A priority system for series-type hydraulic circuits including a plurality of hydraulic work systems disposed in serial fluid communication with a source of fluid under pressure and a priority valve operatively associated with a supply line between two of the work systems operatively dividing them into upstream and downstream work systems and responsive to fluid pressure between the source and the upstream system in excess of a predetermined pressure level automatically to reduce pressure in the downstream work system and maintain a predetermined minimum pressure differential between the downstream and upstream systems when they are operated simultaneously to insure positive actuation of the upstream system.

11 Claims, 1 Drawing Figure
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PRIORITY SYSTEM FOR SERIES-TYPE HYDRAULIC CIRCUITS

BACKGROUND OF THE INVENTION

In many vehicle applications it is desirable to employ series-type hydraulic circuits to minimize total flow requirements and cost and to achieve simultaneous operation of several circuits. Since the actuating pressure of each active circuit is imposed as back pressure on the preceding circuits, it is possible that only the last system in the series is capable of positive actuation. For this reason, series circuits have been generally unacceptable where it is necessary that priority be given to a work system other than the last in the series.

One commonly used solution is to place the high priority system in parallel with another circuit and employ a flow divider to insure positive actuation of the high priority system. This is undesirable in that a flow divider is inherently inefficient and generally requires a larger and more costly pump.

The most obvious solution is to place the high priority system last in the series. In instances where the high priority system also has the higher pressure requirement, this is undesirable due to the back pressure imposed on the lower pressure systems. As a result, the valves must be designed to withstand the higher pressures thus increasing size and cost thereof. This also increases the incident of relief valve operation in the relatively low pressure circuits and can result in accelerated wear on the relief valve components.

SUMMARY AND OBJECTS OF THIS INVENTION

Accordingly, it is an object of this invention to provide an improved priority system for series-type hydraulic circuits.

Another object of this invention is to provide such an improved priority system which automatically insures a predetermined pressure differential across a hydraulic steering system when the supply pressure exceeds a predetermined value.

Another object of this invention is to provide an improved priority system of the character described which is particularly adapted for a hydraulically controlled vehicle and which is responsive to supply pressure to a hydraulic steering system on the vehicle automatically to establish a bypass flow path in parallel to a secondary work system on the vehicle when the supply pressure exceeds a predetermined value to apportion a predetermined portion of the supply pressure for positive actuation of the steering system.

Other objects and advantages of the present invention will become more readily apparent upon reference to the accompanying drawing and following description.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of a series-type hydraulic circuit with sectional valve portions including a priority system embodying the principles of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawing, a priority system embodying the principles of the present invention is generally indicated by the reference numeral 10 as operatively associated with a series-type hydraulic circuit generally designated by the reference numeral 12. The hydraulic circuit is operatively associated with a vehicle indicated generally at 14 for controlling the steering of the vehicle and work implements mounted thereon.

The vehicle 14 includes a rear frame 16 which is supported on a rear axle 18 having a pair of wheels 20 individually rotatably supported at its opposite terminal ends. A front frame 26 is supported on a front axle 28 having a pair of wheels 30 individually rotatably mounted at its opposite terminal ends. The inner ends of the front and rear frames are pivotally connected by a pivot connection 32 to permit articulation of the frames about a substantially vertical axis for purposes of steering the vehicle. Articulation of the frames is controlled by a pair of steering jacks 36 and 38 which are individually pivotally connected at one end to a pair of brackets 40 and 42, respectively, which are secured to the opposite outer sides of the rear frame 16. The opposite ends of the jacks are individually pivotally connected to the front frame 26 by means of a pair of brackets 44 and 46 secured thereto. With this arrangement, extension of the jack 36 and retraction of the jack 38 is effective to steer the vehicle to the right by articulation of the frame sections about the pivot connection 32. Alternately, retraction of the jack 36 and extension of the jack 38 is effective to steer the vehicle to the left by articulation of the front and rear frames about the pivot connection 32.

In order to permit the accomplishment of useful work with the vehicle 14, an implement generally indicated at 50 is supported at the outer end of the rear frame 16 and in this case constitutes a grapple mechanism for lifting and transporting a load. The grapple includes a base member 51 which is preferably universally connected to a rotator mechanism 52 secured to the outer free end of the boom 53. The boom includes a pair of laterally spaced mounting legs 54 which are pivotally connected to suitable brackets 55 and 56 secured to the rear frame 16. Any suitable power device such as a hydraulic jack, not shown, may be provided for raising and lowering the boom to control the elevational position of the grapple.

