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(54) IMPLEMENT CIRCUIT FOR MOTOR WITH SLOW AND FAST DUMP

(71) We, CATERPILLAR TRACTOR CO., a corporation organized and existing under the laws of the State of California, United States of America, of 100 N.E. Adams Street, Peoria, Illinois, 61629, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a control system for a vehicle including a loading implement, and more particularly, to a vehicle incorporating a bucket which may be moved in a slow dump and a fast dump mode.

A system has previously been proposed for use with a vehicle including an implement movable between a rack-back and a dump position. In this system, the operator of the vehicle may select a relatively high speed movement from the rack-back to the dump position, or a relatively low speed movement thereof. In the system, once a certain dump mode is chosen, the dump mode remains in effect until the operator of the vehicle selects a different dump mode. In order to add to the overall flexibility of operation of the apparatus, it would be useful to provide means wherein, after selection of the fast-dump mode with the implement in the rack-back position, the implement moves automatically to the slow-dump mode after a certain amount of movement thereof, to provide highly effective control of the load carried by the implement.

According to the present invention a control system for a vehicle having tilt cylinder means actuable in opposite directions to move a bucket to a dump position and to a rack-back position respectively, comprises a fluid pump, and means for operatively interconnecting the fluid pump and tilt cylinder means for selectively providing a first, and a second relatively higher, speed of movement of the bucket from the rack-back position toward the dump position through actuation of the tilt cylinder means, the means for operatively interconnecting the fluid pump means and tilt cylinder means including means whereby, after initial selection of the second, relatively higher speed of movement of the bucket from the rack-back position toward the dump position and after a given degree of the higher-speed movement having taken place, the first, relatively lower speed is automatically instituted.

One example of a control system according to the invention will now be described with reference to the accompanying drawings in which:—

Fig. 1 is a side elevation of a vehicle including a system according to the invention; and,

Fig. 2 is a generally schematic representation of a hydraulic control circuit of the invention.

Shown in Fig. 1 is a vehicle 10' including lift arms 12' forwardly disposed thereof, pivotally attached to the frame 14' of the vehicle 10', and raisable and lowerable by extension and retraction of the piston rod of a lift cylinder 16'. Pivotally secured to the extended ends of the lift arms 12' is a bucket 18' which may be pivoted through link means 22' by extension and retraction of tilt cylinders 20'. It will be seen that retraction of these cylinders 20' moves the bucket 18' to a rack-back position, and extension of the cylinders 20' moves the bucket to a dump position.

The vehicle includes an operator's station 23' with operator controls for selectively actuating the lift and tilt cylinders 16', 20'.

The operator controls include actuator valve 26' as shown in Fig. 2 readily accessible to the operator of the vehicle 10'.

A first fixed displacement implement fluid pump 28' draws fluid from a reservoir

30' through a conduit; past a main relief valve 34'; and to a pair of control valves 36', 38'. A second fixed displacement implement fluid pump 40' draws fluid from reservoir 30' through a conduit past a main relief valve 32' to a second pair of control valves 44', 46'.

The control valve 36' is operatively associated with the control valve 44', which is similar in construction, in the same manner as disclosed in our U.S. Patent Specification No. 3,847,059, (the disclosure of which is specifically incorporated herein by reference). The control valve 44' also, of course, includes similar service ports generally shown in Fig. 2. In accordance with the disclosure of U.S. Patent No. 3,847,059, equalizing conduits communicate between respective service ports in the valves 36' and 44'. These conduits assure equal pressure to the head ends and rod ends respectively of the cylinders 20' in accordance with the above U.S. Patent No. 3,847,059, as will be further discussed.

Similar to the control valve 36', the control valve 38' has an inlet port for receiving fluid from the conduit 32'. The inlet port is in communication with a branched supply conduit by means of an inlet check valve. The valve 38' also includes a pair of upper and lower service ports or chambers spaced apart on opposite side of the branched conduit with drain ports being arranged respectively adjacent the service ports. A valve spool is slidably arranged within a bore to selectively regulate communication of the service ports with either the branched supply conduit or the drain ports. Make up valves provide communication between the service ports and the drain ports, whenever fluid pressure in one of the service ports is less than the fluid pressure in the drain passages. Similar to the above description, the control valve 46' is generally identical to the control valve 38'. The control valves 38', 46' are paired in a similar manner as disclosed in U.S. Patent Specification No. 3,847,059. Equalizing conduits provide communication between the service ports of the respective control vlaves 38', 46'.

