WOODWARD

Installation and Operation Manual

PG-PL Governor

Manual 36694 (Revision P)

IMPORTANT

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.

DEFINITIONS

- **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

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.

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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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.

NOTICE

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.

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*.

Revisions—Text changes are indicated by a black line alongside the text.

Contents

Illustrations and Tables

Chapter 1.
General Information

Introduction

This manual describes the installation, operation, adjustment, and maintenance for the PG-PL governor.

The PG-PL governor is a basic PG governor (pressure compensated governor) with a pneumatic speed setting mechanism (direct or reverse) and a short column that is used primarily for controlling engine or turbine speed. This PG governor was first used on pipelines, hence the PL, but has since found wide acceptance on all types of diesel engines, gas engines, steam turbines driving pumps and compressors, and many special applications. The PG-PL governor includes a pneumatic speed setting mechanism, standard short column, standard base assembly, and 12 ft-lb (16 J) power cylinder assembly.

All PG governors have the same basic components regardless of how simple or complex the complete control may be. The following components, found in each PG-PL 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 positions the fuel racks, fuel valve, or steam valve of the engine or turbine
- a compensating system for stability of the governed system
- a pneumatic speed setting mechanism for adjusting the governor speed setting

A cutaway view of the PG-PL governor is shown in Figure 1-1.

Description

The governor controls engine or turbine speed by controlling the amount of fuel or steam supplied to the engine or turbine. Speed control is isochronous—the governor maintains constant engine or turbine steady state speed, within the capacity of the unit, regardless of load.

The standard operating oil pressure for PG governors is 100 psi (690 kPa). However, with appropriate modifications, the oil pressure may be increased, thus increasing the work capacity of the power cylinder assembly. Output is linear with 1-inch (25 mm) maximum travel or rotary with 30 degrees maximum travel. When making connection to engine or turbine linkage, use 2/3 of the available governor terminal shaft travel between no load and full load. Split overtravel at each end so that the governor can shut down the prime mover and also give maximum fuel when required. Table 1-1 lists typical governor oil pressures versus power cylinder work capacities.

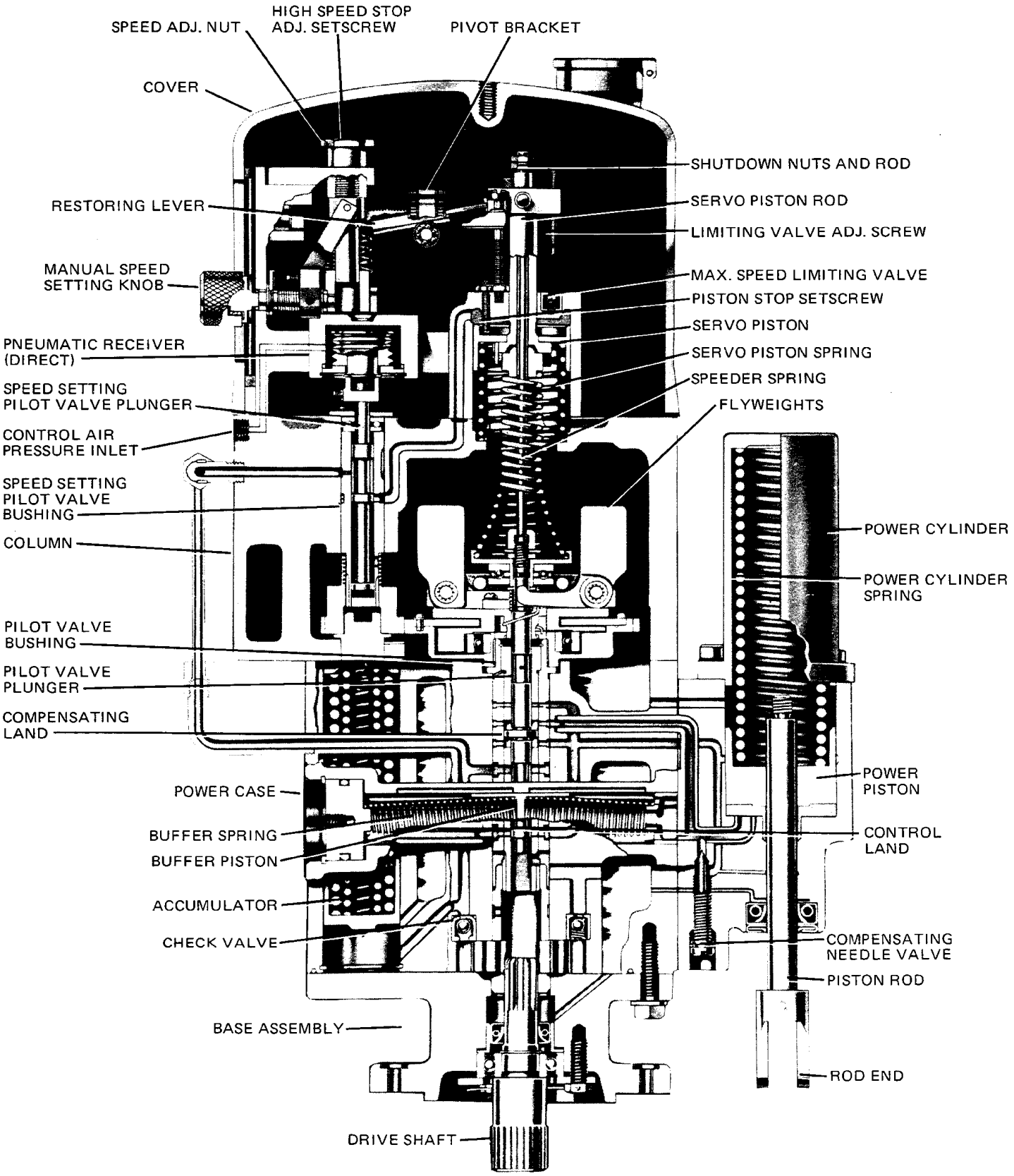

Figure 1-1. Cutaway View of PG-PL Governor

Table 1-1. Power Cylinder Work Capacities

		Rated Work Capacity							
		Spring Loaded Power Cylinder 12 ft-lb (16 J)		**Differential Power Cylinder** 17 ft-lb (23 J)			29 ft-lb (39 J)		200 ft-lb (271 J)
	Stroke	Rotary (32°)	Linear (1”/25 mm)	Rotary (32°)	Linear (1”/25 mm)	Linear (2”/51 mm)	Rotary (32°)	Linear (1”/25 mm)	Rotary (40°)
Governor Oil Pressure	100 psi (690 kPa)	12 ft-lb (16 J)	12 ft-lb (16 J)			17 ft-lb (23 J)	29 ft-lb (39 J)	29 ft-lb (39 J)	200 ft-lb (271 J)
	130 psi (896 kPa)						38 ft-lb (52 J)	38 ft-lb (52 J)	
	200 psi (1379 kPa)				16 ft-lb (22 J)	33 ft-lb (45 J)	58 ft-lb (79 J)	58 ft-lb (79 J)	

Usable work is 2/3 of rated work

An air pressure signal from a pneumatic air transmitter or controller supplies air to the governor speed-setting mechanism. The governor controls the engine at a definite speed for each air pressure. Direct or reverse, with 3 psi (21 kPa) minimum and 100 psi (690 kPa) maximum control air pressure, the ratio of high air control signal must be greater than 2.5 to 1, but less than 10 to 1. Typical pneumatic ranges are 3 to 15 psi (21 to 103 kPa) and 10 to 60 psi (69 to 414 kPa). The governor speed range normally falls between 250 and 1000 rpm, but a low speed of 200 rpm or a high speed of 1600 rpm can be obtained. Contact Woodward for recommended control air pressure to governor speed-setting relationship to meet the requirements of the particular installation.

The pneumatic speed setting mechanism (direct or reverse) is a bellows-type mechanism and is standard equipment on all PG-PL governors now manufactured by Woodward. The speed setting unit is an accurate, durable mechanism which virtually eliminates the hysteresis loops encountered with less sensitive pneumatic speed setting elements. (A hysteresis loop is a plot of the speeds obtained at various control signal pressures—one portion is recorded as speed setting signals are being increased, the other portion as the signals are being decreased.) Bellows-type speed setting provides a definite, accurate relationship between speed and speed set point signal.

The speed setting mechanism is available for use with air input signals of varying range and magnitude [such as 3 to 15 psi (21 to 103 kPa), 20 to 70 psi (138 to 483 kPa), etc.]. Depending on the exact configuration installed in the governor, speeds may be adjusted up to a 5-to-1 range. The speed-setting mechanism can be furnished to increase governor speed setting for an increase in control air pressure (direct type) or to increase governor speed setting for a decrease in control air pressure (reverse type).

The manual speed setting knob permits manual operation when the air pressure signal is not available.

This also raises the pneumatic signal range. Normally, the manual speed setting knob must be set at minimum on direct speed-setting governors to ensure that the pneumatic signal range is correct. On reverse speed-setting governors, the manual speed-setting knob must be set at maximum.

Diaphragm receiver models of the governors are obsolete and no longer manufactured as a complete unit. However, replacement parts for these units are available, and detailed information on the units can be found in Chapter 7.

IMPORTANT

Throughout this manual, the words PRIME MOVER refer to either engine(s), turbine(s), or other types of prime movers.

Reference

Manual No.	Title
36404	Analysis and Correction of PG Governing Troubles
36600	PG Governor Basic Elements
36602	Basic Elements, PG Governor with Differential Servomotor
36605	Overspeed Trip Test Device
36618	PG-200/300 Case, Accumulator and Power Cylinder
36641	Governor Oil Heat Exchanger Remote and Integral Types
36650	Solenoid Operated Shutdown Assembly
36651	Pressure Actuated Shutdown Assembly
36680	Buffer Springs
36684	Booster Servomotor
36692	PG Power Cylinder Assemblies
36693	PG Base Assemblies
36694	PG-PL Governor
54052	PG-PL Governor Installation

Chapter 2.
Installation and Adjustment

Installation

Refer to Figure 5-3 for physical dimensions of the governor. Adequate clearance must be provided for installation, removal, and servicing. At all times, use care in handling the governor; be particularly careful to avoid striking the drive shaft. Such treatment could damage the governor drive shaft, drive shaft bearing, or governor oil pump gears.

When the governor is installed on the engine or turbine, use a gasket between the mounting pad and the governor base. 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 into the internal serrations or splines of the drive freely. 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. The gears should run freely without binding or excessive backlash. Irregularities caused by uneven gear teeth, shaft runout, etc., will result in erratic governing and shorten governor life.

⚠WARNING

Before making any adjustment to a governor on an operating prime mover, make sure that the overspeed shutdown system is operating properly. Life threatening overspeeds are possible should the adjustment be made in the wrong direction or should an adjustment make the governor unable to control engine speed.

Linkage Adjustment

The linkage from the governor to the fuel or steam control should be properly aligned. Any friction or lost motion should be eliminated. Unless the engine or turbine manufacturer has given special instructions, the linkage should be adjusted so that when the governor power piston is at the end of its stroke in the “OFF” direction, the gas or steam valve, or diesel fuel pumps, will just be closed. The fuel control should be fully open slightly before the governor reaches maximum position. For more detailed information concerning linkages and linkage adjustment, see manual 54052, *PG-PL Governor Installation*.

When the governor has been properly mounted and the linkage connections completed, make the air connections to the manual or automatic air controller.

⚠WARNING

Should the governor and steam valve, fuel pump, or gas valve, remain in a fixed position for an extended length of time, governor control may be affected. Make sure the governor, linkage, and fuel or steam control are not sticky or frozen. This could create instability and allow excessive off-speed or overspeed, resulting in personal injury and/or equipment damage.

Oil Specifications

Use Tables 2-1 and 2-2 as a guide in the selection of a suitable lubricating hydraulic oil. Oil-grade selection is based on viscosity change over the operating temperature range of the governor.

This guide is NOT intended to be used in the selection of the lubricating oil for the engine, turbine, or other type of prime mover.

Governor oil is both a lubricating oil and a hydraulic oil. It must have a viscosity index that allows it to perform over the operating temperature range, and it must have the proper blending of additives that cause it to remain stable and predictable over this range. Governor fluid must be compatible with seal materials (nitrile, polyacrylic, and fluorocarbon). Many automotive and gas engine oils, industrial lubricating oils, and other oils of mineral or synthetic origin meet these requirements. Woodward governors are designed to give stable operation with most oils, if the fluid viscosity at the operating temperature span is within a 50 to 3000 SUS (Saybolt Universal Seconds) range. Ideally, at the normal operating temperature the viscosity should be between 100 and 300 SUS; Poor governor response or instability might be an indication that the oil is too thick or too thin.

A loss of stable governor control and possible prime-mover overspeed may result if the viscosity of the oil used is outside the 50 to 3000 SUS range.

