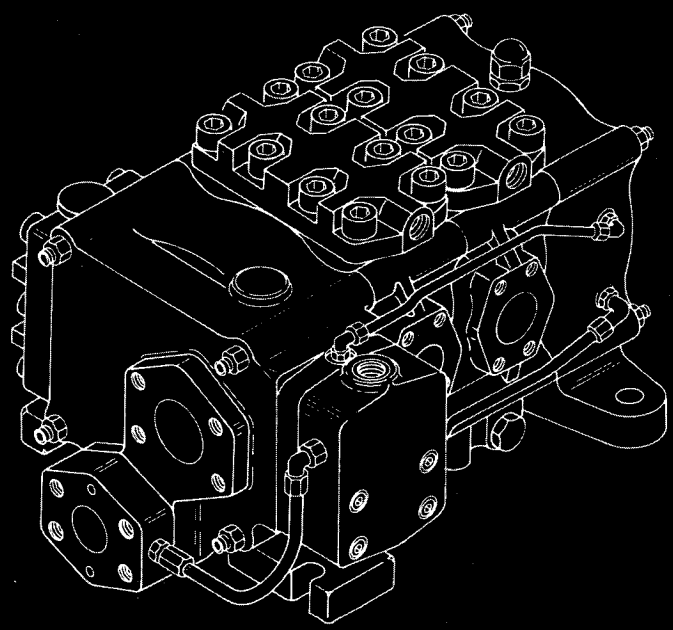
SPLIT SPOOL HYDRAULIC VALVE 9070



CLARK

Michigan Company

SPLIT SPOOL HYDRAULIC VALVE

Operation, Adjustment and Troubleshooting

Introduction . . .

There are three versions of the Split Spool Valve covered in this publication. The PHASE I valve which was used on 175B, 275B and 475B was the original valve. The Pilot Valve had mechanical detents that were released with system air pressure. The PHASE 1½ refers to these early valves with the dampening kit installed. The PHASE II valves are currently being used on 175C, 275C, 375C and 475C. There are many improvements in the PHASE II valve, the pilot valve now has magnetic detents.

There are two sizes of split spool valves. The 6400 is used on the 175, 275 and 375; the 6500 is used on the 475.

NOTE: All specifications in this manual are subject to change. Always refer to specific model service manual for specifications.

CLARK

SPLIT SPOOL HYDRAULIC VALVE
OPERATION, ADJUSTMENT AND TROUBLESHOOTING

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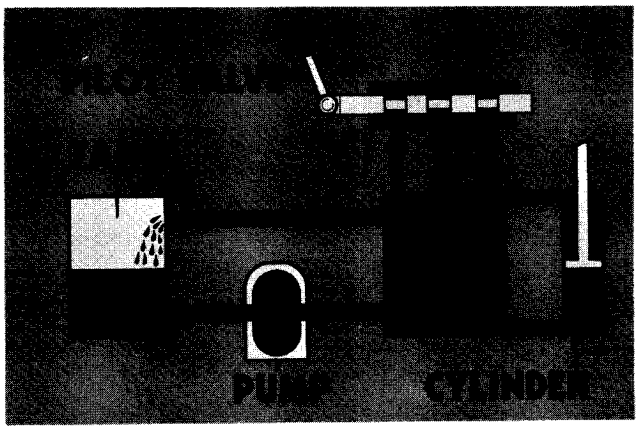
SPLIT SPOOL VALVE HYDRAULIC SYSTEM

THEORY OF OPERATION



In the Split Spool System, there is a tank, a pump, a main control valve, a pilot valve, and finally, there are the cylinders. The pilot valve and main control valve are the two major components. The pilot valve directs pilot flow to and from the main control valve's spools. When the main control valve's spools shift, main flow oil is directed to move the cylinders.

— PILOT FLOW IS CONTROLLING OIL —

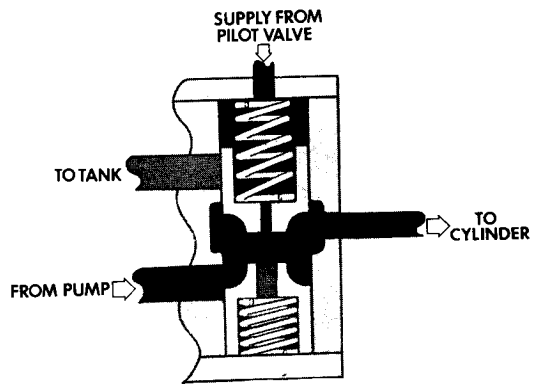
Pilot flow refers to oil that passes from the main valve, through the pilot valve, and is either directed to move a spool in the main valve or returned to the hydraulic tank.

— MAIN FLOW IS WORKING OIL —

Main flow refers to oil that flows from the pump to the main valve, where it is either directed to a cylinder to do work or is returned to the hydraulic tank.

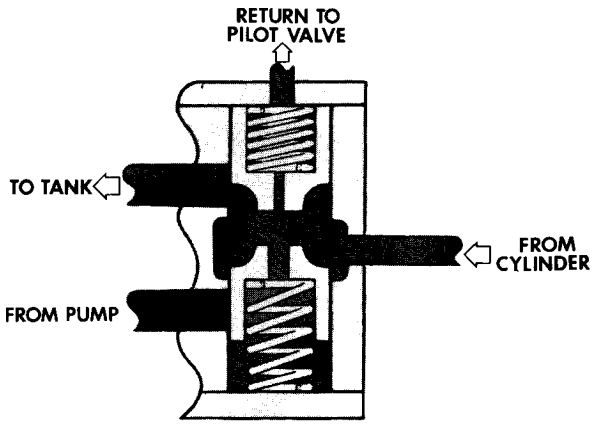
SPOOL OPERATION IN THE MAIN CONTROL VALVE

To move the spool downward, pilot oil is directed to the top of the spool. Oil flows through the hole in the center of the spool to the cylinder.

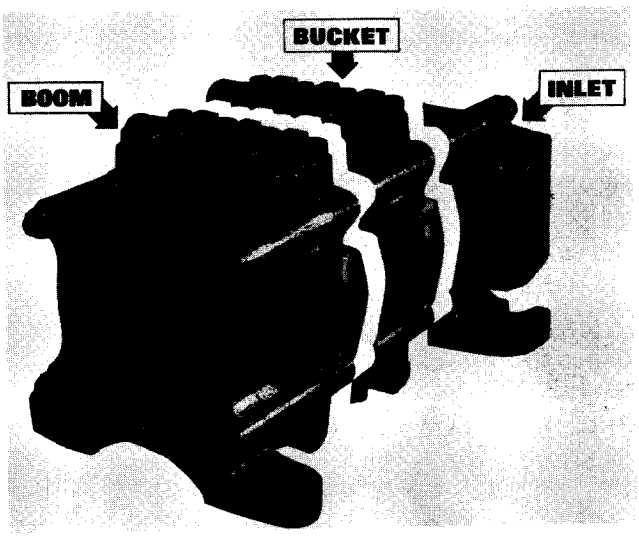


Flow through the small hole in the center of the spool meets resistance which causes a pressure rise in the upper end of the spool. The spool moves downward against spring tension.

To move the spool upward, the pilot oil is exhausted to tank through the pilot valve.

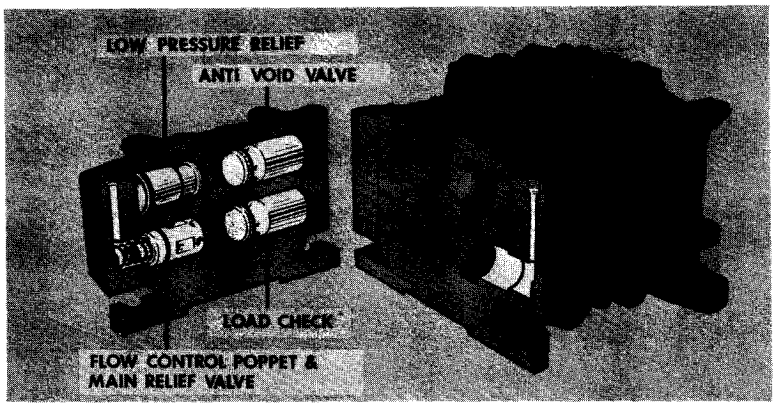


Oil flows from the cylinder through the hole in the center of the spool, and back to tank. Oil passes through the larger bottom hole easily; it meets resistance when passing through the smaller, top hole. This causes a rise in pressure in the bottom of the spool and the spool shifts upward.



In the main control valve, there are three sections:

1. the inlet.
2. the bucket.
3. and the boom section.



INLET SECTION

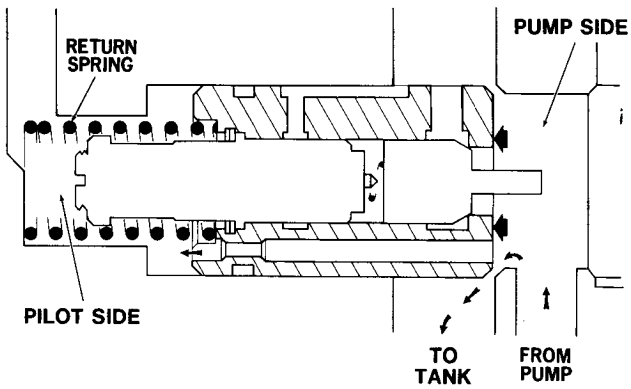
The inlet section houses four components: the low pressure relief, the load check, the anti-void poppet, and the main flow control poppet and relief valve assembly.

Low Pressure Relief:
The low pressure relief valve maintains a small amount of pressure in the low pressure chamber to keep everything full of oil as oil returns from the cylinders to tank. The ball, located in the low pressure relief, allows quick escape of the oil in the spring area when a high volume of flow is directed to tank. A small passage is drilled from the front face into the spring area to allow oil to flow behind the valve to help hold it on its seat.

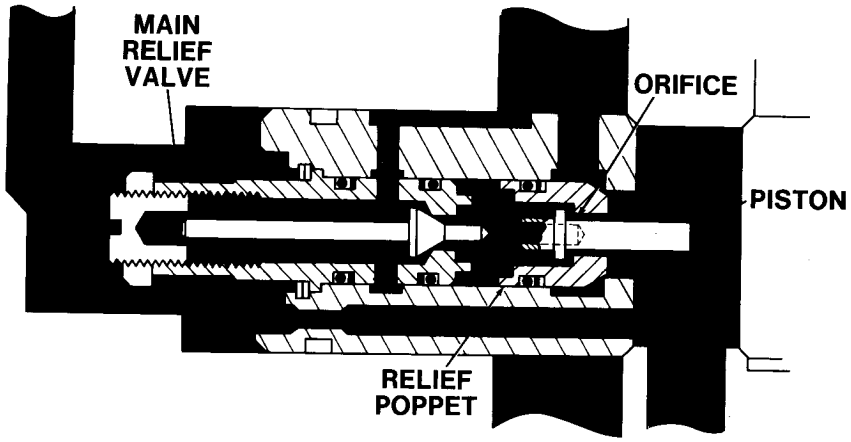
Anti-Void Poppet:
The anti-void poppet will open when the pressure is less in the supply, or high pressure chamber than in the return, or low pressure chamber. This allows return oil from the cylinders to flow into the high pressure chamber to prevent voids in the cylinders.

Load Check:
The load check is a one way check valve. Its function is to hold the load, or hold the cylinders in a given position, until the pump can build up enough pressure to overcome the pressure in the system created by the load on the cylinders. If the boom was part way up and the boom lever was activated to raise the boom farther, without this load check in the system, the boom would drop before it would start moving up.

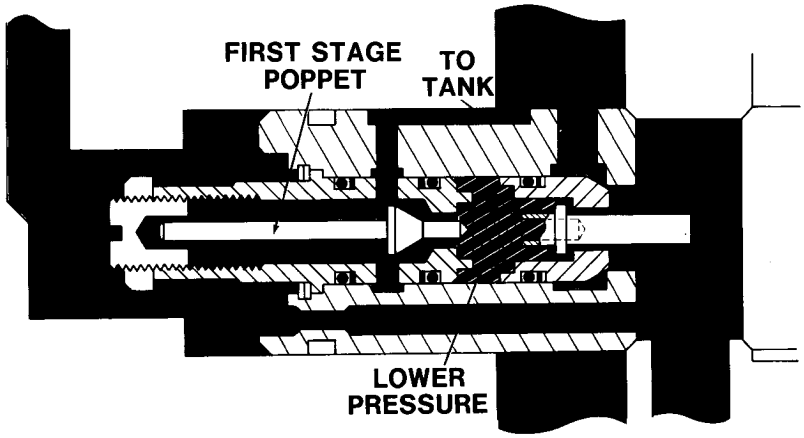
Main Flow Control Poppet and Relief Valve Assembly:
The main flow control poppet will allow oil to return directly to tank when the pilot system is not in use and it directs oil to the cylinders to do the work. The relief valve will protect the pump if the pressure in the system exceeds the spring tension or main relief valve setting. This is how it works:



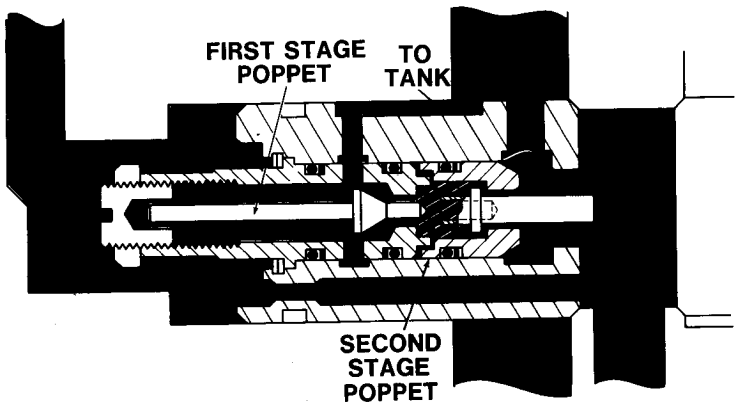
The main flow control poppet has a drilled passage down through the side of it to supply oil to the pilot valve. This passage allows only four to eight gallons of oil per minute to pass. When the pump flow is more than eight gallons of oil per minute, pressure builds up on the pump side of the flow control poppet. Since the pilot side of the flow control poppet is open to tank, the pressure here is less and the poppet is pushed against the return spring and the main flow of oil is returned to tank. When the pilot valve spool is shifted out of neutral, the pilot side of the flow control poppet is no longer opened to tank. Now the pressure equalizes on both sides of the flow control poppet and the return spring pushes it closed.



Now for the main relief portion of this assembly. On the initial start-up, oil flows down the orifice between the piston and second stage relief poppet, and, up to the smaller first stage poppet. Once the area between the poppets is full, flow into this area ceases until relief pressure is reached. Which...



starts forcing the first stage poppet off its seat. This allows oil to flow back to tank, creating a pressure drop between the first and second stage poppet.



This causes the second stage poppet to open and allows main flow back to tank.

When the system pressure goes below the relief setting, the first stage poppet reseats itself. Then the pressure equalizes on both sides of the second stage poppet and the second stage spring closes it. That completes all the parts and functions of the inlet control section.

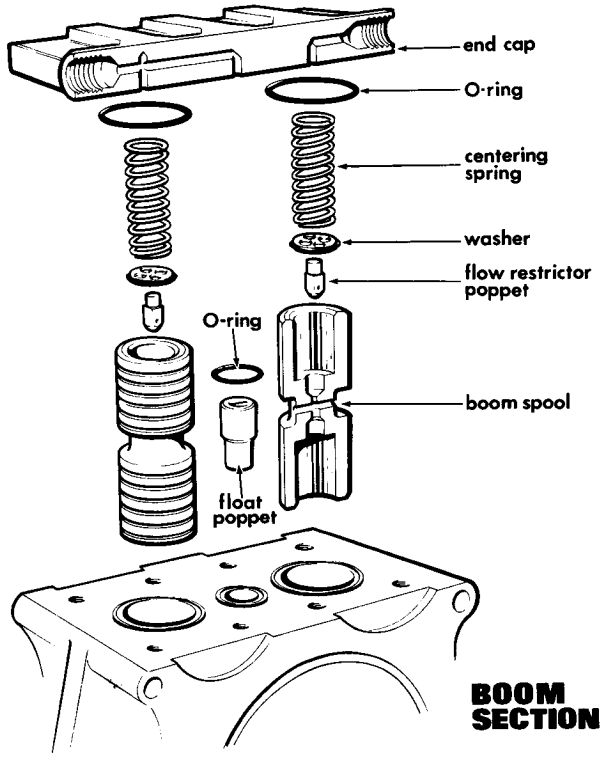
Parts Identification

MAIN VALVE — BOOM & BUCKET SECTION

The boom and bucket sections of the main valve are similar in parts and operation. Therefore, the boom section illustrates the various component functions for both:

End Caps
The pilot pressure end caps direct the flow from the pilot valve into and out of the spools of the main valve.

NOTE: All caps on the main valve sections must be installed correctly for proper alignment of oil passages.



BOOM SECTION

Centering Springs
The springs center the spools.

Washers
The washers provide a seat for the springs and hold the restrictor poppets in place. O-rings help hold the washer in place.

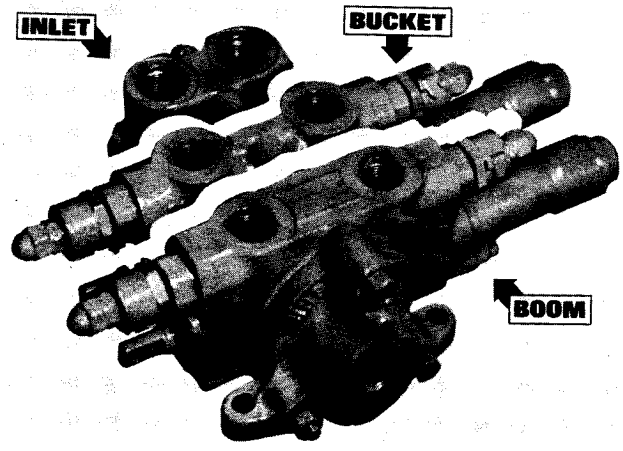
Flow Restrictor Poppets
The flow restrictor poppets restrict the flow of oil through the center of the spools so they will shift smoothly. These poppets are color coded and must be put in their proper places for the valve to function properly.

Spools
The spools direct the flow from the high pressure supply chamber into the cylinder and from the cylinders into the low pressure return chamber. For each operation of the boom or bucket, both spools in that section must shift. One shifts down to supply one side of the cylinders, the other one must shift up to allow the oil to return to tank from the other side of the cylinders. The exception to the one up and one down spool position is when the valve is shifted to float. Then both spools shift up.

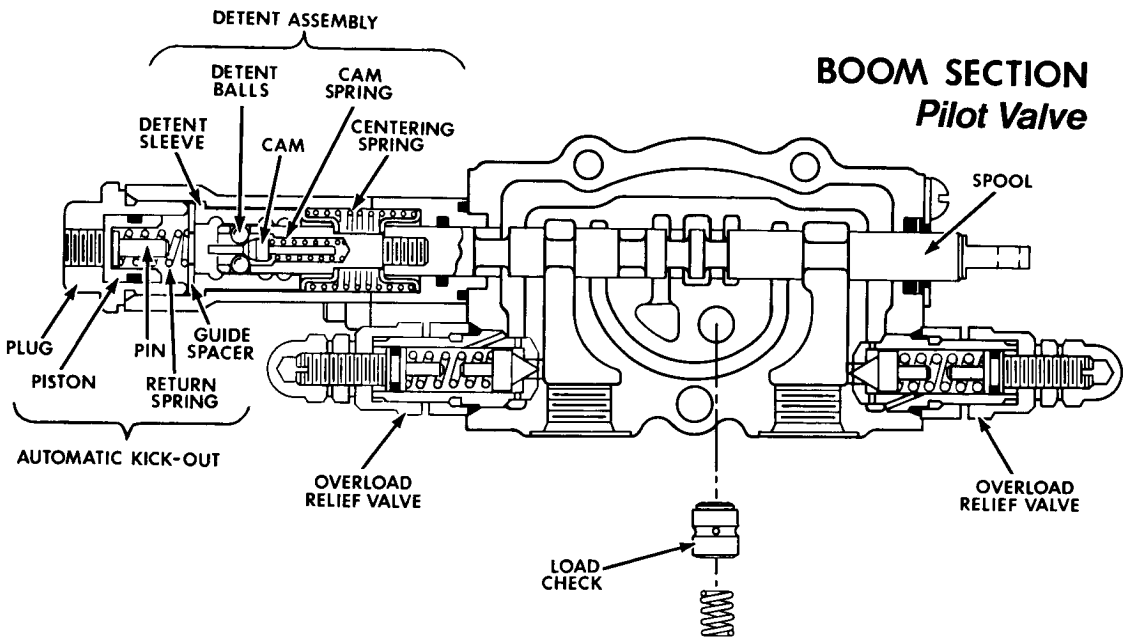
Float Poppets
The long poppet shown and the short poppet (not illustrated) direct oil from the return circuit into the ends of the spools when in float and power down. This allows the spools to shift. The long poppet also contains a ball poppet with a pin retainer to prevent voids. It is also referred to as the float and anti-void poppet.

PILOT VALVE

The pilot valve consists of three sections: the inlet section, the bucket section, and the boom section. The boom and bucket sections are so similar in parts and operation that the boom section illustrates the various component functions for both.



Parts Identification



The Boom Section — Pilot Valve

A. The boom spool is manually shifted to direct the flow into and out of the main control valve.

B. The load check is a one-way check valve with the function of holding a load in a given position until the pilot valve spool has completely shifted. If the load check valve was not there, oil could escape from the base end of the cylinder to the return port. Therefore, the boom would be allowed to fall as the spool was being moved.

C. There are two overload relief valves in each of the boom & bucket sections of the pilot valve; one at the rod end and one at the base end. These overloads protect the machine from shock loads when the control valve is in the neutral position.

