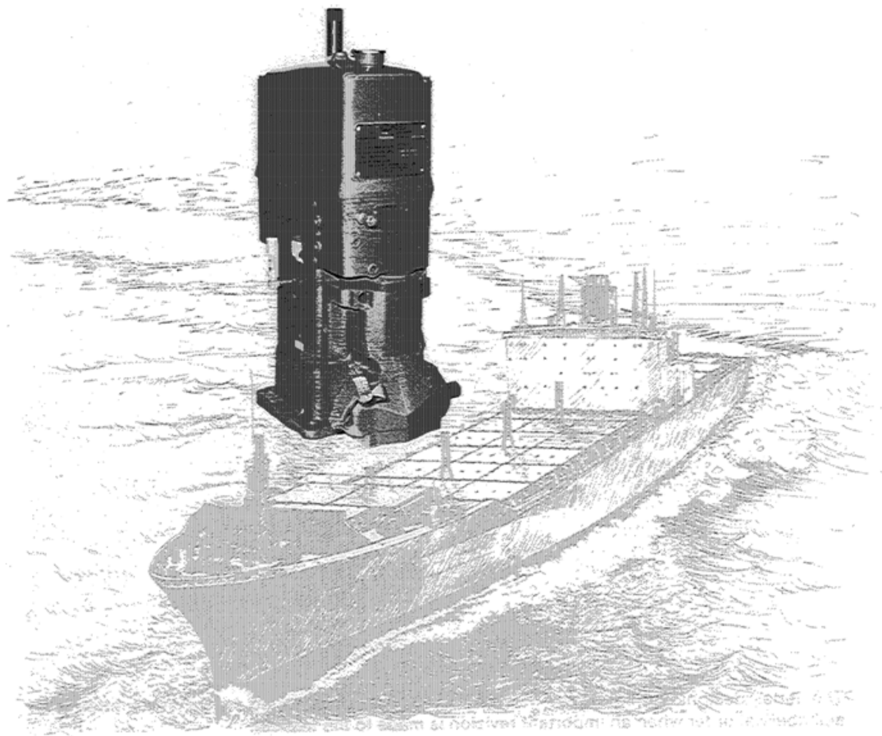
WOODWARD

Product Manual 36604
(Revision M, 4/2004)
Original Instructions



PGA Governor

Installation and Operation Manual

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

Revisions	**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:** **www.woodward.com/publications** **The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

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

Translated Publications	**If the cover of this publication states "Translation of the Original Instructions" please note:** **The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.**

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

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

WARNING

Overspeed / Overtemperature / Overpressure

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

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

WARNING

Personal Protective Equipment

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

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

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

WARNING

Start-up

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

WARNING

Automotive Applications

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

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

Electrostatic Discharge Awareness

NOTICE **Electrostatic Precautions**	**Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:** • **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).** • **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.** • **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.** **To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.**

Follow these precautions when working with or near the control.

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

Chapter 1.
General Information

Introduction

This manual covers the Woodward model PGA (pressure compensated–air speed setting) marine governor. The PGA marine governor with a long column consists of a basic PG hydraulic governor for automatic regulation of prime mover speed and pneumatic speed changing mechanism for remote control of speed. Two types of power cylinders are available, a single-acting spring-return, or double-acting differential-piston-type power cylinder with tailrod (see Table 1-1). For the 12 ft-lb (16 J) type, a spring return power cylinder is available for either pull or rotary output. For the 29 ft-lb (39 J) type, a differential power cylinder is available with rotary output.

Table 1-1. Governor Oil Pressure Versus Power Cylinder Work Capacities (Typical)

Governor Operating Oil Pressure	**Power Cylinder Work Capacity**	
	12 ft-lb (16 J) spring return	**29 ft-lb (39 J) differential**
100 psi (690 kPa)	12 ft-lb (16 J)	29 ft-lb (39 J)
200 psi (1379 kPa)	——	58 ft-lb (79 J)

All PGA marine governors have the same basic components regardless of how simple or complex the complete control may be. The following components, found in each PGA marine 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 oil accumulator, and a relief valve maintains a uniform oil pressure
- A centrifugal flyweight head-pilot valve assembly controls the flow of oil to and from the governor power cylinder assembly
- A power cylinder assembly—sometimes referred to as a servomotor—positions the fuel racks, fuel valve, or steam valve of the prime mover
- A compensation system stabilizes the governor system
- A pneumatic speed setting mechanism is used to adjust the governor speed setting remotely

Description

Governor

The governor controls engine or turbine speed by regulating the amount of fuel or steam supplied to the prime mover. Speed control can be isochronous (the governor maintains a constant steady state speed, within the capacity of the unit, regardless of load), or with droop (speed decreases as load increases).

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. The most common air pressure range for the governor is 7 to 71 psi (48 to 490 kPa). Normal minimum control air pressure is 3 psi (21 kPa); maximum is 100 psi (690 kPa). We recommend a governor operating speed of between 250 to 1000 rpm.

The pneumatic speed setting mechanism is a bellows-type mechanism. Bellows speed setting permits load division of paralleled units, and also provides a definite, accurate relationship between speed and speed signal. The speed setting mechanism is available for use with air input signals of varying range and magnitude. Depending upon the exact configuration installed in the governor, speeds may be adjusted up to 5-to-1 range. A manual speed setting knob is incorporated in the unit to permit manual operation when the air pressure signal is not available.

Base Assemblies

Various base assemblies are available for use on PGA governors. Five types of bases are mentioned in this manual, along with appropriate outline drawings, and exploded views:

- PG standard
- PG/UG-8 standard
- PG/UG-8-90° (base rotated 90° with respect to PG/UG-8 standard)
- PG/UG-40
- PG extended square

These base assemblies have essentially the same basic components. The difference between units is the base configuration and the type of drive shaft used (see Figures 1-3 through 1-7). The PG standard base uses a serrated or a special drive shaft: the PG/UG-8, PG/UG-8-90°, and PG/UG-40 base may use either a serrated or keyed drive shaft; and the PG extended square base uses only a keyed drive shaft.

The drive shaft, driven by a mechanical connection to the engine or turbine, rotates the governor oil pump drive gear, flyweight heads, and pilot valve bushing.

References

36652 PG Automatic Safety Shutdowns and Alarms
36695 PG Manifold Air Pressure Bias Fuel Limiter
36701 PGA Governor product specification

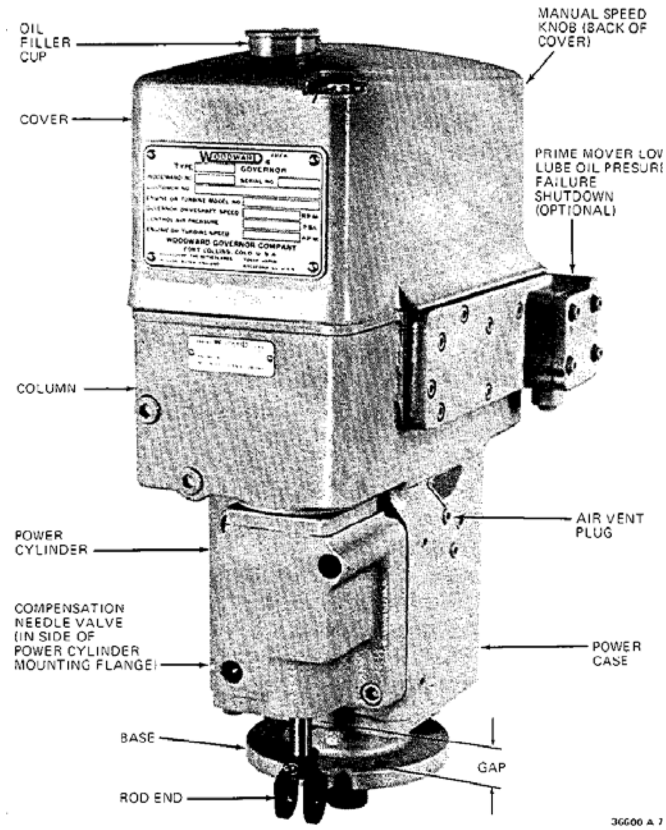


Figure 1-1. PGA Governor with 12 ft-lb Linear Output Power Cylinder

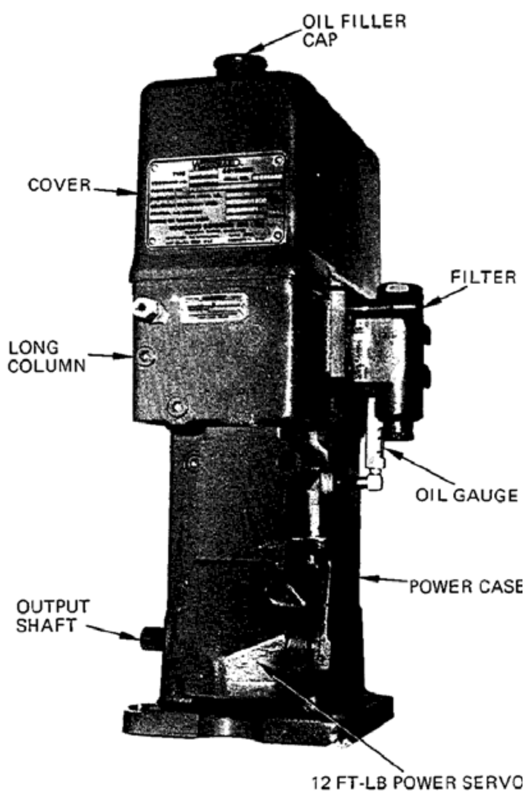


Figure 1-2. PGA Governor with 12 ft-lb Rotary Output Power Cylinder

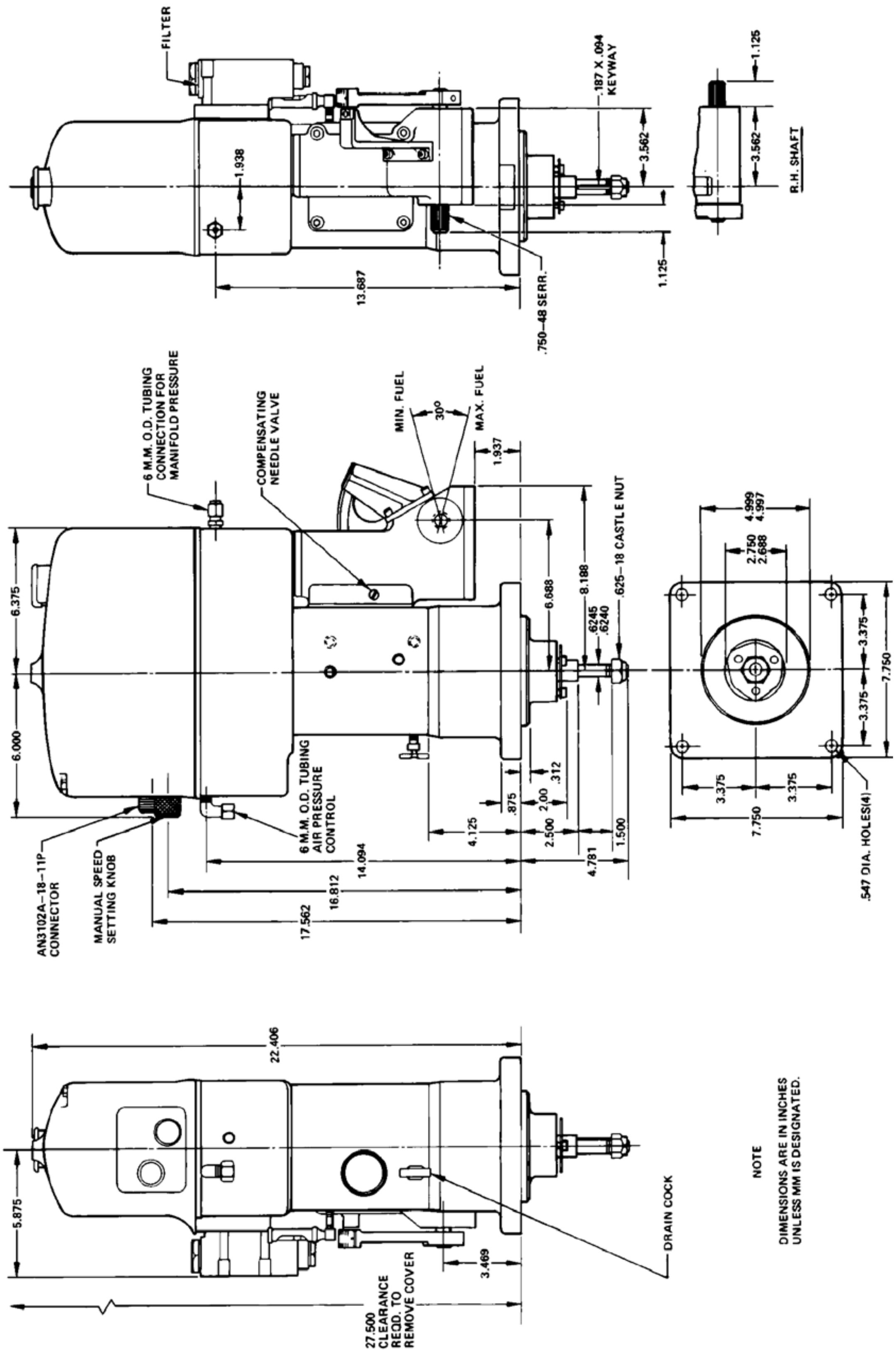


Figure 1-3. Outline Drawing of PGA with 12 ft-lb Rotary Servo and UG-40 Base
(Do not use for construction.)

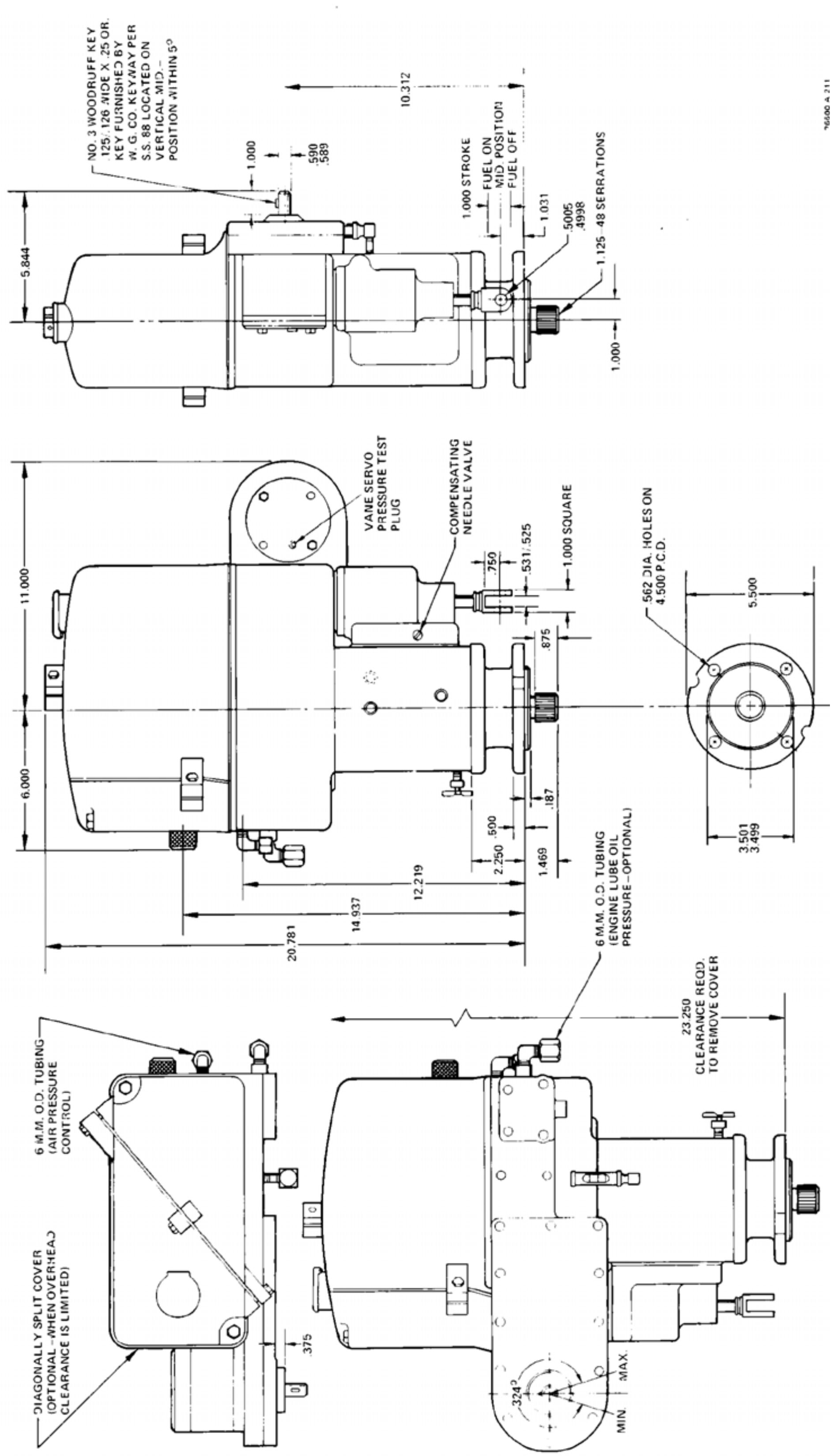


Figure 1-4. Outline Drawing of PGA with 12 ft-lb Linear Output, PG Standard Base, and Vane Servo with Shaft Extension
(Do not use for construction.)

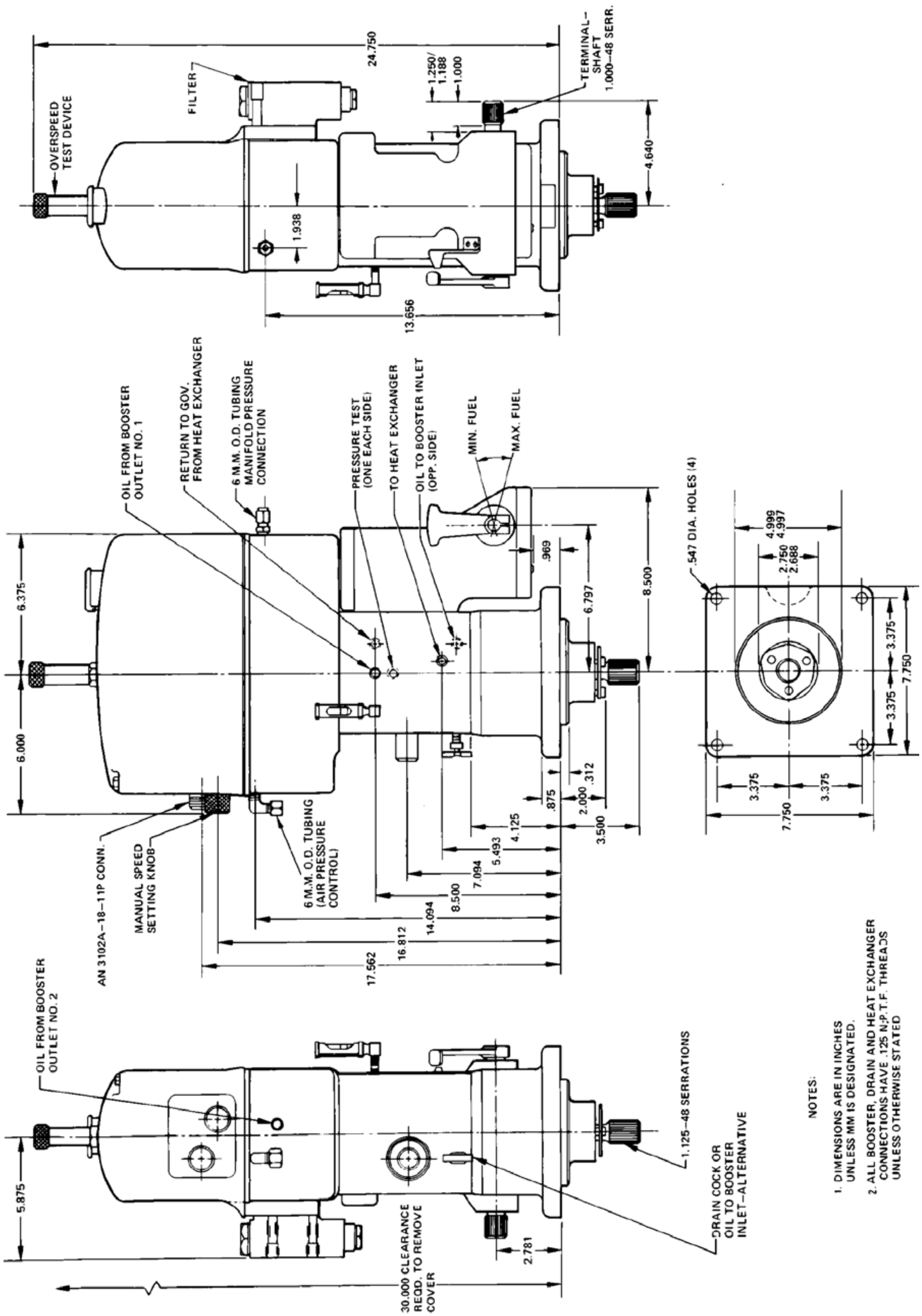


Figure 1-5. Outline Drawing of PGA with 58 ft-lb Rotary Output and UG-40 Base
(Do not use for construction.)

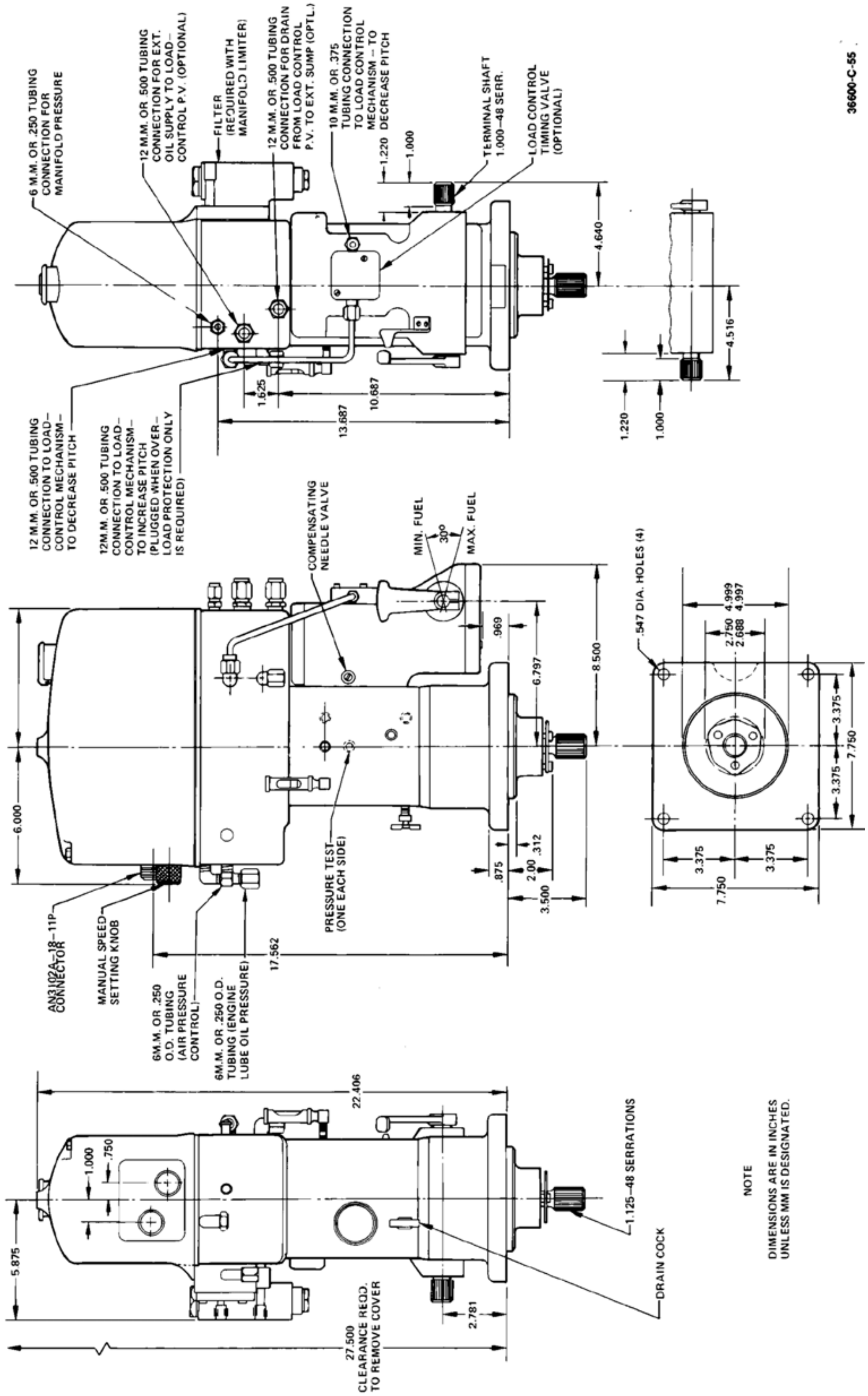


Figure 1-6. Outline Drawing of PGA with 58 ft-lb Rotary Output, UG-40 Base, and Load Control
(Do not use for construction.)

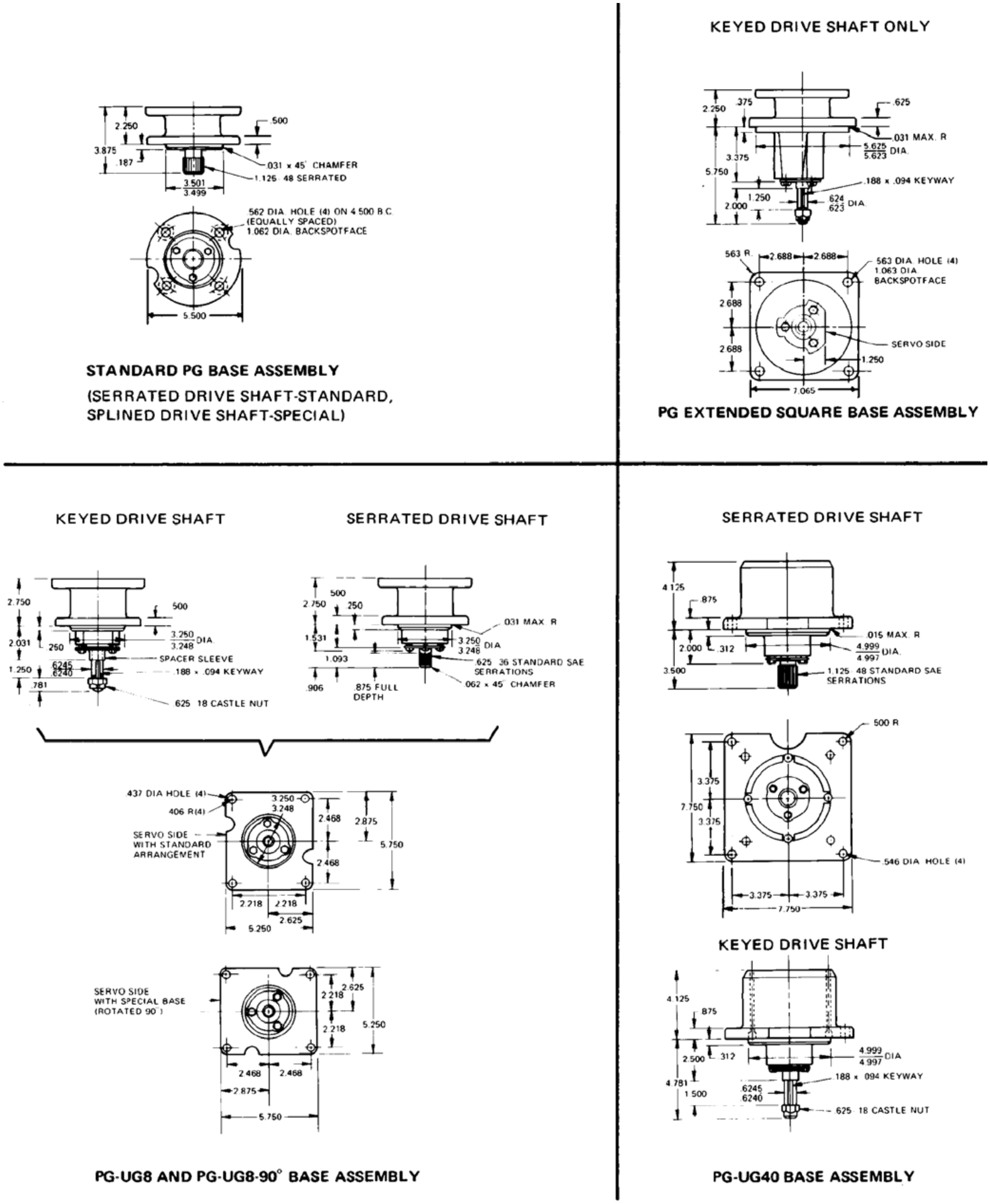


Figure 1-7. Outline Drawing of Base Assemblies
(Do not use for construction.)

Chapter 2.
Installation

Introduction

Refer to Figures 1-3 through 1-7 for physical dimensions of a PGA governor.

Use care in handling the governor and be particularly careful to avoid striking the drive shaft. Do not drop or rest the governor on its drive shaft. Such treatment could damage the governor oil pump gears.

> **⚠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.**

Receiving

Your PGA governor is received from our factory bolted to a wooden platform in a vertical position. After testing the governor at the factory, it is drained of oil. This leaves a light film of oil covering the internal parts. preventing rust. No internal cleaning is required.

Storage

Store the governor in a vertical position and full of oil. To hold the governor in a vertical position, bolt it to a platform or leave it in the shipping crate. Before storing the governor, fill it with oil since it is shipped empty.

Mounting Requirements

A gasket must be used between the governor and accessory mounting pad. Mount the governor square on its mounting pad using the correct length of coupling between the governor and the drive. Be sure there is no binding, or excessive side load in the drive shaft assembly, or excessive looseness in the coupling. There should be no forces pushing the drive shaft into the governor. Mount the governor in a vertical position.

> **NOTICE**
>
> **If the governor being installed has been designed for rotation in one direction only, be sure the engine or turbine drive to governor drive rotation is the same, otherwise the governor could be damaged. Specifications for individual governors indicate if the unit has been plugged to limit rotation to one direction only and is not equipped with check valves.**

Align the linkage from the governor to the fuel pumps properly to eliminate binding and/or excessive backlash. The relationship of governor terminal shaft angular position to fuel control position must be adjusted in accordance with the engine manufacturer's specifications. Many governors include a feature commonly referred to as compensation "cutoff". Due to the location of the compensation cutoff port in the power cylinder wail, it is necessary that the governor to fuel control linkage be adjusted so that at idle no-load the output of the governor is at least 15% of its travel from minimum position.

Make the hydraulic and electrical connections (if any) required for the particular model governor being installed.

Oils for Hydraulic Controls

Use this manual as a guide in the selection of a suitable lubricating/hydraulic oil for governor use. Oil grade selection is based on viscosity change over the operating temperature range of the governor. Also, use this manual to aid in recognizing and correcting common problems associated with oil used in governors. This manual is not intended to be used in the selection of the lubricating oil for the engine, turbine, or other type prime mover.

For applications where the Woodward governor shares the oil supply with the prime mover, use the oil recommended by the prime mover manufacturer.

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 to 300 SUS. Poor governor response or instability usually is an indication that the oil is too thick or too thin.

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

1. Insufficient lubrication caused by:
    - A. An oil that flows slowly either when it is cold or during start-up.
    - B. No oil in the governor.

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

3. Oil not suitable for the operating conditions caused by:
    - A. Changes in ambient temperature.
    - B. 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 oxidation resistant at the operating temperature.

WARNING

A loss of stable governor control and possible prime mover overspeed, capable of causing physical injury or death, may result if the viscosity exceeds the 50 to 3000 SUS range.

Specific oil viscosity recommendations are given in the chart (Table 2-1). 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-2104B, MIL-L-2104C, MIL-L-46152, MIL-L-46152A, 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 lubricity (kerosene), before refilling with new oil. If drain time is insufficient for the solvent to completely drain or evaporate. flush 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.

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 to two or more years. 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.

