WOODWARD

Product Manual 36606
(Revision B)
Original Instructions

PGA Governor
8554-255

Supplement to Manual 36604

Operation Manual

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

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

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Proper Use

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

Translated Publications

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

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 Out-of-date translations are marked with ⚠.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

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Important Definitions

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

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

⚠WARNING

Overspeed / Overtemperature / Overpressure

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

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

⚠WARNING

Personal Protective Equipment

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

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

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

⚠WARNING

Start-up

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

⚠WARNING

Automotive Applications

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

NOTICE

Battery Charging Device

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

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

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

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

Follow these precautions when working with or near the control.

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

Chapter 1.
General Information

This manual, when used in conjunction with manual 36604 (*PGA Governor*), describes PGA governor 8554-255. Various auxiliaries incorporated in model 8554-255 are explained in the following chapters of this manual.

Chapter 2.
Power Servo

Introduction

The 8554-255 PGA governor has 58 ft-lb (79 J) work capacity. This is obtained by using a Woodward 29 ft-lb (39 J) servo and 200 psi (1379 kPa) governor accumulator pressure.

Description

With differential power cylinder, the governor pilot valve plunger controls the movement of the power piston. The piston, acting through the connecting linkage at the rod end, controls the fuel or steam to the engine or turbine.

In the differential power cylinder, the area on one side of the power piston is smaller than the area on the other side. Therefore, less oil pressure is required against the larger side than against the smaller side to move the piston. Pressured oil is directed to the side of the piston with the smaller area. This pressure urges the piston to the increase fuel direction. However, the piston can move only when the governor pilot valve plunger is un-centered to permit oil to flow. The pilot valve plunger moves only when a change in prime mover speed is required. With the pilot valve plunger centered, the power piston is, in effect, hydraulically locked.

Surrounding the power piston and its piston rod are grooves connected to the intermediate oil pressure between the governor pilot valve plunger and the buffer piston. The seal grooves insure that any leakage of pressure oil from the power cylinder to the sump comes from a part of the hydraulic circuit where it will not interfere with governor operation.

29 ft-lb Differential Power Cylinder

Reciprocating Motion

Figure 2-1 illustrates a typical 29 ft-lb (39 J) power cylinder, with reciprocating (push-pull) motion, installed on a PG governor. Two separate power cylinders are available with push-pull motion. One arrangement provides for a “push” to increase fuel or steam to the prime mover, and the second arrangement provides for a “pull” to increase. In either arrangement, the oil pressure is directed to the side of the power piston with the larger piston area to move the piston in the increase fuel direction. The power cylinder is also available with rotary motion.

Figure 2-1 shows a “push” to increase fuel type of power piston. In this type of power cylinder, the power piston area is larger and requires a larger volume of oil to move the piston (in response to load changes on the prime mover) than the normal buffer piston displacement is capable of producing. A direct passage is provided between the governor pilot valve plunger control land and power piston to provide the large volume of oil needed to move the piston for fast responses. Pressured oil is released to the power piston when the pilot valve plunger is lowered below its centered or balanced position. The open port admits pressure oil to the power piston and buffer piston area, forcing the power piston towards the increase fuel direction.

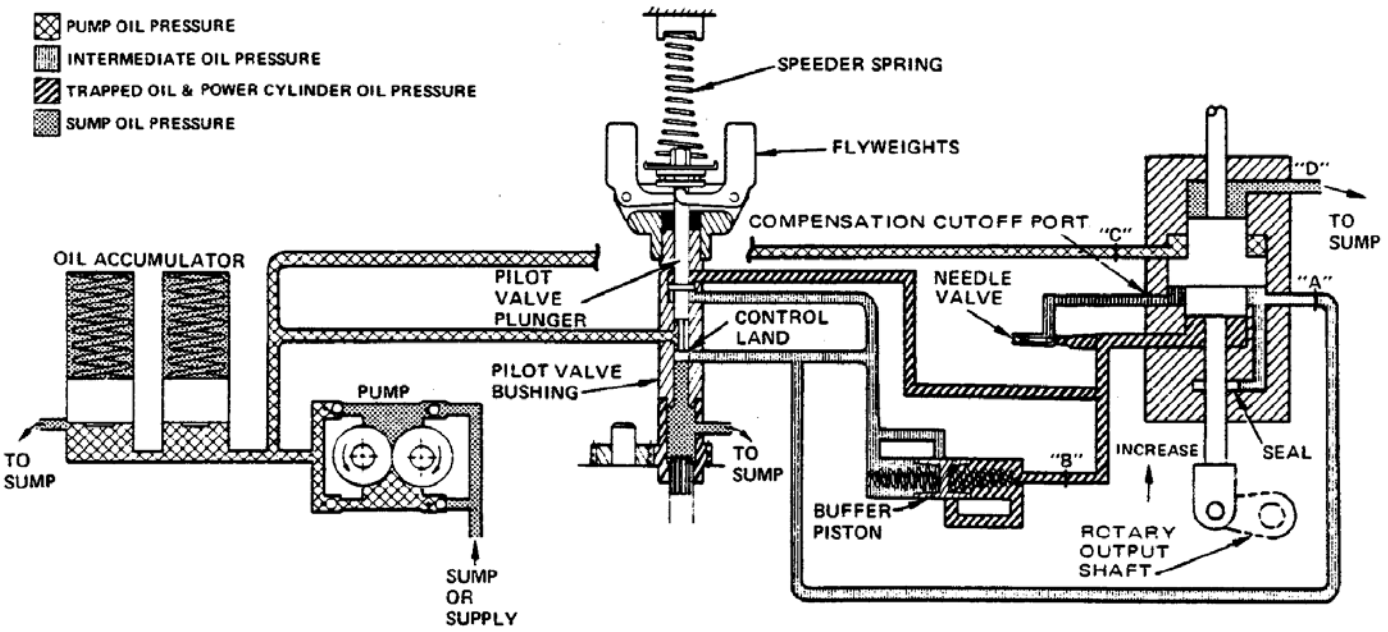

Figure 2-1. Schematic Diagram of 29 ft-lb Differential Power Cylinder (linear output)

Raising the pilot valve plunger above its centered position releases the trapped oil from below the power piston to sump. The pump pressured oil forces the piston and terminal shaft in the decrease fuel direction. Refer to the appropriate manual for the principles of operation of your particular governor. All power cylinders used with reciprocating output operate on the same principal.

Rotary Motion

With rotary motion power cylinders, the reciprocating motion is converted to a rotary motion.

When the pilot valve plunger is lowered below its centered or balanced position, the control port releases pressured oil to. the needle valve and the buffer piston area, moving the buffer piston. Oil is released to the power cylinder and forces the power piston in the direction to increase fuel to the prime mover.

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

Replacement Parts Information

Figure 2-2 shows all replaceable parts of the governor. When ordering replacement parts, it is essential to include the following information:

- Governor serial number and part number shown on nameplate
- Manual number (this is manual 36606)
- Part reference number in parts list and description of part or part name

The numbers assigned in the parts list are used as reference numbers and are not specific Woodward part numbers. Woodward will determine the exact part number for your particular governor.

Parts List for Figure 2-2, 29 ft-lb Power Servo

Ref. No.	Part Name	Quantity
36606-1	Screw, cap, soc. hd., 5/16-24 x 3/4	6
36606-2	Washer, splitlock, 5/16	8
36606-3	Power cylinder head	1
36606-4	Screw, cap, soc. hd., 1/4-28 x 1/2	1
36606-5	Washer, flat, 17/64 ID x 9/16 OD x 1/16 Thk	1
36606-6	Tailrod end	1
36606-7	Tailrod, power piston	1
36606-8	Screw, cap, soc. hd., 1/428 x 7/8	8
36606-9	Washer, splitlock, 1/4	8
36606-10	Cover, power cylinder	1
36606-11	Plug, pipe, 1/8-27 NPT	1
36606-12	Gasket	1
36606-13	Screw, cap, soc. hd., 5/16-18 x 1	2
36606-14	Screw, fil. hd., 10-32 x 5/8	1
36606-15	Pin, taper, +2/0 x 3/4	1
36606-16	Rack dial segment	1
36606-17	Screw, drive	2
36606-18	Scale, terminal shaft	1
36606-19	Ring, retaining	2
36606-20	Pin, power lever	1
36606-21	Pin, power lever	1
36606-22	Power lever	1
36606-23	Nut, 7/16-20	1
36606-24	Link, power piston	2
36606-25	Pin, piston rod	1
36606-26	Packing, preformed	1
36606-27	Power piston	1
36606-28	Seal, oil	1
36606-29	Bearing, needle	1
36606-30	Seal, oil	1
36606-31	Bearing, needle	1
36606-32	Screw, cap, soc. hd., 8-32 x 1/4	2
36606-33	Washer, splitlock #8	2
36606-34	Pointer, rack scale	1
36606-35	Valve, needle	1
36606-36	O-ring, 0.438 OD	1
36606-37	Power cylinder	1

36606-38 through -50 Not used

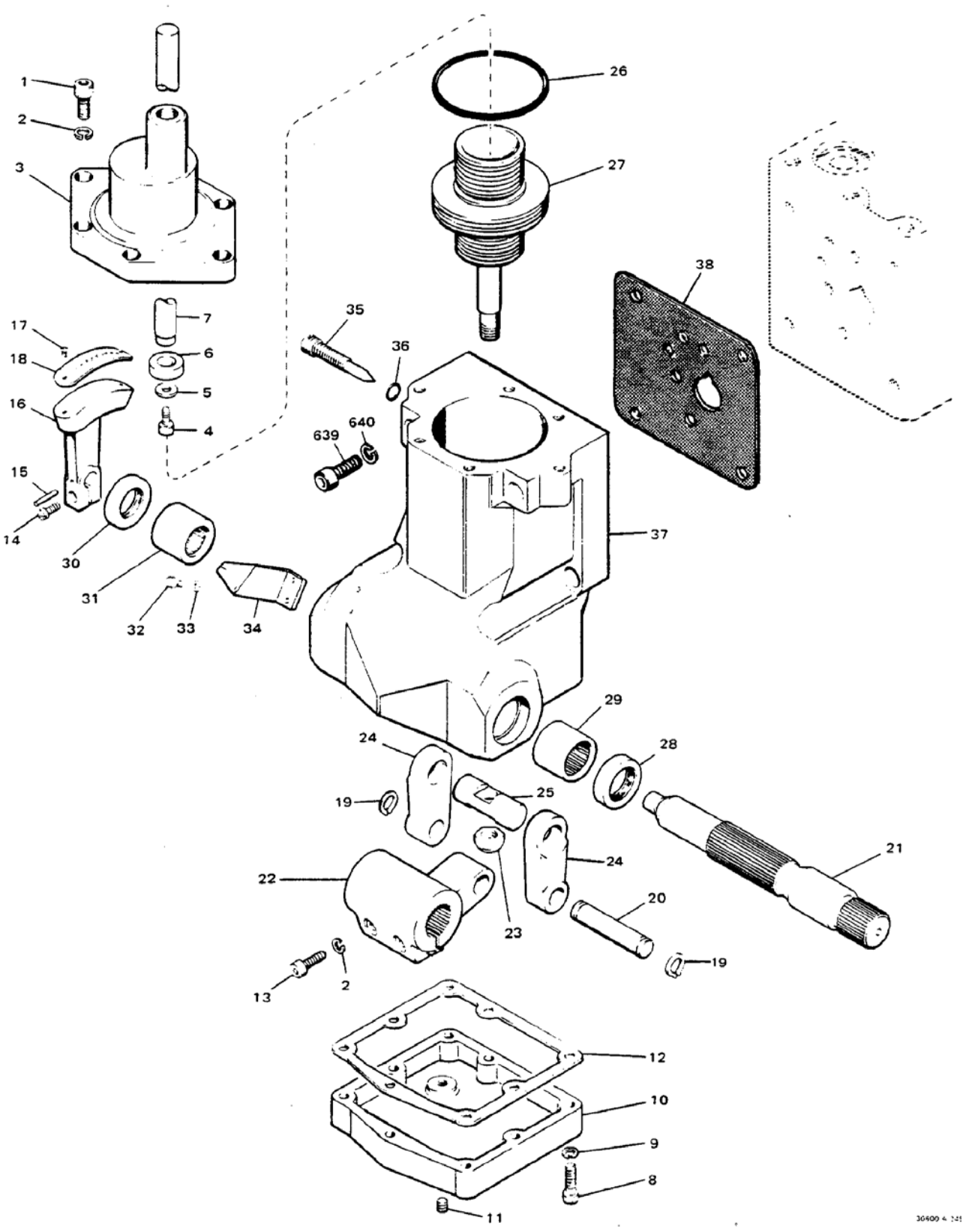

Figure 2-2. Exploded View of 29 ft-lb Differential Power Cylinder
(rotary output with tailrod)

Chapter 3.
PG Base Assemblies

Introduction

The base assemblies described in this manual are essential to the operation of all PG governors; the governor is incomplete without its base. Refer to the applicable governor manual for information on how the base assemblies relate to the governor.

