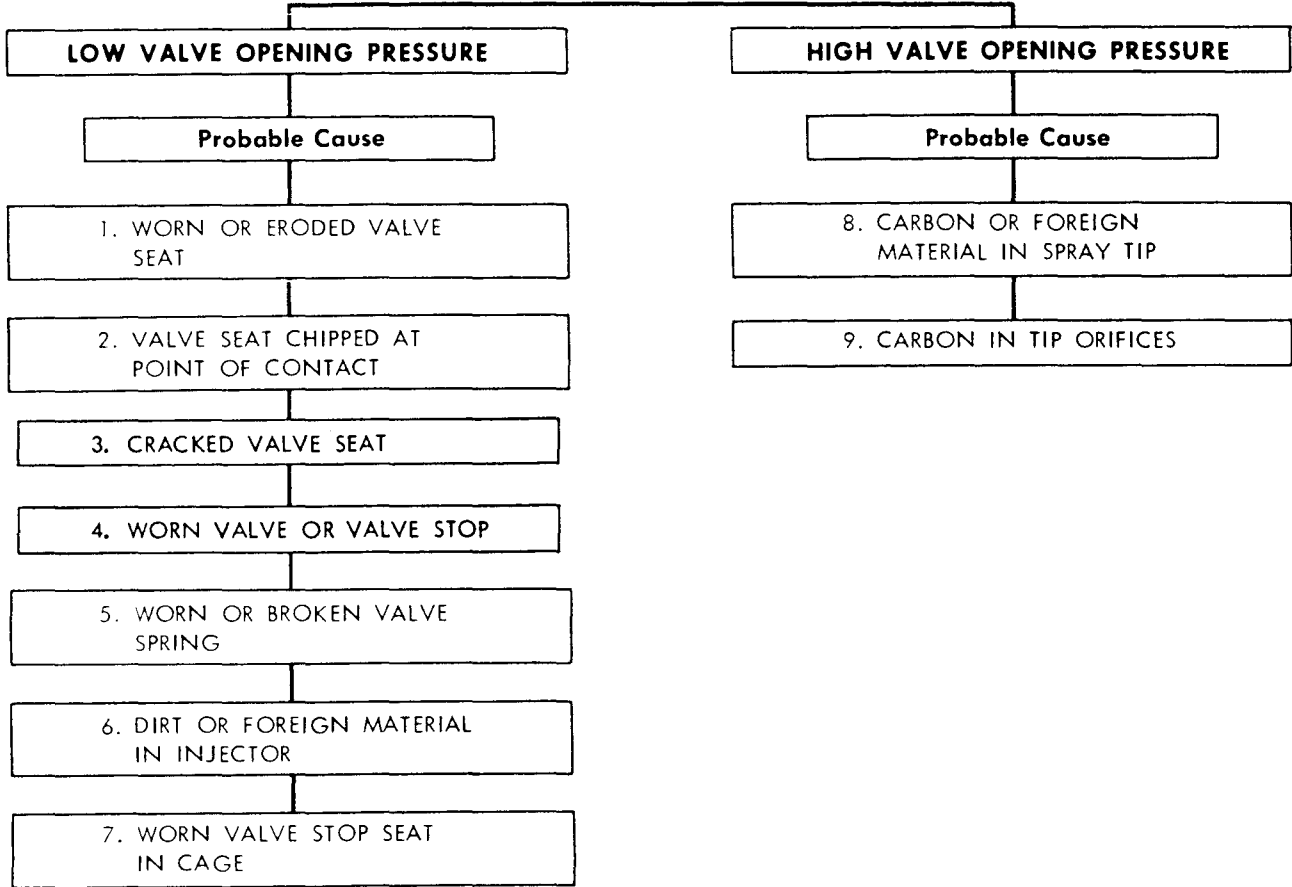
Be sure a restricted fitting of the proper size is used to connect the fuel return line to the fuel return manifold. Do not use restricted fittings anywhere else in the fuel system.

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, the engine should be run long enough to determine whether or not all connections are sufficiently tight. If any leaks occur, connections should be tightened only enough to stop the leak. Also check filter cover bolts for tightness.

TROUBLE SHOOTING CHARTS (Crown Valve Injectors)

Chart 1

LOW OR HIGH VALVE OPENING PRESSURE



SUGGESTED REMEDY

1. A worn or eroded valve seat may be lapped, but not excessively, as this would reduce the thickness of the part causing a deviation from the valve stack-up dimension.

2. If the valve seat is chipped at the point of contact with the valve, lap the surface of the seat and the I.D. of the hole. Mount tool J 7174 in a drill motor and place the seat on the pilot of the tool, using a small amount of lapping compound on the lapping surface. Start the drill motor and apply enough pressure to bring the seat to the point of lap. Check the point of lap contact after a few seconds. If the edge of the hole appears sharp and clear, no further lapping is required. Excessive lapping at this point will increase the size of the hole and lower the injector valve opening pressure.

