Lesson 2: Steering System (LSPC with Hand Metering Unit)

Introduction

This lesson discusses the nomenclature, the component functions and the system operations of the Load Sensing, Pressure Compensated (LSPC) steering system currently used on the 928G Wheel Loader.

The information in this lesson may be treated as general information and can be applied to other LSPC hydraulic systems.

928G Wheel Loader

- Implement Hydraulic System (Pilot Operated System)
- **Steering System (LSPC with Hand Metering Unit)**

Objectives

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

1. Identify components of the 928G Wheel Loader LSPC steering hydraulic system.
2. State the function of the 928G Wheel Loader LSPC steering hydraulic system in all positions (hold, gradual right or left turn, full right or left turn, etc...)
3. Trace the oil flow through the 928G Wheel Loader LSPC steering hydraulic system in all positions (hold, gradual right or left turn, full right or left turn, etc...).
4. Perform the testing and adjusting procedures as stated in the 928G Wheel Loader, IT28G Integrated Toolcarrier Steering, Systems Operation, Testing and Adjusting Module (Form No. SENR1222).

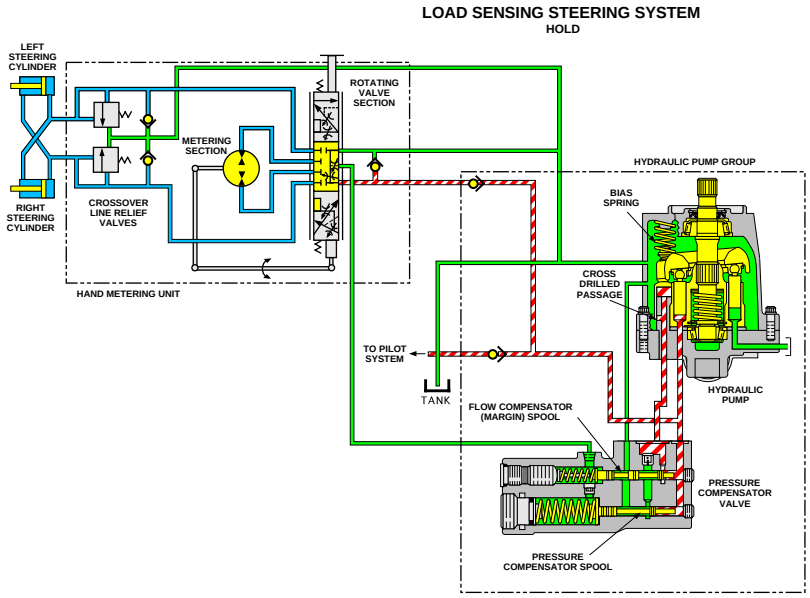

Fig. 1.2.1

STEERING SYSTEM

Steering System Components

The main components of the load sensing steering system are the tank, the variable displacement hydraulic pump group, the hand metering unit (HMU) and the two steering cylinders.

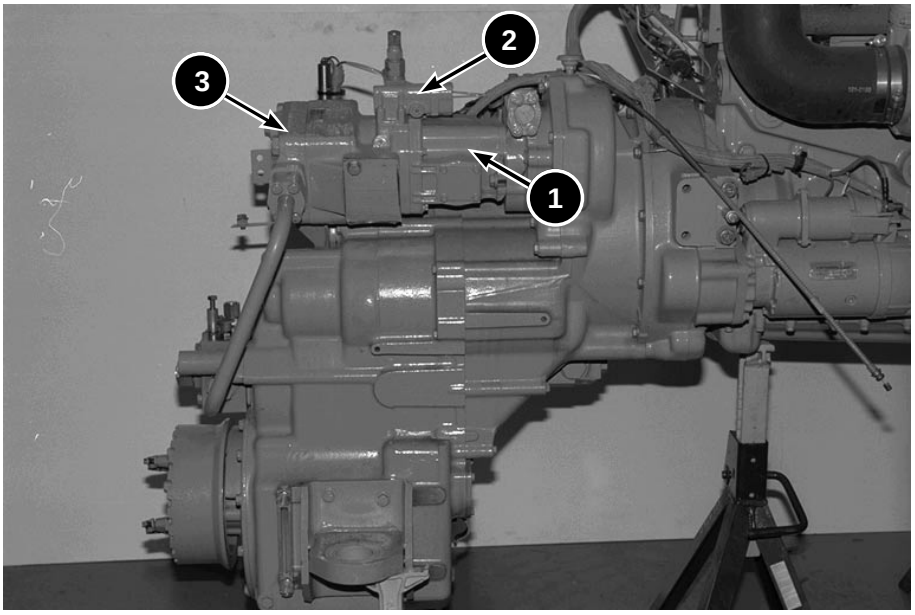

Fig. 1.2.2

The variable displacement steering pump (1) is located on the left side of the machine below the cab. The variable displacement steering pump is similar to the variable displacement pumps on other Caterpillar machines.

