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[54] **HYDRAULIC SYSTEM AND VALVE THEREFOR**

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[51] **Int. Cl.**.....**F16b 15/18**

[58] **Field of Search**.....60/52 HE, 97 P; 91/414

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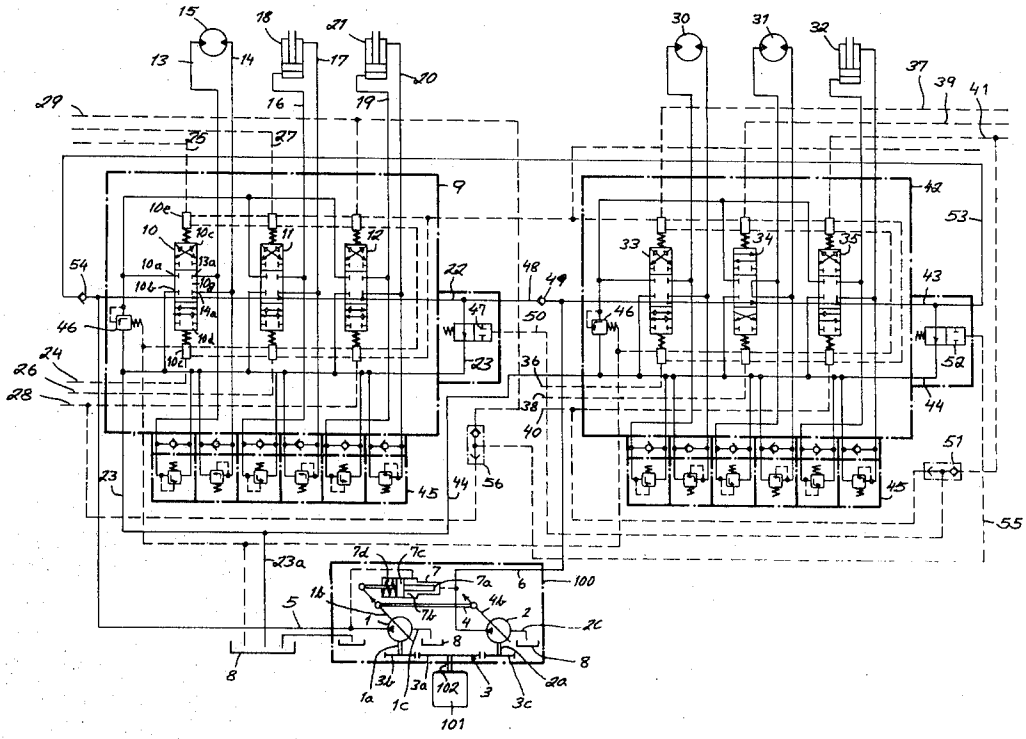
[57] **ABSTRACT**

A two-pump hydraulic system having a hydraulic load which, when actuated, is automatically pressurized by both pumps through a novel valve system. Normally each of the pumps circulates hydraulic fluid along a closed path to a reservoir and can be used independently to operate respective loads.