Excessive component wear or seizure in a governor indicates the possibility of:

1. Insufficient lubrication caused by:
   - An oil that flows slowly either when it is cold or during start-up.
   - An oil sump that is located too far from the governor.
   - An oil line with restrictions caused by either obstructions within or bends in the line.
   - No oil in the governor.

2. Contaminated oil caused by:
   - Dirty oil containers.
   - A governor exposed to heating-up and cooling-down cycles, which create condensation of water in the oil.

3. Oil not suitable for the operating conditions caused by:
   - Changes in ambient temperature.
   - An improper oil level which creates foamy, aerated oil.

Operating a governor continuously beyond the high-limit temperature of the oil will result in oil oxidation. This is identified by varnish or sludge deposits on the governor parts. To reduce oil oxidation, lower the governor operating temperature with a heat exchanger or other means, or change to an oil more resistant to oxidation at the operating temperature.

Specific oil viscosity recommendations are given on the chart. Select a readily available good brand of oil, either mineral or synthetic, and continue using it. Do not mix the different classes of oils. Oil that meets the API (American Petroleum Institute) engine service classification in either the “5” group or the “C” group, starting with “SA” and “CA” through “SF” and “CD”, is suitable for governor service. Oils meeting performance requirements of the following specifications are also suitable: MIL-L-2104A, MIL-L-21 04B, MIL-L-21 04C, MIL-L-461 52, MIL-L-461 52A, MIL-L-46152B, MIL-L-45199B.

Replace the governor oil if it is contaminated. Also change it if it is suspected of contributing to governor instability. Drain the oil while it is still hot and agitated; flush the governor with a clean solvent having some lubricating quality before refilling with new oil.

NOTICE

Be sure the solvent is compatible with seals. If in doubt, contact Woodward. Improper solvents could cause extensive damage to seals and gaskets in the governor, requiring factory overhaul.

If drain time is insufficient for the solvent to completely drain or evaporate, flush the governor with the same oil it is being refilled with to avoid dilution and possible contamination of the new oil.

To avoid recontamination, the replacement oil should be free of dirt, water, and other foreign material. Use clean containers to store and transfer oil.

⚠WARNING

Observe manufacturers' instructions or restrictions regarding the use of solvents. If no instructions are available, handle with care. Use the cleaning solvent in a well ventilated area away from fires or sparks. Solvents can cause dangerous life threatening explosions if improperly used. Improper use of some solvents can cause illness and death.

Oil that has been carefully selected to match the operating conditions and is compatible with governor components should give long service between oil changes. For governors operating under ideal conditions (minimum exposure to dust and water and within the temperature limits of the oil), oil changes can be extended. If available, a regularly scheduled oil analysis is helpful in determining the frequency of oil changes.

Any persistent or recurring oil problems should be referred to a qualified oil specialist for solution.

The recommended oil temperature for continuous governor operation is 140 to 200 °F (60 to 93 °C). Measure the temperature of the governor or actuator on the outside lower part of the case. The actual oil temperature will be slightly warmer by approximately 10 °F (6 °C). The ambient temperature range is –20 to +200 °F (–29 to +93 °C).

IMPORTANT

The primary concern in the selection of a suitable lubricating hydraulic oil is for the hydraulic fluid properties in the governor.

Oil Level

With the engine idling, fill the governor with oil to the mark on the oil level gauge. If the oil level gauge has two marks, fill the governor with oil to a level visible between the two marks with the engine idling. Oil must be visible in the oil level gauge under all other conditions.

The oil must never be above the line where the case and column castings meet. Oil above this level will be churned into foam by rotation of the flyweight head. The oil capacity of the governor is 1.6 US quart (1.5 L) for the 29 ft-lb (39 J) rotary servo governor. The total capacity depends on the type of servo. Servos with smaller work ratings require slightly less oil.

WARNING

Always check governor oil level during operation once the governor has reached normal operating temperature. Add oil if necessary to the required level. The oil level can drop during initial operation of a governor, causing the governor to lose control of engine speed, with resulting property damage and possible personal injury or loss of life.

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. If it is necessary to change or readjust speed settings or other operating adjustments, refer to the engine manufacturer's instructions. Do not attempt internal adjustment of the governor unless thoroughly familiar with the proper procedures.

WARNING

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.

Engine Start Speed Settings

For maximum safety during start-up, the speed adjusting knob should always be at its minimum speed setting (counterclockwise) position. This prevents erroneous pneumatic pressures from causing overspeeds, which could damage the engine and endanger the life of the operator.

Direct Acting Governors

Direct acting governors, which use minimum air pressure for minimum speed and maximum air pressure for maximum speed, normally operate with the manual speed setting at minimum.

Reverse Acting Governors

Governors which require a maximum pneumatic pressure for minimum speed normally operate with the speed adjusting knob at its maximum (clockwise) position (high speed). Unless the operator knows that the maximum air signal is at the governor, the knob should be turned to its full counterclockwise position before starting the engine.

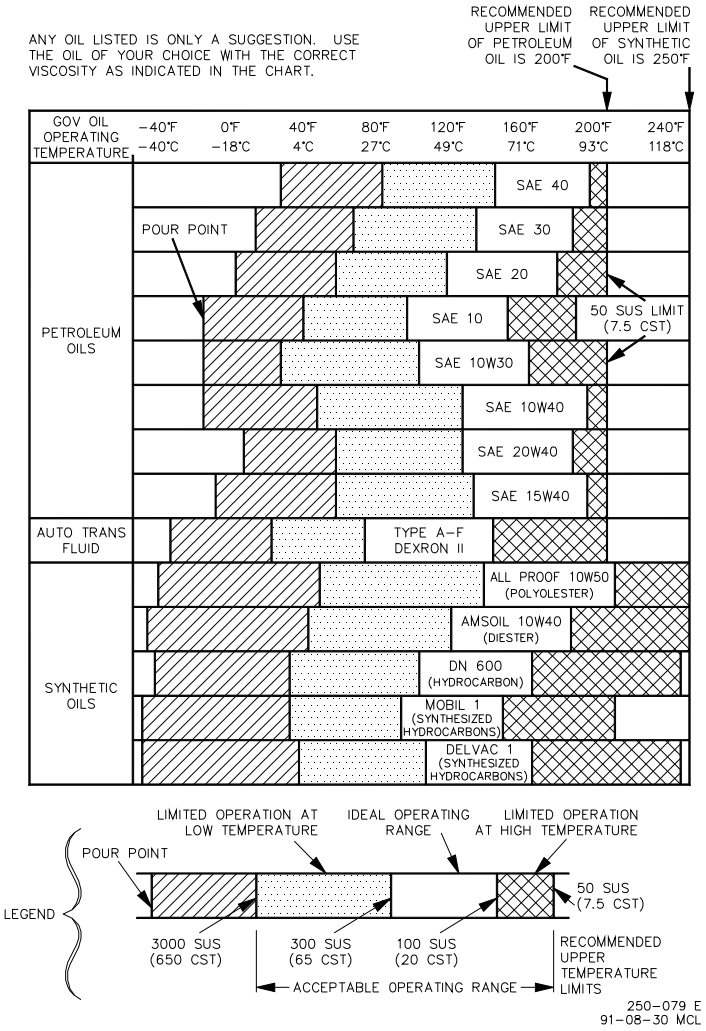

Table 2-1. Oil Comparison Chart

VISCOSITY COMPARISONS				
CENTISTOKES (CST, CS, OR CTS)	SAYBOLT UNIVERSAL SECONDS (SUS) NOMINAL AT 100 DEGREES F	SAE MOTOR (APPROXIMATE)	SAE GEAR (APPROXIMATE)	ISO
15	80	5W		15
22	106	5W		22
32	151	10W	75	32
46	214	10	75	46
68	310	20	80	68
100	463	30	80	100
150	696	40	85	150
220	1020	50	90	220
320	1483	60	115	320
460	2133	70	140	460

250−087
97−11−04 skw

Table 2-2. Viscosity Comparison Chart

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 induce the governor to move through its full output stroke. 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 with the needle valve closed.

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.

IMPORTANT

Remote servo applications may require venting to remove air in addition to the needle valve adjustments outlined above.

4. Loosen the vent plug (see Figure 5-3) on the side of the governor case enough to establish an oil leak. Bleed until air bubbles stop.

⚠WARNING

The vent screw is under pressure. Should it be removed while the governor is operating, high-pressure hot oil will flow from the governor. This will cause governor failure and possible governor damage. Prime mover overspeed with possible personal injury or loss of life could occur.

5. Tighten the vent screw and refill the governor with oil. Check the vent screw for leaks after tightening.

6. Repeat steps 1 through 3.

IMPORTANT

Higher scale buffer springs can be installed to help control stability.

With preloaded buffer springs (optional equipment), the needle valve should not be more than 1/16 turn open for smooth operation. The needle valve must never be closed tight, as the governor cannot operate satisfactorily with the needle valve closed.

Speed Adjustment

The recommended speed range for the PG governor is 250 to 1000 rpm with a maximum speed range of 200 to 1600 rpm. The speed setting of the governor is set at the factory to the specifications. Do not make adjustments unless the governor has been disassembled or the factory speed settings need to be changed.

The pneumatic speed setting mechanism furnished with the governor is either (1) a direct type which increases the governor speed setting as the control air pressure signal increases or (2) a reverse type which increases governor speed setting as the control air pressure signal decreases. Perform the following procedures as applicable to set the maximum and minimum operating speed of the governor. See Figures 1-1, 3-1, and 5-1.

Direct Speed Setting Mechanism

1. Set the manual speed adjusting knob 45 to the minimum speed position (fully counterclockwise until clutch slips).

2. Adjust the high speed adjusting setscrew 61 as required until upper end of screw is flush with top of speed adjusting nut 59.

3. Apply specified minimum control air pressure signal to the unit; adjust the speed adjusting nut as required to obtain corresponding specified minimum speed (clockwise to decrease); be sure the low speed adjusting screw 22 does not touch the restoring lever 13 at this time.

4. Adjust limiting valve adjusting screw 85 so that it does not unseat the maximum speed limiting valve 90 as speed is increased. Set governor speed range to control air pressure range as follows:

    a. Slowly increase control air pressure signal to maximum. Be sure that the engine does not exceed specified maximum speed.

    b. If specified maximum speed is obtained before control air pressure signal is increased to maximum, adjust pivot bracket 68 to move the ball bearing pivot toward the speed setting servo.

    c. If specified maximum speed is not obtained with maximum control air pressure signal, adjust the pivot bracket to move the ball bearing pivot away from the speed setting servo.

    d. Adjust the pivot bracket as follows: Loosen the socket head screw in top of the pivot bracket; loosen the knurled nut on appropriate side of bracket and turn opposite knurled nut to move bracket; tighten the screw and knurled nuts.

5. Repeat steps 3 and 4 above until specified minimum speed is obtained with minimum control air pressure and specified maximum speed is obtained with maximum control air pressure. Speed should begin to increase as the control air pressure begins to increase from minimum.

6. Apply maximum control air pressure for maximum speed. Adjust the limiting valve adjusting screw so that it just contacts the ball in the maximum speed limiting valve. Increase control air pressure slightly above specified maximum; the maximum speed limiting valve should open prior to engine reaching 10 rpm above specified maximum speed. Readjust the screw as necessary.

7. Apply minimum control air pressure signal for minimum engine speed. Perform step a or b as applicable.

    a. If engine is to go to low speed upon loss of control air pressure signal to the governor:

    (1) Set low speed adjusting screw 22 to just contact the stop pin in restoring lever 15 with the engine running at low speed. Shutdown nuts (77) are usually omitted on governors which are arranged to go to low speed upon loss of control air pressure. If nuts are included but not used, lower nuts should be a minimum of 1/32 inch (0.8 mm) above the speed setting piston rod with engine running at low speed.

    (2) Set speed setting servo piston stop (83). With the governor at idle position, turn the screw in until it contacts the piston and then back it out 2 turns.

    b. If engine is to shut down upon loss of control air pressure signal to the governor:

    (1) Lift up on the shutdown rod 222 to take out any slack or lost motion; do not lift the rod so far as to cause the engine speed to drop. While holding the rod up, position the lower shutdown nut (77) 1/32-inch (0.8 mm) above the top of the speed setting servo piston 89 rod and lock in position with upper nut.

    (2) Turn the piston stop setscrew 83 down until it touches the speed setting piston, then turn the screw counterclockwise 2 turns and lock in position with nut. This adjustment limits the upper movement of the piston when the engine is shut down and it minimizes the cranking required when the engine is restarted.

    (3) Adjust low speed adjusting screw 22 so it is 0.040–0.050 inch (1.02–1.27 mm) below the stop pin in the restoring lever. Turn off the control air pressure signal to the governor. The engine will stop. Adjust the clearance between the adjusting screw 22 and stop pin 15 so it is from 0.002 to 0.005 inch (0.05 to 0.13 mm).

