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TEREX Service Rep.

TEREX

GM
MARK OF EXCELLENCE

Service PRESENTS-

UNDERSTANDING 72-81 LOADER HYDRAULICS

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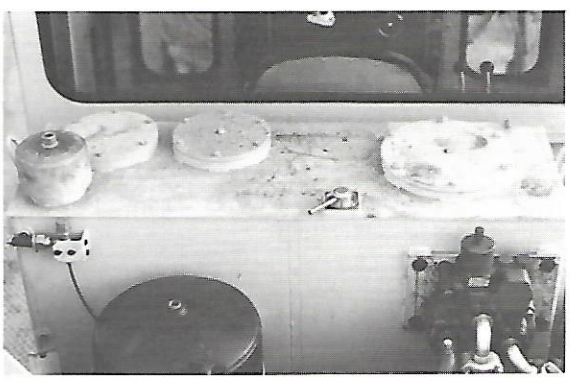
In order to efficiently maintain and diagnose the hydraulic system of the TEREX 72-81 front end loader, it is important to understand how it works.

SYSTEM COMPONENTS

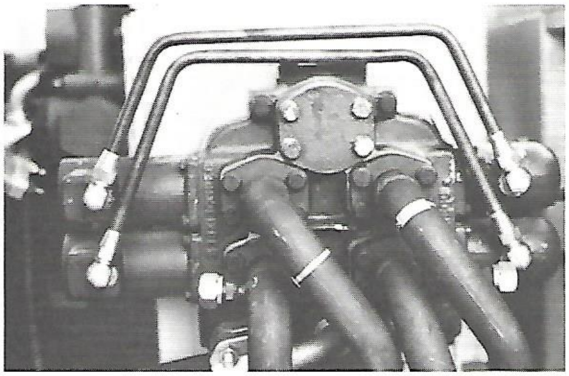
First we will introduce the major components of the system.



The 62-1/2 gallon hydraulic tank is located immediately behind the operator's compartment.

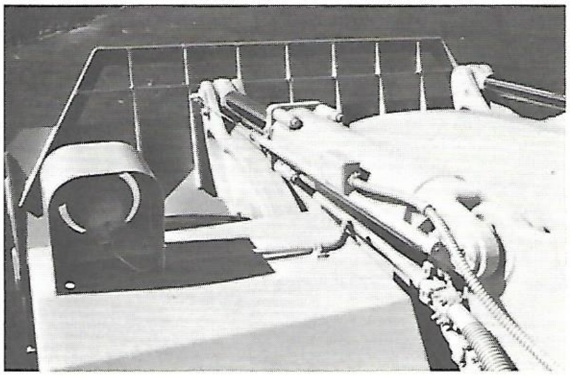
Two gear-type pumps are driven by the power take-off (PTO) unit located on the rear of the engine. The larger pump on the left is the main hydraulic pump and the one on the right is the demand pump.

The main hydraulic pump supplies the hydraulic control valve (shown). It is located on the right side of the hydraulic tank.

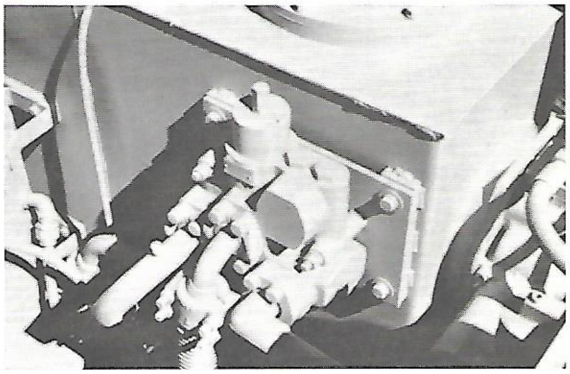


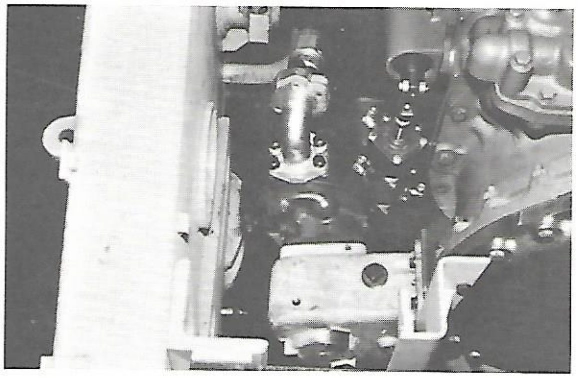
It controls the lift cylinders shown at the front of this unit

And the tilt cylinders which are located on the outboard side of the lift arms.

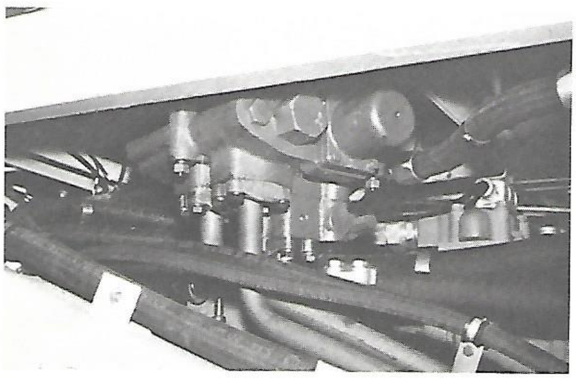


The demand pump supplies the demand valve (shown) on the front of the hydraulic tank, which assigns the fluid from the pump to the bucket hydraulic system and the steering system. The portion which each system receives depends on engine RPM.

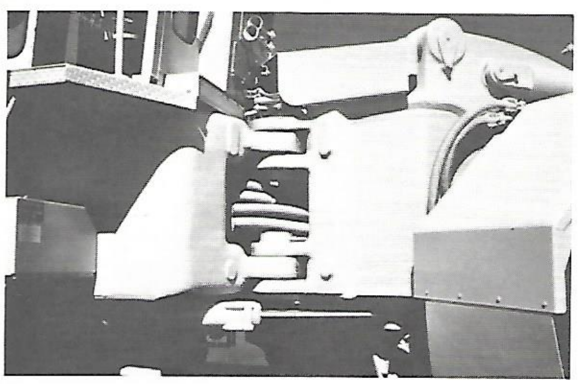




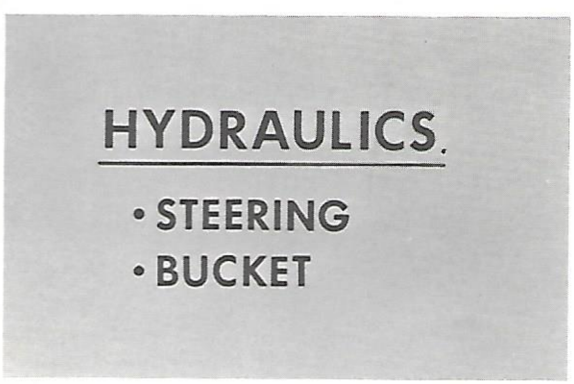
Looking towards the front of the Loader, the steering pump is mounted on the PTO on the left side of the transmission.



This pump supplies oil, by way of the demand valve, to the steering valve (shown) which is located almost directly below the operator's seat.



The steering valve controls the steering cylinders shown underneath the pivot area.



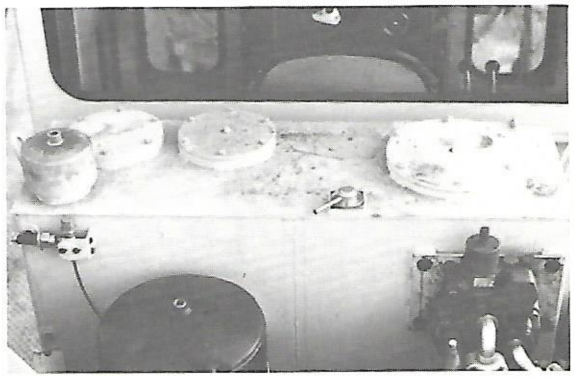
This concludes the introduction of the major components. We will now begin to study them in more detail in an effort to tie the components together into a working system. The hydraulic system is divided into two major areas:

1) Steering
and 2) Bucket Hydraulics.

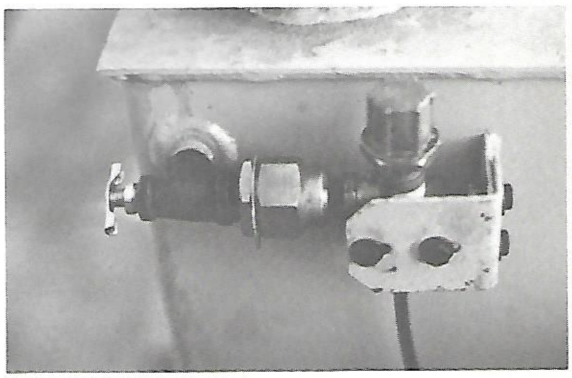
We will study these two areas separately except for the components which are important to both systems.

