WOODWARD

Product Manual 37517
(Revision B)
Original Instructions

PG-12R / PG-12L Actuator

Installation and Operation Manual

General Precautions

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

Practice all plant and safety instructions and precautions.

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

Revisions

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

www.woodward.com/publications

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

Proper Use

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

Translated Publications

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

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 Out-of-date translations are marked with ⚠.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

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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

Description

The PG-12R/PG-12L Actuator is a proportional electro-hydraulic actuator which can be used with electronic controls which provide a 0 to 200 mA position signal. The actuator is designed for use with Woodward LEC and CLC locomotive controls, as well as the 2301A series, 500-series, and 700-series controls.

The actuator converts a given electrical signal to an output shaft position through the action of a torque motor and follower-type pilot valve. The rotary output version has 30 degrees of terminal (output) shaft travel. The linear output version has 25.4 mm (1 inch) stroke. Recommended travel from the no-load to the full-load position is 2/3 of full actuator travel.

The PG Actuator is used on diesel engines to replace PGA and PGE governors with 12 ft-lb power cylinders, providing the advantages of electronic control with the convenience of the existing PG-type drive and linkage.

The PG Actuator provides a maximum work capacity of 25.4 J (18.7 ft-lb) in the increase direction and 20.2 J (14.9 ft-lb) in the decrease direction. Work capacity is based on the full 30 degree travel (or 1 inch travel) of the terminal (output) shaft. Rated work capacity is 2/3 of maximum work capacity.

PG Governor Similarities

The PG-12R/PG-12L Actuator uses a new base that locates the drive shaft and output shaft in the same relative positions as the PG governor. The output shaft or rod end and rack position indicators are the same parts used in the PG governor. The base is designed to fit any drive designed for a standard PG governor with a 1.125-inch serrated drive. In addition, UG or UG/90° bases are available with 0.625-inch serrated or keyed drive.

The actuator may be equipped with a special gear and magnetic pickup, using the governor drive to sense engine speed. This permits an added convenience when converting from a PG hydraulic-mechanical governor to an electronic control system (the MPU is not available with the UG base).

The MPU will sense the speed of the governor drive, which is not necessarily the same rpm as the engine. The frequency sensed by the MPU must match the frequency range of the electronic control.

Hydraulic Pump

The PG Actuator is equipped with a Gerotor pump. The pump uses oil from the self-contained PG Actuator sump to provide 1379 kPa (200 psi) internal operating pressure.

The direction of rotation is selected by pump housing alignment. The pump operates in one direction only. The drive uses a maximum of 375 W (0.5 hp). In some cases the actuator may require an oil cooler to operate at the high end of the drive speed range.

Actuator Response

The PG Actuator output is directly proportional to a 0 to 200 mA signal from an electronic control system.

This manual provides outline drawings to show the base and drive configurations. The outline drawings include information on electrical wiring, installation dimensions, drive requirements, oil requirements, and output shaft dimensions. The drawings are provided for reference only. Do not use the drawings for construction.

References

The following publications provide additional information about installation, operation, and storage of Woodward products.

25071, *Oils for Hydraulic Controls*
25075, *Commercial Preservation Packaging for Storage of Mechanical- Hydraulic Controls*
50516, *Governor Linkage for Butterfly Control Valve*

This manual does not attempt to provide information about the electronic control which determines the position of the PG Actuator output. This information must be obtained from the appropriate manual for the electronic control.

Chapter 2. Installation

Introduction

Use care while handling and installing the PG Actuator. Be particularly careful to avoid striking the drive shaft, terminal shaft, or the electrical connector. Abuse can damage seals, internal parts, and factory adjustments. Do not set the actuator on its drive shaft.

Receiving

After factory testing and calibration, the PG Actuator is drained of oil. This leaves a light film of oil on internal parts to prevent rust. External parts are painted or coated with a spray lubricant/rust inhibitor.

No internal cleaning or flushing is necessary before installation and operation. The little oil left in the actuator is clean, multiviscosity engine oil which will not contaminate the oil selected to operate the actuator.

Fill the actuator with 6.0 L (6.3 qt) of oil selected to match the expected operating conditions. (If the actuator is a direct replacement for a PG governor, you may use the same grade and weight of oil that was being used in the governor.) Use only new, clean oil in the actuator. Do not allow dirt or contamination to enter the actuator while filling with operating oil. Do not use oil drained from the PG governor.

Storage

The PG Actuator may be stored for short periods of time (less than a year) as received from the factory. For long-term storage (more than a year), storage in an environment with large temperature changes, humid or corrosive atmosphere, etc., or if the actuator is installed on the engine for storage, fill the actuator with oil and follow preservation packaging instructions in Woodward Manual 25075, *Commercial Preservation Packaging for Storage of Mechanical-Hydraulic Controls*.

Drive Shaft Rotation

The actuator drive-shaft rotation is one direction only. Rotation, as viewed from the top of the actuator, must be the same as that of the engine drive when looking down on the mounting pad.

If the actuator oil pump is rotated in the wrong direction, oil pressure will not be generated in the actuator.

NOTICE

Be sure engine mounting-pad drive and actuator-drive rotation are the same. Incorrect drive rotation will cause the actuator to become inoperative, and may cause actuator damage.

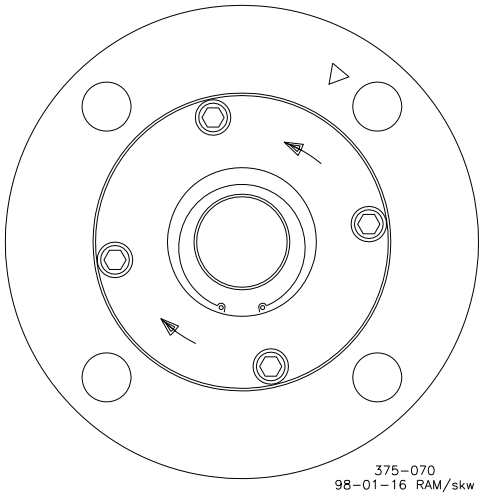

Figure 2-1. Alignment of Reference Notch and Arrow

Use the following procedure to change the direction of rotation:

1. Remove the four pump-housing screws.
2. Index the pump plate 180 degrees to align the arrow corresponding to the direction of rotation selected with the reference notch in the base.
3. Replace the four screws, and torque the screws to 9.2 N·m (81 lb-in).
4. Make sure that the actuator drive shaft rotates freely.

Attitude

The PG Actuator should be installed in a vertical or near vertical position. See the outline drawing for installation instructions and dimensions.

Drive Connection

Make sure the actuator drive shaft turns freely before installing the actuator. The drive gear or coupling must slip freely into the governor drive of the engine. Do not apply external force. The drive must be free of binding, side load, or excess end-play. Improper alignment or fit between the parts can result in excessive wear or actuator-drive seizure.

Mount the actuator squarely on the mounting pad. Torque the mounting bolts evenly. There can be no movement or rocking of the actuator on the engine-mounting pad.

Control Linkage

The terminal shaft rotates 30 degrees or 25.4 mm (1 inch) of linear stroke. Use 2/3 of the total travel between no load and full load. The additional “overtravel” should be split and used at both ends to provide maximum fuel when required and to assure shutdown at minimum-fuel actuator position (see Figure 2-2).

WARNING

To prevent possible serious injury or loss of life, or damage to the engine, be sure to allow sufficient overtravel at each end of the terminal shaft, so the actuator can shut down the engine, and also give maximum fuel when required. Misadjusted linkage could prevent the actuator from shutting down the engine.

