Lesson 2: Command Control Steering System

950G Wheel Loader

- Electro-Hydraulic Implement System
- **Command Control Steering System**

Introduction

The Command Control steering system uses a steering pilot valve instead of the hand metering unit (HMU) that is used on conventional steering system.

When a machine is equipped with the Command Control steering system, the machine's turning speed is directly proportional to the position of the steering pilot valve.

When a machine is equipped with the conventional steering system, the machine's turning speed is directly proportional to the turning speed of the steering wheel.

Objectives

Upon completion of this lesson, the student will be able to:

1. Identify components of the 950G Wheel Loader Command Control steering system.
2. State the components functions and trace the oil flow through the 950G Wheel Loader Command Control steering system schematic in all positions (hold, steer right etc...).
3. Perform the testing and adjusting procedures as stated in the 950G Wheel Loader and 962G Wheel Loaders Command Control Steering System, Testing and Adjusting Module (Form No. SENR2644).

Fig. 2.2.1

This presentation discusses the component locations, systems operation and testing and adjusting procedures for the Command Control Steering System on the 950G and 962G Wheel Loaders. When discussing systems operation, both sectional view and graphic symbol schematics will be used. The systems will be explained by tracing oil flow from the tank, through the system and back to the tank.

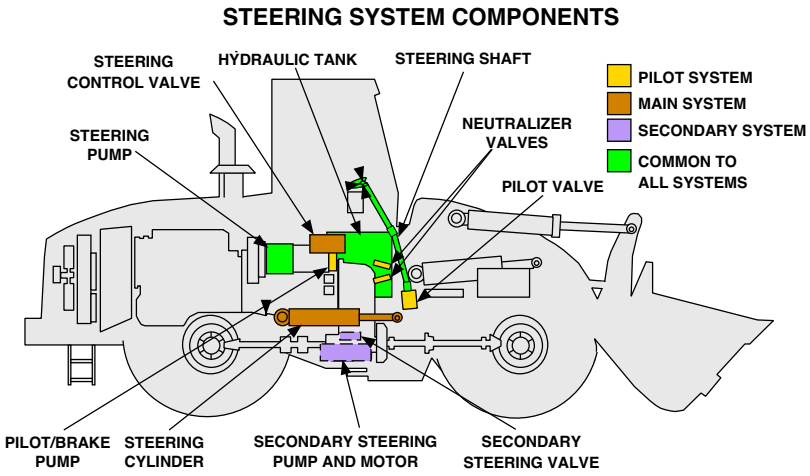

Fig. 2.2.2

STEERING SYSTEM COMPONENTS

Figure 2.2.2 shows the components of the steering hydraulic system on the 950G and 962G Wheel Loaders. The hydraulic tank is common to all hydraulic systems on the machine. The color codes for the components in the steering hydraulic system are:

Orange	- Pilot system
Brown	- Main steering system
Green	- Common to all systems
Purple	- Secondary steering system

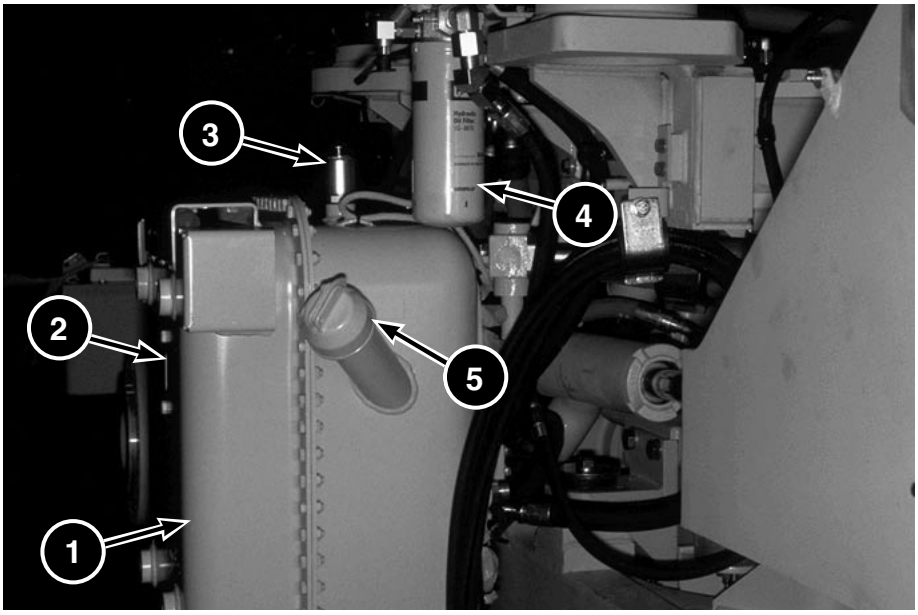

Fig. 2.2.3

Main System Components

The hydraulic tank (1) is located on the right side of the machine. A sight glass (2) indicates the level of the oil in the tank.

The tank has a vent valve (3) that protects the tank from excessive pressure and/or vacuum and an ecology-type drain valve (not visible) for changing the oil.

The hydraulic oil filter (4) is located above the tank. The oil filter is in the return line for the fan drive system.

Also shown is the fill cap (5).

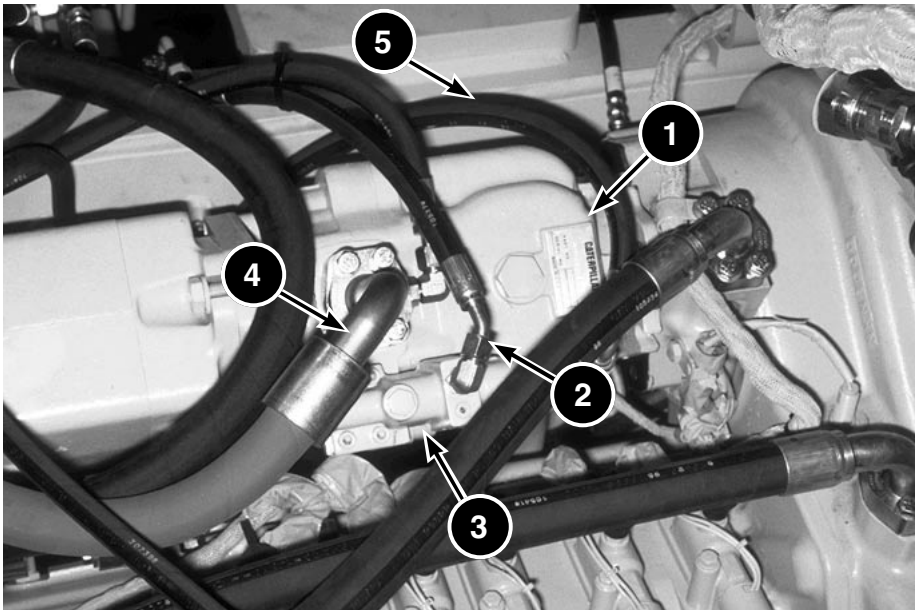

Fig. 2.2.4

The 950G/962G steering system pump (1) is mounted in the pump group below the operator's compartment on the right side of the machine. The variable displacement piston pump senses the pressure and flow requirements for the system through the signal line (2) connected to the compensator valve. The pump compensator valve (3) controls pump flow and limits the maximum system pressure. The steering system pump draws oil from the hydraulic tank through a suction tube and sends flow through the supply line (4) to the steering control valve. Case drain oil returns through the case drain line (5) to the tank.

