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J. J. SLOMER

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EMERGENCY OPERATED DUAL PRESSURE HYDRAULIC SYSTEM

Filed March 31, 1951

2 Sheets-Sheet 1

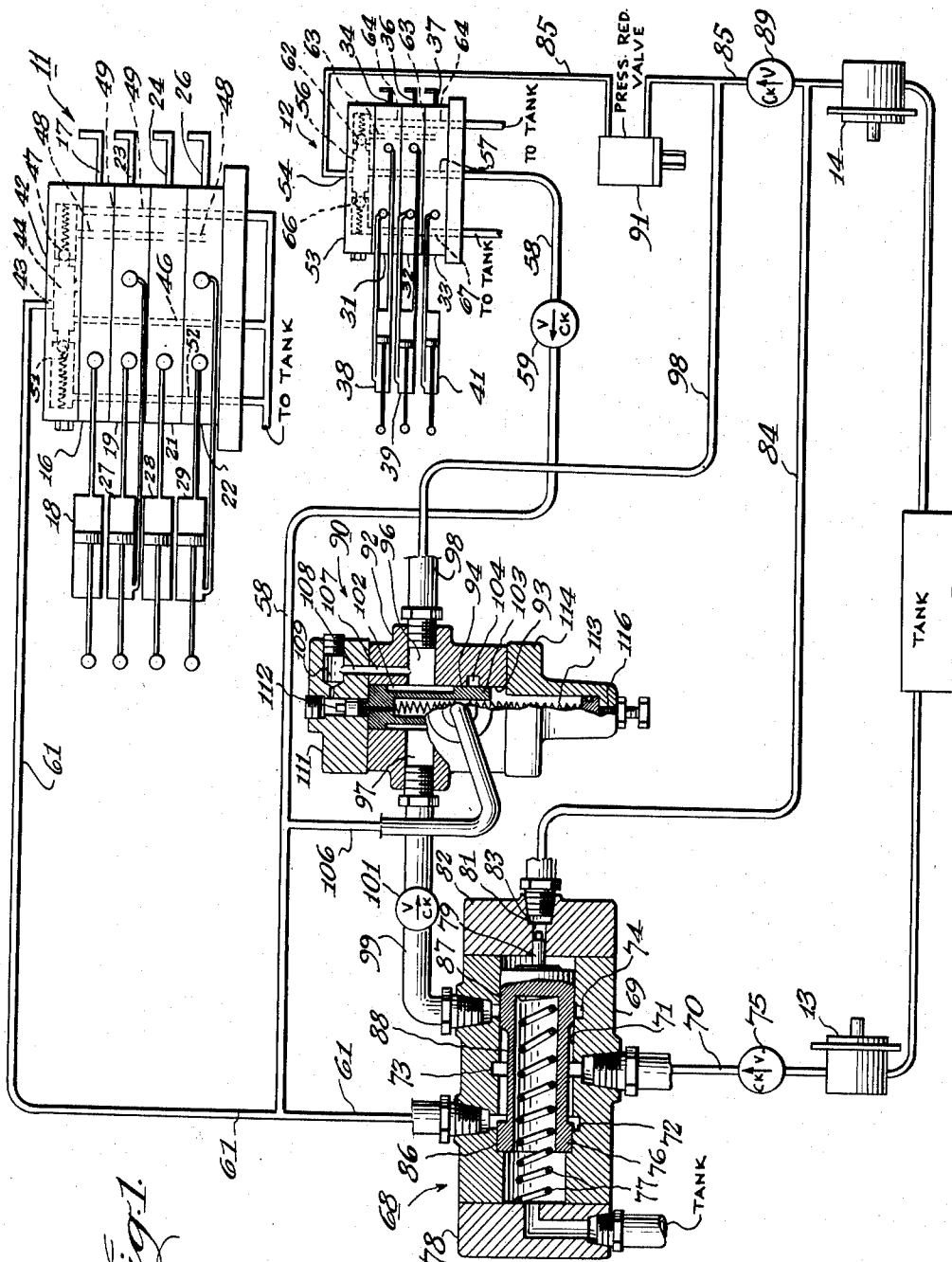


Fig. 1

Inventor
Joseph J. Slomer
By Murray A. Gleason
Attorney

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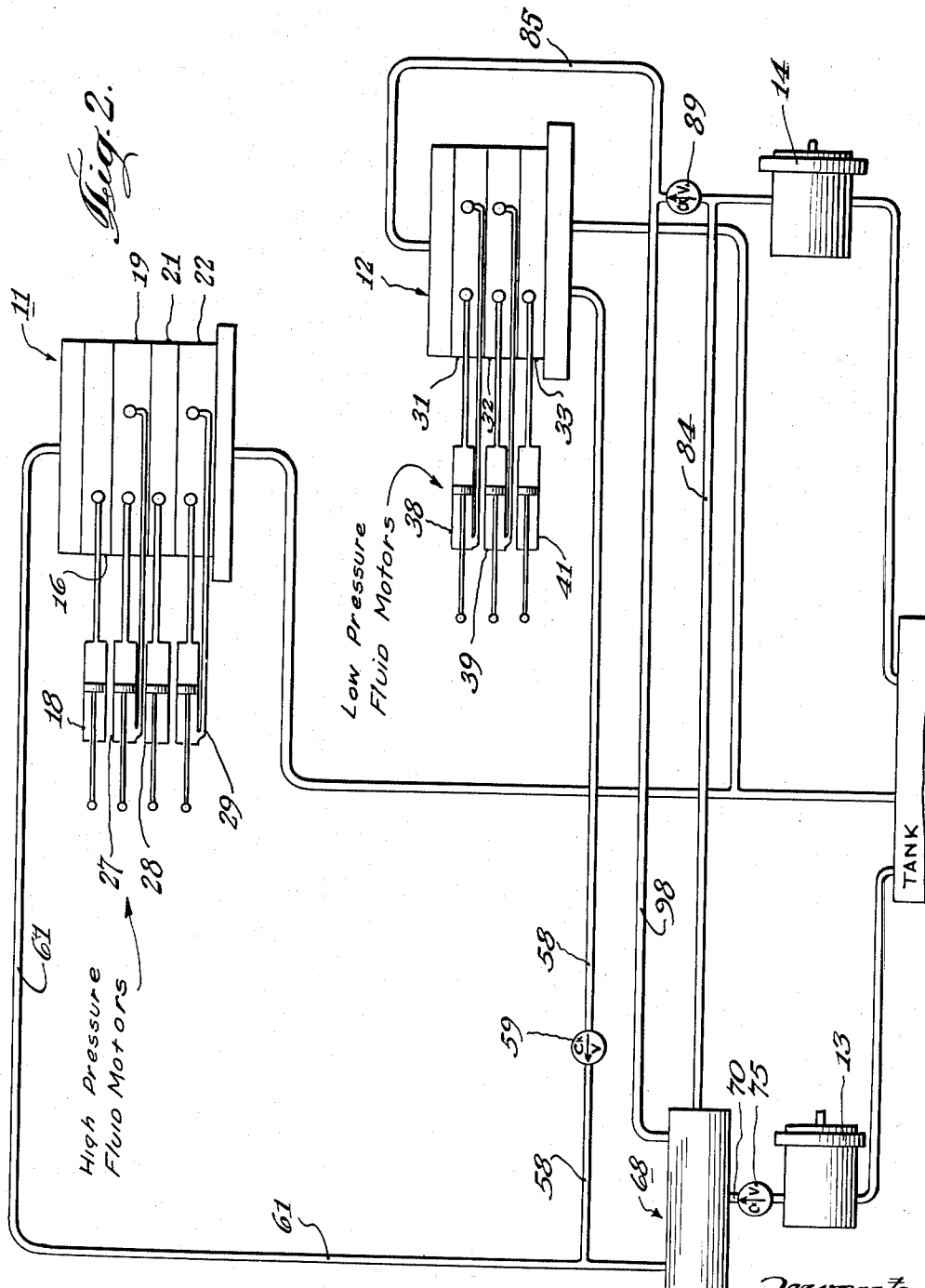
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2 Sheets-Sheet 2



High Pressure Fluid Motors

Low Pressure
Fluid Mot-

TANK

Inventor
Joseph J. Slonimer
By Murray A. Gleason
Attorney

UNITED STATES PATENT OFFICE

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EMERGENCY OPERATED DUAL PRESSURE
HYDRAULIC SYSTEM

Joseph J. Slomer, Chicago, Ill., assignor to Goodman Manufacturing Company, Chicago, Ill., a corporation of Illinois

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13 Claims. (Cl. 60—52)

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This invention relates generally to fluid pressure systems and more particularly to a system supplied with pressure fluid from more than one fluid pressure pump, and wherein the system may continue to operate in the event of failure of one of the fluid pressure pumps.

