WOODWARD

Product Manual 89009
(Revision B)
Original Instructions

Hydraulic Amplifier (Mechanical Input Control)

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:

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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 Out-of-date translations are marked with ⚠.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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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 Woodward hydraulic amplifier is a linear, pilot-operated servo actuator used where relatively large forces are required to operate power control mechanisms such as steam control valves of turbines or the fuel control linkages of large engines. The mechanically controlled hydraulic amplifier is used in conjunction with a governor having a mechanical output and serves to amplify the low level governor output to a useable level for actuating the prime mover power control mechanism. The governor, through mechanical linkage (not supplied by Woodward), controls the position of the amplifier. The amplifier pilot valve directs high pressure control oil (supplied from the prime mover lubricating system or an external pump) to the open (increase) side of a double-acting servo cylinder. Closing (decrease) forces are provided by a combination of Oil at supply pressure and return spring force acting on the close side of the servo cylinder piston. The piston, in turn, is connected to the power control mechanism of the prime mover.

In most applications, the return spring is specifically designed to counteract the unbalanced forces tending to open the steam valve. This provides a balanced system with a linear response over the foil stroke of the amplifier. Secondarily, the return spring ensures closing in the event of loss of oil pressure and, in some instances, also ensures that the fuel control or steam valve remains in the closed position during shutdown. In other applications, the return spring may provide only a low-force biasing load. Various return spring preloads within a range of 50–2000 pounds (222–8896 N) may be used depending on the closing forces of the steam valve itself (or other fuel control) and/or the steam valve unbalance forces of the particular application. Maximum spring force for 5-1/4 inch (133 mm) size is 400 pounds (1779 N).

Two models of mechanically controlled hydraulic amplifiers era covered In this bulletin. These models are basically identical except for the diameters of their respective servo cylinders. The work output of either amplifier is proportional to the oil pressure and the distance of the stroke.

Either model amplifier may be equipped to suit the requirements of the particular application in which it is used. Many applications require a source of pressurized oil to the amplifier to open the fuel or steam control preparatory to starting the prime mover. Other applications may require a higher opening force than that available from the standard amplifier. An oil transfer plug. pressure sensing (starting) valve, or a transfer sleeve are variously used in one of the internal oil transfer passages in the amplifier case to adapt the amplifier for use in differing applications. In all applications where starting oil is required, a port in the amplifier case allows starting oil to be used to hydraulically raise the pilot valve plunger since the prime mover governor is Inoperative prior to start-up.

The oil transfer passage plug is used in all standard applications and also in those applications where starting oil is required and is available at or above the minimum pressure necessary for normal amplifier operation. The starting valve is substituted for the plug in starting oil applications where the pressure (such as from a hand pump) is below the minimum required but is within the range of 20–35 psi (138–241 kPa).

The oil transfer sleeve is used in applications where a higher opening force is required and a like decrease in closing force can be tolerated. The sleeve blocks the flow of oil to the closing side of the piston and simultaneously vents the area to drain, which converts the double-acting servo cylinder to a single-acting, spring-return type. This increases the effective piston area on the opening side of the piston and thus the opening force of the amplifier. The closing force is reduced to that of the spring alone.