NOTE: The color codes used for hydraulic oil throughout this presentation are:

Red	**- System or high pressure**
Red and White Stripes	**- Reduced pressure**
Orange	**- Pilot pressure**
Blue	**- Blocked oil**
Green	**- Tank or return oil**

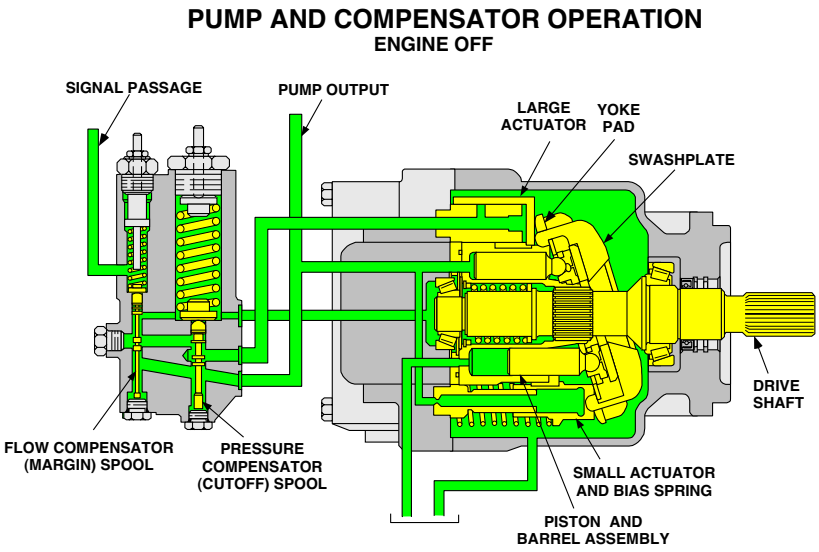

Fig. 2.2.5

Pump and Compensator

Shown is a sectional view of the steering pump and compensator valve group.

The pump has two actuator pistons which work together to continually adjust the angle of the swashplate. The small actuator piston, assisted by the small actuator spring, is used to upstroke the pump. The large actuator piston is used to destroke the pump.

The compensator valve group consists of a flow compensator (margin) spool and a pressure compensator (cutoff) spool. The valve group maintains the pump flow and pressure at a level needed to fulfill the demands of the steering system.

The margin spring maintains the pump supply pressure at 2400 ± 100 kPa (350 ± 15 psi) above the signal pressure. The cutoff spool spring limits the system pressure to 20000 ± 350 kPa (2900 ± 50 psi).

When the engine is OFF, the small actuator spring moves the swashplate to maximum angle.

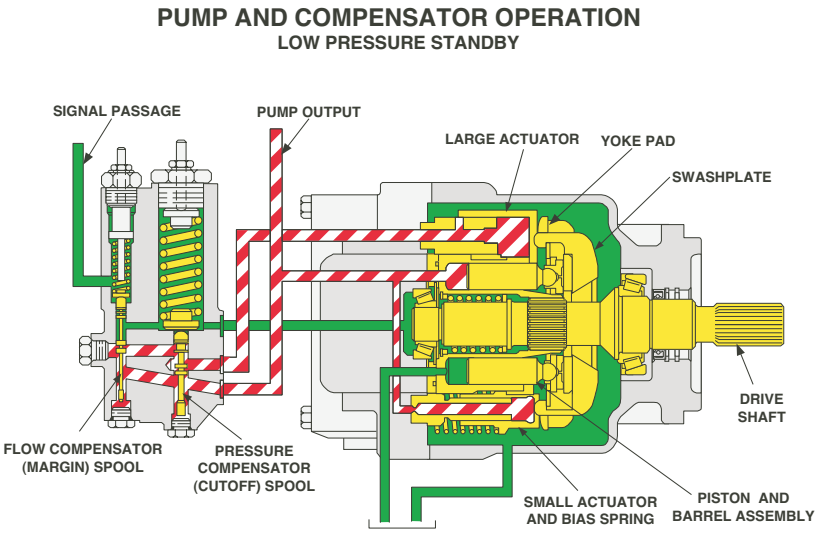

Fig. 2.2.6

Shown is the hydraulic pump in the LOW PRESSURE STANDBY mode.

At machine start-up, the small actuator spring holds the swashplate at maximum angle. When the steering control valve is in the HOLD position, pump flow is blocked at the steering control valve and no signal pressure is generated. As the pump produces flow, the system pressure begins to increase. This pressure is felt at the lower end of both the flow compensator (margin) spool and the pressure compensator (cutoff) spool. The margin spool moves up against the low spring force and permits system oil to flow to the large actuator piston.

The oil pressure inside the large actuator piston overcomes the combined force of the small actuator spring and system pressure inside the small actuator piston. The large actuator piston moves the swashplate to the LOW PRESSURE STANDBY position.

With no demand for flow, the pump remains at LOW PRESSURE STANDBY. In this condition, the pump produces only enough flow to compensate for internal leakage and maintain sufficient pressure to ensure instantaneous response when the brakes are applied, an implement is activated or the steering is activated.

NOTE: Depending on margin spool adjustments and the amount of pump leakage, LOW PRESSURE STANDBY and margin pressure can be equal. However, margin pressure can never be higher than LOW PRESSURE STANDBY.

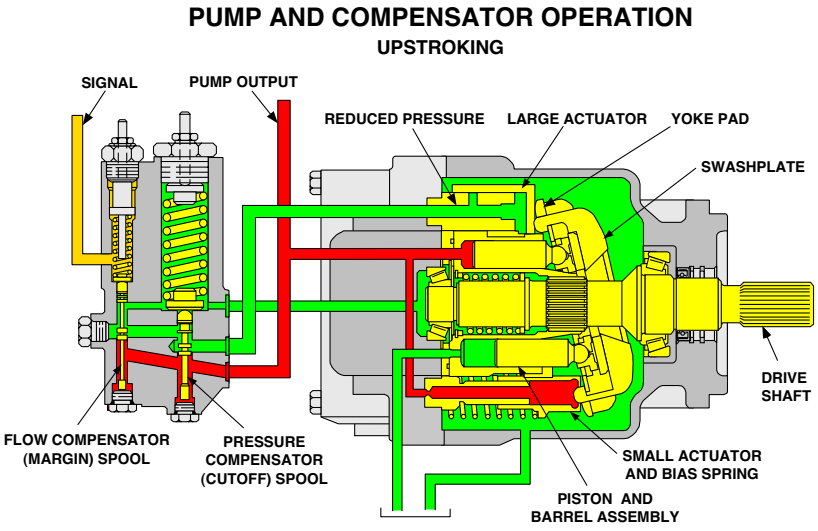

Fig. 2.2.7

This slide shows the pump and pump controls during UPSTROKE.

