

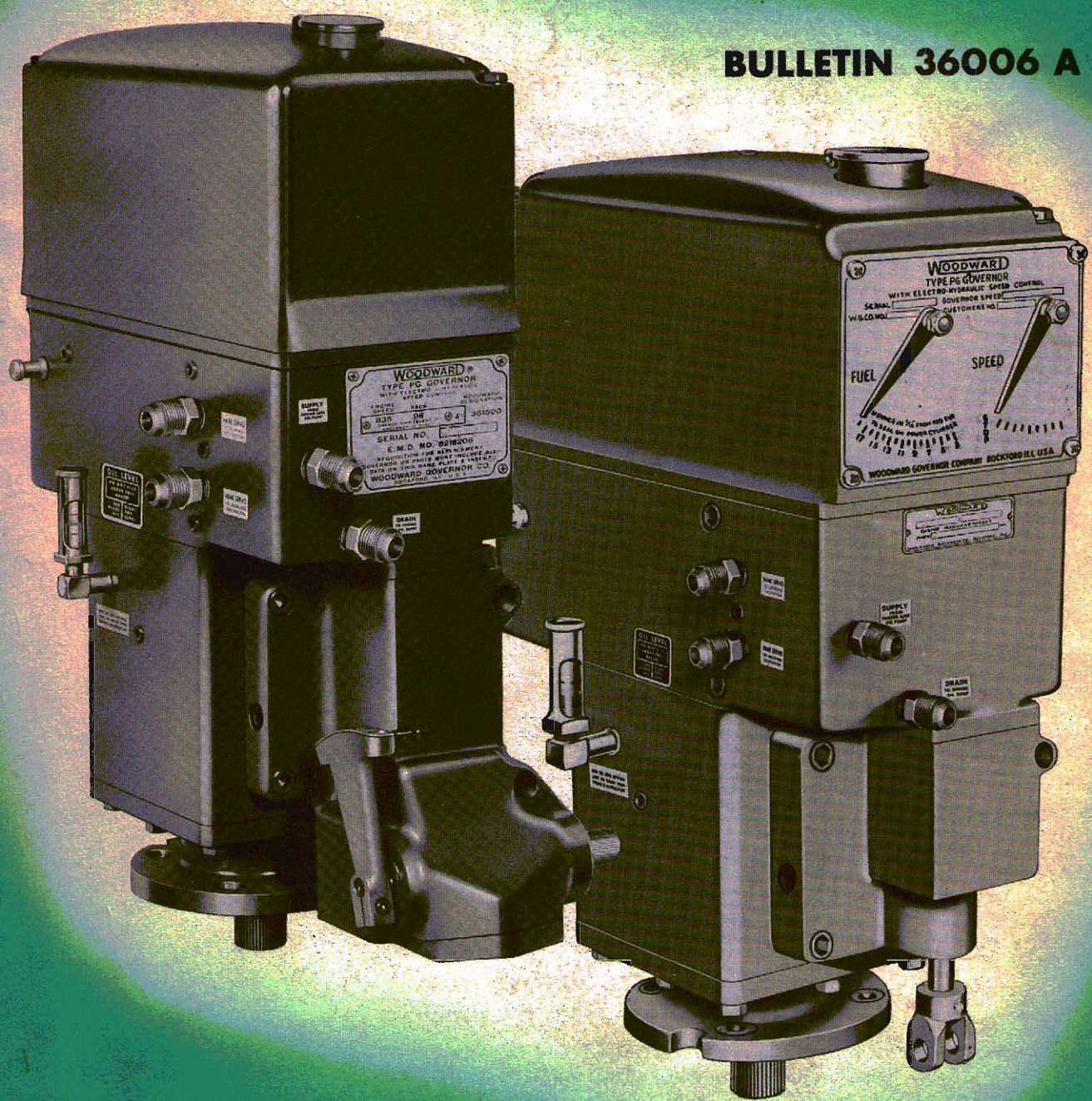
WOODWARD

®

PG LOCOMOTIVE GOVERNOR

ELECTRO-HYDRAULIC AND PNEUMATIC-HYDRAULIC CONTROL

BULLETIN 36006 A



WOODWARD GOVERNOR COMPANY ROCKFORD, ILLINOIS

FORT COLLINS, COLORADO • SCHIPHOL, THE NETHERLANDS • SLOUGH, ENGLAND

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PG GOVERNOR

ELECTRO-HYDRAULIC AND PNEUMATIC-HYDRAULIC SPEED CONTROL FOR LOCOMOTIVE SERVICE

SECTION 1 — GENERAL DESCRIPTION

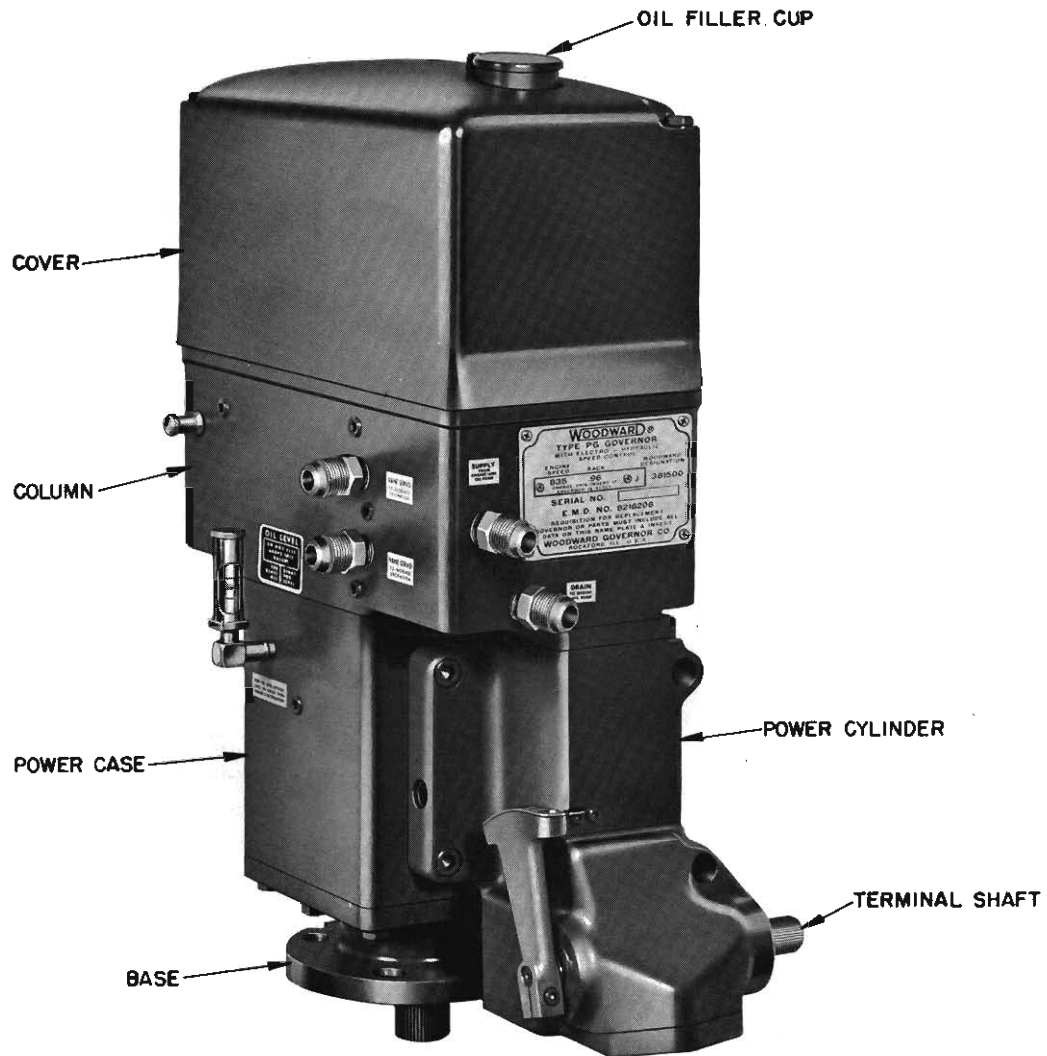


Figure 1

GENERAL: The WOODWARD PG governor for railroad service is basically the standard PG hydraulic governor to regulate engine speed, and includes a number of auxiliary devices designed to meet the peculiar conditions occurring in locomotive and train operation.

The basic PG governor, described in Woodward Bulletin 36002, controls the speed of a diesel engine by regulating the amount of fuel supplied to the engine cylinders. At any speed setting, speed control is isochronous, and the

governor will maintain constant engine speed with steady or changing conditions of load.

The auxiliary equipment in the locomotive governor includes devices to permit remote control of engine speed, to provide control of engine load, and to protect the diesel engine against failure of the engine lubrication system. These and other auxiliary features as listed in the following paragraphs, are available in various combinations, as specified by the locomotive manufacturer.

8. Manual operation of the automatic shutdown device (No. 6) either to effect shutdown or to reset after a shutdown has occurred. Automatic operation of this shutdown control cannot be manually "blocked" to allow normal operation when the automatic shutdown mechanism is functioning.
9. Electrical indication in engine cab, and mechanical indication at the governor, in event of shutdown due to failure of the engine lubricating system.
10. On governors equipped with protection against excessive lubricating oil pump suction, the shutdown device can be tested for proper operation while the engine is running at idle speed, without effecting complete shutdown.
11. Vane regulator (generator field rheostat) integral with the governor — see Figure 3 — providing a complete load control system within the governor assembly.

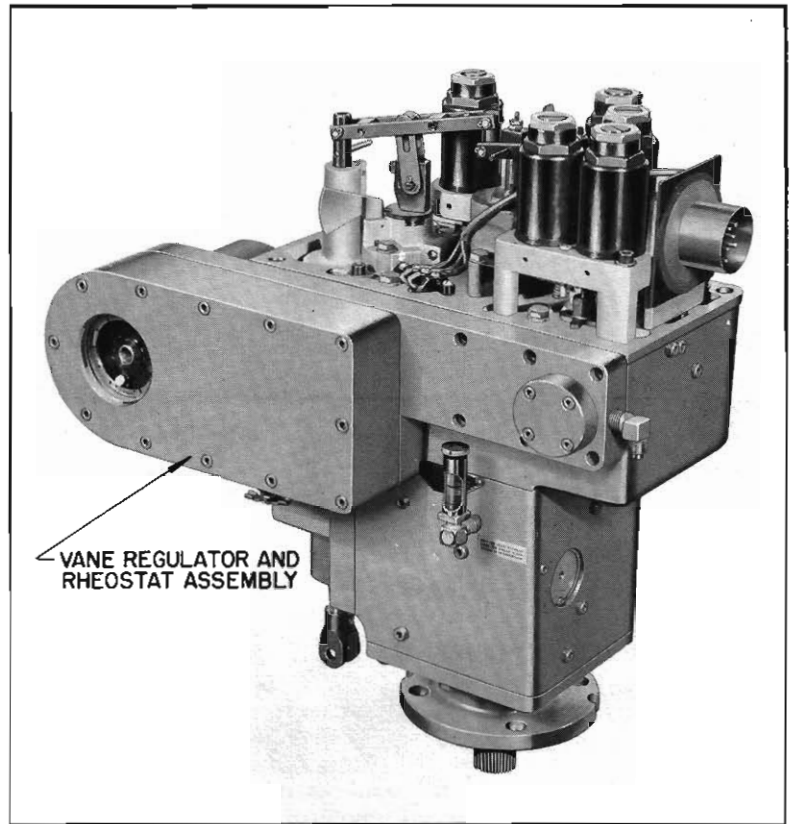


Figure 3

12. Rotary terminal (output) shaft to connect the governor to the fuel control linkage — see Fig. 4. This is alternate to the standard reciprocating fuel rod end. One end of the terminal shaft carries a lever to connect to the fuel linkage, and the opposite end carries an indicator scale which, in conjunction with a fixed pointer, indicates at all times the position of the power piston and/or fuel racks.

This feature is especially useful when setting and checking the load control system.

Not discussed in this bulletin, but available if required:

13. Altitude compensating mechanism, which automatically provides correct air-fuel ratio on units operating from low to high altitudes.

As is the case with any governor of any type, it is considered essential that the engine be equipped with a separate overspeed shutdown device, to prevent runaway in the event of any failure which might render the governor inoperative.

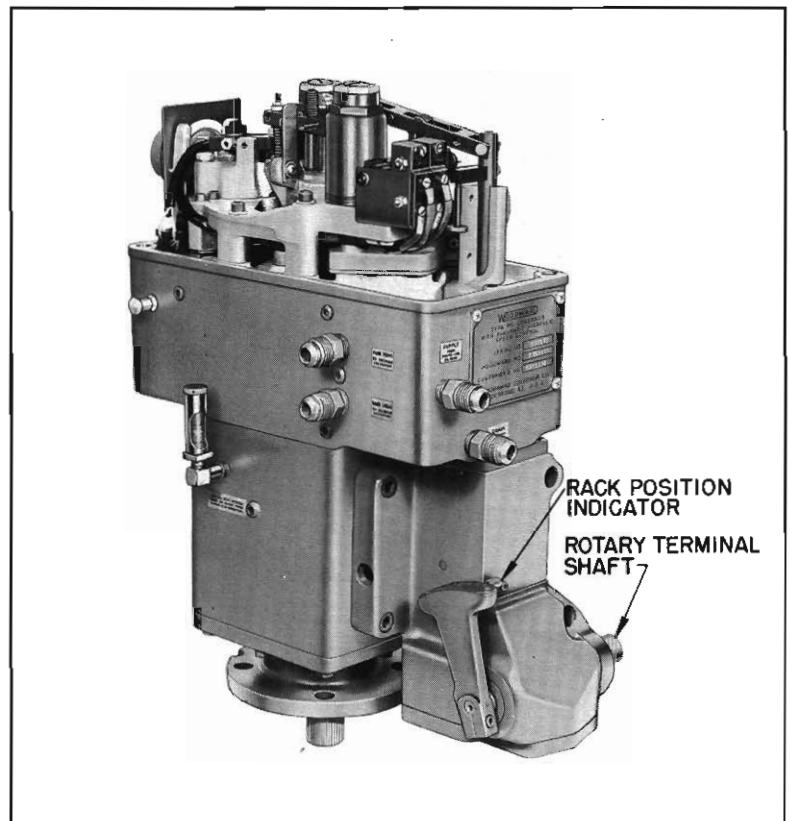


Figure 4

SECTION II — INSTALLATION

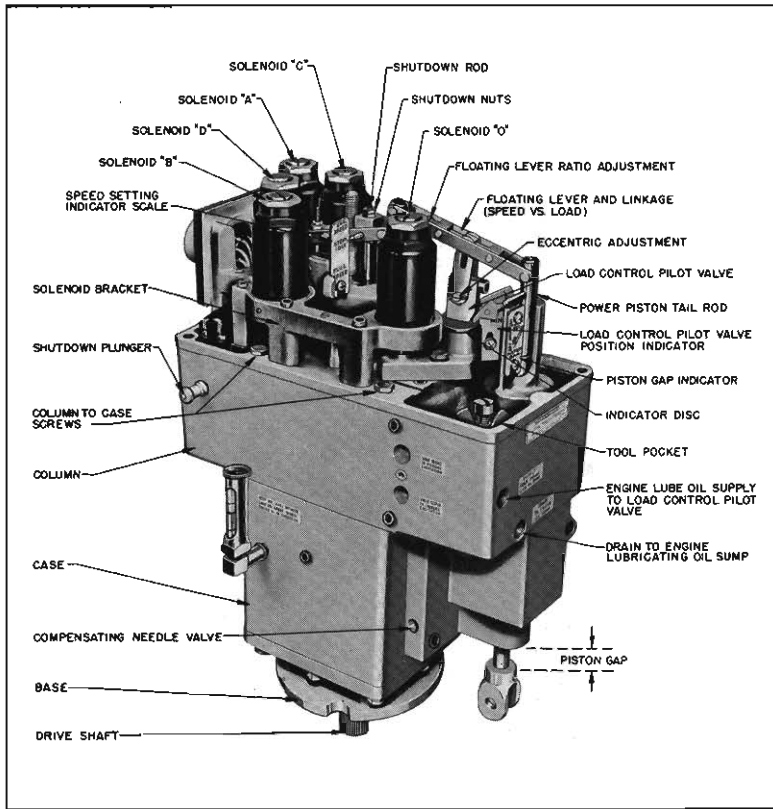


Figure 5

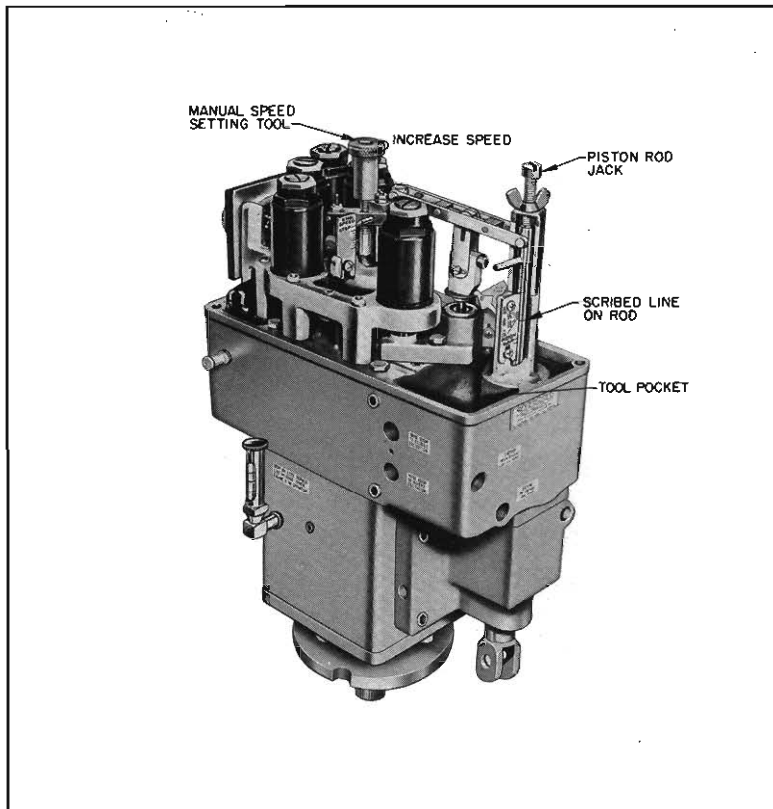


Figure 6

INSTALLATION: When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is properly aligned. A gasket should be used between the mounting pad and governor base. The linkage from the governor to the fuel system should also be properly aligned; any friction or lost motion should be eliminated.

When connecting the fuel linkage the relation of "piston gap" (See Fig. 5) to fuel pump rack position must be adjusted according to engine manufacturer's specifications.

Make the hydraulic, pneumatic and electrical connections required for the style of governor being used.

OIL SPECIFICATIONS: Use SAE 20 or 30 oil for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or 50; if extremely cold, use SAE 10. The oil must not contain additives which are used to free up rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge when agitated, or form gummy deposits when heated. (See Bulletin 25007).

DIRTY OIL CAUSES MOST GOVERNOR TROUBLES: Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil or kerosene before using.

Keep governor oil level BETWEEN lines in the oil gauge WHILE ENGINE IS RUNNING. The oil may be added to the governor through the oil filler cup in the top cover. Add slowly to avoid over-filling. Oil level above or below the lines on the gauge when running, will cause aeration of the oil resulting in a hunting condition.

INSTALLATION ADJUSTMENTS: On all new or factory rebuilt governors, the speed settings and other operating adjustments are made at the factory when the governor is tested before shipment, leaving only the compensating needle valve — See Fig. 5 — to be adjusted to suit the engine on which the governor is to be used. For detailed procedure see section on Compensation Adjustments.

If found necessary to change or readjust speed settings or other operating settings refer to special instructions which should be provided by the engine manufacturer for the particular installation.

When checking or adjusting the governor settings, be sure that the governor and the governor oil are at operating temperature. In no case should internal adjustments of the governor be attempted without a full knowledge of the correct procedure.

With the governor cover removed, two special tools will be found in the tool pocket just above the power cylinder assembly. One of these tools is the piston rod jack, used to position the power piston at the correct "piston gap" when setting the fuel racks to connect the fuel linkage to the governor — see Figs. 5 and 6. The other tool is the manual speed setting nut, used to set or change governor speed setting, manually in case of emergency — see Fig. 6.

NOTE — When using this nut to control speed all auxiliary features and safety devices in the governor will be inoperative.

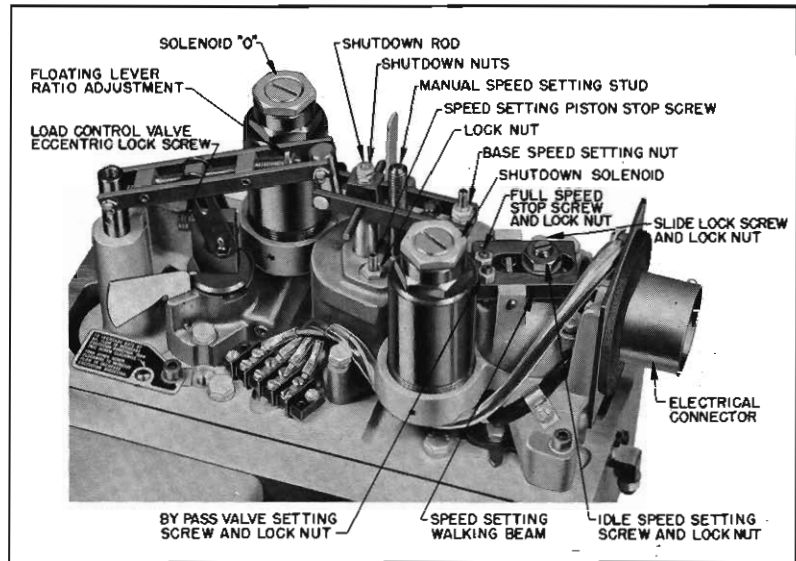


Figure 7

COMPENSATION ADJUSTMENT: When the engine is started for the first time, or after the governor has been drained and cleaned, the governor must be filled with oil to the prescribed level — See Section on oil, Page 4 — and the governor oil system purged of trapped air.

To do this loosen the air vent plug — shown in Fig. 2 — far enough to establish a leak. Set the throttle — electrical or pneumatic — at IDLE and start the engine. Open the compensating needle valve — shown in Fig. 5 — several turns. This should cause the engine to hunt, and the alternating movements of the governor parts will force all trapped air out of the governor oil passages and out of the governor at the vent plug.

Allow the engine to hunt at idle speed long enough to bleed all trapped air from the governor oil system. This will be evidenced by leakage of only oil at the vent screw. Tighten the vent screw and, if necessary, add oil to the governor to restore the correct level. Close the compensating needle valve slowly until the hunting condition is minimized — or eliminated — and allow the engine to run at idle speed until engine and governor reach normal operating temperature.

When operating temperature has been reached, open the compensating needle valve again several turns — enough to cause the engine to hunt — then close the needle valve slowly until the hunting is entirely eliminated. This will usually occur when the needle valve is open between one-quarter turn and three full turns. The correct setting will depend upon the characteristics of the engine.

Test stability by disturbing the engine speed. If the engine returns to steady speed the adjustment is satisfactory, but if it starts hunting, close the needle valve slightly and test again.

Keep the needle valve as far open as possible to prevent sluggishness and still obtain stability. Once it is correctly adjusted for the engine, it should not be necessary to change the setting of the needle valve except for a large permanent temperature change affecting the viscosity of the governor oil.

ADJUSTMENT OF SHUTDOWN NUTS: While all governor adjustments are important and should be made only by experienced operators or service men, special reference is made here to the adjustment of the shutdown nuts and speed setting piston stop screw. Premature shutdown, failure to shutdown, or even failure to operate at all can result if the shutdown nuts and/or piston stop screw are out of adjustment.

The shutdown nuts (2) will be found at the top of the shutdown rod projecting out of the top of the speed setting cylinder — See Fig. 7. These nuts, and the speed setting piston stop screw — also shown in Fig. 7 — are adjusted according to the following procedure:

1. Loosen and back off the shutdown nuts to the top of the shutdown rod.
2. Loosen the lock nut on the speed setting piston stop screw, and back out the screw 3 or 4 turns.
3. Have the engine running at idle speed and operating temperature to make the adjustments.
4. Turn the speed setting piston stop screw down until it touches the top of the piston — back it off 1 1/2 turns and tighten the lock nut. This provides 3/64" clearance between the piston and the stop screw with the engine running at idle speed.
5. Run the shutdown nuts down on the shutdown rod enough to enable lifting the rod with the fingers to take out any slack or lost motion at the bottom end of the shutdown rod.
6. With the slack out — adjust the lower shutdown nut to have 1/32" clearance over the top of the piston rod, and lock into position with the upper nut.

Function of the shutdown rod and nuts, and the speed setting piston stop screw, is described in the section on Normal Shutdown.