This chapter provides description, maintenance/overhaul, and replacement parts information for Woodward PG/UG-40 base assembly. This base is used on the 8554-255 governor.

All PG base assemblies have essentially the same basic components. The difference between units is the base configuration and the type of drive shaft used (see Figure 3-1). Special drive shafts and bases (not covered in this manual) are available to facilitate adapting the governor to a particular engine or turbine configuration. Contact Woodward for special installations. The PG/UG-40 base may use either a serrated or 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.

General

At all times, use care in handling the base assembly; be particularly careful to avoid striking the drive shaft. Do not drop or rest the bass on the drive shaft. Such treatment could damage the drive shaft, bearing, and seal.

Generally, the base assembly should operate maintenance free for several years. About the only maintenance needed prior to a general overhaul is the replacement of the oil seal around the drive shaft, if it leaks excessively. Refer to disassembly procedure and parts breakdown figure.

Disassembly

Disassemble the base assembly in the sequence of index numbers assigned to Figure 3-2.

Clean exterior surface of base with clean cloth moistened with cleaning solvent (US Federal Specification P-D-680 or similar).

Discard gasket, seal, cotter pin, retaining ring, etc., removed in the process of disassembly.

Wash all parts with cleaning solvent. Use a non-metallic brush or jet of compressed air to clean slots and holes.

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

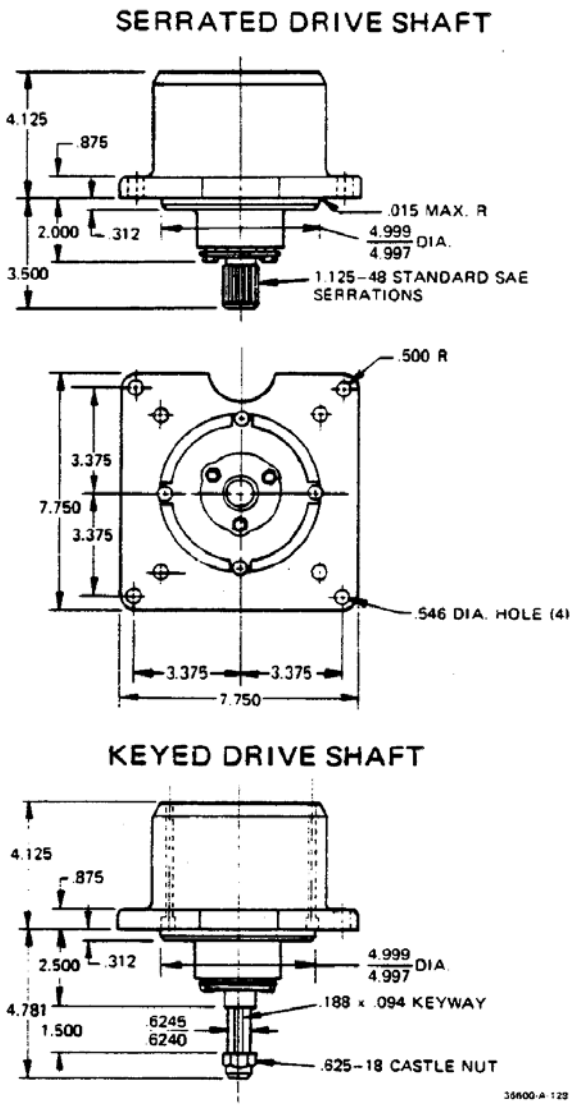

Figure 3-1. Outline Drawing of PG/UG-40 Base Assembly

Inspection

Visually inspect parts for evidence of wear; pitting, scoring, nicks, cracks or other damage.

Inspect bearing in accordance with standard practice. Replace bearing when there is any detectable roughness or stickiness.

If the base has a serrated or splined drive shaft, ensure it engages or slips freely into the internal splines or serrations of the drive. If the base has a keyed drive shaft, the drive gear must slip on the shaft freely and should be checked to insure that it meshes properly with its mating gear, without binding or excessive backlash.

Repair or Replacement

Repair of small parts is impractical and shall generally be limited to removal of nicks and burrs from mating flanges, replacement of bearing, and light burnishing of mating parts.

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

Reassembly

Assemble the base assembly in reverse order of index numbers assigned to Figure 3-2.

Obtain new gasket, seal, retaining ring, cotter pin, etc., to replace those discarded during disassembly.

Parts Replacement Information

The same parts ordering information as in Chapter 2 is required for ordering parts in Chapter 3. Use Figure 3-2 for the index numbers.

Parts List for Figure 3-2, PG/UG-40 Base

Ref. No.	Part Name	Quantity
36606-51	Lockwire (MS9226-3)	3
36606-52	Screw, dr. hd. cap, 1/4-28 x 5/8 (MS5109-5)	1
36606-53	Bearing retainer	1
36606-54	Cotter pin (MS24665-372)	1
36606-55	Castellated nut, 1/4-28 (AN310-10)	1
36606-56	Spacer	1
36606-57	Bearing	1
36606-58	Key	1
36606-59	Drive shaft (keyed)	1
36606-60	Oil seal retainer	1
36606-61	Oil seal	1
36606-62	Gasket	1
36606-63	Pin	2
36606-64	Base, PG/UG-40	1

36606-65 through -100 Not used

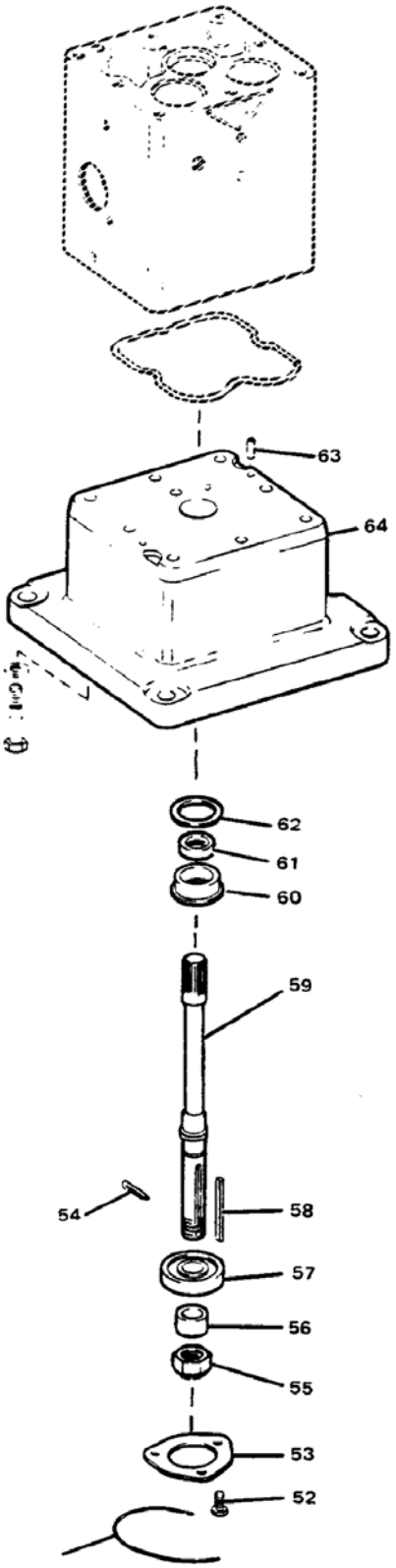

Figure 3-2. Exploded View of PG/UG-40 Base

Chapter 4.
Manifold Air Pressure Bias Fuel Limiter

Introduction

This chapter presents theory, operation and maintenance instructions for the single barrel fuel limiter as used on 8554-255 PGA.

Fuel Limiter

When a conventional (unlimited) governor is used on a turbo-supercharged engine, the normal lag of supercharger speed, and consequently MAP, with respect to engine speed during accelerations makes it possible for the governor to supply more fuel to the engine than can be burned with the available air. This results in an overly rich fuel/air mixture ratio causing incomplete combustion with attendant smoke and poor acceleration.

The fuel limiter functions to restrict the movement of the governor power piston in the increase fuel direction and thus limit engine fuel during accelerations as a function of MAP (an approximation of the weight of air available at any instant). Limiting engine fuel to that which can be burned with the air available at any instant during the acceleration transient ensures more complete combustion of the fuel, reducing smoke to a minimum and improving engine acceleration. The fuel limiter also serves as a protective device to limit engine fuel if the turbo-supercharger fails or other large reduction occurs in the engine air supply. Figure 4-1 illustrates the unlimited, limited, and steady state fuel schedules for a typical engine together with a typical acceleration transient from one steady-state condition to another.

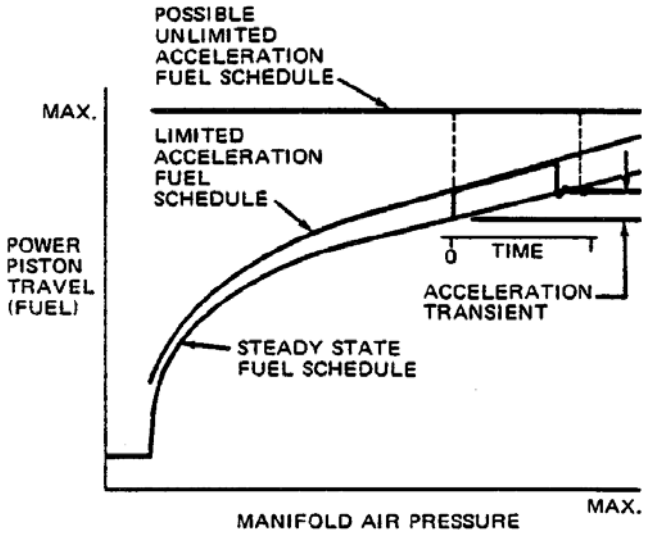

Figure 4-1. Typical Limited Acceleration Fuel Schedule Curve

Principles of Operation

Figure 4-2 schematically illustrates the fuel limiter and the optional load control override linkage as added to the basic PG governor equipped with load control and load control overriding solenoid.

Description

The fuel limiter consists essentially of 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 pilot point, is determined by the position of the fuel limit cam. By altering (raising) the floating lever pivot as MAP increases, the governor power piston can move upward a proportionally greater distance before fuel limiting occurs.

The pressure sensor is a force-balance device consisting of an inlet check valve, a restriction (orifice pack), a piston and cam assembly, a restoring spring, a diaphragm type 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 MAP. The relationship between MAP and governor power piston position (fuel flow) at which limiting occurs is determined by the profile and/or angular tilt of the cam. Cam profiles may be either linear or non-linear depending on engine and turbo-supercharger characteristics.

