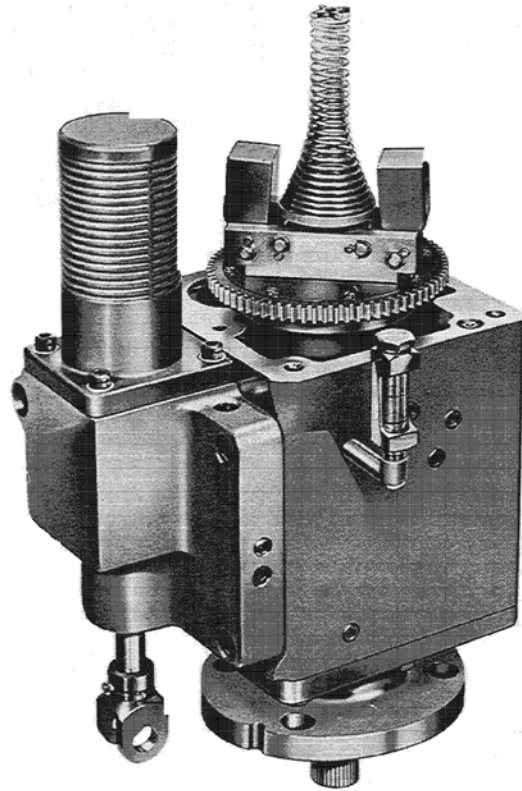




## Installation and Operation Manual



## PG Governor Basic Elements

Manual 36600 (Revision G)



## WARNINGS

**FOLLOW INSTRUCTIONS**—Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.



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**OVERSPEED PROTECTION**—The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.



## CAUTIONS

**BATTERY CHARGING**—To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.



**ELECTROSTATIC DISCHARGE**—Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).
- Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.
- Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.



## IMPORTANT DEFINITIONS

**WARNING**—indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



**CAUTION**—indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment.



**NOTE**—provides other helpful information that does not fall under the warning or caution categories.

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# Chapter 1.

## PG Governor Basic Elements

### Introduction

This manual is one of several covering various components of the type PG governor, and can be combined with other “sectional” manuals to describe fully a particular PG governor model.

Woodward PG governors control the speed of diesel, gas, and dual fuel engines and steam turbines used in a variety of fields. They find service on engines and turbines driving pumps, compressors, alternators, variable speed dc generators, marine propulsion units, and papermaking machines.

In addition to the primary function of controlling engine or turbine speed, the governor is often required to perform such auxiliary functions as limiting engine load, varying engine load to maintain a constant engine power output for a given speed setting, shutting the engine down in the event of lubricating oil pressure failure, etc. Each governor is designed to meet the needs of the engine and the operating requirements of the installation in which it is used.

All PG governors have similar basic elements regardless of how simple or complex the complete control may be. The following elements, found in each PG governor, are sufficient to enable the governor to maintain a constant engine speed as long as the load does not exceed engine capacity:

- an oil pump, storage area for oil under pressure, and a relief valve by which maximum oil pressure may be limited;
- a centrifugal flyweight head-pilot valve assembly which controls flow of oil to and from the governor power cylinder assembly;
- a power cylinder assembly—sometimes referred to as a servomotor—which repositions the fuel racks, fuel valve, or steam valve of the engine or turbine;
- a compensating system which gives stability to the governed system;
- a means of adjusting the governor (and thus, engine) speed setting.

Either of two kinds of power cylinder assemblies can be used: a spring-loaded assembly or a differential assembly.

This manual describes the operation of the basic elements of a PG governor having a spring-loaded power cylinder assembly. Manual 36602 describes the arrangement having a differential power cylinder assembly.

Figure 1-2 shows the schematic arrangement of these elements in the relative positions they assume when the engine is operating on-speed under steady-state conditions. While differences exist in the actual design details of these elements from one governor to another, the scheme of operation is the same in each.

