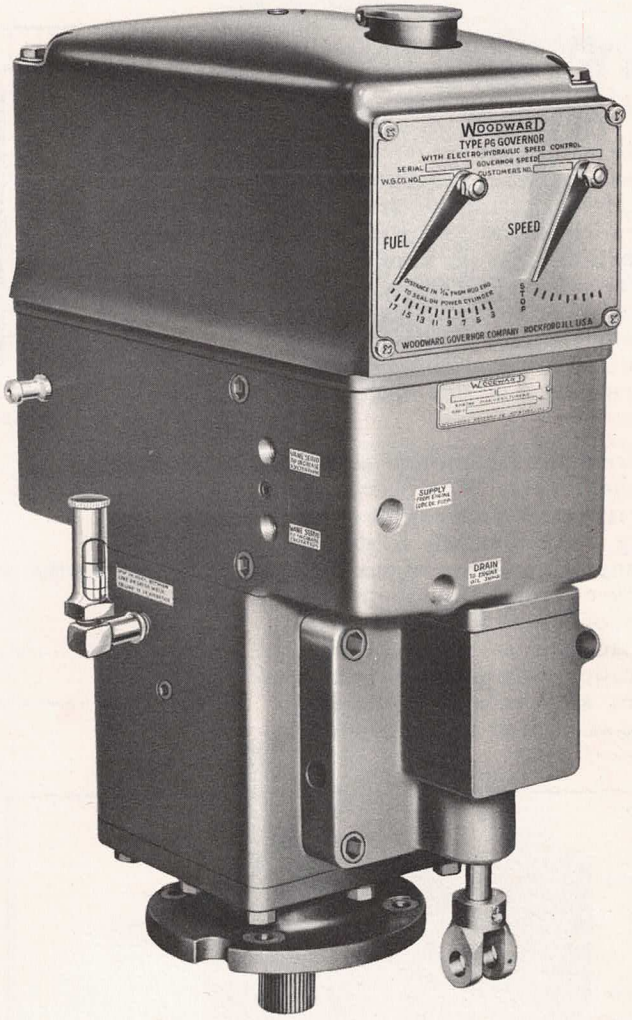
# PG LOCOMOTIVE GOVERNOR

## ELECTRO-HYDRAULIC AND PNEUMATIC-HYDRAULIC CONTROL
## BULLETIN PGR-2-51

WOODWARD
Governor
COMPANY
ROCKFORD • ILLINOIS



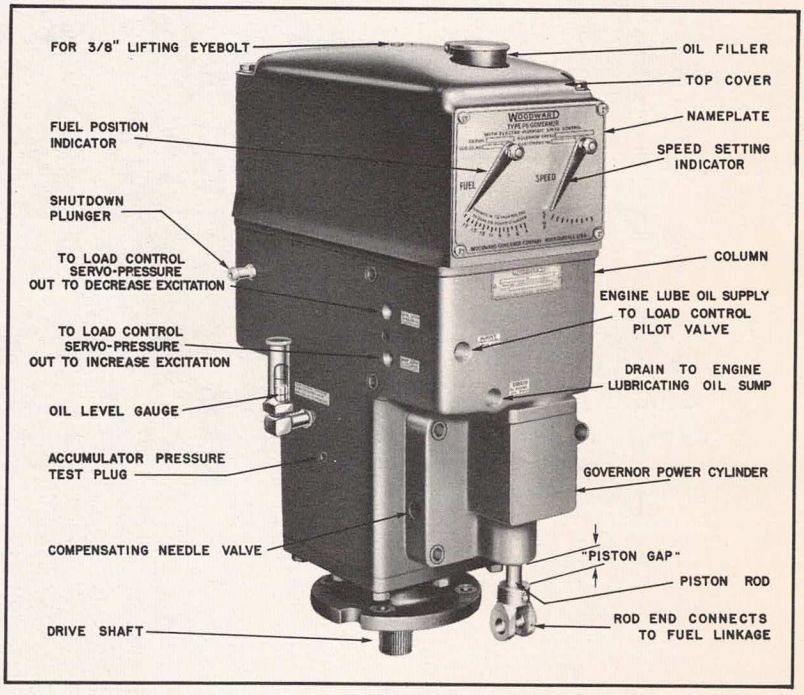

# PG GOVERNOR

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

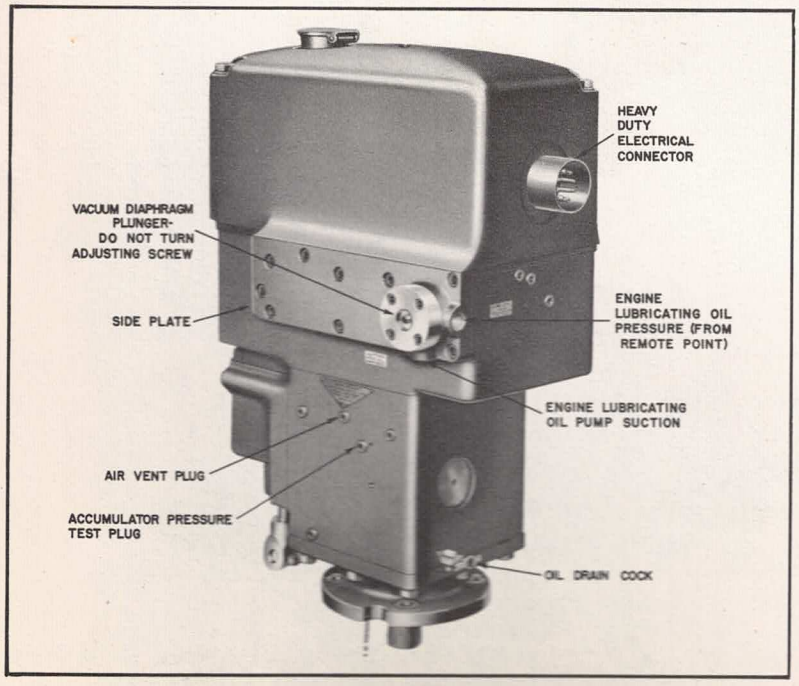
### DESCRIPTION — INSTALLATION — OPERATION

**GENERAL:** The PG governor is a hydraulic governor with a self contained oil supply, oil pump, and accumulators for storing pressure oil. Its overall size and work capacity (12 foot pounds) are the same as the SI governor and many parts are interchangeable. However, the PG is an improved governor. It has fewer parts, is easier to maintain, and requires less critical adjustments for peak performance. Normally the governor is isochronous (maintains a constant engine speed regardless of load) but it may be supplied with speed droop characteristics if this feature is required.

The PG governor for locomotive service is basically the regular Woodward PG governor and it regulates the engine speed by controlling the fuel supply in exactly the same manner. A number of auxiliary devices have been incorporated to provide remote control of engine speed, to control the engine load, and to protect against engine lubricating oil pressure failure. These features are available in several combinations, as desired by the locomotive builder.




Cut No. 1




Cut No. 2

**THESE AUXILIARY DEVICES PROVIDE FOR:**

1. Remote electrical speed control in any number of steps up to 14, plus shutdown and idling speed positions.
2. Remote pneumatic speed control (as an alternate to the above). This provides stepless speed adjustment over the full speed range, including idling speed. An electrically operated shutdown device is provided with this arrangement.
3. Automatic load regulation to maintain a constant steady-state horsepower output for each speed setting.
4. Adjustment for maximum or minimum field train starts.
5. Over-riding of normal functioning of load control system for starting, transition, wheel slip, and other conditions.
6. Automatic shutdown of the engine in event of engine lubricating oil pressure failure or excessive lubricating oil pump suction.

7. Adjustable time delay at idle for shutdown of engine, due to either lubricating oil pressure failure or excessive pump suction, which allows starting of engine without oil pressure (normal procedure), but shutting down of engine if pressure is not established in a reasonable time.
8. Engine operation at idling speed, temporarily, if necessary to trace the cause of oil pressure failure.
9. A manual shutdown control which cannot be blocked to give normal operation when the safety shut-down mechanism is functioning.
10. Electrical indication of oil pressure failure in cab and mechanical indication of failure at the governor.
11. Test of the shutdown mechanism for proper operation while the engine is running, without producing shutdown. (Applies only to governors equipped with excessive lubricating oil pump suction protection.)
12. Manual shutdown of the engine at the governor.

**INSTALLATION:** Install the governor on the engine, making sure that it is mounted squarely and that the drive connection to the engine is carefully aligned. Bolt the governor to the governor drive base using a gasket between the two. Connect the linkage from the governor to the fuel system and eliminate any friction or lost motion in it. Make the hydraulic and pneumatic connections required for the style of governor you are using.

An electrically controlled governor with engine lubricating oil pressure used to operate the load control mechanism and with engine lubricating oil pressure failure and suction shutdown requires six tube connections at the locations indicated in Cuts No. 1 and No. 2. These connections are as follows:

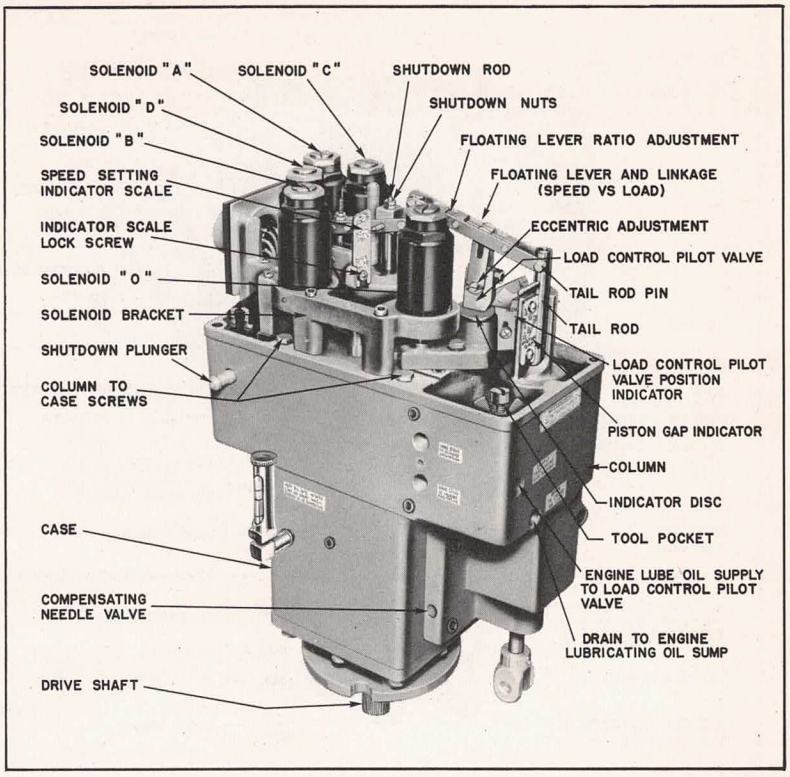
Lubricating Oil pressure line from engine lubricating oil pump.

Lubricating oil drain to engine sump.

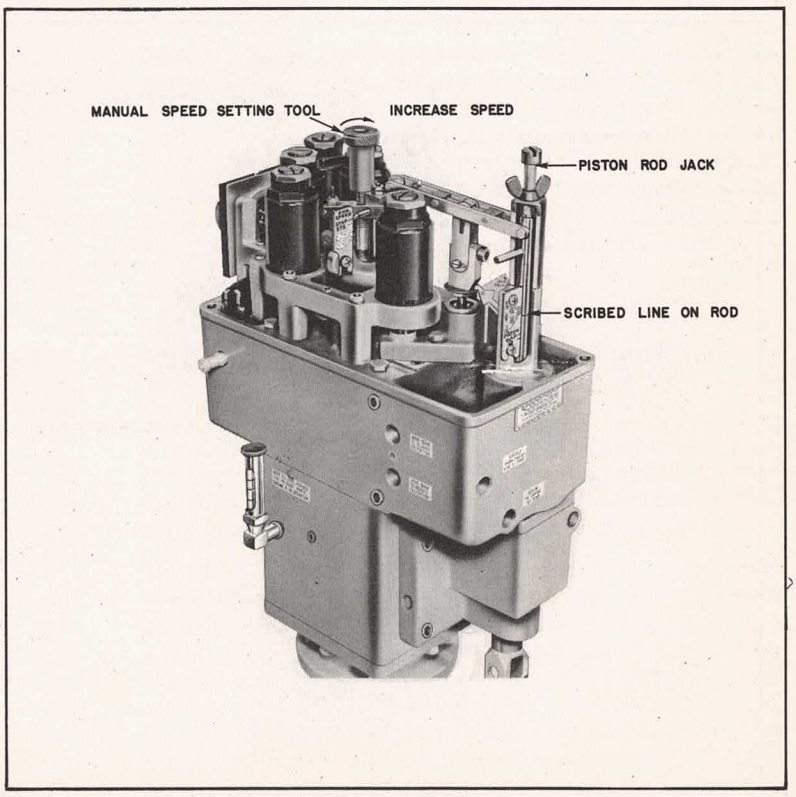
Lubricating oil pressure line from most remote point in engine oil pressure system.

Vacuum line to suction side of engine lubricating oil pump; not less than 3/8" tubing.

Two control oil lines to "Load Control" vane servo, which are used for changing generator excitation.




Cut No. 3




Cut No. 4

7. Adjustable time delay at idle for shutdown of engine, due to either lubricating oil pressure failure or excessive pump suction, which allows starting of engine without oil pressure (normal procedure), but shutting down of engine if pressure is not established in a reasonable time.
8. Engine operation at idling speed, temporarily, if necessary to trace the cause of oil pressure failure.
9. A manual shutdown control which cannot be blocked to give normal operation when the safety shut-down mechanism is functioning.
10. Electrical indication of oil pressure failure in cab and mechanical indication of failure at the governor.
11. Test of the shutdown mechanism for proper operation while the engine is running, without producing shutdown. (Applies only to governors equipped with excessive lubricating oil pump suction protection.)
12. Manual shutdown of the engine at the governor.

**INSTALLATION:** Install the governor on the engine, making sure that it is mounted squarely and that the drive connection to the engine is carefully aligned. Bolt the governor to the governor drive base using a gasket between the two. Connect the linkage from the governor to the fuel system and eliminate any friction or lost motion in it. Make the hydraulic and pneumatic connections required for the style of governor you are using.

An electrically controlled governor with engine lubricating oil pressure used to operate the load control mechanism and with engine lubricating oil pressure failure and suction shutdown requires six tube connections at the locations indicated in Cuts No. 1 and No. 2. These connections are as follows:

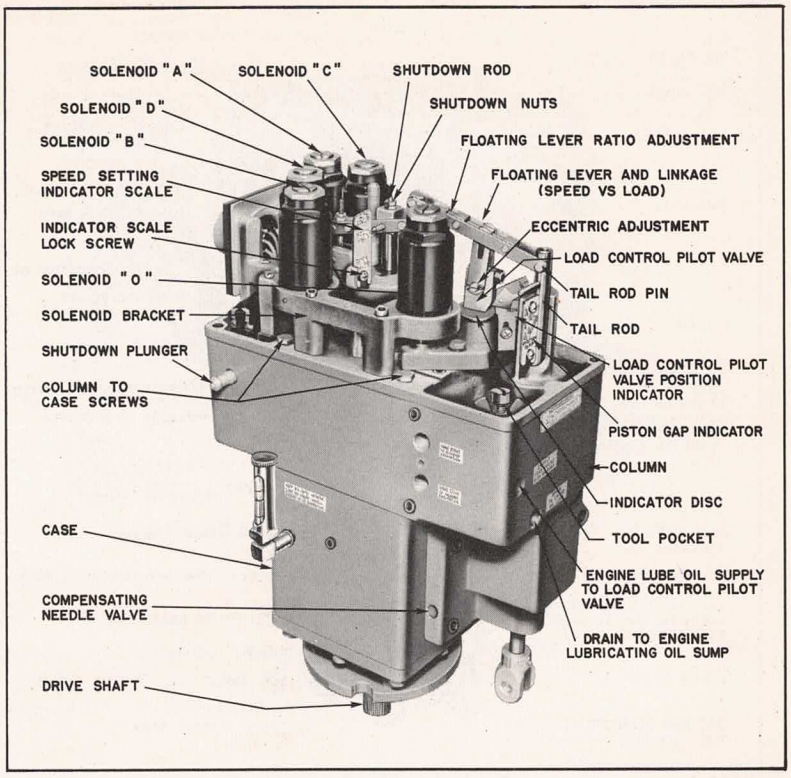
Lubricating Oil pressure line from engine lubricating oil pump.

Lubricating oil drain to engine sump.

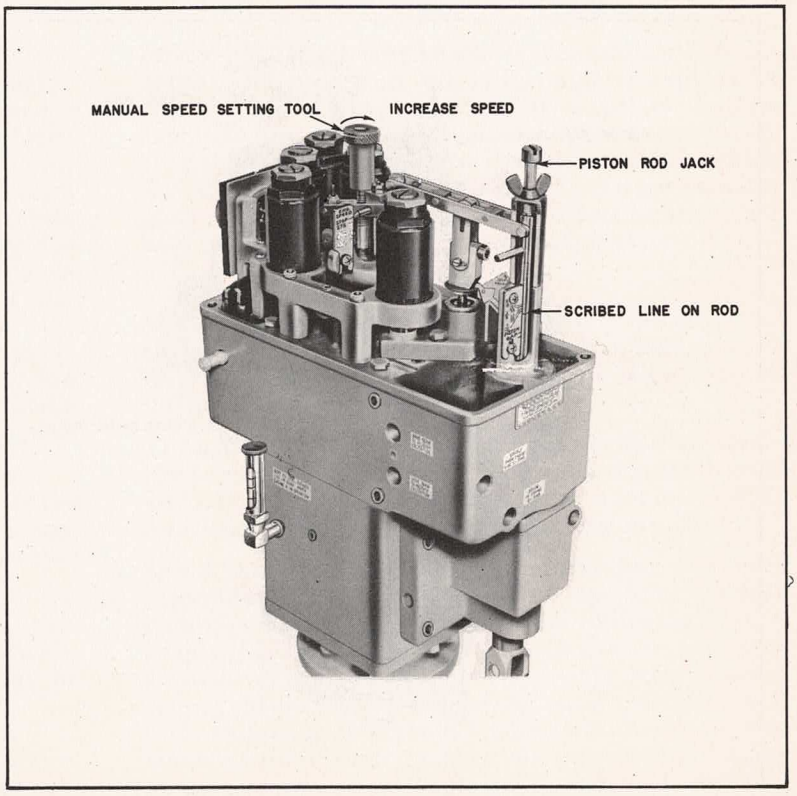
Lubricating oil pressure line from most remote point in engine oil pressure system.

Vacuum line to suction side of engine lubricating oil pump; not less than 3/8" tubing.

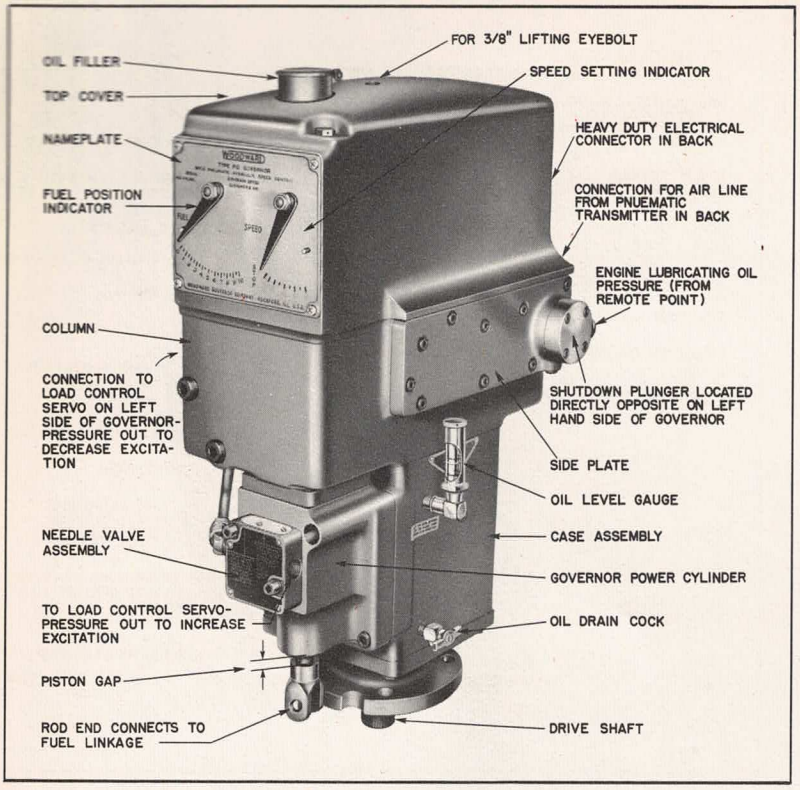
Two control oil lines to "Load Control" vane servo, which are used for changing generator excitation.



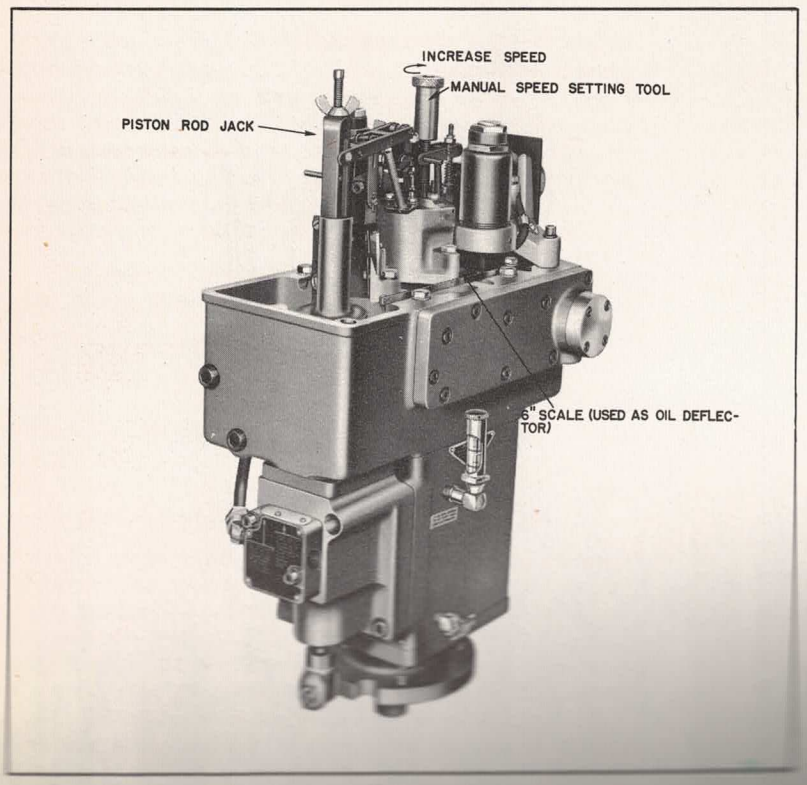

Cut No. 3




Cut No. 4




Cut No. 5




Cut No. 6

A pneumatically controlled governor with a self contained oil pressure supply for operating the load control mechanism and with engine lubricating oil pressure failure shutdown requires only four tube connections as shown in Cut No. 5. These connections are:

Lubricating oil pressure line from most remote point in engine oil pressure system.

Two control oil lines to "Load Control" vane servo.

An air line from the pneumatic transmitter.

Attach the heavy duty electrical connector shown in Cut No. 2. This connector makes all electrical connections required as shown by the Wiring Diagram in Cuts No. 10 or No. 11.

**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 excessively, when agitated, or form gummy deposits when heated.

**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.

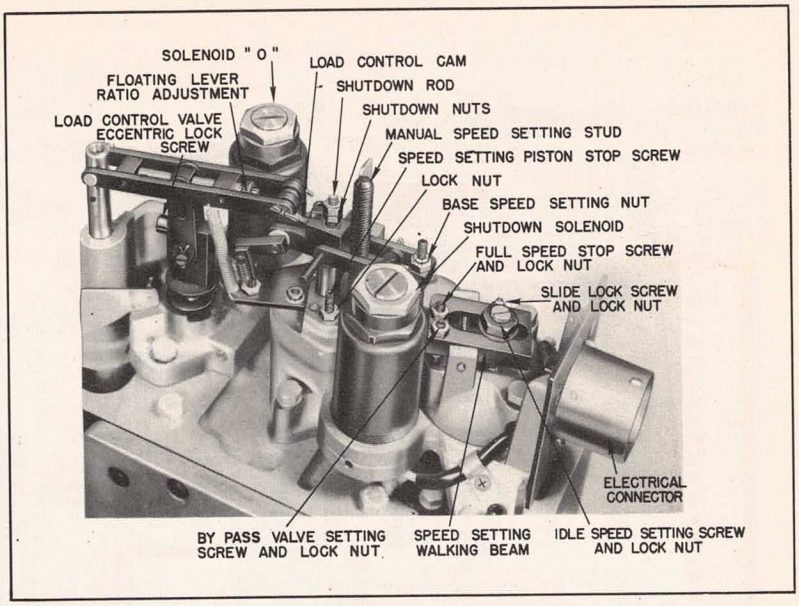
**INSTALLATION ADJUSTMENTS:** Speed setting and compensating needle valve adjustment are the only adjustments to be made. Adjustment of speed setting versus fuel pump rack position must be made to specifications furnished by the engine manufacturer as follows:

1. Remove top cover, see Cuts No. 3 or No. 6. Place one cover bolt down bolt or a 6" scale along the edge of the governor to prevent oil from running down side of governor. (See Cut No. 6). Note the two special nuts in the end position.
2. Use the governor rod nuts to position the rod end for correct linkage con-

as per specifications (see Cut no. 4.). The manual speed setting tool is shown on the governor in Cut No. 4 for convenience only. It is not used for these adjustments. Explanation of its use is on page 27.

3. Engine idling speed is adjusted by means of the base speed setting nut shown in Cut No. 7. Turning the nut counterclockwise increases engine speed.

4. For pneumatic-hydraulic governors, speed setting walking beam parts used in adjusting or for locking purposes are shown in Cut No. 7. The walking beam is in the idling position when free to rest on its right hand stop. The full speed setting may be adjusted with the beam tipped in the opposite direction and resting against the full speed stop screw.