19 Claims, 2 Drawing Figures



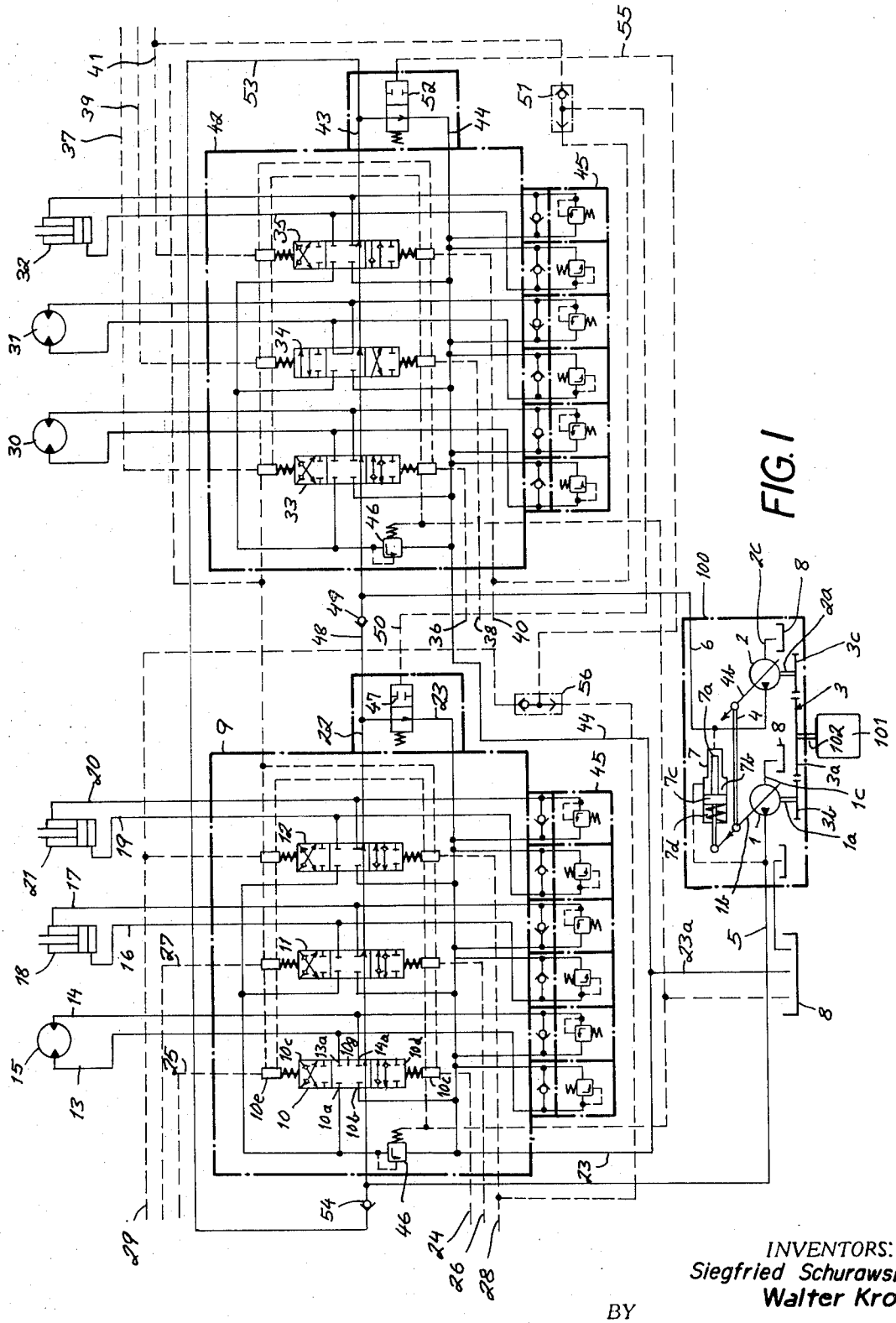


FIG. 1

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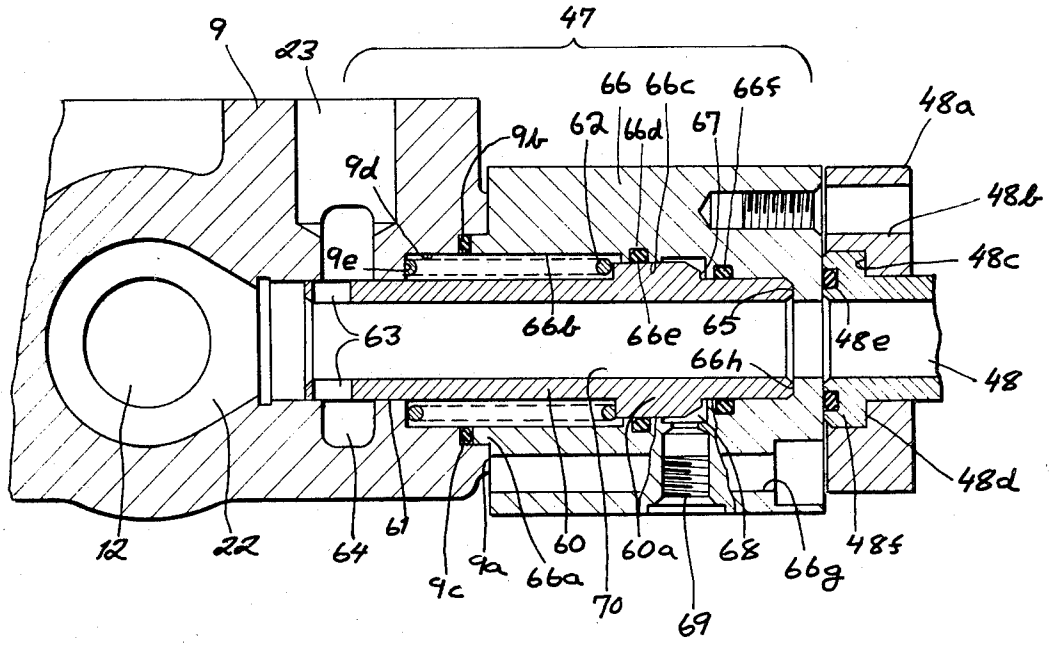

FIG. 2

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HYDRAULIC SYSTEM AND VALVE THEREFOR

1. FIELD OF THE INVENTION

Our present invention relates to a hydraulic system and, more particularly, to a hydraulic system having a plurality of pumps which may be independently connected to respective hydraulic loads through controllable valve means. In addition, the invention relates to a valve arrangement for enabling a plurality of pumps to be connected to a given load.

BACKGROUND OF THE INVENTION

Hydraulic systems generally comprise a source of fluid under pressure, e.g. a motor-driven pump, adapted to circulate a hydraulic fluid from a reservoir in a closed path, controllable valve means for shunting all or a portion of this fluid to a load and a hydraulic motor forming part of this load. The pump may be of the constant-displacement or variable-displacement type while the motor may be a rotary or piston motor. The valve means may be controlled manually, electrically or by a control fluid and various auxiliary equipment may be associated with the hydraulic network depending upon requirements.

Hydraulic systems may be used in various equipment and, in some cases, a particular hydraulic network may operate a number of independently controllable loads or one or more interrelated loads. In fact, the term "load" is used herein to indicate any consumer of the power fluid and is intended, therefore, to include the reciprocable or rotary hydraulic motors mentioned earlier and any force-transmitting or motion-transmitting transmission means normally associated therewith. Such systems are employed in agricultural vehicles, industrial plants and elsewhere since they afford precise regulation of the operation of the load, are of sufficient versatility, with appropriate transmission means, to enable operation of many different types of loads. The systems are of particular interest in dredges and the like for performing a number of movements and operating the various parts of a dredge or other excavator. For example, rotary hydraulic motors may be provided to effect translation of the excavator vehicle and rotation of any turntable or turret carried thereby while reciprocable hydraulic motors, e.g. piston-and-cylinder arrangements may be employed to operate the excavator arms, to position the bucket and to open or close the latter.

