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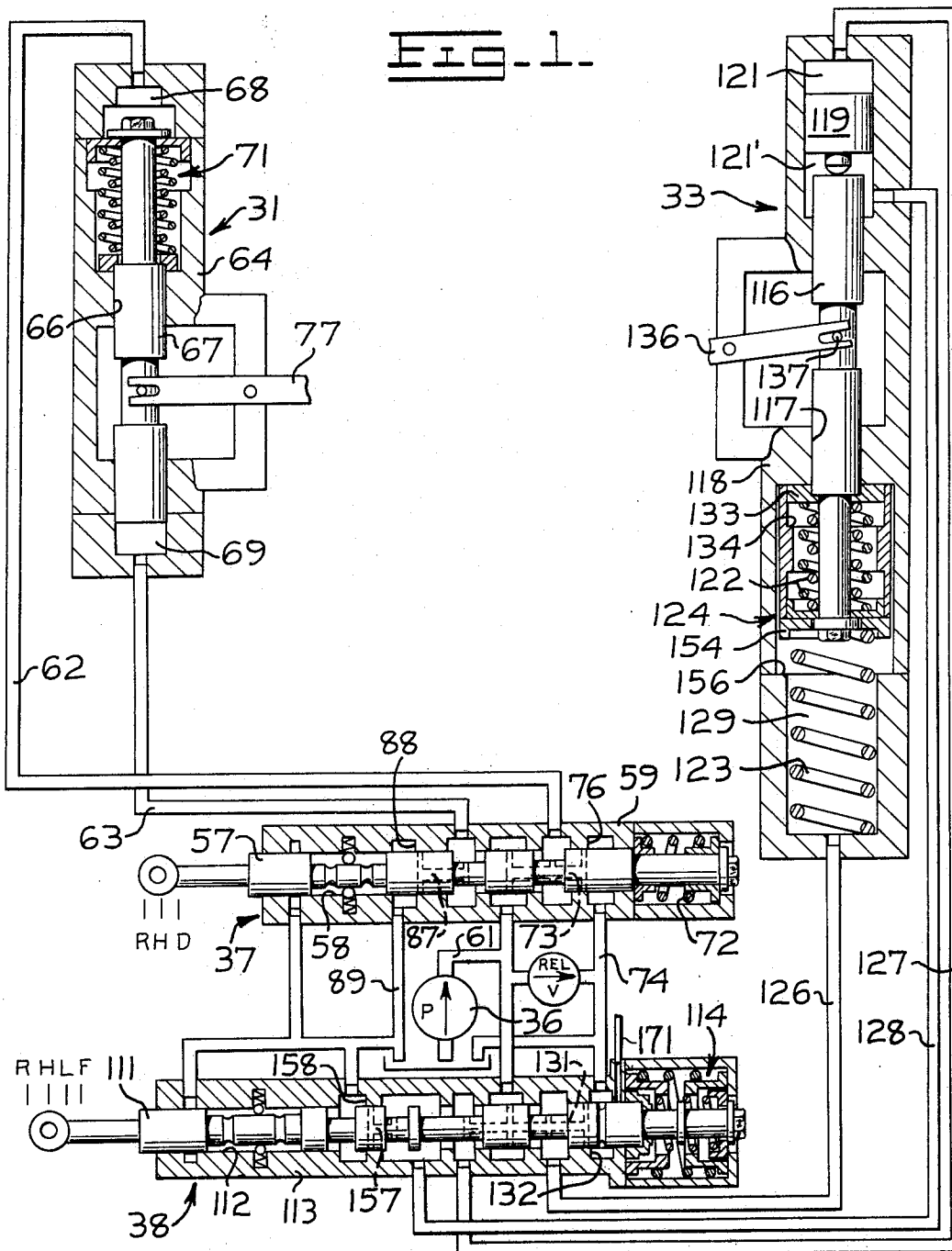
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CONTROL SYSTEM FOR DUAL MOTORS