D. The detent assemblies hold the pilot valve spools in a desired position until a specific hydraulic function is completed. It is then disengaged by either the operator manually shifting back to the neutral position, or by an automatic kick-out system. The detent assembly consists of:

(1) a detent cap,

(2) a centering spring,

(3) the detent balls, which locate in the groove of the detent sleeve,

(4) the detent sleeve,

(5) the cam and cam spring, which keep tension on the detent balls to hold them in the groove of the sleeve.

On those machines having automatic kick-out, there are air actuated release mechanisms on the detents. The parts that provide the release are:

(1) a piston,

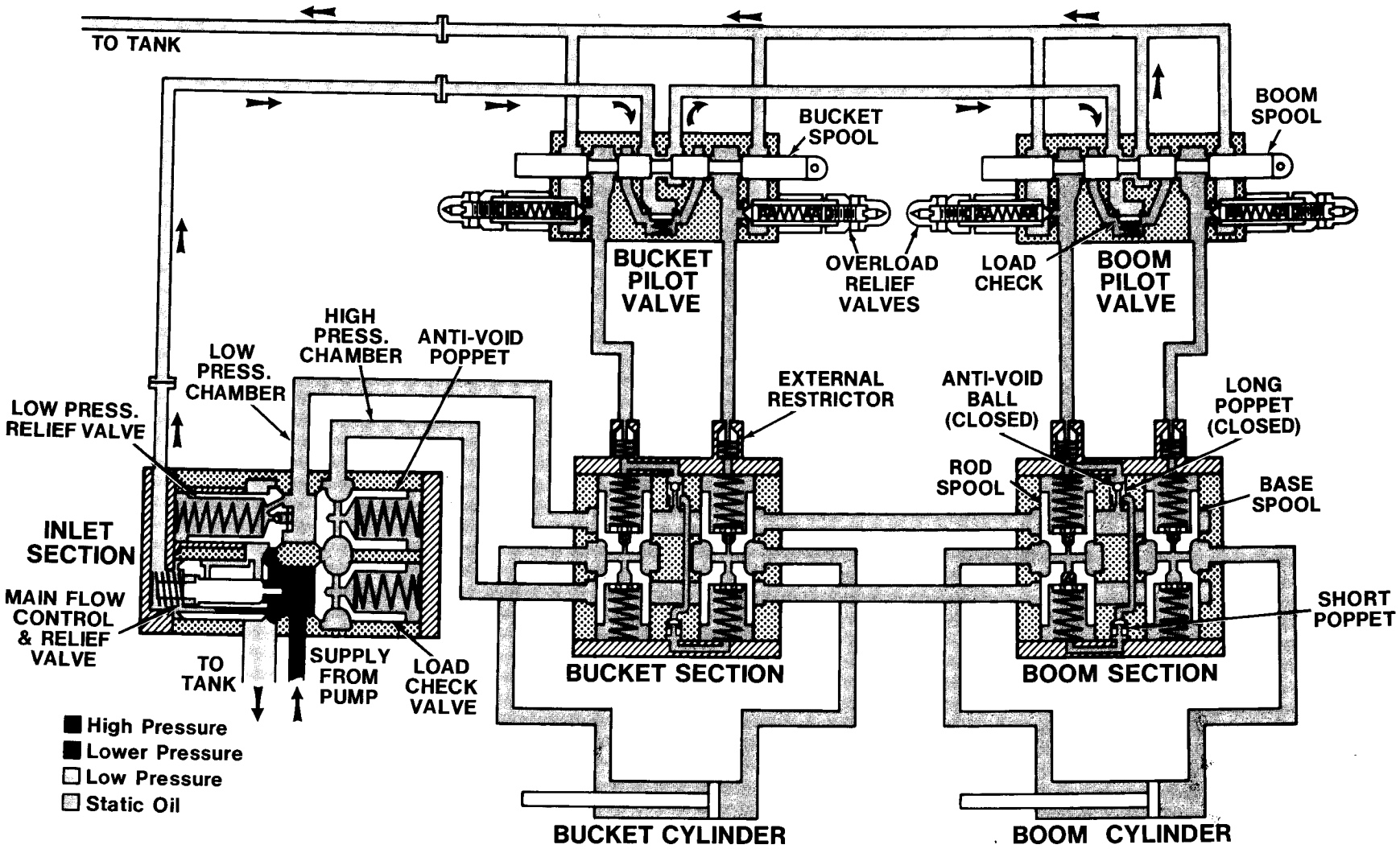
(2) a pin,

(3) a guide spacer,

(4) a return spring,

(5) and a plug.

NEUTRAL POSITION



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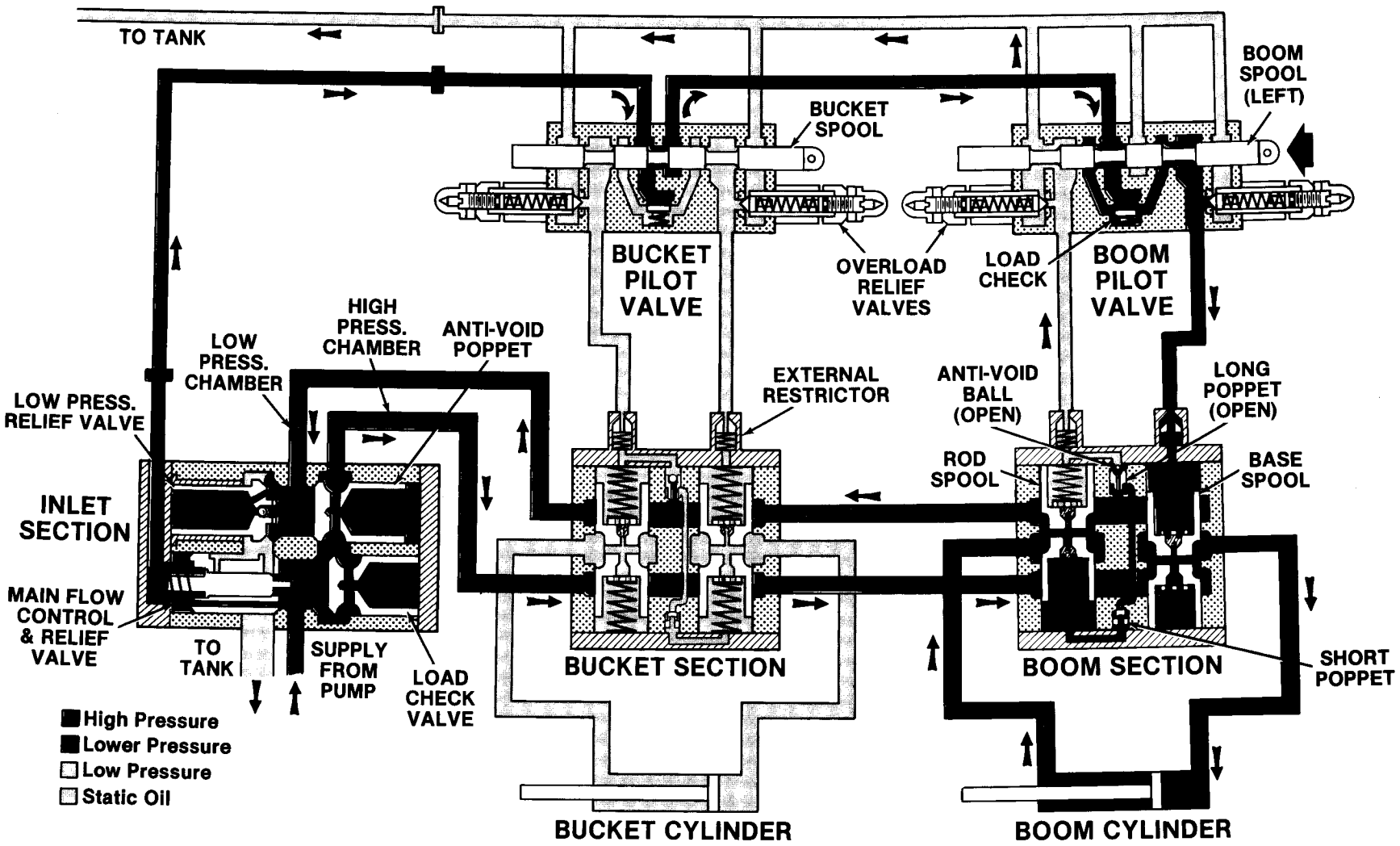
NEUTRAL (HOLD) POSITION

When the main hydraulic valve is in the "NEUTRAL" position, fluid from the pump flows into the inlet section of the valve. This fluid pushes the main flow control and relief valve off its seat. Now fluid from the pump flows around the main flow control and relief valve and to tank. The load check, anti-void, and the low pressure relief valve are held in the closed position by the springs. Fluid from the pump also flows to the end cap through the flow control. This fluid flows through the end cap to the pilot valve. The fluid flows around the spool in the bucket section of the pilot valve. With the bucket spool in the neutral position, fluid can only flow around the spool and to the boom section. The flow of fluid through the boom section of the pilot valve is the same as through the bucket section. The fluid then flows to the tank.

Both spools in the boom section and the bucket section of the main valve are in the "NEUTRAL" position. The spools are held in the "NEUTRAL" position by the tension of the spring on each end of each spool.

EXTENDING BOOM CYLINDER



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EXTENDING BOOM CYLINDER

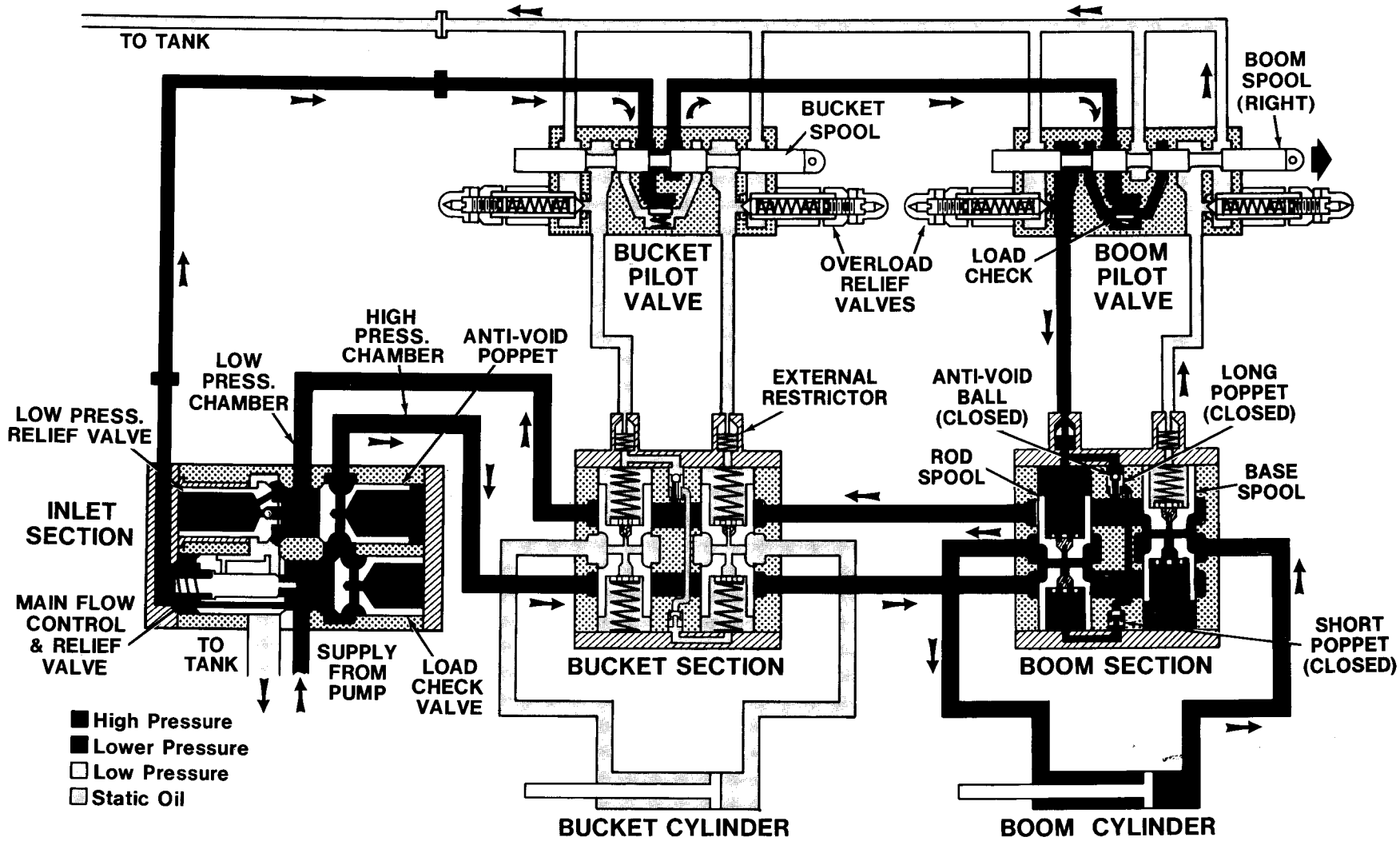
To raise the boom, the boom spool in the boom pilot valve is moved to the left.

Fluid from the pump flows through the flow control to the end cap and through the end cap. Fluid from the end cap flows to the pilot valve. This fluid flows around the bucket spool and to the boom pilot valve. The fluid flows around the boom spool and pushes the load check off its seat. The fluid then flows around the boom spool and to the boom section of the main valve. This fluid flows through an external restrictor and into the chamber above the base spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension. The fluid from below the spool is pushed out through the ports in the center of the spool. This lets the spool move. As the spool moves, this pressure is sensed all of the way back to the spring side of the main flow control. When the pressure on both sides of the main flow control becomes the same, the spring closes the main flow control. This stops the fluid from flowing to tank.

Now, the fluid from the pump opens the load check in the inlet section of the main valve. Fluid from the pump flows around the load check into the high pressure chamber. This fluid also helps keep the anti-void on its seat. Fluid from the high pressure chamber flows through the bucket section and into the boom section. This fluid flows around the base spool, which is down, and into the base end of the boom cylinder. This causes the piston in the cylinder to move. As the piston moves, fluid is pushed from the rod end of the cylinder. This fluid flows into the boom section and into the rod spool in the main valve.

With the boom spool in the pilot valve moved to the left, a port is open. Fluid from the chamber above the rod spool is open through this port to tank. Fluid from the rod end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the rod spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the rod end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the long poppet and the anti-void ball. This measured amount of fluid flows through the pilot valve and back to tank. The pressure on both sides of the short poppet is the same. The short poppet remains closed. Fluid from the rod end of the cylinder flows around the rod spool, and through the bucket section. This fluid flows into the inlet section and pushes the low pressure relief off its seat. The fluid flows around the low pressure relief valve, around the main flow control and back to tank.

RETRACTING BOOM CYLINDER (Power Down)



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RETRACTING BOOM CYLINDER (Power Down)

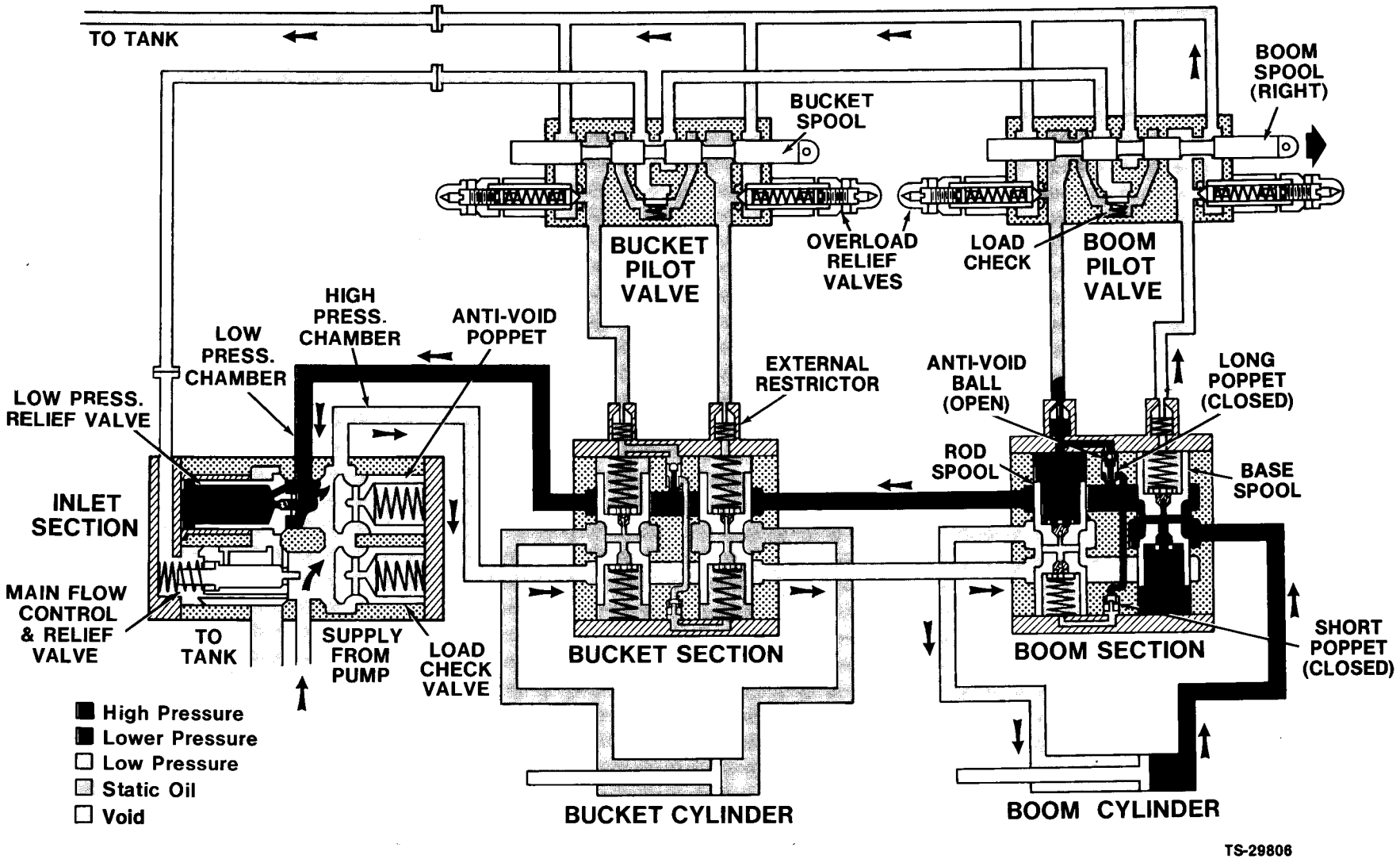
To lower the boom, the boom spool in the boom pilot valve is moved to the right.

Fluid from the pump flows through the flow control to the end cap and through the end cap. Fluid from the end cap flows to the pilot valve. This fluid flows around the bucket spool and to the boom pilot valve. The fluid flows around the boom spool and pushes the load check off its seat. The fluid then flows around the boom spool and to the boom section of the main valve. This fluid flows through an external restrictor into the chamber above the rod spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension. The fluid from below the spool is pushed out through the ports in the center of the spool. This lets the spool move. As the spool moves, this pressure is sensed all of the way back to the spring side of the main flow control. When the pressure on both sides of the main flow control becomes the same, the spring closes the main flow control. This stops the fluid from flowing to tank.

Now, the fluid from the pump opens the load check in the inlet section of the main valve. Fluid from the pump flows around the load check into the high pressure chamber. This fluid also helps keep the anti-void on its seat. Fluid from the high pressure chamber flows through the bucket section and into the boom section. This fluid flows through the base spool, which is down, and into the rod end of the boom cylinder. This causes the piston in the cylinder to move, plus as the piston moves, fluid is pushed from the base end of the cylinder. This fluid flows into the boom section and into the base spool in the main valve.

With the boom spool in the pilot valve, moved to the right, a port is open. Fluid from the chamber above the base spool is open through this port to tank. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. The fluid that moved the rod spool down also holds the anti-void ball on its seat. Because there is no fluid flowing through the anti-void ball, both the short poppet and long poppet remain closed. Fluid from the base end of the cylinder flows around the base spool, and through the bucket section. This fluid flows into the inlet section and pushes the low pressure relief off its seat. The fluid flows around the low pressure relief valve, around the main flow control and back to tank.