References

Manual 25071 *Oils for Hydraulic Controls*

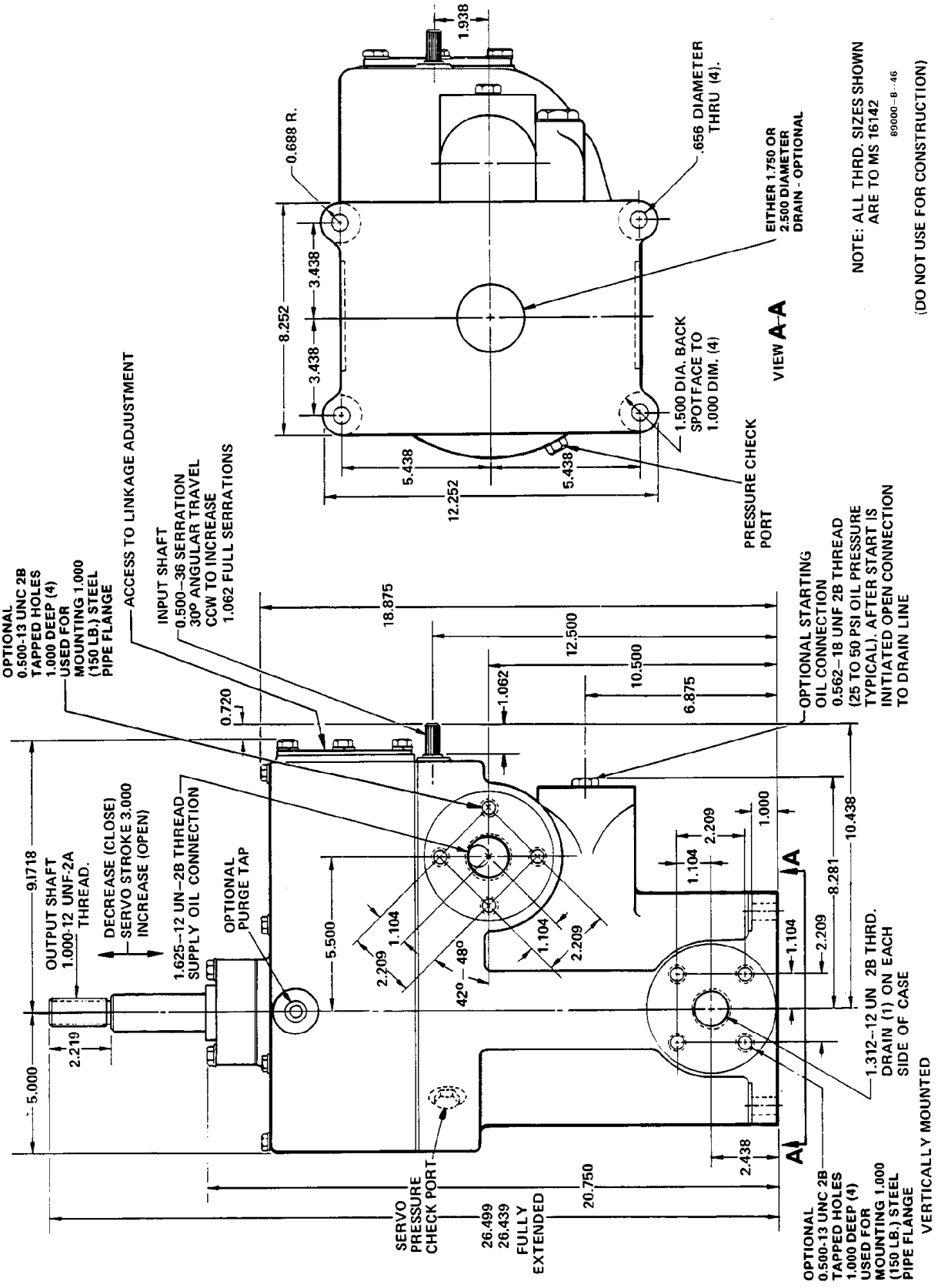

Figure 1-1. Outline Drawing, 7-1/4” Mechanical-Hydraulic Amplifier

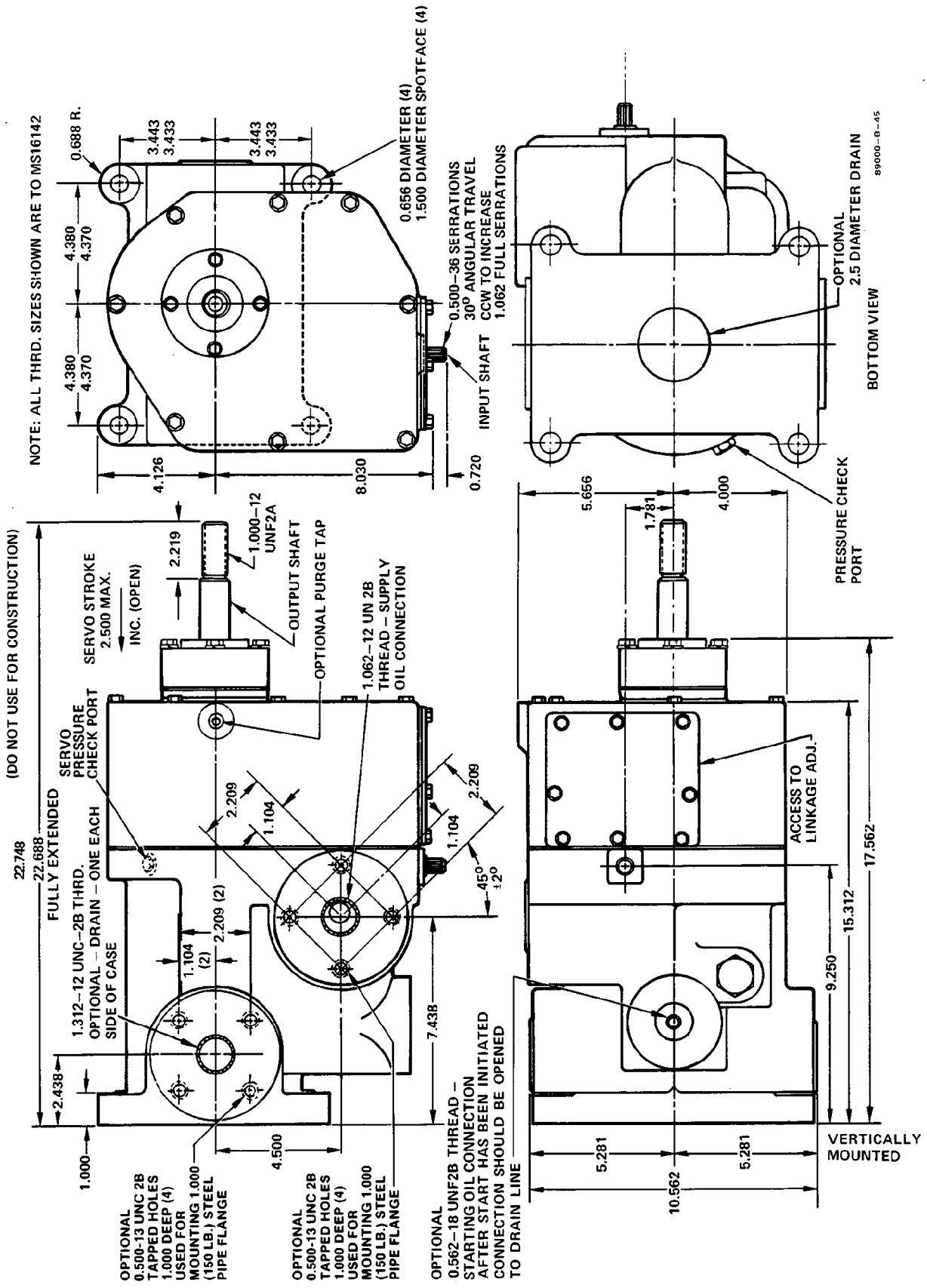

Figure 1-2. Outline Drawing, 5-1/4” Mechanical-Hydraulic Amplifier

Chapter 2.
Installation and Adjustment

Installation

The hydraulic amplifier should normally be mounted upright. If a good transient response (piston movement in the order of 30 inches/s [76 cm/s]) is required, it is essential that the amplifier be provided with an adequate supply of oil. For the 5-1/4 inch (133 mm) amplifier, this rate of movement requires a flow of 330 in^3/s (85 USgal/min or 320 L/min). The 7-1/4 inch (184 mm) amplifier requires a flow of 780 in^3/s (200 USgal/min or 760 L/min). Accumulators will normally be required to provide the necessary flow rate if it is impractical to do so directly from a pump. A two gallon (7.6 L) minimum accumulator is recommended. Connecting lines should be as large, short, and straight us possible. Elbows should be avoided. The drain line should receive equal consideration, If the prime mover mounting pad has integral provisions for drain' to sump or reservoir, the sealing cup in the bottom of the amplifier case may be removed to provide direct drainage through the mounting pad. A 40 µm (nominal) oil filter is recommended for oil filtration.

⚠WARNING

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

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

Where the amplifier has porting provisions for starting oil applications, and regardless of whether starting oil is used or not, the starting oil port must be directly connected to drain for normal operation. The use of a 3-way valve in the starting oil line is recommended where starting oil is to be used. If the starting oil port is plugged or otherwise closed during operation, normal leakage will result in hydraulic locking of the pilot valve plunger and render the amplifier inoperative. The area under the pilot valve plunger is internally drained in amplifiers which do not have external porting provisions for starting oil.

Adjustment

The governor-to-amplifier linkage must be free of binding with minimum backlash and be provided with positive stops external to the amplifier. Damage may occur to the internal linkage in the amplifier if external stops are not provided. Adjust the external stops so stop the amplifier input shaft 0.5 to 1 degree from the extreme CCW (maximum power) and CW (shutdown) positions.