Filed May 22, 1968

2 Sheets-Sheet 1



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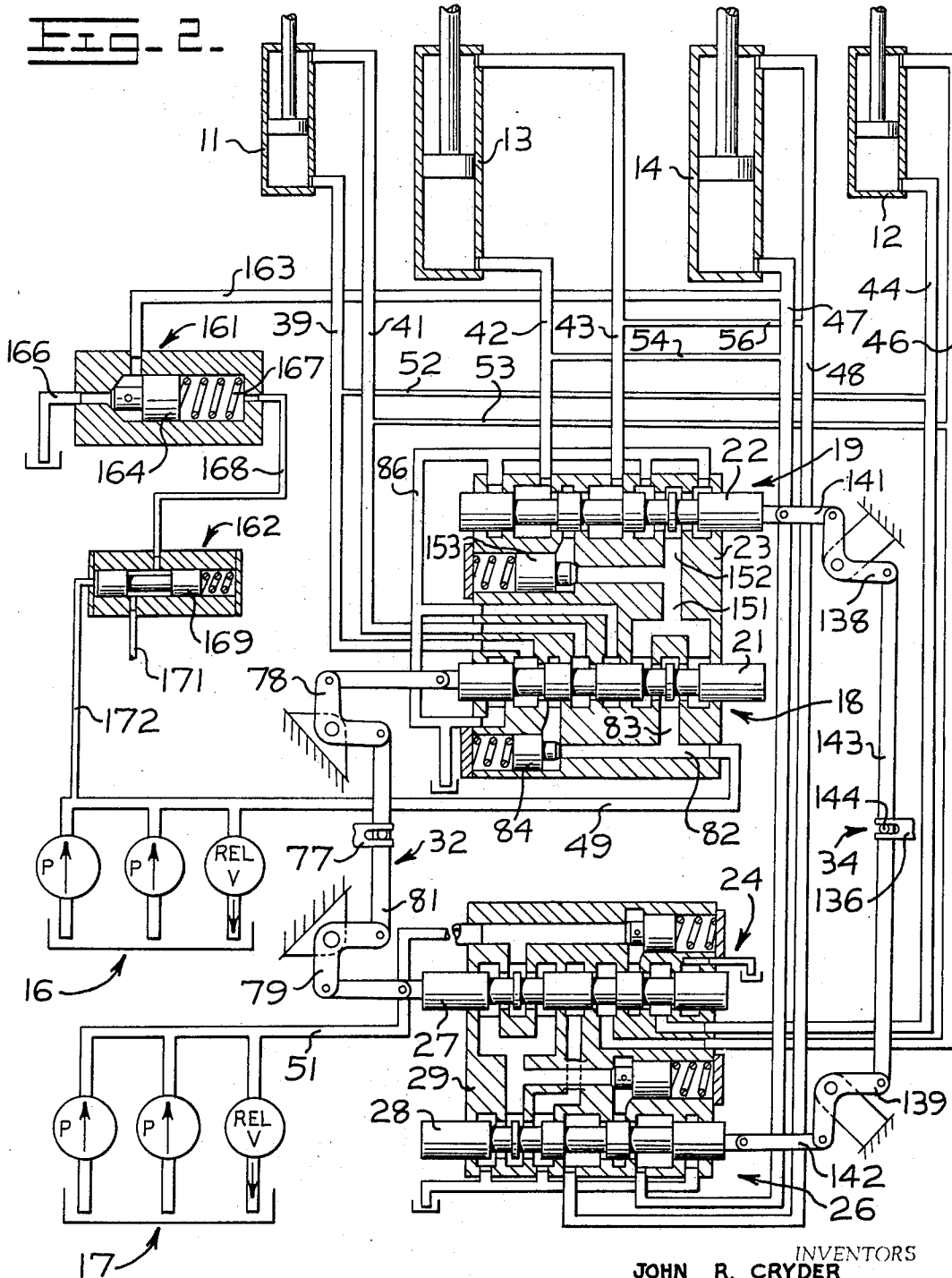
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FIG. 2.



