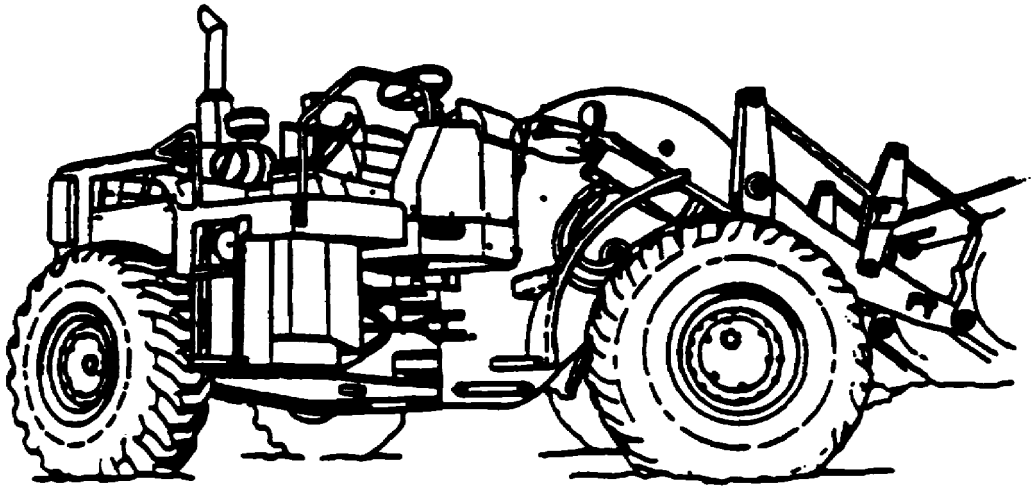
SUBCOURSE
EN5262

EDITION
7

US ARMY ENGINEER SCHOOL

ENGINEER CONSTRUCTION EQUIPMENT

STEERING SYSTEMS



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM

AIPD

READINESS/ PROFESSIONALISM THRU GROWTH

US ARMY ENGINEER
CONSTRUCTION EQUIPMENT REPAIRER

MOS 62B SKILL LEVEL 2 COURSE
ENGINEER CONSTRUCTION EQUIPMENT
STEERING SYSTEMS
SUBCOURSE EN5262

US Army Engineer School
Fort Leonard Wood, Missouri

Four Credit Hours

GENERAL

The Engineer Construction Equipment Steering Systems subcourse teaches you how to diagnose malfunctions. make adjustments. and repair a clutch and brake steering system and a power steering system. The subcourse Is presented in two lessons. Each lesson corresponds to a specific learning objective.

Lesson 1

Clutch and Brake Steering System

TASK: Describe how to operate a clutch and brake steering system, troubleshoot a clutch and brake steering system, replace a steering clutch and brake, and adjust a steering clutch and brake linkage.

CONDITIONS: You will be given information describing how to replace the steering clutch and brake, adjust the steering clutch and brake linkage, and troubleshoot a clutch and brake steering system.

STANDARDS: Study the lesson until you can answer all of the review questions. You must correctly answer 70 percent of the examination questions.

This objective supports Soldier's Training Publication (STP) 5-62B24-SM-TG, Task 051-235-2520, Replace Steering Brakes and Clutches.

Lesson 2

Power Steering System

TASK: Describe how to operate a power steering system, troubleshot(, a power steering system, and replace a steering control valve.

CONDITIONS: You will be given information describing how to operate a power steering system, troubleshoot a power steering system, and replace a steering control valve.

STANDARDS: Study the lesson until you can answer all of the review questions for this lesson. You must correctly answer 70 percent of the examination questions.

This objective supports STP 5-62B24-SM-TG, Task 051-235-2521, Replace a Steering Valve.

SUBCOURSE CONTENT
This subcourse contains two lessons that discuss diagnosing malfunctions, making adjustments, and reqpairing and replacing components of steering systems found on engineer construction equipment. Lesson 1 explains how to correctly perform tasks associated with the clutch and brake steering system; Lesson 2 covers the power steering system.

SUPPLEMENTARY REQUIREMENTS
The following training extension courses provide additional information that may be beneficial to you.

610-091-6088-J Inspecting the steering System of Wheeled Vehicle

610-051-6671-A Troubleshooting Steering System Malfunctions 5-Ton Truck, M-809

612-051-9682-F Troubleshoot Hydraulic Steering—Rough Terrain Crane

REFERENCES
no supplementary training materials are required. however, references listed at the beginning of each lesson provide additional information that may be beneficial to you. if you wish to use the references, request them from your unit commander or supervisor.

INTRODUCTION

As a construction equipment repairer, you must know the operation and the components of clutch and brake steering systems found in crawler tractors such as bulldozers and excavators. You must also understand the power steering systems found in scrapers, loaders, and other construction equipment.

This subcourse will teach you how to diagnose malfunctions and repair or replace parts in both types of steering systems.

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Lesson 1

CLUTCH AND BRAKE STEERING SYSTEM

TASK: Describe how to operate a clutch and brake steering system, troubleshoot a clutch and brake steering system, replace a steering clutch and brake, and adjust a steering clutch and brake linkage.

CONDITIONS: You will be given information describing how to replace the steering clutch and brake, adjust the steering clutch and brake linkage, and troubleshoot a clutch and brake steering system.

STANDARDS: Study the lesson until you can answer all of the review questions. You must correctly answer 70 percent of the examination questions.

This objective supports STP 5-62B24-SM-TG, Task 051-235-252, Replace Steering Brakes and Clutches.

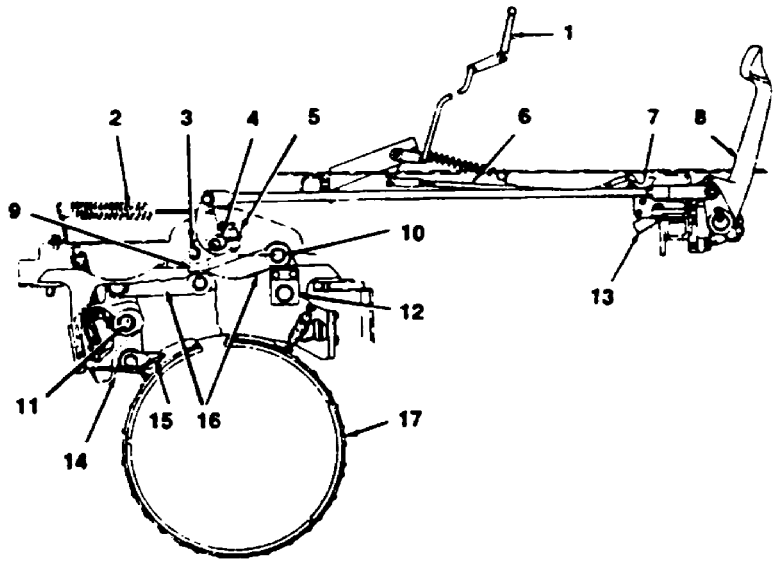
REFERENCES:
TM 5-2410-214-12
TM 5-2410-214-35
TM 5-2410-233-20
TM 5-2410-234-14&P-1
DA Pam 738-750

Learning Event 1
FUNDAMENTALS OF A CLUTCH AND BRAKE STEERING SYSTEM

Before you can repair clutch and brake steering systems, you must be able to identify their components and understand how they work.

BRAKE OPERATION

The steering system has two contracting band brakes that are independent of one another (Figure 1). They supplement the action of the steering clutch and stop the tractor. The brake lock pawls hold one or both brakes in the locked position. A single hand lever activates these pawls. The two brakes operate the same way.



1 Parking brake lever
2 Spring
3 Brake lever
4 Brake shaft
5 Brake control lever
6 Parking brake linkage
7 Brake lock pawl
8 Brake pedal
9 Brake link
10 Brake lever assembly
11 Brake lever shaft
12 Brake lever shaft
13 Ratchet
14 Brake strut support lever assembly
15 Brake band strut
16 Brake toggle link
17 Brake band

FIGURE 1. BRAKE OPERATION

When the brake pedal is depressed, the brake control linkage moves the brake control level forward. The brake shaft and brake lever rotate and pull up on the brake link. This flattens the brake toggle links, causing the brake strut support lever assembly to rotate around the brake lever shafts. The brake band struts are forced against the lugs on the brake band, causing it to contract on the steering clutch outer drum.

When the brake pedal is released, the spring returns the brake pedal, the linkage, and the brake band to their normal positions. The steering brakes also act as parking brakes and are engaged by depressing either or both brake pedals before pushing the parking brake lever down. This moves the parking brake linkage forward, engaging the pawl with the ratchet. The brake lock pawls hold the brakes in position.

CAUTION

Push the brake pedals down before pulling the parking brake lever up when releasing the brakes. This prevents damage to the ratchet teeth or pawl.

STEERING CLUTCH COMPONENTS

To fully understand the components of the steering clutches, you must also understand the final drive because the clutches are attached to the final drive.

The main components of a steering clutch arc: the bevel gear, the bevel gear shaft, the steering clutch inner drum, the disc assemblies, and the steel discs (Figure 2).

The main components of a final drive are: the steering clutch outer drum or brake drum, the final drive pinion, the idler pinion, the final drive gear, the sprocket shaft, and the sprocket (Figure 3).

STEERING CLUTCH LOCATION AND LUBRICATION

The bevel gear and steering clutches are located in the bevel gear and steering clutch case. The bevel gear case is the reservoir for the transmission and steering hydraulic systems. The bevel gear turns, throwing lubricant on the bevel gear. The bevel pinion, and the steering clutches. The steering clutch control valve lubricates the bearings for the bevel gear shaft.

STEERING CLUTCH OPERATION

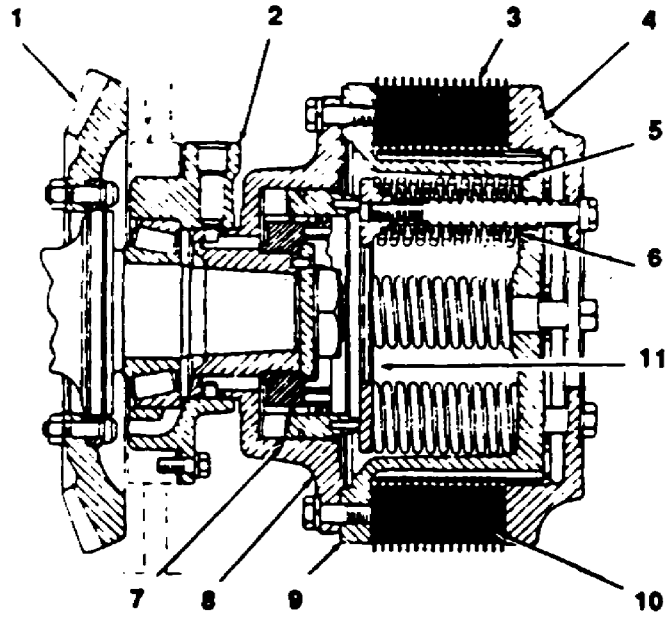
When the steering clutch (Figure 2) is engaged, the inner and outer springs force the pressure plate, steel discs, and disc assemblies, against the inner drum, supplying power through the discs to the outer drum. The steering clutches normally arc engaged with the steering clutch released.

Pressure oil from the hydraulic controls for the steering clutches moves the piston toward the outside of the machine. The piston pushes on the spring retainer which compresses the inner and outer springs. At the same time, the spring retainer pushes the pressure plate toward the outside of the machine. Now, the pressure plate is not in contact with the steel discs and disc assemblies. Because the steel disc and disc assemblies are not held together, power cannot go from the inner drum to the outer drum.

POWER TRANSFER

When the steering clutch is engaged (Figures 2 and 3), power flows from the bevel gear through the bevel gear shaft to the inner drum. The inner drum turns the steel discs which turn the disc assemblies. The disc assemblies turn the outer drum which turns the final drive pinion. The final drive pinion turns the idler gear which turns the final drive gear. This gear turns the sprocket which then turns the track.

When a steering clutch is not engaged, the connection between the bevel gear and the final drive pinion is broken. Power cannot go through the final drive to the track.



1 Bevel gear
2 Bearing cage
3 Disc assemblies
4 Pressure plate
5 Outer springs
6 Inner springs
7 Piston
8 Hub
9 Steering clutch inner drum
10 Steel discs

FIGURE 2. STEERING CLUTCH

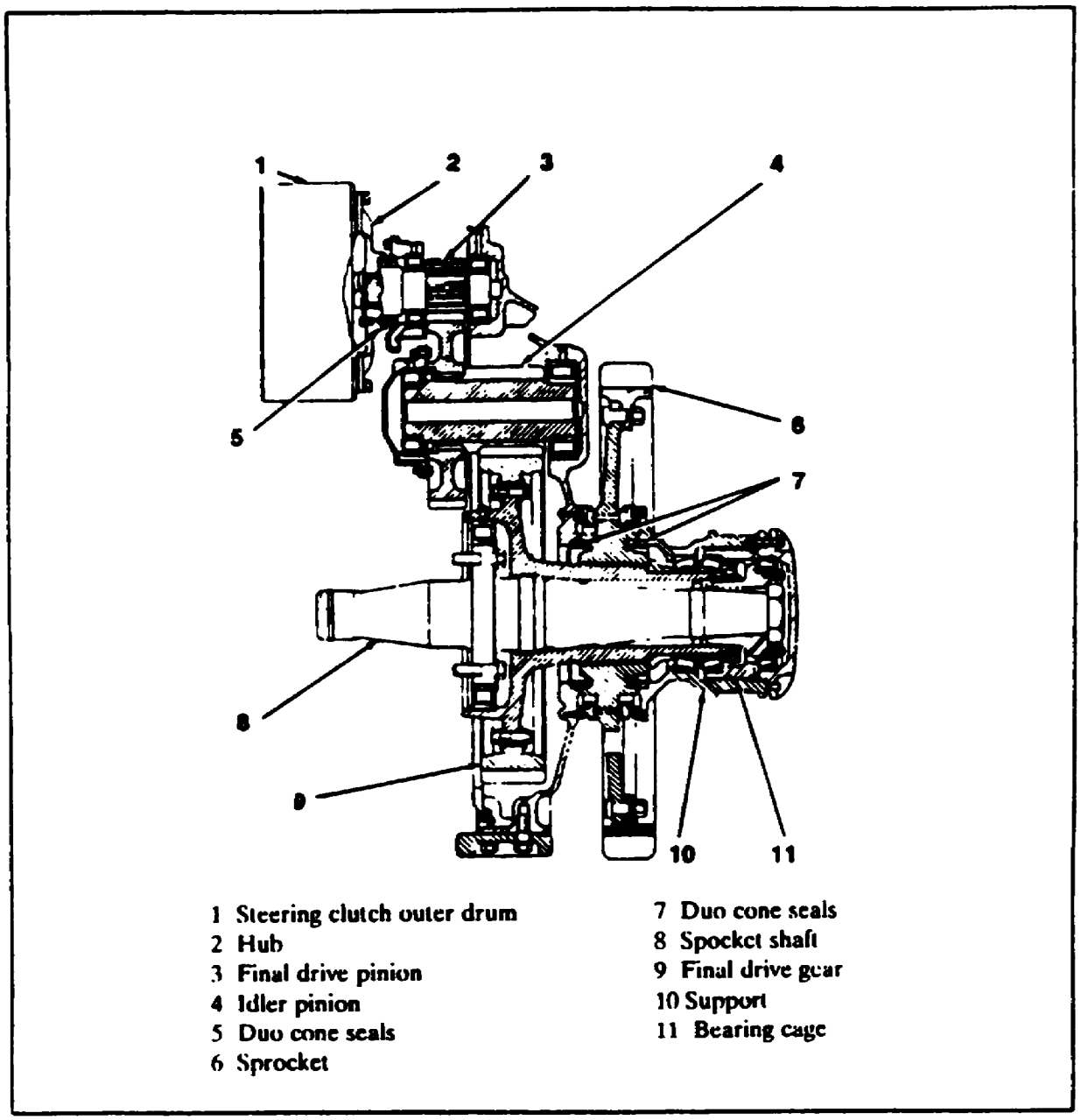


FIGURE 3. FINAL DRIVE

Learning Event 2
TROUBLESHOOT A CLUTCH AND BRAKE STEERING SYSTEM

This learning event presents five job situations which require you to troubleshoot a clutch and brake steering system.

In each situation:

- You are a sergeant, E5, assigned to the 91st General Support Maintenance Company, Fort Wilson, Kansas. You are the senior construction equipment repairer, 62B20, in the engineer equipment repair section.
- Your equipment is a model D7E Caterpillar tractor.
- You will use a Department of the Army (DA) Form 2407 (Maintenance Request), a maintenance allocation chart, and a troubleshooting guide from technical manual (TM) 5-2410-234-14&P-1.

NOTE: Safety is always your prime concern.

SITUATION 1

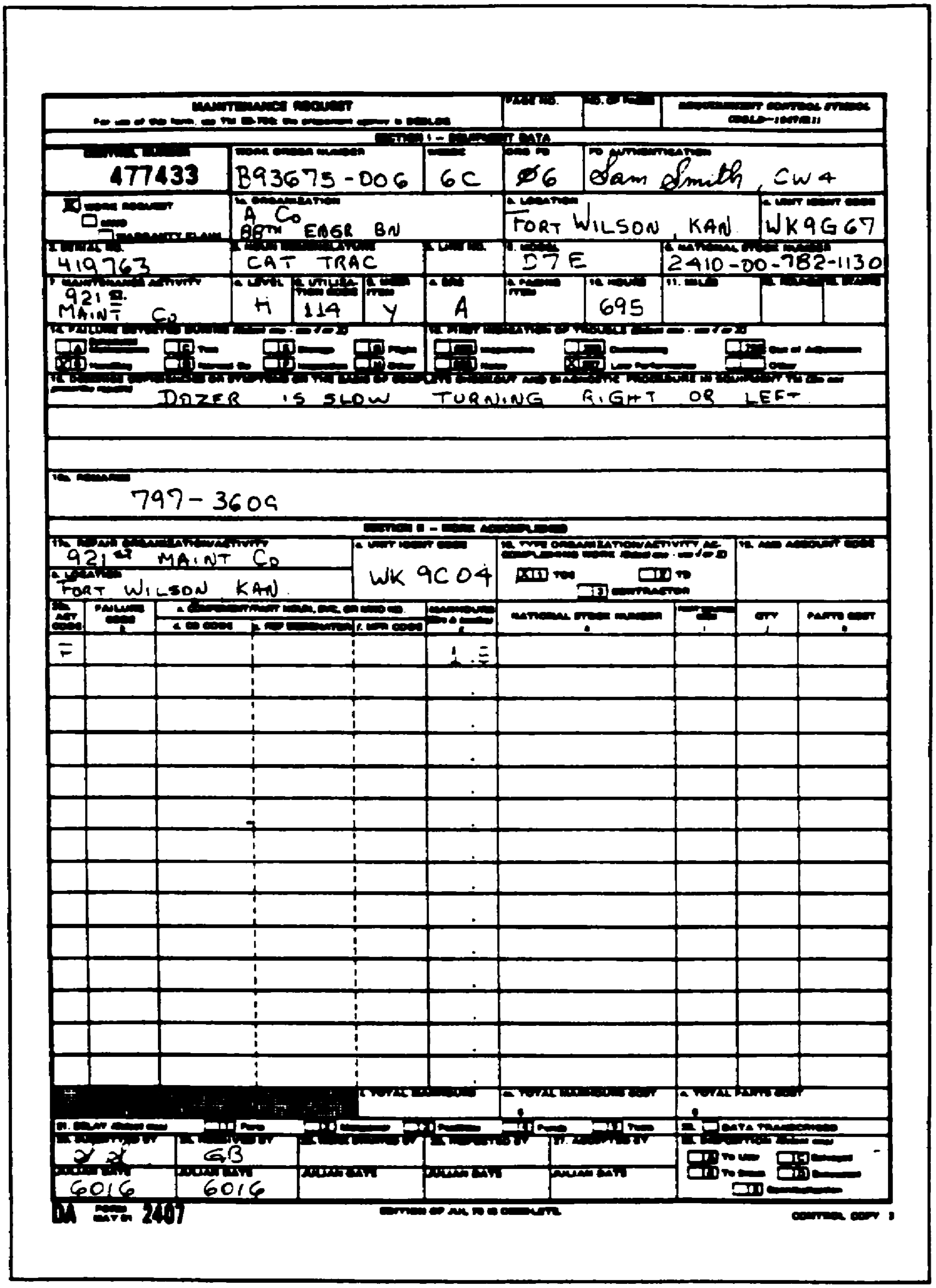
Your supervisor tasks you to verify a reported malfunction on a D7E and identify probable causes. Use DA Form 2407 (Figure 4) and the troubleshooting guide from TM 5-2410-234-14&P-1 (Table 1).

SOLUTION 1

You review the DA Form 2407 and see that Section 16 states that the tractor is slow turning right or left. Verify the problem by starting and operating the tractor. Check both the right and left steering clutches. You find that the tractor turns slowly to the left and even slower to the right.

Since the malfunction is correctly stated on DA Form 2407, refer to the troubleshooting guide (Table 1). You eliminate all malfunctions that do not apply. You see that there are five probable causes for slow steering. You next inform your supervisor of your findings.

- Control linkages for the steering clutches and brakes liise or adjustment not correct.
- Brake linings have wear or damage.
- Low oil pressure to steering clutch control valve.
- Splines on steering clutch hubs have damage.
- Leaks in steering clutch control valve.



MAINTENANCE REQUEST

SECTION I - EQUIPMENT DATA

CONTROL NUMBER: 477433
WORK ORDER NUMBER: B93675-DOG
6C
Ø6
Sam Smith, CW4

WORK REQUEST
A Co
88TH ENGR BN
FORT WILSON, KAN
WK9G67

419763
CAT TRAC
D7E
2410-00-782-1130

921st MAINT Co
H
114
Y
A
695

DOZER IS SLOW TURNING RIGHT OR LEFT

797-3609

SECTION II - WORK ACCOMPLISHED

921st MAINT Co
FORT WILSON KAN
WK 9C04

GB
6016
6016

DA FORM 2407

FIGURE 4. DA FORM 2407

TABLE 1. TROUBLESHOOTING GUIDE

STEERING	
PROBLEM	**PROBABLE CAUSE**
Machine will not turn in one direction.	Adjustment of steering control linkage not correct. Too much leakage in steering clutch control valve. Steering clutch discs or plates have wear damage. Seals of steering clutch piston have damage.
Machine will not turn in either direction.	Low oil pressure to steering clutch control valve. Leaks in control valve. Adjustments of control linkages for the steering clutches and brakes not correct. Steering clutch or clutches not releasing.
Machine moves in either direction when both steering clutches are engaged.	Adjustments of the control linkages for the steering clutch discs or plates have wear or damage. Steering clutch springs that are weak or have damage. Bolts that hold the steering clutch springs are broken. Splines on the steering clutch hubs have damage. Weak or broken springs in control valve
Slow steering	Control linkages for the steering clutches and brakes loose or adjustment not correct. Brake linings have wear or damage. Low oil pressure to steering clutch control valve. Splines on steering clutch hubs have damage. Leaks in steering clutch control valve

SITUATION 2
Your supervisor gives you the go-ahead to troubleshoot the problem to determine the actual cause. Start with the easiest area to check. In this case you first check for leaks in the steering clutch control valve (Figure 5) since only a visual inspection is required.

SOLUTION 2
You check the valve for leaks at all oil supply lines and wherever there is a seal or gasket. You also check the control valve housing for cracks and breaks. You find no visible leaks. You eliminate the steering control valve as a probable cause.

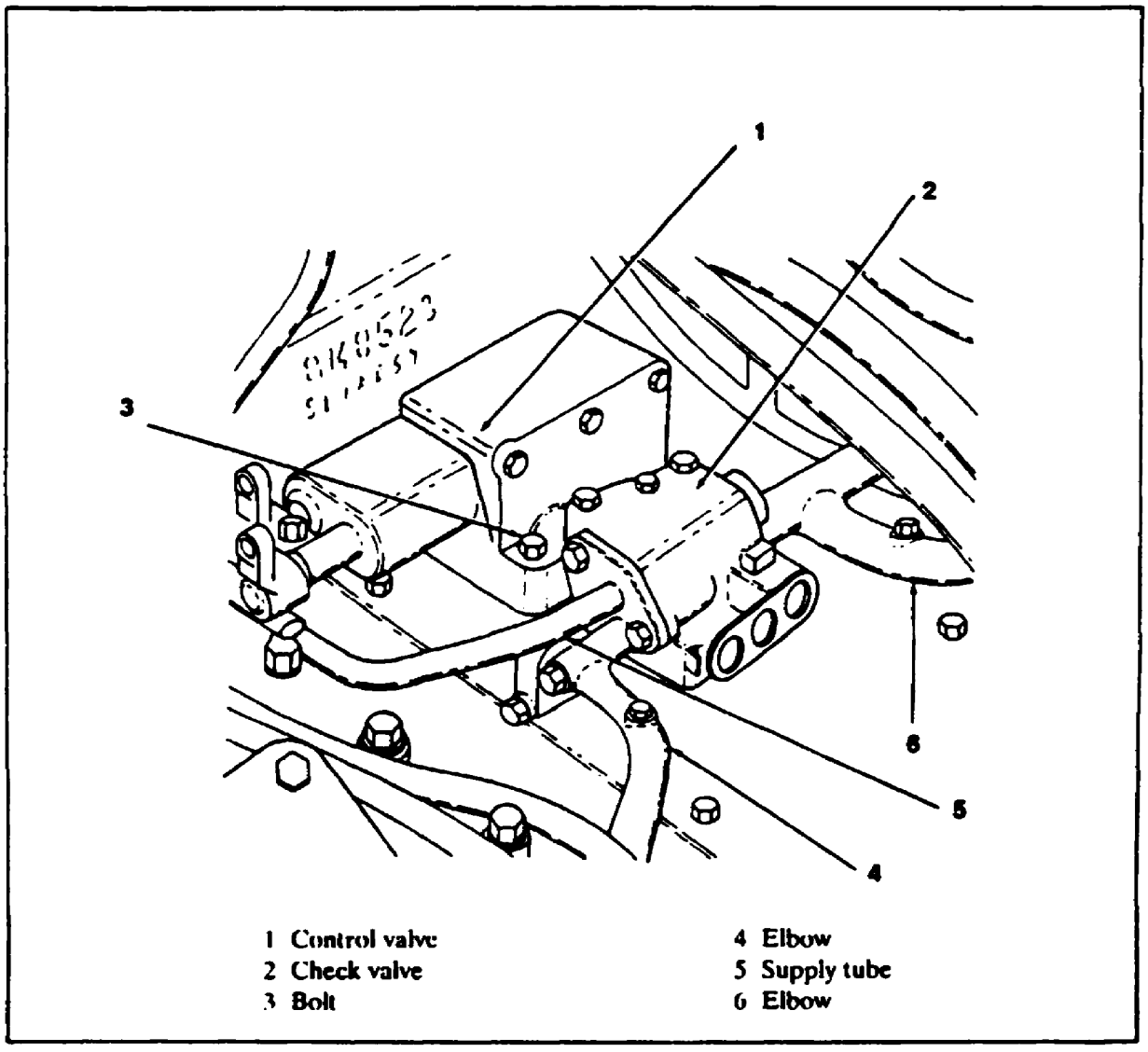


FIGURE 5. STEERING CONTROL VALVE

SITUATION 3

You next check the control linkages for looseness and steering clutches for incorrect adjustment. Break the operation into three steps:

1. Check steering brake pedal for free movement
2. Check the clutch brake adjustment
3. Check the steering clutch linkage adjustment

SOLUTION 3

Step 1. Performing the simplest task first, check the steering brake pedal for free movement. Use Figure 6 and Table 2. You find the brake pedal free travel is correct.

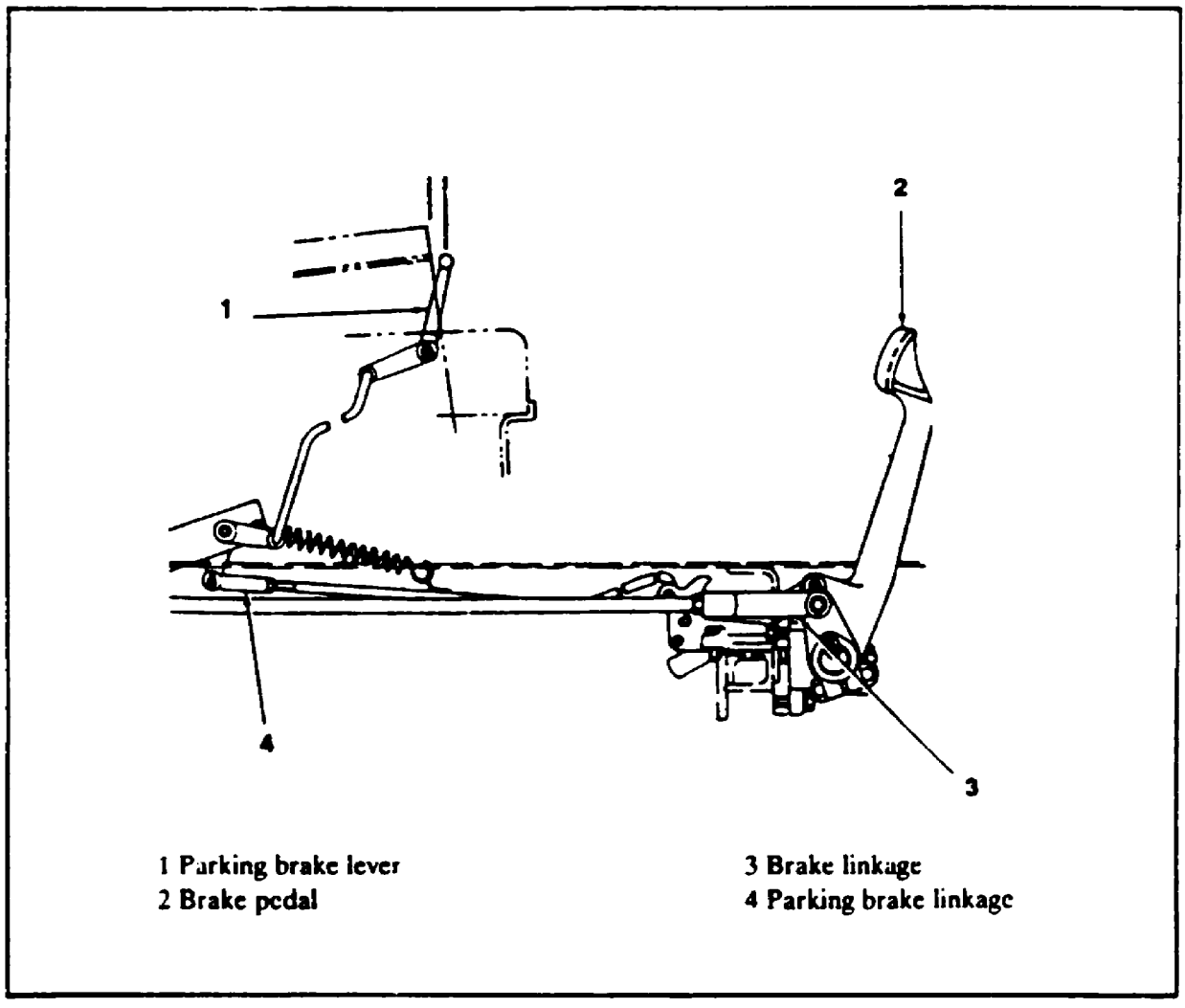


FIGURE 6. STEERING BRAKE LINKAGE

TABLE 2. BRAKE PEDAL ADJUSTMENT SPECIFICATIONS

Component		Manufacturer's dimensions and tolerances in inches		Desired clearance		Maximum allowable wear and clearance
		Minimum	Maximum	Minimum	Maximum	
Minimum overall width of 10 disc assemblies and 9 discs (worn)	2.744 in.					
Pressure relief valve set to bypass at	350–400 psi					
Steering clutch control valve minimum pressure with clutch disengaged, engine at low idle speed	265–300 psi					
Steering clutch and transmission hydraulic pump						
Permissible clearance between pump shafts and bearings						.006
Capacity at 1,760 rpm (pump speed at 1,200 rpm engine speed)	22.5 gpm					
When developing pressure of	350 psi					
Brakes						
Adjustment:						
Tighten down adjusting socket until band is tight and back off	1 turn					
Distance between top of pin and the milled notch in the engaging mechanism support				.860	.900	
Distance between front face of seat armrest support and center line of parking brake lever				.820	.940	
Distance between front face of seat support and rear face of brake pedal	17.67–17.87 in.					
Final drive						
Flange-to-final drive pinion press fit, tons	35–40					
Dimension between face of flange and the shoulder of the pinion shaft when pressed on to 35–40 tons	.094–.154 in.					
Sprocket-to-hub press fit, tons	60–65					
Dimension between face of sprocket and the end of the splines on the final drive hub when pressed on to 60–65 tons	.440–.560 in.					
Sprocket shaft-to-case press fit, tons	55–60					
Sprocket shaft must be straight within	.12 in.					

Step 2. Check the steering clutch brake adjustment. See Figure 7 and use the following procedures to adjust.