In certain types of fluid pressure operated devices it has heretofore been the practice to employ separate pumps for supplying pressure fluid to individual groups of fluid pressure operated motors. In such types of equipment, the failure of one pump has resulted in the inability to operate the fluid motors supplied thereby, and while the remaining pump may have sufficient capacity to operate all of the fluid motors, at least on an emergency basis, the isolation of one group of fluid pressure operated motors from the other has made such emergency operation impossible.

According to the present invention, the system is provided with a pair of fluid pressure pumps, each operating to furnish a share of the pressure fluid necessary to operate the fluid motors of the system, and so connected that upon failure of either of the pumps, the remaining operative pump may be utilized to operate the entire system on an emergency basis though such operation may be at a somewhat reduced speed. In carrying out the invention, the pumps are connected to banks of selector or control valves regulating the admission of pressure fluid to various fluid motors. In a particular embodiment of the invention, one such bank of control valves is designed to control the operation of fluid motors at relatively low working pressures and the other such bank of control valves is designed to control the operation of fluid motors at relatively high working pressures. In order to minimize the wear attendant upon the pumps from working against high back pressures, the pumps are so arranged as to work against the back pressures occasioned only by the resistance to flow through the banks of selector or control valves when in the neutral or off position. Under conditions when the low pressure fluid motors are operating only one of the pumps is required to work against the back pressure from such fluid motors while the other pump is required to work against substantially no back pressure or that occasioned by the resistance to flow through the bank of control valves for the high pressure fluid motors when in the neutral or off position. Under conditions when the high working pressure fluid motors are operating, both pumps are arranged to supply pressure fluid at such high pressures, and also

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under such condition the low working pressure motors may be supplied with pressure fluid at a proper pressure.

The present invention may also be considered as affording a supply of pressure fluid to two different banks of fluid motors, one bank of such fluid motors requiring for their operation a large volume of pressure fluid, substantially the output from both of said pumps, the other bank of such fluid motors requiring for their operation but a small portion of the output from either of the pumps and at a low working pressure. The pumps supplying pressure fluid for both banks of fluid motors are so arranged as to pump against a minimum back pressure occasioned by the resistance to flow through the selector or control valves when said valves are in the neutral or off position.

The invention is further characterized by a pressure responsive valve having a shuttle valve member therein which is movable when one of the pumps fails to operate for some reason, said shuttle valve member being so constructed as to pass the pressure fluid into the portion of the system normally supplied by the inoperable pump, while at the same time providing for the supply to the other portion of the system. Said shuttle valve member and the system are also so constructed that pressure fluid may be supplied to both portions of the system when the other pump fails for some reason, so that irrespective of the failure of either pump the system may continue to operate.

With the foregoing considerations in mind it is a principal object of the invention to afford a fluid pressure system including a pair of pumps for supplying pressure fluid, and to enable the system to continue to operate irrespective of the failure of one of the pumps of the system.

Another object is to provide a fluid pressure system characterized by fluid pressure motors operating at different working pressures, and to provide a pair of fluid pressure pumps for supplying pressure fluid to the system, and to enable the system to function irrespective of the failure of one of the pumps.

Yet another object comprehends a fluid pressure system having a pair of pumps, the pumps being adapted to supply pressure fluid for all of the fluid pressure motors of the system, and one of the pumps being connected to supply pressure fluid for a group of intermittently operated fluid motors which require a lower working pressure than the other fluid motors of the system.

Still another object of the invention is to pro-

vide a hydraulic system including fluid motors operable at high pressure and requiring a large volume of pressure fluid, and other fluid motors operable at low pressure and requiring but a small volume of pressure fluid, the system including a pair of pumps each supplying pressure fluid in quantity to operate both the high pressure large volume fluid motors, and the low pressure low volume motors, one of the pumps of the system being considered as being connected to supply the low pressure low volume fluid motors during periods when no demand is made by the high pressure large volume fluid motors.

The foregoing and other objects and important features of the invention will be apparent from a study of the within specification taken with the drawings which together show preferred embodiments of the invention and what is now considered to be the best mode of applying the principles thereof. The invention is not intended to be limited, however, by the precise embodiment shown herein, and other embodiments of the invention will become apparent to those having the teachings herein, and it is therefore intended that the scope of the invention be limited only as defined in the appended claims.

In the drawings:

Figure 1 shows a fluid pressure system embodying the invention herein, certain valve elements thereof being shown in longitudinal section; and

Figure 2 shows a fluid pressure system embodying the invention herein in a more simplified form.

