WOODWARD

Product Manual 36608
(Revision B)
Original Instructions

PG Governor

Transducer Type Load Control (LVDT) and Two-Slope Pressure Bias Linkage with Fuel Limit

Operation Manual

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

⚠ **Revisions**	**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:** **www.woodward.com/publications** **The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

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

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 Out-of-date translations are marked with ⚠.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

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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

Introduction

Chapter 1 of this manual provides an introduction outlining the purpose for using the linear variable displacement transformer (LVDT) load control arrangement, manifold air pressure fuel limiter (here-after called fuel limiter) and mechanical two slope load control bias linkage. Chapter 2 provides description of adjustment of the LVDT load control device, fuel limiter and pressure bias linkage. A schematic diagram is used to clarify the various systems. Normally these adjustments should be performed at the factory on a test stand. Chapter 3 provides replaceable parts information for ordering parts and the association of the parts lists with the assembly drawing.

The fuel limiter is an auxiliary system designed primarily for use on Woodward PG load control governors installed on turbo-supercharged locomotive engines. It may be used with absolute manifold air pressure as a reference.

Figure 1-1 illustrates the basic fuel limiter and bias linkage installed on a locomotive governor equipped with LVDT load control.

LVDT Load Control System

Purpose

With most governor applications, the primary function of the governor is to schedule fuel to the engine in sufficient amounts to maintain a constant engine speed under varying load conditions. In most locomotive governors a secondary objective is to maintain a definite horsepower output of the engine for each specific speed setting of the governor. For each speed setting of these governors, not only is a predetermined engine speed desired but also a predetermined amount of fuel for the engine.

To achieve these objectives, the load control system incorporated within the governor together with an external electric control unit, adjusts the load on the engine to a predetermined value for each specific speed setting of the governor. For example, control of load on railroad engines is obtained by adjusting the generator field excitation current so that a definite, predetermined load is absorbed by the traction motors at each setting. In this instance, the load control system operates an LVDT which through external circuitry adjusts the generator excitation.

Description

The LVDT is a differential transformer providing a linear output voltage over the displacement measuring range of ±0.100 inch (±2.54 mm).

It consists of a primary coil and two separate secondary windings of enameled copper wound on a common cylindrical, resin bonded, glass fiber former. A ferromagnetic stainless steel case houses the coil assembly and provides full electro static and electro magnetic shielding. All internal voids are filled with epoxy resin. The spring loaded, captive core is manufactured from nickel iron alloy and moves freely in PTFE guides. With applied excitation of 6 Vac (rms) at 2.5 kHz, the resolution of the device is typically 25 mV per 0.001 inch (984 mV/mm) displacement.

Operation

The LVDT operates on the principle whereby the center primary winding is energized from the alternating current source. The outer pair of secondary windings are externally connected in series opposing configuration (see Figure 1-2).

When the movable core is centered signals induced in the secondary coils are in antiphase and hence cancel resulting in zero electrical output. In practice however, due to variations and idiosyncrasies in the windings a true zero is not usually obtained, there being a very small output defined as the differential null voltage. Movement of the core away from center results in a weakening of the flux linkage associated with one secondary coil while simultaneously causing a corresponding enhancement to that of the other giving rise to the differential output voltage. Equal displacement of the core either side of center will give voltage outputs equal in magnitude but differing in phase.

A rectifier assembly is connected directly to the secondary windings in order to determine the direction of displacement. This device serves to rectify and subtract the secondary voltages thus providing a dc output the amplitude of which is proportional to load error, the polarity of the signal indicates the direction of error. A simple filter circuit is incorporated to improve the noise immunity of the system. Inclusion of the rectifiers makes it possible to achieve a true null. It attenuates the LVDT output such that the resolution is reduced to the order of 10 mV per 0.001 inch (394 mV/mm) displacement.

A simplified schematic of the basic load control system is shown in Figure 1-1. The speed setting servo piston position determines the loading on the speeder spring and hence the governor speed setting. The governor ballhead compares the actual governor speed (proportional to engine speed) with the established speed setting. If they are not equal, the pilot valve plunger is moved from its central position to initiate a repositioning of the governor power piston to which the engine fuel linkage is connected. If the engine speed is slower than desired, the power piston moves up to increase fuel: moves down to decrease fuel.

One end of a floating lever is attached to the speed setting servo piston rod; the other end is connected to the power piston tailrod. The load control plunger controls the LVDT and is suspended from the floating lever. It is readily seen from Figure 1-1 that for each speed setting, there is but one fuel setting at which the LVDT plunger is centered.