Cut No. 7

5. The shutdown nuts (Cut No. 7) are factory set to have approximately 1/32″ clearance (with slack removed) above the end of the speed setting piston while the engine is idling.

6. The speed setting piston stop screw and lock nut (Cut No. 7) are also factory set. The screw is adjusted to provide approximately 3/64″ clearance for the speed setting piston above the engine idling position.

**COMPENSATION ADJUSTMENTS:** When the engine is started for the first time or started after the governor has been drained and cleaned, it is necessary to bleed the trapped air from the governor. Loosen the air vent plug shown in Cut No. 2 several turns to allow oil to flow slowly. Also loosen the compensation needle valve shown in Cut No. 1 several turns. Allow the engine to surge freely at idling speed for 30 seconds to remove the trapped air from the governor oil passages. After all air is removed, tighten the air vent plug and reset the governor compensating needle. Close the needle slowly until all surging or hunting is eliminated. This will usually occur when the needle valve is between one quarter turn and three full turns open.

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 slightly and test again.

Keep the needle valve open as far as possible to prevent sluggishness and still obtain stability. After it is correctly adjusted for the engine, it should not be necessary to change it.

**SCHEMATIC DIAGRAMS:** The schematic diagrams, Cuts No. 8 and No. 9, show the relationship of the various parts of the governor to each other and to the engine. All parts are shown in normal operating positions and oil pressures are shown for normal pressure conditions.

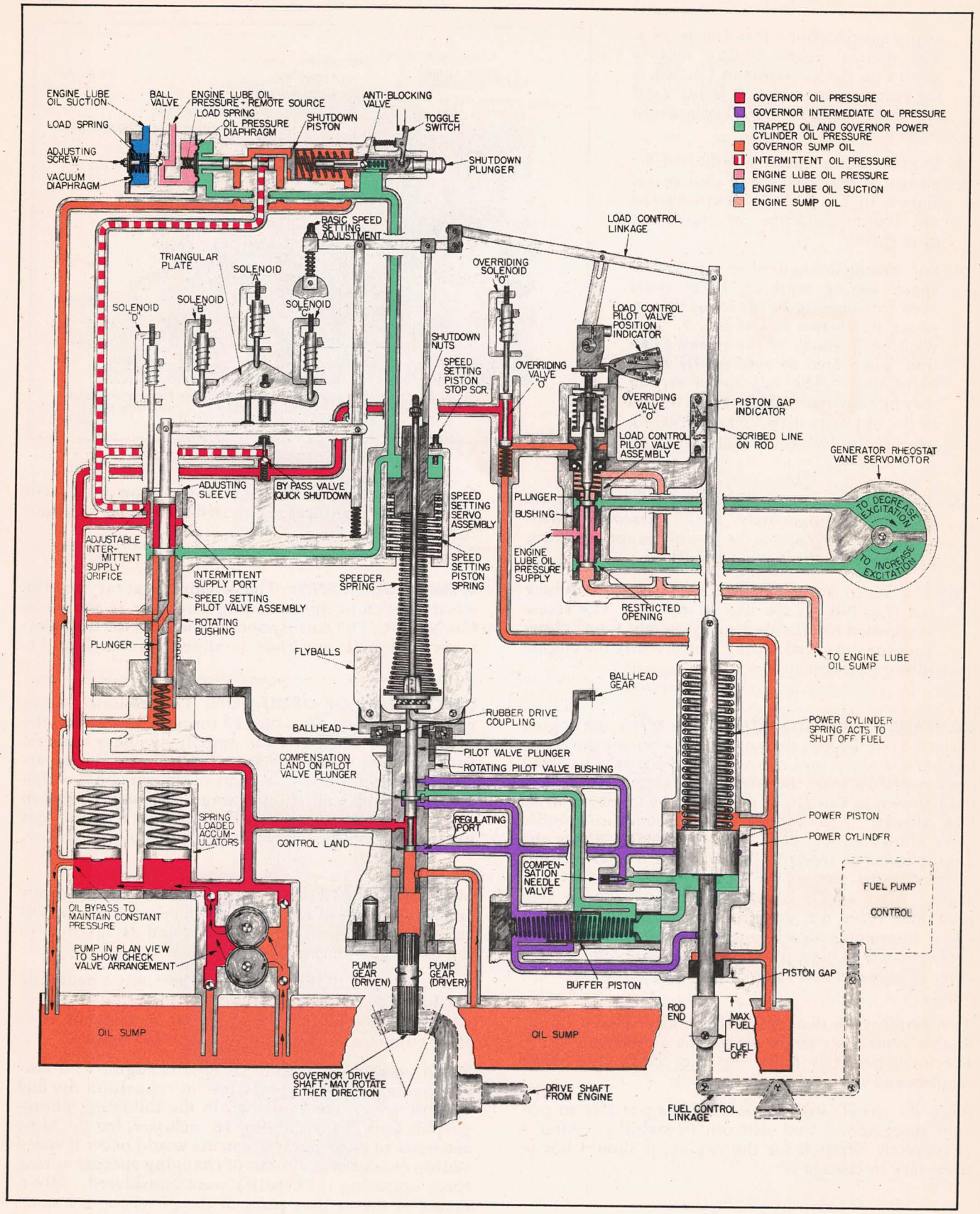
**WIRING DIAGRAMS:** The wiring diagram for the electro-hydraulic speed setting governor is shown in Cut No. 10. The corresponding diagram for the pneumatic hydraulic governor is shown in Cut No. 11.

**DESCRIPTION OF OPERATION:** The sectional photographs following, Cuts No. 12 through 33, explain the operation of the governor and its auxiliary devices. Each function of the governor has been treated separately showing only those parts of the assembly which are directly affected. Connecting oil passages between parts are not necessarily in their correct location, but have been simplified to facilitate tracing of the oil flow.

**SPEED REGULATING:** The upper half of the governor contains the speed changing mechanism, load control valve, and the protective devices and is ignored in the following discussion.

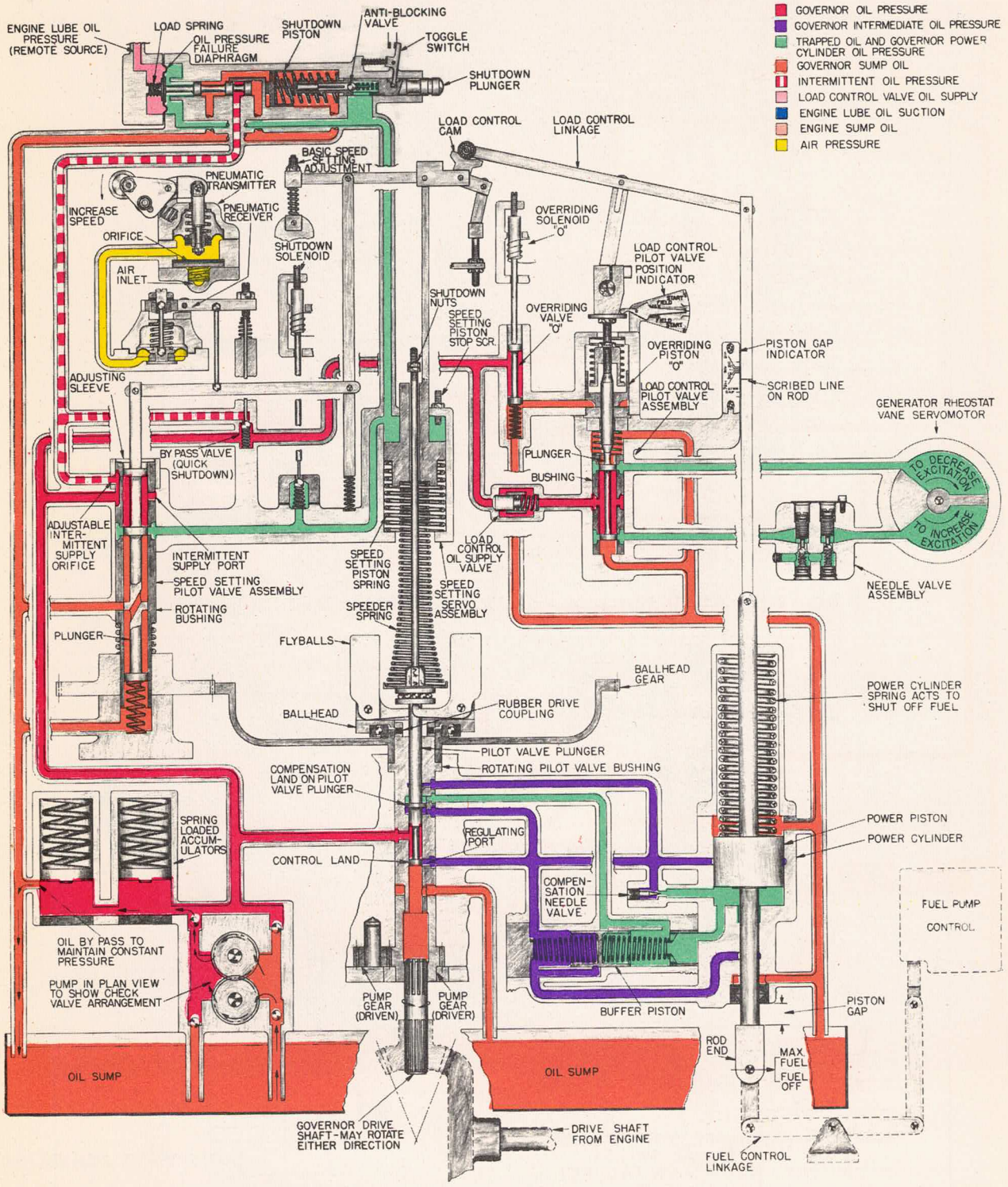
The lower half of the governor is basically a hydraulic isochronous governor identical to the regular Woodward PG governor. It acts quickly to maintain constant engine speed by changing the fuel supply.

Speed changes as a result of load changes, with corresponding governor reaction to reposition the fuel control valves, are explained in the following photographs, Cuts No. 12 to No. 18 inclusive, but the same sequence of governor movements would occur if speed setting changes (as a result of changing speeder spring force opposing the flyballs) were considered. Movements of the various parts of the governor are exaggerated to represent large speed and load changes, whereas under constant speed conditions the movements would be extremely small.



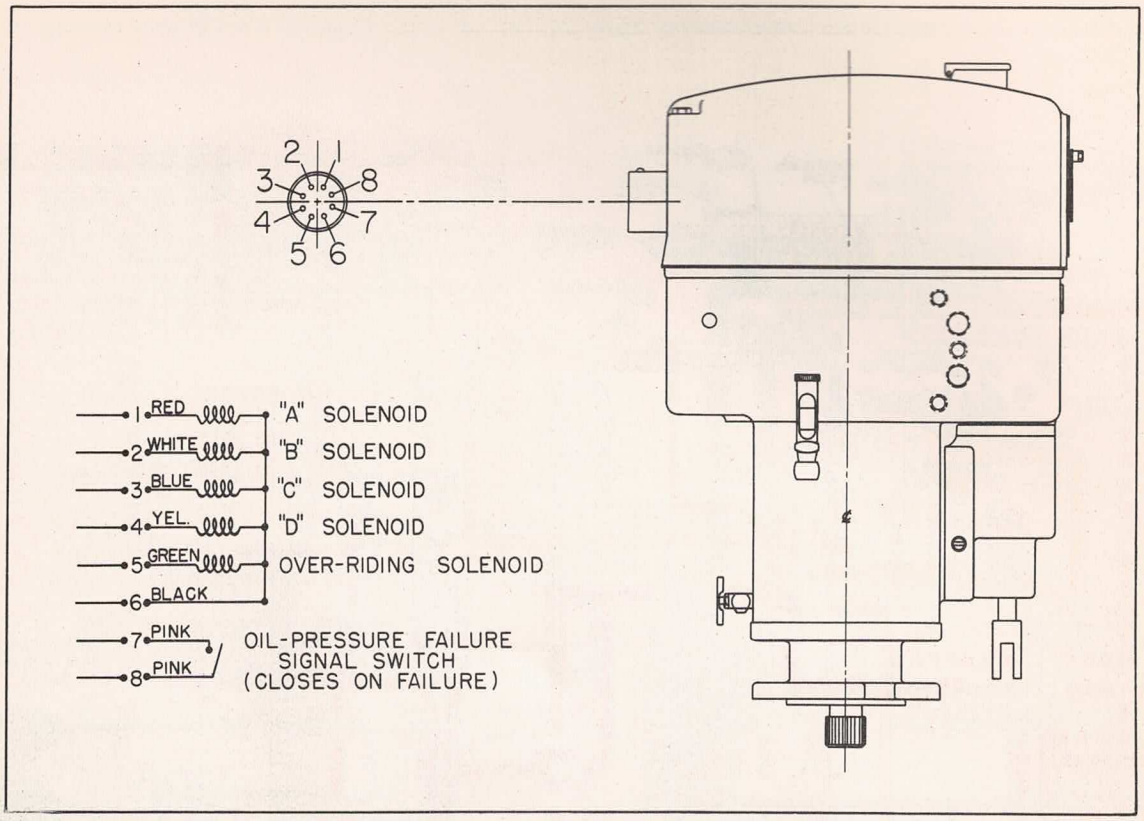

**Cut No. 8**

**Schematic Diagram for PG Locomotive Governor with Electro-Hydraulic Control**



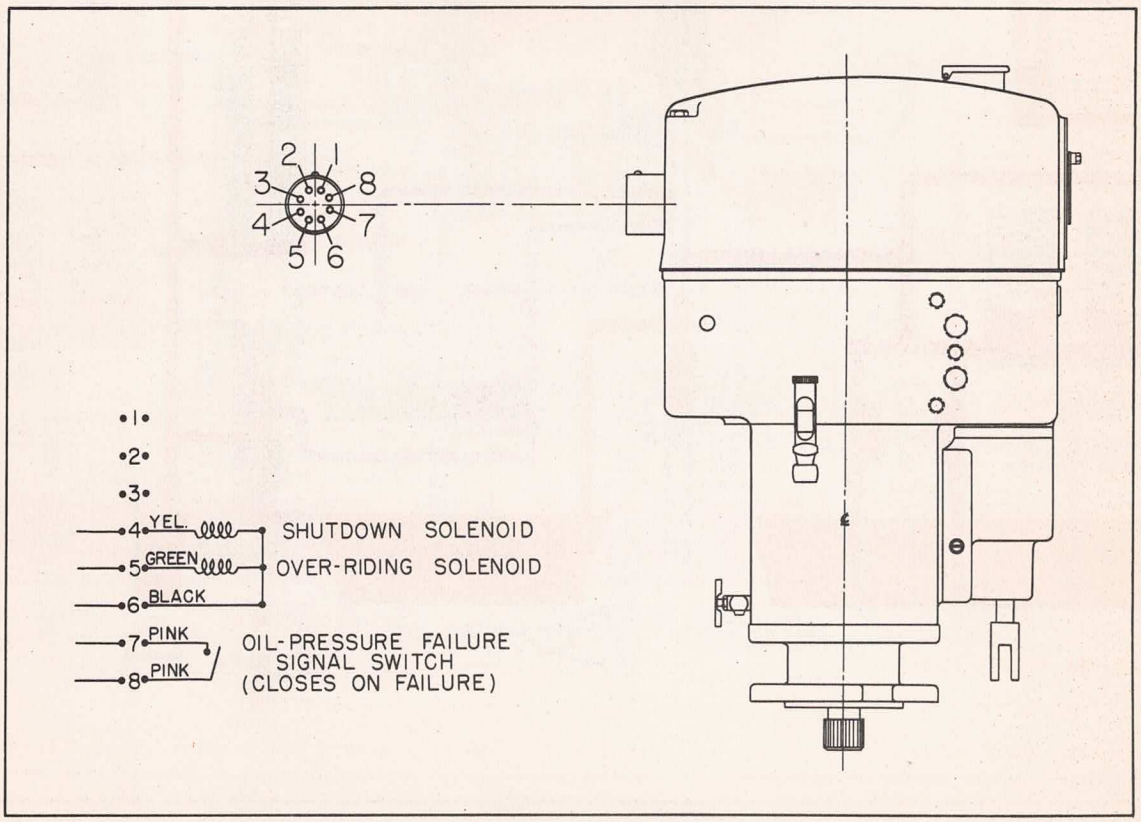

Cut No. 9

Schematic Diagram for PG Locomotive Governor with Pneumatic-Hydraulic Control



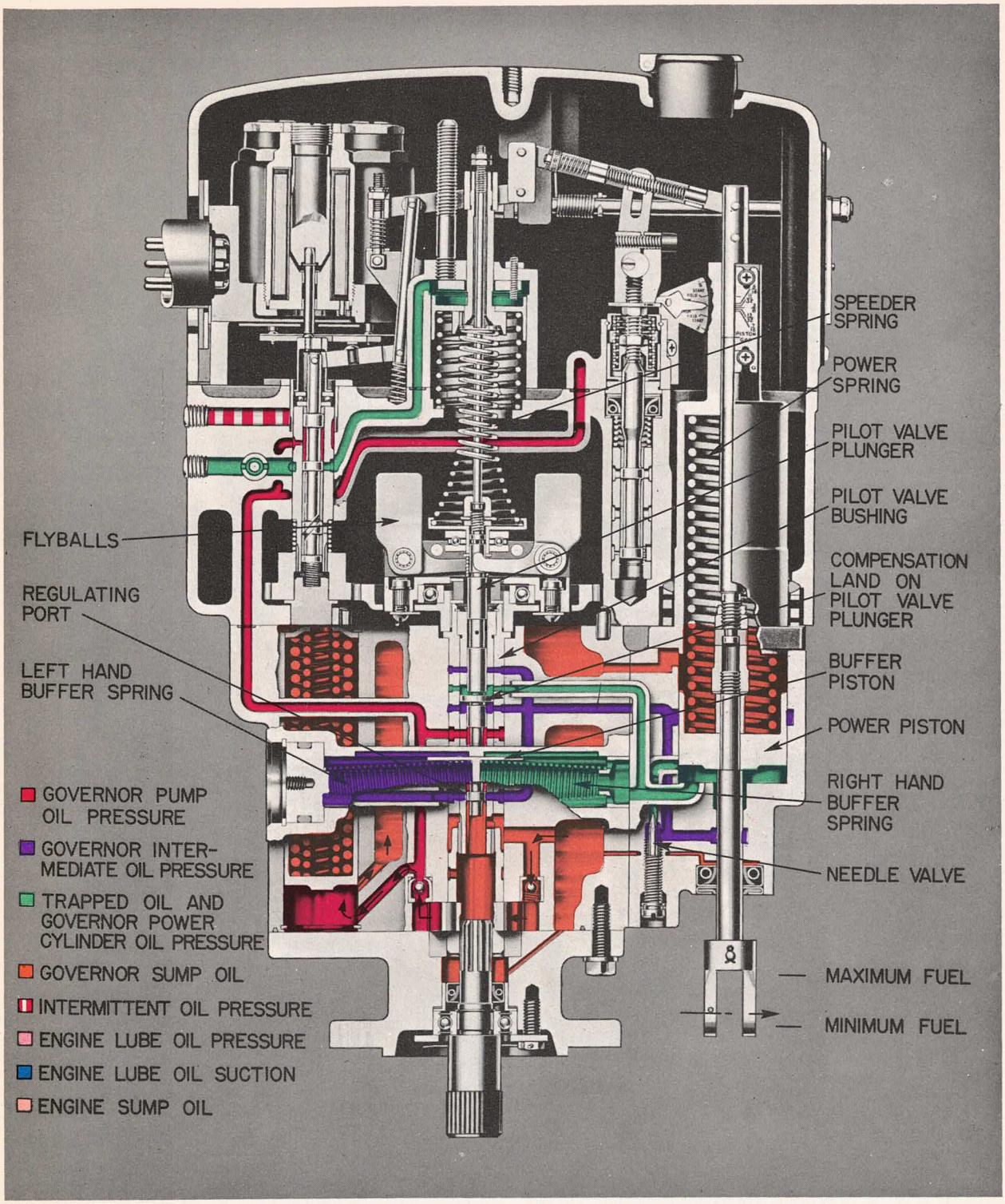

Cut No. 10

**Wiring Diagram for Governor with Electro-Hydraulic Speed Adjustment**




Cut No. 11

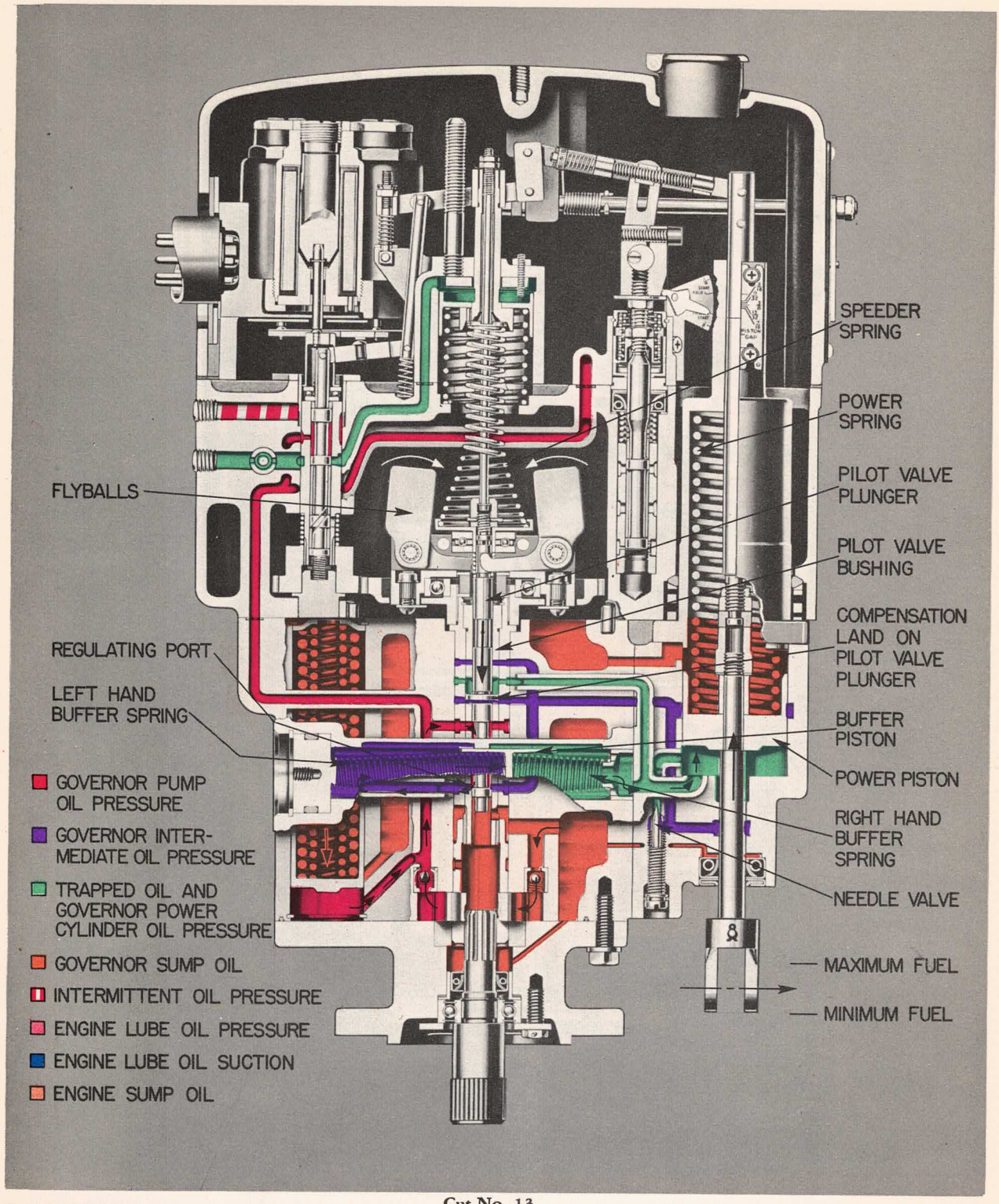
**Wiring Diagram for Governor with Pneumatic-Hydraulic Speed Adjustment**




Cut No. 12

**EQUILIBRIUM CONDITION:**

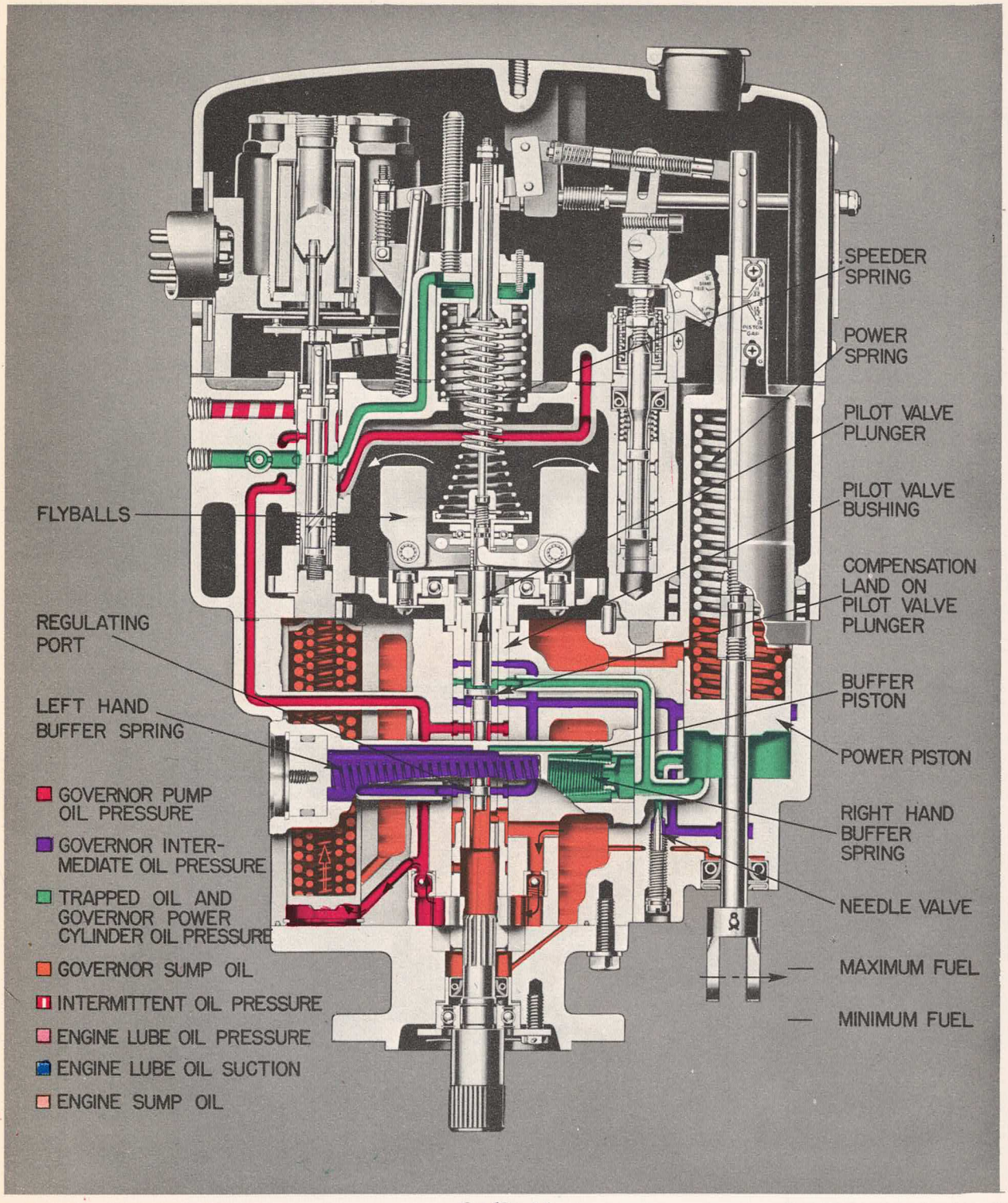
1. Assume that the engine is running at normal speed under a small steady load.
2. The flyballs are in a vertical position and the pilot valve plunger is centered with its control land covering the regulating port in the rotating pilot valve bushing.
3. The buffer piston is centered. The forces of the two springs which oppose it are equal and the intermediate and power cylinder oil pressures are therefore equal.
4. The power piston is stationary near minimum load position.