A conduit communicates a three-way vent valve 112 with the back chamber of make-up valve in valve 38', and another conduit communicates the valve 112 with a back chamber of the makeup valve in control valve 46'. Cross-conduits provide communication between the back chambers of control valve 38' and the corresponding back chambers of control valve 46'.

The center portion of the entire control valve assembly 36', 38', 44', 46' is a common drain manifold which communicates with tank 30' through a conduit, again generally similar to the apparatus disclosed in U.S. Patent No. 3,847,059. Each of the drain conduits of the individual control valves 36', 38', 44', 46' communicates with this manifold.

As shown in Fig. 2, first service ports of valves 38', 46' communicate with the head ends of the lift cylinders 16' through conduits 128', 130', and second service ports communicate with the rod ends of the lift cylinders 16' through conduits 132', 134'. First service ports of valves 36' and 44' communicate with the head ends of the tilt cylinders 20' through conduits 136', 138', and second service ports communicate with the rod ends of the tilt cylinders 20' through conduits 140', 142'.

A pilot pressure system includes a pilot pump 152 which communicates through a conduit 154' to the actuator valve 26'. Such conduit 154' feeds over a pilot pressure relief valve 156' or to a pilot supply pressure port 158'. The valve body has first and second valve spools reciprocable therein and a port 172' which communicates with the end 174' of the control valve 36' and also the end 176' of the control valve 44' through conduit 175' and branch conduits 177', 179'. The valve body further defines a port 178' which communicates with the opposite end 189' of the control valve 44' through a conduit 182'.

The body of actuator valve 26' also defines a port 184' which communicates with the end 186' of the control valve 38', and the end 188' of the control valve 46', through conduit 190' and branch conduits 192', 194'. The body further defines a port 196' which communicates with the end 198' of the control valve 38' and the end 200' of the control valve 46' through a conduit 202 and branch conduits 204', 206'. A conduit 208' interconnects a port 210' of the body and the valve 112, and pilot pressure is supplied to the valve 112 through a conduit 212'. The valve 112 also communicates with tank 214 through a conduit 216.

The body of valve 26' also defines an outlet port communicating with tank 30' through a conduit 220'.

For description of operation of an actuator valve generally similar to actuator valve 26', reference is made to our U.S. Patent Specification 3,869,107.

In accordance with U.S. Patent Specification No. 3,847,059 pilot pressure applied to one or the other side of each control valve 36', 38', 44', 46' will shift the spool operatively associated therewith in a manner to provide appropriate communication between certain ports for actuating the tilt and lift cylinders 20', 16'.

The spools in the actuator valve 26' and their association with the various ports

generally follows the construction and operation of the spools in U.S. Patent Specification No. 3,771,564, assigned to the assignee of this invention.

Movement of a first spool of valves 26' in an upward direction to a "raise" position provides communication of pilot pressure with the port 196', with close control and modulation of such pressure during movement of the spool, and pressure build up in the port 196' to provide pilot pressure to the conduit 202', and to the control valves 38', 46', in accordance with U.S. Patent No. 3,771,564.

The application of pilot pressure to the control valves at ends 198' and 200' provides for shifting of the spools thereof in accordance with U.S. Patent No. 3,847,059 to supply pressurized fluid to the head ends of the lift cylinders 16', to extend the lift cylinders 16' to in turn raise the lift arms 12' of the vehicle 10'. The rod ends of the lift cylinders 16' are relieved through control valves 38', 46'.

Returning the first spool to the "hold" position, of course, again blocks off pilot pressure from any of the ports, and also provides that none of the ports communicating with the lift cylinders 16' communicates with tank, so that the lift arms 12' are held in position relative to the vehicle.

In order to lower the arms 12', the first spool is moved to the lower position, wherein pilot pressure is supplied to the port 184', in turn supplying pilot pressure to the control valves 38', 46' at ends 186' and 188', to retract the cylinders 16', to in turn lower the lift arms 12' of the vehicle 10'. An equalizing conduit assures equal pressurization in the rod ends respectively of these cylinders 16', in accordance with U.S. Patent No. 3,847,059.