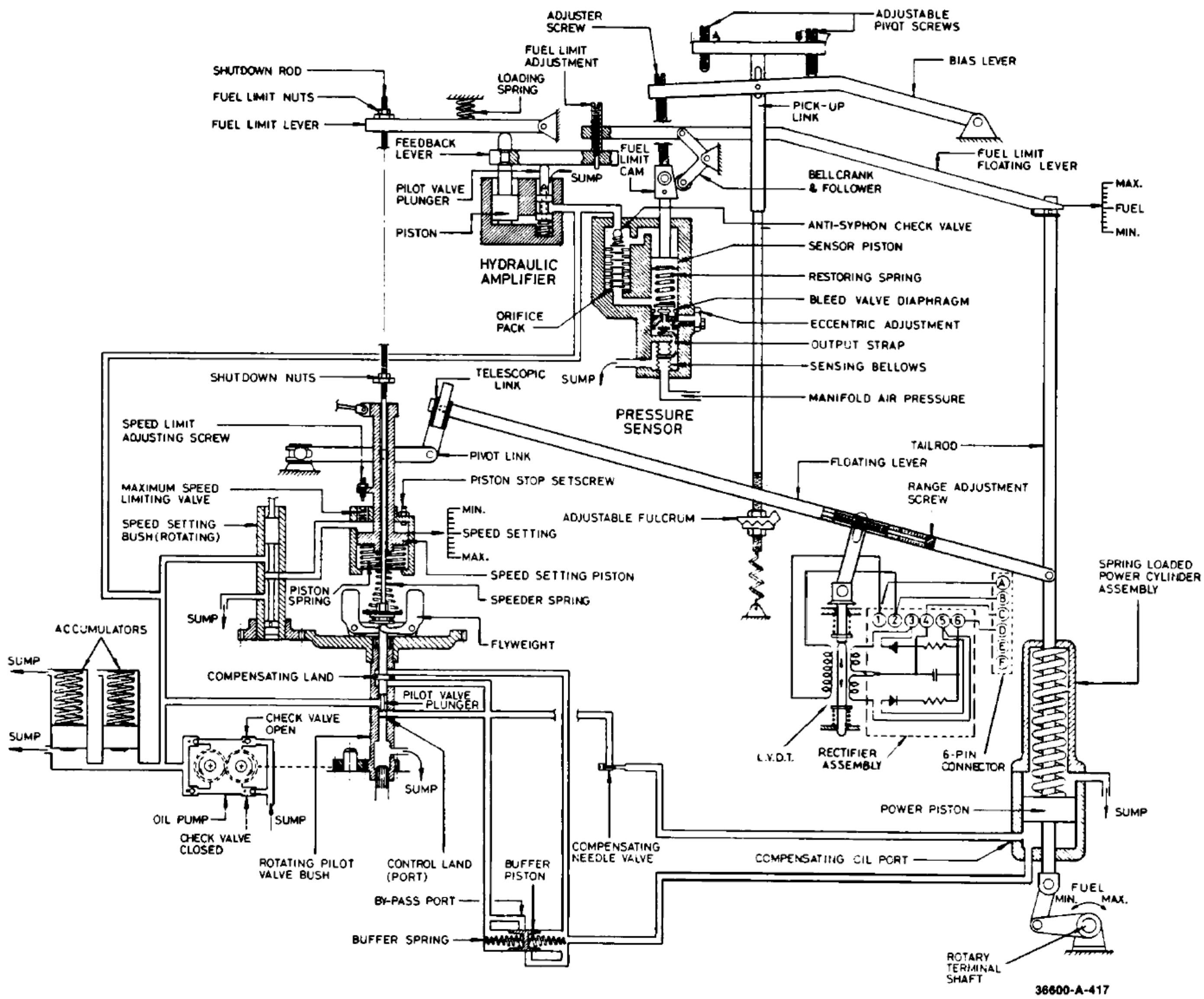

Figure 1-1. Load Control and Fuel Limiter with Two-Slope Load Control Bias Linkage

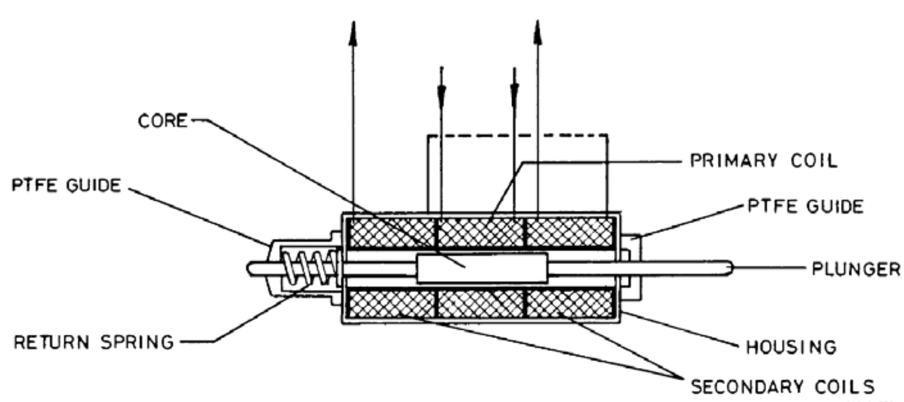

Figure 1-2. Linear Variable Differential Transformer

Consider the LVDT load control system in a governor when the plunger is "centered"—equal opposing currents flow in each of the secondary windings resulting in a minimum output—referred to as the null position. This condition occurs whenever the load on the engine is equal to the horsepower output of the engine as programmed for the existing speed setting. Assume that the load on the engine increases. The engine slows down, the ballhead lowers the governor pilot valve, and the power piston moves up to give the engine the additional fuel needed to carry the increased load at the set speed. As the power piston moves up, it lifts one end of the floating lever, lifting the load control plunger. This allows the LVDT plunger to rise above its centered position resulting in a voltage increase in the direction which causes a decrease in the generator field winding excitation to decrease load. With the load reduced the new, higher power piston position now provides more fuel to the engine than is needed to maintain the set speed. Consequently, the engine speed rises above the set speed and the governor ballhead effects a lowering of the power piston and a decrease in fuel, at the same time lowering the load control plunger.

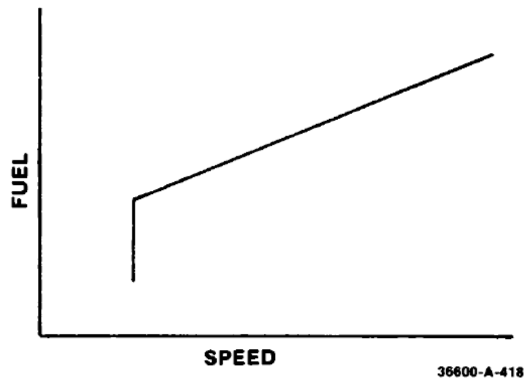

Figure 1-3. Typical Fuel Versus Engine Speed Curve

The reduction in engine load and of fuel to the engine occurs simultaneously until the engine speed has returned to the set speed and the power piston has returned to its original position, thereby centering the LVDT plunger again.

In responding to the increased load and the resulting underspeed of the engine, by temporarily increasing the fuel setting the governor has operated the load control plunger in the direction to reduce the engine load so that the horse-power demand on the engine has returned to the designed value for the existing speed setting of the governor. The governor action described has taken place entirely because of the increase in load with no change having been made in governor speed setting.

When the engine load decreases, similar movements occur, but in the opposite directions.

When an increase in governor speed setting is made, the speed setting servo piston moves down and lowers the left hand end of the floating lever, also lowering the load control plunger. This causes the LVDT plunger to fall below the center thus effecting an increase in engine load at the same time that the increase in governor speed setting is causing the power piston to move up to increase fuel to raise the engine speed. As the power piston moves up, it raises the right hand end of the floating lever and also raises the load control plunger. This action continues until the power piston is at its proper new position for fuel required at the higher speed setting and the LVDT plunger is re-centered after changing the load control electronics output to provide the desired engine load at the higher engine speed.

Similar movements occur, but in the opposite direction, when the governor speed setting is decreased.

A typical fuel versus engine speed curve is shown in Figure 1-3. The slope of the curve is determined by the point along the floating lever at which the load control plunger link is connected. The load control system will maintain this fuel versus speed relationship throughout the entire speed range except momentarily during transient conditions.

Fuel Limiter

Purpose

During acceleration, on turbo-supercharged engines, it is possible to supply more fuel to the engine than can be burned with the available air. This results from the normal lag of supercharger speed, and consequently manifold air pressure decreases with respect to engine speed.

The fuel limiter restricts the movement of the governor power piston towards the increase fuel direction, limiting engine fuel during acceleration as a function of manifold air pressure (an approximation of the weight of air available at any instant). Fuel limiting improves the fuel to air ratio during acceleration and allows more complete combustion. This improves acceleration and reduces smoke. Fuel limiting also protects the engine if the turbo-supercharger fails or reductions in engine air supply occur.

Figure 1-4 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.