Also shown are the compensator valve (2) and the implement pump (3).

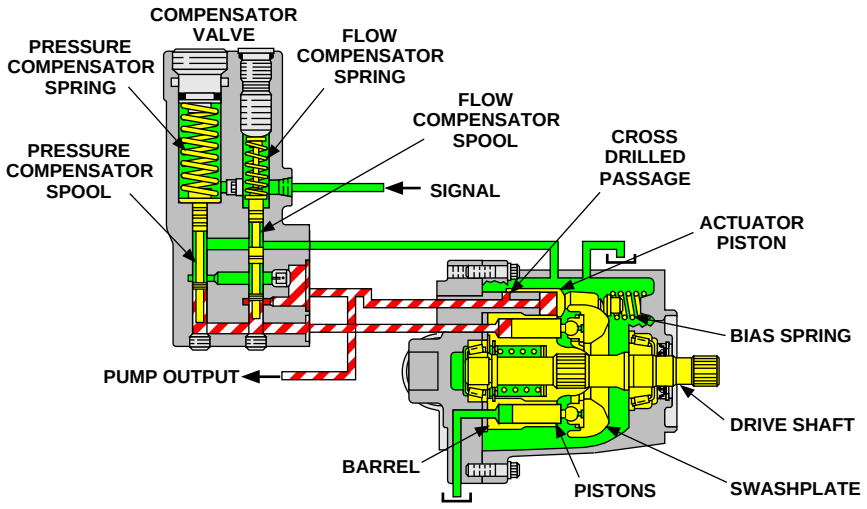

Fig. 1.2.3

The compensator valve controls the pump output by controlling the movement of the actuator piston. The actuator piston works against a swashplate bias spring to continuously adjust the angle of the swashplate. The amount of oil delivered during each pump revolution is determined by the angle of the swashplate. The swashplate angle is infinitely variable between maximum (corresponding to maximum flow) and zero (no flow).

The pump operation is further explained in slides 1.2.11, 1.2.12 and 1.2.13.

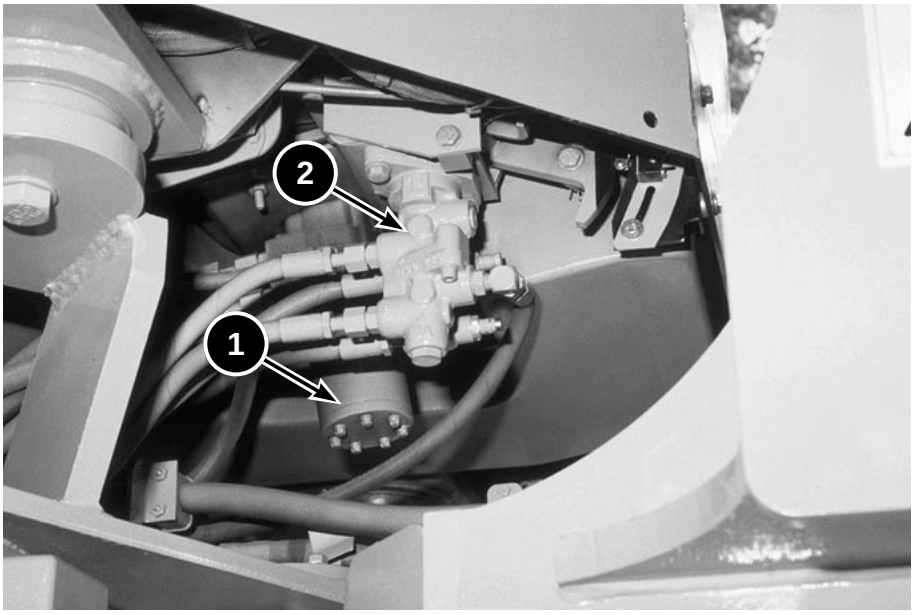

Fig. 1.2.4

The hand metering unit(HMU) (1) is located at the base of the steering column and can be accessed from below the operator's station. The HMU contains a metering and rotating valve that control the movement of the steering cylinders.

Also shown is the brake valve (3).