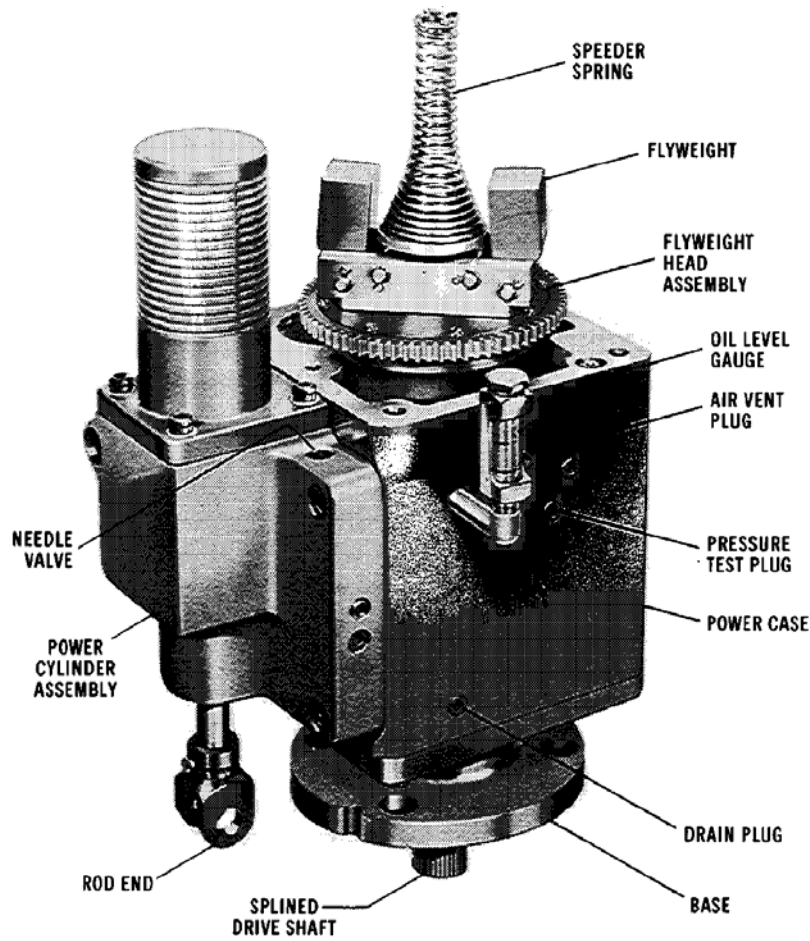


Figure 1-1. PG Basic Elements

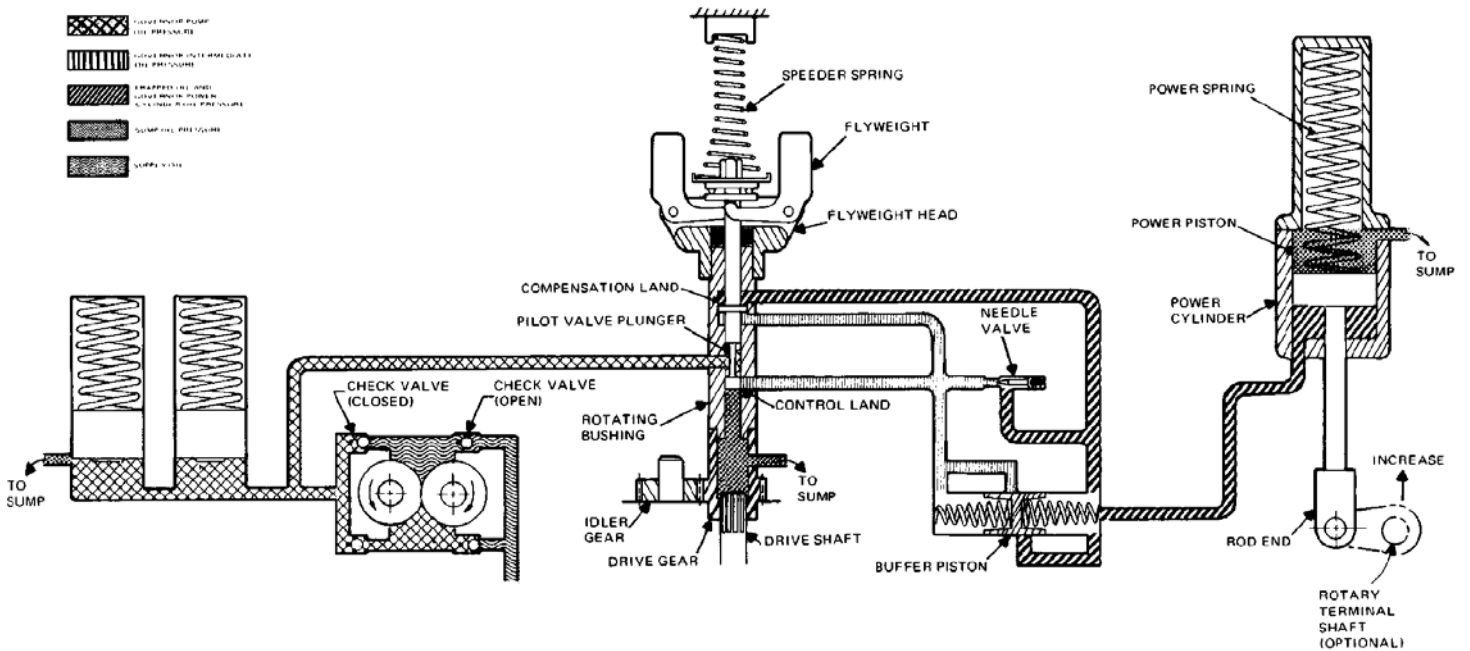


Figure 1-2. PG Schematic

## Governor Oil Pump

Each PG governor contains its own oil sump and oil pump. The governor drive shaft, driven at a speed proportional to engine speed by a mechanical connection to the engine, rotates the pump drive gear and the governor pilot valve bushing. As the rotating drive gear turns the idler gear, oil is drawn from the oil sump and is carried in the space between the gear teeth and the walls of the gear pocket to the discharge side of the pump. The oil is forced from the space between the gear teeth as the drive and idler gears mesh.

Assume that all control valves of the governor are closed. Oil deposited on the discharge side of the pump first fills the various oil passages, and then forces the accumulator pistons up against the downward force of the accumulator springs. When the piston uncovers the bypass hole, the excess oil from the governor pump returns to sump. The accumulators thus not only provide a reservoir for pressure oil but also act as a relief valve to limit maximum pressure in the hydraulic circuit.

The arrangement of the four check valves on the suction and discharge sides of the oil pump permits the governor drive shaft to be rotated in either direction without any changes being made in or to the governor. The direction of pump rotation does not affect the oil pressure system or governor operation. Were the pump gears rotated in the directions opposite those shown in Figure 1-2, the open check valves would be closed and the closed check valves opened.

(Some governor models are built without check valves. In these units, two plugs replace the two closed check valves so that the governor must be rotated in one direction only.)

## Flyweight Head–Pilot Valve Assembly

The pilot valve plunger moves up and down in the rotating pilot valve bushing to control the flow of oil to or from the power cylinder assembly. When the pilot valve plunger is centered (the control land of the plunger exactly covers the control port of the bushing), no oil flows to or from the power cylinder assembly.

The greater of two forces moves the pilot valve plunger up or down. The centrifugal force developed by the rotating flyweights is translated into an upward force which tends to lift the plunger. The centrifugal force is opposed by the downward force of the speeder spring. When the opposing forces are equal, the pilot valve plunger is stationary.

With the pilot valve plunger centered and the engine running on-speed, a change in either of the two forces will move the plunger from its centered position. The plunger will be lowered (1) if the governor speed setting is unchanged but an additional load slows the engine and governor (thereby decreasing the centrifugal force developed by rotating flyweights) or (2) if the engine speed is unchanged but the speeder spring force is increased to raise the governor speed setting. Similarly, the pilot valve plunger will be raised (1) if the governor speed setting is unchanged but load is removed from the engine causing an increase in engine and governor speed (and hence, an increase in the centrifugal force developed by the rotating flyweights), or (2) if the engine speed is unchanged but the speeder spring force is reduced to lower the governor speed setting.

The thrust bearing atop the ballarm toes permits the pilot valve bushing to rotate while the pilot valve plunger does not rotate. In this way, static friction between the bushing and plunger is minimized.

There are several styles of flyweight head assemblies available. The exact model used in any one governor depends on the application.

A “solid” head assembly is used in governors on prime movers which afford a smooth drive to the governor.

“Spring driven” and “spring driven, oil damped” head assemblies are used to filter torsional vibrations which may be imparted to the governor by the drive from the engine. (These torsional vibrations may originate from a source other than the drive itself but reach the governor through the drive connection.) Unless minimized or eliminated, the flyweight head will sense these torsional vibrations as speed changes and continually adjust the fuel valve or racks in an attempt to maintain a constant speed.

## Spring-Loaded Power Cylinder Assembly

The governor pilot valve plunger controls the movement of the power piston in the power cylinder assembly. The power piston, acting through the connecting linkage, controls the engine or turbine fuel.

The power spring continually urges the power piston down in the “decrease fuel” direction. However, the power piston will not move down unless the pilot valve plunger is raised above its centered position. Only when the pilot valve plunger is above center can the oil trapped in the circuit between the plunger and power piston escape to sump. If the pilot valve plunger is lowered, pressure oil from the governor pump will be directed to the power piston and will push the piston up—against the force of the power spring—in the direction to increase fuel.

Note that the power piston will move only when the pilot valve plunger is uncentered to permit the oil flow required. With the plunger centered, the power piston is, in effect, hydraulically locked.

The output of the power cylinder assembly is normally a push-pull motion. Appropriate linkage within the power cylinder assembly can change the output to rotary motion. The power piston movement is the same in either case.

It should also be recognized that positioning the power cylinder assembly at an angle other than that shown in Figure 1-1 would have no effect on the assembly operation.

## Compensating System

Stability of the governed system is achieved by the use of a temporary negative feedback signal which biases the speed signal to the pilot valve plunger. This temporary feedback signal is in the form of a pressure differential applied across the compensating land of the pilot valve plunger. The pressure differential is derived from the “buffer compensating system”, and is dissipated as engine speed returns to the normal or set speed.

The buffer piston, buffer springs, and needle valve in the hydraulic circuit between the control land of the pilot valve plunger and the power piston comprise the “buffer compensating system” of the governor. Lowering the pilot valve plunger permits a flow of pressure oil into the buffer cylinder and power cylinder to move the power piston up to increase fuel. Raising the pilot valve plunger permits oil to flow from the buffer cylinder and power cylinder to the governor sump, and the power piston spring moves the power piston down to decrease fuel.

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. The buffer piston movement, increasing the loading on one buffer spring while decreasing the loading on the other, creates a slight difference in the oil pressures on the two sides of the buffer piston. The higher oil pressure is on the side of the piston opposite the spring being compressed. The difference in oil pressure is proportional to the buffer piston displacement, and is dependent on the rate of the buffer springs selected for the particular installation.

The oil pressure on one side of the buffer piston is transmitted to the lower side of the compensation land on the pilot valve plunger, the pressure on the other side of the piston is transmitted to the upper side of the compensation land. The difference in oil pressures produces a net force (often termed a “compensating force”)—upward or downward, as the case may be—which assists the flyweights or speeder spring in re-centering the pilot valve plunger whenever a fuel correction is made.

Operation of the buffer system can be seen by following the sequence of operations when the engine speed slows down because of the addition of a relatively small load.

The decrease in centrifugal force developed by the rotating flyweights permits the speeder spring to push the flyweights in, lowering the pilot valve plunger and opening the control port.

As the buffer piston moves in the direction of the oil flow—from pilot valve to power cylinder—the right-hand buffer spring is compressed and the left-hand spring is relieved. The oil displaced by the buffer piston as it moves to the right forces the power piston up, thereby increasing fuel to the engine, and the engine begins to accelerate. The buffer piston moves to the right, moving the power piston up, until the upward force created by the pressure differential across the buffer piston and compensating land is sufficient, when added to the centrifugal force from the rotating flyweights, to re-center the pilot valve plunger. As soon as the pilot valve plunger is re-centered, the power piston movement stops. When the governor is properly adjusted, this new piston position corresponds to the fuel increase needed to operate the engine at a set speed with the new load even though the engine has not yet returned to the set speed.