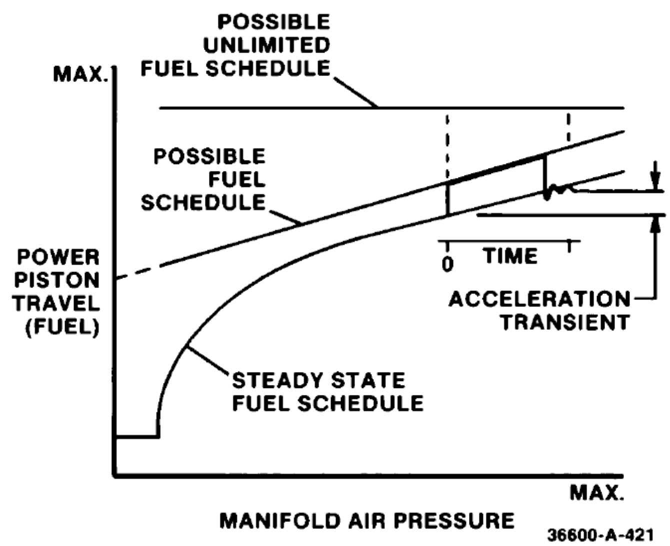

Figure 1-4. Typical Limited Acceleration Fuel Schedule Curve

Description

Figure 1-1 is essentially a floating lever, a bell crank, a pressure sensor and cam, and a hydraulic amplifier together with a feedback lever and a fuel limit 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 bell crank. The left end of the floating lever rests on the right end of the hydraulic amplifier feedback lever. The position of the bell crank, 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 increase, 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 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.

The hydraulic amplifier is a pilot-operated, signal-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.

Operation

Oil at constant pressure 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 under side 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 startup. 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 absolute-pressure-type fuel limiter consists of two opposed, flexible, metallic bellows of equal effective area. The upper bellows is evacuated, and the lower bellows senses manifold air pressure. A spacer joins the bellows at the center while the outer end of each bellows is restrained to prevent movement. Manifold air pressure acting internally on the sensing bellows produces a force causing the spacer to move towards the evacuated bellows. The evacuated bellows provides an absolute reference, therefore the sensing bellows force is directly proportional to the absolute manifold air pressure. Movement of the bellows spacer is transmitted through an output strap and a bleed valve pin to the bleed valve diaphragm.

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 bell crank 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 bell crank 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 fly-weights 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 bell crank rotates in a clockwise direction, following the cam profile. 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, bell crank, 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 over ridden 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 below the effective limiting point.

Conversely, a drop in manifold air pressure rotates the bell crank in a counterclockwise direction. This lowers the fuel limit lever, depressing the pilot valve plunger, and releases pressure 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 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.

Two Slope Load Control Bias Linkage

Purpose

The load control system on the PG governor adjusts the load on the engine as a function of governor speed setting and power piston position to maintain a definite engine power output (fuel flow) for a given speed setting.

If a constant amount of fuel is supplied to the engine for a given speed without respect to the actual air available, this will result in an excess amount of fuel supplied to the engine when manifold air pressure falls below the optimum value for the speed setting. Prolonged operation of the engine with a rich fuel/air mixture ratio results in excessive engine operating temperatures, excessive smoke and excessive fuel consumptions.

The two-slope load control bias linkage biases the basic load control system and reduces the load on the engine as a function of manifold air pressure. The governor reduces engine fuel to provide a proper fuel/air ratio for efficient burning. Figure 1-5 illustrates a typical two-slope load biasing (derating) curve, Note in Figure 1-5 derating occurs along two different slopes which generally parallel the normal power (load) curve.

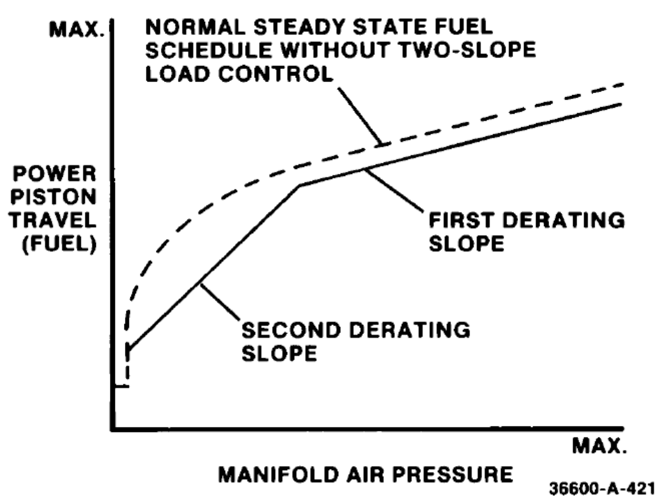

Figure 1-5.Typical Two-Slope Load Derating Curve

Description

The two-slope load control bias linkage functions during periods of steady state operation where the manifold air pressure is less than the minimum required for safe operation of the engine at its rated load for a given speed. The bias lever linkage rests on top of the fuel limiter cam and is connected via a pick up link and adjustable pivot to the load control floating lever. A telescoping link connects the lower left end of the floating lever to the right end of the restoring lever on the governor speed setting piston rod.

Operation

Figure 1-1 illustrates the load control bias linkage and associated governor components in their normal positions at rated speed and load with normal manifold air pressure. The lower position of the fuel limiter cam allows the bias lever to move downward, compressing the telescoping link to a solid height. In this position the bias lever contacts the 'B' derating adjustment screw. The load control system adjusts the load on the engine as a function of governor speed setting and power piston position. If the manifold air pressure drops below the minimum required for safe engine operation at rated load, the fuel limit cam raises the bias lever an equivalent amount. The bias lever picks up the first derating screw and, through extension of the telescoping link lifts the left end of the floating lever. The telescoping link permits the floating lever to move independent of the speed setting. Increases in speed setting may be made without directly affecting the load control.

Raising the left end of the floating lever lifts the load control plunger allowing the LVDT plunger to rise above center to reduce load. With reduced load, engine speed increases and the governor acts to reduce fuel. The governor power piston moves downward until the LVDT plunger is re-centered and the engine is operating at reduced load and fuel at full rated speed. Derating occurs in the same manner as described above at all intermediate speed settings where a condition of abnormally low manifold air pressure exists.

Figure 1-5 shows the derating slope to be more acute along the lower one-third of the normal power curve than along the upper two-thirds. This is due to the different ratios of bias lever movement transmitted through the derating adjustment screws to the load control floating lever.

A greater ratio of pick up arm movement is transmitted through the second derating screw (Screw 'A') than through the first derating screw (Screw 'B'). When de-rating is operative the effective length of the load control floating lever also changes.

For a given movement of either derating screw, the second derating screw ('A') lifts the left end of the floating lever further than the first derating screw ('8'). This combination of bias lever ratios and floating lever length reduces load (derate) more rapidly along the lower one-third of the normal power curve than along the upper two-thirds.

During acceleration, the downward movement of the governor speed setting piston extends the telescoping link between the restoring lever and load control floating lever.

Chapter 2.
Adjustment of the Basic Load Control

Test Stand Adjustment

A signal generator capable of providing a six volt amplitude sine wave output at a frequency of 2.5 kHz together with a digital voltmeter with operating ranges from 10 mV to 10 Vac/dc will be required.