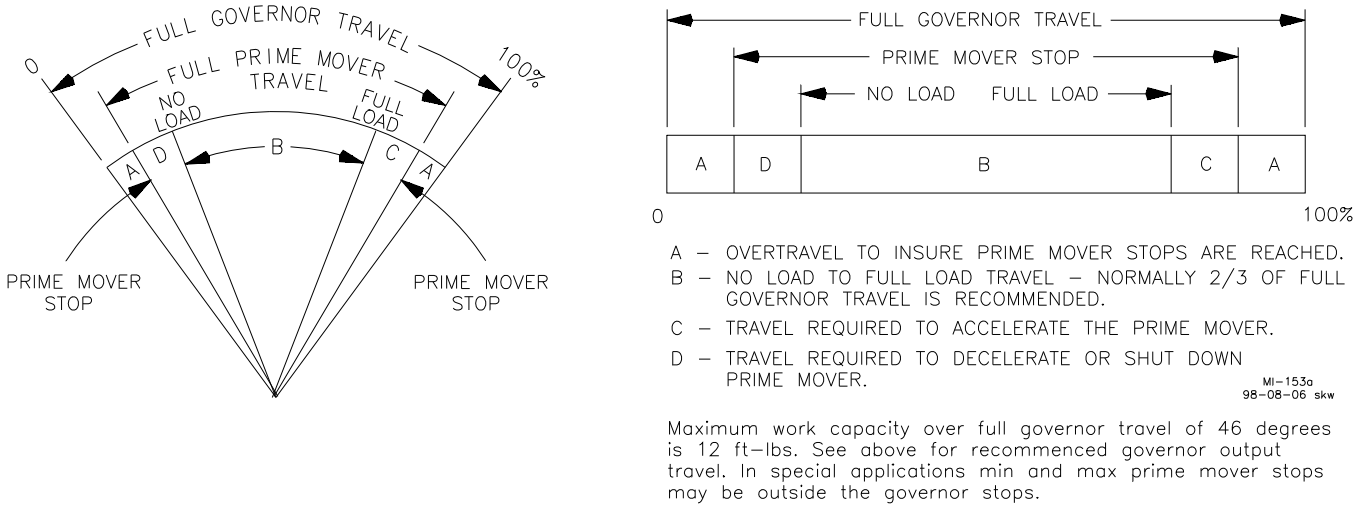

Figure 2-2. Terminal Shaft Travel

Many control problems are related to linkage between the actuator and the engine. Use only first-quality rod ends for the linkage, rod ends that will last under the nearly constant motion associated with precise speed control. The linkage must be stiff, not subject to engine caused vibration. The linkage must be as light as possible and still maintain the attributes of stiffness. Linkage which is too heavy can damage the actuator as well as make it difficult to achieve steady control. Installed linkages must operate smoothly, be free of binding, and free of lost motion due to worn parts. If there is a collapsible member in the linkage, be sure it does not yield each time the actuator moves the linkage rapidly.

Use a linear linkage for most diesel applications. Linear linkage moves the fuel setting shaft in direct proportion to the movement of the actuator output. Design the linkage so the power output of the engine is proportional to the position of the actuator output shaft.

Follow the engine manufacturer's instructions on linkage selection, installation, and adjustment. In almost all cases, the linkage designed for a PG governor will work with the PG Actuator. In the case of a direct exchange, make sure that the linkage is in good condition and the installation of the lever on the actuator is in the same position as it was on the governor.

Oil Supply

Use the information given in Figures 2-5 and 2-6 as a guide in the selection of a suitable oil. Oil grade selection is based on the operating temperature range of the actuator. Also use this information to aid in recognizing and correcting common problems associated with oil used in the actuator. Many operation and maintenance problems associated with PG Actuators are directly related to the selection and condition of the oil in the actuator. Use care in the selection and make sure that the oil in the actuator is not contaminated.

The oil in the PG Actuator is both a lubricating and hydraulic oil. It must have a viscosity index that allows it to perform over the operating temperature range and it must have the proper blending of additives that cause it to remain stable and predictable over this range.

The PG Actuator is designed to give stable operation with most oils, if the fluid viscosity at the operating temperature is within a 50 to 3000 SUS (Saybolt Universal Seconds) range (see Figure 2-4). Poor actuator response or instability is an indication that the oil is too thick or too thin.

Actuator oil must be compatible with seal material, that is, nitrile, polyacrylic, and fluorocarbon. Many automotive and gas engine oils, industrial lubricating oils, and other oils of mineral or synthetic origin meet these requirements.

Fill the actuator with about 6.0 L (6.3 qt) of oil, to the mark on the oil sight glass. After the engine is started and the actuator is at operating temperature, add oil if necessary. *Oil must be visible in the glass under all operating conditions*.

Excessive component wear or seizure in the actuator indicates the possibility of:

1. Insufficient lubrication caused by:
   - an oil that flows slowly when it is cold, especially during start-up;
   - no oil in the actuator.

2. Contaminated oil caused by:
   - dirty oil containers;
   - an actuator exposed to heating and cooling cycles, which created condensation of water in the oil.

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

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

⚠WARNING

To prevent possible serious injury or loss of life, or damage to the engine, resulting from engine overspeed or a runaway engine, be sure to use only oil that falls within the 50 to 300 SUS range. Using oils outside this range could cause the actuator to be unable to prevent a runaway engine.

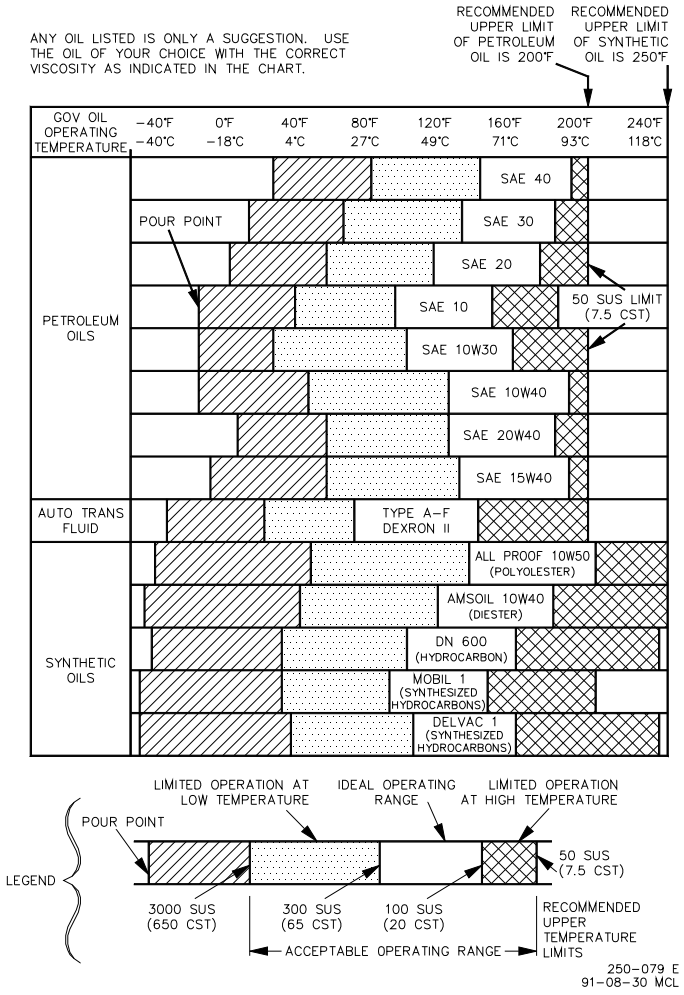

Figure 2-3. Oil Chart

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

250−087
97−11−04 skw

Figure 2-4. Viscosity Comparisons

Oil Maintenance

Replace the actuator oil if it is contaminated, and change it if it is suspected of contributing to instability. Drain the oil while it is still hot. Flush the actuator with a clean solvent having some lubricating quality (fuel oil or kerosene) before refilling with new oil. If drain time is insufficient for the solvent to completely drain or evaporate, flush the actuator with the same oil it is being refilled with to avoid dilution and possible contamination of the new oil.

Oil that has been carefully selected to match the operating conditions and is compatible with actuator components should give long service between oil changes. Check oil conditions regularly and change oil if any deterioration or contamination is suspected.

Regularly scheduled oil changes will extend the life of the actuator and improve actuator operation. Properly selected oil should permit annual oil changes, but more frequent changes are recommended.

Electrical Connection

The electrical connector on the PG Actuator is an 11-pin (MS-3440H-18-11P) plug connector or a 5-pin plug connector.