When the operator turns the steering wheel, pilot oil moves the steering control valve spool. The steering control valve spool opens a passage to the steering cylinders and to the shuttle valve in the control valve. A hose connects the shuttle valve to the margin spool spring chamber in the pump compensator valve. The pressure in the steering cylinders becomes signal pressure to the margin spool spring chamber in the compensator valve group. (Margin spool signal pressure is also called the load sensing signal.) As pressure increases in the steering cylinders, the signal pressure increases in the margin spool spring chamber. The combined forces of the margin spool spring and the signal pressure overcome the system pressure. The margin spool moves down blocking oil to the large actuator piston and opening a passage for oil in the large actuator piston to flow to drain. The small actuator spring and small actuator piston move the swashplate toward maximum angle, increasing pump flow.

Changes in the signal pressure that cause the pump to UPSTROKE are:

1. When the system pressure increases.
2. When hydraulic flow demand is increased.
3. When engine rpm changes. (If engine speed is decreased while a certain load is on the steering cylinders, pump flow and pump output pressure decrease. The signal pressure from the steering cylinders moves the margin spool down. The large actuator piston is open to case drain. Spring force plus system pressure on the small actuator piston move the swashplate toward maximum angle.)

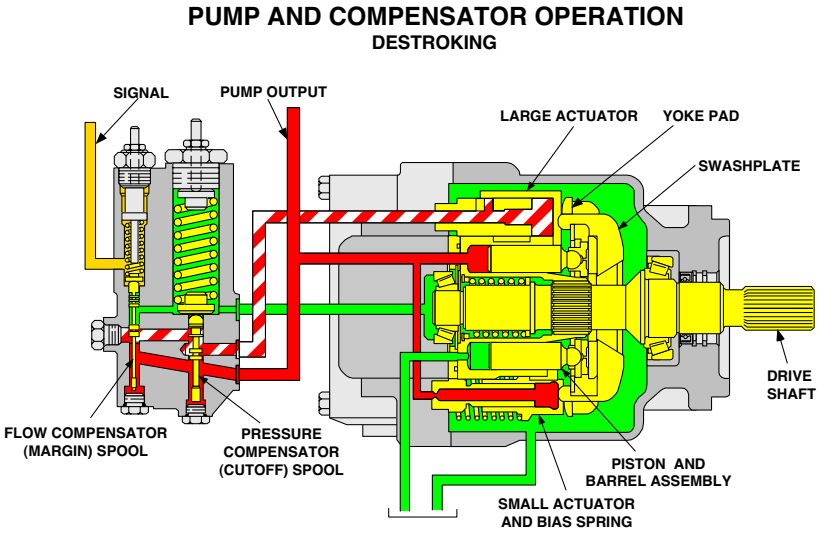

Fig. 2.2.8

This slide shows the pump and pump controls during DESTROKE.

When pump flow begins to exceed the demand, pump output pressure increases. Pump output pressure pushes up on the lower end of the margin spool and overcomes the spring force and signal pressure on top of the spool. When the margin spool moves up, system pressure goes around the lower end of the spool to the large actuator piston. The large actuator piston moves the swashplate toward minimum angle, destroking the pump.

If the engine speed is increased while the steering system or an implement is in operation, pump flow increases. The increase in pump flow causes an increase in pump output pressure. The increase in pump output pressure pushes the margin spool up. Pump output pressure, reduced by the margin spool, goes to the large actuator piston to destroke the pump.

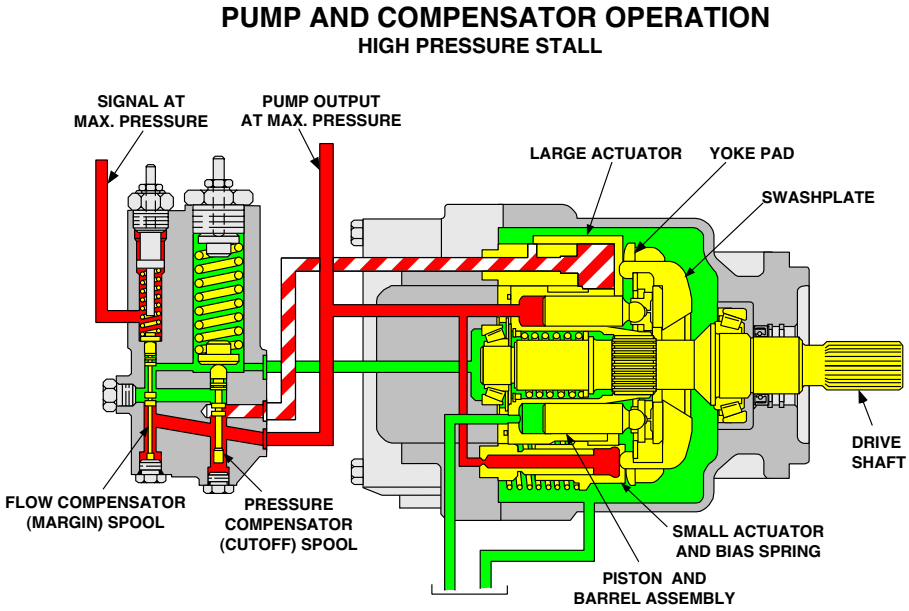

Fig. 2.2.9

This slide shows the pump and pump controls during HIGH PRESSURE STALL.

When signal pressure and pump output pressure are equal, the margin spool moves down and blocks the pump output pressure to the large actuator spool. When pump output pressure increases to the setting of the cutoff spool, the spool moves up. Pump output pressure, reduced by the pressure cutoff spool, is then directed to the large actuator piston. The large actuator piston moves the swashplate to minimum angle. At this point, the pump output decreases to the point where only enough flow is created to maintain the system pressure and to compensate for internal leakage.

When system pressure decreases to less than the setting of the cutoff spool, spring force pushes the spool down and the margin spool again controls the flow from the pump.

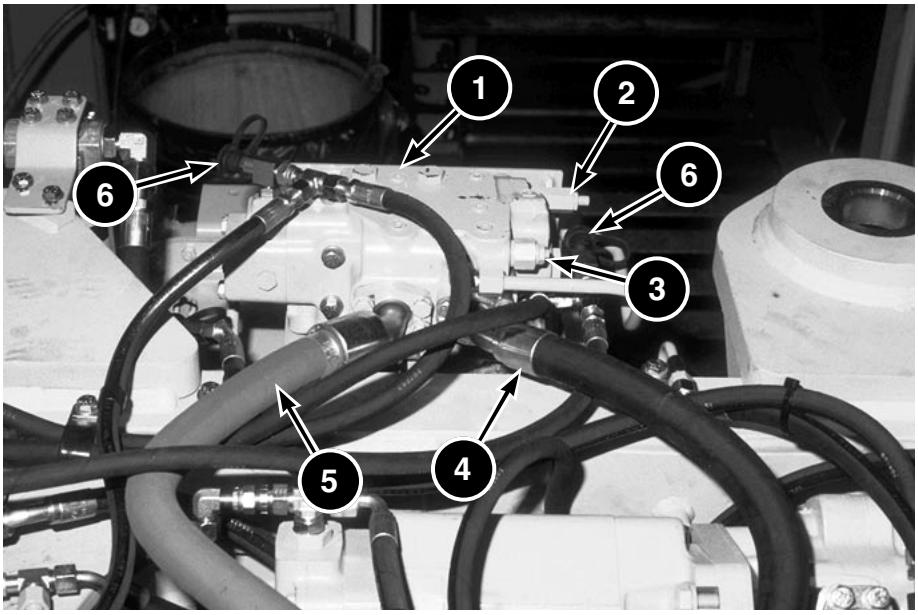

Fig. 2.2.10

The steering control valve (1) is bolted to the frame above the hydraulic tank on the right side of the machine. The steering control valve directs the flow to the steering cylinders.