As the engine continues to accelerate to the set speed, the centrifugal force developed by the rotating flyweights increases. To offset this increase in centrifugal force, it is necessary to reduce the net upward force resulting from the pressure differential across the compensation land as the centrifugal force increases. (Otherwise, the pilot valve plunger would be lifted above center and the power piston would move down to decrease fuel.) This is accomplished by equalizing the pressures on both sides of the compensation land as a rate proportional to the rate at which the engine speed returns to normal. As the pressure differential is decreased, the net compensating force is decreased. If the decrease in compensating force can be made as the same rate as the centrifugal force is increased, the pilot valve plunger will remain centered and the power piston will remain stationary. As the pressure differential is being dissipated, the buffer spring compressed returns the buffer piston to its normal, central position. When the pressure differential has been reduced to zero, the compensating force will be reduced to zero. At this time the engine should be back to its set speed, developing the centrifugal force necessary from the flyweights to keep the pilot valve plunger centered.

The rate at which the pressure differential is reduced to zero depends on the needle valve setting. The needle valve setting allows each governor to be "matched" to the engine on which it is used. The final setting of the needle valve cannot be made until the governor is installed on its engine.

When a relatively small load is removed from the engine while it is running on-speed under steady-state conditions, the sequence of events is similar but in the opposite directions.

The engine speed increases. The rotating flyweights develop additional centrifugal force and lift the pilot valve plunger. The oil between the buffer piston and the pilot valve plunger is connected to sump. The power spring pushes the power piston down, forcing the buffer piston towards the pilot valve plunger. A pressure differential again exists between the oil lines to the upper and lower sides of the compensating land of the pilot valve plunger.

The greater pressure is now on the upper side of the compensating land, tending to push the pilot valve plunger back down to its centered position.

When the compensating force becomes sufficient to offset the increase in centrifugal force, the pilot valve plunger is returned to its centered position even though the engine speed is still greater than the set speed. As before, the compensating force is again dissipated at a rate proportional to the rate at which the engine returns to normal speed so that the pilot valve plunger remains centered.

The sequence of movements within the governor occur almost simultaneously rather than in the step-by-step manner described.

Bypass passages are provided in the buffer cylinder to facilitate large corrective movements of the power piston. A large increase or decrease in speed setting, or a large increase or decrease in load on the engine, requires a correspondingly large movement of the power piston to make the necessary fuel correction. At such times, the buffer piston moves far enough to uncover the bypass port (to pressure or drain, depending on the correction being made).

The difference in oil pressures on the opposite sides of the buffer piston and the compensation land cannot exceed the difference which exists when the buffer piston uncovers the bypass port. With the bypass port uncovered, oil flows directly to or from the lower cylinder without further increasing the pressure differential existing on the compensation land.

The bypass ports permit the power piston to move quickly in response to large changes in load or speed setting. Since the pressure differential across the compensating land of the pilot valve plunger does not continue to increase, the speed more than returns to normal (or to the new setting). This overshoot in speed is not large, and is tolerated in order to obtain the desired fast response. As soon as the speed changes beyond the desired point, normal governor action reverses the power piston movement, and stable operation is quickly established.

Surrounding the power piston and its piston rod are grooves connected to the intermediate oil pressure between the pilot valve and the buffer piston. These seal grooves—not shown in the schematic—have nothing to do with operation of the governor, but are used to ensure that any leakage of pressure oil from the power cylinder to the sump comes from a part of the hydraulic circuit where it will do no harm.

“Remote” power cylinder assemblies (assemblies which are located away from the governor power case) have three tubes connecting the power cylinder to the power case. These tubes carry (1) oil to and from the buffer, (2) drain oil from the power cylinder, and (3) oil to the power cylinder seal grooves. To eliminate the possibility of trapping air in the oil, the cylinder must be mounted below the governor oil level, and the connecting tubes must slope upward to the governor.

## Speed Setting Adjustment

A number of speed setting arrangements are available for the PG governor. The exact method used depends upon the operating scheme of the installation in which it is used.

It is enough to observe at this point that no matter how simple or complex the means employed may be, the ultimate objective is to increase or decrease the compression of the speeder spring. An increase in the speeder spring compression requires that the engine run faster so that the rotating flyweights will develop the additional centrifugal force needed to re-center the pilot valve plunger. Conversely, a decrease in spring compression requires a slower engine speed.

The various speed setting arrangements are described in separate manuals.

The recommended speed range for the PG governor is 250 rpm to 1000 rpm with a maximum speed range of 200 rpm to 1600 rpm.

## Chapter 2. Installation

### General

At all times, use care in handling the governor; be particularly careful to avoid striking the drive shaft. Do not drop or rest the governor on its drive shaft. Such treatment could damage the governor drive components.

A gasket should be used between the mounting pad and the governor base when the governor is installed on the engine or turbine. The governor should be mounted squarely and the drive connection properly aligned. If the governor is equipped with a serrated or splined drive shaft, it should slip freely into the internal serrations or splines of the drive. If a keyed type governor drive shaft is used, the gear must slip on the shaft freely and should be checked to ensure that it meshes properly with its mating gear. The gears should run freely without binding or excessive backlash. Irregularities caused by uneven gear teeth, shaft runout, etc., will result in erratic governing.

### Linkage Adjustment

The linkage from the governor to the fuel or steam control must be properly aligned. Any friction or lost motion must be eliminated. Adjustments of fuel linkage must provide for control of fuel from "OFF" to "FULL FUEL" within the limits of the stroke of the governor output connection. For specific information on fuel linkage installation, refer to the engine instruction manual.

When the governor has been properly mounted and the linkage connections completed, make the other connections (pneumatic, electrical, etc.) to the governor.

### Oil Specifications

Information on oils for use in hydraulic governors is available in manual 25071. The recommended continuous operating temperature is 140 to 200 °F (60 to 93 °C). The ambient temperature limits are -20 to +210 °F (-29 to +99 °C). Contact Woodward if the temperature is beyond these limits. Hydraulic fluid pour point must be below the lowest expected starting temperature. Use SAE 20 or 30 oil for ordinary temperature conditions. If governor operating temperatures are extremely hot, use SAE 40 to 50; if extremely cold, use SAE 10. In most cases the same oil that is used in the engine or turbine may be used in the governor.

### Adjustments

Normally, the only requirements for putting a new or overhauled governor into service are filling the governor with oil and adjusting the compensation needle valve to obtain maximum stability. All other operating adjustments are made during factory testing according to engine manufacturer's specifications and should not require further adjustment. Do not attempt internal adjustment of the governor unless thoroughly familiar with the proper procedures.

## Compensation Needle Valve Adjustment

The compensation needle valve is an adjustable part of the compensation system. Its setting, which directly affects governor stability, depends on the individual characteristics of the prime mover:

1. With the prime mover operating at IDLE, open the compensation needle valve several turns to cause the engine to hunt. In some cases, opening of the needle valve alone may not cause the engine to hunt, but manually disturbing the governor speed setting will. Allow several minutes of hunting to remove trapped air in the hydraulic circuits.
2. Close the compensation needle valve gradually until hunting is just eliminated. Keep the needle valve open as far as possible to prevent sluggishness in the governor response. The needle valve setting varies from 1/16 to 2 turns open. Never close it tight, the governor cannot operate satisfactorily when this condition exists.
3. Check the governor stability by manually disturbing the governor speed setting. The compensation adjustment is satisfactory when the governor returns to speed with only a slight over- or undershoot. Once the needle valve adjustment is correct, it is not necessary to change the setting except for large, permanent changes in temperature which affect governor oil viscosity.