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 and lift the shutdown rod to re-center the governor pilot valve plunger when the fuel limit is reached for a given MAP.

Operation

Governor oil at a constant pressure enters the fuel limiter through the inlet check valve and is then directed to the upper side of the sensor piston and through the restriction (orifice pack) to the under side of the sensor piston. The inlet check valve prevents siphoning of the oil from the limiter housing during shutdown periods so that, during starting, the sensor piston will not go to the maximum fuel position during the time which would otherwise be required to refill the housing with oil. The bleed valve regulates the rate of oil flow from the area under the sensor piston to sump as a function of MAP. When the bleed valve bypasses a greater flow of oil from this area than is admitted through the orifice pack, the sensor piston will move downward; conversely, reducing the bypass oil flow to less than that admitted will cause the sensor piston to rise. When the inflow and outflow of oil are equal, the piston will remain stationary.

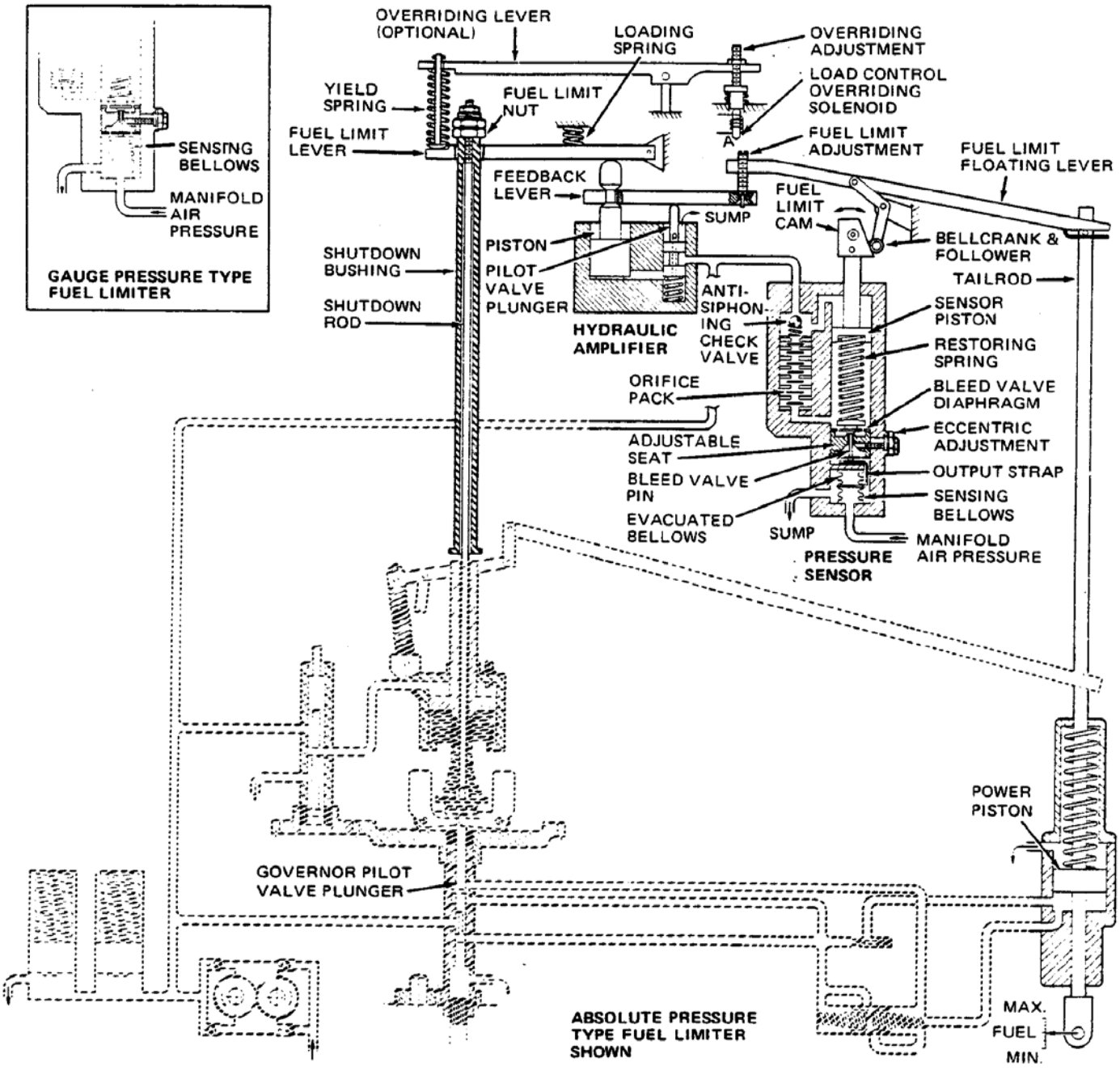

Figure 4-2. Schematic Diagram of Fuel Limiter and Optional Load Control Override Linkage

The sensing element of the absolute-pressure-type fuel limiter consists of two opposed, flexible, metallic bellows of equal effective area. The upper bellows is evacuated, the lower bellows senses MAP. A spacer joins the bellows at the center. The outer end of each bellows is restrained to prevent movement. MAP acting internally on the sensing bellows produces a force which causes the spacer to move toward the evacuated bellows. The evacuated bellows provides an absolute reference so that the sensing bellows force is directly proportional to the absolute MAP. Movement of the bellows spacer is transmitted through an output strap and a bleed valve pin to the bleed valve diaphragm. The sensing element of the gauge-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. Bellows force acts to open the bleed valve and is opposed by restoring spring force which acts to close the valve. Whenever these opposing forces are in balance, the bleed valve diaphragm floats just off its seat and bypasses oil to the sump at a rate which will maintain a constant volume of oil in the area under the sensor piston.

Assuming that the governor speed setting is advanced from some lower speed and corresponding MAP, the governor power piston will begin moving upward to supply the additional fuel required for engine acceleration. Since MAP will lag engine acceleration, the fuel limiter cam and bellcrank will initially remain stationary until MAP begins to rise. As the governor power piston moves upward to increase 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 governor pressure oil to flow into the area under the amplifier piston which causes the piston to rise. As the piston rises, it simultaneously lifts the left ends of both the fuel limit 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 will continue until the left end of the feedback lever has been raised 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 will have re-centered the governor pilot valve plunger, stopping upward movement of the governor power piston and thus limiting engine fuel to that amount which can be efficiently burned with the air available at that instant. Although the governor flyweights are in an underspeed condition at this time, the power piston will remain stationary until MAP begins to rise.

As engine speed and load increases, MAP will begin to rise after a short time lag. The increase in MAP produces a proportionate increase in sensing bellows force. Bellows force, now greater than 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 will continue 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 MAP, the bellcrank is allowed to rotate in a cw direction as permitted by the diverging profile and angular tilt of the cam. This raises the floating lever pivot point and thereby the left end of the lever which, in turn, allows the right end of the amplifier feedback lever to rise and with it, the amplifier pilot valve plunger. 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 thus attenuates 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 and lowers the shutdown rod to un-center the governor pilot valve plunger in the direction to further increase engine fuel.

The sequence of events described above occur in a continuous and more or less simultaneous manner and, in effect, override normal governor operation during an acceleration transient to schedule engine fuel as a function of MAP irrespective of governor speed setting. As engine speed nears the new setting, MAP will normally rise above the design minimum value for that speed setting. The sensor piston and cam will thus continue their downward movement until sufficiently below the effective limiting point as to prevent interference with normal governing action during steady state operation.

Conversely, a significant drop in MAP below the design minimum for a given engine speed will cause the sensor piston and cam to rise into effective limiting range. The converging profile and angular tilt of the cam will force the bellcrank to rotate in a ccw direction. This lowers the floating lever pivot point and thereby the left end of the lever. The hydraulic amplifier will then act to lift the governor pilot valve plunger above center and allow the oil under the governor power piston to drain to sump. The downward movement of the power piston to increase engine fuel will continue until the left end of the floating lever, pivoting cw about the bellcrank, permits the amplifier pilot valve plunger to rise above center and allow the oil under the amplifier piston to bleed to sump. This lowers the shutdown rod and re-centers the governor pilot valve plunger to stop the downward movement of the power piston at the moment engine fuel is reduced to that which can be burned with the available air.

Adjustments

Adjustment of the fuel limiter, load control override linkage, and/or two-slope load control bias linkage involves several unique sets of conditions relating to several independent variables (governor speed setting, power piston position—engine fuel, and load on the engine). The various functional systems of the governor are closely interrelated and an adjustment to one system will, in most instances, require compensatory adjustments in other related systems. Due to the many variables involved, adjustment of the governor while installed on the engine is not recommended. A test stand equivalent to Woodward test stand, part number 8909-001, should be used whenever adjustments are required.

The specific adjustment/test parameters vary with the governor and its intended application. Therefore, the procedures given below are of a descriptive rather than specific nature and are intended for use with the governor mounted on a test stand. Contact Woodward to obtain the specific adjustment/test parameters for the particular governor involved. The request must include the model and serial number(s) of the governor(s) to be serviced. All basic governor adjustments (base speed setting, speed setting piston stop, load control system balance and timing, electric operation of overriding solenoid, low lubricating oil pressure shutdown bypass valve, etc.) except shutdown must be made prior to any adjustment of the fuel limiter, load control override linkage, or two-slope load control bias linkage. The shutdown bushing, fuel limit nut, fuel limit adjustment screw, and overriding lever adjustment screw (if used) should be backed off sufficiently to prevent inadvertent interference when making adjustments to the basic governor and load control system. If the two-slope load control bias option has been provided, disengage the two derating adjustment screws from the pivot blocks and lay the bias lever back so that access can be gained to top of fuel limit cam for positioning a dial indicator. If desired, the lever and bracket may be removed for greater convenience.

Fuel Limiters without Two-Slope Load Control Bias

Refer to Figures 4-1 and 4-2 as required when making adjustments to the basic fuel limiter and load control override linkage.

1. Operate governor at idle speed setting.

2. Adjust position of shutdown bushing on shutdown rod as required to obtain 0.032 ±0.005 inch (0.81 ±0.13 mm) clearance between bottom of bushing and top of speed setting piston rod. Secure bushing with jam nut. Recheck clearance and readjust if necessary. Make certain governor will shut down.

3. Operate governor at some speed setting above mid-range.

4. Connect a source of regulated air pressure to engine MAP fitting on governor column. Regulate air pressure to lowest value of MAP specified in the fuel limiting schedule (typically 0” Hg/0 kPa gauge pressure).

5. Set up a dial indicator with plunger contacting top of fuel limit cam so that sensor piston travel can be determined.

6. Loosen locking screw in eccentric adjustment (see Figure 4-1) and turn eccentric cw until sensor piston (and fuel limit cam) travels to top of its stroke. Zero dial indicator or note indicator reading.

7. Tighten locking screw slightly and then turn eccentric ccw until fuel limit cam travels the specified distance downward (typically 0.150 inch/3.81 mm). Fully tighten locking screw.

8. Make certain sensor piston travels to bottom of its stroke with increasing MAP. Reset MAP to value specified at low end of schedule.

9. Reposition dial indicator with plunger contacting top of governor power piston tailrod so that power piston travel (1.156 inches/29.36 mm minus specified gap) can be determined. Zero indicator with power piston in full down position.

10. Adjust test stand speed control so that power piston travels upward the specified distance (mid-point of tolerance range) corresponding to the given MAP at the low end of the schedule.

11. Turn fuel limit adjustment screw cw until hydraulic amplifier piston lifts the fuel limit lever to a horizontal position (as visually determined).

