PNEUMATIC GOVERNOR

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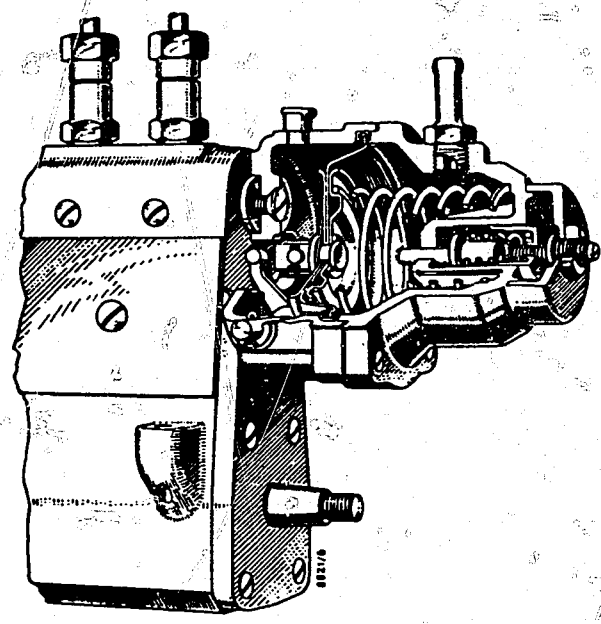
GENERAL INFORMATION AND SERVICE INSTRUCTIONS FOR PNEUMATIC GOVERNORS

Purpose of the Pneumatic Governor

The advent of the small, high speed Diesel engines has necessitated the building of smaller fuel injection pumps and brought forth the problem of governing the idling and maximum speeds of the engine. On the larger size of fuel injection pumps, a centrifugal flyweight type of governor is mounted directly on the pump housing. This governor controls the idling and maximum speeds of the engine and provides definite speed control over certain speed ranges.

However, since this type of governor is large in dimensions and heavy in weight, it cannot be applied to the smaller sizes of fuel injection pumps of the "A" edition. Also, controlling the low speeds as well as the very high maximum speeds of the smaller engines with a centrifugal type of governor is impractical. Consequently, in place of using centrifugal force, a different regulating force is employed in the pneumatic governor. This force is obtained by the flow of air passing through a venturi which tends to create a vacuum in a smaller pipe or tubing entering it at an angle. The velocity of the air passing through the venturi, regulated by a butterfly valve, determines the amount of vacuum.



Inside Cross-sectional View of Pneumatic Governor

The principle underlying the action of the pneumatic governor is that air passing through a pipe tends to create a vacuum in another smaller pipe entering it at an angle. The amount of vacuum created depends upon the air velocity passing through the larger pipe.

In the case of the pneumatic governor, the air velocity passing through the engine suction pipe is controlled by causing it to pass through an orifice with variable cross-sectional area. This orifice forms the throat of a venturi attached directly to the engine suction pipe, the venturi being necessary to impart a steady motion to the air stream. The higher the velocity of the air stream, the greater will be the vacuum created in the small pipe. Consequently, by decreasing or increasing the throat cross-section, a higher or lower velocity and therefore a greater or lower vacuum can be obtained.

The movement of the fuel injection pump control rod is governed by causing this variation in vacuum to act upon a diaphragm directly connected to the control rod.

How the Pneumatic Governor is Constructed (see Fig. 1 on next page)

Fig. 1 shows a schematic diagram of the pneumatic governor, its connecting hose (f) between diaphragm housing (g) and air inlet manifold of the engine, and the control linkage.

Connected to the inlet manifold of the engine is a butterfly valve housing, the cross-section of which gradually decreases to the form of a venturi (b). A butterfly valve (c) is located at the smallest cross-section of the butterfly valve housing, and the butterfly valve (c) is connected to the foot accelerator pedal (d), by means of a linkage rod, to a lever (n). An air filter is usually mounted to the outer end of the butterfly valve housing.

The diaphragm housing constitutes an important part of the pneumatic governor. It consists chiefly of two chambers (g and i) separated one from the other by a leather diaphragm (h). One side of this diaphragm (h) is loaded with a spiral spring (m), while the opposite side is flexibly connected to the fuel injection pump control rod (k). The spiral spring (m) tries to push the diaphragm (h) and its control rod (k) toward the "full delivery" position, i.e., away from the "stop" position. Chamber (g) is connected to the venturi (b) of the butterfly valve housing through the connecting hose (f), while chamber (i) is connected to atmosphere.