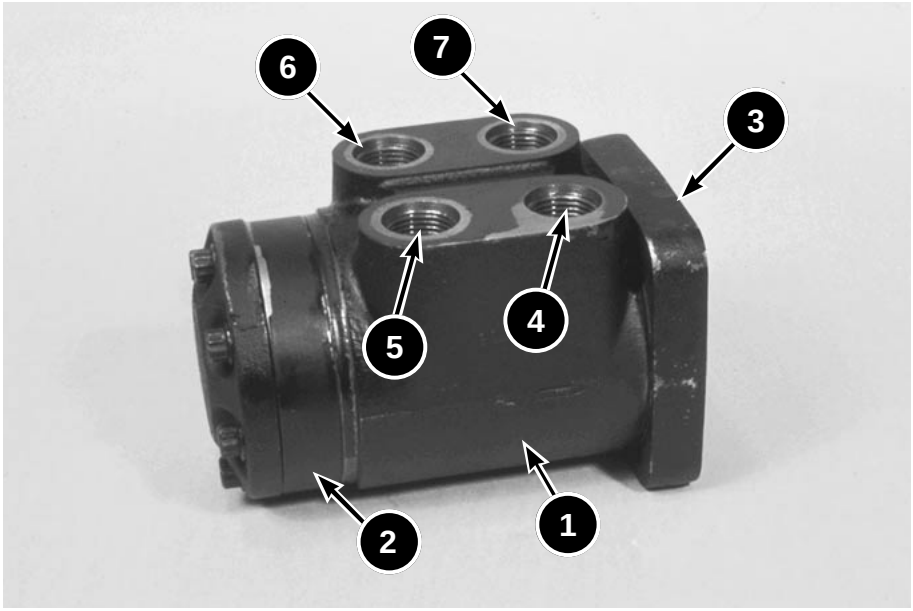

Fig. 1.2.5

The HMU is divided into two main sections. The largest section (1) is the rotating valve section and the smallest section (2) is the metering pump section. The rotating valve section blocks pump oil when the HMU is in the neutral position and directs oil to the metering section and the steering cylinders when the HMU is turned to the left or right.

The right end (3) of the HMU bolts to the steering column shaft. The HMU is driven by turning the steering wheel. The four hydraulic connection ports are the pilot oil for left turn (4), the pilot oil for right turn (5), the oil supply from the hydraulic pump (6) and the return to tank (7).

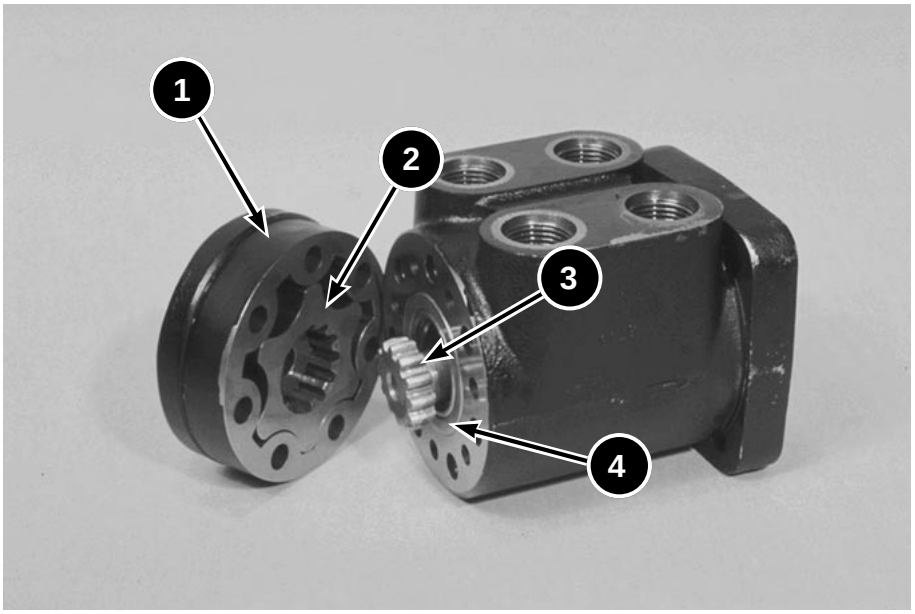

Fig. 1.2.6

The metering pump section consist of the stator (1) and the rotor (2).

The drive shaft (3) splines into the rotor. The opposite end of the shaft is attached to a pin that is held by the outer spool (4) in the rotating valve section.