### **WARNING—OVERSPEED PROTECTION**

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

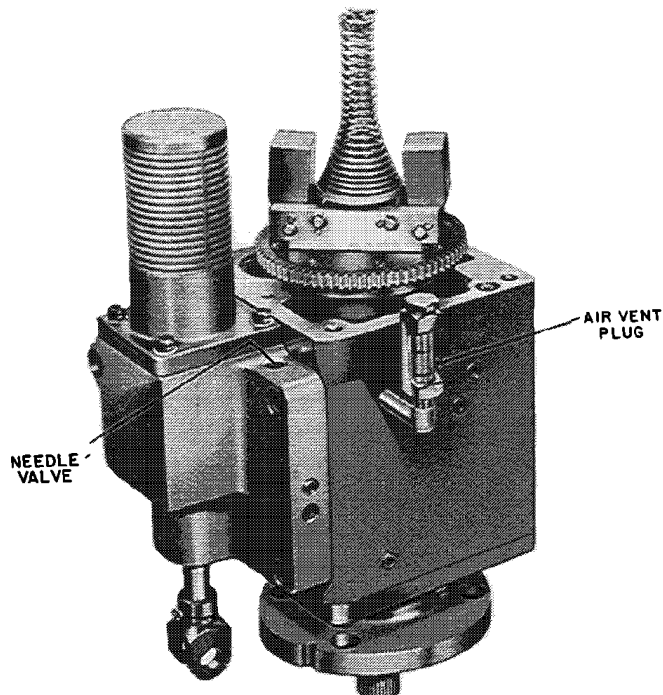


Figure 2-1. Adjustment Locations

## Chapter 3. Maintenance

### General

A governor should operate for several years before needing replacement if it is kept clean, and if the drive from the turbine or engine is smooth and free from torsional oscillations. Except for isolated cases, so rare they can be almost disregarded, governors do not fail or break down suddenly. Instead, they wear gradually, and give an external indication of their condition in the form of slight hunting, sluggish operation, etc. Further deterioration is at a slow enough rate so that an exchange governor may be ordered for installation at the next scheduled shutdown. Because there is so little chance of failure, we do not recommend keeping a complete stock of spare parts on hand. However, plants at which an unplanned shutdown would be very costly often keep a complete spare governor on hand.

It is advisable that the best mechanic available, preferably one experienced with small parts assembly, be permanently assigned to all governor repair work. Cleanliness of tools and work space is essential. A work bench, vise, arbor press, speed lathe, air supply, and containers for cleaning solvents should be provided, if possible. The usual small hand tools are required, and a few special Woodward tools may be desirable if sub-assemblies are to be disassembled.

### Governor Oil

Contaminants and foreign matter in the governor oil are the greatest single source or cause of governor troubles. Use only new or filtered oil. Be sure that all containers used for the governor oil are clean. The time interval between governor oil changes depends on many factors: type of service, operating temperature, quality of oil, etc. Begin an oil maintenance program by inspecting the oil after three months' service. If inspection shows the oil to be satisfactory, gradually lengthen the time between inspections. Anytime the governor oil appears to be dirty or breaking down from contaminants or excessive temperatures, drain the governor while it is hot, flush with the lightest grade of the same oil, and refill with fresh oil. In any event, it is recommended that the oil be changed at least once every eighteen months.

### Inspection and Test

Manual 36404 lists the most frequent indications of governor malfunctioning, and suggests possible causes and the corrective actions needed. A brief summary of these suggestions follows.

Governor faults are usually revealed in speed variations of the engine, but it does not necessarily follow that all such speed variations indicate governor faults. Therefore, when improper speed variations appear, make these checks:

1. Check the load to be sure that the speed changes observed are not the result of load changes.
2. Check the engine operation to be sure that all cylinders are firing properly, and that the injectors are in good operating condition.
3. See that the operating linkage between the governor and engine is free from binding or lost motion.

4. Check the setting of the compensating needle valve. It is impossible for the governor to function correctly if the needle valve is closed tight.

If neither load nor engine irregularities are found to be the cause of the speed variation, and adjustments of the needle valve are unable to correct the malfunctioning, the cause may be either in the governor or the drive to the governor.

If the speed variations are erratic but small in magnitude, the fault may lie in the drive to the governor. Excessive backlash or a tight meshing of the gears driving the governor may be the cause. No amount of adjustment or other work on the governor can correct this condition.

If the speed variations of the governor are large and erratic, and unaffected (except perhaps in magnitude) by changes of adjustment, or if the governor fails to control at all, it should be repaired or replaced.

As a last resort, to prove whether the engine or governor is at fault, another governor, known to be in good condition, should be installed on the engine. When this is done, the test governor must be of the exact same model as the one being removed.

## Removal of Governor from Engine

In cases of major repairs or a complete governor change, the unit may be removed from the engine as follows:

1. Remove the oil drain plug. Drain oil from the governor and replace the drain plug. NOTE: The governor may be equipped with a drain cock for draining.
2. Disconnect linkage from the governor. If levers are removed from serrated shafts, mark their radial positions on the shafts so that they can be reinstalled in the same positions.
3. Disconnect, at the governor, other connections (electrical, pneumatic, hydraulic, etc.) to the governor.
4. Remove the four stud nuts holding the governor assembly to the governor mounting pad and lift the governor off the studs and away from the engine. Remove the gasket between the governor and governor mounting pad.



### **CAUTION—DRIVE SHAFT CARE**

**At all times use care in handling and setting the governor down. Be particularly careful to avoid striking the end of the drive shaft a sharp blow. Such treatment can damage the governor components.**

## Disassembly Procedures

An outline of the order of disassembly of the basic components follows. Hints for the disassembly of subassemblies are given where necessary. (The numbers in parentheses refer to the parts shown in Figure 4-1.)

1. Remove speeder spring (62).

2. Lift out the flyweight head-pilot valve bushing assembly. (items 63 through 101). After detaching the flyweight head (item 93), take out snap ring (81) to permit removal of items (82) and (85).
3. Remove snap ring (60) and items (55) through (59).
4. Remove four screws (8) and lockwashers (9) to detach the power cylinder assembly (items 5 through 22).
  - a. To remove spring guard (20), position the power cylinder assembly in an arbor press as shown in Figure 3-1. Use the arbor press to hold the spring guard down against the force of power spring (17) while removing screws (22) and washers (21).



Figure 3-1

- b. Use a rod end puller tool (Woodward tool 012281) to remove fuel rod end (5). See Figure 3-2 for use of the puller.
- c. Grip power cylinder (10) in a vise to remove oil seals as shown in Figure 3-3.

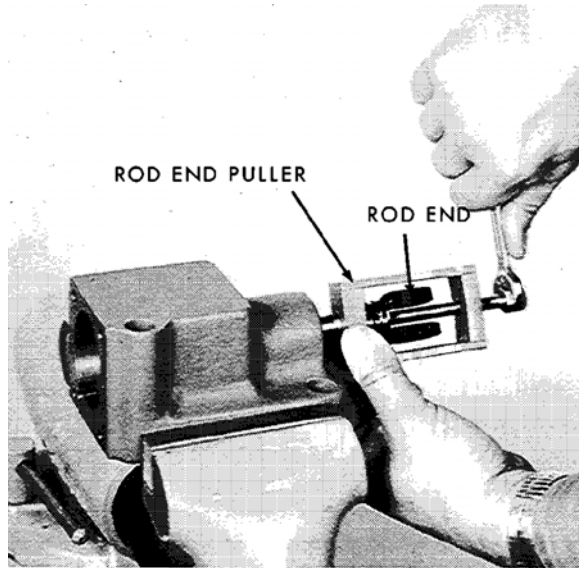


Figure 3-2

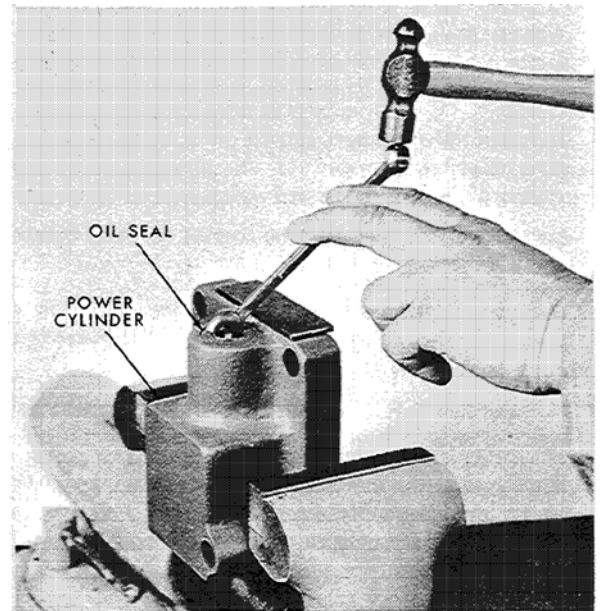


Figure 3-3

5. Remove screws (53) and retainer (52). Take out drive shaft (51) and items (46) through (50). Remove drive shaft oil seal (47) as shown in Figure 3-4.