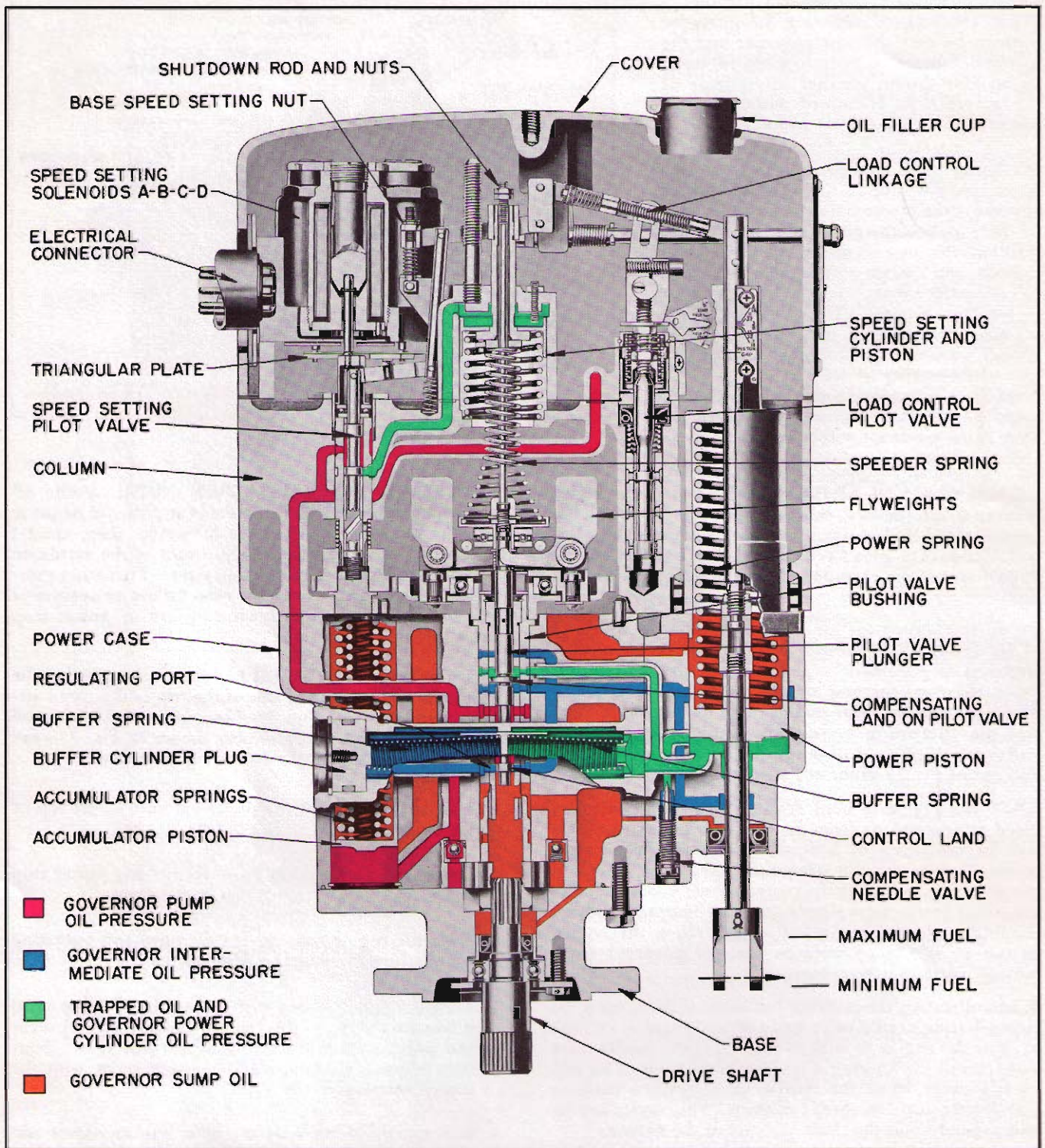


Figure 8

The sectional illustration — Fig. 8 — serves to indicate the relative position of the various governor components in the complete assembly. The connecting oil passages between parts are not necessarily in their correct location, but have been simplified to facilitate tracing of the oil flow. The lower half of the governor is basically the Woodward Hydraulic PG Isochronous Governor, which

functions to maintain a constant engine speed by controlling the fuel supplied to the engine cylinders. The upper half, consisting of the column and cover and the related internal parts, contains the mechanism for changing governor speed setting, the control valve for the load regulating device, and the shutdown and protective devices.

SECTION III — OPERATION OF BASIC GOVERNOR

OPERATION OF GOVERNOR

In the following section — Description of Operation — we discuss the effect on the governor of changes in speed setting, with the corresponding governor reaction to position the fuel control mechanism at the required point. The same sequence of governor movements would occur in considering the result of an increase or decrease of load on the engine.

Figure 9, Schematic Diagram of the basic PG speed regulating governor, is used to illustrate the sequence of operations.

Operation of the various auxiliary components located in the upper half of the governor will be discussed separately in succeeding sections of this bulletin.

DESCRIPTION OF OPERATION

The schematic diagram — Fig. 9 — illustrates the essential parts of the basic PG governor used to regulate fuel and control engine speed.

The governor drive shaft passes through the governor base into the pump drive gear, which is direct connected to the rotating pilot valve bushing. The flyweight head is secured to the upper end of the pilot valve bushing, thus providing a direct drive from the engine to the flyweights. At any speed setting of the governor, when the engine is on speed the centrifugal force of the flyweights will balance the opposing force of the speeder spring with the flyweights in the vertical position, and the control land of the pilot valve plunger will be covering the regulating ports in the rotating pilot valve bushing.

Pressure seal grooves A, B and C are supplied with pressure oil through the regulating port to prevent the oil trapped between the power piston and the buffer piston from leaking past the power piston, power piston rod and pilot valve stem. To make up leakage of the seal oil and hold the power piston in a steady state position against the power spring — when the engine is on speed with a steady load — the pilot valve plunger will be below center enough to supply the required amount of oil through the regulating port.

The governor pump supplies pressure oil to the accumulators and rotating pilot valve bushing, with excess oil (at maximum pressure) bypassing from the accumulators to the governor oil sump. Duplicate suction and discharge ball check valves at the governor pump permit rotation of the governor in either direction. NOTE — Governors for GM-EMD locomotives are plugged for only one direction of rotation, and are not equipped with check valves.

Movements of the power piston are transmitted by the piston rod to the engine fuel linkage. Regulated oil pressure under the power piston is used to raise the power piston — to increase fuel — and the power spring above the power piston is used to lower the power piston to decrease fuel.

Located between the pilot valve bushing and the power piston is the "buffer" compensating system, consisting of the buffer cylinder and piston, the buffer springs, and the compensating needle valve. Lowering the pilot valve plunger permits a flow of pressure oil from the pilot valve bushing into the buffer system and power cylinder

to raise the power piston and increase fuel. Raising the pilot valve results in a flow of oil from the power cylinder and buffer system to the governor sump, and the power spring moves the power piston down to decrease fuel to the engine.

This flow of oil in the buffer system — in either direction — carries the buffer piston in the direction of flow, compressing one of the buffer springs and releasing the other. This action creates a slight differential in the pressures of the oil on opposite sides of the buffer piston, with the higher pressure on the side opposite the spring which is compressed. These differential oil pressures are transmitted to the areas above and below the compensating land on the pilot valve plunger, producing an upward or downward force on the compensating land which assists in re-centering the pilot valve plunger whenever a fuel correction is made.

The position of the power piston near the bottom of its stroke indicates a low speed setting, and the vertical position of the flyweights with the control land of the pilot valve covering the regulating port indicates that the engine is on speed.

SPEED INCREASE: Raising the speed setting of the governor increases the downward pressure of the speeder spring on the toes of the flyweights and the flyweights move in, lowering the pilot valve plunger and opening the regulating port.

Opening the port in this direction admits pressure oil into the buffer system, causing the buffer piston to move to the left and transfer an equal volume of oil to the power cylinder, forcing the power piston up in the direction to increase fuel.

As the buffer piston moves in the direction of the oil flow — from pilot valve to power cylinder — the left hand buffer spring is compressed and the right hand spring is relieved. This produces an intermediate oil pressure on the right side of the buffer piston which is higher than the pressure of the trapped oil on the left side of the buffer piston by an amount proportional to the buffer piston and spring displacement.

Simultaneously with the movement of the power piston and buffer piston, the differential oil pressures on opposite sides of the buffer piston are transmitted to the upper and lower sides of the compensating land, with the higher pressure on the lower side causing an upward force on the compensating land which will increase until (added to the upward force of the flyweights) it will balance the speeder spring force, raise the pilot valve plunger enough to cover the regulating port, and return the flyweights to the vertical position. As soon as the regulating port is covered the power piston will be stopped at a new position corresponding to the increased amount of fuel needed to operate the engine at the desired higher speed. The engine is still accelerating toward the new speed setting.

As the centrifugal force of the flyweights increases to a higher value with engine acceleration, the upward oil force at the compensating land is reduced to zero by the equalization of the oil pressures in the buffer system through the compensating needle valve. If the needle valve is correctly adjusted the oil pressures will equalize

at the same rate as the increase in the centrifugal force of the flyweights, and the flyweights will remain in the vertical position, keeping the regulating port covered by the control land of the pilot valve, and holding the power piston stationary at the new position. Equalizing the oil pressures in the buffer system allows the buffer springs to return the buffer piston to center in the buffer cylinder.

The engine will now be running at a higher speed with an increased fuel setting.

SPEED DECREASE: Lowering the speed setting of the governor decreases the downward pressure of the speeder spring on the toes of the flyweights and the flyweights move out, raising the pilot valve plunger and opening the regulating port.

Opening the port in this direction permits oil to flow from the buffer system to the governor sump. This will lower the oil pressure in the buffer system and the power spring will force the power piston down in the direction to decrease fuel.

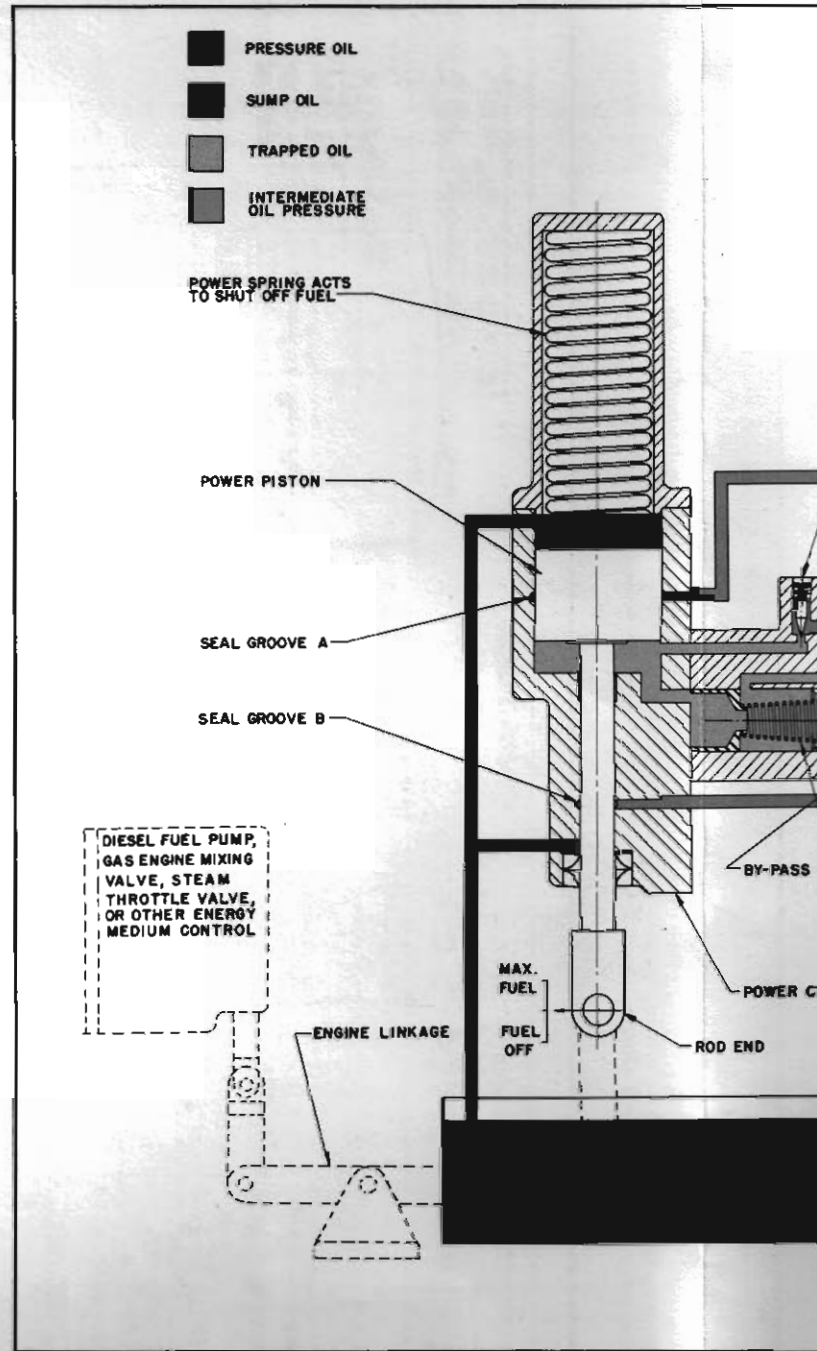
As the buffer piston moves in the direction of the oil flow — from power cylinder to pilot valve — the right hand buffer spring is compressed and the left hand spring is relieved. This produces a pressure in the trapped oil on the left side of the buffer piston which is higher than the intermediate oil pressure on the right side of the buffer piston, by an amount proportional to the displacement of the buffer piston and spring.

Simultaneously with the power piston and buffer piston movement, these pressures will be transmitted to the compensating land, with the higher pressure now on the upper side of the land, causing a downward force which will increase until (added to the downward force of the speeder spring) it will balance the flyweight force, lower the pilot valve plunger enough to cover the regulating port, and return the flyweights to the vertical position. As the regulating port is covered the power piston will stop at a new position to correspond to the reduced amount of fuel required to operate the engine at the desired lower speed. The engine will be still decelerating toward the new speed setting.

As the centrifugal force of the flyweights decreases with engine deceleration, the downward oil force at the compensating land will again be reduced to zero by the equalization of the oil pressures in the buffer system through the compensating needle valve. With the needle valve correctly adjusted the oil pressures will equalize at the same rate as the decrease of centrifugal force in the flyweights, and the flyweights will remain in the vertical position, keeping the regulating port covered by the control land of the pilot valve, and holding the power piston stationary at the new position. Again, the buffer piston will be returned to center by the action of the buffer springs.

The engine will now be running at a lower speed with a reduced fuel setting.

Bypass passages are provided in the buffer cylinder to facilitate large corrective movements of the power piston. A large increase or decrease in the speed setting of the governor, or a large increase or decrease of load on the engine, will require a correspondingly large movement of the power piston to make the necessary correction to the fuel setting. Under such conditions, the buffer piston will move only far enough to the left or right to effect an opening at the bypass port (pressure or drain). Oil will then flow directly to or from the power cylinder



Figure

through the bypass passage without further increasing the differential oil pressure force existing on the compensating land.

As soon as sufficient governor movement and fuel correction has occurred to effect a correction of engine speed towards the speed at which the governor is set, the differential oil pressures — still present — will act on the compensating land to re-center the pilot valve plunger, as described in the previous paragraphs.

With a large decrease in load the power piston assembly moves to the "no fuel" position, closing the compensating oil passage from the power cylinder to the compensating needle valve and blocking passage of oil from the left end to the right end of the buffer cylinder, so that

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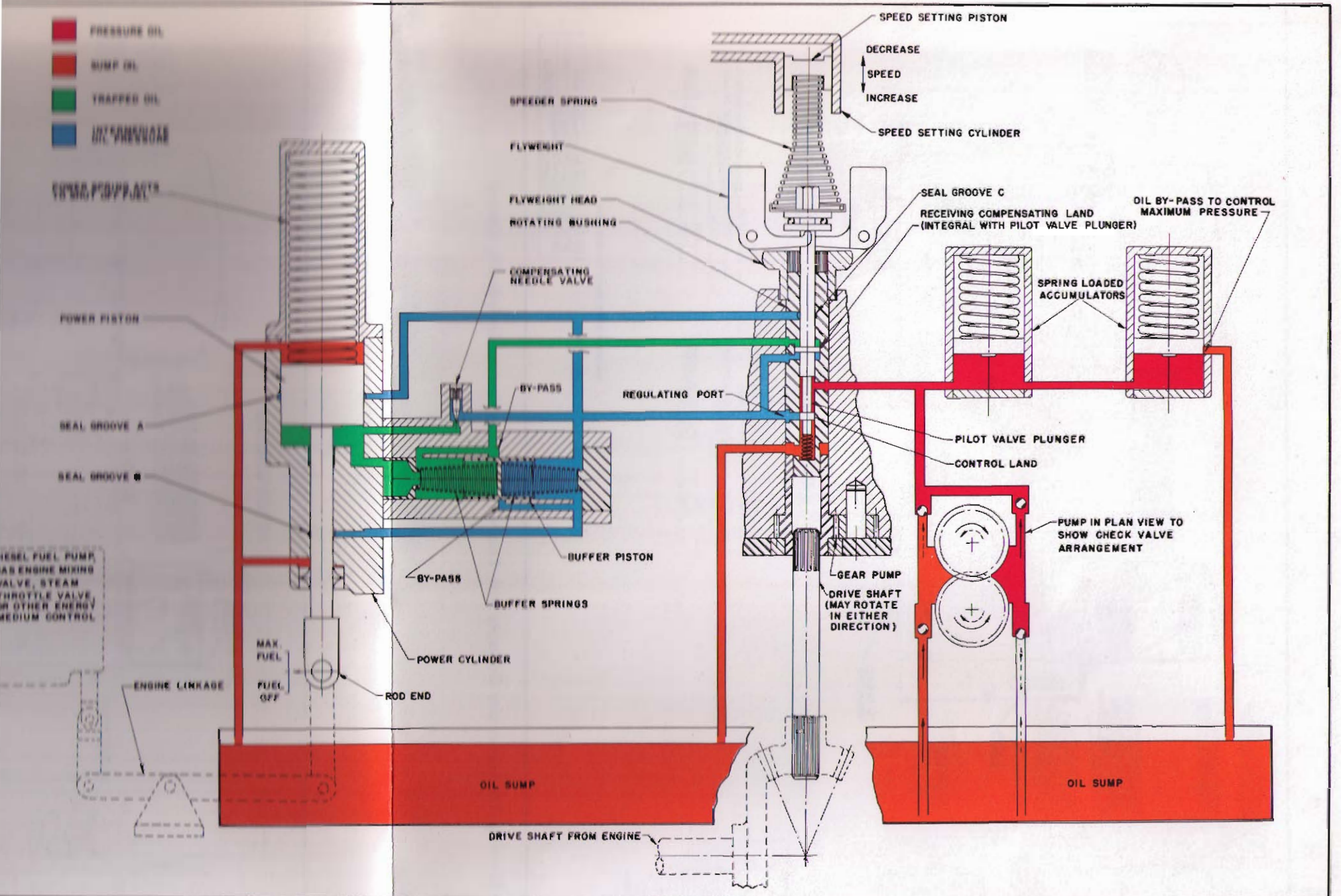


Figure 9 — Schematic Diagram of Basic PG Governor

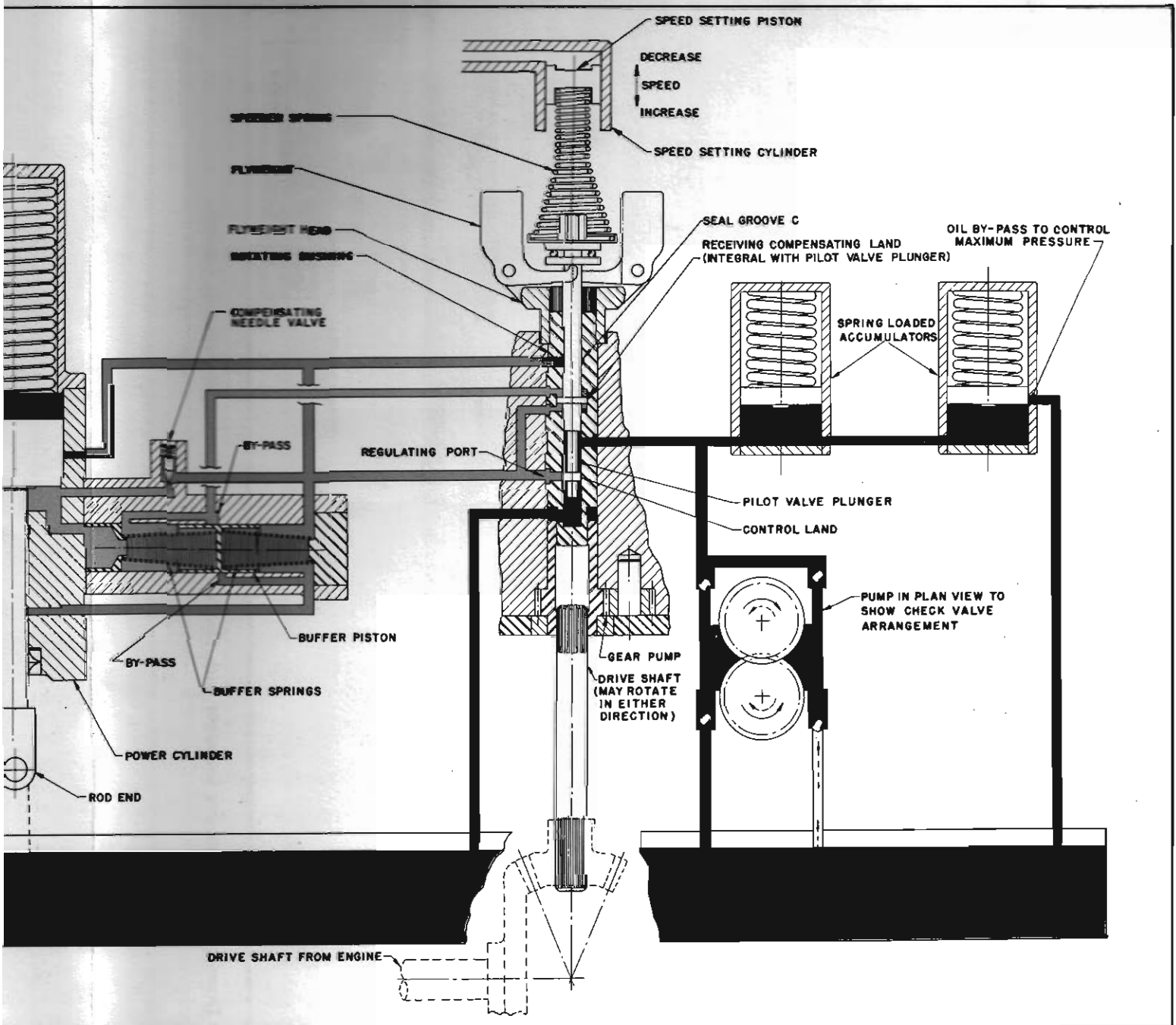


Figure 9 — Schematic Diagram of Basic PG Governor

the needle valve cannot equalize buffer oil pressures in the usual manner. The buffer piston will have moved off center to the right and will be held there by the oil now trapped between the power piston and the buffer piston.

The higher pressure of the oil on the left side of the buffer piston — produced by the compression of the right hand buffer spring — will act on the receiving compensating land to add to the effect of the speeder spring setting and provide a temporary higher speed setting of the governor.

As the engine decelerates to a speed slightly below this higher speed setting, the governor will respond to raise the power piston (and restore fuel supply) in the normal

manner, uncovering the port to permit passage of oil through the compensating needle valve so that the governor and engine will stabilize at the speed corresponding to the actual speed setting of the governor. This minimizes possible under-speeding of the engine when a large load decrease occurs.

NOTE: The location of the compensation oil opening in the power cylinder wall makes it necessary to adjust the fuel linkage so that at IDLE SPEED NO LOAD the PISTON GAP should not exceed 1-1/32".

In actual practice, the sequence of events occurring in the governor take place more or less in a simultaneous manner, rather than step by step as described in the foregoing paragraphs.

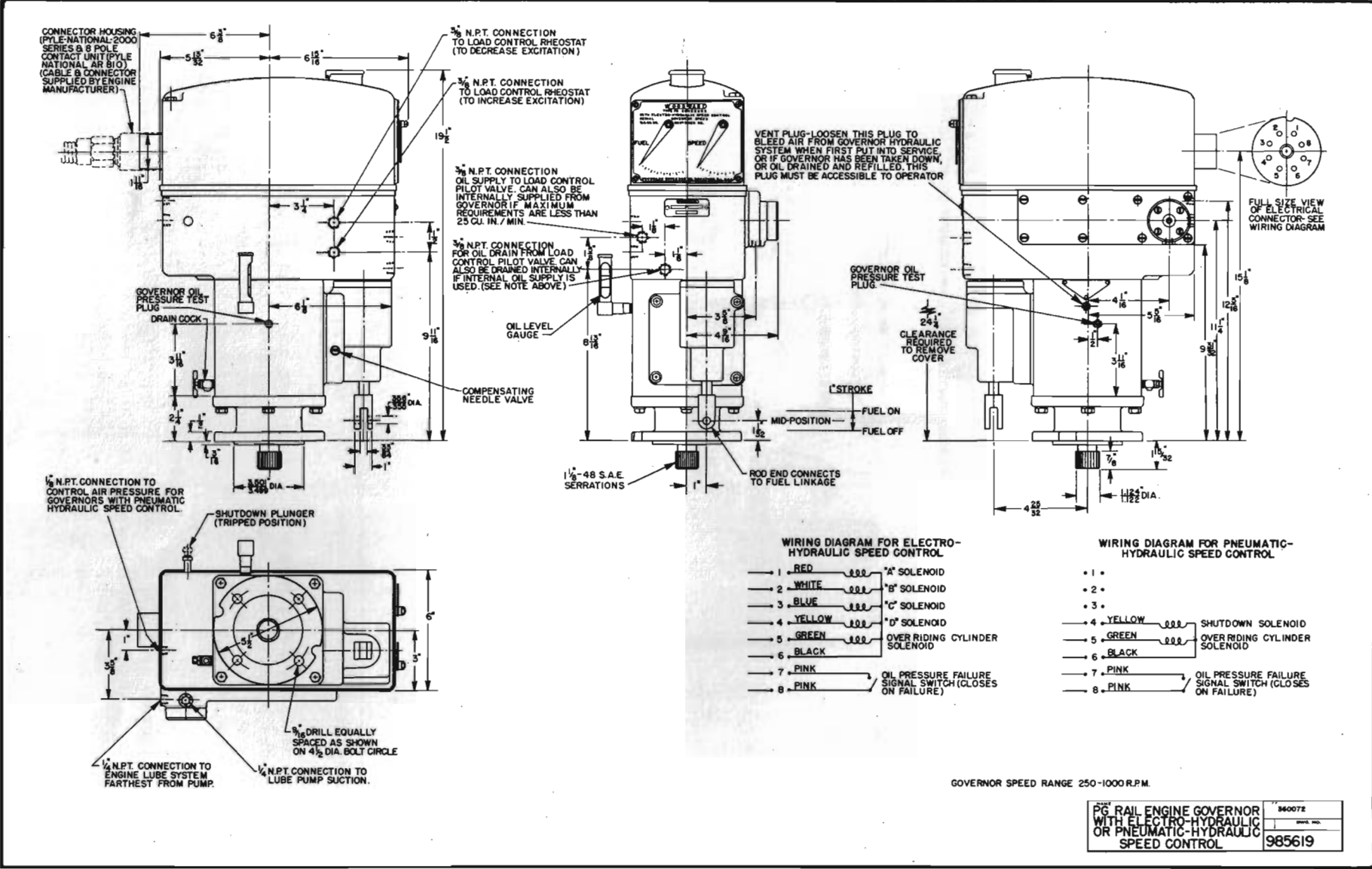


Figure 10 — Outline Drawing, PG Locomotive Governor with Electro-Hydraulic or Pneumatic-Hydraulic Control.