COMMON COMPONENTS

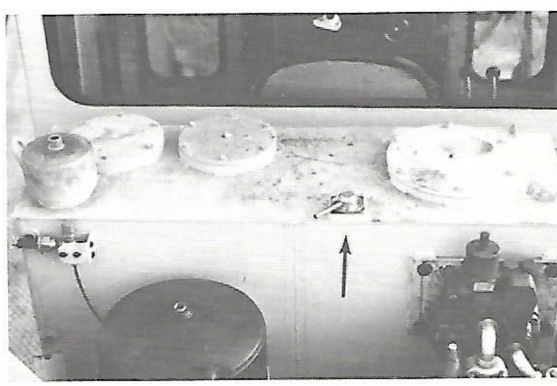
The first of these common components to be considered is the hydraulic tank. As we said before, this tank has a 62-1/2 gallon capacity. It is pressurized by air from the transmission air shift system.

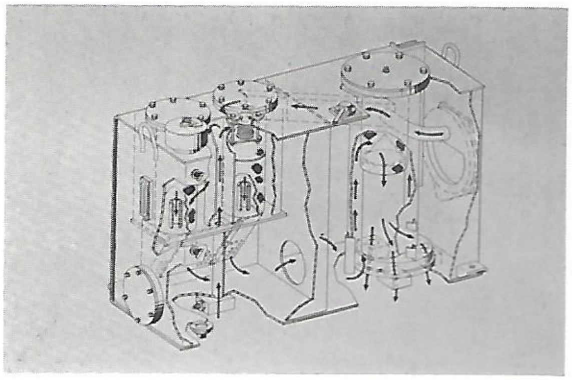


The pressure reducing valve is located on the upper left-hand corner of the tank. It reduces the air shift system pressure to 6 PSI and insures that this is the minimum pressure inside.

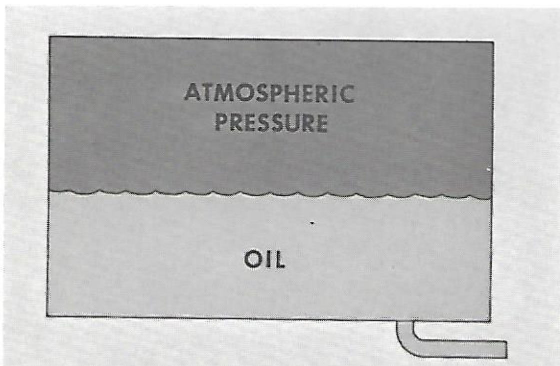


Mounted on the top of the tank is the pressure relief valve which opens when pressure in the tank reaches 14-16 PSI. Pressure can increase since, at low fluid levels, pressure is maintained at 6 PSI and, when the fluid level raises, the air in the tank is compressed. If the pressure was not relieved, the tank would bulge or burst.

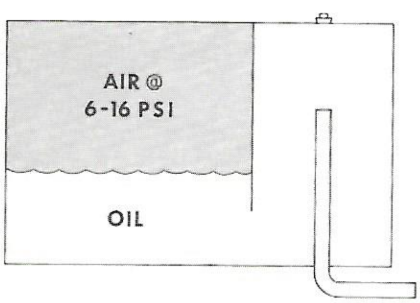




Oil enters the tank on the left bottom from the oil cooler of the steering system and on the right side from the bucket system. These inputs are ducted to the filter area in the upper left corner. In this compartment are two filters, each containing two filter elements and a by-pass valve. These by-pass valves begin to open at 25 PSI, and are completely open at 40 PSI. In cases where restriction in the filters is high or the oil is cold, the by-pass opens and unfiltered oil is allowed to flow into the storage area. A filter screen is located around the high-rise tube. The purpose of this screen is to catch any foreign elements let through by the by-pass valve. The tank is well baffled to limit oil movement.

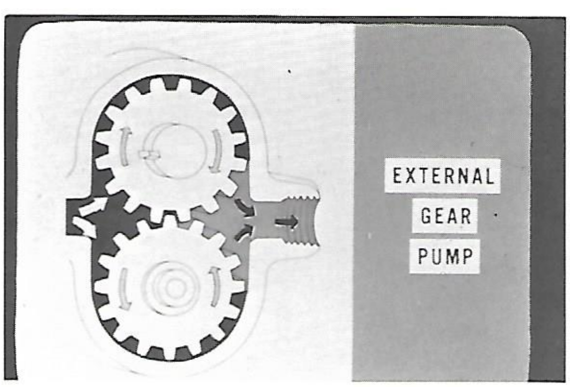


The 72-81 hydraulic tank operates on a pressurized feed and anti-syphoning drain principle. In a standard tank, if a line is disconnected, all the oil would flow out of the tank due to gravity.



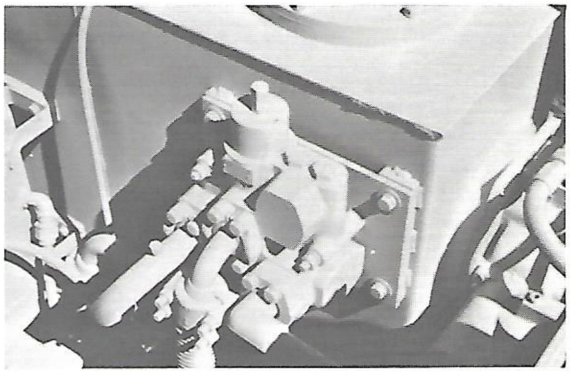
In a pressurized feed and anti-syphoning drain type tank, the air pressure from the pressure reducing valve forces the oil level down in one half of the tank (in this case the left) and, as a result, up in the other half. The oil then flows down the high-rise tube and to the pumps, all under pressure.

If a line was disconnected with this arrangement, the oil would syphon out of the tank even after the air pressure had been released. For this reason, an anti-syphon plug is installed directly above the high-rise tube. Now, when the air pressure is released and the plug is removed, the oil levels in the two halves of the tank are allowed to equalize below the top of the tube. Consequently, when a line is disconnected, only the oil which remains in the tube is lost.

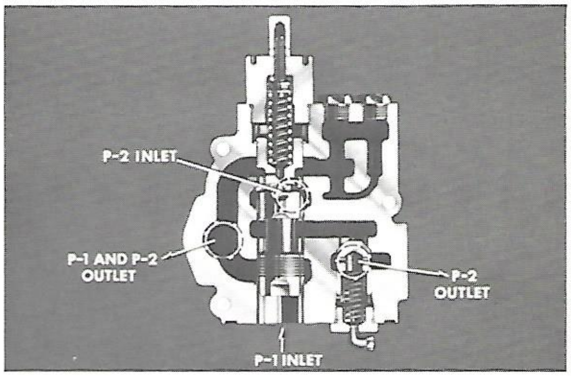


Another component group common to both systems is the pumps. All three are external gear type. Oil from the tank flows into the inlet (in this case, left) side. The drive gear (top) is keyed to a shaft which is turning at engine speed. It meshes with the driven gear which turns freely. Oil is caught in pockets which are formed by gear teeth, the thrust plates and the pump housing. Remeshing of the gears at the outlet port forces the oil out of these pockets and through the outlet. It is important to remember that a pump pumps volume, not pressure. Pressure is created by a resistance to flow.

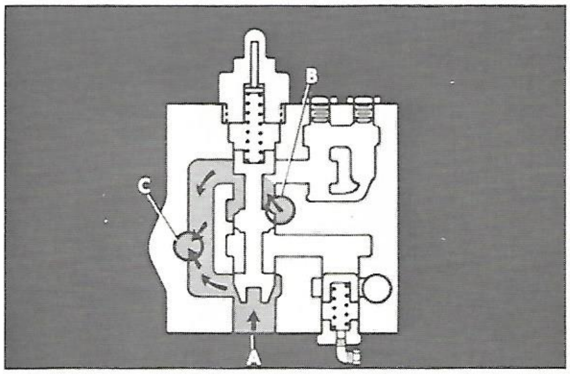
The demand valve assigns the oil from the demand pump to either the steering valve or the bucket hydraulic control valve, depending on engine speed.



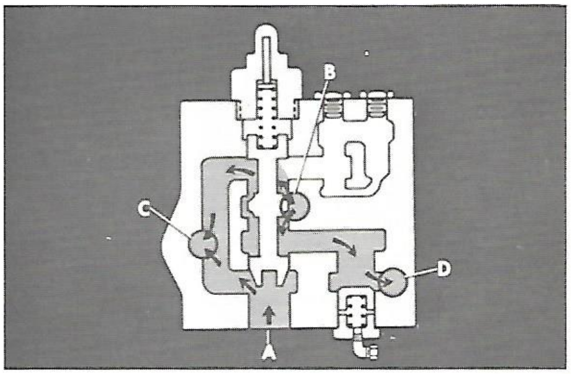
This is a cutaway view of the demand valve showing the inlet and outlet ports. P-1 is the steering pump and P-2 is the demand pump. The outlet port labeled P-1 and P-2 goes to the steering valve and the outlet port labeled P-2 goes to the bucket hydraulic valve.