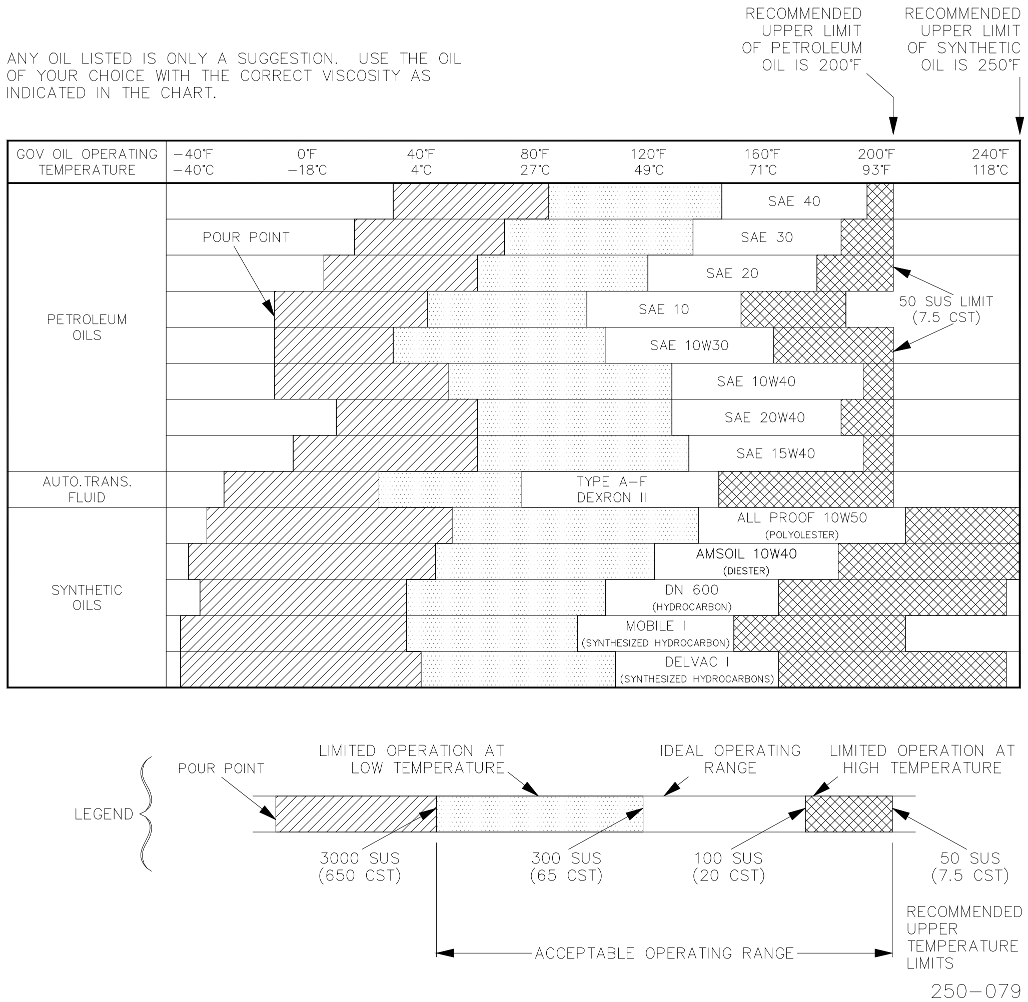
The recommended oil temperature for continuous governor operation is 140 to 200 °F (60 to 93 °C). Measure the temperature of the governor or actuator on the outside lower part of the case. The actual oil temperature will be slightly warmer, by approximately 10 °F (6 °C). The ambient temperature range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

IMPORTANT

The primary concern is for the hydraulic fluid properties in the governor.

Clearances

Leave adequate clearance for connecting the control linkage, filling the governor with oil, and removing the cover.



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 2-1. Viscosity and Operating Temperature of Oils

Chapter 3.
Adjustments

Introduction

⚠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.

These adjustments may be made in the field for optimum performance or after repairs. Always note the starting point before making any adjustments.

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

Compensation Needle Valve Adjustment

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

1. With the prime mover operating at IDLE, open the compensation needle valve several turns to cause the engine to hunt. In some cases, opening of the needle valve alone may not cause the engine to hunt, but manually disturbing the governor speed setting will. Allow several minutes of hunting to remove trapped air in the hydraulic circuits.

2. Close the compensation needle valve gradually until hunting is just eliminated. Keep the needle valve open as far as possible to prevent sluggishness in the governor response. The needle valve setting varies from 1/16 to 2 turns open. Never close it tight, the governor cannot operate satisfactorily when this condition exists.

3. Check the governor stability by manually disturbing the governor speed setting. The compensation adjustment is satisfactory when the governor returns to speed with only a slight over-or undershoot. Once the needle valve adjustment is correct, it is not necessary to change the setting except for large, permanent changes in temperature which affect governor oil viscosity.

IMPORTANT

If after a disturbance the engine does not return to a stable condition and the needle valve is almost closed, replace the existing buffer springs with springs having the next higher scale.

Speed Setting Adjustment

The pneumatic speed setting mechanism is a direct type which increases the governor speed setting as the control air pressure signal increases. Perform the following procedures as applicable to set the maximum and minimum operating speed of the governor.

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

Direct Speed Setting Mechanism

(Figure 3-2)

IMPORTANT **The governor speed setting adjustments, particularly those which establish the governor speed range versus the control air pressure range, are mutually interactive and a change cannot be made to one end of the range without also affecting the other end. For this reason, the entire adjustment procedure should be performed in sequence whenever any change in the low or high speed setting is necessary. It is preferable that speed adjustments be made on a test stand, however, they may be made on the prime mover if care is taken to avoid any possibility of overspeeding the prime mover.**

1. If governor is equipped with an optional solenoid or pressure actuated shutdown device:
   a. Solenoid type—must be energized if adjusted to shut down when de-energized.
   b. Pressure type—must be pressurized above shutdown point if adjusted to shut down upon low pressure.

2. Turn the manual speed adjusting knob fully ccw (until clutch slips) to the minimum speed position.

3. Initially position the high speed adjusting set screw (125, Figure 3-1) so that upper end is flush with top of the T-shaped speed setting screw (123).

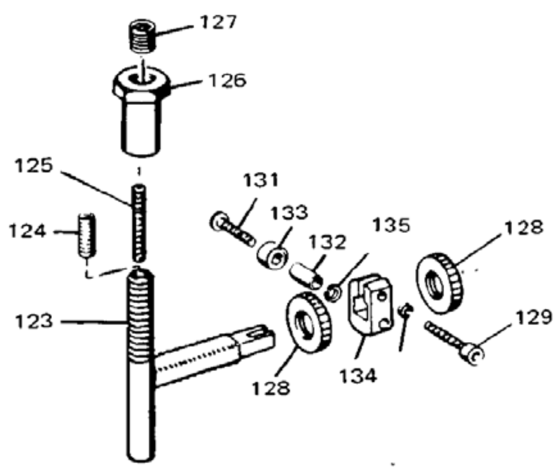


Figure 3-1. Exploded View of High Speed Adjustment

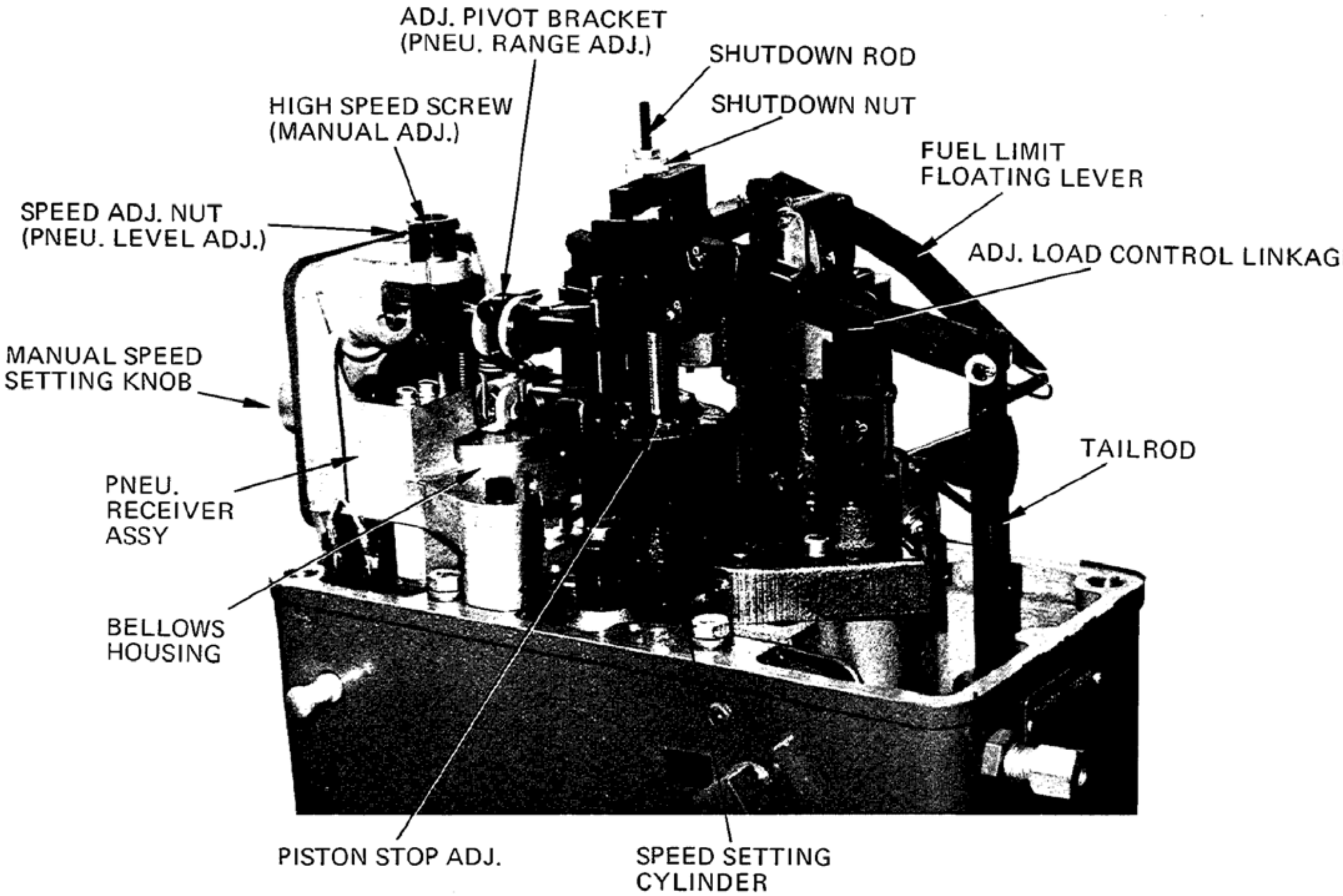


Figure 3-2. Left Side View of Governor with Cover Removed
(Governor Shown has Load Control and Single Barrel Limiter)

4. Initially position the speed setting piston stop setscrew (48, Figure 3-3) so that it projects 1/2 inch above top of the speed setting cylinder.

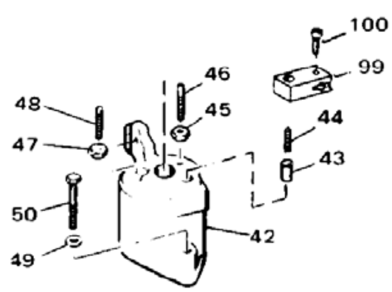


Figure 3-3. Exploded View of Speed Setting Cylinder

5. Adjust governor low speed setting as follows:
   a. Turn on control air to the governor and adjust to the required minimum pressure corresponding to the required low (idle) speed.
   b. Turn speed adjusting nut (Figure 3-2) on speed setting screw as required (ccw to increase) until the required low speed is reached at minimum control air pressure.

> **IMPORTANT** — **Make certain the pneumatic low speed adjusting screw (109) is not contacting stop pin (106) in the restoring lever and that the piston stop setscrew (48) is not interfering with upward movement of the speed setting piston.**

6 Calibrate the governor speed range to the control air pressure range as follows:

a. Slowly increase control air pressure toward the required maximum value. Exercise care not to overspeed the prime mover.

> **IMPORTANT** — **Make certain the maximum speed limiting valve adjusting screw (44, Figure 3-3) on speed setting piston rod is not contacting and' prematurely unseating the limiting check valve (43) in top of the speed setting cylinder.**

b. If the required high speed is reached before control air pressure is adjusted to the required maximum value, move the ball bearing pivot bracket (fulcrum) (134, Figure 3-1) toward the speed setting cylinder to decrease the governor speed range in relation to the control air pressure range.

c. If control air pressure is adjusted to the required maximum value before the required high speed is reached, move the ball bearing pivot away from the speed setting cylinder to increase the governor speed range in relation to the control air pressure range.

d. To adjust the ball bearing pivot, loosen uppermost screw in pivot bracket on arm of the speed setting screw. Adjust position of bracket (and ball bearing pivot) on arm by loosening the knurled nut on appropriate side of bracket and tightening the opposite nut.

7. After every adjustment of the pivot bracket, the low speed setting must be readjusted. Repeat steps 5 and 6 until the required low speed exactly corresponds with the required minimum control air pressure and both high speed and maximum control air pressure are reached simultaneously. Speed must begin to increase instantly with any increase in control air pressure above the minimum value.

8. Adjust control air pressure to the maximum value. Allow prime mover speed to stabilize. Turn the limiting valve adjusting screw (44, Figure 3-3) cw until prime mover speed just begins to drop, then back out 1/4 to 1/2 turn and lock in position. This will prevent or limit accidental overspeeding of the prime mover should the speed setting piston be moved past its high speed position for any reason.

9. Reduce control air pressure to the minimum value.

10. Turn the piston stop setscrew (48, Figure 3-3) cw until it just contacts top of the speed setting piston and then back out three full turns (3/32 inch/2.4 mm) and lock in position.

IMPORTANT	**The piston stop setscrew is normally used to limit upward movement of the speed setting piston during shutdown periods to 3/32 inch (2.4 mm) above the low speed position of the piston. This allows the governor to open the fuel control more quickly on start-up and therefore, minimize cranking time.** **Some governor applications may require a low or minimum speed stop, in which case the piston stop setscrew is used to limit upward movement of the piston at the low or minimum speed point. Where this is done, the governor cannot then be used to shut down the prime mover and some means external to the governor must be provided for this purpose.**

11. Lift the shutdown rod upward far enough to remove any end play (lost motion) but not so far as to cause prime mover speed to drop below the low speed setting. While holding the shutdown rod up, position shutdown nut on the rod so that it is 0.050 inch (1.27 mm) above upper end of the fulcrum block on the speed setting piston rod and lock in place with upper nut.

IMPORTANT	**The shutdown nuts are usually omitted where the governor application does not require a shutdown capability. If the nuts have been included but shutdown is not a requirement, make certain the nuts are positioned at top of shutdown rod at maximum distance from the fulcrum block.**

12. If the governor is to shut down the prime mover when control air is turned off or accidentally interrupted, adjust the pneumatic low speed stop screw so that it is 0.040 to 0.050 inch (1.02 to 1.27 mm) below stop pin in the restoring lever at low speed. Turn off control air to the governor and allow the prime mover to shut down. Readjust stop screw for 0.002 to 0.005 inch (0.05 to 0.13 mm) clearance between head of screw and stop pin in the restoring lever.

13. If the governor is to go to low speed when control air is turned off or interrupted, adjust the pneumatic low speed stop screw so that the desired speed is reached with no control air pressure. Speed should be at least 20 rpm below idle.

NOTICE	**Loosen and tighten lock nut (108, Figure 3-4), to adjust the low speed stop screw (109), only when the governor is stopped. Governor rotation, while making this adjustment, causes the pilot valve plunger to bind in the pilot valve bushing.**

14. Adjust maximum speed setting for the manual speed setting knob as follows:
    a. Turn off control air to the governor. If the governor is adjusted to shutdown upon interruption of control air, turn the manual speed adjusting knob cw until prime mover speed increases slightly before turning off control air.
    b. Turn the manual speed knob cw until prime mover is running at high speed.
    c. Turn the high speed adjusting setscrew 125, Figure 3-1) in the speed adjusting screw 123 cw until it just contacts the high speed stop pin. If the setscrew is turned too far, prime mover speed will decrease.

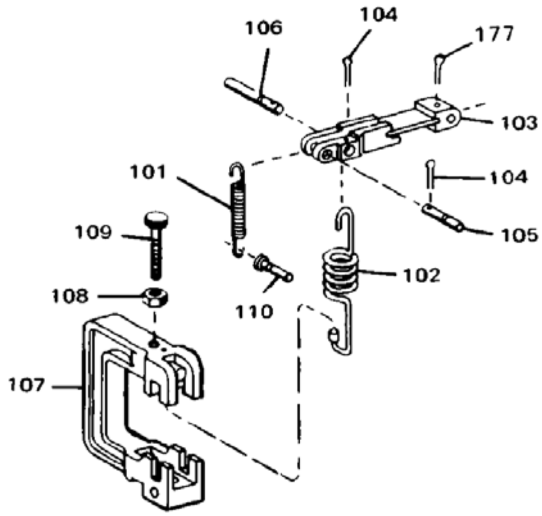


Figure 3-4. Exploded View of Low Speed Adjustment

15. Make certain to turn the manual speed adjusting knob fully ccw to the minimum speed position before resuming normal operation under pneumatic control.

Speed Droop Adjustment

Normally, the governor is adjusted at the factory for the speed droop specified by the prime mover manufacturer. Prime mover characteristics or system requirements may necessitate minor readjustment. To adjust, loosen the lock screw and slide cam along slot in fulcrum pin (see Figure 3-5). Move the cam lobe away from the fulcrum pin centerline toward power piston tailrod to increase speed droop or toward the centerline to decrease the speed droop. When the centerlines of the cam lobe and fulcrum pin coincide (“0” droop), the governor will operate isochronously.

NOTICE	**Do not move the cam past the “0” droop position as ‘negative’ droop will occur (prime mover speed increases as the governor power piston moves toward the maximum fuel or steam position). This will result in very unstable governing action.**

With the prime movers operating in parallel, the droop unit(s) must have sufficient droop to prevent load interchanges between prime movers.

Oil or Water Pressure Failure Shutdown Devices

Refer to manual 36652, *PG Automatic Safety Shutdowns and Alarms*.

Overspeed-Trip Test Device

Refer to Chapter 7, Auxiliary Features and Devices.

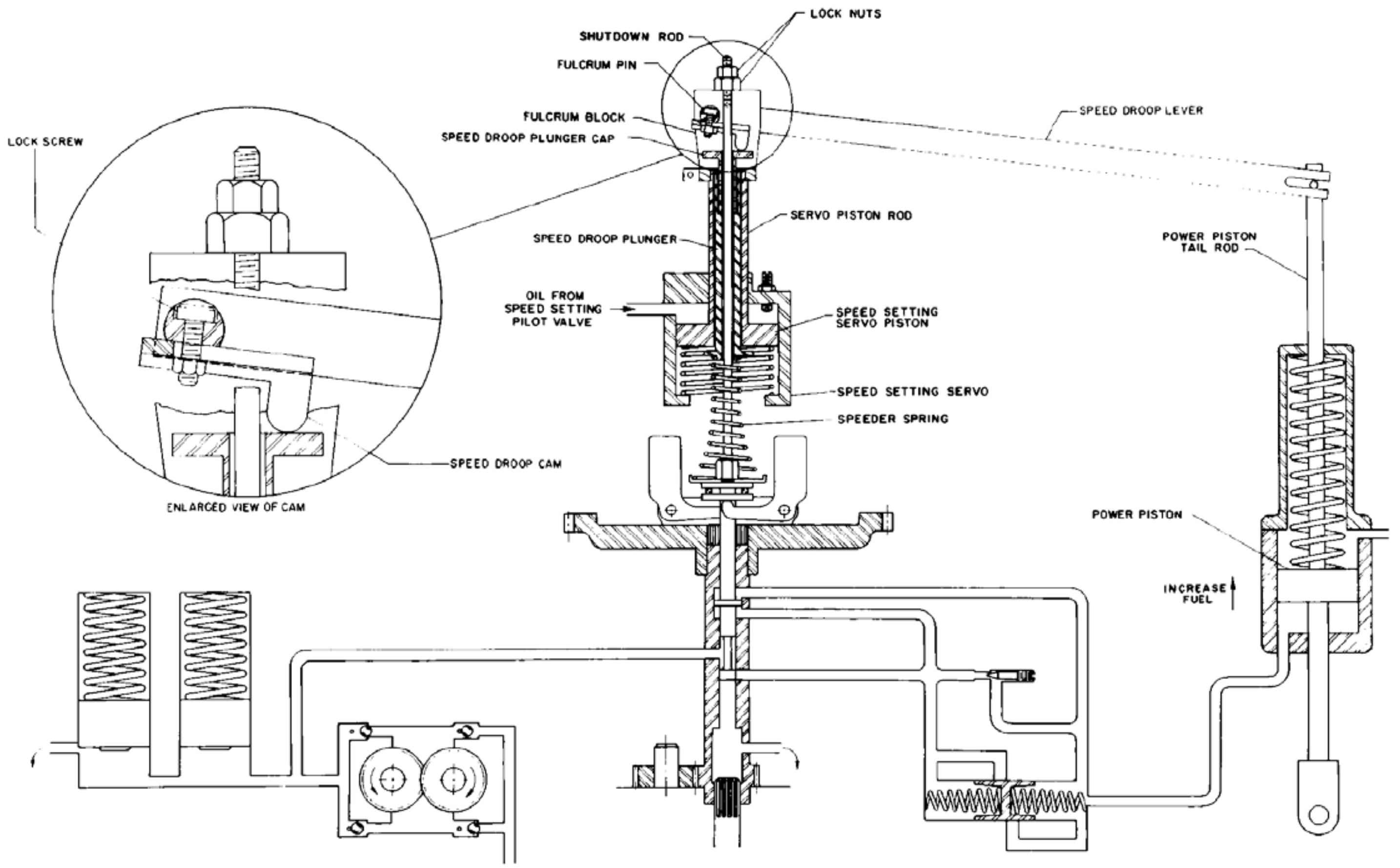


Figure 3-5. Schematic Diagram of the Speed Droop Linkage

Solenoid Operated Shutdown

Refer to Chapter 7, Auxiliary Features and Devices.

Field Adjustment of Angle Fuel Limiter Linkage

The following information applies only to the manifold pressure fuel limiter of the type illustrated in Figure 3-6.

Some governors are equipped with a fuel limiter of the type illustrated in Figure 7-21. Since adjustment of this type of limiter is only possible on a test stand, no instructions are provided in this manual. Complete Test stand adjustment procedures are available in manual 36695, *PG Manifold Air Pressure Bias Fuel Limiter*.

Figures 3-6 and 3-7 show various adjustments, and indicate the effect of each adjustment.

It should be clearly understood that these are approximate since variations inevitably exist between governors. Adjustment (C) is likely to show this variation more than others due to its proximity to a linkage pivot pin. The graphs are plotted as increments of tailrod travel, at point of fuel limit, per unit of adjustment above and below the datum settings given for the particular governor.

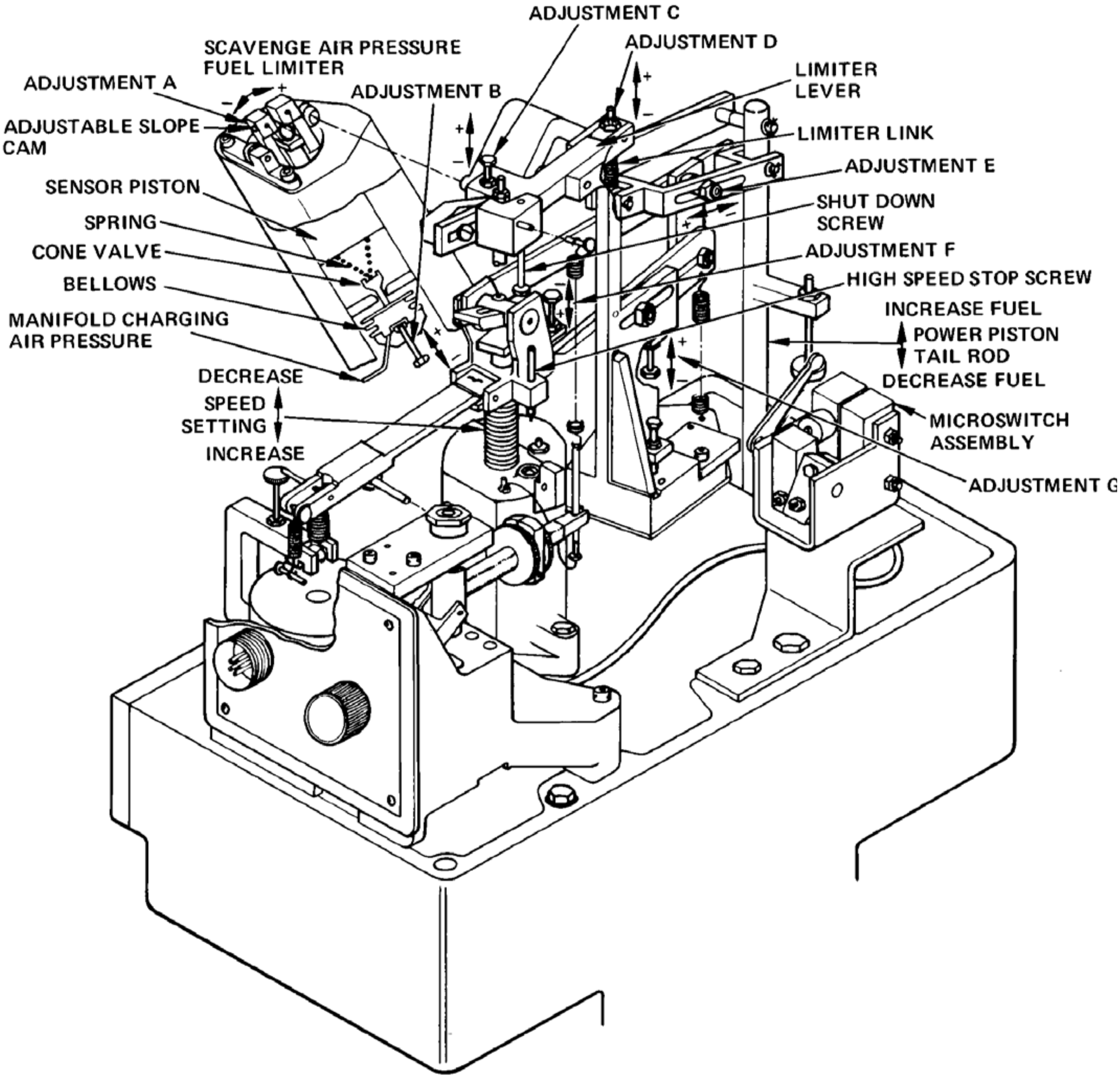


Figure 3-6. PGA Governor Fuel Limiter Linkage Adjustment
(Shown with Angle Fuel Limiter with Speed Setting Fuel Limiter)

Adjustment (A)
Adjusting this screw varies the angle of the charge pressure fuel limiter cam and the slope of the fuel limiter characteristic.

After making use of this adjustment it is necessary to trim the base of the limiter curve, by means of adjustment (C), in order to restore it to its original value. The graph shows the relationship between increments of governor tailrod travel at fuel limit against units of adjustment after both adjustments have been made.

Adjustment (B)
This is the bellows datum adjusting screw. Its setting determines the manifold charge pressure at which the fuel limiter piston begins to move downwards, increasing the governor tailrod travel at which fuel limit occurs. Its effect is to move the limiting characteristic sideways parallel with the charge pressure axis.

Adjustment (C)
Adjustment of this screw raises or lowers the entire manifold charge pressure fuel limiting characteristic.

Adjustment (D)
This is the speed setting fuel limiter datum setting nut. Its adjustment raises or lowers the entire limiting characteristic.

Adjustment (E)
Adjustment of the position of this linkage pivot pin in the slotted lever changes the linkage ratio such that for a fixed advance in speed setting piston position, the corresponding movement of governor power piston tailrod, at the point of fuel limit, may be increased or decreased (the slope of the fuel limiting characteristic may be altered).

After making use of this adjustment it is necessary to trim the base of the limiter curve, by means of adjustment (D), in order to restore it to its original level. The graph shows the relationship between increments of governor tailrod travel at fuel limit against units of adjustment, after both adjustments have been made.

Adjustment (F)
A constant fuel limit is held for all speeds below the speed setting at which this screw contacts the lower limiter lever.

Adjustment of the screw varies the speed setting at which the sloping portion of the limiting characteristic is reached. Its effect is to move the characteristic sideways, parallel with the speed setting axis.

Adjustment (G)
This adjustment varies the level of the constant "fuel limit" at low speed settings referred to under adjustment (F). It influences only this lower portion of the characteristic.

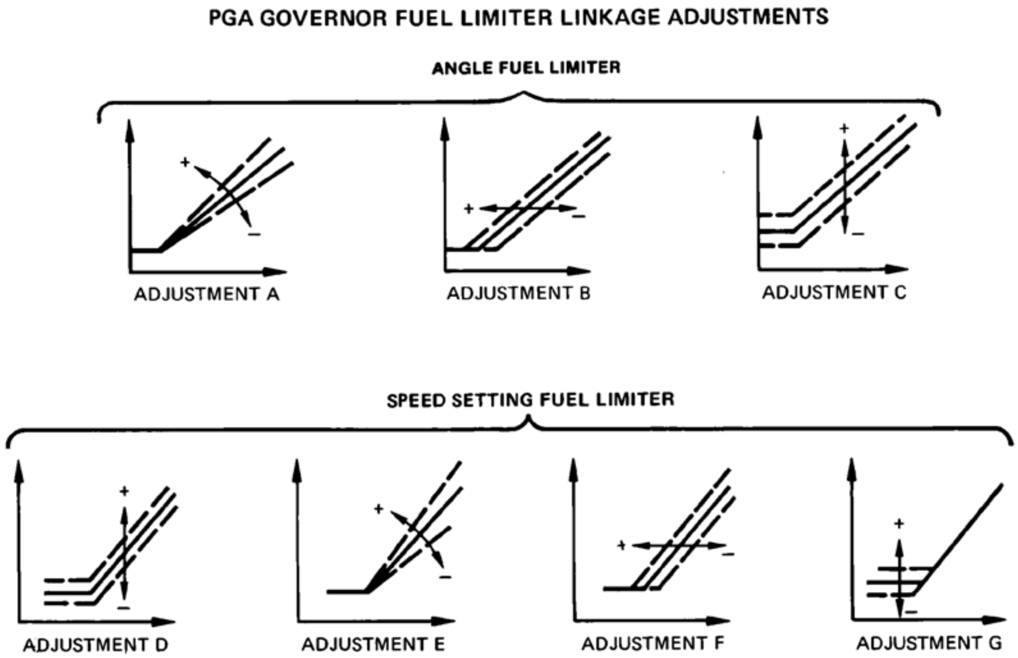


Figure 3-7. Graphic Effects of Fuel Limiter Adjustments

Chapter 4. Troubleshooting

Introduction

It is impossible to anticipate every kind of trouble that is encountered in the field. This covers the most common troubles experienced. Poor governing may be due to faulty governor performance, or it may be due to the governor attempting to correct for faulty operation of the engine or turbine auxiliary equipment. The effect of any auxiliary equipment on the overall control required of the governor must also be considered.

⚠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.**

Oil

Governor oil level must be kept between the lines on the oil level gauge glass with the unit operating. The correct level is at the joint line of the power case and column—the upper line on the gauge glass—and no higher. Instructions given on decals near the oil gauge should be strictly adhered to. Dirty oil causes approximately 50% of all governor troubles. Use clean new or filtered oil. Containers used to fill governors from bulk containers should be perfectly clean. Oil contaminated with water breaks down rapidly, causes foaming and corrodes internal governor parts.

Compensating Needle Valve

The compensating needle valve must be correctly adjusted with the governor controlling the engine or turbine, even though the compensation may have been previously adjusted at the factory or on governor test equipment. Although the governor may appear to be operating satisfactorily because the unit runs at constant speed without load, the governor still may not be correctly adjusted.

High overspeeds and low underspeeds, or slow return to speed, after a load change or speed setting change, are some of the results of an incorrect setting of the compensating needle valve.

Definitions

Use the chart on the following pages to determine the probable causes of faulty operation, and to correct these troubles. Terms used in the chart are defined as follows:

Hunt
A rhythmic variation of speed which can be eliminated by blocking governor operation manually, but which will recur when returned to governor control.

Surge
A rhythmic variation of speed, always of large magnitude, which can be eliminated by blocking governor action manually and which will not recur when returned to governor control, unless speed adjustment is changed or the load changes.

Jiggle
A high frequency vibration of the governor fuel rod end (or terminal shaft) and fuel linkage. Do not confuse this with normal controlling action of the governor.

Preliminary Inspection

Governor troubles are usually revealed in speed variations of the prime mover, but it does not necessarily follow that such variations are caused by the governor. When improper speed variations appear, the following procedure should be performed.

1. Check the load to be sure the speed changes are not the result of load changes beyond the capacity of the prime mover.

2. Check engine operation to be sure all cylinders are firing properly and that the fuel injectors are in good operating condition and properly calibrated.