The present invention is concerned, for the most part, with a control arrangement in which a plurality, i.e. at least two, hydraulic pumps are provided and are designed to work into respective loads or to be connected in common to a single load. Systems of the latter type generally comprise individual networks for each of the pumps and respective controllable valve means in each network, connecting the respective pump with the corresponding load or loads. A typical arrangement provides a pressure line running from the discharge side of the pump in a closed path to a pressureless reservoir from which the pump draws hydraulic fluid from this line to the load and returning the bypassed fluid to the reservoir. The supply and return lines of the load are generally coupled to the controllable valve associated therewith so that a reversible flow of fluid is permitted to the hydraulic motor whereby the hydraulic motor operated in the double-acting sense, i.e. is

reversible. With such systems it frequently happens that one of the pumps is underutilized while the hydraulic demand from the other pump, e.g. for a particular load, exceeds the available supply and hence means have been employed in such systems to bypass a portion of all of the fluid from the second pump to the network of the first and thereby reinforce the operation of the latter. For the most part, the second pump, from the network of which the fluid is shunted to the network of the first pump, is not intended to operate any load during this period.

A case in point is the operation of an excavating machine, such as a dredge, in which the translation of the excavator and rotation of its turntable may be effected by hydraulic motors. For a particular excavation, neither translation nor rotation may be desired while an increased force is necessary at the excavator arms or bucket, for example, when a loaded bucket is to be lifted to the surface. In such cases, the hydraulic pump associated with movement of the excavator or rotation of the turntable may be connected to the network supplying hydraulic fluid to the bucket-lifting means. Control arrangements of this type have, for the most part, involved the use of manually operable valves. One of the problems encountered with such arrangements, however, is the feedback from one load to another through the interconnected networks of such systems. It is difficult with conventional arrangements to maintain operations of the several loads in an independent fashion, especially when the additional pump is connected into a particular network. Moreover, the control valves necessary to permit such shunting have been inordinately complex, have required complicated conduit arrangements and have been susceptible to human failure because of the necessity for mechanical control mentioned earlier.

OBJECTS OF THE INVENTION

It is, therefore, the principal object of the present invention to provide an improved hydraulic system of the general class described.

Another object of our invention is the provision of an improved valve for automatically operating such a system.

It is also an object of this invention to provide an improved hydraulic system using a plurality of fluid-displacement pumps circulating the hydraulic medium along respective paths, to operate a plurality of loads singly or jointly and for automatically delivering the output of one or more pumps to a particular load.

It is another object of the instant invention to provide an improved hydraulic system of the general character described with improved versatility and efficiency.

Yet another object of our invention is the provision of an improved hydraulic system for multiple-load installations, e.g. excavators, dredges, and the like.

SUMMARY OF THE INVENTION

These and other objects of the invention, which will become apparent hereinafter, are attained in accordance with the principles of the invention, with a hydraulic system having a plurality of fluid-displacement pumps (e.g. two pumps each of which works into a respective network returning the fluid to a reservoir in a closed path), respective control-valve means con-

necting each of said paths with at least one load for reversible operation of the latter, depending upon the position of the valve means, at least one load operated by a respective valve means and adapted to be energizable by fluid derived from both networks or paths. To this end, the two or more fluid paths are connected together by check-valve and shunt-conduit means while an auxiliary or additional valve is provided for operation upon actuation of the load drawing upon both fluid paths. The additional valve is provided in the circulating path and has a first position permitting the circulation of the fluid from the pump to the reservoir and a second position blocking such circulation such that, upon blockage of the circulation in one network, hydraulic fluid is forced into the other network through the respective check valve and shunt-conduit. According to a more specific feature of this invention, between the control valve of the load to be operated with fluid derived from both paths and the additional valve, or in the latter itself, a connection conduit is provided between the two paths and is formed with the check valve. When two such paths are employed, each may have a respective auxiliary valve operable to block the respective circulation and a respective check valve connecting each path with the other to admit fluid from one path to the other when the auxiliary valve blocks the circulation of the one path.

Consequently, as long as this auxiliary valve is not in its blocking or closed condition, the fluid circulation in the path containing same continues unimpeded and the individual control valves of the respective loads, each of which requires the fluid from the single circulating path. The check valves, under these conditions, block flow from one path to the other in either direction and prevent the loading of one path or the energization of control valves thereof from affixing the other path. In this case, the high-pressure side of each check valve functions to retain the latter in a closed condition since the opposite side of the check valve is at the pressureless condition of the reservoir or the return line of the other circulating path. When, however, either circulating path is blocked by operation of the auxiliary valve in circuit therewith, and the return line to the respective reservoir closed off, the high pressure generated by the corresponding pump ahead of this auxiliary valve suffices to open the check valve which is connected between the pressure side of the pump and the auxiliary valve of that path and bleeds hydraulic fluid into the other path whose circulation continues in the usual manner. Any load of the latter path which requires a greater supply of the hydraulic medium can then be energized.

We have already observed that the present invention finds its principal applications in hydraulic installations wherein each of the circulating networks or paths, and each pump is associated with a plurality of loads, each of which may be provided with a respective control valve. According to the principles of this invention, control means is provided for the auxiliary valve in such manner that, upon operation of the control valve associated with one or more loads of one circulating path or network (but less than all of the loads thereof), the auxiliary valve of the other path is shifted from its "open" to its "closed" position to bypass some of the fluid of this other circulating path into the circulating path and supply duct of the operated load. In this manner, we are able to ensure that the auxiliary valve will be switched only when a particular load is intended to be energized with the hydraulic medium derived from a plurality of pumps. When the control valves are hydraulically actuated, the auxiliary valve may be provided with a piston or like fluid-responsive member in fluid communication with the control input to the hydraulic input of the control valve of the load to be operated by more than one pump. Of course, the control valves can be operated hydraulically, pneumatically, electrically or mechanically and we prefer a similar mode of actuation of the auxiliary valve of the other path with an operative connection between the actuating means of the control valve and the auxiliary valve of the other path.

