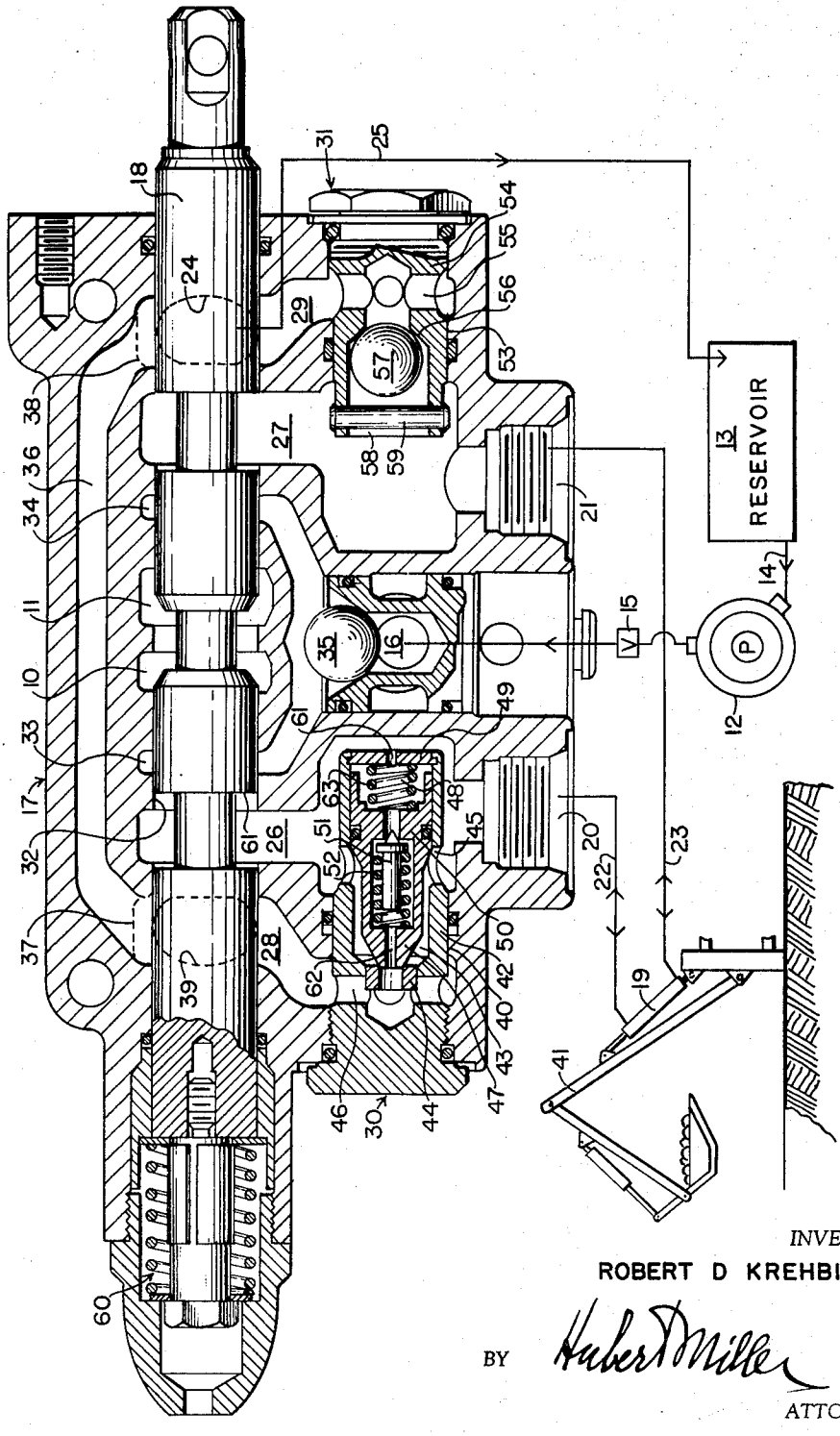
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PRESSURE FLUID CONTROL SYSTEM AND VALVE

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PRESSURE FLUID CONTROL SYSTEM AND VALVE

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This invention relates to a control system for double acting hydraulic motors, whether or not the major components are grouped in a single housing, as well as to a unitary valve in which the essential components of the control are grouped in a single housing.

More particularly the invention relates to a system and valve for controlling the flow of fluid under pressure to and from a double acting hoist cylinder, such as a cylinder used to raise and lower the boom of a power shovel, in which a very appreciable inertia force is built up during fast lowering or "dropping" of the boom.

