

**MICHIGAN**

**STEERING**

**GEAR**

**AND**

**VALVE**

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## STEERING GEAR AND VALVE ASSEMBLY

The steering gear is a recirculating ball type steering gear. The steering valve is an open center, open port, manually controlled valve.

Movement of the steering wheel causes the spool to move up or down. The spool movement meters hydraulic oil flow to and from the steering cylinders. The pitman arm is attached to the front frame of the machine to give the "feel" of steering.

When the steering wheel is turned to the right, the spool shifts, directing hydraulic oil from the pump to the rod side of the right hand steer cylinder and to the base side of the left hand steer cylinder. Hydraulic oil from the rod side of the left hand steer cylinder and the base side of the right hand cylinder flows through the steering valve and to the tank.

In the neutral position, hydraulic oil flows from the pumps, through the center of the valve and back to the tank. The work ports (which are connected to the work ports of the steer cylinders) are also open to the tank.

## ADJUST STEERING GEAR

Put the machine in the service position.

The steering gear assembly consists of a manual gear of the recirculating ball type with a hydraulic control valve mounted at the base.

The manual gear requires two adjustments to maintain proper operation: (1) worm bearing adjustment, (2) overcenter or pitman shaft adjustment. The worm bearing adjustment is performed only at the time the control valve is assembled to the gear. The adjusting nut is securely staked in place and does not require further attention.

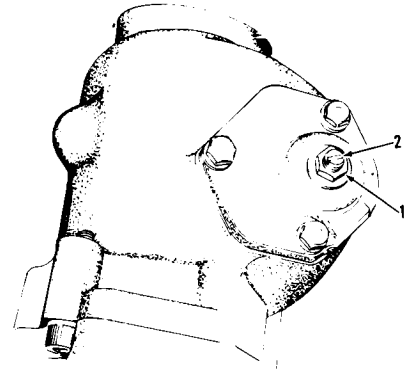
Check the overcenter or pitman shaft adjustment when the steering gear has been in operation for 1000 hours. The adjustment will not need to be checked again. Check the adjustment as follows with the engine off.

1. Disconnect the steering drag link from the pitman arm.
2. Turn the steering wheel from one stop all the way to the other stop, counting the total number of turns. Then turn the steering wheel back exactly half way to the center position. Mark the top center of the steering wheel with a piece of tape.

**Note:** The steering wheel must be kept in the center position during adjustment.

3. Move the pitman arm toward the front and toward the rear of the machine.

**Note:** If too much force is used to move the pitman arm, the valve spool and worm shaft will move in the valve. Move the arm carefully so only the movement between the ball nut and the pitman shaft gear is shown.