Referring to the wiring diagram (Figure 2-1), make up a connector for the six pin receptacle as follows: Connect pins A & B to the output of the signal generator. Pins C & D provide the input to the digital voltmeter, these connections are polarized. Use screened cable throughout. Ground at one end only.

Proceed in this manner, referring to Figure 2-2.

1. Set digital voltmeter to by range. Switch on signal generator.

2. Use adjusting screw knob in floating lever to set “A” dimension to 0.938 inch (23.83 mm).

3. Loosen lock screw and position eccentric so that screwdriver slot is horizontal and on the side furthest from the adjusting screw knob as shown. Retighten lock screw.

4. Set the governor speed setting at idle speed (or the selected low reference speed); adjust the governor power piston position to the height (or relative terminal shaft position) programmed for idle (or low reference) speed.

5. If the digital voltmeter is not reading zero, the LVDT plunger is not “centered”.

   If the plunger is not centered, loosen upper locknut, slip a long screwdriver under the indicator washer and pry up to raise the load control plunger approximately 1/2” (13 mm). Use a thin, 7/16 open-end wrench to turn the lower locknut and thereby thread plunger stem out of adjusting block if voltmeter reads in decrease load direction or into block if voltmeter reads in the increase load direction.

   After each adjustment, release load control plunger and observe voltmeter. Continue to adjust until zero voltage reading is achieved. This indicates that the LVDT load control plunger is centered.

IMPORTANT — **These adjustments are extremely sensitive. Take care when approaching the centered position, for if the plunger should go through center, the voltage will increase again in the decrease load direction. Tighten the upper locknut and recheck.**

6. Set the pointer on the indicator washer; loosen scale adjusting screw and position load indicating scale so that pointer indicates exactly “0” when the digital voltmeter is showing zero.

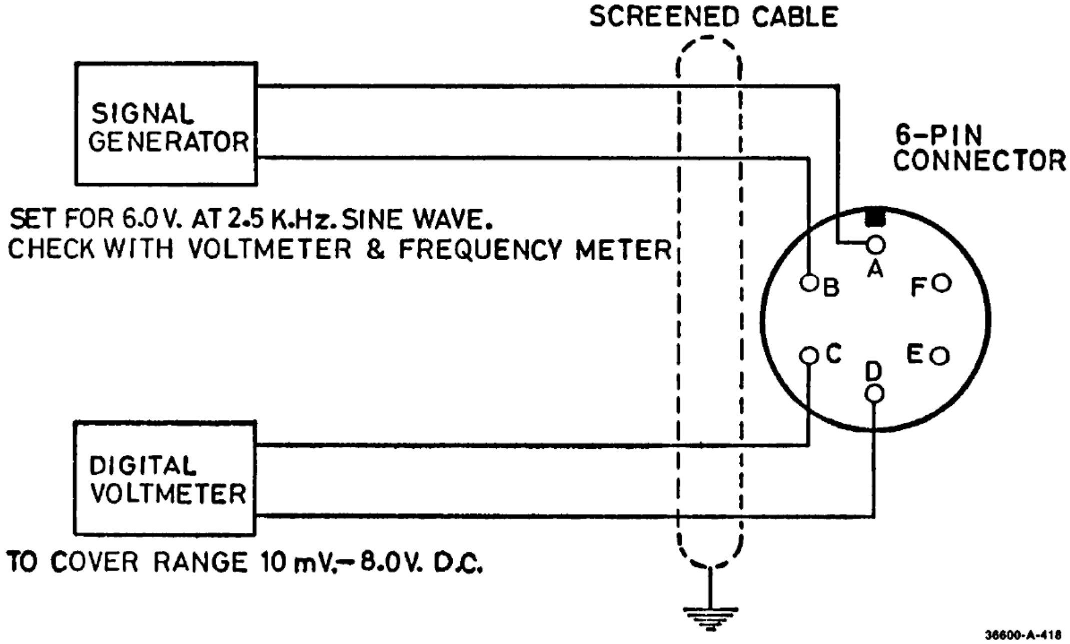

Figure 2-1. Electrical Schematic Diagram for Governor Test

7. Move speed control to maximum speed; adjust power piston tailrod position to the exact height (or relative terminal shaft position) specified for maximum speed setting. Pointer should now indicate "0", and the digital voltmeter should be reading zero.

8. If the voltmeter shows a reading other than zero the indicator pointer position will show whether the LVDT plunger is above or below center. If above then lower the plunger by using adjusting screw knob to move the adjusting block in the direction to decrease "A" dimension; move the block only enough to bring the pointer half way to the zero mark on the scale. Adjust the eccentric to bring the pointer the rest of the way back to zero (and thus center the LVDT plunger).

9. Return to the idle or low reference speed and power piston positions used in step 5. Pointer should now indicate "0" and the voltmeter reading zero.

10. If the voltmeter does not read zero, the indicator pointer will show whether the LVDT plunger is above or below center. If below then raise the plunger by using the adjusting screw knob to move the adjusting block in the direction to increase the "A" dimension; move the block only enough to bring the pointer half way to the zero mark on the scale. Adjust the eccentric to bring the pointer the rest of the way back to zero.

11. Repeat steps 4 through 10 to confirm specified load control settings are achieved at both idle and maximum speeds.

IMPORTANT

When setting the basic load control characteristic, the telescopic link of the floating lever assembly must remain fully seated. Similarly during this operation the floating lever must be free of contact with the adjustable fulcrum.