- Remove the brake adjusting screw cover, taking care not to damage the gasket.
- Using a torque wrench, turn the adjusting screw in (clockwise) until you have applied a torque of 15 foot-pounds.
- Turn the adjusting screw out (counterclockwise) one and one-half turns to provide proper clearance between the brake lining and the brake lining and the brake drum.

You find the steering clutch brake adjustment is correct.

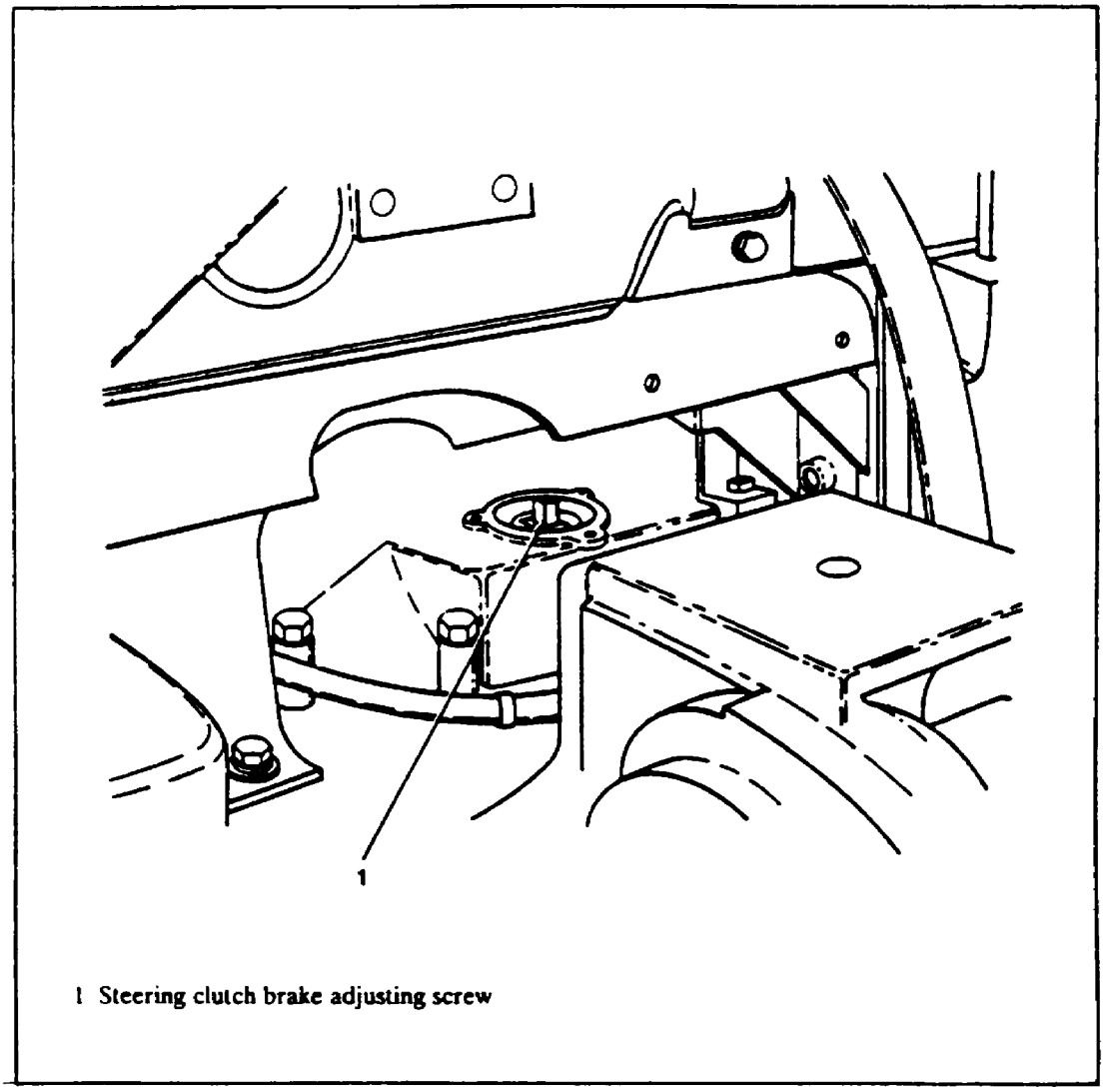


FIGURE 7. STEERING CLUTCH BRAKE ADJUSTING SCREW

Step 3. Check the adjustment of the steering clutch linkage (Figure 8). Use the following procedures from the operator's manual.

- Remove the pins from the linkage lever and loosen the locknut on the control rod end.
- Be sure the steering clutch control levers are in the full forward position. Move the control rods forward to take up clearance in the linkage. After removing the clearance, you will feel spring resistance. Do not move the rods forward enough to compress the extent that the steering clutch hydraulic control.
- Adjust the rod end on the control rod so you can easily install the pin in the rod end and linkage lever. Then turn the rod ends one-half turn clockwise to shorten the reach of the rod and install the pins.
- Loosen the stop bolt locknut.
- Pull the steering clutch control lever to the rear as far as it will go and hold. Turn the stop bolt *in* (clockwise) until there is clearance between the stop bolt and the bumper mounting angle. At this point, the hydraulic control prevents further movement of the control lever. Hold the lever in this position until you complete the next procedure.
- Turn the stop bolt *out* (counterclockwise) until it contacts the angle. Then turn it an additional one-half turn. Release the control lever and lock the stop bolt with the locknut.

SOLUTION 3

You find the clutch and brake linkage adjustments are correct. You can eliminate the clutch and brake adjustments as a probable cause.

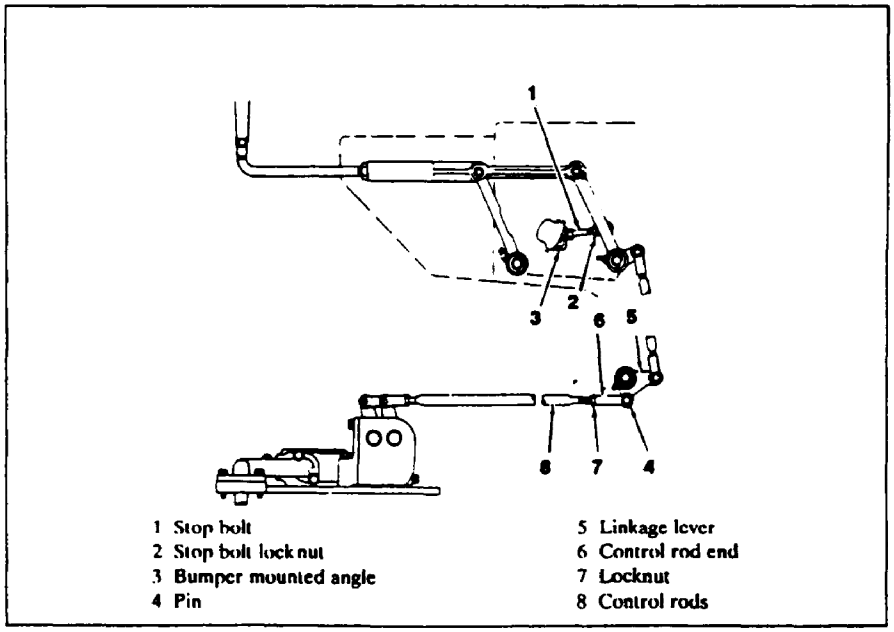


FIGURE 8. STEERING CLUTCH LINKAGE

SITUATION 4

Having eliminated two of the five probable causes for slow steering, only one remains which does not require removing the steering clutch assembly . You next check for low pressure to the steering clutch control valve. Refer to Figure 9 and determine the flow of oil going to both the right and left steering clutches. You should find that item A (Figure 9) is the left steering clutch and item F is the right steering clutch. Determine the required pressure for the steering clutch pistons (Table 3).

Once you determine the correct pressure for the steering clutch pistons, identify where you should conduct the pressure test (Figure 10). You may start with either the right or left steering clutch.

Oil within the system must be at operating temperature. If the engine is running and the oil has reached operating temperature, shut the engine off.

Remove the oil pressure tap plug from the steering clutch and install the multirange pressure gage (Figure 11).

Next, restart the engine to build pressure in the system. Be sure the pressure reading is within the limits stated in Table 3.

Once you have completed the first test, shut the engine off, remove the pressure gage, and install the oil pressure tap plug.

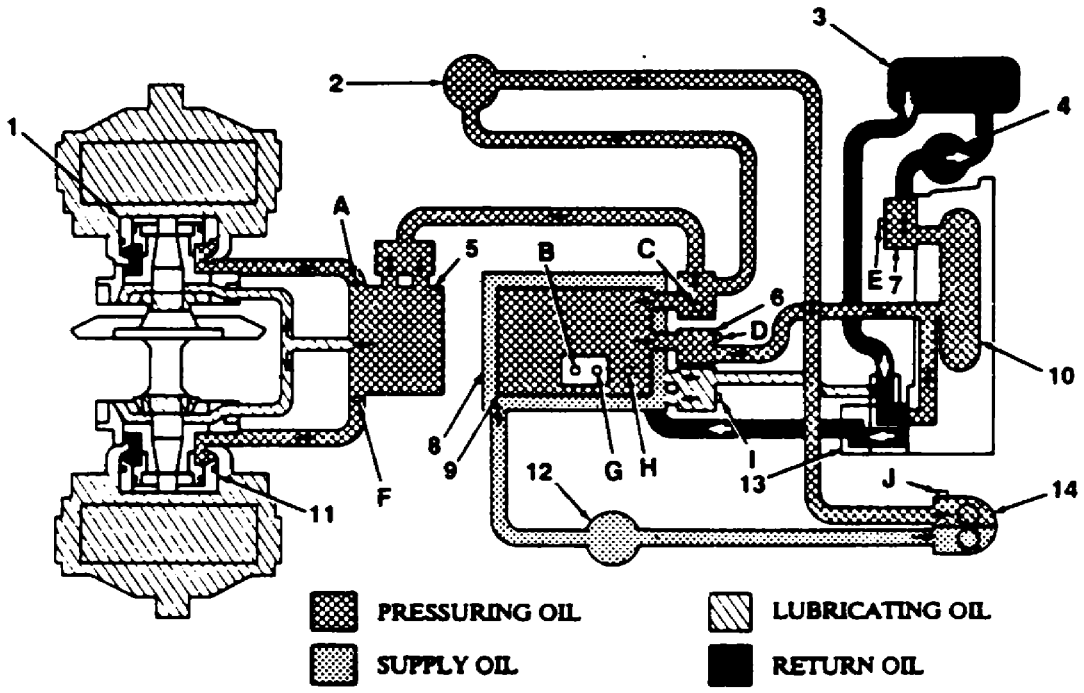
Check the oil pressure on both steering clutches.

TABLE 3. STEERING CLUTCH CONTROL TEST

Pressure	Location	Value
Steering clutch pistons (steering clutches disengaged and engine at low idle)	A-F	250-280 psi
Hydraulic oil pump (engine at high idle)	J	310-330 psi
Hydraulic pump (steering clutches disengaged and engine at low idle)	J	275-psi min

SOLUTION 4.

You find the pressure going to both steering clutches is within the required limits. You can eliminate oil pressure as a probable cause.



HYDRAULIC COMPONENTS

1 Left steering clutch piston
2 Oil filter
3 Oil cooler
4 Magnetic strainer
5 Steering clutch hydraulic control
6 Torque converter inlet relief valve
7 Torque converter outlet relief valve
8 Transmission case
9 Transmission pressure control valve
10 Torque converter
11 Right steering clutch piston
12 Magnetic strainer
13 Scavenge and circulating pump
14 Oil pump (transmission and steering clutch)

TEST TAPS

A Left steering clutch oil pressure tap
B Speed clutch pressure tap
C Transmission oil pump pressure tap
D Torque converter inlet relief valve pressure tap
E Torque converter outlet relief valve pressure tap
F Right steering clutch oil pressure tap
G Directional clutch high and low pressure tap
H Check valve dump poct tap
I Transmission lubricating oil pressure tap
J Oil pump pressure tap

FIGURE 9. HYDRAULIC FLUID FLOW DIAGRAM

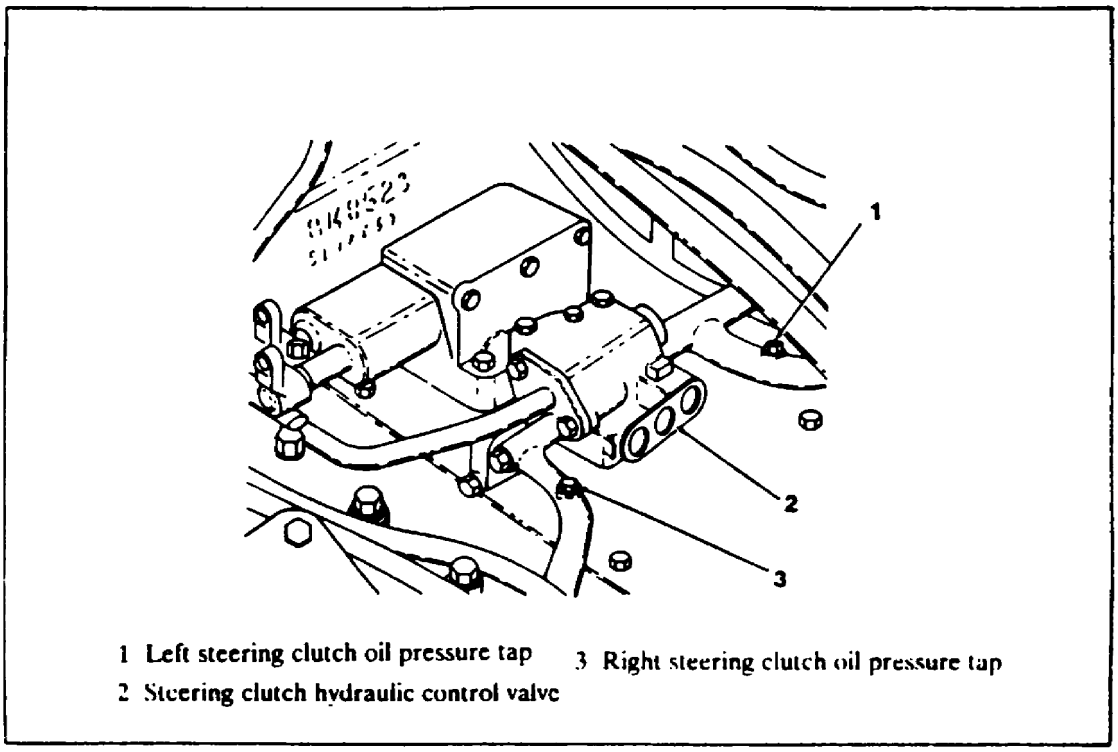


FIGURE 10. STEERING CLUTCH CONTROL VALVE

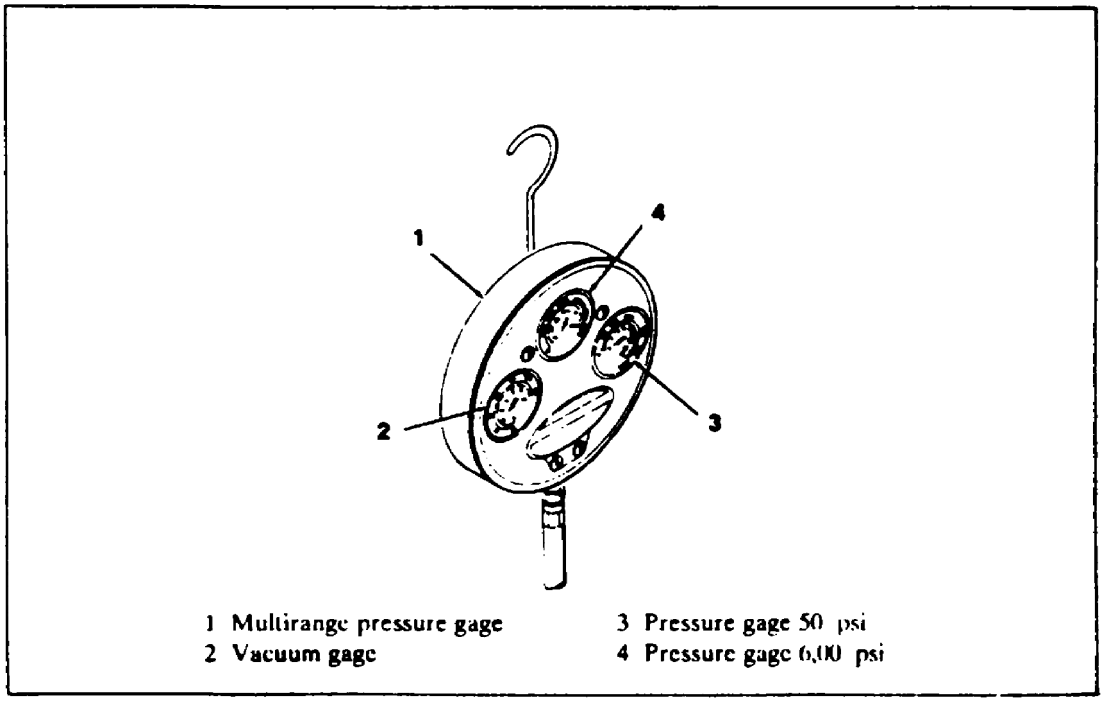


FIGURE 11. MULTIRANGE PRESSURE GAGE

SITUATION 5
Two possible causes for steering failure remain:

Brake linings have wear or damage

Splines on steering clutch hubs have damage

These operations require removal of the steering clutches.

Determine if you, a repairer at general support level, are authorized to perform these checks by referring to Table 4.

TABLE 4. MAINTENANCE ALLOCATION CHART

CATERPILLAR MODEL D-7E TRACTOR

(1) Group number	(2) Component/assembly	(3) Maintenance function	(4) Maintenance category C	O	F	H	D	(5) Tools and equipment
09	**STEERING**							
0901	Steering brakes:							
	Brakes, steering	Replace				16.0		
		Repair				24.0		
	Clutch, steering	Replace				42.0		
		Repair				42.0		
	Controls and linkage	Inspect		0.4				
		Adjust		0.2				
		Replace			3.5			
		Repair			3.5			
0902	Hoses, lines, fittings	Replace			3.0			
		Repair			5.0			

SOLUTION 5
You determine that general support maintenance is responsible for steering brakes and clutches. You advise your supervisor that you have made all external checks, found no minor problems and determined that the brakes need to be replaced. (Learning Event 3)

Learning Event 3
REPLACE A STEERING BRAKE

This learning event presents eight job situations which require you to replace a steering brake.

SITUATION 1
You informed your supervisor that the most probable cause for the tractor steering slowly in both directions is worn brake bands (Learning Event 2). Your supervisor says that because of a shortage of shop personnel you will have to replace the brake bands.

SOLUTION 1
Before you disassemble the tractor contact the supply personnel to be sure that new brake bands are on hand. Since you must remove the clutch assembly to install the brake bands, check to see if clutch parts are also on hand. If you remove the clutch assembly and find a fault within the clutch mechanism, you can replace those damaged parts, too.

SITUATION 2
Before removing the steering clutch assemblies, you must remove the tractor's fuel tank and brake actuating mechanism.

Remove the Fuel Tank
Start the repair job by first removing the fuel tank. Refer to Figure 12 while completing the following steps.

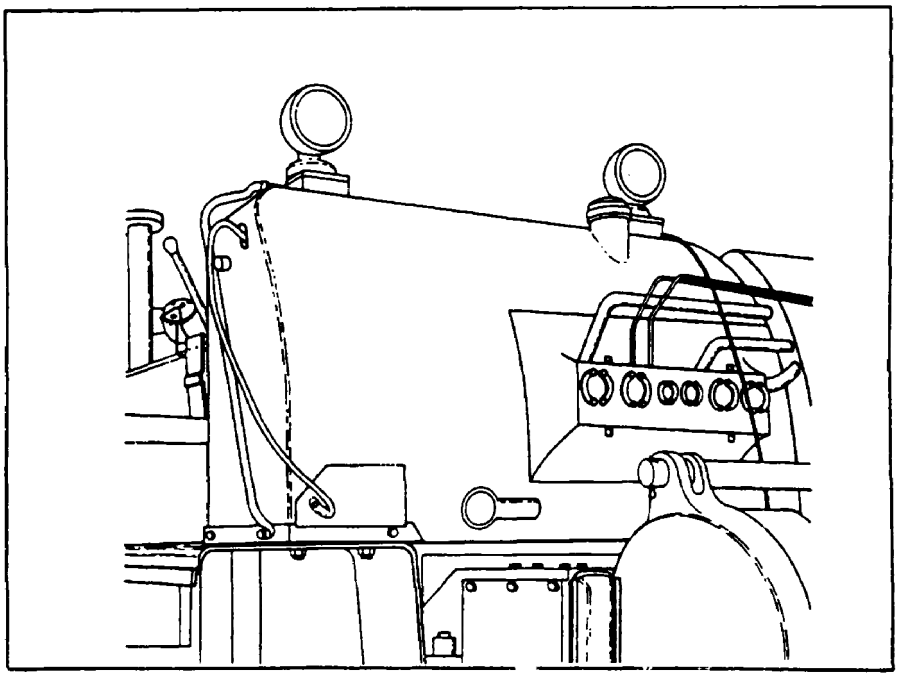


FIGURE 12. FUEL TANK REMOVAL

Step 1. Remove the rear guard and shut off the fuel supply (Figure 13).

Step 2. Disconnect the fuel supply line and the fuel drain line at the tank.

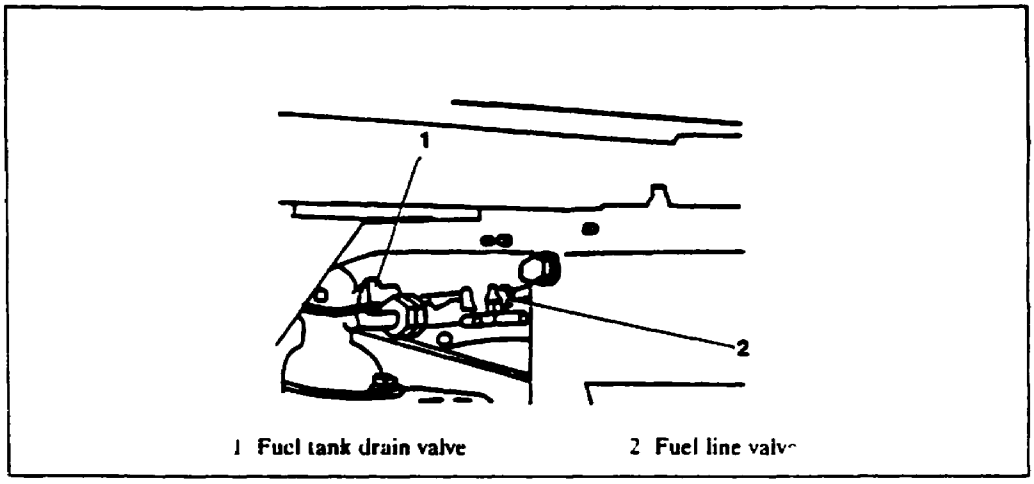


FIGURE 13. FUEL SHUTOFF VALVE

Step 3. Remove the seat (Figure 14).

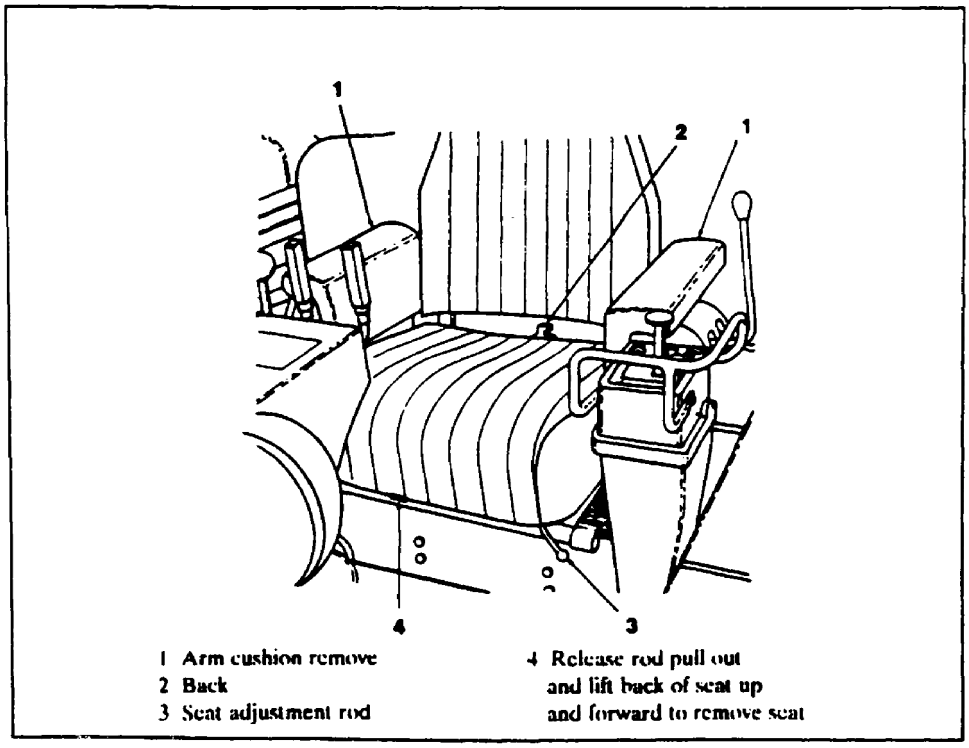


FIGURE 14. SEAT REMOVAL

Step 4. Remove the seat frame (Figures 15 and 16) as follows:

- Remove the left arm rest.
- Remove the winch control levers and bracket.
- Disconnect the brake lock linkage.
- Disconnect the transmission linkage.

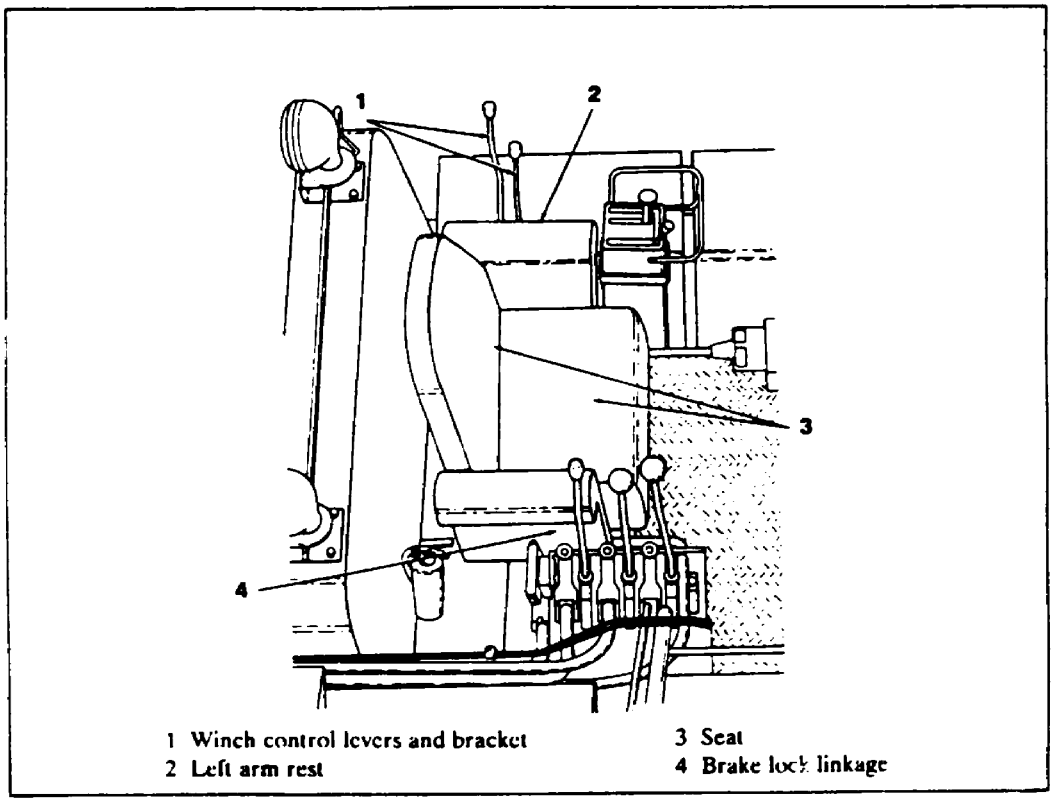


FIGURE 15. SEAT FRAME REMOVAL

- Disconnect the electric cable (3, Figure 16).
- Disconnect the electric cables (4, Figure 16) from the battery.
- Pull the electric cables through the seat frame opening and into the seat frame.
- Disconnect the rod at the linkage assembly.
- Remove the mounting bolts.
- Turn the linkage assembly so you can move the seat frame to the left.
- Use a hoist to lift out the seat frame.

Step 5. Remove the grab iron and lights.

Step 6. Remove the guard.

Step 7. Pull the wiring back into the conduit.

Step 8. Loosen the clip and move the conduit aside.

Step 9. Remove the wires from the clip mounted on the front lower left corner of the fuel tank.

Step 10. Remove the bolts and mounting bolts.

Step 11. Install two eyebolts in the light brackets.

Step 12. Attach a hoist to the eyebolts and lift the fuel tank up and to the left.

Step 13. Place the fuel tank out of the way in the work area.

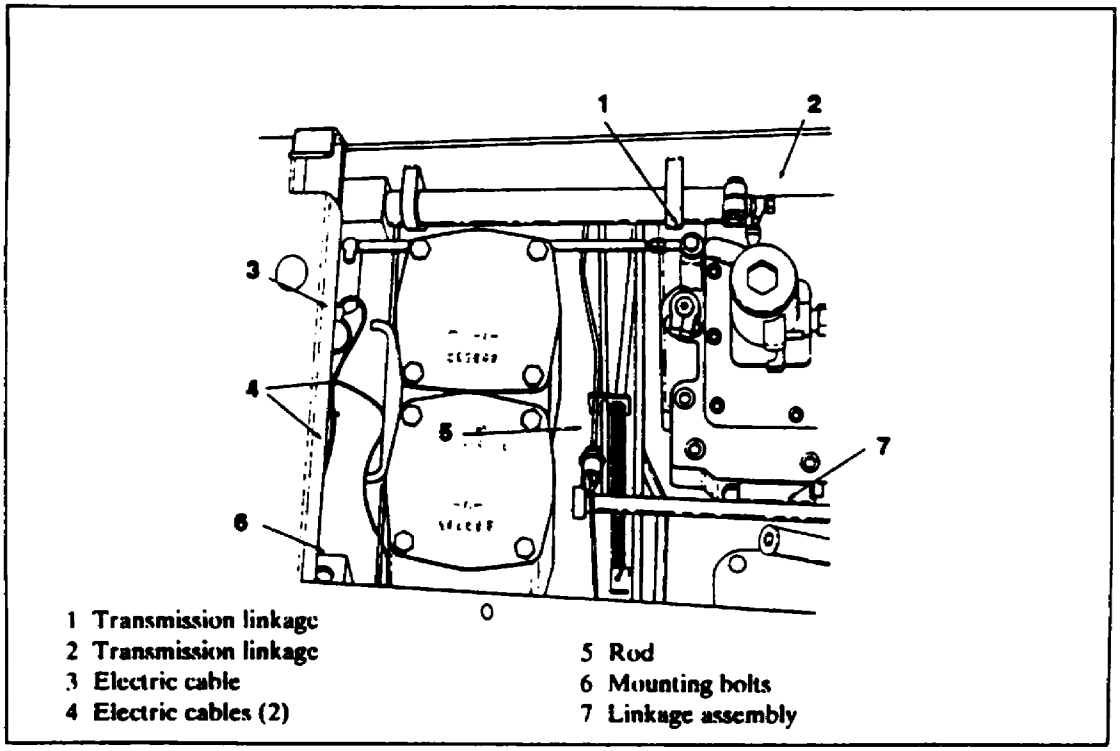


FIGURE 16. BATTERY CABLE REMOVAL

Remove the Brake Actuating Mechanism

After removing the fuel tank, continue the procedures for removing the brake bands. Refer to Figure 17 while completing the following steps.

Step 1. Remove the support bar.

Step 2. Remove the bolts and cover.

Step 3. Disconnect the brake rod attached to the brake control lever.

Step 4. Remove the pin and cotter pin that secure the brake Link to the brake lever.

Step 5. Remove the brake lever return spring.

Step 6. Remove the bolts and steering clutch cover.