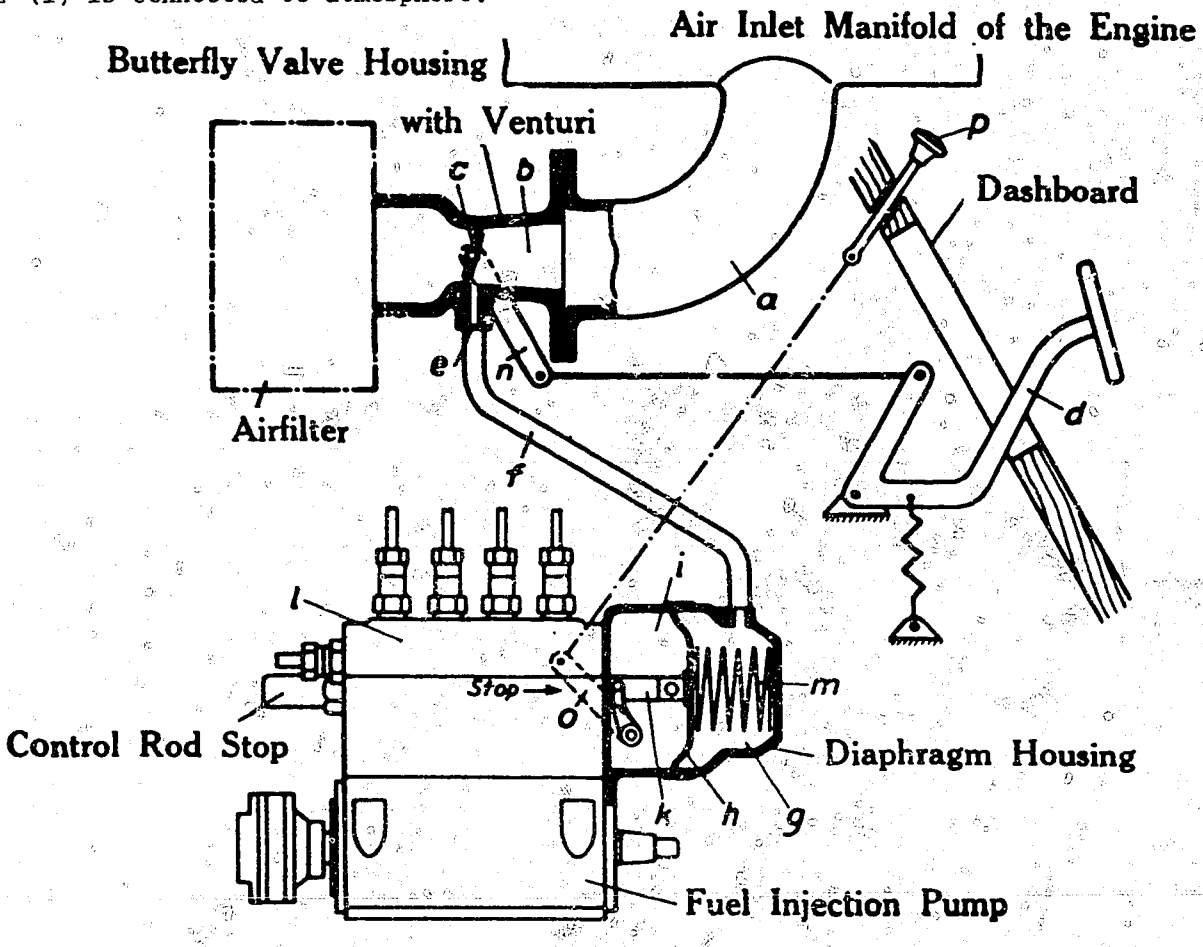


Fig. 1 Schematic Diagram of the Pneumatic Governor

How the Pneumatic Governor Operates (see Fig. 1)