Under such condition of use, when a conventional control valve is moved to a position in which the flow of fluid to and from the double acting cylinder is blocked in order to stop the downward travel of the boom, inertia forces in the boom and the load it carries cause excessive pressure to build up in that end of the cylinder from which the return of fluid to the system reservoir is blocked. Such excessive pressure causes hammer and often causes a break in some part of the system.

It is an important object of this invention to eliminate the above described difficulty by providing a means incorporated in the control system which affords relief of excess pressure when flow of fluid to and from the hydraulic motor is suddenly stopped by a control valve, such pressure relief also affording a slight further movement of the cylinder plunger and of the controlled boom or other controlled element, and thus providing a cushioned stop in the downward movement of the element.

Since the slightest movement of the plunger in a cylinder forces some fluid out one end of the cylinder, there must be an equivalent inflow of fluid into the other end of the cylinder else cavitation or fluid "starving" occurs in the cylinder. Consequently it is an additional important object of the invention to eliminate cavitation by providing an associated means which affords flow of the necessary amount of fluid into the cylinder to compensate for the slight cushioned movement of the plunger after flow of fluid to and from the cylinder through the normal supply and return passages has been blocked by the fluid control valve.

It is an additional object of the invention to provide a unitary fluid control valve which incorporates the above described features.

Other objects and advantages of the invention will be apparent when the following description is read in connection with the accompanying drawing.

The single drawing figure is a schematic view of a hydraulic system including a double acting motor for actuating the boom of a power shovel, my invention being embodied therein in the form of a unitary control valve, shown in longitudinal vertical central section.

While the valve shown in the drawing is specifically designed for cooperative association with other valves in a multiple valve bank, and consequently includes a so-called zig-zag type neutral by-pass passage 10—11 through which fluid may continuously flow from the pump discharge back to the reservoir when there is no demand on

the system, it will be understood by those familiar with this art that the invention described herein can be embodied in unitary valves designed to function independent of any association with other valves in a multiple bank.

Excepting the fluid flow control means shown in the drawing, the hydraulic system shown is considered conventional. A pump 12 is supplied with fluid from a reservoir 13 through a conduit 14 and delivers that fluid at an increased pressure through a relief valve 15 to a pressure fluid passage 16 in the body 17 of the flow control valve.

Under selective control by a shiftable valve spool 18 pressure fluid may be delivered from the supply passage 16 to either end of a double acting working cylinder 19 through motor ports 20 and 21 and lines 22 and 23, respectively, while fluid is simultaneously returned from the other end of the cylinder through the valve body, out through a return passage 24, into return line 25, and back to reservoir 13 to complete the circuit.

Generally, my invention includes a fluid supply means 16; a fluid return means 24—25; means forming two circuit control passages 26 and 27, connectible respectively to opposite sides of a double acting motor 19; a shiftable valve means 18 which has a neutral position in which flow of fluid to and from both circuit control passage is blocked, and which is capable of selectively connecting either circuit control passage with the fluid supply means 16 while connecting the other circuit control passage with the fluid return means 24; two separate by-pass passages 28 and 29 both openly communicating with the fluid return means 24, and each associated with and connectible to a respective one of the circuit control passages independent of the shiftable valve spool 18; and directional valves 30 and 31, one in each of said by-pass passages, each directional valve being shiftable to open in response to differential pressure, the one valve 30 being oriented to afford flow of fluid from its associated circuit control passage 26 into its associated by-pass passage 28 and thence to the fluid return means 24, and the other directional valve 31 oriented to afford flow from the fluid return means 24 through its associated by-pass passage 29 into the associated circuit control passage 27.

More specifically the valve illustrated, which embodies my control system, includes a housing 17 which has a longitudinal valve spool receiving bore 32. This bore is intersected by two cooperating branches 10 and 11 of a neutral by-pass passage, and by two separated but communicating fluid pressure supply ducts 33 and 34 which are delivered fluid from a fluid pressure supply passage 16 through a ball check valve 35. Bore 32 is also intersected by two circuit control passages 26 and 27, each located adjacent a respective one of the supply ducts 33 and 34, and by two by-pass passages 28 and 29, each located adjacent a respective one of the circuit control passages 26 and 27.

The two circuit control passages 26 and 27 communicate respectively with motor ports 20 and 21, which in turn are connected by means of conduits 22 and 23 to opposite ends of a hydraulic motor or double acting cylinder 19.

In the system illustrated, by-pass passage 28 functions as a circuit relief passage, while by-pass passage 29 functions as an anti-cavitation passage.