The steering control valve houses the directional spool (not shown), the back-up relief valve (2) and a pressure reducing valve (3). The pressure reducing valve lowers the steering pump supply pressure for use as a secondary source of pilot oil.

When the engine is running, the steering pump sends flow to the steering control valve. If the steering pump fails and the machine is moving, the secondary steering pump sends flow to the steering control valve.

Also shown are the tank outlet (4), the steering pump inlet (5), and the pilot system pressure taps (6).

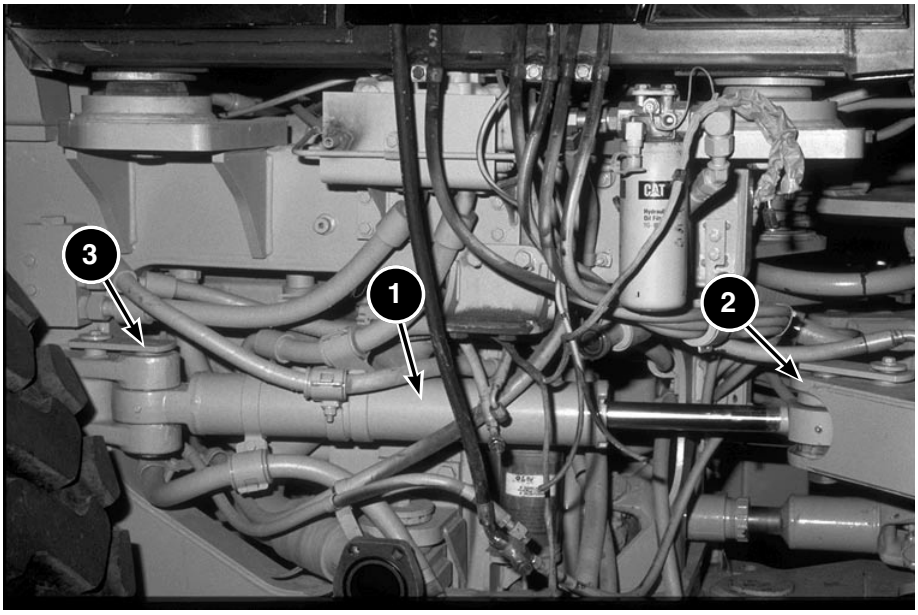

Fig. 2.2.11

The steering cylinders (1) are mounted on each side of the machine between the front frame (2) and the rear frame (3). The steering control valve directs oil flow to the head end of one cylinder and the rod end of the opposite cylinder, causing the machine to articulate.

A crossover relief valve in the steering control valve protects the steering system from shock loads from the steering cylinders if the wheels contact a stationary object. If the shock load pressure exceeds the setting of the crossover relief valve, the valve will open and permit the higher pressure oil to flow to the lower pressure side of the circuit.

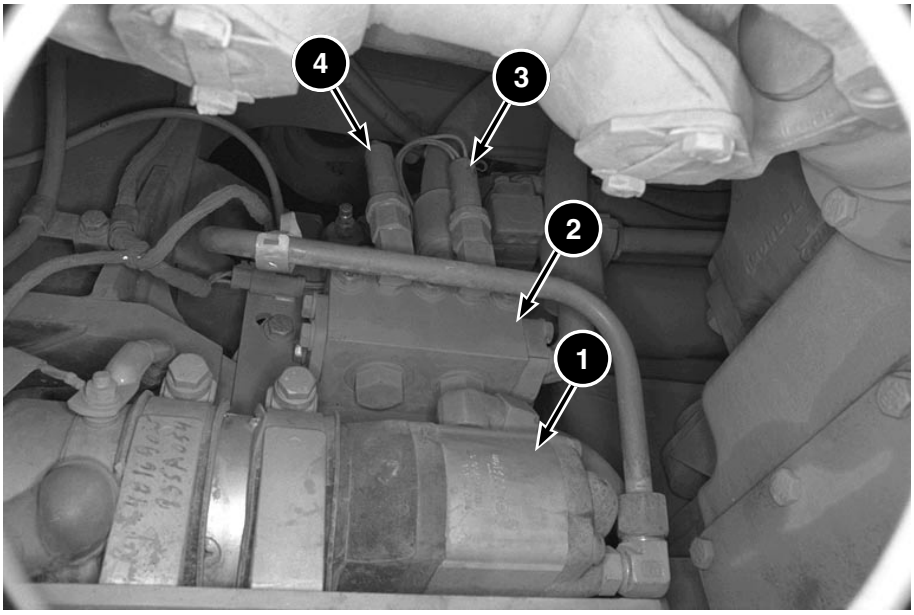

Fig. 2.2.12

Secondary Steering System

The optional secondary steering pump (1) and motor are mounted on the lower left inner frame. The diverter valve (2) is also mounted to the frame near the secondary steering pump.

Primary steering pump oil flows through the diverter valve to the steering control valve. The primary pressure switch (3) is mounted on the diverter valve. If a primary steering pump or engine failure occurs, the primary pressure switch closes, which causes a Category 3 Warning to occur. The operator should safely shut down the engine as soon as possible.

After a one millisecond delay, the relay for the secondary steering pump and electric motor is energized. The oil flow from the secondary steering pump causes the secondary pressure switch (4) to close. The secondary pressure switch then activates the secondary steering indicator to alert the operator that the secondary system has started and steering action will be reduced.

Oil from the secondary steering pump flows through the diverter valve to the steering control valve.

If an engine or primary pump failure occurs, the steering control valve uses the oil flow from the secondary steering pump as pilot system oil.

Fig. 2.2.13

Steering Pilot System Components

The steering wheel (1) and the steering column (not visible) are mechanically connected. The steering column extends from the steering wheel, through the steering column cover and connects with the steering shaft below the floor of the cab.

Moving the steering wheel height knob (2) counterclockwise allows the steering wheel to be raised or lowered to the desired height.

Rotating the steering column tilt knob (3) counterclockwise allows the steering wheel to be moved to the desired tilt position.