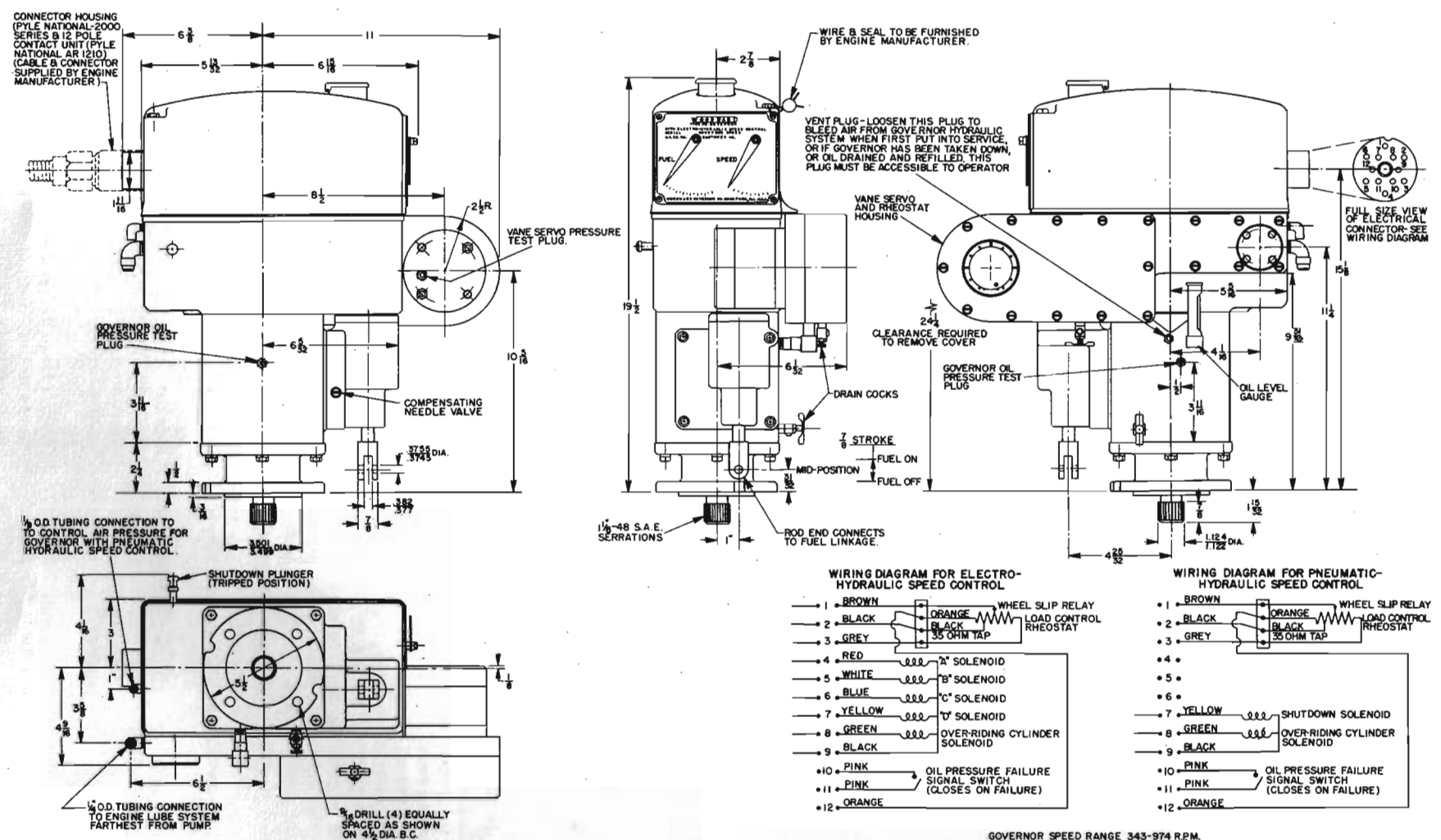


Figure 11 — Outline Drawing, PG Locomotive Governor with Integral Load Regulator.

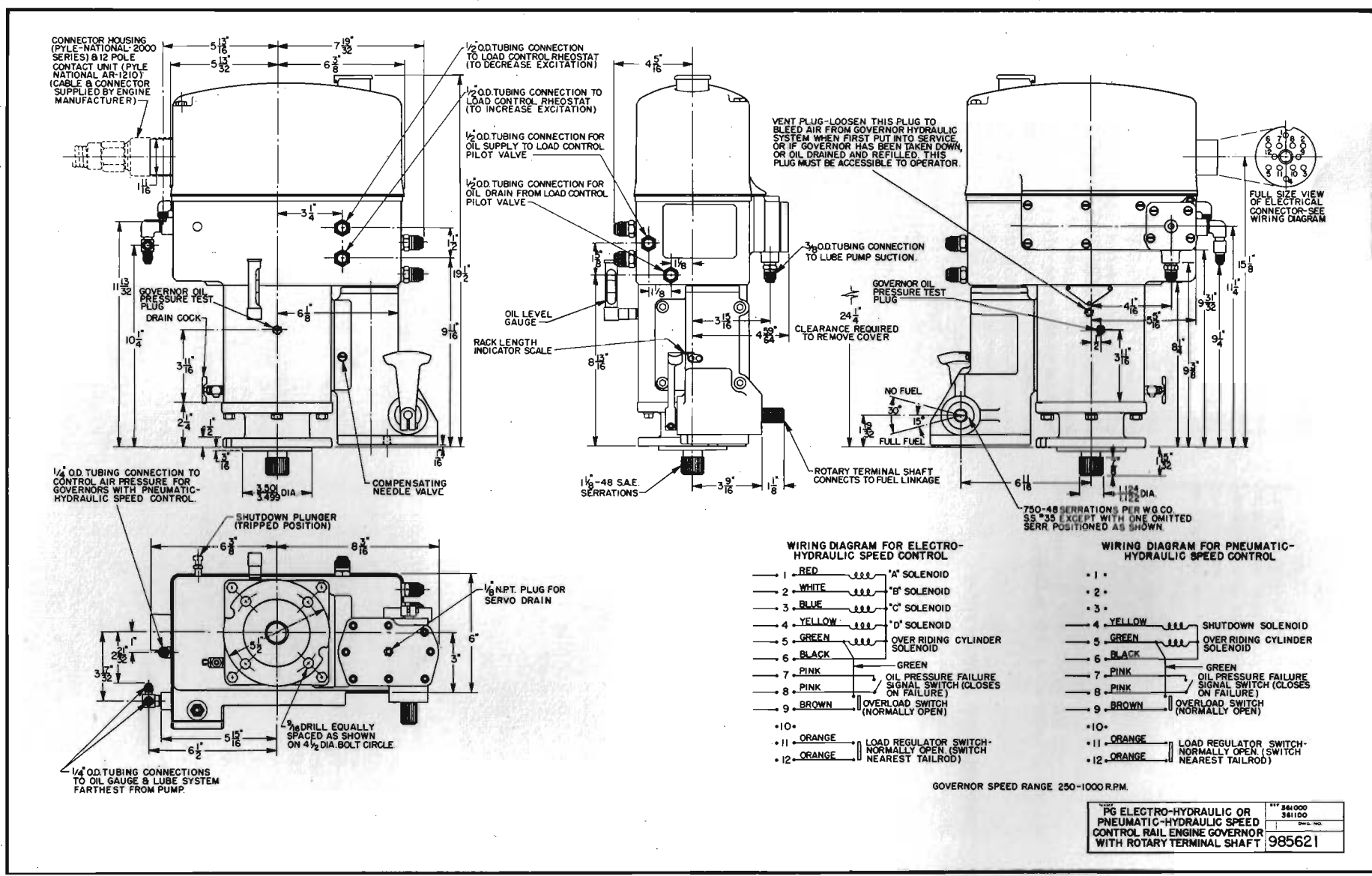


Figure 12 — Outline Drawing, PG Locomotive Governor with Rotary Terminal Shaft.

— **NOTES** —

SECTION IV — SPEED SETTING, SPEED CHANGING AND NORMAL SHUTDOWN

GENERAL: Speed adjusting in the PG railroad governor is effected by setting or changing the spring force of the speeder spring opposing the flyweights, by means of the speed setting piston in the speed setting cylinder, positioned directly over the governor speeder spring (See Fig. 13). Downward movement of the speed setting piston to a higher speed setting is obtained by admitting governor pressure oil to the speed setting cylinder above the piston. Upward movement of the piston to a lower speed setting is obtained by draining the oil away from the speed setting cylinder, allowing the speed setting piston spring to raise the piston as the oil is drained out.

Flow of the governor oil to and from the speed setting cylinder is controlled by the speed setting pilot valve plunger — contained in the rotating bushing — which is actuated by solenoids in the electro-hydraulic governor (See Fig. 13), or by air pressure in the pneumatic-hydraulic governor (See Fig. 19). The solenoid operated system provides "step" control of speed from idle to full speed in equally spaced steps — usually 8 — while the pneumatic system provides stepless control through the full range of speed. Rotation of the speed setting pilot valve bushing is obtained through a large drive gear which is part of the governor flyweight head, and a driven gear into which the splined lower end of the bushing is inserted.

In both types of governor — electric and pneumatic speed control — the rate of movement of the speed setting piston in the downward direction, to increase speed setting, is retarded to a certain number of seconds for full stroke by admitting governor pressure oil into the rotating speed setting pilot valve bushing through a sized port which registers with the supply port once in each revolution of the bushing. The size of this intermittent supply port is determined from the engine manufacturers specifications. For example, the time for the governor to go from idle speed setting to full speed setting on typical switching and suburban service units is usually around 5 seconds; for road units, freight or passenger, about 15 seconds; for turbo-charged engines the timing might be retarded to as much as 50 seconds, to permit the exhaust driven turbo-charger to accelerate with the engine, thus holding exhaust smoke to a minimum.

With the governor properly adjusted, correct positioning of the speed setting piston when a speed setting change is made is obtained through the use of "restoring" linkage between the speed setting piston and the speed setting pilot valve plunger. As the speed setting piston moves to a new speed setting, this linkage returns the speed setting pilot valve plunger to the closed port position, stopping the flow of oil to or from the speed setting cylinder, thus holding the speed setting piston at the proper position for the particular setting of the governor.

Succeeding paragraphs will explain in more detail the operation of the speed setting equipment in the electro-hydraulic and pneumatic-hydraulic PG railroad type governors.

ELECTRO-HYDRAULIC SPEED CHANGING: Three solenoids — A, B, and C — actuate the speed setting pilot valve by controlled movements of the triangular plate and connecting linkage, while a fourth solenoid — D — works directly on the speed setting pilot valve bushing. Energizing the A, B and C solenoids, singly or in combinations, pushes down on the triangular plate and results in a downward movement of the speed setting pilot valve plunger, which opens the regulating port to passage of intermittent pressure oil to the speed setting cylinder, to affect an increase in the speed setting. Energizing the D solenoid causes a downward movement of the speed setting pilot valve bushing, which opens the regulating port to allow oil from the speed setting cylinder to drain out and return to the governor sump, resulting in a decrease in speed setting. De-energizing the solenoids will affect the governor speed setting in opposite directions to those described above. The identifying letter for each solenoid is marked on the surface of the casting carrying the solenoids.

Operation of the throttle control in the engine cab from one step to the next energizes or de-energizes the solenoids in various combinations, to increase or decrease engine speed by speed increments which are usually — but not necessarily — equal within a few revolutions per minute. A typical arrangement of the speed setting assembly — See Figure 14 — provides IDLE and LOW SPEED with all four solenoids de-energized. Energizing Solenoid A increases engine speed by one increment; energizing B solenoid adds four increments; energizing C solenoid adds two increments; and energizing the D solenoid, which pushes down the speed setting pilot valve bushing, reduces the speed by two increments, when used in combination with the A, B and C solenoids. When the throttle is in the STOP position the D solenoid is the only one energized. This arrangement, which is very commonly used, provides eight normal speed settings, in addition to IDLE and STOP (see under NORMAL SHUTDOWN, Page 19, and AUXILIARY DEVICES, Paragraph 1, on Page 2).

The following paragraphs explain the operation of the speed setting components of the governor.

EQUILIBRIUM CONDITION:

Figure No. 13.

1. The engine is running at low speed, as indicated by the de-energized solenoids, and the speed setting piston in its upper position.
2. The speed setting pilot valve plunger is centered, with the control land covering the regulating port, trapping the oil above the speed setting piston and holding the piston in a fixed position representing a certain speed.
3. The engine is on speed as indicated by the vertical position of the flyweights.

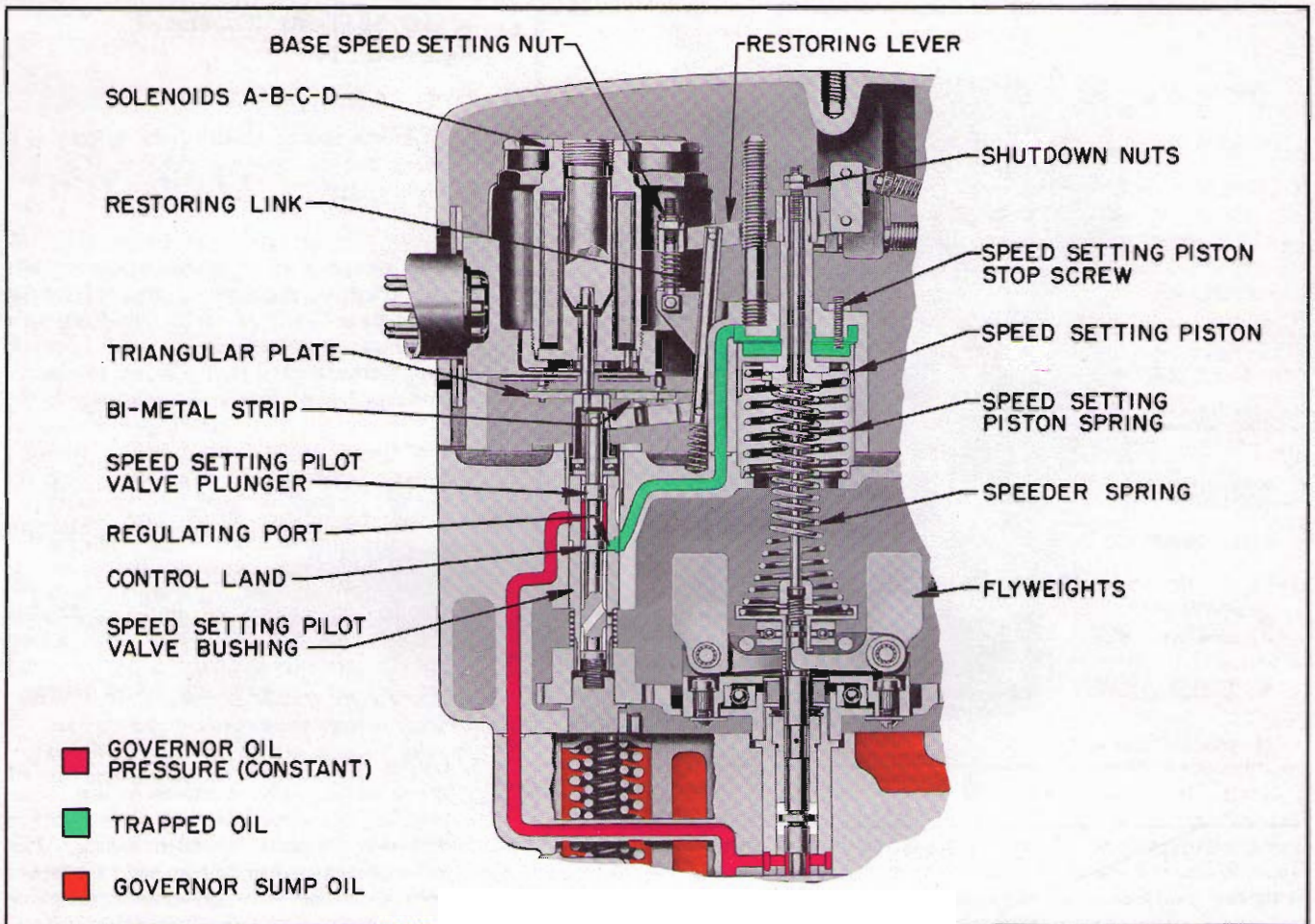


Figure 13

TYPICAL ENGINE SPEED CHART ELECTRO-HYDRAULIC CONTROL					
THROTTLE POSITION	SOLENOIDS ENERGIZED				ENGINE R.P.M.
	A	B	C	D	
STOP				*	0
IDLE					275
1					275
2	*				350
3			*		425
4	*		*		500
5		*	*	*	575
6	*	*	*	*	650
7		*	*		725
8	*	*	*		800

Figure 14

**SPEED SETTING INCREASE:
Figure No. 15.**

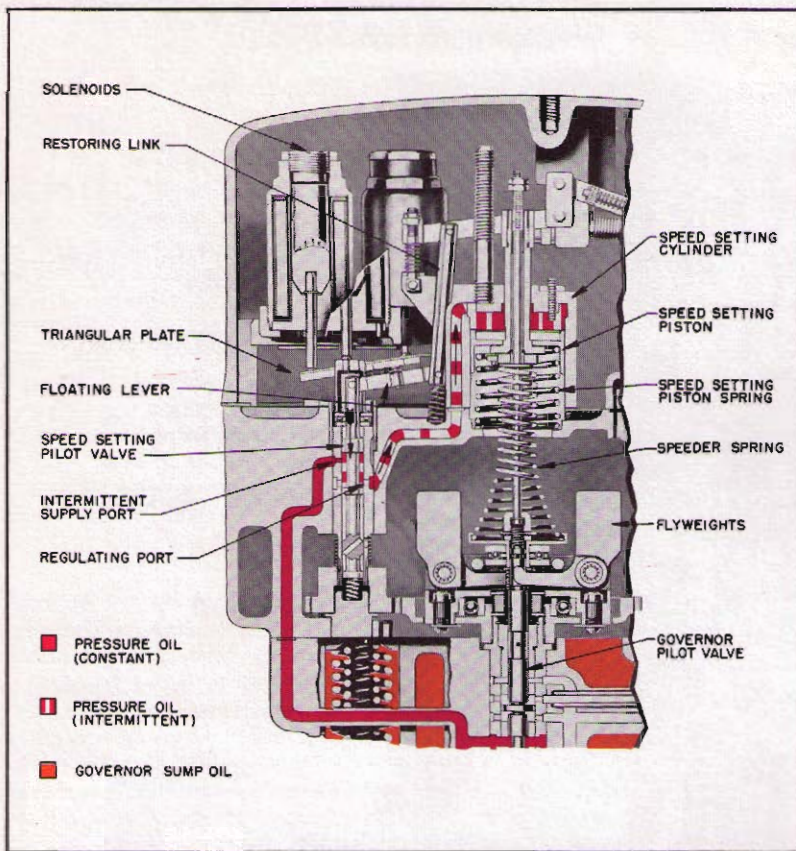


Figure 15

1. One or a combination of the solenoids is energized by moving the throttle to a higher step.

2. The solenoid plungers move down and the plunger rods move the triangular plate to a lower position, resulting in a downward movement at the bi-metal strip* transmitted to the nylon pin in the floating lever. This lever, pivoting at the lower end of the restoring link, moves the speed setting pilot valve plunger down, opening the regulating port to permit passage of governor pressure oil to the speed setting cylinder (intermittent supply).

*The bi-metal strip is used in the speed setting mechanism of both electro-hydraulic and pneumatic-hydraulic governors to minimize the effect of temperature changes on the governor speed settings.

3. Under force from the pressure oil, the speed setting piston moves down, compressing the speed setting piston spring and the governor speeder spring. The increased downward force of the speeder spring will move the governor pilot valve plunger down and the flyweights inward (See Paragraph 5).

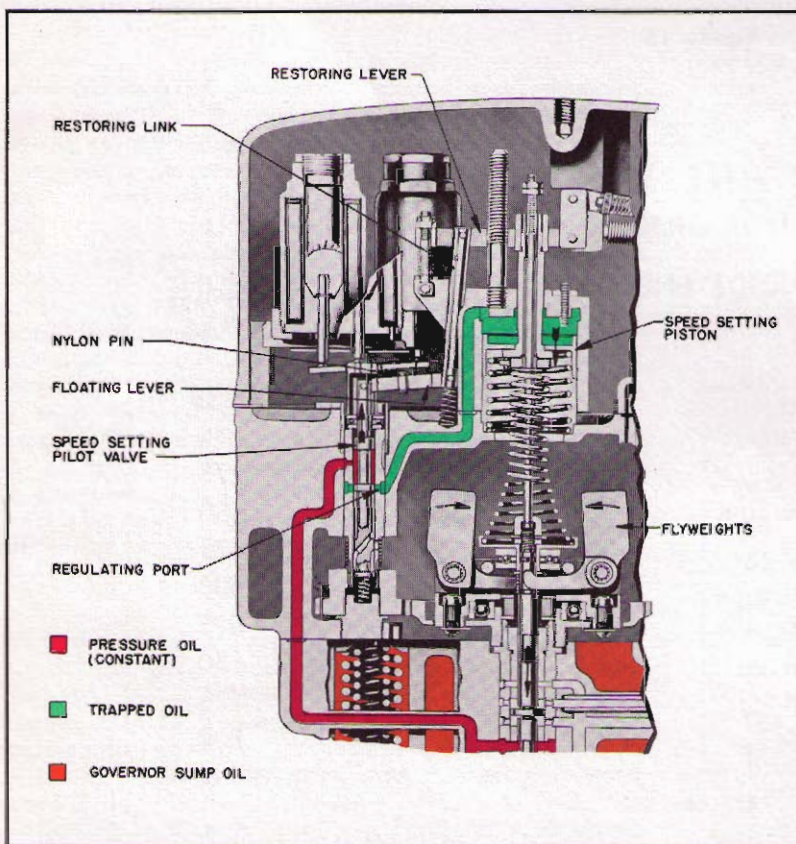


Figure 16

4. As the speed setting piston moves down, the restoring lever and link operate to push down on the inner end of the floating lever. See Figure 16. Pivoting on the nylon pin, the outer end of the floating lever will be raised, carrying with it the speed setting pilot valve plunger. The speed setting piston will continue its downward movement until the restoring linkage has raised the speed setting pilot valve plunger far enough to close the regulating port and stop the flow of pressure oil to the speed setting cylinder. The speed setting piston will therefore be stopped and held at a definite position for each position of the triangular plate, with a resulting definite speed setting of the governor for each position of the engineman's throttle.

5. Since the flyweights move inward when the speeder spring force is increased, as a result of moving the throttle to a higher step, the governor will act to increase the fuel supply to the engine and increase the speed. This is explained under "Description of Operation" on Pages 7 and 8.

SPEED SETTING DECREASE:

Figure No. 17.

1. One or more of the solenoids will be de-energized (or energized) — see typical speed chart, Figure 14 — by moving the throttle to a lower step.
2. The triangular plate will follow the movement of the solenoid plunger rods to a higher position. **NOTE**— The triangular plate is held up in contact with the solenoid plunger rods at all times by a spring located centrally under the plate, around the top of the "by-pass valve" case.
3. With the floating lever pivoting at the lower end of the restoring link, the spring under the speed setting pilot valve will raise the valve and the outer end of the floating lever, holding the nylon button in contact with the bi-metal strip. This action opens the regulating port to permit passage of the oil above the speed setting piston back through the speed setting pilot valve bushing and out through a drain port into the governor sump. (See Figure 17).
4. As the oil drains out from above the speed setting piston, the piston return spring will force the speed setting piston up and reduce the downward force of the speeder spring. This will allow the flyweights to move outward and raise the governor pilot valve plunger. (See Paragraph 6).
5. As the speed setting piston moves up, the restoring lever and link operate to raise the inner end of the floating lever. Pivoting on the nylon pin, the outer end of the floating lever will move down, and the speed setting pilot valve plunger will be moved down. Thus, the speed setting piston will continue its upward movement until the restoring linkage has lowered the speed setting pilot valve plunger far enough to close the regulating port and stop the flow of oil from the speed setting cylinder. The speed setting piston will be stopped at a new position, and the governor will have a new speed setting as determined by the position of the throttle.
6. Since the flyweights move outward as a result of moving the throttle to a lower step, the governor will act to decrease the fuel supply to the engine and reduce the engine speed, as explained under "Description of Operation" on Pages 7 and 8.

NOTE that the drain control land of the speed setting pilot valve plunger normally overlaps the drain port in the bushing, also that its diameter is a little less than the other lands (See Fig. 18). When a speed reduction of one throttle step is made, the small upward movement of the speed setting pilot valve plunger is not enough to open the drain port, and oil coming from the speed

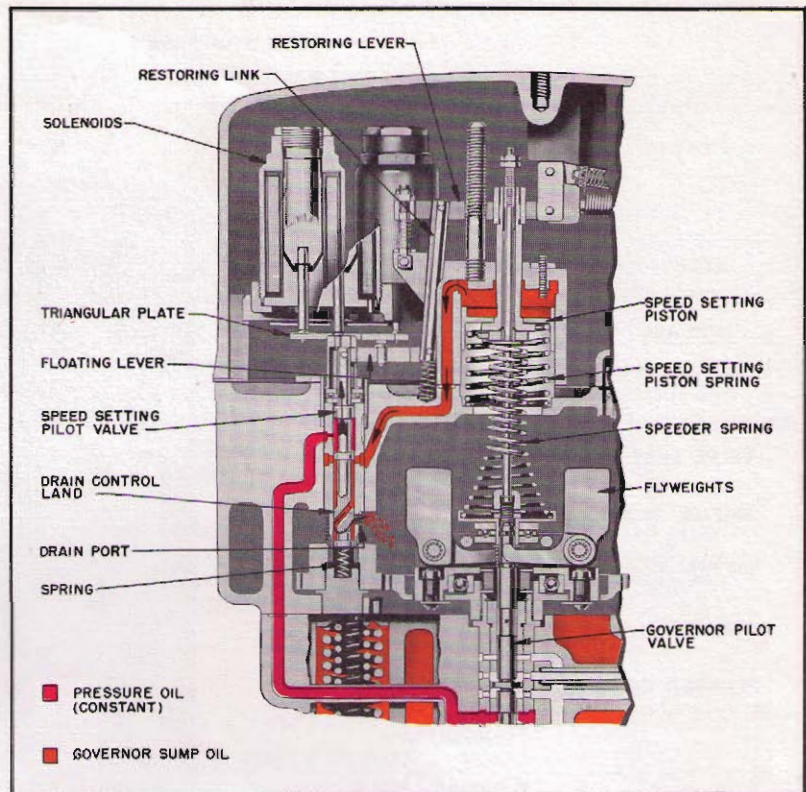


Figure 17

setting cylinder must leak through the clearance existing around the drain control land in order to pass through the drain port. Consequently the rate at which governor speed setting can be reduced one step is quite slow. For a two (or more) step reduction the pilot valve plunger will move up enough to open the drain port (below the drain control land) and oil from the speed setting cylinder can pass freely through the diagonal hole and out through the drain port to the governor sump, permitting a faster decrease of governor speed setting.