3. Replace the valve seat.

4. Replace the valve or valve stop.

5. Replace the spring. Check the valve cage and valve stop for wear; replace them if necessary.

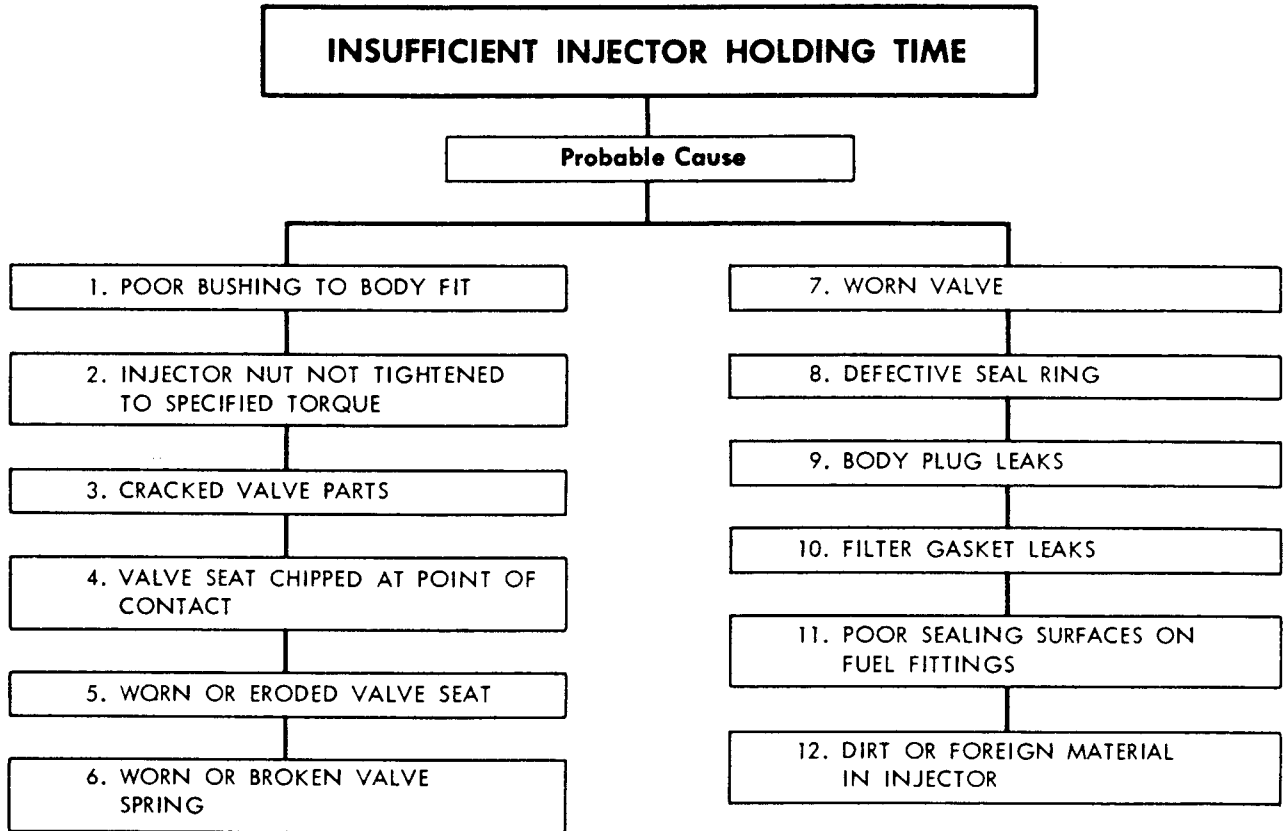
6. Disassemble and clean the injector.

7. Replace the valve cage.

8. Carbon in the tip should be removed with tip reamer J 1243 which is especially designed and ground for this purpose.

9. Check the hole size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

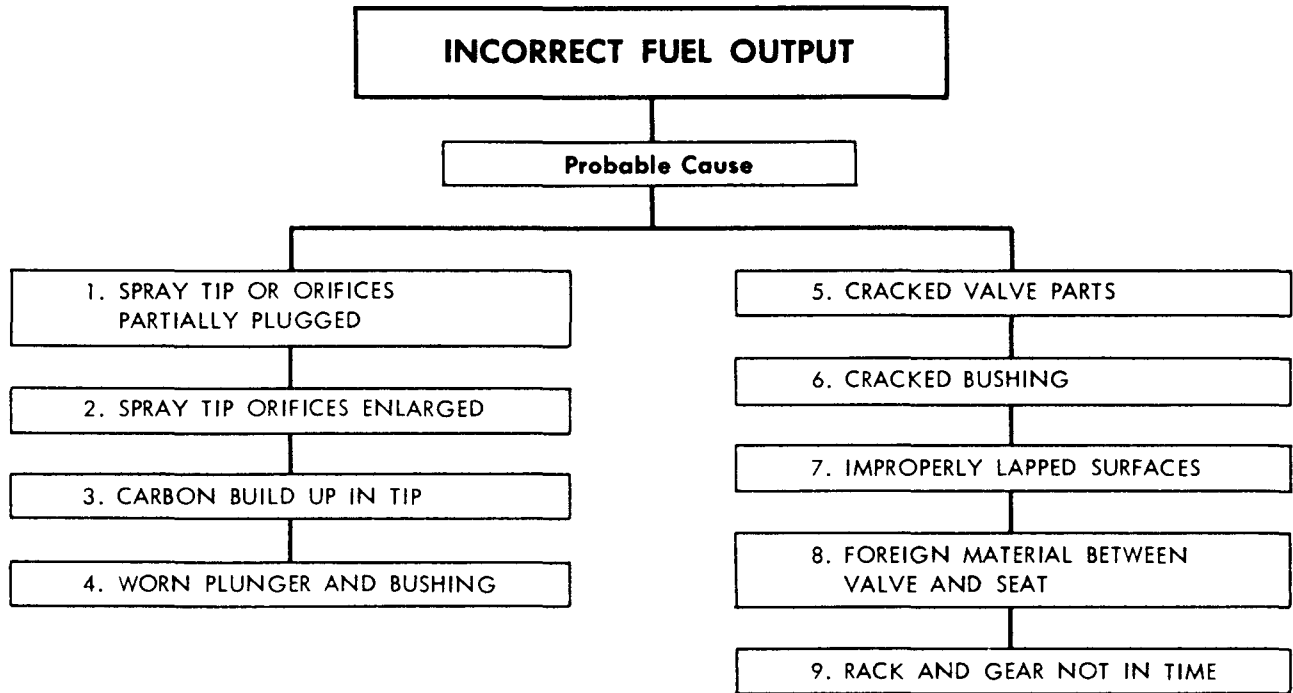
Chart 2



SUGGESTED REMEDY

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

Chart 3



SUGGESTED REMEDY

1. Clean the orifices with tool J 4298-1, using the proper size wire.

2. Replace the spray tip.

NOTE: 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.

3. Clean the injector tip with tool J 1243.

4. After the possibility of an incorrect or faulty tip has been eliminated and the injector output still does not fall within its specified limits, replace the plunger and bushing with a new assembly.