With the engine at rest, both governor chambers (g and i) are at atmospheric pressure and the spring (m) has pushed the diaphragm (h) to the extreme left and the control rod (k) is therefore in the "full delivery" position. When the engine is running, however, the pressure in governor chamber (g) is reduced below the atmospheric pressure existing in chamber (i), the amount of pressure reduction depending on the position of the butterfly valve (c) and the speed of the engine. Naturally, any difference in the existing pressures in the two governor chambers (g and i) has a definite effect on the relative position of the diaphragm (h) and consequently also on the control rod (k) position. For example, if the engine speed increases, due to a reduction in load but with the

butterfly valve in a fixed position, the pressure in chamber (g) is lowered by the increased air velocity past the venturi take-off tube, resulting in the creation of a vacuum in the connecting hose. The diaphragm (h) then compresses the spring (m) and moves the control rod (k) toward the "stop" position (reduces the speed). The diaphragm (h) continues to move until it has reached a position at which the depression in chamber (g) balances the pressure exerted by spring (m). An opposite procedure obviously takes place when the engine speed is decreased. From this it can be seen that every impulse which tends to change the engine speed is utilized to influence the amount of fuel delivery of the injection pump in such a way that normal operating conditions are always restored and average, constant speeds maintained through the automatic action of the pneumatic governor.

This adjustment is fully automatic at all speeds, or at any position of the butterfly valve (c), because each position of the butterfly valve (c) represents a definite speed. The frequency of governor control is also influenced by changes in engine loads.

If, for instance, the engine is running idle (no load) then the butterfly valve (c) is closed except for a small slot which is adjustable by means of a stop screw located on the butterfly valve housing. The depression created beyond the butterfly valve (c) pulls the diaphragm (h) back and moves the control rod (k) toward the "stop" position. When engine speeds fluctuate, stronger or weaker depressions alternately occur, and consequently the control rod moves back and forth (floats) and adjusts or evens-out the speed fluctuations, with the result that a constant speed is maintained.

When the engine operates under full load with the foot accelerator pedal (d) pressed down to the floor board, the butterfly valve (c) is wide open and the resultant depression in the venturi, inlet manifold and chamber (g) is very small. Therefore, the spring (m) moves the diaphragm (h) to the left, and the control rod (k) moves toward "full delivery" position until maximum engine speed has been reached.

For the control of the maximum engine speed, the "venturi effect" is utilised. Very high speeds produce a "suction effect" at the mouth (e) of the connecting hose (f), which is due to the increased air velocity in the venturi. This results in a depression or in a lower pressure (below atmospheric) in chamber (g). As a consequence, the control rod (k) moves in the "stop" direction and the engine speed is thereby controlled. This feature prevents the engine from "running away". For any position of the butterfly valve (c) between "idling" and "full load" of engine (with foot accelerator pressed down as far as it will go) the diaphragm (h) finds its relative position. Since any movement of diaphragm (h) is also transmitted to the control rod (k), the amount of fuel delivery is definitely controlled at all engine speeds.

In order to make it possible to "stop" the engine, a lever (o) connected to control rod (k) is provided on the diaphragm housing. The lever (o) in turn is connected by a Bowden wire with a pull button (p) located on the dash, and provides a ready means for stopping the engine. When the operator pulls the button (p), the lever (o) forces the control rod (k) into the "stop" position, the fuel oil supply is cut off and the engine stops.

How to Diagnose and Remedy Pneumatic Governor Difficulties

The pneumatic governor is a variable speed, variable load governor, incorporating features which make it adjustable for idling speeds and limiting the engine speed. Irregular functioning of the spray nozzles always results in speed fluctuations which affect the governor. Load conditions also affect the governor. Therefore, all nozzles should be checked first to see whether or not they operate regularly and are all adjusted to the same opening pressures.

If great speed fluctuations occur at idling in connection with a jerkily-moving control rod, the fault may be a control rod which moves too hard. Do not work on the governor until all other causes for a badly operating engine have been eliminated.

Since the pneumatic governor is very simple in construction, only a few details need be checked to make sure that the unit is in perfect working order.

The following should be investigated:

a. Is governor housing air-tight?

Disconnect connecting hose (f Fig. 1) from the top of diaphragm housing (g Fig. 1).

Next remove the inspection cover from the fuel injection pump. Now shift lever (o Fig. 1) to the "stop" position and place your thumb over the outlet from which the connecting hose (f) has been removed. Carefully observe whether the pump control rod moves and shifts the control sleeves of the pump elements when you let go of the stop lever (o Fig. 1). You will observe a slight movement and then this movement should STOP and hold the control rod in a steady position. If the movement of the control rod continues, it indicates that the governor housing is not air-tight. The cause may be found in a broken or cracked leather diaphragm (18 Fig. 2), leakage at the end cap fastening screws (20j Fig. 2), leakage in governor housing due to loose mounting screws (21 Fig. 2), or leakage due to loosely-fitting idling adjusting screw lock nut (20f Fig. 2).

