



Bulletin 2751-001-M1/USA

# Hydraguide™ Service Procedure

Effective: July 1, 2000

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## HGA Series Hydrostatic Steering System

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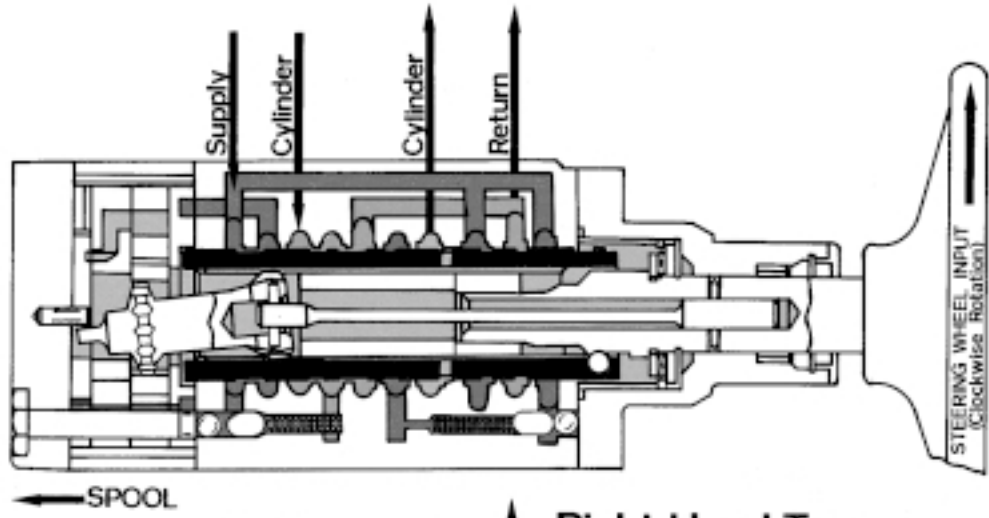
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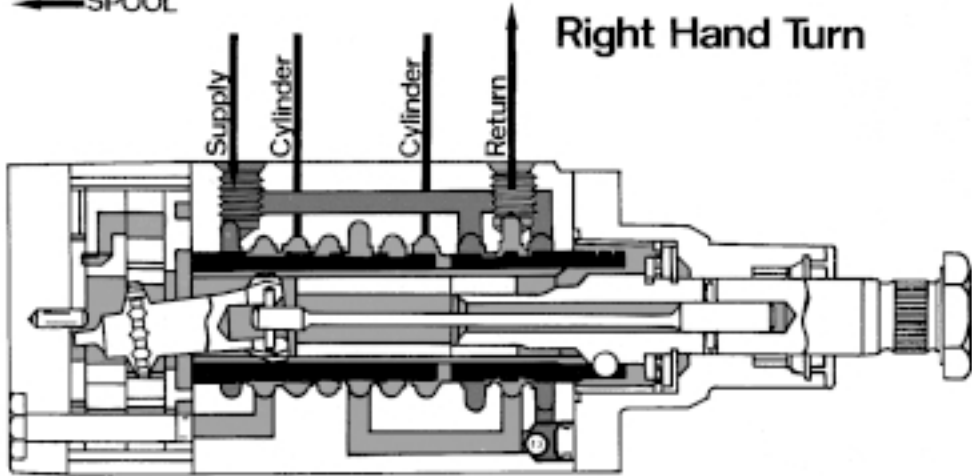
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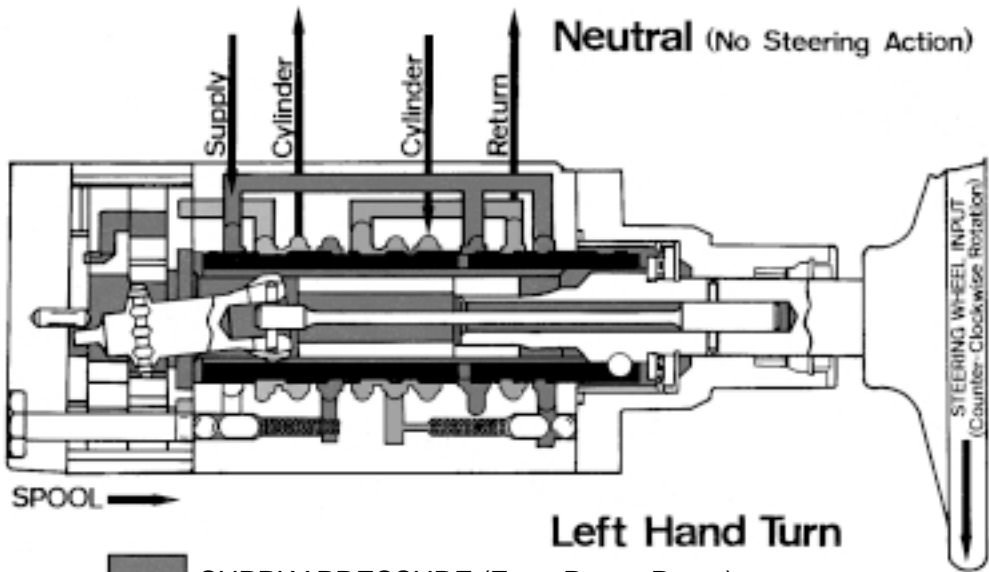
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**Right Hand Turn**

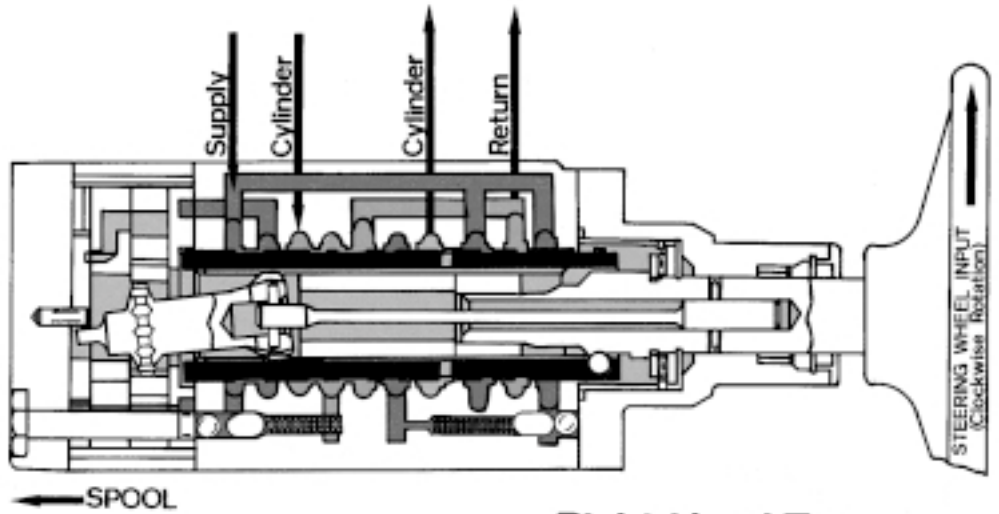


**Neutral (No Steering Action)**

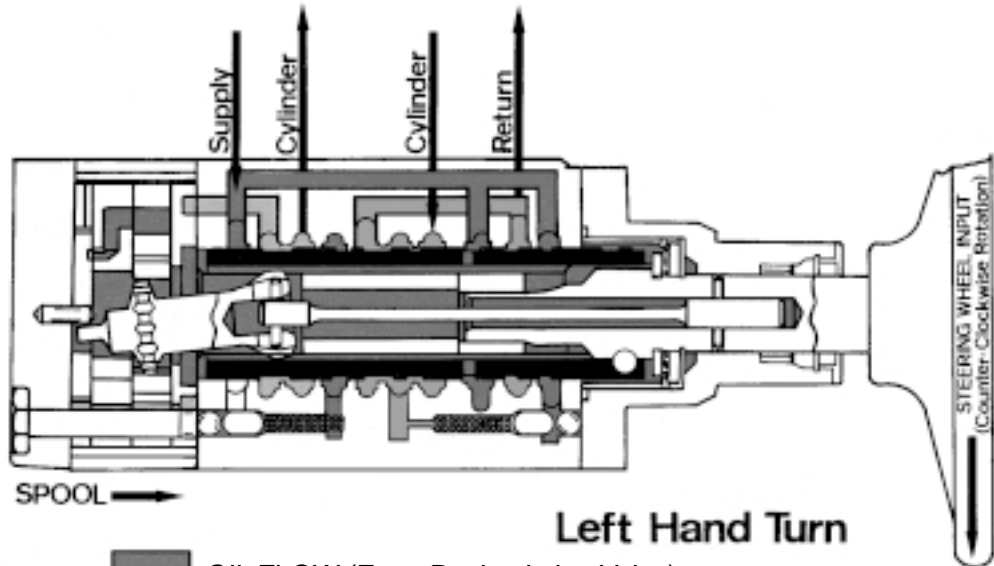


**Left Hand Turn**




- SUPPLY PRESSURE (From Power Pump)
- RETURN OIL FLOW (To Reservoir)
- METERED OIL FLOW (To Cylinder)



**Right Hand Turn**



**Left Hand Turn**

-  OIL FLOW (From Recirculating Valve)
-  RETURN OIL (To Recirculating Valve)
-  METERED OIL FLOW (To Cylinder)

## MODEL HGA

Hydraguide™ is the name given to hydrostatic steering systems. In the HGA type Hydraguide™ steering system, an engine-driven pump, relief valve, cylinder, reservoir, filter, fluid lines, and an HGA control unit are needed. An automotive type steering wheel is attached to the HGA unit and the cylinder is connected by suitable means to the steered wheels.

The driver has power steering control at all times, so long as system components work together, system integrity is maintained, and adequate fluid is present. If there is a failure in the high-pressure circuit, a loss of power steering will result. The HGA, however, is designed to have some manual steering capability, depending on the installation. If you can't manually steer the vehicle without using extraordinary measures, such as leaving your seat, or pushing with your legs, don't try it. Repair the failure in the power circuit. Some vehicles may be impossible to steer manually because of their weight and size.