ANTI-VOID FUNCTION



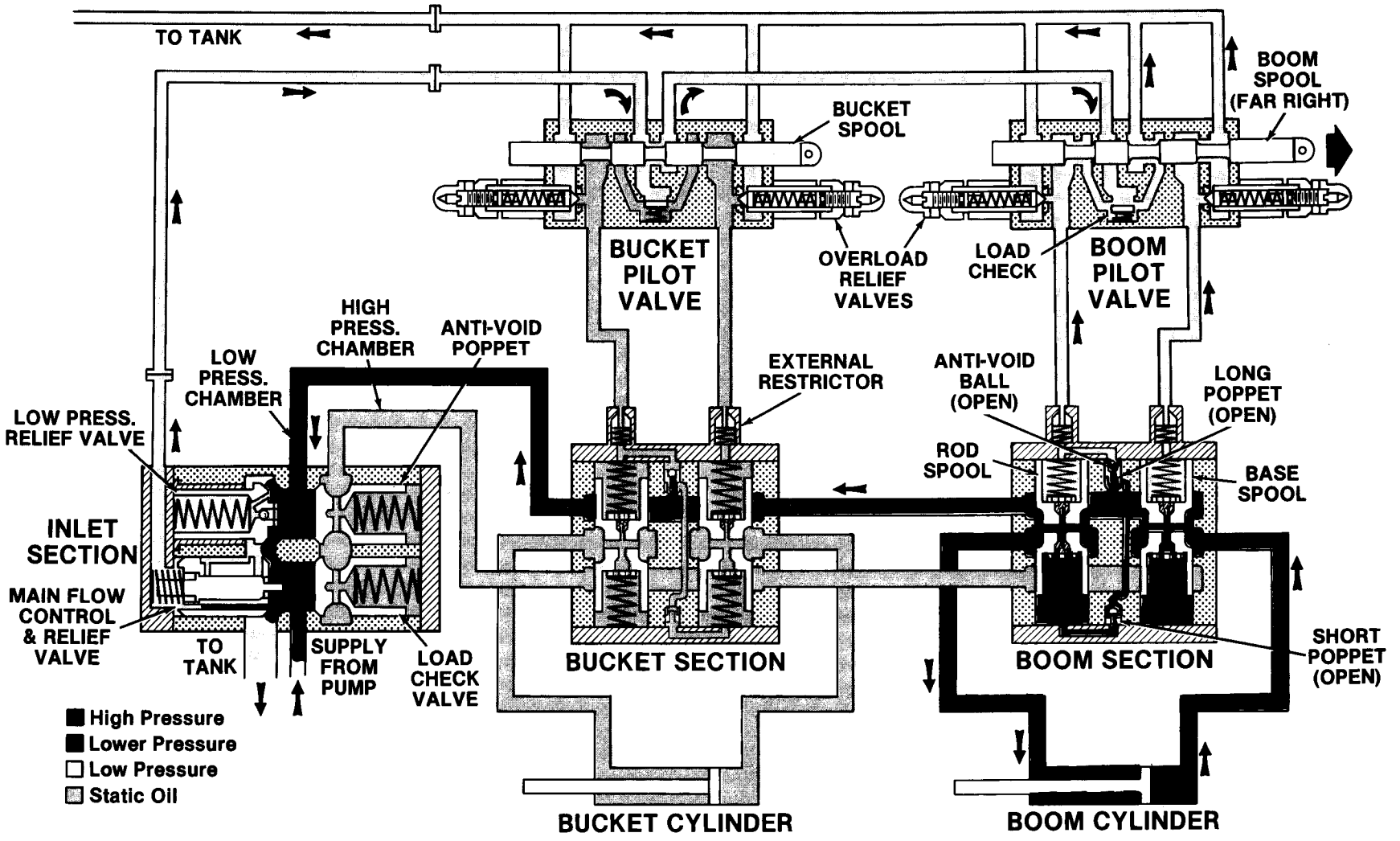
ANTI-VOID FUNCTION

The pilot valve is in the "NEUTRAL" position. The boom is up and there is a load in the bucket. The weight of this load causes the fluid in the base end of the boom cylinder to be under pressure. This pressure is felt through the base spool and is held by the boom spool in the pilot valve. When the boom spool, in the pilot valve, is moved to the right, it is in the "POWER DOWN" position. In this position, the base end of the boom cylinder is open to tank through the pilot valve. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the anti-void ball. This measured amount of fluid flows to the pilot valve where it is stopped by the load check. This fluid then flows into the chamber above the rod spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension.

When the boom starts to move down, the pressure of the fluid in the rod end of the cylinder decreases and becomes a void. The void, which is felt through the large hole in the rod spool and chamber below the spool, lets the spool move down. If the engine is running at low R.P.M. there is not enough fluid from the pump to fill the cylinder. This causes a void in the rod end of the boom cylinder. This void is felt in the supply circuit to the pilot valve and to the pump.

Fluid from the base end of the boom cylinder flows through the bucket section and into the inlet section. This fluid pushes the anti-void off its seat against spring tension and flows into the high pressure chamber. Because the low pressure relief valve opens at a higher pressure than the anti-void, it remains closed. The fluid from the pump pushes the load check off its seat against spring tension and flows into the high pressure chamber. Because the main flow control has the same pressure on both ends the spring holds the main flow control closed. The fluid, from the pump, joins the fluid from the base end of the boom cylinder. This extra volume of fluid flows to the rod end of the boom cylinder to help prevent voids.

LOWERING BOOM IN FLOAT POSITION



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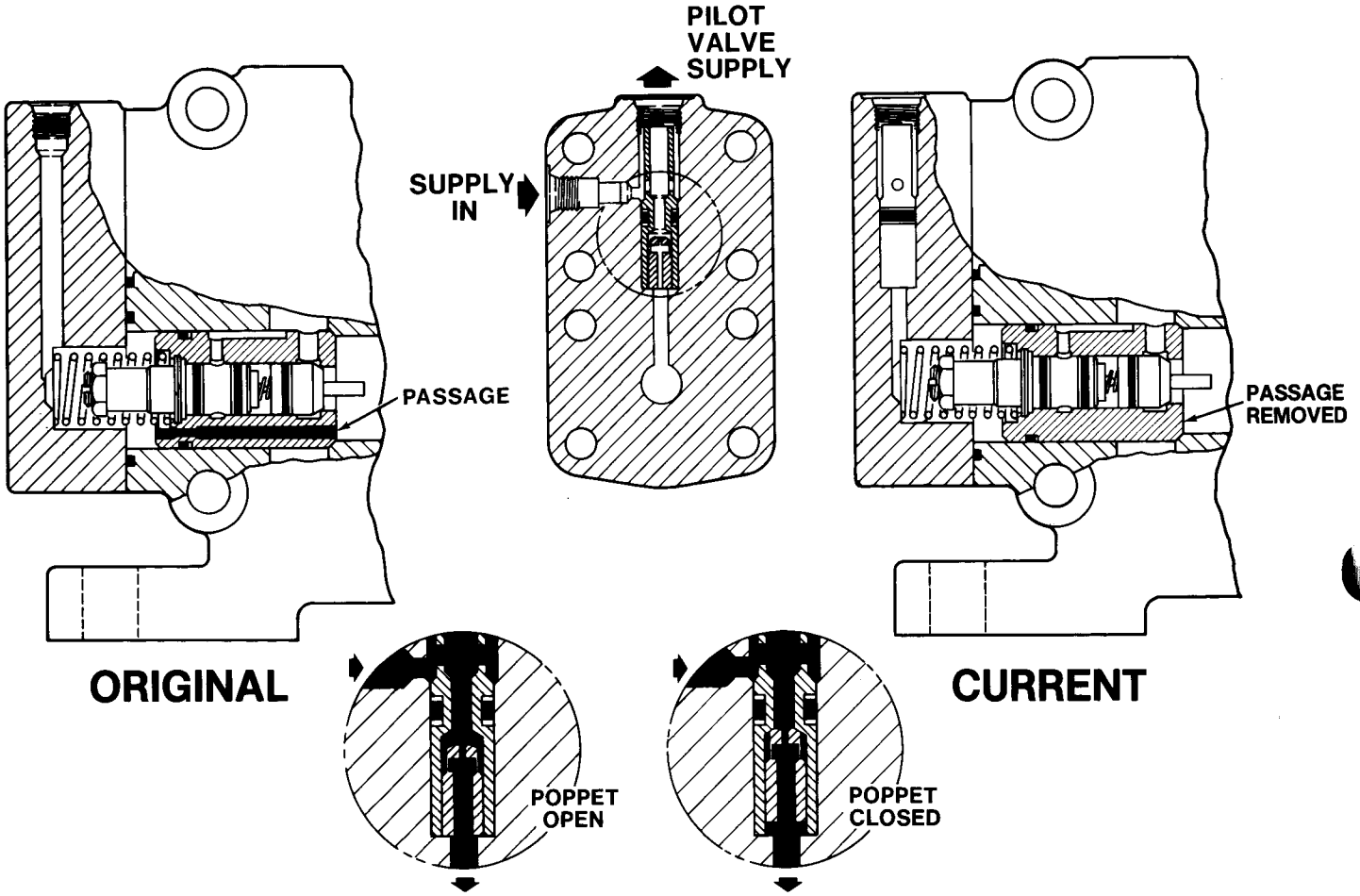
LOWERING BOOM IN FLOAT POSITION

The pilot valve is in the "NEUTRAL" position. The boom is up and there is a load in the bucket. The weight of this load causes the fluid in the base end of the boom cylinder to be under pressure. This pressure is felt through the base spool and is held by the boom spool in the pilot valve. When the boom spool in the pilot valve is moved to the far right, it is in the "FLOAT" position. In this position, the base end and rod end of the boom cylinder is open to tank through the pilot valve. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the long poppet and the anti-void ball. This measured amount of fluid flows to the pilot valve. With the long poppet open, some of the fluid flows through and opens the short poppet. Fluid flows through the short poppet to the chamber below the rod spool. This fluid pushes the rod spool up. Now, fluid from the base end of the boom cylinder flows around the base spool and rod spool. The fluid that is needed in the rod end of the cylinder flows to the cylinder. Any remaining fluid flows through the bucket section to the inlet section. This fluid pushes the low pressure relief off its seat and flows to tank. The anti-void and load check are closed. The main flow control is pushed off its seat by fluid from the pump. Fluid from the pump flows around the flow control and to tank. Fluid from the pump flows through the circuit to the pilot valve and to tank.

The rest of this manual will be devoted to covering improvements and major changes made to the pilot operated, split spool hydraulic system, and troubleshooting the system.

A major improvement was the Pilot Valve Dampening Kit. This kit was developed to reduce pressure spikes in the hydraulic system to help lengthen the life of hoses, tubes, o-rings and seals. This kit is made up of a redesigned flow control poppet and a redesigned end cap.

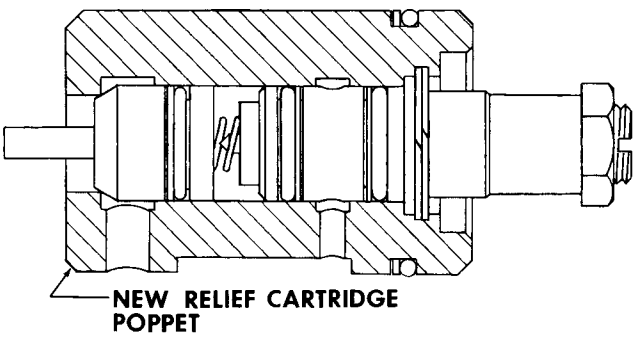
PILOT VALVE DAMPENING KIT

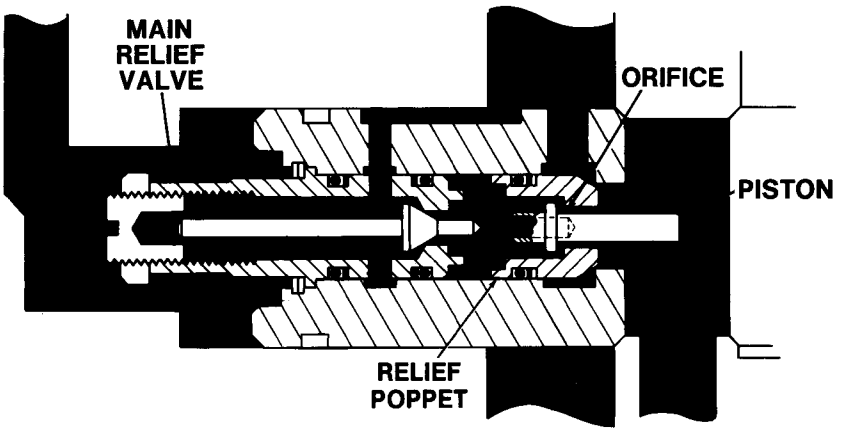


The flow control has been redesigned, the pilot supply orifice has been removed. The main relief can be used with either the redesigned or original flow control.

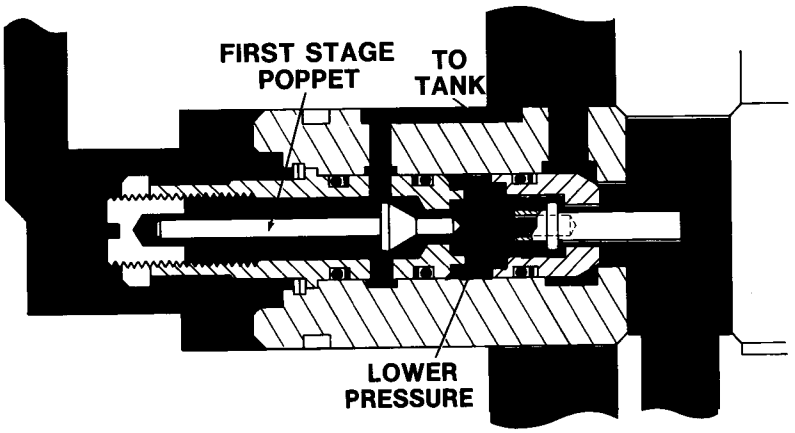
Pilot supply oil is delivered to the end cap through an external hose or tube.

NOTE: This flow control is not interchangeable with the original style flow control.

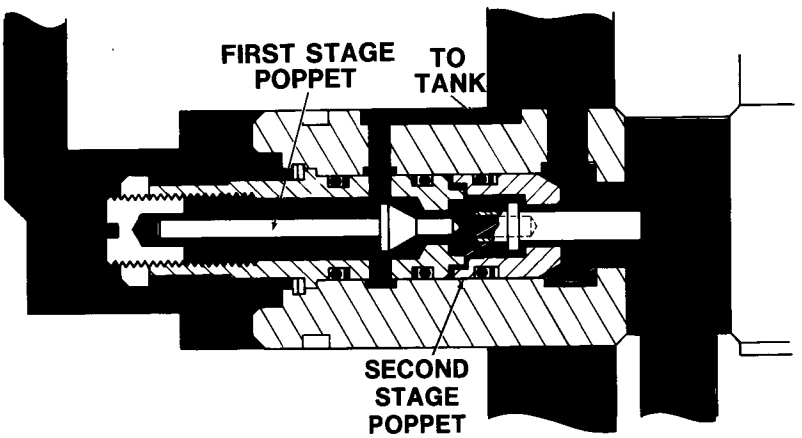




Now for the main relief portion of this assembly. On the initial start-up, oil flows down the orifice between the piston and second stage relief poppet, and, up to the smaller first stage poppet. Once the area between the poppets is full, flow into this area ceases until relief pressure is reached. Which...



starts forcing the first stage poppet off its seat. This allows oil to flow back to tank, creating a pressure drop between the first and second stage poppet.



This causes the second stage poppet to open and allows main flow back to tank.

When the system pressure goes below the relief setting, the first stage poppet reseats itself. Then the pressure equalizes on both sides of the second stage poppet and the second stage spring closes it. That completes all the parts and functions of the inlet control section.

END CAP

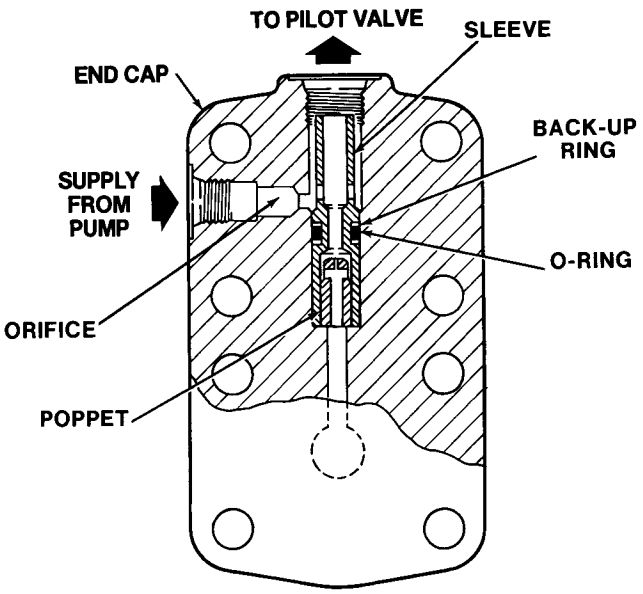
The end cap has been crossed drilled and an orifice, poppet and sleeve assembly has been added.

ORIFICE

The orifice limits the amount of oil that is allowed to the pilot valve and flow control.

SLEEVE ASSEMBLY

The sleeve assembly is made up of a sleeve and a two-way restrictor. The restrictor poppet allows oil from the inlet of the main valve to close the flow control slowly. When the flow control opens, the restrictor poppet closes due to the oil flow from the flow control opening. The oil must now flow through the small orifice in the poppet. This slows down the opening of the flow control. The slower the opening and closing of the flow control is what dampens the surge pressures in the hydraulic system.

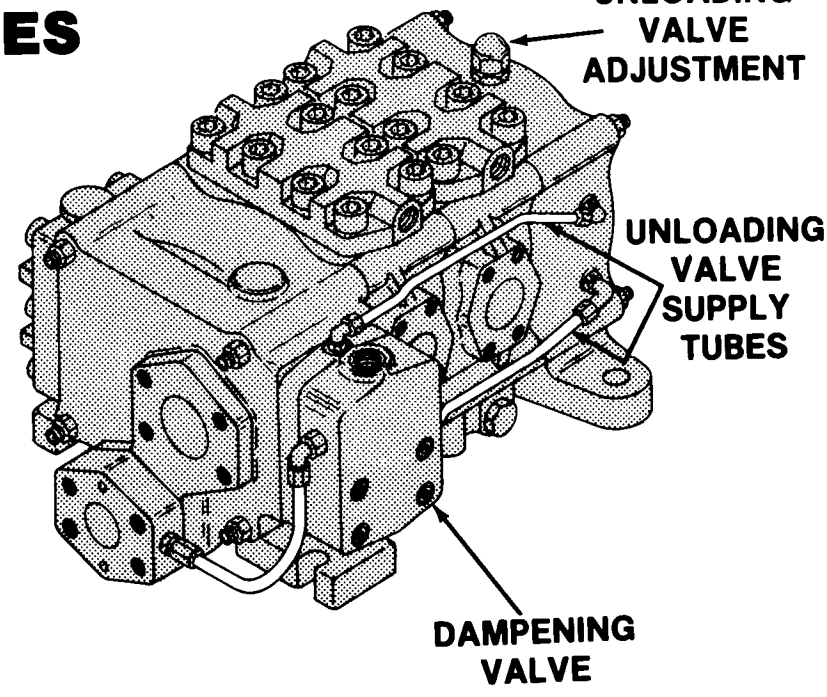


PHASE II
6400 SERIES SPLIT SPOOL VALVE

A few improvements have been incorporated in the Phase II valve for smoother operation, better metering, and a more efficient hydraulic system.

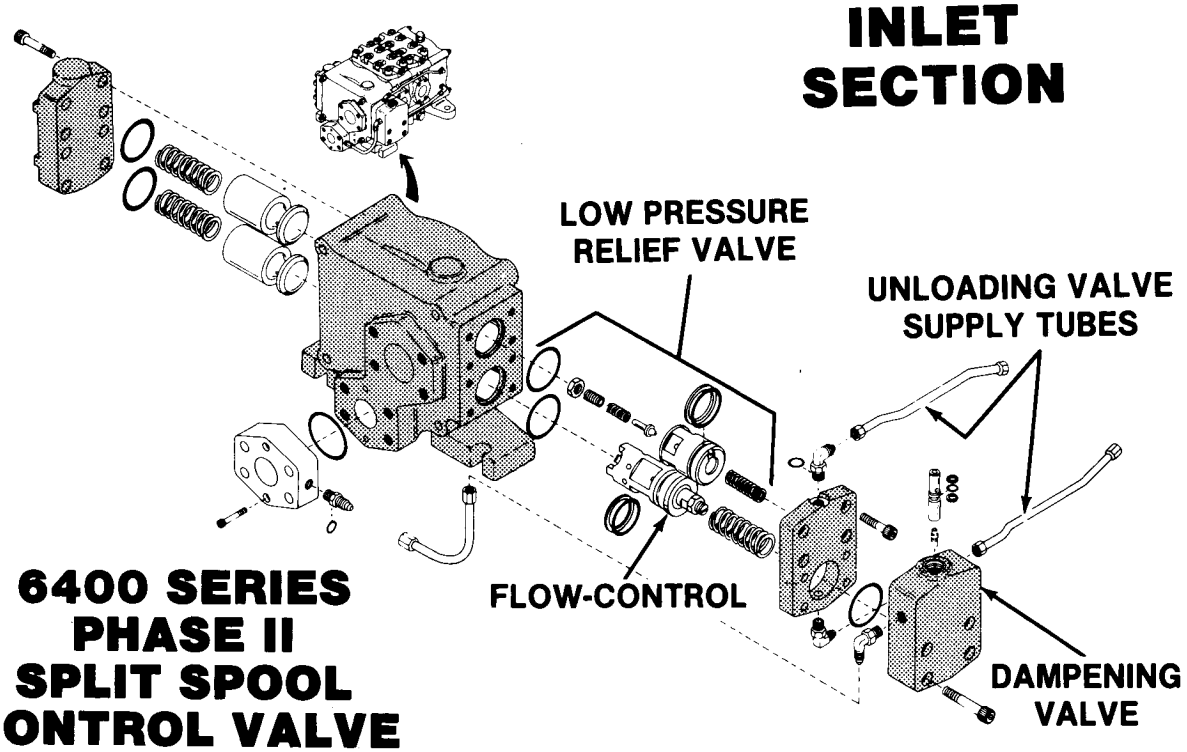
The physical size of the valve does not change. The dampening valve is now standard on all split spool valves.

PHASE II 6400 SERIES HUSCO CONTROL VALVE



TS-20529-SER

INLET SECTION



6400 SERIES PHASE II SPLIT SPOOL CONTROL VALVE

TS-20531-SER

LOW PRESSURE RELIEF:

This valve keeps a small amount of pressure in the low pressure chamber of the main valve. This keeps the main valve full of fluid. This pressure in the low pressure chamber is also needed to operate the anti-void poppet.

NOTE: The low pressure relief valve can be adjusted. See adjustment procedure for the low pressure relief.

ANTI-VOID POPPET:

This poppet opens when the pressure in the high pressure chamber is less than the pressure in the low pressure chamber. This lets fluid from the cylinders flow into the high pressure chamber and flow to the other end of the cylinder. This helps prevent voids in the cylinders.

UNLOADER VALVE:

This valve senses the pressure of the fluid from the pump and controls the operation of the low pressure relief. When this pressure is high, the unloader valve opens. This lets the low pressure relief open at a low pressure by compressing the spring behind it. When the pressure of the fluid from the pump is low, the unloader valve is closed. The first stage poppet in the low pressure relief must be pushed off its seat before the low pressure relief can open. It opens at a higher pressure.