Preferably, each of the loads, which may be rotary-hydraulic motors (see pages 194 – 200 of FLUID POWER, U.S. Government Printing Office, 1966) or reciprocable actuators of the piston-and-cylinder type (pages 188 – 194 of FLUID POWER) is reversible and is provided with two hydraulic lines interchangeably serving as supply and return lines while the control valve associated with this load is a three-position or three-way, four-port or six-port valve. In a first position thereof, i.e. one extreme position, the control valve connects one of the lines to the circulating path under pressure while the other line is connected through a pressure reducer to the closed transport path and, conversely, in another extreme position, the lines are functionally interchanged to reverse the load. Between these positions, there is a cut-off or control position wherein flow to and from the load is blocked and flow along the circulating path is permitted through the particular control valve. We have found it to be advantageous with such a system to connect the actuators for the reversible control valve of the load to be energized by both pumps with the actuating chamber of the auxiliary valve of the other path, via a reversible valve means independent of the sense of operation of this control valve for actuating the auxiliary valve of the other path in either case.

According to still another feature of this invention, means are provided to prevent operation of the auxiliary valve of the other circulating path in response to operation of the control valve of a doubly energized load of the first circulating path only when all of the loads associated with the second circulating path are in a de-energized state, i.e. when the control valves of these loads are in their neutral position. With this precaution, it is possible to avoid a situation which may occur in the absence of such means. For example, each one or more loads of the second circulating path are intended to be energized by the respective control valves and the auxiliary valve of this path is shifted into its blocking position to couple the two paths together via the check valves, the loads associated with the path of the closed auxiliary valve will no longer be effective. Moreover, the danger that the doubly energized load will feed back energy to the hydraulic system and thereby influence an energized load of the circulating path supplying the additional medium, is precluded.

The auxiliary valve can be provided directly in the circulating path, i.e. in the return line which is connected with the high-pressure line of the network. It has

been found to be most desirable to assemble the control valves in a control valve block, e.g. a metallic body bored with cylinders each receiving a respective valve member and provided with a common return duct. The auxiliary valve is then mounted directly in this block and is so constituted that two distinct outlets for the return fluid are provided, preferably at right angles, to one another, one of these outlets serving to accommodate the auxiliary valve.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompany-ing drawing in which:

FIG. 1 is a hydraulic circuit diagram illustrating the invention as applied to an excavator; and

FIG. 2 is an axial cross-sectional view through an auxiliary valve as used in this system.

SPECIFIC DESCRIPTION

In FIG. 1 of the drawing, I show a housing **100** of the mobile excavator which has an internal combustion engine **101**, the crankshaft of which is represented at **102** and leads into the housing **100** of the hydraulic drive. The crankshaft **102** operates a mechanical transmission of the step-up type consisting of a large-diameter drive gear **3***a* carried by the shaft **102** and meshing with the small-diameter driven gear **3***b* and **3***c* respectively carried by the shafts **1***a* and **2***a* of a pair of hydraulic pumps **1** and **2**.

The hydraulic pumps are of the variable-displacement type and may be axial piston pumps as described at pages 109 – 113 of FLUID POWER, cited earlier. As noted in this work, the pumps are provided with tiltable control blocks cylinder drum or the like to adjust the strokes of the axial pistons and hence the displacement of the pump. The displacement-control means is represented by the tiltable control blocks, cylinder drum or the like to adjust the strokes of the axial pistons and hence the displacement of the pump. The displacement-control means is represented by the tiltable members **1***b* and **4***b* of the pumps, these members being connected together by a link **4** pivotally coupled thereto.

A control-piston arrangement **7** defines a chamber **7***a* energized from the high-pressure line **6** of the pump **2** and a chamber **7***b* of equal cross-section energized by the fluid from high-pressure line **5** of pump **1**, both pressures working upon a piston **7***c* working against a spring **7***d* to maintain the predetermined output of the pumps by automatic adjustment of the control members **1***b* and **2***b*. The pumps **1** and **2** have intake ducts **1***c* and **2***c* drawing fluid from a sump or reservoir **8**, shown to be made up of a number of sections for clarity in illustrating the hydraulic flow path, but actually constituting a single reservoir.

The installation comprises a valve block **9** formed with a plurality of valves **10**, **11** and **12** each of which is of the three-position, six-port type, as will be described in connection with the valve **10**. Furthermore, the valves **10** – **12** are hydraulically actuated as also will be apparent hereinafter, each operating a respective load **15**, **18** and **21**. The load **15**, which may be a hydraulic motor of the character previously described, has a pair of hydraulic lines **13** and **14** which are connected to the ports **13***a* and **14***a* of the valve **10**, respectively. The block **9** is provided with a high-pressure passage **22** which is supplied from the discharge side of pump **1** via line **5** and with a passage **23** constituting the return line. Passage **23**, of course, opens via line **23***a* into the reservoir **8** and sustains no back pressure, the reservoir being pressureless. The line **23** may, of course, have a cross-section slightly smaller than that of line **22**.

The valve **10** is provided with a port **10***a* connected with the reservoir **8** via a pressure-relief or pressure-limiting valve **46** while the port **10***b* is connected in the circulating path **22**, **23** of the pump **1**. The first position of the valve **10**, represented at **10***c*, blocks line **22** and connects ports **10***a* and **14***a* and ports **13***a* and **10***b* via check valves built into the valve body. The hydraulic load represented by motor **15** is thereby operated in one sense. The other position of the valve **10**, represented at **10***d*, likewise blocks line **22** but connects port **10***a* directly with port **13***a* and port **14***a* directly with port **10***b* for operation of the load in the other direction. In the control position **10***e*, throughflow of fluid through the circulating path **22** is permitted while ports **10***a*, **10***b*, **13***a* and **14***a* are blocked. It will be appreciated that one need not provide blockages for the line **22** in any of the positions of the valve but merely for diversion of fluid to the load in a sense depending upon the sense of operation of the valve member. The valve member **10** is provided with hydraulic actuators **10***e* and **10***f* effective to displace the valve member from its neutral position into either extreme position by the application of a control signal in the form of a hydraulic pressure at the line **24** or **25**. The motor **15** may be the drive motor for the excavator.