NOTE: If the connecting hose (f Fig. 1) has been damaged and needs replacing, be sure to apply only a hose furnished by the engine manufacturer and check it for air leaks.

b. Does control linkage move freely?

To check the free movement of the control rod linkage, remove the hose connection (f Fig. 1) at governor housing and the pump inspection cover. Push lever (o Fig. 1) to the "stop" position. Free movement of the assembly is had when the lever (o Fig. 1) is released and the control rod is observed through pump inspection opening to move rapidly toward "full load" position without binding, sticking or jerking. Try this several times and make sure that this assembly moves easily and freely.

c. Has governor too much or too little oil?

The leather diaphragm (18 Fig. 2) must always be kept well-lubricated. However, an excessive quantity of oil in the end cover (2a Fig. 2) will hinder the free movement of the diaphragm and so interfere with the proper operation of the governor. The governor housing should at no time contain more than one fluid ounce of good engine oil which is applied through the oil cup (2h Fig. 2).

d. Has idling speed adjustment been made correctly?

In case an idling adjustment has to be made on the engine in order to slightly increase or decrease the engine's idling speed, it should be done by means of the adjusting screw on the butterfly valve. The idling adjusting screw (20e Fig. 2) can also be used for this purpose to some extent, since by turning it to the left the idling speed is increased and by turning it to the right the idling speed is decreased. It is important to remember, however, that the basic purpose of the idling adjusting screw is to steady the governor diaphragm at idling speed when this diaphragm often has a tendency to oscillate due to the fluctuations in the vacuum of the engine intake manifold. Such a condition can be recognized by a decided rolling or galloping of the engine at idle. Careful adjustment of the governor idling adjusting screw will normally overcome this undesirable condition. (Turning the adjusting screw to the left will limit the oscillations of the diaphragm and thereby steady the engine idling speed. Care must be exercised not to turn the adjusting screw too far to the left as this will bring about excessive high maximum speed of the engine when the butterfly valve is in wide open position. Some practice will be necessary to make this adjustment properly.)

If it is found that the idling spring must be adjusted to near its maximum tension, a careful investigation should be made to determine whether this maximum adjustment is due to a leaky diaphragm or incorrect functioning of the nozzles, because too great a tension of the idling spring results in lack of governor control at top speed. The correct adjustment is had when the engine idles smoothly, without rolling or hunting, at the predetermined idling speed.

If the difference between high speed "full load" and high speed "no load" is excessive, the idling spring adjusting screw (20e Fig. 2) is relatively too far or too close to the diaphragm of the governor. To correct this, turn adjusting screw to the right or clockwise direction so that the movement of the diaphragm is increased. The opening of the butterfly valve controls the maximum engine speed.

e. Has maximum speed adjustment been made correctly?

If the maximum speed at wide-open butterfly valve position is too high, the proper

adjustment should be made. If this is not possible, there probably is a leakage somewhere in the inlet manifold, butterfly valve housing, connecting hose, governor housing or diaphragm. In the case of "oil bath" air cleaners, low oil level or absence of oil may also be responsible. Eliminate all air leaks, clean air filter and fill with recommended oil to proper indicated level. Then make final adjustment.

If the maximum speed at wide-open throttle is below normal, making it impossible to carry full load, air filter may be clogged. Remove latter and clean thoroughly. This applies only to air cleaners or filters employing steel wool, copper wool or other materials as filtering elements.

CAUTION: Under no circumstances remove or adjust the pump control rod stop bushing (29b Fig. 2), because this bushing has been adjusted by the engine manufacturer and its adjustment may result in harm to the engine.