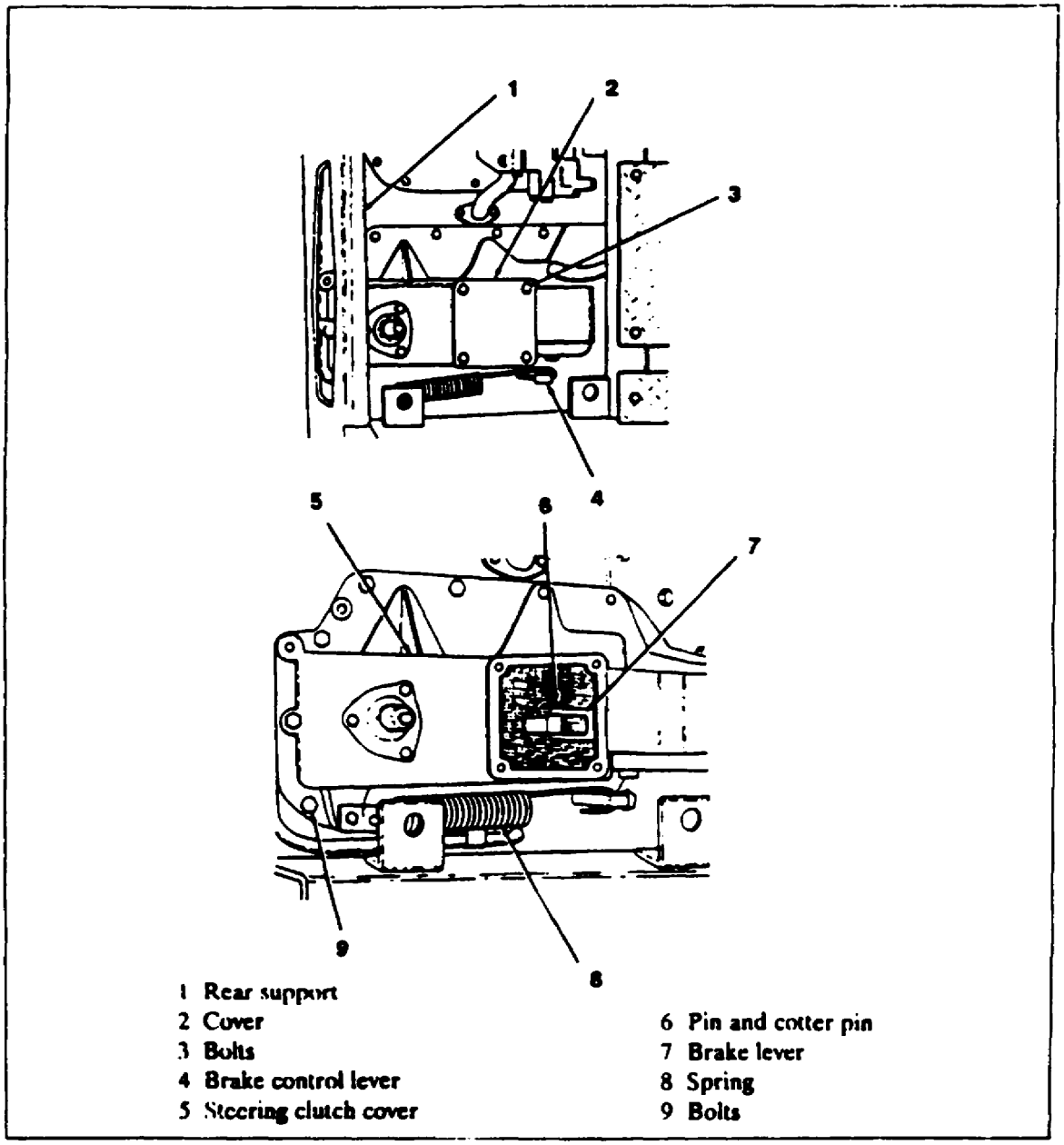


FIGURE 17. BRAKE ENGAGING MECHANISM REMOVAL

Step 7. Loosen the socket assembly to remove tension on the brake bands (Figure 18).

Step 8. Remove the bolts that hold the brake actuating mechanism to the bevel gear case.

Step 9. Use a hoist to remove the [rake actuating mechanism.

NOTE: The brake actuating mechanism weighs 100 pounds.

SOLUTION 2

To reach the steering clutches, you removed the fuel tank and brake actuating mechanism.

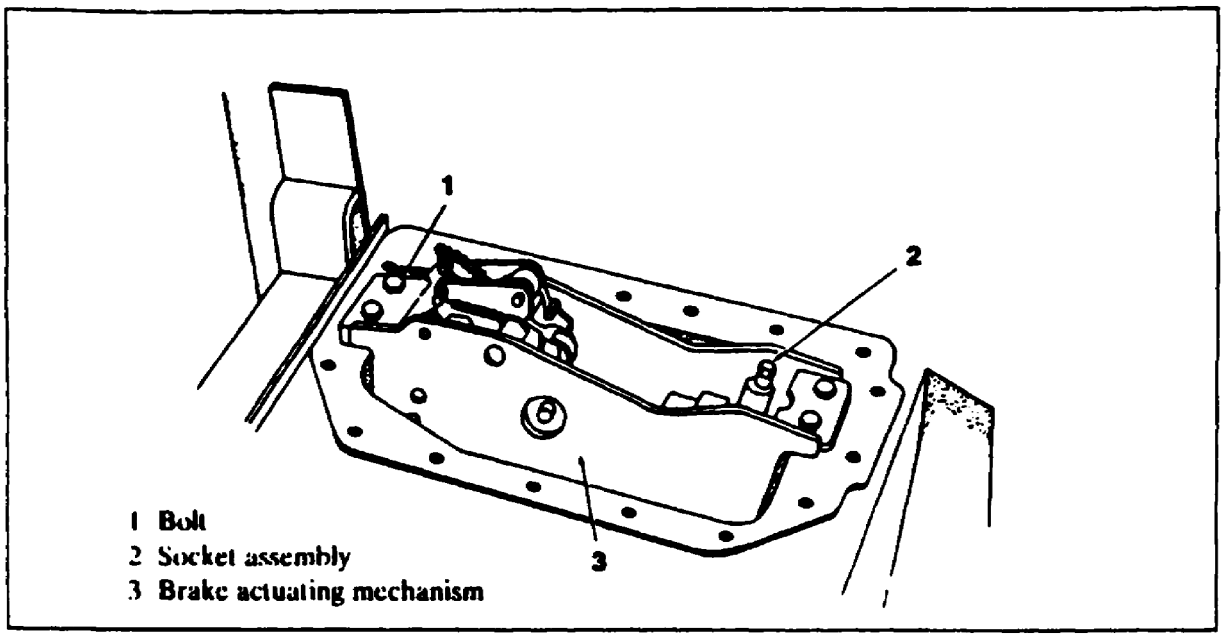


FIGURE 18. BRAKE ACTUATING MECHANISM REMOVAL

SITUATION 3

You must now raise the tractor and remove the steering clutch before replacing the steering brake band.

Raise the tractor

Before you can remove the steering clutch, you must raise the tractor. Proceed as follows:

Step 1. Rotate the tracks to locate the bolts attaching the steering clutch to the steering clutch driving hub and driven drum flange.

CAUTION

Jack up the tractor and crib it. Use a 20-ton floor jack.

Step 2. Starting at the rear of the tractor, place the jack under the drawbar. Raise the jack until the rear tracks just clear the surface.

Step 3. Once the tracks clear the surface, crib up the rear of the tractor and lower the jack.

Step 4. Move the jack to the front of the tractor and place it under the tow hook on the front of the belly pan.

Step 5. Place cribbing between the jack and the tow hook, or you will not be able to raise the front of the tractor high enough for the tracks to clear the surface.

Step 6. Raise the jack slowly, making sure the cribbing does not slip.

WARNING

In lifting operations. misalignment may let the cribbing slip.
Safety must be your first concern.

Step 7. Raise the front of the tractor until the tracks just clear the surface.

Step 8. Place cribbing under the tractor and then lower the jack.

Remove the Steering Clutch

Now that you have raised the tractor, remove the clutch.

Step 1. Remove as many bolts as you can reach easily (Figure 19). You should be able to remove approximately five bolts before rotating the clutch.

Step 2. Place a jack under the grouser of the track. Raise the jack and rotate the track. This will rotate the clutch assembly. Remove the remaining bolts.

Step 3. Remove all but two of the remaining bolts. These two remaining bolts will secure the clutch assembly to the inner drum until you can attach a hoist to raise the assembly.

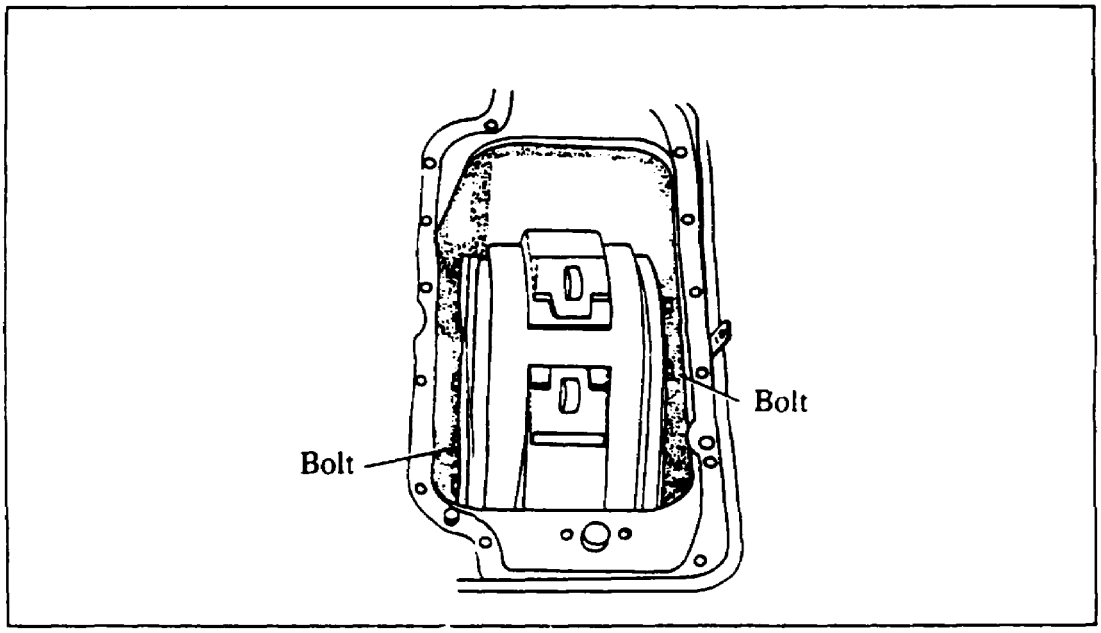


FIGURE 19. STEERING CLUTCH REMOVAL

Step 4. Place two .38 inch diameter rods, 6 inches long, through the holes in the brake band (Figure 20).

Step 5. Attach a hoist to the rods in the brake band. Apply pressure to keep clutch assembly from falling.

Step 6. Remove the two remaining bolts.

Step 7. Pry the outer drum from the drum flange.

Step 8. Pry the drum away from the hub.

Step 9. Use a hoist to lift and remove the steering clutch assembly.

CAUTION

Keep the steering clutch assembly level because the clutch is free to slide out of the outer drum. Run a strap or rope through the clutch and secure the ends to keep the clutch from falling.

Step 10. Lay down the clutch assembly with the cribbing pressure plate side up.

Step 11. Remove the hoist and pins from the brake band.

Step 12. Slide the brake band straight up and over the drum.

Step 13. Inspect the brake band for wear. If the band is worn to within 1/16 inch of the rivets, you must replace it.

SOLUTION 3

After removing the steering clutch assembly and inspecting the brake band, you find that the brake band has worn to within 1132 inch of the rivets. You must get a new brake band and use it when assembling the clutch.

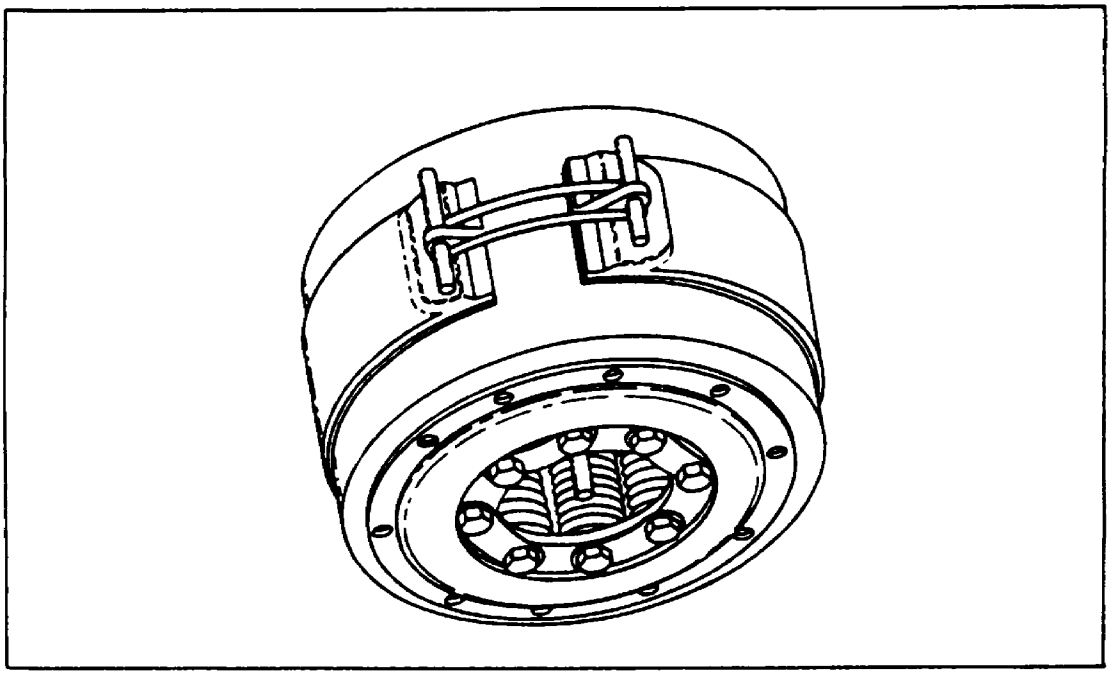


FIGURE 20. STEERING CLUTCH ASSEMBLY REMOVAL

SITUATION 4

Inspect the clutch assembly to see if any of the clutch parts are damaged. It is more cost effective to make this inspection now than to go through another complete disassembly later.

Place the clutch assembly on blocks with the pressure plate side up (Figure 21). Allow at least 5 inches of clearance below the assembly.

Step 1. Lift the outer drum from the clutch assembly.

Step 2. Compress the clutch springs and remove the bolts.

WARNING
The pressure of the springs pushing against the pressure plate could hurt someone or damage the clutch assembly. Compress the clutch springs before removing he bolts holding the pressure plate to the clutch assembly.

Use one of the following methods, or a similar method of your own, to safely remove the bolts from the pressure plate:

- Place the clutch assembly in an arbor press, apply pressure, and remove the bolts. Slowly release the pressure.
- Use two C-clamps and four small blocks of wood. To protect the outer drum and pressure plate, place a block of wood on the top and the bottom of the clutch assembly. Tighten a C-clamp around the blocks of wood. Repeat the process 180 degrees from the first C-clamp. Remove the bolts. Slowly loosen the pressure with equal turns on the two C-clamps.

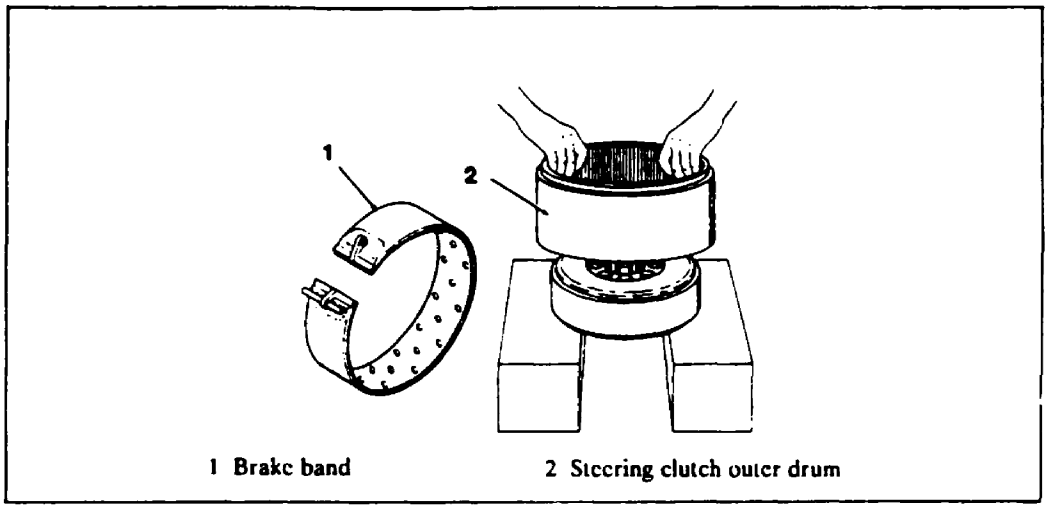


FIGURE 21. OUTER DRUM REMOVAL

Step 3. Remove the pressure plate (Figure 22).

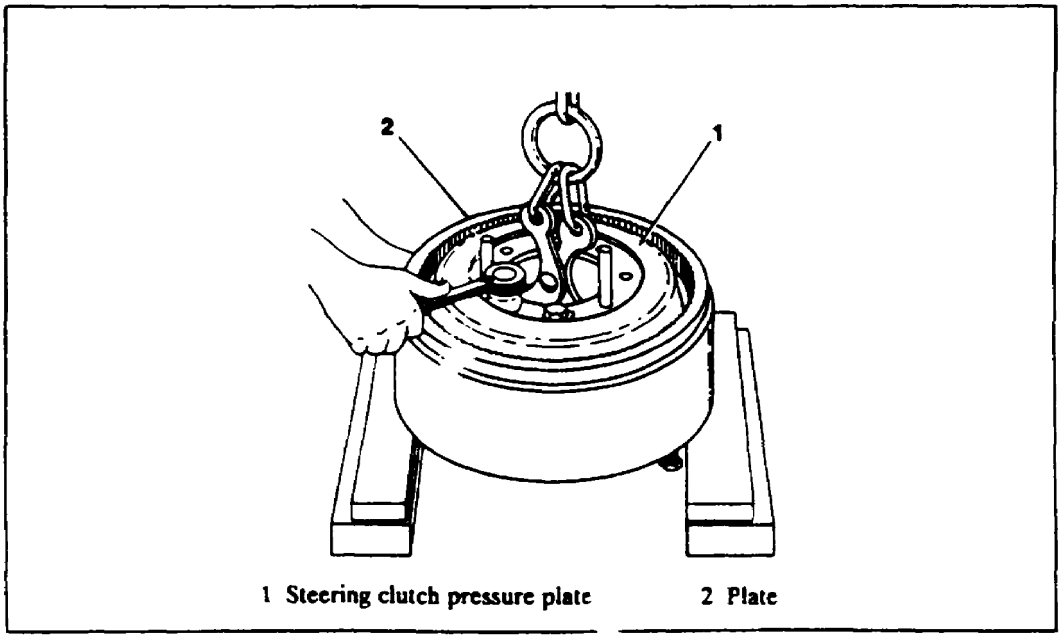


FIGURE 22. PRESSURE PLATE LOCATION

Step 4. Remove the clutch disc assembly and the clutch driving discs from the inner drum (Figure 23).

NOTE: Number the tops of the disc assemblies and driving discs as you remove them. This will become important when you install the discs.

Step 5. Inspect the clutch discs for warping, roughness, and excessive wear. Use a micrometer and measure the thickness of the discs. Table 5 gives the minimum and maximum overall widths and the thickness of the discs.

Step 6. Remove the clutch springs and clutch spring sleeves. Inspect for broken springs and excessive wear on the retainers.

SOLUTION 4

You removed the outer drum from the clutch assembly and took out the pressure plate, the clutch discs, and the clutch springs. Inspect the clutch springs and discs to ensure that all parts are serviceable.

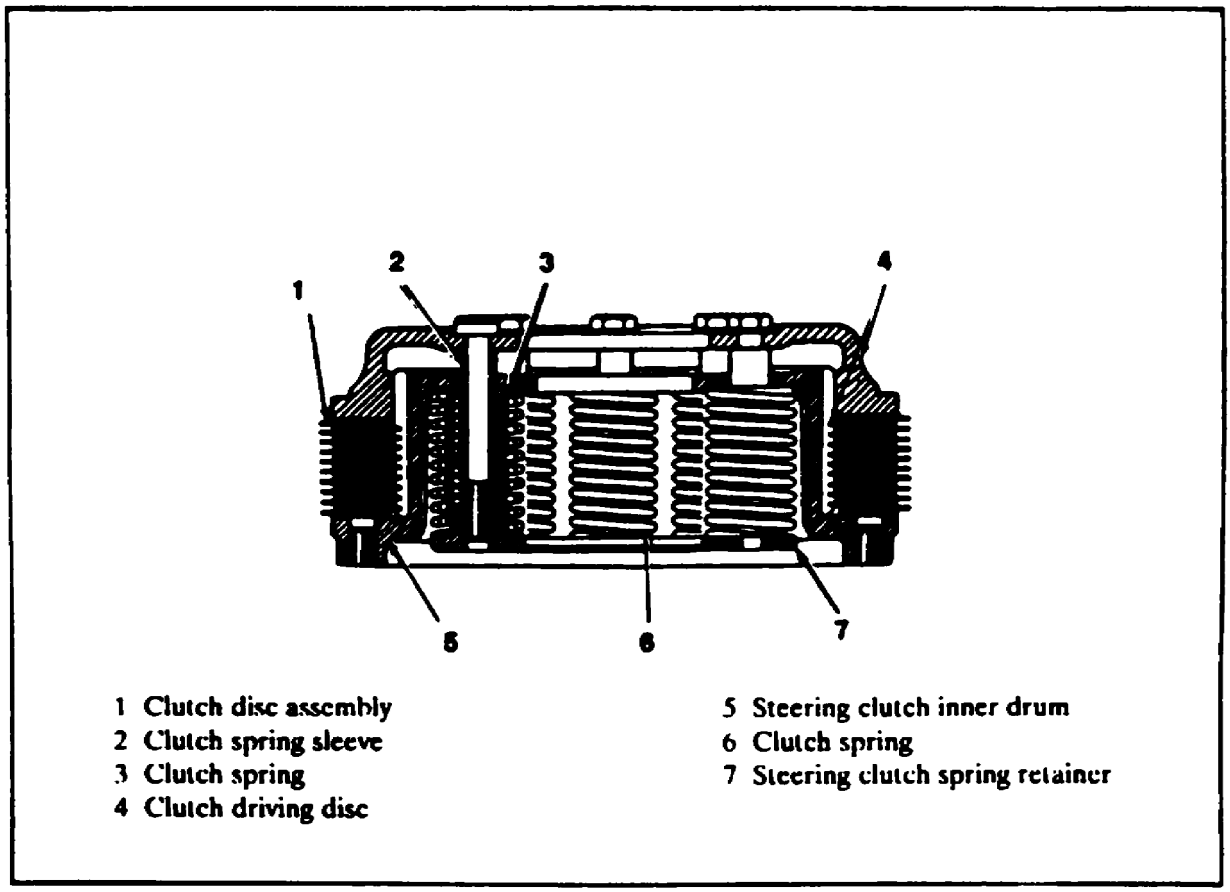


FIGURE 23. CLUTCH ASSEMBLY CROSS SECTION

Component		Manufacturer's dimensions and tolerance in Inches		Desired clearance		Maximum allowable wear and clearance
		Minimum	Maximum	Minimum	Maximum	
No 1 clutch, No 3 clutch and No 4 clutch						
Overall width of 3 new disc assemblies and 2 new plates	1 142-1 202 in					
No 2 clutch						
Overall width of 4 disc assemblies and 3 new plates	1 605-1 962 in					
No 5 clutch						
Overall width of 2 new disc assemblies and 1 new plate	679- 712 in					
Clutch piston release springs Nos 1 and 2 clutches						
Pounds force	28 60-33 60 in					
When compressed to	4 094 in					
Free length after test	5 094 in					
Spring diameter	563 in					
Clutch release springs Nos 3 4 and 5 clutches						
Pounds force	26 45 31 05					
When compressed to	1 884 in					
Free length after test	2 469 in					
Spring diameter	563 in					
Clutch reaction pins Nos 1 and 2 clutches						
Length	5 781 in					
Clutch reaction pins Nos 3, 4, and 5 clutches						
Length	8 25					
Shafts (planet gear) outside diameter		1 3877	1 3883			
Bevel gear						
Bevel gear and pinion backlash as marked on pinion gear (with pinion held in forward position)				0 015	0 016	
Bevel gear bearing preload						
Shims to be removed after end clearance taken up, approximately	013 in					
Or, torque to rotate	6-7 lb-ft					
Steering clutch						
Clutch springs						
Outer						
Pounds force	286-316					
When compressed to	3 90 in					
Inner						
Pounds force	185-205					
When compressed to	3 71 in					
Steering clutch hub-to bevel gear shaft press fit tons	35-40					
Dimensions between the face of the hub and the shoulder of the bevel gear shaft when pressed on with 35-40 tons	095 155 in					
Steering clutch (134 in thick discs)						
Overall width of 10 new disc assemblies and 9 new discs		2 923	3 189			

TABLE 5. REPLACEMENT STANDARDS

SITUATION 5

Now, reassemble all parts. Start by putting the steering clutch back together.

Step 1. Insert three 5/8-inch, number 11, forcing screws into the bolting flange of the outer drum until they touch the splines (Figure 24). This prevents the first clutch disc assembly from dropping below the end of the splines on the outer drum.

Step 2. Place the outer drum on blocks as shown in Figure 24.

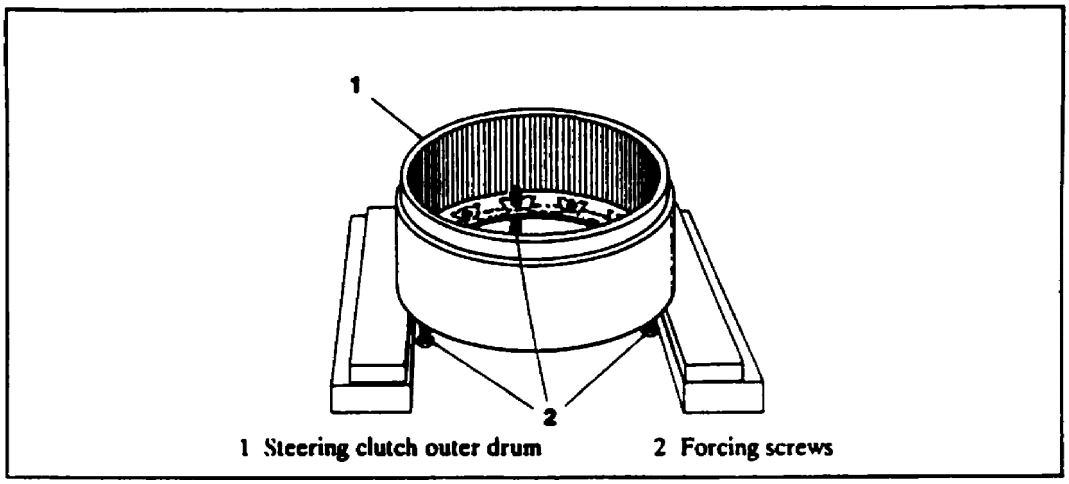


FIGURE 24. CLUTCH ASSEMBLY

Step 3. Install two 5/8-inch guide pins into the clutch spring retainer (Figure 25). Insert the bolt through the plate, placing the retainer on the plate and over the bolt. Place this assembly into the outer drum on blocks about 2 inches lower than the outer drum (Figure 25).

Step 4. Insert the clutch spring sleeves into the smaller clutch springs and then place the small springs and sleeves into the large clutch springs.

Step 5. Place the clutch springs and sleeves over the bosses on the clutch spring retainer.

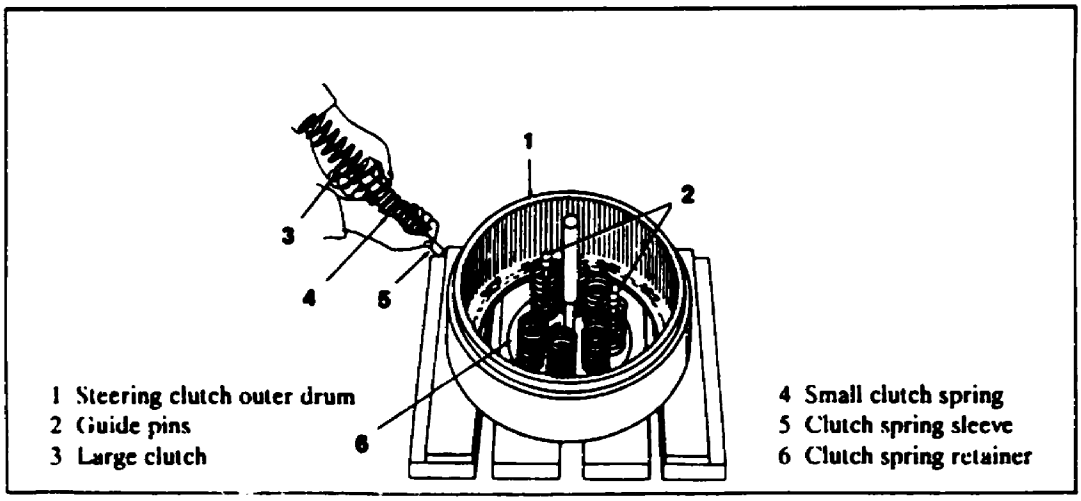


FIGURE 25. SPRINGS AND SLEEVES ASSEMBLY

Step 6. Place the inner drum on the guide pins and over the spring and sleeve assemblies (Figure 26).

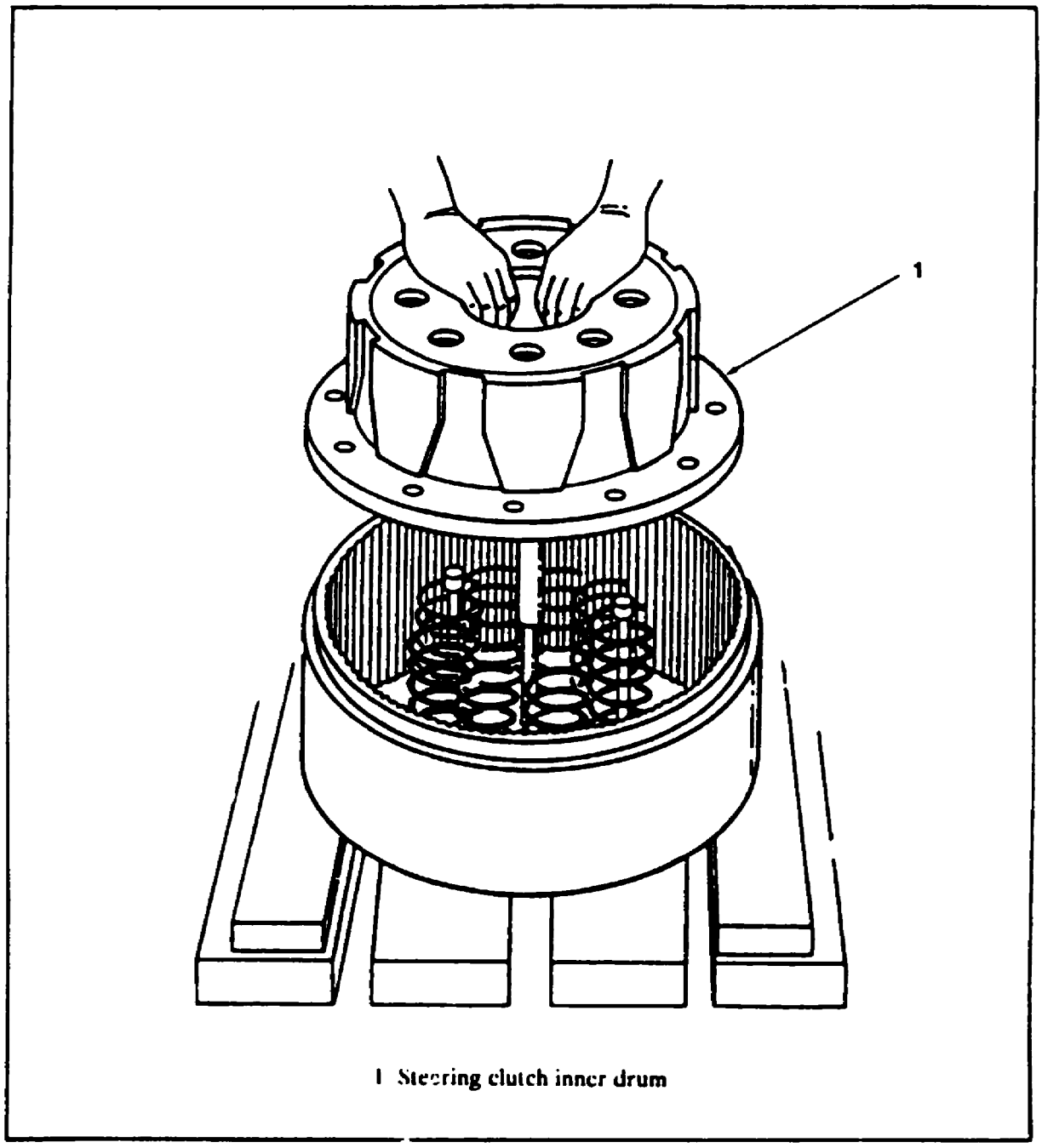


FIGURE 26. INNER DRUM INSTALLATION

Step 7. Now install the clutch discs.

NOTE: You numbered the clutch discs and marked the tops as you removed them (Step 4, Situation 4).

