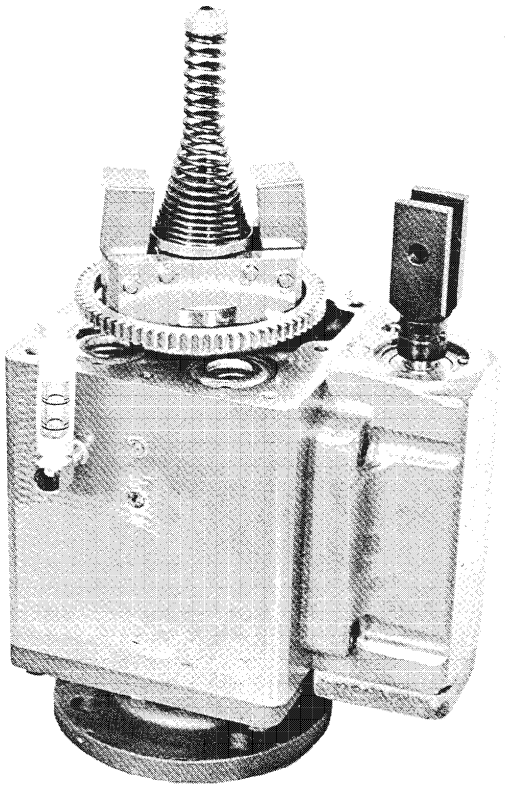
WOODWARD

Product Manual 36602
(Revision F)
Original Instructions



PG Governor with Differential Servomotor Basic Elements

Installation and Operation Manual

General Precautions

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.

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:

www.woodward.com/publications

The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Contents

Illustrations and Tables

Warnings and Notices

Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

⚠WARNING

Overspeed / Overtemperature / Overpressure

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.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

⚠WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

NOTICE

Battery Charging Device

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 Awareness

NOTICE

Electrostatic Precautions

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.**

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*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Chapter 1.
PG Governor Basic Elements

Introduction

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 generator excitation or propeller pitch 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 differential power cylinder assembly. Manual 36600 describes the arrangement having a spring-loaded power cylinder assembly.

Figures 1-4 and 1-5 show the schematic arrangement of these elements in the relative positions they assume when the prime mover is operating on-speed under steady-state conditions. The two schematics differ due to the two designs of differential power cylinder assemblies depicted. (Figure 1-4 is the schematic for the unit shown in Figure 1-2; Figure 1-5 is the schematic for the assembly in Figure 1-3.) The functional differences between the power cylinder assemblies are outlined in the section entitled “Compensating System”. While differences exist in the actual design details of individual parts from one governor to another, the scheme of operation is the same.

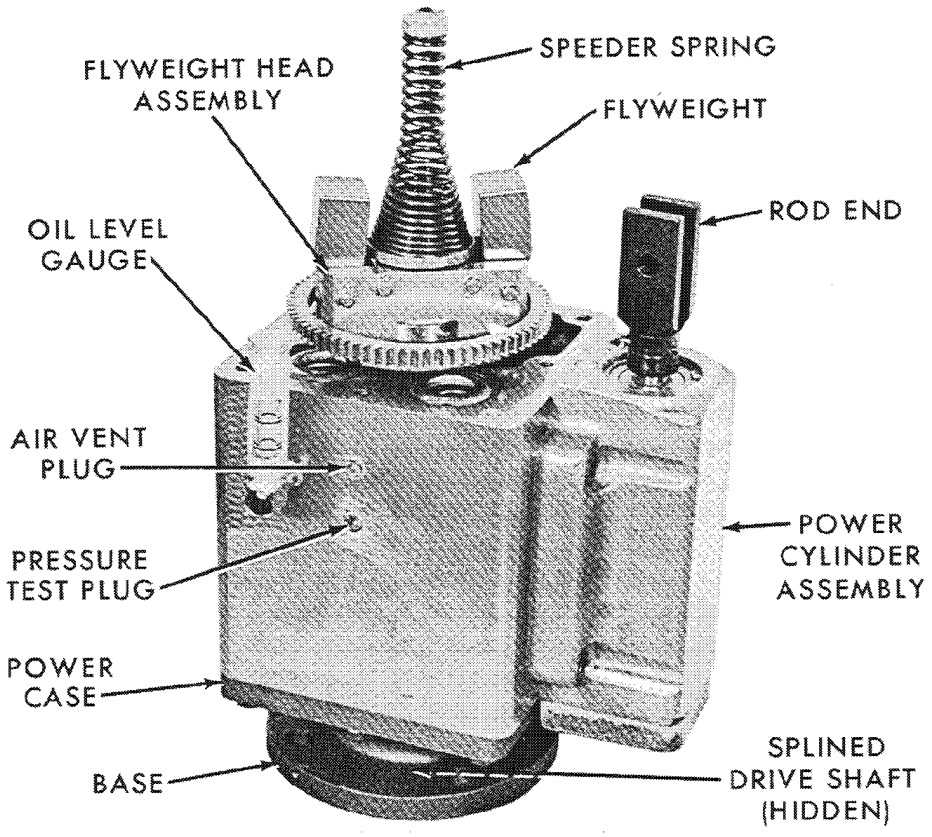


Figure 1-1. PG Components

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 so 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 Figures 1-4 and 1-5, the open check valves would be closed end 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 tortes 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 by raising 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 by lowering 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.

Differential Power Cylinder Assembly

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

The power piston requires pressure oil to move it either in the “increase fuel” or “decrease fuel” directions. The power piston, a differential type piston, has pressure oil continually directed to the side of the piston with the smaller area. This constant pressure continually urges the piston in the decrease fuel direction. However, the piston cannot move to decrease fuel unless oil in the passages between the opposite side of the piston (the side with the larger area) and the pilot valve plunger control land can escape to sump. This oil is connected to sump only when the pilot valve plunger is above its centered position.

If the pilot valve plunger is below its centered position, oil flows to the side of the power piston with the larger area (as well as to the side with the smaller area). Though the pressures on the two sides of the piston are approximately the same, the force resulting from the oil acting on the greater surface area is greater and moves the piston in the increase fuel direction.

Note that the power piston can 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.

Two different hydraulic circuits are used for the oil passages between the pilot valve plunger control land and the power piston. The scheme used in a particular model depends on the size of the power piston. Both are discussed in the next section.

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 a rotary motion. The power cylinder assembly can sometimes be positioned at an angle other than perpendicular to the governor base. In all such arrangements, the power piston movement is a reciprocating movement.

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 in a direction to increase fuel. Raising the pilot valve plunger permits oil to flow from the buffer cylinder and power cylinder to the governor vamp, and the constant oil pressure moves the power piston in a decrease fuel direction.

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 upon 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 she 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.

A relatively small power piston is used in power cylinder assemblies such as that shown in Figure 1-2. In these assemblies, the oil displaced by the buffer piston movement is usually sufficient to move the power piston the distance necessary to correct for small load changes. This power cylinder arrangement is shown schematically in Figure 1-4.