8. Set the high speed adjusting setscrew 61 to stop the speed adjusting nut from moving down at high speed.

    a. Increase the speed with the manual speed adjusting knob (when the governor is set to shutdown on loss of air signal) to prevent the engine from stopping.

    b. Close the air signal to the governor.

    c. Turn the manual speed adjusting knob to the right to increase the engine speed to maximum.

    d. Turn high speed adjusting setscrew 61 to the right until it touches high speed stop pin 51.

Reverse Speed Setting Mechanism

1. Set the manual speed adjusting knob 45 to the minimum speed position (fully counterclockwise until the clutch slips).

2. Adjust the speed adjusting nut 59 so that the speed setting assembly protrudes approximately 1/4-inch (6 mm) above the nut.

3. Adjust the high speed adjusting setscrew 61 as required until screw is flush with the top of speed setting screw.

4. Adjust the limiting valve adjusting screw 85 as required so that it does not unseat the maximum speed limiting valve 90 as speed is increased. Apply minimum control air pressure signal to the governor (pressure at which specified maximum engine speed is to be obtained). Be careful that the engine does not exceed the specified maximum speed.

5. Turn the manual speed adjusting knob clockwise to increase engine speed to the specified maximum. Turn the high-speed adjusting setscrew 61 in until it just touches the high speed stop pin 51. If screw is turned down too far, speed will decrease.

   If the specified maximum speed is not obtained with the manual speed adjusting knob fully clockwise, turn the knob approximately 2 turns counterclockwise, back out the high speed stop adjusting setscrew 61 a few turns, then turn speed adjusting nut 59 counterclockwise until specified maximum speed is obtained. Turn the high speed adjusting setscrew down until it just touches the high speed stop pin (if the screw is turned down too far, speed will decrease). Turning the speed adjusting knob fully clockwise should not increase speed beyond the specified maximum.

6. Slowly increase control air pressure signal until specified minimum speed is obtained. The pneumatic low speed adjusting screw should not touch the stop pin in the restoring lever and the piston stop setscrew 83 should not stop the speed setting piston 89 as it moves up to decrease speed.

   If specified minimum speed is obtained before the control air pressure signal is increased to specified maximum, adjust the pivot bracket 68 to move the ball bearing pivot toward the speed setting cylinder.

   Adjust the adjustable pivot bracket as follows: Loosen the socket head screw on top of the pivot bracket; loosen knurled nut on appropriate side of pivot bracket and turn opposite knurled nut to move the pivot bracket; tighten screw and knurled nuts.

7. Repeat steps 4, 5, and 6 above until specified minimum speed is obtained with maximum control air pressure signal and specified maximum speed is obtained with specified minimum control air pressure signal. Ensure that engine speed begins to increase as the control air pressure signal begins to decrease from maximum.

8. After setting speeds pneumatically, apply minimum control air pressure signal (governor will go to maximum speed setting). Turn the manual speed adjusting knob counterclockwise until the specified minimum speed is obtained. Alternately turn the speed adjusting nut 1/2 turn counterclockwise (increasing speed) and the adjusting knob counterclockwise (decreasing speed) until the adjusting knob is fully counterclockwise. Turn off the control air supply (speed will rise slightly). Adjust the speed adjusting nut to obtain the specified minimum speed.

If the adjusting knob is turned fully counterclockwise without reaching the specified minimum speed, turn off control air supply (speed will rise slightly). Adjust the speed adjusting nut to obtain specified minimum speed.

9. With the engine operating at specified minimum speed, turn the piston stop setscrew down until it just touches the top of the speed setting piston; then turn the screw 2 turns counterclockwise; lock in position with locknut. This adjustment limits the upward movement of the piston when the engine is shut down, and it minimizes the cranking required when engine is restarted.

10. If shutdown nuts are used, lift up on the shutdown rod to take out any slack or lost motion; do not lift the rod so far as to cause the engine speed to drop. While holding the rod up, position the lower shutdown nut 1/32-inch (0.8 mm) above the top of the speed setting servo piston rod and lock in position with upper nut.

11. With the control air pressure signal turned off, turn the manual speed adjusting knob clockwise to increase engine speed to maximum. Adjust the limiting valve adjusting screw so that it just contacts the ball in the maximum speed limiting valve. Increase engine speed slightly above the specified maximum; the maximum speed limiting valve should open prior to engine reaching 10 rpm above maximum speed. Readjust screw as necessary.

12. Turn the manual speed adjusting knob fully clockwise and apply maximum control air pressure to the governor. Adjust the pneumatic low speed adjusting screw to just contact the stop pin in the restoring lever with the engine running at low speed.

13. Turn the manual speed setting knob fully clockwise for normal pneumatic speed control operation.

Chapter 3.
Principles of Operation

Introduction

Figure 1-1 shows a sectional view of the PG-PL governor, which indicates the relative position of the various governor components in the complete assembly. The connecting oil passages between parts are not necessarily in their actual locations, but are simplified for clarity. The lower part of the governor consists of the base and power case and the basic components of the hydraulic PG isochronous governor, which functions to maintain a constant engine speed by controlling the fuel supplied to the engine. The upper part of the governor consists of the column, cover, and related parts; it also consists of the pneumatic speed setting mechanism, and optional shutdown and protective devices where applicable.

Description of Operation

The schematic diagram (Figure 3-1) illustrates the essential parts of the governor and speed setting mechanism which are required to regulate fuel and control engine speed.

Speed adjusting in the governor is effected by controlling the position of the speed setting servo piston. Movement of the servo piston to a higher or lower speed setting is obtained by admitting or draining pressure oil to or from the area above the servo piston.

The flow of governor oil to or from the area above the servo piston is controlled by the speed setting pilot valve plunger—contained in a rotating bushing—which is actuated by a controlled air pressure signal or by a manual control knob.

After each speed setting change, a restoring lever connected between the servo piston rod and speed setting pilot valve plunger returns the plunger to the closed port position. This stops the flow of oil to or from the area above the servo piston, and holds the piston at the position for the particular speed setting of the governor.

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

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

The governor oil pump supplies pressure oil to the rotating pilot valve bushing, speed setting pilot valve bushing, pressure seal grooves, and to the accumulators, with excess oil (at maximum pressure) bypassing from the accumulators to the governor sump. Duplicate suction and discharge ball check valves at the pump permit rotation of some governors in either direction.

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. Then the pilot valve plunger is centered (the control land of the plunger exactly covers the control port of the bushing), and 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 moves 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 flyweight 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.

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

Located between the pilot valve bushing and the power piston is the buffer compensating system, consisting of the buffer cylinder and piston, the buffer springs, and the compensating needle valve. Lowering the pilot valve plunger permits a flow of pressure oil from the pilot valve bushing into the buffer system and power cylinder to raise the power piston and increase fuel. Raising the pilot valve results in a flow of oil from the power cylinder and buffer system to the governor sump, and the power spring moves the power piston down to decrease fuel to the engine.

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

The vertical position of the flyweights with the control land of the pilot valve covering the regulating port indicates that the engine is on-speed.

Theory of Operation

See Figure 3-1 for the schematic diagram of the essential components of the basic governor and speed setting mechanism and the relative positions they assume when the engine is operating on-speed under steady-state conditions. Differences may exist in the actual design details of these components from one governor to another, but the scheme of operation is the same in each.

The schematic arrangement of the “direct” speed setting mechanism (governor speed increases as the control air pressure signal increases) is incorporated into the diagram of Figure 3-1. The inset shown on the figure shows the “reverse” speed setting (governor speed decreases as the control air pressure signal increases) version.

The following theory of operation describes the direct speed setting mechanism. The sequence of events occurring in the governor take place more or less in a simultaneous manner, rather than step by step as described in the following paragraphs.

Speed Increase

An increase in the control air pressure signal to the pneumatic receiver assembly is sensed by a bellows.

Through a mechanical connection to the speed setting pilot valve plunger, the bellows movement—caused by changes in the input signal pressure—displaces the speed setting pilot valve plunger to change the governor speed setting. The increased pressure compresses the bellows to lower the speed setting pilot valve plunger. Pressure oil flows to the area above the speed setting servo piston to force the piston down, and thus increase the governor speed setting.

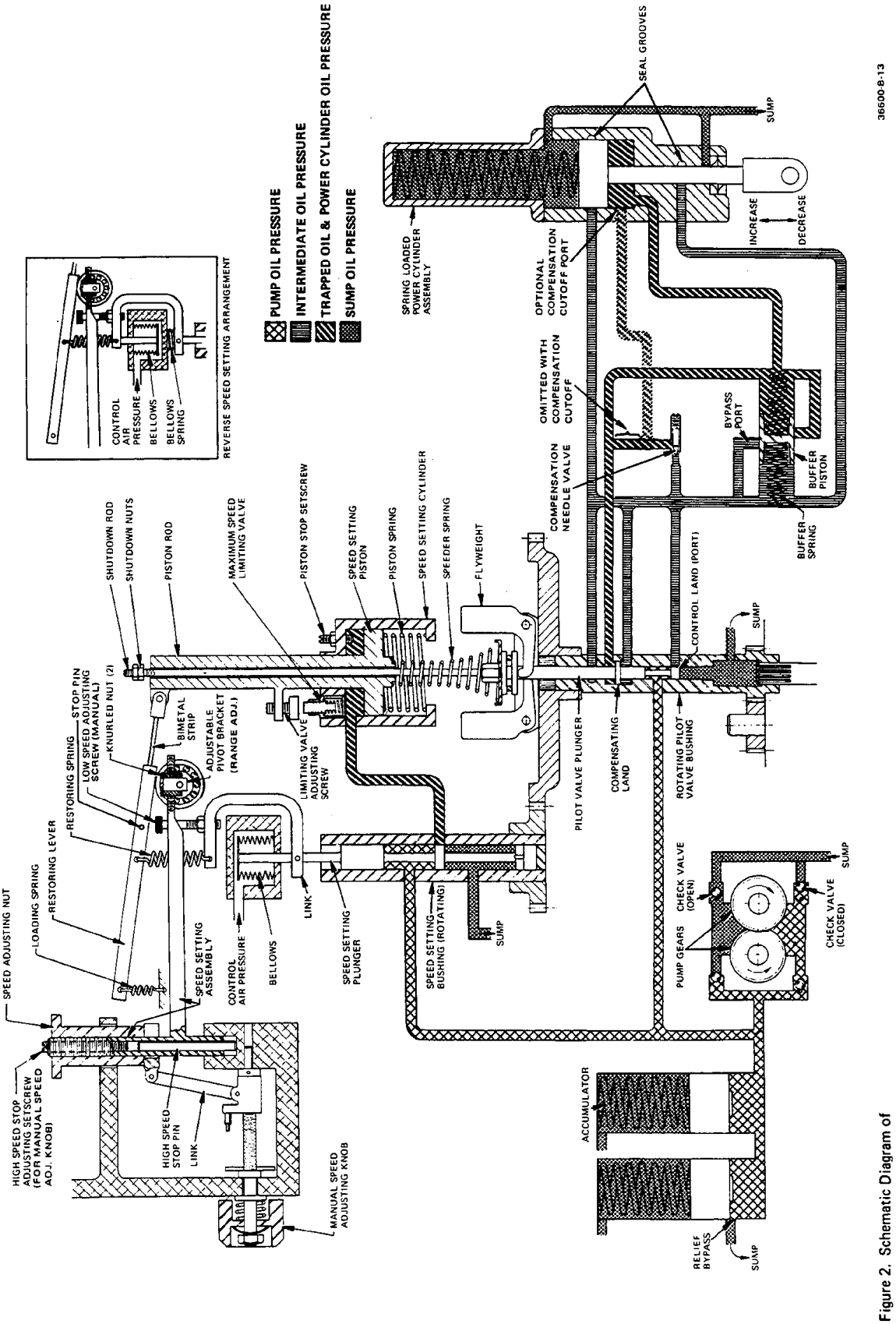

Figure 2. Schematic Diagram of PG-PL Governor

Figure 3-1. Schematic Diagram of PG-PL Governor

As the servo piston moves down, a restoring lever—connected between the servo piston rod and speed setting pilot valve plunger on a ball bearing pivot—increases the lifting force on a restoring spring attached to the restoring lever. When the lifting force of the restoring spring is equal to the downward force resulting from the increased pressure signal, the speed setting pilot valve plunger is returned to its centered position.

Increasing the speed setting of the governor increases the downward pressure of the speeder spring on the toes of the flyweights and the flyweights move in, lowering the pilot valve plunger and opening the control port.

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

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

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

As the centrifugal force of the flyweights increases to a higher value with engine acceleration, the upward oil force at the compensating land is reduced to zero by the equalization of the oil pressures in the buffer system through the compensating needle valve. If the needle valve is correctly adjusted the oil pressures will equalize at the same rate as the increase in the centrifugal force of the flyweights, and the flyweights will remain in the vertical position, keeping the control port covered by the control land of the pilot valve, and holding the power piston stationary at the new position. Equalizing the oil pressures in the buffer system allows the buffer springs to return the buffer piston to center in the buffer cylinder.