3. Check linkage between governor and fuel or steam control to be sure there is no binding or excessive backlash.

4. Check setting of governor compensation needle valve.

5. Check operation of control air pressure transmitter.

6. Check governor oil pressure. A test port is provided in two sides of the governor power case for this purpose.

7. The source of most troubles in any hydraulic governor stems from dirty oil. Grit and other impurities can be introduced into the governor with the oil, or form when the oil begins to breakdown (oxidize) or become sludgy. The internal moving parts are continually lubricated by the oil within the unit. Valves, pistons and plungers will stick and even “freeze” in their bores, due to excessive wear caused by grit and impurities in the oil. If this is the case erratic operation and poor response can be corrected by flushing the unit with fuel oil or kerosene. The use of commercial solvents is not recommended as they may damage seals or gaskets.

   Change the oil and flush the governor twice a year if possible. Remove the cover, open the drain cock and drain out the old oil. Flush the governor by filling it with fuel oil, and with the engine running at low speed, cycle the governor. Cycle the governor by opening the needle valve two or three turns. Let the governor hunt for a minute or two and then stop the engine and drain the governor. Flush the governor once again. Fill the governor with oil, pouring it over all the internal parts that are visible. Start the engine and reset the compensation needle valve.

8. Check drive to governor for any evidence of misalignment, roughness, excessive backlash, etc.

Table 4-1. Troubleshooting

Trouble	Cause	Correction
1. Engine hunts or surges.	A. Needle valve adjustment incorrect.	Adjust needle valve as described in governor manual.
	B. Buffer springs too light. This may occur on a new Installation—or on an old installation as a result of a radical change in load conditions.	Install heavier buffer springs (consult Woodward).
	C. Lost motion in engine linkage, fuel pumps, or gas valve.	Repair linkage, fuel pumps, or gas valve.
	D. Binding in engine linkage, fuel pumps, or gas valve.	Repair and re-align linkage, fuel pumps or gas valve.
	E. Governor stroke too short. This may occur on a new installation. Should be at least 50% of total governor travel between idle and full load.	Redesign or rework the fuel linkage to require more governor stroke. (Consult manufacturer of engine and Woodward).
	F. Low oil level. No harm will be done if top of oil is still visible in gauge glass.	Add oil slowly to the correct level in gauge.
	G. Dirty oil or foaming oil in governor.	Drain governor oil, flush governor to clean, and refill with proper clean oil. Bleed air and adjust the needle valve as described in governor manual.
	H. Governor worn or not correctly adjusted.	Try spare governor or repair and adjust governor. a. Check flyweight pins and bearings for wear. b. Check flyweight toes for wear and/or flat spots. c. Check flyweight head thrust bearing, also centering bearing. d. Pilot valve plunger may be sticking. Clean and polish if necessary. **NOTICE** **Do not break corners of control land.** e. Check vertical adjustment of pilot valve plunger and correct if necessary. f. Clean and polish all moving parts to ensure smooth and free operation.
	I. Spring too weak in telescopic link.	Install heavier spring so that link stays solid at all times.
	J. Governor not suitable for engine.	Consult Woodward.
2. Fuel pump racks do not open quickly when cranking engine.	A. Low oil pressure in governor.	a. Check governor pump gears and gear pockets for excessive wear. No correction except to replace worn parts. b. Flush governor and refill with clean oil to remove dirt in pump check valves. c. Examine pump check valves. If not seating tight, install new ones.
	B. Cranking speed too low.	Install a booster servomotor (consult Woodward).
	C. Booster servomotor (if used) not functioning properly.	a. Check action of automatic air starting valve. b. Check air and oil connections.
	D. Solenoid shutdown not wired properly.	Check wiring for the de-energize to shutdown type. A small voltage must be applied for starting.
	E. Shutdown nuts not adjusted correctly.	Loosen nuts and start engine. Readjust nuts for proper clearance at idle.
	F. Speed setting or manifold pressure fuel limiter set too low.	Increase maximum starting fuel. Consult engine manufacturer for correct settings.

Trouble	Cause	Correction
3. Jiggle at governor rod end or terminal shaft.	A. Rough engine drive.	Inspect drive mechanism: a. Check alignment of gears. b. Inspect for rough gear teeth, eccentric gears, or excessive backlash in gear train. c. Check gear keys and nuts or set screws holding drive gears to shafts. d. Tighten chain between crankshaft and camshaft (if used). e. Check engine vibration dampener (if used). f. If governor has serrated drive shaft check for wear of shaft and serrated coupling.
	B. Failure of flexible drive in flyweight head.	Remove, disassemble and clean flyweight head parts. Check spring and install new spring coupling assembly if necessary. Center the coupling for equal travel in opposite directions.
	C. Governor not bolted down evenly on engine mounting pad.	Loosen screws, disconnect fuel linkage and turn governor 45° cw and ccw on its mounting pad a few times. Tighten screws.
4. Load does not divide properly between connect-ed units for ship propulsion or similar type installation. All units on droop.	A. Droop setting too low on one or more units.	a. Check if governor travel is at least 50% of total travel. If necessary increase governor travel by shortening terminal shaft lever. b. Adjust droop on each unit until desired division of load is obtained. c. Increasing droop results in the unit taking a smaller share of load changes. d. Decreasing droop results in the unit taking a larger share of load changes.
	B. Speed settings of the governors are not the same.	a. Check control air pressures at both governors with accurate pressure gauges. b. Check if both manual speed setting knobs are at minimum. c. If the load unbalance between the engines is a constant value correct by resetting base speed setting nut (125). Turn cw to decrease and vice versa. d. If load unbalance moves from one engine to the other when changing speed from minimum to maximum readjust pivot bracket (134).
5. Engine is slow to recover from a speed deviation resulting from a change in load or slow to respond to a change in speed setting.	A. Incorrect buffer springs in governor.	Install correct buffer springs (consult Woodward).
	B. Governor oil pressure is low.	See item 2A of this table.
	C. Fuel supply restricted.	Clean fuel filters and fuel supply lines.
	D. Engine may be overloaded.	Reduce the load.
	E. Type PG governors with pneumatic-hydraulic speed control are designed to increase speed setting slowly. If this is objectionable, special parts can be supplied to obtain faster action.	Consult Woodward. Changes in field may require services of a governor engineering specialist.
	F. Supercharger does not come to new speed quickly to supply sufficient air to burn the added fuel.	No simple field correction. Consult engine manufacturer and Woodward or overhaul the supercharger.

Trouble	Cause	Correction
6. Engine does not pick up rated full load.	A. Fuel racks do not open far enough.	a. Check fuel pump stops and adjust as necessary. b. Check linkage between governor and fuel pumps and adjust if necessary. c. Certain special PG governors are equipped with a load limiting device, and the governor may be against the load limit. Adjustment may be made, if considered advisable. d. Oil pressure may be too low, see item 2A of this table.
	B. Fuel supply restricted.	See item 7C of this table.
	C. Supercharger does not supply sufficient air.	Overhaul supercharger.
	D. Slipping clutch (if used) between engine and driven load.	See clutch instruction manual.
7. Engine does not reach full speed and full load.	A. Low control air pressure.	Check pneumatic transmitter and air lines.
	B. Maximum speed stop too low.	At maximum control air pressure stop screw (46) should not touch ball check (52).
	C. Minimum and maximum speed too low.	Raise level by readjusting base speed setting nut (125) ccw.
	D. Maximum speed too low only.	Readjust pivot bracket (134).
	E. Leaking bellows.	Install new bellows (118).
	F. Governor at end of travel (position 10).	a. Check fuel linkage adjustment. b. Check fuel supply and filters.
	G. Speed setting or manifold pressure fuel limiter set too low.	Readjust settings A–G. (Consult engine manufacturer).
	H. Propeller too large.	Consult shipyard.
8. Load oscillates between geared engines. Both governors are hunting.	Resonant condition between natural frequency of system and 0.5 order engine torsional.	Consult engine manufacturer. Changing governor characteristics may attenuate the oscillations. It may be necessary to install stiffer couplings or couplings with more damping.
9. Engine overspeeds on starting.	A. Governor too slow.	Adjust needle valve for highest opening. Install lighter buffer springs, if possible.
	B. Speed setting too high.	Decrease starting speed setting.
	C. Governor admits too much fuel for starting.	a. Limit travel of booster servomotor. b. Readjust speed setting or manifold pressure torque limiter (consult engine manufacturer).
	D. Compensation bypass retarded.	Install short buffer piston.
10. Engine stalls on deceleration to minimum speed.	A. Governor too slow.	Adjust needle valve for maximum opening. Install lighter buffer spring. Try shorter buffer piston.
	B. Minimum speed too low.	Raise minimum speed.
	C. Compensation not being cut-off at idle.	Consult Woodward to check how governor is built.

Chapter 5. Principles of Operation

Introduction

For purposes of description, the PGA governor consists of three major sections; a basic governor section, a speed setting section, and a speed droop linkage. A schematic diagram (Figure 5-1) provides a visual means of understanding the operation of the governor.

Basic Governor

The basic governor consists of an oil pump, two accumulators, a speeder spring, a flyweight head assembly, a thrust bearing, a pilot valve plunger, a rotating bushing, a buffer compensation system, and a power cylinder.

The governor drive shaft passes through the governor base and engages the rotating bushing. The oil pump drive gear is an integral part of the bushing. The pump supplies pressure oil for operation of the basic governor section, the speed setting section, and all other auxiliary features or devices except applications using a remote load regulator where engine oil is supplied to the load control system. The accumulators provide a reservoir of pressurized oil and the relief valve bypasses excess oil to the governor sump.

Where accumulator pressure exceeds 100 psi (690 kPa), a pressure reducing valve is fitted to the main power case. This reduces pressure of the oil supplied to the speed setting mechanism and auxiliary devices. Duplicate suction and discharge check valves at the pump permit either cw or ccw rotation of the governor without modification or change to the governor.

IMPORTANT **Some governors are plugged to limit rotation to one direction only and are not equipped with check valves.**

Operation of Basic PGA

Ballhead and Bushing
The upper end of the rotating bushing engages the flyweight head assembly and provides a direct drive from the prime mover to the flyweights. The thrust bearing translates the in-out movement of the flyweights to an up-down movement of the pilot valve plunger while allowing the plunger to remain stationary with respect to the rotating flyweights. The relative motion between the bushing and plunger also minimizes static friction. Two styles of flyweight head assemblies are available. The exact style used depends on the type of drive train to the governor. A solid head is used when the drive is relatively free of torsion vibrations. A spring-driven oil-damped ballhead assembly is used to attenuate objectionable levels of torsional vibration which may be imparted to the governor from the prime mover. These vibrations may originate from a source other than the drive itself but reach the governor through the drive connection. Unless minimized or eliminated, these vibrations are sensed as speed changes and the governor continually adjusts the fuel control in an attempt to maintain a constant speed.

Pilot Valve Plunger

Flyweight centrifugal force tends to lift the plunger while speeder spring force tends to lower the plunger. The greater of two opposing forces moves the pilot valve plunger up or down. When the prime mover is on-speed at any speed setting, these forces are equal and the flyweights assume a vertical position. In this position, the control land on the pilot valve plunger is centered over the regulating port in the rotating bushing. No oil, other than leakage make-up, flows to or from the buffer compensation system or power cylinder. A change in either of these two forces moves the plunger from its centered position.

The plunger is lowered:

1. When the governor speed setting is unchanged but an additional load slows the prime mover and governor (thereby decreasing flyweight centrifugal force).

2. When the prime mover speed is unchanged but speeder spring force is increased to raise the governor speed setting.

Similarly, the pilot valve plunger is raised when:

1. The governor speed setting is unchanged but load is removed from the prime mover causing an increase in prime mover and governor speed (and hence, an increase in flyweight centrifugal force).

2. The prime mover speed is unchanged but speeder spring force is reduced to lower the governor speed setting.

When the plunger is lowered (an underspeed condition), pressure oil is directed into the buffer compensation system and power cylinder to raise the power piston and increase fuel or steam. When lifted (an overspeed condition), oil is permitted to drain from these areas to sump and the power piston moves downward to decrease fuel or steam.

Buffer Compensation System

The buffer piston, springs, and needle valve in the hydraulic circuits between the pilot valve plunger and power cylinder make up the buffer compensation system. This system stabilizes the governing action by minimizing over or undershoot following a change in governor speed setting, or a change in load on the prime mover. It establishes a temporary negative feedback signal (temporary droop) in the form of a pressure differential which is applied across the compensation land of the pilot valve plunger. The flow of oil into or out of the buffer system displaces the buffer piston in the direction of flow. This movement increases the loading on one spring while decreasing the other and creates a slight difference in the pressures on either side of the piston with the higher pressure on the side opposite the spring being compressed. These pressures are transmitted to opposite sides of the plunger compensation land and produce a net force, upward or downward, which assists in re-centering the plunger whenever a fuel or steam correction is made.

Speed Setting or Load Increase

Increasing the speed setting or increasing load on the prime mover at a given speed setting have an identical effect. In either case, the flyweights move inward (underspeed) due to either the increase in speeder spring force or to the decrease in centrifugal force caused by the decrease in prime mover speed as load is added. The movement of the flyweights is translated into a downward movement of the pilot valve plunger. This directs pressure oil into the buffer system, causing the buffer piston to move toward the power cylinder. The oil displaced by the movement of the buffer piston forces the power piston to move upward in the increase direction.

The oil pressures on either side of the buffer piston are simultaneously transmitted to opposite sides of the plunger compensation land with the higher pressure on the lower side. This pressure differential is proportional to buffer piston displacement which, in turn, is determined by the buffer spring rate, rate of power piston travel, and needle valve setting. The new upward force produced is added to flyweight force and assists in restoring the balance of forces and re-centering the pilot valve plunger slightly before the prime mover has fully accelerated. In effect, this enables the governor to cut off the additional fuel needed for acceleration by stopping the power piston when it has reached a point corresponding to that amount of fuel or steam required for steady state operation at the new higher speed or load. As the prime mover continues to accelerate toward the set speed, the compensation force is gradually dissipated to offset the continuing increase in flyweight force. This is done by equalizing the pressures on each side of the compensation land through the needle valve at a rate proportional to the continued rate of acceleration. If the rate of dissipation is the same as the rate of increase in flyweight force, the pressure differential is reduced to zero at the instant flyweight force becomes exactly equal to speeder spring force. This minimizes speed overshoot and permits the governor to quickly re-establish stable operation. The needle valve setting determines the rate at which the differential pressure is dissipated and allows the governor to be "matched" to the characteristics of the prime mover and its load. The compressed buffer spring returns the buffer piston to its centered position as the pressure differential is dissipated.

Whenever large changes in speed setting or load are made, the buffer piston moves far enough to uncover a bypass port in the buffer cylinder. The pressure differential across the buffer piston is restricted to some maximum value, and oil is to flow directly to the power cylinder. The power piston responds quickly to large changes in speed setting or load. Since the pressure differential across the compensating land is restricted, the prime mover may overshoot or undershoot slightly more than normal.

Speed Setting or Load Decrease

Decreasing the speed setting or decreasing load on the prime mover at a given speed setting are also identical in effect and cause a reverse action to that described above. The flyweights move outward (overspeed), lifting the pilot valve plunger and allowing oil to drain from the buffer compensation system. The buffer piston moves away from the power cylinder, permitting oil to drain from the area under the power piston which then moves downward in the decrease direction. The differential pressures acting across the compensation land produce a net downward force tending to assist the speeder spring in re-centering the pilot valve plunger slightly before the prime mover has fully decelerated. Power piston movement is stopped when it has reached a point corresponding to that amount of fuel or steam required for steady state operation at the new lower speed or load. Dissipation of the compensation force occurs in the same manner as previously described and, in this instance, minimizes speed undershoot.

With large decreases in speed or load, the power piston moves to the “no fuel” position and blocks the compensation oil passage between the power cylinder and needle valve. This prevents normal equalization of the compensation pressures. The buffer piston is held off center and the level of the pressure transmitted to the upper side of the plunger compensation land is increased. The increased pressure differential, added to the effect of the speeder spring, temporarily increases the governor speed setting. The governor begins corrective action as soon as prime mover speed drops below the temporary speed setting. This starts the power piston upward to restore the fuel or steam supply in sufficient time to prevent a large underspeed transient. The above action is sometimes referred to as “compensation cutoff”. When the upward movement of the power piston again uncovers the compensation oil passage, normal compensating action resumes and stabilizes prime mover speed at the actual speed setting of the governor.

Speed Setting Section

The speed setting section (Figure 5-1) consists of a bellows housed within a pressure chamber, a hydraulic speed setting pilot valve (pilot valve plunger and rotating bushing), a single-acting spring-return speed setting hydraulic cylinder, a restoring linkage for re-centering the pilot valve plunger, and a manual speed setting mechanism.

The governor speed setting is directly proportional to control air pressure (speed setting increases as air pressure increases). An increase in control air pressure causes the bellows to contract and move the pilot valve plunger downward (increase speed).

The speed at which the governor controls is determined by the force exerted on the toes of the flyweights by the speeder spring in the basic governor section. Speeder spring force is determined by the position of the piston in the speed setting cylinder. The position of the piston, in turn, is determined by the volume of oil trapped in the area above the piston. The direction and rate of oil flow into or out of this area is controlled by the speed setting pilot valve plunger which is mechanically linked to the bellows. If the plunger is moved downward, uncovering the upper edge of a metering port in the bushing, pressure oil is allowed to flow into the speed setting cylinder. This displaces the piston downward, further increasing speeder spring tension and increasing the speed setting. If the plunger is moved upward, uncovering the lower edge of the metering port, oil is permitted to drain from the cylinder. This allows the piston spring to raise the piston, decreasing speeder spring force and lowering the speed setting.

The rate of movement of the speed setting piston over its full downward stroke (idle to maximum speed) is retarded to occur over some specific time interval. This is done by admitting governor pressure oil into the rotating bushing through an orifice which registers with the main supply port once in every revolution of the bushing. This reduces the rate at which oil is supplied to the control port in the bushing and therefore, the rate of oil flow to the speed setting cylinder. The diameter of the orifice determines the specific time interval which may be anywhere within a nominal range of 1 to 50 seconds. Therefore, the rate at which the speed setting may be increased is restricted under all conditions of operation. The longer rates are generally used with turbo-supercharged units to permit the supercharger to accelerate with the engine. The rate of movement of the power piston over its full upward stroke (maximum to idle speed) is also restricted on turbo-supercharged units to prevent compressor surge during decelerations. This timing may be anywhere within a nominal range of 1 to 15 seconds. In these cases, the speed setting pilot valve plunger has an additional land (not illustrated) which covers the drain port in the bushing. A vertical slot in the drain land registers with a second orifice in the rotating bushing once each revolution. This restricts the rate at which the oil is allowed to drain from the speed setting cylinder. The width of the slot in the drain land determines the length of time the drain port (orifice) is open during each revolution and therefore the specific deceleration time interval.

Direct Pneumatic Operation

IMPORTANT

The manual speed setting knob must be turned fully ccw to raise the manual speed setting screw to its uppermost (minimum or low speed) position during pneumatic operation, If the speed setting screw (knob) is in any position other than minimum speed, it will, in effect, raise the pneumatic low speed setting of the governor and prevent normal pneumatic operation at speed below this setting.

The bellows and restoring spring comprise a force-balance system which is mechanically connected to the speed setting pilot valve plunger through a C-shaped link. Control air pressure acting externally on the bellows exerts a downward force on the lower leg of the C-shaped link. The restoring spring connected to the upper leg of the link exerts an opposing upward force. Except during a speed setting change, the downward force of the air pressure acting upon the bellows exactly counterbalances the upward force of the restoring spring. With these forces in ‘balance’, the control land on the pilot valve plunger covers the metering port in the bushing and no oil, other than leakage, can flow into or out of the speed setting cylinder. A change in control air pressure disturbs this balance and results in a speed setting change.

With an increase in control air pressure (increase speed setting), the force acting on the bellows becomes greater than the restoring spring force and the bellows contracts in a downward direction. This pushes the C-shaped link downward and lowers the pilot valve plunger. Intermittent pressure oil then flows into the speed setting cylinder, forcing the piston downward to further compress the speeder spring and thereby increase the governor speed setting. As the piston moves downward, the restoring lever attached at the right end to the upper end of the piston rod pivots cw about an adjustable ball bearing fulcrum on the extended arm of the manual speed setting screw. The left end of the lever is connected to the restoring spring and a loading spring. The cw movement of the lever causes a proportional increase in restoring spring force which, acting through the link, gradually expands the bellows to its original length while simultaneously lifting the plunger. When the net increase in restoring spring upward force equals the increase in downward force resulting from the increase in control air pressure, the bellows and plunger is re-centered (restored) with the plunger control land covering the metering port in the bushing. This stops the flow of oil into the speed setting cylinder, halting downward movement of the piston at the instant speeder spring force reaches its new higher value corresponding to that higher control air pressure. The loading spring ‘loads’ the restoring lever to maintain positive contact between the lever and ball bearing fulcrum at all times.

With a decrease in control air pressure (decrease speed setting), the force acting on the bellows becomes less than the restoring spring force and the bellows expands in an upward direction. This allows the restoring spring to lift the C-shaped link and pilot valve plunger. As oil drains from the speed setting cylinder the piston rises, decreasing speeder spring force and the governor speed setting. As the piston rises, the restoring lever pivots in a ccw direction, proportionally reducing restoring spring force. The bellows gradually contracts to its original length and simultaneously lowers the plunger. A decrease in control air pressure decreases the downward pressure of the bellows. When the upward force of the restoring spring equals the downward force of the bellows, the control land of the speed setting pilot valve plunger centers the metering port in the bushing. This stops oil drainage from the speed setting cylinder, halting upward movement of the piston at the instant the speeder spring force reaches its new lower value corresponding to the lower control air pressure.

The ratio of change in restoring spring force for a given movement of the speed setting piston is determined by the distance between the ball bearing fulcrum and the point at which the restoring lever is attached to the piston rod. Shortening this distance decreases the governor speed range for a given control air pressure range; lengthening this distance increases the speed range for a given air pressure range.

Some applications may require that the governor be adjusted to go to low speed upon intentional or accidental interruption of control air pressure or when control air pressure drops below the required minimum value. In these instances, the pneumatic low speed adjusting screw is set to contact a stop pin projecting from the restoring lever when control air pressure and prime mover speed are at their normal minimum values. If control air pressure is lost or reduced below the minimum value, the restoring spring raises the speed setting pilot valve plunger until the low speed adjusting screw contacts the stop pin in the restoring lever. As the speed setting piston moves upward, the stop pin in the restoring lever simultaneously pushes downward on the pneumatic low speed adjusting screw re-centering the speed setting pilot valve plunger at the moment the piston reaches its low speed position. Governors set to go to low speed upon loss of control air pressure are usually equipped with an auxiliary shutdown device.

If the governor is adjusted to go to shutdown upon loss of control air pressure, the pneumatic low speed adjusting screw is set so that a definite clearance exists between it and the stop pin in the restoring lever when the control air pressure is reduced to zero and the governor is shut down. In this case, should control air pressure be interrupted or reduced below the minimum value, the movement of the restoring lever as the speed setting piston moves upward does not tend to re-center the speed setting pilot valve plunger. Therefore, the piston continues to move upward past the low speed position to the shutdown position.

Normal Shutdown

The shutdown device consists of a shutdown rod which projects upward through the center of the speed setting piston rod and is attached to the top of the main pilot valve plunger in the basic governor section. Two nuts on the upper end of the shutdown rod complete the device. When control air pressure is turned off the speed setting piston moves upward past its normal low speed position. After a movement of 1/16-inch, the fulcrum block on the end of the piston rod contacts the lower (shutdown) nut, lifting the shutdown rod and pilot valve plunger. Oil drains from the power cylinder, and the power piston moves downward to the zero fuel or steam position. Some governor applications may require that the speed setting piston stop be used as a positive low speed stop. In such cases, the shutdown nuts are usually omitted since the governor cannot be used or adapted to shutdown the prime mover and some shutdown method external to the governor must be provided.

Manual Speed Setting Mechanism

The manual speed setting mechanism consists of a knob and friction clutch, a leadscrew and nut linked to a sliding collar, a speed adjusting nut, high speed adjusting setscrew and stop pin, and a T-shaped manual speed setting screw with a ball bearing fulcrum. The knob can be used to adjust the speed setting to any point within the normal speed range when control air pressure is not available or its use is not desired.

Manual Operation

With no control air pressure, the pneumatic low speed adjusting screw is held against the stop pin in the restoring lever by the restoring spring. The restoring lever is directly connected, through the C-shaped link, to the speed setting pilot valve plunger. Turning the knob cw (increase speed setting) causes the leadscrew nut to move outward and lower the sliding collar under the speed adjusting nut on the vertical shaft of the speed setting screw. This allows the loading spring to move the speed setting screw (and ball bearing fulcrum) downward with the collar until the high speed adjusting setscrew contacts the high speed stop pin.

As the speed setting screw moves downward to a new position, the left end of the restoring lever, pulled downward by the loading spring, pushes downward on the pneumatic low speed adjusting screw and link, uncentering the speed setting pilot valve plunger. Pressurized oil flows into the speed setting cylinder and forces the piston downward, increasing the speed setting. The movement of the piston causes a cw rotation of the restoring lever. Since the pneumatic low speed adjusting screw is held against the stop pin in the restoring lever by the restoring spring, the speed setting pilot valve plunger is lifted upward as the lever rotates until the plunger is again re-centered at the instant the new higher speed position is attained by the piston.

Turning the knob ccw (decrease speed setting) causes the leadscrew nut to move inward and raise the sliding collar under the speed adjusting nut. This lifts the speed setting screw (and ball bearing fulcrum) upward, raising the left end of the restoring lever and thereby lifting the speed setting pilot valve plunger above its centered position. As oil drains from the speed setting cylinder, the piston moves upward, decreasing the speed setting. The ccw movement of the restoring lever re-centers the plunger at the instant the new lower speed position is attained by the piston.

Maximum Speed Limiting Valve

The maximum speed limiting valve is a check valve located in the top of the speed setting cylinder. A limiting valve adjusting screw in a lug on the rod of the speed setting piston unseats the valve whenever the piston reaches the maximum speed position (approximately 5 rpm above the normal high speed rpm). With the valve unseated, excess oil tending to increase the speed setting beyond the maximum speed set point is released to sump. The valve is effective whether the speed setting is changed pneumatically or manually.

Piston Stop Setscrew

The piston stop setscrew limits upward travel of the speed setting piston at shutdown to 3/32 inch (2.4 mm) above the low speed position of the piston. The cranking time required when the prime mover is restarted is minimized since a lesser volume of oil is required to move the piston downward to the low speed position.

Temperature Compensation

In early model governors, a bi-metal strip incorporated in the restoring lever compensated for differential expansion and changes in spring rates due to temperature variations. In late model governors, a temperature compensated (reverse modulus) speeder spring is used in place of the bimetal strip. The governor speed settings are better stabilized and drifting, due to changes in ambient and/or operating temperatures are minimized.

Speed Droop Linkage

Description

Speed droop is a governor feature which allows the prime mover to run at a proportionally lower speed as load is increased while at the same time it increases fuel, compensating for the additional load. Speed droop increases initial stability of the governor and permits division and balancing of loads between prime movers operated in tandem to drive a common shaft. Speed droop is defined as the proportional decrease in speed which occurs as the governor power piston moves from the minimum to the maximum fuel or steam position. It is normally expressed as the difference in rpm from no-load to full-load as a percentage of maximum rated speed.

Operation

The linkage automatically changes the governor speed setting by reducing speeder spring force a slight amount as a function of power piston travel in the increase direction. Conversely, it increases speeder spring force as the piston moves in the decrease direction. It consists of a fulcrum block attached to the upper end of the speed setting piston rod, a lever and fulcrum pin assembly connected between the fulcrum block and power piston tailrod, an adjustable cam attached to the fulcrum pin, and a moveable plunger housed within the speed setting piston rod. The movement of the power piston, transmitted through the lever assembly causes a rotational movement of the cam which contacts the top of the plunger. This, in turn, causes an upward (or downward) movement of the plunger which rests on top of the speeder spring.

The position of the cam lobe with respect to the centerline of the fulcrum pin determines the proportion of lever movement transmitted to the plunger. When the centerline is common to both pin and cam lobe, no movement is transmitted to the plunger. With such a setting (0 droop), the governor attempts to maintain the set speed regardless of load (isochronous operation). If the lobe of the cam is positioned at increasing distances from the centerline of the fulcrum pin, an increasing proportion of lever movement is transmitted to the plunger (droop operation). The exact position of the cam is determined by the prime mover characteristics and the share of the load to be carried by that prime mover. The cam must never be positioned on the opposite side of the fulcrum pin centerline (toward the pneumatic receiver) as “negative” droop (speed increases with movement of the power piston in the increase direction) occurs and results in unstable operation.

Power Cylinders

12 ft-lb (16 J)

All power cylinder assemblies operate under the same basic principle, with a reciprocating (push-pull) motion. Power cylinder assemblies with a rotary terminal shaft are available as an alternate, depending upon the installation requirements. In the arrangement shown in Figure 5-2, the oil needed to move the power piston in the increase fuel direction is obtained when the governor pilot valve plunger is lowered below its centered or balanced position. The opened port admits pressure oil to the buffer piston area, moving the buffer piston, transferring an equal volume of oil to the power cylinder, and forcing the power piston to move in the direction to increase fuel to the prime mover.

To move the power piston in the decrease fuel direction, the governor pilot valve plunger is raised above its centered position. The trapped oil in the power cylinder is released to the sump and the power spring forces the power piston in the decrease fuel direction.

29 ft-lb (39 J) (Rotary Output)

With rotary output power cylinders, the linear motion is converted to a rotary motion. This power servo (Figure 5-3) “pulls” to increase fuel to the prime mover. The oil needed to move the power piston is obtained when the governor pilot valve plunger is lowered below its centered or balanced position. The open port admits pressure oil to the buffer piston area, moving the buffer piston, transferring an equal volume of oil to the power cylinder and forcing the power piston to move in the direction to increase fuel to the prime mover.

To move the power piston in the decrease fuel direction, the pilot valve plunger is raised above its centered position. When the trapped oil below the power piston is released to the sump, the pump pressure forces the piston in the decrease direction.

Compensation Cutoff

With large decreases in speed setting, or large load decrease, the power piston moves to the “no fuel” position and blocks the compensation oil passage between the power cylinder and needle valve to prevent normal equalization of the compensation pressures. This holds the buffer piston off center and increases the level of the pressure transmitted to the upper side of the plunger compensation land. The increased pressure differential,- added to the effect of the speeder spring, temporarily increases the governor speed setting. The governor begins corrective action as soon as engine speed drops below the temporary speed setting and starts the power piston upward to restore the fuel supply in sufficient time to prevent a large underspeed transient. The above action is referred to as “compensation cutoff”. When the upward movement of the power piston again uncovers the compensation oil passage, normal compensating action is resumed and engine speed is stabilized at the actual speed setting of the governor.

