

[54] CONTROL SYSTEM FOR AUTOMATICALLY SEQUENCING OPERATION OF A PLURALITY OF HYDRAULIC PUMPS FOR SUPPLYING A PLURALITY OF HYDRAULIC ACTUATORS

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[56] References Cited
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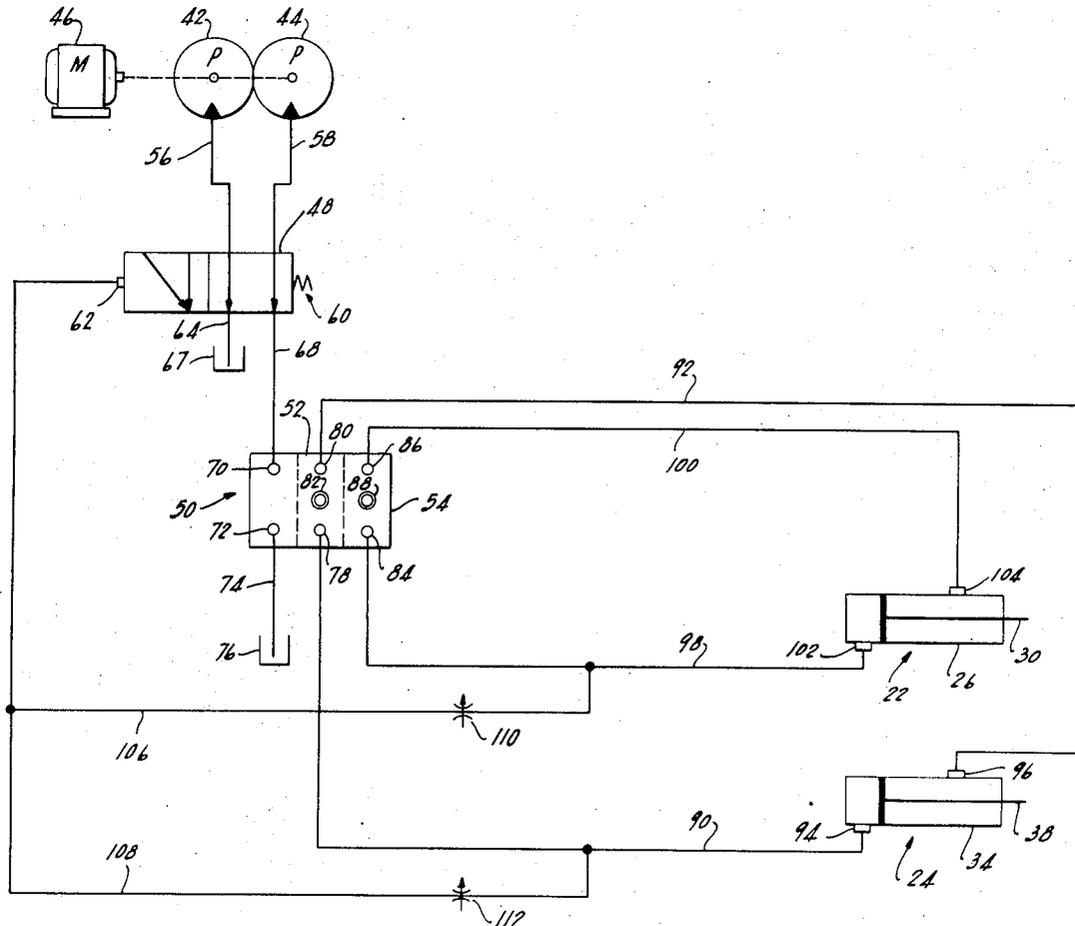
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[57] ABSTRACT

A machine such as a mobile hydraulic crane has a telescopic boom comprising two independently movable boom sections. Each boom section is movable to extended and retracted positions by separate independently operable hydraulic actuators. Each actuator is operated or controlled by a manually operable three position hydraulic control valve. A plurality of hydraulic pumps are provided for supplying the actuators and a control system including a pressure-responsive sequencing valve is provided for automatically and sequentially connecting one or more pumps to supply the cylinders, depending on the number of cylinders that are being actuated at any given time. The sequencing valve responds to a pressure increase which occurs in the event the supply lines to both actuators are operated simultaneously in the boom-extend direction. If either actuator is being operated in the boom-extend direction, only one pump is connected to supply it. If more than one actuator is being operated in the boom-extend direction, more than one pump is then automatically connected to supply fluid to the system by the pressure-responsive sequencing valve.