12. Adjust position of fuel limit nut on shutdown bushing to obtain specified clearance (mid-point of tolerance range) between bottom of nut and top surface of fuel limit lever. Secure with jam nut.

13. Turn overriding adjustment screw in overriding lever cw until load control pilot valve plunger just begins to rise to the fast unloading position.

14. Check fuel limit nut clearance by cycling power piston, first downward and then slowly upward to the point where the load control pilot valve plunger just begins to rise. Clearance between shutdown nut and fuel limit lever must be within the specified tolerance range. Readjust if necessary.

15. Reposition power piston and verify MAP as instructed in step 10.

16. Turn fuel limit adjustment screw cw until governor speed drops 10 (±5) rpm. Power piston will travel downward slightly but must remain within the specified tolerance range. If power piston travels too far, adjust test stand speed control so that piston rises to the mid-point of the tolerance range, (speed drop will increase) and then turn fuel limit adjustment screw ccw to obtain 10 rpm drop in speed.

17, Operate governor at maximum speed setting and regulate air pressure to highest value of MAP specified in the fuel limiting schedule.

18. Manipulate test stand speed control so that power piston travels downward (governor should be running on-speed) and then slowly upward to the point where a 10 (±5) rpm drop in speed occurs. Governor power piston travel (gap) must be as specified for that MAP.

19. If power piston travel is not within the specified limits, loosen the fuel limit cam locking screw and tilt top of cam toward bellcrank to decrease power piston travel or away from bellcrank to increase travel. Tighten locking screw and repeat step 18.

20. Following any adjustment of the fuel limit cam, the low end of the fuel limiting schedule must be re-checked and readjusted as necessary. Repeat steps 15 through 19 until no further adjustment is required at either end of the fuel limiting schedule. Figure 4-3 illustrates the interrelationship and individual effects of the fuel limit adjustment screw and fuel limit cam angle (tilt) on the fuel limiting schedule. An adjustment of the fuel limit screw will raise (or lower) the schedule a like amount over its entire length. An adjustment of the fuel limit cam will alter the slope of the schedule with the greatest change occurring at the high end. The contour of the schedule is a reflection of the cam profile and may be non-linear as illustrated or linear (straight line).

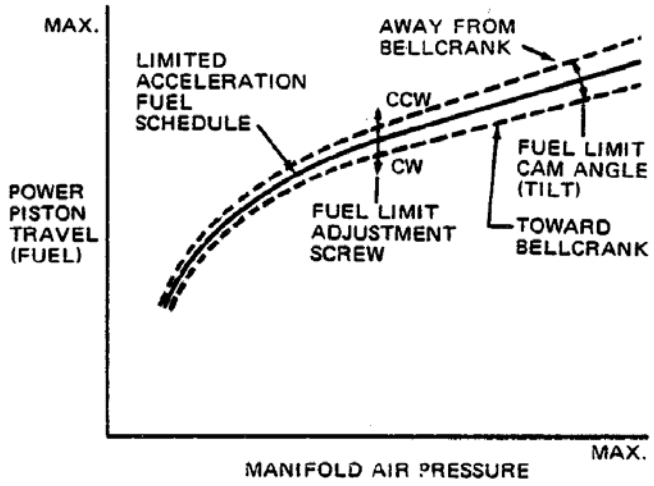

Figure 4-3. Typical Effects of Fuel Limit Adjustment Screw and Fuel Limit Cam Angle (Tilt) on Fuel Limiting Schedule

IMPORTANT

In some instances, particularly where a non-linear cam is used, the extreme limit of cam adjustment may be reached before attaining the specified power piston travel at either or both ends of the schedule. In such case, it will be necessary to reposition the sensor piston (steps 3 through 8) and then repeat all subsequent step& With many non-linear cams, the lower portion changes profile very rapidly and therefore the initial or starring position of the sensor piston has great effect in establishing the desired fuel limiting schedule. The dimension given in step 7 is not critical as long as it is within the active range of the sensor piston travel. Repositioning the sensor piston will affect the fuel limiting schedule in essentially the same manner as the fuel limit adjustment screw. Shorten the dimension given in step 7 to decrease power piston travel, lengthen the dimension to increase travel.

Maintenance

Troubleshooting

A troubleshooting chart (Table 4-1) is provided below for use in determining the probable causes and corrective action for fuel limiter troubles which may be encountered in the field. Every possible trouble which may be experienced cannot be anticipated and may, in some instances, be due to faulty operation of the basic governor or other equipment used in conjunction with the governor. Fuel limiter troubles such as erratic operation or slow response to changes in MAP, are usually the result of oil contamination. In many instances, this type of trouble can be corrected by flushing the governor with fuel oil or kerosene. The use of non-petroleum base solvents is not recommended as damage to oil seals or gaskets may result.

Special Tools

Special tools are not required for maintenance of the fuel limiter, load control override linkage, or two-slope load control bias linkage.

Disassembly

Removal and disassembly procedure for the fuel limiter will vary in degree depending on the optional features with which it is equipped and the extent of maintenance required. Complete removal and disassembly involves partial disassembly of the basic governor and should be accomplished in the sequence given below and in general accordance with the order of reference numbers assigned to Figure 4-4. Circled reference numbers on the illustrations indicate parts or groups of parts which need not necessarily be totally removed or disassembled unless replacement of parts is required. Discard, do not reuse, preformed packings (O-rings), gaskets, copper sealing washers, retaining rings, cotter pins, etc., removed in the process of disassembly.

IMPORTANT

The following procedure assumes that the fuel limiter is equipped with both the load control override and two-slope load control bias options. Omit those steps which do not apply to the particular fuel limiter being serviced.

Table 4-1. Troubleshooting the Manifold 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.	Adjust as instructed in Adjustments.
	Restoring spring fatigued or broken.	Replace restoring spring.
Engine bogs during accelerations.	Load control override linkage improperly adjusted.	Adjust as instructed in Adjustments.
Erratic operation. Excessive engine operating temperatures (governor with two-slope load control bias).	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 MAP line for presence of oil which would indicate leakage at fuel limiter bellows.
	Leakage in MAP lines or fittings.	Repair leaks.
	Fuel limiter bellows leaking.	Replace bellows.
	Two-slope load control bias linkage not adjusted properly.	Adjust as instructed in Adjustments.
Dead band at low or high end of fuel limiting schedule.	Sensor piston travel not properly calibrated with MAP. range.	Adjust as instructed in Adjustments.

IMPORTANT

Refer to the applicable governor manuals for removal of basic governor parts and/or assemblies as required in the following steps.

1. Remove component parts of governor load control valve from sensor housing (167, Figure 4-4).

2. Remove governor speed setting mechanism and bracket assembly.

3. Remove overriding valve plunger and spring from sensor housing.

4. Remove fuel limit lever and attaching parts (105 through 108).

5. Remove fuel limit floating lever and attaching parts (109, 110, and 1 11). Hold pivot (112) stationary while removing lever and then remove pivot together with adjusting screw (113). Remove feedback lever (114).

6. Disconnect coupling nut (115) and then back fitting (118) out of governor column far enough to clear end of connecting tube from sensor bellows (154). Do not bend or otherwise place any strain on tube during removal of the sensor assembly.

7. Remove screws (119 and 120) and washers (1 sensor assembly (122 through 167) off column. Remove O-ring (169) from seat in governor column.

8. Disassemble sensor assembly in the order of the reference numbers assigned to Figure 4-4.

9. Cylinder head (165) is a press fit with housing (167).

Cleaning

Wash all parts ultrasonically or by agitation while immersed in cleaning solvent. 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, paying 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 or 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 (138, Figure 4-4), amplifier piston (133) and amplifier pilot valve plunger (131) 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, in the form of 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 worn area for an out-of-round condition. Replace pistons if worn area is out-of-round more than 0.001 inch (0.02 mm). Replace plunger if worn areas on lands are out-of-round more than 0.0005 inch (0.013 mm).

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 (141 and 158) 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 (0.02 mm) in depth, etc., in necked area of diaphragm center section is cause for replacement of the part.

9. Examine sensor bellows (154) for evidence of distortion, cracks or other damage. The longitudinal length of the bellows assembly, as measured on the bellows centerline without strap (157), and barometric pressure at time of factory assembly are marked on upper end of 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 MAP tube and immerse 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 (129) for freedom of rotation. Replace bearing if there is any detectable roughness.

Repair or Replacement

Repair of parts should be limited 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 so that mating edges and surfaces will not be damaged. Sharp edges of plunger lands, piston grooves, metering ports, etc., must be maintained. Rounded edges, nicks, or other damage to such edges will result in excessive internal leakage and/or decreased control sensitivity.

Lubrication

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

Reassembly

IMPORTANT **Reassembly should be performed in a dust-free work area.**

Reassemble and install the fuel limiter and load control override linkage in reverse order of the disassembly instructions, paying 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 (149, Figure 4-4) and orifice plates (150). Make certain to install a gasket between orifice plate and washer at each end of stack. Plates must be alternated so that adjacent orifice holes are diametrically opposite.

Parts Replacement Information

The same parts ordering information as in Chapter 2 is required for ordering parts in Chapter 4. Use Figure 4-4 for the index numbers.

Ref. No.	Part Name	Quantity
36606-101	Nut, hex., 8-32 (MS35469-282)	1
36606-102	Nut, hex., 5/16-24 (MS35691-522)	1
36606-103	Nut, hex., 5/16-24 (fuel limit) (MS35690-522)	1
36606-104	Shutdown bushing	1
36606-105	Cotter pin, 1/16 x 5/8 (MS24665-1 52)	1
36606-106	Pivot pin (fuel limit lever)	1
36606-107	Loading spring	1
36606-108	Fuel limit lever	1
36606-109	Cotter pin, 1/16 x 3/8 (MS24665-130)	1
36606-110	Retaining ring, E-type (MS16633-1014)	1
36606-111	Fuel limit floating lever	1
36606-112	Pivot	1
36606-113	Adjusting screw (fuel limit)	1
36606-114	Feedback lever	1
36606-115	Coupling nut, 1/2-20	1
36606-116	Ferrule, 1/4 tube	1
36606-117	Nut, hex., 1/2-20 (MS35691-822)	1
36606-118	Bulkhead union, 1/4 tube	1
36606-119	Screw, soc hd., 1/4-28x 1-1/8 (MS35458)	1
36606-120	Screw, soc. hd., 1/4-28 x 1-3/4 (MS35458-28)	1
36606-121	Washer, lock, 1/4 (MS51848)	2
36606-122	Screw, soc. hd., 10-32 x 1/2 (MS24678-20)	2
36606-123	Screw, soc. hd., 10-32 x 1-1/2 (MS24678-16)	1
36606-124	Washer, lock, #10 (MS35338-43)	3
36606-125	Cotter pin, 1/16 x 5/8 (MS24665-152)	2
36606-126	Pivot pin (bellcrank)	1
36606-127	Bellcrank	1
36606-128	Straight pin, drilled	1
36606-129	Needle bearing	1
36606-130	Linkage bracket	1
36606-131	Amplifier pilot valve plunger	1
36606-132	Pilot valve loading spring	1
36606-133	Amplifier piston	1
36606-134	Sensor piston sleeve	1
36606-135	Screw, button soc. hd, nyloc, 8-32 x 3/8	1
36606-136	Roll pin, 1/8 x 3/8 (MS171524)	1
36606-137	Fuel limit cam	1
36606-138	Sensor piston	1
36606-139	Restoring spring	1
36606-140	Restoring spring seat	1
36606-141	Bleed valve diaphragm	1
36606-142	Filter screen	1
36606-143	Preformed packing, 1/2 OD (NA51593-012)	2
36606-144	Check valve assembly	1
36606-145	Retaining ring, internal (MS16625-1037)	1
36606-146	Washer, 9/64 ID x 3/8 (max.) OD x 1/32	1
36606-147	Orifice pack spring	1
36606-148	Washer, 3/16 ID x 3/8 (max.) OD x 1/16	2
36606-149	Gasket	33
36606-150	Orifice plate	32
36606-151	Orifice case	1
36606-152	Spring washer	1
36606-153	Screw, button soc. hd., nyloc, 8-32x3/8	2
36606-154	Sensor bellows (absolute pressure type)	1
36606-155	Preformed packing, 1-1/4 OD (NAS 1593-024)	1
36606-156	Bellows spacer (used with item 154 only)	1
36606-157	Bellows output strap (used with item 154 only)	1
36606-158	Bleed valve pin assembly	1
36606-159	Retaining ring, internal (MS16627-1 125) (used with item 154 only)	1
36606-160	Screw, hex. hd, 1/4-28 x 3/4 (M535298-6)	1
36606-161	Washer, soft copper, 1/4 ID x 1/2 OD x 1/32	1
36606-162	Eccentric	1
36606-163	Gasket, copper	1
36606-164	Valve seat	1
36606-165	Cylinder head (overriding)	1
36606-166	Taper screw	9
36606-167	Housing	1
36606-168	Straight pin (tailrod)	1
36606-169	Preformed packing, 0.338 OD (NA51593-011)	1
36606-170	Pilot valve plunger nut	1
36606-171	Loading spring	1
36606-172	Sensor bellows (gauge pressure type)	1
36606-173	Screw, soc. hd., 10-32 x 1-1/4 (MS24678-15)	1
36606-174	Washer, lock, #10 (MS35338-43)	1
36606-175	Overriding solenoid bracket	1
36606-176	Headed pin, drilled	2
36606-177	Overriding lever loading spring	1
36606-178	Cotter pin, 1/16 x 3/8 (MS24665-130)	2
36606-179	Washer, plain, #10 (MS27183-8)	1
36606-180	Overriding lever yield spring	1
36606-181	Straight pin, drilled	1
36606-182	Overriding lever	1
36606-183	Nut, hex, 8-32 (MS35649-282)	1
36606-184	Setscrew, soc. hd., oval pt., 8-32 x 1 (MS51981)	1
36606-185	Solenoid plunger stop	1
36606-186 through –200	Not used	