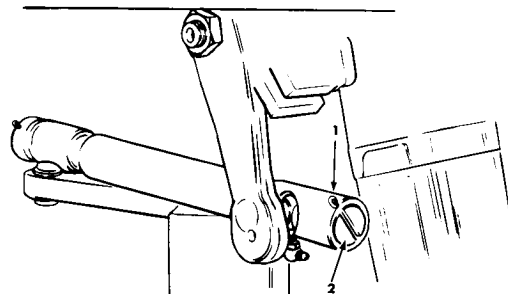


TS-11088

1. Locknut      2. Adjusting Screw

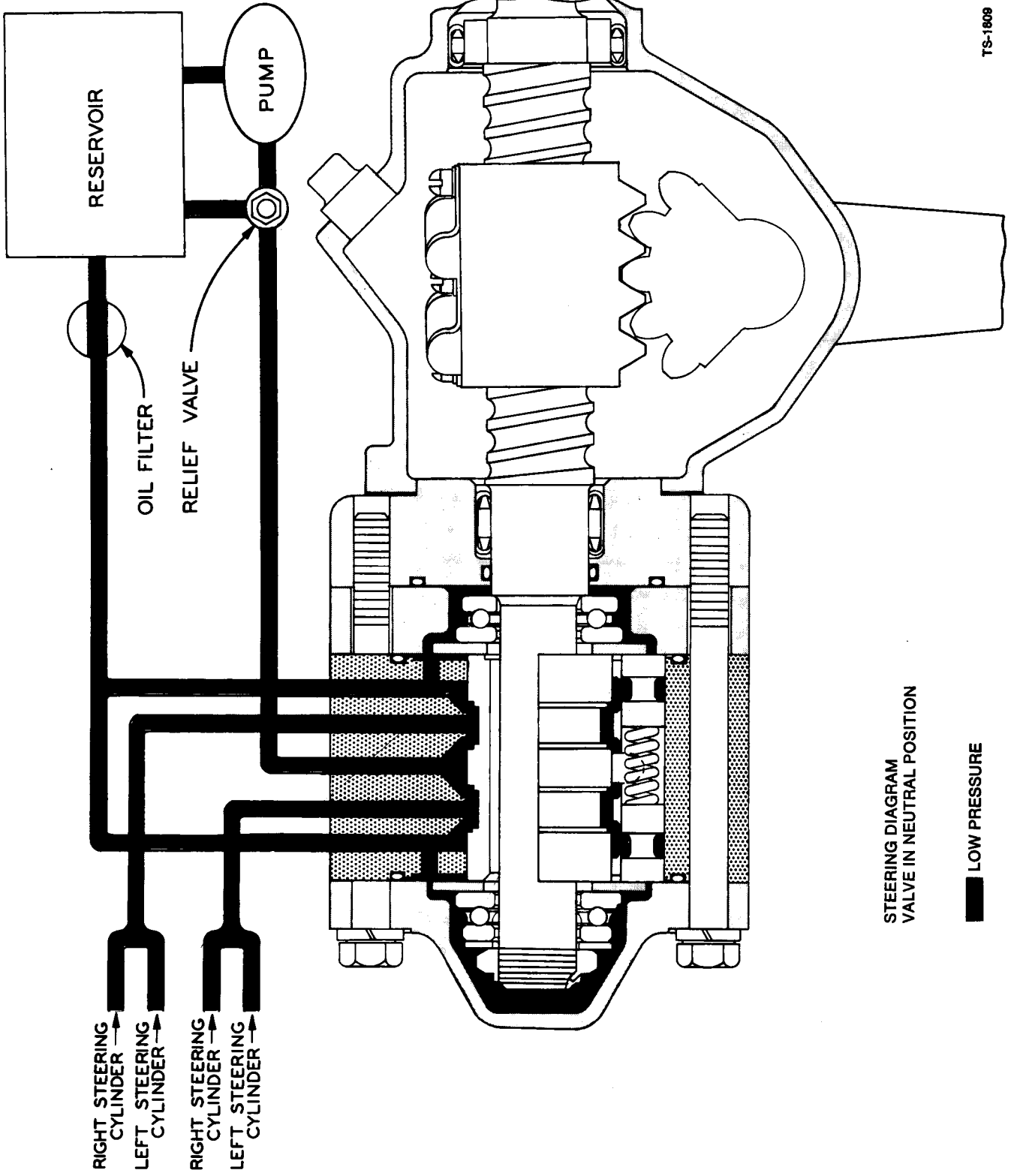
4. If there is any movement between the ball nut and the pinion shaft gear, loosen the locknut (1). Turn the adjustment screw (2) in until there is no movement between the ball nut and the pinion shaft gear. Hold the adjusting screw (2) in that position and tighten the locknut (1).
5. Turn the steering shaft through the center of travel: From 90° right of center to 90° left of center. The steering shaft must not become difficult to turn through the center of travel.
6. Connect the drag link to the pitman arm.
7. Adjust the drag link ball joints.