IMPORTANT	**Due to the location of the compensation cutoff port in the power cylinder wall, the governor/fuel rack linkage must be adjusted so that the power piston “gap” does not exceed 1-1/32 inches (26.2 mm) at idle-speed no-load, or less than 4° from minimum fuel.**

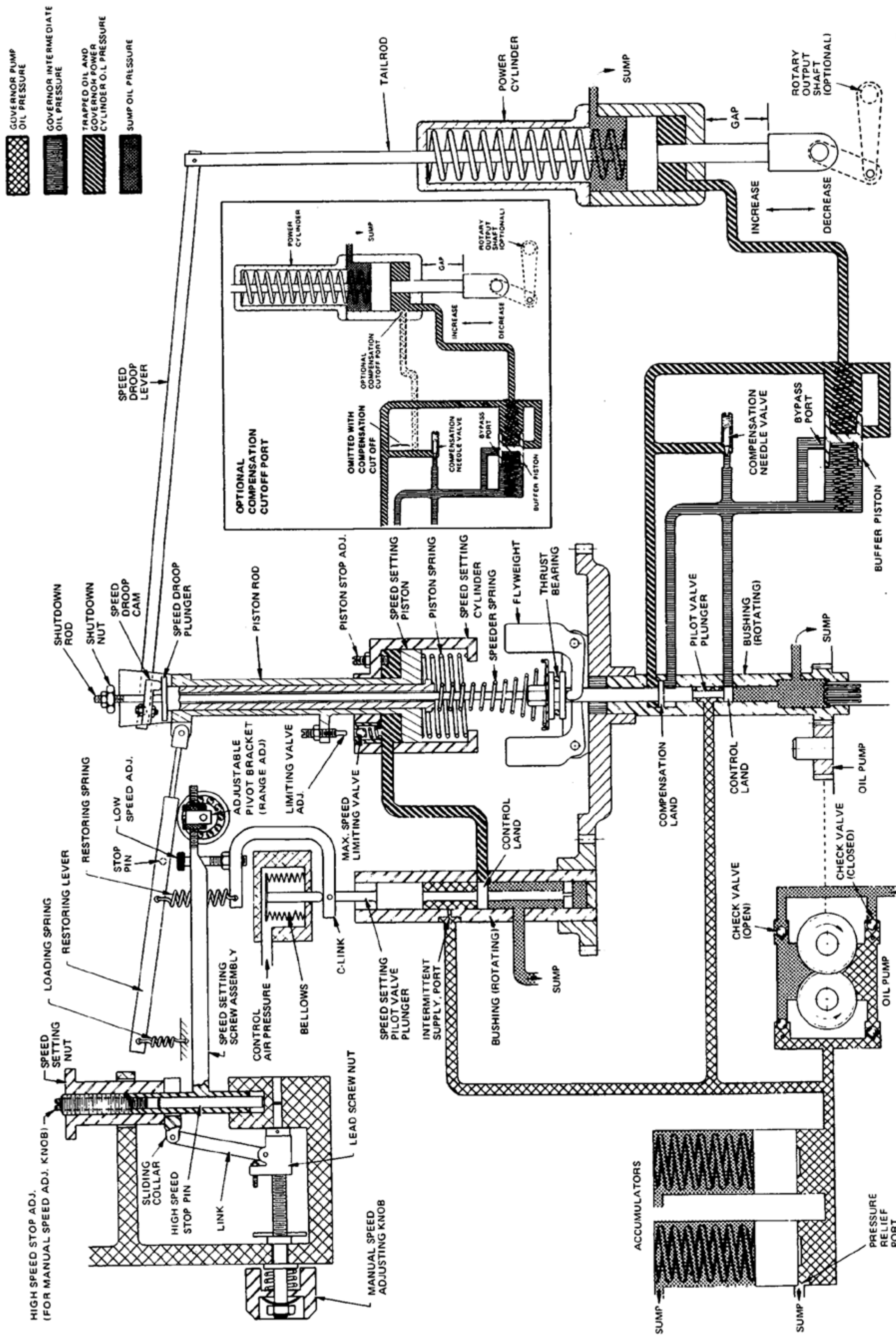


Figure 5-1. Schematic Diagram of PGA with Direct Bellows

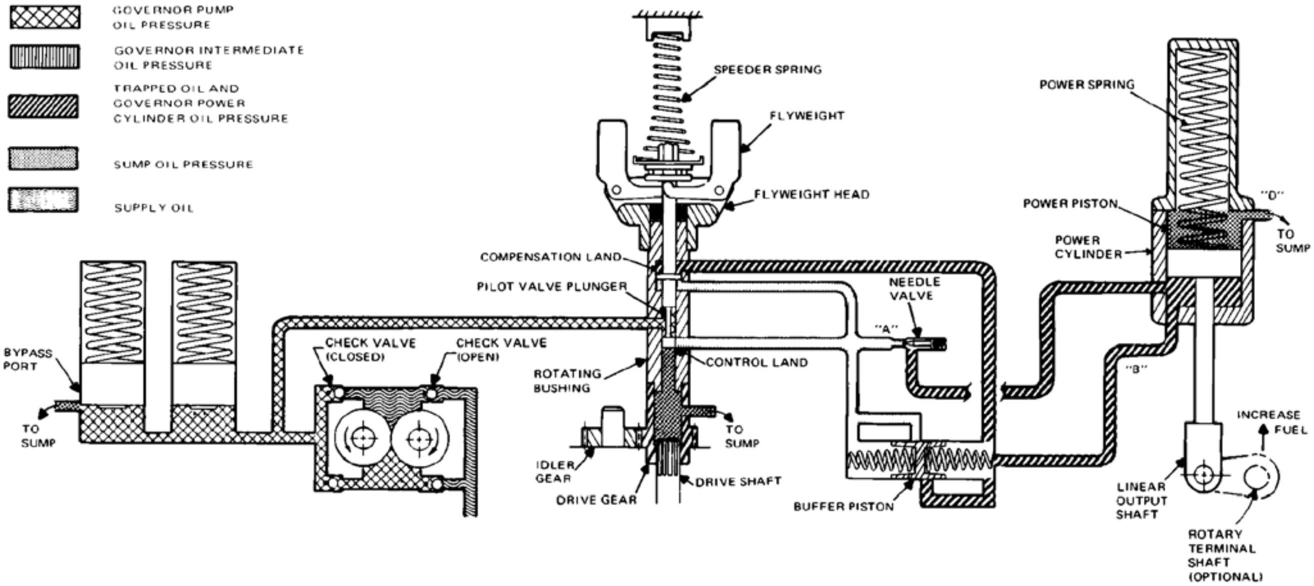


Figure 5-2. Schematic Diagram of 12 ft-lb Spring Loaded Power Cylinder

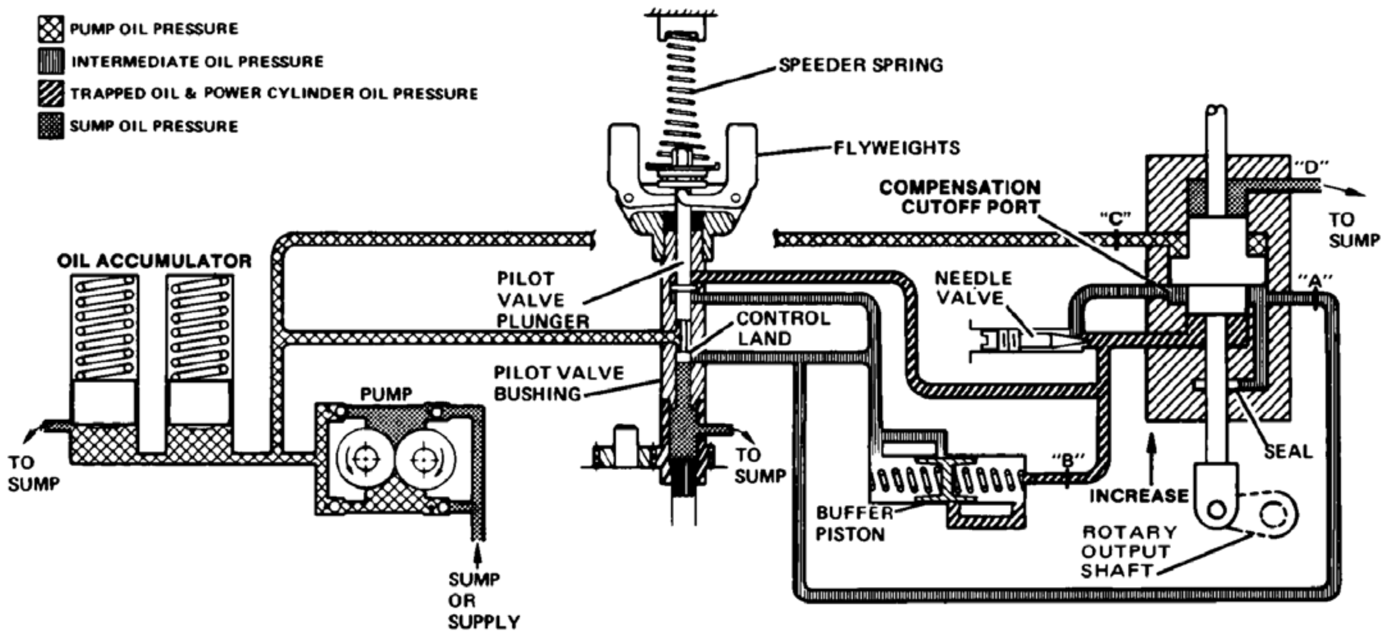


Figure 5-3. Schematic Diagram of 29 ft-lb Differential Power Cylinder (Linear or Rotary Output)

Chapter 6.
Replacement Parts

Replacement Parts Information

This chapter provides replacement parts information for the PGA marine governor. When ordering replacement parts, include the following information:

- Governor serial number and part number shown on nameplate
- Manual number (this is manual 36604)
- Parts reference number in parts list and description of part or part name

⚠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.**

Parts List for Figure 6-1

Ref. No.	Part Name	Quantity
36604-1	Screw, hex. hd., drilled, 5/16-24 x 6-1/4	2
36604-2	Plain washer, 5/16 x 1/2 x 1/32	2
36604-3	Oil filler cup (press-fit)	1
36604-4	Cover dowel bushing (press-fit)	2
36604-5	Drive screw, #2 x 3/16	4
36604-6	Nameplate	1
36604-7	Cover	1
36604-8	Cover gasket	1
36604-9	Screw, soc. hd., 5-40 x 1/2	1
36604-10	Lockwasher, split, #5	1
36604-11	Screw, soc. hd., 1/4-28 x 2	1
36604-12	Screw, soc. hd., 1/4-28 x 1-1/4	1
36604-13	Lock washer, split, 1/4	2
36604-14	Pneumatic receiver assembly (see Figure 6-2)	1
36604-15	Cap screw, 0.250-28 x 0-.750	1
36604-16	Regulating bushing retainer spring	1
36604-17	Retainer spring collar	1
36604-18	Washer, 0.328 x 0.562 x 0.064 thick	1
36604-19	Regulating bushing retainer	1
36604-20	Retainer screw	1
36604-21	Washer. 0.265 x 0.500 x 0.032 thick	1
36604-22	Regulating bushing	1
36604-23	Spacer	1
36604-24	Thrust bearing	1
36604-25	Pilot valve plunger (speed setting)	1
36604-26	Rotating bushing (SS PV plunger)	1
36604-27	Plug (press-fit)	1
36604-28	Loading spring (SS bushing)	1
36604-29	Nut	1
36604-30	Nut	1
36604-31	Droop plunger cap	1
36604-32	Power piston fulcrum assembly	1
36604-33	Speed droop cam	1
36604-34	Nut	1
36604-35	Screw	1
36604-36	Washer	1
36604-37	Droop lever assembly	1
36604-37A	Droop lever	1
36604-38	Droop pivot lever assembly	1
36604-38A	Pivot pin	1
36604-39	Pin spacer	1
36604-39A	Pin spacer	1
36604-40	Washer	1
36604-40A	Washer	1
36604-41	Cotter pin	1
36604-41A	Cotter pin	1
36604-42	Speed setting cylinder	1
36604-43	Limiting valve assy. (max. speed)	1
36604-44	Adjusting screw (max. speed)	1
36604-45	Nut, 10-32	1
36604-46	Guide stud	1
36604-47	Nut, 10-32	1
36604-48	Oval point soc. hd. set screw	1
36604-49	Split lockwasher, 0.250	2
36604-50	Hex hd. screw, 0.250-28 x 1.375	2
36604-51	Speed setting piston	1
36604-52	Speed droop plunger	1
36604-53	Speed setting piston return spring	1
36604-54	Power piston fulcrum (used without speed droop)	1
36604-55	Indicator plate	1
36604-56	Washer	1
36604-57	Screw	1
36604-58	Hex hd. screw, 0.3 125-24 x 4.9688	4
36604-59	Split lockwasher, 0.3125	4
36604-60	Plain washer, 0.3125	4
36604-61	Column sub-assy. (includes item 94)	1
36604-62	O-ring, 0.375	1
36604-63	By-pass hole plug	1
36604-64	O-ring, 0.375	1
36604-65	Plug	1
36604-66	Inner plug	1
36604-67	Soc. hd. pipe plug 0.125	A.R.
36604-68	Standard power case assy. illustrated (see Figure 6-3)	1
36604-69	O-ring	1
36604-70	Gasket (column to power case)	1
36604-71	Drive gear bearing stud (press-fit)	1
36604-72	Speed setting bushing drive gear	1
36604-73	Spring check plug	1
36604-74	Gasket	1
36604-75	Column side plate	1
36604-76	Screw	10
36604-77	Lockwasher	10
36604-78	Base	1
36604-79	Hex hd. screw, 0.3125-18 x 1	4
36604-80	Lockwasher, 0.3125	4
36604-81	Oil seal	1
36604-82	Gasket (power cylinder to power case)	1
36604-83	Soc. hd. screw 0375-16 x 1	4
36604-84	Lockwasher, 0375	4
36604-85	12 ft-lb., spring-return, linear output, power cylinder (see Figure 6-6)	1
36604-86	Bushing gasket	1
36604-87	Bushing	1
36604-88	Washer, .250 ID x .031 thick, max. OD .490	1
36604-89	Soc. hd. cap screw, .250-28 x .375	1
36604-90	Spring	1
36604-91	Spring	1
36604-92	O-ring	1
36604-93	12 ft-lb., spring return, rotary output, power cylinder	1
36604-94	Thread insert (included in column assy)	1
36604-95	Plug	1
36604-96	Plug	1
36604-97	Plug	1
36604-98	Pin	1
36604-99	Bracket	1
36604-100	Screw	1

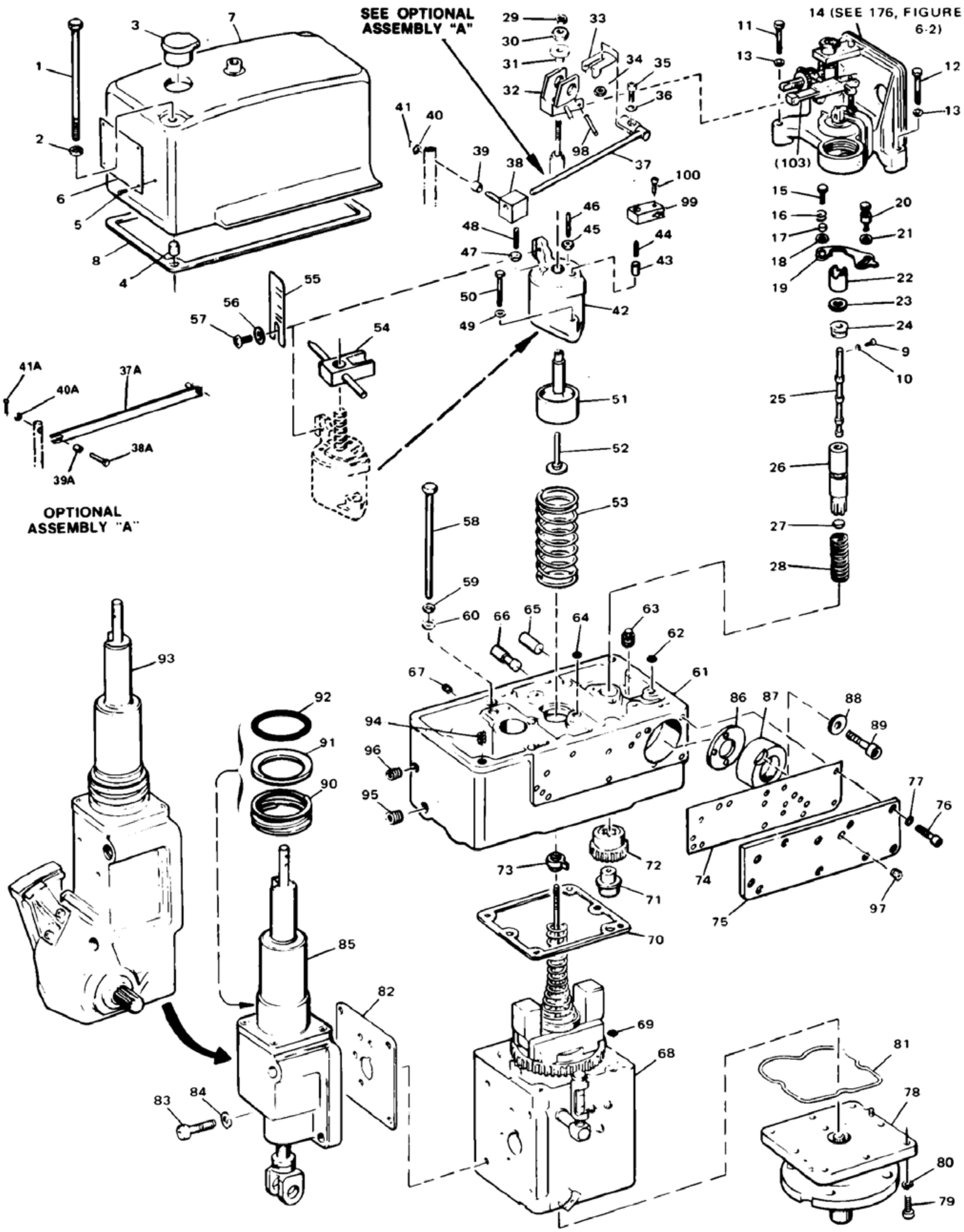


Figure 6-1. Exploded View of PGA Long Column

Parts List for Figure 6-2

Ref. No.	Part Name	Quantity
36604-101	Loading spring (restoring lever)	1
36604-102	Restoring spring	1
36604-103	Restoring lever	1
36604-104	Cotter pin, 1/16 x 3/8	A.R.
36604-105	Loading spring pin	1
36604-106	Stop pin (pneumatic low speed)	1
36604-107	Pilot valve C-link	1
36604-108	Nut, 10-32	1
36604-109	Stop screw (pneu. low speed adj.)	1
36604-110	Headed pin	1
36604-111	Bellows coupling	1
36604-112	Setscrew, soc. hd, cone pt., 8-32 x 5/16	1
36604-113	Passage screw	1
36604-114	Washer, soft copper	1
36604-115	Receiver cup gasket	1
36604-116	Setscrew, soc. hd., cone pt., 5-40 x 1/4	1
36604-117	Retaining ring, int., 1 .650 OD	1
36604-118	Bellows assy	1
36604-119	Preformed packing, 1-1/2 OD	1
36604-120	Pneumatic receiver cup	1
36604-121	Speed setting collar	1
36604-122	Stop pin (high speed)	1
36604-123	Speed setting screw	1
36604-124	Thread insert, 10-32 x 3/8, mid-grip	1
36604-125	Setscrew. soc. hd., oval pt., 10-32 x 1	1
36604-126	Speed adjusting nut (manual low speed)	1
36604-127	Thread insert, 7/16-20 x 7/16, mid-grip	1
36604-128	Knurled nut	2
36604-129	Screw, soc. hd., 10-32 x 1-1/8	1
36604-130	Lockwasher, hi-collar, #10	2
36604-131	Screw, soc. button hd., 10-32 x 1	1
36604-132	Spacer	1
36604-133	Ball bearing	1
36604-134	Pivot bracket	1
36604-135	Lockwasher, #10 hi-collar	1
36604-136 through 148 Not used		
36604-149	Shutdown solenoid	1
36604-150	Gasket	1
36604-151	Electrical connector	1
36604-152	Washer	4
36604-153	Screw	4
36604-154	Friction spring	1
36604-155	Dial plate	1
36604-156	Receiver bracket gasket	1
36604-157	Philips rd. hd. screw, 6-32 x 3/8	4
36604-158	Washer, 25/64 x 5/8 x 1/16	1
36604-159	Soc. hd. setscrew, 8-32 x 3/8	1
36604-160	Mid-grip thread insert, 8-32 x 1/4	1
36604-161	Pivot pin	4
36604-162	Lead screw nut	1
36604-163	Spring washer	1
36604-164	Shoulder washer	1
36604-165	Speed setting link	1
36604-166	Lead screw	1
36604-167	Spring roll pin, 3/32 x 5/8	1
36604-168	Clutch spring	1
36604-169	Manual speed adjusting knob	1
36604-170	Belleville washer	2
36604-171	Self-locking nut, 1/4-28	1
36604-172	Mid-grip thread insert 8-32 x 1/4	1
36604-173	Friction spring seat	1
36604-174	Dowel pin	2
36604-175	Spacer	4
36604-176	Receiver bracket	1
36604-177	Cotter pin	1
36604-178	Diode	1
36604-179	Screw	1
36604-18	Set Screw, 10-32 x .250	1
36604-181 through 200 Not used		

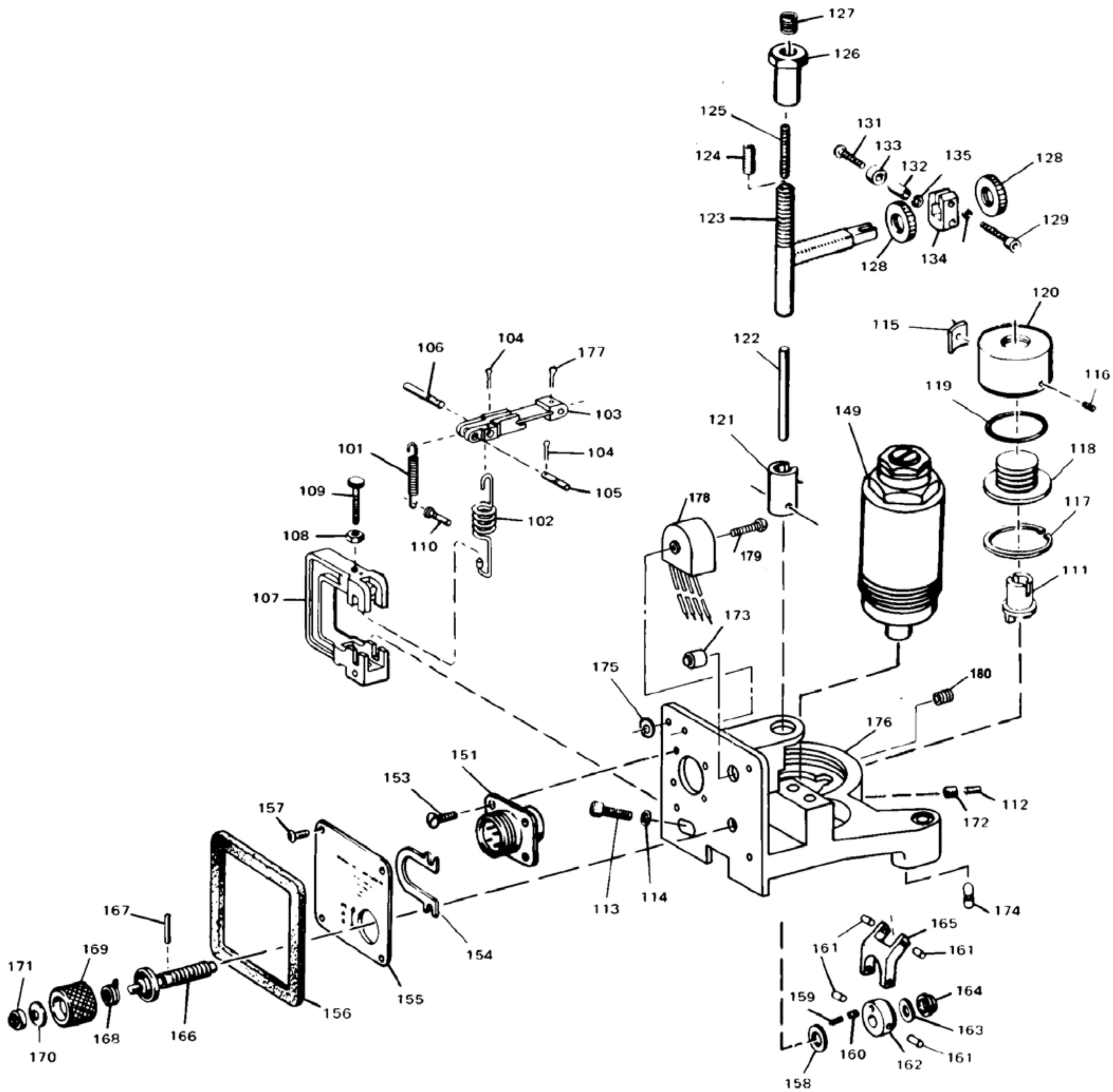


Figure 6-2. Exploded View of PGA Receiver Assembly

Parts List for Figure 6-3

Ref. No.	Part Name	Quantity
36604-201	Pipe plug, 1/8	4
36604-202	Pipe plug, 1/16	2
36604-203	Dowel pin	2
36604-204	Instruction plate	1
36604-205	Drive screw	3
36604-206	Power case	1
36604-207	Small accumulator spring	2
36604-208	Large accumulator spring	2
36604-209	Retaining ring	2
36604-210	Spring seat	2
36604-211	Spring seat	1
36604-212	Buffer spring	2
36604-213	Buffer piston	1
36604-214	Plug	1
36604-215	O-ring	1
36604-216	Snap ring	1
36604-217	Oil level gauge	1
36604-218	Oil gauge elbow	1
36604-219	Drain cock	1
36604-220	Accumulator piston	2
36604-221	Retainer ring	2
36604-222	Idler gear stud	1
36604-223	Idler gear	1
36604-224	Drive gear	1
36604-225	Check valve assy (plain)	2
36604-226	Check valve assy (spring loaded)	2
36604-227	Retainer ring	1
36604-228	Plug	1
36604-229	Spring seat	1
36604-230	Spring	1
36604-231	Pilot valve bushing & flyweight head gear assembly	1
36604-232	Oil seal ring	1
36604-233	Bearing	1
36604-234	Pilot valve plunger	1
36604-235	Compensating bushing	1
36604-236	Retainer ring	1
36604-237	Flyweight pin	4
36604-238	Cotter pin	8
36604-239	Flyweight head	1
36604-240	Lockwasher, #5	8
36604-241	Fil. hd. screw, 5-40 x 9/32	8
36604-242	Spring coupling assembly	1
36604-243	Splitlock washer, #8	1
36604-244	Rd. hd. screw, 8-32 x 5/16	1
36604-245	Flyweight	2
36604-246	Bearing	4
36604-247	Spring	1
36604-248	Spring washer	1
36604-249	Thrust bearing	1
36604-250	Speeder spring seat	1
36604-251	Cotter pin	1
36604-252	Pilot valve plunger nut	1
36604-253	Speeder spring	1
36604-254	Speeder spring check plug	1
36604-255	Not used	
36604-256	Shutdown rod	1
36604-257	Shutdown nut	1
36604-258	Pilot valve bushing assy (optional)	1
36604-259	Solid flyweight head assy (optional)	1
36604-260	Pressure spacer	1
36604-261	Pressure reducing valve sleeve	1
36604-262	Plunger	1
36604-263	Retaining ring, 0.103 ID	1
36604-264	Spring	1
36604-265	Roll pin 0.062 dia. x 0.438	1
36604-266	Plug	1
36604-267	Spring	1
36604-268 to 280	Not used	

WARNING

Injury may result if compressed springs 207 and 208 are released suddenly. Use the proper equipment to remove springs and spring covers

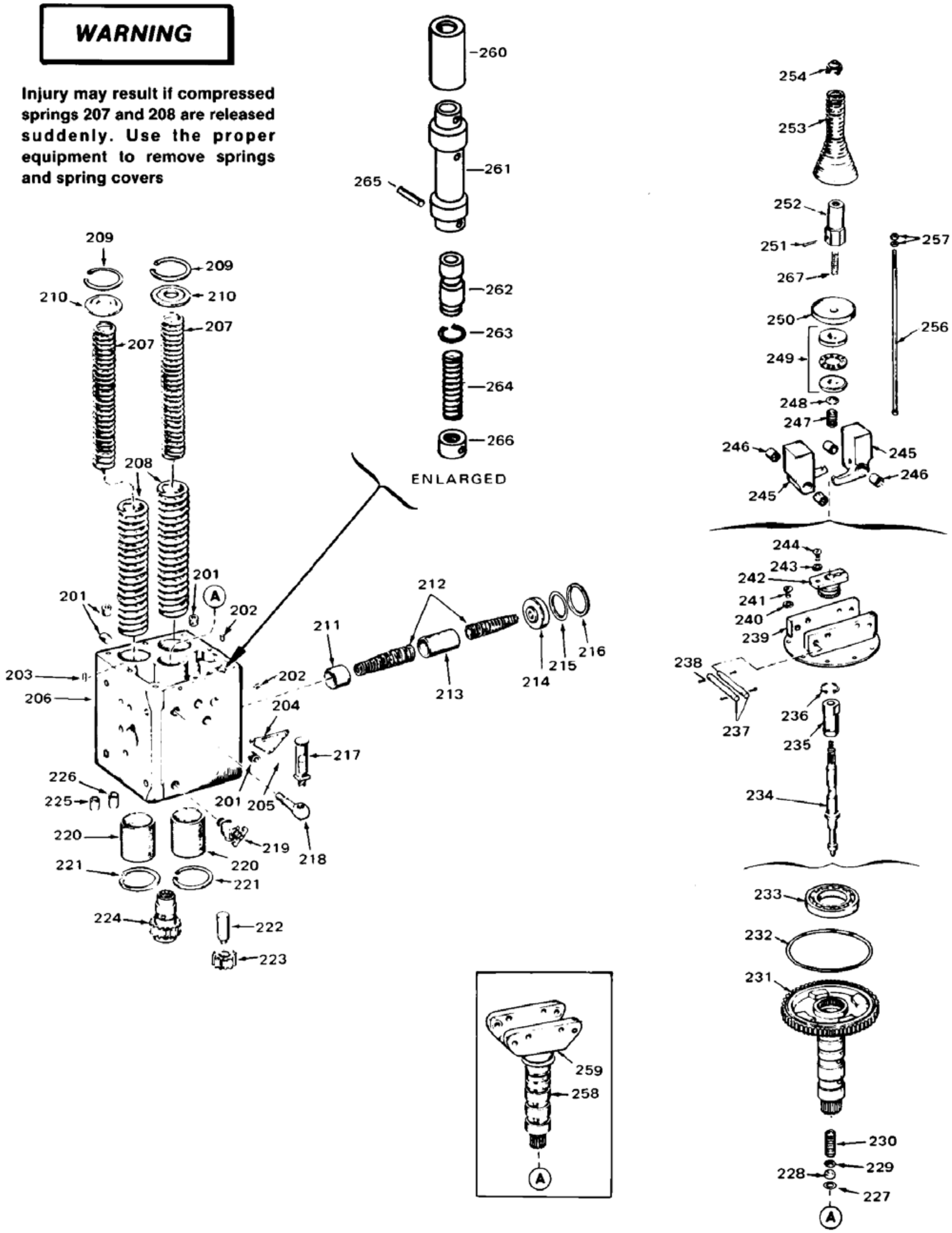


Figure 6-3. Exploded View of PGA Power Case

Parts List for Figure 6-4

Ref. No.	Part Name	Quantity
36604-281	Lockwire	A.R.
36604-282	Screw, dr. hd. cap, 1/4-28 x 5/8	3
36604-283	Bearing retainer	1
36604-284	Gasket	1
36604-285	Oil seal retainer	1
36604-286	Oil seal	1
36604-287	Retaining ring	1
36604-288	Bearing	1
36604-289	Drive shaft	1
36604-290	Pin	2
36604-291	Base	1
36604-292	Washer	4
36604-293	Screw	4
36604-294 to -300 Not used		

Parts List for Figure 6-5

Ref. No.	Part Name	Quantity
36604-301	Lockwire (MS9226-3)	A.R.
36604-302	Screw, dr. hd. cap, 1/4-28 x 5/8 (MS5109-5)	3
36604-303	Bearing retainer	1
36604-304	Cotter pin (MS24665-372)	1
36604-305	Castle nut, 5/8-18 (AN310-10)	1
36604-306	Spacer	1
36604-307	Bearing	1
36604-308	Key	1
36604-309	Drive shaft (keyed)	1
36604-310	Retaining ring	1
36604-311	Drive shaft (serrated or splined)	1
36604-312	Oil seal retainer	1
36604-313	Oil seal	1
36604-314	Gasket	1
36604-315	Plug	2
36604-316	Pin	2
36604-317	Base, PG/UG-8 standard	1
36604-318	Base, PG/UG-8-90°	1
36604-319	Base, PG/UG-40	1
36604-320	Base, PG-Extended Square	1
36604-321	Washer	4
36604-322	Screw	4
36604-323	Washer	4
36604-324	Screw	4
36604-325	Washer	4
36604-326	Screw	4
36604-327	Washer	4
36604-328	Screw	4
36604-329 & -330 Not used		