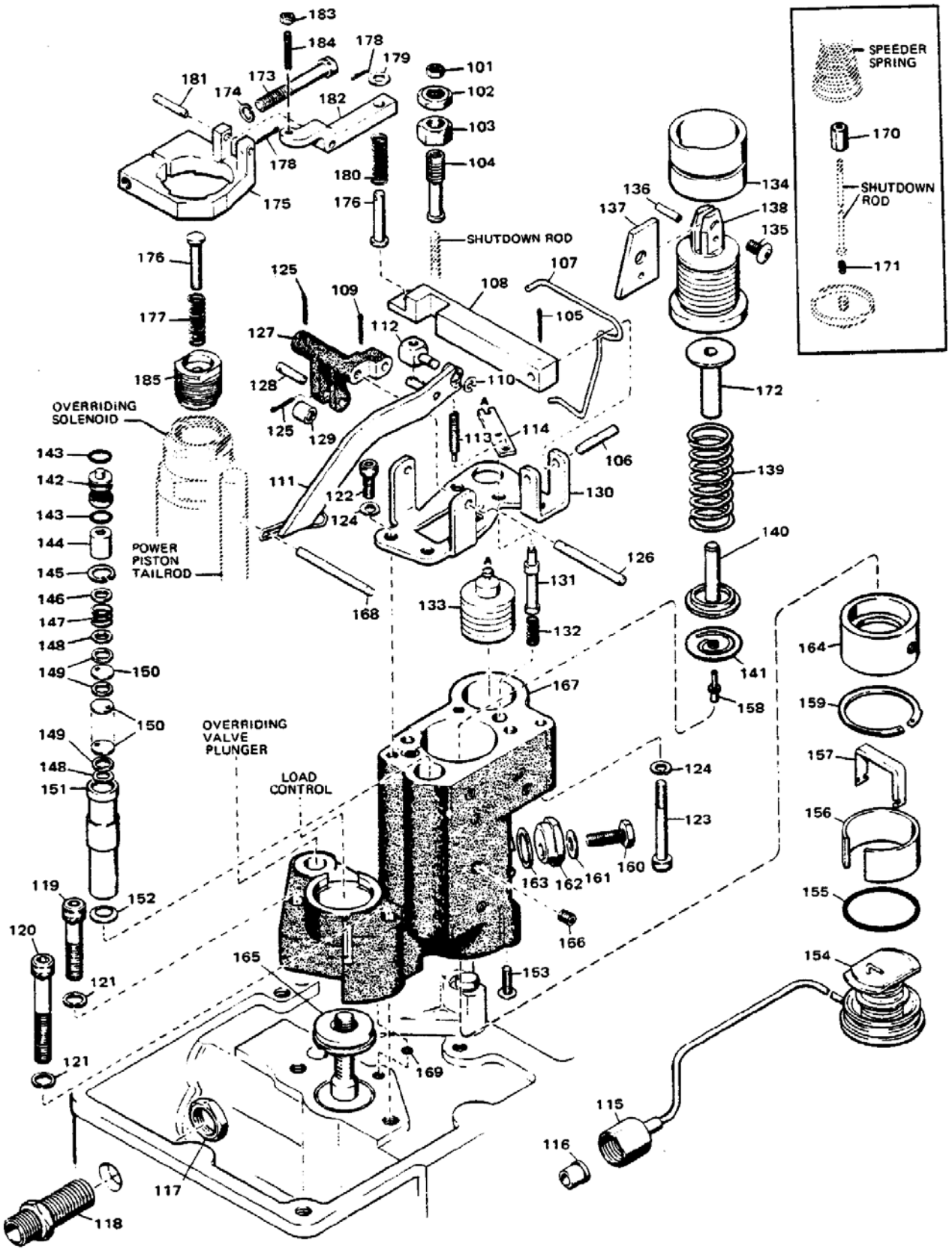

Figure 4-4. Exploded View of Fuel Limiter and Optional Load Control Override Linkage

Chapter 5.
Pneumatic Load Balance System

Introduction

Where two or more engines are driving a common load, such as a propeller shaft of a ship, it is desirable that the engines can be controlled in unison and that the loads on all engines are proportionally shared, especially if the speed and load is to be varied over a wide range. This requirement could be met by supplying a common speed setting signal to all governors from a master speed controller if the speed setting, the speed droop and the governor to engine rack relationship were identical. To achieve and maintain this identical relationship with mechanical-hydraulic governors, however, is difficult in practice. The load balance system has been devised to operate in conjunction with the master speed controller to accomplish the desired results.

PGA Governors

The PG (Pressure compensated Governor) series of governors consists of many types. The pneumatic load balance system is designed to operate with the PGA (Pressure compensated Governor Air (pneumatic) speed setting) type which is distinguishable by a long column. The governor must have a power piston tailrod to accommodate the load balance equipment and other auxiliary devices. The principal reference is manual 36604 for the basic PGA components including the base, power case, differential power servo and long column.

Master Speed Controller

The master speed controller is provided by others. It transmits an adjustable pneumatic pressure signal to all bellows speed setting mechanisms on governors operating in unison. This common speed setting signal is adjustable from a minimum to a maximum value corresponding from idle to full speed of the governor.

Load Balance System

Basic Principle

The load balance system is based on a position comparison principle. The servo or fuel output position of a selected governor, designated the master, is compared with that of other governors, designated slaves. The servo positions are converted into proportional air pressure signals. A differential air receiver for each governor does the comparing. Any difference in the signal of the master governor and that of the slave governor results in an error signal. The error signal is used to bias the common master speed setting of the slave governor and is in a direction to increase or decrease the slave governor servo position to match that of the master governor. In so doing, the error in servo positions approaches zero as the error signal approaches zero.

Operation

Figure 5-1 shows the schematic diagram of the load sharing system. A pneumatic transmitter mounted on each governor produces an air pressure proportional to its servo position. A differential diaphragm assembly, or receiver, on each governor is connected through linkage to the speed setting system. The master governor transmitter feeds its signal to the lower side of all slave governor receivers. The top side of each slave governor receiver receives its own transmitter signal. Differential forces in the receiver will raise or lower the speed setting of the slave governor. If the master governor carries more, or less, load than the slave, the differential force will increase, or decrease, the speed setting of the slave until it carries about the same load as the master.

The master governor receiver must have both sides of its diaphragm either bled to atmosphere or impressed with its own transmitter pressure, as shown in Figure 5-1. Therefore, if No. 1 Engine is always the chosen master governor, its receiver can be omitted.

On loss of the slave signal but retention of the master signal, the speed setting of the slave governor will increase. A yield spring between the receiver and the speed sensing system prevents the speed setting from reaching a dangerous value.

As long as the load balance system is in operation, all participating governors can operate either isochronously or with speed droop. Operation with speed droop is recommended to maintain a degree of load division in the event the load balance system is taken out of service.

Setup Procedure (Figure 5-3)

1. With the engines shutdown, check the governor to engine fuel rack linkages to insure they are the same for all engines. If the rack linkage is adjustable and the rack settings appear to be different, adjust the linkage so that from minimum fuel to maximum fuel (the rack stops must also be set the same) you have an equivalent amount of governor servo travel on all engines using as much of the available governor stroke as possible. For example, when using a governor with a servo indicator scale, zero on the scale should read zero fuel at the fuel pumps. Moving the fuel racks toward maximum fuel, should give the same governor servo to fuel pump relationship at any given point on all engines. When the rack stops are reached most (not all) of the servo travel should be used. Proper linkage adjustment is vital for good load division since the load balance system compares governor servo positions only.

2. To check the load sharing transmitter output, apply 60 to 150 psi (414 to 1034 kPa) to the “make this governor master” connection and 30 psi (207 kPa) to the “supply” connection on the transfer valve block. Vent all other connections. Install a precision gauge (preferably a 0 to 30 psi/0 to 210 kPa) in the “master line” connection on the transfer valve block.

3. The transmitter output is proportional to servo travel. This output is from 3 psi (21 kPa) at minimum servo travel to 15 psi (103 kPa) at maximum servo travel.

4. With the governor servo at the minimum position the transmitter output is 3 ±0.1 psi (21 ±0.7 kPa). Manually move the servo to its full maximum position where the transmitter output should be 15 ±0.1 psi (103 ±0.7 kPa). Some applications may make it difficult to move the servo. In that case, simulate the full maximum position by leaving the servo at minimum and disconnecting the transmitter lever so it lifts the servo 1.000 inch (25.40 mm) to give you a 15 psi (103 kPa) transmitter output. (Refer to Figure 5-3.)

5. If the transmitter output pressures are not correct, first check for possible leaks around the tubing connections on the transmitter and on the transfer valve block.

6. If no leaks are found, adjust the transmitter output as follows:

   A. Turn the small self-locking nut on the bottom of the transmitter clockwise until it is tight, then back it off approximately 1/2 turn to 1 turn.

NOTICE **Do not overtighten.**

   B. Supply 30 psi (207 kPa) air to the transmitter, and set the governor servo at minimum position. Adjust the pressure level to 3 ±0.1 psi (21 ±0.7 kPa)by first loosening the 7/16 lock nut, then turn the entire transmitter spring assembly counterclockwise (viewed from top) to increase pressure and clockwise to decrease pressure. Retighten the nut and check the pressure.