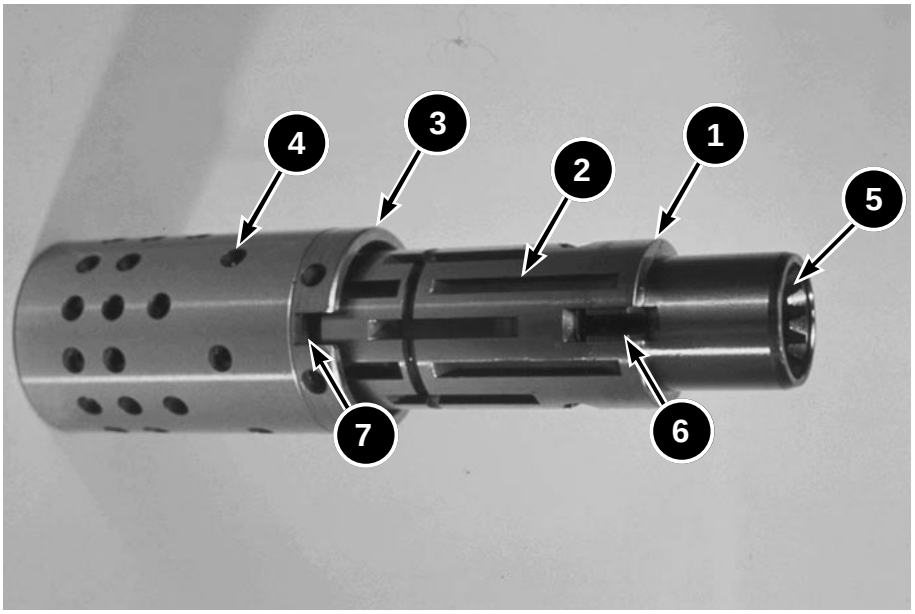

Fig. 1.2.7

The rotating valve control section contains the inner spool (1) with spool passages (2) and the outer spool (3) with orifices (4). The inner spool is splined (5) to the steering wheel shaft. The outer spool is connected through a pin to the metering pump section.

When the inner spool is completely inserted into the outer spool, the leaf type centering springs (6) are inserted in the sleeve slot (7).

When the steering wheel is stationary, the control section is in the neutral position. There is no alignment between the passages in the inner spool and the orifices in the outer spool. The spools function as a closed centered valve. When the steering wheel is turned to the right or to the left, certain passages in the inner spool aligns with orifices in the outer spool allowing pump oil to flow through. When the steering wheel is released, the leaf spring turns the outer spool back to the neutral position.

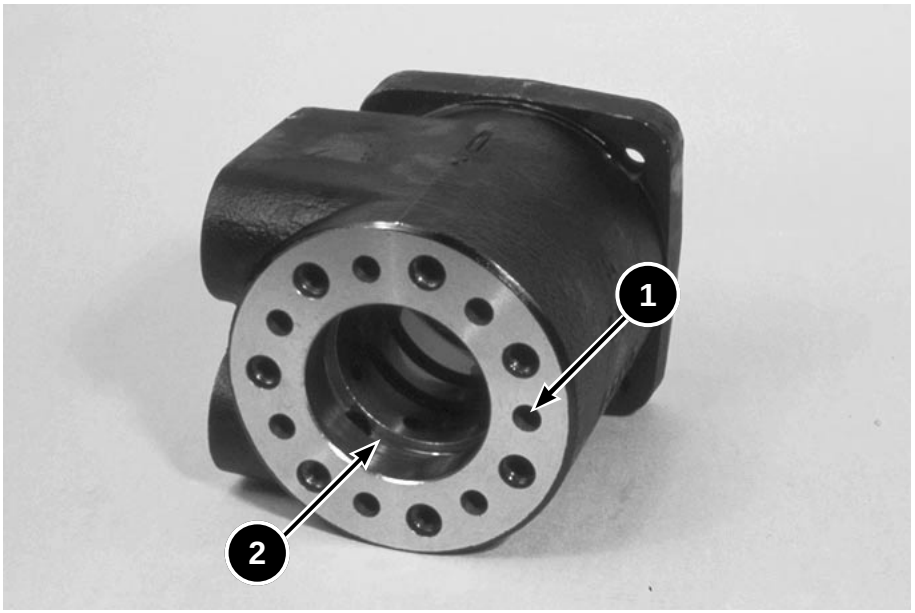

Fig. 1.2.8

In the rotating valve housing of the HMU there are passages (1) which take oil to and from the metering pump section. There are also groove-type passages (2) in the housing where oil is sent to and from the rotating valve assembly. Each groove connects to one of the ports that comes into the side of the housing.