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

Speed Decrease

A decrease in the control air pressure signal to the bellows of pneumatic receiver assembly allows the restoring spring—attached to restoring lever—to lift the speed setting pilot valve plunger. Oil drains from the area above the servo piston, the servo piston spring forces the piston to rise and thus decrease the speeder spring compression and lower the governor speed setting.

The restoring lever follows the movement of the servo piston, moves up and, in so doing, decreases the lifting force on the restoring spring. When the servo piston and right end of the restoring lever has moved up sufficiently to balance the upward force of the restoring spring to equal the decrease in downward force resulting from the decrease in control air pressure signal, the speed setting pilot valve plunger will have returned to its centered position.

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

Opening the port in this direction permits oil to flow from the buffer system to the governor sump. This will lower the oil pressure in the buffer system and the power spring will force the power piston down in the direction to decrease fuel. As the buffer piston moves in the direction of the oil flow—from power cylinder to pilot valve—the left buffer spring is compressed and the right spring is relieved. This produces a pressure in the trapped oil, on the right side of the buffer piston which is higher than the intermediate oil pressure on the left side of the buffer piston, by an amount proportional to the displacement of the buffer piston and spring.

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

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

Bypass ports are provided in the buffer cylinder to facilitate large corrective movements of the power piston. A large increase or decrease in the speed setting of the governor, or a large increase or decrease of load on the engine, will require a correspondingly large movement of the power piston to make the necessary correction to the fuel setting. Under such conditions, the buffer piston will move only far enough to the left or right to effect an opening at the bypass port (pressure or drain). Oil will then flow directly to or from the power cylinder through the bypass port without further increasing the differential oil pressure force existing on the compensating land.

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

With a large decrease in load, the power piston assembly moves to the “no fuel” position. This closes the compensating oil passage from the power cylinder to the compensating needle valve and blocks passage of oil from the right end to the left end of the buffer cylinder. The needle valve cannot equalize buffer oil pressures in the usual manner. The buffer piston having moved off center to the left will be held there by the oil now trapped between the power piston and the buffer piston.

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

As the engine decelerates to a speed slightly below this higher speed setting, the governor will respond to raise the power piston (and restore fuel supply) in the normal manner, uncovering the port to permit passage of oil through the compensating needle valve so that the governor and engine will stabilize at the speed corresponding to the actual speed setting of the governor. This minimizes possible under-speeding of the engine when a large load decrease occurs.

Manual Speed Setting

The manual speed setting mechanism can be used to adjust the speed setting of the governor to any point within the normal speed range when the control air pressure signal is not available.

With no air signal, the restoring spring holds the low speed adjusting screw in contact with the pin on the restoring lever. The speed setting pilot valve plunger is thus mechanically connected to the movement of the restoring lever. The grounded loading spring which keeps the restoring lever against the ball bearing pivot continually urges the bearing and speed setting screw in the downward direction.

Turning the manual speed adjusting knob clockwise (to increase the governor speed setting) lowers the stop collar under the speed adjusting nut. The speed setting screw with the ball bearing pivot will move down with the stop collar until the high speed stop adjusting setscrew hits the high speed stop pin; further clockwise turning of the manual knob will have no effect on the speed screw position.

As the speed setting assembly and the ball bearing pivot are lowered, the left end of the restoring lever pushes the low speed adjusting screw down and, in so doing, lowers the speed setting pilot valve plunger. Oil flows to the speed setting cylinder to push the speed setting piston down and raise the governor speed setting. The downward movement of the piston raises the left end of the restoring lever to “lift” the pilot valve plunger back to center.

Turning the manual speed adjusting knob counterclockwise raises the speed setting screw and ball bearing pivot, raises the left end of the restoring lever, and thereby lifts the speed setting pilot valve plunger. As the piston moves up to decrease the governor speed setting, the restoring lever movement re-centers the pilot valve plunger.

Temperature Compensation

Temperature compensation on older governors is incorporated in the speed setting mechanism through a bimetal strip in the restoring lever. The temperature compensation in later governors is in the speeder spring and there is no bimetal strip.

Loss of Pneumatic Signal

"Direct" Type Bellows—The low speed adjusting screw is adjusted to contact the pin on the restoring lever when the control air signal and governor speed are at their normal minimum. Thus, if the air signal is interrupted or reduced below the pressure required for minimum speed, the restoring spring will lift the speed setting pilot valve plunger until the adjusting screw contacts the pin on the restoring lever. With the pilot valve plunger raised, the speed setting piston will move up to the low speed position. At this position, the restoring lever, turning about the ball bearing pivot and pushing down on the low speed adjusting screw, will have re-centered the pilot valve plunger. The governor will, therefore, go to minimum speed setting if the air signal is lost.

"Reverse" Type Bellows—The low speed adjusting screw is adjusting to just clear the restoring lever when the control air signal is at its normal maximum setting. Thus, should the air signal be interrupted—either accidentally or intentionally—the spring under the bellows will act to lower the speed setting pilot valve plunger and allow the governor to go to maximum speed setting.

Engine Start Speed Settings

For maximum safety during startup, the speed adjusting knob should always be at its minimum speed setting (counterclockwise) position. This prevents possible overspeed due to erroneous pneumatic pressures causing overspeeds which could damage the engine and endanger the life of the operator.

Direct Acting Governors

Direct acting governors, which use minimum air pressure for minimum speed and maximum air pressure for maximum speed, normally operate with the manual speed setting at minimum.

Reverse Acting Governors

Governors which require a maximum pneumatic pressure for minimum speed normally operate with the speed adjusting knob at its maximum (clockwise) position (high speed). Unless the operator knows that the maximum air signal is at the governor, the knob should be turned to its full counterclockwise position before starting the engine.

Chapter 4.
Maintenance

Troubleshooting

Governor faults are usually revealed in speed variations of the engine or turbine, but it does not necessarily follow that such speed variations indicate governor faults. Therefore, when improper speed variations appear, the following procedure should be performed.

⚠WARNING

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.

1. Check the load to be sure that the speed changes observed are not the result of load changes beyond the capacity of the engine or turbine.

2. If the governor is on an engine, check the operation to be sure that all cylinders are firing properly and that the injectors are in good operating condition. If the governor is on a turbine, check the steam valves for proper operation.

3. Check the operating linkage between the governor and the engine or turbine to make certain there is no binding or lost motion.

4. Check for steam or fuel gas pressure changes.

5. Check the setting of the compensating needle valve.

6. Check air transmitter for specified output pressure. If neither load nor engine or turbine irregularities are found to be the cause of the speed variation, the cause may be either in the governor or in the engine or turbine drive to the governor.

7. Check governor for specified operating oil pressure. Normal oil pressure for PG governors is 100 psi (690 kPa). However, this value may vary between governors, depending on the required output work capacity of the power cylinder (refer to table). With the engine shut down, remove the plug from the pressure port on the governor power case and install a pressure gauge rated above the specified operating oil pressure.

The source of most troubles in any governor stems from dirty oil. The moving parts within the governor are continually lubricated by the oil within the governor. Thus, grit and other impurities will cause excessive wear of valves, piston, and plungers, and can cause these parts to stick and even to “freeze” in their bores.

In many instances, erratic operation and poor repeatability can be corrected by flushing the unit with fuel oil or kerosene while cycling the governor. The use of commercial solvents is not recommended as they may damage seals or gaskets.

If the speed variations of the governor are erratic but small, excessive backlash or a tight meshing of the gears driving the governor may be the cause. If the speed variation is erratic and large and cannot be corrected by adjustments, the governor should be repaired and/or replaced.

⚠WARNING

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.

Lubrication

The oil used in the governor should be clean and free of foreign particles to obtain maximum performance from the governor. Under favorable conditions, the oil may be used for six months or longer without changing. Change oil immediately when it starts to break down or darken.

Disassembly

Disassemble the governor following the sequence of index numbers assigned to Figures 5-1 and 5-2, giving special attention to the following. Circled index numbers do not require further disassembly unless replacement parts are required.

Refer to the applicable modular manual (listed in Chapter 1) for parts information and disassembly procedures on auxiliary equipment.

1. Clean the exterior surfaces of the governor with a clean cloth moistened with cleaning solvent.

2. Discard all gaskets, O-rings, seals, retaining rings, cotter pins, clips, etc., removed in the process of disassembly.

3. Do not remove press fit components unless replacement is required.

⚠CAUTION

Injury may result if compressed springs are released suddenly. Use the proper equipment to remove spring and spring covers.

4. Disassemble power cylinder assembly as applicable per instructions contained in manual 36692.

5. Disassemble base assembly as applicable per instructions contained in manual 36693.

6. To remove the compressed accumulator springs and pistons from the power case, place the power case (260, Figure 5-2) in an arbor or drill press with the bottom down.

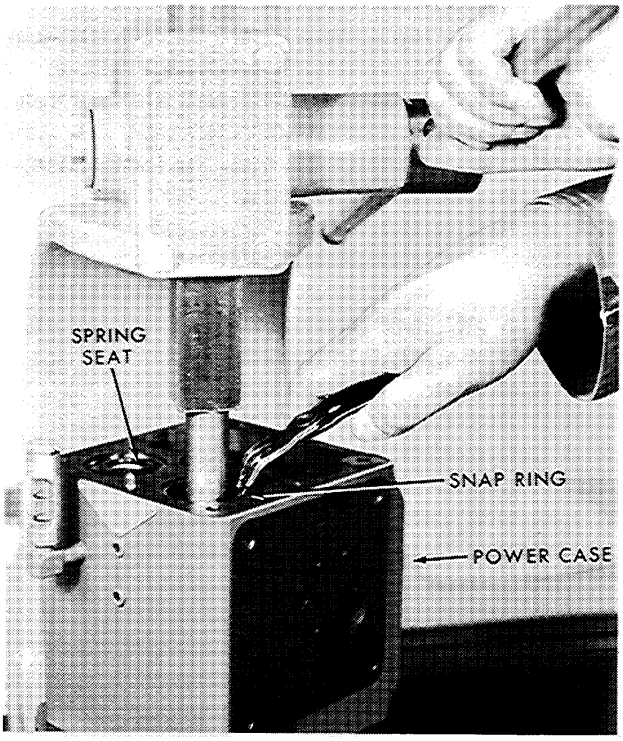

Figure 4-1. Removing Accumulator Retaining Ring

With a rod against the spring seat (246), compress the accumulator springs (247 and 248) to permit removal of upper retaining ring (245). Remove the spring seat and spring (see figure 3).

Invert the power case and remove the lower retaining ring and accumulator piston (249).

7. If necessary to remove check valve assemblies (250 and 251), proceed as follows:

   a. To remove the inner check valves (250), pry the retainer plate from the check valve assembly and remove the springs and check balls.

   b. To remove the outer check valves (251), press the 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.

   d. Remove the two balls from the lower case.

Cleaning

1. Wash all parts ultrasonically or by agitation while immersed in cleaning solvent (Federal Specification P-D-680 or similar).

2. Use a non-metallic brush or jet of compressed air to clean slots, holes, or apertures.

3. Dry all parts after cleaning with a jet of clean, dry compressed air.

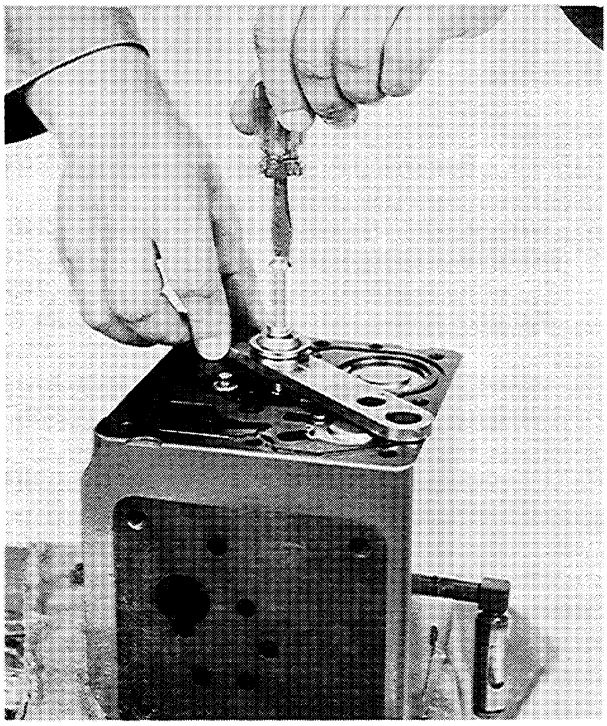

Figure 4-2. Removal of Check Valves

Inspection

1. Visually inspect all parts for wear and damage.

2. Inspect the bearings in accordance with standard shop practice. Replace bearings when there is any detectable roughness.