Replace the discs with the tops face up. For better wear distribution, install the clutch discs *last removed first installed.* Stack the discs in reverse order, placing the top one on the bottom, until all discs have been installed. Start with a clutch disc assembly (Figure 27) and follow with a clutch driving disc. Alternate from one to the other until all discs are installed.

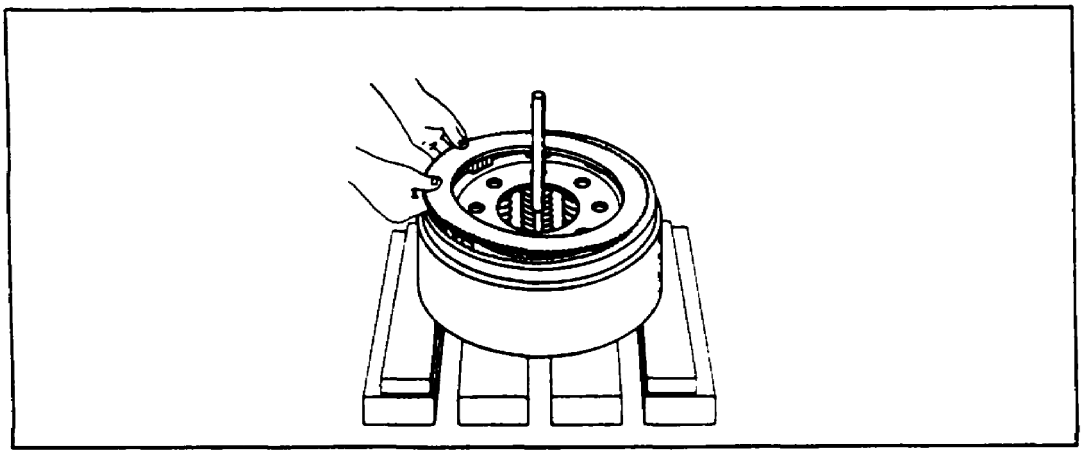


FIGURE 27. CLUTCH DISC INSTALLATION

Step 8. Place the pressure plate over the clutch discs as shown in Figure 28. Use the tow guide pins to align the holes in the plate with the tapped holes in the retainer.

Step 9. Install as many of the retaining bolts and locks as possible to serve as guides for the spring and sleeve assemblies.

Step 10. Compress the springs with the same tool arrangement used to disassemble the clutch assembly. Tighten the retaining bolts.

Step 11. Remove the compressor tools and guide pins and install the remaining bolts. Torque all bolts to 600 to 800 foot-pounds and bend the metal locks.

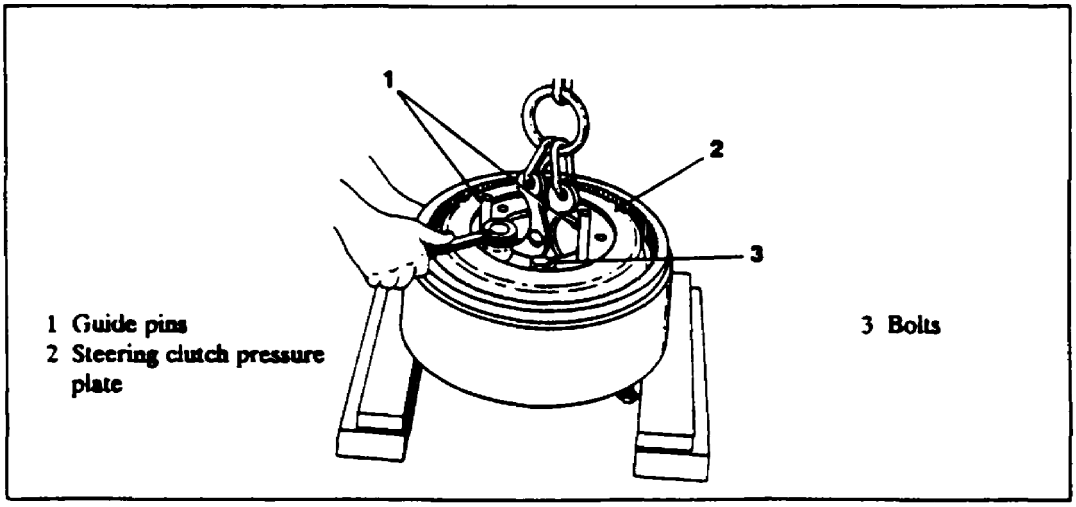


FIGURE 28. STEERING CLUTCH SPRINGS INSTALLATION

Step 12. Using a suitable lifting hook, remove the steering clutch assembly from the outer drum (Figure 29). Invert the outer drum, remove the forcing screws, and replace the outer drum on the steering clutch assembly.

Step 13. Install the brake band on the outer drum as shown in Figure 29.

SOLUTION 5

You assembled the steering clutch assembly, ensuring that each part was properly installed. After assembling the steering clutch, remove all bolts and guides and install the brake band on the outer drum.

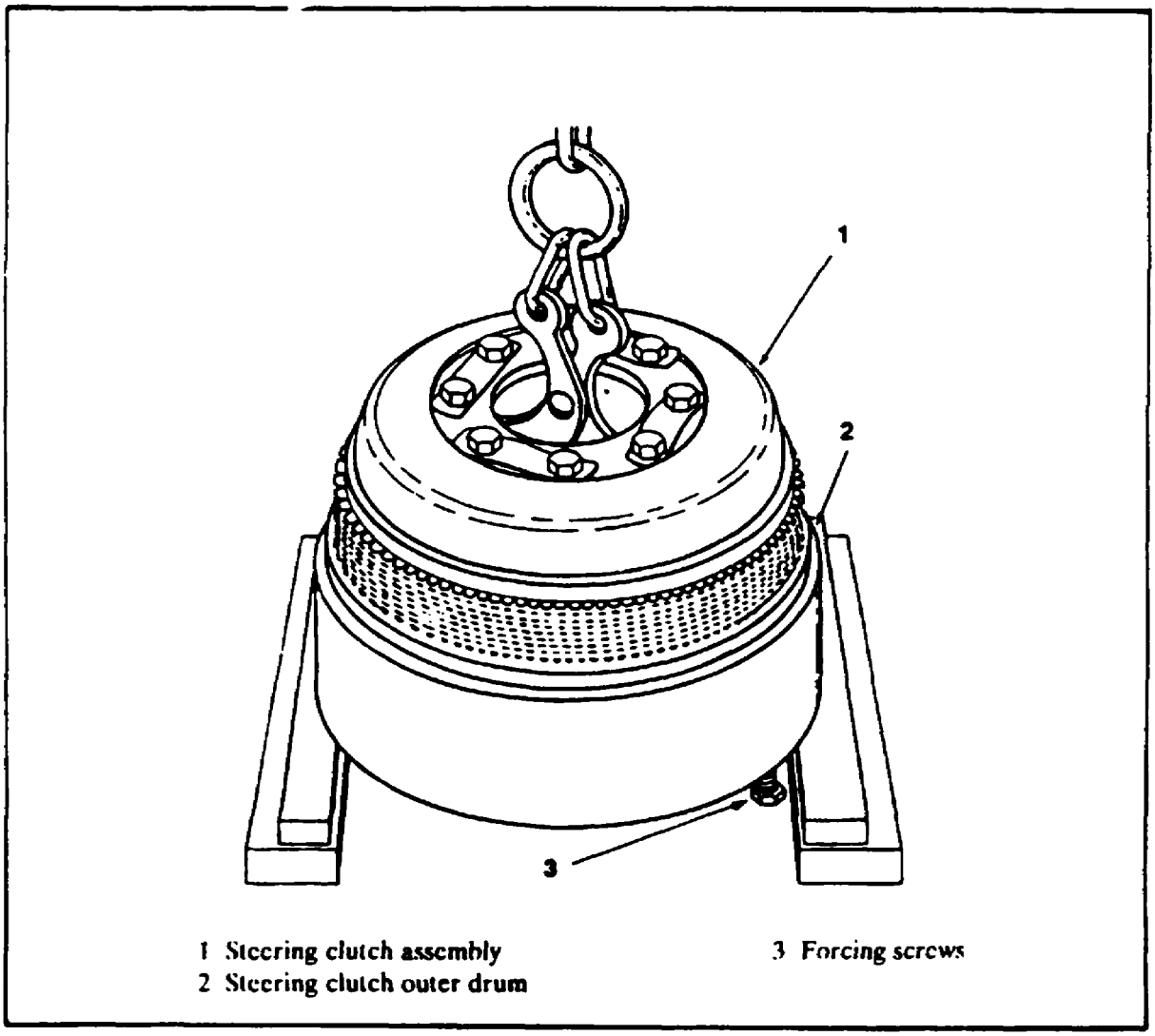


FIGURE 29. STEERING CLUTCH ASSEMBLY REMOVAL

SITUATION 6

Now, it is time to replace the clutch. Use the reverse order of the removal procedures.

Step 1. Place two .38-inch diameter rods, 6 inches long, through the holes in the brake band.

Step 2. Attach a hoist to the rods in the brake band.

Step 3. Lift the steering clutch into position as shown in Figure 28.

CAUTION

Keep the steering clutch assembly level while lifting. The clutch is free and could slide out of the outer drum. Use a strap to secure the clutch, but remove the strap before moving the clutch to the flange.

Step 4. The following procedure will let the flange on the pinion shaft and the steering clutch outer drum to draw together without binding. Install one bolt that secures the outer drum to the flange, but do not tighten the bolt too tightly. Place a jack under the track, raise the jack, and rotate the track 180 degrees. Install a second bolt that secures the outer drum to the flange and tighten this bolt securely.

Step 5. Install the remaining bolts, rotating the clutch assembly as necessary.

Step 6. After installing all bolts, use a torque wrench to torque all bolts to 180 to 220 foot-pounds.

SOLUTION 6

You lifted the clutch assembly into position without letting the clutch assembly fall out of the outer drum and installed all bolts, torquing them to 180 to 220 foot-pounds.

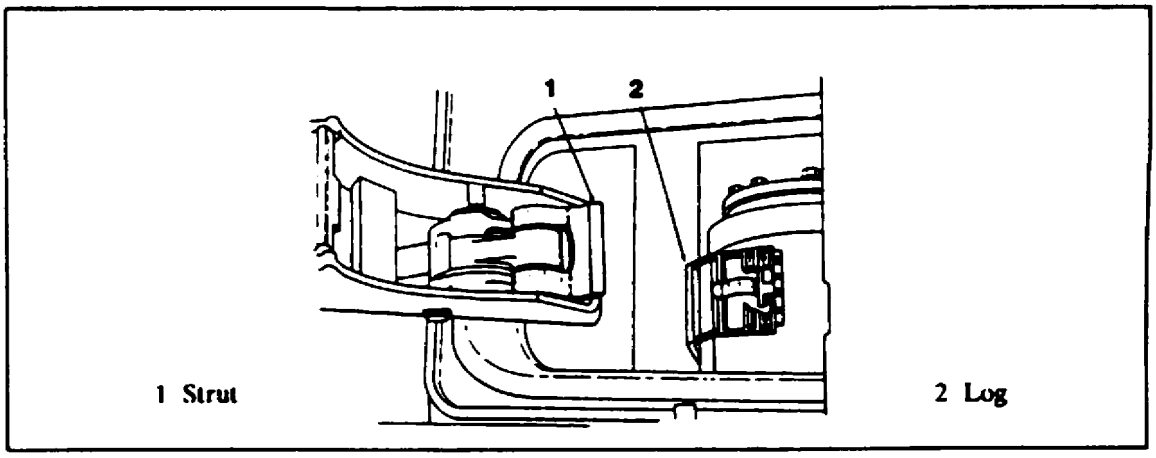


FIGURE 30. BRAKE ENGAGING MECHANISM

SITUATION 7

The next step is to install the brake actuating mechanism. Proceed as follows:

Step 1. Lift the brake actuating mechanism into position.

Step 2. Ensure the brake band struts engage the lugs on the brake band as you install the brake actuating mechanism (Figure 30).

Step 3. Install the bolts holding the brake actuating mechanism to the bevel gear case.

Step 4. Install the steering clutch cover (Figure 31).

Step 5. Install the steering clutch cover bolts. Torque these bolts to 100 ± 5 foot-pounds.

Step 6. Install the spring.

Step 7. Use the pin and cotter pin to secure the brake link to the brake lever.

Step 8. Connect the brake rod to the brake control lever.

Step 9. Install the cover and bolts.

Step 10. Install the rear support.

SOLUTION 7

You installed the brake actuating mechanism, ensuring that the brake struts engaged the lugs on the brake band, that all linkage was connected properly, and that all springs were attached and secured.

NOTE: Repeat the removal and installation procedures on both clutches.

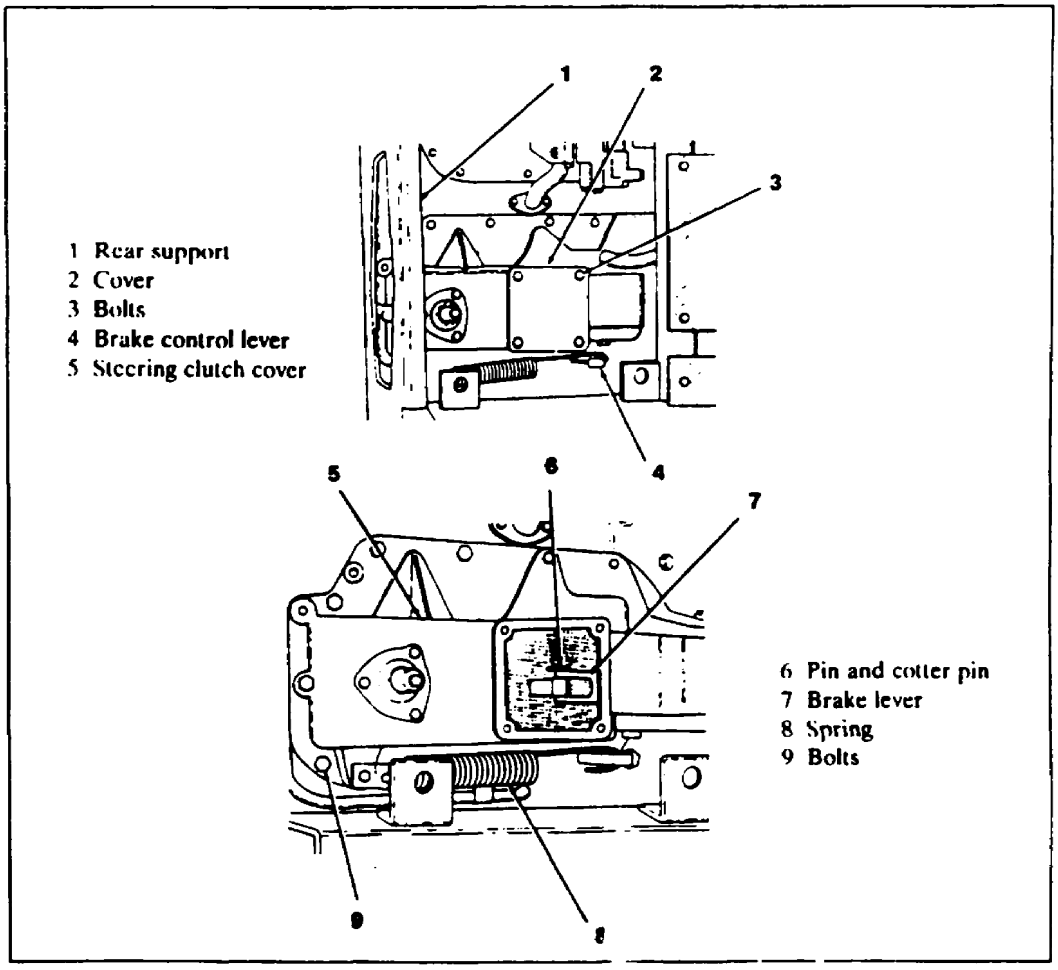


FIGURE 31. BRAKE ENGAGING MECHANISM INSTALLATION

SITUATION 8

Now, install the fuel tank, seat frame, and seat. Use the reverse order of the removal procedures.

Step 1. Attach a hoist to the two eyebolts which you installed in the light mounting brackets.

Step 2. Lift the fuel tank into position. Move the fuel tank slightly forward and to the left, lower it, and bring it back to the proper position.

Step 3. Install the mounting bolts (8, Figure 32) and bolts (4, Figure 32).

Step 4. Install the wires in the clip mounted on the front lower left corner of the fuel tank.

Step 5. Move the conduit back under the clip, tightening the clip and pulling the wiring back through the conduit to the left light bracket.

Step 6. Install the guard, making sure the ground wire is under the bolt.

Step 7. Install the grab iron.

Step 8. Remove the eyebolts placed in the light brackets for lifting. Install the lights and connect the light wires to the lights (5, Figure 32).

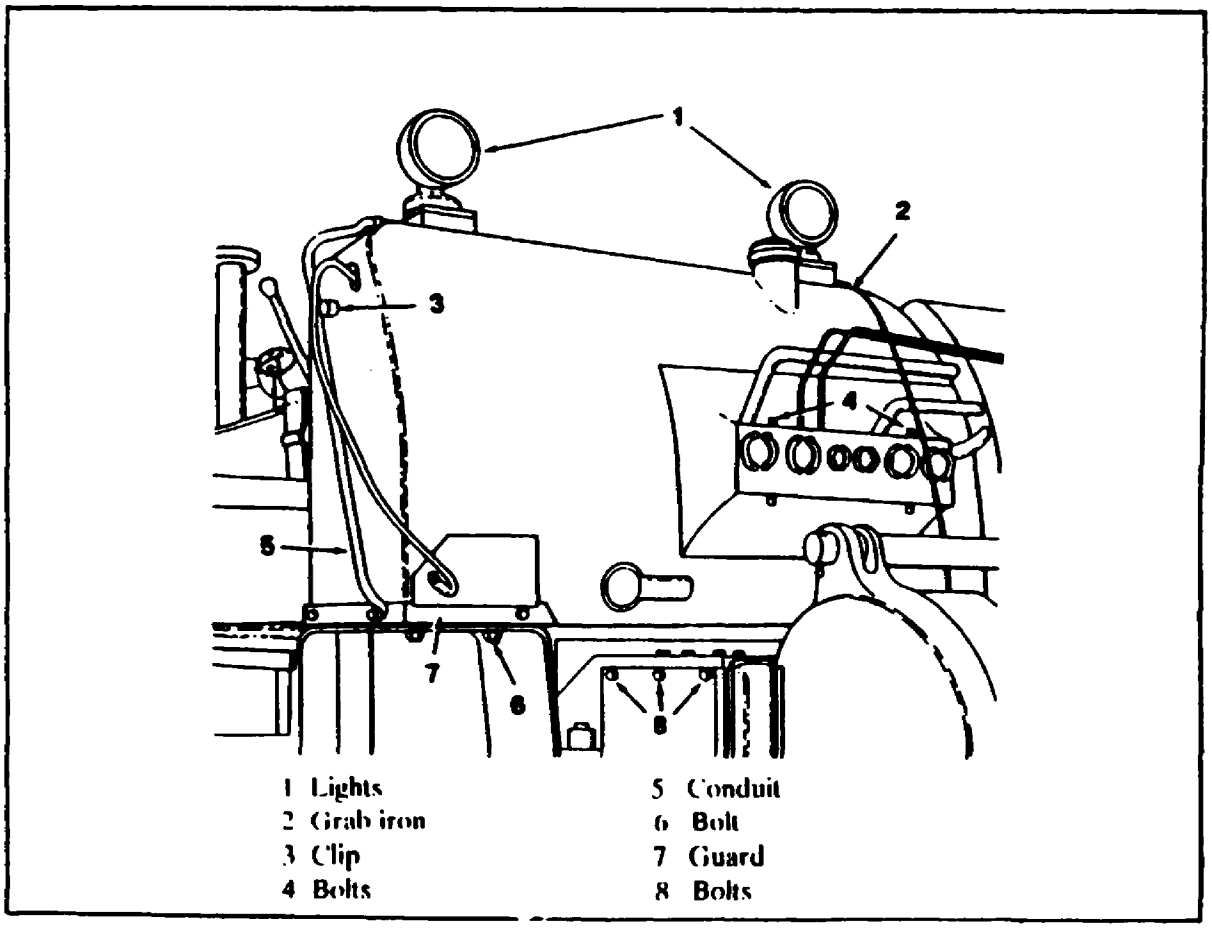


FIGURE 32. FUEL TANK INSTALLATION

Step 9. Install the scat frame (Figure 33).

- Use a hoist to lift the seat frame. Move the seat to the left, then into position.
- Install the mounting bolts.
- Reposition the linkage assembly and connect the rod to the linkage.
- Run the electrical cables through the seat frame opening and back to the battery box. Connect the cables to the batteries and tighten them.
- Connect the electric cable.
- Connect the transmission linkage.

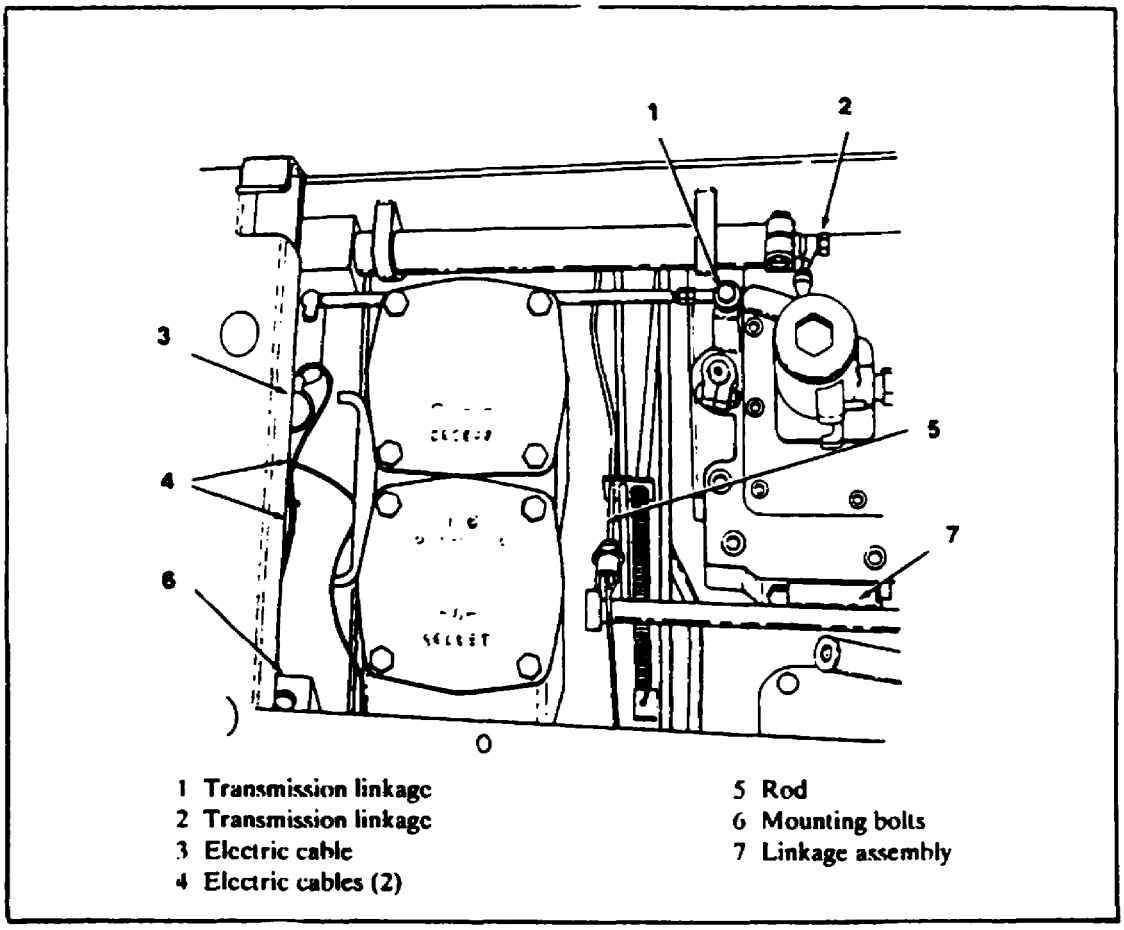


FIGURE 33. SEAT FRAME INSTALLATION

- Connect the brake lock linkage (Figure 14).
- Install the winch control levers and bracket.
- Install the left arm rest.
- Install the seat.

Step 10. Connect the fuel supply line and drain line to the fuel tank.

Step 11. Turn on the fuel shut off valve at the tank.

SOLUTION 8

You installed the fuel tank, seat frame, and seat. Also, you checked all fuel lines for leaks, tighten all electrical cables, and checked all linkages for proper installation and adjustment. Now, jack up the tractor. Remove all cribbing and return it to the storage area away from the work area.

You have replaced the steering brakes. Be sure to adjust the brake bands to compensate for their additional lining. Also test-operate the tractor to ensure it will steer properly.

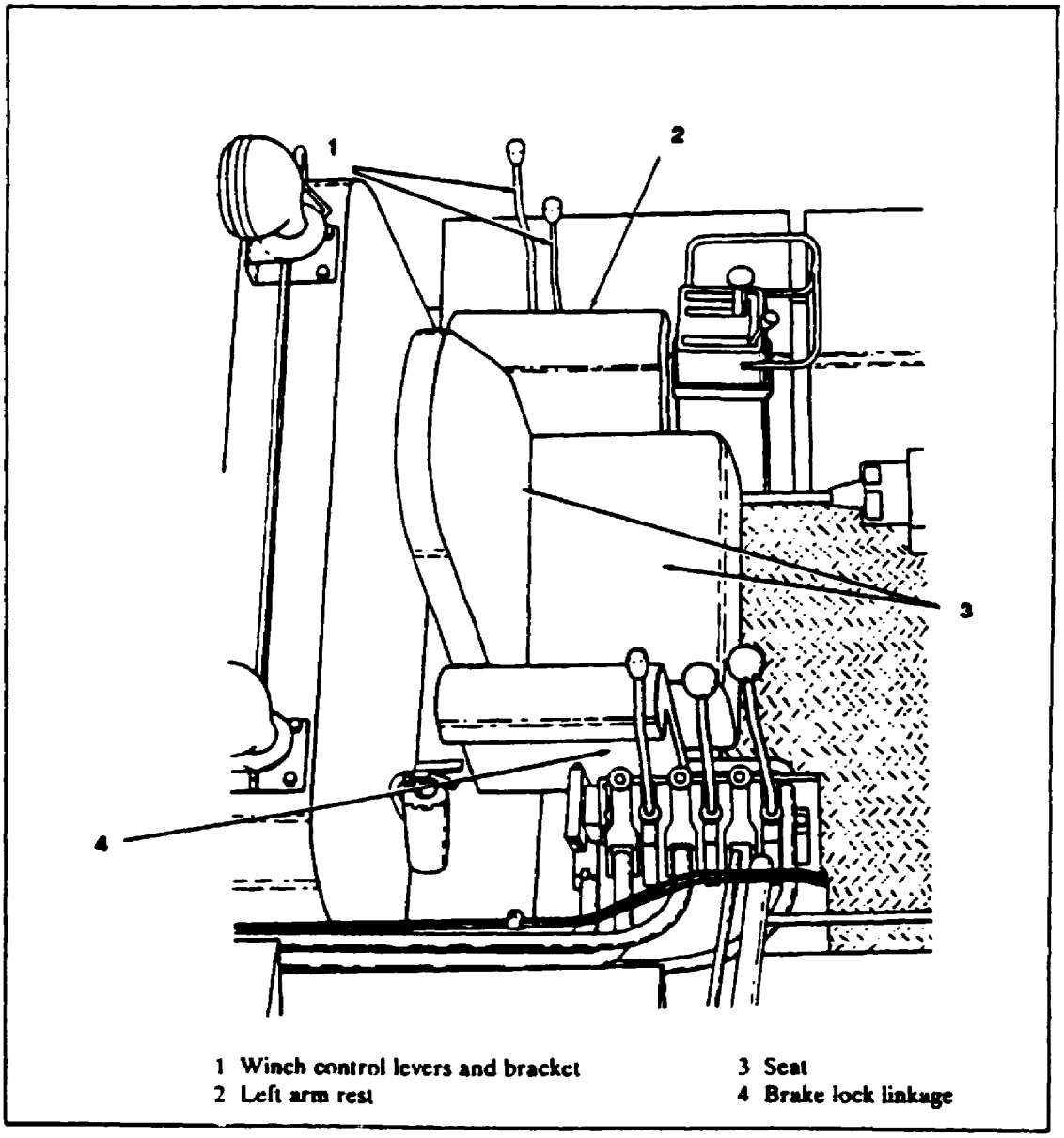


FIGURE 34. SEAT FRAME INSTALLATION

Lesson 1

REVIEW EXERCISE

Check your understanding of Lesson 1 by completing these review questions. Try to complete all the questions without looking back at the lesson. When you are finished, turn to the solutions on page 40 and check your responses. If you missed any questions, go back and study that section of the lesson again.

l. Where is the steering control valve located?

A. Under the steering control levers

B. On the steering clutch assembly

C. On top of the bevel gear case

D. Under the fuel tank

2. What is the brake pedal free travel measurement, in inches?

A. 15.67 to 16.87

B. 16.67 to 17.87

C. 17.67 to 17.87

D. 17.68 to 17.89

3. You are making the brake band adjustment. You must torque the adjusting screw to how many foot-pounds?

A. 13

B. 14

C. 15

D. 16

4. What do you use to check the pressure to the steering clutch control valve?

A. Multirange pressure gage

B. Hydraulic systems tester

C. Vacuum pressure gage

D. Air pressure gage

5. What is the correct pressure for the steering clutch pistons, in psi?

A. 200 to 230

B. 220 to 250

C. 230 to 260

D. 250 to 280

6. You art removing the fuel tank. Why must you remove the lights mounted on top?

   A. To keep from damaging the lights
   B. To provide clearance for removing the tank
   C. To remove the wires and conduit
   D. To install eyebolts so you can attach the hoist

7. You are removing the steering clutch assembly. Why must you rotate the track?

   A. To remove the bolts
   B. To remove the clutch discs
   C. To remove the clutch springs
   D. To remove the brake band

8. Within what fraction of an inch can the brake lining be from the rivets before you must replace the brake bands?

   A. 1/32
   B. 1/16
   C. 1/8
   D. 1/4

9. You are installing the pressure plate retaining bolts. You must torque them to how many foot-pounds?

   A. 300 to 500
   B. 400 to 600
   C. 500 to 700
   D. 600 to 800

Lesson 1
REVIEW EXERCISE SOLUTIONS

1. c (page 22)
2. B (page 11)
3. C (page 12)
4. A (page 14)
5. D (page 14)
6. D (page 21)
7. A (page 24)
8. B (page 25)
9. D (page 31)

Lesson 2

POWER STEERING SYSTEM

TASK: Describe how to operate a power steering system, troubleshoot a power steering system, and replace a steering control valve.

CONDITIONS: You will be given information describing how to operate a power steering system, troubleshoot a power steering system, and replace a steering control valve.

STANDARDS: Study the lesson until you can answer all of the review questions. You must correctly answer 70 percent of the examination questions.

This objective supports STP 5-62B24-SM-TG, Task 051-235-2521, Replace a Steering Valve.

CREDIT HOURS: 2

REFERENCES

TM 5-2420-222-14& P- 1

TM 5-2420-222-14&:P-2

DA Pam 738-750

Learning Event I

FUNDAMENTALS OF A POWER STEERING SYSTEM

Steering systems are important to off-the-highway construction equipment. These vehicles are difficult to steer because they are large and heavy and often operate on soft, uneven ground. Power steering systems reduce the effort required to turn the steering wheel.

You must know the parts of power steering systems for different kinds of construction equipment. You also must know how to diagnose malfunctions in these systems and repair and replace parts.

A review of the steering system on an automobile will help you understand the more complicated systems on construction equipment because many of the basic parts are the same.

AUTOMOBILE STEERING SYSTEM

The steering wheel on an automobile turns right and left and is attached to the end of the steering shaft (Figure 35). A worm gear at the bottom of the shaft rotates as the steering wheel turns.

The worm gear engages a section gear (Figure 36) which is a partial gear that pivots slightly to the right or left at the center. However, the section gear cannot turn the worm gear.

A lower extension of the section gear is the steering arm or pitman arm (Figure 37). The steering arm is connected to one of the two front wheels and moves as the steering wheel turns. The two front wheels are attached to a single axle with a pivot pin or king pin (Figure 38). The pivot pin acts as a hinge allowing each wheel to move from side to side.