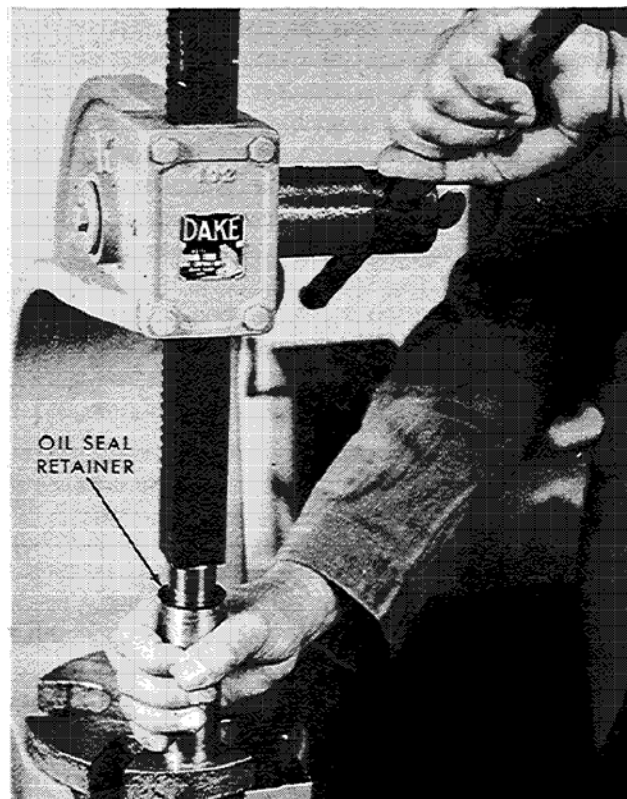


Figure 3-4

6. Remove screws (45) and washers(44). Lift off base (43) taking care that idler gear (40) and drive gear (38) do not fall out. Remove the idler gear and drive gear.
7. Set the power case (28), bottom end (end with idler stud 39) down, in an arbor press or small drill press. With a rod against spring seat (24), compress accumulator springs (25) and (26) to permit removal of upper snap ring (23). See Figure 3-5. Remove spring seat (24) and springs (25) and (26).

Invert the power case and remove snap rings (23) and accumulator pistons (37).

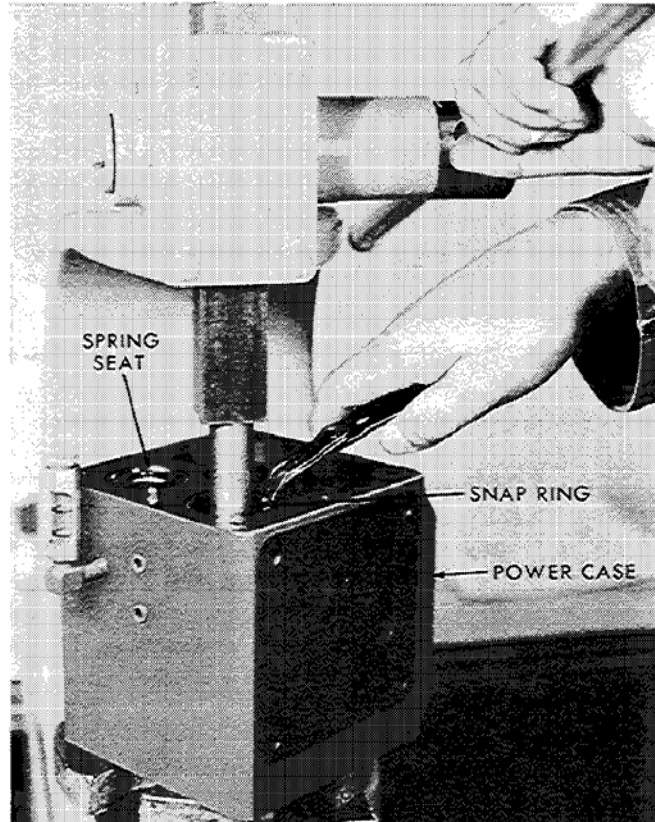


Figure 3-5

8. If necessary to remove check valve assemblies (29 and 30), proceed in this manner:
  - a. To remove inner check valves (29), pry the retainer plate from the check valve assembly and remove springs and check balls.
  - b. To remove outer check valves (30), press the check balls through and out of the valve case.

- c. Then tap all four check valve cases with a 1/4"-28 tap. Using a 1/4"-28 bolt with a small plate as a jack, pull the four valve cases. See Figure 3-6.
- d. Remove two balls from the power case.



Figure 3-6

### Inspection after Disassembly

After disassembling the governor, wash all parts in clean fuel oil and carefully inspect for wear. Generally, most of the repair work consists of cleaning and polishing the governor parts. All pistons, plungers, valves, and rods should move freely without binding or catching. Do not lap in parts if possible to free up by other means.

Inspect the check valves (if used) in the bottom of the governor power case. They must be clean, operating freely, and seating properly.

The flat, joint surfaces at top and bottom of both governor case and base, must be free of burrs and high spots.

Carefully avoid scratching or scoring these faces, particularly the top of the base and the bottom of the case. Avoid damage to the neoprene seal ring and the groove in the bottom face of the governor power case.

The pilot valve plunger should move freely in the pilot valve bushing assembly. If the plunger surfaces are scratched, they may be dressed with a hard Arkansas stone.

**CAUTION—PROTECT EDGES**

The edges of the control land and compensating piston **MUST** be left sharp.

The power piston assembly should move freely in the power cylinder, and the buffer piston should move freely in the buffer cylinder.

Ballhead flyweights must work freely on the needle bearings and pivot pins.

If the toes of the flyweights have flat spots, it will be necessary to disassemble the ballhead and round off the worn spots with emery cloth. If wear is excessive, install new flyweights.

Ball races and bearing balls of the flyweight thrust bearing should be in perfect condition.

## Assembly Procedures

While assembling the parts into the governor, take care to ensure that no lint or other foreign matter is present on the parts. The governor may be assembled dry, or if preferred a small amount of clean lubricating oil can be applied to the parts as they are placed into the governor. Replace all pipe plugs removed from the governor, using a good joint compound on the threads of the plug—NOT IN THE HOLE. When the governor is assembled, apply a liberal amount of clean lubricating oil over all the moving parts, to ensure initial lubrication.

The order of assembly is, in general, the reverse of the disassembly process. The following hints should aid in assembly of the basic elements. (The numbers shown in parentheses refer to the parts shown in Figure 4-1.)

1. Use Woodward tool 360689 to press check valve assembly (29) into power case (28). Use Woodward tool 360690 to press in check valve assembly (30).
2. After installing lower snap rings (23), accumulator pistons (37), and springs (25) and (26), use a rod and an arbor press to compress spring seats (24). Install upper snap rings (23).
3. With the power case components installed and the power case resting upside down (with idler gear stud 39 up), install idler gear (40), drive gear (38), and oil seal ring (41). Be sure the gears turn freely.

Attach base (43) to the power case with screws (45). Do not tighten the screws. Insert drive shaft (51) with bearing (50) and snap ring (49) already on the drive shaft into the base and turn until the splined end slips into the splines in the pump drive gear. Continue turning to check alignment and free rotation of the drive gear and idler gear while tightening screws (45).

Withdraw the drive shaft from the base.

4. Press oil seal (47) into oil seal retainer (48) flush with the end opposite the flange end of retainer.

5. Install gasket (46) and the assembly consisting of the oil seal and oil seal retainer. Install the drive shaft assembly. Attach retainer (52) with screws (53). Tighten screws evenly. Do not attempt to bring the retainer into contact with the base. Install lock wire (54) on screws (53).
6. Press oil seals (6) and (7) into power cylinder (10). Seal (7) should be inserted with the part number facing out. Seal (6) should be inserted with the part number facing in and pressed in to 0.005" (0.13 mm) below flush.
7. Place oil seal inserter (Woodward tool 360066) on over rod of power piston assembly (16) to avoid damaging oil seals (6) and (7) when inserting the piston assembly in the power cylinder.
8. Position the power cylinder in an arbor press, align the taper pin holes, and press rod end (5) onto the end of power piston (16). See Figure 3-7. Place a small steel block in the rod end slot so that pressure is applied against the bottom of the slot.