5. Replace the cracked parts.

6. Replace the plunger and bushing assembly.

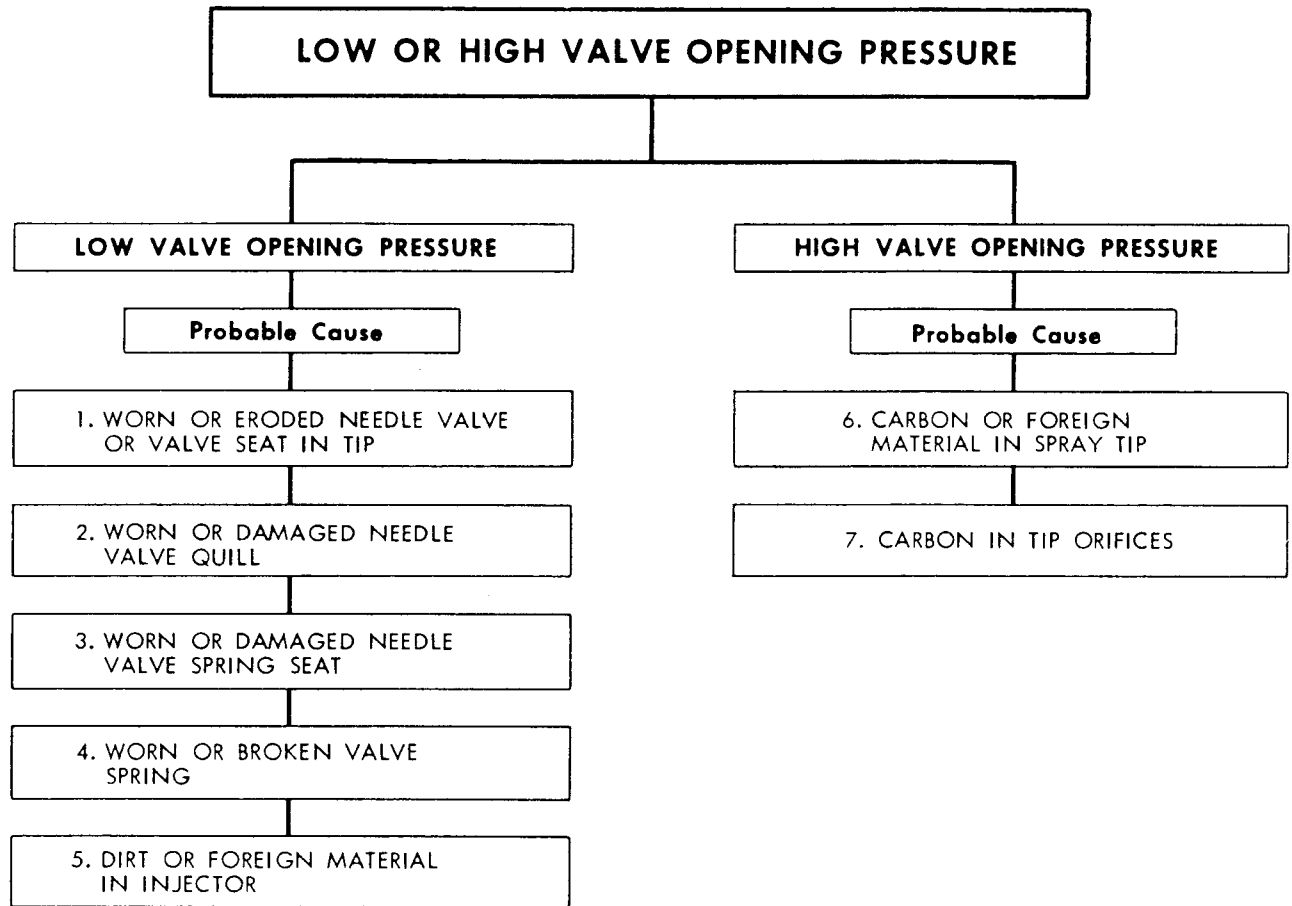
7. Re-lap the sealing surfaces.

8. Disassemble the injector and clean the parts.

9. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth of the rack.

TROUBLE SHOOTING CHARTS (Needle Valve Injectors)

Chart 4



SUGGESTED REMEDY

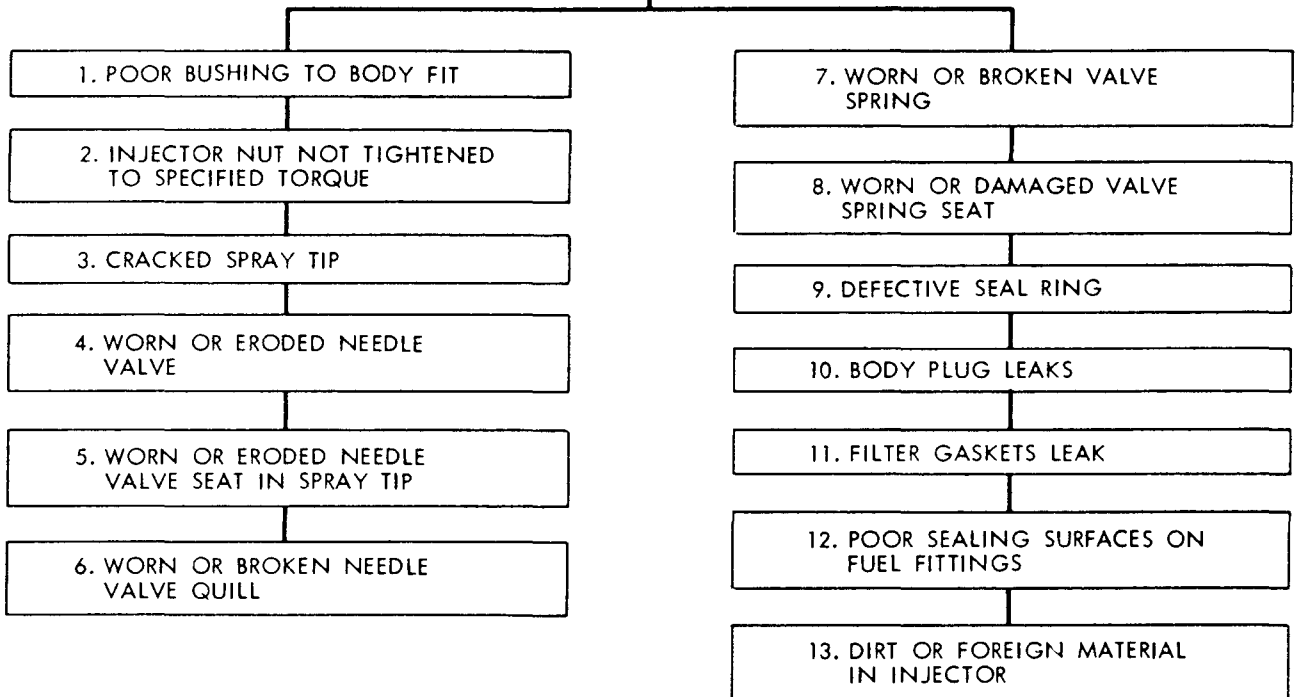
1. Replace the needle valve and tip assembly.
2. Replace the needle valve and tip assembly.
3. Replace the spring seat.
4. Replace the valve spring.
5. Disassemble the injector and clean the parts.