The following adjustments are made ax the factory and are required only if the unit has been disassembled. After the linkage has been installed and the stops adjusted, remove the amplifier cover. Place the amplifier input shaft against the CW stop and make certain the servo piston is fully extended in the shutdown position. The opening between the top of the land on the pilot valve plunger and the top edge of the control port should be 0.005 to 0.015 inch (0.13 to 0.38 mm). Adjust the length of the turnbuckle, as required, to obtain this opening. When adjusting the turnbuckle, make sure a flat is facing toward the pilot valve plunger to avoid interference between the turnbuckle and the edge of the casing. A minimum opening of 0.005 inch (0.13 mm) should always be maintained to assure that the increase side of the servo piston is open to drain at shutdown. At an opening of 0.015 inch (0.38 mm), approximately 1 degree rotation of the input shaft is required before movement of the servo piston occurs (deadband). Decreasing the opening shortens the deadband, and increasing the opening lengthens the deadband.

NOTICE

Considerable oil spray over a large area will occur if the cover is removed and the amplifier cycled while under pressure. Always make certain the cover is installed before operating the amplifier.

Chapter 3.
Principles of Operation

Refer to Figure 3-1. The input shaft of the hydraulic amplifier is connected to the mechanical output of a governor, such as a Woodward PG, UG, or PSG governor. Any change in position of the governor output shaft is transmitted through linkage to the amplifier input shaft. The amplifier input shaft, in turn, is connected to a floating lever by an input lever and turnbuckle. The movement of the floating lever is transmitted to a pilot valve plunger which controls the flow of oil to and from the servo cylinder. A 30 degree rotation of the amplifier input shaft gives full stroke of the servo piston. Each degree of input shaft rotation is equal to 0.083 inch (2.11 mm) stroke for the small amplifier and 0.100 inch (2.54 mm) stroke for the large amplifier.

The pressurized oil from the external supply is directed from the amplifier inlet to the pilot valve plunger and also to the bottom (decrease) side of the servo piston. In applications which require starting oil, the pressure sensing (transfer) valve is Installed n the closing oil passage to the servo piston. The transfer (starting) valve has no function during normal operation, being held in the open position by normal oil supply pressures. A functional description of the transfer valve is at the end of this chapter.

When the governor senses an underspeed condition and signals for an increase in speed (power), the amplifier input shaft is rotated ccw (Figure 3-1). This raises the left end of the floating lever which lifts the pilot valve plunger, admitting oil at supply pressure (less the pressure drop occurring across-the pilot valve) to the top (increase) side of the servo piston. Although the oil pressure on the top side of the piston is the same as that on the bottom (decrease) side, it acts over a much larger surface area and moves the servo piston in the increase direction. As the piston moves, the end of the floating lever connected to the piston rod also moves in the same direction until the land on the pilot valve plunger is recentered over the oil control port, stopping further movement of the servo piston.

The yield plunger in the pilot valve does not have any function other than during starting and only where there is a requirement to open the steam or fuel valve before the prime mover can be started.

During an on-speed condition, the amplifier input shaft is maintained in a given position by the governor, and the pilot valve plunger land Is held in the centered position over the control port. With flow to the top side of the servo piston blocked, except to compensate for leakage, the servo piston maintains its position In relation to the speed setting of the governor and load on the prime mover.

When the governor senses an overspeed condition and signals for a decrease in speed, the amplifier input shaft is rotated cw. This lowers one end of the floating lever and pushes the pilot valve plunger downward which allows oil to drain from the top side of the servo piston The oil pressure acting on the bottom side of the servo piston, along with the return spring force, causes the servo piston to move in the decrease direction. Piston movement continues until the pilot valve plunger is again recentered by the floating lever.

In applications which require the steam or fuel control to open before the prime mover is started, one of two starting methods is used, depending on the available source of pressurized oil for operating the amplifier. When the normal oil supply is provided by an auxiliary or external lubrication oil pump, an additional connection is made to a starting oil port in the amplifier case. Make the connection using a 3-way valve with one port connected to drain. During starting, starting oil from the 3-way valve is directed through the starting oil port to the underside of the pilot valve plunger. The yield plunger allows the starting oil to raise the pilot valve plunger, which admits normal oil supply pressure to the top side of the servo piston. Open the 3-way valve to drain after starting, otherwise oil trapped under the pilot valve plunger renders the amplifier inoperative.

When the oil supply is ordinarily provided by or is dependent on the prime mover, and an auxiliary source of low pressure oil (such as a hand pump) is used for starting, a pressure sensing (transfer) valve is used to minimize the forces acting on the bottom side of the servo piston. Auxiliary supply oil pressures within the range of 20 to 30 psi (138 to 207 kPa) (typical) cannot generate sufficient force on the increase side of the servo piston to overcome the combined forces of starting oil pressure (25 to 50 psi/172 to 345 kPa) and spring tension on the decrease side of the piston.

In the shutdown position, the transfer valve blocks the flow of auxiliary supply oil to the decrease side of the servo piston and simultaneously opens the area to drain (see Figure 3-2). When the prime mover starts and the normal supply pressure begins to build up, oil flows upward through the axial passage in the transfer valve plunger into the area under the large diameter of the plunger. This gradually lifts the plunger against the opposing spring force, closing the drain port and partially opening the control port which admits supply oil to the top (decrease) side of the servo piston. When the supply oil pressure in the area at the lower end of the plunger reaches 45 to 60 psi (310 to 414 kPa), the plunger snaps to the fully open position where it remains during normal operation. At shutdown, spring force returns the plunger to the closed position.

Figure 3-3 is a schematic of the amplifier that has a sleeve in place of the transfer valve. This is used for increasing fuel or steam control opening force.

Figure 3-4 is a schematic of the amplifier that has a plug in place of either the transfer valve or sleeve. It is used with high pressure oil systems and systems not requiring starting oil.

Amplifiers are normally supplied with the pilot valve plunger spring loaded to minimum fuel, so that upon loss of input control to the amplifier, the amplifier will go to minimum fuel.

Some of the older amplifiers have their pilot valve plungers spring loaded upward. If supply pressure should decrease to where the spring pressure forces the pilot valve plunger upward, supply pressure could move the servo piston in the increase fuel direction.