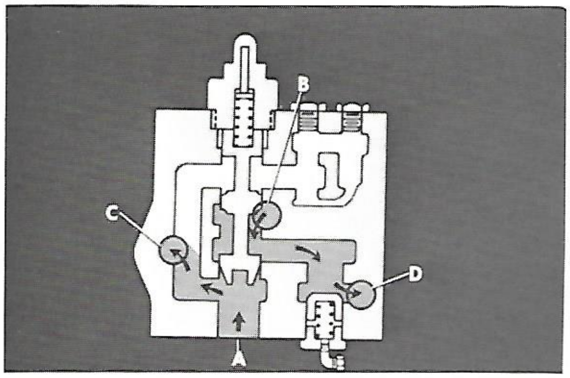


This is how the demand valve operates. At an engine speed of less than 1000 RPM the steering pump pressure is not great enough to move the spool inside the valve significantly. Under these circumstances, the spool directs all of the oil from both pumps (A & B) to the steering valve (C).

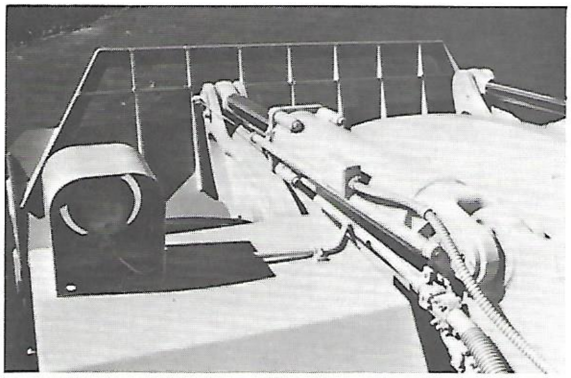


As engine speed varies between 1000 and 1500 RPM, so does the position of the valve spool. At 1000 RPM the spool begins to allow some of the oil from the demand pump (B) to flow into the bucket hydraulic control valve (D). As speed continues to increase, so does the percentage of the demand pump's output which goes into the bucket system. When the engine approaches 1500 RPM, almost all of the demand pump's oil is allocated to the hydraulic control valve.

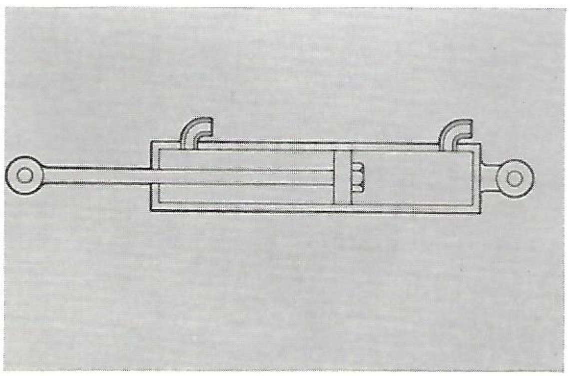




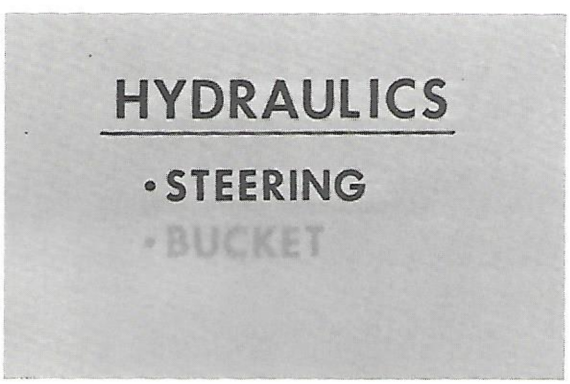
At speeds above 1500 RPM, pressure from the steering pump (A) is sufficient to displace the valve spool to a point where all of the demand oil goes to the bucket system. It is important to note that all the oil from the steering pump always goes to the steering valve.



The last group of items common to both systems are the hydraulic cylinders. This tilt cylinder is a common example. The base end is usually attached to a fixed frame, whereas the rod end is secured to that which is to be moved.



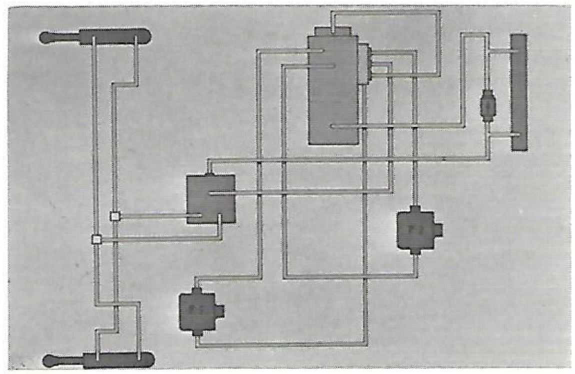
Hydraulic cylinder operation is very simple to understand. At the end of the rod which is inside the cylinder is a leak-proof piston which divides the inside into two parts. When the cylinder is to be extended, oil is pumped into the base end. The pressure of this oil acts against the piston. Since the oil on the other side is under less pressure (or no pressure at all), the piston moves in the direction which will relieve this pressure and, as a result, the rod is extended. If the oil in the rod end were not allowed to escape, the piston would hardly move at all since oil is incompressible. However, when the valve which controls the cylinder directs oil to one end, it also allows oil to flow from the other enabling considerable movement of the rod. Contracting the cylinder assembly is, of course, accomplishe in the opposite way - - by pressurizing the rod end and allowing the base end to drain. Any movement of the cylinder is stopped when the valve locks the oil in each end.



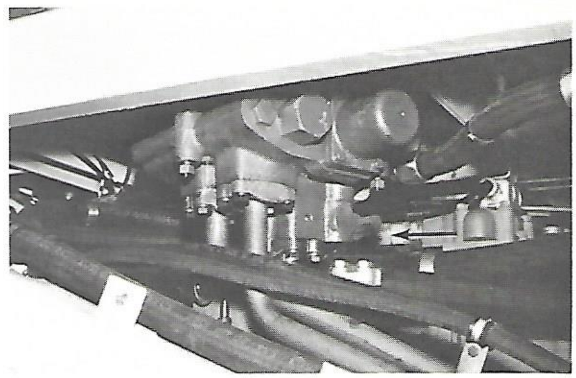
We are now ready to proceed into the two main areas of concern - the steering hydraulics and the bucket hydraulics. Steering will be covered first.

The purpose of the steering system is to provide hydraulic force to the steering cylinders for steering the loader.

The steering system consists of the hydraulic tank, the transmission PTO driven steering pump (P-1), the engine PTO driven demand pump (P-2), the steering valve, the demand valve, two double-acting steering cylinders, a one-way check valve, and a radiator type oil cooler.

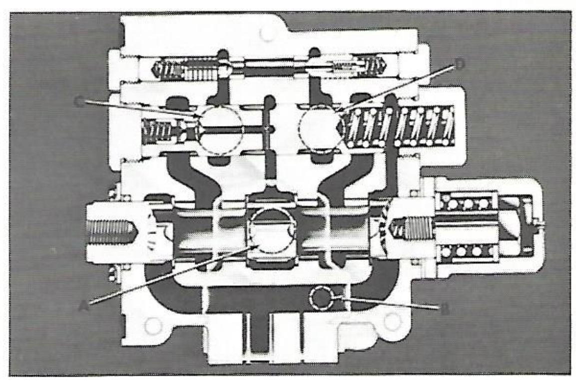


We have previously discussed all but three of these components. Of the three that remain, we shall start with the steering valve. As we noted before, this valve is located almost directly below the operator's seat. In this photo you can see the 2000 PSI main system relief valve which is bolted to the bottom of the valve housing.

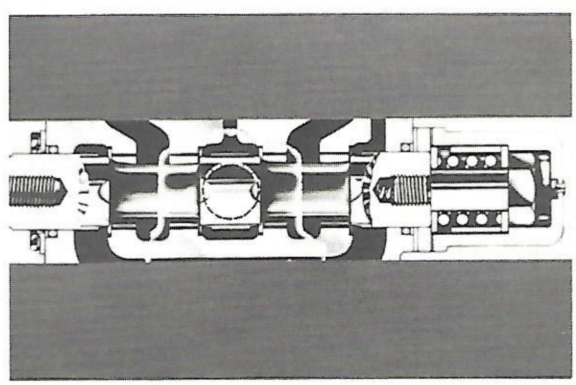


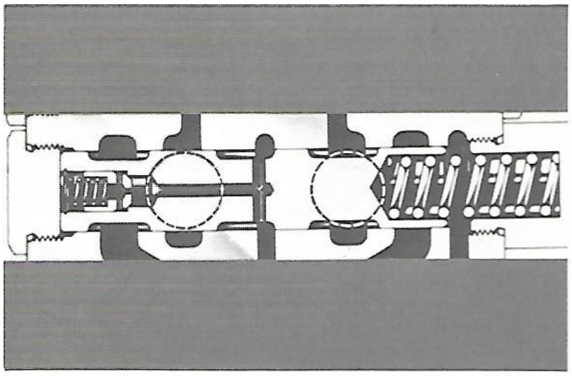
The steering valve consists of a control spool (at the bottom), a plunger (in the middle), and two double relief valve assemblies. Port A is the high pressure inlet from the main system relief valve (which is shadowed in white). Port B is the return to tank port for that relief valve. It empties into the passage that returns steering oil to tank through the port at the bottom of the picture. Ports C and D are connected to the steering cylinders.