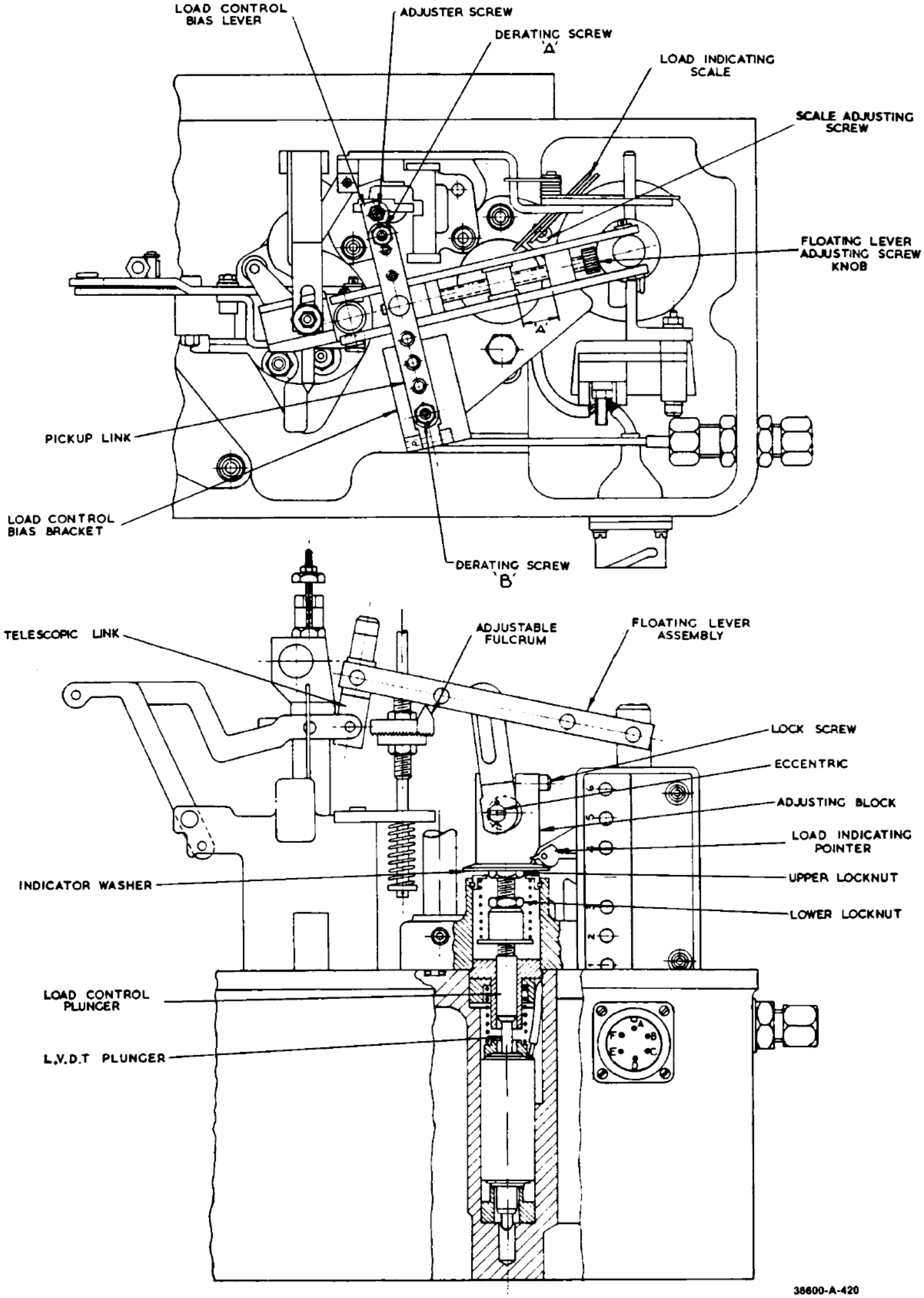

Figure 2-2. Layout of LVDT Load Control, Fuel Limiter, and Bias Linkage

Fuel Limiter with Two-Slope Load Control Bias

Refer to Figures 2-2 and 3-2 when making adjustments to the two-slope load control bias linkage.

IMPORTANT **Disengage and lay the bias lever back so access can be gained to the top of the fuel limit cam for positioning a dial indicator.**

1. Operate governor at idle speed setting.

2. Adjust clearance between bottom of shutdown bushing and top of speed setting piston rod to 0.032 ±0.005 inch (0.81 ±0.13 mm). Secure bushing with jam nut. Recheck clearance and readjust if necessary making certain governor shuts down.

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

4. Connect air pressure to engine manifold air pressure fitting on governor column. Regulate air pressure to value specified for adjustment of sensor piston.

5. Determine sensor piston travel using a dial indicator with its plunger contacting top of fuel limit cam (57).

6. Loosen lock screw (79) in eccentric adjustment and turn eccentric (81) fully ccw. Sensor piston (and fuel limit cam) travel downward until piston bottoms on adjustable seat of bleed valve.

7. Tighten the lock screw slightly. Slowly turn the eccentric cw while observing dial indicator for a sudden change in rate of sensor piston travel in upward direction. This indicates that the sensor piston has moved off the adjustable seat and into the active range of its travel. Note approximate point change in rate occurred and continue turning eccentric cw until sensor piston travels 0.010 to 0.015 inch (0.25 to 0.38 mm) above the point the change in rate occurred. If sensor piston travels a minimum of 0.005 inch (0.13 mm) downward with an increase in air pressure, the adjustment is satisfactory. Fully tighten lock screw.

8. Make certain sensor piston (58) travels to top of its stroke with decreasing air pressure.

9. Reposition dial indicator with plunger contacting top of power piston tailrod. Zero indicator with power piston in full down position (power piston travel is 1.00 inch/25.4 mm).

10. Operate governor at maximum speed setting.

11. Regulate air pressure to lowest value of manifold air pressure specified for fuel limiter adjustment.

12. Adjust test stand speed control so governor power piston travels specified distance (mid-point of tolerance range) corresponding to given manifold air pressure.

13. Turn fuel limit adjustment screw cw until hydraulic amplifier piston (53) lifts fuel limit lever (22) to a horizontal position.

14. Adjust position of fuel limit nut (21) on shutdown rod to obtain specified clearance (mid-point of tolerance range) between bottom of nut and top surface of fuel limit lever. Secure with jam nut (20).

15. Check fuel limit nut clearance and power piston travel by cycling power piston. First downward and then slowly upward to point where load control plunger just begins to rise. The fuel limit nut clearance and power piston travel must be within their respective tolerance ranges at the given manifold air pressure.

16. Regulate air pressure to highest value of manifold air pressure specified for fuel limiter adjustment.

17. Cycle power piston, first downward and then upward to a point where the load control plunger just begins to rise to the unloading position. Power piston travel must be within the specified tolerance range for the specified manifold air pressure (step 16).

18. If power piston travel is not within specified limits, loosen fuel limit cam locking screw (55) and tilt top of cam toward bell crank (47) to decrease power piston travel or away from bell crank to increase travel. Tighten locking screw and repeat step 17.

19. Following adjustment of the fuel limit cam, recheck and readjust the fuel limit adjustment screw as necessary. Repeat steps 11 through 18 until no further adjustment of the fuel limit adjustment screw or fuel limit cam is necessary. Figure 2-3 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 adjustment screw raises (or lowers) the schedule a like amount over its entire length. An adjustment of the fuel limit cam alters 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 as illustrated is linear (straight-line).

20. Reinstall load control bias lever and bracket if previously removed. The adjuster screw functions as a pickup point and should be set to position the bias lever horizontally with cam at the mid point of its travel.

21. Regulate air pressure to specified (higher) value of manifold air pressure where derating along the first slope is to begin (see Figure 1-5). Position power piston at specified travel corresponding to that air pressure.

    Adjust first “By’ derating screw in bias lever to pick up left end of load control floating lever to achieve load control balance.

    Regulate air pressure to specified (lower) value where load derating along second slope is to begin.

    Adjust second “A” derating screw in bias lever to balance load control at specified power piston travel corresponding to that air pressure.

22. If load control balance cannot be achieved within the adjustment range of the A & B screws it will be necessary to reposition the adjustable fulcrum.