Similarly, the valve **11** is connected via lines **16** and **17** with the double-acting piston-cylinder arrangement **18** which may serve to operate the scoop of the excavator while control valve **12** is connected via lines **19** and **20** with a cylinder **21** for energizing the outrigger cylinders for stabilizing the excavator.

In the neutral positions of the valves **10**, **11** and **12** illustrated in FIG. **1**, these valves connect the supply duct **4** of pump **1** with a circulating conduit **22** which, in turn, is connected with the pressureless return line **23** running to the reservoir **8**.

The control valves **10**, **11** and **12** are hydraulically actuated, to which end, each of the valves is provided with a respective actuating cylinder (actuator) such as is shown at **10***e* and **10***f* and energizable via control lines as described. The actuating cylinders for the control valve **10**, for example, are energized by control lines **24** and **25** which, in turn, may be connected to a control and pressure regulator, a manually operated valve or other actuating lines not further illustrated. The actuating cylinders of the control valve **11** are provided with control lines **26** and **27** while the actuating cylinders of control valve **12** are provided with control lines **28** and **29**.

Since the hydraulic motor **15** constitutes a reversible hydraulic load associated with the control valve **10**, the double-acting cylinder **18** constitutes a reversible hydraulic load associated with the control valve **11** and the double-acting cylinder **21** constitutes a reversible

hydraulic load energized through the control valve 12, the members 15, 18 and 21 constitute three hydraulic loads associated with the pump 1 and the closed circulating paths 22 and 23 in which the pump is provided.

According to the principles of the present invention, at least one further circulating path and associated set of hydraulic loads is provided. Hence, the hydraulic load 30 can be a hydraulic motor connected by suitable lines to the control valves 33, the hydraulic motor 31 may be connected to the control valve 34 and the reciprocable double-acting piston can be guided to the control valve 35 of another valve block 32 in the manner already described with reference to the loads 15, 18 and 21.

The control valve 33 is provided with hydraulic actuators which may be energized via control lines 36 and 37, the control valve 34 has its actuators energized via control lines 38 and 39, and the control valve 34 is energized at its actuators via the control lines 40 and 41. Here again, the control lines may be tied to a regulator and other means for generating the hydraulic pressure for operating the control valve. The valve block 42 is provided with the circulating passage 43 which is connected within the valve block with the pressureless return line 44 which is returned to the same reservoir 8 into which the line 23 empties. The pump 2 feeds the pressure line 6 which communicates with the line 43. The lines 6, 43 and 44 constitute a closed circulating path for the second pump 2. The valve 46 of this path likewise serves for pressure regulation and limitation.

In addition, the valve block may be provided with an array of pressure-relief valves 45, advantageously connected to the respective lines of each load for operation in either sense thereof to maintain a predetermined maximum pressure in each line.

Between the circulating passage 22 and the pressureless return passage 23 of the circulating network containing pump 1, we provide a two-port, two-position valve 47 (2/2 distributing valve) constituting the auxiliary valve for the purposes of the present invention. This valve is illustrated in greater detail in FIG. 2.

The circulating conduit 22 is, moreover, provided upstream of the valve 47 with a duct 48 connected by a check valve 49 with the circulating conduit 43 of the other fluid-circulating path. The check valve 49 is built such that the side connected valve 47 is normally a low pressure side whereas the other side is at higher pressure to maintain the valve 49 in a closed condition and prevent flow of fluid line from the path associated with pump 2 from the path associated with pump 1. The line 48, of course, opens into line 6 at or before its junction with conduit 43 and the valve block 42. The auxiliary valve 47 is hydraulically actuated via a control line 50 whoch is energized via a transformation valve 51, the inputs to which are the control lines 40 and 41 of the valve 35 for piston arrangement 43 in the other circulating path. Similarly and symmetrically, an auxiliary valve 52 is provided between the circulating passage 43 and the pressureless return passage 44 and is connected via a reversing valve 56 and line 55 with the circulating path of pump 1. Valve 56 is energized from control lines 28 and 29 associated with the load 21. Ahead of this auxiliary valve 52, a connecting line 53 is tied to the circulating conduit 43 and communicates via a check valve 54 with the high pressure line 5 of pump 1 prior to its entry into the valve block 9.

The network or circuit of FIG. 1 operates as follows:

with the auxiliary valve 47 and 52 in their positions illustrated in FIG. 1, the circulating conduit 22 is connected with the pressureless return conduit 23 through the normally open valve 47 while the circulating passage 43 is connected with the pressureless return passage 44 via the normally open valve 52. The circuit then operates in accordance with the usual practice. Upon actuation of one of the control valves 10, 11 or 12, for example, the loads 15, 18 or 21 can be selectively connected to the pump 1 and energized in a sense dependent upon the extreme position of the control valve 10, 11 or 12 which is used. Correspondingly, actuation of one of the control valves 33, 34 and 35 connects the corresponding load 30, 31 and 32 to the pump 2 independently of whether one, two or all of the valves of the other hydraulic network being energized. There is of course no feedback to the loads 15, 18 and 21 from energization of the loads 30, 31, 32 or vice versa. However, upon the energization of a reduced pressure in one of the control lines 20 or 29, the load 21 is connected to the pump 1, whereupon pressure is developed in line 55 to shift the auxiliary valve 52 of the other circulating network so that the connection between lines 43 and 44 is terminated. The valve 56, of course, is effective to generate a pressure in line 55 regardless of which of the lines 28 or 29 is energized and hence regardless of the sense of operation of the control valve 12. As soon as the connection between lines 43 and 44 is blocked, and provided the control valves 33 – 35 are in their neutral positions as illustrated, line 6 of pump 2 is blocked at the end of line 43 whereby pressure builds up at the junction of line 6 and 43 of a sufficient level to exceed the pressure in line 22 and deliver fluid via check valve 54 from the pump 2 to the line 22. The load 21 is thereupon energized via both pumps 1 and 2 together.