LOAD CHECK:

The load check is a one-way check valve. The purpose of the load check is to hold the load or hold the cylinders in a given position. It holds the load until there is enough pressure to open the load check against the pressure in the cylinders. This pressure is caused by the load on the cylinders. If the boom is part way up and the lever is moved to raise the boom, the boom raises. If there is no load check the boom will fall before it starts to move up.

MAIN FLOW CONTROL:

The main flow control will let fluid from the pump flow to tank when the pilot system is not activated. It also sends fluid to the cylinders to do the work when the pilot system is activated. The relief valve is inside of the main flow control.

RELIEF VALVE:

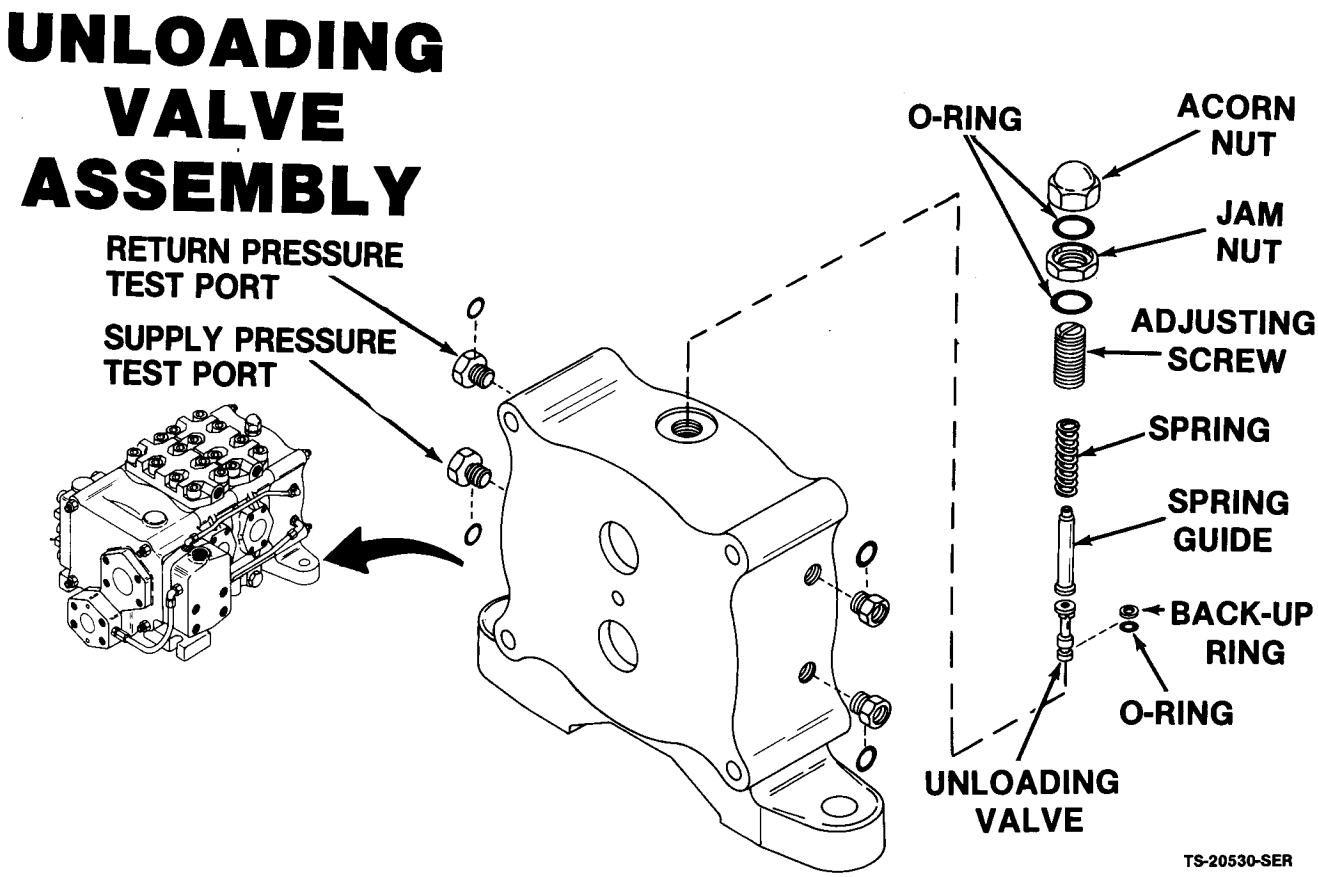
This valve will protect the pump and hydraulic system from high pressure. It will not let the pump generate pressure higher than the setting of the relief valve.

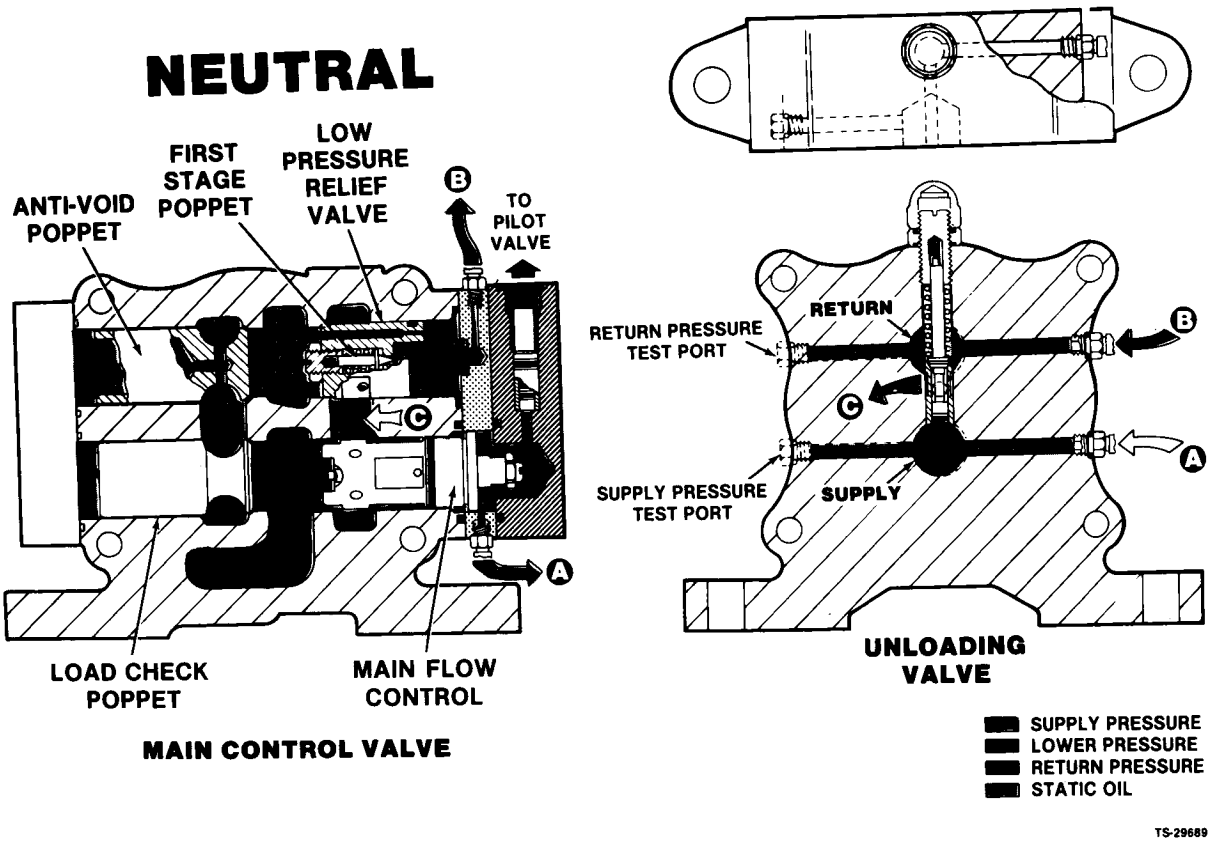
DAMPENING VALVE:

This valve controls the flow of fluid to and from the chamber behind the main flow control. When the main flow control closes, the dampening valve lets fluid flow into the chamber freely. When the main flow control opens, it must push the fluid through the small orifice in the poppet. This causes the main flow control to close fast and open slow.

UNLOADING VALVE ASSEMBLY

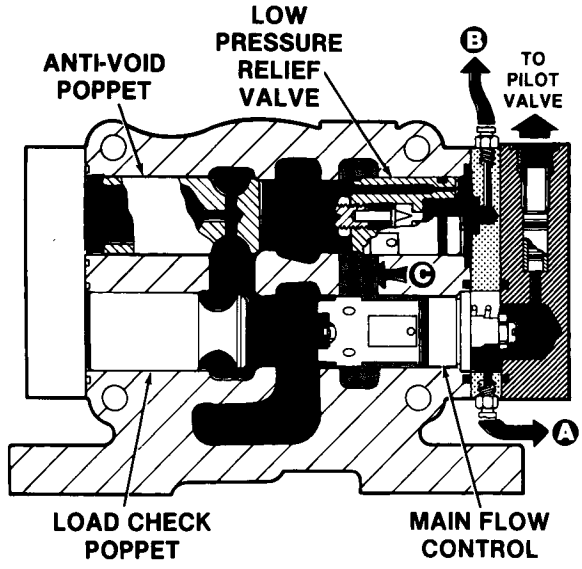
The parts of the unloading valve and the location of the test ports.



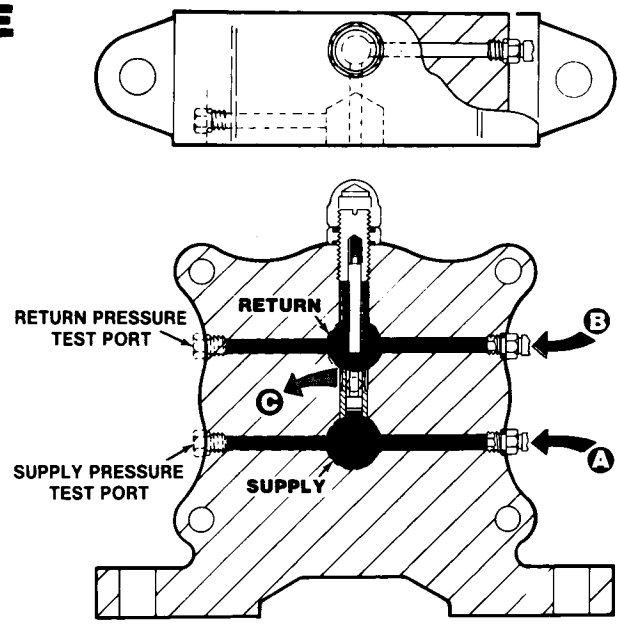


When the control valve is in "NEUTRAL", the pressure of the fluid that flows into the control valve is low. Because the pressure is less then the setting of the unloading valve, the unloading valve is on its seat. This causes the pressure on both sides of the low pressure relief valve to be the same. The spring holds the low pressure relief valve on its seat. The pressure on both sides of the anti-void poppet is the same. The spring holds the anti-void poppet on its seat. The spring holds the load check poppet on its seat. The chamber behind the main flow control is open through the pilot valve to tank. Fluid from the pump pushes the main flow control off its seat. This fluid flows around the main flow control and out the return port to tank.

OPERATING PRESSURE UNDER 1000 psi



MAIN CONTROL VALVE



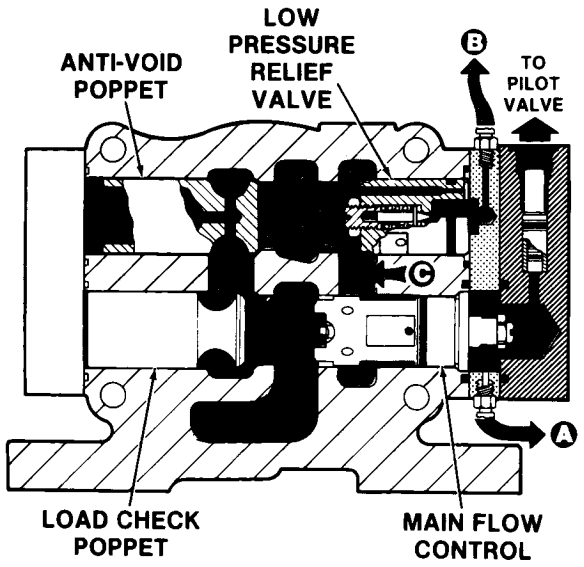
UNLOADING VALVE

SUPPLY PRESSURE
LOWER PRESSURE
RETURN PRESSURE
STATIC OIL

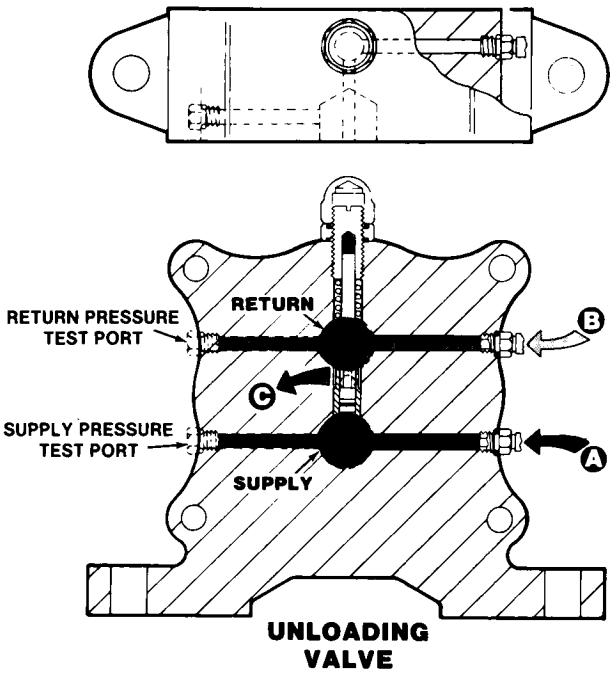
TS-29692

When the pressure of the fluid from the pump (operating pressure) is lower than the setting of the unloading valve, the spring holds the unloading valve on its seat. The operation of the low pressure relief valve is controlled by the first stage poppet. One of the spools in the pilot valve is not in the "NEUTRAL" position. The fluid in the chamber behind the main flow control can not flow out of the chamber. The pressure on both sides of the main flow control is the same. The spring holds the main flow control on its seat. The pressure of the fluid in the chamber in front of the load check increases. When the pressure becomes high enough, the fluid pushes the load check poppet off its seat. This fluid flows through the valve to one end of the cylinders. Fluid from the other end of the cylinders flows into the chamber in front of the low pressure relief valve. This fluid tries to move the low pressure relief valve. The pressure of this fluid increases until it becomes approximately 200-250 psi (1380-1725 kPa) (14-17,5 kgf/cm^2). At this pressure, the fluid moves the low pressure relief valve. As the low pressure relief valve moves, the fluid behind it pushes the first stage poppet off its seat. Fluid from behind the low pressure relief valve now flows through around the first stage poppet. This lets the low pressure relief valve move. The low pressure relief moves enough to let the fluid from the cylinders flow around it and to tank. The anti-void poppet is held on its seat by the fluid behind it and the spring.

OPERATING PRESSURE OVER 1000 psi



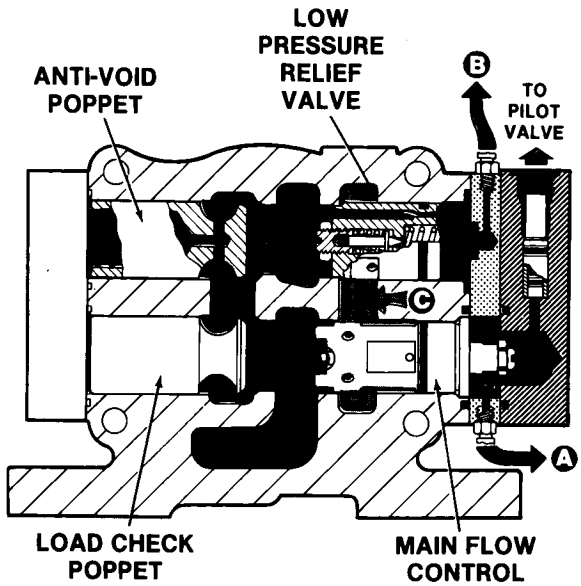
MAIN CONTROL VALVE



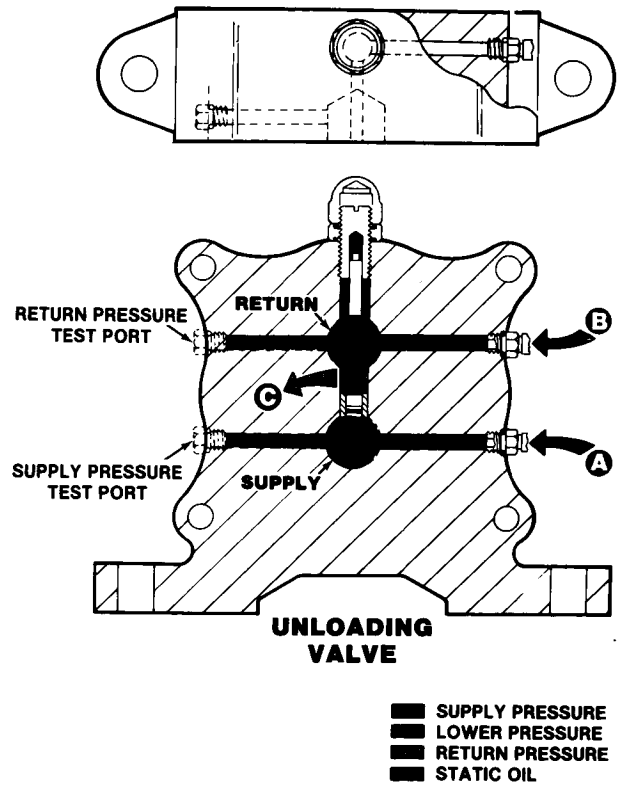
TS-29691

When the pressure of the fluid from the pump (operating pressure) is higher than the setting of the unloading valve, the fluid pushes the unloader valve off its seat. One of the spools in the pilot valve is not in the "NEUTRAL" position. The fluid in the chamber behind the main flow control can not flow out of the chamber. The pressure on both sides of the main flow control is the same. The spring holds the main flow control on its seat. The pressure of the fluid in the chamber in front of the load check increases. When the pressure becomes high enough, the fluid pushes the load check poppet off its seat. This fluid flows through the valve to one end of the cylinders. Fluid from the other end of the cylinders flows into the chamber in front of the low pressure relief valve. This fluid pushes on the low pressure relief valve. The fluid from the chamber behind the low pressure relief valve can flow out through port B to the open unloading valve. As the pressure in front of the low pressure relief valve increases, it pushes the valve open. The pressure only has to increase 10-20 psi (68,9-137,9 kPa) (0,7-1,4 kgf/cm²) before the low pressure relief valve opens. Fluid from the cylinders flows around the low pressure relief valve and to tank. Because of this low pressure in the return passage, the system operates with more efficiency. The anti-void poppet is held on its seat by the fluid behind it and the spring.

ANTI-VOID



MAIN CONTROL VALVE



TS-29690

When lowering the boom in "POWER DOWN", the anti-void function is used. The pressure of the fluid from the pump is lower than the setting of the unloading valve. The spring holds the unloading valve on its seat. The operation of the unloading valve is controlled by the first stage poppet. The boom spool in the pilot valve is in the "POWER DOWN" position. The fluid in the chamber behind the main flow control can not flow out of the chamber. The pressure on both sides of the main flow control is the same. The spring holds the main flow control on its seat. The pressure of the fluid in the chamber in front of the load check increases. When the pressure becomes high enough, the fluid pushes the load check poppet off its seat. This fluid flows through the valve to the rod end of the boom cylinders. Fluid from the base end of the cylinders flows into the chamber in front of the anti-void poppet. There is no pressure behind the anti-void poppet to help the spring hold it on its seat. It takes less pressure to move the anti-void poppet than it does to open the low pressure relief valve. The anti-void poppet opens and the low pressure relief valve remains closed. Fluid from the base end of the cylinders flows around the anti-void poppet and to the rod end of the cylinders. The low pressure relief valve causes the anti-void poppet to operate. This helps prevent voids in the hydraulic system.

CHECKING AND ADJUSTING PRESSURES

I. Main Relief (Refer to Anti-Void page 25)

A. To check main hydraulic relief pressure:

1. With hydraulic oil warmed up to normal operating temperature 150°F (65.5°C)

2. Install a 3000 P.S.I. (20700 kPa) (210 kgf/cm^2) gauge in the main hydraulic test port.

3. With engine at low idle, bottom out one set of cylinders.

NOTE: Bucket rollback is probably the safest.

4. If pressure is within specifications, recheck pressure at high idle. A difference of more than 200 P.S.I. (1380 kPa) (14 kgf/cm^2) between low and high idle indicates a malfunctioning relief valve.

B. Adjusting main relief valve:

1. Remove pilot supply cap (4) allen head cap screws.

2. The low pressure relief valve and the flow control valve are now held in position by the thin plate.

a. This greatly reduces the loss of hydraulic oil when adjusting main relief valve.

3. The main relief valve can now be adjusted without removing the plate.

a. One complete turn of the adjusting screw will change the relief approximately 1000 P.S.I. (6900 kPa) 70 kgf/cm^2)

b. Jam nut must be torqued to 20 ft. lbs. (2.8 kgf•m)

II. Low Pressure Relief Valve (Refer to Anti-Void page 25)

A. To check the low pressure relief valve pressure:

1. Warm hydraulic oil to normal operating temperature 150° (65.5°C).

2. Install a 1000 P.S.I. (6900 kPa) (70 kgf/cm^2) gauge in the return pressure test port of the main valve.

a. This test port is located in the end cap of the main valve (port farthest from the mounting pads).

3. Lower boom to ground.

4. With the engine at high free idle, shift the boom control lever to the boom raise position and watch the gauge. The pressure should be 200-250 P.S.I. (1380-1725 kPa) (14-17.5 kgf/cm^2).