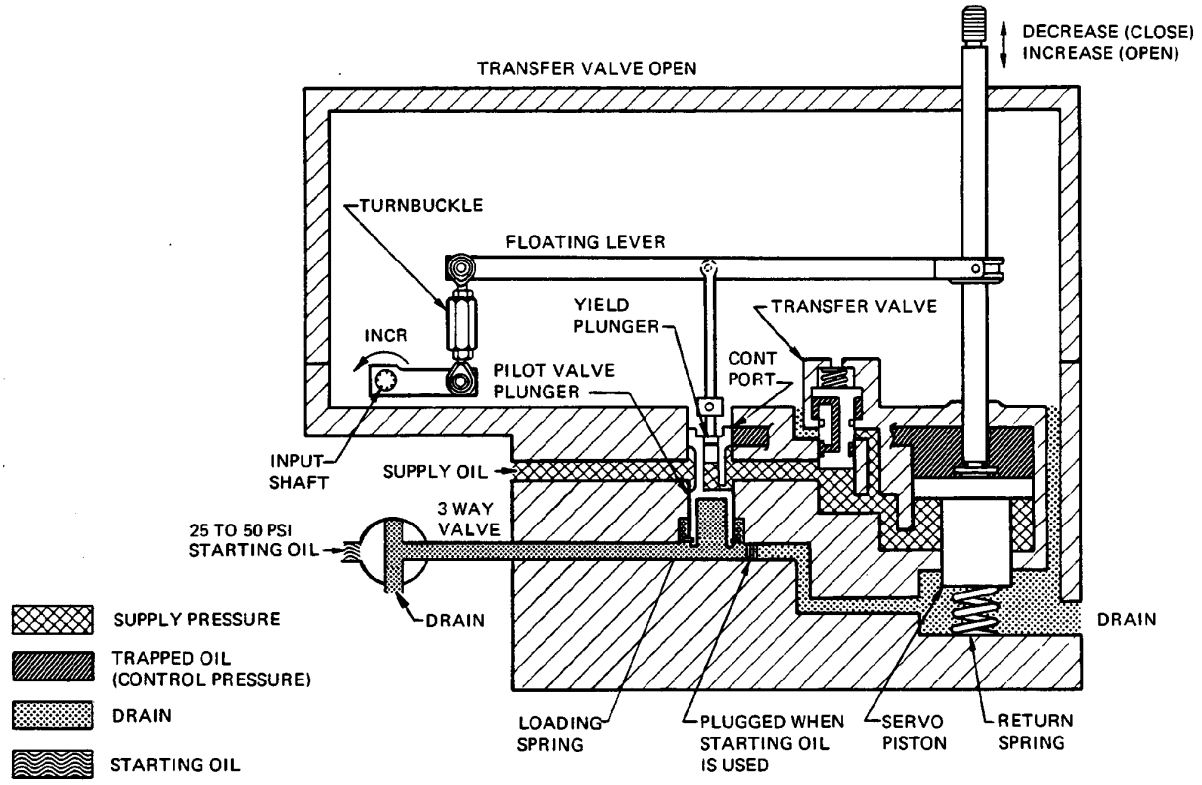

Figure 3-1. Schematic of Mechanical-Hydraulic Amplifier with Transfer Valve Open

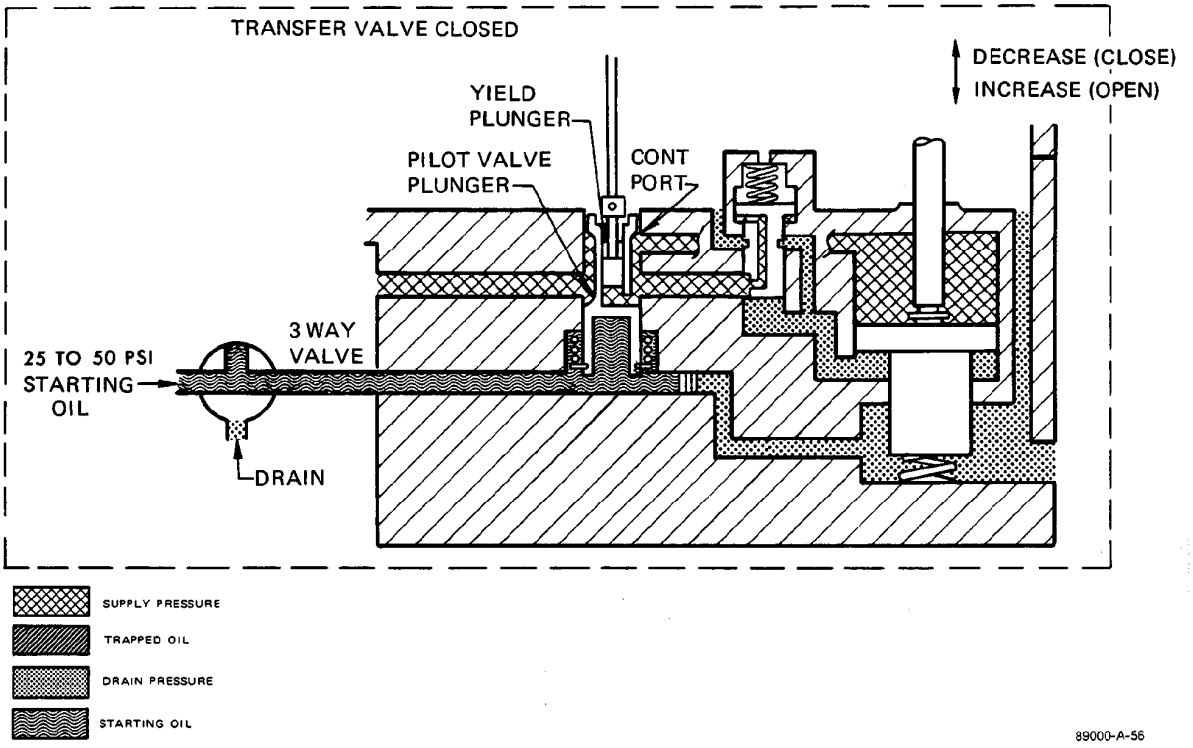

Figure 3-2. Schematic of Mechanical-Hydraulic Amplifier with Yield Plunger and Transfer Valve Closed