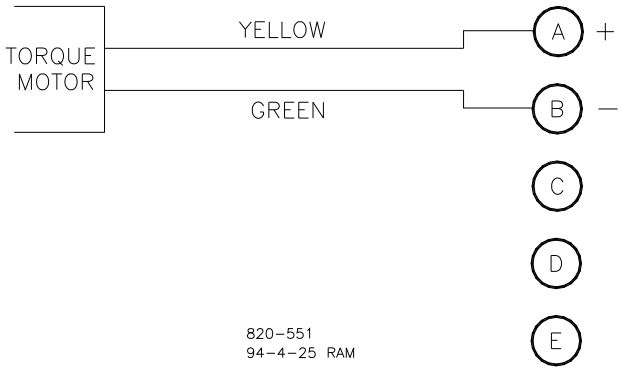

Figure 2-5. Wiring for a PG Actuator (5-pin connector)

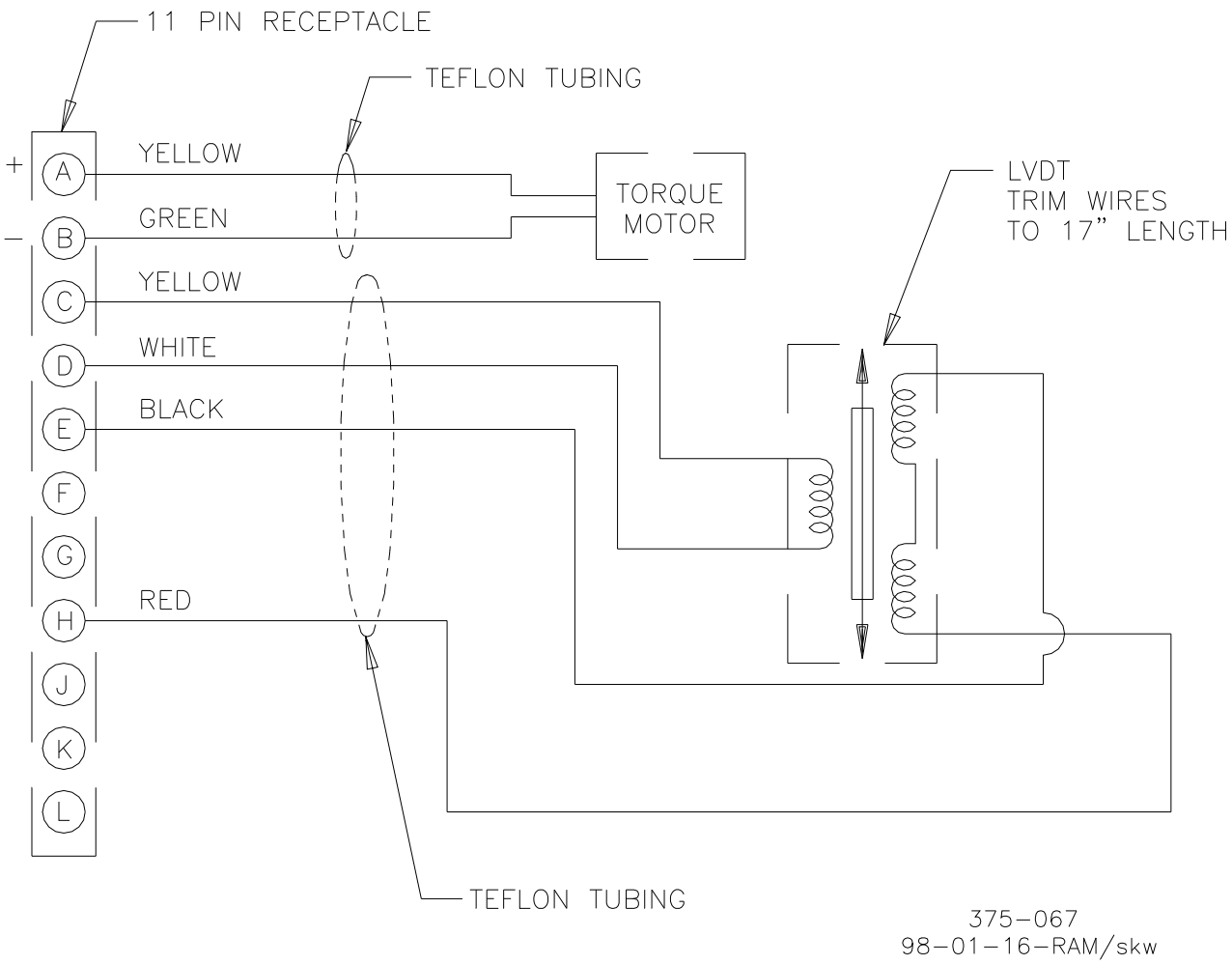

Figure 2-6. Wiring for a PG Actuator with an LVDT (11-pin connector)

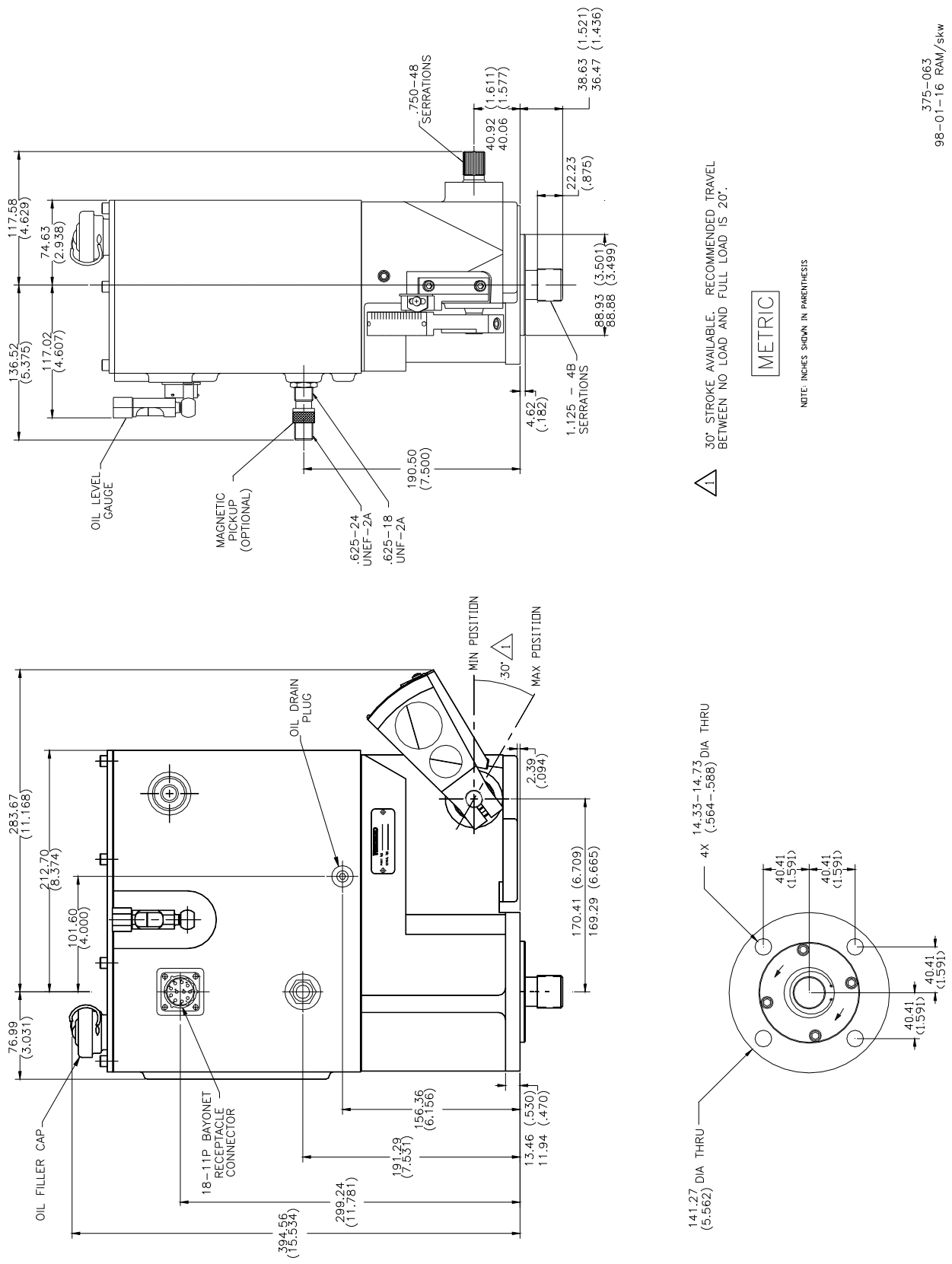

Figure 2-7. Outline Drawing of PG Actuator (linear output/UG base)