23. Reset A & B screws to their mid positions. These screws bear on the bias lever which follows the movement of the fuel limiter cam, causing the pickup link to raise or lower the adjustable fulcrum which provides a pivot for the floating lever assembly, effecting lifting or lowering of the load control plunger.

The fulcrum assembly incorporates two adjustments.

24. The level is set by means of the two locking nuts on the threaded portion of the pickup link.

    The adjustable fulcrum being positioned such that at the appropriate settings of speed, tailrod and fuel limiter cam positions the pivot points are in contact with the underside of the floating lever assembly. This contact must be maintained while pressure bias derating is operative. Similarly, during derating the telescopic link of the floating lever assembly, must never completely close.

25. Subsequent adjustment of the fulcrum being made by advancing or withdrawing it towards or away from the tailrod one or more serrations to ensure load control balance can be accommodated within the adjustment range of the “A” & “B” screws.

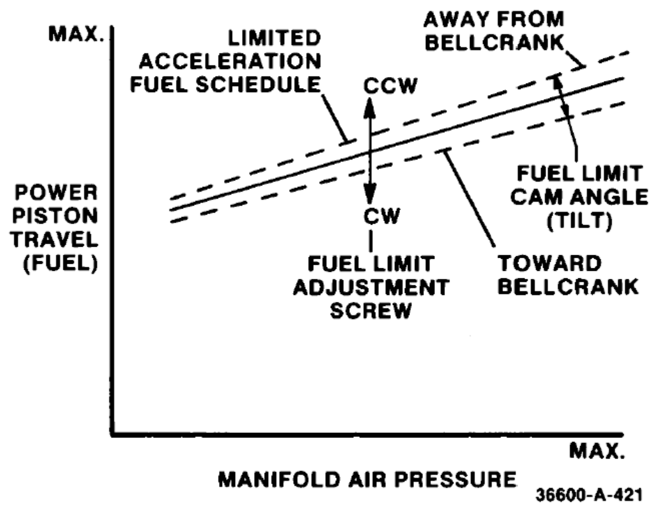

Figure 2-3. Typical Effects of Fuel Limit Adjustment Screw and Fuel Limit Cam Angle (Tilt) on Fuel Limiting Schedule

Chapter 3.
Replacement Parts

When ordering replacement parts, include the following information:

- Governor serial number and part number shown on nameplate
- Manual number (this is manual 36608)
- Parts reference number in parts and description of part or part name

The illustrated parts breakdown lists replaceable parts for the fuel limiter, load control, and bias linkage. The numbers assigned are used as reference numbers and are not specific Woodward part numbers. Woodward will determine the exact part number for your particular actuator.

Parts List for Figure 3-1, Filter and Side Plate Assembly

Ref. No.	Part Name	Quantity
36608-1	Screw Taper	1
36608-2	Valve Bushing Gasket	1
36608-3	Bushing	1
36608-4	Washer	1
36608-5	Screw Socket Head 1/4-28 x 3/8"	1
36608-6	Side Plate Gasket	1
36608-7	Side Plate	1
36608-8	Preformed Packing 7/16" O.D.	2
36608-9	Case	1
36608-10	Gasket, Soft Copper	1
36608-11	Plug	1
36608-12	Lockwasher, Split 1/4"	12
36608-13	Screw Socket Head 1/4-28 x 2-3/4"	3
36608-14	Preformed Packing 11/16" O.D.	1
36608-15	Preformed Packing 1'/4" O.D.	1
36608-16	Plug and Filter Assembly	1
36608-17	Screw Socket Head 1/4-28 x 3/4"	9

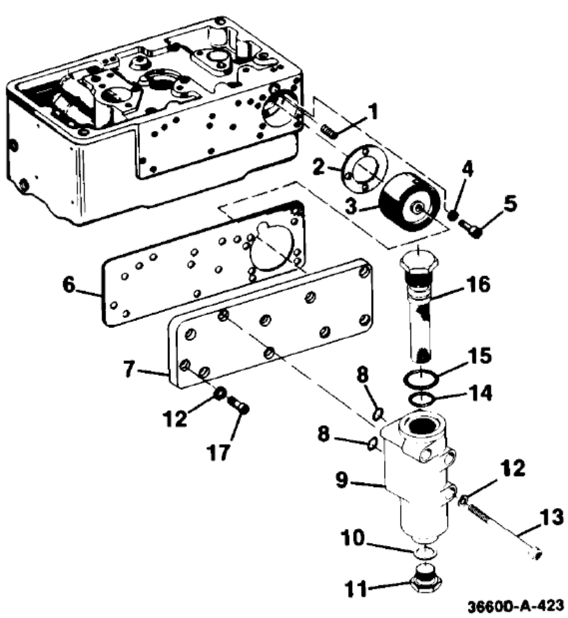

Figure 3-1. Filter and Side Plate Assembly

Parts List for Figure 3-2, Fuel Limiter Assembly

Ref. No.	Part Name	Quantity
36608-20	Nut Hex. 8-32 (MS35469-282)	2
36608-21	Nut Hex. 8-32	2
36608-22	Fuel Limiter Lever	1
36608-23	Loading Spring	1
36608-24	Cotter Pin .062 x .375 (MS24665-130)	2
36608-25	Floating Lever End	1
36608-26	Pivot Pin (Fuel Limit Lever)	1
36608-27	Yield Spring	1
36608-28	Washer	1
36608-29	Cotter Pin 0.062 x 0.375 (MS24665-130)	2
36608-30	Retaining Ring, E-Type (MS16633-1014)	1
36608-31	Feedback Lever Assembly	1
36608-32	Pivot	1
36608-33	Adjusting Screw (Fuel Limit)	1
36608-34	Feedback Lever	1
36608-35	Not Used	
36608-36	Ferrule, 0.250 Tube	1
36608-37	Nut Hex. 0.500-20 (MS35691-822)	1
36608-38	Ballhead Union, 0.250 Tube	1
36608-39	Screw Soc. Head, 0.250-28 x 1.125 (MS35458)	1
36608-40	Screw Soc. Head, 0.250-28 x 1.750 (MS35458-28)	1
36608-41	Washer, Lock 0.250 I.D. (M551848)	2
36608-42	Screw Soc. Hd. 10-32 x 0.500 (MS24678-20)	2
36608-43	Screw Soc. Hd. 10-32 x 1.500 (MS24678-16)	1
36608-44	Washer, Lock #10 (MS35338-43)	3
36608-45	Cotter Pin 0.062 x 0.625 (MS24665-152)	2
36608-46	Not Used	
36608-47	Bell crank	1
36608-48	Straight Pin, Drilled	1
36608-49	Needle Bearing	1
36608-50	Linkage Bracket	1
36608-51	Amplifier Pilot Valve Plunger	1
36608-52	Pilot Valve Loading Spring	1
36608-53	Amplifier Piston	1
36608-54	Sensor Piston Sleeve	1
36608-55	Screw, Button So. Hd. Nylock, 8032 x 0.375	1
36608-56	Roll Pin, 0.125 x .375 (MS171524)	1
36608-57	Fuel Limit Cam	1
36608-58	Sensor Piston	1
36608-59	Restoring Spring	1
36608-60	Restoring Spring Seat	1
36608-61	Bleed Valve Diaphragm	1
36608-62	Filter Screen	1
36608-63	Preformed Packing .500 O.D. (NAS1593-012)	2
36608-64	Check Valve Assembly	1
36608-65	Retaining Ring, Internal (MS16625-1037)	1
36608-66	Washer .1406 ID. x 0.375 (Max) 0.D.x 0.031	1
36608-67	Orifice Pack Spring	1
36608-68	Washer,.1871.D.x.375(Max) O.D. x 0.062	2
36608-69	Gasket	33
36608-70	Orifice Plate	32
36608-71	Orifice Case	1
36608-72	Spring Washer	1
36608-73	Screw, Button Soc. Hd. Nylock 8-32 x 0.375	2
36608-74	Sensor Bellows (Absolute Pressure Type)	1
36608-75	Preformed Packing 1.250 O.D. (NAS1593-024)	1
36608-76	Bellows Spacer (Used with Item 74 Only)	1
36608-77	Bellows Output Strap (Used with Item 74 Only)	1
36608-78	Retaining Ring (Internal) (MS16627-1125)	1
36608-79	Screw, Hex. Hd. .250-28 x .750 (MS35298-6)	1
36608-80	Washer, Soft Copper .250 I.D. x 0.500 O.D. x 0.031	1
36608-81	Eccentric	1
36608-82	Gasket Copper	1
36608-83	Valve Seat	1
36608-84	Cylinder Head	1
36608-85	Taper Screw	9
36608-86	Housing	1
36608-87	Straight Pin (Tailrod)	1
36608-88	Preformed Packing, 0.338 O.D. (NA51593-011)	1
36608-89	Pilot Valve Plunger Nut	1
36608-90	Loading Spring	1
36608-91	Not Used	1
36608-92	Spring Seat	1
36608-93	Pin 0.059 x 0.082 Dia. x 0.782 LOA	1