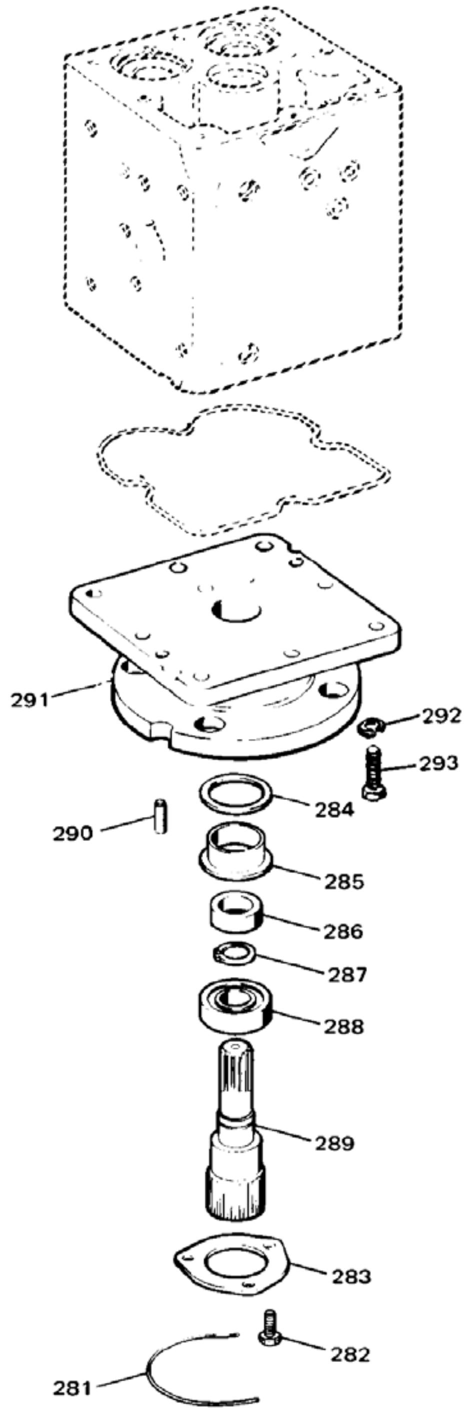


Figure 6-4. Exploded View, Standard PG Base Assembly

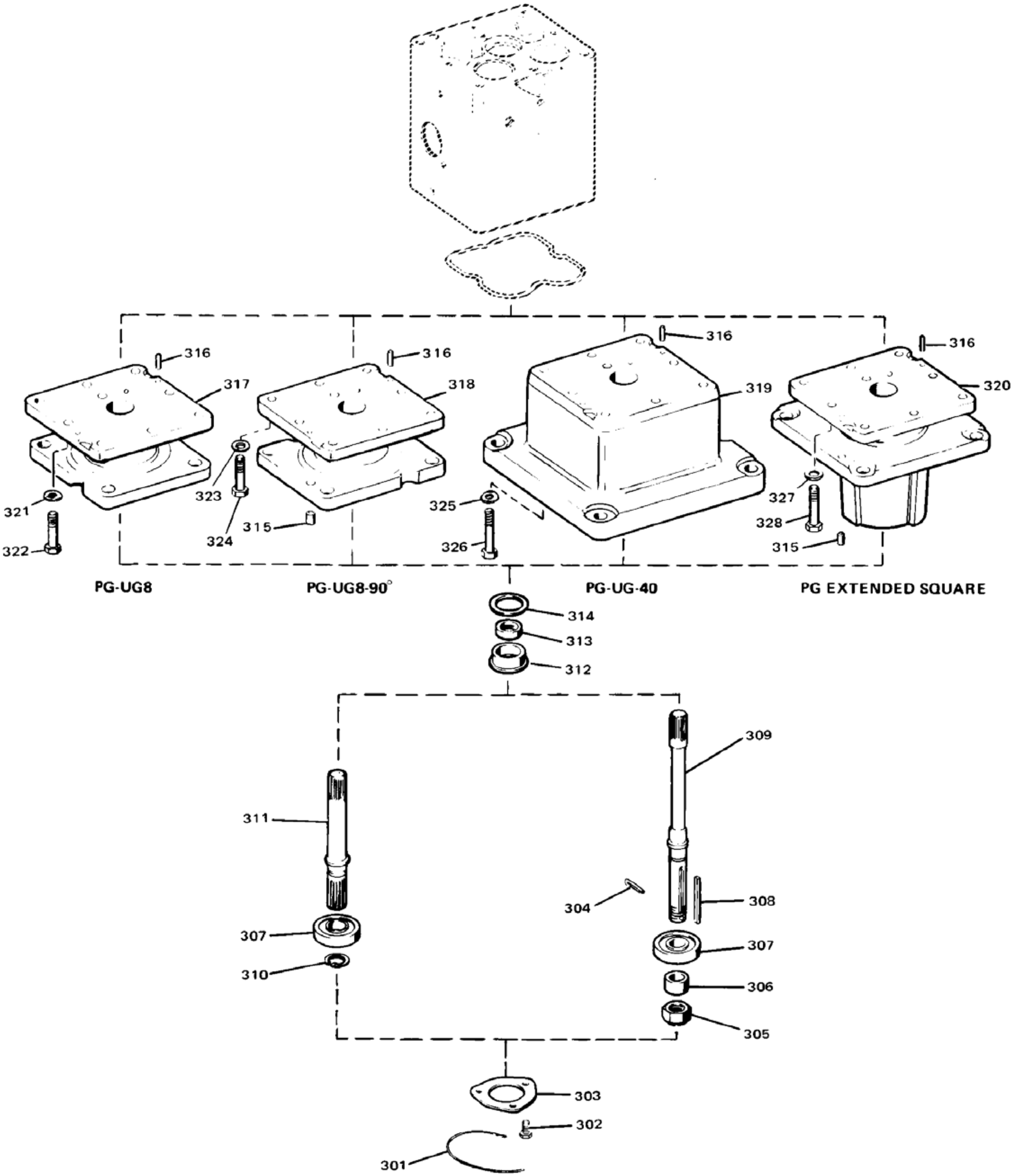


Figure 6-5. Exploded View of PG/UG-8, PG/UG-8-90°, PG/UG-40, and PG Extended Square Bases

Parts List for Figure 6-6

Ref. No.	Part Name	Quantity
36604-331	Screw, cap, soc. hd., 1/4-28 x 3/4	4
36604-332	Washer	4
36604-333	Spring guard	1
36604-334	Spring, power cylinder	1
36604-335	Gasket	1
36604-336	Pin	1
36604-337	Tailrod	1
36604-338	Tailrod locknut	1
36604-339	Tailrod lift nut	1
36604-340	Shakeproof washer	1
36604-341	Piston & rod assembly	1
36604-342	Power cylinder assy (linear)	1
36604-343	Oil seal	1
36604-344	Oil seal	1
36604-345	Not used	
36604-346	Rod end	1
36604-347	Not used	
36604-348	Taper pin	1
36604-349	Not used	
36604-350	Screw	1
36604-351	Nut	1
36604-352	Indicator plate	1
36604-353	Washer	2
36604-354	Screw	2
36604-355	Spring	1
36604-356	Spring guard seal ring	1
36604-357	O-ring	1
36604-358	Gasket	1
36604-359	Washer	4
36604-360	Screw	4
36604-361	O-ring	1
36604-362	Needle valve	1
36604-363 to -470	Not used	

WARNING

Injury may result if compressed spring 334 is released suddenly. Use the proper equipment to remove spring and spring cover.

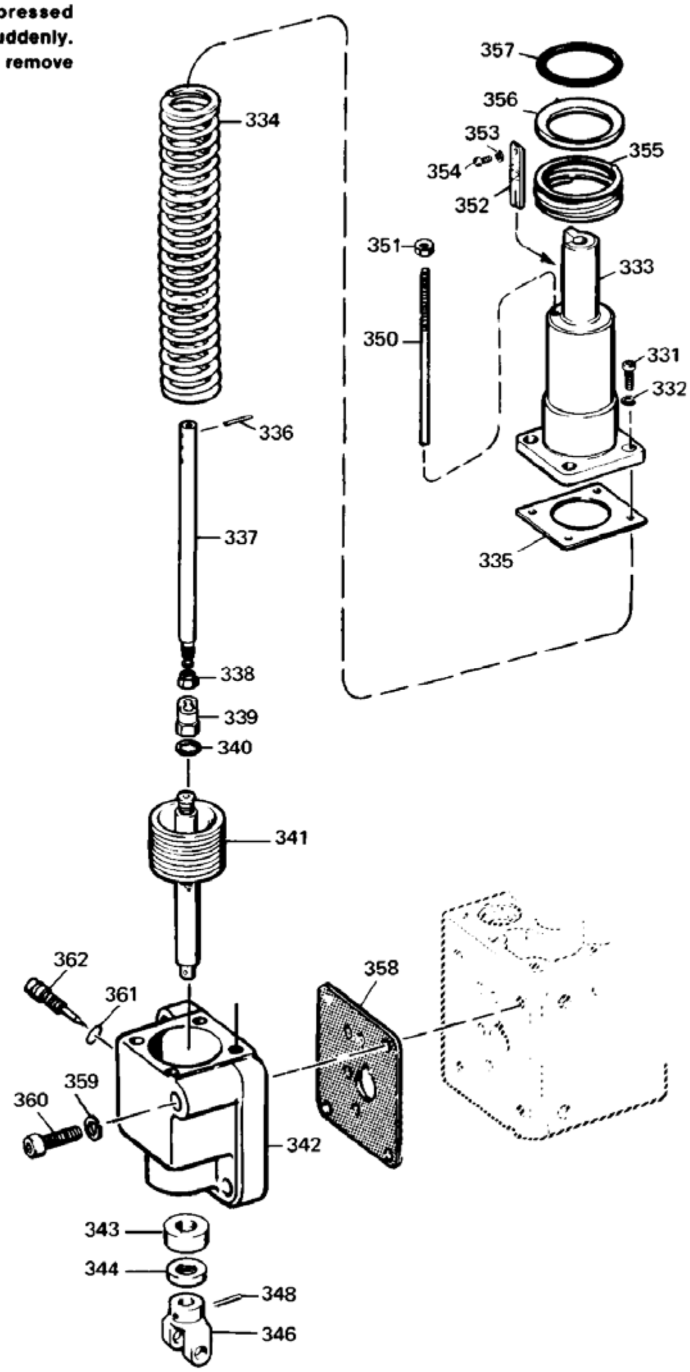
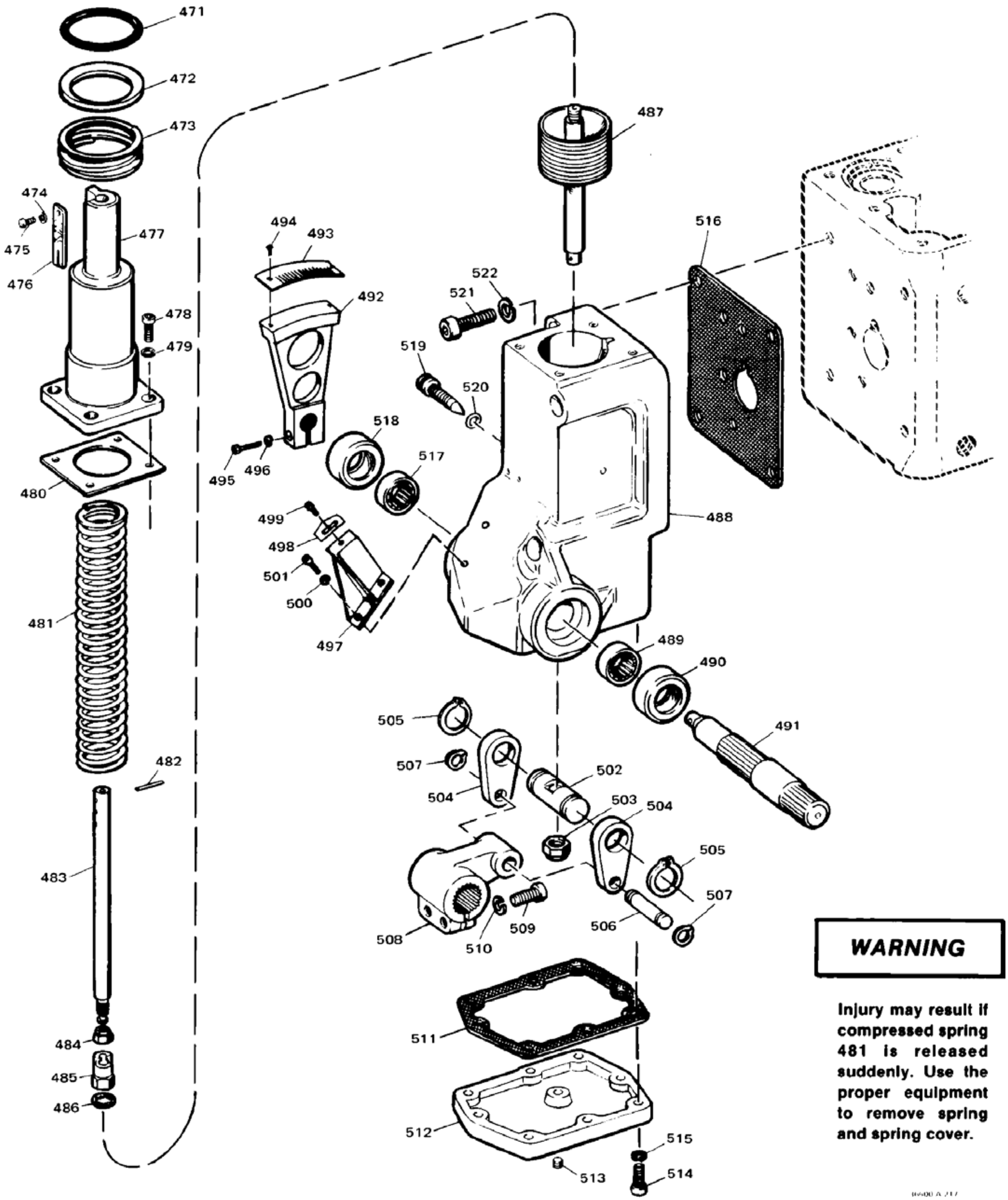


Figure 6-6. Exploded View of 12 ft-lb Spring Loaded Power Cylinder (Linear Output)

Parts List for Figure 6-7

Ref. No.	Part Name	Quantity
36604-471	O-ring	1
36604-472	Spring guard seal ring	1
36604-473	Spring	1
36604-474	Washer	2
36604-475	Screw	2
36604-476	Indicator plate	1
36604-477	Spring guard	1
36604-478	Screw	4
36604-479	Lockwasher	4
36604-480	Gasket	1
36604-481	Spring	1
36604-482	Pin	1
36604-483	Tailrod	1
36604-484	Tailrod locknut	1
36604-485	Tailrod lift nut	1
36604-486	Shakeproof washer	1
36604-487	Power piston	1
36604-488	Power cylinder assy (rotary)	1
36604-489	Needle bearing (large)	1
36604-490	Oil seal (large)	1
36604-491	Terminal shaft	1
36604-492	Rack dial segment	1
36604-493	Terminal shaft scale	1
36604-494	Drive screw	1
36604-495	Screw	1
36604-496	Washer	1
36604-497	Pointer rack	1

Ref. No.	Part Name	Quantity
36604-498	Pointer	1
36604-499	Screw	1
36604-500	Washer	2
36604-501	Screw	2
36604-502	Power rod pin	1
36604-503	Nut, 7/16-20	1
36604-504	Power piston link	2
36604-505	Retaining ring	2
36604-506	Power lever pin	1
36604-507	Retaining ring	2
36604-508	Power lever	1
36604-509	Screw	2
36604-510	Lockwasher	2
36604-511	Gasket	1
36604-512	Sub-cap	1
36604-513	Plug	1
36604-514	Screw	8
36604-515	Lockwasher	8
36604-516	Gasket	1
36604-517	Needle bearing (small)	1
36604-518	Oil seal (small)	1
36604-519	Needle valve	1
36604-520	O-ring	1
36604-521	Screw	4
36604-522	Lockwasher	4
36604-523 to -600 Not used		



WARNING

Injury may result if compressed spring 481 is released suddenly. Use the proper equipment to remove spring and spring cover.

Figure 6-7. Exploded View of 12 ft-lb Spring Loaded Power Cylinder (Rotary Output)

Parts List for Figure 6-8

Ref. No.	Part Name	Quantity
36604-601	Screw, soc. hd. 5/16-24 inch	6
36604-602	Washer, 5/16 split lock	10
36604-603	Power cylinder head	1
36604-604	Screw, soc. hd., 1/4-28 x 1/2	1
36604-605	Washer, 17/64 x 9/16, flat	1
36604-606	Tail rod end	1
36604-607	Tallrod, power piston	1
36604-608	Screw, soc. hd, 1/4-28 x 7/8	8
36604-609	Washer, 14 In. split lock	8
36604-610	Cover, power cylinder	1
36604-611	Plug, pipe, 1/8-27 NPT	1
36604-612	Gasket	1
36604-613	Screw, soc. lid., 5/16-18 x 1	2
36604-614	DO NOT USE	
36604-615	DO NOT USE	
36604-616	DO NOT USE	
36604-617	DO NOT USE	
36604-618	DO NOT USE	
36604-619	Ring, retaining	2
36604-620	Pin, power lever	1
36604-621	DO NOT USE	
36604-622	Power Lever	1
36604-623	Nut, 7/16-20	1
36604-624	Link, power piston	2
36604-625	Pin, piston rod	1
36604-626	Packing, preformed	1
36604-627	Power Piston	1
36604-628	Oil Seal	2
36604-629	Needle Bearings	2
36604-630	DO NOT USE	
36604-631	DO NOT USE	
36604-632	DO NOT USE	
36604-633	DO NOT USE	
36604-634	DO NOT USE	
36604-635	Needle Valve	1
36604-636	O-ring, 438 OD	1
36604-637	Power Cylinder	1
36604-638	Gasket	1
36604-639	Screw	4
36604-640	Lock Washer	4
36604-641	Terminal Shaft	2
36604-642	Pointer Bracket	1
36604-643	Screw, 8-32 x .625	1
36604-644	Lock Washer, No. 8	1
36604-644A	Flat Washer, No. 8	1
36604-645	Pointer	1
36604-646	Screw, .250-28 x 1.000	2
36604-647	Lock Washer, .250	2
36604-648	Screw, .250-28 x 1	1
36604-649	Lock Washer, .250	1
36604-650	Lever	1
36604-651	Drive Screw	2
36604-652	Scale	1

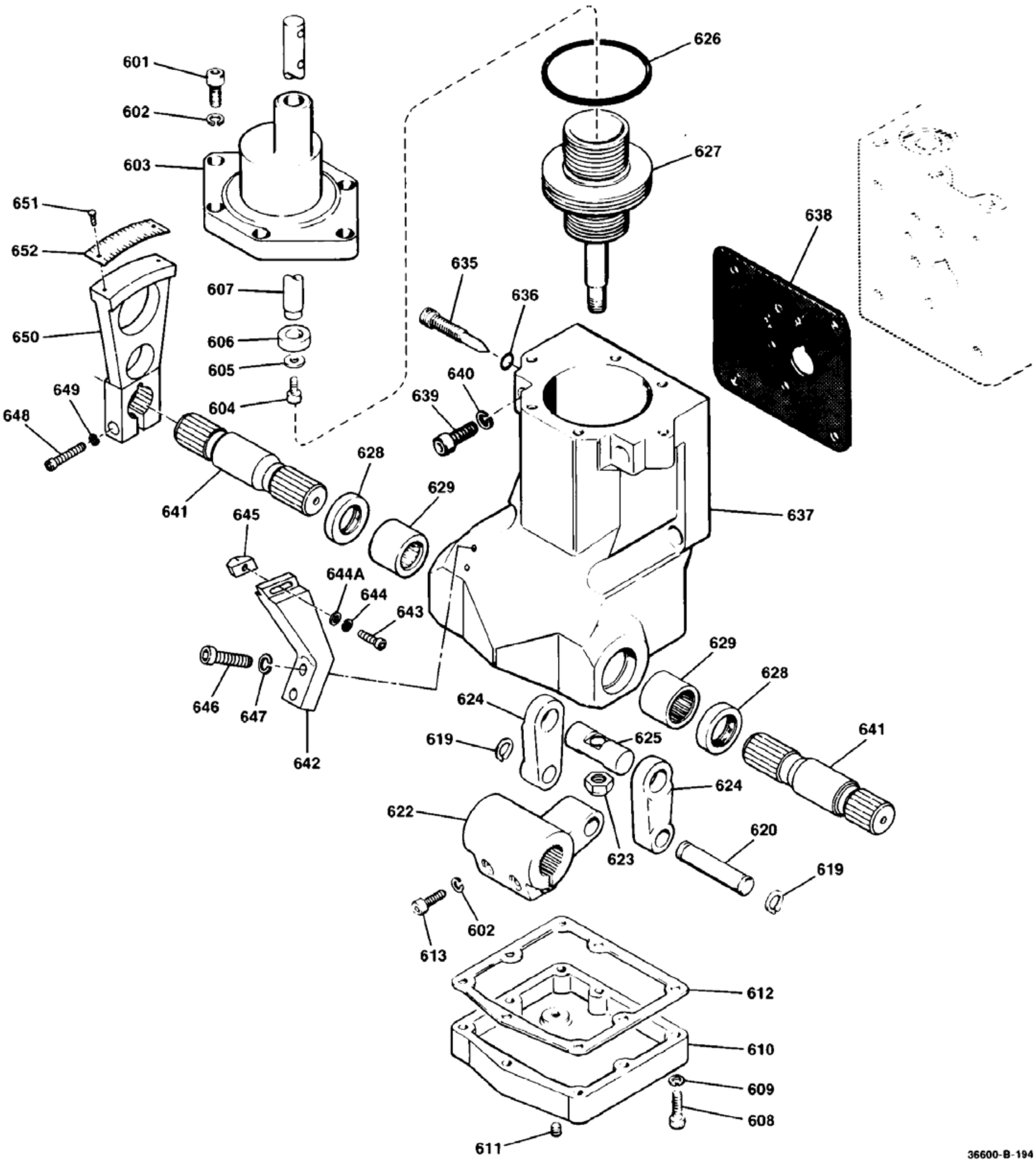


Figure 6-8. Exploded View of 29/58 ft-lb Differential Cylinder (Rotary Output with Tailrod)

Chapter 7. Auxiliary Features and Devices

Introduction

A number of optional auxiliary features and devices are available for use, either singly or in combination, with the PGA governors. These devices permit the governor to perform other secondary functions such as limiting engine load, controlling engine load to maintain a constant power output for each speed setting, minimizing the tendency to overfuel when starting, permitting temporary overloads, emergency shutdown, loss of lubricating oil pressure, etc. Auxiliary equipment should be supplied as original equipment in the governor. It is recommended that the customer contact Woodward if field installations are desired.

The following paragraphs give a brief description of the auxiliary equipment available and list the manuals where detail information may be obtained. This chapter is divided into two parts; commonly used auxiliary devices, and additional accessories.

Commonly Used Auxiliary Devices

Solenoid Operated Shutdown

This device may be set up to automatically effect shutdown either when energized or when de-energized. Coils are available to accommodate most common dc voltages. For ac operation, an internal rectifier is used to provide the required dc voltage.

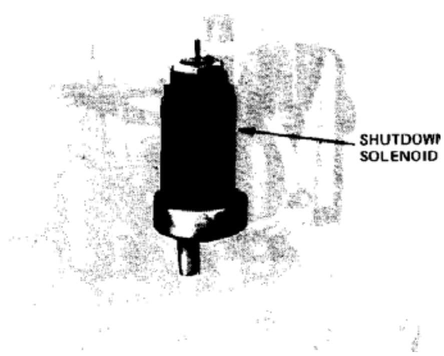


Figure 7-1. PGA with Shutdown Solenoid

Description
The solenoid operated shutdown assembly shown in Figure 7-2 can be incorporated in almost all PG governors having speed setting arrangements which use hydraulically operated speed setting servo assemblies (direct bellows speed setting, current controlled speed setting, etc.). The solenoid is actuated by switches in the protective circuit being monitored. When actuated, the shutdown solenoid initiates a sequence of actions within the governor which results in the fuel or steam valve linkage being moved to the shutdown or off position.

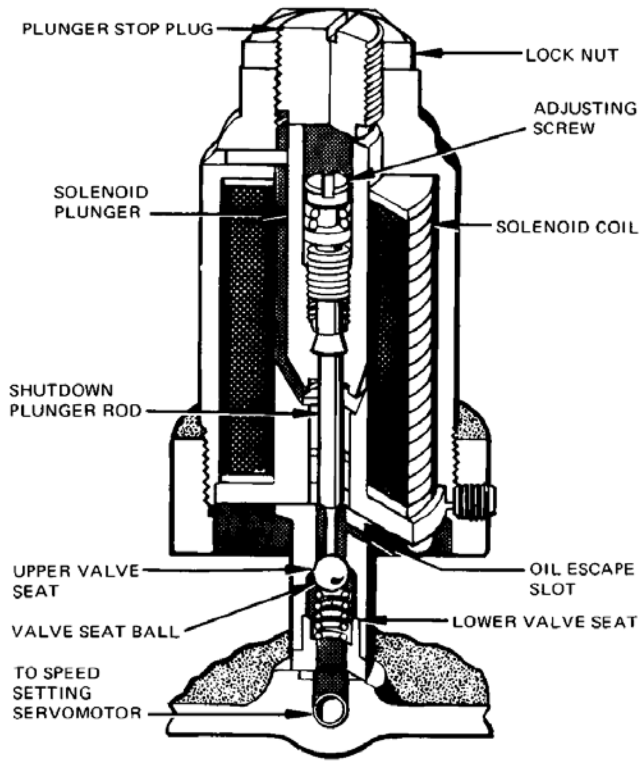


Figure 7-2. Cutaway of Solenoid Operated Shutdown

Operation

Figure 7-3 shows the shutdown device which consists of a check valve and a solenoid. The check valve is inserted in the hydraulic circuit between the speed setting servo assembly and the speed setting pilot valve plunger and bushing. When the ball in the check valve in unseated, oil1 above the speed setting servo piston escapes to sump. This allows the servo piston spring to push the speed setting servo piston up. When the servo piston moves up sufficiently, the piston rod lifts the shutdown nuts and shutdown rod which is connected to the governor pilot valve plunger. Therefore, lifting the shutdown rod lifts the pilot valve plunger. With the pilot valve above center, oil is released through the control port to sump and the governor power piston moves the fuel linkage in the decrease fuel direction.

The check ball (Figure 7-3) seats against two valve seats. In units adjusted to shutdown when the solenoid coil is energized, the spring holds the check ball against the upper seat during normal operation. When the coil is energized, the plunger rod moves down, unseating the check ball. In units adjusted to shut down when the solenoid is de-energized, the plunger rod is adjusted to hold the check ball on the lower seat during normal operation when the solenoid is energized. When the, solenoid coil is de-energized, the spring pushes the check ball upward, unseating it.

Adjustments

Refer to Figure 7-2 and adjust the ENERGIZE-TO-SHUTDOWN arrangement in the following manner, Remove the locknut and the plunger stop plug; then energize the solenoid. Turn the adjusting screw down (clockwise) until oil starts to seep from the slot in the shutdown valve body. Turn the adjusting screw down 1-1/4 turns further. De-energize the solenoid; insert the plunger stop plug, and screw the plug down until it touches the solenoid plunger. Back off the plunger stop plug 2 turns, and lock it in place with the lock nut.

Adjust DE-ENERGIZE-TO-SHUTDOWN in the following manner. Remove the locknut and the plunger stop plug; then energize the solenoid. Turn the adjusting screw down until the ball contacts the lower valve seat. Screw down 1/4 turn farther (forcing the solenoid plunger up). Insert the plunger stop plug, and screw the plug down until it touches the solenoid plunger. Back off the plunger stop plug 2 turns and lock it in place with the lock nut.

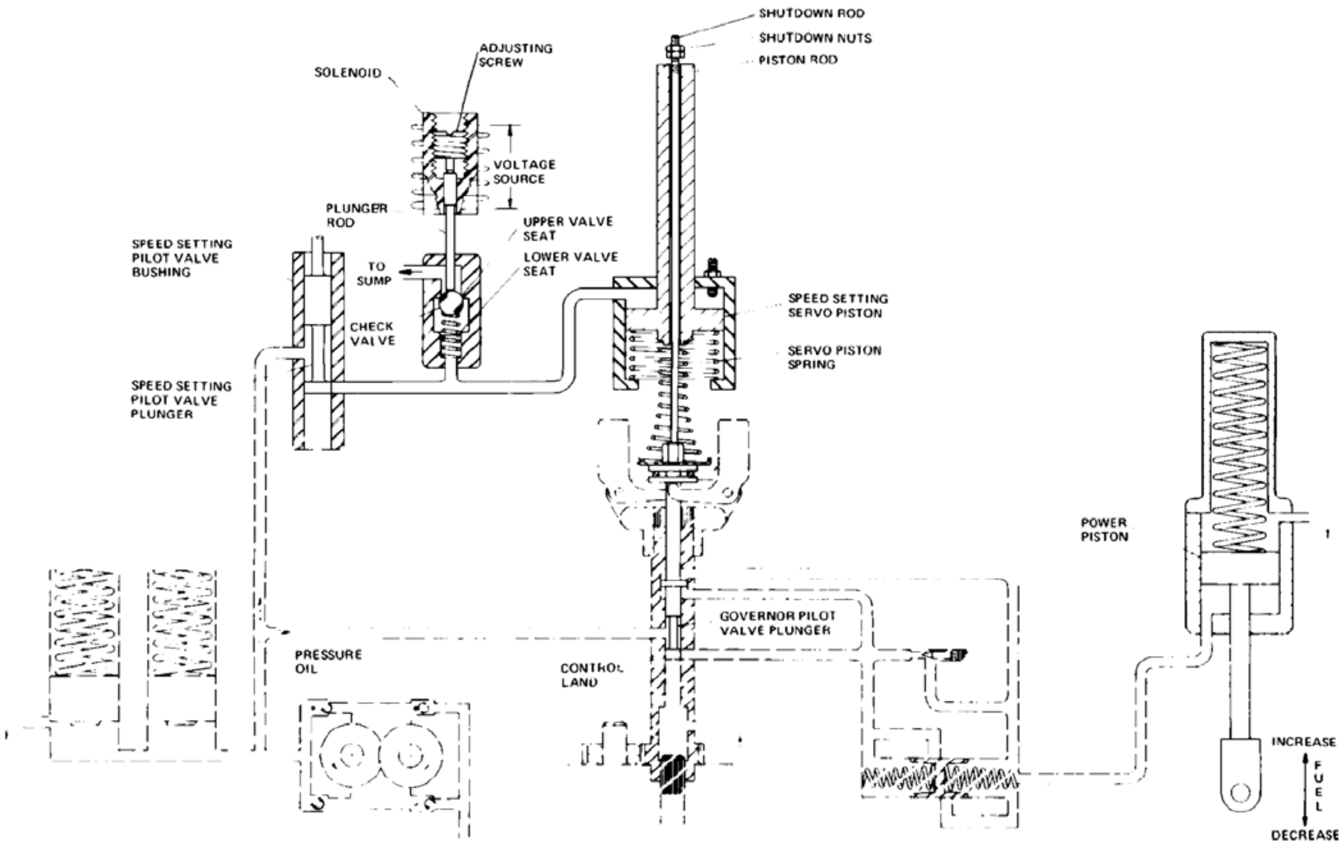


Figure 7-3. Schematic Diagram, Basic PG and Solenoid Shutdown

Parts List for Figure 7-4

Ref. No.	Part Name	Quantity
36604-701	Solenoid locknut	1
36604-702	Plunger stop plug	1
36604-703	Solenoid plunger lock pin	1
36604-704	Solenoid case	1
36604-705	Load spring	1
36604-706	Insulating paper	1
36604-707	Solenoid coil	1
36604-708	Soldering shield washer	2
36604-709	O-ring	2
36604-710	Adjusting screw	1
36604-711	Solenoid plunger assembly	1
36604-712	Solenoid plunger washer	1
36604-713	Solenoid plunger rod	1
36604-714	Solenoid plunger bushing	2
36604-715	Shutdown valve body	1
36604-716	Varnished tubing	2
36604-717	Plunger guide locating pin	1
36604-718	Steel ball, 1/4" dia.	1
36604-719	Unloading spring	1
36604-720	Valve seat	1
36604-721	Valve seat	1
36604-722	Roll pin	1
36604-723	Spring	1
36604-724	Bearing plug	1
36604-725	Manual shutdown plunger	1
36604-726	Plunger stop plug	1
36604-727	Headed pin	1
36604-728	Receptacle	1
36604-729	Connector (optional)	1
36604-730	Coupling (optional)	1
36604-731	Spacer	1
36604-732	Dial plate	1
36604-733	Screw, 6-32 x 3/8"	1
36604-734	Gasket	1
36604-735	Screw, 4-40 x 1/4"	1
36604-736	O-ring	1
36604-737	Diode assembly	1
36604-738 to 740 Not used		