6. Remove the carbon in the tip with tip reamer J 9464 which is especially designed and ground for this purpose.
7. Check the hole size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

Chart 5

INSUFFICIENT INJECTOR HOLDING TIME

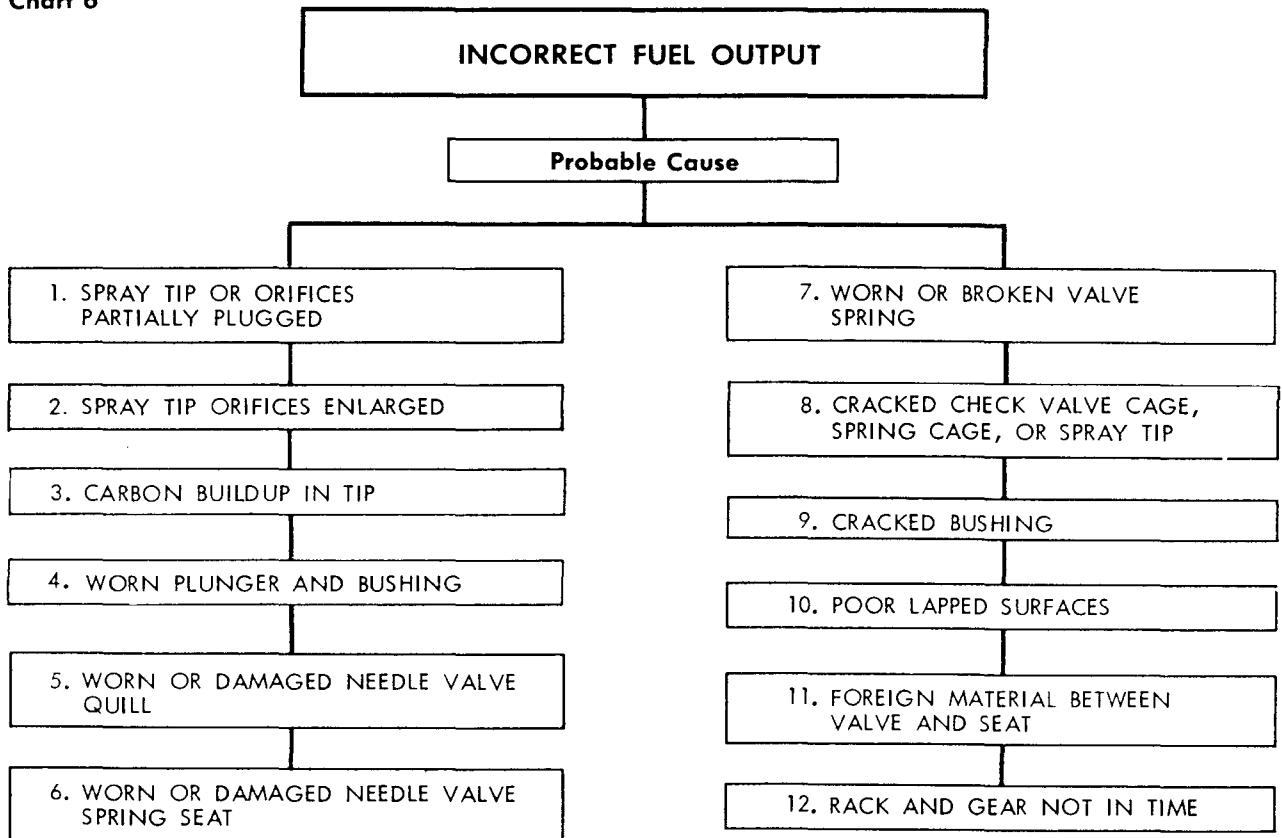
Probable Cause



SUGGESTED REMEDY

- | | |
|--|--|
| <ul style="list-style-type: none"> 1. Lap the injector body. 2. Tighten the nut to 75-85 lb-ft torque. Do not exceed the specified torque. 3,4,5 and 6. Replace the needle valve and spray tip assembly. 7. Replace the valve spring. 8. Replace the valve spring seat. | <ul style="list-style-type: none"> 9. Replace the seal ring. 10. Install new body plugs. 11. Replace the filter cap gaskets and tighten the filter caps to 65-75 lb-ft torque. 12. Clean up the sealing surfaces or replace the filter caps, if necessary. Replace the filter if a cap is replaced. 13. Disassemble the injector and clean the parts. |
|--|--|

Chart 6



SUGGESTED REMEDY

1. Clean the spray tip as outlined under *Clean Injector Parts*.

2. Replace the spray tip assembly.

NOTE: 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.

3. Clean the injector tip with tool J 1243.

4. After the possibility of an incorrect or faulty tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

5. Replace the needle valve.

6. Replace the spring seat.

7. Replace the valve spring.

8. Replace the cracked parts.

9. Replace the plunger and bushing assembly.

10. Re-lap the sealing surfaces.

11. Disassemble the injector and clean the parts.

12. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth of the rack.

FUEL PUMP MAINTENANCE

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, filter gaskets and air heater lines. 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 whether the wire vibrates. Vibration will be felt if the pump shaft rotates.

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

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

Therefore, if the fuel pump is not functioning properly, remove the relief valve plug, spring and pin and check the movement of the valve within the valve bore. If the valve sticks, recondition it by using fine 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. Reassemble the valve in the pump.