Cut No. 13

**LOAD INCREASE:**

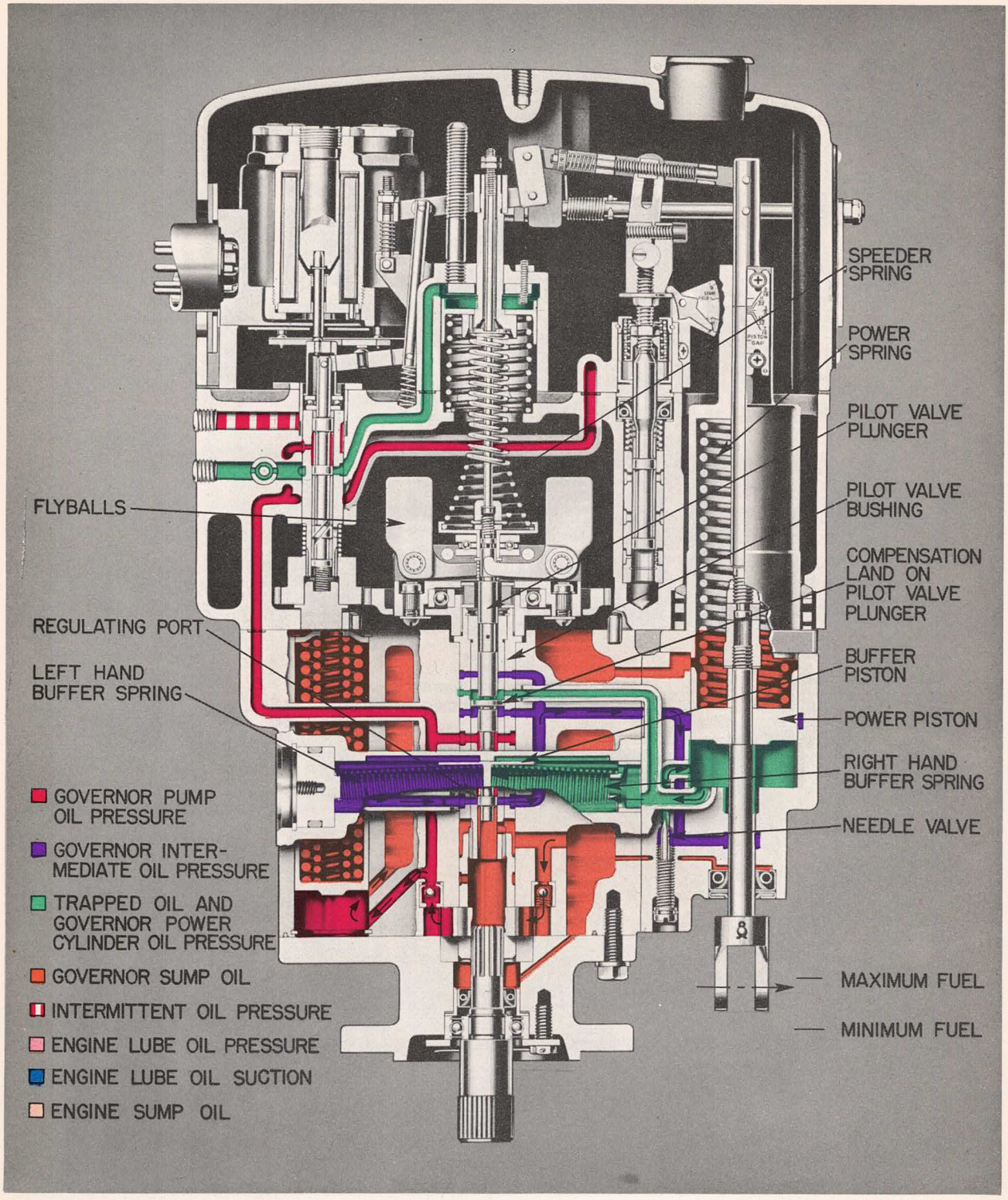
1. Load is increased and speed decreases.
2. As speed decreases, the flyballs move in, lowering the pilot valve plunger and uncovering the regulating port in the pilot valve bushing.
3. The opened regulating port admits pressure oil to the buffer piston area, causing the buffer piston to move to the right and to transfer an equal volume of oil to the power cylinder, forcing the power piston up in the direction to increase fuel.
4. As the power piston moves up, the buffer piston is forced in the direction of oil movement, from pilot valve to power cylinder, which compresses the right hand buffer spring and relieves the left hand spring.
5. The buffer piston movement against its springs produces an intermediate oil pressure which is higher than the power cylinder oil pressure by an amount proportional to the buffer piston displacement.




Cut No. 14

**LOAD INCREASE (CONT'D):**

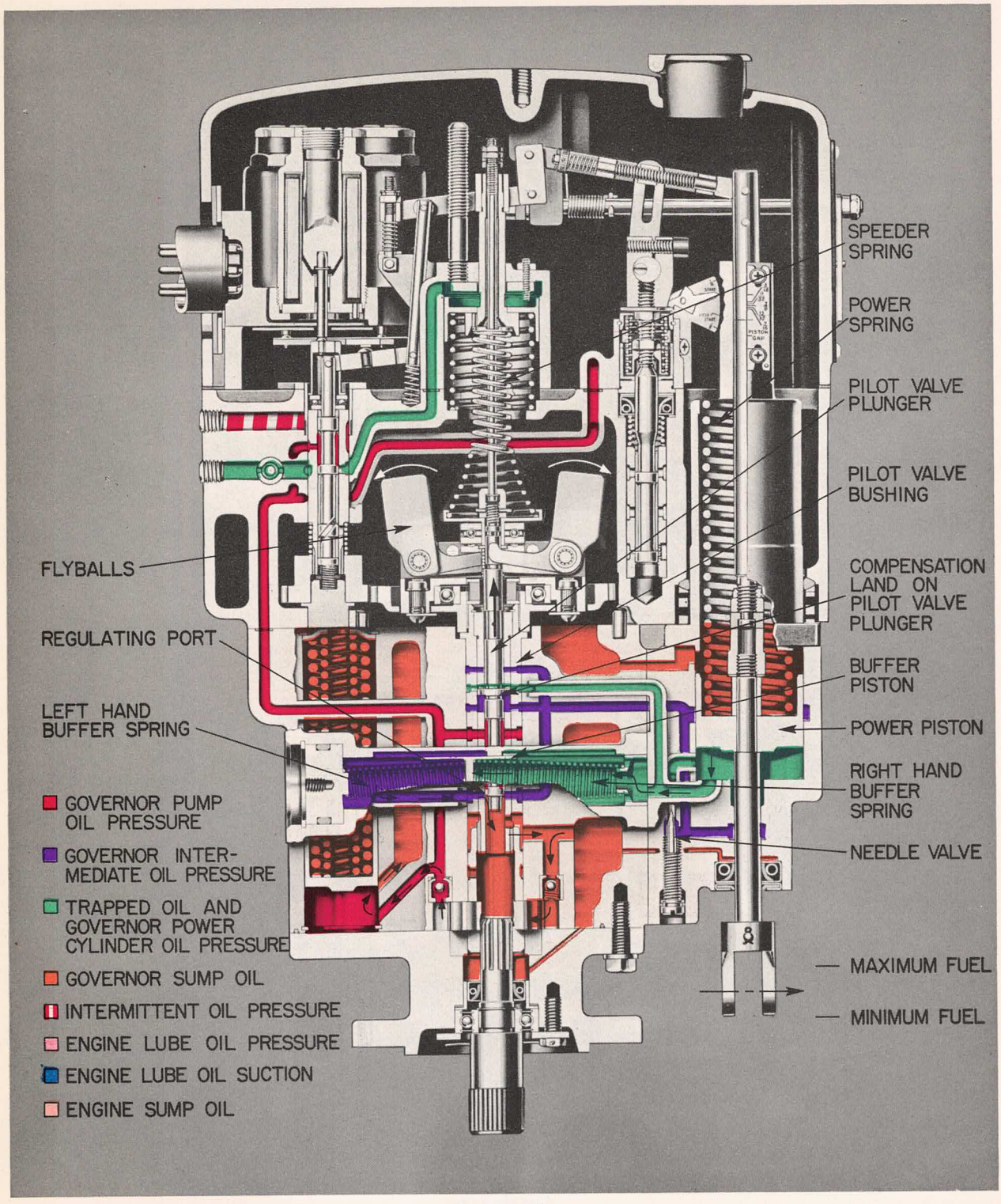
6. The compensation land on the pilot valve plunger is acted on by the intermediate and power cylinder oil pressures. The higher intermediate oil pressure existing momentarily in the fuel increase movements being discussed causes a force upward on the compensation land which increases until it (added to the upward force of the flyballs) overcomes the speeder spring and forces the pilot valve plunger up enough to cover the regulating port.
7. As soon as the regulating port is covered, the power piston is stopped at a position corresponding to the increased amount of fuel required to operate the engine under the new larger load.
8. As the speed increases to normal, the upward force of the flyballs will increase.




Cut No. 15

**LOAD INCREASE (CONT'D):**

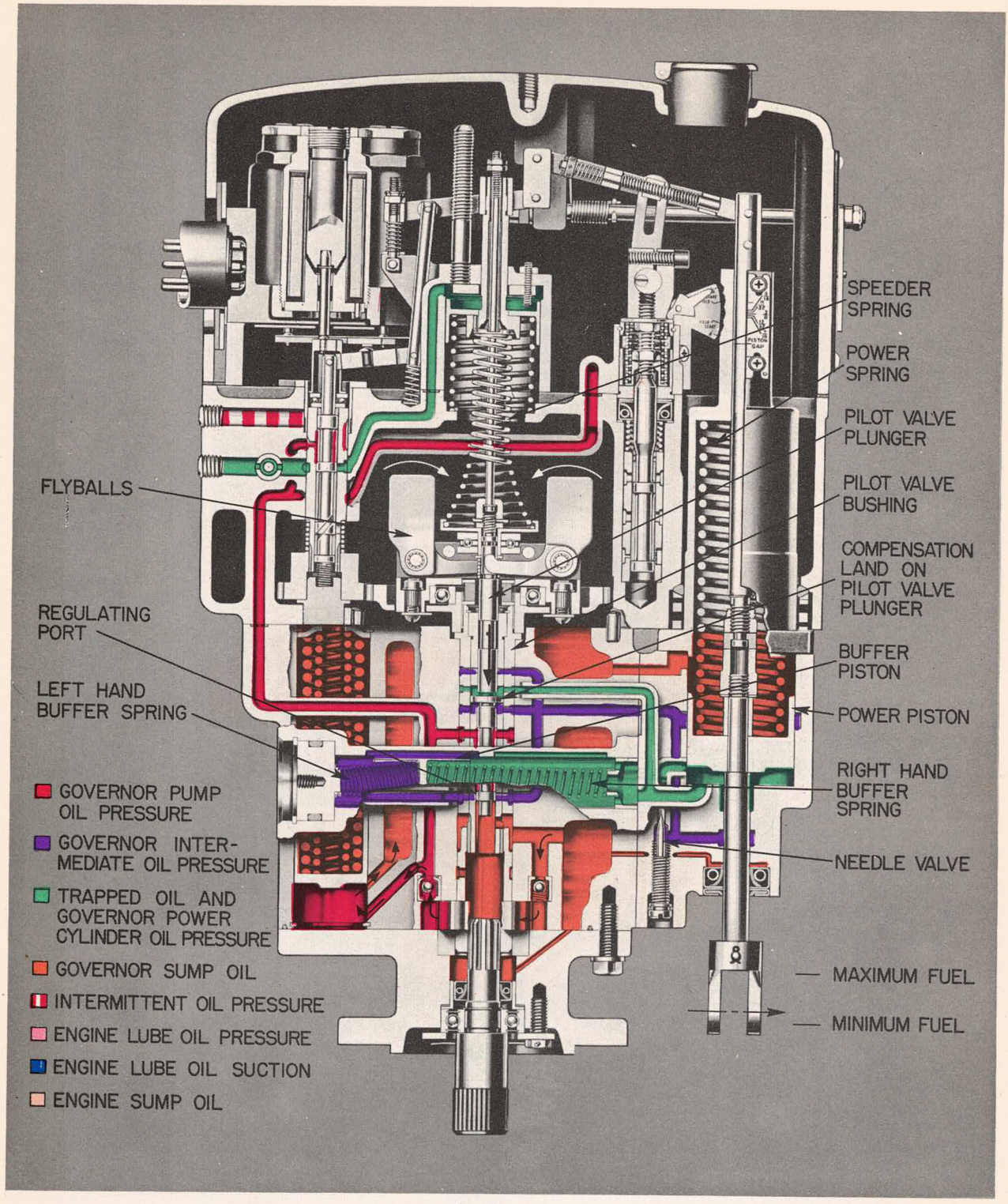
9. The buffer piston is returned to center by its controlling springs as oil flows through the needle valve, causing the intermediate oil pressure to decrease until it again is equal to the power cylinder oil pressure. The needle valve setting will determine the rate at which the pressures equalize. This rate must be set to correspond with the speed recovery rate of the engine so the decrease of upward force on the compensation land will occur at the same rate as the increase in engine speed, thus keeping the regulating port in the bushing covered by the control land on the plunger and holding the power piston stationary. The engine speed will now have returned to normal.
10. The upward movement of the power piston raised the load control pilot valve plunger, and as explained on pages 20 and 21, the load control mechanism has been slowly reducing the load on the engine until it is correct for the existing speed setting. The load control pilot valve plunger will recenter as the power piston returns to its original position. This action is not shown in the cut above.




Cut No. 16

**LOAD DECREASE:**

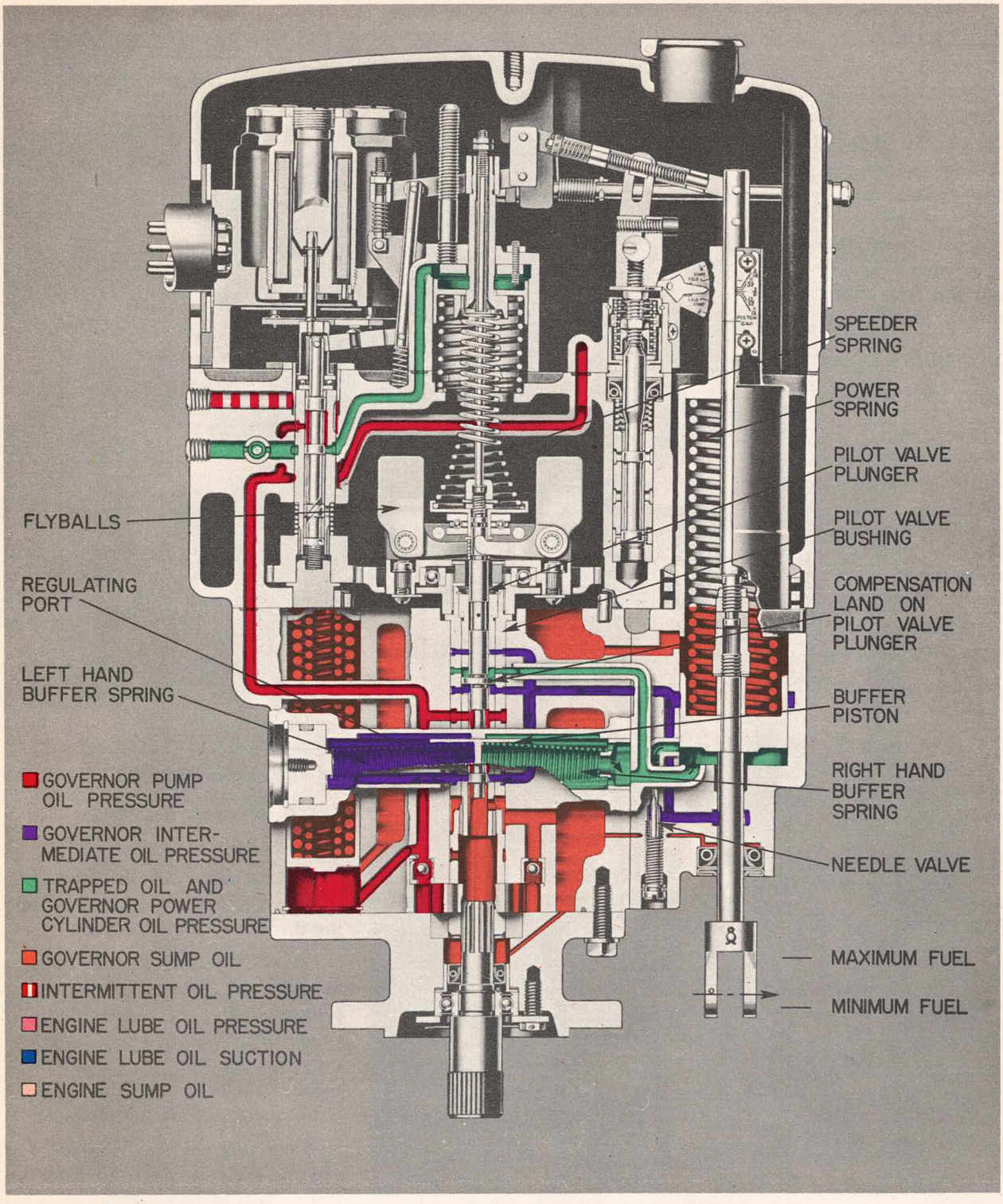
1. The load is decreased and the speed increases.
2. As the speed increases, the flyballs move out, raising the pilot valve plunger and uncovering the regulating port in the pilot valve bushing.
3. The opened regulating port opens the area to the left of the buffer piston to sump and allows the power spring to force the power piston down in the direction to decrease fuel.
4. As the power piston moves down, the buffer piston is forced in the direction of oil movement, from power cylinder to pilot valve, which compresses the left hand buffer spring and relieves the right hand spring.
5. The buffer piston movement against its springs produces an intermediate oil pressure which is lower than the power cylinder oil pressure by an amount proportional to the buffer piston displacement.




Cut No. 17

**LOAD DECREASE (CONT'D):**

6. The decreased intermediate oil pressure, now existing, causes a force downward on the compensation land on the pilot valve plunger which increases until it (added to the downward force of the speeder spring) overcomes the force of the flyballs and forces the pilot valve plunger down enough to cover the regulating port.
7. As soon as the regulating port is covered, the power piston is stopped at a position corresponding to the decreased fuel requirements for the engine under the new smaller load.
8. As the speed decreases to normal, the upward force of the flyballs will decrease.




Cut No. 18

**LOAD DECREASE (CONT'D):**

9. The buffer piston is returned to center by its controlling springs as oil flows through the needle valve, causing the intermediate oil pressure to increase until it again is equal to the power cylinder oil pressure. The needle valve setting establishes this rate to match the speed loss rate of the engine so the increase in upward force on the compensation land will occur at the same rate as the decrease in engine speed, thus keeping the regulating port in the bushing covered by the control land on the plunger and holding the power piston stationary. The engine speed will now have returned to normal.

10. The downward movement of the power piston lowered the load control pilot valve plunger and, as explained on pages 20 and 21, the load control mechanism has been slowly increasing the load on the engine until the load is correct for the existing speed setting.

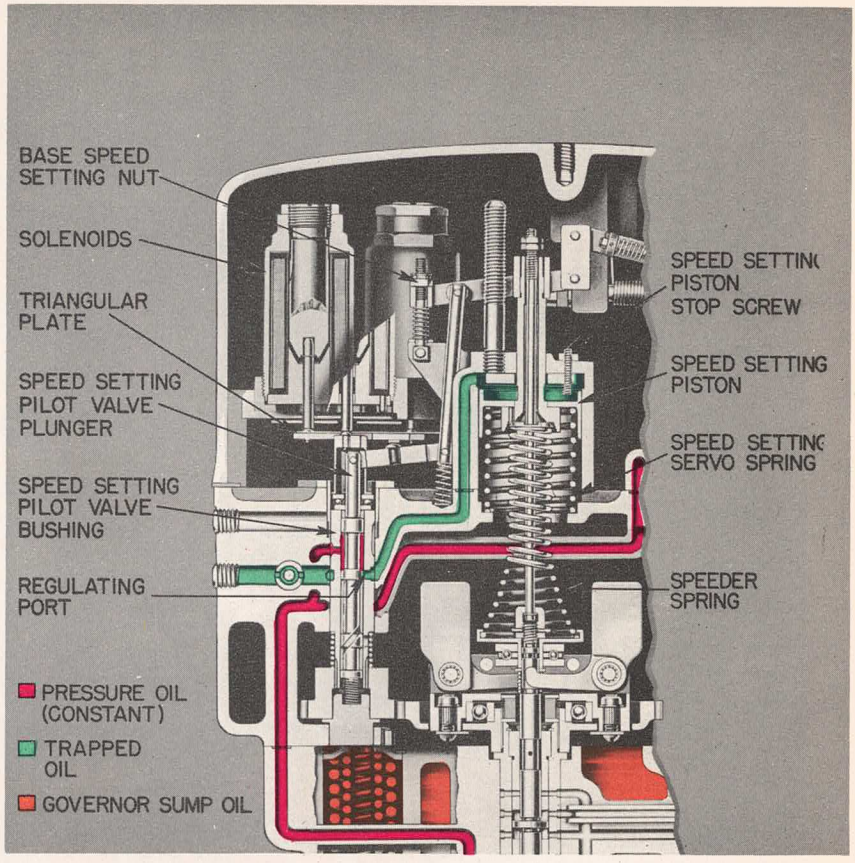
**ELECTRO-HYDRAULIC SPEED CHANGING:** Three solenoids "A", "B", and "C" acting on the triangular plate and speed setting pilot valve, and one solenoid "D" acting on the pilot valve bushing are used to effect changes in speed setting. The speed setting pilot valve positions a speed setting piston which varies the amount of spring load acting against the governor flyballs. (see cut No. 8). The action is as follows:

**EQUILIBRIUM CONDITION:**

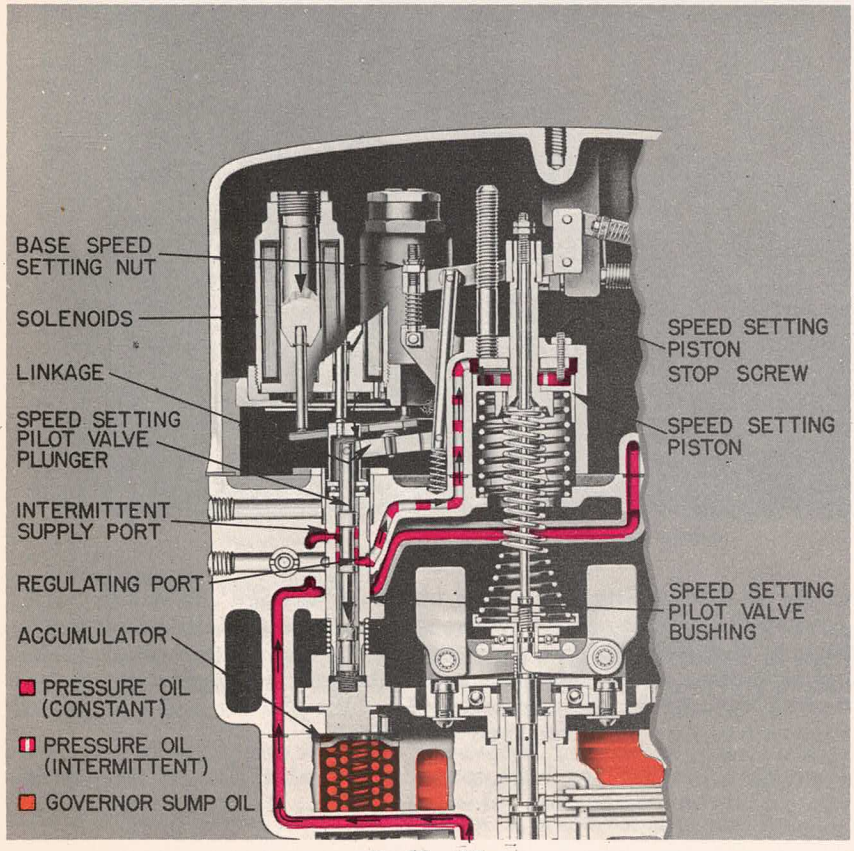
**Cut No. 19**

1. The engine is running at low speed as indicated by the speed setting piston being in its upper position.

2. The speed control valve plunger is centered with its land completely covering the control port thus trapping oil in the area above the speed setting piston and maintaining it in a fixed position for a certain speed setting.