A plurality of suitable grapple forks 57 and 58 are individually pivotally supported on the base 51 for grasping and supporting a load therein. The pivotal movement of forks 57 and 58 is controlled by a pair of hydraulic jacks 62 and 64, respectively, which are individually pivotally interconnected between the base 51 and suitable brackets 66 and 68 on the forks 57 and 58, respectively. With this arrangement, extension of the jacks 62 and 64 rotate the forks inwardly about their pivotal connections toward a closed load-grasping position while retraction of the jacks rotates the forks outwardly about their pivotal connections to an open load-release position as illustrated in the drawing.

The series-type hydraulic circuit 12 includes a pump 74 which is adapted to draw fluid from a reservoir 76 for supply of fluid under pressure through a pump discharge passage, depicted as a line 78, to a steering control valve generally indicated at 82. The valve 82 is of the type disclosed in U.S. Pat. No. 3,260,325 assigned to the Assignee of the subject invention and a detailed disclosure and description of the construction and operation of that valve may be had by reference to that patent. Accordingly, the following brief summary of
the construction of the steering valve 82 will suffice for an understanding of the present invention. The valve 82 includes a body 84 having a pair of substantially parallel bores 86 and 88. The body further includes an inlet port 89 in fluid receiving relation to the supply line 78, a pair of work ports 90 and 92 and a pair of discharge ports 96 and 98 all of which communicate with the bore 88 for axially spaced points therealong. One of the discharge ports 98 also communicates with the bore 88 which reciprocally houses a spring biased compensating spool 100. The position of the compensating spool is controlled by a spring biased pilot poppet 101 and a shuttle valve 102 which has a signal port 103 in fluid communication by way of a line 104 with a chamber 105 disposed between the compensating spool and the pilot poppet. The compensating spool is normally biased into a closed seating relation with a hollow adapter plug 106 having a plurality of radial ports 107 communicating the interior of the plug with the inlet port 89. The compensating spool also includes an internal bore 108 and a plurality of staggered metering orifices 109 for selective communication of the inlet port with the discharge port 98.

A control spool 116 is reciprocally disposed in the bore 86 for selectively controlling communication between inlet port 89, work ports 90 and 92 and the discharge ports 96 and 98. A centering spring mechanism 118 is adapted resiliently to urge the spool 116 toward a neutral position which may be selectively moved in either direction from neutral to toward left and right steering positions. The motor ports 90 and 92 are connected by a pair of motor lines 120 and 122 to the steering jacks 36 and 38 for selective direction of fluid pressure to the jacks for controlling steering of the vehicle 14. A pair of signal lines 126 and 128 connect the motor lines 120 and 122, respectively, with a pair of signal ports 130 and 132 which are individually axially spaced on opposite sides of the signal port 103 of the shuttle valve 102. A shuttle spool 136 is reciprocally disposed in a bore 138 of the shuttle valve to control communication between the ports 130 and 132 and the signal port 106.

The discharge ports 96 and 98 are connected by a supply passage or line 144 to the inlet port 146 of a grapple control valve 148. The valve 148 is a three-position four-way valve including a body 150 housing a reciprocable spool 152 for selective control of communication between the inlet port 146, a pair of work ports 154 and 156 and a discharge port 158. The work ports are connected by a pair of lines 162 and 164, respectively, to the grapple actuating jacks 62 and 64 for selectively controlling the movements of the forks 57 and 58. The valve is of the open center type wherein fluid pressure in the inlet port 146 is communicated directly to discharge port 158 when the spool 152 is in the neutral position as shown. A pressure supply passage 170 in the body directs fluid by way of a check valve 172 from the inlet port 146 to a pressure supply annulus 174 which communicates with the spool 152 intermediate the axially spaced work ports 154 and 156. The fluid pressure in the annulus is available to either one of the work ports depending on the direction the spool is moved. Fluid discharged from the valve 148 returns to the reservoir by way of a return line 176.

A relief valve 180 controls communication between the line 144 and the line 176 by way of a bypass line 182 to limit the maximum working pressure in the grapple control system independently of the pressure in the steering system as controlled by the compensating spool 100 and pilot poppet 101 of the steering control valve 82. In one typical example, the relief valve 180 is set to open at and limit the grapple actuating pressure to approximately 2,040 psi.