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

CHECKING FUEL FLOW

1. Disconnect the fuel return tube from the fitting at the fuel tank or source of supply and hold the open end of the tube in a convenient receptacle.

2. Start and run the engine at 1200 rpm and measure the fuel flow return from the manifold. Refer to Section 13.2 for the specified quantity per minute.

3. Immerse the end of the fuel tube 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 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 screw driver. 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. If the cylinder has been firing properly there will be a noticeable difference in the sound and operation of the engine when the injector is 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.

SPECIFICATIONS**STANDARD BOLT AND NUT TORQUE SPECIFICATIONS**

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

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)
Governor control housing to flywheel housing	5/16-18	10-12
Blower drive assembly to flywheel housing	3/8 -16	20-25
Injector clamp bolt	3/8 -16	20-25
Fuel line connector	3/8 -24	20-28
Rocker arm bracket bolt	7/16-14	50-55
Governor drive gear retaining nut (in-line engine)	5/8 -18	125-135
Injector filter caps	5/8 -24	65-75
Injector nut (crown valve)	15/16-24	55-65
Injector nut (needle valve)	15/16-24	75-85

SERVICE TOOLS

TOOL NAME	TOOL NO.
INJECTOR TOOLS	
Injector body reamer	J 21089
Pin vise	J 22800-3
Injector bushing Inspectalite	J 21471
Injector calibrator	J 22410
Adaptor (standard body)	J 7041-61
Adaptor (offset body, high clamp)	J 7041-72
Adaptor (4-valve, low clamp)	J 7041-88
Adaptor (offset body, low clamp)	J 7041-130
Seat	J 22410-226
Injector comparator	J 7041
Adaptor	J 7041-61
Adaptor	J 7041-72
Adaptor	J 7041-88

SERVICE TOOLS

TOOL NAME	TOOL NO.
Adaptor	J 7041-130
Injector holding fixture	J 22396
Injector nut tip seat reamer (needle valve)	J 9418-1
Injector nut tip seat reamer (needle valve)	J 9418-5
Injector service tool set	J 1241-05
Spray tip cleaner	J 1243
Spray tip remover and bushing cleaner	J 1291-02
Injector spray tip hole cleaner	J 4298-1
Injector nut socket wrench	J 4983-01
Injector nut tip seat reamer	J 4986-01
Injector valve seat deburring tool	J 7174
Injector rack hole brush	J 8150
Injector body brush	J 8152
Injector wire honing stone	J 8170
Injector test oil (one gallon)	J 8130
Injector tester	J 9787
Test block	J 9787-49
Adaptor	J 8538-10
Injector tip carbon remover (needle valve)	J 9464-01
Special drill	J 9464-1
Injector tip concentricity gage	J 5119
Lapping block set	J 22090
Lapping compound	J 23038
Metyl Ethyl Keystone solvent (one gallon)	J 8257
Needle valve injector auxiliary tester	J 22640
Needle valve lift gage	J 9462-01
Polishing stick set	J 22964
Socket	J 8932-01
Spring tester	J 9666
INJECTOR TUBE TOOLS	
Cylinder head holding plate set	J 3087-01
Injector tube service tool set	J 22525
GOVERNOR TOOLS	
Control link lever bearing installer	J 8985
Governor cover bearing installer	J 21068
Governor cover bearing remover	J 21967
Governor operating shaft fork installer set (8V engine)	J 21995
Governor weight carrier installer	J 8984
Knurled nut	J 21995-1
Nut wrench	J 5895
Rod	J 21995-2
Spanner wrench	J 5345-5
Variable speed governor spring housing bearing installer set	J 9196
Installer body	J 9196-1
Installer body rod	J 9196-2

SECTION 3

AIR INTAKE SYSTEM

CONTENTS

Air Intake System	3
Air Cleaner	3.1
Air Silencer	3.2
Air Shutdown Housing	3.3
Blower (In-Line and 6V-53)	3.4
Blower (8V-53)	3.4.1
Turbocharger (Airesearch)	3.5
Intercoolers	3.5.2
Shop Notes - Trouble Shooting - Specifications - Service Tools	3.0

AIR INTAKE SYSTEM

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

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

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

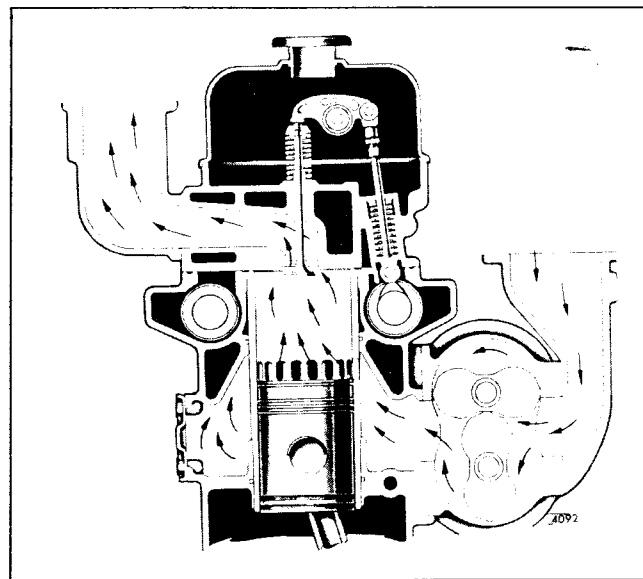


Fig. 1 - Air Flow Through Blower and Engine
(In-Line Engine)

