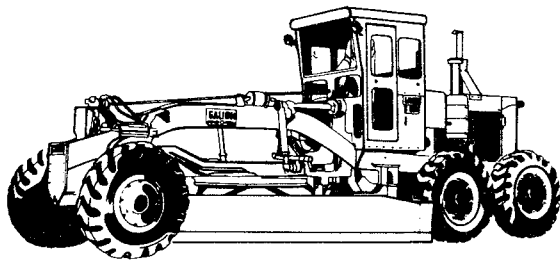
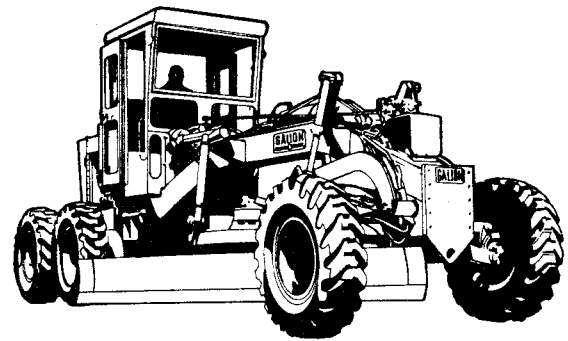
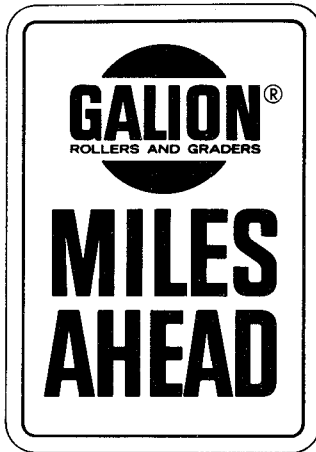
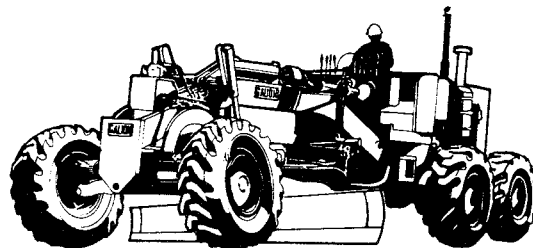


No. 2221



GRADER
HYDRAULIC
SYSTEM



May 1, 1973

The purpose of this booklet is to provide a basic understanding of Galion grader hydraulic systems. Specific function, purpose, and use of each component in our present Galion grader hydraulic systems are discussed in depth. Moreover, certain aspects of past motor grader systems are briefly discussed.


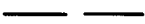


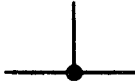


It is hoped that this booklet will provide both service and sales personnel a valuable reference to Galion hydraulic systems in general. It should also be mentioned that this booklet concerns only basic Galion grader hydraulic systems. Please refer to the pertinent Galion Parts Book or Shop Manual section when dealing with particular models of Galion motor graders.


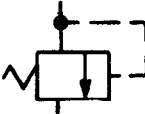
Sales & Service Training Center
Galion Manufacturing Company


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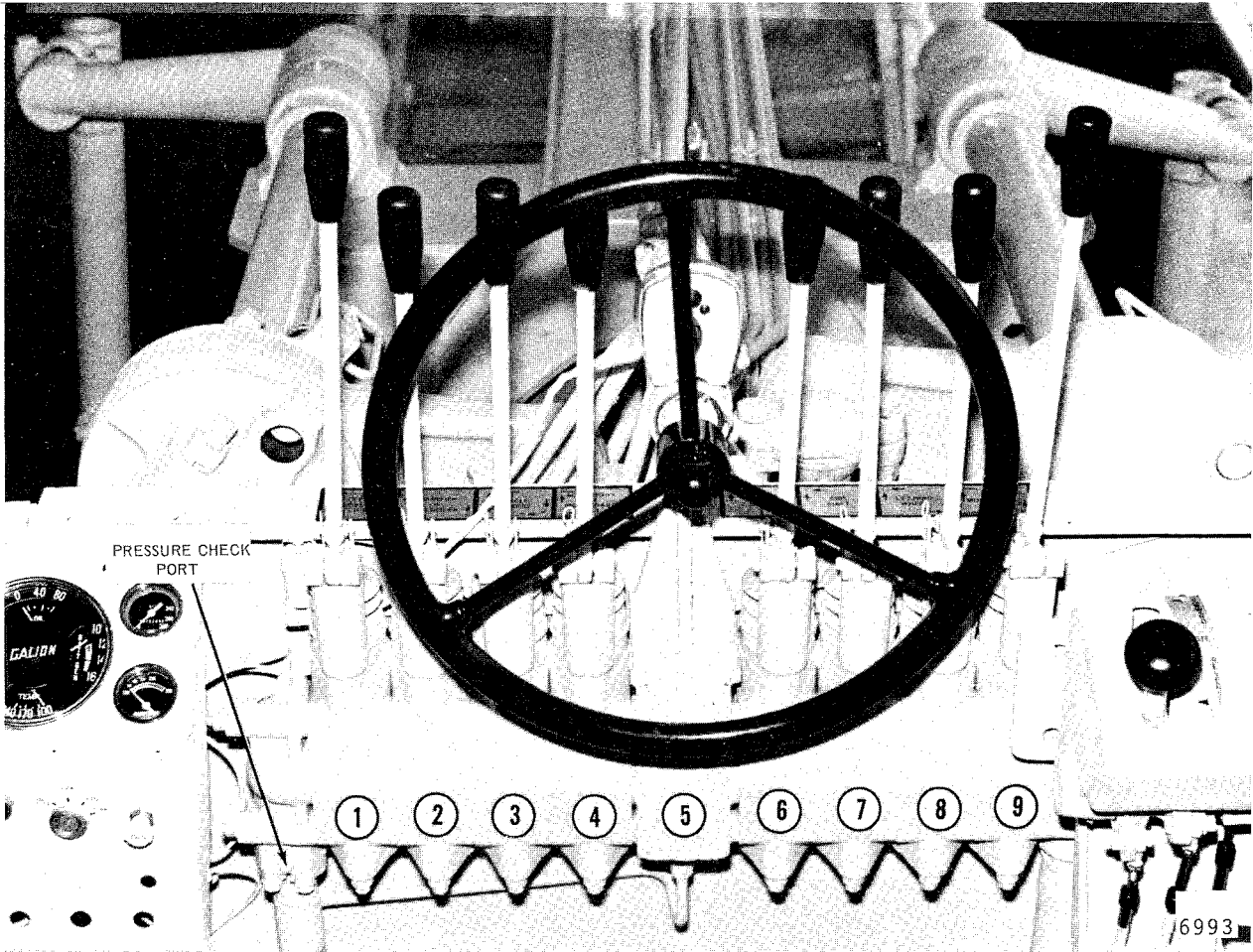
STANDARD GRAPHICAL SYMBOLS

LINES AND LINE FUNCTIONS	
LINE, WORKING	
LINE, PILOT ($L > 20W$)	
LINE, DRAIN ($L < 5W$)	
LINE, FLEXIBLE	
LINE, JOINING	
LINE, PASSING	
PLUG OR PLUGGED CONNECTION	

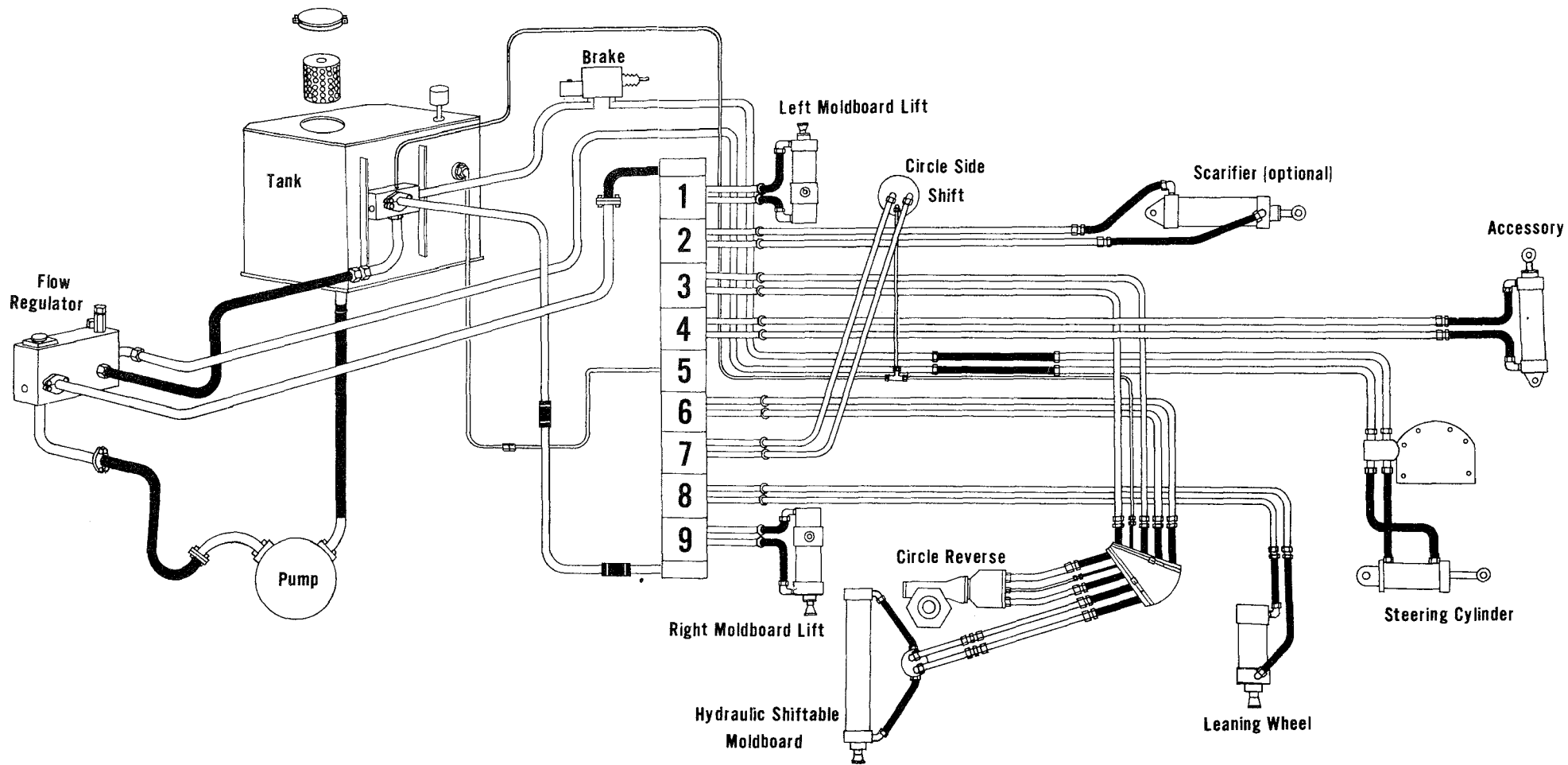
VALVES AND BASIC SYMBOLS	
VALVE, FLOW DIVIDER WITH BY-PASS	
VALVE, MAXIMUM PRESSURE (RELIEF)	

MOTORS AND CYLINDERS	
CYLINDER, DOUBLE ACTING SINGLE END ROD	

MANIFOLD CONTROLS



1. Left moldboard lift
 - a) Push - left side of moldboard down.
 - b) Pull - left side of moldboard up.
2. Scarifier or bulldozer (optional)
 - a) Push - scarifier or bulldozer down.
 - b) Pull - scarifier or bulldozer up.
3. Circle reverse
 - a) Push - circle rotation counter clockwise
 - b) Pull - circle rotation clockwise
4. Moldboard power tilt or accessory (optional)
 - a) Push - down
 - b) Pull - up
5. Steering wheel support block.
6. Hydraulic shiftable moldboard
 - a) Push - moldboard shift left.
 - b) Pull - moldboard shift right
7. Circle side shift (can be hydraulic/mechanical or full hydraulic)
 - a) Push - circle side shift left
 - b) Pull - circle side shift right
8. Leaning wheel
 - a) Push - leaning wheel left
 - b) Pull - leaning wheel right
9. Right moldboard lift
 - a) Push - right side of moldboard down.
 - b) Pull - right side of moldboard up.
10. Optional accessories would be added to the right end of the manifold. Up to 3 more controls could be added.



HYDRAULIC SYSTEM

GRADER MANIFOLD AND STEERING CIRCUIT

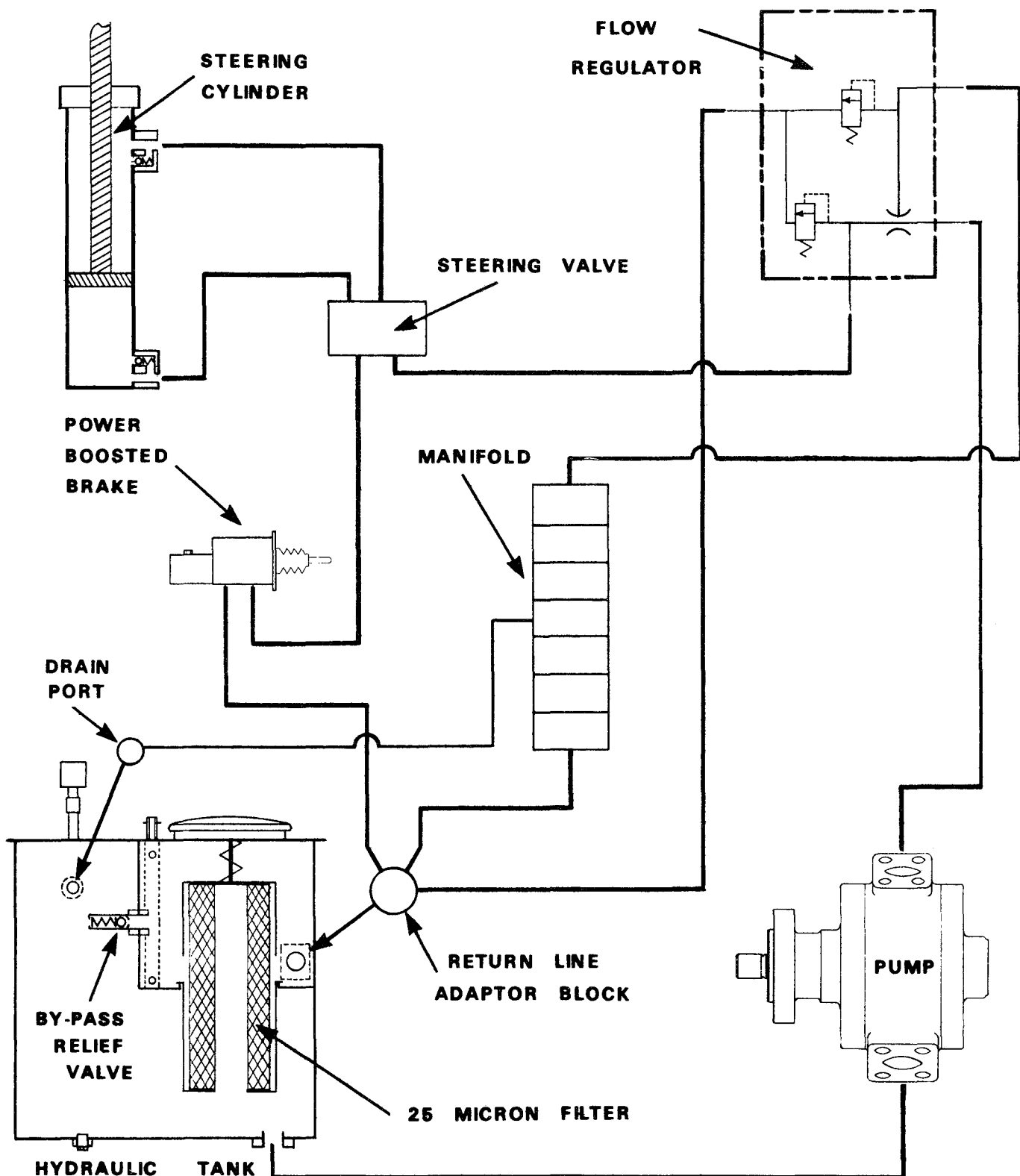


Fig. 1

CURRENT GALION GRADER HYDRAULIC SYSTEM

Filtered oil from the hydraulic tank is provided to the inlet side of a 30-40 gpm positive displacement pump. As the engine turns, a corresponding displacement of fluid exits from the pump. This flow is directed to a flow regulator, where a priority flow of 8 gpm (5.5 gpm on the 503-L) is diverted to the steering circuit. This provides maximum efficiency at all times to hydraulic steering and power boosted brakes. From the steering circuit this 8 gpm priority flow returns to the tank. (See Figure 1)

The excess flow from the flow regulator (above 8 gpm) is directed to the left side of the hydraulic manifold. Through a series flow system, fluid becomes available for use by all valves in the manifold. If all manifold controls are in neutral position, fluid passes through the manifold and back to the tank. Fluid in the tank is then ready to be recirculated through the system again.

If any one or more controls in the hydraulic manifold are operated, then succeeding controls down stream function with exhausting fluid from double-acting cylinders upstream. This allows any number or combination of controls to be operated at one time.

Both hydraulic circuits, steering and manifold, are each protected from overload pressures by relief valves pre-set at the factory. These valves prevent each system from damage in the event of, for example, extending a cylinder to its limit. These valves automatically re-set themselves when an overload condition ends, and the hydraulic system will again operate normally.

HYDRAULIC TANK & FILTER

The hydraulic tank on Galion graders provides two purposes. It provides a means of storing fluid for use by the pump, and a means of filtering the fluid prior to its recirculating through the system. The hydraulic tank capacity is approximately 14 gallons at operating level.

The flow of the fluid through the tank occurs at a very rapid rate when the hydraulic pump is at full output. Return oil lines from both manifold and steering circuits meet at the return line adaptor block mounted directly to the hydraulic tank. (Circle reverse and mechanical side shift hydraulic motor case drain leakage line(s) would also join with steering and manifold return oil at this adaptor block.) From the adaptor block oil passes through port (A) and into compartment (B) of the hydraulic tank. (See Figure 2)

The oil entering compartment (B) will completely fill this chamber. At this time enough pressure exists (very slight) to cause a flow of oil through the 25 micron filter (C). Once this oil passes through the filter, it will flow into compartment (D).