In a corresponding manner, a pressure reduction in one of the lines 40 or 41 of the load 32 generates a pressure in line 50 sufficient to displace the valve 47 and thereby block the connection between lines 22 and 23 to build up pressure at line 48 until the check valve 49 cracks to deliver fluid to line 43 from pump 1. The load 32 is, in this case, operated with the augmented flow of the two pumps. However, in this latter case when any of the valves 10, 11 or 12 are operated, actuation of valve 47 will have no effect and the two networks will operate independently and without feedback between them.

In the system of FIG. 1, it will be observed that each of the control valves 10, 11 or 12 or 33, 34 and 35, upon displacement from its neutral position in which, for example, the valve portion 10*e* is effective, blocks the circulating passage 22 or 43 and permits fluid to flow only to the corresponding load. Since all of the control valves 10 – 12 and 33 – 35 are disposed between the respective auxiliary valve 47 or 52 and the corresponding pump 1 or 2, actuation of one of the control valves (10 – 12 or 33 – 35) renders the corresponding auxiliary valve (47 or 52) ineffective since no further fluid circulation is provided through this valve and the position of the valve is unimportant. It has already been observed that this arrangement

prevents undesired influence from being fed back from one load to another.

In FIG. 2, we have shown in cross-section a portion of the control block 9 (valve block) illustrating the cylinder bore for the control valve 12 by way of example. The circulating passage 22 is thus seemed to be formed by a passage opening it to the bore of control valve 12. The auxiliary valve 47 illustrated in FIG. 2, which may be structurally identical to the valve 52 as noted earlier, comprises a tubular piston 60 which is actually shiftable in the bore 61 against the force of a helical coil compression spring 62 and is provided with radial openings 63 which, in the indicated position of the piston 60, connects the passage 22 with the return line 23, the latter then extending radially to the bore 61. The valve block 9 is provided with an annular boss 9*a* surrounding a recess 9*b* receiving a seal 9*c* against which the tubular boss 66*a* of the valve housing is seated coaxially with the bore 61. The recess 9*c* is, moreover, coaxial with the further recess 9*d* defining a shoulder 9*e* against which the spring 62 is seated, the spring 62 being received within the recess 9*d* and the bore 66*b* of housing 66 in axial alignment therewith. Remote from the connection of housing 66 with the valve block 9, the bore 66*b* is provided with a small-diameter step 66*c* having an annular groove 66*d* receiving a seal 66*e* which slidably engages the head 60*a* of the piston. A further seal 66*f* slidably engages the piston 60 rearwardly of the head 60*a* to define a compartment 68 between the seals 66*d* and 66*f* and behind the shoulder 67 of this head. Both traversing bars 66*g* may be used to connect the housing 66 to the valve block 9 and any conventional coupling system may serve to connect the conduit 48 therewith. A suitable coupling includes a ring or flange 48*a* bolted axially to the housing 66 by a screw traversing the boss 48*b* and having a shoulder 48*c* bearing axially upon a shoulder 48*d* of the duct 48. A sealing ring 48*e* may be clamped between the flange 48*f* of this duct and the exposed external face of the housing 66.

The radial openings 63 communicate between the passage 22 and the passage 23 via an annular compartment 64 formed in the valve block 9 and constituting, together with duct 23, a pressureless return path for the fluid. The piston 60, moreover, is urged by the spring 62 to the right so that its end face 65 abuts the end face 66 of the housing 66 at the righthand end of the bore 62. The annular chamber 68 is, moreover, connected via a port 69 with the conduit 50 serving to supply the actuating pressure to the valve (see FIG. 1). When the chamber 68 is pressurized as previously described, the piston 60 is urged to the left against the force of spring 62 to block communication between ducts 22 and 23 and maintain communication between ducts 22 and 48 through the interior of the valve. The passages 63 in the valve body and the housing portion cooperating therewith are so shaped that with increasing displacement of the valve body, the communication between passages 22 and 23 is proportionally reduced and finally completely cut off. In the closed position of this valve 47, the central bore 70 of the valve piston 60 connects passages 22 and 48. The housing 66 is provided directly at a part of the valve block 9 at which the pressureless return conduit communicates with line 22 thereby minimizing the cost of producing the system.

We claim:

1. A hydraulic system comprising:

a plurality of pumps, each having a pressure side and an intake side;

conduit means defining two distinct circulating paths including a respective circulating path for each of said pumps, each said conduit means including respective ducts connected to said pressure side and said intake side of each pump;

two independently operable control valves including a respective control valve connecting each of said paths with a respective hydraulically operable load;

a selectively shiftable auxiliary valve in at least one of said paths permitting circulation of a hydraulic medium therealong but actuatable to block such circulation, said auxiliary valve having a first position communicating between said duct connected to said pressure side and said duct connected to the intake side of the respective pump and permitting return flow of fluid from the respective path to the respective pump and a second position blocking return flow of fluid:

a shunt conduit connecting said one of said paths, between said auxiliary valve and the pump associated with said one of said paths at the duct connected to the pressure side of the latter pump, with another of said paths; and

an automatically operable check valve in said shunt conduit automatically opening upon shifting of said auxiliary valve into said second position for undirectional flow of the medium between said one of said paths and said other of said paths upon blockage of circulation in said one path by said auxiliary valve and upon the fluid pressure at said shunt conduit exceeding the fluid pressure at said other path whereby a load energized through the control valve of said other path may draw upon medium from both said one of said paths and said other path.