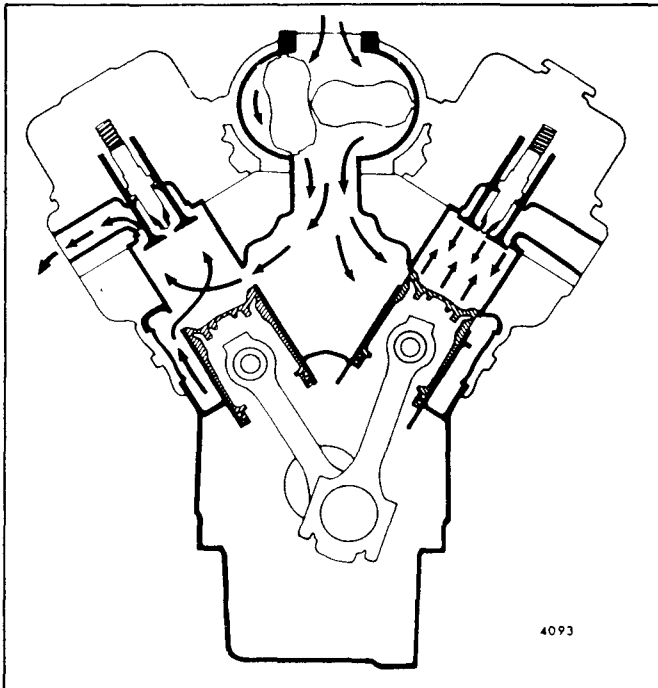


Fig. 2 - Air Flow Through Blower and Engine
(V-Type Engine)

AIR CLEANER

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

The importance of keeping dust and grit-laden air out of the engine cannot be over-emphasized, since clean air is so essential to satisfactory engine operation and long engine life. Should dust in the air supply enter the engine, it would be carried directly into the cylinders and, due to its abrasive properties, cause premature wear of the moving parts. Dirt, which is allowed to build-up in the air cleaner passages, will eventually restrict the air supply to the engine and result in heavy carbon deposits on the valves and pistons due to incomplete combustion. The air cleaner sump must have a capacity large enough to retain the material separated from the air to permit operation for a reasonable length of time before cleaning is required.

Air Cleaner Maintenance

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

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

No set rule for servicing an air cleaner can be given since it depends upon the type of air cleaner, the condition of the air supply, and the type of application. An air cleaner operating in severe dust will require more frequent service than an air cleaner

operating in comparatively clean air. The most satisfactory service period should be determined by frequently inspecting the air cleaner under normal operating conditions, then setting the service period to best suit the requirements of the particular engine application.

The following maintenance procedure will assure efficient air cleaner operation.

1. Keep the air cleaner tight on the air intake pipe to the engine.
2. Keep the air cleaner properly assembled so the joints are strictly oil and air tight.
3. Repair any damage to the air cleaner or related parts immediately.
4. Inspect and clean or replace the air cleaner element as operating conditions warrant. In certain dry type cleaners, it is possible to clean and reuse the element several times as long as the paper is not ruptured in the process. In an oil bath type cleaner, keep the oil at the level indicated on the air cleaner sump. Overfilling may result in oil being drawn through the element and into the engine, thus carrying dirt into the cylinders and also resulting in excessive engine speed.
5. After servicing the air cleaner, remove the air inlet housing and clean accumulated dirt deposits from the blower screen and the inlet housing. Keep all air intake passages and the air box clean.
6. Where rubber hose is employed, cement it in place. Use new hose and hose clamps, if necessary, to obtain an air tight connection.
7. Carefully inspect the entire air system periodically. Enough dust-laden air will pass through an almost invisible crack or opening to eventually cause damage to an engine.

OIL BATH TYPE AIR CLEANER

LIGHT-DUTY AIR CLEANER

The light-duty oil bath air cleaner (Fig. 1) consists of a metal wool cleaning element supported inside a housing beneath which is contained a bath of oil. The lower portion of the housing incorporates a chamber which serves as a silencer for the incoming air to the blower.

Air drawn into the cleaner by the blower passes over the top of the oil bath, where a major portion of the dirt is trapped, then up through the metal wool where the finer particles are removed, then down the central duct to the blower.

Service

Service the light-duty oil bath air cleaner as follows:

1. Loosen the wingbolt and remove the cleaner from the air inlet housing. The cleaner may then be separated into two sections; the upper section contains the metal wool element, the lower section is made up of the oil sump, removable baffle and center tube.
2. Soak the upper shell and element in fuel oil to loosen the dirt; then flush the element with clean fuel oil and allow it to drain thoroughly.

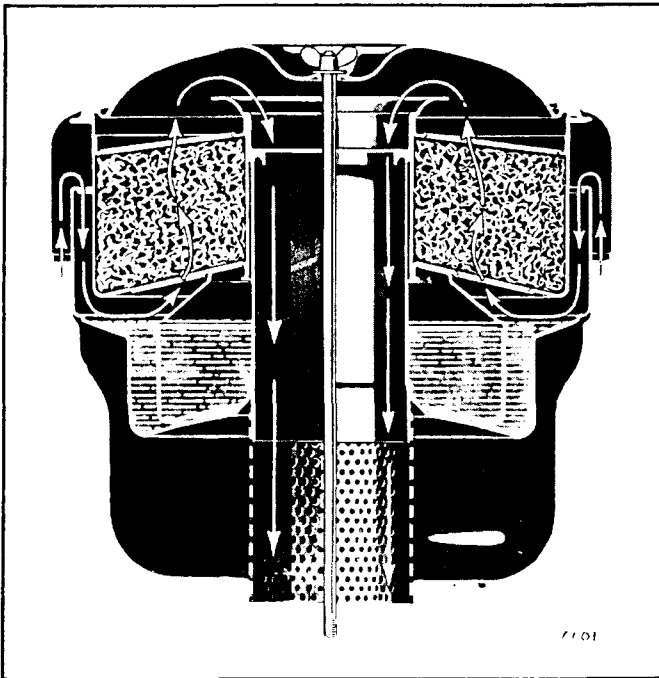


Fig. 1 - Light-Duty Oil Bath-Type Air Cleaner

3. Empty the sump, remove the baffle and clean both the sump and the baffle with fuel oil to remove all sediment.
4. Push a lint-free cloth through the center tube to remove dirt or oil from the walls.
5. Clean and check all gaskets and sealing surfaces to insure air tight seals.
6. Refill the sump to the oil level mark **ONLY**, with the same grade of oil used in the engine.
7. Before installing the air cleaner on the engine, check the air inlet housing for dirt. If the service period has been too long, or if dust-laden air has been leaking past the air cleaner to the air inlet housing seals, the inlet will be dirty. This will serve as a good check on the servicing of the air cleaner. When installing the cleaner (and its seal) on the inlet housing, be sure the cleaner seats properly, then tighten the wingbolt securely until the cleaner is rigidly mounted.
8. Install the baffle and reassemble the air cleaner.