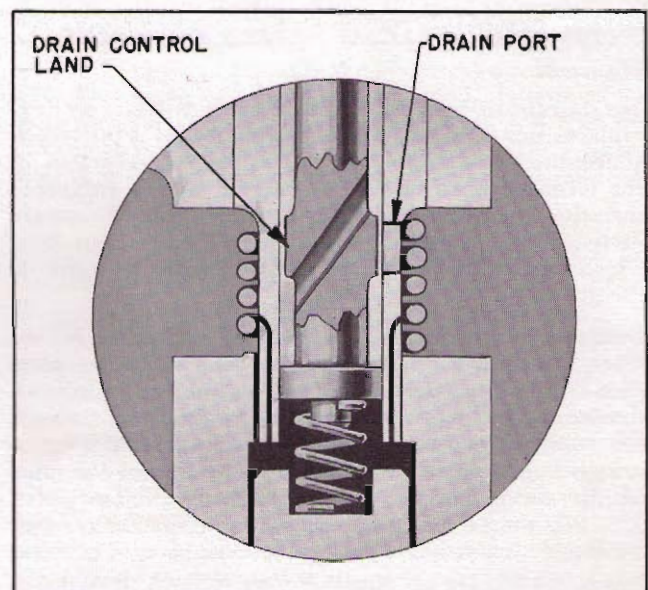


Figure 18

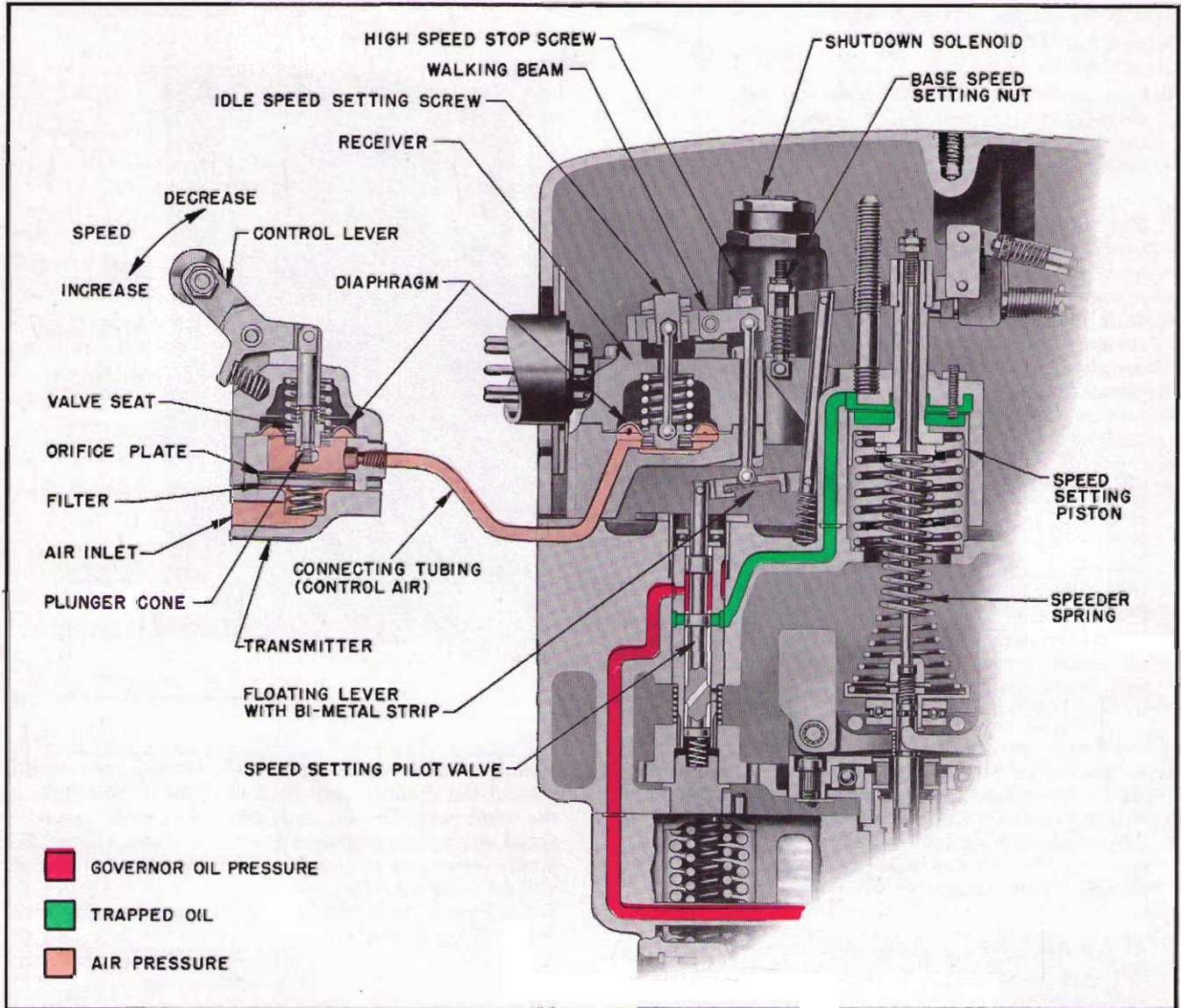


Figure 19

**PNEUMATIC-HYDRAULIC SPEED CHANGING:
Figure No. 19.**

For pneumatic-hydraulic control, a pneumatic receiver replaces the solenoids in the governor and a pneumatic transmitter is mounted in the control mechanism of the locomotive, so that it is operated by the engineer's throttle. The transmitter described here is the Woodward designed unit. However, any other type of transmitter, which would provide the required variable air signal to the governor, could be used.

Locomotive control air passes through a sintered bronze filter, and into the transmitter through an orifice plate (see Figure 19). Control air pressure builds up beneath the transmitter and receiver diaphragms and through the connecting tubing until the loading on the transmitter diaphragm is just sufficient to overcome the force of the spring for the existing control lever position. This lifts the valve seat a minute distance off the plunger cone and establishes a leak to atmosphere. This very small rate of leakage equals the amount of air entering through the supply orifice, thereby holding the pressure constant.

Advancing the control lever, to increase speed, the plunger cone is lifted, stopping the leak. The pressure increases until it is great enough to lift the diaphragm valve seat to re-establish the leak.

Retarding the control lever, to decrease speed, moves the plunger cone downward and rapidly releases the control pressure to atmosphere until the pressure is reduced, allowing the valve seat to overtake the cone and establish the leak at the proper control pressure value.

The receiver responds directly to the air pressure set up by the transmitter, so that with changes in control air pressure from the transmitter, the receiver diaphragm will move to a new position. By means of the walking beam and push rods, any movement of the receiver diaphragm is relayed to the bi-metal strip which in this governor is secured to the floating lever. Movement of the floating lever operates the speed setting pilot valve, thus causing changes in governor speed setting as is accomplished by action of the solenoids in the electro-hydraulic governor.

NORMAL SHUTDOWN: Under normal operating conditions the engine is shut down by moving the throttle in the engine cab to the STOP position.

In the Electro-Hydraulic governor this movement of the throttle energizes the "D" solenoid alone, which pushes down the speed setting pilot valve bushing and opens the regulating port to permit passage of oil from the speed setting cylinder to the governor sump.

With only the "D" solenoid energized, the restoring linkage cannot recenter the speed setting pilot valve to close the regulating port before the speed setting piston has moved up to the stop screw. At this point the shutdown nuts and shutdown rod will have been raised 1/64th of an inch (see section on the adjustment of the stop screw and shutdown nuts on Page 5). Raising the shutdown rod raises the governor pilot valve plunger, opening the governor regulating port to permit flow of regulating oil from the buffer system to the governor

sump, which will allow the power spring to force the power piston down to the NO FUEL position, with resultant shut down of the engine.

In the Pneumatic-Hydraulic governor, moving the throttle to the STOP position operates the SHUTDOWN solenoid, which opens a valve in the oil passage between the speed setting pilot valve bushing and the speed setting cylinder, allowing the oil above the speed setting piston to drain out to the governor sump.

The speed setting piston will be moved up until it reaches the stop screw, picking up the shutdown rod and the governor pilot valve plunger. The power piston will move to the NO FUEL position and the engine will shut down as described above.

The speed setting piston STOP SCREW is a piston travel limiter (when the engine is shut down) to effect a reduction in cranking time when starting the engine.

SECTION V — LOAD CONTROL, OVERRIDING AND FAST UNLOADING

GENERAL: With most governor applications, the primary purpose of the governor is to control fuel flow to the engine in sufficient amounts to maintain a certain set speed under varying load conditions. In the application of the locomotive governor, however, while the primary objective is still to maintain a desired engine speed, a secondary function is incorporated to maintain a constant horsepower output of the engine for each specific speed setting. Thus, for each setting of the throttle, not only is there a constant engine speed desired, but also a fixed, pre-determined setting of fuel to the engine. To accurately establish these conditions, it is necessary to control the load ON the engine at a constant value for each position of the throttle, and it is the function of the load control mechanism in the governor to do this.

NOTE: While considering the operation of the governor in controlling the load on the engine, it must be understood that maintaining a constant engine speed does NOT mean that road speed of the locomotive and train will be held constant. For example, a locomotive developing 2400 horsepower could pull a 2000 ton load on level track at about 50 miles per hour, while the same horsepower pulling the same load on a 1% up grade would result in only a small fraction of that speed.

Control of load on the engine is obtained by adjusting the strength of the generator field excitation current whenever the electrical load on the generator varies, and so controlling the horsepower required of the engine by the generator at a constant value for each specific speed setting. The excitation current of the generator is adjusted through the use of a variable resistance in the field excitation circuit, actuated by a servomotor under control of the governor load control pilot valve. As

explained later, the load control linkage in the governor is so arranged that for each speed setting there is only one fuel setting (or horsepower output) at which the load control pilot valve will be centered. A change in speed setting of the governor, or a change in engine speed caused by a change in horsepower requirements (load on the generator) will uncenter the load control pilot valve and adjust excitation.

In some installations the variable resistor is a separate piece of equipment located away from the governor and connected to the governor by tubing, and the actuating servomotor can be either a rotary or piston type operated by pressure oil from either the engine lubricating system or the governor. (Governor oil should be used only with Woodward approval). In other installations the variable resistor and its servomotor are integral with the governor, as shown in Figure 3, Page 3, using a rotary vane type servomotor operated by governor pressure oil.

In governors having the integral resistor unit, a commutator type selector switch and a pair of contact brushes are used to change the value of the resistance in the excitation field circuit. Rotation of the contact brushes around the commutator is controlled by the Load Control Pilot Valve, shown in Fig. 20. Correct positioning of the vane servomotor and contact brushes to meet the varying load conditions results from the correct assembly and adjustment of the load control pilot valve and its operating linkage, according to definite specifications set up for the particular engine-governor combination. Remote servomotor-resistor units—usually provided by the locomotive manufacturer—differ in size and construction from the integral unit described above, but the method of control and operation is identical.

The load control pilot valve is suspended from an approximately central (adjustable) position in the linkage connecting the top of the power piston tail rod to the top of the speed setting piston rod. Any movement of the speed setting piston or power piston — or both — will cause a corresponding movement of the load control pilot valve. The pilot valve is contained in a load control bushing which does not rotate. As shown in Figures 20 and 22, pressure oil is supplied to the load control pilot valve, through ports in the bushing, from either the engine lubricating oil system or the governor pressure oil supply. Two lands on the pilot valve control the flow of pressure oil to the vane servomotor and the flow of return oil from the vane servomotor either to the governor sump or to the engine oil sump.

OPERATION OF LOAD CONTROL

WITH LOAD INCREASE:

1. Fig. 20 shows the load control system stationary, with the pilot valve in its "centered" position — control ports closed. The train is in motion and the load on the generator is equal to the horsepower output of the engine at the existing speed of the engine. The engineer does not change the speed setting, but for some reason the electrical load on the generator increases.
2. This added load is transmitted to the engine, the engine slows down, and the governor operates to increase fuel to the engine with an upward movement of the power piston. This is the basic governor action described on pages 7-9, and will be indicated by a movement of the fuel pointer (if used) on the governor cover, or at the "rack scale" on a governor with a rotary terminal shaft (Fig. 4), or at the piston gap indicator (Fig. 21).
3. In Fig. 21 the power piston has moved to an increased fuel position needed to bring the engine back to the desired speed as set by the governor, but the engine is now carrying more load than desired for the existing speed setting. However, the upward movement of the power piston has raised the right end of the load control linkage and this has raised the load control pilot valve above center.
4. Pressure oil flows through the load control bushing and out the upper control port to the vane servomotor of the generator field rheostat, in the direction to reduce excitation of the field coils, and thus reduce the total load on the engine.
5. With this reduction of load, the engine speed will increase and the governor will now operate to reduce fuel to the engine, with a downward movement of the power piston.

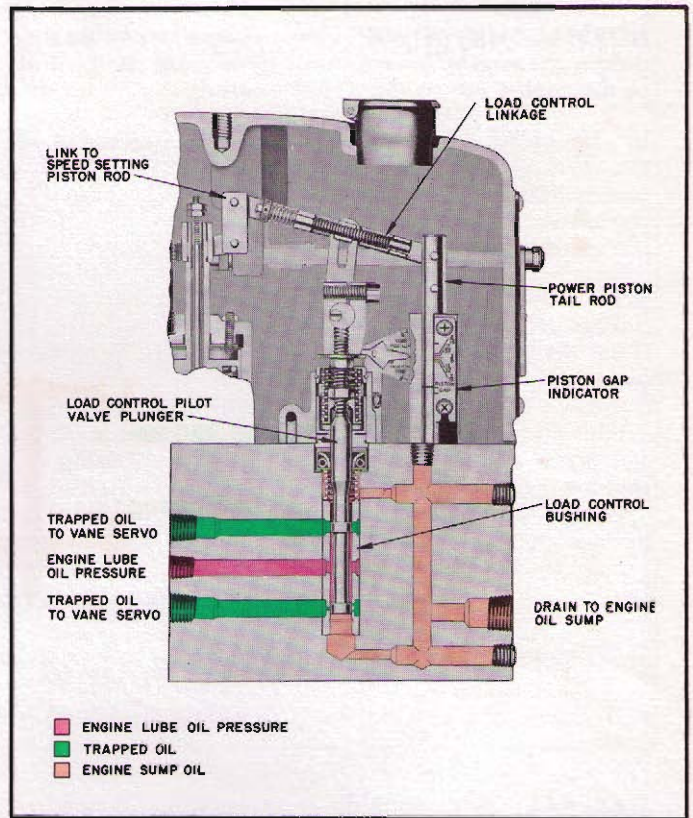


Figure 20

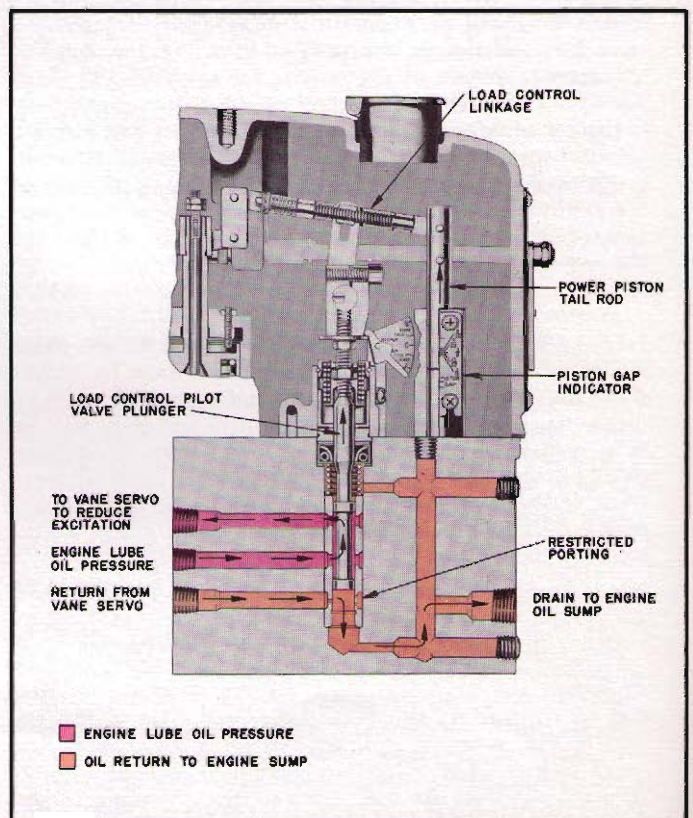


Figure 21

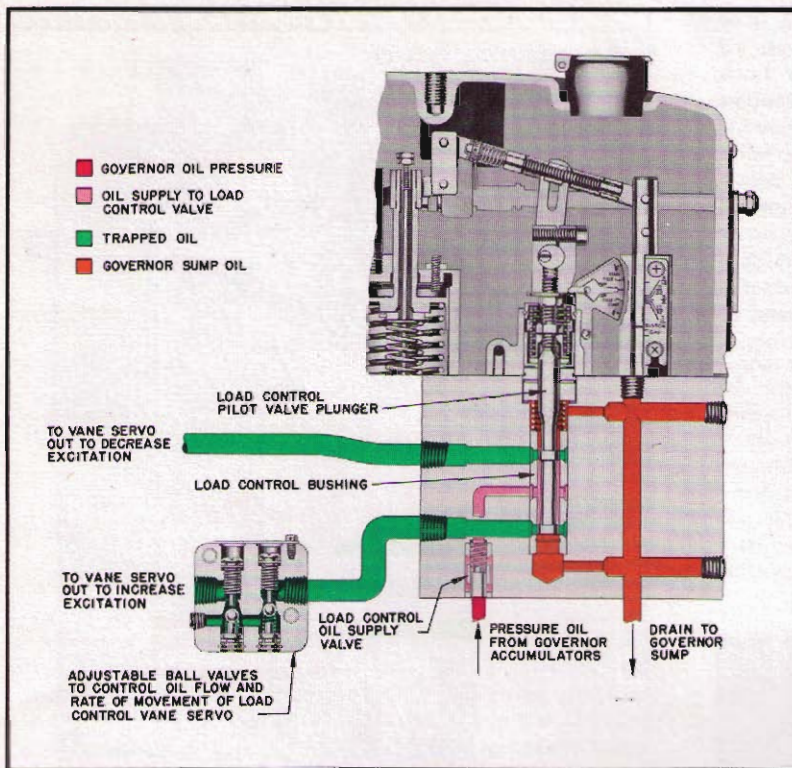


Figure 22

6. Reduction of the field excitation current and of the fuel to the engine will continue simultaneously until the speed of the engine has returned to the set point, and the power piston has returned to its original position, lowering the right hand end of the load control linkage. The load control pilot valve will again be centered, covering the control ports and stopping the movement of the vane servomotor.

In responding to the offspeed of the engine and attempting to correct the fuel setting, the governor has operated the load control pilot valve in the direction to reduce the generator field excitation to suit the increased generator load condition, and the horsepower demand on the engine has returned to the designed point for the existing speed setting of the governor.

WITH LOAD DECREASE:

If the electrical load on the generator decreases — without any change made in the speed setting of the governor — the action of the load control mechanism will be the reverse of that described in the preceding paragraphs.

1. The decrease in electrical load at the generator will reduce the load on the engine and engine speed will increase. The governor will operate to reduce fuel to the engine.
2. The downward movement of the power piston will lower the right end of the load control linkage, and the pilot valve will move down below center. Pressure oil will flow through the lower port to the vane servomotor to effect an increase in the field excitation current, and thus increase the total load on the engine.
3. With this added load the engine speed will be lowered, and the governor will respond to increase the fuel by raising the power piston.
4. Raising the field excitation current and increasing the fuel to the engine will continue simultaneously until

the power piston has returned to its original position, raising the right end of the load control linkage and the pilot valve to the point where the ports in the bushing are again closed to stop movement of the vane servomotor.

5. At the end of this sequence the engine speed and fuel supply will have returned to their original setting, and the engine loading will be correct for the existing speed setting of the governor.

WITH INCREASED SPEED SETTING:

1. The engineer moves the throttle to a higher notch, raising the speed setting of the governor and the speed setting piston moves down.
2. This will lower the left end of the load control linkage and move the load control pilot valve below center. Pressure oil will flow out of the lower port to the vane servomotor to move the rheostat in the direction to increase excitation. Return oil from the vane servomotor will flow back through the upper control port to the engine oil sump (or the governor sump).

3. With a higher speed setting, the governor operates to increase the fuel supply and the power piston will move up. This will raise the right end of the load control linkage to return the load control pilot valve to center and stop the movement of the vane servomotor.

4. At the end of this sequence the fuel supply, engine speed, and field excitation has been increased, with a resultant increase of engine horsepower output and generator output, to provide the correct loading for the new speed setting.

WITH DECREASED SPEED SETTING:

1. Moving the throttle to a lower notch decreases the speed setting of the governor, and the speed setting piston moves up.
2. The left end of the load control linkage is raised and the load control pilot valve is moved above center. Pressure oil flows out the upper port to the vane servomotor to move the rheostat in the direction to reduce excitation. Return oil from the servomotor flows back through the lower control port to the oil sump.
3. With a lower speed setting, the governor operates to decrease the fuel supply and the power piston moves down. This lowers the right end of the load control linkage to return the load control pilot valve to its centered position and stop the movement of the vane servomotor.
4. At the end of this sequence the fuel supply, engine speed, and field excitation has been decreased, with a resultant decrease of engine horsepower output and generator output, again providing the correct loading for the new speed setting.

This balanced action between the governor and the load control rheostat is obtained by controlling the rate of movement of the vane servomotor, in either or both directions, in the various applications of the locomotive governor. In some installations the rate of movement is controlled by the number, size, and position of a group of orifice holes in the load control bushing which are opened and closed by movements of the load control pilot valve. This method restricts the flow of oil to or from the vane servomotor in such a way as to provide a progressively increasing (or decreasing) rate of movement, in both directions, depending on displacement of the load control pilot valve from its centered position.

In other installations a separate assembly, which may be attached to the governor, contains two spring loaded ball valves which can be set for minimum opening position by adjusting screws (See Fig. 22). Connected into one of the lines from the governor to a remote vane servomotor these valves can be adjusted to provide the desired maximum rate of movement — not necessarily the same — in either the increase or decrease excitation direction.

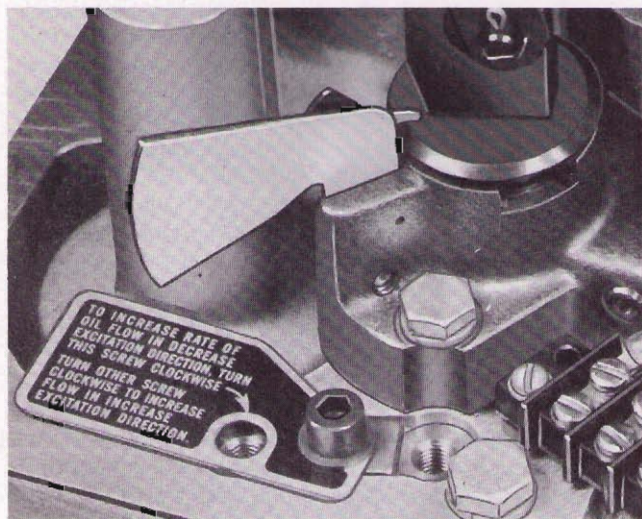


Figure 23

Still another arrangement provides two adjustable spring loaded ball valves built into the governor column (see Fig. 23) which function in the same manner as the external fitting described in the previous paragraph. This arrangement would be used only with the integral load control system.

When governor oil is used to operate the load control servomotor, a spring loaded valve is used in the oil supply line to the load control bushing (See Figure 22). When cranking the engine, and governor oil pressure is building up, this oil supply valve remains closed, so that all oil delivered by the governor pump is available to lift the power piston and set the fuel racks in the starting position. After the engine starts the governor oil pressure will increase, the oil supply valve will open, and the load control mechanism will function as required. There is always a definite pressure drop across this valve, and in some cases it is used (with specific spring loading) to reduce the pressure of the oil supplied to the load control system and thus further slow down the rate of movement of the resistor servomotor if used in combination with the adjustable ball valves or the restricted port load control bushing.

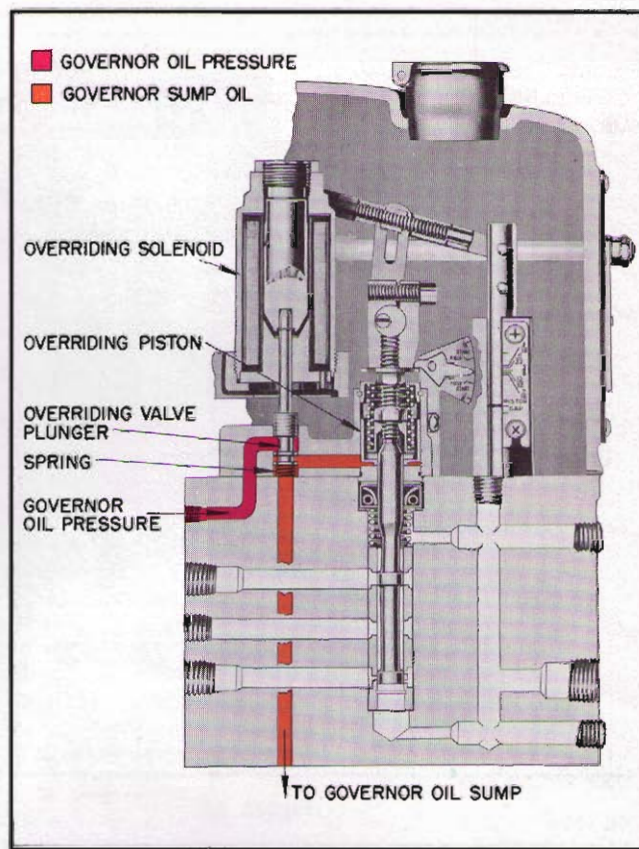


Figure 24

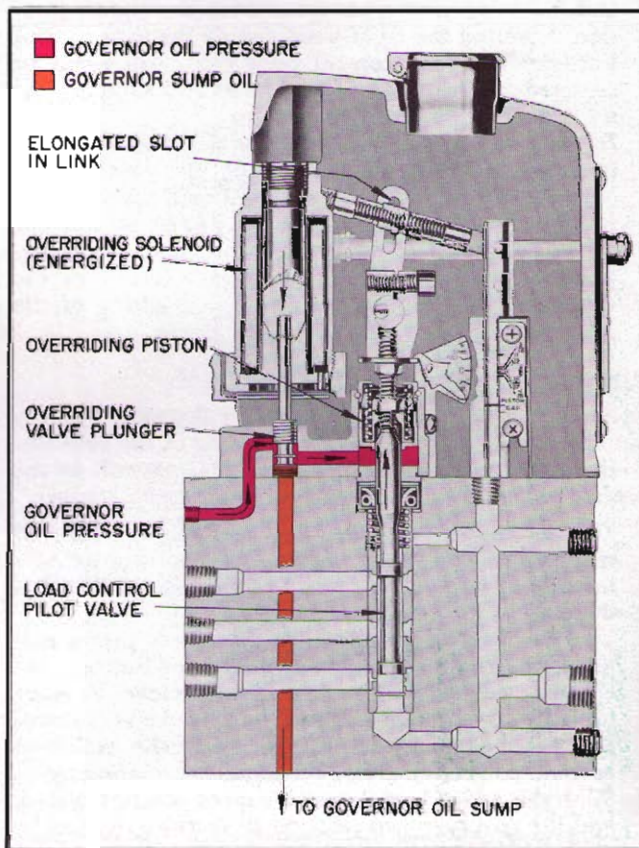


Figure 25

OVERRIDING ASSEMBLY:

Certain conditions in the operation of a locomotive occasionally make it advisable or necessary to override the normal action of the load control device, usually to effect a reduction of field excitation current at a time when load control would normally respond to operating conditions with a resultant increase in field excitation current. Examples of such occasions are:

- a. When "transition" occurs, that is whenever the electrical circuits between the generator and the traction motors are automatically changed, as train speed increases or decreases, to provide correct transmission of electrical power.
- b. To hold the vane servomotor and field rheostat in minimum field position while the engine is running at idle, in some applications, where the load control system is adjusted for "maximum field start".
- c. When rail and load conditions cause wheel slip, if the locomotive has wheel slip relays.