3. All pistons, valves, plungers, rods, and gears should move freely without excessive play. Do not lap in parts if possible to free by other means.

4. Mating surfaces must be free of nicks, burrs, cracks, or other damage.

5. Inspect flyweight toes for wear. Replace flyweights if any detectable wear or doubtful areas are found.

6. It is recommended that the speeder spring be replaced at time of overhaul if it is pitted or damaged in any way.

Repair or Replacement

1. Repair of small parts of the governor is impractical and should generally be limited to removal of nicks and burrs from mating flanges and light burnishing of mating parts.

2. Replace damaged thread inserts in accordance with standard shop practice.

3. Polish slightly corroded areas with fine grit (600 grit) abrasive cloth or paper and oil.

Assembly

Assemble the governor in reverse order of index numbers assigned to Figures 5-1 and 5-2, following the special instructions given below.

IMPORTANT **A dust free area is recommended for assembly if acceptable results are to be obtained.**

During assembly, ensure that lint or other foreign matter is present on the parts. The governor may be assembled dry, or a small amount of clean lubricating oil may be applied to the parts as they are assembled into the governor. When the governor is assembled, apply a liberal amount of clean lubricating oil over all moving parts to ensure initial lubrication. Apply a small amount of joint compound to pipe plug threads as plugs are installed. Ensure that compound does not enter the cavity.

Obtain new gaskets, O-rings, seals, retaining rings, cotter pins, etc., to replace those discarded during disassembly.

1. Press the spring-loaded check valve (250, Figure 5-2) into the power case (260) using Woodward tool 360689. Press the plain check valve into the power case using Woodward tool 360690.

2. Install the accumulator piston (249) and lower retaining ring (245) into the power case. Place the power case in an arbor or drill press with bottom down (see Figure 4-1), and install springs (247 and 248) and spring seat (246); compress the springs, using a rod on the spring seat, and install the upper retaining ring.

3. Attach the base assembly (207) to the power case loosely, rotate the drive shaft until the splined end engages with the splines in the pump drive gear. Continue turning the drive shaft to check for alignment and free rotation of the drive gear and idler gear while tightening base screws.

4. Attach the power cylinder assembly (203) to the power case in the proper plan and quadrant; ensure that the holes in the gasket (204) are aligned with the holes in the power case.

IMPORTANT **When replacing a power cylinder (servo) on a governor or mounting pad, it is imperative that the securing bolts be torqued to 45 lb-ft (61 N·m).**

5. When assembling the flyweight head pilot valve bushing assembly (238), align the missing tooth in the bushing with the corresponding missing tooth in the spring coupling assembly (229).

6. Install the three-piece thrust bearing (218) onto the stem of the pilot valve plunger (235) (bearing race with the larger hole must be against the flyweight toes).

7. When items 216 through 238 have been assembled, center the pilot valve plunger as follows (see Figure 4-3): apply a slight pressure to the speeder spring seat (217), adjust the pilot valve plunger nut (216) until the flyweights (225) move from their extreme inward to their extreme outward position and there is the same amount of control land showing in the control port at each extreme. The control ports are the bottom holes in the pilot valve bushing.

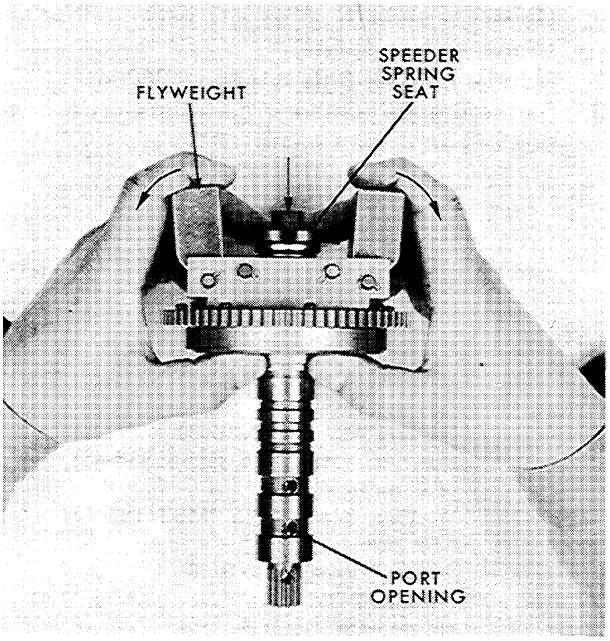

Figure 4-3. Centering Pilot Valve Plunger

8. When assembling the speed setting mechanism, ensure that the retaining ring (30, Figure 5-1) is positioned with the opening in line with setscrew (33).

9. Assemble the manual speed setting shaft assembly (43 through 47), tighten nut (43) approximately seven turns, insert roll pin (39) to protrude through shaft (43) approximately 0.090 inch (2.29 mm).

Testing

The PG governor has been manufactured in such a wide variety of arrangements that it would be impractical to cover specifications and testing procedures for each model.

It is recommended that the customer contact one of the Woodward offices for detailed specifications and testing instructions for the particular models at the installation. When ordering information, it is essential to supply the governor serial number (as shown on nameplate).

Chapter 5.
Parts Information

Parts Replacement

When ordering replacement parts it is essential that the following information be given:

1. Governor serial number and part number (as shown on nameplate).
2. Manual number (this is manual 36694).
3. Part reference number in parts list and description of part or part name.

Illustrated Parts Breakdown

The illustrated parts breakdown (Figures 5-1 and 5-2) illustrates and lists all parts of the basic PG governor. Index numbers are assigned in disassembly sequence. Circled index numbers indicate items which do not require further disassembly unless repair or replacement of the part is required.

Parts List for Figure 5-1

Ref. No.	Part Name	Quantity Required
36694-1	Screw, hex hd., 5/16-24 x 5-13/32	2
36604-2	Washer, lock, 5/16 (MS35338-45) (7.9 mm)	2
36694-3	Washer, plain, 5/16 (MS27183-12) (7.9 mm)	2
36694-4	Screw, drive #2 x 3/16 (AN535-2-3)	4
36694-5	Nameplate	1
36694-6	Oil filler cap	1
36694-7	Cover	1
36694-8	Cover gasket	1
36694-9	Loading spring	1
36694-10	Restoring spring	1
36694-11	Cotter pin, 1/16 x 3/8 (MS24665-1 30)	1
36694-12	Pivot pin (Restoring lever)	1
36694-13	Restoring lever	1
36694-14	Pin (loading spring)	1
36694-15	Stop pin (low speed-pneumatic)	1
36694-16	Screw, soc. hd., 5-40 x 1/2	1
36694-17	Washer, lock, #5 (AN935-5)	1
36694-18	Screw, soc. hd., 1/4-28 x 1-1/4 (MS 16998-46)	1
36694-19	Screw, soc. hd., 1/4-28 x 2 MS1 6998-49	1
36694-20	Washer, lock, 1/4 (MS35338-44) (6.4 mm)	2
36694-21	Pilot valve link	1
36694-22	Low speed adjusting screw	1
36694-23	Nut, hex., 10-32 (MS35650-302)	1
36694-24	Bellows spring	1
36694-25	Bellows coupling	1
36694-26	Setscrew, soc. hd., cup pt. 8-32 x 5/16 (MS51973-30)	1
36694-27	Passage screw	1
36694-28	Washer, soft copper	1
36694-29	Receiver cup gasket	1
36694-30	Retaining ring, int., 1.660 OD (42.2 mm OD)	1
36694-31	Bellows	1
36694-32	Packing, preformed, 1-1/2 OD (38.1 mm OD) (NA51593-028)	1
36694-33	Setscrew, soc. hd., cup Pt., 5-40x 1/4	1
36694-34	Pneumatic receiver cup	1
36694-35	Screw, Phillips, rd. hd., 6-32 x 3/8 (MS35206-25)	4

Ref. No.	Part Name	Quantity Required
36694-36	Dial plate	1
36694-37	Spacer	4
36694-38	Friction spring	1
36694-39	Roll pin, 3/32 x 5/8 (MS9048-071)	1
36694-40	Stop washer	1
36694-41	Spring washer, 1/4” (6.4 mm)	1
36694-42	Washer, plain, 25/64 ID x 5/8 OD	1
36694-43	Nut, hex., slflkg, 1/4-28 (MS21 083N4)	1
36694-44	Belleville washer, 1/4’ (6.4 mm)	2
36694-45	Knob (Manual speed adjusting)	1
36694-46	Clutch spring	1
36694-47	Shaft (head screw)	1
36694-48	Receiver bracket gasket	1
36694-49	Screw, soc. hd, 10-24 x 1/2 (MS1 6997-44)	2
36694-50	Washer, lock, #10 (MS35338-43)	2
36694-51	Stop pin (High speed)	1
36694-52	Collar	1
36694-53	Pivot pin	4
36694-54	Link	1
36694-55	Setscrew, soc. hd., dog Pt., 8-32 x 3/8 (MS51977-31)	1
36694-56	Thread insert, scr. 1kg., 8-32 x 1/4 (MS21 209C081 5)	1
36694-57	Nut (Lead screw)	1
36694-58	Thread insert, 7/16-20 x 7/16	1
36694-59	Speed adjusting nut	1
36694-60	Guide	1
36694-61	Setscrew, soc. hd, oval Pt.,10-32x 1 (MS51982)	1
36694-62	Nut, knurled	2
36694-63	Screw, soc. hd., 10-32 x 1-1/8	1
36694-64	Washer, lock, hi-collar, #10 (MS51848)	2
36694-65	Screw, soc. button hd., 10-32 x 1	1
36694-66	Spacer	1
36694-67	Ball bearing	1
36694-68	Pivot bracket	1
36694-69	Thread insert, scr. 1kg., 10-32 x 3/8 (MS21 209F 120)	1
36694-70	Speed setting screw	1
36694-71	Pin (Loading spring anchor)	1
36694-72	Friction spring seat	1
36694-73	Dowel pin	2
36694-74	Thread insert, scr. 1kg., 8-32 x 1/4 (MS21 209C081 5)	1
36694-75	Receiver bracket	1
36694-76	Packing, preformed, 3/8 (9.5 mm) OD (NAS1593-010)	2
36694-77	Nut, hex., 8-32 (MS35649-282)	2
36694-78	Screw, hex. hd., 1/4-28x 1-3/16 (MS90726-9)	2
36694-79	Washer, plain, 1/4 (6.4 mm) (AN960-41 66)	2
36694-80	Speed setting piston spring	1
36694-81	Nut, hex., 10-32 (MS35650-302)	2
36694-82	Guide pin	1
36694-83	Setscrew, soc. hd., oval Pt., 10-32 x 7/8 (MS51982)	1
36694-84	Screw, soc. hd., 10-32 x 3/8 (MS 16998-26)	1
36694-85	Adjusting screw (Max. speed)	1
36694-86	Thread insert, scr. 1kg., 10-32 x 9/32 (MS21209F 1-15)	1
36694-87	Adjusting screw bracket	1
36694-88	Fulcrum	1
36694-89	Speed setting piston	1
36694-90	Check valve assembly (Max. speed)	1
36694-91	Speed setting cylinder	1
36694-92	Screw, hex. hd., 5/16-24 x 5 (MS90726-52)	4
36694-93	Washer, lock, int. tooth, 5/16(7.9 mm) (MS35333-41)	4
36694-94	Screw, Phillips, rd. hd., 10-32 x 3/8 (MS35207-53)	2
36694-95	Washer, lock, #10 (MS35338-43)	2
36694-96	Retainer	1
36694-97	Spacer	1
36694-98	Thrust bearing	1
36694-99	Speed setting plunger	1

Ref. No.	Part Name	Quantity Required
36694-100	Plug	1
36694-101	Speed setting bushing	1
36694-102	Bushing loading spring	1
36694-103	Bushing gear	1
36694-104	Bearing stud	1
36694-105	Elbow, 90 0	3
36694-106	Tubing, 1/4-inch	1
36694-107	Dowel pin	2
36694-108	Cover dowel	2
36694-109	Dowel bushing	2
36694-110	Thread insert, 5/16-24	2
36694-111	Pipe plug, soc. hd., 1/16-27 NPTF (AN93251)	5
36694-112	Taper screw (Not used with solenoid or pressure actuated shutdown option)	1
36694-113	Column	1
36694-114	Cotter pin, 1/32” x 3/8” (0.8 x 9.5 mm)	2