**WARNING: EXTRAORDINARY MEASURES SHOULD NOT BE USED IN ATTEMPTING TO MANUALLY STEER THE VEHICLE, AS THEY MAY GENERATE FORCES IN EXCESS OF 125 FT. LBS., THEREBY DAMAGING THE UNIT INTERNALLY, WHICH COULD RESULT IN A COMPLETE LOSS OF STEERING.**



**WARNING: ALL STEERING MECHANISMS ARE LIFE AND LIMB ITEMS. AS SUCH, IT IS IMPERATIVE THAT THE INSTRUCTIONS IN THIS BOOKLET ARE FOLLOWED TO THE LETTER. FAILURE TO OBSERVE THE PROCEDURES SET OUT IN THIS PAMPHLET MAY RESULT IN LOSS OF STEERING.**

## SYSTEM OPERATION

This literature with the illustrations shown covers the basic design of the HGA unit. Variations may be engineered to suit special requirements.

The description of the operation of the HGA unit and the illustrations explain the functioning of the system for the utilization of the hydraulic power generated by the engine-driven pump for power steering. Emergency manual operation is also described.

Satisfactory performance of this system requires a **well engineered installation designed for the particular type of vehicle and the type and kind of service for which it will be used.** Parker Engineering advice and assistance is available and we welcome requests.

Information on the required engine-driven pump capacity and the power cylinder size and connecting lines are provided through engineering contacts. A balanced cylinder design is preferred.

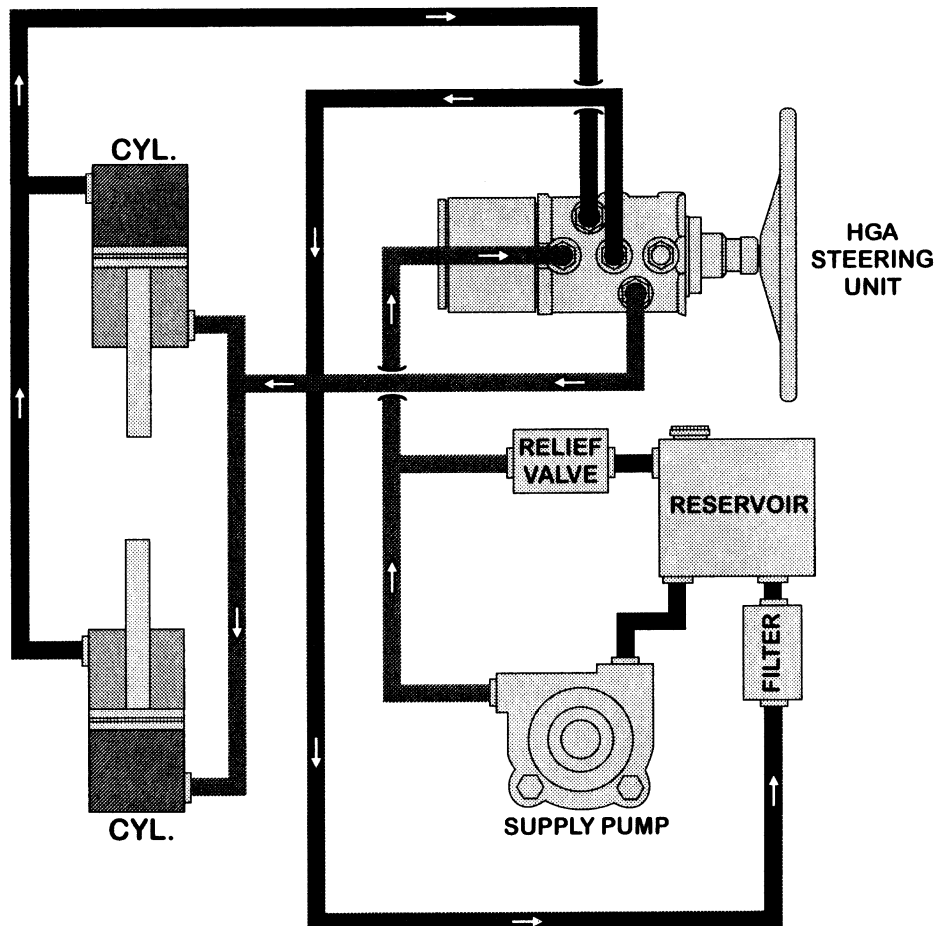


Figure HGA-1

## DESIGN & FUNCTION

The HGA unit consists of a fluid control valve section and a fluid metering section which are hydraulically and mechanically inter-connected.

**CONTROL VALVE**

The control valve section contains a mechanically actuated linear spool which is torsion bar centered.

The function of the control valve section is to direct fluid to and from the metering section, and the cylinder, and to regulate the pressure supplied to the cylinder. The valve is provided with unique pressure chambers which insure effective circuit isolation.

**METERING SECTION**

The metering section consists of a commutator and bi-directional gerotor element, which contains an orbiting rotor and a fixed stator. The commutator rotates at orbit speed with the rotor and channels the fluid to and from the rotor set and the valve section.

The rotor incorporates unique sealing vanes which are spring and hydraulically forced into sealing contact between the rotor and stator to reduce leakage across the metering section.

The function of the metering section is to meter the oil to the power cylinder, maintaining the relationship between the hand wheel and the steered wheels. An additional function of the metering section is to act as a manually operated pump providing manual steering in the event of an inoperative engine-driven pump.

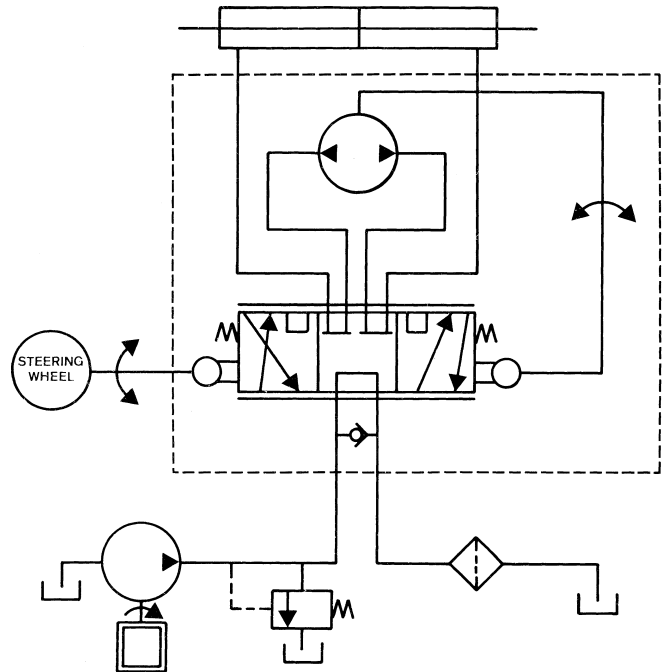


Figure HGA-2

**ROTOR OPERATION IN THE ROTOR SET (See Fig. HGA-3)**

Each lobe of the rotor has a diametrically opposite lobe, therefore, when one lobe is in a cavity its opposite lobe is at the crest of the stator's convex form opposite the cavity. As the rotor is rotated, each lobe in sequence is moved out of its cavity to the crest of the stator's convex form and this forces each opposite lobe, in sequence, into a cavity. Due to the interaction between the rotor and the stator, there are 42 fluid discharging actions in one revolution of the rotor. When the rotor is moving, fluid is always flowing out of three of the cavities while fluid is flowing into three other cavities, and one of the cavities is inactive as it changes from one of discharging fluid to one of admitting fluid. The commutator rotates with the rotor and channels the fluid to and from the valve section, and to and from the rotor set.

**METERING ELEMENT**

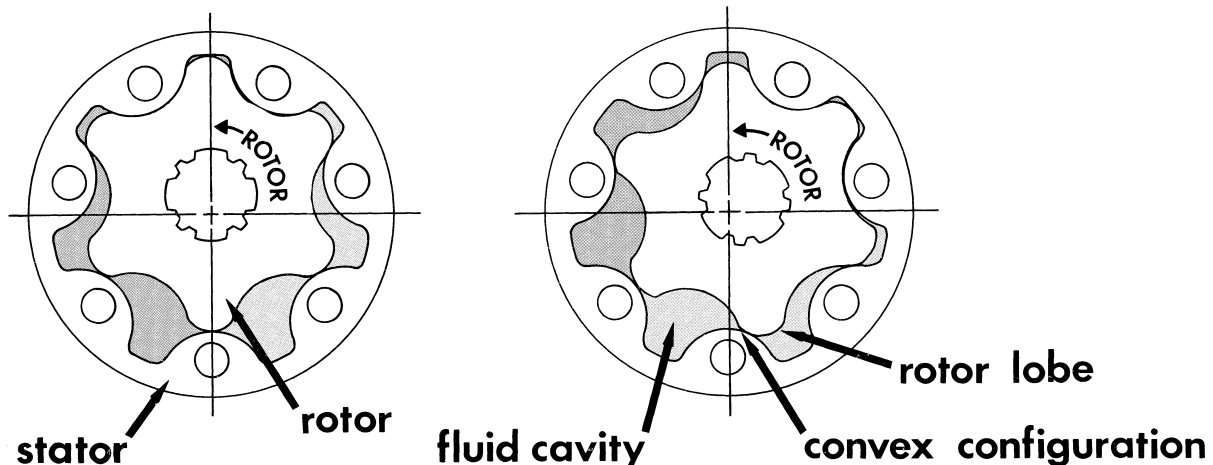


Figure HGA-3



## **POWER STEERING OPERATION**

When the spool is in center or neutral position, the hydraulic oil from the engine-driven pump circulates through the valve section, directly back to the reservoir with sufficient pressure only to overcome friction of valve channels and lines. There is no circulation of engine-driven pump oil to or from the cylinder. Note the center diagram showing neutral position (See diagram on inside front cover) on which no directional arrows appear in the metering channels. The oil pressure at the two cylinder ports is equal and produces ineffective forces in the cylinder.

In order to accomplish a power steering maneuver, the operator must rotate the steering wheel in the direction of the steering maneuver. The initial rotation of the steering wheel rotates the input shaft which tends to rotate the drive link and rotor set through the torsion bar centering spring. Rotation of the rotor set and spool which are coupled by the drive link, is resisted by the cylinder pressure required to overcome the steering forces. As the input shaft is rotated relative to the spool, the centering spring is torsionally deflected. Axial shift of the spool is induced by the ball which is captive in the spool and engaged in the helical groove provided in the input shaft.