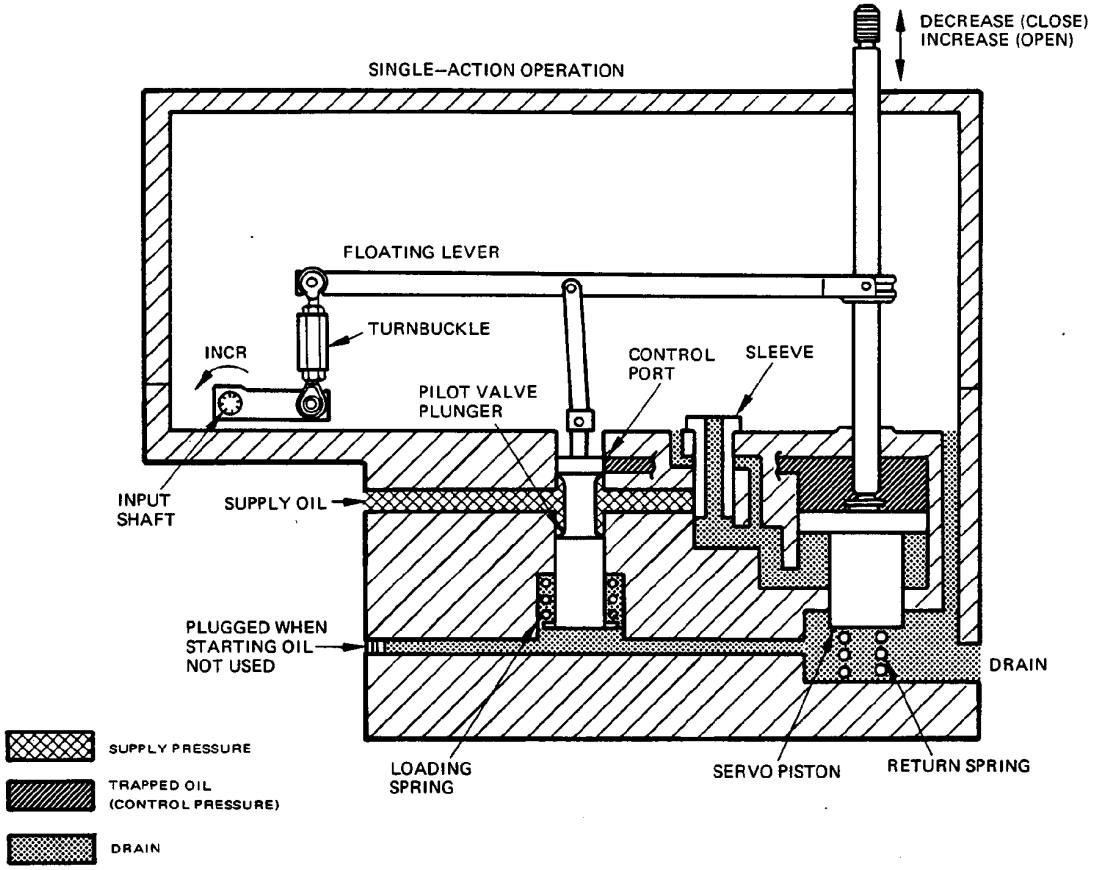

Figure 3-3. Schematic of Mechanical Input Hydraulic Amplifier with Sleeve

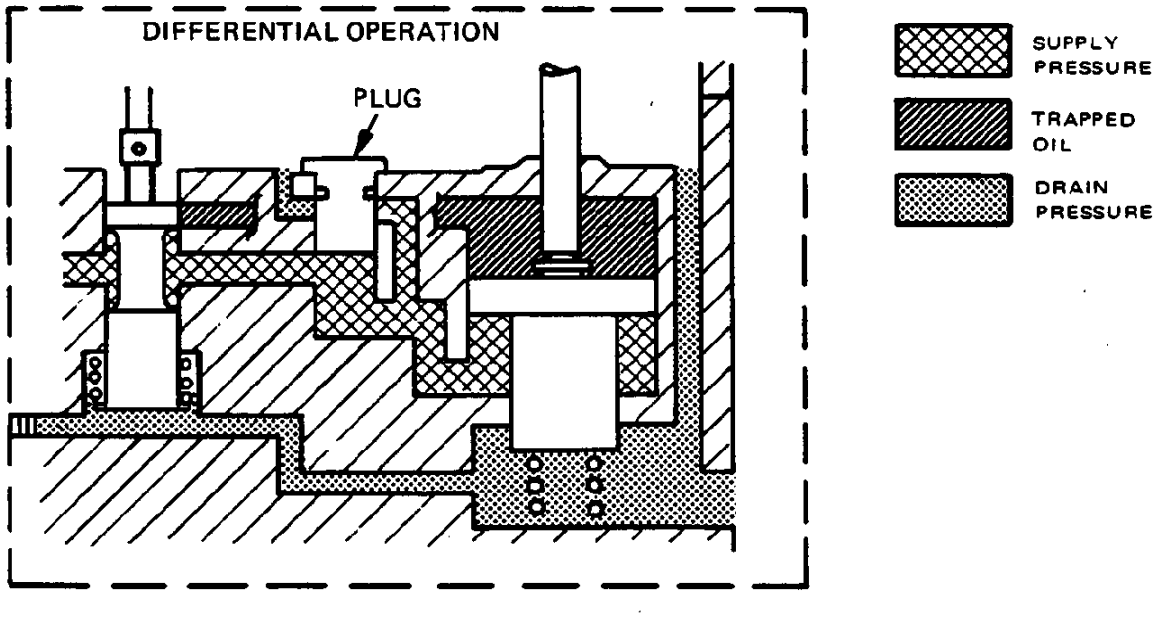

Figure 3-4. Schematic of Mechanical Input Hydraulic Amplifier with Plug

Chapter 4.
Maintenance

Troubleshooting

Use the following table in determining probable causes and corrective actions for common troubles which may be encountered in the field. Every possible trouble which may be experienced cannot be anticipated and may, in some instances, be due to faulty operation of auxiliary equipment. The effect of the governor, oil supply system and prime mover power control mechanism must be considered when troubleshooting apparent malfunctions of the hydraulic amplifier.

Table 4-1. Troubleshooting

Trouble	Probable Cause	Correction
No servo response to movement of input shaft.	Low or no oil pressure to amplifier.	Check prime mover lubricating oil or external oil supply system for proper operation.
	Fuel control or steam valve sticking.	Disconnect linkage and check operation of fuel control or steam valve. Check steam valve unbalance forces.
	Internal amplifier linkage components damaged or disconnected.	Replace damaged components or make connections as required.
Erratic or lagging servo response to movement of input shaft.	Fluctuating oil supply pressure-pump cavitation.	Check prime mover lubricating oil or external oil supply system for proper operation.
	Fuel control or steam valve sticking.	Disconnect linkage and check operation of fuel control or steam valve. Check steam valve unbalance forces.
	Pilot valve plunger loading spring broken or missing.	Replace loading spring.
Input shaft jammed.	Internal amplifier linkage components damaged.	Replace damaged components as required.
	Pilot valve sticking—oil supply contamination with foreign particles.	Disassemble and clean amplifier. Drain, flush, and refill oil supply system. Replace filters.
	Pilot valve plunger cocked in bore—input lever stop broken, bent, or missing	Replace damaged components as required. Adjust shutdown position of pilot valve plunger as instructed under Installation and Adjustment.
Amplifier input shaft locked in full CCW position or will not rotate fully CW.	Starting oil port not connected to drain or internal drain passages clogged.	Make proper connections to drain. Disassemble amplifier and clean drain passages.
	External stop adjustment, faulty linkage or governor operation.	Adjust external stop as instructed under Installation and Adjustment. Check linkage for binding. Check governor for adjustment and operation.