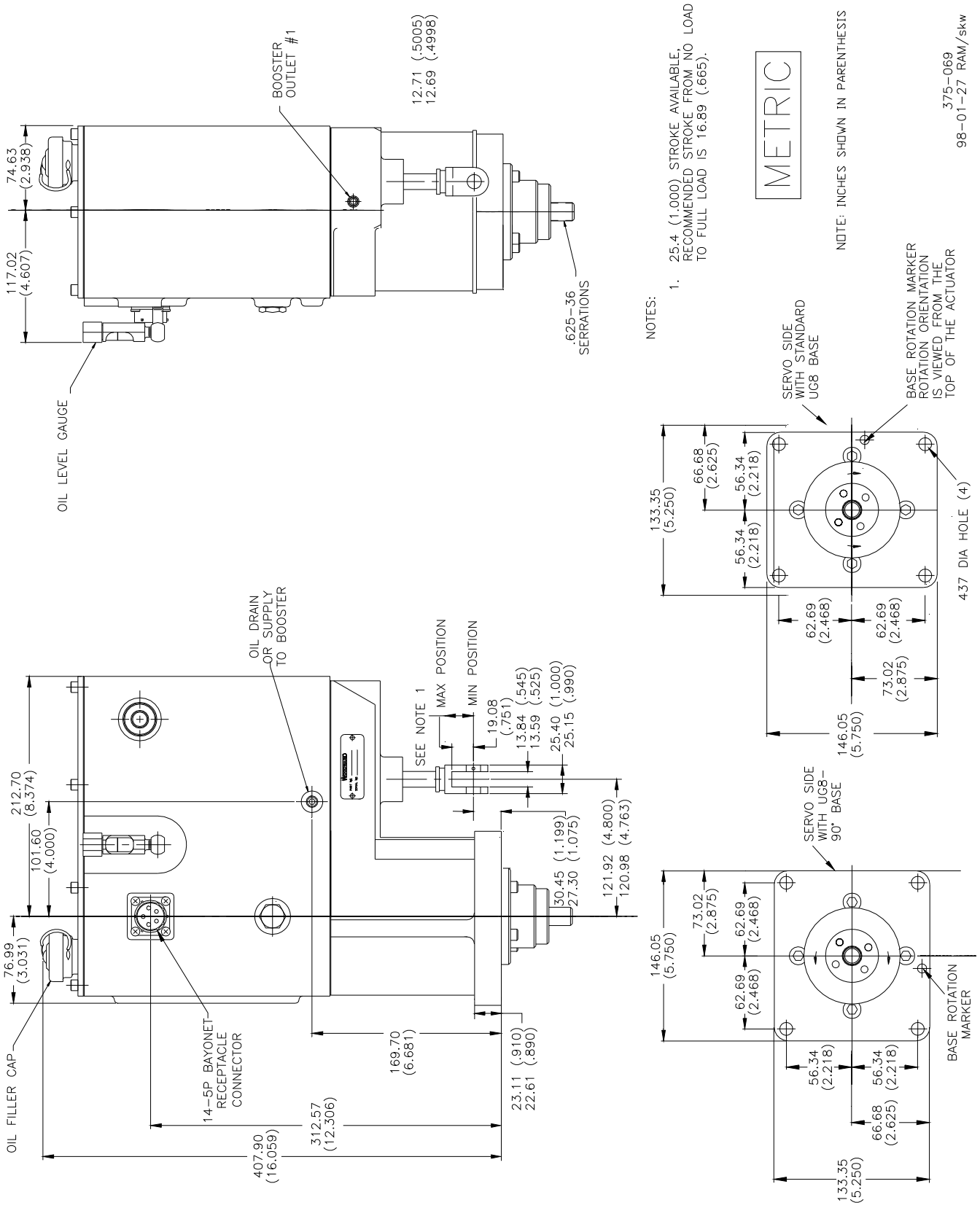

Figure 2-8. Outline Drawing of PG Actuator (linear output/UG base)

Chapter 3.
Operation and Adjustment

Initial Operation

Before initial operation of the engine equipped with a PG Actuator, read all of Chapter 2, Installation Procedures. Make sure that all installation steps have been correctly accomplished and all linkages are secured and properly attached.

Carefully review the direction of rotation for the actuator oil pump.

Follow this procedure when putting a new or repaired PG Actuator into service.

1. Check that the actuator is full of the proper type and grade of clean oil.

2. Properly adjust the linkage.

⚠WARNING

To prevent possible serious injury or loss of life, or damage to the engine, be sure to allow sufficient overtravel at each end of the terminal shaft, so the actuator can shut down the engine, and also give maximum fuel when required. Misadjusted linkage could prevent the actuator from shutting down the engine.

3. Select a LOW SPEED setting on the Woodward electronic control to give low engine speed at initial start up.

⚠WARNING

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

4. Follow the engine manufacturer's instructions, and start the engine.

5. Adjust the selected speed setting on the Woodward electronic control as necessary to bring the engine to rated speed.

6. Obtain system stability as outlined in the electronic control instruction manual. (If less than the recommended actuator output stroke is used, it may cause for less than optimum engine stability or response.)

All operating adjustments of the PG Actuator are made during factory calibration. Additional adjustment should not be needed.

Calibration Procedure

Should the PG Actuator need to be calibrated, use a test stand and follow this procedure.

1. Install the actuator vertically on the test stand and remove the actuator covers.

2. Fill the actuator with 71 ± 5 °C (160 ± 10 °F) SAE 30 weight or equivalent oil to a level half way up the torque motor.

3. Set the test stand for rotation to match the actuator specification sheet. (See Figure 2-3 for help in determining actuator rotation.)

NOTICE

Incorrect drive rotation will cause the actuator to become inoperative, and may cause damage to the actuator.

4. Rotate the actuator drive at 300 to 600 rpm.

5. Adjust the rack pointer to read 1.96 at minimum fuel (rotary version).

6. Remove the torque motor cover screws with a 7/64-inch Allen wrench. Replace the 3412-061 armature stop with the 8993-507 tool. This positions the armature in the center of the torque motor magnetic poles.

   With zero current to the actuator, use a 3/32-inch Bandhas-style Allen wrench to adjust the 3492-049 pilot valve flapper so that the actuator just begins to drift toward minimum fuel. Install the armature stop and tighten the torque motor cover.

7. Apply 40 mA and adjust the 3509-083 feedback rod and lock nut until the servo piston is between 1.76 and 1.80 rack for the rotary output actuator (3.5 to 4.5 degrees rotation) or at 0.00 ± 1.27 mm (0.000 ± 0.050 inch) from the 25.4 mm (1.00 inch) gap position on the linear output actuator.

8. Increase current slowly to 165 mA and note smooth operation between minimum and maximum. The terminal shaft should move to 0.68 to 0.80 rack (26.0 to 28.7 degrees rotation) or 1.90 ± 0.25 mm (0.750 ± 0.100 inch) from the 25.4 mm (1.00 inch) gap position.

9. If there is not enough travel, loosen the range-adjustment screw with a 0.156- inch (5/32) Allen wrench and move the range adjustment toward the centerline of the feedback lever. If the output moves to maximum with too low a signal, move the range adjustment away from the centerline of the feedback lever.

10. Retest with 40 and 165 mA signals until no additional adjustment is needed.

11. Verify that maximum terminal shaft position can be reached below 200 mA and that minimum position is reached above 0 mA.

12. If your actuator has an LVDT, connect LVDT test box T86986 with wiring harness number 5403-265. Adjust the excitation voltage to 2.99 to 3.01 Vrms. Adjust the LVDT rod for the following output:
    - max. fuel (0.62)—0.098 to 0.102 Vrms
    - min. fuel (1.96)—1.205 to 1.335 Vrms

13. Verify that the actuator develops at least 1034 kPa (150 psi) pump pressure at 200 rpm, and 1379 kPa (200 psi) pump pressure at 300 rpm.

14. Verify that there are no external leaks.

Chapter 4.
Principles of Operation

This chapter describes the operation of the PG Actuator. The schematic drawing in Figure 4-1 illustrates the working relationship of the various parts.

Connecting oil passages between components are simplified for ease in visualizing the system.

The PG Actuator contains its own sump.

The PG Actuator consists of the following basic components:

1. Oil Pump
Gerotor pump. Pump is driven by the actuator drive shaft.

2. Relief Valve
Set to maintain internal operating pressure at 1379 kPa (200 psi).

3. Oil Filter
Filters oil to the pilot valve to prevent contamination of the orifice and nozzle. Bypass oil flows through the filter, providing a filter-cleaning function.

4. Torque Motor, Torque Motor Beam, Feedback Spring, and Loading Spring
Used to establish a mechanical position of the pilot valve flapper in response to the dc current being sent to the actuator.

5. Pilot Valve Plunger
A follower-type valve, which duplicates the movement of the torque- motor beam, but at a much higher force level, controls flow of oil to and from the servo. The pressure regulator is used to minimize calibration shifts due to speed-induced pump pressure changes.

6. Power Piston, Terminal Lever, and Terminal Shaft
The terminal lever converts the linear motion of the differential-type servo piston to rotary motion of the terminal shaft, which in turn moves the fuel linkage. [On the linear version, there is no terminal lever or terminal shaft.]

7. Feedback Shaft and Feedback Levers
The power piston position is fed back to the torque-motor beam to provide the proportional control.