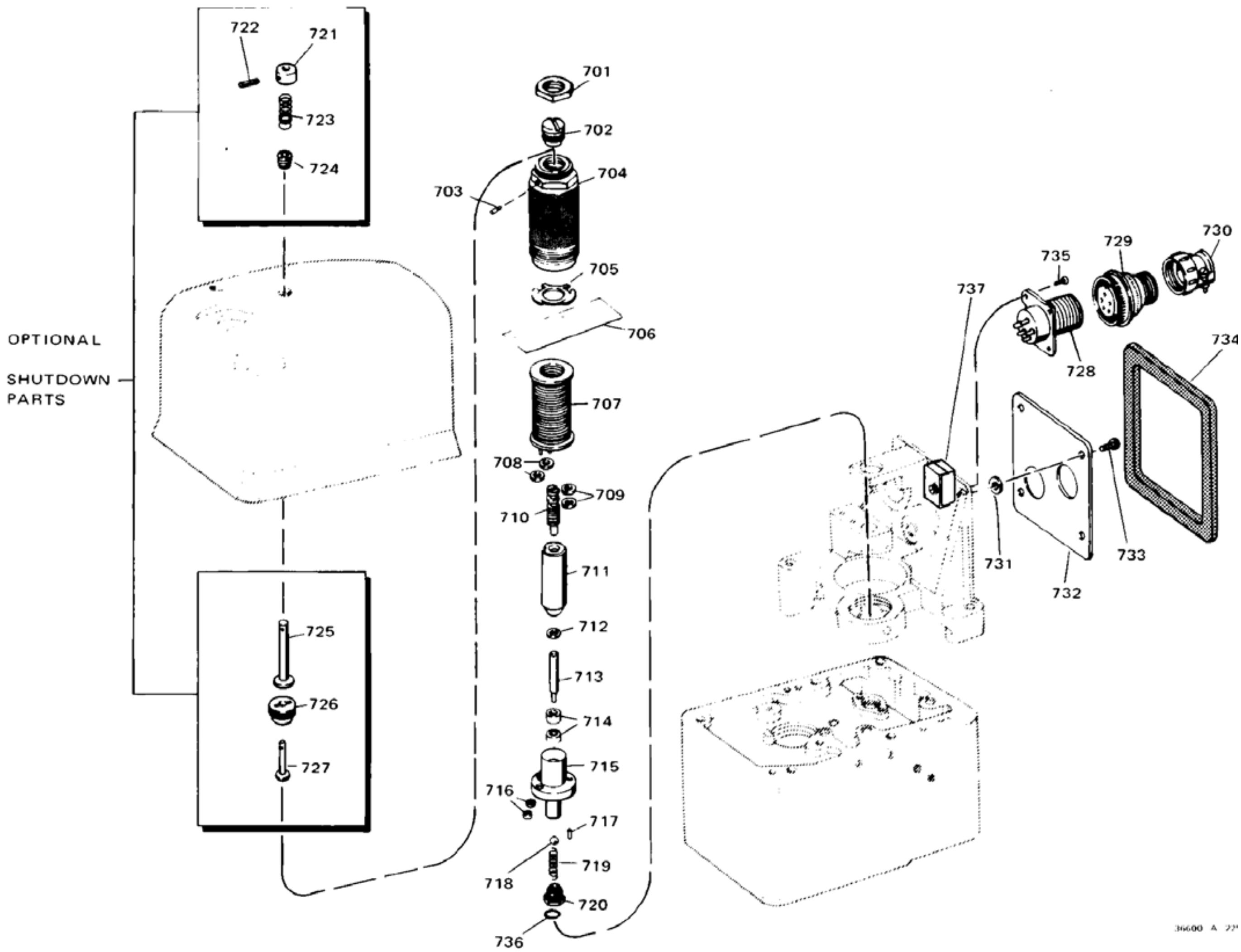


Figure 7-4. Exploded View, Solenoid Shutdown

Overspeed Trip Test Device

(Figures 7-5 & 7-6)

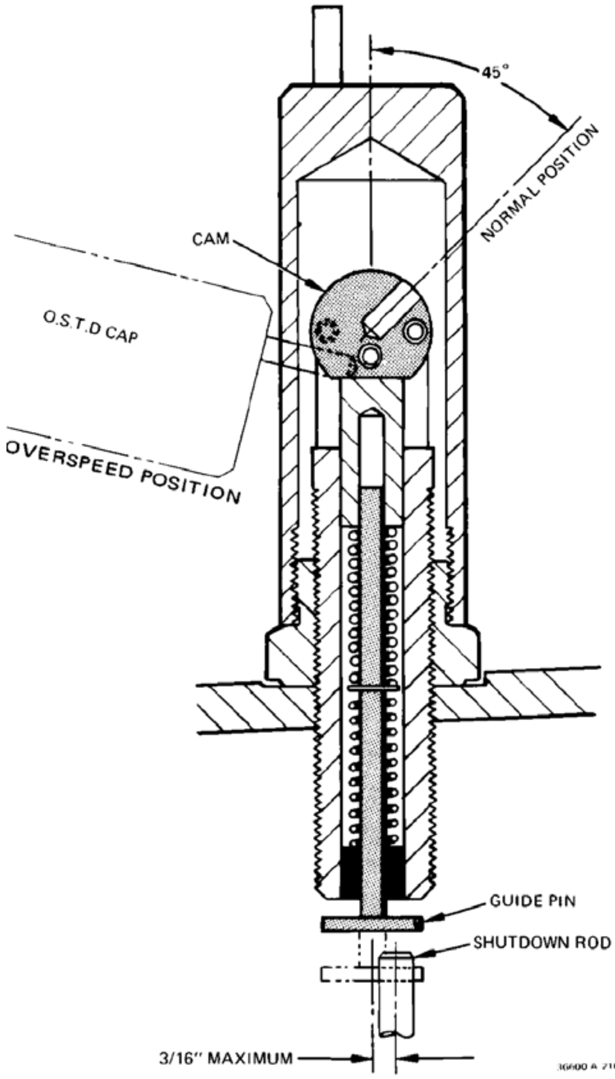


Figure 7-5. Overspeed-Trip Test Device

Parts List For Figure 7-6

Ref. No.	Part Name	Quantity
36604-741	Governor cover	1
36604-742	Nut	1
36604-743	Guide pin	1
36604-744	Quite bushing, 0.314 OD	1
36604-745	Spring	1
36604-746	Retaining ring	1
36604-747	OST spring	1
36604-748	Guide sleeve	1
36604-749	Adjusting sleeve	1
36604-750	Cam	1
36604-751	Roll pin, 0.125 dia. x .625	1
36604-752	Roll pin, 0.135 OD x 0.500	1
36604-753	O.S.T.D. cap assembly	1

36604-754 to –820 Not used

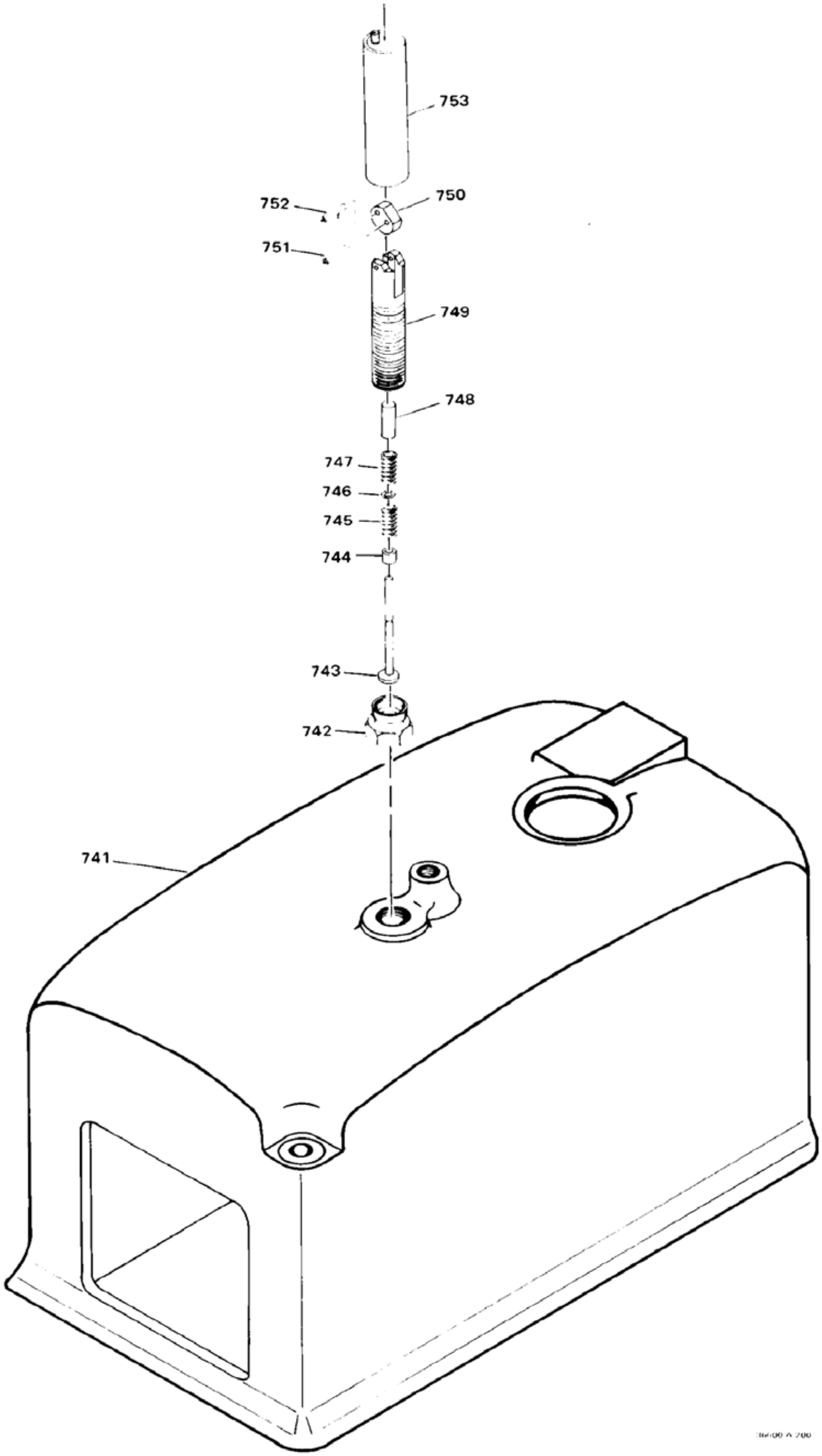


Figure 7-6. Exploded View of the Overspeed Trip Test Device

The overspeed test device shown in Figure 7-5 offers a means of temporarily increasing the governor speed setting to check the operation of the engine overspeed trip mechanism. It can be installed on any PG governor which has a shutdown rod, including one already in service.

Return your governor to Woodward for addition of the overspeed trip test device.

Operation

To test the overspeed-trip mechanism remove the test device cap (753) and slide the pin in the top of the cap (754) into the socket in the cam face. Move the cam slowly to the overspeed position. The guide pin (743) is pushed against the shutdown rod, which causes the control port in the pilot valve bushing to open. The governor power piston is forced in the "increase fuel" direction, accelerating the engine to the speed level at which the engine mounted overspeed trip shuts down the engine.

⚠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.

Load Indicating (Tailrod) Switches

(Figures 7-7 & 7-8)

The load indicating switch is used to indicate tailrod position. These switches are a function of tailrod or fuel rack position.

The load indicator switch is mechanically operated by set screw (825) attached to the power piston tailrod. The load indicator switch is energized when the tailrod moves past the preset position while increasing fuel to the engine. This switch may be connected to an alarm signal or an indicator light. Refer to the engine manufacturer's instruction manual for the particular connections. if load is increased past the preset position the switch is energized.

A load control indicator switch is also available to connect to the load control linkage. This indicator switch is then a function of speed setting and fuel rack position and not just tailrod position.

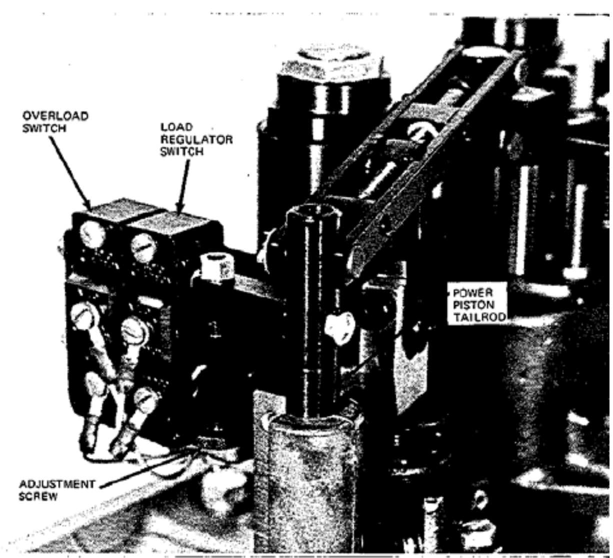


Figure 7-7. Load Indicating Switches

Parts List For Figure 7-8

Ref. No.	Part Name	Quantity
36604-821	Screw, hex. hd., 10-32 x 7/8	1
36604-822	Lockwasher, int. tooth, #10	1
36604-823	Tailrod arm	1
36604-824	Nut, 10-32	1
36604-825	Knurled adjustment screw	1
36604-826	Nut, self-locking, 6-32	2
36604-827	Screw, rd. hd., 6-32 x 1-7/8	2
36604-828	Plunger switch (microswitch)	2
36604-829	Nut, 10-32	2
36604-830	Lockwasher, int. tooth, #10	2
36604-831	Screw, hex. hd, 10-32 x 3/4	2
36604-832	Screw, hex. hd., 10-32 x 1/2	2
36604-833	Lockwasher, int. tooth, #10	2
36604-834	Retaining ring	1
36604-835	Actuating lever	1
36604-836	Spacer	1
36604-837	Actuator shaft	1
36604-838	Switch actuator lever (overload)	1
36604-839	Nut, 10-32	1
36604-840	Setscrew, soc. hd., oval pt., 10-32 x 5/8	1
36604-841	Switch actuator (regulator)	1
36604-842	Shaft spring	1
36604-843	Stop pin, 1/4 x 7/16	1
36604-844	Bushing, 1/4 x 3/8 x 1/4	2
36604-845	Switch bracket	1
36604-846	Screw, rd. hd., 8-32 x 3/8	1
36604-847	Lockwasher, int. tooth, #8	1
36604-848	Cable clamp	1
36604-849 and -850 Not used		

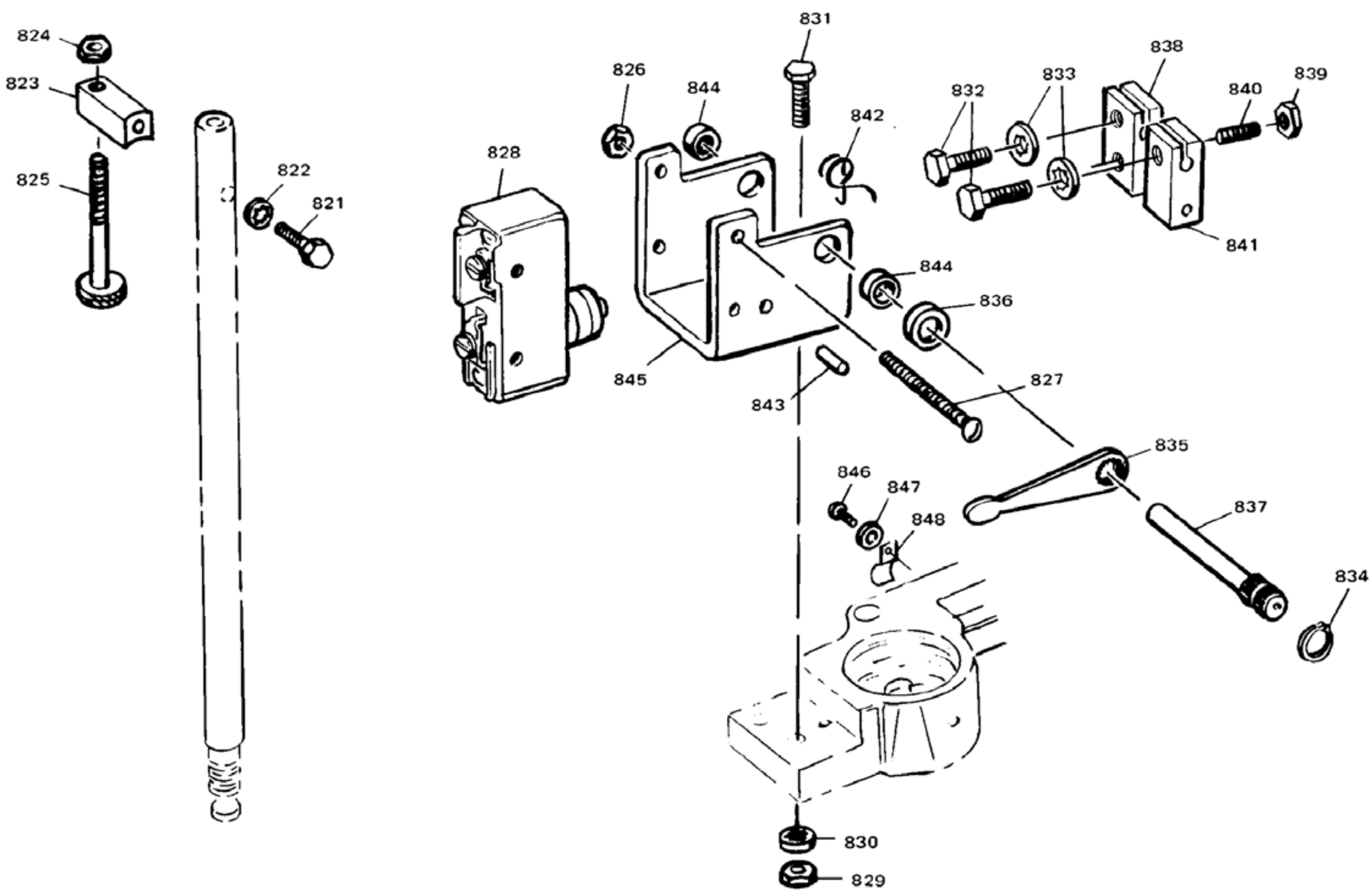


Figure 7-8. Exploded View of Load Indicating Switches

Adjustment

Refer to Figure 7-8 and the following.

1. Adjust screw (825) until its threads are centered in tailrod arm (823).

2. Position the tailrod to obtain the correct rack length per engine specifications.

3. Adjust switch actuator (841) to just actuate the load regulator switch (828). Secure switch actuator (841) with screw (832).

4. Adjust switch actuator (838) to actuate overload switch (828) when screw (832) in switch actuator (841) has moved approximately an additional 1/4" from actuating the load regulator switch. This setting is also per engine specifications.

Manifold Gauge Pressure Angle Type Fuel Limiter

Two types of fuel limiters are described in this manual. The Angle Fuel Limiter is found on many older PGA governors and on some current governors which also have a speed setting fuel limiter or other options which prevent the use of the Single Barrel Fuel Limiter.

The Single Barrel Limiter is preferred because it contains a hydraulic amplifier section which converts the low-force sensor output into a high-force output for biasing the pilot valve-speeder spring system. A description of this limiter can be found later in this chapter.

The Angle Type Fuel Limiter biases the limit curve as the manifold charging air gauge pressure varies.

The normal lag of the turbo-supercharger speed to the engine speed makes it possible during periods of acceleration with a large increase in load, to supply more fuel to the engine than can be burned with the air available from the supercharger. The resulting imbalance of fuel and air leads to poor combustion and excessive smoke, and often retards the ability of the engine to return to normal speed after a load change. The governor power piston is restricted in the opening direction to limit engine fuel as a function of manifold charging air pressure. This insures that sufficient air is maintained for proper combustion.

The fuel limiter consists essentially of a pressure sensor, a cam, and a connecting beam (see Figure 7-11).

One end of the connecting beam is attached to the tailrod of the governor power piston. The other end is positioned as a function of the cam position. The beam passes under the shutdown block. Raising the beam sufficiently raises the shutdown block, and with it, the shutdown rod. Lifting the shutdown rod lifts the pilot valve plunger, since the shutdown rod is an extension of the governor pilot valve plunger.

The governor power piston moves up, increasing fuel when the pilot valve plunger is below its centered position. Fuel is increased only until the upward movement of the power piston causes the connection beam to return the pilot valve plunger to its centered position. The cam position establishes the height the power piston may rise before the connecting beam lifts the pilot valve plunger. Therefore, the cam position determines the maximum fuel allowed to the engine at any instant.

The cam is mounted on a hydraulically operated sensor piston which is connected to a force-balance system and takes a position proportional to manifold charging air gauge pressure. The slope of the cam is adjustable.

Manifold charging air is brought into the bellows and tends to push the cone valve off its seat. This force is opposed at the cone valve by the force of the spring between the cone valve and sensor piston.

The unrestricted flow of pressure oil applies constant pressure to the upper-side of the sensor piston. A series of orifices restricts the flow of pressure oil to the underside of the piston. Except while changes are occurring in the manifold charging air pressure, the bellows force tending to push the cone valve up is balanced or equaled by the spring force from the opposite direction. The cone valve normally “floats” just off its seat and continually releases the oil admitted through the orifice stack to sump. If the bellows force is greater than the opposing spring force, the cone valve is forced upward, allowing oil to flow from under the piston at an increased rate. The pressure oil above the piston forces it down, compressing the spring until the spring force again equals the bellows force. If the manifold charging air pressure is decreased, the bellows output force is reduced, and the spring pushes the cone valve onto its seat. The oil pressure under the piston moves the piston up and reduces the spring load on the cone valve until the opposing forces are again equal.

The preload on the spring within the bellows assembly determines the charging air pressure below which a constant maximum fuel limit is held (line RS in Figure 7-9). Preload is adjusted by means of the adjusting screw in the end of the bellows case and is factory set. The contour of the cam determines the slope of line ST (Figure 7-9).

Since the fuel limiter is effective at idle speed, the fuel limit must be set high enough to give sufficient fuel for starting. See Figure 7-10 for exploded view of the manifold gauge pressure fuel limiter.

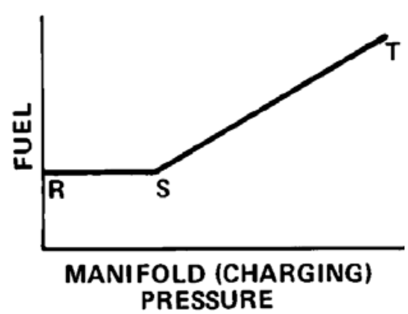


Figure 7-9. Manifold Pressure Versus Fuel Flow

Pressure Override Switch

A pressure override switch is used with the microswitch. The pressure switch automatically cancels the false signal when the engine and governor are stopped normally.

Fuel Limiter Microswitch

(Figure 7-10)

A speed setting fuel limiter microswitch (1457) is used with a manifold pressure fuel limiter. It indicates when the governor is limiting fuel as a function of either engine speed or manifold charging pressure.

When boost beam (1416) reaches its limiting position (horizontal) it activates the microswitch and in turn either an audio or visual alarm.

To adjust the microswitch loosen nut (1460) and position microswitch (1457) until the correct set point is attained.

Parts List For Figure 7-10

Ref. No.	Part Name	Quantity
36604-1001	Body	1
36604-1002	Poppet valve bushing	1
36604-1003	Valve plunger	1
36604-1004	Lower spring seat	1
36604-1005	Piston spring	1
36604-1006	Spring seat	1
36604-1007	Fuel limiter piston	1
36604-1008	DO NOT USE	
36604-1009	Lever fulcrum pin	1
36604-1010	Piston sleeve	1
36604-1011	Cam guide bracket	1
36604-1012	Screw	1
36604-1013	Spring washer	1
36604-1014	Orifice case	1
36604-1015	Washer	2
36604-1016	Washer	33
36604-1017	Orifice plate	32
36604-1018	Orifice pack spring	1
36604-1019	Washer	1
36604-1020	Internal retaining ring	1
36604-1021	Check valve	1
36604-1022	O-ring	2
36604-1023	Plug & screen assembly	1
36604-1024	Bellows assembly	1
36604-1025	O-ring	1
36604-1026	Retaining ring	2
36604-1027	Speeder spring power cylinder	1
36604-1028	Cam follower arm	1
36604-1029	Pin	1
36604-1030	Set screw	1
36604-1031	Soc. hd. screw	1
36604-1031a	Nut	1
36604-1032	Lockwasher	1
36604-1033	Ball bearing	2
36604-1034	Nut	1
36604-1035	Screw	1
36604-1036 through 1056 DO NOT USE		
36604-1057	Shutdown rod	1
36604-1058 through 1067 DO NOT USE		
36604-1068	Hex hd. cap screw	1
36604-1069	Nut	1
36604-1070	Clamp	1
36604-1071	Splitlock washer, 0.250	2
36604-1072	Cap screw	2
36604-1073	Hex hd. screw, 0.250-28	1
36604-1074	Retaining ring	1
36604-1076	Ball bearing	1
36604-1077	Headed pin	1
36604-1078	Tube assembly	1
36604-1079 through 1100 DO NOT USE		
36604-1401	Connecting beam	1
36604-1402	Headed pin .185 x 1.094	1
36604-1403	Cotter pin, 1/18 x 3/8	5
36604-1404	Washer, .203 x .438 x .032 thick	5
36604-1405	Pin spacer	1
36604-1406	Set screw, 10-32 x 1.000	1
36604-1407	Slotted link	1
36604-1408	Nut	2
36604-1409	Pivot pin	1
36604-1410	Beam	1
36604-1411	Washer	1
36604-1412	Washer, .265 x .500 x .032 thick	2
36604-1413	Elastic hex nut, .250-20	2
36604-1414	Cotter pin	1
36604-1415	Boost beam stop	1
36604-1416	Boost beam assembly	1
36604-1417	Pivot pin	1
36604-1418	Fuel limit beam assembly	1
36604-1419	Screw, 6-32 x 1	1
36604-1420	Hex nut, 10-32 NF 28 R.H.	5
36604-1421	Pivot screw	1
36604-1422	Speed setting fuel limiter spring	1
36604-1423	Screw	1
36604-1424	Pin guide, 10-32 UNF 2A	1
36604-1425	Clamp	1
36604-1426	Spring anchor	1
36604-1427	Hex hd. cap screw	1
36604-1428	Power piston fulcrum assembly	1
36604-1429	Bracket	1
36604-1430	Self locking nut, 1/4-28 UNF-3B	1
36604-1431	Spacer	1
36604-1432	Lock washer .250 ID	2
36604-1433	Socket head cap screw, .250-28 x 1.000	1
36604-1434	Washer	1
36604-1435	Hex nut, 10-32 NF-2B R.H. thread	1
36604-1436	Lock washer, #10	1
36604-1437	Cotter pin	1
36604-1438	Soc. hd. screw. .250-28 x 1.750	1
36604-1439	Elastic hex nut, 10-32	1
36604-1440	Spherical washer	1
36604-1441	Bracket pin	1
36604-1442	Cut-off valve spring	1
36604-1443	Spring	1
36604-1444	Headed pin	1
36604-1445	Adj. fulcrum screw	1
36604-1446	Speed spring cylinder spacer	1
36604-1447	O-ring	1
36604-1448	Power system fulcrum	1
36604-1449	DO NOT USE	
36604-1450	Screw	1
36604-1451	Set screw, 8-32 x .375	1
36604-1452	Torsion spring	1
36604-1453	Fuel limit cam	1
36604-1454	Fuel limit cam	1
36604-1455	Screw, 4-40 x 0.562	2
36604-1456	Actuator	1
36604-1457	Microswitch	1
36604-1458	Switch mounting plate	1
36604-1459	Washer, 0.203 x 0.438 x 0.064 thick	1
36604-1460	Nut, 10-32	1
36604-1461	Pressure switch	1
36604-1462	Pressure switch adapter	1
36604-1463	O-ring, 0.239 ID x 0.070	1
36604-1464	Wire, 20 ga. Red	1
36604-1465	Wire, 20 ga. Green	1
36604-1466	Wire, 20 ga. Orange	1
36604-1467	Set screw, 10-32 x 0.250	1
36604-1468	Crimp terminal	3
36604-1469	Tubing (shrink) 0.125 x 0.625	3
36604-1470	Pin	1
36604-1471	Check valve	1
36604-1472 through 1500 Not used		

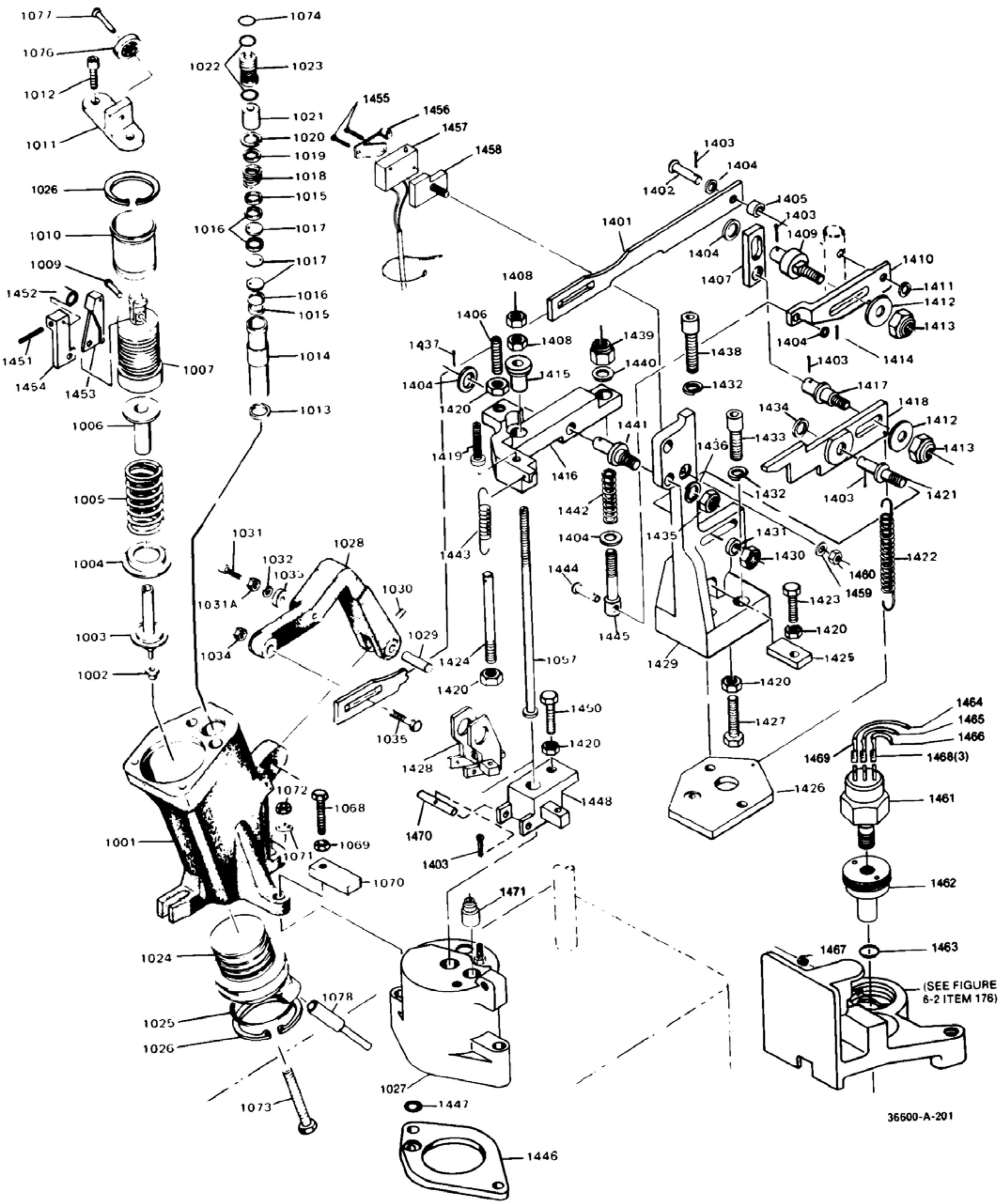


Figure 7-10. Exploded View of Angle Type Manifold Gauge Pressure Fuel Limiter (Shown with fuel limiter microswitch, pressure override switch, and speed setting fuel limiter)

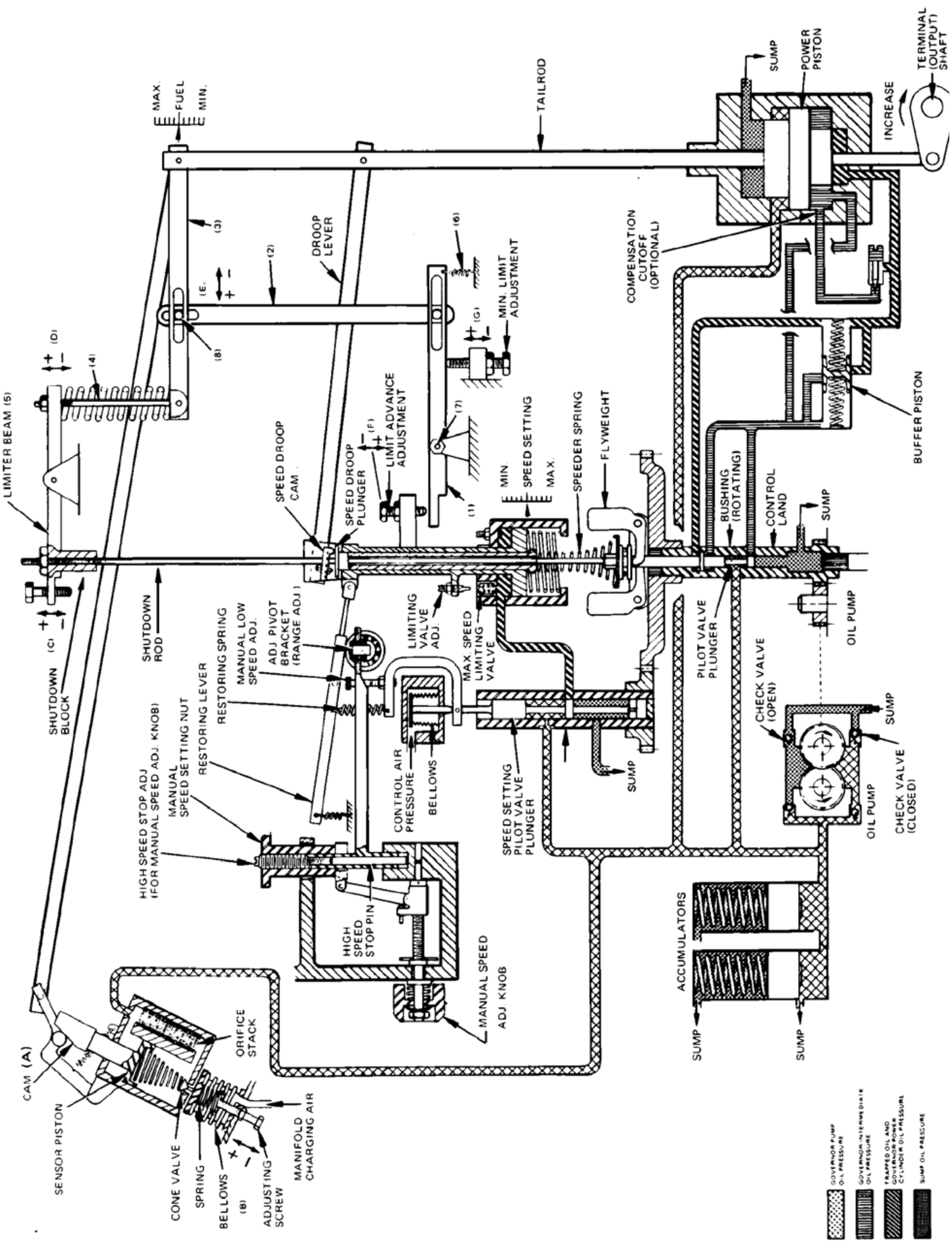


Figure 7-11. Schematic Diagram of PGA Governor with Manifold Pressure Fuel Limiter and Speed Setting Fuel Limiter

Speed Setting Fuel Limiter

This fuel limiter is dependent only on the governor speed setting. Figure 7-12 shows a schematic arrangement of linkage as related to a basic PG governor.