One of the chief advantages of the two-spool design is that the upper spool (which actually controls the steering cylinders) is not subject to terrain irregularities that might cause steering difficulty if attached to the steering linkage.

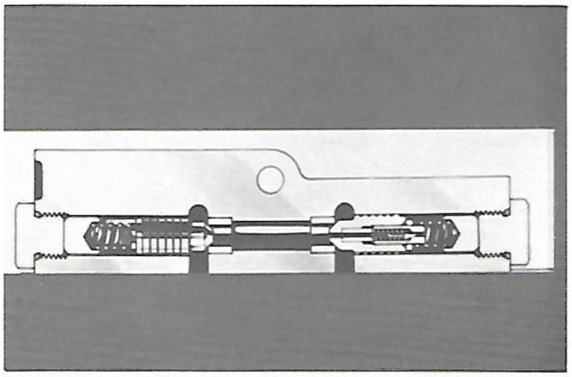


The purpose of the control spool is to direct oil to the plunger. The apparatus on the right hand side is a self-centering device containing a spring, two end washers, and a sleeve which limits the travel of the spool.



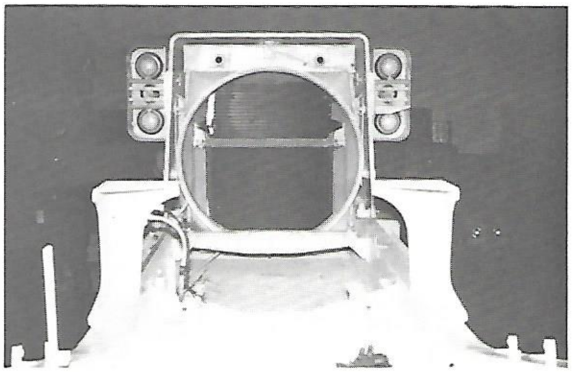


The plunger directs oil to the appropriate ends of the steering cylinders. It consists of the plunger itself, a return spring, a poppet, a poppet spring, a snap ring, and a washer.

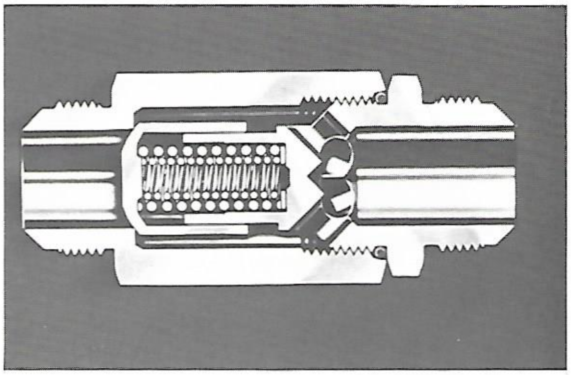


The purpose of the two double relief valves is to relieve shock loads in excess of 2400 PSI placed on the steering cylinders. Each of these valve assemblies consists of a seat, the valve itself, a spring, a plug, an "O" ring, and an end cap.

Note: The double relief valves are not serviceable; they are sold as assemblies only.

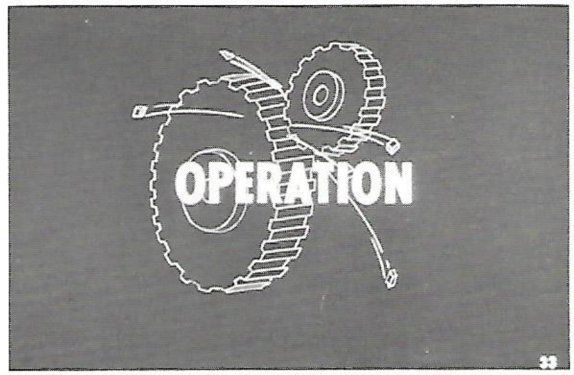


The steering system oil cooler is the larger of the two radiator type coolers located in front of the engine radiator. Remember that only steering oil passes through this cooler.

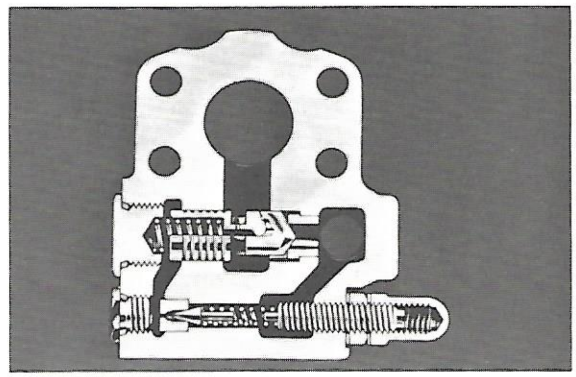


The one-way check valve is found on the bottom of the hydraulic tank between the two T fittings. It protects the oil cooler from high pressure by by-passing it. The poppet begins to crack at 45 PSI and is fully open at 65 PSI.

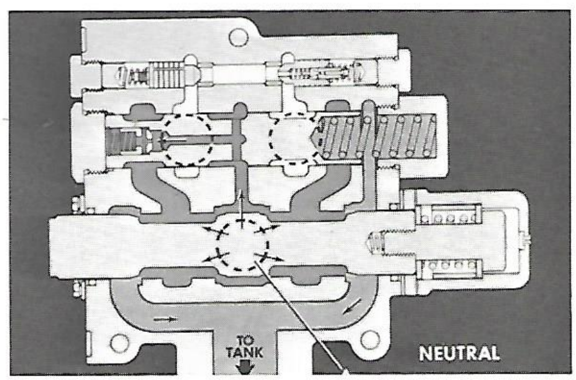
In the next few pages we will discuss the oil flow through the steering system under various steering situations.



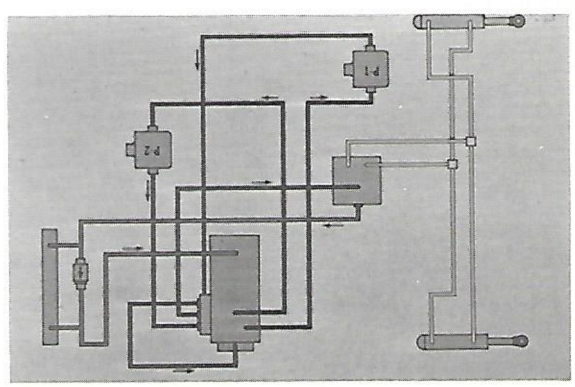
Oil from the demand valve passes through the large hole in the main system relief valve (shown). Oil flows through the drilled opening in the check valve and down the left side passages until it is stopped by the poppet. Under normal operation, oil lies in these areas and assumes the same pressure as system oil. When system pressure exceeds 2000 PSI, the poppet is unseated and oil is allowed to flow past the poppet, through the small port, and on its way back to tank. The poppet allows more oil to pass than can be supplied through the drilled opening. This situation creates a low pressure area which allows the check valve to shift left and return to tank any amount of oil necessary to drop pressure to 2000 PSI. When this pressure is reached, the poppet closes, the cavity behind the check valve fills up and forces the check valve to seat.

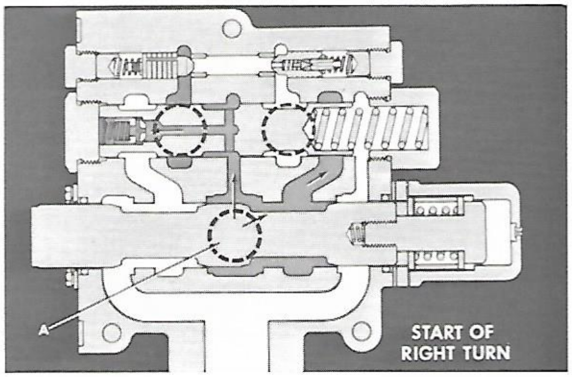


Pressurized oil which has passed through the relief valve enters the main steering valve at Port A. In a neutral position, the valve control spool is centered and oil flows around the control spool and into the outlet passage which is connected to the oil cooler.

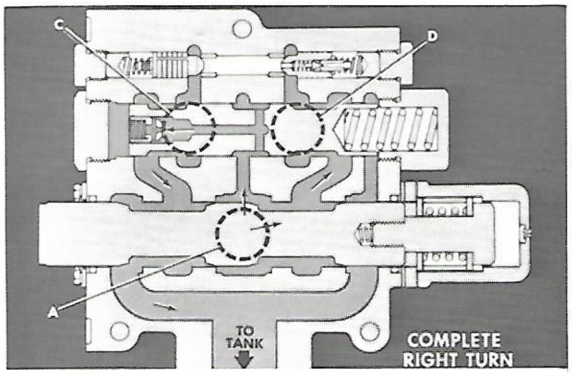


This picture shows the steering system oil flows in the neutral position.