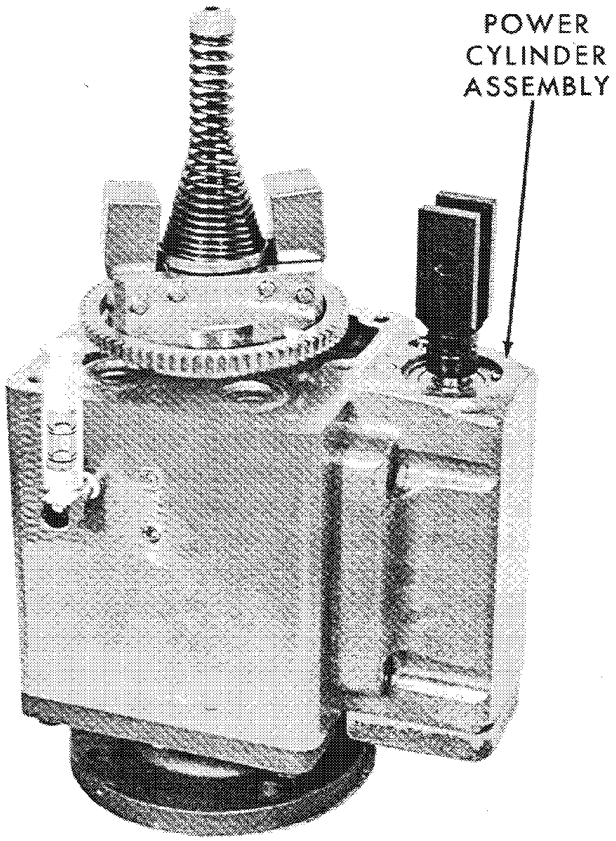


Figure 1-2. PG with Small Power Piston

A larger power piston is used in the power cylinder assembly shown in Figure 1-3. The volume of oil needed to move this piston in response to small load changes would exceed the volume resulting from the normal buffer piston displacement. For this reason, a direct passage is provided between the pilot valve plunger control land and the power piston. This arrangement is shown schematically in Figure 1-5. The buffer piston is hydraulically connected to a smaller “compensation” area in the power cylinder assembly. The pressure differential resulting from the buffer piston displacement provides the compensating force needed to give stability to the governed system.

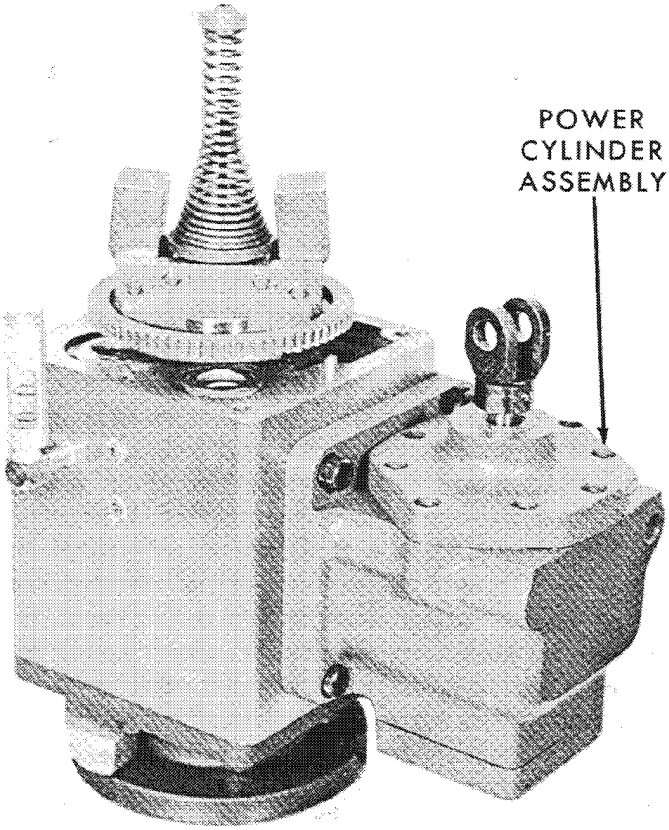


Figure 1-3. PG with Larger Power Piston

Operation of the buffer system can be seen by following the sequence of operations when the engine 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 and, in units with the large power piston, oil from the pilot valve, forces the piston in a direction to increase fuel to the engine: the engine begins to accelerate. The buffer piston moves to the right 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 in a direction to decrease fuel.) This is accomplished by equalizing the pressures on both sides of the compensation land at a rate proportional to the rate at which the engine speed returns to normal. As the pressure differential is decreased, the new compensating force is decreased. If the decrease in compensating force can be made at 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 compressed buffer spring 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; in a power cylinder assembly with the large power piston, oil from the control area is also connected to sump. Constant pressure forces the power piston in a direction to decrease fuel, causing the buffer piston to move toward 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 buffet piston and the compensation land cannot exceed the difference which exists when the buffer piston uncovers the bypass port. With the bypass port uncovered, all oil flows directly to or from the power 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 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 is minimized.

“Remote” differential power cylinder assemblies (assemblies which are located away from the governor power case) have four tubes connecting the power cylinder to the power case. These tubes carry (1) constant pressure oil to the power cylinder, (2) oil to and from the buffer piston, (3) drain oil from the power cylinder, and (4) 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

There are a number of speed setting arrangements available for the PG governor. The exact method used depends on 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 in order 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.