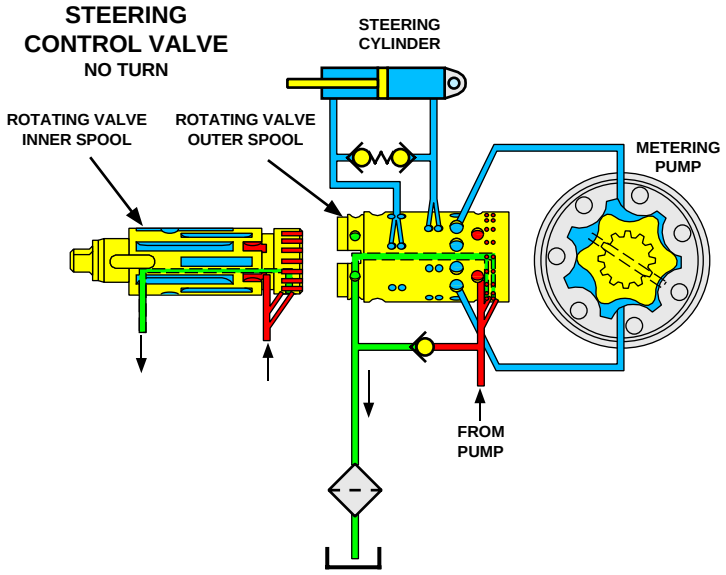

Fig. 1.2.9

Hand Metering Unit (HMU) Operation

In the above graphic the HMU directs oil to the steering cylinder. In some systems, the HMU directs oil to the steering control valve.

The HMU contains a rotating valve and a metering pump. The rotating valve consists of an inner and outer spool that directs oil for a right or left turn. The metering pump consists of a gerotor type pump that controls the amount of oil flow to the steering cylinder.

The inner spool of the rotating valve is splined to the steering wheel shaft. The outer spool is connected to the inner spool by a leaf spring. A pin through the outer spool passes through a larger hole in the inner spool. The inner spool can travel a maximum of eight degrees in either direction relative to the outer spool before the pin contacts the I.D of the larger hole. The leaf springs return the spools to the neutral (NO TURN) position. The metering pump is connected to the outer spool of the rotating valve. One complete rotation of the steering wheel causes one complete revolution of the metering pump drive shaft. However, the rotor walks around the inside of the stator multiple times during this one complete rotation.

During a NO TURN condition, the rotating valve is in the neutral position. Oil flows from the steering pump, through the rotating valve, and returns to the tank. No oil flows to the metering pump or to the steering cylinder.

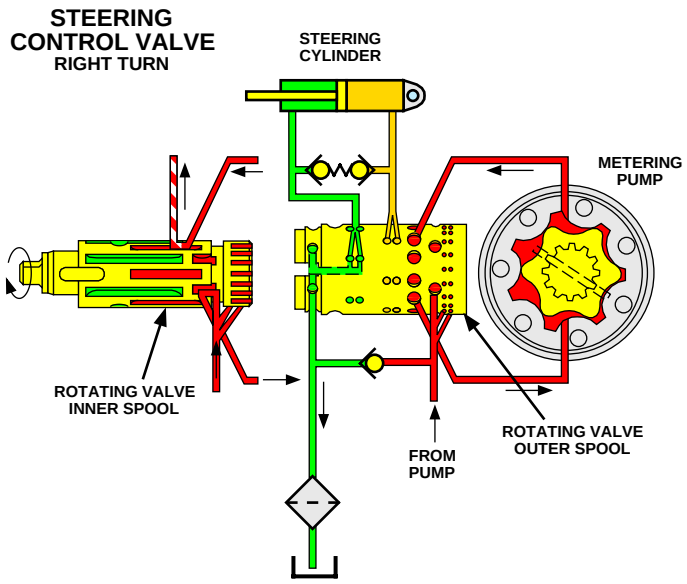

Fig. 1.2.10

When making a RIGHT TURN, the steering wheel turns the inner spool clockwise. During the first eight degrees of steering wheel rotation, the outer spool remains stationary. When the inner spool has rotated 1.5 degrees inside the outer spool, oil flow is directed to the metering pump.

After four degrees of steering wheel rotation, the metering pump begins to meter oil flow back to the rotating valve.

After eight degrees of rotation, oil passages of the inner spool and the outer spool are fully aligned in the right turn position. The inner spool, the outer spool and the metering pump rotate together.

The rotating valve directs the oil flow from the metering pump to the steering cylinder. Return oil from the steering cylinder flows through the rotating valve to the tank.