During operating conditions, a makeup valve in control valve 38' and a corresponding back chamber of control valve 46' communicate with the pilot valve port 210'. This is accomplished through vent valve 112 and conduit 208'. If the first spool is moved to the float position, the outlet port in valve 26' communicates with port 210' so that the pressure in the chambers behind the makeup valve is relieved allowing them to open.

A second spool in valve 26' is generally identical with the first spool. Movement of the second spool to a rack-back position provides for communication between the port 158' and port 172', and provides pressure buildup in the port 172', to in turn supply pilot pressure to the end 174' of the control valve 36' and the end 176' of the control valve 44', to in turn supply fluid pressure to the rod ends of the cylinders 20'. The head ends of the cylinders 20' are communicated to tank through valves 36', 44', so that the cylinders 20' are retracted, moving the bucket 18' to a rack-back position. The rod ends of the cylinders 20' are relieved through conduits 142', 140'. If the spool is placed in the "hold" position, pilot fluid pressure is blocked from communication with the control valves 36', 44', and the bucket 18' is held in position.

If the second spool is moved to the second or slow dump position, fluid pressure is supplied to the port 178', pressure buildup is provided in the port 178'. Such pressure is communicated to end 180' of the control valve 44' through conduit 182', providing movement of the spool therein to in turn direct fluid pressure to the head end of the tilt cylinder 20' shown in the lower right of Fig. 2, such pressure is communicated from the lower service port in control valve 44' to the upper service port in control valve 38' and through conduit 136' to the head end of the other tilt cylinder 20' (Upper right in Fig. 2). The pressure supplied to the head ends of these cylinders is supplied only by the pump 40, the pump 28 being blocked from communication with the tilt cylinders 20', since the other control valve 36' operatively associated with the tilt cylinders 20' is not actuated. That is, only one of the two pumps is used to extend the tilt cylinders 20' to in turn move the bucket 18' toward a dump position, thus providing a relatively low speed of movement of the bucket 18' from the rack-back position toward the dump position.

As shown in Fig. 2, the conduit 168' does not communicate with the port 170', but rather communicates with a valve 300, movably actuated by the rod 302 of a tilt cylinder 20' so as to be movable thereby upon extending and retraction thereof. A branch conduit 304 communicates with the conduit 168', and is operatively connected with another valve 306. Pressure is supplied to valve 300 by a line 318 communicating with line 212'. A resilient spring 308 biases the valve 306 into a leftward position, and pressure applied in the conduit 168' and branch conduit 304 move the valve 306 rightwardly against the bias of the spring 308. A branch conduit 310 communicates the conduit 182' and the valve 306 also. The conduit 168' also communicates with the valve 306, rather than the port 166'. In this application, port 166' is blocked and pressure to port 316 of valve 26' actuate a detent mechanism to prevent detenting 26' in the full rack-back mode. Such mechanism can be found in our U.S. Patent No. 3,972,264.

Further included is a restrictor 312 in the conduit 142' and another restrictor 312' and conduit 314 are added, communicating the

conduit 142' with the makeup valve 70' of the valve 36'. During the slow dump mode, oil returning from the lower cylinder 20' (as seen in Fig. 2) passes through valve 36', makeup valve 70' and enters line 314, containing restriction 312', and joins flow from the upper cylinder 20'. Both flows then pass through restrictor 312 and allows that restrictor to be sized to prevent undue pressure buildup on pump 40 during rack-back mode of operation.

In the use of the apparatus, assuming that the bucket 18' is in full rack-back position, i.e., the tilt cylinders 20' are fully retracted, the valves 300, 306 will be in positions opposite that shown in Fig. 2. Actuation of the valve 26' to provide a dump mode provides pressure into conduits 182' and 168' to port 180' and 170' of control valves 36' and 44' until such time as valve 300 is de-actuated. The pressure in conduit 168' moves the valve 306 rightwardly against the spring 308, so that pressure in conduit 168' passes through the valve 306 to conduit 168" to port 170' of control valve 36'. It will be seen that a fast-dump mode is achieved as pilot pressure is now supplied to end 170' of control valve 36' *and* end 180' of control valve 44' so that both pumps supply fluid to the head ends of cylinders 20'.