## ADJUST DRAG LINK BALL JOINTS

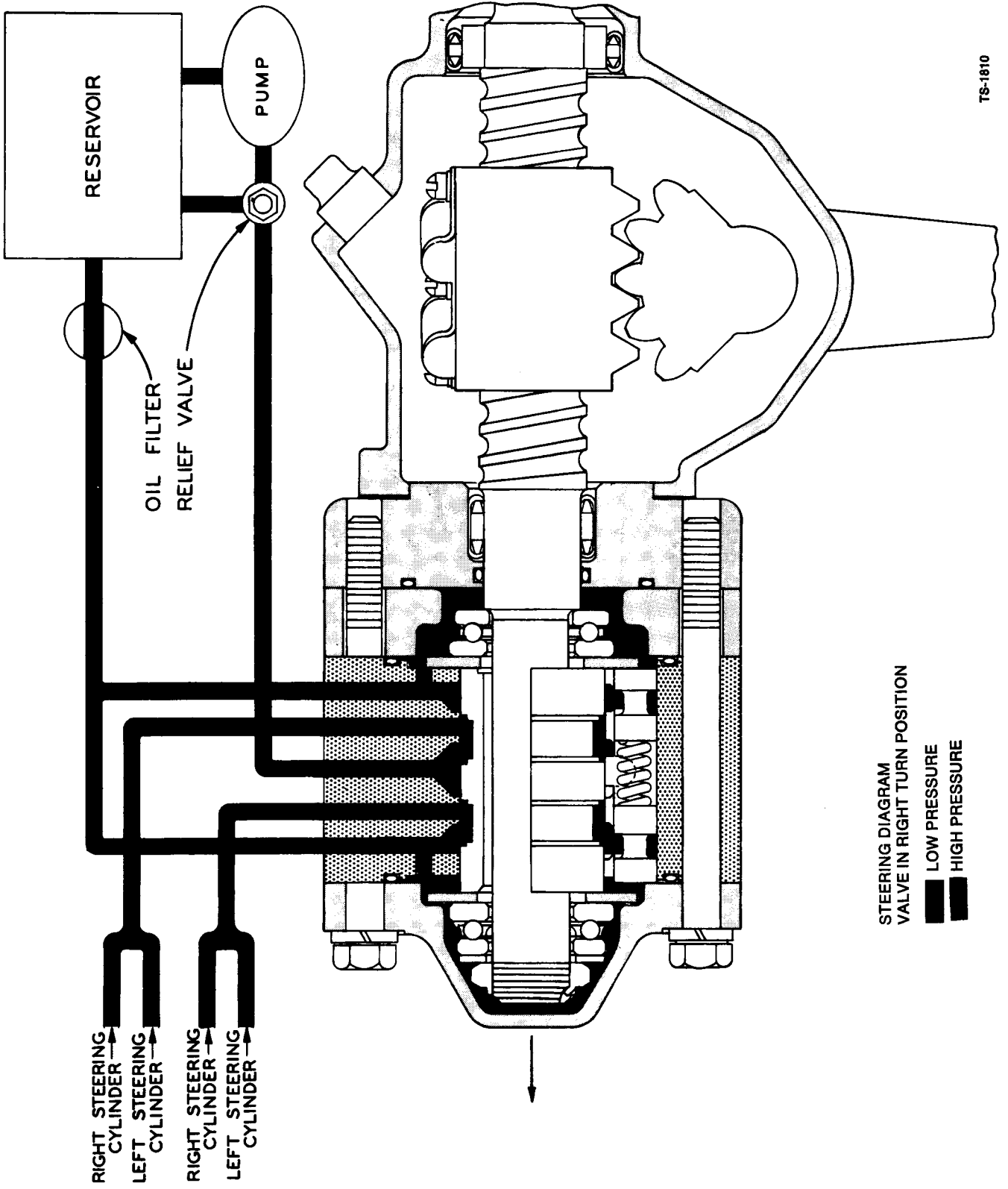


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Remove the cotter pins (item 1) from both ends of the steering drag link. Turn the screws (item 2) in until all clearance is removed. Turn the screws out until the cotter pins can be installed. Install new cotter pins.