NOTICE **Take care to turn the entire assembly and not the spring only, which might change the spring rate.**

   C. Move the transmitter lever to the maximum servo position (1.000”/25.40 mm from minimum). If 15 ±0.1 psi (103 ± 0.7 kPa) is not achieved, adjust the transmitter spring rate by first loosening the lock nuts and winding the transmitter spring coils on or off the rate adjuster nut. Fewer active coils increase the rate and widen the pressure range. After adjusting the spring rate, repeat steps 6B and 6C until the correct pressure outputs are achieved. All governors must have the correct transmitter outputs for good load division.

NOTICE **Tighten all locking devices before checking final pressures.**

   Reconnect the master line piping, install the gage in the lower part of the slave governor receiver and apply 60 to 150 psi (414 to 1034 kPa) to the “make this governor slave” connection. Move the master governor transmitter lever as in step 6C and read the pressure at the slave. If the pressure is not the same as when checked at the master governor in step 6C, check for leaks in the master line piping. These pressures must be the same for proper load division.

7. Apply 60 to 150 psi (414 to 1034 kPa) pressure to the isolate hole, start the engines, and check the speed settings of all the governors using a reliable tach. If possible use the same tach on all the engines to get an accurate comparison. Also, use a precision gage in the speed setting air line to check if each governor is receiving the correct speed setting air signal. Maintain the speeds of each engine as close as possible for the best load balancing.

8. If the speeds are incorrect, disconnect the uniball from the load sharing receiver and let it hang on the shutdown rod. Recheck the speeds; if they are still incorrect, refer to the PGA manual 36604 for the correct procedure for resetting the governor speeds.

   After resetting the speeds to the correct specifications, run the engine at any given speed, noting the rpm. Reconnect the uniball to the receiver being careful to center the shutdown rod in the clearance hole in the speed setting servo piston.

NOTICE **Do not allow the shutdown rod to touch or rub the I.D. of the speed setting servo piston, because the rubbing may affect governor stability.**

If the engine rpm changed after reconnecting the uniball, adjust the threaded uniball bushing up or down on the shutdown rod until the speed returns to the original rpm. To further check this setting, apply 60 to 150 psi (414 to 1034 kPa) to the “make this governor slave” connection and attach a line between the top and the bottom of the load sharing receiver. Use the pipe tapped holes that are normally plugged. Also, remove the master line fitting from the transfer block and plug. Disconnect the transmitter lever and move it up to increase the pressure output from the transmitter. This action applies an equal pressure to both sides of the receiver and tends to center the uniball. When the pressure is increased the rpm of the engine should not change. If the speed changes, adjust the uniball accordingly until no rpm change is noted when moving the transmitter lever up and down.

NOTICE **Make sure there are no leaks around the receiver or transfer valve.**

When the uniball is set, remove the jumper line from the receiver and reinstall the pipe plugs. Reconnect the transmitter lever to the tailrod. Also reconnect the master line to the transfer valve block.

9. Run the engines and check for equal load division. The governor servos should be in the same relative position. If they are the same, a slight adjustment to the engine fuel rack linkages (if adjustable) may be necessary to achieve near perfect load division. If the servos are not in the same position, check for possible leaks at all the master signal connections. Also check the mode selections on all governors. Select one governor only as master, make all others slaves. If the mode selection is correct and no leaks are found, then the governor calibration is incorrect. Recheck the calibration.