2. The system defined in claim 1 further comprising common actuating means for said auxiliary valve and said control valve of said other of said paths.

3. The system defined in claim 1 further comprising means interconnecting said auxiliary valve and at least one of said control valves for joint operation.

4. A hydraulic system comprising:

a plurality of pumps, each having a pressure side and an intake side;

conduit means defining a respective circulating path for each of said pumps, said conduit means including respective ducts connected to said pressure side and said intake side of each pump;

a respective control valve connecting each of said paths with a respective hydraulically operable load;

a selectively shiftable auxiliary valve in at least one of said paths permitting circulation of a hydraulic medium therealong but actuatable to block such circulation, said auxiliary valve having a first position communicating between said duct connected to said pressure side and said duct connected to the intake side of the respective pump and permitting return flow of fluid from the respective path to the respective pump and a second position blocking return flow of fluid;

a shunt conduit connecting said one of said paths, between said auxiliary valve and the pump associated with said one of said paths at the duct connected to the pressure side of the latter pump, with another of said paths;

an automatically operable check valve in said shunt conduit automatically opening upon shifting of said auxiliary valve into said second position for undirectional flow of the medium between said one of said paths and said other of said paths upon blockage of circulation in said one path by said auxiliary valve and upon the fluid pressure at said shunt conduit exceeding the fluid pressure at said other path whereby a load energized through the control valve of said other path may draw upon medium from both said one of said paths and said other path; and

means interconnecting said auxiliary valve and at least one of said control valves for joint operation, said control valve of said other of said paths being provided with reversibly energizable hydraulic actuators and said actuating means includes transformation valve means energizable in parallel with said actuators for generating a control pressure regardless of the sense of operation of the control valve of said other paths, said auxiliary valve including a fluid-responsive member coupled with said transformation valve means for actuation by said control pressure.

5. A hydraulic system comprising:

a plurality of pumps, each having a pressure side and an intake side;

conduit means defining a respective circulating path for each of said pumps, said conduit means including respective ducts connected to said pressure side and said intake side of each pump;

a respective control valve connecting each of said paths with a respective hydraulically operable load;

a selectively shiftable auxiliary valve in at least one of said paths permitting circulation of a hydraulic medium therealong but actuatable to block such circulation, said auxiliary valve having a first position communicating between said duct connected to said pressure side and said duct connected to the intake side of the respective pump and permitting return flow of fluid from the respective path to the respective pump a second position blocking return flow of fluid;

a shunt conduit connecting said one of said paths, between said auxiliary valve and the pump associated with said one of said paths at the duct connected to the pressure side of the latter pump, with another of said paths;

an automatically operable check valve in said shunt conduit automatically opening upon shifting of said auxiliary valve into said second position for unidirectional flow of the medium between said one of said paths and said other of said paths upon blockage of circulation in said one path by said auxiliary valve and upon the fluid pressure at said shunt conduit exceeding the fluid pressure at said other path whereby a load energized through the control valve of said other path may draw upon medium from both said one of said paths and said other path; and

means interconnecting said auxiliary valve and at least one of said control valves for joint operation, said auxiliary valve being so constructed and arranged as to maintain communication between said shunt conduit and said one path in both blocking and nonblocking positions of said auxiliary valve.

6. The system defined in claim 5 wherein said other path is formed with a respective auxiliary valve actuatable for the selective blocking and unblocking of flow of the medium through said other path, said paths each including a pressureless return line for carrying medium to the intake side of the respective pump, each of said auxiliary valves being disposed between the respective control valve and return line of the corresponding path, said system further comprising another shunt conduit communicating with said other path between its control valve and auxiliary valve and connected to said one path between the pump thereof and the control valve of said one path at the duct connected to the pressure side of the latter pump, said other shunt conduit including a check valve permitting unidirectional flow of medium from said other path to said one path upon the blockage of circulation in said other path by the auxiliary valve associated therewith and upon the further shunt conduit exceeding the pressure in said one path.

7. The system defined in claim 6 wherein said pumps of said one and said other paths are provided with a common reservoir and a common drive, said return lines emptying into said reservoir, each of said paths being provided with a plurality of control valves each energizing when operated a respective load and disposed along said path between the respective pump and auxiliary valve, the control valves of each path being so constructed and arranged as to block, upon operation, the flow of the medium to the respective auxiliary valve.

8. The system defined in claim 7 for an excavator in which said loads include rotary hydraulic motors and piston-and-cylinder arrangements connected with said control valves.

9. The system defined in claim 3 wherein said control valve is formed in a valve block provided with a circulating duct and a return duct branching from said circulating duct, said auxiliary valve comprising a housing mounted on said block, a pressure responsive valve member shiftable in said piston for selectively blocking and unblocking communication between said circulating and return ducts, and means for connecting said shunt conduit to said housing.

10. A hydraulic system comprising :

a plurality of pumps;

conduit means defining a respective circulating path including each of said pumps;

a respective control valve connecting each of said paths with a respective hydraulically operable load;

an auxiliary valve in at least one of said paths permitting circulation of a hydraulic medium therealong but actuatable to block such circulation;

a shunt conduit connecting said one of said paths with another of said paths between said auxiliary valve and the pump associated with said one of said path;

a check valve in said shunt conduit for undirectional flow of the medium between said one of said paths and said other of said paths upon blockage of circulation in said one of path by said auxiliary valve and upon the fluid pressure at said shunt conduit exceeding the fluid pressure at said other path whereby a load energized through the control valve of said other path may draw upon medium from both said one of said paths and said other path;

common actuating means for said auxiliary valve and said control valve of said other of said paths; said control valve of said other of said paths being provided with reversibly energizable hydraulic actuators and said actuating means including transformation valve means energizable in parallel with said actuators for generating a control pressure regardless of the sense of operation of the control valve of said other path, said auxiliary valve including a fluid-responsive member coupled with said transformation valve for actuation by said control pressure.