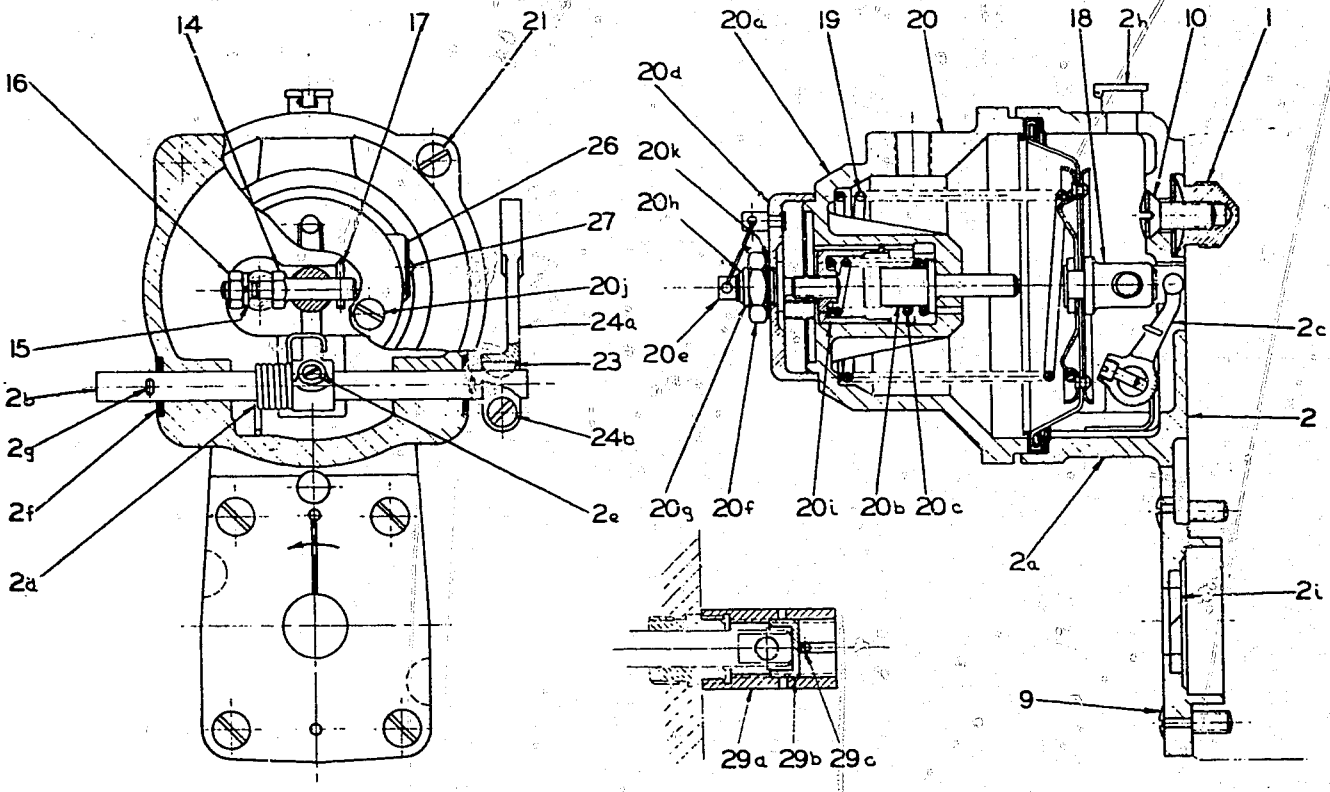


Fig. 2 Cross-section of Pneumatic Governor

NOMENCLATURE

1 Screw plug
2 End cover assy., consisting of parts 2a to 2i
2a End cover only
2b Stop lever shaft
2c Stop lever
2d Stop lever spring
2e Stop lever set screw
2f Stop lever shaft plain washer
2g Cotter pin
2h Oil cup
2i End plate packing ring
9 End cover fastening screw
10 Screw plug screw
14 Linkage pin
15 Linkage pin lock washer
16 Linkage pin hexagon nut
17 Linkage pin cotter pin
18 Diaphragm assembly
19 Main spring
20 Governor housing assy., consisting of parts 20a to 20k
20a Governor housing only
20b Contact pin
20c Idling spring
20d End cap
20e Adjusting screw
20f Adjusting screw lock nut
20g Lock nut stop ring
20h Spring lock ring
20i Idling spring adjusting bushing
20j End cap fastening screw
20k Spring steel washer
21 Governor housing fastening screw
23 Woodruff key
24a Operating lever
24b Operating lever clamping screw
26 Name plate
27 Name plate rivet
29a Control rod stop bushing
29b Control rod stop adjusting screw
29c Cotter pin