Trouble	Probable Cause	Correction
Fuel control or steam valve will not close or closes too slowly.	Fuel control or steam valve sticking.	Disconnect linkage and check operation of fuel control or steam valve.
	Starting valve plunger sticking in closed position, opening decrease side of servo piston to drain.	Disassemble and clean starting valve plunger. Check oil supply for contamination.
	Fatigued or broken servo piston return spring—excessive leakage past servo piston.	Disassembly of amplifier to the extent necessary to replace the return spring or servo piston is not recommended in the field unless absolutely necessary.
Fuel control or steam valve will not open for starting (low-starting-oil-pressure systems).	Fuel control or steam valve sticking.	Disconnect linkage and check operation and force requirements of fuel control or steam valve.
	Starting valve plunger sticking in open position—plunger spring broken or missing.	Disassemble and clean starting valve plunger. Check oil supply for contamination. Replace plunger spring.
	Starting oil pressure too low.	Increase starting oil pressure to a minimum of 20 psi (138 kPa). Do not exceed 25 psi (172 kPa).
Servo piston will not hold position—erratic over-or undershoot, full stroke either direction with minor change in speed setting.	Low oil pressure causing yield plunger to yield. Piston rod ring not properly secured.	Replace yield spring and/or retaining rings as required.
Servo piston goes to full increase where input shaft rotated CW.	Foreign particle wedged between land on pilot valve plunger and sleeve, causing sleeve to move down with plunger.	Cycle input lever CCW to remove particle by increasing flow. If condition persists, disassemble and clean amplifier. Replace plunger and/or sleeve if sharp edges have been damaged.

* If oil pressure is available, stroke amplifier (with steam valve disconnected) by manually rotating input shaft.

Disassembly

Refer to Figure 6-1 for disassembly of the hydraulic amplifier. Important points and special precautions to be observed are noted below. Do not disassemble the amplifier to any greater degree than necessary for replacement of worn or damaged parts.

1. When replacing wiper seal (78), pry out the old seal using a screwdriver or similar tool. Use care not to nick the edges of bore or seating surfaces in seal plate (76).

2. When removing component parts of internal linkage, do not disturb the length adjustment of the turnbuckle assembly (items 41 through 45) unless replacement of parts is necessary.

3. In some very old 5-1/4 inch diameter model amplifiers, the pilot valve sleeve (22) is retained in its bore by an overlapping edge of the cylinder cover (53). Additionally, some models have a linkage loading spring (20) acting in reverse to that shown in Figure 5-1. In such cases, the spring is loaded between the pilot valve sleeve and a retainer in the lower skirt of the pilot valve plunger (24). If any spring resistance is noted when attempting to lift the plunger, the cylinder cover must first be removed and then the plunger, sleeve, and spring removed as a unit. Make certain to observe the following WARNING if removal of a cylinder cover is necessary.

⚠WARNING

Removal of the cylinder cover is not recommended except in unusual circumstances. The servo piston return spring (90) may be preloaded anywhere within the range of 50 to 2000 pounds (222–8896 N) depending upon system requirements, An arbor or hydraulic press with a minimum stroke of 7 inches (18 cm) must be used. Make adequate provisions to anchor the amplifier securely and also to prevent the piston rod from slipping off the ram face. This operation requires two people, one to operate the press and the second to disassemble the parts.

4. Do not disassemble the servo piston and piston rod. The piston is ground concentric with the rod after assembly and, if disassembled, cannot be properly reassembled to maintain the required concentricity.

Cleaning

Clean parts in fuel or oil or kerosene. Do not use commercial solvents, as they may damage gaskets or oil seals. Do not handle parts roughly or allow highly polished sealing surfaces to contact other objects.

Repair

Repair should generally be limited to light burnishing of component parts to remove superficial corrosion and other minor scores and scratches in finely finished surfaces, Do not remove sharp edges from lands of plungers, the servo piston, or from oil ports in sleeves. Use a fine grit crocus cloth or paper and oil to remove corrosion or other damage.

Reassembly

Refer to Figure 5-1 for reassembly of the hydraulic amplifier. Important points and special precautions to be observed are noted below.

1. Never reuse cotter or roll pins. Replace them with new parts.

2. Lubricate O-rings (preformed packing) with petrolatum or lubricating oil prior to assembly.

3. When installing O-rings over threaded surfaces, tape the threaded area to prevent damage to the O-rings.

4. When assembling parts into the amplifier case, observe strict rules of cleanliness to prevent the introduction of lint or other foreign material into interior cavities.

5. When reassembling parts of the servo cylinder, refer to the WARNING following step 3 in the Disassembly instructions. A hydraulic press Is not recommended for reassembly since the operator cannot “feel” whether or not the piston is entering the cylinder without binding or cocking. Do not force the piston if it begins to bind in the bore. Make certain that the pilot valve sleeve (or sleeve with captive plunger) is installed in the bore in cases where the sleeve is normally retained by an edge of the cylinder cover.

6. When replacing wiper seal (78), make certain that the new seal is installed with wiping edge outward. Install vee seal (77) with vee facing inward.

7. Prior to installing the amplifier cover, recheck the opening between the top of the pilot valve plunger land and the top edge of the oil control port in the sleeve. Refer to the Installation and Adjustment instructions. Apply a liberal amount of clean lubricating oil to alt moving parts to ensure initial lubrication.

Chapter 5.
Replaceable Parts

Replacement Parts Information

When ordering replacement parts, it is essential to include the following information:

1. Mechanical amplifier serial number and part number shown on nameplate.
2. Manual number (this is manual 89009).
3. Parts reference number in parts list and description of part or part name.

Illustrated Parts Breakdown

The illustrated parts breakdown (Figure 5-1) illustrates and lists all the replaceable parts for the mechanical amplifier. 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 mechanical amplifier.