In keeping with the principles of the present invention, the priority system 10 is disposed in fluid communicating relation between the line 144 supplying the inlet port 146 of the valve 148 and the return line 176 interconnecting the valve 148 and the reservoir 76. This location of the priority system operatively divides the steering and grapple systems into upstream and downstream systems, respectively, relative thereto. The priority system includes a priority valve 190 having a multi-part body 192 with a relatively large diameter bore 194 and a relatively small diameter bore 196 formed therein in end-to-end coaxial relation. An inlet port 198 and a discharge port 200 open into the bore 194 at axially spaced points therealong. A pilot control port 206 communicates with a control chamber 208 formed in the body adjacent to the outer end of the small diameter bore 196. The chamber 208 is closed by a plug 210 screw-threadedly received within the outer end of the bore. A drain port 212 communicates the opposite end of the bore 194 with the return line 176 by way of a line 214.

A spool 220 is reciprocably disposed in the bore 194 of the priority valve 190 for controlling communication between the inlet port 198 and the discharge port 200. A pair of springs 222 resiliently urge the spool 220 upwardly as viewed in the drawing into engagement with a shoulder 224 formed by the juncture of the bores 194 and 196 normally to block communication between the inlet port and the discharge port. Spool 220 further includes a plurality of axially staggered radially disposed modulating ports 226 and a plurality of diametrically aligned radial ports 230 disposed in axially spaced relation to the modulating ports for communication with a central bore 232 in the spool. The outer end of the bore 232 is closed by a cap 234 with the opposite end of the bore communicating by way of a restricted passage 236 with the lower end of the bore 194 which is, as previously described, communicated with the reservoir 76 by way of the port 212 and the line 214.

An actuating piston 240 is disposed in the bore 196 for engagement with the cap 234 at the upper end of the spool 220 whereby pressure in the chamber 208 acting on the piston 240 exerts a downward force on the spool 220 in opposition to the bias of the springs 222. In one preferred embodiment, the area of the piston 240 and the force of the springs 222 are correlated such that a pressure of approximately 2,200 psi is required to initiate opening movement of the spool 220.

The inlet port 198 of the valve 190 is communicated by a line 244 with the line 144 extending between the valve 82 and the inlet port 146 of the valve 148. The discharge port 200 of the valve 190 communicates by way of a line 246 with the return line 176 connected to the reservoir. The chamber 208 is in communication by way of the port 206 and a control passage or line 250 with the supply line 78 interconnecting the pump 74 and the valve 82.
While the operation of the present invention is believed clearly apparent from the foregoing description, further amplification will subsequently be made in the following brief summary of such operation. With reference to the drawing, when the valves 82 and 148 are in the neutral position as shown, the output of the pump 74 is returned to the reservoir by way of the line 78, the compensating spool 100, the line 144, the inlet port 146, the valve 148, the discharge port 158, and the return line 176. Under these conditions, the spool 116 of the valve 82 blocks the inlet port 80 from the work ports 90 and 92 with the work ports having restricted communication with the discharge ports 96 and 98. In the valve 148, the pressure supply passage 174 is blocked by the spool 152 from communication with the work ports 154 and 156 with communication between the work ports and the discharge passage 158 being blocked by the spool.

Movement of spool 116 of the valve 82 to either of its operative positions is effective to communicate the inlet port 80 with a respective one of the work ports 90 and 92 with the other work port being communicated to the respective one of the discharge ports 96 and 98. Such communication results in steering of the vehicle in one direction or the other depending on the direction of spool movement with the fluid displaced by the jacks 36 and 38 being directed to the valve 148 by way of the line 144. Fluid pressure in the steering system is limited to a safe predetermined value, for example 2,750 psi, by cooperation of the compensating spool 100 and the pilot poppet 101. The pressure compensation, as is more fully described in U.S. Pat. No. 3,260,325, is provided by a signal from the pressurized one of lines 120 and 122 being directed to the chamber 105 by way of the shuttle valve 102.