Referring now to Figure 1 of the drawings, the hydraulic system according to the present invention includes a bank of selector or control valves 11, and another bank of selector or control valves 12 which are supplied with pressure fluid from fluid pressure pumps 13 and 14. The bank of selector valves 11 includes a control valve 16 having a shiftable valve actuator 17 controlling the entrance of pressure fluid to a single acting fluid motor 18. Control valves 19, 21 and 22 are provided respectively with shiftable valve actuators 23, 24, and 26, and control respectively the operation of a double acting fluid motor 27, a single acting fluid motor 28, and a double acting fluid motor 29. The bank of selector or control valves 12 includes control valves 31, 32 and 33 having shiftable valve actuators 34, 36 and 37 and respectively controlling double acting fluid motors 38 and 39, and a single acting fluid motor 41.

The precise form of each of the selector valves 16, 19, 21 and 22 is no part of the invention herein, except that such valves may be claimed in combination with a fluid pressure system, and the bank 11 of selector valves 16, 19, 21, 22 includes a valve body 42 having an inlet pressure port 43 and a pressure chamber 44. When all of the valves 16, 19, 21 and 22 are in the neutral position, the pressure chamber 44 is connected to tank by a passageway 45 common to all of said valves, and as is common in such valves, the passageway 45 is closed by the actuation of one or more of the control valves 16, 19, 21 or 22. The pressure chamber 44 is provided with a check valve 47 which passes pressure fluid to pressure ports 48 within the several control valves 16, 19, 21 and 22, and the pressure fluid may be exhausted to tank upon release of each valve by one or more exhaust ports 49 within each of said valves. The pressure chamber 44 is also provided with a relief valve 51 which opens when the

working pressure within the several fluid motors is in excess of a desired value, which in the application here may be of the order of 700 p. s. i., and the excess of pressure is relieved through the bank of selector valves 11 by a relief passageway 52 connected to tank.

The bank of selector or control valves 12 similarly includes a valve body 53 having an inlet pressure port 54 and a pressure chamber 55. When all of the valves 31, 32 and 33 are in the neutral position, the pressure chamber 55 is connected by a passageway 57 through the several valves to a pressure line 58 having a check valve 59 therein. The pressure line 58 is connected to a pressure line 61 which connects with the bank of selector valves 11 at the entrance port 43, and pressure fluid will be exhausted to tank through the passageway 46 of the valves 16, 19, 21 and 22 when the control valves of bank 11 are in the neutral position.

The pressure chamber 56 of the bank of control valves 12 is provided with a check valve 62 which permits pressure fluid to pass to pressure ports 63 within the several control valves 31, 32 and 33, and the pressure fluid is ported to tank upon release of each valve by one or more exhaust ports 64 within each of said valves. The pressure chamber 56 is also provided with a pressure relief valve 66 which opens when the working pressure within the several fluid motors 38, 39 and 41 is in excess of a desired value, which in the case of said motors may be of the order of 250 p. s. i., and the excess of such pressure is relieved through the bank of selector valves 12 by a relief passageway 67 connected to tank.

The pumps 13 and 14 are both adapted to supply pressure fluid to the bank of selector valves 11 and 12 and the respective fluid motors controlled thereby, the flow of pressure fluid from the pumps 13 and 14 being controlled by a pressure responsive valve indicated generally by the reference numeral 68. The pressure responsive valve 68 includes a valve body 69 having a bore 71 therein intersected by annular ports 72, 73 and 74 spaced longitudinally of the bore 71. A hollow spool valve member 76 is slidable within the bore 71 and is urged to the right as seen in the drawing by a spring bottomed at one end within the hollow spool 76 and bottomed at the other end by an end cap 78 secured to the valve body 69. Port 72 is connected to the pressure line 61, and port 73 is connected to the pump 13 by a pressure line 70 including a check valve 75 therein.

The spool valve member 76 is formed with a piston-like extension 79 which fits within a bore 81 of an opposite end cap 82 of the valve body 69. The piston 79 is subjected to the pressure at a port 83 connected by a pressure line 84 to the output side of the pump 14. The spool valve member 76 is also formed with end lands 86 and 87 and with a portion 88 between the lands 86 and 87 of diameter less than the diameter of the bore 71, so that the pressure fluid from the pump 13 may flow from port 73 and out port 72 or 74 depending upon the position of the spool valve member 76.