3 Claims, 2 Drawing Figures



CONTROL SYSTEM FOR AUTOMATICALLY SEQUENCING OPERATION OF A PLURALITY OF HYDRAULIC PUMPS FOR SUPPLYING A PLURALITY OF HYDRAULIC ACTUATORS

BACKGROUND OF THE INVENTION

1. Field of Use

This invention relates generally to hydraulic control systems for automatically sequencing the operation of a plurality of hydraulic pumps which supply fluid to operate one or more of a plurality of hydraulic actuators or cylinders.

2. Description of the Prior Art

Some types of machines such as mobile hydraulic cranes, for example, employ a boom which comprises telescoping boom sections which can be extended or retracted to suit a particular situation. Usually each boom section is movable by a separate hydraulic cylinder or actuator, each such actuator is actuated by a separate control valve, and all actuators are supplied with hydraulic fluid from a single motor-driven pump. The control valves and actuators can be actuated individually or simultaneously. Therefore, the pump must always be ready to deliver the maximum amount of pressurized fluid that would be required if all actuators were actuated simultaneously. However, as a practical matter, such a demand is infrequently made and the net result is that energy is wasted by continually maintaining fluid pressure and volume at the maximum demand level.

SUMMARY OF THE INVENTION

A machine such as a mobile hydraulic crane has a telescopic boom which includes several boom sections which are independently movable to extended and retracted positions. Each boom section is movable by its own individual hydraulic cylinder or actuator. Each actuator is actuated in the extend or retract direction by means of a manually operable control valve which has neutral, extend and retract positions. The several control valves are arranged in a common manifold and are supplied from a common source of pressurized hydraulic fluid. The fluid source includes a plurality of fluid pumps which are selectively connectible to the control valve manifold through a pressure responsive valve which is responsive to fluid pressure in each of the supply lines between the control valves and the actuators. Normally, only one pump is continuously connected to supply fluid. However, if more than one actuator is actuated, in the boom-extend direction, a pressure increase momentarily occurs in the supply lines to the actuators and this results in operation of the pressure responsive valve to connect more than one pump to the system to supply the actuators.

DRAWINGS

FIG. 1 is a schematic cross-section view of a telescopic boom and hydraulic actuators therefor with which a control system in accordance with the invention is employed; and

FIG. 2 is a diagrammatic view of a control system in accordance with the invention showing it connected to the telescopic boom actuators shown in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1, the numeral 10 designates a telescopic boom such as is used on a machine such as a

crane, back-hoe or the like. Boom 10 comprises a first tubular steel section 12, open at both ends, and having a bracket 14 at its inner end which adapts it for pivotal connection or mounting on a machine (not shown) of which it is a part. Boom 10 further comprises a second tubular steel section 16, open at both ends, which can telescope within first section 12. Boom 10 also comprises a third tubular steel section 18, open at its inner end, which can telescope within second section 16 and which is provided with a working head member 20 which in practice could be a support for pulleys in a crane or a shovel attachment in a back hoe. In FIG. 1, boom 10 and the sections thereof are shown in fully telescoped position and it is to be understood that the sections 16 and 18 are independently movable by means of first and second hydraulic rams or actuators 22 and 24, respectively, from the retracted position shown to fully extended position or any position therebetween.

Referring to FIGS. 1 and 2, actuator 22 comprises a cylinder 26 which is fixedly secured by a pin 28 to first boom section 12 and a movable piston rod 30 which is fixedly secured by a pin 32 to second boom section 16. Actuator 24 comprises a cylinder 34 which is fixedly secured by a pin 36 to second boom section 16 and a movable piston rod 38 which is fixedly secured by a pin 40 to third boom section 18.