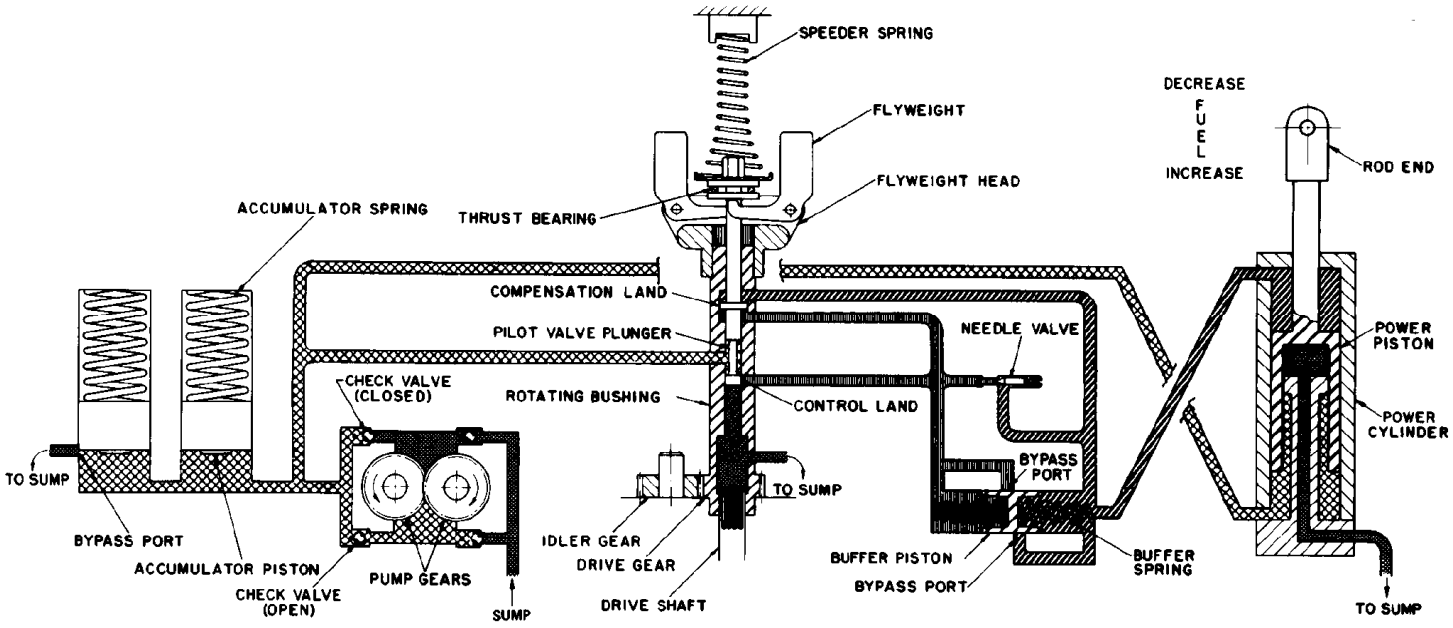


Figure 1-4. Schematic for PG in Figure 1-2

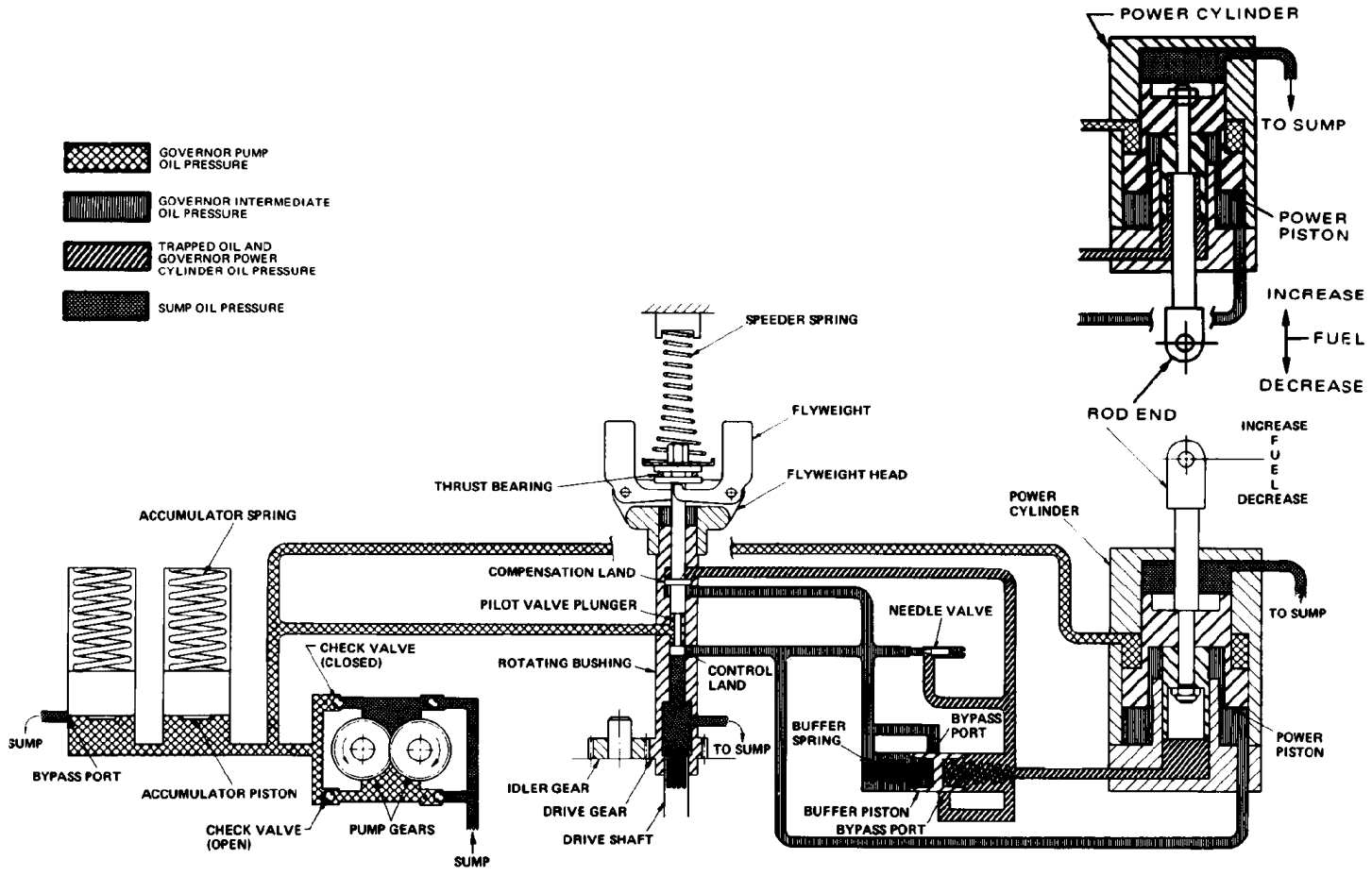


Figure 1-5. Schematic for PG in Figure 1-3

Chapter 2. Installation

General

An 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 recessive 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

The oil used in the governor should have a minimum tendency to foam, retain air, form sludge, or deposit varnish. It should protect governor parts from corrosion, but not be detrimental to seals or paint. The oil selected should have a high viscosity index; the viscosity should be within the range of 100 to 200 Saybolt Universal Seconds (SUS) at normal operating temperatures. Use the following grades of oil based on average operating temperature of the governor oil:

temperature	grade
below 120 °F (49 °C)	SAE 10 oil is usually satisfactory
from 120 to 140 °F (49 to 60 °C)	SAE 20 oil
from 140 to 160 °F (60 to 71 °C)	SAE 30 oil
from 160 to 180 °F (71 to 82 °C)	SAE 40 oil
above 180 °F (82 °C)	SAE 50 oil

If the engine oil meets these requirements, it may be used in the governor as well.

Oil contamination is the major cause of governor troubles. Use only new oil or filtered oil. Containers used for governor oil must be clean, and should be rinsed with a light grade of the same oil before using.

Installation Adjustments

Speed setting and compensating needle valve adjustments are the only external adjustments to be made. The range of speed setting adjustment is set at the factory on new or rebuilt governors and should not need changing. On initial start-up, the speed setting should be at minimum or idle speed.

Purging Air From Governor and Adjusting Needle Valve

When the engine or turbine is started for the first time, or after the governor has been drained and cleaned, the governor must be filled with oil, and any air trapped in the governor removed. To bleed off the trapped air, set the governor at the idle speed position. Start the engine or turbine and open the compensating needle valve (Figure 2-1) several turns. This should cause the engine to hunt.