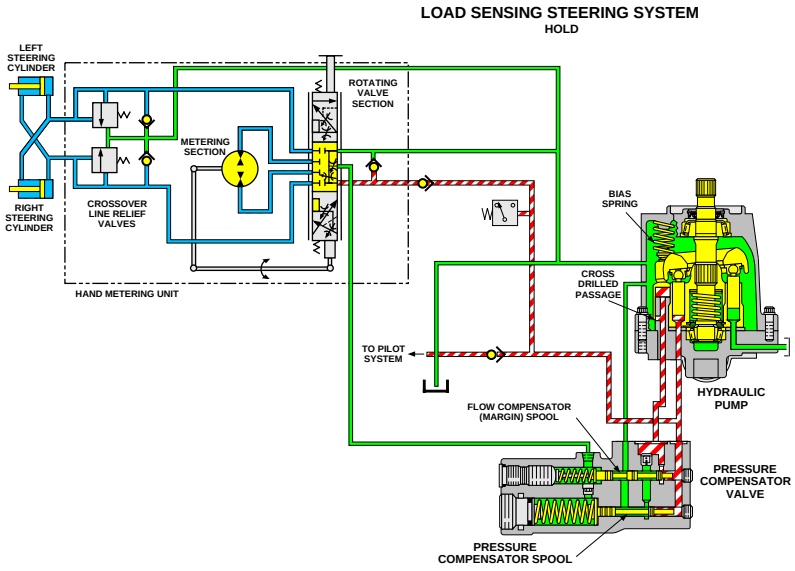

Fig. 1.2.11

This schematic shows the oil flow in the HOLD position.

When the steering system is in the HOLD position, the load sensing steering system variable displacement piston-type hydraulic pump is in the LOW PRESSURE STANDBY position. Most oil flow from the pump is blocked at the HMU. A small quantity of oil is allowed to bleed through the orifice and return to the tank. The oil flow through the orifice ensures that oil is always available to the HMU to equalize heat in the parts and provide quick response when the steering system is operated. The signal pressure passage to the flow compensator spool is open to the tank.

The blocked pump flow causes the system pressure to increase. This pressure is felt at the right end of both the flow compensator (margin) spool and the pressure compensator spool. The margin spool moves left against the low spring force and permits system oil to go to the actuator piston. The actuator piston moves against the pump bias spring and moves the swashplate toward minimum angle.

The actuator piston moves against the bias spring until the cross-drilled passage is uncovered in the actuator piston rod or piston on some pumps. As system oil flows to drain, the pressure in the actuator piston and the force of the bias spring balance. The pump produces enough flow to compensate for system leakage and maintains a minimum system pressure.

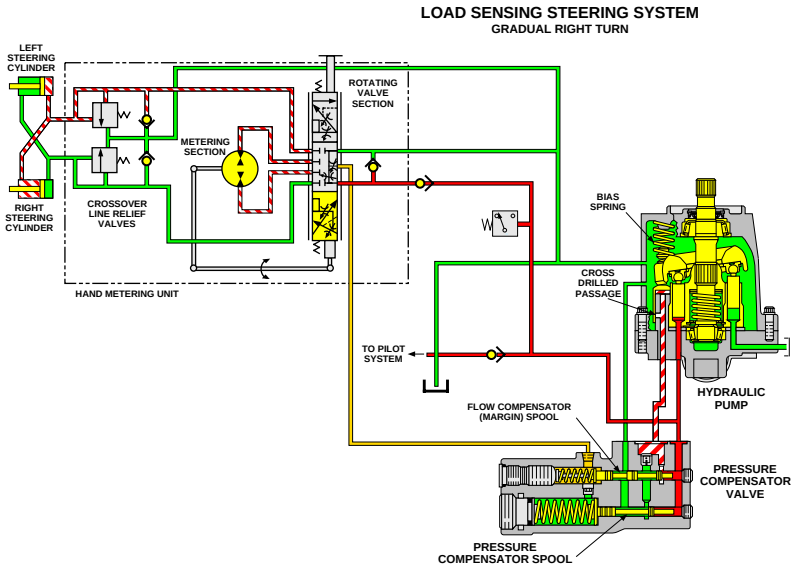

Fig. 1.2.12

This schematic shows the oil flow during a GRADUAL RIGHT TURN.

When the steering wheel is slowly turned clockwise to make a GRADUAL RIGHT TURN, the HMU rotating valve directs oil to the metering section. The oil flows through the metering section and back through the rotating valve to the cylinders. The cylinder return oil flows through the rotating valve to the tank.

The cylinder oil passage is connected through the HMU signal line to the margin spool spring chamber in the compensator valve. The oil pressure in the cylinders is the same as the oil pressure in the margin spool spring chamber. When the oil pressure in the cylinders increase, the force caused by the increased signal oil pressure at the left of the margin spool plus the margin spring force becomes greater than the force of the pump supply oil pressure at the right of the margin spool. The greater force moves the margin spool to the right, blocks the flow of system oil to the actuator piston and opens a passage for oil in the actuator piston to flow to drain.