Cut No. 19




Cut No. 20

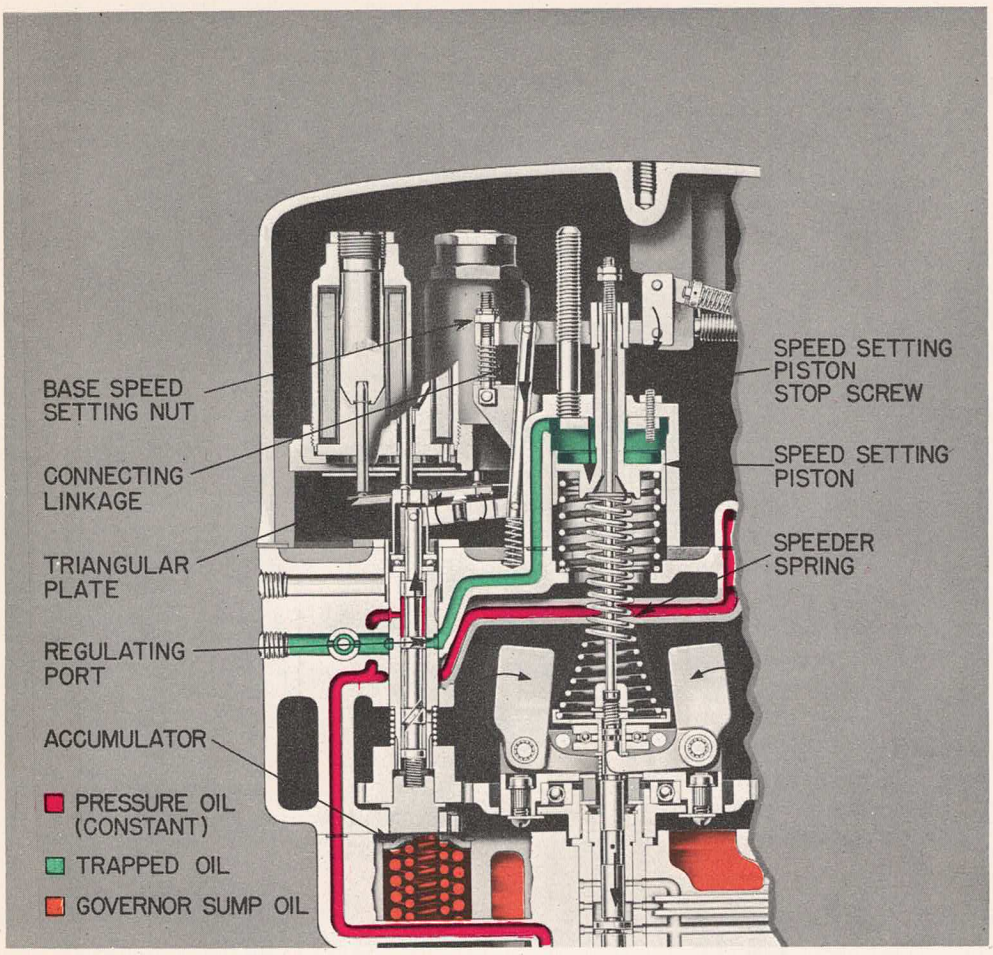
**SPEED SETTING INCREASE:**

**Cut No. 20**

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

2. The solenoid, or solenoids, pushes down the linkage and speed setting pilot valve plunger, displacing the pilot valve control land. This will allow oil pressure from the accumulators to pass through the regulating port to the area above the speed setting piston.

Note that the oil from the accumulators goes through an intermittent supply port in the rotating speed setting pilot valve bushing which retards the rate at which the oil is supplied to the valve. This port is sized to allow the speed setting piston to move full stroke in a certain number of seconds, instead of instantaneously. Thus, the rate at which speed may be increased is definitely limited under all conditions of operation.




Cut No. 21

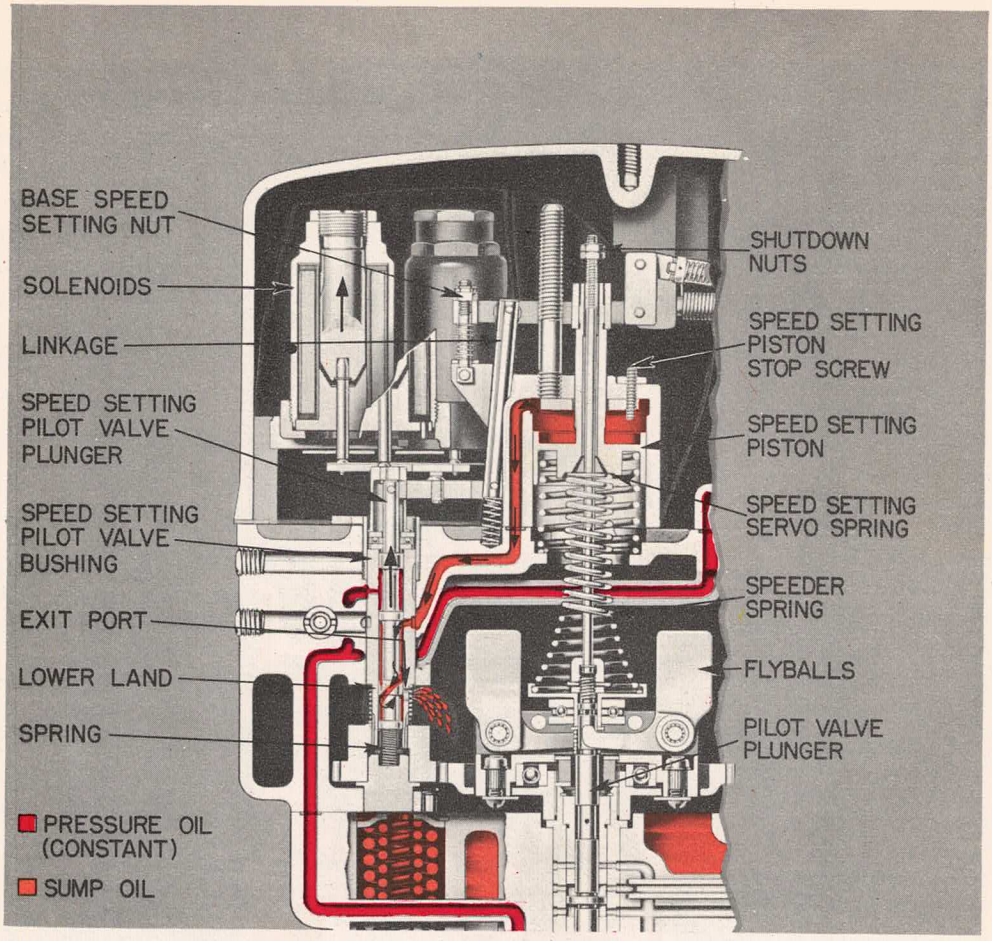
**SPEED SETTING INCREASE (CONT'D): Cut No. 21**

3. The speed setting piston is forced down by the oil pressure, compressing the speeder spring, and moving the flyballs inward.

4. At the same time the connecting linkage between the piston and pilot valve plunger restores the plunger to its centered position, closing the port, and stopping the piston at the proper position.

In other words, the speed setting piston will assume a definite position for each triangular plate position, resulting in a definite speed setting change.

Since the fly balls moved inward when the speeder spring force was increased, the governor will act to increase fuel as shown in Cuts No. 13 through No. 15 resulting in an increased engine speed.




Cut No. 22

**SPEED SETTING DECREASE: Cut No. 22**

1. One or a combination of the three solenoids are now de-energized by moving the throttle to a lower step.

2. The linkage and speed setting pilot valve plunger will then be pushed up by the spring under the plunger, opening the area above the speed setting piston to sump as shown.

3. The speed setting piston would then be pushed up by the speed setting servo spring, reducing the speed setting by reducing the speeder spring force, and allowing the flyballs to move outward.

4. As the piston moves upward it will, through the linkage, restore the plunger to its original position with closed ports.

5. The piston will thus assume a position of reduced speed setting.

Since the flyballs would move outward when the speeder spring force was reduced, the governor will act to reduce fuel as shown in Cuts No. 16 through No. 18.

The speed reduction shown is for change of two or more throttle steps and the oil is free to pass by the lower land of the plunger through the exit port and allow an instantaneous reduction of speed setting.

The lower land normally overlaps the exit port and is slightly undersized in diameter. Therefore, when a speed reduction of one controller step is made, the exit port is not opened and the oil must leak past the land. Consequently, the rate at which speed setting is reduced when a one step reduction is made is quite slow.

**"D" SOLENOID:** A fourth solenoid "D" as shown in Cut No. 8 acts on the speed setting pilot valve bushing (opposed by the spring under the bushing). The result of its movement is opposite to that of the "A", "B", and "C" solenoids.

When this solenoid is energized, the bushing will move down opening the port to drain to decrease speed. The port is closed by mechanical restoring of the plunger land as the speed setting piston moves to a lower position. Likewise, if this solenoid were de-energized, the bushing would be moved up by the spring, opening the area above the speed setting piston to pressure, and resulting in a speed increase. When used in combination with the three "A", "B", and "C" solenoids, a large combination of speed settings is obtained.

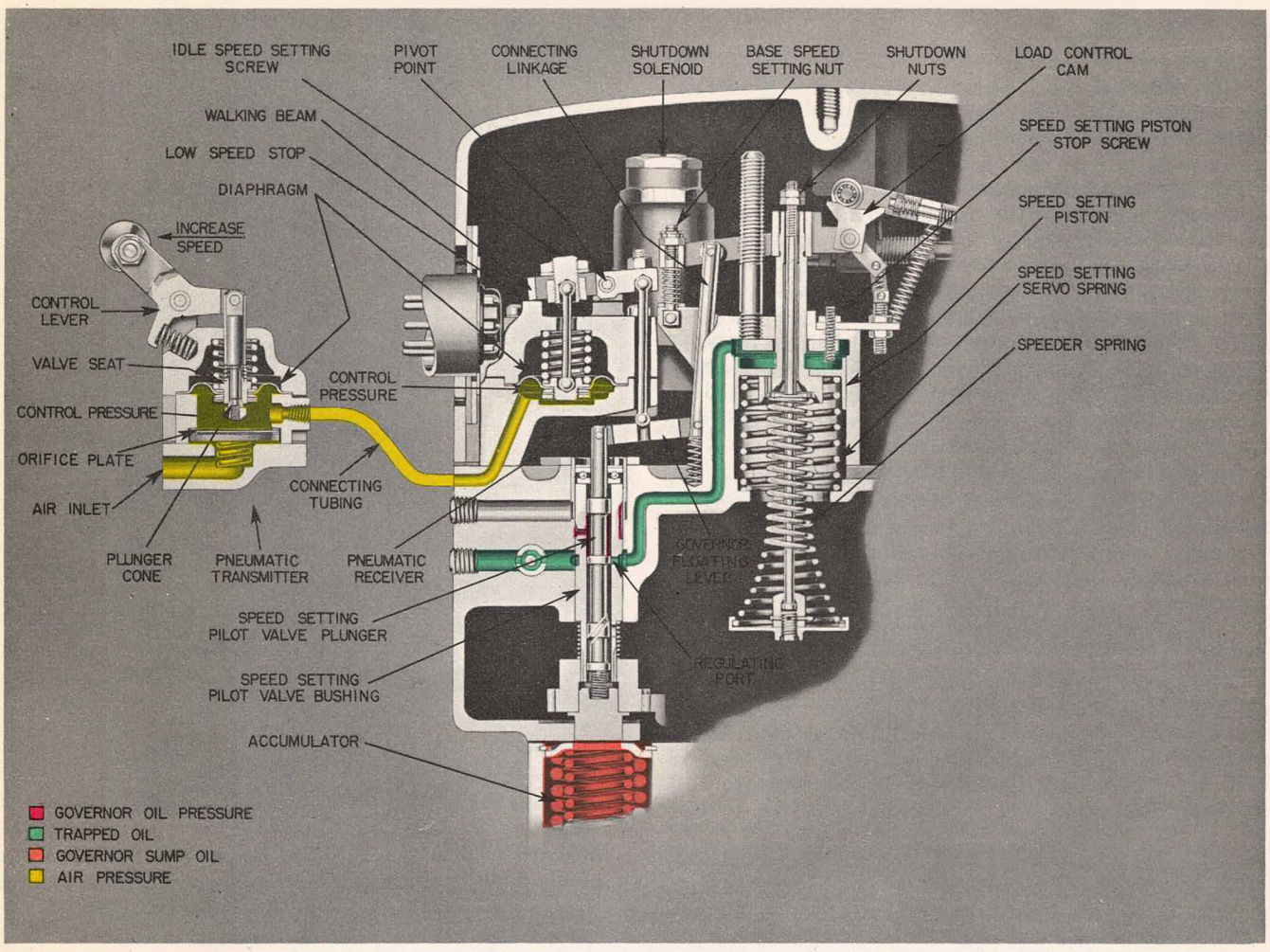
**LOW SPEED SHUTDOWN:**

1. When the throttle is moved to the "STOP" position, the speed setting pilot valve plunger rises and dumps the oil from the speed setting servo.

2. The speed setting piston moves up, contacts the shutdown nuts and continues moving up until it touches the speed setting piston stop screw.

3. As the piston moves up, after contacting the shutdown nuts, it lifts the pilot valve plunger with it.

4. This permits the governor power cylinder to dump oil and the power piston moves down closing off the fuel supply to the engine.




Cut No. 23

## PNEUMATIC-HYDRAULIC SPEED CHANGING:

### Cut No. 23

For pneumatic-hydraulic control, a pneumatic receiver replaces the "A", "B", "C", and "D" 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.

Locomotive control air is passed through a filter and is admitted to the transmitter through an orifice. 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 transmitter, so with changes in the control pressure the receiver takes positions corresponding to those taken by the transmitter cone. By means of the walking beam, receiver movement is relayed to the lower floating lever, producing changes in speed setting in the same manner as is accomplished by action of the solenoids of the Electro-Hydraulic governor.

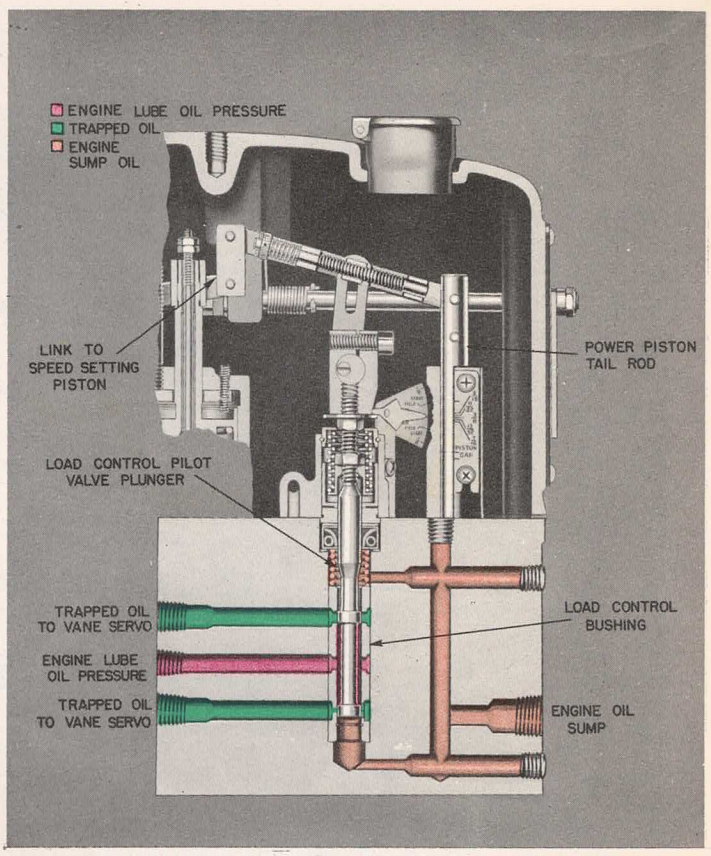
## LOAD CONTROL:

A load control pilot valve, shown in Cuts 24, 25 and 26, is provided to position a vane type load control servomotor. This servomotor may be entirely separate from the governor and connected to it by tubes, or it may be built as a part of the governor, in which case it is referred to as an integral servomotor. This servomotor turns a rheostat which changes excitation of the generator and thus changes the load on the engine.

If the servomotor is mounted separate from the governor, oil to operate it is supplied to its pilot valve either from the engine lubricating oil system or from the governor oil pump, as specified by the locomotive manufacturer. If the servomotor and rheostat are integral with the governor, oil is always taken from the governor pressure system.

As will be seen from the explanations given below, the effect of this mechanism is to cause the engine to produce a certain definite amount of power for each particular speed setting. Governors are built either with a simple link and lever arrangement, shown in Cuts 24 and 25, or with a cam, shown in Cut 26, to determine the amount of power produced at each speed setting.

The maximum rate of movement of the load control servomotor is limited on some governors by the size and number of ports in the load control pilot valve bushing. On other governors, where it is desired to have the maximum rate different in the increase and decrease directions, the arrangement shown in Cut



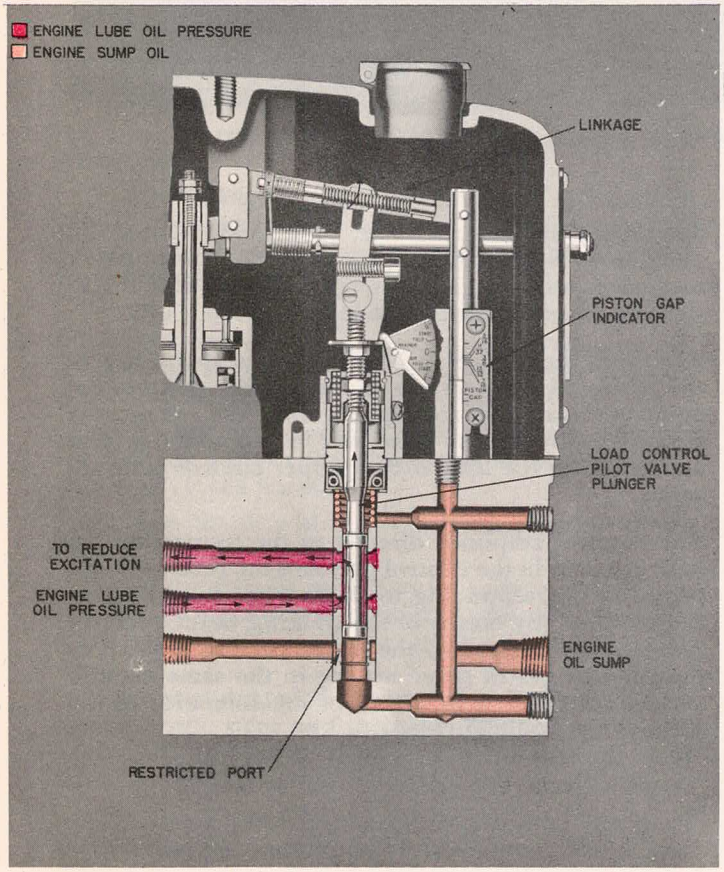

Cut No. 24

No. 26 is used in addition to somewhat restricted ports in the bushing. This consists of a double, spring loaded, ball check valve, the balls being held off their seats by needles. Adjusting these needles changes the rate of movement in the two directions. In some cases this needle and ball valve is mounted on the side of the governor, and in other cases it is built inside the governor.

Any combination of the above may be furnished, as specified by the locomotive manufacturer, that is, integral or separate load control servomotor, engine oil or governor oil to operate it, link and lever or cam and lever to operate the pilot valve plunger, and restricted porting or the double check valve to limit the rate of servomotor movement.

When governor oil pressure is used to operate the load control servomotor, a load control oil supply valve, shown in Cut No. 26, is used to serve two purposes. When cranking the engine and governor oil pressure is building up, the supply valve remains closed, so that all the oil delivered by the governor pump is available to lift the servomotor and open the fuel pump racks. After the engine starts, the governor oil pressure increases and the oil supply valve opens, permitting the load control mechanism to function as required. There is always a definite pressure drop across this valve, and in some locomotives this reduced pressure is used to further slow down the travel of the load control servomotor.

The sequence of operations in controlling the load is the same regardless of what combination of the above equipment and arrangement is used.




Cut No. 25

**LOAD INCREASE:**

1. Cut No. 24 shows the load control pilot valve in its centered position. This is because the engine is now carrying exactly the right amount of load for its present speed setting. The train is in motion. The engineer does not change the speed setting, but for some reason the load on the engine increases. (Many things can change the load on the engine — for instance, the train could start up a grade so that the traction motors would slow down and thus draw more power).

2. This added load causes the engine to slow down and the governor starts moving its servomotor piston to open the racks to give the engine more fuel. This is the regular speed governor action that was described on pages 10 through 12. This is indicated by the fuel position indicator on the governor cover, and in the cuts here can be seen on the piston gap indicator.

3. In Cut No. 25 the piston has reached its new position needed to bring engine speed back to normal. The engine is now carrying more load than it should for the present speed setting, and this may damage the engine, generator, or both. In Cut No. 25, this upward movement of the piston has raised the right end of the linkage attached to the power piston tail rod and this has raised the load control pilot valve plunger above center.

4. Oil now flows through the pilot valve from the engine lubricating oil system (in this particular case) to the load control servomotor (external in this particular case) and starts turning it in the direction to reduce excitation, and thus reduce the load on the engine.

5. As soon as the load starts to reduce, the speed of the engine rises a little, and the governor starts reducing the fuel supplied to the engine, by moving its power piston in the direction to close the racks. This is also normal speed governor action, previously described.

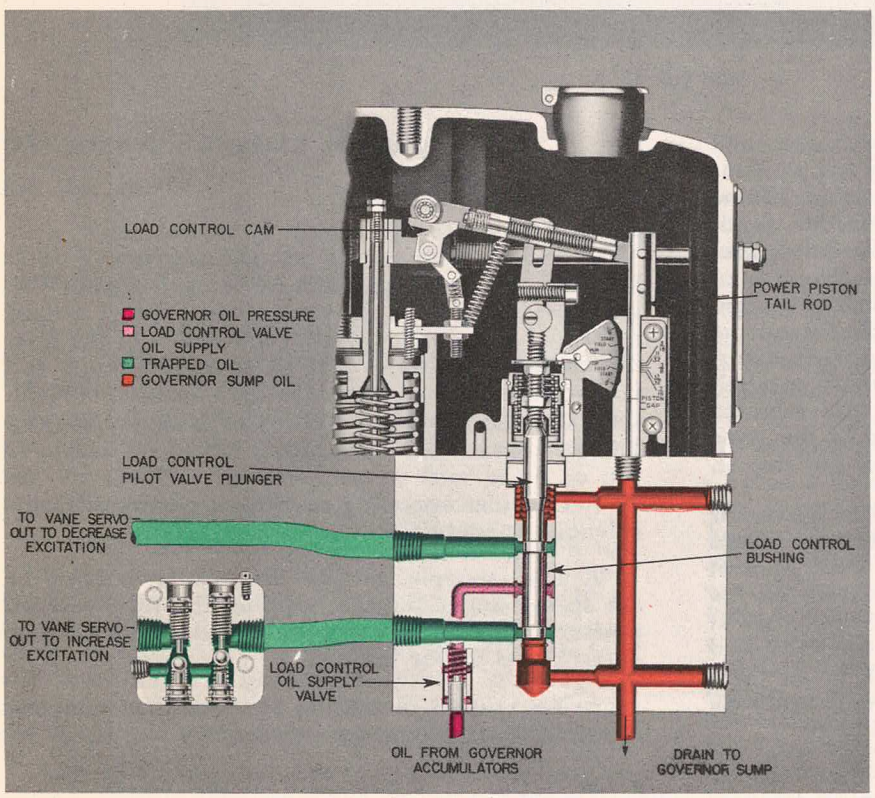
6. This downward movement of the power piston and reducing of generator excitation continue until the power piston tail rod has lowered the right end of the linkage to the point where the load control pilot valve plunger again covers the ports in its bushing. This stops the movement of the load control servomotor. Since the speed governor acts much faster than the load control mechanism, the engine speed will also have come back to normal, stopping the servomotor movement.

7. In this condition, the parts of the governor are again in the positions shown in Cut No. 24. The speed is normal, the load is correct for the particular speed setting, but the excitation has been reduced to keep the load down to this correct value.

**LOAD DECREASE:**

If the engineer does not change the speed setting of the governor, but for some reason the load decreases, the action is just the reverse of that described above.

The decrease in load will cause the engine speed to rise a little, and the governor servomotor will move to reduce the fuel to the engine. This will lower the right end of the linkage which will lower the load control pilot valve and start the load control servomotor moving in the direction to increase excitation.