Under conditions when the pump 14 is functioning properly, the pressure in the line 84 and against the piston 79 will force the spool valve member to the left against the force of the spring 77 so that the port 74 is lapped by the land 87, and so that the port 72 is uncovered for movement of the pressure fluid from pump 13 past port 73 and into the line 61 to supply the pressure fluid to

the bank of selector valves 11 and the fluid motors controlled thereby.

The pressure fluid from the pump 14 is also supplied to the bank of selector valves 12, and the motors controlled thereby, by a pressure line 85 having a check valve 89 therein, and the pressure of the fluid from pump 14 is reduced by a pressure reducing valve 91, the pressure being reduced to a value of around 250 p. s. i.

The back pressure against the pump 14 is relieved through a back pressure relief valve indicated generally by the reference numeral 90 which is so connected that the back pressure on the pump 14 upon actuation of the fluid motors 38, 39 and 41 is relieved through passageway 57 of the bank of control valves 12. The back pressure relief valve 90 includes a valve body 92 having a central bore 93 therein fitted with a hollow valve spool member 94. The valve body 92 has a pair of aligned ports 95 and 97, the port 95 being connected by a pressure line 98 to the output of the pump 14. The port 97 is connected by a pressure line 99 to the annular port 74 of the valve body 69, and a check valve 101 in the pressure line 99 is so arranged as to block the flow of pressure fluid from the back pressure relief valve 90 to the pressure responsive valve 68.

The valve spool member 94 is arranged with a portion of reduced diameter 102 and has a land 103 lapping a port 104 connecting with a relief pressure line 106 connecting with the pressure line 58. The pressure at the port 96 is communicated by a pressure passageway 107 and pressure passageways 108 and 109 against a piston 112 slidable in an end cap 111 of the valve body 92. The piston 112 rests upon the spool valve member 94 and the pressure against the piston 112 is opposed by a spring 113. An end cap 114 is affixed to the valve body 114 and forms a support for an adjusting screw 116 against which the spring 113 is bottomed, the other end of the spring being bottomed, within the hollow valve spool member 94. The spring 113 is so adjusted as to provide for movement of the hollow spool valve member 94 so that the land 103 unlaps the port 104 to pass pressure fluid from the pressure line 98 into the back pressure line 58 when the back pressure against pump 14 increases beyond a value of the order of 300 p. s. i.

The system thus far described is operable to supply pressure fluid to the several fluid motors when both pumps are functioning properly, or when either pump has failed for some reason. In the case where both pumps are functioning properly, pump 13 is required to pump only against a minimum back pressure in the neutral position of the control valves 11 as may be occasioned by the construction of the control valves 11 and the head losses of the supply line. In such case, the pumped fluid passes from the port 72 of the pressure responsive valve 68, the spool valve member being in the position shown by the pressure from pump 14, and to the control valves 11 by the pressure line 61. When both banks of control valves 11 and 12 are in the neutral position, pump 14 is required to pump against a minimum back pressure as determined by the resistance to flow through the pressure reducing valve 91 and the resistance to flow through the bank of selector valves 12.

When fluid motors 38, 39 and 41 are operated pump 14 will operate against the back pressure created by said fluid motors. The working pressure for the fluid motors 38, 39 and 41 being limited by the pressure reducing valve 91, and the

back pressure relief valve 90, which will be remembered as giving a back pressure of the order of 300 p. s. i.

When fluid motors 18, 27, 28 and 29 are operated both pumps will operate at the same pressure, since the back pressure from said motors will be placed against the check valve 59. The back pressure against pump 14 will open the pressure relief valve 90, so that the pressure fluid will be supplied past the spool valve member 94 and into the line 106.

If the pump 13 should fail to operate for some reason, pressure fluid is supplied by pump 14 to both banks of fluid motors. The fluid motors 38, 39 and 41 under such conditions of the system will be supplied with fluid at a pressure as determined by the pressure reducing valve 91, the supply of fluid during neutral or off position of the valve being circulated through the passageway 57, the lines 58 and 61 and to tank through the bank of control valves 11. When the fluid motors 18, 27, 28 and 29 are operated, fluid will be supplied thereto from the pump 14 and through the bank of selector valves 12. However, when the motors 38, 39 and 41 are operated and at times when the fluid motors 18, 27, 29 and 29 are also operated, the back pressure from the motors 38, 39 and 41 will cause the fluid to be supplied through the back pressure relief valve 90, the pressure fluid being supplied past the spool valve member 94 and into the line 61 to the fluid motors 38, 39 and 41.