How to Dismantle the Pneumatic Governor (see Figs. 1 and 2)

NOTE: The numbers used in the following description are reference numbers only. Never order parts by these numbers but refer to the specific parts list in Section D-290 of the manual.

a. After the connecting hose (f) has been disconnected from the governor housing (20), withdraw the four housing cover screws (21) and pull the governor housing assembly (20) away. The governor main spring (19) will drop out.

b. Carefully pry out the diaphragm assembly (18), using two small screw drivers. Be careful that you do not injure the leather diaphragm. Pull assembly out only far enough to enable you to remove the cotter pin (17) from linkage pin (14). Then slide the diaphragm assembly (18) out of engagement with the linkage pin (14).

c. Remove the linkage pin (14) by first removing its hexagon nut (16) and lock washer (15), and pull the linkage pin (14) out.

d. Next withdraw operating lever clamping screw (24b) and its lock washer, and pry the keyed operating lever (24a) from its shaft (2b). Pull out Woodruff key (23) and cotter pin (2g) and lift off plain washer (2f). Remove stop lever set screw (2e) and push the shaft (2b) out of the end cover (2a). This will release stop lever spring (2d) and stop lever (2c).

NOTE: Before you attempt to remove the governor end cover (2a) from the pump housing, you must remove the pump inspection cover and insert the tappet holders as explained on Page D 3001 (in Paragraph 2, Fig. 3). This is absolutely necessary in order to prevent the cam shaft of the pump from dropping down. If you do not insert the tappet holders, you will not be able to reinstall the governor end cover (2a) without using force and possibly causing damage to the inner parts of the pump.

e. In order tc remove the governor end cover (2a) from the pump, simply remove the four end cover fastening screws (9) located at the lower flange and the large single screw (10) located on the inside of end cover (2a), and carefully pry the end cover (2a) away from the pump. It will be noted that the outer ball race of the cam shaft bearing is located in the back of end cover (2a). If it becomes necessary to replace the outer ball race, refer to Page D 4001 and select the correct tool for removing the outer ball race.

f. Next remove governor seal and then withdraw the two end cap fastening screws (20j) and pry the end cap (20d) away from the governor housing (20a).

NOTE: On earliest execution of pneumatic governors, the adjusting screw (20e) is provided with a screw driver slot which is a ready means of holding the screw when removing the lock nut (20f) later mentioned.

g. Now lift out idling spring (20c) located in governor housing (20a) and push out contact pin (20b).

h. The idling spring adjusting bushing (20i) located on the inside of end cap (20d) can now be unscrewed from its adjusting screw (20e).

i. The adjusting screw (20e) is removed in the following manner:
   1. Lift off spring lock ring (20h) and remove lock nut stop ring (20g).
   2. Holding adjusting screw (20e) with a small pin in sealing wire hole, remove lock nut (20f).
   3. Lift off spring steel washer (20k) and remove adjusting screw (20e) from governor housing (20a).

j. The end cover fastening screw (10) has its location in a screw plug (1), screwed into the pump housing. This screw plug (1) is slotted and can be removed with offset screw driver EF 8182.

NOTE: The control rod stop bushing (29a) is definitely adjusted and limits the control rod movement to the particular requirements of the engine. Therefore, do not remove stop bushing (29a) or the setting of the control rod stop adjusting screw (29b), as otherwise the maximum fuel oil delivery set by the engine manufacturer will be altered, resulting in damage to the engine. This is of utmost importance!

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How to Assemble the Pneumatic Governor (see Fig. 2)

NOTE: It is always best practice to make the assembly in a systematic manner. Do the work in progressive steps as outlined below. Make sure you are working on a clean bench, entirely free from iron filings, dirt, etc. It is only possible to do a perfect job when all parts, hands and tools are kept thoroughly clean. All the parts should be washed in clean gasoline or kerosene, blown dry with compressed air (free from water and dirt) and then lubricated with a good grade of engine oil before reassembling. DO NOT WASH THE LEATHER DIAPHRAGM IN GASOLINE OR KEROSENE, but remove all foreign matter carefully with a soft rag and then apply some good grade of engine oil to the assembly.

a. If the screw plug (1) has been removed from the housing, it must first be reinstalled before the governor end cover can be mounted. Use offset screw driver EF 8182 and draw screw plug (1) up tight.