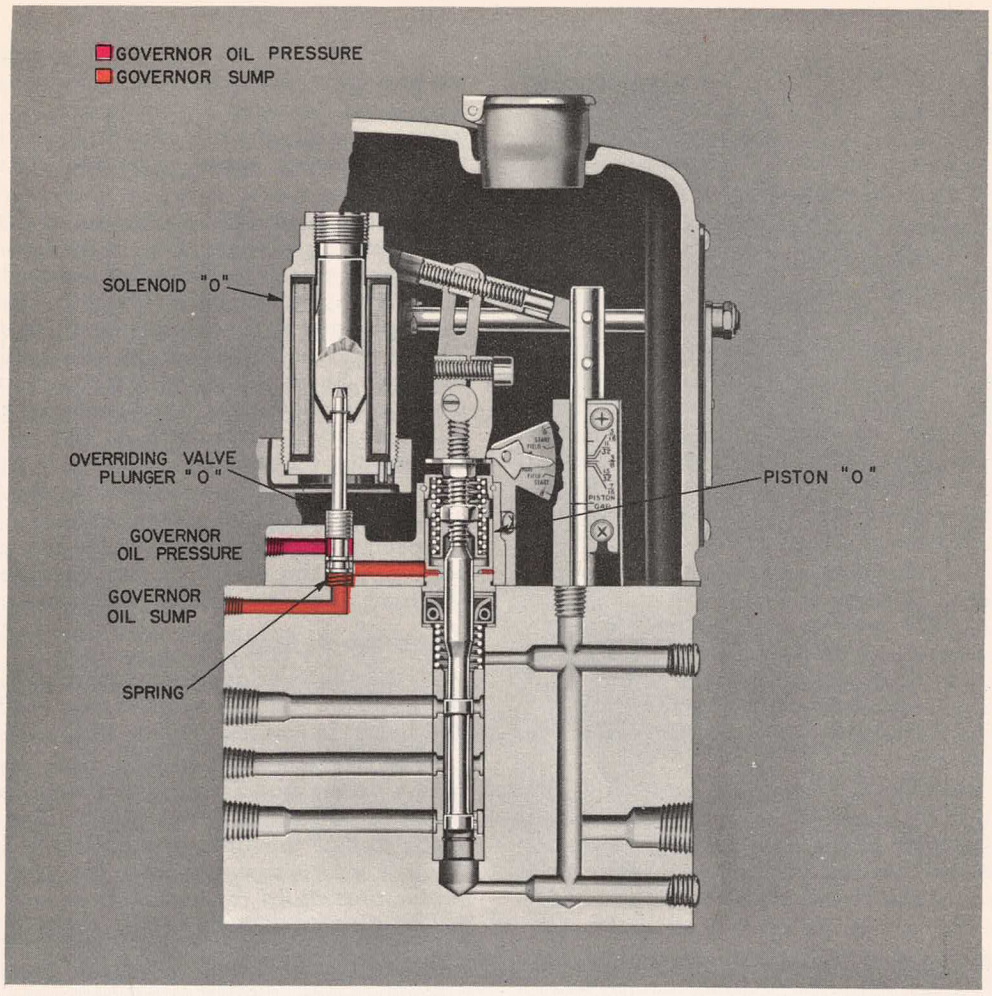

Cut No. 26

This will cause the engine to slow down a little below the speed for which its governor is set, and the servomotor will move to give the engine more fuel. This upward movement of the servomotor piston will raise the load control pilot valve until it covers the ports in the load control pilot valve bushing. The engine is again carrying the correct amount of load for its speed setting.

The load control servomotor moves much slower than the speed governor servomotor, so there is no overtravel, which would result in hunting.

**SPEED CHANGE:**

If the engineer moves the throttle to change the engine speed, the movement to the speed setting piston raises or lowers the left end of the linkage, and this raises or lowers the load control pilot valve plunger. The governor servomotor moves to a new fuel position to bring the engine speed to its new value. In a similar manner to that described above, this causes the load control servomotor to change the excitation so the engine will carry the correct amount of load at the new speed.




Cut No. 27

**TRANSITION:** The electrical characteristics of the unit, and the type of service, determine whether or not transition is used. The example given here describes one system now in use. Transition is the changing of the traction motor connections to obtain the desired locomotive tractive effort and speed within the voltage and current operating limits of the main generator. When changing from series parallel shunt to parallel, excitation must be reduced to a very low value to lengthen the life of the switchgear and at the same time give almost complete unloading of the engine.

During this period of reduced load, the governor power piston would normally cut off fuel to reduce overspeed and this would lower the load control pilot valve plunger below center, resulting in the vane servo traveling toward maximum excitation at maximum rate. If load would then be re-established by restoring excitation, there would be be an overload due to excess excitation which would continue until the vane servo reaches proper position.

To avoid this overload, the overriding assembly is incorporated in the governor load control arrangement. It operates as follows:

**OVERRIDING ASSEMBLY:**

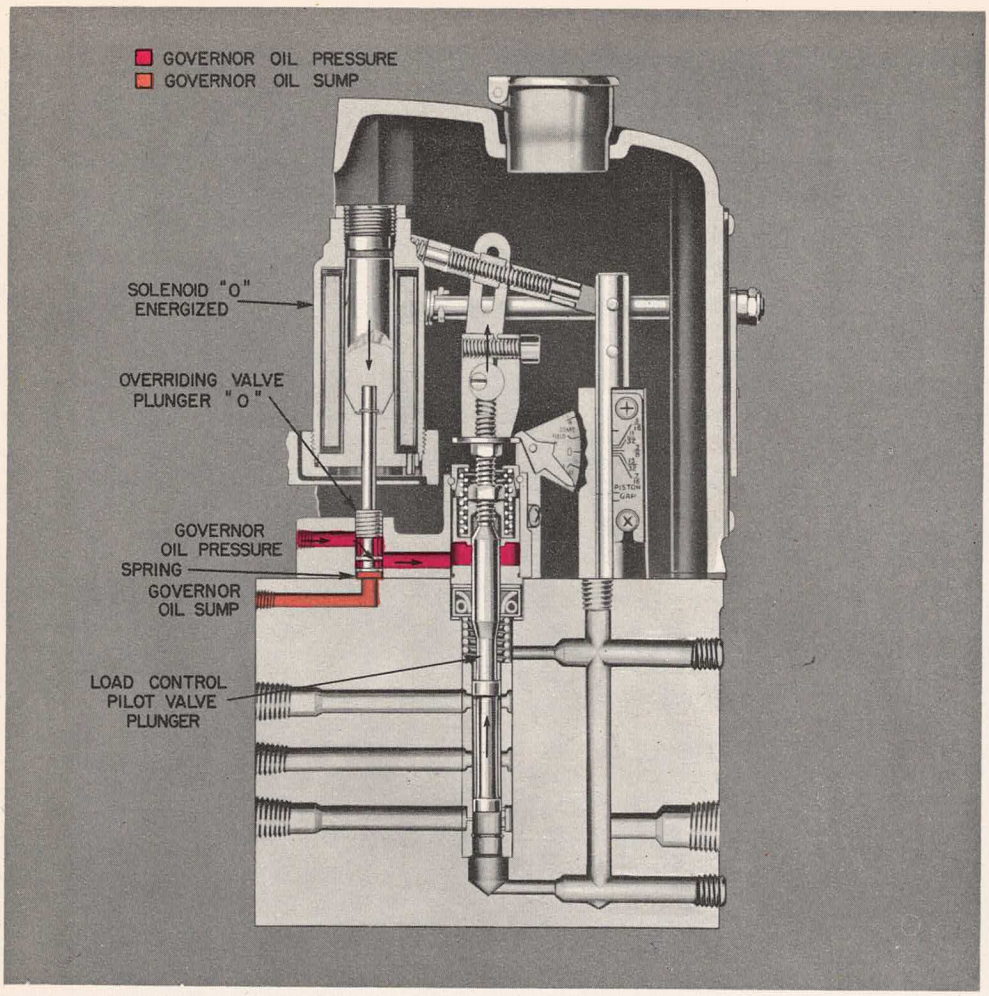
**Cut No. 27**

Solenoid "O", overriding valve "O", and piston "O", are provided to force the vane servo to travel toward decreased excitation while the transition of the traction motors from series parallel shunt to parallel and vice versa is taking place. On the transition control, these changes would be from step 2 to step 3, or step 3 to step 2.

1. Consider operating conditions normal with the solenoid de-energized.

2. The valve plunger "O" is normally held up by the spring under it, thus trapping the supply of oil pressure from the governor accumulators above the control land on the plunger.

3. The areas beneath the piston and plunger are open to drain to the governor oil sump.




Cut No. 28

**OVERRIDING ASSEMBLY (CONT'D):**

**Cut No. 28**

4. When transition occurs, the solenoid is automatically energized by the battery field contactor and the valve plunger is moved down.

5. Governor oil pressure will then pass above the control land on the plunger and under the overriding piston.

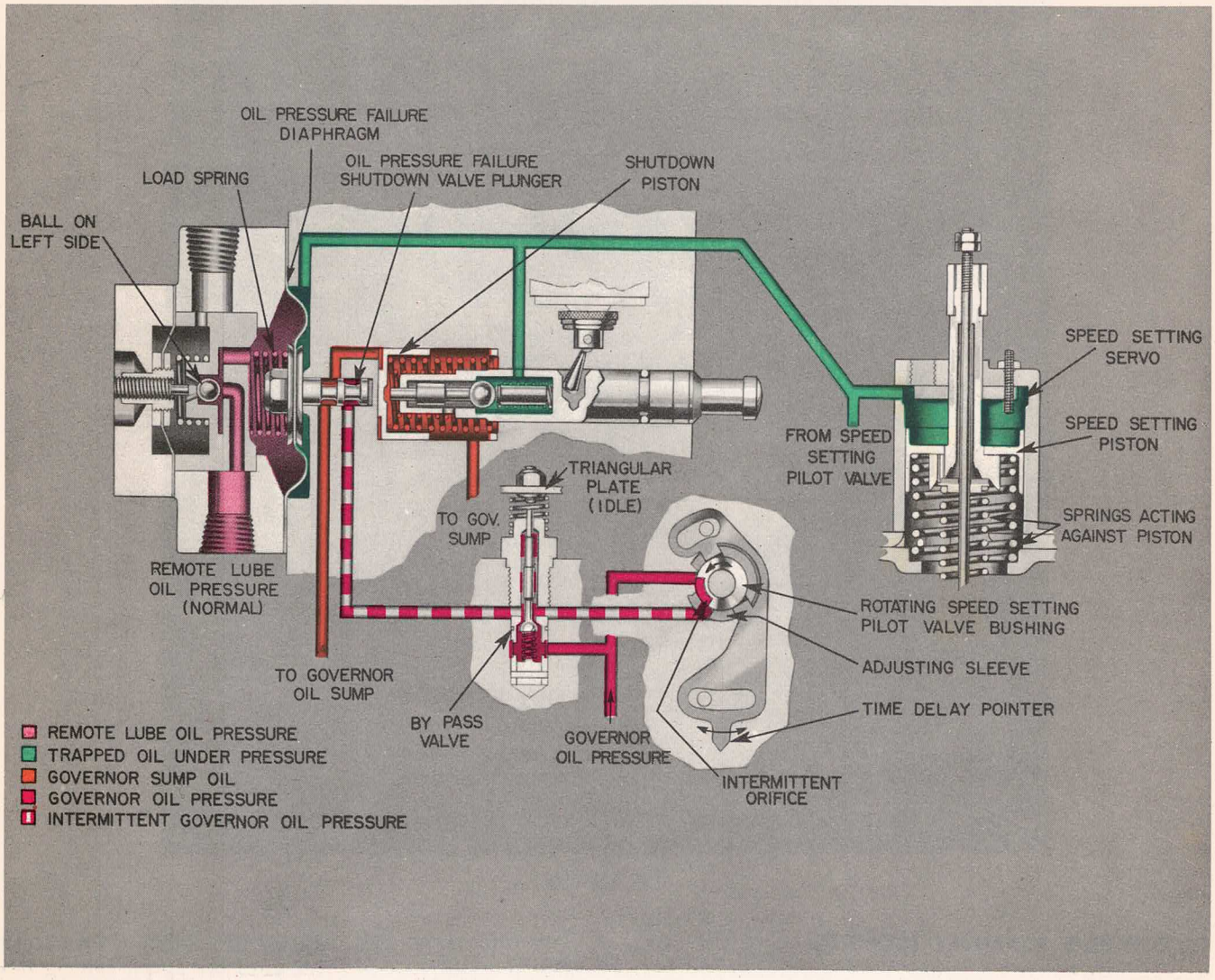
6. The load control pilot valve plunger will then be picked up by the piston and, as illustrated in Cuts No. 24 and No. 25, will cause a flow of oil to the vane servo which will reduce excitation.

7. When the transition has taken place, the solenoid will be automatically de-energized by the battery field contactors and the valve plunger "O" will be pushed back up by the spring to normal position as shown in Cut No. 27. This movement of the plunger will drain the area beneath the piston, allowing the load control pilot valve plunger to be positioned by the floating lever as explained on pages 20 and 21.

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 valve plunger is set to be above center when the speed setting and fuel racks are at "Idle". The vane servo will then go to minimum excitation position and remain there until the speed setting has been increased enough to drop the load control valve plunger below center. This results then, in minimum load for the first two speed steps.

If arranged for "Maximum Field Start", the load control valve plunger is set to be below center with the speed setting and fuel racks at "Idle". The vane servo will then go to maximum excitation position, so that when the throttle is moved to "Step 1" the load will build up, until the main power piston increases the fuel supply, and centers the load control valve plunger.

Under some conditions the over-riding assembly may be employed to over-ride this action. This is done by setting the load control valve plunger for "Maximum Field Start", but having the Over-Riding Solenoid energized at idle, thus lifting the valve to "Minimum Field Start" position. On entering Step No. 1, the load control will be at minimum, but will tend to advance towards maximum. The vane servo will stop at the correct position without over-loading. Exact settings for the Load Control Valve Plunger and Power Piston for either Minimum or Maximum Field Start are determined after the engine manufacturers requirements are known, at which time specification sheets are set up for adjusting and testing each type of governor. These specification sheets, for each governor designation, are available to interested parties.




Cut No. 29

## ENGINE LUBRICATING OIL PRESSURE FAILURE SHUTDOWN

A connection is made from a remote point of the engine lubricating system to a diaphragm in the shutdown mechanism of the governor as shown in Cut No. 29.

The diaphragm is acted upon by three forces; the engine lube oil pressure and the load spring force on the left, and oil pressure from the speed setting servo on the right.

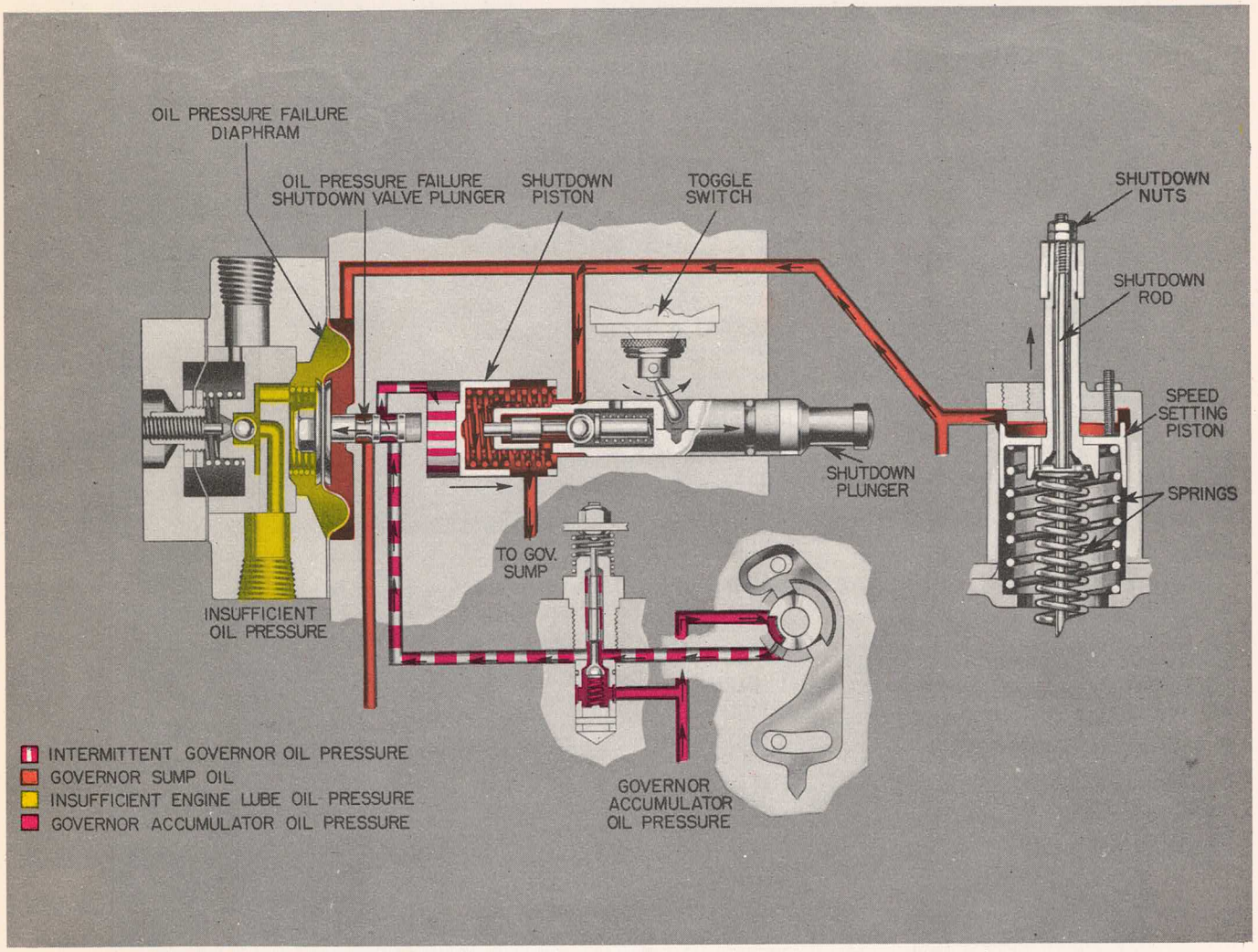
Oil pressure above the speed setting piston (which is dependent on speed setting) will move the diaphragm to the left, when engine oil pressure drops. A characteristic of this system is that shutdown occurs at lower lubricating oil pressures at idle speed than at higher engine speeds.

When normal engine oil pressure exists, the lube oil pressure and the spring hold the valve plunger to the right, which connects the area to the left of the shutdown piston to sump.

Governor pump oil pressure is supplied to the shutdown valve in two ways. When the triangular plate is in the idle speed position, or Step No. 1, the oil will be admitted through the intermittent supply orifice in the top part of the rotating speed setting pilot valve bushing. With each rotation of the bushing a slot registers with a hole in the casting 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 changed to increase or decrease the volume of oil supplied. Turn pointer clockwise to reduce tripping time.

When the triangular plate is down at Step 2 or higher, the bypass valve plunger will be depressed, pushing the ball off its seat, and allowing governor oil pressure to pass to the shutdown valve plunger freely.

Thus, for idle, the engine will be shut down after the desired time delay and, for the higher speeds, it will be shut down quickly.




Cut No. 30

## OIL PRESSURE FAILURE: Cut No. 30

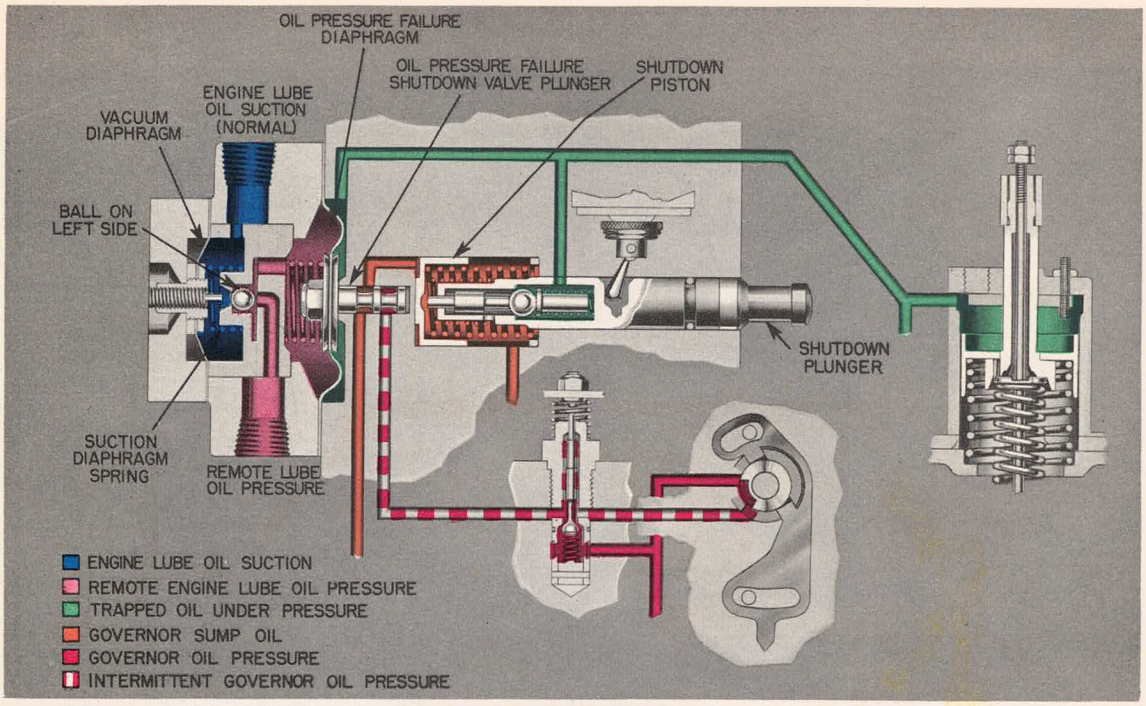
1. Assume that the engine oil pressure has dropped, causing the diaphragm and valve plunger to move to the left, allowing accumulator oil pressure (shown here as intermittent supply at idle speed) to pass through the valve and to the left side of the shutdown piston.

2. The shutdown piston is then forced to the right slowly if speed setting is at idle, or rapidly if speed setting is at Step 2 or higher, and it in turn pushes the shutdown plunger to the right. When the toggle switch goes over center, it snaps the shutdown plunger out, as shown, and closes an alarm circuit.

3. Oil, previously trapped above the speed setting piston, is then free to pass to sump. The speed setting piston is pushed up by the springs, picking up the shutdown nuts, shutdown rod, and governor pilot valve plunger to close off the fuel supply and shut down the engine.

## STARTING ENGINE AT "IDLE"

The speed setting must be at idle, when the engine is started, or the tripping action will occur as soon as the engine is revolved by the starter. This is because the time delay is not effective above idle speed setting and tripping will occur before lubricating oil pressure is established at the remote points. Thus, the operator cannot "Race" the engine before oil pressure is established.




Cut No. 31

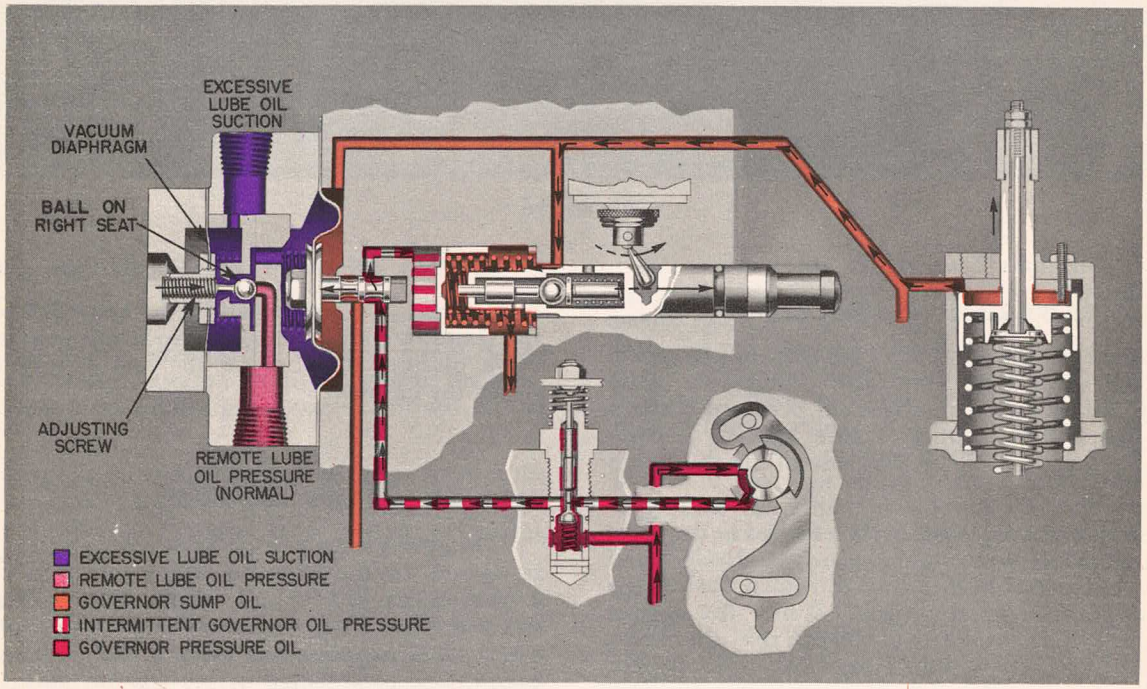
**ENGINE LUBRICATING OIL SUCTION SHUTDOWN:**

**Cut No. 31**

A connection is made from the suction side of the engine lubricating oil pump to a second diaphragm and ball valve.

1. Assume that the pump suction is normal. The suction diaphragm is held to the left by the suction diaphragm spring and the ball is held tight against its left seat by the engine oil pressure.

2. The engine lubricating oil pressure acting against the lubricating oil diaphragm is normal and the shutdown valve, piston, and plunger are in normal operating positions.