11. the system defined in claim 10 wherein said auxiliary valve is so constructed and arranged as to block communication between said one path and said shunt conduit when circulation along said one path is permitted.

12. The system defined in claim 10 wherein said auxiliary valve is so constructed and arranged as to maintain communication between said shunt conduit and said one path in both blocking and nonblocking positions of said auxiliary valve.

13. the system defined in claim 12 wherein said other path is formed with a respective auxiliary valve actuatable for the selective blocking and unblocking of flow of the medium through said other path, said paths each including a pressureless return line for carrying medium to the respective pump, each of said auxiliary valves being disposed between the respective control valve and return line along the corresponding paths, said shunt conduit communicating with said one path between its control valve and auxiliary valve, said system further comprising another shunt conduit communicating with said other path between its control valve and auxiliary valve and connected to said one path between the pump thereof and the control valve of said one path, said other shunt conduit including a check valve permitting unidirectional flow of medium from said other path to said one path upon the blockage of circulation of said other path by the auxiliary valve associated therewith and upon the further shunt conduit exceeding the pressure in said one path.

14. The system defined in claim 13 wherein said pumps of said one and said other paths are provided with a common reservoir and a common drive, said return lines emptying into said reservoir, each of said paths being provided with a plurality of control valves each energizing a respective load and disposed along said path between the respective pump and auxiliary valve, the control valves of each path being so constructed and arranged as to block, upon operation, the flow of the medium to the respective auxiliary valve.

15. The system defined in claim 14 for an excavator in which said loads include rotary hydraulic motors and piston-and-cylinder arrangements connected with said control valves.

16. The system defined in claim 10 wherein said control valve is formed in a valve block provided with a circulating duct and a return duct branching from said circulating duct, said auxiliary valve comprising a housing mounted on said block, a pressure responsive valve member shiftable in said piston for selectively blocking and unblocking communication between said circulating and return ducts, and means, for connecting said shunt conduit to said housing.

17. A hydraulic system comprising:

a plurality of pumps each having an intake side and a pressure side;

conduit means defining a respective circulating path including each of said pumps;

a respective control valve connecting each of said paths with a respective hydraulically operable load;

an auxiliary valve in at least one of said paths permitting circulation of a hydraulic medium therealong but actuatable to block such circulation;

a shunt conduit connecting said one of said paths with another of said paths, said shunt conduit communicating with said one of said paths between said auxiliary valve and the pressure side of the pump associated with said one of said paths;

a check valve in said shunt conduit for unidirectional flow of the medium between said one of said paths and said other of said paths upon blockage of circulation in said one path by said auxiliary valve and upon the fluid pressure at said shunt conduit exceeding the fluid pressure at said other path whereby a load energized through the control valve of said other path may draw upon medium from both said one of said paths and said other path, said auxiliary valve being so constructed and arranged as to maintain communication between said shunt conduit and said one path in both the blocking and nonblocking positions of said auxiliary valve, said other path being formed with a respective auxiliary valve actuatable for the selective blocking and unblocking of flow of the medium through said other path, said paths each including a pressureless return line for carrying medium to the respective pump, each of said auxiliary valves being disposed between the respective control valve and return line along the corresponding paths;

another shunt conduit communicating with said other path between its control valve and auxiliary valve and connected to said one path between the pressure side of the pump thereof and the control valve of said one path, said other shunt conduit including a check valve permitting unidirectional flow of medium from said other path to said one path upon the blockage of circulation of said other path by the auxiliary valve associated therewith and upon the further shunt conduit exceeding the pressure in said one path, said pumps of said one and said other paths being provided with a common reservoir and a common drive, said return lines emptying into said reservoir, each of said paths being provided with a plurality of control valves each energizing a respective load and disposed along said path between the respective pump and auxiliary valve, the control valves of

each path being so constructed and arranged as to block, upon operation, the flow of the medium to the respective auxiliary valve, at least one of said control valves being provided with a pair of hydraulic actuators for reversible operation of said one of said control valves and the load associated therewith; and a transformation valve connected to said actuators for producing a control pressure regardless of the direction of operation of said one of said control valves and the load associated therewith and conduit means for applying said control pressure to the auxiliary valve of a path other than that of said one of said control valves.

18. The system defined in claim **17** wherein said control valve is formed in a valve block provided with a circulating duct and a return duct branching from said circulating duct, said auxiliary valve comprising a housing mounted on said block, a pressure responsive valve member shiftable in said piston for selectively blocking and unblocking communication between said circulating and return ducts, and means for connecting said shunt conduit to said housing.

19. A hydraulic system, comprising:

at least two hydraulic pumps;

means forming a respective hydraulic network connected to each of said pumps and including a load energized by fluid under pressure therefrom;

a respective auxiliary valve in each of said networks and having a first position enabling energization of the respective load by blocking a path shunting fluid from the respective network to the respective pump, and a second position shunting fluid from the respective network to the respective pump;

a respective check valve connected between each network at the pressure side of its pump and the other network behind its auxiliary valve for automatically admitting fluid from a network having its said auxiliary valve in its first position to the other network;

respective control means for regulating the operation of the respective loads and including at least one control valve in each network; and

means for shifting the auxiliary valve of one of said networks automatically in response to actuation of a control valve of the other network.

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