When the spool is axially displaced within the body, fluid channels are selected connecting the engine-driven pump to the intake side of the rotor set via the

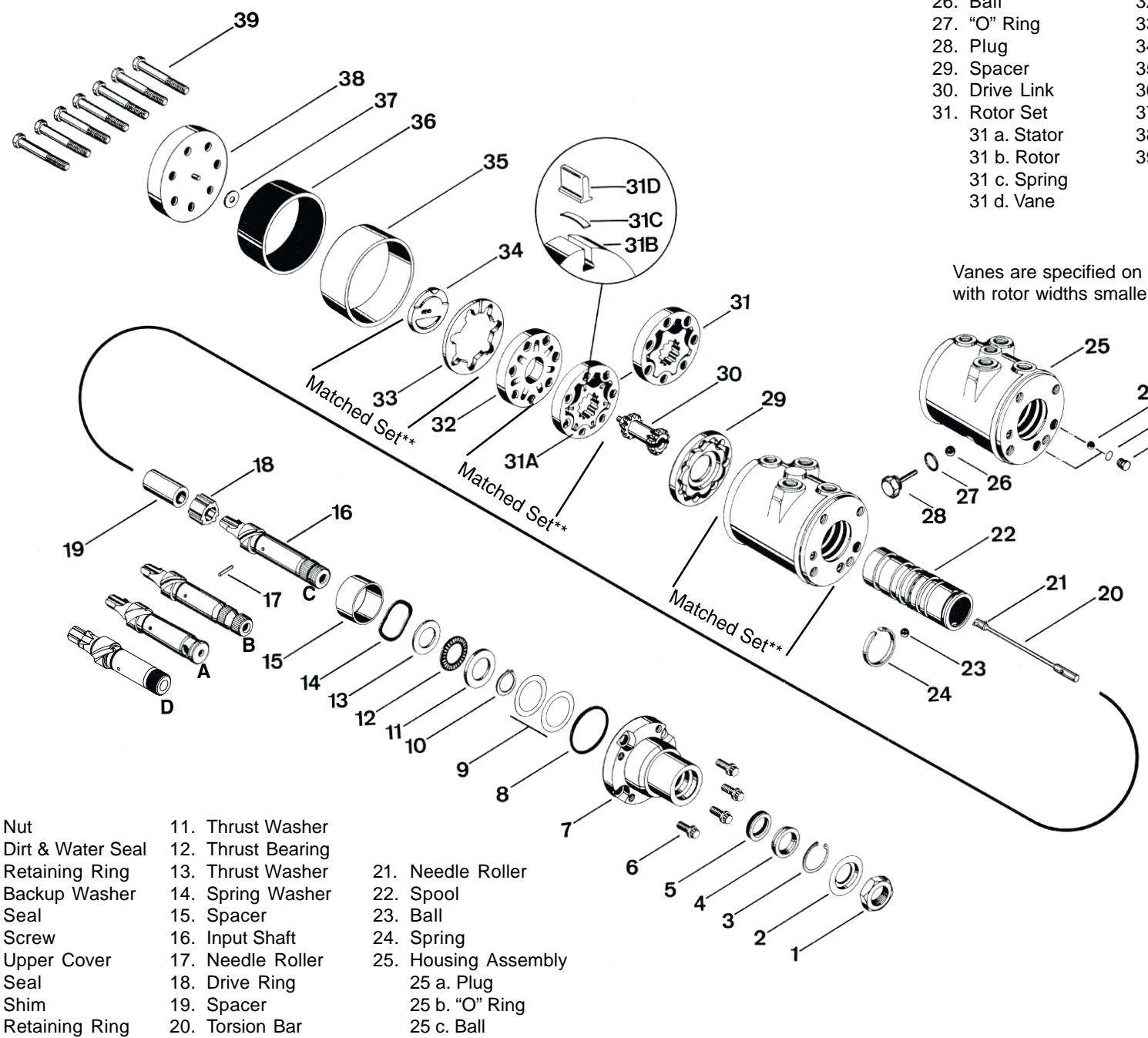
commutator. The exhaust side of the rotor set is connected, through the commutator, to one side of the cylinder while the other side of the cylinder is connected to the reservoir. (See Figures HGA-1 and 2).

Further axial displacement of the spool results in increased system pressure to provide the level of pressure required. A portion or all of the hydraulic fluid at the required pressure from the engine-driven pump, depending upon the speed of steering, is directed to the cylinder via the metering section, using cylinder movement to accomplish the steering maneuver.

## **MANUAL STEERING OPERATION**

In the absence of system pressure, the driver's manual effort displaces the spool axially. When the spool is displaced within the body, fluid channels are selected connecting the rotor set, which is now acting as a pump, via the commutator to one side of the cylinder. The return flow from the other side of the cylinder is channeled through a recirculation valve so that the oil will flow to the intake side of the rotor set via the commutator instead of back to the reservoir. (See. Figure HGA-5) The recirculation valve is a ball check valve in a channel connecting the return flow chamber to the engine-driven pump pressure inlet chamber. The recirculation valve is closed during power operation.

**WARNING: ALL STEERING MECHANISMS ARE LIFE AND LIMB ITEMS. AS SUCH, IT IS IMPERATIVE THAT THE INSTRUCTIONS IN THIS BOOKLET ARE FOLLOWED TO THE LETTER. FAILURE TO OBSERVE THE PROCEDURES SET OUT IN THIS PAMPHLET MAY RESULT IN LOSS OF STEERING.**



- 26. Ball
- 27. "O" Ring
- 28. Plug
- 29. Spacer
- 30. Drive Link
- 31. Rotor Set
  - 31 a. Stator
  - 31 b. Rotor
  - 31 c. Spring
  - 31 d. Vane
- 32. Manifold
- 33. Commutator Ring
- 34. Commutator
- 35. Seal Retainer
- 36. Seal
- 37. Washer
- 38. End Cover
- 39. Special Bolt

Vanes are specified on "HGA" units with rotor widths smaller than 1.00.

- 1. Nut
- 2. Dirt & Water Seal
- 3. Retaining Ring
- 4. Backup Washer
- 5. Seal
- 6. Screw
- 7. Upper Cover
- 8. Seal
- 9. Shim
- 10. Retaining Ring
- 11. Thrust Washer
- 12. Thrust Bearing
- 13. Thrust Washer
- 14. Spring Washer
- 15. Spacer
- 16. Input Shaft
- 17. Needle Roller
- 18. Drive Ring
- 19. Spacer
- 20. Torsion Bar
- 21. Needle Roller
- 22. Spool
- 23. Ball
- 24. Spring
- 25. Housing Assembly
  - 25 a. Plug
  - 25 b. "O" Ring
  - 25 c. Ball

(\*Items 2, 4, 5 included in HG500007 Kit)  
(\*\*Items sold in matched sets only)

Figure HGA-6

**USE WITH HGA SERVICE MANUAL EXPLODED VIEW**

<b>1</b> Wheel Nut 026045	<b>2, 4, &amp; 5</b> Seal Kit* HG500007	<b>3</b> Snap Ring 401233	<b>6</b> Screw (4 ea.) 021434 (Fine)	<b>7</b> Upper Cover HGA016005X1	<b>8</b> Seal 032840X1	<b>9</b> Shim Kit 033157X2	<b>10</b> Snap Ring 401367	<b>11</b> Thrust Washer 400100		
<b>12</b> Thrust Bearing 063979	<b>13</b> Thrust Washer 400075	<b>14</b> Spring Bearing 401366	<b>15</b> Spacer Washer 477277	<b>16A</b> Pinhole Shaft 089181	<b>16C</b> Wheel Mount Shaft 089180	<b>16B</b> Full Bolt Groove 089193	<b>16D</b> Straight Spline 089178	<b>17</b> Needle Roller 040114	<b>18</b> Drive Ring HGA013003	<b>23</b> Ball 5/16" dia. 400013
<b>24</b> Spring 401412	<b>25-A&amp;B</b> Plug & "O" Ring 036147A1	<b>25C &amp; 26</b> Ball 1/4 dia. G453570	<b>27 &amp; 28</b> Plug Assy. 415395A2	<b>29</b> Spacer 477235	<b>32</b> Manifold HGA015001	<b>33 &amp; 34</b> Commutator Assy. HGA014000A1	<b>37</b> Washer 028395	<b>38</b> End Cover 402803A1		

22 & 25 Housing & spool are non-serviceable due to select fit. If either needs to be replaced the housing assembly must be replaced.

**STANDARD PARTS THAT CHANGE WITH DISPLACEMENT**

Series	31C/D Vane Kit	31 Rotor Set	Length of Rotor Set	35 Seal Retainer	Length of Seal Retainer	36 Rubber Boot Seal	Length of Rubber Boot Seal	39 5/16-24 Thread Bolts (7 ea.)		20 & 21 Torsion Bar**	30 Drive Link	19 Spacer
								Before Date Code195-94	After Date Code195-94			
HGA 08	506607	HGA087010	.501	099070	1.522	032626	1.648	021269	021428	BASE-A10506	HGA013008	4772480184
HGA 10	506606	HGA107010	.626	099071	1.647	032618	1.786	021280	021356	BASE-A10525	HGA013008	4772480196
HGA 12	506611	HGA127007	.751	099072	1.772	032619	1.923	021283	021311	BASE-A10538	HGA013008	4772480209
HGA 14	506610	HGA147005	.876	099073	1.897	032627	2.066	021290	021306	BASE-A10550	HGA013008	4772480221
HGA 16	506609	HGA167005	1.001	099074	2.022	032628	2.203	021292	021382	BASE-A10562	HGA013008	4772480234
HGA 20	_____	HGA207005	1.252	099075	2.272	032620	2.511	021294	021357	BASE-A10525	HGA013005	4772480196
HGA 24	_____	HGA247005	1.502	099076	2.522	032629	2.753	021295	021444	BASE-A10550	HGA013005	4772480221
HGA 28	_____	HGA287005	1.752	099077	2.772	032621	3.026	021296	021358	BASE-A10538	HGA013006	4772480209
HGA 32	_____	HGA327004	2.002	099095	3.022	032759	3.313	021349	021435	BASE-A10562	HGA013006	4772480234

\*Use part number 020206 on assemblies manufactured prior to date code 195-94

\*\*Torsion bars are unit specific. To select the correct replacement, measure the diameter of the center section of the bar and the length between holes, then select the correct base number from the following chart:

Base Number	Bar Center Diameter - in.	Length Between Holes - in.
401360	0.147	5.00 - 5.62
401363	0.160	6.00 - 6.50
401368	0.160	5.00 - 5.62
401413	0.154	5.00 - 5.62
401432	0.147	6.00 - 6.50
401435	0.139	5.00 - 5.62
401627	0.139	6.00

**SERVICE PROCEDURE**

For service information on the steering pump (engine-driven) and power cylinder, see information provided by the manufacturer of these units.