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CONTROL SYSTEM FOR DUAL MOTORS

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12 Claims

ABSTRACT OF THE DISCLOSURE

For operating a pair of hydraulic tilt motors and a pair of hydraulic lift motors of a single bucket on a loader, a pilot control system for each pair of motors comprises a separate fluid source of each motor, a separate control valve regulating fluid flow between each source and motor and a pilot operated actuator valve mechanically coupled to both of the control valves.

The use of pilot operated valves to facilitate operator control over large hydraulic motors is well known in the art. However, the present invention contemplates a novel control system for overcoming problems which are exemplified as follows. The control system of the present invention is particularly contemplated for use with an articulated bucket loader having a large bucket, with a capacity of ten cubic yards or more, for example, supported on its forward section and motor means for driving the vehicle and operating the bucket mounted upon its rearward section. Accordingly, hydraulic motors large enough to control motion of the bucket are mounted upon the forward section while pumps for providing fluid to the motors are normally mounted on the rearward section along with the engine for the loader. Conventional pumps and control components would have to be excessively large in order to provide the large volume of fluid necessary for the motors. As the size of these components is increased, associated problems such as pressure deflection in the control components, leakage rates, machining costs, etc. correspondingly increase until they become prohibitive. These problems are further magnified in that normally a large number of high pressure hoses and swivel connections are necessary at the articulated joints of the vehicle for communicating operating fluid to the motors. An additional problem of some importance in these systems is the provision for generally simultaneous operation of both motors in response to control elements which require a minimum of operator effort. To achieve adequate operating efficiency, it is further necessary to achieve positive control over the bucket actuation while maintaining rapid positioning of the bucket during various phases of its loading cycle.

The present invention overcomes these problems by providing a control system for each pair of hydraulic motors comprising a separate main source of fluid for each motor, a separate control valve regulating fluid flow to each motor and means associated with both control valves for simultaneously positioning them and providing generally equal fluid flow to both motors from their respective fluid sources. With this arrangement, the control valve may be positioned near the hydraulic motors to enhance response of the motors. Further, makeup valves which are commonly associated with the control valve to prevent cavitation in the motors and to fill voids in the motors, for example, when they are operating under the effect of gravity, also have increased effectiveness since they may also be located adjacent the motors. Operation of relief valves associated with the motors and the control systems is similarly enhanced. Placement of the control valves near the motors substantially re-

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duces the length of the large number of high pressure fluid lines connecting those components. In an articulated vehicle of the type referred to above, this arrangement also avoids the necessity of providing swivel connections in those lines at the articulated joints. Although the use of two fluid sources requires two main supply lines to the motors, the sources and associated components may be substantially reduced in size so that conventional components need not be redesigned and enlarged because of increased size of the hydraulic motors. The actuator means are preferably associated with both control valves by means of a mechanical coupling for positive control over the motors while providing for simultaneous and high speed operation of the motors.

Other objects and advantages of the present invention are made apparent in the following description having reference to the drawings which show two pilot control systems for operating a pair of tilt jacks and a pair of lift jacks of a bucket loader as a preferred embodiment. The main control valves may also be actuated by an electrical or mechanical means rather than the pilot system shown.

In the drawings:

FIG. 1 is a view, with parts in section, of a pilot control valve and actuators for both control systems; and

FIG. 2 is a view, with parts in section, of the hydraulic motors and the control valves, couplings and main fluid sources making up the remainder of the control systems.