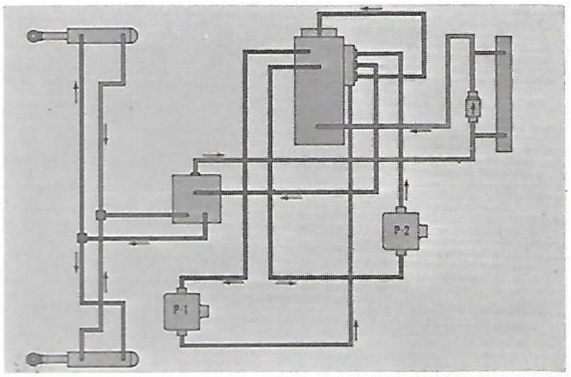




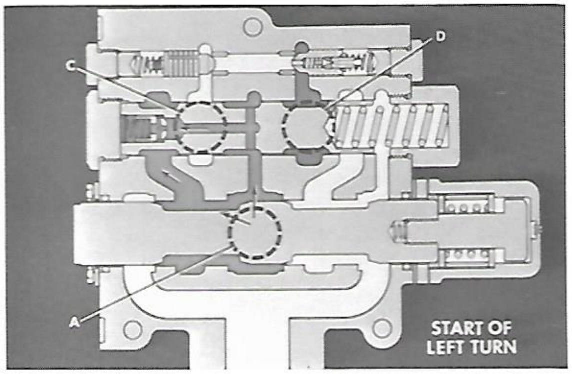
In a right turn, the steering valve control spool is slowly pulled out of the steering valve housing up to a maximum of .31 inches. This movement closes off the left side of the main oil passage. Oil enters the housing at Port A, flows into the right hand passage and is dead-ended at the plunger.



At the same time, oil flows upward into the small passage directly above Port A, into the plunger, and against the poppet. The poppet moves toward the left, compressing the small spring. This allows the oil pressure to act against the left end of the housing and to push the plunger to the right. The oil pressure which was previously dead-ended is now able to flow out the upper right hand port to the base end of the left steering cylinder and to the rod end of the right steering cylinder. Oil returning from the steering cylinders enters the upper left hand port and flows down to the return to tank port.



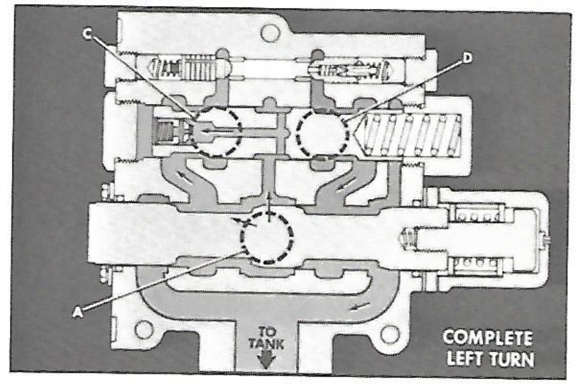
These are the steering system oil flows during a right turn.



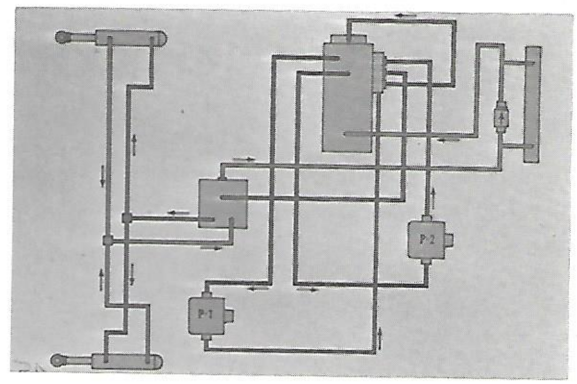
When making a left turn, the control spool is moved <u>into</u> the valve housing shutting off the right side passages to the pressurized oil. The oil flows up the left side and is blocked by the plunger.

Plunger operation is the same as in the right turn. The plunger simply allows oil to be transmitted to the steering cylinders according to the position of the control spool. In this case the oil is allowed to flow into the upper left hand port and to the base end of the right cylinder and the rod end of the left cylinder.

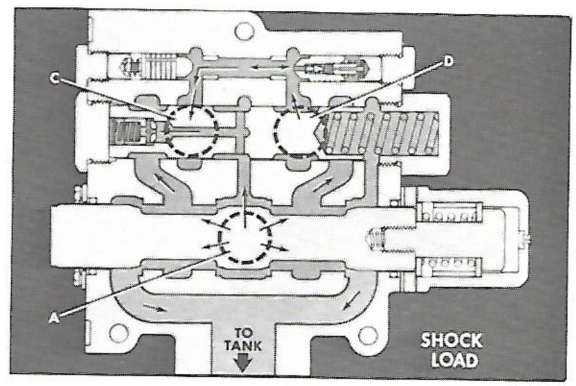
It should be noted that the control spool is centered when steering wheel rotation is stopped. This locks the oil in the steering cylinders and the loader maintains this turning angle until the steering wheel is rotated again.



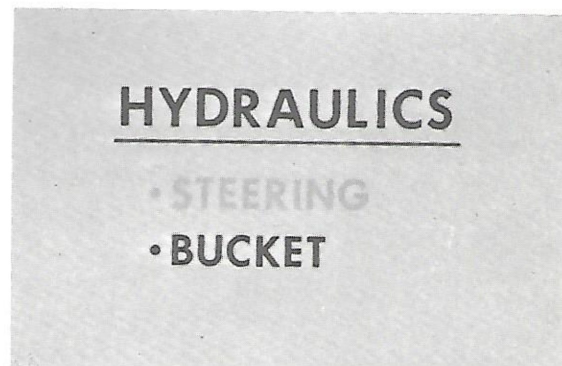
Flows for the left turn are the same, except those to the steering cylinders, which are reversed.



Any time a unit is moving on irregular ground or a tire hits an object, a shock load can be created in the steering cylinders and transmitted to the steering valve. Let's assume that a shock load is placed on the rod end of the left steering cylinder. Oil that is displaced in the base end of that cylinder is sent to Port D of the steering valve and a high pressure situation is created. Oil will now flow around the right hand double relief valve through slots machined in the sleeve and into the cavity between the valve and the adjusting screw. It now forces open the cone-shaped pilot poppet. Oil suddenly flowing through this poppet creates a low pressure area and causes the entire relief valve assembly to shift to the right. The excess oil now flows to the other relief valve and unseats it allowing the oil to flow into Port C. This relief system will also work with a high pressure situation in Port C, the only difference being that the functions of the identical double relief valves are reversed.

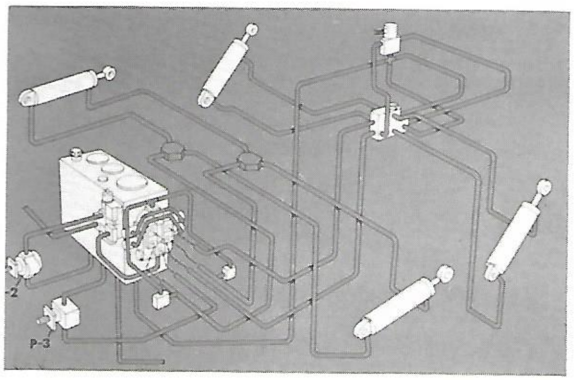


Having completed the discussion of the steering system, we are ready to begin the study of the second of our two areas of concern - the bucket hydraulic system.



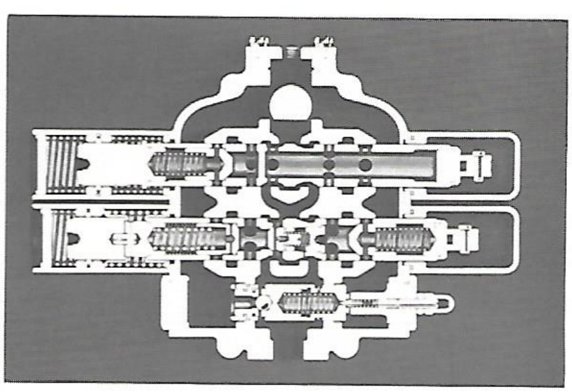
BUCKET HYDRAULIC SYSTEM COMPONENTS

The components comprising the system include:



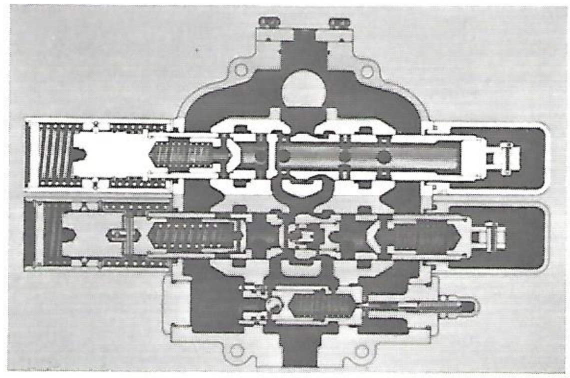
A hydraulic tank, two hydraulic pumps, a control valve, a demand valve, two lift cylinders, two tilt cylinders, a drop valve, a solenoid valve, and two relief valves.

Again, as was in the steering system discussion, we have already discussed many of these components. As a small review, the main hydraulic pump is located on the left half of the engine mounted PTO, the demand pump is located on the right.