As FIG. 2 shows, the actuators 22 and 24 are adapted to be supplied with hydraulic fluid for operation thereof from a fluid source comprising a pair of conventional constant volume hydraulic fluid pumps 42 and 44 driven by a conventional constant speed electric motor 46, through a pressure responsive valve 48 (which serves as a sequencing valve), and a control valve manifold 50 comprising first and second control valves 52 and 54.

The pumps 42 and 44 are connected to the fluid inlet ports of pressure-responsive valve 48 by fluid lines 56 and 58, respectively. Valve 48 is a two-position valve which is biased leftward into a first position shown in FIG. 2 by an internal biasing spring 60 and is understood to be movable rightward (with respect to FIG. 2) to a second position in response to a change in fluid pressure at its pressure port 62. When pressure-responsive sequencing valve 48 is in its first position as shown in FIG. 2 it connects the fluid lines 56 and 58 to fluid lines 64 and 68, respectively. Fluid line 64 is connected to a reservoir 67 and fluid line 68 is connected to the fluid inlet port 70 of manifold 50. Manifold 50 has a fluid outlet port 72 which is connected by a fluid return line 74 to a reservoir 76. In practice, reservoirs 67 and 76 are combined. When valve 48 is in its second position, it connects both the fluid lines 56 and 58 to fluid supply line 68. Thus, the control valves 52 and 54 are furnished with fluid from a common fluid supply line 68 and a common fluid source comprising either pump 44 or both pumps 42 and 44, depending on valve position.

The first and second control valves 52 and 54 are identical to each other and each is a conventional three-position valve. Valve 52 comprises first and second fluid output ports 78 and 80 and a manually movable control lever 82. Valve 54 also comprises first and second fluid output ports 84 and 86 and a manually movable control lever 88. Both control levers 82 and 88 have a neutral position and are movable downwardly (with respect to FIG. 2) from neutral toward

boom-extend position and upwardly from neutral toward boom-retract position to effect corresponding operation of the actuators 22 and 24, respectively, and their associated boom sections 16 and 18, respectively. The degree or extent of control lever movement in either direction effects the rate of fluid flow from the control valves 54 and 52 to the actuators 22 and 24, respectively, and thereby controls the speed of movement of the actuator piston rods 30 and 38, respectively, and their associated boom sections 16 and 18, respectively.

Valve 52 has its ports 78 and 80 connected by fluid lines 90 and 92 to ports 94 and 96, respectively, of actuator 24. Pressurization of port 94 or 96 of actuator 24 by movement of control lever 82 of control valve 52 downwardly or upwardly, respectively, results in extension or retraction of piston rod 38 of actuator 24 and corresponding movement of boom section 18. Valve 54 has its ports 84 and 86 connected by fluid lines 98 and 100 to ports 102 and 104, respectively, of actuator 22. Pressurization of port 102 or 104 of actuator 22 by movement of control lever 88 of control valve 54 downwardly or upwardly, respectively, results in extension or retraction of piston rod 30 of actuator 22 and corresponding movement of boom section 16.

Fluid pressure sensing lines 106 and 108 are connected between the fluid lines 98 and 90, respectively, and pressure port 62 of pressure responsive sequencing valve 48. Adjustable orifice valves or flow control devices 110 and 112 are provided in the lines 106 and 108 to balance fluid flow therein. A pressure increase in either line 106 or 108 alone, caused by pressurization of the lines 98 or 90, respectively, as the control valves 54 or 52, respectively, are operated is insufficient to cause sequencing valve 48 to move from its first position shown in FIG. 2. However, a pressure increase in both lines 106 and 108 simultaneously as both control valves 54 and 52 are operated causes sequencing valve 48 to move to its second position wherein both pumps 42 and 44 are connected to line 68.

OPERATION

A machine having a telescoping boom 10 as shown in FIG. 1 and a control system for the hydraulic actuator 22 and 24 thereof as shown in FIG. 2 operates as follows.

Assume that boom 10 is in the fully retracted configuration shown in FIG. 1 and that the actuators 22 and 24 are in the configuration shown in FIGS. 1 and 2. Also assume that electric motor 46 and pumps 42 and 44 are in operation, that sequencing valve 48 is in the position shown in FIG. 2, and that the control levers 82 and 88 of the control valves 52 and 54, respectively, are in the neutral position as shown in FIG. 2.