B. To adjust the low pressure relief valve:

1. Shut down engine and relieve static pressure in hydraulic system.

2. Remove pilot supply cap (4) allen screws.

II. Continued

3. Remove plate (4) allen cap screws.

4. Remove low pressure relief valve.

NOTE: Return oil from the reservoir will escape out the low pressure relief valve hole. This hole must be either plugged, the oil drained into clean containers, or a vacuum pump may be used to draw a vacuum in the reservoir.

5. The low pressure relief valve should be clamped in a *soft* jawed vice.

6. Loosen the adjusting screw lock nut, then turn adjusting screw clockwise to increase pressure or counter-clockwise to lower pressure setting.

7. One full turn of screw will change the pressure setting approximately 70 P.S.I. (483 kPa) (4.9 kgf/cm²).

   a. Torque lock nut to 45 ft. lbs. (6.2 Kgf•m)

III. Unloading Valve (Refer to Operating Pressure Over 1000 P.S.I. page 24)

A. To check the unloading valve setting:

1. Warm hydraulic oil to normal operating temperature 150° (65.5 °C).

2. Install a 3000 P.S.I. (20700 kPa) (210 kgf/cm²) gauge in the supply pressure test port, located in the end cap of the main valve (port closest to mounting pads).

3. Install 1000 P.S.I. (6900 kPa) (70 kgf/cm²) gauge in return pressure test port in the end cap of the main valve (port furthest from mounting pads.)

4. With boom on ground, bucket rolled back against stops and engine at high free idle, raise the boom and watch both gauges. When operating pressure is below the unloading valve setting 1000-1200 P.S.I. (6900-8280 kPa) (70-84 kgf/cm²). The low pressure gauge should be reading greater than 200 P.S.I. (1380 kPa) (14 kgf/cm²) and be steady. Once this pressure is reached the operator must slowly meter the bucket control lever back. **NOTE:** If the bucket lever is pulled back too far the boom will stop moving and the test must be repeated. This will cause the operating pressure to increase. When the operating pressure becomes high enough to open the unloading valve the low pressure gauge will drop below 75 P.S.I. (517.5 kPa) (5.25 kgf/cm²).

B. To adjust the unloading valve:

1. Remove acorn nut.

2. Loosen jam nut.

NOTE: There are o-rings between the acorn nut and the jam nut, and between the jam nut and the housing — replace if cut or damaged.

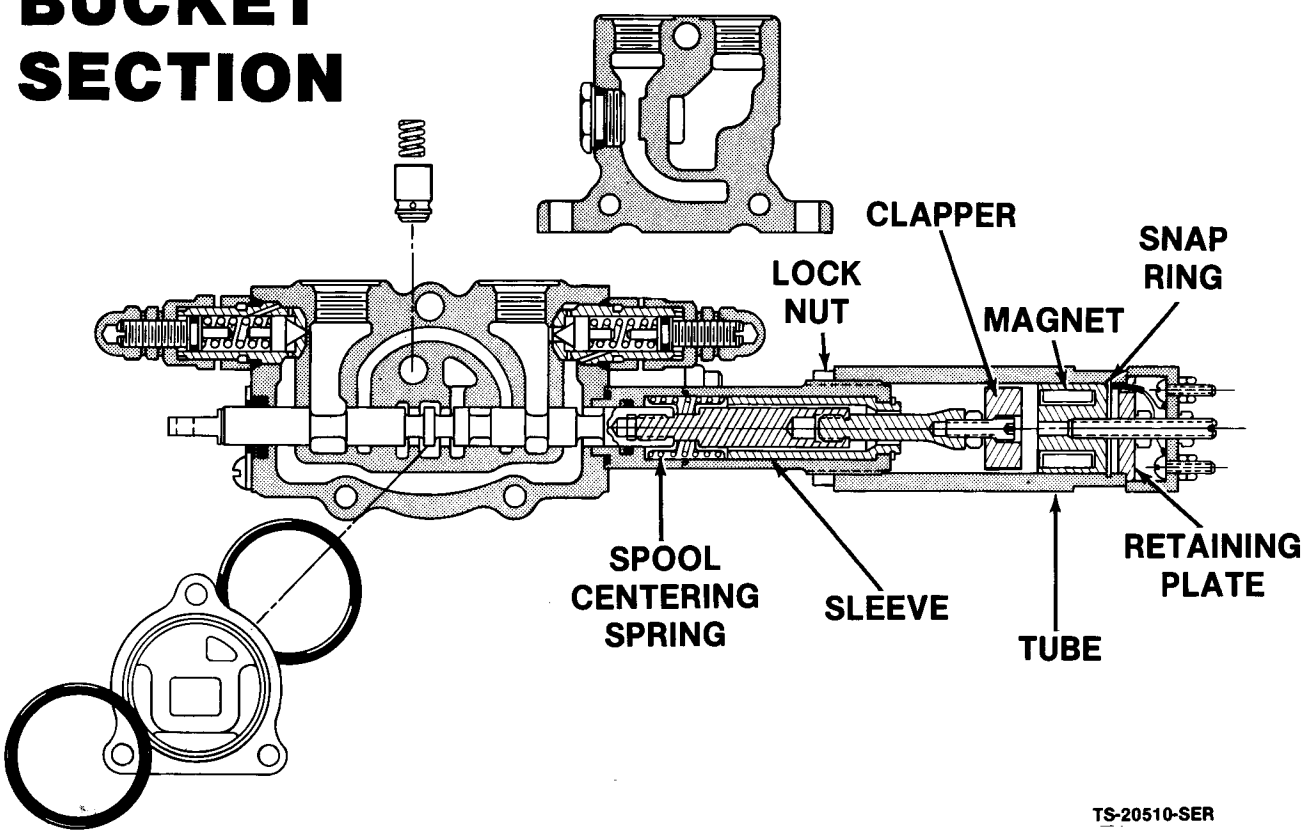
3. Turn adjusting screw clockwise to increase the spring tension on the unloading valve.

4. One turn of the adjusting screw will change the pressure approximately 225 P.S.I. (1552.5 kPa) (15.8 kgf/cm²).

ELECTRIC DETENT ASSEMBLIES

The pilot valve has a detent assembly on each spool. The detent assembly on the bucket spool will hold the spool in the "ROLLBACK" position. The detent assembly on the boom spool will hold the boom spool in the "RAISE" position or in the "FLOAT" position.

BUCKET SECTION



BUCKET DETENT ASSEMBLY

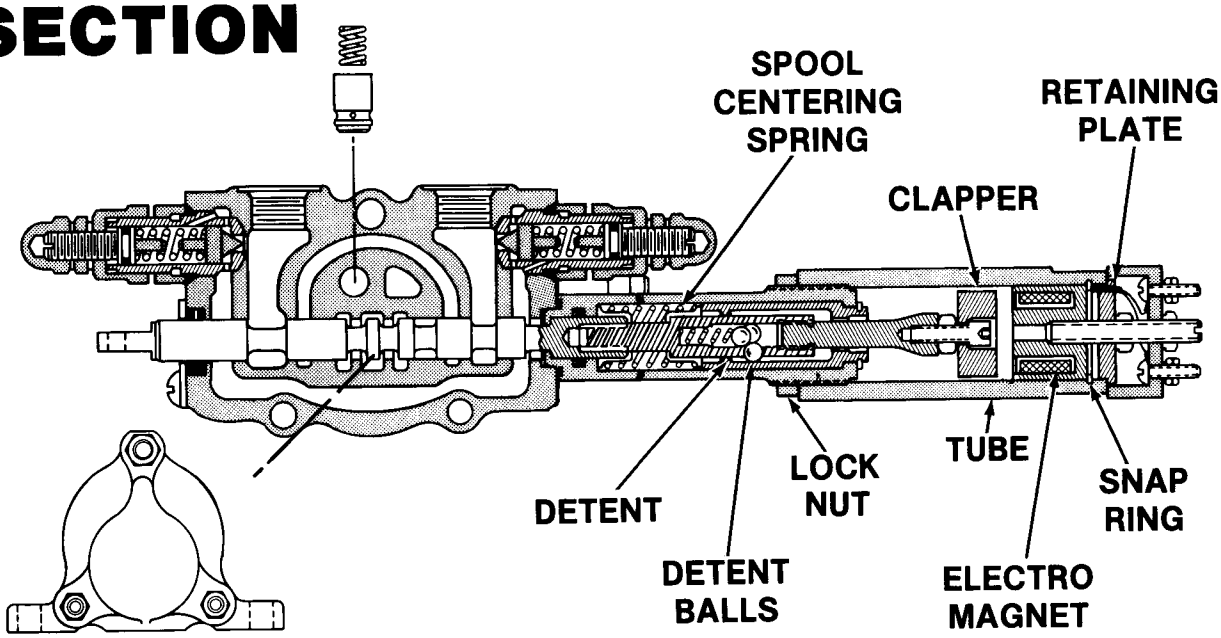
When the bucket spool is moved to the end of its stroke in the "ROLLBACK" position, the clapper touches the electromagnet. When there is electric current to the electromagnet, it holds the clapper. The clapper is fastened to the spool. This holds the spool in the "ROLLBACK" position. When the electric current to the electromagnet is stopped, the electromagnet releases the clapper. The centering spring moves the spool to the "HOLD" position. The clapper can be moved away from the electromagnet by moving the bucket lever. The bucket leveler uses this detent.

BOOM DETENT ASSEMBLY

When the boom spool is moved to the end of its stroke in the "RAISE" position, the clapper touches the electromagnet. When there is electric current to the electromagnet, it holds the clapper. The clapper is fastened to the spool. This holds the spool in the "RAISE" position. When the electric current to the electromagnet is stopped, the electromagnet releases the clapper. The centering spring moves the spool to the "HOLD" position. The boom kickout uses this detent.

The boom spool is held in the "FLOAT" position by a mechanical detent. When the spool is moved to the "FLOAT" position, the detent balls are behind the shoulder in the sleeve. The detent spring holds tension on the center detent balls. The center detent ball pushes the other detent balls against the sleeve. This holds the spool in position. There is no automatic release for this detent position. Boom float uses this detent.

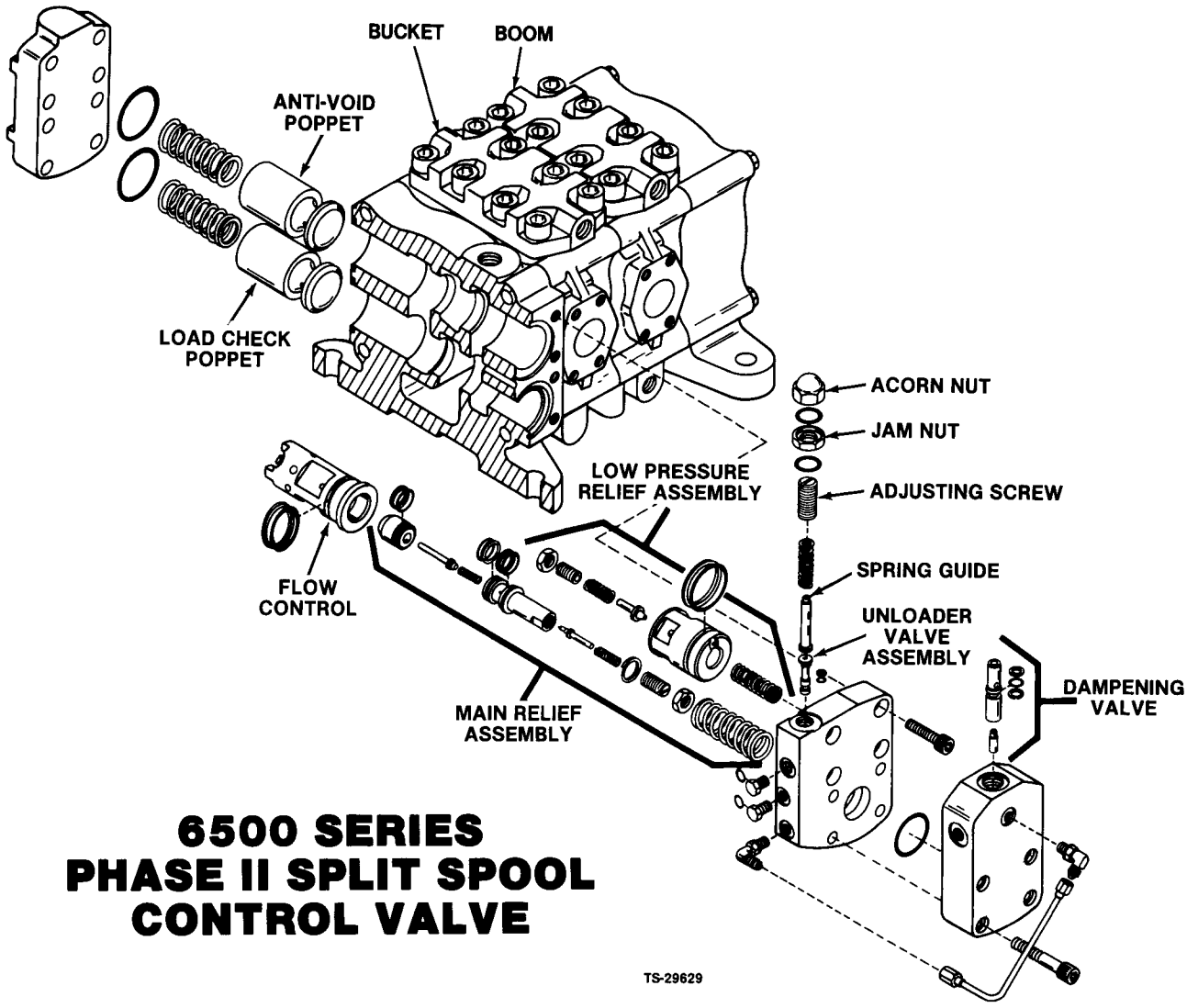
BOOM SECTION



TS-20506-SER

To adjust magnetic detent assembly.

1. Remove wires.
2. Loosen jam nut.
3. Back tube out turning counter-clockwise about 1/2 inch (127 mm).
4. With engine off, pull lever back against stop, then turn tube in clockwise until the magnet hits the clapper then back the tube out 1/2 turn.
5. Connect wire leads.
6. Start machine and check detent operation.
   a. If tube is turned in too far, the detents will function properly, but operating times may be slow.
   b. If bucket tube is turned in too far, then when boom is raising, and the bucket is activated to the rollback position, the boom will continue to raise.
7. Tighten jam nut.



6500 SERIES PHASE II SPLIT SPOOL CONTROL VALVE

INLET SECTION

The following parts are in the inlet section:

LOW PRESSURE RELIEF:

This valve keeps a small amount of pressure in the low pressure chamber of the main valve. This keeps the main valve full of fluid. This pressure in the low pressure chamber is also needed to operate the anti-void poppet.

NOTE: The low pressure relief valve can be adjusted. See adjustment procedure for the low pressure relief.

ANTI-VOID POPPET:

This poppet opens when the pressure in the high pressure chamber is less than the pressure in the low pressure chamber. This lets fluid from the cylinders flow into the high pressure chamber and flow to the other end of the cylinder. This helps prevent voids in the cylinders.

UNLOADER VALVE:

This valve senses the pressure of the fluid from the pump and controls the operation of the low pressure relief. When this pressure is high, the unloader valve opens. This lets the low pressure relief open at a low pressure by compressing the spring behind it. When the pressure of the fluid from the pump is low, the unloader valve is closed. The first stage poppet in the low pressure relief must be pushed off its seat before the low pressure relief can open. It opens at a higher pressure.

LOAD CHECK:

The load check is a one-way check valve. The purpose of the load check is to hold the load or hold the cylinders in a given position. It holds the load until there is enough pressure to open the load check against the pressure in the cylinders. This pressure is caused by the load on the cylinders. If the boom is part way up and the lever is moved to raise the boom, the boom raises. If there is no load check the boom will fall before it starts to move up.

MAIN FLOW CONTROL:

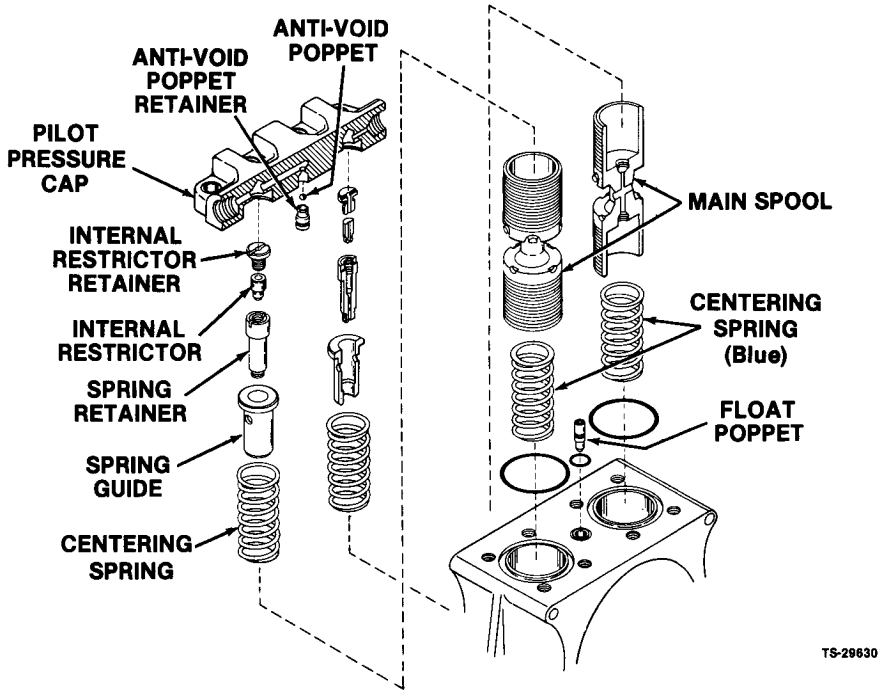
The main flow control will let fluid from the pump flow to tank when the pilot system is not activated. It also sends fluid to the cylinders to do the work when the pilot system is activated. The relief valve is inside of the main flow control.

RELIEF VALVE:

This valve will protect the pump and hydraulic system from high pressure. It will not let the pump generate pressure higher than the setting of the relief valve.

DAMPENING VALVE:

This valve controls the flow of fluid to and from the chamber behind the main flow control. When the main flow control closes, the dampening valve lets fluid flow into the chamber freely. When the main flow control opens, it must push the fluid through the small orifice in the poppet. This causes the main flow control to close fast and open slow.



1. The main spools have metering notches. The notches give smoother movement, of the spools, from one position to other positions. Shocks, caused by sudden changes in the direction of the flow of fluid, are decreased by the notches.
2. The spool centering springs, both upper and lower, are compressed by spring retainers. The retainers slide through the spring guides and are fastened to the spools with threads. The threads have Loctite on them. The guides are tightened to a torque of 25 lbf.ft (33,9 N•m) (3,5 kgf•m). The preload on the springs gives better movement of the main spools and makes it easier to install the pilot pressure cap. The lower centering springs have less tension than the upper springs.
3. The internal restrictors are round poppets that are marked with a color code. The restrictors are held in the spring retainers by the internal restrictor retainers. The internal restrictor retainers are fastened to the spring retainers with threads. The threads have Loctite on them. The retainers are tightened to a torque of 15 lbf•ft (20,3 N•m) (2,1 kgf•m).
4. The bores for the springs in the pilot pressure cap are deep enough so that there is no spring tension. This lets the caps be easily installed.
5. The anti-void poppet is in the pilot pressure cap. The poppet is held in place by the anti-void poppet retainer.
6. The float poppet is in the valve housing between the main spools.