After a certain amount of the fast-dump movement of the bucket 18', the valve 300 is moved to the leftward position shown wherein fluid pressure in the line 168' is dumped therethrough the tank. This allows the valve 306 to move leftwardly under the resilience of spring 308 as shown, whereupon fluid pressure in the conduit 168' is relieved to tank through valve 306. Thus, pressure is relieved from the port 170', so that the bucket 18' is automatically shifted into the slow-dump mode after a certain amount of travel thereon in the fast-dump mode from the full rack-back position. Such automatic change is directly related to bucket position because of the interaction of the valve 300 and rod 302 of the tilt cylinder 20'. Thus, after a certain degree of travel of the bucket 18' from the rack-back position, only the slow-dump mode of the bucket 18' can be achieved, for highly efficient operating control of the bucket 18'.

The restrictor aids in slowing fluid flow from the rod end of the cylinder 20' for highly effective control of the bucket 18' with the bucket 18' carrying a very high load.

The slow dumping action of the bucket 18' allows the operator more time to control dumping operation. Also, the bucket velocity is reduced at the appropriate time to reduce shock when the bucket 18' contacts the dump limiting stops. Additionally, the flow of pump 28', cut off from the dump cycle by the valve 36' returning to a neutral condition can be routed to the lift cylinders 16' by actuating the lift control of the valve means 26', adding to the overall utility of the vehicle 10'.

WHAT WE CLAIM IS:—

1. A hydraulic control system for a vehicle having tilt cylinder means actuable in opposite directions to move a bucket to a dump position and to a rack-back position respectively, the hydraulic control system comprising a fluid pump, and means for operatively interconnecting the fluid pump and tilt cylinder means for selectively providing a first, and a second relatively higher, speed of movement of the bucket from the rack-back position toward the dump position through actuation of the tilt cylinder means, the means for operatively interconnecting the fluid pump means and tilt cylinder means including means whereby, after initial selection of the second, relatively higher speed of movement of the bucket from the rack-back position toward the dump position and after a given degree of the higher-speed movement having taken place, the first, relatively lower speed is automatically instituted.

2. A control system according to claim 1, wherein the means for operatively interconnecting the fluid pump means and tilt cylinder means comprises a bucket position sensing means arranged to be operatively associated with the tilt cylinder means for sensing the degree of actuation of the tilt cylinder means.

3. A control system according to claim 1 or claim 2, which includes two fluid pumps for moving the bucket.

4. A control system according to claim 2 and claim 3, wherein the means for operatively connecting the fluid pump means and tilt cylinder means further comprises valve means operatively connected with the bucket position sensing means and actuable in response thereto to provide, in use, communication between the first fluid pump and tilt cylinder means and block communication between the second fluid pump and tilt cylinder means.

5. A control system according to claim 4, wherein the means for operatively interconnecting the fluid pump means and tilt cylinder means comprise means for selectively providing communication of only a first of the fluid pumps with the tilt cylinder means for providing the first speed of movement of the bucket from the rack-back position toward the dump position, and for selectively providing communication of both the first and second fluid pumps with the cylinder means for

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conduit 142' with the makeup valve 70' of the valve 36'. During the slow dump mode, oil returning from the lower cylinder 20' (as seen in Fig. 2) passes through valve 36', makeup valve 70' and enters line 314, containing restriction 312', and joins flow from the upper cylinder 20'. Both flows then pass through restrictor 312 and allows that restrictor to be sized to prevent undue pressure buildup on pump 40 during rack-back mode of operation.

In the use of the apparatus, assuming that the bucket 18' is in full rack-back position, i.e., the tilt cylinders 20' are fully retracted, the valves 300, 306 will be in positions opposite that shown in Fig. 2. Actuation of the valve 26' to provide a dump mode provides pressure into conduits 182' and 168' to port 180' and 170' of control valves 36' and 44' until such time as valve 300 is de-actuated. The pressure in conduit 168' moves the valve 306 rightwardly against the spring 308, so that pressure in conduit 168' passes through the valve 306 to conduit 168" to port 170' of control valve 36'. It will be seen that a fast-dump mode is achieved as pilot pressure is now supplied to end 170' of control valve 36' *and* end 180' of control valve 44' so that both pumps supply fluid to the head ends of cylinders 20'.