From the drawing it will be seen that the upper end of by-pass passage 29 communicates directly with return passage 24. In the preferred form of valve shown the upper end of by-pass passage 28 also communicates with return passage 24 through a fluid transfer duct 36. Alternatively passages 28 and 29 may terminate respectively at the broken lines 37 and 38, and transfer duct 36 eliminated. In such case the housing is provided with a second return passage 39, which would communicate di-

rectly with the upper end of passage **28** as well as with return line **25**.

From the drawing it will be noted that passages **28** and **26** are intersected and connected by a cross bore **40** and that a directional relief valve assembly **30** is sealed in this cross bore to afford flow of fluid under excessive pressure from passage **26** into passage **28**.

The particular relief valve shown is pilot operated, although other types of pressure relief valves will serve the purpose of my invention provided the valve used opens only at a pressure greater than the normal operating pressure existing in control passage **26** during the raising and lowering of the boom **41** by cylinder **19**. Although the specific relief valve construction shown is not essential to the operation of the invention described in this application, and is disclosed completely and in greater detail in a separate patent application, it will be briefly described to assure that the operation of my invention is clearly understood.

Valve assembly **30** includes a housing **42** having a longitudinal bore **43** extending part way through the housing from its inner end. A valve seat insert **44** is fixed in the inner end of bore **43**. The housing has an inlet **45** which communicates with chamber **26**, and has an outlet **46** which communicates with by-pass passage **28**. A longitudinally bored valve head **47** is reciprocable in bore **43** and is normally maintained on seat **44** by a spring **48**, which bears against an orifice plate **49** and against a combination pilot valve seat and spring tension adjusting member **50**. A spring pressed pilot valve **51** is normally maintained seated on seat **50** by a spring **52**. The operation of this relief valve will be described along with the description of the operation of my complete control system.

In the control valve illustrated the lower portions of passages **27** and **29** are connected by an intersecting cross bore **53** in which is sealed a differential pressure opened directional valve in the form of a simple check valve assembly **31**. This includes a housing **54** having an inlet **55**, a valve seat **56**, a ball check **57**, an outlet **58** forming a ball cage, and a fixed cross pin **59** to hold the ball in its cage.

To control fluid flow through the housing a shiftable valve means in the form of a cannelured valve spool **18** is reciprocably mounted in the bore **32** of the housing. The spool is urged toward the neutral or centered position shown in the drawing by a conventional spring centering assembly designated as a whole by the numeral **60**.

The lands and grooves of spool **18** are so located that when the spool is in its neutral position communication between the fluid pressure supply means **16** and both circuit control passages **26** and **27** is blocked. Likewise communication is blocked between both circuit control passages and the respective by-pass passages **28** and **29**, and hence no fluid can be returned through spool bore **32** into the return means **24**. During normal operation this condition will positively lock the plunger in cylinder **19** against movement in either direction, thus holding boom **41** in a desired position.

Operation

It will be understood that pressure of fluid in circuit relief passage **28** is relatively low because it communicates only with the fluid return side of the system.

When boom **41** is in the raised position shown and the operator desires to lower or "drop" it, he moves spool **18** to the left. Pressure fluid flows from passage **16** past ball check **35**, thru duct **34**, bore **32**, control passage **27**, line **23** and into the inner end of cylinder **19** causing the plunger therein to move outward rapidly. As boom **41** drops fluid from the outer end of the cylinder **19** flows thru line **22**, control passage **26**, bore **32**, transfer duct **36** and out thru return passage **24**.

When the operator desires to stop the downward travel of the boom **41** he returns spool **18** to its neutral position,

as shown in the drawing. This stops the normal flow of fluid from the supply means **16** to the inner end of the cylinder **19** and also stops the flow of return fluid from the outer end of cylinder **19** back to the return passage **24**. Ordinarily, due to the inertia forces built up during the downward travel of boom **41** the boom would come to an abrupt and complete stop which would result in an extreme pressure being built up in circuit control passage **26**, and a resulting "hammer" throughout the entire hydraulic system shown. Such pressure and hammer could easily damage various parts of the system.

With my invention, however, as the excess pressure builds up in control passage **26** fluid passes through orifice **61** into the bore in valve seat **50**, lifts pilot valve **51** off its seat, flows through bore **62** in valve head **47** and into circuit relief passage **28**. As fluid flows past the pilot valve **51** there is a resulting pressure drop in chamber **63** of the circuit relief valve **30**, and valve head **47** moves to the right in the drawing against the pressure of spring **48**. Thereafter fluid may flow from the lower portion of circuit control passage **26** through inlet **45** and around the valve head **47** and out through the valve seat **44** into passage **28**, and thence to the return passage **24**. As soon as a sufficient amount of fluid has escaped from control passage **26** to lower the pressure therein below the pressure at which the relief valve is set to open, valve head **47** again moves to the left and seats under the urging of spring **48**. It will be understood that only a very minor amount of liquid actually flows through the relief valve.