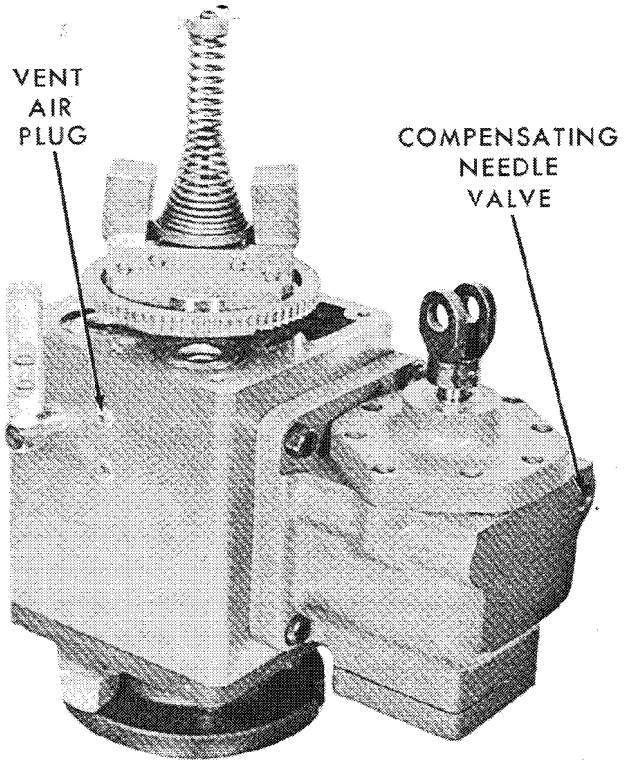


Figure 2-1. Location of Adjustments

Loosen the air vent plug (Figure 2-1) far enough to establish a leak, and allow the engine to hunt a sufficient length of time to permit all air trapped in the governor oil passages to escape at the vent plug. When no more air bubbles are apparent, tighten the vent plug, and if necessary add oil to the governor to restore the correct level in the gauge glass.

The compensating needle valve can now be closed gradually until hunting is just eliminated. The proper setting depends upon the characteristics of the prime mover. Keep the needle valve open as far as possible to prevent sluggishness. The needle valve setting will vary from 1/16 to 2 turns open. The needle valve must never be closed tight, as the governor cannot operate satisfactorily when this condition exists.

On some installations, opening the needle valve will not cause the engine or turbine to hunt. In such cases, bleed the air from the governor by disturbing engine or turbine speed to cause the governor to move through full stroke in both directions a sufficient number of times to force out all trapped air. After the needle valve is adjusted correctly for the engine, it should not be necessary to change the setting except for a large permanent temperature change affecting the viscosity of the governor oil.

Chapter 3. Maintenance

General

A governor should operate 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. Governors rarely 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 way be desirable if sub-assemblies are to be disassembled. Manual 36405 lists and illustrates tools available for PG governor maintenance.

Governor Oil

Contaminants and foreign matter in the governor oil are the greatest sources of governor troubles. Use only new or filtered oil. Be sure that all containers used for 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. Any time 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 is 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 non 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 case 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 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.

NOTICE

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 drive 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 parenthesis refer to the parts shown in Figure 4-1.)

1. Remove speeder spring (67).

2. Lift out the flyweight head-pilot valve bushing assembly. (items 66 through 106).
   a. After detaching the flyweight head (item 98, take out snap ring (86) to permit removal of items (87) and (90).

3. Remove snap ring (65) and items (60) through (64).

4. Remove four screws (112) and lockwashers (113) to detach the power cylinder assembly (items 1 through 24).
   a. Use a rod end puller tool (Woodward tool 012281) to remove fuel rod end (24). See Figure 3-1 for use of puller.

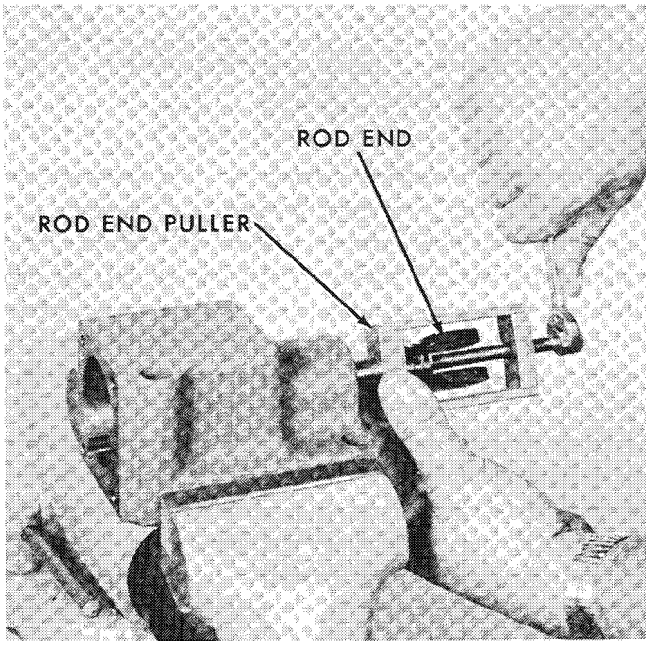


Figure 3-1

b. Grip power cylinder (12) in a vise to remove the oil seals as shown in Figure 3-2.

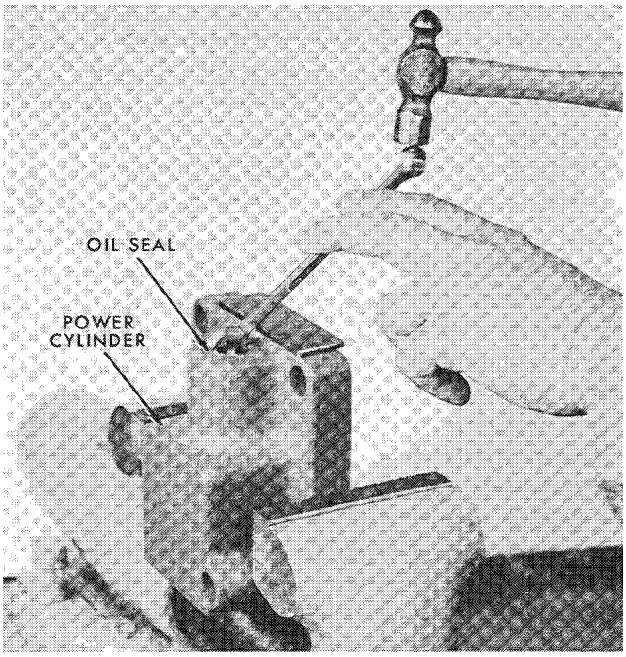


Figure 3-2

5. Remove screws (58) and retainer (57). Take out drive shaft (56) and items (51) through (55). Remove drive shaft oil seal (52) as shown in Figure 3-3.