Cut No. 32

**EXCESSIVE LUBRICATING OIL SUCTION:**

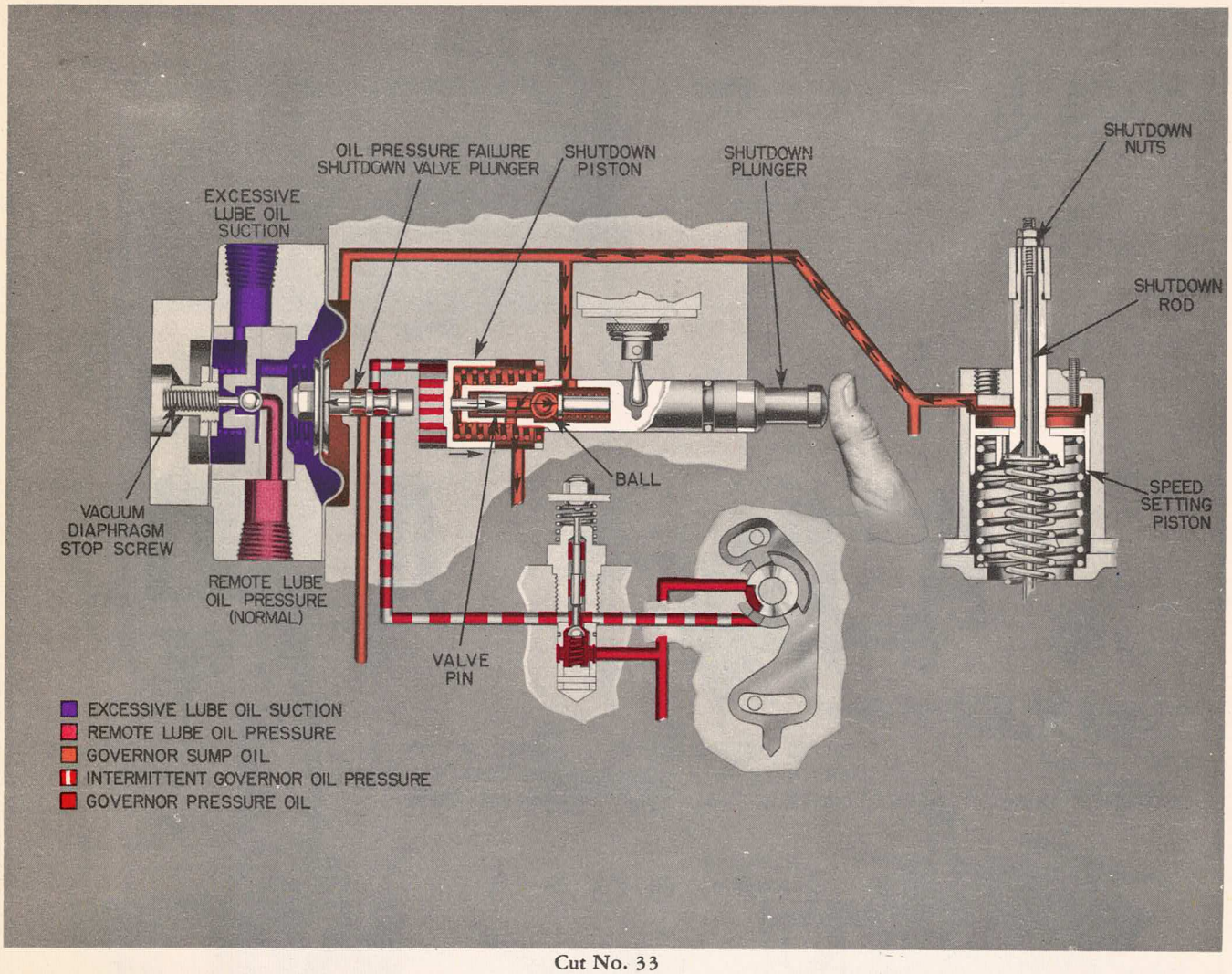
**Cut No. 32**

1. The suction increases to an excessive value.

2. The vacuum diaphragm and adjusting screw are pulled to the right, which pushes the ball off its left hand seat and onto the right hand 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.

4. The effect on the shutdown valve mechanism is identical to that explained under oil pressure failure and the engine is shut down.




Cut No. 33

## ANTI-BLOCKING VALVE: Cut No. 33

"Blocking" the shutdown mechanism will not prevent it from acting to protect the engine.

In this cut the shutdown mechanism is attempting to function, but the operator is holding the shutdown plunger in with his finger.

1. Since the oil pressure failure shutdown valve plunger is to the left, oil pressure is forcing the shutdown piston to the right contacting the valve pin and pushing the ball off its seat.

2. When the ball is pushed off its seat, the oil above the speed setting piston is bypassed to the sump, as shown, the speed setting piston contacts the shutdown nuts, lifts the governor pilot valve, and causes the engine to shut down.

## MANUAL SHUTDOWN

Pull the shutdown plunger out, or push it in, to bypass the oil above the speed setting piston past the plunger to sump as shown in Cut No. 30 and Cut No. 33.

## TO KEEP ENGINE RUNNING TEMPORARILY TO TRACE CAUSE OF SHUTDOWN:

Start engine at idle. If no oil pressure is established, trip will shut engine down in about forty seconds. When the shutdown plunger has snapped out, it may be pushed back in and the engine restarted.

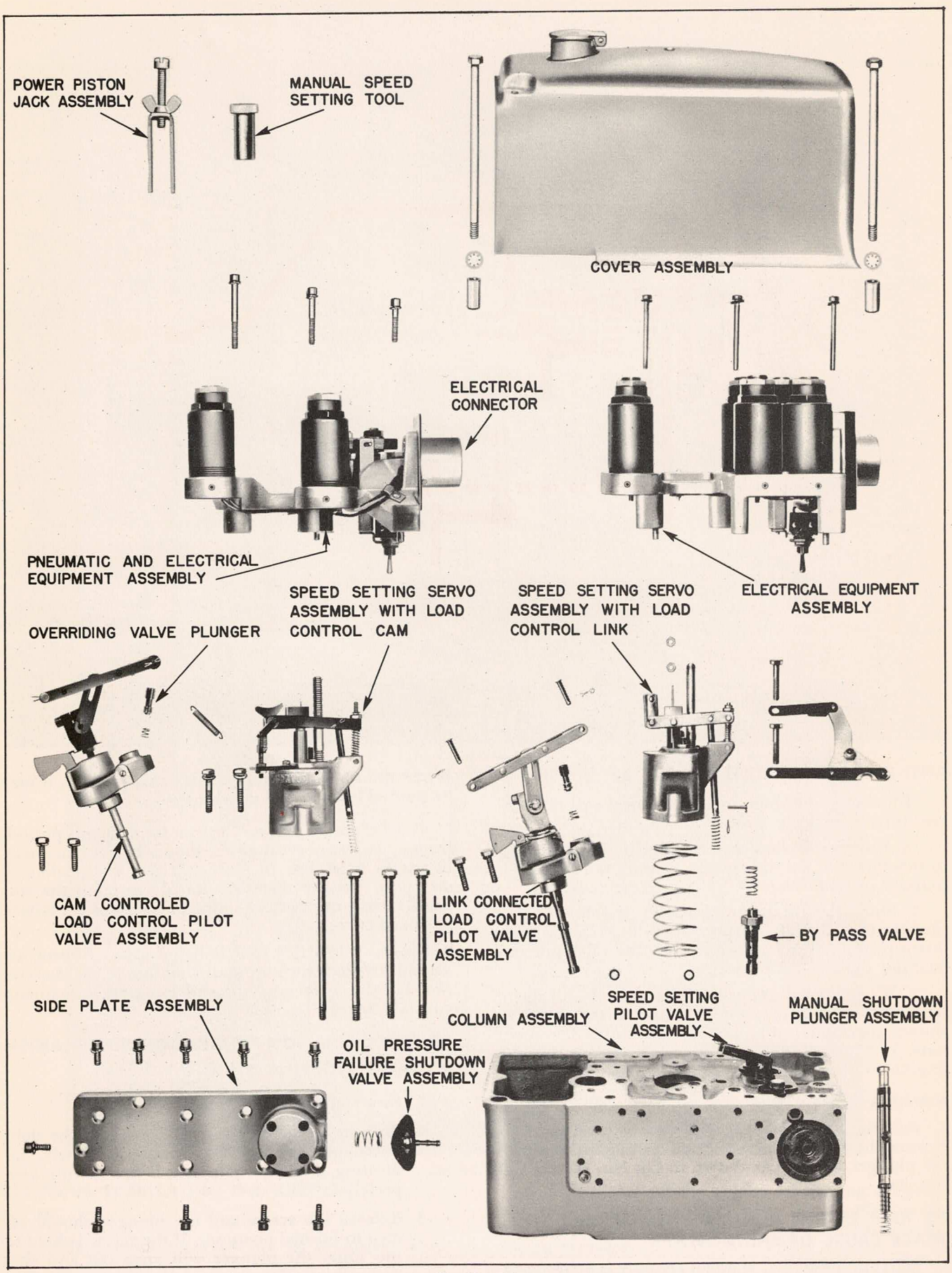
If it becomes necessary to run for a longer period, the manual speed setting tool shown in Cut No. 4 may be used. With this in place, speed may be adjusted manually, but the throttle control (through the solenoids) will not operate until the cause of oil failure has been corrected.

Note: When this tool is being used, *all governor auxiliary devices* including all shutdowns are *inoperative,* but the governor will still function to maintain constant speed.

## TO TEST OPERATION OF SHUTDOWN MECHANISM WITHOUT STOPPING ENGINE: *

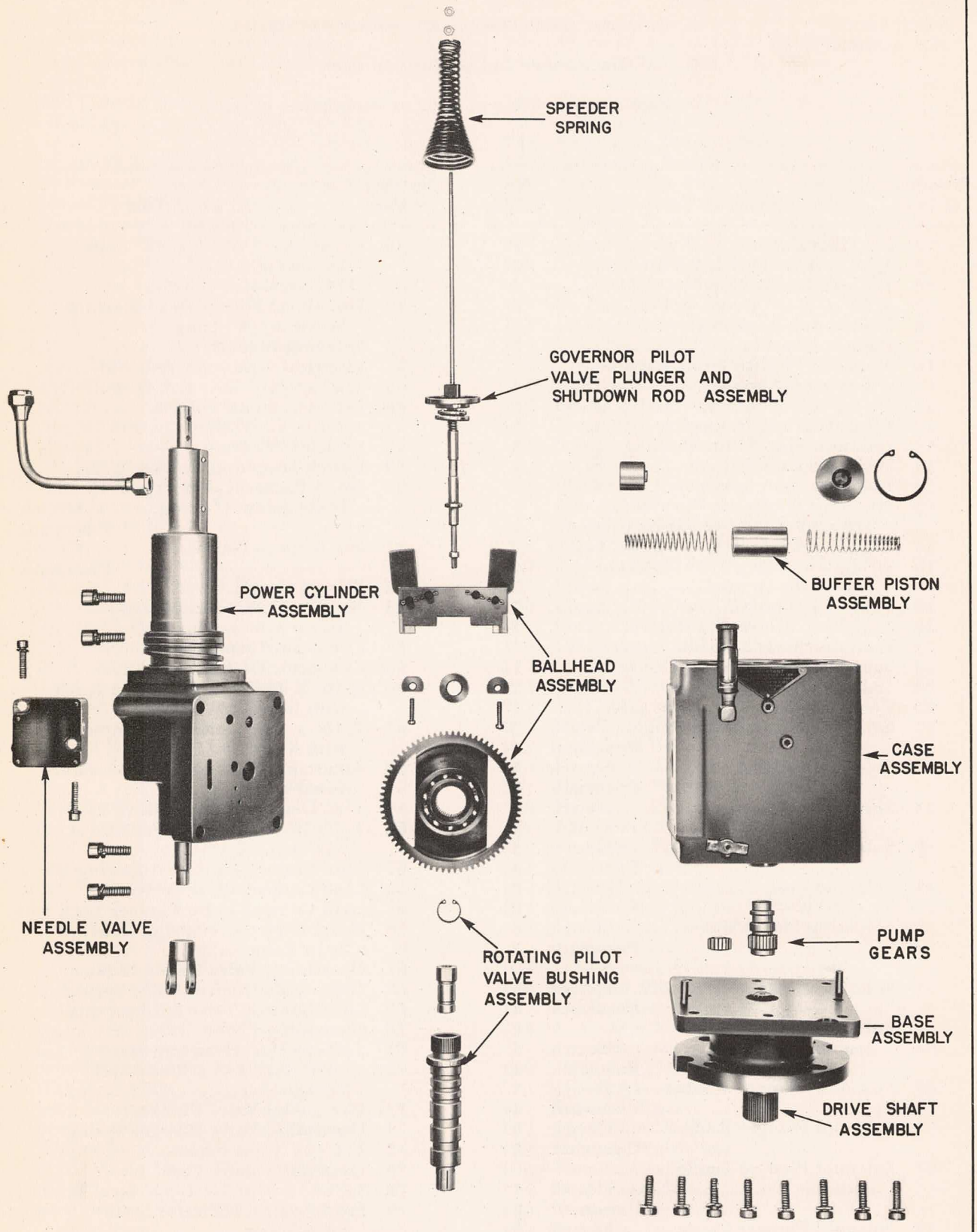
1. Run engine at idle speed.
2. Push in on the diaphragm screw until the shutdown plunger starts moving out slowly, indicating that the equipment is functioning properly.
3. Release the screw and the plunger should return to normal position. If the screw is held in too long, the plunger will snap out and shut down the engine.

***NOTE:** Applies only to governors equipped with excessive lubricating oil suction protection.




Cut No. 34

Sub-Assemblies of Cover and Column




Cut No. 35

Sub-Assemblies of Case, Base, and Power Cylinder

**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 and publication date.
3. Part number, name of part, or description of part.

| Number of Part | Name of Part | No. Req'd. |
|---|---|---|
| 2 | Oil Filler Cup | 1 |
| 5 | 3/32" x 5/8" Driv-Lok Pin | 2 |
| 6 | 1/4"-28 Elastic Stop Nut | 2 |
| 7 | 3/32" x 7/16" Driv-Lok Pin | 2 |
| 8 | Pointer Sub-Assembly | 2 |
| 9 | Pointer Stop Pin | 2 |
| 10 | No. 8-32 Phillips Head Machine Screw 1/4" Long | 4 |
| 11 | 17/64" x 1/2" x 1/32" Steel Washer | 2 |
| 12 | Cover Dial and Nameplate | 1 |
| 13 | Indicator Shaft Oilite Bushing | 4 |
| 14 | Fuel Indicator Shaft | 1 |
| 15 | Indicator Shaft Spring | 2 |
| 16 | Straight 1/2" Union Pipe Fitting 3/8" N.P.T. to 1/2" Tube (if used) | 2 |
| 17 | 21/64" x 9/16" x 1/16" Steel Washer | 2 |
| 18 | 90° Elbow Fitting 3/8" N.P.T. to 1/2" Tube (if used) | 2 |
| 19 | 5/16"-24 Hex. Nut | 2 |
| 20 | 3/32" x 5/8" Cotter Pin | 2 |
| 21 | Indicator Shaft Arm Pin | 2 |
| 22 | Speed Indicator Shaft | 1 |
| 23 | Indicator Shaft Arm | 2 |
| 26 | Cover Gasket | 1 |
| 27 | Solenoid Plunger Stop Plug...Electric | 5 |
| | Pneumatic | 2 |
| 28 | Solenoid Locknut...Electric | 5 |
| | Pneumatic | 2 |
| 29 | Solenoid Case...Electric | 5 |
| | Pneumatic | 2 |
| 30 | Solenoid Load Spring...Electric | 5 |
| | Pneumatic | 2 |
| 31 | Solenoid Coil...Electric | 5 |
| | Pneumatic | 2 |
| 32 | Soldering Shield Washer...Electric | 10 |
| | Pneumatic | 2 |
| 33 | Solenoid Plunger...Electric | 5 |
| | Pneumatic | 1 |
| 34 | Solenoid Plunger Rod Snap Ring...Electric | 5 |
| | Pneumatic | 1 |
| 35 | Solenoid Plunger Washer...Electric | 5 |
| | Pneumatic | 2 |
| 36 | Solenoid Plunger Rod...Electric | 5 |
| | Pneumatic | 1 |
| 37 | Solenoid Plunger Guide Locating Pin...Electric | 5 |
| | Pneumatic | 2 |
| 38 | Solenoid Plunger Guide...Electric | 5 |
| | Pneumatic | 1 |
| 39 | 1/4"-28 Socket Head Cap Screw 2-3/8" Long...Electric | 3 |
| | Pneumatic | 1 |
| 40 | 17/64" x 27/64" x 1/16" Split Lockwasher | 3 |
| 41 | .035" Lockwire 4" Long | 1 |
| 42 | No. 10-32 Filister Head Machine Screw 2-1/8" Long | 2 |
| 43 | Solenoid Bracket | 1 |
| 44 | Electrical Connector Assembly | 1 |
| 45 | 1/2" x 9/16" Driv-Lok Dowel | 2 |
| 46 | Lube Oil Signal Switch | 1 |
| 47 | 1/16" x 5/16" Driv-Lok Pin | 2 |
| 48 | Switch Lock Nuts | 2 |
| 49 | Switch Mounting Bracket | 1 |
| 50 | No. 8 Parker Kalon Type Z Round Head Screw 1" Long...Electric | 3 |
| | Pneumatic | 1 |
| 51 | No. 8 Speed Nut...Electric | 3 |
| | Pneumatic | 1 |
| 52 | Wiring Cover | 1 |
| 53 | No. 10-32 Flat Head Machine Screw 3/8" Long | 4 |
| 54 | Connector Clamp Plate | 1 |
| 55 | Connector Gasket | 1 |
| 56 | 3/16" x 25/32" Headed Pin (used with link) | 2 |
| 57 | 1/16" x 3/8" Cotter Pins (used with link) | 2 |
| 58 | Adjustable Floating Lever Assembly (used with link) | 1 |
| 59 | 1/2" Dia. Pivot Pin Link (if used) | 1 |
| 60 | 1/4"-28 Socket Head Cap Screw 3/4" Long | 1 |
| 61 | Load Control Plunger Adjusting Block | 1 |
| 62 | Load Control Valve Eccentric | 1 |
| 65 | Load Control Valve Plunger Lock Nut | 2 |
| 66 | Overriding Valve Spring Retainer Snap Ring | 1 |
| 67 | Overriding Valve Spring Retainer | 1 |
| 68 | Outer Load Control Valve Spring | 1 |
| 69 | Load Control Valve Spring Collar | 1 |
| 70 | Overriding Piston | 1 |
| 71 | 1/4"-28 Hex. Head Cap Screw 1" Long | 2 |
| 72 | 17/64" x 27/64" x 1/16" Split Lockwasher | 2 |
| 73 | Overriding Valve Plunger | 1 |
| 74 | Overriding Valve Plunger Spring | 1 |
| 75 | 1/4"-28 Taper Screw | 2 |
| 76 | Overriding Valve Case | 1 |
| 78 | 13/64" x 7/16" x 1/32" Steel Washer | 4 |
| 79 | Load Control Indicator Scale Lock Screw | 1 |
| 80 | 1/16" x 5/16" Driv-Lok Pin | 1 |
| 81 | Overriding Valve Cylinder Head | 1 |
| 82 | Load Control Plunger Oil Seal (if used) | 1 |
| 83 | Load Control Valve Oil Seal Gasket | 1 |

| Number of Part | Name of Part | No. Req'd. |
|---|---|---|
| 84 | Load Control Pilot Valve Plunger | 1 |
| 85 | Load Control Pilot Valve Bushing Spring | 1 |
| 86 | Load Control Pilot Valve Bushing.....Electromotive | 1 |
| | Fairbanks-Morse | 1 |
| 87 | No. 50-43 Waldes Snap Ring | 1 |
| 88 | Oil Pressure Failure Bushing Gasket | 1 |
| 89 | Manual Speed Setting Tool | 1 |
| 90 | Manual Speed Setting Stud | 1 |
| 91 | Triangular Plate Screw | 1 |
| 92 | Triangular Plate Assembly | 1 |
| 93 | Base Speed Setting Nut | 1 |
| 94 | Adjustable Fulcrum Pin | 1 |
| 95 | Shutdown Nut | 2 |
| 96 | Power Piston Fulcrum Assembly (used with link) | 1 |
| 97 | Fulcrum Spring | 1 |
| 98 | Fulcrum Spring Washer | 1 |
| 99 | Adjustable Fulcrum Screw | 1 |
| 100 | Adjustable Fulcrum Screw Hinge Pin | 1 |
| 101 | 1/8" Straight Pin | 1 |
| 102 | 1/16" x 3/8" Cotter Pin | 6 |
| 103 | Upper Speed Setting Floating Lever (used with link) | 2 |
| 104 | Link Spacer | 2 |
| 105 | Floating Lever Link | 1 |
| 106 | 1/8" x 47/64" Drilled Pin | 1 |
| 107 | Floating Lever Link Spring | 1 |
| 108 | No. 10-32 Hex. Nut | 1 |
| 109 | Speed Setting Piston Stop Screw | 1 |
| 110 | Speed Setting Indicator Scale | 1 |
| 111 | 21/64" x 9/16" x 1/16" Steel Washer | 1 |
| 112 | Speed Setting Indicator Scale Lock Screw | 1 |
| 113 | 1/4"-28 Hex. Head Cap Screw 1-3/8" Long | 2 |
| 114 | 17/64" x 1/2" x 1/32" Steel Washer | 2 |
| 115 | Speed Setting Cylinder Plug | 1 |
| 117 | Speed Setting Cylinder Spacer | 1 |
| 118 | Speed Setting Cylinder Rivet | 2 |
| 120 | Speed Setting Servo Spring | 1 |
| 124 | 1/8" Socket Head Pipe Plug | 7 |
| 125 | AN6227-5 "O" Ring | 2 |
| 126 | 5/16"-24 Column to Case Hex. Head Cap Screw 5" Long | 4 |
| 127 | 21/64" Split Lock Washers | 12 |
| 129 | Oil Pressure Failure Valve Bushing Sub-Assembly | 1 |
| 131 | No. 4 Drive Screw 3/16" Long | 1 |
| 132 | "D" Solenoid Cup | 1 |
| 133 | Speed Setting Lower Floating Lever Sub-Assembly | 1 |
| 134 | Speed Setting Pilot Valve Pin | 1 |
| 135 | Speed Setting Valve Thrust Bearing Upper Race | 1 |
| 136 | Speed Setting Valve Thrust Bearing Cage | 1 |
| 137 | Speed Setting Valve Thrust Bearing Lower Race | 1 |
| 138 | Speed Setting Pilot Valve Plunger | 1 |
| 139 | Retainer Screw | 1 |
| 140 | Regulating Bushing Retainer and Pointer | 1 |
| 141 | 17/64" x 1/2" x 1/32" Steel Washer | 1 |
| 142 | 1/4"-28 Hex. Head Cap Screw 3/4" Long | 1 |
| 143 | Regulating Bushing Retainer Spring Collar | 1 |
| 144 | Regulating Bushing Retainer Spring | 1 |
| 145 | Regulating Bushing | 1 |
| 146 | Speed Setting Pilot Valve Bushing | 1 |
| 147 | Speed Setting Pilot Valve Bushing Spring | 1 |
| 148 | Speed Setting Pilot Valve Spring | 1 |
| 149 | Triangular Plate and Solenoid Counterbalance Spring | 1 |
| 150 | By Pass Valve Case | 1 |
| 153 | By Pass Valve Spring | 1 |
| 155 | 1/16" x 3/32" Pin | 1 |
| 156 | AN6227 1/16" x 5/16" "O" Ring | 1 |
| 157 | Inner Load Control Valve Spring | 1 |
| 159 | Speed Setting Bushing Drive Gear | 1 |
| 160 | Speed Setting Valve Gear Bearing Stud | 1 |
| 161 | Straight 1/2" Union Pipe Fitting 1/4" N.P.T. to 3/8" Tube (if used) | 1 |
| 162 | 90° Elbow Pipe Fitting 1/4" N.P.T. to 1/4" Tube (if used) | 1 |
| 163 | Ballhead Flatted Washer (164 and 165 used in SI Ball Head) | 2 |
| 166 | .035" Lockwire 2" Long | 1 |
| 167 | Cover | 1 |
| 168 | Cover Hold Down Bolt | 2 |
| 169 | Cover Dowelling Bushing | 2 |
| 170 | Oil Pressure Failure Piston | 1 |
| 171 | Oil Pressure Failure Piston Spring | 1 |
| 172 | Manual Shutdown Plunger Spring | 1 |
| 173 | Ball Valve Seat | 1 |
| 174 | Shutdown Plunger Pin | 1 |
| 175 | 1/4" Steel Ball | 1 |
| 176 | Shutdown Plunger Headed Pin | 1 |
| 177 | Shutdown Plunger Ball Spring | 1 |
| 178 | Shutdown Plunger | 1 |
| 179 | AN6227-7 1/16" x 3/8" "O" Ring | 1 |
| 180 | Shutdown Plunger Tubing | 1 |
| 181 | Side Plate Gasket | 1 |
| 182 | Oil Pressure Failure Diaphragm Spring | 1 |
| 183 | No. 10-32 Thin, Elastic Stop Nut | 1 |
| 184 | Oil Pressure Failure Diaphragm Washer | 2 |
| 185 | Oil Pressure Failure Diaphragm | 1 |
| 186 | Grooved Pin (used in 191 and 193) | 1 |
| 187 | Oil Pressure Failure Plunger | 1 |
| 188 | 1/4"-28 x 5/8" Socket Head Cap Screw | 10 |
| 189 | 17/64" x 27/64" x 1/16" Split Lockwasher | 10 |
| 191 | Lube Oil Plate | 1 |
| 192 | 3/16" Steel Ball | 1 |
| 193 | Lube Oil Valve Seat | 1 |
| 194 | Vacuum Diaphragm Spring | 1 |
| 195 | Diaphragm Nut | 2 |
| 196 | Vacuum Diaphragm | 1 |
| 197 | Washer | 1 |
| 198 | Vacuum Diaphragm Holder | 1 |
| 200 | Diaphragm Stop Screw | 1 |
| 201 | No. 10-32 Socket Head Machine Screw 5/8" Long | 4 |