As a result of the escape of this small amount of fluid from control passage **26**, however, the plunger in cylinder **19** is not brought to an immediate and complete stop. The escape of fluid first slows and then stops the plunger travel and results in what is commonly termed a "cushioned" stop, which completely eliminates the "hammer" which normally accompanies the stopping of a plunger which is being subjected at the time to inertia forces.

During the described "cushioned" stop the plunger moves slightly in cylinder **19**, creating a partial vacuum in the inner end of the cylinder, in line **23**, and in circuit control passage **27**, because this circuit is unable to obtain supply fluid from the duct **34**. As a result of the drop in pressure in control passage **27** the pressure in anti-cavitation passage **29** causes fluid to flow from the return line through that passage past ball check **57** and thence through line **23** to the inner end of cylinder **19**, thus preventing that end of the cylinder from being "starved" of fluid.

It is believed that those familiar with this art will understand that by shifting spool **18** to the right of its neutral position, shown in the drawing, supply fluid will pass from supply passage **16** through duct **33**, bore **32**, control passage **26**, line **22** and into the outer end of cylinder **19**. Simultaneously fluid will return from the inner end of cylinder **19** through line **23**, circuit control passage **27**, bore **32** and into return passage **24**.

Having described the invention with sufficient clarity to enable those familiar with this art to construct and use it, I claim:

1. A pressure fluid control system for a double acting fluid motor comprising: fluid supply and fluid return means; means forming two circuit control passages connected respectively to opposite sides of said motor; shiftable valve means for selectively connecting either circuit control passage with the fluid supply means while connecting the other circuit control passage with the fluid return means, and in one position for blocking flow of fluid to and from said circuit control passages; means openly communicating with the fluid return means and forming two separate by-pass passages, each associated with and connectible to a respective one of said circuit control passages independent of the shiftable valve means; and means responsive to an appreciable pressure

increase in one circuit control passage and a pressure decrease in the other circuit control passage to by-pass excess fluid from the higher pressure circuit control passage to the fluid return means, and to by-pass supplemental fluid from the fluid return means into the lower pressure circuit control passage.

2. A pressure fluid control system for a double acting fluid motor comprising: fluid supply and fluid return means; means forming two circuit control passages connected respectively to opposite sides of said motor; shiftable valve means for selectively connecting either circuit control passage with the fluid supply means while connecting the other circuit control passage with the fluid return means, and in one position for blocking flow of fluid to and from said circuit control passages; means openly communicating with the fluid return means and forming two separate by-pass passages, each associated with and connectible to a respective one of said circuit control passages independent of the shiftable valve means; and means responsive to an appreciable pressure increase in one circuit control passage and a pressure decrease in the other circuit control passage to by-pass excess fluid from the higher pressure circuit control passage through its associated by-pass passage to the fluid return means, and to by-pass supplemental fluid from the fluid return means through the other by-pass passage into the lower pressure circuit control passage, independent of said shiftable valve means.

3. A control system for a double acting fluid motor comprising: fluid supply and fluid return means; means forming two circuit control passages connected respectively to opposite sides of said motor; shiftable valve means for selectively connecting either circuit control passage with the fluid supply means while connecting the other circuit control passage with the fluid return means, and in one position for blocking flow of fluid to and from said circuit control passages; means openly communicating with the fluid return means and forming two separate by-pass passages, each associated with and connectible to a respective one of said circuit control passage independent of the shiftable valve means; a valve interposed between and capable of by-passing excess fluid from one circuit control passage into its associated by-pass passage in response to a predetermined pressure differential in those two passages when the shiftable valve means is in its flow blocking position; and a second valve interposed between and capable of by-passing supplemental fluid from the other by-pass passage into its associated circuit control passage when pressure in the latter drops below pressure in the said other by-pass passage and in the connected fluid return means.

4. A pressure fluid control system for a double acting fluid motor comprising: fluid supply and return means; means forming two circuit control passages connected respectively to opposite sides of said motor; shiftable valve means for selectively connecting either circuit control passage with the fluid supply means while simultaneously connecting the other circuit control passage with the fluid return means, and in one position for blocking flow of fluid to and from both said circuit control passages; a separate by-pass passage between each circuit control passage and the fluid return means; a directional valve in each of said by-pass passages, each valve shiftable in response to differential pressure, one oriented to afford flow of fluid from its associated circuit control passage into its associated by-pass passage and to the fluid return means, and the other oriented to afford fluid flow from the fluid return means through its associated by-pass passage into its associated circuit control passage.