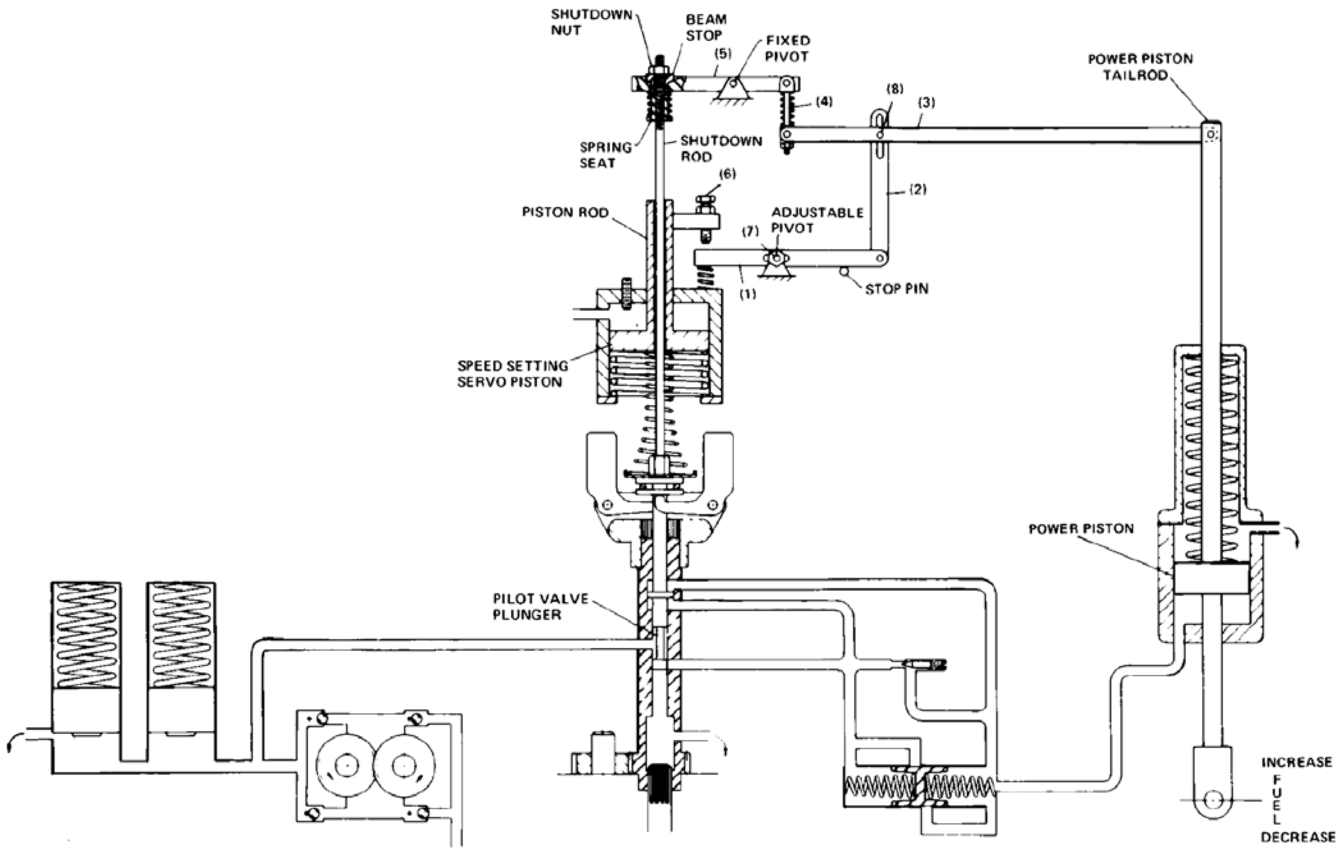


Figure 7-12. Schematic Diagram of PGA with Speed Setting Fuel Limiter

The speed setting servo piston positions the left end of limiter beam (1). As the speed setting servo piston moves down, screw (6) forces beam (1) to pivot about (7). The right hand end of beam (1) moves upward raising the lower limiter link (2), thereby positioning the slot at the upper end of beam (2) relative to the slope adjustment pivot locknut (7).

Since the right hand end of limiter beam (3) is attached to the power piston tailrod its position is a function of fuel setting. The left end of beam (3) is supported by the upper limiter link (4), the length of which is adjustable. As the tailrod moves upward, it also moves the slope adjustment pivot (8) until it reaches the top of the lower limiter link slot. Limiter beam (3) then pivots about the end of the slot, lowering the left hand end of beam (3). The upper limiter link (4) moves down, forcing the right end of limiter beam (5) downward. This results in the left end of limiter beam (5) raising the shutdown rod which is connected to the main pilot valve. Oil is dumped from under the main servo piston to drain. Therefore, fuel is limited as a function of the speed setting piston position.

A typical speed setting fuel-limit schedule is shown in Figure 7-13.

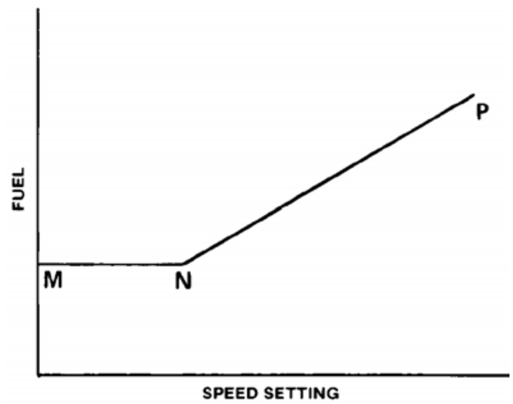


Figure 7-13. Fuel Limit Speed Setting Schedule

The constant fuel portion M-N of the curve is maintained when a gap exists between the limit advance adjustment screw and the left end of limiter beam (1).

The slope of N-P is set by the position of the slope adjustment pivot (8 on Figure 7-12) in limiter beam (2, Figure 7-12).

Load Control

Introduction

A governor's function is, primarily, to schedule fuel to the engine in sufficient quantities to maintain a constant engine speed under varying load conditions. In some marine governors driving controllable pitch propellers, a secondary objective is to maintain or limit a definite horsepower output of the engine for each specific speed setting of the governor.

In order to achieve this, the governor can be provided with a load control valve or load control vane servomotor. The load control adjusts the load on the engine to a predetermined value for each specific speed setting of the governor.

Operation

Refer to Figure 7-18. The load control pilot valve plunger is suspended from the load control floating lever. The lever is connected to the power piston tailrod at one end and to the speed setting piston rod at the other end. Any movement of either or both pistons causes a corresponding movement of the plunger which is housed within a non-rotating bushing.

Pressure oil is supplied to the plunger either externally from the propeller pitch setting mechanism or from the governor oil pump through a pressure reducing valve. The pilot valve has two control lands to give signals in the increase and decrease load direction. Most propeller manufacturers use only the signal from the upper land to decrease pitch, if the engine load exceeds a predetermined maximum. On these governors the lower or increase pitch oil line is plugged.

A few propeller manufacturers specify our integral vane servo as shown in Figures 7-14 and 7-18. They mount a cam on the keyed shaft which operates a pneumatic transmitter to obtain a varying air pressure depending on the position of the vane servo. This pressure is used to decrease pitch gradually. Through a pressure reducing valve oil from the governor pump is used to operate the servo. On starting the engine the valve is closed to use all of the oil from the pump to move the main governor servomotor to open the fuel racks.

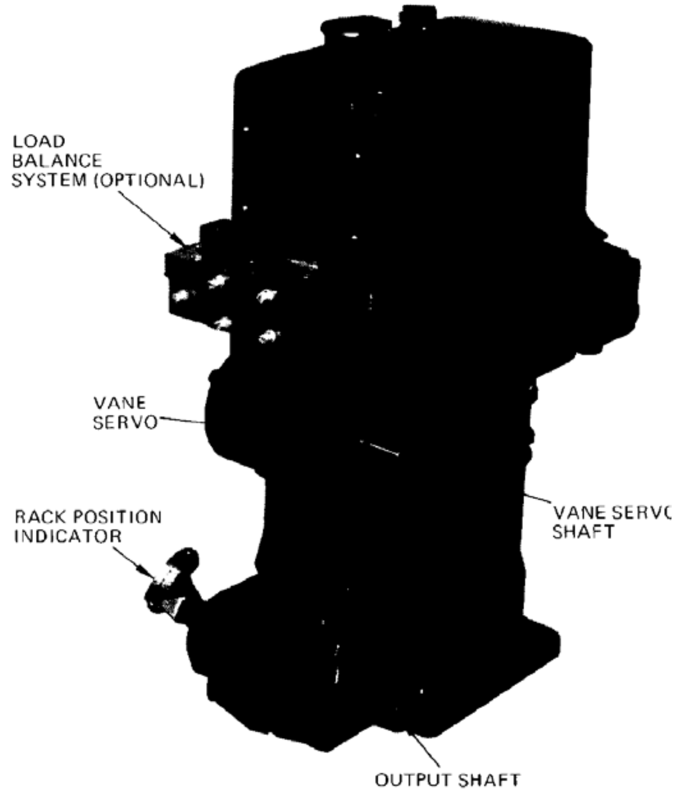


Figure 7-14. PGA with Vane Servo

Since the load-control valve is mainly used to control pitch and load, governor operation for this condition is described. From the schematic it can be seen that there is a fixed and linear relationship keeping the load control valve centered. If for a given speed setting the engine needs more fuel than allowed by the adjustment of the load control valve the power piston will lift it up to uncover the upper port. The propeller manufacturer uses the hydraulic pressure in the oil line coming from the governor to decrease pitch, so that equilibrium is being restored by decreasing load.

If the vane servo is used, it rotates a cam and operates a pneumatic transmitter installed by the propeller manufacturer to send a modulated pneumatic signal to the propeller pitch setting mechanism to decrease pitch. At the same time the other side of the vane is drained and oil flows back to governor sump.

It is possible to obtain non-linear load control curves by incorporating cams and yield links in the load control floating levers and links. Please consult Woodward.

Adjustment

Adjust the load (pitch) control line in two ways, by the range screw (1111) and the eccentric (1103). The range screw affects the slope of the curve. Moving the point from where the load control valve is suspended toward the power piston tailrod flattens the curve. This means that the governor allows higher load at lower speeds. Readjusting the eccentric moves the curve up or down affecting engine loading at all speeds. If the slope is changed it is usually necessary to also readjust the eccentric.

Timing Valves

Timing valves (Figure 7-17) may be located internally in the governor for an integrally mounted vane servo or they may be mounted on the external part of the governor column for an externally mounted vane servo. In either case their function is the same, to control the rate of movement of the vane servo in either the increase or decrease direction. These valves are adjustable to increase or decrease flow as required.

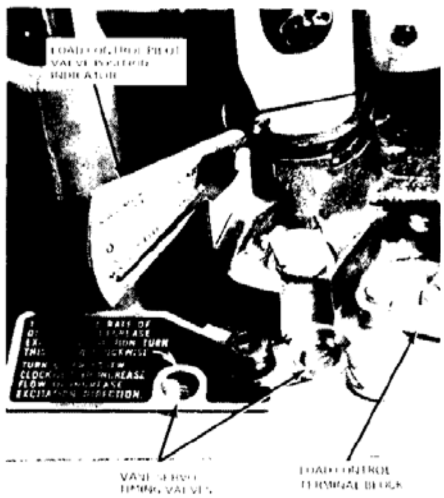


Figure 7-15. Timing Valves for Integral Vane Servo

Figure 7-16. Timing Valves for Externally Mounted Vane Servo

Single Barrel Fuel Limiter

Description

The fuel limiter (Figure 7-18) is essentially a floating lever, a bellcrank, a pressure sensor and cam, and a hydraulic amplifier together with a feedback lever and a fuel limit floating lever. The right end of the floating lever is connected to the tailrod of the governor power piston and pivots about one leg of the bellcrank. The left end of the floating lever rests on the right end of the hydraulic amplifier feedback lever. The position of the bellcrank, and therefore the position of the floating lever pivot point, is determined by the position of the fuel limit cam. Raising the floating lever pivot as manifold air pressure increases, allows the governor power piston to move upward a proportionally greater distance before fuel limiting occurs.

The pressure sensor is a force-balance device consisting of an inlet check valve, an orifice pack restriction, a piston and cam assembly, a restoring spring, a bleed valve, and either a gauge pressure or an absolute pressure bellows arrangement. The sensor establishes a corresponding piston (and cam) position for each different manifold air pressure. The relationship between manifold air pressure and governor power piston position (fuel flow) where limiting occurs is determined by the profile and angular tilt of the cam. Cam profiles are either linear or non-linear depending on engine and turbo-supercharger characteristics.

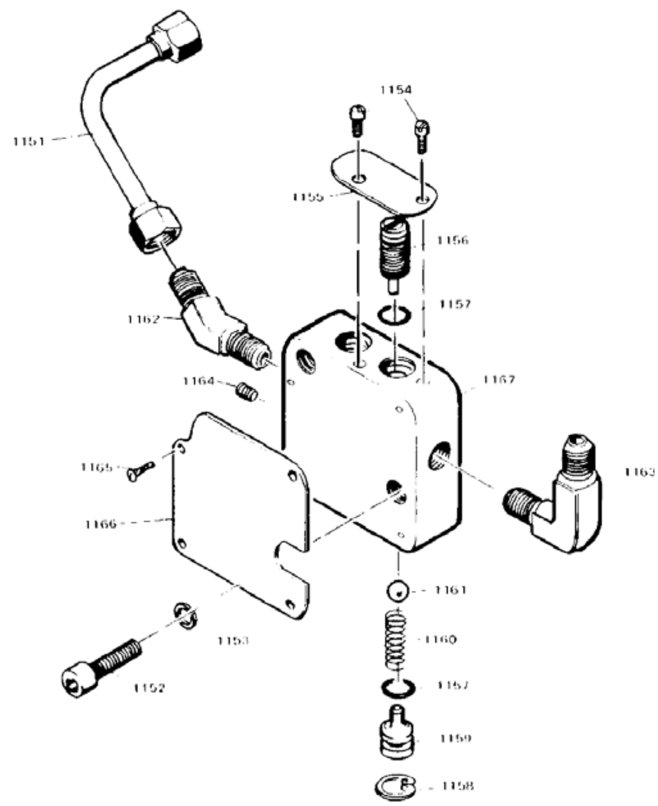


Figure 7-17. Exploded View of Vane Servo Timing Valve Assembly (External Type)

Parts List for Figure 7-17

Ref. No.	Part Name	Quantity
36604-1151	Tube assembly, 3/8	1
36604-1152	Soc. hd. screw, 1/4-28 x 1	2
36604-1153	Splitlock washer, 1/4	2
36604-1154	Fil.hd.screw,8-32x 1/4	2
36604-1155	Valve cover	1
36604-1156	Needle screw	2
36604-1157	O-ring, 0.338 OD	4
36604-1158	Retaining ring	2
36604-1159	Plug	2
36604-1160	Ball spring	2
36604-1161	Check ball, 1/4dia.	2
36604-1162	Elbow, 90°, 1/4 NPTF-to-3/8 tube	1
36604-1163	Elbow, 90° 1/4 NPTF-to-3/8 tube	1
36604-1164	Pipe plug, 1/16-27 NPTF	1
36604-1165	Drive screw, #2 x 3/16	4
36604-1166	Instruction plate	1
36604-1167	Valve case	1
36604-1168 to -1180 Not used		

The hydraulic amplifier is a pilot-operated, single-acting hydraulic cylinder. The amplifier provides the force necessary to overcome the resistance of the speeder spring, lift the shutdown rod, and re-center the governor pilot valve plunger when the fuel limit is reached for a given manifold air pressure.

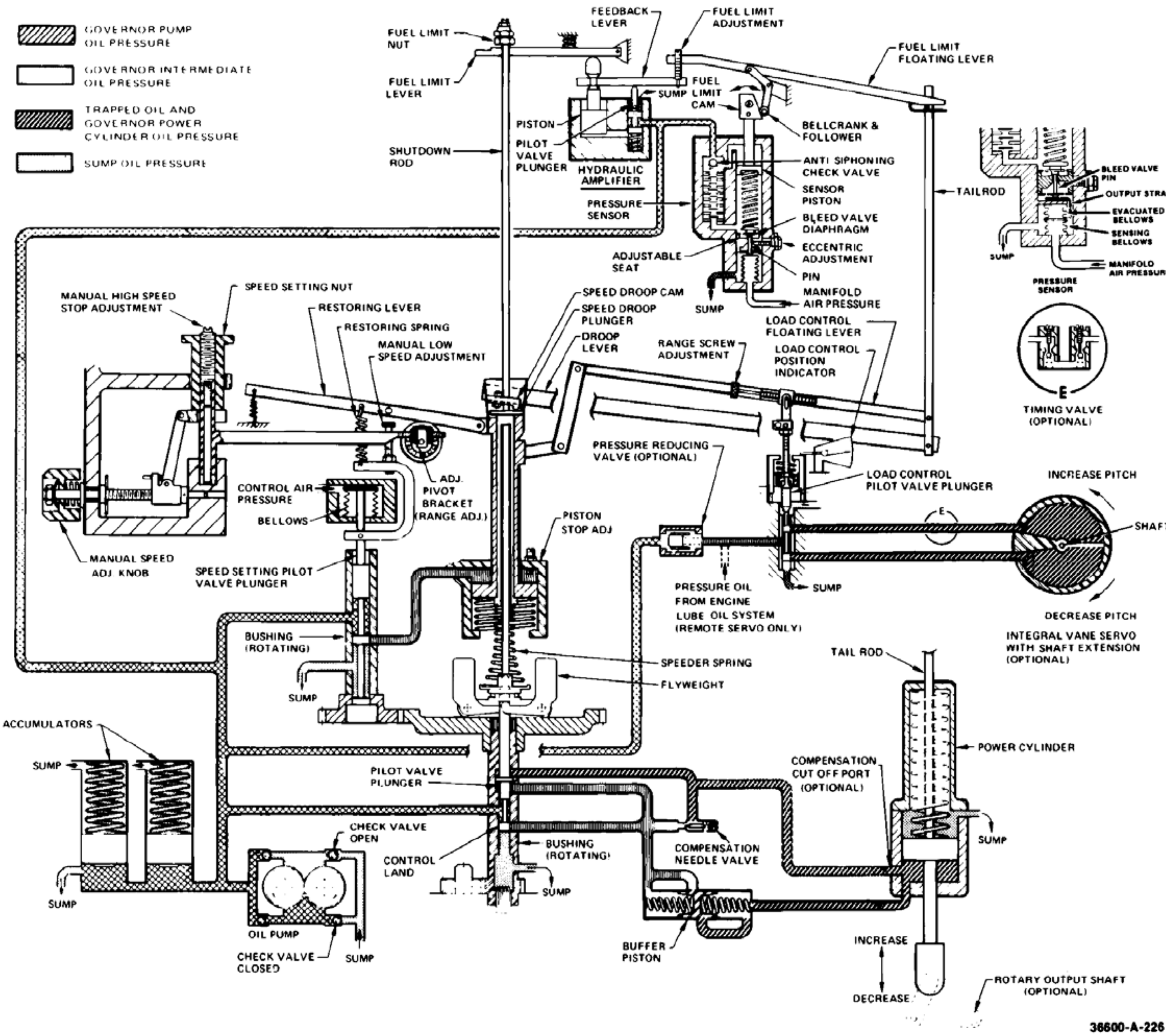


Figure 7-18. Schematic Diagram, Fuel Limiter and Optional Load Control Override Linkage, and Vane Servo

Operation

Pressured oil enters the fuel limiter through the inlet check valve. Oil is directed to the upper side of the sensor piston and through the orifice pack restriction to the underside of the sensor piston. The inlet check valve prevents siphoning of the oil from the limiter housing during shutdown periods and omits the time lag to refill the orifice pack and piston cylinder. This prevents the sensor piston from going to maximum fuel position during start-up.

The bleed valve regulates the rate of oil flow from the area under the sensor piston to sump as a function of manifold air pressure. When the bleed valve bypasses a greater flow of oil from this area than is admitted through the orifice pack, the sensor piston moves downward. Conversely, reducing the bypass oil flow to less than that admitted causes the sensor piston to rise. When the inflow and outflow of oil are equal, the piston remains stationary.

The sensing element of the gage-pressure-type fuel limiter consists of a single, flexible, metallic bellows. Movement of the gauge pressure bellows is transmitted directly to the bleed valve pin. The bellows force tends to open the bleed valve while the restoring spring force tends to close the valve. When these opposing forces balance, the bleed valve diaphragm floats just off of its seat bypassing oil to sump. This rate of oil flow maintains a constant volume of oil in the area under the sensor piston.

Assume that the governor speed setting is advanced to a higher speed setting and a higher manifold air pressure. The governor power piston moves upward supplying the additional fuel required for engine acceleration. Since manifold air pressure lags engine acceleration, the fuel limiter cam and bellcrank initially remain stationary until manifold air pressure rises. As the governor power piston moves upward increasing fuel, the fuel limit floating lever pivots about the upper leg of the bellcrank and depresses the right end of the feedback lever on the hydraulic amplifier. This pushes the amplifier pilot valve plunger below center, allowing pressured oil to flow into the area under the amplifier piston, causing the piston to rise. As the piston rises, it simultaneously lifts the left ends of both the fuel limiter lever and the feedback lever. When the fuel limit lever contacts the fuel limit nut on the shutdown bushing it begins lifting the shutdown rod to re-center the governor pilot valve plunger. The upward movements of the fuel limit and feedback levers continue until the left end of the feedback lever raises far enough to re-center the amplifier pilot valve plunger and stop the flow of oil to the amplifier piston. At this point, the fuel limit lever re-centers the governor pilot valve plunger, stopping the upward movement of the governor power piston. This limits the amount of fuel to provide a proper fuel/air ratio for efficient burning. Although the governor flyweights are in an underspeed condition at this time, the power piston remains stationary until manifold air pressure rises.

As engine speed and load increases, manifold air pressure begins to rise after a short time lag. The increase in manifold air pressure produces a proportionate increase in the sensing bellows force. The bellows force, now greater than the restoring spring force, causes the bleed valve diaphragm to move further off its seat. This allows a greater flow of oil to sump than is admitted through the orifice pack. Governor oil pressure acting on the upper side of the sensor piston forces the piston (and cam) downward and, in the process, further compresses the restoring spring. The piston continues its downward movement until the net increase in restoring spring force equals the net increase in bellows force. This restores the bellows and bleed valve diaphragm to their original positions. At this point, the outflow of oil is again equal to the inflow and movement of the piston is halted.

As the sensor piston and cam move downward in response to a rise in manifold air pressure, the bellcrank rotates in a cw direction. This allows the floating lever pivot point, the left end of the lever, and in turn the hydraulic amplifier pilot valve plunger to rise.

The loading spring under the pilot valve plunger maintains a positive contact between the plunger, levers, bellcrank, and cam. When the pilot valve plunger rises above center, the oil under the amplifier piston bleeds to sump through a drilled passage in the center of the plunger. The passage in the plunger restricts the rate of oil flow to sump and decreases the rate of movement of the amplifier piston to minimize hunting. As the amplifier piston moves downward, the left end of the fuel limit lever also moves downward. This lowers the shutdown rod which in turn lowers the governor pilot valve plunger and increases engine fuel.

The sequence of events described above occurs in a continuous and rapid sequence. Normal governor operation is overridden during an acceleration transient and engine fuel is scheduled as a function of manifold air pressure, regardless of governor speed setting. To prevent interference with normal governing action during steady state operation, the sensor piston and cam continue their downward movement until sufficiently below the effective limiting point.

Table 7-1. Troubleshooting the Manifold Pressure Fuel Limiter

Trouble	Probable Cause	Correction
Hard starting and/or excessive smoke for short duration during starting after a relatively long shutdown period.	Anti-siphoning check valve leaking—sensor piston goes to maximum fuel position at start-up and then returns to minimum fuel position as housing refills with oil.	Replace check valve.
Excessive smoke during accelerations.	Orifice pack clogged—sensor piston goes to and remains at maximum fuel position.	Drain governor oil, flush with fuel oil or kerosene. Refill with clean oil, operate for a short time, drain and refill. If necessary, remove fuel limiter orifice pack, disassemble and clean.
	Fuel limiter not adjusted correctly.	Fuel limiter must be adjusted on a test stand.
	Governor/engine linkage not adjusted correctly.	Adjust linkage to manufacturer's specifications.
	Restoring spring fatigued or broken.	Replace restoring spring.
Engine bogs during accelerations.	Fuel Limiter not adjusted correctly. Governor/engine linkage not adjusted correctly.	Adjust Fuel Limiter. Adjust linkage to manufacturer's specification.
Erratic operation.	Contaminated or foamy oil. Sludge formation.	Drain governor oil, flush with fuel oil or kerosene. Refill with clean oil, operate for a short time, drain and refill. If necessary. remove fuel limiter, disassemble and clean.
	Low governor oil level—air entrainment.	Add oil to correct level as indicated on sight gauge glass. Check for leakage, particularly at governor drive shaft oil seal. Check manifold air pressure line for presence of oil which would indicate leakage at fuel limiter bellows.
	Leakage in manifold air pressure lines or fittings.	Repair leaks.
	Fuel limiter bellows leaking.	Replace bellows.
Dead band at low or high end of fuel limiting schedule.	Sensor piston travel not properly calibrated with manifold air pressure range.	Readjust on test stand.

Conversely, a drop in manifold air pressure rotates the bellcrank in a ccw direction. This lowers the fuel limit lever, depressing the pilot valve plunger, and releases pressured oil to the underside of the amplifier piston. The shutdown rod and governor pilot valve plunger are raised, releasing oil from the power piston cylinder to sump and decreasing fuel to the engine. The left end of the fuel limit floating lever pivots upwards, releasing the hydraulic amplifier pilot valve plunger upward. As the control land of the pilot valve plunger opens the port from the piston cylinder, oil is bled to sump through a hole in the pilot valve plunger shaft. The shutdown rod is lowered, allowing the governor pilot valve plunger to re-center.

Disassembly

The removal and disassembly procedure for the fuel limiter varies depending on the optional features it is equipped with and the extent of maintenance required. Complete removal and disassembly involves partial disassembly of the basic governor and should be performed in the sequence given below as well as in the order of reference numbers assigned to the exploded view (Figure 7-21). Discard o-rings, gaskets, copper sealing washers, retaining rings, cotter pins, etc., removed during disassembly.

IMPORTANT	**Omit those steps which do not apply to the particular fuel limiter being serviced. Do not disassemble the unit any more than absolutely necessary.**

1. Remove component parts of governor load control valve from sensor housing (1280).

2. Remove governor speed setting mechanism and bracket assembly.

3. Remove fuel limit lever and attaching parts (1218 through 1221).

4. Remove fuel limit floating lever and attaching parts (1222, 1223 and 1224). Hold pivot (1225) stationary while removing lever and then remove pivot together with adjusting screw (1226). Remove feedback lever (1227).

5. Disconnect coupling nut (1228) and then back fitting (1231) out of governor column far enough to clear end of connecting tube from sensor bellows (1267). Do not bend or place any strain on tube during removal of the sensor assembly.

6. Remove screws (1232 and 1233) and washers (1234). Lift sensor assembly (1235 through 1280) off governor column. Remove o-ring (1282) from seat in governor column.

7. Disassemble sensor assembly in the order of the reference numbers assigned to Figure 7-21.

8. Cylinder head (1278) is press-fit with housing (1280).

NOTICE	**Calibration of a governor after disassembly of the fuel limiter can be extremely difficult if the governor cannot be removed from the engine and adjusted on a test stand.**

Cleaning

Immerse all parts in solvent and wash ultrasonically or by agitation. Use a nonmetallic brush or jet of compressed air to clean slots and holes. Dry parts after cleaning with a jet of clean, dry air.

Flush orifice pack with a pressurized stream of filtered solvent. Disassemble orifice pack for more thorough cleaning if clogging or sludge buildup is evident.

Apply a light film of lubricating oil to all finely machined surfaces. Store parts in dust-free, moisture-proof containers until reassembled.

Inspection
Visually inspect all parts for damage or wear. Pay particular attention to the following.

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

2. Screws, plugs, and internal threads must be free of corrosion, cracks, burred slots, rounded corners, or damaged threads.

3. All threaded areas, apertures and passages must be free of foreign matter.

4. All linkages must be free of corrosion and must move freely without excessive play.

5. Inspect sensor piston (1251, Figure 7-21) amplifier piston (1246) and amplifier pilot valve plunger (1244) for scuffing, scoring, or wear. If scuffing or scoring is evident, inspect the respective piston or plunger bores for similar damage. Replace all parts which are scuffed or scored. Wear on highly polished areas is generally acceptable if less than one-third the length of the piston or plunger land is affected. If excessive wear is suspected, check the worn area for an out-of-round condition. Replace the pistons if the worn area is more than 0.001 inch out-of-round. Replace the plunger if the worn areas on the lands are more than 0.005 inch out-of-round.

6. Corners of plunger lands must be sharp. Replace plunger if corners of lands are nicked or rounded off to any extent.

7. Piston and plungers must move freely in their respective bores.

8. Bleed valve diaphragms (1254) must be flat within 0.040 inch (1.02 mm). Any damage such as nicks, creases or other deformities, scratches in excess of 0.001 inch (0.03 mm) in depth, etc., in necked area of diaphragm center section is cause for replacement of the part.

9. Examine sensor bellows (1267) for evidence of distortion, cracks or other damage. The longitudinal length of the bellows assembly, as measured on the bellows centerline without strap (1270), and barometric pressure at time of factory assembly are marked on the upper end of the bellows. If this length has increased more than 0.015 inch (0.38 mm) at the specified barometric pressure, the evacuated bellows is leaking and the assembly must be replaced. Plug the tube and immerse the bellows assembly in hot water (200 °F/93 °C). If bubbles are observed, the sensing bellows is leaking and the assembly must be replaced.

10. Check needle bearing (1242) for freedom of rotation. Replace bearing if there is any detectable roughness.

Repair or Replacement

Limit repair of parts to removal of minor nicks, burrs or corrosion from mating surfaces. Polish slightly corroded areas in mating surfaces using a fine (600 grit) abrasive cloth or paper and oil. Repair or rework to any other extent is impractical and the part should be replaced.