HEAVY-DUTY AIR CLEANER

The heavy-duty oil bath air cleaner (Fig. 2) consists of a metal wool cleaning element supported inside a housing, beneath which a removable screen and an oil cup is located. Air, drawn into the air cleaner by the blower, enters the cleaner at the air inlet hood, passes down the central duct over the oil bath and up through

the removable screen and metal wool cleaning element. The air leaves the cleaner through a tube at the side and enters the blower.

The major portion of dirt is washed from the air as it passes over the oil bath, and any remaining foreign matter is removed as the air passes up through the removable screen and the metal wool cleaning element.

Service

Service the heavy-duty air cleaner as follows:

1. Remove the oil sump from the cleaner by loosening the retaining band (or wing nuts). Empty the sump and wash it with fuel oil to remove all of the sediment.
2. Remove the detachable screen by loosening the wing nuts and rotating the screen one-quarter turn.

One of the most important steps in properly cleaning the tray type oil bath air cleaner is a step that is most overlooked. Unless the filter tray is thoroughly cleaned, satisfactory performance of any engine

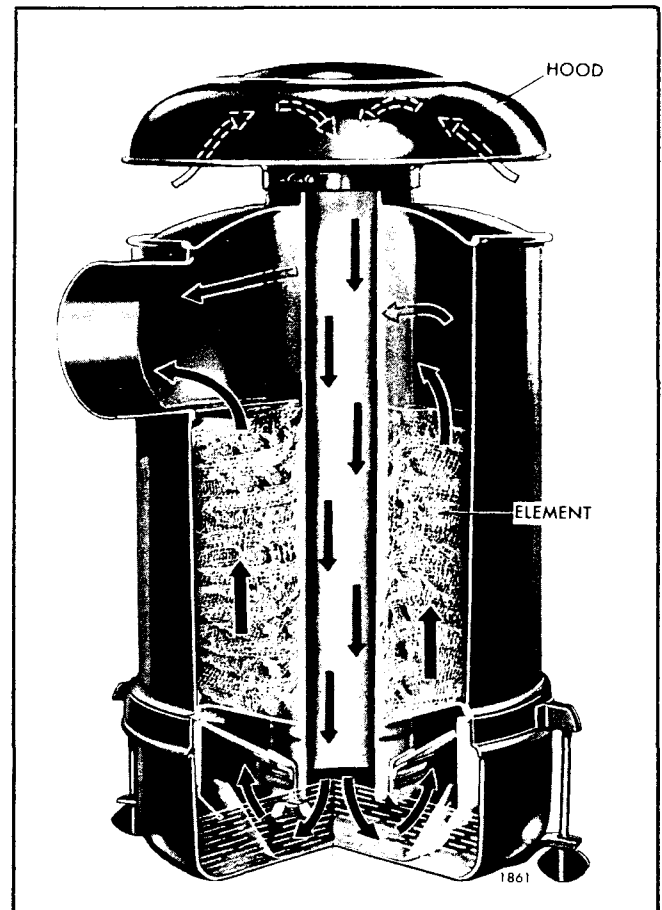


Fig. 2 - Heavy-Duty Oil Bath-Type Air Cleaner

cannot be realized. The presence of fibrous material found in the air is often underestimated and is the main cause of the malfunctioning of heavy-duty air cleaners. This material comes from plants and trees during their budding season and later from airborne seed from the same sources. Figure 3 illustrates the severity of plugging in a tray that is 50% plugged. The solid black areas in the mesh are accumulations of this fibrous material. When a tray is plugged in this manner, washing in a solvent or similar washing solution will not clean the tray satisfactorily. It must also be blown out with high velocity compressed air or steam to remove the material that accumulates between the layers of screening. When a clean tray is held up to the light, an even pattern of light should be visible. It may be necessary, only as a last resort, to burn off the lint. Extreme care must be taken not to melt the galvanized coating in the tray screens. Some trays have equally spaced holes in the retaining baffle. Check to make sure that they are clean and open. A thoroughly cleaned tray is illustrated in Fig. 4. The dark spots in the mesh indicate the close overlapping of the mesh and emphasize the need for using compressed air or steam. It is suggested that users of heavy-duty air cleaners have a spare tray on hand to replace the tray that requires cleaning. Having an extra tray available makes for better service and the dirty tray can be cleaned thoroughly as recommended. Spare trays are well worth their investment.

3. Remove the hood and clean it by brushing or by blowing out with compressed air. Push a lint-free cloth

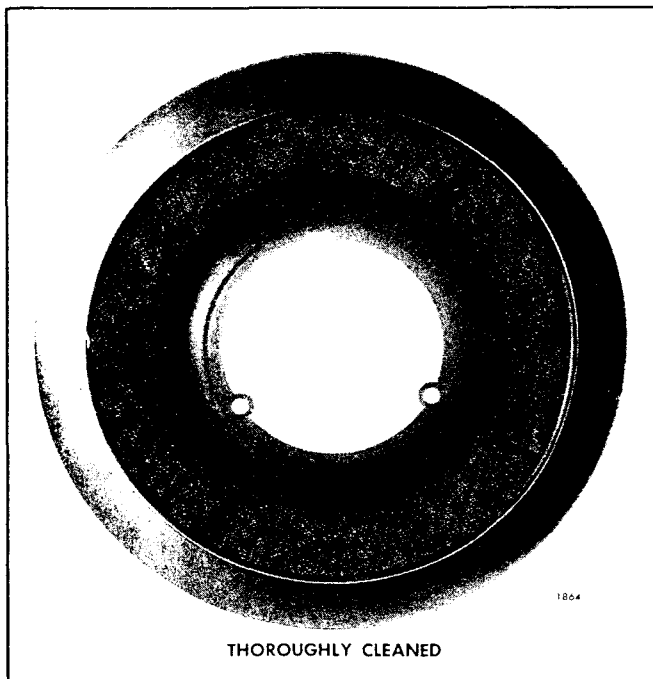


Fig. 3 - Air Cleaner Tray (50% Plugged)