Increase in Load or Speed Setting

An increase in load, or speed setting, causes an increase in control current from the electronic control to the torque motor. This, in turn, causes an increase in the torque-motor force, tending to lower the centering adjustment end of the torque motor beam. The flow of oil through the nozzle is decreased, which increases pressure on the top side of the differential power land. Pressure above the differential power land then moves the pilot-valve plunger down, or allows the plunger to follow the torque-motor beam as if they were one piece. Pressure oil is now directed to the underside of the power piston, causing it to move upward, which rotates the terminal lever and terminal shaft in the increase-fuel direction.

The upward movement of the power piston rotates the range adjustment and feedback linkage, increasing the feedback spring force, causing the torque-motor beam to move away from the nozzle. As flow through the nozzle is less restricted, pressure decreases on the top side of the differential power land to start moving the pilot-valve plunger up. The terminal shaft and pilot-valve plunger movement continues until the increase in feedback-spring force equals the increase in force seen in the torque motor. When the pilot-valve control land is centered, all movement stops at the new position required to run the engine at the increased load or speed setting.

Decrease in Load or Speed Setting

A decrease in load or speed setting causes a decrease in control current from the electronic control to the torque motor. This, in turn, causes a decrease in torque motor force, and raises the centering adjustment of the torque motor beam. The pilot valve follows the beam and uncovers the control port. Oil trapped under the power piston escapes to drain, causing the power piston to move downward and the terminal shaft to rotate in the decrease-fuel direction.

The downward movement of the power piston rotates the range adjustment and feedback linkage, decreasing the feedback-spring force. The terminal shaft rotates until the decrease in spring force equals the decrease in force in the torque motor, and the pilot-valve plunger is centered. This stops the power piston and the actuator shaft in the new position needed to run the engine at the decreased load or speed setting.

Loss of Control Voltage

Upon loss of control voltage, the actuator terminal shaft goes to minimum fuel, thus offering a safety feature.

With loss of control voltage, there is no current sent to the torque motor and no magnetic force generated. The torque motor and attached beam and the force of the loading spring causes the center adjustment to raise. The pilot valve follows, keeping the control port uncovered. Trapped oil escapes to drain, and the power piston moves down until it reaches minimum fuel position.

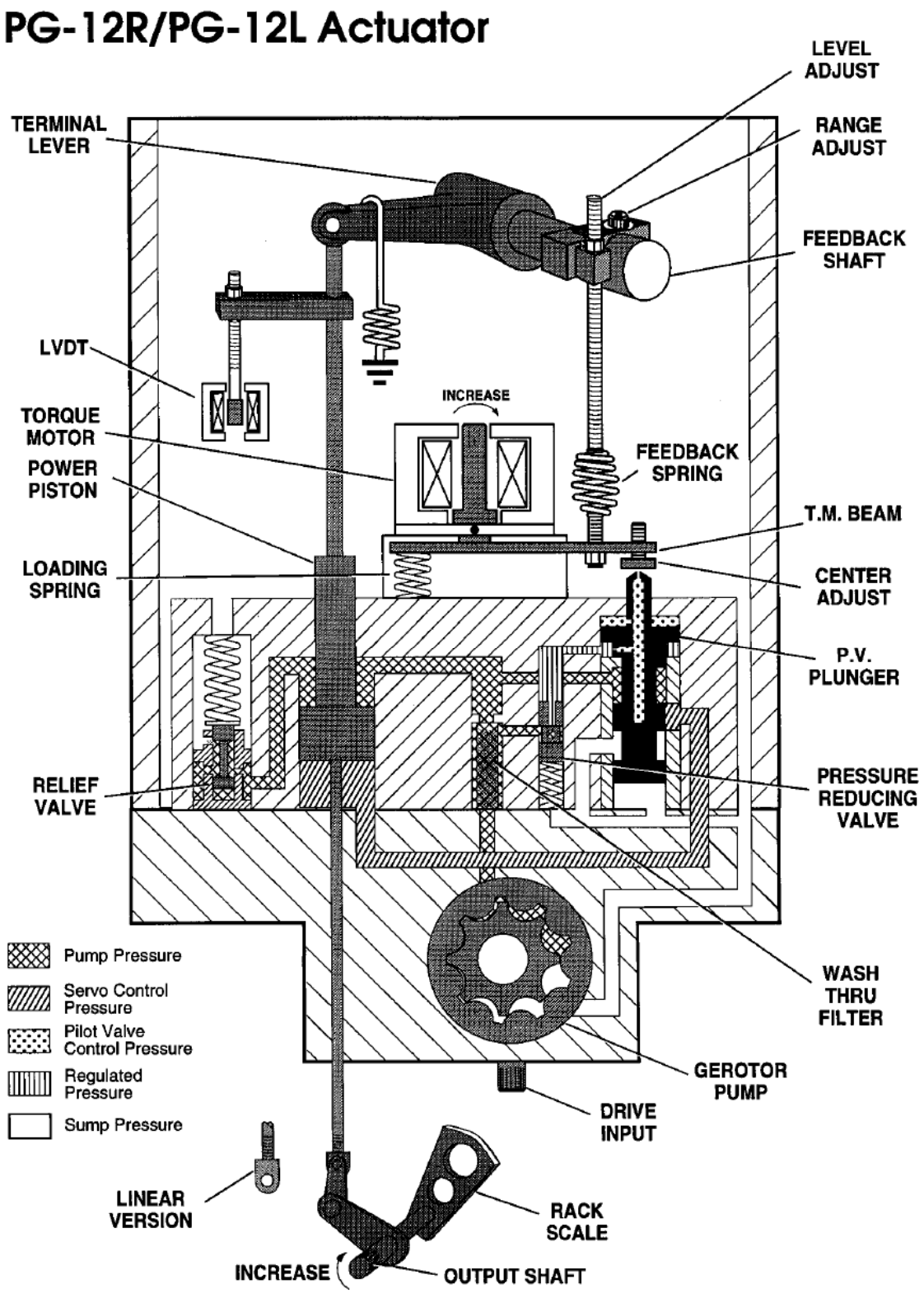

Figure 4-1. Schematic of PG Actuator

Chapter 5. Troubleshooting

Introduction

Poor governing may be due to faulty actuator performance, or it may be due to the actuator attempting to correct for faulty operation of the engine or the equipment driven. When improper operation is evident, check all components, adjustment settings, and the engine for proper operation.

Actuator troubles also can be related to control-signal problems. Refer to the applicable Woodward manual for troubleshooting the Woodward electronic control used with the PG Actuator.

Use the following troubleshooting table to isolate and remedy suspected faults in the governed system.

Terms used in the chart are defined as follows:

HUNT—A rhythmic variation of speed which can originate in the actuator or in the engine. A hunt usually has a frequency of less than 50 cycles per minute.

SURGE—A sudden variation of speed occurring at periodic intervals which also can originate in the actuator or in the engine.

JIGGLE—A high frequency movement of the actuator terminal shaft and fuel linkage. Do not confuse this with normal controlling action of the actuator. A jiggle has a frequency of more than 50 cycles per minute.

⚠WARNING

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

Troubleshooting

The actuator and electronic control cannot control engine speed during this test procedure. If the engine is to be used to provide pump rotation of the actuator, other means must be provided to control engine speed. Other means to provide the needed rotation (a test stand) should be used if possible.

1. Shut down the engine.
2. Disconnect the actuator from the electronic control. Disconnect the linkage from the actuator to the engine.
3. Verify that there is a 23 to 26 Ω resistance at 20 °C (68 °F) across the torque motor.
4. Remove the PG Actuator from the engine and set it on the test stand.
5. Make sure that the actuator is full of oil. (See Chapter 2, Oil Supply.)
6. Rotate the drive shaft in the proper direction at about 700 rpm.