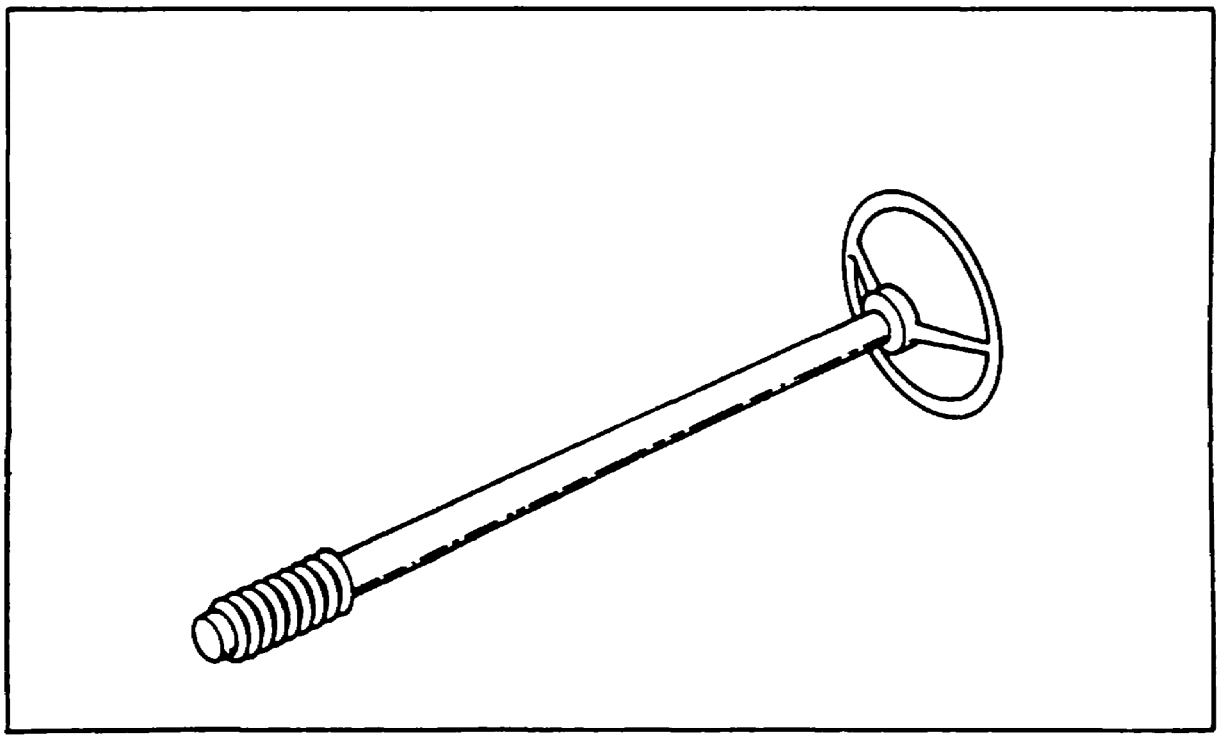


FIGURE 35. STEERING COLUMN AND WORM GEAR

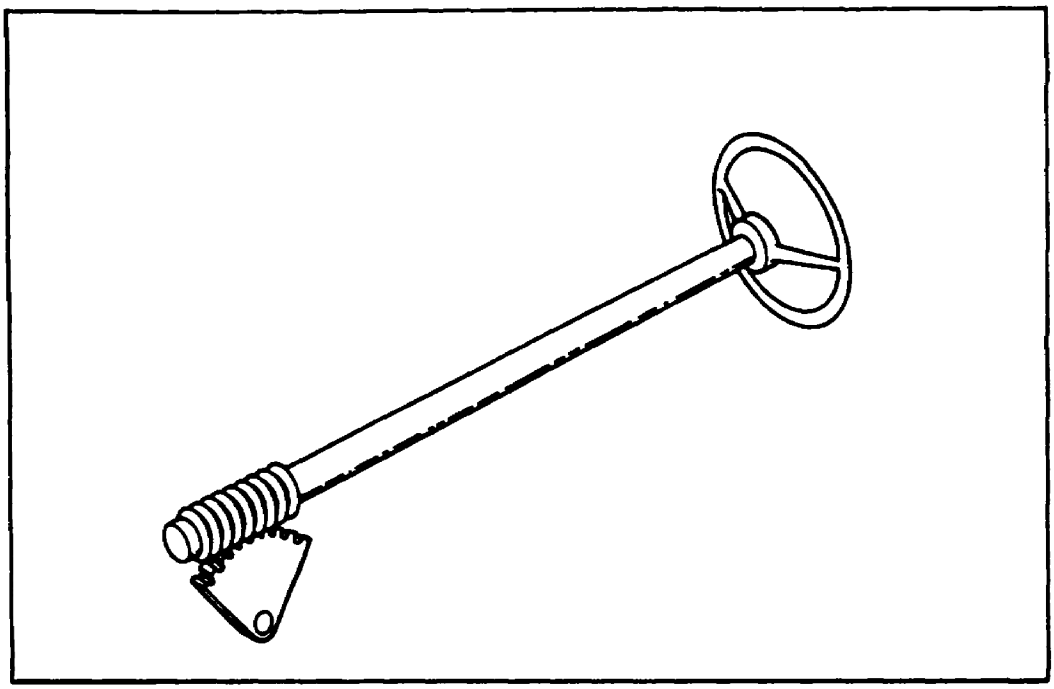


FIGURE 36. SECTION GEAR

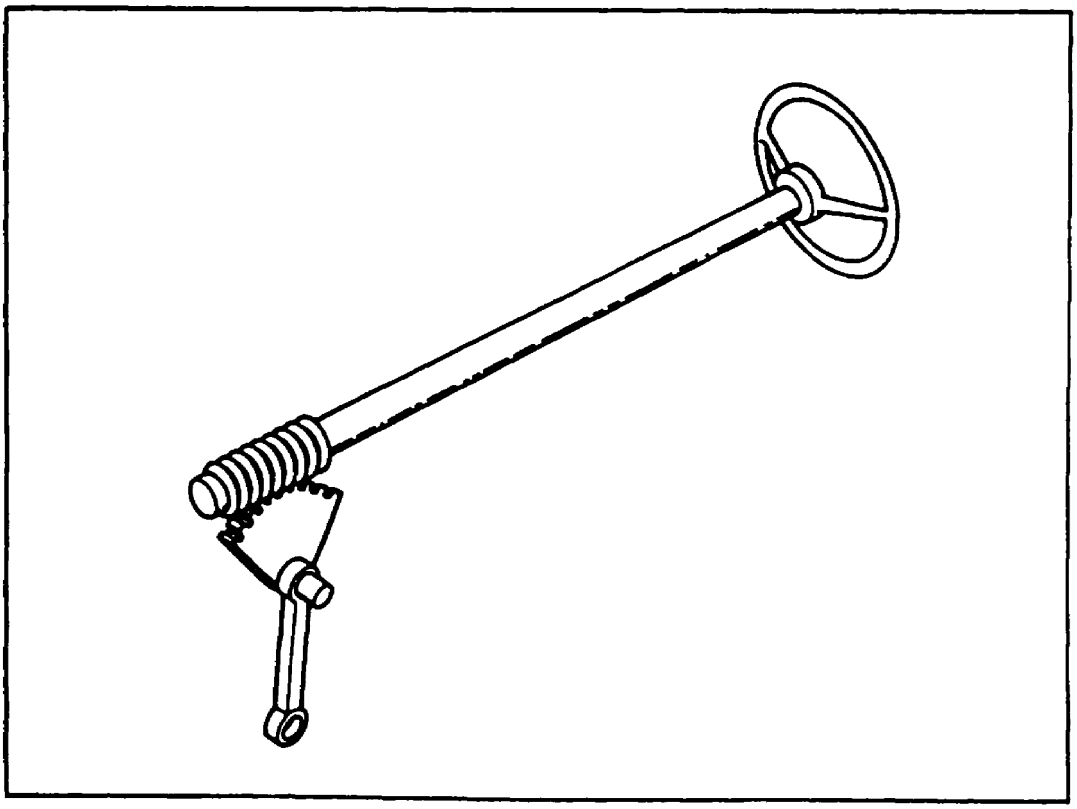


FIGURE 37. STEERING ARM (PITMAN ARM)

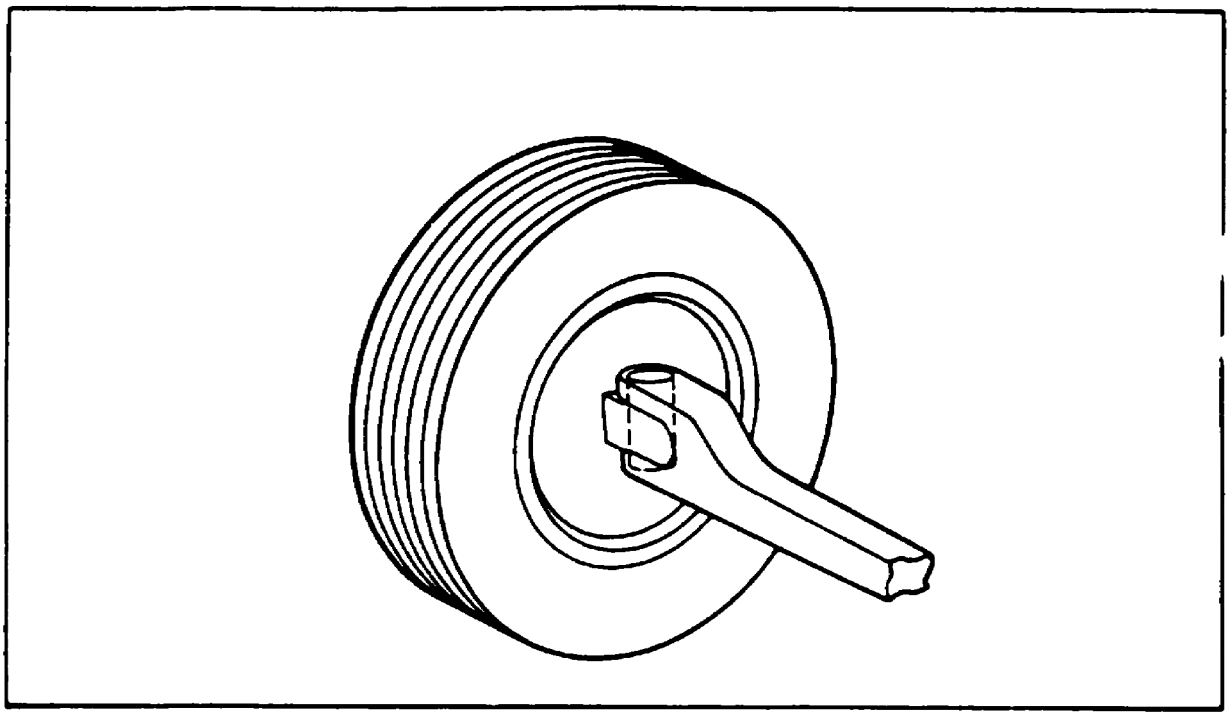


FIGURE 38. PIVOT PIN

A steering control arm connected to one wheel (Figure 39) acts like a lever or handle. It controls wheel movement and turns the wheel.

A rod or drag link (Figure 40) connected to the control arm leads back to the steering arm. The steering arm pushes and pulls the drag link and turns the wheel.

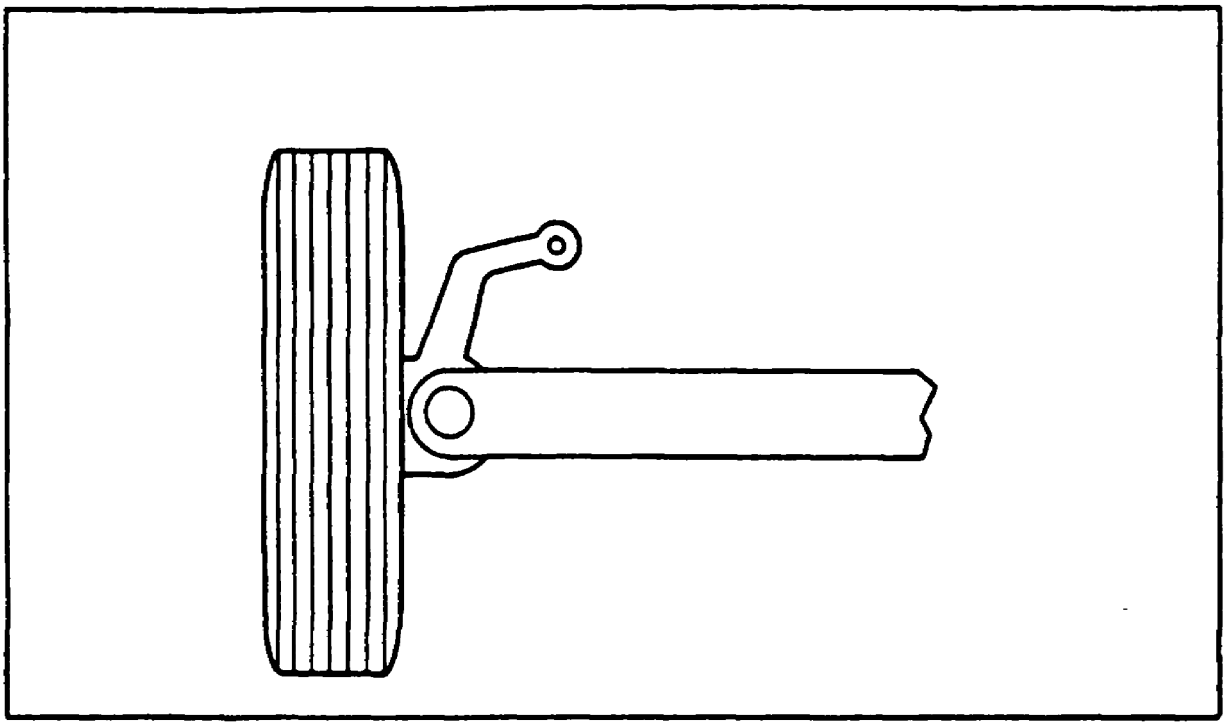


FIGURE 39. STEERING CONTROL ARM

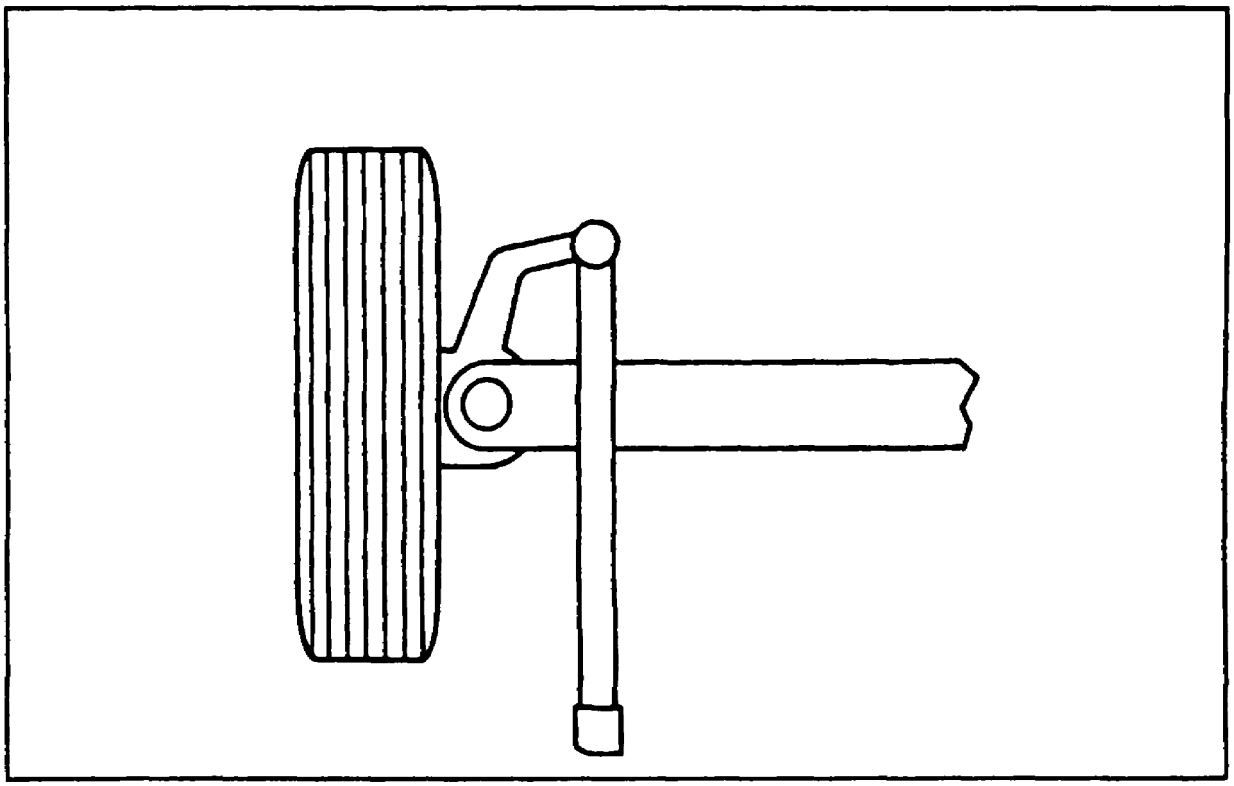


FIGURE 40. DRAG LINK

Because the steering mechanism is connected to only one wheel, the wheels must be made to move together. This is accomplished by connecting a tic rod or track rod to an extension of the control arm (Figure 41). The tie rod forces both wheels to operate together, even though only one is turned by the steering wheel. When one wheel strikes a curb or stone, the worm gear arrangement helps keep the steering wheel from being jerked out of the driver's hands.

CONSTRUCTION EQUIPMENT STEERING SYSTEMS

While many of the basic parts of steering systems for automobiles and construction equipment are the same, there are differences (Figure 42). For example:

- Tractors such as the JD410 have front wheels that turn like automobile wheels, but some loaders have rear wheels that turn.
- Three-axle scrapers are drawn by a tractor with front wheels that turn.
- Articulated steering systems on some construction equipment pivot in the middle. This two-axle design is used on some scrapers, wheeled dozers. compactors, and wheeled loaders. Figure 42 shows several kinds of steering systems on engineer construction equipment.

Steering large engineer construction equipment is more difficult than steering an automobile because they have larger tires, larger area of ground contact, and greater ground resistance. Also, these machines often operate on soft or muddy ground where manual steering would require too much effort. We could lessen the effort by using higher gear ratios, but this would be impractical because steering would be too slow. So, we must resort to power steering systems.

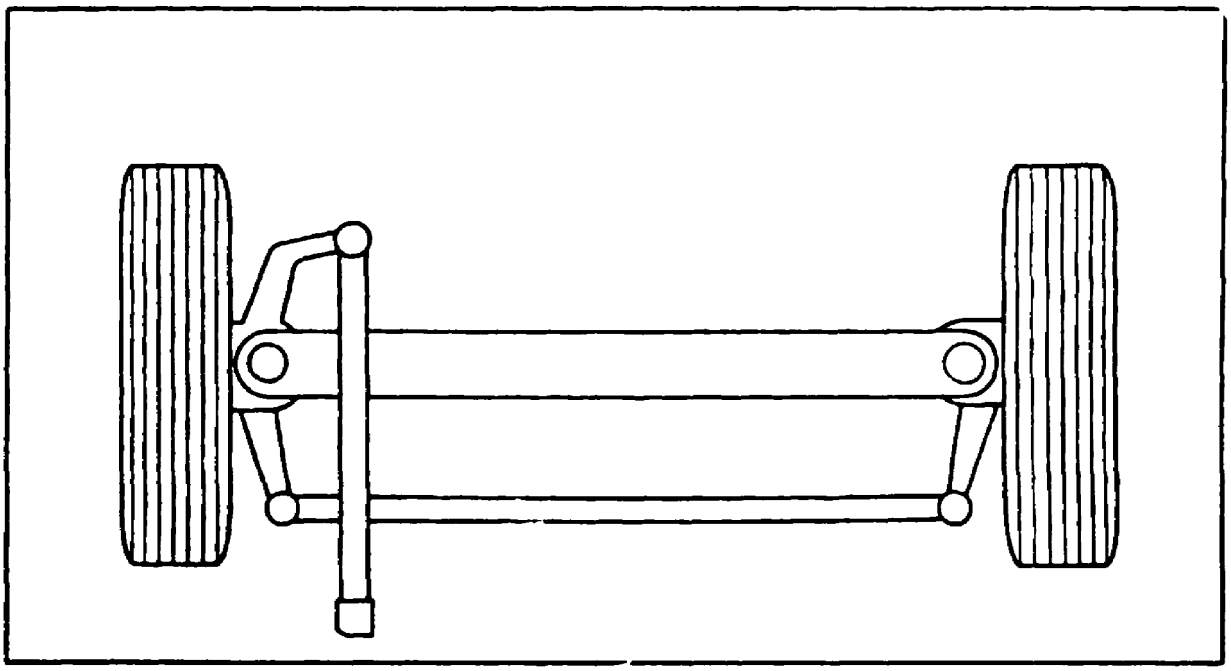


FIGURE 41. TIE ROD

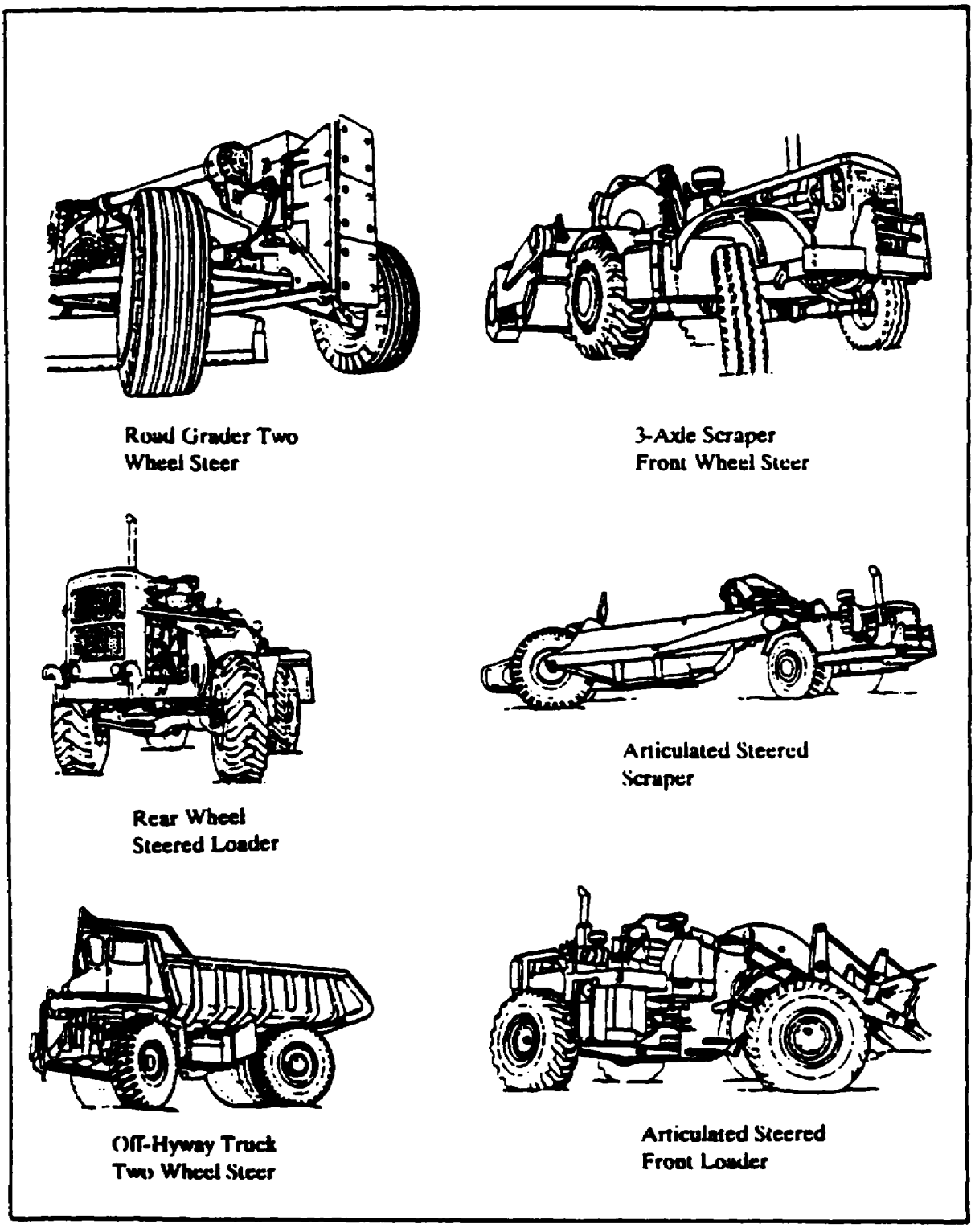


FIGURE 42. STEERING SYSTEMS ON CONSTRUCTION EQUIPMENT

The power steering system reduces the effort required to turn the steering wheel and lets the equipment operator maneuver the vehicle easily and precisely. If hydraulic cylinders are attached to control arms on the equipment, hydraulic fluid or oil in the cylinders can move the wheels. For example, as the pistons move to the left, the wheels also turn left (Figure 43).

The question is, how do we *control* the flow of hydraulic oil to the steering cylinders? We want the wheels to turn only as *fast* and as *far* as the steering wheel turns.

The hydraulic steering control on a two-axle scraper (Figure 44) consists of the mechanical steering assembly, the hydraulic valve mechanism, and the hydraulic system which includes a tank, hydraulic pump, and steering cylinders.

From the front, the steering system resembles an automotive steering unit (Figure 45). It has a worm gear on the shaft, a nut gear that moves up and down, a section gear, and steering or pitman arm on the left. However, the hydraulic steering system on the scraper operates quite differently than the manual steering system on an automobile.

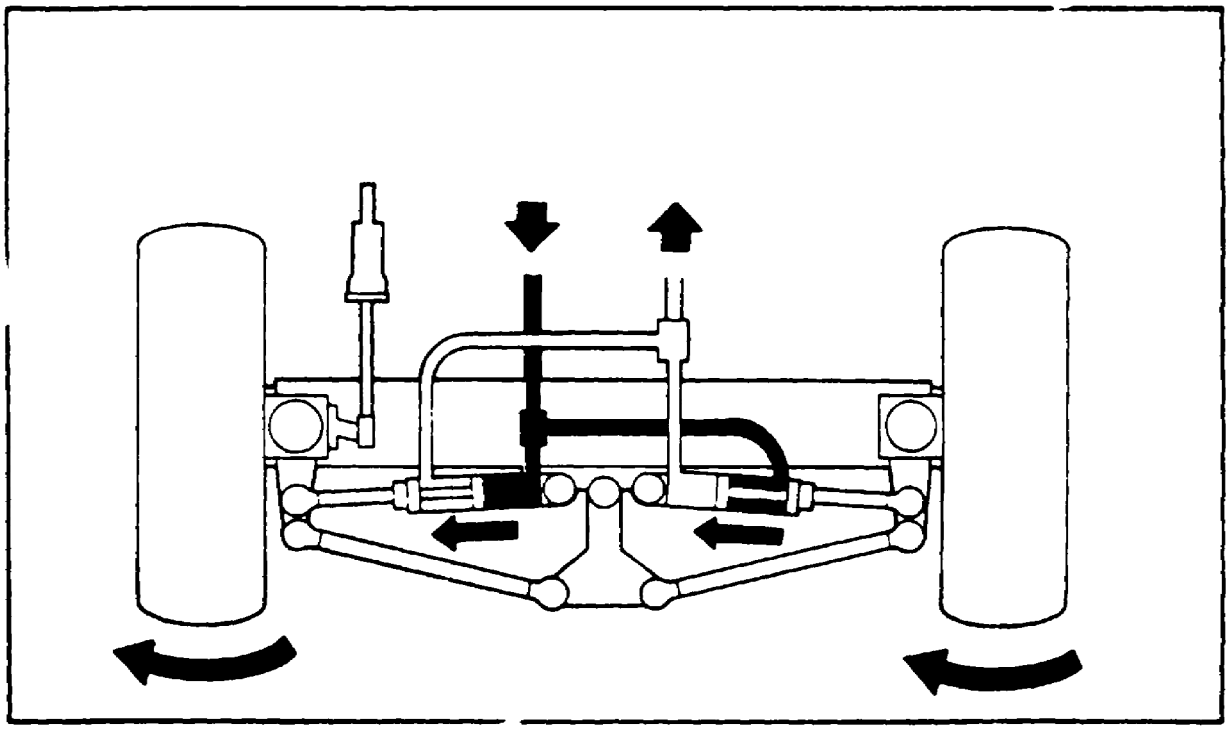


FIGURE 43. HYDRAULIC CYLINDERS ADDED TO CONTROL ARMS

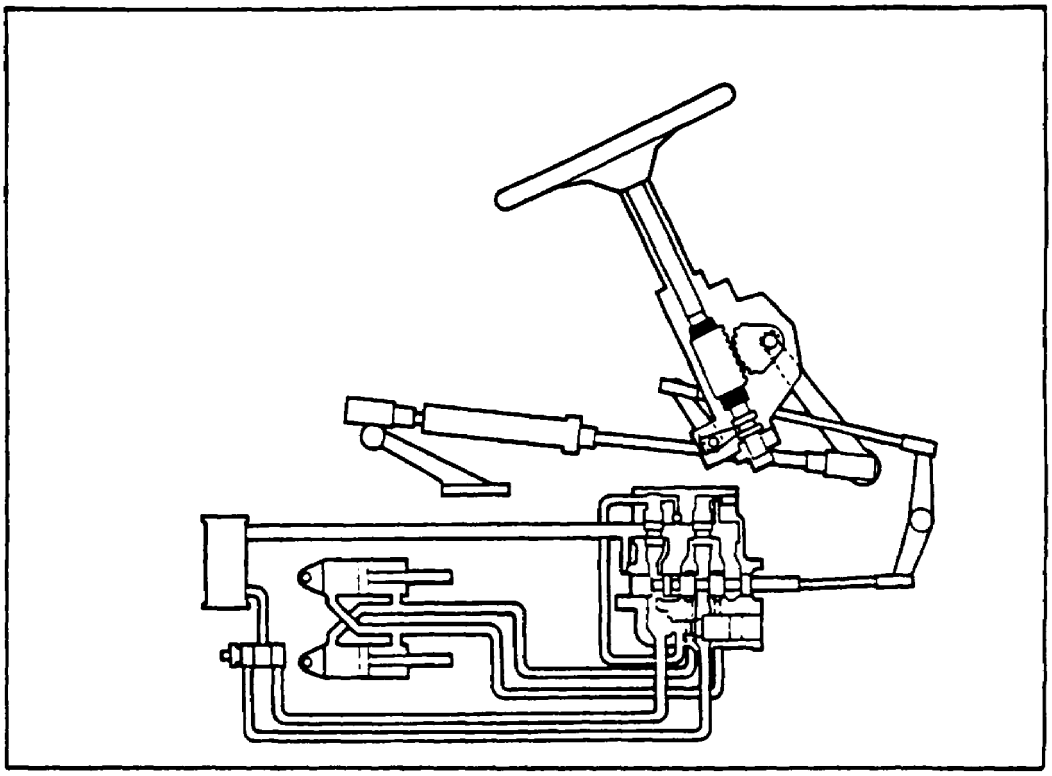


FIGURE 44. HYDRAULIC STEERING CONTROL

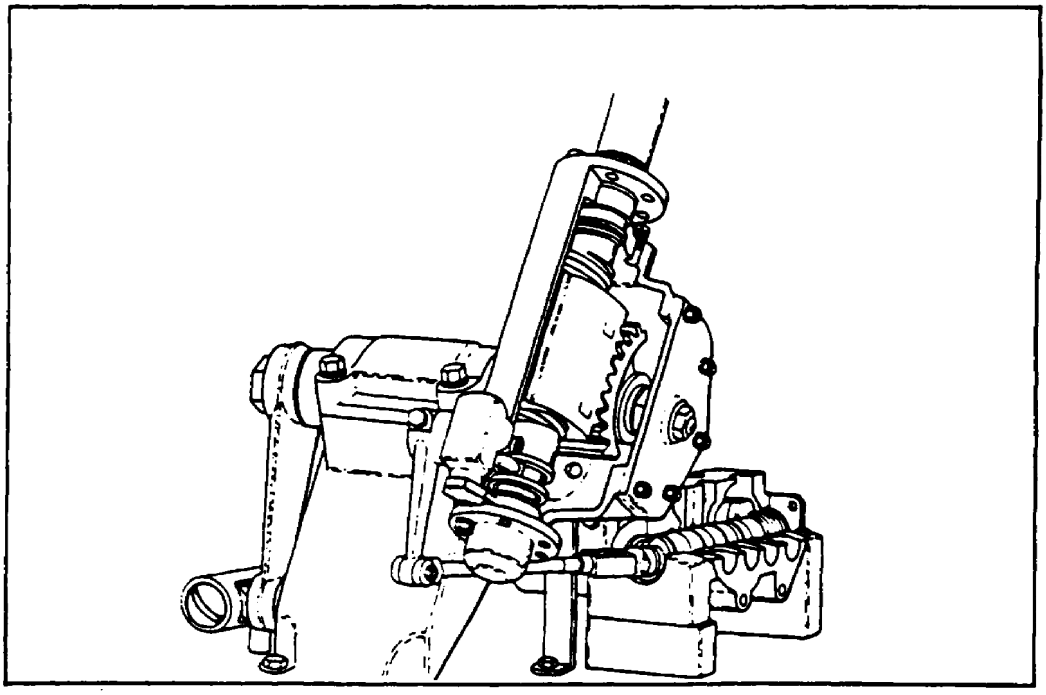


FIGURE 45. CUTAWAY OF A HYDRAULIC STEERING CONTROL

TYPICAL STEERING SYSTEM

Let us see how a theoretical steering system (Figure 46) works. On an automobile, the steering wheel worm turns inside a threaded, unmoving part called the restraining member. When the steering wheel turns, the worm gear moves up or down. If a hydraulic control valve is connected to the lower end of the worm gear, the spool in the valve moves up or down when the steering wheel turns.