Ref. No.	Part Name	Quantity
89009-1	Case	1
89009-2	O-ring, 1.171 ID x.11	2
89009-3	Bleeder plug. AN 814-16D	2
89009-4	Plug	1
89009-5	O-ring. .468 ID x .078	1
89009-6	Plug, 1.062-12 (AN814-12D)	1
89009-7	O-ring. .924 ID x .103	1
89009-8	Soc. hd. pipe plug. .250	1
89009-9	Dowel pin, .294	2
89009-10	Plug	1
89009-11	Input lever stop	1
89009-12	Lockwasher, .250 ID high collar	1
89009-13	Soc. hd. cap screw, .250-28 x .688	1
89009-14	O-ring, 1.049 ID x 0.10	1
89009-15	Transfer valve plug	1
89009-16	Sensing valve clamp	1
89009-17	Lockwasher, .250 ID high collar	1
89009-18	Soc. hd. cap screw, .250-28 x .750	1
89009-19	Spring seat	1
89009-20	P.V. plunger spring	1
89009-21	P.V. sleeve spring	1
89009-22	P.V. sleeve	1
89009-23	Soc. hd. pipe plug, .375	1
89009-24	P.V. yield plunger	1
89009-25	O-ring, .426 ID x .070	1
89009-26	Yield plunger	1
89009-27	Yield plunger retainer	1
89009-28	Retaining ring, 1.249 OD	1
89009-29	Pilot valve stop block	1
89009-30	Lockwasher, .312	1
89009-31	Soc. hd. cap screw, 0.1875-18 x 1	1
89009-32	Lever stop plate	1
89009-33	Lockwasher, .250	1
89009-34	Soc. hd. cap screw, .250-28 x .750	1
89009-35	Screw	1

IMPORTANT

An optional clamp tool is available to secure to the output shaft (52). This clamp (94 and 95) allows the output shaft to be turned with a wrench.