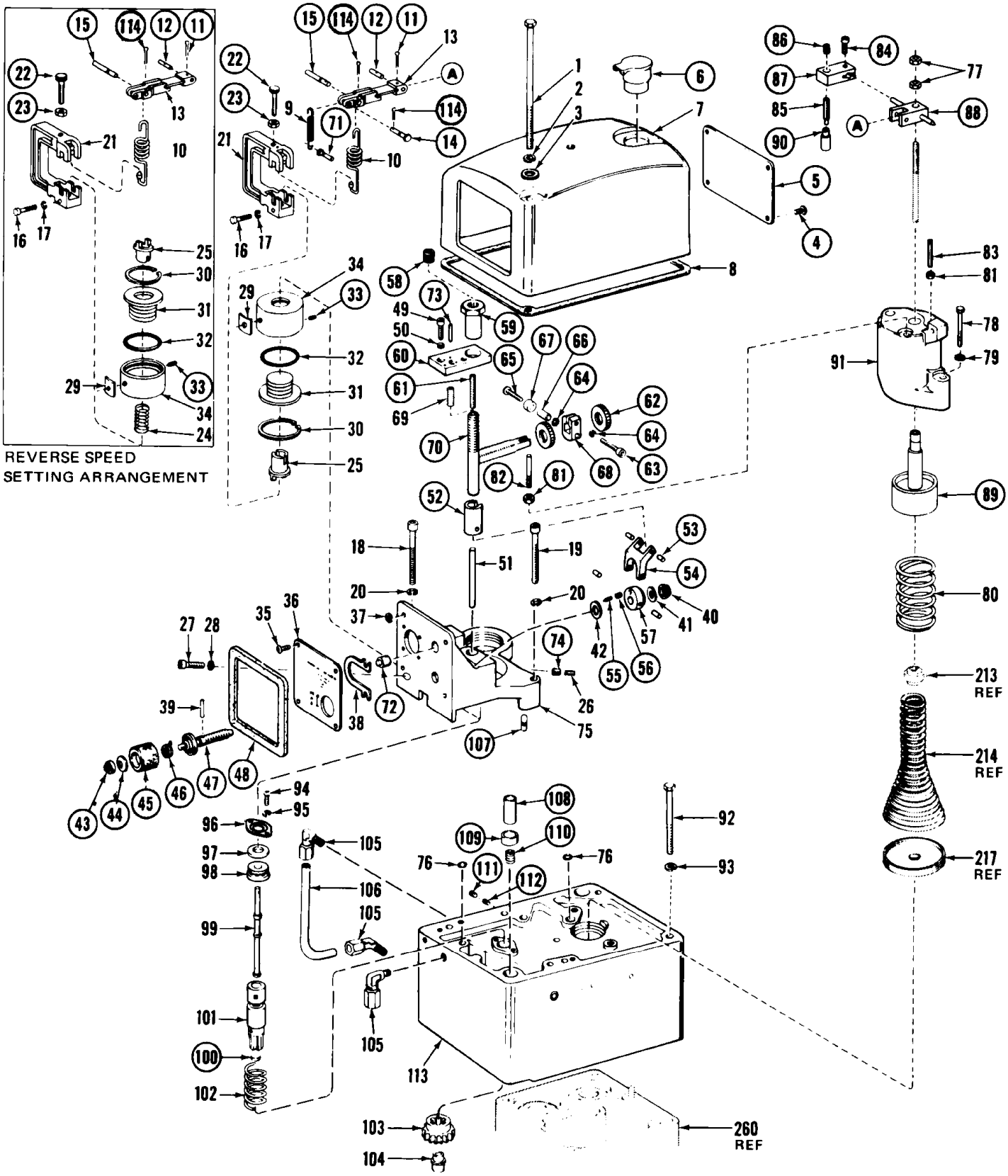

Figure 5-1. Exploded View of Column

Parts List for Figure 5-2

Ref. No.	Part Name	Quantity Required
36694-201	Screw, soc. hd,3/8-16x 11/4	4
36694-202	Washer, lock, 3/8 (9.5 mm)	4
36694-203	Power cylinder assembly (refer to Manual 36692)	1
36694-204	Gasket, power cylinder case	1
36694-205	Screw, hex hd., 5/16-18 x 1	8
36694-206	Washer, lock, 21/64	8
36694-207	Base assembly (refer to Manual	1
36694-208	Power case-base oil seal ring	1
36694-209	Idler gear	1
36694-210	Idler stud	1
36694-211	Drive gear	1
36694-212	Gasket	1
36694-213	Speeder spring check plug	1
36694-214	Speeder spring	1
36694-215	Cotter pin, 1/16 x 5/8 (1.6 mm x 15.9 mm)	1
36694-216	Pilot valve plunger nut	1
36694-216A	Spring, shutdown rod	1
36694-217	Speeder spring seat	1
36694-218	Thrust bearing	1
36694-219	Washer, adjusting spring	1
36694-220	Adjusting spring	1
36694-221	Not used	
36694-222	Shutdown rod	1
36694-223	Cotter pin, 1/16x 1 (1.6mm x 25.4 mm)	8
36694-224	Flyweight pin-limit pin	4
36694-225	Flyweight	2
36694-226	Flyweight bearing	4
36694-227	Screw, rd. hd., 8-32 x 5/16	1
36694-228	Washer, lock, #8	1
36694-229	Spring coupling assembly	1
36694-230	Screw sems, pan head, 5-40 X 5/16	8
36694-231	Not used	
36694-232	Flyweight head sub-assembly	1
36694-233	Retaining ring	1
36694-234	Compensating bushing	1
36694-235	Pilot valve plunger	1
36694-236	Bearing	1
36694-237	Oil seal ring	1
36694-238	Flyweight head-bushing assembly	1
36694-239	Retaining ring	1
36694-240	O-ring	1
36694-241	Plug	1
36694-242	Buffer spring	2
36694-243	Buffer piston	1
36694-244	Buffer seat	1
36694-245	Retaining ring	4
36694-246	Spring seat	2
36694-247	Small accumulator spring	2
36694-248	Large accumulator spring	2
36694-249	Accumulator piston	2
36694-250	Spring loaded check valve	2
36694-251	Plain check valve	2
36694-252	Drain cock	1
36694-253	Elbow	1
36694-254	Oil gage	1
36694-255	Not used	
36694-256	Not used	
36694-257	Pipe plug, 1/8	4
36694-258	Pipe plug, 1/16	2
36694-259	Dowel pin	2
36694-260	Power case	1

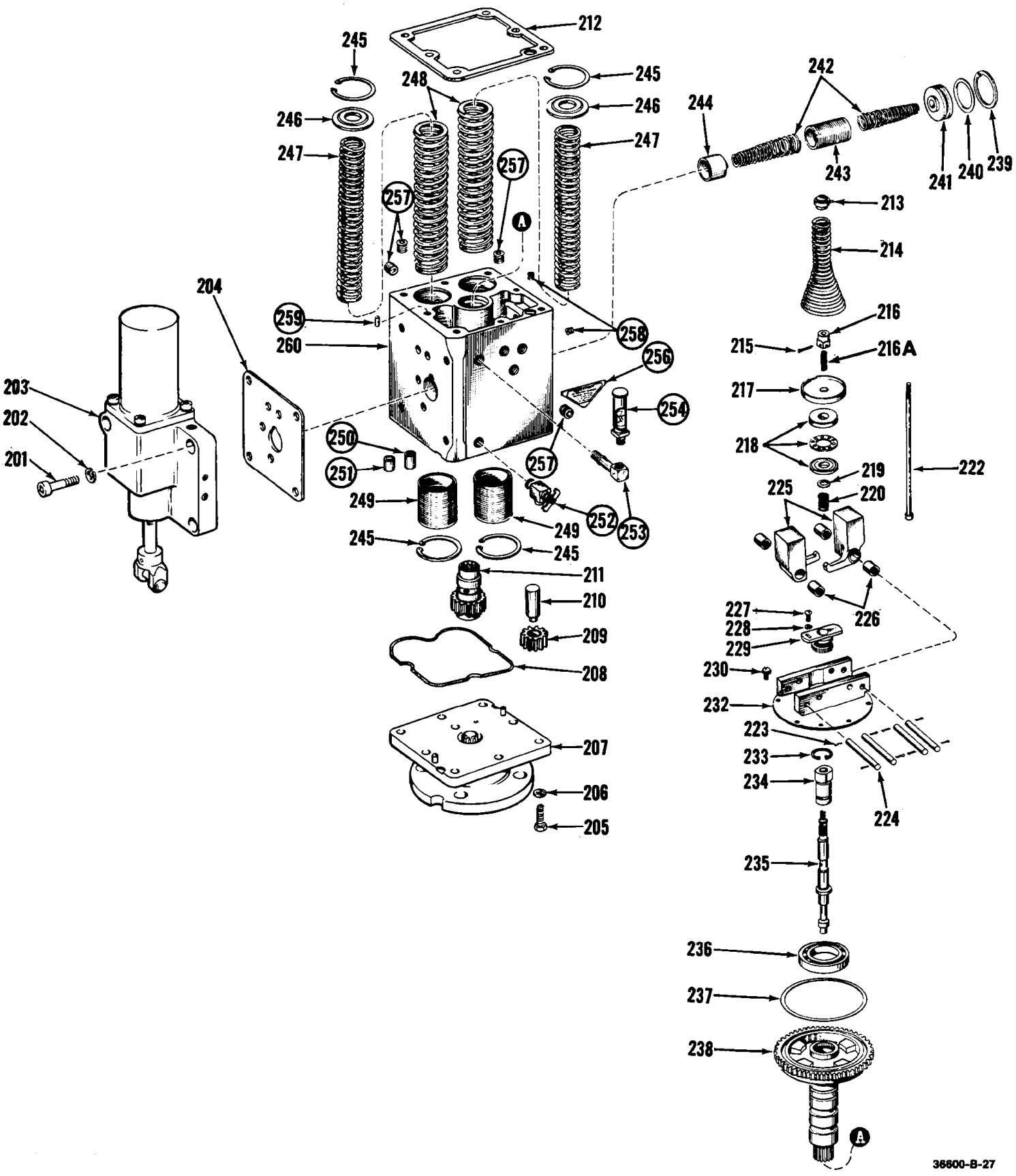

Figure 5-2. Exploded View of Case

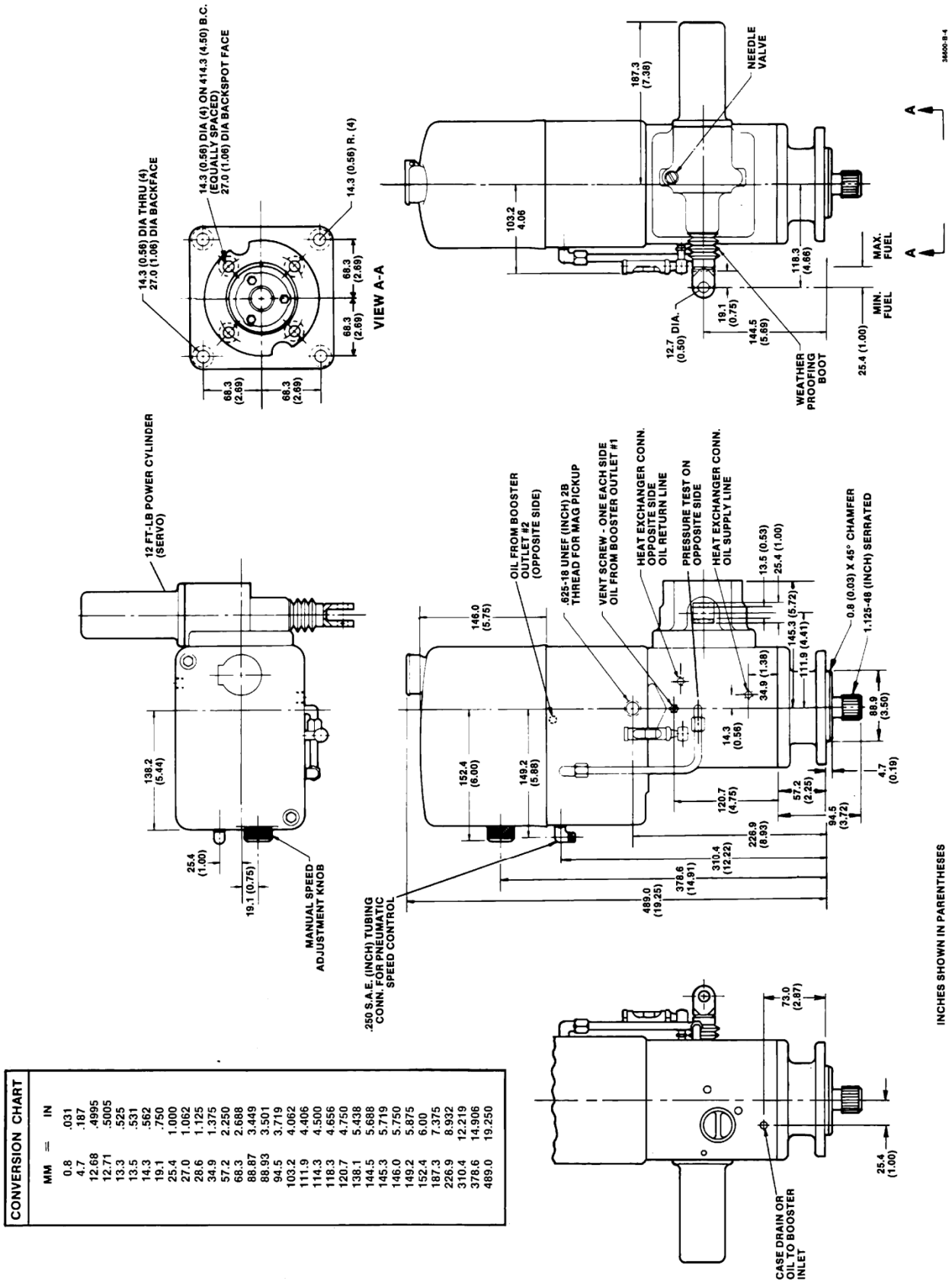

Figure 5-3. Outline Drawing of PG-PL Governor

Chapter 6.
Auxiliary Features

Auxiliary Features (optional)

Many auxiliary devices are available for use, either singly or in combination, on the PG governor to meet the numerous control requirements of the installation requiring precise speed setting. Each governor is designed to meet the needs of the engine or turbine and the operating requirements of the installation.