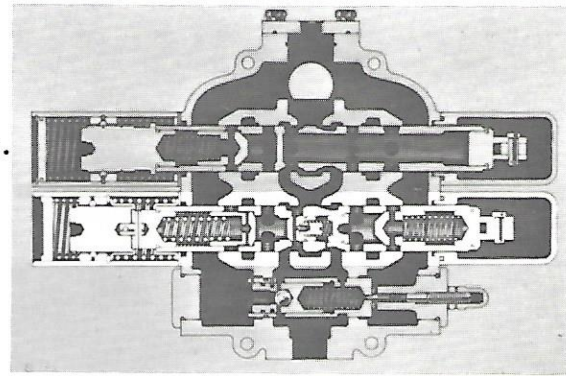


The hydraulic control valve is a two-spool type with a 2500 PSI relief valve. The upper spool controls the raise, hold, lower, and float positions on the bucket arms while the lower spool controls the rollback, hold, and dump positions of the bucket.

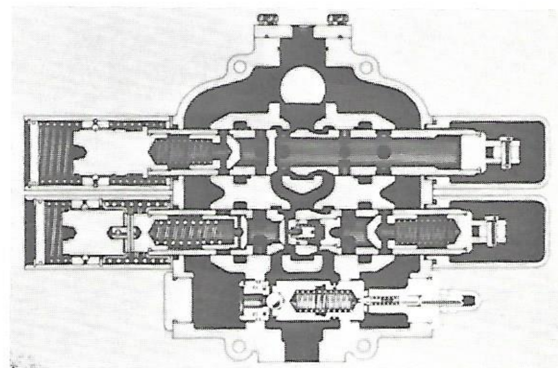
The upper valve spool (which controls the lift cylinders) has detents for all positions. The left end of the spool contains a check valve to hold oil pressure in the base end of the lift cylinders when shifting from hold to raise. Otherwise, the lift arms could drop until sufficient pressure builds up to overcome the load and begin to lift. The port associated with the left half of this spool goes to the base end of the lift cylinders while the port on the right end goes to the rod end.



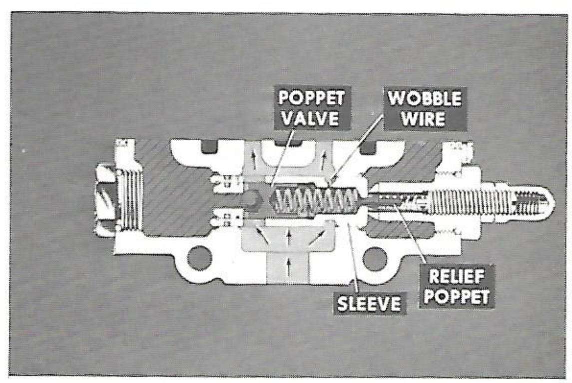
The lower valve spool controls the bucket dumping and rolling back. It has one detent (tilt back) and is self-centering when out of detent. The spool has a check valve in each end to hold pressure in either end when shifting the tilt lever from the "hold" position. The left port goes to the base end of the tilt cylinder and the right port to the rod end. This spool is a regenerative type, which means that the spool uses oil from one end of the cylinder to help the pump fill the other end.

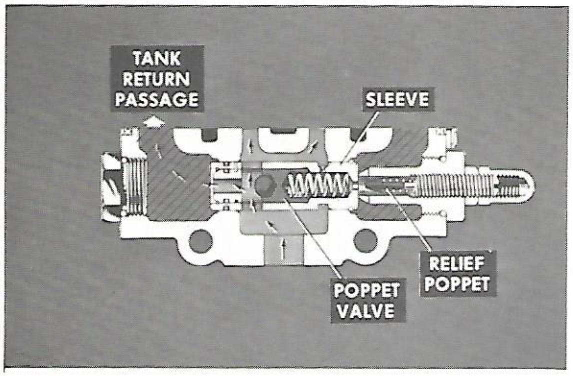


The pilot operated relief valve which controls the bucket hydraulic system pressure is located in the bottom part of the control valve housing.

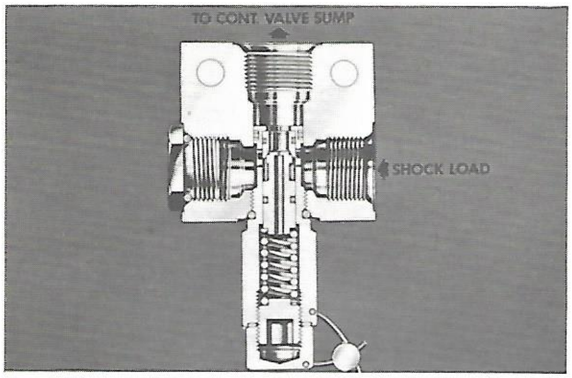


When the pressure of the oil inside the sleeve (which is the same as system pressure) exceeds 2500 PSI, the relief poppet is unseated and it allows some of the oil to return to tank. As in other pilot relief valves we have studied, a low pressure situation is now created.

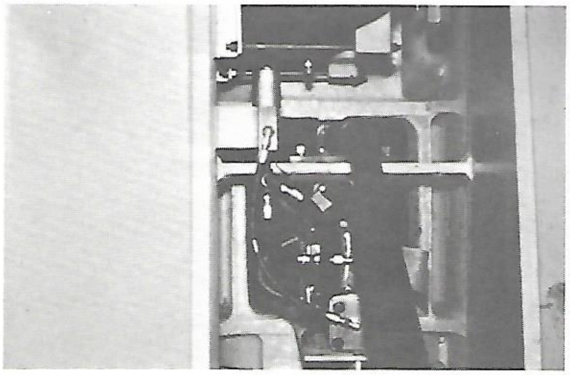




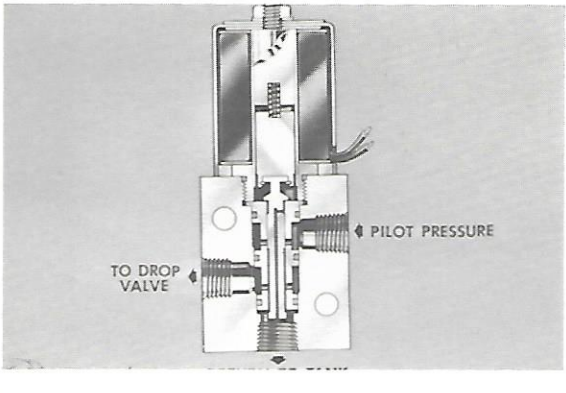
This allows the poppet valve to shift towards the right and draw the ball off its seat. Oil flows out the tank return passage to the extent necessary to receive the high pressure problem.



Two 3500 PSI relief valves are found in the Y tubes leading to the tilt cylinders on the front support structure. When the tilt spool is in a neutral position, the main system relief valve cannot relieve excessive pressure in the tilt cylinders. This pressure can be caused by the bucket position while working on the ground or by a shock load from the front or rear. This shock load enters the side of the valve and forces the piston off its seat. A small amount of oil is now allowed to escape to the tank. This will drop the pressure and the valve will reseat.

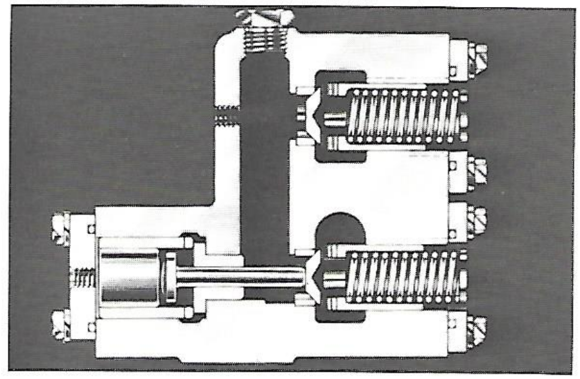


The drop valve and the solenoid valve are built into the lift cylinder circuit to provide a quick drop or "float" feature. The valves themselves are located in the front frame just below the air tank. Their close location to the lift cylinders means less distance for the oil to travel when quick dropping the bucket. The drop valve is actuated by the solenoid valve which is tripped by a switch when the control lever is in the float position.

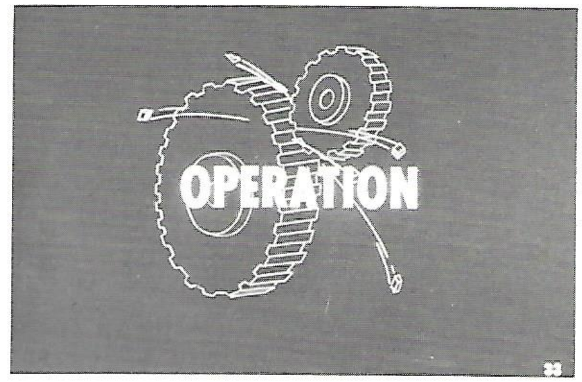


The solenoid valve, when in its normal position, has its inner spool aligned so that the pilot pressure (a small amount of oil tapped from the plumbing of the base end of the lift cylinders), is dead-ended. However, when the valve is shifted, pilot pressure is directed to the drop valve.