If the pump 14 should fail to operate for some reason, pressure fluid is supplied to the system by pump 13 to both banks of fluid motors. Upon failure of pump 14, the pressure against the piston 79 of the spool valve 76 no longer obtains, and the spring 77 therefore urges the spool valve member 76 to the right to lap the port 72 by the land 86. The pressure fluid from the pump 13 then moves past port 74 which is unlapped by the land 87, through the back pressure relief valve 90 past the spool valve 94 to the pressure line 98 and thence to the pressure line 85 leading from the pump 14. During periods of no demand by either of the banks of selector valves 11 or 12, the pumps 13 and 14 are operating only against a minimum back pressure of the supply lines and the banks of control valves when in the neutral position. If the fluid motors 38, 39 and 41 are operated by the bank of control valves 12 fluid will be supplied at the limiting pressure afforded by the pressure reducing valve 91. If the fluid motors associated with the bank of control valves 11 are operated while the fluid motors 38, 39 and 41 are operating, fluid will be supplied thereto through the back pressure relief valve 90, the path of the pressure fluid from the pump 14 being through the pressure line 98, around the spool valve member 94, the pressure lines 106, 58 and 61. If fluid motors 18, 27, 28 and 29 are operated, pressure fluid will be supplied through the bank of control valves 12 until the back pressure from said motors causes the back pressure relief valve 90 to open to pass fluid from pump 13 through valve 90 and into the pressure line 61. Obviously, when both sets of motors are operated the back pressure on the pump 13 will be that determined by the high working pressures of the fluid motors 18, 27, 28 and 29.

Referring now to Figure 2 of the drawings, there is shown a simplified form of the invention, characterized by the elimination of the back pressure relief valve for bypassing fluid upon failure of one of the fluid pressure pumps. In

this form of the invention the same reference numerals are used to designate the parts of the system common also to the form shown in Figure 1 of the drawings. In this form of the invention both pumps 13 and 14 are arranged to pump against substantially no back pressure when the banks of control valves 11 and 12 are in the neutral or off position. When pump 14 is operating, pressure responsive valve 58 is arranged to pass the pressure fluid from pump 13 to the pressure line 61 and to the bank 11 of control valves. Pump 14 may be considered as supplying pressure fluid to the bank of control valves 12. When any of the fluid motors 38, 39 and 41 are operated a back pressure will be placed against pump 14 in accordance with the working pressure of each and the setting of the relief valve 66 associated with the control valves 12. Under such condition pump 13 continues to operate against substantially no back pressure as before.

When fluid motors 18, 27, 28 and 29 are operated a back pressure will be maintained against the pump 13, and until the limiting pressure is reached as determined by the setting of the pressure relief valve 66 of bank 12, fluid will also be supplied by the pump 14. When such limiting pressure is reached the output from pump 14 will be relieved through passageway 67. If fluid motors 38, 39 and 41 are operated during operation of the motors 18, 27, 28 and 29 the limiting pressure thereon will be as determined by the pressure relief valve 66, as shown in Figure 1.

If pump 13 should fail to operate, pressure fluid is supplied to the system by the pump 14, fluid being supplied to the bank of control valves 11 by pressure line 35, pressure passageway 57, pressure lines 58 and 61. It should be noted that under such condition the maximum pressure of the fluid supplied to the motors 18, 27, 28 and 29 will be as limited by the pressure relief valve 66.

If pump 14 should fail to operate, pressure fluid is supplied by the pump 13, the pressure responsive valve 58 then being positioned to pass pressure fluid from pump 13 to the line 98 and thence to the line 35. Fluid is then supplied under pressure via passageway 57 and pressure lines 58 and 61 to the bank of control valves 11.

From the foregoing description it will be apparent that there has been provided a novel fluid pressure system characterized by the use of a pair of pumps for supplying pressure fluid to fluid motors of different capacities and working pressures. The system according to the present invention enables large volume high pressure motors to be supplied by the output from both pumps, and enables one pump to supply low volume low pressure motors without affecting the back pressure against the other pump. The system according to the present invention also enables the motors to be operated on an emergency basis should one of the pumps fail, the properly operating pump being connected by the pressure responsive valve to supply pressure fluid to the entire system.

In one form of the invention a back pressure relief valve is employed to provide for high pressure fluid for the high pressure motors upon failure of one of the pumps, although the total volume available for operating the high pressure large volume motors is reduced by the capacity of the inoperable pump. In another form of the invention the back pressure relief valve is dispensed with so that upon failure of one of the

pumps the system is supplied with fluid at a pressure as may be limited by the setting of a pressure relief valve associated with the low pressure motors.