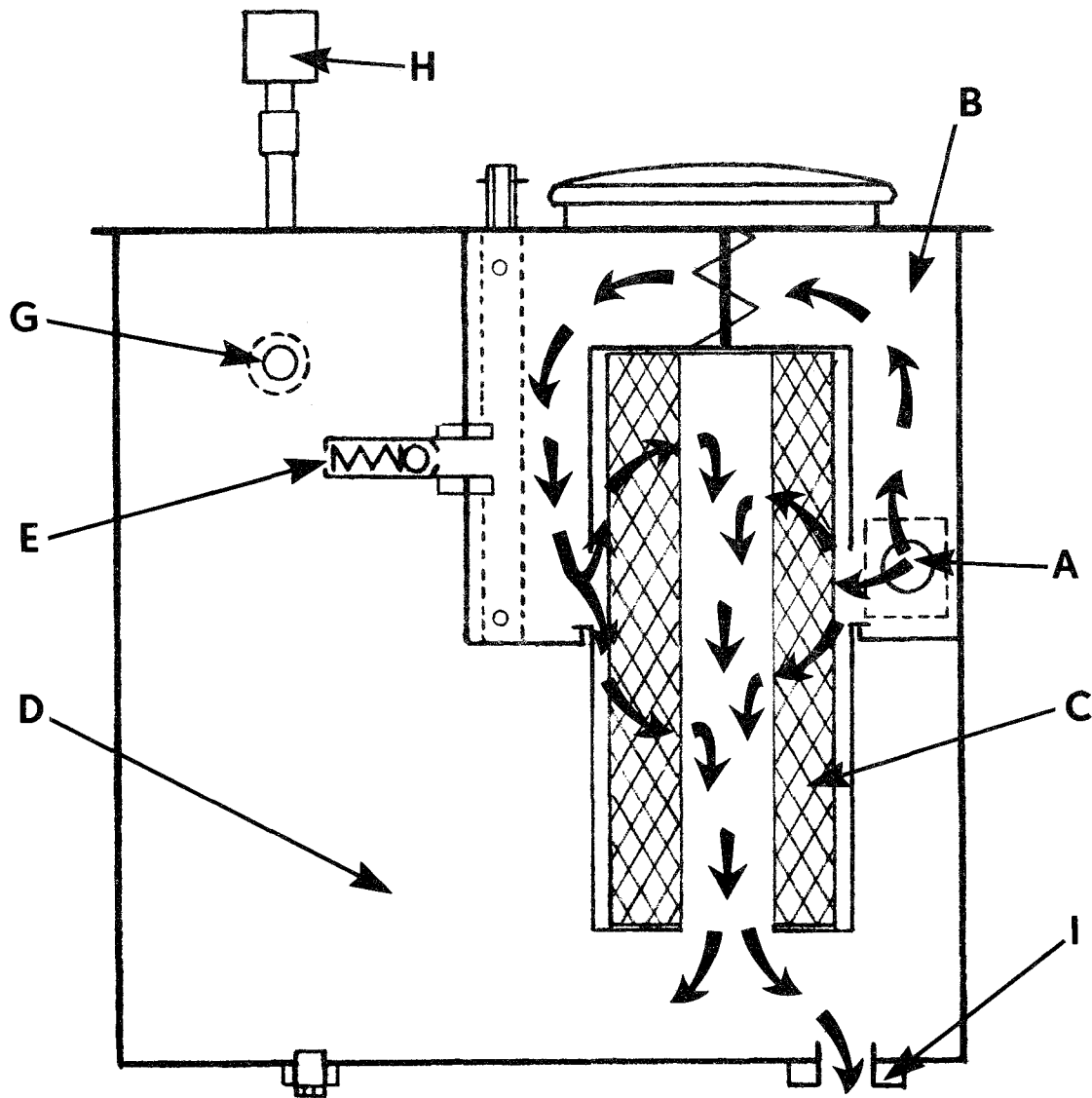


Fig. 2

If in the event the oil is very cold and too thick for easy flow through the filter, or, should the filter element be so dirty that the oil cannot pass through at the required rate, then the differential by-pass valve (E) will open. This valve opens at approximately 15 psi to provide a by-pass for the fluid around the filter from compartment (B) to compartment (D). When the by-pass valve is opened, some fluid is not being filtered. However, the pump will always have a sufficient supply of oil and therefore eliminate the possibility of cavitation (being starved for oil).

When there is a passage of oil through the by-pass valve, a very loud "hammering" sound will come from inside the tank. This sound is the ball raising and lowering off its seat to allow the passage of oil through this valve.

There are two cases when this "hammering" sound may be heard:

- 1) During initial start-up on a cold morning this valve will open and close to allow oil to by-pass the filter. When cool, oil is thicker than it should be for normal operation. In this case the thick (cold) oil will travel the path of least resistance and flow through the by-pass valve rather than the filter. As the oil warms to operating temperature and thins, the "hammering" sound from the by-pass valve will cease and the oil will flow freely through the filter element.
- 2) When the filter becomes so dirty that the required amount of oil cannot pass through it, the by-pass valve will open and close. In this case the "hammering" sound will continue after the oil is at operating temperature. The recommended procedure for draining the tank and replacing the filter should be followed when this condition occurs.
(See page 10)

A small amount of oil also enters compartment (D) from the drain port (G). Controlled lubrication leakage from the hydraulic manifold enters the tank at this point. This oil will not be filtered and will join in compartment (D) the other previously filtered flow of oil. The manifold drain is ported to the lower compartment of the tank to prevent any back-pressure to the manifold and control boots. This allows for a simple gravity drain.

Compartment (D) contains a breather (H) to allow atmospheric pressure to be equalized within this compartment. Atmospheric pressure of 14.7 psi will then be applied to the top level of the oil in compartment (D). The difference in the pressure above the oil and the very low pressure at the inlet side of the pump will cause a flow from compartment (D) to the inlet side of the pump. Oil will exit compartment (D) by way of the port marked (I), flow to the pump, and be recirculated throughout the system again.

DIPSTICK

A dipstick is provided in each grader hydraulic tank (optional 503-L) for checking the hydraulic fluid level. The proper procedure for checking the oil level is as follows:

Check oil level at 100° minimum with moldboard centered, wheels straight, lift and scarifier cylinders retracted. Shut engine down, remove dipstick, and wait 15 seconds minimum. Insert dipstick again and screw in. Remove dipstick again. Oil level should be between HI and LO marks on dipstick.

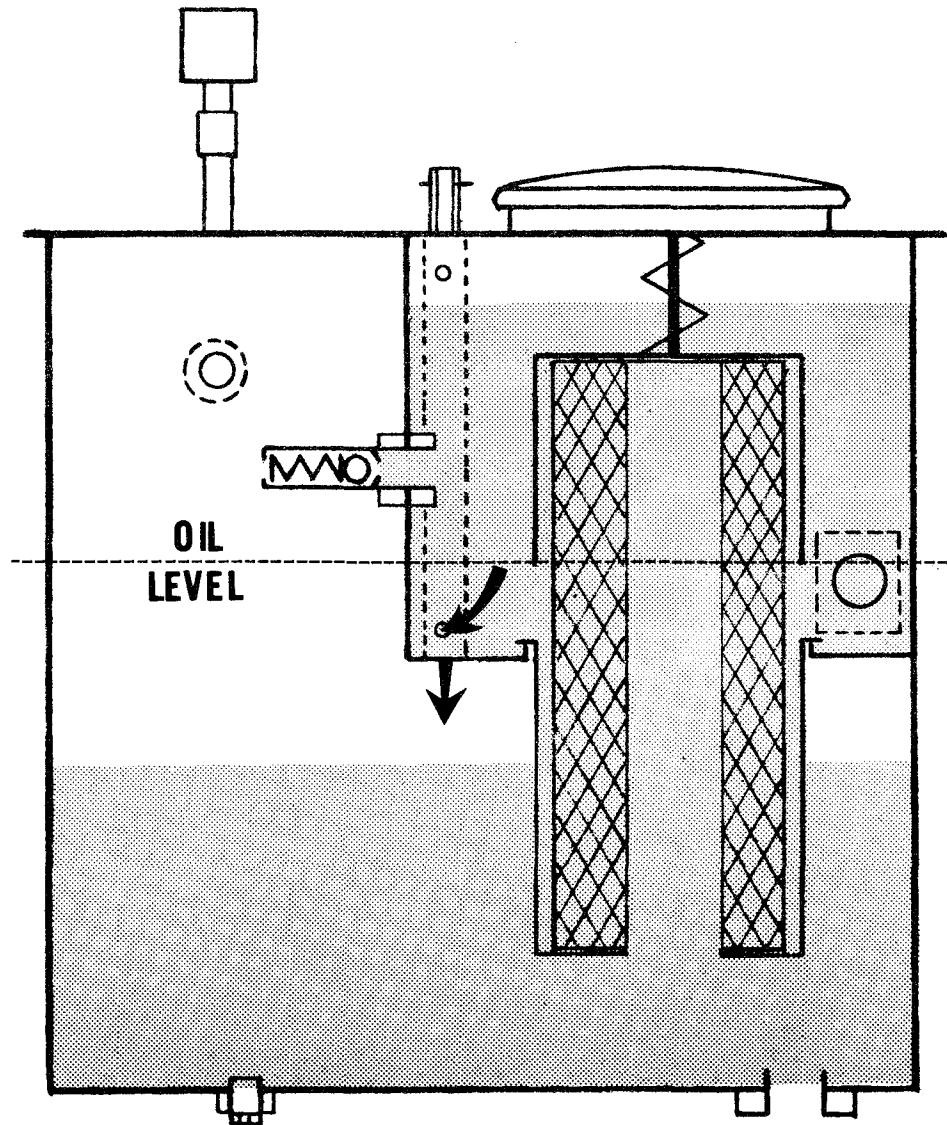


Fig. 3

Removing the dipstick for 15 seconds when the engine is shut down, allows sufficient time to equalize the level of fluid in both compartments of the tank. The dipstick is located in a standpipe in the upper compartment. (See Figure 3). At the bottom of this standpipe is a port to allow oil from the upper compartment (B) to drain into the lower compartment (D).

There are also two holes at the top and bottom of this standpipe. The top holes allow air to enter the upper compartment from the dipstick hole and standpipe. The lower holes allow the oil in the upper compartment to drain into the lower compartment by way of the port at the bottom of the standpipe.

When the dipstick is installed in the tank and screwed in, an "0" ring at the tip of the dipstick prevents oil from exiting the upper compartment through the port in the bottom of the standpipe. Also one should be certain that the dipstick is securely screwed in prior to re-starting the engine. Failure to do so will cause oil to escape from the dipstick hole at the top of the tank.

FILTER

The filter in the grader hydraulic tank is of the replaceable type. The filter is to be replaced at the end of 100 hours of operation on a new machine, or one one which has had the hydraulic system repaired. The filter element should be replaced each 1000 hours of operation thereafter. To service the filter the following steps should be followed (Refer to Figure 4):

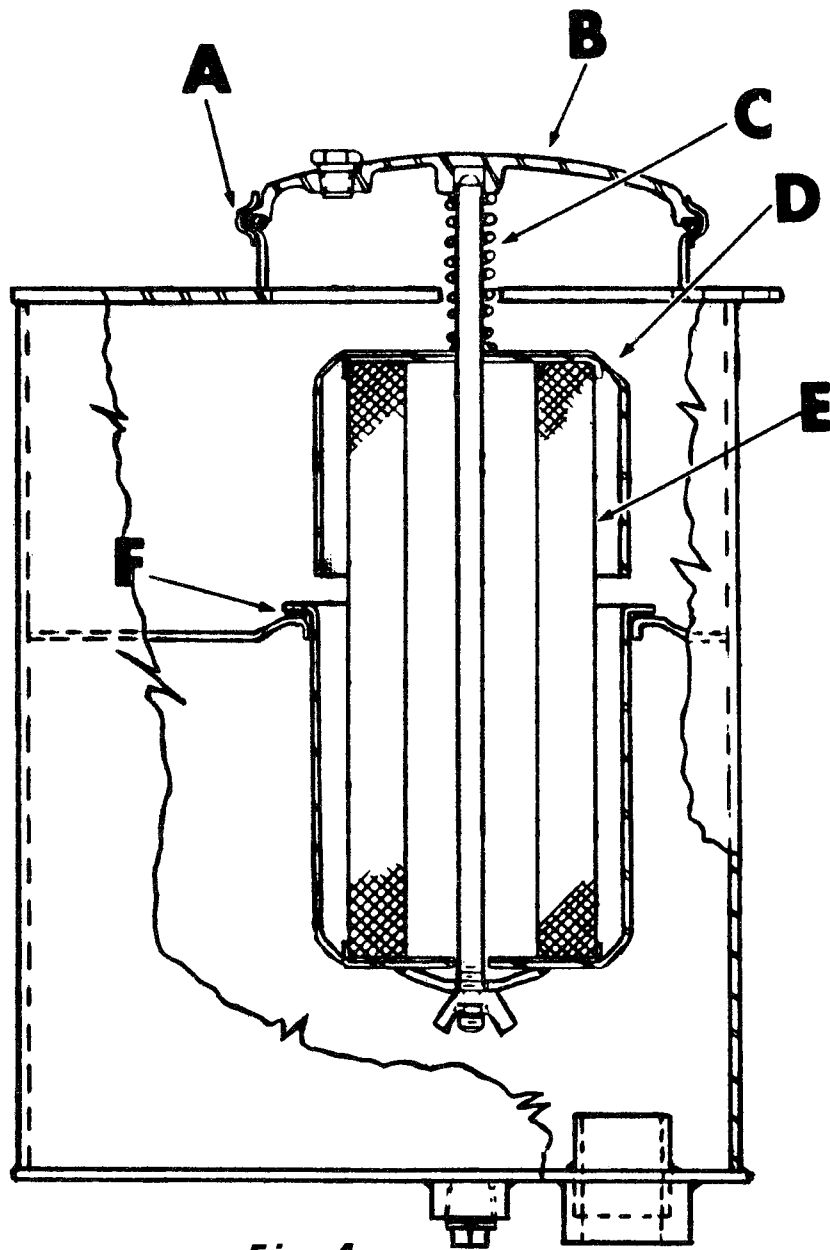


Fig. 4

- 1) Shut down engine
- 2) Remove dipstick to equalize air pressure within compartments of the tank.
- 3) Remove drain plug and drain tank (both compartments) of approximately 14 gallons oil. Properly dispose of oil - do not reuse.
- 4) Loosen bolts on clamping ring "A" and remove cover "B".
- 5) Lift filter assembly from tank; filter assembly includes filter, two container halves, and spring.
- 6) Remove wing nut (self-locking) from shaft hold assembly halves together.
- 7) Remove filter from two assembly halves.
- 8) Filter should be inspected for excessive foreign material which could indicate additional hydraulic system maintenance. Inspect filter by cutting off paper cover and checking trapped material in paper pleats.
- 9) Thoroughly clean all components of filter assembly. Clean both compartments of tank interior.
- 10) Reassemble two halves of filter assembly with new Galion filter. Be certain not to crush filter during assembly by over tightening wing nut.
- 11) Install filter assembly in tank making certain that gasket "F" is installed correctly between upper compartment ledge and bottom halve of filter assembly.
- 12) Install drain plug in bottom of tank.
- 13) Fill tank with recommended oil. When adding oil, allow time for oil to pass through filter. Continue to add until level is correctly indicated on dipstick. Capacity of tank approximately 14 gallons.
- 14) Install filter cover spring "C" and cover "B" making certain that stem of filter assembly pockets into cover properly. Inspect gasket on cover "B" for damage prior to installation. Be certain gasket is properly seated during installation.
- 15) Secure clamping ring "A" over cover "B".
- 16) Re-check oil level when motor grader at operating temperature.

It is extremely important when servicing tank or filter that dirt be kept out of the system. Dirt in any hydraulics system can cause premature component failure.

HYDRAULIC TANK BREATHER

A breather is employed on the hydraulic tank to allow atmospheric pressure to enter the lower compartment. This breather contains an element which can be of either cloth or paper construction. Both types effectively filter the air entering the tank, but there are specific maintenance procedures for each.

The cloth type element should be checked every 50 hours. If dirty, this type of filter can be cleaned in diesel fuel. This element can be cleaned repeatedly as long as there is no deterioration of the element. Replace this filter every 500 hours, or sooner if necessary.

The paper type element should be checked every 50 hours also. This element must be discarded and replaced as conditions require. This element cannot be cleaned.

HYDRAULIC SYSTEM LUBRICANT

Present Galion graders use either automatic transmission fluid, ATF, type A, suffix A identification, or "DEXRON". Both lubricants are approved for use in Galion graders. Both Type A, ATF and Dexron are completely compatible. Type A, ATF can be "topped" or added to with Dexron, and, Dexron can be "topped" with Type A, ATF. Both Dexron and Type A, ATF can be mixed in any amount and still be compatible.

Hydraulic oil meeting Military Specifications MIL - L - 17672A, Grader 2110th, can also be used in Galion motor graders. It should be noted that hydraulic oil used should always be from a reputable supplier and should always be a premium grade. The following is an example of reputable suppliers:

Rando Oil HDA
Tellus 927
Duro Oil 160
Nuto 43 or Nuto H44
Sunvis 2110th
D.T.E. 13

Texaco, Inc.
Shell Oil Co.
Sinclair Refining Co.
Humble Oil & Refining Co.
Sun Oil Co.
Mobil Oil Co.

In the event that a grader hydraulic system contains hydraulic oil, Dexron or Type A, ATF, can be added to the hydraulic oil. However, *NEVER ADD HYDRAULIC OIL TO A SYSTEM CONTAINING DEXRON OR TYPE A, ATF.*

For further specific information concerning lubricants, consult the machine's particular operator's manual.