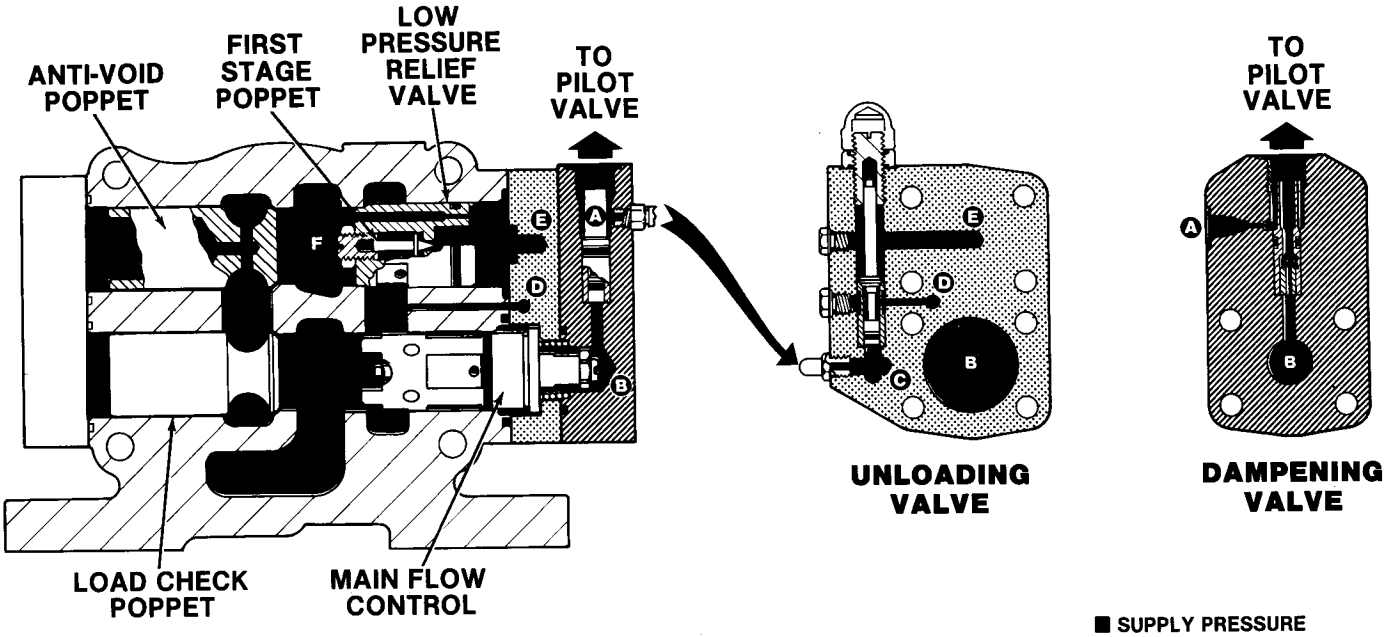
INTERNAL RESTRICTOR COLOR CODE GUIDE (6500 Series only)

BUCKET SECTION

Rod spool pilot supply end — white poppet
Base spool pilot supply end — white poppet

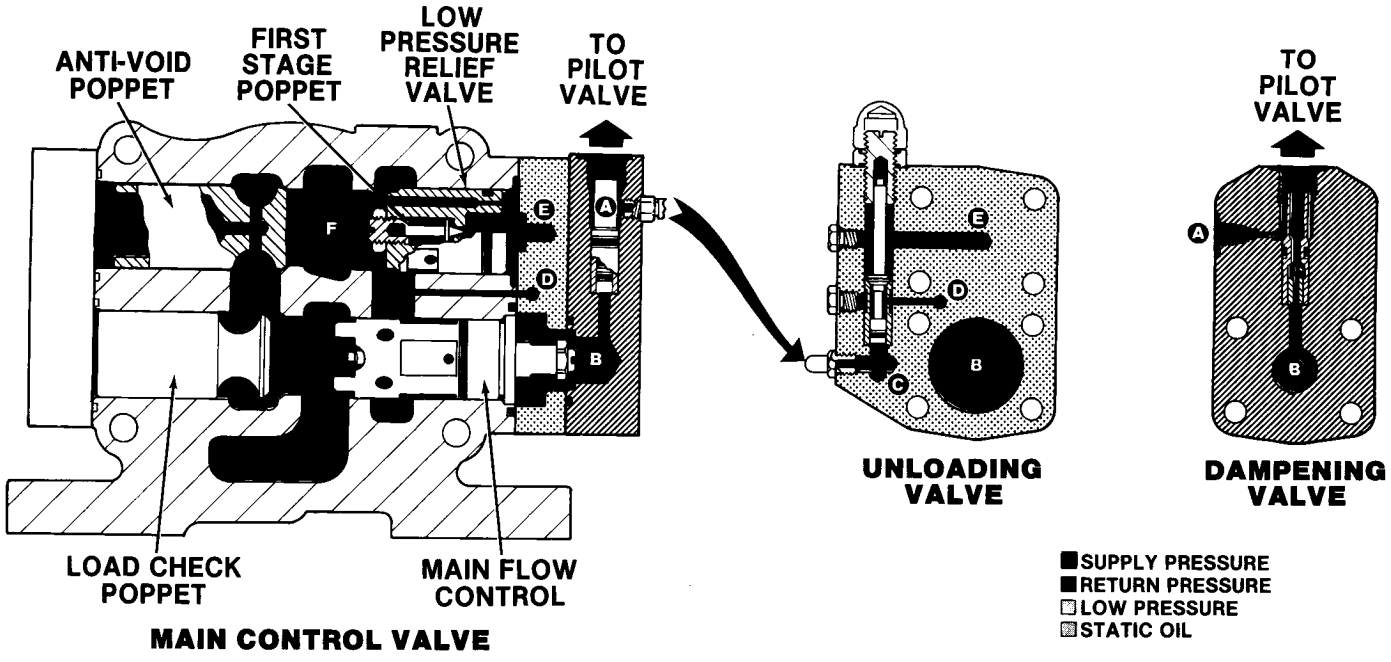
BOOM SECTION

Rod spool pilot supply end — white poppet
Rod spool opposite end — red poppet
Base spool pilot supply end — red poppet



NEUTRAL

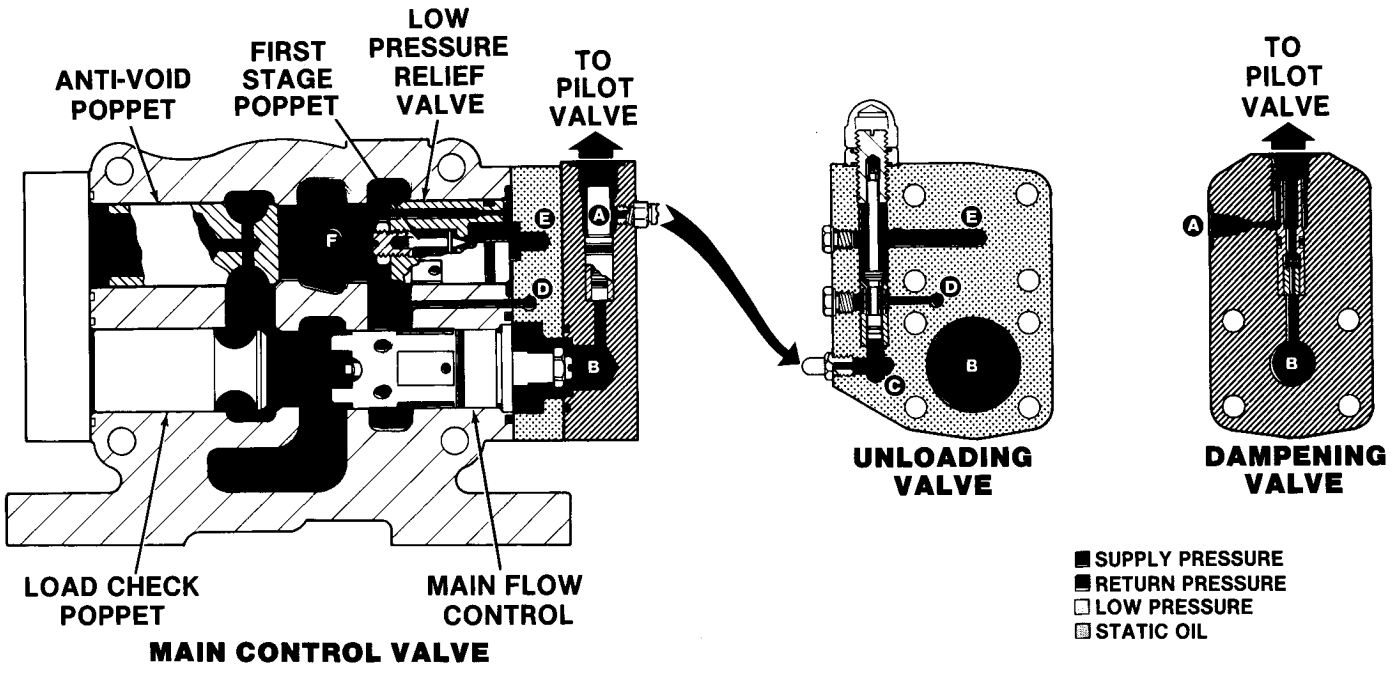
When the control valve is in "NEUTRAL", the pressure of the fluid that flows into the control valve is low. Because the pressure is less than the setting of the unloading valve, the unloading valve is on its seat. This causes the pressure on both sides of the low pressure relief valve to be the same. The spring holds the low pressure relief valve on its seat. The pressure on both sides of the anti-void poppet is the same. The spring holds the anti-void poppet on its seat. The fluid behind the load check poppet has no opening to flow through. This fluid and the spring holds the load check poppet on its seat. The chamber behind the main flow control is open through the pilot valve to tank. Fluid from the pump pushes the main flow control off its seat. This fluid flows around the main flow control and out the return port to tank.



OPERATING PRESSURE UNDER 1000 psi

TS-29793
MAR 82

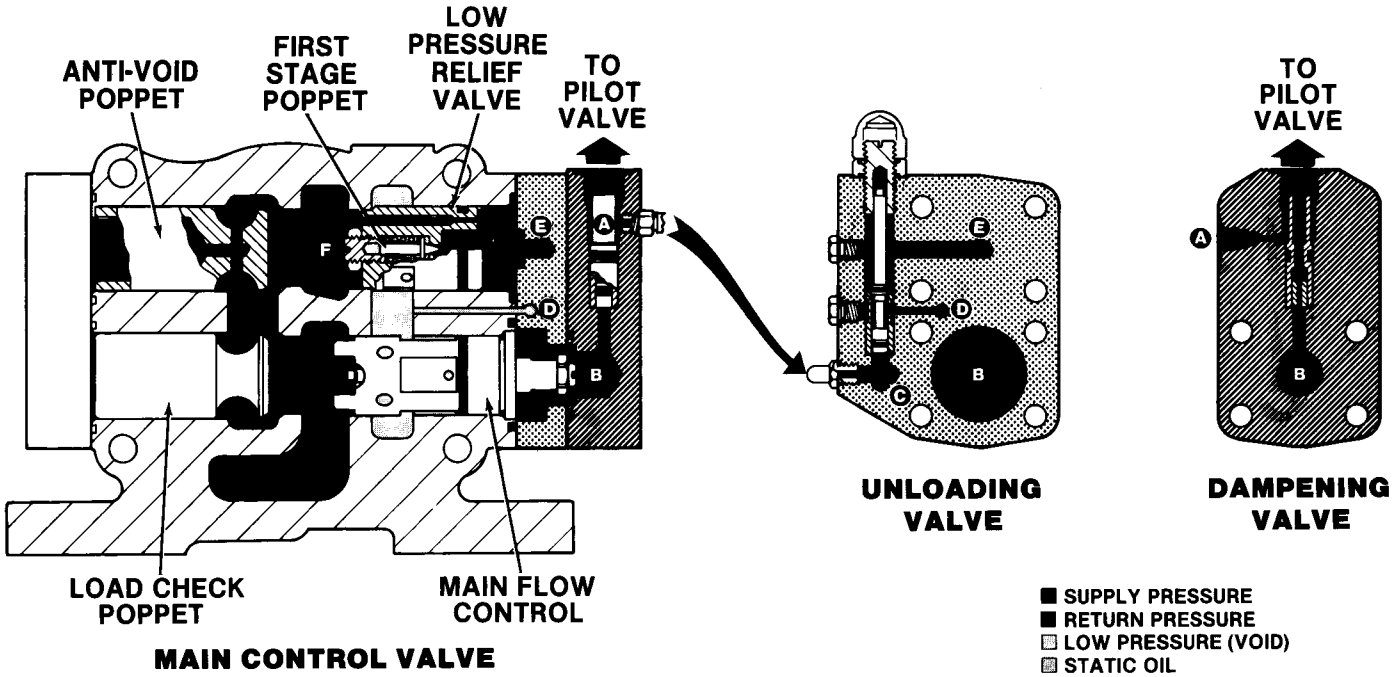
The pressure of the fluid from the pump (operating pressure) is lower than the setting of the unloading valve. The spring holds the unloading valve on its seat. The operation of the low pressure relief valve is controlled by the first stage poppet. One of the spools in the pilot valve is not in the "NEUTRAL" position. The fluid in the chamber behind the main flow control can not flow out of the chamber. The pressure on both sides of the main flow control is the same. The spring holds the main flow control on its seat. The pressure of the fluid in the chamber in front of the load check increases. When the pressure becomes high enough, the fluid pushes the load check poppet off its seat. This fluid flows through the valve to one end of the cylinders. Fluid from the other end of the cylinders flows into the chamber in front of the low pressure relief valve. This fluid tries to move the low pressure relief valve. The pressure of this fluid increases until it becomes approximately 200-250 psi (1380-1725 kPa) (14-17,5 kgf/cm^2). At this pressure, the fluid moves the low pressure relief valve. As the low pressure relief valve moves, the fluid behind it pushes the first stage poppet off its seat. Fluid from behind the low pressure relief valve now flows through around the first stage poppet. This lets the low pressure relief valve move. The low pressure relief moves enough to let the fluid from the cylinders flow around it and to tank. The anti-void poppet is held on its seat by the fluid behind it and the spring.



OPERATING PRESSURE OVER 1000 psi

TS-29633
MAR 82

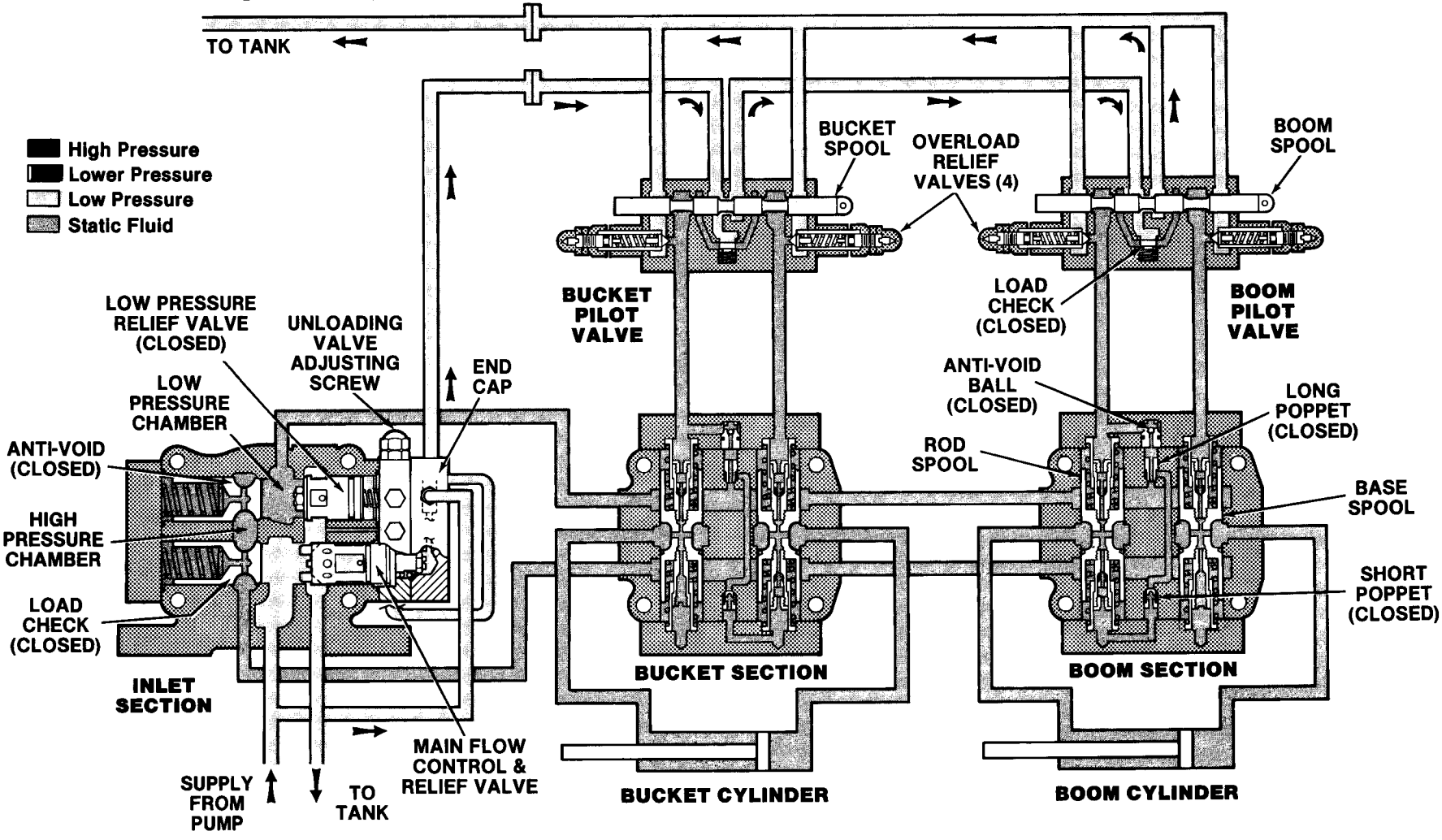
The pressure of the fluid from the pump (operating pressure) is higher than the setting of the unloading valve. This fluid pushes the unloader valve off its seat. One of the spools in the pilot valve is not in the "NEUTRAL" position. The fluid in the chamber behind the main flow control can not flow out of the chamber. The pressure on both sides of the main flow control is the same. The spring holds the main flow control on its seat. The pressure of the fluid in the chamber in front of the load check increases. When the pressure becomes high enough, the fluid pushes the load check poppet off its seat. This fluid flows through the valve to one end of the cylinders. Fluid from the other end of the cylinders flows into the chamber in front of the low pressure relief valve. This fluid pushes on the low pressure relief valve. The fluid from the chamber behind the low pressure relief valve can flow out through the open unloading valve. As the pressure in front of the low pressure relief valve increases, it pushes the valve open. The pressure only has to increase 10-20 psi (68,9-137,9 kPa) (0,7-1,4 kgf/cm^2) before the low pressure relief valve opens. Fluid from the cylinders flows around the low pressure relief valve and to tank. Because of this low pressure in the return passage, the system operates with more efficiency. The anti-void poppet is held on its seat by the fluid behind it and the spring.



ANTI-VOID

When lowering the boom in "POWER DOWN" the *ANTI-VOID* function is used. The pressure of the fluid from the pump is lower than the setting of the unloading valve. The spring holds the unloading valve on its seat. The operation of the unloading valve is controlled by the first stage poppet. The boom spool in the pilot valve is in the "POWER DOWN" position. The fluid in the chamber behind the main flow control can not flow out of the chamber. The pressure on both sides of the main flow control is the same. The spring holds the main flow control on its seat. The pressure of the fluid in the chamber in front of the load check increases. When the pressure becomes high enough, the fluid pushes the load check poppet off its seat. This fluid flows through the valve to the rod end of the boom cylinders. Fluid from the base end of the cylinders flows into the chamber in front of the anti-void poppet. There is no pressure behind the anti-void poppet to help the spring hold it on its seat. It takes less pressure to move the anti-void poppet than it does to open the low pressure relief valve. The anti-void poppet opens and the low pressure relief valve remains closed. Fluid from the base end of the cylinders flows around the anti-void poppet and to the rod end of the cylinders. The low pressure relief valve causes the anti-void poppet to operate. This helps prevent voids in the hydraulic system.

NEUTRAL (HOLD) POSITION

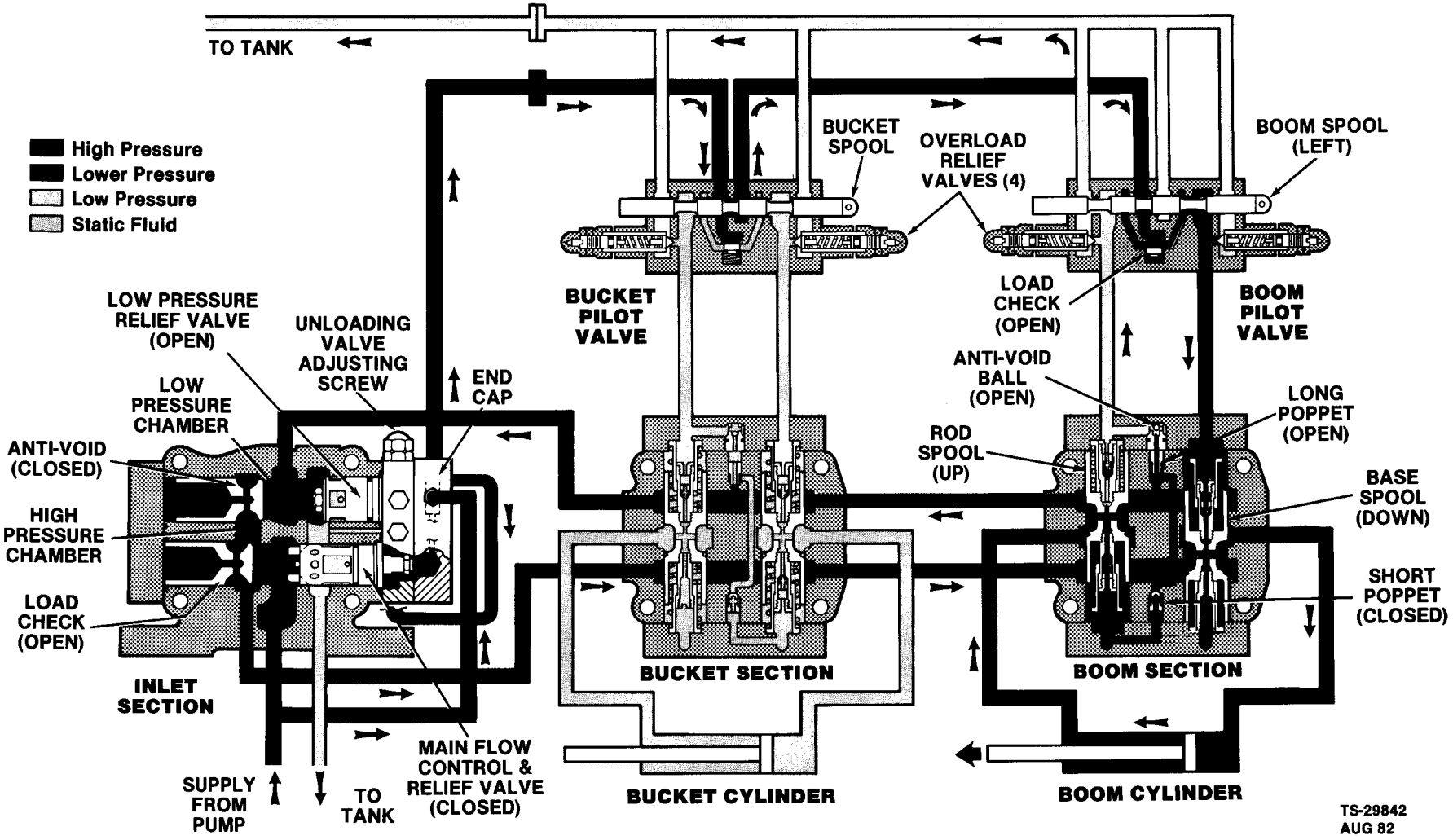


NEUTRAL (HOLD) POSITION

When the main hydraulic valve is in the "NEUTRAL" position, fluid from the pump flows into the inlet section of the valve. This fluid pushes the main flow control and relief valve off its seat. Now fluid from the pump flows around the main flow control and relief valve and to tank. The load check, anti-void, and the low pressure relief valves are held in the closed position by the springs. Fluid from the pump also flows to the end cap through an outside line. This fluid flows through the end cap (see INLET SECTION — NEUTRAL) to the pilot valve. The fluid flows around the spool in the bucket section of the pilot valve. With the bucket spool in the neutral position, fluid can only flow around the spool and to the boom section. The flow of fluid through the boom section of the pilot valve is the same as through the bucket section. The fluid then flows to the tank.