Referring now to FIGS. 1 and 2, a pair of double acting hydraulic tilt cylinders 11 and 12 and a pair of double acting hydraulic lift cylinders 13 and 14 are of a type for conventionally positioning the bucket of a bucket loader (not shown) for example. A pair of dual hydraulic pump arrangements 16 and 17 each provide hydraulic fluid under high pressure to one of the tilt motors and one of the lift motors. As shown in FIG. 2, pump arrangement 16 provides fluid for motors 11 and 13 while pump arrangement 17 provides fluid for motors 12 and 14. Fluid flow from pump arrangement 16 to hydraulic motors 11 and 13 is separately and respectively regulated by control valves 18 and 19 which include spools 21 and 22 reciprocally mounted within a single housing 23. Fluid flow from pumps 17 to hydraulic motors 12 and 14 is regulated by control valves 24 and 26 which respectively include spools 27 and 28 reciprocally mounted in a single valve housing 29. The control valve spools 21 and 27 which regulate fluid flow to the tilt motors are positioned by an actuator valve 31 (see FIG. 1) through mechanical linkage indicated at 32. The control valve spools 22 and 28 which regulate fluid flow to the lift motors are positioned by an actuator valve 33 (see FIG. 1) through mechanical linkage 34. Pilot fluid for operating both of actuator valves 31 and 33 is provided by a single low pressure pump 36. A pilot control valve 37 communicates the pump 36 with the actuator valve 31 and is operable into a rackback or dump position to regulate fluid flow to the tilt actuator valve 31 for appropriately operating the tilt motors 11 and 12. Another pilot control valve 38 communicates the pump 36 with the lift actuator valve 33 and is operable into Raise, Hold, Lower or Float positions, indicated respectively by R, H, L and F for directing fluid to the actuator valve 33 to appropriately operate the lift motors 13 and 14.

The novel control system summarized above offers numerous operating advantages, for example, when the lift and tilt motors and their respective control systems are employed in a high capacity, articulated bucket loader (not shown). The control valve housings 23 and 29 may be located adjacent the hydraulic motors along with the actuating valves 31 and 33. Referring particularly to FIG. 2, for providing high pressure fluid to the hydraulic motors, control valves 18, 19, 24 and 26 are respectively

connected with the head and rod ends of motors 11, 13, 12 and 14 by pairs of conduits 39-41, 42-43, 44-46 and 47-48. Since the control valves are located adjacent the hydraulic motors, this necessarily large number of high pressure hydraulic lines may be of relatively short length to permit numerous advantages as discussed above. Since the pump arrangements 16 and 17 are desirably located adjacent the engine or motor means for the loader vehicle, in its rearward articulated section, only the two conduits 49 and 51 which respectively communicate those pumps with the control valve housings 23 and 29 are required to cross the articulated joint of the vehicle. The low pressure lines which communicate the pilot control valves 37 and 38 with the actuator valves 31 and 33 do not prevent similar problems since the pilot fluid which they carry is at low pressure. Further, since each of the pump arrangements 16 and 17 provide fluid to only one tilt motor and one lift motor, which are not simultaneously operable, the capacity of those pumps and associated components is substantially reduced relative to the size of the motor. The positive linkages 32 and 34 permit accurate and simultaneous positioning of the control valve pairs 18-24 and 19-26. Further, since the control valves 24 and 26 are of similar but opposing construction compared to the control valves 18 and 19, a single motion of the actuator valve 31 or 33 causes similar operation of the two tilt motors or two lift motors respectively. The mechanical coupling with the control valve pairs further permits individual adjustment of each control valve to enhance the simultaneous operation of each pair. To insure equal pressure rise in the tilt motors 11 and 12, the conduits in communication with their head and rod ends are also in limited communication by means of cross conduits 52 and 53, respectively. The conduits in communication with the head and rod ends of the lift motors are in similar limited communication by means of conduits 54 and 56.

To describe the structure and operation of the tilt control system in greater detail, the pilot valve 37 shown in FIG. 1 has a spool 57 reciprocally mounted in a bore 58 formed by housing 59 and in communication with the pump 36 by means of a conduit 61. The valve bore 58 is also in fluid communication with opposite ends of the actuator valve 31 by means of conduits 62 and 63. The tilt actuator valve 31 includes a housing 64 defining a bore 66 for reciprocally receiving a spool 67. Fluid from the conduits 62 and 63 is communicated into chambers 68 and 69 formed by the valve housing 64 to act against opposite ends of the spool 67 while the spool 67 is normally urged into a centered position by means of springs 71.