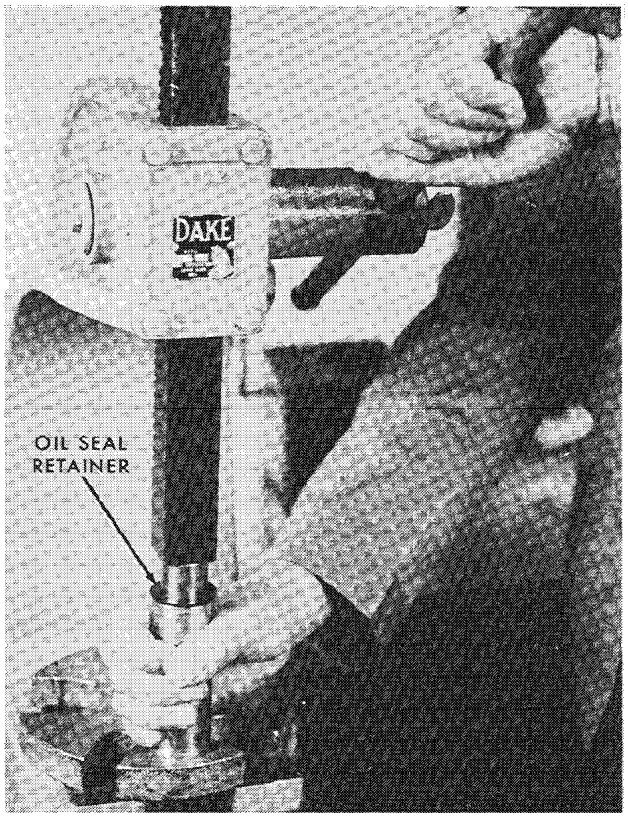


Figure 3-3

6. Remove screws (50) and washers (49). Lift off base (48) taking care that idler gear (45) and drive gear (43) do non fall out. Remove the idler gear and drive gear.

7. Set the power case (32), bottom end (end with idler stud 44) down, in an arbor press or small drill press. With a rod against spring seat (28), compress accumulator springs (29) and (30) to permit removal of upper snap ring (27). See Figure 3-4. Remove spring seat (28) and springs (29) and (30).

   Invert the power case and remove snap rings (27) and accumulator pistons (42).

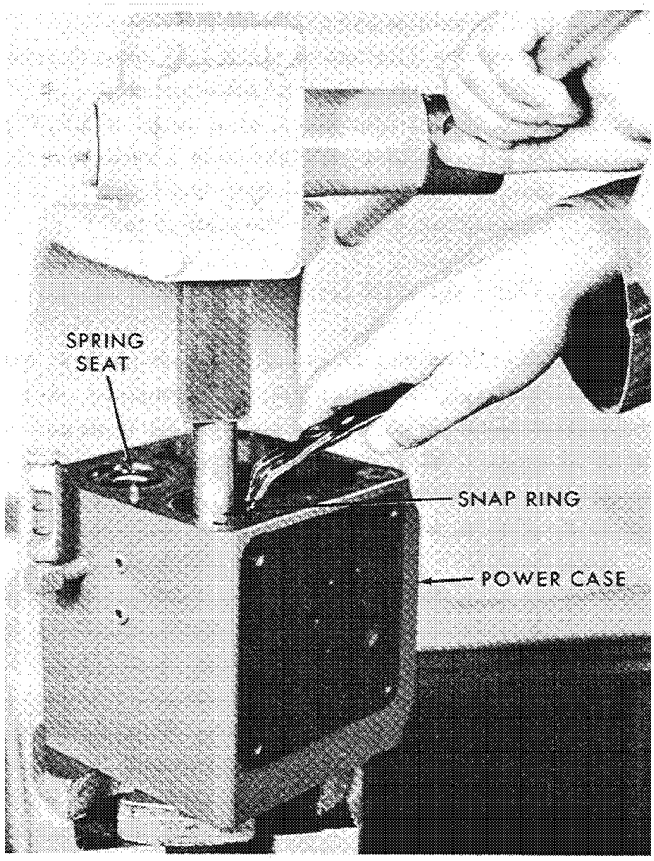


Figure 3-4

8. If necessary to remove check valve assemblies (33 and 34), proceed in this manner:
   a. To remove inner check valves (33), pry the retainer plate from the check valve assembly and remove springs and check balls.
   b. To remove outer check valves (34), press the check valves 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 3-5.

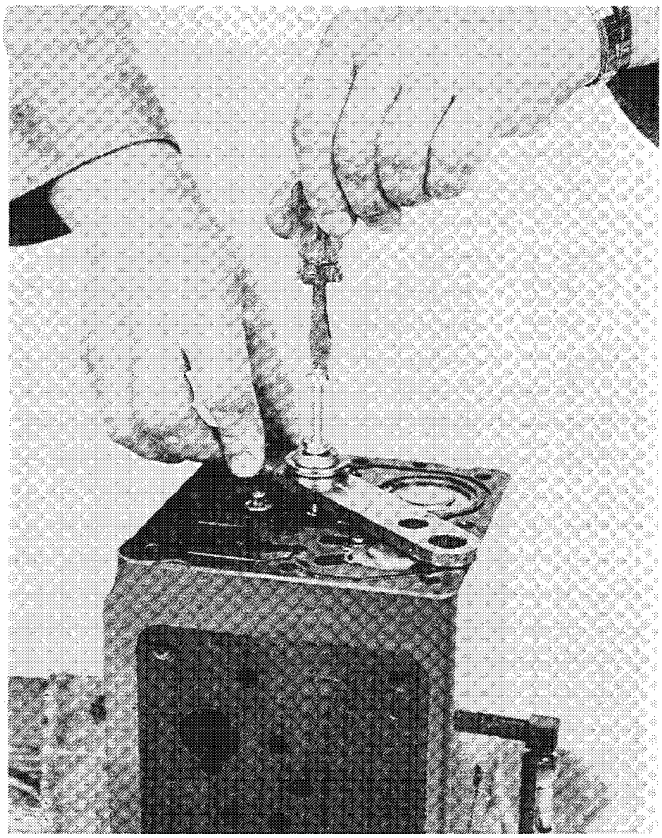


Figure 3-5

d. Remove the two balls from the lower case.

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 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.

NOTICE **The edges of the control land and compensating land 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 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 disassembly process. The following hints should aid in assembly of the basic elements. (The numbers shown in parenthesis refer to the parts shown in Figure 4-1.)

1. Use Woodward tool 360689 to press check valve assembly (33) into power case (32). Use Woodward tool 360690 to press in check valve assembly (34).

2. After installing lower snap rings (27), accumulator pistons (42), and springs (29) and (30) use a rod and an arbor press to compress spring seats (28); install upper snap rings (27).

3. With the power case components installed and the power case resting upside-down (with idler gear stud 44 up), install idler gear (45), drive gear (43), and oil seal ring (46). Be sure the gears turn freely.