While the invention has been described in terms of some preferred embodiments thereof, it is not intended that the invention herein be limited by the precise embodiments herein shown, which have been by way of illustration only and not by way of limitation, nor otherwise than by the terms of the claims here appended.

I claim:

1. A fluid pressure system comprising a high pressure fluid motor including a control valve therefor, a low pressure fluid motor including a control valve therefor, a pump adapted to supply fluid under pressure to said first named control valve for said high pressure fluid motor with substantially no back pressure against said pump when said first named control valve is in an off or neutral position, a second pump adapted to supply fluid under pressure to said second named control valve for said low pressure fluid motor, a back pressure relief valve for maintaining a back pressure against said second pump below a predetermined value upon operation of said low pressure fluid motor, and means for causing said system to remain operative irrespective of the failure of either of said pumps comprising a valve having a movable valve member therein responsive in its movement to the pressure from said second named pump, said valve having a port therein for the passage of pressure fluid from said first named pump to said first named control valve when said second named pump is operative, and having a port therein for passage of pressure fluid from said first named pump to the output side of said second named pump when said second named pump is inoperative.

2. A fluid pressure system comprising a high pressure fluid motor including a control valve therefor, a low pressure fluid motor including a control valve therefor, a pump adapted to supply fluid under pressure to said first named control valve for said high pressure fluid motor with substantially no back pressure against said pump when said first named control valve is in an off or neutral position, a second pump adapted to supply fluid under pressure to said second named control valve for said low pressure fluid motor, a back pressure relief valve for maintaining a back pressure against said second pump below a predetermined value upon operation of said low pressure fluid motor, and means for causing said system to remain operative irrespective of the failure of either of said pumps comprising a valve having a movable valve member therein responsive in its movement to the pressure from said second named pump, said valve having a port therein which is unlapped by movement of said valve member in response to the pressure from said second named pump for the passage of pressure fluid from said first named pump to said first named control valve, a port in said valve which is uncovered when said second named pump is inoperative for passage of pressure fluid from said first named pump to the output side of said second named pump.

3. In a fluid pressure system, a low pressure small volume fluid motor having a control valve therefor, a high pressure large volume fluid motor having a control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off

position, a fluid pressure conduit connecting the first of said pumps to said high pressure fluid motor, and a second fluid pressure conduit connecting the second of said pumps to said low pressure motor, a valve responsive to the pressure from said second pump for maintaining the back pressure against the said first pump at a minimum when the low pressure motor is being operated by said second pump.

4. In a fluid pressure system, a low pressure small volume fluid motor having a control valve therefor, a high pressure large volume fluid motor having a control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said high pressure fluid motor, a second fluid pressure conduit connecting the second of said pumps to said low pressure motor, a valve responsive to the pressure from said second pump for maintaining the back pressure against the said first pump at a minimum when the low pressure motor is being operated by said second pump, and a valve member in said pressure responsive valve which is movable upon failure of said second pump so that pressure fluid may be supplied to both of said fluid motors by the remaining operative pump.

5. In a fluid pressure system, a low pressure small volume fluid motor having a control valve therefor, a high pressure large volume fluid motor having a control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said high pressure fluid motor, a second fluid pressure conduit connecting the second of said pumps to said low pressure motor, a back pressure relief valve for maintaining the back pressure against said second pump below a predetermined value upon operation of said low pressure fluid motor, said back pressure relief valve affording a connection from the output side of said second pump to said first fluid pressure conduit for the supply of pressure fluid from both of said pumps when said high pressure large volume fluid motor is being operated.

6. In a fluid pressure system, a low pressure small volume fluid motor having a control valve therefor, a high pressure large volume fluid motor having a control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said high pressure fluid motor, a second fluid pressure conduit connecting the second of said pumps to said low pressure motor, a back pressure relief valve for maintaining the back pressure against said second pump below a predetermined value upon operation of said low pressure fluid motor, said back pressure relief valve affording a connection from the output side of said second pump to said first fluid pressure conduit for supply of pressure fluid from both of said pumps when said high pressure large volume fluid motor is being operated, and a valve responsive to the pressure from said second pump for maintaining the flow of pressure fluid from said first pump to said first named control valve.