For servicing the HGA unit and the system, see instructions in the following sections.

Servicing of HGA Unit	Page 14
Filling and Air Bleeding the System When Drained of Oil	Page 24
Hydraulic Fluid	Page 24

**CLEAN WORK CONDITIONS**

It is a must that the system be kept free of dirt or foreign matter in the oil circuit. Cleanliness in servicing this power steering system is absolutely necessary.

If it is necessary to disassemble any of the units, make sure that a clean work bench or table is used. (A piece of clean wrapping paper makes an excellent disposable top).

Outside dirt should be cleaned off before disconnecting lines and port holes should be plugged immediately after disconnecting lines.

Finish cleaning off outside dirt before placing on work bench.

When disassembled, parts should be cleaned only in clear-clean petroleum base solvent and blown dry with clean, dry air. Other solvents may cause deterioration of rubber seals. Avoid wiping parts with cloth and never steam clean hydraulic steering assemblies.

**WARNING: SINCE SOLVENTS ARE FLAMMABLE, BE EXTREMELY CAREFUL WHEN USING THEM. EVEN A SMALL EXPLOSION OR FIRE COULD CAUSE DEATH OR INJURY.**

**WARNING: EYE PROTECTION SHOULD BE WORN.**

**WARNING: OSHA MAXIMUM AIR PRESSURE REQUIREMENTS SHOULD BE COMPLIED WITH TO PREVENT INJURY.**

**SEAL REPLACEMENT INSTRUCTIONS**

For numerous installation you may want to purchase the J26910 tool kit available from KENT MOORE TOOL DIVISION, 29784 Little Mack, Roseville, Michigan 48066 - Phone (800) 345-2233.

Caution: Follow the instructions and do not disassemble the Hydraguide unit upper cover (7) to replace the shaft seal (5).

1. Remove the steering wheel nut (1), steering wheel and steering wheel column, if applicable. Refer to page 18 for instructions on removal of steering wheel column.
2. Remove the dirt seal (2) over the end of the Hydraguide unit upper cover, if applicable. Discard this part.
3. Remove the retaining ring (3), do not discard, this part must be reinstalled during assembly procedure.
4. Remove the seal package parts (4) (5) from the Hydraguide unit by one of the following methods:
  - a) If the Hydraguide unit has not been removed from the vehicle, rotate the Hydraguide unit input shaft either clockwise or counter clockwise to pressurize the system and force the seal package out. Discard these parts.
  - b) If the Hydraguide unit has been removed from the vehicle plug three of the four ports in the Hydraguide unit and pressurize the other port with air pressure to force the seal package out. Discard these parts.
5. Note: Clean the Hydraguide unit input shaft (16) and upper cover (7) seal bore to remove particles of dirt, felt, lint, etc. with a clean, lint-free rag. Caution: excessive particles of felt or lint can cause the new seal package to leak.
6. Cover the end of the Hydraguide unit input shaft with cellophane tape to protect the new seal (5) when it is assembled over the sharp edges of the input shaft.
7. Lubricate the new seal using hydraulic oil and install the new seal (5) with lip side first, onto the Hydraguide unit input shaft.
8. Remove the cellophane tape from the Hydraguide unit input shaft.
9. Assemble the new washer (4), with small end first, onto the Hydraguide unit input shaft and push the new washer and the new seal (5), previously installed, down into the Hydraguide unit upper cover. (A short piece of metal tubing 15/16 minimum I.D. x 1-3/16 maximum O.D. or a 7/8 deep well socket may be used to push these parts into place.)
10. Assemble the previously used retaining ring (3) onto the Hydraguide unit input shaft and down into the Hydraguide unit upper cover groove. Be sure the rounded edge of the retaining ring (3) is faced inward.
11. Assemble the new seal (2) onto the Hydraguide unit input shaft and down into the Hydraguide unit upper cover (7) counter bore.
12. Assemble the steering column, if applicable.
13. Assemble the steering wheel and wheel nut, torque the wheel nut to 35 ft. lbs.

**SERVICING OF HGA UNIT**

Refer to exploded view, Figure HGA-6 for parts identification.

The spool (22) and the housing (25), the commutator (34), and commutator ring (33), as well as the rotor (31B) and the stator (31A) are not separately replaceable because they are selectively fitted at the factory. If the spool or housing need replacement, the complete housing assembly must be replaced. If the commutator or the commutator ring need replacement, both must be replaced as a matched set. If the rotor or stator need replacement, the complete rotor set (31) must be replaced. The pin in the end cover is not separately replaceable. If the pin or end cover need replacement, the end cover and pin assembly (38) must be replaced.

Plug the four port holes and clean the exterior of the unit thoroughly. Then remove the plugs.

1. To prevent possible distortion or damage to unit if placed directly in vise, the following procedure should be used. Insert "o" ring tube fitting, with tube nut or fitting cap attached, into one of the four threaded ports in the housing. Clamp the fitting in a vise in a manner which will locate the seven end cover bolts in an upright position. (See Figure HGA-7).

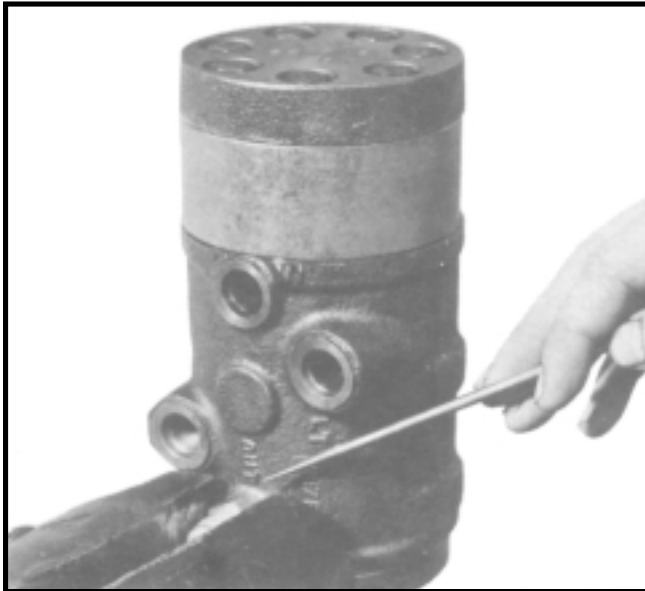


Figure HGA-7

2. Unscrew the seven special bolts (39) from the end cover (38). **Note: Special care should be used in the following steps to insure protection of the ground and lapped faces of the components. Avoid scratching or nicking of finished surfaces.**
3. Remove end cover (38) by bumping it sideways with a soft hammer to loosen it from the rotor seal (36) and seal retainer (35), and lift from unit. **Caution: The washer (37) and commutator (34) may adhere to the end cover, and may be removed with the end cover. Do not attempt to remove pin because pin is press fit in the plate and is non-serviceable. (See Figure HGA-8).**
4. Remove the rotor seal (36) and seal retainer (35) by bumping the can sideways with a soft hammer to loosen it from the housing and lift off the rotor seal and seal retainer. Discard the rotor seal.
5. If the wear washer (37) and commutator (34) were not removed with the end cover (38), remove these parts from the HGA unit.
6. Remove the commutator ring (33) from the mani-



Figure HGA-8

fold (32), by a sliding and lifting motion. Care should be used in the handling of this fragile component.

7. Remove the manifold (32) from the rotor set (31) by sliding and lifting motion.
8. Remove the rotor set (31), spacer (29) and drive link (30) as an assembly by grasping the spacer and removing the assembly with a sliding and lifting motion. (See Figure HGA-9).

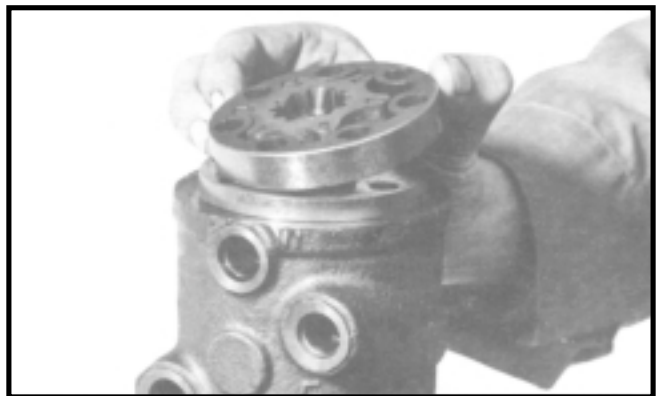


Figure HGA-9

9. Separate drive link (30) by sliding the rotor set (31) on the spacer (29), allowing the drive link teeth to clear the spacer hole. Remove drive link and separate rotor set from spacer. **Use extreme caution to keep vanes (31D) and springs (31C) from falling out. When handling the rotor set, pressure should be applied to the rotor (31B) by gripping the rotor set between the fingers and urging the rotor into contact with the stator (31A). (See Figure HGA-10)**

Carefully protect against damage to side faces.  
Note: The rotor (31B) and the stator (31A) must be kept in a matched set.



Figure HGA-10

10. Reverse the HGA unit in the vise to place the input shaft (16) in a vertical position. Using a center punch, mark the upper cover flange (7) in relation to a similar mark placed on the port face of the housing (25) to facilitate reassembly. (See figure HGA-11).