7. Connect the circuit in Figure 5-1 to the actuator.

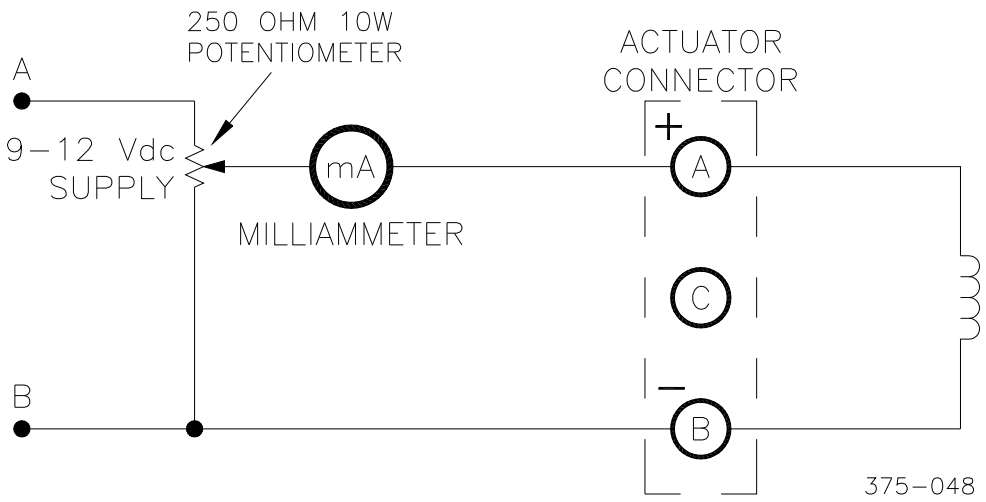

Figure 5-1. Wiring for Test Circuit

8. At 40 mA, the actuator should be between 1.76 and 1.80 rack for the rotary output actuator (3.5 to 4.5 degrees rotation) or at 0.00 ± 1.27 mm (0.000 ± 0.050 inch) from the 25.4 mm (1.00 inch) gap position on the linear output actuator.

9. At 165 mA, the actuator should be between 0.68 and 0.80 rack (26.0 to 28.7 degrees rotation) or at 1.90 ± 0.25 mm (0.750 ± 0.100 inch) from the 25.4 mm (1.00 inch) gap position.

10. The movement of the terminal shaft from minimum to maximum should be linear, and the actuator should return to the same location at the same current setting when changed from the increase or decrease position.

11. Rotate the potentiometer and watch the output as it moves through the range of travel.

12. If the terminal shaft does not move, or if the actuator movement is erratic, or the actuator is not in calibration, return the unit to the factory for repair.

13. Verify the proper current output from the electronic control. Refer to the applicable Woodward manual for troubleshooting the electronic control used with the PG Actuator.

Symptom	Cause	Correction
Failure to open racks. Failure to start.	Actuator is not receiving an electrical signal.	Make sure the electronic control is sending a signal.
	No oil pressure generated by the actuator oil pump.	Oil pump is rotated in the wrong direction. Index pump housing to provide the correct direction of rotation.
	Actuator leads shorted or open.	See wiring diagram in Chapter 2.
Fuel racks do not open quickly.	Cranking speed too low.	Pump rotation must be adequate to provide internal pressure required to move rack or fuel valve. Use booster servo if necessary.
	Oil viscosity too low.	Use higher viscosity oil.
	Yield link too weak.	Install heavier springs.
	Actuator pump worn.	Return actuator to a repair facility.
Actuator leaks.	Actuator worn or improperly assembled.	Replace gasket. Return actuator to a repair facility.
Excessive heat buildup.	Drive speed too fast for the ambient temperatures.	Investigate way to lower ambient temperature or attach an oil cooler to the actuator.
Instability.	Dirty or foaming oil.	Oil should be changed. Check that the oil used is properly matched to the operating conditions.
	Linkage provides insufficient output movement.	Correct linkage for recommended actuator output between minimum and maximum fuel.
	Electronic control out of adjustment.	Make sure electronic control is properly adjusted.
Does not maintain rated speed.	Improper linkage arrangement. Actuator stops before achieving full fuel.	Rework or reset the linkage.
	Speed changes may be the result of load changes beyond the capacity of the engine.	Reduce load on the engine.
The engine hunts or surges.	Linkage between actuator and engine.	Repair or reset linkage as required. Check strength of yield springs in linkage. Check for binding in linkage or in fuel racks or valves. Linkage must be nearly linear in respect to power output of engine.
	Engine misfiring.	Check pyrometer readings of each cylinder and make necessary repairs to injectors, valves, pilot fuels, or other engine problems.
Drive shaft seizure.	Misalignment, binding, or excessive backlash of the actuator-driving gears.	Correct alignment, binding, or backlash.
	Improper lubrication of actuator. Actuator is too hot.	Check oil level and oil condition in actuator. Consider an oil cooler. Consider changing grade or weight of oil used in the actuator.

Chapter 6.
Replacement Parts

When ordering replacement parts, include the following information:

- Actuator serial number and part number shown on the nameplate
- Manual number (this is manual 37517)
- Part reference number and part name from parts list

NOTICE

Do not loosen screws 55 unless alignment tool 271503 or equivalent is available. Armature 53 will not center in the magnet assembly without this tool. Should parts 53, 54, 58, 61, and 62 be separated, reassembly is greatly aided by Woodward tool 27332.

Parts for Figure 6-1

Ref. No.	Part Name	Quantity
37517-1	PG Actuator Column	1
37517-2	Hex Socket Plug, 125-27	1
37517-3	Plug for MPU	1
37517-4	Washer, 0.641 x 0.875 inch	1
37517-5	Connector O-ring	1
37517-6	11-pin Receptacle Assembly	1
37517-7	Screw	4
37517-8	Bearing Assembly	2
37517-9	Oil Seal, 1.128 inch OD	2
37517-10	Feedback Shaft	1
37517-11	Column Gasket	1
37517-12	Oil Gauge	1
37517-13	Oil Gauge Elbow, 0.797 inch long	1
37517-14	Screw, 0.312-24 x 1 inch	8
37517-15	Power Lever Assembly	1
37517-16	Roll Pin, 0.125 dia x 0.875	2
37517-17	Linkage Loadspring	1
37517-17A	Screw, 8-32 x 0.375 inch	1
37517-17B	Washer	1
37517-18	Feedback Lever	1
37517-19	Feedback Linkage Pivot	1
37517-20	Spring Washer	1
37517-21	External Retaining Ring, .225 Inch dia.	1
37517-22	Feedback Linkage Adjuster	1
37517-23	Washer, #10	1
37517-24	Screw, 10-32 x 0.375 inch	1
37517-25	Nut, 10-24 hex	2
37517-26	Screw, 0.25-28 x 0.875 inch	1
37517-27	Feedback Bearing	1
37517-28	Elastic Nut, 0.25-28	1
37517-29	LVDT Rod	1
37517-30	Jam Nut, 0.750-16 inch	1
37517-31	LVDT	1
37517-31A	LVDT Core	1
37517-32	Cover Gasket	1
37517-33	Cover	1
37517-34	Screw, 0.25-28 x 0.625 inch	10
37517-35	Oil Fill Cup Assembly	1
37517-36	Power Block Assembly	1
37517-37	Torque Motor Magnet Assembly	1
37517-38	Stabilizer Spring	1
37517-39	Screw, 6-32 x 0.375 inch	2
37517-40	Washer, 0.375 OD	2
37517-41	Rubber Grommet, 0.125 inch ID	1
37517-42	Torque Motor Cover	1
37517-42A	Wire Clip	1
37517-43	Torque Motor Armature Stop	1
37517-44	Torque Motor Armature	1
37517-45	Torsion Spring Assembly	1
37517-46	Screw, 6-32 x 0.500 inch	4
37517-47	Screw, 8-32 x 0.500 inch	4
37517-48	Feedback Rod	1
37517-49	Feedback Spring	1
37517-50	Torque Motor Beam Assembly	1
37517-51	Screw, 10-24 x 0.375 inch	1
37517-52	Pilot Valve Adjuster	1
37517-53	Washer, #8 x 0.032 thick	1
37517-54	Screw, 8-32 x 0.625 inch	1
37517-55	Loading Spring	1
37517-56	Spring, 200 psi	1
37517-57	Relief Valve Piston	1
37517-58	Relief Valve Sleeve	1
37517-59	Power Piston	1
37517-60	Filter Assembly, 140 micron	1
37517-61	Regulator Spring	1
37517-62	Pilot Valve Pressure Regulator	1
37517-63	Screw, 0.250-28 x 1 inch	4
37517-64	Pilot Valve Plunger Assembly	1
37517-64A	Plug, 0.25-28	1
37517-65	Pilot Valve Bushing	1
37517-66	Retaining Ring	1
37517-67	Washer	1
37517-68	Internal Retaining Ring	1
37517-69	Feedback Link	1
37517-70	Spring Washer	2
37517-71	Elastic Nut, 0.500-20	1
37517-72	Guide Bracket	1
37517-73	Screw, 0.250-28 x 0.625	1
37517-74	Nut, 0.250-28	1
37517-75	Guide Rod	1