To extend the tilt motors 11 and 12, which corresponds to forward tilting or dumping of the loader bucket, the pilot valve spool 57 of FIG. 1 is shifted to its position D against its centering spring 72. As the spool 57 is shifted rightwardly, the chamber 68 in the actuator valve 31 is communicated to drain through the conduit 62, the pilot valve bore 58, a cross drill passage 73 in the spool 57 and a drain conduit 74. Fluid pressure in the chamber 69 of the actuator valve 31 is maintained by the pump 36 so that the spool 67 tends to be shifted upwardly as viewed in the drawing. The passage 73 provides for modulated motion of the actuator valve spool 67 and accordingly modulation of the tilt motors 11 and 12 since fluid flow from the chamber 68 is metered by the passage 73 in cooperation with a land 76 in the pilot valve bore 58.

Positive positioning of the control valve spools 21 and 27 is effected in response to motion of the actuator spool 67 by means of the interconnecting mechanical linkage 32. The linkage comprises a pivoted lever 77 (shown in both FIGS. 1 and 2) and bellcranks 78 and 79, respectively, connected to the control valve spools 21 and 27. The pivoted lever 77 is connected at one end to the actuator spool 67 and at its other end to a link 81 which is also connected with both bellcranks 78 and 79. The control valves 18 and 24 are of similar but opposing con-

struction so that the tilt motors are similarly operated in response to any motion transmitted by the actuating spool 67 through the linkage 32. Accordingly, structure and operation of the control valve 18 is described in detail for operating tilt motor 11 and it is to be understood that control valve 24 operates similarly for simultaneous operation of the tilt motor 12 with motor 11. High pressure fluid from the pump arrangement 16 and conduit 49 is received in control valve 18 by a passage 82 which is in communication with a drain passage 83 and a spring loaded check valve 84. Upward shifting of the actuator spool 67 results in rightward motion of the control valve spool 21 which closes off the drain passage 83. The resulting pressure rise in passage 82 overcomes the check valve 84 and communicates fluid across the spool 21 into the conduit 39 and the head end of the tilt motor 11 while the conduit 41 from the rod end of the tilt motor 11 is communicated with a drain conduit 86 by means of the rightwardly positioned controlled valve spool 21. As discussed above, the rate of fluid flow to and from the tilt motor 11 and accordingly its rate of operation is determined by the amount of motion of the spools 21 and 67 which are in turn closely controlled by the rate at which fluid is metered through the passage 73 in the pilot valve spool 57.

To retract the motor 11, which corresponds to rack-back of the loader bucket, the pilot valve spool 57 is shifted leftwardly to its position R so that fluid from the actuator valve chamber 69 is similarly communicated to drain at a rate determined by the metering effect of another passage 87 in pilot valve spool 57 and a land 88 in the pilot valve bore 58. Fluid metered through the passage 87 is communicated into a drain conduit 89. The actuator valve spool 67 is accordingly shifted downwardly so that the control valve spool 21 is shifted leftwardly while the control valve spool 27 is shifted rightwardly. The drain passage 83 in the control valve 18 is similarly closed and fluid passing the check valve 84 is communicated into the conduit 41 and passes to the rod end of the tilt motor 11. Fluid from the head end of the tilt motor 11 passes through the conduit 39 across the control valve spool 21 and into the drain conduit 86. As noted above, the control valves 18 and 24 may be separately adjusted so that they operate generally simultaneously to set motors 11 and 12 in motion. The cross conduits 52 and 53 further assure equal pressure rises in both of the motors 11 and 12 and more accurately maintain simultaneous operation of those motors.

Operation of the lift motors 13 and 14 is regulated by a separate control system in response to actuation of the pilot valve 38. To describe the structure and operation of this control system in greater detail, the pilot valve 38 has a spool 111 reciprocally located in a bore 112 formed by a housing 113 and normally urged into a centered position by means of spring arrangement 114. Fluid from the pump 36 is communicated into the spool bore 112 through the conduit 61. The lift actuator valve 33 comprises a spool 116 reciprocally mounted in a bore 117 formed by a housing 118. Differential action of the actuator valve 33 is developed through a piston 119 reciprocally mounted in a chamber 121 formed by the housing 118 at one end of the spool 116 and a spring arrangement comprising a pair of dual acting springs 122, a larger spring 123 and a retainer arrangement 124 at the opposite end of the spool 116. Three conduits 126, 127 and 128, respectively, communicate the pilot valve bore 112 with the actuator valve chamber 129 containing the large spring 123, the chamber 121 at the opposite end of the housing 118 and a chamber 121' formed generally between the spool 116 and the piston 119.