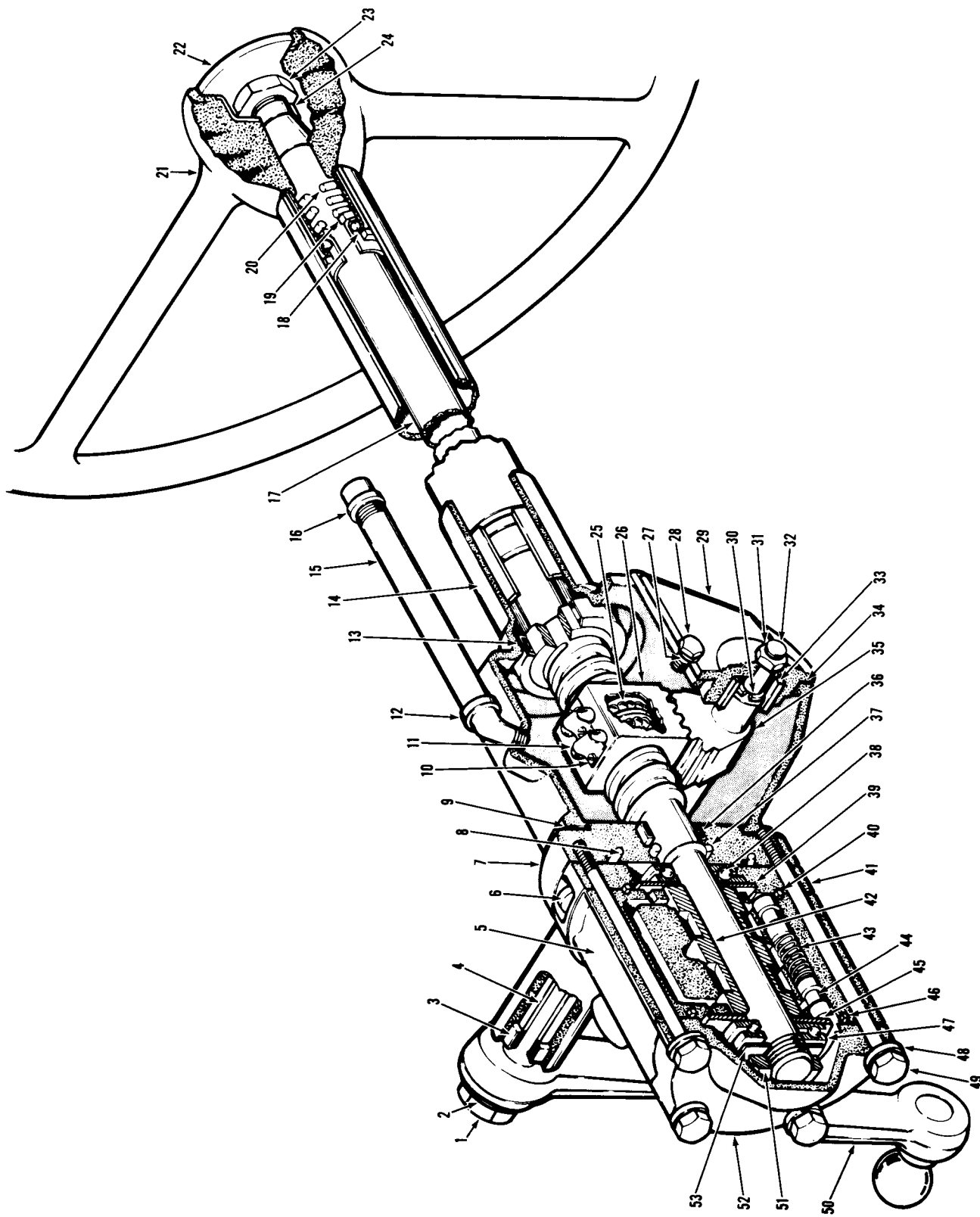


TS-1809



STEERING DIAGRAM  
VALVE IN RIGHT TURN POSITION

LOW PRESSURE  
 HIGH PRESSURE



TS-11009

## STEERING GEAR AND VALVE PARTS IDENTIFICATION

No.	Qty.	Description	No.	Qty.	Description
1	1	Nut	27	3	Lockwasher
2	1	Lockwasher	28	3	Bolt
3	1	Seal	29	1	Cover
4	1	Bushing	30	1	Shim kit
5	1	Valve body	31	1	Nut
6	4	Bolt	32	1	Adjusting screw
6A†	4	Lockwasher	33	1	Bushing
7	1	Adapter	34	1	Gasket
8	1	O-ring	35	1	Pitman shaft
9	1	Gasket	36	1	Bearing
10	3	Screw	37	1	Seal
11	1	Clamp	38	1	Bearing
12	—	Omit	39	1	Washer
13	1	Bearing	40	1	O-ring
14	1	Housing	41	1	Spacer
15	1	Nipple	42	1	Spool
16	1	Cap	43	4	Spring
17	1	Shaft	44	8	Plunger
18	1	Bearing	45	1	Washer
19	1	Washer	46	1	O-ring
20	1	Spring	47	1	Bearing
21	1	Steering wheel	48	6	Lockwasher
22	1	Nameplate	49	6	Bolt
23	1	Nut	50	1	Pitman arm
24	1	Key	51	1	Locknut
25	106	Ball	52	1	Cover
25A†	4	Guide	53	1	Spring
26	1	Nut			

†Not illustrated

## STEERING GEAR AND VALVE OVERHAUL

In most cases, complete disassembly of the steering gear will not be necessary. It is suggested that only those sub-assemblies which are faulty be disassembled. Disassembly and assembly procedures must be performed on a clean workbench. As in repairing any hydraulically operated unit, cleanliness is of the utmost importance; therefore, the bench, tools, and parts must be kept clean at all times. Thoroughly clean the exterior of steering gear with a suitable solvent, and when necessary, drain as much of the hydraulic fluid as possible from the unit. Overhaul as follows:

### REMOVAL OF THE VALVE

**Note:** See TS-11009.

1. Mount the steering gear in a vise with the worm shaft horizontal to prevent loss of springs and plungers.
2. Scribe a mark on the valve cover (52), valve body (5), spacer (41), adapter (7) and steering gear housing (14) to ensure the proper positioning of parts when steering gear is reassembled.
3. Remove six bolts (49) and lockwashers (48), that secure the valve cover to valve body. Remove valve cover.
4. The control valve worm bearing adjuster nut (51) is staked in a groove provided in the worm shaft. Cut out the staked area being careful not to damage threads on the worm shaft. Remove and discard the nut (51).
5. Remove valve spool preload spring (53) from worm shaft.
6. Remove the lower bearing assembly (47). Keep the parts together as an assembly so that the same three pieces will be installed together on reassembly of steering gear.
7. Remove the valve body (5), spool (42), plungers (44), and centering springs (43) as an assembly, being careful not to drop any parts. Place valve on a clean piece of paper to protect parts from foreign material.
8. Remove the bearing assembly (38). Keep the parts together as an assembly so same three parts will be used together on reassembly.
9. Remove the spacer (41).
10. Remove the four bolts (6) and lockwashers (6A) that secure the adapter (7) to steering gear housing. Remove adapter from worm shaft.

### DISASSEMBLY OF THE VALVE

**Note:** See TS-11009.

1. Remove valve centering plungers (44) and springs (43) from their bores in valve body (5).
2. Remove valve spool (42) from valve body (5), noting which end of the spool has a groove or counterbore on the I.D. so parts can be assembled properly.

### CLEANING AND INSPECTION

**Note:** See TS-11009.

1. Clean all parts thoroughly in cleaning solvent. Blow parts dry with air.
2. Inspect spool (42) and valve body (5) for signs of damage or wear. If these parts are damaged or worn, valve body and spool must be replaced as an assembly.
3. Inspect the centering springs (43) for wear, cracks, or breaks. Replace if necessary.
4. Inspect valve centering plungers (44) for nicks or scratches. Replace if damaged.
5. Inspect thrust bearings (38 and 47) for smooth turning. Replace if turning is rough or parts are damaged.

### ASSEMBLY OF THE VALVE

**Note:** See TS-11009.

1. Coat valve centering plungers (44), and valve spool (42) with grease containing zinc oxide.
2. Install valve spool (42) in valve body (5) with the groove or counter-bore at same end in relation to the valve body as was noted upon removal. **DO NOT FORCE THE SPOOL INTO VALVE BODY.** When spool is properly aligned it will drop into place. Forcing the spool will damage both spool and the valve bore.
3. Install valve centering springs (43) into their bores in the valve body (5).
4. Install a plunger (44) at each end of the centering springs.



## END COVER AND ADAPTER REPAIR

**Note:** See TS-11009.

1. Remove gasket (9), o-ring seals (8, 40 and 46) and seal (37). Install new sealing parts.
2. Check the needle bearing (36) in adapter (7). The rollers should be smooth, polished, and free to turn in their retainer. If bearing is worn, remove and replace with a new part. Press the new bearing in place with trademark side out. Bearing should be pressed in below the adapter face BUT NOT BOTTOMED IN ADAPTER BORE.

## STEERING GEAR

Steering gear parts should be kept free from dirt or other foreign matter during overhaul procedures. When handling parts, make certain that clean cloths are used. Prelubricate all bearings, oil seals, and moving parts at assembly with proper lubricants.

## DISASSEMBLY OF THE STEERING GEAR

**Note:** See TS-11009.

1. Remove the screws and plate (22). Remove the steering wheel mounting nut (23), steering wheel (21), key (24), spring (20) and washer (19).
2. Mount the steering gear assembly in a vise or holding fixture with worm shaft in horizontal position to keep the ball nut from running down to end of worm shaft.
3. Remove nut (1), lockwasher (2) and pitman arm (50).
4. Remove lock nut (31) from preload adjuster screw (32).
5. Remove side cover to housing attaching bolts (28) and lock washers (27). Remove side cover (29) by turning the preload adjuster screw (32) clockwise through side cover. Remove and discard side cover gasket (34).
6. Make sure worm shaft (17) is horizontal and turn shaft as necessary to position sector gear on pitman shaft (35) so it will pass through housing opening. Remove pitman shaft from gear housing.