Both spools in the boom section of the main valve are in the "NEUTRAL" position. The spools are held in the "NEUTRAL" position by the tension of the spring on each end of each spool.

EXTENDING BOOM CYLINDER



EXTENDING BOOM CYLINDER

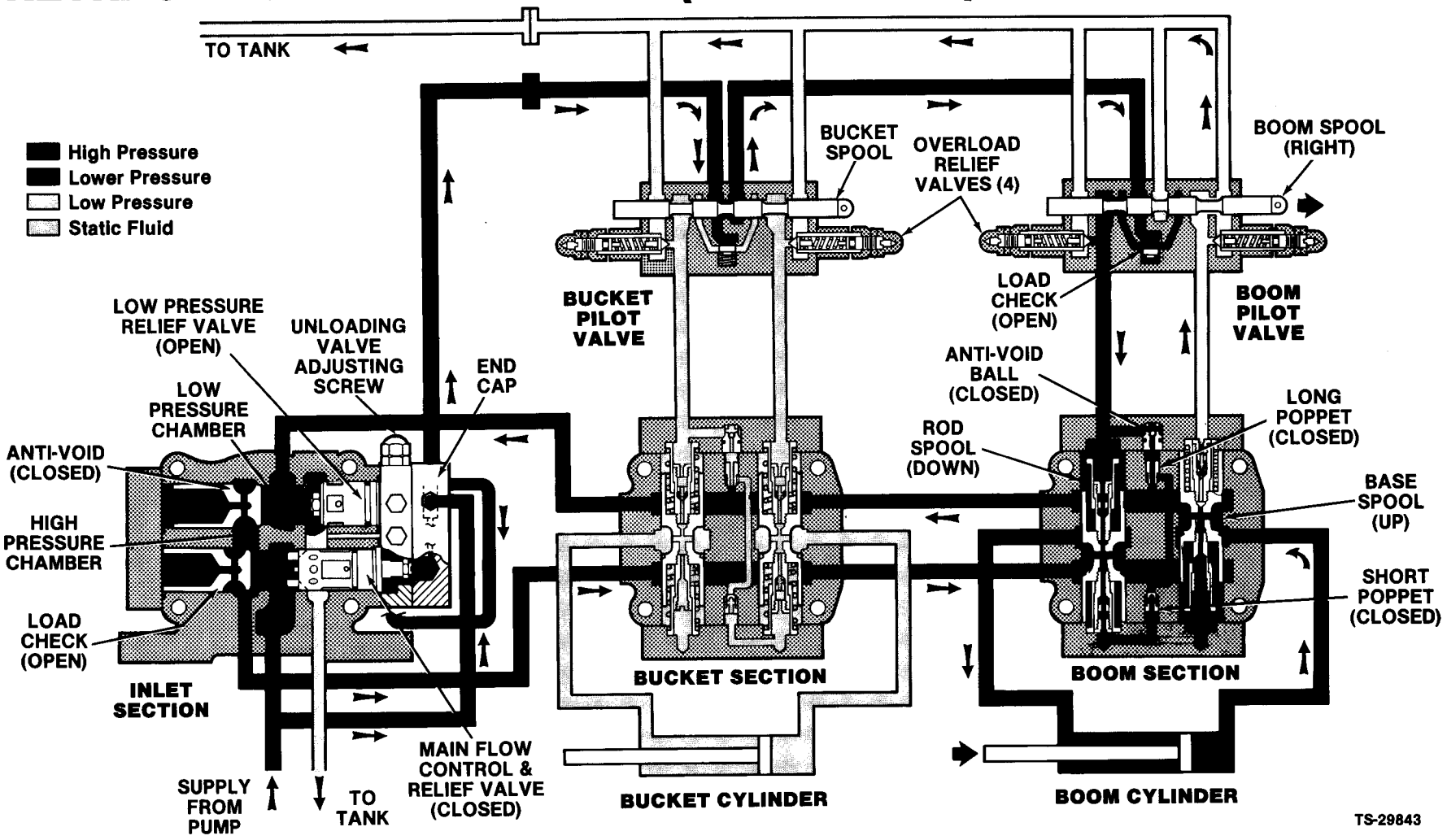
To raise the boom the boom spool in the boom pilot valve is moved to the left.

Fluid from the pump flows through an outside line to the end cap and through the end cap [See INLET SECTION — OPERATING PRESSURE OVER 1000 psi (6900 kPa) (70 kgf/cm²)]. Fluid from the end cap flows to the pilot valve. This fluid flows around the bucket spool and to the boom pilot valve. The fluid flows around the boom spool and pushes the load check off its seat. The fluid then flows around the boom spool and to the boom section of the main valve. This fluid flows into the chamber above the base spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension. The fluid from below the spool is pushed out through the ports in the center of the spool. This lets the spool move. As the spool moves, this pressure is sensed all of the way back to the spring side of the main flow control. When the pressure on both sides of the main flow control becomes the same, the spring closes the main flow control. This stops the fluid from flowing to tank.

Now, the fluid from the pump opens the load check in the inlet section of the main valve. Fluid from the pump flows around the load check into the high pressure chamber. This fluid also helps keep the anti-void on its seat. Fluid from the high pressure chamber flows through the bucket section and into the boom section. This fluid flows around the base spool, which is down, and into the base end of the boom cylinder. This causes the piston in the cylinder to move, plus, as the piston moves, fluid is pushed from the rod end of the cylinder. This fluid flows into the boom section and into the rod spool in the main valve.

With the boom spool in the pilot valve moved to the left, a port is open. Fluid from the chamber above the rod spool is open through this port to tank. Fluid from the rod end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the rod spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the rod end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the long poppet and the anti-void ball. This measured amount of fluid flows through the pilot valve and back to tank. The pressure on both sides of the short poppet is the same. The short poppet remains closed. Fluid from the rod end of the cylinder flows around the rod spool, and through the bucket section. This fluid flows into the inlet section and pushes the low pressure relief off its seat. See INLET SECTION — OPERATING PRESSURE OVER 1000 psi (6900 kPa) (70 kgf/cm²). The fluid flows around the low pressure relief valve, around the main flow control and back to tank.

RETRACTING BOOM CYLINDER (Power Down)



RETRACTING BOOM CYLINDER (POWER DOWN)

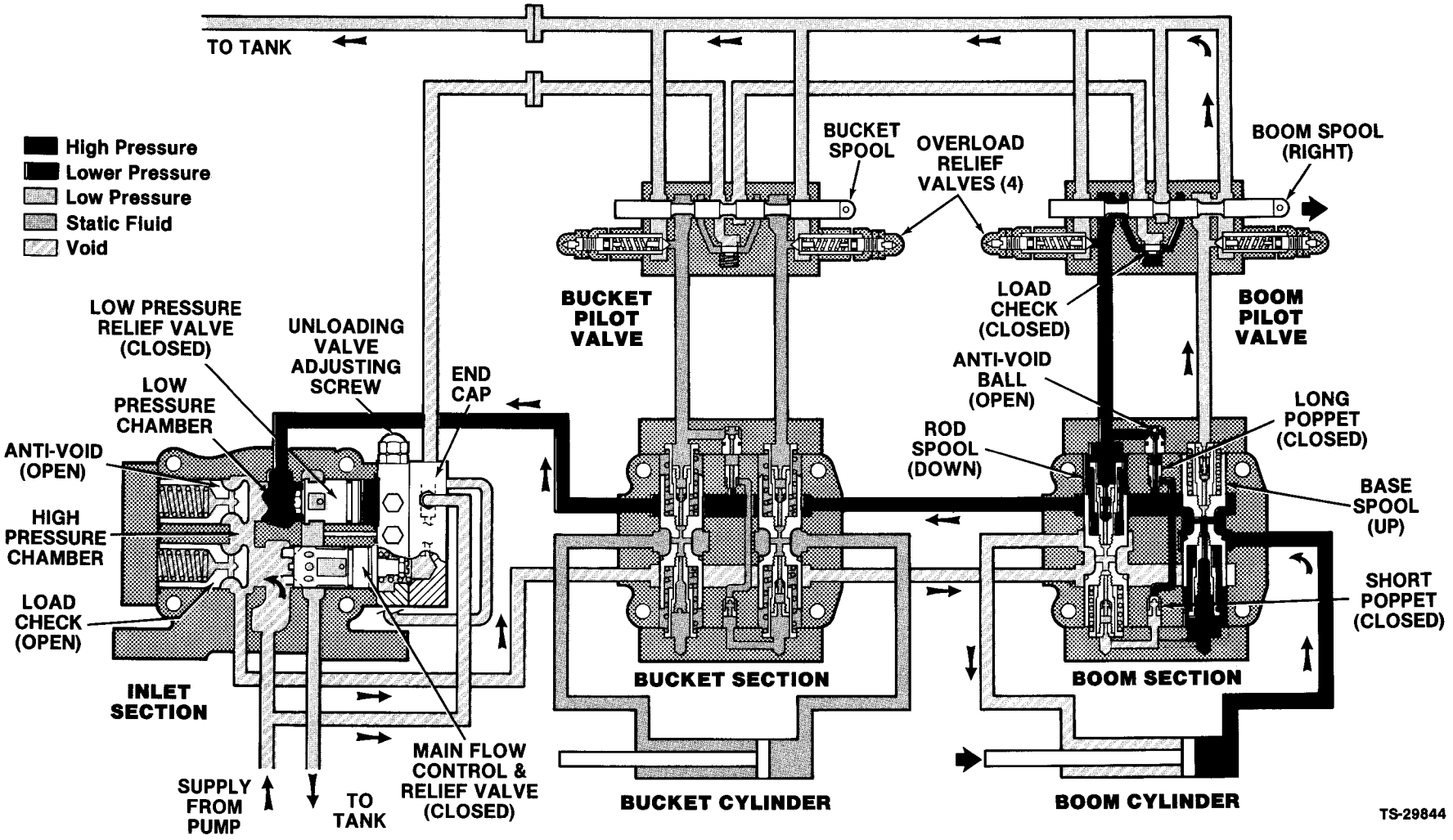
To lower the boom, the boom spool in the boom pilot valve is moved to the right.

Fluid from the pump flows through an outside line to the end cap and through the end cap. See INLET SECTION — OPERATING PRESSURE UNDER 1000 PSI (6900 kPa) (70 kfg/cm^2). Fluid from the end cap flows to the pilot valve. This fluid flows around the bucket spool and to the boom pilot valve. The fluid flows around the boom spool and pushes the load check off its seat. The fluid then flows around the boom spool and to the boom section of the main valve. This fluid flows into the chamber above the rod spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension. The fluid from below the spool is pushed out through the ports in the center of the spool. This lets the spool move. As the spool moves, this pressure is sensed all of the way back to the spring side of the main flow control. When the pressure on both sides of the main flow control becomes the same, the spring closes the main flow control. This stops the fluid from flowing to tank.

Now, the fluid from the pump opens the load check in the inlet section of the main valve. Fluid from the pump flows around the load check into the high pressure chamber. This fluid also helps keep the anti-void on its seat. Fluid from the high pressure chamber flows through the bucket section and into the boom section. This fluid flows through the base spool, which is down, and into the rod end of the boom cylinder. This causes the piston in the cylinder to move, plus as the piston moves, fluid is pushed from the base end of the cylinder. This fluid flows into the boom section and into the base spool in the main valve.

With the boom spool in the pilot valve, moved to the right, a port is open. Fluid passage from the chamber above the base spool is open through this port to tank. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. The fluid that moved the rod spool down also holds the anti-void ball on its seat. Because there is no fluid flowing through the anti-void ball, both the short poppet and long poppet remain closed. Fluid from the base end of the cylinder flows around the base spool, and through the bucket section. This fluid flows into the inlet section and pushes the low pressure relief off its seat. See INLET SECTION — OPERATING PRESSURE UNDER 1000 psi (6900 kPa) (70 kgf/cm^2). The fluid flows around the low pressure relief valve, around the main flow control and back to tank.

ANTI-VOID FUNCTION



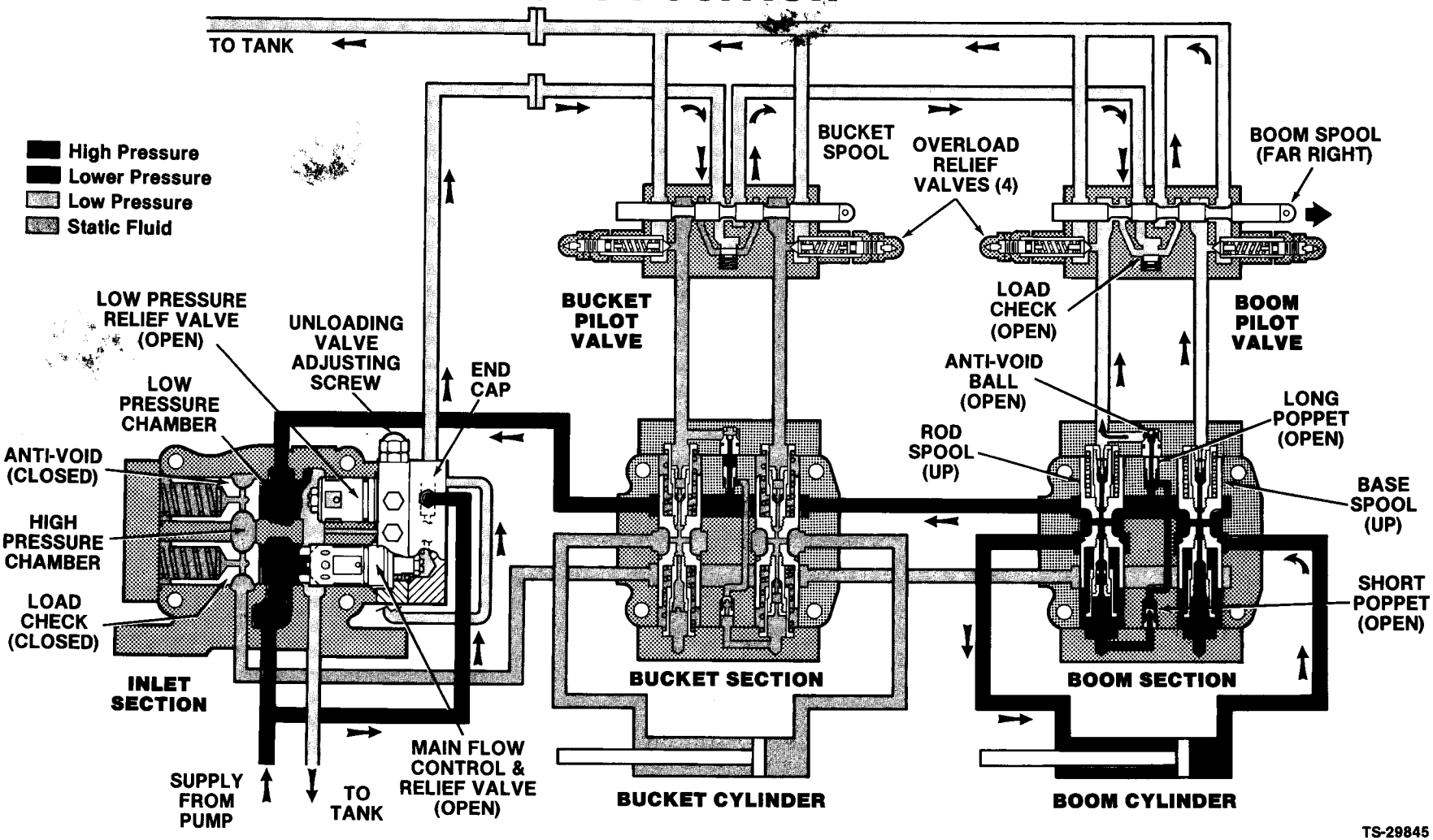
ANTI-VOID FUNCTION

The pilot valve is in the "NEUTRAL" position. The boom is up and there is a load in the bucket. The weight of this load causes the fluid in the base end of the boom cylinder to be under pressure. This pressure is felt through the base spool and is held by the boom spool in the pilot valve. When the boom spool, in the pilot valve, is moved to the right, it is in the "POWER DOWN" position. In this position, the base end of the boom cylinder is open to tank through the pilot valve. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the anti-void ball. This measured amount of fluid flows to the pilot valve where it is stopped by the load check. This fluid then flows into the chamber above the rod spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension.

When the boom starts to move down, the pressure of the fluid in the rod end of the cylinder decreases and becomes a void. The void, which is felt through the large hole in the rod spool and chamber below the spool, lets the spool move down. If the engine is running at low R.P.M. there is not enough fluid from the pump to fill the cylinder. This causes a void in the rod end of the boom cylinder. This void is felt in the supply circuit to the pilot valve and to the pump.

Fluid from the base end of the boom cylinder flows through the bucket section and into the inlet section. This fluid pushes the anti-void off its seat against spring tension and flows into the high pressure chamber. Because the low pressure relief valve opens at a higher pressure than the anti-void, it remains closed. The fluid from the pump pushes the load check off its seat against spring tension and flows into the high pressure chamber. Because the main flow control has the same pressure on both ends the spring holds the main flow control closed. The fluid, from the pump, joins the fluid from the base end of the boom cylinder. This extra volume of fluid flows to the rod end of the boom cylinder to help prevent voids.

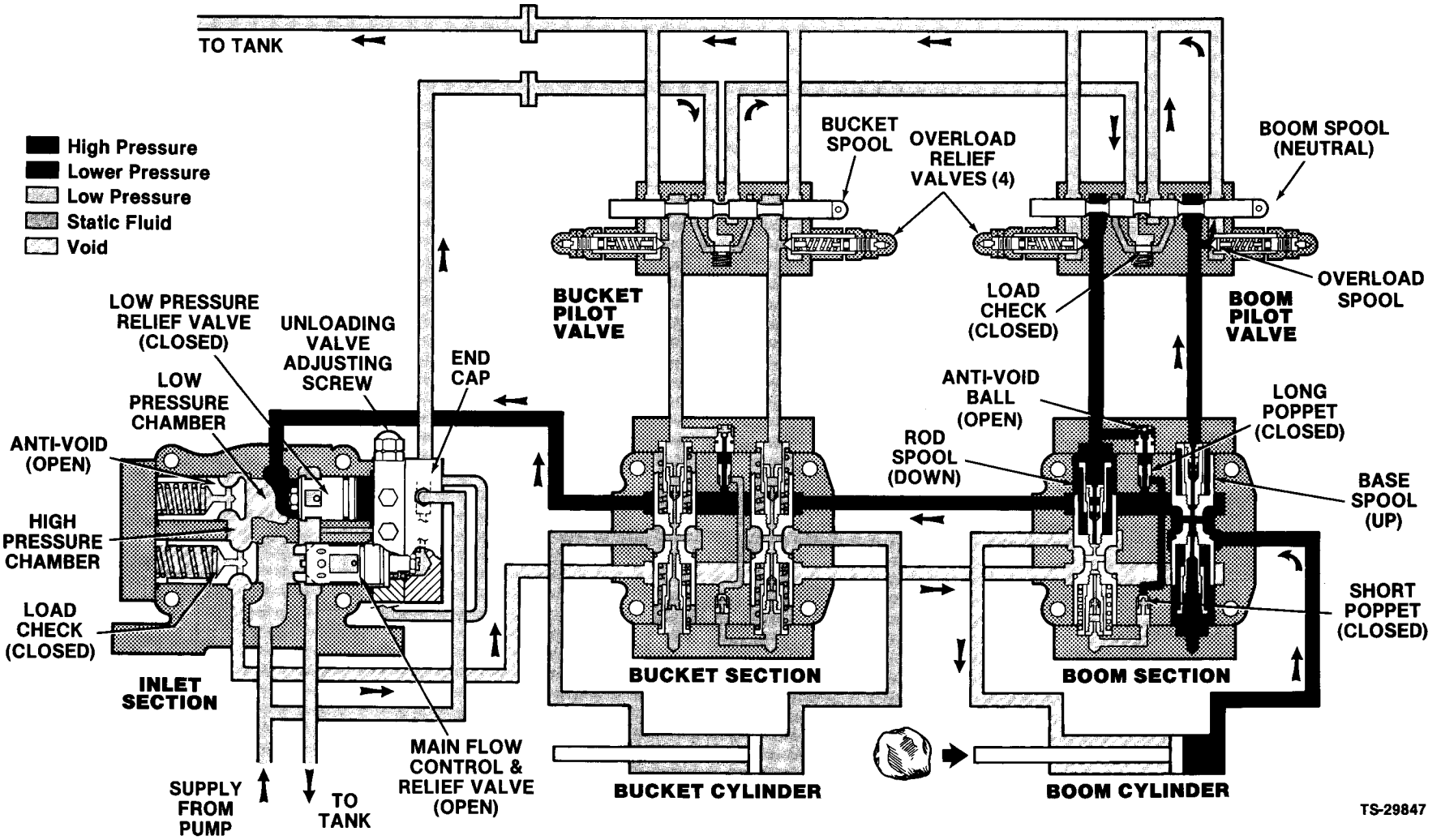
LOWERING BOOM IN FLOAT POSITION



LOWERING BOOM IN FLOAT POSITION

The pilot valve is in the "NEUTRAL" position. The boom is up and there is a load in the bucket. The weight of this load causes the fluid in the base end of the boom cylinder to be under pressure. This pressure is felt through the base spool and is held by the boom spool in the pilot valve. When the boom spool in the pilot valve is moved to the far right, it is in the "FLOAT" position. In this position, the base end and rod end of the boom cylinder is open to tank through the pilot valve. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the long poppet and the anti-void ball. This measured amount of fluid flows to the pilot valve. With the long poppet open, some of the fluid flows through and opens the short poppet. Fluid flows through the short poppet to the chamber below the rod spool. This fluid pushes the rod spool up. Now, fluid from the base end of the boom cylinder flows around the base spool and boom spool. The fluid that is needed in the rod end of the cylinder flows to the cylinder. Any remaining fluid flows through the bucket section to the inlet section. This fluid pushes the low pressure relief off its seat and flows to tank. The anti-void and load check are closed. The main flow control is pushed off its seat by fluid from the pump. Fluid from the pump flows around the flow control and to tank. Fluid from the pump flows through the circuit to the pilot valve and to tank.