With the foregoing assumptions, pump 42 is discharging its fluid to reservoir 67 and pump 44 is supplying its fluid to valve manifold 50 through line 68. However, since both control valves 52 and 54 are in neutral, the fluid from pump 44 is discharged through line 74 to reservoir 76. Neither actuator 22 nor 24 is being pressurized for operation in either direction and the fluid lines 90 and 98 are not pressurized. Therefore, no pressure exists in lines 106 and 108 to cause movement of sequencing valve 48 from its first to its second position. Boom 10 remains in the condition shown in FIG. 1.

Now assume that it is desired, for example, to extend one of the boom sections 16 or 18. If section 18 is to be extended, control valve 52 is operated by moving its control lever 82 downwardly from neutral to pressurize fluid line 90 and port 94 of actuator 24. This causes extending movement of piston rod 38 and boom section 18 at a rate of speed determined by the extent of downward movement of control lever 82. Residual fluid in cylinder 34 of actuator 24 is expelled through port 96 and line 92 to port 80 of control valve 52 and from there into manifold 50 and through line 74 to reservoir 76. Since line 90 is pressurized, line 108 and port 62 of sequencing valve 48 are also pressurized but this pressurization is insufficient to cause movement of valve 48 from first to second position.

Therefore, only pump 44 supplies operating fluid to the system. When control lever 82 of control valve 52 is returned to neutral pressurization of port 94 of actuator 24 ceases and movement of piston rod 38 and boom section 18 stops.

If boom section 18 is to be retracted, control lever 82 of control valve 52 is moved upwardly from neutral to pressurize fluid line 92 and port 96 of actuator 24. This causes retracting movement of piston rod 38 and boom section 18 at a rate of speed determined by the extent of upward movement of control lever 82. Residual fluid in cylinder 34 of actuator 24 is expelled through port 94 and line 90 to port 78 of control valve 52 and from there into manifold 50 and through line 74 to reservoir 76. However, such fluid flow through line 90 is of negligible pressure and not intended to operate sequencing valve 48.

Extension and retraction of boom section 16 is carried out in the same manner as that of boom section 18 as hereinbefore described, except that control lever 88 of control valve 54 is operated to effect operation of actuator 22 and boom section 16. It is to be understood that pressurization of fluid line 98 effects pressurization of line 106 but such pressurization alone is insufficient to cause movement of valve 48 from first to second position. Therefore, only pump 44 supplies operating fluid to the system. Pressurization of line 100 to effect retracting movement of actuator 22 and boom section 16 results in fluid flow from port 102 of cylinder 26 to port 84 of control valve 54. However, such fluid flow through line 98 is of negligible pressure and not intended to operate sequencing valve 48.

Now assume that both control valves 52 and 54 are being operated simultaneously by downward movement of the control levers 82 and 88, respectively, to effect extending movement of piston rods 38 and 30 (and boom sections 18 and 16) of the actuators 24 and 22, respectively. In such a case, both lines 90 and 98 are simultaneously pressurized initially from pump 44. However, pump 44 is incapable of delivering a sufficient volume of fluid at the pressure necessary to operate both actuators 22 and 24 simultaneously in the extending direction against a load (i.e., lifting the weight of the boom sections and any load thereon). It is to be noted, however, that the initial pressurization of both lines 106 and 108 is sufficient to pressurize port 62 of sequencing valve 48 and cause the valve to move from its first position (shown in FIG. 2) to its second position wherein it connects both pumps 42 and 44 to supply line 68 to provide operating fluid for the system. The fluid supply from both pumps 42 and 44 is commingled in manifold 50 and available for use by both actuators

at an appropriate pressure and volume level. However, as soon as one or the other or both of the control levers 82 or 88 of control valves 52 and 54, respectively, are returned to neutral or moved to the boom-retracting position, the fluid pressure at port 62 of sequencing valve 48 drops sufficiently to allow sequencing valve 48 to return from its second position (wherein both pumps 42 and 44 are connected to supply the system) to its first position (wherein only pump 44 is connected to supply the system).