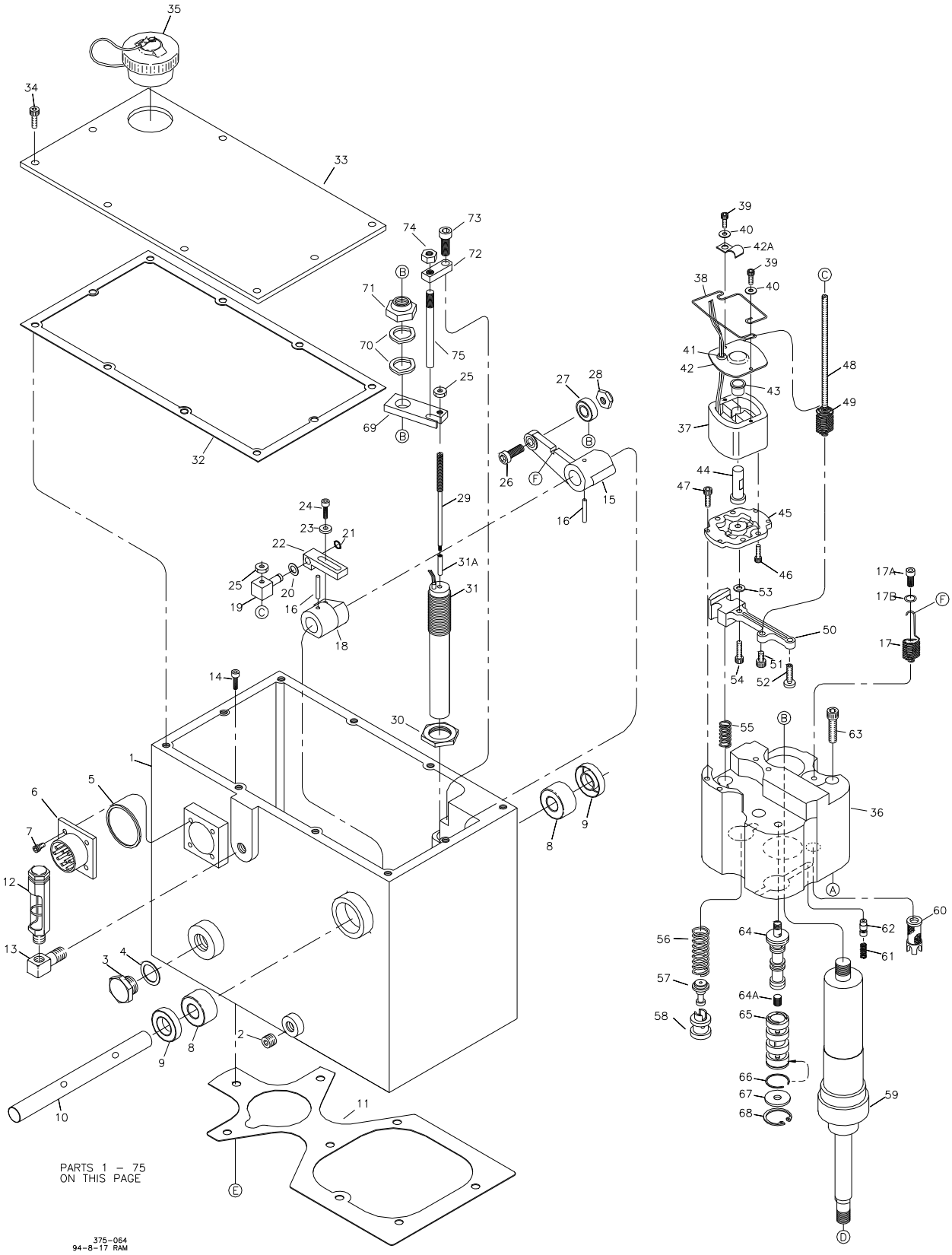

Figure 6-1. Exploded View of PG Actuator Upper Assembly

Parts for Figure 6-2

Ref. No.	Part Name	Quantity
37517-76	Base Housing	1
37517-77	Terminal Shaft	1
37517-78	Bearing	2
37517-79	Oil Seal	2
37517-80	Dial Rack Lever	1
37517-81	Rack Scale	1
37517-82	Drive Screw, #2 x 0.188	2
37517-83	Flat Washer, 0.265 ID x 0.420 inch	1
37517-84	Socket Head Screw, 0.25-28 x 1.000 inch	1
37517-85	Hex Socket Plug, 125-27 (same as 37517-2)	1
37517-86	Rack Scale Pointer Bracket	1
37517-87	Rack Scale Pointer	1
37517-88	Pan Head Screw, 8-32 x 0.375 inch	1
37517-89	Socket Head Screw, 0.25-28 x 0.625 inch	2
37517-90	Flat Washer, 0.250 inch	2
37517-91	O-ring	2
37517-92	Piston Rod Pin	1
37517-93	Elastic Nut, 0.438 x 20	1
37517-94	Power Piston Link	2
37517-95	External Retaining Ring, 0.693 inch	2
37517-96	External Retaining Ring, 0.338 inch	2
37517-97	Power Lever Pin	1
37517-98	PG Power Lever	1
37517-99	Spiral Pin, 0.250 x 1.375 inch	2
37517-100	Power Cylinder Gasket	1
37517-101	Power Cylinder Cover	1
37517-102	Flat Washer, 0.265 ID x 0.420 inch	8
37517-103	Socket Head Screw, 0.25-28 x 0.750 inch	8
37517-104	Pump Housing	1
37517-105	Screw, 0.25-28 x 0.750 inch	4
37517-106	Pump Outer Element	1
37517-107	Pump Inner Element	1
37517-108	O-ring, 1.989 ID x 0.070 inch	1
37517-109	Oil Seal	1
37517-110	External Retaining Ring, 0.621 dia.	1
37517-111	Bearing	1
37517-112	Drive Shaft	1
37517-113	Key	1
37517-114	Internal Retaining Ring, 1.734 inch free dia.	1

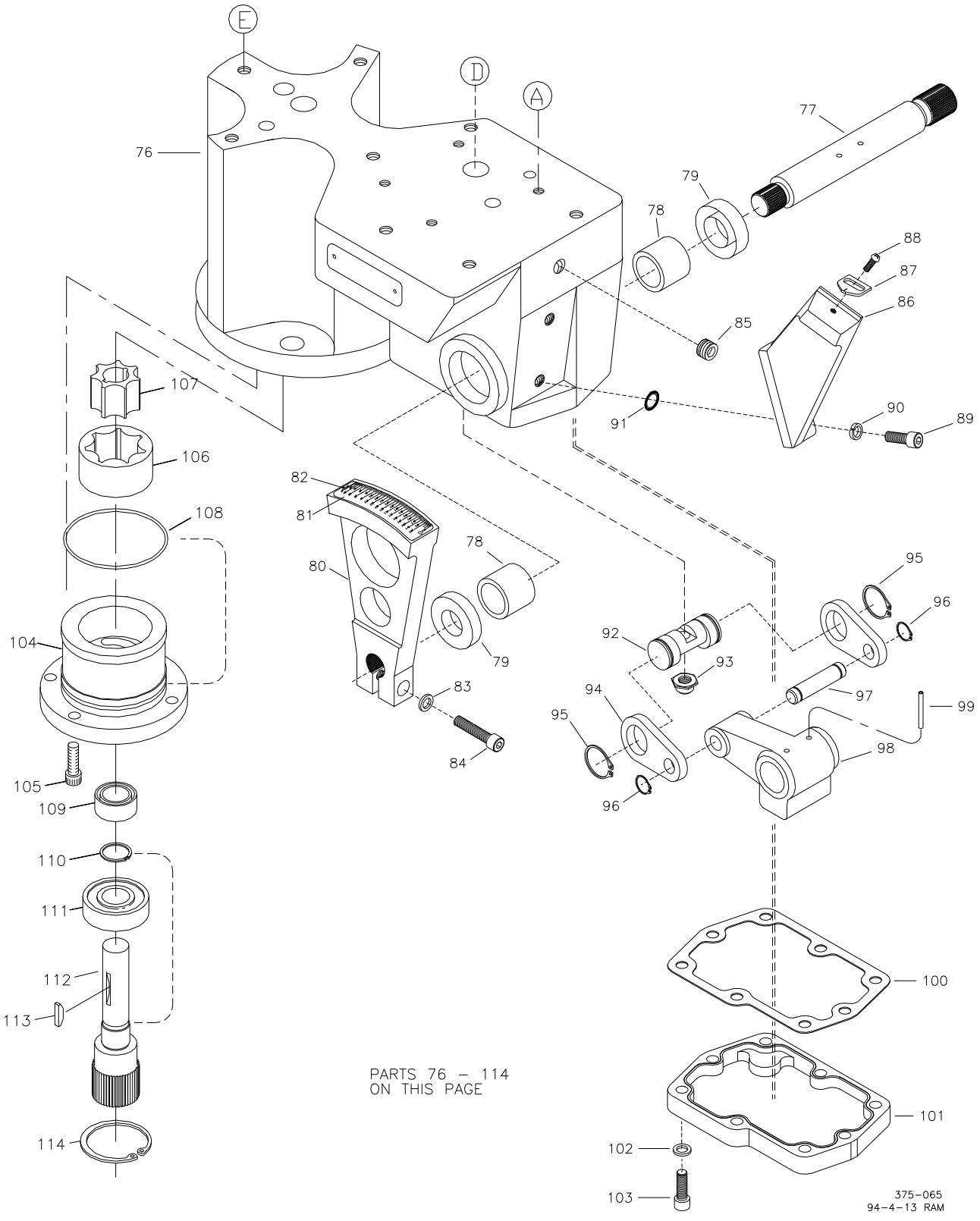

Figure 6-2. Exploded View of PG Actuator Lower Assembly (rotary output)