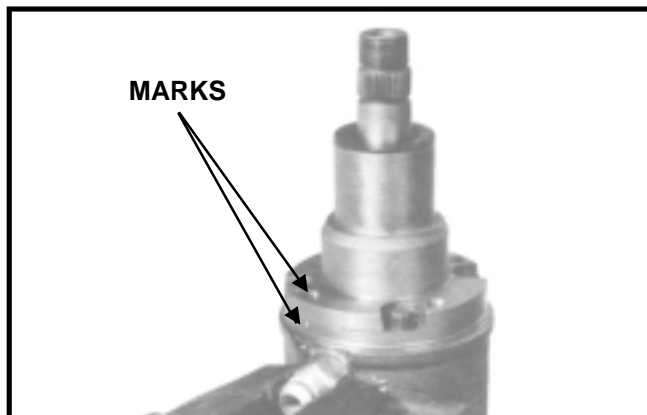


Figure HGA-11

11. Remove the four special cap screws (6) by using a 5/16-12 point socket.
12. Grasp the input shaft (16) and with a smooth upward motion, remove the input shaft (16), upper cover (7) and spool (22) assembly from the housing (25). **Note: Avoid applying side forces to the spool which would cause binding of the closely fitted assembly. Never use excessive force to remove the spool from the housing.**
13. Remove and discard seal (8).
14. Remove the upper cover (7) with shaft seal package (Items 2 thru 5) intact. Remove spacer item (15).
15. Remove shims (9) from either upper cover (7) cavity or from face of thrust washer (11). Count and record the number of shims to aid in reassembly of unit.

16. Remove seal (2), retaining ring (3), using proper snap ring pliers. Discard seal (2). Remove and discard backup washer (4). Remove and discard seal (5).
17. Remove the retaining ring (10), thrust washer (11), thrust bearing (12), thrust washer (13) and spring washer (14) from input shaft (16). **Note: Retaining ring is twisted design. Do not straighten ring.**
18. Remove the needle roller (17) by using a pin punch of .125-inch max. diameter for a minimum of .625 length. The input shaft (16) should be placed on a block of wood (to avoid shaft damage) and the needle roller (21) removed by impact, using light hammer blows. (See Figure HGA-12).
19. Remove the torsion bar (20) and spacer (19) by inverting the spool assembly and allowing the parts to fall free. Do not remove needle roller (21) from torsion bar. (See Figure HGA-13).

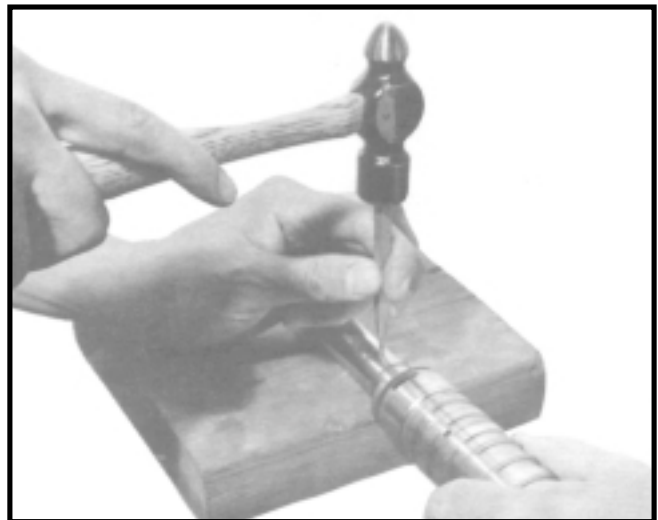


Figure HGA-12

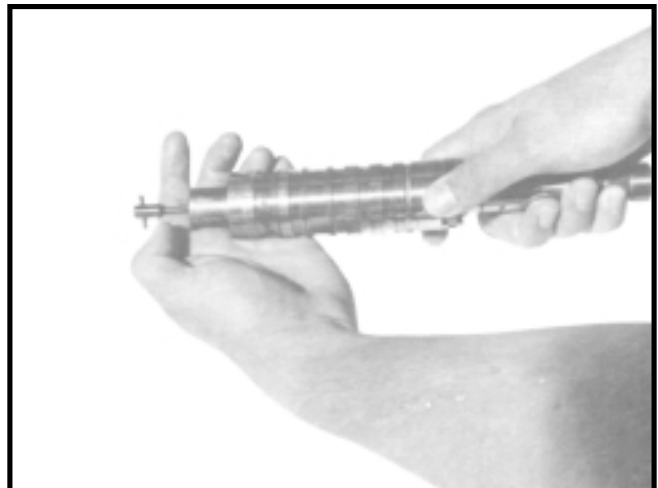


Figure HGA-13



20. Remove the drive ring (18) by placing the end of the spool (22) on a table surface. Rotate the input shaft (16) to extremes of travel until the drive ring falls free. (See Figure HGA-14).

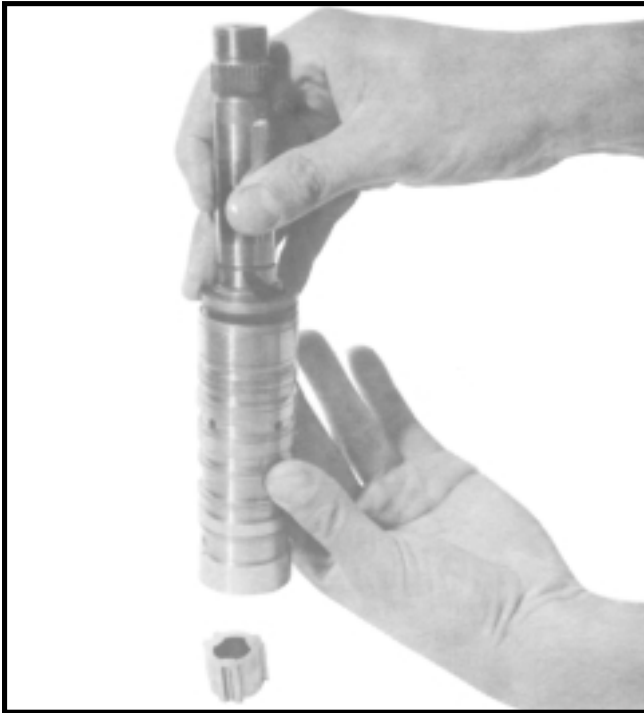


Figure HGA-14

21. With the spool assembly in the same position as the step above, rotate the input shaft (16) in a clockwise direction until the actuator ball (23) disengages from the helical groove in the input shaft. Lift out input shaft. **Caution: The actuator ball may fall free and care should be used to not lose it.**

22. **Do not remove the ball retainer spring (24) unless replacement is required.** If necessary to remove this spring, discard the retainer (24) if moved.

A screwdriver may be used to assist in the prying of the spring over the shoulder of the spool (22). Care must be used to avoid scratching or nicking of the spool outside diameter and control edges.

(The following procedure is optional).

23. Return to the housing (25) which is mounted in the vise. Remove the plug and roll pin assembly (28). A steel ball is captivated by the plug and roll pin assembly. Care must be used to avoid the loss of the ball. Remove ball by shaking after housing is removed from the vise. Discard "O" ring (27).

This completes the disassembly of the HGA unit.

Visually inspect all parts and replace those parts which are not in good condition. The following finished surfaces should be inspected for abnormal wear, scoring or damage.

1. Housing (25) bore and ends.
2. Valve spool (22) outside diameter. Some burnishing due to use may be observed.
3. Valve spool (22) control edges.
4. Valve spool (22) splines.
5. Input shaft (16) seal area. Check for rust, pitting and excessive wear. Light circumferential polishing due to seal contact may be observed.
6. Input shaft (16) helical groove. Note the contact pattern created by the actuator ball (23). Surface should be free from pits chipping or surface break down.
7. Thrust bearing (12) and thrust washers (11) and (13). Inspect for pitting of rolls and faces of thrust washers.
8. Drive link (30) pin slot. Width of slot must not exceed .001 inch difference at any point in its length.
9. Drive link (30) teeth.
10. Torsion bar and needle roller assembly (20).  
Difference in diameter of needle roller (21) should not exceed .001.

The following parts may show a polish pattern due to the rotor action and the circular motion of the commutator. The sides of these components are ground and lapped and should be free from nicks, burrs and scoring.

1. Spacer (29).
2. Manifold (32).
3. Rotor (31).
4. Commutator (34) and Commutator Ring (33).  
**Note: Thickness difference between commutator and commutator ring (33) shall not exceed .002 inch.**
5. End cover and pin assembly (38).

**Note: The rotor set (31) requires special attention in handling to avoid nicks and scratching. It is recommended that the rotor (31B), stator (31A), vanes (31D) and springs (31C) be checked in the assembled condition. To inspect the rotor set, place the assembly face down on the lapped face of the end cover (38) and check for freedom of rotor rotation within the stator. The action of the spring loaded vanes may be observed during rotation. The vanes should move freely in their slots, without bind, due to the forces of the springs. (See Figure HGA-15).**



Figure HGA-15

Using a feeler gage, check the rotor (31B) to the stator (31A) clearance as shown in figure HGA-16. If there is more than a .007 inch clearance, the rotor set (31) must be replaced. **Note: This applies to rotor sets with and without vanes.**



Figure HGA-16

Carefully lift the rotor set assembly (31) from the end cover (38) and measure the thickness of the rotor (31B) and stator (31A). Thickness difference between the rotor and stator shall not exceed .003 inch.

The internal splines in the rotor should not allow abnormal wear or damage.

**IMPORTANT; Before starting assembly, clean all parts with clean petroleum base solvent and air dry. Do not wipe dry with rags. Be sure all dried paint chips have been removed from edges of lapped surfaces. Unless otherwise indicated, DO NOT oil parts before assembly.**

1. Insert ball (26) into its cavity in the housing.
2. Install new "o" ring (27) on plug and roll-pin assembly (28) and install in the housing (25) to 10-14 ft. lbs. torque.
3. Reclamp housing (25) in the vise as shown in Figure HGA-11.
4. Assemble thrust washer (13), thrust bearing (12), thrust washer (11) and retaining ring (10) on input shaft (16).
5. If the retaining spring (24) has been removed, install a new retaining spring. The spring must fit tightly.
6. Insert actuator ball (23) into ball seat located inside spool (22).
7. Assemble wave spring washer (14) over thrust washer (13) and thrust bearing (12). Insert the input shaft (16) into the spool, engaging the helix and ball with a counter-clockwise motion. This operation is best done while holding the spool in a horizontal position.
8. Using the mid-section of the torsion bar (20) as a gage, insert the gage between the spool end and the thrust washer (13). (See Figure HGA-17). This will position the spool in the necessary radial relationship with the input shaft spline teeth for assembly of drive ring (18).
9. Place the input shaft (16) and spool (22) assembly in a vertical position, with the shaft end on the table surface.