Under conditions wherein the steering system is activated with the grapple valve 148 in the neutral position, the pressure in the line 78 reflects only the pressure required to steer the vehicle. This pressure is communicated to the control chamber 208 by way of the line 250. Should the steering pressure exceed 2,200 psi, the spool 220 is biased toward an open position with no effect on the supply pressure. Steering pressure below 2,200 psi is ineffective to overcome the bias of springs 222 such that the spool 220 remains in the position illustrated blocking communication between the inlet port 198 and the discharge port 200 of the valve 190.

During operation of the steering system as last described, it is at times desirable that the operator move the spool 152 of the control valve 148 to an active position for actuation of the grapple 50 to avoid slipping of the load. The pressure required by the grapple is imposed as back pressure on the contracting ends of the steering cylinders 36 and 38. In instances where substantial pressure is required for operation of the grapple, the effective pressure acting on the steering cylinders with the steering system at relief valve pressure will be equal to the difference between the steering and grapple pressures. If both systems are at relief valve pressure, the differential across the steering system is only 710 psi with the supply pressure in line 78 being approximately 2,750 psi. As a result, the output of the pump 74 is bypassed across the compensating spool 100 such that positive steering control of the vehicle may be limited.

The addition of the priority system 10 to such a series-type hydraulic circuit overcomes this deficiency in the following manner. The pressure in the line 78 is communicated by the line 250 to the chamber 208. When the pressure in the control chamber 208 exceeds 2,200 psi, in one preferred embodiment of the priority system, the force exerted by the piston 240 against the spool 220 is sufficient to overcome the bias of the springs 222 thus the spool 220 begins to move downward. This establishes controlled communication between the line 144 and the return line 176 to limit the pressure build up in the line 144 and hence the grapple circuit associated with the valve 148. Such conditioning of the valve 190 provides a controlled bypass circuit in parallel with the grapple circuit to limit the maximum pressure therein in inverse proportion to the pressure in the supply line 78. This maintains a predetermined pressure differential between the steering and grapple systems when they are operated simultaneously to insure positive actuation of the steering system while permitting the grapple system to operate at an acceptable level somewhat lower than when the steering system supply pressure is below 2,200 psi or the steering system is inactive. For example, when the vehicle engine is operating at high idle with the steering circuit at relief valve pressure of 2,750 psi, the valve 190 opens sufficiently to limit pressure in the grapple circuit to 610 psi thus providing a differential across the steering circuit of 2,140 psi which is effective to steer the vehicle under all conditions.

Since the grapple relief valve 180 is set at 2,040 psi, operation of the grapple circuit alone is ineffective to actuate the valve 190; therefore, the grapple circuit is capable of working at full relief valve pressure when the steering system is inactive.

In view of the foregoing, it is readily apparent that the priority system of the present invention as employed with a series-type hydraulic circuit automatically insures a predetermined pressure differential between the steering system and the grapple control system when the supply pressure exceeds a predetermined minimum value. The priority system is responsive to supply pressure from the source automatically to establish a by-pass flow path in parallel to the grapple control system when the supply pressure exceeds a predetermined value to apportion a predetermined portion of the supply pressure for positive actuation of the steering system. This automatically provides a system wherein the steering circuit is given priority to insure that the vehicle may be steered by selectively limiting pressure in remaining circuits on the vehicle downstream of the steering circuit.

While the invention has been described and shown with particular reference to the preferred embodiment, it will be apparent that variations might be possible that would fall within the scope of the present invention which is not intended to be limited except as defined by the following claims.

What is claimed is:
1. A priority system for series-type hydraulic circuits comprising:
a source of fluid under pressure;
a plurality of hydraulic work systems;
means connecting said work systems in serial fluid communication to said source of fluid under pressure which fluctuates in response to varying work loads on the systems; and
priority valve means operatively associated with said connecting means between at least two of said work systems in a stream and downstream work systems on opposite sides of said priority valve means which is respon-
vive to fluid pressure between said source and said upstream system in excess of a first predetermined pressure level for automatically reducing pressure in the downstream work system so that a predetermined minimum pressure differential is maintained between the downstream and upstream work systems when they are operated simultaneously to insure positive actuation of the upstream system while permitting the downstream work system to operate at an acceptable level somewhat lower than when the upstream work system is inactive.