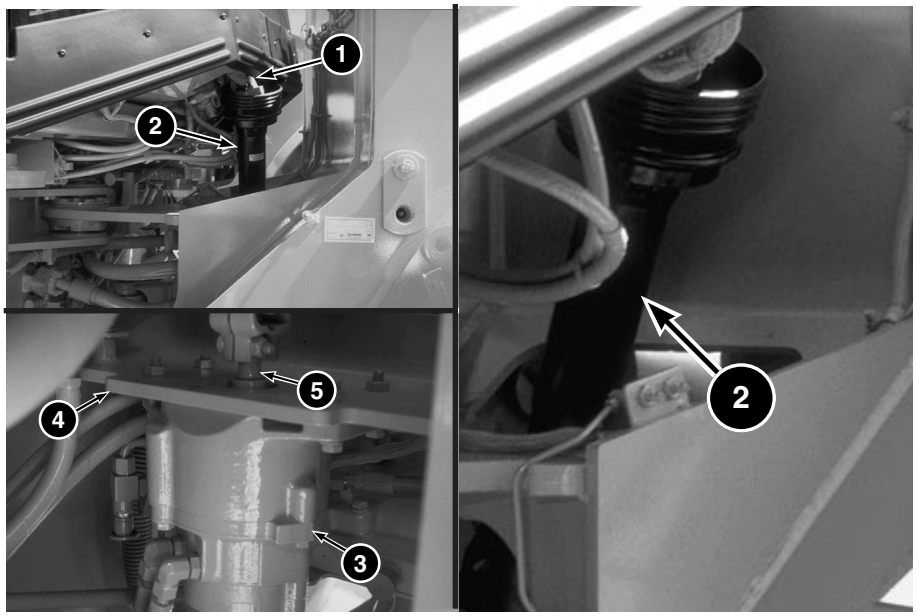

Fig. 2.2.14

The steering column is connected through a constant velocity joint (1) to the steering shaft located inside a tube (2). At the bottom of the steering shaft, another constant velocity joint connects the steering shaft to the pilot valve.

The use of constant velocity joints instead of universal joints results in reduced steering effort, constant steering wheel effort as the machine articulates, smoother steering response and improved roading control.

The pilot valve (3) is bolted to the front frame (4). The steering wheel and steering column are attached to the rear frame (not shown). The steering shaft connects the steering column to the input shaft (5) of the pilot valve. This configuration allows the pilot valve shaft to pivot as the machine articulates.

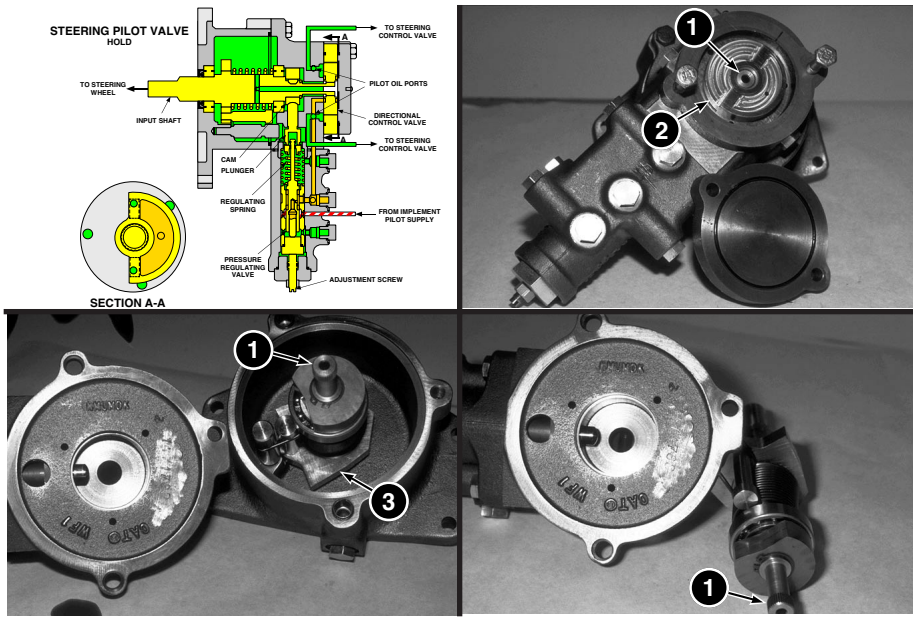

Fig. 2.2.15

The main components of the pilot valve are the input shaft (1), the directional control valve (2) and the pressure regulating valve (top left frame).

The pressure regulating valve controls the steering pilot valve pressure. The pressure regulating valve is actuated by the cam (3) on the input shaft.

Both the directional control valve and the cam are mounted on the input shaft. The input shaft is connected to the steering wheel by the steering shaft with a key and bolt assembly.

When the steering wheel is turned, the cam and the directional control valve rotate in the same direction.

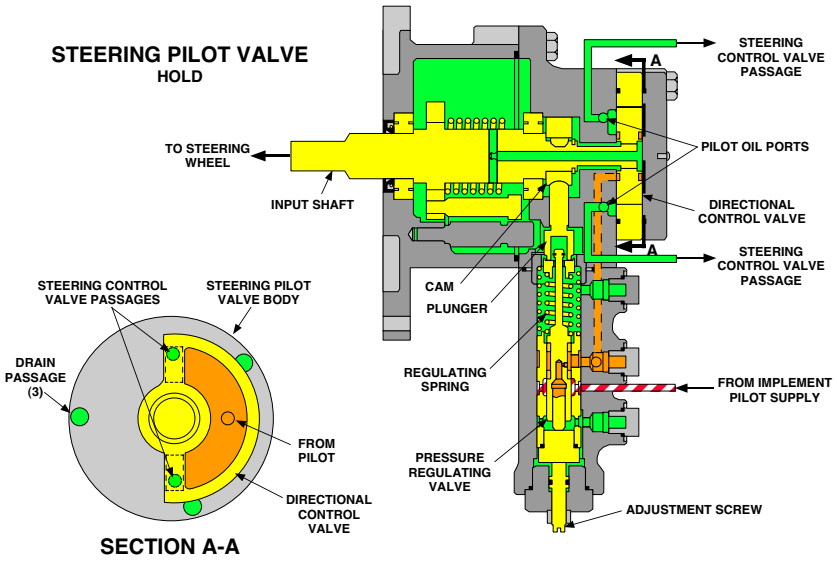

Fig. 2.2.16

This schematic shows the engine ON, the steering wheel in the CENTER position and the pilot valve in the HOLD position.

The steering wheel, steering column and steering shaft are attached to the rear frame. The steering column is attached to the steering shaft through a constant velocity joint.

The steering pilot valve is attached to the front frame. The steering shaft connects through a constant velocity joint to the steering pilot valve input shaft. The steering pilot valve input shaft is splined to the directional control valve.

When the pilot valve is in the "HOLD" position, the directional control valve blocks pilot oil flow to the steering control valve. The oil at both ends of the steering control valve is open to drain.

When the steering wheel is in the CENTER position and the pilot valve is in the HOLD position, the machine front and rear frames are straight and the pilot oil is blocked at the pilot valve. The machine will now travel in a straight line.

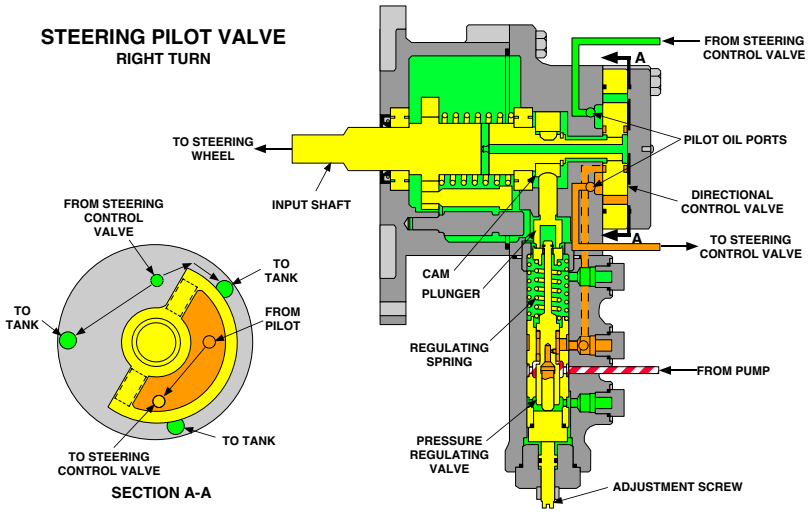

Fig. 2.2.17

When the steering wheel is moved to the RIGHT TURN position, the steering wheel causes rotation of the steering column, the steering shaft, the pilot valve input shaft, the cam and the directional control valve.