HYDRAULIC PUMP

There are basically two different types of pumps employed with Galion graders. Galion graders with an oil clutch use a hydraulic pump in tandem. This type of pump consists of a spur gear section for the manifold and steering hydraulic controls, and, a gerotor section for clutch cooling, transmission lubrication, and transmission stop brake activation. Although this pump is in tandem, each section operates a completely separate system. This tandem pump is indirectly geared to the engine by a shaft connected to the flywheel. This means that as the engine turns each revolution, the hydraulic pump at the front of the transmission will displace a set amount of fluid. One can imagine this pump as actually being directly coupled to the engine flywheel.

Galion graders with a power shift transmission and torque converter use a pump with only one section. This one section pump is a spur gear type and is basically the same as the spur gear section of the tandem pump previously discussed. Figure 5 shows a pump employed on a power shift model motor grader. This pump is attached to the torque converter on these models. It is, by indirect means, connected to the engine. This means that as the engine turns, the pump will correspondingly turn.

Another pump, called the torque converter charging pump, is also connected to the torque converter. This pump is completely separate from the hydraulic pump mentioned above. The charging pump operates only the converter/transmission system.

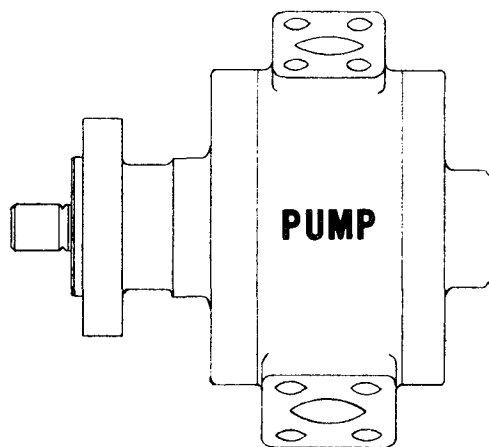


Fig. 5

FUNCTION OF THE HYDRAULIC PUMP

A pump produces a flow of oil. This flow of oil will then accomplish the various hydraulic functions throughout the system. In Figure 6 we have a diagram showing the cross section of a spur gear type pump such as that used on all Galion graders.

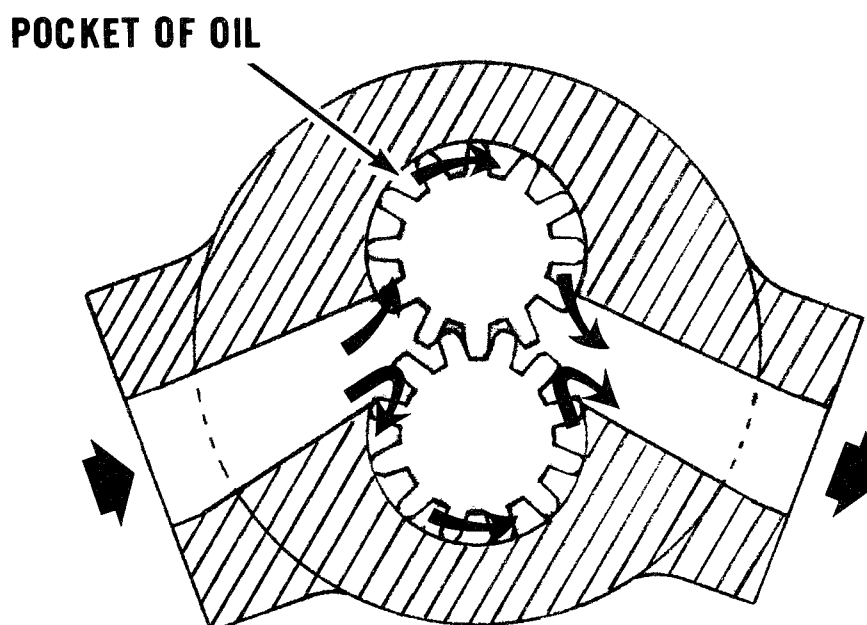


Fig. 6

This type of pump consists of two gears meshing within a housing. There is a very fine tolerance between the gears themselves and the housing around them. This means that between each gear tooth and the housing there is a sealed "pocket" where oil or fluid can be trapped. As the gears in this pump revolve and mesh, due to the engine driving the pump, oil is displaced from the left side (inlet side) to the right (exhaust side). Each pocket, between gear teeth and housing, carries a fixed amount of fluid from inlet side to exhaust side. Notice that as the fluid is displaced, a void is left at the inlet side of the pump. This void tends to create a vacuum. This then allows air pressure within the tank to force fluid from the tank to the inlet side of the pump. The gear teeth then cause displacement within the pump.

The displacement rating of this type of pump in gallons per minute or gpm, is determined by the amount of fluid each pocket can contain and how fast this amount of fluid is carried from one side of the pump to the other. In this case, if the pump was turned at a faster rpm, then a larger amount of fluid would be carried or displaced from inlet to exhaust side. Also, if both gears in this pump were wider in size, then each "pocket" would hold more fluid. And, as the pump's gears revolved, more fluid would be displaced from inlet to exhaust side. This is the basic way in which pump displacement is increased (or conversely decreased) from one size pump to another. The difference in flow rating in gpm between two spur gear pumps driven at the same rpm, is usually determined by the width of the gears in each. For example, most Galion cranes employ a tandem pump for their hydraulic systems. This pump contains two spur gear pump sections, one with a displacement of 30 gpm at high idle and the other with a displacement of 50 gpm. The only difference between each pump section is the larger width of gears in the 50 gpm section. Thus a larger displacement spur gear pump will have wider gears.

TOLERANCE OF THE PUMP

The life of the hydraulic pump in Galion graders is directly related to how clean the entire hydraulic system is kept. The close tolerances within the pump enable maximum efficiency rated in gpm output. As the tolerance between gear teeth and housing increases, pump output decreases. In general, the most common reason for pump failure is dirt or foreign material entering the hydraulic system. This dirt scores the housing of the pump and the gear teeth thus disabling proper displacement of fluid to occur within the pump. For this reason, it is imperative to keep a hydraulic system free from dirt or foreign material.

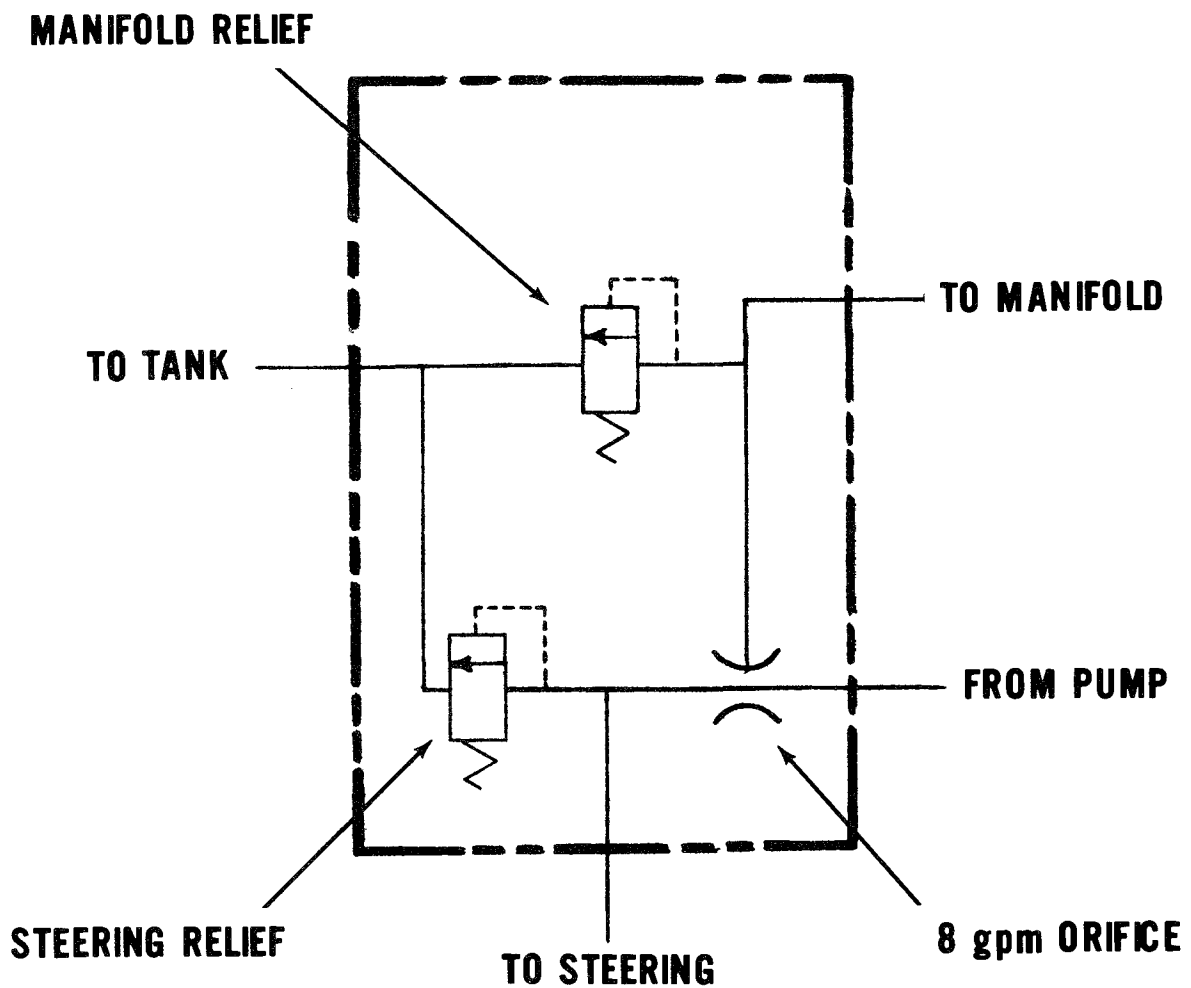
It should also be remembered that a hydraulic pump is a precision instrument. Care should be taken when handling or installing a pump that damage does not occur. Also pumps should always be protected from rust when storing. Always thoroughly lubricate interior components prior to prolonged storage.

FLOW REGULATOR

Current grader flow regulators are mounted on a frame cross-member behind the operator's compartment. Some past motor graders have had the flow regulator mounted on the hydraulic tank and various other locations. The flow regulator assembly consists of the following:

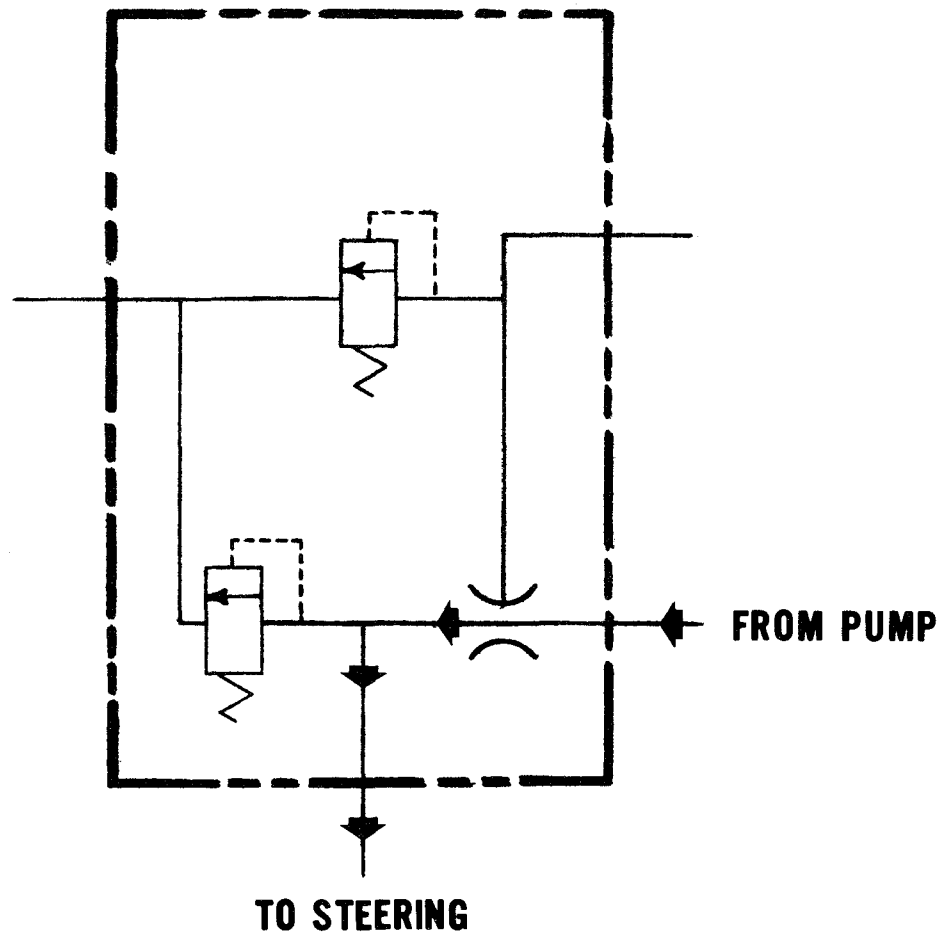
- 1) A by-pass type flow regulator (honed assembly).
- 2) A steering relief valve .
- 3) A by-pass circuit relief valve (manifold relief valve).
- 4) A housing for the above components.

The function of the flow regulator is to maintain a constant flow of oil to the regulated steering circuit. Excess flow is by-passed and made available for use at the manifold.

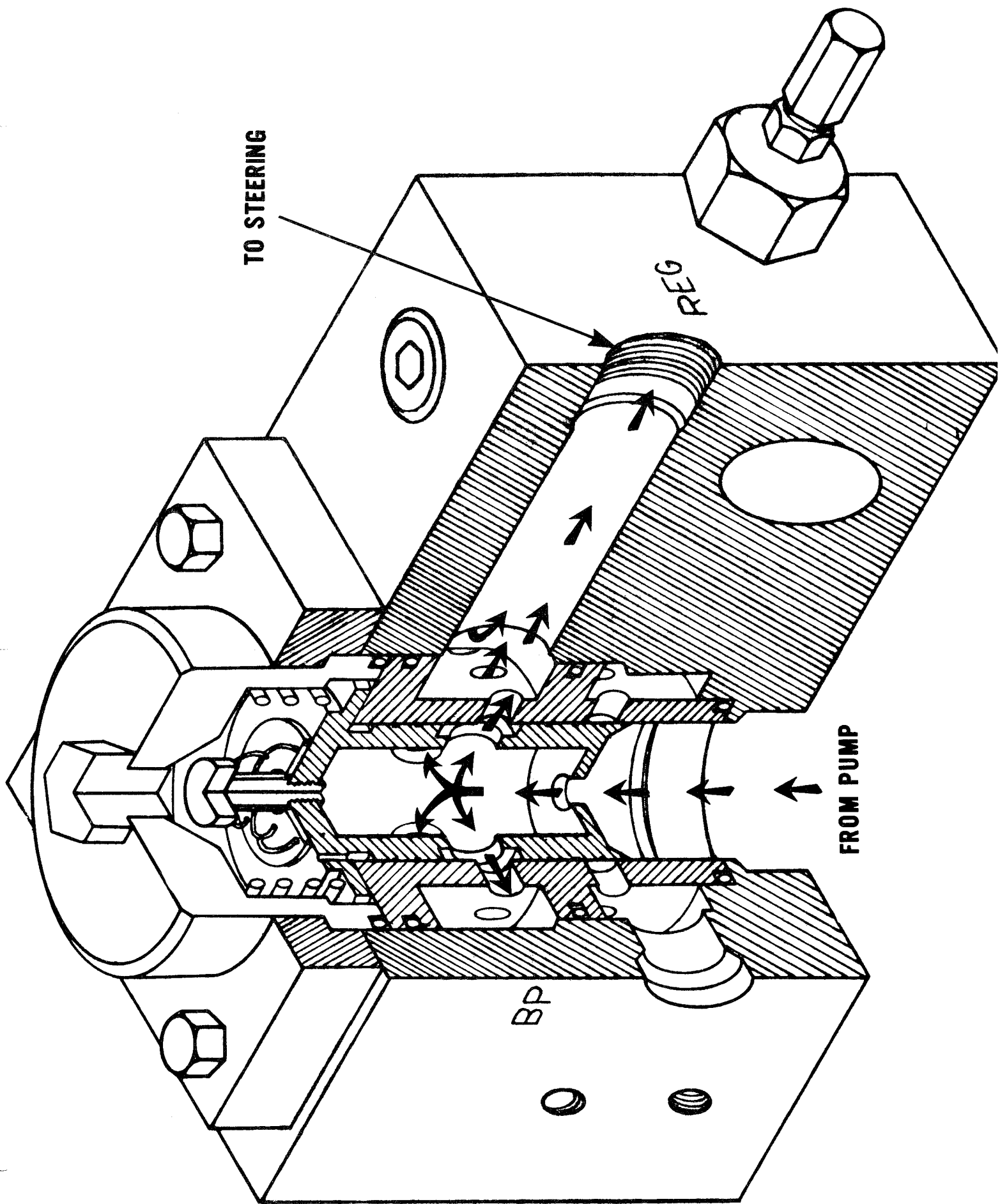


The flow regulator assembly has four different flow conditions:

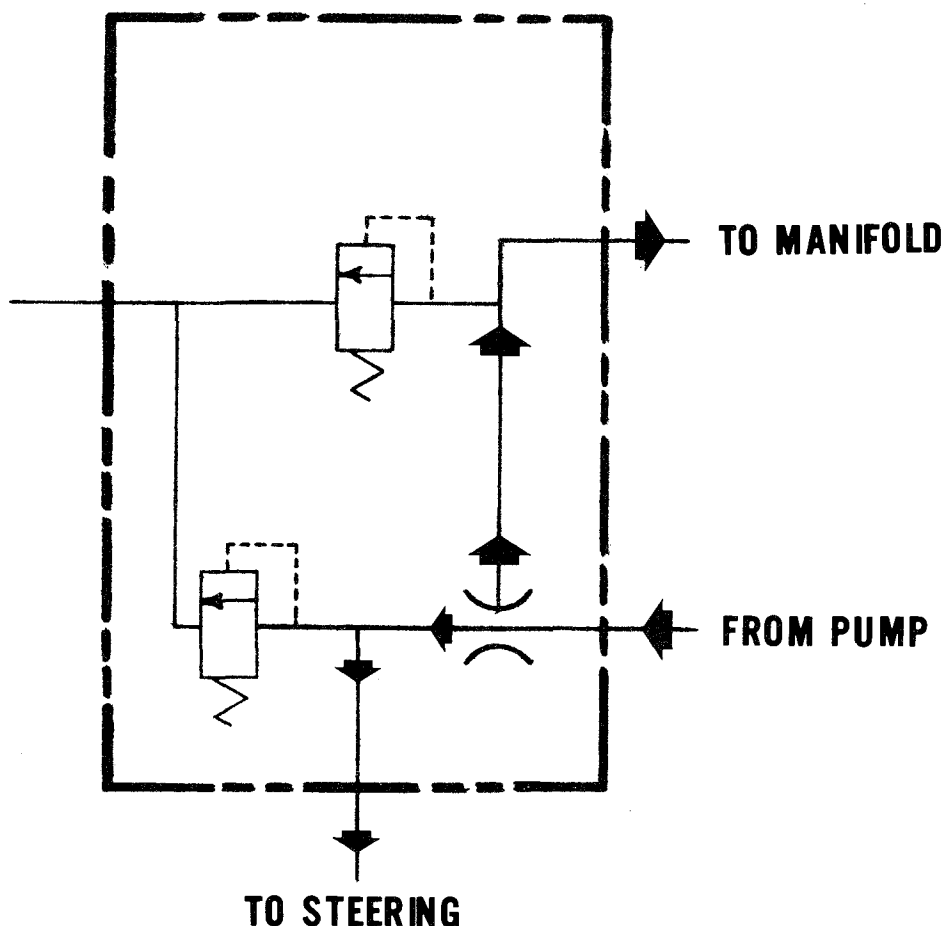
1. PUMP OUTPUT 8 gpm OR LESS



When the pump output is 8 gpm or less, flow from the pump goes to the flow regulator, passes through the 8 gpm orifice and goes to the steering valve. This 8 gpm or less flow will circulate through the steering and power boosted brake circuit and return to the tank. This condition will happen only with a badly worn pump and extremely low engine idle speed setting. Under this condition you will have steering but no manifold controls functioning. The following cross-section drawing shows exactly what configuration the 8 gpm orifice of the honed assembly is in for the above condition:



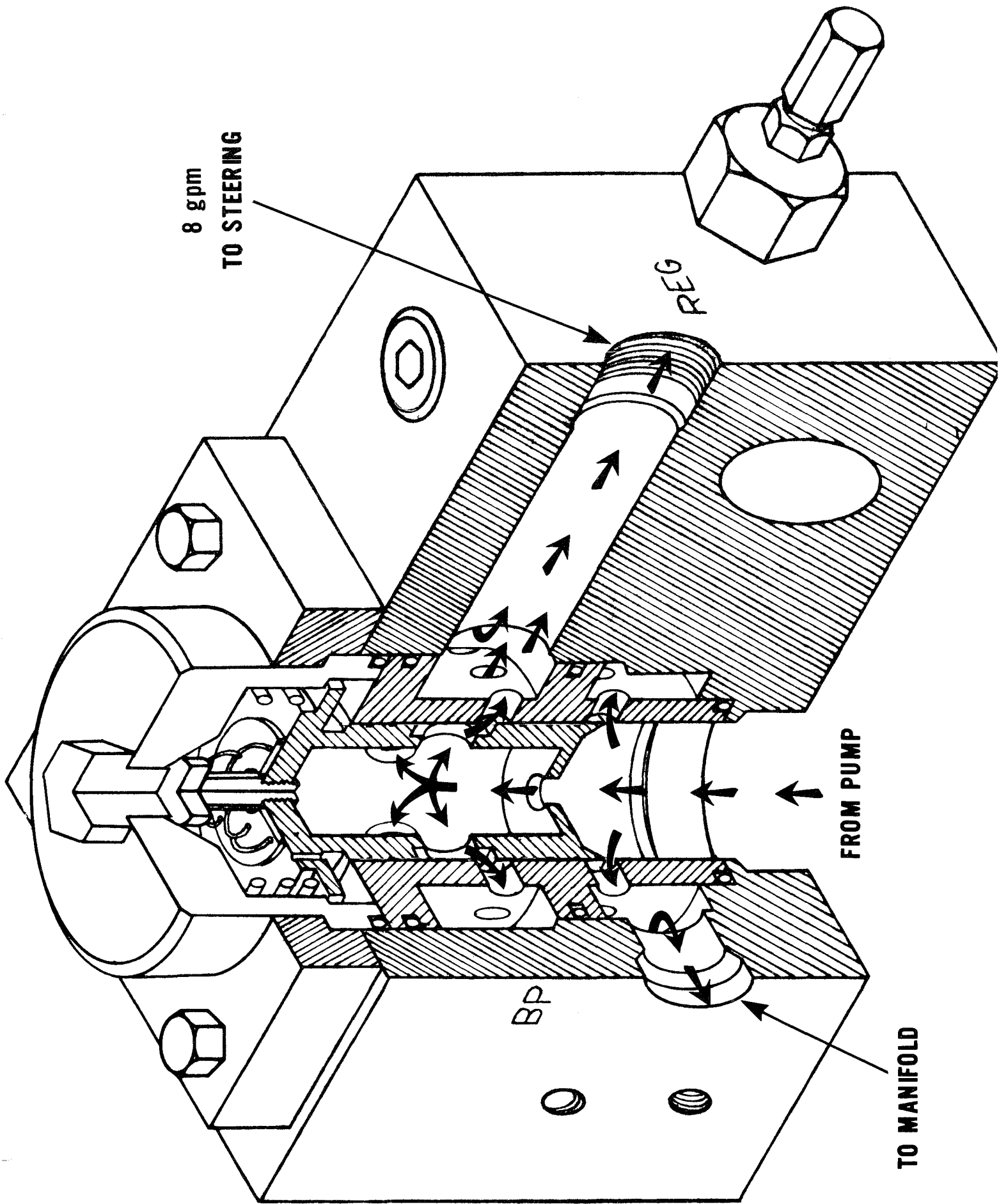
2. PUMP OUTPUT 8 gpm OR MORE



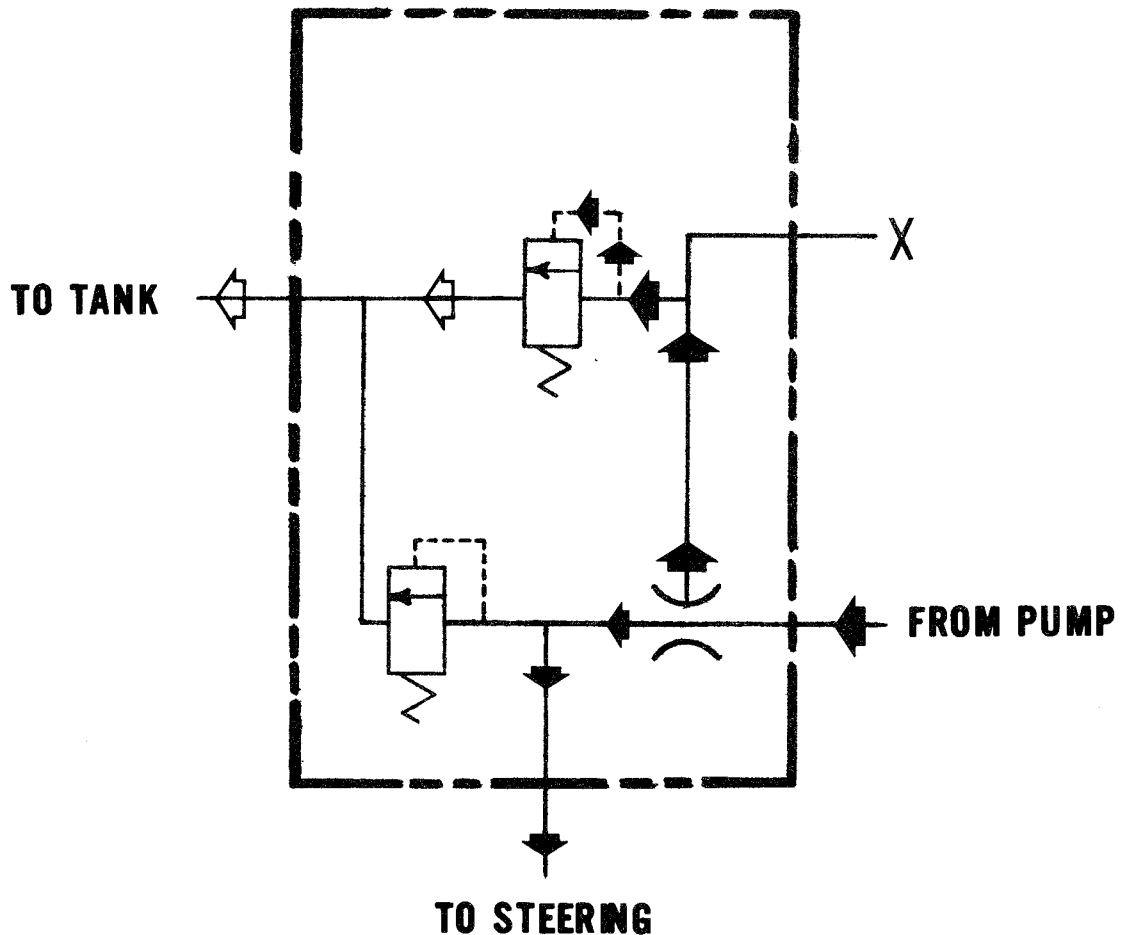
When pump output is above 8 gpm, the flow from the pump again goes to the flow regulator. Here the first 8 gpm flows out to the steering valve, and the excess flow is by-passed to the manifold. Thus at full pump output, both steering and manifold circuits are receiving their maximum flow.

The following cross-section drawing shows the configuration of the honed assembly when over 8 gpm flow is introduced. Notice that the orifice at the bottom of the spool in the honed assembly can only handle a maximum flow of 8 gpm. (This rating is determined by the size of this orifice hole.) If the flow of oil introduced to the orifice is less than 8 gpm then the previous cross-section drawing would hold true. For 8 gpm or less flow, the oil simply flows through the orifice with no resistance and continues out to steering.

However, when more than 8 gpm flow is introduced to the honed assembly, a resistance to flow is met at the 8 gpm orifice. This resistance to flow causes a pressure beneath the sliding spool of the honed assembly. The pressure (when flow above 8 gpm) works against the lower surface of the spool causing it to rise against the spring tension above the spool. As this spool rises, it exposes ports where the excess flow above 8 gpm can exit. From these ports the excess flow of oil travels to the manifold for use.



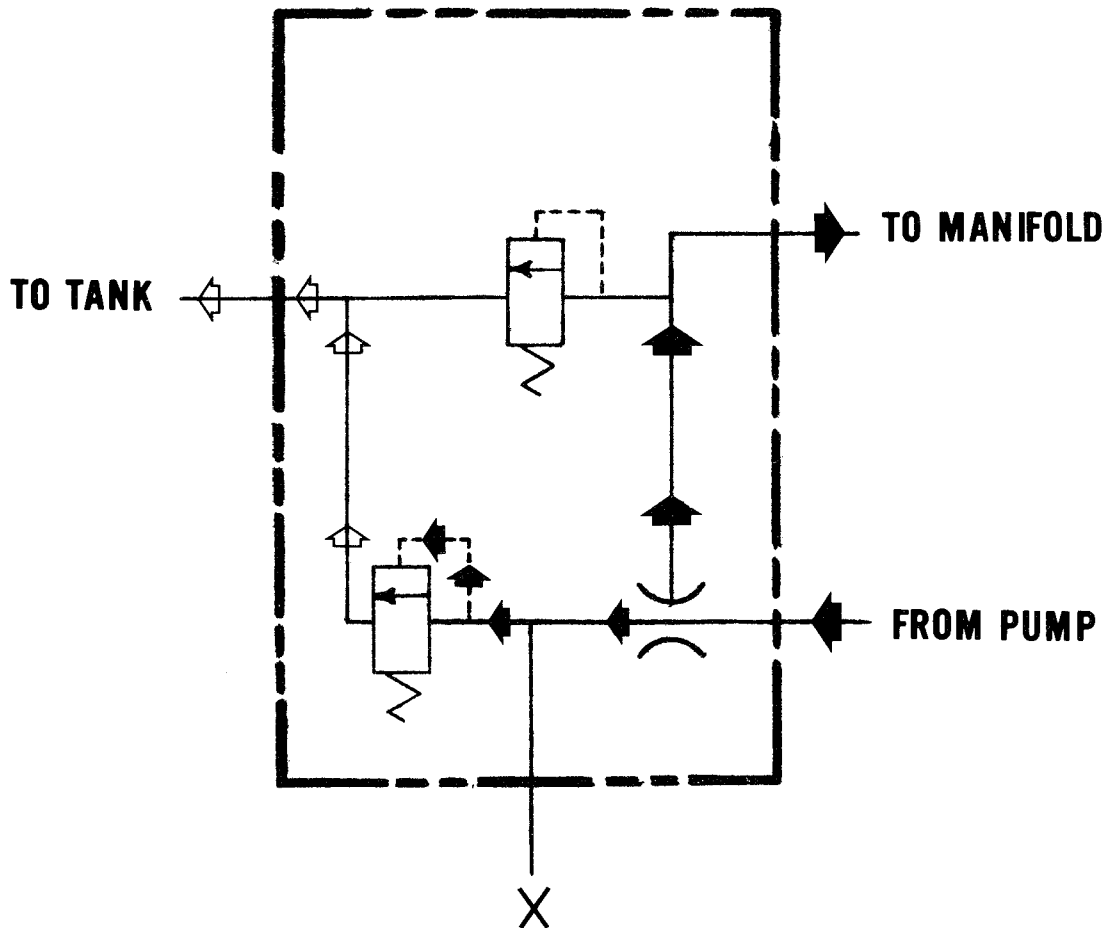
3. MANIFOLD RELIEF OPENS DUE TO EXCESSIVE PRESSURE BUILD-UP IN MANIFOLD CIRCUIT.



Should a cylinder in the manifold circuit be extended to its limit, then there will be an excessive pressure build-up within the circuit. Should this pressure exceed the systems relief valve setting, the flow of oil for the manifold circuit will be vented back to the tank. Should the above condition cease to exist, the relief valve will automatically reset itself and the system will function normally again.

It should be noted that the manifold relief valve is located in the aluminum body of the flow regulator. *This valve is pre-set at the factory and should never be adjusted. Tampering with this valve can only cause component damage. If the relief valve cartridge is faulty, it is a remove and replace item only.*

4. STEERING RELIEF VALVE OPENS DUE TO EXCESSIVE PRESSURE BUILD-UP IN THE STEERING CIRCUIT.



The steering relief valve will open in only one event. Should the steering cylinder not be extended or retracted fully in one direction or the other, and the wheels are steered into a stationary obstruction, then enough pressure build-up could occur to open the steering relief valve. This relief valve will not open in the event the machine is steered fully in one direction; by-pass check valves are incorporated in the steering cylinder to prevent this. (This is true only with current model graders).

This relief valve functions rarely if ever, but is incorporated as a safety device for such a rare occurrence as that above. This relief valve, and all other Galion relief valves are pre-set at the factory. *Never attempt to adjust a Galion relief valve.*

STEERING CIRCUIT

There are two basic types of steering systems employed on Galion graders. One system contains a mechanical power boosted steering gear with by-pass check valves incorporated in the steering cylinder. The other system contains full hydrostatic power steering. When a grader is equipped with hydrostatic steering, there are no by-pass check valves in the steering cylinder, but, steering relief is vented to the power boosted brake unit before returning to the tank. Each of these two types of systems warrant separate study.

MECHANICAL POWER BOOSTED STEERING

The schematic drawing on page 4 refers to a typical hydraulic system employing this type of steering circuit. From the flow regulator, a priority flow of 8 gpm travels to a mechanical power boosted steering gear.

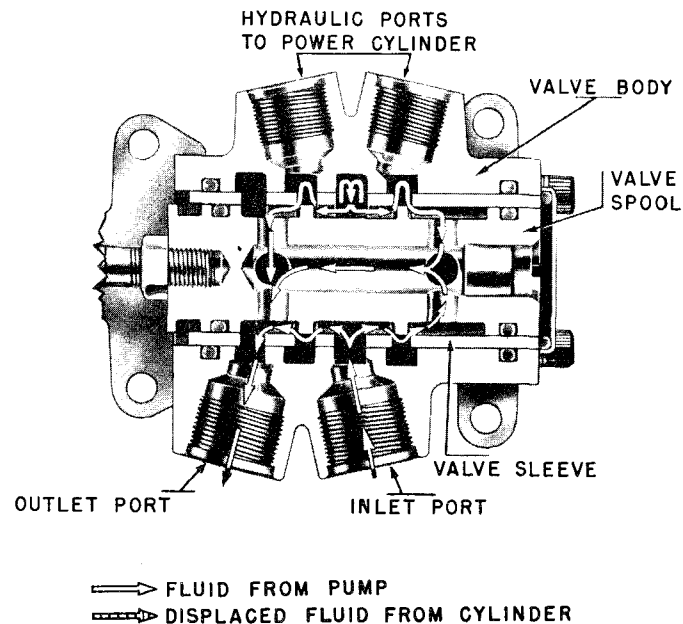
The combined mechanical and hydraulic sections of the steering gear are located above the head block of the grader frame. The steering linkage is then connected to the lower portion of the gear box. Activation of this unit occurs when the steering wheel and connecting shaft are rotated.