The overriding device (see Figs. 24 and 25) consists of a piston within a cylinder around the upper end of the load control pilot valve, and a solenoid operated oil control valve which allows flow of governor pressure oil to the cylinder and under the piston when the solenoid is energized, or from the cylinder to the governor sump when the solenoid is de-energized.

Fig. 24 shows the load control pilot valve centered, with the engine and generator running at steady speed with a steady load. The overriding solenoid is de-energized, the overriding valve plunger is held up by its spring, and the overriding cylinder is connected to the governor sump with the overriding piston resting on the bottom of the cylinder.

When the solenoid is energized (Fig. 25) the valve plunger is pushed down, closing the drain to sump and allowing flow of governor pressure oil to the overriding cylinder. The piston moves up until it contacts the spring seat secured to the pilot valve stem when its continued movement will raise the load control pilot valve above center, permitting flow of pressure oil to the vane servomotor in the direction to reduce excitation, thus reducing the load on the engine and the power output of the generator. Lifting of the load control pilot valve by the overriding piston, independently of the load control linkage, is made possible by the use of the elongated slot in the link connecting the pilot valve to the linkage.

Governors having the integral vane servo-load regulator system can also be arranged for FAST UNLOADING whenever the overriding solenoid is energized to raise the load control pilot valve. In this position an additional control land at the lower end of the load control pilot valve uncovers a drain port which allows oil coming from the load regulator vane servo to bypass the restricted porting in the pilot valve bushing (or the adjustable ball valves, if used) which normally controls the rate of movement of the load regulator. This results in a fast movement of the load regulator toward minimum field position.

When the overriding solenoid is de-energized, the valve plunger and the pilot valve will return to normal operating position as shown in Fig. 24, and the load control system will again be operative.

Use of the overriding device under conditions (a), (b) and (c) previously mentioned:

- a. In transition the overriding cycle is used primarily to protect the switchgear against damage from arcing which would occur if high current flow existed in the electrical circuits to the traction motors. Therefore, if and when transition is used, the overriding solenoid will be automatically energized and excitation current reduced until transition is completed, when the solenoid will be de-energized and normal load control conditions will be in effect.
- b. Known as "Modified Maximum Field Start", the load control pilot valve is adjusted to below center with the speed setting piston at idle speed position and the power piston at idle fuel position. This would normally position the vane servomotor to provide maximum field excitation. However, in operation, the overriding solenoid is automatically energized when the throttle control is at IDLE, to raise the pilot valve above center and position the vane servomotor at minimum field. As the throttle is moved to 1st. notch the solenoid is de-energized, allowing the load control device to function to increase excitation toward maximum as the train starts.
- c. Slipping of the locomotive drive wheels would result in an immediate decrease of load at the traction motors and generator, and the resulting increase of engine speed would cause the load control mechanism to increase field excitation to compensate for the loss of traction load. This would build up generator power output for which there is no demand. However, by the use of wheel slip relays the overriding solenoid can be energized to cause the vane servomotor to move to minimum field excitation and reduce the current flow. When wheel slip ceases the overriding solenoid will be de-energized and the load control mechanism will again function to set up a balanced load condition between the engine and generator for the existing speed setting.

MINIMUM OR MAXIMUM FIELD START:

The load control system in the governor may be set up for either "Minimum Field Start" or "Maximum Field Start".

If arranged for Minimum Field Start, the load control pilot valve is adjusted to be above center with the speed setting and fuel racks at IDLE. The vane servomotor will then move to minimum excitation position and remain there until the speed setting has been increased enough to lower the pilot valve to below center to increase excitation. This results in minimum loading for the first two speed steps.

For Maximum Field Start the load control pilot valve is set to be below center with the speed setting and fuel racks at IDLE. The vane servomotor will then be at maximum field position as the throttle is moved to 1st. notch and the load will build up until the governor power piston moves the load control pilot valve to or above center, to adjust the field excitation current to provide the desired loading for the existing speed setting.

SECTION VI — AUTOMATIC SAFETY SHUTDOWN

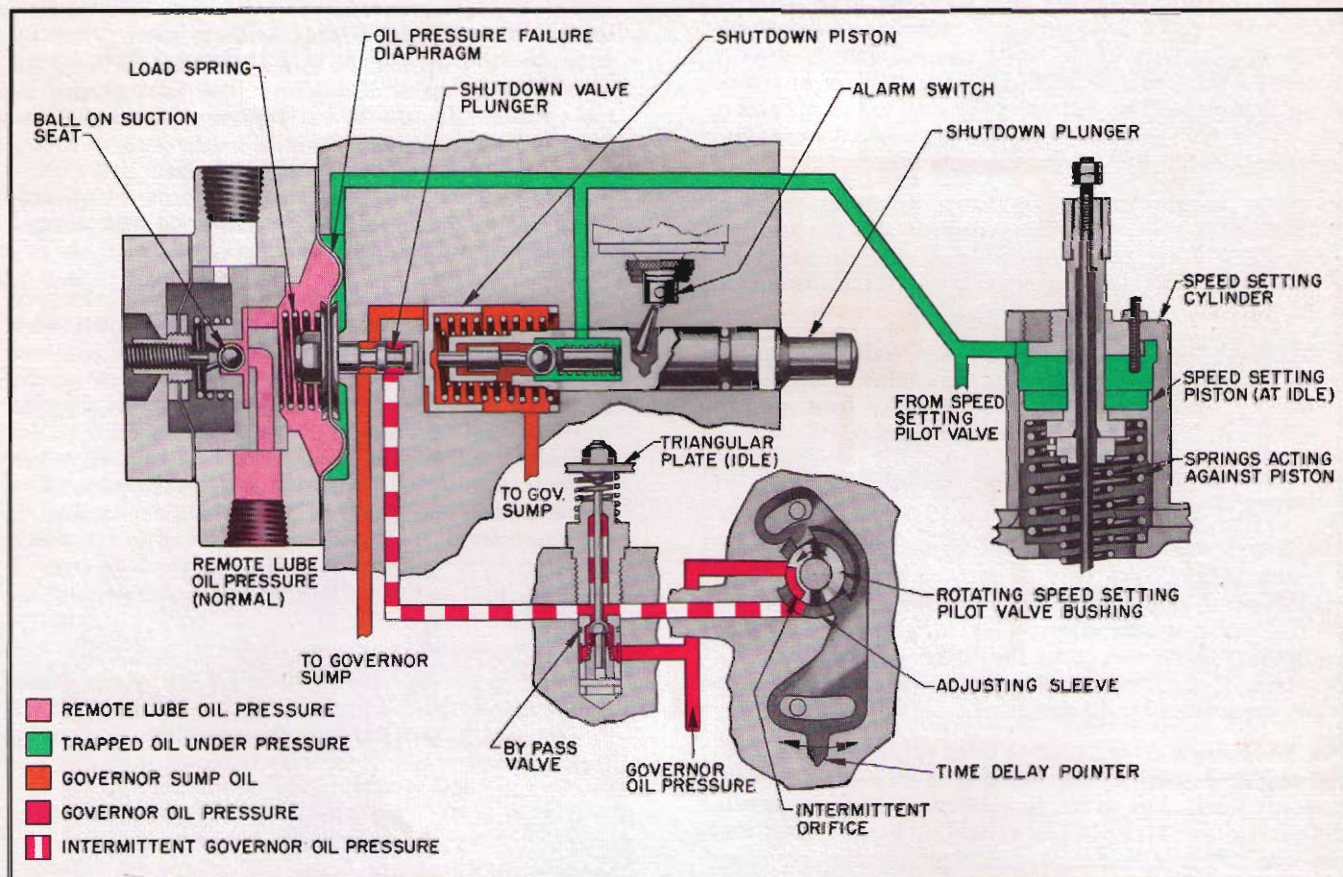


Figure 26

To protect the engine in the event of failure of the lubricating oil system an automatic shutdown device is incorporated in the standard locomotive governor. This device also prevents prolonged operation of the engine without sufficient lubricating oil pressure, or racing of the engine before sufficient oil pressure is established. It is arranged to provide a fast shutdown at speeds above 1st notch, with an adjustable delay feature at Idle or 1st notch speed (see Starting Engine at Idle Speed on page 25). This device can also be used as a manual shutdown at the governor. It effects engine shutdown by allowing the oil in the speed setting cylinder to drain to the governor sump, causing the speed setting piston to move up and pick up the shutdown nuts (see Normal Shutdown on page 19).

OPERATION: A connection is made from a remote point of the engine lubricating system to a diaphragm in the shutdown device in the governor as shown in Fig. 26. This diaphragm is acted upon by three forces: engine lubricating oil pressure and the load spring force on the left, and oil pressure from the speed setting cylinder on the right. When normal conditions exist, the lubricating oil pressure and the spring will hold the shutdown valve plunger to the right, connecting the area to the left of the shutdown piston to the governor sump. When engine oil pressure drops below a safe point the speed setting oil pressure (which is dependent on the existing speed setting) will move the diaphragm and valve plunger to

the left, connecting the shutdown piston to pressure oil from the governor pump.

Governor pump oil pressure is supplied to the shutdown valve in two ways. When the triangular plate is in the Idle or 1st notch speed position the oil will be supplied through an intermittent flow orifice in the top part of the rotating speed setting pilot valve bushing. With each revolution of the bushing a slot in the bushing registers with an oil supply passage in the governor column and a hole in the adjusting sleeve, to pass a small volume of oil. By means of the time delay pointer, the sleeve may be turned so that the duration of the register may be adjusted to increase or decrease the volume of oil supplied. Turn the pointer clockwise to reduce tripping time. When the triangular plate is down at 2nd notch (or higher speed) position, the bypass valve is moved down off its seat, allowing governor pressure oil to pass directly to the shutdown valve plunger.

In governors with pneumatic speed control, the bypass valve is operated by an adjustable screw located next to the high speed stop screw at the inner end of the walking beam above the pneumatic receiver (see Fig. 7 on page 5). Thus, at Idle — or 1st notch — speed the engine will be shut down after the desired time delay, and at any higher speed it will be shut down quickly, in event of failure of engine lubricating oil system. A characteristic of this system is that shutdown will occur at idle speed with lower lubricating oil pressures than at higher engine speeds.

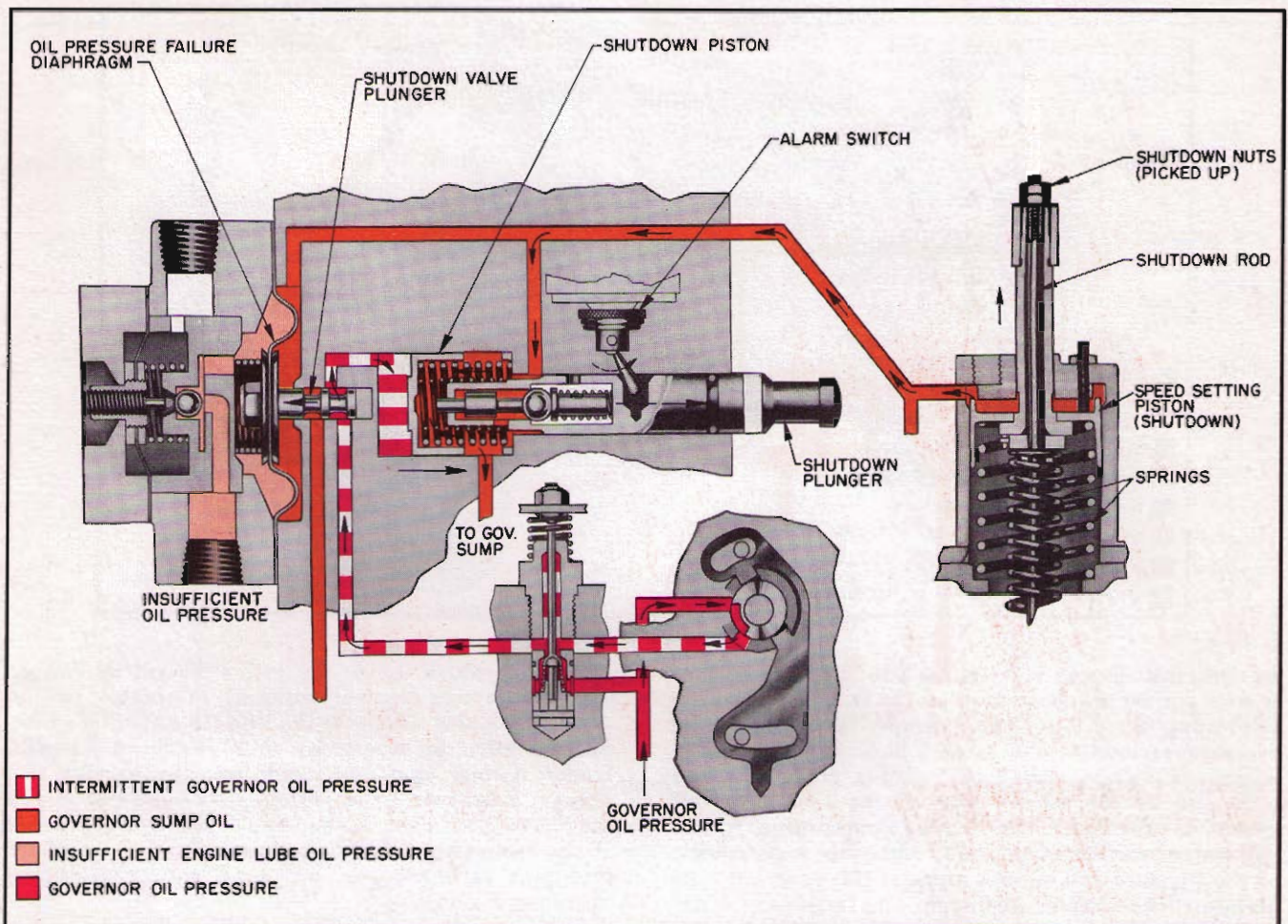


Figure 27

OIL PRESSURE FAILURE: Figure 27

1. Engine lubricating oil pressure has dropped below the safe minimum, and the pressure of the speed setting oil has moved the diaphragm and shutdown valve plunger to the left, allowing governor pressure oil (shown as intermittent supply with engine running at idle speed) to pass through to the left side of the shutdown piston.
2. The shutdown piston is then forced to the right — slowly — causing the inner spring, between the shutdown piston and a shoulder on the shutdown plunger, to move the shutdown plunger to the right. When the toggle switch is moved past center, it snaps the shutdown plunger out as shown, and also closes an alarm circuit.
The shutdown piston will move to the right fast if the governor is set at 2nd notch speed or higher. The bypass valve will be open and governor pressure oil will have direct passage to the shutdown valve plunger and piston.
3. Oil previously trapped above the speed setting piston now passes around the reduced diameter of the shutdown plunger and out to the governor sump. The speed setting piston is forced up by the springs, picking up the shutdown nuts, shutdown rod, and the governor pilot valve plunger, causing the governor to close off the fuel supply and shut down the engine.

RUNNING ENGINE TEMPORARILY TO TRACE CAUSE OF SHUTDOWN:

When the shutdown plunger has snapped out, it may be pushed back in and the engine restarted.
CAUTION: Start engine at IDLE speed setting. If the lubricating oil pressure is not established, the shutdown device will operate to shut engine down in about 40 seconds.

STARTING ENGINE AT "IDLE"

The throttle should always be set at IDLE when starting the engine. If set at a higher speed, the shutdown device will receive pressure oil direct from the governor pump before lubricating oil pressure is built up at the remote connection. Because the time delay feature is not effective at speed settings above IDLE, immediate shutdown of the engine would result. Under these conditions, the operator is prevented from "racing" the engine before lubricating oil pressure is established.

MANUAL SHUTDOWN

To effect engine shutdown manually at the governor, simply pull out the shutdown plunger — or push it in — to bypass the speed setting cylinder oil past the shutdown plunger to the governor sump, as shown in Figure 27 and Figure 30. Shutdown will occur in exactly the same way it would with lubricating oil pressure failure.

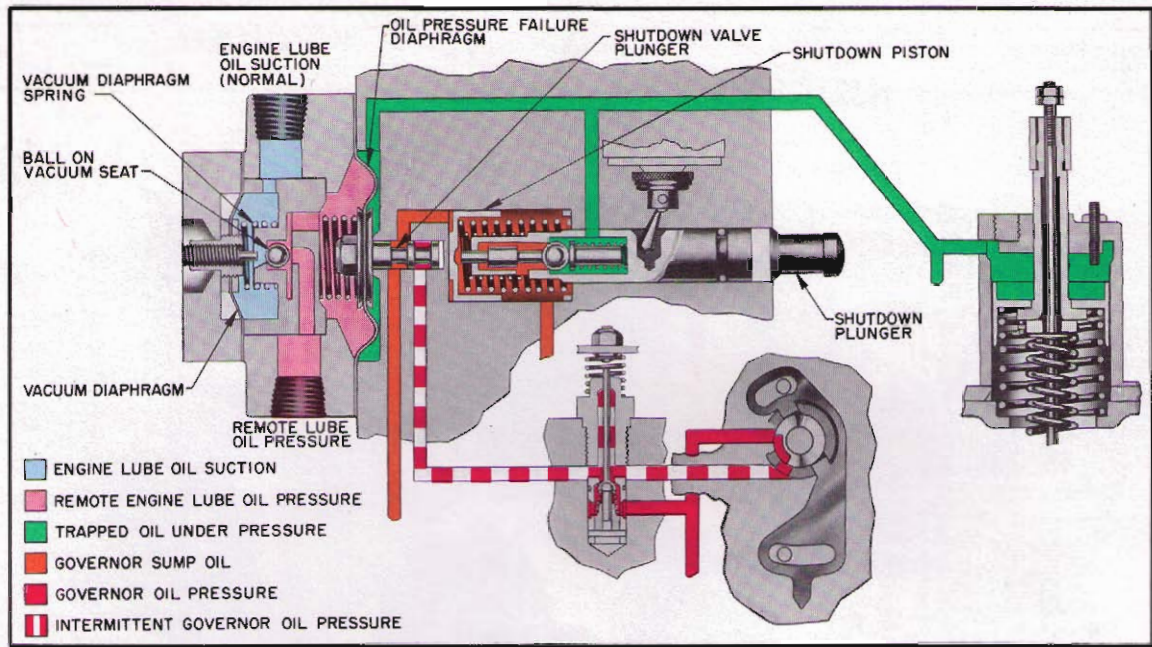


Figure 28

In some installations it is desirable to also provide protection against any restriction on the suction side of the lubricating oil pump, which would be evidenced by excessive vacuum in the suction line. In such cases a second diaphragm, called the vacuum diaphragm and connected to the suction side of the lubricating oil system, is provided in the shutdown mechanism, with a ball valve which automatically maintains a separation of the pressure and suction areas at the governor connections. The vacuum diaphragm also carries an adjust-

able screw which moves the ball valve off its seat on the vacuum side (normal position) to another seat on the pressure side whenever the vacuum diaphragm functions to effect an emergency shutdown of the engine. Under normal operating conditions the vacuum diaphragm is held out by its spring — see Figure 28 — and the ball valve is held on the vacuum side by the pressure of the lubricating oil. The pressure diaphragm and the shutdown valve plunger and piston will be in normal operating position.

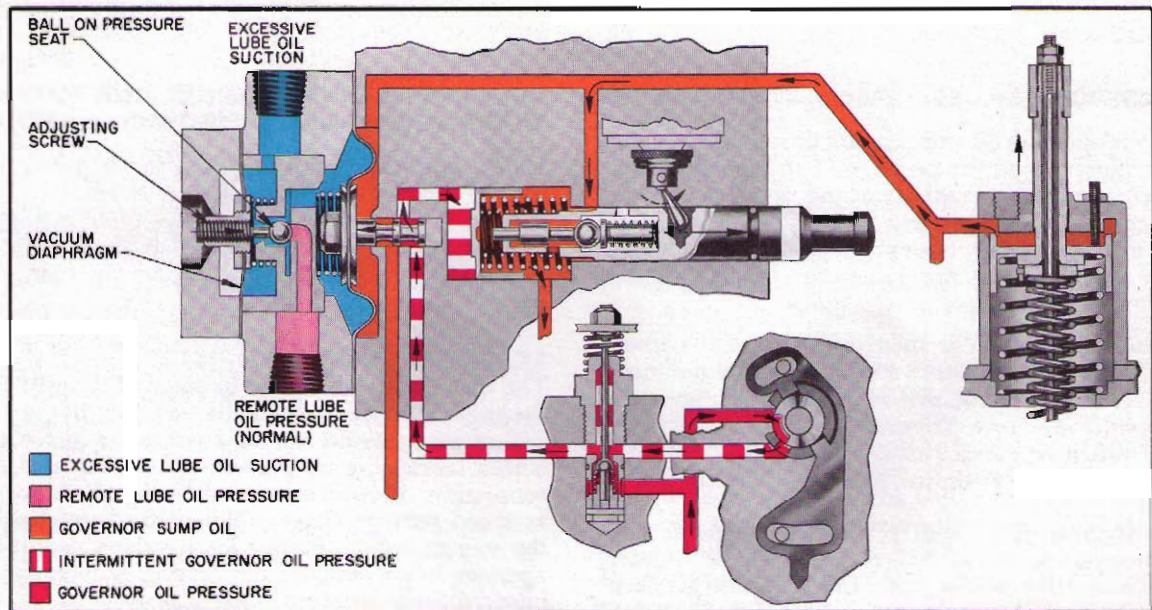


Figure 29

**EXCESSIVE LUBRICATING OIL SUCTION:
Figure 29**

1. The suction increases to an excessive value.
2. The vacuum diaphragm and adjusting screw are pulled to the right, which pushes the ball valve off its vacuum seat and onto the pressure seat.

3. This closes off the engine lubricating oil pressure and at the same time opens the oil diaphragm area and trapped engine lubricating oil to suction, reducing pressure on the oil pressure diaphragm.
4. The effect on the shutdown valve mechanism is identical to that explained under oil pressure failure and the engine is shut down.

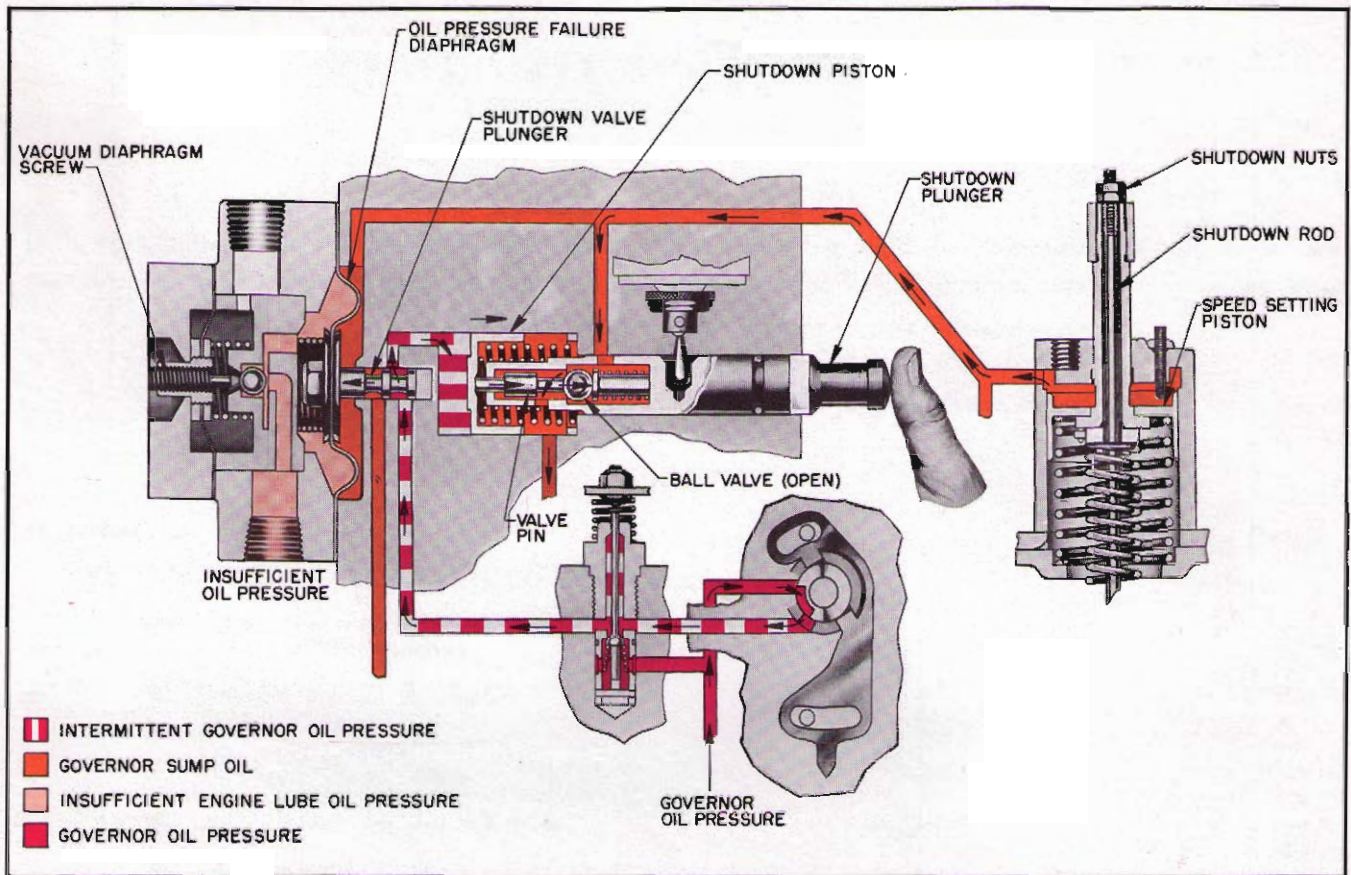


Figure 30

ANTI-BLOCKING VALVE:

“Blocking” the shutdown mechanism by pushing the plunger back in and holding it — as shown in Figure 30 — will not prevent it from acting to protect the engine. A spring loaded ball valve within the shutdown plunger is normally held on its seat and has no effect on the operation of the shutdown mechanism when failure occurs in the lubricating oil system. However, if an attempt is made to run the engine following an oil pressure failure shutdown by holding the plunger in, the action of the shutdown piston (as soon as governor oil pressure builds up after the engine starts) pushing on the valve pin, will effect an opening at the ball valve, and oil from the speed setting piston will drain through the shutdown plunger and out to the governor sump. The speed setting piston will be moved up by its return spring, to pick up the shutdown nuts and rod and shut the engine down as previously explained.