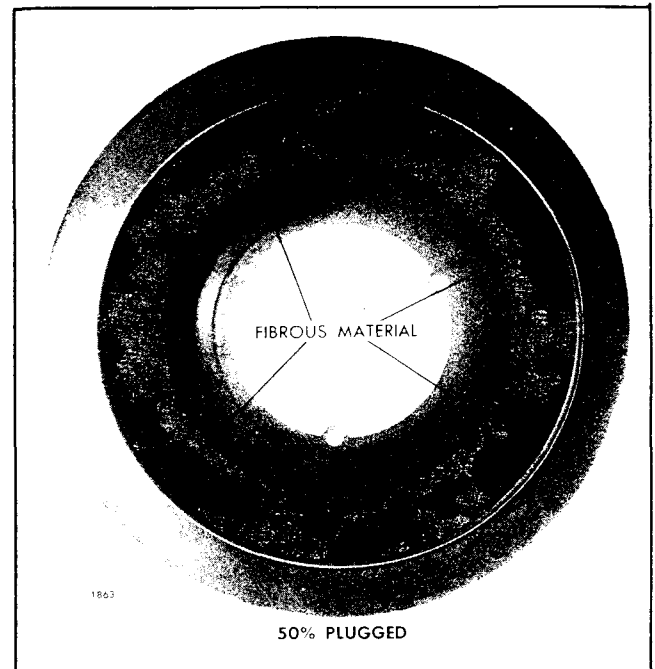


Fig. 4 - Air Cleaner Tray (Clean)

through the center tube to remove dirt or oil from the walls.

4. The fixed element should be serviced as operating conditions warrant. Remove the entire cleaner from the engine, soak the unit in fuel oil to loosen the dirt, then flush with clean fuel oil and allow to drain thoroughly.

5. Clean and check all gaskets and sealing surfaces to insure air tight seals.

6. Refill the oil cup to the oil level mark **ONLY**. Use oil of same grade as used in the engine crankcase.

7. Install the removable screen in the housing and reinstall the housing.

8. Install the oil cup and the hood.

9. Check all of the joints and tubes and make sure they are air tight.

All oil bath air cleaners should be serviced as operating conditions warrant. At no time should more than 1/2" of "sludge" be allowed to form in the oil cup or the area used for sludge deposit, nor should the oil cup be filled above the oil level mark.

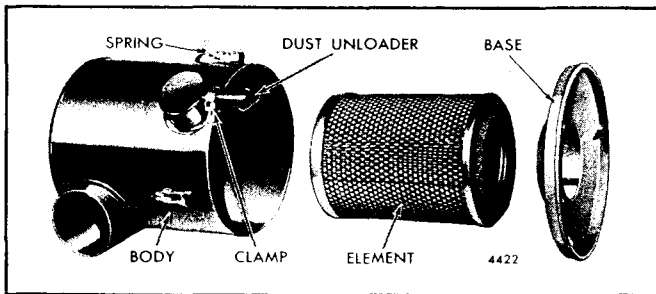
DRY TYPE AIR CLEANER

Fig. 5 - United Specialties Dry Type Air Cleaner

UNITED SPECIALTIES AIR CLEANER

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

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

Service

Service the dry type United Specialties air cleaner as follows:

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

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

- b. Compressed air can be used when the major contaminant is dust. The compressed air (not to exceed 100 psi) should be blown through the element in a direction opposite to the normal air

flow. Insert the nozzle inside of the element and gently tap and blow out the dust with air. When cleaning the dust from the outside of the element, hold the nozzle at least 6" from the element.

- c. Wash the element if compressed air is not available, or when the contaminant is carbon, soot, oily vapor or dirt which cannot be removed with compressed air. Agitate the element in warm water containing a non-sudsing detergent.

CAUTION: Do not use water hotter than your hand can stand, solvents or oil, fuel oil or gasoline.

Preceding the washing, it helps to direct air (not exceeding 100 psi) through the element in a direction opposite to the normal air flow, to dislodge as much dust as possible. Reverse flush with a stream of water (not exceeding 40 psi) until the water runs clean to rinse all loosened foreign material from the element. Shake out excess water from the element and allow it to dry thoroughly.

CAUTION: Do not attempt to remove excess water by using compressed air.

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

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

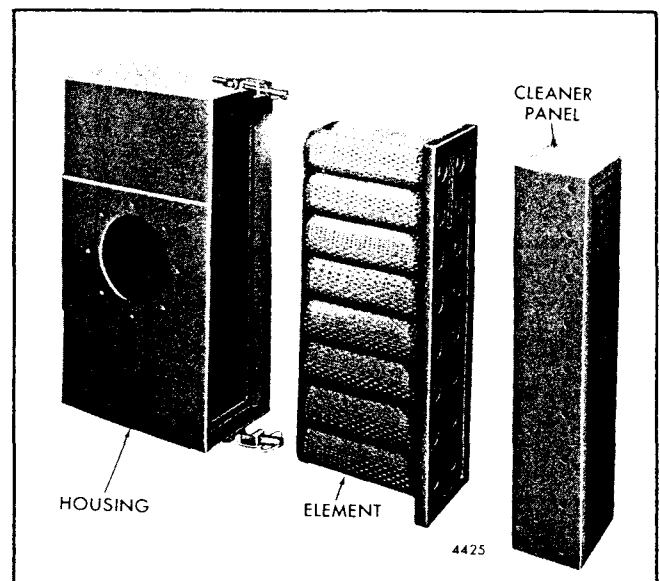


Fig. 6 - Farr Dry Type Air Cleaner

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

Replace the element after 10 washings or 1 year of service, whichever comes first, or any time damage is noted.

7. Install the dust unloader and tighten the clamp.

FARR AIR CLEANER

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

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

Operation

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

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

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

Service

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

Replace the filter element as follows:

1. Loosen the wing nuts on the fasteners and swing the retaining bolts away from the cleaner panel.
2. Lift the cleaner panel away from the housing and inspect it. Clean out any accumulated foreign material.
3. Withdraw the paper filter element and discard it.
4. Install a new filter element.
5. Install the cleaner panel and secure it in place with the fasteners.