The hydraulic actuating unit of the steering gear contains the following components:

- 1) A sliding spool which directs fluid to the proper port(s) for steering.
- 2) Triggering linkage which moves the spool in the corresponding direction.
- 3) An actuating collar connected to the worm in the mechanical linkage which actuates the triggering linkage.
- 4) Centering springs to indirectly center the spool (whenever the steering wheel is not being rotated).
- 5) A housing with ports to contain the above items.

This hydraulic unit accomplishes two basic functions. First, when the steering wheel is not rotated, the spool valve will be in the neutral position. In this case the valve will act as a holding device for the steering cylinder. Second, when rotating the steering wheel in the appropriate direction for travel, the spool will slide within the housing to expose ports. By exposing these ports, fluid will flow to the corresponding side of the steering cylinder thus providing hydraulic actuation of the steering linkage. The following cross-section drawings show the various flow conditions within the hydraulic unit.

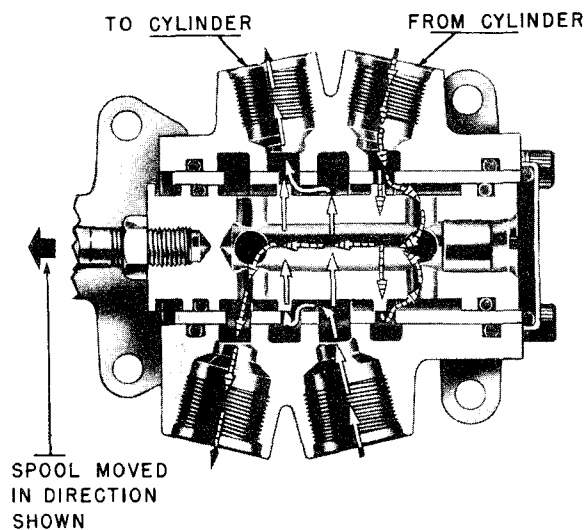
1. STEERING WHEEL NOT ROTATED - SPOOL IN NEUTRAL POSITION.



When the sliding spool valve is in the neutral position, oil flows freely past the two ports leading to the steering cylinder, and exits the valve downstream to the rest of the steering circuit. This free flow through the valve causes very minimal pressure. And, although both ports are exposed to the oil flow, there is very little pressure in the valve to cause any activation of the steering cylinder.

It is important to remember that since both ports are equally exposed to the oil flow, no movement will occur in the steering cylinder. The oil is just "by-passing" through the valve and downstream.

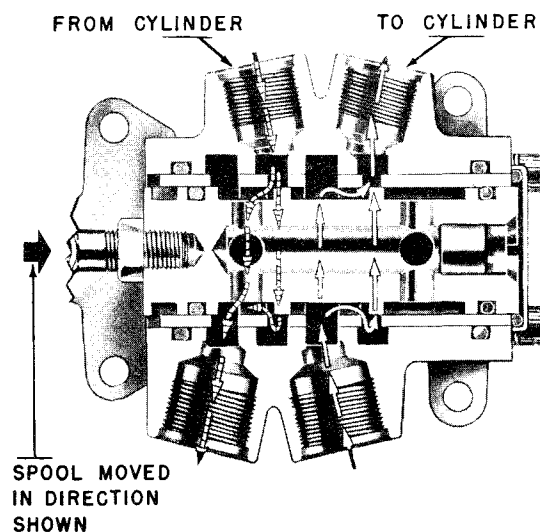
2. STEERING WHEEL ROTATED LEFT



When the steering wheel is rotated to the left, a force is applied to the centering springs. As these springs are overcome, the triggering linkage is activated causing the sliding spool to shift in the valve body as shown. The maximum travel of the spool within the body is approximately sixty-five thousandths of an inch. As the spool shifts its position, one port is closed to the oil flow while the other is still exposed. This causes an immediate pressure differential between ports.

When the spool has shifted as above, oil can flow to the proper side of the cylinder to actuate the piston. At the same time, the return port in the valve has enlarged in such a manner as to allow passage of the discharging oil from the cylinder through the valve and then to other downstream functions. The slightest movement of the steering wheel will activate this valve. The end result of the activation of this valve is hydraulic power assisting the steering linkage.

3. STEERING WHEEL ROTATED RIGHT



Rotating the wheel to the right activates the valve causing hydraulic power to assist in making a right turn. A similar sequence of events occurs as before only in this case, the spool will shift in the opposite direction.

Whenever the effort at the steering wheel is released, the spool will return to the neutral position by the action of the centering springs.

Compensation for shock loading

If the wheels are subjected to shock loading, then the spool in the valve will automatically shift in the appropriate direction thus directing the fluid to the proper side of the piston to resist the shock forces. This compensating action prevents kickbacks at the steering wheel.

STEERING CYLINDER

The steering cylinder incorporated on current Galion graders with mechanical power boosted steering are equipped with poppet type by-pass check valves. These valves enable a downstream flow to the power boosted brake unit at all times. Even if the piston is extended (or retracted) to its limit, there still will be a flow of oil available downstream; the steering relief valve will not open in this case.

PISTON ROD EXTENDED TO LIMIT:

If the machine is steered completely to the right, then the piston rod of the steering cylinder will be completely extended. If the steering cylinder is maintained in the bottomed position, the flow within the cylinder will be as shown in Figure 7.

When the piston rod is completely extended, the by-pass check valve is exposed. The flow of oil enters the cylinder, raises the ball against the spring tension, and exits out the line leading back to the steering valve. This means a continuous flow of oil will be provided downstream to the power boosted brake unit even when the machine is steered to its limit. During this condition, the steering relief valve will not open.

If the machine is steered completely in the opposite direction (left), the piston rod will be retracted and bottomed. In this event, the other by-pass check valve will be exposed and allow a continuous downstream flow in a similar manner as mentioned before.

PISTON ROD EXTENDED AND FLOW INTRODUCED TO RETRACT:

When the piston rod is in the configuration of Figure 8 and flow is introduced to retract, then oil pressure will work against the small surface marked (A). At this time, the check ball is seated tighter against its port due to the pressure above and the spring tension. As the piston retracts, the entire surface of the piston plate will be exposed to fluid pressure while the by-pass check valve remains closed.

Exhausting fluid from the other side of the piston can exit the cylinder by either the by-pass check valve port or the line port.

FLOW WITHIN CYLINDER WHEN PISTON PLATE IS BETWEEN BY-PASS CHECK VALVES:

When the piston plate is between by-pass check valves, the flow within the cylinder is much like any other cylinder.

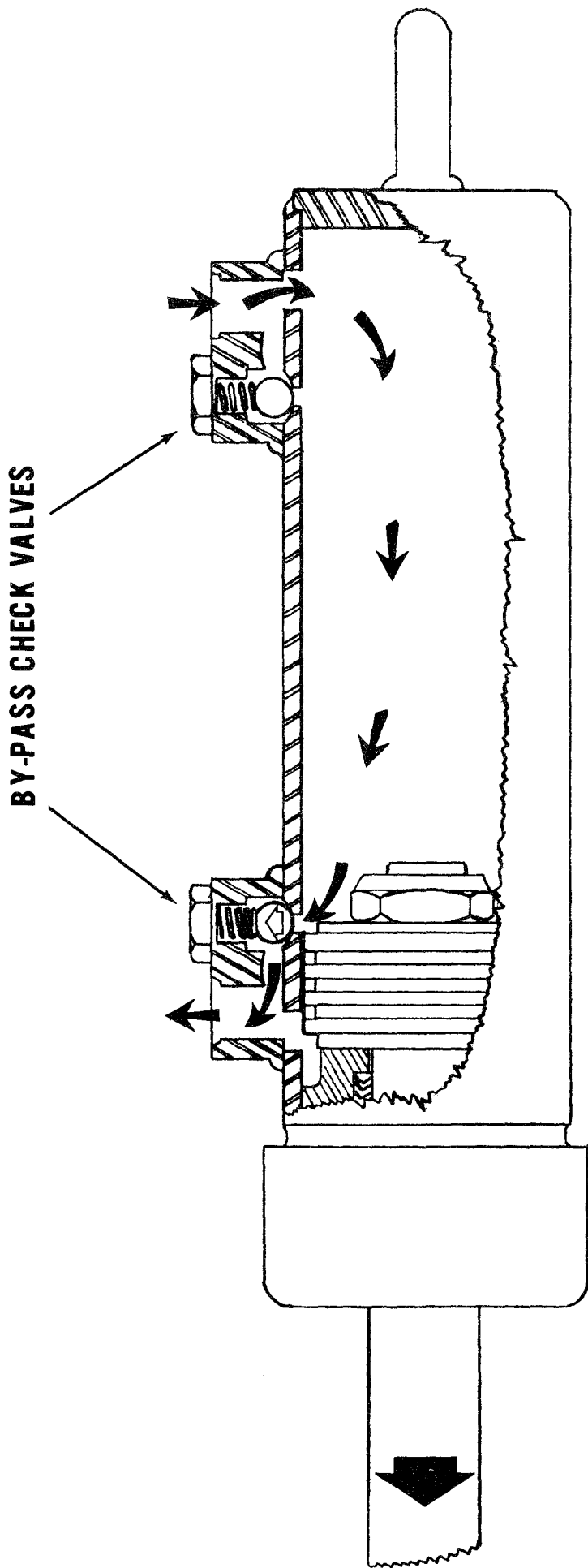


Fig. 7

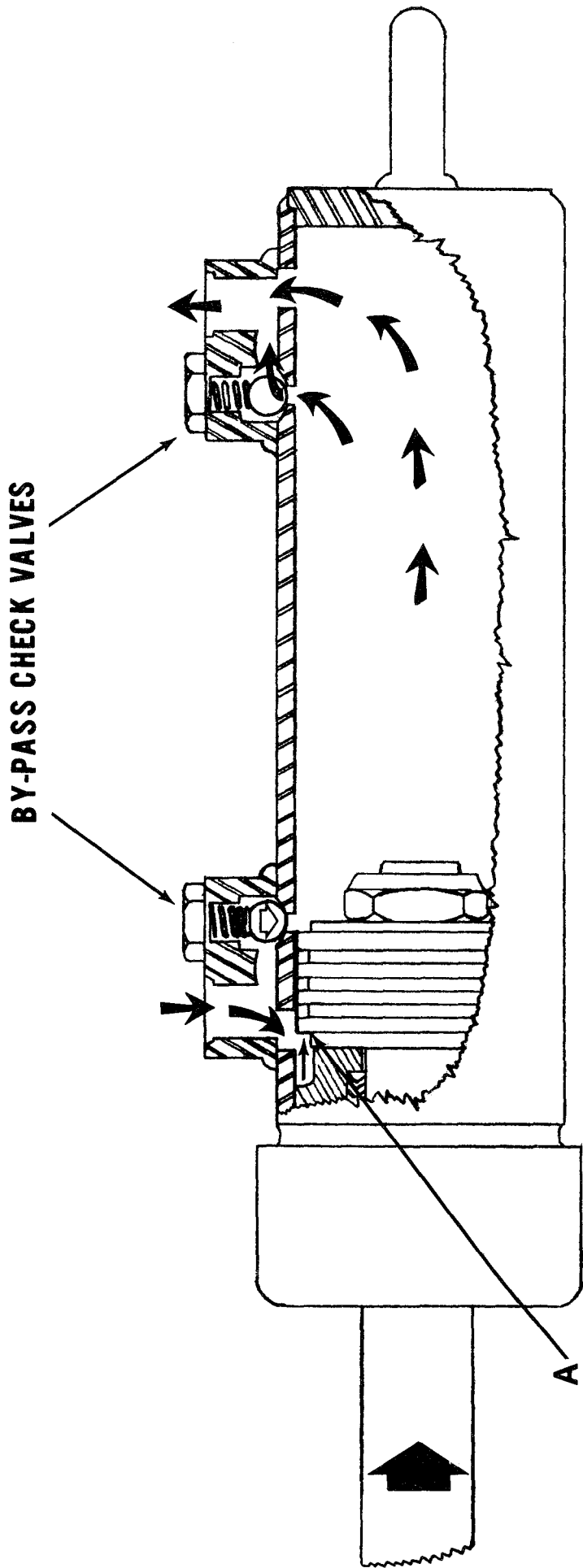
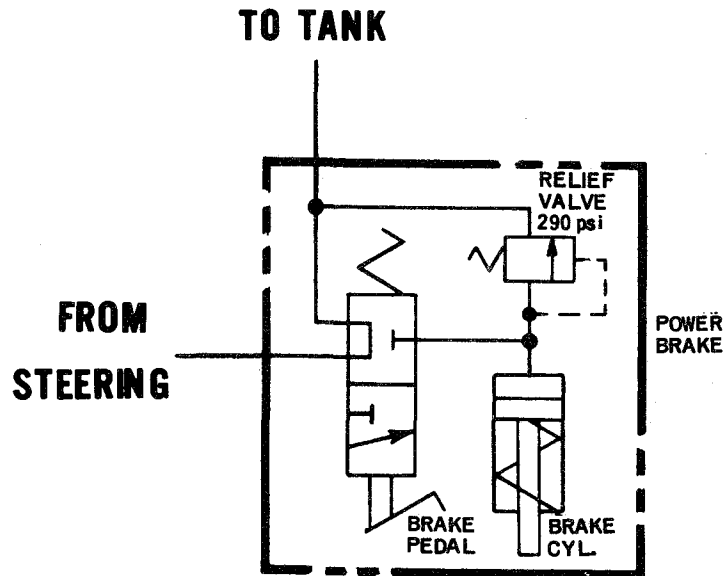


Fig. 8

POWER BOOSTED BRAKES

Directly downstream from the steering valve is a power boosted brake unit. When the service brake is applied, approximately 290 psi is needed to attain full braking capability with this unit. Whenever the pressure within this unit exceeds 290 psi, oil is vented through a relief valve incorporated in the unit, downstream and back to the tank. If the service brake is not applied, oil flows freely through the brake unit and back to the tank.



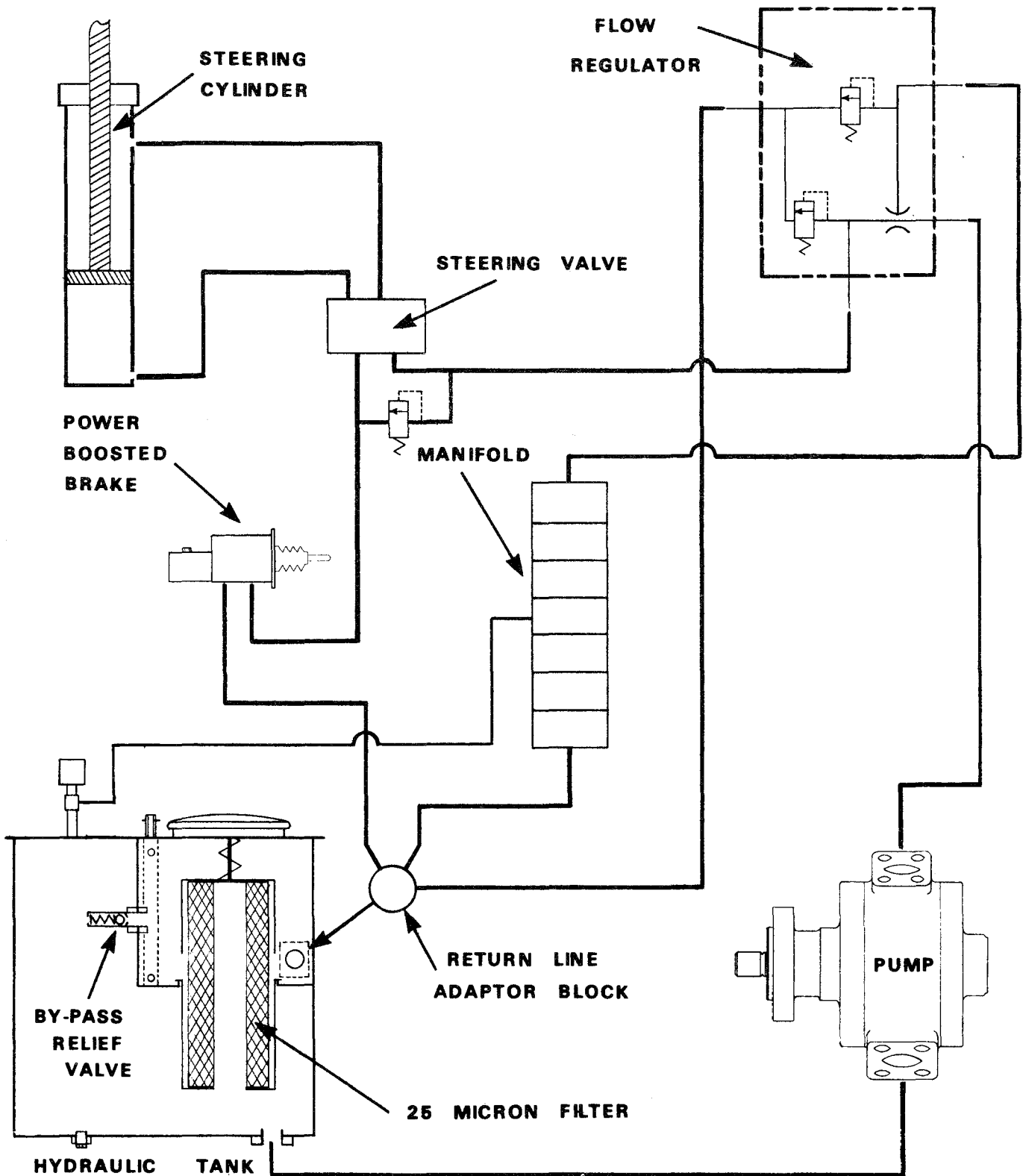
The power brake unit is located on the right side frame channel beneath the operator's compartment.

It should be noted that a flow of oil will always be available to the power boosted brake unit at all times due to the by-pass check valves incorporated in the steering cylinder. This means that power boosted brakes are always available even when the steering is "bottomed".