Parts for Figure 6-3

Ref. No.	Part Name	Quantity
37517-115	Base Housing	1
37517-116	Hex Socket Plug, 125-27 (same as 37517-2)	1
37517-117	Oil Seal	1
37517-118	Oil Seal	1
37517-119	Rod End	1
37517-120	Roll Pin, 0.125 dia. x 0.750	1
37517-121	Base Assembly	1
37517-122	Expansion Plug, 0.281 OD x 0.250	2
37517-123	Pump Housing	1
37517-124	Pump Outer Element	1
37517-125	Pump Inner Element	1
37517-126	O-ring	4
37517-127	O-ring, 1.989 ID x 0.070	1
37517-128	Screw, 0.375-16 x 1.250	1
37517-129	Screw, 0.250-28 x 0.750	4
37517-130	Drive Shaft	1
37517-131	Key	1
37517-132	Oil Seal	1
37517-133	Drive Shaft Bearing	1
37517-134	External Retaining Ring, 0.621	1
37517-135	Internal Retaining Ring, 1.734	1
37517-136	O-ring, 2.739 ID x 0.070	1
37517-137	O-ring, 0.364 ID x 0.070	1

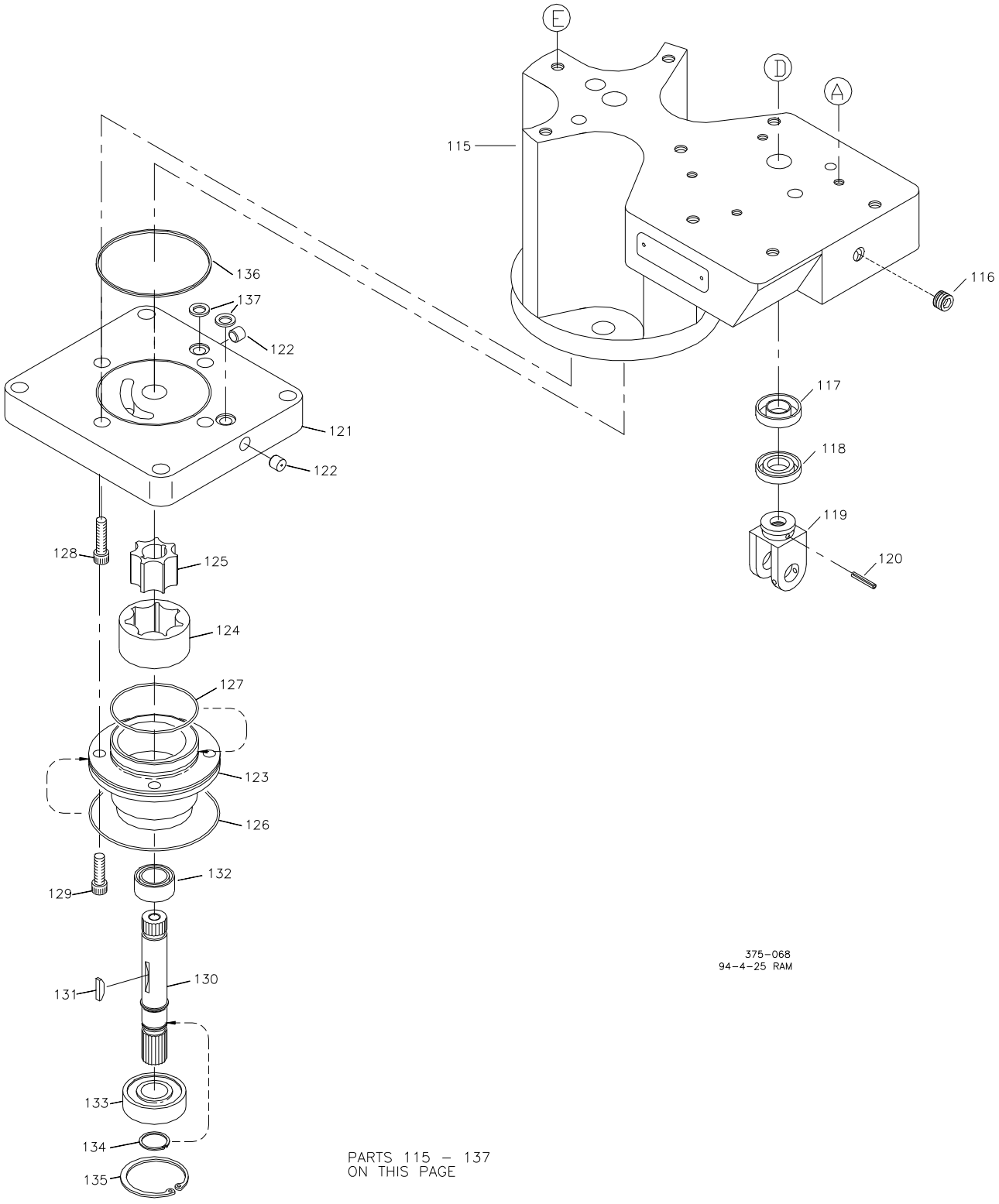

Figure 6-3. Exploded View of PG Actuator Lower Assembly (linear output/UG base)

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.

PG-12R/PG-12L Actuator Specifications

Control Qualities	
Hysteresis	Within 3% of maximum travel when measured over full 30 degree (25.4 mm/1 inch) travel. Within 0.5% of maximum travel when measured over 4% of full travel at 0.1 Hz.
Temperature Drift	Nominally ±1 degree per 38 °C (100 °F)
Time Constant	65 to 85 ms for 50 mA step with 1379 kPa (200 psi) actuator oil pressure and 80 SUS oil viscosity
Linearity	Within 2.5% of full travel
Stalled Torque	48.5 N·m (35.8 lb-ft) in the increase direction 38.8 N·m (28.6 lb-ft) in the decrease direction
Work Output over Full Stroke	25.4 J (18.7 ft-lb) in the increase direction 20.2 J (14.9 ft-lb) in the decrease direction
Pump	Gerotor. Relief valve set at 1379 kPa (200 psi).
Output Shaft	0.750-48 inch serrated or 0.500 inch diameter rod end. In same location relative to drive as PG governor.
Drive Shaft	1.125-48 serration is standard.
Weight	34 kg (75 lb) dry weight
Vibration Resistance	Vibration tested to US MIL-STD 810C, Curve D (10 G to 2000 Hz; in Y-axis, parallel to drive shaft, 8 G maximum)
Drive/Hydraulic Specifications	
Drive Speed and Rotation	200 to 1200 rpm. Drive operates in one direction only.
Drive Power Requirement	Drive will use a maximum of 375 W (0.5 hp)
Hydraulic Supply	Self contained sump, 6.0 L (6.3 qt) capacity. See Woodward Manual 25071, *Oils for Hydraulic Controls*, for specific recommendations. In most cases, the same type and weight of oils used in the engine can be used in the governor.
Ambient Temperature Range	–29 to +93 °C (–20 to +200 °F)
Operating Temperature	–29 to +104 °C (–20 to +220 °F), within the limits of the oil being used in the governor
Electrical Specifications	
Electrical Connector	11-pin, US MIL-STD 3440H-18-11P, or 5-pin, located in column
Coil Resistance	23–26 Ω at 20 °C

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 37517B.

B37517:B

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as well as authorized distributors and other authorized service and sales facilities throughout the world.**

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

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