5. The system described in claim 4 in which the said one directional valve is of the relief type and opens only at a pressure in excess of that normally supplied by the fluid supply means, and the said other directional valve is a simple check valve.

6. A valve for controlling the flow of fluid to and from both ends of a double acting hydraulic working cylinder or motor comprising: a housing having a bore therein; fluid pressure supply and fluid return means defined by the housing, for connection with a source of fluid under pressure and with a reservoir, respectively, both the fluid supply and return means communicating with said bore; means in the housing defining two circuit control passages for connection respectively to opposite ends of said motor, both said passages communicating with said bore; shiftable valve means in said bore effective in one position to block flow of fluid to and from both circuit control passages, and shiftable to selectively connect either circuit control passage with the fluid supply means while simultaneously connecting the other circuit control passage with the fluid return means; means in the housing defining by-pass passages in open communication with the fluid return means and respectively connecting the circuit control passages with said fluid return means; a directional valve in each by-pass passage openable in response to differential pressure, one oriented to afford flow of fluid from its associated control passage into its associated by-pass passage in response to a pressure in that control passage greater than the pressure required to operate the motor under a loaded condition, the other directional valve being oriented to afford fluid flow from the fluid return means into its associated circuit control passage in response to the slightest excess of pressure in the fluid return means.

7. The valve described in claim 6 in which each of said by-pass passages is closely associated with a respective one of said circuit control passages, and is capable of connecting its associated control passage with the fluid return means independent of the bore and the shiftable valve means therein, through the opening of its respective directional valve.

8. A valve for controlling the flow of fluid to and from both ends of a double acting hydraulic working cylinder or motor comprising: a housing having a valve spool receiving bore therein; a pressure fluid inlet passage in said housing in communication with said bore and connectible to a source of fluid under high pressure; a fluid outlet passage in the housing in communication with said bore and connectible to a reservoir; a pair of circuit control passages in communication with said bore for connection to the respective opposite ends of the cylinder; a cannelured flow controlling valve spool reciprocable in said bore, effective in a neutral position to block the flow of fluid from the inlet to both circuit control passages and to block flow from both circuit control passages into said outlet through the bore, said spool being shiftable to selectively connect either circuit control passage with the inlet while simultaneously connecting the other circuit control passage with the outlet; a circuit relief by-pass passage in open communication with the outlet and in valve controlled communication with one of said circuit control passages independent of said valve spool; a pressure opened circuit relief valve interposed between the circuit relief passage and its connected circuit control passage and oriented to by-pass fluid from the control passage into the circuit relief passage in response to a pressure increase in the said control passage to a value greater than the pressure supplied by the inlet; an anti-cavitation by-pass passage in open communication with the outlet and in valve controlled communication with the other circuit control passage independent of said valve spool; and a check valve interposed between the anti-cavitation passage and the said other circuit control passage and affording flow of fluid from the former into the latter in response to a pressure drop in said other circuit control passage to a value lower than the pressure in the anti-cavitation passage.

9. A valve for controlling the flow of liquid to and from both ends of a double acting hydraulic hoisting cylinder comprising: a housing having a longitudinally disposed valve spool receiving bore therein; a pressure

passage in the housing for connection to a source of high pressure liquid; a liquid return passage in the housing for connection to a liquid reservoir; a circuit relief by-pass passage in the housing; an anti-cavitation by-pass passage in the housing; a pair of circuit control passages in the housing; two motor ports communicating respectively with said circuit control passages and constituting means to connect the valve with the opposite ends of a double acting hydraulic hoisting cylinder, all said passages communicating with said bore, said by-pass passages both being in open communication with the liquid return passage, each by-pass passage being connectible directly with a respective one of said circuit control passages through said bore and also at a location spaced from said bore, said circuit control passages being connectible selectively with said pressure passage and with said liquid return passage through said bore; a cannelured liquid flow controlling valve spool reciprocable in said bore and movable to a neutral position in which liquid flow from both circuit control passages through the bore and to the return passage is blocked, and in which flow from the pressure passage into both circuit control passages is blocked; a circuit relief valve interposed between and capable of by-passing liquid from one circuit control passage into its associated circuit relief passage in response to a predetermined pressure differential in the two passages when the valve spool is in its neutral flow blocking position; and a check valve interposed between and capable of by-passing liquid from the anti-cavitation passage into the other circuit control passage when pressure in the latter drops below pressure in the anti-cavitation passage and in the connected liquid return passage.

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