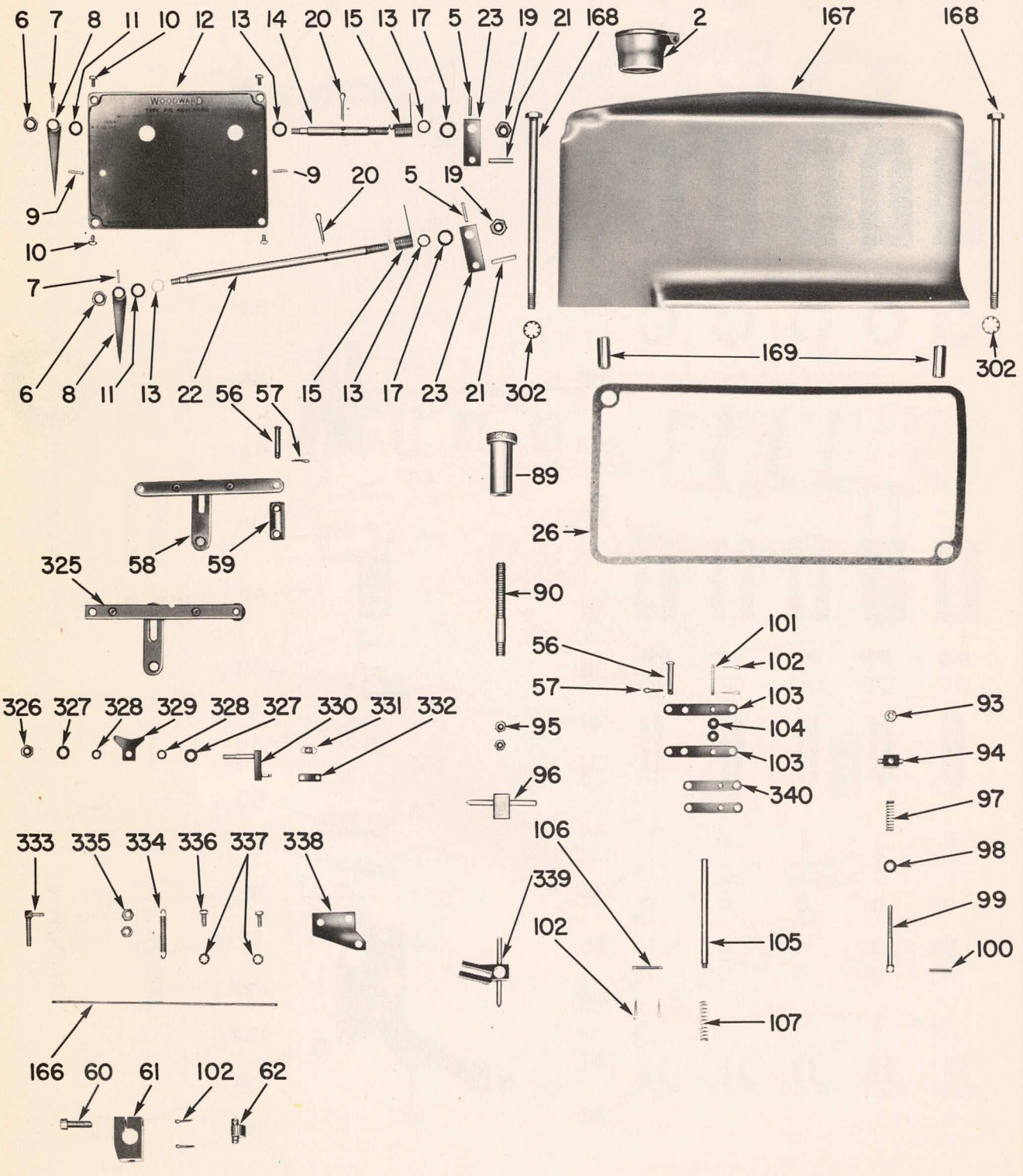
| Number of Part | Name of Part | No. Req'd. |
|---|---|---|
| 202 | No. 10 Split Lockwasher | 4 |
| 203 | Vacuum Diaphragm Cover | 1 |
| 204 | Speeder Spring | 1 |
| 206 | Pilot Valve Plunger Nut | 1 |
| 207 | Pilot Valve Plunger Cotter Pin | 1 |
| 222 | Pilot Valve Plunger Snap Ring | 1 |
| 239 | Shutdown Rod | 1 |
| 240 | Tailrod Lift Nut | 1 |
| 241 | 3/8" Shakeproof Tailrod Washer | 1 |
| 245 | 1/16" x 5/8" Cotter Pin | 1 |
| 249 | Spring Guard 1/4" Shakeproof Washer | 4 |
| 252 | Power Piston Rod End....Fairbanks | 1 |
| | Electromotive | 1 |
| 253 | 1/16" x 3/8" Cotter Pin | 1 |
| 254 | Taper Pin | 1 |
| 255 | Spring Guard Seal "O" Ring | 1 |
| 256 | Spring Guard Seal Ring | 1 |
| 257 | Spring Guard Seal Spring | 1 |
| 259 | Piston Gap Scale | 1 |
| 261 | No. 10-32 Filister Head Screw 1/4" Long | 2 |
| 262 | 1/16" x 5/16" Piston Gap Scale Driv-Lok Pin | 1 |
| 263 | 1/4"-28 Spring Guard Socket Head Cap Screw 3/4" Long | 4 |
| 264 | 3/8" x 1-13/16" Headed Rod End Pin | 1 |
| 266 | 3/16" x 1-7/16" Pin | 1 |
| 267 | Power Piston Tail Rod | 1 |
| 268 | 3/8"-24 "Flex Loc" Tailrod Hex Nut | 1 |
| 269 | Power Piston Jack Sub-Assembly | 1 |
| 270 | Case to Column Gasket | 1 |
| 278 | Case to Column Dowel | 2 |
| 279 | Neoprene Washer | 1 |
| 280 | 1/16" Socket Head Pipe Plug | 1 |
| 285 | Oil Drain Cock | 1 |
| 292 | Base to Case Dowel | 2 |
| 302 | 5/16" Shakeproof Washer | 2 |
| 308 | .035" Lockwire 6" Long | 1 |
| 309 | Load Control Indicator Scale | 1 |
| 310 | Load Control Indicator Pointer | 1 |
| 311 | Load Control Indicator Washer | 1 |
| 312 | Pointer Spring | 1 |
| 313 | Pointer Pivot Screw | 1 |
| 314 | Oil Level Gauge | 1 |
| 315 | Oil Level Gauge Elbow | 1 |
| 316 | No. 10-32 Socket Head Set Screw 1/4" Long....Electric | 5 |
| | Pneumatic | 2 |
| 318 | Solenoid Coil Insulating Paper....Electric | 5 |
| | Pneumatic | 2 |
| 319 | Varnished Tubing....Electric | 10 |
| | Pneumatic | 4 |
| 320 | Solenoid Plunger Rod Bushing....Electric | 10 |
| | Pneumatic | 4 |
| 325 | Adjustable Floating Lever Assembly (used with cam) | 1 |
| 326 | No. 10-32 Elastic Stop Nut | 1 |
| 327 | 13/64" x 7/16" x 1/16" Thick Washer | 2 |
| 328 | Load Control Cam Shaft Spacer | 2 |
| 329 | Load Control Cam | 1 |
| 330 | Load Control Cam Lever and Shaft Sub-Assembly | 1 |
| 331 | Extension Spring | 1 |
| 332 | Load Control Cam Lever Link | 1 |
| 333 | Load Control Cam Anchor and Link Pin Sub-Assembly | 1 |
| 334 | Extension Spring | 1 |
| 335 | No. 10-32 Hex Nut | 2 |
| 336 | No. 10-32 Filister Head Machine Screw 3/8" Long | 2 |
| 337 | No. 10 Shakeproof Washer | 2 |
| 338 | Load Control Cam Lever Anchor Plate | 1 |
| 339 | Speed Setting Fulcrum Assembly | 1 |
| 340 | Upper Speed Setting Floating Lever (used with cam) | 2 |
| 350 | Idle Speed Setting Screw | 1 |
| 351 | 3/8"-24 Hex Jam Nut | 1 |
| 352 | Pneumatic Receiver Speed Setting Walking Beam | 1 |
| 353 | Diaphragm Link | 1 |
| 354 | Pneumatic Receiver Control Lever Pivot Pin | 1 |
| 355 | Control Lever Needle Bearing | 2 |
| 356 | 1/4"-28 Hex Head Cap Screw 1-3/8" Long | 3 |
| 357 | 17/64" x 27/64" x 1/16" Lockwasher | 3 |
| 358 | Pneumatic Control Spring | 2 |
| 359 | Pneumatic Receiver Spring Seat | 1 |
| 360 | Pneumatic Control Diaphragm Washer | 3 |
| 361 | Pneumatic Control Diaphragm | 2 |
| 363 | Pneumatic Control Keyed Retaining Washer | 2 |
| 364 | Pneumatic Control Diaphragm Nut | 2 |
| 366 | Electrical Connector Assembly | 1 |
| 367 | No. 10-32 Filister Head Machine Screw 1-1/2" Long | 2 |
| 368 | No. 10 Split Lockwasher | 2 |
| 369 | Wire Cover | 1 |
| 370 | "1 Wire" Metal Cleat | 1 |
| 371 | Speed Setting Bracket | 1 |
| 372 | Speed Setting Pilot Valve Pin | 1 |
| 373 | 1/16" x 3/8" Cotter Pin | 2 |
| 374 | Speed Setting Lower Floating Lever Sub-Assembly | 1 |
| 375 | AN6227-5 "O" Ring | 1 |
| 376 | Solenoid Shutdown Valve Seat | 1 |
| 377 | Solenoid Shutdown Valve Spring | 1 |
| 378 | 1/4" Steel Ball | 1 |
| 379 | Solenoid Shutdown Valve Body | 1 |
| 380 | Shutdown Solenoid Plunger Rod | 1 |
| 381 | Pneumatic Receiver Cap | 1 |
| 382 | By-Pass Valve Actuating Rod Spring | 1 |
| 383 | By-Pass Valve Actuating Rod | 1 |
| 384 | Floating Lever Link | 1 |
| 385 | No. 10-32 Hex. Lock Nut | 2 |
| 386 | No. 10-32 Socket Head Set Screw 3/4" Long | 2 |
| 387 | Diaphragm Retainer Assembly | 1 |
| 388 | Orifice Plate Gasket | 2 |
| 389 | Orifice Plate | 1 |
| 390 | Filter Disc | 1 |
| 391 | Filter Load Spring | 1 |
| 392 | Pneumatic Transmitter Cover Gasket | 1 |
| 393 | Pneumatic Transmitter Cover | 1 |
| 394 | No. 10 Split Lockwasher | 4 |

| Number of Part | Name of Part | No. Req'd. |
|---|---|---|
| 395 | No. 10–32 Socket Head Cap Screw 5/8" Long | 4 |
| 396 | Plunger Rod Pin | 1 |
| 397 | 1/16" x 3/8" Cotter Pin | 1 |
| 398 | Pneumatic Transmitter Control Lever (if used) | 1 |
| 399 | Pneumatic Transmitter Valve Lever Plunger Rod | 1 |
| 400 | Pneumatic Transmitter Case | 1 |
| 401 | Damping Spring | 1 |
| 402 | Pneumatic Transmitter Valve Seat | 1 |
| 403 | Pneumatic Transmitter Valve Plunger | 1 |
| 404 | No. 6–32 Elastic Stop Nut | 1 |
| 405 | 1/4"–28 Elastic Stop Nut | 1 |
| 406 | Ball Bearing | 1 |
| 407 | Roller Eccentric | 1 |
| 408 | Lever Spring | 1 |
| 409 | Fulcrum Pin | 1 |
| 410 | Oilite Bushing | 2 |
| 411 | Serial Number Nameplate | 1 |
| 412 | Escutcheon Pin | 2 |
| 413 | Pneumatic Transmitter Diaphragm Gasket | 1 |
| 414 | Pneumatic Transmitter Roller Lever (if used) | 1 |
| 415 | Pneumatic Transmitter Control Lever (if used) | 1 |
| 416 | Washer (if used) | 1 |
| 417 | Shakeproof Washer (if used) | 1 |
| 418 | Socket Head Screw (if used) | 1 |
| 460 | 1/4"–28 Socket Head Screw | 2 |
| 461 | Shutdown Valve Solenoid Plunger | 1 |
| 462 | Speed Setting Valve Washer | 1 |
| 463 | Idle Screw Washer | 1 |
| 464 | Pneumatic Receiver Walking Beam Slide | 1 |
| 465 | Slide Lock Screw | 1 |
| 466 | No. 10–32 Hex Lock Nut | 1 |
| 467 | 1/4"–28 Socket Head Cap Screw 1-1/4" Long | 1 |
| 468 | 1/4"–28 Socket Head Cap Screw 1-3/4" Long | 1 |
| 469 | No. 8–32 Round Head Machine Screw 3/8" Long | 1 |
| 480 | Load Control Valve Spacer (if used) | 1 |
| 481 | Column Serial Number Nameplate | 1 |
| 482 | Escutcheon Pin | 2 |
| 483 | 90° Elbow Pipe Fitting 3/8" N.P.T. to 3/8" Tube (if used) | 3 |
| 484 | Short Nut for 3/8" Tubing (use with 483) | 1 |
| 485 | Load Control Oil Supply Valve Plunger (if used) | 1 |
| 486 | Load Control Oil Supply Valve Spring (if used) | 1 |
| 487 | Load Control Oil Supply Valve Sleeve (if used) | 1 |
| 488 | 3/8" Socket Head Pipe Plug (if used) | 2 |
| 489 | 90° Elbow Pipe Fitting 1/8" N.P.T. to 1/4" Tube (if used) | 1 |
| 490 | Speed Setting Cylinder used with Part No. 338 on Cam Type Load Control | 1 |
| 491 | Speed Setting Cylinder used without Part No. 338 on Link Type Load Control | 1 |
| 492 | Speed Setting Piston Sub-Assembly | 1 |
| 493 | Column and Insert Sub-Assembly used with External Oil Supply to Load Control Pilot Valve | 1 |
| 494 | Column and Insert Sub-Assembly used with Governor Oil Supply to Load Control Pilot Valve | 1 |
| 495 | By-Pass Valve Pin and Seat | 1 |
| 496 | Washer | 1 |
| 497 | Oil Pressure Failure Valve Bushing Retainer Screw | 1 |
| 500 | 1/4" Socket Head Pipe Plug (if used) | 1 |
| 501 | 90° Brass Street Elbow 1/4" N.P.T. (used with 502) | 1 |
| 502 | Right Angle Tee Pipe Fitting 1/4" N.P.T. to 1/4" Tube (if used) | 1 |
| 503 | Vacuum Cover Gasket | 1 |
| 504 | Vacuum Cover | 1 |
| 505 | Side Plate (used with External Oil Supply to Load Control Pilot Valve) | 1 |
| 506 | Side Plate (used with Governor Oil Supply to Load Control Pilot Valve) | 1 |
| 520 | 3/8" Tubing from Column to Needle Valve | 1 |
| 521 | 45° Elbow Pipe Fitting 1/4" N.P.T. to 3/8" Tube | 1 |
| 522 | 90° Elbow Pipe Fitting 1/4" N.P.T. to 3/8" Tube | 1 |
| 523 | Needle | 2 |
| 524 | AN6227 "O" Ring | 4 |
| 525 | Needle Valve Case | 1 |
| 526 | 1/16" Socket Head Pipe Plug | 1 |
| 527 | 1/4" Split Lockwasher | 2 |
| 528 | No. 2 Drive Screw | 4 |
| 529 | Nameplate | 1 |
| 530 | 1/4"–28 Socket Head Cap Screw 1" Long | 2 |
| 531 | 1/4" Steel Ball | 2 |
| 532 | Needle Valve Spring | 2 |
| 533 | Plug | 2 |
| 534 | 5000–50 Waldes Snap Ring | 2 |
| 535 | No. 8–32 Filister Head Machine Screw 1/4" Long | 2 |
| 536 | Needle Valve Cover | 1 |
| 550 | Spring Check Plug | 1 |
| 551 | Speeder Spring Seat | 1 |
| 552 | Pilot Valve Thrust Bearing | 1 |
| 553 | Pilot Valve Washer | 1 |
| 554 | Pilot Valve Adjusting Spring | 1 |
| 555 | Pilot Valve Plunger | 1 |
| 556 | Pilot Valve Bushing Snap Ring | 1 |
| 557 | Compensation Bushing | 1 |
| 558 | Pilot Valve Bushing Sub-Assembly ..... Old Style (New Style — Flanged Top) | 1 |
| 559 | Drive Gear | 1 |
| 560 | Ballarm Cotter Pin | 8 |
| 561 | Ballarm Pin | 4 |
| 562 | Ballarm | 2 |
| 563 | Ballarm Needle Bearing | 4 |
| 564 | Ballhead | 1 |

| Number of Part | Name of Part | No. Req'd. |
|---|---|---|
| 565 | No. 10–32 Round Head Machine Screw 3/4″ Long | 2 |
| 566 | No. 10–32 Spline Nut | 2 |
| 567 | Ballhead Ball Bearing | 1 |
| 568 | Rubber Drive Coupling Assembly | 1 |
| 569 | Ballhead Gear (Old Style) (New Style) | 1 |
| 585 | Accumulator Piston Snap Ring | 4 |
| 586 | Accumulator Spring Seat | 2 |
| 587 | Large Accumulator Spring | 2 |
| 588 | Small Accumulaotr Spring | 2 |
| 589 | Accumulator Piston | 2 |
| 600 | Power Case | 1 |
| 601 | Check Valve Sub-Assembly | 2 |
| 602 | Check Valve Sub-Assembly | 2 |
| 603 | Idler Gear Stub | 1 |
| 604 | Idler Gear | 1 |
| 605 | Case to Base Oil Seal Ring | 1 |
| 606 | Round Head Drive Screw | 3 |
| 607 | Bleed Hole Nameplate | 1 |
| 608 | Buffer Spring Seat | 1 |
| 609 | Buffer Spring | 2 |
| 610 | Buffer Piston | 1 |
| 611 | Buffer Cylinder Plug | 1 |
| 612 | Buffer Cylinder "O" Ring | 1 |
| 613 | Buffer Cylinder Snap Ring | 1 |
| 614 | 21/64″ Split Lockwasher | 8 |
| 615 | Case to Base Hex. Head Cap Screw | 8 |
| 630 | Spring Guard to Power Cylinder Gasket | 1 |
| 631 | 3/8″–16 Socket Head Cap Screw 1″ Long | 4 |
| 632 | 3/8″ Split Lockwasher | 4 |
| 633 | Needle Valve "O" Ring | 1 |
| 634 | Power Cylinder | 1 |
| 635 | Power Cylinder to Case Gasket | 1 |
| 636 | Power Piston Assembly | 1 |
| 637 | Power Cylinder Oil Seal | 1 |
| 638 | Spring Guard | 1 |
| 639 | Compensation Needle Valve | 1 |
| 640 | Power Cylinder Spring | 1 |
| 641 | 1/16″ x 3/8″ Cotter Pin | 1 |
| 642 | Tail Rod Headed Pin | 1 |
| 660 | Base Sub-Assembly | 1 |
| 661 | Drive Shaft Oil Seal | 1 |
| 662 | Gasket | 1 |
| 663 | Drive Shaft Oil Seal Retainer | 1 |
| 664 | Drive Shaft Snap Ring | 1 |
| 665 | Drive Shaft Bearing | 1 |
| 666 | 1/4″–28 Drilled Hex. Head Cap Screw 5/8″ Long | 1 |
| 667 | Drive Shaft Bearing Retainer | 1 |
| 668 | Drive Shaft | 1 |

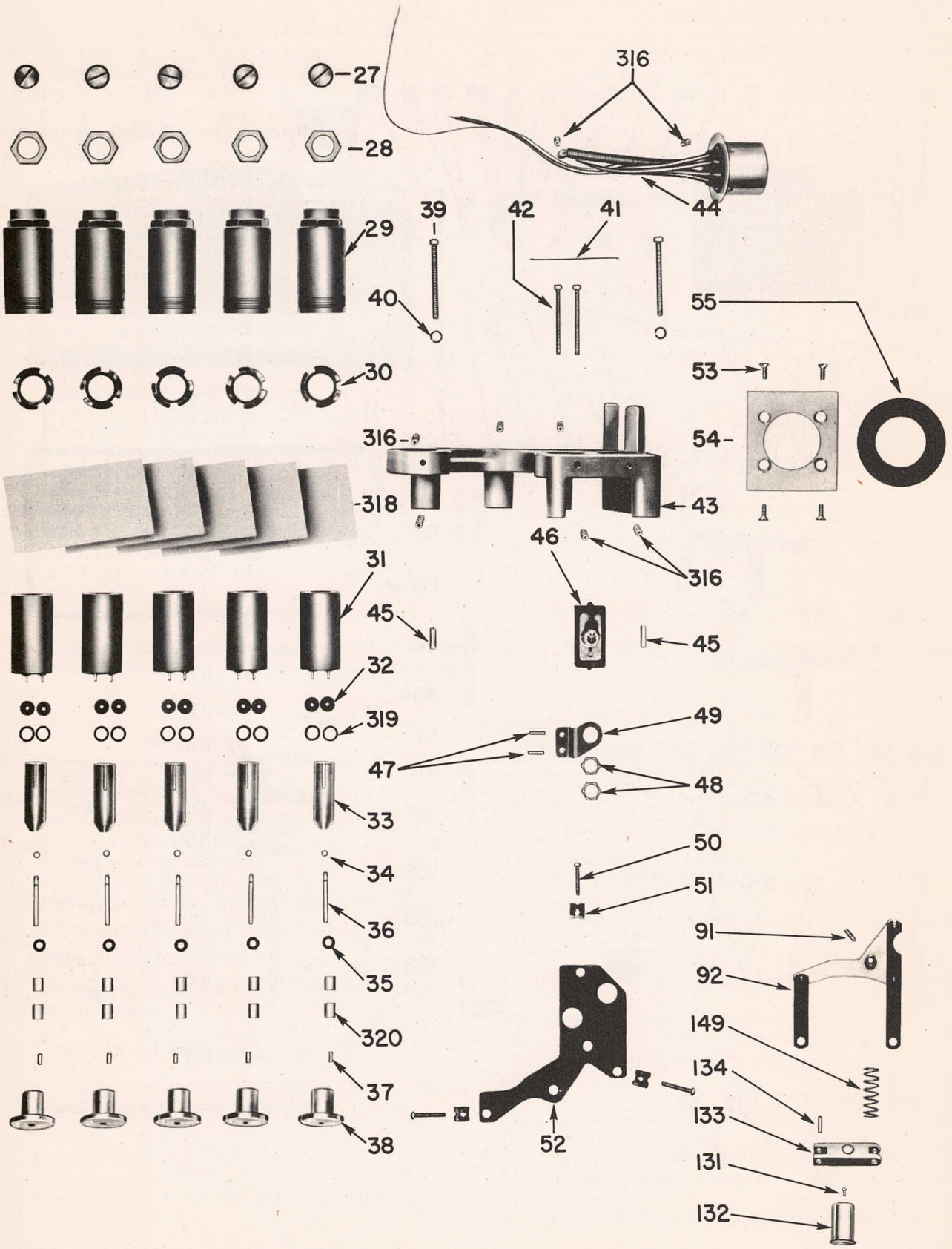
NOTE: Because of the special equipment and processes involved, there are some components of the governor which must be supplied as complete sub-assemblies, as listed below:

| Number of Part | Name of Part |
|---|---|
| 43, 45 | Solenoid Bracket with Dowels (2) |
| 44 | Electrical Connector Assembly |
| 58 | Adjustable Floating Lever Assembly |
| 92 | Triangular Plate Assembly |
| 96 | Power Piston Fulcrum Assembly |
| 129 | Oil Pressure Failure Valve Bushing Assembly |
| 131, 132 | "D" Solenoid Cup and Drive Screw Assembly |
| 133 | Speed Setting Lower Floating Lever Assembly |
| 135, 136, 137 | Complete Speed Setting Valve Thrust Bearing Assembly |
| 167, 169 | Cover with Dowelling Bushings |
| 191, 192, 193, 186 | Lubricating Oil Valve Assembly |
| 269 | Power Piston Jack Assembly |
| 309, 310, 312, 313 | Load Control Indicator Scale and Pointer Assembly |
| 325 | Adjustable Floating Lever Assembly |
| 330 | Load Control Cam Lever and Shaft Assembly |
| 333 | Load Control Cam Anchor and Link Pin Assembly |
| 353 | Diaphragm Link |
| 366 | Electrical Connector Assembly |
| 371, 45 | Speed Setting Bracket with Dowels (2) |
| 384 | Floating Lever Link |
| 387 | Diaphragm Retainer Assembly |
| 490, 117, 118 | Speed Setting Cylinder Assembly (Cam Type) |
| 491, 117, 118 | Speed Setting Cylinder Assembly (Link Type) |
| 492 | Speed Setting Piston Assembly |
| 493, 124, 160 | Column (External Oil Supply) |
| 494, 124, 160 | Column (Governor Oil Supply) |
| 495 | Bypass Valve Pin and Seat |
| 636 | Power Piston Assembly |
| 558, 567, 569 | P.V. Bushing, Ballhead Gear and Bearing |
| 562, 563 | Ballarm and Bearings |
| 564, 566 | Ballhead and Spline Nuts |