TO TEST OPERATION OF SHUTDOWN MECHANISM WITHOUT STOPPING ENGINE:

This instruction applies only to governors equipped with the vacuum diaphragm for excessive lubricating oil suction protection.

1. Have the engine running at IDLE speed.
2. Push in on the vacuum diaphragm screw (Figure 30) until the shutdown plunger starts moving out slowly, indicating that the device is functioning properly.
3. Release the screw, and the plunger should return to normal position. If the screw is held in too long, the plunger will snap out and the engine will shut down.

— **NOTES** —



PARTS LISTS AND ILLUSTRATIONS

INFORMATION AND PARTS REPLACEMENT: When requesting additional information concerning governor operation, or when ordering repair parts, it is very essential that the following information accompany the request.

1. Governor serial number (shown on nameplate).
2. Bulletin number (this bulletin is No. 36006).
3. Part reference number, name of part, or description of part.

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NOTE — On the following pages, parts for the main governor and auxiliary devices are listed in component groupings, and in the normal order of dis-assembly of the governor.

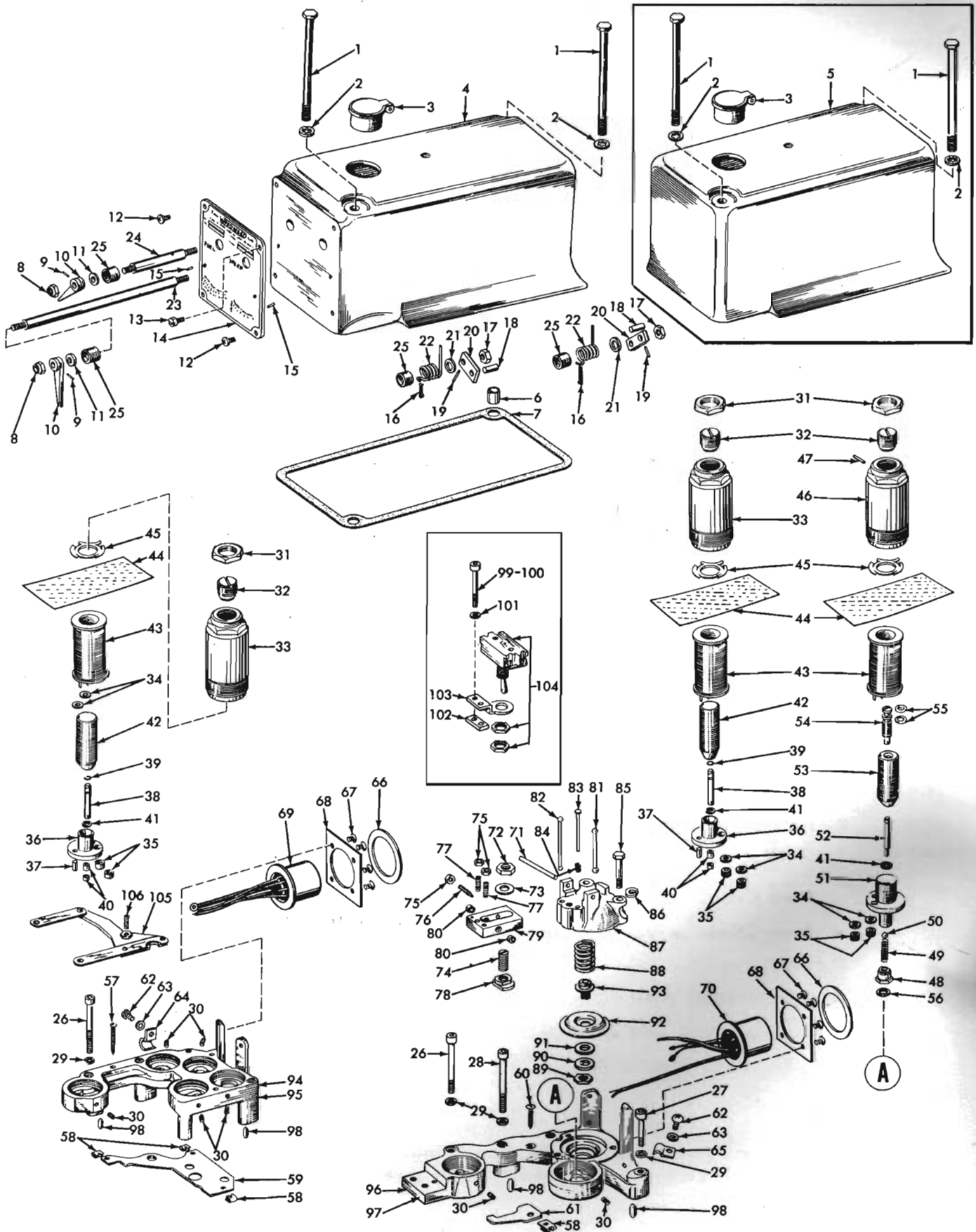


Figure 31 — Covers, Pointers, and Top of Column Parts, Electric and Pneumatic

REF. NO.	PART NAME	NO. REQ'D.
A. COVER ASSEMBLIES		
36006-1	Cover Bolt	2
36006-2	Shakeproof Washer, 5/16	2
36006-3	Oil Filler Cap	1
36006-4	Cover, with Pointers	1
36006-5	Cover, no Pointers	1
36006-6	Cover Dowelling Bushing	2
36006-7	Cover Gasket	1
36006-8	Elastic Snap Nut, 1/4-28	2
36006-9	Pointer Hub Pin, 3/32 x 7/16 Driv-Lok	2
36006-10	Pointer, Speed and Fuel Indicator	2
36006-11	Steel Washer, 17/64 x 1/2 x 1/32	2
36006-12	Phillips Screw, 8-32 x 1/4	3
36006-13	Drilled Fil. Head Screw, 8-32 x 1/4	1
36006-14	Dial, Indicator — Nameplate	1
36006-15	Pointer Stop Pin	2
36006-16	Corner Pin, 3/32 x 1	2
36006-17	Hex. Nut, 5/16-24	2
36006-18	Indicator Shaft Arm Pin	2
36006-19	Driv-Lok Pin, 3/32 x 5/8	2
36006-20	Indicator Shaft Arm	2
36006-21	Steel Washer, 21/64 x 9/16 x 1/16	2
36006-22	Indicator Shaft Spring	2
36006-23	Speed Indicator Shaft	1
36006-24	Fuel Indicator Shaft	1
36006-25	Indicator Shaft Bearing (Oilite)	4

B. SOLENOID BRACKET ASSEMBLIES

36006-26	Cap Screw, Soc. Hd., 1/4-28 x 2 3/8	3
	Electric	3
	Pneumatic	1
36006-27	Cap Screw, Soc. Hd., 1/4-28 x 1 1/4	1
	Pneumatic	1
36006-28	Cap Screw, Soc. Hd., 1/4-28 x 1 3/4	1
	Pneumatic	1
36006-29	Split Lock Washer, 17/64 x 27/64 x 1/16	3
36006-30	Set Screw, Soc. Hd., 10-32 x 1/4	5
	Electric	5
	Pneumatic	2
36006-31	Solenoid Lock Nut	5
	Electric	5
	Pneumatic	2
36006-32	Solenoid Plunger Stop Plug	5
	Electric	5
	Pneumatic	2
36006-33	Solenoid Case	1
	Electric	10
	Pneumatic	4
36006-34	Soldering Shield Washer	10
	Electric	10
	Pneumatic	4
36006-35	Varnished Tubing	4
	Electric	5
	Pneumatic	1
36006-36	Solenoid Plunger Guide	5
	Electric	5
	Pneumatic	2
36006-37	Solenoid Plunger Guide Locating Pin	5
	Electric	5
	Pneumatic	2
36006-38	Solenoid Plunger Rod	5
	Electric	5
	Pneumatic	1
36006-39	Solenoid Plunger Rod Snap Ring	5
	Electric	5
	Pneumatic	1
36006-40	Solenoid Plunger Guide Bushing	10
	Electric	10
	Pneumatic	4
36006-41	Solenoid Plunger Washer	5
	Electric	5
	Pneumatic	2
36006-42	Solenoid Plunger	5
	Electric	5
	Pneumatic	1
36006-43	Solenoid Coil	5
	Electric	5
	Pneumatic	2
36006-44	Solenoid Coil Insulating Paper	5
	Electric	5
	Pneumatic	2
36006-45	Solenoid Load Spring	5
	Electric	5
	Pneumatic	2
36006-46	Shutdown Solenoid Case	1
	Pneumatic	1
36006-47	Shutdown Solenoid Plunger Lock Pin	1
	Pneumatic	1

REF. NO.	PART NAME	NO. REQ'D.
36006-48	Spring Retainer Nut	1
36006-49	Shutdown Valve Spring	1
36006-50	Shutdown Valve, 1/4 Steel Ball	1
36006-51	Shutdown Valve Body	1
36006-52	Shutdown Sol. Plunger Rod	1
36006-53	Shutdown Solenoid Plunger	1
36006-54	Shutdown Solenoid Plunger Adjusting Screw	1
	Pneumatic	1
36006-55	"O" Ring, Adjusting Screw	2
36006-56	"O" Ring (SD Transfer Hole)	1
36006-57	Screw, Round Head, Parker Kalon No. 8 x 1 1/4	3
	Electric	3
	Pneumatic	1
36006-58	Speed Nut, No. 8	3
	Electric	3
	Pneumatic	1
36006-59	Wiring Cover	1
	Electric	1
36006-60	Screw, Round Head, Parker Kalon No. 8 x 1	1
	Pneumatic	1
36006-61	Wiring Cover	1
	Pneumatic	1
36006-62	Screw, Rd. Hd., 8-32 x 3/8	2
36006-63	Washer, No. 8 Shakeproof	2
36006-64	Wire Clamp (2-wire)	2
	Electric	2
36006-65	Wire Clamp (1-wire)	2
	Pneumatic	2
36006-66	Gasket (Elect. Conn. Plate)	1
36006-67	Screw, Flat Hd., 10-32 x 3/8	4
36006-68	Electrical Connector Plate	1
36006-69	Electrical Connector Assembly—Electric	1
36006-70	Electrical Connector Assembly—Pneumatic	1

C. AIR RECEIVER and PNEUMATIC SPEED CONTROL PARTS

36006-71	Pivot Pin (Control Lever)	1
36006-72	Hex. Nut, 3/8-32 (Idle Speed Screw)	1
36006-73	Washer, 3/8 x 3/4 x 1/16	1
36006-74	Idle Speed Setting Screw	1
36006-75	Hex. Nut, 10-32	3
36006-76	Set Screw, Soc. 10-32 x 1/2 (Slide Block)	1
36006-77	Set Screw, Soc. 10-32 x 3/4 (Bypass and High Speed Stop)	2
36006-78	Slide Block (Control Lever)	1
36006-79	Speed Control Lever	1
36006-80	Needle Bearings (Control Lever)	2
36006-81	Diaphragm Link	1
36006-82	Floating Lever Link	1
36006-83	Headed Pin (Bypass)	1
36006-84	Spring (Bypass Pin)	1
36006-85	Cap Screw, Hex. Hd., 1/4-28 x 1 3/8	3
36006-86	Washer, 17/64 Split Lock	3
36006-87	Pneumatic Receiver Cap	1
36006-88	Receiver Diaphragm Spring	1
36006-89	Receiver Diaphragm Nut	1
36006-90	Keyed Retaining Washer	1
36006-91	Diaphragm Washer	1
36006-92	Receiver Diaphragm	1
36006-93	Diaphragm Spring Seat	1

SPEED SETTING BRACKETS

36006-94	Electro-Hydraulic, (No Micro Switches)	1
36006-95	Electro-Hydraulic with Mtg. Pad for Micro Switches	1
36006-96	Pneumatic-Hydraulic, (No Micro Switches)	1
36006-97	Pneumatic-Hydraulic, with Mtg. Pad for Micro Switches	1
36006-98	Bracket Dowels, 1/4 x 9/16 Driv-Lok	2
36006-99	Cap Screw, Soc. Hd. 10-32 x 2 1/4	2
36006-100	Cap Screw, Soc. Hd. 10-32 x 1 3/4	2
36006-101	Washer, No. 10 Split Lock	2
36006-102	Switch Bracket Clamp Plate	1
36006-103	Signal Switch Mounting Bracket	1
36006-104	Signal Switch (Lube Oil Failure)	1
36006-105	Triangular Plate Assembly	1
36006-106	Bypass Screw (in Triangular Plate)	1

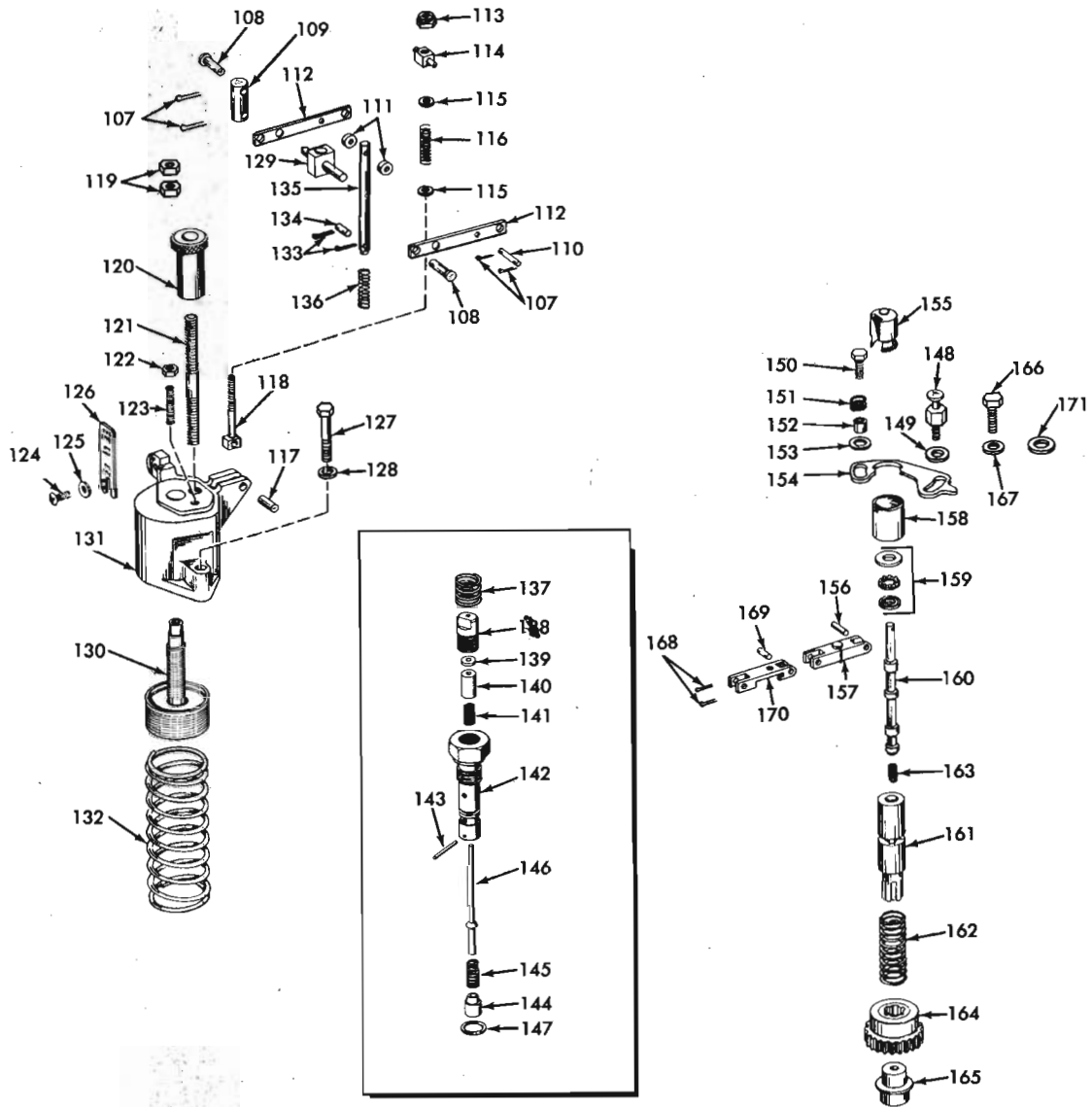


Figure 32 — Speed Setting Servo, Bypass Valve, Speed Setting Pilot Valve and Bushing

REF. NO.	PART NAME	NO. REQ'D.
D. SPEED SETTING SERVO ASSEMBLY		
36006-107	Cotter Pin, 1/16 x 3/8	4
36006-108	Headed Pin, 3/16 x 25/32	2
36006-109	Pivot Pin Link, 1/2 Diam.	1
36006-110	Straight Pin, 1/8 Diam.	1
36006-111	Link Spacer	2
36006-112	Restoring Lever	2
36006-113	Base Speed Setting Nut, 10-32 Flex Lok	1
36006-114	Adjustable Fulcrum Pin	1
36006-115	Fulcrum Spring Washer	2
36006-116	Adjustable Fulcrum Spring	1
36006-117	Fulcrum Screw Hinge Pin	1
36006-118	Adjustable Fulcrum Screw	1
36006-119	Shutdown Nuts, 8-32 Hex.	2
36006-120	Manual Speed Setting Tool	1
36006-121	Manual Speed Setting Stud	1
36006-122	Lock Nut, 10-32 Hex.	1
36006-123	Speed Setting Piston Stop Screw	1
36006-124	Screw, Phil. Rd. Hd., 10-32 x 3/8	1
36006-125	Washer, 13/64 x 7/16 x 1/32	1
36006-126	Speed Indicator Scale	1
36006-127	Cap Screw, Hex. Hd., 1/4-28 x 1 3/8	2
36006-128	Washer, 17/64 x 1/2 x 1/32	2
36006-129	Speed Setting Piston Fulcrum Assembly	1
36006-130	Speed Setting Piston Assembly	1
36006-131	Speed Setting Cylinder Assembly	1
36006-132	Speed Setting Piston Spring	1
36006-133	Cotter Pin, 1/16 x 3/8	2
36006-134	Restoring Link Pin, 1/8 x 47/64	1
36006-135	Restoring Link	1
36006-136	Restoring Link Spring	1
E. BYPASS VALVE ASSEMBLY		
36006-137	Solenoid Counter Balance Spring	1
36006-138	Seal Retaining Nut	1
36006-139	Seal Ring	1

REF. NO.	PART NAME	NO. REQ'D.
36006-140	Seal Spring Retainer	1
36006-141	Seal Spring	1
36006-142	Bypass Valve Body	1
36006-143	Valve Spring Seat Pin, 1/16 x 13/32	1
36006-144	Valve Spring Seat	1
36006-145	Valve Spring	1
36006-146	Bypass Valve Plunger	1
36006-147	"O" Ring, (Valve Body)	1
F. SPEED SETTING PILOT VALVE and BUSHING ASSEMBLY		
36006-148	Bushing Retainer Screw	Electric 1
36006-149	Washer, 17/64	Electric 1
36006-150	Cap Screw, Hex. Hd. 1/4-28 x 3/4	1
36006-151	Bushing Retainer Spring	1
36006-152	Retainer Spring Collar	1
36006-153	Retainer Spring Washer, 21/64	1
36006-154	Regulating Bushing Retainer	1
36006-155	"D" Solenoid Cup with Pin	Electric 1
36006-156	Pilot Valve Pin	Electric 1
36006-157	Floating Lever Assembly	Electric 1
36006-158	Regulating Bushing	1
36006-159	Thrust Bearing (Complete—3 pcs.)	1
36006-160	Pilot Valve Plunger	1
36006-161	Pilot Valve Bushing	1
36006-162	Pilot Valve Bushing Spring	1
36006-163	Pilot Valve Plunger Spring	1
36006-164	Pilot Valve Bushing Drive Gear	1
36006-165	Bearing Stud	1
36006-166	Cap Screw, Hex. Hd. 1/4-28 x 1/2	Pneumatic 1
36006-167	Washer, 17/64	Pneumatic 1
36006-168	Cotter Pin, 1/16 x 3/8	Pneumatic 2
36006-169	Pilot Valve Pin, 1/8 x 47/64	Pneumatic 1
36006-170	Floating Lever	Pneumatic 1
36006-171	Thrust Bearing Retaining Washer	Pneumatic 1

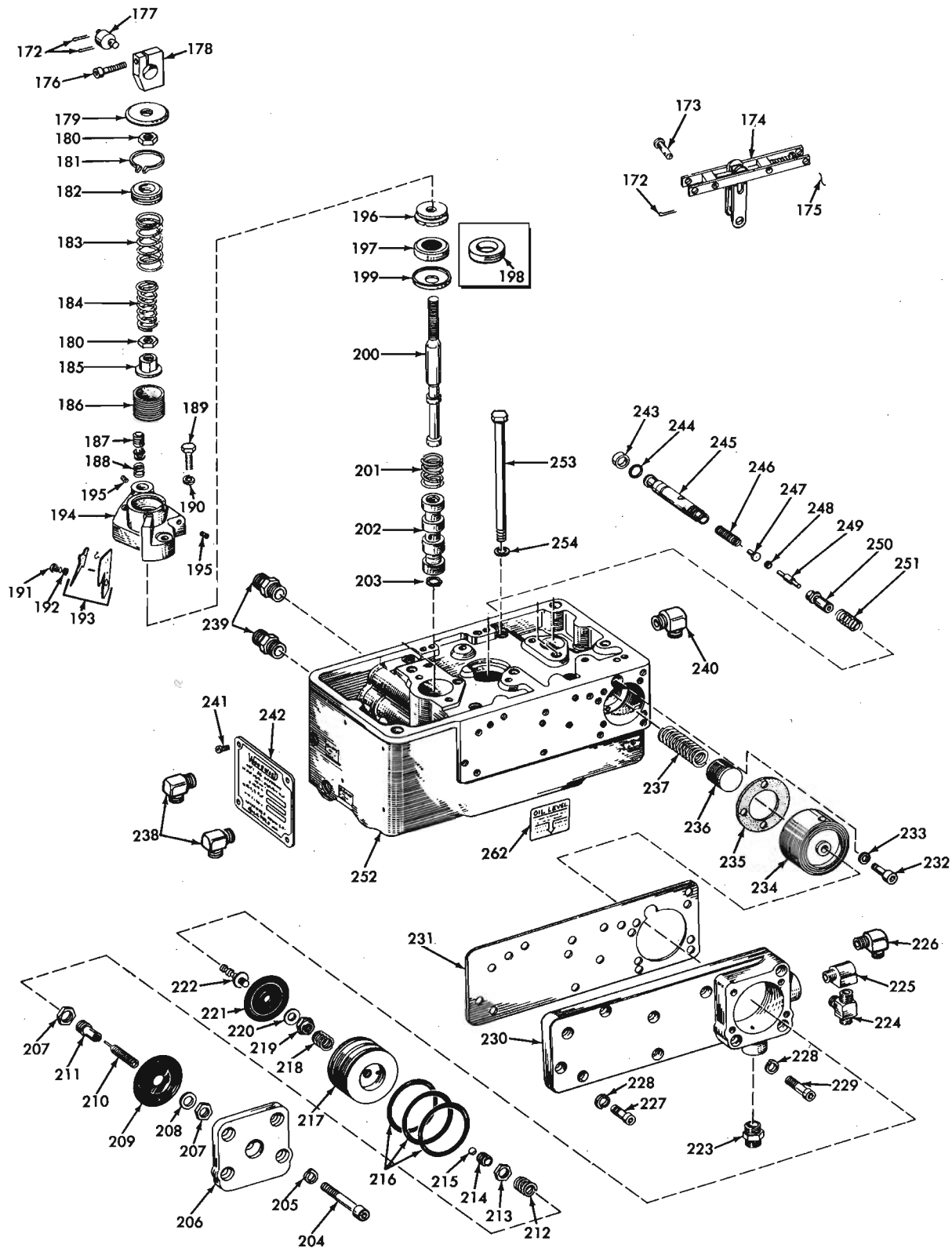


Figure 33 — Load Control Valve, Overriding Valve, Oil Failure Shutdown Valve, Column, Tubing Connections, Pipe Plugs, etc.