RESUME

A machine such as a mobile hydraulic crane has a telescopic boom 10 comprising boom sections 16 and 18 which are independently movable in extend or retract directions by hydraulic actuators 22 and 24, respectively. The actuators 22 and 24 are operated or controlled by three-position control valves 54 and 52, respectively, which have control levers 88 and 82, respectively, which are movable from neutral to boom-extend or boom-retract positions. The control valves 52 and 54 are connectible to either one pump 44 or two pumps 44 and 42 which supply operating fluid to the system by means of a two-position pressure-responsive sequencing valve 48. Control valve 52 is connected by fluid lines 90 and 92 to actuator 24 for boom section 18. Control valve 54 is connected by fluid lines 98 and 100 to actuator 22 for boom section 16. Fluid line 90 is connected by a fluid pressure line 108 to pressure port 62 of sequencing valve 48. Fluid line 98 is also connected by a fluid pressure line 106 to pressure port 62 of sequencing valve 48. When either (but not both) control valve 52 or 54 is operated to actuate its associated actuator 24 or 22, respectively, to move the boom section 18 or 16 to extended position, either fluid line 90 or 98 is pressurized. However, pressurization of either line 90 or 98 alone is insufficient to cause sequencing valve 48 to move from its first position wherein pump 44 is connected to supply the system. However, if both control valves 52 and 54 are operated simultaneously in the boom extend direction, both fluid lines 90 and 98 are simultaneously pressurized and this causes sufficient pressurization at port 62 of sequencing valve 48 to cause the valve to move to a second position wherein both pumps 42 and 44 are connected to supply the system. Pressurization of either or both actuators 22 and 24 for operation in the boom-retract direction does not result in movement of valve 48 from first to second position.

I claim:

1. A machine having a telescopic boom comprising a plurality of boom sections, each movable to extended and retracted positions, a plurality of individually operable hydraulic actuators for moving said boom sections, each actuator being operable in boom extend and boom retract directions, one actuator being provided for each boom section, a multiposition control valve for each actuator, said control valve having neutral, extend and retract positions, a fluid supply line connected between each control valve and its associated actuator to

effect operation of the actuator in the boom extend direction, a plurality of pumps for supplying hydraulic fluid to said actuators through said control valves, a pressure responsive sequencing valve having a pressure port, a fluid pressure line connected between each of said supply lines and said pressure port, and a flow control device connected in each fluid pressure line, said sequencing valve being connected between said pumps and said control valves and operable in response to fluid flow conditions to said actuators to connect one pump for fluid supply purposes when one actuator is operating in either the boom extend or retract direction when the control valve therefor is moved from neutral and to connect more than one pump for fluid supply purposes when more than one actuator is operating in the boom extend direction when all of the control valves therefor are moved from neutral to extend position.

2. A machine having a telescopic boom comprising a plurality of boom sections, each boom section being movable between extended and retracted positions: a pair of pumps; an engine for driving said pumps; a two-position pressure responsive sequencing valve having a fluid output port, two fluid inlet ports, each of said inlet ports being connected to one of said pumps, and a pressure port, said sequencing valve normally connecting one of said pumps to provide fluid at said fluid output port and said sequencing valve being responsive to application of a predetermined fluid pressure at its pressure port to connect both of said pumps to provide fluid at said fluid output port; a plurality of individually operable hydraulic actuators for moving said boom sections, one actuator being provided for each boom section and each actuator having a pair of fluid ports, each actuator movable in extend and retract directions depending on which of its fluid ports is pressurized; a plurality of manually operable multiposition control valves for effecting operation of said actuators, one control valve being provided for each actuator and each control valve having a pair of fluid ports connected to the pair of fluid ports on its associated actuator, each control valve having a neutral, extend and retract position, each control valve having a fluid inlet port connected to said fluid output port of said sequencing valve; fluid lines connected between the pressure port of said sequencing valve and one port of each said pairs of fluid ports of said control valves; and a flow control device in each of said fluid lines; said sequencing valve being responsive to pressurization of one of said fluid lines in response to operation of any one of said control valves to the extend position to connect one of said pumps to a selected actuator, said sequencing valve being responsive to operation of more than one of said control valves to extend position to connect said pair of pumps to said plurality of actuators.

3. A machine according to claim 2 comprising two movable boom sections, two hydraulic actuators and two control valves.

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