Figure 47 shows a complete hydraulic system. The restraining member forces the worm gear to move up and down. The hydraulic tank, at the bottom left, contains oil that the hydraulic pump pressurizes and delivers to the control valve. A hydraulic cylinder, to the right of the control valve, moves the wheels.

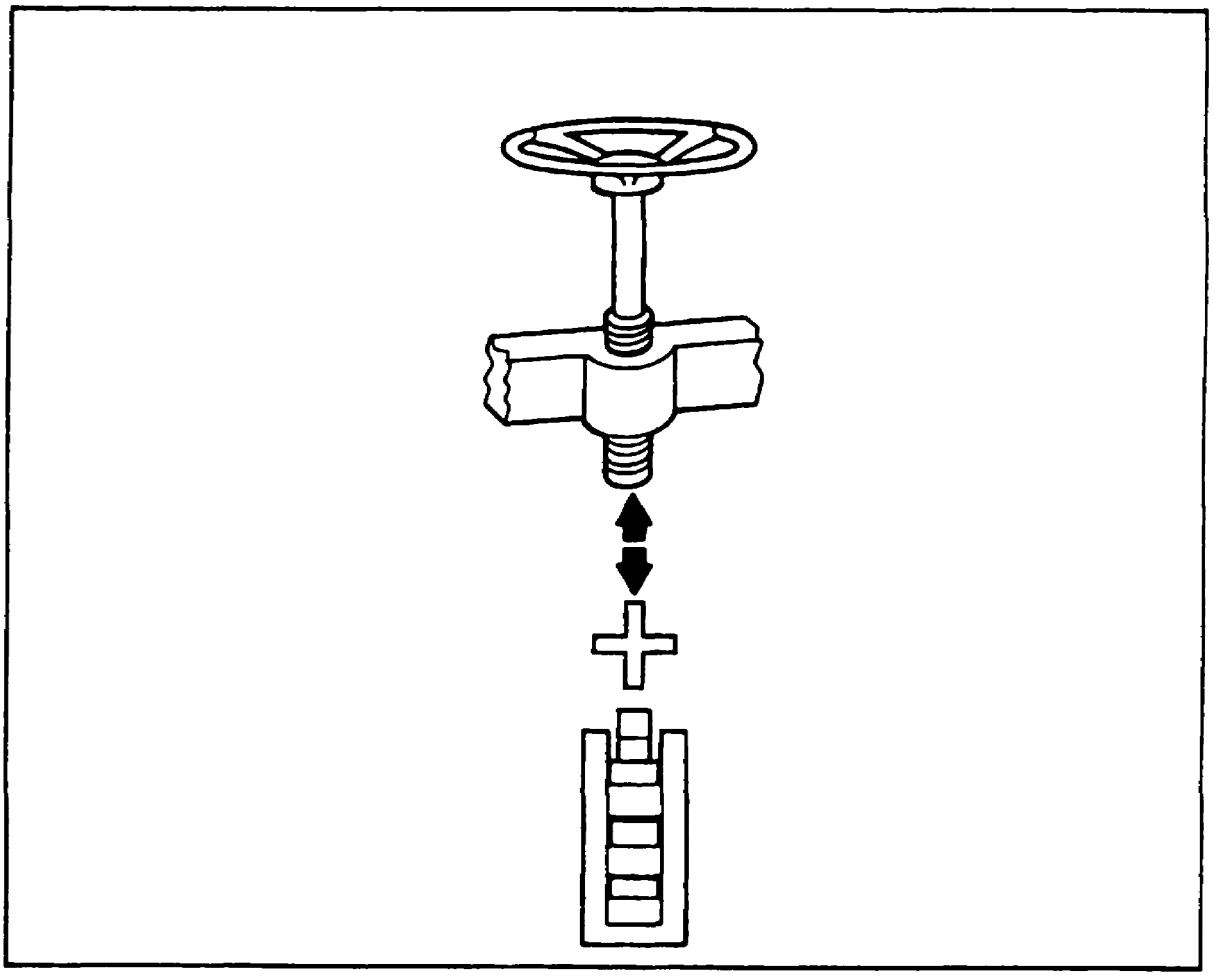


FIGURE 46. TYPICAL STEERING SYSTEM

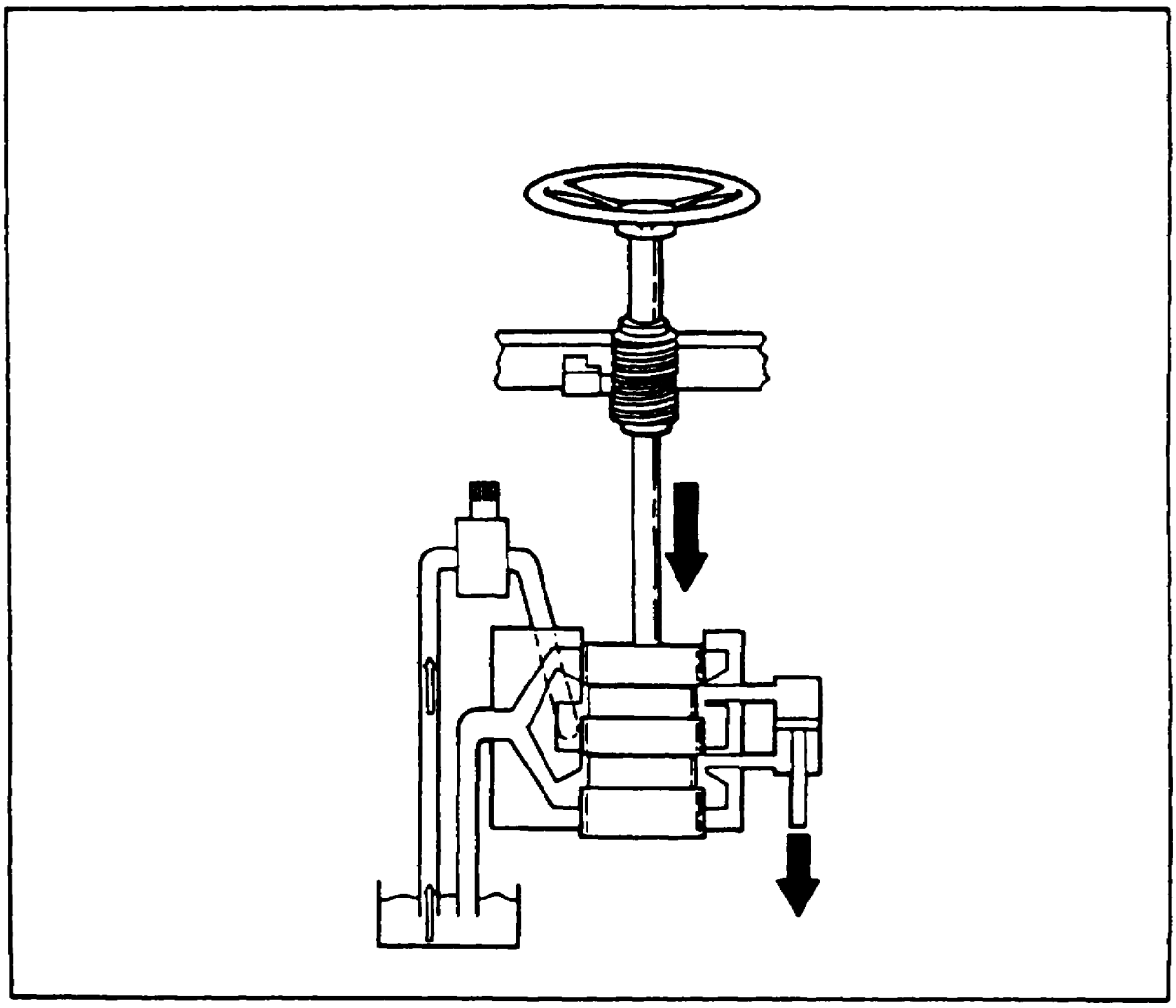


FIGURE 47. COMPLETE HYDRAULIC STEERING SYSTEM

Because the control valve spool movement is small, the steering wheel shaft must move up or down only slightly to change the direction of the oil flow. For example, the shaft at the left (Figure 48) is down. Oil flows from the port at the left center of the spool and around the top groove to the cylinder head. When the steering wheel turns in the opposite direction, the spool rises and reverses the direction of the oil flow.

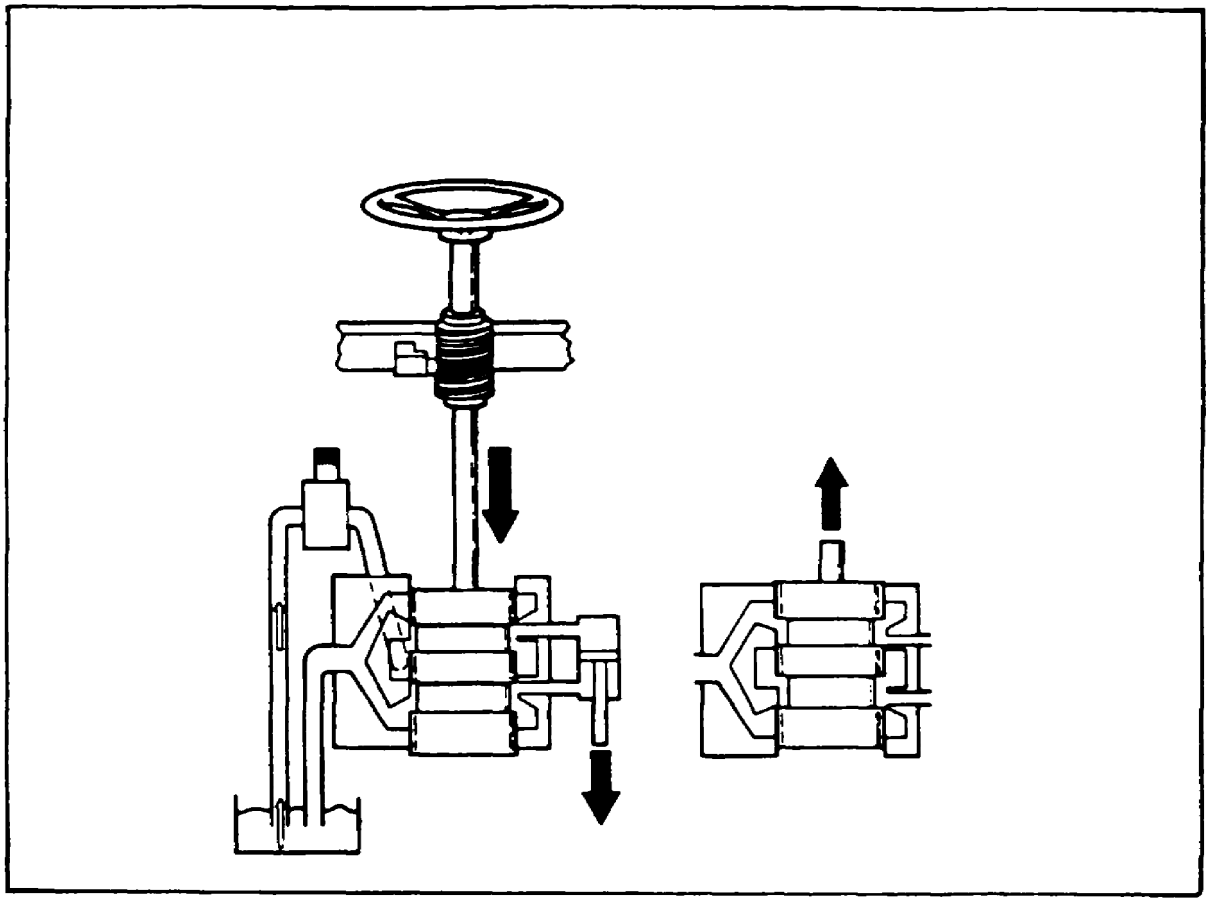


FIGURE 48. CONTROL VALVE SPOOL MOVEMENT

When the control valve spool is in the neutral (center) position (Figure 49), the oil flow to either end of the cylinder is not completely blocked. The oil returning to drain acts on both ends of the cylinder. This type of system is called open center steering

Open center steering allows for some wheel deflection. The oil can flow through the valve from one end of the cylinder to the other, but oil at both ends quickly stops any further movement. If the cylinder is completely blocked, there is no way to absorb the shock when the wheel hits a rock or other obstruction. The wheel or hydraulic cylinder would receive the full impact of the blow and might be bent or otherwise damaged.

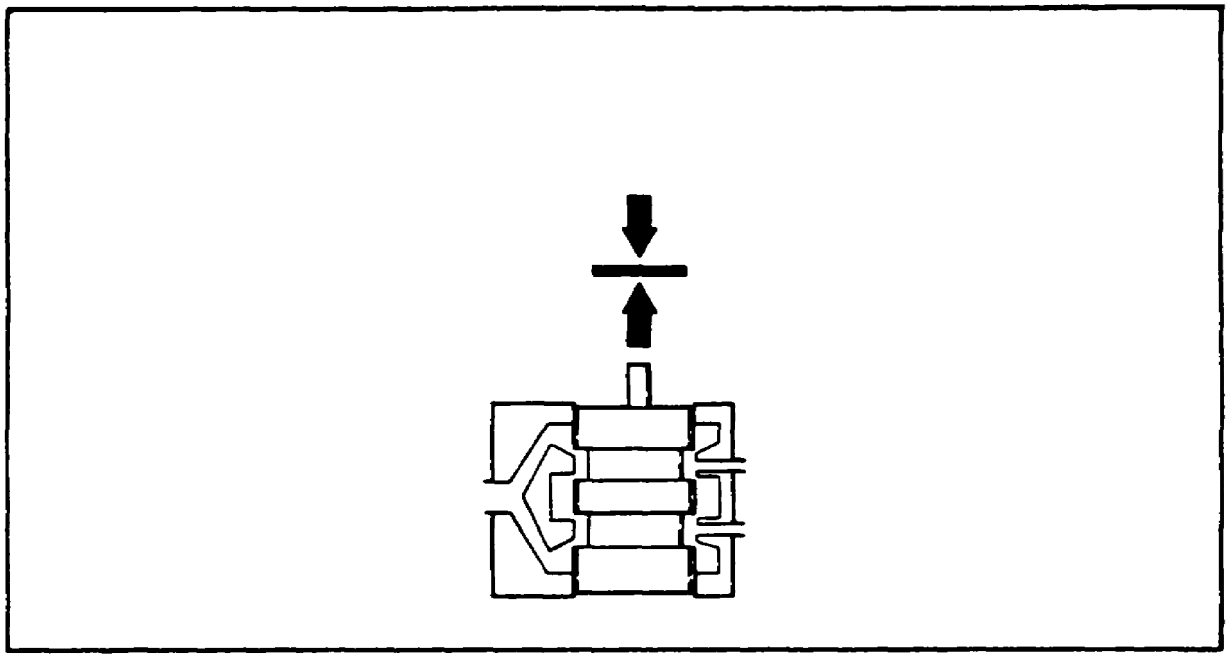


FIGURE 49. STEERING CONTROL VALVE IN NEUTRAL POSITION

Flexible hoses carry oil to the steering cylinder (Figure 50). The follow-up linkage signals to stop the flow of oil when the wheels have turned far enough. As stated earlier, front wheel movement should match that of the steering wheel -- turning no further or faster than directed. Another device must signal the turning of the wheels to the control valve to stop the flow of oil when the wheels have turned far enough.

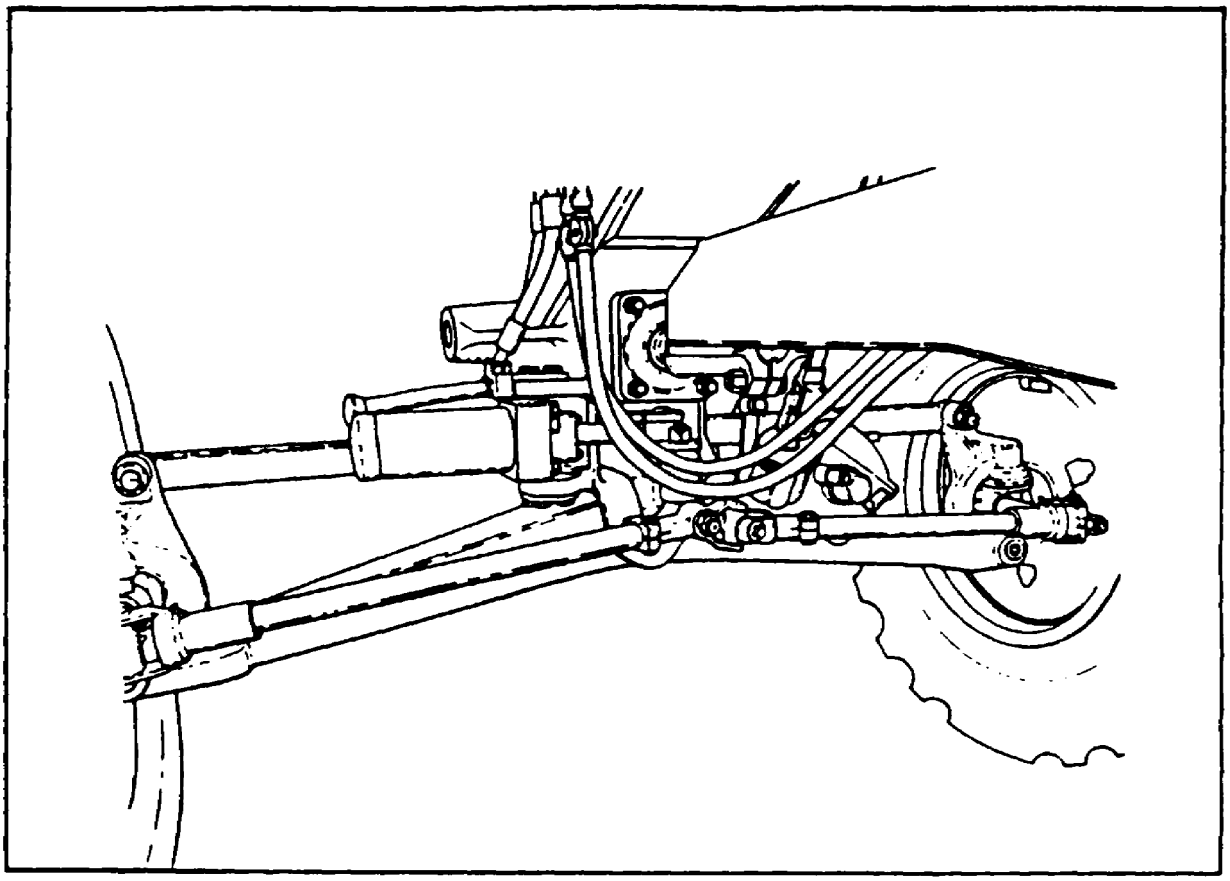


FIGURE 50. STEERING CYLINDER HOSES

The follow-up linkage, a mechanical connection between the wheels and the steering shaft, links the control arm to the restraining member (Figure 51). The follow-up linkage functions like the drag link on an automobile. The upper end of the linkage connects to the restraining member.

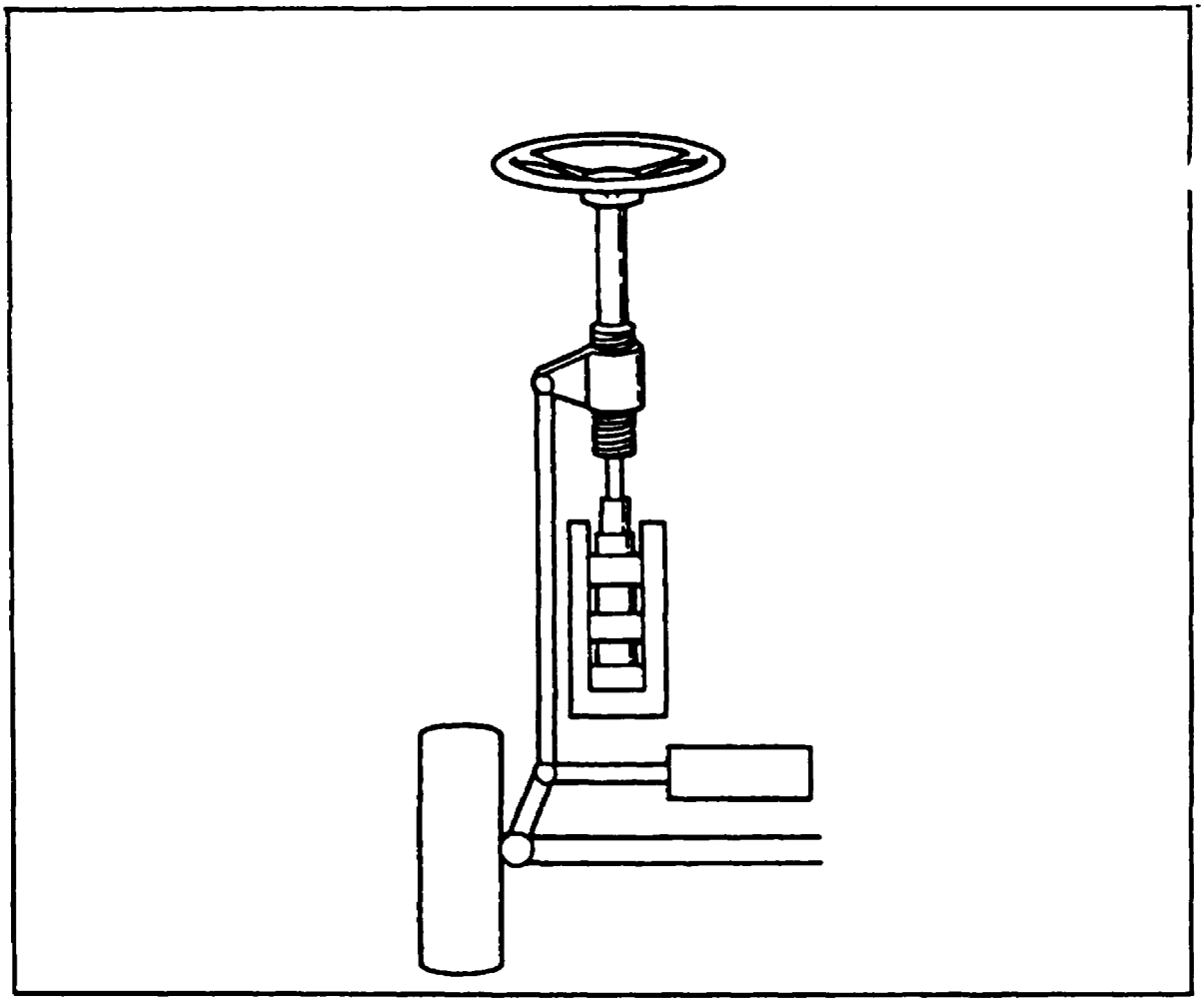


FIGURE 51. FOLLOW-UP LINKAGE

Hydraulic oil flow starts when the steering wheel turns (Figure 52). The follow-up linkage stops the oil flow when the wheel movement corresponds to the steering wheel movement. A slight upward or downward movement of the worm gear reverses or stops the oil flow. The steering shaft moves because the worm gear turns against the stationary restraining member.

As the worm gear screws into the restraining member, the valve opens and allows the hydraulic cylinder to move the wheels accordingly. As the wheels move, the follow-up linkage pushes or pulls the restraining member and centers the spool valve in the neutral position. This action shuts off the flow of oil to the steering cylinder.

NOTE: Turning the steering wheel *starts* the oil flow. The follow-up linkage *stops* the oil flow when wheel movement corresponds to steering wheel movement.

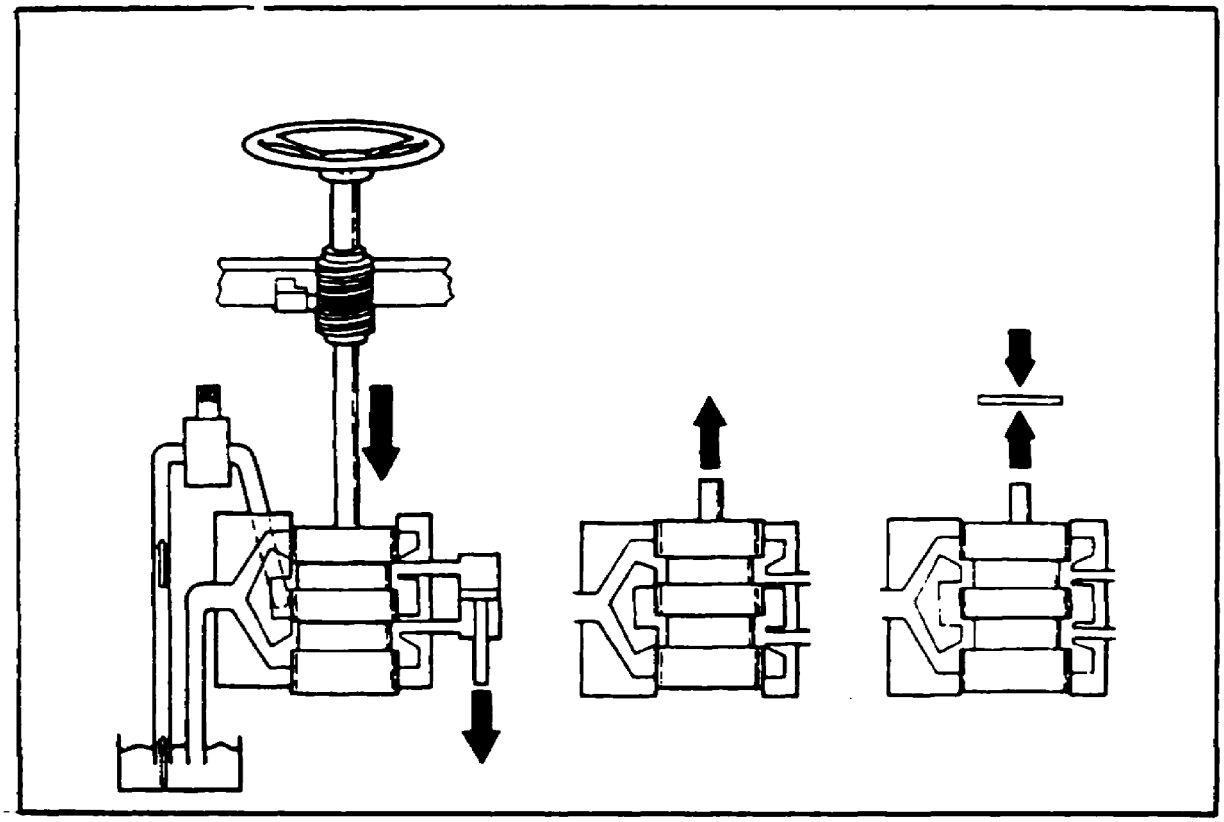


FIGURE 52. HYDRAULIC SYSTEM

POWER STEERING COMPONENTS

There are several types of power steering units. Although this learning event discusses only one, the basic principles apply to all of them. Main components that make up the network of a power steering system are the pump, reservoir, control valve, gearbox, and hydraulic cylinder.

Pump. All power steering systems contain a pump that supplies hydraulic fluid under pressure to other components in the system. Most construction equipment is operated hydraulically. The pump that supplies the hydraulic fluid to the blade, pan, and other components and also supplies the power steering fluid. Pressure and flow relief valves are built into the pump. These valves limit the amount of pressure and flow that the pump develops at each engine speed.

Reservoir. The pump receives oil from the reservoir. You must check the amount of hydraulic fluid in the reservoir and add more as necessary.

Control Valve. The control valve directs the flow of pressurized hydraulic fluid to the proper location in the steering system. The valve is actuated when the steering wheel turns. The control valve is mounted either in the steering box or on the steering linkage, depending on equipment design.

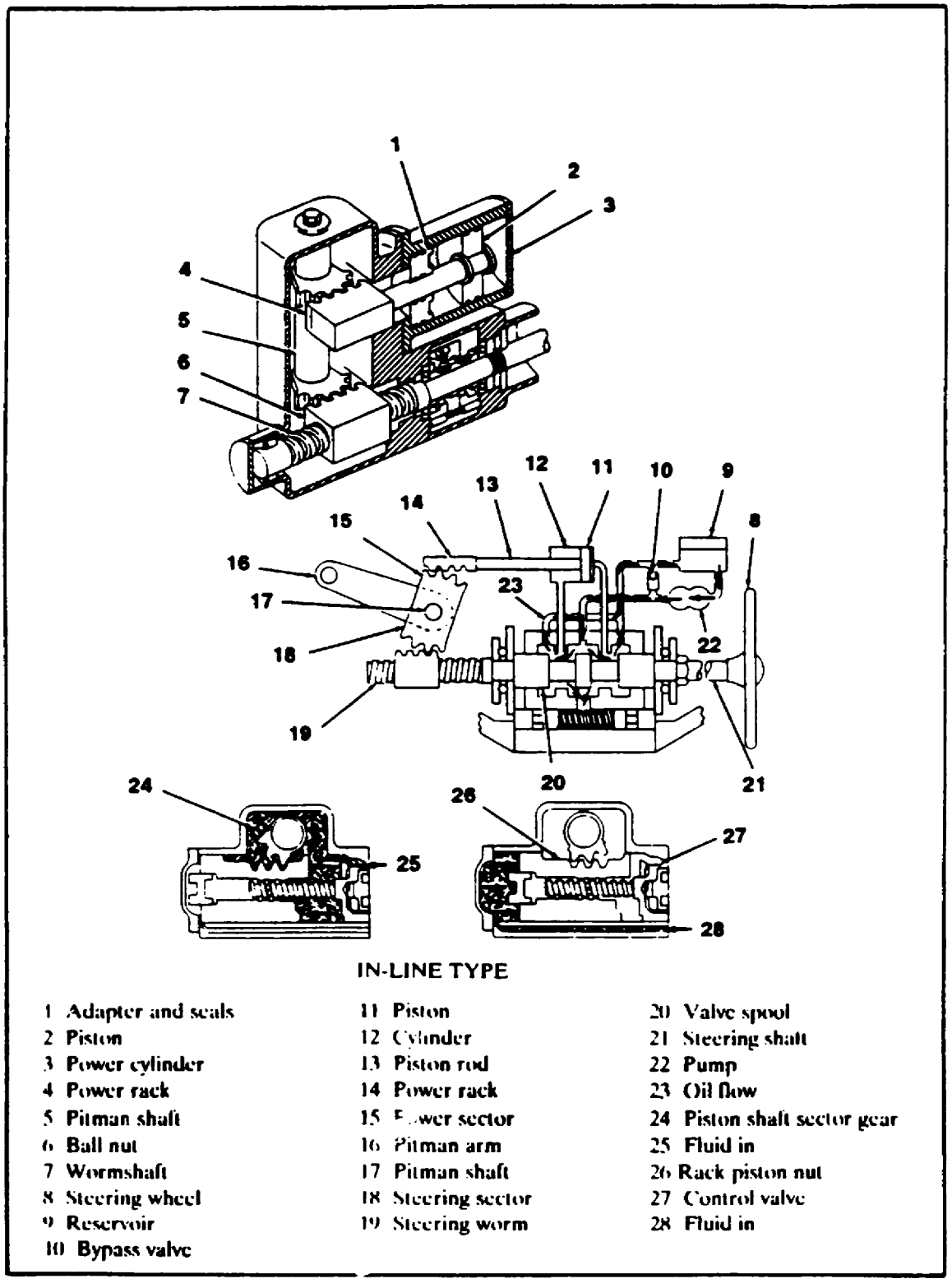
Gearbox. The gearbox in an integral power steering system is similar to the gearbox in a manual system, but it includes a power assist package. Two types of integral power steering gearboxes are offset and in-line.

- The offset gearbox uses a recirculating ball with a rack meshed to the pitman section gear above or on the opposite side of the ball nut. The power assist develops in the power piston, which is offset from the worm and nut and attached to the rack.
- The in-line design uses the recirculating ball nut assembly as the power piston. The ball nut is scaled inside a cylindrical part of the steering gear housing. The power assist is produced by alternately pressurizing one side of the power piston. Figure 53 shows the components of a power steering gearbox.

Hydraulic Cylinder. The hydraulic cylinder is used on semi-integral and integral power steering systems. It is located on the steering linkage (Figure 54). The power assist is developed in the hydraulic cylinder through the action of pressurized hydraulic fluid. Hydraulic cylinders may have single-wall or double-wall construction.

- A single-wall cylinder has a connection for a hydraulic hose. at each end.
- A double-wall cylinder has connections for two hydraulic hoses on one end and an internal passageway between the walls to pressurize the other end.

Some cylinders have a shuttle valve built into the piston. The shuttle valve opens at the end of the piston stroke so fluid can flow through the piston. This action helps eliminate full hydraulic pressure from acting on the cylinder when the piston bottoms out.