The cam moves the plunger against the spring and valve spool of the pressure regulating valve. As the valve spool moves down, pilot oil flow increases between the valve spool and the valve body, which function as an orifice. The pressure of the pilot oil is proportional to the downward movement of the plunger and valve spool.

The further the steering wheel is turned from the CENTER (or HOLD) position, the further the cam moves the plunger against the regulating spring and the pressure regulating valve. This increases the size of the orifice which increases the pilot pressure to the directional control valve. The increased pilot pressure allows increased steering speed. When the steering wheel is fully turned, the pilot pressure should be a minimum of 1650 kPa (240 psi).

When the steering pilot valve is in the RIGHT TURN position, the directional control valve is turned to the right. The "to steering control valve" passage is connected to the "pilot oil" passage and the "from steering control valve" passage is connected to the"to tank" passage. The pilot oil flows to the steering control valve spool for a right turn. The oil at the opposite end of the steering control valve spool flows to the tank.

The steering control valve spool directs the main steering system pump oil to the steering cylinders and the front end of the machine begins to turn (articulate) to the right.

NOTE: The machine turning speed depends on the rotational position of the steering wheel. The farther the steering wheel is turned, the faster the machine will turn. The turning speed of the machine does not depend on how fast the steering wheel is turned.

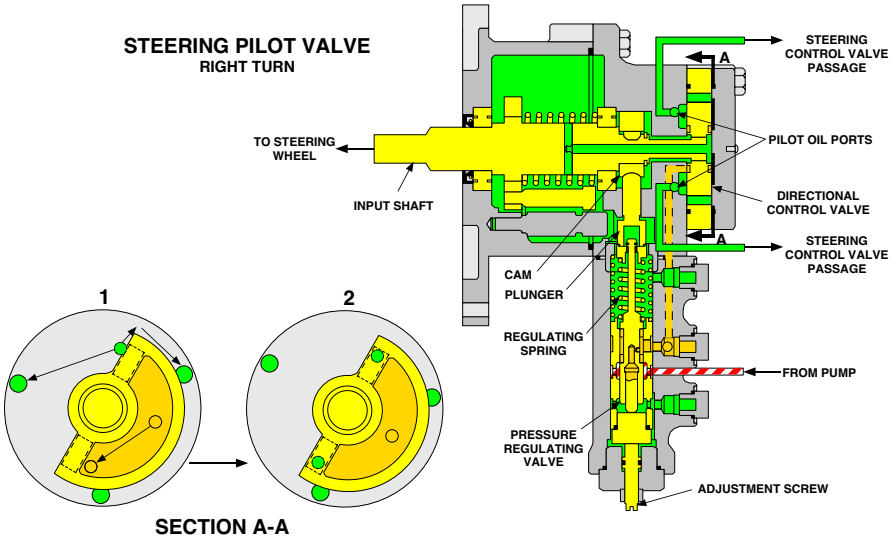

Fig. 2.2.18

As the front end of the machine turns to the right, the steering pilot valve [SECTION A-A (1)] also turns to the right. The constant velocity joints allows the steering shaft to pivot as the machine articulates. The machine continues to turn until the passages in the steering pilot valve are realigned in the HOLD position [SECTION A-A (2)]. At this point, the pilot oil is block to the steering control valve spool passages and the steering control valve spool passages are open to the tank.

The spring in the control valve returns the control valve spool to the HOLD position and the machine stops turning.

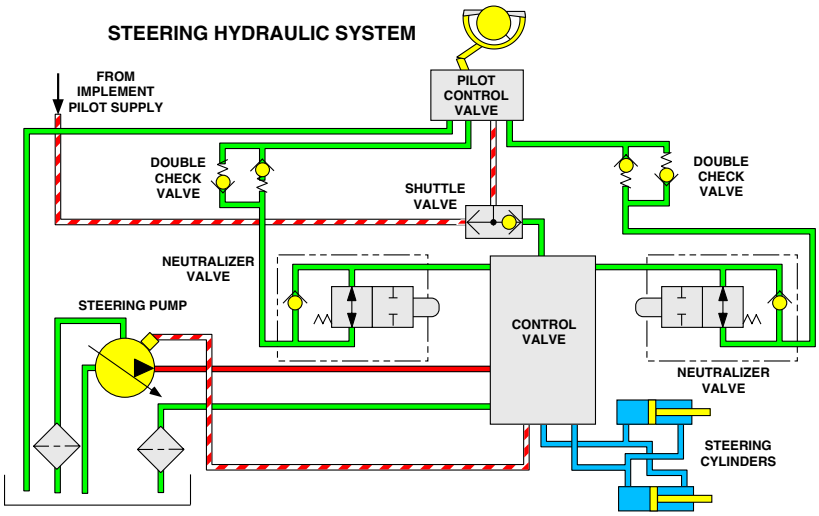

Fig. 2.2.19

Main System Diagram

Shown is a simplified diagram of the steering system. The steering system component are:

Steering pump: Sends supply oil from the tank to the steering control valve.

Steering control valve: Controls the pump flow to the steering cylinders. Other components in the steering control valve housing are:

- Back-up relief valve; protects the system from excessive pressure if a malfunction in the pump compensator valve occurs
- Pressure reducing valve; reduces the supply pressure to 2070 ± 200 kPa (300 ± 29 psi) and sends low pressure oil flow to the pilot valve
- Directional spool; directs oil flow to the steering cylinders
- Cylinder crossover relief valve; limits the maximum pressure in the steering cylinders and cylinder hoses when the directional spool is in the HOLD position
- Makeup ball check valves; allow tank oil to flow into the cylinders when the cylinder pressure is less than the tank pressure
- Shuttle valve; allows the highest cylinder pressure to serve as signal pressure to the steering pump compensator valve and to the secondary steering diverter valve

Shuttle valve: When the engine is running, the shuttle valve allows the higher pressure oil at 3500 ± 250 kPa (500 ± 35 psi) from the implement pilot system to supply the pilot valve. When the engine is not running and the secondary steering system is ON, the shuttle valve allows the lower pressure oil at 2070 ± 200 kPa (300 ± 29 psi) from the pressure reducing valve in the steering control valve to supply the pilot valve.

Double check valves: Prevent pilot oil flow from the steering control valve to the pilot valve. They also provide a passage to the tank if the cushion orifice becomes plugged and pilot oil is trapped behind the steering control valve spool.

Pilot control valve: Sends pilot oil to move the steering control valve spool.

Steering cylinders: Extend and retract to steer the machine.

Neutralizer valves: Block pilot flow to the steering control valve when the machine reaches full articulation.

Cushion orifice: Provides a smooth return of the directional spool to the HOLD position.

Screen: Protects the cushion orifice.