7. Carefully withdraw steering shaft and ball nut as an assembly (10, 11, 17, 25, 25A and 26) from gear housing and column (14).

**IMPORTANT:** If the shaft with the ball nut is held in a vertical position, the ball nut will travel by its own weight to the end of the shaft. If the ball nut sharply strikes end of the worm, ball guides will be damaged. If worm ball nut does not require disassembly, tape lower end of wormshaft.

8. Try action of ball nut (26) on wormshaft (17). Ball nut must rotate smoothly with no evidence of binding or roughness. If there is evidence of roughness or damage, disassemble in the following manner:
  - a. Remove screws (10) which attach ball guide clamp (11) to ball nut (26). Remove clamp. Pull ball guides (25A) out of ball nut, one pair at a time. Remove balls (25) from guides by separating guides.
  - b. Turn ball nut (26) upside down, and rotate shaft (17) back and forth until all balls (25) have dropped out of ball nut into a clean pan. With the balls removed, pull ball nut end-wise from worm shaft.
9. Remove and discard pitman shaft seal (3). A new seal should be used when steering gear is reassembled.
10. Removal of steering jacket upper bearing assembly (18), and replacement of housing bearings (13) should be deferred until inspection of parts indicates necessity for removal.

## CLEANING AND INSPECTION

**Note:** See TS-11009.

1. Clean all parts thoroughly in suitable cleaning solvent and wipe or blow parts dry prior to inspection, repair, and assembly of the steering gear.
2. Inspect steering gear housing (14) for cracks, distortion, and condition of threads in tapped holes. Replace housing if damaged.
3. Check side cover (29) for cracks or other damage.
4. Inspect pitman shaft (35) for damaged serrations and threads. Examine sector gear teeth for scuffing or scoring. Check outside diameter of shaft at hous-

ing and side cover ends. If excessive wear is evident, replace shaft.

5. Thoroughly inspect the steering worm (17) for scoring, bending and wear.
6. Examine ball nut (26) for scuffing, scoring or wear on rack teeth and on ball thread groove. Check all holes and passages for obstructions. Check worm ball for flat spots, wear, or damage.
7. Inspect ball return guides (25A) for distortion or damage. Place two halves of a guide together and try action of balls in guide. Replace guides if any restriction exists. Check return guide clamp (11).
8. Check end cover (52) for cracks or damage to tapped holes.
9. Check condition of upper needle bearing (13) in housing. If rollers are damaged or worn, replace bearing assembly. If inner race is damaged or worn, press it off the worm shaft (17) and replace. When installing new bearings, make sure trade-mark side of retainer is against the installer tool.
10. Check condition of hose connection parts. Replace if not in first-class condition.

## ASSEMBLY OF THE STEERING GEAR

**Note:** See TS-11009.

1. Place steering worm shaft assembly (17) flat on bench.
2. Install ball nut (26) over worm shaft (17) with ball return guide holes in ball nut up. Align grooves in worm and ball nut by sighting through bottom of ball return guide holes.
3. Divide the 106 balls (25) into two clean containers. Each container should then contain 53 balls for one circuit.
4. Drop balls (25) into one of the return guide holes in the upper circuit of nut (26). Gradually turn shaft (17) away from that hole while inserting balls. Continue until the circuit is filled from bottom of one hole to bottom of the other, or until stopped by reaching end of the shaft worm.
5. In event balls are stopped by reaching end of worm shaft, hold down balls already installed with a rod or punch in return guide hole. Turn shaft in the reverse direction a few turns. Filing of the circuit can then be continued. It may be necessary to work shaft back and forth, holding balls down, first in one hole and then in the other. This will close up spaces between balls, filling the circuit completely.
6. Lay one-half of the ball guide (25A) on bench with groove up. Place the remaining balls (25) for the first circuit into groove of the guide. Close this half of ball guide with other half. Hold the two halves together and plug each open end with heavy grease to prevent balls from dropping out.
7. Push ball return guides (25A) with balls (25), completely into return holes in ball nut (26). Tap guide lightly with screwdriver handle or small plastic hammer to seat if necessary. This completes one circuit of balls.
8. Fill lower ball circuit in ball nut (26) in same manner as described for upper ball circuit.
9. Install ball return guide clamp (11) on ball nut (26), using the three screw and lock washer assemblies (10). Tighten screws securely.
10. Thoroughly lubricate ball nut (26) and balls (25); then test assembly by rotating ball nut (26) on worm shaft (17). Do not rotate ball nut to lower end of worm threads as this may damage ball guides (25A). If motion of ball nut is not free, cause of bind must be located and trouble corrected. Bent ball guides (25A) may restrict ball circuit travel.
11. Temporarily tape worm shaft (17) at lower end of ball nut (26) to keep nut from running down, then until ready to install in gear housing, lay the assembly flat on workbench.
12. Remove tape. Grip worm (17) below and above the ball nut (26) to prevent nut from running to extreme ends of shaft. Insert steering shaft assembly through