   Attach base (48) to power case with screws (50). Do nor tighten screws. Insert drive shaft (56) with bearing (55) and snap ring (54) already on drive shaft into base and turn until the spliced 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 (50).

   Withdraw the drive shaft assembly from the base.

4. Press oil seal (52) into oil seal retainer (53) flush with the end opposite the flange end of retainer.

5. Install gasket (51) and the assembly consisting of the oil seal and oil seal retainer. install the drive shaft assembly. Attach retainer (57) with screws (58). Tighten screws evenly. Do not attempt to bring retainer into contact with base.

6. Press oil seals (21) and (22) into power cylinder (12). Seal (21) should be inserted with the part number facing out. Seal (22) 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 the rod of power piston assembly (18) to avoid damaging oil seals (21) and (22) when inserting the piston assembly in the power cylinder.

8. Position the power cylinder in an arbor press, align taper pin holes, and press rod end (24) onto the end of power piston (18). See Figure 3-6. Place a small steel block in the rod end slot so that pressure is applied against the bottom of the slot.

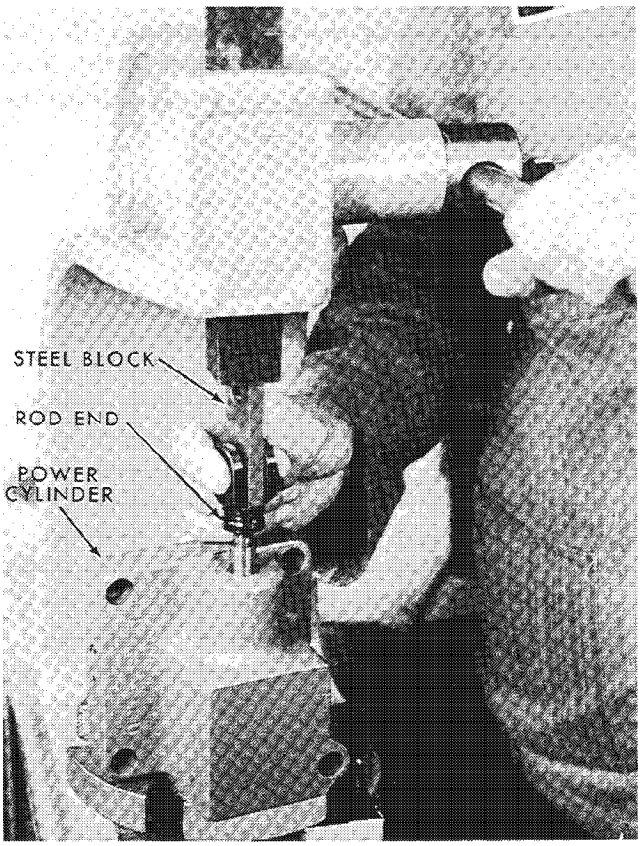


Figure 3-6

9. When mounting the power cylinder assembly onto the power case, align the holes in gasket (11) with the holes in the power case (32) 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 81 and 92).

11. The three-piece thrust bearing (71) fits onto the stem of the pilot valve plunger (90) with the bearing race with the larger hole on the bottom (against the flyweight toes).

12. “Center” the pilot valve plunger in this manner: with slight pressure on the speeder spring seat (70), adjust the pilot plunger nut (68) until, as the flyweights (75) 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 bashing assembly. See Figure 3-7. (Note: Shutdown rod (77) with retaining ring (78), if used, must be inserted through nut (68) before the centering adjustment is made.)

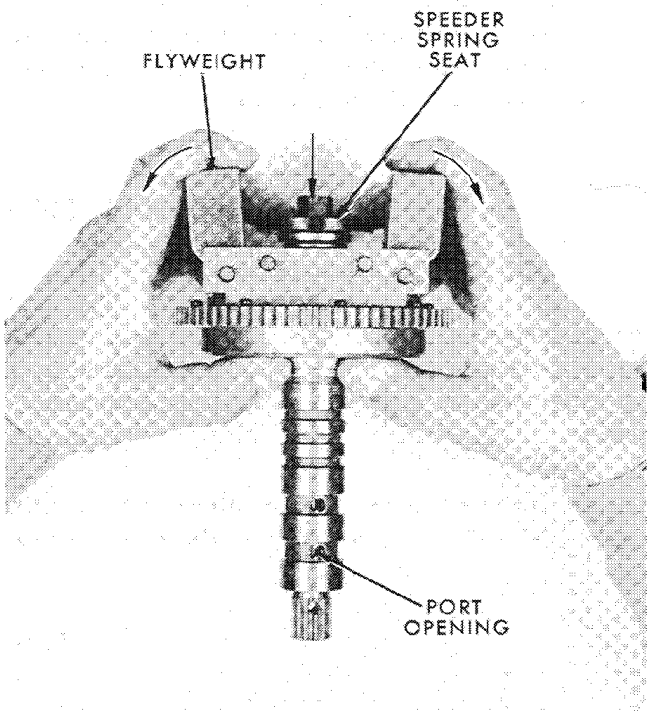


Figure 3-7

Chapter 4.
Replacement Parts

When requesting additional information concerning governor operation, or when ordering repair parts, it is essential that the following information accompany the request:

- Governor serial number (shown on nameplate); needed since the manual reference numbers do not identify the exact part number required for any one governor
- Manual number (this is manual 36602)
- Part reference number, name of part, or description of part

Ref. No.	Part Name	Quantity
36602-1	Socket hd cap screw (1/4-28 x 3/4)	4
36602-2	Lockwasher (17/64 x 27/64 x 1/16)	4
36602-3	Cylinder head (large)	1
36602-4	Pipe plug (1/8)	AR1
36602-5	Cylinder head gasket	1
36602-6	Retainer	1
36602-7	Snap ring	1
36602-8	O-ring	1
36602-9	Piston	1
36602-10	Socket head screw (10-32 x 3/8)	2
36602-11	Gasket	1
36602-12	Power cylinder	1
36602-13	Needle valve	1
36602-14	O-ring	1
36602-15	Plug	1
36602-16	O-ring	2
36602-17	Plug	1
36602-18	Power piston	1
36602-19	Stop collar	1
36602-20	Cylinder head (small)	1
36602-21	Oil seal	1
36602-22	Oil seal	1
36602-23	Snap ring	1
36602-24	Rod end	1
36602-25	Cotter pin (1/16 x 5/16)	1
36602-26	Taper pin	1
36602-27	Snap ring	4
36602-28	Spring seat	2
36602-29	Accumulator spring (large)	2
36602-30	Accumulator spring (small)	2
36602-31	Case-to-column dowel pin	2
36602-32	Power case	1
36602-33	Check valve assy (spring loaded)	2
36602-34	Check valve assembly (plain)	2
36602-35	Gasket	1
36602-36	Pipe plug (1/16)	AR
36602-37	Not Used	
36602-38	Not Used	
36602-39	Oil level gauge	1
36602-40	Elbow	1
36602-41	Drain cock	1
36602-42	Accumulator piston	2
36602-43	Drive gear	1
36602-44	Idler gear stud	1
36602-45	Idler gear	1
36602-46	Oil seal ring	1
36602-47	Case-to-base dowel pin	2
36602-48	Base	1
36602-49	Split lockwasher (21/64)	8
36602-50	Hex heed screw (5/16-18 x 1)	8
36602-51	Gasket	1
36602-52	Oil seal	1
36602-53	Oil seal retainer	1
36602-54	Snap ring	1
36602-55	Bearing	1
36602-56	Drive shaft	1
36602-57	Bearing retainer	1
36602-58	Hex head screw (1/4-28 x 5/8)	3
36602-59	Lockwire	AR
36602-60	Spring seat	1
36602-61	Buffer spring	2
36602-62	Buffer piston	1
36602-63	Plug	1
36602-64	O-ring	1
36602-65	Snap ring	1
36602-66	Speeder spring check plug	1
36602-67	Speeder spring	1
36602-68	Pilot valve plunger nut	1
36602-69	Cotter pin	1
36602-70	Speeder spring seat	1
36602-71	Thrust bearing	1
36602-72	Adjusting spring washer	1
36602-73	Adjusting spring	1
36602-74	Flyweight bearing	4
36602-75	Flyweight	2
36602-76	Shutdown nut	1
36602-76A	Shutdown nut, 8-32 special	1
36602-77	Shutdown rod	1
36602-78	Retaining ring	1