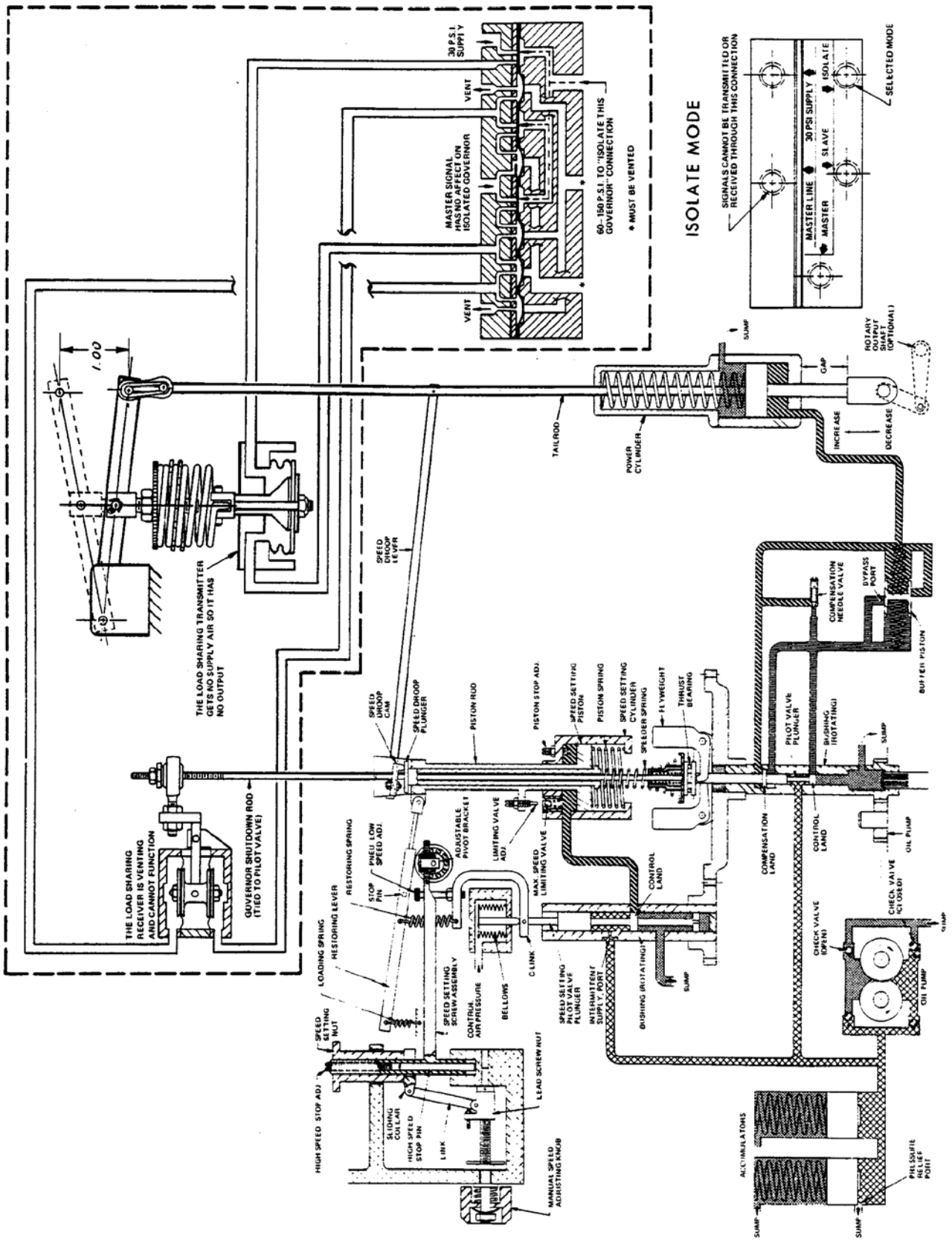

Figure 5-1. Schematic Diagram of System in Isolate Mode

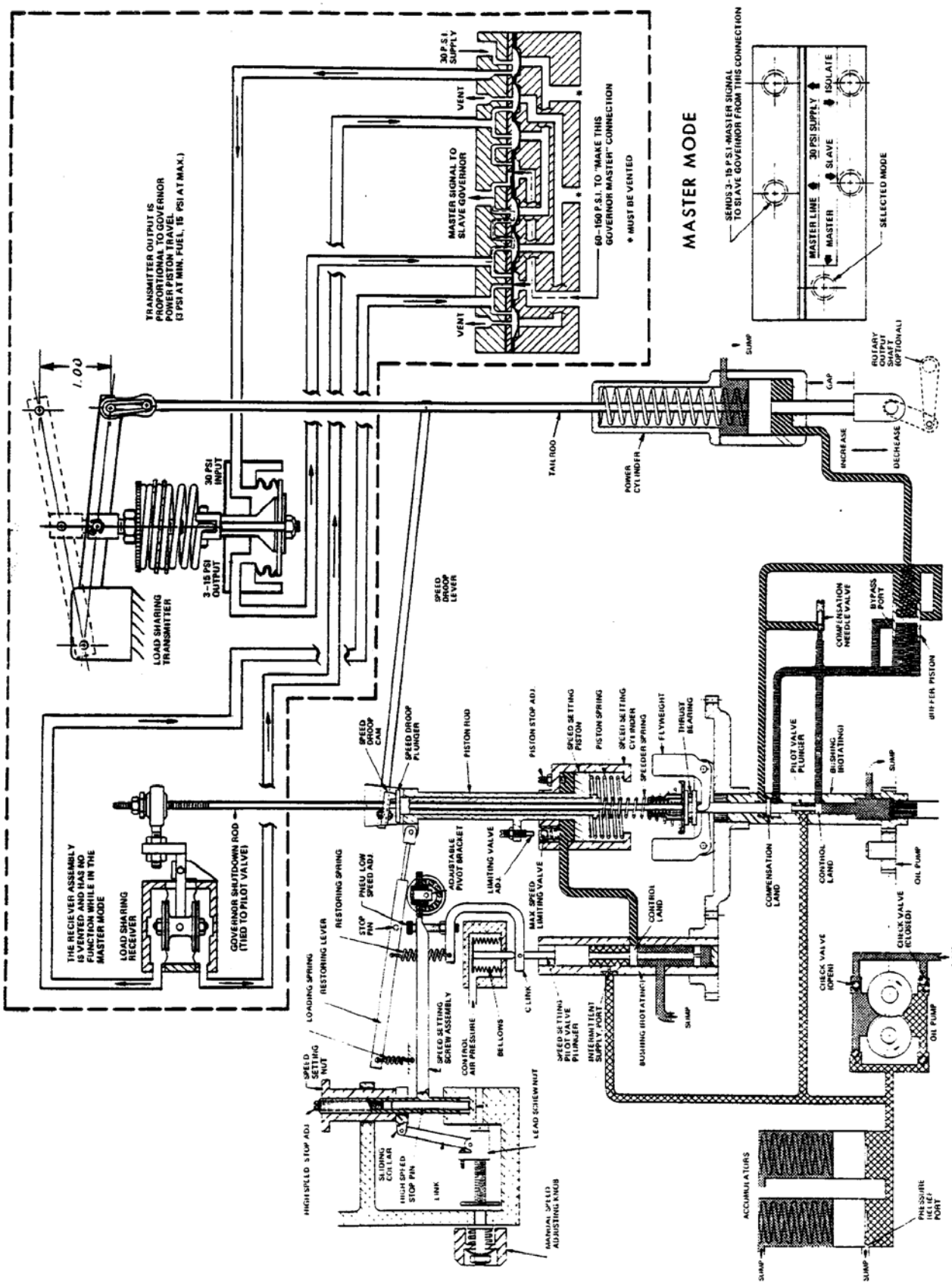

Figure 5-2. Schematic Diagram of System in Master Mode

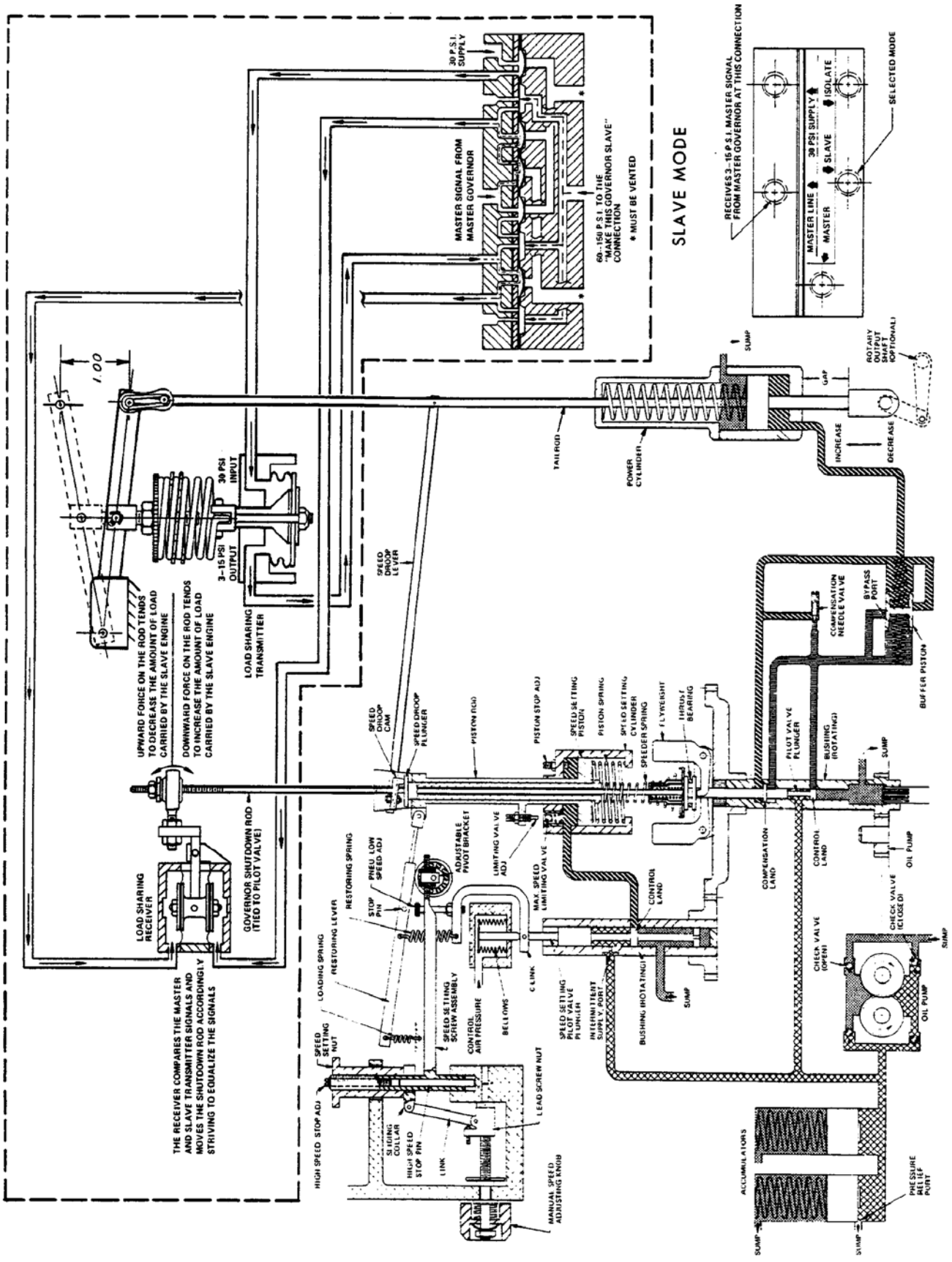

Figure 5-3. Schematic Diagram of System in Slave Mode

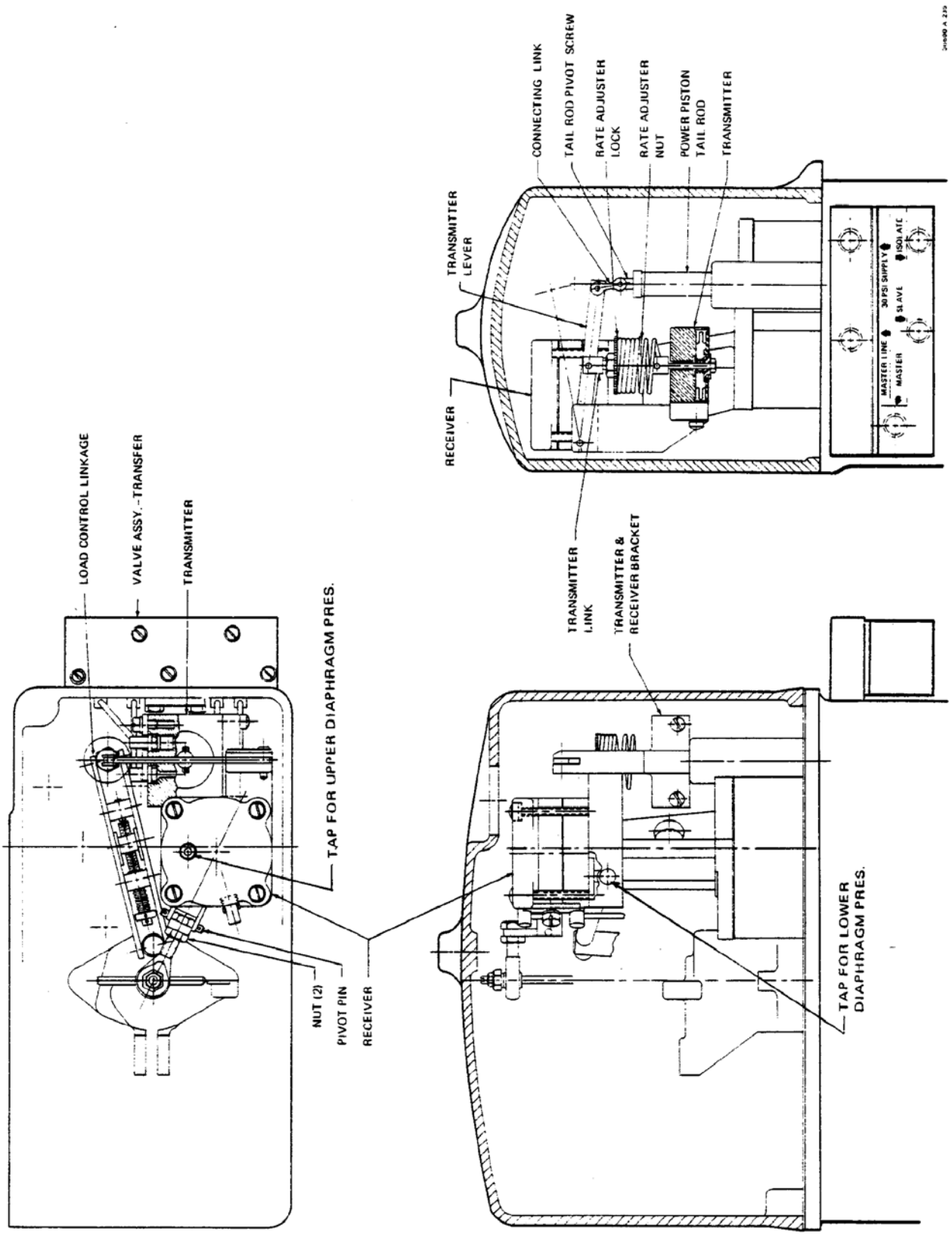

Figure 5-4. Parts Callout for Load Balance System

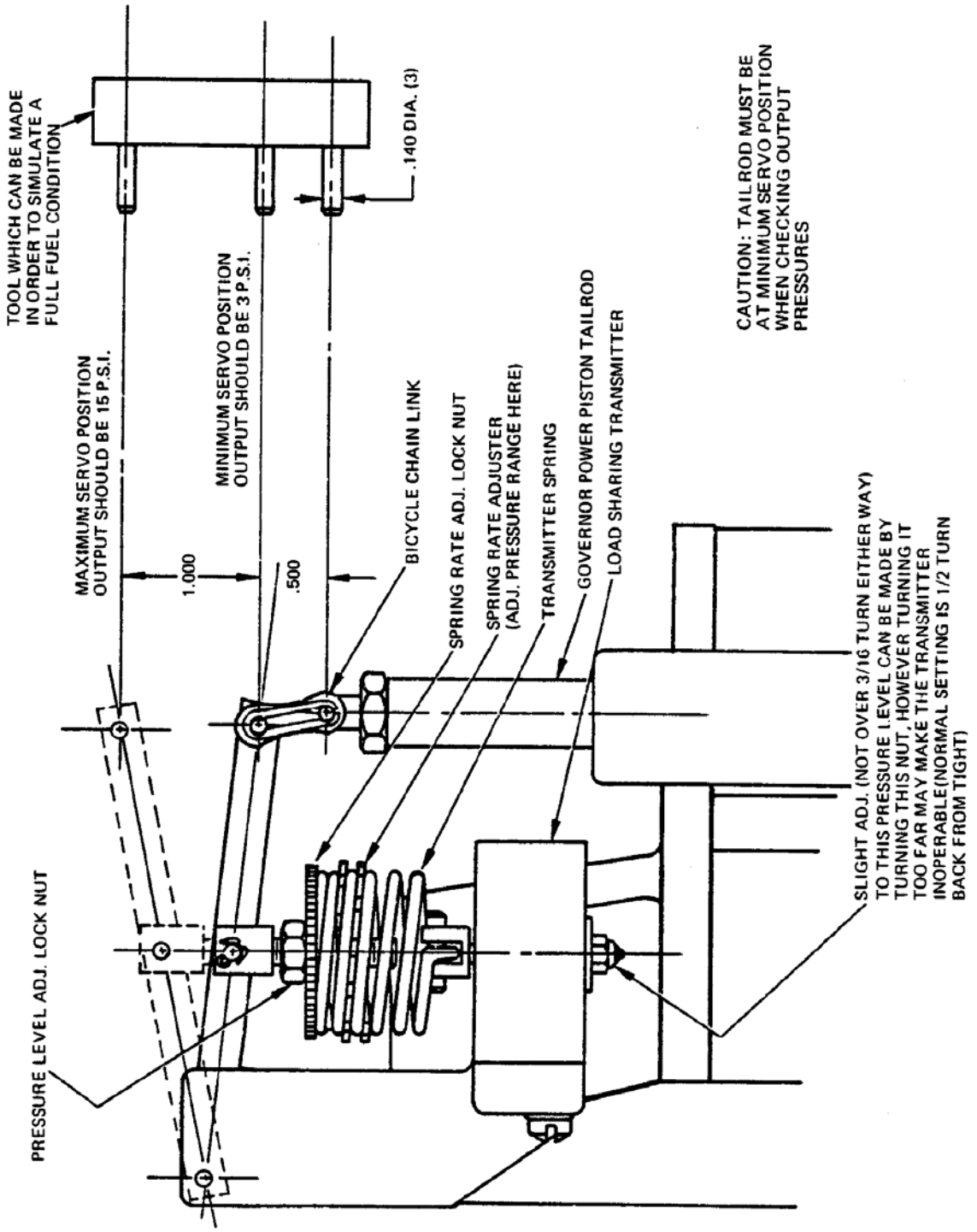

Figure 5-5. Load Sharing Transmitter Pressure Adjustments

Chapter 6.
Transfer Valve for Load Balance System

Introduction

This chapter is a supplement to Chapter 5, “Pneumatic Load Balance System for PGA Governors”.

In this installation of the load balance system, a transfer valve is supplied for each governor. This valve is air actuated. It simplifies and facilitates the remote control of the transfer function for the load balance system.

Operation

The transfer valve is essentially a remotely operated pneumatic switch for conveniently switching the load balance receiver and transmitter air signals and air supply for each governor.

Figures 5-1, 5-2, and 5-3 show the schematic diagram of the transfer valve block. There are eight valves being controlled. A diaphragm sandwiched between the valve block is manipulated by high pressure control air to close certain combinations of these valves according to a schedule. The remote control signal of 60 to 150 psi (414 to 1034 kPa) is applied (only one control signal at one time) from the right side of the diagram.

Figures 5-1, 5-2, and 5-3 show the position of the diagram in the three operating modes.