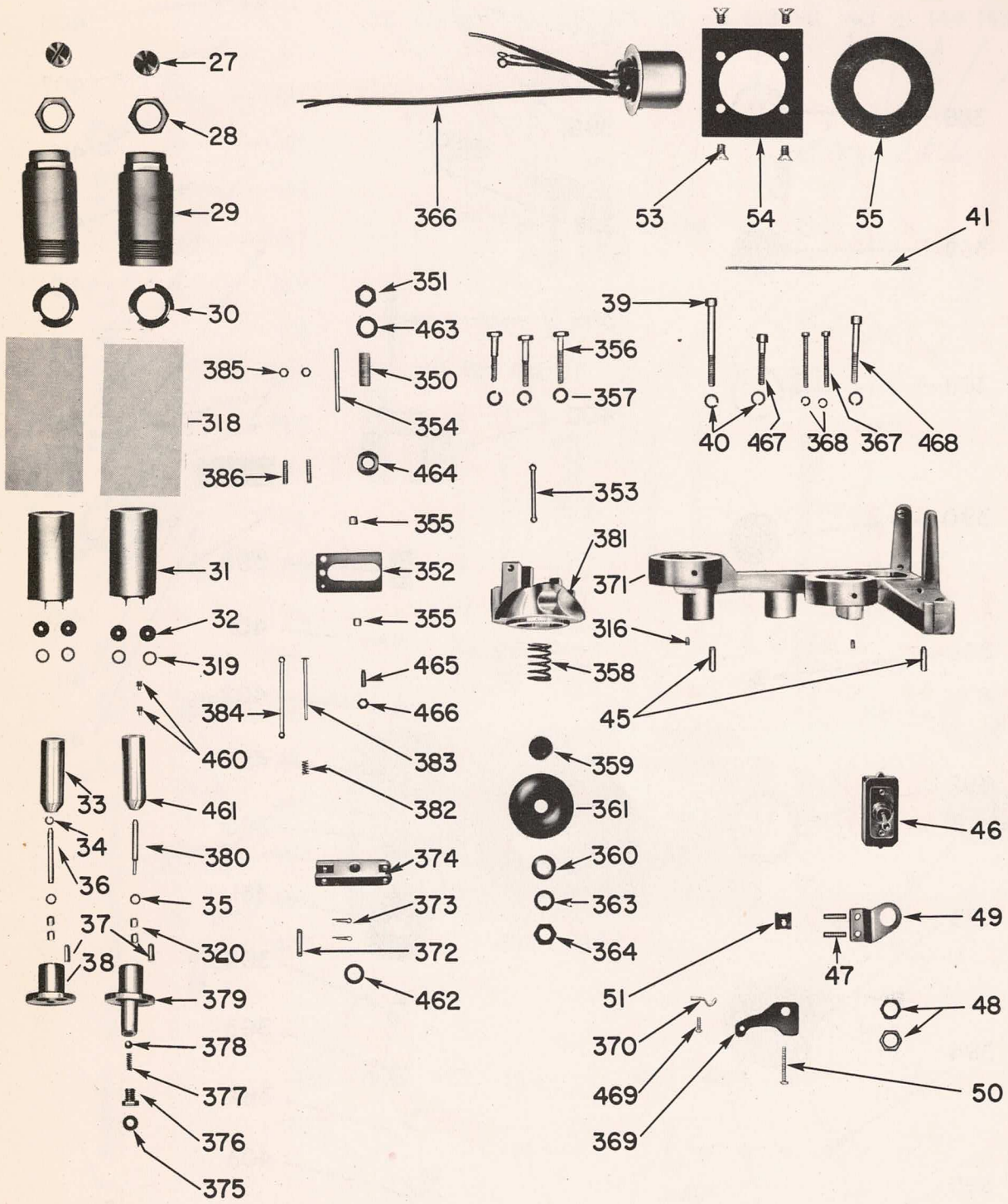

Cut No. 36

Cover and Top Column Linkage Parts



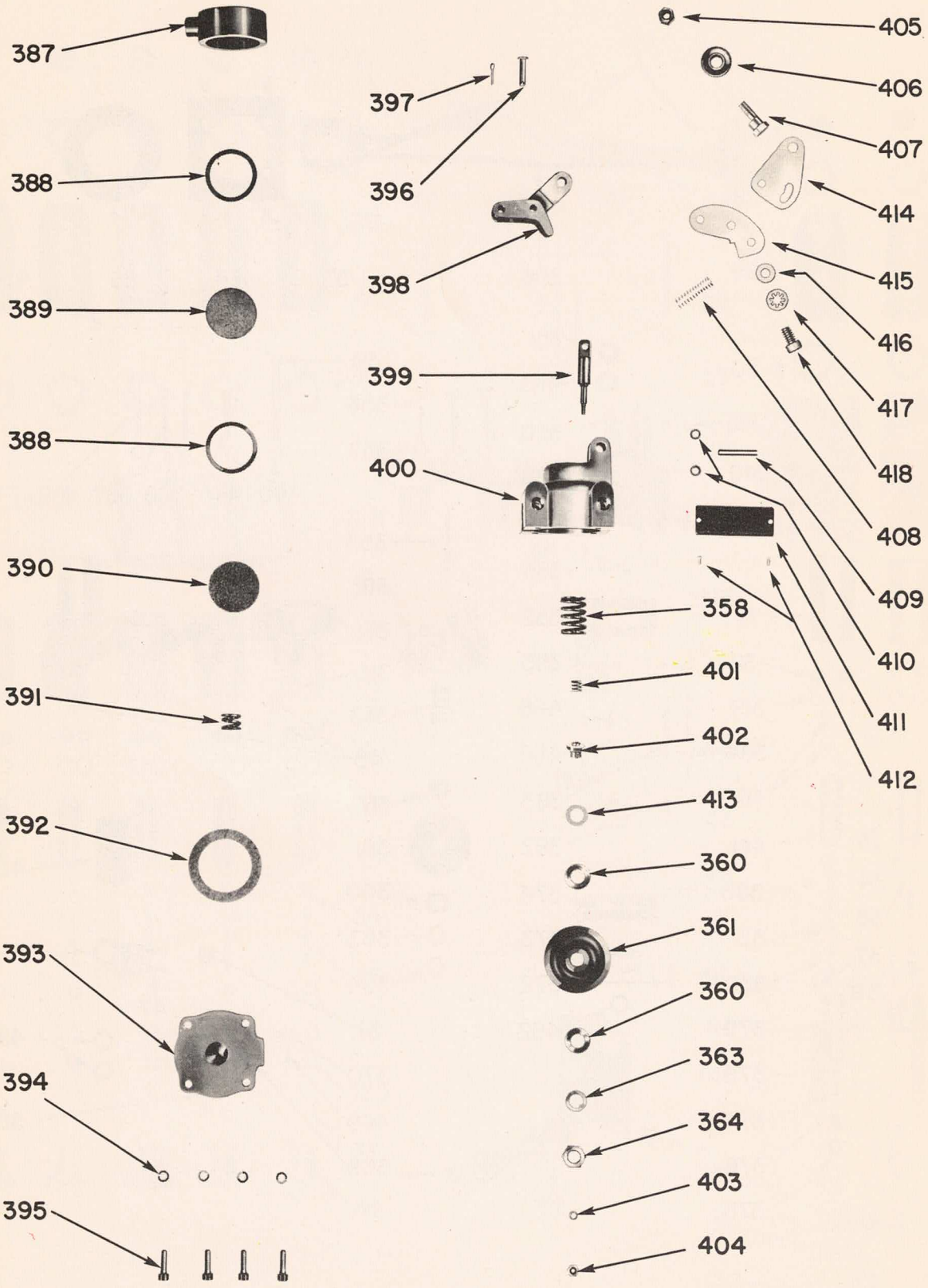

Cut No. 37

Column Parts for Electro-Hydraulic Speed Setting Mechanism



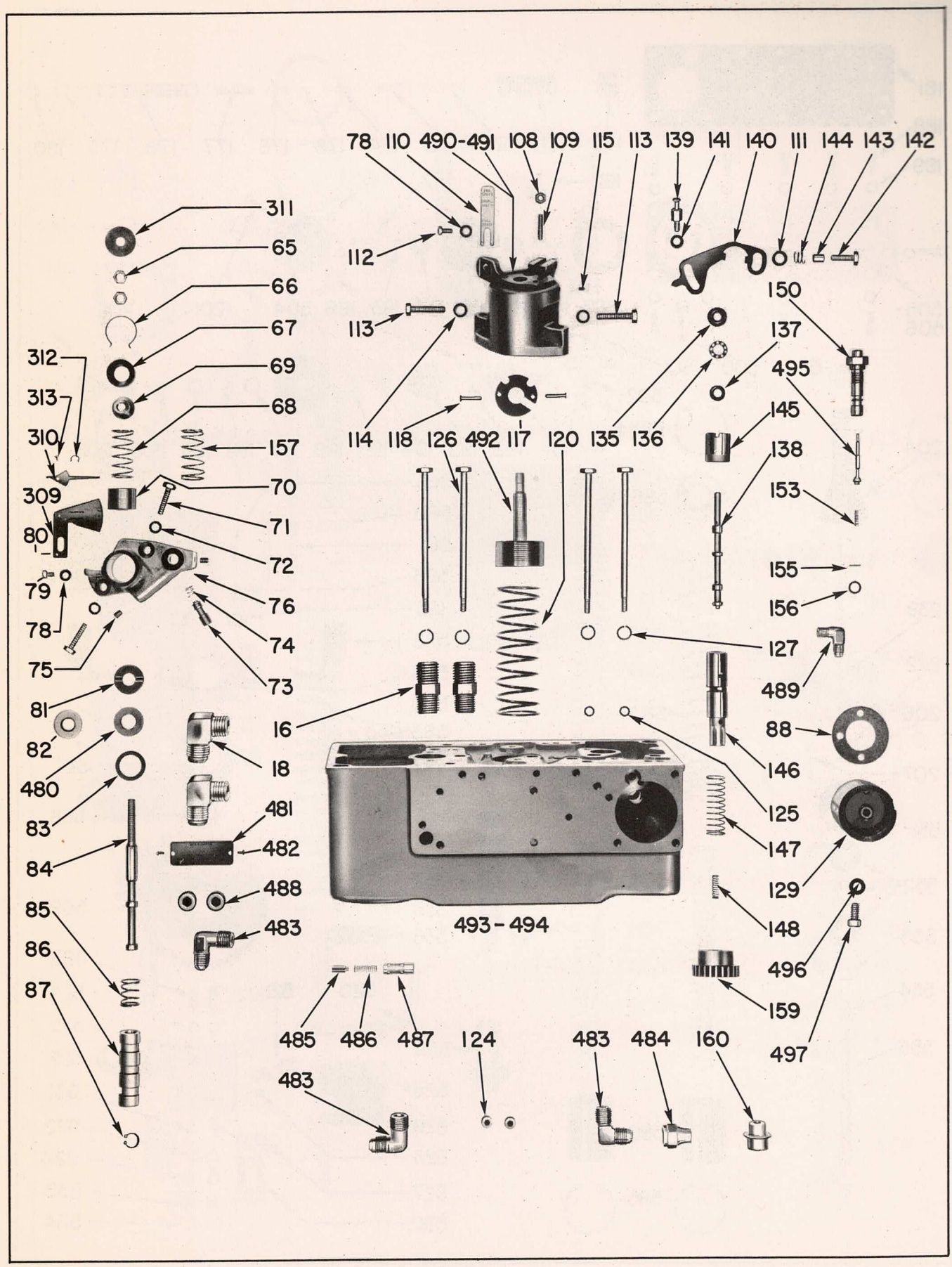

Cut No. 38

Column Parts for Pneumatic-Hydraulic Speed Setting Mechanism



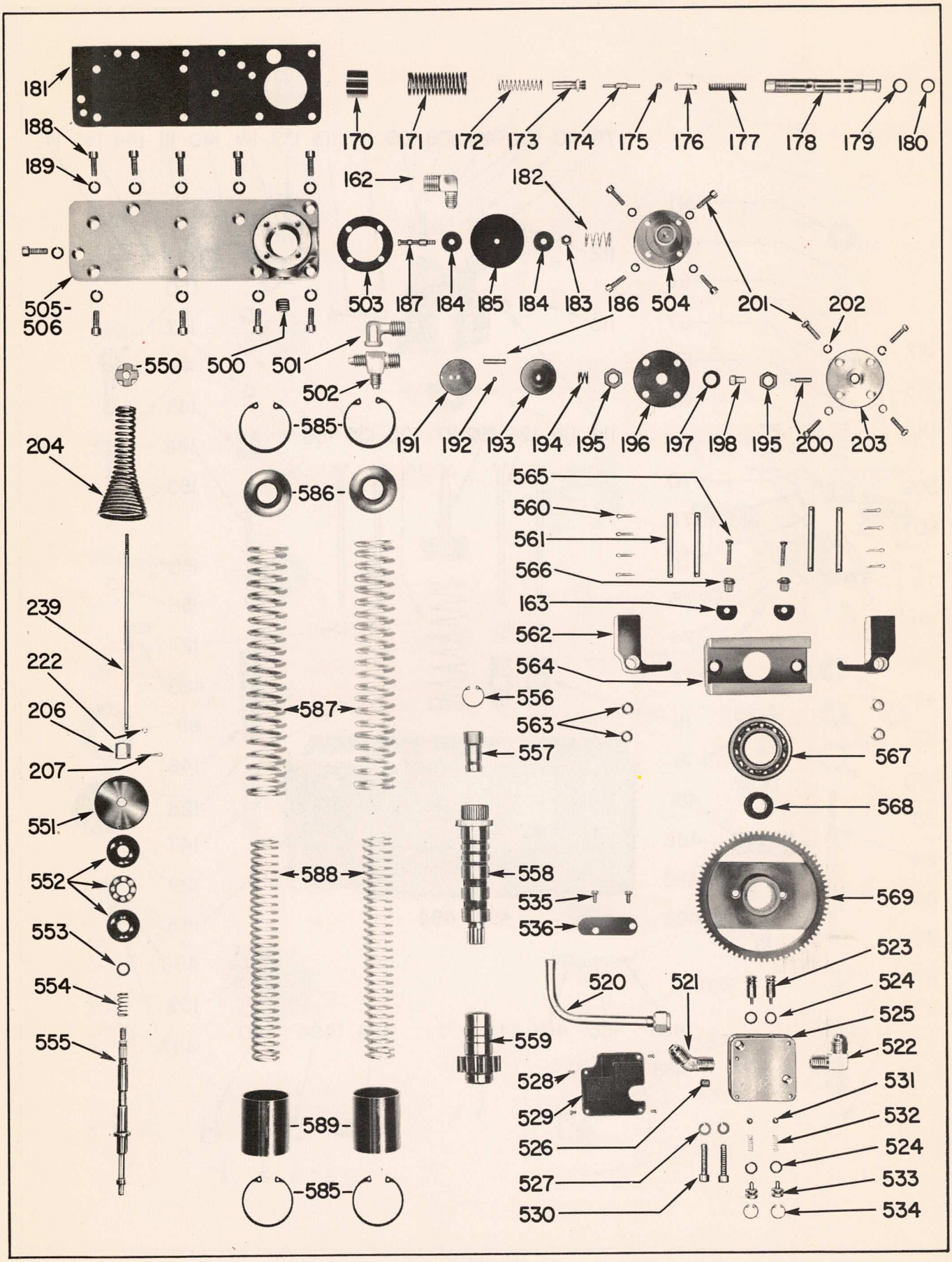

Cut No. 39

Pneumatic Transmitter Parts



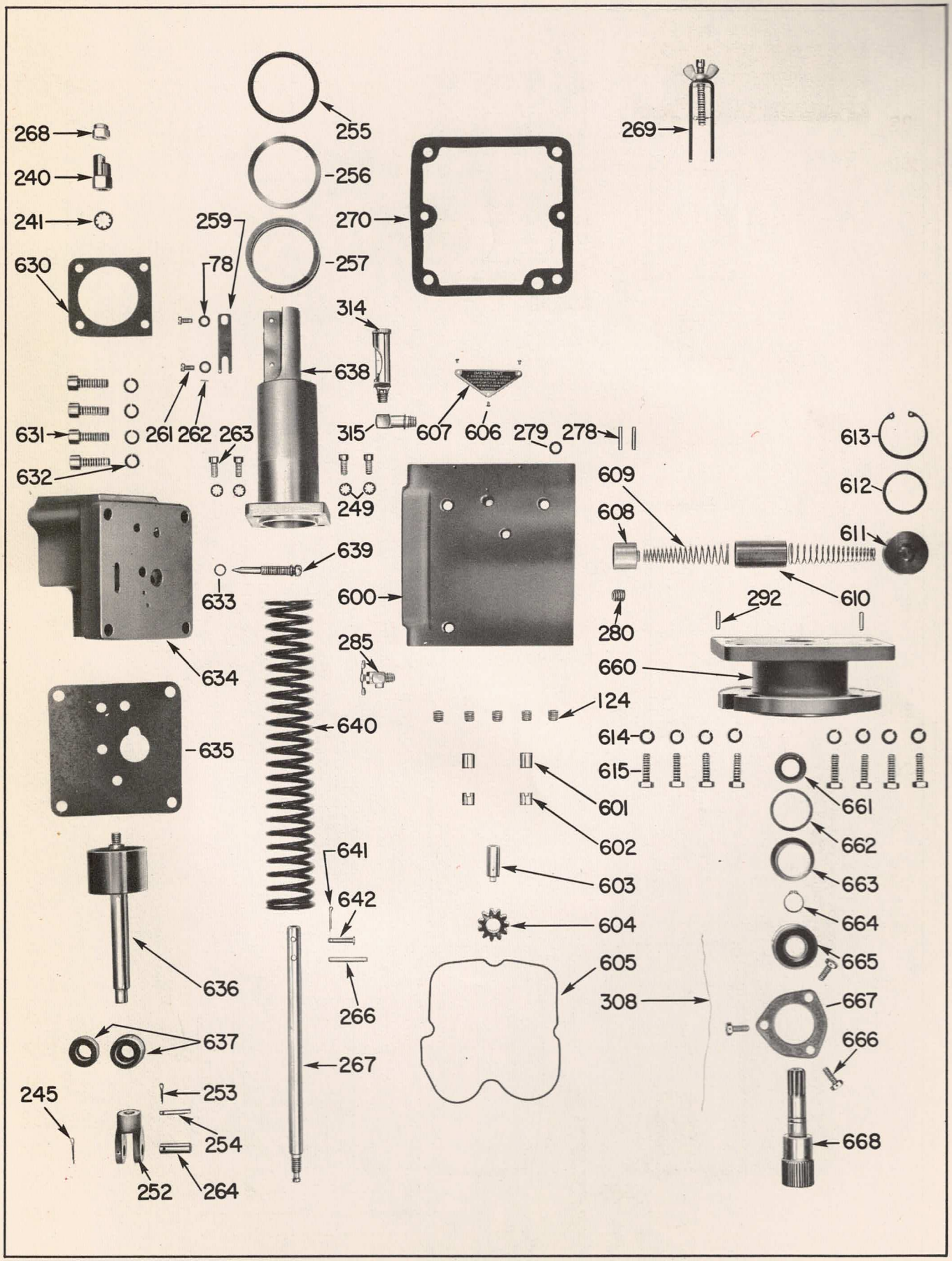

Cut No. 40

Column Parts Common to Either System of Speed Setting



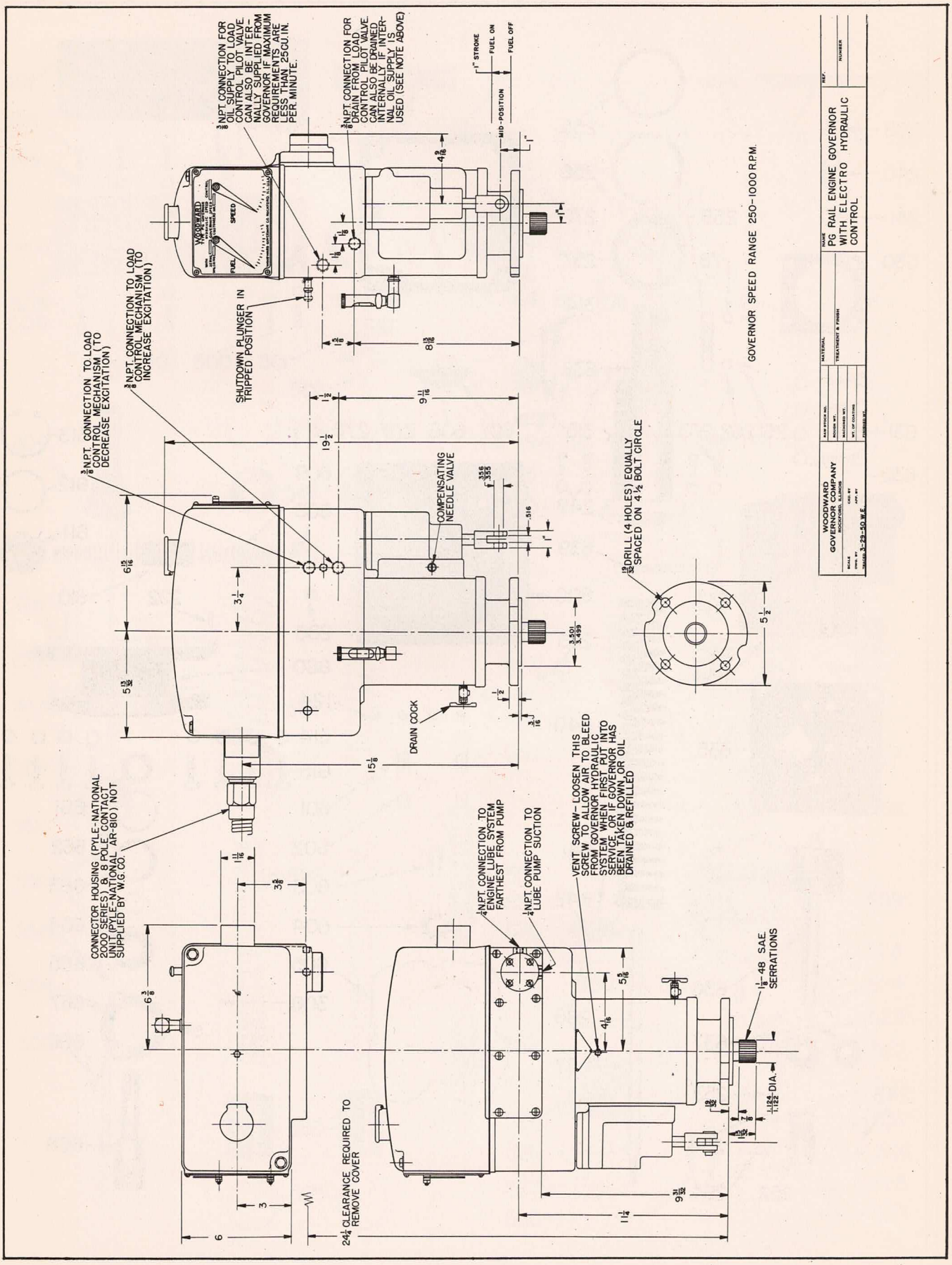

Cut No. 41

Needle Valve Assembly, Shutdown, and Rotating Element Parts



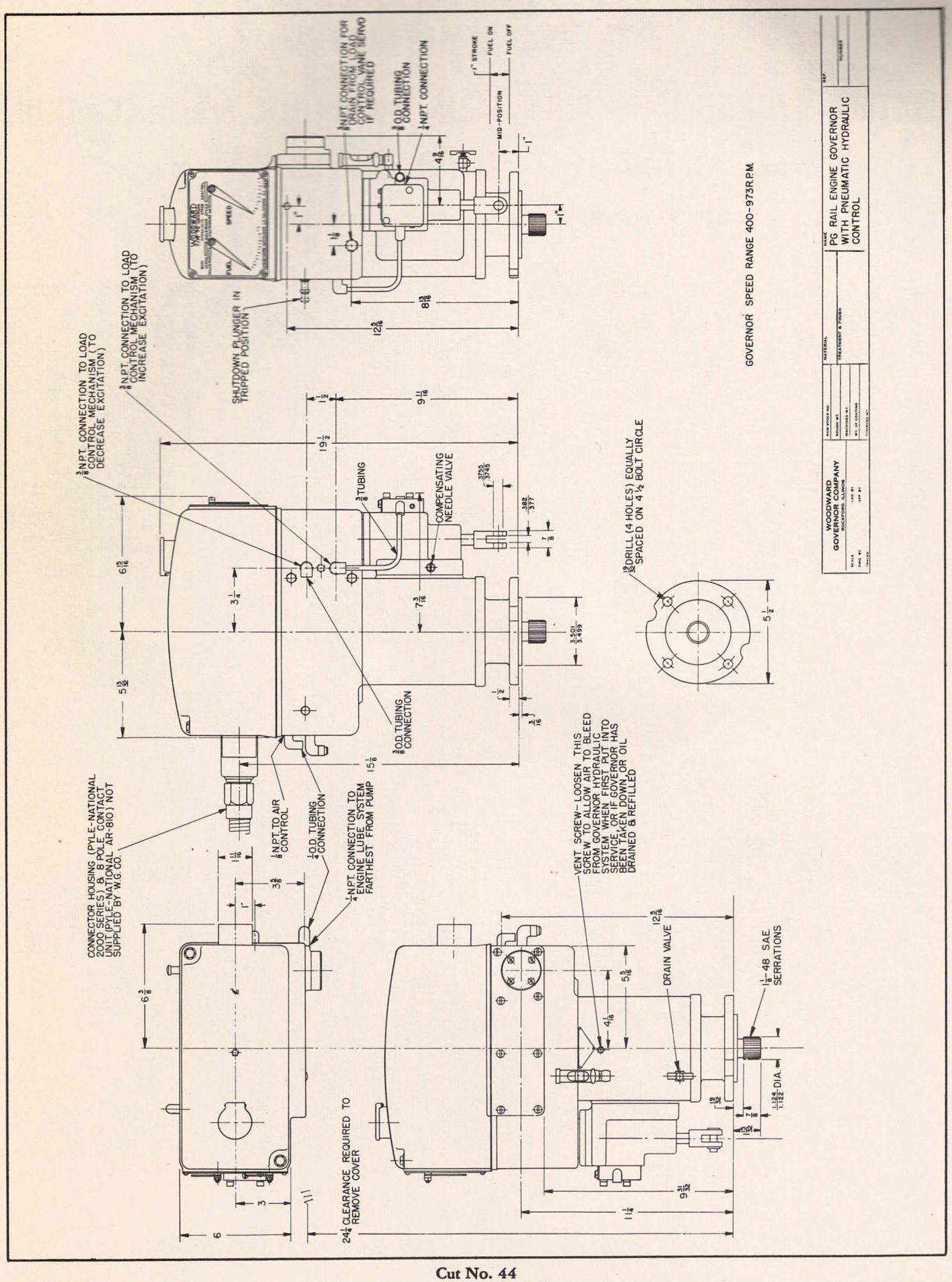

Cut No. 42

Power Cylinder, Case, and Base Parts. Power Piston Jack




Cut No. 43

## Outline Drawing for Electro-Hydraulic Governor




Cut No. 44

**Outline Drawing for Pneumatic-Hydraulic Governor**