IN-LINE TYPE

1 Adapter and seals
2 Piston
3 Power cylinder
4 Power rack
5 Pitman shaft
6 Ball nut
7 Wormshaft
8 Steering wheel
9 Reservoir
10 Bypass valve
11 Piston
12 Cylinder
13 Piston rod
14 Power rack
15 Power sector
16 Pitman arm
17 Pitman shaft
18 Steering sector
19 Steering worm
20 Valve spool
21 Steering shaft
22 Pump
23 Oil flow
24 Piston shaft sector gear
25 Fluid in
26 Rack piston nut
27 Control valve
28 Fluid in

FIGURE 53. POWER STEERING GEARBOX

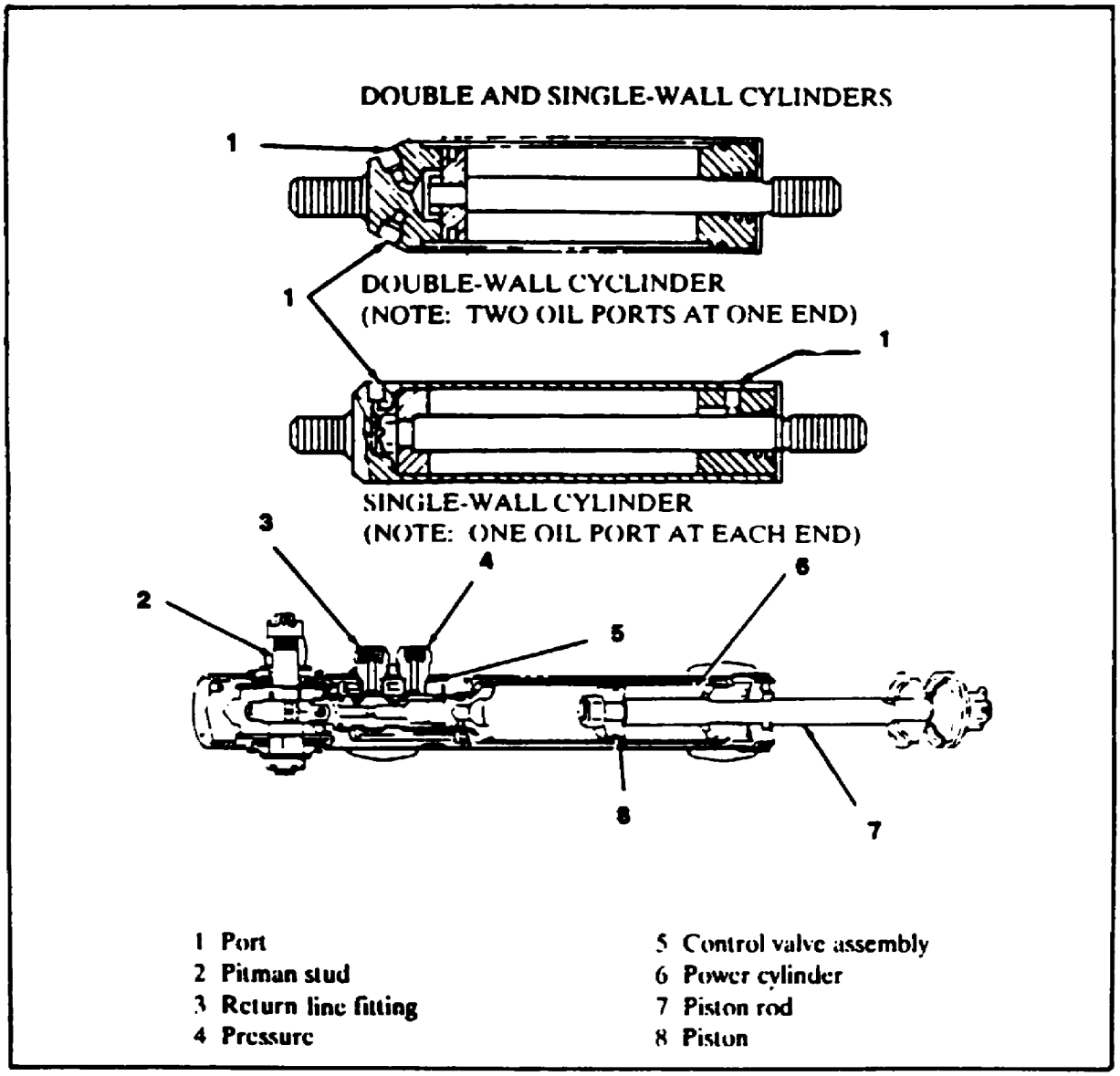


FIGURE 54. HYDRAULIC CYLINDER

POWER STEERING SYSTEMS

Three types of power steering systems are linkage, integral, and semi-integral.

Linkage. The control valve and power cylinder may be separate parts and may be mounted on different parts of the linkage (Figure 55).

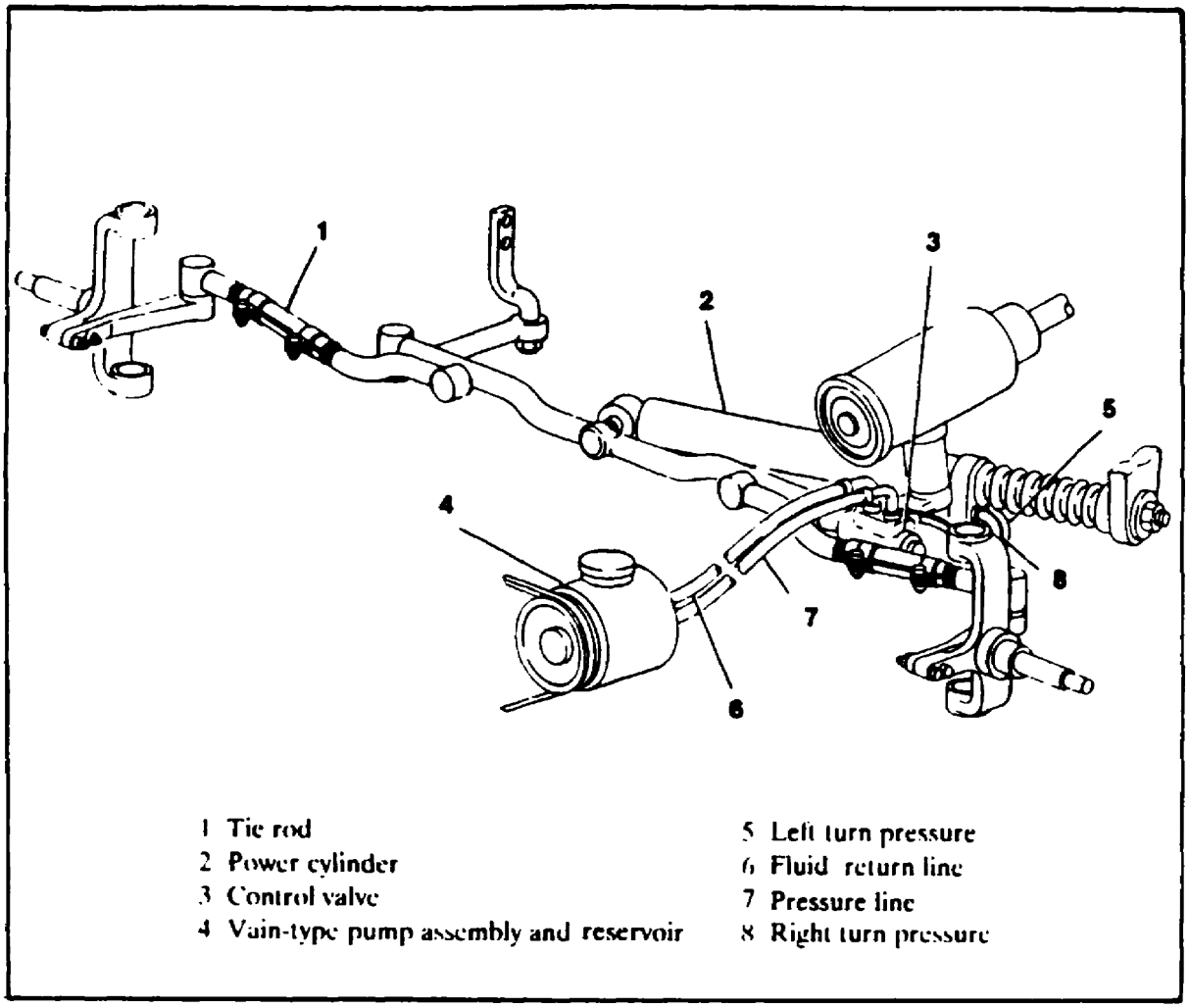


FIGURE 55. LINKAGE SYSTEM

Integral. The control valve and power assist are incorporated as a unit into the steering gear (Figure 56).

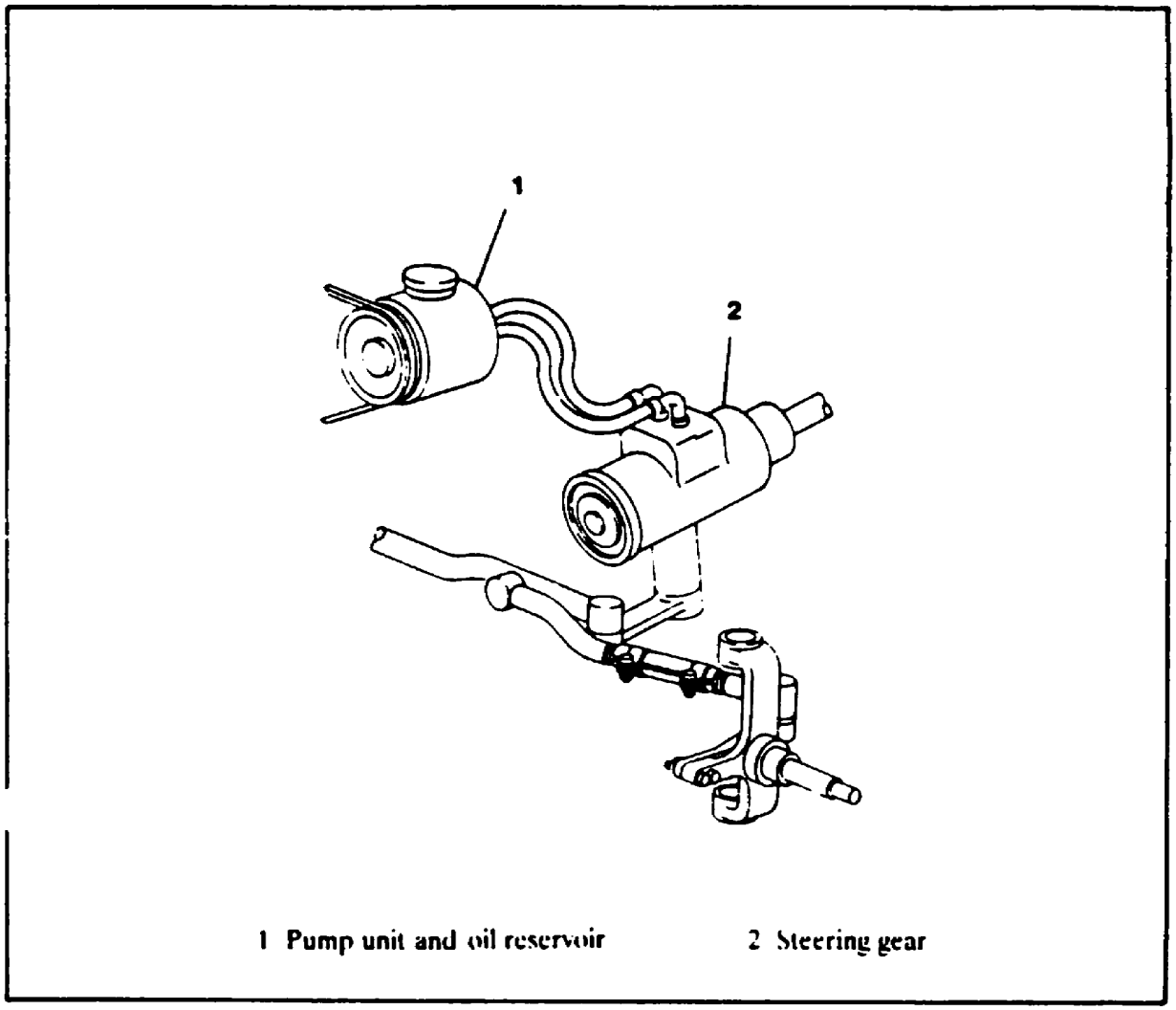


FIGURE 56. INTEGRAL SYSTEM

Semi-integral. The control valve is mounted on the steering gear, and a separate hydraulic cylinder is mounted on the linkage (Figure 57).

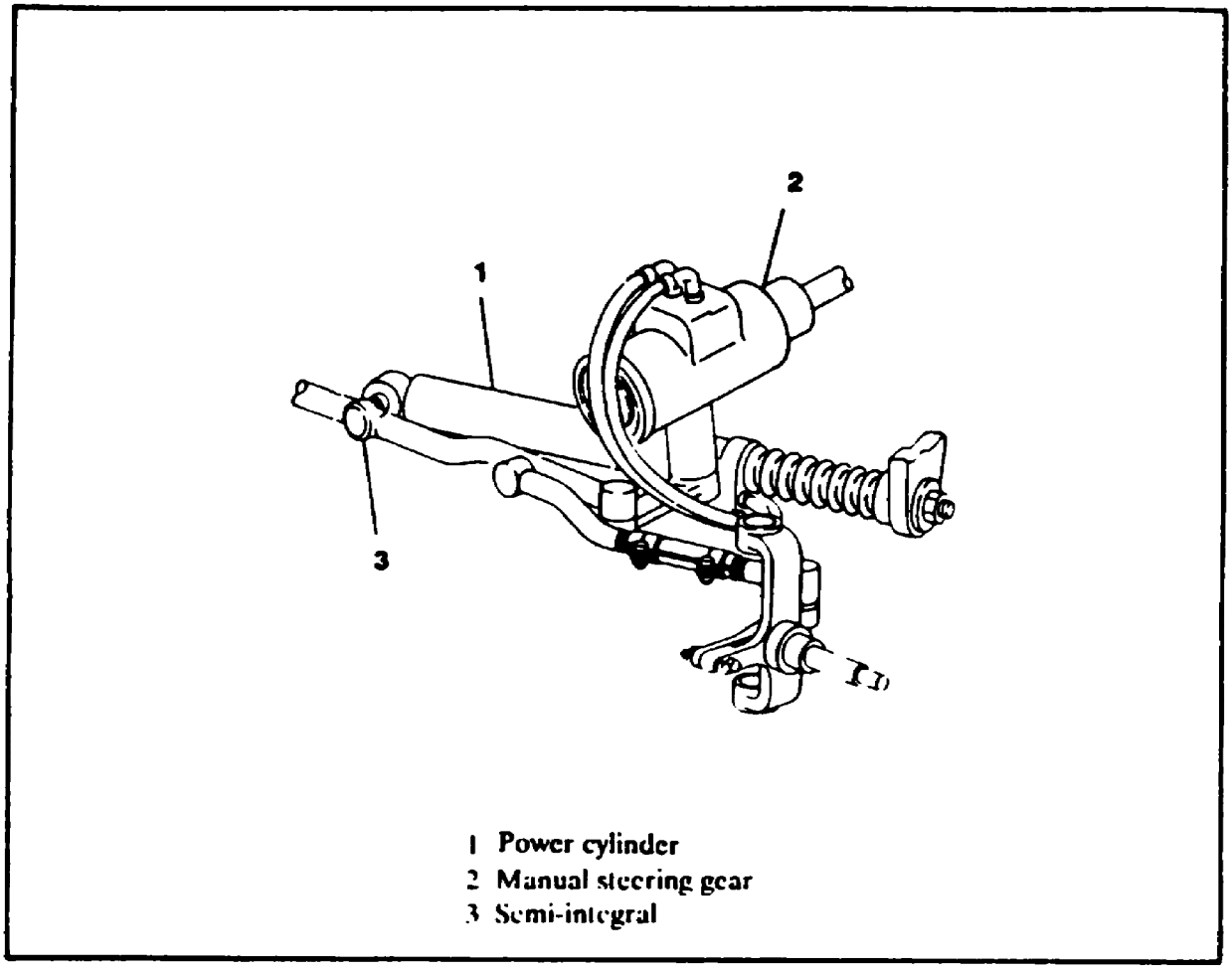


FIGURE 57. SEMI-INTEGRAL SYSTEM

Learning Event 2

TROUBLESHOOT A POWER STEERING SYSTEM

This learning event presents six job situations which require you to troubleshoot a disabled power steering system.

In each situation:

- You are a sergeant, ES, assigned to A Company, 88th Engineer Battalion, Direct Support Maintenance Platoon, Fort Wilson, Kansas.
- Your equipment is a model JD410 tractor wheeled loader-backhoe.
- You will use a DA Form 2404 (Equipment Inspection and Maintenance Worksheet), and a troubleshooting guide from TM 5-2420-222-14&P-1.

NOTE: Safety is always your prime concern.

SITUATION 1

Your supervisor tasks you to verify deficiencies reported on a JD410 and identify probable causes. Use DA Form 2404 (Figure 58) and a troubleshooting guide from TM 5-2420-222-14 & P-1 (Table 6).

SOLUTION 1

You review DA Form 2404 and see it states that the tractor does not respond when the steering wheel is turned slowly. You verify the problem by starting the tractor and slowly operating the wheel both right and left. While slowly turning the steering wheel, you find that there is no response in either direction. You refer to the troubleshooting guide and find there are five possible causes for the malfunction. You eliminate malfunctions that do not apply. You next begin to determine the most probable cause by eliminating areas which are easiest to check.

NO RESPONSE WHEN STEERING WHEEL IS TURNED SLOWLY	
CAUSE	**REPAIR**
Low pump pressure and dirt in system	Drain, flush, and refill with clean oil
Wear on sleeve and spool	Replace
Oil level low	Fill to proper level
Trouble in pump and generator	Check and correct
Trouble in lines or filter	Check and correct

TABLE 6. TROUBLESHOOTING GUIDE

EQUIPMENT INSPECTION AND MAINTENANCE WORKSHEET

1 ORGANIZATION: C Co 88th ENGR BN				2 NOMENCLATURE AND MODEL: TRACTOR JD 410			
3 REGISTRATION/SERIAL NO: 00U582	4a MILES	5 HOURS: 762	6 ROUNDS FIRED	7 HOT STARTS	8 DATE: 28 JAN 86	9 TYPE INSPECTION: DAILY PMCS	

7 APPLICABLE REFERENCE

TM NUMBER	TM DATE	TM NUMBER	TM DATE
5-2420-222-14 &P	OCT 82		

COLUMN a — Enter TM item number.
COLUMN b — Enter the applicable condition status symbol.
COLUMN c — Enter deficiencies and shortcomings.
COLUMN d — Show corrective action for deficiency or shortcoming listed in Column c.
COLUMN e — Individual ascertaining completed corrective action initial in this column.

STATUS SYMBOLS

"X"—Indicates a deficiency in the equipment that places it in an unoperable status.
CIRCLED "X"—Indicates a deficiency, however, the equipment may be operated under specific limitations as directed by higher authority or as prescribed locally, until corrective action can be accomplished.
HORIZONTAL DASH "(-)"—Indicates that a required inspection, component replacement, maintenance operation check, or test flight is due but has not been accomplished, or an overdue MWO has not been accomplished.
DIAGONAL "(/)"—Indicates a material defect other than a deficiency which must be corrected to increase efficiency or to make the item completely serviceable.
LAST NAME INITIAL IN BLACK, BLUE-BLACK INK, OR PENCIL—Indicates that a completely satisfactory condition exists.
FOR AIRCRAFT—Status symbols will be recorded in red.

ALL INSPECTIONS AND EQUIPMENT CONDITIONS RECORDED ON THIS FORM HAVE BEEN DETERMINED IN ACCORDANCE WITH DIAGNOSTIC PROCEDURES AND STANDARDS IN THE TM CITED HEREON

10a SIGNATURE (Person performing inspection)	10b TITLE	11a SIGNATURE (Maintenance Supervisor)	11b TITLE	12 MAN-HOURS REQUIRED
Bob Hill		Bill Williams		

TM ITEM NO a	STATUS b	DEFICIENCIES AND SHORTCOMINGS c	CORRECTIVE ACTION d	INITIAL WHEN CORRECTED e
1	/	BOLT MISSING LEFT		
		FRONT OF HOOD	REPLACED	JH
7	X	TEMPERATURE GAGE		
		INOPERATIVE	REPLACED	MHC
6	X	NO RESPONSE WHEN	REFER TO DIRECT	
		STEERING WHEEL	SUPPORT FOR REPAIR	MHC
		IS TURNED SLOWLY		

DA FORM 2404

FIGURE 58. DA FORM 2404

SITUATION 2

Check the oil level. The hydraulic reservoir for the steering and other hydraulic components is incorporated in the transmission of the JD410 tractor. To check the hydraulic fluid level, start the engine and run it two or three minutes to fill all circuits. Then check the oil level (Figure 59). The tractor must be on level ground and the backhoe in transport position. Put the range shift lever in park (P), put the gear-shift lever in neutral, and engage the clutch. The fluid level should be between the high and low marks on the dipstick, preferably 1/4 inch below the high mark.

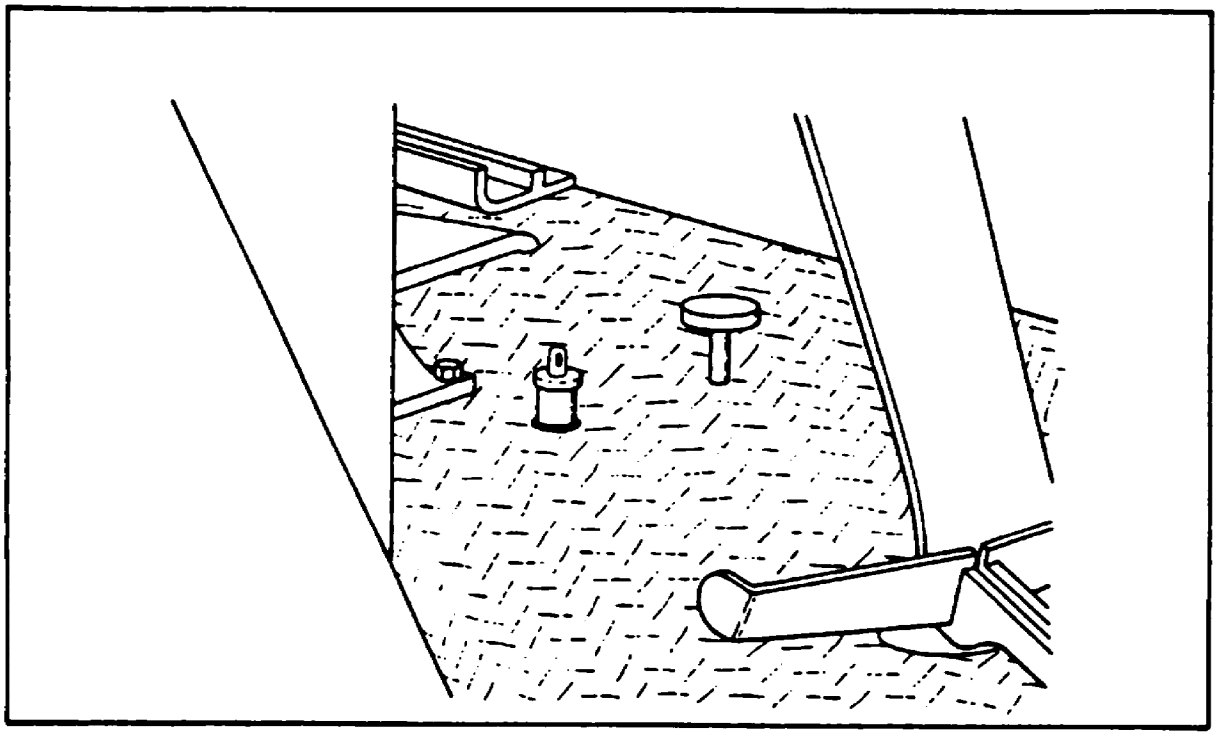


FIGURE 59. TRANSMISSION DIPSTICK AND FILLER CAP

SOLUTION 2

You check the hydraulic fluid level and rind it is within the preferred range. This eliminates low hydraulic fluid as a probable cause of the malfunction.

SITUATION 3

Check the lines and filter. First, inspect the hoses, lines, and fittings for leaks, damage, and deterioration. Next, remove the transmission-hydraulic system oil filter, cover and pull out the rubber packing and filter element (Figure 60). Install a new filter element and gasket.

Install a new gasket in the groove in the transmission case. Be sure the gasket is fully seated. Install a new filter element and replace the filter cover. Tighten the filter cover's retaining cap screw to 55 foot-pounds.

Run the engine two or three minutes to fill the circuits. Then check the oil level with the tractor on level ground with the engine running at slow idle. The loader should be lowered and the backhoe in transport position. Put the range shift lever in park (P), put the gear shift lever in neutral, and engage the clutch. After you check the oil level, turn the steering wheel slowly to see if there is any response or if the problem still exist.

SOLUTION 3

You find the steering hydraulic lines are in good shape. Now, check the transmission-hydraulic filter to be sure it is not clogged or leaking. After determining that the filter is not leaking, remove it and install a new filter element and gasket. While installing the filter element and cover, torque the filter cover's retaining cap screw to 55 foot-pounds. After you install the new filter element and check the fluid level, the steering is still malfunctioning.

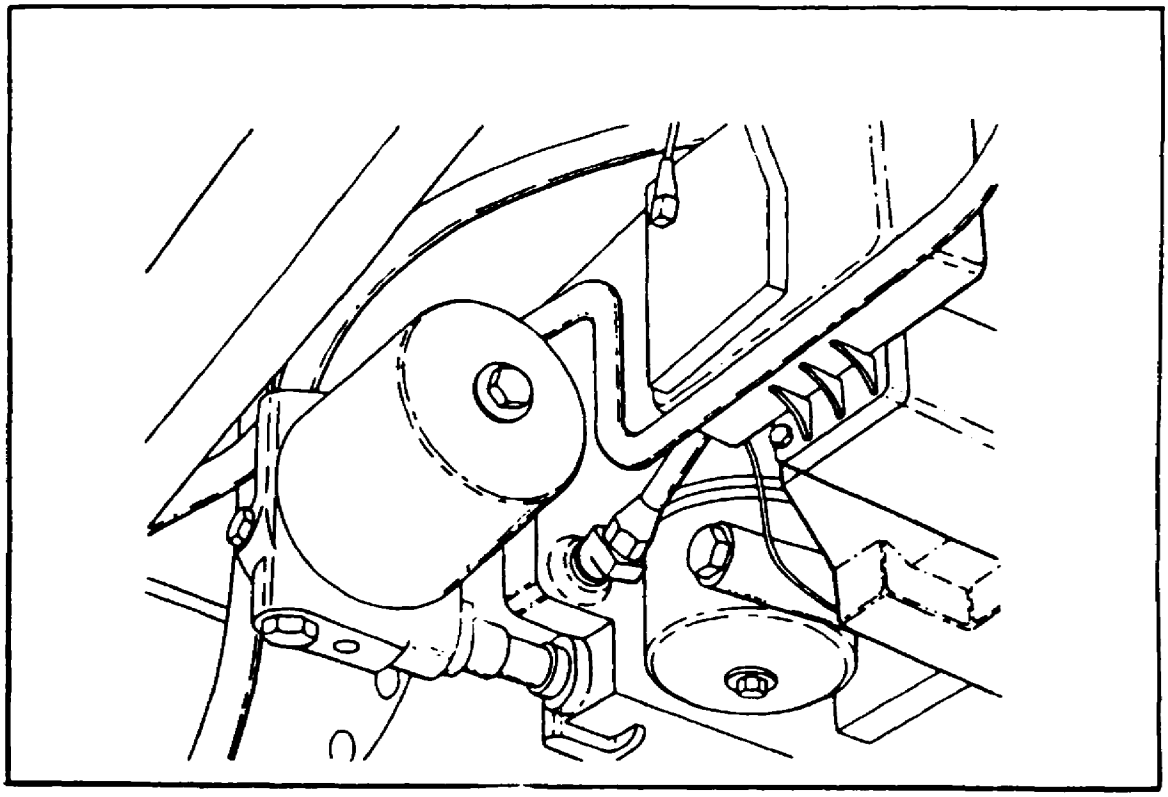


FIGURE 60. TRANSMISSION HYDRAULIC SYSTEM FILTER

SITUATION 4

Check for dirt in the system. Since you have just removed the transmission-hydraulic filter and found it to be clean, your next step is to call the using unit's maintenance supervisor to find out when the oil was last changed.

NOTE: This will save time and materials that you would have used to drain the system and install new oil.

The maintenance supervisor states that before sending the tractor to field maintenance, the using unit changed the hydraulic oil while trying to determine the cause of the malfunction.

SOLUTION 4

After talking with the using unit's maintenance supervisor and finding that the hydraulic fluid had just been changed, you can eliminate this item as a probable cause of the malfunction.

SITUATION 5

Check the hydraulic pump pressure. Locate the pump pressure taps (Figure 61).

CAUTION

Before making this check, relieve the pressure. Stop the engine and turn the steering wheel right and left.

With the engine stopped, locate the pressure taps on the hydraulic pump, remove tap A, and install the multirange pressure gage (Figure 62).

Start the engine, run it at 1,250 rpm, and observe the pressure gage reading. The reading should be between 2,300 and 2,400 psi standby pressure. After taking the pressure reading, stop the engine, remove the multirange gage, and install the tap plug.

SOLUTION 5

You take the hydraulic pump pressure reading and find it has a steady pressure of 2,378 psi. This indicates that the pump is functioning properly and that the problem must be in another area of the system.

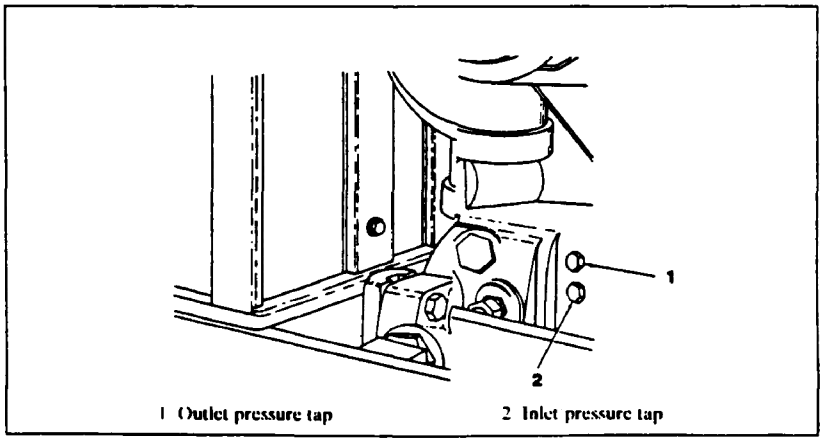


FIGURE 61. HYDRAULIC PRESSURE TAPS

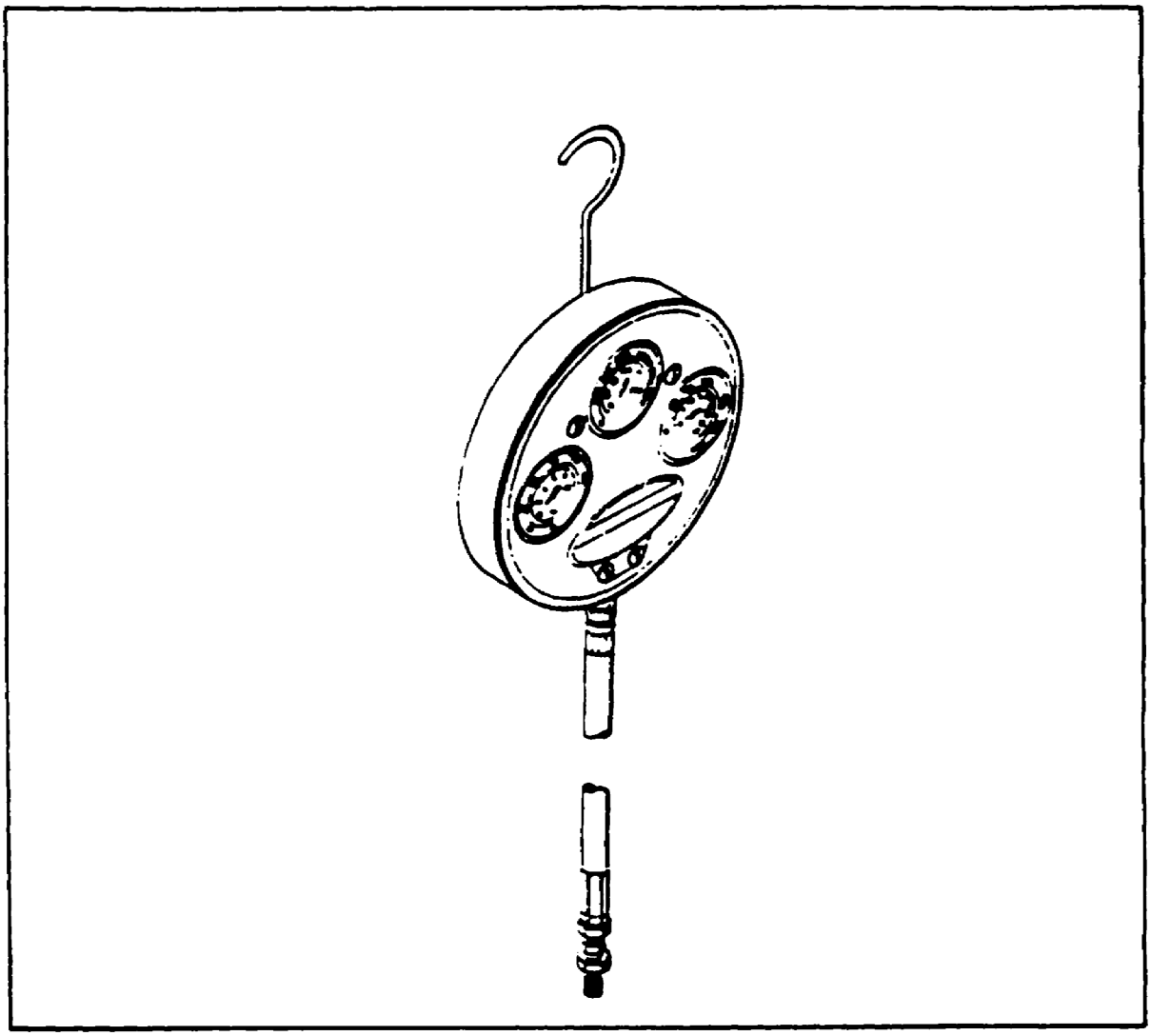


FIGURE 62. MULTIRANGE PRESSURE GAGE

SITUATION 6

You have now eliminated all but two possible malfunctions. The two remaining possibilities involve the internal parts of the steering control valve such as trouble in the gerotor or wear on the sleeve and spool. At this point you may safely assume that the problem lies within the steering control valve.