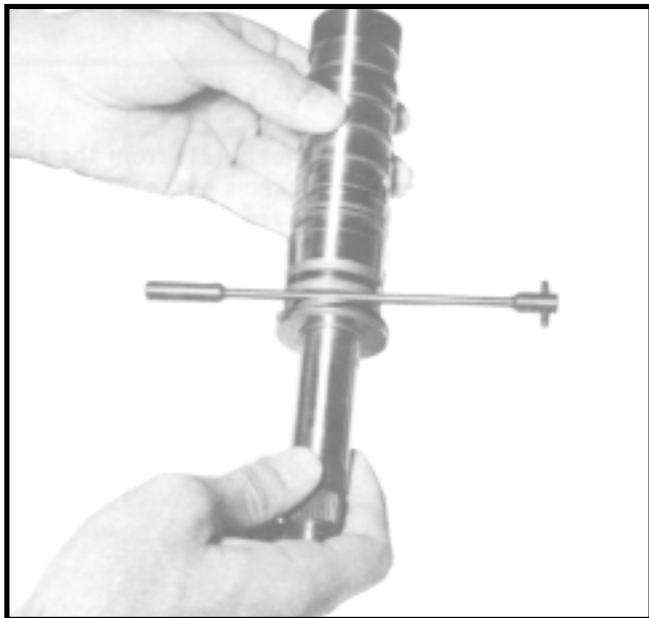


Figure HGA-17

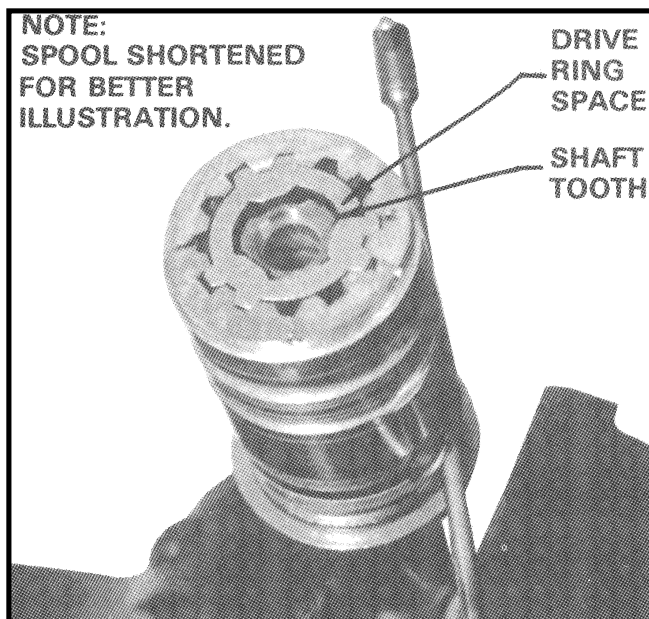


Figure HGA-18

**NOTE: Rotate the input shaft (16) out of the valve spool (22) until input shaft will no longer rotate. There will be a gap of approximately .350 between end of valve spool (22) and thrust washer (13) if the drive ring (18) is assembled properly.**

10. Insert the drive ring (18) into the spool (22) end by visually aligning an internal space on the drive ring with a tooth on the input shaft (16) split, and allow the drive ring to drop to the limit of its travel. If the drive ring does not engage the input shaft spline, a slight rotation of the input shaft will allow the drive ring to become fully engaged. Remove torsion bar (20) gage. (See Figure HGA-18).
- CAUTION: The HGA will not function properly if the correct relationship of spool, drive ring and input shaft is not achieved.**
11. Install spacer (19) over torsion bar and pin assembly (20) and insert the assembly into the spool (22) end.
12. Align the cross-hole in the torsion bar (20) with the cross-hole in the input shaft (16) and insert a .120 diameter pin punch to maintain alignment.
13. Insert the needle roller (17) into cross-hole in input shaft (16); and while retracting the pin punch, engage the pin in the torsion bar (20) cross-hole.
14. Initiate press of needle roller (17) into torsion bar (20) with a few light impacts. Press needle roller flush with outside diameter of input shaft (16) using a 1/2" drive socket of 11/16 size for supporting the input shaft. (See Figure HGA-19). With a few light impacts on a .120 diameter pin punch, drive needle roller (17) approximately 1/32 below the input shaft (16) O.D. (See Figure HGA-12).

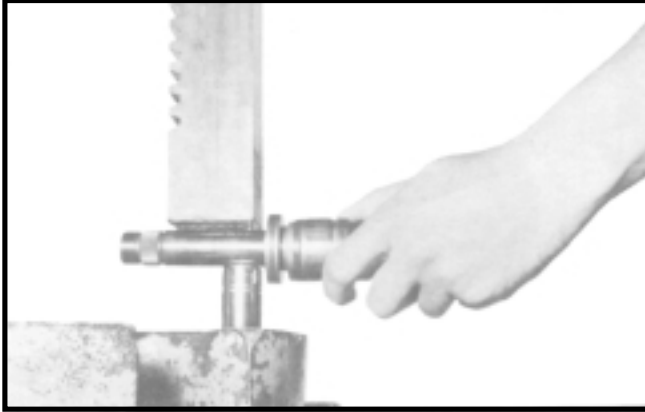


Figure HGA-19

15. Assemble spacer (15) over valve spool (22), against spring washer (14). If so constructed, the inside lip end of spacer must be toward the spring washer. Place assembly, spool end first, into housing (25). **Caution: Avoid applying side forces to the spool which would cause binding of the closely fitted assembly.**

**Note: If neither the input shaft (16) or upper cover (7) are replaced, the original shims (9) may be reused. However, if in the inspection of parts, damage is found to the shims, discard these shims and replace with new parts of equal thickness.**

- 16a. Place shims on top of the thrust washer (11). Coat seal (8) with clean grease and place in upper cover (7) counterbore. Assemble upper cover onto input shaft (16) and rotate to align punch marks previously made during disassembly. **Note: If a new upper cover is used no angular orientation is required. However, it is necessary to align the upper cover (7) and housing (25).** Replace with screws, finger tight, and then use a pilot ring or a worm drive type hose clamp tightened around the upper cover flange and the body pilot diameter to achieve the required alignment. Now tighten screws to 18-22 ft. lbs. torque. (See Figure HGA-20).

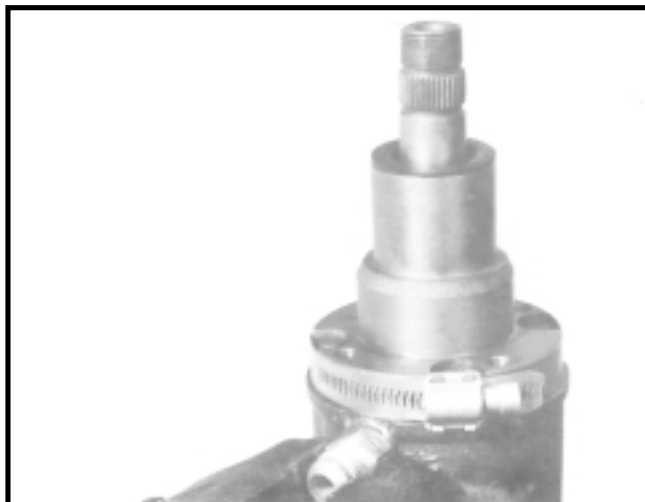


Figure HGA-20

**NOTE: If any of the input shaft (16), housing and spool, torsion bar or upper cover (7) have been replaced, the following procedure for checking and shim adjustment must be used.**

- 16b. Re-assemble as in "a" above using the required new parts. After torquing the four screws (6) revolve unit in vise so that the input shaft is pointing downward. In order to determine that the unit is shimmed correctly, the drive link (30) must be in its proper position. To do this, grasp the input shaft (16), pull downward, and prevent rotation. Engage drive link splines in spool (22) and rotate to position spool essentially flush with end of housing (25). Remove drive link and orient drive link slot to engage torsion bar needle roller (21) and insert drive link. Observe relationship of spool end to body. The valve spool must protrude  $.020 \pm .0025$  from the adjacent counterbore surface. If within spec. no additional shimming required. If not within  $.0025$ , add or remove shims (9) until this requirement is satisfied repeating assembling steps as outlined in "a" above. (See Figure HGA-21).

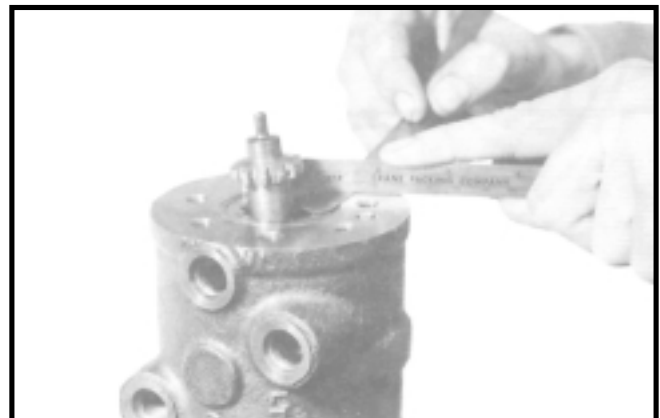


Figure HGA-21

- 16c. The correct shimming must be checked on the vehicle or on a suitable hydraulic test stand. The amount of steering effort required to steer the vehicle when the vehicle is at rest on dry pavement must be equal within three inch pounds. For example: if twenty-one inch pounds is required to steer to the right, not less than eighteen or more than twenty-four inch pounds should be required to steer to the left.

If a test stand is available to place a load between cylinder ports in the same manner as on the vehicle, a test stand should be used. **Add shims to increase steering efforts in a left turn, subtract shims to increase steering effort in a right turn.**

17. With the drive link (30) installed as described above, assemble two assembly posts into the housing (25) as shown in Figure HGA-22. These assembly posts can be made by simply cutting the heads off of two bolts similar to the special bolts (39).