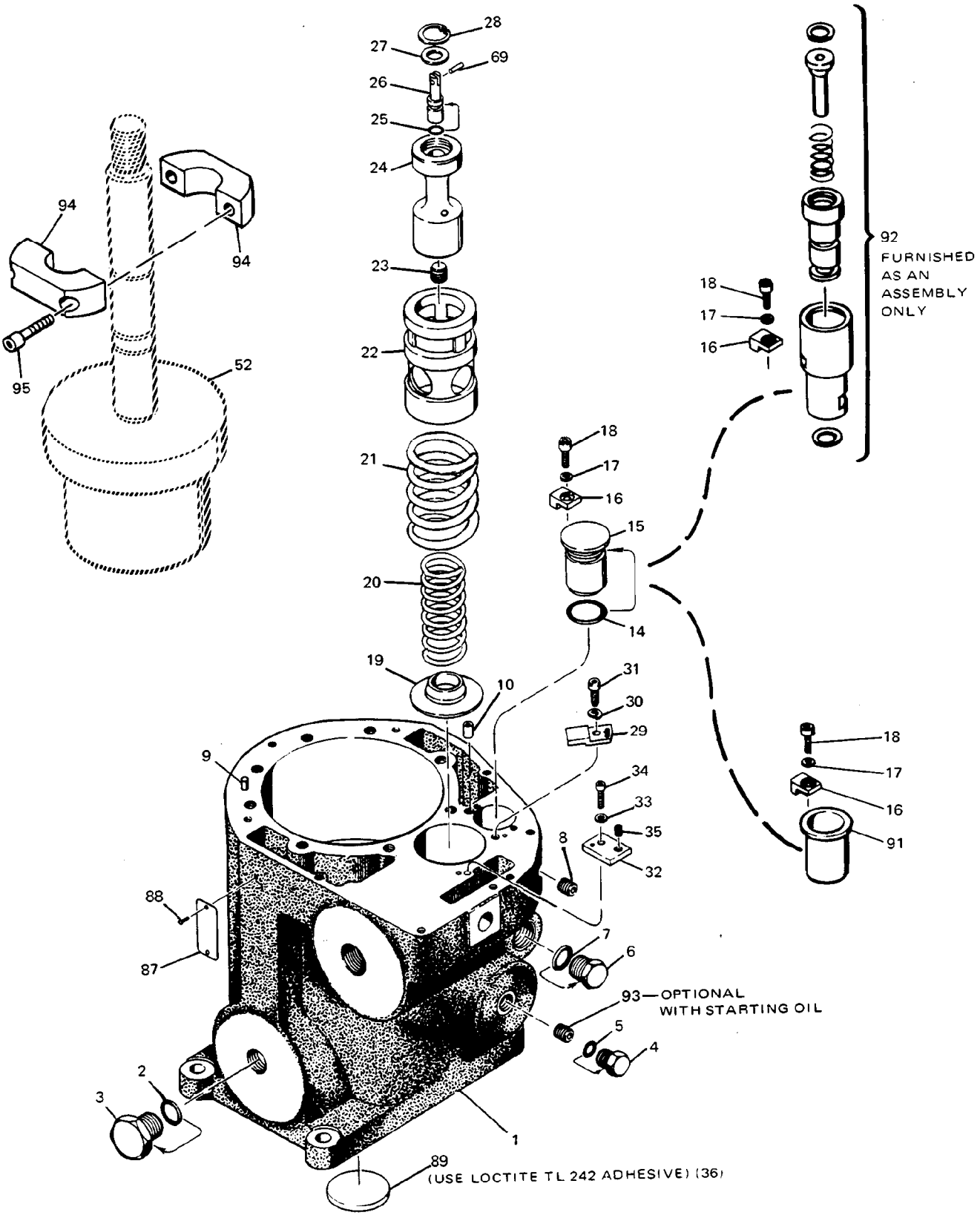

Figure 5-1a. Exploded View, Mechanical Input-Hydraulic Amplifier

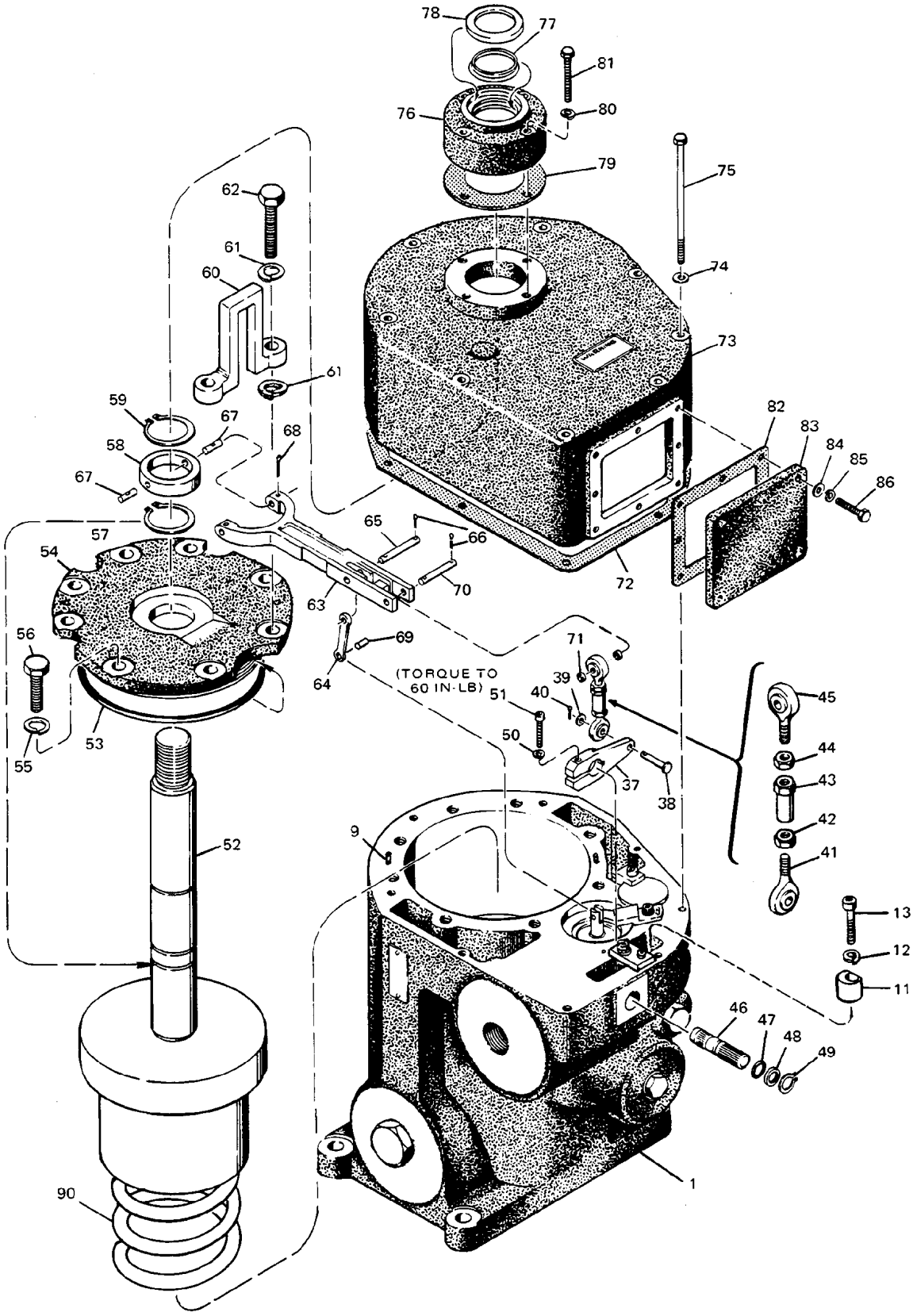

Figure 5-1b. Exploded View, Mechanical Input-Hydraulic Amplifier

Ref. No.	Part Name	Quantity
89009-36	Loctite TL 242 adhesive	AR
88009-37	Input lever	1
89009-38	Headed pin	1
89008-39	Spacer	1
89008-40	Cotter pin	1
88009-41	Spherical rod end bearing	1
89009-42	Hex nut, 10-32	1
89009-43	Adj. link turnbuckle	1
89009-44	Nut, LH 10-32	1
88009-45	Spherical rod end bearing (LH)	1
89009-46	Input shaft	1
89009-47	O-ring, .487 ID x.103	1
89009-48	Spacer, .502 ID	1
89009-49	Retaining ring, .392 ID	1
89009-50	Lockwasher, #10	1
89009-51	Soc. hd. screw, 10-32 x .875	1
89009-52	Servo piston	1
89009-53	O-ring, 6.984 ID x .13	1
89009-54	Cylinder cover	1
89009-55	Lockwasher 5/8	6
89009-56	Hex hd. screw .625-11 x 1.5	6
89009-57	Retaining ring, 1.272 ID	1
89009-58	Piston rod ring	1
89009-59	Retaining ring, 1.272 ID	1
89009-60	Floating lever brace	1
89009-61	Lockwasher, 5/8	4
89009-62	Cap screw, .625-11 x 2	2
89009-63	Floating lever	1
89009-84	P.V. plunger link	1
89009-65	Drilled straight pin	1
89009-66	Cotter pin	4
89009-67	Straight pin	2
89009-68	Cotter pin	2
89009-69	P.V. link pin	1
89009-70	Straight pin	1
89009-71	Washer, .203 ID	2
89009-72	Cover gasket	1
89009-73	Cover	1
89009-74	Washer, .265 x .5 OD x .031	8
89009-75	Hex hd. screw	8
89009-76	Seal plate	1
89009-77	Block yes seal	1
89009-78	Wiper scraper seal	1
89009-79	Ring gasket	1
89009-80	Lockwasher, .250	4
89009-81	Hex hd. screw, .250-20 x 2	4
89009-82	Side plate gasket	1
89009-83	Side plate	1
89009-84	Washer, .375 OD x .195 ID x .031	8
89009-85	Lockwasher, #10	8
89009-86	Screw	8
89009-87	Nameplate	1
89009-88	Drive screw	2
89009-89	Sealing cup	1
89009-90	Spring	1
89009-91	Sleeve	1
89009-92	Starting oil relief-valve	1
89009-93	Plug	1
89009-94	Clamp tool	1
89009-95	Screw	2

Chapter 6.
Service Options

Product Service Options

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

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

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

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

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

You can locate your nearest Woodward distributor, AISF, RER, or RTR on our website at:

www.woodward.com/directory

Woodward Factory Servicing Options

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

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

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

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

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

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

When shipping the item(s), attach a tag with the following information:

- return authorization number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:

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

NOTICE

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

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

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

- Technical Support
- Product Training
- Field Service

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

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

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

For information on these services, please contact us via telephone, email us, or use our website: **www.woodward.com**.

How to Contact Woodward

For assistance, call one of the following Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
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

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

Turbine 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

You can also locate your nearest Woodward distributor or service facility on our website at:

www.woodward.com/directory

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

Your Name	
Site Location	
Phone Number	
Fax Number	
Engine/Turbine Model Number	
Manufacturer	
Number of Cylinders (if applicable)	
Type of Fuel (gas, gaseous, steam, etc)	
Rating	
Application	
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	

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 89009B.

B89009:B

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**Woodward has company-owned plants, subsidiaries, and branches,
as well as authorized distributors and other authorized service and sales facilities throughout the world.**

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