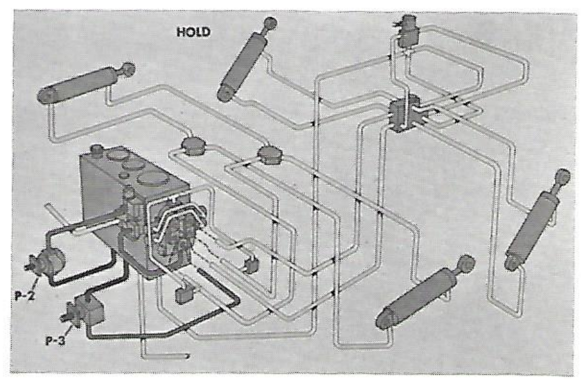
The drop valve is divided into two areas which contain spring loaded poppets. The top area is connected to the rod end of the lift cylinder while the bottom area is connected to the base end. Pilot pressure is monitored from the bottom area and is the same as the pressure in the cylinders themselves. Both areas are also ported to the main control valve. The bottom poppet has a piston and pin positioned against it.



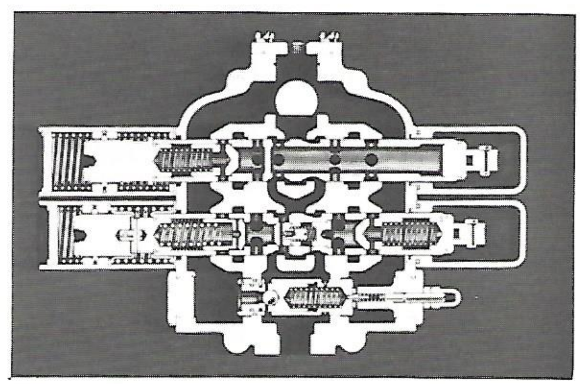
We are now ready to discuss the operation of the bucket hydraulic system.

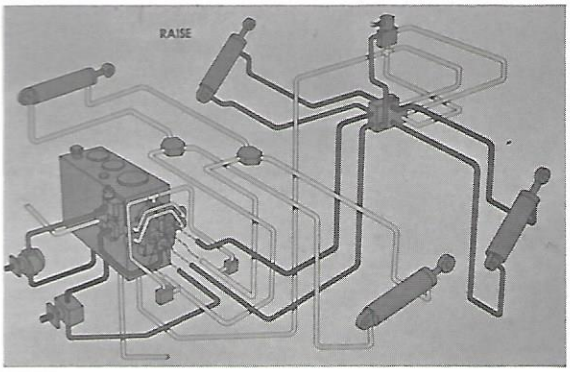


When the bucket control levers are in the "hold" position, oil from the tank is directed by the oil pumps to the hydraulic control valve. The oil passes through the central passage of the valve and out the return-to-tank port. The valve spools block the ports which lead to both ends of the lift and tilt cylinders, thus preventing movement of the bucket and lift arms.

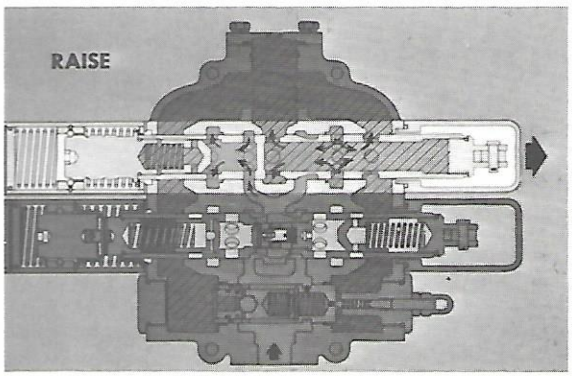


Here we can see how the valve spool blocks the passages leading to the lift and tilt cylinders.

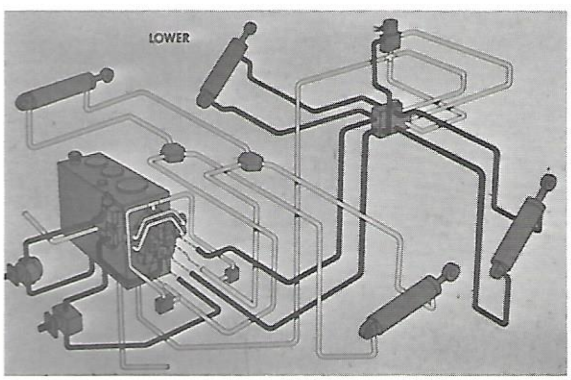




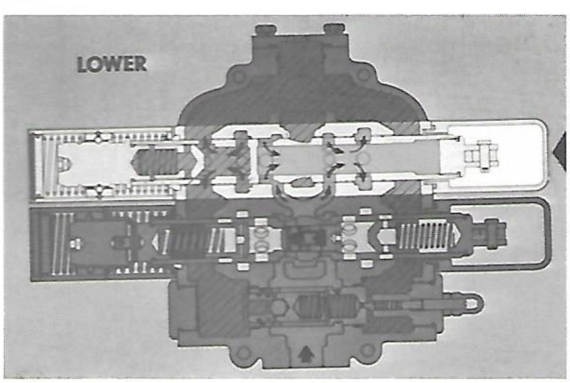
When the bucket arm control lever is pulled back to the "raise" position, oil flow from the pumps passes through the control valves and lines to the drop valve. From the drop valve, the oil goes to the base end of the lift cylinders to extend them. This raises the lift arms since they are pinned to the rod end. Oil from the rod end is sent through the drop valve, and the control valve back to the tank.



This cutaway shows the lift spool pulled into the "raise" position. When the spool is moved to the right, pump oil passes through the central passage of the valve and enters the spool through the ports at the left. The check valve that holds the pressure in the base end is unseated and oil is sent through it to raise the lift arms. Displaced oil from the rod end enters the valve at the port at the upper right, enters the spool and returns to the tank.

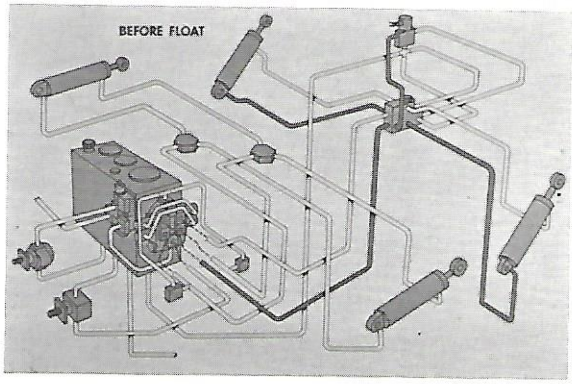


When the bucket arm control lever is pushed forward to the "lower" position, oil from the pumps passes through the control valve and lines to the drop valve. From the drop valve, oil goes to the rod end of the lift cylinders and retracts them. This lowers the lift arms. Oil from the base end of the cylinders is sent through the drop valve to the control valve and back to the tank.

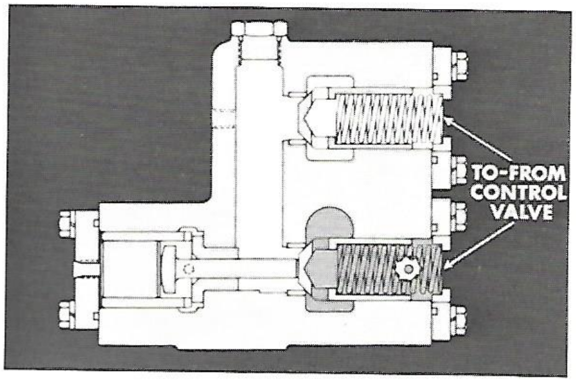


When the lift spool is moved to the left into the "lower" position, pump oil passes through the central passage and enters the ports in the lift spool. The oil then passes through the spool and to the ports leading to the rod end of the lift cylinders. Oil returning from the base ends enters the valve and valve spool at the left, unseats a check valve, and flows from the spool into the return-to-tank passage.

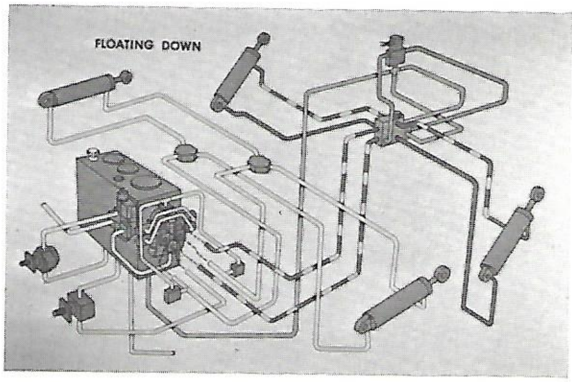
With the bucket and arms raised and in the carry position before shifting into "float", carry pressure is in the lines leading to the bottom port of the drop valve and to the base ends of the lift cylinders (the weight of the bucket and arms pressurizes the oil). Pressure from the bottom port of drop valve is sent to the solenoid valve which is still unshifted.



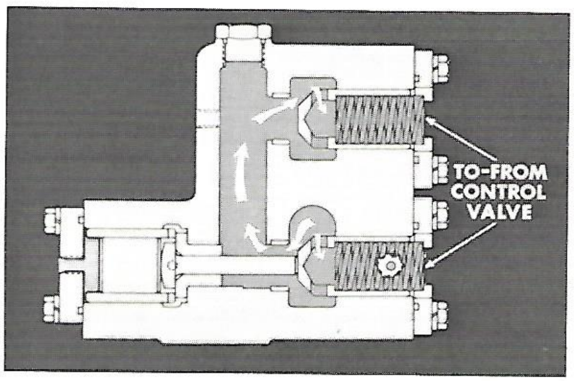
Here we see the drop valve while the bucket and arms are in the carry position. The small hole in the bottom port leads to the solenoid valve.