To retract the lift motors 13 and 14 under hydraulic power, which corresponds to powering down of the loader bucket, the pilot valve spool 111 is shifted rightwardly toward or into its Lower position indicated at L. Fluid from the actuator valve chamber 129 and the conduit

126 is accordingly metered into the drain conduit 74 by interaction of a passage 131 in the pilot valve spool 111 with a land edge 132 formed in the pilot valve bore 112. The metering effect achieved by means of the passage 131 permits very precise modulation of the positions of the actuator valve spool 116, the control valve spools 22 and 28 and accordingly of the rate at which the lift motors 13 and 14 are retracted. While fluid from the actuator valve chamber 129 is being drained, substantially full pressure from the pump 36 exists in the actuator valve chamber 121 and in the chamber 121'. Pressure in the chamber 121' partially offsets that in the chamber 121 so that even with the pilot valve spool 111 shifted completely into its lower position, the actuator valve spool 116 is urged downwardly against the springs 122 only until the retainer 133 engages the shoulder 134.

Motion of the actuator valve spool 116 positively and accurately positions both of the lift control valve spools 22 and 28 by means of the mechanical coupling 34 which comprises a pivotal lever 136 (shown in both FIGS. 1 and 2) having one end pivotally joined at 137 to the actuator valve spool 116. Bellcranks 138 and 139 are respectively joined to the control valve spools 22 and 28 by means of links 141 and 142. Another link 143 is pivotally joined to both of the bellcranks 138 and 139 and at 144 to an end of the lever 136 opposite its connection with the actuator valve spool 116. The positioning and functioning of the control valve 19 is precisely regulated by the linkage 34 for controlling operation of the lift motor 13. Control valve 26 functions similarly to achieve simultaneous operation of the lift motor 14 so that the following discussion relative to the control valve 19 also applies to the control valve 26. High pressure hydraulic fluid from the drain conduit 83 of tilt control valve 18 is normally communicated across the control valve spool 21 into an inlet passage 151 for the lift control valve 19. The inlet passage 151 is in communication with a drain passage 152 and a spring loaded check valve 153.

The association of the fluid inlet for the tilt control valve 18 and the lift control valve 19 provides for operating priority of the tilt motor relative to the lift motor. When the tilt control valve spool 21 is in its normal position as shown in FIG. 2, fluid from its drain passage 83 is freely communicated to the lift control valve 19 to permit operation of lift motor 13. However when the tilt control valve spool 21 is shifted to operate the tilt motor 11, the fluid passage to the lift control valve 19 is closed to prevent operation of the lift motor 13.

With the lift control valve spool 22 shifted partially to the left by motion of the actuator valve spool 116 as described above, communication between its drain passage 152 and the drain conduit 86 is closed. The resulting pressure rise in the passage 151 acts against the spring loaded check valve 153 and communicates fluid across the shifted control valve spool 22 into the conduit 43 and the rod end of the lift motor 13. The head end of the lift motor 13 is simultaneously communicated with the drain passage 86 to permit retraction of the lift motor 13.

To permit lowering of the lift motor under the force of gravity, which corresponds to float lowering of the loader bucket, the lift pilot valve spool 111 is shifted completely to the right into its float position F. In this position, substantially full pressure from the pump 36 remains in the chamber 121 while fluid from the chamber 121' and the conduit 128 is communicated across the pilot valve spool 111 into the drain conduit 89. In this manner, the actuator valve spool 116 is urged downwardly against the large spring 123 until the retainer 154 engages a seat 156. This motion is transmitted through the mechanical linkage 34 to shift the lift control valve spool 22 further leftwardly so that pump fluid crossing the check valve 153 as well as fluid from both the head and rod ends of the lift motor 13 in conduits 42 and 43 is communicated into the drain conduit 86. The lift motor 13 is thus permitted to retract under the force of gravity

while residual pressure in the lift control valve 19 provides makeup fluid for the rod end of the lift motor 13.