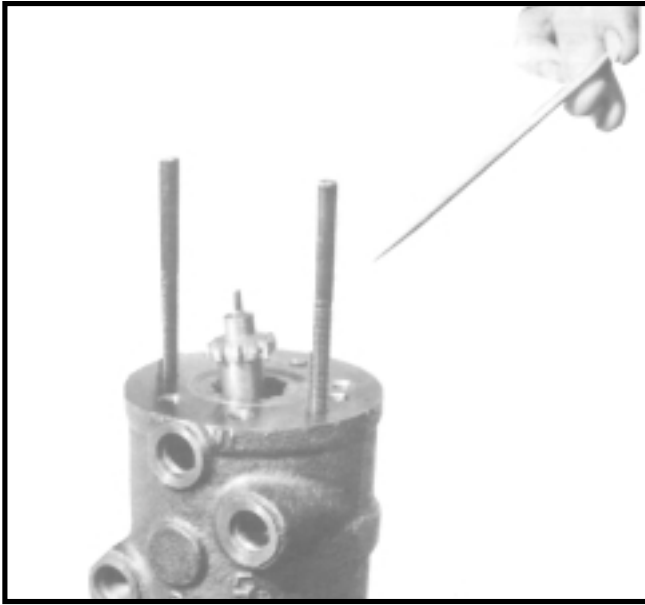


Figure HGA-22

18. Assemble spacer plate (29) over assembly posts and onto housing (25) with plain side up. (See Figure HGA-23).



Figure HGA-24

20. Install manifold (32) over assembly posts and onto rotor set (31), make sure circular slot side of manifold is up. (See Figure HGA-25).

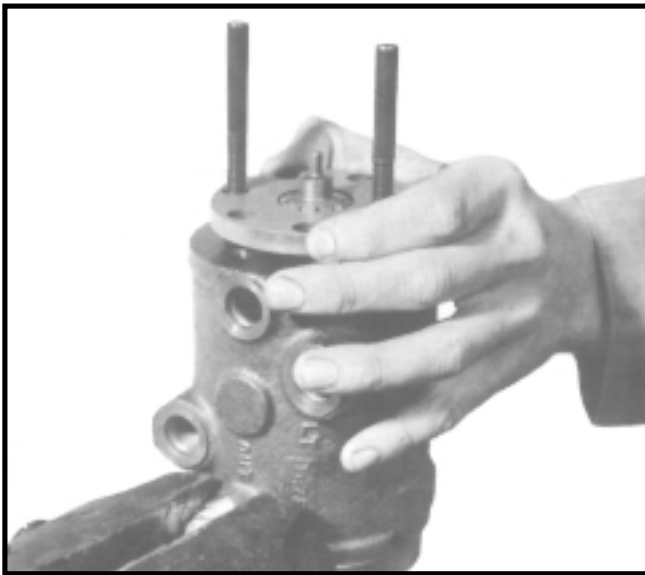


Figure HGA-23

19. Install rotor set (31) over assembly posts and onto spacer plate (29). **Note: One of the seven holes in the rotor set may be smaller than the other six holes. Position this hole, if applicable, over one of the assembly posts. (See Figure HGA-24). Warning: All vane springs (31C) must be down in their slots with no part of spring protruding out either side of metering element.**

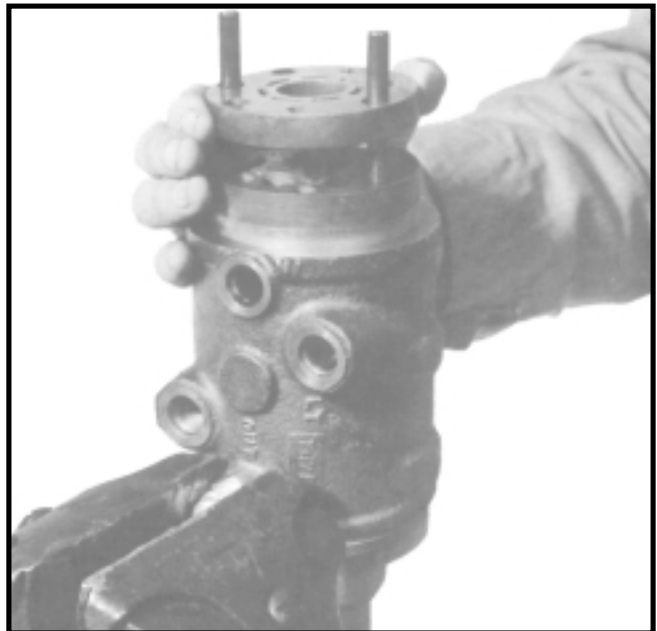


Figure HGA-25

21. Install commutator ring (33) over assembly posts and onto manifold (32), make sure slot side is down. (See Figure HGA-26).

22. Install rotor seal (36) and seal retainer (35) over rotor set (31) and down against housing.

23. To allow for washer (37) assemble commutator (34) with counterbore up into commutator ring (33) with slotted hole in commutator engaging nose of drive link (30). Align commutator outside diameter concentric with inside diameter of commutator ring. (See Figure HGA-27).

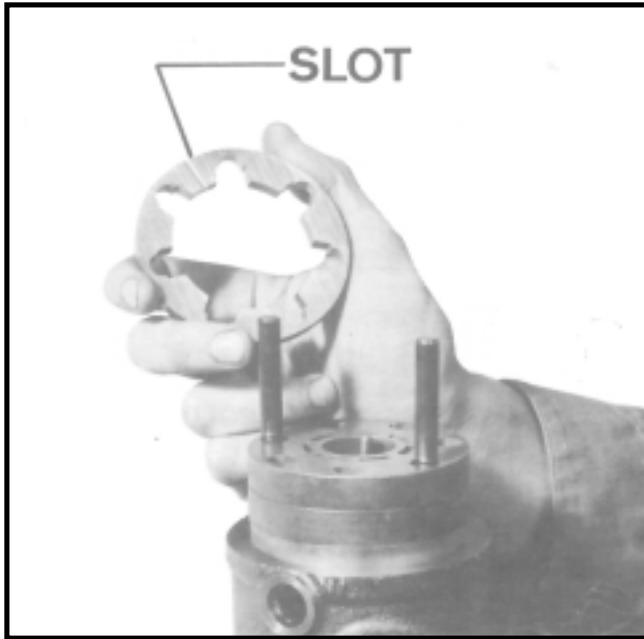


Figure HGA-26

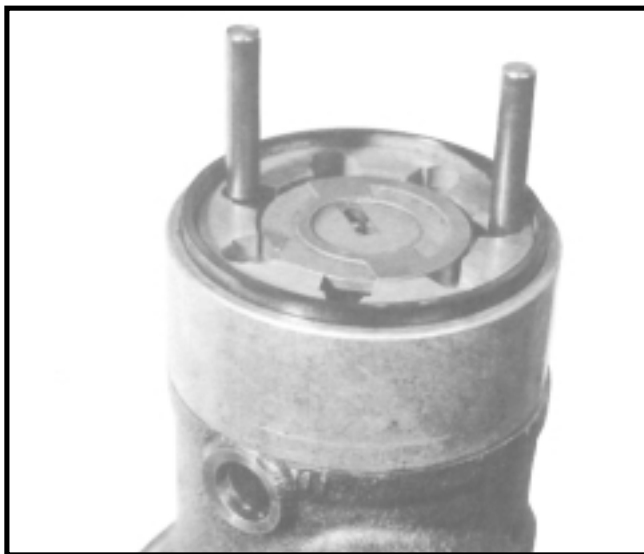


Figure HGA-27

24. Apply a small amount of clean grease to washer (37) and install over pin in end cover assembly (38). Grease should hold washer (37) to end cover assembly.
25. Assemble end cover assembly (38) with washer (37) attached over assembly posts and onto HGA unit.
26. Install five of the special bolts (39) finger tight. Remove two assembly posts and assemble the other two special bolts per steps 1 and 2 as follows, and do not over torque as it will cause unreparable damage:
  1. Torque all seven special bolts to 2-3 ft. lbs in sequence as shown in Figure HGA-28.

2. Torque all seven special bolts to 15-19 ft. lbs. in sequence as shown in Figure HGA-28.
 

**Note: Rotate input shaft during step 2 to prevent binding.**

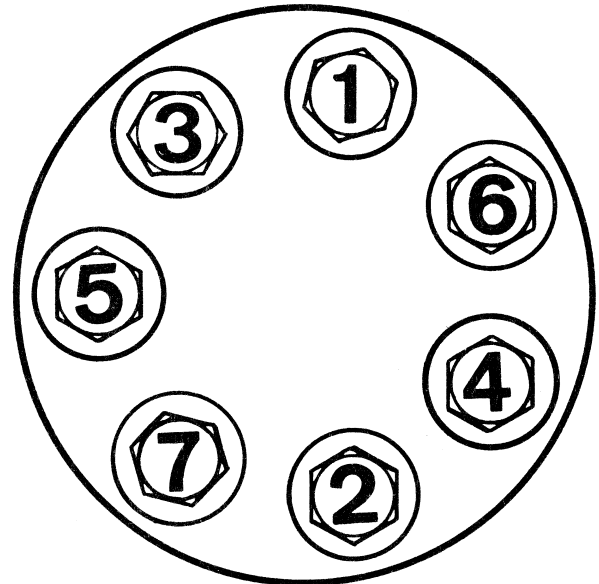
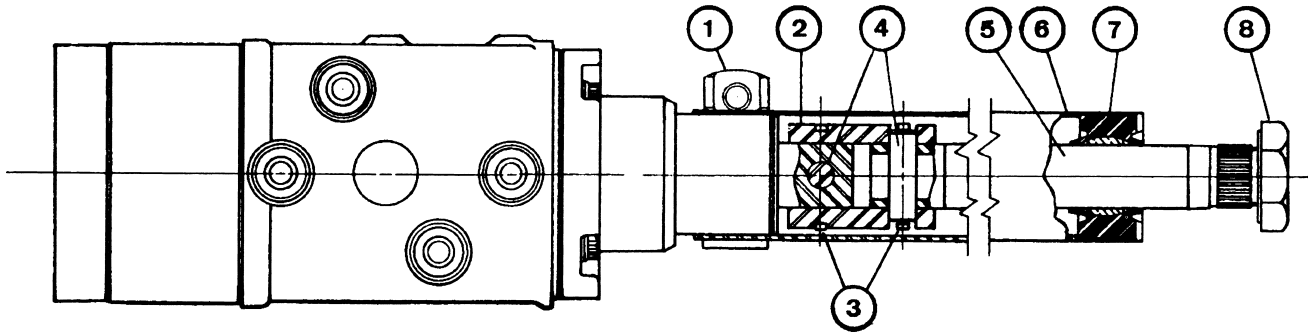


Figure HGA-28

27. Relocate HGA unit in a vise with the input shaft up. Cover end of input shaft with cellophane tape, to protect new seal (5) when it is assembled over sharp edges of input shaft.
28. Lubricate and install new seal (5) with lip side first onto input shaft.
29. Assemble new washer (4), with small end first, onto input shaft and push new washer and new seal down into upper cover (7). (A short piece of metal tubing, 15/16" minimum I.D. x 1-3/16" maximum O.D. or a 7/8" deep well socket may be used to push these parts into place.)
30. Assemble retaining ring (3) into upper cover (7) groove. Be sure rounded edge of retaining ring is faced inward.
31. Assemble new dirt seal (2) into upper cover (7) counterbore.
32. Note: If the HGA unit is to be stored, plug the cylinder ports and fill the inlet port with clean oil. Rotate input shaft until oil appears at outlet port.
33. Plug the port holes to prevent entrance of dirt. This completes assembly of the HGA unit.