lower opening in gear housing (14) guiding shaft carefully through the upper column bearing (18).

13. Install the adapter (7) and a new gasket (9). Make sure the alignment marks are aligned. Install the attaching bolts (6) and lockwashers (6A). Tighten the bolts to a torque of 25-30 lbf·ft (33,9-40,7 N·m) (3,4-4,1 kgf·m). Install the spacer (41) and a new o-ring (8). Make sure the alignment marks are aligned.

14. Place worm thrust bearings (38 and 47) against each side of the control valve body (5) then install the assembly on worm shaft, with a new o-ring. Be sure to check the following **IMPORTANT** items:

- a. The thrust bearings (38 and 47) have small races away from valve faces.
- b. Scribed marks on valve body (5), spacer (41), adapter (7) and steering gear housing (14) are aligned.

**IMPORTANT:** The internal groove end of valve body should be positioned towards the top.

15. Install valve spool preload spring (53), on worm shaft (17).

16. Install a new worm bearing adjuster nut (51) finger tight.

17. Install valve clamping ring and valve end cover to adapter bolts (49) and lockwashers (48). Tighten bolts to 15-20 lbf·ft (20-27 N·m) (2,8-3,7 kgf·m) torque.

**NOTE:** Valve clamping ring can be fabricated from a valve cover (52) by cutting out the middle portion and leaving outer ring only.

18. Install the washer (19), spring (20), key (24) and steering wheel (21) on the shaft (17). Install the nut (23). Tighten the nut (23) to a torque of 35-40 lbf·ft (47,5-54,2 N·m) (4,8-55,5 kgf·m). Hold wheel on center and tighten adjuster nut (51) firmly to remove all end play of the valve spool (42).

19. Back off nut (51) and retighten lightly. Release steering wheel making sure nut exerts light pressure against spring loaded plungers (44).

20. Tighten nut (51) until a preload of 9-18 lbf·in (1-2 N·m) (0,1-0,2 kgf·m) is measured at the steering shaft. Stake nut (51) in place.

21. Remove valve clamping ring and position valve cover (52) with a new o-ring (46) with marks scribed previously in gear housing (14), spacer (41), adapter (7), valve body (5) and cover aligned on valve body.

22. Install attaching bolts (49), lockwashers (48) and tighten to 15-20 lbf·ft (20,3-27,1 N·m) (2,1-2,8 kgf·m) torque.

23. Position the preload adjuster (32), with shim (30), in the slotted end of the pitman shaft. Check the clearance between the adjuster head and bottom of the slot with a feeler gauge. The adjuster must be free to turn, but the clearance should not be greater than .002 in (0.05mm). If clearance is greater than .002 in (0.05mm), or if the adjuster is not free to turn, a preload adjuster shim unit is available. It contains four shims — .063" (1.60mm), .065" (1.65mm), .067" (1.70mm) and .069" (1.75 mm) thick. Install the correct shim on the adjuster. Install the adjuster.

24. Turn steering shaft (17) until ball nut (26) is in approximate center of worm shaft. Center tooth of pitman shaft (35) sector gear must enter center tooth space of ball nut rack.

25. Start side cover (29) over end of shaft (35). Insert screwdriver into hole in side cover to engage slot in screw (32). Turn adjuster counterclockwise until pitman shaft bottoms, then turn clockwise one-half turn.

26. With new side cover gasket (34) in place on side cover (29), insert pitman shaft (35) into housing (14), meshing center tooth of pitman shaft with center tooth space of ball nut (26).

27. Install side cover bolts (28) and lockwashers (27) and tighten to 30 lbf·ft (40,7 N·m) (4,1 kgf·m).

28. With gear on center, adjust pitman shaft preload adjusting screw (32) so that preload is 23-36 lbf·in (2,6-4,1 N·m) (0,27-0,41 kgf·m) through a 90 degree arc either side of center. Tighten lock nut (31). Total preload for all adjustments should be 30-36 lbf·in (3,4-4,1 N·m) (0,35-0,41 kgf·m) over center.