Ref. No.	Part Name	Quantity
Spring Coupled–Undamped Flyweight Head Assembly		
36602-79	Round head screw (6-32 5 5/16)	1
36602-80	Split lockwasher (#6)	1
36602-81	Spring coupling assembly	1
36602-82	Splined nut (10-32)	1
36602-83	Flyweight head	1
36602-84	Special washer	1
36602-85	Round head screw (10-32 x 3/4)	1
36602-86	Snap ring	1
36602-87	Compensating bushing	1
36602-88	Cotter pin	8
36602-89	Flyweight pin–limit pin	4
36602-90	Pilot valve plunger	1
36602-91	Centering bearing	1
36602-92	Flywt hd gear–pilot vlv bshng assy	1
Spring Coupled–Oil Damped Flyweight Head Assembly		
36602-93	Round head screw (8-32 x 5/16)	1
36602-94	Split lockwasher (#8)	1
36602-95	Spring coupling assembly	1
36602-96	Fillister head screw (5-40 x 9/32)	1
36602-97	Lockwasher (#5)	1
36602-98	Flyweight head	1
36602-99	Centering bearing	1
36602-100	Oil seal ring	1
36602-101	Flywt hd gear-pilot vlv bshng assy	1
36602-102	Flywt hd cup-pilot vlv bshng assy	1
Parts For Special Low Speed Governor Operation		
36602-103	Spring	1
36602-104	Spring seat	1
36602-105	Plug	1
36602-106	Snap ring	1
Rubber Damped Flyweight Head Assembly		
36602-107	Rubber coupling assembly	1
36602-108	Flyweight head	1
36602-109	Flywt hd cup-pilot vlv bshng assy	1
Solid Flyweight Head Assembly		
36602-110	Flyweight head	
36602-111	Pilot valve bushing assembly	
36602-112	Socket head screw (3/8-16 x 1-1/4)	
36602-113	Split lockwasher (3/8)	
36602-114	Retainer clip	