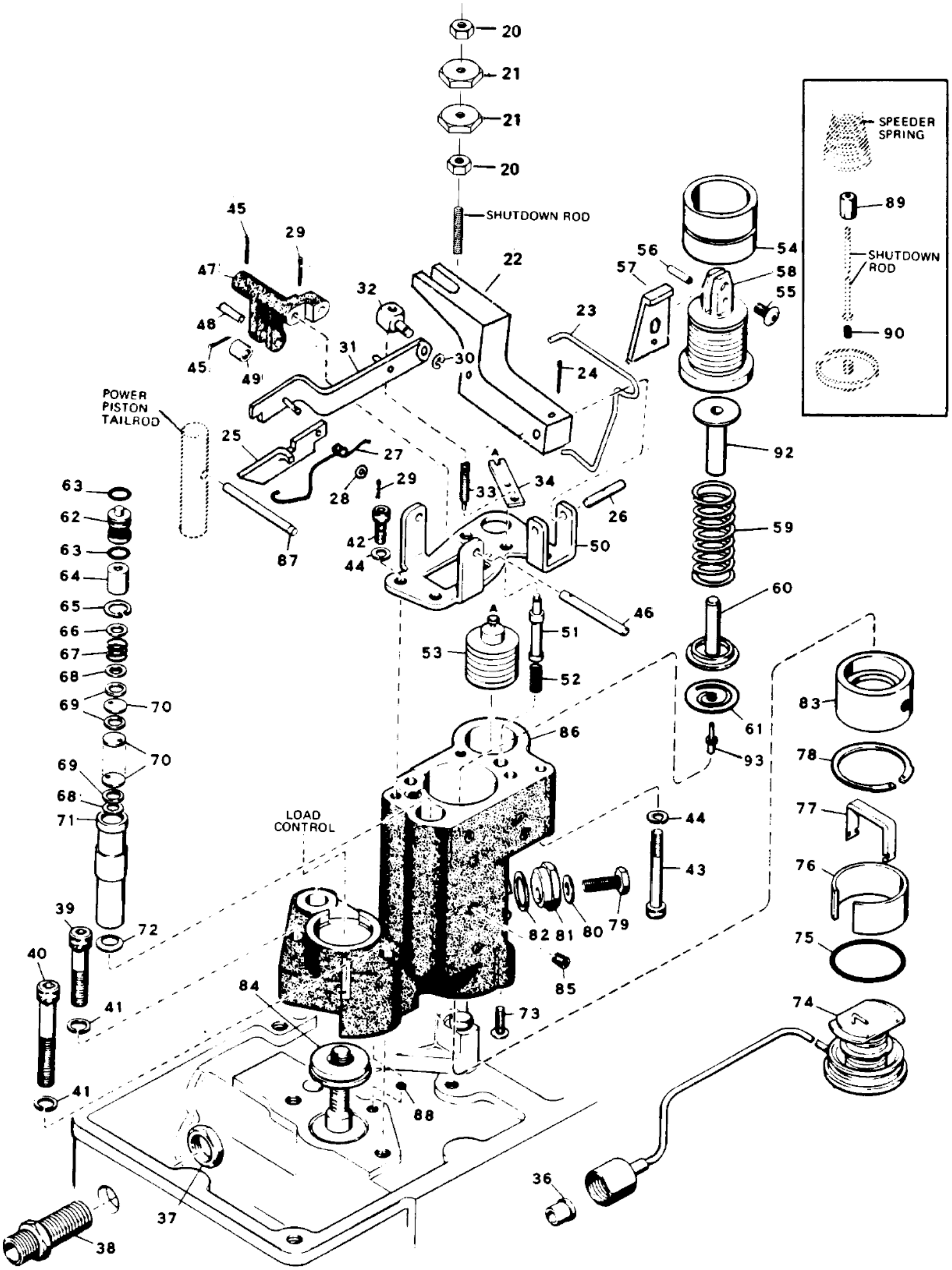

Figure 3-2. Exploded View—Fuel Limiter Assembly

Parts List for Figure 3-3, Load Control and Two-Slope Load Control Bias Linkage

Ref. No.	Part Name	Quantity
36608-100	Pick-up Lever	1
36608-101	#10-32 Nut	1
36608-102	#10-32 x .750 Soc. Hd. Screw	1
36608-103	#6-32 x .750 Soc. Hd. Cap Screw	2
36608-104	#6-32 Nut	2
36608-105	Pick-up Link Assembly	1
36608-106	Fuel Limit Floating Lever Assy	1
36608-107	Lock Washer	1
36608-108	0.250-28............ x 1.125 Soc. Hd. Cap Screw	1
36608-109	Yield Spring	1
36608-110	Cotter Pin	1
36608-111	Washer	1
36608-112	#10-32 x .250 Ph. Rd. Hd. Screw	1
36608-113	#10 Spring Lock Washer	3
36608-114	Indicator Assembly	1
36608-115	Floating Lever End	1
36608-116	otter Pin	1
36608-117	Washer	1
36608-118	Headed Pin	1
36608-119	#10-32 Ph. Hd. Screw x 0.500	2
36608-120	#10 Spring Lock Washer	2
36608-121	#10-32 Elastic Insert Nut	2
36608-122	#10 Washer	2
36608-123	Bracket	1
36608-124	Rectifier Assembly	1
36608-125	#10-32 x 1.375 Soc. Hd. Cap Screw	2
36608-126	Gasket	1
36608-127	#4 Spring Lock Washer	4
36608-128	#4-40 x 0.312 Fillister Head Screw	4
36608-129	Receptacle Assembly	1
36608-130	0.125 N.P.T.F. Plug	1
36608-131	0.250-28 x 1.750 Soc. Hd. Cap Screw	1
36608-132	Lock Washer	2
36608-133	Cotter Pin	1
36608-134	Bushing	1
36608-135	Spring-Torsion	1
36608-136	Cotter Pin	1
36608-137	Drilled Pin	1
36608-138	Drilled Headed Pin	1
36608-139	Spacer 0.125 I.D.	2
36608-140	Headed Pin	1
36608-141	Link	1
36608-142	Screw	1
36608-143	Adjustable Floating Lever Assy.	1