The pressure at the actuator piston is reduced or eliminated which allows the bias spring to move the swashplate to an increased angle. The pump will now produce more flow. This condition is called UPSTROKING.

As pump flow increases, pump supply pressure also increases. When the force of the pump supply pressure equals the force of the cylinder load pressure plus the margin spool spring force, the margin spool moves to a new metering position and the system becomes stabilized. The swashplate is held at a relatively constant angle to maintain the required flow. This condition is called CONSTANT FLOW.

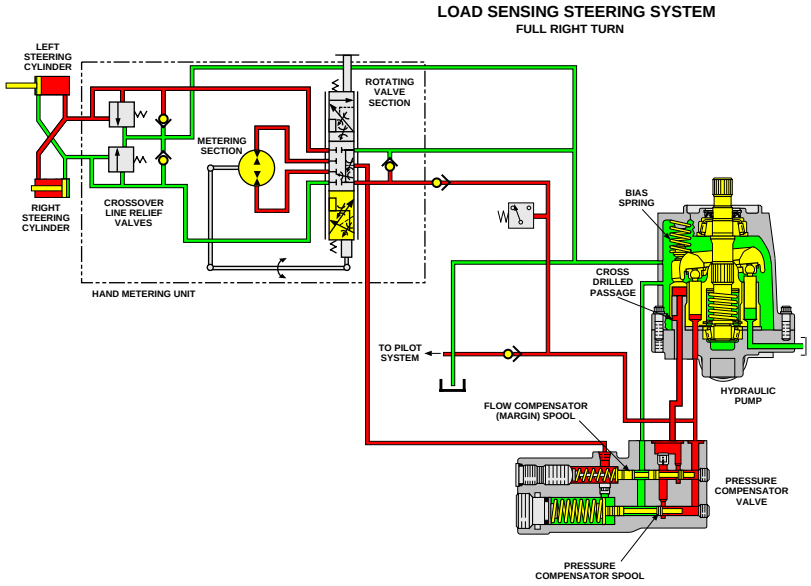

Fig. 1.2.13

This schematic shows the oil flow during a FULL RIGHT TURN.

When the machine is prevented from turning or the cylinders reach the end of their stroke, the supply oil can no longer displace the cylinder piston movement. Supply oil ceases to flow into the cylinders. The supply oil pressure, the cylinder pressure and the signal pressure equalizes. The force of the oil pressure in the margin spool spring chamber plus the force of the margin spool spring is greater than the force of the supply oil pressure. The margin spool is moved to the right and the oil is drained through the margin spool and the pressure compensator spool from the actuator piston. The bias spring sends the pump swashplate toward the maximum angle.

When the force of the supply oil pressure overcomes the force of the pressure compensator spool spring, the pressure compensator spool moves to the left and supply oil flows to the actuator piston. The actuator piston strokes the swashplate towards minimum angle to a position that supplies enough oil flow to maintain the system at the pressure compensator valve setting. This condition is called HIGH PRESSURE STALL.

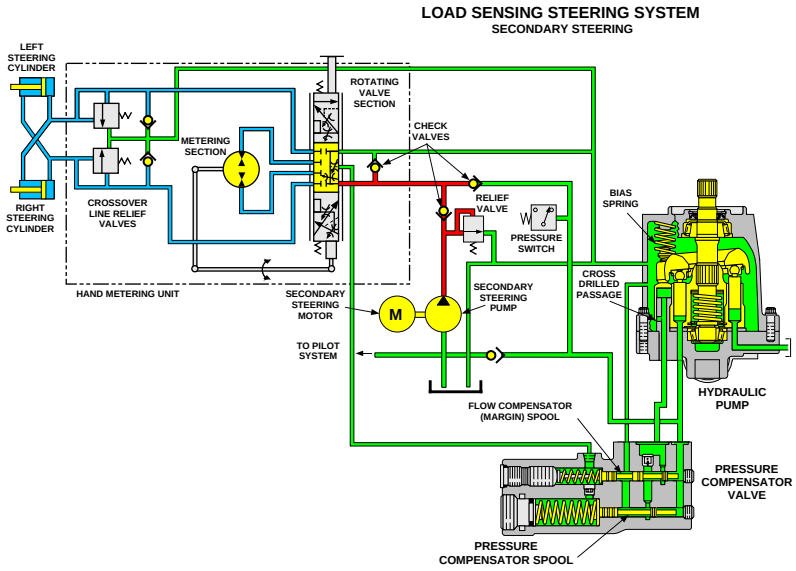

Fig. 1.2.14

Secondary Steering

The function of the secondary steering pump is to supply oil to the steering system when the engine stops and the machine is moving.