2. The priority system of claim 1 wherein said source of fluid under pressure includes a pump, a pump discharge passage communicating between said pump and said upstream work system, and a low pressure reservoir, said connecting means comprises a fluid supply passage for said downstream work system, said priority valve means includes a bypass passage disposed in parallel with said downstream work system for communicating said fluid supply passage with said reservoir, and a body housing a spring biased spool means normally to block said bypass passage but being moveable to provide a variable orifice in said bypass passage for metering fluid from said fluid supply passage when the pressure in said pump discharge passage exceeds said first predetermined pressure level.

3. The priority system of claim 2 including actuating means operatively engaging said spool means in opposition to said spring bias and control passage means operatively connecting said actuating means with said pump discharge passage whereby said actuating means is responsive to pressure in said pump discharge passage in excess of said first predetermined pressure level for moving said spool and opening said variable orifice to vent fluid from said fluid supply passage and control pressure in said downstream system inversely to said source pressure.

4. The priority system of claim 3 wherein the series-type hydraulic circuits are operatively associated with a hydraulically steered vehicle having at least one other hydraulically controlled function therein.

5. The priority system of claim 4 wherein the upstream work system is a steering system operative to control vehicle steering and the downstream work system is an implement system operative to control said at least one other hydraulically controlled function.

6. The priority system of claim 5 wherein said spool means includes an elongated reciprocable spool having metering means cooperating with said body to provide said variable orifice upon movement of said spool away from the spring biased blocking position, said actuating means includes a reciprocable piston disposed in an actuating chamber and engaging said spool in opposition to said spring bias, and said control passage means communicates with said actuating chamber for supply of pressure from said pump discharge passage thereto so that pump discharge pressure in excess of said first predetermined level acting on said piston will overcome said spring bias to move said elongated spool away from said blocking position.

7. The priority system of claim 6 wherein said steering system includes a steering control valve for select-
tive control of vehicle steering, a steering relief valve in said steering system for limiting fluid pressure in said steering system to a second predetermined level, and said implement circuit includes an implement control valve for selectively controlling fluid flow therein and an implement relief valve for limiting fluid pressure in said implement circuit to a third predetermined level less than said second predetermined maximum level.

8. The priority system of claim 7 wherein the magnitude of said spring bias is selected so that said first predetermined pressure level is intermediate said second and third predetermined pressure levels.

9. A priority system for serially arranged vehicle steering and implement hydraulic circuits supplied respectively from a source of fluid pressure including a pump and a reservoir with a supply passage communicating between the steering and implement circuits comprising:

a bypass flow path communicating between such a supply passage and the reservoir and arranged in parallel to the implement circuit;

Priority valve means disposed in said bypass flow path and normally resiliently biased to a closed position blocking flow therethrough and moveable to progressively open said bypass flow path to permit variable restricted communication between the supply passage and the reservoir; and actuating piston means operatively associated with said priority valve means in opposition to said resilient bias and responsive to fluid pressure between the pump and the steering circuit above a predetermined value to move said priority valve means away from said closed position and vent fluid pressure from the supply passage and limit pressure in the implement circuit so that a predetermined minimum pressure differential is maintained between the steering circuit and the implement circuit when the steering and implement circuits are both active.

10. A priority system for series-type hydraulic circuits comprising:

a source of fluid under pressure;

primary work system including primary valve means for selectively controlling fluid flow in said work system;

means connecting said primary work system with said source of fluid under pressure;

secondary work system including secondary valve means for selectively controlling fluid flow therein;

supply passage means serially connecting said secondary valve means through said primary work system and said connecting means to said source of fluid under pressure; and

priority valve means operatively associated with said supply passage means between said primary and secondary valve means and responsive to fluid pressure in said connecting means automatically to establish a bypass flow path in parallel to said secondary work system when the pressure in said connecting means exceeds a predetermined value so that a predetermined minimum pressure differential is maintained between said supply passage means and said connecting means when the primary and secondary valve means are operated simultaneously to insure positive actuation of said primary work system.
11. The priority system of claim 10 including a primary relief valve in said primary work system for limiting pressure in said primary work system to a first predetermined maximum level, a secondary relief valve in said secondary work system for limiting pressure in said secondary work system to a second predetermined maximum level which is substantially less than said first predetermined maximum level and said predetermined pressure value to which said priority valve is responsive is less than said first predetermined maximum level and higher than said second predetermined maximum level so that said priority valve is responsive only to pressure in said connecting means between said source of fluid pressure and said primary work system.