29. Install new pitman shaft grease seal (3).

30. Install the pitman arm (50). Install the pitman arm mounting lockwasher (2) and nut (1).

**NOTE:** Check the pitman shaft adjustment when the steering gear has been in operation for 1000 hours.

## STEERING SYSTEM TROUBLESHOOTING

The following is a step by step procedure for troubleshooting the steering system. The machine must be on a hard and flat surface. Make sure the steering gear mounting bolts are tight. Make sure the cockpit mounting bolts are tight. Make sure to check the hydraulic reservoir for the correct fluid level and the filters for plugged condition before proceeding with troubleshooting procedures.

### I. Poor steering at low engine R.P.M.:

A. Check steering system relief pressure. Install a pressure gauge and turn the machine into a full turn position against the steering stops. If specified relief pressure cannot be reached:

1. Check for relief valve leakage. Adjust the relief valve to see if the pressure can be increased. If the pressure does not change, remove the steering system relief valve. Inspect the relief valve for broken springs, scored or scratched poppets and seats.
2. Check the steering cylinders for leakage. Turn the machine to a full turn position, apply the parking brake and stop the engine. Disconnect the hydraulic hose from the rod port of the extended cylinder. Cap the hose ends in a manner that will hold pressure. Start the engine and turn the machine in the same direction against the steering stops. A large volume of fluid escaping from the cylinder port indicates cylinder leakage. Check each cylinder separately.
3. Check for worn pump. Install a flow meter in the line on the outlet side of the pump. Check the flow of fluid from the pump.
4. Check for leakage by the steer valve spool and housing. Disassemble the steering valve and inspect for scratches and abnormal wear.

B. Check steering system operating pressure. Turn the machine while observing the pressure gauge. If the system operating pressure is at or near system relief pressure:

1. Check for binding hinge pins.
2. Check for binding differentials.
3. Check for binding brakes.
4. Check for binding planetaries.

### II. Jerky and/or chatters when turning the machine:

A. Check for aeration or cavitation.



**Remove the hydraulic reservoir cap slowly. With the engine running, inspect for foaming fluid. Check all suction tube connections and suction filters.**

B. Check the center hinge for excessive wear.

C. Check the steering valve for broken centering springs and/or improper steering valve adjustment. Disassemble the steering valve and inspect the centering springs. Inspect the centering spring pistons and the spring bores for scratches and abnormal wear. Reassemble and adjust the steering valve.

### III. Machine will not turn:

A. Check the steering system relief pressure. If relief pressure is low:

1. Check the steering cylinders and the steering system relief valve for leakage:
  - a. Disconnect the hydraulic hose from the base port of the right steering cylinder. Disconnect the hydraulic hose from the rod port of the left steering cylinder. Cap the hose ends in manner that will hold system pressure. Block the machine from moving. Start the engine and turn the steering wheel to the right. A large volume of hydraulic fluid escaping from the open cylinder ports indicates cylinder leakage.
  - b. If a small volume of hydraulic fluid escapes through the open cylinder ports when performing the above check, adjust the relief valve to see if the pressure can be increased. If the pressure does not change, disassemble the steering system relief valve and inspect for broken springs, scored poppets and any abnormal wear.

2. Check the steering system pump for wear. Install a flow meter in the line on the outlet side of the pump. Check the flow of fluid from the pump.

B. If relief pressure is reached:

1. Check for locked axle differentials.
2. Check for binding brakes.
3. Check for binding planetaries.

**IV. Machine turns hard in one direction:**

- A. Check for binding worm gear.
- B. Check for binding spool in the steering valve.
- C. Check for binding steering cylinders. Check one cylinder at a time. Turn the machine to a full turn position. Remove the rod pin of the extended steering cylinder. Start the engine. Observe the steering cylinder while turning the steering wheel to retract and extend the cylinder. Chattering cylinder movement indicates a binding steering cylinder. Check each cylinder separately.

**V. Self steering:**

- A. Check the steering valve for binding valve spool.
- B. Check the steering valve for broken centering springs.
- C. Check for excessive back pressure. Install a pressure gauge and measure the steering system operating pressure. If operating pressure is near relief pressure, inspect all return hoses, connections, and the return filters.