36608-144	Wide Link Eccentric	1
36608-145	Cotter Pin	1
36608-146	Adjusting Block	1
36608-147	Screw	1
36608-148	Modified Cup Washer	1
36608-149	0.312 x 24 Jam Nut	2
36608-150	Spring Retainer	1
36608-151	Snap Ring Retainer	1
36608-152	Spring — P.V. Loading	1
36608-153	Spring Collar	1
36608-154	Load Control Spacer	1
36608-155	Variable Linear Transducer	1
36608-156	Spacer	1
36608-157	Spring Seat	1
36608-158	Head – Cylinder	1
36608-159	Retaining Spring	1
36608-160	Plunger — Load Control	1
36608-161	0.301 I.D.x.070 O-ring	2
36608-162	0.250-28 Set Screw	1
36608-163	Post	1
36608-164	Cotter Pin	1
36608-165	Dished Spacer	1
36608-166	Pickup Link Spring	1
36608-167	Guide	1
36608-168	Pickup Link Guide	1
36608-169	#6-32 x 0.375 Soc. Hd. Cap Screw	2
36608-170	Adjusting Block	1
36608-171	Adjustable Fulcrum Block	1
36608-172	0.312-24 Hexagon Nut	2
36608-173	#8-32 Elastic Hex Nut	1
36608-174	Load Control Link	1
36608-175	#10-32 x .500 Soc. Hd. Cap Screw	1
36608-176	Pivot Lever Assembly	1
36608-177	Bypass Valve Link Assembly	1
36608-178	#10-32 Kaylock Nut	1
36608-179	Cotter Pin	1

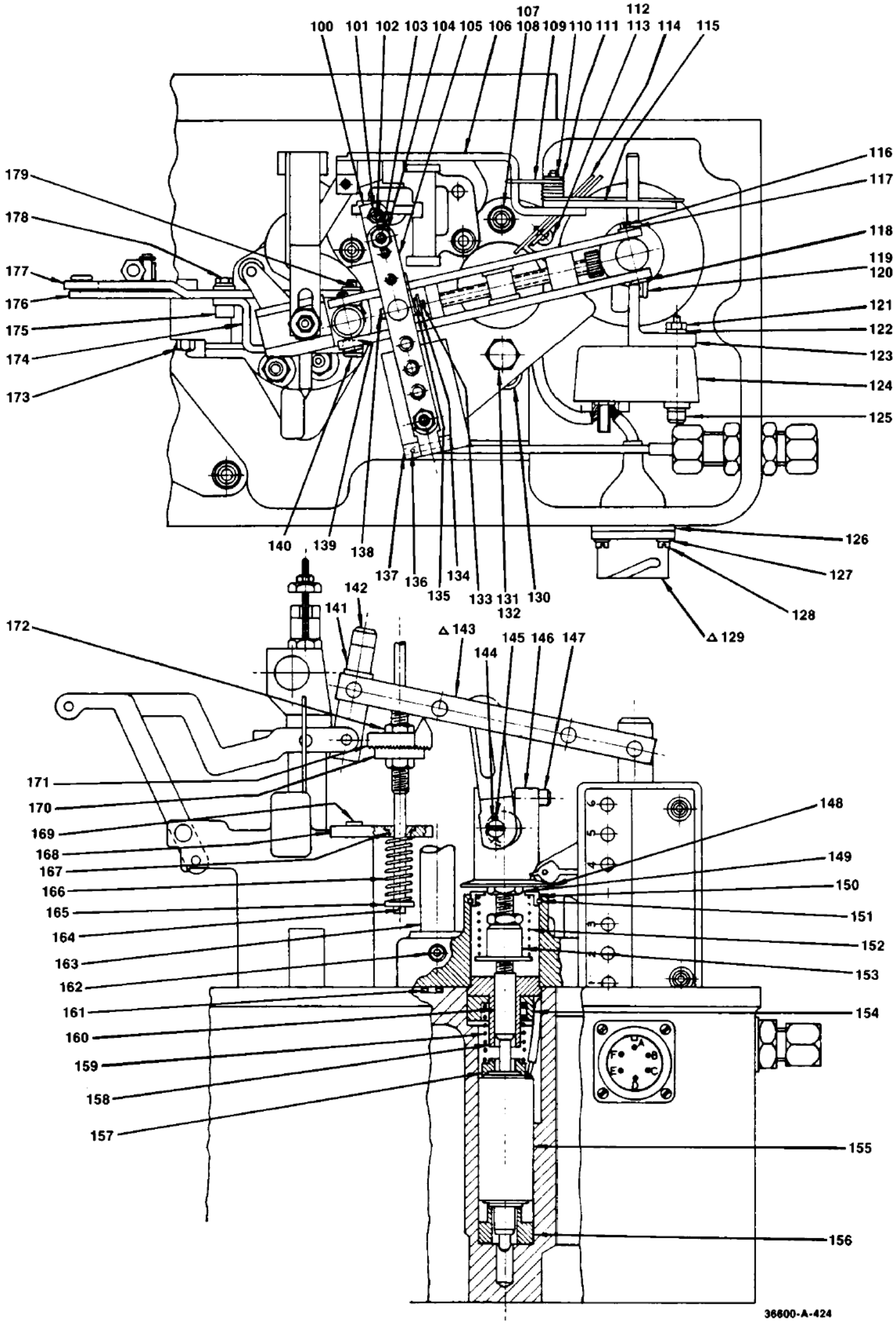

Figure 3-3. Load Control and Two-Slope Load Control Bias Linkage Parts Identification

Chapter 4.
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 ____________________

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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 36608B.

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

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