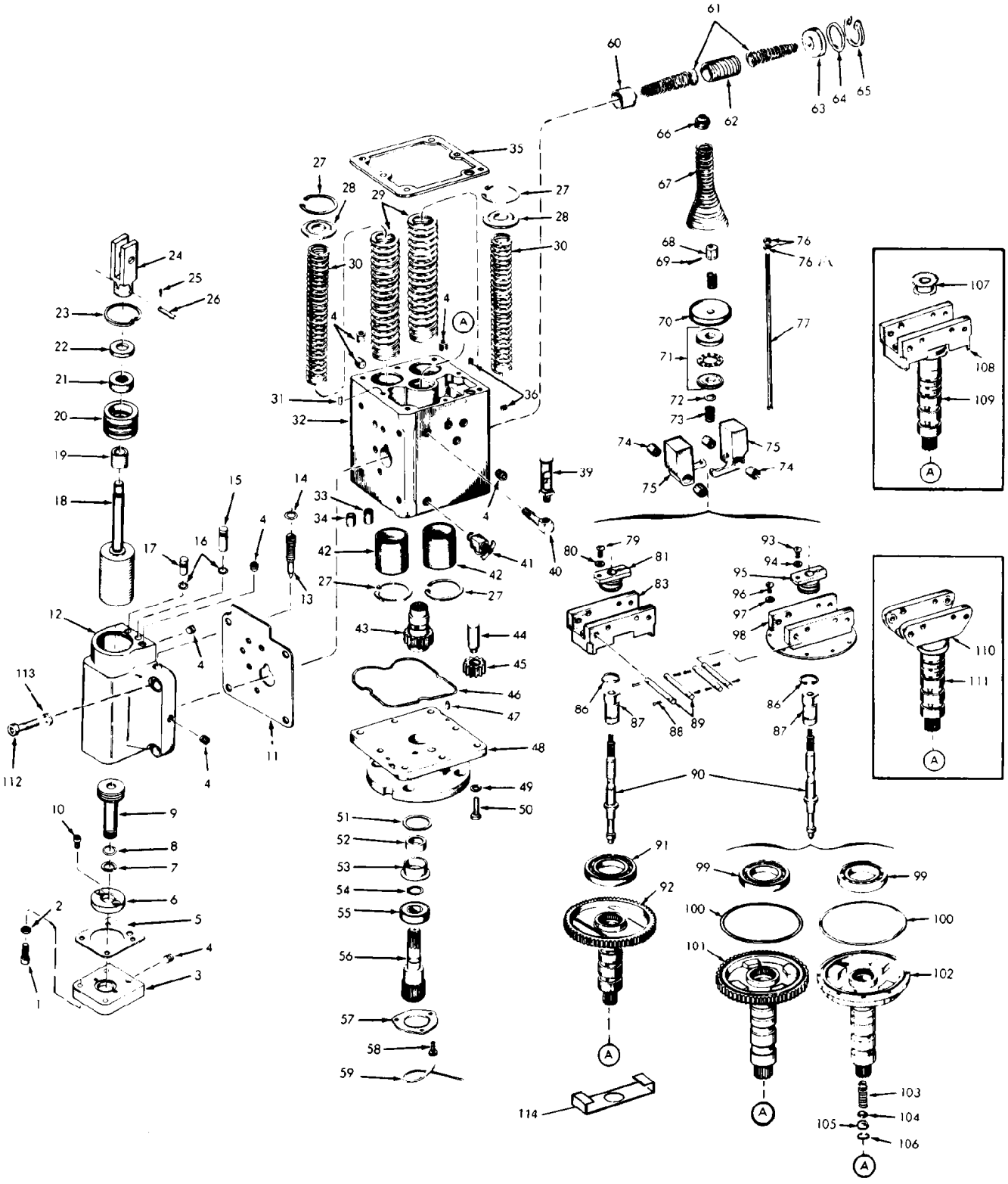


Figure 4-1. Exploded View

Ref. No.	Part Name	Quantity
Alternate Power Cylinder Assemblies		
36602-125	Rod end	1
36602-126	Gasket	1
36602-127	Power cylinder	1
36602-128	Gasket	1
36602-129	Differential piston rod	1
36602-130	Power piston	1
36602-131	Cotter pin (1/16 x 1/4)	1
36602-132	Taper pin	1
36602-133	Socket hd cap screw (5/16-18 x 1)	4
36602-134	Lockwasher (5/16)	4
36602-135	Shakeproof washer (1/2)	1
36602-136	Power piston nut	1
36602-137	O-ring	1
36602-138	Piston	1
36602-139	Spring	1
36602.140	Washer (25/64)	1
36602-141	Elastic stop nut (3/8-24)	1
36602-142	Gasket	1
36602-143	Differential servomotor cover	1
36602-144	Split lockwasher (1/4)	8
36602-145	Socket hd cap screw (1/4-20 x 3/4)	8
36602-146	Cylinder head	1
36602-150	Rod end	1
36602-151	Taper pin	1
36602-152	Cylinder head	1
36602-153	Retaining ring	1
36602-154	Washer	1
36602-155	Spring	1
36602-156	Piston	1
36602-157	O-ring	1
36602-158	Differential piston rod	1
36602-159	Power piston	1
36602-160	Power cylinder	1
36602-161	Elastic stop nut	1
36602-162	Cylinder head	1
Alternate Base Assembly		
36602-170	Base	1
36602-171	Gasket	1
36602-172	Oil seal	1
36602-173	Oil seal retainer	1
36602-174	Serrated drive shaft (long)	1
36602-175	Bearing	1
36602-176	Snap ring	1
36602-177	Bearing retainer	1
36602-178	Hex, head screw (1/4-28 x 5/8)	3
36602-179	Lockwire	AR
36602-180	Straight key	1
36602-181	Spacer sleeve	1
36602-182	Castle nut (5/8-18)	1
36602-183	Keyed drive shaft	1

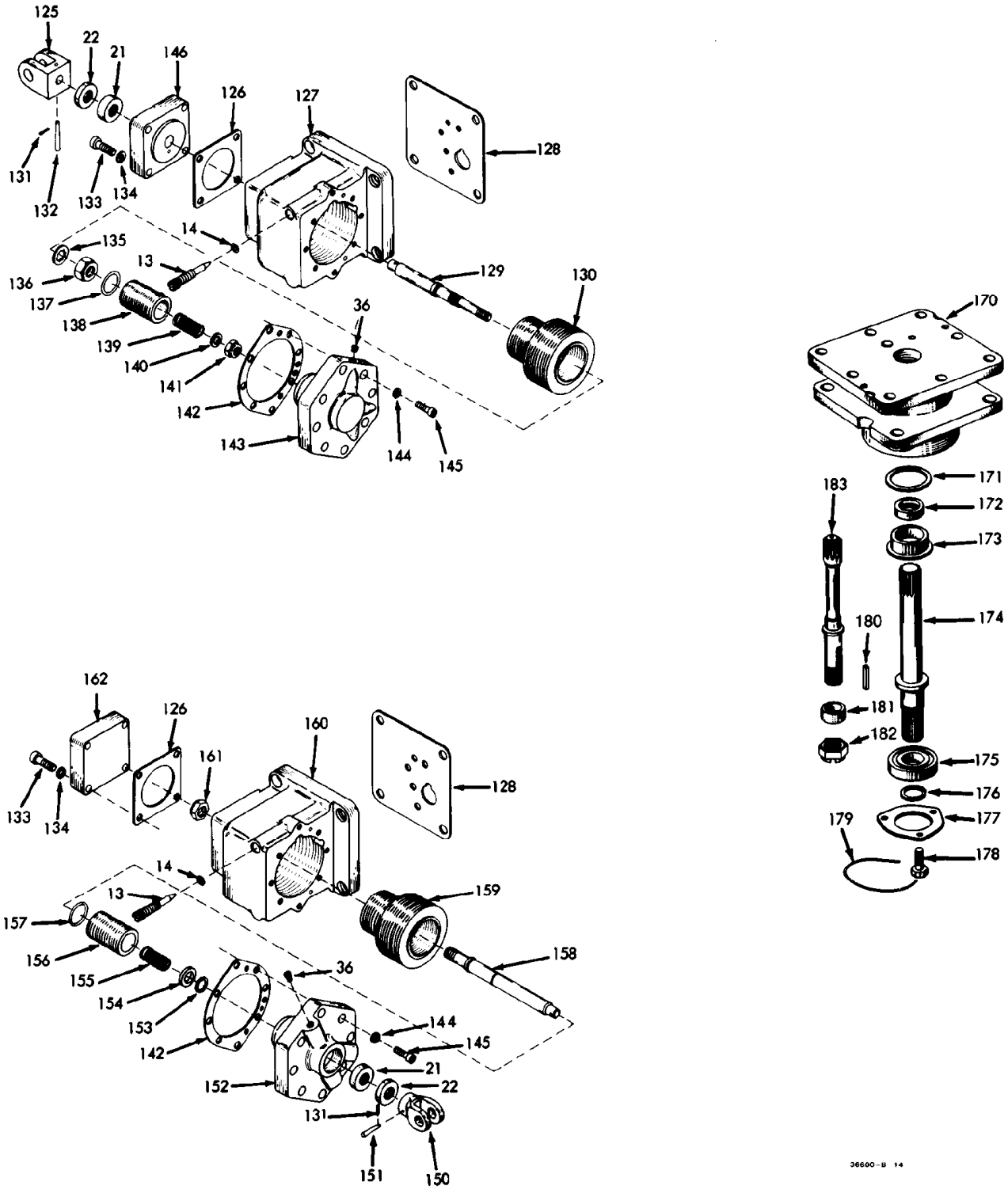


Figure 4-2. Exploded View, Alternate Power Cylinder and Base Assemblies

Chapter 5.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

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

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 option allows you to call your Full-Service Distributor 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 Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic 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.

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. 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 for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- 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.

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.

NOTICE

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*.

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.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service 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 information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at **www.woodward.com/directory**.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used In Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used In Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

For the most current product support and contact information, please visit our website directory at **www.woodward.com/directory**.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Symptoms

Description _____

_____

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

Please reference publication 36602F.

B36602:F

PO Box 1519, Fort Collins CO 80522-1519, USA
1000 East Drake Road, Fort Collins CO 80525, USA
Phone +1 (970) 482-5811 • Fax +1 (970) 498-3058

Email and Website—www.woodward.com

**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.

2012/11/Colorado