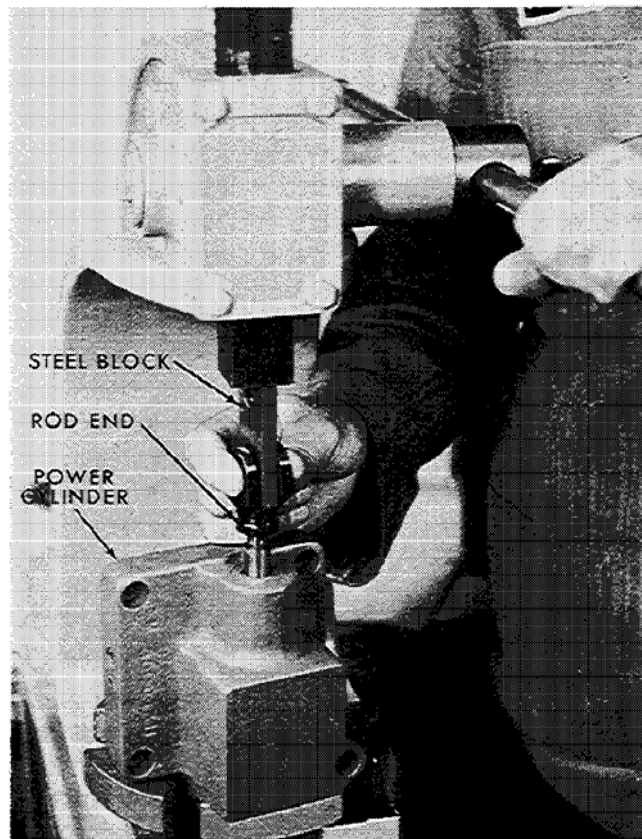


Figure 3-7

9. When assembling the power cylinder assembly onto the power case, align the holes in gasket (13) with the holes in power case (28) instead of with those in the power cylinder.
10. When assembling the flyweight head pilot valve bushing assembly, align the missing tooth in the pilot valve bushing with the corresponding missing tooth in its mating part (items 76 and 87).

11. The three-piece thrust bearing (66) fits onto the stem of the pilot valve plunger (85) with the bearing race with the larger hole on the bottom (against the flyweight toes).
12. "Center" the pilot valve plunger in this manner: wish slight pressure on the speeder spring seat (65), adjust the pilot valve plunger nut (63) until, as the flyweights (70) are moved from their extreme inward to their extreme outward position, there is the same amount of control land showing in the control port at each extreme.

The control ports are the bottom row of holes in the pilot valve bushing assembly. See Figure 3-8. (Note: Shutdown rod (72) and retaining ring (73), if used, must be inserted through nut (63) before the centering adjustment is made.) Be sure to install cotter pin (64).

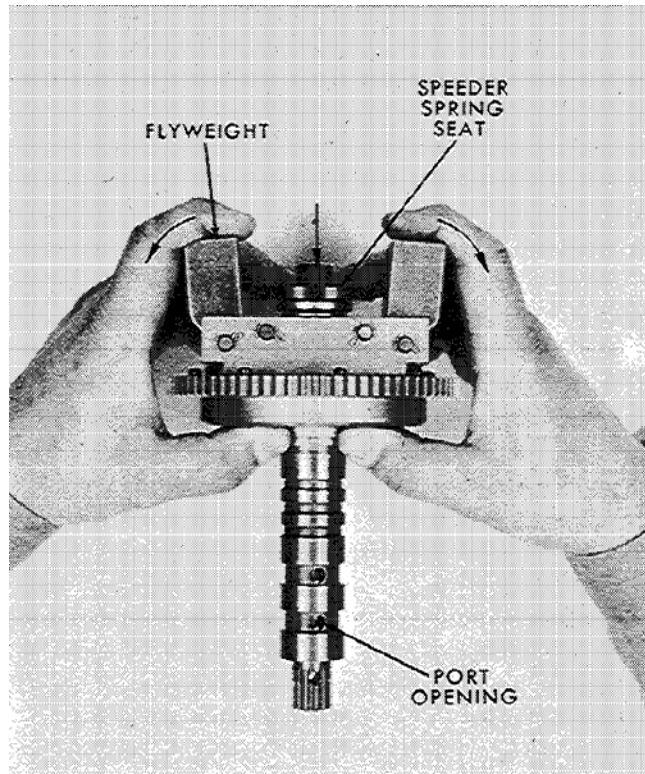


Figure 3-8

## Chapter 4. Replacement Parts

When ordering replacement parts, include the following information:

- Governor serial number and part number shown on the nameplate
- Manual number (this is manual 36600)
- Part reference number in parts list and description of part or part name.

Ref. No.	Part Name .....	Quantity	Ref. No.	Part Name .....	Quantity
36600-1	Rod End Pin .....	1	36600-57	Buffer Piston .....	1
36600-2	Cotter Pin .....	1	36600-58	Plug .....	1
36600-3	Taper Pin .....	1	36600-59	O-ring .....	1
36600-4	Rod End Pin Washer .....	1	36600-60	Snap Ring .....	1
36600-5	Rod End .....	1	36600-61	Speeder Spring Check Plug .....	1
36600-6	Oil Seal .....	1	36600-62	Speeder Spring .....	1
36600-7	Oil Seal .....	1	36600-63	Pilot Valve Plunger Nut .....	1
36600-8	Socket Head Screw (3/8"-16 x 1-1/4) .....	4	36600-64	Cotter Pin .....	1
36600-9	Split Lockwasher (3/8") .....	4	36600-65	Speeder Spring Seat .....	1
36600-10	Power Cylinder .....	1	36600-66	Thrust Bearing .....	1
36600-11	Pipe Plug (1/8") .....	as req.	36600-67	Adjusting Spring Washer .....	1
36600-12	Pipe Plug (1/16") .....	as req.	36600-68	Adjusting Spring .....	1
36600-13	Gasket .....	1	36600-69	Flyweight Bearing .....	4
36600-14	O-ring .....	1	36600-70	Flyweight .....	2
36600-15	Needle Valve .....	1	36600-71	Shutdown Nut .....	2
36600-16	Power Piston and Rod Assembly .....	1	36600-72	Shutdown Rod .....	1
36600-17	Power Cylinder Spring .....	1	36600-73	Not Used	
36600-18	Gasket .....	1	<b>Spring Coupled—Undamped Flyweight Head Assy</b>		
36600-19	Piston Stop Ring .....	1	36600-74	Round Head Screw (#6-32 x 5/16") .....	1
36600-20	Spring Guard .....	1	36000-75	Split Lockwasher (#6) .....	1
36600-21	Shakeproof Washer (1/4") .....	4	36600-76	Spring Coupling Assembly .....	1
36600-22	Socket Head Screw (1/4"-28 x 3/4) .....	4	36600-77	Not Used	
36600-23	Snap Ring .....	4	36600-78	Flyweight Head .....	1
36600-24	Spring Seat .....	2	36600-79	Not Used	
36600-25	Accumulator Spring (Large) .....	2	36600-80	Not Used	
36600-26	Accumulator Spring (Small) .....	2	36600-81	Snap Ring .....	1
36600-27	Case-to-Column Dowel Pin .....	2	36600-82	Compensating Bushing .....	1
36600-28	Power Case .....	1	36000-83	Cotter Pin .....	8
36600-29	Check Valve Assembly (Spring Loaded) .....	2	36000-84	Flyweight Pin—Limit Pin .....	4
36600-30	Check Valve Assembly (Plain) .....	2	36000-85	Pilot Valve Plunger .....	1
36600-31	Gasket .....	1	36600-87	Flyweight Hd Gear-Pilot Vlv Bshng Assy .....	1
36600-32	Not Used		36600-94	Centering Bearing .....	1
36600-33	Not Used		<b>Spring Coupled— Oil Damped Flyweight Head Assy</b>		
36600-34	Oil Level Gauge .....	1	36600-88	Round Head Screw (#8-32 x 5/16) .....	1
36600-35	Elbow .....	1	36600-89	Split Lockwasher (#8) .....	1
36600-36	Drain Cock .....	2	36600-90	Spring Coupling Assembly .....	1
36600-37	Accumulator Piston .....	1	36600-91	Fillister I-lead Screw (#5-40 x 9/32) .....	8
36600-38	Drive Gear .....	1	36600-92	Lockwasher (#5) .....	8
36600-39	Idler Gear Stud .....	1	36600-93	Flyweight Head .....	1
36600-40	Idler Gear .....	1	36600-94	Centering Bearing .....	1
36600-41	Oil Seal Ring .....	1	36600-95	Oil Seal Ring .....	1
36600-42	Case-to-Base Dowel Pin .....	2	36600-96	Flyweight Hd Gear-Pilot Vlv Bshng Assy .....	1
36600-43	Base .....	1	36600-97	Flyweight Hd Cup-Pilot Vlv Bshng Assy .....	1
36600-44	Split Lockwasher (21/64") .....	8	<b>Parts for Special Low Speed Governor Operation</b>		
36600-45	Hex Head Screw (5/16"-18 x 1") .....	8	36600-98	Spring .....	1
36600-46	Gasket .....	1	36600-99	Spring Seat .....	1
36600-47	Oil Seal .....	1	36600-100	Plug .....	1
36600-48	Oil Seal Retainer .....	1	36600-101	Snap Ring .....	1
36600-49	Snap Ring .....	1	<b>Rubber Damped Flyweight Head Assembly</b>		
36600-50	Bearing .....	1	36600-102	Rubber Coupling Assembly .....	1
36600-51	Drive Shaft .....	1	36600-103	Flyweight Head .....	1
36600-52	Bearing Retainer .....	1	36600-104	Fly eight Hd Cup—Pilot Vlv Bshng Assy .....	1
36600-53	Hex Head Screw (1/4"-28 x 5/8) .....	3	<b>Solid Flyweight Head Assembly</b>		
36600-54	Lockwire .....	as req.	36600-105	Flyweight Head .....	1
36600-55	Spring Seat .....	1	36600-106	Pilot Valve Bushing Assembly .....	1
36600-56	Buffer Spring .....	2			