Auxiliary equipment may be supplied as original equipment in the governor and some may be installed in the field. It is recommended that the customer contact Woodward Governor Company on any field installations as some auxiliaries cannot be installed in the field.

The following paragraphs give a brief description of some of the auxiliary equipment available from Woodward Governor Company and list the manuals where detail information may be obtained.

Manual No.	Title
36641	Governor Heat Exchanger
36650	Solenoid Operated Shutdown Ass.
36651	Pressure Actuated Shutdown Ass.
36680	Preloaded Buffer Springs
36684	Booster Servomotor
36692	PG Power Cylinder Assemblies
36693	PG Base Assemblies

Governor Oil Cooler

A governor oil cooler is required if operating temperatures exceed 200 °F (93 °C), and speeds exceed 1200 rpm on an engine application and 1100 rpm on a steam turbine. It may also be necessary to use an oil cooler at lower governor drive shaft speeds if the governor is mounted close to valves or steam lines which result in high ambient temperature.

Water (or some other liquid coolant) from an external supply enters the oil cooler cover and passes through a tube to the oil cooler body. The water circulates through the body cavity to the discharge.

A special governor case may be required to mount the oil cooler or to connect to the external heat exchanger. Where it might be desirable to add an oil cooler to a governor already in service, the governor should be returned to the factory for conversion.

Shutdown Devices

A shutdown device can be incorporated in the PG governor to stop fuel to the engine or turbine if equipment fails. This is not a primary overspeed protective system and should not be construed as such. This is an auxiliary system only. These assemblies are used in a variety of applications including plants where automatic safety devices are a necessity. Shutdown devices can be supplied in the following arrangements to suit the particular operating conditions:

⚠WARNING

The shutdown solenoid must not be used as an overspeed protection device. Overspeed protection must come from a unit completely separate from the PG-PL Governor. Overspeed protection must be designed to protect against governor failure. It must be separate from the governor to prevent damage to the engine, turbine, or other type of prime mover with possible personal injury or loss of life should the governor fail.

1. Shutdown assemblies which will operate from air, oil, or water pressure. These assemblies are generally supplied where electrical devices cannot be used. The air, oil, or water shutdown device can be arranged to shut down the engine or turbine on either high or low signal pressure.

2. A solenoid shutdown device which can be arranged to energize or de-energize to shut down. Solenoid coils are available to accommodate most common dc and ac voltages.

Preloaded Buffer Springs

Preloaded buffer springs are often installed in PG governors used on two-cycle spark ignition engines and on some engines driving reciprocating pumps. As a result of preloading, the governor minimizes fuel linkage movements resulting from changes in speed due to misfiring or pump instability. The use of preloaded buffer springs does not affect the capability of the governor to recognize and respond to speed changes. Preloaded buffer springs do retard the rate at which the governor output piston (or terminal shaft) moves when responding to small or momentary off speeds. The output piston (or terminal shaft) moves at the normal rate for large speed changes.

Booster Servomotor

The booster servomotor is used in conjunction with the PG governor to assist the engine in starting quickly. The function of this device is to supply oil under pressure to the governor at the instant starting air is supplied to the engine; this enables the governor to move the engine linkage to the fuel-on position immediately.

PG Base and Power Cylinder Assemblies

A number of different base and power cylinder arrangements are available to conform to engine or turbine manufacturer's specifications. These are factory installed.

The base assembly can be furnished with either a serrated or keyed drive shaft. Refer to manual 36693.

Power cylinder work capacities are available from 12 to 200 ft-lb (16 to 271 J). Manual 36692 explains the various power cylinders while manual 36618 explains the PG 200 governor.

Chapter 7.
Diaphragm Speed Setting

Introduction

Many of the earlier PG-PL governors are still in operation. These governors are of a type that uses an air receiver diaphragm instead of a bellows. The linkage for speed setting is also different and requires other instructions for adjustment. Both direct and reverse mechanisms are available in the diaphragm PG-PL governor. This section deals with the description, setting, and parts lists for the diaphragm type speed setting.

Description of Operation

The following is a description of how the diaphragm direct speed setting mechanism operates (see Figures 7-1 and 7-2). When a higher air pressure is sent under the pneumatic receiver diaphragm, the diaphragm rises against atmospheric and spring pressures on the opposite side. This movement, carried by the diaphragm link, pivots the speed control lever and pushes the speed setting pilot valve down through the action of the connecting link and the lower floating lever. The displacement of the speed setting pilot valve allows pressure oil to be admitted above the speed setting piston. The piston moves downward until the upper floating lever, floating lever link, and lower floating lever restore the pilot valve to its steady-state position.

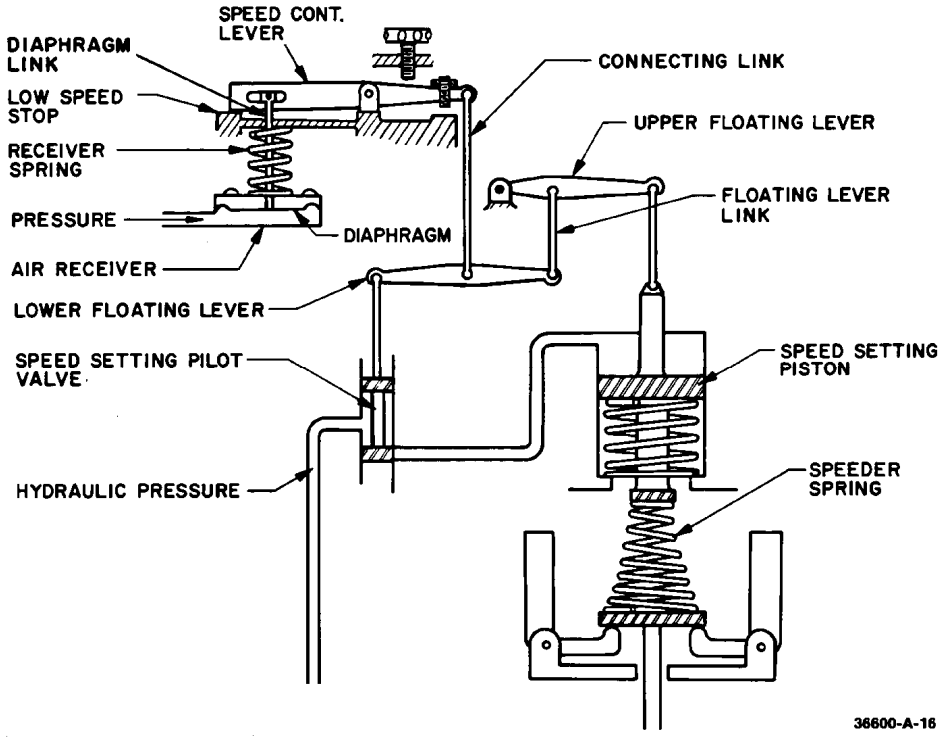

Figure 7-1. Schematic of Diaphragm Direct Speed Setting

With a lower air pressure signal, the receiver diaphragm would lower because of the receiver spring pressure atop it. Through the linkage previously described the speed setting pilot valve is raised, opening the port to sump and allowing the piston return spring to raise the piston. The linkage attached to the speed setting servo shaft closes the pilot valve again.

The diaphragm reverse mechanism runs the engine or turbine at high speed for minimum control air pressure, and low Speed for maximum control air pressure. The special linkage arrangement is shown in Figure 7-3. Note that the base speed setting nut pivot and upper end of the floating lever link have exchanged places from the arrangement shown in Figure 7-2. A special speed setting pilot valve plunger is used. It must now move upward to admit oil to the speed setting servomotor. Converting a governor from direct operation to reverse speed setting involves changing a few parts so it is preferable, though not absolutely necessary, to specify the correct arrangement when a governor is ordered. See the description of operation in Chapter 3 for information on the rest of the governor.

Adjustment and Parts List

Air pressure versus engine or turbine speed relationships are set at the factory with more precise measuring instruments than are available in the field. The governor speed settings normally will never need to be readjusted, and under no circumstances should they be altered without thorough knowledge of the procedure. If it is necessary to change or reset the governor speed settings, first determine the pressure range of the associated air pressure instrument, and the engine or turbine speed range corresponding to this pressure range.

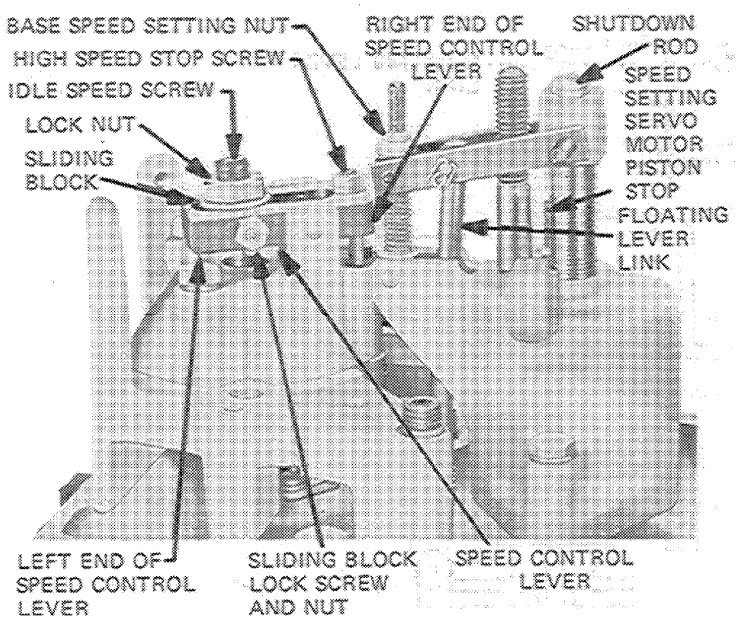

Figure 7-2. Adjustment Points of Diaphragm Direct Air Receiver

Back off the high speed stop screw, shown in Figure 7-2. Loosen the idle speed screw locknut and the sliding block lockscrew and nut. The sliding block can now be moved freely to either end of the slot. Set it at approximately the mid-point in its travel and lock it with the lockscrew and nut. Turn the idle speed screw (see Figure 7-2) counterclockwise (ccw) so that it does not control the pilot-valve plunger position. Start the engine or turbine following the prime mover manufacturer's instructions and apply zero psi air pressure. Adjust the base speed setting nut for 15 rpm less than idle speed. Apply the specified low air pressure. Adjust the idle speed screw for idle speed.

⚠WARNING

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.

Adjust the base speed setting nut to obtain the specified engine speed corresponding to minimum air pressure. Screw down to decrease speed, or up to increase speed. Slowly raise control air pressure to the specified maximum value, making sure the engine does not overspeed. The speed obtained will probably be either higher or lower than the desired maximum. Check to be sure the high speed stop screw is not limiting speed by touching the screw head below it.

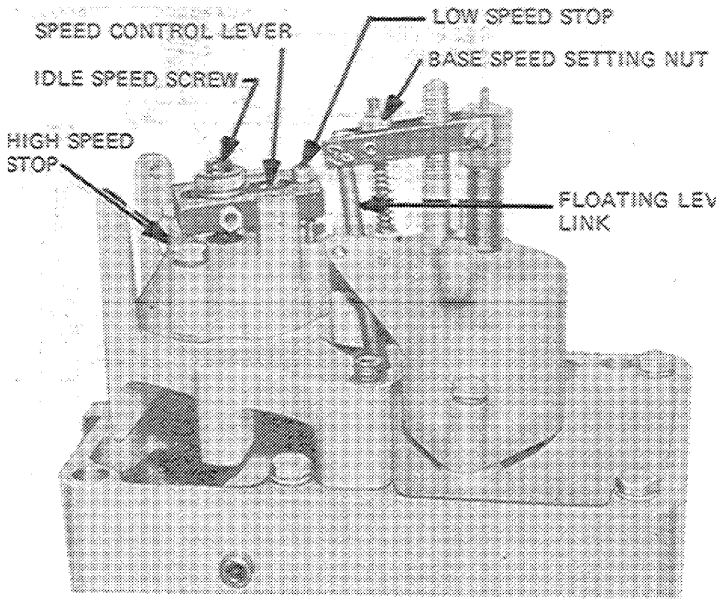

Figure 7-3. Reverse Diaphragm Linkage Arrangement

If the maximum speed obtained is too low, loosen the sliding block lockscrew and nut and the idle speed screw locknut. Move the sliding block (see Figure 7-2) a short distance to the right. Moving the sliding block to the right (toward the pivot) increases the amount of rpm change that results from a specified air pressure change.