The secondary steering pump is a gear type pump driven by an electric motor. Power to the electric motor is controlled by an electronic control module (not shown). The electronic control module monitors the primary pump pressure through the pressure switch. When the pressure in the primary system decreases to below 1200 kPa (175 psi), the switch closes and signals the.control module to start the secondary pump motor. The electronic control module also illuminates the secondary steering indicator lamp in the cab. The secondary steering indicator lamp alerts the operator that the secondary steering system is ON.

When the primary system pressure increases above 1200kPa (175 psi) or the machine stops moving, the electronic control module turns the secondary steering system OFF

The secondary steering hydraulic components are the secondary steering pump, the relief valve, the check valves and the hydraulic pressure switch. The pressure relief valve limits the secondary steering system pressure to 17125 kPa (2500 psi).

NOTES

Lab 1.2.1: 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 component on the hydraulic system schematic and record the schematic item number for each component.

Materials Needed

Lab 1.2.1 Worksheet

Pen or pencil

928G Wheel Loader or IT28G Integrated Toolcarrier

Mechanic's tool box with hand tools

Service Manual module "928G Wheel Loader, IT28G Integrated Toolcarrier Steering, Systems Operation, Testing and Adjusting" (Form No. SENR1222)

928G Wheel Loader, IT28G Integrated Toolcarrier Hydraulic System Schematic (Form No. SENR1227).

Lab 1.2.1: 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 Tank

Location: _____

Function: _____

Item Number: _____

_____ Steering Pump

Location: _____

Function: _____

Item Number: _____

_____ Hand Metering Unit (HMU)

Location: _____

Function: _____

Item Number: _____

_____ Steering Cylinders

Location: _____

Function: _____

Item Number: _____

Lab 1.2.2: Steering System Testing and Adjusting

Shop Lab Exercise

When testing and adjusting the steering system, use the Service Manual module "928G Wheel Loader, IT28G Integrated Toolcarrier Steering, Systems Operation, Testing and Adjusting" (Form No. SENR1222).

Procedure:

Using Lab 1.2.2 Worksheets, follow the directions in Service Manual module "928G Wheel Loader, IT28G Integrated Toolcarrier Steering, Systems Operation, Testing and Adjusting" (Form No. SENR1222) and perform the following tasks.

1. Low Pressure Standby Test
2. High Pressure Stall Test
3. Margin Pressure Test
4. Pressure Compensator Spool Adjustment
5. Flow Compensator Spool Adjustment
6. Steering Time Check
7. Steering Slip Check

Record all test results on "Lab 1.2.2: Steering System Testing and Adjusting Worksheet."

⚠ WARNING

To avoid possible personal injury, follow all warnings listed in the Service Manual module "928G Wheel Loader, IT28G Integrated Toolcarrier Steering, Systems Operation, Testing and Adjusting" (Form No. SENR1222).

Lab 1.2.2: Steering System Testing and Adjusting (continued)

Material Needed

Lab 1.2.2 Worksheets

928G Wheel Loader

Service Manual module "928G Wheel Loader, IT28G Integrated Toolcarrier Steering, Systems Operation, Testing and Adjusting" (Form No. SENR1222)

1 - 8T3311 Tee

1 - 6V3965 Quick Disconnect Nipple

3 - 6V3014 Hose Assembly

1 - 8T0857 Pressure Gauge

1 - 8T0852 Pressure Gauge

4 - 6V4143 Quick Disconnect Fitting

1 - 1U5796 Differential Pressure Group

1 - Stop Watch

Mechanic's tool box with hand tools

Lab 1.2.2: Steering System Testing and Adjusting Worksheet

⚠ WARNING

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

STEERING PUMP PRESSURES		
	ACTUAL	SPECIFICATION
Low Pressure Standby		
High Pressure Stall		
Margin Pressure		

COMPENSATOR VALVE PRESSURE AND FLOW ADJUSTMENT

Does the pressure compensation valve need adjustment? YES / NO

Which pressure test indicates if the pressure compensator valve needs adjustment?

_____

Does the flow compensator valve need adjustment? YES / NO

Which pressure test indicates if the flow compensator valve needs adjustment?

_____

STEERING TIME TEST

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

Steering Time Check: ___°F Specifications: High Idle _____, Low Idle _____

High Idle 1st Test_____2nd Test_____3rd Test_____ Average_____

Low Idle 1st Test_____2nd Test_____3rd Test_____ Average_____

Is the average time within machine specification? ___Yes ___No

STEERING SLIP CHECK

Steering Slip Check: R1___, R2___, R3___, Avg.___; L1___, L2___, L3___, Avg.___

Is the average time within machine specification? ___Yes ___No

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