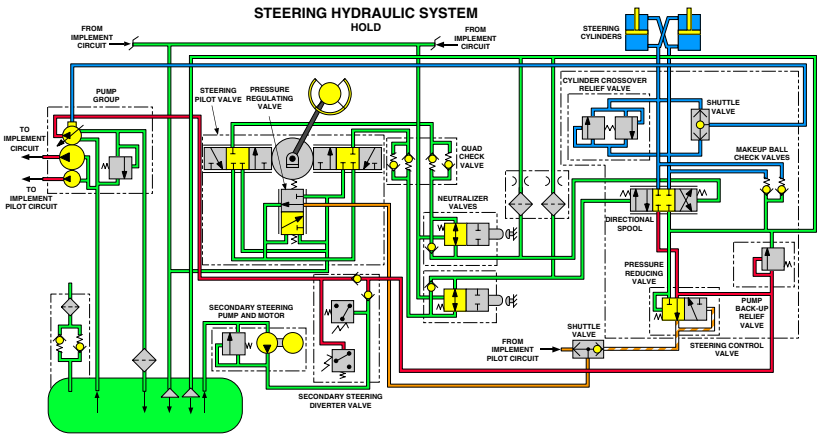

Fig. 2.2.20

Steering System Schematics

When the engine is running and the steering system is in the HOLD position, the steering pump supply oil flows to the steering control valve. In the steering control valve, supply oil flows past the pump back-up relief valve to the directional spool and the pressure reducing valve. The directional spool blocks supply oil flow to the steering cylinders. The pressure reducing valve reduces the supply oil pressure to 2070 ± 200 kPa (300 ± 29 psi) and sends oil flow to the shuttle valve.

At the shuttle valve, the higher pressure implement pilot system oil 3500 ± 250 kPa (500 ± 35 psi) blocks the lower pressure oil 2070 ± 200 kPa (300 ± 29 psi) from the pressure reducing valve. The implement pilot system oil flows through the shuttle valve to the steering pilot valve. In the HOLD position, the pilot oil flow is blocked at the pressure regulating valve in the pilot steering valve.

In the HOLD position, (when the engine is first started and the steering wheel has not been turned) there is no pressure in the steering cylinders and no signal pressure is sent to the compensator valve on the steering pump. The steering pump goes to the LOW PRESSURE STANDBY position.

If any trapped pressure is in the steering cylinders (which occurs when the engine is running and the steering wheel has been turned), the high signal pressure will send the pump to HIGH PRESSURE STALL.

In either position, the pump output decreases to the point where only enough flow is created to compensate for internal leakage.

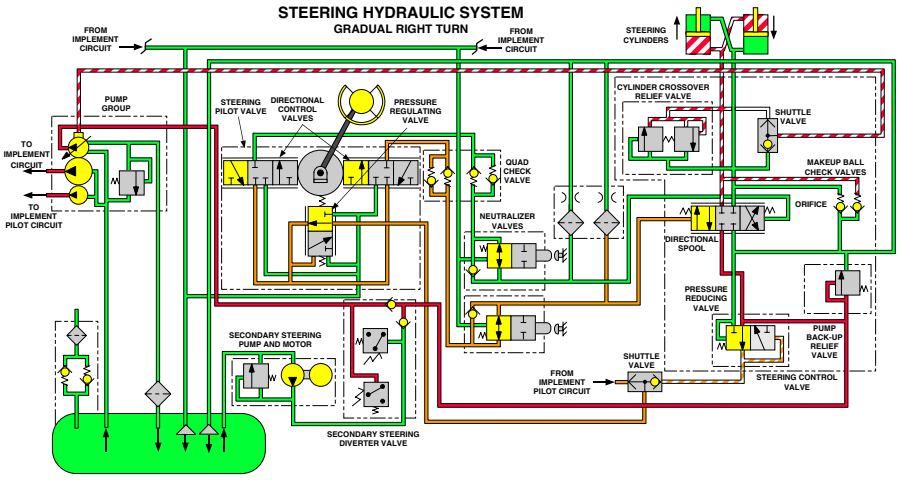

Fig. 2.2.21

This schematic shows the steering hydraulic system during a RIGHT TURN.

The pilot valve is bolted to the front frame of the machine and turns with the front frame. The steering shaft connects the pilot valve input shaft to the steering column. The steering column is connected to the steering wheel.

When the operator turns the steering wheel to the right, torque is transmitted through the steering column and the steering shaft to the pilot valve input shaft. The pilot valve input shaft rotates the cam and the directional control valve to the right. The cam moves the plunger against the pressure regulating valve spring and valve spool. Pilot oil flows through the pressure regulating valve, the directional control valve, the quad check valve and the neutralizer valve to the directional spool in the steering control valve.

When the pilot oil moves the steering control valve directional spool to the RIGHT TURN position, the directional spool directs the steering pump oil to the steering cylinders.

The pressure in the steering cylinders also becomes the signal oil pressure. The signal oil pressure moves the shuttle valve to the opposite side and signal oil flows to the steering pump compensator valve margin spool spring chamber. The signal oil pressure combines with the force of the margin spring and causes the pump to UPSTROKE. The machine turns to the right.

NOTE: The machine turning speed depends on the rotational position of the steering wheel. The farther the steering wheel is turned, the faster the machine will turn. The turning speed of the machine does not depend on how fast the steering wheel is turned.

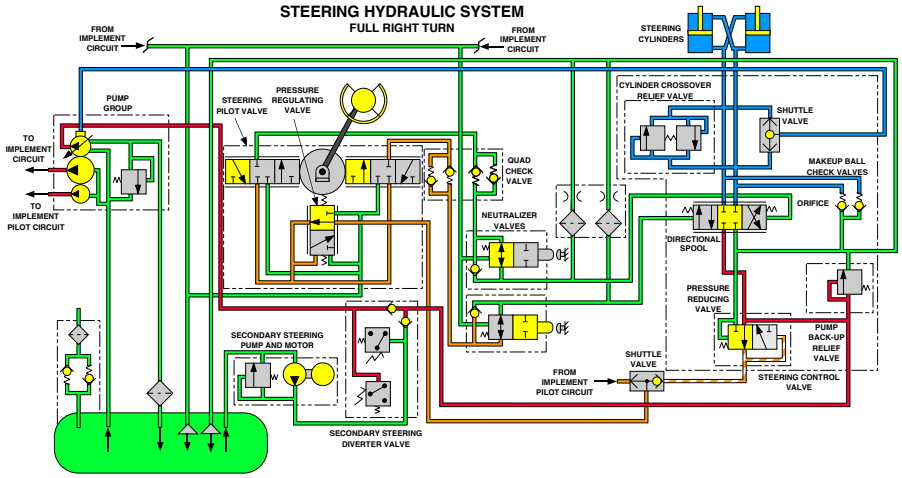

Fig. 2.2.22

The machine turns to the right until the stop mounted on the front frame contacts the neutralizer valve mounted on the rear frame. The stop on the front frame moves the neutralizer valve and blocks the pilot oil flow at the neutralizer valve. The directional spool centering spring returns the directional spool to the CENTER position.

When the directional spool returns to the CENTER position, the flow of supply oil to the steering cylinders is blocked and the machine stops turning.