It is now necessary to start over again with the specified air pressure at minimum, and adjust and lock the idle speed screw as explained previously. Set the base speed setting nut as before to obtain the specified minimum speed corresponding to minimum air pressure. Again apply maximum specified air pressure and check the speed. Repeat this process until the desired high and low speeds are obtained.

When desired speeds have been obtained for the specified air pressures, adjust the high speed stop screw so it just contacts the screw head below it at maximum specified air pressure. Tighten the locknut.

Make sure the diaphragm link between the diaphragm and the idle speed screw does not rub on the edge of the hole where it passes through the pneumatic receiver casting. This could happen if the sliding block were either too far from or too near the pivot. If it is too far from the pivot, use a stronger receiver spring. If it is too near the pivot, use a weaker spring.

See Figure 7-3 for PG-PL governors equipped with reverse speed setting (minimum control air pressure produces maximum speed). With zero pressure applied and the idle speed screw adjusted so that it does not control the pilot-valve plunger position, adjust the base speed nut for 15 rpm over high speed. USE CAUTION NOT TO OVERSPEED ENGINE. Apply the specified low air pressure and adjust the idle speed screw for high speed. Slowly raise air pressure to the specified maximum. If speed is not to specification, adjust the sliding block and lock nut, and repeat the procedure. When correct range is obtained, adjust the low speed stop at minimum speed to just touch the speed control lever.

Speed Setting Servomotor Piston Stop Screw Adjustment

Set the governor for the minimum speed position. Turn the speed setting servo motor piston stop screw down until it contacts the top of the piston, then back it off 1-1/2 turns and tighten the locknut.

Information and Parts Replacement

When ordering replacement parts it is essential that the following information be given:

1. Governor serial number and part number (as shown on nameplate).
2. Manual number (this is manual 36694).
3. Part reference number in parts list and description of part or part name.

Parts List for Figure 7-4

Ref. No.	Part Name	Quantity Required
36694-301	5/16-24 x 5-15/32 hex head screw	2
36694-302	5/16 (7.9 mm) shakeproof washer	6
36694-303	Oil filler cup	1
36694-304	Set screw (knob)	1
36694-305	Control knob	1
36694-306	Taper pin	1
36694-307	Drive screw	6
36694-308	Manual speed adjustment plate	1
36694-309	Friction plunger	1
36694-310	Friction spring	1
36694-311	5/16 (7.9mm) lockwasher	1
36694-312	Gasket	1
36694-313	Bushing-dowel	2
36694-314	Bushing	2
36694-315	5/16-24 x 5/8 threaded insert	2
36694-316	Stud	1
36694-317	Power piston stop screw	1
36694-318	#10-32 hex nut	1
36694-319	Adjustable fulcrum screw	1
36694-320	13/64 x 7/16 x 1/32 washer (5.1 x 11.1 x 0.8 mm)	1
36694-321	Link adjusting spring	1
36694-322	Adjustable fulcrum pin	1
36694-323	#10-32 stop nut	1
36694-324	Fulcrum link	2
36694-325	Link spacer	2
36694-326	Piston fulcrum assembly	1
36694-327	Floating lever link	1
36694-328	Floating lever link spring	1
36694-329	1/8 straight pin (3.2 mm)	1
36694-330	1/16 x 3/8 cotter pin (1.6 x 9.5 mm)	6
36694-331	Lower floating lever assembly	1
36694-332	1/8 x 47/64 drilled pin (3.2 x 18.7 mm)	2
36694-333	0.186 x 3/4 pin (4.7 x19.0 mm)	1
36694-334	Speeder spring power cylinder	1
36694-335	1/4-28 x 1 3/8 hex head cap screw	5
36694-336	17/64x 1/2x 1/32 washer (6.7 x 12.7 x 0.8 mm)	2
36694-337	Speeder spring power piston assembly	1
36694-338	Speeder spring servo spring	1
36694-339	Speed setting pilot valve plunger	1
36694-340	Pilot valve plunger spring	1
36694-341	Speed setting pilot valve bushing	1
36694-342	Pilot valve bushing spring	1
36694-343	Column assembly	1
36694-344	Gear	1
36694-345	Bearing stud	1
36694-346	Thrust bearing	1
36694-347	Bushing retainer	1
36694-348	#10-32 x 3/8 round head Phillips screw	2
36694-349	#10 lockwasher	2
36694-350	1/4 x 9/16 dowel pin (6.3 x 14.3 mm)	4
36694-351	1/4-28 socket head screw	1
36694-352	Speed control bracket	1
36694-353	17/64 x 27/64 x 1/16 lockwasher (6.7 x 10.7 x 1.6 mm)	2
36694-354	1/4-28 x 1 1/4 socket head cap screw	1
36694-355	1/4-28 x 1 3/4 socket head cap screw	1
36694-356	Diaphragm nut	1
36694-357	Retaining washer	1
36694-358	Diaphragm washer	1
36694-359	Diaphragm	1
36694-360	Spring seat	1
36694-361	Diaphragm spring	1
36694-362	Pivot pin	1

36694-363	Floating lever link assembly	1
36694-364	Diaphragm link assembly	1
36694-365	Speed control bracket cap	1
36694-366	Control lever slide	1
36694-367	Idle speed setting screw	1
36694-368	Needle bearing	2
36694-369	Speed control lever	1
36694-370	3/8 washer (9.5 mm)	1
36694-371	3/8-32 hex jam nut	1
36694-372	#10-32 x 3/4 socket set screw	1
36694-373	#10-32 hex nut	2
36694-374	#10-32 x 1/2 socket set screw	1
36694-375	Speed adjusting screw	1
36694-376	9/16 x 21/64 x 1/16 washer	1
36694-377	3/32 x 1/2 cotter pin (2.4 x 12.7 mm)	1
36694-378	Solenoid locknut	1
36694-379	Plunger stop plug	1
36694-380	Solenoid plunger lock pin	1
36694-381	Solenoid case	1
36694-382	Insulating paper	1
36694-383	Load spring	1
36694-384	Solenoid coil	1
36694-385	Soldering shield washer	2
36694-386	O-ring	2
36694-387	Adjusting screw	1
36694-388	Solenoid plunger assembly	1
36694-389	Solenoid plunger rod	1
36694-390	Solenoid plunger washer	1
36694-391	Plunger guide locating pin	1
36694-392	Shutdown valve body	1
36694-393	Varnished tubing	2
36694-394	Solenoid plunger bushing	2
36694-395	1/4 steel ball (6.3 mm)	1
36694-396	Unloading spring	1
36694-397	Shutdown valve seat	1
36694-398	O-ring	1
36694-399	Friction plunger retaining screw	1
36694-400	Nameplate (column)	1
36694-401	Elbow	2
36694-402	Tubing	1
36694-403	Nameplate (cover)	1
36694-404	Drive screw	4
36694-405	Cover	1
36694-406	Oil level decal	1
36694-407	O-ring	2
36694-408	Plate	1
36694-409	#10-32 x 3/8 screw	1
36694-410	Gasket	1
36694-411	Plate	1
36694-412	#10-32x1/2screw	4
36694-413	Gasket	1
36694-414	#6-32x3/8 screw	4
36694-415	Receptacle	1
36694-416	Plug	1
36694-417	Cable clamp	1
36694-418	5/16-24 x 4-31/32 hex head screw	4

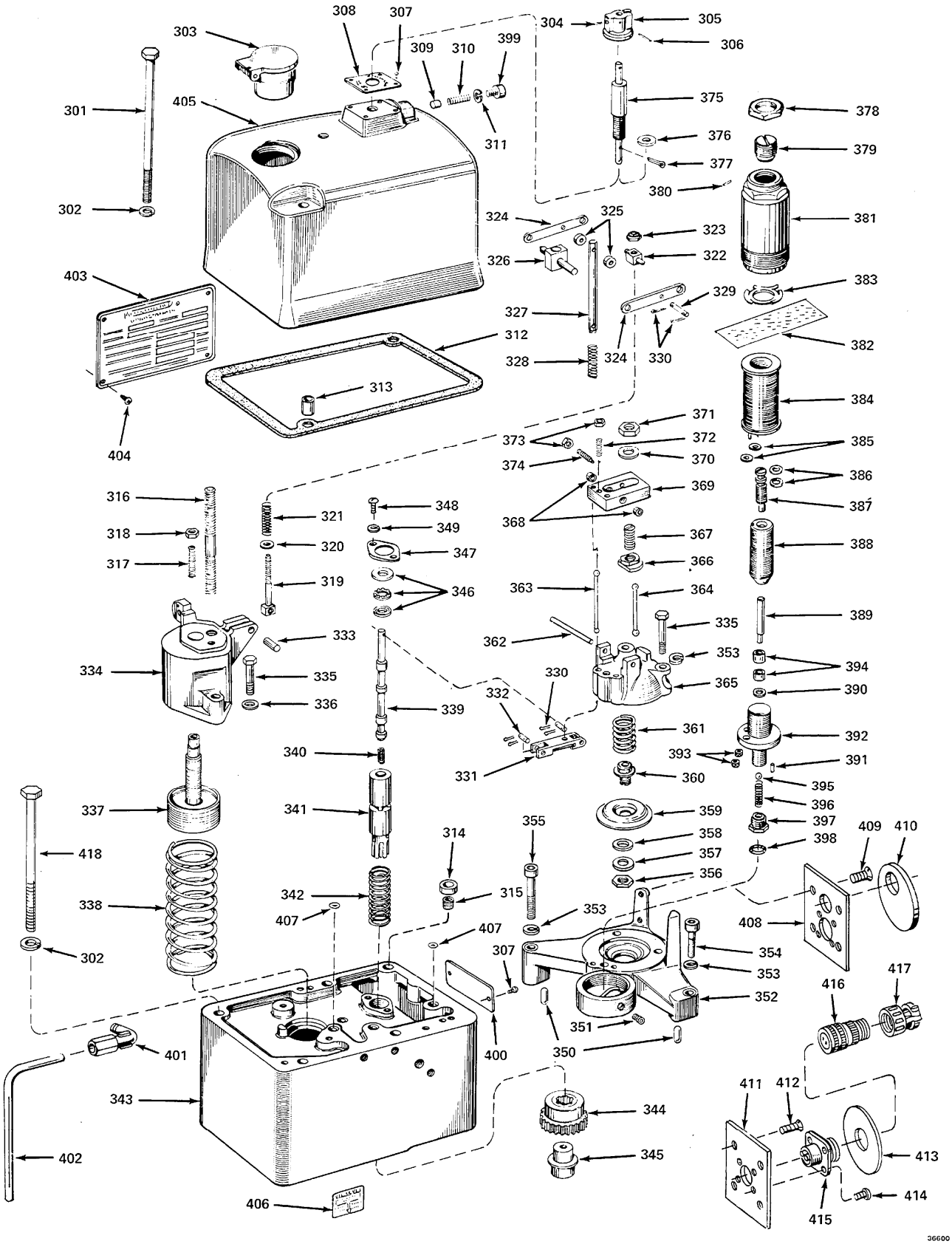

Figure 7-4. Exploded View of Diaphragm Column Parts

Chapter 8.
Service Options

Product Service Options

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

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

OEM and 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 **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

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

Woodward Factory Servicing Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- 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 is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

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.

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 within 60 days, a credit for the core charge will be issued.

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 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 offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- 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. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. 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.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or 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 us via telephone, email us, or use our website and reference **www.woodward.com/support**, and then ***Customer Support***.

How to Contact Woodward

For assistance, call one of the following 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.

Electrical Power Systems

Facility	Phone Number
Australia	+61 (2) 9758 2322
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-0
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 618 92 00
United States	+1 (970) 482-5811

Engine Systems

Facility	Phone Number
Australia	+61 (2) 9758 2322
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Stuttgart	+49 (711) 78954-0
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

Turbine Systems

Facility	Phone Number
Australia	+61 (2) 9758 2322
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
United States	+1 (970) 482-5811

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

For the most current product support and contact information, please refer to the latest version of publication **51337** at **www.woodward.com/publications**.

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

Please reference publication 36694P.

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WOODWARD

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.

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