REF. NO.	PART NAME	NO. REQ'D.	REF. NO.	PART NAME	NO. REQ'D.
G. LOAD CONTROL, PILOT VALVE ASSEMBLY and OVERRIDING VALVE					
36006-172	Cotter Pin, 1/16 x 3/8	3	36006-223	Straight Half-Union, 1/4 NPT - 1/4 Tube (Lube Oil Suction)	AR
36006-173	Headed Pin, 3/16 x 25/32 (Tail Rod)	1	36006-224	90° Tee, 1/4 NPT - 1/4 Tube (Lube Oil Pressure, used with 225)	AR
36006-174	Adjustable Floating Lever Assembly	1	36006-225	Street Elbow, 1/4 NPT (Lube Oil Pressure)	AR
36006-175	Bronze Lock Wire .035 x 2	1	36006-226	90° Elbow, 1/4 NPT - 1/4 Tube (Lube Oil Pressure)	AR
36006-176	Soc. Hd. Cap Screw, 1/4-28 x 3/4	1	36006-227	Soc. Hd. Screw, 1/4-28 x 3/4	7
36006-177	Load Control Valve Eccentric	1	36006-228	Split Lock Washer, 17/64	10
36006-178	Adjusting Block	1	36006-229	Soc. Hd. Screw, 1/4-28 x 1 1/2	3
36006-179	Load Control Indicator Washer	1	36006-230	Side Plate (Square Diaphragm Cover)	1
36006-180	Lock Nut, 5/16-24	2	36006-231	Side Plate Gasket	1
36006-181	Spring Retainer Snap Ring	1	NOTE: For Side Plate and related parts used on Governors with Integral Load Regulator — See Section X.		
36006-182	Load Control Spring Retainer	1	36006-232	Soc. Hd. Cap Screw, 1/4-28 x 3/8	1
36006-183	Outer Load Control Valve Spring	1	36006-233	Washer, 1/4	1
36006-184	Inner Load Control Valve Spring	1	36006-234	Oil Failure Valve Bushing Assembly	1
36006-185	Load Control Valve Spring Collar	1	36006-235	Oil Failure Valve Bushing Gasket	1
36006-186	Overriding Piston	1	36006-236	Oil Pressure Failure Piston	1
36006-187	Overriding Valve Plunger	1	36006-237	Oil Failure Piston Spring	1
36006-188	Overriding Valve Plunger Spring	1	36006-238	90° Elbow, 3/8 NPT - 1/2 Tube (Load Control — Load Regulator Oil)	AR
36006-189	Cap Screw, Hex. Hd., 1/4-28 x 1	2	36006-239	Straight Half Union, 3/8 NPT - 1/2 Tube (Load Control — Load Regulator Oil)	AR
36006-190	Split Lock Washer, 17/64	2	36006-240	90° Elbow, 1/8 NPT - 1/4 Tube (Control Air)	AR
36006-191	Phil. Screw, 10-32 x 1/4	1	36006-241	Nameplate Screws, 8-32 x 1/4	4
36006-192	Washer, 13/64 x 7/16 x 1/32	1	36006-242	Nameplate (Large) on Column Automatic and Manual Shutdown Plunger Parts	1
36006-193	Load Control Indicator Scale and Pointer Assembly	1	36006-243	Plunger Tubing — Red	1
36006-194	Overriding Cylinder	1	36006-244	"O" Ring, AN 6227-7	1
36006-195	Taper Screw, 1/4-28	2	36006-245	Shutdown Plunger	1
36006-196	Overriding Cylinder Head	1	36006-246	Ball Valve Spring	1
36006-197	L.C. Plunger Oil Seal	1	36006-247	Headed Pin	1
36006-198	Spacer (if no Oil Seal)	1	36006-248	Steel Ball, 1/4	1
36006-199	L.C. Oil Seal Gasket	1	36006-249	Shutdown Plunger Pin	1
36006-200	L.C. Pilot Valve Plunger	1	36006-250	Ball Valve Seat	1
36006-201	L.C. Pilot Valve Bushing Spring	1	36006-251	Shutdown Plunger Spring	1
36006-202	L.C. Pilot Valve Bushing	1	J. STRIPPED COLUMN,		
36006-203	Bushing Snap Ring, Waldes 50 - 43	1	36006-252	Column and Insert Assembly	1
H. OIL FAILURE SHUTDOWN MECHANISM			36006-253	Hex. Hd. Cap Screw, 5/16 x 4-23/32	4
(with High Oil Suction — Vacuum — Protection)			36006-254	Split Lock Washer, 5/16	4
36006-204	Soc. Hd. Cap Screw, 1/4-28 x 2	4	36006-255	"O" Ring, AN6227-5 (Transfer Holes, Oil and Air, Top of Column)	NI AR
36006-205	Split Lock Washer, 17/64	4	36006-256	Neoprene Ring (Transfer Hole for Speed Setting Oil, Case to Column) See Fig. 34	1
36006-206	Diaphragm Cap	1	36006-257	Pipe Plug, Hex. Soc., 1/16 NPT. See Fig. 34	AR
36006-207	Vacuum Diaphragm Nut, Special 3/8-24	2	36006-258	Pipe Plug, Hex. Soc., 1/8 NPT. See Fig. 34	AR
36006-208	Vacuum Diaphragm Washer	1	36006-259	Pipe Plug, Hex. Soc., 1/4 NPT.	NI AR
36006-209	Vacuum Diaphragm	1	36006-260	Pipe Plug, Hex. Soc., 3/8 NPT.	NI AR
36006-210	Diaphragm Stop Screw	1	36006-261	Decal Pipe Connection Labels	NI AR
36006-211	Vacuum Diaphragm Holder	1	36006-262	Decal Oil Level Label	1
36006-212	Vacuum Diaphragm Spring	1	36006-263	Nameplate Insert	NI 1
36006-213	Valve Seat Nut, Special 3/8-24	1	36006-264	Nameplate Insert Screws, 5 - 40 x 1/4	NI 2
36006-214	Ball Valve Seat	1	36006-265	Nameplate (Small) on Column (if used)	NI 1
36006-215	Steel Ball, 3/16 Diam.	1	36006-266	Drive Screw	NI 2
36006-216	Valve Body "O" Rings, AN 6230-2	3			
36006-217	Valve Body	1			
(All units with Lube Oil Pressure Failure Protection)					
36006-218	Oil Pressure Failure Diaphragm Spring	1			
36006-219	Elastic Stop Nut, Thin, 10-32	1			
36006-220	Oil Failure Diaphragm Washer	1			
36006-221	Oil Pressure Failure Diaphragm	1			
36006-222	Oil Failure Valve Plunger	1			

NOTE: AR — As Required, NI — Not Illustrated.

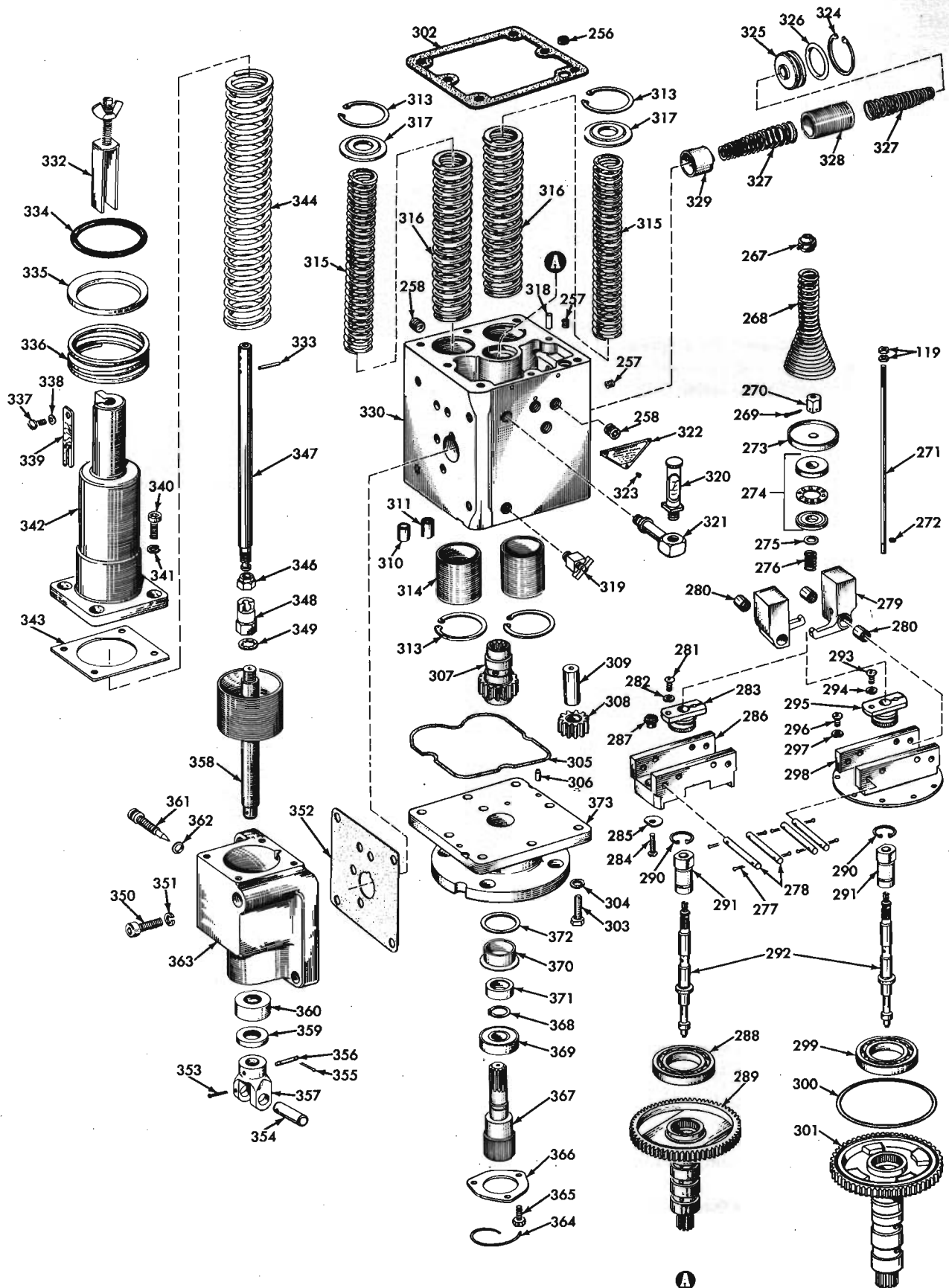


Figure 34 — Flyweight Heads, Rotating Sleeve, Power Case, Power Cylinder, and Base

REF. NO.	PART NAME	NO. REQ'D.	REF. NO.	PART NAME	NO. REQ'D.
K. FLYWEIGHT HEAD and ROTATING SLEEVE ASSEMBLY			36006-318	Dowel Pin, Case/Column	2
36006-267	Speeder Spring Check Plug	1	36006-319	Drain Valve	1
36006-268	Speeder Spring	1	36006-320	Oil Gage	1
36006-269	Cotter Pin, 1/16 x 5/8.....	1	36006-321	Oil Gage Elbow	1
36006-270	Pilot Valve Plunger Nut	1	36006-322	Bleed Plug Name Plate	1
36006-271	Shutdown Rod	1	36006-323	Bleed Plate Drive Screw	3
36006-272	Shutdown Rod Retaining Ring	1	36006-324	Snap Ring — Buffer Plug	1
36006-273	Speeder Spring Seat	1	36006-325	Buffer Plug	1
36006-274	Thrust Bearing	1	36006-326	"O" Ring — Buffer Plug	1
36006-275	Adjusting Spring Washer	1	36006-327	Buffer Spring	2
36006-276	Adjusting Spring	1	36006-328	Buffer Piston	1
36006-277	Cotter Pin, 1/16 x 7/16	8	36006-329	Inner Spring Seat	1
36006-278	Flyweight Pin/Limit Pin	4	36006-330	Power Case	1
36006-279	Flyweight	2	M. POWER CYLINDER ASSEMBLY — (Rod End Governor)		
36006-280	Flyweight Bearing	4	36006-332	Fuel Jack Assembly (Adjusting Tool).....	1
Spring Coupled — Undamped Flyweight Head Assembly			36006-333	Fuel Indicator Pin (in Tail Rod).....	1
36006-281	Screw, Rd. Hd., 6-32 x 5/16	1	36006-334	"O" Ring, Spring Guard Seal	1
36006-282	Lock Washer, No. 6	1	36006-335	Spring Guard Seal Ring	1
36006-283	Centering Spring Coupling Assembly.....	1	36006-336	Spring Guard Seal Spring	1
36006-284	Screw, Rd. Hd., 10-32 x 3/4	2	36006-337	Screw, Phil. Hd., 10-32 x 3/8	2
36006-285	Washer, Special	2	36006-338	Washer, No. 10	2
36006-286	Flyweight Head	1	36006-339	Piston Gap Scale	1
36006-287	Spline Nut, 10-32	2	36006-340	Screw, Soc. Hd., 1/4-28 x 1/2	4
36006-288	Centering Bearing	1	36006-341	Washer, 1/4 Shakeproof	4
36006-289	Flyweight Head Gear and Pilot Valve Bushing Assembly	1	36006-342	Spring Guard	1
36006-290	Snap Ring	1	36006-343	Spring-Guard Gasket	1
36006-291	Compensating Bushing	1	36006-344	Power Spring	1
36006-292	Pilot Valve Plunger	1	36006-345	Power Piston Stop Ring (if used).....	1
Spring Coupled — Oil Damped Flyweight Head Assembly			36006-346	Tail Rod Flex-Loc Nut, 3/8-24	1
36006-293	Screw, Rd. Hd., 8-32 x 5/16	1	36006-347	Power Piston Tail Rod	1
36006-294	Lock Washer, No. 8	1	36006-348	Tail Rod Lift Nut	1
36006-295	Centering Spring Coupling Assembly	1	36006-349	Washer, 3/8 Shakeproof	1
36006-296	Screw, Fil. Hd., 5-40 x 9/32	8	36006-350	Screw, Soc. Hd., 3/8 x 1	4
36006-297	Lock Washer, No. 5	8	36006-351	Split Lock Washer, 3/8	4
36006-298	Flyweight Head, Sub-Assembly	1	36006-352	Gasket, Power Cyl./Case	1
36006-299	Centering Bearing	1	36006-353	Cotter Pin, 3/32 x 1 1/4	1
36006-300	Oil Seal Ring	1	36006-354	Rod End Pin, 3/8 x 7/8	1
36006-301	Flyweight Head Gear and Pilot Valve Bushing Assembly	1	36006-355	Cotter Pin, 1/16 x 3/8	1
Also Parts 290, 291, 292 — Listed Above.			36006-356	Taper Pin (Rod End)	1
L. POWER CASE ASSEMBLY			36006-357	Rod End	1
36006-302	Gasket — Case/Column	1	36006-358	Power Piston and Rod Assembly	1
36006-303	Cap Screw, Hex. Hd., 5/16-18 x 1, Case/Base..	8	36006-359	Oil Seal, Type G	1
36006-304	Lock Washer, 21/64, Case/Base	8	36006-360	Oil Seal, Type P	1
36006-305	Oil Seal Ring, Case/Base	1	36006-361	Compensating Needle Valve	1
36006-306	Dowel Pin, Case/Base	2	36006-362	"O" Ring (Needle Valve)	1
36006-307	Drive Gear	1	36006-363	Power Cylinder	1
36006-308	Idler Gear	1	N. BASE ASSEMBLY		
36006-309	Idler Gear Stud	1	36006-364	Bronze Lock Wire, .035 x 6.....	1
36006-310	Check Valve Assembly, Pump Discharge.....	2	36006-365	Cap Screw, Dr. Hex. Hd., 1/4-28 x 5/8	3
36006-311	Check Valve Assembly, Pump Suction.....	2	36006-366	Drive Shaft Retainer Ring	1
36006-312	Check Valve Hole Plug (EMD No Check Valves)	2	36006-367	Drive Shaft, Serrated	1
36006-313	Snap Ring (Accumulator)	4	36006-368	Bearing Snap Ring	1
36006-314	Accumulator Piston	2	36006-369	Drive Shaft Bearing	1
36006-315	Accumulator Spring, Small	2	36006-370	Oil Seal Retainer	1
36006-316	Accumulator Spring, Large	2	36006-371	Oil Seal	1
36006-317	Accumulator Spring Seat	2	36006-372	Gasket Ring	1
			36006-373	Base	1

SECTION VIII — ROTARY TERMINAL SHAFT

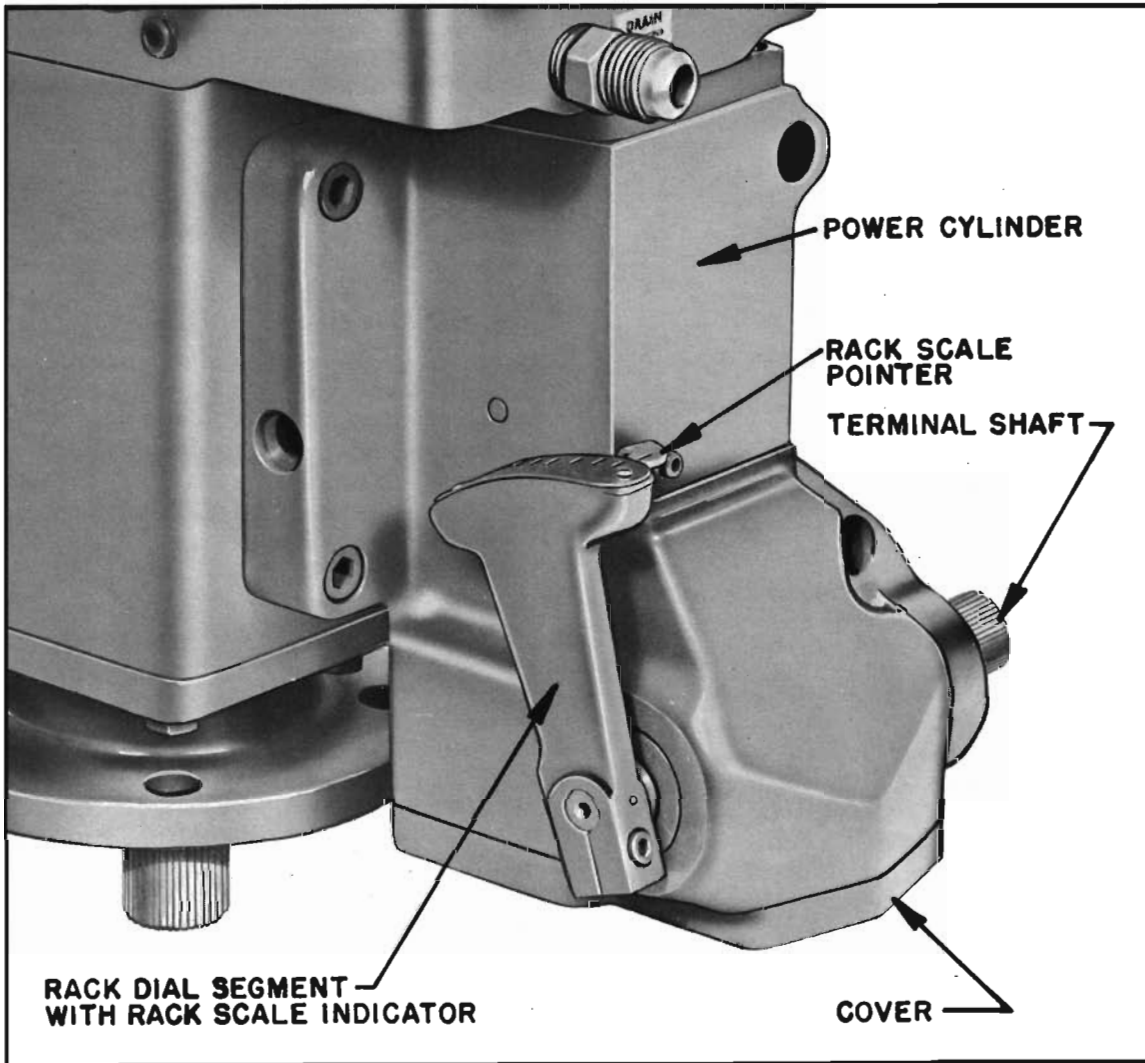


Figure 35

A rotary terminal shaft—instead of the reciprocating rod end—is available for the railroad governor to permit a more convenient method of connecting and operating the fuel linkage on certain types of engines. This arrangement also provides a means of setting and checking power piston position with relationship to the fuel rack settings, by the use of a graduated scale and pointer on the side of the power cylinder.

A different style power cylinder is used in which provision is made to carry the rotary terminal shaft mounted in needle bearings, offset and below the end of the power piston rod. By means of a lever secured to the terminal shaft, and connecting linkage between this lever and the piston rod, the reciprocating movement of the power piston and rod are translated into rotary motion at the terminal shaft. (See parts illustration on facing page).

Both ends of the terminal shaft project from the power cylinder assembly, and on one end a segment arm carrying the graduated scale plate is mounted. The opposite end of the terminal shaft is serrated to take the lever which would be used to connect the governor to the fuel linkage of the engine.

Oil seals at the terminal shaft bearings and a gasketed cover close up the entire assembly, so that oil leaking from around the power piston rod (no oil seals at this point) will accumulate in the lower part of the housing to lubricate the internal linkage and the terminal shaft bearings. To prevent any possibility of building up pressure on this oil from the power cylinder, a bypass hole is provided from the terminal shaft area back into the governor oil sump.

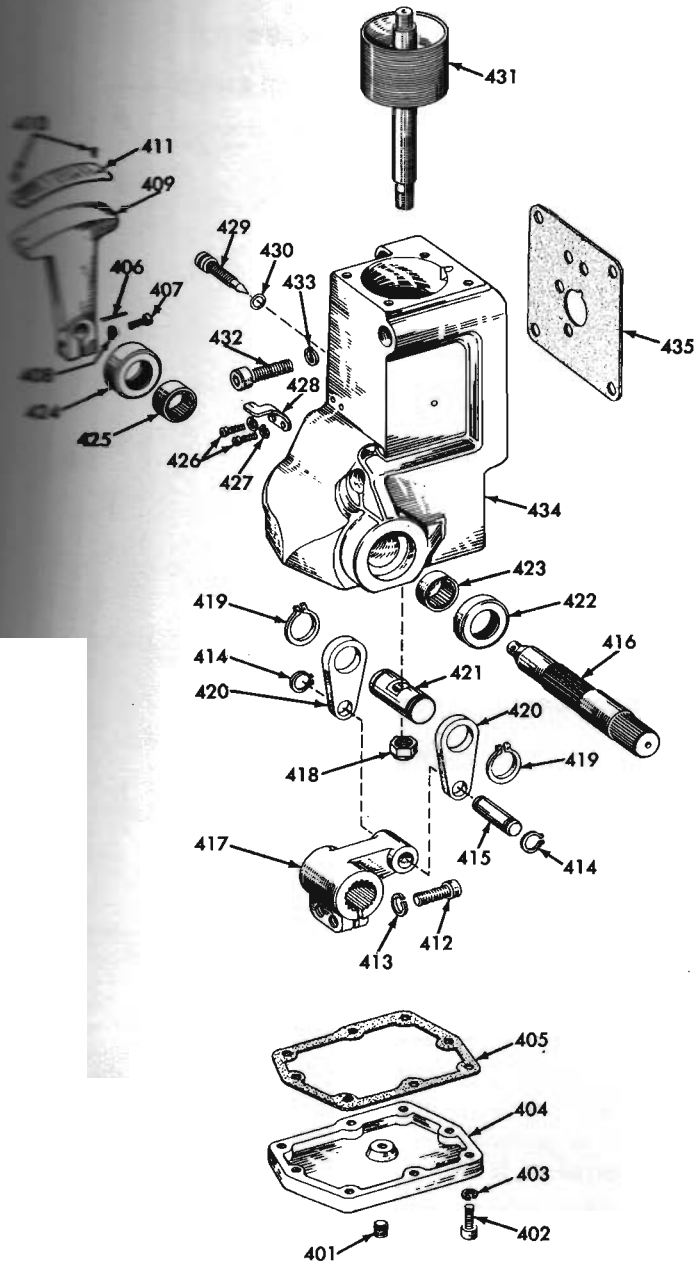


Figure 36

REF. NO.	PART NAME	NO. REQ'D.
36006-401	Drain Plug, 1/8 NPT.....	1
36006-402	Screw, Soc. Hd., 1/4-28 x 3/4.....	8
36006-403	Split Lock Washer, 1/4.....	8
36006-404	Power Cylinder Cover	1
36006-405	Cover Gasket	1
36006-406	Taper Pin, No. 2/0, (Rack Dial Segment)	1
36006-407	Screw, Soc. Hd., 10-32 x 5/8.....	1
36006-408	Split Lock Washer, No. 10.....	1
36006-409	Rack Dial Segment	1
36006-410	Drive Screw	2
36006-411	Terminal Shaft Scale	1
36006-412	Power Lever Clamp Screw, 5/16-18 x 7/8	2
36006-413	Split Lock Washer, 5/16	2
36006-414	Snap Ring, Small	2
36006-415	Power Lever Pin	1
36006-416	Terminal Shaft	1
36006-417	Power Lever	1
36006-418	Stop Nut, 7/16-20 (Rod End)	1
36006-419	Snap Ring, Large	2
36006-420	Power Piston Link	2
36006-421	Piston Rod Pin	1
36006-422	Oil Seal, Large	1
36006-423	Needle Bearing, Large	1
36006-424	Oil Seal, Small	1
36006-425	Needle Bearing, Small	1
36006-426	Screw, Soc. Hd., 8-32 x 3/8	2
36006-427	Split Lock Washer, No. 8.....	2
36006-428	Rack Scale Pointer	1
36006-429	Compensating Needle Valve	1
36006-430	"O" Ring, (Needle Valve).....	1
36006-431	Power Piston Assembly	1
36006-432	Screw, Soc. Hd., 3/8-16 x 1.....	4
36006-433	Split Lock Washer, 3/8	4
36006-434	Power Cylinder Assembly	1
36006-435	Gasket, Power Cyl./Case	1

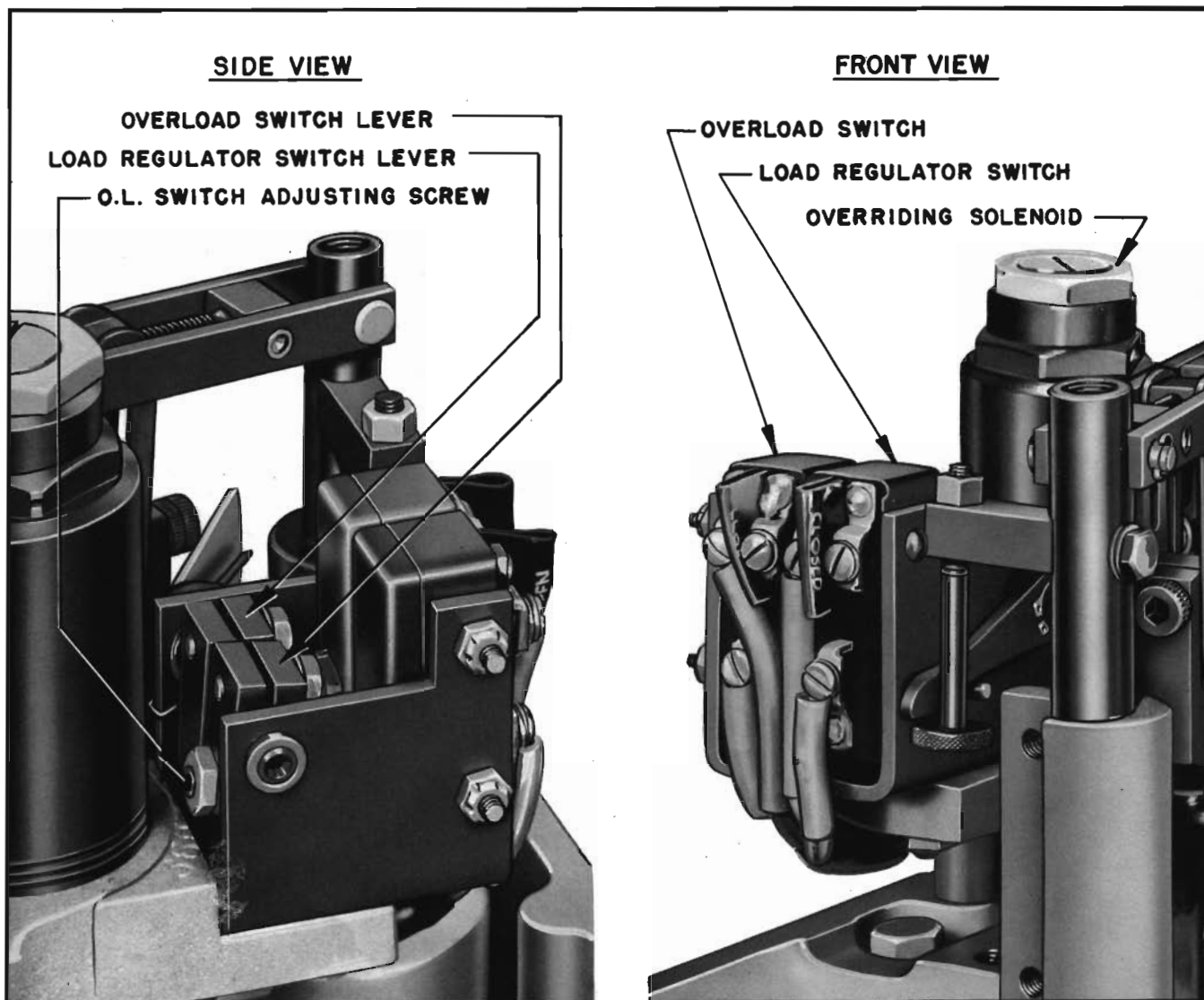
SECTION IX — LOAD REGULATOR AND OVERLOAD SWITCHES

Figure 37

The load regulator switch controls a "quick starting" feature on some locomotives. This quick starting or fast loading feature consists of a fixed resistance paralleling the load regulator, which is connected in series with the battery field of the main generator. A normally closed interlock maintains this fixed resistance as the throttle is advanced, until a predetermined rate of fuel injection is reached. This point is determined by the setting of the load regulator switch in the governor. When the load regulator switch closes, the interlock is opened, cutting out the fixed resistance and returning full control of the engine loading to the load regulator. The interlock remains open until the throttle is returned to Idle, thus making the fast loading feature effective only when increasing throttle from Idle position. The overload switch acts to prevent engine overloading

by energizing the over-riding solenoid to move the load regulator toward minimum field. The load regulator, which is essentially an automatically operated rheostat connected in series with the battery field of the main generator, reduces the battery field strength and consequently reduces the engine load in moving toward the minimum field position. When the load is reduced, the engine speed rises to normal and the governor returns the fuel linkage to its normal position thus opening the overload switch returning full control of engine loading to the load regulator.