b. Apply a small quantity of L'Hermetic sealing compound to the outside rim of the hub, in which the outer ball race is located, so that the pump opening around the cam shaft will be sealed when the end cover (2a) is put in place. Carefully place the end cover (2a) over the pump housing, engaging the outer ball race with the ball cage. Do not use force, but carefully tap end cover (2a) into position with a light mallet.

c. Now install the four end cover fastening screws (9) in the flange of end cover (2a) and draw them up tight until the entire end cover (2a) rests securely against the pump housing. Stake the screws so that they will not come loose.

d. Next install the screw plug screw (10) in screw plug (1), located in top of the end cover (2a) and draw up tight. Stake the screw (10).

e. Remove tappet holders and install inspection cover on pump.

f. Push stop lever shaft (2b) through its bearing in left side of end cover (2a). Over the end of stop lever shaft (2b) in end cover (2a) slide the stop lever spring (2d) with its hooked end to the right and pointing upwards. Hold the stop lever (2c) so that the arm points upward and the set screw hole is in front. In this position, force arm of lever under hooked end of spring and slide stop lever shaft (2b) through center hole of stop lever (2c) and through the other end cover bearing. Rotate the shaft (2b) until set screw hole in stop lever (2c) lines up with hole in shaft (2b). Then insert stop lever set screw (2e) and tighten. With this assembly correctly made, the spring (2d) will always force the lever (2c) toward the pump housing. Place plain washers (2f) over each free end of the stop lever shaft (2b) and insert cotter pins (2g).

g. Now insert Woodruff key (23) into keyway of shaft (2b) and slide operating lever (24a) into position, with reinforced part toward housing. Insert clamping screw (24b) with lock washer in screw hole of operating lever (24a) and tighten.

NOTE: Try the lever operation. If correctly assembled, the operating lever (24a) will always pull back toward the pump housing.

h. Push threaded end of linkage pin (14) into hole of control rod with the pin end extending toward the center of housing. Place lock washer (15) over the threaded end of linkage pin (14) and screw on hexagon nut (16). Use proper end wrench for tightening hexagon nut (16).

i. Now install the diaphragm assembly (18). This assembly has a projection on its metal rim to definitely locate it in the end cover (2a), which prevents it from turning. First engage the hole of the diaphragm stud with the linkage pin (14) and secure this engagement with cotter pin (17). Then carefully press the diaphragm assembly (18) into the end cover (2a), engaging the projection on diaphragm rim with the opening provided in the end cover (2a).

j. The end cap (20d) should now be assembled. Push the adjusting screw (20e) through the cap center so that the large threaded portion of the adjusting screw (20e) is on the outside of the end cap (20d). Place spring steel washer (20k) over large end of adjusting screw (20e) and hold the assembly together with lock nut (20f). This is an adjusting nut and should not be drawn up tight. Place lock nut stop ring (20g) over lock nut (20f) and snap spring lock ring (20h) into its groove. Screw idling spring adjusting bushing (20i) into threaded end of adjusting screw (20e) with the open end away from the end cap (20d).

k. Next assemble the governor housing (20a). Insert contact pin (20b) through the center hole of governor housing (20a) so that pin projects into governor housing (20a), and its flange seats in the center housing hole. Next place idling spring (20c) over large end of contact pin (20b) now in center housing hole.

l. Mount the end cap assembly (20d), described in paragraph "j", on the governor housing (20a). Note that a guide key is provided on the idling spring adjusting bushing (20i) which must engage the keyway of the governor housing (20a). After this engagement has been completed, turn the end cap (20d) until the two end cap fastening screws (20j) can be inserted. The end cap fastening screw seats should be painted with white lead or shellac to insure air-tight fit. Draw the screws (20j) up tight and stake them.

m. Place main spring (19) on the spring seat of diaphragm assembly (18). Carefully slide the open end of the governor housing assembly (20) over the main spring (19) and into contact with governor end cover (2). Turn the governor housing assembly (20) until the threaded hole provided for connecting hose to butterfly valve housing is located on top, and then fasten the governor housing assembly (20) with the four fastening screws (21). Draw the screws (21) up tight and stake them.

NOTE: Means are provided for sealing the governor end cap (20d) so that the idling adjustment will not be disturbed. Do not attach the wire seal until the final adjustment for idling has been made.