SOLUTION 6

You tell your supervisor that the problem probably exists within the steering control valve. Your supervisor decides to replace the steering control valve with a new one rather than repair the old one. Your next task is to replace the steering control valve (Learning Event 3).

Learning Event 3

REPLACE A STEERING CONTROL VALVE

This learning event presents two job situations which require you to replace a steering control valve.

SITUATION 1

Your supervisor told you to replace the steering control valve (Learning Event 2). Your first action is to contact the supply personnel to be sure the necessary replacement parts are on hand. If they are not, order the parts you need.

Get the parts, and put the tractor in a location where you can work without interference.

First, you must remove the inoperative steering control valve.

WARNING

When working on any portion of the hydraulic system, remember that escaping fluid has enough force to penetrate the skin and cause serious personal injury. If you are injured by escaping fluid, see a doctor at once. Serious infection or reaction can develop if you don't get proper medical treatment immediately.

Before disconnecting any lines, relieve all pressure on the system by shutting off the engine and turning the steering wheel right and left. Be sure all connections are tight and that lines, pipes, and hoses are not damaged. Use a piece of wood or cardboard, not your hands, to search for suspected leaks.

Remove the necessary components to get access to the steering control valve. Begin with the floor panel.

Step 1. Disconnect the batteries. The batteries must be disconnected because electrical wires will be moved when you remove the dash.

CAUTION

Disconnecting the batteries will avoid electrical burns to you and damage to the equipment when working around the electrical system.

The batteries are located under the left floor panel. First, disconnect the negative (ground) cable, then the positive cable. Lay the cables aside where they cannot make contact with the battery terminals. Since you will be working in the area of the left floor panel, place the panel back into position but do not bolt it down.

Step 2. Remove the steering wheel. First, remove the steering wheel emblem, O-ring, nut, and washer (Figure 63). Now, lift the steering wheel from the steering column. You may have to tap the bottom of the wheel with a rubber hammer to break it free. If the wheel still will not break free, use a penetrating oil around the steering column and steering wheel and again try to break it loose. If this does not work, attach a wheel puller to the steering wheel and remove it.

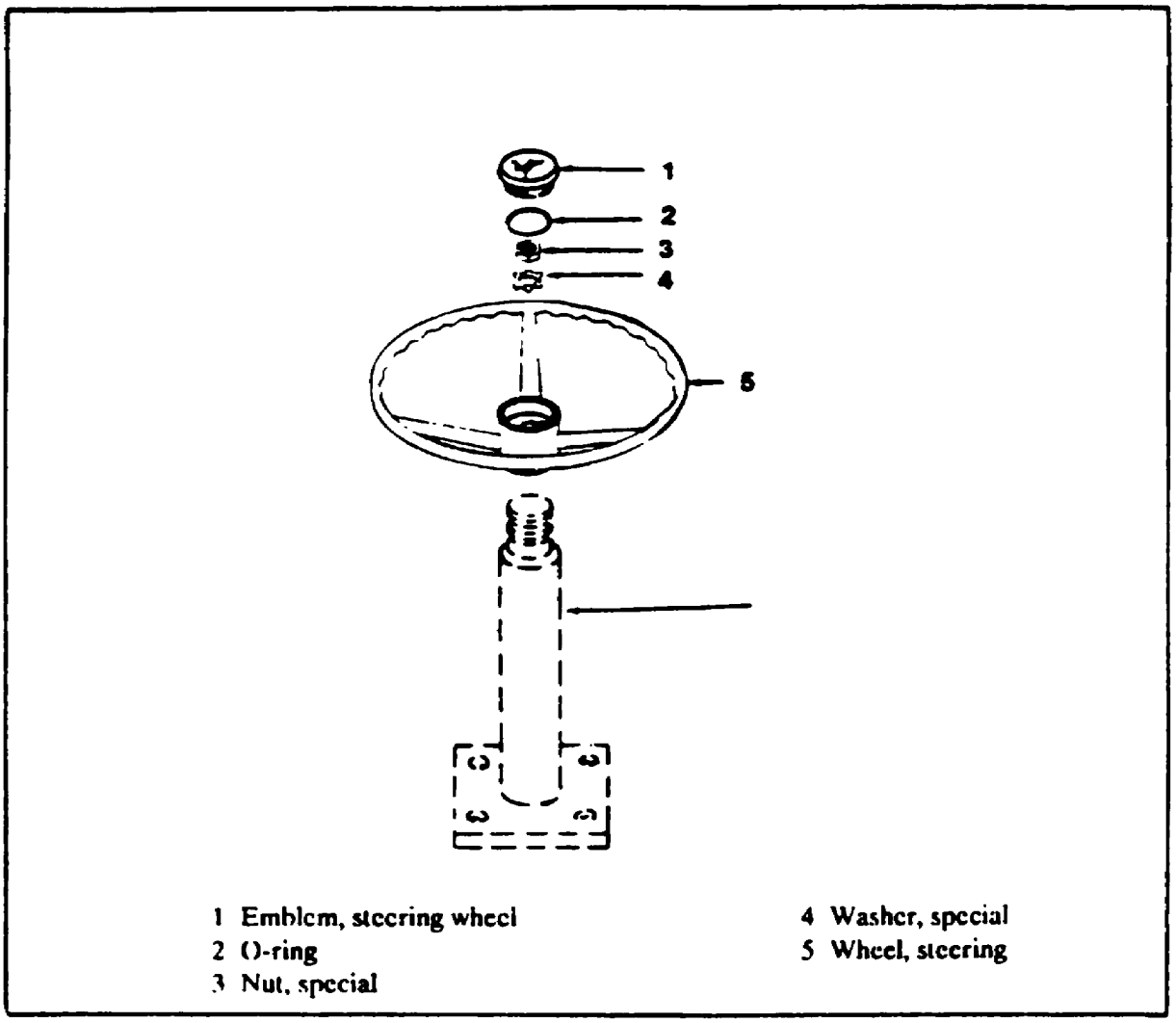


FIGURE 63. STEERING WHEEL REMOVAL

Step 3. Remove the cowl cover. First, remove the three screws securing the dash panel to the cowl cover (Figure 64). Turn the dash panel sideways and slide it inside the cover. The cowl cover can now slide up over the dash panel, and you do not have to remove the wires attached to the gages mounted in the dash cover. After positioning the dash inside the cowl cover, remove the four bolts securing the rear of the cowl cover to the cowl support (Figure 64).

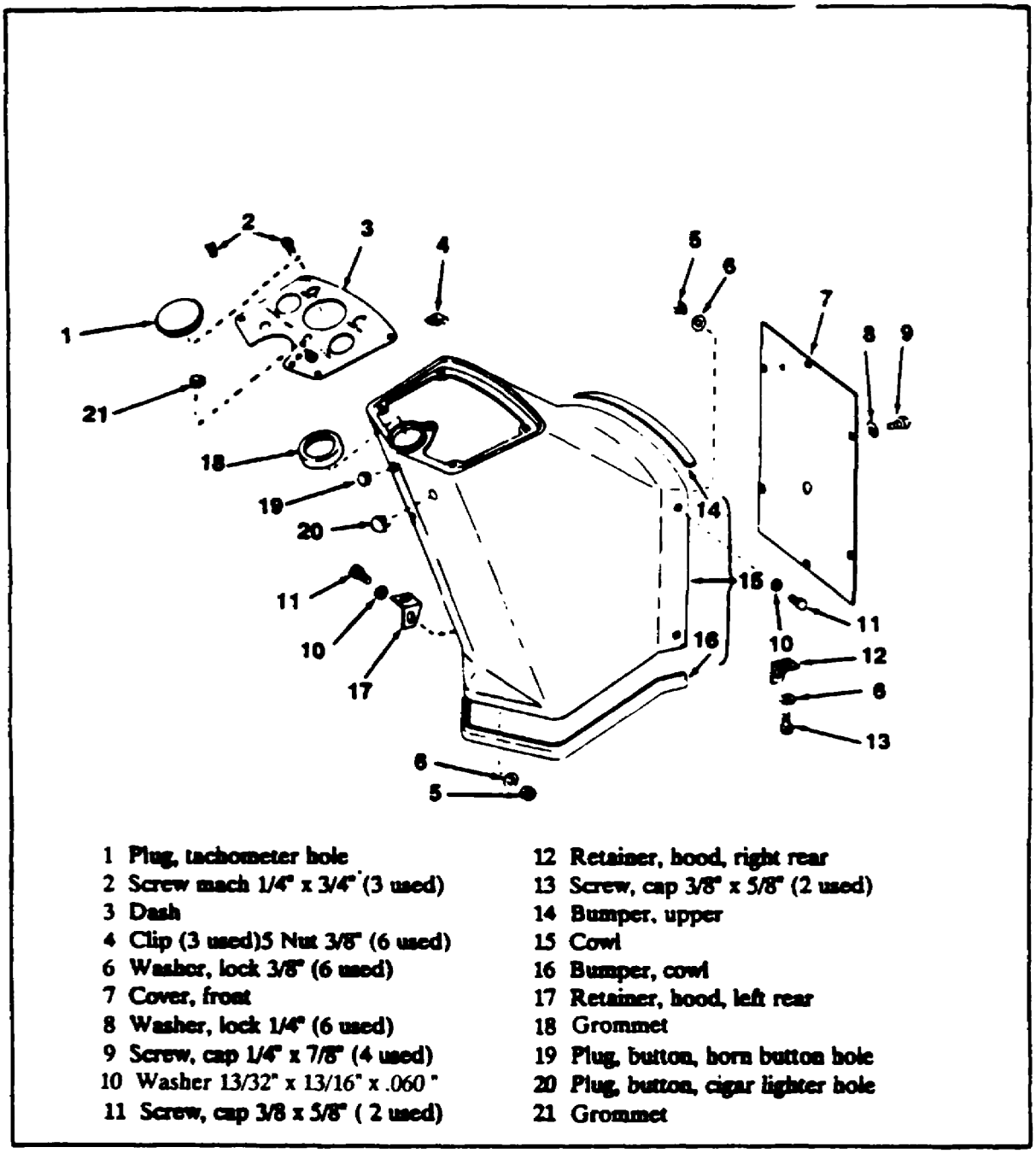


FIGURE 64. COWL AND DASH

Remove the reverser lever. Slide the cover up against the bend in the reverser lever and block it. Remove the spring roll pin so the reverser lever can be raised and removed with the cowl cover (Figure 65).

Disconnect the wire running to the hour meter on the left side of the cover. Slowly raise the cowl cover up and over the steering column. Lift the cowl cover free of the steering column and place it out of the work area.

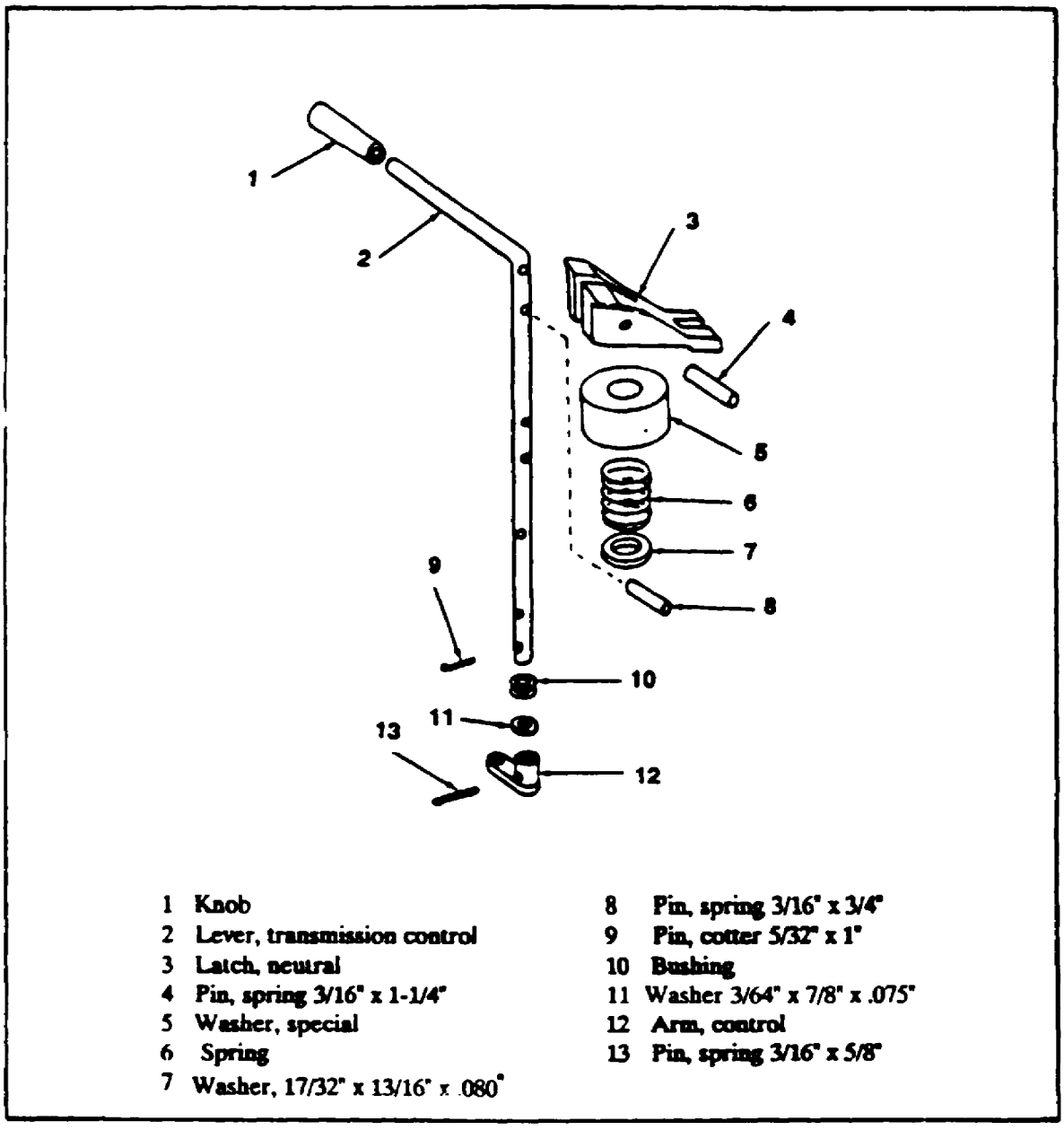


FIGURE 65. REVERSER CONTROL LEVER

Step 4. Raise the steering column from the top of the steering control valve. Loosen the U-bolt and remove the bolts holding the steering column to the steering control valve (Figure 66). Lift the steering column away from the steering control valve and secure it to the cowl support.

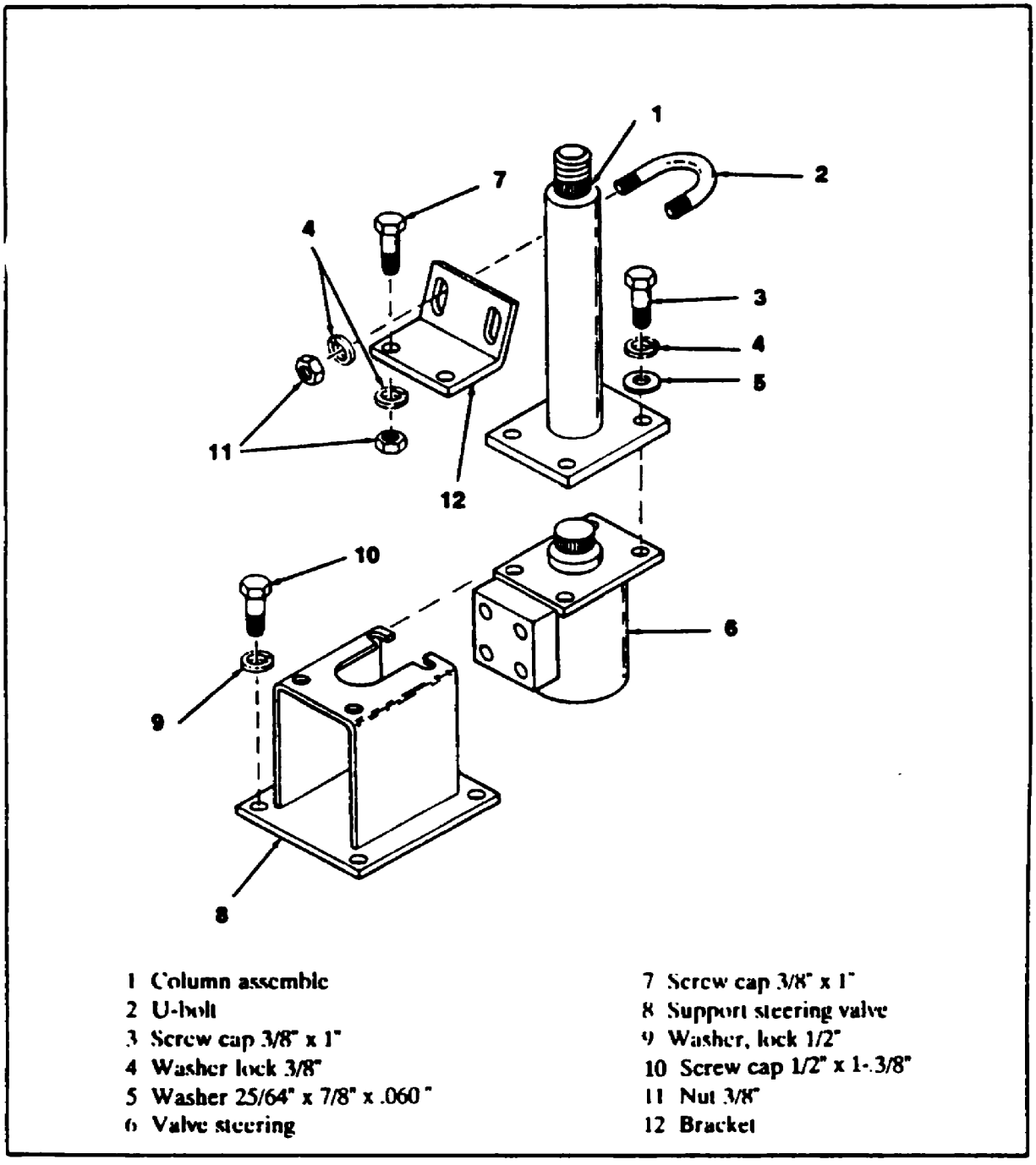


FIGURE 66. STEERING COLUMN AND STEERING VALVE SUPPORT

Step 5. Remove the power steering oil lines from the rear of the steering control valve (Figures 67 and 68).

NOTE: Mark all lines to ensure proper installation when putting in the new steering control valve.

After removing the oil lines, slide the steering control valve forward under the steering valve support and lift it from the machine.

SOLUTION 1

You should have started this repair job by turning the steering wheel right and left to relieve the hydraulic pressure on the steering system. Once you relieve the pressure, remove the necessary components to get space to work and access to the steering control valve. Then remove the steering control valve.

Since your supervisor said to replace the steering control valve rather than repair it, proceed to Situation 2 and install the new steering control valve.

SITUATION 2

You have removed the old steering control valve and must now install the new one. The procedures for installing a steering control valve are just reverse of the removal procedures.

After installing the steering control valve, check the hydraulic lines and fittings to ensure they are not leaking.

WARNING
Personal injuries can occur while checking the hydraulic lines and fitting.

If there are no leaks, test the steering to see if installing a new steering control valve has solved the steering malfunction.

NOTE: Do not install the cowl cover until you have checked the lines and fittings and tested the steering. At this point, you can start putting the remaining components hack on the tractor. Follow these steps:

Step 1. Slide the steering control valve into the steering valve support. Be sure the holes for the power steering oil lines are toward the front of the tractor. Once the steering control valve is in the support, install the power steering oil lines (Figures 67 and 68). In Situation 1, Step 5, you marked these lines for proper positioning on the new valve.

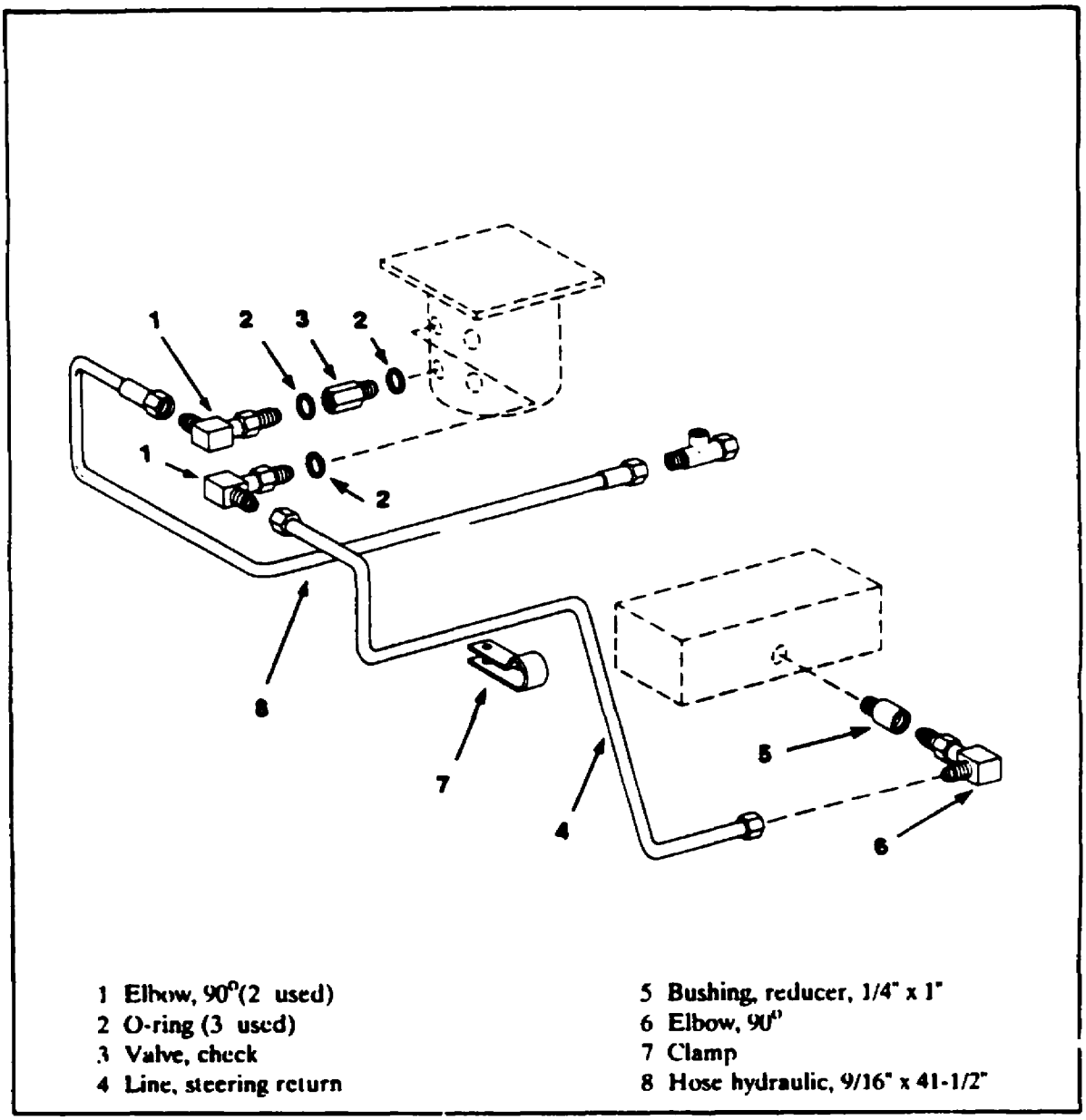


FIGURE 67. POWER STEERING VALVE RETURN LINE AND ACCUMULATOR HOSE

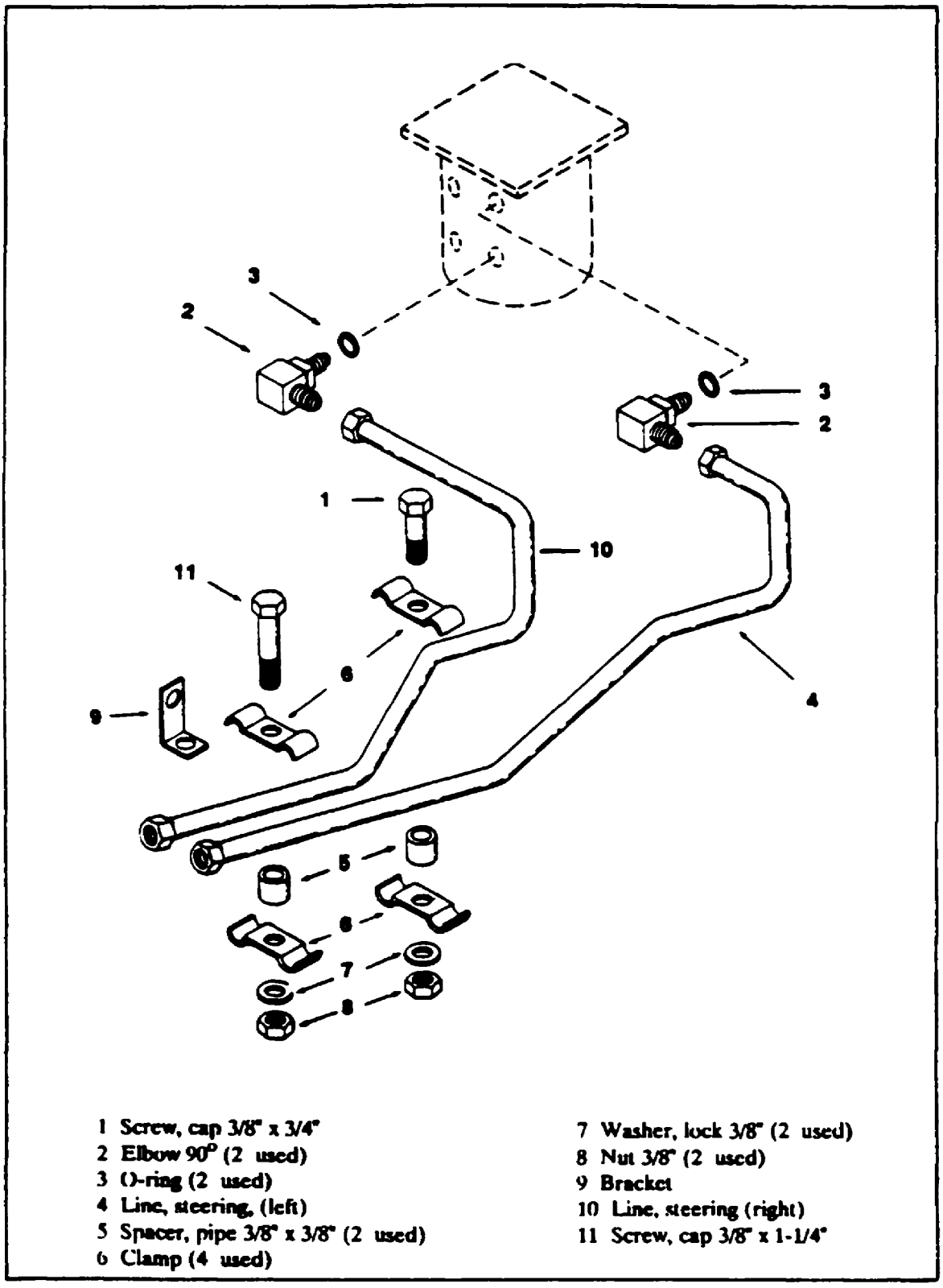


FIGURE 68. POWER STEERING CYLINDER OIL LINES

Step 2. Install the steering column on the steering control valve. Align the holes in the base of the steering column with those on the top of the steering control valve (Figure 66). Install and tighten the bolts (Figure 65). Then tighten the U-bolt and connect the battery cables.

Step 3. At this point, check for leaks and ensure the steering is functioning properly. Start the tractor.

NOTE: The dash panel is hanging loose.

Check for leaks at all the points where the lines were disconnected. Place the steering wheel on the steering column and turn the wheels right and left to ensure they are functioning properly. Once again, check the power steering oil lines to ensure they do not leak under the additional pressure. If everything functions properly, remove the steering wheel and reassemble the tractor.

Step 4. Install the cowl cover by lifting it over the steering column and sliding it down over the steering column and the dash panel. Slowly lower the cover far enough to connect the wire to the hour meter on the left side of the cowl cover. Continue to lower the cover far enough to connect the reverser lever. Install the spring roll pin to secure the reverser lever (Figure 65). Lower the cowl cover onto the cowl support ensuring it fits into the cowl bumper (Figure 64), then install and tighten the bolts.

Step 5. Lift the dash panel back through the cowl cover. Check to ensure all wires are connected, then place the dash panel into position. Install and tighten the three screws (Figure 64).

Step 6. Place the steering wheel on the steering column (Figure 63). Place a washer over the extruding end of the steering column. Place a nut on the threads of the extruding end of steering column and torque the nut to 50 foot-pounds. Place the emblem on top of the steering wheel and press it into position.

Step 7. Connect the battery cables. Tighten the terminal of the positive cable onto the positive post of the battery. Tighten the terminal of the negative (ground) cable onto the negative post. Position the floor panel and tighten the bolts.

Step 8. Start the tractor to ensure the steering functions properly.

SOLUTION 2

You have installed the steering control valve and replaced the other components. When checking for leaks and ensuring the steering system was functioning properly in Step 3, you found that all areas were working properly, so you reassembled the tractor.

Lesson 2

REVIEW EXERCISE

Check your understanding of Lesson 2 by completing these review questions. Try to complete all of the questions without looking back at the lesson. When you are finished, turn to the solutions on page 80 and check your responses. If you missed any questions, go back and study that section of the lesson again.

1. What type of steering system is on the JD410 tractor?
    A. Articulated
    B. Rear wheel
    C. Three axle
    D. Front wheel
2. What does power steering provide to construction equipment?
    A. Quick steering
    B. Reduced effort
    C. Shorter turning radius
    D. Longer turning radius
3. What are the five basic components of a power steering system?
    A. Reservoir, control valve, auxiliary pump, hydraulic cylinder, gearbox
    B. Pump, reservoir, gearbox, hydraulic cylinder, steering wheel
    C. Pump, reservoir, gearbox, hydraulic cylinder, control valve
    D. Pump, reservoir, gearbox, control valve, steering wheel
4. Where is the hydraulic reservoir for the JD410 tractor located?
    A. Under the hood
    B. At the rear of the tractor
    C. In the transmission
    D. In the reverser housing
5. You are checking the hydraulic fluid level. How should it appear on the dipstick?
    A. On the high mark
    B. One fourth inch below the high mark
    C. On the low mark
    D. One fourth inch below the low mark

6. How do you relieve the pressure on the hydraulic system of a JD410 tractor?
    A. Remove the tap plug at the pump
    B. Turn the steering wheel right and left
    C. Crack the line at the steering cylinder
    D. Open the vent on the top of the reservoir

7. You are working on a hydraulic system and are injured by escaping fluid. What should you do?
    A. Report the injury to your supervisor
    B. Wash off and wrap the injured area
    C. Continue to work
    D. See a doctor at once

8. You are disconnecting the batteries. What do you remove first?
    A. Battery caps
    B. Positive cable
    C. Negative cable
    D. Battery hold down

Lesson 2
REVIEW EXERCISE SOLUTIONS

1. D (page 46)
2. B (page 48)
3. C (page 57)
4. C (page 65)
5. B (page 65)
6. B (page 69)
7. D (page 69)
8. C (page 69)