NOTICE	**Handle critical parts with extreme care to prevent damage to mating edges and surfaces. Maintain sharp edges of plunger lands, piston grooves, metering ports, etc. Rounded edges, nicks, ,or other damage to such edges results in excessive internal leakage and decreased control sensitivity.**

Lubrication

Lubricate metal parts liberally with lubricating oil at time of reassembly. Lubricate O-rings with petrolatum before installation.

Reassembly

Use a dust-free work area for reassembly. Reassemble and install the fuel limiter and load control override linkage in reverse order of the disassembly instructions. Pay particular attention to the following:

1. Obtain new O-rings, gaskets, sealing washers, retaining rings, cotter pins, etc., to replace those removed during disassembly.

2. Install retaining rings with sharp edge in the direction of the applied force.

3. If orifice pack was disassembled for any reason, alternately install gaskets (1262), and orifice plates (1263). Be sure to install a gasket between orifice plate and washer at each end of stack. Plates must be alternated so adjacent orifice holes are diametrically opposite.

Parts List For Figure 7-19

Ref. No.	Part Name	Quantity
36604-1101	Adjusting block	1
36604-1102	Soc. hd. screw. 8-32 x .875	1
36604-1103	Wide link eccentric	1
36604-1104	Cotter pin, 0.060 x 0.375	2
36604-1105	Pivot valve link R.H.	1
36604-1105a	Pivot valve link L.H.	1
36604-1106	Movable fulcrum pin	1
36604-1107	Headed pin	1
36604-1108	Cotter pin. 0.060 x 0.375	1
36604-1109	Floating lever adj. screw	1
36604-1110	Link adjusting spring	1
36604-1111	Adjusting screw knob	1
36604-1112	Roll Pin	1
38604-1113	Cotter pin, 1/16 x 5/8	1
36604-1114	DO NOT USE	
36604-1115	DO NOT USE	
36604-1116	Floating lever assembly	1
36604-1117	through 1135 DO NOT USE	
36604-1136	Washer	2
36604-1137	Floating lever stop pin	1
36604-1138	Lock nut	1
36604-1139	Slotted set screw, .250-20 x 2.375	1
38604-1140	Speeder servo lever pin	1
36604-1141	Speed spring power cylinder	1
36604-1142	Hex nut, 10-32 UNF-2B	2
36604-1143	Set screw. 10-32 x 1.750	1
36604-1144	Guide pin	1
36604-1145	Shutdown rod & speeder spring power piston	1
36604-1146	Power piston fulcrum	1
36604-1147	Droop plunger cap	1
36604-1148	Droop lever assembly	1
36604-1149	Shutdown lock nut	1
36604-1150	Shutdown nut	1
36604-1151	through 1180 See Figure7-17	
36604-1177	Pivot pin link (optional)	1
36604-1178	Grooved link pin (optional)	1
36604-1179	Retaining ring, (optional)	4
36604-1180	Grooved adj. floating lever pin (optional)	1
36604-1181	Screw	1
36604-1182	Lockwasher	1
36604-1183	Load control link	1
36604-1184	Droop cam	1
36604-1165	Nut	1
36604-1186	Load control link	1
36604-1187	Stop screw, 8-32	1
36604-1188	Check valve	1
36604-1189	Pivot pin link (optional)	1
36604-1190	Grooved linkage pin (optional)	1
36604-1191	Retaining ring, .145 ID (optional)	4
36604-1192	Grooved adj. floating lever pin (optional)	1
36604-1193	through 1200 Not used	

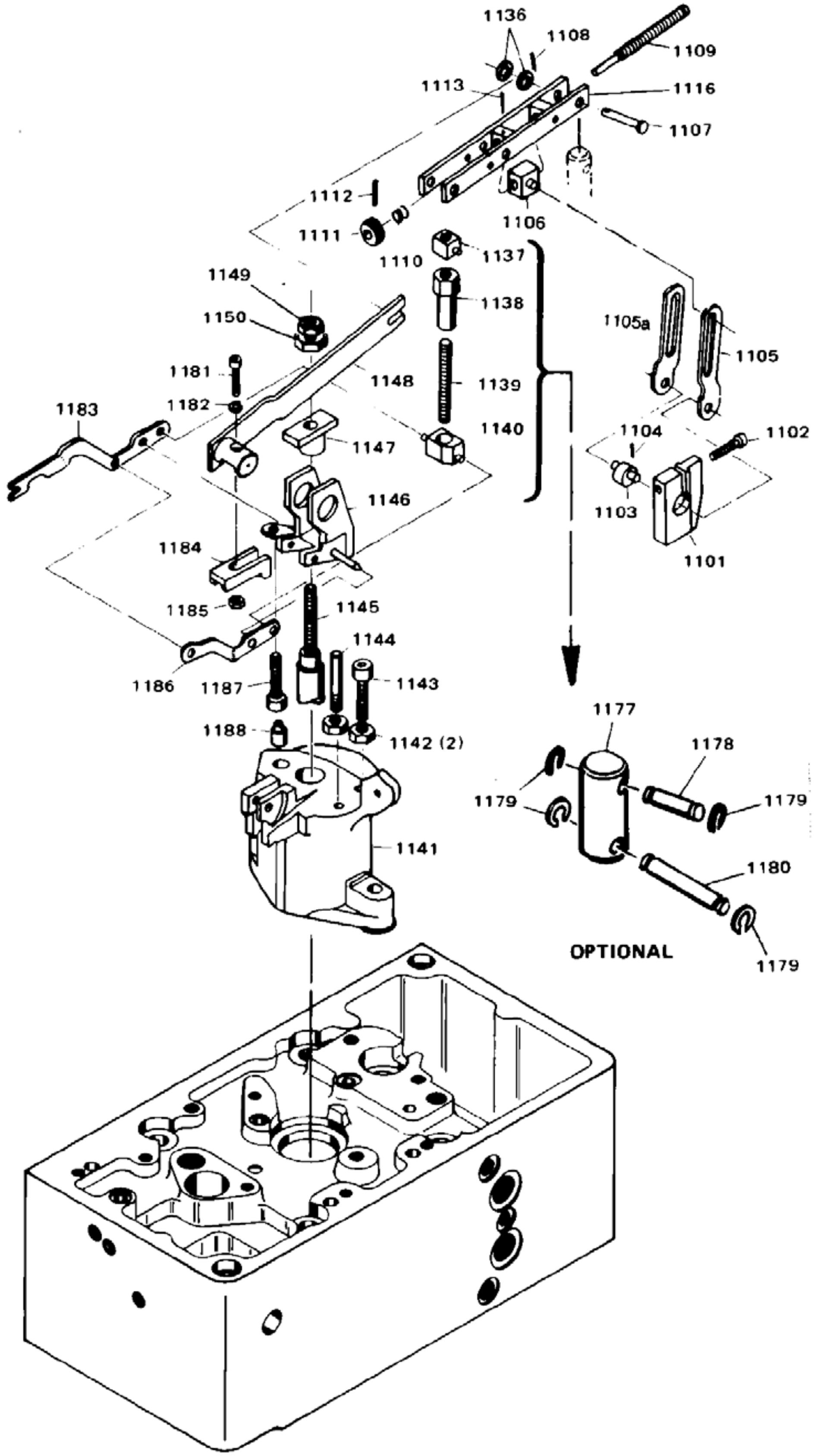


Figure 7-19. Exploded View of Adjustable Load Control Linkage

Parts List For Figure 7-20

Ref. No.	Part Name	Quantity
36604-1501	Overriding cylinder	1
36604-1502	Load control indicator scale and pointer assembly	1
36604-1503	Washer, 13/64 x 7/16 x 1/32	1
36604-1504	Screw, phillips head, 10-32 x 1/4	1
36604-1505	Taper screw, 1/4-28	2
36604-1506	Split lock washer, 17/64	2
36604-1507	Cap screw, hex head, 1/4-28 x 1	2
36604-1508	Overriding piston	1
36604-1509	Load control valve spring collar	1
36604-1510	Lock nut, 5/16-24	1
36604-1511	Inner load control valve spring	1
36604-1512	Outer load control valve spring	1
36604-1513	Load control spring retainer	1
36604-1514	Spring retainer snap ring	1
36604-1515	Load control indicator washer	1
36604-1516	Overriding cylinder head	1
36604-1517	Load control plunger oil seal	1
36604-1518	Load control oil seal gasket	1
36604-1519	Spacer (if no oil seal)	1
36604-1520	Load control pilot valve plunger	1
36604-1521	Load control pilot valve bushing spring	1
36604-1522	Load control pilot valve bushing	1
36604-1523	Internal snap ring	1
36604-1524	Straight half union, 3/8 NPT-1/2 tube	2
36604-1525	Column and insert assembly	1
36604-1526	90° elbow, 3/8 NPT-1/2 tube	2

36604-1527 through 1600 Not used

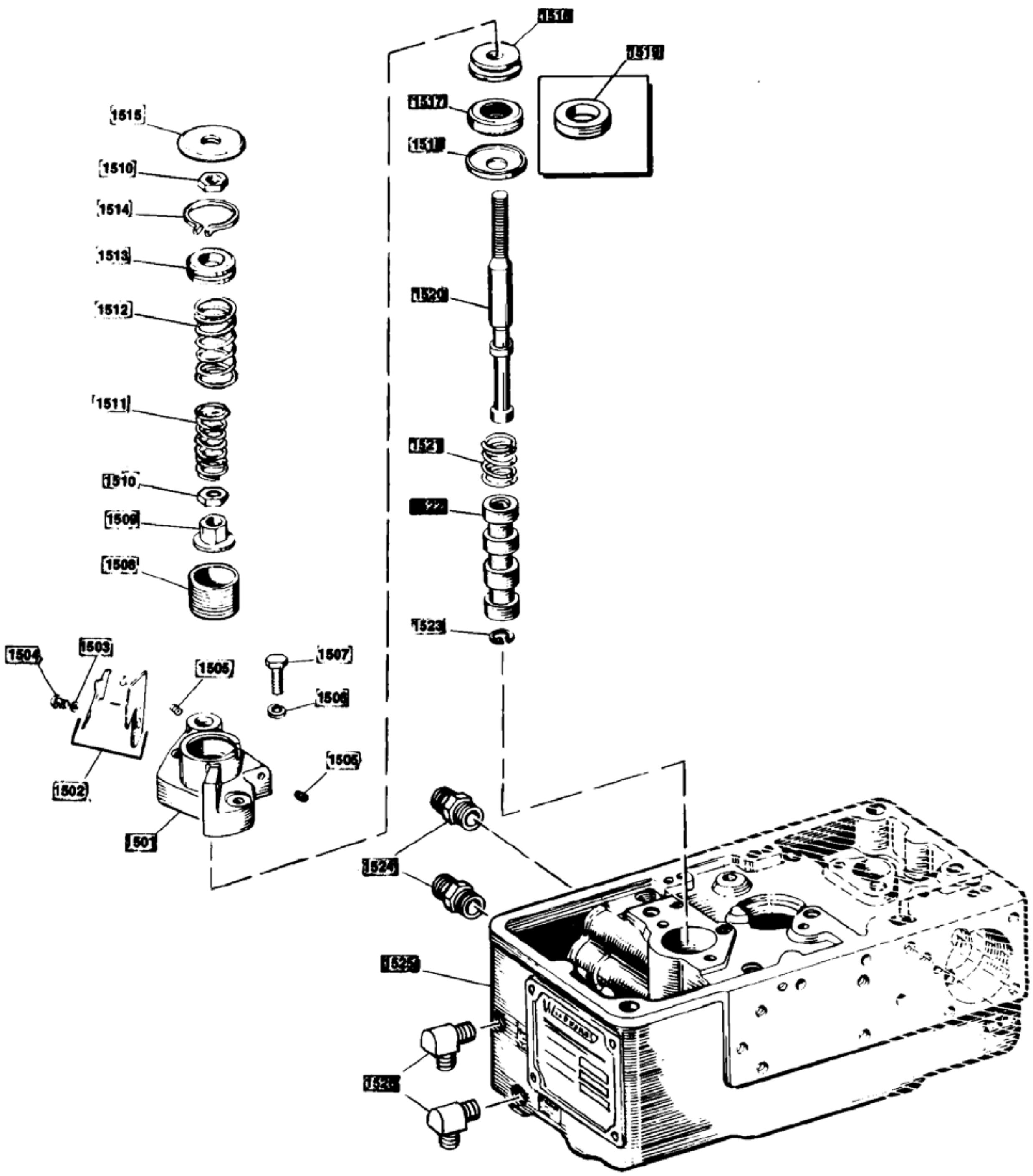


Figure 7-20. Exploded View of Load Control Pilot Valve

Parts List For Figure 7-21

Ref. No.	Part Name	Quantity
36604-1214	Nut, hex., 8-32	1
36604-1215	Nut, hex., 5/16-24	1
36604-1216	Nut, hex., 5/16-24 (fuel limit)	1
36604-1217	Shutdown bushing	1
36604-1218	Cotter pin, 1/16 x 5/B	1
36604-1219	Pivot pin (fuel limit lever)	1
36604-1220	Loading spring	1
36604-1221	Fuel limit lever	1
36604-1222	Cotter pin, 1/16 x 3/8	1
36604-1223	Retaining ring, E-type	1
36604-1224	Fuel limit floating lever	1
36604-1225	Pivot	1
36604-1226	Adjusting screw (fuel limit)	1
36604-1227	Feedback lever	1
36604-1228	Coupling nut, 1/2-20	1
36604-1229	Ferrule, 1/4 tube	1
36604-1230	Hex, nut, 1/2-20	1
36604-1231	Ballhead union, 1/4 tube	1
36604-1232	Soc. hd. screw 1/4-28 x 1-1/8	1
36604-1233	Soc. hd. screw 1/4-28 x 1-3/4	1
36604-1234	Lockwasher 1/4	2
36604-1235	Soc. hd. screw 10-32 x 1/2	2
36604-1236	Soc. hd. screw 10-32 x 1-1/2	1
36604-1237	Lockwasher #10	3
36604-1238	Cotter pin, 1/16 x 5/8	2
36604-1239	Pivot pin (bellcrank)	1
36604-1240	Bellcrank	1
36604-1241	Drilled straight pin	1
36604-1242	Needle bearing	1
36604-1243	Linkage bracket	1
36604-1244	Amplifier pilot valve plunger	1
36604-1245	Pilot valve loading spring	1
36604-1246	Amplifier piston	1
36604-1247	Sensor piston sleeve	1
36604-1248	Nyloc button soc. hd. screw 8-32 x 3/8	1
36604-1249	Roll pin, 1/8 x 3/8	1
36604-1250	Fuel limit cam	1
36604-1251	Sensor piston	1
36604-1252	Restoring spring	1
36604-1253	Restoring spring seat	1
36604-1254	Bleed valve diaphragm	1
36604-1255	Filter screen	1
36604-1256	O-ring, 1/2 OD	2
36604-1257	Check valve assembly	1
36604-1258	Retaining ring	1
36604-1259	Washer, 9/64 ID x 3/8 (max.) OD x 1/32	1
36604-1260	Orifice pack spring	1
36604-1261	Washer, 3/16 ID x 3/8 (max.) OD x 1/16	2
36604-1262	Gasket	33
36604-1263	Orifice plate	32
36604-1264	Orifice case	1
36604-1265	Not used	1
36604-1266	Nyloc button soc. hd. screw, 8-32 x 3/8	2
36604-1267	Sensor bellows (gauge pressure)	1
36604-1268	O-ring 1-1/4 OD	1
36604-1269	Bellows spacer	1
36604-1270	Bellows output strap	1
36604-1271	Pin, .059 x .082 dia. x 0.782 OAL	1
36604-1272	Retaining ring, internal	1
36604-1273	Hex. hd. screw, 1/4-28 x 3/4	1
36604-1274	Soft copper washer 1/4 ID x 1/2 OD x 1/32	1
36604-1275	Eccentric	1
36604-1276	Copper gasket	1
36604-1277	Valve seat	1
36604-1278	Cylinder head (overriding)	1
36604-1279	Taper screw	9
36604-1280	Housing	1
36604-1281	Straight pin (tailrod)	1
36604-1282	O-ring, 0.338 OD	1
36604-1283	Pilot valve plunger nut	1
36604-1284	Loading spring	1
36604-1285	Spring seat	1
36604-1286 to -1300	Not used	

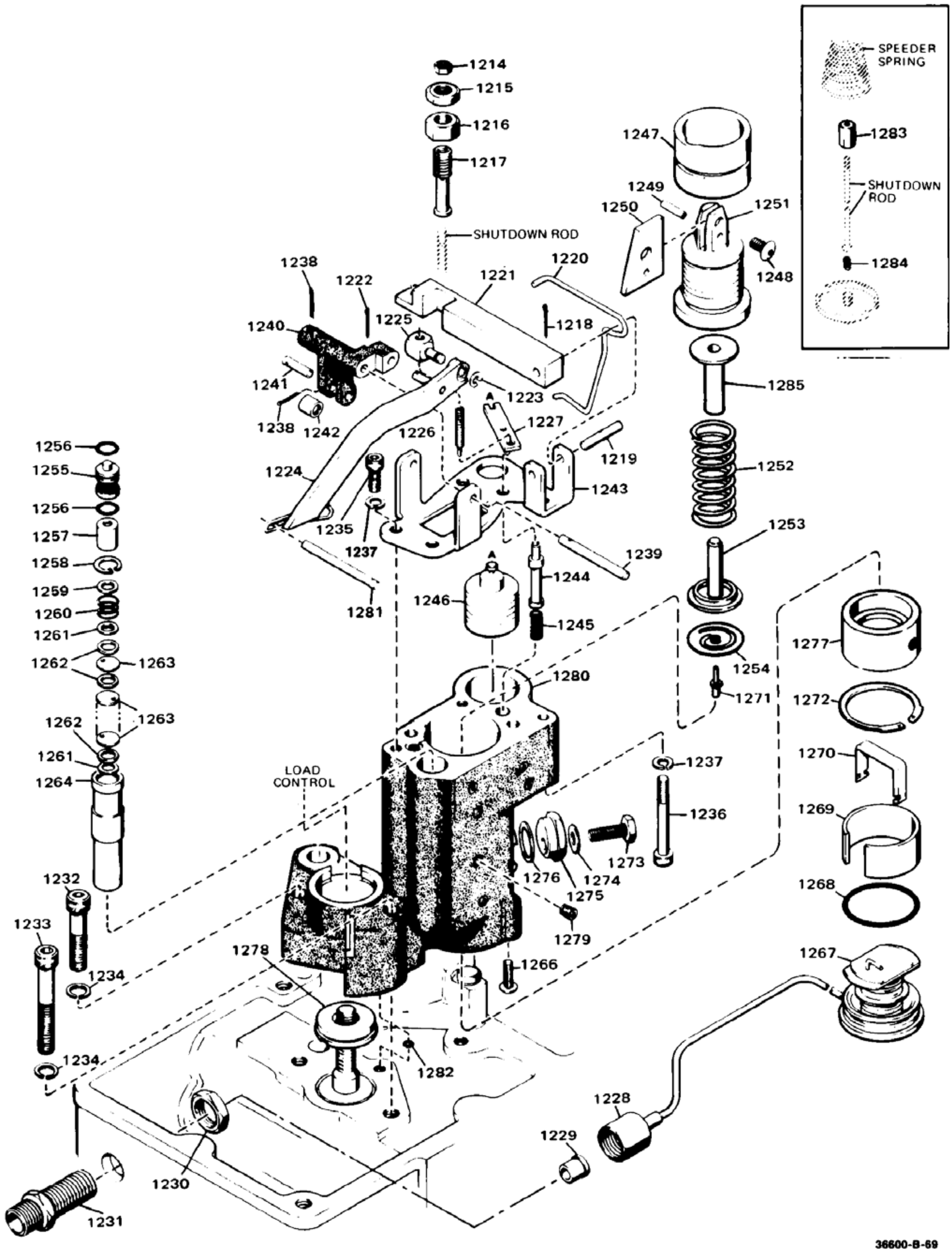


Figure 7-21. Exploded View of Fuel Limiter

Additional Accessories

Introduction

A number of other optional auxiliary features and devices are available for use, either singly or in combination, with the PGA governors. These devices permit the governor to perform other secondary functions such as limiting engine load, controlling engine load to maintain a constant power output for each speed setting, minimizing the tendency to overfuel when starting, permitting temporary overloads, emergency shutdown in the event of ancillary equipment failure or loss of lubricating oil pressure, etc. Auxiliary equipment should be supplied as original equipment in the governor. It is recommended that the customer contact Woodward Governor Company if field installations are desired.

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

Booster Servomotor

The booster servomotor is used in conjunction with the governor to assist the prime mover in starting quickly. This device supplies oil under pressure to the governor at the instant starting air is supplied to the prime mover and enables the governor to move the linkage to the fuel-on position immediately. See manual 36684.

Extensible Power Cylinder Tailrod

This device may be used in governors equipped with any type of fuel (or load) limit mechanism to permit the prime mover to temporarily carry overloads. See manual 36640.

Governor Heat Exchanger

A heat exchanger may be necessary in applications where the governor is mounted near heat producing equipment or where high drive speeds generate so much heat that the governor oil becomes too hot. The heat exchanger may be integral with the governor, externally mounted on the governor, or remotely located. See manual 36641.

Shutdown Devices

Various devices can be incorporated in the governor to shutdown the prime mover or provide an alarm signal in the event of equipment failure. These devices are used in a variety of applications including installations where automatic safety devices are a necessity. Shutdown devices are available in the following arrangements to suit the particular operating conditions:

Pressure Actuated Shutdown
The pressure actuated shutdown (air, oil, water) provides the same protective function as the solenoid operated shutdown. It may be set up to effect shutdown with either loss of or excessive signal pressure. See manual 36651.

Lubricating Oil Pressure Failure Shutdown

This is an automatic shutdown device which protects the prime mover in the event of a partial or complete failure of the prime mover lubricating oil system. It monitors lubricating oil pressure and is so designed that the shutdown pressure level becomes progressively higher as prime mover speed increases. This allows a relatively low minimum oil pressure level for safe operation at idle speed while requiring increasingly higher levels for safe operation at higher speeds. Some of these devices also include a capability to monitor prime mover oil pump inlet pressure and effect shutdown if excessive vacuum (suction) occurs. A time delay feature (adjustable within a range of 15–40 seconds) allows the prime mover to be started without lubricating oil pressure yet prevents prolonged operation if a safe pressure level is not reached within the preset time. At operating speeds above idle, the time delay is normally bypassed so that shutdown is immediate. See manual 36652.

Load Balance System

Pneumatic Load Balance

A pneumatic load balance system is available for PGA governors. This unit is desirable when two or more engines are driving a common load, such as a propeller shaft of a ship. The engines can be controlled in unison so the loads on all engines are proportionally shared. This is necessary if the speed and load is to be varied over a wide range. See manual 36686.

Transfer Valve

A transfer valve is available for use with the pneumatic load balance system. It facilitates the remote control of the transfer functions for the pneumatic load balance system. See manual 36686.

Parts List For Figure 7-22

Ref. No.	Part Name	Quantity
36604-1301	Hex, nut, .250-28	2
36604-1302	Shakeproof washer, .250	2
36604-1303	Stud	2
36604-1304	Rotary servo end plate	1
36604-1305	Pin	2
36604-1306	Plug	1
36604-1307	Soc. cap screw	2
36604-1308	Plain washer	2
36604-1309	Lockwasher, .250	2
36604-1310	Needle bearing	1
36604-1311	Oil seal ring, 2.664 OD	1
36604-1312	Rotary servo housing	1
36604-1313	Dowel pin	2
36604-1314	Soc. hd. screw, 8-32 x .500	2
36604-1315	Lockwasher, .281 OD	2
36604-1316	Rotary servo	1
36604-1317	Vane insert leaf spring	2
36604-1318	Vane insert	2
36604-1319	Rotary servo shaft assy.	1
36604-1320	Needle bearing	1
36604-1321	Oil seal ring, 2.664 OD	1
36604-1322	Pin	1
36604-1323	Rotary servo back plate	1
36604-1324	Plain washer	2
36604-1325	Lockwasher, .250	2
36604-1326	Soc. hd. cap screw	2
36604-1327	Straight pin	1
36604-1328	O-ring	1
36604-1329	Straight pin, 0.0638 OD	1
36604-1330	Woodruff key	1
36604-1331	Shaft assembly	1
36604-1332	O-ring	2
36604-1333	Side panel gasket	1
36604-1334	Side plate	1
36604-1335	Soc. hd. cap screw	8
36604-1336	Ball bearing	1
36604-1337	Side plate gasket	1
36604-1338	Side plate cover	1
36604-1339	Soc. cap screw, .250-28 x 1.50	4
36604-1340	Oil seal, 1.125 OD	1
36604-1341	Soc. hd. cap screw, .250-20 x .625	8
36604-1342	High collar lockwasher, .250 ID	22

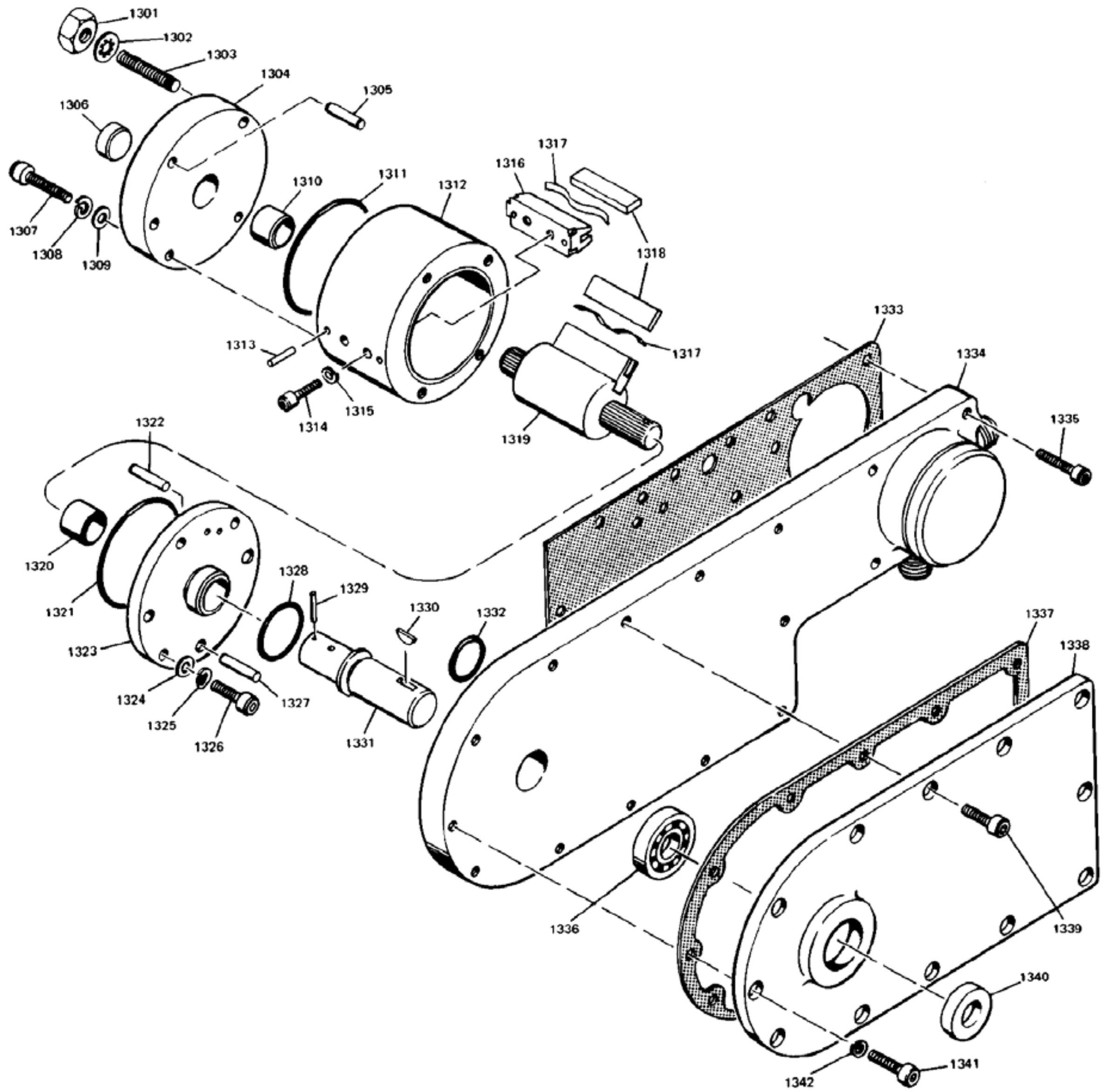


Figure 7-22. Exploded View of Integral Vane Servo

Parts List For Figure 7-23

Ref. No.	Part Name	Quantity
36604-1381	Screw, soc. hd., 1/4-28 x 2 3/4	A.R.
36604-1382	Lockwasher, split, 1/4	A.R.
36604-1383	Preformed packing, 7/16 OD	1
36604-1383a	Preformed packing	1
36604-1384	Plug and filter assembly	1
36604-1385	Preformed packing, 11/4 OD	1
36604-1386	Preformed packing, 11/16 OD	1
36604-1387	Plug	1
36604-1388	Gasket, soft copper	1
36604-1389	Case, 3-hole	A.R.
36604-1390	Case, 4-hole	A.R.

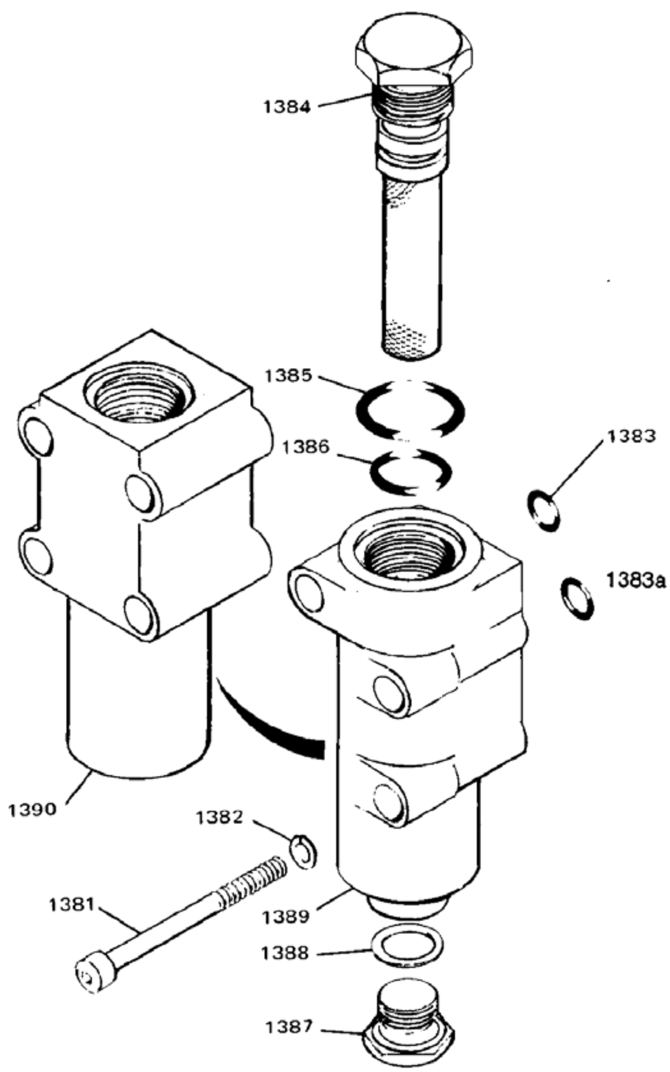


Figure 7-23. Exploded View of Fuel Limiter Oil Filter

Chapter 8.
Product Support and Service Options

Product Support Options

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

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

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

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

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.

- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.

- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

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

Product Service Options

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

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

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in “like-new” condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

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

NOTICE

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

Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

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

- Technical Support
- Product Training
- Field Service

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

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

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

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

Products Used in Electrical Power Systems

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

Products Used in Engine Systems

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

Products Used in Industrial Turbomachinery Systems

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

Technical Assistance

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

General

Your Name ______________________

Site Location ______________________

Phone Number ______________________

Fax Number ______________________

Prime Mover Information

Manufacturer ______________________

Engine Model Number ______________________

Number of Cylinders ______________________

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

Power Output Rating ______________________

Application (power generation, marine, etc.) ______________________

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter ______________________

Control Description or Governor Type ______________________

Serial Number ______________________

Control/Governor #2

Woodward Part Number & Rev. Letter ______________________

Control Description or Governor Type ______________________

Serial Number ______________________

Control/Governor #3

Woodward Part Number & Rev. Letter ______________________

Control Description or Governor Type ______________________

Serial Number ______________________

Symptoms

Description ______________________

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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 36604M.

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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.