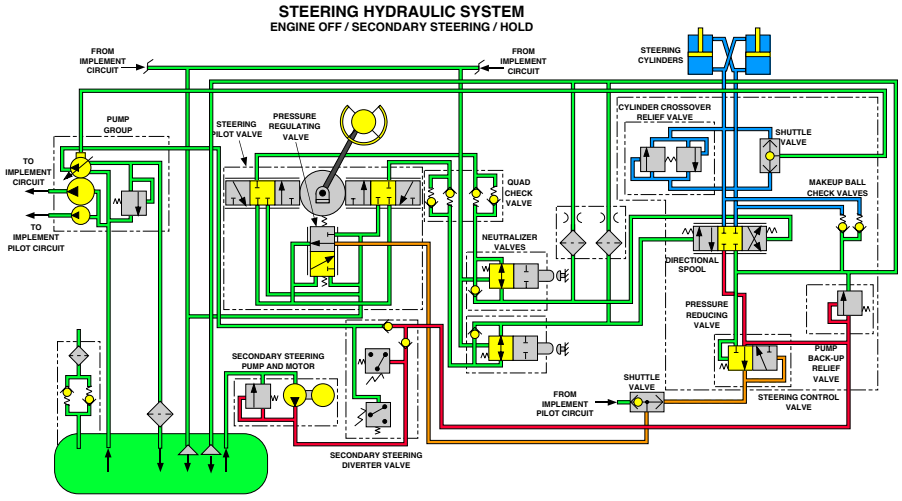

Fig. 2.2.23

Shown is a schematic of the steering system with the engine OFF and the secondary steering system ON.

The secondary steering system consists of the secondary pump and motor, and the secondary steering valve (also referred to as the "diverter" valve). The secondary steering pump and motor are mounted on the rear frame left inner frame rail. The diverter valve is mounted in the same location above the secondary pump and motor.

The diverter valve consists of two check valves and two pressure switches.

When the engine is ON, oil from the primary steering pump flows to the diverter valve. In the diverter valve, steering pump oil flows past the primary pressure switch and the primary check valve. The oil flow seats the secondary check valve to prevent primary steering pump flow from entering the secondary steering pump. Primary steering pump flow is directed to the steering control valve.

The primary pressure switch signals the Caterpillar Monitoring System if a primary steering pump failure occurs.

If a primary steering pump or engine failure occurs, the primary pressure switch causes a Category 3 Warning. This warning alerts the operator to shut down the engine as soon as is safely possible.

After a one millisecond delay, the relay for the secondary steering pump and electric motor is energized. Supply oil from the secondary steering pump flows past the secondary pressure switch. The secondary pressure switch activates the secondary steering indicator to alert the operator that the secondary system has started, and the steering action will be reduced.

Oil from the secondary steering pump opens the secondary check valve and closes the primary check valve to prevent secondary steering pump flow from entering the primary steering pump. The oil then flows to the steering control valve. The oil also flows through the pressure reducing valve and shuttle valve to supply pilot oil at reduced pressure to the steering pilot valve. Turning the steering wheel will provide reduced steering action as previously described.

NOTES

Lab 2.2.1: Steering System Component Identification

Shop Lab Exercise

Procedure:

You will identify Steering System components by matching the lettered or numbered tags on the components with the names on the worksheets.

After locating the components on the machine, you will locate the components on the hydraulic system schematic and record the appropriate schematic item number for each component.

You may refer to the Service Manual or class notes during the lab.

Materials Needed

Lab 2.2.1 Worksheet

Pen or pencil

950G Wheel Loader

Mechanic's tool box with hand tools

Service Manual module "950G Wheel Loader and 962G Wheel Loaders Steering System, Testing and Adjusting Module" (Form No. SENR2644)

Lab 2.2.1: Steering System Component Identification Worksheet

Directions: Use this worksheet during the slide presentation to take notes on the function and location of each component. During the lab exercise, write the letter or number attached to the component next to the correct name. After locating the components on the machine, locate and record the hydraulic schematic item number for each component.

_____ **Hydraulic Oil Tank**

Location: _____

Function: _____

Item Number: _____

_____ **Steering Pilot Valve**

Location: _____

Function: _____

Item Number: _____

_____ **Steering Pump**

Location: _____

Function: _____

Item Number: _____

_____ **Neutralizer Valves**

Location: _____

Function: _____

Item Number: _____

Lab 2.2.1: Steering System Component Identification Worksheet (continued)

_____ Steering Control Valve

Location: _____

Function: _____

Item Number: _____

_____ Secondary Steering Pump and Motor

Location: _____

Function: _____

Item Number: _____

_____ Steering Cylinders

Location: _____

Function: _____

Item Number: _____

_____ Secondary Steering Diverter Valve

Location: _____

Function: _____

Item Number: _____

Lab 2.2.1: Steering System Component Identification Worksheet (continued)

_____ Primary Steering Pressure Switch

Location: _____

Function: _____

Item Number: _____

_____ Secondary Steering Pressure Switch

Location: _____

Function: _____

Item Number: _____

Lab 2.2.2: Steering System Tests

Shop Lab Exercise

This lab measures your ability to perform the steering system tests.

Procedure:

Following the procedure in the 950G Wheel Loader Steering System Operation, Testing and Adjusting Module (Form No. SENR2644), perform the steering system tests.

1. Steering System Pressure Tests
   A. Pump Standby Pressure
   B. Low Pressure Standby
   C. Margin Pressure

2. Pressure and Flow Compensator Valve Adjustment

3. Relief Valve (Pump Backup) Test

4. Steering Pilot System Pressure Test

5. Pilot Valve Supply Pressure Test and Adjustment

6. Command Control Steering Adjustment

7. Steering Time Check

8. Steering Neutralizer Valve Check and Adjustment

Record all test results on "Lab 2.2.2: Steering System Tests Worksheets."

⚠ WARNING

To avoid possible personal injury, follow all warnings listed throughout the "950G Wheel Loader and 962G Wheel Loaders Steering System, Testing and Adjusting Module (Form No. SENR2644)."

Lab 2.2.2: Steering System Tests (continued)

Materials Needed

Lab 2.2.2 Worksheet

950G Wheel Loader and 962G Wheel Loaders Steering System, Testing and Adjusting Module (Form No. SENR2644).

950G Wheel Loader

8T-0854 Pressure Gauge

8T-0855 Pressure Gauge

8T-0856 Pressure Gauge

8T-0859 Pressure Gauge

8T-0860 Pressure Gauge

1U5796 Differential Pressure Group

6 in. Ruler

Stop Watch

2 in. Diameter Ball of Puddy

Mechanic's tool box with hand tools

Lab 2.2.2: Steering System Tests Worksheet

⚠ WARNING

To avoid possible personal injury and damage to equipment, DO NOT steer the machine during the pump standby pressure test.

STEERING PUMP PRESSURES		
	ACTUAL	SPECIFICATION
Low Pressure Standby		
High Pressure Stall		
Margin Pressure		
Relief Valve (Backup)		
Steering Pilot System		
Pilot Valve Supply Pressure		

Steering Time Check:

1. Run the test three times.
2. Compare the average time to the Service Manual specification.

Oil Temp ____°F	1st Test	2nd Test	3rd Test	Average
Cycle Time				
Specification				

Is the average time within machine specification? ___Yes ___No

NOTES