The E.M.D. Operating Manual covering the GP9 locomotive, pages 511, 512 and 513, contain as much information concerning the operation of the overload and load regulator switches as is available.

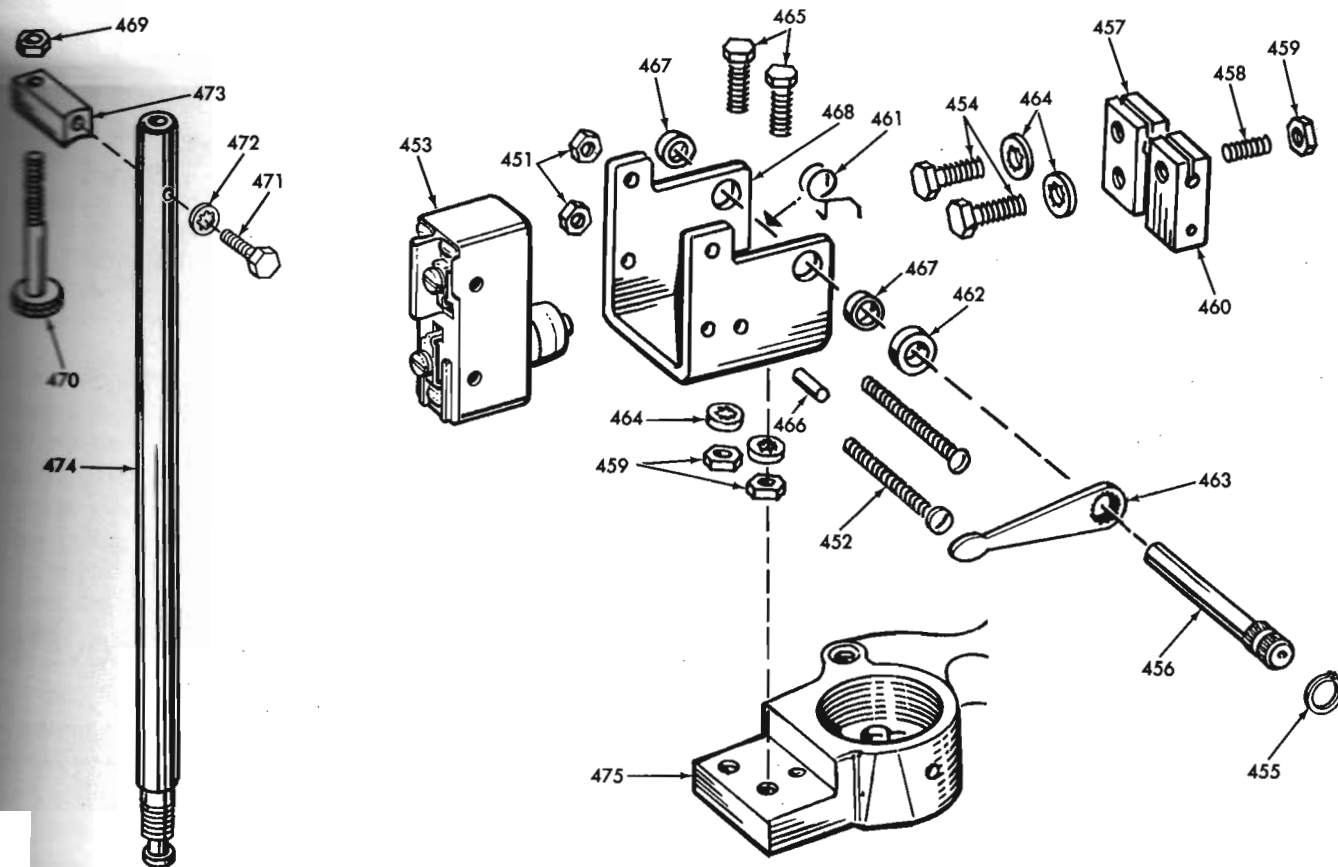


Figure 38

REF. NO.	PART NAME	NO. REQD.	REF. NO.	PART NAME	NO. REQD.
36006-451	Elastic Stop Nut, 6-32	2	36006-464	Washer, No. 10 Shakeproof	4
36006-452	Switch Screws, 6-32 x 1 7/8, Rd. Hd.	2	36006-465	Screw, Hex. Hd., 10-32 x 3/4	2
36006-453	Micro-Switch	2	36006-466	Stop Pin, 1/4 x 7/16	1
36006-454	Screw, Hex. Hd., 10-32 x 1/2	2	36006-467	Bushing, 1/4 x 3/8 x 1/4	2
36006-455	Snap Ring	1	36006-468	Switch Bracket	1
36006-456	Switch Lever Shaft	1	36006-469	Hex. Nut, 10-32 (Knurled Screw)	1
36006-457	Switch Lever, Adjustable	1	36006-470	Knurled Head Screw	1
36006-458	Set Screw, Soc. Hd., 10-32 x 5/8	1	36006-471	Screw, Hex. Hd., 10-32 x 7/8	1
36006-459	Hex. Nut, 10-32	3	36006-472	Shakeproof Washer, No. 10	1
36006-460	Switch Lever	1	36006-473	Tail Rod Arm	1
36006-461	Switch Shaft Spring	1	36006-474	Power Piston Tail Rod	1
36006-462	Switch Shaft Washer	1	36006-475	Solenoid Bracket	1
36006-463	Switch Operating Lever	1			

SECTION X — INTEGRAL VANE SERVO AND RESISTOR ASSEMBLY

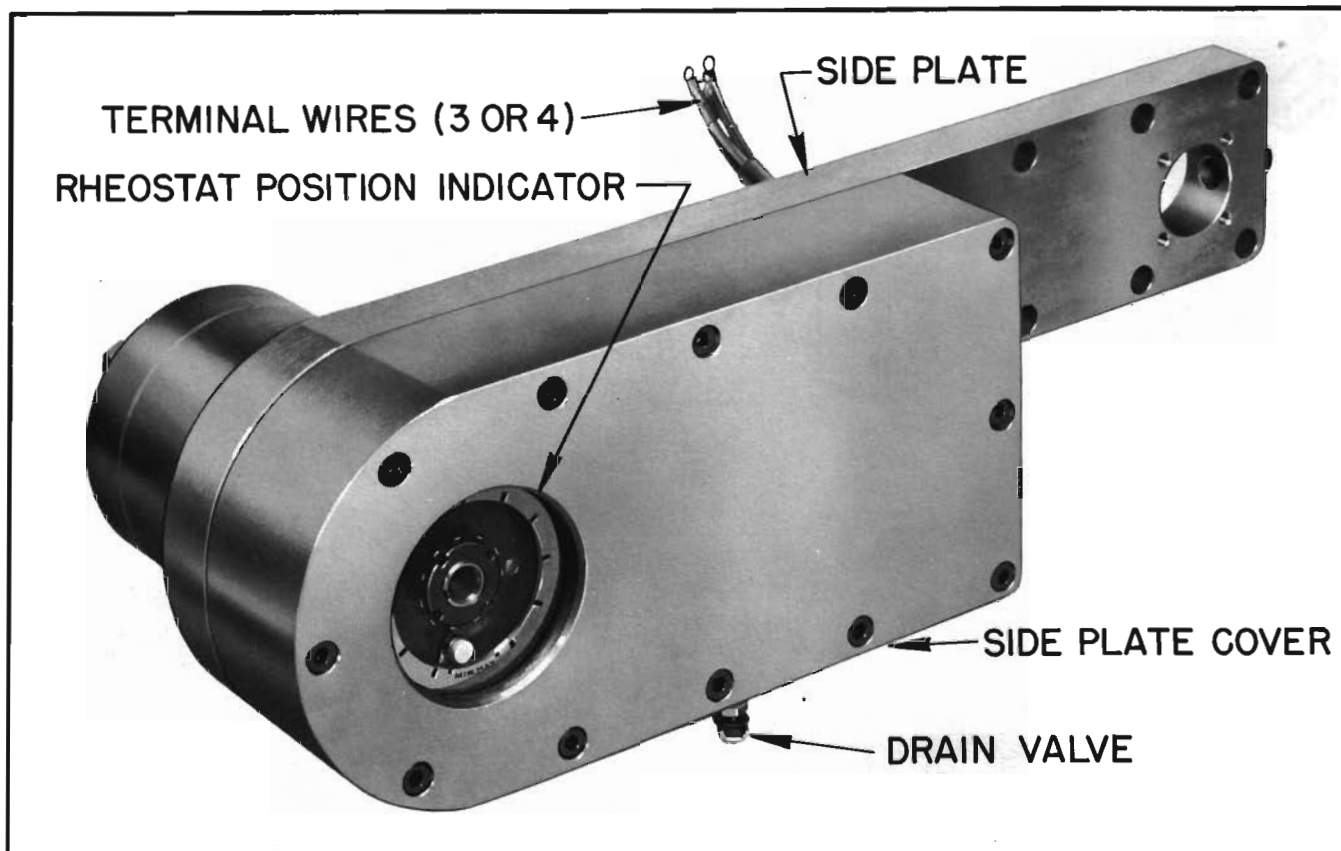


Figure 39

GENERAL: The integral vane servo and resistor assembly is furnished as an auxiliary for the Woodward Type PG Railroad Governor. It is used with pilot or amplifier type excitation systems where the wattage dissipated in the resistor section does not exceed limits set up by our engineering department. Being an integral system, governor oil pressure is used to operate the vane servo assembly and to cool the resistor assembly.

The purpose of a vane servo and resistor assembly is the same whether mounted in the governor as an integral part or mounted externally, as on many applications. In combination with the load control pilot valve and linkage, its purpose is to adjust generator excitation, thus automatically providing a constant steady state horsepower output from the engine at each speed or throttle setting. The vane servo is directly connected to a brush and commutator type tap switch and resistor combination which controls excitation of the generator field (see Section V, page 19).

Where electrical conditions permit, incorporation of the vane servo and resistor assembly in the governor proper has the advantage of saving space, simplifying maintenance, eliminating piping and fittings, and allowing

the servo to be operated by the usually cleaner oil in the governor system.

CONSTRUCTION: The integral vane servo and resistor assembly, with cover removed, is shown in Figure No. 40. The vane servo assembly is fastened to the governor side plate directly opposite the electrical unit by means of two mounting studs. Both the commutator and the resistor pack assembly are insulated from the governor itself. The assemblies are connected by slipping the serrated end of the rotary servo shaft into a serrated bore in the end of the brush drive shaft. Force should not be needed to make this connection. The rotary servo shaft should slide easily and smoothly into the brush drive shaft. Note that the omission of one serration allows only one position where the shaft will enter the serrated hole freely.

OPERATION: The load control pilot valve is located in the governor linkage between the speed setting system and the governor power piston tail rod (see Pages 20 and 21). This load control system establishes a definite fuel or rack setting for each speed setting of the governor, and any change in position of the speed

setting piston and/or the governor power piston will uncenter the load control pilot valve. Changes in the position of the speed setting piston are caused by changes in throttle setting. Changes in the position of the governor power piston are caused by any condition which causes a change in engine speed, or as a result of a change in the throttle setting.

Flow of oil through the uncentered load control pilot valve rotates the vane servo to either increase or decrease generator field excitation.

The rate of vane servo movement is specified by the engine manufacturer to obtain the desired locomotive performance. This rate of servo movement is controlled in the governor either by restrictive porting in the load control pilot valve bushing (see Page 22) or by adjustable spring loaded ball valves (see Page 22). Check the applicable engine manufacturer's specifications to determine settings to be made in the governor if it is equipped with the adjustable spring loaded ball valves.

For any fixed throttle setting, any condition that causes a change in the load on the engine will affect the governor as an engine speed change. The governor will change fuel setting and the movement of the governor power piston to correct the speed error will uncenter the load control pilot valve to start a change in excitation. This action will continue until the engine speed is re-established to conform to the throttle setting, the governor power piston and engine fuel racks return to their previous setting, and the load control pilot valve is recentered, with excitation at a new value to result in the correct steady state horsepower output from the engine for the existing throttle setting.

With the Integral Load Regulator, some additional parts may be found installed in the column of the governor. The Load Control Oil Supply Valve (if used) will be found in the side of the column after the side plate is removed. Spring loaded adjustable Ball Valves to control the rate of movement of the Load Regulator Servo may be installed in the top of the column close to the overriding cylinder, as shown in Figure 23 on page 22.

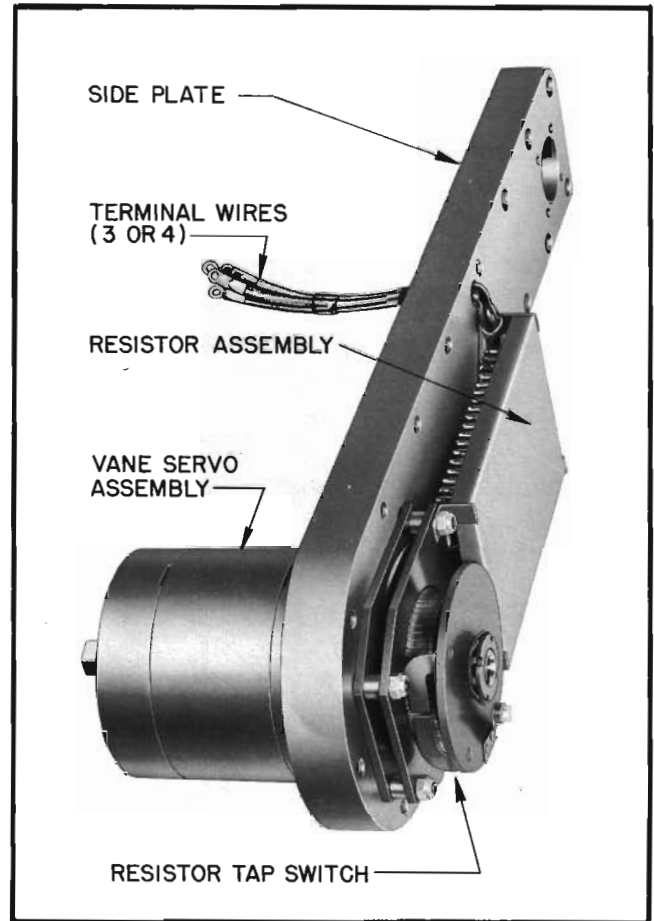


Figure 40

If the column is machined to take these valves and they are not used, special plugs are inserted into the holes.

Operation of these parts in connection with the Integral Load Regulator is described on page 22, just below Figure 23, and the individual parts are illustrated and listed on pages 44 and 45.

The round diaphragm cover — usually used with the Integral Load Regulator — is also listed in the parts list for this section.



CAUTION:

It is very important that the governor be surged enough to cause oil to fill the cavity about the resistor pack before putting a load on the unit. This is required to dissipate heat generated within the resistor.

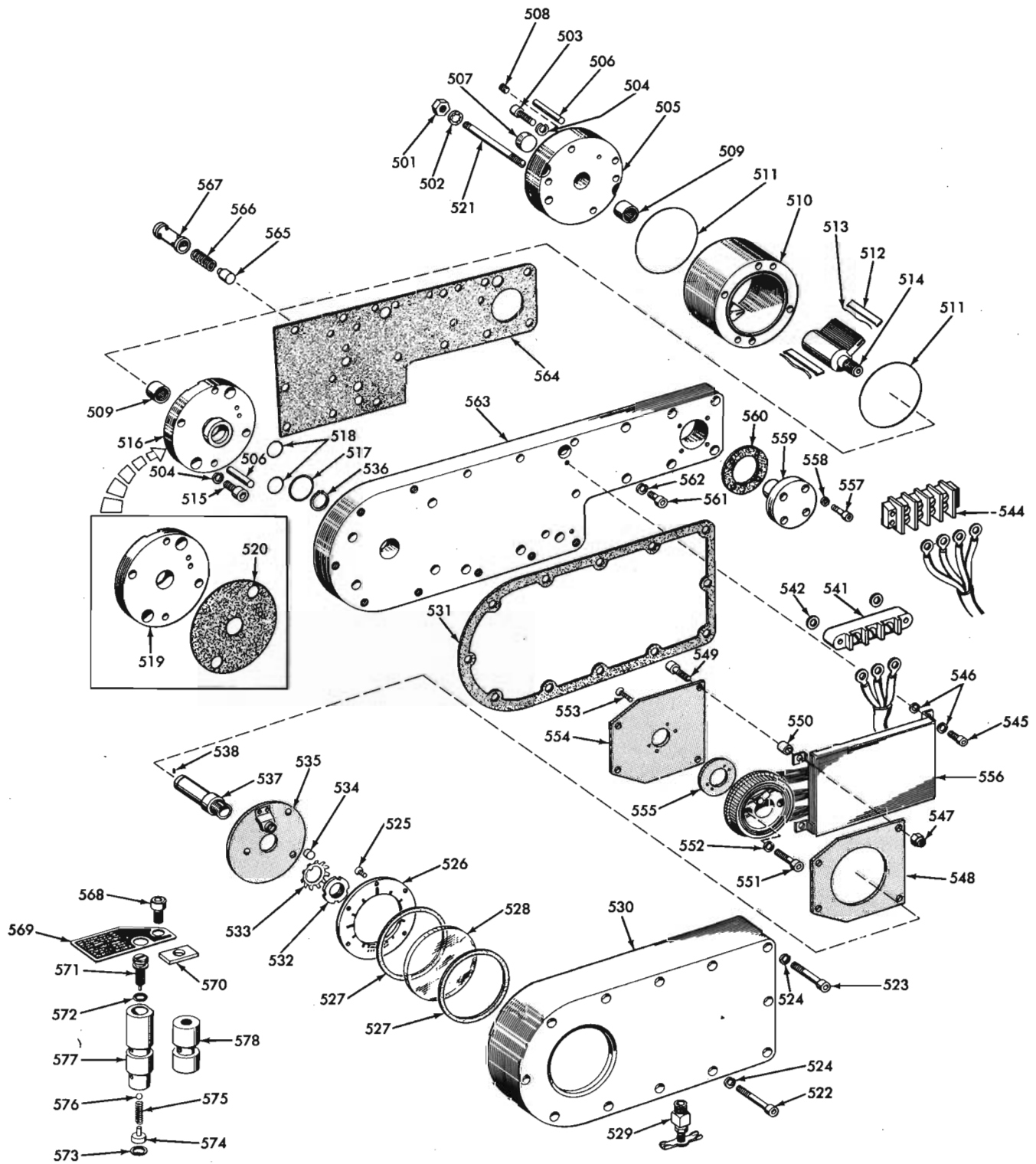


Figure 41 — Integral Load Regulator, Load Control Oil Supply Valve, and Adjustable Ball Valves for Column Installation.

REF. NO.	PART NAME	NO. REQD.	REF. NO.	PART NAME	NO. REQD.
A. ROTARY VANE SERVO ASSEMBLY:			36006-540	"Sems" Screw, 6-32 x 1/2 (for 541)	NI 2
36006-501	Hex. Nut, 1/4-28	2	36006-541	Terminal Block (3 wire)	1
36006-502	Washer, 1/4 Shakeproof	2	36006-542	Fibre Insulating Washer (for 541)	2
36006-503	Cap Screw, Soc. Hd., 1/4-28 x 1	2	36006-543	"Sems" Screw, 6-32 x 1/2 (for 544)	NI 4
36006-504	Washer, Split Lock, 1/4 x 1/16	4	36006-544	Terminal Block (4 wire)	1
36006-505	Servo End Plate	1	36006-545	Cap Screw, Soc. Hd., 8-32 x 3/8	2
36006-506	Dowel, .250 x 1	4	36006-546	Insulating Washer	4
36006-507	End Plate Plug	1	36006-547	Elastic Stop Nut, 8-32	4
36006-508	Soc. Pipe Plug, 1/8 NPT	1	36006-548	Resistor Lead Wire Retainer	1
36006-509	Needle Bearing	2	36006-549	Screw, Dr. Soc. Hd., 8-32 x 3/4	4
36006-510	Servo Housing and Divider Assemblies	1	36006-550	Spacer Bushing	4
36006-511	Oil Seal Ring	2	36006-551	Screw, Soc. Hd., 8-32 x 1 1/8	2
36006-512	Vane Insert	2	36006-552	Lock Washer, No. 8	2
36006-513	Insert Load Spring	2	36006-553	Screw, Phil. Flat Hd., 8-32 x 7/8	2
36006-514	Rotary Servo Shaft Assembly	1	36006-554	Commutator Plate	1
36006-515	Cap Screw, Soc. Hd., 1/4-28 x 3/4	2	36006-555	Spacer Disc	1
36006-516	Servo Back Plate	1	36006-556	Commutator and Resistor Pack Assbly.	1
36006-517	"O" Ring, Back Plate Seal	1	36006-557	Soc. Hd. Cap Screw, 10-32 x 3/4	4
36006-518	"O" Ring, Servo Oil Connections	2	36006-558	Split Lock Washer, No. 10	4
36006-519	Servo Back Plate (old style)	1	36006-559	Diaphragm Cap, Round	1
36006-520	Back Plate Gasket (old style)	1	36006-560	Diaphragm Cap Gasket	1
36006-521	Mounting Stud (in side plate)	2	36006-561	Cap Screw, Soc. Hd., 1/4-28 x 3/4	10
B. SIDE PLATE COVER ASSEMBLY:			36006-562	Washer, 1/4 Split Lock	10
36006-522	Cap Screw, Soc. Hd., 1/4-28 x 2 1/8	8	36006-563	Side Plate	1
36006-523	Cap Screw, Soc. Hd., 1/4-28 x 3	4	36006-564	Side Plate Gasket	1
36006-524	Washer, 1/4 Split Lock	12	Additional parts used with Integral Load Regulator:		
36006-525	Screw, Phil. Flat Hd., 6-32 x 3/8	6	36006-565	Load Control Oil Supply Valve Plunger	1
36006-526	Rheostat Dial Plate	1	36006-566	Load Control Oil Supply Valve Spring	1
36006-527	Dial Glass Gasket	2	36006-567	Load Control Oil Supply Valve Sleeve	1
36006-528	Dial Glass	1	Ball Check Valves — in Column — for Integral Load Regulator Timing:		
36006-529	Drain Valve	1	36006-568	Soc. Hd. Screw, 1/4-28 x 3/8	1
36006-530	Side Plate Cover	1	36006-569	Instruction Plate	1
36006-531	Side Plate Cover Gasket	1	36006-570	Retainer Block	1
C. EXCITER FIELD RESISTOR ASSEMBLY:			36006-571	Adjusting Needle	2
36006-532	Indicator Lock Nut	1	36006-572	"O" Ring (Adjusting Needle)	4
36006-533	Lock Washer	1	36006-573	Snap Ring, Waldes 50-31	2
36006-534	Indicator Button	1	36006-574	Ball Valve Spring Plug	2
36006-535	Indicator Assembly	1	36006-575	Ball Valve Spring	2
36006-536	Brush Drive Shaft Snap Ring	1	36006-576	Steel Ball, 3/16	2
36006-537	Brush Drive Shaft	1	36006-577	Ball Check Valve Body	2
36006-538	Drive Shaft Locator Pin	1	If Ball Check Valves are NOT used, Holes are plugged with:		
36006-539	"Sems" Screw, 5-40 x 1/4 (Terminals)	NI 3	36006-578	Ball Check Valve Hole Plug	2

NOTE: NI — Not Illustrated.