HYDROSTATIC POWER STEERING

The schematic drawing on page 30 refers to a typical hydraulic system employing this type of steering circuit. From the flow regulator, a priority flow of 8 gpm travels to a hydrostatic steering valve. In this system there are no by-pass check valves on the steering cylinder, but, steering relief is vented to the power boosted brake unit prior to returning to the tank.

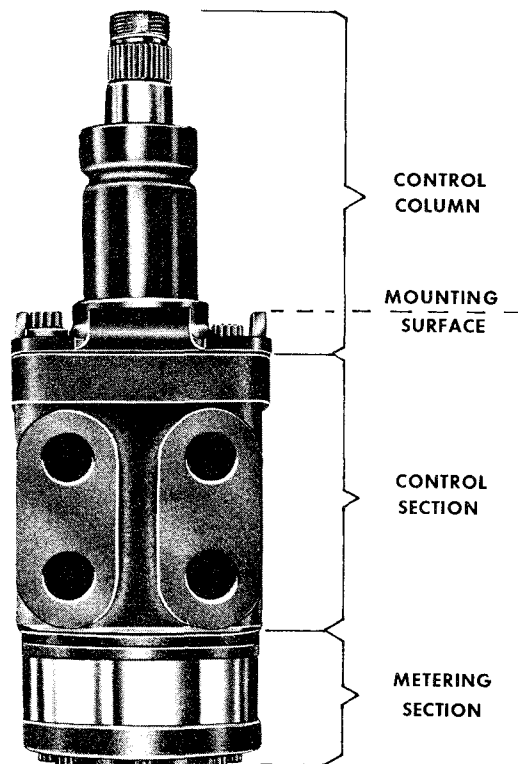
GRADER MANIFOLD AND STEERING CIRCUIT



HYDROSTATIC STEERING VALVE

In this type of system, hydraulic lines take the place of the mechanical gear box linkage of the previous type system. One can think of this control unit containing only a hydraulic steering valve.

The combined hydrostatic steering unit contains three (3) separate sections each producing a separate function. Each of these sections are shown below.



The control column is connected to the steering wheel by a shaft. Whenever the steering wheel is turned in the appropriate direction, the control column is also rotated. Connected to this control column is the control section.

Inside the control section are two spools inside each other with centering springs to locate each in neutral position. This section functions basically the same as the hydraulic actuating unit on the mechanical power boosted steering gear box. It accomplishes a free flow downstream when in neutral, and, directs a flow to the respective side of the steering cylinder when steering. Exhausted fluid from the cylinder when steering returns through the steering valve and downstream.

In conjunction with the control section is a metering section. The metering section consists of a gerotor type housing and metering gear. The metering gear is connected to the control section and indirectly to the steering wheel. As the steering wheel is turned, the control section designates the proper flow direction for steering and the metering gear regulates the displacement flow out to the cylinder. In this way a controlled actuation of hydrostatic steering is accomplished.

In the event of engine failure or stall, the hydrostatic steering unit automatically reverts to a manual steering control. In this condition, the fluid metering section becomes a rotary pump and directs fluid to move the cylinder in either direction when the steering wheel is manually rotated. A check valve within the unit allows a closed circuit for the fluid between this steering unit and the cylinder.

STEERING CYLINDER

The steering cylinder, on graders with a hydrostatic steering unit, are not equipped with by-pass check valves. If the steering cylinder with hydrostatic steering had by-pass check valves, then the steering wheel could continually be rotated after the steering cylinder was "bottomed". To prevent this, by-pass check valves have been eliminated from steering cylinders used with hydrostatic steering.

However, without by-pass check valves, a downstream flow to the power boosted brake unit would be eliminated whenever steering is "bottomed", but, a relief valve has been installed in the steering line. This relief valve has been installed between the flow regulator and the hydrostatic steering unit. This relief valve has a setting 50 psi less than the steering relief valve located in the flow regulator. In the event the machine is steered to its limit, pressure will build to this relief valve setting, and oil will be vented to the power boosted brake unit. Actually this relief valve allows a "by-pass" around the hydrostatic steering unit to the boosted brake unit whenever the steering is "bottomed".

This means that machines equipped with hydrostatic steering will always have a flow of oil available to the boosted brake unit at all times, including when steering is bottomed. (The 503 A & L both do not have power boosted brakes).

POWER BOOSTED BRAKES WITH HYDROSTATIC STEERING

The power brake unit for hydrostatic steering models is located on the right side frame channel beneath the operator's compartment. Flow to this unit is received from downstream steering, or, from the previously mentioned relief valve. This brake unit is the same in all respects as the brake unit discussed previously with mechanically power boosted steering.

MANIFOLD CIRCUIT

From the flow regulator, the excess flow above 8 gpm travels to the left side of the control manifold. Oil enters the manifold and, if all controls are in neutral, travels through the manifold and back to the tank. If one or more controls are activated, oil travels through the manifold in series flow. This allows the capability of one or more controls operating at one time.

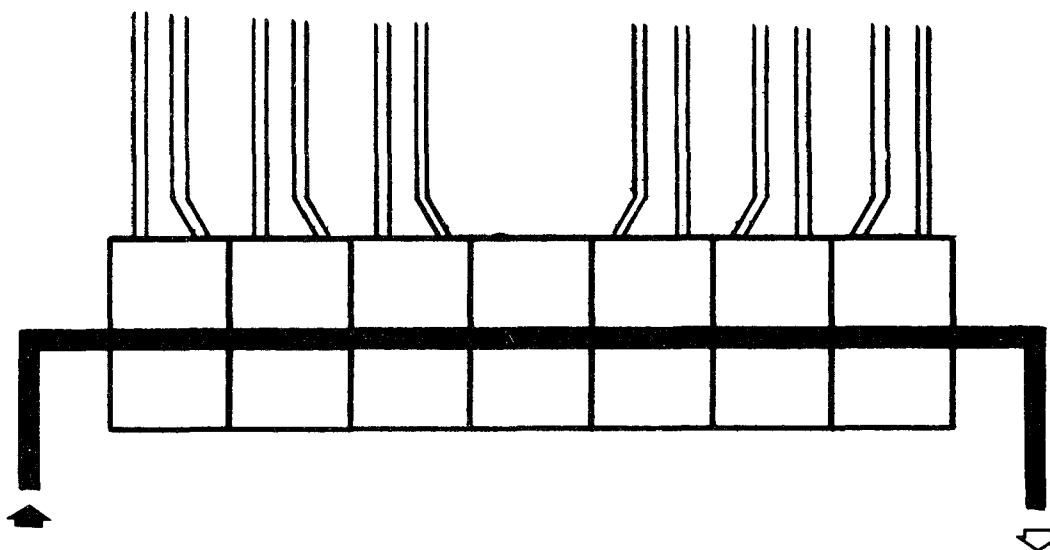
The manifold circuit is protected from overload pressures by a manifold relief valve located in the flow regulator. Should a cylinder be "bottomed" in the manifold circuit, excessive pressure will build and cause this relief valve to open. Oil will then be vented back to the tank as long as this condition exists.

MANIFOLD AND CONTROL VALVES

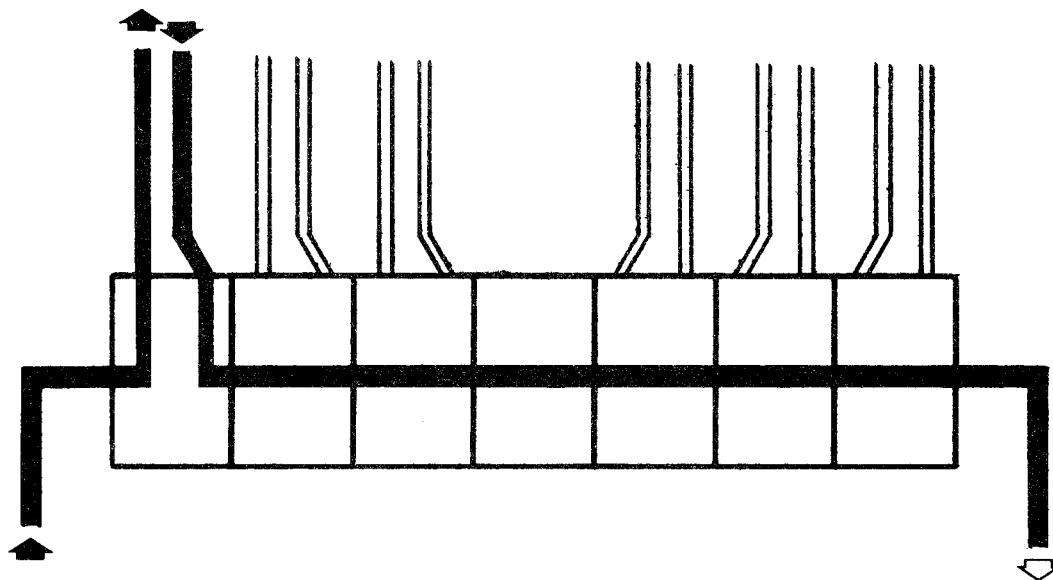
Galion designs and manufactures its own control valves. The standard manifold on all current Galion graders (except 503L) consists of six (6) controls with an optional five (5) controls which can be added. The picture on page 2 shows a typical manifold on a Galion grader.

SERIES FLOW

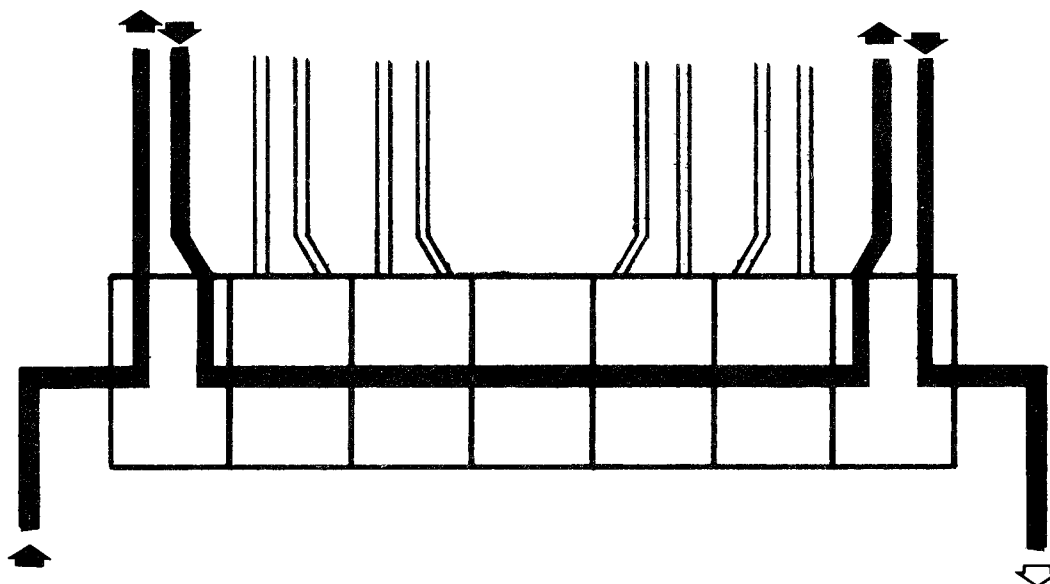
When all controls in the manifold are in neutral position, the flow of oil enters the left side of the manifold, passes through each control valve, and exits at the right. In this case, oil is flowing through the manifold with very little resistance, and in turn very little pressure. The figure below shows this condition:



Whenever a control is activated, however, the flow of oil is diverted at the respective control valve. Oil then flows out from this control valve to the particular cylinder (or motor). Since the hydraulic cylinders employed on Galion graders are double-acting type, the exhausting oil will return back to the manifold. It will then resume its travel downstream in the manifold, exit at the right, and travel back to the tank. The figure below shows this condition:



Whenever more than one control is activated, succeeding controls downstream operate on exhausted fluid from double-acting cylinders upstream. This provides the ability to use several controls at one time. The figure below shows this condition:



GALION CONTROL VALVES

The control valves employed on Galion graders are precision products which should be handled as such. Each control valve contains the following components:

- 1) An open center sliding spool
- 2) A valve body to contain the spool
- 3) A centering spring connected to the spool to locate neutral position
- 4) A lower cover plate
- 5) An upper cover plate with a sealing boot and actuating lever

Manufacture of this assembly is extremely accurate. First, the spool is ground round, to within one ten-thousandth inch taper end to end. The spool is then sized with an air gauge and coded within a range of one thousandth inch; within this range of one thousandth inch, each code represents one subdivision to an accuracy of one ten-thousandth of an inch. Precision must be maintained during this entire operation.

Second, the valve body bore is honed round, also to within one ten-thousandth of an inch taper end to end. It is then sized and coded in a similar manner as the spools. Each code represents a bore size within one ten-thousandth inch. Precision is also maintained during this honing operation.

When a large quantity of spools and valve bodies have been produced, they are matched for size with their corresponding codes. When any one spool and body are mated, there is only 4 to 6 ten-thousandths clearance between the two components. This type of production provides excellent tolerances between any mated set of spool and valve body.

The close tolerance of 4 to 6 ten-thousandths inch between spool and body assures each control valve the capability of "locking" the oil between the valve and cylinder. This prevents oil from escaping a cylinder when the control valve is in neutral.

The slight clearance between spool and body does provide, however, enough oil for lubrication to pass between each. This controlled lubrication is very minimal but is necessary to allow easy sliding of the spool. Each control valve has two holes bored within the body to allow this lubrication flow to drain back to the tank.

Another machining operation is performed on the valve body prior to assembly. Both side surfaces must be machined flat to a fine tolerance also. This provides a tight fit between valve bodies when oil flows through the manifold.

Each control valve is then assembled in the proper sequence for the particular manifold. An "O" ring is installed between each control valve to prevent leakage. Also .005 inch shims are placed between each control valve on the three tie-bolts holding the manifold together. These shims must be used to permit a small amount of flexibility in the manifold. If a grader flexes in any way, a small amount of movement is desirable so a "racking" effect will not take place.

When all components of the manifold are in place, nuts and lock washers are installed on the tie-bolts. These tie-bolt nuts are then torqued to 17-25 ft. pounds. Over torquing can cause the control valve spools to stick in the body.

The manifold is then ready to be installed on the grader.

IN SUMMARY:

It should be noted that the control valve spools are each designed for a particular function. Never attempt to interchange the function of control valves. The valve spool of any one control can have particular size holes, lands or grooves, and diameter than any other valve in the manifold.

Never attempt to interchange valve spools within a manifold. Since each control consists of a mated spool and body, switching cannot guarantee a 4-6 ten thousandths inch clearance. Whenever a control is ordered for a manifold, the spool and body are received as a mated set. Switching spools within a manifold can only cause serious problems.

FLOW WITHIN A CONTROL VALVE

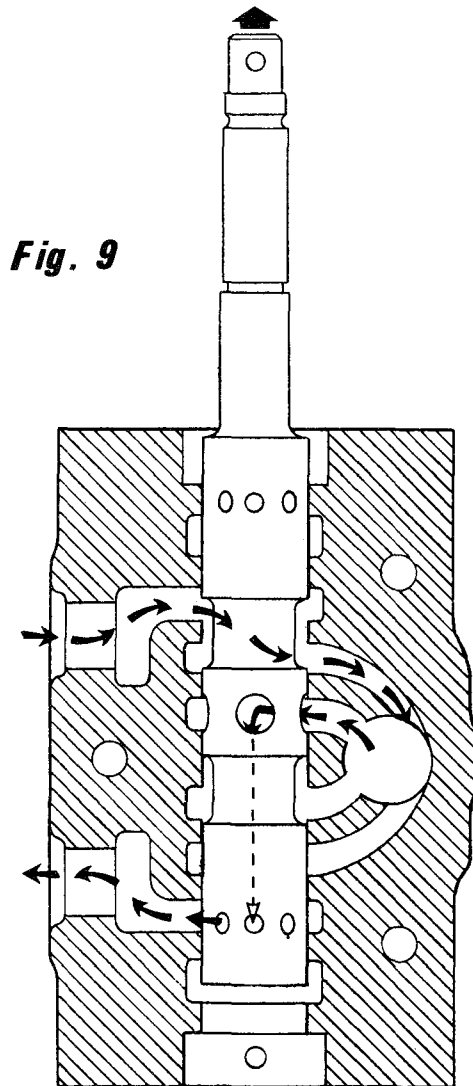
Activation of the control lever causes the sliding spool to either raise or lower in the control valve body. When this is done, the flow of oil passing through the manifold can be diverted either partially or fully, depending on the design characteristics of the spool. The following three (3) conditions of flow can occur within a control valve:

1. CONTROL LEVER PULLED:

When the control lever is pulled, the open center sliding spool is raised in the control valve body. As this is done, the four large center holes of the spool are exposed to the mainstream flow of the manifold. The oil will then enter the open center section of the spool and flow out the bottom set of holes.

The oil will then exit the control valve at the lower port and flow to the corresponding cylinder (or motor).

The exhausting oil from the double-acting cylinder will enter the top port of the control valve. The oil then flows around the "lands" or grooves of the spool and then exits the control valve at the opposite side from the initially intaking oil. The exhausting oil from this control valve (and cylinder) is now made available for use by the next downstream control valve. Figure 9 shows the above flow condition through the control valve.



2. CONTROL LEVER PUSHED:

When the control lever is pushed, the open center sliding spool is lowered in the control valve body. The four large center holes of the spool are exposed again to the mainstream flow. Oil then flows through the center of the spool and out the top holes to the cylinder.

Returning oil from the cylinder then travels around the lower land and is made available to the next control valve. Figure 10 shows this flow condition.