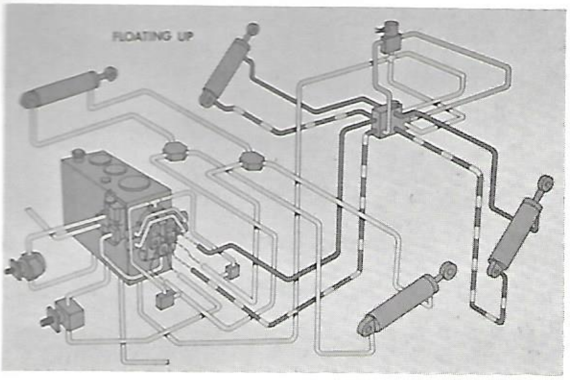


When the bucket arm control lever is pushed all the way forward to the float position, oil flow from the pumps passes through the control valve into the lift valve spool and into the return-to-tank passage. The spool is pushed forward so that the ports leading to both ends of the lift cylinders are open to both the pump oil pressure and the return-to-tank port. Also when the control lever is placed in the float position, a micro-switch is closed by the lever and the solenoid valve is actuated. The solenoid valve shifts and allows pilot pressure from the base end of the cylinders to pass through the drop valve, through the solenoid valve and back to the forward end of the drop valve. This oil now moves the piston and rod which unseats the lower poppet. Now the bulk of oil from the base end is allowed to flow through the drop valve to the rod end of the cylinders to fill the void or go back to the tank.

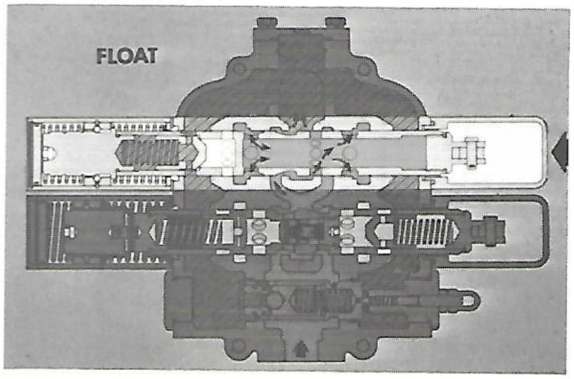


When the solenoid valve is shifted, pilot pressure from the bottom port of the drop valve is allowed to flow through the solenoid valve and back to the left end of the drop valve where it shifts the piston, rod, and bottom poppet. This allows bucket carry oil in the base end of the lift cylinders to shift the upper poppet and pass into the upper port of the drop valve into the rod end of the lift cylinder to fill the void as the bucket drops.

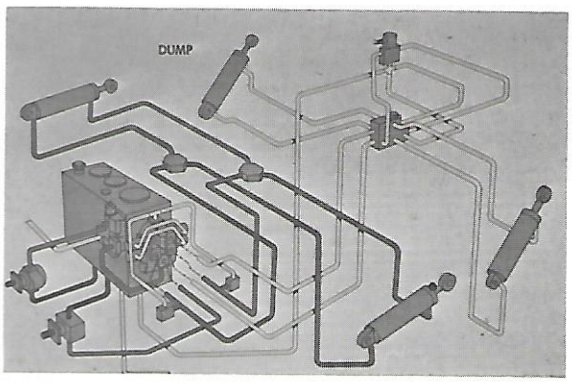




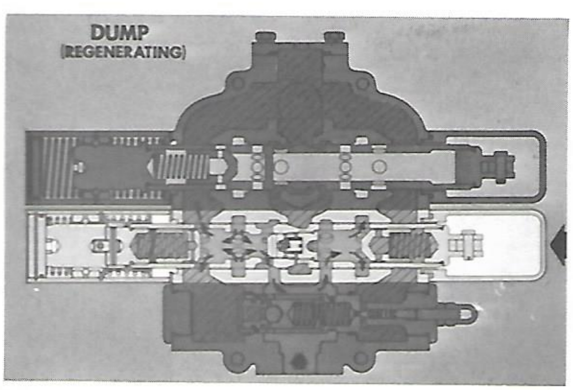
It is possible, with the lift control lever in "float", for the bucket and arms to float upward (as in back dragging). When this happens, oil in the rod end of the cylinders is compressed and returned to the upper port of the drop valve. From the drop valve, oil goes to the control valve. Oil from the control valve flows into the base end of the cylinder to satisfy the need for it. While there is pressure going through the solenoid to the left side of the drop valve, it is not sufficient to move the piston, rod, and poppet in the lower port.



When the lift spool is pushed into float position, the valve passages leading to both ends of the lift cylinders are open to each other, to pump pressure, and to the return-to-tank passage.

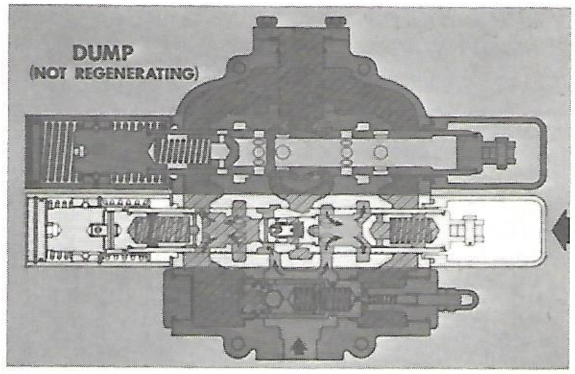


Pushing the bucket tilt control lever forward into the "dump" position allows pump oil to pass through the control valve and lines to the rod end of the tilt cylinders. The tilt cylinders retract and move the bucket forward to dump its load. Oil in the base end of the cylinders returns to the control valve. Oil returns to tank or to the rod end of the cylinders, if pumps cannot supply oil fast enough.

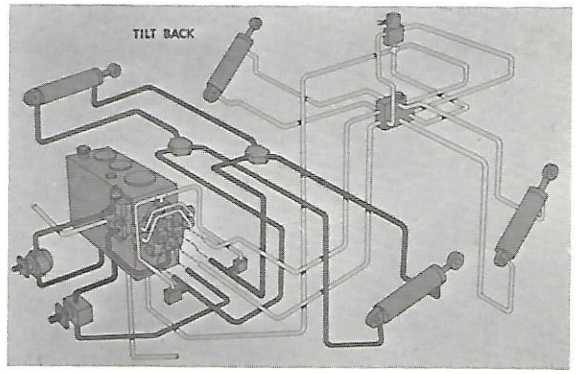


When moving the tilt lever up into the dump position, the control valve spool is moved into the valve body. Oil from the pumps enters the spool area in the right half of the housing, unseats a check valve, and passes out the spool into the right passage leading to the rod end of the tilt cylinder. Oil returning from the base ends enters the spool and unseats a check valve to the left so some oil can return to the tank. Due to the large volume of oil returning, the regenerative check valve is moved off its seat. Then pump oil and returned oil join forces to supply the needs of the rod end.

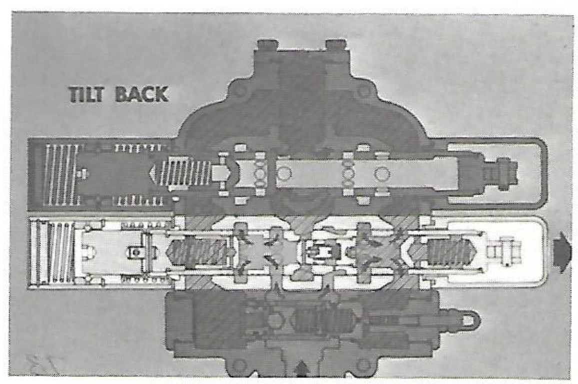
It is possible for the tilt control lever to be in the "dump" position and for the spool not to be regenerating. For example, when digging in a pile, large amounts of pressure are often required in the rod end, but the amount of oil returning from the base end may be very small. For this reason, the regenerative check valve will remain seated and all returning oil will return to the tank. With the check valve seated, pump oil is allowed to enter a cross-drilling, unseat the small poppet, and enter the cavity to the right of the poppet. This pocket build-up of oil helps keep the check valve seated.



When the tilt control lever is pulled back into the "tilt back" position, the oil flow from the pumps passes through the control valve and lines to the base ends of the tilt cylinders. The cylinders extend and the bucket is rolled back. Oil from the rod ends return to the control valve and finally back to the tank.



The tilt spool is moved to the right in the "tilt back" position. Oil from the pumps enters the left half of the spool, unseats the check valve, and passes to the base end of the tilt cylinders. Oil also flows into the cavity behind the regenerating check valve to keep it from opening.



This concludes the explanation of the 72-81 hydraulic system. By using common sense and applying your understanding of hydraulic operation, diagnosis can be carried out in a more efficient manner than is possible without this understanding.

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