1.	475109A1	Jacket Tube Clamp	6.	096245	Jacket Tube (Chart)
2.	403813	Coupling	7.	063980	Bushing
3.	401362	Retaining Ring (Spring)	8.	026045	Wheel Nut
4.	040050	Dowel Pin	6. & 7.	096245A1	Jacket Tube
5.	089142	Input Shaft			

## TO DISASSEMBLE COLUMN

1. Remove steering wheel and wheel nut (8).
2. Loosen clamp assembly (1) on upper cover of HGA unit. If the system has a column support clamp, this clamp should be loosened at this time.
3. If there is a horn contact assembly on the column, remove the 4 small screws from the metal cover (if applicable), and remove the metal cover and gasket. Remove the 2 small screws from the horn contact assembly.
4. Pull the jacket tube (6) and bearing assembly (7) off of the wheel tube (5).
5. Remove the retaining springs (3) and discard.
6. Lightly tap out the pins (4) with brass rods and hammer. Do not hit the pins with heavy hammer blows, as this may damage the HGA unit.
7. Remove the wheel tube (5).
8. Remove the coupling (2).
9. Remove the clamp assembly (1).

## TO ASSEMBLE COLUMN

1. Assemble the clamp assembly (1) onto the HGA unit. (Do not tighten.)
2. Assemble the coupling (2) and align pin hole.
3. Assemble one of the pins (4) and one of the new retaining rings (3).
4. Assemble the wheel tube (5) and align pin hole.
5. Assemble the other pin (4) and retaining ring (3).
6. Apply a small amount of clean grease to the inside of bearing assembly (7).
7. Assemble the jacket tube (6) and bearing assembly (7) over the wheel tube, through the clamp assembly (1) and onto the HGA unit upper cover.
8. Tighten the clamp assembly (1) bolt to 15-20 ft. lbs.
9. Assemble the steering wheel and tighten the wheel nut to 32.5 - 37.5 ft. lbs.
10. If the system has a column support clamp, it is extremely important that the jacket tube (6) align with this clamp in the free state. If misalignment is evident, the HGA unit must be shimmed at the mounting surface to eliminate the misalignment, or damage may result to the HGA unit.
11. If applicable, assemble the horn contact assembly, cover gasket and metal cover on the jacket tube (6).

## FILLING AND AIR BLEEDING THE SYSTEM WHEN DRAINED OF OIL

1. Fill reservoir nearly full. Be ready to add oil when the engine is started. Do not let oil level drop below the inlet to the power pump so that the power pump will not suck air into the system.
2. Start engine and let it idle. Immediately add oil to the reservoir as needed.

**NOTE: This oil will now be circulating only from the power pump to and through part of the HGA control valve and to the reservoir and back to the power pump.**

When no more oil can be added and oil is clear, proceed as follows.

3. With one finger on a spoke of the steering wheel, spin wheel as rapidly as possible to bleed the air in the steering cylinder(s) and lines.
4. Immediately upon HGA valve spool actuation oil must be added to the reservoir — to replenish the oil moving into the circuit.
5. Keep rotating the steering wheel to keep the HGA valve spool actuated. Do this until the road wheels have reached the stop in that direction, then quickly reverse the steering wheel rotation to actuate the HGA valve spool in the opposite direction.
6. Keep rotating the steering wheel left and right from stop to stop of the road wheels to bleed out air. Replenish oil as necessary.
7. The air will bleed out only at the reservoir, therefore, the oil must be circulated in both directions repeatedly until the air has bled out.

**NOTE: The oil in the lines to the power cylinder reaches a “dead end” at the piston. The oil in the cylinder does not flow in a circuit. As the piston moves back and forth the oil moves back and forth in the lines. Therefore, air in these lines and the cylinder may be slow moving into the HGA control valve and to the reservoir.**

**CAUTION: Do not operate vehicle until air is bled out.**

8. When the oil in the reservoir is clear (not cloudy or creamy), the system is free of air. (Slight creep or drift of the steering wheel is normal.)
9. Adjust the oil to recommended level in reservoir and assemble reservoir cover.
10. Always fill reservoir to recommended level.

## HYDRAULIC FLUID

Keep the steering system filled with one of the following:

- Automatic Transmission Fluid Type “F”
- Automatic Transmission Fluid Dexron II
- Hydraulic fluid as recommended by the vehicle manufacturer.

**WARNING: DO NOT MIX OIL TYPES, ANY MIXTURE, OR AN UNAPPROVED OIL, COULD DETERIORATE THE SEALS. ENOUGH FLUID COULD THEN LEAK TO CREATE A LOSS OF POWER STEERING ASSIST. DO NOT ALLOW FLUID LEVEL TO GO BELOW FILL LINE ON DIPSTICK. BEFORE ADDING NEW FLUID, COMPLETELY DRAIN OLD OIL FROM THE SYSTEM. IT MAY BE NECESSARY ALSO THAT YOU FLUSH THE SYSTEM WITH CLEAN OIL.**



**TIPS FOR MAINTAINING THE HYDROSTATIC STEERING SYSTEM**

- Top off fluid level in reservoir as necessary.
- Maintain correctly inflated tires.
- Always use a puller to remove the steering wheel. Do not use a hammer, torch, or crow bar.
- Investigate and correct immediately any play, rattle, shimmy, or other unusual occurrence in the steering system.
- Remove cause of steering column misalignment.
- Encourage all drivers or operators to report any malfunction or accident that may have damaged a steering system part.
- Do not attempt to weld any broken steering component. Replace the component with original equipment only.
- Do not cold straighten, hot straighten, or bend any steering part.
- Prevent dirt or other foreign matter from entering the hydraulic system. Clean off around filler caps before checking oil level.
- Investigate and correct any external leak in the steering system, no matter how minor the leak.
- Comply with manufacturer's specifications for cleaning or replacing the filter.

**WARNINGS for Proper Steering System Operation**

**WARNING: DO NOT WELD, BRAZE, OR SOLDER ANY STEERING SYSTEM COMPONENT.**

**WARNING: MAXIMUM OPERATING PRESSURE MUST NOT EXCEED VEHICLE MANUFACTURER'S RECOMMENDED PUMP PRESSURE CAPACITY.**

**WARNING: ALWAYS CAREFULLY INSPECT ANY STEERING SYSTEM COMPONENT THAT MAY HAVE BEEN STRUCK OR DAMAGED DURING OPERATION OR IN AN ACCIDENT. REPLACE ANY COMPONENT THAT IS DAMAGED OR THAT IS QUESTIONABLE.**

**Parker extends close technical cooperation and assistance. If steering problems occur which you cannot solve, please contact our Parker Field Service Department. Our phone number and address are on the back cover of this manual.**

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## Offer of Sale

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**2. Payment:** Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Amounts not timely paid shall bear interest at the maximum rate permitted by law for each month or portion thereof that the Buyer is late in making payment. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer's receipt of the shipment.

**3. Delivery:** Unless otherwise provided on the face hereof, delivery shall be made F.O.B. Seller's plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller's delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

**4. Warranty:** Seller warrants that the items sold hereunder shall be free from defects in material or workmanship for a period of 18 months from date of shipment from Parker Hannifin Corporation. **THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO ITEMS PROVIDED HEREUNDER. SELLER MAKES NO OTHER WARRANTY, GUARANTEE, OR REPRESENTATION OF ANY KIND WHATSOEVER. ALL OTHER WARRANTIES, INCLUDING BUT NOT LIMITED TO, MERCHANTABILITY AND FITNESS FOR PURPOSE, WHETHER EXPRESS, IMPLIED, OR ARISING BY OPERATION OF LAW, TRADE USAGE, OR COURSE OF DEALING ARE HEREBY DISCLAIMED. NOTWITHSTANDING THE FOREGOING, THERE ARE NO WARRANTIES WHATSOEVER ON ITEMS BUILT OR ACQUIRED WHOLLY OR PARTIALLY, TO BUYER'S DESIGNS OR SPECIFICATIONS.**

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**6. Changes, Reschedules and Cancellations:** Buyer may request to modify the designs or specifications for the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order, however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification or cancellation shall be at Seller's discretion, and shall be upon such terms and conditions as Seller may require.

**7. Special Tooling:** A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstand-

ing any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

**8. Buyer's Property:** Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property, Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

**9. Taxes:** Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the items sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

**10. Indemnity For Infringement of Intellectual Property Rights:** Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Part 10. Seller will defend and indemnify Buyer against allegations of infringement of U.S. Patents, U.S. Trademarks, copyrights, trade dress and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it noninfringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.

If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret or any similar right.

**11. Force Majeure:** Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials and any other cause beyond Seller's control.

**12. Entire Agreement/Governing Law:** The terms and conditions set forth herein, together with any amendments, modifications and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder or this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

9/91-P



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