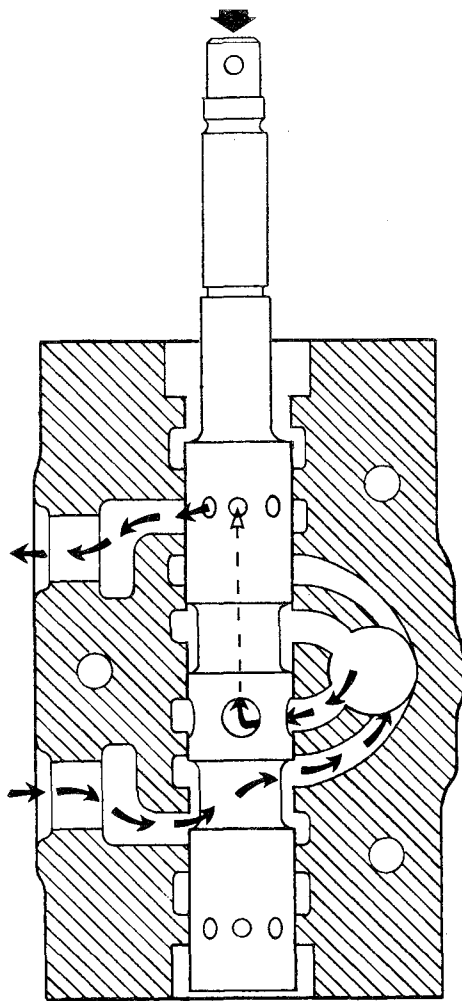


Fig. 10

3. CONTROL LEVER IN NEUTRAL POSITION

When the control is not pushed or pulled, oil enters at the left port of the control valve, flows freely with little resistance around the lands of the spool, and out the opposite side of the control valve. During this condition oil is locked in the cylinder preventing movement.

Controlled lubrication between the spool and body is occurring during all three of the above conditions. This slight lubrication flow is vented back to the tank through two rifle drilled holes marked (A) and (B) below. These rifle drilled holes join at a 3/8" drain line which carries the lubrication oil back to the lower compartment of the hydraulic tank.

The figure below shows the neutral position flow condition of the control valve.

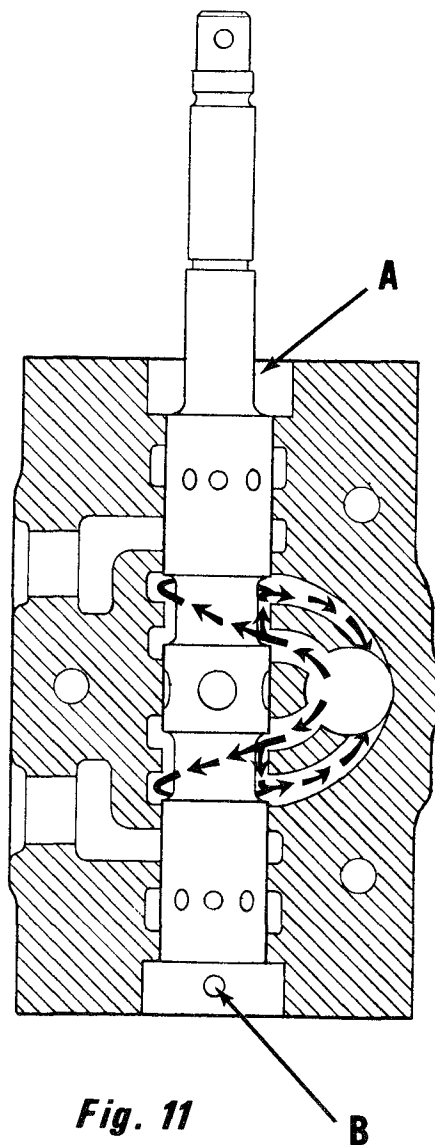


Fig. 11

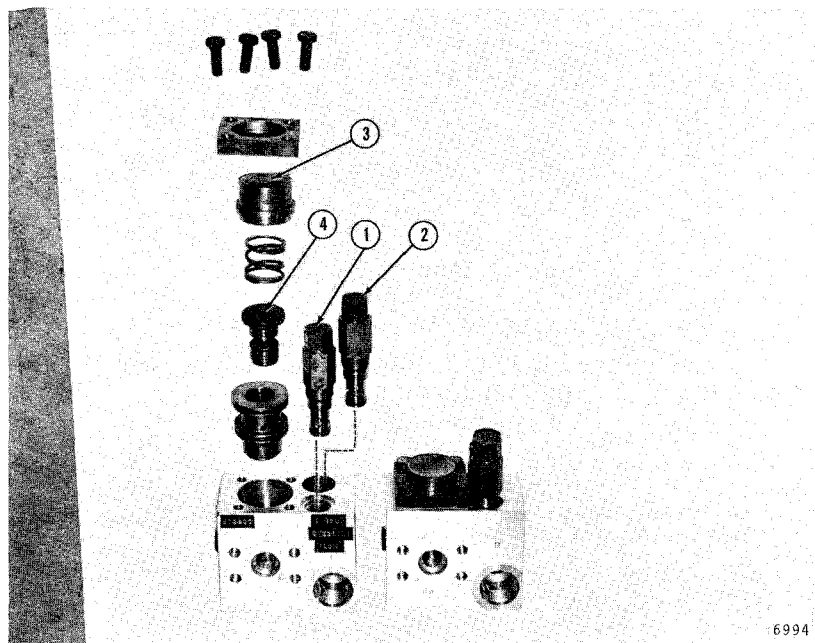
PAST GRADER HYDRAULIC SYSTEMS

Several changes in component design of the Galion grader hydraulic system have been made in past years. The following information can be used to determine the particular components of any past hydraulic system. Since components within a hydraulic system can vary in design, *visual identification of components is necessary to determine the type of hydraulic system.* Refer to the pertinent parts book for further information concerning a particular system.

FLOW REGULATORS

Flow regulators used on Galion graders can vary widely in design. However, there are two basic designs which one should look for - old style and new style.

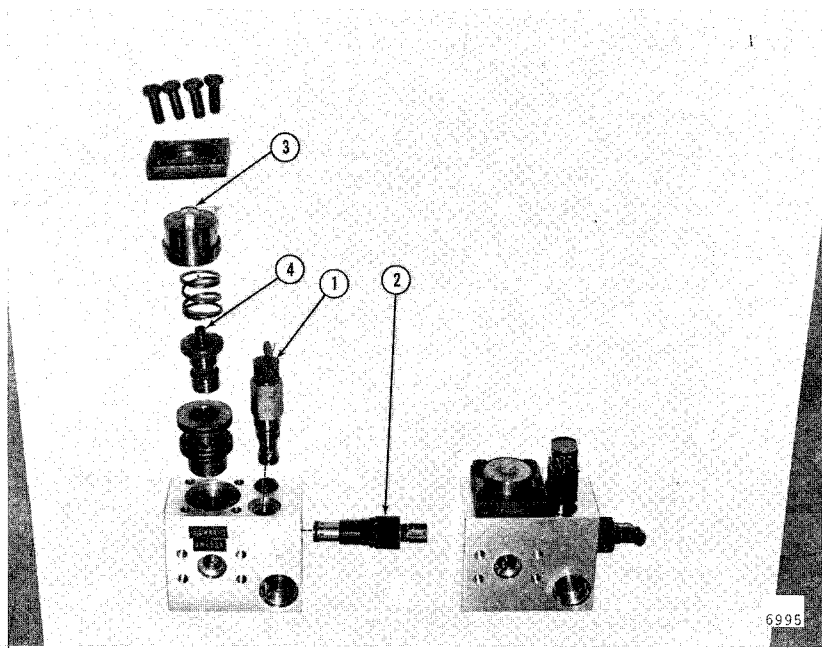
OLD STYLE



Visual identification of components by:

1. Steering relief valve:
 - a) Valve is located on top of flow regulator and marked REG.
 - b) Relief valve is piston plunger type.
2. Manifold relief valve:
 - a) Valve is located on top of flow regulator and marked BP.
 - b) Relief valve recessed lower in body than steering relief valve.
 - c) Relief valve is piston plunger type.
3. Cover on honed assembly:
 - a) Cover has plain smooth surface
4. Spool in honed assembly:
 - a) Top of the honed assembly spool valve has plain straight hole in the center.

NEW STYLE



Visual identification of components by:

1. Steering relief valve:
 - a) Valve is located on top of flow regulator beside honed assembly cover and is marked REG.
 - b) Relief valve is piston plunger type.
2. Manifold relief valve:
 - a) Valve is located on the side of flow regulator and is marked BP.
 - b) Relief valve is pilot operated type. Small holes on the relief valve body denote this.
3. Cover on honed assembly:
 - a) Cover has 1/2" hex plug located in the center.
4. Spool in honed assembly:
 - a) Honed assembly spool valve has washer type "one-way" check valve located on the top of the spool ("flapper valve").

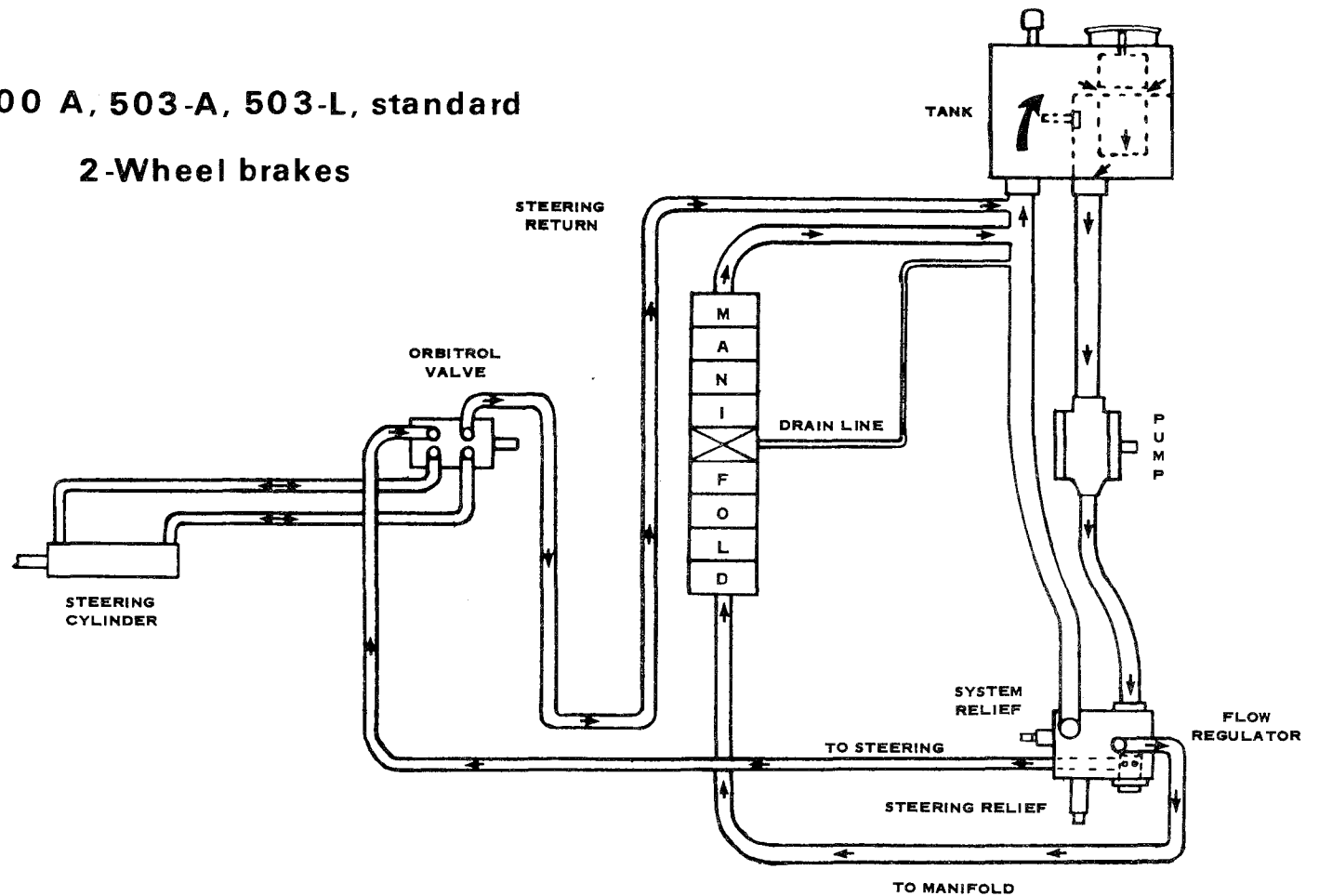
Refer to the respective grader parts book for specific component parts of any particular flow regulator.

PAST HYDRAULIC SYSTEMS

The following circuit diagrams can be used to identify components of past grader hydraulic systems.

T-400 A, 503-A, 503-L, standard

2-Wheel brakes

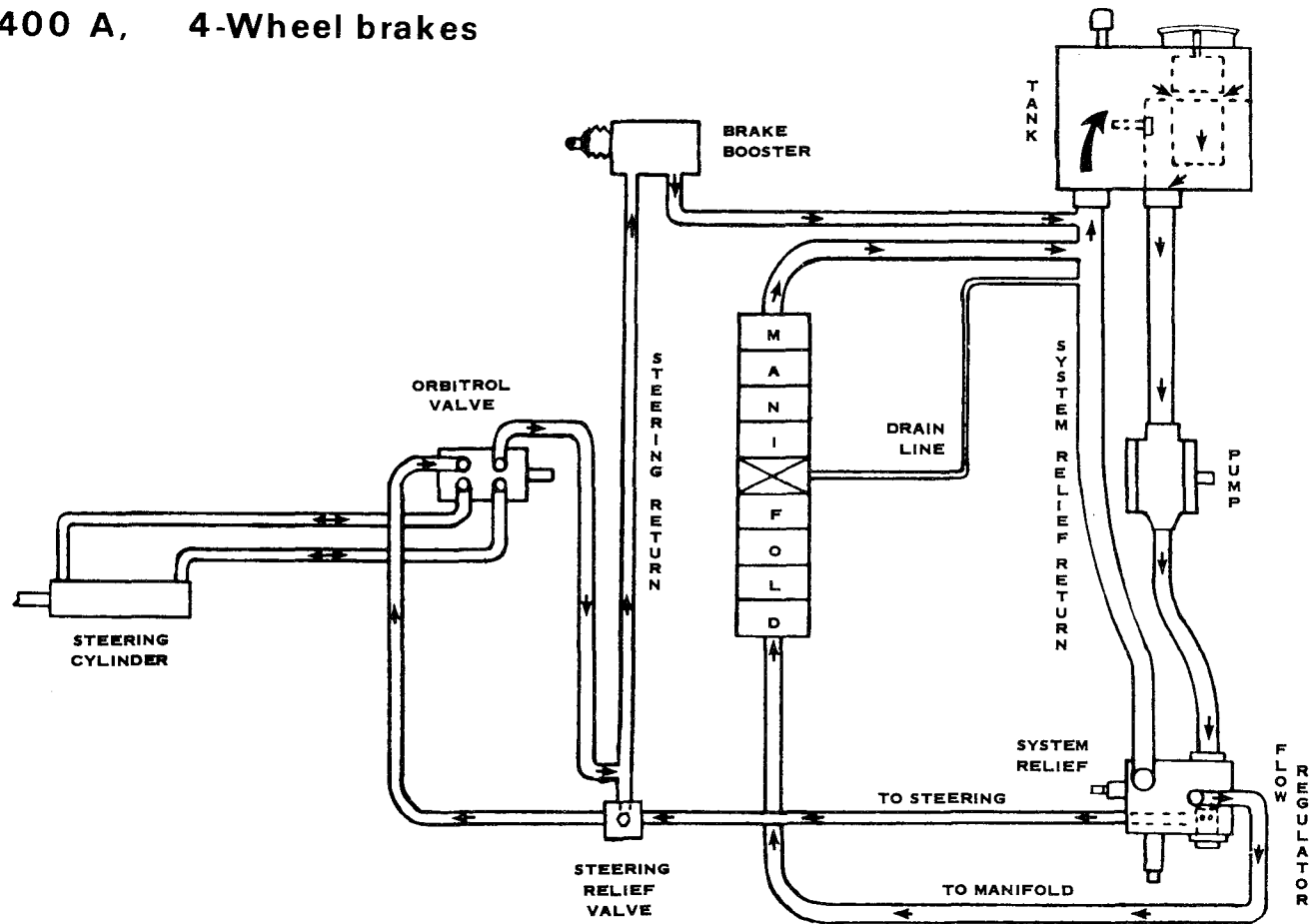


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Visual identification of components by:

- 1) Hydrostatic steering
- 2) No by-pass check valves on steering cylinder
- 3) 2-wheel brakes - not power boosted.