OVERLOAD FUNCTION



OVERLOAD FUNCTION

The pilot valve is in the "NEUTRAL" position. The boom is up and there is a load in the bucket. The weight of this load causes the fluid in the base end of the boom cylinder to be under pressure. This pressure is felt through the base spool and is held by the boom spool in the pilot valve. When an extra load is applied, such as a rock falling in the loaded bucket, enough pressure can be created to open the overload relief valve. In this position, the base end of the boom cylinder is open to tank through the pilot valve. Fluid from the base end of the cylinder flows through the small hole in the spool. This fluid flows through the pilot valve through the overload relief valve and back to tank. Fluid flowing through the small hole in the base spool causes resistance. This resistance causes the pressure below the spool to increase. The high pressure below the spool moves the spool up. This opens the passage and lets fluid flow from the base end of the cylinder through the boom section. Some of the fluid from the cylinder flows through a port between the rod spool and the base spool. This fluid opens the anti-void ball. This measured amount of fluid flows to the pilot valve where it is stopped by the spool. This fluid then flows into the chamber above the rod spool. The restrictor in the spool will not let fluid flow through the spool as fast as it enters the chamber. This causes the pressure in the chamber to increase and push the spool down against spring tension.

When the boom starts to move down, the pressure of the fluid in the rod end of the cylinder decreases and becomes a void. The void, which is felt through the large hole in the rod spool and chamber below the spool, lets the spool move down. This causes a void in the rod end of the boom cylinder. This void is felt in the supply circuit to the pilot valve and to the pump.

Fluid from the base end of the boom cylinder flows through the bucket section and into the inlet section. This fluid pushes the anti-void off its seat against spring tension and flows into the high pressure chamber. Because the low pressure relief valve opens at a higher pressure than the anti-void, it remains closed.

Troubleshooting the

SPLIT SPOOL

GENERAL TROUBLESHOOTING GUIDE

If the hydraulic system does not function properly, check the following steps in the order listed:

1. Secure the machine into the SERVICE POSITION:
   - Boom and bucket on ground
   - All controls must be in the neutral position.
   - Remove the ignition key.
   - Connect the steering frame lock and put the parking brake into the on position.
   - Block the wheels.
   - Tie a red warning flag to the steering wheel.
2. Check the hydraulic fluid level and fill if low. CAUTION: Do not overfill the hydraulic reservoir under any circumstance.
3. Make a visual inspection; look for the obvious:
   - Leaks
   - Worn or pinched hoses
   - Damaged hydraulic connections
   - Control valve linkage binding
   - Pilot control valve spools sticking
   - Detents not positioned properly
4. Verify operator's complaint — check the operating times.
5. Check the hydraulic pressures in the following order:
   - Neutral pressure
   - Main relief pressure
   - Spool actuating pressure
   - Operating pressure
6. If hydraulic pressures check out normal, check the engine stall speed.
7. If voids are suspected, perform a void test.

NOTE: *The hydraulic oil must be at operating temperature, a minimum of 150° F (65.5°C), before these checks are to be made. After completing the necessary checks and adjustments in one step, operate the machine to see if the problem has been corrected.*

TEST CHECK GLOSSARY

OPERATING TIMES:
When checking the time necessary to perform each hydraulic operation of the machine, operating times are to be checked with an empty bucket, the hydraulic oil at operating temperature and with the engine at high free idle. If the operation times do not agree with specifications, refer to the specific problem outline to determine how to find cause and remedy in the easiest and fastest way.

If all the operation times check out normal with an empty bucket, then check out the times with a rated load in the bucket (3000 lbs. per cubic yard). If the times doe not agree with specifications, again refer to the specific problem outline.

PRESSURES:

The following suggested procedures should be followed when checking a machine for specific hydraulic pressures: the hydraulic oil must be at operating temperature, an accurate 3000 psi pressure gauge must be installed in the line from the pump to the inlet side of the main control valve, and all pressure checks should be taken with the engine at high free idle, unless otherwise specified.

Remember: High pressures indicate restriction — Low pressures indicate either leakage or low volume.

Neutral Pressure:

Main valve inlet pressures, with the valve in the neutral position, are to be checked and recorded.

1. Normal neutral pressure is anything under 100 psi (690 kPa) (7 kgf/cm^2) with the engine at high free idle. Most machines check out around 40 to 75 psi (276-517,5 kPa) (2,8-5.25 kgf/cm^2).
2. A high reading, in excess of 100 psi, would indicate a restriction to flow.

NOTE: 475C Neutral pressure can be 150 psi (1035 kPa) (10.5 kgf/cm^2) maximum.

Main Relief Pressure:

Main relief pressure is to be checked with the following cylinders bottomed out. Check each circuit separately at high free idle.

1. Boom cylinders in the boom raised position.
2. Bucket cylinders in the bucket roll-back position.

Spool Actuating Pressure:

With the engine at low idle, the pressure required to actuate a spool in the main valve should not exceed 600 psi (4140 kPa) (42 kgf/cm^2). The pilot valve spools are to be shifted (slowly) into each position to check actuating pressures:

1. Boom raise.
2. Boom lower.
3. Bucket roll back.
4. Bucket dump.

Operating Pressure:

Operating pressures are to be taken with the engine at high free idle and with an empty bucket. These pressures are to be checked while performing the following functions:

1. Boom raise.
2. Boom lower.
3. Bucket roll back.
4. Bucket dump.

Refer to the applicable manual for correct operating pressures for each machine.

ENGINE STALL SPEED

Measure the stall RPM as outlined in the operator's manual. If stall RPM is low, the engine and hydraulic functions will all be slow. Stall must be measured with the engine and transmission at operating temperature and with the main relief at the correct pressure setting.

1) Check engine RPM with hydraulics over relief and transmission in 4th speed reverse, parking and service brakes applied.

NOTE: 475C turbo transmission use 2nd forward, service brakes applied and wheels blocked.

VOID TEST

Operate boom and bucket circuits at high idle approximately 3 times to clear the system of voids if possible.

Bucket level.

Raise boom to maximum height.

Float down.

Return boom lever to neutral and immediately dump bucket to raise the front wheels off the ground.

With the engine operating at high idle during foregoing test, there should be no movement of the rod of the boom cylinder before the front of the machine moves. With the engine at low idle, the boom rod may move outward from .5 to 1 inch (12.7 to 25.4 mm).

Repeat test with boom in power down. There should be no rod movement at either high or low idle.

To simulate a system with voids, leave the boom lever in float and dump the bucket. Machine action will duplicate a valve that is not operating correctly. (Boom rods will move out of cylinders).

SPLIT SPOOL TROUBLESHOOTING
— SPECIFIC PROBLEM OUTLINE —

BEFORE MAKING ANY SPECIFIC TROUBLESHOOTING CHECKS, BEGIN WITH STEPS 1 THROUGH 7 IN THE GENERAL TROUBLESHOOTING GUIDE, PAGE 50.

I. **HIGH NEUTRAL PRESSURE** (With a test gauge placed between the pump and main valve, pressure reads above 100 psi with both levers in neutral @ HFI.) See Note on neutral pressure.

A. Neutral pressure is high, but operating pressure is normal.
1. Check for the main flow control poppet sticking in the closed position.

B. Both neutral pressure and operating pressure are higher than normal.
1. Stop the engine, disconnect the pilot supply line at the pilot valve and direct the line into a container.
2. Start the engine and check the neutral pressure.
a. If the neutral pressure now reads below 100 psi @ HFI), the problem is restriction to flow in either the pilot valve or in the return line from the pilot valve to tank.
1. Next, stop the engine, reconnect the pilot supply line, and disconnect the pilot return line at the pilot valve. Then, start the engine and check the neutral pressure.
a. If the neutral pressure is high with the pilot valve return line disconnected, repair or replace pilot valve.
b. If the neutral pressure is normal with the pilot valve return line disconnected, replace the return line.
b. If the neutral pressure is still too high (above 100 psi) with the pilot supply line disconnected at the pilot valve, the problem is restriction to flow in either the pilot pressure supply line, the pilot pressure supply cap, or in the return circuit from the main valve to tank.
1. Stop the engine, disconnect the pilot supply line at the pilot pressure supply cap, install a temporary hose and direct the flow into a container.
a. Start the engine. If the neutral pressure is normal, replace the supply line.
b. If the neutral pressure is still too high, remove the pilot pressure supply cap and check the flow passage for blockage.
c. If the flow passage through the pilot pressure supply cap is free of blockage, check the main return line from the main valve to tank for blockage.

II. **BOOM WILL NOT RAISE OR RAISES SLOWLY.**

HIGH PRESSURE PROBLEMS

A. High operating pressure in boom circuit — one direction only.
1. Flow restricted through the external flow restrictors on the boom section of the main valve.
a. Remove poppets and springs from both external flow restrictors. Operate the boom and check the operating pressure. If the pressure is normal, install new restrictors.
2. If the problem still exists, switch the pilot lines around at the main valve — boom to bucket, bucket to boom.
a. If the problem switches with the pilot lines (from high pressure in boom circuit to high pressure in bucket circuit), the pilot supply lines or the pilot valve have a restriction to flow.
1. To check whether the problem is in the pilot line or pilot valve, disconnect all pilot lines at the pilot valve. Then switch them.
a. If the problem changes with the lines, replace the line on the problem side.
b. If the problem does not change, then the pilot valve has a restriction. Clean or replace as needed.

HIGH PRESSURE PROBLEMS (Con't.)

b. If the problem does not switch with the pilot lines, the problem would be in either the main valve boom section, the boom cylinders, or the boom cylinder lines.
   1. Disconnect one of the boom cylinder lines at the base port, install a gauge, and reconnect line.
      a. If the pressure is low at the gauge, there is a restriction in either the main valve or the base line to the boom cylinders.
         1. Move the gauge to the boom base supply port of the main valve.
            a. If the pressure is high, the problem is in the base supply lines. Replace lines.
            b. If the pressure is low, there is a restriction in the boom section of the main valve.
               1. Remove the base spool (boom up spool) and look for damage. Inspect spool and valve housing bore for burrs. If defective, replace boom section.
               2. If broken centering springs are found, inspect for damage to valve. If valve is undamaged, replace springs.
   2. If the operating pressure was high at the boom cylinder's base port, move the gauge to the rod port of the cylinder.
      a. If the pressure is low, the problem would be mechanical.
         1. The cylinder rod might be bent and binding. Replace cylinder if needed.
         2. The boom pin and bushings may be binding.
            a. Replace pins and bushings.
   3. If the operating pressure was high at the boom cylinder's rod port, move the gauge to the rod port of the main valve.
      a. If the pressure is low, a restriction is in the rod line. Replace the line.
   4. If the operating pressure was high at the rod port of the main valve.
      a. Remove the rod spool (boom down spool) and inspect for damage. Check the spool and bore for burrs. If defective parts are found, replace as needed.

B. High operating pressure in boom circuit — both directions.
   1. The problem causes for high operating pressure in both directions are the same as the problem causes for high operating pressure in one direction.
      a. The most probable cause for high operating pressure in both directions is one or both external restrictors or spools binding in the boom section, main valve.

C. High operating pressure in both circuits, all operations, and with normal neutral pressure.
   1. Remove the pilot pressure supply cap and check the low pressure relief valve for binding or damaged parts.
      a. Replace all defective parts.
   2. If the low pressure relief valve is functioning properly, pull the main flow control poppet assembly out and check the load check valve. Insert a screwdriver through the flow control poppet's bore, press the load check in and let it snap back. Do this several times to see if it's binding.
      a. Replace parts as needed.

D. High operating pressure in both circuits, all operations, and with high neutral pressure.
   1. The problem causes for this condition would be the same as in high operating pressure in both circuits, all operations, normal neutral pressure (II, C, above) and as in both neutral pressure and operating pressure when higher than normal (I, B, page 53).

LOW PRESSURE PROBLEMS

E. Low pressure readings in boom circuit, one direction only.
1. The boom sections' overload relief valve on the up spool supply side of the pilot valve could be set too low or stuck open.
   a. Switch the overload relief valves on the pilot valve — switch the boom up spool overload with the bucket roll-back overload and the boom down overload with the bucket dump overload. Operate the bucket and check pressure readings.
      1. If operating pressure is still low, adjust the overload relief cartridge or replace if necessary.
2. If the overload relief is not malfunctioning, switch the pilot lines around. Connect the bucket pilot lines to the main valve's boom section and then connect the boom pilot lines to the main valve's bucket section.
   a. Actuate the bucket lever and check pressure.
      1. Low pressure would indicate leakage by the boom up spool in the main valve. Replace the boom section of the main valve.
      2. Normal pressure would indicate leakage by the boom spool of the pilot valve. Replace the boom section of the pilot valve.
      3. Switch the pilot lines back and take a final operating pressure check.

F. Low pressure readings in boom circuit only — both directions.
1. Take a leakage test at the boom cylinders to check for cylinder piston seal leakage.
   a. To check the cylinders for seal leakage, bottom them out in power down and disconnect the base end line at the cylinder. Plug the line and actuate the boom lever to power down. Power down will pressurize the rod side of both cylinders. If the piston seals are bad at the disconnected cylinder, oil will leak out the open base port.
      1. Repeat this test for the other cylinder. If leakage is detected, reseal leaking pistons.
2. If the boom cylinders check out normal, go to the pilot valve next.
   a. The low pressure problem is in the boom circuit, so disassemble the boom section of the pilot valve and inspect for leakage. Look for a cracked housing.
      1. Replace defective valve section.

G. Low pressure readings in all operations (boom up, boom down, bucket dump, and bucket roll-back).
1. Leakage in the inlet sections of the pilot valve.
   a. Check for pilot valve leakage by disconnecting the pilot supply line at the main valve. Plug the open pilot pressure supply port, then start the engine. If the system pressure goes to relief, the pilot valve is defective.
      1. Repair or replace pilot valve.
2. Relief valve or pump malfunctioning.
   a. While watching the pressure gauge, with bucket over relief, increase and decrease the engine R.P.M.'s. If pressure readings stay low at all R.P.M.'s, that indicates that the main flow control poppet is stuck open or that the main relief valve is malfunctioning.
      1. Remove the main flow control poppet and relief valve assembly. If the assembly moves freely in the bore, disassemble it and check the relief valve's return springs, all o-rings, and back-up rings. Be sure all poppets move freely and seat properly. Check the second stage poppet's piston to make sure it moves freely in the bore. Remove any contamination or replace flow control assembly.
      2. When adjusting the main relief valve's pressure setting, check the anti-void poppet for free movement in the bore.
         a. This check can be made by removing the low pressure relief valve, inserting a screwdriver through its bore and then by pushing the head of the anti-void poppet in, to see if it snaps back.

LOW PRESSURE PROBLEMS (Con't.)

1. If anti-void poppet does not move freely, remove it, clean it, and replace any parts as needed.

b. If pressure readings vary up and down, at the same time the engine R.P.M.'s are varied, a bad pump could be the cause.
1. Check the pump and replace if needed.
a. The only 100% sure method of checking the pump is with a flow meter.
b. When a system has a pressurized reservoir, or if the oil level is higher than the inlet of the pump, you can shut down the engine and disconnect the pump outlet line, at the pump. If the pump is good, it will act as a one way check valve and allow only a small trickle of oil to drain out.

3. If none of the above corrects the problem, the cause is probably a cracked housing in the main valve.
a. Replace valve.

NORMAL PRESSURE PROBLEMS

H. Hydraulics slow in one circuit only, pressures normal.
1. Pilot valve spool not positioned properly because of damaged spool or detent balls in the detent section.
a. Repair or replace pilot valve as necessary.

I. Hydraulics slow in both circuits, pressures normal.
1. Run engine stall speed test.
a. Repair defective engine.
2. Test the pump for proper flow rate.
a. Replace defective pump.

III. BOOM OR BUCKET DRIFTS WITH THE CONTROL VALVES IN NEUTRAL.

A. Leakage by the cylinder piston seals.
1. This will cause drifting in both down and up.
a. Actuate down pressure on the boom cylinders and lift the front wheels off the ground.
b. If the cylinders allow the front wheels to drift back down to the ground, test the cylinders for leakage. Refer to procedure outline in section II, F, 1, on page 55.

B. Overload relief valve leaking.
1. Switch the overloads and test them, as described in section II, E, 1, on page 55.
2. Adjust or replace cartridge as needed.

C. Excessive leakage by the pilot valve spools or by the spools in the main valve.
1. To determine which valve is leaking, switch the pilot lines around at the main valve — boom to bucket, and then bucket to boom. Check for drift in neutral.
a. if the problem switches with the pilot lines, the pilot valve is leaking.
1. Remove and disassemble pilot valve. Inspect the spools and bores for excessive wear. Replace valve or section as needed.
b. If the boom still drifts, check for excessive leakage by the spools in the main valve.
1. Remove the pilot pressure end cap on the main valve's boom section. Inspect the up and down spools and the bores for excessive wear or scoring. Replace valve section as needed.

IV. BOOM DROPS OR BUCKET DUMPS WHEN LOADED WITH CONTROL LEVERS IN NEUTRAL POSITION.

A. Pilot valve spools not centering properly.
1. Maneuver the boom or bucket into the position where it drops or dumps; turn the engine off and shift the pilot valve to the raise or roll-back position.
a. If the boom stops falling, or the bucket stops dumping, the problem is definitely in the pilot valve.
1. Repair or replace the pilot valve.

2. Check the control linkage for bent or binding rods and bellcranks.
   a. Adjust or replace defective parts.
3. Check the return spring area of spool for loose or damaged parts.
   a. Adjust or replace as needed.

B. Check the overload reliefs.
1. They could be set too low or stuck open.
2. Test the overloads as described in section II, E, 1 on page 55.
   a. Readjust or replace as needed.

C. Main valve spools not centering properly.
1. Remove the pilot pressure end cap and inspect the spools in the problem section of the main control valve. Check for broken springs. Repair or replace as necessary.

V. BOOM DROPS WHEN WORKING BUCKET LEVER.

A. Boom up spool binding when extending the boom cylinder.
1. Remove the pilot pressure end cap of the boom section, main control valve.
2. Inspect the boom up spool and the spool's bore
3. Check the spool's flow restrictor, it could be plugged.
4. Look for broken springs, burrs, and contamination.
5. Clean and replace all damaged parts.
6. Replace the boom sections of the valve if spool is defective.

B. Load check in the boom section of pilot valve stuck open. (NOTE: The boom lever would have to be in the raise position.)
1. Disassemble the boom section of the pilot valve and inspect it.
   a. Clean or replace parts as needed.

VI. BUCKET WILL NOT ROLL BACK OR ROLLS BACK SLOWLY.

A. The same problem causes for this problem are outlined under, "Boom will not raise or raises slowly," section II. Substitute the word "boom" with the word "bucket."

VII. VOIDS OR CHATTERING WHEN LOWERING THE BOOM.

A. Voids in both the bucket and the boom operations.
1. The low pressure relief valve stuck open or the anti-void poppet is stuck closed.
   a. Check the low pressure relief valve first.
      1. If it is stuck open, oil would be open to tank and could not open the anti-void poppet.
         a. Remove the pilot pressure supply cap, remove the low pressure relief valve, and clean the valve of all contamination.
         b. Replace all broken parts.
   b. Check the anti-void poppet by inserting a screwdriver through the low pressure relief valve's bore. Then press in on the anti-void poppet to see if it's sticking.
      1. If it's stuck, remove the anti-void poppet, clean and replace all broken parts.

B. If the chattering occurs only in the boom section when lowering the boom in power down, go to the boom section of the main control valve and check the following:
1. Check the main valve's rod (down) spool.
   a. The center holes or the restrictor poppets may be plugged.
   b. Remove all foreign material and make sure that the restrictor poppets are seating properly.
2. Examine the passage in the pilot pressure end cap to the long poppet (float and anti-void poppet), the poppet, the passage from the long poppet to the short poppet (float poppet), the poppet, and the passage from the poppet to the bottom side of the down spool.
   a. Remove all foreign material from the passages, poppet bores, poppets, and poppet seats.

VIII. HYDRAULIC OIL IS OVERHEATING.

NOTE: *This condition could be caused by any of the problems previously mentioned in addition to the following malfunctions:*

A. Hydraulic oil cooler malfunctioning.
   1. Clean or replace cooler as necessary.
B. Steering by-pass valve plugged. (This valve is found on the wheel loader model 475 only).
   1. Clean or replace as needed.

IX. PHASE II ONLY

A. Drill passage plugged in low press relief poppet
   1. Voids after first normal operation.
B. Low pressure poppet stuck open
   1. Voids
C. Low pressure *relief* poppet stuck open
   1. Voids
D. "B" tube plugged (6400 series only refer to page 24).
   1. Higher operating pressures above 1000 psi (6900 kPa) (70 kfg/cm^2).
   2. Heat build up in hydraulic system.
E. Low pressure first stage poppet stuck on seat
   1. Pressure will rise to whatever the unloader valve is set at when levers are actuated. Even with an empty bucket.
F. Unloader on seat (stuck or adjusted too high)
   1. High operating pressure above 1000 psi (6900 kPa) (70 kgf/cm^2).
   2. Heat build up in hydraulic system.
G. Unloader off seat
   1. Voids
H. Leakage by unloader valve
   1. Low relief pressure at low R.P.M.
      a. Slow operations.
I. Unloader set too low (Below pressure needed to roll bucket back.)
   1. Draw a void when lowering the boom and rolling the bucket back.
J. Line to Dampening Kit crimped
   1. Low operating psi