After a certain amount of the fast-dump movement of the bucket 18', the valve 300 is moved to the leftward position shown wherein fluid pressure in the line 168' is dumped therethrough the tank. This allows the valve 306 to move leftwardly under the resilience of spring 308 as shown, whereupon fluid pressure in the conduit 168' is relieved to tank through valve 306. Thus, pressure is relieved from the port 170', so that the bucket 18' is automatically shifted into the slow-dump mode after a certain amount of travel thereon in the fast-dump mode from the full rack-back position. Such automatic change is directly related to bucket position because of the interaction of the valve 300 and rod 302 of the tilt cylinder 20'. Thus, after a certain degree of travel of the bucket 18' from the rack-back position, only the slow-dump mode of the bucket 18' can be achieved, for highly efficient operating control of the bucket 18'.

The restrictor aids in slowing fluid flow from the rod end of the cylinder 20' for highly effective control of the bucket 18' with the bucket 18' carrying a very high load.

The slow dumping action of the bucket 18' allows the operator more time to control dumping operation. Also, the bucket velocity is reduced at the appropriate time to reduce shock when the bucket 18' contacts the dump limiting stops. Additionally, the flow of pump 28', cut off from the dump cycle by the valve 36' returning to a neutral condition can be routed to the lift cylinders 16' by actuating the lift control of the valve means 26', adding to the overall utility of the vehicle 10'.

WHAT WE CLAIM IS:—

1. A hydraulic control system for a vehicle having tilt cylinder means actuable in opposite directions to move a bucket to a dump position and to a rack-back position respectively, the hydraulic control system comprising a fluid pump, and means for operatively interconnecting the fluid pump and tilt cylinder means for selectively providing a first, and a second relatively higher, speed of movement of the bucket from the rack-back position toward the dump position through actuation of the tilt cylinder means, the means for operatively interconnecting the fluid pump means and tilt cylinder means including means whereby, after initial selection of the second, relatively higher speed of movement of the bucket from the rack-back position toward the dump position and after a given degree of the higher-speed movement having taken place, the first, relatively lower speed is automatically instituted.

2. A control system according to claim 1, wherein the means for operatively interconnecting the fluid pump means and tilt cylinder means comprises a bucket position sensing means arranged to be operatively associated with the tilt cylinder means for sensing the degree of actuation of the tilt cylinder means.

3. A control system according to claim 1 or claim 2, which includes two fluid pumps for moving the bucket.

4. A control system according to claim 2 and claim 3, wherein the means for operatively connecting the fluid pump means and tilt cylinder means further comprises valve means operatively connected with the bucket position sensing means and actuable in response thereto to provide, in use, communication between the first fluid pump and tilt cylinder means and block communication between the second fluid pump and tilt cylinder means.

5. A control system according to claim 4, wherein the means for operatively interconnecting the fluid pump means and tilt cylinder means comprise means for selectively providing communication of only a first of the fluid pumps with the tilt cylinder means for providing the first speed of movement of the bucket from the rack-back position toward the dump position, and for selectively providing communication of both the first and second fluid pumps with the cylinder means for

providing the second, relatively higher speed of movement of the bucket from the rack-back position toward the dump position.

6. A control system according to claim 1, substantially as described with reference to the accompanying drawings.

7. A vehicle having tilt cylinder means actuatable in opposite directions to move a bucket to a dump position and to a rack-back position respectively, and a hydraulic control system according to any of claims 1 to 3.

8. A vehicle according to claim 7, further comprising restrictor means operatively associated with the tilt cylinder means such that fluid leaving the tilt cylinder means during actuation thereof in a first direction, passes through the restrictor means.

9. A vehicle according to claim 8, wherein the restrictor means is operatively associated with the tilt cylinder means such that fluid leaving the tilt cylinder means during actuation thereof in the other direction, to move the bucket to a dump position, passes through the restrictor means.

10. A vehicle according to claim 7, substantially as described with reference to the accompanying drawings.

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