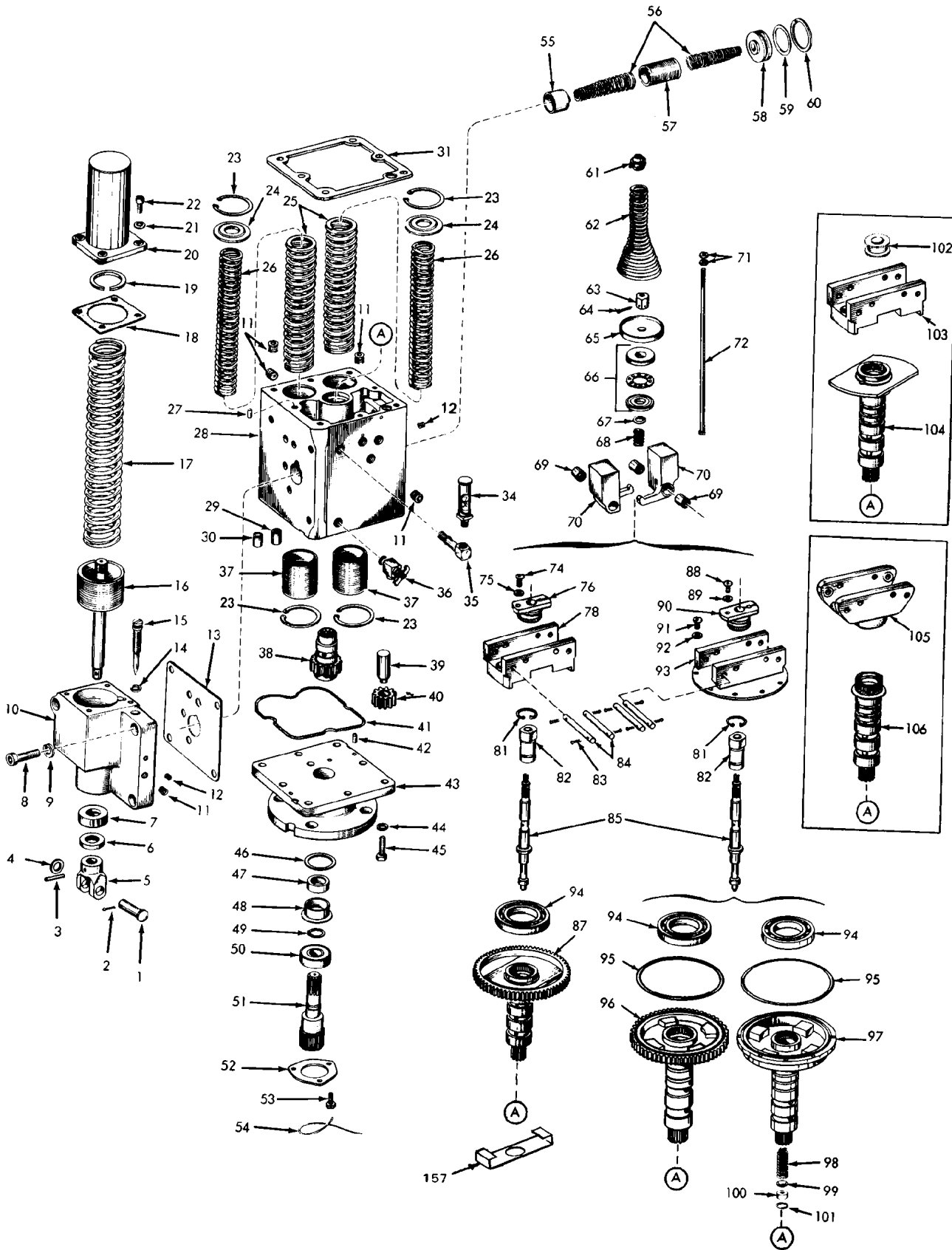


Figure 4-1. Exploded View

**Power Cylinder Assembly with Rotary Terminal Shaft**

36600-107	Power Piston and Rod Assembly .....	1
36600-108	Drive Screw .....	2
36600-109	Terminal Shaft Scale .....	1
36600-110	Rack Dial Segment.....	1
36600-111	Taper Pin.....	1
36500-112	Socket Head Screw (#10-32 x 5/8") .....	1
36600-113	Split Lockwasher (#10).....	1
36600-114	Oil Seal (Small) .....	1
36600-115	Needle Bearing (Small) .....	1
36600-116	Socket Head Screw (#8-32 x 3/4") .....	2
36600-117	Split Lockwasher (#8).....	2
36600-118	Compensating Needle Valve .....	1
36600-119	O-ring .....	1
36600-120	Split Lockwasher (#3/8").....	4
36600-121	Socket Head Screw (3/8"-16 x 1") .....	1
36600-122	Rack Scale Pointer.....	1
36600-123	Snap Ring (Large) .....	2
36600-124	Snap Ring (Small) .....	2
36600-125	Power Piston Link.....	2
36600-126	Stop Nut (7/16"-20) .....	1
36600-127	Power Lever .....	1
36600-128	Split Lockwasher (5/16").....	2
36600-129	Clamp Screw .....	2
36600-130	Gasket.....	1
36600-131	Cover.....	1
36600-132	Split Lockwasher .....	8
36600-133	Socket Head Screw (1/4"-28 x 3/4") .....	8
36600-134	Pipe Plug (1/8" NPT) .....	1
36600-135	Gasket.....	1
36600-136	Power Cylinder .....	1
36600-137	Needle Bearing (Large) .....	1
36600-138	Oil Seal (Large) .....	1
36600-139	Terminal Shaft.....	1
36600-140	Piston Rod Pin .....	1
36600-141	Power Lever Pin .....	1
36600-142	Snap Ring (Small) .....	2

**Alternate Base Assembly**

36600-143	Base .....	1
36600-144	Gasket.....	1
36600-145	Oil Seat .....	1
36600-146	Oil Seal Retainer .....	1
36600-147	Serrated Drive Shaft (Long) .....	1
36600-148	Bearing.....	1
36600-149	Snap Ring .....	1
36600-150	Bearing Retainer .....	1
36600-151	Hex Head Screw (1/4"-28 x 5/8").....	3
36600-152	Keyed Drive Shaft .....	1
36600-153	Straight Key.....	1
36600-154	Spacer Sleeve.....	1
36600-155	Castle Nut (5/8"-18).....	1
36600-156	Lockwire .....	as req.
36600-157	Retainer Clip .....	