To extend the lift motor 13, which corresponds to raising of the loader bucket, the pilot valve spool 111 is shifted leftwardly toward or into its position R. In this manner, fluid from both of the actuator valve chambers 121 and 121' are communicated to drain through a passage 157 in the pilot valve spool 111. The passage 157 meters flow from both chambers in cooperation with a land edge 158 formed by the pilot valve bore 112 to permit modulation of the positioning of the actuator valve spool 116. The control valve spools 22 and 28 are accordingly positioned by the spool 116 through the lever 136 and linkage 34 to vary the rate at which the lift motors 13 and 14 are extended. Fluid pressure from the pump 36 existing in the actuator valve chamber 129 urges the actuator valve spool 116 upwardly. This motion is transferred by the linkage 34 and shifts the lift control valve spool 22 rightwardly to communicate pump fluid pressure with the head end of the lift motor 13 and to communicate the rod end of the lift motor 13 through conduit 43 and the control valve 19 to the drain conduit 86 in a manner generally similar to the lift operation described above.

Referring particularly to FIG. 2, two additional valves 161 and 162 function to permit retraction of the lift motors 13 and 14, corresponding to lowering of the loader bucket when an engine (not shown) driving the various pumps is shut down or stalled. With the lift motors 13 and 14 in an extended position, the load supported by those motors creates residual pressure in their head end and in the conduits 42 and 47. These two conduits are in communication with the valve 161 by means of a conduit 163 which communicates the residual lift motor pressure to the valve 161. The valve 161 has a spring loaded check valve 164 normally positioned by its spring to block communication between the conduit 163 and a drain conduit 166. The spring chamber 167 of the valve 161 is in communication with the valve 162 by means of a conduit 168. The valve 162 has a spring loaded spool 169 normally positioned to communicate the conduit 168 with another conduit 171. Referring momentarily to FIG. 1 in particular, the conduit 171 is also in communication with the lift pilot valve spool 111 which is operable to communicate the conduit 171 to drain. During operation particularly of the pump arrangement 16, fluid under pressure is delivered to the valve 162 through a conduit 172 which shifts the spool 169 against its spring and blocks the conduit 168 from drain. In the position, residual pressure in the conduit 168 and the spring chamber 167 combines with the spring load on the poppet valve 164 to maintain it in a closed position and isolate the conduit 163 from the conduit 166. With the components of the valves 161 and 162 normally positioned as described above while the pump arrangement 16 is in operation, the lift motors 13 and 14 operate only in response to the lift control valves 19 and 26. However, when the pumps 16 cease operating, pressure in the conduit 172 drops and the spool 169 is shifted leftwardly by spring to communicate the conduit 168 with the conduit 171. This condition is normally maintained since the conduit 171 is blocked by the spool 111 and residual pressure in the lift pilot valve 38 (see FIG. 1). When the pumps cease operating, the control valves 19 and 26 are generally ineffective for operating the lift motors 13 and 14. However, when the lift pilot valve spool 111 is shifted rightwardly in the same manner as to normally retract the lift motors, the conduit 171 is communicated with the drain conduit 89 to reduce pressure existing within the spring chamber 167 of the valve 161. Residual pressure from the conduit 163 is then effective to overcome the spring load on the poppet valve 164 so that the poppet valve is shifted rightwardly to communicate the conduit 163 and the head end of the lift motors with the drain conduit 166. In this manner, the lift control system permits the lift jacks to be com-

pletely retracted under the force of gravity without the need of normal operating fluid pressures in the control system.