Assembly

Figures 5-1, 5-2, and 5-3 show the transfer valve assembly. The remote control air signal connections are clearly shown by the transfer valve decal. Likewise, the master line and 30 psi (207 kPa) supply are clearly shown. The piping connections from the transfer valve block to the transmitter and receiver are shown by the dashed line.

Checkout

1. Connect 30 psi (207 kPa) constant air supply to the tap marked “30 PSI supply”.

2. Apply 30 to 150 psi (207 to 1034 kPa) to the tap marked “Make This Governor Master”.

3. Connect a pressure gauge to the tap marked “Master Line” to read the 3 to 15 psi (21 to 103 kPa) transmitter signal of the governor.

4. Shift the 30 to 150 psi (207 to 1034 kPa) connection to the tap marked “Make This Governor Slave”.

5. Apply 3 to 15 psi (21 to 103 kPa) to the tap marked “Master Line”.

6. Connect a pressure gauge to the tap marked “A” to read the 3 to 15 psi (21 to 103 kPa) transmitter signal of the governor.

7. Shift the 30 to 150 psi (207 to 1034 kPa) connection to the tap marked “Isolate This Governor”.

8. Check for air passage from the vent holes of the transfer valve block. These holes bleed air from both sides of the receiver spool to atmosphere.

Table 6-1. Troubleshooting the Load Balance System

Trouble	Probable Cause	Correct1on
Sudden total loss of load balance.	Improper mode selection.	Check other parts of control system.
	Bad leak or restriction in master piping.	Repair leaks if any. Blow through line to check for possible restriction.
	Blown receiver diaphragm in slave governor.	Replace diaphragm.
	Master receiver not venting properly.	Disassemble and check transfer valve for dirt or oil accumulation, clean and reassemble.
	Loss of transmitter signal on either master or slave.	Check 30 psi (207 kPa) supply to transmitters. Check transmitter outputs using procedure outlined in this manual. The 0.010” (0.25 mm) orifice may be clogged in transmitter block.
Engines not sharing load equally but governor servo scales are equal.	Misadjusted fuel rack linkage.	Readjust linkage to be the same on all engines.
Engines not sharing load equally and governor servo scales also indicate an imbalance.	Leak in the master line.	Check all fittings or connections which the master signal passes through.
	Improper calibration of the load sharing transmitter on either slave or master governors,	Recheck calibration. (Slight adjustments may be necessary to the transmitters or fuel rack linkage to achieve perfect load division.)
Load balance system cannot be made to work under any circumstances.	Don’t have any spare parts or problems can’t be resolved.	Isolate or disconnect the load balance system and run the engine on droop load sharing. See manual 36606 for explanation of this type of operation.

Parts Replacement Information

The same parts ordering information as in Chapter 2 is required for ordering parts in this chapter. Use Figure 6-1 for the index numbers.

Ref. No.	Part Name	Quantity
36606-201	Column case	1
36606-202	Speeder spring power piston assembly	1
36606-203	Droop plunger cap	1
36606-204	Nut	1
36606-205	Speed droop cam	1
36606-206	Power piston	1
36606-207	Droop lever assembly	1
36606-208	Screw	1
36606-209	Lockwasher	1
36606-210	Elastic hex nut, 5-40	1
36606-211	Transmitter valve plunger	1
36606-212	O-ring, .364 1.0. x .070	1
36606-213	Transmitter valve seat	1
36606-214	Transmitter bellows assembly	1
36606-215	Transmitter stem	1
36606-216	Cotter pin .030 x .375	4
36606-217	Pin	2
36606-218	Fitting clamp	1
36606-219	O-ring	1
36606-220	Orifice disc	1
36606-221	Filter element	1
36606-222	Lockwasher, #I0-.190 ID	1
36606-223	Fil. screw. 10-32 x .375	1
36606-224	Transmitter link spring	1
36606-225	Rate adjuster nut assembly	1
36606-226	Rate adjuster lock	1
36606-227	Jam nut, .250-12	1
36606-228	Jam nut. 5/16-18	1
36606-229	Tailrod pivot screw	1
36606-230	Connecting link	1
36606-231	Load divider cover	1
36606-232	O-ring	1
36606-233	Transmitter lever	1
36606-234	Transmitter link	1
36606-235	Hex nut, 8-32	1
36606-236	Shutdown bushing	1
36606-237	Screw	1
36606-238	Fil. screw, 10-32 x .375	1
36606-239	Lockwasher, 10-.190 ID	1
36606-240	Tube end clamp	1
36606-241	Spherical bearing rod end	1
36606-242	Jam nut, .250-28	2
36606-243	Cotter pin, .060 x .312	1
36606-244	Pin, .156 DX 1.000 inch	1
36606-245	Lockwasher, 10-.190 lD	4
36606-246	Fil. hd. screw, 10-32 x 2.000	4
36606-247	Soc. hd. pipe plug, .125	1
36606-248	O-ring	1
36606-249	Elastic stop nut. 10-32	1
36606-250	Washer	1
36606-251	Diaphragm	1
36606-252	Diaphragm	1
36606-253	Diaphragm crosshead	1
36606-254	Headed pin	1
36606-255	Cotter pin .060 x .312	1
36606-256	Transmitter cylinder	1
36606-257	Diaphragm	1
36606-258	Diaphragm plate	1
36606-259	Washer	1
36606-260	Elastic stop nut. 10-32	1
36606-261	Load divider cover	1
36606-262	O-ring	1
36606-263	Transmitter bracket	1
36606-264	Soc. hd. pipe plug, .125	1
36606-265	O-ring, .549 1.0. x .103	1
36606-266	Lockwasher, 10-.190 ID	2
36606-267	Fil. hd. screw 10-32, .750	2
36606-268	Cotter pin .060 x .312	1
36606-269	Headed pin, .124	1
36606-270	Pivot pin link	1
36606-271	Floating lever assembly	1
36606-272	Headed pin	1
36606-273	Cotter pin	1
36606-274	Not used	
36606-275	Not used	
36606-276	Transfer valve body	1
36606-277	Transfer valve gasket	1
36606-278	Valve adapter plate	1
36606-279	Transfer valve diaphragm	1
36606-280	Transfer valve block	1
36606-281	Transfer valve assembly (includes parts 276 to 280)	1
36606-282	Fil. screw, 10-32 1.000 inch	5
36606-283	Lockwasher, #10 x .190 ID	5
36606-284	Soc. hd. pipe plug, 1/16 NPTF	3
36606-285	Transfer valve gasket	1
36606-286	O-ring	2
36606-287	Load division tube assembly	1
36606-288	Load division tube assembly	1
36606-289	Load division tube assembly	1
36606-290	Load division tube assembly	1
36606-291	Transfer valve clamp	1
36606-292	Elastic hex thin nut, .250-20	2
36606-293	Stud. .250-20 x 1.000 inch	2
36606-294	Actuating lever	1
36606-295	Needle bearing	2
36606-296	Speeder spring power cylinder	1
36606-297	Transmitter valve spring	1
36606-298	Power piston tailrod	1
36606-299	Adjustment screw	1
36606-300	Cotter pin	1
36606-301	Spacers	2
36606-302	Pin	1
36606-303	Knurled knob	1
36606-304	Spring	1
36606-305	Movable fulcrum pin	1
36606-306	Pilot valve link	2
36606-307	Eccentric	1
36606-308	Cotter pin	1
36606-309	Adjusting block	1
36606-310	Screw	1

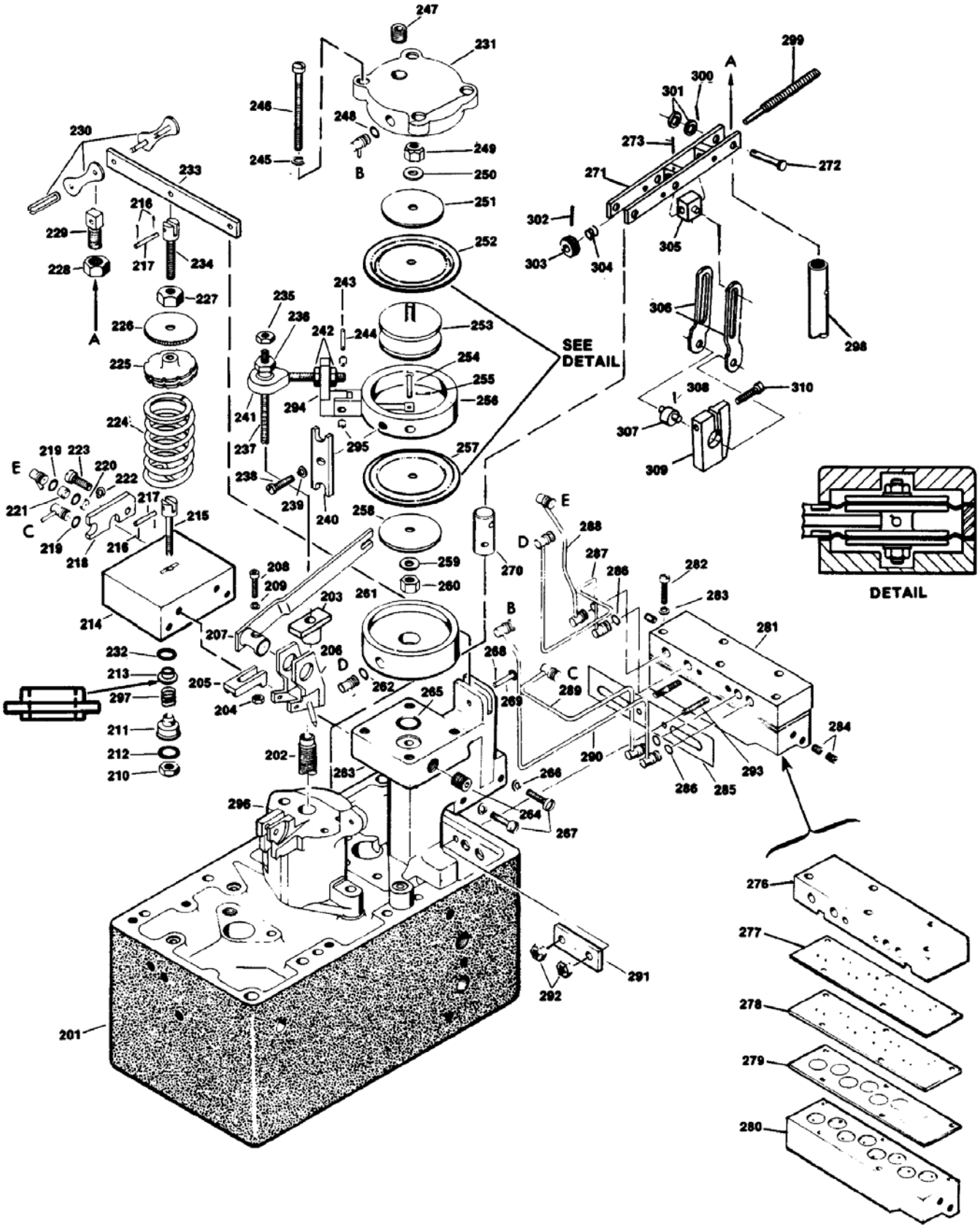

Figure 6-1. Exploded View of the Load Balance System

Chapter 7.
Product Support and Service Options

Product Support Options

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

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

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

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

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

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

Product Service Options

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

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

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

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

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

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

Returning Equipment for Repair

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

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

Packing a Control

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

NOTICE

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

Replacement Parts

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

Engineering Services

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

- Technical Support
- Product Training
- Field Service

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

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

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

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

Contacting Woodward's Support Organization

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

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

Products Used In Electrical Power Systems

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

Products Used In Engine Systems

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

Products Used In Industrial Turbomachinery Systems

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

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

Technical Assistance

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

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

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

Power Output Rating _____

Application (power generation, marine, etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Symptoms

Description _____

_____

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

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 36606B.

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