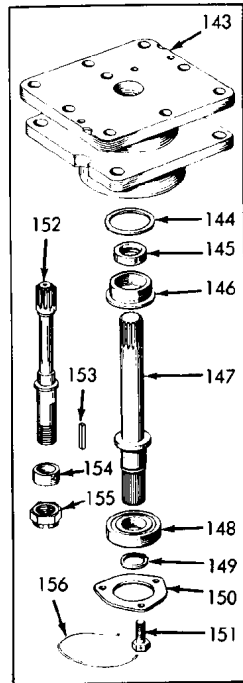
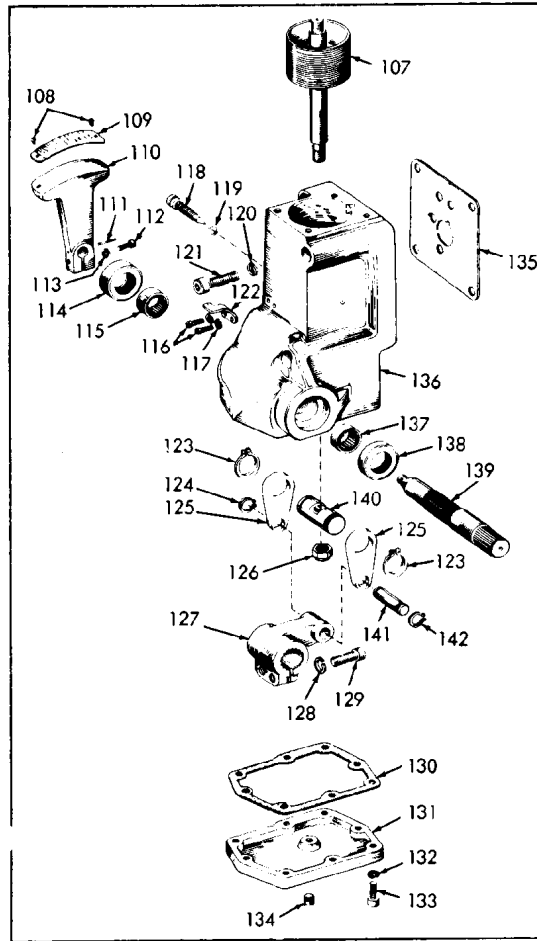


Figure 4-2. Exploded View, Alternate Power Cylinder and Base Assemblies

## Chapter 5. Service Options

### Product Service Options

The following factory options are available for servicing Woodward equipment, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is purchased from Woodward or the service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

If you are experiencing problems with installation or unsatisfactory performance of an installed system, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In most cases, your problem can be resolved over the phone. If not, you can select which course of action you wish to pursue based on the available services listed in this section.

### Replacement/Exchange

Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is also a flat rate structured program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Woodward facility as explained below (see “Returning Equipment for Repair” later in this chapter).

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned to Woodward within 60 days, Woodward will issue a credit for the core charge. [The core charge is the average difference between the flat rate replacement/exchange charge and the current list price of a new unit.]

**Return Shipment Authorization Label.** To ensure prompt receipt of the core, and avoid additional charges, the package must be properly marked. A return authorization label is included with every Replacement/Exchange unit that leaves Woodward. The core should be repackaged and the return authorization label affixed to the outside of the package. Without the authorization label, receipt of the returned core could be delayed and cause additional charges to be applied.

## Flat Rate Repair

Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

## Flat Rate Remanufacture

Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

## Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned to Woodward for repair, please contact Woodward in advance to obtain a Return Authorization Number. When shipping the item(s), attach a tag with the following information:

- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.



### **CAUTION—ELECTROSTATIC DISCHARGE**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

## Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

## Return Authorization Number

When returning equipment to Woodward, please telephone and ask for the Customer Service Department [1 (800) 523-2831 in North America or +1 (970) 482-5811]. They will help expedite the processing of your order through our distributors or local service facility. To expedite the repair process, contact Woodward in advance to obtain a Return Authorization Number, and arrange for issue of a purchase order for the item(s) to be repaired. No work can be started until a purchase order is received.



### NOTE

**We highly recommend that you make arrangement in advance for return shipments. Contact a Woodward customer service representative at 1 (800) 523-2831 in North America or +1 (970) 482-5811 for instructions and for a Return Authorization Number.**

## Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

## How to Contact Woodward

In North America use the following address when shipping or corresponding:

Woodward Governor Company  
PO Box 1519  
1000 East Drake Rd  
Fort Collins CO 80522-1519, USA

Telephone—+1 (970) 482-5811 (24 hours a day)  
Toll-free Phone (in North America)—1 (800) 523-2831  
Fax—+1 (970) 498-3058

For assistance outside North America, call one of the following international Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

<u>Facility</u>	<u>Phone Number</u>
Brazil	+55 (19) 3708 4800
India	+91 (129) 230 7111
Japan	+81 (476) 93-4661
The Netherlands	+31 (23) 5661111

You can also contact the Woodward Customer Service Department or consult our worldwide directory on Woodward's website ([www.woodward.com](http://www.woodward.com)) for the name of your nearest Woodward distributor or service facility.

## Engineering Services

Woodward Industrial Controls Engineering Services offers the following after-sales support for Woodward products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Contact information:

Telephone—+1 (970) 482-5811

Toll-free Phone (in North America)—1 (800) 523-2831

Email—[icinfo@woodward.com](mailto:icinfo@woodward.com)

Website—[www.woodward.com](http://www.woodward.com)

**Technical Support** is available through our many worldwide locations or our authorized distributors, depending upon the product. This service can assist you with technical questions or problem solving during normal business hours. Emergency assistance is also available during non-business hours by phoning our toll-free number and stating the urgency of your problem. For technical support, please contact us via telephone, email us, or use our website and reference **Customer Services** and then **Technical Support**.

**Product Training** is available at many of our worldwide locations (standard classes). We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability. For information concerning training, please contact us via telephone, email us, or use our website and reference **Customer Services** and then **Product Training**.

**Field Service** engineering on-site support is available, depending on the product and location, from one of our many worldwide locations or from one of our authorized distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface. For field service engineering assistance, please contact us via telephone, email us, or use our website and reference **Customer Services** and then **Technical Support**.

## Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

### General

Your Name \_\_\_\_\_  
 Site Location \_\_\_\_\_  
 Phone Number \_\_\_\_\_  
 Fax Number \_\_\_\_\_

### Prime Mover Information

Engine/Turbine Model Number \_\_\_\_\_  
 Manufacturer \_\_\_\_\_  
 Number of Cylinders (if applicable) \_\_\_\_\_  
 Type of Fuel (gas, gaseous, steam, etc) \_\_\_\_\_  
 Rating \_\_\_\_\_  
 Application \_\_\_\_\_

### Control/Governor Information

Please list all Woodward governors, actuators, and electronic controls in your system:

Woodward Part Number and Revision Letter

Control Description or Governor Type

Serial Number

Woodward Part Number and Revision Letter

Control Description or Governor Type

Serial Number

Woodward Part Number and Revision Letter

Control Description or Governor Type

Serial Number

*If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.*

**We appreciate your comments about the content of our publications.**

**Send comments to: [icinfo@woodward.com](mailto:icinfo@woodward.com)**

**Please include the manual number from the front cover of this publication.**



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**Woodward has company-owned plants, subsidiaries, and branches,  
as well as authorized distributors and other authorized service and sales facilities throughout the world.**

**Complete address / phone / fax / email information for all locations is available on our website.**