7. In a fluid pressure system, a low pressure small volume fluid motor having a control valve therefor, a high pressure large volume fluid mo-

tor having a control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said high pressure fluid motor, a second fluid pressure conduit connecting the second of said pumps to said low pressure motor, a back pressure relief valve for maintaining the back pressure against said second pump below a predetermined value upon operation of said low pressure fluid motor, said back pressure relief valve affording a connection from the output side of said second pump to said first fluid pressure conduit for supply of pressure fluid from both of said pumps when said high pressure large volume fluid motor is being operated, and a valve responsive to the pressure from said second pump including a valve member which is movable upon failure of said second pump so that pressure fluid may be supplied to both of said fluid motors from said first pump.

8. In a fluid pressure system, a low pressure small volume fluid motor having a control valve therefor, a high pressure large volume fluid motor having a control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said high pressure fluid motor, a second fluid pressure conduit connecting the second of said pumps to said low pressure motor, a back pressure relief valve for maintaining the back pressure against said second pump below a predetermined value upon operation of said low pressure fluid motor, said back pressure relief valve affording a connection from the output side of said second pump to said first fluid pressure conduit for directing the supply of pressure fluid from both of said pumps when said high pressure large volume fluid motor is being operated, and means for causing said system to remain operative irrespective of the failure of either of said pumps comprising a valve having a movable valve member therein responsive in its movement to the pressure from said second pump, said valve having a port therein for the passage of pressure fluid from said first pump to said first control valve when said second pump is operative, and having a port therein for passage from said first named pump to the output side of said second named pump when said second named pump is inoperative.

9. A fluid pressure system comprising a first fluid motor including a first control valve therefor, a second fluid motor including a second control valve therefor, a pump adapted to supply fluid under pressure to said first named control valve for said first fluid motor with substantially no back pressure against said pump when said first named control valve is in an off or neutral position, a second pump adapted to supply fluid under pressure to said second named control valve for said second named fluid motor, a back pressure relief valve for maintaining a back pressure against said second pump below a predetermined value upon operation of said second named fluid motor, and means for causing said system to remain operative irrespective of the failure of either of said pumps comprising a valve having a movable valve member therein responsive in its movement to the pressure from said second named pump, said valve having a port therein for the passage of pressure

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fluid from said first named pump to said first named control valve when said second named pump is operative, and having a port therein for passage of pressure fluid from said first named pump to the output side of said second named pump when said second named pump is inoperative.

10. In a fluid pressure system, a first fluid motor having a first control valve therefor, a second fluid motor having a second control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said first named fluid motor, a second fluid pressure conduit connecting the second of said pumps to said second named fluid motor, and a valve responsive to the pressure from said second pump for maintaining the back pressure against the first pump at a minimum when the second named fluid motor is being operated by said second pump.

11. In a fluid pressure system, a first fluid motor having a first control valve therefor, a second fluid motor having a second control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said first named fluid motor, a second fluid pressure conduit connecting the second of said pumps to said second named fluid motor, a valve responsive to the pressure from said second pump for maintaining the back pressure against the said first pump at a minimum when the second named fluid motor is being operated by said second pump, and a valve member in said pressure responsive valve which is movable upon failure of said second pump so that pressure fluid may be supplied to both of said fluid motors by the remaining operative pump.

12. In a fluid pressure system, a first fluid motor having a first control valve therefor, a second

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fluid motor having a second control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral position, a fluid pressure conduit connecting the first of said pumps to said first named fluid motor, a second fluid pressure conduit connecting the second of said pumps to said second named fluid motor, a back pressure relief valve for maintaining the back pressure against said second pump below a predetermined value upon operation of said second named fluid motor, said back pressure relief valve affording a connection from the output side of said second pump to the first fluid pressure conduit for the supply of pressure fluid from both of said pumps when said first named fluid motor is being operated.

13. In a fluid pressure system, a first fluid motor having a first control valve therefor, a second fluid motor having a second control valve therefor, a pair of pumps adapted to supply pressure fluid to said system with substantially no back pressure when both of said control valves are in a neutral or off position, a fluid pressure conduit connecting the first of said pumps to said first named fluid motor, a second fluid pressure conduit connecting the second of said pumps to said second named fluid motor, a back pressure relief valve for maintaining the back pressure against said second pump below a predetermined value upon operation of said second named fluid motor, said back pressure relief valve affording a connection from the output side of said second pump to said first named fluid pressure conduit for the supply of pressure fluid from both of said pumps when said first named fluid motor is being operated, and a valve responsive to the pressure from said second pump including a valve member which is movable upon failure of said second pump so that pressure fluid may be supplied to both of said fluid motors from said first pump.

JOSEPH J. SLOMER.

No references cited.