T-400 A, 4-Wheel brakes

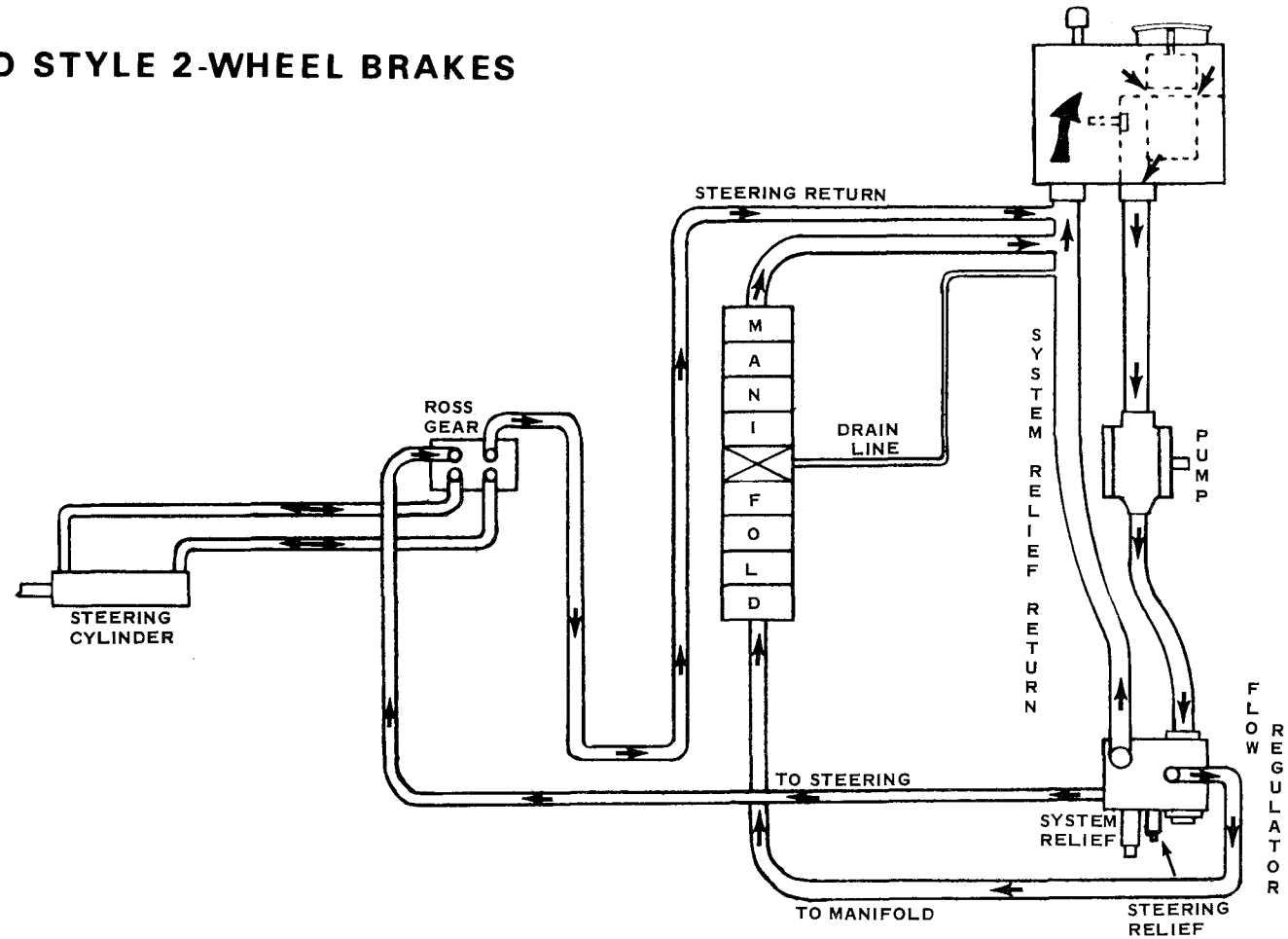


-43-

Visual identification of components by:

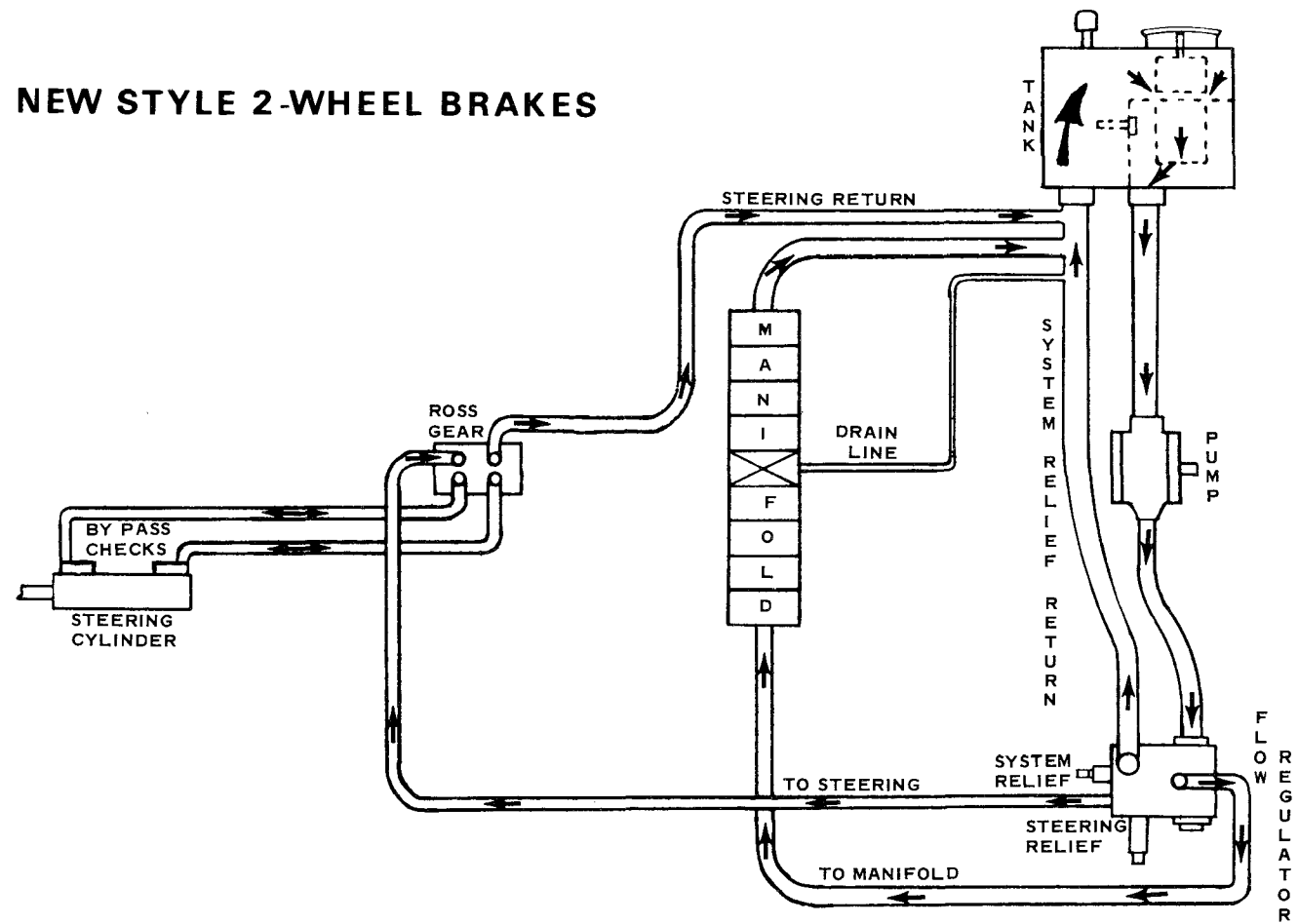
- 1) Hydrostatic steering
- 2) No by-pass check valves on steering cylinder
- 3) Power boosted brakes
 - a) Brake unit located downstream from hydrostatic steering unit.

OLD STYLE 2-WHEEL BRAKES



- Visual identification of components by:
- 1) Mechanical power boosted steering unit.
 - 2) 5/8" O.D. diameter steering lines
 - 3) No by-pass check valves on steering cylinder.

NEW STYLE 2-WHEEL BRAKES

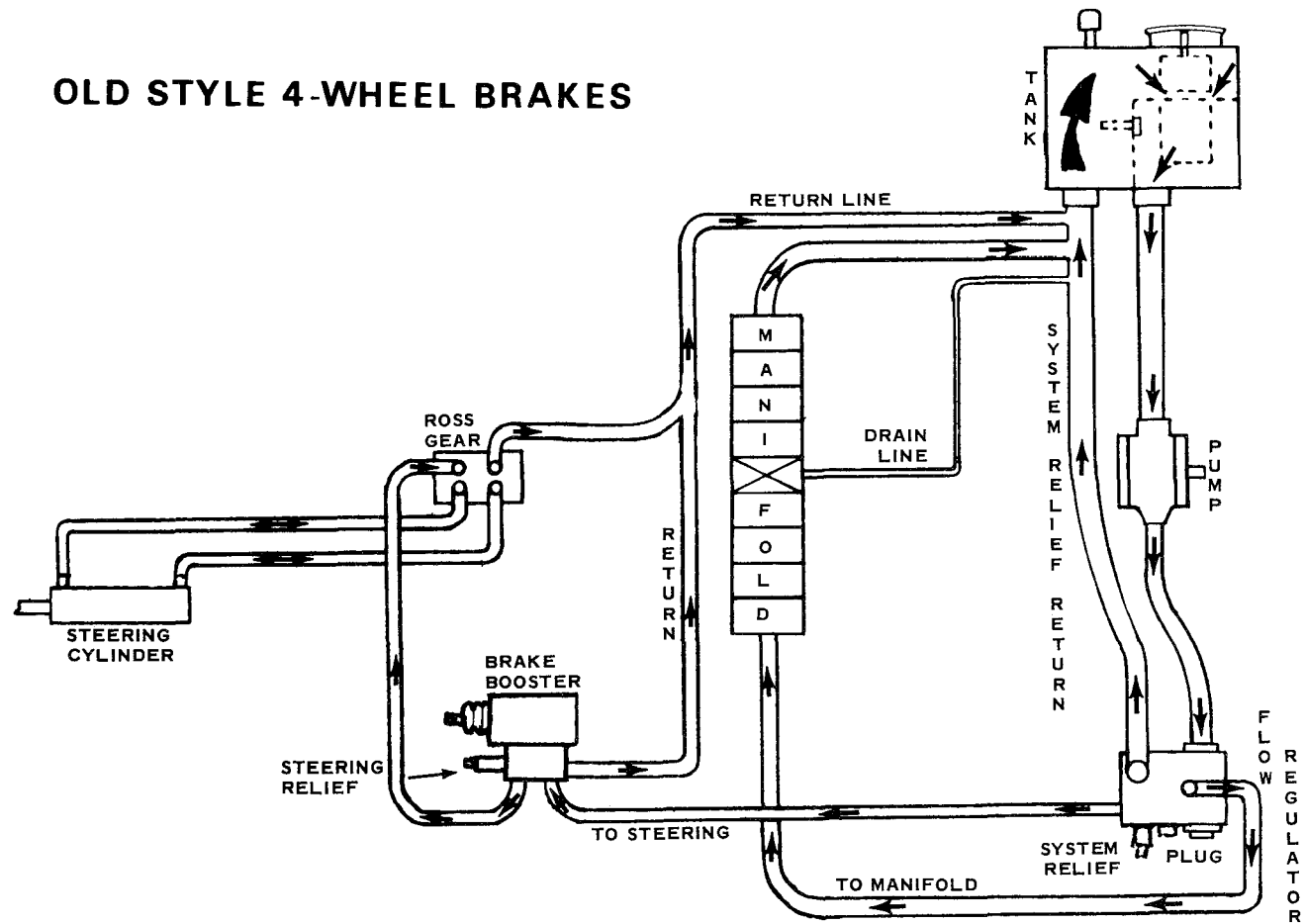


-45-

Visual identification of components by:

- 1) Mechanical power boosted steering unit.
- 2) 3/4" O.D. diameter steering lines
- 3) By-pass check valves on steering cylinder
- 4) Brakes not power boosted.

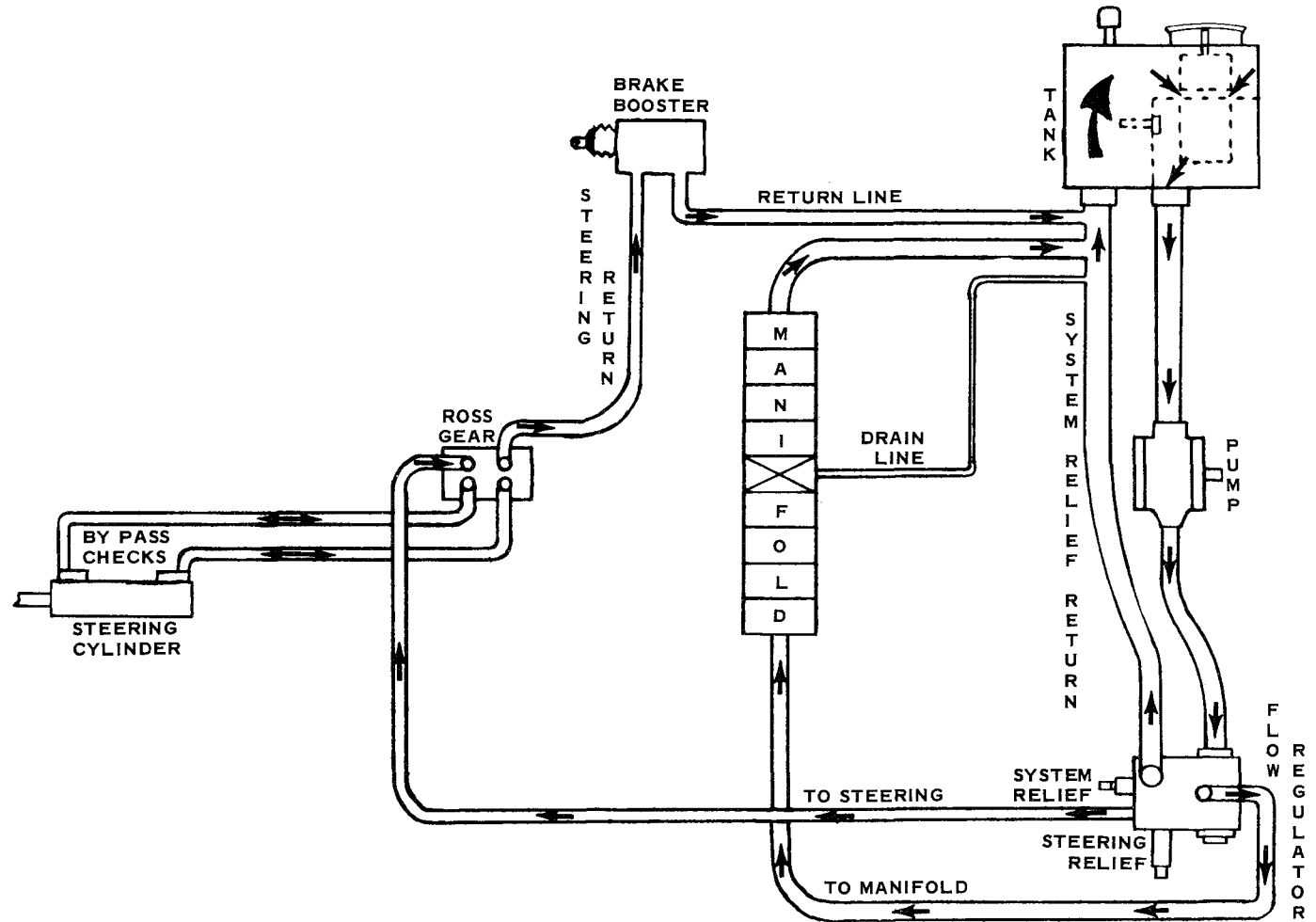
OLD STYLE 4-WHEEL BRAKES



Visual identification of components by:

- 1) Mechanical power boosted steering unit.
- 2) 5/8" O.D. diameter steering lines
- 3) No by-pass check valves on steering cylinder
- 4) Power boosted brake unit upstream from steering unit.
- 5) Steering relief valve located on brake unit.

NEW STYLE 4-WHEEL BRAKES



Visual identification of components by:

- 1) Mechanical power boosted steering unit.
- 2) 3/4" O.D. diameter steering lines.
- 3) By-pass check valves on steering cylinder.
- 4) Power boosted brake unit downstream from steering unit.
- 5) Steering relief valve on flow regulator.

Refer to the respective grader parts book for specific component parts of each system.

HYDRAULIC SYSTEM PRESSURES

<u>MODEL</u>	<u>SERIAL NO.</u>	<u>STEERING</u>	<u>MANIFOLD</u>
503-A & L	05101 & Up	1200 ± 50	1200 ± 50
303-A	26888 & Up	1100 ± 50	1200 ± 50
104-B & C	07601 - 09950 09951 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50
104H-B & C	07619 - 09954 09950 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50
118-B & C	07614 - 09652 09653 - 09765 09766 - 09938 09939 & Up	1100 ± 50 1100 ± 50 1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50 1200 ± 50 1050 ± 50
160-B & C	02111 - 02517 02518 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50
160-L	02101 - 02514 02515 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50
T400-A	01001 & Up	1100 ± 50	1050 ± 50
T500-A	02601 - 03314 03315 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50
T500-L	03286 - 03314 03315 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50
T600-B	01501 - 01744 01745 & Up	1100 ± 50 1100 ± 50	1200 ± 50 1050 ± 50

(All pressures at engine high idle (Limited high idle on power shift models))

MANIFOLD PRESSURE CHECK

Install a reliable 1500 PSI gage in the 1/8" NPT port on the left-hand end of the control manifold, with oil at operating temperature, set engine at high idle. Bottom (deadhead) leaning wheel control in either direction and record pressure.

NOTE: On 503-A or L grader, disconnect hose on the piston rod side of the leaning wheel cylinder. Adapt a reliable 1500 PSI gage to this hose. Lean wheel to the *RIGHT* (pull control lever) and record pressure.
DO NOT ATTEMPT TO LEAN WHEELS TO THE LEFT AT THIS TIME.

STEERING PRESSURE CHECK

To check steering pressure, the hydraulic oil must be at operating temperature. Disconnect the front hose on the steering cylinder (except on the 503-A & L and the T-400-A). Connect a reliable 1500 psi gage directly into the end of the hose. Start engine and turn the steering wheel to the LEFT. Raise engine speed to maximum RPM and take pressure reading.

CAUTION: DO NOT ATTEMPT TO TURN STEERING TO THE RIGHT DURING THIS OPERATION.

To check the steering pressure on the 503-A & L grader, disconnect the hose on the piston rod side of the steering cylinder. Adapt a reliable 1500 psi gage directly into this hose. Start engine and turn steering wheel to the RIGHT. Raise engine speed to maximum RPM and take reading.

CAUTION: DO NOT ATTEMPT TO STEER LEFT DURING THIS OPERATION.

To check the steering pressure on the T-400-A grader, disconnect the hose on the piston rod side of the steering cylinder. Adapt a reliable 1500 psi gage directly into this hose. Start engine and turn steering wheel to the LEFT. Raise engine speed to maximum RPM and take reading.

CAUTION: DO NOT ATTEMPT TO STEER MACHINE TO THE RIGHT DURING THIS OPERATION.

TROUBLESHOOTING

For troubleshooting of the grader hydraulic system, refer to File E, Section 17 of the Galion Grader Shop Manual.

For troubleshooting of the Galion crane hydraulics, refer to File E, Section 15 of the Galion Crane Shop Manual.