What is claimed is:

1. A pilot control system for simultaneously operating a pair of hydraulic motors controlling a single implement, comprising

a separate main source of fluid under pressure for each motor,

a separate control valve associated with each motor and its respective fluid source for regulating fluid flow to the motors,

actuator means, and

a mechanical coupling associated with the actuator means and both control valves for simultaneously positioning both control valves and providing generally equal fluid flow to both motors from their respective fluid sources in response to operation of said actuator means, said mechanical coupling including a pivotable lever connected to said actuator means,

a separate bellcrank connected to each control valve and a link interconnecting both bellcranks with said lever.

2. The invention of claim 1 wherein said two control valves have reciprocable spools connected to their respective bellcranks, said two control valves having similar and opposing configurations so that both motors are similarly operable by movement of said lever in response to said actuating means.

3. A pilot control system for simultaneously operating a pair of hydraulic motors controlling a single implement comprising

a separate main source of fluid under pressure for each motor,

a separate control valve associated with each motor and its respective fluid source for regulating fluid flow to the motors,

actuator means,

means associated with the actuator means and both control valves for simultaneously positioning both control valves and providing generally equal fluid flow to both motors from their respective fluid sources in response to operation of said actuator means, and

a pilot system for operating said actuator means, the pilot system including a source of pilot fluid and a pilot control valve for regulating the flow of pilot fluid to said actuator means, said actuator means being responsive to fluid pressure.

4. The invention of claim 3 wherein the motors are double acting, said control valves are effective to deliver fluid to operate the motors in one of two directions and said actuating means comprise a spool reciprocably disposed in a housing, said pilot means comprising a pilot fluid source and a pilot control valve for selectively directing fluid into one of two chambers defined by the housing at opposite ends of the spool.

5. The invention of claim 4 wherein said control valves are additionally effective to permit gravity operation of the motors, said actuating means comprising differential springs and differential pressurizing means for positioning said control valves in response to movement of said pilot control valve.

6. The invention of claim 5 further comprising means for permitting retraction of the motors during absence of normal operating fluid pressure in the pilot control system.

7. A pilot control system for simultaneously operating a pair of hydraulic motors controlling a single implement, comprising

a separate main source of fluid under pressure for each motor,

a separate control valve associated with each motor and its respective fluid source for regulating fluid flow to the motors,

actuator means,

means associated with the actuator means and both control valves for simultaneously positioning both control valves and providing generally equal fluid flow to both motors from their respective fluid sources in response to operation of said actuator means, and

means for effectively equalizing fluid pressures acting upon the two motors, said equalizer means comprising a conduit in effective fluid communication between the motors.

8. A pilot control system for simultaneously operating a pair of double acting hydraulic motors controlling a single implement, comprising

a separate main source of fluid under pressure for each motor,

a separate control valve associated with each motor and its respective fluid source for regulating fluid flow to the motors, each control valve being effective to regulate fluid flow to its respective motor through one of two fluid paths, the fluidpaths for the two motors being respectively in effective communication to equalize pressures acting upon the two motors, actuator means, and

means associated with the actuator means and both control valves for simultaneously positioning both control valves and providing generally equal fluid flow to both motors from their respective fluid sources in response to operation of said actuator means.

9. A pilot control system for simultaneously operating a pair of hydraulic tilt motors and a pair of hydraulic lift motors for a bucket loader comprising a control system for simultaneously operating each pair of motors, the control system for each pair of motors including

a separate main source of fluid under pressure for each motor of the pair of motors,

a separate control valve associated with each motor and its respective fluid source for regulating fluid flow to the pair of motors,

actuator means, and

means associated with the actuator means and both control valves for simultaneously positioning both control valves and providing generally equal fluid flow to both motors of the pair of motors from their respective fluid sources in response to operation of said actuator means.

10. The invention of claim 9 wherein the control valves and actuator means are disposed adjacent their respective motors.

11. The invention of claim 9 wherein the main fluid sources each comprise dual pumps for supplying high pressure fluid to one of the tilt motors and one of the lift motors.

12. The invention of claim 9 further comprising means for establishing operating priority in the tilt rotors relative to the lift motors.

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